

**MOBILE PHONE TECHNOLOGY
APPLICATIONS IN THE CONSTRUCTION
PROJECT MANAGEMENT SECTOR
IN SRI LANKA**

**MASTER OF SCIENCE
IN
CONSTRUCTION PROJECT MANAGEMENT**

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Department of Civil Engineering

University of Moratuwa

October 2022

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APPLICATIONS IN THE CONSTRUCTION
PROJECT MANAGEMENT SECTOR
IN SRI LANKA**

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“This dissertation was submitted to the Department of Civil Engineering of the University of Moratuwa in partial fulfillment of the requirements for the Master of Science in Construction Project Management”

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October 2022

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university to the best of my knowledge and believe it does not contain any material previously published, written or orally communicated by another person or myself except where due reference is made in the text. I also hereby give consent for my dissertation, if accepted, to be made available for photocopying and for inter-library loans, and for the title and summary to be available to outside organizations.

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Abstract

Managing resources effectively in all fields including Construction and Project management industry is essential for the development of the country. Many countries have tended to adopt modern technologies such as mobile phone technology to succeed in their projects. Various mobile phone apps designed for the Construction and Project management sectors are freely available. It was observed that many foreign researchers have broadened their study area into applications of mobile phone technology in the construction and project management sector while local researchers are lagging. Therefore, this study attempted to review the awareness and usage of mobile phone applications designed for the construction and project management sector and to identify the pros and cons of using mobile phone apps.

Both primary and secondary data were collected. A comprehensive literature review was carried out to identify the research gap as well as to select an appropriate methodology. The primary survey consisted of a questionnaire survey and structured interviews. The targeted group for the study was professionals involved in the Construction and Project management sector.

Out of the responses received 100 fully answered survey data was converted into a coded format for analysis. The data analysis was performed using data analysis tools available in excel.

According to the data analysis, it was found that respondents are not much aware of apps related to Construction Project Management but they use those apps unknowingly. Also, it was observed that respondents are not aware of the usefulness of those apps for their profession. Documenting apps were observed as the most popular app category among respondents. The second and third popular types of apps were drawing apps and Estimation apps. Usage of other types of apps was very low. However, it was found that few respondents are using different types of apps at the same time.

It was justified that, mobile phone apps help to make work more effective, time-saving, user-friendly. Also, the mobile phone is convenient to use from any location, convenient to connect to the internet, and memory capacity is satisfactory.

This study attempted to expand the study on beneficial ways of using mobile phones in the Construction Project Management sector. The findings of this study can be used as a baseline study for further studies relevant to this research area.

Keywords: *Mobile phones, apps/applications, Construction Project management sector/industry, Technology/ies*

Dedication

*“This dissertation report is dedicated to my beloved parents,
my husband, daughter, two brothers,
my teachers, relations, and colleagues
for their endless support and encouragement
given throughout my life
in every success and loss.”*

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Abbreviations

App	Application/s
CPM	Construction and Project Management
DWG	Drawing
G	Generation
GDP	Gross Domestic Products
GIS	Geographic Information System
GPS	Global Positioning System
ICRD	International Centre for Research and Development
OS	Operating System
QS	Quantity Surveyor
RAM	Random Access Memory
RF	Reinforced concrete
SL	Sri Lanka
SIM	Subscriber Identification Module
TRCSL	Telecommunication Regulatory Commission Sri Lanka
US	United States
USA	United State of America
USB	Universal Serial Bus
USD	United State Dollars
3D	Three Dimensional

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- Annexure 1 - Request to fill out the Questionnaire and Format used for the Survey published on www.freeonlinesurveys.com
- Annexure 2 - Table of Coded Responds received

1. CHAPTER 01 - INTRODUCTION

1.1. General

The mobile phone has become the best friend in human life due to the development of an uncountable amount of facilities provided since its introduction to the market. It can be introduced as one of the best innovations in this technology era. The majority of the population is unable to complete their day-to-day tasks even without using a basic phone.

The first invention, the basic telephone was only facilitated for calling from a distance. With time, it has been developed as a mobile phone with limited applications such as messaging facilities. Further, it was equipped with other applications such as the clock, calculator, calendar, etc. The modification of mobile phones into the smart mobile phone resulted in the rapid development of mobile phone technology.

In present human life, mobile phone usage has become an important necessity also, and it has created employment opportunities and accelerated economic growth. Also, mobile phone usage has become a source of communication among people even between different countries. People are not only fulfilling their social needs using mobile phones but also, it has brought a positive change on both environmental and social levels (Donya and Kumah,2011).

Default mobile phone apps (ex: camera, calendar, maps, clock), other entertainment apps (ex: music, radio, games), and downloadable mobile phone apps (ex: mail, social media apps, money transfer apps) have resulted to gain huge attraction from its users. This has caused to create an addictiveness which has resulted to increase time spent on mobile phones even during working hours.

Mobile phones have been developed to be used as supportive devices in various fields. Engineering-based fields also use mobile phones as a supportive device including the construction and project management (CPM) industry. Many foreign countries use mobile phone technology to succeed in their projects. The construction industry is one of the most competitive and challenging industries in developing countries such as Sri Lanka. In that contest, using updated technologies is essential to overcome the difficulties as well as to produce more conservative results.

There is various kind of mobile phone apps related CPM sector that can be used for project purposes without any cost.

However, it was observed that a reluctance to adopt new technologies in the CPM sector in our country. It may due to lack of facilities, lack of awareness, lack of assistance, restrictions, or any other matter.

However, managing all three components of time, cost and quality affect the success of any project. Therefore, the adaptation of new technologies is a must to succeed in all those components in this technological era.

Therefore, this study attempted to discover the awareness of mobile phone apps designed for the CPM sector as well as to define the current level of mobile phone technology usage in the Sri Lankan CPM sector.

1.2. Objectives

1.2.1. Definition of the problem

The construction industry is one of the major symbols in the country's economy as it helps to develop the infrastructure in the country. So adapting new technologies to overcome the obstructions and to succeed in all the projects is essential for the development in this sector.

People all around the world use mobile phone technology to fulfill all their daily needs. There are various kinds of mobile phone apps that have been developed to fulfill all those needs. Mobile phone technology can also be utilized as a tool to manage many tasks in the CPM sector. However, compared to other developed countries, it was observed a reluctance to adapt mobile phone technology to the CPM sector in Sri Lanka, whether the technology has developed so far. Therefore, it was observed a gap between technology design and technology usage in the CPM sector in our country.

1.2.2. Main objective

The main objective of this study was to analyze the awareness and usage of mobile phone technology applications in the CPM industry in Sri Lanka. Also, this study attempted to identify the advantages and potential problems of using mobile phone apps.

1.2.3. Sub Objectives

This study attempted to highlight facts related to mobile phone technology usage in the CPM sector in Sri Lanka. An approach to the main objectives was made through sub-objectives covered by available literature data. Findings of sub-objectives have been used to indicate the research gap as well as to structure the study. The sub objectives of the study were;

- Identifying and categorizing apps designed for the CPM sector.

- Identifying the current level of CPM apps usage whole over the world
- Summarizing the benefits and difficulties of using mobile phones
- Establishing the current level of studies on mobile phone app usage in the CPM sector both locally and internationally.

All those sub-objectives have been covered under chapter 2 literature review section.

1.2.4.Scope of the study

Since there are an uncountable amount of mobile phone apps have been designed and available for CPM purposes, only several apps were selected from each subcategory followed by a detailed literature review based on their relevancy, popularity, free availability, user-friendliness, etc. Also, whether there are many technical and non-technical staffs employed in the CPM sector, only a few professionals engaged in the technical category were selected for the study. Therefore, the findings of this study can be directly applied to aspects relevant to the studied CPM mobile phone apps as well as the selected professional categories.

1.3. Brief Method of study adopted

This research was mainly conducted through a process of data collection, data analysis, and interpretation of results. Data collection was carried out in terms of primary surveys and secondary surveys. Data analysis was carried out using data analysis tools available in Microsoft excel.

- **Primary Survey**

An online questionnaire survey followed by four structured interviews was carried out to collect primary data for the study.

The main objectives of the primary survey were;

- to collect data on mobile phone usage behavior of the professionals engaged in the CPM sector
- to collect data on awareness of mobile phone apps designed for the CPM sector
- to collect data on the usage behavior of CPM apps
- to collect data on the advantages and potential problems of using CPM apps

- **Secondary Survey**

A comprehensive literature review was carried out as a secondary survey. Many past studies related to this research area were referred to identify the current level of previous studies,

indicate the research gap, and for structuring the study by selecting an appropriate methodology and procedure for data analysis of the study.

Collected primary data was converted into a coded table format for facilitating the analysis. The analysis was performed using data analysis tools available in excel.

The results received from data analysis were used to formulate the outcomes of the study. Finally, the findings of the study were concluded and recommendations were made for future use.

1.4. Brief of previous studies (similarities and differences)

The history of the studies on mobile phones is shorter than two decades. Basically, during the first stage, researchers tended to study mobile phone usage. They have tried to identify the percentage of usage, advantages, and disadvantages of using mobile phones, changes in people's livelihood due to mobile phone usage, etc. However, soon after the introduction of smart mobile phones researchers tended to analyze the aspects related to the usage of mobile internet. Later on, they studied on benefits as well as dangers of using mobile internet. Also, they have tried to analyze the application of smartphones on job sites and rank the mobile phone service providers or mobile phone apps, etc.

By observing the tendency of research on mobile phones, it was found that many countries have tended to analyze the technology-based applications of mobile phones while our country is lagging. The gap between technology design and technology usage has not yet been analyzed by any other research in the Sri Lankan context. Therefore, analysis on this subject is a must for a developing country like Sri Lanka. It would serve the development of future research related to mobile phone technology applications for the CPM sector in Sri Lanka.

Observations on the transition in the trend of the previous studies related to mobile phone usage are presented in the Literature Review section. The gap in research is also discussed in detail and included in the same.

1.5. Main findings of the study

From the data analysis, it was found that only a few respondents are aware of CPM-related mobile phone apps. However, according to the response received for app usage, many are using some mobile phone apps related to the CPM sector such as documenting apps, drawing apps and estimation apps, etc. Therefore, it was found that people were not much aware of CPM apps but they use CPM apps unknowingly.

Also according to the results of data analysis, it was observed that the majority of the respondents spend almost total daily mobile internet on social media rather than on other useful apps. It also verified that participants are not much aware of the usefulness of mobile phone apps related to their occupational work.

According to the primary data collected majority of the respondents are engineers. It was found that the most popular app category among engineers is documenting apps. The second most popular app category was drawing apps and the third type was Estimation apps. Usage of the other app categories was observed as very low. However, it was found that, few are using different app categories at the same time.

According to the analysis following statements were found to be 'True' statements;

- Using mobile phone apps helps to make work more effective/ time-saving
- Most of the apps are designed to be used as user-friendly
- The mobile phone device /Tab is convenient to be used in any location
- It is convenient to connect to the internet via a mobile device
- The memory and Capacity of the mobile device are satisfactory

Due to the higher amount of negative and neutral answers received following two statements were found to be neither 'True' nor not 'False'.

- The battery life of the mobile device is satisfactory
- It is safe to use a mobile device at work

1.6. Guide to the report

This report includes five chapters. The first chapter is the 'Introduction' chapter. It mainly describes the main objectives and sub-objectives of the study. It also includes a brief of findings and the methodology adopted for the study as well.

The second chapter is the 'Literature Review' chapter. This chapter includes past study data related to the subject area. Mainly all the sub-objectives have been discussed in this chapter. It also indicates the research gap which highlights the necessity of this study.

The third chapter is the 'Methodology' chapter. It focuses on describing the data collection procedures and data analysis procedures selected for adoption for the study. It also describes the research framework that guided the study. All the steps followed in selecting a suitable sample, and the formation of the questionnaire format is described in detail in this chapter.

The fourth chapter is the 'Data Analysis and Discussion of Results' chapter. This chapter discusses the procedures adopted for analyzing collected data in detail. Also, it includes a discussion of the final results followed by the data analysis.

The fifth chapter is the 'Conclusions and Recommendations' chapter. This chapter includes a discussion of the findings. Also, it describes the application of results into the CPM sector in Sri Lanka and proposals for extending future studies relevant to this research area.

The annexures include the questionnaire format used for data collection and a table of coded answers used for data analysis.

2. CHAPTER 02 - LITERATURE REVIEW

2.1. General

Key figures of global statistics indicate that the 1292 Million number of smartphone shipments within year the 2020 exceeded all other electronic devices (Liu, 2020). Therefore, it is no doubt that the mobile phone is the mostly used and populated electronic device among all age groups whole over the world. Due to massive development in mobile phone apps during the past decade attraction and addiction to mobile phones have rapidly increased day by day. Some people couldn't manage their day-to-day tasks even without using a basic mobile phone. It indicates to what extent people have addicted to mobile phones.

A massive transformation of technology was begun after stepping into the 20th century. Many publications were found on this unbelievable technological transformation from the beginning of the 20th century. According to the e-journal article by Leadem (2017), many improvements related to technology were invented after the 20th century. The author has listed the top 10 things invented in the 2000s such as the camera phone in 2000, USB flash drive in 2000, Bluetooth in 2000, Toyota Prius in 2001, Blu-ray disc in 2002, Facebook in 2004, YouTube in 2005, Wifi in 2006, iPhone in 2007 and Android-powered smartphones in 2008 (Leadem, 2017).

On the ABC news website, Heussner (2009) has listed the top 10 innovations of the decade in her article. According to her ranking, the list of top 10 innovations are; removing the obstacle to producing GPS-enabled consumer products in May 2000, Introducing Toyota Prius hybrid car to the US market in July 2000, AT&T introducing text messaging to the US in October 2000, the launch of Wikipedia in January 2001, Napster's demise lead to the drawing of file sharing in July 2001, Social networking revolution by Friendster on March 2003, Completion of Human Genome Project in April 2003, Allowing the public to use Google in August 2004, Revolution of video game play by Nintendo Wii in November 2006, Launch of Apple's iPhone introducing smartphone mania in June 2007(Heussner, 2009).

The community whole over the world has renewed all their expectations to survive in the new technological era. According to the web paper written by Dimock(2019) published on the Pew research center website on "Defining generations: Where Millennials end and Generation Z begins" the categorization of Generations is as follows;

- Silent (ages 74-91) – born 1928-45
- Baby Boomers (ages 55-73) – born 1946-64
- Generation X (ages 39-54) – born 1965-80

- Millennials (ages 23-38) – born 1981-96
- Generation Z (ages 7-22) – born 1997-2012

(Dimock, 2019)

He states that “generations are a lens through which to understand societal change, rather than a label with which to oversimplify differences between groups”. The paper describes that baby boomers grew up with the basic revolutionary changes in society after the innovation of Television, Generation X grew up with changes in society after the innovation of computers, Millennials grew up with changes in society with internet facilities and Generation Z grew up exposing to the progressive development of all those innovations. It also states that due to the launch of the iPhone in 2007 Millennials adapted to these new technological innovations while the oldest Generation Z is at age 10 and willing to expose to the innovative technology. Recent research has indicated some significant changes in Generation Z in youth behavior, attitudes and livelihood both positively and negatively (Dimock, 2019).

The price of mobile phones and mobile connection service chargers was higher during the first stage of the introduction. It caused a limit on the number of users at that time. However, soon after its formation adding new options evoke eager of people to afford a mobile phone to show their wealth to society. It caused to increase in the demand for mobile phones creating more opportunities for manufacturers and service providers to enter the mobile phone industry. The cost of mobile phones and service charges of operating systems reduced drastically due to the competition between the manufacturers and service providers. Finally, it caused to increase in the number of users opt out of their economic class (Donya and Kumah, 2011).

Mobile phones have been developed to provide more facilities rather than basic communication services. The formation of the basic mobile phone into the smart mobile phone opened up a new chapter in the telecommunication industry. Improvements in smart mobile phones enhanced the performance of mobile phones similar to a portable mini laptop. Due to these improvements smart mobile phone users could utilize their devices simply for day-to-day occupational purposes. The mobile phone has sprouted in the consumer market and it is sprouting in the industrial network too (Owusu and Emmanuel, 2016a).

2.2. Country Overview

Sri Lanka is a small island situated in the Indian Ocean covering approximately 66,000 km² land area (Wikipedia, 2020b). Sri Lanka was categorized as a lower-middle income country generating USD 3,852 (2019) GDP per capita with a 21.8 million population. The economy

grew by an average of 5.3% during 2010 – 2019 after terminating the 30-year war. The economy was transitioning from a predominantly rural-based economy toward a more urbanized economy oriented around manufacturing and services (The World Bank, 2020). However, due to the recent financial crisis in the country, inflation has accelerated to 17.5% and is elevating according to the published data available on the World Bank website last updated on April 2022.

The Covid 19 pandemic caused to crash the economy of the country severely as in other South Asian countries. According to the news article by Jayawardena (2020), more than 1.7 million casual jobs in the private sector were at risk of termination due to the Covid 19 pandemic in Sri Lanka. An article written by Jayasinghe (2020) stated that more than 100 billion rupees payments for construction projects were outstanding. Wijeratne, the Secretary of the Sri Lanka Chamber of the construction industry has stated that the construction industry is the mainly affected industry in Sri Lanka.

Mobile telephone service has been introduced to Sri Lanka in 1989 as the first generation (1 G) analog network. The second generation (2 G) digital system has been introduced in 1990. The mobile network has been upgraded from 2 G to 2.5 G and then to 3 G with the increase in demand. Later 4 G technology has been introduced to Sri Lanka in 2013 (TRCSL, 2014).

The number of Mobile phone subscriptions in Sri Lanka increased rapidly within a short duration after its introduction. Initially, it was limited to urban areas. But later, it was spread whole over the country with the improvements in network facilities by service providers (Silva, 2019a).

2.2.1.Number of users

According to after access report by Galpaya (2019), the majority of the population resides in rural areas, only about 15% of the total population resides in urban areas, and around 45-50% of people own a mobile phone.

A graphical illustration of the comparison between usage of fixed access telephone subscriptions and cellular mobile telephone subscriptions based on data published by Sri Lankan telecommunication statistics updated in June, 2022 is shown in Figure 2-1 (considering the 2021 mid-year population as 21.156 million in Sri Lanka as updated data was not available for the year 2022). However, the number of cellular mobile telephone subscriptions is higher is about 29.56 million because of multiple SIM card usage by consumers as stated in Galpaya's (2019) report (TRCSL, 2022).

Figure 2-2, shows that huge increase in cellular mobile subscriptions up to 2019 and a sudden decrease in 2020. Also, a huge decrease in fixed access telephone subscriptions shows during the last decade after the year 2012. However, the number of fixed access telephone subscriptions increased again by 2020 (TRCSL, 2022).

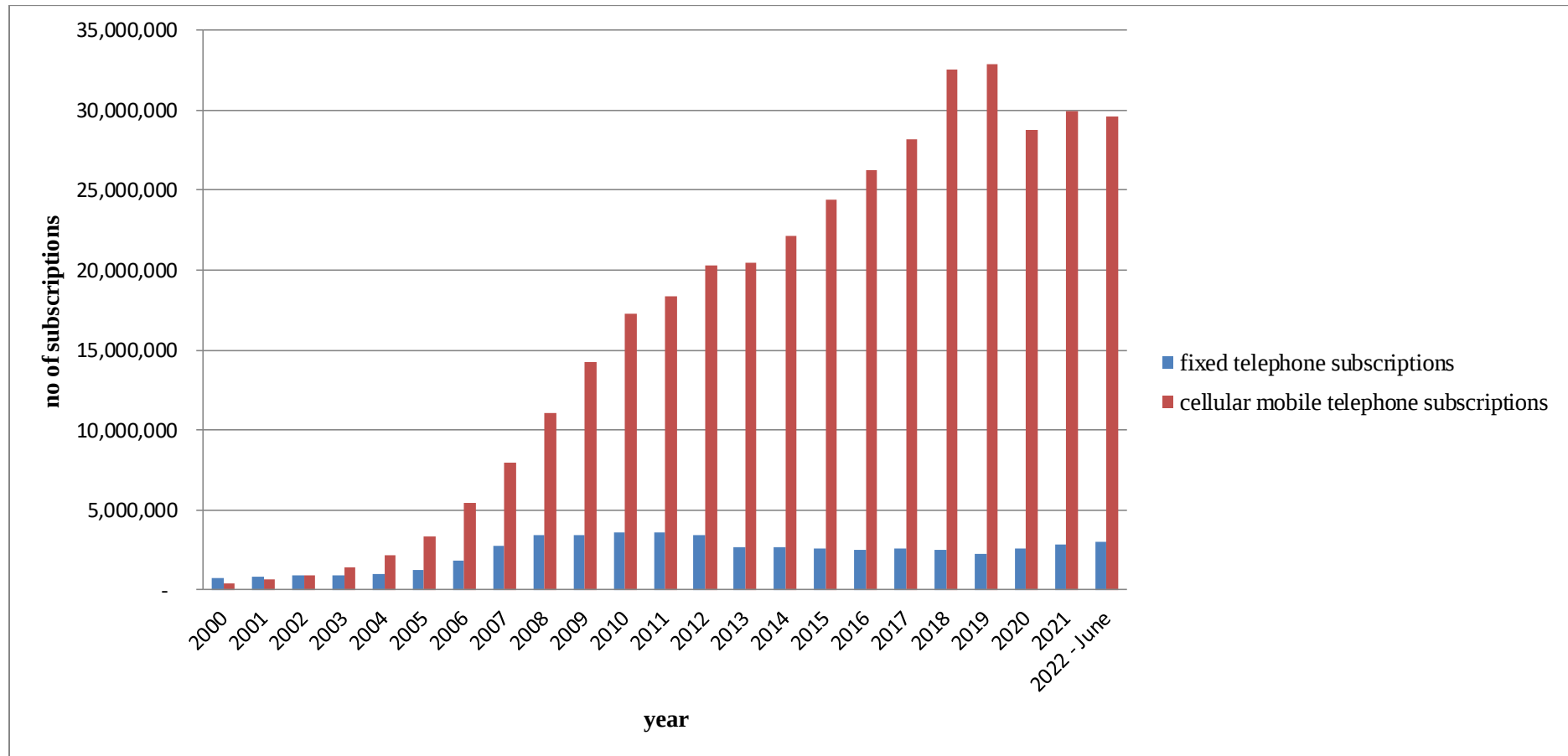


Figure 2-1 Fixed Access and Mobile telephone subscriptions (2000 – June 2022 (TRCSL, 2021)

2.2.2.Number of devices

The ‘after-access report’ of, Galpaya (2019), states that of 21.4 million populations, about 13.5 million use mobile phones equipped with 17.9 million active SIM cards. According to the telecommunication statistical data for 2022, it stated 29.56 million which more reliable. However, the total number of devices could be lower than the total number of subscriptions due to multiple SIM card usage (TRC SL, 2022).

According to Galpaya’s report, she states that nearly half of Sri Lankan mobile phone users own a smartphone. This statement may vaguely apply to urban and rural areas. However, it indicates that half of the mobile phone users can use internet facilities and mobile apps. Also, the report states that 45% urban population and 35% of the rural population use the internet which is nearly half of the population (Galpaya, 2019a).

2.2.3.Number of service providers

Several service providers were found in the Sri Lankan telecommunication sector. The summary of the telecommunication statistical data is as follows (TRC SL, 2022);

Fixed access telephone service	-	3
Cellular mobile telephones	-	4
Data communication (facility based)	-	2
Data communication (non-facility based & internet service providers (ISP)-		3
Trunk mobile radio	-	1
International telecommunication operators	-	6
Direct-to-home satellite broadcasting service	-	4
Cable TV distribution network	-	3
Other operators	-	2

2.2.4.Time spend on making calls

According to telecommunication statistics (2022), about 5,743 million minutes of local incoming/local outgoing call duration, 21.5 million minutes of international incoming, and 11.2 million minutes of international outgoing call duration has recorded only during June, 2022. There are about 32.59 million cellular and fixed telephone subscribers as of June 2022 (TRCSL, 2022). Therefore, one subscriber has spent an average of 177 minutes equals 2.5 hr

call duration per day. The call duration per person could be multiplication of the above duration due to multiple SIM card usage stated in Galpaya's (2019) paper.

A considerable increase in time spent on communication was observed in the year 2021, which may be due to an increase in leaves and work-from-home schedules granted for employees during to Covid 19 pandemic. The exact call duration may not indicate by the statistics as there are many apps available for communication other than making calls. However, no evidence was found from the published documents up to date.

2.3. Usage of mobile phones other than calling and messaging

Modification of basic mobile phones into smart mobile phones including enhanced features other than basic communication facilities (calling and messaging) was the crucial factor in increasing usage and addictiveness. The research paper by Ketheeswaran and Mukuthan (2016) states that people use smartphones not only for communication but also for fulfilling social needs and academic purposes. In Silva's (2019) paper, the author states that people use mobile phones for complicated tasks rather than for communication.

Some basic mobile phones are equipped with limited tools such as clock, calendar, contacts, games, radio, torch, etc. But, smartphones have more applications such as cameras, music players, video players, and other Playstore apps (Google, social media, weather, games, etc.) designed to fulfill human needs (Ketheeswaran & Mukunthan, 2016a).

Mobile phone technology is also sprouting in industrial networks and efforts have been made to apply mobile phones to the CPM sector. Some heavy tablets were used on construction sites at the early stages of its introduction. However, modification of smartphones with lightweight, compact, economic designs with higher performance and user-friendliness encouraged to use of mobile phone devices even in the field. Therefore, the employees in the construction sector, mostly the younger generation in developed and developing countries tended to harvest the best out of the latest technology (Owusu and Emmanuel, 2016a).

2.4. Transformation of Livelihood after the mobile phone trend

Chakraborty (2006) states that society changed fast with the introduction and innovation of mobile phone technology. People tend to use mobile phones even in common places to communicate with their colleagues due to their mobile facility while traveling. Some mobile phone users only communicate with other users according to their preferences and others tend to share information with any other user without barriers (Chakraborty, 2006a).

The mobile phone has become a basic need in human life during the past two decades. Some people use mobile phones not only for communication purposes but also to achieve other aspects of their life. The mobile phone industry has been upgraded together with the growth in consumer needs and preferences (Riyath, 2014).

After the massive development in technology, communication and interaction between human beings has been shaped in each generation with time. Baby boomers (ages 55-73) – born in 1946-1964 grew up with the development of television which has caused them to change their lifestyle and social interactions. Generation X (ages 39-54) – born in 1965-1980 grew up with the development of computer technology and Millennials (ages 23-38) – born in 1981-1996 born with the internet exploration. Generation Z (ages 7-22) – born in 1997-2012 grow up exposed to all of the above massive developments in technology from their birth. Gen Z connected with the web through mobile phones, WiFi, and other network services. By the time Millennials adapted to social media and other connectivity platforms for communication as well as for entertainment. Impact due to growing up exposed to all technological developments is still on researching. Recent research has indicated that there's a massive transformation in youth behaviors, attitudes, and lifestyles (Dimock, 2019).

Introduction and promotion of new mobile phone brands have become more competitive recently. Preferences expected by the consumers are depending on various factors such as price, value-added facilities, product quality, third-party recommendations, celebrity endorsement, etc. (Riyath, 2014).

2.5. Mobile phone apps

2.5.1. Definition

The term 'mobile phone app' is a popular term whole over the world. Without the existence of mobile phone apps smart mobile phone is useless. It would be like a lake without water. So both the smart mobile phone and mobile phone apps need to make the smart mobile phone a beneficial device.

Wikipedia defines 'mobile phone app' as "a computer program or software application designed to run on a mobile device such as a phone, tablet, or watch" (Wikipedia, 2020a).

Huang and Wu (2018) states "the Mobile application is the objective of the Service composition system. The Infrastructure consists of the three players that are involved in the service composition process: the Mobile device, the Surrogate sites, and the Network between them"(Huang and Wu, 2018).

There are a million mobile phone apps designed to fulfill a single task. Each app provides a different level of service whether it has designed to perform the same task. Users can select the most appropriate mobile phone app to meet their expectations and needs simply by going through the reviews and comments published on the developer's website page or via Google search. Choosing the most relevant app has become a difficult task due to countless amounts of suggestions loads for a single task while searching. The user is free to use the app selected if fitting or move into another app while uninstalling or keeping the previously installed app.

When some apps are installed on smart mobile devices numerous annoying notifications could appear periodically reminding us to update the application software while connected to the internet. Sometimes those apps could not function without a periodical update. Most of the time updates cause to consume a higher space of phone memory which could result to slow down the functionality of the device. Also, some apps cause to reduce the battery life drastically and need charging the device several times per day. As a solution, some memory boosting and battery power boosting apps have been also designed to address those problems. As a solution some manufacturers have introduced external memory chips and power banks to function mobile phones with fewer complaints. Therefore, the smart mobile phone user should be keen to understand the capacity of the device owned and whether it requires improving hardware or software for gaining maximum output from the device.

Mobile phone app developers have tended to concentrate on the constraints and features of the devices. Mobile phones run on battery power. So they have less powerful processors than personal computers. So the developers could consider many facts such as screen size, hardware specifications, and configurations (Wikipedia, 2020a).

“Mobile phone applications development requires the use of specialized integrated development environments. Mobile apps are being first tested indoors which is in a development environment using emulators and later subject to field testing. Emulators provide an inexpensive way to test applications on mobile phones to which developers may not have physical access.” (Wikipedia, 2020a).

The usability of Mobile phone apps depends on the extent of future forecasting, addressing the future trends and needs of the society by its developers.

2.5.2.Functions

Mobile phone apps were principally introduced to support basic functions of mobile phones such as mail, calendar, contacts, etc. However, mobile phone apps have drastically developed during the last two decades due to an increase in demand. Therefore, many apps are being designed to fulfill daily needs such as shopping, paying bills, communicating, weather, traffic, delivery, taxi, etc. Some mobile phone apps are created to fulfill specialized desires such as news alerts, medical assistance, job vacancies, remote learning, etc. Many companies use mobile phone apps to provide better customer service for their customers in the banking sector, telecommunication sector, marketing sector, etc.(Wikipedia, 2020a).

At present, the usage of mobile phone apps for fulfilling day-to-day tasks has become a habit. Users tend to select the most appropriate mobile phone application service depending on the availability of apps. The needs of people rose rapidly after exposing to the technology era. A smart mobile phone user may use his mobile phone for different tasks during the day. As an example, a man wakes up in the morning to the alarm using an alarm app, hears religious or motivational music using a music player app, exercises using a video or any exercise guidance app, checks the date and time using a calendar and clock apps, goes through the appointments and plan the day using a scheduling app, checks the mails received using the mail app, checks news updates on a news reader app, checks weather of the day using a weather reader app, search a path/location/traffic using a GIS-based map app, checks notifications on social media apps, checks the account balance and makes payments via mobile banking apps, searches a difficult word using a dictionary app, calculates using a calculator app, etc.

Development of new apps could observe after Covid 19 pandemic whole over the world. In Sri Lanka, the introduction of the 'stay safe' app to keep a log of visits to public places for notifying on exposure to an infected person has become viral. Even many government institutions introduced this system to provide a better and safe service for their customers. Many companies have offered work-from-home facilities to their employees to reduce the risk of contact with virus infection. They used various mobile apps to communicate with other staff members. As an example conducting meetings via zoom app become popular among employees in Sri Lanka recently after the Covid 19 pandemic. Unfortunately, no documentary evidence is available about the increase in mobile phone usage after Covid 19 pandemic whole over the world.

2.5.3.Operating systems

“Apps are generally downloaded from application distribution platforms which are operated by the owner of the mobile operating system, such as Appstore (IOS) or Google Playstore.” There are some freely available apps while some apply charges (Wikipedia, 2020a).

“The three biggest app stores are Google Playstore designed for android mobile phones, Apple AppStore designed for iOS and Microsoft store designed for windows 10, windows 10 mobile and Xbox One.” (Wikipedia, 2020a)

Google playstore is one of the top-class international online software stores developed by Google for android devices. There are more than one million apps developed for Google Playstore and the number of downloads exceeds 50 billion. More than 80% of apps are freely available apps (Wikipedia, 2020a).

According to the records of the year 2012, there were more than 0.65 million apps available in Apple’s Appstore for iOS and over 60 billion downloads have been made by the users (Wikipedia, 2020a).

Other app stores available are Microsoft store designed for Windows 8 and Windows RT platforms, Amazon app store designed for Android and Blackberry 10, Blackberry world designed for Blackberry 10 and Blackberry OS, Nokia store designed for Nokia devices, windows phone store designed for Windows platform, Samsung apps designed for Windows mobile, Android and Bada platforms, etc. (Wikipedia, 2020a).

2.5.4.Categorization of mobile phone apps

Mobile phone apps can classify into various categories according to the service provided or their usage. According to Wikipedia, mobile phone apps can divide into three categories such as native, hybrid, and web-based apps (Wikipedia, 2020a).

Native apps are the apps that can use on a specific device such as Apple device or Android device which are having a specific supportive operating system, Apple’s Appstore, or Android Playstore. Native apps help to provide a better service for their users (Wikipedia, 2020a).

Web-based apps are coded in HTML, CSS, or JavaScript. It needs internet access to perform those apps and occupies lesser memory space compared to the other two types as all the data is saved on internet servers. Also, the user can access data from any device via the internet (Wikipedia, 2020a).

The Hybrid app is a combination of both native apps and web-based apps. They have been designed to facilitate the use of the same app on any kind of operating system. They can develop simply and efficiently. However, this kind of app usually fails to provide the same features on different operating systems (Wikipedia, 2020a).

Borysov (2020) categorizes mobile phone apps based on their type. Other than categorizing based on the design principle, he has categorized based on the functionality which is based on the purpose of its usage. There are 49 app categories on the Google Playstore (16 for gaming) and 41 categories on the iOS Appstore (19 for gaming). He has described the most popular mobile app types as Tools, Social Networking, Lifestyle, Productivity, Entertainment, and Games (Borysov, 2020).

Tools apps are popular on Android devices as they have mostly been designed for optimizing the performance of the device. Clean master is one of the most popular android apps (Petro Borysov, 2020).

Social networking apps have become the top-rated downloaded apps on both platforms. Facebook, Instagram, Twitter, Youtube, Skype, TikTok, Snapchat, etc. are some of them. After being popularization of social networking apps in society, some other categories also integrated social networking features in one form or another such as, Venmo – a mix of financial and social networking app and FitBit – a social network for fitness enthusiasts (Borysov, 2020)

Lifestyle apps help to improve the quality of life. The use of lifestyle apps is not notably popular in society. However, they are well-known and loved by mobile phone users. These kinds of apps can divide into subcategories such as Fitness and Wellness helpers, Dating apps, Travel guidance, Music streaming service apps, etc. normally they have a specific kind of product connected with them and they are often sponsored and promoted by a certain brand. (Borysov, 2020)

Productivity apps are similar to Lifestyle apps. However, it gives broader applications and does not focus on a specific product. As an example, a simple calendar app which is categorized as a productivity app provides the facility to plan the work and increase the efficiency and work according to a schedule. Finance apps also help to manage funds efficiently and spend money carefully. (Borysov, 2020)

Entertainment apps are also very popular apps among mobile phone users. Duolingo, Coursera, Netflix, Comedy Central, etc. are some of the popular entertainment apps. (Borysov, 2020).

Gaming apps are the other type of apps in the popular category. Most mobile phone users tend to spend their leisure time on gaming apps (Borysov, 2020).

Another way to categorize mobile phone apps is the kind of service provided. Apps can be divided into different fields such as accounting, financing, management, construction, project management, etc.

2.6. Usage of mobile phones in the construction and project management sector

The construction industry is normally slower in adapting to new technologies. But mobile devices have challengingly prompted technology advancement in the construction sites. The main benefit of using mobile devices in construction field is saving costs and time. During the construction stage of a project, communicating accurate information right at time is a crucial factor to project success. Physically visiting the sites for collecting information as well as for delivering messages spends more labor hours and isn't effective. But the adaptation of mobile phone technology to construction sites has made it easier to achieve goals utilizing fewer resources (Azhar et al, 2015).

Increasing productivity is one of the main goals of the construction industry. So companies tend to adopt new methods to improve the efficiency and productivity in their construction sites. The introduction of smart or android mobile devices could help to gain those targets (Owusu and Emmanuel, 2016b).

Improvements in technology have resulted in providing an uncountable amount of opportunities to upgrade the existing management process. Using a mobile phone by employees during work is common in all industries. During the past decade, rough-use tablets were introduced to use in the construction industry. The usage of mobile devices was increased in construction industry because of their lightweight, cheapness, high performance, and user-friendliness. Especially, due to the simplicity of its design, the majority of the industrial personnel were able to handle it easily without any expert knowledge. Mobile phone technology will step start the next level of technological advancement in the construction industry (Owusu and Emmanuel, 2016b).

Some of the developed countries like the USA and developing countries tend to invest in advancing technology in their companies. The companies tend to provide room to the younger generation as they are believed as familiar with new technologies (Owusu and Emmanuel, 2016b).

Many kinds of research could be found in studying the usage of mobile devices on construction sites. However, it is more useful to analyze the application of mobile phones in the CPM sector.

2.7. Usage of mobile phone apps in the construction and project management sector

It is no doubt that mobile phone apps have penetrated the CPM sector during the last two decades. Mobile devices were first introduced to construction sites in the '90s and they contained very primitive features. Currently, with the invention of the iPad and similar devices, the use of construction technologies has increased enormously (Sattineni & Schmidt, 2015).

Owusu and Emmanuel (2016) state, “Since the introduction of Apple’s apps store and Google’s Android market around late 2008, there have been many applications which downloads exceed 102 billion of which the construction industry is of no exception”.

Azhar et al (2015) state that, about 13,000 construction-related apps were available on Apple iPad by late 2013. Therefore, it was a challenge to select suitable apps to be used during the life cycle of the project (Azhar et al, 2015).

Some of the project managers use mobile phones to collect work-related information. Also, some companies have designed apps to manage their active construction projects. Previous researchers have found that mobile communication network effectively combines information, experience, and competence to solve any problem caused by an unforeseen event (Sattineni & Schmidt, 2015).

Building information models (BIM) are software developed to utilize for construction management. It offers opportunities not only to construction managers but also to their clients and owners (Sattineni & Schmidt, 2015).

2.8. Categorization of apps designed for construction and project management

Categorization of apps based on their usage, service provided, productivity, popularity, user-friendliness, or any other criteria is troublesome. Many researchers have categorized mobile phone apps into different groups based on the data available. They have selected only several apps for their research work. Azhar et al. have listed mobile phone apps under five different categories depending on the trend of construction apps also based on research data available within the research period in 2013 as follows;

- General office Productivity - Ustream broadcaster, Prontoforms, Toodledo, Punch List, Crane – Operator Hand Signals, OSHA Heat and Safety Tool, Dropbox, Good Reader, Evernote, eWeather, OSHA Heat Index
- Construction documents & Drawings – On-site Planroom, Control Center 7, Bluebeam Revu, Tracing Paper Lite
- 3D Visualization/Drawings – BIMX, Turbo Viewer, Autodesk Sketch Book Express/Pro, Autodesk BIM 360 Field
- Construction Calculations – Home Builder Pro-Calcs, My Measures & Dimensions, Drywall Calculator, My Dimensions pro, Decibel Ultra Pro

(Azhar et al, 2013)

However, they have selected only four categories, simply considering the usage of apps for their research work. Also, they have picked up a few mobile phone apps for their study depending on the ratings of users as follows;

- Information- Safety, News, Construction Code, Sustainability, Equations, Product Data, Cost Information, Claims, Specifications
- Productivity - Facility Management, Claims, Estimating, Change Order, BIM, Bid Management, Contract Maker, Quality Control, CAD, Document Viewer, Project Management, Video
- Calculation Tools - Calculator, Measuring, Level
- Cloud Storage – Information Sharing

(Azhar et al, 2015)

Owusu and Emmanuel (2016) have researched on ‘Use of mobile construction applications in the Ghanaian construction industry’ to identify the root causes of technology design and technology used in the Ghanaian construction industry. They have categorized the mobile phone apps related to construction into several groups based on previous research data for their study.

- CAD, Design and Drawing – AutoCAD WS, AndCAD, Rilievo, DAKO PRO Civil Engineering
- Calculators – Concrete Design, Carpenter’s Calculator, Construction Master Pro, Roofing Calculator, Concrete Calculator

- Estimating – Universal Estimator, A Estimate All Pro, Painting estimator, Material estimator calculator
- Construction site – Spirit level, Site Boss, Site photos,, Daily construction records
- Project Management – iConfirm, Tradies App, Construction manager, Architecture of the Construction Mobile Application, Microsoft Office.

(Owusu and Emmanuel, 2016b)

Dr. Sattineni and Schmidt (2015) researched on ‘Implementation of mobile devices on job sites in the construction industry’ to reveal the benefits and advantages of using mobile devices on construction sites and to study how construction companies use mobile devices. They conducted a questionnaire survey and analyzed data based on thematic analysis and content analysis (Sattineni & Schmidt, 2015).

For the thematic analysis, they have divided construction-related apps into three categories.

- Applications – Weather, Punchlist, Planrid for RFI’s, Web-Based Scheduling, Timesheets, PDF Viewers, Visual Conferencing
- Basic Functions – Default device software, Tracking Materials, Photo Documentation, E-mail, Photo Messaging
- Construction Specific – Autodesk BIM 360, Procore, Bluebeam, Bela software, Latista, Carlson for layouts, Prolog

(Sattineni & Schmidt, 2015)

For the content analysis, Dr. Sattineni and Schmidt(2015) have listed the uses of mobile devices in the field such as BIM 360, Document Viewing, File Sharing, Email, Photo Sharing, Bluebeam, Punchlists, Collision Detection, Decision Making, Applications, Texting, Dropbox, Bela Software, 3D Modeling, Skype.

2.9. Identified benefits and difficulties in using mobile devices and mobile apps designed for the construction and project management sector by previous studies

Currently, tons of mobile phone apps can find related to the CPM field. Therefore, categorizing apps is quite tricky for both Apple’s Appstore and Android Playstore as some apps are providing all three services information, productivity (management), and calculation tools altogether. Also, some mobile phone apps are not user-friendly as some mobile phone apps formulate lots of annoying notifications, can’t use when offline, demands lots of inputs, needs constant updates, demands lots of memory space, etc. which causes to reduce the performance of the mobile phone.

Many researchers have illustrated both pros and cons of using mobile devices and mobile phone apps related to the CPM industry. The research paper on ‘Implementation of mobile devices on job sits’ by Dr. Sattineni and Schmidt (2015) has listed both ‘pros and cons’ of using mobile phones in the construction sector. Those pros and cons were developed based on the collected questionnaire data as follows;

Table 2-1 Pros and Cons of using mobile phones in the construction sector

Pros	Cons
Document viewing and sharing	Distracted workers
e-mail reading and responding	Safety issues
Ubiquitous data availability	Privacy concerns
Augmented reality	Internet connectivity issues
Improved productivity	Data synchronization
Paperless communication	Sub-contractor buy-in
Better documentation	Older worker reluctance
	Software bugs
	Cost of apps

(Sattineni & Schmidt, 2015)

The research by Azhar et al. has indicated potential problems in using construction apps based on the questionnaire data collected for their study.

- Security
- Lack of training
- Difficulty in viewing
- Poor performance

Azhar et al’s study has discussed the application of mobile computing in construction. Many companies didn’t have a clear strategy to adopt mobile computing. Also, they hadn’t been given proper training to apply those technologies. Mobile computing includes major components such as mobile computers (hardware), wireless networks, and mobile applications (software). The study has concluded past study data on how mobile computing was applied to the construction industry. According to his paper, mobile computing for construction has divided into five areas as development of a framework to determine how mobile computing should be used for construction, using mobile computing as a tool for construction management, mobile computing for deficiency tracking, mobile computing for

managing safety or disaster response, development of specific mobile computing feature, etc. it has also concluded that, user satisfaction as an important indicator of beneficial adaptation of mobile computing in the construction industry (Azhar et al, 2015).

The study by Tilaksiri (2006) has concluded that there is a positive relationship between the usage of mobile phones and the country's productivity and it is also caused to increase the road accidents too.

The research conducted by Silva (2019) also studied the impact of mobile phone usage on the livelihood of Sri Lankans. He has concluded that, people tend to make social relationships using mobile phones. Also, he states that the risk of facing accidents is three times higher during engaged in a complex task rather than in simple communication. (Silva, 2019b).

2.10. Previous research studies on mobile phones and mobile phone apps related to the construction and project management sector in Sri Lanka

It is no doubt that, researching an area related to the day to day life makes researchers enthusiastic. The mobile phone has become one of the main necessities in modern human life. Therefore, manufacturers and service providers attempt their best to develop products to meet consumer satisfaction and increase sales. The manufacturers, as well as service providers, tend to enquire about the experience their customers had with their products or services to upgrade their products or services. With the development of modern technology, people can share their views on products and services they had simply on social media as well as on other rating websites. Therefore, consumers have a handful of options to express their views free of charge.

“The main purposes of a research are to inform action, gather evidence for theories, and contribute to developing knowledge in a field of study” (Zarah, 2021). Therefore, researchers tend to research fast-growing technologies. As the mobile phone industry is one of the fast-growing industries together with technology many researchers have tended to study this area to appease their thirst for research. It has resulted to make available many publications relevant to this subject area.

Many local and international research papers can find on mobile phone usage, mobile phone apps, and apps related to the CPM sector. Some research data is outdated even more than a decade ago.

During the last decade, various technological advancements have been introduced into the mobile phone industry as it is a fast-growing industry. Therefore, the Literature review for

this research was updated referring to the most updated data available until the completion of the thesis.

In the Sri Lankan context, the research related to the mobile phone industry was found in the year 2006 (Tilakasiri, 2006) which is far ahead of the increase in popularity and usage of mobile phones whole over the world.

Many papers have been published related to mobile phone usage before and after the increase in popularity of mobile phones during the past two decades. During the first stage, the authors have attempted to analyze the areas such as mobile phone usage (Liyanage, 2014), the impact of mobile phone usage on livelihood (Silva, 2019b) and country productivity (Tilakasiri, 2006), etc. Some researchers have tended to analyze specific areas such as mobile phone brand preference (Riyath, 2014), service quality of operators(ICRD), social influence in adoption (Silva et al, 2011), usage of internet media (Jinadasa, 2016) and so far. It has shown massive growth in research related to mobile phone usage in Sri Lanka.

More reliable and updated numerical data on the usage of mobile phones in Sri Lanka are freely available in publications of the Sri Lanka Telecommunication Regulatory Commission (TRCSL, 2021). It facilitates researchers to initiate their study with a handful of data.

It can observe a massive growth in usage of mobile phones and mobile phone apps after the progression of covid19 pandemic whole over the world. There is a remarkable growth in the usage of mobile phone technology inside Sri Lanka as well as in other foreign countries. Unfortunately, there are no published documents available indicating this growth at the moment.

2.11. Research gap

Mobile phone technology is a constantly developing and upgrading area. It is also a complex study area. Therefore, researching this area is a nationwide necessity to advance the technology and for achieving the best.

The papers discussed in previous sections could categorize into sub-sections as illustrated in Table 2-2.

The following facts could observe in Table 2-2;

- Many local researchers have analyzed the usage and impact of using mobile phone devices in society. Only a few studies were found on mobile phone usage related to the construction industry of Sri Lanka.

- However, there are many foreign studies on the impacts of mobile phone usage in the CPM sector.
- There are only a few local researches found on the usage of mobile phone apps but couldn't find any study related to the analysis of usage of construction apps in Sri Lanka.
- However, several pieces of research can be found on the usage of mobile phone apps in the CPM sector in other countries.

This indicates how far the foreign countries have broadened their research area and the lack of development in the local research area. There was no research available on the usage of mobile phone apps related to the CPM sector in Sri Lanka. Therefore, there is a lack of concentration on the beneficial use of improvements in mobile phone technology. So, it could identify a gap between a study on technology design and technology usage in the Sri Lankan context.

However, mobile phone technology advances day by day to be compatible with the competition between developers and to facilitate consumer needs. The other countries have already stepped on exploring on the technological advancements and their usage.

Therefore, the diversion of the research area by taking examples from other countries is a must for Sri Lankans as a developing country. This study attempted to step into a new chapter in CPM sector studies in Sri Lanka and attempted to fill that gap.

Table 2-2 Classifications of previous studies on mobile phones

Study Area	Research Topic	Author/s	Local/Foreign
Mobile phone usage and impacts of using mobile phone devices	seven new facts we learnt about mobile and internet Sri Lanka	Helani Galpaya (Galpaya, 2019b)	Local
	Mobile cellular telephones and children	G.N.Lucas (Lucas, 2012)	Local
	Usage of mobile phones among university students in Sri Lanka	L.N.Liyanaage (Liyanaage, 2014)	Local
	Impact of mobiles phones on peoples' lives in Sri Lanka	H.P.T.N. silva (Silva, 2019b)	Local
	The impact of usage of mobile telephone on country productivity in Sri Lanka	K.K. Tilakasiri (Tilakasiri, 2006)	Local
	Factors affecting mobile phone brand preference : empirical study on Sri Lankan university students	Mohomad Ismail Moomad Riyath & Sulaima Lebbe Musthafa (Riyath and Musthafa, 2014)	Local
	Service quality of cellular mobile service operators in Sri Lanka – a comparative analysis of customer satisfaction	unknown	Local
	Social influence in mobile phone adoption : evidence from the bottom of the pyramid in emerging Asia	Harsha De Silva et al(Silva, et al, 2011)	Local
	Usage of the smart phones for learning purposes by students- a case study	K.Ketheeswaran & T.Mukunthan (Ketheeswaran & Mukunthan, 2016b)	Local
	Representation of youth generation in the mobile phone and internet media in Sri Lanka	Manoj Jinadasa(Jinadasa, 2016)	Local
	Mobile phone usage patterns amongst university students : a comparative study between India and USA	Sayan Chakraborty (Chakraborty, 2006b)	Foreign
	The influence of mobile technology usage behavior on perceived work performance improvement	Laleska Lebioda et al (Lebiodaet al, 2019)	Foreign

Cont. Table 2-3 Classifications of previous studies on mobile phones

Study Area	Research Topic	Author/s	Local/Foreign
Mobile phone usage and impacts of using mobile phone devices	Mobile phone usage and employees performance : a perspective from Pakistan	Rabia Sarwar Wahla (Wahla & Awan, 2014)	Foreign
	Cellular phone usage and productivity among employees in a Ghanian SME: an assessment	Roland Kwame Donya and E.Afari-Kumah (Donya and Kumah, 2011)	Foreign
Usage of mobile apps/ mobile apps related to construction & project management	implementation of mobile devices on job sites in the construction industry	Dr.Anoop Sattinei & Taylor Schmidt (Sattineni & Schmidt, 2015)	Foreign
	The use of mobile construction applications in the Ghanian construction industry	Adjei Kofi Owusu and Emmanuel Eyiah Botwe (Owusu and Emmanuel, 2016b)	Foreign
	Construction apps : a critical review and analysis	Salman Azhar et al (Azhar et al, 2015)	Foreign

3. CHAPTER 03 - METHODOLOGY OF STUDY

This study attempted to identify and analyze the mobile phone usage and adoption of mobile phone technology in the CPM sector in Sri Lanka. Many previous studies could find regarding mobile phone usage in the country. However, no research was found on the adoption of mobile phone technology in the construction and management sector in Sri Lanka.

However, many similar foreign pieces of research were found related to this area. Therefore, methodologies adopted for previous similar research as well as the methodologies proposed in the 'Research methods for business students' book by Saunders et al(2016) were studied before selecting a research methodology (Saunders et al, 2016).

This chapter discusses in detail the research framework developed for the study, steps taken to select a suitable data collection method, methodologies adopted for data collection, steps followed to select a sample, special attention taken while creating the survey format, the content of the survey format, the steps taken to select data analysis procedure for the study, methodologies adopted for the data analysis, etc.

3.1. Research framework

Proper guidance is essential to conduct a study. Developing a framework for the research is one of the top most things to be done before starting a study.

Therefore, a framework for the study was developed to follow throughout the study as illustrated in figure no 3-1. This framework was much help to direct the study until achieving the targeted objectives.

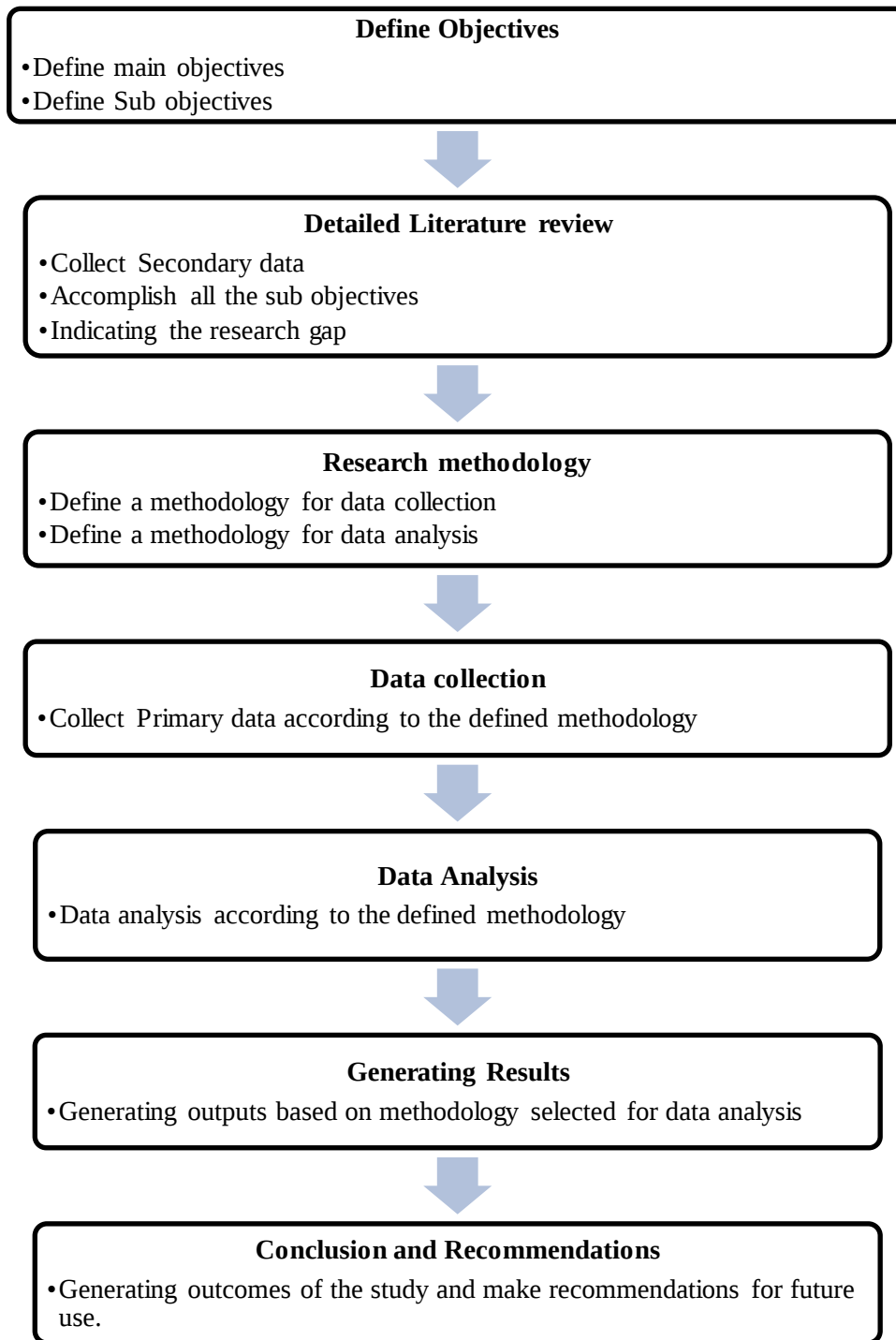


Figure 3-1 Research Framework

3.2. Reviewing the methodologies adopted for previous research

Many previous studies can be found similar to this research area. Therefore, methodologies adopted for data collection and data analysis for those researches were studied at first before selecting the most suitable methodology for this study.

3.2.1.Methodologies adopted for previous similar local research

Methodologies adopted for data collection and data analysis in similar local research were studied at first.

For the research on, ‘Usage of mobile phones among university students in Sri Lanka’, the authors have used questionnaires and interviews to collect primary data. They have collected data on the behavior of the university students covering 100 respondents for their study. They have collected quantitative data and generated results simply based on the percentage of replies received for each question (Liyanage, 2014).

Ketheeswaran and Mukunthan(2016) also used a survey method to collect data from 74 populations for their research on ‘Usage of the smartphones for learning purposes by students who follow Diploma in Commonwealth youth development programs in the Colombo and Batticaloa Centre of the Open University of Sri Lanka’. They used a quantitative research design and analyzed collected data using SPSS software. The results have been generated simply by generating diagrams, tables, figures, numbers, and percentages (Ketheeswaran & Mukunthan, 2016b).

Silva et al(2011) conducted 9,540 face-to-face interviews from six countries to collect data for their research on ‘Social influence in mobile phone adoption: evidence from the bottom of the pyramid in emerging Asia’. The study has been conducted using both quantitative and qualitative research methods. The results have been generated by analyzing the collected data using a logistic regression model (Silva et al, 2011).

The paper on ‘Representation of youth generation in the mobile phone and internet media in Sri Lanka’ by Jinadasa (2016) states that both quantitative and qualitative methods have been used for their study. They collected data by conducting surveys from 100 participants and conducting 20 in-depth interviews covering 20 cities to collect data (Jinadasa, 2016).

For the research on ‘Service quality of cellular mobile service operators in Sri Lanka – a comparative analysis of customer satisfaction’, the authors have used statistical models to validate the modifications introduced to the service quality standards formulated by the Telecommunications Regulatory Commission of Sri Lanka. Finally, a comparative analysis has been performed using an analytical hierarchy programming model to rank the cellular mobile service providers (ICRD, 2019).

From the above, it was observed that many local researchers have collected primary data by conducting interviews and questionnaire surveys. Some of the questionnaire surveys were web-based surveys. Both qualitative and quantitative data have been collected for analysis.

Data analysis has been carried out according to the research objectives and expected results of the study. Most of the researchers have used simple analysis methods for the data analysis.

3.2.2.Methodologies adopted for similar foreign research

The research on ‘Mobile phone usage and employees’ performance: a perspective from Pakistan’ has used primary and qualitative data collection techniques to collect data. A questionnaire has been conducted among 200 employees who were employed in major industries. The collected data has been analyzed using SPSS software. Appropriate percentages and frequencies have been computed to assist in analyzing data (Wahla & Awan, 2014).

For the research on ‘Cellular phone usage and productivity among employees in a Ghanaian SME: an assessment’ the author has used a questionnaire survey. The author has selected the employees of ‘Omega Beverages’ as the sample. The questionnaire has been tested on 10 staff members for validation. After validating the questionnaire, the author collected data from 30 employees. The collected data was analyzed using SPSS software and appropriate percentages and frequencies have been computed to generate results (Donya and Kumah, 2011).

A questionnaire-based exploratory method has been used for the study on ‘Mobile phone usage patterns amongst university students: a comparative study between India and USA’. Survey data has been collected from 50 participants in India and 50 participants in the USA. The study has generated results through a cross-cultural analysis using the collected data (Chakraborty, 2006).

For the research by Leboida et al(2019), the survey cross-section method has been used where the information is found directly from the group of interest. Univariate and multivariate statistical techniques have been used to evaluate the relationship between different variables. The authors have used SPSS and IBM AMOS programme for data analysis (Leboida et al, 2019).

For the research on ‘The use of mobile construction applications in the Ghanaian construction industry’, the authors have used a quantitative research approach. A questionnaire has been conducted among the selected group of respondents to collect data. The collected data has been analyzed using descriptive statistics (Owusu and Emmanuel, 2016a).

For the research by Dr. Sattineni and Schmidt (2015), semi-structured interviews with construction managers and information technology specialists of companies have been used for primary data collection. Twelve individuals have been interviewed for 30 minutes

duration to collect data. Thematic analysis and content analysis have been used for data analysis and generating results (Sattineni & Schmidt, 2015).

Both qualitative and quantitative techniques have been used for the research on ‘Construction apps: a critical review and analysis’ by Azhar et al (2015). Seven interviews have been conducted to collect data for qualitative data analysis. The data has been gathered from app stores for quantitative analysis. The score-based method has been used for the data analysis and formulating of results (Azhar et al, 2015).

From the above all it was understood that many researchers have used interviews and questionnaires for data collection. Also, they have collected data on mobile phone applications from app stores and using an internet search. Some have used data analyzing software such as SPSS, IBM AMOS programme for generating results. Also, some have used thematic, content analysis and statistical methods. Many have computed percentages and frequencies to generate results.

3.3. Tools and Techniques Selected for Data Collection and Data Analysis of the Study

After analyzing methodologies applied in similar local and foreign research it was found that almost all researchers have collected data by conducting interviews and questionnaires. Both quantitative and qualitative data have been collected for analysis. Data analysis methods have been selected according to the objectives of the research and expected outcomes. Some researchers have used data analysis software while some used basic analytical techniques such as generating tables and graphs.

According to the objectives of this research both qualitative and quantitative data are needed for this study. Therefore, by referring to the book by Saunders et al(2016) and by studying the methodologies used in previous similar studies the most preferable data collection technique to meet the main objectives of this study were selected as the survey research strategy (Saunders et al, 2016). A questionnaire was developed to collect both qualitative and quantitative data. The questionnaire format used for the study is annexed under Annexure 1. The content of the questionnaire is discussed in detail under section 3.5.

Conducting a detailed literature review was sufficient to meet the sub-objectives of this study. Therefore, secondary data available in already published documents were used for meeting sub-objectives

As mentioned above both qualitative and quantitative data were collected for the study. Therefore, by considering the nature of data collected by questionnaire format and the expected outcomes of the study the Mixed – model research method which is the use of both quantitative and qualitative methods was selected for data analysis (Saunders et al, 2016).

To meet the objectives of the study both open-end questions and hypothetical questions have been included in the questionnaire format. Therefore, both inductive and deductive approaches have been selected to perform qualitative and quantitative data analysis to generate results (Saunders et al, 2016).

3.4. Population and Sample

Mobile phone technology has been used for facilitating many tasks. Therefore, analyzing mobile phone usage, its benefits, and technology aspects in each industry is an interesting research area. However, this research was limited to analyzing awareness and usage of mobile phone technology in the CPM sector in Sri Lanka.

3.4.1. Population

According to Saunders et al (2016), “population is a full set of cases from which a sample is taken”. Therefore, it is a must to identify the population of the study before selecting the sample.

This research focused only on analyzing mobile phone usage in the CPM sector. CPM is a field that includes all technical and non-technical staff both in project offices as well as on construction sites. Therefore, the people who work in the CPM sector were identified as the population of this research.

3.4.2. The necessity of Selecting a Sample

According to Saunders et al (2016), it may be possible to collect data from the entire population when the population is a manageable size. However, it can't assume that “a census would necessarily provide more useful results than collecting data from a sample which represents the entire sample”(Saunders et al, 2016). So selecting a sample provides a valid alternative to a census when it is impracticable to collect data from the whole population due to budget and time constraints (Saunders et al, 2016). This describes the necessity of selecting a sample for the study.

It was observed that using any distractive equipment such as earphones, radios, mobile phones, etc. is prohibited using in many construction sites due to safety hazards. However, it is essential to use any communication device to coordinate between coworkers. The mobile phone is one of the best communication devices whole over the world. Therefore, some of the technical staff and operators are allowed to use mobile phone devices during work at sites and offices subjected to limitations. Therefore, that technical staff who are allowed to use mobile phones during working hours were identified as the sample of this research.

3.4.3.Sampling Technique used for the research

This research focuses on a specific study area. Therefore, a combination of the self-selection sampling technique and convenience sampling technique was identified as the most preferable sampling method for this research (Saunders et al, 2016). Therefore the questionnaire was shared among professionals who are employed in the CPM sector, using internet media, requesting their support, both by filling the questionnaire and by sharing among their known contacts.

3.4.4.Sample Size

Any systematic procedure to be followed for identifying the sample size was not found in the book by Saunders et al (Saunders et al, 2016). However, many past similar researches have collected questionnaire data lesser than 50 participants. Therefore, the minimum sample size was defined as 100 participants for this study. An online questionnaire survey was conducted within two weeks duration to collect data from a targeted number of participants.

3.4.5.Elements

From the population discussed above, only a few elements have been selected for data collection for this study. The population of the study includes all the technical and non-technical staff including Managers, Engineers, Architects, Assistant Engineers, Surveyors, Quantity surveyors, Draughtsmen, Supervisors, Technicians, Operators, Drivers, Labors, etc. The sample includes only the technical staff including Managers, Engineers, Architects, Assistant Engineers, Surveyors, QS, Draughtsmen, etc. However, for the study purpose, only a few elements were selected from the sample including professionals Managers, Engineers, Architects, Assistant Engineers, Supervisors, and Quantity surveyors who engaged in the CPM industry in Sri Lanka. A graphical illustration of the population, sample, and elements is shown in the following figure no 3-2.

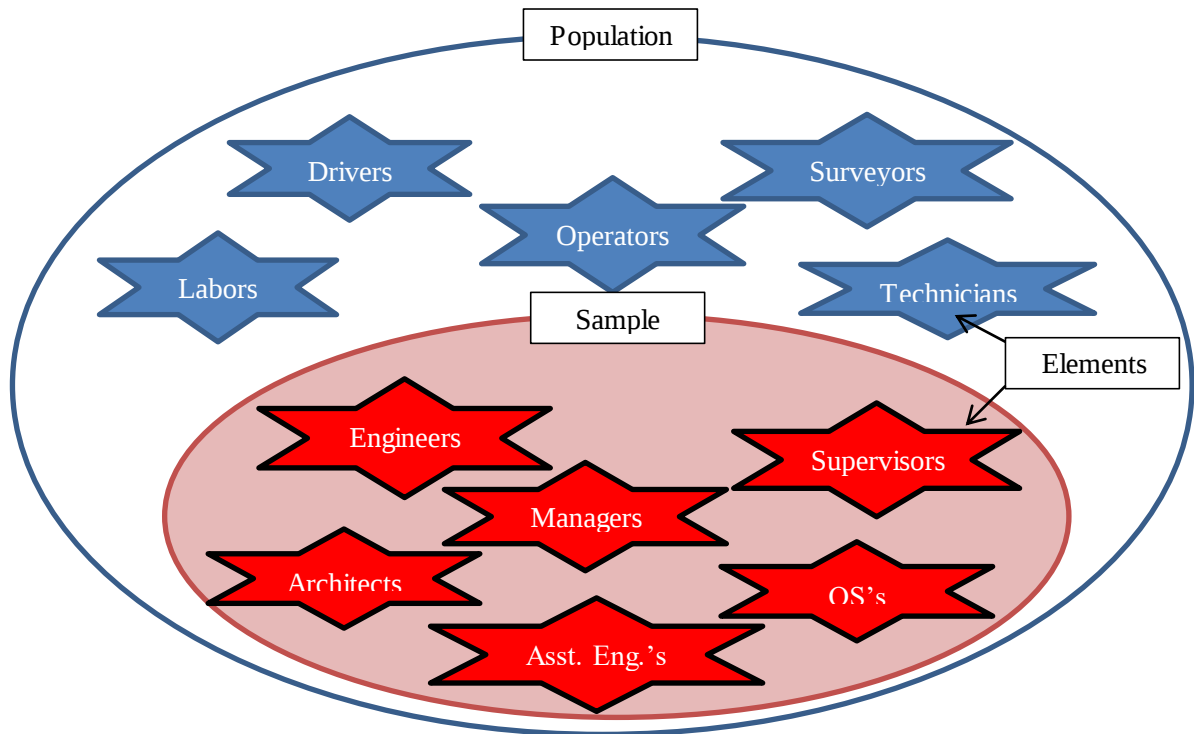


Figure 3-2 Population, Sample, and Elements of the study

3.5. Collection of primary data using a questionnaire survey

The most appropriate methodology to collect data was identified as email interview which is an asynchronous category under electronic interviews. It was selected for this study as the sample selected is geographically dispersed (Saunders et al, 2016). Also, it was most preferable due to time limitations and distance limitations during Covid 19 pandemic. Therefore, the questionnaire was published on a free online survey website and the link was shared between all the known parties requesting to fill and share among known contacts. The targeted 100 numbers of answers were collected within two weeks period.

3.5.1.Preparation of initial questionnaire structure

Initially, a structure was drafted to identify to what extent data was to be collected from the representative sample. The questionnaire data collected in similar published studies were used as guidance for drafting a questionnaire structure for this research to cover the main objectives.

Previous research has collected basic ‘Demographic data of the respondents’ in the first few questions. Next, they questioned the respondents’ understanding of the selected study area as well as their awareness and opinion on using those techniques being studied. Finally, they collected data on respondents’ views and the experiences in the selected study area.

As an initial study, a few questions were included covering the understanding of the subject research area, opinions, and experiences of the respondent. The questionnaire format was finalized after conducting structured interviews.

3.5.2. Conducting structured interviews

Few structured interviews were conducted to adjust the questionnaire structure as well as to improve the questionnaire format. Above mentioned basic questionnaire structure was used for conducting those interviews.

Two face-to-face interviews were conducted among a selected managerial level engineer engaged in construction and an engineer engaged in the project management sector to identify their views. Two telephone interviews were conducted among a selected engineer and a selected quantity surveyor both engaged in the construction field.

From the interviews, it was observed that all the respondents have upgraded their phones to smart mobile phones. All of them are using mobile internet during working hours to ease their office work. They are using some apps related to the CPM sector. However, they were not aware that, they are using apps related to the CPM field.

3.5.3. Finalizing the questionnaire format

After conducting several structured interviews and studying the guidelines provided in the 'a Business method for Research students' book by Saunders et al (2016), the self-administered internet and intranet-mediated questionnaire technique was selected for this study.

The questionnaire format was improved further according to the instructions given in a Business method for Research student's book by Saunders et al (2016). As an example, earlier it was too lengthy and demanded more than 15 minutes to go through the questionnaire. As the selected sample was the professionals engaged in the CPM field, the respondents work with tough schedules and have limited time to fill out the questionnaire. Therefore, some insignificant questions such as lengthy questions on respondents' background details were avoided. All the questions were designed as open-ended questions. The questionnaire was divided into four major sections to keep the attention of the respondents and to make them clear on the kind of data expected.

This study was focused to analyze awareness and usage of mobile phone applications related to CPM. Also, the study was planned to identify the advantages and problems of using mobile phone apps. Additionally, for analysis purposes, it was needed to collect demographic data.

Therefore, the questionnaire was divided into 4 major sections demographic information, awareness of project management apps, project management apps usage, and strengths and weaknesses of project management apps. About 10 questions were included under each section. The finalized questionnaire format is annexed under Annexure 1.

Section 1 – Demographic information

Initially, it was planned to collect detailed Demographic information from the respondent. It was caused to increase the length of the questionnaire unnecessarily. The purpose of collecting demographic information is to use it for analysis. Therefore only eight open - end questions were included in this section to collect only the basic demographic information.

The questions included Gender, Age, Working place, Job sector, Job title, Educational qualifications, Field, and working experience.

Section 2 – Awareness of Project Management apps

In section two of the initially developed questionnaire format, it was targeted to collect data on time spend on mobile phones and mobile internet for calling and on mobile phone apps during working hours in detail to perform a cost-benefit analysis. However, this was neglected as it makes the questionnaire lengthy and it would discourage the respondent to answer the balance questions. Also, it is not directly related to the research objectives.

Therefore, it was focused to collect data of mobile phone usage and awareness on mobile phone apps designed for project management. Seven open-end questions were included in this section.

Collecting data on usage of mobile phone, internet facility, average time spent on mobile internet, the understanding term ‘mobile phone apps’, average time spent on social media apps, awareness on ‘CPM apps’, usage of CPM apps were targeted by section 2.

Section 3 – Project management apps usage

Section 03 of the questionnaire was Project Management apps usage. Initially, it was planned to collect data on the usage of mobile phone apps related to the CPM field, both available in the Apple Appstore and Android Playstore.

Finally, it was curtailed focusing only to collect data on usage of project management mobile phone apps available in Android Playstore. It was assumed that Android operating system is the most widely used mobile phone operating system in the Sri Lankan context as the price of the Android mobile phones is far below that of Apple phones. Therefore, it is no doubt that

the majority of the population tends to buy Android phones. Ten open-end questions targeted to identify the awareness and usage of basic mobile phone apps related to the CPM sector was included in section 03.

The data on the kind of mobile phone operating system installed in the device, documenting apps usage, drawing/3D visualization apps usage, RF design/Concrete design apps usage, Estimate/quantity/level/calculation/measurement apps usage, construction management apps usage, survey apps usage, progress apps usage, weather apps usage, safety apps usage were covered by section 3.

Section 4 – Strengths and weaknesses of project management apps

Under section 4, it was expected to identify the strengths and weaknesses of project management apps. For this purpose, the deductive approach was used. Hypothetical statements were generated to seek the impression of the respondent whether they agree, disagree, or are not sure about the validity of the statement. Only seven statements were included for this section assuming that the respondent will discourage to fill the last section of the questionnaire gets lengthier.

Respondents' opinions on effectiveness and user-friendliness of mobile phone apps, capability to use in any location, capability to access mobile internet, memory capacity and battery life of the devices, and safeness using during work were targeted by section 4.

3.5.4. Conducting questionnaire survey and data collection

As discussed earlier the questionnaire was formatted as a self-administered questionnaire format. The email interview method was selected for collecting data (Saunders et al, 2016). Therefore, the finalized questionnaire was developed using 'freeonlinesurveyes.com'. The freeonlinesurvey was selected as it has an attractive format when it's open on both computer and mobile devices. The website offered only two-week duration to collect responses free of charge.

The questionnaire was shared with the link asking for support from known contacts both by mail and using social media. A kind reminder was sent again after one week to remind the participants to fill out the questionnaire. Also, support was asked from the friends contacted over the phone.

The online surveys could have the facility only to copy and paste each response. Therefore, each set of responses is saved in word document format. Each response was saved in a separate word document. The targeted number of respondents for the study was 100. All the

responses received during the survey period were collected. Of the all responses received only 100 numbers of fully answered responses were selected for data analysis.

3.6. Data analysis techniques adopted for the study

As mentioned earlier, Mixed – model research method was selected for data analysis considering the nature of data collected using the questionnaire format and the expected outcomes of the study. Also, both inductive and deductive approaches were selected to perform qualitative and quantitative data analysis to generate results (Saunders et al, 2016).

Data coding

For data analysis purposes, numerical codes were applied for each answer. As an example for the first question on gender, code 1 was given for the answer ‘male’, and code 2 was given for the answer ‘female’. Applying a coding system was much helpful to sort the data collected and also, convert collected data into a quantitative data format.

All the answers collected from the questionnaire were transferred into a numerical values and tabulated using Excel sheets. The conversion of data into numerical value was a time-consuming and lengthy procedure as the responses were copied into word format and there was no option to copy data in table format directly from the online survey platform. Therefore, all the values were revisited and rechecked to minimize human errors.

Data analysis

The same Excel sheets were used for the data analysis. The data collected needed to be cleaned before the analysis. The cleaning was carried out only for definite answers to be made after the previous question.

As an example, the approximate average time spent on social media using mobile internet could not be larger than the approximate average time spent on mobile internet. Therefore, the second answer was cleaned appropriately.

The tables and graphs were formulated using excel sheets to illustrate the general view of the responses obtained for each question. After that, further data comparisons were carried out using data analysis tools in excel sheets for generating results.

The procedure followed for generating each result has been discussed in detail in the next chapter.

4. DATA ANALYSIS AND DISCUSSION OF RESULTS

The main objective of the study was to identify and analyze the mobile phone usage and adoption of mobile phone technology in the CPM sector in Sri Lanka. Also, this study attempted to identify advantages and problems in using mobile phone applications.

All the sub-objectives of the study were covered under the Literature review chapter. Findings of the sub-objectives were used to refine the main objectives as well as to prepare the questionnaire format.

The data analysis was targeted to generate outcomes expected by the study. This chapter discusses in detail the procedure followed to analyze responses collected by the survey. Also, the outcomes of the data analysis are discussed in this chapter.

4.1. Data preparation for the analysis

All the data collected were tabulated into a single table format using codes for each response as described in the previous chapter. Code from numbers 1 to 7 was applied for each answer according to the number of answers indicated in each question. Zero code was applied for non-responded questions. Coding the data was helpful to overcome the complexity of the analysis.

As an example, question 17 inquiries regarding ‘the usage of documenting apps’. As the questionnaire included structured open – end questions, five possible answer options were included as answers such as; Microsoft word, Microsoft excel, Microsoft PowerPoint, PDF reader, or Other. Therefore the codes given for each response were as follows;

Microsoft word	-	1
Microsoft Excel	-	2
Microsoft PowerPoint	-	3
PDF Reader	-	4
Other	-	5

However, it was observed that some of the respondents had not answered any of the answers given in the questionnaire. As an example, if one of the respondents is not using any of the above apps related to documents. Therefore he/she could not select any answer to the relevant question. Therefore, code ‘0’ was given to all the non-responded questions.

Also, code ‘0’ was used for the balance of answers when the respondent has not marked it. As an example if a respondent has marked only Microsoft word for the previously discussed

question code 0 was given to all other answer options; Microsoft Excel, Microsoft PowerPoint, PDF reader, and Other.

4.2. Data Cleaning

All the entered data were double-checked for cleaning. None of the fully answered responses was neglected due to time limitations to collect responses again. All the responses were taken for analysis after cleaning.

The answers for question 11 on time spent on mobile internet and question 13 on time spent on social media was cross-checked for cleaning. Time spent on social media should be the same or lower than time spent on mobile internet. The inaccurate answers were corrected accordingly. Three responses were identified as inappropriate and cleaned.

Also, answers received for question 14 on awareness of CPM apps and question 15 on the usage of CPM apps were cross-checked for cleaning. If the answer given for question 14 is 'No' or 'Not sure', definitely the answer for question 15 can't be 'Yes'. Six answers were identified as inappropriate and cleaned.

4.3. Preliminary Data Analysis

After cleaning the coded data all the sections were divided into separate sheets for general observation. Some tables and graphs were developed for each answer for picturing the answers received for each sub-section. It was extremely helpful for framing the procedure to be followed for data analysis. Also, it was helpful to have an early sense of the final results of the study.

4.4. Detailed Data Analysis

After forming the initial tables and graphs the procedure for the detailed data analysis was identified. At first separate question was analyzed separately. Next, each question that can be combined with other one or two questions considered. After, the questions can be compared with other questions was considered. Finally, the results were generated based on the most meaningful combination and the expected outcomes of the study.

4.4.1. Section 1 – Demographic information

This section was targeted to observe the background of the respondent. The questions on Gender, Age, Working place, Job sector, Job title, Educational qualifications, Field, and working experience were included in this section. According to the responses received results were generated as follows.

The combination of both answers received for gender and field of work was graphed together into a column chart using excel sheets as follows;

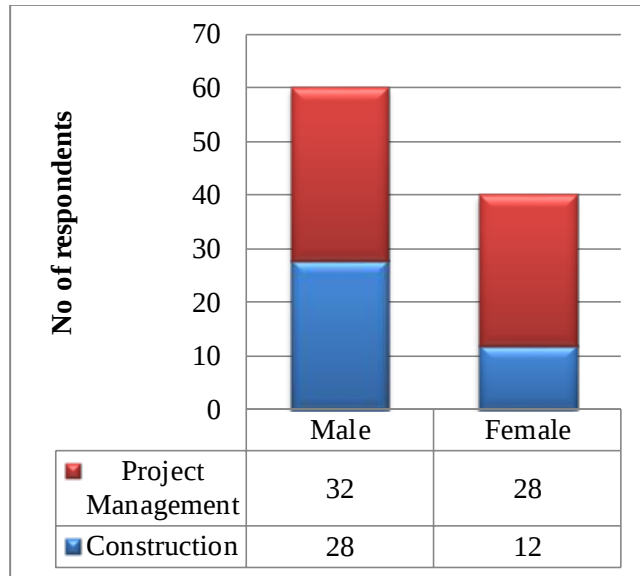


Figure 4-1 Gender and Field of work

According to the above graph, it could observe that out of 100 responses received 60 were Male and 40 were female. Out of the 60 males 32 are engaged in the Project management field and 28 are in the construction field. Out of 40 female respondents, 28 are in the project management field and 12 are in the construction field. It would have the potential of getting the majority of respondents in the project management field as the author had more known contacts in the same.

The age distribution of the participants was graphed into a pie chart using excel sheets as follows;

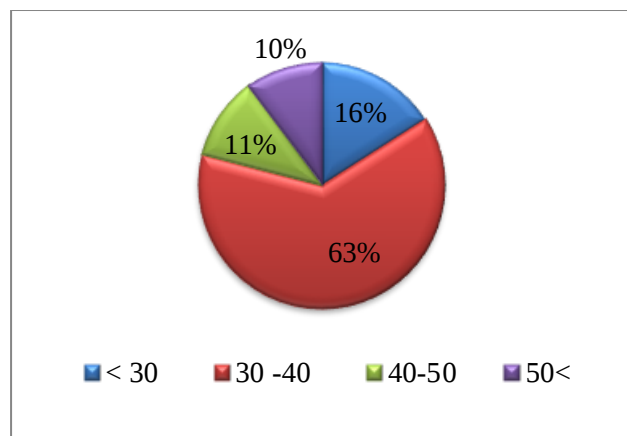


Figure 4-2 Age distribution of the respondents

Accordingly, the majority of the respondents were from 30 – 40 groups which are 63%. The most important observation was that more than 10 respondents from each age group participated in the survey. Therefore the results of the study represent all age groups.

Data collected on the place of work was graphed into a pie chart as follows;

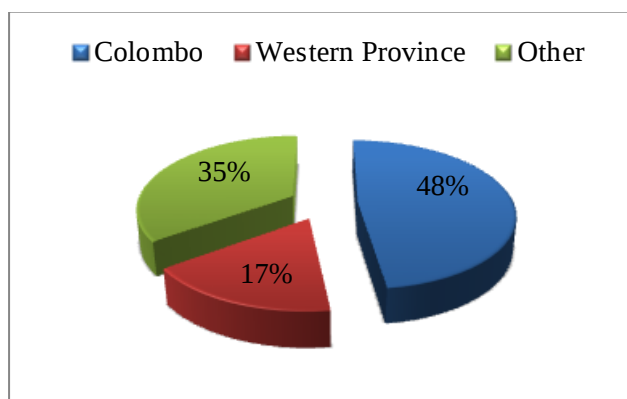


Figure 4-3 Working Place

According to the above figure, half of the participants were from the Colombo district which is about 48%. It is proof of availability of more job opportunities in the CPM sector within Colombo city as many of the infrastructure development projects take place within the city as it is the capital city in Sri Lanka.

The fourth question was about the job sector involved by the respondent. The answers received were formatted into a donut pie chart using excel sheets as follows;

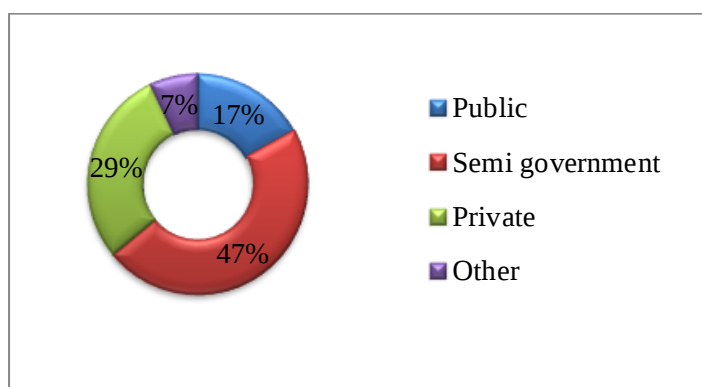


Figure 4-4 Occupation category

According to the above graph majority of the respondents were occupied in the semi-government field. It may cause due to more known contacts being occupied in the semi-government sector. However, all the other two sectors have more than 10% participants.

Therefore the results of the study represent all three sectors public, semi-government and private.

The job title of the respondents combined with their maximum educational qualifications was graphed into chart format using excel sheets as follows;

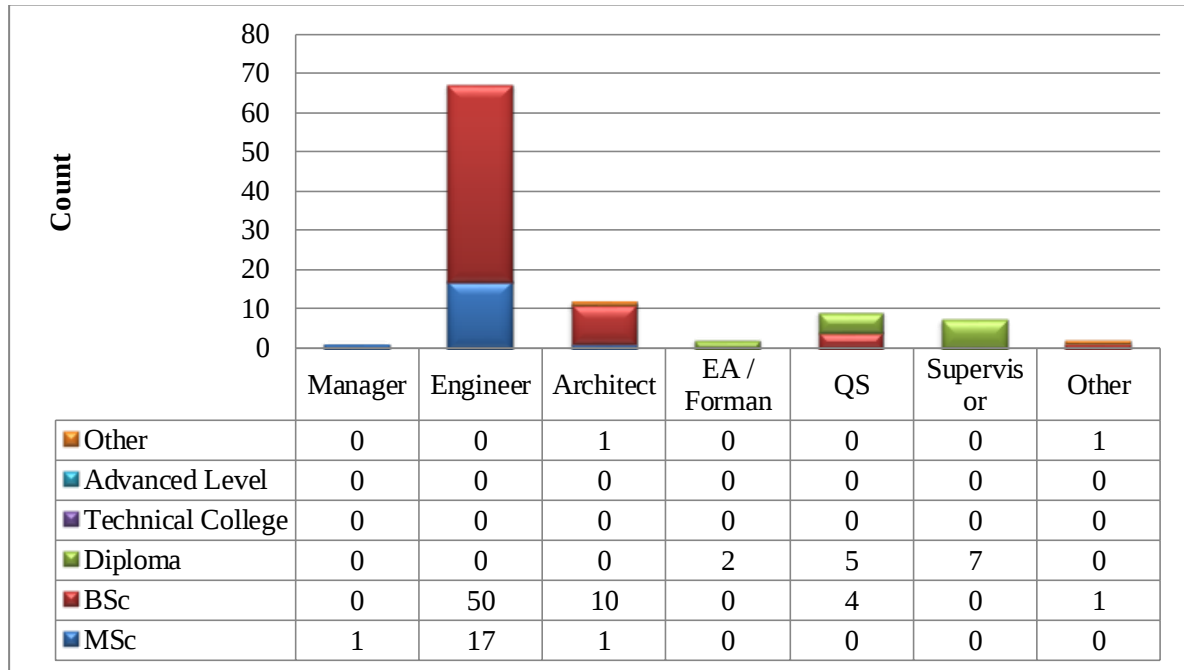


Figure 4-5 Job title and Qualifications

As observed from the above graph, half of the respondents were BSc engineers. There was only one managerial level participant and a few other professionals representing each category. Therefore, the results of the study wouldn't be applied directly to professions other than engineering without modification.

The number of years of experience the respondents gathered up to the data collection date was formed into a pie chart using Excel sheets as follows;

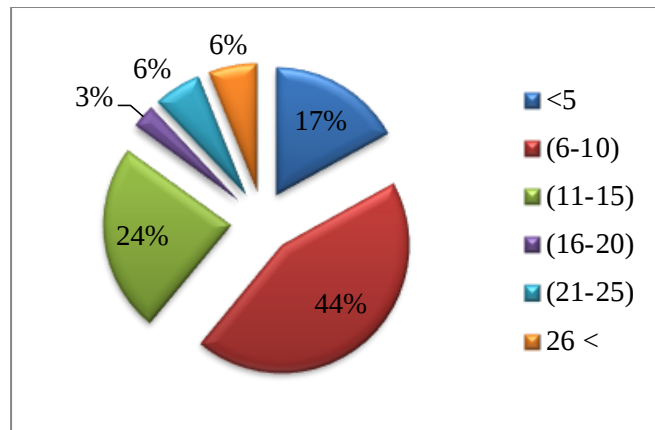


Figure 4-6 No of Years Work Experience

The above graph clearly indicates that the maximum number of respondents has 6-10 years of experience. This result was also matched with the previous result as half of the respondents were in the 30-40 age group. Also, about 60% of the participants were having lower than 10 years of experience.

4.4.2.Section 2 – Awareness of Project Management apps

This section was focused to collect data on awareness about project management apps by the respondents. As an initial approach few questions were asked about mobile phone facilities they used such as type of mobile phone, whether they have the facility to use mobile internet, time spend on mobile internet, etc.

Almost all the respondents had mobile phones with internet facilities. It may be because the targeted respondents were from the professional category.

By question 11, the respondents were asked to tick the average minutes spend on mobile internet per day. The following pie chart was developed using responses received for that question;

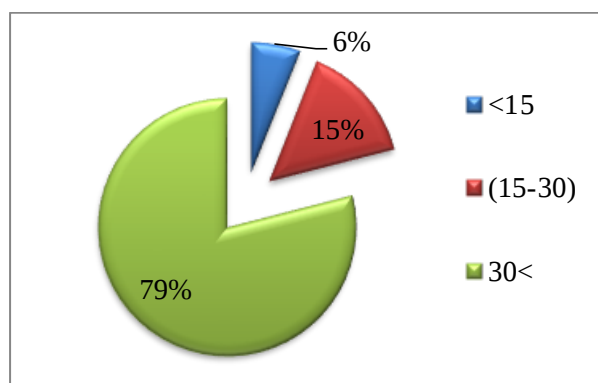


Figure 4-7 Average time spent on mobile internet (minutes)

The graph shows that majority of the participants which was about 79% were using an average of 30 minutes of mobile internet per day.

Also, the average time spent on social media was asked by the respondents and the result was graphed into a pie chart as follows;

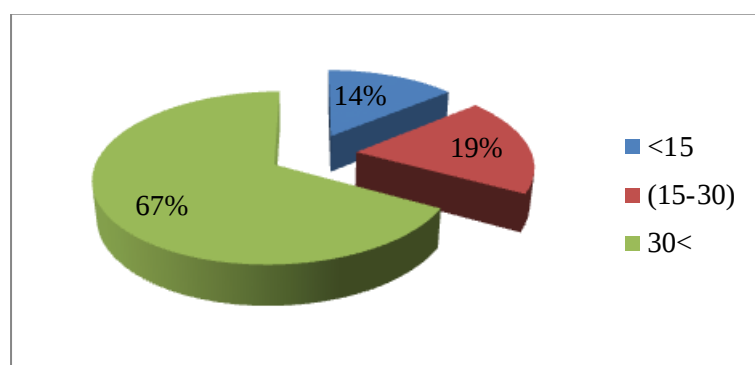


Figure 4-8 Average time spent on social media (minutes)

According to the above graph, it could observe that majority of the respondents were spending more than 30 minutes on mobile internet per day on social media. Time spent on mobile internet Vs. time spent on social media can be compared as below.

Table 4-1 Time spent on Mobile internet Vs. Time spent on Social media

Time spent on mobile internet	Time spent on social media		
	<15 - 1	(15-30) - 2	30< - 3
<15 - 1	6	0	0
(15-30) - 2	4	11	0
30< - 3	4	8	67

According to the above table, it was observed that 67% of respondents use over 30 minutes of mobile internet time on social networking other than on productive apps.

The 12th question was about understanding the term 'mobile phone app'. The answers received to that question were as follows;

Yes	-	94
No	-	4
Not Sure	-	2

Accordingly, 94% understand the term ‘mobile phone app’ while 4% do not know and 2% are not sure about it. However, almost 100% of respondents own smartphones and use some mobile phone apps. Therefore, 6% of the participants may haven’t read and understood the question well. However, it is assumed that the participants answered after understanding the questions well.

The awareness of construction apps Vs. use of CPM apps was tabulated as shown below.

Table 4-2 Awareness and Usage of Construction apps

Use construction apps Aware about construction apps	Yes	No	Not sure
Yes	12	14	2
No	0	46	8
Not Sure	0	14	4

Accordingly, only 12% of the participants were aware of apps designed for CPM. About 88% of respondents were not aware of CPM apps. However, almost all of the participants were using those apps unknowingly according to the responses received for section 3 of the questionnaire discussed below.

4.4.3. Section 3 – Project management apps usage

Section 3 of the questionnaire was focused on collecting data on the usage of apps related to CPM. The apps which are freely available in the Android Playstore were divided into subcategories based on the type of usage.

The percentages of the operating system installed into the mobile phone marked by the respondents were as follows;

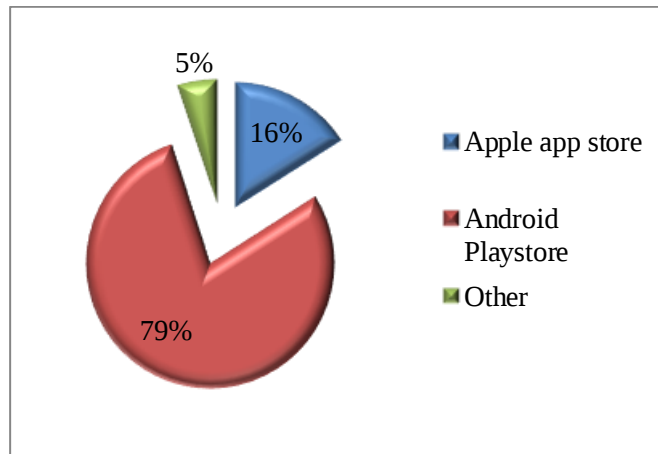


Figure 4-9 Operating System of the device

Same as the author assumed the majority of the respondents were using Android smartphones. Many of the apps selected for study are available in both the Android Playstore and Apple Appstore.

The responses received for the usage of apps related to CPM are graphed and shown in Figure 4-10.

According to the graph, the majority of the respondents are using documenting apps. It may be because the majority of the participants are occupied in project management offices.

Also, the percentage of estimation apps is the second highest ranking app category. The third highest app category is drawing apps.

The usage of each app was graphed separately to identify its usage.

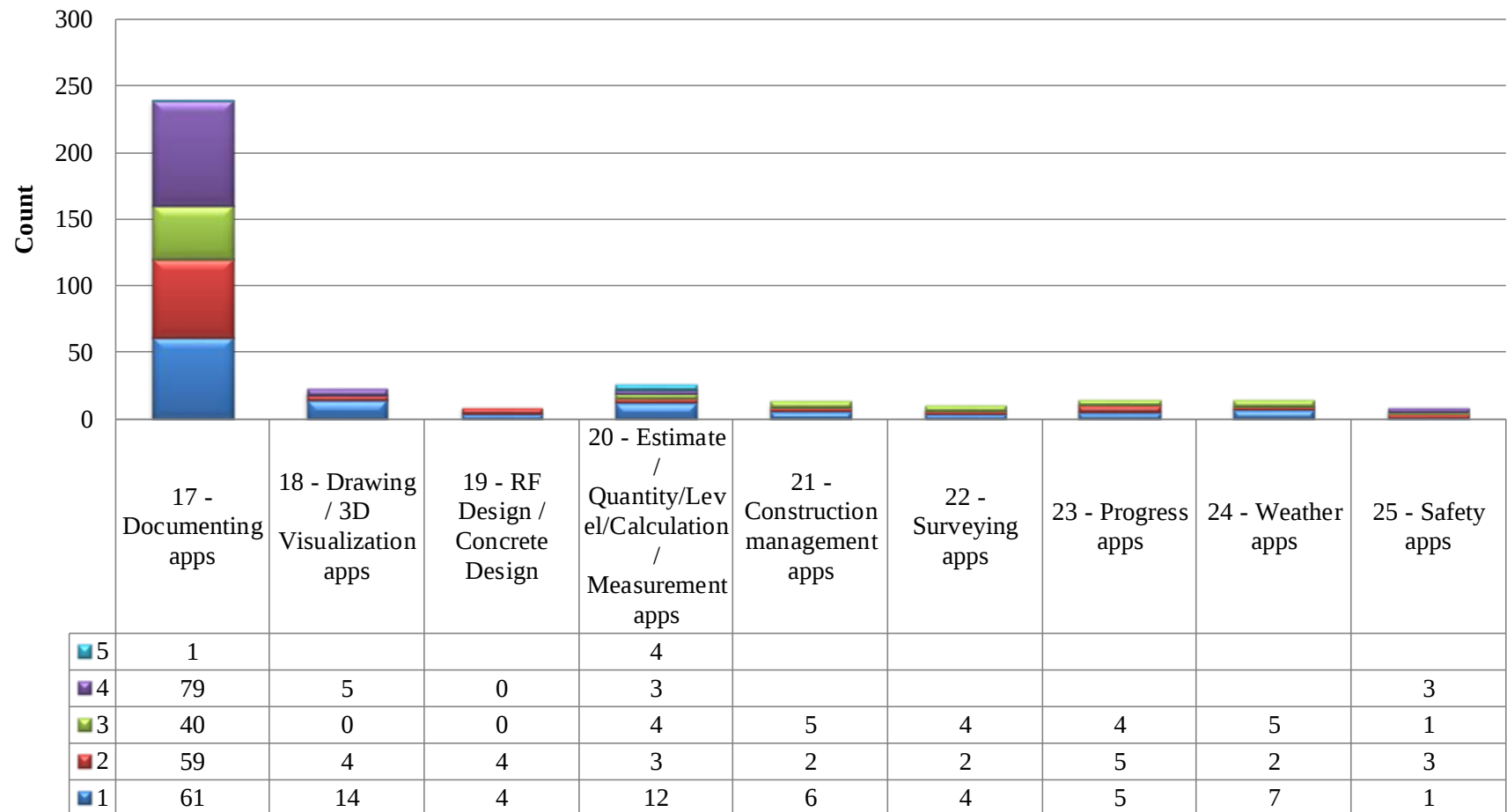


Figure 4-10 Usage of Construction and Project Management apps

Out of all app categories, the most used app category by the participants is documenting apps. The distribution of documenting apps usage is graphed as follows;

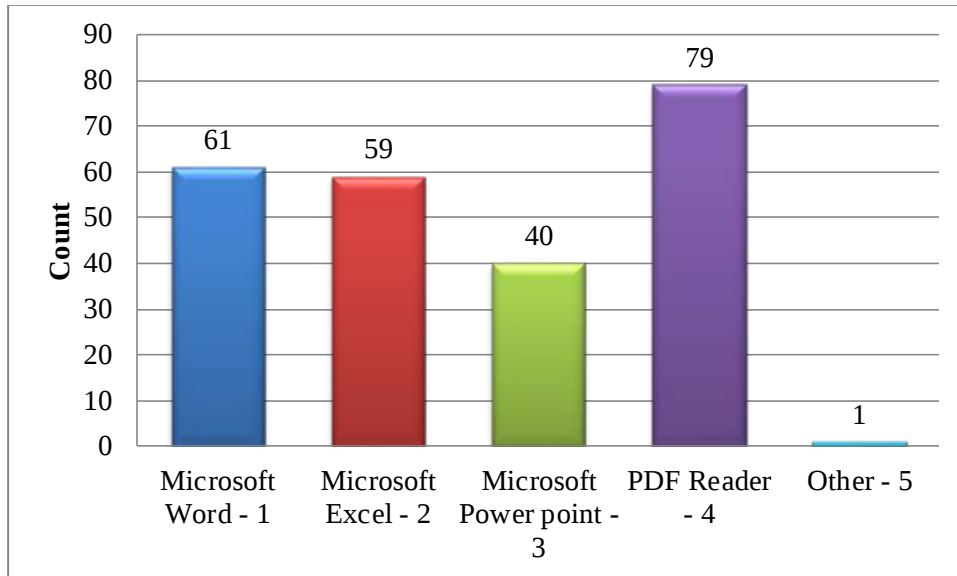


Figure 4-11 Usage of Documenting apps

According to the above graph, the most popular documenting app is PDF reader. 79% of respondents are using PDF reader app. Microsoft word, excel, and power point also observed as popular apps among the respondents. Percentages of each app including Microsoft word, Microsoft excel, Microsoft power point, and PDF reader are higher than percentages of all other apps listed for study.

The distribution of drawing apps usage was graphed as follows;

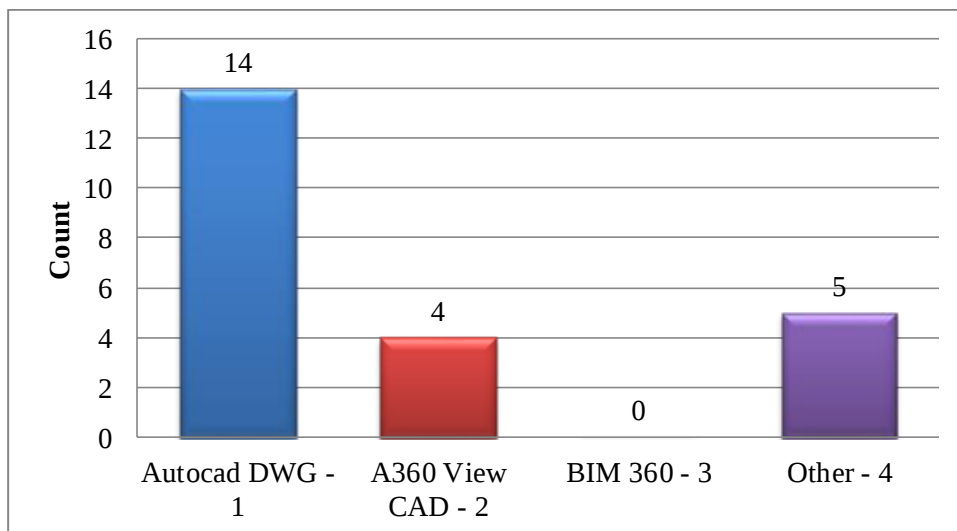


Figure 4-12 Usage of Drawing apps

It could observe that majority of the respondents are using AutoCAD DWG app. Few are using A360 view CAD and other apps. The number of responses received for drawing apps altogether is 23. It is a comparatively higher value than other kinds of apps.

The distribution of usage of apps designed for RF design and Concrete design is graphed as follows;

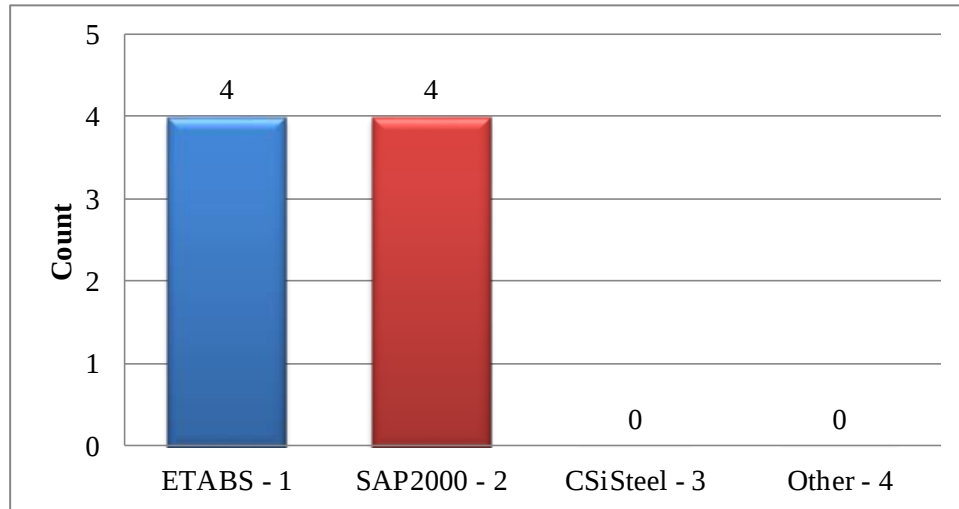


Figure 4-13 Usage of Design apps

According to the above graph, usage of RF design / concrete design apps is very low. Only 4% use ETABS and 4% use SAP2000 mobile apps. A total number of 8 respondents are using apps related to designs.

The distribution of usage of Estimate / Quantity/Level/Calculation/ Measurement apps is graphed as follows;

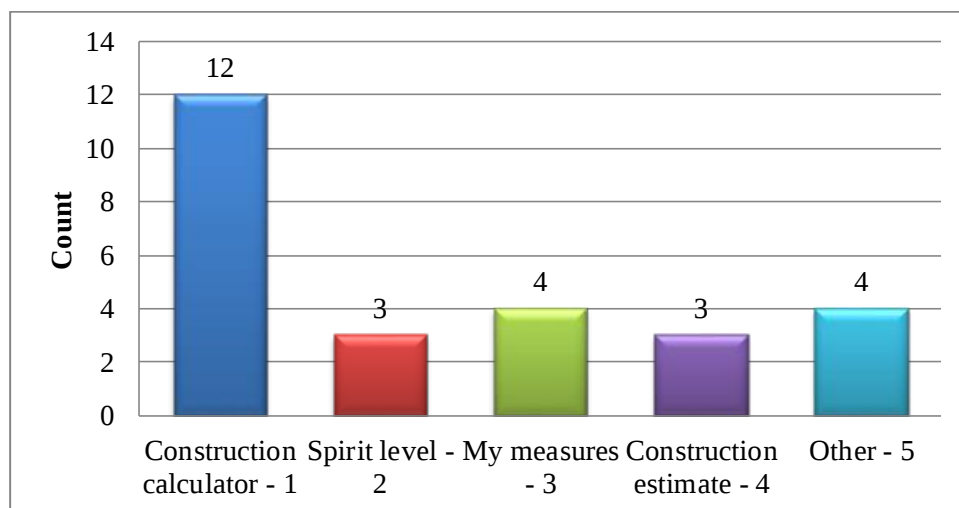


Figure 4-14 Usage of Estimate / Quantity/Level/Calculation/ Measurement apps

According to the above graph, the percentage use of Estimate / Quantity / Level /Calculation and Measurement apps is the second highest app category marked by the respondents. The majority are using the construction calculator app.

The distribution of construction management apps usage is graphed as follows;

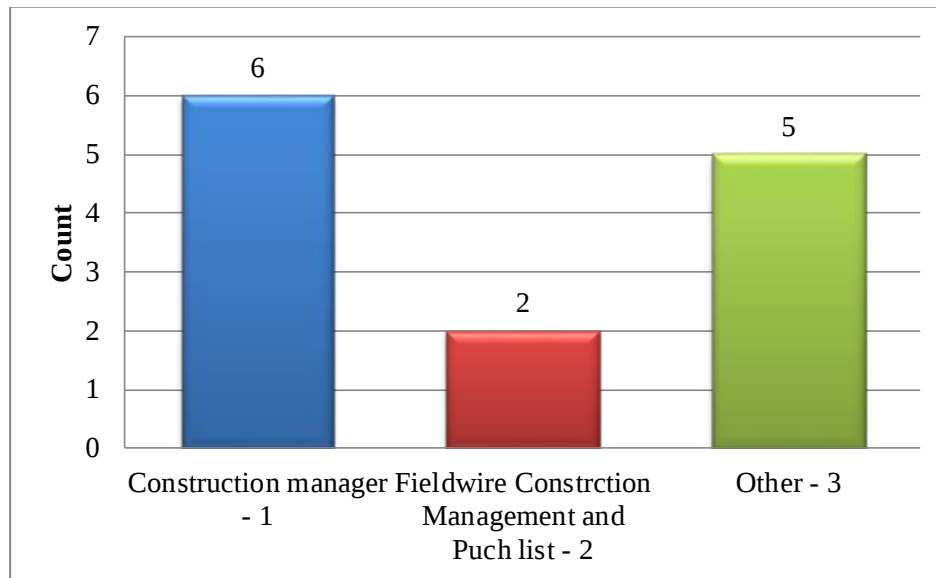


Figure 4-15 Usage of Construction Management apps

According to the above graph usage of construction management apps is very low compared to documenting app usage. However, about 13% of respondents are using construction management mobile apps.

The distribution of usage of apps related to surveying was graphed as follows;

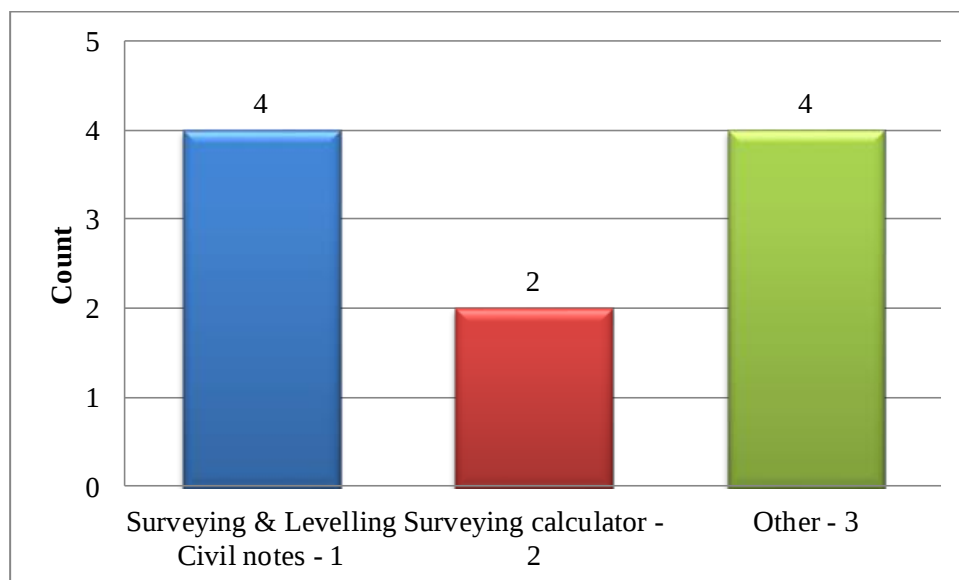


Figure 4-16 Usage of Surveying apps

The percentage usage of surveying apps is also very low compared to documenting app usage. Only 10% of the participants are using surveying and leveling mobile phone apps.

The distribution of percentage usage of progress apps was graphed as follows;

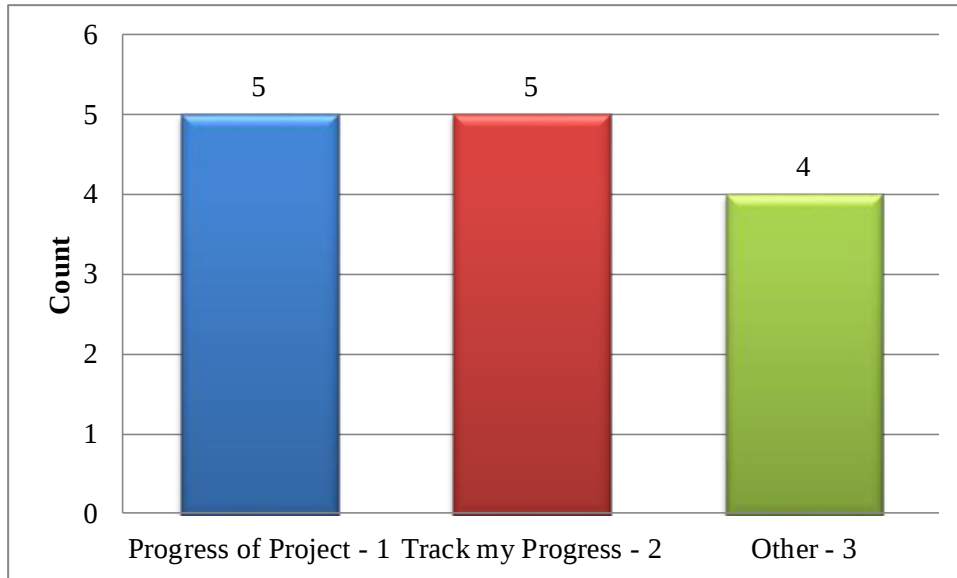


Figure 4-17 Usage of Progress apps

According to the above graph, usage of progress apps is also very low. However, total about 14% are using mobile phone apps developed for progress.

The distribution of weather apps usage is graphed as follows;

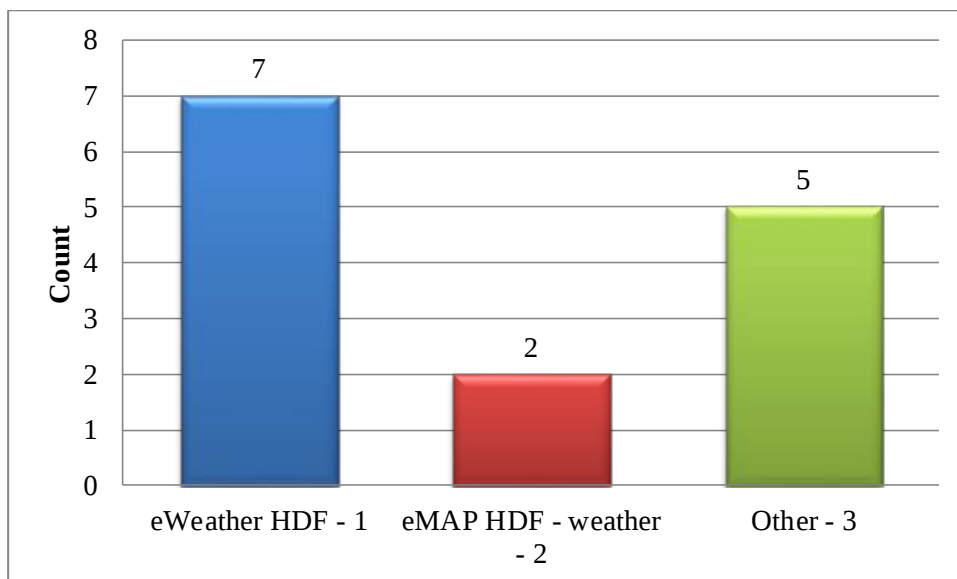


Figure 4-18 Usage of Weather apps

According to the above graph, usage of weather apps is also very low. However, a considerable amount of the participants which is about 14% were using mobile phone apps created for the weather.

The distribution of safety apps percentage usage is graphed as follows;

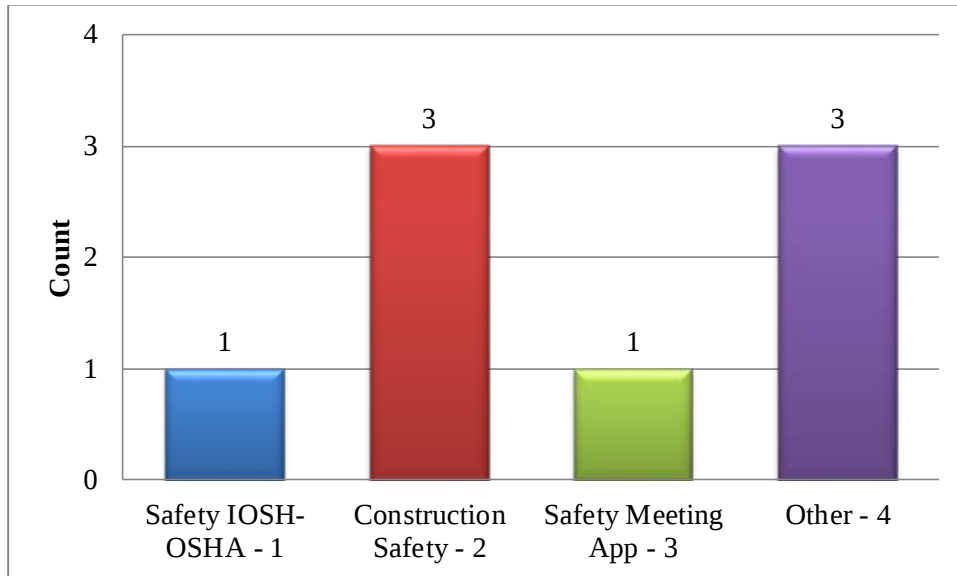


Figure 4-19 Usage of Safety apps

According to the above graph, usage of safety apps is comparatively low. However, 8% of the participants use safety apps.

From the above graphs, it could observe that no null percentages have got for any of the app categories listed. Therefore all app categories listed are being used. The percentage usage of all app categories is greater than 8%. It shows that some of the professionals engaged in the CPM sector tend to use mobile phone apps related to their field other than the common apps.

4.4.4. Relationship between ‘engineer profession’ and ‘usage of construction and project management apps’.

According to the data collected, it was observed that the majority of the respondents are engineers which are 67 persons. Therefore, the results of this study would be used as a representative of the mobile phone usage behavior of engineers. Therefore, the relationship between ‘engineer’ and ‘the usage of CPM apps’ is graphed as shown in Figure 4-20.

According to the above graph, the most popular app category among engineers is also observed as Documenting apps. The second most popular app category is drawing app and the third is Estimation apps. Usage of other app categories is low. However, out of 67 engineers, few are using different types of apps at the same time.

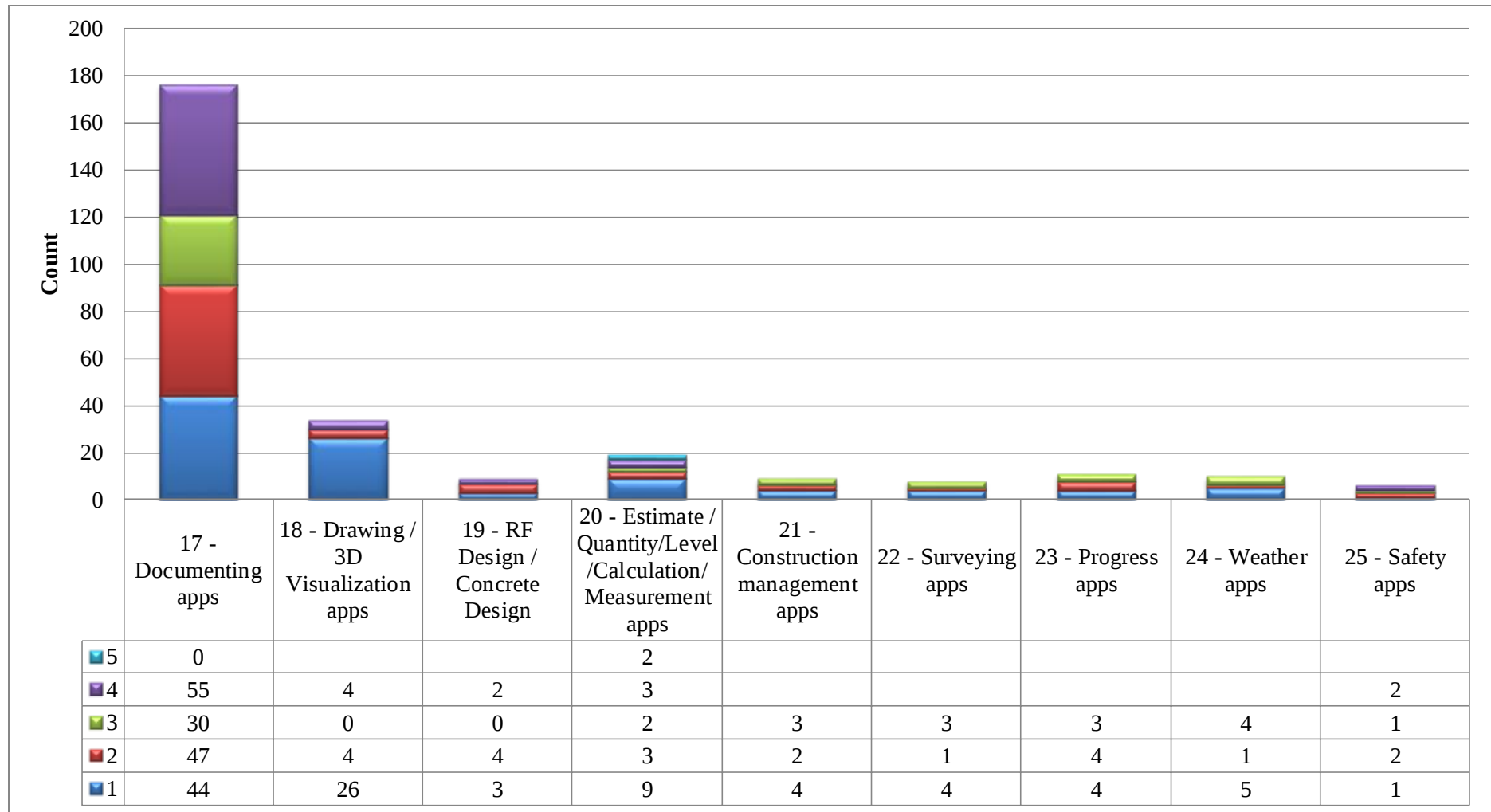


Figure 4-20 Relationship between 'Engineer' and 'CPM Apps usage'

4.4.5. Addiction to Social Media

The relationship between ‘usage of social media apps’ respect to ‘time spent on mobile internet’ illustrates the tendency of adaptation to social media by the respondents. The following table is developed to analyze the tendency of adaptation.

Table 4-3 Time Spent on Mobile Internet Vs. Time Spent on Social Media

Time spent on mobile internet	Time spent on social media		
	<15	(15-30)	30<
<15	6	0	0
(15-30)	4	11	0
30<	4	8	67

The above table clearly shows that majority of the respondents which is 84% are using almost the total daily spent mobile internet time on social media. Only 12% of the participants spend a portion of daily mobile internet time on other app categories. Therefore, this indicates that most of the participants are addicted to social media apps rather than other useful apps. It means the respondents use mobile devices for entertainment purposes rather than making benefits for their work life.

Many companies in Sri Lanka provide smartphones with mobile packages for their staff to make benefit their companies. However, the above analysis shows that many employees would not make benefit from those facilities provided by the company.

4.4.1. Section 4 – Strengths and weaknesses of project management apps

According to the responses received for section 4 on hypothetical statements regarding the advantages and problems of using mobile devices and facilities a column chart was developed as follows;

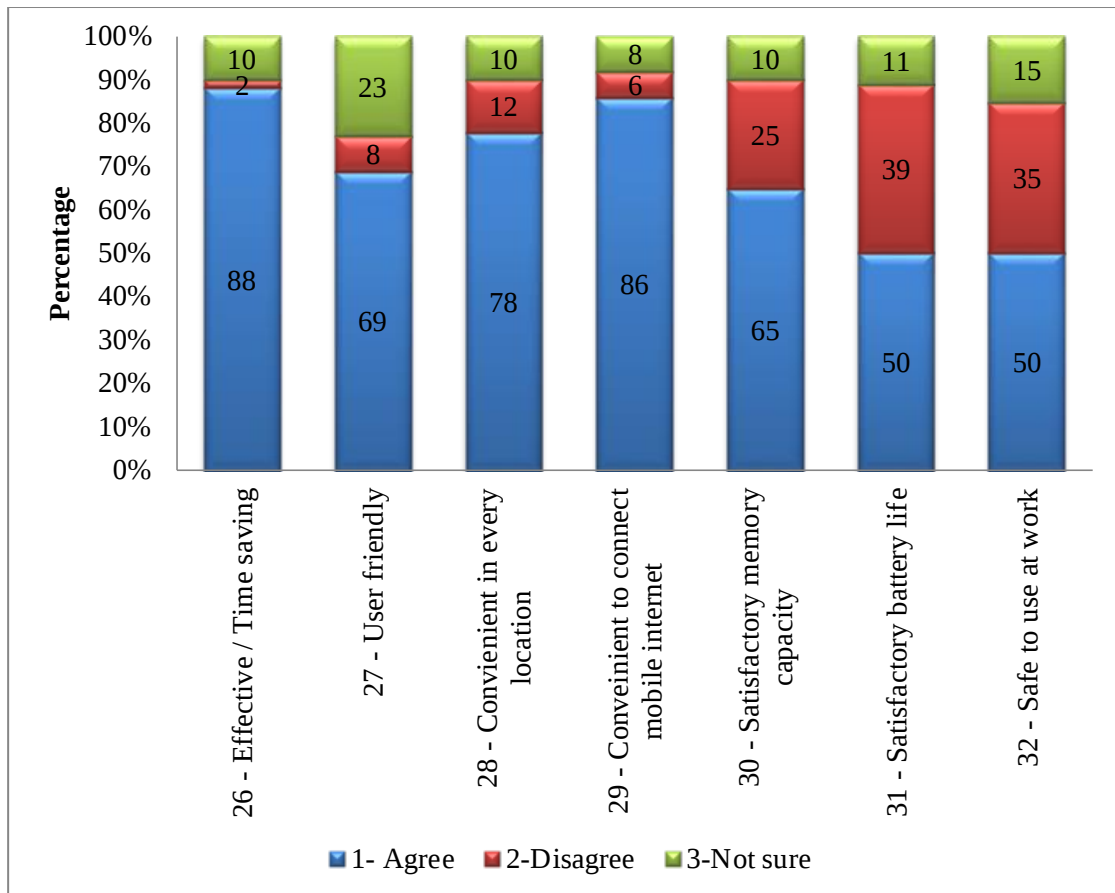


Figure 4-21 Strengths and Weaknesses of Construction & Project Management apps

Three definite answers were given to select for each statement Agree, Disagree, and Not sure.

The validity of each statement was analyzed based on the percentage of positive or negative responses received. Answers made as ‘Agree’ was considered positive, ‘Disagree’ was considered negative, and ‘Not sure’ was considered ‘neutral or zero’ for analysis purposes. If the percentage of positive answers got for any statement is higher than the negative answers the statement is considered a ‘True’ statement. And balance is considered a ‘False’ statement.

Accordingly, 88% of positive answers were got for the first statement, ‘Using mobile phone apps helps to make work more effective/time-saving’. Therefore, this statement is a ‘True’ statement. Therefore, the majority of the participants have agreed that they can use mobile phones to make work efficient.

69% positive answers were got for the second statement, ‘Most of the apps are designed to be used as user- friendly’. So it is a ‘True’ statement. This statement was included to clarify if there is any reason behind not aware of or not using specialized mobile phone apps rather

than general apps. The percentage of agreeable answers, illustrates that majority of the respondents are keen to understand and adopt any kind of mobile phone app available.

78% positive answers were got for the third statement, 'Mobile phone device /Tab is convenient to be used in any location'. Therefore, it is a 'True' statement. This question also made to understand whether there is any reason for not using specific mobile phone apps for their work. According to the answers received the respondents are not having problems using mobile phones during work.

86% positive answers were got for the fourth statement, 'It is convenient to connect to the internet via a mobile device'. Therefore, it is a 'True' statement. There are other ways to connect to the internet other than using mobile internet such as via cable connection, wifi connection, using dongles, etc. However, the responses received from the respondents, show that using mobile internet is also convenient to use as well as other methods.

About 65% positive answers were got for the fifth statement, 'Memory and Capacity of mobile device is satisfactory' which means; it is a 'True' statement. However, it has received 25% negative answers and 10% neutral answers which mean a considerable amount.

With the development of mobile phone technology, many manufacturers have upgraded the internal storage area and RAM capacity of mobile devices very recently. Many Sri Lankans use a newly brought mobile phone than 3 years without upgrading due to the high cost of those upgraded mobile phones. Therefore, those outdated mobile phones would not have memory capacity at satisfactory levels.

50% positive answers, 39% negative answers, and 11% neutral answers were got for the sixth statement, 'Battery life of the mobile device is satisfactory' which arithmetically means a 'True' statement. However, due to the considerable amount of negative answers and neutral answers got it can't consider a True statement entirely. It means many respondents are not much satisfied with the battery life of their mobile devices.

Smartphones have many features other than basic phones as discussed in earlier chapters. Most of the apps require connecting to the internet for operation. While the device is connected to the internet it causes to consume more power. Therefore, the battery life of the device deteriorates rapidly. Whether the technology has developed so far, the manufacturers still use the same old cell batteries for mobile devices. Therefore, the statement 'Battery life of the mobile device is satisfactory' can't accept as a 100% true statement.

50% positive answers were got for the seventh statement, 'It is safe to use a mobile device at work' which arithmetically means; it is a 'True' statement. However, 35% of negative answers and 15% of neutral answers have been received for this statement.

Safety is one of the higher-ranking concerns on Construction sites. Usage of Mobile phones causes to distract people from their work which would make the path to accidents. Therefore, this statement, 'It is safe to use a mobile device at work' can't accept as a 100% true statement.

5. CONCLUSIONS AND RECOMMENDATIONS

This study attempted to identify the gap between technology design for Mobile phone apps and technology usage in the Sri Lankan context based on published data and survey data. The study was limited to research on the awareness and usage behavior of selected professionals who are engaged in the CPM sector.

Primary data was collected through a questionnaire survey followed by four structured interviews were used for achieving the main objectives of the study. Secondary data collected from previous publications were used for reaching the sub-objectives of the study.

All the sub-objectives were covered by the Literature review under Chapter 2. The methodology adopted for achieving the main objectives is discussed in detail in Chapter 3. Data analysis and results are discussed in Chapter 4. This Chapter includes outcomes of the study as well as applications and recommendations for future uses.

5.1. Conclusions

This study attempted to analyze the awareness and usage of CPM apps as well as to identify advantages and problems in using CPM apps in the CPM sector the Sri Lanka.

Primary data was collected by a questionnaire survey published on an online platform. Due to the limitations, few professionals engaged in the CPM sector were selected for the study to represent the sample which is the technical staff. 100 numbers of fully answered respondents were collected out of the answers received within two weeks duration.

The responses received were copied and saved in word document format. The responds were formed into a tabulated format applying a coding system defined for analysis purposes. The table values were revisited to minimize human errors. Also, the data was cleaned appropriately. A simple analysis was carried out using data analysis tools in excel and making significant relationships between different data categories to reach the objectives of the study as discussed in the previous chapter.

Sub objectives of the study were,

- Identifying and categorizing apps designed for the CPM sector
- Identifying the current level of CPM apps usage whole over the world
- Summarizing the benefits and difficulties of using mobile phones
- Establishing the current level of studies on mobile phone app usage the CPM sector in both locally and internationally.

Currently, available published data was used for achieving sub-objectives. The results got for sub-objectives were used to indicate the research gap and to structure the questionnaire format for achieving the main objectives of the study.

5.2. Apps designed for CPM Sector

From the results of a detailed literature review and according to the rates and reviews, apps designed for the CPM sector were categorized into nine different groups which were used for the questionnaire survey as follows;

- Documenting apps – Microsoft Word, Microsoft Excel, Microsoft PowerPoint, PDF Reader, and Other
- Drawing/3D visualization apps – AutoCAD DWG, A360-View CAD, BIM360, and Other
- R/F Design & Concrete Design apps – ETABS, SAP 2000, CSiSteel, and Other
- Estimate/ Quantity / Level/ Calculation/Measurement apps – Construction calculator, Spirit level, my measures, Construction estimate, and Other
- Construction Management apps – Construction Manager, Fieldwire Construction Management & Punch list, and Other
- Surveying apps – Surveying & Leveling Civil notes, Surveying Calculator, and Other
- Progress monitoring apps – Progress of Project, Track my progress, and Other
- Weather apps – eWeather HDF, eMap HDF-Weather, and Other
- Safety apps – Safety IOSH-OSHA, Construction Safety, Safety Meeting App, and Other

5.3. The current level of CPM apps usage whole over the world

From the detailed literature review, it was found that mobile phone apps have penetrated the CPM sector during the last two decades, and also some companies have designed apps to manage their active construction projects (Sattineni & Schmidt, 2015). There are so many apps available for the CPM sector that downloads exceed 102 billion (Owusu and Emmanuel, 2016).

5.4. Identified benefits and difficulties of using mobile phone apps

Based on the literature review, the advantages and problems in using mobile phone apps selected for the questionnaire survey are as follows;

- Effectiveness of mobile phone apps

- User-friendliness of mobile phone apps
- The convenience of using from any location
- Convenience of connecting to mobile internet
- Satisfaction of Memory capacity
- Battery life of the Mobile device
- Safeness of using the Mobile device during work

5.5. The current level of studies on CPM apps usage whole over the world

Many papers have been published related to mobile phone usage before and after the increase in popularity of mobile phones during the past two decades. According to the literature review, massive growth in research related to mobile phone usage was found in the Sri Lankan context. However, foreign studies have been broadening into analyzing mobile phone usage in beneficial ways. They have attempted to analyze the usage of mobile phone apps in the CPM sector. According to the comparison between previous foreign and local studies data, it was identified that there is a gap between technology design for mobile phone apps and technology usage in Sri Lanka.

5.6. Awareness and usage of CPM apps

According to Table 4-1 in the Data analysis and discussion of results, only 12% of respondents were aware of construction-related apps and use them. 14% have replied that they were aware but not using construction-related apps. 46% were not aware and not using CPM apps. However, according to the responses received for app usage, more than 40% were using documenting apps and all other app categories including drawing, estimate, etc. apps. Therefore, it means that respondents are using apps related to CPM without a clear understanding. It highlights that, 'Respondents are not much aware of CPM apps'.

Also according to the results on 'time spent on mobile internet Vs. time spent on social media', indicates that the majority of the respondents which is about 84% spent almost total daily mobile internet time on social media rather than on other apps. It indicates that 'Respondents are not aware of the usefulness of CPM apps for their day-to-day works'.

According to Figure 4-10, the widely used app category was observed as Documenting apps. According to Figure 4-11 PDF reader app is the most popular app among the respondents out of the other documenting apps.

The second highest ranking app category observed in Figure 4-10 is Estimation apps. According to Figure 4-14, the most popular Estimation app is the 'Construction calculator app'.

The third highest ranking app category observed in Figure 4-10 is Drawing apps. According to Figure 4-12 AutoCAD DWG is the most popular drawing app among respondents out of the other documenting apps.

According to the answers received, the majority of the respondents which is 67% were engineers. Therefore, the results of usage of apps related to the CPM sector were further analyzed separately concerning engineers as shown in figure 4-20.

According to that graph, the most popular app category among engineers also was observed as Documenting apps. The second most popular app category was drawing app and the third category was Estimation apps. Usage of other types of apps was comparatively low. However, it was observed that out of 67 engineers few were using different app categories concurrently. Therefore, the results of the analysis indicate that the 'Most popular apps between respondents are, Documenting apps, Drawing apps and Estimation apps'.

The fourth section of the questionnaire targeted on advantages and difficulties of using mobile phones and apps during working hours. According to the answers received, the hypothetical statements are validated as below.

- The statement, 'Using mobile phone apps helps to make work more effective/time-saving' has received 88% positive answers. Therefore this statement could define as a 'True' statement.
- The second statement, 'Most of the apps are designed to be used as user-friendly' has received 69% positive answers. Therefore, it could also define as a 'True' statement.
- The third statement, 'Mobile phone device /Tab is convenient to be used in any location' has received 78% positive answers. Therefore, it could define as a 'True' statement.
- The fourth statement, 'It is convenient to connect to the internet via a mobile device' has received 86% positive answers. Therefore, it could define as a 'True' statement.
- The fifth statement, 'Memory and Capacity of the mobile device is satisfactory' has received 65% positive answers. Therefore, it could define as a 'True' statement.
- 50% positive answers, 39% negative answers, and 11% neutral answers have been received for the sixth statement, 'Battery life of the mobile device is satisfactory'. Therefore, this statement couldn't accept as a 100% true statement.
- 50% positive answers have been received for the seventh statement, 'It is safe to use a mobile device at work'. However, 35% negative answers and 15% neutral answers also have been received for this statement. Therefore, this statement also couldn't accept as a 100% true statement.

5.7. Recommended applications for the CPM sector

As mentioned earlier, primary data collected for this study is limited to selected professionals engaged in the CPM sector, listed CPM apps, and listed advantages and weaknesses. Also, more than 50% of the participants were engineers. Therefore results of this study could apply directly to the engineers who are engaged in the CPM sector.

Following recommendations have been made for applying to the CPM sector based on the outcomes of the study;

- Project managers should be keen to select beneficial CPM apps from each subcategory to apply for their project works.
- Proper guidance should be given to the professionals to apply those selected CPM apps.
- All required facilities to use mobile phone technology including smart mobile devices, internet connections, etc. should be provided to use CPM apps and some barriers should be made for distracting apps such as social media apps during working hours.
- Project managers should be keen to collect ubiquitous data using CPM apps for decision-making.
- Precautions should be made to avoid safety hazards due to distractions while using mobile devices.

5.8. Recommendations for future studies

The construction and Project Management field is one of the most competitive industries due to the limitation of time and resources. Therefore, as the dedicated professionals engaged in this field engineers are responsible to manage their resources effectively and proceed their work efficiently. Therefore, studies in this area need to be expanded to explore more effective and efficient ways to achieve the targets in the CPM sector.

The mobile phone industry is one of the fast-growing industries. The manufacturers attempt to fulfill all human needs up grading the technology. The introduction of smartphones is one of them. Smart mobile phone users could access different tasks using different mobile phone apps from the same device at the same time without moving.

According to this study, it was found that the majority of the CPM professionals are not aware and not using mobile phones for their work in beneficial ways. However, many foreign countries have tended to apply mobile devices to the CPM industry. Therefore, it would be

more useful if the study area is expanded to analyze the beneficial ways of using mobile phones for the CPM sector taking examples from foreign countries.

As an expansion to this study, it can be extended to study the pros and cons of different mobile phone app categories. Also, it can be expanded to analyze the effectiveness of using those mobile phone apps. The findings of this study would be used as a baseline for further studies relevant to this research area.

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ANNEXURES

Annexure 1 : Request to fill Questionnaire and Format used for the survey published on www.freeonlinesurveys.com

Request to fill the questionnaire and help Inbox x

 **Madhubhashini Amila** <amilamadh@gmail.com> Mar 9, 2021, 4:32 PM ☆ ↶ ⋮

to L.A.Nimal, Hanseka, Nabris, K.K.D.M.P.K., Pushpa, Imasha, N.Y., H.M.U, manjula, Sentahan, Sainthan, Pavithra, Salika, Gihan, U.J., Amila, Niroshan, U.S.Viyana, G.I., Kassapa, Malshan, G.A.D., M.S., Sarany

Dear Sir /Madam /My friends,
I am Amila Madhubhashini, following MSc in Construction Project management, Faculty of Engineering, University of Moratuwa.

I am researching on "Mobile phone technology applications for Construction and Project Management in Sri Lanka" as my MSc research project.

I would be grateful if you could spend a little time filling my questionnaire.
The responses collected are completely anonymous and will be used only for research purposes.

Please share this questionnaire with your friends who are involved in civil engineering field and help me.

you can access to my questionnaire using following link;
<https://freeonlinesurveys.com/s/9fz3eY0C>

thank you.

--
With Best Regards
Amila Madhubhashini,
(Bsc Eng AMIESL)
Civil Engineer,
SLLR&DC.

 **Department of Civil Engineering**
University of Moratuwa

Page 1

Section 01 : Demographic Information

1) Gender

☐ A Male ☒ B Female

2) Age

☐ A below 30 ☐ B 30-40 ☐ C 40-50
☐ D above 50

3) Working place

☐ A Colombo district ☐ B Western Province ☒ C Other

4) Job sector

☐ A Public ☐ B Semi government ☐ C Private
☐ D Other

 Done
 Done
press ENTER

5) Job title

A	Manager	B	Engineer	C	Architect
D	Engineering Assistant / Foreman	E	Quantity Surveyor	F	Supervisor
G	Other				

6) Educational Qualifications

A	MSc	B	BSc	C	Diploma
D	Technical College	E	Advanced Level	F	Other

Done
press ENTER

7) Field

A	Construction/ site	B	Project Management/ Office
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8) Working Experience

A	Less than 5 years	B	6-10	C	11-15
D	16-20	E	21-25	F	over 26

Done
press ENTER

Next Page



Page 2

Section 02 : Awareness on project management apps

9) Do you use a mobile phone ?

☒ A Yes ☐ B No

Note : If your answer is 'No' for above question you can finish the questionnaire by here leaving blank for balance questions.

Done
press ENTER

10) Do your mobile phone has internet facility ?

☐ A Yes ☐ B No ☐ C Not sure

Note : If your answer is 'No' or 'Not Sure' for above question you can finish the questionnaire by leaving blank for balance questions.

11) Approximate average time spend on using mobile phone internet per day Less than 15 mins

☒ A Less than 15 mins ☐ B 15-30 mins ☐ C More than 30 mins

Done
press ENTER

12) Do you understand term 'mobile phone app'?

☐ A Yes ☐ B No ☐ C Not Sure

Note : If your answer is 'No' or 'Not Sure' for above question you can finish the questionnaire by leaving blank for balance questions.

13) Approximate average time spend per day on social media apps installed in mobile phone Ex : Facebook ,
Skype, viber, WhatsApp, YouTube, tiktok etc.

☐ A Less than 15 mins ☐ B 15-30 mins ☐ C More than 30 mins

14) Do you aware about mobile phone Apps designed to use for construction and project management sector?

☒ A Yes ☐ B No ☐ C Not sure

Done
press ENTER

15) Do you use any mobile phone App related to construction and project management sector ?

☐ A Yes ☐ B No ☐ C Not Sure

Note : Please do not edit you're your opinion on above question after completing the balance questions.



Page 3

Section 03 : Project management apps usage

16) What kind of application used in your mobile phone / Tablet

- A Apple app store B Android Play store C Other

Note : If your answer is 'Apple app store' or 'Other' for above question you can finish the questionnaire here by leaving blank for balance questions.

Done
press ENTER

17) Mark mobile phone apps related to documenting if you are using

A  Microsoft Word

B  Microsoft Excel

C  Microsoft Powerpoint

D  Adobe Acrobat Reader

Done
press ENTER

Other (Please Specify)

18) Mark mobile phone apps related to Drawing/3D visualization if you are using

A  Autocad DWG

B  A360-View CAD

C  BIM 360

Other (Please Specify)

19) Mark mobile phone apps related to R/F Design / Concrete design if you are using

A  ETABS

B  SAP 2000

C  CSISteel

Other (Please Specify)

20) Mark mobile phone apps related to Estimate/Quantity / Level / Calculation / Measurement if you are using

A  Construction Calculator	B  Spirit Level	C  My Measures
D  Construction Estimate		

Other (Please Specify)

Done
press ENTER

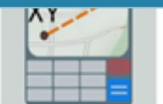
21) Mark mobile phone apps related to Construction Management if you are using

A  Construction Manager	B  Fieldwire Construction Management & Punch list
--	--

Other (Please Specify)

Done

22) Mark mobile phone apps related to survey if you are using

A  Surveying & Leveling Civil Notes	B  Surveying Calculator
--	--

Other (Please Specify)

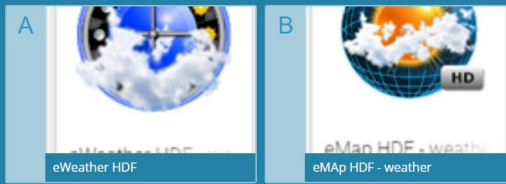
23) Mark mobile phone apps related to progress if you are using

A  Progress of Project	B  Track My Progress
---	---

Other (Please Specify)

Done

24) Mark mobile phone apps related to weather if you are using



Other (Please Specify)

25) Mark mobile phone apps related to safety if you are using



Other (Please Specify)



Page 4

Section 04 : Strengths and Weaknesses of project management apps
Please mark your opinion about following statements.

26) Using mobile phone apps helps to make work more effective / Time saving

☒ A Agree ☐ B Disagree ☐ C Not Sure

Done
press ENTER

27) Most of the apps are designed to be used as user-friendly

☐ A Agree ☐ B Disagree ☐ C Not Sure

28) Mobile phone device / Tab is convenient to be used in any location

☒ A Agree ☐ B Disagree ☐ C Not Sure

Done
press ENTER

29) It is convenient to connect to the internet via a mobile device

☐ A Agree ☐ B Disagree ☐ C Not sure

30) Memory and Capacity of mobile device is satisfactory

☐ A Agree ☐ B Disagree ☐ C Not Sure

31) Battery life of mobile device is satisfactory

☐ A Agree ☐ B Disagree ☐ C Not Sure

32) It is safe to use a mobile device during at work

☐ A Agree ☒ B Disagree ☐ C Not Sure

Done
press ENTER

Previous Page

Finish Survey

Annexure 2: Table of Coded Responds received

[illegible]