CFaR Center for Facilities Research

Glenda Mayo, Ph.D., CDT, LEED-AP, CFM
Assistant Professor

and

Pauline Karanja, M.S.

2017

CFaR034-16

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

Table of Contents

Contents

The benefits of this research to the FM community have been corroborated by reviewers and our research mentor, Dr. 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, Dr. Kaiser has written books such as *Mortgaging the Future: The Cost of Deferring Maintenance*; *The Facilities Audit Workbook: A Self-Evaluation Process for Higher Education* (later revised as *The Facilities Audit: A Process for Improving Facilities Conditions*); *A Foundation to Uphold: A Study of Facilities Conditions at U.S. Colleges and Universities* (with Jerry S. Davis); 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 "Facilities Condition Assessment" chapter in APPA's online BOK (Body of Knowledge). We thank Dr. Kaiser for his dedication and assistance in this research effort.

Condition Assessments – Introduction

"FCAs are generally 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."—"State of Practice for Facility Condition Assessment," Pauline Karanja and Glenda K. Mayo (2016)

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 overcapacity (Hunter, 2009). Vanier (2001) provides an overview of asset management and the various tools and metrics used in the industry. A Facility Condition Assessment (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 preventive maintenance needs and the prioritization of capital expenditures. FCAs are used to measure this deterioration with the aim of collecting data to determine the need and timing of the predictive, preventive, or remedial action, and 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. However, the limitations of research for the state of practice for facilities management FCAs is due to the limited number of years that most owners have been conducting assessments. Owners often contract services to have condition assessments completed because they are unsure of the process or do not have the resources to conduct them on their own. Therefore, there are a limited number of owners to contribute to the body of knowledge in this area, and consultants are often reluctant to provide their specific methods as an industry contribution. Notwithstanding 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 although the industry has established general practices, there remains a lack of standardization regarding the methods and metrics for condition assessments. The identified issues may hamper the frequent and widespread use of performance metrics for measuring and evaluating performance within the industry. Therefore, there is an industry need to initially identify the current state of practice for data collection and analysis methods used during the FCA process. Due to industry inconsistencies in terms of how assessments are conducted, this study evaluated the practice of condition assessments by the FM industry. The study was not intended to provide prescriptive findings or recommended practices, but to identify current practices in order to establish a benchmark for future improvements.

Condition Assessments – Background

The purpose of an FCA is to establish the basis for determining the level of preventive maintenance needed for a building's systems and components (NCES, 2003). One of the greatest obstacles to developing an efficient condition assessment process is the subjectivity involved, and the ensuing lack of accuracy. Traditionally, a condition assessment for a building is performed

through visual inspection by experts in specific building systems, for example, 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. It is important to note that there are components in a condition assessment that are also objective (facility size, location, maintenance records, etc.) and that some organizations that have utilized the FCA process for many years develop a consistent nomenclature and dependable internal metrics. The condition assessment has been defined in different ways, some of which are tabulated in Table 1 (see Figure 1 on p. 11 for a diagram of the overall process for this study).

Table 1. Summary of Definitions

Reference	Definition
Rush et al., 1991 (NACUBO)	"A visual inspection of all architectural, civil/structural, mechanical, and electrical components of each facility; the inspection is performed to identify specific maintenance and repair requirements."
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 subcomponents 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 (National Center 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 on Educational Facilities)	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."

Brooks (2004) identified a timeframe (around 1989) when the Society for College and University Planning (SCUP), NACUBO, and APPA addressed the topic of condition assessments. A subsequent publication (Rush et al., 1991) provided a comprehensive foundation for the practice of condition assessments.

Current Issues

To establish existing practices and determine the current industry struggles with FCAs, a review was conducted using both the existing literature and industry contacts. It should be noted that this study was carried out with consideration of all commercial structures and for multiple types of owners, not just college and university buildings. There are instances when a college or university may own (or purchase from a different type of owner) a nontraditional building at a remote campus location. Additionally, it is important to emphasize the need to develop a common ground for standards; although owners have different building uses and requirements, an overarching standard should be used regardless of building ownership.

Unstructured, time-consuming, and expensive processes: Field inspection of buildings is carried out by experienced, knowledgeable inspectors who perform both the inspection and the analysis onsite, in order to identify the component's condition. The time required for inspecting a building depends on the level of detail involved, the size and number of components, the accessibility and complexity of the facility, and the resources allocated. The inspection process requires the inspectors to spend a lot of time 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. The current approach of manually adding/deleting/managing instances of components (e.g., a single boiler with specific components) is extremely time-consuming; the list of components should be standardized, to avoid the addition or deletion of instances and thus reduce the time required for the inspection process. Further, adding pictures of the inspected components is done manually, takes a great deal of time, and is difficult to manage.

To demonstrate the complexity of managing building assets, consider a typical university campus setting. For example, a single building may have about 200 components (roof, doors, boilers, HVAC systems, transformers, etc.). Even if we assume that each component has only three subcomponents, the resulting total is about 600 unique components. Therefore, to evaluate the condition of this hypothetical university building, 600 discrete components (grouped into multiple categories) must be inspected, rated, and further analyzed to determine the overall condition (Amani and Hosseinpour, 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.

Assessments can also be time-consuming due to the condition of a structure. Despite huge investments in constructing facilities, the maintenance of many 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, maintenance costs increase in subsequent years, with repairs equaling five times the maintenance costs (De Sitter, 1984). In a more recent publication, Geaslin's Inverse-Square Rule states that if repairs are not implemented in time, then renewal expenses can reach the square of the cost of the failure part (Geaslin, 2014).

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 and Hosseinpour, 2012; Underwood and Alshawi, 1999).

Lack of a mechanism for standardizing and prioritizing inspections: No mechanism exists for prioritizing inspection tasks and identifying critical items that need immediate inspection, and for determining the frequencies of inspections. In addition, no mechanism exists for efficiently deploying available inspectors and minimizing the frequency of inspections. Some organizations use AiM from Assetworks or similar systems as their IWMS (integrated workplace management system). AiM includes modules that link the maintenance work performed, FCA data, capital planning, and inspection scheduling to generate what can be described as a prioritization report.

Subjectivity of the assessments: The existing condition assessment process is highly subjective, because it involves the varied perceptions of the field inspectors. Recent improvements in this area have introduced electronic checklists or deficiency lists. However, to save time, deficiency lists (which need detailed analysis of their relative weights) are often bypassed in favor of quick subjective assessments. In addition, no support mechanism exists to help the inspector differentiate between assessment categories. As noted by Rush et al. (1991) in the original description, "these *subjective* ratings" were developed based on comprehensive inspections and discussions. Not only is there subjectivity in the assessment processes, but also in the reporting metrics, such as condition scales. Examples of condition scales and corresponding linguistic representations are listed in Table 2.

Table 2. Rating Scales

Reference	Asset Type	Condition Scale	Representation
Rush et al. (1991)	College and Univ. Bldgs.	0 – > .10	Under .05 = good; .05–.10 = fair; over .10 = poor.
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 (roofing)	1–7	Condition category (1 = failed; 2 = very poor; 3 = Poor; 4 = fair; 5 = good; 6 = very good; and 7 = excellent)
NCES, 2003	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)
DfES, 2003	Buildings	A–D	Condition category (grade A = good; grade B = satisfactory; grade C = poor; grade D = bad)

Lack of time-related condition records: Almost all existing condition assessment systems lack permanent documentation of the evolution of each component's condition over time. Therefore, the field inspector cannot quickly make visual comparisons with the previous condition of the building component. This study focused on the process, the metrics, and the final use of the information. Based on earlier articles on condition assessments and the Facility Condition Index (FCI) metric, the FM industry is maturing in asset management practices. APPA's newly developed Total Cost of Ownership (TCO 1000) standard is focused on many of the long-term ownership decisions that require good record keeping. Christensen (2016) stated that "good decision-makers require consistent accurate data over time. Measuring and metering performance is a critical part of the Strategic Investment Pyramid."

Inspection levels and techniques: DfES (2003) outlines methods such as visual inspections with manual input, tape dictation, and the more modern tablet and laptop method. Depending on the level of detail, some inspection reporting is unsuitable for replacement-based strategies. There is a need to determine a good balance between conducting the condition inspection at the detailed deficiency level (which is excessively time-consuming and is sometimes too detailed) and a direct ranking of Good, Fair, Poor, or Critical (which is more useful, but requires that subjectivity be reduced). Often, decisions about asset replacements are necessary, and examples such as this tie to the need to determine the purpose of condition assessments and how the resulting information is eventually utilized.

Analysis and metrics used: Brooks (2004) provided a history of the FCI, and states that Applied Management Engineering, Inc. developed the index, adding that it has become evident that the index ratings "are a great starting point to measure success"—which was what the FCI was developed for. "It was designed to be a quantitative method of uniformly comparing and monitoring groups of comparable facilities over time."

In addition to those metrics shown in Table 3, Kaleba (2013) also adds the use of hybrid methods, such as one developed by the University of Virginia for a formula combining the FCI with a Facility Renewal Index (FRI) for a total termed the "Facility Assessment Index" (FAI). There are numerous deviations, expansions, and adaptations of the metrics used in FM, whether they are used for commercial, education, or public entity purposes. One reason for these deviations is, as Rush et al. (1991) first stated, because the FCI does not take into account the priorities of facilities. For example, Kincaid (2013) extended the concept of the FCI in an article about the needs of the National Park Service (NPS) and the development of two key approaches combined with the FCI metric. The first was an Asset Priority Index (API), which reported the "value" or contribution of each asset in the existing portfolio to the NPS's mission. The second was the addition of critical systems identification. Overall, the FCI should be used hand-in-hand with a Needs Index (NI) to provide a model that takes into consideration the concepts of TCO and life-cycle cost principles. Kaiser (2004) states that condition, functionality, and regulatory needs are combined into a Facilities Needs Index (FNI), for a benchmark comparison with other facilities and institutions.

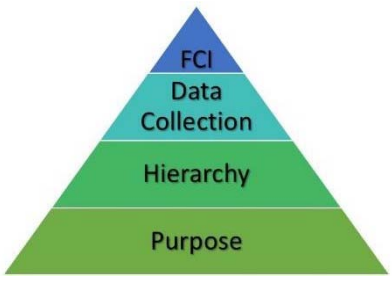
$$\text{FNI} = \frac{\text{condition needs + functionality needs + regulatory needs (times \%)}}{\text{CRV (current replacement value)}}$$

Cable et al. (2004) outlines the procedures and metrics used (for performance indicators) for organizations like the U.S. Coast Guard, the Department of Defense (DoD), Department of Energy (DOE), and other federal level organizations.

Table 3. Performance and Assessment Metrics

Metric	Reference	Description	Units
Current Replacement Value (CRV)	IFMA, 2008	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.	$
Deferred maintenance (DM), & deferred maintenance backlog	IFMA, 2008	The cost of maintenance of the property, and equipment that is postponed from a facility's operating budget cycle due to financial constraints.	$
Maintenance Efficiency Indicators (MEI)	Lavy and Shohet, (2003)	Indicates the efficiency with which maintenance activities are implemented. **Lavy et al. (2014) also suggests the development of a replacement efficiency index (REI), which could be used in consolidating capital costs, renewals, and replacement expenditure.* MEI values in three categories; low, reasonable, and high.	Based on the investment in maintenance, compared to the actual performance of the building
Facility Condition Index (FCI)	Rush et al. (1991) and Evans, (2007)	Represented by the ratio between the total cost of deficiencies to the CRV, or by the ratio between the costs of DM to the CRV.	Percentage of CRV
Capital renewal	IFMA, (2002)	The budget required for performing major renovations in the building, its systems, subsystems, and components.	$
Churn rate and churn costs	IFMA, (2002)	Represents the process of moving a group of employees and equipment within a period (per month or year).	Percentage of total average employees in $
Accessibility for physically challenged	Nkala, (2015)	Provision for physically challenged and preparedness of facility to accommodate special needs of physically challenged people.	Level of accessibility

Clayton (2013) states that a close study of these equations, makes it readily apparent why the Government Accountability Office (GAO) found that "condition indexes, which agencies report to the 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).

Figure 1. Research Breakdown

Research Background and Methods

The purpose of the study was to identify 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. Lastly, it also aimed at identifying whether there is consistency in how the FCI is calculated and its benefits and limitations. This was achieved through a comparison of the literature reviewed and an expert panel who took part in a Delphi questionnaire. The research also aimed at identifying the actions that industry experts believe may help to improve the current levels of practice and serve as a guide for FM. To make the research more manageable, it was organized as a progression from the "big-picture" of practices to the more formalized identification of specific metrics; it was first approached from a qualitative purpose and reasoning perspective, then from a more detailed, quantitative perspective, as shown in Figure 1.

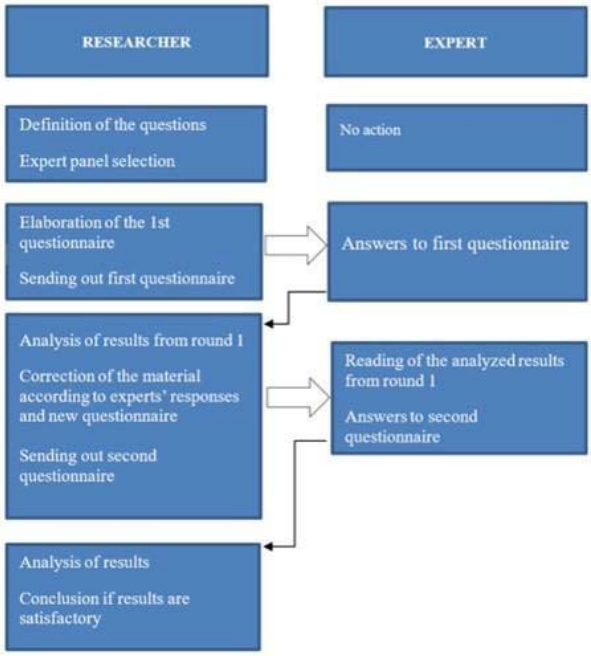


Figure 2. Delphi Steps

Methodology – Delphi Survey

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

was optimal for this study, because it allowed the expert panel to review results, contribute changes, and correct misunderstandings in the results as the research progressed.

The Delphi questionnaire comprised 17 statements divided into the four highlighted topic areas (Figure 1). The survey began on February 13, 2017, and panel members were given one week to complete the survey, with the conclusion of Round 1 being February 20, 2017. The first round consisted of the initial brainstorming, and a second round served as a confirmation round. 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- and third-round survey questionnaires. *Note: 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.*

Criteria

The purpose of the Delphi study is to obtain panel consensus. Round 1 served as a brainstorming round; in addition to having close-ended questions, the respondents could also 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 and qualitative data to ensure that the panelists were fully understanding each question. The feedback directed the research to additional information to be included in Round 2. One comment provided in Round 1 pertained to the calculation of the FCI, which added an additional formula to the list (for Round 2).

Table 4. Consensus Criteria

Level of Agreement	Conditions
Consensus	· Interquartile range (IQR) ≤1 and a percentage score ≥60% in a single level on all scales including yes/no
Strong Agreement (Round 2 only)	· 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	· Remaining items (met either IQR or % score but not both)
Total Disagreement	· IQR >1 and a percentage score <60% on all scales
Split Disagreement	· Regardless of IQR, percentage scores >25% on extreme ends of all scales · Regardless of IQR, percentage scores >40% on both ends of yes/no questions

After Round 1, statements that met the consensus level conditions (highlighted in Table 4) for both the frequency of the response percentage score and the interquartile range (IQR) were determined to be in consensus, and thus omitted after Round 1. All statements that met one condition and not the other remained in Round 2. Lastly, Round 3 was conducted to ensure that the panelists were comfortable with their answers and that there was stability in their responses.

Panel Qualifications and Background

The literature states that in selecting a panel for the Delphi process, criteria establishment is a requirement. Hallowell and Gambatese (2010) list ideal qualifications that include being in active practice with five years of professional experience, chairmanship of or membership in a nationally recognized professional body, writer/editor of a book, writer of a book chapter, authorship, and advanced degrees. They also state that the panelists should meet four of the qualifications as a minimum, whereas 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.

FCAs are generally conducted by the FM team employed by the owner, by a consultancy firm, or by a hybrid of both. However, it is not common for the owner to employ a specific FCAP (facilities condition assessment program) manager who oversees FCAs full-time and has the necessary expertise; in this case the owner had a limited set of options to select from, although this group was represented in the study. The experts invited to participate were all involved in carrying out FCAs and were deemed experts and selected based on their involvement with both APPA and the International Facility Management Association (IFMA). Since this study was endorsed by APPA, potential participants were referred to the researcher by APPA, while some were approached during the IFMA's World Workplace 2016 Conference, for the purpose of including two primary FM organizations.

Hallowell and Gambatese (2010) suggest that studies have not found a significant correlation between the number of panel members and the effectiveness of a Delphi study. However, they 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, and the current occupation of all participants was in FM. A purposive sample of 16 FM experts both from the owner and consultant sectors were short-listed for this study, and solicitation letters were sent out via email in December 2016 and continued until February 2017. A short solicitation survey was prepared highlighting the purpose of the study and asking for basic demographic data.

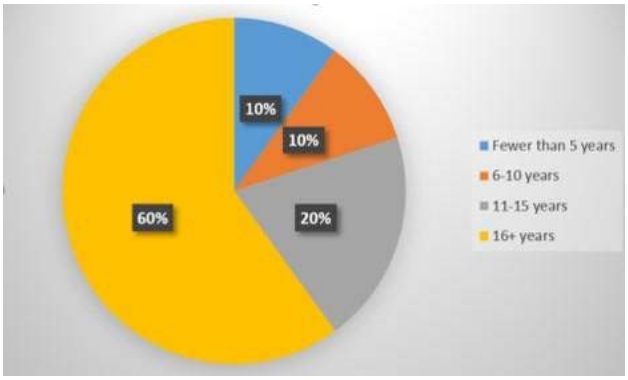


Figure 3. **Number of years of experience in Facilities Management**

Of the original 16 approached, 13 responded positively (81% response rate) to the initial solicitation. The participants were all located in the United States. Twelve of the participants (92%) had more than 10 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. The Northwest, South, and West regions of the United States were well represented, with no representation from the Midwest.

Delphi Results

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, six days before inviting the panelists to Round 2 of the survey, the results of Round 1 were shared with the panelists to allow review, and to allow them to change their answers in Round 2 should they need to. The survey began on March 20, 2017, and the participants were provided with one week to complete it, with the conclusion date being March 27, 2017. Of the original respondents, 10 out of 13 filled out the questionnaire.

The comments made in Round 2 indicated that responses varied slightly between the two rounds, and Round 3 unfortunately did not indicate stability in the responses. However, the most surprising result was that over half of the questions resulted in some form of disagreement. According to Gracht (2012), the absence of consensus is important as well.

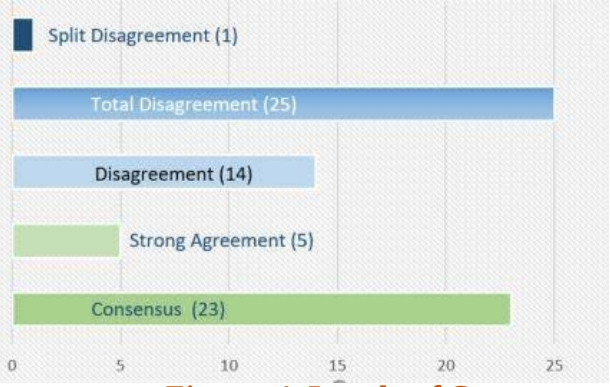


Figure 4. **Levels of Consensus**

The results presented in Tables 5–17 are delineated and presented by each of the categories outlined in Figure 1. Within each category, there are multiple questions that are shown in summary format in each of the tables. The results are discussed to showcase the observations and any qualitative comments from the panel pertaining to each of the topics.

In Tables 5–17, there are cases of disagreement among the panelists (even though 80% of the panel may agree). See Table 4. If the IQR is higher than 1 (as in this example), it indicates that two panel members responded with a very different answer.

IQR	% Score	Level of agreement
1.25	80	Disagreement

Purpose

The questions in the Purpose section of the Delphi survey aimed at gaining insight from the panelists on their opinion of the FCA and the process, as well as the format in which FCA reports are presented and what owners do with the reports upon receiving them. To collect data and measure deficiencies, FCAs are often carried out through visual surveys. These surveys or inspections should be carried out consistently and accurately, and with as much objectivity as possible. The FCI is considered a standard industry tool and is used to compare the condition of facilities and determine whether it is more economical to fully modernize them or to replace them (NCES, 2003). It was therefore not surprising that the panel agreed in Round 2 that the FCI is the overall desired metric and that it provides a good overall indication of a facility's condition. However, Round 3 dropped to disagreement due to a higher IQR.

Table 5. Purpose Category Results

Survey Response (Purpose)	IQR	% Score	Level of agreement
Ranking based on opinion:			
The FCI is typically the overall desired metric	1.5	62.5	Disagreement
The FCI provides a good overall indication of the structure's condition level	0.75	62.5	Consensus of "yes"
The FCA should be tied to a scorecard or Key Performance Indicator (KPI)	1	87.5	Strong Agreement
One of the difficulties of an FCA is the subjectivity of the assessments	.75	62.5	Consensus
Most FCAs are conducted because there is a mandatory requirement	1.75		Total Disagreement
The resulting information from an FCA is used at the administrative level only	1	62.5	Consensus (that it's not)

The panel came to a consensus that the FCA is not used at the administrative level only (70% on a combined disagree and strongly disagree scale in Round 1). Some of the panel members changed their response to the question in Round 2 on the FCA being tied to a scorecard or KPI, and the IQR of 1 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 or KPI, and the other half with a neutral response, neither agreeing nor disagreeing. One of the problems highlighted in the literature regarding the FCA inspection is the subjectivity involved. Regarding the FCA being subjective in its methods, which the literature discusses widely, the Round 1 analysis indicated total disagreement between the panel members; the answers were divided at 23% on levels ranging from "definite agreement" to "somewhat agree." In the second round, although panel members strongly agreed that the FCA is subjective in nature

(validating the conclusion from the literature review), the consensus level was disagreement, because there were opposing views resulting in an IQR of 1.25. However, by Round 3, there was consensus on the fact that there is subjectivity. 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 that subjectivity can be due to the inspector's specific individual experience, attitude toward risk, use of "rules of thumb," and biases (Scott and Anumba, 1996; Hogarth, 1987).

Table 6. Purpose Category Results (After Round 1)

Survey Response (Purpose)	IQR	% Score	Level of agreement
FCA format			
Excel spreadsheet	1	87.5	Consensus on "useful" format
Word or PDF report	1	53.8	Disagreement
Database	1	69.2	Consensus on "best" format
Hard copy binder	0.5	76.9	Consensus on format to avoid

The panel responded to the question about the best format for the reports, with 1 indicating the best format and 3 being a format to avoid. They were also given the option to add "other" to the list. The panelists were in consensus (after Round 1) that Excel is a good format, but they were not in consensus regarding the Word format. Regarding whether data from an FCA should go into a database, 69.2% of the panelists responded that a database was the best format. The comment here was that putting the data into a database allows for periodic real-time updates. This question ties to the question regarding what happens to the FCA once it is shared with the owner (Table 7). 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 chief financial officer 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.

Table 7 includes a summary of the responses on how the FCA is distributed once provided to the owner. The responses 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 (In Round 2, 80% agreed that the prevalence was low.) There was a higher response indicating the opinion that the information is disseminated to few users in the organization as opposed to widely distributed. A panelist commented that "unshared data is a waste of money and resources." This question also ties to the use of the information. With budget cuts and financial struggles faced by facilities, Carlson (2008) brings attention to the lack of "stewardship commitment," whereby funding from donors and legislature to roll out new projects is readily available, but funding to repair and maintain the very same facilities once they are constructed is difficult to come by. The FCA may be feeding directly into a budget approval process, but the question remains whether those approvals to spend are realized.

Table 7. Purpose Category Results

Survey Response (Purpose)	IQR	% Score	Level of agreement
FCA report distribution once provided			
Sits on a shelf	1.0	87.5	Consensus that report does not sit on a shelf
Disseminated to few users	.75	62.5	Consensus that the report is distributed to at least a few users
Disseminated to multiple users	1.0	87.5	Strong Agreement
Effort is made to make the information widely available to those in the organization	1.75		Total Disagreement

The results shown in Table 7 also indicate that at the higher levels of effort and distribution, the panelists were not in agreement. Overall, although there is no consensus that the information is widely distributed, the panelists evidently agreed that the information is disseminated, indicating that the condition assessments are not just requested or completed for the sake of the exercise. One of the panelists 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 extensive 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 is published for the public, while portions that trace back to the FCA are part of the publication. (3) The items most in need are listed with associated costs, which are used externally and politically to raise additional funding from the government." The last statement rings true when attempting to exploit the reports in terms of any resulting funding. Although the result of FCAs is a report that is then used for budgeting and planning (Hammad et al., 2003), it is important to ask the question, "Is the report getting to the right people and then ultimately materializing with funding?" Another question to consider is "Must the FM work politically to rationalize the reports in order to see a financial benefit?"

The questions above feed into the ultimate use of the collected data in terms of where the information is stored (Table 8). Surprisingly, the panel members disagreed on the whether the data collected following an FCA survey is uploaded into a system capable of analyzing, tracking, reporting, and prioritizing it, such as an IWMS, computerized maintenance management system (CMMS), or capital project management system (CPMS). This is in complete opposition to the literature, which states that the data in an FCA should be used continually to ensure that deficiencies noted are acted upon should funds be released. However, with regards to the frequency percent, the panelists leaned toward the import of data into a management system (50% of panelists agreed).

Table 8. Purpose Category Results

Survey Response (Purpose)	IQR	% Score	Level of agreement
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 project management system	1.75		Total Disagreement
Used to prioritize capital spending	1.0	87.5	Strong Agreement that it should be used

However, one of the panelists provided a comment that alludes to the difficulty of this task, and stated that FCAs need to be "refreshed" regularly because in their experience, the data is often not 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 dedicated FM personnel to upload the data and keep it updated. 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. Lastly, 87.5% of the panelists agreed that the report should be used to prioritize their capital spending, and that although the frequency met the condition for agreement, the IQR did not meet the condition due to the opposition of other panelists.

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 the Construction Specifications Institute (CSI), such as 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. An additional question to consider is how "deep" into a hierarchy should assets be tracked? At the component level? The questions in this section are posed to address the standards currently used in industry.

Requirements and Standards

It was imperative that the research inquire whether the panel was aware of any states (federal governments) that have requirements for structuring FCA methodologies. In both Rounds 1 and 2, panelists did not agree (Total Disagreement) on whether there was a government requirement to structure the FCA in a specific format, but in Round 3, there was a consensus of 75%—most likely due to clarifications after initial rounds. However, one of the panel members commented 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 or may ask consultants to develop their own for the project. These funding structures and priorities drive the method and content of the FCA, and the lack of a standardized format may lead to the inability to compare results. So, although owners often mandate a "structure," it may not follow a formalized or standardized structure.

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 previously discussed, although not an exhaustive list, current standards include OmniClass, MasterFormat, and UniFormat. The question was asked, "Which of the following formats for categorizing assets are used most often to organize the information in a facility condition assessment?" (on a Likert 5-point scale, ranging from "Always" to "Never" to "I'm not sure").

Table 9. Hierarchy Category Results

Survey Response (Hierarchy)	IQR	% Score	Level of agreement
Formats most often used for categorizing assets in an FCA			
UniFormat (ASTM E1557)	3		Total Disagreement
MasterFormat	2.25		Total Disagreement
OmniClass	2.0		Total Disagreement
ASTM FACTS (GSA)	2.0	62.5	Disagreement
No standard format	1.75		Total Disagreement
Our own internally developed format	1.75		Total Disagreement

One of the panelists made an accompanying comment that the classification standards available are limited in their effective granularity, which suggested a probable reason as to why these standard formats are not used consistently. After Round 1, a suggestion for a different format (ASTM FACTS (Facility Asset Component Tracking System), developed by the General Services Administration), was added to the list of formats for Round 2.
Uniformat was mentioned as coming up in conferences, but the results indicate that an internally developed format is the most prevalent, with Uniformat being the most frequent followed by MasterFormat (Table 9). This may be the reason why part of the difficulty in developing a standard for FCAs is the formation of hierarchy and the organization of assets. Setting standards to the main terms for asset inventory and management is very important at both the institutional level and the industry level; doing so will benefit the asset management system by allowing 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 the owner uses internally.

FCA Content

The panel agreed after Round 1 on the title headings (content) used in the reports they prepare for their company. However, there was disagreement on whether the building summary is included in the FCA report, with 42% of panelists indicating that they do not include one, and 58% indicating that they do (Table 10).

Table 10. Hierarchy Category Results

Survey Response (Hierarchy)	IQR	% Score	Level of agreement
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	Consensus
Inspection Team Data	1	75	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

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. Often, data is collected from visual walk-through inspection or in-depth studies that use a variety of technological diagnostic techniques. This decision is dependent on the needs of the facility owner or FCAP Manager. This research purposed to learn 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 in order to give their input on deficiencies noted during their interaction with the facility under survey.

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. Not surprisingly, there was consensus on the use of iPads and handheld computers such as tablets, laptops, and phone apps used for data collection, which could be explained by recent advances in technology. Surprisingly, there was also consensus on the use of forms or paper-based systems (61.5%); however, some of the panelists disagreed, stating that these tools should be avoided, and citing that they

create inaccuracies in 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; however, in hindsight of the survey, some respondents commented that iPads could be used to include photographs in the report (Table 11, Tools).

Table 11. Data Collection Category Results – Tools

Survey Response (Data Collection)	IQR	% Score	Level of agreement
Tools used for collecting data during FCAs			
Forms	1	61.5	Consensus
iPads	0.5	76.9	Consensus
Handheld computers (tablets, laptops, phone apps)	1	69.2	Consensus
Cameras	1		Split Disagreement

Diagnostic Analysis

During FCAs, there will be times when a diagnostic analysis is needed to determine the nature and extent of problems in order to allow corrective action. In Round 2, (comparable to Round 1), there was a greater consensus that moisture analyzers and smart levels are used. However, the smart level had a higher IQR than allowable for agreement. The panel disagreed on the use of handheld laser measurements, infrared thermographs, and tape measures. In Round 3, panelists again showed a greater level of disagreement. One panelist stated that thermography for moisture detection was in use for roofs, referring to a recently completed project in which the roofs were visually inspected as well as reviewed with infrared thermographs. This was due to a serious roof issue, which required a fixed-wing aircraft to take the infrared photographs, and was a one-off occurrence (Table 11, Analysis).

Table 11. Data Collection Category Results – Analysis

Survey Response (Data Collection)	IQR	% Score	Level of agreement
Technologies utilized while conducting FCA surveys			
Infrared thermographs	2.5		Total Disagreement
Handheld laser measurements	3.0		Total Disagreement
Moisture analyzers	2.0		Total Disagreement that they are rarely used
Smart levels	2.75		Total Disagreement
Tape measures	5.25		Total Disagreement

Occupant Consultation

The panelists were in consensus on the need to consult occupants. Occupants may provide insight into an ongoing problem that is not visually evident during an assessment. However, 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" (Table 12).

Table 12. Data Collection Category Results – Occupants

Survey Response (Data Collection)	IQR	% Score	Level of agreement
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

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. In Round 1, it seemed that the results were due to the need for clarification, so in Round 2 the question was revised, offering an example that included both the gross square footage and age of three hypothetical facility sizes. However, after Round 2, the panelists still disagreed on the amount of time taken for the FCA. Following rewording, the results indicated total disagreement on all the highlighted types of buildings; but 50% of the panelists did state that for buildings with complex systems, such as laboratories with a complex mechanical, electrical, and plumbing (MEP) system, two days were adequate (Table 13). The Committee on Advanced Maintenance Concepts for Buildings (National Research Council, 1990) stated that not only should the owner stipulate the scope of the FCA, they should also be interested 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.

Table 13. Data Collection Category Results – Time

Survey Response (Data Collection)	IQR	% Score	Level of agreement
Estimate of the time required to carry out an FCA survey on a 35,000-sq.-ft. space in a 15-year-old building.			
Complex Building, e.g., laboratory, theater, with a complex MEP system	3.5		Disagreement
Typical Commercial Building, e.g., standard office building	3.5		Disagreement
Light Commercial, e.g., warehouse	1.5		Disagreement

FCA Cycles

Together with finding out how long FCA surveys take, the research aimed at finding out how often they are carried out. The question asked of panelists was "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" (4-point ranking scale (1 – 4)).

The literature recommends that FCAs be done every three years or conducted annually as a portion of the overall portfolio (Brandt and Rasmussen, 2002). Lewis and Payant (2000) 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. The survey results indicated that the highest-ranking period was five years, with 50% of panelists indicating that a five-year cycle was the most feasible. A three-year cycle was seen as the second-most feasible cycle. The least feasible was the annual FCA cycle; this result also reflects what the literature states. However, one of the panelists suggested that "the best FCAs are done once, and then the data is managed in a life-cycle database. As assets reach the end of their useful life, they are assessed individually, but the campus-wide FCA is only done once." One question not asked, which may be addressed in future research, is to understand how an FCA is carried out once, the data managed, and then another FCA carried out as an update. Subsequent "updates" are the same as conducting a new condition assessment. Additionally, a panelist stated that FCAs should be conducted annually for all assets that are at or near the end of their useful life as determined by the life-cycle tracking system.

The FCI

The purpose of an FCA is to gain data in the form of quantitative measurements required to evaluate the condition of a facility. This is done by calculating a numeric value that reflects a specific condition indicating the severity of a facility's deficiencies, and may be presented through the FCI to establish prioritization of future expenditures. The consistency of how the FCI is calculated was one of the concerns highlighted in the literature. The different formulas for calculating the FCI have led to these indexes not being comparable for benchmarking purposes; therefore they cannot be used to understand the relative condition of assets. The purpose of the questions in this category was to find out what formulas the panelists used for the FCI, and to learn about other metrics used for condition assessment reporting.

FCI Formula

The formula given for calculating the FCI was identified in the literature as:

FCI = Deferred Maintenance ($)/Current Replacement Value (CRV) ($)

A member of the panel commented that the numerator selection is dependent on the client's mission and peer-group analysis (and it therefore differs from project to project). Another member provided an "other" formula that was added to Round 2. The statement was, "Renewal

cost is the current fiscal-year renewal costs and not the aggregate total. Also, deferred maintenance should be more appropriately termed 'deferred capital renewal.' Deferred maintenance denotes incomplete PM (preventive maintenance) and routine repairs. Deferred capital renewal denotes assets beyond their useful life that require replacement, renewal or retrofit."

$$FCI = \frac{\textit{Deferred Capital Renewal + Current FY Recapitalization Costs}}{\textit{CRV Total Database Value (\$)"}}$$

This formula was added to Round 1, but was corrected in a comment for Round 2. The panelists in Round 2 were in agreement that the above formula was not used. The correction comment provided in Round 2 was that "Deferred Maintenance is preventive or planned maintenance that was not or has not yet been done. 'Deferred Capital Renewal' refers to assets that are beyond economic useful life and should be considered for renewal or replacement. None of these formulas above correctly indicate the most commonly accepted formula for FCI." It is:

$$FCI = \frac{\textit{Deferred Capital Renewal (\$)}}{\textit{Aggregate CRV of all Managed Assets (\$)"}}$$

The overall view of the responses for this question validates the research problem stating that there is currently no standard method of calculating FCI. There was therefore total disagreement on most of the questions; this was also reflected in the high IQRs related to these questions (Table 14). 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. *Note: The Round 3 confirmation survey utilized the correction to the added formula.*

Table 14. FCI Category Results – FCI Formula

Survey Response (FCI)	IQR	% Score	Level of agreement
The standard formula for the FCI is Deferred Maintenance ($)/Current Replacement Value ($). Which formula does your organization utilize?			
Deferred Maintenance ($)/Current Replacement Value ($)	5.75		Total Disagreement
Deferred Maintenance ($) + Renewal Costs ($)/ Current Replacement Value ($)	4.5		Total Disagreement
Deferred Maintenance ($) + Renewal Costs ($) + Regulatory Compliance ($) + Adaptation (ADA) ($) /Current Replacement Value ($)	4.75	62.5	Disagreement (but 62.5% responded used 90–100% of the time)
Deferred Capital Renewal ($) + Current FY Recapitalization Costs/CRV for total Database Value	3.75		Total Disagreement but most responded "never"

A panelist provided this comment regarding the FCI: "Per the APPA TCO 1000 ANSI Standard in development, the term 'Deferred Maintenance' is more appropriately termed 'Deferred Capital Renewal.' This term connotes a more accurate definition of what is needed and omits the inference to routine preventive maintenance and repairs that are not applicable to condition assessments."

CRV Computation

The panel came to a consensus regarding the fact that the CRV formula is used as a standard calculation. The formula provided to the panelists was:

$$CRV = \textit{gross square footage of the existing building} \times \textit{estimated cost (per sq. ft.) to design and build a new facility}$$

There was Round 1 consensus among the panelists regarding the use of the above formula for calculating CRV. There is, however, the question of how the actual figures are derived, especially with regard to the estimated cost (per square foot) to design and build a new facility. But after Round 2, the remaining panelists were split between using the estimate given by an internal estimator without any standard set by the organization, or using a standard agreed upon by the institution. Another formula clarification from a panelist in Round 2 stated, "The CRV is taken from the aggregate value of the inventoried and managed assets. It is NOT the same value that the insurance would use for a total loss, as is more closely described above." Although the formula may be standardized, the methods of arriving at the figures to use in the formula differ. Again, these results support the literature, which states that the FCI is inconsistent (Clayton, 2013).

The next question asked the panelists how their organization obtained their costs for use in the formula. The panelists were in consensus that they did not use any kind of formula determined by insurance requirements; 25% stated that an internal estimator calculates CRV, but 62.5% stated that the cost-per-square-foot model is used. Table 15 summarizes the responses for the CRV formula and calculation method.

Table 15. FCI Category Results – CRC Formula

Survey Response (FCI)	IQR	% Score	Level of agreement
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
Standard for calculating CRV			
As an estimate by an internal estimator (w/or w/out standard), insurance requirements, or cost per square foot.	1.75	62.5	Disagreement

FCI Benefits and Limitations

At the beginning of the questionnaire (Question 1), the panel members agreed on the FCI being the desired overall metric, as 80% of the panelists agreed. However, when asked more specifically if it is a "tried and true" metric, the response dropped to 60%. They disagreed about whether this information should be tied to a balanced scorecard or KPI (50% of the panelists were neutral on the issue). Regarding the benefits of the FCI, the panelists were in partial agreement that the metric should be used as a KPI. However, it is not surprising that the panel did not find the FCI to be ideal as a benchmark that assists in reducing the backlog; moreover, a comment by a member of the panel indicated that the FCI has too much variance to be used as a benchmark. Nevertheless, one of the panel members positively commented that 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. Although some of the statements (Table 16) were determined to not be in consensus for the entire panel (those statements with high IQRs), the statements with a percent score show that there is at a minimum a sway toward similar thoughts on the topic.

Table 16. FCI Category Results – Benefits

Survey Response (FCI)	IQR	% Score	Level of agreement
Benefits of the FCI			
Is a tried and tested metric	1.75		Total Disagreement
The FCI creates a common language among organizational staff to describe the condition of assets	2.25	75	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	1.75		Total Disagreement
Industry has an acceptance of the thresholds set for good, fair, poor, and critical conditions	2.50	75	Disagreement
The FCI is used as a snapshot in time to compare similar assets	1.0	87.5	Strong Agreement
The FCI as a benchmark assists facilities managers reduce a backlog in deferred maintenance through its use in calculating "catch-up" costs and therefore assisting in getting budget approval	2.0	62.5	Disagreement
The FCI is a good indicator of whether maintenance is being carried out	.75	62.5	Consensus
The FCI is a good indicator of renovation opportunities	1.75		Total Disagreement

A panelist summed up their thoughts this way: "FCI is a way to reduce conversation with budget approvers. It is a leadership commitment to a specific, defined condition and is also a parameter for stakeholder investment and satisfaction. It may take some time to figure out which measurement methodology is best, and at what level (an FCI for a total facility is somewhat useless. It must be backed up by more detailed asset-oriented condition information), but it is one way, when used consistently, to measure the condition of assets and facilities and can be used for relative comparisons both inside and outside of the facility. Until there is a database of FCI information available for common assets and industries, and a common standard for measurement of conditions across industries but specific to asset classes, FCI will continue to be viewed as a one-sided, almost biased view."

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 in 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, meaning that it is only considered whenever there is a need to justify capital spending. Another member of the panel commented that they feel as though the industry is moving past the FCI and toward more predictive approaches to managing deficiencies. This is an opportunity for further research regarding a more dynamic use of the FCI. The open suggestions (other) resulted in additional questions for Round 2, including the addition of the concerns of the FCI (Table 17).

Table 17. FCI Category Results – Limitations

Survey Response (FCI)	IQR	% Score	Level of agreement
Concerns of the FCI			
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	2.75		Total Disagreement
The FCI cannot be used to compare diverse assets	2.5	62.5	Total Disagreement (but most state that it cannot be used)
The FCI does not include future renewal projects	.75	62.5	Consensus
Values become rapidly outdated due to factors such as deterioration; the FCI is always relative to the year of the survey	2.75		Disagreement

CRV calculation is fluid and can differ year on year, resulting in an inconsistent FCI and difficulty in benchmarking	1.75		Total Disagreement
The deferred maintenance aspect of the standard FCI formula does not prioritize relative importance of backlog associated with each system	1.75	75	Disagreement
The industry is moving past the FCI and toward more predictive approaches to managing deficiencies	1.0	87.5	Strong Agreement

Regarding limitations of the FCI (Table 17), although in overall disagreement, most of the panelists agreed that it does not include future renewal projects (87.5% when including strong agreement and agreement). There was consensus on the FCI values becoming rapidly outdated due to factors such as deterioration, although the IQR on this statement was above the allowable threshold at 2.75. It was agreed that the DM aspect of the FCI does not prioritize relative importance of individual system backlog. The panel was in strong agreement that the industry is moving past the FCI and toward more predictive approaches.

Stability of Consensus

Round 3 served to establish whether there was stability in the responses. For example, there may be cases where the panelists may never reach consensus regardless of how many rounds are conducted. Scenarios whereby panelists disagree provides important insight into future research and industry discussions that may eventually assist to improve methodologies. With regards to stability of the responses between rounds for group stability, the Wilcoxon test was used. If the responses are *not significantly* different from 0 ($p < 0.05$), this indicates little or no change in responses; the results after Round 3 indicated that the group responses were not stable there. However, the weighted kappa (K-value) statistic was also used. This test determines the within-subject level of agreement (individual stability), not level of agreement between participants (group stability). This statistic is sometimes preferred over group stability. When used in conjunction with the Wilcoxon test (group stability), it provides greater support for decision-making. In summary, there were still updated responses during Round 3. The researchers felt that in view of the open-ended responses during the Delphi process, the continued discussions contributed to the lack of stability in the results.

Table 18. Level of agreement represented by K-values (Anthony, 1999; Fliess, 1981)

K-value	Agreement level	Agreement level totals
0.0 – 0.20	Poor agreement	13
0.21 – 0.40	Fair agreement	10
0.41 – 0.60	Moderate agreement	6
0.61 – 0.80	Substantial agreement	2
0.81 – 1.00	Almost perfect agreement	4

Conclusions of the Study

The researchers felt the need to not only collect data, but to ensure that the qualitative responses were reflected in the overall study and to provide a foundation for future research regarding current issues that the panelists felt exist in the FM industry. The panelists' comments helped to highlight ambiguities in the questions due to the broad nature of FM, and additionally helped researchers to understand how questions were interpreted. The main objective of this study was to highlight what the industry feels is the current state of practice. The basis was to understand how FCA surveys are carried out, how data is collected, what is reported in the FCA, and why. Although the methodology (Delphi study) was designed to obtain consensus, this study was unable to obtain full consensus, and therefore provides an indication that further development of FM standards and metrics is necessary. The progression of the survey was from a purpose perspective (overall) to the specifics of the FCI, and a greater level of consensus was obtained with regards to the "why," or purpose, and lower levels with regards to the "how" for the metrics. Progress has continued since the inception of the FCA in the 1980s, but there remains room for further growth, especially regarding the calculation and use of specific metrics such as the FCI.

The results showcase several topics that should be explored in future research initiatives. Since metrics represent indicators that *can* be used for comparison within and between institutions, they may provide an essential common platform for comparison based on which improvements can be sought. The FCI (or similar culmination of asset indices) are being used by owners outside of educational institutions; therefore standardization regarding the asset classification and the combination of the needs index is required. Due to structures required by specific owners' needs and mandates, standardization of the FCA may be difficult to establish. However, with further refinement of methods, the FCA process can be utilized in broader applications with greater capabilities for comparison. Third parties can help to reduce biases and inconsistencies within an institution; however, there remains the issue of consistency across organizations that do not utilize the same consultants or the same metric calculations.

Additionally, questions raised regarding the use of technologies may indicate that currently, owners are required to manually enter reports into CMMS systems, which may lead to the information remaining in static reports (snapshots in time) as opposed to the integrated and dynamic use of data. The industry is working to ensure that a conduit exists to transition design and construction data into an owner's database, and this study confirms that condition assessment data is also another data entry need that should be considered. Owners are working to collect information about their assets automatically; thus condition information obtained during ownership can provide critical data for determining the remaining useful life of an asset, and more importantly, the timing for possible intervention steps to bring levels of service back to a desired standard. Technology considerations may also allow for a more seamless means of using previous FCAs. Institutions are spending excessive amounts of funds on redoing the survey as opposed to updating current condition data. The study shows a consensus that facility users are consulted during the FCA process, but it is also important to understand that the front-line crew must be engaged in the process as well. If they are not informing the data and are not given the data to act upon, the FCA is merely an administrative tool with limited value to the institution.

Lastly, according to the panelists, the FCI 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 and that its use is functional, but also that owners should be purposeful about its use. One panelists stated that in several cases, the response could have been "it depends," based on additional variables to consider. For example, in determining whether maintenance is being carried out, figures and reporting are difficult—even though maintenance may be completed, one can still ask how "well" the work is being done. An additional example would be a situation where the facilities manager has a backlog, but then also adds a new facility. In this case, there is a lowered figure for backlog that indicates a false "success" or improvement simply based on the calculation. A panelist summed up the researchers' thoughts in stating that "condition assessments drive the FCI, but there is so much more that can be done with the data to tell the real story." In summary, the conclusions may not provide an indication for best practices or recommendations for methods of conducting FCAs. However, the study has initiated the discussion regarding industry improvements for condition assessments—and additionally, how facilities managers utilize the data they collect.

Limitations and Future Research

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

1. The panelists indicated that due to the need to answer in a survey format, they had several questions whereby they felt the response could be "it depends," based on their experiences. Interviews, whether face-to-face or by telephone, attempted to solve this issue; although time was also a constraint, and the researchers were attempting to minimize disruption for the busy panelists.
2. To assess reliability of the results gained from the Delphi survey, it was the intention of the research to compare actual FCA reports, but many owners and consultants were reluctant to share these.

The present research also opens new opportunities for similar studies on FCAs in the asset management arena. 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 facilities managers.
- Whether the industry is moving past the use of the FCI and toward more predictive approaches to managing deficiencies (as one of the panelists indicated). This is an area that requires further study, to learn whether this is indeed the trend and how capital expenditure is justified.
- Whether the front-line crew in FM are engaged in the FCA process, or whether they receive the information and must run with it in as far as rectifying the deficiencies.
- Whether available classification standards are limited in their effective granularity (as one of the panelists commented). Future research may examine current classification standards with the aim of understanding how owners classify their assets and whether

industry agrees with the panelist's deduction.

Appendix A

2016-17 Delphi Panel Participants

A special thank you to the panel participants. The process of completing the rounds of surveys was time-consuming, and we sincerely appreciate your time and talent in providing valuable input to this study. Affiliations are correct as of the time of the study.

If you would like to be recognized in this section of the report, please respond to the email and let us know. Otherwise, you will remain anonymous as shown below, with only a state listed.

Bob Askerlund	Salt Lake Community College
Cameron Christensen	CEFP, FMP, AVP Campus Planning and Facilities Management CUNY College of Staten Island
Jim Johnson	FCAP Manager, UNC Charlotte
Nancy Johnson	President/CEO, Facility Matters LLC
Lauren Moss, CFM, PMJ-1	CBRE
Edmond P. Rondeau	(Retired) Georgia Institute of Technology
Ana Thiemer	Associate Director, Planning, at the University of Texas at Austin
Steven Warshaw	Warshaw Group, Inc. – www.intellis.io
Anonymous	MA
Anonymous	PA

Appendix B

List of Questions for Each Round

ROUND 1	ROUND 2 and Round 3
Q2. Rank the following based on your personal opinion – Likert 5 scale (Definite Agreement to Disagree)	Q2. 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)	(Consensus in Round 1) – Removed.
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	Q3. How is the FCA report distributed once provided to the owner (with 1 being the most prevalent)? – Ranking 4 scale (1 – 4)
Q4 was split into two questions.	Q4. 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)	Q5. 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)	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 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	(Consensus in Round 1) – Removed.
Q8. Which of the following tools are used for collecting data during facility condition assessments (Check all that apply) – Select all that apply	(Consensus in Round 1) – Removed.
Q9. Which technologies are utilized while conducting facilities condition assessment surveys? – Select all that apply	Q7. How frequently are the following technologies utilized while conducting facilities condition assessment surveys? – Likert 7 scale (Every time to Never)
Q10. Are facility users consulted during the FCA process in order to identify deficiencies or functional issues of the spaces they occupy? – Yes/No	(Consensus in Round 1) – Removed.

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)	Q8. *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)
Q12. How often should FCAs be carried out (per facility)? – Select all that apply	Q9. 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)
Q13. The standard formula for the FCI is Deferred Maintenance ($)/Current Replacement Value ($). Which formula does your organization utilize? Select all that apply	Q10. 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)
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	(Consensus in Round 1) – Removed.
Q15. How is the CRV calculated? – Select all that apply	Q11. What do you feel is the best and most appropriate method to calculate the CRV for most owners? – Select one that applies.
Q16. Rate the following benefits of the FCI based on your personal opinion. – Likert 5 scale (Definite Agreement to Disagree)	Q12. Rate the following benefits of the FCI based on your personal opinion. – Likert 5 scale (Strong Agreement to Strongly Disagree)
Q17. Rate the following concerns of the FCI based on your personal opinion. – Likert 5 scale (Definite Agreement to Disagree)	Q13. Rate the following concerns of the FCI based on your personal opinion. – Likert 5 scale (Strong Agreement to Strongly Disagree)

References

Amani, N., and A. Hosseinpour. (2012). "An Overview of Component Condition Assessment Systems (CCAS)." ICSDEC 2012: Developing the Frontier of Sustainable Design, Engineering, and Construction: Proceedings of the 2012 International Conference on Sustainable Design and Construction, November 7-9, 2012, Fort Worth, Texas. ASCE, 2013.

American Society for Testing and Materials (ASTM 2008). "Standard Guide for Property Condition Assessments: Baseline Property Condition Assessment Process." ASTM E2018-08. West Conshohocken, PA: ASTM International.

American Society for Testing and Materials (ASTM 2015). "Standard Guide for Property Condition Assessments: Baseline Property Condition Assessment Process." ASTM E2018-15. West Conshohocken, PA: ASTM International.

Anthony, D. M. (1999). *Understanding Advanced Statistics: A Guide for Nurses and Health Care Researchers*. New York, NY: Churchill Livingstone.

APPA, IFMA, et al. (2002), *A Framework for Facilities Lifecycle Cost Management: Asset Lifecycle Model for Total Cost of Ownership Management Framework*.

Bourke, K., and H. Davies. (1997). "Factors Affecting the Service Life Predictions of Buildings, a Discussion Paper, Laboratory Report." Garston, U.K.: Building Research Establishment.

Brooks, R. (2004). "History of the Facility Condition Index." *Facilities Manager*, March/April 2004: 41-43.

Cable, J., J. Davis, Federal Facilities Council, Federal Facilities Council Ad Hoc, and the Committee on Performance Indicators for Federal Real Property and Asset Management. (2004). "Key Performance Indicators for Federal Facilities Portfolios." Washington, D.C.: National Academies Press.

Carlson, S. (2008). "As Campuses Crumble, Budgets Are Crunched." (cover story). *Chronicle of Higher Education* 54(37): A1-A14.

Chouinard, L. E., G.R. Andersen, and V.H. Torrey. (1996). "Ranking Models Used for Condition Assessment of Civil Infrastructure Systems." *Journal of Infrastructure Systems* 2(1): 23-29.

Christensen, D. (2016). "What is TCO? Why TCO?" *Facilities Manager*, July/August 2016: 21-23.

Clayton, J.B. (2013). "Condition Assessment in Facility Asset Management." *Report to Congress: Identification of the Requirements to Reduce Backlog of Maintenance and Repair Defense Facilities.*

Council of Great City Schools (2014). "Reversing the Cycle of Deterioration in the Nation's Public School Buildings."

Department for Education and Skills (DfES 2003). "Assessment Management Plans – Condition Assessments, Section 3a: Getting into Condition." DfES/0175/2003. Sherwood Park, Annesley, Nottingham: DfES.

De Sitter, W.R. (1984). "Costs for Service Life Optimization: The Law of Fives, Durability of Concrete Structures." Workshop Report, Copenhagen, Denmark, pp. 131-134.

Elhakeem, A. (2005). "An Asset Management Framework for Educational Buildings with Life-Cycle Cost Analysis." Ph.D. Thesis, University of Waterloo, Waterloo, Canada.

Elhakeem, A., and T. Hegazy. (2005a). "Towards a Visual Guidance System for Condition Assessment of the Building Infrastructure." *Proceedings of 1st CSCE Specialty Conference on Infrastructure Technologies, Management, and Policies*. CSCE, Toronto, Ontario, Canada, June 2-4, FR-159.

Elhakeem, A., and T. Hegazy. (2005b). "Improving Deterioration Modeling Using Optimized Transition Probability Matrices for Markov Chains." *Proceedings of the 84th Transportation Research Board Annual Meeting.* Washington, D.C., Transportation Research Board, Jan. 9-13, No. 05-2656.

Fagan, M.M., and D.M. Kirkwood. (1997). "Facility Condition Assessments: More than Just Making a List." American Society for Healthcare Engineering, 34th Annual Conference and Technical Exhibition.

GAO (2015). "Preliminary Results Show Continued Challenges to the Oversight and Support of Education Facilities." General Accounting Office Study, GAO-15-389T. Published February 27, 2015.

Geaslin, D.T. (2014). "Geaslin's Inverse-Square Rule for Deferred Maintenance Effort." http://www.geaslin.com/invers-square_rule.htm.

Hallowell, M.R., and J.A. Gambatese. (2010). "Qualitative Research: Application of the Delphi Method to CEM Research." *Journal of Construction Engineering and Management* 136 (1): 99-107.

Hammad, A., J.H. Garrett, and H.A. Karimi. (2003). "Mobile Infrastructure Management Support System Considering Location and Task Awareness." 4th Joint Symposium on Information Technology in Civil Engineering, ASCE, Nashville, TN.

Hunter, R.C. (2009). "The Public School Infrastructure Problem: Deteriorating Buildings and Deferred Maintenance." *School Business Affairs,* February 2009: 365–374.

Infrastructure (1992). A Century of Building America, Infrastructure, July 1992. International Facility Management Association

International Facility Management Association (IFMA) (2008). *Operations and Maintenance Benchmarks Survey 2008*. Houston, TX: IFMA.

Joint Committee for Educational Force (JCEF 2004). "Arkansas Statewide Educational Facilities Assessment." State of Arkansas.

Kaleba, F. (2013). "Facility Condition Assessment from A to Z." *Facilities Manager,* January/February 2013: 26-30.

Kempton, J., S. Nicol, C. Anumba, and J. Dickens. (2001). "Surveyor Variability in Large Scale House Condition Surveys." *Structural Survey* 19(4): 156-62.

Kaiser, H.H. (1993). *A Foundation to Uphold: A Study of Facilities Conditions at U.S. Colleges and Universities*. Alexandria, VA: APPA – Leadership in Educational Facilities, p. 195.

Kaiser, H.H. (2004). "Reviewing the State of Deferred Maintenance." APPA – Leadership in Educational Facilities. *Facilities Manager,* November/December 2004: 14-21.

Kaiser, H.H. (2014). "Facilities Condition Assessment." In *Body of Knowledge,* Alexandria, VA: APPA – Leadership in Educational Facilities, pp. 15–33.

Kincaid, D. (2013). "National Park Service's Asset Priority Index Helps Guide Maintenance, Operations." Facilitiesnet.com. https://www.facilitiesnet.com/facilitiesmanagement/article/National-Park-Services-Asset-Priority-Index-Helps-Guide-Maintenance-Operations-Facilities-Management-Facilities-Management-Feature--14350

Lavy, S., J.A. Garcia, and M.K. Dixit. (2014). "KPIs for Facility Performance Assessment Part I: Identification and Categorization of Core Indicators." *Facilities* 32 (5/6): 256-272.

Lee, J.H., and H.M. Aktan. (1997). "A Study of Building Deterioration." In *Infrastructure Condition Assessment: Art, Science, and Practice*, conference proceedings, American Society of Civil Engineers: New York, NY, pp. 1-10.

Lee, H., and E. Chou. (1993). "Survey of Image Processing Applications in Civil Engineering." In *Proceedings of the Conference on Digital Image Processing: Techniques and Applications in Civil Engineering*, ASCE, Kona, Hawaii, February 28-March 5, pp. 203-210.

Lewis, B., and R. Payant. (2000). *Facility Inspection Field Manual: A Complete Condition Assessment Guide.* New York, NY: McGraw-Hill.

Lounis, Z., M.A. Lacasse, D.J. Vanier, and B.R. Kyle. (1998). "Towards Standardization of Service Life Prediction of Roofing Membranes." *Conference: Roofing Research and Standards Development*, Nashville, TN. ASTM Special Technical Publication STP 1349.

Mayo, G. (2014). "Non-Geometric Building Information Needs Assessment Matrix for Facility Owners." Ph.D. Dissertation, University of Florida, Gainesville, FL.

Mayo, G., and R. Issa. (2015). "Non-Geometric Building Information Needs Assessment for Facilities Management." *J. Manage. Eng*. http://ascelibrary.org/doi/abs/10.1061/(ASCE)ME.1943-5479.0000414.

McCall, H.C. (1997). "School Facilities Condition, Problems and Solutions." State of New York, Office of the State Comptroller.

U.S. Department of Education, National Center for Education Statistics, National Forum on Education Statistics. (NCES 2003b). *Facilities Information Management: A Guide for State and Local Education Agencies*. NCES 2003-400, prepared by the Education Facilities Data Task Force. Washington, D.C.

National Research Council (U.S.), Committee on Advanced Maintenance Concepts for Buildings, R.F. Jortberg. (1990). *Committing to the Cost of Ownership: Maintenance and Repair of Public Buildings*. Washington, D.C: National Academy Press.

Nkala, S. (2015). "Defining Early Facilities Management Involvement Using the Concepts of Performance Management." Master's Thesis, Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, South Africa.

Rayens, M.K., and E.J. Hahn. (2000). "Building Consensus Using the Policy Delphi Method." *Policy, Politics, and Nursing Practice* 1 (4): 308-315.

Rugless, J. (1993). "Condition Assessment Surveys." *Facilities Engineering Journal* 21(3): 11-13.

Rush, S.C., National Association of College and University Business Officers (NACUBO), Coopers and Lybrand, and Applied Management Engineering, P.C. (1991). *Managing the Facilities Portfolio: A Practical Approach to Institutional Facility Renewal and Deferred Maintenance.* Washington, D.C.: National Association of College and University Business

Officers.

Sadek, A.W., A. Kvasnak, and J. Segale. (2003). "Integrated Infrastructure Management Systems: Small Urban Area's Experience." *Journal of Infrastructure Systems* 9(3): 98-106.

Scott, D., and C.J. Anumba. (1996). "An Intelligent Approach to the Engineering Management of Subsidence Cases, Engineering." *Construction and Architectural Management* 3: 233-48.

Skulmoski, G. J., F.T. Hartman, and J. Krahn. (2007). "The Delphi Method for Graduate Research." *Journal of Information Technology Education* 6: 1-21.

Straub, A. (2003). "Using a Condition Dependent Approach to Maintenance to Control Costs and Performances." *Journal of Facilities Management* 1(4): 380-395.

Teicholz, E. (1995). "Computer Aided Facility Management and Facility Condition Assessment Software." *Facilities* 13(6): 16-20.

Teicholz, E. (2001). *Facility Design and Management Handbook*. New York, NY: McGraw-Hill.

Teicholz, E., and A. Edgar. (2001). *Facility Condition Assessment Practices*. Houston, TX: IFMA, September 2001.

Underwood, J., and M. Alshawi. (1999). "Towards an Integrated Application for Forecasting Building Element Maintenance." *International Journal of Computer Integrated Design and Construction* 1 (1): 39-48.

Vanier, D.J. (2000). "Advanced Asset Management: Tools and Techniques, Innovations in Urban Infrastructure." APWA International Public Works Congress, NRCC/CPWA Seminar Series "Innovations in Urban Infrastructure 2000," pp. 39-57.

Vanier, D.J. (2001). Why Industry Needs Asset Management Tools. *Journal of Computing in Civil Engineering*, January 2001, 15(1): 35-43.

Xia, B., and A.P.C. Chan. (2012). "Measuring Complexity for Building Projects: a Delphi Study." *Engineering, Construction and Architectural Management* 19 (1): 7-24.