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Investigation on Wall Cracking by Using Visual Inspection and Determine The Suitable Methods for Maintenance Action

Bong Zhang Min[1], Mohammad Ashraf Abdul Rahman[1]*

[1]Department of Civil Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

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Abstract: Cracking walls in existing constructions is one of the components that need to be a concern. Therefore, the study is carried out to investigate the cracking wall by using visual inspection. Then, Building Condition Assessment (BCA) is used to determine the suitable methods for maintenance action. Moreover, the study will be conducted at Sekolah Jenis Kebangsaan (SJKC) Chung Hua Kranji. According to the research, the conditions of the cracking walls are justified, and maintenance actions are proposed to the cracking wall. After evaluation and investigation, Figure 4 has the highest score which is 9 with a good grade. So, the maintenance action required is condition-based maintenance. Figure 9, Figure 10, Figure 11, and Figure 12 get the lowest score which is 2. This is due to the condition of the cracking wall is hairline crack. Therefore, the maintenance action required is preventive maintenance and rated very good grade. Although the maintenance actions required are maintenance based on condition, and preventive maintenance, inspections will be conducted first before any maintenance work begins. This is to ensure that the building's maintenance will properly cure the issue and prevent it from causing further failure to the building's structures.

Keywords: Cracking wall, Visual Inspection, Building Condition Assessment

1. Introduction

Cracking walls in the building is a common problem faces throughout the world. The walls develop cracks due to stress in the wall exceeding its strength, humidity, settling, and so on. Some of the cracks in the wall at building inspection may be identified as indicators of serious and symptomatic structural failure. Cracking in walls is unsightly, but it can be an indicator of serious structural problems. It is required to know if the wall crack can be easier fixed with a bit of strategically placed filler and a lick of paint or whether costly structural repairs the cracking wall [1].

Cracks that exist in the building have many different reasons which are responsible for structural crack and non-structural crack [2]. So, cracking can be separated into two, which are structural crack

*Corresponding author: ashrafr@uthm.edu.my

and non-structural crack. Structural crack is more aggressive and at present state threatens the structural integrity of the building. Normally, structural crack is easy to identify [3]. It can take on many shapes and sizes. When it's crack wider than 2.00 mm, it can be a continuous horizontal crack along the wall, vertical cracks significantly wider at top or bottom, diagonal cracks, and stair-step crack. While non-structural crack emerges at the foundation but does not threaten the structural integrity of buildings [3]. It can happen anywhere in the foundation when there are voids and openings on the foundation wall. Moreover, a non-structural crack is usually a thin hairline crack which less than 2.00 mm. Nevertheless, it should be observed well and repaired since it may turn into a structural crack when water seeps through and deteriorate the inner concrete and wider the crack.

Moreover, not all cracking walls have a serious problem. For example, structural crack is formed due to faulty design, faulty construction which are heavy risks the safety of the building while non-structural crack appears at the foundation but does not risk the structure of the building. So, some of the hairline cracks that do not bring risk to the building may be patched with filler and paint. However, the large gaping cracks that have risks to the building can be indicators of more costly structural or foundation problems that needed the involvement of a structural engineer. Then, the building inspection report will provide the assessment of the severity and likely cause of the crack in the wall.

Therefore, the conditions of the cracking wall are investigated and justified. Then, the maintenance actions are proposed to the cracking wall. These types of solutions are proposed to protect the building from collapse, unsightly, and defects. With the proposed solutions, the buildings can preserve a long time.

1.1 Problem statement

Nowadays, most of the buildings may face the problems of wall cracking after the years. Thus, cracking walls is one of the components of the building that needed to take attention. In Malaysia, cracking walls in a new building are too common and bring bad effects such as high maintenance costs.

Besides that, clients or owners of the building must always pay attention to their buildings or houses especially the hidden corners. Clients or owners can query the inspector or consultant to propose a solution for them to maintain the crack. According to [4], one such couple from Askeaton built their house in 1990 but it began to crack forming in the plaster in 2010. Over the years, the cracks are spread throughout the house. [4]

SJK Chung Hua Kranji also faced the same problem which is wall cracking. This will affect the progress of school users who carry out their activities in that area since the condition of the wall cracking is ignored and the maintenance actions have not been identified. Besides that, it also will affect the safety and health of the users. According to The Star, some 170 residents of block 4 at Taman Jaya, Skudai, are living in fear as the building they occupy may collapse anytime due to severe cracks on the walls and floors.

A building inspection is important to discover the causes of the cracking wall earlier and prevent the cracking exists. Yet there is information on building problems in general, it is not accessible for existing buildings, even though new buildings should supposedly be defect-free. So, this research is carried out to investigate the condition of the cracking wall and propose suitable maintenance actions to solve it and save the cost of repairing. Moreover, the study is conducted to let the people understand the condition of cracking walls. So, everyone can know the knowledge of the cracking wall and the maintenance action required for the different conditions of the cracking wall.

1.2 Objectives of the study

To solve the problem of this research, the objectives have been listed as follow:

i. To investigate the cracking wall by visual inspection
ii. To determine the most suitable methods for maintenance action.

2. Methods

Due to the Covid-19 pandemic, visual inspection is chosen for observation. Therefore, the information or the data of cracking walls is analyzed and investigated by visualized. In "Illuminating the Path", Thomas and Cook define visualized is characterized as a procedure of scientific observation made possible through an interactive visual interface [5]. Visualization mixes computerized analysis methodology with interactive visualization to enable efficient comprehension, reasoning, and decision making from complicated data sets [5]. It is convenient the process of the research, especially in the Covid-19 pandemic. The equipment that is needed to use in the inspection process is a ruler and camera. Through the photo caught by the camera, the information of cracking wall can record easily.

After the data is obtained, Building Condition Assessment (BCA) is used to monitor the asset condition, prediction of defects for future performance, and ensure the building is safe to occupy [6]. The method to solve the cracking wall also can be obtained from Building Condition Assessment (BCA) after the data taken is finalized.

In this study, the first objective is to investigate the cracking wall by using visual inspection. To attain the first objective, an investigation or inspection is carried out at SJK Chung Hua Kranji. The cracking wall is found and investigate the causes which affect the wall to crack. The photos of the cracking wall are taken and the data such as the measurement, location, and so on are recorded. The second objective is to propose a maintenance action to the cracked wall. The cracking wall is then analyzed by using Building Condition Assessment (BCA) method to find out the most suitable maintenance action to propose it. The flowchart of the methodology to conduct the research is shown in Figure 1.

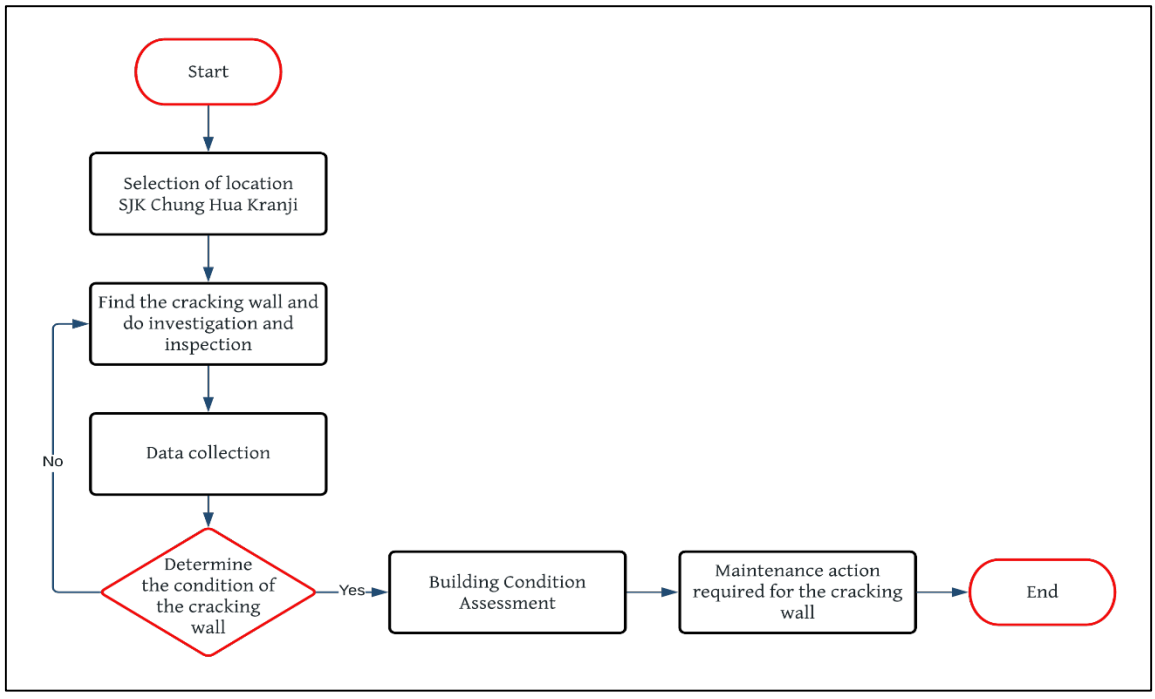

Figure 1: Flow of Methodology

After the location of the research is selected, visual inspection is started with searching for the cracking wall. All the cracking is observed by visual observation. After the cracking area is found, the data is collected. The cracking areas were caught by using the camera and the width of the cracking areas are measured by using a ruler. All the data of the measurement is recorded manually. The purpose of the measurement is to determine the condition of the school in Building Condition Assessment (BCA). The photos are taken for further observation in detail. After the data collection, the cracking

characteristics are more obvious. The cracking areas are known from the photos and sites. At the same time, the observation is conducted to find out the causes of the cracking wall. Then, the collecting data will rate by using Building Condition Assessment (BCA). Table 1 showed Building Physical Condition Level from JKR standard with additional width size from Bakri and Mydin, 2014 [7]. This has been evaluated based on their descriptions where width up to 0.10 mm is a hairline crack of less than about 0.10 mm widths is classed as negligible; width up to 1.00 mm is fine crack width can be easily treated during normal decoration; width up to 5.00 mm is crack easily filled and recurrent crack can be masked by suitable linings; width size from 5.00 mm to 15.00 mm and 15.00 mm to 25.00 mm are extensive damage required breaking out and replacing sections of walls or crack which required some opening and can be patched by a mason while width size greater than 25.00 mm is Structural damage requires a major repair job involving partial or complete rebuilding.

Table 1: Building Physical Condition Level [8]

Grade	Inspection Scale	Width (mm)	Description
1	Very Good	Up to 0.1	As new, no defect, performing as intended
2	Good	Up to 1	Minor defect, good condition, performing as intended
3	Fair	Up to 5	Major defect, Moderate condition, still can function with supervision
4	Poor	5 to 15 (Or several of 3mm) 15 to 25	Major or minor defect, critical, not functioning as agreed service level
5	Very Poor	Usually greater than 25	Very critical, not functioning, risky to safety and health

Table 2: Maintenance Action [8]

Priority	Scale	Description
Normal	1	No defect or damages, element / component well maintained
Routine	2	Minor Defects / damages, needs for monitoring, repairs, replaced to prevent serious defect / damages
Repairs	3	Major defects / damages, needs for major repairs and replacement
Rehabilitation	4	Critical / serious defects / damages, needs for urgent and immediate repairs
Replacement	5	Critical / serious defects / damages, needs for urgent replacement, refer to expert detail inspection / Expert judgement

Table 3: Matrix Analysis of Building Physical Condition Level and Maintenance [8]

		Maintenance Analysis				
Scale		5	4	3	2	1
Building Physical Condition Level	5	25	20	15	10	5
	4	20	16	12	8	4
	3	15	12	9	6	3
	2	10	8	6	4	2
	1	5	4	3	2	1

Table 4: Building Rating and Maintenance Action [8]

Rating	Physical Condition	Action Matrix	Score
A	Very Good	Preventive Maintenance	1 to 5
B	Good	Condition Based Maintenance	6 to 10
C	Fair	Repairs	11 to 15
D	Poor	Rehabilitation	16 to 20
E	Very Poor	Replacement	21 to 25

The cracking areas are analyzed by using Building Condition Assessment (BCA) that shown in Table 1, Table 2, Table 3 and Table 4. The score of the cracking area is given based on the condition and the description in Table 1 and Table 2. Then, the score of Table 1 is multiplied by the score in Table 2 to get the score in Table 3. Equation 1 showed the formula of matrix analysis.

$$\text{Matrix Analysis (Table 3)} = \text{Building Condition (Table 1)} \times \text{Maintenance Action (Table 2)} \quad Eq.1$$

Table 4 is building rating and maintenance action showed the score after the multiplication. From Table 4, the condition of the cracking wall is rated, and the maintenance action required to propose to the cracking wall.

3. Results and Discussion

After the data collection is analyzed and evaluated, the results are produced. Visual inspections are done against the cracking wall in SJK Chung Hua Kranji and Building Condition Assessment is used to rate the condition of the cracking wall and maintenance action required.

3.1 Results

Table 5: Condition Analysis of Cracking Wall

Figure	Crack Type	Width (mm)	Building Condition	Maintenance Action	Matrix Analysis	Building Rating	Physical Condition	Action Required
3	Diagonal	2	3	2	6	B	Good	Condition Based Maintenance
4	Vertical	5	3	3	9	B	Good	Condition Based Maintenance
5	Vertical	1	2	2	4	A	Very Good	Preventive maintenance
6	Vertical	1	2	2	4	A	Very Good	Preventive maintenance
7	Horizontal	1	2	2	4	A	Very Good	Preventive maintenance
8	Horizontal	3	3	2	6	B	Good	Condition Based Maintenance
9	Vertical	1	2	1	2	A	Very Good	Preventive maintenance
10	Horizontal	1	2	1	2	A	Very Good	Preventive maintenance
11	Vertical	2	2	1	2	A	Very Good	Preventive maintenance
12	Vertical	1	2	1	2	A	Very Good	Preventive maintenance
13	Vertical	2	3	2	6	B	Good	Condition Based Maintenance
14	Vertical	1	2	2	4	A	Very Good	Preventive maintenance
15	Vertical	1	2	2	4	A	Very Good	Preventive maintenance
16	Vertical	2	2	2	4	A	Very Good	Preventive maintenance
17	Diagonal	3	3	2	6	B	Good	Condition Based Maintenance

18	Diagonal	3	3	2	6	B	Good	Condition Based Maintenance
19	Vertical	2	2	3	6	B	Good	Condition Based Maintenance

Table 5 showed the condition analysis of the cracking wall. The score given in the building condition is based on Table 1 while the maintenance action's score is based on Table 2. Both scores are given through the description in Tables 1 and Table 2. To obtain the score of matrix analysis, building condition is timed by maintenance action. From Table 5, it can see that the wall at SJK Chung Hua Kranji is well maintained. The building ratings of the wall cracking are at Grade A and Grade B which mean very good and good. The score of matrix analysis between 1 to 5 rating Grade A, the action required is preventive maintenance. While the score of matrix analysis between 6 to 10 rating Grade B, the action required is condition-based maintenance. So far, there are no big repairs to the cracking walls.

3.2 Discussions

From Table 5, the cracking wall in Figure 4 has the highest score of matrix analysis which is 9. It is because the building condition's score of the cracking in Figure 3 is 3 and the maintenance action's score is also 3. From the view of building condition, there is a major cracking with the simple condition. Although the cracking wall is still stable, it needs to be monitored. However, maintenance action is required that it needs for major repairs and replacement. After the combination of both building condition and maintenance action, the physical condition is good, and the action required is condition-based maintenance. Although the rating of the cracking wall in Figure 4 is in grade good it exists of danger. So, the cracking in Figure 4 needs to monitor closely to avoid accidents happening as mentioned in The Star News, some 170 residents of block 4 at Taman Jaya, Skudai, are living in fear as the building they occupy may collapse anytime due to severe cracks on the walls and floors.

Figure 4: Combination of Vertical Crack and Diagonal Crack

The second-highest score of matrix analysis is 6. The rating is B which means Grade good. Figures 3, 8, 13, 17, 18, and 19 are scored in 6 which are good grades. These cracking areas need to be monitored even though they do not bring harm to the users in SJK Chung Hua Kranji in a short time. Otherwise, maintenance is needed based on the condition. The cracking is formed due to the school is near to the stone quarry and they always have rock blasting activities. So, it will affect a little bit of vibration at the school. The consequences are almost the same as earthquake conditions. According to [9], if there have any earthquake movement, generally it depends on how the structure moves.


Figure 3

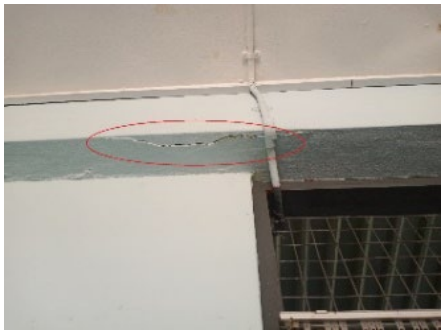
Figure 8


Figure 13


Figure 17


Figure 18


Figure 19

The second-lowest of the matrix analysis's score is 4. The cracking walls which are rated in 4 are Figures 5, 6, 7, 14, 15, and 16. These cracks do not bring any harm to the building so the building rating for these four cracking areas is in very good condition. Action required for this cracking is monitoring closely this cracking and preventive maintenance. To carry out preventive maintenance works, a template is used indicating the production area and the line of the equipment for intervention. This template allows indicating the sequencing of the tasks, the tools needed, the expected time and some images to help the technician. [10]

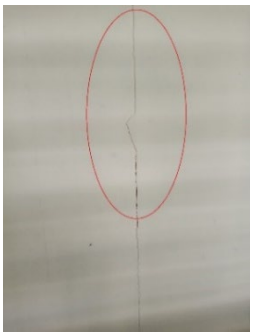
Figure 5


Figure 6


Figure 7


Figure 14

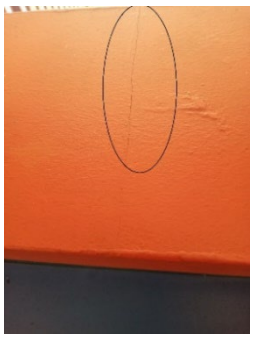
Figure 15


Figure 15

The lowest value of the matrix analysis's score is 2. The cracking walls which are rated in 2 are Figures 9, 10, 11, and 12. Four of these cracking is hairline crack. Normally hairline crack can be maintained with apply a layer of paint on it. These cracks do not bring any harm to the building so the building rating for these four cracking areas is in very good condition. Action required for these cracking is monitoring them and maintaining them.

Figure 9

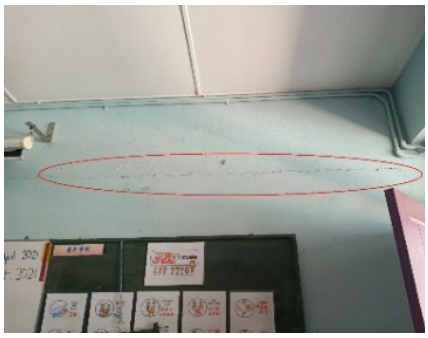

Figure 10

Figure 11

Figure 12

4. Conclusion

According to the visualization performed by using the current Building Condition Assessment, it is possible to conclude that the standard Building Condition Assessment may be used to evaluate the building structures. So, data on the cracking wall at SJK Chung Hua Kranji was collected and evaluated using the Building Condition Assessment standard. Furthermore, SJK Chung Hua Kranji received an overall rating of 2, 4, and 6 which indicates that the cracking should be monitored, and maintained based on condition, however, inspections will be conducted first before any maintenance work begins. This is to ensure that the building's maintenance will properly cure the issue and prevent it from causing further failure to the building's structures. Finally, the objectives of the research are achieved.

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References

[1] U. Tunku, & A. Rahman, INVESTIGATION OF DEFECTS IN NEW BUILDINGS IN MALAYSIA HONG CHIN HANG A project report submitted in partial fulfillment of requirement for the award of the degree of Bachelor of Science (Hons) Construction Management Faculty of Engineering and Green Technology (2016)

[2] *Home Inspector Offers Tips For Spotting Earthquake Damage*. (n.d.). Retrieved January 26, 2022, from https://www.news9.com/story/5e35a53683eff40362be5c29/home-inspector-offers-tips-for-spotting-earthquake-damage

[3] How Do You Define Structural and Non-structural Cracks at Home? — Ram Jack OKC. (n.d.). Retrieved December 28, 2021, from https://www.ramjackokc.com/articles/how-do-you-define structural-and-non-structural-cracks-at-home

[4] D. Raleigh (2021, June 17). "You'd be listening to cracking sounds, wondering if the walls are going to fall": Couple call for wider pyrite redress. Obreakingnews.Ie. https://www.breakingnews.ie/ireland/youd-be-listening-to-cracking-sounds-wondering-if-the-walls-are-going-to-fall-couple-call-for-wider-pyrite-redress-1143074.html

[5] D. Keim, G. Andrienko, J.-D. Fekete, C. Görg, J. Kohlhammer, G. Melançon, & Vi-, al. (n.d.). Visual Analytics: Definition, Process and Challenges Visual Analytics: Definition, Process, and Challenges. Retrieved June 21, 2021, from https://hal-lirmm.ccsd.cnrs.fr/lirmm-00272779

[6] IPM Professional Services. (n.d.). Building Condition Assessment | Building Inspection & Visual Inspection. Retrieved December 27, 2021, from https://ipm.my/building-inspection/building-condition-assessment/

[7] N. N. O. Bakri, & M. A. O. Mydin, General Building Defects: Causes, Symptoms and Remedial Work. *European Journal of Technology and Design*, *3*(1), 4–17. https://doi.org/10.13187/ejtd.2014.3.4 (2014)

[8] S. Yacob, A. Shah Ali, & A.-Y. Cheong Peng, (n.d.). Building Condition Assessment: Lesson Learnt from Pilot Projects. https://doi.org/10.1051/00072

[9] Home Inspector Offers Tips For Spotting Earthquake Damage. (n.d.). Retrieved January 26, 2022, from https://www.news9.com/story/5e35a53683eff40362be5c29/home-inspector-offers-tips-for-spotting-earthquake-damage

[10] A. Bruno, Isabel. S. Carvalho, Lopes, Preventive Maintenance Development: A Case Study in a Furniture Company. Retrieved from http://www.iaeng.org/publication/WCE2015/WCE2015_pp978-983.pdf (2015)