DOME STRUCTURE IN COASTAL AREA CONDITION ASSESSMENT USING CSP 1 MATRIC APPLICATION

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Abstract - The maintenance of a building often causes the waste of much money due to unnecessary or improper building maintenance. Thus, the need for a proper building condition assessment (BCA) is vital to provide a good operating, maintaining and refurbishing of buildings. One of the rating system available to assess the conditions of building structure is the CSP 1 Matrix. This rating system enables surveyor to collect data at a short time possible by giving ratings on the condition of the structure being inspected thus avoiding the conventional longhand descriptive building survey report. To further enhance the available rating system, a software application that utilises the criteria of the CSP 1 Matrix will be developed using the Visual Basic .NET.

Index Terms - Building condition, CSP 1-Matrix, dome structure, Visual Basic .NET.

I. INTRODUCTION

Operating, maintaining and, eventually, refurbishing constructed assets is every year harder because new performance requirements must be fulfilled whilst assuring economic yield. As a consequence, decisions of asset managers are becoming more complicated and a deep knowledge of the asset condition is needed [1]. Typically, asset managers must make decisions about maintenance and renewal alternatives based on sparse data about the actual state of their own assets [2] and this often causes the waste of much money whereby one third of all maintenance costs are used inefficiently as the result of unnecessary or improper maintenance activities [3]. Moreover, researches highlight that most of the stakeholders in the construction industry; designers, contractors, suppliers and owners are wasting a huge amount of money looking for, validating and/or recreating facilities information that should be readily available [4]. In order to increase stakeholder's satisfaction, this lack of information must be filled and one possible way to improve the knowledge about assets is given by Building Condition Assessment (BCA), an example of this is a technical inspection by a competent assessor to evaluate the physical state of building elements and services and to assess facility maintenance needs.

The condition survey protocol (CSP) 1 matrix is an assessment method for evaluating building condition. This development was made with the aim of contributing to the development of building inspection rating systems while concentrates on providing rating criteria that can be used to assess a building's defects [5].

With computer application that utilises the condition survey protocol (CSP) 1 matrix, surveyors will be able to conduct their works at a much faster rate whilst producing satisfactory results. Although site investigation and data input is required to be conducted by the surveyor, there is no need for the analysis of the long handwork data from conventional building inspection survey. This paper presents the application of Visual Basic.NET to produce a Windows application that computes building condition assessment by utilising the condition survey protocol (CSP) 1 matrix.

A. Objective of Study

Determination of building condition based on longhand surveys is time consuming and requires long analysis of data. Thus, the development of a Windows application using Visual Basic .NET is effective. The main objectives of this paper are to assess the condition of dome roof structure available at coastal area of Kota Kinabalu, Sabah using a developed software that utilises the CSP 1 Matrix.

B. Scope of Study

The condition survey protocol (CSP) 1 matrix is a developed rating system that is applicable to any types of building. It allows surveyor to conduct building condition assessment by giving the components of the building a rating instead of a longhand description. This enables a result of a numerical value for statistical analysis. Obtaining data will still require the surveyor to conduct a building inspection and data will then be computed to a developed Windows application. With the aid of a computer application utilising the condition survey protocol (CSP) 1 matrix, the calculation of the result ratings can be computed easily at a fast rate. Time cost will significantly be reduced.

II. LITERATURE REVIEW

A. Dome Structure

The roofs are a critical part of the building envelope and are highly susceptible to the constantly changing weather and other environmental changes, thereby, influencing the indoor comfort conditions for the occupants. Roofs come in different shapes and sizes. To name one of the steep roofs which had been used centuries ago is the dome structure and these structures can still be seen used in the twenty-first century. The uniqueness and aesthetically pleasing design of the dome has compelled the continuous usage of this structure by designers since the beginning of time until today itself. The advantages of dome structures are its strength which is highly durable and strong. While the average building life is measured in decades, the dome structures can be measured in centuries. Having fire, water, and wind resistant, these structures are impervious to hurricanes, tornadoes, fires and other threatening natural disasters. However, depending of the materials used and the quality of the materials, the durability and strength of dome structure can vary.

A dome is a type of a roof structure that looks like a half of a sphere. They can be churches, mosques, synagogues, sports arenas, igloos, government buildings or dwellings. Dome structures are used in buildings of different shapes and functions. Dome was also designed as a sharp, cool and innovative idea that can facilitate sport's industry in desert-covered areas which is the Shaded Dome^{TM} which was designed in a way that it actually constitutes a smart, cool and adaptable facility, which meets the highest standards of comfort, sustainability, flexibility, accessibility, safety and security for both its visitors and users, protecting them from the often harsh or unfavorable climatological conditions [6]. Mosques, which is the central building for worship activities in Islamic community utilizes the domical structure in its design as it could potentially produce concentrated distribution of sound energy to reflect speeches which includes for a variety of worship activities such as praying, Quran recitation, and Friday praying with lecture mode [7]. A structure uniquely designed with multiple purposes brings about the need to assess the modern twenty first century dome structure for its condition.

B. CSP 1 Matrix

The purpose of conducting a building inspection is to assess the building's condition. Traditionally, building surveyors have primarily relied on descriptive longhand surveys. This means that surveyors recorded every detail by hand when performing on-site building inspections. Through this type of approach, the building survey report is usually longer, more detailed and more technical which propels the need for a quick and practical approach in performing building inspections under reasonable property conditions.

The goals behind the CSP1 matrix [5] are to;

1) Enable the surveyors to collect data within the shortest possible time by avoiding descriptive, longhand write-ups during fieldwork;
2) Record the existing defects of the building, the main source of data, by assessing the condition and assigning priority or repair to each defect recorded;
3) Obtain an overall rating of the building's condition. The proposed remedial work is not the main concern of this matrix. Moreover, the repair work usually cannot be carried out immediately after the survey's completion because of budget constraints. Therefore, the validity of any proposed remedial work would need to be reconfirmed later; and
4) Use the numerical rating acquired from the survey work to perform statistical analysis.
5) The data required for the CSP1 matrix are the condition and the priority assessments, as shown in Tables 1 and 2. Each numerical score (1 to 5) is accompanied by a scale value and description. This will help surveyors to rate the building's defects and to determine the exact condition implied by the scale values. The scale values and their descriptions depend on the maintenance standard of the building being evaluated.

Condition	Scale Value	Description
1	Good	Minor Servicing
2	Fair	Minor Repair
3	Poor	Major Repair/Replacement
4	Very Poor	Malfunction
5	Dilapidated	Damage/Replacement of Missing Part

Table 1: Condition Assessment Protocol 1

Condition	Scale Value	Description
1	Normal	Functional; cosmetic defect only
2	Routine	Minor defect, but could become serious if left unattended
3	Urgent	Serious defect, doesn't function at an acceptable standard
4	Emergency	Element/structure doesn't function at all; or Presents risks that could lead to fatality and/or injury

Table 2: Priority Assessment

Each recorded defect is assigned a condition and priority rating. Each rating is then multiplied to determine the total score for each defect. The total score is then matched with the matrix, as shown in Fig 1. The scores range from 1 to 20.

Scale		Priority Assessment			
		E 4	U 3	R 2	N 1
Condition Assessment	5	20	15	10	5
	4	16	12	8	4
	3	12	9	6	3
	2	8	6	4	2
	1	4	3	2	1

Fig 1: The Matrix

After scoring every defect, the overall building rating is calculated, which summarises the building's condition. The score of each defect is added up and divided by the total number of defects to get the overall building rating. The building is then rated Good, Fair or Dilapidated, according to the score (out of 20). Table 3 shows the overall building ratings. An executive summary will be produced to present the final findings.

No	Matrix	Score
1	Good	1 to 4
2	Fair	5 to 12
3	Dilapidated	13 to 20

Table 3: Overall Building Ratings

III. METHODOLOGY

Building having domes structures in coastal area of Kota Kinabalu, Sabah were identified prior to the conduction of the building inspection. Inspections will be made at different components of the dome structure namely the beams, trusses, ceiling cover, insulation, roof sheeting, etc., whichever components available on the dome roof structure of the building. Photographs of these components will be taken as a reference to the ratings given.

Inspection will be carried out starting from the interior part of the structure which is the ceiling cover, beam, truss and roof insulation whichever is available. Inspection will then move to the exterior part of the structure which are the roof coverings and roof finishes. Inspection will be conducted in a circular motion covering the circular shape of the dome structure in an anti-clockwise direction. Structures will be devided into 4 sections based on its orientation direction to make it easier for the inspection to be carried out.

IV. RESULTS AND DISCUSSION

A total of 6 building with dome structure in coastal area of Kota KInabalu was assessed as shown in Table 4, whereby 3 of the building which is the DSB-A, DSB-B and DSB-C was found to have defects. The other 3 of the inspected building has no visible defects.

No	Name of Building	Number of Domes Structure	Dome Material
1	Dome Structure Building A (DSB-A)	1	Concrete, Metal Sheet
2	Dome Structure Building B (DSB-B)	6	Steel Truss, Metal Sheet
3	Dome Structure Building C (DSB-C)	10	Concrete
4	Dome Structure Building D (DSB-D)	2	Concrete, Metal Sheet
5	Dome Structure Building E (DSB-E)	1	Concrete
6	Dome Structure Building F (DSB-F)	1	Concrete, Marble

Table 4 Dome Structures Assessed for the Study

Defects				Condition	Assessment	Score	Defect Tagging
Category	Element	Sub-Element	No.				
Exterior	Coverings	Metal Sheet	1	1	1	1	E1 (N-W)
	Black stain covering surface.						
	Finishes	Strip Metal Sheet	2	1	1	1	E1 (N-W)
	Strip metal sheet chirping off.						
	Coverings	Metal Sheet	3	1	1	1	E1 (S-W)
	Black stain covering surface.						
	Finishes	Strip Metal Sheet	4	1	1	1	E1 (S-W)
	Strip metal sheet chirping off.						
	Coverings	Metal Sheet	5	1	1	1	E1 (S-E)
	Light stain covering surface.						
	Finishes	Strip Metal Sheet	6	1	1	1	E1 (S-E)
	Strip metal sheet chirping off.						
	Coverings	Metal Sheet	7	1	1	1	E1 (N-E)
	Black stain covering surface. Appearance of vegetation.						
	Finishes	Strip Metal Sheet	8	1	1	1	E1 (N-E)
	Strip metal sheet chirping off.						

Fig 2: Schedule of Dome Condition for DSB-A

Defects				Condition	Assessment	Score	Defect Tagging
Category	Element	Sub-Element	No.				
Exterior	Coverings	Metal Sheet	1	1	1	1	D1 (N-W)
	Black stain covering surface.						
	Coverings	Metal Sheet	2	1	1	1	D2 (N-W)
	Black stain covering surface.						
	Coverings	Metal Sheet	3	3	3	9	D2 (S-E)
	Part of metal sheet is stripped off.						
	Coverings	Metal Sheet	4	1	1	1	D3 (N-W)
	Black stain covering surface.						
	Coverings	Metal Sheet	5	1	1	1	D5 (N-W)
	Black stain covering surface.						
	Coverings	Metal Sheet	6	1	1	1	D6 (N-W)
	Black stain covering surface.						

Fig 3: Schedule of Dome Condition for DSB-B

Defects				Condition	Assessment	Score	Defect tag
Category	Element	Sub-Element	No.				
Exterior	Finishes	Paint	1	1	1	1	M1 (N-E)
	Black stains covering surface. Cracks in paints.						
	Finishes	Paint	2	1	1	1	M2 (N-W)
	Chirping off of paints.						
	Finishes	Paint	3	1	1	1	M2 (N-E)
	Black stains covering surface.						
	Finishes	Paint	4	1	1	1	M3 (N-W)
	Black stains covering surface. Cracks in paints.						
	Finishes	Paint	5	1	1	1	M4 (S-W)
	Black stains covering surface.						
	Finishes	Paint	6	1	1	1	M5 (N-W)
	Black stains covering surface.						
	Finishes	Paint	7	1	1	1	M5 (S-W)
	Black stains covering surface. Appearance of vegetation.						
	Finishes	Paint	8	1	1	1	M6 (S-W)
	Black stains covering surface.						
	Finishes	Paint	9	1	1	1	M6 (S-E)
	Black stains covering surface.						
	Finishes	Paint	10	1	1	1	M6 (N-E)
	Black stains covering surface.						
	Finishes	Paint	11	1	1	1	M7 (N-W)
	Black stains covering surface.						
	Finishes	Paint	12	1	1	1	M7 (S-W)
	Black stains covering surface.						
	Finishes	Paint	13	1	1	1	M7 (N-E)
	Black stains covering surface.						
	Finishes	Paint	14	1	1	1	M9 (N-W)
	Black stains covering surface.						
	Finishes	Paint	15	1	1	1	M9 (S-W)
	Chirping off of paints.						
	Finishes	Paint	16	1	1	11	M10 (S-W)
	Cracks in paints.						
Interior	Finishes	Paint	17	1	1	1	M2
	Chirping off of paints.						
	Finishes	Paint	18	1	1	1	M3
	Chirping off of paints.						

Fig 4: Schedule of building Condition for DSB-C

Fig 2, Fig 3 and Fig 4 displays the findings of the inspection conducted on each respective building. Comparatively, based on the results of all three-building inspected for its dome structure, there is a higher percentage of the external section of the dome structure having defects compared to the internal section. This is due to the fact that there are many environmental stresses on the roof of buildings such as sunlight and temperate variations, wind, rain, atmospheric gases and pollutants and even bacterial growth [8]. Moreover, roof is a part of the building envelope which separates the outside environment of a building and the inside environment of a building, thus it is the first line of defence of a building against natural hazards. This puts a strain on the condition of the roof structure. Besides that, it was also seen that most of the defects reported were the presence of black stains on the surface of the dome structure. This defect tarnishes the aesthetic value of the dome structure itself. The presence of these black stains may be linked to the moisture and bacterial growth on the surface of the dome structure. High water content or surface contact with moisture in long period of time will cause mold formation [9]. Thus, with moisture present there are a lot of types of building defects that are cause by moisture problems such as staining, discolouration paint, peeling paint, blistering of wallpaper, corrosion and mould [10]. Peeling of paint and blistering of paint was also observed on some of the dome structures in DSB-C. Works [8] also showed that the cause of staining of roofing is due to biological growth such as cyanobacteria, algae, lichens, mildew, moss, etc..

It was noted on the results of the inspection of all three building that the elements which has the most defect was the finishes and the coverings. Finishes such as paints as well as roof coverings are materials that are most exposed to the natural hazards as it is the outmost layer of a roof system thus the most susceptible to environmental stresses.

Relatively, the results based on the orientation direction of all three buildings showed that more defect occurring mainly at the West direction with N-E and S-E orientation recording a high number of defects. Sunlight factor may not be the cause of these defect as the works by [11] has shown that the geometric proportion of a circular shape of the dome structures are of W/L 1:1. This indicates that the circular shape with W/L ratio 1:1 received lowest amount of solar insolation on a yearly basis. Circular shape is considered as the optimum shape in minimising the total solar insolation on high-rise buildings.

CONCLUSION

The dome structures available in coastal area of Kota Kinabalu Sabah was assessed using the software developed with a total of 6 building having dome structures available was assessed for its condition. Among all 6 buildings, only 3 building were found to have minor defects while the other 3 has no visible defects. The results of from the conduction of building inspection showed that these structures have minor defects with an average building rating score of 1.3 which indicates that the dome structures in coastal area of Kota Kinabalu Sabah are in good condition.

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