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## **Distinctive Structural and Non-Structural Building Defects and Failures in Educational Buildings**

*Although the maintenance-free building may be a theoretical possibility, all buildings are subject to the vagaries of defects, failures, deterioration and variation. The examples of these problems are fungus growth, peeling paint, termite attack, dampness, defective rainwater goods, roof defects, harmful growth, settlement, foundation failure, roof collapse and others. There are a great number of building defects and failures arose and being reported officially by mass media, especially problems with educational buildings. Theoretically, all buildings tend to deteriorate over period of time due to aging or other factors, regardless the types of buildings. There are several main factors can be taken into account such as design fault, poor maintenance, poor workmanship, building age and location of building. This paper will discuss on distinctive structural and non-structural building defects and failures than frequently happened in educational buildings. This paper is noteworthy to render varies of problems generally faced by Malaysian educational buildings to the public. As such, the awareness among them can be raised or improved. Furthermore, the public will concern, especially the government authorities should emphasize the laws and regulations to enforce the safety of construction work as well as the procedure in giving approval to the occupation of educational buildings.*

**Keywords:** *educational building, building defects, failures, common defects, maintenance, termite attack, settlement*

### **1. Introduction**

A building defect is defined as a failing or shortcoming in the function, performance, statutory or user requirement of a building [1]. In other words, it can be defined as a depreciation, reduction or failure in the functional performance of a building. Besides, building defect is the building flaw or design mistake that reduces the value of the building, and causes a dangerous condition. Some defects

are obvious while many are less obvious and do not become apparent until years after a building was constructed completely. Therefore, building defects can be divided into patent defects and latent defects. The terms patent and latent are opposites. In general, a patent defect is discoverable and obvious. On the contrary, a latent defect will exist before it is discovered as hidden or concealed flaws in the work. When a latent defect becomes obvious it ceases to be a latent defect and becomes patent [2]. Other than that, building defect is a violation of the applicable building code, a violation of the standard of care in the community in which the project is located, or a violation of the manufacturer's recommendations. Defect sets up inner psychological stress in the users themselves and, if the defect is not rectified immediately and with proper remedy action, this could lead to vandalism, arsons and death [3]

A defective building is no longer to perform the needed or required functional, aesthetic or economic values it is designed and constructed to provide. Defect affects the serviceability, performance, acceptance or appearance of the building or their combination [4]. Moreover, building defect can be a physical problem in the building whether in the fabric, structure or services, especially one that impairs correct function. It is also a deficit in performance occurring at any time in the life-cycle of the element or building in which it occurs.

Failure of the building or any building component to be erected in a reasonably workmanlike manner or to perform in the manner intended by the manufacturer or reasonable expected by the buyer, which proximately causes damage to the structure. Building defects are said to be contagious. This is because if they are not addressed immediately, they are not only getting worse but also destroying the adjoining components, elements and building parts [4]. Building defects could be divided into two categories, which are structural defects and non-structural defects.

#### **(i) Structural Defects**

Structural defects are defects which happen to the structure of the buildings, such as columns, beams, walls, roofs, floors and foundations. This type of defects happens due to building settlement, deformation, serious cracking and bowing of the buildings [4].

#### **(ii) Non-Structural Defects**

Non-structural defects are defects which happen to the non-structural elements of the buildings. For example, the façade, floor finishes, doors, windows and rainwater downpipes goods. The defects are mostly caused by chemicals and biological substances, significant temperature differences, condensation process and small cracks [4].

## **2. Typical Building Defects in Educational Buildings**

Severe building defects are that which cause a building in unsafe, insecure or even can bring real harm to its occupants. Research showed that many educational buildings have small cracks in concrete column, beams, structural walls, and floors but there is no major damage involved. This is because many educational buildings are more than 25 years old [5]. Building defects in educational can affect the educational society broadly due to possible danger posed. They may result in direct and indirect repair costs, abnormally high maintenance, disputes and possible loss of building use. There are 12 building defects which are usually found on educational buildings. The respective building defects are explained as below:

### **2.1 Erosion of Mortar Joints**

The primary function of mortar joint is to balance irregularities of individual blocks, whether they are of stone or bricks. It also provides some adhesion between the blocks. Defective mortar can be removed easily by the use of a mechanical disc or raked out by knife manually. Generally, erosion of mortar joints is caused by weathering action, salt crystallization, unaccommodated building movement and effect of the freeze/thaw cycle [6]. Figure 1 shows the problem of worn mortar joints between the bricks



**Figure 1.** Problem of worn mortar joints

## **2.2 Peeling Paint**

This defect can be easily found on building facades, usually on plastered walls, columns and other components which are exposed to excessive weather such as rain and dampness. Some buildings situated near to the sea may have greater risk to peeling paint [6] Peeling paint occurs due to poor preparation of the previous surface, for example, dust and grease were not cleaned thoroughly. Efflorescence can occur under the paint film if it is applied before the background has dried out. Sometimes, dampness of walls can result in peeling paint too.

## **2.3 Defective Plastered Rendering**

Defective plastered rendering usually can be found on external walls, columns and ceiling. Prior to being decayed and broken apart, plastered rendering may become cracked because of either shrinkage or movement in the substrate. In a hot and humid country, like Malaysia, the defects of rendering are caused by biological attacks such as penetration of rain, evaporation, condensation, thermal stress and dehydration. Other factors may include mould or harmful growth, insects, animals and traffic vibration [6].

## **2.4 Cracking of Walls**

There are two types of cracks in wall, which are vertical or diagonal. When a crack occurs in wall, there will be a symptom of structural instability. Therefore, this defect should be investigated and diagnosed properly. The cracking of wall happens normally due to settlement of foundation, deterioration and shrinkage of concrete or mortar [7].

## **2.5 Roof Defects**

Roof is an important part of buildings that can provides weather shield and protection to building users and occupants from external weather such as rain, wind and sun [1]. Roof defects include roof leakage, blocked rainwater downpipes, missing roof tiles and sagging. The accumulation of leaves and debris leads to the problems of blocked rainwater downpipes and leaking gutters. Meanwhile, sagging and deformation occur as a result of overloading, dry rot or fungal attack. Poor maintenance is also another factor leading to roof defects.

## **2.6 Dampness**

Dampness is generally defined as unwanted water or moisture and it can be a serious matter if do not solve it properly. This defect not only deteriorates the

building structures but also damages the finishing and furnishing. It can also affect the health of the occupants as well as create an ideal condition for termite attack and beetle infestation. Dampness can be divided into rising damp, penetrating damp, and condensation and entrapped moisture. Penetration of water through walls exposed to prevailing wet wind or rain can cause dampness. With the presence of gravity, water may penetrate through capillaries or cracks between mortar joints, bricks and blocks. Moreover, dampness occurs due to other factors such as leaking gutter and downpipes and defective drains. Besides, dampness may penetrate from the ground through cracks or mortar joints in the foundation walls. Figure 2 shows an example of dampness problem which occurred on wall



**Figure 2.** Dampness on wall section

### **2.7 Termite Attacks**

Termite attacks normally occur in a damp and digestible timber at which the structure is composed of timber materials such as wall plates, rafters, beams and battens. It is dangerous when the timber becomes softer and forms further cracks [6]. The use of wood in building structure can lead to termite attack. Moreover, wood is the choicest food for termites to build sheds or decks in the backyard. Another important element in termite infestation is the moisture content because moisture is very attractive for the termite infestation. Figure 3 shows a serious termite attack on door frames.



**Figure 3.** Serious termite attacks ondoor frames

### **2.8 Corrosion of Reinforced Steel**

When steel reinforcement corrodes, the formation of rust causes a loss of bond between the steel and the concrete and subsequently delamination and spalling. Steel in concrete is normally in a non-corroding, passive condition. Corrosion of reinforced steel happens due to the presence of de-icing salt. When chloride moves into the concrete, it interrupts the passive layer which protects the steel, causing it to rust and pit. Besides, steel corrosion is also caused by carbonation of concrete.

### **2.9 Defective Tiles**

Sometimes, the floors and walls are finished with tiles to enhance its aesthetic value. The types of tiles include ceramic tiles, homogeneous tiles, glazed tiles and rectified tiles. Most of the problems found on tiles are cracks, lippage, bumps, depressions, pin-holes, dirt and colour and texture defects. Tiles can be cracked by impact damage where heavy items dropped on the tiles will crack or break them. Lippage in floor tiling often causes discomfort to users and may result in injury, especially on sharp edged tiles. It further affects the visual appearance of the floor and in wet areas because it can impede water flow and build up stagnant water.

### **2.10 Discoloration**

Surface discoloration of paintwork is the non-uniformity of colour or hue on the surface of a single concrete placement. Some discoloration is noticeably brown,

pink, purple or black. This problem is usually permanent or temporary where dampness or moisture is present. Paint deteriorates by first soiling or by a slight build-up of dirt under normal conditions. Then, a flattening stage develops when the coating slowly starts to chalk and erode away. Discoloration of paintwork is caused by mildew, blue stain, wood extractives and metal ions [9]. Discoloration in protected areas becomes darker and more difficult to remove with time. Furthermore, serious discoloration will lead to degradation of building materials, such as structural damage or appearance damage. The colour changes are principally caused by chemical reaction or mould growth which creates the characteristics of pink, purple, brown and blackish discoloration.

### **2.11 Mould Growth**

Mould growth usually happens when there is excessive moisture accumulates in the buildings or on the building materials, especially if the moisture problem remains undiscovered or unaddressed. The presence of mould growth can be an unpleasant sight. Besides, the appearance of mould growth indicates that the building or room is not being adequately ventilated. Water leakage through roofs, defective plumbing installations and condensation are the common causes of mould growth.

### **2.12 Timber Decay**

Timber decay is caused by a biological attack within the wood by certain species of fungi. Basically, timber decay can occur under certain conditions, which are oxygen, moisture and nutrients. Moisture is the most critical components in the process of timber decay. If moisture is not present in the timber, then the fungi will remain dormant, even when oxygen and the nutrients are abundant. There are three main types of timber decay, which are wet rot, dry rot and wood boring beetles.

## **3. Typical Building Failures in Educational Buildings**

Building failure is also known as building collapse or structural failure. In literature, failure can be defined as the inability of a constructed facility or its components to perform as specified in the design and construction requirement [10]. Building failure occurs when any system or building component does not perform its function as intended. Furthermore, building failures can be categorized into 2 groups of physical and structural failures and performance failures. Structural failure corresponds to the exceedance of ultimate or critical limit state in many of the load-carrying elements, which compromise the structural stability of the building. Practically, this type of failure corresponds to extensive damage, partial or total collapse of the building, resulting in repair costs is higher than replacement costs.

of the building. Meanwhile, performance failure can be induced by the failure of structural elements and non-structural elements.

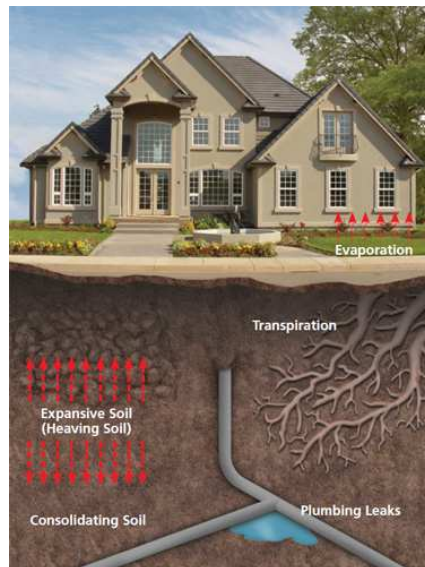
Buildings are designed as structural systems, and consequently, when a major component of the building fails, it can trigger a series of failures [10]. Examination of building failures is necessary just after the implementation of new design procedures and changes in construction detail. When the failure of a structure occurs, builders and designers are responsible to analyze the destruction and determine if and where there were weakness in overall building design

Failure refers to two conditions, which are collapse and distress. A building collapses when the whole structure or components comes down because the structure has losing its ability to perform its required function. Distress is the un-serviceability of a structure or its component that may or may not result in a collapse [11]

Sometimes, an assessment known as 'forensic engineering', is required to identify what happens before and during failure, and make necessary predictions to inform the design and construction of new buildings or the nature and extent of interventions to existing buildings [11]

### 3.1 Foundation Failure

Foundation is one of the major structural members of any building. Foundation failure will surely affect the whole building [10] Cracks found on walls and floors, doors and windows cannot open and fascia board pulls away; these all are signs of foundation failure. Figure 4 shows causes of foundation failure



**Figure 4.** Causes of foundation failure in building



The possible causes of foundation failure are soil erosion caused by flowing water, changes in ground water level, evaporation, transpiration, movement due to shrinkage or swelling of clay soils, uneven bearing capacities of differing subsoils, poor soil conditions and poor building site preparation.

### **3.2 Roof Collapse**

The roof collapsed when the roof structure loses its strength from advanced corrosion and deterioration of the roof joists. This failure occurs principally due to overloading, construction faulty, improper installation of components, wrong building materials, poor maintenance and inadequate design.

### **3.3 Structural Failure**

The factors of structural failure range from design and construction problems to material defects, overloads, natural and man-made disasters or others. Moreover, this failure can result from unskilled workers, design faults, inadequate maintenance, unprofessional conduct and unstable foundation.

### **4.0 Conclusion**

All buildings are subject to the vagaries of defects, failures, deterioration and variation, as well as educational buildings. The literature has explored a number of contribution factors which can be related to the main theme of this research. It is important to evaluate every defect and failure in every part of educational building and find out the primary causes of each individual defect and failure. Then, remedy them appropriately. The contribution factors to these defects and failures must be investigated deeply. Once founding out the possible causes of the defects and failures, it is important to distinguish how to avoid it in the future and reduce the effect to the minimum.

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