Regular Article

Building Condition Assessments – Methods and Metrics

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ABSTRACT

The aim of the research included an exploration of the condition assessment process, and the Facilities Condition Index (FCI) as a metric to assign condition levels for commercial structures. The computation and use of various metrics for the asset management process are not standardized. The paper aims to clarify the current industry practices regarding how various assessments are currently utilized and to also compare existing literature to existing industry practices. Utilizing the Delphi Technique, an industry panel provided a synopsis of current practices. The research included organized discussions with industry as a method to supplement the Delphi survey responses and ensure accurate representation of industry practices. 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. Although the intent was to establish consensus, the results of this study provide a clear indication that the disagreement levels in the categories represent the overall industry struggles, the lack of standards, and issues in the use of metrics, especially with the varied computation of the FCI. Existing literature is limited in the areas of condition metrics, especially for applied recommendations. The results provide a foundational state of practice and highlight the needed industry improvements for condition assessments and additionally, how FM's utilize the data they collect.

Keywords: Facility Condition Assessment; FCA; FCI; Facility Metrics; Delphi

INTRODUCTION

An instrumental part of managing a facility includes facilitation of a condition assessment and then reporting that information in a concise and usable format. But, there are currently minimal standards in the industry for carrying out facility condition assessments (FCA), the analysis process, and reporting the results. This is especially true with regards to the use of specific metrics like the Facility Condition Index (FCI) and benchmarks for planning purposes. 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 to identify whether there is consistency in the way that the FCI is calculated and its benefits and limitations. 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 for assessing the condition of a facility. 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 FCA procedures and the FCI reporting to facilitate future capabilities for benchmarking.

LITERATURE REVIEW

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). Kaiser (2009, p. 3) defines it as a "process for developing a comprehensive picture of the conditions and the functional performance of buildings and infrastructure." To review current practices, the literature was explored for the topic areas of condition assessments, the reporting of the resulting assessments, and lastly the current noted issues throughout the literature.

Assessments

One of the greatest obstacles to the development of an efficient condition assessment process is the subjectivity and ensuing lack of accuracy. However, based on Brooks' (2004) historical account of the FCI, Applied Management Engineering, Inc. originally developed the index as a "great starting point to measure success" and it was not developed as an accurate account of condition. "It was designed to be a quantitative method of uniformly comparing and monitoring groups of comparable facilities over time." 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. 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. 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 and 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 furniture, fixtures, and equipment (FFE).

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).

The Reporting

Metrics represent quantitative indicators that can be used for comparison within and between institutions. They provide an essential common platform for benchmarking. 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). 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). 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. This is problematic when comparisons are made between facilities owned by different entities or facilities within the same campus settings when the FCA has been carried out by different consultants using different formulae to calculate FCI.

Current Issues

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. Assessments are often resource intensive, subjective, time-consuming, and costly. 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 issues pertaining to adoption methods and the issue that that there is presently no established asset assessment methodology. The lack of this proper standardization hampers the frequent and widespread use of performance metrics for measuring and evaluating performance within the industry.

Unstructured, Time-Consuming, and Expensive Processes: Field inspection of buildings is carried out by experienced and knowledgeable inspectors who perform both the inspection and the analysis on-site, in order 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 and the resources allocated. 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. The current approach of manually adding/deleting/managing instances of components (e.g., a boiler with sub-components) 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. 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 multiple categories) need to be inspected, rated, and further analyzed to determine the overall condition (Amani and Hosseninpour, 2012). Since these 600 components apply to only one

TABLE 1.—Rating Scales

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 (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)

building within the university, the degree of complexity is multiplied many times in the case of an entire campus.

Subjectivity of the Assessments: The existing 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 (ASTM, 2018). Often, however, to save time, deficiency lists (which need detailed analysis of their relative weights) are bypassed in favor of use quick subjective assessments. In addition, no support mechanism exists to help the inspector differentiate between assessment categories (good/fair/poor/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 overall, many do not provide adequate guidance. Not only is there subjectivity in the processes, but also in the reporting metrics such as condition scales. Examples of condition scales and corresponding linguistic representations are listed in Table 1.

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. Ideally, condition assessments, once completed the first time, are not as time-consuming because records are updated instead of created.

Inspection Levels and Techniques: DfES (2003) outlines methods such as visual inspections with manual input, tape dictation, and the more modern tablets 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 actually utilized.

Analysis and Metrics Used: Condition indexes such as a Facilities Condition Index (FCI) cannot be compared because their repair estimates are not comparable due to a lack of a standard for calculation. As a result, these condition indexes cannot be used to understand the relative condition or management of assets. Additionally, the FCI should be used hand-in-hand with the Needs Index (NI) to provide a fully funded model that takes into consideration the concepts of total cost of ownership and life cycle cost principles (Cain and Kinnaman, 2004). 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 Facilities Management, whether they are used for the commercial, education or public entity purposes. Clayton (2013) states that a close study of the many equations, makes it readily apparent 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 an agencies' assets. Thus, they should not be used to inform or prioritize funding decisions between agencies" (GAO, 2015).

RESEARCH METHOD

Delphi Technique: 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. 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. Unlike typical surveys, the Delphi was optimum for this study because the expert panel can review results, contribute changes and correct misunderstandings in the results as the research progressed.

Panelists: The participant selection type was homogenous sampling, where the current occupation of all participants was in FM. A purposive and 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 e-mailed in December 2016 and continued until February 2017. A short solicitation

TABLE 2.—Consensus Criteria

Level of Agreement	Conditions
Consensus	IQR $\leq$1 and a percentage score $\geq$ 60% in a single level on all scales including yes/no
Strong Agreement	IQR $\leq$1 and a percentage score $\geq$ 67% in combined adjacent levels, for a Likert scale of 7
	IQR $\leq$1 and a percentage score $\geq$ 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

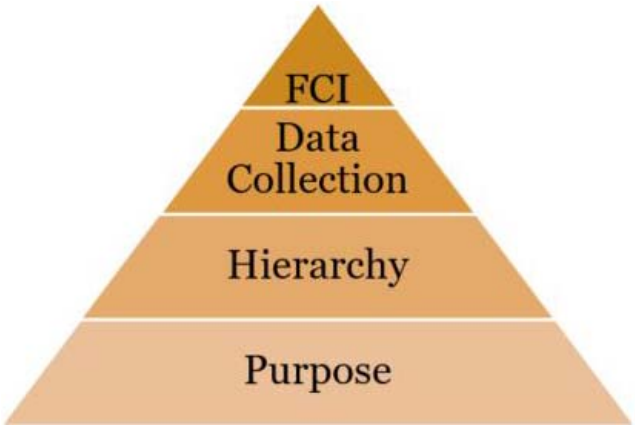

FIGURE 1.—Research Categories

survey was prepared highlighting the purpose of the study and requiring the potential panelists to provide 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. The potential participants were solicited and of the original 16 approached, 13 responded positively (81% response rate). 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.

The Survey: To categorize the research into a manageable progression from the "big-picture" practices to a more formalized identification of specific metrics, the research was approached from a qualitative purpose and reasoning perspective, to the more detailed perspective. The survey followed Hsu and Sandford et al. (2007) who recommends 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. The questionnaire was divided into four categories to address the needs of the study. The first section included three (3) questions concerning the purpose of the condition assessment to determine the format in which FCA reports are presented and what owners do with the FCA reports after completing or receiving them. The second section included three (3) questions on hierarchy, to establish the common format and how in-depth into the data hierarchy the assessment typically is completed. The third section included five (5) questions on data collection, to determine the process for how data is collected, whether from visual walk-through inspection or in-depth studies using a variety of technological diagnostic techniques. The fourth section included six (6) questions on the FCI and other metrics for condition assessment reporting. These sections are resultant of the emphasis the literature has placed on the importance of 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.

Criteria: The purpose of the Delphi method is to obtain panel consensus. Table 2 outlines the criteria for establishing consensus. To ensure a thorough analysis, both the frequency of the response percentage score and Interquartile Range (IQR) were utilized to determine consensus. For example, when there were cases of overall agreement in panel responses but the IQR was higher than one, it represented a case where a few panel members responded with a very different answer and thus resulting in disagreement.

Round 1 served as a brainstorming round and 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 pertaining to the calculation of the FCI, which added an additional formula to the list (for Round 2). After each survey, the results were shared prior to the next survey round. For each round, those line items that met the consensus level conditions highlighted in Table 2 for both the frequency of the response percentage score and Interquartile Range (IQR) were determined to be in consensus and thus omitted after that round. There were cases of disagreement in panel (even though 80% of the panel may agree) if the IQR was higher than one - a case that represents at least two panel members who responded with a very different answer.

RESULTS

There were four categories of questions (Figure 1) and therefore the results are presented by category (4.1 through 4.4).

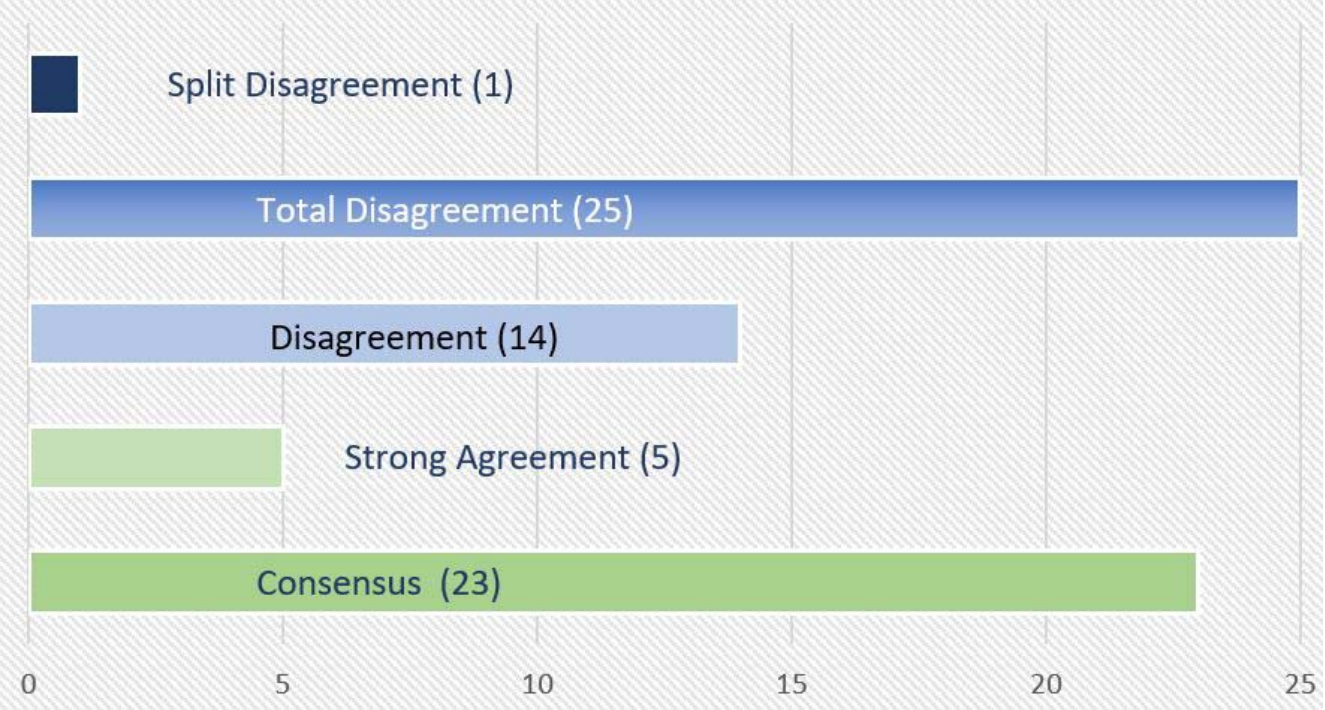

FIGURE 2.—Levels of Consensus

Category 1: Purpose

The questions in the "purpose" section of the Delphi survey aimed at gaining insight from the panelists on their opinion of the overall FCA process. The first question required a ranking of 7 question to assess an overview of FCI and the assessment process. The FCI is considered a standard tool in industry and is used to compare the condition of facilities and to make lifecycle decisions (NCES 2003). It was therefore not surprising that the panel agreed FCI is the overall desired metric and that it provides a good overall indication of a facilities' condition level, but in terms of the FCI being a desired metric, there was a higher IQR indicating that although FCI is primarily used as a metric and provides an indication of condition, there are still concerns to address with regards to using it as a metric. The second question asked, "When assessments are conducted, in what format is the resulting information provided?"

It was determined that the FCA is not used at the administrative level only, meaning that the data is shared to some degree. Some of the panel members changed their response to the question in Round 2 on the FCA being tied to a scorecard or a Key Performance Indicator (KPI) and the IQR of 1 indicated some modicum of convergence which is reflected in the percentage score. One of the problems highlighted in the literature regarding the FCA inspection is the subjectivity. Round 1 analysis indicated total disagreement between the panel members, where the answers were divided at 23% on levels ranging from "definite agreement" to "somewhat agree" but with several clarifications and feedback, R3 resulted in consensus in 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 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).

Question 3 asked the panel about the best format for condition reports (and were also given the option for "other" to add to the list). The panelists were in consensus (after Round 1) that Excel is a good format but they were not in consensus regarding Word format. Regarding whether data from an FCA should go into a database, 69.2% of the panelists responded that it was best format. The comment here was that putting it into a database allows for periodical real-time updating of data. This also ties to the question regarding what happens to the FCA once it is shared with the Owner. 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. But, the general feeling that the FCA typically sits on the shelf was deemed low. The FCA may be feeding directly into a budget approval process but the question remains whether approvals to spend are realized.

Question 4 asked how the FCA report is used once provided to the owner. The results in this case indicate that the condition assessments are not just requested or completed for the sake of the exercise. One of the members

TABLE 3.—Purpose Category Results

Survey Response (Purpose)	IQR	% Score	Level of agreement
FCI is typically the overall desired metric	1.5	62.5	Disagreement
FCI provides a good overall indication of the structure's condition level	0.75	62.5	Consensus of "yes"
FCA should be tied to a scorecard or KPI	1	87.5	Strong Agreement
One of the difficulties of an FCA is the subjectivity of the assessments	0.75	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)
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
Sits on a shelf	1	87.5	Consensus that report does not sit on a shelf
Disseminated to few users	0.75	62.5	Consensus that the report is distributed to at least a few users
Disseminated to multiple users	1	87.5	Strong Agreement
Effort is made to make the information widely available to those in the organization	1.75		Total Disagreement
Added manually to a computerized tracking system	2		Total Disagreement
Imported into a CMMS or Integrated with a Capital Plan Management System	1.75		Total Disagreement
Used to prioritize Capital spending.	1	87.5	Strong Agreement that it is used

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 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 to the public while portions that trace back to the FCA are part of the publication 3) The items in most 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 materialize on 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), is the report getting to the right people and then ultimately materializing with funding? Additionally, must the FM work politically to rationalize the reports 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. Surprisingly, the panel members were in disagreement 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. But, 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 the data is often, in their experience, not converted to a database and actively managed. If actively managed, the "refresh" requirement would be all that is necessary. 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 then maintain it. 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 is used to prioritize their capital spending.

Category 2: Hierarchy

Although there are standards available for defining a building hierarchy as developed by CSI (2018) -MasterFormat, UniFormat and OmniClass, there is no specific recommended standard for facility condition assessment reporting. Part of the difficulty in the development of a standard for FCA methods is the organization of assets. Additionally, how "deep" into a hierarchy should assets be tracked? At the system level, location level, or a component level? The 2 questions in this section pose to address the standards used in industry. The questions included:

- 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).
- 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

The hierarchy is intended to classify and cluster these components in different categories. 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. After Round 1, a suggestion for a different format, ASTM FACTS (2018) developed by GSA was added to the list of formats for Round 2 but ultimately the panel was in disagreement about FAST being utilized as a standard. Uniformat was mentioned as "commonly discussed at conferences" but the results indicate internally developed formats are also prevalent, along with Uniformat. Setting standards to the for organizing assets has great implications in terms of ease

TABLE 4.—Hierarchy Category Results

Survey Response (Hierarchy)	IQR	% Score	Level of agreement
UniFormat (ASTM E1557)	3		Total Disagreement
MasterFormat	2.25		Total Disagreement
OmniClass	2		Total Disagreement
ASTM FACTS (GSA)	2	62.5	Disagreement
No standard format	1.75		Total Disagreement
Our own internally developed format	1.75		Total Disagreement
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

of benchmarking from building to building and from institution to institution.

The headings used in a FCA report provides insight into the overall content. This question was the only section of responses that indicated the standard of practice for industry since consensus was reached for most of the line items. Since panelists were in agreement after Round 1 on the list of titles presented, the results represent the perceptions of the content that should be included in an FCA report.

Category 3: 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 using a variety of technological diagnostic techniques. This decision is dependent on the needs of the facility owner or FCAP Manager. The research purposed to find the technologies and tools currently in use during condition 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. The specific questions were:

- Which of the following tools are used for collecting data during facility condition assessments (Check all that apply) – Select all that apply
- How frequently are the following technologies utilized while conducting facilities condition assessment surveys? – Likert 7 scale (Every time to Never)
- Are facility users consulted during the FCA process to identify deficiencies or functional issues of the spaces they occupy?
- Estimate of the time required to carry out an FCA survey 35,000 sq. Ft. Space in a 15-year-old building.
- 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)

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. There was consensus on the use of I-Pads and handheld computers (tablets, laptops and apps on phones for data collection). 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; however, in hindsight of the survey, I-Pads could be used (as a camera) to include photographs in the report.

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. The use of tools such as the smart level however, had a higher IQR than allowable for agreement. The panel disagreed on the use of handheld laser measurements, infrared thermographs and tape measures. One panel member clarified that

TABLE 5.—Data Collection Category Results

Survey Response (Data Collection)	IQR	% Score	Level of agreement
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
Infrared thermographs	2.5		Total Disagreement
Handheld laser measurements	3		Total Disagreement
Moisture analyzers	2		Total Disagreement, but indications that they are rarely used
Smart level	2.75		Total Disagreement
Tape measure	5.25		Total Disagreement
User Consultation	0.5	76.9	Consensus
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

often more extensive analysis is completed only when issues are detected during the first visual inspection, meaning that these uses are a one-off occurrence.

The panelists were in consensus on the need to consult occupants. Occupants may provide insight to an ongoing problem that is not evident visually 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". However, in a previous APPA study (Quirk, 2006) it was determined that there was a statistically relevant relationship to the satisfaction of the occupants to that building's FCI. Additionally, Quirk (2006) concluded his report with, "the FCI would gain further credibility by more stringent and universal standards for the development of this index."

One of the aims of the research was to find out how long it takes to carry out an FCA. In Round 1, the results required clarification so in Round 2 the question was revised and offered an example in terms of giving both the gross square footage and age of three hypothetical facility sizes. However, after Round 2 the panelists were still in disagreement on the amount of time taken. Following rewording the results indicated total disagreement on all the highlighted types of buildings; but, 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.

Together with finding out how long FCA surveys took, the research aimed at finding out how often FCAs are carried out. The literature recommends 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). The survey results were that 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. Therefore the results corroborate what the literature states. 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 question should have clarified the first-time assessment versus the follow-up assessments; but future research should be conducted to understand how an FCA is carried out once, data managed, and another FCA carried out as an update. Additionally, a panelist stated that FCA's should be conducted annually for all assets that are at or near end of useful life as determined by the life cycle tracking system.

Category 4: 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 through calculating a numeric value that reflects a specific condition of the severity of the deficiencies of a facility 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 formulae for calculating the FCI inhibits benchmarking capabilities and the abilities to compare across different organizations. The purpose of the questions in this category was to find out the formulae the panel members used for the FCI and other metrics for condition assessment reporting.

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

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

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 1.

$$FCI = [Deferred\ Capital\ Renewal + Current\ FY\ Recapitalization\ Costs] \div [Aggregate\ Current\ Replacement\ Value\ (CRV)\ of\ all\ Managed\ Assets(\$)]$$

Although this formula was added to Round 1, it was corrected in a comment for Round 2, which could explain the disagreement. The correction comment provided in Round 2 was, "Deferred Maintenance is preventative or planned maintenance that was not or has not yet been done. Deferred Capital Renewal refers to assets that are beyond 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:

$$FCI = [Deferred\ Capital\ Renewal(\$)] \div [Aggregate\ Current\ Replacement\ Value\ (CRV)\ of\ all\ Managed\ Assets(\$)]$$

The overall view of the responses for this question validates the research problem that states 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. The results therefore remained the same as those in Round 1 inferring that there are indeed several variations of the FCI in used in industry. A panelist provided this stated regarding the FCI, "Per the APPA TCO 1000 ANSI Standard (APPA, 2018 in development at the time of the research), 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 preventative mainte-

TABLE 6.—FCI Category Results

Survey Response (FCI)	IQR	% Score	Level of agreement
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"
CRV formula	1	69.2	Consensus
As an estimate by an internal estimator (w/ or w/out standard), insurance requirements or CPSF.	1.75	62.5	Disagreement
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	2.5	75	Disagreement
The FCI is used as a snapshot in time to compare similar assets	1	87.5	Strong 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	2	62.5	Disagreement
The FCI is a good indicator of whether maintenance is being carried out	0.75	62.5	Consensus
The FCI is a good indicator of renovation opportunities	1.75		Total Disagreement
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	0.75	62.5	Consensus
Values become rapidly outdated due to factors such as deterioration; 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 towards more predictive approaches to managing deficiencies	1	87.5	Strong Agreement

nance and repairs that are not applicable to condition assessments."

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. The panelists were asked if this the formula adopted by their organization. The panel came to a consensus regarding the fact that the CRV formula is used for as a standard calculation. There is, however, the question of how the actual figures are derived, especially with regards to the estimated cost (per square foot) to design and build a new facility. But the remaining panelists, after Round 2, were split between 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." The panelists were in consensus that they did not use any kind of formula determined by insurance requirements and 25% stated that an internal estimator calculates CRV but 62.5% stated that the cost per square foot model is used.

At the beginning of the questionnaire (Question 1), the panel members agreed that the FCI is the desired overall metric. However, when asked more specifically if it is a "tried and true" metric, the panelists were in disagreement. Additionally, 50% of the panelists were neutral about whether this information should be tied to a balanced scorecard or KPI. Regarding the benefits of the FCI, the panel did not find the FCI to be ideal as a benchmark that assists in reducing the backlog and 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. Although some of the statements were determined to not be in consensus for the entire panel (those statements with high IQRs), the statements with a higher frequency/percent score show that there is some agreement with regard to how and when and FCI is used. A panelist summed up their thought this way:

"FCI is a way to reduce conversation with budget approvers. It is a leadership commitment to a specific, defined condition and 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 common standard for measurement of condition 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 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. 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.

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 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. Overall, the results provide a platform for the standard of practice and where further research can help to refine the FM industry's ability to benchmark internally and externally with improved metrics.

DISCUSSION AND CONCLUSIONS

To assess reliability of the results gained from the Delphi Survey, the panelists' comments assisted to highlight ambiguities due to the broad nature of facilities management and how questions were interpreted. Their feedback also provided possible reasons for the lack of consensus. 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 or not maintenance is being carried out, figures and reporting is difficult because maintenance may be completed, but how "well" is the work being done? An additional example would be a situation where the FM has a backlog, but then also adds a new facility. In this case, there is a lowered figure for backlog which indicates a false "success" by only an improvement in the calculation. A panelist summed up the researcher's 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." Therefore, the conclusions may not provide an indication for best practices or recommendations for methods of conducting FCAs. However, the results of this study provided a clear indication that the disagreement levels in the categories represent the overall industry in terms of the lack of standards in how the FCA is carried out, how it is reported and the varied computation of the FCI.

The results showcase several topics that should be explored in future research initiatives. Progress has continued since the inception of the FCA in the 80's but there remains room for further growth, especially regarding the calculation and use of specific metrics like the FCI. There is consensus that FCI metric is being used and the data is typically shared. The limitation however is in the needed industry improvements for condition assessment metrics with regards to standardization. For example, the FCI serves the original purpose to use overall metrics to quantify conditions for comparison but there are multiple ways to utilize facilities data and owners should be aware of the FCI limitations. Additionally, standardization is needed with regards to how the metrics are calculated. The methods used in an FCA, according to one panelist, are driven by funding structures within an institution as well as the priorities they have for capital renewal projects. There are also other areas where standardization may be needed (and additional research) such as for the classification of assets. This is especially true when considering the use of Building Information Modeling and the handover process after construction. 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 static reports (snapshots in time) as opposed to the integrated and dynamic data.

The methods of using previous FCAs (any method) is important; 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.

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 use of an FCI (or similar culmination of asset indices) for owners outside of educational institutions are being used, therefore standardization with regards to the classification of assets and the combination of the needs index are needed. Although the formulas were not included in the Rounds 1 and 2, additional feedback contributions included the mention of newer and combined applications of condition data to include asset priorities based on the value of the asset and combinations of condition, function, regulations, ADA needs and any owner priorities to evaluate a "needs" index. To conclude, many of the line items for the purpose of the FCA process reached

consensus and the panelists agree regarding the use and benefits but when the panelists responded to the more specific questioning regarding the FCI (Figure 1), there was minimal agreement and indication that more research is needed to provide a more standardized recommendation for metrics used to indicate asset conditions as well as future budgeting needs.

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