FLOOD DAMAGE INSPECTION METHOD FOR PUBLIC BUILDINGS IN MALAYSIA

Norain Binti Osman*
MEE20722

Supervisors: 1. Prof. OHARA Miho**
2. Prof. TAKEUCHI Kuniyoshi***
3. Prof. TAKEDA Fumio****

ABSTRACT

Floods cause more damage than other disasters in Malaysia. Currently, there is no suitable method for determining the damage caused by floods alone. Malaysian Public Works Department, the principal technical agency of the government has developed a method on how to manage the assets and determining the condition of the building with a matrix system called Building Condition Assessment (BCA). In this study, the suitability of the BCA method as a tool in flood damage inspection was evaluated. The results showed the BCA method was reliable and that the processes were standardized and systematic. The BCA method could be used to group the damages by cause and analyze the findings using qualitative and quantitative analyses for each space and area. In addition, the BCA method can be used to compile an urgent budget to rectify damages due to disasters.

Keywords: Flood Damage Inspection, Building Condition Assessment (BCA), Public Building, Flood Disaster Risk Reduction.

INTRODUCTION

There are few studies on how flood damage in public buildings is inspected in Malaysia. In addition, the data required for flood damage assessment are limited. Yusop et al. (2018) stated that flood damages assessment is based on two general approaches: 1) the use of an existing database, created by conducting interview survey or secondary sources such as local authorities, newspapers, and the internet, 2) a modeling approach that relates the flood damages to other factors such as economic variables and the nature of the damage. To meet the needs in terms of managing Malaysian government assets, a method called Building Condition Assessment (BCA) was developed by the Public Works Department (PWD) in 2013 with the aim of identifying deficiencies in buildings, and planning and budgeting for maintenance or recovery plans such as repairs, renovations, and refurbishment. BCA also aims to measure, make improvements and monitor the maintenance recovery conditions, including a review of disaster recovery plans such as flood lines, refurbishment works, etc. It is also used to determine the potential risk of a building and its systems.

Although the BCA method was established in 2013 and 2014 for pilot inspections done to assess the damage caused by a flood event, no study has been conducted to assess this method as a tool for flood damage inspection in Malaysia and the suitability of this method for flood damage assessment has never been reviewed. Therefore, the purpose of this research was to conduct a review of the BCA practice in public buildings in Malaysia, with the following objectives; -

1. To review the current method of BCA using actual inspection results,
2. To analyze the results of BCA of inundated buildings using the qualitative and quantitative approaches of analysis, and
3. To improve government service delivery towards effective decision-making for building maintenance and risk resilience.

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* Senior Civil Engineer, Malaysian Public Works Department (PWD)
** Professor, International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute (PWRI), Japan
***Advisor of International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute (PWRI), Japan
**** Professor, National Graduate Institute of Policy Study (GRIPS), Tokyo, Japan

Building Condition Assessment (BCA)

Without BCA, a building's condition and sustainability against disaster, and the actions required to keep the building and its system in good repair are in question. Condition assessment relies on the qualification and quantification of defects at the building and its system components. In many countries, the conditions of buildings and their systems are assessed and inspected based on the diagnosis of the extent of deterioration in the elements of the buildings (Pedro et. al,2008).

Until this research was conducted, there was no study on the use of the BCA method as a tool for a flood damage inspection. A study on BCA on a school building in Sabah, Malaysia related the BCA method with structural analysis (Syahirah Mohd Noor et al., 2020), and another on the BCA Imperative and Process by Nurul Wahida R et al. (2012) was conducted in the context of facility management. To perform BCA, a person with multilevel skills and technical discipline is appointed as the assessor. The components inspected vary from an architectural, civil, mechanical, or electrical component, to the infrastructure within the building complex. Using the Guideline for Building Condition Inspection of Existing Buildings (PWD, 2013), the assessor performs the inspection by identifying and listing the conditions for each of the components. During the inspection process shown in Figure 1, the assessor uses a checklist or floor plan that comprises component locations as a reference. The assessor then identifies the scale of the physical condition of the component using Table 1. The priority action for maintenance of the component identified using Table 2.

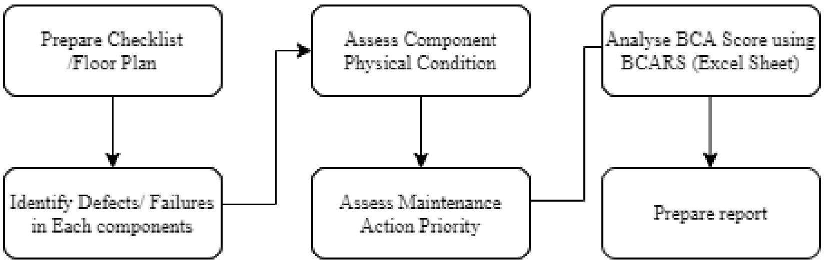

Figure 1. Overall BCA Process

Table 1 – Component Physical Condition

Grade	Assessment Scale	Description
1	**Very Good**	As New, No Defect, Performing as intended
2	**Good**	Minor defect, Good condition, performing as intended
3	**Fair**	Major defect, moderate condition, still can functioning as agreed service level
4	**Poor**	Major Defect, critical, not functioning as agreed service level
5	**Very Poor**	Major defect, very critical, not functioning, risky to safety and health

Table 2. Maintenance Priority Action

Scale	Priority	Description
1	**Normal**	No defect/damages, component well maintained
2	**Routine**	Minor defects/damages, Needs for monitoring, minor repairs/replacement to prevent serious
3	**Repairs**	Major defects/damages, Needs major repairs/replacement
4	**Rehabilitation**	Critical/Serious defects/damages, Needs for urgent and immediate repairs
5	**Replacement**	Very Critical/serious defects/damages, Needs for urgent replacement or action, Needs for expert detail inspection/judgement

Table 3. Matrix Analysis System

Scale		**Maintenance Priority Action**				
		Replacement	**Recovery**	**Repair**	**Routine**	**Normal**
Building Physical Condition	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. Overall Building Rating

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	**Critical**	**Rehabilitation /Recovery**	**16 to 20**
E	**Very Critical**	**Replacement**	**21 to 25**

Table 5. BCA Rating System in Excel Sheet

BIL.	SPACE	ELEMENT/COMPONENT	FIINDINGS	BARIS				
				Condition Assessment [a]	Maintenance Action [b]	Matrix Analysis [c] = (a x b)	Conditions No.	Conditions Code
4 STOREY BLOCKS								
1	ER A1	Switch 1	Damaged by Flood	5	5	25	001	0
151	Toilet A2	Lights 1	In good condition, but in a need of	4	5	20	0	0
152	Toilet A2	Lights 2	In good condition, but in a need of	2	3	6	0	0
168	Office	Plug 2	In good condition, but in a need of	3	5	15	0	0
Total Marks [d] (∑ of c)						9380		
No.Of Findings [e]						478		
Total Score (d/e)						19.62		
Building Rating						CRITICAL		

The findings are transferred to the Building Condition Assessment Rating System (BCARS) in an Excel sheet as shown in Table 5. As mentioned by Yacob et al. (2016), the BCA that was implemented by the PWD is a five-point scale rating system matrix as shown in Table 3. The overall condition of the building after the assessment of the components is scored and rated as shown in Table 4.

METHODOLOGY

This research was executed with the BCA output obtained for the target buildings inundated by the Yellow Flood in the Kelantan River Basin in December 2014. Figure 2 shows the framework of the proposed method. The goal was to perform a qualitative and quantitative analysis of the BCA method. A sample of buildings was analyzed based on the actual and virtual BCA results. Actual BCA is based on the actual inundated depth of the buildings whereas, virtual BCA imposes four levels of hypothetical inundation depths which are 4.2, 3.0, 2.0, and 1.0 m. This scale with maximum and minimum depth was chosen because the average inundated depth for buildings in the area was identified to be 4.2 m (source: Drainage and Irrigation Department, [DID]) and 1.0m was chosen because this was the lowest height of the windows (source: PWD).

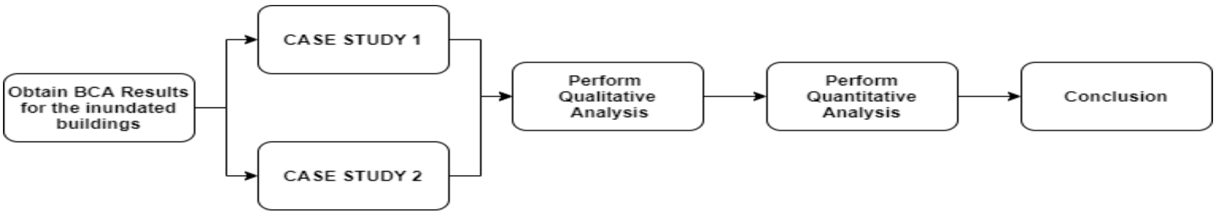

Figure 2. Method Framework

The sample buildings were located in the town of Kuala Krai, Kelantan. Two case studies were performed in this research, the first was to obtain the BCA results for four school blocks which comprised four multi-story buildings and the second were an additional six samples of BCA results with different building functions, floor levels, and different numbers of components. Figure 3 shows the locations of the Kelantan River and the sample buildings in the town of Kuala Krai, Kelantan.

Figure 3. Locations of Kelantan River Basin and Sample Buildings

RESULTS AND DISCUSSION

1) Qualitative Analysis

a) The BCA method was found to be a standardized and systematic process to assess the condition of components in buildings. The BCA findings indicated a variety of causes, not only due to the defects/damage caused by the disaster but also due to the aging factor, design failure, the use of building functions features as evacuation shelters, etc. The analysis results also comprised all the components conditions: - therefore, the report delivered to the building's owner will include actions unrelated to the disaster. Hence, such assessments should be done focusing only on components related to a disaster, such as damages and dirtiness due to the disaster, and/or the condition of components during the post-disaster period. For flood damage inspection, the BCA report should focus only on components rated E (Very Critical), D (Critical), and C (Fair) for further priority actions and urgent budget requirements.

b) The BCA method aims to identify and prioritize actions and budgets. With the color represented in the Budget Risk Matrix, building owners can plan and contest budget requirements using the BCA report. For any components that were identified in the BCA Score 21-25 (Rating E, Very Critical) the urgency of budget required is at the highest and becomes a priority to the building's owner.

c) The BCA method is considered as a whole building assessment approach. It is used to enable the ranking of all the components in any situation: - lead to action of proposing countermeasures and budgets.

2) Quantitative Analysis

a) Analysis of BCA Results with Causes of Defects.

The initial findings of BCA will consist of inundated depth, number of components, overall BCA scoring, and rating. Further analysis shows that the BCA findings can be grouped into a few types of defects. shown in Table 6.

Table 6. List of Target Buildings with BCA Score

Nos.	Building's Name	Inundation Depth (m)	Nos. Of Component	Overall BCA Score	BCA Score based on Causes			
					Damaged Due to Flood	Dirty by Flood	Dirty due to Usage by Evacuees	Daily Routine Maintenance
1	Sultan Yahya Petra 1 Elementary School (SYP1)	4.2	983	19.82	24.88	22.36	23.67	17.49
2	Kuala Krai Elementary School (KK)	3.0	983	16.62	24.80	23.99	10.15	14.80
3	Banggol Guchil Elementary School (BG)	0.3	983	9.84	0.00	11.40	0.00	9.83
4	Bandar Kuala Krai Elementary School (BKK)	0.3	983	6.54	0.00	0.00	0.00	6.53
5	District Police Headquarters (IPDKK)	5.2	432	15.64	24.46	24.63	0.00	10.40
6	Traffic District Police Office (TDPO)	5.2	160	25.00	25.00	25.00	0.00	0.00
7	Bandar Mosque (BM)	0.2	560	10.71	0.00	11.86	0.00	10.19
8	Department of Information District Office (DoSM)	0.2	151	5.36	0.00	0.00	0.00	5.36
9	PWD Workshop (PWDW)	4.6	342	20.98	24.56	18.17	0.00	11.17
10	PWD Quarters (PWDQ)	0.0	171	4.68	0.00	0.00	0.00	4.68

Two school buildings, Sultan Yahya Petra 1 (SYP1) and Kuala Krai (KK), were used as temporary evacuation shelters during the flood events; therefore, the results show the BCA scores for the causes of "dirty due to usage by evacuees". In each school block, approximately 983 components were identified. As all components in the building are assessed under any condition, the most severe components can be identified from the same BCA result.

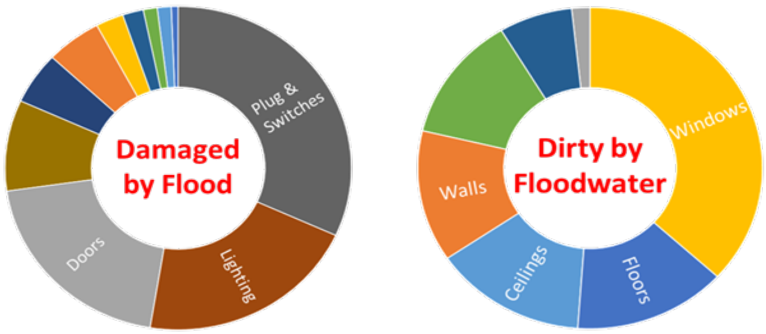

Figure 4. Components Most Severely Damaged by Flood/ Dirtied by Flood in Sultan Yahya Petra 1 (SYP1)

SYP1 was used as a sample to determine the components that were most severely damaged and dirtied by the flood. The components most severely damaged by the flood were doors, plugs, switches, and lighting. On the other hand, the components that were most severely dirtied by the floodwater were the ceilings, walls, windows, and floors. (See Figure 4).

b) Relationship between BCA Scoring and Inundated Depth.

An analysis of BCA results in Case Study 1 provided a relationship graph between the BCA Scoring and inundated depth as shown in Figure 5. When the actual and virtual inundation depths were put into the same graph, the results showed that the higher the depth of the inundation, the higher the BCA Scoring which represents the damage rate. The buildings used as evacuation shelters in actual occurrences such as SYP1 and KK also exhibited higher scores for virtual inundation. In addition, the BCA method could determine the current conditions, predict deterioration and forecast the buildings' future performance.

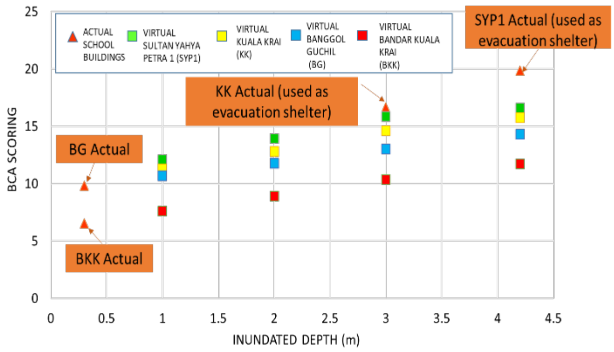

Figure 5. BCA Scoring with actual and virtual Inundated Depth

c) Relationship between the Cost of Repair for Inundated/Non-Inundated Floors of Buildings with Inundated Depth.

The cost of repair for the inundated and non-inundated floor was estimated using the number of components and floor area that was obtained from the BCA method. It is either calculated in a form of a bill of quantity or a lump sum amount and using the record of projects and the cost reference from the PWD Cost Guideline.

A graph of **Cost of Repair for Inundated/Non-Inundated Floors with Inundated Depth** was created from Case Study 1 (See Figure 6). The higher the depth of the inundation, the higher was the cost required for rectification works. This analysis also shows that the actual costs for SYP1 and KK were high due to the usage of buildings as temporary evacuation shelters. The BCA method allows the

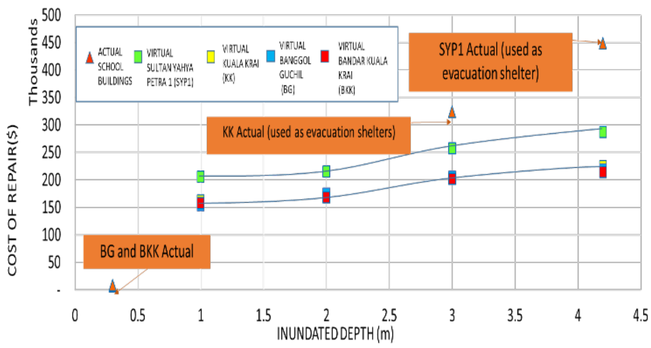

Figure 6. Cost of Repair for Inundated/Non-Inundated Floor with Inundated Depth

assessor to plan budget requirements for 5 years. This is another reason for the color in the five matrix system for the Overall Building Rating represented. **The Relationship between the Cost of Repair at Inundated Floor with Inundated Depth** also created with ten sample buildings. At certain inundated depth, the floor area and components quantities that were inundated will vary for each building. The bigger is the floor area, the more number components will be affected and the higher cost is needed for rectification works. A virtual inundated depth and all components conditions were imposed equally to the ten sample buildings. The graph shows that the buildings with two-story were having the highest cost of repair where else, buildings with one story were having a lower cost of repair.

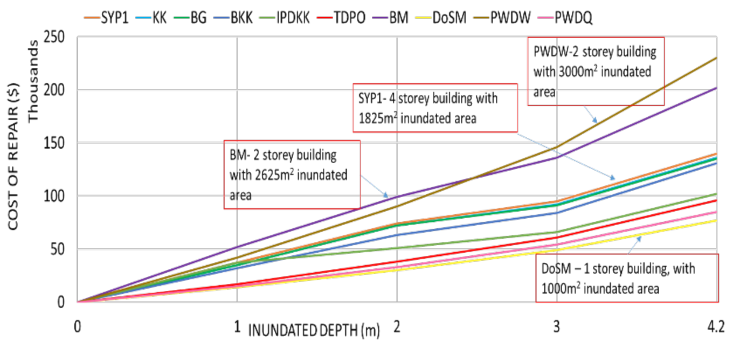

Figure 7. Cost of Repair for Inundated Floors with the Inundated Depth for 10 sample of buildings.

CONCLUSIONS AND RECOMMENDATION

The purpose of the BCA method helps manage assets and determine the condition of buildings based on a building score and rating, and proposal countermeasures and budget requirements via a standardized and systematic process. The results of this study indicate that the BCA method is reliable and suitable for use as a tool to inspect flood damage. The relationships derived from the graph with the cost of repair and the actual and virtual inundated depth will help the building's owner contest for budget and perform the rectification works for the safety of the building and its users. For this matter, the BCA method should be expanding to other flood events for further enhancement. It shall be put into the government policy to use the BCA method as a disaster tool for inspection. In addition, the BCA method should also be disseminated to non-government agencies or publish for sharing its processes and benefits. The analysis shows that, although the BCA method itself uses a risk matrix system, with some improvement, such in combination with other risk assessments such as flood analysis and applications such as ArcGIS, can provide a very good output to the building's owner. Such improvement will make the output more accentuated and significant. The BCA methods also benefit buildings' users if the countermeasure proposed by the BCA report is physically implemented. Users will not have problems such as repeated relocations or pending classes because of the cleaning and repair works after the post-disaster events.

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