

A Qualitative Approach to the Quality Assessment of Facilities

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In the architecture, engineering, and construction industry, quality control measures are critical in ensuring the successful delivery of a project. Quality can be assessed through a punch list, through a post occupancy evaluation, through daily onsite logs, and many others. The purpose of this study was to develop a quality assessment matrix and a scoring system that could be manipulated and applied to any space or situation required. The research was conducted in a collaborative effort between a universities facilities division and the researcher. This paper looks at different methods of assessment and the implications of each. Covered is the process in which the assessment matrix and scoring system was developed, tested and implemented. The developed assessment matrix is centered around restroom spaces located on a university campus and data presented is a result of the restroom assessments. In order to perform the assessment, the use of mobile technology was implemented. The findings resulting from this study showing that visual assessments are a viable option for assessing the quality of spaces. The implementation of mobile technology proved to increase team efficiency and decreased the amount of time needed for data management.

Key Words: Facilities Management, Quality Assessment, Visual Assessment, Scoring System, Mobile Technology

Introduction

A research opportunity arose out of a collaborative effort between university faculty, undergraduate students, and the university facilities division. The objective was to generate a method of quality assessment for restroom spaces across the university's campus. This study was to conduct assessments of a high traffic area that is regularly used by university stake holders: faculty, staff, students, and visitors. This study looks at 681 restroom spaces with goal of providing a quality assessment method to the university that will be expandable and applicable to other spaces for use in the campus's preventative maintenance plan.

The objective in assessing the quality of an object or space is to attain data specific to the object or space and, in turn, analyzing that data to put it to some applicable use. In construction, quality assessments are a part of every component of a project. Quality assessments exist in a variety of different forms such as visual assessment and assessment through the use of instrumentation. The measure of quality is not an arbitrary task. It must be linked to some objective scoring or rating system that translates to some usable data set.

Visual assessment offers a variety of opportunities as well as drawbacks. Visual assessment is subjective. It relies on the expertise and competence of the individual performing the assessment. Visual assessments provide data that only shows surface flaws and provides a more generalized analysis of an object or spaces quality. This method of assessment is, however, faster and cheaper to perform and allows datasets to be obtained immediately.

Using instrumentation for quality assessment provides a more thorough and complex approach to quality assessments. By using instrumentation, more accurate data about the object or space which is being assessed can be attained. It does, however, increase the amount of time and monetary resources that must be allocated to assessment. Instrument based assessment will take longer to acquire and analyze data.

The aims and objective of this research endeavor is to provide an assessment method that is capable of being manipulated and applied to any space on the university's campus. This research will look at the classification of items in a space, the visual scoring of those items, the development of a data set storage mechanism, and the use of mobile technology in the assessment process.

Review of Literature

This literature review outlines examples of quality assessment that have been employed for different applications. This review looks at commonalities between assessment processes, assessment types, and methods of scoring assessment items. These commonalities will be used as the foundation for the assessment matrix that will be developed for the university's facilities division.

In performing a quality assessment there are four steps that should be considered:

- "Identify goals and select an appropriate audit" (Hayes, 2006, 311)
- "Selecting the right person or team for the job" (Hayes, 2006, 312)
- "Collecting data" (Hayes, 2006, 312)
- "Using the deliverable" (Hayes, 2006, 312)

The following paragraphs outline different applications of visual quality assessments as well as scoring systems developed that correlate to the method in which this research outlines.

A visual inspection method was implored to measure the quality and functionality of a building roofing system (Coffelt, et al, 2010). This research looked at 100,000 square meters of roof at the Carnegie Mellon University with roofing systems ranging in age from new to over 50 years (Coffelt, et al, 2010). The researchers created a rating method that scores roofs on a scale of one to seven with seven being the best score achievable (Coffelt, et al, 2010). The score is determined by indexing a count of the quantity and severity of defects against a condition table (Coffelt, et al, 2010).

A second researched method presents a visual condition rating system that is based on field experience and expert judgment with the purpose of identifying and replacing degraded cross arms that are near the end of service life (Pandey, et al, 2005, 480). This scoring system rates the cross arms on a scale of one to five with one reflecting like new quality and five reflecting substandard quality (Pandey, et al, 2005, 482). The assessment method is implemented through the visual analysis of multiple in service transmission cross arms (Pandey, et al, 2005). The research presents two approaches to assessment: condition based and reliability based. Condition based reflects the actual condition of the cross arms and reliability based represents the probability of failure as a result of deterioration and is based on actual measured structural loads (Pandey, et al, 2005).

Through the assessment of many buildings facilities a unit of measure, termed the "condition index," (Xueqing & Hui, 2010) was used to represent the quality of these facilities. The developed scoring system uses a scale of zero to one hundred with zero representing the worst condition and 100 representing the best condition (Xueqing & Hui, 2010). This visual method analyzes building components like structural systems and other variable components which are in turn inserted into a matrix (Xueqing & Hui, 2010). Through the use of a program the data was analyzed to create a life cycle management plan (Xueqing & Hui, 2010).

In November 1999, the city of Sacramento, California commissioned a third party organization to perform building assessments on 331 of their older buildings in need of repair (Reagin, 2002). The company examined all constructed components of the buildings and identified deficiencies based on visual observations and through discussion with the building occupants (Reagin, 2002). The organization reported the data along with recommendations and cost estimates of the repairs needed to correct each deficiency (Reagin, 2002).

Assessing the quality of an object or process can be applied across all disciplines in any industry. Quality Assessments provide quantitative information that can be used to develop preventative maintenance plans, replacement plan, and to improve the overall quality of an object or process. The end goal of a quality assessment is

to offer management the opportunity to appraise the overall progress being made and to seek improvements for increased efficiency and more effective utilization of available resources (Ali, et al, 2009, 144).

The results of the literature review show similar systems that present an assessment method with a subsequent scoring method. The data received due to the assessments leads to action on the part of an entity that is considered to be a stakeholder. The review of the previous systems leads to two base conclusions: an assessment matrix including all assessable items must be included and the development of a scoring system is required in order to extrapolate the data to a useable form.

Methodology

Assessment Matrix Development

The initial step in this research was to develop an assessment matrix. The assessment matrix is the corner stone of the assessment process. It provides an object or group of objects that are in the assessment field. Based on commonalities between restroom spaces, a list was generated and a sample matrix was derived. Through multiple test assessments the matrix was refined and reworked and, thus, created a final assessment matrix.

Plumbing Fixtures			Excellent(1)	Acceptable(2)	Poor(3)	Unacceptable(4)
Water Closets	2	ea			2	
Toilet Seats	2	ea				2
Urinals	2	ea				2
Lavatory's	2	ea			2	
Lavatory Faucets	2	ea			2	
Subtotal	10		0	0	18	16
	Average Score for Plumbing			3.40		

Figure 1: Assessment Matrix Excerpt

The original list matrix consisted of 25 listed items. These items were based on requisite knowledge of items that are commonly found in a restroom space. In order to refine the matrix, test assessments were performed on two separate buildings with differing age ranges of over thirty years. A list was generated of items omitted by the initial development stage. The revised list was implemented into the matrix bringing the total items assessed in each space to 56. Assessment testing was then repeated in order to further refine the assessment matrix. In order to adequately organize information the assessment items were organized into eight categories: openings, finishes, specialties, millwork, HVAC, fire stopping, electrical, and plumbing fixtures. The openings and finishes categories are further divided into sub categories. Each category is assigned a total score based on the rating system. An excerpt of this matrix can be found in Figure 1.

The same process was followed to assess the standards set forth by the American with Disabilities Act (ADA). A pass or fail matrix was developed to determine whether the space meets ADA requirements. This assessment was developed through the use of pre-developed specification sheets created by the university facilities division. Items checked included maximum heights and clearances for specified items along with special requirements as indicated by the specification sheets. The ADA Assessment matrix went through a series of test assessments for revision and further development. Like the ADA standards, the assessments were broken down into stall types. Five different stall types were used. These stall type represent the different configurations listed in ADA as acceptable.

Scoring System Development

The scoring system provides quantitative data that will reflect the overall quality of a restroom space. The scoring system is designed to reflect four levels of visual observation: Excellent, Acceptable, Poor, and Unacceptable. An item considered to be excellent has no cosmetic or functional issues. An example of an excellent sink is shown in

Figure 2. As illustrated in Figure 3, an item that is acceptable will have no noticeable deficiencies other than normal wear and tear. A poor item, shown in Figure 4, will have mainly cosmetic issues beyond normal wear and tear or functionality issues that need to be addressed. Unacceptable condition reflects major cosmetic issues or damage beyond simple repair. This can be seen in Figure 5 with the rusting and corrosion of the sink basin.

The development of the scoring system went through two iterations. The first system implemented was an average system. This system looked at the total points scored and divided that by the total number of items. A second score was then generated that took the total score of the items and divided by the total number of plumbing fixtures multiplied times four. The final score was then determined by averaging the first and second score.

Figure 2: Excellent Sink
Score: 1.0

Figure 3: Acceptable Sink
Score: 2.0

Figure 4: Poor Sink
Score: 3.0

Figure 5: Unacceptable Sink
Score: 4.0

The second scoring system was developed based on a simple algebraic formula. The scores associated with the individual items assessed are multiplied by the number of items under that rating. That number is then divided by the total amount of items assessed. The exact formula is shown below. A score is calculated for each division in which the system is broken into and a final score is generated at the end of the assessment to give a complied score for the entire space. This score is calculated with the same formula and it includes all items and ratings for each division. This is the iteration that was ultimately chosen for determining the assessment score. An example of the assessment matrix calculation can be seen below.

Scoring Matrix Example Calculation

Figure 1 provides an example of the plumbing division breakdown of the assessment matrix. The example data is derived from this figure.

Score = ((1*Excellent Items)+(2*Acceptable Items)+(3*Poor Items)+(4*Unacceptable Items))/Total Assessed Items

Score = ((1*0) + (2*0) + (3*6) + (4*4)) / 10

Score = 3.40 Poor

Estimate Development

Throughout the course of the assessment process a cost factor was implemented. The estimation was developed over two stages. Initial estimation was completed through a spread sheet using known unit costs including labor and materials. The numbers used in the initial estimate matrix were provided by a visiting faculty member. This method was completed through the use of Excel just as the assessment matrix was. The estimate matrix was developed based on a standard estimate sheet.

The second iteration of the estimate sheet was developed with minor style modifications. It was decided by the university facilities division to create a more detailed cost breakdown that would reflect the labor and material rates used by the facilities division. The costs were entered and calculated based on quantities measured in the field during assessment. The estimate coincides with the assessments matrix. It was determined by the facilities division that only unacceptable items in the restroom assessments would be estimated as those items would be more critical to repair in the short term. The estimation component was added at the midway point of the assessment endeavor.

Building Number	AA_T0202
Building Name	Building X
Restroom #	1
Surveyor/s	SM
Labor Rate (1 man crew):	$42.50

Description	Quantity	Unit	Unit $	Material	Labor Cost/Unit $	Labor	Sub	Total	Notes
Openings									
Hardware									
Locksets/Latchets		EA	225.00	0.00	1.750	0.00	0.00	0.00	
Door Handle		EA	25.00	0.00	1.000	0.00	0.00	0.00	
Closers		EA	165.00	0.00	1.750	0.00	0.00	0.00	
Push-Pulls		EA	50.00	0.00	1.000	0.00	0.00	0.00	
Door		EA	275.00	0.00	3.000	0.00	0.00	0.00	prepped, painted
Door Lite		EA	150.00	0.00	2.000	0.00	0.00	0.00	View Lite
Frame		EA	150.00	0.00	2.000	0.00	0.00	0.00	
Butts/Hinges		EA	15.00	0.00	1.500	0.00	0.00	0.00	
Stops		EA	5.00	0.00	0.750	0.00	0.00	0.00	
Door Threshold		EA	35.00	0.00	1.500	0.00	0.00	0.00	
Kick Plates		EA	40.00	0.00	1.500	0.00	0.00	0.00	
Window		SF	0.00	0.00	0.000	0.00	0.00	0.00	Subcontract Item
Total Openings								0.00	

Figure 6: Excerpt of Estimate Matrix

Data Set Storage

The initial method of data storage utilized Microsoft Excel. The assessment matrix was built in Excel and included formulas built into the cells to automatically calculate the restroom rating and transfer to a summary sheet included within the Excel workbook. This method was deemed impractical due to the amount of data being collected. An alternative method of data storage was desired and explored.

The decision was made to develop a Microsoft Access database to house the data. This database was developed to emulate the assessment matrix in order to facilitate efficient data entry in the field. The database created uses the same formula to calculate the space score for each restroom space. The database is not formatted to be an online database. It is strictly computer based. The database can be used to generate reports that manipulate and arrange data into a useable format. Any information related to the restroom scoring can be presented in the reports.

Data Collection

Assessments were performed on a restroom by restroom basis. Each assessing team, comprised on two to three members, visited multiple spaces each day and completed assessments of those spaces. These assessments were completed through the use of visual assessments and mobile technology. The assessment required the use of experienced and qualified team members to visually inspect each assessment matrix item and rate that item based on its condition and functionality.

Visual Assessment

Visual assessment requires the assessor to have a level of expertise in quality assessment. The assessor must understand the definition of excellent, acceptable, poor, and unacceptable quality in terms of the assessments definition as stated above. In order for the spaces to be scored accurately, the assessor(s) must have a common judging ground that each assessor is rating each item by. Each assessor was taken to various facilities to be shown representations of each level of quality. This was done to ensure standard and accurate assessments were completed.

To visually assess the items included in the assessment matrix one must look at each aspect of the item. During assessment, the assessor looked at qualitative factors such as: cracking, missing parts, non-functioning parts, cleanliness, and general wear and tear. The visual assessment was implemented as a quicker method of assessment as opposed to testing through instrumentation. Ultrasonic scanning is an example of instrumentation technology that could be used. Like previously discussed examples, visual assessment in this application is cheaper and more time efficient that testing through the use of instrumentation.

Digital Media

A paperless system was implemented to record the assessment data during the assessment process. This method implements the use of an iPad to record assessment data. The assessment process was completed through the use of three iPads and three laptops. The iPads were used to control the laptops through a remote desktop (RDP)

application. By using this RDP application, the use of a full service computer was available. Data was entered initially through Excel and transferred to the Microsoft Access database created to store the data. Figure 7 illustrates the iPad and the interface in which the iPad was used to assess.

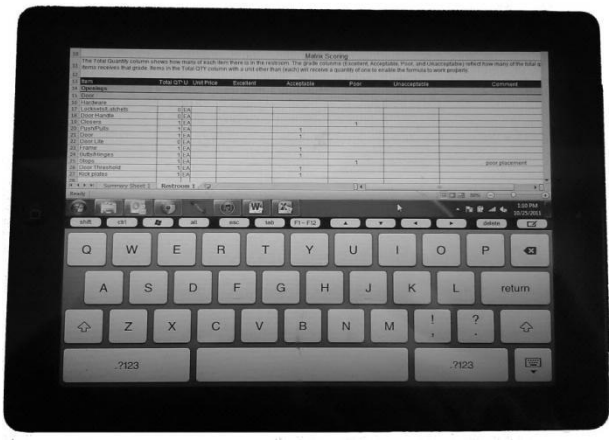

Figure 7: iPad and Assessment Interface

This method tested the iPads ability to go mobile in the field. Using a standard Wi-Fi connection each assessor went to restroom spaces and performed visual quality assessment with a touch based recording system. The use of the RDP application tested several independent variables that included: remote capability over wireless networks, ability to access critical information in regards to diagrammatic information, and effectiveness as a tool for use in field work.

Results

Rating System Analysis

In developing a rating system, it was a goal of the project team to create a rating system that could be manipulated to fit any space in any building and to develop a method of scoring that could be universally implemented and understood by anyone looking at the assessment matrices. The development of this scoring system has proven to be a solution that meets the criteria of these goals. The assessment matrix format can be easily manipulated to fit any space in a building. Only the assessable items will need to change for this spatial transition to take place. The scoring system is easily understood as the calculation is similar to a grade point average calculation in an academic setting. The key difference is that the lower the score in our system represents the better quality. This rating system provides a cheap and reliable method for rating the overall quality of a space.

Understanding Quality

The method that this research offers is learning through experience. This Endeavor gave the assessment team a better and more thorough understanding of what quality is and, in turn, provides more accurate results and allows the assessment to be further developed in order to assess the quality of any space. Quality is not an arbitrary feature to any component of a space. Throughout the assessment process the assessors learn that quality is about the functionality, aesthetics, and cleanliness of a space. The way in which people perceive a space will reflect the definition of quality. Through experience and continual assessment the assessor understands what quality is and what it means to the user in the space.

Numerical Data

Through the totality of the assessment process, the assessing team visited and assessed 681 restroom spaces on a university campus. Through this assessment process the assessors looked at more than 38,136 items. After completing assessments the data yielded an average restroom space score of 2.07 which reflects an acceptable rating. The cost to repair unacceptable conditions ranged from $0.00 to $12,359.00 in all restroom spaces.

Table 1:

Numerical Data Information

Numerical Data Information	
Total Spaces Assessed	681
Average Score	2.07/4.0
Best overall Building Score	1.29/4.0
Worst Overall Building Score	3.11/4.0
Best Overall Space Score	1.16/4.0
Worst Overall Space Score	3.46/4.0
Total Cost of All Repairs	$273,527.00
Highest Cost of Repairs-Building	$20,273.27
Highest Cost of Repairs-Space	$12,359.00

Table 1 represents average, minimum and maximum data recovered from the developed database. This information is indicative of the data recovered through assessment and populated through the database. This data can be analyzed and applied through the development of a facilities management preventative maintenance plan. The data shown here is for demonstration purposes only and will not be analyzed further in this research paper.

Preventative Maintenance

In application this data can be used to further develop and implement a preventative maintenance plan. This data, in conglomerate, shows common points of degradation throughout the campus. The database that houses this data is capable of generating customized reports that will organize data into sets of common degradation. The generated reports can then be used to structure a plan to repair these spaces.

The data revealed general building deterioration. In most instances the restrooms for a particular building would have similar results in terms of restroom similarities. These similarities reflected the same cleanliness standards and the same level of functionality.

Mobile Technology

The use of mobile technology in this endeavor has shown positive and negative results. The results of this implementation proved that a standard Wi-Fi enabled iPad was not 100% reliable in the field. Every space explored did not have the same wireless capabilities. Often times this forced the assessors to use a paper based system and transfer data to Excel and into the database. This result decreased the efficiency of the assessment team.

The use of a remote desktop application proved highly useful. The ability to turn the iPad into a virtual computer and use that virtual computer for assessment was a faster solution to the paper based system. It should be said that it does take a few minutes longer to do the actual assessment, but the time is made up during post data entry. By not stopping assessments early, the team was able to assess more spaces in a given day and still maintain the data entry required for data storage.

Access to information while in the field was critical for the assessment team. The use of campus diagrammatic plans for obtaining square footage measurements and locations were necessary for use in the assessment process. The

ability to use RDP on the iPad allowed each user to have continual access to the campus diagrammatic plans along with all assessment and estimate matrices. The use of mobile technology proved to be useful in the field.

Discussion

The methodology used was process and repetition based and provided the facilities division with useable and data driven information which can be used to develop a facilities management preventative maintenance plan. The testing of the restroom spaces proves to be valuable in the development of a preventative maintenance plan and in developing a plan of action toward the restoration and renovation of unacceptable restroom spaces. The database developed is capable of sorting and generating custom reports specific to each assessed item and determining which item in which building is in the worst condition. This allows for the facilities division to create a strategic plan for replacing item and determining which buildings are in the poorest condition. Providing this information to the facilities division has shown to be useful as results of the information have already been seen in parts of the campus.

In terms of mobile technology, testing will continue through continued research and development of the assessment system. A deeper look into the mobile sector will commence and further research will explore the potential for the use of mobile technology for the assessment system.

Conclusion

Like the assessment methods and scoring systems presented in the literature review, the system developed in this study has an assessment matrix that defines assessable criteria and creates a measurable scale in which to score the items. The literature review looks at assessments in which specific items were analyzed for general deterioration with a numerical score attached to them. The systems that were explored presented systems that could potentially be applied to other items given the necessity. This paper describes the research and development of a quality assessment model that is easily manipulated and that can be easily applied to any item in which the quality must be assessed. This approach proves to be effective in presenting useful data and analytical tools for the implementation and use of said data. This research shows that visual assessment can provide a simple and effective means of quality assessment and that it provides useable information about the relative condition of a space. This research also shows that quality assessment through the use of mobile technology in the field can increase the efficiency of users and decrease the time required to perform quality assessments. In terms of statistical data, further data analysis will be conducted and the application of that data will be presented in future written scholarship. Quality is an attribute including in all aspects of construction and maintenance. The definition of quality is not always clear, but it can be narrowed through the implementation of a quality assessment.

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