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Visual Inspection using Unmanned Aerial Vehicle (UAV): Case Study of Building Defects at Canteen and Surau Between SK Kampong Raja and SK Pekan Pagoh

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Abstract : Building inspection is essential in determining the condition of a building and is one of the most important aspects to conserve the building. To determine the defect, visual inspection was conducted as an early phase of building inspection. Without an adequate inspection, it would be challenging to assess a building's current state as using binocular and camera to visual inspection in high building.This research aims to study Sk Kampong Raja and Sk Pekan Pagoh defects at exterior structure and the roof structure especially at canteen and surau by using the drone, Phantom 3 Advanced. The obtained data were processed using the Condition Survey Protocol (CSP1) Matrix to determine the overall condition of the building. This study's processes include site visits, planning and preparation prior to flight, data collection utilising a drone, image processing, and data analysis from images. The result shows, rating for canteen Sk Kampong Raja and Sk Pekan Pagoh are 5.3 and 5.4, while for surau Sk Kampong Raja 5.4 and surau Sk Pekan Pagoh 5.7 respectively. Overall the result shows that the canteen and surau building for both school were in fair condition.

Keywords: Building Inspection, CSP1, Defects Drone, School, Defects

1. Introduction

A building is typically a roofed and walled structure constructed for long-term usage[1]. The early construction materials were perishable, such as branches, leaves, wood and animal hides, and these structures lacked durability. Next, the natural materials are more durable such as clay, stone, wood, and

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synthetic materials such as brick, concrete, metals, and plastics were used allowing structures to last for decades and even centuries. A building structure has 12 essential components: the roof, lintels, damp proof course (DPC), beams, parapet, floor, stairs, columns, walls, plinth beam, foundation, and plinth. Since the growth of massive projects in the early 1990s, the construction industry has been recognized as a key producing sector in Malaysia[2].

A building is a place where people may stay, engage in activities and work, or where an organization may carry out its work[3]. A building's main purposes include providing a safe, load support, temporary shelter, and a healthy environment for people to carry out their activities. Buildings are classified according to their use and occupancy under the International Building Code (IBC 2018) and the Uniform Building Code (UBC). The IBC and UBC requirements are reasonable since they govern structural design and construction, and each building reflects a particular amount of risk and neighboring properties[4]. There is a residential building for general residential purposes, an educational building for education or recreation, and an institutional building for medical or other treatment.

The building sector is becoming more contemporary, advanced, and increasing all around the world. As evidence, there are many unique and beautiful skyscrapers in the world. The most famous one is the Burj Khalifa, the world's tallest building and Park Avenue New York [5]. Despite its development, the construction sector is plagued by one major problem: building defects. Structural Engineers are continuously working to solve the challenges of structural flaws, but eliminating them is tough. The two forms of maintenance that must be a part of the maintenance process are preventive and corrective. Preventative maintenance is more crucial when comparing the two, and individuals engaged in the building of the structure must recognize its importance from the beginning [6].

A defect is invariably a flaw in the structure or a design mistake that diminishes the building's economic worth over time and leads it to be in poor condition [7]. Despite recent advances in construction technology, it appears that the number of building defects has not decreased. Some flaws are more common as a result of factors including pollution, poor workmanship, or the use of inferior materials, as well as environmental factors. Defective building construction has an impact on not just the final product cost, but also the continuing maintenance costs, which can be significant. Apart from that, an unnecessary effort was needed to correct the construction error which is reworked [8]. This could result in a structure's complete failure.

Therefore in this study, Unmanned Aerial Vehicle (UAV) technique can be used as an alternative tools in visual inspection [9]. This device consists of a camera that can capture clear photos other than capturing videos. The usage of a micro UAV could identify the damage on the outer section of the buildings [10].Morover, the Condition Survey Protocol (CSP1) helps in utilised as a rating tool, shortening the time needed for data interpretation and on-site inspection[11].This study was conducted by observing the condition of the surau and canteen in SK Pekan Pagoh and SK Kampong Raja. The result was used to study the types of defects and recommends a solution.

2. Materials and Methods

The two primary stages of this study are UAV method using drone and CSP1 Matrix. The material that had been used was drone Phantom 3 Advanced. The visual inspection using UAV method by visiting Sk Kampong Raja and Sk Pekan Pagoh. The assessment of condition evaluation using the CSP1 Matrix is the last stage to do to rate the building defects in these two schools.

2.1 Conducting the Visual Inspection

The first stage performed on surau and canteen at Sk Kampong Raja and Sk Pekan Pagoh was by using the method of visual inspection which is Phantom 3 Advanced. Data were collected to record the type of defect surau and canteen building. By using the latest technology drone, Phantom 3 Advanced,

it can capture pictures in a high location such as roofs. With a 2.7K camera, Phantom 3 Advanced can easily capture images from above [12]. Furthermore, this drone can fly as far as 3.1 miles which are 5 kilometers can be made it easier to capture roof pictures. The battery of the drone would last about 23 minutes [13].

2.2 Evaluation by using CSP1 Matrix

The data that are required for the CSP1 Matrix is the condition and the priority assessments. Each numerical score (from 1 to 5) has a scale value and an explanation [14]. The CSP1 Matrix can assist this investigation in determining the actual condition represented by the scale values and grading the building's defects[15]. The scale values and their descriptions are determined by the building's maintenance standard. For example, the scale can be set more rigorous than in the example presented here. The condition and priority assessments are the most fundamental scales in the CSP1 Matrix[16].

Table 1 : Condition Assessment Protocol [15]

Condition	Description	Scale Value
1	Good	Minor Servicing
2	Fair	Minor repair
3	Poor	Major repair/Replacement
4	Very poor	Malfunction
5	Dilapidated	Damaged/Replace the missing part

Table 2: Priority Assessment [15]

Priority	Scale Value	Description
1	Normal	Cosmetic defect only
2	Routine	Minor defect but can be serious if unattended
3	Urgent	Serious defect but does not function at an acceptable standard
4	Emergency	Structure does not function at all / Presents risk that can lead to fatality or injury

Condition **(Table 1)** and priority **(Table 2)** rating are assigned for each recorded defect. After that, the sum of multiplied each rating is calculated for each flaw. The scores that ranged from 1 to 20, and each of the 3 criteria scores was represented by a colour (green, yellow or red): Plan Maintenance (1 to 4), Condition Monitoring (5 to 12) and Serious Attention (13 to 20). CSP1 Matrix has also been

developed in order to shorten the process of interpreting the data which would then help shortening on-site inspection time. It is then proven to be useful and reliable in carrying building inspections [14].

3. Results and Discussion

As the result and discussion of this study, the defect has been discovered by CSP1 matrix to utilize its type and condition of it [5].

Table 3: Matrix Assessment [5]

Scale		Priority Assessment			
		E4	U3	R2	N1
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

Table 3 and **Table 4** show Matrix Assessment, planned maintenance, and overall rating of the building, that has been used in this study.

Table 4: Planned Maintenance [5] & Overall Building Rating

Planned Maintenance		
No	Matrix	Score
1	Planned maintenance	1 to 4
2	Condition monitoring	5 to 12
3	Serious attention	13 to 20
Overall Building Rating		
1	Good	1 to 4
2	Fair	5 to 12
3	Dilapidated	13 to 20

After evaluating each defect, the overall building rating, which summarises the building condition, is determined. The overall building rating is calculated by adding the scores and dividing them by the total number. The building is then rated Good, Fair or Dilapidated based on score out of 20. **Figure 1** and **Figure 2** shows the information obtained for the CSP1 Matrix comprises a picture box, a defect plan tag and an executive summary.

Details	Pictures

No of defect: 1

Condition	Priority	Matrix	Colour
3	**3**	**9**	

Level: Exterior

Element/component: EL/CS 01: Beam

Defect Description: DS/CS 17: Leakage, DS/CS 20: Mould Growth

Recommendation: Fix the leakage, clean the mould and repaint the affected area

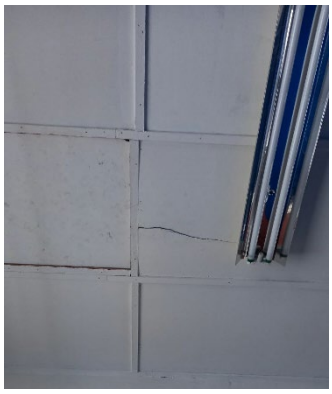
(a)

Details	Picture

No of defect: 1

Condition	Priority	Matrix	Colour
3	**2**	**6**	

Level: Interior
Element/component: EL/A 02: Ceiling
Defect Description: DS/A 25: Crack
Recommendation: Replace the ceiling with the new one.



(b)

Figure 1: (a) Defect (leakage and mould growth), & (b) Defect from Surau Sekolah Kebangsaan Pekan Pagoh

3.1 Defect of Canteen and Surau at Sk Kampong Raja

Based on **Figure 2 (a),** shows how much of each defect is found at the canteen Sk Kampong Raja. The defects are composed of crack, leakage, uneven, missing, exposed rebar, spalling, mould growth and also decay. From the analysis, cracking was the most severe defect in the canteen at SK Kampong Raja which is 27% but it can be fixed. The flood in 2014 was one of the main factors for the most of defects at this school, especially at the canteen. Other than that, the other defect can be caused by poor maintenance and also by the environment. For cracking at plaster ceiling, it may be fixed by replacing it with a new one. While the tiles can remedy by applying glaze on the crack surface.

The whole list of defects from pie chart **Figure 2 (b)** is presented above, along with their percentages, which indicate how common each defect is in the surau. During the investigation, water stain, mould growth, spalling, uneven, vegetation growth, and other defects were detected with damage and mould growth representing 34 percent of all defects which is the most common defect. Long-term

deterioration is the most likely cause, which may be fixed by cleaning and repainting the damaged area with a new coat of paint. Other defects that represent 11% of defects may be caused by poor maintenance but still can be fixed.

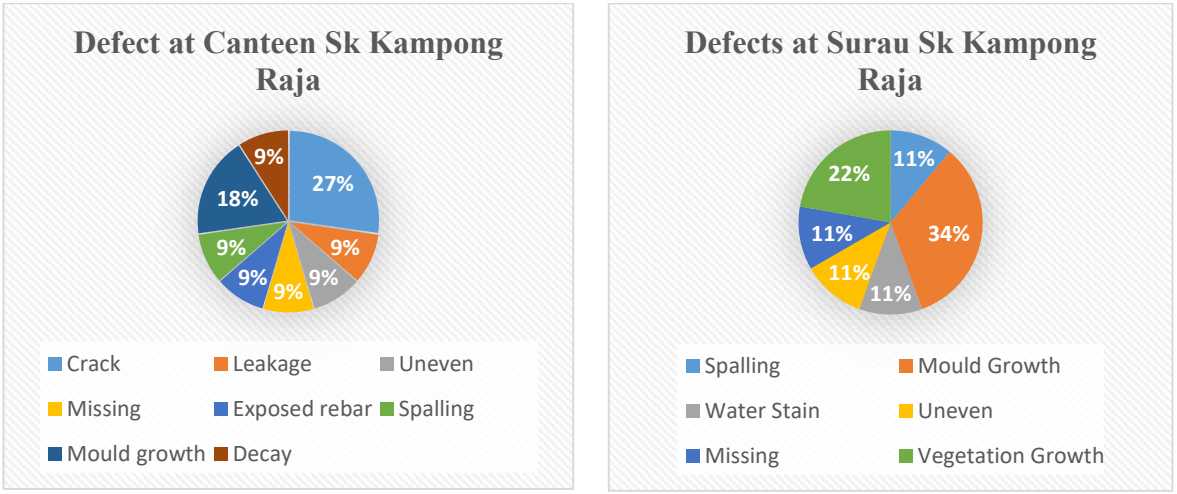
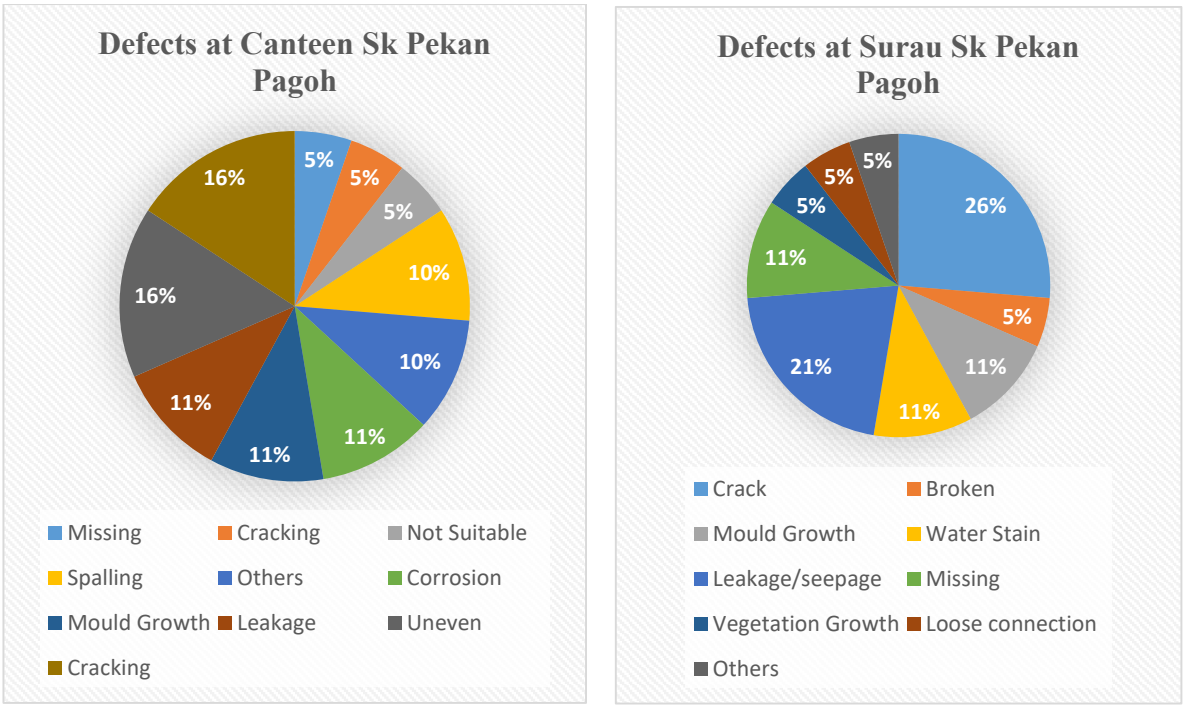


Figure 2: (a) Defect at Canteen Sk Kampong Raja (b) Defect at Surau Sk Kampong Raja

3.2 Defect of Canteen and Surau at Sk Pekan Pagoh

The complete list of defects in pie chart **Figure 3 (a)** is shown above, along with their percentages, which show how much of each defect is found in the canteen. Cracks, mould growth, spalling, damage, uneven, not suitable, corrosion, and other defects were discovered throughout the analysis, with damage and uneven being the most common defects which are 16% each. In addition, the defects found after the analysis are missing, cracking and not suitable which is 5%. The most likely cause is long-term deterioration, which may be remedied by rendering cement mortar and repainting a new coat on the affected area.

From the list of defects from **Figure 3 (b),** along with their percentages, indicates how much of each defect is present at the surau Sk Pekan Pagoh. Crack was the most severe defect which is 26% and the cause of this is most likely long-term deterioration but surely can be fixed by patching new cement mortar and came along with a new coat of paint on the area that has been affected. The least percentage for this defect are vegetation growth, leakage, broken and others which is 5%. This can be caused by poor monitoring and also environmental changes.



(a) **(b)**

Figure 3: (a) Defect in Canteen Sk Pekan Pagoh (b) Defect in Surau Sk Pekan Pagoh

3.3 Rating Score at Canteen and Surau Between Sk Kampong Raja and Sk Pekan Pagoh

Figure 4 shows that surau and canteen between two schools had been built in 2009. By referring to the CSP1 matrix, both buildings have been discovered that it is still in a fair condition. After analyzing the results, it shows that Sk Pekan Pagoh's rating score is better than Sk Kampong Raja in both buildings which are 5.3 for the canteen and 5.4 for surau. Meanwhile, the rating condition for both buildings at Sk Kampong Raja is 5.5 for the canteen and 5.7 for surau which means worse than Sk Kampong Raja. This is because Sk Pekan Pagoh had been renovated in the past few years for the surau and canteen building as it was in the same building. Other than that, the defect that had been found were also can be caused by the environment as it has been closed for a long time because of the pandemic Covid-19. So it is hard to monitor the building as well as it should be but the condition for the building is still in a good condition.

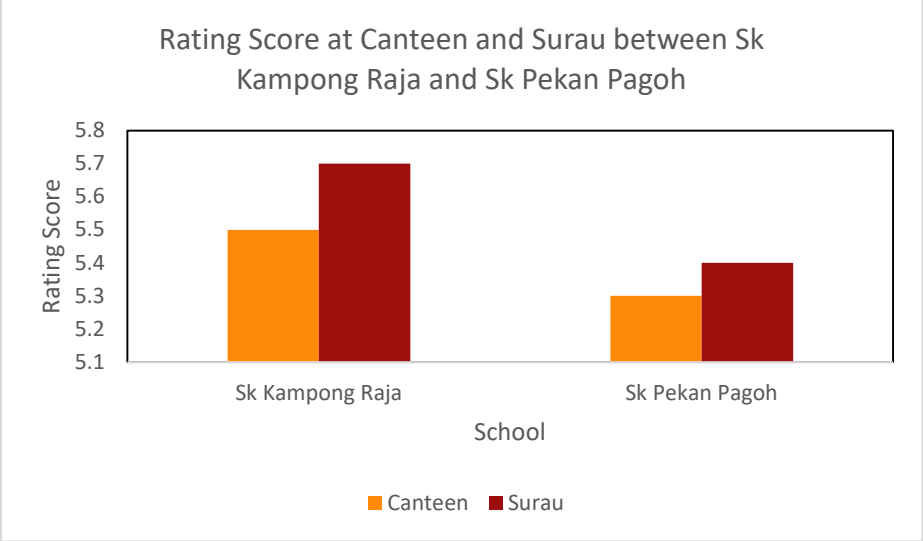


Figure 4: Rating Score at Canteen and Surau between Sk Kampong Raja and Sk Pekan Pagoh

4. Conclusion

The inspection was carried out to determine the extent of structural damage and defects at Sk Kampong Raja and Sk Pekan Pagoh. Almost all types of buildings, even those that have been renovated are not free from defects. This has lowered the building's aesthetic value, created interference, and put teachers' and students' safety at risk. This research also discusses the use of a drone as an alternate approach for obtaining clear flaws, particularly on rooftops. The CSP 1 Matrix is used as a rating tool for determining the reasonable condition of a property. According to the results of the study, the canteen and surau of Sk Kampong Raja and Sk Pekan Pagoh are in good condition, especially the canteen and surau of Sk Pekan Pagoh, despite new building and recent renovations. The Ministry of Education, Sk Pekan Pagoh and Sk Kampong Raja shall cooperate in preserving the building structure of the school building.

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