Building Component Defects Due to Land Settlement: A Case Study of Miri Industrial Training Institute

Rosnah Muhamad Tahir

Miri Industrial Training Institute (ILP Miri),
Bandar Baru Permyjaya, 98000 Miri, Sarawak, Malaysia.

Abstract: Building maintenance is very essential in order to prolong the building life cycle, to reduce owner lost and down time for rectification works. Hence, a case studies on the defective of building of Miri Industrial Training Institute (ILP Miri) due to land settlement. This study was carried to identify what are the most building components have been damaged and the level of damages due to land settlement. This research used primary data and data of site inspection approach. The result of this study found that almost all major defects appeared at the buildings located in the active zone of land settlement such as the building of an administration, resources centre, 2 halls and 4 blocks of training workshops but less building defects at the accommodation area. The result also shows that defective of non-structural elements are highly frequency such as cracking on brickwork and cement plaster, breaking on ceiling finishes, peeling and fungus on painted surface, defective of wall and floor tiles, damages of doors, cracking and sagging of concrete drain and concrete apron all-around of building etc. There were a few damages of building services such as electrical wiring and fittings, firefighting system, sanitation system, cold water supply system, telecommunication system, air conditioning ducting system because the consequence of defective of ceiling finishes, cracking on brickwork and cement plaster.

Keywords: Building component defect, land settlement and rectification works

1. Introduction

Building defects and failures due lacked of design and specification, poor labour workmanship, low quality of materials used; lacked of supervision level and environmental disaster are common phenomena often occurred in Malaysia and it caused accidents and owner lost. Building defect also is one of the major components of building problems that significantly needed attention. When a building fails to function, as it should, we must immediately seek for the determination stated in code of British Standard (BS 3811 1964) [1]. Hence, it is very important the government properties to be designed and constructed properly and the maintenance works to be managed effectively to prolong the lifecycle of the assets and to ensure the building to be occupied safely and comfortable to occupants. Building defect occurs to either the new building or the old one. Defect within new buildings is maybe of non-compliance with Building Code and published acceptable tolerances and standards. Meanwhile the older buildings, or building out of warranty period, may not comply with these standards but must be judged against the standard at the time of construction or refurbishment (David Hall) [2]. To avoid the delay and promote the recovery activities of building damages, Tanaka, S. [3] proposed a self-damage inspection system for non-expert in this study. With this system, the owners could inspect the damage appeared both outside and inside the building by themselves, and could get the same result as the local government inspector does. In the Kashiwazaki secondary inspection, a self-inspection sheet introduced to promote the understanding of the defects inspection method and held the inspection activity through self-inspection.

2. Problem Statement and Objectives

2.1 Problem Statement

The ILP Miri has been operated since 2006 and it was built on land 60 acres that originally a clay peat soil property. According to the maintenance’s records, it seems that since 2008 the rectification works process done because of land settlement. The problem occurred might be due to the unstable soil condition and it damaged a few existing building components. There were many rectification works have been done since 2008 until 2016 and there were also a lot of users’ complaints about the building component damages. Poor appearance of building condition that would be affected the reputation of ILP Miri as government agency. This problem become major when building component damages become critical, and high risk to the occupants’ safety even though...
there were a few damages have been rectified. The latest result of land settlement points form the qualified Geology Consultant, within July 2016 until June 2017 at 5 main points, it shows that the land settlement process is still active but very mild progress at the average range 0.75mm/6 months or about 1.5cm depth/year. They estimated that land settlement in the ILP Miri area will be increased approximately at 15cm depth (6 inches) by the year 2026 (10 years later) and more building component damages will be occurred and more money to be allocated for the remedies work.

2.2 Objectives

The main objectives of this research as stated bellows:

a. To identify what type of the building components defects occurred in ILP Miri due to land settlement problem;
b. To identify which group of the building components defect/damaged got highly frequency and highly percentages due to land settlement problem;
c. To identify the degree of building defects (major/medium/minor) and the level of damaged value of each building component and also percentages scored by the damaged component (according to the closed assumption or prediction of safety risks level and cost of repairs); and
d. Which building blocks of ILP Miri are considered got extra risks of building components’ defect due to land settlement (highly safety risk level and costly for rectification work).

3. Literature Review

The building defects may include damage caused by land movement or earth settlement claimed by Nurul & Azree; Tanaka S and S. Tanaka , K. Shigekawa & M. Takashima and they mentioned that this problem may cause the defective of non-structural and structural of building [3,5-6]. According to the Engineering Encyclopedia, non-structural defect includes defect in brickwork, dampness in old structures, and defects in plaster works. Tan Wei Cheun [7] noted that there are several building defects, what usually occurred to the building parts such as roofs, walls, floors, ceiling, toilets, doors and windows. While, (Johnson, Roger W.;) mentioned that brick wall cracking is a common building defect and it may be the first sign of a serious defect that may affect the serviceability or the stability of the building and correctly assessing the significance of cracks is very essential [8]. Studies done by Nurul & Azree [5], Rosnah MT [9] and Kasim N.D [4] found that building defect are regularly consists of wall cracks, peeling paint, dampness, timber decay, fungi and small plant attack, sagging or deformation, erosion of mortar joint, defective plaster rendering, damages of building finishes, insect or termite attack, roof defect, and also unstable foundation, and building services installation. According to the Engineering Encyclopedia, structural defect that can be categorized as cracks in foundations (Substructure), cracks in floor or slabs (superstructure), and cracks in walls (superstructure). These building defects because of improper soil analysis done, inappropriate the site selection, and the use of defective materials stated by David Hall [2]. Most of the structural defects problem could be avoided by implying the proper specification and in detail design and planning.

Structural defects in a building can occur over time due to deterioration, wear and tear, overloading, and poor maintenance (Kasim N.D) [4]. The rectification of minor defects should be done in order to maintain the building’s structure condition and to prevent any further major failures for future [4]. According to Richardson, B.A. [10]; he said that regular inspection is the key to protecting the ‘health’ of a building’s structure. Structural defect that always occurred are steel corrosion, cracks, and deflection. The contribution factors to these defects and failures must be investigated intensely and once found out the possible causes of the defects and failures; remedial work must be carried out to reduce the effect of critical and major problem occurs for the future Yuseni & Samad [11]; S. Tanaka, K. Shigekawa & M. Takashima [12] and S. Tanaka, K. Shigekawa & M. Takashima [3]. The implications of an incorrect assessment the building defects can lead to expensive cost and unnecessary rectification work to be executed.

4. Methodology and Analysis

In general, this research scope focused on the building component defects of eight (8) building blocks located at the area of land settlement active zone. To meet the objectives of this research, the researcher approached the self-assessment of visual site inspection. The site investigation process focused on the architecture building’s component defects including the building services fittings and installation of the related buildings which consists of an administration block, resources centre, multipurpose hall, lecture halls, cafeteria, and 4 blocks of training workshop. Before site inspection was started, the researcher must understand the whole processes of site inspection of the study proposed by Marziah K & Md Azree O.M [8], Tanaka S. [9] and Basari ASH [13]. The preliminary observations have been carried out after the researcher understood the whole process of site inspection to be done, such as permission of premise’s owner, observation of safety wise, equipment to be used, support documents/drawing, glanced through the appearance of defects etc. The data of defect components have been collected manually using visual inspection approach and aided by video-cam and still camera. The related information about the defects have been recorded into the special form and compile together with related photos as important evidences of this research [14-16]. The collected data of the building components defects have been tabulated according to building blocks and be summarised based on the components of building defects. The analysis of the collected data has been carried out using frequency and percentages according to the strength of damages (3 levels of component defects) [16-19]. The degree of defect level (major/medium/minor) have been calculated using weightage that was formulated by the researcher based on selected criteria; such as level of safety and risk of the damages to the occupants, cost incurred for the rectification process, the risk level of defects that would be affected to others building components (Table below). The graphs have been plotted according to the objectives and analysis process that was carried out by the researcher. The whole process of this research methodology has been illustrated in the Diagram 1 as below.
Diagram 1: The Methodology Framework of the research in order to investigate the damages of building components of ILP Miri due to land settlement (Source: Rosnah MT 2016).

The table below shows the proposed weightages of the strength of damages as follows:

<table>
<thead>
<tr>
<th>No</th>
<th>The Strength of Damages</th>
<th>The Damages Weightage</th>
<th>Code of Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Major (High Risk)</td>
<td>3</td>
<td>Red</td>
</tr>
<tr>
<td>ii</td>
<td>Medium (Medium Risk)</td>
<td>2</td>
<td>Blue</td>
</tr>
<tr>
<td>iii</td>
<td>Minor (Lowest Risk)</td>
<td>1</td>
<td>Green</td>
</tr>
</tbody>
</table>

5. Finding

This research found that there are a lot of building components damages due to settlement in the area of ILP Miri. Table 1, shows the pictures of building components defect due land settlement in ILP Miri.

Table 1: A few photo of ILP Miri building component damages

- A lot of brickwall cracked near door /window frame
- Brickwall cracked along the bottom part
- PC surface drain broken & land settled (holes)
- Wall fungus and ceiling finishes sagged
- Concrete lintel broken and ceiling finishes sagged
- Cement plaster of RC beam/column cracked
- Painted wall surface mossy/fungus.
- External wall paints peeled out and faded
- Concrete apron broken and land settle (holes)
- Floor level settled and gap between foyer and administration
- RC beam cement plaster cracked and peeled out
- Painted wall peeled out and got fungus problem
- Concrete apron floating because land settled and got holes/gaps
- Brickwall broken and painted wall got fungus/mossy
The researcher concludes that land settlement problem or soil movement was a root of building component damages and need to be rectified. Researcher observed visually and based on symptom for three years observation that the stability of clay peat soil condition might be very weak due to underground water level is too high and the surface drainage system was not properly design (ponding water at all perimeter of main trunk surface drain and no proper discharge flow for the monsoon drain). The researcher was informed by the local community that backfill compaction process during construction work was done in a short period (only 6 months) and supposed to be done at least 2 years and meaning that lacked of soil treatment before piling work started. The latest soil investigation report done by the qualified consultant (2015), reported that underground hard layer depth is 39 meter. While, the existing foundation design using piling penetration at 25 meters depth and many piling points applied for every foundation. The skin frictions have been used to distribute the building loads because of soft soil condition and to avoid slender piles because too long piling penetration. The graph 1.1 and pie graph 1.2 shows that brickwall and cement cracks and damages of concrete apron and precast concrete (pc) surface drain were highly frequencies. Meaning that safety risk level is considered very high and the rectification work also costly.

Graph 1.2: The pie chart shows the distribution of percentages (%) of building components were damage.

According to the results of analysis and the plotted Pie Graph 1.3, the damages considered at major damaged scored 42% and 55% for medium level of damages shown in the plotted pie chart Graph 1.3. The result of the analysis shows that, an administration block including resources centre and four training workshop blocks (Telecommunication and computer, Air Conditioning and Electrical, Welding & Oil and Gas Pipe Fitting) scored highest point of damaged components shown in Graph 1.4.

Graph 1.3: The Pie chart shows the distribution (percentages) of damaged level of building component according to three (3) level of damaged: Major, Medium and Minor damaged.
According to the bar graph 1.5, the points of damages scored by the group of building component are brick wall and cement cracks and also the damages of concrete apron all around and p.c surface drain were also highly frequency.

The finding of the research shown that the damage of fire alarm system including the related wiring system was the highest percentages (56%) and highly cost incurred for rectification work and it was a among the group of Mechanical dan electrical work of maintenance (Graph 6).

6. Discussion

6.1 Signs of Land Settlement

According to the results of this case study on the damages of building components of ILP Miri due to land settlement through visual assessment and site inspection, we found that the building components average damages level are at moderate levels. This problem happened most probably because of the land settlement problem or seasonal movement and also because of soil properties consist of clay peat soil without proper soil treatment before they started the construction works. The soil movement downward occurred because of load impact or the nature of soil properties with highly moisture contents. Wall cracks are common sign of land settlement that usually happened at many places when the building components are damage. Another building component damages commonly happened such as ceiling, wall and floor finishes such as ceramic tiles, hairlines cracks appeared at many cement plaster walls surface whether externally and internally. More serious cases, when the sinking or sagging and broken of the precast concrete drainage system and concrete apron appeared and that were appeared the component of building. It same cases, doors and windows developed sticking problems, plumbing, sewerage, mechanical and electrical fittings also adversely affected too (Richardson, B.A.; 2001). It is rare for land settlement was zero affect the structures of the building due land settlement problem. The researcher found that building material such as bricks, concrete blocks, glass panel, asbestos sheets, gypsum board, and precast concrete was broken or cracked. The results shows there are a few building structures got minor defects of the concrete mortar of a few r.c beams and r.c column at foyer area of ILP Miri and also a few 1st floor level of r.c beam of Telecommunication and Computer workshops was damaged (broken). Whilst situations vary from site to site, a general rule is that a crack is considered to be of a structural nature, if it approaches or exceeds a width of one-quarter inch.

6.2 Structural Defects

According to the Engineering Encyclopedia and Code of British Standards (BS 3811: 1964), structural defect can be categorized as cracks in foundations (Substructure), cracks in floor or slabs (superstructure), and cracks in walls (superstructure). These defects of structural because improper soil analyses, inappropriate site selection, and the use of defective materials. It might be possible the factors of poor soil treatment and inappropriate site selection may be caused of land settlement and consequently damaging the building structural and this stamet supporting the findings of this study.

6.3 Crack, Wear and Tear of Component Building is Common Building Defects

In general, there have several common building defects which usually occur to building parts and components of buildings in ILP Miri due to land settlement such as drain, roofs, walls, floors slab, ceiling structure and finishes, toilets sanitations fittings, doors and windows elements and those defects were the same findings by Tan Wei Cheun (2008).

6.4 Peeling Paint

Based on the results of visual observation and the appearances of damages of wall condition (peeling paints), it
usually occurs on the ILP’s building facades, mainly on the plastered walls, columns and them surfaces and other areas which are exposed to excessive rain and great dampness or moistures especially closed to toilet area (leakage of piping system). Some buildings that are located near the sea may face a much higher risk once the signs of peeling paint are visible on the exterior walls. According Kasi N.D. (2009), peeling paint is always the result of poor surface preparation. The majority of peeling paint problems occurs on surfaces exposed to the weather condition (rain and sun and the variation degree of temperature), poor material used, and poor workmanship of labour (lacked of competency), lacked of supervision level etc.

6.5 Rising Dampness

Dampness is generally defined as unwanted and excessive water or moisture. The existing of dampness in building is one of the most damaging failures that really must be taken care of. It can cause damage in brickwork by saturating them, decaying and breaking up of mortar joints, rotting in the timber structures, defecting by the corrosion of iron and steel materials and also destroying the equipment in the building. Dampness in walls has been taken in consideration in recent years. If even the level of dampness is low, the value of the building can be highly affected. According Belgrade Charter (1975), dampness can be a serious matter, particularly to the building located near water sources. Somehow, the water can enter the building bit by bit through different routes resulting in dampness. Furthermore, prevailing wet wind and rain will due to water penetrations that occur through walls. Dampness also occur when water penetrate through capillaries or cracks between mortar joints, and bricks or blocks before building up trap moisture behind hard renders.

6.6 Defective Plaster Rendering

Mostly the defective of plaster rendering occurs on the external walls, column and ceiling. Defective rendering are normally caused by biological attacks arising from penetrating rain, evaporation, condensation, air pollution, dehydration and thermal stress. The moulds or harmful growth, insect, animals, and traffic vibration also will contribution causes of defective plaster rendering. Prior to being decomposed and broken apart, rendering may crack due to either shrinkage or movement in the substrate also found by Ghafar Ahmad (1998) and Rosnah M.T (2016).

6.7 Building Services (M &E)

The results of the study show that the M&E fittings and appliance defects were defects and deterioration are common problems in any building components. However, various defects are more common in an old structure (Ransom, 1981). But different situation in ILP Miri the defect were caused by land settlement which affected the mechanical and electrical fittings and appliances fitted or mounted to the wall and ceiling features such as electrical wiring, air conditioning ducting, lamps, fire protection system. According to California Civil Code 896, common types of building defects include: structural defects resulting in cracks or collapse; defective or the faulty of electrical wiring or lighting, defective or faulty plumbing, inadequate drainage systems, faulty ventilation, cooling or heating systems, insufficient insulation or sound proofing, and also inadequate fire protection suppression systems.

7. Implication Of The Study, Suggestions For Future Research And Limitations Of The Research

7.1 Implication of the Study

The findings of this applied research would contribute a clearer understanding the implication of building components damages due land settlement and because of soil properties condition and reaction. This issue occurred might be due to the lacked of structural design during design stage, lacked of soil investigation report and interpretation, document contract, lacked of supervision level during the construction stage, lacked of material used and specifications, lacked of workmanship of labour, lacked of maintenance cost for rectification and etc.

7.2 Suggestions for Future Research

Based on the outcomes of this study, there should be further research conducted regarding the building component defects and the following suggestions for further research as follows:

a. The same research approached to be extended to others building blocks such as the accommodation building blocks (quarters and hostel blocks) and support building including such as dining hall, mosque, sport grandstand, guard house, garage, sub-station, dust bin compartment etc.);

b. The future research to be extended in depth study on how the process of defects was occurred and the measurement of damages progress of building component and physical such as the progress measurement of brickworks cracks including cement plaster, cracks measurement of R.C floor slab, measurement of r.c beam or r.c column cracks etc.

c. The future research to be extended in depth study on the building services system damages such as Mechanical and Electrical fittings and appliances (M & E) including internal and external building services system and installation damages such as sewerage system, water reticulation system, sanitation system, air conditioning ducting system damages, etc.

7.3 Limitations of the Research

There were a few limitations in this study such as below:

a. There was limited numbers of ILP Miri building blocks have been investigated because of times constraint which all accommodation blocks and a few supporting buildings were excluded

b. This research focused on the architecture building components and less in detail investigations has been done on the M & E fittings and installations e.g. wiring system, sewerage system, water reticulation

c. This research not in detail inspection for the substructures of building such as piles and,
This research was done totally through visual inspection approach and there was no physical testing at the actual site has been carried out to measure the damages building component.

8. Conclusion

The issue of the building defects was raised up many times by the occupants or users of the building (staff and students) of the ILP Miri to the top management. They felt worried about their family safety and uncomfortable due to building component damages. Apparently, the damages affected the reputation of the ILP Miri as a government training institution. Hence, the researcher carried out this case study on 8 building blocks of ILP Miri including administration and workshops blocks. The research has approached visual observation through site inspection in order to collect the data and data analysis used frequency and percentage then has been plotted into graphs for further discussion. Through visual observation and land settlement marker test and report, it might be the land settlement dragged the piles settled in uneven and it affected to the superstructures settled uneven too. Due to land settlement issues, the results of study shows that highly frequency of building component damages for non-structural such as solid brick walls including cement plaster and defective (cracked and settled) of surface drainage system including concrete apron all-around of all the buildings and big gap appeared between concrete apron and ground level. This research also found that the major defects of structural components including cracked r.c beam and r.c column, r.c floor slab settled down. It seems that very dangerous when the cracks of brickwork become critical and ceiling cement plaster was broken and debris falling down to the floor area. The results shown the building of an administration including the resources centre and all training workshops got highly percentage of major building defects and need urgent rectification work. The fire protection alarm system and fire of protection apparatus and electrical wiring system were among the M & E fittings and appliances are affected components that were damaged and need to do rectification urgently and it might be costly. Those results of this study are mostly consistently to the literature reviews.

9. Recommendation

Based on findings result, there are a few recommendations to be proposed as follows:

a. Due to the rapid growth development of infrastructures facilities in Malaysia, it is impossible to avoid constructing on clay. Clay makes up 20% of the total soils in Peninsular Malaysia. It can be found in the West and East Coast of Peninsular Malaysia. This type of soil is generally classified as marine clay. This clay originates from flooding during ancient times. The sedimentation of seabed was very thick and can be up to 60 meters in depth, or roughly the height of a 20 storey-building. Hence, the construction over clay may experience bearing capacity failure and excessive settlement.

b. Stabilization of soil using cementitious materials becomes optional to solve this problem. Cementitious materials are several binding or glue materials that may mix with water to form a plastic paste that holds the concrete together with soil.

c. Ordinary Portland Cement (OPC) is used as a common cementitious binding agent. From a previous study, stabilization of soil using cement was one of the soil treatment applied to improve soil plasticity and workability. Therefore, this research focuses on the strength of soil that can be produced by using waste material ashes as part of the additive mixture. This will decrease the use of Ordinary Portland Cement (OPC) to help stabilize clay. By doing this, more economical soil mixes can be produced.

d. The main contractor should improve the communication among the technical construction team during the site meeting especially the implementation of into the quality of design and specification or work, materials to be used, the method to applied, the design requirement to be proposed. All these characteristic may involving the quality of materials, labours, equipment and methodology of construction to be implied to meet the specification required.

e. CIDB or the employers should provide regularly reskilling and skill upgrading program to the construction team worker forces in order to improve the performance of person that involve in construction works; such as site supervisors, engineers, architects, suppliers, contactors and clients too. The related program to be proposed such as in technical skill area, ethical in the construction implementation, regulations and laws procedures, and the construction management application to ensure they are skilled and highly knowledge and be more responsible to their duty.

f. Contractor should hire well trained/killed labour and knowledgeable labour for all related disciplines of construction works to ensure the quality of the construction workforces’ skills and workmanship are meet the construction specification that have been approved by qualified professional consultants.

References