BARRIERS IN THE ADOPTION OF INTERNET OF THINGS (IoT) IN THE CONSTRUCTION INDUSTRY OF PAKISTAN

Final Year Project UG 2017

By

ABDUL BASIT REHMAN (G.L)	**00000221823**
HANAN ASIF	**00000208656**
SYED IMDAD ALI SHAH	**00000211901**
MAARIJ ZAFAR CHEEMA	**00000212022**

(2017-2021)

PROJECT ADVISOR: DR KHURRAM IQBAL AHMAD KHAN

NUST Institute of Civil Engineering (NICE)

School of Civil and Environmental Engineering (SCEE)

National University of Sciences and Technology (NUST)

Islamabad, Pakistan

This is to certify that the

Report entitled

BARRIERS IN THE ADOPTION OF INTERNET OF THINGS (IoT) IN THE CONSTRUCTION INDUSTRY OF PAKISTAN

Submitted by

ABDUL BASIT REHMAN (G.L)	**00000221823**
HANAN ASIF	**00000208656**
SYED IMDAD ALI SHAH	**00000211901**
MAARIJ ZAFAR CHEEMA	**00000212022**

Has been accepted towards the requirements

for the award of bachelor's degree

in

Civil Engineering

Dr. KHURRAM IQBAL AHMAD KHAN

Assistant Professor

NUST Institute of Civil Engineering (NICE)

School of Civil and Environmental Engineering (SCEE)

National University of Sciences and Technology, Islamabad, Pakistan

Declaration

We certify that this research work titled “barriers in the adoption of Internet of Things (IoT) in the construction industry of Pakistan” is our own work carried out during the course of our study under the supervision of Dr. Khurram Iqbal Ahmad Khan.

I assert the statements made and conclusions drawn are an outcome of my research work. I further certify that

- The work contained in the report is original and has been done by me under the general supervision of my supervisor.
- The work has not been submitted to any other Institution for any other degree/diploma/certificate in this university or any other University of Pakistan or abroad.
- We have followed the guidelines provided by the university in writing the report.
- Whenever we have used materials (data, theoretical analysis, and text) from other sources, we have given due credit to them in the text of the report and giving their details in the references.

Signature of students

Abdul Basit Rehman

Hanan Asif

Syed Imdad Ali Shah

Maarij Zafar Cheema

Copyright statement

- Copyright in text of this thesis rests with student author. Copies (by any process) either in full, or of extracts, may be made only in accordance with instructions given by the author and lodged in the library of NUST Institute of Civil Engineering (NICE). Details may be obtained by the librarian. Further copies may not be made without the permission of the author.
- The ownership of any intellectual property right which may be described in this thesis is vested in NUST Institute of Civil Engineering, subject to any prior agreement to the contrary, and may not be available for use by third parties without the written permission of nice, which will prescribe the terms and conditions of any such agreement.
- Further information on the conditions under which disclosures and exploitation may take place is available from the library of NUST Institute of Civil Engineering, Islamabad.

Acknowledgements

In the Name of Allah, the Most Beneficent, the Most Merciful for without His blessings, this research would not have been possible. First and foremost we are extremely grateful to our supervisor, Assistant Professor Dr. Khurram Iqbal Ahmad Khan Head of Department (HoD) for his invaluable advice, continuous support, and patience during my research. His immense knowledge and plentiful experience have encouraged me in all the time of my academic research and daily life. We would also like to thank all the participants who have taken part in our research surveys and interviews and have helped along. We would like to thank all our friends and batch mates. It is their kind help and support that have made our study and life in NUST a wonderful time. Finally, we would like to express our gratitude to our parents. Without their tremendous understanding and encouragement in the past few years, it would be impossible for us to complete our study.

Dedicated to our Parents and Families

ABSTRACT

Pakistan is a developing country, but it has a lot of potential in the construction industry. In the recent era every other industry is shifting towards advancements and sustainability by adopting automation and innovative technology. On the contrary in technology adoption the construction industry of Pakistan is at a snail's pace. Internet of things (IoT) has been adopted by many other industries and its results are astonishing but in construction it is limited to a very few applications.

The aim of this study is to identify challenges in adoption of IoT in the construction industry of Pakistan, provide a reasonable conceptual framework which will help the stakeholders in its adoption and it will also pave a road for the future researchers in IoT in Pakistan. This study will not only benefit Pakistan but other developing countries as well.

To carry out this research a mixed research method is adopted. Quantitative and qualitative research methods are used for data collection. A web based questionnaire and interviews of the concerned focus groups clients, Contractors, subcontractors, consultants, and individuals having construction experience were conducted for data collection. The sample size of the respondents is 74. The data analysis is done using Statistical software for data analysis IBM SPSS Statistics 26.

The research concludes on developing a conceptual framework for IoT adoption which will help the Construction sector of Pakistan. Moreover, according to this research the main factors which restrain IoT adoption in the construction industry of Pakistan are Lack of awareness about IoT, its benefits to improve the industry, cost of initial investment, very limited research on IoT in Construction., PEC and other related agencies are not confident enough to invest in this area., presence of less skilled labour in construction industry causes lag in adoption of new technology. The poor attitude of the top management in technology adoption is also a dictating factor in IoT adoption. In addition, Pakistani culture acts as a barrier in adoption of new technology in construction industry.

Table of Contents

List of Abbreviations

IoT	Internet of Things
UAVs	Unmanned Aerial Vehicles
RFID	Radio Frequency Identification
IT	Information Technology
GPS	Global Positioning System
SPSS	Statistical Package for Social Sciences

List of Tables

List of Figures

CHAPTER 1

1 INTRODUCTION

1.1 **BACKGROUND**

Among the major industries in the world construction sector plays a vital role. It has a significant impact in the economics of both developed and developing countries. On the other side when innovativeness and technology adoption is concerned it is one of the conservative industry. The developing technologies force the construction industry to utilize novel approaches to overcome cost and time overruns of construction projects. (Louis, J., & Dunston, August 2017). Pakistan is a developing country and has a lot of potential in the construction industry, but it has yet to adopt to the changes and innovations made in this field. To bring innovativeness and advancements in the construction sector IoT adoption is very much necessary because automation, integration of technology and sustainability has revolutionized other industries.

To abandon old traditions and adopt newer approach in the construction industry is a strenuous job but the first step is to comprehend the innovation itself, to gain insight in understanding the hindering factors in adoption (Blayse, K. Manley, & A.M., 2004). For a country like Pakistan barriers in adoption of innovation is mainly due to lack of investment in research and development, disruptive supply chain and poor communication between industry and academia (Dulaimi et al., 2002)

This study will not only benefit Pakistan but other developing countries as well. Therefore the aim of this study is to identify challenges in adoption of IoT in the construction industry of Pakistan, provide a reasonable conceptual framework which will help the stakeholders in its adoption and it will also pave a road for the future researchers in IoT in Pakistan

1.2 PROBLEM STATEMENT

In construction industry, IoT is a completely new concept and known as "Internet of the future" with basic concept of connecting all the elements across the globe to the internet.. Developed countries like Japan, Malaysia, and USA have done significant research in it. There are numerous benefits for utilizing internet of things in the development area. These consist of monitoring, successful controlling, superior execution, cost, efficient, and best quality. It has been extended additionally to be utilized on settling the quick dynamic on account of accessibility analysis of real-time data (Ning & Xu, 2010) (Gubbi et al, 2013) (Dave et al., 2016). In addition, it improves the crisis management and emergency responses by introducing efficient monitoring of the structure (Zhao et al, 2013). The innovation in IoT can be utilized for the viewpoints related to ecological like waste administration, flood focus investigation and lake contamination (Wei & Li, 2011). In Pakistan, this concept is completely new, and no one is taking risk in its adoption because of very limited research. Furthermore, IoT will bring innovation and smartness to the construction sector. IoT adoption will enhance efficiency, reduce losses and delays, and improve Health and Safety problems etc. which are among the major issues related to the Construction sector of Pakistan.

1.3 OBJECTIVES

- To classify the barriers in implementation of IoT in the construction industry of Pakistan.
- To develop a conceptual framework for the adoption of IoT in Pakistan.

1.4 RESEARCH METHODS

To carry out our research a mixed research method is used. Both quantitative and qualitative research methods are adopted. A factor analysis sheet is used to identify the factors involved in IoT adoption. A web based questionnaire and interviews of the concerned focus groups were conducted for data collection. The

data analysis is done using Statistical software for data analysis IBM SPSS Statistics 26. Based on results a conceptual framework is developed for IoT adoption which will help the Construction sector of Pakistan.

CHAPTER 2

2 LITERATURE REVIEW

2.1 INTRODUCTION

The world is shifting towards automation, sustainability, and technology advancement. On the contrary in technology adoption the construction industry of Pakistan is at a snail's pace. To improve the construction industry of Pakistan there is a need to adopt new technology, innovative approach, and promote technology adoption in construction industry.

Internet of things (IoT) is an innovative concept developed by Kevin Ashton in 1999 (Ashton, 2009). It is also known as "Internet of the future". It can be also explained as a system of devices, mechanisms for computing, and data exchange/transfer connected to each other and to the internet to give benefits and ease for use.

IoT in construction has many benefits. Some of them are on site monitoring, improving quality and cost reduction, effective controlling and timesaving (Ning & Xu, 2010) (Gubbi et al, 2013) (Dave et al., 2016). It can also improve emergency situations and crisis management with well-organized monitoring of the structure (Zhao et al, 2013). Moreover, effective communication with machines related to the coordination and optimization of construction works, effective communication of partners to share information, smart cities, risk management applications, and so on are some of the benefits of IoT.

The aim of this study is to identify the barriers involved in IoT adoption by the construction industry of Pakistan. To carry out this research the following literature review was conducted.

2.2 WHAT IS INTERNET OF THINGS (IoT)?

To get an answer to this question first we need to define some terms

2.2.1 History

The introduction of IoT was given by Kevin Ashton in 1998 and has gained increasingly more attention in the academia and industry (Santucci, 2009)

2.2.2 Radio-frequency identification (RFID) technology

Radio-frequency identification (RFID) technology is a modern technology used to identify and track an object or a person by means of radio waves. This identification system consists of chip based tags and readers.

2.2.3 Sensors

Also known as transducers, a sensor is defined as a gadget that identifies the adjustment of the climate and reacts to some yield on the other framework. A sensor changes a physical phenomenon into a quantifiable simple voltage (or in some cases a computerized signal) changed over into a comprehensible showcase or sent for perusing or further handling.

2.2.4 Actuators

An actuator can be defined as a part of a device or machine that helps it to achieve physical movements by converting energy, often electrical, air, or hydraulic, into mechanical force. Simply put, it is the component in any machine that enables movement.

2.2.5 IoT

The term IoT was a first intended to refer to uniquely identifiable interoperable connected objects with radio-frequency identification (RFID) technology (Ashton, 2009).

2.2.6 Concept of IoT

The idea of IoT is that of an ecosystem of objects and things which can communicate and co-operate with each other through some mean so that the work is

done in a more efficient manner. The means here are sensors, radio frequency identification (RFID) tags, mobile phones, actuators etc for pre-set objectives.

2.2.7 Definition

The term IoT was firstly proposed to refer to uniquely identifiable and interoperable objects connected with radio-frequency identification (RFID) technology. Later, specialists referred IoT with modern technology and advancements like actuators, GPS gadgets, cell phone and sensors. Nowadays, an acknowledged definition for IoT is a framework of powerful worldwide organization with self-arranging abilities which are dependent on interoperable and norm conventions where virtual and physical 'Things' have actual qualities, virtual characters. Utilize savvy interfaces, characters and are consistently coordinated into the data organization.

2.3 ADVANTAGES IN IoT ADOPTION

Extracted from the literature following are some of the advantages of IoT adoption in the construction industry.

2.3.1 Productivity

The construction industry is retrained with timelines and goals. It is essential to avoid backlogs because they increase the project cost. With IoT adoption there will be more efficiency and readiness so that the productivity is more enhanced. IoT allows individuals with modest work, and, all things considered, they have presented a better opportunity to communicate effectively with team members and project proprietors, producing ground-breaking plans to improve project conveyance and consumer loyalty.

Moreover, sufficient supply of materials is necessary in construction projects. Though, there might be a possibility of late supply of material at site due to scheduling errors. By adopting IoT the materials supply branch can be equipped with

proper sensors which can determine the quantity of materials and inform the concerned.

2.3.2 Maintenance

If not actively managed consumption of energy can cause wastage leading to increase in project costs. With real time information analysis, it is more likely to knows the condition of every working and idle equipment, to organize timely upkeep and refuelling of non-working equipment. Moreover, field sensors can play an important role in preventing problems from happening eventually reducing warranty claims. Moreover, sensors can also be used for quality assurance of materials and structure health monitoring.

2.3.3 Health, Safety & Security

Health and safety are one of the extreme dares on a project site and it can cost more than the total project cost. Health monitoring officers are not satisfactory enough to monitor a complex construction project of large scale. With IoT adoption health and safety problems can be tackled easily. Moreover, IoT enabled tags can help in recovering any displacement of items, as these instruments will identify the exact location of material or items and inform the concerned. Furthermore, IoT can play a role in risk management by allowing us to be updated about associated risks of a project and it can also enable workers to work in a risk free environment by notifying them when getting close to a hazard or entering a hazardous setting.

Moreover, dealing with gear and hardware for a long time may likewise make laborers experience exhaustion, which thus upsets their focus and usefulness. IoT makes it conceivable to screen indications of pain like unusual heartbeat rates, heights, and client area.

2.3.4 Unmanned Aerial Vehicles (UAVs) & Autonomous vehicles

UAVs and autonomous vehicles are very popular now a days and has gained public interest. Monitoring large scale construction projects are being made easy through UAVs more specifically drones. Furthermore, Autonomous construction

equipments are being tested in certain projects to limit human life exposure to unsafe work situations. Moreover, they play a certain role in preventing accidents on site. In addition, utilizing robots to accumulate precise overview guides and airborne pictures of a place of work, just as track progress distantly, saves money on an undertaking's time and cost. Moreover, the elevated pictures can give project administrators an alternate point of view of the venture and help spot potential issues that might not have been obvious starting from the earliest stage.

2.3.5 Real time Concrete Monitoring.

IoT in concrete curing is trending now a days. In this process sensors are installed in mix during concrete placement on-site, and then the construction managers follow the curing in real time and can manage their schedule more accurately. This accurate in situ estimation of concrete compressive strength provides opportunity to enhance crucial on-site construction processes such as time for removal of scaffoldings and improve properties of concrete mix design. In addition, time for opening of rehabilitated road and bridge for traffic can also be determined. With concrete maturity known the loss of scheduling and cycling of form work can be optimized, thus reducing labour requirement and reduction in costs.

Figure 2-1 Smart Monitoring of concrete at a construction site in Copenhagen

2.3.6 Monitoring structural health and waste management

Waste management has been a critical concern on building sites in recent years. To create space and eliminate hazards on a job site, waste must be removed. Trash levels should be checked and eliminated on a regular basis. Through IoT trackers, cost-effective monitoring of garbage disposal bins or trucks is possible. The authorities may impose sanctions on the contractor if he or she fails to properly handle garbage. During and after construction, IoT is also utilised in structural health monitoring to identify vibrations, cracks, and states of essential building members and civil structures.

2.3.7 Wearables

Wearables get smarter thanks to the Internet of Things. The ability to embed sensors in any machine or object to monitor execution levels, working conditions, actual statuses, and other data over a network is what propels IoT forward. When inert objects are connected to the internet, they open new possibilities. A wearable is a device that may be worn on the body that provides additional data to the client via connectivity. Smart glasses with augmented reality (AR), virtual reality (VR), and mixed reality (MR) technology are among them. For planning and modelling, these are now in use. Smart glasses can be used to create a full suite floor with all the furniture. The subtleties of the work behind the walls can be studied and planned by peeling back the layers of the mock-up. Clients can also use the smart-glasses for sales, giving residents a first-hand experience of how their new facility feels and looks. Employees are additionally empowered on and off the job site since they may access work instructions while executing specific activities using connected smart glasses, potentially enhancing their performance.

2.4 Barriers in adoption of IoT

With new technology there comes barriers. In this section some of the barriers are discussed in the adoption of IoT in the construction industry. These barriers are extracted through extensive literature review.

2.4.1 Inability of existing systems

This means that there is an inability in existing systems to manage errors while functioning. Because IoT requires advance systems (Stankovic & J.A, 2014).

2.4.2 Lack of documented standards

There are not documented methods for IoT application which makes its adoption risky (Al-Qaseemi et al, 2016).

2.4.3 Safety and security issue

This means that there is the possibility that the connected devices security can be compromised because they are after all connected to the internet. It is difficult to protect connected objects information, entities of IoT components and layers from external threats. Therefore, without proper protection Internet of things might be weak (Babar et al, 2010).

2.4.4 Improper understanding of IoT

There is not enough knowledge about the techniques used to apply IoT in the industry, this clarifies that there is an improper understanding of IoT (Bertino & Islam, 2017).

2.4.5 Society response

As IoT prioritizes things over social aspects which leads to a bad influence on the society. In addition, IoT brought alteration on all the social standards such as the way we connect, deal, and exchange data (Riggins & Wamba, 2015).

2.4.6 Poor network connectivity

The poor connectivity on construction sites and remote areas is a dictating factor and still remains a challenge (Syamsul & Laromi et al, 2018).

2.4.7 Complexity

Due to big data structure dealing with IoT is a complex process to stimulate (Al-Qaseemi et al, 2016).

2.4.8 Information privacy issues

As all the devices are connected to the internet so there is a possibility of security breach which makes the information insecure (Matharu et al, 2014).

2.4.9 Legalisation issues

There are no proper legal laws which binds the usage of IoT, claims assessments and binding of project contracts (Syamsul & Laromi et al, 2018).

2.4.10 Lack of confidence

Due to possibility of information leakages of construction parties involved in projects there is a lack of confidence to adopt IoT (Zhao et al, 2013).

2.4.11 Not enough expertise

As the technology is new to the industry so it lacks experienced staff to guide the interested (Syamsul & Laromi et al, 2018).

2.4.12 Not enough knowledge about the benefits of IoT

There is not enough knowledge about the benefits of IoT (Zhao et al, 2013).

2.4.13 Fear to fail

Due to large scale of projects and high stakes involved, trial of new expertise becomes a barrier because of the worry of breakdown (Syamsul & Laromi et al, 2018).

2.4.14 Top management official support

There is a lack of support from the top management officials (Chandanshive & Kazi, 2017).

2.4.15 Lack of training centres

There are very limited IoT training centres (Tang et al, 2019).

2.4.16 Not enough IoT technology

There is a limited research in IoT in construction which leads to lack of IoT technology in construction (Tang et al, 2019).

2.4.17 Not enough IoT knowledge

There is very limited research in the field of IoT in construction (Syamsul & Laromi et al, 2018).

2.4.18 Bad teamwork among construction parties

There is very poor cooperation among the construction parties which makes IoT adoption difficult (Tang et al, 2019).

2.4.19 Diversity of connected things

There are different methods to perform a certain task. This makes the diversity and heterogeneity of techniques in using things to perform specific jobs (Al-Qaseemi et al, 2016).

2.4.20 Incompatibility between the systems

The contrariness between the framework of IOT, its gadgets and the trouble to share and impart administration. Likewise, the test depicts to receive new applications for the framework (Noura & Atiquzzaman,, 2018).

2.4.21 Big data Issue and Inaccuracy of data

Due to enormous amount of data it is more difficult to understand. Also, as information is extracted from large set of data, this causes ambiguity of information selection to perform a certain function (Matharu et al, 2014).

2.4.22 Cost

Cost is one of the major factor which act as a barrier in IoT adoption in the construction industry (Matharu et al, 2014).

CHAPTER 3

3 RESEARCH METHODOLOGY

3.1 GENERAL

To carry out this research a mixed research methodology was adopted. To develop a questionnaire and interview questions a detailed literature review was conducted. The factors were identified using factor analysis sheet on Microsoft Excel. Both qualitative and quantitative data were collected through web based questionnaire on google forms and by interviewing focus groups clients, contractors, subcontractors and individuals having construction experience. Furthermore, the data analysis was done using statistical software for data analysis IBM SPSS Statistics 26.

3.2 DATA COLLECTION AND ANALYSIS

The data was collected through web based questionnaire using google forms in the form of excel spreadsheet. Moreover, interviews were conducted on focus groups clients, contractors, sub-contractors, and individuals having construction experience. The questionnaire comprised of 30 questions based on the results of factors analysis sheet. The theme of the questionnaire was about the benefits of IoT and factors which are causing hindrance in its adoption. The data was then analysed using statistical software for data analysis IBM SPSS Statistics 26.

3.3 FRAMEWORK DEVELOPMENT

To meet our objective of the research, based on the analysed data, a conceptual framework was developed that will help the construction industry to adopt IoT.

3.4 RESEARCH FLOWCHART

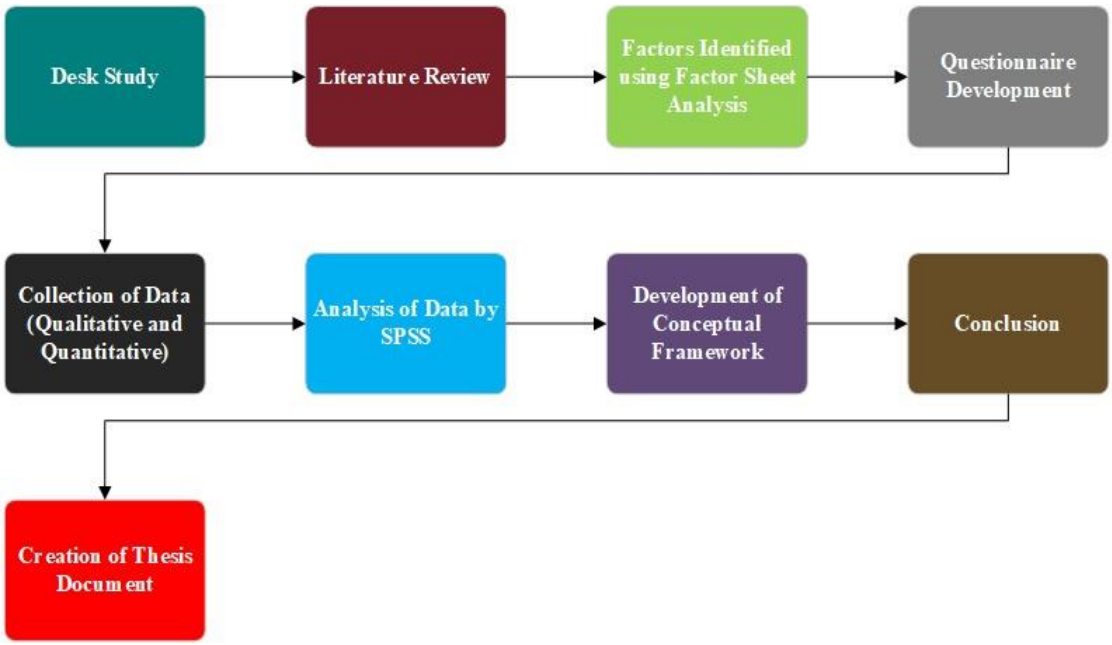


Figure 3-1 Research Flowchart

CHAPTER 4

4 RESULTS AND DISCUSSIONS

A detailed literature review was conducted, and factors were identified using factor analysis sheet. A questionnaire (Annex-A) was developed using these factors. It comprised of 31 questions and an online survey was conducted on google forms. Interviews were also conducted. There were a total of 74 respondents to the survey. The questionnaire comprised of 30 questions based on the Factor analysis sheet results. The data was then analysed using statistical software for data analysis IBM SPSS Statistics 26. The results of the questionnaire Annex-B

4.1 FACTOR ANALYSIS SHEET

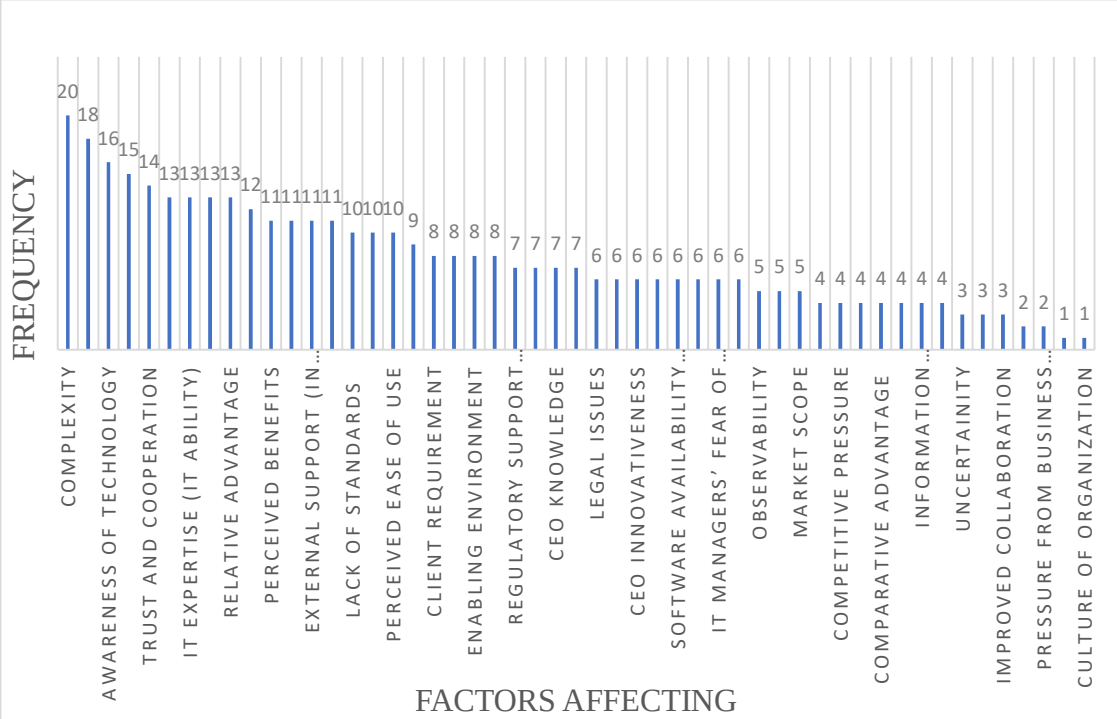


Figure 4-1 Factor Analysis Result

The factor analysis sheet shows the factors which are inhibiting the adoption of technology in the construction industry. These inhibiting factors are

Table 4-1 Factors inhibiting Internet of Things (IoT) adoption

S.no	Factors
1	Complexity
2	Awareness of technology
3	Trust and cooperation
4	Information Technology (IT) expertise availability
5	Perceived benefits
6	Client requirements
7	Enabling Environment
8	Regulatory Support
9	Legal Issues
10	Software Availability
11	IT managers fear of failure
12	Market scope
13	Comparative advantage
14	Uncertainty
15	Culture of Organization
16	Security issues

Using these factors, a questionnaire (ANNEX A) was developed for further evaluation

There were a total of 76 respondents and 74 were considered valid.

4.2 FOCUS GROUPS

The focus groups considered for data collection are clients, consultants, contractors, sub-contractors, and individuals having construction experience.

4.3 RESULT DISCUSSION USING PIE CHARTS

The results are discussed using PIE charts generated from the data analysis. Pie charts can be found in (Annex C).

4.3.1 The following distribution of responses was observed

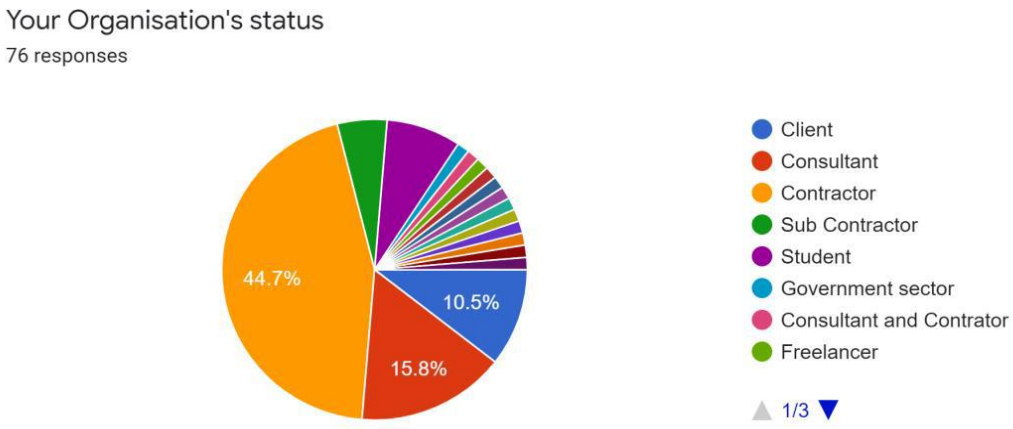


Figure 4-2 Pie chart showing organization status

As from the pie chart it is clear that majority consists of contractors and consultants while the rest are individuals having construction experience.

4.3.2 How many of the respondents knew about Internet of Things (IoT)?

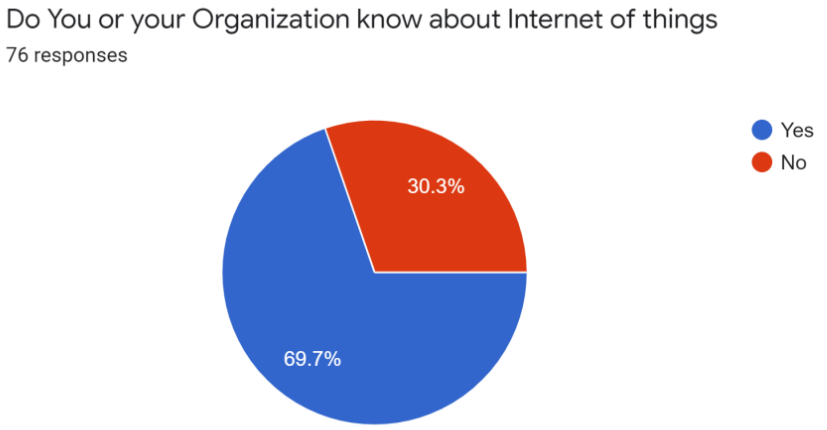


Figure 4-3 knowledge of IoT

As the above chart shows that out of 76 respondents 30.3 percent were unaware of internet of things (IoT).

4.3.3 Knowledge about advantages of Internet of Things

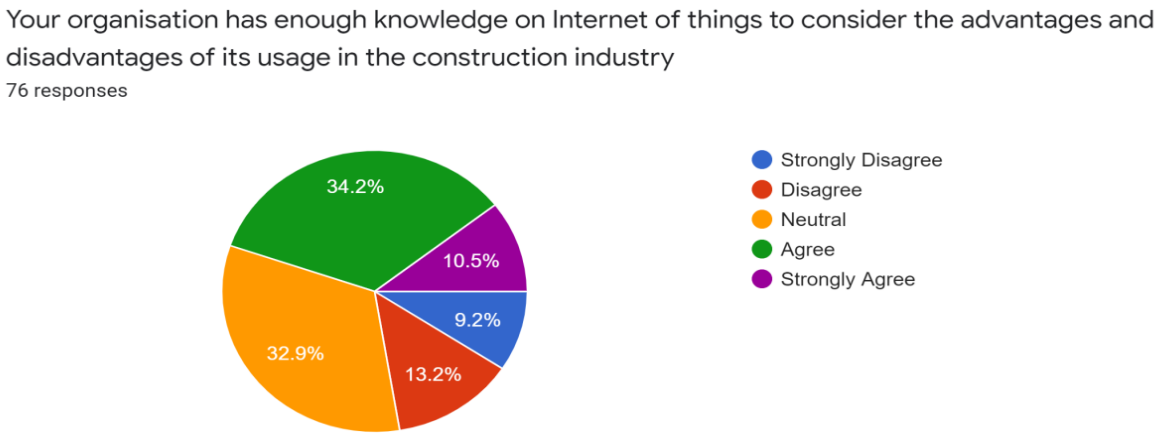


Figure 4-4 Knowledge about advantages of IoT

As from the results 34.9 percent agreed, and 10.5 percent strongly agreed but the rest of them were unaware about the advantages of Internet of Things.

4.3.4 IoT can help top management

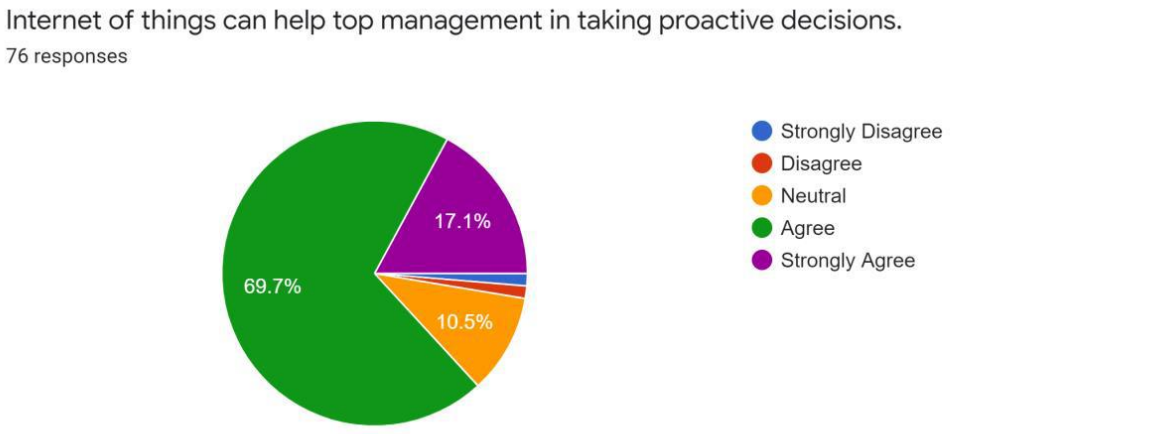


Figure 4-5 Benefits of IoT

The pie chart shows that majority believes that IoT adoption can help the top management in taking proactive decision to avoid material losses, improve efficiency and reduce cost and delays for construction projects.

4.3.5 Technical uncertainties

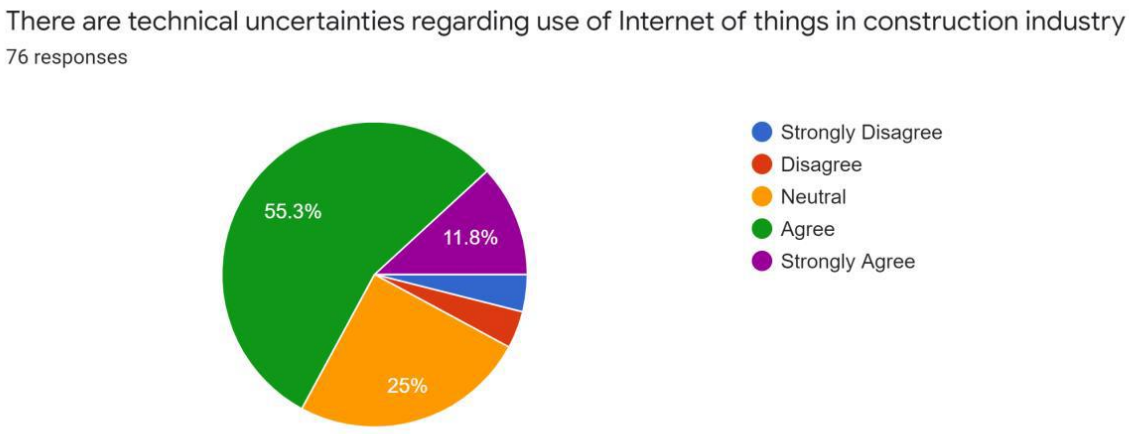


Figure 4-6 Technical uncertainties

Out of all the respondents 55.3 percent agreed and 11.8 percent that there may be technical uncertainties in IoT adoption this is one of the prohibiting factors for IoT adoption.

4.3.6 Lack of standards

Figure 4-7 Lack of standards

51.1 percent agreed and 15.6 strongly agreed that one of the reasons for not adopting IoT came out to be unavailability of experts and Lack of standards.

4.3.7 Pakistani culture

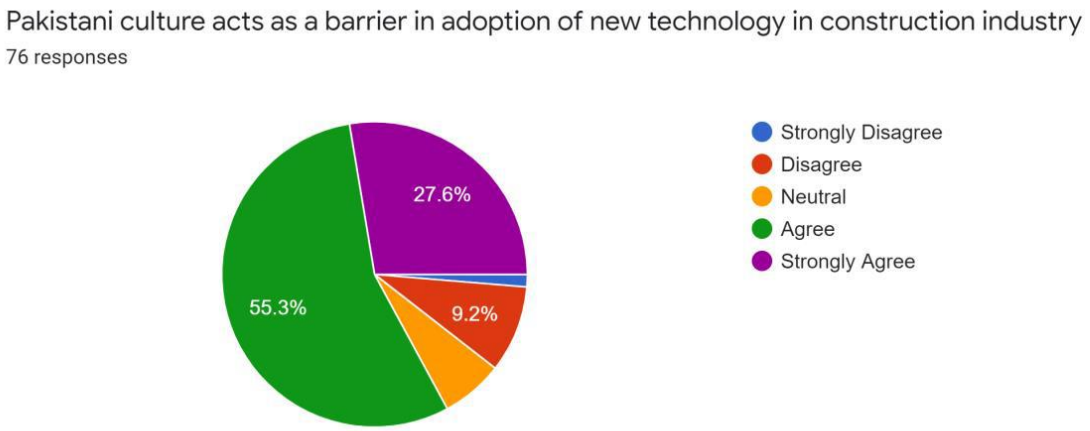


Figure 4-8 Response of Pakistani culture

The above chart explains that one of the hindering factors in IoT adoption is the resistance of Pakistani culture towards change.

4.3.8 Traditional methods are sufficient

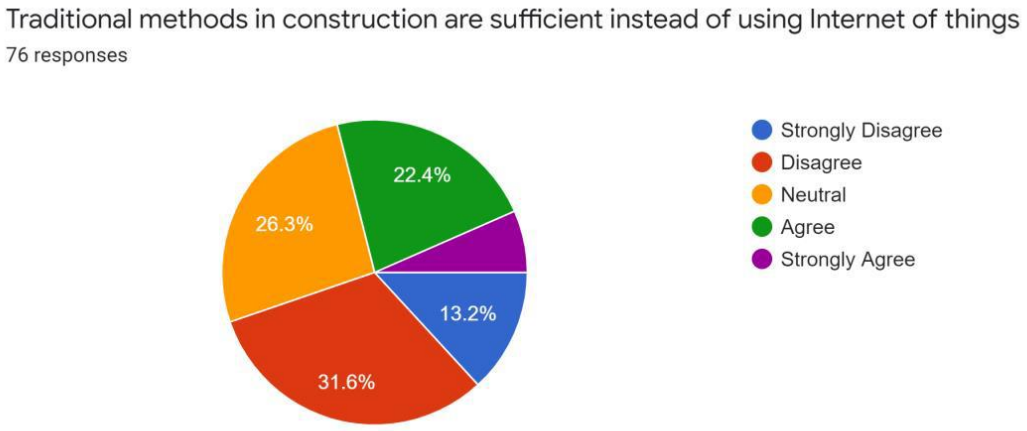


Figure 4-9 Sufficiency of traditional construction methods

The chart explains that there is a difference of opinion regarding the traditional methods in construction. 26.3 percent were neutral,31.6 percent disagree, 13.2 percent strongly disagree, and 22.4 percent agreed and the rest strongly agreed to this statement. This shows that there is a flexibility in changing the construction practitioner opinion about IoT adoption.

4.3.9 Regulations and Acts

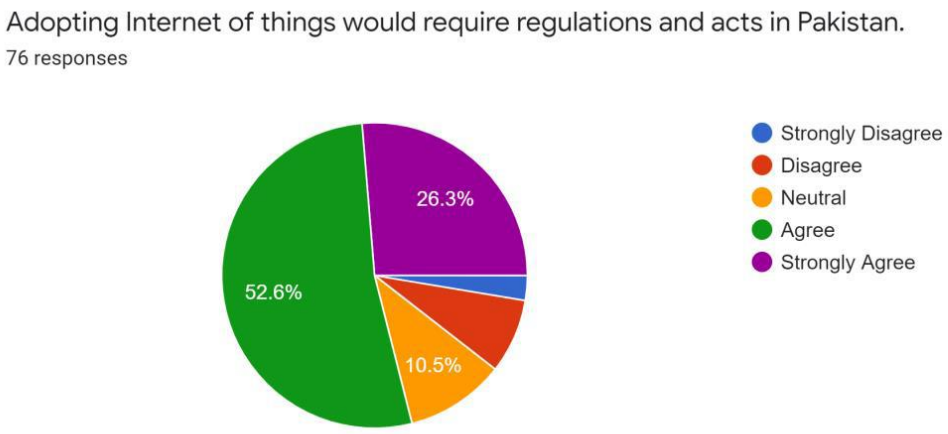


Figure 4-10 Demand for regulations and acts

Respondents were of the high opinion that IoT adoption would require formation of new rules and regulations across the construction industry.

4.3.10 Cost of initial investment

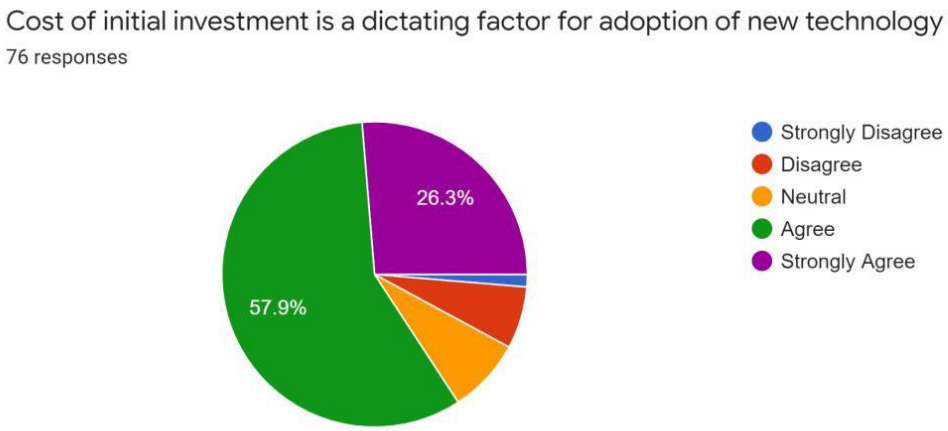


Figure 4-11 Cost of initial investment

Majority of the respondents believed that cost of initial investment is a dictating factor in adoption of IoT.

4.3.11 Incentives by Pakistan Engineering Council (PEC)

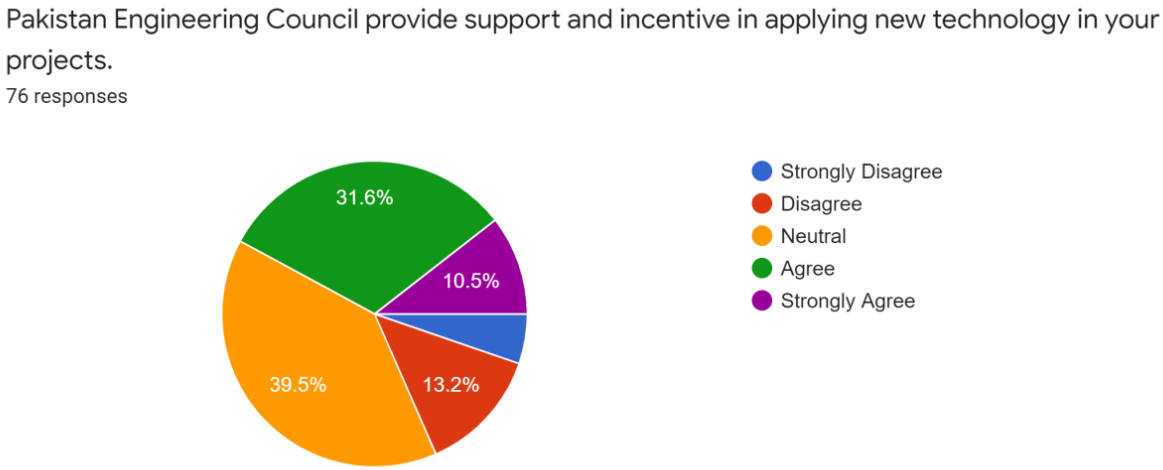


Figure 4-12 Incentives from Pakistan Engineering council PEC

Moreover, most of the respondents believe that there was a lack of investment by the construction industry into technology and safety. Incentives from PEC and other governing agencies can improve the adoption of IoT by the construction Industry.

The rest of the pie charts are in the Annex-C.

4.4 RESULT DISCUSSION USING STATISTICS

For input in SPSS software we assumed that

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree.

Total respondents = 74

Missing = 0

The statistics table shows the barriers which are involve in adoption of IoT in the Pakistan construction industry. To understand the results of the table simply analyse the mode for each row. All tables can be found in (Annex B)

Table 4-2 Statistics Table

	Mean	Median	Mode	Variance	Range
Do You or your Organization know about Internet of things?	.69	1.00	1	.217	1
Your organisation has enough knowledge on Internet of things	3.20	3.00	4	1.123	4
Your organisation implements new technology in different construction processes	3.53	4.00	4	1.129	4
IOT can help in reduction of health and safety problems and improving the overall efficiency of the Construction industry	3.99	4.00	4	.808	4
Internet of things can be beneficial to your business and stakeholders.	4.12	4.00	4	.492	4
with IOT construction industry will become less labour	3.81	4.00	4	.868	4
IOT can be useful for multiple purposes including security, monitoring, health and safety.	4.12	4.00	4	.492	3
ROI on technology like IOT can be recovered with ease.	3.61	4.00	4	.653	4
IOT can help top management in taking proactive decisions.	3.97	4.00	4	.438	4
IOT can improve efficiency of workers during project activities	4.05	4.00	4	.655	4
IOT can help in reduction of project time	4.00	4.00	4	.466	3

IOT will invade privacy of citizens in the construction sector	3.18	3.00	4	.969	4
IOT would cause more hindrance then helping	2.66	3.00	3	1.021	4
Technical uncertainties regarding use of IOT	3.64	4.00	4	.755	4
IOT would require regulations and acts in Pakistan.	3.89	4.00	4	.920	4
Cost of initial investment is a dictating factor for adoption of new technology	3.99	4.00	4	.726	4
Attitude and commitment from top management and stakeholders is a challenge in adoption of new technology	3.97	4.00	4	.712	4
Pakistani culture acts as a barrier in adoption of new technology in construction industry	3.96	4.00	4	.834	4
Traditional methods in construction are sufficient instead of using Internet of things	2.72	3.00	2	1.192	4
Presence of less skilled labour in construction industry causes lag in adoption of new technology	3.93	4.00	4	.804	4
Your organization frequently consults academic institutions with regards to new technologies and new techniques being developed	3.15	3.00	4	1.115	4

Your organization records worker accidents and things that are affecting the performance of a particular project.	3.39	4.00	4	1.146	4
You have experienced delays due to hazardous job sites that were easily preventable.	3.66	4.00	4	.419	3
Instead of increasing the efficiency Internet of things can be a factor in its reduction.	3.16	3.00	4	.987	4
Health and safety management takes a big chunk of the project budget and compensation of your injured workers involves large sum	3.41	4.00	4	.847	4
For adopting Internet of things Pakistan has no experts available and there is a lack of standards.	3.72	4.00	4	.644	3
Internet of things requires a lot of innovativeness and technical feasibility.	3.73	4.00	4	.803	4
Your organization conducts seminars and conferences in which new research and technology is made aware to the employees.	3.11	3.00	4	1.194	4
Pakistan Engineering Council provide support and incentive in applying new technology in your projects.	3.24	3.00	3	.954	4

You would be willing in adopting Internet of things at construction sites	3.92	4.00	4	.596	4
Your organization will adopt Internet of things if your competitor organization started it	3.96	4.00	4	.779	4

4.5 **FRAMEWORK**

The cyclic framework is developed for the adoption of IoT by the industry. The first step in its adoption begins with awareness of technology, its advantages, and the benefits it will give to the industry. Awareness eventually leads to convincing stakeholders to accept IoT existence and adopt it for their benefit. Moreover, motivating researchers with incentives to research in IoT will promote the technology adoption. As with research one is aware with the risks involved. Furthermore, Initial investment requires motivation from Pakistan Engineering Council PEC and other responsible authorities for adoption of technology. After adoption of IoT by the construction industry professional staff will be required for labour training to increase quantity of skilled labour. IoT will help in top management proactive decision making which eventually leads to reduction in delays, wastage of material, cost saving and enhancement of efficiency and productivity. This will demand formation of new rules and regulations after IoT adoption and IoT can be used effectively. First cycle of IoT adoption will reveal the unseen factors and can be used to improve rules and regulations regarding its adoption.

4.5.1 IoT adoption Framework

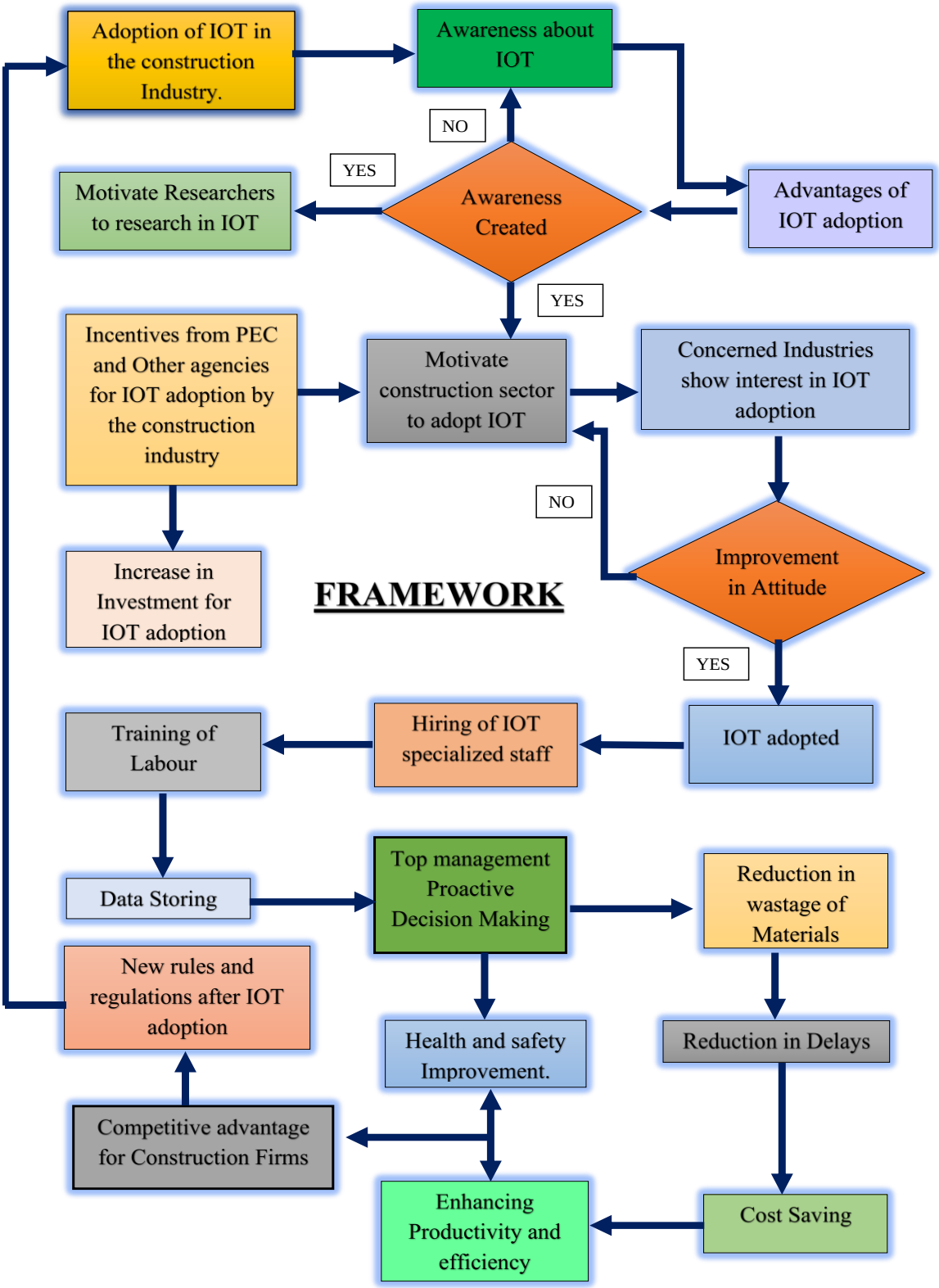


Figure 4-13 IoT adoption framework

CHAPTER 5

5 CONCLUSION

This research was conducted considering general practices in construction, attitude, and behaviour of the industry towards technology adoption. No industry is riper for change than construction and IoT has the potential to increase productivity, on-site safety, and operational efficiency. Pakistan is a developing country and can benefit a lot from IoT adoption. With our research we came to know that this will be the first research conducted in Pakistan on Barriers in adoption of IoT in the construction industry of Pakistan. Our research was able to highlight some of the major factors which confines the adoption of IoT by the construction industry of Pakistan.

According to this research the main factors which restrain IoT adoption in the construction industry of Pakistan are

- Lack of awareness about IoT.
- Connectivity issues as there are still some regions in Pakistan where even mobile network is not available.
- Lack of knowledge about the benefits of IoT adoption to improve the industry.
- High cost of initial investment.
- Very limited research on IoT in Construction leads to lack of IoT technology
- PEC and other related agencies are not confident enough to invest in this area
- Lack of technical expertise.
- Construction practitioners opinion about adequacy of traditional methods of construction.
- Presence of less skilled labour in construction industry causes lag in adoption of new technology.
- The poor attitude of the top management in technology adoption is also a dictating factor in IoT adoption.

- Fear of failure.
- In addition, Pakistani culture acts as a barrier in adoption of new technology in construction industry.

CHAPTER 6

6 RECOMMENDATIONS

This study is limited to a theoretical study as the concept IoT in construction is new. Here are few of the recommendations for future research.

- Because of the pandemic the collected data is small so the same research can be adopted on a large scale of data.
- Understanding the concept of IoT in construction is necessary before adopting research in IoT in construction in Pakistan.
- Study must not be only limited to construction sector but should be adopted in supply chain integration and sustainability.

7 REFERENCES

Al-Qaseemi et al. (2016). IoT architecture challenges and issues; lack of standardization. *Future Technologies Conference (FTC) IEEE*, 731-738.

Ashton, K. (2009). The internet of things. *RFID Journal, 22*, 97-114.

Babar et al. (2010). proposed security model and threat taxonomy for the internet of things (IoT). *Interational conference on Network Security and application, Springer, Berlin, Heidelbeerg*, 420-429.

Bertino, & Islam. (2017). Botnets and internet of things security",. *Computer, 50*, 76-79.

Blayse, K. Manley, & A.M. (2004). Key influences on construction innovation. *construction innovation*, 143-154.

Chandanshive, & Kazi. (2017). Application of internet of things in civil engineering construction projects-a state of the art. *Proceedings of the 11th INDIACom, 4th International Conference on Computing for sustainable global development, 4*, pp. 1836-1839. India.

Dave et al. (2016). Opportunities for enhanced lean construction management using internet of things standards. *Auomation in construction, 61*, 86-91.

Dulaimi et al. (2002). Enhancing integration and innovation in construction. *Buildind Research Information*, 237-247.

Gubbi et al. (2013). Internet of things (IoT): a vision,architectural elements, and future directions. *Future generation computer systems*, 1645-1660.

Louis, J., & Dunston. (August 2017). Integrating IoT into operational workflows for real-time and automated decision-making in repititive construction operations. *Automation in Construction*, 317-327.

Matharu et al. (2014). The internet of things: challenges and security issues. *International Conference on Emerging Technologies (ICET), IEEE*, 54-49.

Ning, & Xu. (2010). Research on global internet of things' developments and its constuction in china. *Dianzi Xuebao(Acta Electronica Sinica), 38*, 2590-2599.

Noura, & Atiquzzaman,. (2018). Interoperability in internet of things taxonomies and open challenges. *Mobile Networks and Applications*, 1-14.

Riggins, & Wamba. (2015). Research directions on the adoption, usage, and impact of the internet of things through the use of big data analytics. *48th HI International Conference on System Sciences, IEEE*, (pp. 1531-1540).

Santucci. (2009). From internet to data to internet of things. *In Proceedings of the International Conference on Future Trends of the Internet. Luxembourg.*

Stankovic, & J.A. (2014). Research directions for the internet of things. *IEEE internet of things journal, 1*, 3-9.

Syamsul, & Laromi et al. (2018). Potentials of internet of things (IoT) in malaysian construction industry. *Annals of Emerging Technologies in Computing (AETiC), 2*.

Tang et al. (2019). A review of building information modeling (BIM) and the internet of things (IoT) devices integration: present status and future trends. *Automation in Construction, 101*, 127-139.

Wei, & Li. (2011). Design of energy consumption monitoring and energy-saving management system of intelligent building based on the internet of things. *international conferenceon electronics, communications and control (ICECC)*, 3650-3652.

Zhao et al. (2013). The planning, construction, and management toward sustainable cities in China need the environmental internet of things. *International Journal of Sustainable Development and World Ecology*, 195-198.

Abdul Gbadmosi. (2019).The role of Internet of Thngs in Delivering Smart construction

Fengchen chen. (2020). Real time monitoring of construction quality for gravel piles based on Internet of things

Manuel Alexander, Silverio Fernandez (2019) Implementation of smart devices in the construction industry

Gamil, Yaser & Abdullah, Majid & Rahman, Ismail & Asad, Engr. (2020). Internet of things in construction industry revolution 4.0: Recent trends and challenges in the Malaysian context. Journal of Engineering, Design and Technology. ahead-of-print. 10.1108/JEDT-06-2019-0164.

Arslan, Volkan & Ulubeyli, Serdar & Kazaz, Aynur. (2019). THE USE OF I INTERNET OF THINGS IN THE CONSTRUCTION INDUSTRY.

Annex A

8 APPENDICES

8.1 SURVEY FORM

Barriers in adoption of Internet of Things in the Construction Industry of Pakistan

Thank you for agreeing to take part in the survey. We are students of NUST institute of Civil Engineering and are currently working on our Final year project. The aim is to identify the barriers in the adoption of IOT in the construction industry of Pakistan. Your valuable opinion is required in order to know the barriers involved and develop a conceptual framework in the adoption of IOT in the construction industry of Pakistan. This survey should take 5-10 minutes of your precious time.

All your responses will be kept confidential and will not be shared with anyone.

*Required

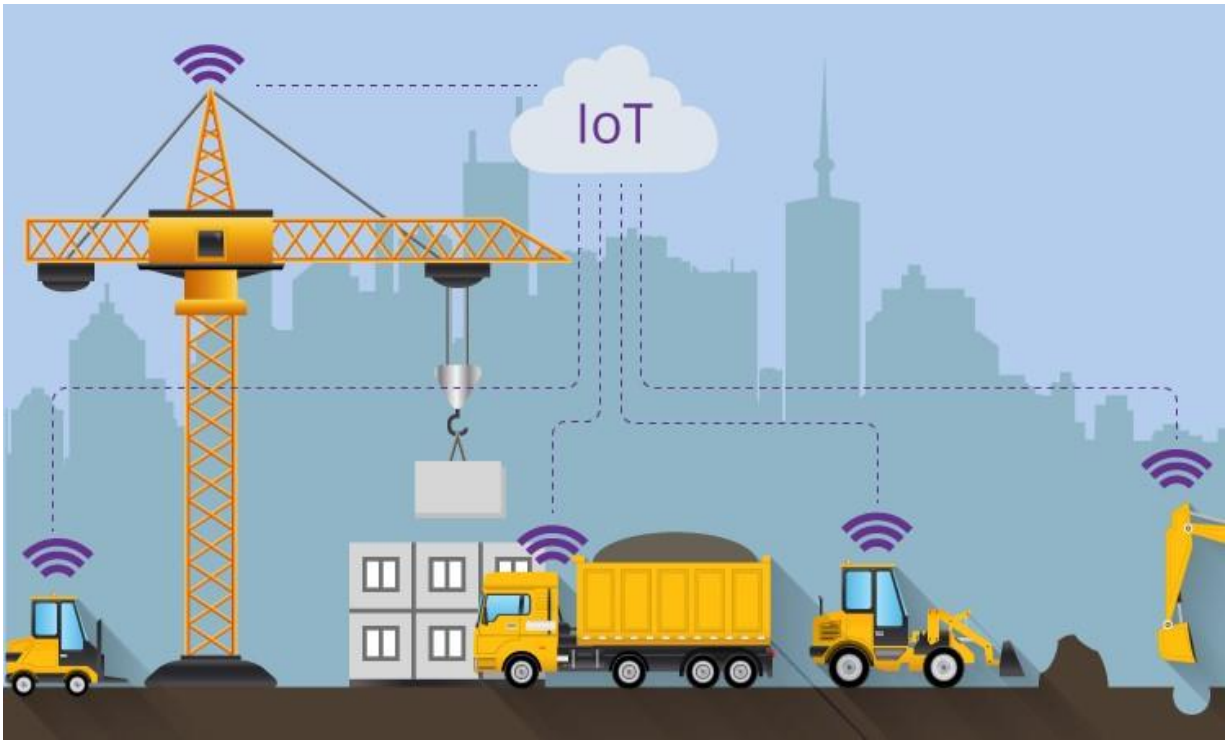
What is Internet of Things?

Internet of Things (IoT) is an innovative concept of the internet, which was initially introduced by Kelvin Ashton in 1999.

It is defined as the possibility of connecting things using the internet to form a platform that is used to execute certain activities. It uses the internet connectivity and all the things around to have the capability to connect and communicate with each other to perform any specific function through the network.

It is an approach of giving the possibility to things around to communicate using internet connectivity. The method is carried out by connecting all things with everyone in all times and locations using the built-in wireless connection.

Moreover, this facility enables easy linkage with all the surroundings, which ease the monitoring and control process via the internet.



Personal Information

Your Name

Contact (optional)

Email (optional)

Your Organisation's Name

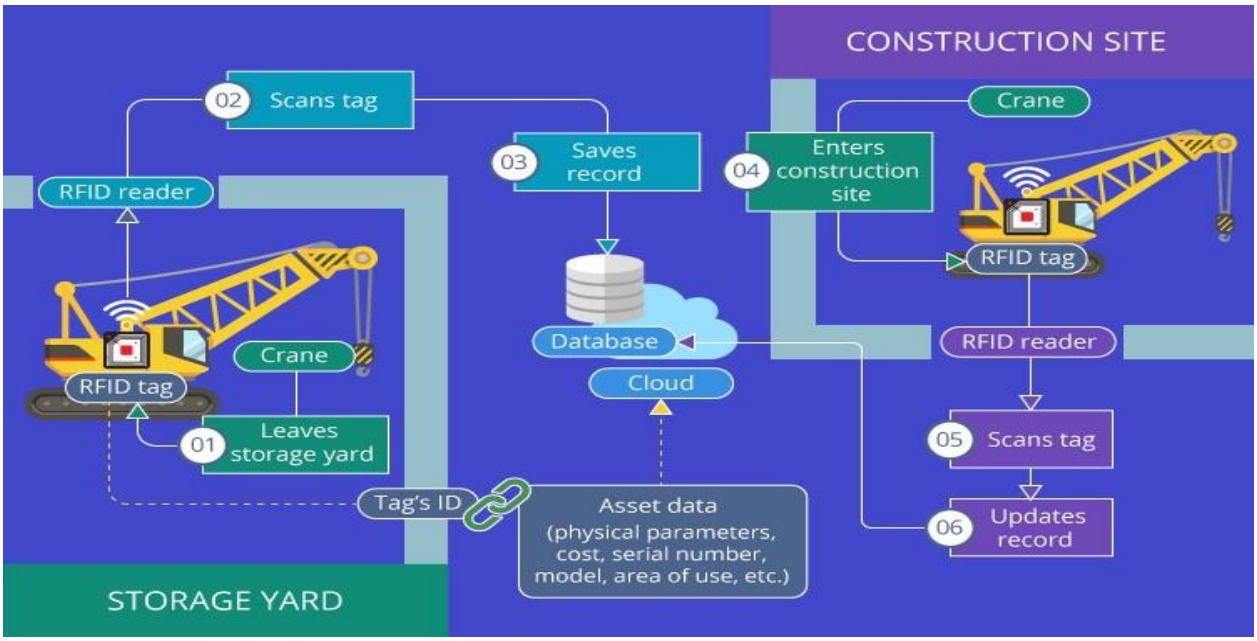
Your Organisation's status *

Mark only one oval.

- Client
- Consultant
- Contractor
- Sub-Contractor
- Other:

Your Designation *

Awareness



1. **Do You or your Organization know about Internet of things ****Mark only one oval.*

Yes ◯

No ◯

2. **Your organisation has enough knowledge on Internet of things to consider the advantages and disadvantages of its usage in the construction industry *** *Mark only one oval.*

◯ Strongly Disagree

◯ Disagree

◯ Neutral

◯ Agree

◯ Strongly Agree

3. **Your organisation implements new technology in different construction processes ***

Mark only one oval.

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

4. **Internet of things can be a best choice in reduction of health and safety problems and improving the overall efficiency of the Construction industry ***

Mark only one oval.

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

Benefits of Internet of things

5. **Adopting Internet of things can be beneficial to your business and stakeholders. ***

Mark only one oval.

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

6. **By adopting Internet of things, the construction industry will become less labour*** *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

7. **Internet of things can be used for multiple purposes including security, monitoring, health and safety. *** *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

8. **The return on investment on technology like Internet of things can be recovered with ease. *** *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

9. **Internet of things can help top management in taking proactive decisions. ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

10. **Adopting Internet of things can improve efficiency of workers during project activities ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

11. **Adopting Internet of things can help in reduction of project time ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Issues and Challenges In the adoption of Internet of things

12. **Adopting Internet of things will invade privacy of citizens in the construction sector*** *Mark only one oval.*

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

13. **Internet of things would cause more hindrance to working parties on construction sites rather than helping them *** *Mark only one oval.*

- ◯ Strongly Disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

14. **There are technical uncertainties regarding use of Internet of things in construction industry *** *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

15. **Adopting Internet of things would require regulations and acts in Pakistan. ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

16. **Attitude and commitment from top management and stakeholders is a challenge in adoption of new technology *** *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

17. **Pakistani culture acts as a barrier in adoption of new technology in construction industry ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

18. **Traditional methods in construction are sufficient instead of using Internet of things ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

19. **Presence of less skilled labour in construction industry causes lag in adoption of new technology ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

20. **Your organization frequently consults academic institutions with regards to new technologies and new techniques being developed *** *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

21. **Your organization records worker accidents and things that are affecting the performance of a particular project. ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

22. **You have experienced delays due to hazardous job sites that were easily preventable. *** *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

23. **Instead of increasing the efficiency Internet of things can be a factor in its reduction. ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

24. **Health and safety management takes a big chunk of the project budget and compensation of your injured workers involves large sum *** *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

25. **For adopting Internet of things Pakistan has no experts available and there is a lack of standards**. * *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

26. **Internet of things requires a lot of innovativeness and technical feasibility. ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

27. **Your organization conducts seminars and conferences in which new research and technology is made aware to the employees. * *Mark only one oval.***

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

28. Pakistan Engineering Council provide support and incentive in applying new technology in your projects. * *Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Implementation preference

29. You would be willing in adopting Internet of things at construction sites *

Mark only one oval.

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

30. **Your organization will adopt Internet of things if your competitor organization started it ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

31. **Cost of initial investment is a dictating factor for adoption of new technology ****Mark only one oval.*

- Strongly Disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

Any Suggestions (optional)

Annex-B

8.2 STATISTICAL RESULTS

For input in SPSS software we assumed that

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree.

Total respondents = 74

Missing = 0

Statistics

	Mean	Median	Mode	Variance	Range
Do You or your Organization know about Internet of things?	.69	1.00	1	.217	1
Your organisation has enough knowledge on Internet of things	3.20	3.00	4	1.123	4
Your organisation implements new technology in different construction processes	3.53	4.00	4	1.129	4

IOT can help in reduction of health and safety problems and improving the overall efficiency of the Construction industry	3.99	4.00	4	.808	4
Internet of things can be beneficial to your business and stakeholders.	4.12	4.00	4	.492	4
with IOT construction industry will become less labour	3.81	4.00	4	.868	4
IOT can be useful for multiple purposes including security, monitoring, health and safety.	4.12	4.00	4	.492	3
ROI on technology like IOT can be recovered with ease.	3.61	4.00	4	.653	4
IOT can help top management in taking proactive decisions.	3.97	4.00	4	.438	4
IOT can improve efficiency of workers during project activities	4.05	4.00	4	.655	4
IOT can help in reduction of project time	4.00	4.00	4	.466	3
IOT will invade privacy of citizens in the construction sector	3.18	3.00	4	.969	4
IOT would cause more hindrance then helping	2.66	3.00	3	1.021	4
Technical uncertainties regarding use of IOT	3.64	4.00	4	.755	4
IOT would require regulations and acts in Pakistan.	3.89	4.00	4	.920	4
Cost of initial investment is a dictating factor for adoption of new technology	3.99	4.00	4	.726	4

Attitude and commitment from top management and stakeholders is a challenge in adoption of new technology	3.97	4.00	4	.712	4
Pakistani culture acts as a barrier in adoption of new technology in construction industry	3.96	4.00	4	.834	4
Traditional methods in construction are sufficient instead of using Internet of things	2.72	3.00	2	1.192	4
Presence of less skilled labour in construction industry causes lag in adoption of new technology	3.93	4.00	4	.804	4
Your organization frequently consults academic institutions with regards to new technologies and new techniques being developed	3.15	3.00	4	1.115	4
Your organization records worker accidents and things that are affecting the performance of a particular project.	3.39	4.00	4	1.146	4
You have experienced delays due to hazardous job sites that were easily preventable.	3.66	4.00	4	.419	3
Instead of increasing the efficiency Internet of things can be a factor in its reduction.	3.16	3.00	4	.987	4

Health and safety management takes a big chunk of the project budget and compensation of your injured workers involves large sum	3.41	4.00	4	.847	4
For adopting Internet of things Pakistan has no experts available and there is a lack of standards.	3.72	4.00	4	.644	3
Internet of things requires a lot of innovativeness and technical feasibility.	3.73	4.00	4	.803	4
Your organization conducts seminars and conferences in which new research and technology is made aware to the employees.	3.11	3.00	4	1.194	4
Pakistan Engineering Council provide support and incentive in applying new technology in your projects.	3.24	3.00	3	.954	4
You would be willing in adopting Internet of things at construction sites	3.92	4.00	4	.596	4
Your organization will adopt Internet of things if your competitor organization started it	3.96	4.00	4	.779	4

Frequency Table

1. Do You or your Organization know about Internet of things?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	no	23	31.1	31.1	31.1
	yes	51	68.9	68.9	100.0
	Total	74	100.0	100.0	

2. Your organisation has enough knowledge on Internet of things

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	6	8.1	8.1	8.1
	Disagree	11	14.9	14.9	23.0
	Neutral	25	33.8	33.8	56.8
	Agree	26	35.1	35.1	91.9
	Strongly Agree	6	8.1	8.1	100.0
	Total	74	100.0	100.0	

3. Your organisation implements new technology in different construction processes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	4.1	4.1	4.1
	Disagree	14	18.9	18.9	23.0
	Neutral	7	9.5	9.5	32.4
	Agree	41	55.4	55.4	87.8
	Strongly Agree	9	12.2	12.2	100.0
	Total	74	100.0	100.0	

4. IOT can help in reduction of health and safety problems and improving the overall efficiency of the Construction industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	6	8.1	8.1	9.5
	Neutral	6	8.1	8.1	17.6
	Agree	41	55.4	55.4	73.0
	Strongly Agree	20	27.0	27.0	100.0
	Total	74	100.0	100.0	

5. Internet of things can be beneficial to your business and stakeholders.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Neutral	8	10.8	10.8	12.2
	Agree	45	60.8	60.8	73.0
	Strongly Agree	20	27.0	27.0	100.0
	Total	74	100.0	100.0	

6. with IOT construction industry will become less labour

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	8	10.8	10.8	12.2
	Neutral	10	13.5	13.5	25.7
	Agree	40	54.1	54.1	79.7
	Strongly Agree	15	20.3	20.3	100.0
	Total	74	100.0	100.0	

7. IOT can be useful for multiple purposes including security, monitoring, health and safety.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	2	2.7	2.7	2.7
	Neutral	8	10.8	10.8	13.5
	Agree	43	58.1	58.1	71.6
	Strongly Agree	21	28.4	28.4	100.0
	Total	74	100.0	100.0	

8. ROI on technology like IOT can be recovered with ease.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	5	6.8	6.8	8.1
	Neutral	23	31.1	31.1	39.2
	Agree	38	51.4	51.4	90.5
	Strongly Agree	7	9.5	9.5	100.0
	Total	74	100.0	100.0	

9. IOT can help top management in taking proactive decisions.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	1	1.4	1.4	2.7
	Neutral	8	10.8	10.8	13.5
	Agree	53	71.6	71.6	85.1
	Strongly Agree	11	14.9	14.9	100.0
	Total	74	100.0	100.0	

10. IOT can improve efficiency of workers during project activities

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	3	4.1	4.1	5.4
	Neutral	7	9.5	9.5	14.9
	Agree	43	58.1	58.1	73.0
	Strongly Agree	20	27.0	27.0	100.0
	Total	74	100.0	100.0	

11. IOT can help in reduction of project time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	1	1.4	1.4	1.4
	Neutral	14	18.9	18.9	20.3
	Agree	43	58.1	58.1	78.4
	Strongly Agree	16	21.6	21.6	100.0
	Total	74	100.0	100.0	

12. IOT will invade privacy of citizens in the construction sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.7	2.7	2.7
	Disagree	19	25.7	25.7	28.4
	Neutral	22	29.7	29.7	58.1
	Agree	26	35.1	35.1	93.2
	Strongly Agree	5	6.8	6.8	100.0
	Total	74	100.0	100.0	

13. IOT would cause more hindrance then helping

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	10	13.5	13.5	13.5
	Disagree	23	31.1	31.1	44.6
	Neutral	24	32.4	32.4	77.0
	Agree	16	21.6	21.6	98.6
	Strongly Agree	1	1.4	1.4	100.0
	Total	74	100.0	100.0	

14. Technical uncertainties regarding use of IOT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	4.1	4.1	4.1
	Disagree	3	4.1	4.1	8.1
	Neutral	19	25.7	25.7	33.8
	Agree	42	56.8	56.8	90.5
	Strongly Agree	7	9.5	9.5	100.0
	Total	74	100.0	100.0	

15. IOT would require regulations and acts in Pakistan.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.7	2.7	2.7
	Disagree	6	8.1	8.1	10.8
	Neutral	8	10.8	10.8	21.6
	Agree	40	54.1	54.1	75.7
	Strongly Agree	18	24.3	24.3	100.0
	Total	74	100.0	100.0	

16. Cost of initial investment is a dictating factor for adoption of new technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	5	6.8	6.8	8.1
	Neutral	6	8.1	8.1	16.2
	Agree	44	59.5	59.5	75.7
	Strongly Agree	18	24.3	24.3	100.0
	Total	74	100.0	100.0	

17. Attitude and commitment from top management and stakeholders is a challenge in adoption of new technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	5	6.8	6.8	8.1
	Neutral	6	8.1	8.1	16.2
	Agree	45	60.8	60.8	77.0
	Strongly Agree	17	23.0	23.0	100.0
	Total	74	100.0	100.0	

18. Pakistani culture acts as a barrier in adoption of new technology in construction industry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	7	9.5	9.5	10.8
	Neutral	5	6.8	6.8	17.6
	Agree	42	56.8	56.8	74.3
	Strongly Agree	19	25.7	25.7	100.0
	Total	74	100.0	100.0	

19. Traditional methods in construction are sufficient instead of using Internet of things

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	10	13.5	13.5	13.5
	Disagree	24	32.4	32.4	45.9
	Neutral	20	27.0	27.0	73.0
	Agree	17	23.0	23.0	95.9
	Strongly Agree	3	4.1	4.1	100.0
	Total	74	100.0	100.0	

20. Presence of less skilled labour in construction industry causes lag in adoption of new technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.7	2.7	2.7
	Disagree	3	4.1	4.1	6.8
	Neutral	11	14.9	14.9	21.6
	Agree	40	54.1	54.1	75.7
	Strongly Agree	18	24.3	24.3	100.0
	Total	74	100.0	100.0	

21. Your organization frequently consults academic institutions with regards to new technologies and new techniques being developed

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	5.4	5.4	5.4
	Disagree	18	24.3	24.3	29.7
	Neutral	21	28.4	28.4	58.1
	Agree	25	33.8	33.8	91.9
	Strongly Agree	6	8.1	8.1	100.0
	Total	74	100.0	100.0	

22. Your organization records worker accidents and things that are affecting the performance of a particular project.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	6	8.1	8.1	8.1
	Disagree	9	12.2	12.2	20.3
	Neutral	15	20.3	20.3	40.5
	Agree	38	51.4	51.4	91.9
	Strongly Agree	6	8.1	8.1	100.0
	Total	74	100.0	100.0	

23. You have experienced delays due to hazardous job sites that were easily preventable.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	3	4.1	4.1	4.1
	Neutral	23	31.1	31.1	35.1
	Agree	44	59.5	59.5	94.6
	Strongly Agree	4	5.4	5.4	100.0
	Total	74	100.0	100.0	

24. Instead of increasing the efficiency Internet of things can be a factor in its reduction.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	4.1	4.1	4.1
	Disagree	17	23.0	23.0	27.0
	Neutral	24	32.4	32.4	59.5
	Agree	25	33.8	33.8	93.2
	Strongly Agree	5	6.8	6.8	100.0
	Total	74	100.0	100.0	

25. Health and safety management takes a big chunk of the project budget and compensation of your injured workers involves large sum

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.7	2.7	2.7
	Disagree	10	13.5	13.5	16.2
	Neutral	24	32.4	32.4	48.6
	Agree	32	43.2	43.2	91.9
	Strongly Agree	6	8.1	8.1	100.0
	Total	74	100.0	100.0	

26. For adopting Internet of things Pakistan has no experts available and there is a lack of standards.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Disagree	6	8.1	8.1	8.1
	Neutral	19	25.7	25.7	33.8
	Agree	39	52.7	52.7	86.5
	Strongly Agree	10	13.5	13.5	100.0
	Total	74	100.0	100.0	

27. Internet of things requires a lot of innovativeness and technical feasibility.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.7	2.7	2.7
	Disagree	4	5.4	5.4	8.1
	Neutral	18	24.3	24.3	32.4
	Agree	38	51.4	51.4	83.8
	Strongly Agree	12	16.2	16.2	100.0
	Total	74	100.0	100.0	

28. Your organization conducts seminars and conferences in which new research and technology is made aware to the employees.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	5	6.8	6.8	6.8
	Disagree	19	25.7	25.7	32.4
	Neutral	19	25.7	25.7	58.1
	Agree	25	33.8	33.8	91.9
	Strongly Agree	6	8.1	8.1	100.0
	Total	74	100.0	100.0	

29. Pakistan Engineering Council provide support and incentive in applying new technology in your projects.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	5.4	5.4	5.4
	Disagree	10	13.5	13.5	18.9
	Neutral	30	40.5	40.5	59.5
	Agree	24	32.4	32.4	91.9
	Strongly Agree	6	8.1	8.1	100.0
	Total	74	100.0	100.0	

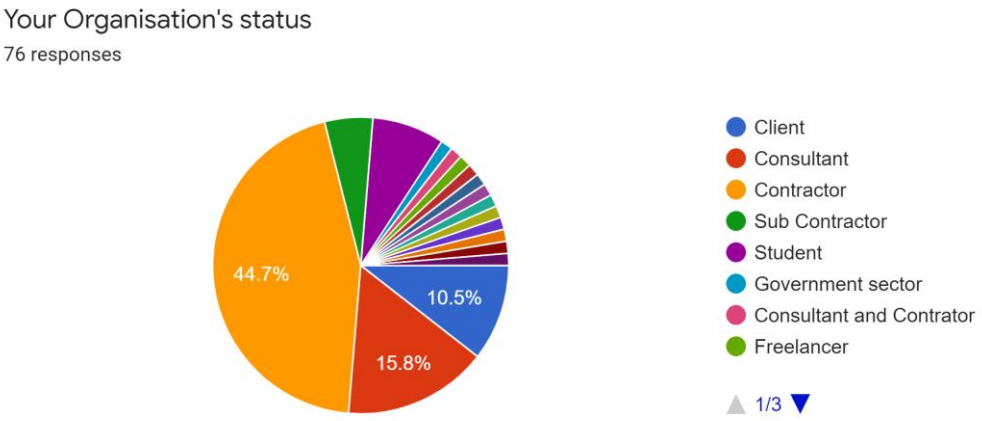
30. You would be willing in adopting Internet of things at construction sites

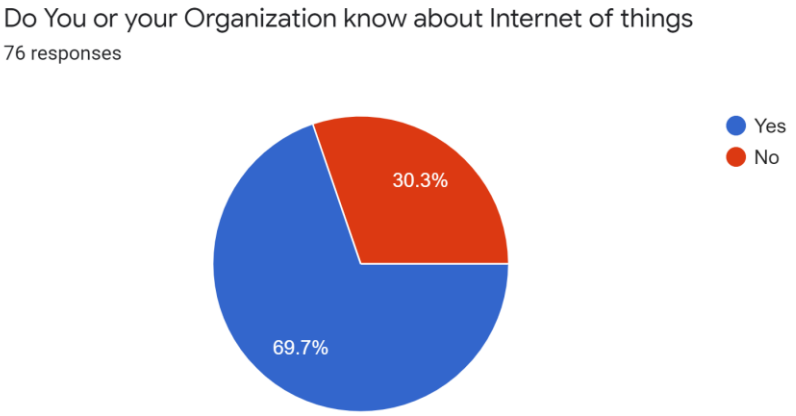
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	1	1.4	1.4	1.4
	Disagree	3	4.1	4.1	5.4
	Neutral	10	13.5	13.5	18.9
	Agree	47	63.5	63.5	82.4
	Strongly Agree	13	17.6	17.6	100.0
	Total	74	100.0	100.0	

31. Your organization will adopt Internet of things if your competitor organization started it

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	2	2.7	2.7	2.7
	Disagree	2	2.7	2.7	5.4
	Neutral	12	16.2	16.2	21.6
	Agree	39	52.7	52.7	74.3
	Strongly Agree	19	25.7	25.7	100.0
	Total	74	100.0	100.0	

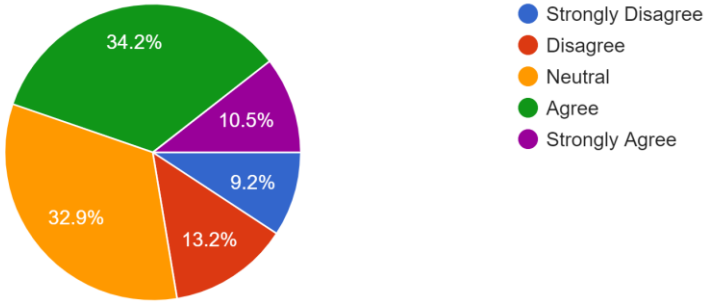
8.3 **PIE CHARTS**





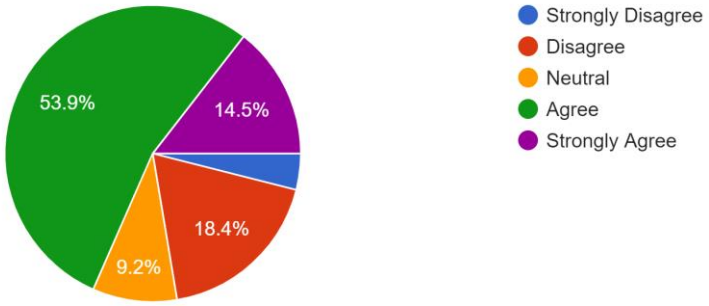
Your organisation has enough knowledge on Internet of things to consider the advantages and disadvantages of its usage in the construction industry

76 responses



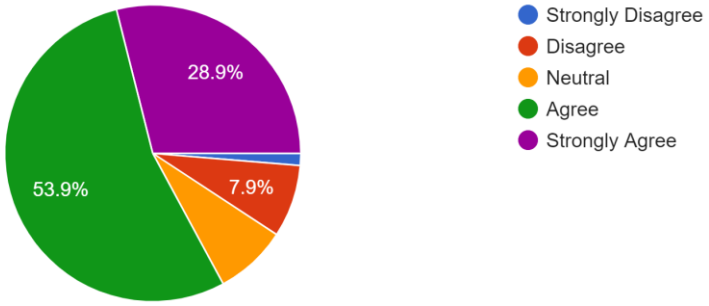
Your organisation implements new technology in different construction processes

76 responses



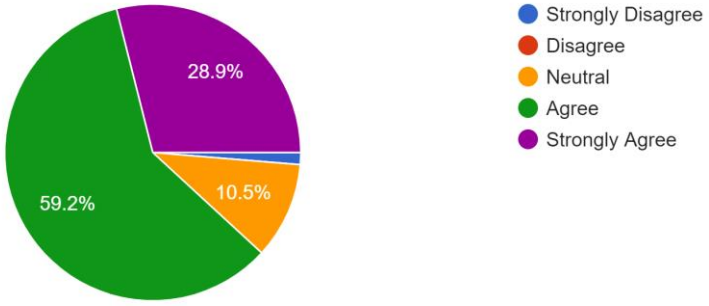
Internet of things can be a best choice in reduction of health and safety problems and improving the overall efficiency of the Construction industry

76 responses



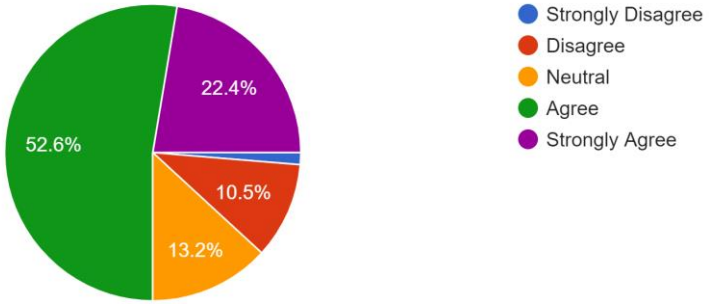
Adopting Internet of things can be beneficial to your business and stakeholders.

76 responses



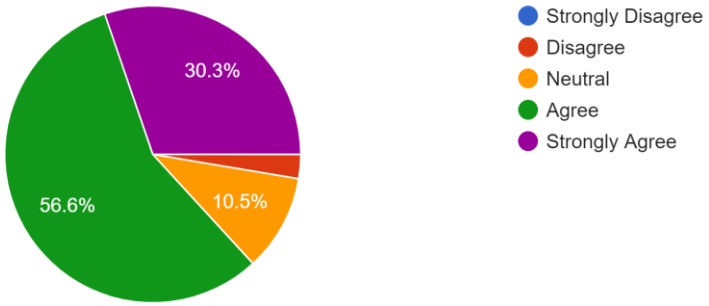
By adopting Internet of things the construction industry will become less labour

76 responses



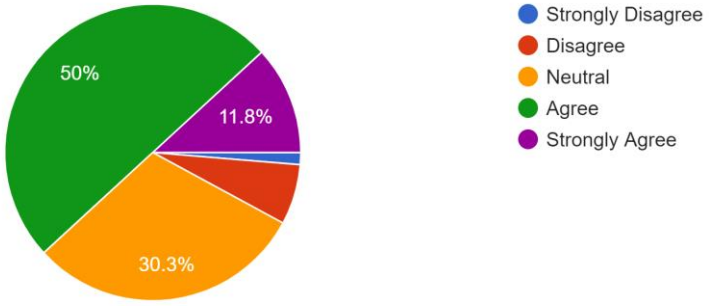
Internet of things can be used for multiple purposes including security, monitoring, health and safety.

76 responses



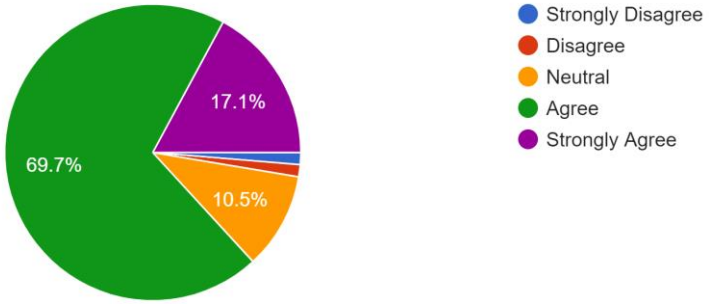
The return on investment on technology like Internet of things can be recovered with ease.

76 responses



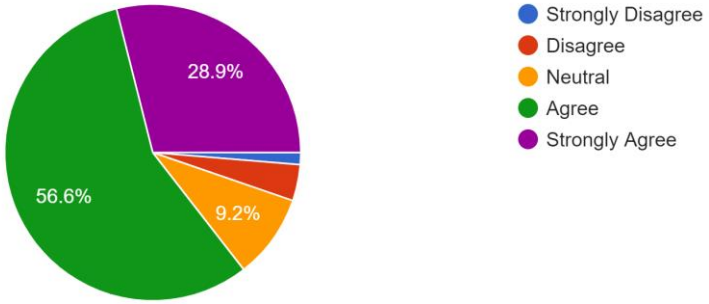
Internet of things can help top management in taking proactive decisions.

76 responses



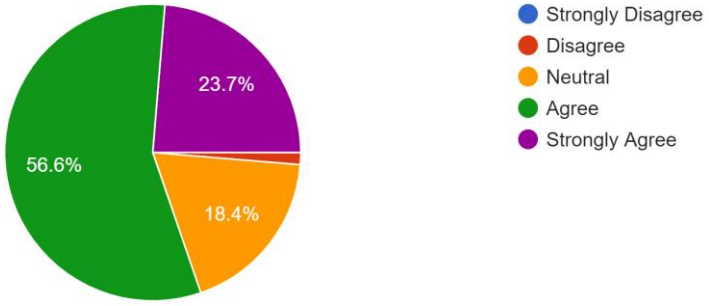
Adopting Internet of things can improve efficiency of workers during project activities

76 responses



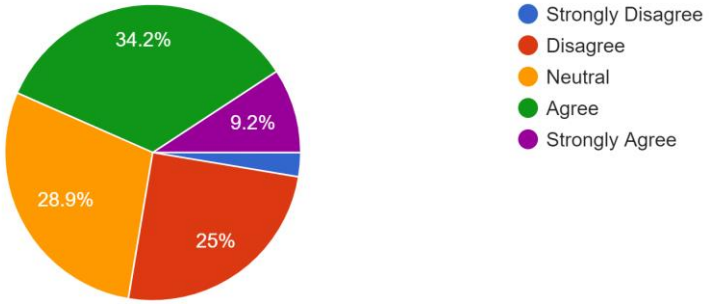
Adopting Internet of things can help in reduction of project time

76 responses



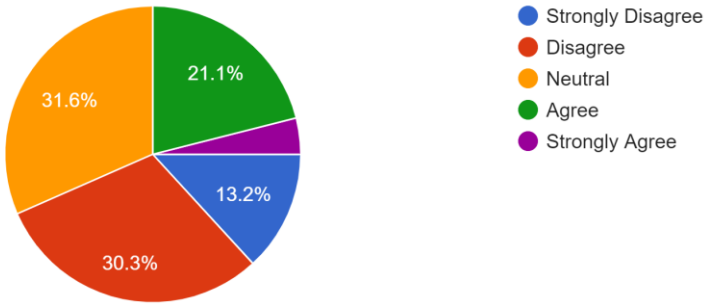
Adopting Internet of things will invade privacy of citizens in the construction sector

76 responses



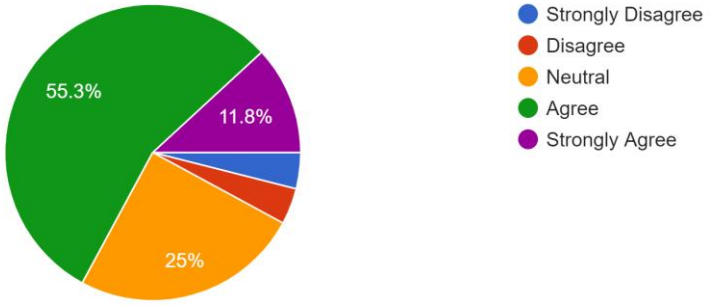
Internet of things would cause more hindrance to working parties on construction sites rather than helping them

76 responses



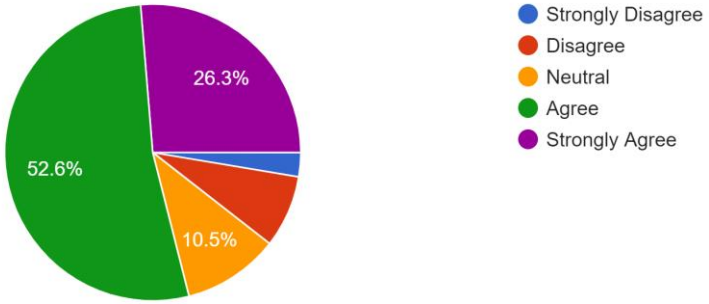
There are technical uncertainties regarding use of Internet of things in construction industry

76 responses



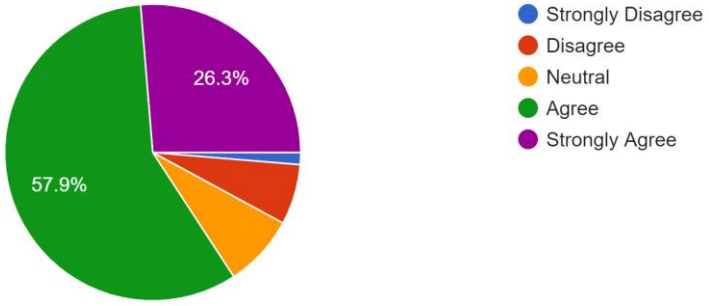
Adopting Internet of things would require regulations and acts in Pakistan.

76 responses



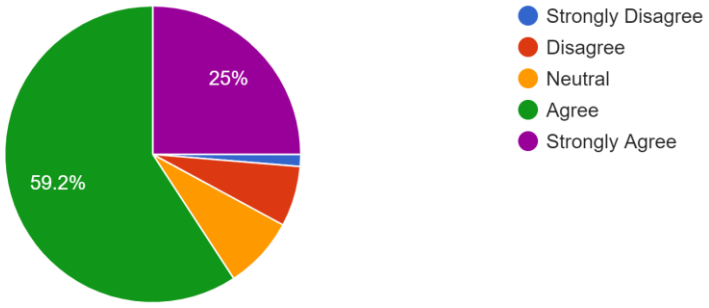
Cost of initial investment is a dictating factor for adoption of new technology

76 responses



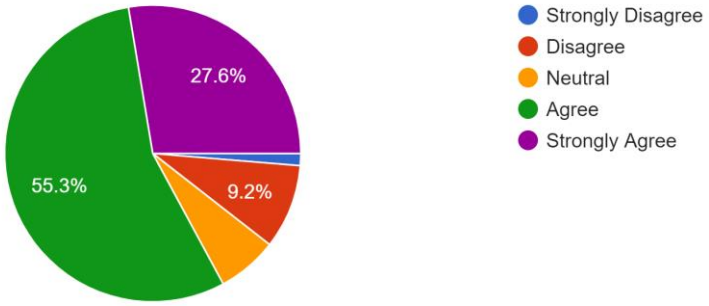
Attitude and commitment from top management and stakeholders is a challenge in adoption of new technology

76 responses



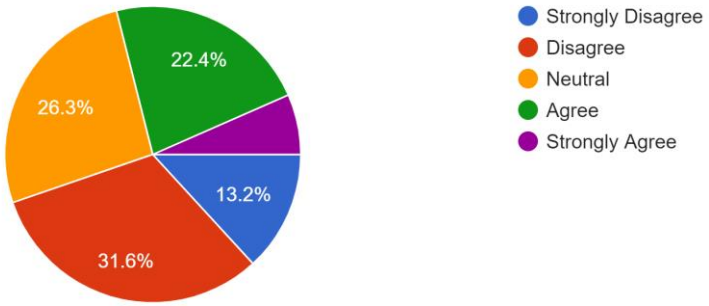
Pakistani culture acts as a barrier in adoption of new technology in construction industry

76 responses



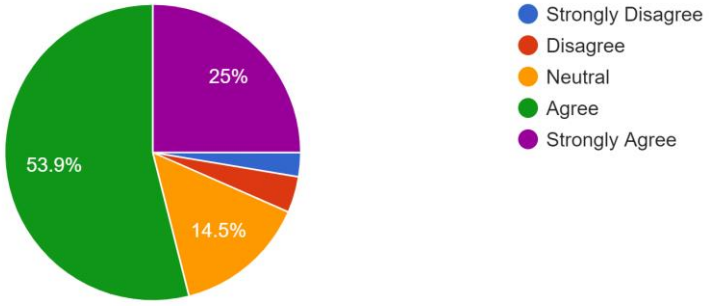
Traditional methods in construction are sufficient instead of using Internet of things

76 responses



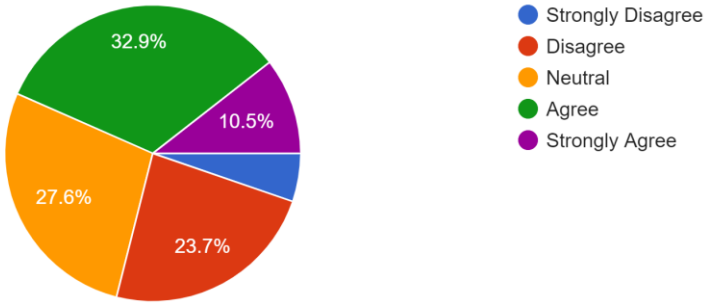
Presence of less skilled labour in construction industry causes lag in adoption of new technology

76 responses



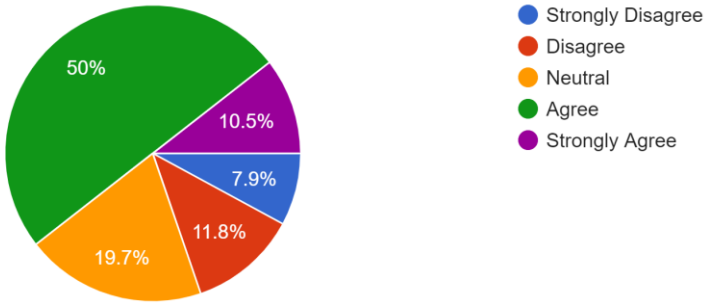
Your organization frequently consults academic institutions with regards to new technologies and new techniques being developed

76 responses



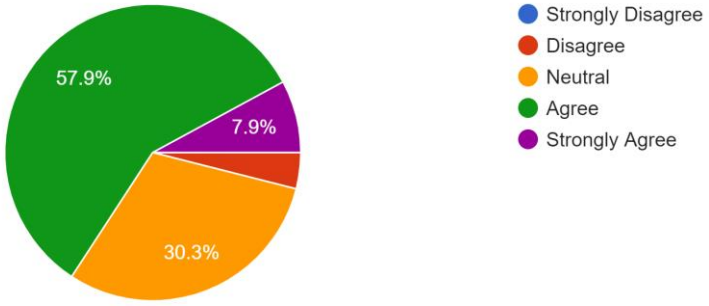
Your organization records worker accidents and things that are affecting the performance of a particular project.

76 responses



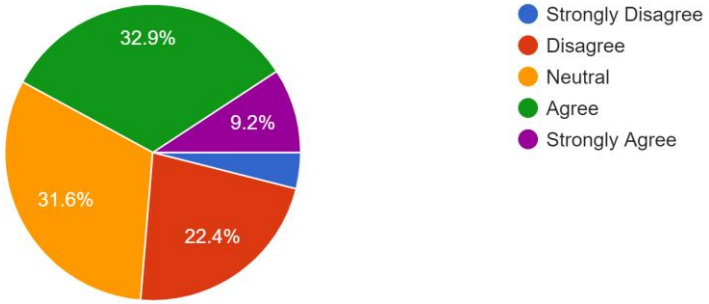
You have experienced delays due to hazardous job sites that were easily preventable.

76 responses



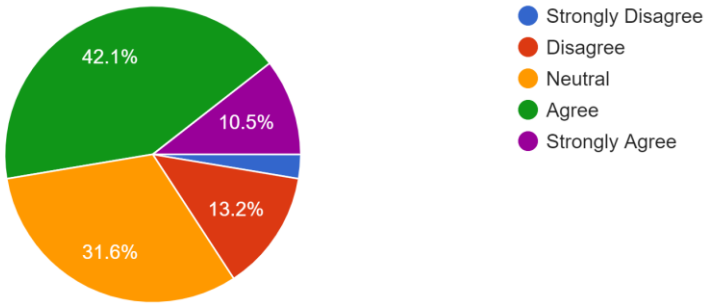
Instead of increasing the efficiency Internet of things can be a factor in its reduction.

76 responses



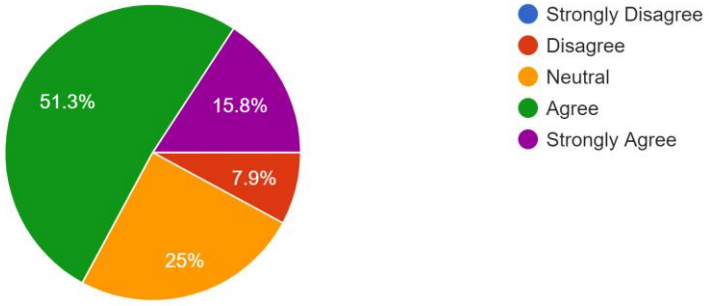
Health and safety management takes a big chunk of the project budget and compensation of your injured workers involves large sum

76 responses



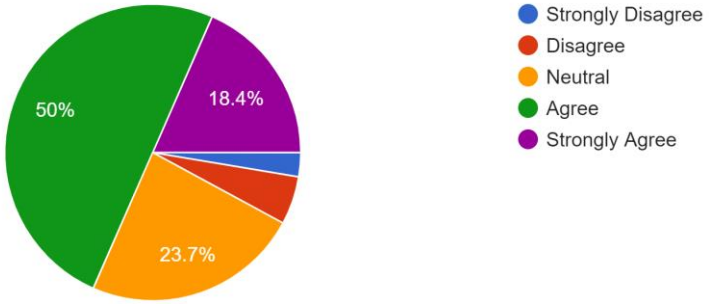
For adopting Internet of things Pakistan has no experts available and there is a lack of standards.

76 responses



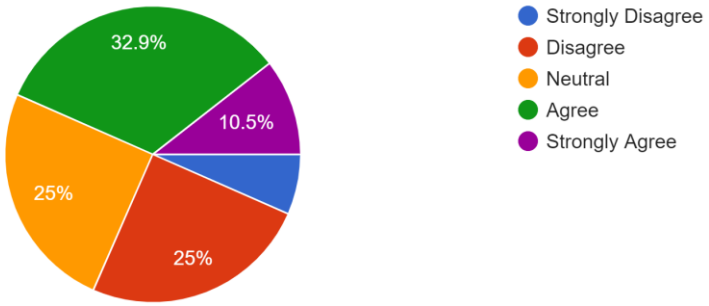
Internet of things requires a lot of innovativeness and technical feasibility.

76 responses



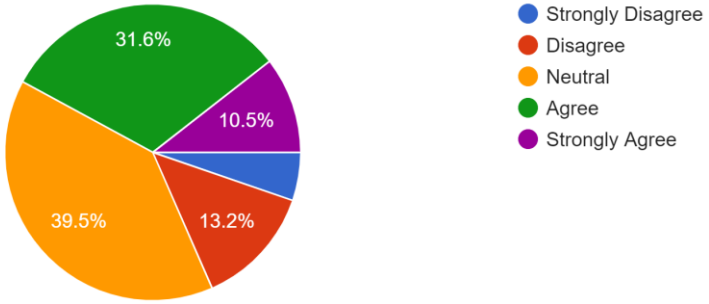
Your organization conducts seminars and conferences in which new research and technology is made aware to the employees.

76 responses



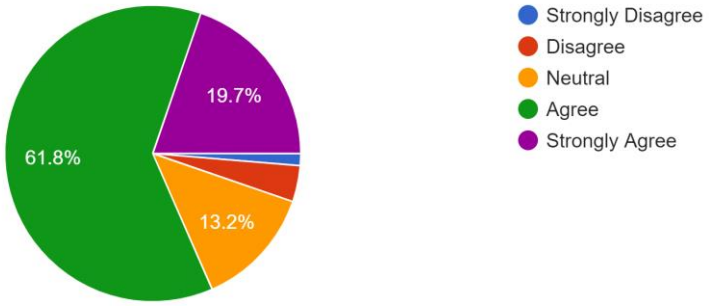
Pakistan Engineering Council provide support and incentive in applying new technology in your projects.

76 responses



You would be willing in adopting Internet of things at construction sites

76 responses



Your organization will adopt Internet of things if your competitor organization started it

76 responses