CURRENT STATE OF PRACTICE FOR CONDITION ASSESSMENT METHODS AND THE FACILITY CONDITION INDEX AS A MEASURE

by

Pauline Wanjiku Karanja

A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Master of Science in
Construction and Facilities Management

Charlotte

2017

Approved by:

_____
Dr. Glenda Mayo

_____
Dr. John Hildreth

_____
Dr. Jake Smithwick

ABSTRACT

PAULINE WANJIKU KARANJA. Current state of practice for condition assessment methods and the facility condition index as a measure. (Under the direction of DR. GLENDA MAYO)

Buildings deteriorate for various reasons which include age, overcapacity, and lack of planning and preventative maintenance. Facility Condition Assessments (FCAs) are used to measure this deterioration with the aim of collecting data to determine the requirement and timing of preventative or remedial action to assess and maintain the desired level of service (Lee and Aktan, 1997). Maintaining a building is vital to keep it performing and functioning throughout its lifecycle but sometimes may not occur due to lack of funds or mismanagement. FCAs are resource intensive, subjective, time-consuming, and costly, however, the importance of the FCA in the asset management process is integral to the overall performance of buildings. Utilizing the Delphi Technique, the research aimed at identifying the current state of practice in the industry with regards to the data collected and analyzed during the FCA process, in comparison to what the literature states should be practice. Additionally, the research explored the Facilities Condition Index (FCI) as a metric to identify its computation and use in the asset management process. The assessment of the current standard of practice revealed that there is currently no established assessment methodology for data collection and the lack of proper categorization of the assets within a building hampers the frequent and widespread use of specific performance metrics within the industry. The FCI is a generalized metric and an industry preferred metric that quantifies levels of condition across a Facility. However, its computation differs from organization to organization

rendering the reporting inconsistent, especially when FCAs are carried out by different consulting firms on the same campus. Respondents in the survey were in agreement that the FCI is therefore not a realistic benchmarking tool. This research is significant in that it highlights the gaps in the industry and creates a foundation for future research which may begin the exploration of setting acceptable levels of achievement or standards. Future standards will aid facility managers and building owners with applications for standard FCA procedures. The study also sets a basis for exploration of setting a standard formula for the FCI to facilitate benchmarking. It is through benchmarking that best practices can be realized which then facilitate continuous improvement.

ACKNOWLEDGMENTS

I would like to convey my heartfelt appreciation and gratitude to my Advisor, Dr. Glenda Mayo whose academic support and assistance throughout the development and writing of this thesis were insurmountable. I would also like to acknowledge my thesis committee, Dr. John Hildreth and Dr. Jake Smithwick for their academic support. I would like to appreciate APPA, thanking Mr. Steve Glezner for assigning a mentor to the research and giving contact details of some of APPA's members. I would like to extend my gratitude to Mr. Harvey Kaiser whose experienced eye and guidance were far reaching in ensuring that the results garnered were true and valid. I owe a great gratitude to all the respondents and their organizations for their support throughout this process without which the quality of the results of this research would have been compromised. I would also like to thank my family for their support during the research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

APPA	Association of Higher Education Facilities Officers
BSC	Balanced Scorecard
CR	Capital Renewal
CRV	Current Replacement Value
CAFM	Computer Aided Facilities Management
DM	Deferred Maintenance
FM	Facilities Management
FCA	Facility Condition Assessment
FCI	Facility Condition Index
FCAP	Facility Condition Assessment Program
IFMA	International Facilities Management Association
KPI	Key Performance Indicator
NACUBO	National Association of College and University Business Officers

CHAPTER 1: INTRODUCTION

PURPOSE OF STUDY

Notwithstanding their great cultural, economic, and historical importance, studies have shown that a large percentage of buildings in America are deteriorating rapidly due to age and over capacity (Hunter, 2009). Facility Condition Assessments (FCAs) are used to measure this deterioration with the aim of collecting data to determine the need and timing of the predictive, preventative or remedial action, to assess and maintain the desired level of service (Lee and Atkan, 1997).

The FCA provides a snapshot of the condition of a facility to define capital budget needs for major repairs and replacements over a specific timeframe. The FCA therefore helps facility management teams to prioritize funds for repair and replacement. In general, an FCA is an assessment that identifies major deficiencies for all of the systems in a facility. The systems included in an FCA may comprise of: on-site systems, mechanical systems, building exteriors, structural assemblies, roof systems, fire and life safety systems, electrical systems, conveying systems, interior finishes and plumbing systems. FCAs are occasionally extended to fixtures, equipment (FFE), and furniture.

There are many approaches to performing an FCA. FCAs can be performed at the component level, where every major piece of equipment is evaluated and the value and remaining service life of the equipment appraised (Uzarski et al., 2007). FCAs can also be performed at a system level, where the emphasis is put on assigning a value and

condition to the system, instead of assigning a value to its assortment of components. There are also statistical approaches such as parametric methods to FCAs where data is collected on a portion of an organization's assets and the results extrapolated over the entire inventory of facilities (Council of Great City Schools, 2014).

Once the Facility Condition Assessment survey has been carried out, the data provided by this process is analyzed and translated into a condition value or an index coined the Facility Condition Index (FCI). This is considered a standard tool in Facilities Management (FM) and is used to compare the condition of facilities and determine whether it is economical to fully modernize an existing facility or replace it (NCES 2003 b).

As a standard, the FCI is calculated by the ratio between the cost of correcting deficiencies (or deferred maintenance) to the facilities' current replacement value (CRV). The calculation of the FCI however varies from institution to institution, as well as from consultancy firm to consultancy firm (Clayton, 2013). The scale of measurement also varies making the FCI less reliable as a benchmarking tool, where comparisons are made between facilities owned by different entities or facilities within the same campus settings, whose FCA has been carried out by different consultants using different formulae to calculate FCI.

Overall, maintaining a building is essential to keep it performing and functioning throughout its lifecycle. Lack of funds and mismanagement are the main reasons for the unsatisfactory performance of building facilities (Ahluwalia, 2008; Ewada, et al., 2015). This is particularly true when capital renewal programs are downsized to save money thus hindering the proper inspection of buildings and the allocation of renewal funds.

Also, FCAs are resource intensive, subjective, time-consuming, and costly (Ewada, et al., 2015).

Notwithstanding all these hindrances, the importance of the FCA stage in the asset management process is integral to the overall performance of buildings. A review of the current standard of practice for FCAs revealed that there is presently no established review methodology and the lack of this proper standardization hampers the frequent and widespread use of performance metrics for measuring and evaluating performance within the industry. Therefore, there is an industry need to identify the current state of practice with regards to methods for data collection and analysis during the FCA process. Additionally, this research also aimed at considering the FCI as a metric and to identify its computation and use in the asset management process.

As a result of the research, the recommendation for future research is to begin the exploration of setting not only a standard, but also acceptable levels of achievement. To aid Facility Managers and building owners, a systematic process and standard FCA procedures will allow for internal comparisons as well as benchmarking methods with other owners.

CONTEXT OF STUDY

There are currently minimal standards in the industry for carrying out FCAs, the analysis process, and reporting the results. This is especially true with regards to the use of specific metrics like the FCI, and benchmarks for planning purposes. Metrics represent indicators that can be used for genuine comparison within and between institutions. They provide an essential common platform for comparison, based on which improvements can be sought for any individual index. Metrics not only facilitate the understanding of

driving forces of a building's performance but also support owners in efficiently operating buildings (Lavy et al., 2014).

Most institutions have significant maintenance backlogs and carry out FCAs to get an understanding of the extent of their deferred maintenance backlog (Teicholz, 2001; Lavy et al., 2010). Many owners use FCA templates generated within the organization (internal FCA) or, look externally towards consultancy firms (external FCA). If the building portfolio is large, the institution will often engage multiple consultants to perform the FCA (Teicholz, 2001) or otherwise carry out part of the FCA and engage consultants in carrying out the other part of the FCA process (hybrid FCA) (Clayton, 2013). The FCA reports provide findings consisting of deficiencies and correction data to aid the institution in prioritizing issues and helping determine deferred maintenance budgets.

There are limitations to this approach, the first of which being that for large portfolios, control of quality is a problem since data collection is often inconsistent between consultants and institutions. Due to the irregular manner in which the FCI is calculated, benchmarking then becomes a challenge. There is, therefore, need to research the reason why FCAs are carried out and reports prepared, because often there is still backlog due to deferred maintenance. Initial questions in the research included: Are the methods and metrics standard? Are the consultants and institutions measuring the same things and for the same purpose? Figure 1 highlights the categorical breakdown of this study.

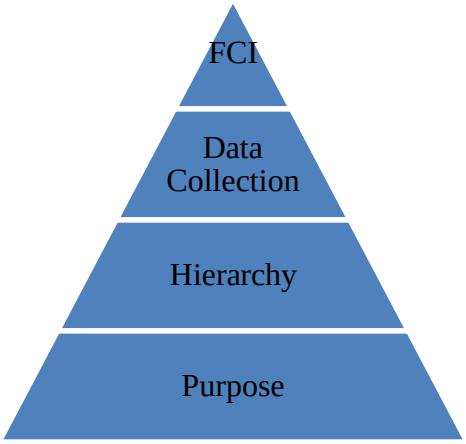

Figure 1: Research Breakdown

There has been no quantitative research exploring what institutions are measuring once FCA data is collected, and what institutions do with the reports prepared and presented following the analysis of the FCAs. Consequently, there is need to consider the concept of taking the different methods used during FCAs and the FCI computation used by different institutions as a current state of practice, and investigating their application in FM. Additionally, there is also need to investigate whether key performance indicators (KPIs) used as measurement tools (through the development of metrics) are applied and tied to a balanced scorecard (BSC) (Teicholz, 2001).

To clarify the terms used in industry and for this research, a metric is a method of measuring FCAs or the results obtained from the FCA process. Metrics are standards of measurement by which building performance following an FCA can be assessed. Indexes are indicators which serve as benchmarks for measuring changes in levels of data collected following an FCA, a good example of this being the FCI. APPA (Association of Higher Education Facilities Officers) have provided the set of ratings for the FCI thus: good (under 0.05), fair (0.05 to 0.10), and poor (over 0.10). A metric is, therefore, a

number giving the magnitude of a measure (metric) in terms of standards during the analysis and preparation of a report following an FCA. Table 6 shows a proposed list of metrics and indexes that can be used in an FCA report.

One of the greatest obstacles to the development of an efficient condition assessment process is the subjectivity and ensuing lack of accuracy. Traditionally, a condition assessment for a building is performed through visual inspection by experts in specific building systems, e.g., architectural, structural, electrical, and mechanical. While many asset management systems incorporate some measures to ensure uniformity such as staff training and the use of a numerically based rating system, the current condition assessment process is nevertheless highly subjective, and its accuracy is highly dependent on the experience and training of the field inspectors and assessors.

PROBLEM STATEMENT

An assessment of the current standard of practice through the review of the literature reveals that there is currently no established Facility Condition Assessment methodology. The lack of this proper standardization hampers the frequent and widespread use of reporting metrics within the industry. Generalized metrics, such as the Facility Condition Index (FCI) are used but are not always calculated in a consistent manner between institutions and industries. Additionally, different means of quantifying the levels of condition (metrics - FCI) may also vary, and therefore reporting is inconsistent.

RESEARCH GOALS AND OBJECTIVES

This research utilized the Delphi methodology to identify the reporting metrics used by institutions i.e. the current state of practice within the industry regarding data collected during an FCA. This includes identifying what the industry is currently reporting, why it

is reporting specific information and how this information is used. Also, the research objective included a review of how often FCAs are conducted and how these FCAs are carried out since the FCA audit/survey methodology affects the metrics directly. It also aimed at identifying whether there is consistency in the way that the FCI (used to measure the condition of buildings) is calculated and additionally, its benefits and limitations. This was achieved through a comparison of the literature reviewed and an expert panel who took part in the Delphi Technique. The research also aimed at identifying what industry experts state may help to improve the current levels of practice as a guide for FM.

The research aimed at identifying and documenting the gaps between current practice and what literature states should be practice. This information was garnered through comparing the review of the literature and the information obtained from the analyzed data as collected.

SIGNIFICANCE OF STUDY

To improve the asset management process, FCAs must be carried out in a standard and systematic manner and likewise, the reporting carried out using standard metrics that can be benchmarked to improve the projection of repair, renewal, or replacement needs. The research explored current practices with the aim of assisting Facility Managers and building owners with the best tools to make appropriate funding and maintenance decisions. As a result of this study, future research may begin the exploration of setting acceptable levels of achievement or creating a condition assessment methodology and metrics framework which will aid FMs and building owners to apply and use standardized metrics and indexes in an FCA.

The benefits of this research to the FM community have been corroborated by reviewers and approved as a research project of APPA's Center for Facilities Research (CfAR). This acceptance led to APPA assigning a research mentor, Mr. Harvey Kaiser who is a longtime consultant, educator, researcher, author, and presenter. He has written for the Association of Governing Boards, the National Association of College and University Business Officers (NACUBO) and the Society for College and University Planning. For APPA, Mr. Kaiser has written books such as "Mortgaging the Future"; "The Facilities Audit Workbook" (later revised as The Facilities Audit); "A Foundation to Uphold: A Study of Facilities Conditions at U.S. Colleges and Universities"; and, most recently, with Eva Klein, "Strategic Capital Development: The New Model for Campus Investment". Also, Harvey was a longtime faculty member at APPA's Institute for Facilities Management and is the author of the Facility Condition Assessment chapter in APPA's online BOK (Body of Knowledge).

Mr. Kaisers' response to being assigned as a mentor to the project and following personal communication with him, was as follows:

"Obviously, it attracted my interest because of my ongoing involvement in developing methodologies, evaluating results, and consulting and writing about it. Canvas an array of institutions prepared to discuss their in-house methodologies, deliverables, and outcomes"

The APPA reviews that led to the acceptance of the research are highlighted below as follows:

Reviewer #1:

"I think the research could be valuable if done objectively and thoroughly…There are several consulting firms that do FCAs and have their

proprietary software. I'm sure you are aware of VFA, AME, FEA, ISES, Jacobs, EMG, Atkins (Faithful+Gould), Parsons, and more. So bottom line, I think it could be valuable research but needs to be done with care, objectiveness, and broad perspective".

Reviewer #2:

"This could prove to produce some very beneficial research, and the research should transcend proprietary approaches. Comprehensive physical condition assessments rarely seem to be acted upon in a grand enough to scale to warrant the investment it takes to produce them. I am more inclined to use modeling to gets you close and then when within your planning window, let's say five years, look at the what the model predicts is coming due and physically condition-assess those areas to determine if the model is spot on, or if you need to invest sooner. Or conversely, it could push the renewal investment further out".

DELIMITATIONS

1. This study concentrated on the current state of practice in as far as FCAs and the FCI are concerned. It aimed at identifying whether, as stated in the literature, there are indeed no standards in as far as carrying out and reporting FCAs is concerned, as well as the role the FCI plays.
2. The focus of this study was concerned mainly with how FCAs are carried out and reported, and how the FCI is calculated.
3. The study also focused on FCAs at the facility level, and not at the component level. The results of the study can however be implemented at the component level and any other FCA stage since it is the condition assessment of these individual components that make up the condition of the entire Facility.
4. The questions raised in the questionnaire were fact-finding in nature and purpose, focusing on what industry is currently undertaking. It did not include questions projecting what the industry should be doing, but instead attempted to find consensus regarding the current best practices.

DEFINITION OF TERMS

Alteration is work required to adjust interior arrangements or other physical characteristics of an existing facility for it to be more effectively adapted to or utilized for a new or changes in use.

Area/Gross Square Footage (GSF) is the sum of the floor areas on all levels of a building that are totally enclosed within a building. (Source: ASTM E 1836-01)

Capital Renewal (CR)/Replacement is the process of planning and budgeting for known future repair and replacement (cyclical) requirements that extend the life of facilities and systems. It is not normally contained in the annual operating budget. Costs are estimated by a current replacement value (CRV) that should be derived from industry standard cost database (e.g. RSMeans).

Churn Rate is the total number of moves made within a 12-month period divided by the number of occupants during the same period. (Source: Project Management Benchmarks, IFMA © 2002). Churn rate is an important metric because it involves change of the workspace. This may include installation of new equipment, reorganization of spaces and changes to the structure of the facility which costs money. This will affect the calculation of other metrics such as the FCI.

Current Replacement Value (CRV) is “the total expenditure in current dollars required to replace any facility at the institution, inclusive of construction costs, design costs, project management costs and project administrative costs” (Source, IFMA © 2002).

Facility Operating Current Replacement Value (CRV) Index is an indicator that represents the level of capital provided for the responsibility of an organization's capital assets.

Deferred Maintenance (DM) is the total dollar amount of the existing maintenance repairs and replacements (capital renewal), which were not accomplished when they should have been, not funded in the current fiscal year or otherwise delayed to the future.

Deficiency is any problem or defect with materials or equipment. It is characteristically in terms of dollar amount, and associated physical requirements, between an assets' current physical or functional condition and an established minimum level of condition or performance.

Facility Condition Assessment Program (FCAP)/Facility Capital Planning and Management Program is a continuous and systematic methodology for "identifying, assessing, prioritizing, and maintaining the specific maintenance, repair, renewal, and replacement requirements for all facility assets to provide valid documentation, reporting mechanisms, and budgetary information in a detailed database of facility issues" (Source, APPA Glossary).

CHAPTER 2: LITERATURE REVIEW

INTRODUCTION

A Facility Condition Assessment (FCA) is defined by Rugless (1993) as "a process of systematically evaluating an organization's capital assets to project repair, renewal, or replacement needs that will preserve their ability to support the mission or activities they are assigned to serve". The FCA is the most important function in the asset management process as it forms the basis of, or the starting point for, other functions such as the decisions to repair or replace.

BACKGROUND

As far back as the late 1970s, signs of an ailing infrastructure in America caught the attention of the media and the public. America in Ruins: The Decaying Infrastructure by Choate and Walter (1981) brought attention to the consequences of infrastructure on the loss of lives and property. Users, investors, and public officials became concerned after hearing of the critical incidents involving the collapse and failure of infrastructure components. Public awareness of these incidents and identification of potential failure areas led to a perception of an infrastructure crisis (Hudson et al., 1997). Bridge inspection was however ahead of its time. In April 1971, standards for developing a bridge-inspection program were issued in the United States (Infrastructure, 1992). Since then, bridge management systems and inspection programs have continually improved. This response was, however, because of the collapse of the 39-year-old Silver Bridge in

West Virginia in 1967, resulting in 46 lost lives and a great deal of property damage (Hudson et al., 1997). The history of collapsed infrastructure has provided strong motivation for research and for governments to invest money, time, and effort.

Table 1 provides examples of failures, none of them due to natural disasters such as earthquakes or tornadoes, but rather to other causes, most probably lack of maintenance and repair, inadequate inspection and condition evaluation, insufficient funding, or more generally, inadequate management.

Table 1: Infrastructure Problems/Failures adapted from Ahluwalia (2008)

Year	Infrastructure Crisis	Consequences	Literature Reference
1982	An 80-year-old aqueduct failed in New Jersey, U.S.A.	Three days with no drinking water for 300,000 residents.	Kwiatkowski
1983	A bridge collapsed in Connecticut, U.S.A.	Three killed and three seriously injured	Wagner
2000	A high school gym roof collapsed in Cleveland, U.S.A.	Three students and two adults are injured.	Civil Engineer
2001	A bridge collapsed in northern Portugal	Up to 70 people were feared dead.	Civil Engineer
2002	A school staircase collapsed in north China.	21 teenage students died, and 47 more were injured.	People's Daily
2002	A nine-story apartment building collapsed in St. Petersburg, Russia.	Three killed, and about 430 people left homeless.	Civil Engineer

In the literature, failure has been defined as the inability of a constructed facility or its components to perform as specified in the design and construction requirements.

Failure refers to two conditions: Collapse and Distress (Wardhana and Hadipriono, 2003). A building's collapse occurs when the entire structure or substantial part of it comes down. The structure, therefore, loses its ability to perform its function. Distress refers to the lack of maintenance of a structure or one or more of its component that may or may not result in a collapse (Wardhana and Hadipriono, 2003). The literature points towards inadequate inspection and maintenance of buildings during the operation and maintenance stage of a building's lifecycle as a cause of distress or unserviceability of a structure or, of one or more of its components. Table 2 represents structure failures and provides an indication of the importance of assessments during the service phase. At the time of the study by Wardhana et al., (2003), a total of 177 failures had occurred during the service phase of facilities versus the 47 failures which had occurred during construction. Figure 2 also provides a visual of this importance.

Table 2: Number of failures vs. stage of failure adapted from Wardhana et al., (2003)

Types of Failure	Construction Phase	Service Phase
Distress	1	16
Partial Collapse	35	126
Total Collapse	11	35
TOTAL	47	177

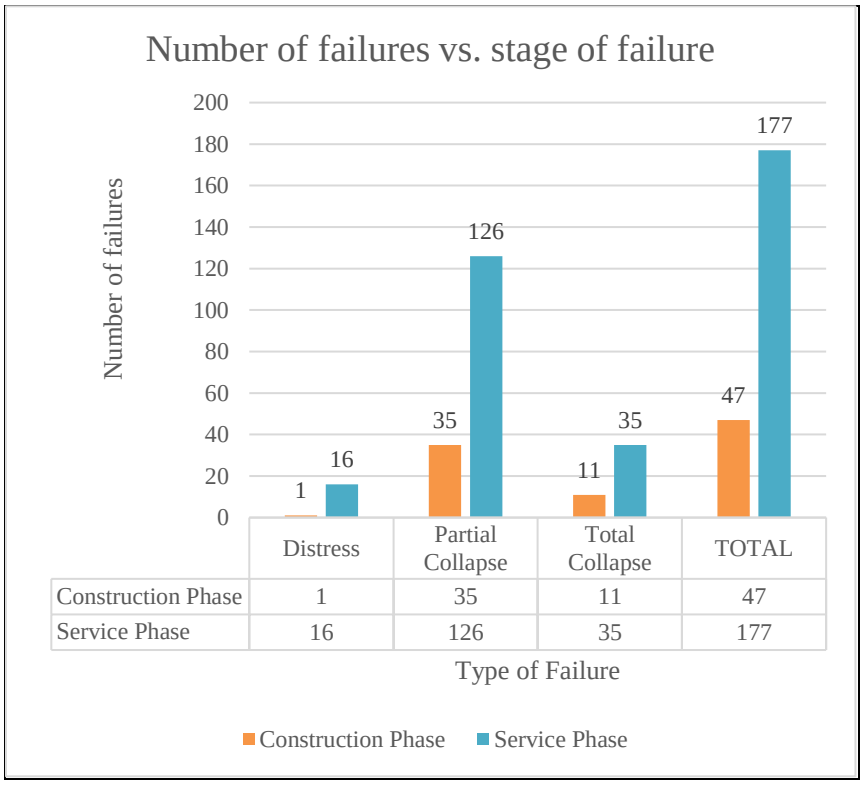

Figure 2: Number of failures against stage of failure

BUILDING MAINTENANCE – CHALLENGES

Building maintenance covers a broad range of activities including inspection, preventive maintenance, repair, and rehabilitation, to preserve an asset in its original condition (Vanier, 2000). Maintenance of buildings is a complex task largely due to the intricacy of buildings and the large number of components that have different maintenance requirements. To demonstrate the complexity of managing building assets, a typical University campus setting can be considered. As an example, a single building may have about 200 components (roof, doors, boilers, HVAC systems, transformers, etc.). Assuming that each component has only three sub-components, the resultant total is about 600 unique components and sub-components. Therefore, to evaluate the condition of this hypothetical university building, 600 discrete components (grouped into 200

categories) need to be inspected, rated, and further analyzed to determine the overall condition (Amani, 2012). Since these 600 components apply to only one building within the University, the degree of complexity is multiplied many times in the case of an entire campus.

Despite huge investments in constructing facilities, the maintenance of buildings has been neglected for a long time due to the scarcity of funds (Teicholz, 1995; Teicholz, 2001; McCall, 1997; Carlson, 2008). As a result, according to De Sitter's Law of Fives, if maintenance is not executed, then repairs equaling five times the maintenance costs are required. Also, if the repairs are not implemented in time, then renewal expenses can reach five times the repair costs (De Sitter, 1984). The result of postponing maintenance activities is the cumulative amount of deferred maintenance (work that has been phased for future action or postponed), leading to a huge backlog. Due to deferred maintenance backlog, there has been a growing awareness worldwide of the importance of building maintenance (Hunter, 2009; Vanier, 2000; Bourke and Davies, 1997; Cane et al., 1998; Amani, 2012; Underwood and Alshawi, 1999).

EDUCATIONAL FACILITY MAINTENANCE - CHALLENGES

Educational facilities pose a challenge because they cover a wide range, from kindergarten schools to large universities. Schools should provide a physical site that is adequate and appropriate for learning (NCES, 2003 a). Therefore, the condition of a school has a direct impact on students' achievement (McCall, 1997). The literature cites numerous instances indicating that students learn better in an environment that is pleasant, safe, and free of health hazards (Earthman et al. 1995; NCES 2003 a). Hinum (1999) emphasizes that poor maintenance increases running costs, such as those for

power, energy, and cleaning. Energy expenditure, for example, can account for more than one-third of premises-related expenditures; reducing energy consumption can, therefore, assist not only in saving money but also in the reduction of carbon dioxide emissions and other forms of pollution (Amani, 2012). Other consequences of poor maintenance include the deterioration of parts of the building leading to an unsafe and unhealthy environment and a lower quality of living.

Currently, the condition of educational buildings in the USA is constantly deteriorating for the following reasons:

I. AGE

The average age of schools in North America is more than 40 years (NCES, 2003 b).

II. EXTERNAL AND INTERNAL CONDITIONS:

A harsh environment is one of the main reasons for the deterioration of most building components. A component's location (e.g., direct or indirect exposure to sunlight) and usage (e.g., actual use as opposed to recommended use), also affects the level of deterioration of building components (NCES, 2003a).

III. ADVANCES IN INFORMATION TECHNOLOGY AND CHURN:

Advancements in information technology with its accompanying fast rate of obsolescence has brought many changes in the field of facility asset management. These technological changes demand upgrades to the current building systems (McCall, 2011). Also, educational facilities are constantly required to deal with change. Facility Managers, therefore, have to deal with office, classroom and laboratory churn i.e. rearranging office, classroom and laboratory spaces to meet changes in space needs (Kaya and Williams, 2005). The inevitable high rate of churn is expected to allow an

institution cope with change and growth. This is, however, costly due to the lack of flexibility in those buildings where the initial designs did not take exponential growth into consideration, as is seen in today's university campuses.

IV. INADEQUATE MAINTENANCE:

Studies have shown that 90% of schools and colleges in most states in the U.S. need to upgrade or repair buildings to good overall condition (GAO, 2015). Given the tremendously insufficient funds for maintenance and repair, this figure represents a major obstacle to achieving the goal of adequate maintenance. Carlson (2008) brings attention to stewardship commitment where funding from donors and legislature to roll out new projects is readily available, whereas access to funding to repair and maintain the very same facilities that are constructed is difficult to come by. The reason for this is highlighted as being a squeeze in the state budgets that public universities and colleges rely on. Universities and colleges have always struggled with deferred maintenance. Colleges grew rapidly in the postwar years and had a generation of the 1960s or 70s buildings that need major repair or replacement. Colleges have gone through another building boom in the last ten years, adding to the square footage they need to support (Carlson, 2008). Many of those new buildings are costlier and more complicated to maintain than buildings of the past.

ASSET MANAGEMENT SYSTEMS

To respond to the challenges in managing and maintaining assets, several asset management systems have been developed with examples being Archibus, IBM Maximo, IBM Tivoli and Tririga. These systems are valuable for tracking the condition of the components and systems in a Facility but are rarely used. However, multiple systems are

problematic in terms of benchmarking for standardization (Mayo and Issa, 2015). As defined by Hudson et al. (1997), an asset management system is an operation package consisting of the methods, procedures, data, software, policies, decisions, which enable the carrying out of all the activities involved in asset management.

According to literature, as shown in Figure 2, the main functions of an asset management system includes:

a. Assessment of the current condition,

b. Prediction of future deterioration,

c. Selection of maintenance and repair strategies,

d. After-repair condition improvement, and

e. Prioritization of building components for repair given the budget constraints.

Of these functions, the FCA is the most important as its results represent the starting point for other functions such as deterioration prediction and repair selection.

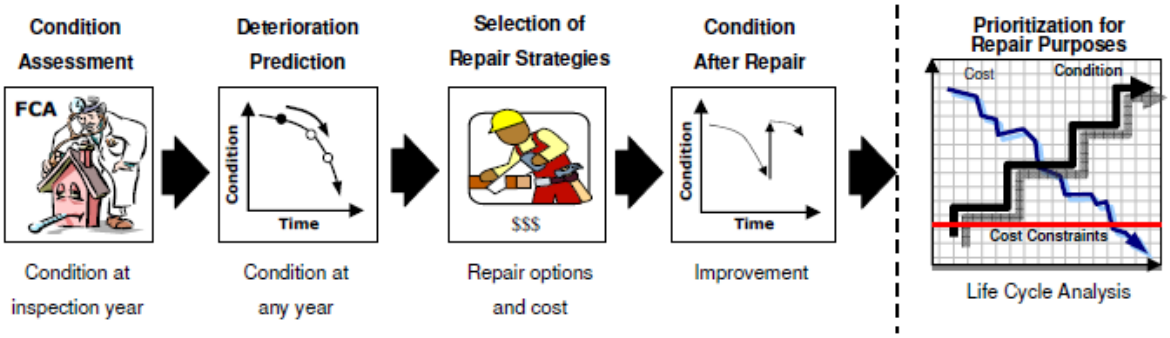

Figure 3: Functions of an Asset Management System adapted from Alhuwalia (2008)

FACILITY CONDITION ASSESSMENT

The FCA is the basis for determining the level of preventive maintenance needed for a building's systems and components (NCES, 2003 b). In literature, condition assessment has been defined in different ways, some of which are tabulated in Table 3.

Table 3: Definitions of Condition Assessment

Reference	Definition
Rugless, 1993	"A process of systematically evaluating an organization's capital assets to project repair, renewal, or replacement needs that will preserve their ability to support the mission or activities they were assigned to serve."
Teicholz, 1995	A service provided by design professionals which included the performance of building audits, primarily for reports of building deficiencies, to raise the building's performance to its original "new potential."
Chouinard, et al. 1996	The evaluation of the condition of the functional system that meets the desired objectives
Fagan and Kirkwood, 1997	An information system customized for the input, storage, manipulation, and reporting of facility-related information
Lewis and Payant, 2000	A process whereby the organization's facility systems, components, and sub-components are evaluated as to their condition
Sadek et al., 2003	A system inventory and inspection to evaluate the current condition of the system based on established measures of the condition
Straub, 2003	A tool for assessing the technical performance of the properties to

	underpin long-term maintenance expectations
NCES, 2003 a (National Centre for Education Statistics)	A data collection process with the goal of conducting a comprehensive inventory that meets the needs of the entire district management effort in a coordinated manner and thereby avoids the need for redundant collection efforts
DfES, 2003 (Department for Education and Skills)	A tool to provide a systematic, uniform and objective basis for getting information on the state of the premises
JCEF, 2004 (Joint Committee for Educational Force)	A state of repair of building infrastructure that takes into consideration all the building systems from roofs to electrical and mechanical systems
Strong 2004	A vehicle for producing a complete inventory of deficiencies in a facility by thoroughly assessing the existing physical conditions and functional performance of buildings, equipment, utilities, and grounds
Kaiser, 2009 (APPA)	"A process of developing a comprehensive picture of physical conditions and the functional performance of buildings and infrastructure; analyzing the results of data collection and observations; and reporting and presenting findings".

The literature suggests that, ideally, a condition assessment must be performed annually (Lewis and Payant, 2000; NCES, 2003 b; DfES, 2003) with the reasoning being that the longer the period between inspections, the more extensive the inspection becomes. FCAs that are performed on a regular basis result in these assessments being less intense and thus easier (NCES, 2003 b). However, a limiting factor when considering

the frequency of condition assessments is the cost involved in the inspection. Information with an appropriate level of detail must be collected during the field inspection. Collecting information that is too detailed and not subsequently used is wasteful. On the other hand, information with insufficient detail also wastes resources. FCAs can be performed by an outside consultant (or contractor) or by in-house staff. In the determination of who performs the assessment process, cost is a major constraint. Smaller institutions may not be able to afford a specialist whereas larger institutions might employ several. It is important, however, that the condition assessment team possess a thorough understanding of facility operations and maintenance and have enough time to perform the task properly.

Literature (Lewis and Payant, 2000; NCES, 2003 b; DfES, 2003) states that all inspection team members be well trained in the inspection procedures and be qualified to conduct the inspection. In addition, NCES (2003 b) states that regardless of the size of the school district and the organizational affiliation of the inspectors, the inspection should be carried out by teams of two or more rather than by an individual (Shahin et al., 1987). The inspector should be accompanied by someone who is intimately familiar with the facility being assessed, e.g., a custodian or maintenance staff member who works in the facility on a regular basis.

Since the 1980s, condition assessment systems have been developed exclusively for individual types of infrastructure assets. For example, PAVER was developed for pavement management (Shahin, 1992), RAILER for railroad tracks (Shahin, 1986), BRIDGER for bridges (NRC, 1998), ROOFER for roofs (Bailey et al. 1989), GRIPPER for underground gas pipes (NRC, 1998), and BUILDER for buildings (Uzarski and

Burley, 1997). RECAPP and TOBUS are also condition assessment tools developed for buildings.

The following is a brief description of some of these systems:

a. BUILDER - was developed by the U.S. Army Corps of Engineers at the Engineering Research and Development Center - Construction Engineering Research Laboratory (ERDC-CERL) in Champaign, Illinois. BUILDER provides engineers and facility managers with a tool that supports decisions regarding where, when, and how best to maintain buildings and their components. BUILDER is a Windows® -based software with functions that include an inventory of major building components; checklist-style, pen-based inspections; condition indexes; functionality ratings; and condition prediction capabilities (BUILDER, 2002). Condition indexes provide a benchmark to compare the relative condition of a group of facilities.

b. RECAPP® (Re-Engineering the Capital Asset Priority Plan) - was initially developed to support data gathering and reporting for audit clients. It includes an inventory of building major components, checklist-style inspections, and condition indexes. It has been used widely for school boards, municipal infrastructure management, and airport authorities (PPTI, 2006; Kaizer, 2014).

c. TOBUS - is the most recent framework developed by the European Commission (D.G. XII) in the JOULE II program. Its condition assessment covers the degree and extent of physical degradation and the work necessary to renovate office buildings (Brandt and Rasmussen, 2002; Kaizer, 2014).

It is recommended that the FCAs are done approximately every three years, or conducting a portion of the overall portfolio annually (Brandt and Rasmussen, 2002). The

FCA identifies existing deficient conditions (requirements), in logical grouping and priorities, and also, associated recommended corrections and corrective costs. Costs are based upon industry standard cost databases (e.g., Building News, Craftsman Book Company, Richardson General Construction Estimating Standard, and RSMeans).

An FCA system is performed primarily to facilitate the ranking or classification of the components of all assets according to the amount of repair required. Four main steps in a detailed condition assessment are discussed.

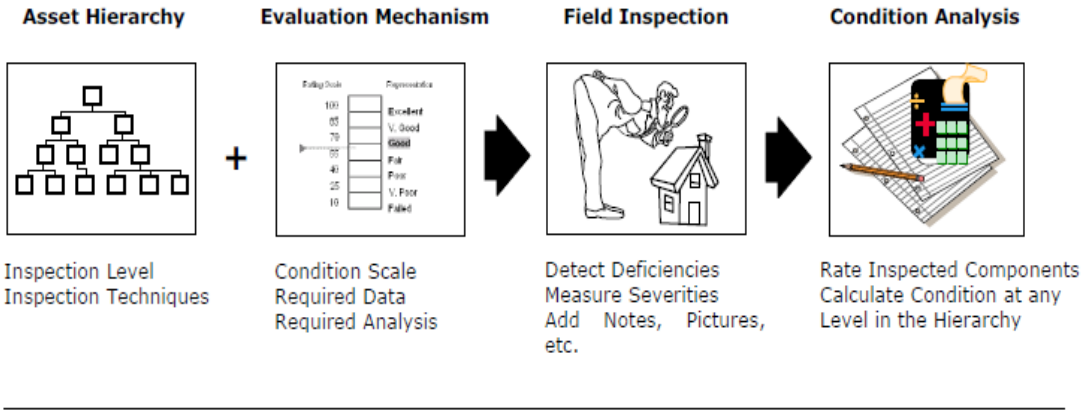

Figure 4: Main Steps in FCA adapted from Lavy et al. (2001)

ASSET HIERARCHY

As an essential step in condition assessment, a building must be hierarchically decomposed into its main components. The hierarchy is intended as a means to classify and cluster these components in different categories. An example is that, a building can be divided into different disciplines or systems (electrical, mechanical, etc.), that can be further divided into the more detailed component level (interior doors/exterior, doors, ceilings, windows, etc.). The combination or grouping of components into a branch in the

hierarchy may be completed to reflect similar characteristics and similar inspection needs (Uzarski and Burley, 1997). A standardized and consistent format for defining a building hierarchy can help in the sharing of data within the FM department of an organization. A study by Elhakeem (2005) combined the benefits of existing hierarchies and suggested a five-level building hierarchy (system, subsystem, component, type/element, and instance) correspond to the Organizational Breakdown Structure (OBS) of educational institutions (e.g. school boards). The main benefits of the proposed hierarchy are to facilitate the process of revising assessed components, to evaluate the performance of each facility in keeping its components in a safe and satisfactory condition, and to permit the organization to allocate funds. Other efforts to establish a hierarchy of building objects have been discussed within the domain of building information modeling and in the proprietary efforts by government agencies to establish asset management systems. One example of information models is the work by Hegazy et al. (2001) that involved the creation of a building project hierarchy (BPH) from a central library of building components. The hierarchy was useful in representing multidisciplinary design data within each building space.

Standardized systems have been established for the categorical organization of data, which include OmniClass, UniFormat and Masterformat, all developed by the Construction Specification Institute (Mayo et al., 2015). Hierarchy has also been addressed in terms of project handover data to the owner by Mayo and Issa (2015) who identified the importance due to the owner's intended ultimate use and retrieval of information. There is, however, no definite recommended standard for use by owners for their data, therefore they most likely do not specify a standard for their FCA structures. However, it can be concluded that

asset hierarchy is an essential part of all condition assessment systems. Irrespective of the type, an ideal building hierarchy should have logical and consistent asset hierarchy breakdown so that a component or some backlog can be quickly and easily tracked. In addition, it should have an appropriate mechanism for calculating condition indices for the building components. Part of the difficulty in the development of a standard for FCA is the formation of hierarchy and organizing assets. The vocabulary used throughout the industry is not consistent. Setting standards to the main terms for asset inventory and management is very important. The words or vocabulary used (acronyms) in for descriptions and categorization of assets is of great importance as well. It should be well defined and a universal standard. An example of such a standard is using CAD standards for abbreviations. However, this standard is primarily for the design industry and thus may not adequately serve the needs of facilities management.

CONDITION ASSESSMENT EVALUATION

The condition of a component can be appraised using either or both of two approaches; a distress survey and a direct condition rating survey (Uzarski, 2002). Uzarski reported the distress survey as an accurate and reproducible approach as a procedure. It provides a record of what needs to be fixed once an inspection is carried out. The direct-condition rating approach is less accurate but much faster, involving a visual inspection of each component and an assessment of that item against a set of criteria. In a later study by Uzarski (2007), the distress survey approach was divided into two groups: distress surveys with or without sampling. Uzarski also suggested that each type of condition survey is better suited for a particular stage in the component's lifecycle, as shown in Figure 4.

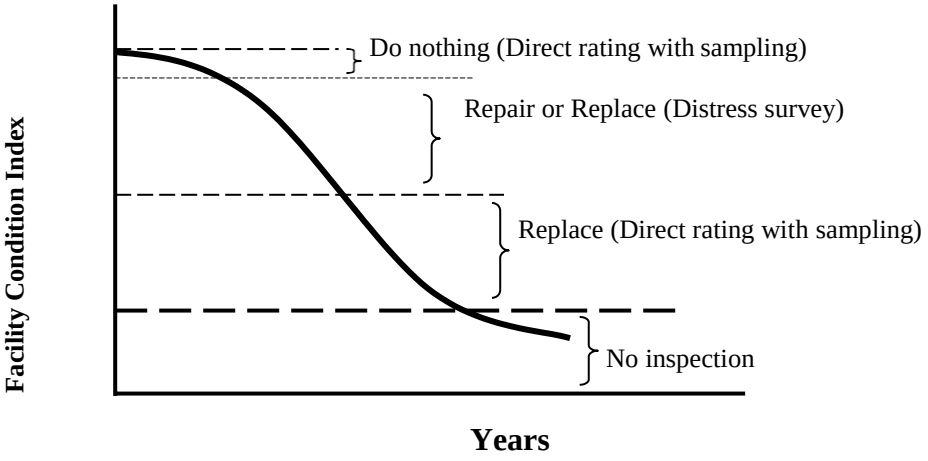

Figure 5: Life cycle repair vs replacement needs adapted from Uzarski (2007)

A decision about the use of a direct rating approach or a distress survey approach requires knowledge of the purpose of the assessment. If the purpose is purely to identify the condition of the component, then the direct condition rating approach is sufficient. However, if the purpose is to identify current problems, then the distress survey approach should be used (Uzarski, 2002). There has been further research directed towards identifying proper evaluation criteria to assess the performance of building components (Ashworth, 1996; Chew and De Silva, 2003), but no solid conclusions have been reached. Regardless of the criteria used and their level of detail, the results of the assessment process, therefore, depends on the accuracy of the individual field inspection process. Existing systems require an experienced inspector to judge the condition of an asset during the inspection process itself. Such inspectors are therefore very costly and require extensive time to carry out these inspections.

In any system, the values of the condition indexes provide the means of comparing the condition of various components. The condition index (CI) scale for building components is usually from 0 to 100, where 0 represents a critical or failure condition and 100 represents mint or new condition. No matter which numeric scale is used, a linguistic representation can be derived from the numeric values (Uzarski and Burley, 1997). Other examples of condition scales and corresponding linguistic representations are listed in Table 4.

Table 4: Rating Scales and Representations

Reference	Asset Type	Condition Scale	Representation
Lee and Aktan, 1997	Buildings	1 – 4	Deterioration: (1 = no, 2 = slight, 3 = moderate, and 4 = severe)
Elhakeem and Hegazy, 2005	Buildings	0 – 100	Deterioration: (0 - 20) = no, (20 - 40) = slight, (40 - 60) = moderate, (60 - 80) = severe, and (80 - 100) = critical
Lounis et al., 1998	Any Asset	1-7	Condition category (1 = failed, 2 = very poor, 3 = poor, 4 = fair, 5 = good, 6 = very good, and 7 = excellent)
NCES 2003 b, (National Centre for Education Statistics)	Buildings	1-8	Condition category (1 = excellent, 2 = good, 3 = adequate, 4 = fair, 5 = poor, 6 = non operable, 7 = urgent building condition, 8 = emergency condition)
Teicholz and Edgar, 2001 adapted from NACUBO (National Association of College and University Business Officers)	Buildings	0.05-1.0	Condition category (Under 0.05 = good, 0.05-0.10 = fair, Over 0.10)
WSDOT, 2000	Buildings	1-5	Condition category (1 -2 = meets current standards, 3 – 4 = adequate, 4 – 5 = poor)
DfES 2003, (Department for Education and Skills)	Buildings	A-D	Condition category (grade A = good, grade B = satisfactory, grade C = poor, grade D = bad)

CONDITION SURVEY AND DATA COLLECTION

Appraising the condition of building components using a distress survey requires full knowledge of all possible deficiencies in each component. To correctly detect these distresses and measure their severity, a systematic approach to field inspection is crucial. The main goal of the inspection process is to obtain the data required to measure and calculate performance or to evaluate the condition (calculating a numeric value that reflects a specific condition). The inspection should be performed consistently, accurately, and as objectively as possible. To ensure uniformity in assessment, training for inspectors is recommended. To standardize the process, researchers have developed paper and electronic checklists and deficiency lists for inspection (e.g., RECAPP 2002; BUILDER 2002). Some researchers, on the other hand, try to automate the inspection process using robots, images, satellite technology, automated devices, and smart sensors (Maser et al., 1997). Many programs and techniques developed in the literature can be categorized into four main groups:

a. Visual inspection
b. Photographic and optical methods
c. Non-destructive evaluation methods and
d. Smart sensors.

Table 5: Inspection Techniques Used in the Literature

	Reference	Application Areas	Technique	Equipment	Measurements	Comments
Visual Inspection	Greimann et al., 1997; Uzarski, 2002; Straub, 2003; Strong, 2004; Shohet et al., 2002.	Buildings, Highway, and other structures	Data is recorded on paper or handheld devices	Simple tools, cameras, and subjective observation	Anchorage movements, elevation changes, deflections, misalignment, cracks, dents, and corrosion	Most useful in buildings, however, time-consuming, costly, subjective, labor-intensive, prone to errors
Photographic and Optical	Abraham et al., 1997; Fukuhara et al., 1990; Fundakowski, 1991.	Mostly for Bridges, Highways, and Underground Utilities	Evaluate the condition by analyzing the images	Video/digital / scan cameras, closed-circuit TV, and/or mechanical gyroscope	Roughness, cracks, and damaged area	Minimum disturbance to public, safe for inspectors, fast, and accurate; needs standardization in the area of image resolution

Non-Destructive	Maser and Zarghame, 1997; Heiler et al, 1993; Lee and Chou, 1993, Lo and Choi, 2004; Maser, 1995; Warhus et al., 1995.	Aqueducts; transportation infrastructure; bridges; some building components; etc.	Collect images from various sources to be analyzed	Infrared thermograps, laser, ultrasonic sensors, and ground penetration radar equipment	Hot or wet areas; bridge deck delamination, rebar corrosion, and pavement roughness	Minimum disturbance to public, safe for inspectors, fast, and accurate
Smart Sensors	Kumapley and Beckemeyer, 1997.	Bridges	Measure the deformation and transmit the results continually using sensors	Small self-contained battery powered transducers	Displacements, strains, rotations, and accelerations of key bridge elements	Real-time data collection and processing

Among the various techniques and technologies highlighted, only visual inspection suits the nature of condition assessments for building assets, which have multiple diverse components with different requirements. Visual inspections are defined as “organized and planned visual examinations conducted by technically proficient personnel” (Lewis and Payant, 2000). The result of these surveys is a report that illustrates the deficiencies or problems for the building components and systems of the facility. This report is then used for budgeting and planning. Visual inspection, however, is not easy. It is expensive and time-consuming (Hammad, 2003). Field inspectors must record the condition of every component in the facility using one of the following methods (DfES, 2003):

a. Manual input: This method uses pen and paper for subsequent input into the management program, which is almost invariably some form of computer software. This option, however, is time-consuming and has drawbacks.
b. Tape dictation: Information is recorded in audio format for subsequent program input. This option is fast, but requires practice; otherwise, problems can be encountered because the inspector cannot see, and hence readily check, the data recorded. Tape dictation can also cause difficulties with the occupiers of the buildings. Extraneous noise, either from the occupiers or other factors such as weather or traffic, can corrupt the recording.
c. Tablets, laptops: This method allows direct input to the management program. This option has the advantage of one-step data entry as opposed to two-step process required for the above methods. Literature also shows that facility managers benefit most from computerized maintenance management systems (CMMS) if they

organize the instructions for and scheduling of their inspections in the same system used to organize other types of facility work.

d. Wearable computers: On-site inspection requires assessors to have their hands free most of the time since they need to move continually while taking measurements and notes. Interesting research has been conducted on the use of wearable computers for inspecting bridges (Hammad, 2005).

Irrespective of the method used for recording the condition of the facility, some problems are associated with field inspection. One of the major problems identified in the literature is the subjectivity of the inspector's judgment about the condition of a building component or a system (Kempton et al., 2001). This subjectivity can be due to the inspector's specific individual experience, attitude towards risk, use of "rules of thumb," and biases (Scott and Anumba, 1996; Hogarth 1987).

ANALYSIS OF CONDITION DATA COLLECTED

Data provided presented by the inspection process is in the form of measurements of the severity of the deficiencies of a component meaning therefore that some analysis is required to translate these measurements into a condition value. After the condition of a component is computed, that value can be used to compute the condition at any level in the asset hierarchy (condition aggregation). An index known as the Facility Condition Index (FCI) is calculated for the whole facility. The FCI is considered as a standard tool, which is used by architects, engineers, and facility planners to compare the condition of campus facilities and determine whether it is more economical to modernize fully or to

replace it (NCES, 2003 b). There are, however, several formulae used for calculating this index. One of the FCI equations is calculated as follows (NCES, 2003 a):

$$\text{Facility Condition Index (FCI)} = \frac{\text{Cost to Correct Deficiencies}}{\text{Current Facility Replacement Value}}$$

The cost to correct deficiencies is the estimated total costs to repair all life-cycle, design deficiencies, and maintenance. Replacement value is the cost of replacing an existing structure with a new structure of the same size at the same location. This can be calculated as follows:

Replacement Value = Gross square footage of the existing building multiplied by the estimated cost (per square foot) to design and build a new facility.

A second equation gives a different formula for FCI, and this has been sanctioned by a task force comprised of representatives of APPA (Association of Higher Education Facilities Officers), IFMA (International Facility Management Association), FFC (Federal Facilities Council), NASFA (National Association of State Facilities Administrators and Holder Construction:

$$\text{Facility Condition Index (FCI)} = \frac{\text{Deferred Maintenance + Capital Renewal}}{\text{Current Facility Replacement Value}}$$

In this equation, deferred maintenance is "total dollar amount of existing maintenance, repairs (i.e. work to restore damaged or worn-out facility systems or components to normal operating condition) and required replacements (capital renewal), not accomplished when they should have been, not funded in the current fiscal year or otherwise delayed to the future" (Clayton, 2013). For the calculation of the FCI values in the second equation, deferred maintenance does not include "grandfathered" items (such

as Americans with Disabilities Act compliance, ADA), or programmatic requirements (such as alterations), whereas those in the first equation include these items.

Capital Renewal is an exchange of one facility system or component for another that has the same capacity to perform the same function. This equation can also be translated thus, (Amani, 2012) and was adopted by the Federal Real Property Council:

FCI = (1-$repair needs/$Plant Replacement Value) * 100

The dollar ($) repair need is the amount necessary to ensure that the facility is restored to a condition significantly equivalent to the originally intended and designed capacity, efficiency or capability and Plant Replacement Value is the cost of replacing an existing facility at today's standards.

Clayton (2013) states that close study of these two equations, few of many available FCI equations, makes it readily seeming why the Government Accountability Office (GAO) found that "…condition indexes, which agencies report to Financial Reporting Review Panel (FRRP), cannot be compared across agencies because their repair estimates are not comparable. As a result, these condition indexes cannot be used to understand the relative condition or management of agencies' assets. Thus, they should not be used to inform or prioritize funding decisions between agencies." (GAO, 2015).

Lavy et al. (2014), suggests the development of a replacement efficiency index (REI) which could be used in consolidating capital costs, renewals and replacement expenditure. This metric would compare the actual replacement expenditure against the cost of expired systems in the facility. The authors state that these are indeed KPIs which, if proper mathematical expressions were formulated, would be measured, calculated and analyzed properly. Another less often discussed metric, though of great interest, for

measuring FCAs is the Needs Index introduced to the Facility Management profession by APPA in their 1999 publication of The Strategic Assessment Model. It is stated that the Needs Index illustrates the overall condition assessment where it is a ratio of;

$$\frac{\text{Deferred maintenance + Capital renewal + Renovation/Moderation + Compliance to Regulations}}{\text{Current replacement value}}$$

This representing a holistic performance indicator as a percentage of the entire needs of a facility (Cain et al., 2004).

Table 6 provides a list of building performance measurement metrics identified in the literature as significant.

Table 6: Building Performance Metrics

Metric	Description	Units	Reference
Current Replacement Value (CRV	An estimated cost of restoring the building to its original state and use. This cost is inclusive of costs for architectural and engineering fees, materials, labor, equipment, construction management, and other contingencies	$US	IFMA, 2008
Deferred maintenance, and deferred maintenance backlog	The cost of maintenance of the property, and equipment that is postponed from a facility's operating budget cycle due to financial constraints.	$US	IFMA, 2008
Maintenance Efficiency Indicators (MEI)	Indicates the efficiency with which maintenance activities are implemented	MEI values can be divided into three categories; low, reasonable, and high, based on the actual investment in maintenance, compared to the actual performance of the building	Lavy and Shohet, (2003)
Facility condition index (FCI)	Represented by the ratio between the total cost of deficiencies to the Current Replacement Value, or by the ratio between the costs of Deferred Maintenance to the Current Replacement Value	Percentage of CRV	Teicholz and Evans, (2007)
Capital renewal	The budget required for performing major renovations in the building, its systems, sub-systems and components	$US (or equivalent)	IFMA, (2002)
Churn rate and churn costs	Represents the process of moving a group of employees and equipment within a period (per month or year)	Expressed as percentage of total average employees in a specific period or currency ($US or equivalent)	IFMA, (2002)
Accessibility for physically challenged	Provision for physically challenged and preparedness of facility to accommodate special needs of physically challenged people	Measured by level of accessibility of the facility for physically challenged individuals	Nkala, (2015)

CONCLUSION

Although there are a variety of techniques and technologies that can be applied to perform condition assessment, only visual inspection suits the nature of building assets because of the diversity of the components involved. There is also a lack of standardization in the methods used to carry out the FCAs, measurements used to report the analyzed data and in calculating indexes. In summary, a literature review reveals that the current condition assessment systems suffer from the following drawbacks:

a. Unstructured, time-consuming, and expensive processes: Currently, field inspection of buildings is carried out by experienced and knowledgeable inspectors who perform both the inspection and the analysis on-site, to identify the component's current condition. The time required for inspecting a particular building depends on the level of detail, the size and number of components, the accessibility, and complexity of the facility, resources allocated, and the time available. The inspection process entails a large portion of the expert's time being spent on tasks that do not require their expertise, such as moving from one location to another, taking pictures, and writing notes. The process can also be extremely expensive when the number of facilities is large. For a typical University campus, for example, inspectors must assess each component in every building, which involves a large amount of time and money. The current approach of manually adding/deleting/managing instances of components (e.g., a group of windows, or a single boiler with specific problems) is extremely time-consuming. There is a need to reduce the time required for the inspection process by standardizing the list of components and avoiding the addition or deletion of instances. Further, adding pictures of the inspected components is a

manual process that again takes a great deal of time and is difficult to manage. Therefore, new, fast, affordable, and reliable condition assessment system is needed.

b. Lack of a mechanism for standardizing and prioritizing inspections: No mechanism exists for prioritizing inspection tasks and identifying critical items that need immediate inspection. Also, no mechanism exists for efficiently deploying available inspectors, and minimizing the frequency of inspections.

c. The subjectivity of the assessments: The current condition assessment process is highly subjective in nature because it involves the varied perceptions of the field inspectors. Recent improvements in this area have introduced electronic checklists or deficiency lists. Often, however, to save time, deficiency lists (which need a detailed analysis of their relative weights) are bypassed in favor of using quick subjective assessments. In addition, no support mechanism exists to help the inspector differentiate between assessment categories (good, fair, poor, or critical). Existing systems, therefore, can be described as good databases that provide enough spaces for the addition of pictures and notes during the condition assessment process but do not provide adequate guidance for the performance of correct assessments.

d. Facilities Condition Index: Condition indexes cannot be compared because their repair estimates are not comparable due to a lack of a standard for calculation. It is for this reason that, these condition indexes cannot be used to understand the relative condition or management of assets. It is also indicated that the FCI should be used hand in hand with the Needs Index to provide a fully funded model that takes into consideration the concepts of total cost of ownership and life cycle cost principles

CHAPTER 3: RESEARCH METHODOLOGY

INTRODUCTION

In chapter two, the literature related to the research problem was analyzed in depth to identify the methods used in carrying out an FCA as a data collection exercise, analyzing data and presenting reports, as well as the role played by the FCI as a metric in the FCA analysis and reporting. Both qualitative and quantitative methods were used in the study.

Qualitative research is often criticized for the subjective nature of its data collection and analysis strategies. It is however critical to research where a particular aim of the research is obtaining in-depth data using social interaction (Saunders et. al., 2012).

RESEARCH DESIGN – DELPHI TECHNIQUE

OVERVIEW

The Delphi Methodology was selected for this research to analyze the opinions of the panel of experts. The Delphi Methodology is described as an approach to analyzing a complex problem with the aim of developing possible solutions without attempting to outline a definitive answer and has several fundamental steps (Mayo and Issa, 2015). According to Skulmoski et al. (2007), the Delphi method works best when the goal of the study is to improve the industry's understanding of problems, opportunities, solutions, or to develop forecasts. Using a panel of experts, the Delphi method seeks to gain consensus

through individuals on a specific topic (Whitehead, 2008). It is an iterative group facilitation process carried out in multiple stages, with the process designed to change opinion into group consensus. However, according to Gracht (2012), the absence of consensus or dissension from the perspective of interpreting data is as important as its existence.

The Delphi technique has been in existence since the 1950s and has gone through changes as its use has increased. Each variants' aim has been to improve the procedure as a response to needs and critiques (Passig, 2004). In his review of variations to the classical Delphi, Passig (2004) noted the Imen-Delphi which was developed in the early 1990s to facilitate a discussion between the panel of experts with the aim of giving qualitative feedback in a quantitative way. The Imen-Delphi procedure is designed to guide the panel of experts towards general agreement and future growth. Passig (2004) and Gracht (2012) indicate five agreement types. These are total agreements or consensus, majority, bipolarity, partial agreement or plurality, or total disagreement. The main objective of the Imen-Delphi is therefore to enable the panelists to "establish a future collective mission and to cope with complex problems regarding the future efficiently" (Passig, 2004). This is the procedure selected for this study.

A Delphi survey questionnaire was used to answer questions regarding the FCA and FCI and was divided into categories based on Figure 1. An expert panel made up of professionals engaged in the field of educational facilities management were approached to give opinions on the current state of practice by answering questions highlighted in the questionnaire.

This Delphi study involved a series of rounds of questionnaires, with controlled feedback from participants whose judgments remained anonymous. The stages of the study process included the selection of the expert panel, formulation of the survey questions, generation of statements, reduction and categorization of statements, rating statements and analysis and iteration (Mead and Mosley, 2001).

In the current study, some efforts were made to make the questionnaire simple and yet sufficient to convey the objectives of the study to the panel of managers. Moreover, Corotis et al. (198) and Chan et al. (2001) reported that the principal difficulties were in maintaining the high level of response and in reaching and implementing a consensus. It is very important to keep the whole panel responding to each round of Delphi. Attrition is undesirable, especially for the Delphi technique; but because of the commitment required, there is a relatively high tendency for the respondents to withdraw in the successive rounds of the Delphi (McKenna, 1994 and Chan et al., 2001). The study was undertaken with relative success with a response rate of 81% achieved. The 81% response rate for this study is relatively high and considered to be acceptable for this research.

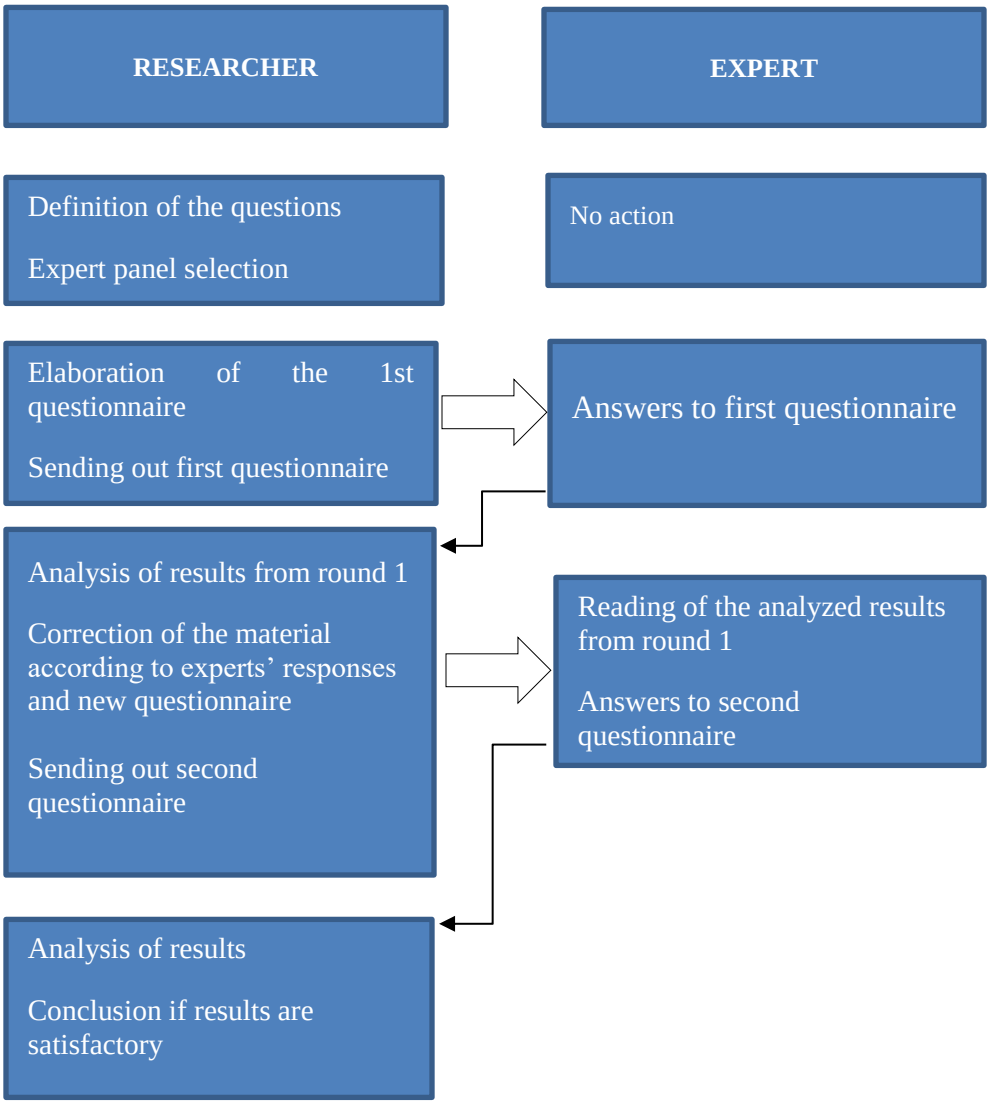

Figure 6: Delphi Technique Strategy for this research

The aim of the rounds in the Delphi technique for this study was to develop four out of the five levels of agreement (Gracht, 2012) methodology as highlighted previously in the list of types of agreements. This was because partial agreement in Gracht's (2012) study focused purely on Round 3 which this study did not. The types of agreement for this study include; consensus, strong agreement, split disagreement (polarity) and total disagreement, thus providing two levels in both the consensus and non-consensus

categories. These levels are beneficial in determining areas for future research. After each round, the data was analyzed and the analyzed results shared with the panel of experts.

Initial analysis of the questions revealed categories from which the questions were grouped. These included the purpose of the FCI, Hierarchy in categorizing assets and components, Data collection in an FCA survey and the FCI. This is displayed in Figure 1.

The list of questions utilized a Likert scale format with several yes/no questions as highlighted in Table 7. Following the first round, these questions were returned to the panel of experts for feedback, confirmation and scoring. The round of questions also included verification of unclear questions as well as a modification to ranking for clarity. Following the brainstorming round and analysis of the answers garnered, some of the questions were re-worded to ensure/enhance clarity as well as include any questions that came up as a result of the comments from the panel of experts. These comments from the panelists were also included in the feedback section.

STEP 1 PARTICIPANT SELECTION CRITERIA

The literature states that in selecting a panel for the Delphi process, criteria establishment is a requirement. Hallowell and Gambatese (2010) list ideal qualifications to include being in active practice with five years of professional experience, chairmanship or membership of a professional body that is recognized nationally, writer/editor of a book, writer of a book chapter, authorship and advanced degrees. Hallowell and Gambatese (2010) state that the panelists should meet four of the qualifications as a minimum while Rogers and Lopez (2002) suggest that the expert panel members meet at least two of the requirements within the field of study under

examination. In this study, panelists were required to meet a minimum of two of these prerequisites.

As mentioned in Chapter 1, FCAs are generally conducted by the FM team employed by the owner, by a consultancy firm or a hybrid of both. It is however not common for the owner to employ a specific FCAP Manager who oversees FCAs full-time and has the expertise meaning therefore the pool to select from on the owner's end was limited, though this group was represented in the study. The experts invited to participate were all involved in the carrying out of FCAs and were deemed experts and selected based on their involvement with both APPA and IFMA. Since this is a study endorsed by APPA, potential participants were referred to the researcher by APPA, while some were approached during the IFMA World Workplace 2016 conference so as to include two primary FM organizations.

STEP 1 PARTICIPANT SELECTION PROCEDURE

Hallowell and Gambatese (2010) suggest that studies have not found a significant correlation between the number of panel members and effectiveness of a Delphi study. They however suggest a minimum of 8 panelists with most studies incorporating between 8 and 16 panelists. A 15 – 20-member panel has also been suggested as being most common (Hsu and Sandford, 2007) as well as a 10 – 15-member panel (Xia and Chan, 2012). Rayens and Hahn (2000) suggest that a typical Delphi study sample size may range from 10 to 30 participants.

The participant selection type was homogenous sampling, where the current occupation of all participants was in FM. A purposive or subjective sample of 16 Facility Management experts both from the owner and consultant end of the business was short-

listed for this study. Solicitation letters were sent out via e-mail in December 2016 and continued until February 2017. A short solicitation survey was prepared highlighting the purpose of the study and requiring the potential panelists to give their names, companies they work for, the state they are in, whether a consultant or owner, years of experience conducting FCAs, professional organization membership and job title. This link was appended in the email sent out through which the potential participants were solicited and a solicitation letter attached to this email. Of the original 16 approached, 13 responded positively (81% response rate) to the initial solicitation letter shown in Appendix A requesting them to participate voluntarily.

The participants were all located in the USA and represented both the owner and consultants. Twelve of the participants (92%) had more than ten years' experience in the FM field. The 13 participants consisted of 4 FM practitioners working for institutes of Higher Education (Owner) and 9 FM consultants. Regarding demographics, the Northwest, South and West regions of the USA were well represented, with no representation from the Midwest. Ethical approval for this study was sought from the Office of Research and Compliance at UNC Charlotte and it was determined that the study did not require Institutional Review Board (IRB) approval.

STEP 2 - ROUND 1

The aim of this round was to begin the process of building consensus among the panelists on questions relating to the FCA and the FCI. These questions covered the purpose of the FCA, hierarchy, data collection and the FCI as a metric. In their article, Hsu and Sandford (2007) mention that it is both acceptable and a common adjustment of the Delphi process format to use a structured questionnaire in Round 1 that is based on an

extensive review of the literature. This is the format selected for this study. The questions utilized were based on information gathered in the literature regarding the methods of conducting FCAs, methods of reporting the data collected and analyzed during and FCA and the metrics used in the report, with special reference to the FCI. This step is deemed "the brainstorming" round where each question had a comments section for the panelists to provide their ideas and remarks based on their experience. It is important to note that all rounds were anonymous, another advantage of the Delphi technique, despite there being the opportunity to give feedback. This reduces the chance of dominant panel members guiding the results through conformance of other panelists, which is experienced in face-to-face focus groups (Xia et al., 2012 and Hsu et al., 2007).

THE QUESTIONNAIRE

The questions in the questionnaire were divided into four categories to address the needs of the study as shown in Figure 1. The first section of Round 1 included three (3) questions concerning the purpose of the condition assessment, the second section included three (3) questions on hierarchy, the third section included five (5) questions on data collection, and the fourth section included six (6) questions on the FCI. These sections are resultant of the emphasis the literature has placed on how important it is to get these right for the FCA to be useful to the entire asset management system and were the tools through which the study would determine was happening in the industry. The panelists were directed to rank the questions raised. The Delphi Survey from Round 1 can be found in Appendix C. In their responses, the panel members were directed to highlight the current practice in their organization. The questionnaires were self-administered online with closed-ended questions, but with the opportunity to make comments in the

comments section for each question. For interpretation of the results, the ranking is highlighted in Table 7. The purpose of the comment sections was to enable feedback which would allow for any clarifications in the question. Table 7 also provides a summary of the questions that were revised to enable better responses to the purpose of the study.

Table 7: Round 1 and Round 2 Ranking

ROUND 1	**ROUND 2**
Q2. Rank the following based on your personal opinion – Likert 5 scale (Definite Agreement to Disagree)	Q3. Rank the following based on your personal opinion – Likert 5 scale (Strong Agreement to Strongly Disagree)
Q3. When assessments are conducted, in what format is the resulting information provided? (Select all that apply and rank the usefulness of that format.) Base your answer on what you think is best not what you typically ask for or provide. Please specify others in the comment section – Likert 3 scale (Best format to Format to avoid)	Q4. How is the FCA report distributed once provided to the owner (with 1 being the most prevalent)? – Ranking 4 scale (1 – 4)
Q4. How is the FCA used once provided to the customer? If you are a consultant provide your best guess as to what you believe is the case – Select all that apply	Q5. How is the FCA report used once provided to the owner? If you are a consultant provide your best guess as to what you believe is the case. – Likert 5 scale (Strongly Agree to Strongly Disagree)
Q5. There generally is a state mandate or a requirement to structure the FCA in a particular format. (If so, provide any pertinent information in the comment section) – Likert 5 scale (Strongly Agree to Strongly Disagree)	Q6. There is generally a state (Government) mandate or requirement to structure the FCA in a particular format for public institutions. (If so, provide any pertinent information in the comment section). – Likert 3 scale (Yes, I'm not sure, No)

Q6. Which of the following formats for categorizing assets are used most often to organize the information in a facility condition assessment. – Likert 5 scale (Always to Never)	Q7. Which of the following formats for categorizing assets are used most often to organize the information in a facility condition assessment. – Likert 5 scale (Always to I'm not sure)
Q7. To obtain a better idea of the overall content for a FCA, which of the following are titled headings in your report? – Select all that apply	Q8. How frequently are the following technologies utilized while conducting facilities condition assessment surveys? – Likert 7 scale (Every time to Never)
Q8. Which of the following tools are used for collecting data during facility condition assessments (Check all that apply) – Select all that apply	Q9. *Note question wording change - Please estimate the time required to carry out an FCA survey from a generalized approximation standpoint for a 35,000 sq. ft. space in a 15 year old building. – 7 item scale (Half a day to More than two weeks)
Q9. Which technologies are utilized while conducting facilities condition assessment surveys? – Select all that apply	Q10. Based on your experience, how often should FCAs be carried out (per facility)? Please rank these in order of importance from 1 to 4 where 1 is the most feasible level of frequency to you and 4 is the least feasible level of frequency to you. – Ranking 4 scale (1 – 4)
Q10. Are facility users consulted during the FCA process in order to identify deficiencies or functional issues of the spaces they occupy? – Yes/No	Q11. The standard formula for the FCI is Deferred Maintenance ($) / Current Replacement Value ($). Which formula does your organization utilize? – Likert 7 scale (Every time to Never)
Q11. Please estimate the time required to carry out an FCA survey from a generalized approximation standpoint. – 7 item scale (Half a day to More than two weeks)	Q12. What do you feel is the best and most appropriate method to calculate the CRV for most owners? – Select one that applies

Q12. How often should FCAs be carried out (per facility)? – Select all that apply	Q13. Rate the following benefits of the FCI based on your personal opinion. – Likert 5 scale (Strong Agreement to Strongly Disagree)
Q13. The standard formula for the FCI is Deferred Maintenance ($) / Current Replacement Value ($). Which formula does your organization utilize? Select all that apply	Q14. Rate the following concerns of the FCI based on your personal opinion. – Likert 5 scale (Strong Agreement to Strongly Disagree)
Q14. The standard formula for calculating Current Replacement Value (CRV) is given as: Gross square footage of the existing building multiplied by the estimated cost (per square foot) to design and build a new facility. Is this the formula adopted by your organization? – Yes/No	
Q15. How is s the CRV calculated? – Select all that apply	
Q16. Rate the following benefits of the FCI based on your personal opinion. – Likert 5 scale (Definite Agreement to Disagree)	
Q17. Rate the following concerns of the FCI based on your personal opinion. – Likert 5 scale (Definite Agreement to Disagree)	

The data provided a quantitative summarization of ordinal values based on answers from each panelist. Before administering the survey, a pilot survey was conducted among four academic colleagues. After obtaining responses to the pilot survey, the questionnaires were revised to correct some of the information in the introduction and the questions section.

STEP 1 – ROUND 2

In the second round, the data analysis was divided into sections similar to those in the first round. The first section included three (3) questions concerning the purpose of the condition assessment, the second section included two (2) questions on hierarchy, the third section included three (3) questions on data collection, and the fourth section included four (4) questions on the FCI. The purpose of Round 2 of the Delphi study was to clarify those questions that were not clear in Round 1 and to also work towards closer consensus on the items that were not in consensus in the first round through changing responses based on the feedback received. The panelists were requested to review Round 1 results before taking Round 2. For interpretation of the results, the ranking is highlighted in Table 7. The data provided a quantitative summarization of ordinal values based on answers from each panelist.

STEP 2 ROUND 2 - DATA ANALYSIS

Data collected was uploaded onto Statistical Package for the Social Science (SPSS) for analysis. The statistical methods used were median, percentage and the interquartile range (IQR) to establish levels of agreement. The IQR assists in understanding the spread of a set of numbers which are organized in ascending order. It is defined as the difference between the upper quartile (the highest 22%) and the lower quartile (the lowest 25%) of a data set. Gracht (2012) recommends the use of the median and interquartile range rather than the mean and standard deviation for the reason that mean is solely valid with interval or ratio data, whereas the Delphi technique utilizes ordinal scales whose intervals or ratio cannot be identified. This is backed by Argyrous (2005) who stresses that the calculation of the mean for ordinal data is not the correct

procedure citing that in group judgments, outliers can skew the mean unrealistically. The debate on the use of the mean for ordinal data remains, but for this research, median to measure central tendency and the IQR to measure dispersion for the median were used to evaluate consensus. Consistent with a study done by Gracht (2012), as a rule of thumb, an IQR of 1 or less is usually found to be a suitable consensus indicator for 4-7 unit Likert scales. Gracht (2012), cites that the IQR is frequently used in Delphi studies and is generally accepted as an objective and rigorous way of determining consensus.

For this study an IQR of 1 or less was found to be a suitable consensus indicator. However, because the IQR method, though rigorous, lacked complexity in separating the degree of agreement (it only indicated that there was either agreement or not), frequency percentages were also utilized to identify the levels of agreement.

There is no universally agreed proportion for the Delphi Survey and the level used will depend on the size of the sample, the aim of the research and resources. Loughlin and Moore (1979) suggested 51% agreement amongst respondents, Sumsion (1998) recommends 70%, while Green *et al.* (1999) opted for 80%. More than 67% on a nominal scale or yes/no responses was considered consensus (Alexandrov et al., 1996 and Pasukevite et al., 2000) while Putnam et al., (1995) opted for more than 80% on a 5-point Likert scale in the top 2 measures (desirable/highly desirable).

With reference to stopping at Round 2, in MacCarthy and Atthirawong (2003), it was assumed that another round would not significantly add to the results and therefore terminated the process. “Overall, it was felt that a third round of the study would not add to the understanding provided by the first two rounds and thus the study was concluded” (MacCarthy and Atthirawong, 2003).

For this study, the agreement levels and qualifications for this research are summarized in Table 8.

Table 8: Agreement Levels and Conditions

Level of Agreement	Conditions
Consensus	• IQR ≤1 and a percentage score ≥ 60% in a single level on all scales including yes/no
Strong Agreement	• IQR ≤1 and a percentage score ≥ 67% in combined adjacent levels, for a Likert scale of 7 • IQR ≤1 and a percentage score ≥ 61% in combined adjacent levels for a Likert scale of 5
Disagreement	• IQR > 1 and a percentage score ≥ 60% in a single level on all scales including yes/no • IQR > 1 and a percentage score ≥ 67% in combined adjacent levels, for a Likert scale of 7 • IQR > 1 and a percentage score ≥ 61% in combined adjacent levels for a Likert scale of 5 • IQR ≤ 1 but percentage score < 60% in a single level on all scales • IQR ≤ 1 but percentage score but percentage score < 67% in combined adjacent levels for Likert scale 7 • IQR ≤ 1 but percentage score < 61% in combined adjacent levels for a Likert scale of 5
Total Disagreement	• IQR > 1 and a percentage score < 60% on all scales and combined adjacent levels < 61%
Split Disagreement	• Regardless of IQR, percentage scores > 25% on extreme ends of all scales for all scales excluding yes/no • Regardless of IQR, percentage scores > 40% on both ends of yes/no questions

Questions that had the defined levels of agreement (Consensus and Strong Agreement) were removed from the questionnaire and were therefore not included in Round 2 while those that had levels of disagreement moved to Round 2.

CHAPTER 4: PRESENTATION OF RESULTS

INTRODUCTION

This chapter presents the key findings of the Delphi Survey conducted and discusses the survey results regarding the statements highlighted in the questionnaires. It also discusses the outcome of the survey results. Since consensus was not reached on most of the statements, the results suggested that there is no set standard on how FCAs are carried out (methods), how assets are categorized, how these are reported and indeed the calculation of the FCI. This chapter is structured to discuss four sections. The survey response, respondents' profiles, results of Delphi Round 1 and results of Delphi Round 2. The sections discussing the Delphi Rounds are further divided into four sub-sections, each discussing the four categories into which the research questions were divided as shown in Figure 1.

1. The purpose of the FCA and the FCI
2. Asset categorization/Hierarchy
3. Data collection and
4. The FCI

SURVEY RESPONSE

Of the 13 experts who voluntarily gave consent to participate, all (response rate at 100%) returned fully completed first round survey questionnaires, and 10 (response rate

at 81 %) returned fully completed second round survey questionnaires. A reminder email was sent to participants who had not responded within ten days, and a second reminder sent via email to those respondents who had not responded to the first reminder within an additional seven days. Data provided by withdrawn participants in the first round was retained as it had been included in the feedback to participants in the first round.

DELPHI PANEL DEMOGRAPHICS

The Delphi panel included representatives from the FM discipline with a background in Facility Condition Assessments. The panel consisted of 13 members with extensive FM experience as highlighted in Figure 7, but more so in FCA and Facility Capital Expenditure. The panel members represented nine states which included the Northwest, South, West, Northeast, East Coast and Southwest regions. This is presented in Figures 6 and 7.

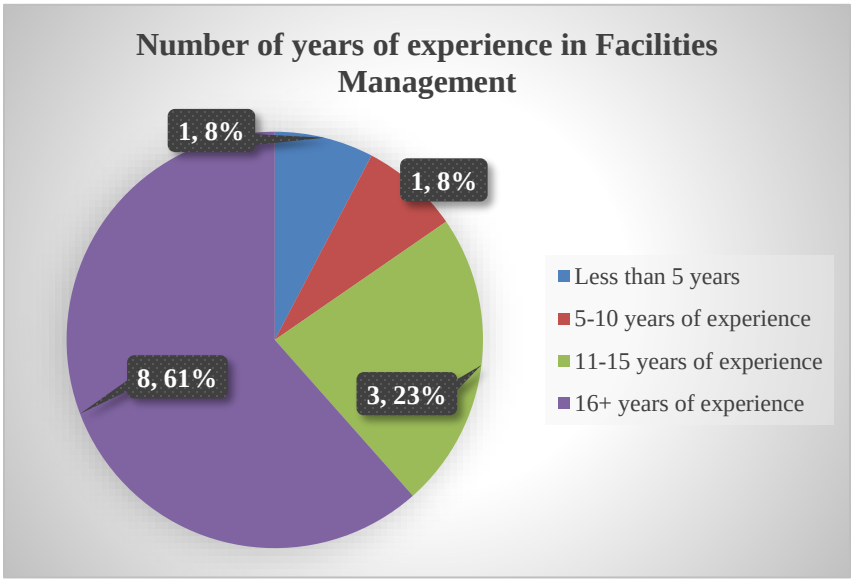

Figure 7: Number of years of experience in Facilities Management

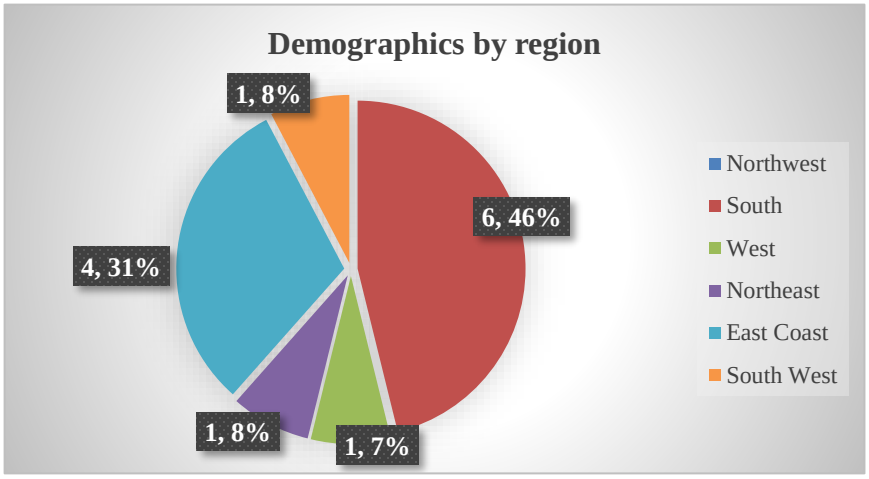

Figure 8: Demographics by Region

DELPHI ROUND 1

INTRODUCTION

This questionnaire comprised of 17 identified statements divided into the four highlighted topic areas described previously. The survey began on February 13, 2017 and panel members were provided with one week to complete the survey, with the conclusion date being February 20, 2017. The survey was extended by an additional three weeks for some of the respondents with the survey remaining open throughout this period. This was done to enhance the prospect of panel participation. All respondents filled out the questionnaire.

The purpose of the Delphi study is to get panel consensus or, as was the case in this study, a high level of agreement. This was a brainstorming round and in addition to having close-ended questions, the respondents could give their comments in a “comments section” provided after every question under the given headings. The open comments section of the questionnaire provided valuable feedback although this qualitative data was

not analyzed. The feedback directed the research to additional information that was pertinent to the study and led to additional questions being asked in Round 2 to enrich the data analyzed. One such comment was on the calculation of the FCI where an additional formula was added to the list of formulae used to calculate this metric to find out whether it was in use in industry. For purposes of reliability, only statements that met the agreement level conditions highlighted in Table 8 of both the percentage score and IQR were omitted in Round 2. All those statements that met one condition and not the other were included in Round 2. Tables 9 through 13 represent data on the questions asked under each category and their corresponding results. The full results are attached in Appendix E.

PURPOSE

The literature states that the FCA is the most important process in an Asset Management System (Kempton et al., 2001) since its results represent the starting point for determining the level of preventative maintenance needs and prioritization of capital expenditure. This prioritization is established through metrics like the FCI. To collect data and measure deficiencies, FCAs are carried out through surveys. These surveys or inspections should be carried out consistently, accurately and as objectively as possible. One of the problems highlighted in the literature regarding the FCA inspection is their subjectivity. The questions in this section of the Delphi Survey aimed at gaining insight from the panelists on their opinion of the FCA and the FCI, the format in which FCA reports are presented and what owners do with the FCA reports on receiving them.

Table 9: Round 1- Question 2 – 4 Summary of the Purpose Category

Survey Response (Purpose)	IQR	% Score	Level of agreement
2. Ranking based on opinion:			
FCI typically the overall desired metric.	2	61.6	Disagreement
The FCI provides a good overall indication of the structure's condition level.	1.5	69.3	Disagreement
Facilities Condition Assessments (FCA) should be tied to a Scorecard of Key Performance Indicator (KPI).	2	61.6	Disagreement
One of the difficulties of an FCA is the subjectivity of the assessment.	2.5		Total Disagreement
Most FCAs are conducted because there is a mandatory (Government) requirement.	3		Total Disagreement
The resulting information from an FCA is used typically at the administrative level only	1.5	77	Disagreement
3. FCA format			
Excel spreadsheet	0	69.2	Consensus
Word or PDF Report	1		Disagreement
Database	1	69.2	Consensus
Hard copy binder	0.5	76.9	Consensus
4. Owner use of the FCA			
Sits on a shelf	0.5	76.9	Consensus
Disseminated to a few users	1	61.5	Consensus
Disseminated to multiple users	1		Split Disagreement
Information made widely available in the organization	1		Split Disagreement
Added manually to a computerized tracking system	0.5	76.9	Consensus
Imported into CMMS	0	84.6	Consensus

The FCI is considered a standard tool in industry and is used to compare the condition of facilities and determine whether it is more economical to modernize fully or to replace it (NCES 2003 b). It was therefore not surprising that the panel agreed that the FCI being the overall desired metric and provides a good overall indication of a facilities' condition level. The panel came to a consensus that the FCA is not used at the administrative level only (77% on a combined disagree and somewhat disagree scale), but agreed that it should be used as a balanced scorecard of KPI. These statements, however, all had a high IQRs and were therefore indicate disagreement since they did not meet the criteria given for levels of agreement in Table 8.

On the subject of the FCA being subjective in its methods which the literature discusses widely, the analysis of the results indicated total disagreement between the panel members, where the answers were divided at 23% on levels ranging from "definite agreement" to "somewhat agree". The panel also disagreed on whether FCAs are being conducted because there is a mandatory requirement by the state or organization.

The panel came to a consensus regarding whether data from an FCA should go into a database. The comment here was that putting it into a database allows for periodical real-time updating of data. The Excel spreadsheet was also deemed a useful format with the hard copy binder being the format to avoid. This ties in with the statement on what happens to the FCA once it is shared with the Owner. There was consensus that the FCA report does not sit on the shelf if in hard copy binder form. One of the panelists commented that the preferred format would depend on the audience receiving the information, which may account for the variability in the responses. For example, the VP or CFO would want a hard copy binder or PDF report for quick reference, whereas the

FM professionals would need to store the data in a database for continued tracking and updating.

Surprisingly, the panel members agreed on the data collected following an FCA survey not being uploaded into a system capable of analyzing, tracking, reporting and prioritizing data; a CMMS or CPMS system. This is in complete opposition to what the literature states, that the data in an FCA should be used continually to ensure that deficiencies noted are acted upon, should funds be released. One of the panelists however commented that FCAs need to be "refreshed" regularly because the data is not often, in their experience, converted to a database and actively managed. If actively managed, the "refresh" requirement would be unnecessary. This is a valid point since data entry after an FCA survey is a labor-intensive exercise that requires a dedicated member of the FM personnel to upload the data and keep it refreshed. This is not often the case. To overcome this shortcoming, a member of the panel commented that the FCA data should be “loaded automatically and integrated with a Capital Plan Management System”. This way the system will analyze, track, report and prioritize data and lead to the prioritization of capital spending. This advised the research that the question was probably not clear due to the positive nature of the feedback being in stark contrast with the results.

HIERARCHY

An FCA is performed primarily to facilitate the ranking or classification of the components of all assets per the amount of repair required. Although there are standards available for defining a building hierarchy as developed by CSI (MasterFormat, UniFormat and OmniClass), there is no specific recommended standard for FM use. Part of the difficulty in the development of a standard for FCA methods is the formation of

hierarchy and organizing assets. The questions in this section pose to address the standards used in industry.

Table 10: Round 1 - Questions 5 - 7

Survey Response (Hierarchy)	IQR	% Score	Level of agreement
5. State (Government) mandate or a requirement to structure the FCA in a format.			
State Mandate	1		Disagreement
6. Formats most often used for categorizing assets in an FCA			
UniFormat (ASTM E1557)	2		Total Disagreement
MasterFormat	3		Total Disagreement
OmniClass	2		Total Disagreement
7. To obtain a better idea of the overall content for an FCA, which of the following are titled headings in your report?			
General Building Information	1	66.7	Consensus
Detailed Assessment Summaries	0.5	75.0	Consensus
Inspection Team Data	1	75.0	Consensus
Detailed Assessment Totals	1	66.7	Consensus
Facility Condition Categorization Descriptions	1	61.5	Consensus
Building Summary	1		Disagreement
Deficiency Audit Report	1	66.7	Consensus
Photographs and Drawings	1	66.7	Consensus

Government Requirements and Standards

It was imperative that the research finds out whether the panel was aware of any States (Federal Governments) that have requirements for structuring FCA methodologies. Although the results indicated split disagreement, these were skewed towards 54% the panelists being undecided on the issue. However, 30.8% stated that there was no state mandate as far as they were aware (disagreed). Two members (15.4%), indicated that they were familiar with state mandates. One panelist stated that there was a requirement in the past, but legislature determined that the way in which the FCAs were being executed was not helpful. There is therefore no longer a requirement. Three panelists commented that the requirements are decided upon by the institution.

Asset Categorization

As an essential step in an FCA, a building must be hierarchically decomposed into its main components. The hierarchy is intended to classify and cluster these components in different categories. As discussed previously, though not an exhaustive list, current standards include OmniClass, MasterFormat and UniFormat. One panel member cited OmniClass as the best of the list provided. In spite of this comment, those panelists who cited using a format acquiesced to using Uniformat (ASTM 1557) (38.5%), and MasterFormat (30.8%). Omniclass was the least represented in the analysis (7.7%). It can be deduced that though there was split disagreement on the format used most often to organize information and indeed assets in an FCA, there is prevelant use of UniFormat and MasterFormat. One of the panelists made an accompanying comment that the classification standards available are limited in their effective granularity which brought forth a probable reason as to why these standard formats are not used consistently. The

panelist also suggested a different format, ASTM FACTS developed by GSA. This format was added to the list of formats for the same question in Round 2.

FCA Title Headings

The panel agreed on the title headings in the reports they prepare for their company. There was split disagreement on whether the building summary is included in the FCA report with 42% of the panelists indicating that they do not include it, while 58% indicated that they do include it.

DATA COLLECTION

The main goal of an FCA is to obtain the data required to measure and calculate performance or to evaluate the condition of a facility. It is often that data is collected from visual walk-through inspections or in-depth studies using a variety of technological diagnostic techniques. This is dependent on the needs of the facility owner or FCAP Manager. This research purposed to find out from the panel members the technologies and tools currently in use during these inspections. The research also sought to find out how often FCAs were carried out and how long each inspection took based on different types of buildings. It was also important to understand whether users were consulted during the inspections to give input on deficiencies noted during their interaction with the facility under survey.

Table 11: Round 1- Question 8 - 12

Survey Response (Data Collection)	IQR	% Score	Level of agreement
8. Tools used for collecting data during FCAs			
Forms	1	61.5	Consensus
I-Pad	0.5	76.9	Consensus
Handheld computers (Tablets, phone apps, laptops)	1	69.2	Consensus
Cameras	1		Split Disagreement
9. Technologies utilized while conducting FCA surveys?			
Infrared thermographs	1	61.5	Consensus
Handheld laser measurements	0	69.2	Consensus
Moisture analyzers	0	100.0	Consensus
Smart level	0.5	92.3	Consensus
Tape measure	1		Split Disagreement
10. Are facility users consulted during the FCA process to identify deficiencies or functional issues of the spaces they occupy?			
User Consultation	0.5	76.9	Consensus
11. Estimate of time required to carry out an FCA survey			
Complex Building e.g. laboratory, theater	2.5		Total Disagreement
Typical Commercial Building e.g. office building	2.5		Total Disagreement
Light Commercial e.g. warehouse	3.5		Total Disagreement
12. How often should FCAs be carried out (per facility)?			
Once a year	0	92.3	Consensus
Every other year	0.5	76.9	Consensus
Once every three years	1	69.2	Consensus
Once every five years	1	69.2	Consensus

Data Recording

The literature is clear in its description of the tools that could be used for recording data (Table 5).The same is true regarding the technologies that could be in use (see Chapter 2, Condition Survey and Data Collection). Not surprisingly, there was consensus on the use of I-Pads and handheld computers like tablets, laptops and apps on phones for data collection, which could be explained by the advances in technology. Surprisingly, there was also consensus on the use of forms or paper-based systems (61.5%). Some of the panelists, however, disagreed stating that these should be avoided, citing that they create inaccuracies in the data transfer and add time and expense to an already costly process. The panelists were split on the use of cameras with 53.8% agreeing to their use and 46.2% stating they did not use them during surveys.

Diagnostic Analysis

During FCAs, there will be times when there is need to perform diagnostic analysis to determine the nature and extent of problems to allow corrective action. While handheld laser measurement devises were used (69.2% agreed), there was minimal support for usage of smart levels, moisture analyzers or infrared theromgraphs. There was split disagreement on the use of the tape measure. To get a bteer understanding of the use of technologies, the research decided to rephrase this question and include it in Round 2.

Occupant Consultation

The panelists were in consensus on the need to consult occupants. One of the panelists stated, “even as the occupants are consulted, their perception of issues lacks building and system knowledge and therefore needs to be researched”.

FCA Time Requirements

The literature states that carrying out FCAs is time-consuming (Ewada, et al., 2015). One of the aims of the research was to find out how long it takes to carry out an FCA. The panelists were in disagreement on the amount of time taken. The panelists offered valuable feedback in the comments section stating that it was difficult to respond to this question without the gross square footage of the space. This question was rephrased in Round 2 giving both the gross square footage and age of three hypothetical Facilities.

FCA Cycles

Together with finding out how long FCA surveys took, the research aimed at finding out how often FCAs are carried out. The results indicated that FCAs are carried out in all the time spans given. The comments given were that this is dependent on the type of Facility they are working with, but one panelist stated that in the beginning, FCAs should be carried out every year to establish a baseline. Another panelist stated that:

> "The best done FCAs are done once and then the data is managed in a lifecycle database. As assets reach the end of useful life, they are assessed individually but the campus-wide FCA is only done once".

The literature recommended that FCAs be done every three years, or conducting a portion of the overall portfolio annually (Brandt and Rasmussen, 2002). Lewis and Payant (2000) also state that FCAs should be carried out every year. However, due to the cost and the resources required, these should be carried out every five years (Lewis and Payant, 2000). To get a better understanding of what the panelists meant regarding the FCAs being carried out within all timespans provided, the question was carried forward to Round 2.

THE FCI

As discussed in the section on data collection, the main aim of an FCA is to gain data in the form of measurements required to evaluate the condition of a facility. This is done through calculating a numeric value that reflects a specific condition of the severity of the deficiencies of a Facility, the FCI, to determine prioritization of capital expenditure. The consistency of how the FCI is calculated was one of the concerns highlighted in the literature. The different formulae for calculating the FCI has led to these not being comparable in as far as benchmarking is concerned, and cannot, therefore, be used to understand the relative condition of assets. The Government Accounting Office advised that the FCI should not be used to inform or prioritize funding decisions between government agencies due to this very reason (GAO, 2015). The purpose of the questions in this section was to find out the formulae the panel members used for the FCI and the benefits of and concerns about the FCI, in their opinion.

Table 12: Round 1- Question 13 - 15

Survey Response (FCI)	IQR	% Score	Level of agreement
13. The standard formula for the FCI is Deferred Maintenance ($) / Current Replacement Value ($). Which formula does your organization utilize?			
Deferred Maintenance ($) / Current Replacement Value ($)	1		Split Disagreement
Deferred Maintenance ($) + Renewal Costs($) / Current Replacement Value ($)	1	66.7	Consensus
Deferred Maintenance ($) + Renewal Costs($) + Regulatory Compliance($) + Adaptation (ADA) ($) / Current Replacement Value ($)	1	72.7	Consensus
14. The standard formula for calculating CRV is given as Gross square footage of the existing building multiplied by the estimated cost (per square foot) to design and build a new facility. Is this the formula adopted by your organization?			
CRV formula	1	69.2	Consensus
15. How is s the CRV calculated?			
As an estimate by an internal estimator (no specific standard)	0.75	75.0	Consensus
As an estimate by an internal estimator (using a standard)	1	66.7	Consensus
By a formula determined by insurance requirements	1		Split Disagreement

Table 13: Round 1- Question 16 - 17

Survey Response (FCI)	IQR	% Score	Level of agreement
16. Benefits of the FCI			
Is tried and tested	3		Total Disagreement
Creates a common language among organizational staff	1		Disagreement
Industry has an acceptance of the thresholds set for good, fair, poor and critical conditions	3		Split Disagreement
Is used as a snapshot in time to compare similar assets	1.5		Total Disagreement
Can be used as a key performance indicator to identify buildings that need to be prioritized in terms of repair, maintenance and capital renewal	1	69.3	Strong Agreement
As a benchmark assists FMs reduce a backlog in deferred maintenance	2	61.6	Disagreement
17. Concerns of the FCI			
Does not account for the condition of a facility's critical components; on its own, fails to capture the important distinction between the condition of the facility and the condition of its individual components	3		Total Disagreement
Cannot be used to compare diverse assets	3.5		Total Disagreement
Does not include future renewal projects	3.5		Total Disagreement
Values become rapidly outdated due to factors such as deterioration and is always relative to the year of the survey	3		Total Disagreement
CRV calculation is fluid and can differ year on year resulting in an inconsistent FCI and difficulty in benchmarking	3		Total Disagreement
The DM aspect of the standard FCI formula does not prioritize relative importance of backlog associated with each system	3		Total Disagreement

FCI Formula

The formulae given for calculating the FCI and CRV were identified from the literature as highlighted in Chapter 2. There was consensus regarding inclusion of Deferred Maintenance, capital renewal, regulatory compliance and adaptation to the numerator and split disagreement on the original formula that took cognizance of Deferred Maintenance only (a 50% split on those who use it and those who do not). A member of the panel commented that the numerator selection is dependent on the client's mission and peer group analysis. It therefore differs from project to project.

This validates the part of the research problem that states that there is currently no standard method of calculating FCI. One panelist introduced a newer concept stating that renewal cost is "the current fiscal year renewal costs" not the aggregate total. This therefore means that they calculate capital renewal on a fiscal year-to-year basis. There was also the comment that deferred maintenance should be more appropriately termed deferred capital renewal since deferred maintenance denotes incomplete preventative maintenance and routine repairs. Deferred capital renewal denotes assets beyond useful life that require replacement, renewal or retrofit, thus: (Deferred Capital Renewal + Current FY Recapitalization Costs) / CRV of Total Database Value. Deferred Capital Renewal is the cost deferred cost of replacing items (say a boiler for example), instead of maintaining it (Deferred Maintenance). This mode of calculating the FCI was introduced to Round 2 as a question to find out whether the other panelists were in agreement with the use of this modified formula.

CRV Computation

The panel came to a consensus on the formula for computing the CRV. This agreement confirmed the CRV as a standard calculation. It would however be interesting to find out what formula the remaining 30.8% who were not in agreement use as a formula for calculating CRV. There is, however, the question of how the actual figures are arrived at, especially with regards to the estimated cost (per square foot) to design and build a new facility. The panelists came to a consensus that they either had the estimate given by an internal estimator without any standard set by the organization or using a standard agreed upon by the institution. Although the formula may be standardized, the method of arriving at the figures to use in the formula differ. This may also explain why the literature states that the FCI is inconsistent (Clayton, 2013).

FCI Benefits and Limitations

At the beginning of the questionnaire, the panel members agreed on the FCI being the desired overall metric and should be tied to a balanced scorecard of KPI. Regarding the benefits of the FCI, the panel members were in partial agreement that the metric should be used as a KPI and is a snapshot in time to compare assets. It is, however, not surprising that the panel did not find the FCI to be ideal as a benchmark that assists in reducing the backlog with 38.5% agreeing and 15.4% somewhat agreeing to this statement. The explanation for this may be because of the inconsistency in the calculation of the FCI noted previously. A comment by a member of the panel indicated that FCI has too much variance to be used as a benchmark. However, one of the panel members positively commented that the despite its fluid nature, the FCI could indicate a lack of

maintenance. This was stated as a benefit of the FCI. A high FCI might also indicate a renovation opportunity.

The panel was also in total disagreement on the identified concerns of the FCI. It was the expectation of the research that there would be some consensus in Round 2. One of the comments made by a member of the panel through a telephone conversation was that if the database against which the FCI is based was kept active, these issues would no longer be of concern. However, the FCA report against which the FCI is based is static which therefore means that it is only considered whenever there is a need to justify capital spending. This makes all the concerns raised valid. Another member of the panel commented that they feel as though the industry is moving past the FCI and towards more predictive approaches to managing deficiencies. This is an opportunity for further research.

The opportunity to provide comments through open suggestions (other) resulted in additional questions for Round 2 including:

I. Formats for categorizing assets
    a. ASTM FACTS (GSA)
    b. Own internally developed format
II. Concerns of the FCI
    a. The industry is moving past the FCI and towards more predictive approaches to managing deficiencies

The open comments of the Delphi survey also provided valuable feedback regarding clarification for Round 2. Three members highlighted that to answer the question on how long it takes to inspect different types of buildings, it would be prudent

to have the size and age of the building. This was given in Round 2 with a side note requesting that the panelists note the change in the wording of the question.

DELPHI ROUND 2

OVERVIEW

The purpose of Delphi Round 2 was to clarify questions and to gain consensus on the statements carried forward from Round 1. On March 14, 2017, 6-days before inviting the panelists to Round 2 of the survey, the results of Round 1 were shared with the panelists to allow them to review them and change their answers in Round 2, should they need to. The survey began on March 20, 2017 with personal e-mails sent to all participants with a link to the survey appended. Instructions indicating the purpose of Round 2 were also included thus:

> The purpose of Round 2 is to clarify those questions that were not clear in Round 1 and to also work toward closer consensus on the items that were not in consensus after the first round. *Please be sure to review the Round 1 results prior to taking this round.

The participants were provided with one week to complete the survey, with the conclusion date being March 27 2017. The survey was extended by an additional seven days for some of the respondents, with the survey remaining open through this period. As was the case in Round 1, this was done to encourage participation. Ten (10) out of the original thirteen (13) respondents filled out the questionnaire. This survey round had close-ended questions but the respondents were able to give their comments in a "comments section" provided after every question under the given headings of the purpose (of the FCA and FCI), hierarchy (format is used), data collection (methods and technologies) and the FCI (calculation, use, benefits and concerns).

The open comments section of the questionnaire provided valuable feedback although this qualitative data was not analyzed. Tables 13 through 16 represent data on the questions asked under each category and their corresponding results. The questions for which consensus was reached in Round 1 were not included in Round 2. The full results are attached in Appendix F.

The comments made in Round 2 indicated that responses did not differ much between the two rounds since the panelists were commenting on actual individual experiences. The discussions with several of the panelists indicated that the responses highlighted in Round 2 would not change significantly should there be a third round since most of the questions referred to how they currently undertake FCAs and the calculation of the FCI thereof. Similarly, equipment utilized would not change between rounds.

PURPOSE

Table 14: Round 2- Question 3

Survey Response (Purpose)	IQR	% Score	Level of agreement
3. Ranking based on opinion:			
FCI is typically the overall desired metric	1	60	Consensus
FCI provides a good overall indication of the structure's condition level	0.25	70	Consensus
FCA should be tied to a scorecard of KPI	1		Disagreement
One of the difficulties of an FCA is the subjectivity of the assessments	1.25	80	Disagreement
Most FCAs are conducted because there is a mandatory requirement	1		Disagreement
The resulting information from an FCA is used at the administrative level only	1	70	Consensus

Table 15: Round 2- Question 4 - 5

Survey Response (Purpose)	IQR	% Score	Level of agreement
4. FCA report distribution once provided to the owner			
Sits on a shelf	0.25	80	Consensus
Disseminated to few users	1	70	Consensus
Disseminated to multiple users	1.25		Total Disagreement
Effort is made to make the information widely available to those in the organization	1.25		Total Disagreement
5. Owner use of the FCA			
Added manually to a computerized tracking system	2		Total Disagreement
Imported into a computerized maintenance management system or Integrated with a Capital Plan Management System	2.25		Total Disagreement
Used to prioritize Capital spending.	1.25	80	Disagreement

The results in this section of Round 2 compared to those in Round 1 were not surprising. Some of the responses remained unchanged except for agreement on the subjectivity of the FCA. In this round, panel members strongly agreed that the FCA is subjective in nature validating the conclusion made following the literature review. One of the panel members commented that in their opinion, the subjectivity of the FCA could be overcome with third party involvement, or by the process being more data driven. In the literature, it is suggested that the FCA is still a visual process and subjectivity can be due to the inspector's specific individual experience, attitude towards risk, use of "rules of thumb," and biases (Scott and Anumba 1996; Hogarth 1987).

Some of the panel members changed their response to the question on the FCA being tied to a scorecard of KPI. The IQR of 1 however indicated some modicum of convergence which is reflected in the percentage score. The responses were tied (50%) with half the panel agreeing that the FCA should be tied to a scorecard of KPI, and the other half neither agreeing nor disagreeing.

The responses on how the FCA is distributed once provided to the owner remained the same as those in Round 1 with the general feeling being that the prevalence of the FCA sitting on the shelf was deemed low (80% agreed that the prevalence was low). It is however disseminated to few users in the organization. One of the members of the panel gave valuable feedback stating:

"I have seen data results used in a few ways: 1) The individual facility reports are used as the starting point for the excursive scoping phase of the project once a project is initiated at the Facility. 2) The FCA feeds directly into a budget approval process and the budget/plan are published to the public while portions that trace back to the FCA are part of the publication 3) Worst list with associated costs are used externally, politically to raise additional funding from the Government"

The last statement rings true when the research refers to the literature review. The result of FCAs is a report that is then used for budgeting and planning (Hammad 2003). With budget cuts, however, Carlson (2008) brings attention to stewardship commitment where funding from donors and legislature to roll out new projects is readily available, whereas access to funding to repair and maintain the very same facilities that are constructed is difficult to come by. This may point to the reason why there is a backlog in deferred maintenance. The FCA may be feeding directly into a budget approval process but the question remains whether approvals to spend are realized.

Table 16: Round 2- Question 6 - 7

Survey Response (Hierarchy)	IQR	% Score	Level of agreement
6. State (Government) mandate structure the FCA in a particular format.			
There is a State (Government) mandate	3		Total Disagreement
7. Formats most often used for categorizing assets in an FCA			
UniFormat (ASTM E1557)	3	60	Disagreement
MasterFormat	3		Total Disagreement
OmniClass	1.25	70	Disagreement
ASTM FACTS (GSA)	1.25		Total Disagreement
No standard format	2	70	Disagreement
Our own internally developed format	2.5	70	Disagreement

Government Requirement or Standard for FCA

Similar to Round 1, the panelists did not agree on whether there was a Government requirement to structure the FCA in a specific format. One of the panel members however stated that the State of Georgia had minimum requirements for each FCA, but no set standard. Another member of the panel stated that the Requests for Proposals (RFPs) sent out by large Government facility owners have different funding structures. These funding structures and priorities drive the method and content of the FCA. The RFPs might require a certain methodology, but they mostly ask consultants to develop one for each project. This leads there being no standard format to carry out FCAs.

Asset Categorization

Again, regarding the formats used to categorize assets, ATSM FACTS came up again as the most flexible for operations to be granular as a comment from one panelist in the comments section. Uniformat was mentioned as coming up in conferences and being used more widely than any other format. One panel member commented that for consultants, the owner is best placed to come up with a hierarchy. This may be the reason why part of the difficulty in the development of a standard for FCA is the formation of hierarchy and organizing assets. Without standards, there is no consistency. Setting standards to the main terms for asset inventory and management is very important at institution level as well as at industry level. It will allow, at the end of the asset management system, ease of benchmarking from institution to institution. It is also important to have the consultants on board with the categorization so that the information uploaded onto the owner's database is consistent with what they use.

DATA COLLECTION

Table 17: Round 2- Question 8 - 10

Survey Response (Data Collection)	IQR	% Score	Level of agreement
8. Use of technologies utilized while conducting FCA surveys?			
Infrared thermographs	3		Total Disagreement
Handheld laser measurements	3.25		Total Disagreement
Moisture analyzers	1	90	Consensus
Smart level	2	70	Disagreement
Tape measure	5		Total Disagreement
9. Estimate of the time required to carry out an FCA survey 35,000 sq. Ft. Space in a 15-year-old building.			
Complex Building e.g. laboratory, theater, with a complex MEP system	2		Total Disagreement
Typical Commercial Building e.g. standard office building	2.75		Total Disagreement
Light Commercial e.g. warehouse	3		Total Disagreement
10. How often should FCAs be carried out (per facility)?			
Once a year	1.25		Total Disagreement
Every other year	1.25		Total Disagreement
Once every three years	1.25		Total Disagreement
Once every five years	3		Total Disagreement

Diagnostic Analysis

In this Round and comparable to Round 1, there was a consensus that moisture analyzers (90%) and smart levels (70%) are used (usually and everytime on the scale). The smart level however, had a higher IQR than allowable. The panel disagreed on the use of handheld laser measurements, infrared thermographs and tape measures. One panel member stated that thermography for interior moisture detection was in use for roofs, referring to a recently completed project where the roofs were visually inspected as well as reviewed using infrared thermographs. This was due to a serious roof issue which required a fix wing aircraft to take the infrared photographs and was a one-off occurrence.

FCA Time Requirements

Following rewording of the question on the amount of time required to carry out an FCA survey, the results were surprising with total disagreement on all the highlighted types of buildings. 50% of the panelists did however, state that for a building that had complex systems, such as laboratories with a complex MEP system, two days were adequate. The results indicate that different institutions and indeed different inspectors, take different amounts of time. The Committee on Advanced Maintenance Concepts for Buildings (1990) stated that not only should the owner stipulate the scope of the FCA, they should also take an interest in how long it should take. This calls for data collection implementation based on “logical, standardized, professionally developed procedures” to ensure that identified deficiencies are efficiently and correctly evaluated to save on cost.

FCA Cycles

Based on the parameters set by the research (Chapter 3), the panel was in total disagreement on how often an FCA should be carried out. This was a change from Round 1. The highest-ranking period was five years with 50% of the panelists indicating that a 5-year cycle was the most feasible. This was followed closely by a 3-year cycle being the second most feasible cycle. The least feasible was the annual FCA cycle. This reflects what the literature states practice should be as highlighted in the Round 1 results. One of the panelists' however suggested that:

"The best done FCAs are done once and then the data is managed in a lifecycle database. As assets reach the end of useful life, they are assessed individually but the campus-wide FCA is only done once".

This was the same comment made in Round 1. It would be interesting to understand how an FCA is carried out once, data managed, and another FCA carried out at the end of the useful life of the Facility. In essence, a capital renewal forecasting tool that would then justify costs to CEOs, CFOs and boards would be required. This is an avenue for future research to study the systems that are currently in use industrywide.

FCI

Table 18: Round 2- Question 11 - 14

Survey Response (FCI)	IQR	% Score	Level of agreement
11. The standard formula for the FCI is Deferred Maintenance ($) / Current Replacement Value ($). Which formula does your organization utilize?			
Deferred Maintenance ($) / Current Replacement Value ($)	4.25		Total Disagreement
Deferred Maintenance ($) + Renewal Costs($) / Current Replacement Value ($)	3.25		Total Disagreement
Deferred Maintenance ($) + Renewal Costs($) + Regulatory Compliance($) + Adaptation (ADA) ($) / Current Replacement Value ($)	5		Total Disagreement
Deferred Capital Renewal ($) + Current FY Recapitalization Costs/CRV for total Database Value	1	90	Consensus
12. Standard for calculating CRV			
As an estimate by an internal estimator (using a standard)	1		Disagreement
By a formula determined by insurance requirements	0.25		Disagreement
Using industry determined cost per square foot building models	1		Disagreement
13. Rate the following benefits of the FCI based on your opinion.			
Is a tried and tested metric	1		Disagreement
The FCI creates a common language among organizational staff to describe the condition of assets	2		Total Disagreement
Industry has an acceptance of the thresholds set for good, fair, poor and critical conditions	1		Disagreement
The FCI is used as a snapshot in time to compare similar assets	1.5	70	Disagreement
With a limited budget, the FCI can be used as a key performance indicator to identify buildings that need to be prioritized in terms of repair, maintenance and capital renewal	1.25	70	Disagreement

Survey Response (FCI)	IQR	% Score	Level of agreement
The FCI as a benchmark assists FMs reduce a backlog in deferred maintenance through its use in calculating "catch-up" costs and therefore assisting in getting budget approval	1.25	70	Disagreement
The FCI is a good indicator of whether maintenance is being carried out	1		Disagreement
The FCI is a good indicator of renovation opportunities	1	70	Consensus
14. Rate the following concerns of the FCI based on your opinion.			
The FCI does not account for the condition of a facility's critical components and fails to capture the important distinction between the condition of the facility and the condition of its individual components	1.25		Total Disagreement
The FCI cannot be used to compare diverse assets	2		Total Disagreement
The FCI does not include future renewal projects	1		Disagreement
Values become rapidly outdated due to factors such as deterioration; is always relative to the year of the survey	1.5	70	Disagreement
CRV calculation is fluid and can differ year on year resulting in an inconsistent FCI and difficulty in benchmarking	1.25		Total Disagreement
The deferred maintenance aspect of the standard FCI formula does not prioritize relative importance of backlog associated with each system	1	70	Consensus
The industry is moving past the FCI and towards more predictive approaches to managing deficiencies	1.25	70	Disagreement

FCI Formula

On considering their responses from Round 1, the responses from the panelists show that there was no standard as to how the FCI was calculated. There was therefore total disagreement on most of the questions. This was also reflected in the high IQRs related to these questions. On the newly added Deferred Capital Renewal ($) + Current FY Recapitalization Costs/CRV for total Database Value mentioned by one of the members of the panel as a formula that is useful, 90% of the members of the panel were in consensus that they had never used this formula (60% never, 30% rarely). The results therefore remained the same as those in Round 1 inferring that there are indeed several variations of the FCI in use in industry. Using the FCI as a benchmarking tool between organizations therefore becomes challenging since the comparison is not one of apples to apples.

CRV Computation

In Round 1, the panel came to a consensus on how the CRV is computed but disagreed on the standard used to calculate the actuall current replacement value of assets. The question therefore remains as to how these actual figures are arrived at, especially with regards to the estimated cost (per square foot) to design and build a new facility. Although the formula is be standardized, the method of arriving at the actual figures to use in the formula differ. This may also explain why the literature states that the FCI is inconsistent (Clayton, 2013).

FCI Benefits and Limitations

Regarding the benefits of the FCI, responses changed with consensus reached on the FCI being a snapshot in time to compare similar assets, the FCI being used as a KPI and assisting in reducing backlog on DM. This is in line with what literature states, a change from Round 1 responses. These statements however had high IQRs. It was also agreed that the FCI is a good indicator of renovation opportunities.

Regarding limitations of the FCI, although in overall disagreements, most of the panelists agreed that the FCI does not include future renewal projects (60%). There was consensus on the FCI values become rapidly outdated due to factors such as deterioration, though the IQR on this statement was above the allowable threshold at 1.5. It was agreed that the DM aspect of the FCI does not prioritize relative importance of individual system backlog. The panel disagreed on whether the industry was moving past the FCI with only 30% of the panelists agreeing to this statement.

CHAPTER 5: DISCUSSION

CONCLUSIONS OF THE STUDY

Because many buildings in America, especially Higher Education buildings, are aging, sustaining their healthy operation has become a great challenge, particularly in the light of constrained budgets which complicate decisions about capital renewal projects. Such decisions are highly dependent on an accurate FCA. This can be measured in terms of consistency, accessibility, capacity, and meeting customer demands and needs (Teicholz, 2001). All of this is critical information for determining the remaining useful life of an asset and more importantly the timing for possible intervention steps to bring levels of service, provided by the asset, back to a desired standard.

The main objective of this thesis was to highlight what industry states the current procedures of carrying out Facility Condition Assessments are and the role of the Facility Condition Index. The basis was to understand how FCA surveys are carried out, how data is collected, what is reported in the FCA report and why, how these reports are presented and how the computation of the FCI is undertaken. This is especially true with regards to the use of specific metrics like the FCI, and benchmarks for planning purposes. Metrics represent indicators that can be used for genuine comparison within and between institutions. They provide an essential common platform for comparison, based on which improvements can be sought for any individual index. Metrics not only facilitate the understanding of driving forces of a building's performance but also support owners in

efficiently operating buildings (Lavy et al., 2010). The study was divided into four categories; the purpose of the FCA and FCI, Hierarchy, Data collection and the FCI.

PURPOSE

For the very reason that consensus was not reached on most of the statements in the Delphi study, the results suggested that there is no set standard on how FCAs are carried out (methods). One of the panelists commented that Requests for Proposals (RFPs) sent out by large Government facility owners have different funding structures. These funding structures and priorities drive the method and content of the FCA. The RFPs might require a certain methodology, but they mostly ask consultants to develop one for each project. This leads to there being no standard format to carry out FCAs. The panelists however indicated that for public projects, the state issues a guideline in the RFP, but this is on a project to project basis. One of the panelists concluded that the result therefore is owners decide what they require audited. The methods used in an FCA, according to one panelist, are driven by funding structures in an institution as well as the priorities they have for capital renewal projects. Most consultants will develop the methodology on their own.

HIERARCHY

Classification of assets is an important step in asset management, but more so in carrying out FCAs. The study concluded that the formats used vary widely among institutions, but formats depend on the owner and their mission. One of the panelists indicated that the available classification standards are limited in their effective granularity. The Delphi panel's responses suggested that there is also no set standard for asset categorization and more often than not, this was left to the owner to create. The

panelists were in consensus on not having an awareness of a state mandate on how FCAs are structured. The study also concluded that FCAs should be carried out every three to five years. This is reflective of what the literature indicates. The results of the study indicate that the panelists are in agreement that data collected should go into a database that is capable of analyzing, tracking, reporting and prioritizing data; a CMMS or CPMS system. This database should be managed as real-time data updated periodically. One panelist however indicated that the format in which the FCA report is received depends on the person who requires the report. The CEO or CFO may require a PDF report for quick reference. There are however those owners who request a hard copy binder which, according to the panelists, ends up sitting on a shelf. One of the panelists commented that "Too many institutions put it on the shelf or use it as justification for a few key projects". The study indicates that data should be disseminated to the key users, including those who will be acting on it; the FM personnel. If they are not notified of the data and given the data to act upon, it is merely an administrative tool that has limited value to the institution.

DATA COLLECTION

There is the use of technologies in the data collection means, such as iPads, tablets, laptops and apps, but the use of technologies for the actual survey, the methods, such as infrared thermographs is limited. The panelists were however in consensus that there was the use of smart levels across the board. It would be of interest to follow up on how institutions are using the data from their FCAs on a wider scale. Too many institutions put it on the shelf or use it as justification for a few key projects. The data from an FCA should go into a database and should be managed as real-time data updated

periodically. Otherwise, institutions are spending excessive amounts of funds on redoing the survey every five years or so. It is also important to understand that the front-line crew must be engaged in the process. If they are not informing the data and given the data to act upon, it is merely an administrative tool with limited value to the institution. Knowing how the front-line crew participates in the survey and utilizes the data would be valuable.

THE FCI

One of the aims of carrying out an FCA is to gain data that will assist in evaluating the condition of a facility. The FCI, according to the panelists, is the overall desired metric to report the condition of Facilities as it provides a structure's condition level. However, the study results indicated that there is no standard in its calculation. One of the panelists indicated that how the FCI is derived is a major factor in how useful it is. Its range is also limited. No one has defined an FCI standard yet and this is has been pointed out in the literature. This is therefore agreed upon by the institutions as shown by the survey results, where the formulae vary. Within the two Delphi survey rounds, two additional formulae were added by the panelists confirming the lack of a standard. This inconsistency makes it difficult to use the FCI as a benchmarking tool within an organization with a large portfolio and between institutions, hindering the process of setting industrywide best practices and opportunities for continuous improvement. This validates the suggestions made by the literature. Though the panelists were in consensus on the standard formula for the CRV being widely in use for calculating the CRV, they also concurred that it is set by an estimator within the organization using a standard such

as RS Means. The CRV however, remains fluid in its determination of the current replacement value of an asset. A standard is also required as a reference for the industry.

INFERENCE

The study was not able to come to a consensus on most of the issues raised. Although the intent is to establish consensus, the results of this study provide a clear indication that there remains work to be done in the area of research for FCAs. These disagreement levels appearing in the categories may also represent the overall industry and its lack of standards in how the FCA is carried out, how it is reported and the varied computation of the FCI.

RESEARCH CONTRIBUTION

The results of this research identify the gaps between what the literature states the procedures should be for carrying out an FCA and the current state of practice. Prior to this study, there were no quantitative studies to review the comparisons between literature and industry practice. This research sets the basis for future research which may begin the consideration of setting not only a standard, but also acceptable levels of achievement. To aid Facility Managers and building owners, a systematic process and standard FCA procedures will allow for internal comparisons as well as benchmarking methods with other owners.

LIMITATIONS

Although the study was carefully planned and has reached its aims, there were some unavoidable limitations.

1. There was a delay in responding to the questionnaires by some panelists which put a strain on the time allowed for the study. Due to the time limit, the Delphi Survey was carried out in two rounds. To confirm the results, one more round would have been undertaken in the study. It was however noted that the results of the responses given by the expert panel did not differ by much from round one to round two.
2. An attempt was made to limit the number of statements or questions to a reasonable minimum to help panelists respond meaningfully and in detail.
3. The use of the questionnaires for the study was limiting in that it did not go in-depth into the thought process of the respondents behind their answers. Interviews, whether face-to-face or by telephone, would have solved this issue although time was also a constraint and the researchers were attempting to minimize the disruption of the very busy panelists.
4. To assess reliability of the results gained from the Delphi Survey, it was the intention of the research to compare actual FCA reports but the owners were reluctant to share these.

CHAPTER 6: RECOMMENDATIONS FOR FUTURE RESEARCH

Future research may begin the exploration of setting not only a standard, but also acceptable levels of achievement. The present research also opens new opportunities for similar studies in the asset management arm of FCA. The following issues need further study:

- The development of a framework for a more standardized FCA program that may become more useful to the entire community of building owners and FMs. A framework for a procedure for carrying out FCAs
- It was mentioned by one of the members of the panel that their opinion is that the industry is moving past the use of the FCI and towards more predictive approaches to managing deficiencies. This is an area that requires further study to find out whether this is indeed the trend and how capital expenditure is justified.
- A study to understand whether the front-line crew in FM are engaged in the FCA process, or whether they receive the information and have to run with it in as far as rectifying the deficiencies.
- One of the panelists made an accompanying comment that the classification standards available are limited in their effective granularity. Future research may look into the current classification standards in use with the aim of understanding how owners classify their assets and whether industry agrees with the panelists' deduction.

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APPENDIX A. DELPHI STUDY EXPERT PANEL SOLICITATION LETTER

UNC CHARLOTTE

STATE OF PRACTICE FOR CONDITION ASSESSMENT METHODS AND METRICS

There are currently minimal resources and/or standards in the industry for carrying out Facility Condition Assessments, especially with regards to the use of specific index metrics and benchmarks for planning purposes. Many owners use Facility Condition Assessment (FCA) templates generated within the organization or, look externally towards consultancy firms. We are conducting graduate research at The University of North Carolina Charlotte, in the Construction & Facilities Management Program, and would like to request your assistance in this important study. This research has been accepted as an APPA's Center for Facilities Research project (CFaR034-16). We are in the process of developing a Delphi panel of condition assessment experts. This study aims to establish a current "state of practice" with regards to where industry currently stands in their levels of conditions assessments. This includes what we are reporting, why we are reporting what we are reporting, how that information is used, how often these condition assessments are conducted and how these condition assessments are carried out. Additionally, the study will explore what the literature and industry experts state that may help to improve the current levels of practice.

We hope to have a formal 8-member panel developed by July 31st 2016. This panel will be made up of owners and consultants who carry out condition assessments and use index metrics, (e.g. FCI, MEI etc.).

Each panelist must agree to:
Participate in two (2) rounds of an anonymous electronic questionnaire, in which you will be asked to identify your perception of where the industry currently stands in their levels of condition assessments. (Each round estimated at approximately 10-15 mins.)

Please respond to this e-mail if you are interested in participating in this study, giving us your contact information including your name, organization, address, cell phone number and e-mail address. We shall work with APPA to ensure that you get the results of this study.

Thank you for your time and contribution. We look forward to working with you in the near future.

Sincerely,

Pauline Karanja: Graduate Student
UNC Charlotte | The William States Lee College of Engineering
Department of Engineering Technology and Construction Management
Smith Building Rm. 216
Phone: 980-474-6746 | pkaranja@uncc.edu

Faculty Mentor: Glenda Mayo, PhD, CDT, LEED-AP | Assistant Professor
UNC Charlotte | The William States Lee College of Engineering
Department of Engineering Technology and Construction Management
Smith Building Rm. 236 | 9201 University City Blvd. Charlotte, NC 28223-0001
Phone: 704-687-5047 | gmayo4@uncc.edu

APPENDIX B. DELPHI STUDY CONSENT TO PARTICIPATE

Panel Solicitation for Facilities Condition Assessment

1) This project is an approved APPA Center for Facilities Research (CFaR) project, conducted by researchers with the University of North Carolina Charlotte. It has been approved through the University IRB process.

I am submitting my contact information in interest of participation on the Delphi Panel for Condition Assessments. I understand that by participating, no personal information during the survey, only for contact purposes. Reported data will include only categorized results and will not include specific information for a single respondent. If you would like to participate, select yes to continue and provide contact information so that you may be provided with further instructions and a link to Round 1 of the Delphi Effort.

- ◯ Yes
- ◯ No

2) Please indicate the company name and state.

F/L Name: _____

Company: _____

State: _____

3) Which best describes the category you respresent with regards to conducting facility condition assessments?

- ◯ A consultant providing assessments for the owner
- ◯ Owner conducting our own assessments

4) How many years of experience do you have specifically with regards to conducting facilities condition assessments?

5) Are you a member of an organization that provides resources pertaining to facilities or condition assessments? If so, what organization. If not, simply state "no."

6) Job title?

7) We are requesting copies of Facilities Condition Assessment reports to establish a categorical list of metrics and KPIs for Round 1. Please select your response below:

- ○ I will provide a copy of an assessment report
- ○ I am not comfortable providing a copy of a report at this time

8) Would like to be notified of the release and link of the resulting publication?

- ○ Yes
- ○ No

APPENDIX C. DELPHI ROUND 1 QUESTIONS

Facilities Condition Assessment Delphi (Round 1)

This project is an approved APPA Center for Facilities Research (CFaR) project, conducted by researchers with the University of North Carolina Charlotte. It has been approved through the University IRB process.

Round 1 is estimated to take approximately 8-10 minutes. Personal information is only requested to track results by respondent. Reported data will include only categorized results in aggregate and will not include personal or specific information for a single respondent.

The purpose of Round 1 is to establish a comprehensive list of survey items. The current survey is based on information throughout current literature. The purpose of Round 2 is to collect results from Round 1 which indicate any items the respondent felt were missing from the Round 1 of the survey. This round is called the "brainstorming" round, so feel free to contribute as much information as possible so the information can be included in Round 2.

1) Please provide:

Name: _____

State: _____

Section 1 includes questions pertaining to the Purpose of a condition assessment.

2) Rank the following based on your personal opinion:

	Definite Agreement	Strong Agreement	Agree	Somewhat Agree	Disagree
The Facilities Condition Index (FCI) is typically the overall desired metric.	○	○	○	○	○
The FCI provides a good overall indication of the structure's condition level.	○	○	○	○	○
Facilities Condition Assessments (FCA) should be tied to a Scorecard of Key Performance Indicator (KPI).	○	○	○	○	○
One of the difficulties of a FCA is the subjectivity of the assessment.	○	○	○	○	○
Most FCAs are conducted because there is a mandatory requirement.	○	○	○	○	○
The resulting information from an FCA is used typically at the administrative level only.	○	○	○	○	○

Are there other questions that you feel should be asked regarding the purpose of condition assessments?

3) When assessments are conducted, in what format is the resulting information provided? (Select all that apply and rank the usefulness of that format.) Base your answer on what you think is best not what you typically ask for or provide. Please specify others in the comment section.

	Best Format	Useful Format	Format to avoid
Excel spreadsheet	☐	☐	☐
Word or PDF Report	☐	☐	☐
Database	☐	☐	☐
Hard copy binder	☐	☐	☐

4) How is the FCA used once provided to the customer? If you are a consultant provide your best guess as to what you believe is the case.

- [ ] Sits on a shelf
- [ ] Disseminated to a few users
- [ ] Disseminated to multiple users
- [ ] Effort is made to make the information widely available to those in the organization
- [ ] Added manually to a computerized tracking system
- [ ] Imported into a computerized maintenance management system
- ( ) Other: _____

Other (please specify)

The questions in Section 2 pertain to the way information is structured and the information Hierarchy.

5) There generally is a state mandate or a requirement to structure the FCA in a particular format. (If so, provide any pertinent information in the comment section).

- ○ Strongly Disagree
- ○ Disagree
- ○ Undecided
- ○ Agree
- ○ Strongly Agree

6) Which of the following formats for categorizing assets are used most often to organize the information in a facility condition assessment.

	Always	For almost all assessments	Rarely	Never	I'm not sure
UniFormat (ASTM E1557)	○	○	○	○	○
MasterFormat	○	○	○	○	○
OmniClass	○	○	○	○	○

7) To obtain a better idea of the overall content for a FCA, which of the following are titled headings in your report?

- ☐ General Building Information
- ☐ Detailed Assessment Summaries
- ☐ Inspection Team Data
- ☐ Detailed Assessment Totals
- ☐ Facility Condition Categorization Descriptions
- ☐ Building Summary
- ☐ Deficiency Audit Report
- ☐ Photographs and Drawings
- ○ Other: _____

Section 3 requests your opinion about the Data Collection process for the FCA.

8) Which of the following tools are used for collecting data during facility condition assessments (Check all that apply)

- ☐ Forms
- ☐ I-pad
- ☐ Handheld computers
- ☐ Cameras
- ○ Other: _____

9) Which technologies are utilized while conducting facilities condition assessment surveys?

- ☐ Infrared thermographs
- ☐ Handheld laser measurements
- ☐ Moisture analyzers
- ☐ Smart level
- ☐ Tape measure
- ○ Other: _____

10) Are facility users consulted during the FCA process in order to identify deficiencies or functional issues of the spaces they occupy?

- ○ Yes
- ○ No

11) **Literature on how time consuming an assessment is scarce. Please estimate the time required to carry out an FCA survey from a generalized approximation standpoint.**

half a day	1 day	2 days	4 days	1 week	2 weeks	More than two weeks

							(please specify)
Complex Building e.g. laboratory, theater	☐	☐	☐	☐	☐	☐	☐
Typical Commercial Building e.g. office building	☐	☐	☐	☐	☐	☐	☐
Light Commercial e.g. warehouse	☐	☐	☐	☐	☐	☐	☐

12) How often should FCAs be carried out (per facility)?

- ☐ Once a year
- ☐ Every other year
- ☐ Once every three years
- ☐ Once every five years
- ☐ Other
- ○ Other: _____

Section 4 requests your opinion about the FCI Formula

13) The standard formula for the FCI is Deferred Maintenance ($) / Current Replacement Value ($). Which formula does your organization utilize?

- ☐ Deferred Maintenance ($) / Current Replacement Value ($)
- ☐ Deferred Maintenance ($) + Renewal Costs($) / Current Replacement Value ($)
- ☐ Deferred Maintenance ($) + Renewal Costs($) + Regulatory Compliance($) + Adaptation (ADA) ($) / Current Replacement Value ($)
- ○ Other: _____

14) The standard formula for calculating Current Replacement Value (CRV) is given as:

Gross square footage of the existing building multiplied by the estimated cost (per square foot) to design and build a new facility.

Is this the formula adopted by your organization?

- ○ Yes
- ○ No
- ○ Other: _____

15) How is s the CRV calculated?

- ☐ As an estimate by an internal estimator (no specific standard)
- ☐ As an estimate by an internal estimator (using a standard)
- ☐ By a formula determined by insurance requirements
- ○ Other: _____

Section 5 requests your opinion on the benefits and concerns of the FCI

16) Rate the following benefits of the FCI based on your personal opinion.

	Definite Agreement	Strong Agreement	Agree	Somewhat Agree	Disagree
Has been tried and tested since 1990	○	○	○	○	○
Industry has an acceptance of the thresholds set for good, fair, poor and critical conditions	○	○	○	○	○
Is used as a snapshot in time to compare similar assets	○	○	○	○	○
With a limited budget, the FCI can be used as a key performance indicator to identify buildings that need to be prioritized in terms of repair, maintenance and capital renewal	○	○	○	○	○
The FCI as a benchmark assists FMs reduce a back-log in deferred maintenance through its use in calculating "catch-up" costs and therefore assisting in getting budget approval	○	○	○	○	○

Are there any other benefits that should be included?

17) Rate the following concerns of the FCI based on your personal opinion.

	Definite Agreement	Strong Agreement	Agree	Somewhat Agree	Disagree
The FCI does not account for the condition of a facility's critical components and, therefore, on its own, fails to capture the important distinction between the condition of the facility and the condition of its	○	○	○	○	○

individual components

The FCI cannot be used to compare diverse assets	○	○	○	○	○
The FCI does not include future renewal projects	○	○	○	○	○
Values become rapidly outdated due to factors such as deterioration and is always relative to the year of the survey	○	○	○	○	○
CRV calculation is fluid and can differ year on year resulting in an inconsistent FCI and difficulty in benchmarking	○	○	○	○	○
The deferred maintenance aspect of the standard FCI formula does not prioritize relative importance of backlog associated with each system	○	○	○	○	○

Are there any other concerns that should be included?

APPENDIX D. DELPHI STUDY ROUND 2 SURVEY QUESTIONS

Facilities Condition Assessment Delphi (Round 2)

The purpose of Round 2 is to clarify those questions that were not clear in Round 1 and to also work toward closer consensus on the items that were not in consensus after the first round. **Please be sure to review the Round 1 results prior to taking this round.*

Round 2 is estimated to take approximately 8-10 minutes (or less since some of the questions in consensus were removed). Personal information is only requested to track results by respondent. Reported data will include only categorized results in aggregate and will not include personal or specific information for a single respondent.

Your participation in this research is greatly appreciated

1) Please provide:

Name: _____

State: _____

2) Do you have any comments regarding the results of Round 1?

Section 1 includes questions pertaining to the Purpose of a condition assessment.

3) Rank the following based on your personal opinion:

	Strong Agreement	Agree	Neither agree or disagree	Disagree	Strongly disagree
The Facilities Condition Index (FCI) is typically the overall desired metric	○	○	○	○	○
The FCI provides a good overall indication of the structure's condition level	○	○	○	○	○
Facilities Condition Assessments (FCA) should be tied to a scorecard of Key Performance Indicator (KPI)	○	○	○	○	○
One of the difficulties of a FCA is the subjectivity of the assessments	○	○	○	○	○
Most FCAs are conducted because there is a mandatory requirement	○	○	○	○	○
The resulting information from an FCA is used typically at the administrative level only	○	○	○	○	○

4) How is the FCA report distributed once provided to the owner (with 1 being the most prevalent)?

	1	2	3	4
Sits on a shelf	○	○	○	○
Disseminated to few users	○	○	○	○
Disseminated to multiple users	○	○	○	○
Effort is made to make the information widely available to those in the organization	○	○	○	○

your best guess as to what you believe is the case.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Added manually to a computerized tracking system	○	○	○	○	○
Imported into a computerized maintenance management system or Integrated with a Capital Plan Management System	○	○	○	○	○
Used to prioritize Capital spending.	○	○	○	○	○

The questions in Section 2 pertain to the way information is structured and the information Hierarchy.

6) There is generally a state (Government) mandate or requirement to structure the FCA in a particular format for public institutions. (If so, provide any pertinent information in the comment section).

- ○ Yes
- ○ I am not sure
- ○ No

7) Which of the following formats for categorizing assets are used most often to organize the information in a facility condition assessment.

	Always	For almost all assessments	Rarely	Never	I'm not sure
UniFormat (ASTM E1557)	○	○	○	○	○
MasterFormat	○	○	○	○	○
OmniClass	○	○	○	○	○
ASTM FACTS (GSA)	○	○	○	○	○
No standard format	○	○	○	○	○
Our own internally developed format	○	○	○	○	○

Section 3 requests your opinion about the Data Collection process for the FCA.

8) How frequently are the following technologies utilized while conducting facilities condition assessment surveys?

	Never	Rarely, 10% of surveys	Occasionally, 30% of surveys	Sometimes, 50% of surveys	Frequently, 70% of surveys	Usually, 90% of surveys	Every time
Infrared thermographs	○	○	○	○	○	○	○
Handheld laser measurements	○	○	○	○	○	○	○
Moisture analyzers	○	○	○	○	○	○	○
Smart level	○	○	○	○	○	○	○
Tape measure	○	○	○	○	○	○	○

9) ***Note question wording change* - Please estimate the time required to carry out an FCA survey from a generalized approximation standpoint for a 35,000 sq. ft. space in a 15 year old building.**

	half a day	1 day	2 days	4 days	1 week	2 weeks	More than two weeks (please specify)
Complex Building e.g. laboratory, theater, with a complex MEP system	○	○	○	○	○	○	○
Typical Commercial Building e.g. standard office building	○	○	○	○	○	○	○
Light Commercial e.g. warehouse	○	○	○	○	○	○	○

10) Based on your experience, how often should FCAs be carried out (per facility)? Please rank these in order of importance from 1 to 4 where 1 is the most feasible level of frequency to you and 4 is the least feasible level of frequency to you.

	1	2	3	4
Once a year	○	○	○	○
Every other year	○	○	○	○
Once every three years	○	○	○	○
Once every five years	○	○	○	○

Section 4 requests your opinion about the FCI Formula

11) The standard formula for the FCI is Deferred Maintenance ($) / Current Replacement Value ($). Which formula does your organization utilize?

	Never	Rarely, less than 10% of the time	Occasionally, about 30% of the time	Sometimes, about 50% of the time	Frequently, about 70% of the time	Usually, about 90% of the time	Every time
Deferred Maintenance ($) / Current Replacement Value ($)	○	○	○	○	○	○	○
Deferred Maintenance ($) + Renewal Costs($) / Current Replacement Value ($)	○	○	○	○	○	○	○
Deferred Maintenance ($) + Renewal Costs($) + Regulatory Compliance($) + Adaptation (ADA) ($) / Current Replacement Value ($)	○	○	○	○	○	○	○
Deferred Capital Renewal ($) + Current FY Recapitalization Costs/CRV for total Database Value	○	○	○	○	○	○	○

12) What do you feel is the best and most appropriate method to calculate the CRV for most owners?

- ○ As an estimate by an internal estimator (no specific standard)
- ○ As an estimate by an internal estimator (using a standard)
- ○ By a formula determined by insurance requirements
- ○ Using industry determined cost per square foot building models

Section 5 requests your opinion on the benefits and concerns of the FCI

13) Rate the following benefits of the FCI based on your personal opinion.

	Strong Agreement	Agree	Neither agree or disagree	Disagree	Strongly disagree
Is a tried and tested metric	○	○	○	○	○
The FCI creates a common language among organizational staff to describe the condition of assets	○	○	○	○	○
Industry has an acceptance of the thresholds set for good, fair, poor and critical conditions	○	○	○	○	○
The FCI is used as a snapshot in time to compare similar assets	○	○	○	○	○
With a limited budget, the FCI can be used as a key performance indicator to identify buildings that need to be prioritized in terms of repair, maintenance and capital renewal	○	○	○	○	○
The FCI as a benchmark assists FMs reduce a back-log in deferred maintenance through its use in calculating "catch-up" costs and therefore assisting in getting budget approval	○	○	○	○	○
The FCI is a good indicator of whether maintenance is being carried out	○	○	○	○	○
The FCI is a good indicator of renovation opportunities	○	○	○	○	○

Are there any other benefits that should be included?

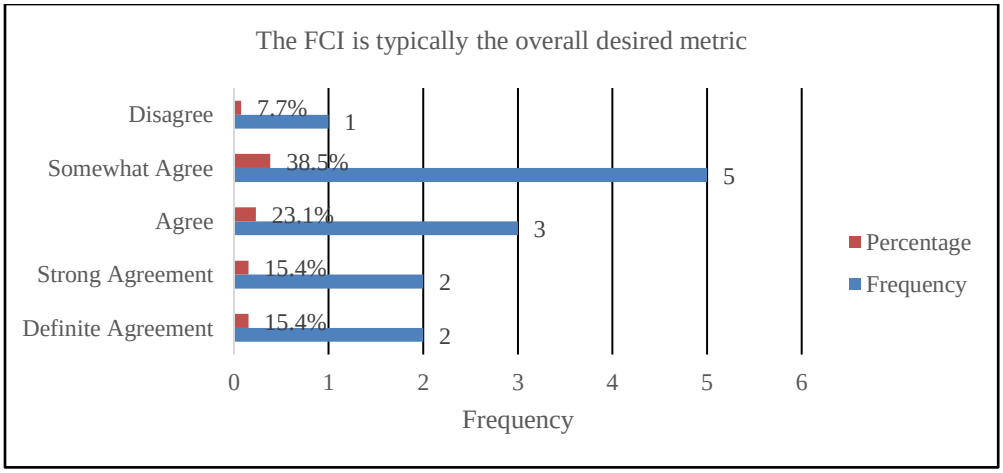
14) Rate the following concerns of the FCI based on your personal opinion.

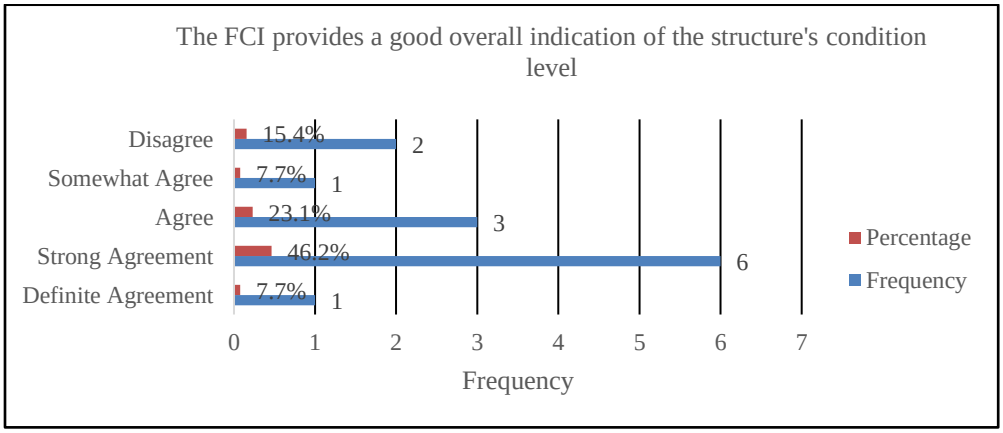
	Strong Agreement	Agree	Neither agree or disagree	Disagree	Strongly disagree
The FCI does not account for the condition of a facility's critical components and, therefore, on its own, fails to capture the important distinction between the condition of the facility and the condition of its individual components	○	○	○	○	○
The FCI cannot be used to compare diverse assets	○	○	○	○	○
The FCI does not include future renewal projects	○	○	○	○	○
Values become rapidly outdated due to factors such as deterioration and is always relative to the year of the survey	○	○	○	○	○
CRV calculation is fluid and can differ year on year resulting in an inconsistent FCI and difficulty in benchmarking	○	○	○	○	○
The deferred maintenance aspect of the standard FCI formula does not prioritize relative importance of backlog associated with each system	○	○	○	○	○
The industry is moving past the FCI and towards more predictive approaches to manage deficiencies	○	○	○	○	○

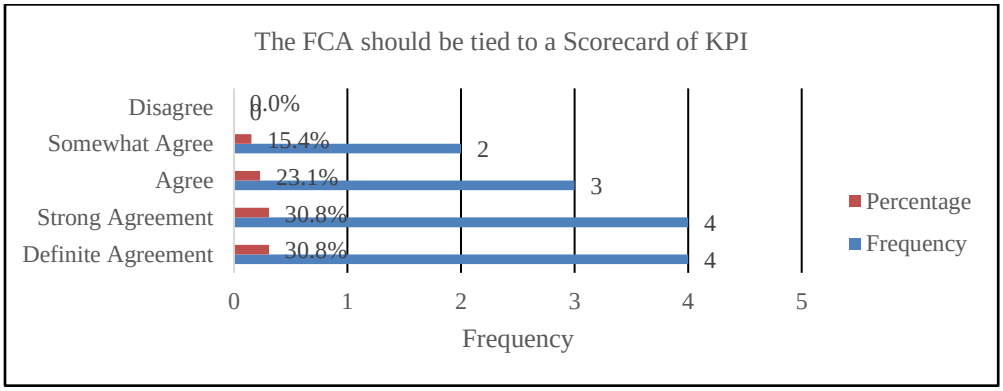
Are there any other concerns that should be included?

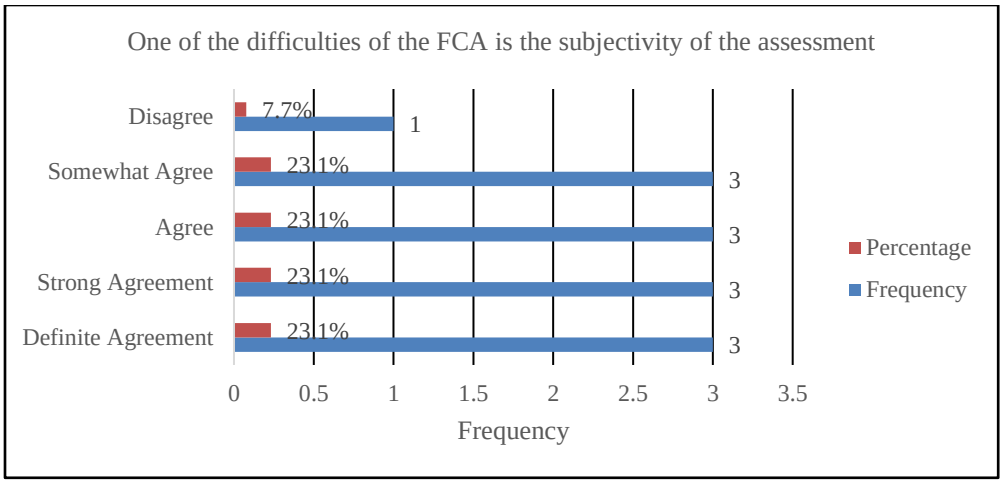
APPENDIX E. SUMMARY RESPONSE HISTOGRAMS – ROUND 1

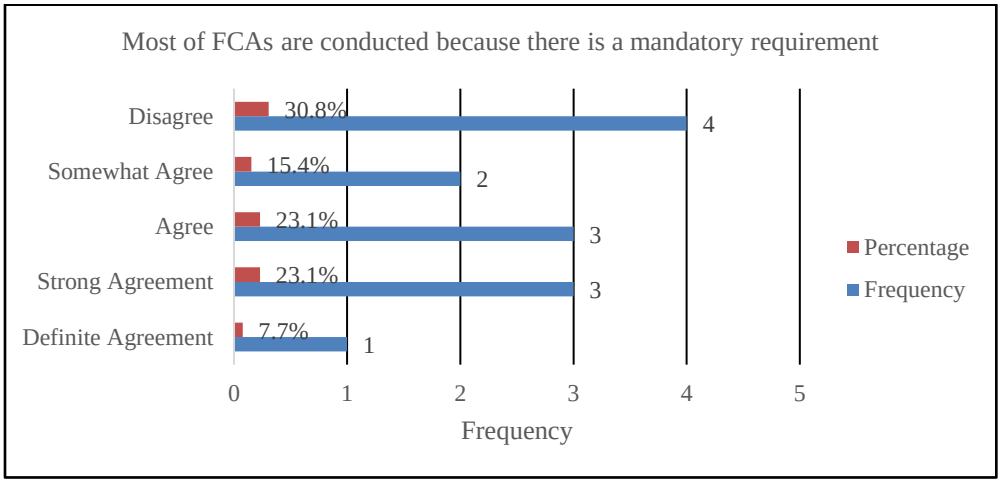
QUESTION 2

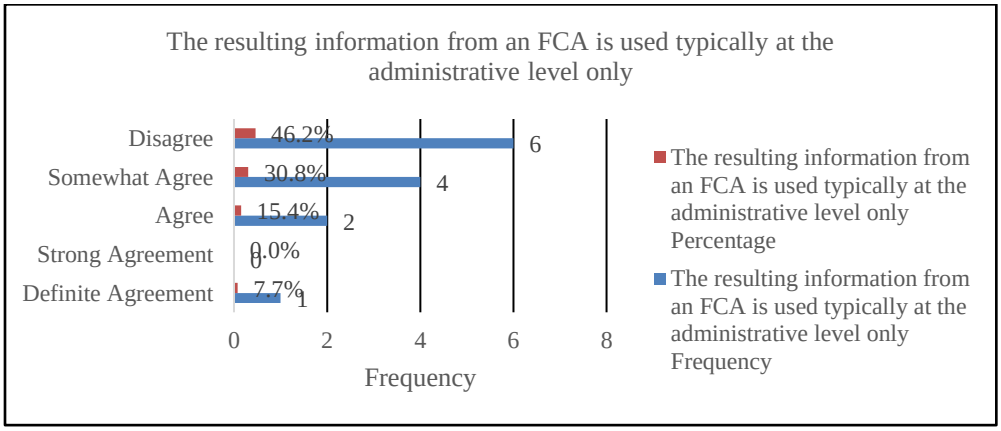




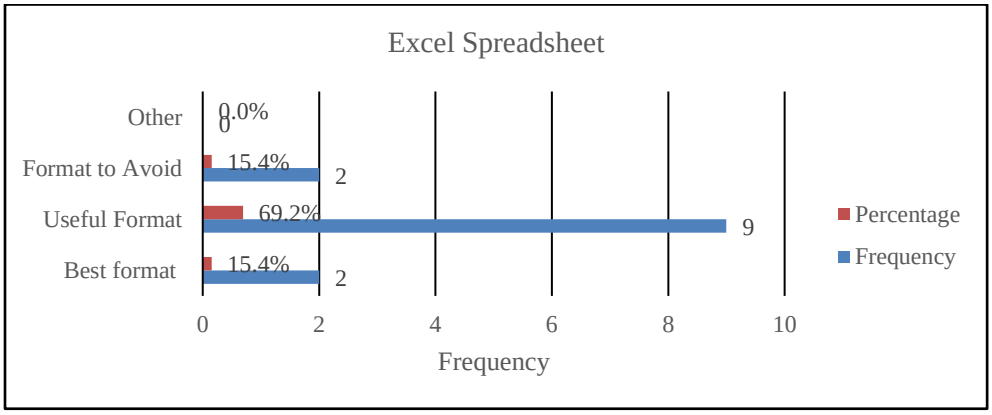


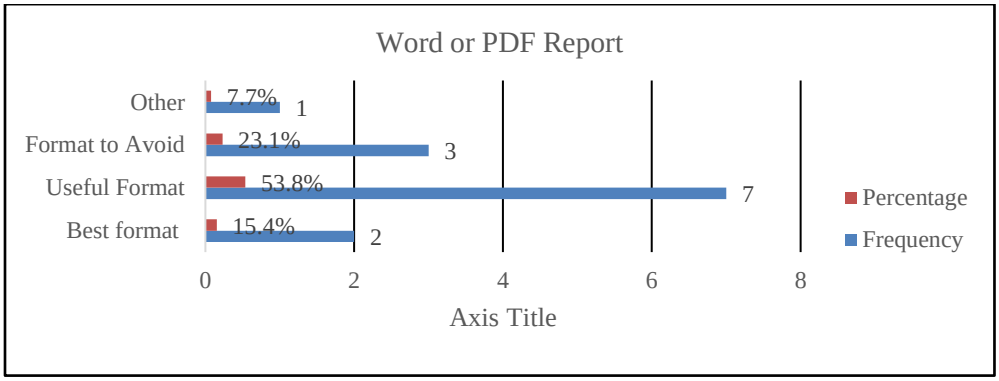

One of the difficulties of the FCA is the subjectivity of the assessment
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
7.7%
23.1%
23.1%
23.1%
23.1%
1
3
3
3
3
0
0.5
1
1.5
2
2.5
3
3.5
Frequency
Percentage
Frequency

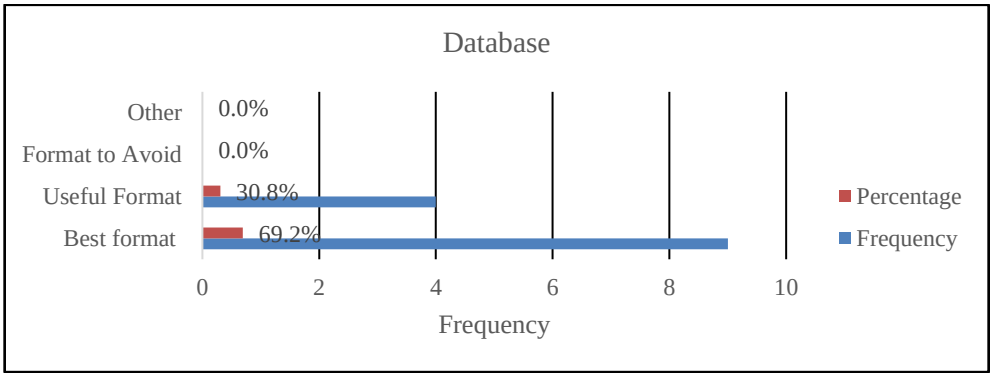

Most of FCAs are conducted because there is a mandatory requirement
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
30.8%
15.4%
23.1%
23.1%
7.7%
4
2
3
3
1
0
1
2
3
4
5
Frequency
Percentage
Frequency

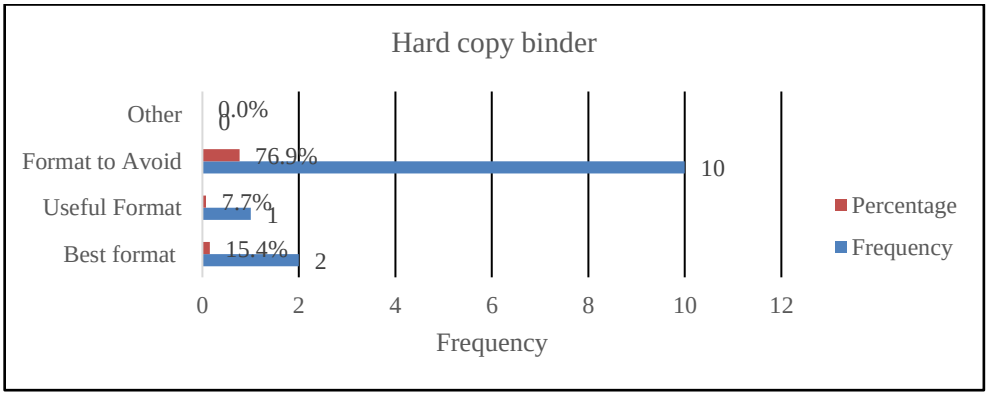

The resulting information from an FCA is used typically at the administrative level only
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
46.2%
30.8%
15.4%
0.0%
7.7%
6
4
2
0
1
0
2
4
6
8
Frequency
The resulting information from an FCA is used typically at the administrative level only Percentage
The resulting information from an FCA is used typically at the administrative level only Frequency

QUESTION 3

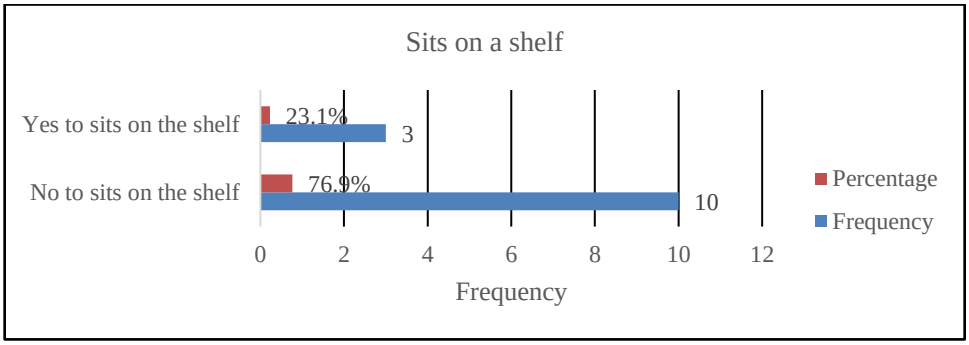

Excel Spreadsheet
Other
Format to Avoid
Useful Format
Best format
0.0%
0
15.4%
2
69.2%
9
15.4%
2
0
2
4
6
8
10
Frequency
Percentage
Frequency

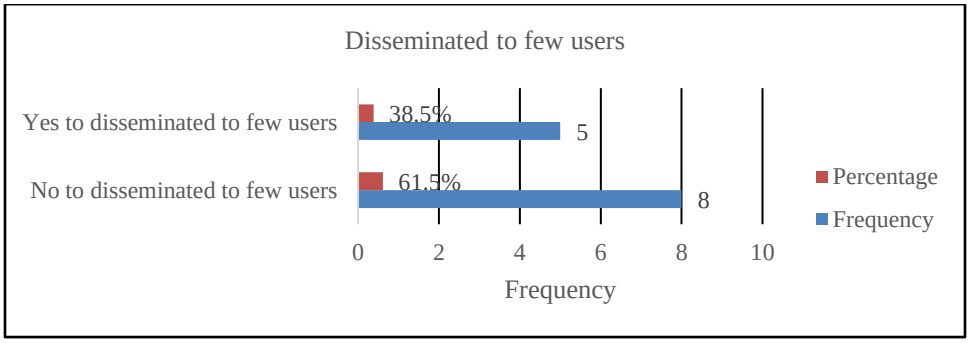

Word or PDF Report
Other
Format to Avoid
Useful Format
Best format
7.7%
1
23.1%
3
53.8%
7
15.4%
2
0
2
4
6
8
Axis Title
Percentage
Frequency

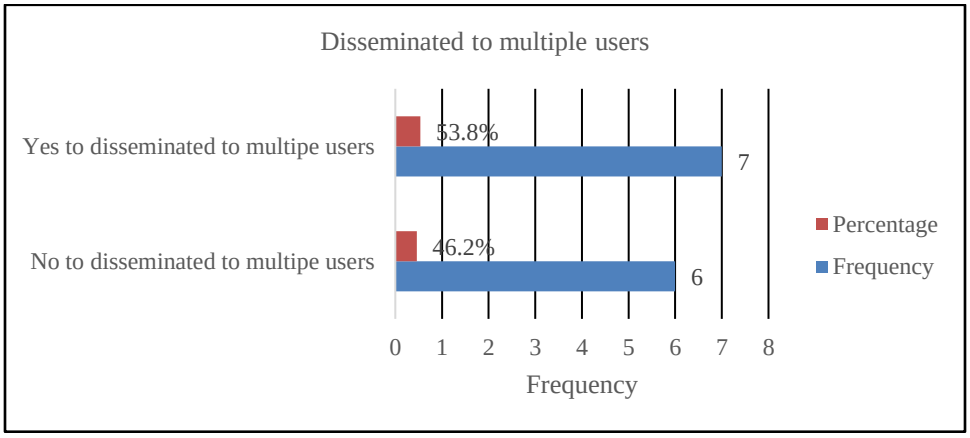

Database
Other
Format to Avoid
Useful Format
Best format
0.0%
0.0%
30.8%
69.2%
0
2
4
6
8
10
Frequency
Percentage
Frequency

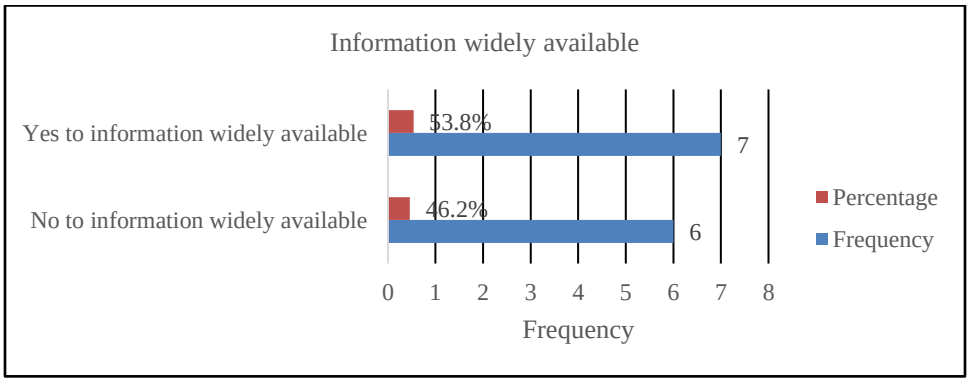

Hard copy binder
Other
Format to Avoid
Useful Format
Best format
0.0%
0
76.9%
10
7.7%
1
15.4%
2
0
2
4
6
8
10
12
Frequency
Percentage
Frequency

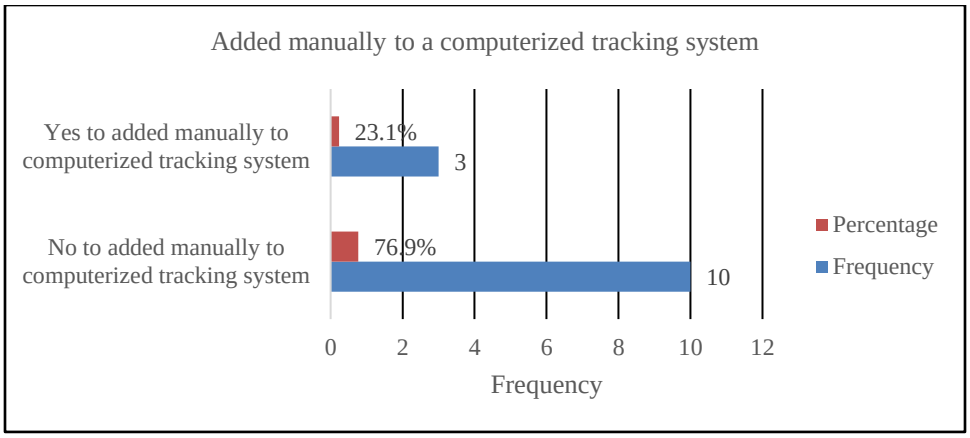
QUESTION 4

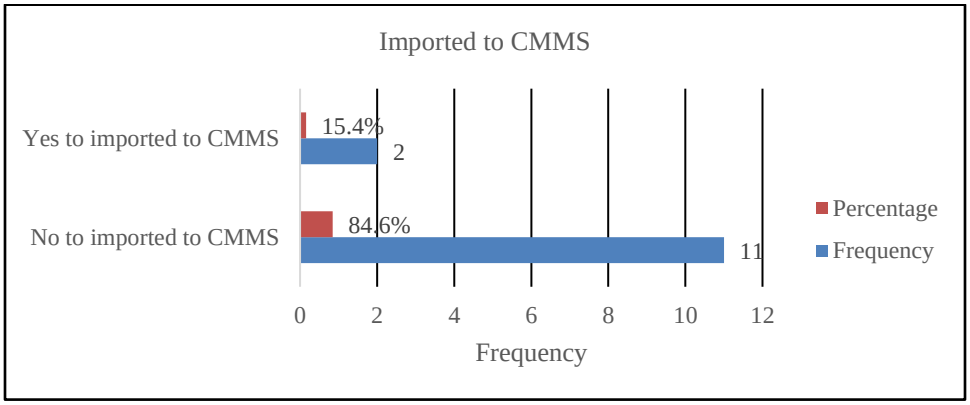

Sits on a shelf
Yes to sits on the shelf
No to sits on the shelf
23.1%
3
76.9%
10
0
2
4
6
8
10
12
Frequency
Percentage
Frequency


Disseminated to few users
Yes to disseminated to few users
No to disseminated to few users
38.5%
5
61.5%
8
0
2
4
6
8
10
Frequency
Percentage
Frequency

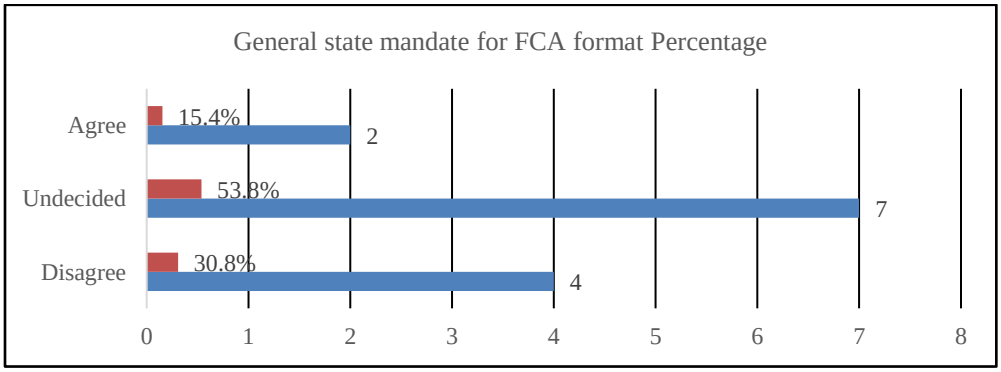

Disseminated to multiple users
Yes to disseminated to multipe users
No to disseminated to multipe users
53.8%
7
46.2%
6
0
1
2
3
4
5
6
7
8
Frequency
Percentage
Frequency


Information widely available
Yes to information widely available
No to information widely available
53.8%
7
46.2%
6
0
1
2
3
4
5
6
7
8
Frequency
Percentage
Frequency

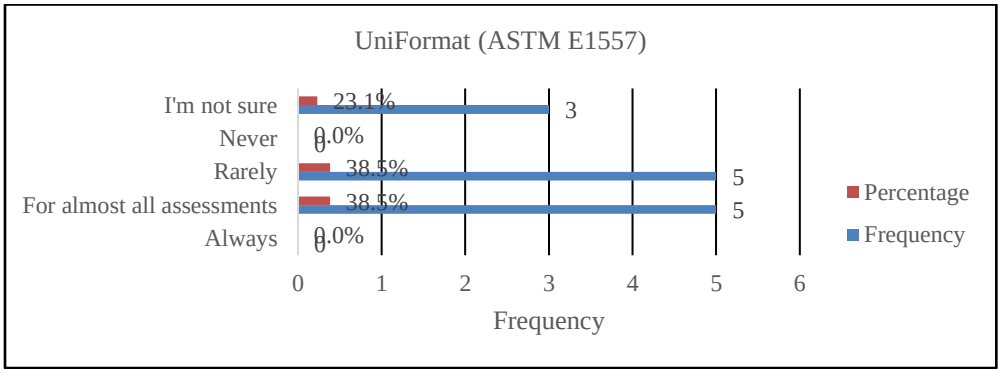

Added manually to a computerized tracking system
Yes to added manually to computerized tracking system
23.1%
3
No to added manually to computerized tracking system
76.9%
10
0
2
4
6
8
10
12
Frequency
Percentage
Frequency

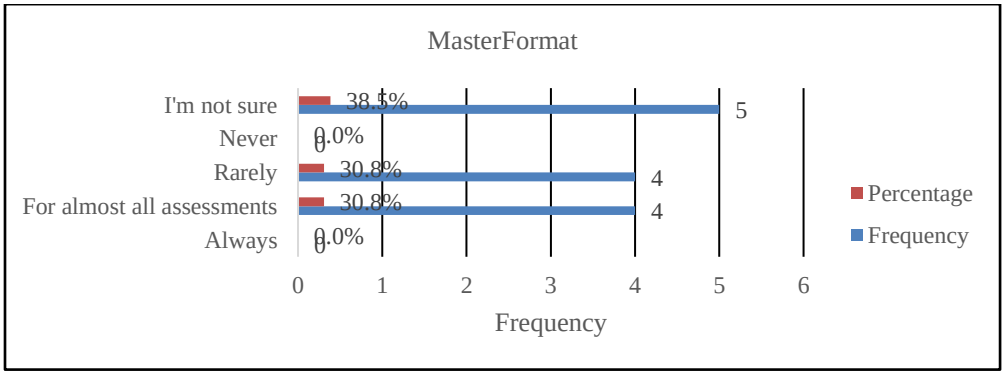

Imported to CMMS
Yes to imported to CMMS
15.4%
2
No to imported to CMMS
84.6%
11
0
2
4
6
8
10
12
Frequency
Percentage
Frequency

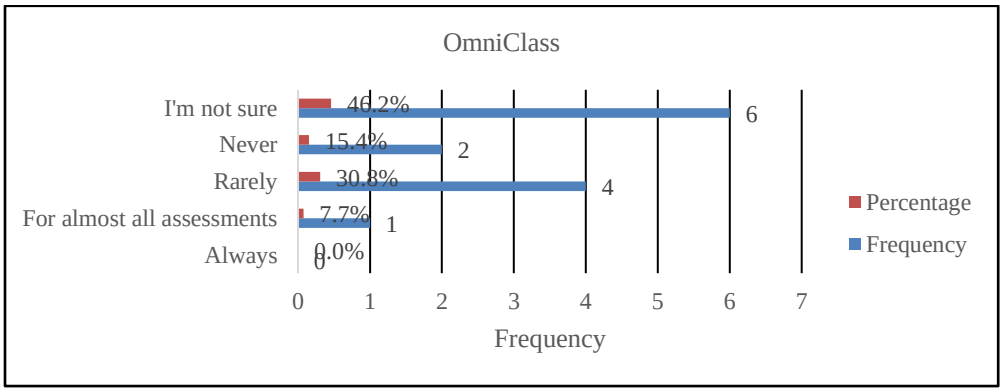
QUESTION 5


General state mandate for FCA format Percentage
Agree
15.4%
2
Undecided
53.8%
7
Disagree
30.8%
4
0
1
2
3
4
5
6
7
8

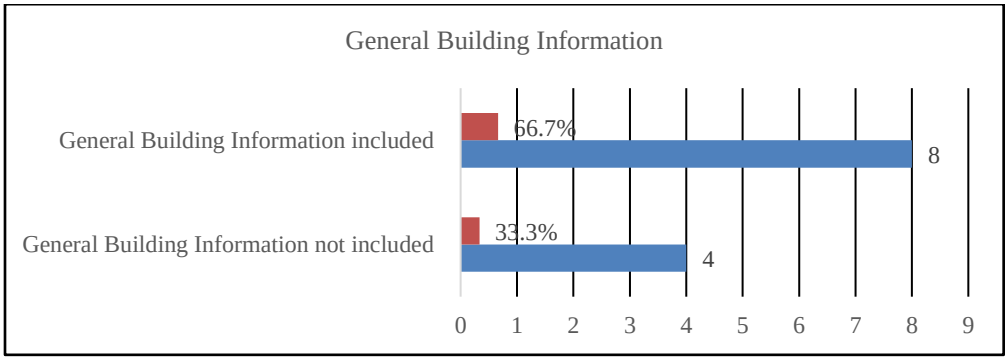
QUESTION 6

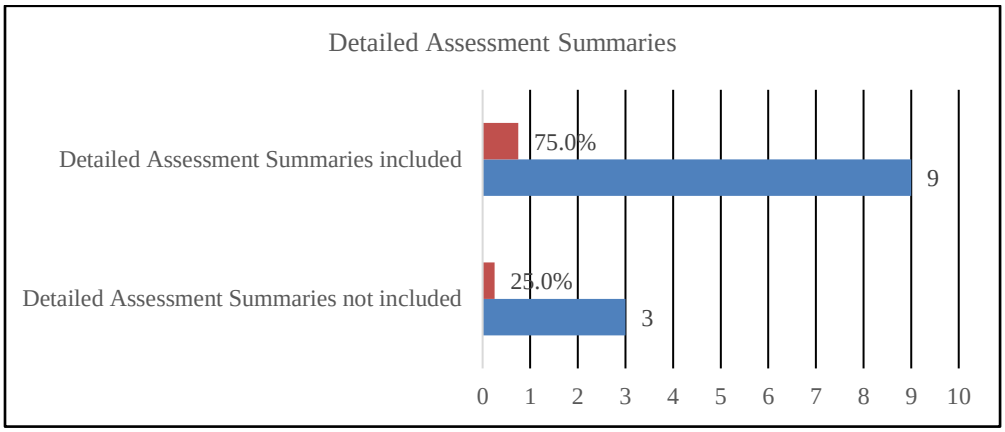


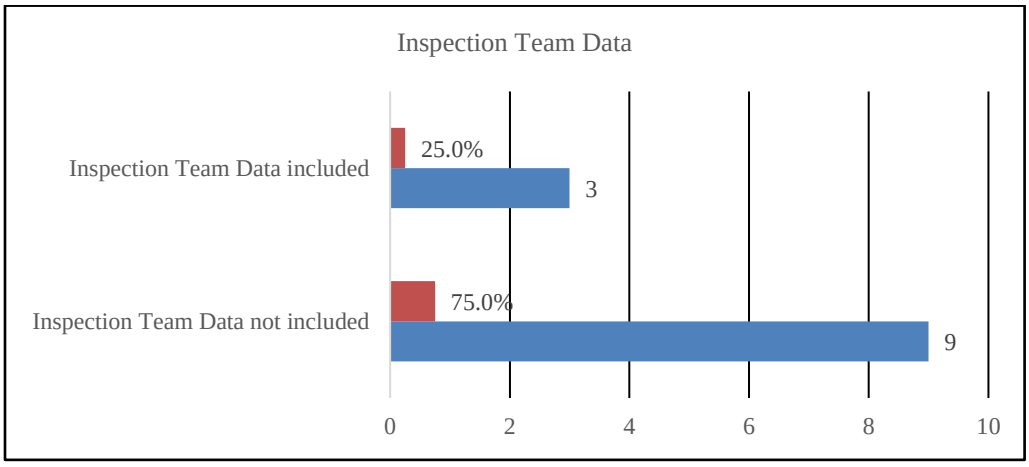


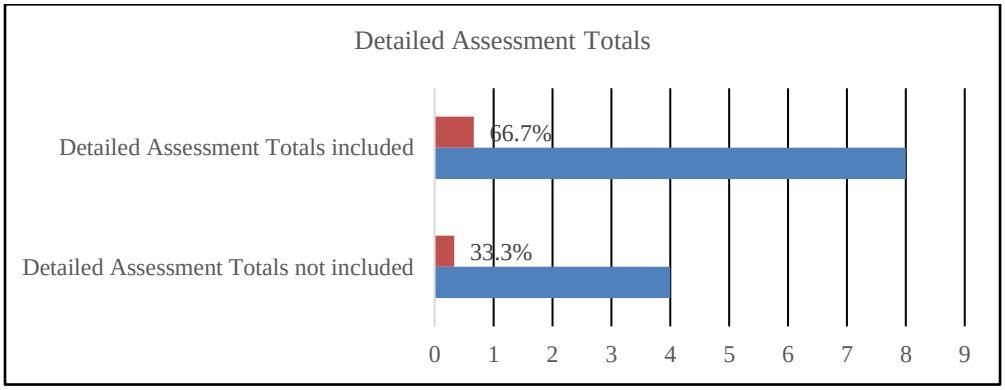


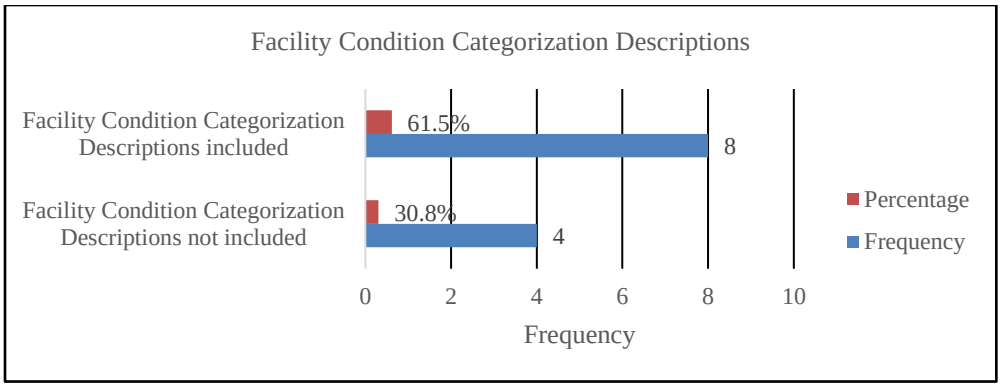
QUESTION 7

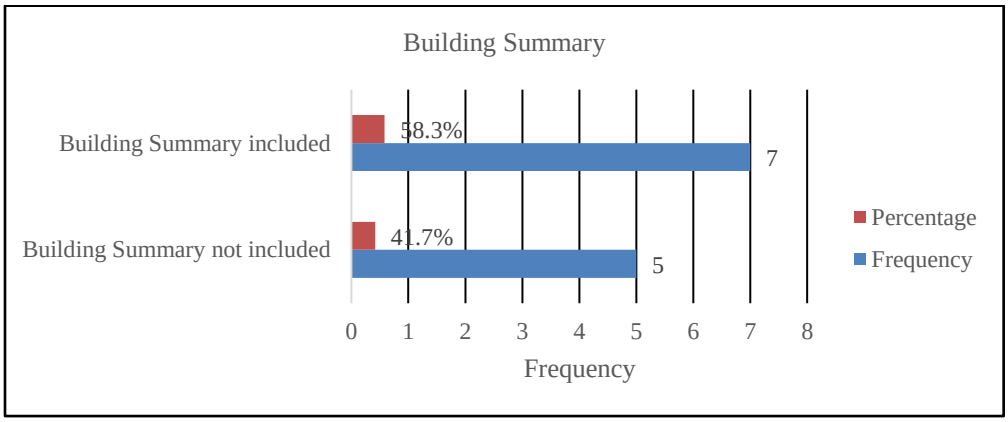


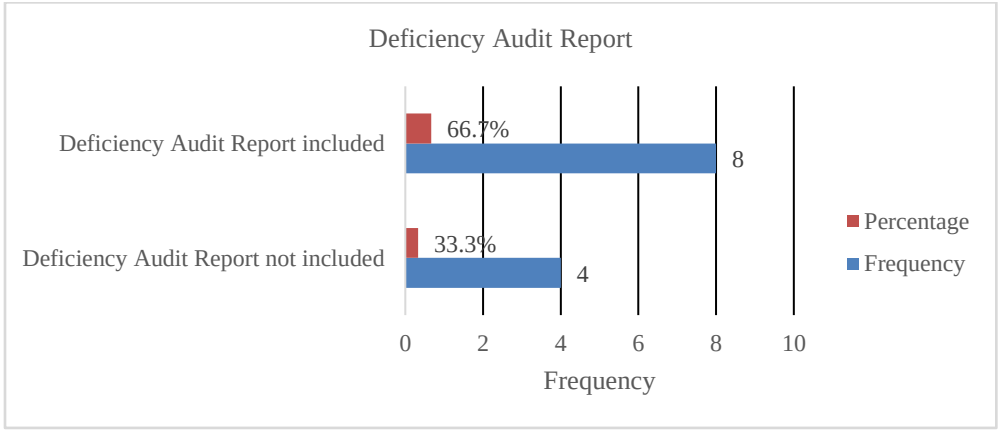

Detailed Assessment Summaries
Detailed Assessment Summaries included
75.0%
9
Detailed Assessment Summaries not included
25.0%
3
0 1 2 3 4 5 6 7 8 9 10

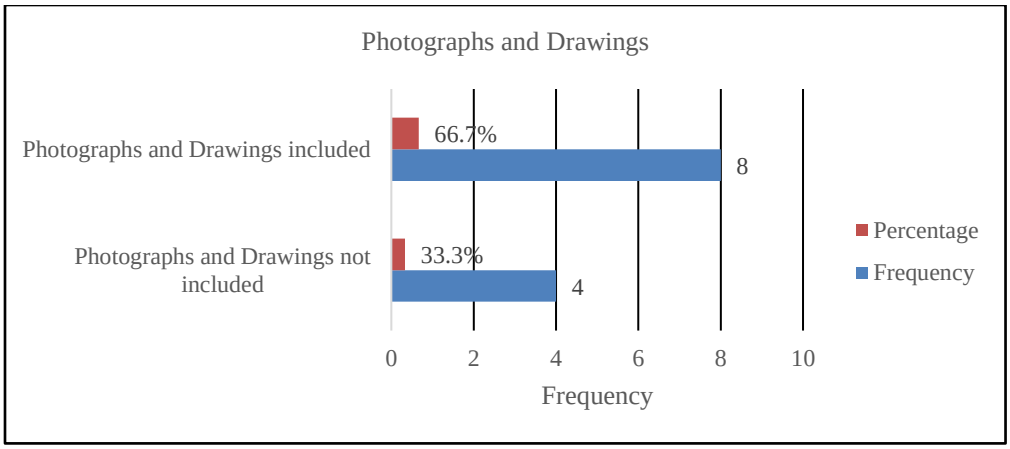

Inspection Team Data
Inspection Team Data included
25.0%
3
Inspection Team Data not included
75.0%
9
0 2 4 6 8 10


Detailed Assessment Totals
Detailed Assessment Totals included
66.7%
Detailed Assessment Totals not included
33.3%
0 1 2 3 4 5 6 7 8 9

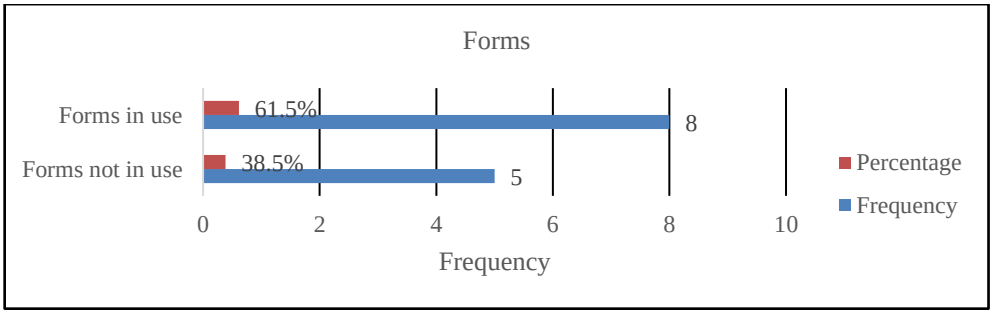

Facility Condition Categorization Descriptions
Facility Condition Categorization Descriptions included
61.5%
8
Facility Condition Categorization Descriptions not included
30.8%
4
Percentage
Frequency
0
2
4
6
8
10
Frequency

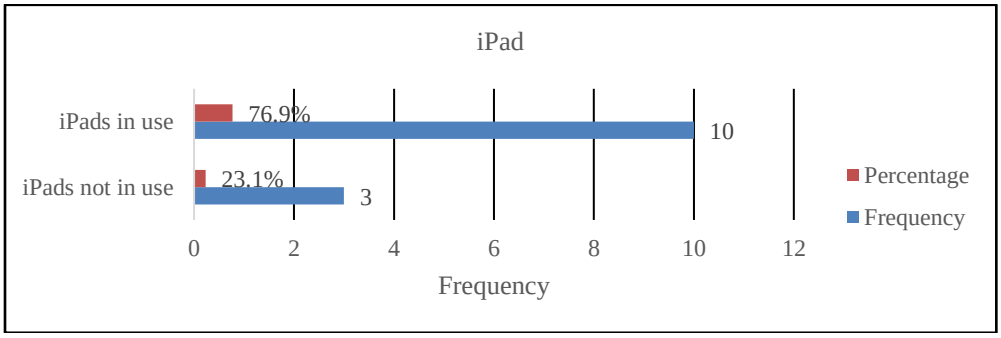

Building Summary
Building Summary included
58.3%
7
Building Summary not included
41.7%
5
Percentage
Frequency
0
1
2
3
4
5
6
7
8
Frequency

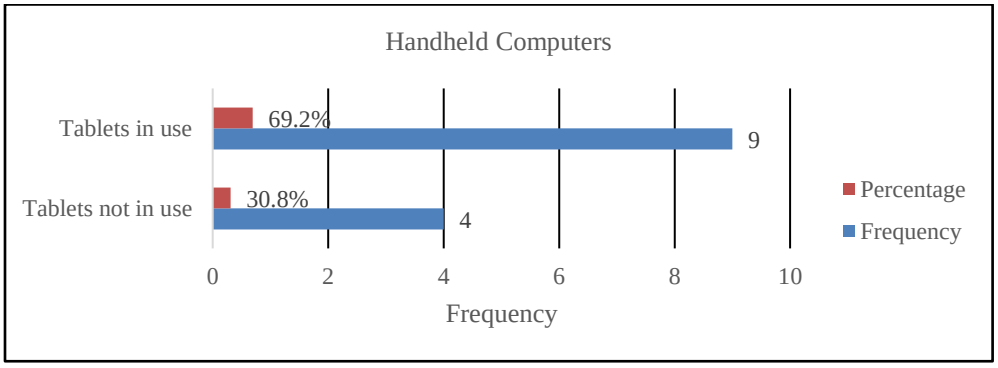

Deficiency Audit Report
Deficiency Audit Report included
66.7%
8
Deficiency Audit Report not included
33.3%
4
Percentage
Frequency
0
2
4
6
8
10
Frequency

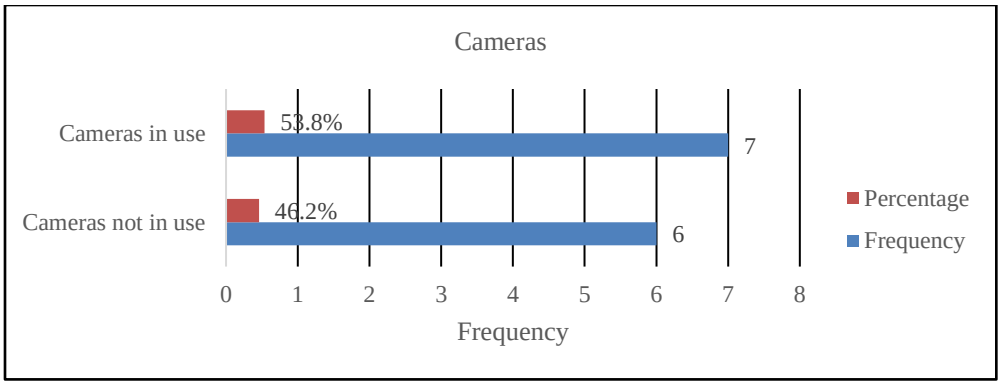

Photographs and Drawings
Photographs and Drawings included
66.7%
8
Photographs and Drawings not included
33.3%
4
Percentage
Frequency
0
2
4
6
8
10
Frequency

QUESTION 8

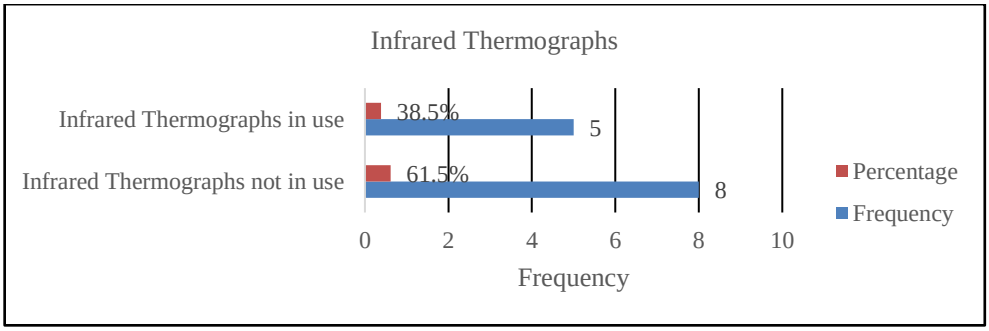

Forms
Forms in use
61.5%
8
Forms not in use
38.5%
5
Percentage
Frequency
0
2
4
6
8
10
Frequency

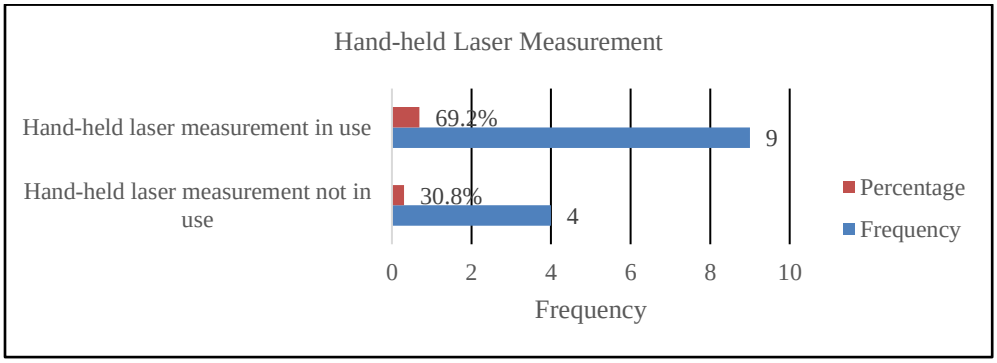

iPad
iPads in use
76.9%
10
iPads not in use
23.1%
3
Percentage
Frequency
0
2
4
6
8
10
12
Frequency

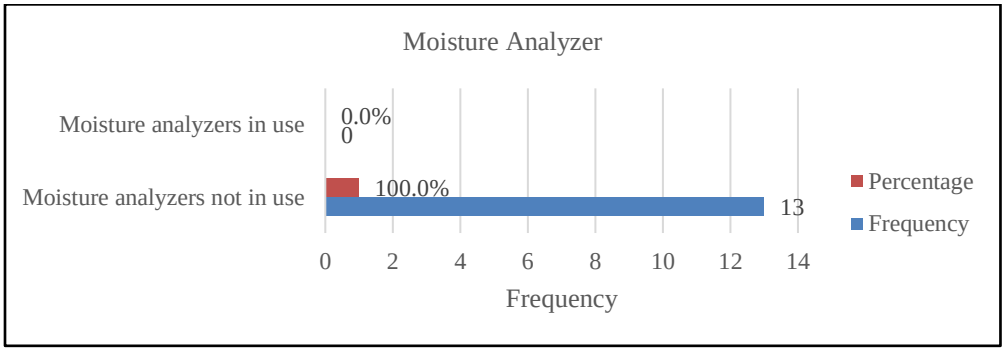

Handheld Computers
Tablets in use
69.2%
9
Tablets not in use
30.8%
4
Percentage
Frequency
0
2
4
6
8
10
Frequency

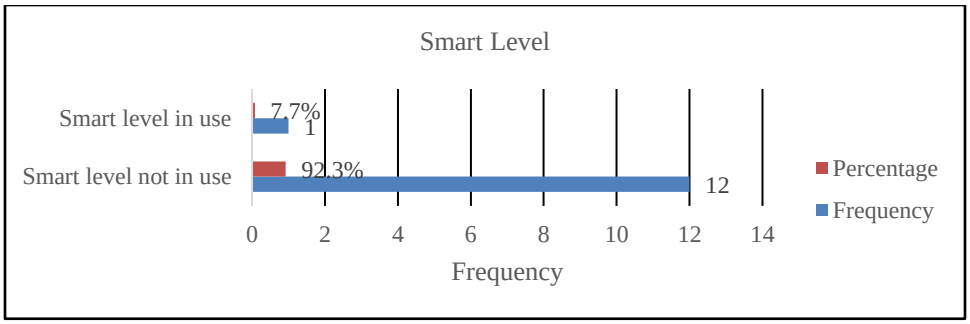

Cameras
Cameras in use
Cameras not in use
53.8%
46.2%
7
6
Percentage
Frequency
0 1 2 3 4 5 6 7 8
Frequency

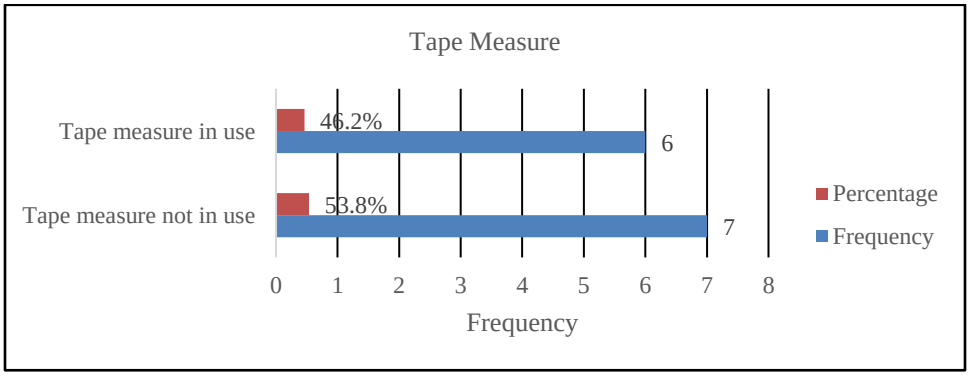
QUESTION 9


Infrared Thermographs
Infrared Thermographs in use
Infrared Thermographs not in use
38.5%
61.5%
5
8
Percentage
Frequency
0 2 4 6 8 10
Frequency

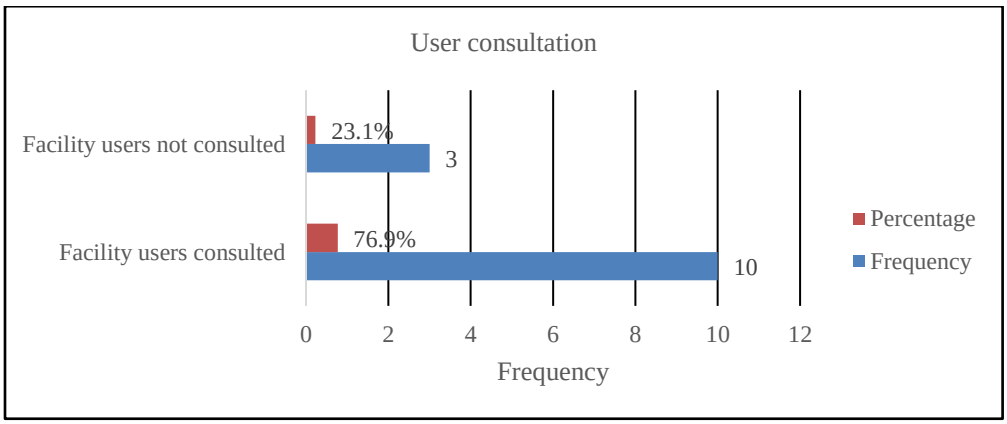

Hand-held Laser Measurement
Hand-held laser measurement in use
Hand-held laser measurement not in use
69.2%
30.8%
9
4
Percentage
Frequency
0 2 4 6 8 10
Frequency


Moisture Analyzer
Moisture analyzers in use
Moisture analyzers not in use
0.0%
0
100.0%
13
Percentage
Frequency
0 2 4 6 8 10 12 14
Frequency

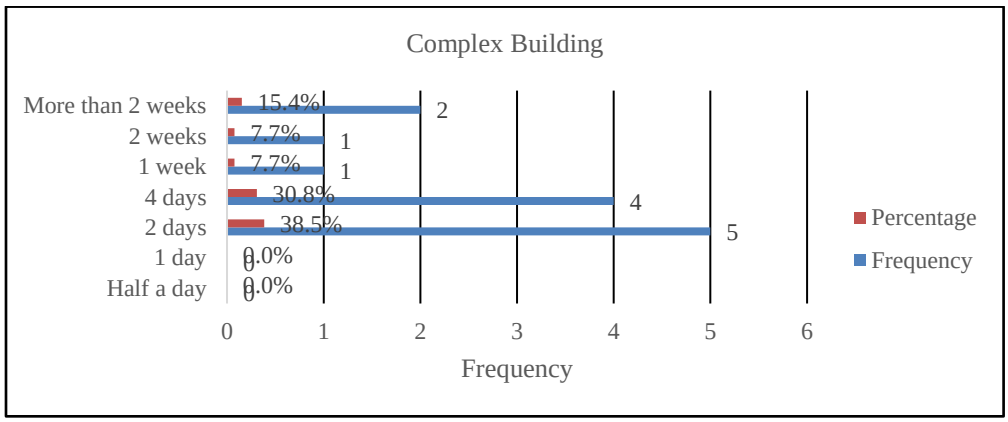

Smart Level
Smart level in use
Smart level not in use
7.7%
1
92.3%
12
0
2
4
6
8
10
12
14
Frequency
Percentage
Frequency

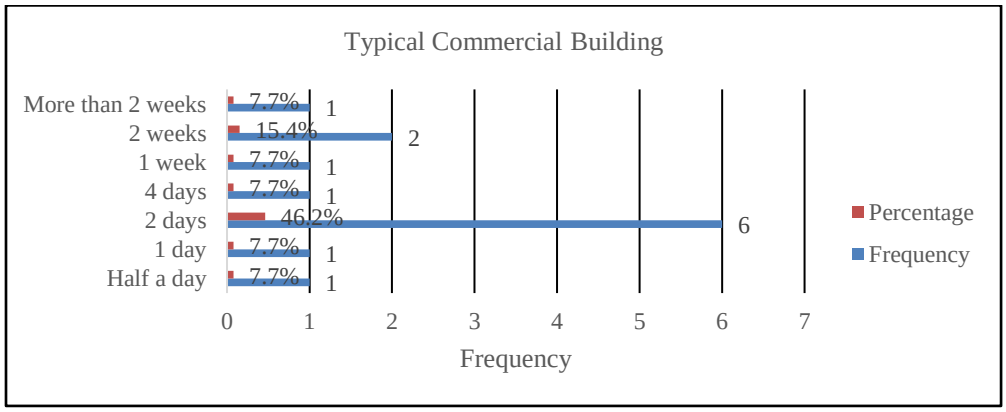

Tape Measure
Tape measure in use
Tape measure not in use
46.2%
6
53.8%
7
0
1
2
3
4
5
6
7
8
Frequency
Percentage
Frequency

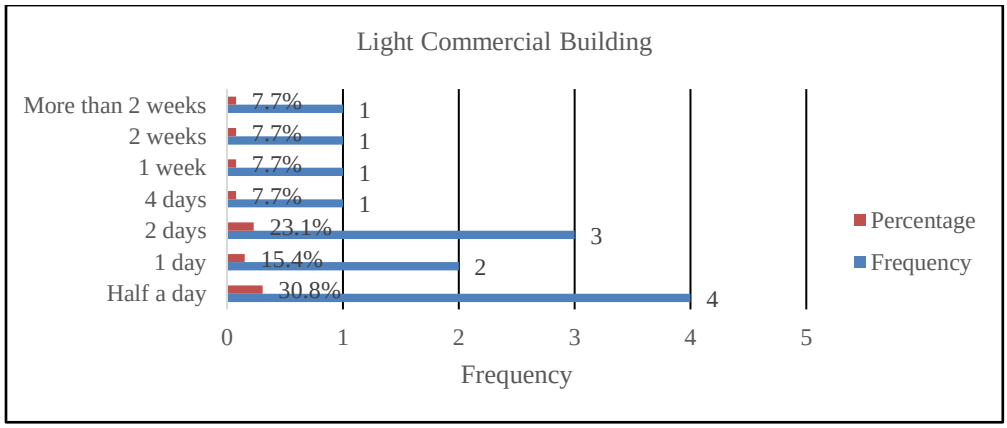
QUESTION 10


User consultation
Facility users not consulted
Facility users consulted
23.1%
3
76.9%
10
0
2
4
6
8
10
12
Frequency
Percentage
Frequency

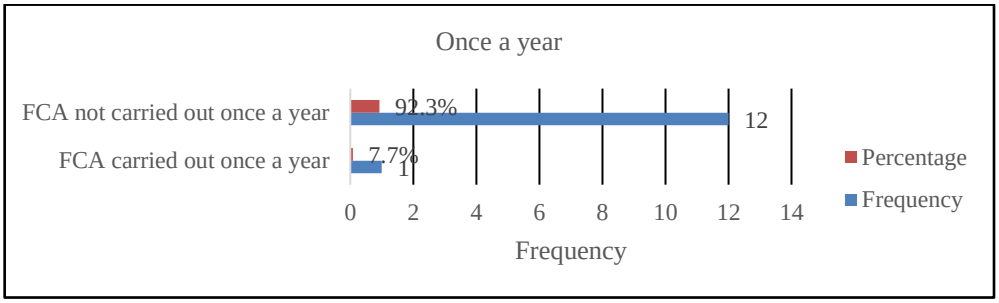
QUESTION 11

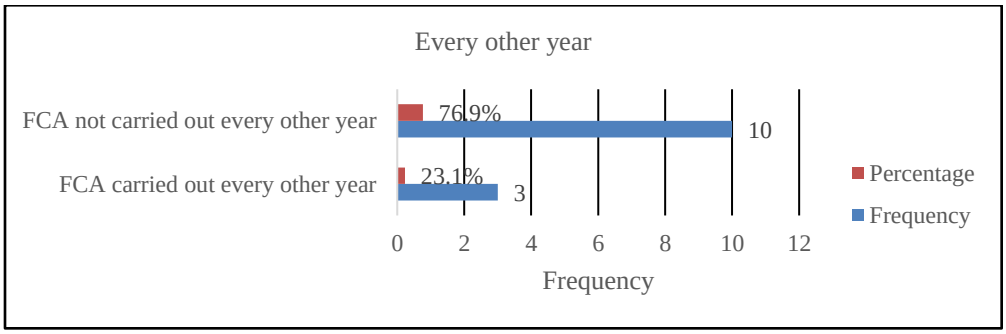

Complex Building
More than 2 weeks
2 weeks
1 week
4 days
2 days
1 day
Half a day
15.4%
7.7%
7.7%
30.8%
38.5%
0.0%
0.0%
2
1
1
4
5
0
0
Percentage
Frequency
0 1 2 3 4 5 6
Frequency

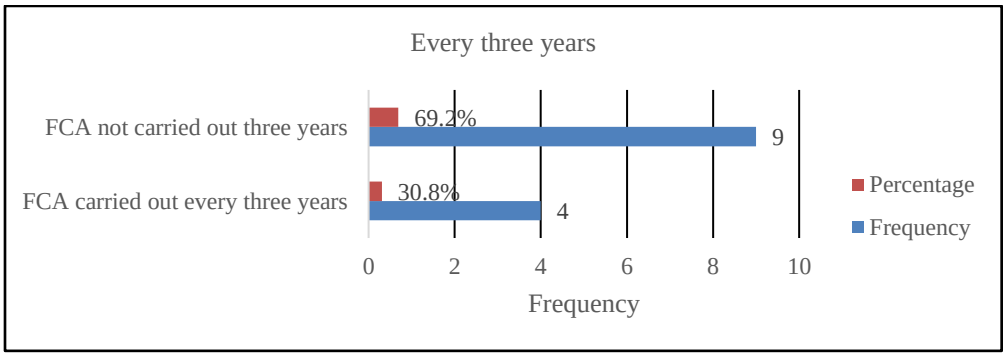

Typical Commercial Building
More than 2 weeks
2 weeks
1 week
4 days
2 days
1 day
Half a day
7.7%
15.4%
7.7%
7.7%
46.2%
7.7%
7.7%
1
2
1
1
6
1
1
Percentage
Frequency
0 1 2 3 4 5 6 7
Frequency

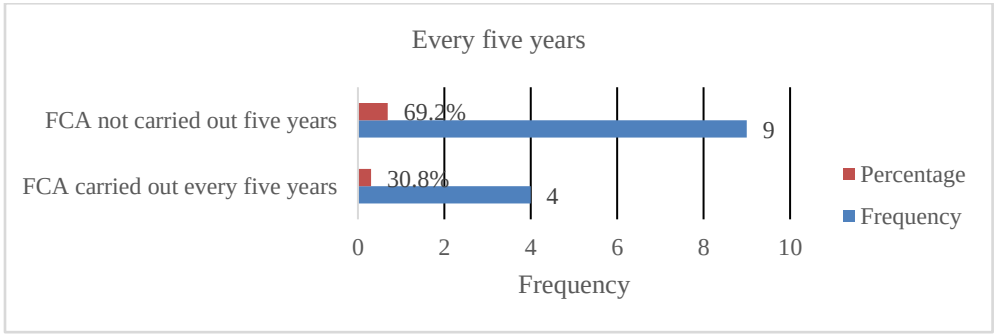

Light Commercial Building
More than 2 weeks
2 weeks
1 week
4 days
2 days
1 day
Half a day
7.7%
7.7%
7.7%
7.7%
23.1%
15.4%
30.8%
1
1
1
1
3
2
4
Percentage
Frequency
0 1 2 3 4 5
Frequency

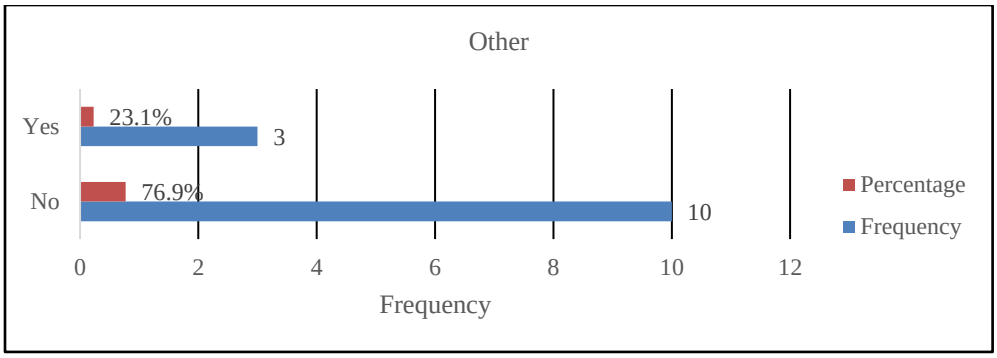
QUESTION 12

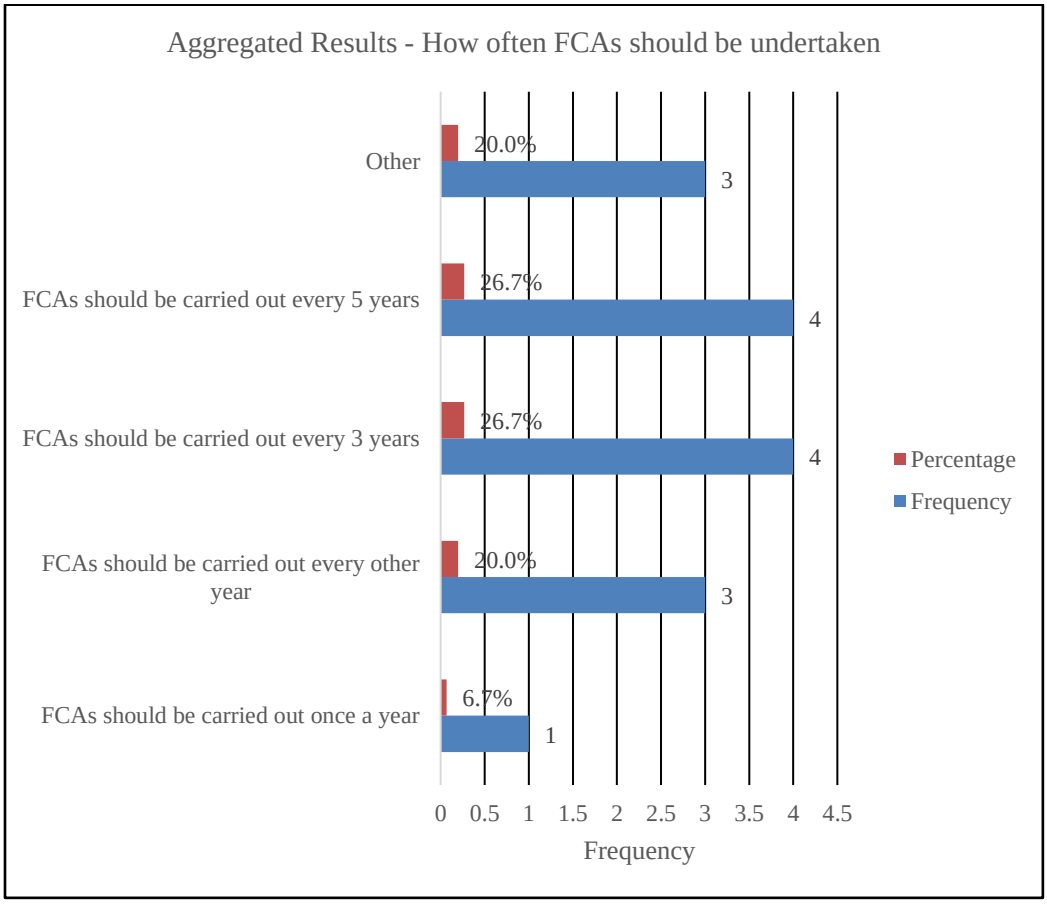

Once a year
FCA not carried out once a year
FCA carried out once a year
92.3%
12
7.7%
1
0 2 4 6 8 10 12 14
Frequency
Percentage
Frequency


Every other year
FCA not carried out every other year
FCA carried out every other year
76.9%
10
23.1%
3
0 2 4 6 8 10 12
Frequency
Percentage
Frequency

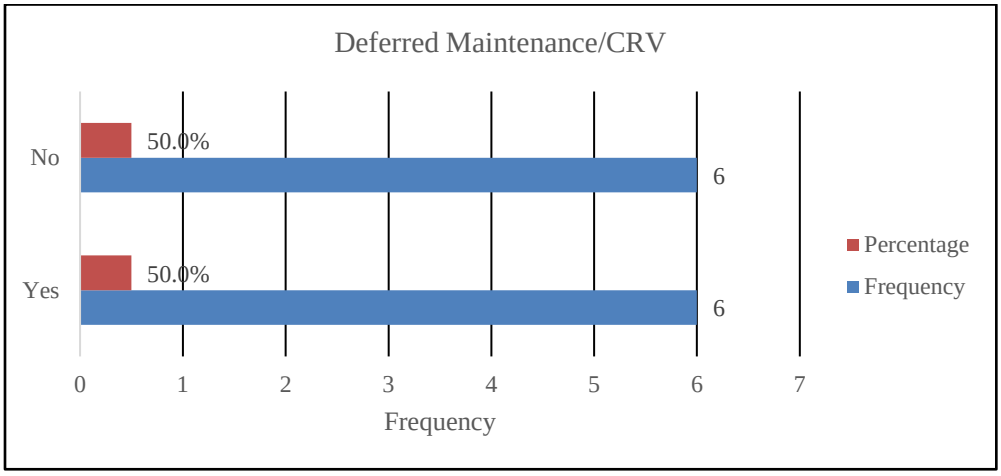

Every three years
FCA not carried out three years
FCA carried out every three years
69.2%
9
30.8%
4
0 2 4 6 8 10
Frequency
Percentage
Frequency

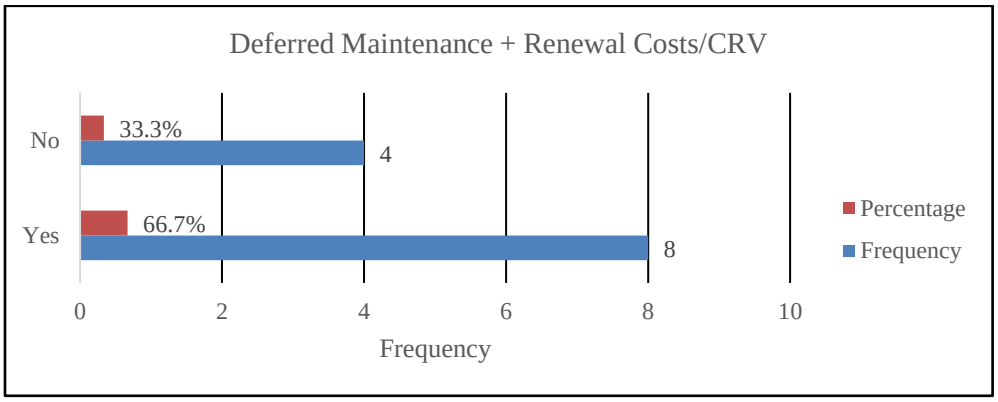

Every five years
FCA not carried out five years
FCA carried out every five years
69.2%
9
30.8%
4
0 2 4 6 8 10
Frequency
Percentage
Frequency

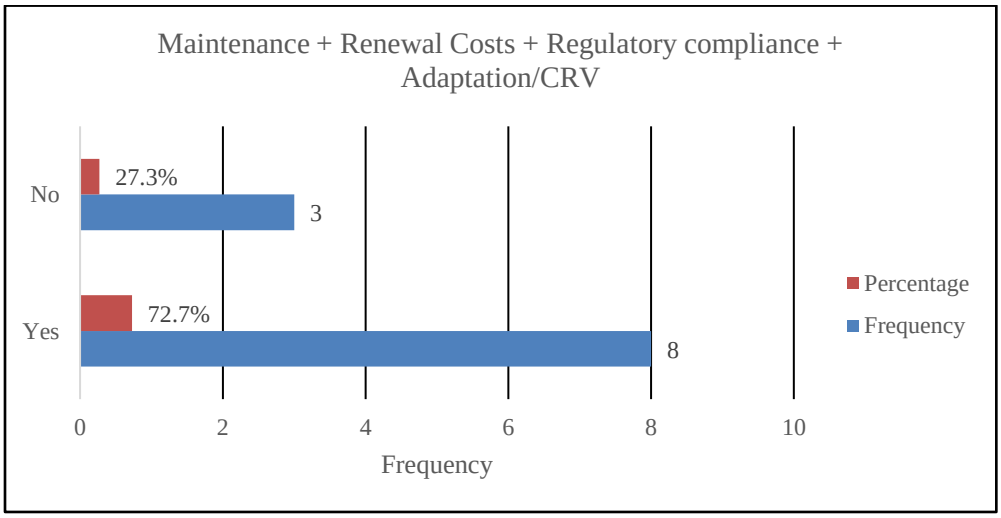

Other
Yes
23.1%
3
No
76.9%
10
0
2
4
6
8
10
12
Frequency
Percentage
Frequency


Aggregated Results - How often FCAs should be undertaken
Other
20.0%
3
FCAs should be carried out every 5 years
26.7%
4
FCAs should be carried out every 3 years
26.7%
4
FCAs should be carried out every other year
20.0%
3
FCAs should be carried out once a year
6.7%
1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Frequency
Percentage
Frequency

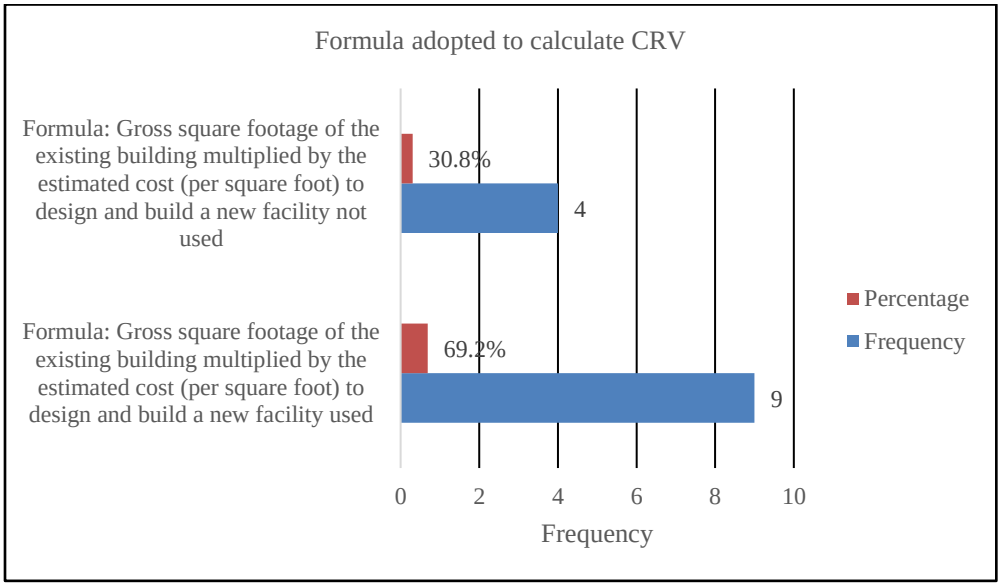
QUESTION 13


Deferred Maintenance/CRV
No
Yes
50.0%
50.0%
6
6
Percentage
Frequency
0
1
2
3
4
5
6
7
Frequency

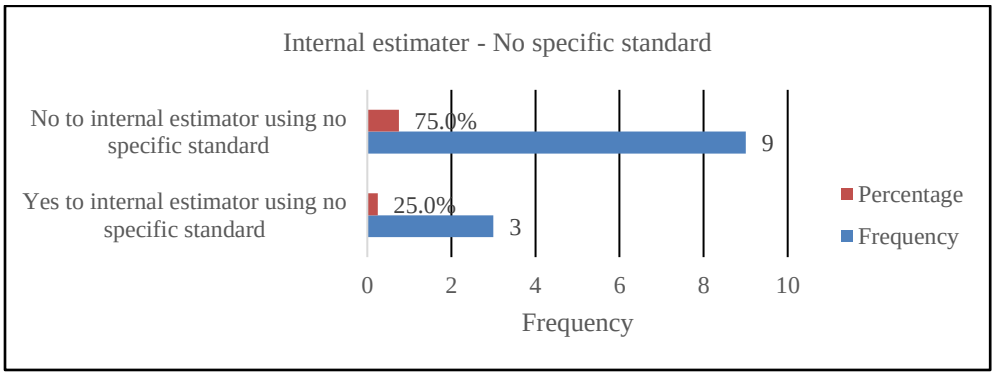

Deferred Maintenance + Renewal Costs/CRV
No
Yes
33.3%
66.7%
4
8
Percentage
Frequency
0
2
4
6
8
10
Frequency

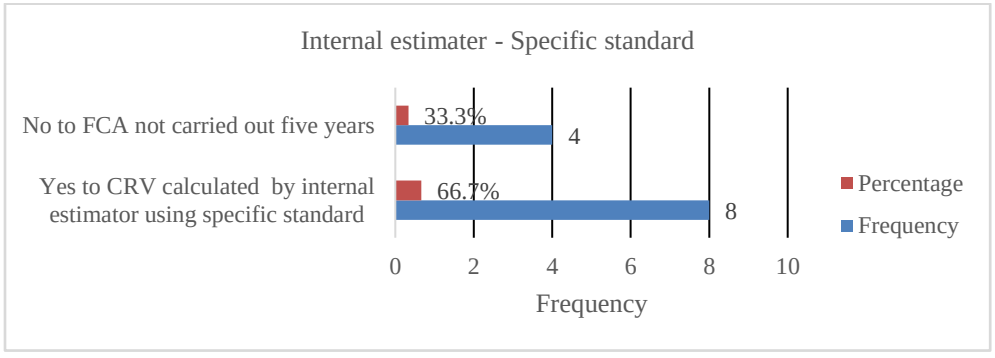

Maintenance + Renewal Costs + Regulatory compliance + Adaptation/CRV
No
Yes
27.3%
72.7%
3
8
Percentage
Frequency
0
2
4
6
8
10
Frequency

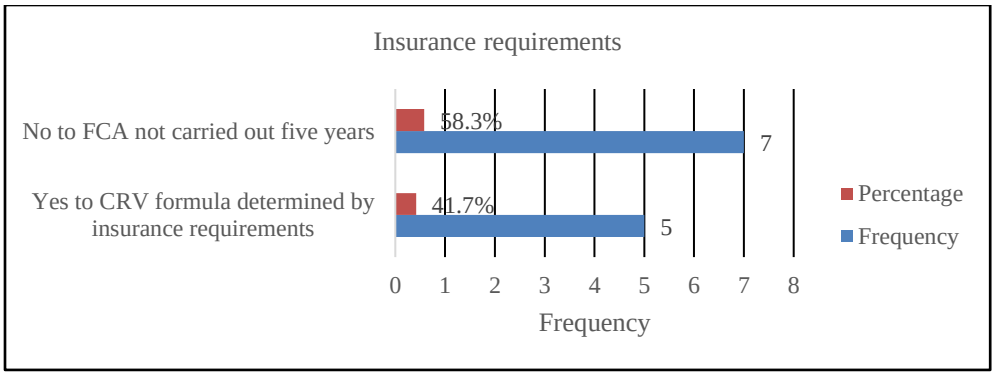
QUESTION 14



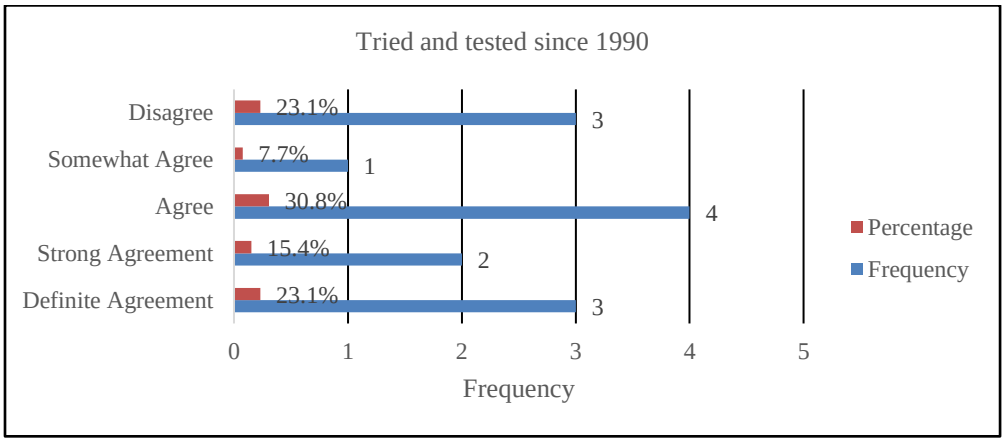
QUESTION 15

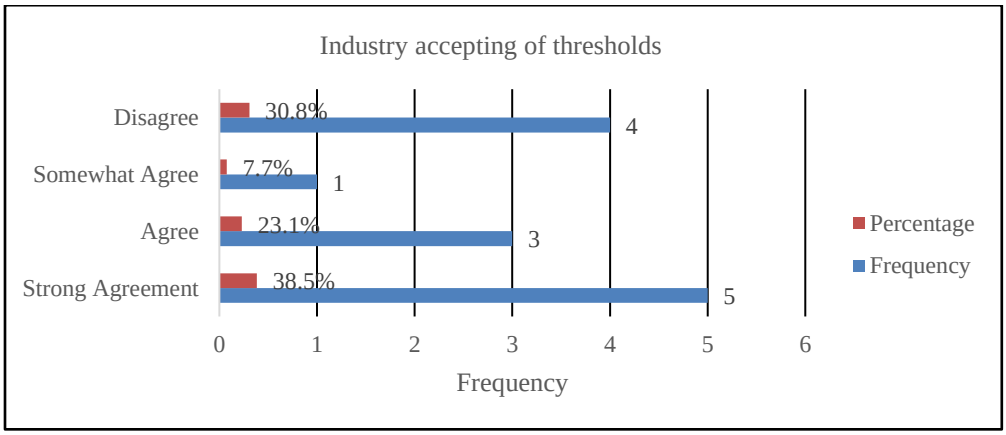


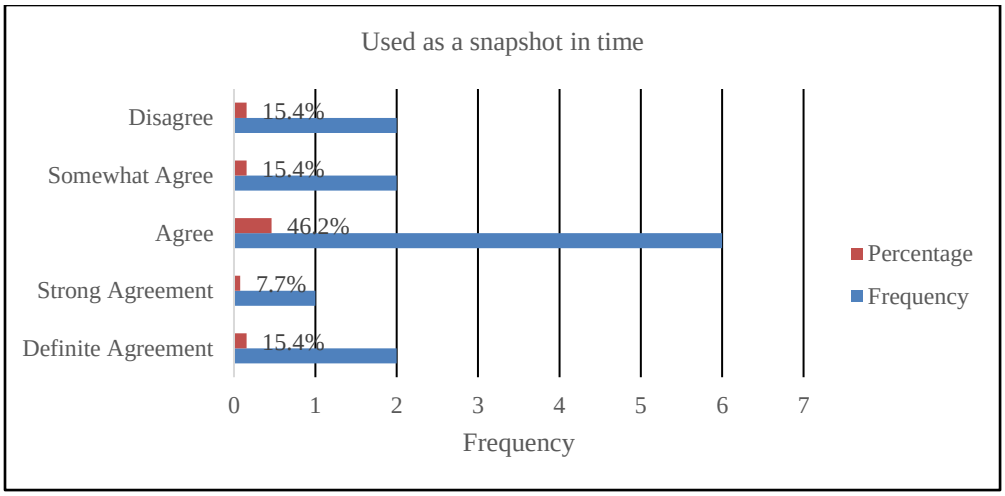


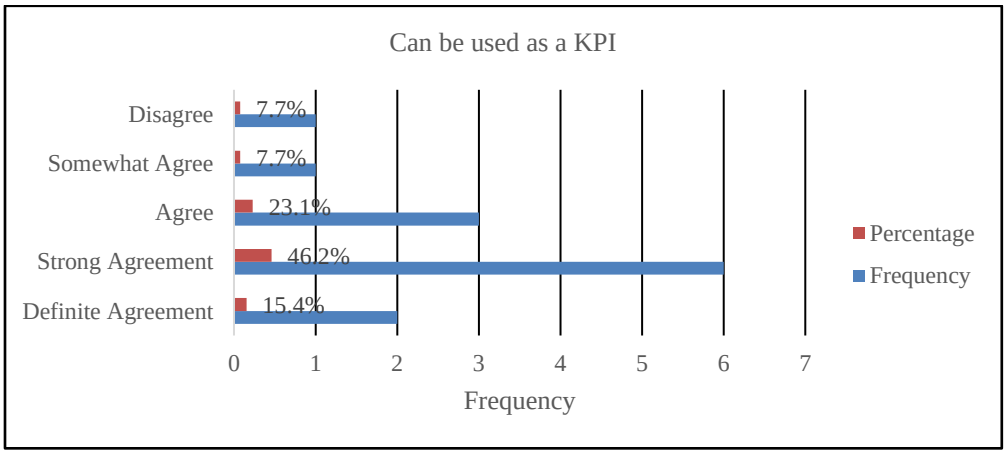

Insurance requirements
No to FCA not carried out five years
Yes to CRV formula determined by insurance requirements
58.3%
41.7%
7
5
Percentage
Frequency
0 1 2 3 4 5 6 7 8
Frequency

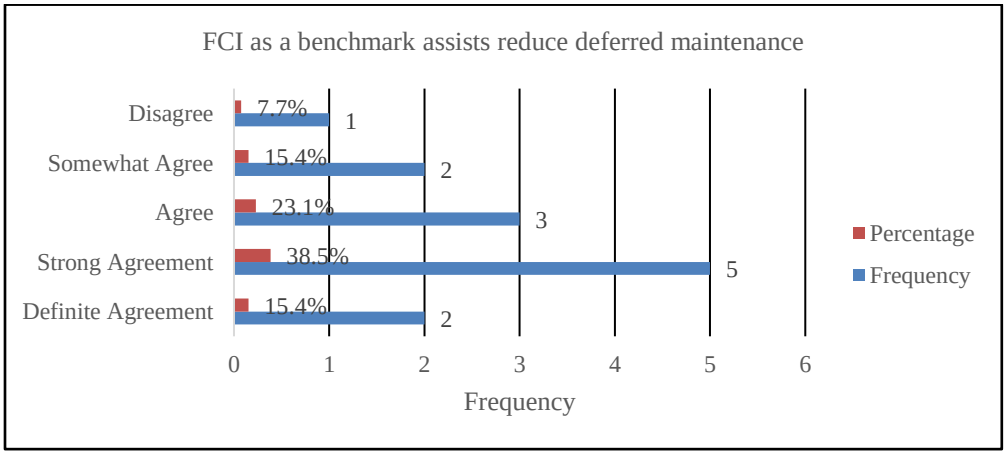
QUESTION 16


Tried and tested since 1990
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
23.1%
7.7%
30.8%
15.4%
23.1%
3
1
4
2
3
Percentage
Frequency
0 1 2 3 4 5
Frequency

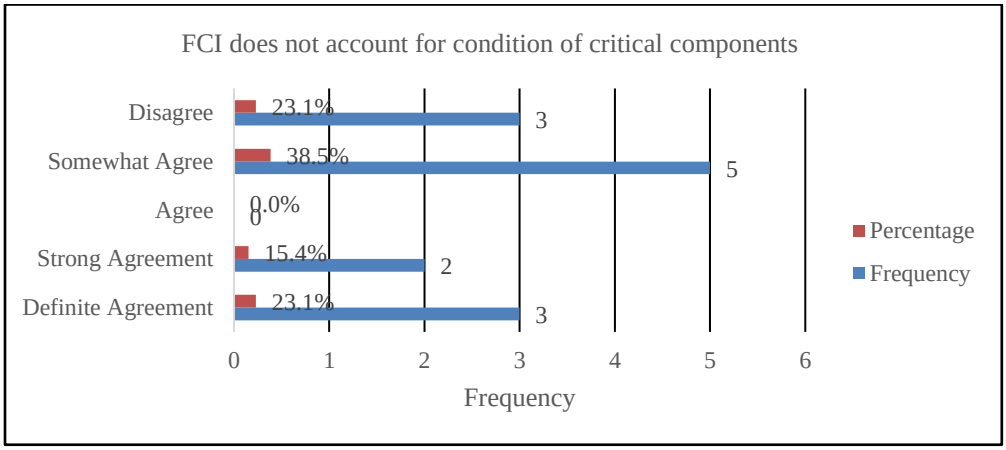

Industry accepting of thresholds
Disagree
Somewhat Agree
Agree
Strong Agreement
30.8%
7.7%
23.1%
38.5%
4
1
3
5
Percentage
Frequency
0 1 2 3 4 5 6
Frequency

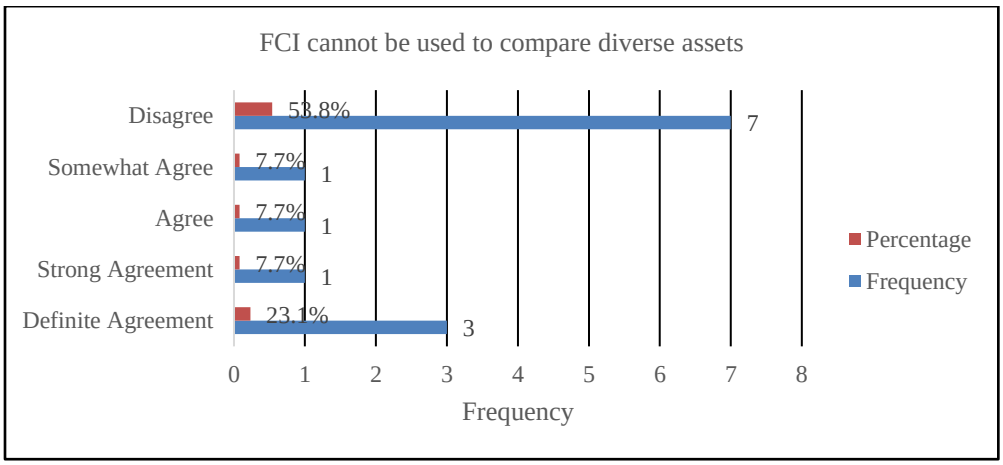

Used as a snapshot in time
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
15.4%
15.4%
46.2%
7.7%
15.4%
0 1 2 3 4 5 6 7
Frequency
Percentage
Frequency

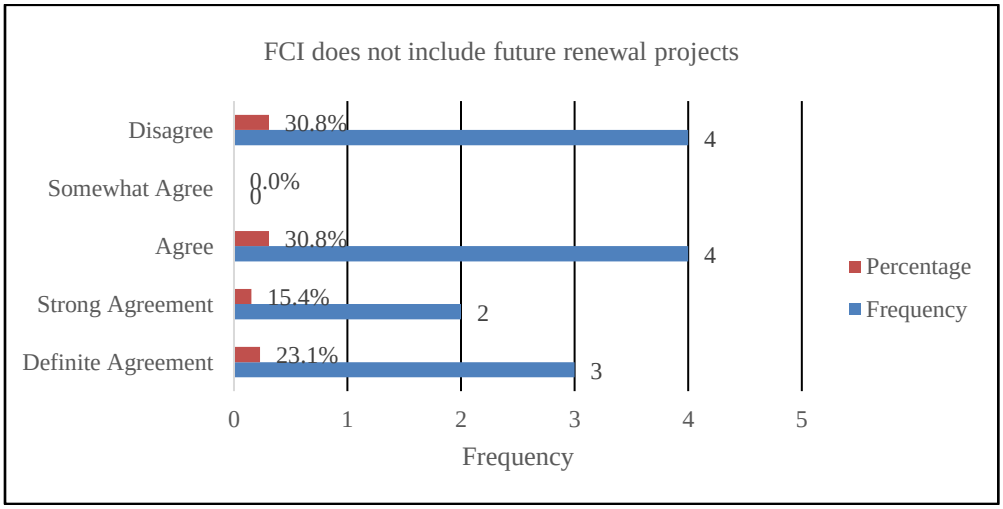

Can be used as a KPI
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
7.7%
7.7%
23.1%
46.2%
15.4%
0 1 2 3 4 5 6 7
Frequency
Percentage
Frequency

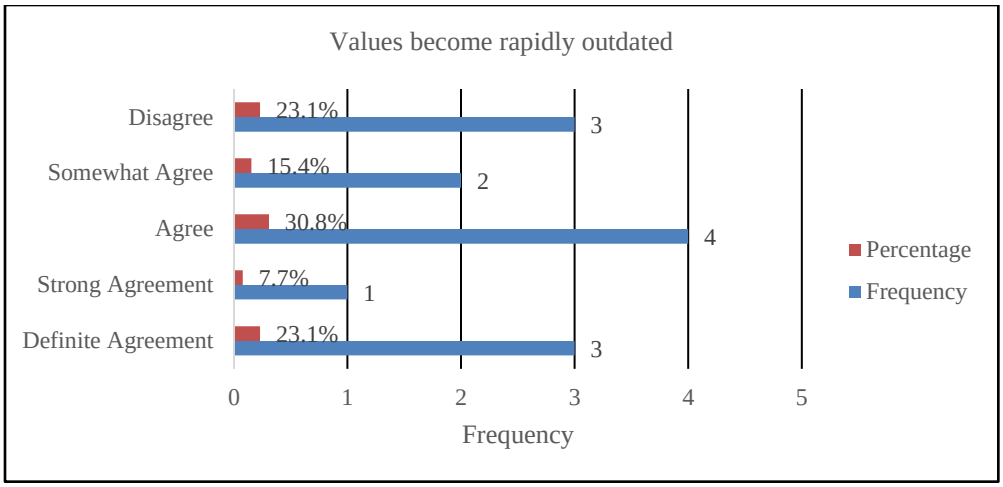

FCI as a benchmark assists reduce deferred maintenance
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
7.7%
15.4%
23.1%
38.5%
15.4%
1
2
3
5
2
0 1 2 3 4 5 6
Frequency
Percentage
Frequency

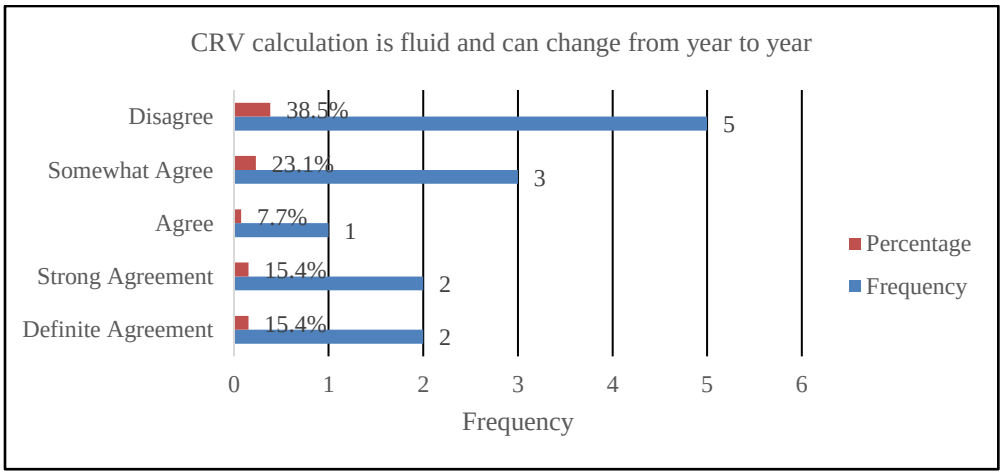
QUESTION 17

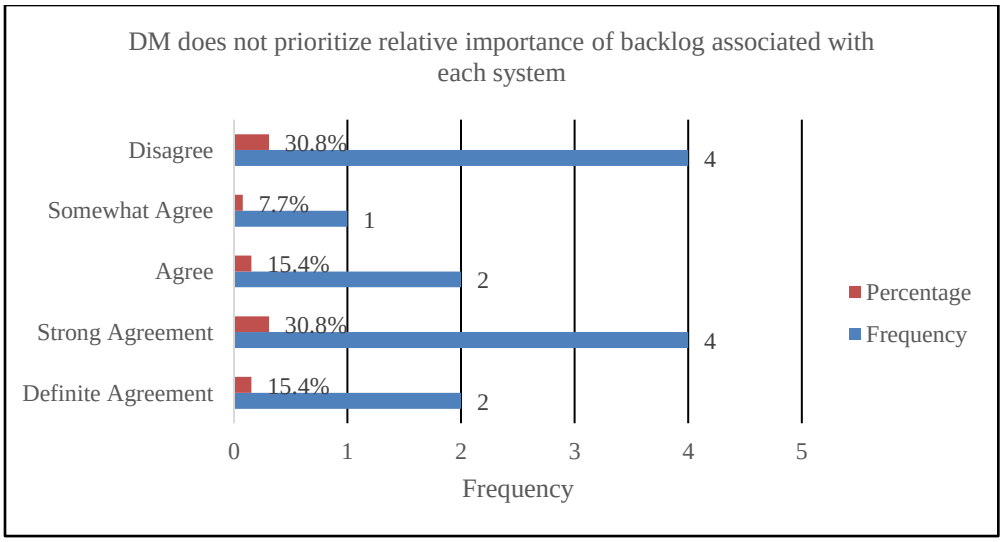

FCI does not account for condition of critical components
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
23.1%
3
38.5%
5
0.0%
0
15.4%
2
23.1%
3
0
1
2
3
4
5
6
Frequency
Percentage
Frequency


FCI cannot be used to compare diverse assets
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
53.8%
7
7.7%
1
7.7%
1
7.7%
1
23.1%
3
0
1
2
3
4
5
6
7
8
Frequency
Percentage
Frequency


FCI does not include future renewal projects
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
30.8%
4
0.0%
0
30.8%
4
15.4%
2
23.1%
3
0
1
2
3
4
5
Frequency
Percentage
Frequency

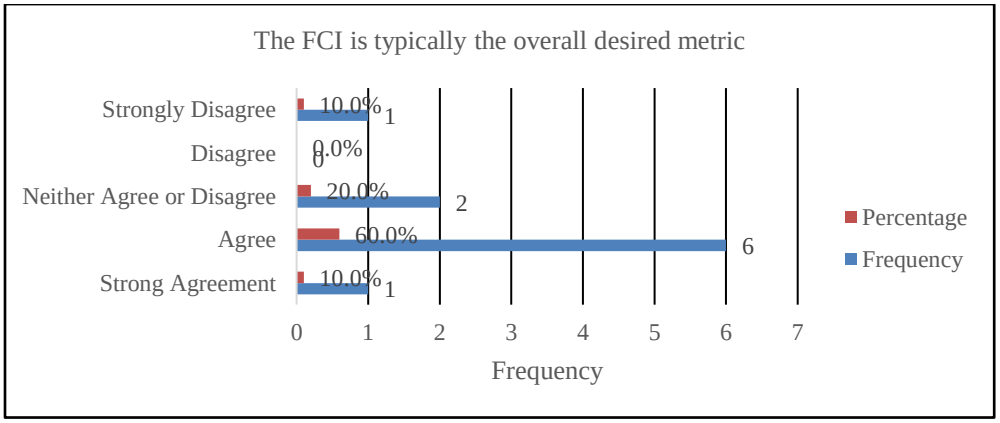

Values become rapidly outdated
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
23.1%
15.4%
30.8%
7.7%
23.1%
3
2
4
1
3
Percentage
Frequency
0
1
2
3
4
5
Frequency

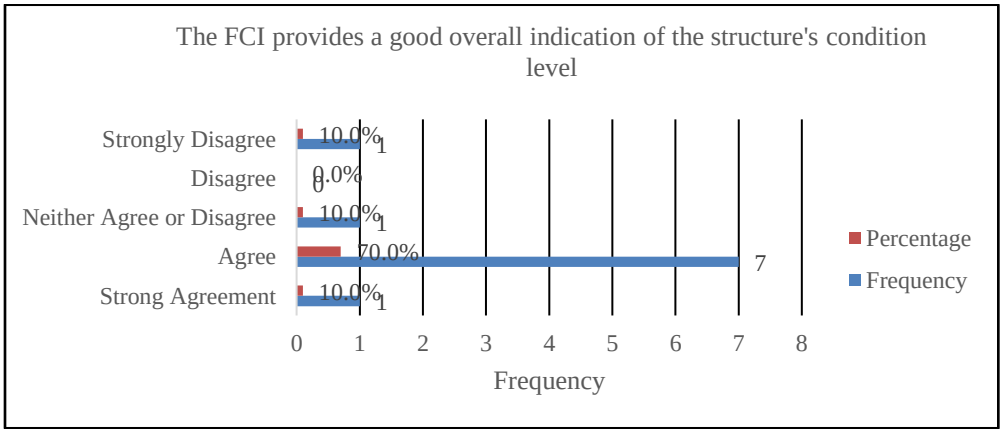

CRV calculation is fluid and can change from year to year
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
38.5%
23.1%
7.7%
15.4%
15.4%
5
3
1
2
2
Percentage
Frequency
0
1
2
3
4
5
6
Frequency

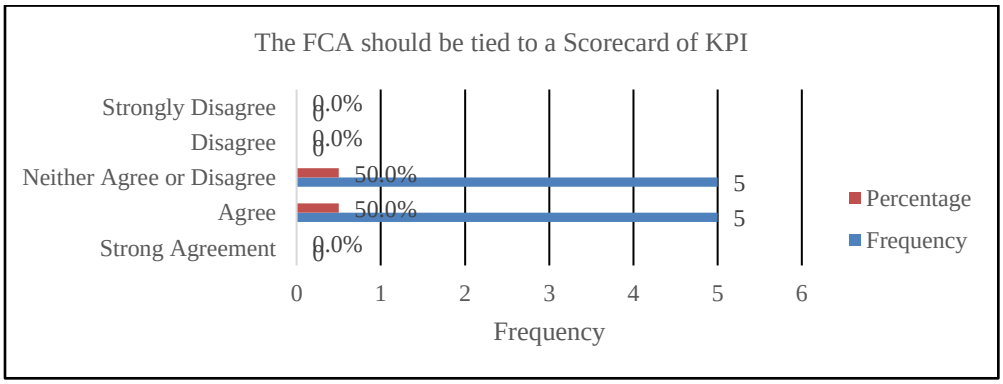

DM does not prioritize relative importance of backlog associated with each system
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
30.8%
7.7%
15.4%
30.8%
15.4%
4
1
2
4
2
Percentage
Frequency
0
1
2
3
4
5
Frequency

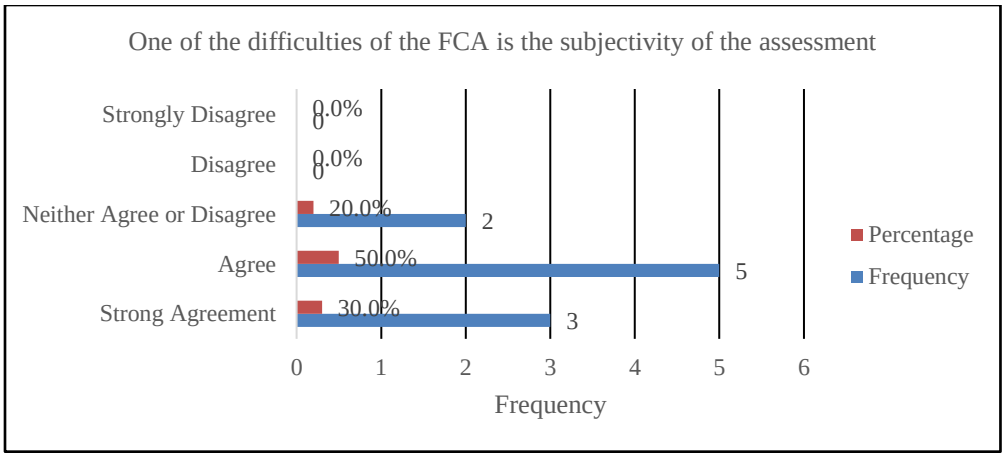
APPENDIX F. SUMMARY RESPONSE HISTOGRAMS – ROUND 2

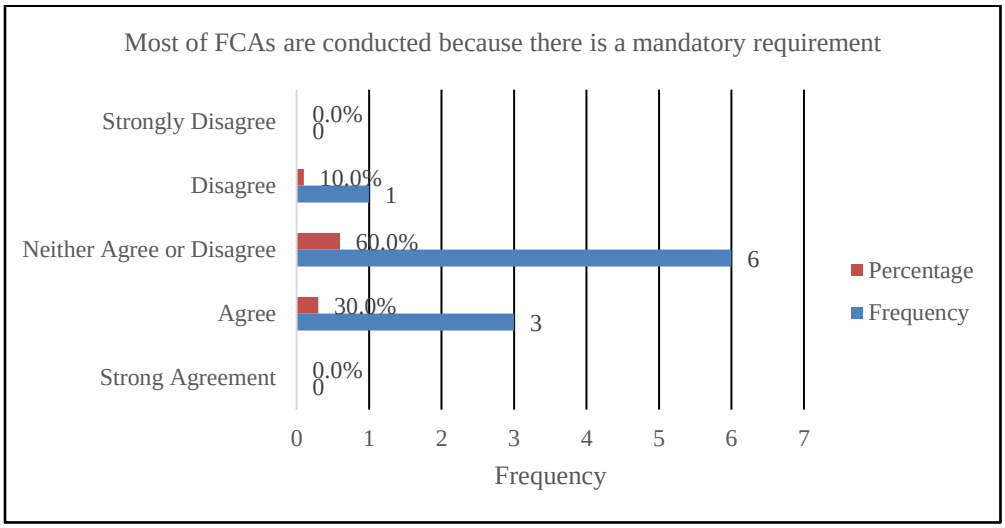
QUESTION 3

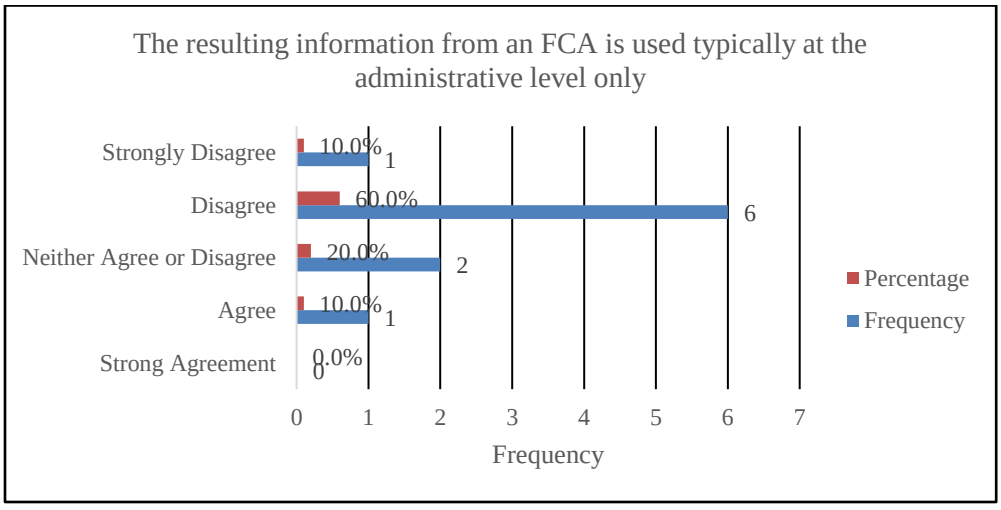




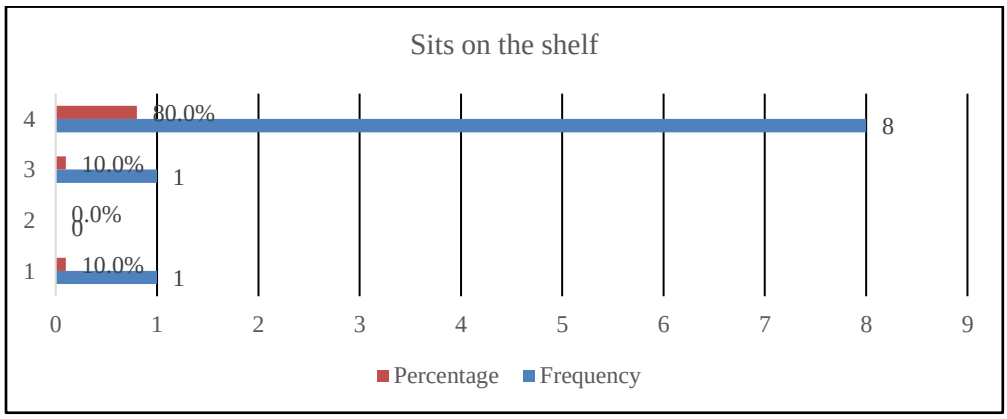


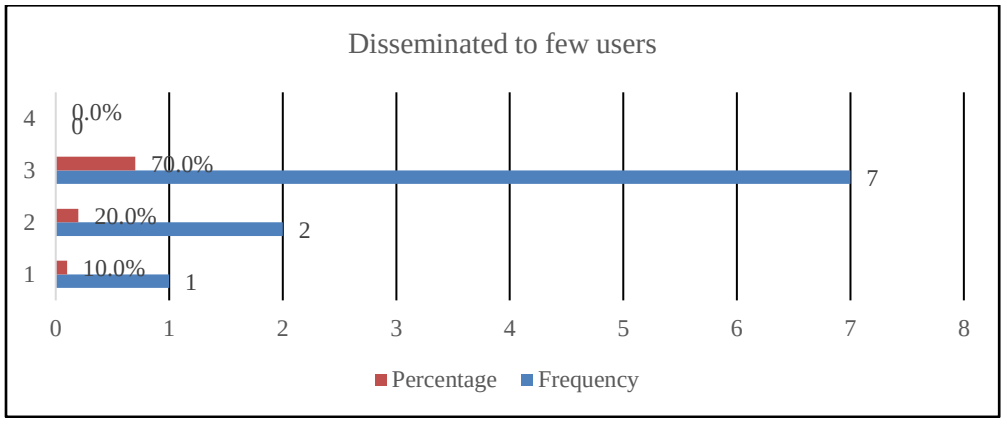

One of the difficulties of the FCA is the subjectivity of the assessment
Strongly Disagree
Disagree
Neither Agree or Disagree
Agree
Strong Agreement
0.0%
0
0.0%
0
20.0%
2
50.0%
5
30.0%
3
0
1
2
3
4
5
6
Frequency
Percentage
Frequency

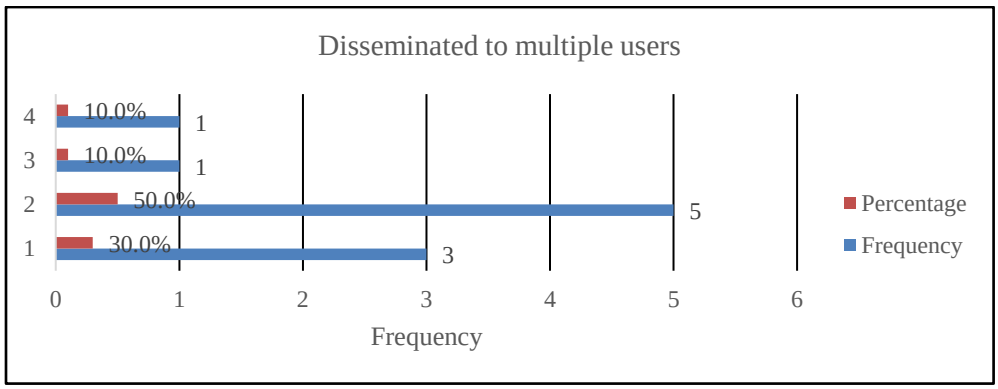

Most of FCAs are conducted because there is a mandatory requirement
Strongly Disagree
Disagree
Neither Agree or Disagree
Agree
Strong Agreement
0.0%
0
10.0%
1
60.0%
6
30.0%
3
0.0%
0
0
1
2
3
4
5
6
7
Frequency
Percentage
Frequency

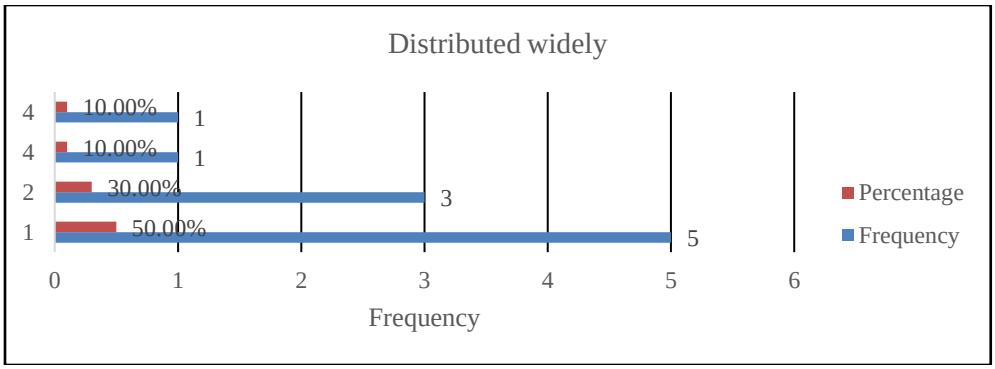

The resulting information from an FCA is used typically at the administrative level only
Strongly Disagree
Disagree
Neither Agree or Disagree
Agree
Strong Agreement
10.0%
1
60.0%
6
20.0%
2
10.0%
1
0.0%
0
0
1
2
3
4
5
6
7
Frequency
Percentage
Frequency

QUESTION 4

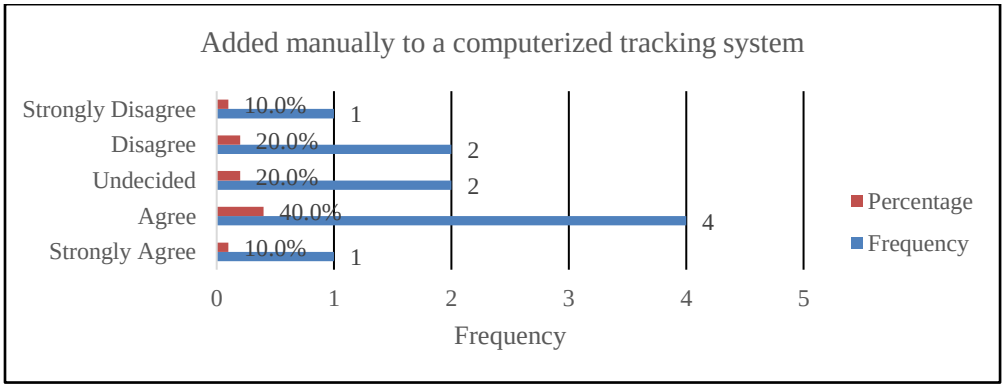

Sits on the shelf
4
3
2
1
80.0%
8
10.0%
1
0.0%
0
10.0%
1
0
1
2
3
4
5
6
7
8
9
Percentage
Frequency

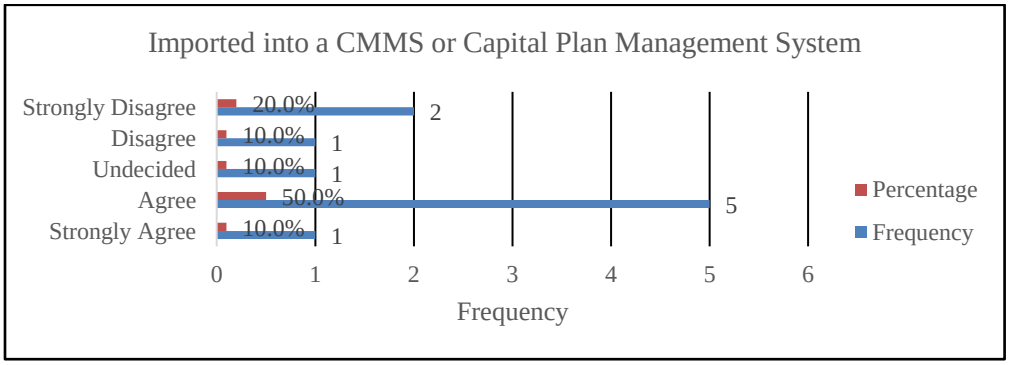

Disseminated to few users
4
3
2
1
0.0%
0
70.0%
7
20.0%
2
10.0%
1
0
1
2
3
4
5
6
7
8
Percentage
Frequency

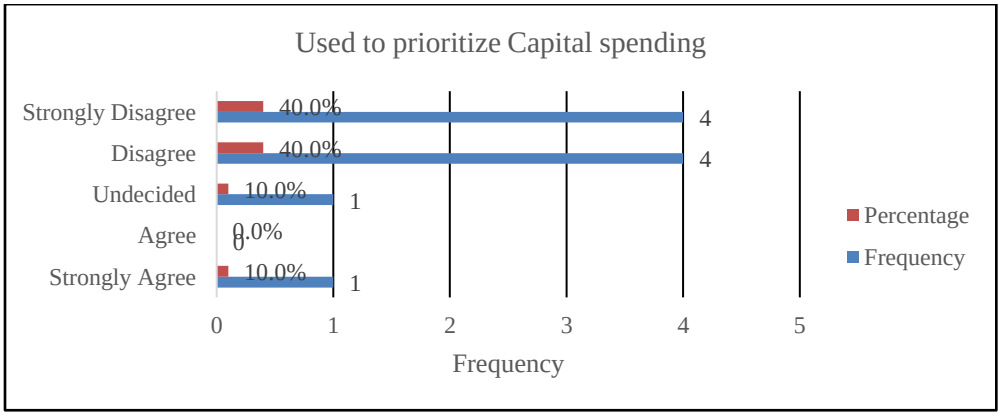

Disseminated to multiple users
4
3
2
1
10.0%
1
10.0%
1
50.0%
5
30.0%
3
0
1
2
3
4
5
6
Frequency
Percentage
Frequency


Distributed widely
4
4
2
1
10.00%
10.00%
30.00%
50.00%
1
1
3
5
0
1
2
3
4
5
6
Frequency
Percentage
Frequency

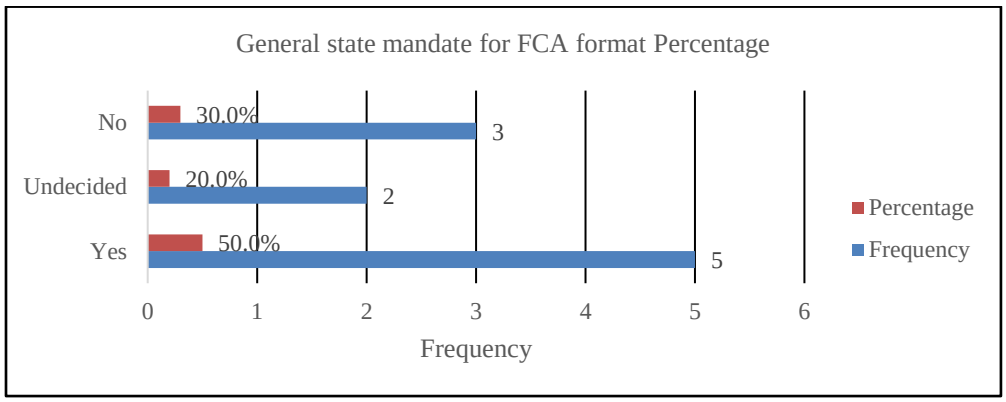
QUESTION 5


Added manually to a computerized tracking system
Strongly Disagree
Disagree
Undecided
Agree
Strongly Agree
10.0%
20.0%
20.0%
40.0%
10.0%
1
2
2
4
1
0
1
2
3
4
5
Frequency
Percentage
Frequency

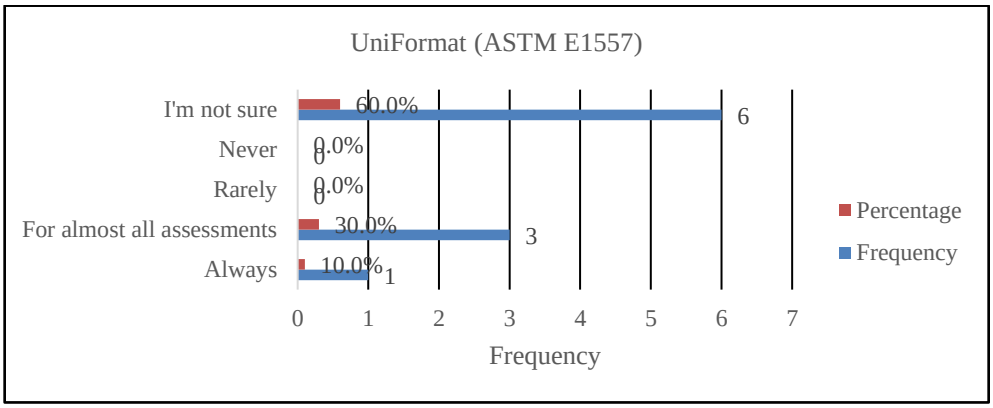

Imported into a CMMS or Capital Plan Management System
Strongly Disagree
Disagree
Undecided
Agree
Strongly Agree
20.0%
10.0%
10.0%
50.0%
10.0%
2
1
1
5
1
0
1
2
3
4
5
6
Frequency
Percentage
Frequency

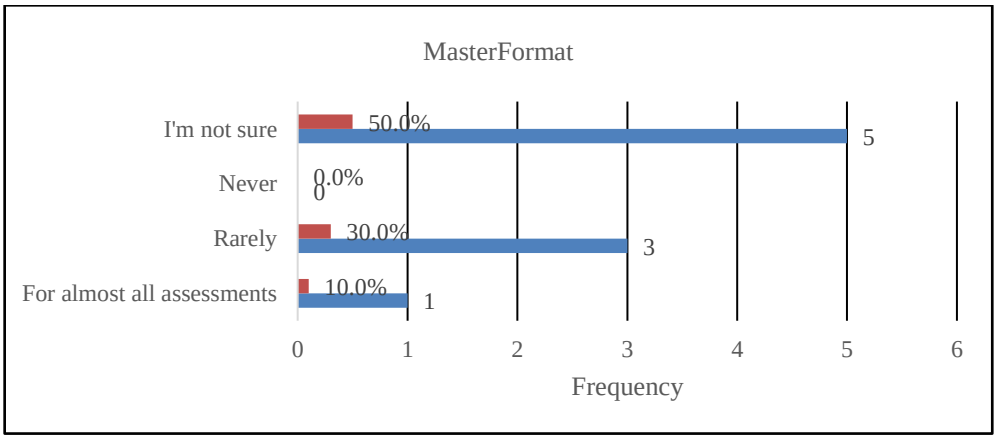

Used to prioritize Capital spending
Strongly Disagree
Disagree
Undecided
Agree
Strongly Agree
40.0%
40.0%
10.0%
0.0%
10.0%
4
4
1
0
1
0
1
2
3
4
5
Frequency
Percentage
Frequency

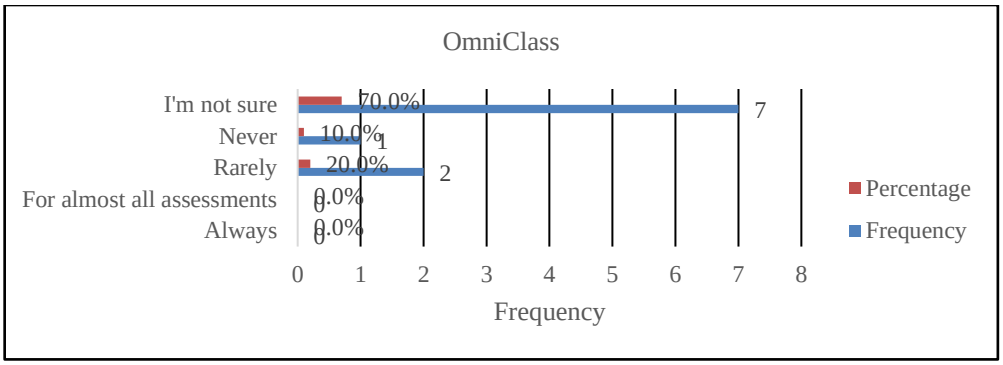
QUESTION 6

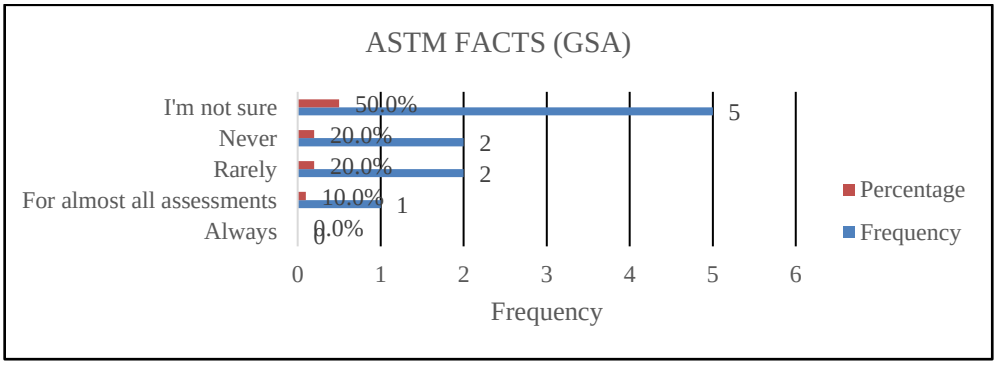


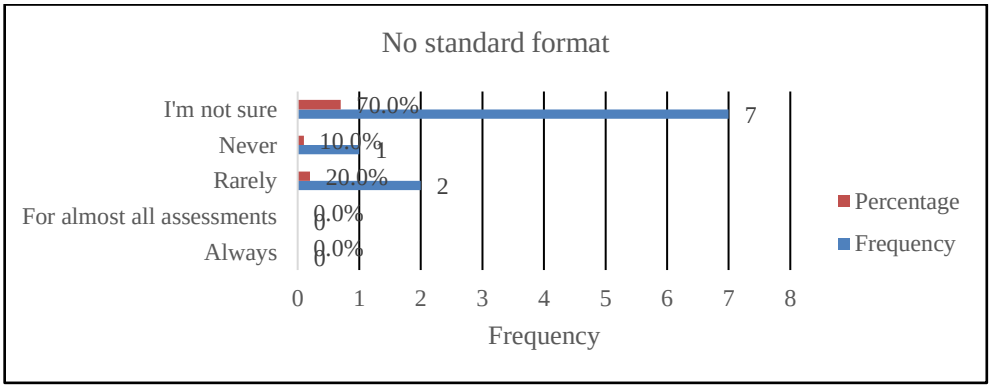
QUESTION 7

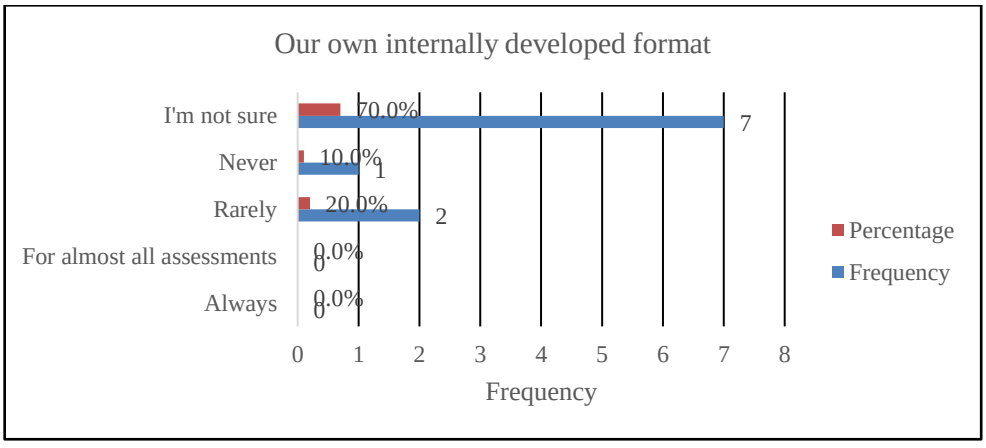




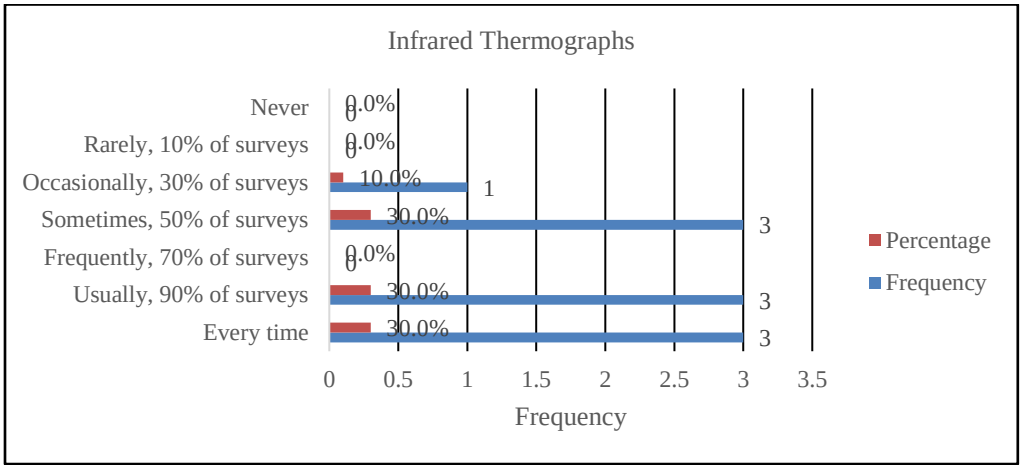

OmniClass
I'm not sure
Never
Rarely
For almost all assessments
Always
70.0%
10.0%
20.0%
0.0%
0.0%
7
1
2
0
0
Percentage
Frequency
0 1 2 3 4 5 6 7 8
Frequency

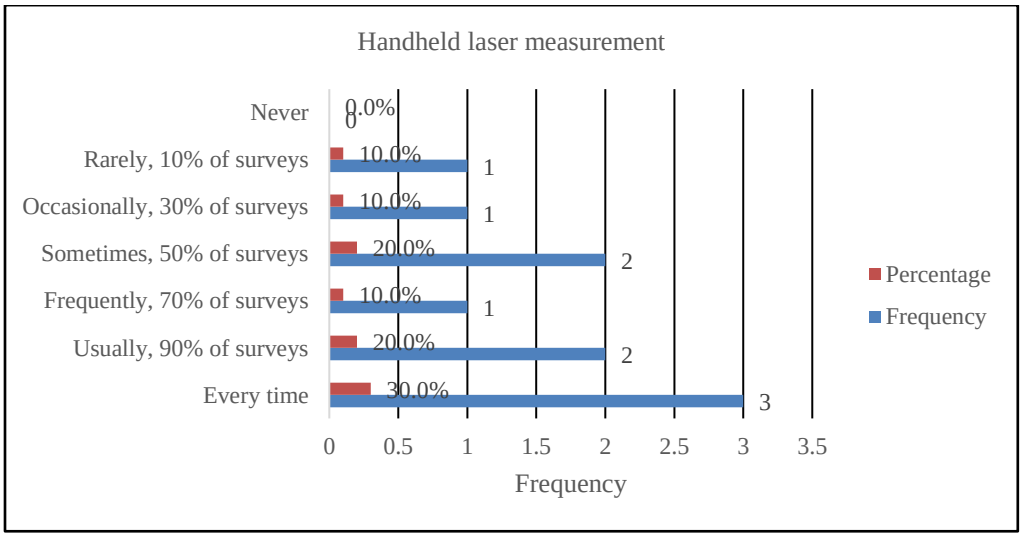

ASTM FACTS (GSA)
I'm not sure
Never
Rarely
For almost all assessments
Always
50.0%
20.0%
20.0%
10.0%
0.0%
5
2
2
1
0
Percentage
Frequency
0 1 2 3 4 5 6
Frequency

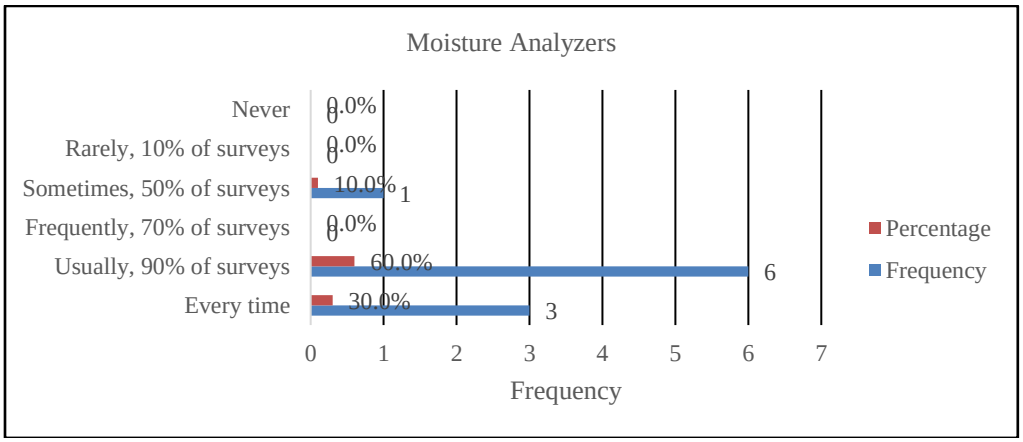

No standard format
I'm not sure
Never
Rarely
For almost all assessments
Always
70.0%
10.0%
20.0%
0.0%
0.0%
7
1
2
0
0
Percentage
Frequency
0 1 2 3 4 5 6 7 8
Frequency

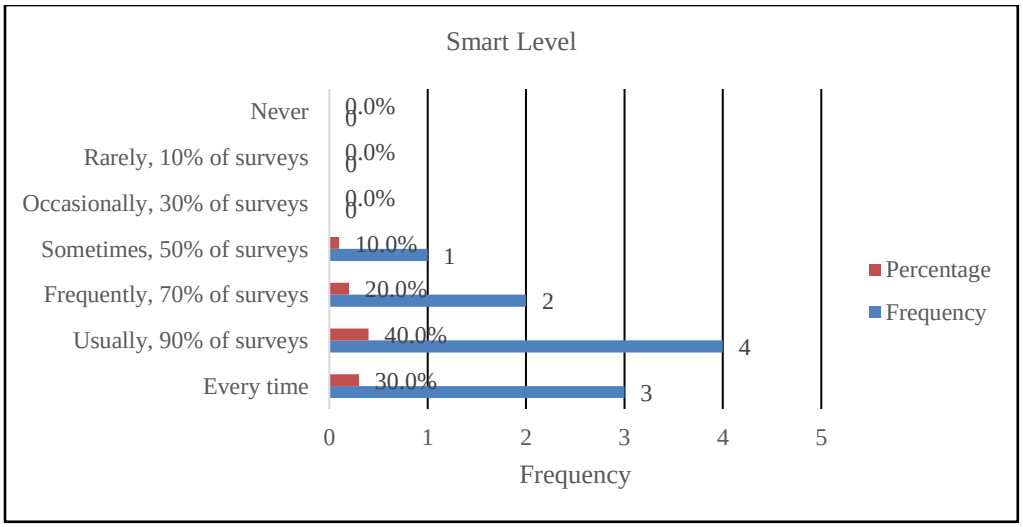

Our own internally developed format
I'm not sure
Never
Rarely
For almost all assessments
Always
70.0%
10.0%
20.0%
0.0%
0.0%
7
1
2
0
0
Percentage
Frequency
0 1 2 3 4 5 6 7 8
Frequency

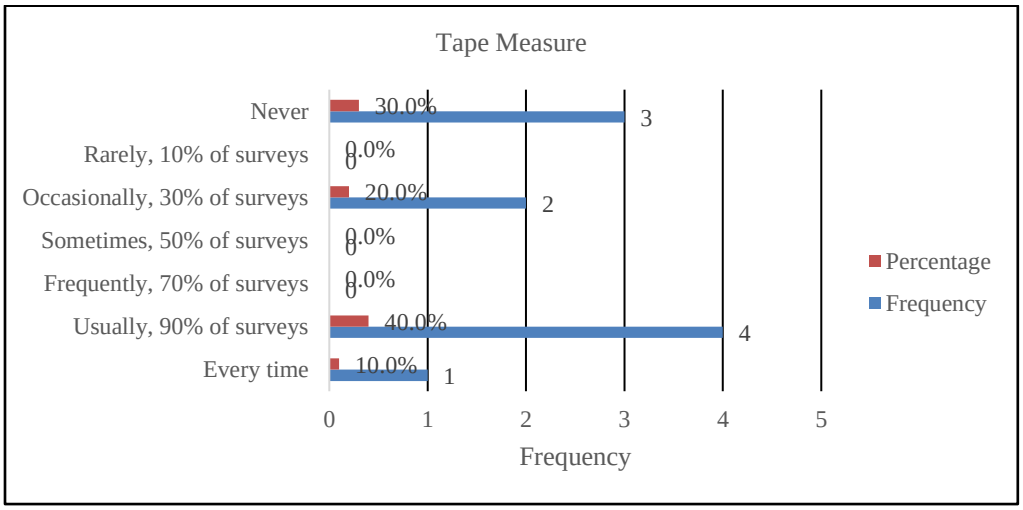
QUESTION 8


Infrared Thermographs
Never
Rarely, 10% of surveys
Occasionally, 30% of surveys
Sometimes, 50% of surveys
Frequently, 70% of surveys
Usually, 90% of surveys
Every time
0.0%
0
0.0%
0
10.0%
1
30.0%
3
0.0%
0
30.0%
3
30.0%
3
0
0.5
1
1.5
2
2.5
3
3.5
Frequency
Percentage
Frequency

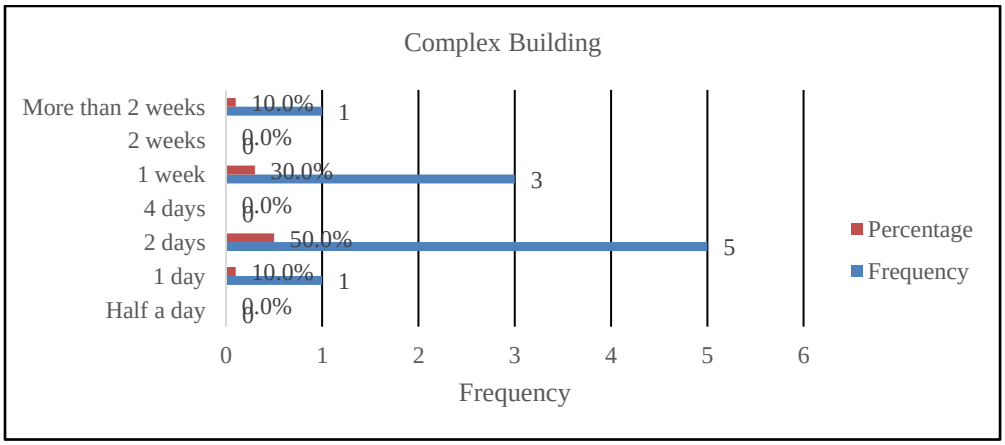

Handheld laser measurement
Never
Rarely, 10% of surveys
Occasionally, 30% of surveys
Sometimes, 50% of surveys
Frequently, 70% of surveys
Usually, 90% of surveys
Every time
0.0%
0
10.0%
1
10.0%
1
20.0%
2
10.0%
1
20.0%
2
30.0%
3
0
0.5
1
1.5
2
2.5
3
3.5
Frequency
Percentage
Frequency

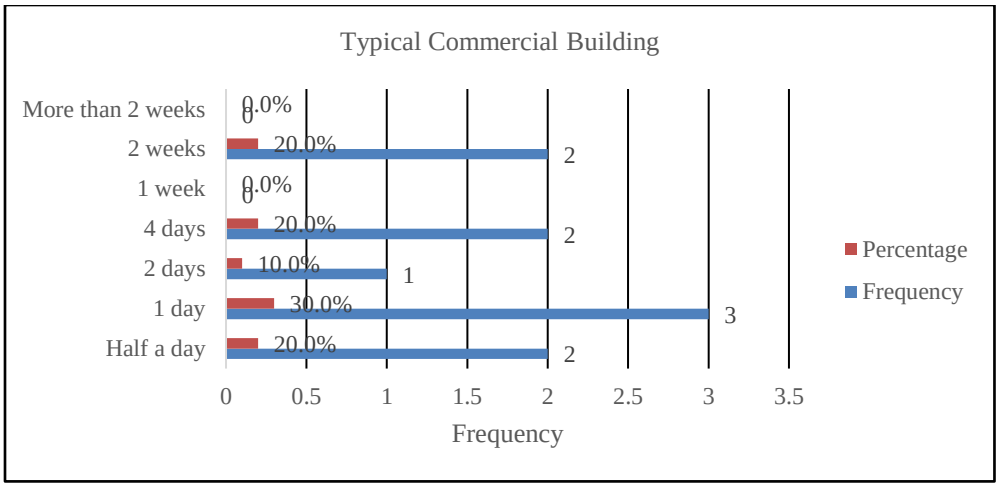

Moisture Analyzers
Never
Rarely, 10% of surveys
Sometimes, 50% of surveys
Frequently, 70% of surveys
Usually, 90% of surveys
Every time
0.0%
0
0.0%
0
10.0%
1
0.0%
0
60.0%
6
30.0%
3
0
1
2
3
4
5
6
7
Frequency
Percentage
Frequency

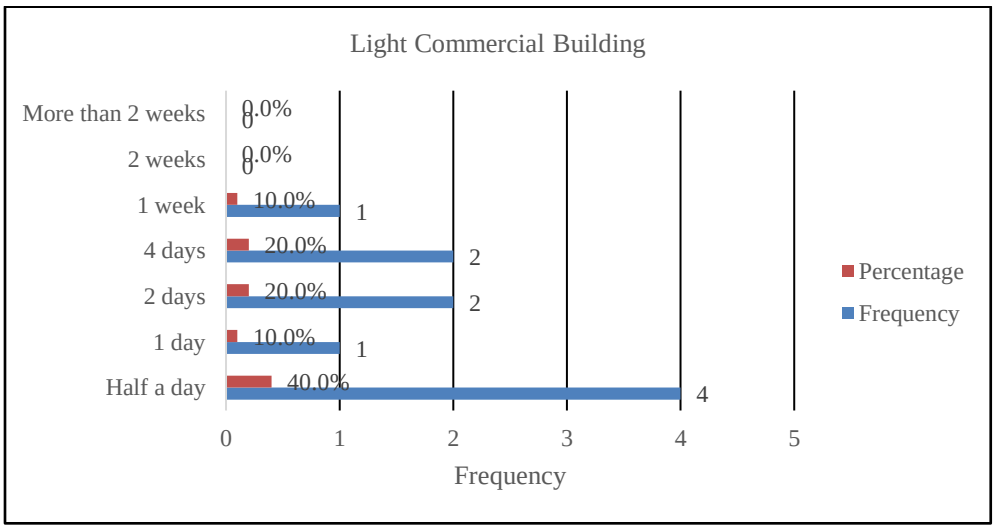

Smart Level
Never
Rarely, 10% of surveys
Occasionally, 30% of surveys
Sometimes, 50% of surveys
Frequently, 70% of surveys
Usually, 90% of surveys
Every time
0.0%
0.0%
0.0%
10.0%
20.0%
40.0%
30.0%
1
2
4
3
0
1
2
3
4
5
Frequency
Percentage
Frequency


Tape Measure
Never
Rarely, 10% of surveys
Occasionally, 30% of surveys
Sometimes, 50% of surveys
Frequently, 70% of surveys
Usually, 90% of surveys
Every time
30.0%
0.0%
20.0%
0.0%
0.0%
40.0%
10.0%
3
2
4
1
0
1
2
3
4
5
Frequency
Percentage
Frequency

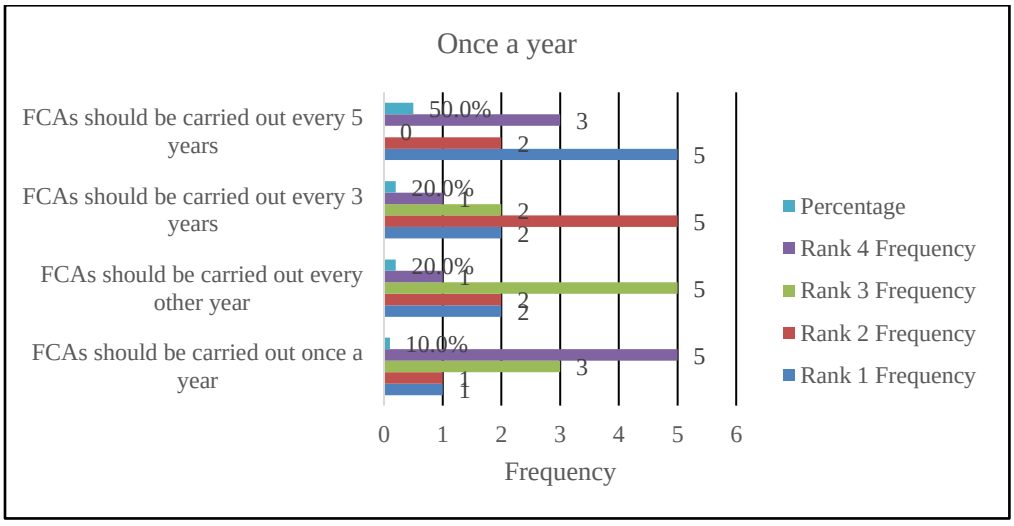
QUESTION 9


Complex Building
More than 2 weeks
2 weeks
1 week
4 days
2 days
1 day
Half a day
10.0%
0.0%
30.0%
0.0%
50.0%
10.0%
0.0%
1
3
5
1
0
1
2
3
4
5
6
Frequency
Percentage
Frequency

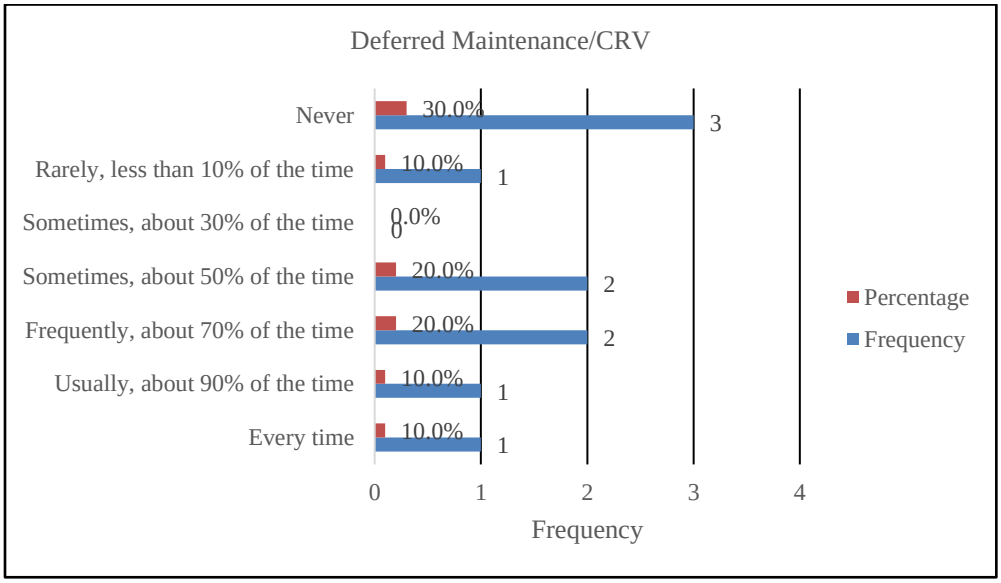

Typical Commercial Building
More than 2 weeks
2 weeks
1 week
4 days
2 days
1 day
Half a day
0.0%
0
20.0%
2
0.0%
0
20.0%
2
10.0%
1
30.0%
3
20.0%
2
0
0.5
1
1.5
2
2.5
3
3.5
Frequency
Percentage
Frequency

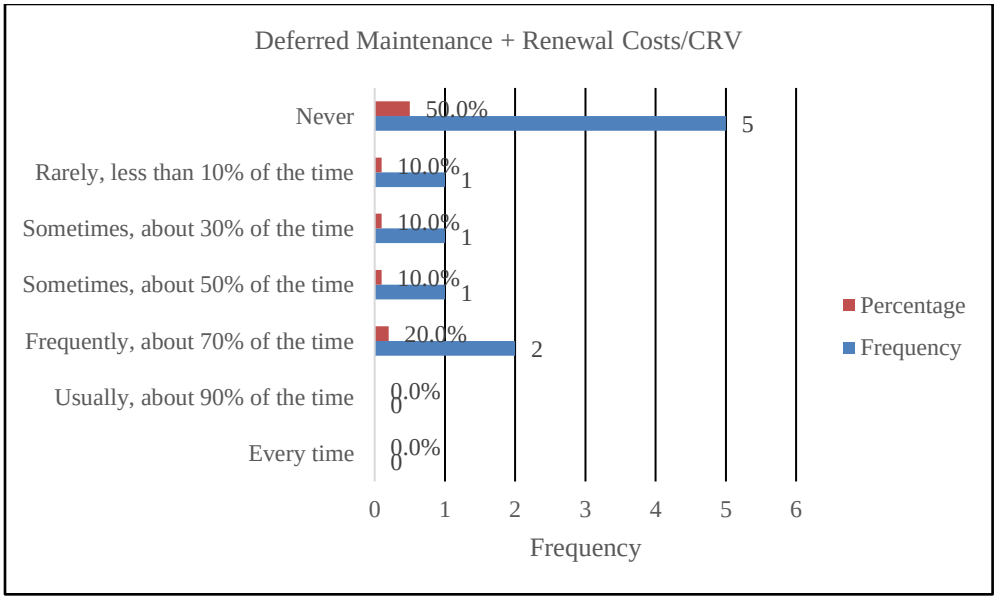

Light Commercial Building
More than 2 weeks
2 weeks
1 week
4 days
2 days
1 day
Half a day
0.0%
0
0.0%
0
10.0%
1
20.0%
2
20.0%
2
10.0%
1
40.0%
4
0
1
2
3
4
5
Frequency
Percentage
Frequency

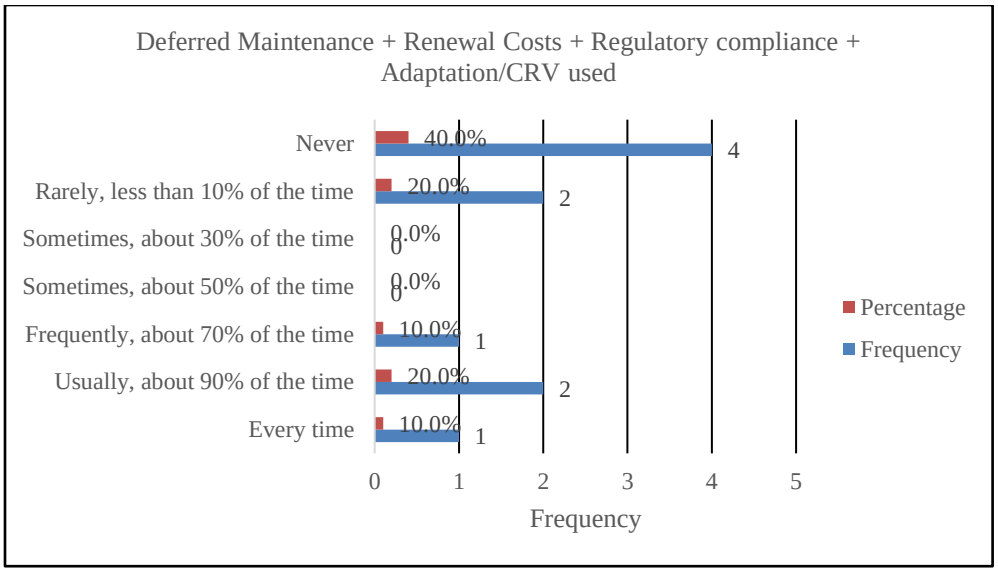
QUESTION 10

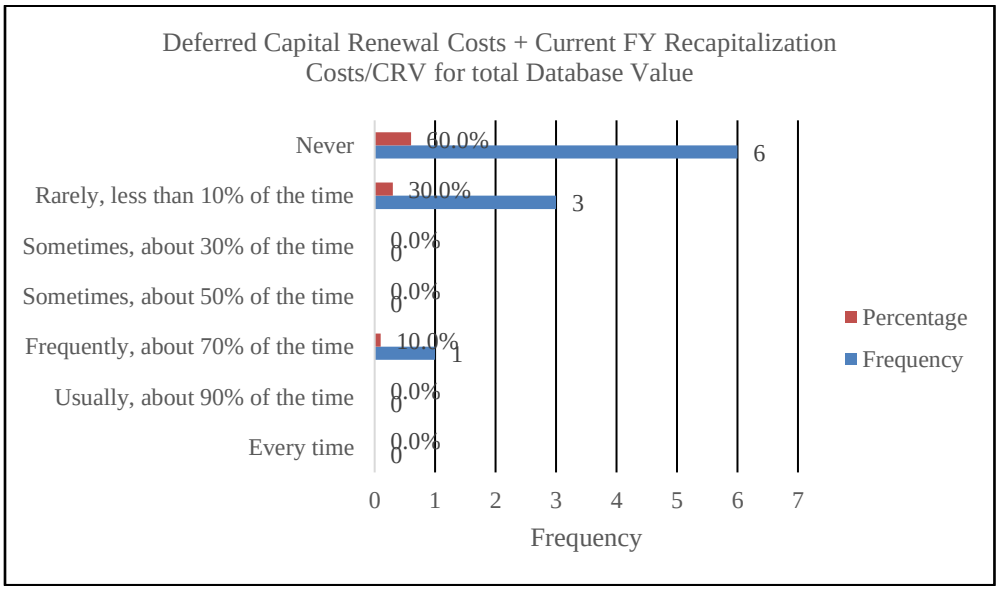

Once a year
FCAs should be carried out every 5 years
FCAs should be carried out every 3 years
FCAs should be carried out every other year
FCAs should be carried out once a year
50.0%
3
0
2
5
20.0%
1
2
5
2
20.0%
1
5
2
10.0%
5
3
1
1
0
1
2
3
4
5
6
Frequency
Percentage
Rank 4 Frequency
Rank 3 Frequency
Rank 2 Frequency
Rank 1 Frequency

QUESTION 11

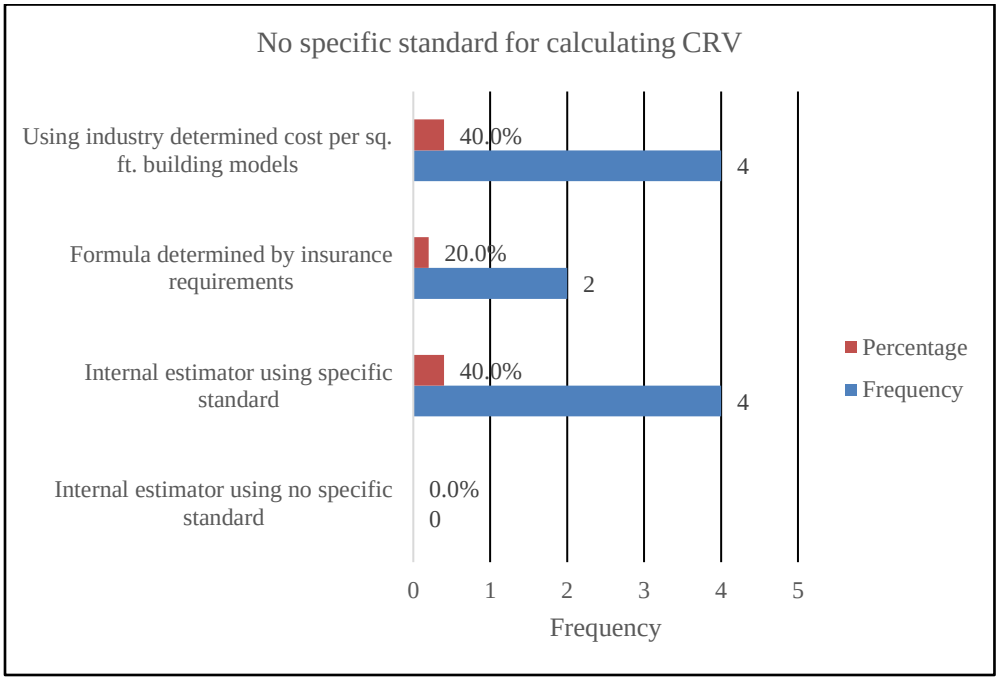

Deferred Maintenance/CRV
Never
Rarely, less than 10% of the time
Sometimes, about 30% of the time
Sometimes, about 50% of the time
Frequently, about 70% of the time
Usually, about 90% of the time
Every time
30.0%
10.0%
0.0%
20.0%
20.0%
10.0%
10.0%
3
1
0
2
2
1
1
0
1
2
3
4
Frequency
Percentage
Frequency


Deferred Maintenance + Renewal Costs/CRV
Never
Rarely, less than 10% of the time
Sometimes, about 30% of the time
Sometimes, about 50% of the time
Frequently, about 70% of the time
Usually, about 90% of the time
Every time
50.0%
10.0%
10.0%
10.0%
20.0%
0.0%
0.0%
5
1
1
1
2
0
0
0
1
2
3
4
5
6
Frequency
Percentage
Frequency

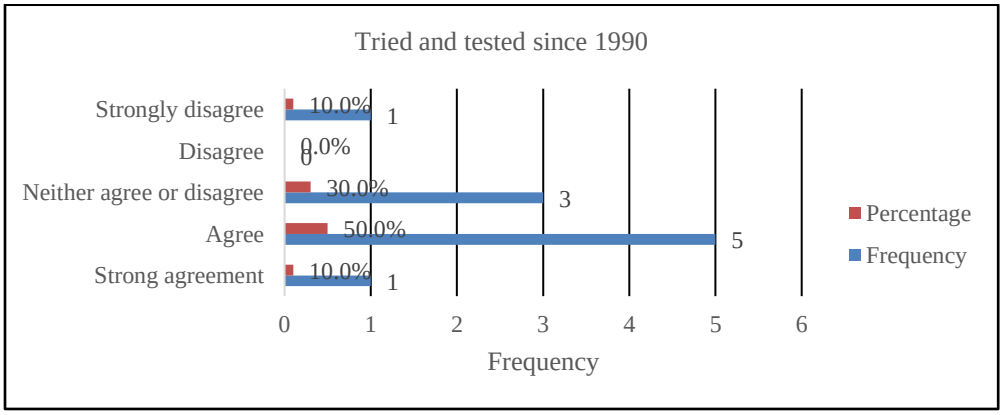

Deferred Maintenance + Renewal Costs + Regulatory compliance + Adaptation/CRV used
Never
Rarely, less than 10% of the time
Sometimes, about 30% of the time
Sometimes, about 50% of the time
Frequently, about 70% of the time
Usually, about 90% of the time
Every time
40.0%
4
20.0%
2
0.0%
0
0.0%
0
10.0%
1
20.0%
2
10.0%
1
0
1
2
3
4
5
Frequency
Percentage
Frequency

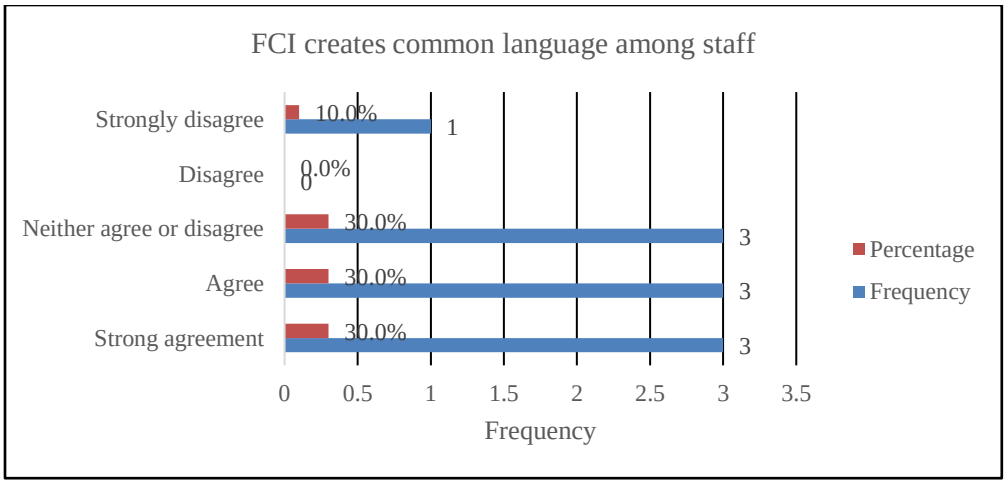

Deferred Capital Renewal Costs + Current FY Recapitalization Costs/CRV for total Database Value
Never
Rarely, less than 10% of the time
Sometimes, about 30% of the time
Sometimes, about 50% of the time
Frequently, about 70% of the time
Usually, about 90% of the time
Every time
60.0%
6
30.0%
3
0.0%
0
0.0%
0
10.0%
1
0.0%
0
0.0%
0
0
1
2
3
4
5
6
7
Frequency
Percentage
Frequency

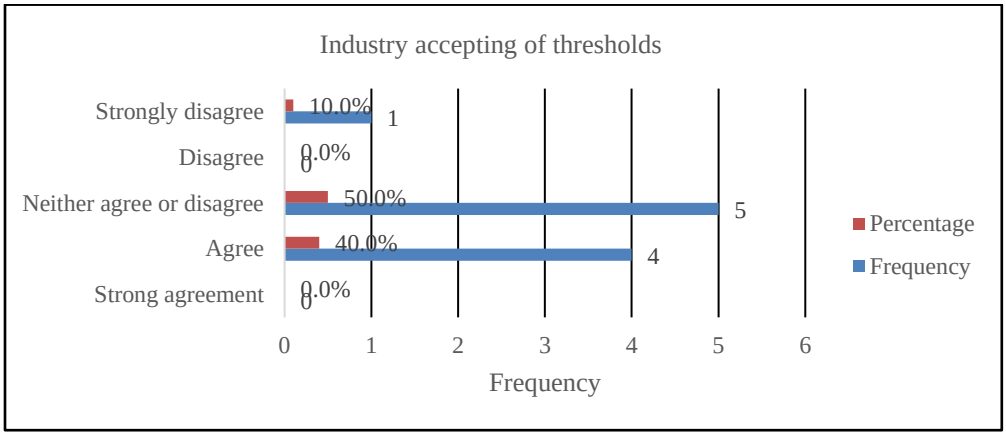
QUESTION 12

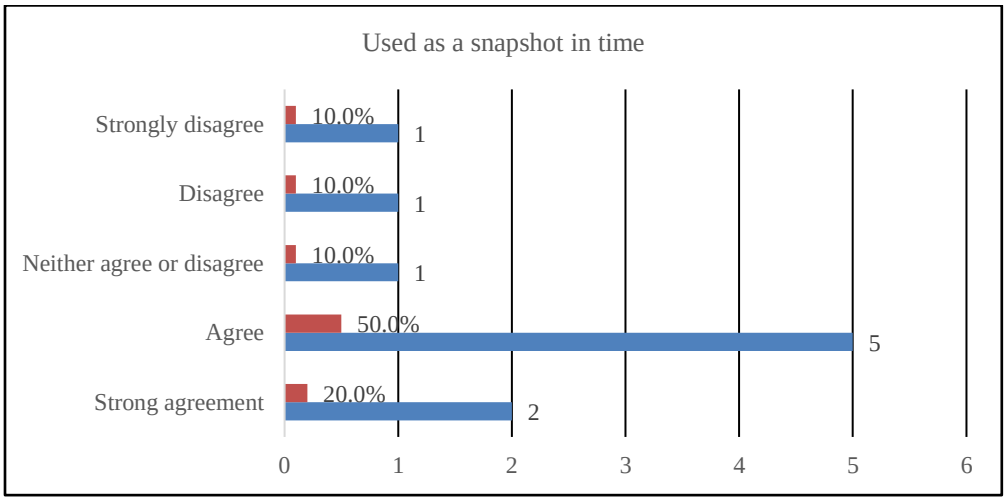


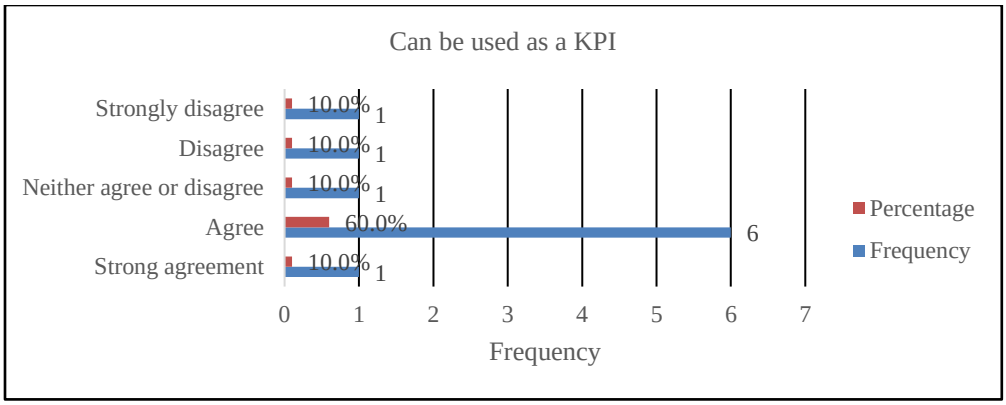
QUESTION 13

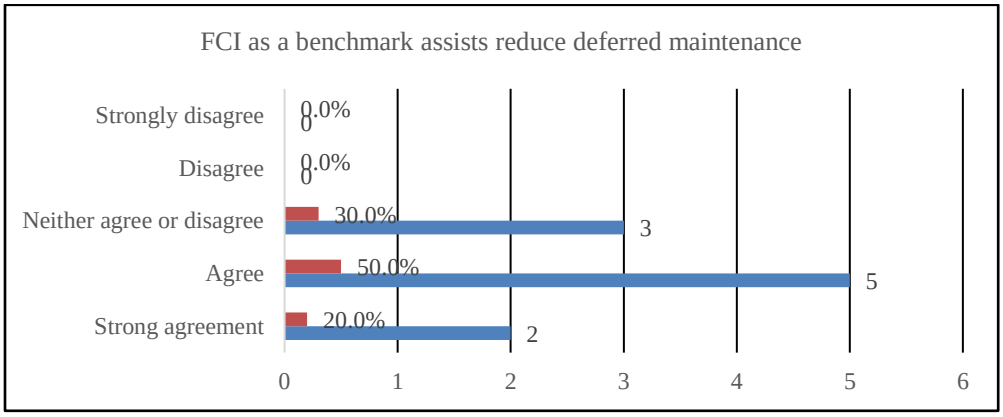


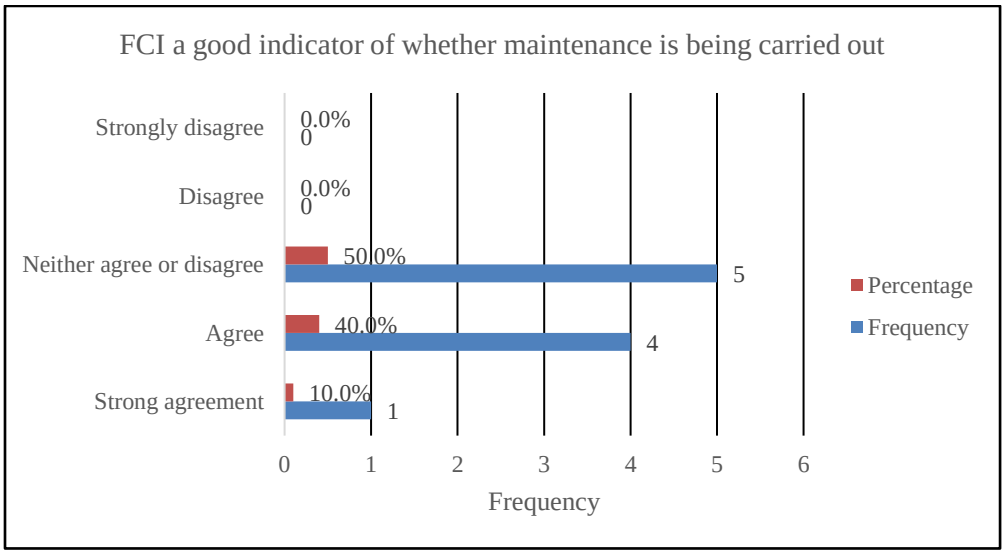

FCI creates common language among staff
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
10.0%
1
0.0%
0
30.0%
3
30.0%
3
30.0%
3
0
0.5
1
1.5
2
2.5
3
3.5
Frequency
Percentage
Frequency

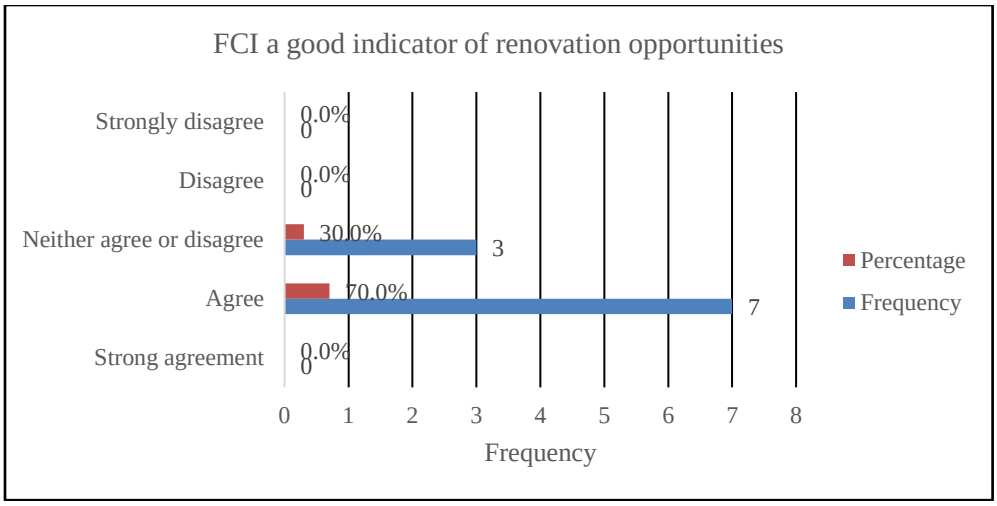

Industry accepting of thresholds
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
10.0%
1
0.0%
0
50.0%
5
40.0%
4
0.0%
0
0
1
2
3
4
5
6
Frequency
Percentage
Frequency


Used as a snapshot in time
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
10.0%
1
10.0%
1
10.0%
1
50.0%
5
20.0%
2
0
1
2
3
4
5
6

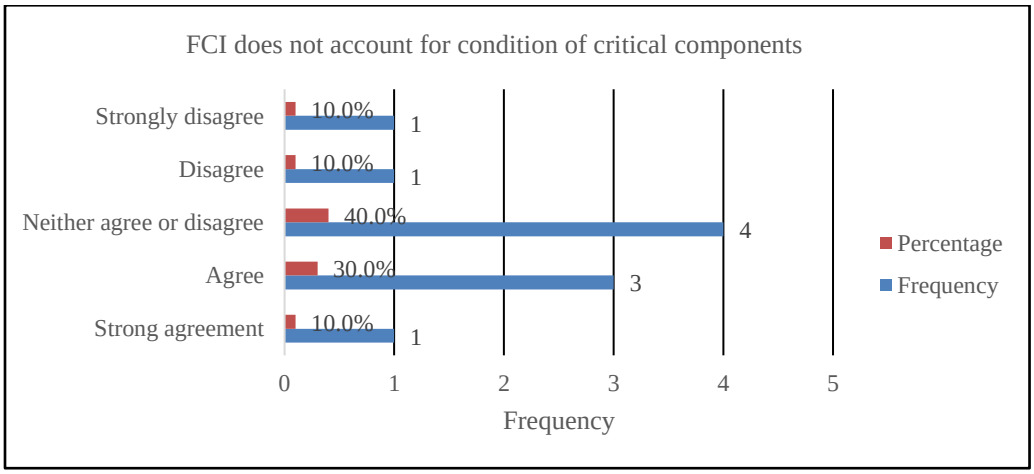

Can be used as a KPI
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
10.0%
10.0%
10.0%
60.0%
10.0%
1
1
1
6
1
0 1 2 3 4 5 6 7
Frequency
Percentage
Frequency

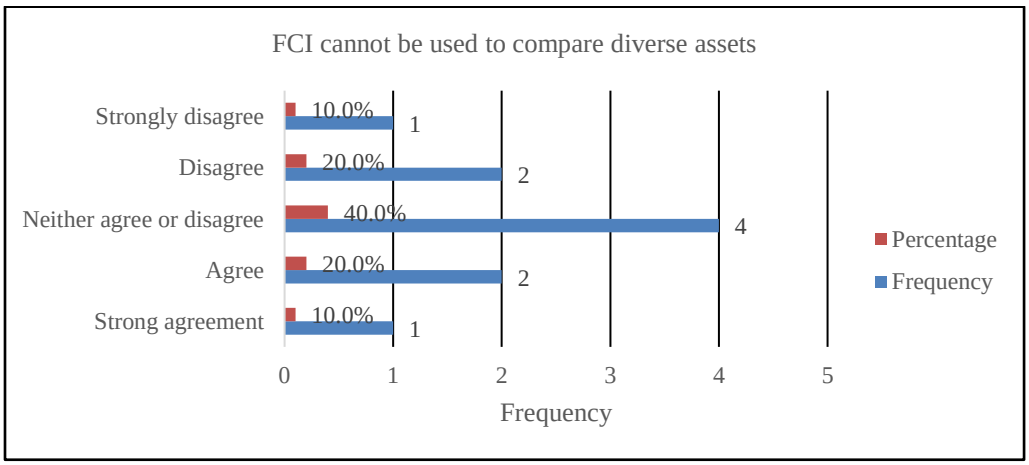

FCI as a benchmark assists reduce deferred maintenance
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
0.0%
0.0%
30.0%
50.0%
20.0%
0
0
3
5
2
0 1 2 3 4 5 6

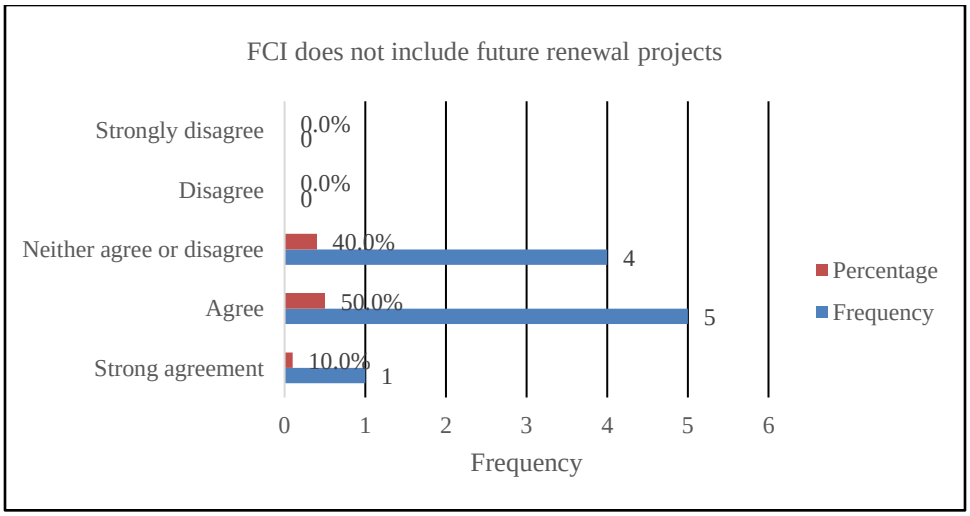

FCI a good indicator of whether maintenance is being carried out
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
0.0%
0.0%
50.0%
40.0%
10.0%
0
0
5
4
1
0 1 2 3 4 5 6
Frequency
Percentage
Frequency

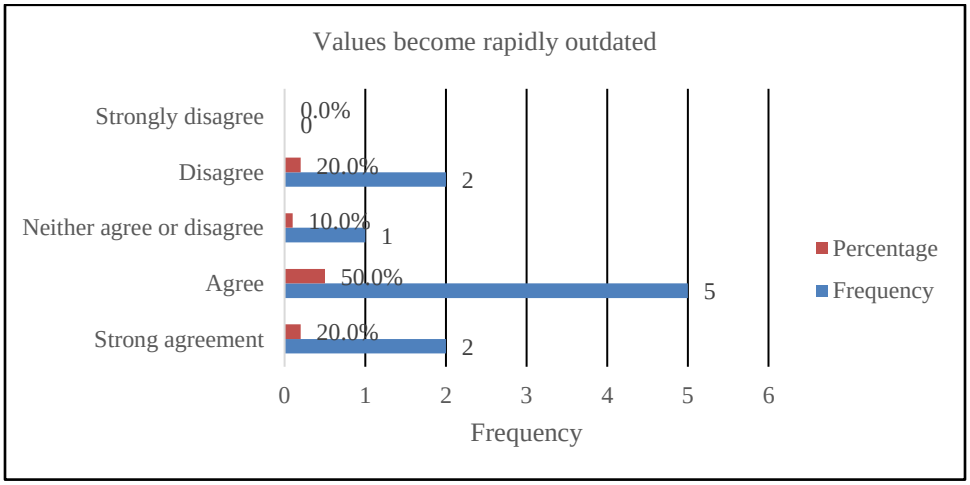

FCI a good indicator of renovation opportunities
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
0.0%
0
0.0%
0
30.0%
3
70.0%
7
0.0%
0
0 1 2 3 4 5 6 7 8
Frequency
Percentage
Frequency

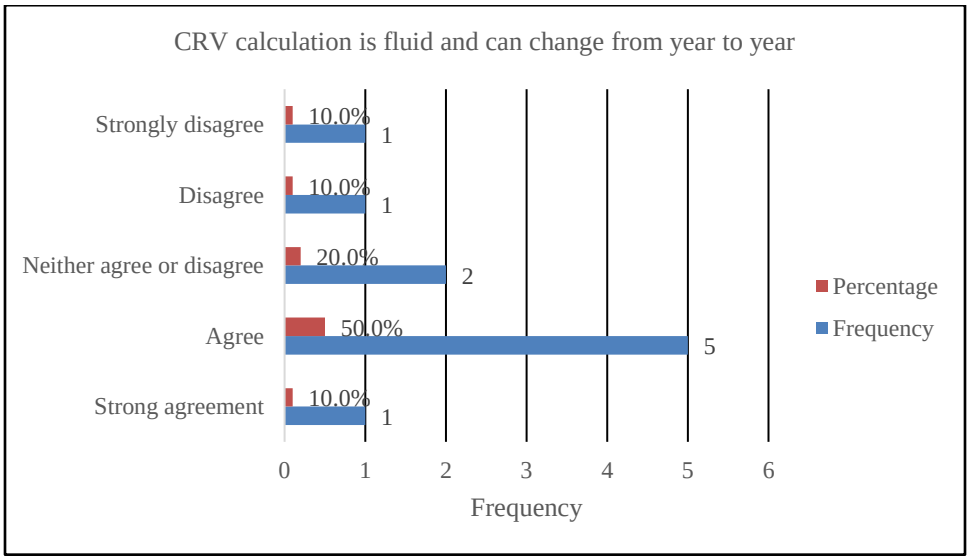
QUESTION 14

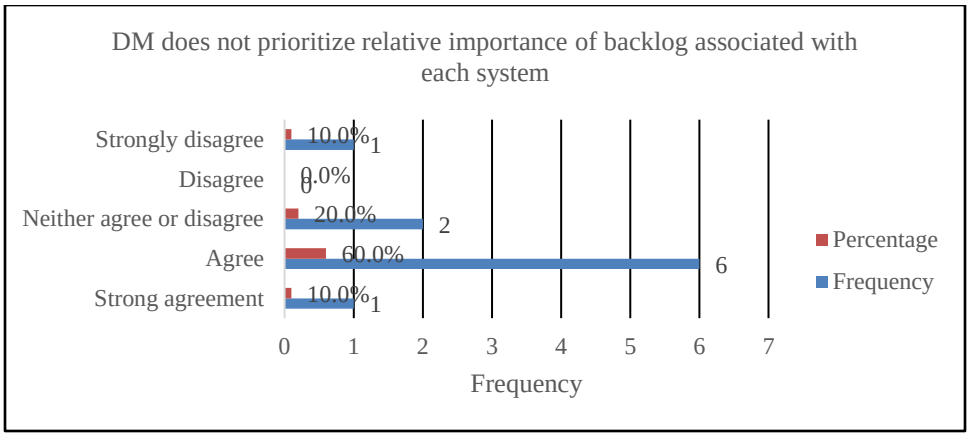

FCI does not account for condition of critical components
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
10.0%
1
10.0%
1
40.0%
4
30.0%
3
10.0%
1
0 1 2 3 4 5
Frequency
Percentage
Frequency

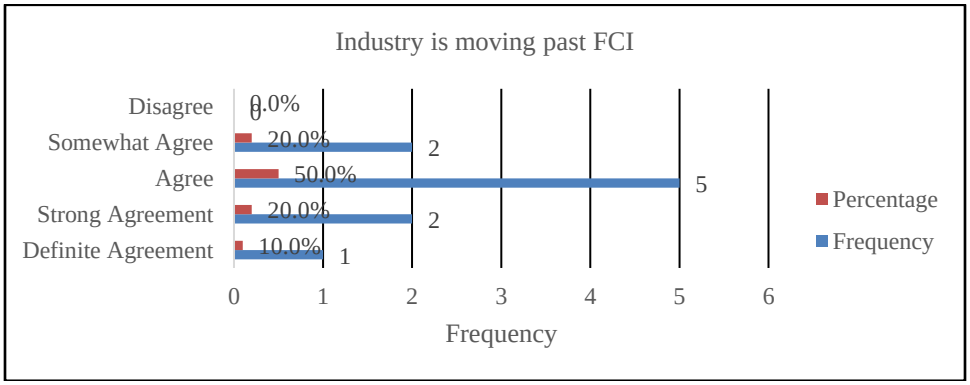

FCI cannot be used to compare diverse assets
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
10.0%
1
20.0%
2
40.0%
4
20.0%
2
10.0%
1
0 1 2 3 4 5
Frequency
Percentage
Frequency


FCI does not include future renewal projects
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
0.0%
0
0.0%
0
40.0%
4
50.0%
5
10.0%
1
0
1
2
3
4
5
6
Frequency
Percentage
Frequency


Values become rapidly outdated
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
0.0%
0
20.0%
2
10.0%
1
50.0%
5
20.0%
2
0
1
2
3
4
5
6
Frequency
Percentage
Frequency


CRV calculation is fluid and can change from year to year
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
10.0%
1
10.0%
1
20.0%
2
50.0%
5
10.0%
1
0
1
2
3
4
5
6
Frequency
Percentage
Frequency


DM does not prioritize relative importance of backlog associated with each system
Strongly disagree
Disagree
Neither agree or disagree
Agree
Strong agreement
10.0%
1
0.0%
0
20.0%
2
60.0%
6
10.0%
1
0
1
2
3
4
5
6
7
Frequency
Percentage
Frequency


Industry is moving past FCI
Disagree
Somewhat Agree
Agree
Strong Agreement
Definite Agreement
0.0%
0
20.0%
2
50.0%
5
20.0%
2
10.0%
1
0
1
2
3
4
5
6
Frequency
Percentage
Frequency

APPENDIX I. IRB NOTICE TO PROCEED

IRB Notice - 17-0027 Inbox x

IRB <uncc-irb@uncc.edu> Feb 1

to me, uncc-irbis, gmayo4

To: Pauline Karanja
Engineering Technology and Construction Management

From: Office of Research Compliance

Date: 2/01/2017
RE: Determination that Research or Research-Like Activity does not require IRB Approval
Study #: 17-0027

Study Title: The state of practice for condition assessment methods and metrics

This submission was reviewed by the Office of Research Compliance, which has determined that this submission does not constitute human subjects research as defined under federal regulations [45 CFR 46.102 (d or f) and 21 CFR 56.102(c)(e)(l)] and does not require IRB approval.

Study Description:

Studies have shown that a large percentage of buildings in America are deteriorating rapidly due to age and over capacity. Facility Condition Assessments are used to measure this deterioration with an aim of collecting data to determine the need and timing of maintenance. An assessment of the current standard of practice reveals that there is presently no established assessment methodology which hampers a widespread use of metrics for measuring/evaluating performance. This research aims at identifying the current state of practice with regards to data collected and analyzed during building surveys and aims at identifying what literature and industry experts state that may help to improve the current levels of practice.

Please be aware that approval may still be required from other relevant authorities or "gatekeepers" (e.g., school principals, facility directors, custodians of records), even though IRB approval is not required.

If your study protocol changes in such a way that this determination will no longer apply, you should contact the above IRB before making the changes.

CC:
Glenda Mayo, Engineering Technology and Construction Management

APPENDIX G. LIKERT SCALE CODING

1 = Strong agreement	1 - Strongly agree	1 = Always
2 = Agree	2 = Agree	2 = For almost all
3 = Neither agree or disagree	3 = Undecided	3 = Rarely
4 = Disagree	4 = Disagree	4 = Never
5 = Strongly disagree	5 = Strongly disagree	5 = I am not sure
1 = Every time	1 = Half a day	1 = Yes
2 = usually	2 = 1 day	2 = No
3 = Frequently	3 = 2 days	
4 = Sometimes	4 = 4 days	
5 = Occasionally	5 = 1 week	
6 = Rarely	6 = 2 weeks	
7 = Never	7 = More than two weeks	