

PAPER • OPEN ACCESS

A comparative of building condition assessment method used in Asia countries: A review

To cite this article: Muhd Zubair Tajol Anuar *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **513** 012029

View the [article online](#) for updates and enhancements.

Recent citations

- [Facade inspections with drones—theoretical analysis and exploratory tests](#)
Jorge Furtado Falorca and João Carlos Gonçalves Lanzinha



240th ECS Meeting ORLANDO, FL

Orange County Convention Center Oct 10-14, 2021

Abstract submission due: April 9

SUBMIT NOW

A comparative of building condition assessment method used in Asia countries: A review

Muhd Zubair Tajol Anuar¹, Noor Nabilah Sarbini^{1*}, Izni Syahrizal Ibrahim¹, Mohd Hanim Osman¹, Mohammad Ismail¹ and Ma Chau Khun¹

¹ Department of Structures & Materials, School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia.

*Corresponding author: noornabilah@utm.my

Abstract. This paper presents a comparative study of methods building condition assessment used in Asian countries. The following methods were compared: a Malaysia method to assess buildings condition, an Indian, Hong Kong and Singapore method about buildings condition assessment and the assessment methods. The comparative analysis included three tasks. First, every approach was described separately. Then, the main features of the methods were compared. Finally, some guidelines to improve or strengthen the Malaysia method were drawn. Main differences of the methods are the objectives and scope of the assessment, the assessment criteria, the type final results obtained and type of surveyor. The main similarities are that the assessment is carried out mainly by visual inspection method, the scope of inspection had to assess structural element and the tools developed for its implementation. Malaysia method should maintain the present assessment model, suggests a website to manage the entire assessment procedure such as document form related to assessment, checklist and guideline. Thus, the summary of this paper shall improvise Malaysia method from perspective defect process or factor, Non Destructive Test (NDT) test procedure and selection of the concrete repair material.

1. Introduction

Building Condition Assessment (BCA) is an effective tool for determining the physical state or condition of buildings. According to Yacob *et al* it is necessary to assess the condition of the building as it reflects the physical state and performance of the building from defects and failures. Defects and failure such as crack and corrosion is a problem faced in any building especially aging building [1]. Defects and failures of a building are often driven by inaccuracy in designing phase manufacturing imperfections damaged materials, unsuitability of materials used in constructions, contractors did not follow the final construction design, or any of these combinations. [2]. Not only that, climates construction site, materials used in constructions, purpose of a building altering its functions, building maintenance, faulty design, dishonesty, and unprofessional supervision also contribute to defects and failures [3]. However, in Malaysia, the main current maintenance management issue is low service quality [4]. The problem is due to failures in the planning of maintenance strategies or methods caused by a few factors, such as deficiency of awareness of maintenance strategies, insufficient performance standards, deficiency of building performance monitoring data, failure to provide adequate design



advice and performance - based planning and other [5]. As a result, the buildings cannot sustain any longer and are unsuitable for the use and function of the building.

Good management of building and infrastructure like planning, implementation and maintenance are critical element in sustainability in construction [6]. There are two types of maintenance activities; scheduled maintenance and condition-based maintenance. However according to N. Tirpude *et al*, both activities requires inspection to examine quality of a building before proceeding to the next step. Output and details from building inspection will later be used to make decisions about repair work [2].

Evaluating the condition of a building could be tough. It requires skills, proper tools and time. The evaluation/assessment of a building's condition should cover different structural components such as beam, column, slab and other. The method to conduct building condition assessment is visual inspection. The data on defects obtained at the on- site assessment is important for the maintenance decision [7].

The aim of this review paper is to differentiate methods assessing buildings' condition between Malaysia and other few Asian countries such as India, Hong Kong and Singapore. These countries are selected because nearest to Malaysia which have good in practising maintenance work. The comparison method made between Malaysia and few Asian countries because to differentiate it's and making some improvements on Malaysia method. The improvement that is content verifies the conditions of the building or supports decisions on rehabilitation, repair or maintenance.

Thus, this review paper present two major parts – the differences and similarities between methods; and suggestions that might reinforce Malaysian assessment method.

2. Building condition assessment guideline

2.1. Guideline of building condition inspection for existing building in Malaysia (PWD)

To implement the building inspection work, the building inspector needs general guide from the guideline. The guideline also creates consistency in the field of inspection and finally preparation of reports [1]. This guideline describes the methods and responsibilities of the Ministry / Department / Agency involved in conducting inspections for the purpose of rating existing buildings [8]. In 2013, the Public Works Department developed a standard assessment of the conditions of building components and services.[1]. The purpose state in Malaysia (PWD) method is to ensure the building inspectors perform inspection fits with the inspection prescribed guidelines.

2.2. Handbook on repair and rehabilitation of India, Nirman Bhawan (CPWD)

Deterioration of reinforced concrete (RC) by chloride, carbon dioxide, freeze-thaw, sulphate, acid attacks, and etc. is a natural phenomenon which could not control. This phenomenon was overlooked by practising engineers. Admittedly, since civil engineers in India still in the beginner phase especially in the safety, repairs, rehabilitation, strengthening and retrofitting of the existing RC structures, they need establishments and professional circulation as guidance [9].

Therefore, having the Central Public Works Department (CPWD) of India and other organisations Repairs & Rehabilitation on board, their experiences and expertise are shared in the handbook [9].

The book consists of deterioration factors, investigative strategies, design standards, determination criteria to repair materials and techniques, guidelines in selecting specialist, short-listing of contractors and preparation for contract agreements for repair/restoration contracts. The purpose of this method is to lead the organization practicing in the construction and maintenance of buildings that have been faced with the problem of deterioration in RC buildings [9].

2.3. Professional guide to building inspections in Hong Kong (HKIS)

This guide is issued not solely to implement the Mandatory Building Inspection Scheme (MBIS) but to surveying professionals to assist them to conduct building inspections. Then, also act as a general guide for inspecting pre-1980 residential and composite buildings in Hong Kong [10].

This guideline was published in 2013 by Building Surveying Division (BSD) of the Hong Kong Institute of Surveyors (HKIS). This guideline consists of forecasting and analysis – usually preparations and planning for inspection of a buildings and defect analysis method can be found in residential and composite buildings.

Distinctive construction methods and features are also available – regulations, practice codes, construction techniques, layout and materials commonly found in age buildings. [10]. The main aim of this procedure is to provide professional guidance on the survey of residential and composite buildings in Hong Kong prior to 1980, it can also be used as a reference for those preparing inspection reports under Building (Inspection and Repair).

2.4. Periodical structural inspection of existing buildings guidelines in Singapore (BCA)

The Building and Construction Authority (BCA) is a National Development Ministry agency that promotes the development of an excellent built environment for Singapore. “Community activities are provided with the setting of "Buildings environment" referring to buildings, structures, and infrastructure in our environment [11]. This guideline was published in 2012 by The Building and Construction Authority (BCA).

Periodic structural inspections of existing buildings were carried out in 1989 when the Building Control Act was promulgated. Part V of the Building Control Act and the Building Control Act stipulates the requirements for periodic structural inspections of existing buildings. There are two stages of inspection which are visual inspection and full structural investigation [6 , 7]. The purpose of this method is to guide structural engineer carry out scope of inspection that need to be assessed.

3. Comparative study of methods

There are four methods of building assessment which be analysed the main characteristics of the methods studied such as Malaysia (PWD), India (CPWD), Hong Kong (HKIS) and Singapore (BCA) standard. The primary features of the methods are summarised in Table 1. The following sections analyse the consequences of each comparison of features.

3.1. Objective of method

For countries as stated above have their objectives in defining the condition of a building to achieve the similar global inspection standards for existing buildings, respectively. Thus, providing rating and information relating to the defects assessed with verifying the condition of the building [1]. Other objectives are to ensure the practicality, safety, and comfort of the building [8].

There are four main objectives in Indian Method. The objective of a building structure's condition survey is to identify the causes and sources of distress. Then also determine the extent of distress caused by corrosion, fire, earthquake or any other reason. The other objectives are residual strength and rehabilitation of the structure, the priority of the distressed elements according to the significance of the repairs and finally selecting and planning an effective remedy [9].

The objectives of the Hong Kong method is to verify the status of the building and its work; conditions and performance of building components and installations. Formulate a close investigation or maintenance and management plan and examine and diagnose the building's symptoms and defects, if any, so that a close investigation or repair, rectification or demolition scheme can be established [10]. The Singapore method also aims to confirm that structural defects due to lack of maintenance are detected and corrected early in order to keep the buildings structurally work and function.[12].

3.2. Inspection method and scope

In order to assess the building, each country has their preferences and guidelines. The preferences and guidelines refer to the methods of assessment. Malaysia, Indian and Hong Kong methods state the assessment/inspection methods are as visual inspection with simple tools and instruments such as camera with flash, magnifying glass, binoculars and gauge for crack width measurement but Singapore method state only visual inspection.

The scope inspection of Malaysia method are split into a few elements such as architecture & civil, mechanical, electrical and external work. Architectural & Civil elements consisting of basic systems, structures, exterior parts, roofs, interior structures, staircases, ceilings, fixtures and even building structures. Mechanical elements consisting piping systems, air conditioning systems, distribution systems, fire prevention systems and elevators. Electrical elements consisting lighting, communication and security systems. External work components consisting roads, outdoor water reticulation, sewerage systems, retaining walls, sewage treatment plants, and landscape [8].

The scope inspection of Hong Kong method split into four element such as external, structural, fire safety and drainage system [10]. The scope inspection of Indian and Singapore only focus on structural element which are reinforced concrete, prestressed concrete, and steel [11,9]

3.3. Distress to be assess

The Malaysian method contains a list of defects or distresses, simply describing the possible cause of the defect. The defect in Malaysia's method is leakage, rust, skin, fungus, wet, bent, settlement, etc [8].

Singapore method has only a list of defects, including are cracks, excessive deflection, connection failure, instability, floor settlement, foundation settlement, tilt, spalling concrete, corrosion of steel, termite infestation, dry & wet rot timber, etc. [11].

The Hong Kong method contains a list of defects that are categorized according to elements such as external elements; (1) tiles and rendering loose or missing; (2) cracks; (3) bulging, bowing, separation and delamination; (4) corrosion of metal parts embedded in external finishes; and (5) spalling. Comment defect on structural element; (1) spalling; and (2) corrosion of reinforcement bars. Fire safety defects such as defective fire doors (broken doors or widened gaps), defective building components resistant to fire, missing exit signs, inadequate lighting and Blocked or obstructed means of escape. Corrosion, leakage, deformation, displacement, damage and blockage of drainage pipes and traps are the defects in the drainage system [10].

The Indian method has a chapter explaining the cause of deformation or distress and the initial concrete damage, which is divided into four categories, such as Construction Deficiency Physical. (High w/c Ratio, Inadequate curing, Poorly Graded Aggregates); Chemical (Chloride, Sulphate, and Reactive aggregates); Design deficiency (Wrong assessment of design Loads, shrinkage, thermal and structural behaviour); and Environmental physical (Heating/ Cooling and Abrasion of Surface). This method also has a crack type and its illustration pattern [9].

3.4. Assessment criteria

The Malaysia and India methods studied use different assessment criteria, except Hong Kong and Singapore method. This method assessment criteria used by Hong Kong and Singapore method is measured by the defects recorded but there is no classification of level defect or condition.

The method evaluation criteria used by the Malaysian method are measured by the registered defects and have a five - point colour - coded building rating. The aggregate score is then used to generate a numerical rating between 1 and 5, where 1 indicates optimal condition and 5 indicates critical conditions [1,8]. Thus, Indian method is measured by the defects recorded and have Classes of Damage and Repair Classification Repair The aggregate class is then used to produce a numerical rating from 0 to 4, where 0 no structure distress and 4 major structure loss [9].

3.5. Findings

The difference finding of these studies methods:

The Malaysian method provides a defect parameter for the building condition and maintenance priority action level in the form of matrix analysis for each component of the evaluated building. [1].

The rules of interpretation of the Indian method and divides the repair classification into five classes for each part of the building. This method also provide Non- Destructive Test (NDT) such as Insitu Concrete Strength (Rebound Hammer Test & Ultrasonic Pulse Velocity), Chemical Attack (Carbonation Test & Chloride Test), Corrosion Potential Assessment (Cover-Meter & Half Cell

Method), Fire Damage Assessment (Thermo-Gravimetric Analysis & Differential Thermal Analysis) and Structural Integrity/Soundness Assessment (Radiography & Impact Echo Test)[9].

Concrete Strength Assessment is the evaluation of concrete quality and it is necessary to estimate the quantitative value of concrete strength to assess a structural member's load carrying capacity. Chemical tests are concrete chemical analysis that can provide very useful information on the cause of concrete failure. Corrosion Potential Assessment is to evaluate the status of corrosion actively in the embedded steel. Fire damage assessment is an assessment of the qualitative and quantitative composition of a sample of concrete and determines the extent of the deterioration in fire - prone concrete. Structural Integrity/Soundness Assessment is an assessment to determine deterioration such as discontinuities, cracks, depth of cracks and detect hidden damage [9].

Beside NDT, India method also explain about selection of repair material for concrete such as use polymer modified cement to recover the damaged cover concrete because their better connection with substrate and reinforcement. Fusion bonded epoxy powder coatings (FBEC) and IPN coatings are used to protect bars against corrosion in concrete reinforcement structures. The system consists of a fibre reinforcement layer that is wrapped on the exterior surface of the retrofitted structural element [9].

The method Hong Kong provides reasons for defects in structural elements and external finishes. The preparation of any plan for rectification or repair work should be established on the results of thorough research and robust diagnoses. The defects in the structural elements are classified. into a four × three matrix [10].

Singapore method result based on visual inspection and judgment & recommendation of professional engineer appropriate actions to be taken based signs of significant structural deterioration. There are no calculation or present specific result of defect [11].

3.6. Implementation tools

The main implementation tools are:-

- Checklist : All four methods have a checklist to guide and record surveys;
- Instructions guideline: The instructions of Malaysia, Hong Kong and Singapore standard present a list of the most common defects for structure components. The guidelines for India include design or pattern of common defects for several structure element.
- Website: The Singapore method has a website (<https://www.bca.gov.sg>) which is to manage the whole assessment process.

Table 1. Summary of the main features of the assessment methods.

	Malaysia((PWD)	India (CPWD)	Hong Kong (HKIS)	Singapore (BCA)
<i>Objective of method</i>	Providing rating and information relating to the defects.	Identify causes and sources of distress	check the status of the building and conditions & performance of the building's	Ensure structural defects are detected due to lack of maintenance
<i>Inspection and method Scope</i>	Assessment methods are as visual inspection with scope; Architectural & Civil Mechanical, Electrical and External work	Assessment methods are as visual inspection with scope on structural element	Assessment methods are as visual inspection with scope external, structural, fire safety and drainage system	Assessment methods are as visual inspection with scope on structural element
<i>Distress assessed/section</i>	List of defects or distresses, simply describing the possible cause of the defect	Cause of deformation or distress and the initial concrete damage. List of crack type and its illustration pattern	List of defects that are categorized according to elements such as external, structural, Fire safety defects and defects in the drainage system	Only a list of defects
<i>Assessment criteria</i>	Defects recorded and have the five-point colour- coded building rating	Defects recorded and have Classes of Damage and Repair Classification Repair	Defects recorded but there is no classification of level defect or condition	Defects recorded but there is no classification of level defect or condition
<i>Implementation tools</i>	Checklist and Instructions guideline	Checklist and Instructions guideline	Checklist and Instructions guideline	Checklist ,Instructions guideline and Website
<i>Finding of method</i>	Building condition defect parameter and priority maintenance action level in the form of a matrix analysis	Subdivide the repair classification in five classes in general. This method also offers non - destructive testing (NDT) and the selection of the concrete repair material.	The causes of structural elements and external flaws and preparation of any plan for rectification or repair work should be established on the results of thorough research.	Visual inspection and judgment & recommendation of professional engineer appropriate actions

4. Conclusion

The main differences and similarities in the methods analysed indicates that the methods studied had different objectives and scopes. They also differ in respect of the section / defect assessed, the assessment criteria and the type of final results obtained. However, some similarities were found between the methods studied. From these four methods, the assessment is mostly carried out by visual inspection, the scope of inspection had to assess structural element and the tools established for its implementation. In addition, the recommendations that can be drawn to improve the Malaysia method (PWD) as follow;

- The inspection method are consistent, attributes assessed, attributes criteria and surveyor. The increase in the number of element would consume more time for the survey without significant purposes to the accuracy of the result.
- Suggested a website or blog to easily access and manage the entire assessment procedure such as document form related to assessment, checklist and guideline.
- Improvement on content of guideline such as NDT test procedure and illustrations of common defects for some structure component.
- Suggested a chapter in Malaysia standard would have a selection of the concrete repair material and explained deeply about process or factor of defect.

Acknowledgments

The authors are thankful to Universiti Teknologi Malaysia under grant No. (QJ130000.7751.4J343) for the completion of this work.

References

- [1] S. Yacob, A. S. Ali, and A. C. Peng 2016 “Building Condition Assessment : Lesson Learnt from Pilot Projects,”. **00072**, p.7.
- [2] C. A. Adi Irfan, M. T. Norngainy, J. Suhana, A. R. Mohd Zulhanif, and Y. Hafsah 2014 “Jurnal Teknologi Full paper Building Condition Assessment for New Houses : A Case Study in Terrace,” *J. Teknol.* **70**, (1), pp. 43–50
- [3] N. Ahzahar, N. A. Karim, S. H. Hassan, and J. Eman 2011 “A study of contribution factors to building failures and defects in construction industry,” *Procedia Eng.* **20** 249–255
- [4] S. Nizam Kamaruzzaman and E. Marinie Ahmad Zawawi 2010 “Development of facilities management in Malaysia,” *J. Facil. Manag.* **8** (1), 75–81
- [5] C. P. Au-yong, A. S. Ali, and F. Ahmad 2014 “Preventive Maintenance Characteristics towards Optimal Maintenance Performance : A Case Study of Office Buildings,” no. September, pp. 1–6
- [6] C. P. Au-Yong, A. S. Ali, and F. Ahmad 2014 “Significant Characteristics of Scheduled and Condition-Based Maintenance in Office Buildings,” *J. Perform. Constr. Facil.* **28** (2) 257–263
- [7] A. Straub, “Dutch standard for condition assessment of buildings 2009 ” *Struct. Surv.* **27** (1) 23–35
- [8] Public Work Department, “Guideline of Building Condition Inspection for Existing Building,” 2013.
- [9] CPWD, “Handbook on repair and rehabilitation of RCC buildings (CPWD),” *Cent. Public Work. Dep. (CPWD), Gov. India, New Delhi.*, p. 498, 2002.
- [10] C. Buildings and H. Kong, “Professional Guide to Building Inspections Professional Guide to Building Inspections,” 1, 1980.
- [11] BCA, “Periodic Structural Insection of Existing Buildings,” 1–14, 2012.
- [12] BCA, “of Existing Buildings Building Owner ’ S Guide,” 2012.