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BUILDING DEFECTS AND FAILURE OF MALAY TIMBER HOUSE: CAUSES AND SYMPTOMS

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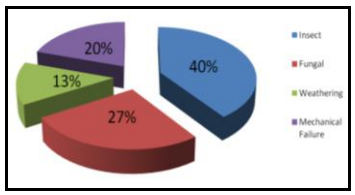
Graphical abstract



Abstract

Defect detection in Malay House can be demeanoured by using two types of methods which is through visual inspection and via Priority Ranking System. To judge the building condition, it is good to have a thorough evaluation, so that a reliable recommendation can be made within a short period of time. This evaluation being carried out using the visual inspection on site and Prioritize Ranking System. The simple methodology of the system is using the numerical coding for the survey checklist. For the data under the priority ranking system then can be used as to foresee the condition of the house; either dilapidated, fair, or good. Furthermore, the system enables the surveyor to identify the major types of defects and the location of defects occurred. Through this, the surveyor can list out the element to be repaired in order of priority. The system is tested to the small-scale timber traditional house namely Rumah Melayu near the School of Housing, Building, and Planning (HBP).

Keywords: Visual inspection, priority ranking system, timber defects

Abstrak

Pengenalpastian kecacatan pada rumah Melayu dapat dilakukan dengan menggunakan dua jenis kaedah iaitu melalui pemeriksaan visual dan melalui sistem kedudukan utama. Dari pemeriksaan visual, beberapa kecacatan berlaku di rumah Melayu ini. Beberapa kecacatan kecil dapat dilihat di beberapa bahagian pada bangunan ini. Dalam menilai keadaan sesebuah bangunan, ia adalah baik untuk mempunyai penilaian yang konkrit, supaya cadangan yang boleh dipercayai boleh dibuat dalam tempoh yang singkat. Penilaian konkrit ini boleh dibuat dengan menggunakan pemeriksaan visual di tapak dan juga menggunakan sistem kedudukan utama. Penyelarasan kaedah sistem ini menggunakan kod berangka bagi senarai semak penyiasatan. Bagi data di bawah sistem ranking keutamaan kemudiannya boleh digunakan untuk meramalkan keadaan rumah itu; sama ada usang, sederhana, atau baik. Tambahan pula, sistem itu membolehkan juruukur untuk mengenal pasti jenis kecacatan utama dan lokasi dimana kecacatan berlaku. Melalui kaedah ini, juruukur boleh menyenaraikan elemen pada rumah yang perlu dibaiki dalam susunan mengikut keutamaan. Sistem ini diuji pada skala kecil rumah kayu tradisional iaitu Rumah Melayu berhampiran Pusat Pengajian Perumahan, Bangunan dan Perancangan (PBP).

Kata kunci: Pemeriksaan visual, sistem peringkat keutamaan, kecacatan kayu

1.0 INTRODUCTION

Under proper conditions, wood provides excellent, lasting performance. However, it also faces several potential threats to service life, including fungal activity and insect damage which can be avoided in numerous ways. Wood is a hygroscopic material, which means it naturally absorbs and releases water to balance its internal moisture content with the surrounding environment. The moisture content of wood is measured by the weight of water as a percentage of the oven-dry weight of the wood fiber. The key to controlling decay is to control moisture. Once decay fungi are established, the minimum moisture content for decay to propagate is 22 to 24 percent, so building experts recommend 19 percent as the maximum safe moisture content for untreated wood in service. Water by itself does not harm the wood, but rather, wood with consistent high moisture content enables fungal organisms to grow [1].

The primary objective when addressing moisture loads is to keep water from entering the building envelope in the first place, and to balance the moisture content within the building itself. Moisture control by means of accepted design and construction details is a simple and practical method of protecting a wood-frame building against decay. Finally, for applications with a high risk of staying wet, designers should specify durable materials such as naturally decay-resistant species or wood that's been treated with preservatives. Cladding, shingles, sill plates and exposed timber beam are examples of potential applications for treating wood.

Defects and damages are common phenomenon that can be found on any structure or building. Defects can be referred as fault on something that detracts from perfection, whilst damages can be seen when any structure, material, equipment or element of the building was not fully functional. Visual inspection is the easiest and the most fundamental method to use in order to inspect the existing structure. However, this method may not be applicable on the defects that do not appear on the surface. Hence; a non-destructive test will be use to assess the properties of material, component or system without tampering the inspection structure [2]. It is important to conserved and preserved historic buildings because it provides a sense of identity and continuity in modern and fast changing world. The aim of this research is to focus on gathering facts related to defects in timber houses. It inclusive of establishment of defects location, types and basis of defects so that specific action can be carried out to overcome the problems as described before. The outcome of this research will be handy and able to recognize or diagnose defects at every inch of building elements on timber house. The research outcome will be a guideline on the findings and suggested solution to overcome the problem. It will cover the approach, method or technique and materials. Therefore it is worthwhile to carry out this research.

Urban area usually consist of concrete building. Rarely timber structure exist among it. The same situation happen to Universiti Sains Malaysia (USM). There are not many buildings that are still used timber as the elements of the building. The building can be count on the fingers of one hand. One of the buildings in USM that are still used timber as a building element is Surau PBP. Since the building was built in 1734, there might be some part of the building that having deterioration. So, the question is, does this building still in good condition? And is save to be used?

Repairing activities have been done by some professionals, specialists, trades, and craft workers in order to preserve the conditions of the buildings. But still it's lacked of periodic maintenance and it does affect the conditions of the buildings.

The lumber house is a building that was built with hundred percent timber components. For example, door, windows, and stair. This study is carried out to investigate the locations of the timber defects in these buildings and to know the types of defects and the causes of the defects that occur in these buildings [3].

In addition, this research will also focus on the major defect on timber components at lumber house so that some appropriate solution can be made.

The aim of this research is to focus on knowledge that related to defects in timber based buildings like; to determine the locations, types and causes of the defect so that specific action can be carried out to overcome the problems as discovered. The outcome of this research is to be able to recognize and diagnose defects at each building element in timber based buildings. A guide is needed in order to study the defects and aid the correct diagnosis of defects; because prevention is better than cure, and action to be taken to reduce the frequency of defects on timber based buildings by choosing appropriate approaches, methods, techniques and materials. Therefore it is worth to do this research. There are three main objectives in this research that need to be fulfilled to ensure that the overall aim of this research is achieved.

2.0 LITERATURE REVIEW

The conservation of old timber building, particularly with traditional vernacular design is as important as conserving other heritage buildings. Some of the old timber buildings had transformed the building materials, some of it had been neglected but mostly they retain the originality of its structure. The old timber building, built using famous local hardwood, undeniable for its unique and displaying fine carpentry skills are rarely seen today. 'Rumah Melayu', as with the other older building are also exposed to defects and deterioration, due to 'wear and tear' process. The problems can be seen

seriously found on a building with no maintenance carried in such a way.

Typically, defect that often struck wood building, especially in tropical country mainly caused by moisture problems and biological attack, such as termite, beetles, and decay fungus. A continuous exposure to these environmental agents and pests without proper preventive measures will rapidly dilapidated buildings. In carrying out a repair work, it is crucial to understand the cause of defects as to ensure the best way to achieve improvement. In fact, understanding the causes and agents of defects must be viewed comprehensively. Repair works should be carried out accurately with the kind of defects and it must not intervene the aesthetic value of the building [4].

Conservation practice requires technical and scientific knowledge of how decay occurs and how to eliminate decay. The definition widens from technical aspects to the active planning and management process to prolong life of the timber building.

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Defects are noticeable within the structure, fabric, services and other facilities of the defective building. Some obvious examples of a defect are rotten timber, a slumped roof, damaged or deteriorated block walls, and slumped ceilings. Defects reduce the durability, functional performance and user satisfaction of the buildings. Therefore, a more efficient practice through a proactive and holistic understanding of the nature and kind of specific defects will focus the maintenance organizations on the user value system via their maintenance requirement.

There are many defects in the growth, the conversion and the seasoning of the timber. Any of these defects can cause timber problems and can deteriorate its appearance. The defects may be classified as natural, chemical, exchange and seasoning. Natural defects occur during the growing period of the timber. Cracks and fissures occur in various parts of the tree. It can indicate decay or the beginning of decay. Knots are the branches embedded by the natural growth of the tree. Grain defects are twisted-grainy, cross-grain, flat-grain, and spiral-grain which can cause problems of distortion in use. Fungal decay which occurs in more mature timber and can even occur in recently converted timber, this timber should be rejected for use. Annual ring width can cause problems with the strength and also reduce the density of the timber.

A chemical defect occurs when timber is being used in unsuitable positions or in association with other materials. This is when the chemicals in the timber such as red cedar which contains tannic acid come in contact with metals as the tannic acid corrodes metal. Conversion defects are due to unsound practice in the use of milling techniques. It can also be due to an undue economy attempting to use every possible piece of timber converted from the trunk. Seasoning defects are directly related to the movement that occurs in the timber due to changes in the moisture content. Seasoning defects can be caused by excessive or uneven drying, exposure to wind and rain, and poor stacking and spacing during drying. These methods can result in producing defects or distortions in the timber. All seasoning defects have an effect on structural strength as well as on fixing, stability, durability and finished appearance [6].

The effect of adverse environmental conditions on building materials and the extent of damage caused depends on both the materials used and the environmental conditions. Although timber is a diminishing resource, it is still widely used in today's construction. In Malaysia, timber is one of the main components of many historic buildings. Appropriate maintenance of such buildings requires an understanding of timber defects and its related problems.

Modern timber construction largely consists of residential structures. This is mainly due to the use of large wall panels being necessary for seismic resistance. Timber moment connections have previously been avoided due to the difficulty of construction and significant costs. However, as global focus shifts towards sustainability and environmental concerns timber construction is an obvious choice for the future.

Building conservation has long been of concern, although its popular application is relatively recent in origin, particularly in Malaysia. The field of conservation had gained a place in the community and reached popularity among the nation. In a country like Malaysia where heritage buildings are regarded as highly valuable assets due to their historical values and tourism potentials, it is paramount to conserve these buildings by continuously caring and protecting them from being destroyed so as to prolong their life span and functions. It is quite natural that as the buildings aged, they will be exposed to serious building defects and deterioration. It is a truism today that no building is maintenance - free. As such, every building whether heritage or new, requires care and protection to limit deterioration.

Defects and damages in the building are common phenomenon that occurs to any building. Defects can be referred to fault on something that detract from perfection, while building damage can be seen when any structure, material, equipment and also element of the building was not fully functional. Some visual inspection will be conducted via observation of the surrounding area. This observation is to check the damp zone and predicts the assumed causes [7].

The amount of water in a piece of wood is known as its moisture content. Because this is expressed as a percentage of the dry weight of the piece, not of the total weight, it is possible to have moisture contents of well over 100%. The moisture content of green varies greatly from one species to another. Moisture content can vary between apparently similar pieces of the same species and in addition there may be differences, between and within species, in the rates at which moisture is lost from timber during drying.

The strength of the timber is dependent on the moisture content which can also affect the resistance to decay. If the moisture content was lower, it could cause a problem with shrinkage in the timber. The moisture content is directly proportional to the strength and stiffness of the timber. Timber is hygroscopic, which means that it will attempt to attain equilibrium moisture content with its surrounding environment.

Building defects can be identified by the user themselves or through an inspection of the facilities by those concerned with facilities management. Practitioners have the capability to identify defects that are not yet obvious, at least for the users. An appraisal of defects is usually undertaken through a sequence of site procedures that provide the necessary information on which to make an assessment as to the condition and fitness for the purposes for which the facility is acquired.

There are a few steps to be carried out during the investigation. The most important step before conducting any inspection is getting the owner approval to proceed with the inspection. Once, the approval is acquired the layout plan and structural drawing of the building need to be taken from the Jabatan Pembangunan, Universiti Sains Malaysia. At this stage, identify the building element spaces are important for coding system. The next step is, doing an inspection through visual observation. The observation will be carried out from the outside to the inside. The third step is, to record all the defects and damages that occur in survey checklist form. This process must include some photos, the location of defects, types of defects and element code. Last but not least, to analyze the collected data. From this finding we can know the number of defects found. The data then will be translated into a Pareto chart as well pie chart as we want to know the major defects that occur in the building.

Maintenance is defined as continuous care and protection involving minor repair works carried out to building elements in order to keep it in good order thereby prolonging the life of such element and the entire building for as long as possible and this will require considerable administrative and managerial expertise. This definition shows the prominence of maintenance as a conservation process for timber buildings. Maintenance management for timber building involves the effective and efficient utilization of resources in the continuous care and protection of building elements in order to keep them in good order, maintain the building fabric and its services and prolong the life of such element and hence the whole building for as long as possible. It is important to conserve these buildings by continuously caring and protecting them from being destroyed so as to prolong their life span and functions. It is quite natural that as the buildings aged, they tend to be exposed to serious building defects and deterioration. As such, every building whether heritage or new, requires care and protection to limit the deterioration. For timber buildings, efficient maintenance management approaches are essential in extending the life of the buildings and avoiding the need for potentially expensive and disruptive repair works, which may damage the building aesthetic value.

Lack of maintenance and repair was the major factor in the worst of defects...early preventive measures are important to minimize the risk of damage or failure. The best remedy is one accurately to defects. The understanding of building defects is, therefore, an essential key for good repair practice, particularly in the conservation of historic buildings [8].

Timber is a very flexible material for building structure, can decay easily if no remedial action is taken to protect and prevent it from deteriorating. The occurrences of defects in timber houses are becoming more common due to the effects of biological agents, temperature and the poor standard of workmanship. A timber defect can only be repaired satisfactorily if its cause has been correctly diagnosed and identified [9].

It is natural that as the building aged, they will be exposed to serious building defects and

deterioration. It is a truism today that no building is maintenance-free [10]. As such, every building, heritage or new, requires continuous care and protection to cut down the deterioration. For timber building, efficient maintenance management approaches are requires in extending the life of the building. There is an urgent need to reconsider the maintenance management approaches being adopted in the conserving timber building especially in Universiti Sains Malaysia because it is through conservation of building we can pass on to future generation what is identified as being of cultural significance today, and this would not be achieved without adopting efficient maintenance management practices for conserving the value of timber building. Therefore, lack of organization's effective and efficient maintenance management approaches for timber building can be of serious consequence in the sense that the building will rapidly decay and threaten the safety of the building and if this building is used by occupants thereby resulting to demolishing the building.

3.0 METHODOLODY

The vital stage in order to retain the state of the building is through the condition survey. This checklist survey is used to identify the types of defect, the location of defects, the causes of the defects and also to recognize the major defect that occurred in this house so that appropriate solution can be made. The inspection is important as it is closely related to the reparation stage, wherein any improvement should be based on the building defects and overall condition. The aim of the is to have a specific knowledge associated with the defects, particularly with Malay house, to determine the locations, types and causes of wood defects so that specification can be carried out to overcome the problems. This research also wants to know the major defect that occurs in this Malay house.

The approval to conduct the research on this house has been obtained from the Dean of SoLLaT. The process to get the key of the house was not so easy as it takes about more than one week to get approval and also the house key.

Once the key is obtained, a few observations and procedures are required in order to inspect and evaluate the building conditions. In this research, the inspection is carried out from the external to the internal of the building. Several items were listed to obtain necessary information. For examples, building's name, year built, and current usage. The survey was carried out through a grid number and all wood defects were noted and recorded on the condition survey checklist form. The analysis was made element-by-element; the column, beams, walls, floors, windows, doors, roof, and stairs. Figure 1 shows the layout plan of the Malay house. Figures 2 and 3 show the exterior and interior of the Malay House respectively.

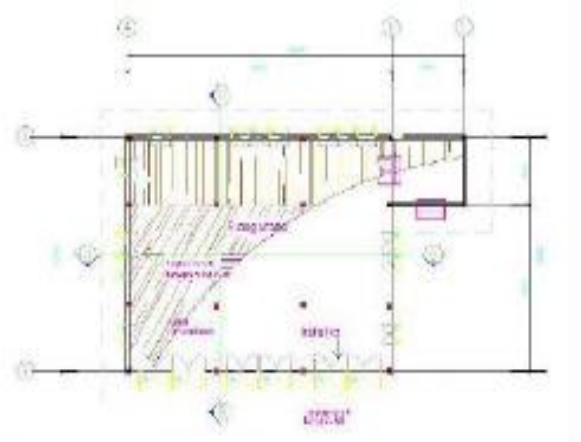

Figure 1 Layout plan

Figure 2 The exterior of Malay House

Figure 3 The interior of Malay House

4.0 RESULTS AND DISCUSSION

4.1 Thermal Comfort

Thermal comfort is a measure of how comfortable the indoor environment is perceived to be by its occupants. Relative humidity is the ratio between the

actual amount of water vapor in the air and the maximum amount of water vapor that the air can hold at that air temperature. From Table 1, the highest relative humidity of the building is 62.0 % at grid number b-c/3-4, followed by 60.0% in grid number c-d/2-3 and b-c/3-4 while the lowest relative humidity is 52.5% at grid number c-d/1-2.

Table 1 Thermal Comfort Test Results

Location	Dry Bulb (%)	Wet Bulb (%)	Relative Humidity (%)	Air Movement (m/s)
Deck	34.5	26.5	53.5	0.5
a-b/1-2	33.2	26.5	53.0	0.0
b-c/1-2	34.5	26.5	53.5	0.0
c-d/1-2	34.0	26.5	52.5	0.0
a-b/2-3	33.5	26.5	53.0	0.0
b-c/2-3	34.5	26.5	53.5	0.0
c-d/2-3	33.2	26.5	60.0	0.0
a-b/3-4	34.5	26.5	53.5	0.0
b-c/3-4	33.1	27.4	62.0	0.0
c-d/3-4	33.2	26.0	60.0	0.0

The percentages of relative humidity having a different at three center point which is at point c-d/1-2, c-d/2-3, and b-c/3-4. This is because on the day of data is collected; this area did not receive the sunlight. That is why the relative humidity is higher than the rest. The air movement deck area is 0.5 m/s while the rest is recorded at 0.0 m/s. This shows that there is no wind flow in that house. On the day data is collected, the condition of the environment is breezy, there is no wind. By the time the survey is conducted, the ventilation meter indicates the surrounding temperature is 28 degree Celsius, with the air velocity of 0.5 m/s. Proceed with the analysis, the result of condition survey is shown in Table 2.

Table 2 Condition survey checklist for timber defects

No.	Construction Elements	Design & Construction	Building Survey		Timber Defects Prioritise Ranking System					
			Defect Diagnosis		a	b	c	d	e	Total marks
			Causes	Types						
1	Beam	Tounge and Groove	4	7	3	3	3	3	4	16
2	Window frame	Double leave window	1	1	4	3	3	3	4	17
3	Floor	Timber joist	1	1	4	3	3	3	4	17
4	Column (under house)	Square in shape	2	5	3	2	2	2	3	12
5	Roof	Fascia board	1	1	3	3	3	3	4	16
6	Floor joist	Square in shape	1	1	3	3	2	2	3	13
7	Roof Beam	Lean-to-roof	1	2	3	3	2	2	3	13
8	Ceiling joist	Lean-to-roof	2	4	3	3	3	3	4	16
9	Staircase	Handrail	3	8	4	3	3	3	3	16
10	Wall	External	3	8	3	3	3	3	4	16
11	Roof	Attap	2	4	2	2	3	2	3	12
12	Floor	timber floor	1	1	3	2	2	2	2	11
13	Roof	Attap	4	7	2	1	1	1	2	7
14	Roof	truss	4	6	3	3	3	3	4	16
15	Column (under house)	Square in shape	2	3	3	2	2	2	3	12
								TOTAL		210

4.2 Causes of Defect

From Table 3, it shows that insect is the highest in frequency of defects. Followed with fungal with the total frequency is 4. The third one is under mechanical failure the frequency recorded is 3 and the last is weathering with total number of frequency is 2.

Table 3 Causes of defect

Causes of Defects	Frequency	Percentage (%)	Cumulative Percentage (%)
Insect	6	40	40
Fungal	4	27	67
Mechanical Failure	3	20	87
Weathering	2	13	100
Total	15	100	100

From Figure 4, it shows the percentage of the causes of defects that occurred in the Malay house. Defects that cause by an insect is recorded as the highest occurance with 40%. Then, followed by fungal and mechanical failure with 27% and 20% respectively. The lowest percentage is caused by weathering which is only 13%.

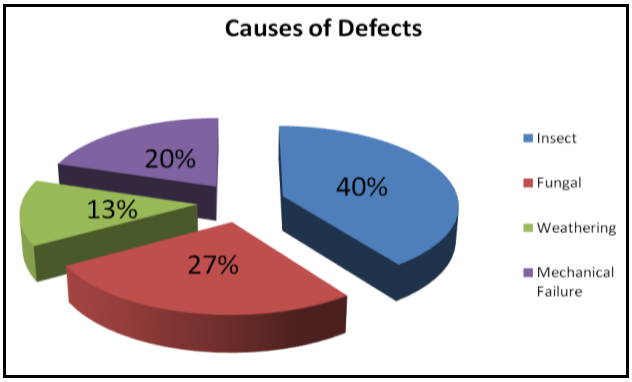

Figure 4 Percentage of defects

By referring the above Figure 5; it shows the cumulative percentage of the total number causes of defects. In order to lower the causes amount of defect by 87%, it is sufficient to solve the first three causes which are; insects, fungal, and mechanical failure.

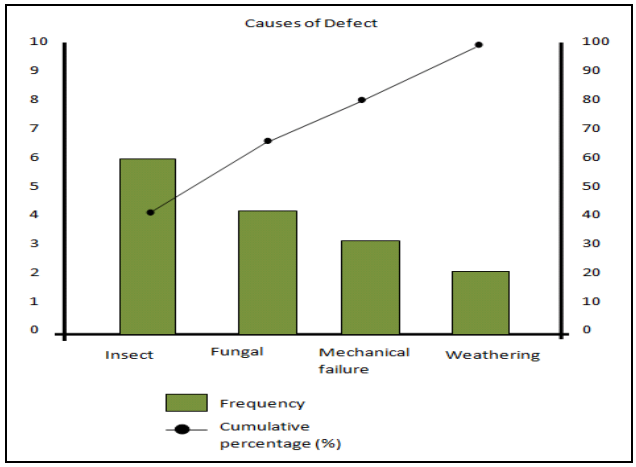

Figure 5 Cumulative percentage of defects

By referring Table 4; it shows that there are eight types of defect. Among the eight types of defects, termites are recorded as the highest frequency with total count of 5. While, wet rot, broken part or missing, and paint blistering have the same frequency which is 2. The rest of it is the lowest one with frequency of 1. It is included ants, white rot, stain mould, and crack.

Table 4 Types of defect

Types of Defects	Frequency	Percentage (%)
Termites	5	33
Wet rot	2	13
Broken part/missing	2	13
Paint blistering	2	13
Ants	1	7
White Rot	1	7
Stain Mould	1	7
Crack	1	7
TOTAL	**15**	**100**

4.3 Locations of Defect

From Table 5, it shows that there are eight locations of defects. Among the eight locations of defects, roof is recorded as the highest frequency. The frequency recorded is 5. The second location with frequency of 3 is floor area. The column is the third highest frequency with the number of frequency is 2. The rest of location which are wall, staircase, ceiling joist, window, and beam tounge is recorded as the lowest frequency of 1.

Table 5 Locations of defect

Location of Defects	Frequency	Percentage (%)
Roof	5	33.3
Floor	3	20
Column	2	13.3
Wall	1	6.7
Staircase	1	6.7
Ceiling joist	1	6.7
Window	1	6.7
Beam tounge	1	6.7
TOTAL	**15**	**100**

From the Figure 6, it shows the percentage of location that defects occurred. The roof of the house is recorded as the highest one with 33%. It is followed by floor area with the percentage of 20%. Then, 13% is recorded occurred at the column. The next four locations which are beam tounge, staircase, ceiling joist, and window having the same percentage with 7% and the lowest percentage is walled with 6%.

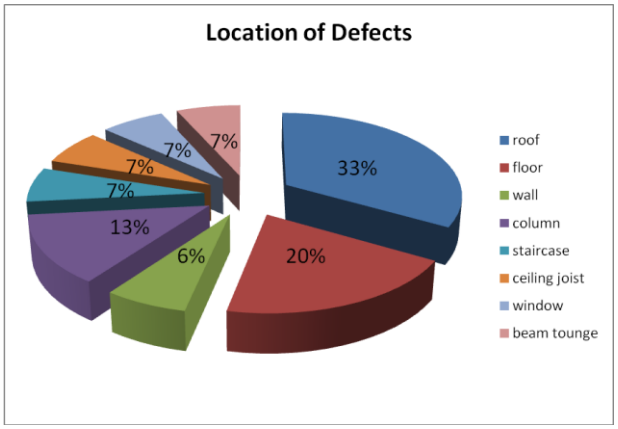

Figure 6 The percentage of Defects (Location)

5.0 CONCLUSION

Based on pareto analysis technique, it can be conclude that we must give extra focus on the roof, floor and column element. The renovation work that took place in 2009 has given quite numbers of changes to existing building. Even though from the survey it shows that the house is still in good condition and classified as good but for the maintenance purpose; the caretaker are advisable to give priority to replace the roof (attap) as the roof are in worst condition. The survey being conducted to Malay house is the first initiative to determine current state of building. The same exercise should be carried out to other timber related building or structure.

Building condition survey reveals that the house is still in a good condition and classified as good. For maintenance purpose, the custodian should give priority for replacement of the roof (attap) at the whole area of roof. Malay house form as a pilot project for the ranking system and it is likely to be

found that the findings reflect the current state of the house.

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