



Selected Melaka traditional houses: comprehensive analysis on building defects, failures and solutions including the Chetti house

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ABSTRACT

Building defects affect society at large due to possible danger posed; they also result in direct and indirect cost in repairs, abnormally high maintenance, disputes and possible loss of building use. Defects are generally caused by inadequacies in design, poor workmanship, building usage not in accordance with design and lack of or incorrect maintenance. Normally, dampness and cracks are common manifestations of defects affecting the exterior and the interior space. Dampness can however often lead to cracks, making it difficult to determine root cause and appropriate repair. Not all manifestations may be considered defects and not all defects are serious to the extent that it will affect building stability and occupant safety. Materials are often blamed for defects when the cause lies in the choice of unsuitable materials and/or when their limitations are recognized and taken into account in design and design detailing. The paper however focusing more into the typical defects found within the construction industry in Malaysia with the highlight stressing more into the best potential technical solution to solve its problem as well as in economic term.

Key words: building defects, construction failures, building leakage, Malaysia.

1. MALACCA CHETTI ASSOCIATION HOUSE

1.1 Introduction

Chetti house is a simple wooden house in terms of architecture. These types of houses are usually elongated with a width of approximately 5 meters and may reach 84 meters in length. There are two types of Chetti house which are single-storey and double-storeys where the double-storeys house usually used up minimum space above the living room of the house and is known as an attic. The entrance door to the Chetti house is made of wood and the design is simple and clean. The entrance to the house will be directly connected with the middle room or the living room and followed by other spaces such as the bedrooms and the kitchen.

1.2 Building Failure Cases Analysis I

Based on the investigation that has been carried out, several categories of defects were identified and wood decay is the most prevalent among the defects. Decay is caused by environmental factors, of which building elements are often exposed to heat and rain and the biological agents such as termite attack. The roof finishes which has rusted was caused by the leakage and this has led to other problems such as water seepage and decay. Analysis of this building has been divided into several key elements to facilitate the study.

A. Floor

a. Refer to Figure 1(a), the floor boards were dirty and dusty because the space is ignored and it has not been used for a long time by the occupants.

b. As in Figure 1(b), it can be seen that the floor boards that have been detached from the fixed position was due to decay caused by roof leaks on the first floor.

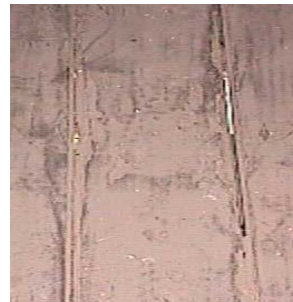


Figure 1(a): Dusty floor



Figure 1(b): Detached boards

B. Wall

a. Refer to Figure 2(a), the wallboard has rotted as a result of exposure to the hot and humid weather.

b. As in Figure 2(b), it can be seen that the wallboard has fallen off because of the low quality installation.

c. Refer to Figure 2(c), the dirty stains were due to the absorption of rainwater from the outside of the house.

d. As in Figure 2(d), the peeling paint finishes was caused by the seepage of rain water from the outside of the building.



Figure 2(a): Rotted wallboard



Figure 2(b): Falling off wallboard



Figure 2(c): Dirty stains on walls



Figure 2(d): Peeling paint finishes

C. Pillar

- Refer to Figure 3(a), the old worn out pillar has rotted.
- As in Figure 3(b), the rotted pillar was due to water infiltration from the outside of the building when it rains.



Figure 3(a): Rotted pillar



Figure 3(b): Rotted pillar

D. Crossbeam

- Refer to Figure 4(a), the decayed roof crossbeam was due to termite infestation.
- As in Figure 4(b), the floor crossbeam has rotted because of the water infiltration from the leaking roof.



Figure 4(a): Decayed roof crossbeam



Figure 4(b): Rotted floor crossbeam

E. Door

- Refer to Figure 5(a), dirt was seen on the door leaves in the living room as a result of the wear and tear factor.
- As in Figure 5(b), the door leaf has decayed from exposure to hot and humid tropical weather.



Figure 5(a): Dirty door



Figure 5(b): Decayed door

F. Staircase

- Refer to Figure 6(a), the plaster has come off because of the low quality finishing work on the ground floor brick stairs.
- As in Figure 6(b), the wood staircase and handrails are unstable as they often absorb the water from the leaking roof.



Figure 6(a): Falling off plaster



Figure 6(b): Unstable wood staircase and handrails

G. Ceiling

a. Refer to Figure 7(a), the paint finishes on the wooden ceiling surface were peeling off as a result of lack of maintenance by the building occupants.

b. As in Figure 7(b), the finishes on the wooden ceiling surface and the girders were peeling off and decaying.



Figure 7(a): Peeling paint



Figure 7(b): Decaying ceiling

H. Roof

a. Refer to Figure 8, the dirty stains were caused by water infiltration into the rafters from the leaking roof.



Figure 8: Dirty stains on roof rafter

1.3 Initial Conclusion I (in table format)

Table 1: Summary of the Defect Types and Situation

Element	Defect	Situation
Roof	• Faded wood color on the rafters were due to roof leaks.	Not serious
	• Leaking roof was a result of the decaying rusted zinc pieces.	Serious
Ceiling	• Decay was due to absorption of water from the roof leaks.	Serious
	• Peeling and falling off paint.	Not serious

Pillar	<ul style="list-style-type: none"> • Peeling and falling off paint. • Decay due to water absorption. 	Not serious Serious
Cross-beam	<ul style="list-style-type: none"> • Decay due to water absorption. • Peeling and falling off paint. 	Serious Not serious
Wall	<ul style="list-style-type: none"> • Decay caused by hot and humid weathering action all year round. • Peeling and falling off paint. • Untidy and poor wall installation. • Dirty stains due to absorption of water from outside when it rains. 	Serious Not serious Serious Serious
Floor	<ul style="list-style-type: none"> • Dirty and dusty. • Decay caused by absorption of rainwater. 	Not serious Serious
Overall	<ul style="list-style-type: none"> • Leaking roof • Hot and humid tropical climate weathering action all year round. • Untidy wall installation. 	Serious Serious Serious

1.4 Initial Conclusion I

Through investigation and analysis of the building, it was found that the building belongs to the category of moderate condition. This is because some elements of the building were damaged and some space in the building is no longer safe to live in. Some serious defects must be repaired to not cause any other damages to the elements that are still in good condition.

1.5 Initial Suggestions I

Based on the investigation and discovery, several proposals have been suggested, which are:

1. Replace the existing roof finishes with new finishes which are more resistant to the surrounding weather. Installation of roof finishes also should be done using the correct method to prevent roof leaks as a result of joining failure.
2. All damages and decays on columns, walls, crossbeams, roof rafters, and wood panelling on the walls need to be replaced with similar materials following the original specification of the materials or using better materials.
3. Cleaning should be done on surfaces with dirty stains by washing and repainting using a suitable paint finish.
4. Repaint the entire building using finishes which are able to withstand the surrounding hot weather and rain.
5. Treatment to be done on all the building elements to prevent attacks from pests.

2. MRS KASMAH BINTI YASSIN'S HOUSE

2.1 Introduction

Refer to Figure 9, this house was built by Mr Yassin 60 years ago. It is located at Kilometer 6, Perigi Hang Tuah, Melaka. It can be categorized as a building which has three houses detached as one with sixteen pillars. The shape of the roof is a long roof. The design of the space comprised of a porch, the main house and the passageway that connects the kitchen to

the main house, four bedrooms and a kitchen without porch. Using a simple form, this house represents many traditional Malacca houses, despite the new elements introduced.



Figure 9: House of Mrs Kasmah Binti Yassin

2.2 Building Failure Cases Analysis II

Based on the investigation that has been carried out, result shows that wood decay is the most prevalent among the defects and damages. Decay is caused by environmental factors such as hot weather and rain, as well as biological agent's factors such as termite attack [2]. Analysis of this building has been divided into several main elements to facilitate study.

A. Floor

- a. Refer to Figure 10(a) and 10(b), the floor boards that have rotted were caused by termite infestation.
- b. As in Figure 10(c), it can be seen that there are insect nests on the surface of the floor outside the house.
- c. Refer to Figure 10(d), the joists and floor boards have decayed due to termite infestation.



Figure 10(a): Rotted boards



Figure 10(b): Rotted floor



Figure 10(c): Insect nests on floor surface



Figure 10(d): Decayed joists and floor boards

B. Sill

- a. Refer to Figure 11, the rotted sill, which is a wooden beam encircling the outer floor regions, was due to termite attack.



Figure 11: Rotted sill

C. Wall

- a. Refer to Figure 12(a), the wall rotted, due to roof leaks.
- b. As in Figure 12(b), the rotted wallboard was caused by termite infestation.



Figure 12(a): Rotted wall



Figure 12(b): Rotted wallboard

D. Pillar

- a. Refer to Figure 13(a), the dirty and mossy pillar was due to submergence in stagnant water under the house when it rains.
- b. As in Figure 13(b), the decayed pillar was caused by the absorption of water from the leaking roof.



Figure 13(a): Mossy pillar



Figure 13(b): Decayed pillar

E. Crossbeam

- a. Refer to Figure 14(a), the faded wooden colour of the floor crossbeams was due to the lack of maintenance by the owner.
- b. As in Figure 14(b), the wood colour of the roof crossbeams has faded as a result of rainwater absorption.



Figure 14(a): Faded wooden colour



Figure 14(b): Faded wooden colour

F. Window

- a. Refer to Figure 15(a), the window panel has fallen out as a result of the poor installation.
- b. As in Figure 15(b), the rotting window frame was due to infiltration of rainwater.

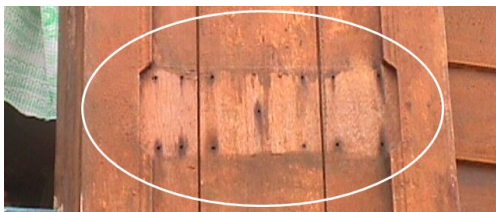


Figure 15(a): Poor installation window panel



Figure 15(b): Rotted window frame

G. Roof

- a. Refer to Figure 16(a), the zinc finishes of the roof have rusted and rotted because of the weathering effect.
- b. As in Figure 16(b), the zinc finishes have fallen off as a result of the strong blowing wind.
- c. Refer to Figure 16(c), the “tebar layar”, which means “sailed ready” for roofing ventilation, has rusted and decayed from the exposure to tropical rain.
- d. As in Figure 16(d), the joining of the “papan pantor”,

- which is a type of fascia board that decorates the roof and also acts as a cover at the end of the roof rafters, has loosen.
- e. Refer to Figure 16(e), the zinc finishes of the roof have holes on it because of the decaying of the zinc.
- f. As in Figure 16(f), the rotted beam was due to the absorption of water from the leaking roof.



Figure 16(a): Rusted zinc roof finishes



Figure 16(b): Fallen finishes



Figure 16(c): Rusted “tebar layar”



Figure 16(d): Loosen “papan pantor”



Figure 16(e): Holes on roof



Figure 16(f): Rotted beam

2.3 Initial Conclusion II (in table format)

Table 2: Summary of the Defect Types and Situation

Element	Defect	Situation
Roof	<ul style="list-style-type: none"> • Decayed rafters due to roof leaks. • Roof leaks caused by detached roof finishes. • Decayed and rusted roof finishes. 	Serious Serious Serious
Pillar	<ul style="list-style-type: none"> • Dirty and mossy pillar surfaces. 	Not serious

	<ul style="list-style-type: none"> • Decay from exposure to hot weather, rain and high humidity. • Decay caused by termite attack. • Faded wood color on surfaces. 	<p>Serious</p> <p>Serious</p> <p>Not serious</p>
Cross-beam	<ul style="list-style-type: none"> • Dirty stains caused by absorption of water when it rains. 	Not serious
Wall	<ul style="list-style-type: none"> • Decay caused by hot and humid weathering action all year round. • Decay caused by termite attack. • Decay as a result of water absorption from the leaking roof. 	<p>Serious</p> <p>Serious</p> <p>Serious</p>
Floor	<ul style="list-style-type: none"> • Decay caused by termite attack. • Insect nests. • Decay as a result of water absorption from the leaking roof. 	<p>Serious</p> <p>Not serious</p> <p>Serious</p>
Overall	<ul style="list-style-type: none"> • Leaking roof • Termite infestation • Hot and humid tropical climate weathering action all year round. 	<p>Serious</p> <p>Serious</p> <p>Serious</p>

2.4 Initial Conclusion II

The investigation which has been carried out has found out that the building was dilapidated. This is because there are building structures which are no longer strong and safe for the occupants to use. Damages have caused the building to be uncomfortable and dangerous to live in by the occupants. Severe roof leaks, pieces of finishes that have fallen out, and the rotted floor have caused the building to be categorized as dilapidated. These serious defects must be repaired in order for it to not cause any other damages to the elements that are still in good condition.

2.5 Initial Suggestions II

Based on the investigation and discovery, several proposals have been suggested, which are:

1. Roof finishes should be replaced with new ones using materials which are better and more resistant to the surrounding weather that is hot and humid.
2. All damages and decay on pillars, walls, sills, crossbeams, roof rafters, and “tebar layar” need to be replaced with similar materials in accordance with the original specification of the materials or using better materials.
3. Cleaning should be done on surfaces with dirty stains by washing and using a suitable paint finish.
4. Build up better and more systematic draining system in order to avoid any stagnant water accumulates at the ground part of the house.
5. Treatment on termite infestation needs to be carried out on the whole building.

3. MRS ZAINAB BINTI JAAFAR’S HOUSE

3.1 Introduction

The original homeowner of this house is the headman of the

village, named Salim bin Pea who comes from Indonesia. Planning and construction of this house began in 1919 and completed in 1926. The house was built step by step by a Chinese sailor who is a friend of Chief Salim.

The Chinese man have built the house using prefabrication method without the needs of nails and make carvings on the house that was paid by Chief Salim. The flora patterned carvings which carry influence from Terengganu and Kelantan were added on every wall in the space to increase the aesthetic value and uniqueness of the building.

Refer to Figure 17(a) and 17(b), the specialty of the construction of Chief Salim’s house is that the veranda was built using the concept of barges which have a long bench with a backrest, built according to the concept of passenger seats on barges. The original building had a storage area located at the loft part of the house underneath the pitch roof in the living room as high as twenty feet (20’) from the ground level.



Figure 17(a): House of Mrs Zainab Binti Jaafar



Figure 17(b): House of Mrs Zainab Binti Jaafar

3.2 Building Failure Cases Analysis III

Based on the investigation that has been carried out, several categories of defects were identified. Wood decaying was recorded as the most prevalent defects on the elements of floor, girders, wall, window, and roof. Analysis of this building has been divided into several main elements to facilitate study.

A. Floor

a. Refer to Figure 18(a) and 18(b), the floor boards were rotted because of the infestation by termites.



Figure 18(a): Rotted floor boards



Figure 18(b): Rotted floor boards

B. Wall

a. Refer to Figure 19(a) and 19(b), the decayed wall was due to termite infestation.

b. As in Figure 19(c), it can be seen that pest nests are found on the timber wall.

c. Refer to Figure 19(d), the wall has deteriorated as a result of the weathering factor.



Figure 19(a): Decayed wall



Figure 19(b): Rotted wall



Figure 19(c): Pest nests on timber wall



Figure 19(d): Deteriorated wall

C. Pillar

a. Refer to Figure 20(a) and 20 (b), the pillars were decaying because of termite infestation.



Figure 20(a): Rotted pillar

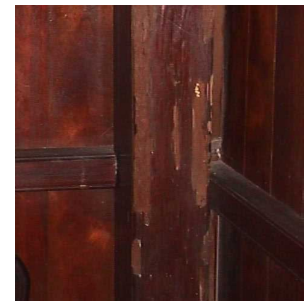


Figure 20(b): Rotted pillar

D. Crossbeam

a. Refer to Figure 21(a), the floor crossbeam was cracked and split as a result of a failure in the connection.

b. As in Figure 21(b), the floor crossbeam which experiencing serious decay was due to termite attack.

c. Refer to Figure 21(c) and 21(d), the roof beams were decaying as a result of termite attack.

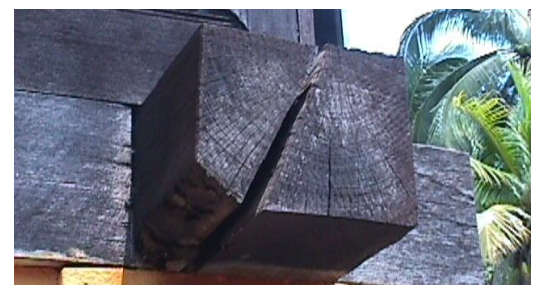


Figure 21(a): Cracked floor crossbeam



Figure 21(b): Decayed floor crossbeam



Figure 21(c): Rotted roof beam



Figure 21(d): Rotted roof beam

E. Door

a. Refer to Figure 22(a), the door leaf has rotted and the paint on the surface has fallen out because of the weathering factor.

b. As in Figure 22(b), the surface of the door leaf was broken as a result of the installation of the iron door lock.



Figure 22(a): Peeling paint



Figure 22(b): Broken surface

F. Window

a. Refer to Figure 23(a), the peeling paint on the surface of the window leaf was due to the weathering factor.

b. As in Figure 23(b), the window frame has rotted as a result of the termite attack.



Figure 23(a): Peeling paint



Figure 23(b): Rotted frame

G. Fretwork

a. Refer to Figure 24(a) and 24(b), the motifs on the fretworks were broken.



Figure 24(a): Broken motif



Figure 24(b): Broken fretwork

H. Roof

a. Refer to Figure 25(a), termites has infested the roof rafters.

b. As in Figure 25(b), the rafter and roof beam have been attacked by termites.

c. Refer to Figure 25(c), the roof rafter has decayed as a result of termite infestation.

d. As in Figure 25(d), dirty stains were seen on the ceiling surface because of the water absorption from the leaking roof.

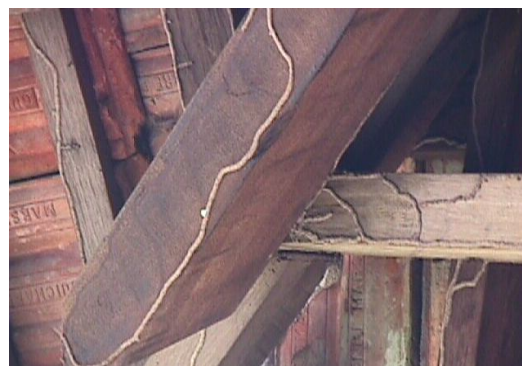


Figure 25(a): Termite-infested roof rafter

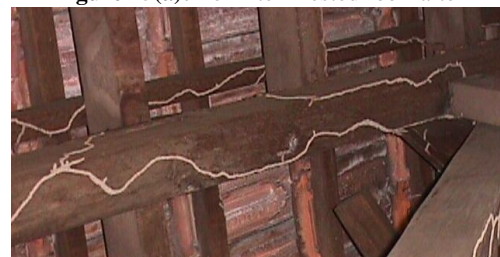


Figure 25(b): Termite-attacked rafter and roof beam



Figure 25(c): Decayed roof rafter



Figure 25(d): Dirty ceiling surface

H. Roof

a. Refer to Figure 26(a), cracks were due to the vibration from the nearby road.

b. As in Figure 26(b), cracks were seen on the steps as a result of the vibration from the nearby road.



Figure 26(a): Cracked stairs



Figure 26(b): Cracked steps

3.3 Initial Conclusion III (in table format)

Table 3: Summary of the Defect Types and Situation

Element	Defect	Situation
Roof	<ul style="list-style-type: none"> Decay caused by termite attack. Falling off roof finishes. 	Serious Not serious
Cross-beam	<ul style="list-style-type: none"> Decay caused by termite attack. Faded wood color. 	Serious Not serious
Pillar	<ul style="list-style-type: none"> Decay caused by termite attack. Absorption of rainwater. 	Serious Not serious
Wall	<ul style="list-style-type: none"> Decay caused by termite attack. Faded wood color. 	Serious Not serious
Floor	<ul style="list-style-type: none"> Decay caused by termite attack. 	Serious
Overall	<ul style="list-style-type: none"> Termite infestation Hot and humid tropical climate weathering action all year round. 	Serious Serious

3.4 Initial Conclusion III

The investigation which has been carried out has found out that the building belongs to the moderate category. This is because some building structures are still strong and safe for the occupants to use, while there are some parts which have already experienced serious defects. On the whole, damages involve serious decays in the floor and roof elements.

3.5 Initial Suggestions III

Based on the investigation and discovery, several proposals have been suggested, which are:

1. Replace all decayed elements of floor, wall, crossbeam, door and window using materials with the same specification.
2. Carry out research on the materials to identify the original type of materials used in the buildings elements.
3. Clean the building elements which are filled with pest's nests.
4. Termite infestation treatment needs to be carried out on the whole building.
5. Apply finishes which are more resistant to the attacks from biological agents and weathering action on the whole building.
6. Conduct further research on the effects of vibration from the main street which is too close to the building.

4. MR UMAR BIN ALI

4.1 Introduction

Refer to Figure 27(a), 27(b) and 27(c), the house is composed of 12 pillars which support the house strongly from the beginning until today. The house as a whole is using wood as the main building material. Mr Umar bin Ali is now in his late 80s and he built his house in Kampung Morten on his own. His father had hired a handyman to build the house. There are some parts that have been modified using the material of stone, which is the kitchen. Most of the wood used in the construction of this house is Bornean ironwood.



Figure 27(a): House of Mr Umar bin Ali



Figure 27(b): House of Mr Umar bin Ali

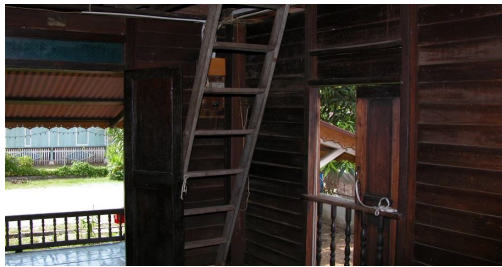


Figure 27(c): House of Mr Umar bin Ali



Figure 28(c): Rotted floor

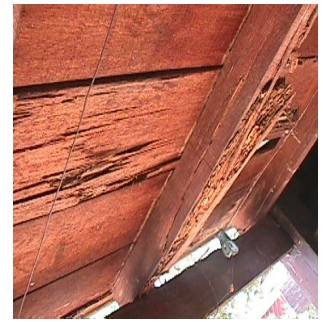


Figure 28(d): Rotted floor

4.2 Building Failure Cases Analysis IV

Based on the investigation that has been carried out, several categories of defects were identified. The most prevalent defects that happened is wood decay. Decay is caused by environmental factors such as weathering and biological agents which is termite attack. Human weakness is one of the factor that leads to the damage of the roof. The installation of the asbestos roof finishes which did not follow the correct method has caused the roof to leak when it rains [6]. Analysis of the building has been divided into several key elements to facilitate the research.

A. Floor

a. Refer to Figure 28(a) and 28(b), the rotted floor girders were due to termite infestation.

b. As in Figure 28(c) and 28(d), the floors have rotted as a result of termite attack.



Figure 28(a): Rotted floor girders



Figure 28(b): Rotted floor girders

B. Wall

a. Refer to Figure 29(a), the wallboard has rotted and the wood colour has faded from exposure to the weathering factor.

b. As in Figure 29(b), the rotted wallboard was due to termite infestation.

c. Refer to Figure 29(c), the wall ledge has rotted as result of termite infestation.

d. As in Figure 29(d), the wall board has fallen off and the installation was untidy.



Figure 29(a): Faded wood colour



Figure 29(b): Rotted wallboard



Figure 29(c): Rotted ledge



Figure 29(d): Fallen wall

C. Pillar

a. Refer to Figure 30(a), the pillar was decaying because of the infestation of termites.

b. As in Figure 30(b), the pillar in the attic was rotted as a result of the termite attack.



Figure 30(a): Decayed pillar

Figure 30(b): Rotted pillar

D. Crossbeam

a. Refer to Figure 31(a), the floor crossbeam was decaying because of termite infestation.

b. As in Figure 31(b), the end part of the roof crossbeam has rotted as a result of the absorption of rainwater.



Figure 31(a): Decayed crossbeam

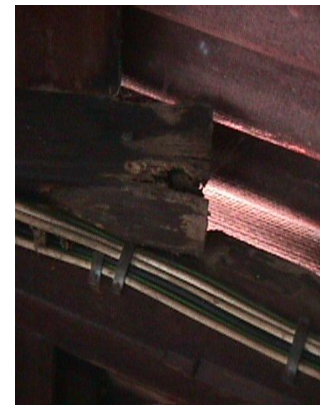


Figure 31(b): Rotted crossbeam

E. Door

a. Refer to Figure 32(a), the loosen door was due to the wear and tear factor, while the faded wood color was due to environmental factor.

b. As in Figure 32(b), the door frame has deteriorated as a result of the rainwater absorption and the wear and tear factor.



Figure 32(a): Loosen door

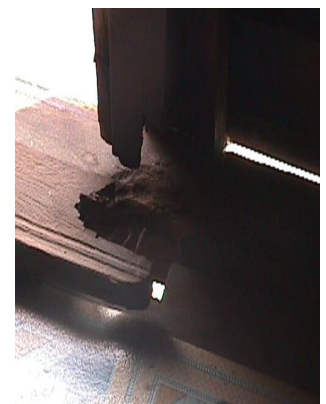


Figure 32(b): Rotted door frame

F. Ceiling

a. Refer to Figure 33, the broken ceiling was due to the wear and tear factor.



Figure 33: Broken ceiling

G. Roof

a. Refer to Figure 34(a), the main rafter in the house attic has decayed as a result of termite infestation.

b. As in Figure 34(b), the “tebar layar” which is made of zinc has rusted from the exposure to rain.



Figure 34(a): Rotted rafter Figure 34(b): Rusted “tebar layar”

4.3 Initial Conclusion IV (in table format)

Table 4: Summary of the Defect Types and Situation

Element	Defect	Situation
Roof	<ul style="list-style-type: none"> Decayed rafters caused by termite attack and exposure to weather. Roof leaks due to connection failure in the roof finishes. Faded colour due to roof leaks. “Tebar layar” rusted from exposure to rainwater. 	Serious
		Serious
		Not serious
		Not serious
Pillar	<ul style="list-style-type: none"> Decay caused by termite attack. 	Serious
Cross-beam	<ul style="list-style-type: none"> Decay caused by termite attack. Decay caused by water absorption from leaking roof. Dirty stains and faded color due to water absorption when it rains. 	Serious
		Not serious
		Not serious
Wall	<ul style="list-style-type: none"> Decay caused by termite attack and weathering effect. Poor wall installation. Faded and peeling paint. 	Serious
		Not serious
		Not serious
Floor	<ul style="list-style-type: none"> Decay caused by termite attack. 	Serious
Overall	<ul style="list-style-type: none"> Leaking roof Termite infestation Hot and humid tropical climate weathering action all year round. 	Serious
		Serious
		Serious

4.4 Initial Conclusion IV

The investigation which has been carried out has found out that this building belongs to the moderate category. This is because almost most elements of the building suffered decay, especially those involving the floor and floor joists. This leads to some space in the building is no longer safe to live in, such as Bedroom 1 and the Middle House. However, some serious defects must be repaired in order for it to not cause any other damages to the elements that are still in good condition.

4.5 Initial Suggestions IV

Based on the investigation and discovery, several proposals have been suggested, which are:

1. Installation of roof finishes should be carried out again following the assigned method.
2. Replace the wooden floor boards and joists with woods that have been treated to prevent the infestation of biological agents such as termites.
3. All damages and decays on pillars, walls, crossbeams, roof rafters, and wood panel on the walls need to be replaced with similar materials according to the original specification of the materials or using better materials.
4. Termite infestation treatment need to be carried out on the whole building.
5. Apply appropriate paint finishes on the whole building to prevent the building from looking dilapidated.

Last but not least, a good maintenance is needed to avoid any failure to the building components. Maintenance programs that are scheduled should be implemented to achieve the optimum results of conservation on the whole.

5. PRELIMINARY CONCLUSION

From the result of the visual finding, it can be concluded that the external factor affecting standard or historical traditional buildings especially those located in the case study location; Melaka are due to climatic change, air pollution, and lack of maintenances (see Fig. 35 below). Climatic condition is the act of atmospheric event such as rainfall, temperature, air pressure and humidity [1]. Due to the tropical climatic condition, Malaysia has heavy rainfall and warm sunshine all year round. Therefore the external part of the building tends to weather rapidly [5].

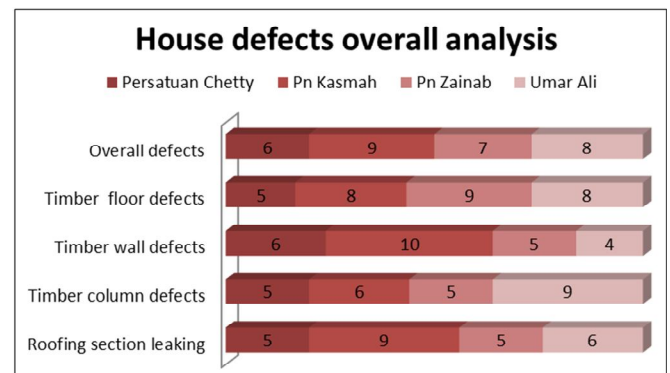


Figure 35: The above chart shows the overall analysis of the buildings based on the defects level of seriousness.

The process of weathering by tropical sun, wind and monsoon rain is defined as the breakdown and alteration of material by mechanical and chemical processes such as even the humid subtle temperature changes triggered building defects naturally [4]. From observation, smoke pollution from vehicle and human activity, causes the soiling of facade by deposition

of black carbonaceous particle. Most buildings located facing or positioned near the main road have black carbonaceous particle. Lastly, lack of maintenances by the owner is another important factor impacting the deterioration of the traditional or heritage buildings in Malaysia. The owner must play important role in preventing defects from reoccurring. Poor maintenances knowledge among the house owner in dealing with the defect and building failures also contributed to the deterioration factor [3].

Finally, Table 5 below shows the initial summary of the selected Melaka traditional houses data and defects overall

percentage. To sum up, it can be concluded that to get effective remedial material, understanding of the deterioration factor and the material characteristic is a must. Therefore, each defect has its own character and the produce of the right remedial material can eliminate the defect to occur. It is hope this paper at least be able to make awareness to prevent building failures reoccur and give guides for better design and maintenance task.

Table 5: Selected Melaka traditional houses data and defects initial summary.

No.	House name	History	Location	Materials	Overall Defect Damages %
1	<i>Persatuan Chetty House</i>	Simply 5 x 84 meter, entirely made of timber	Kg Chetty, 1 km north of city centre	Timber (100%), Brick with cement plaster (0%), asbestos free roofing	80% Mostly timber related defects
2	Pn Kasmah House	16 pillars, ' <i>Berbandung</i> ' 3 with long roof, built 60 years ago	Hang Tuah well, Kg Duyong, KM6 east of Melaka City Centre	Timber (80%), Brick with cement plaster (20%), zinc roofing	80% Mostly timber related defects
3	Pn Zainab House	16 pillars, built between 1919-1926, originally built by Chinese builder	Kg. Sebatu, Merlimau, 8 km south of Melaka City Centre	Timber (80%), Brick with cement plaster (20%), clay roof tile	70% Mostly timber related defects
4	Umar Ali House	12 pillars, claimed house aged circa 80 years old, timber type-' <i>belian</i> ' tree	Kg Morten, within Melaka City Centre	Timber (80%), Brick with cement plaster (20%), asbestos free roofing	90% Mostly timber related defects

ACKNOWLEDGEMENT

We extend our gratitude to the Universiti Sains Malaysia's RCMO office for approving the funding in publishing this paper. The publication of this paper is made possible through USM RCMO's HEPG program. The author also would like to thank all the individuals for the involvement in this study directly or indirectly.

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