



## **Condition Surveys and Assessment of Buildings: A Review of Approaches Adopted**

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### **Abstract**

Building condition surveys and assessment is increasingly becoming an important issue. This is because people spend a lot of time residing or working in buildings and knowledge of the condition of a building can reduce the likelihood of fatalities in the event of a disaster or building collapse. Research on building condition surveys and assessment tends to adopt varying approaches that seems to be contradicting. This study aims at examining the dominant research approaches on building condition surveys/assessment and to underline their assumptions, limitations and arguments. A review of the literature on condition surveys and assessment of building is executed. This literature is categorised into major themes, synthesised and the typical focus is challenged. The results show that four dominant approaches have been adopted in literature namely: model-based approach, fuzzy theory approach, condition index approach and the digital approach. The study argues that a combined or hybrid approach provides an alternative approach that will unearth reliable data on a building that can be triangulated or validated by comparing the different data on the condition of a building.

**Keywords:** Condition survey, Condition assessment, Buildings, Building condition Index and Defects

### **1. Introduction**

Building condition surveys or assessment is increasingly becoming an important issue (Che-Ani *et al.*, 2016; Begić and Krstić, 2024). This is because people spend a lot of time residing or working in buildings and knowledge of the condition of a building can reduce the likelihood of building failures, fatalities or building collapse.

Research on building condition surveys or assessment tends to adopt different approaches that seems to be conflicting. This study aims at examining the dominant research approaches and underlines the limitations in their argument. Specifically, the objectives of this study are: (1) to identify key or dominant studies on the subject building condition surveys and assessment and categorise them. (2) To underline the assumptions and limitations in the argument underlying the dominant research approaches. The section that follows provide a review of the literature on building condition survey or assessment.

### **2. Literature Review**

Discussions on building condition surveys or assessment exist in the construction management and engineering literature adopting varying approaches. Four distinct approaches stand out in literature on building condition survey and assessment namely: model-based approach, fuzzy theory approach, condition index approach and the digital approach. Five keywords were used to search for studies on the subject namely: building condition survey, condition survey, building condition assessment, condition assessment and defects. The section that follows presents the categories of the discussions in literature on building condition survey or assessment and underlines the assumptions in their argument.

#### **2.1 Model-based approach**

Several authors assume that the secret to discerning the condition of a building is by developing a model that can indicate the measure or quantity of damage, repairs or defects on a building (Konior, 2014; Bucoń and Sobotka, 2015; Nowogońska, 2019). For example, Konior (2014) focused on defect occurrence and developed a cause-effect model to analyse the condition of residential buildings elements in Poland. This approach involved visual assessment of 10 building elements from 600 apartments and the result showed that it was possible to analyse the

cause of defect to important elements of apartment block. The author claimed that information gathered with their model influences the maintenance quality level of existing buildings. Similarly, Bucoń and Sobotka (2015) focused on repair works or solutions in deteriorated buildings and developed a decision model for choosing an optimum repair solution for renovation works. This approach involved assessing the functional status of five buildings and calculating their use value with computer algorithms. Their results showed that higher building use values for certain amounts was achievable. They claimed that their model can be used as a tool for supporting administrators in multiple criteria building appraisal and the choice of the optimal repair solution bearing under financial constraints. This approach is not supported because it is prescriptive. In the same vein, Nowogońska (2019) focused on the degradation process of buildings as it ages and developed a predictive model to predict the aging of a building. This approach involved determining changes in the performance characteristics of buildings with results indicating graphical representations on the intensity of aging/degradation. The author claimed that their predictive model serves as the basis for making the right strategic decisions when planning renovation works in residential buildings. It can be seen that authors in the above studies assume that the secret to discerning the condition of a building is by gathering information on the process of defect occurrence, repairs or degradation process in the past to develop models. These authors argue that their proposed models support or provide construction practitioners a basis or criteria for appraising the condition of building and deciding on repair solutions in renovation works and maintenance. However, this argument is not supported because different building types deteriorate differently under different environmental conditions that may be at variance to the prescribed models and the pattern of defects in the past may not occur in the exact same way in the future.

## 2.2 Fuzzy theory approach

In contrast to the model based approach, other studies put forward a fuzzy theory approach and assume that the secret to determining the condition of a building is based on fuzzy categories or criteria that focus on deteriorations or damages (Konior, 2019; Javiri *et al.*, 2019; Konior *et al.*, 2021). For example, Konior (2019) focused on the deterioration of building elements and adopted a fuzzy set theory approach to analyse the deterioration of a group of old apartments for maintenance in Poland. This approach involved developing a model of fuzzy set categories that converts the assessments into quantitative variables. The result of applying their model showed the symptoms and mechanics of defects arising and declining elements of the building. The author claimed that the fuzzy set approach made it possible to analyse the effect of defects relevant to the building elements. Similarly, Javiri *et al.* (2019) focused on maintenance/operational needs of buildings and adopted a fuzzy analytical hierarchy approach to assess the condition of a building elements based on maintenance and operational needs. This approach involved a case study of a dormitory building in Indonesia, visual observations and calculating the weight of different components/elements. The results of applying their approach showed that the weighting of building components and condition of the building can be calculated. They claim that their fuzzy approach can be applied to dormitory buildings with typical design. This claim is not supported because it is prescriptive. In the same vein, Konior *et al.* (2021) focused on the occurrence of damages to buildings elements and adopted a fuzzy criteria approach to assess the degree of damage to selected building elements for maintenance. This approach involved sampling and inspecting 102 apartments on the damages in Poland and transforming them into quantitative fuzzy categories. Their result gave much greater possibilities of studying cause and effect relationships than the probabilistic analysis. They claim that their fuzzy criteria approach gave the greatest approximations of the degree of the wear of building elements.

It can be seen that authors in the above studies assume that the key to determining the condition of a building elements is based on a fuzzy set categories or fuzzy criteria that converts qualitative assessment to quantitative values. These authors argue that the application of the fuzzy set approach makes it possible the analyse effects of defects or degree of wear of building elements with great approximations or probability.

## 2.3 Condition Index Approach

In contrast to the fuzzy theory approach, other studies put forward a condition index approach and assume that the condition of a building can be calculated or rated as values based on the opinion or evaluation of assessors on defects or renovation needs (de Oliveira *et al.*, 2008; Nowogońska, 2016; Mayo and Karanja, 2018). For example, de Oliveira *et al.* (2008) focused on the defect index of rented apartments and developed a method for legally evaluating the condition of rented buildings during arbitrations in Portugal. This approach involved visual inspections, calculating the defect index and then evaluating the condition as maintenance coefficients of 64 buildings. They claimed that the implementation of their method delivered satisfactory results that was accepted by all bodies. This claim is unsupported because the evaluation relies on experience of an assessor that might be limited. In the same way,

Nowogońska (2016) focused on renovation needs with weighted value for building components and proposed a method to evaluate the degree of wear for residential buildings. This approach involved arranging the building components based on a scale of needs for 30 buildings that indicated negative percentages. They claim that the application of their method makes it possible to order the renovation works of building components in terms of necessity. In the same vein, Mayo and Karanja (2018) adopted a facility condition index approach and Delphi technique to analyse the opinion of a panel of experts. This approach involved a survey with 16 facility managers on the purpose, hierarchy, tools/technologies used during condition inspection and methods used to calculate the facility condition index to determine a consensus. Their results showed no established assessment use of the facility condition index metric. They claimed that there is minimal agreement between the panellists on the facility condition index.

It can be seen that authors in the above studies assume that the condition of a building elements can be rated as values and calculated based on the opinion or evaluation of experienced assessors. These authors argue that the application of the condition index method makes it possible to order or arrange the defects or renovation needs on building elements based on weights, necessity or hierarchy.

#### **2.4 Digital approach: Thermography and 3D modelling**

In contrast to the condition index approach, other studies assume that the secret to determining the condition of a building is by generating a digital or visual representation of the building to uncover hidden construction information and put forward digital approach to locate discrepancies and defects using thermal images or 3D models of existing buildings (Reginato, 2014; Ani *et al.*, 2015; Sakalle *et al.*). For example, Reginato (2014) focused on discrepancies or errors in buildings and adopted case study approach that involved the use of laser scanning equipment to determine the condition of a building prior to construction to uncover potential discrepancies. This approach involved developing 3D models and comparing the laser scans with the as built drawings of two medical facilities due for renovations. Their laser scan results showed discrepancies or inaccuracies on the as-built drawings as some dimensions in the atrium listed on the as-built drawings were incorrect and structural elements supporting the deck were not located. They claim that utilizing laser scanning prior to the commencement of construction allows clashes, discrepancies and constructability issues to be identified and mitigated prior to installation. Similarly, Ani *et al.* (2015) focused on water ponding defects and adopted a case study approach that integrated BIM to explore the condition of a flat roof and the possibility of the water ponding defect. This approach involved using Revit to generate a 3D-Model of the roof views and rain water down pipes that were integrated with a 4D-Model. The result of their digital model showed criticality levels of rain water down pipe indicating that water ponding occurs on the flat roof areas during and after heavy rainfall because water is not efficiently discharged through the rainwater pipes. They claim that a BIM-based condition survey has a positive effect by providing a 4D model that is easy to understand, access, and store by the building management team. In the same way, Sakalle *et al.* (2021) focused on the degradation of building elements and adopted a case study in India that involved infrared thermography to assess the condition of a historical building. This approach involved using a thermo camera for real time measurement of the temperature of building elements, infrared inspection and thermal images of three historical buildings. The thermogram or thermal images of their results showed intrusion of moisture, cracks and delamination on the roof, walls, columns and corners. They claim that the infrared thermography approach is fast and reliable method in detecting cracks, discontinuities inside load-bearing walls and conservation treatments in the historical buildings.

It can be seen that authors in the above studies assume that the condition of a building elements can be determined by generating a digital representation of an existing building. These authors argue that the use of digital technologies provides an easy, fast and reliable method to detect cracks, discontinuities, clashes, discrepancies and mitigate constructability issues with information on buildings that can be stored and accessed by construction practitioners. The authors in the above studies concentrate on the integration of digital technologies in determining the condition of buildings and share similar assumptions with earlier studies that concentrate on using traditional approaches on the identification of defects in building elements.

### **3. Evaluating the condition of a building using a hybrid approach**

An alternative to the four dominant approaches discussed above, this study proposes the use of a combined or hybrid approach that involves integrating the traditional approach with the digital approach to evaluate the condition of a building.

This combined or hybrid approach offers to explore the condition of building elements, the building fabric and building services in a very dynamic way by utilising a combination of both the traditional methods that involve

observations, visual inspection and digital technologies such as thermal images, 3D models to unearth reliable, real time data on a building that can provide a clear picture of the aging process of building for construction practitioners to store, access and triangulate multiple times during the life of a building.

This hybrid approach offers an easy and advanced means of examining the patterns of potential and actual defects at the pre-construction, construction and post construction stage as opposed to defects that only arise for maintenance purposes after construction. This approach offers construction practitioners the opportunity to gather construction data from multiple sources that can be compared and validated with different numerical and digital data. This approach offers a different focus on the patterns of defects that was explored by Olubajo *et al* (2024) that focused on residential buildings alone in Nigeria.

This hybrid approach also offers to shift the conversation from arguments on whether qualitative or quantitative data on the condition is more reliable and to focus more closely on gathering different building data on the condition that can be compared and critically evaluated to facilitate in making a decision.

This study recommends that future research on building condition surveys should involve or adopt the use of the synthesis of artificial intelligence and advanced computer algorithms with traditional methods to investigate the condition or status of different building elements.

#### 4. Conclusion

The aim of the study was to examine the dominant research approaches on building condition surveys and assessment in the construction management and engineering literature. The objectives of the study were to identify key or dominant studies on the subject building condition surveys and assessment, categorise them and to underline the assumptions and limitations in argument underlying the dominant research approaches.

This study identified four main categories or themes as the dominant approaches that have been adopted in the literature on building condition surveys and assessment namely: model-based approach, fuzzy approach, condition index approach and the digital approach.

The study observed that three categories of the studies on building condition surveys and assessment put forward the traditional approach that focused on representing the condition of building with numerical values to facilitate in making a decision in renovation works or maintenance with regards to defects. However, one category or group of studies adopted the digital approach that tends to focus on the generated a digital representation of existing buildings.

The results of the study do not suggest that any category or approach is better than another. Rather the study suggests that a combination or a hybrid approach offers to provide multiple data sources for comparison that can unearth comprehensive information on the condition of a building that can be triangulated or validated over the lifespan of the building and prior to construction. Not adopting a systematic review method in this study is a limitation that is recommended in further studies.

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