SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Assessing the Effects of Insect Attacks on Buildings and Practical Corrective Measures

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ARTICLE INFO

Article history:
Received 3 March 2024
Received in revised form 15 June 2024
Accepted 30 July 2024
Available online 15 August 2024

Keywords:
Termite attack; building defects; timber flaws; building inspection; structural damage

ABSTRACT

Termites are a vital component of the soil ecology and are present worldwide. They enhance soil acidity, organic carbon content, water content, and porosity in their native habitat through the decomposition of organic matter. Nevertheless, they have the potential to detrimentally affect human well-being through the destruction of vulnerable wooden constructions, subterranean cables, earthen dams, irrigation channels, and agricultural machinery. This study focused on examining the consequences of insect infestations on the stability of structures and the presence of construction defects. Several residences in specific rural areas, urban centres, and municipalities throughout various regions in Malaysia had been chosen for assessment. An evaluation was conducted on the harmful types of termites and the inherent resistance of construction timber. An assessment was conducted to determine the extent of the timber destruction. Each unit underwent inspection to detect the existence of termites and any impairment caused by termites. Termites were discovered to infiltrate structures through various means. These methods involved drilling holes in walls, manoeuvring through fissures in the base, and scaling the rooftop. In order to avert termites from entering structures, it is necessary to employ different strategies. Prior to commencing building, it is necessary to remove all nests and wood that is suitable for consumption from the site. Prior to commencing development, timber must be chosen based on its inherent repellent properties, when the process of clearing has been finished.

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https://doi.org/10.37934/araset.50.1.117

1. Introduction

Construction faults in buildings are described as the failure of structural and non-structural components due to design, materials, or systems, resulting in property damage, economic loss, injury, and other negative consequences [1]. The reasons of construction failures can be classified into four primary categories: mechanical, biological, chemical, and natural disaster elements [2]. Buildings can have two categories of defects and damage: structural and non-structural. Structural flaws refer to physical harm to the specified load-bearing components of a building caused by the failure of such components, which in turn affects their ability to bear weight [3]. The load-bearing performance is compromised to the point where the building becomes hazardous. The building structure has an intrinsic fault that poses a threat to the safety of its users [4]. For instance, the deterioration of the roof structure and the presence of damaged columns or beams in the building have directly rendered the building non-functional [5]. Professional consultants will immediately monitor these cases in the structure. Non-structural flaws can be found in various construction components, including roofs, walls, columns, beams, windows, doors, floors, staircases, and aprons [6-10]. The extent of the damage does not compromise safety, but it is necessary to restore it in order to optimize the building's functionality.

For instance, the process of paint peeling and the breakdown of lime mortar only require minor repairs and regular maintenance. Biological elements, particularly in timber materials, lead to structural flaws in buildings. The biological ramifications of insect infestations on wood can significantly differ based on the specific insect species attacking the material [11]. However, common culprits include carpenter ants, sea borers, wood beetles, and termites, all of which can cause harm. Wood beetles and termites, the prevalent and hazardous pests of wooden structures, may thrive and multiply in temperatures of 20°C and relative humidity exceeding 60% [12]. Damp basements, attics, and sheds can become damp owing to moisture caused by inadequate insulation, water pipes, or leaky gutters on the exterior of structures [13]. Contrary to fungus, effectively managing insects with wood MC is more challenging due to their ability to survive for multiple years undetected and cause internal damage to wood. Hence this study was conducted to examine the consequences of insect infestations on the stability of structures and the presence of construction defects.

2. Methodology

2.1 Methods Employed

Research technique refers to a systematic and in-depth approach used to carry out a case study, survey, or literature review. This study employs case studies as a methodology to gather detailed information on numerous research issues. The researcher selects a specific house located in Kampung Ayer Hitam, Pulau Pinang, and conducts observations to assess its current condition. The research approach employed in this study involves doing a comprehensive literature review, gathering material from many sources such as journals, papers, the internet, and prior research studies. The aim is to determine the defects present in the house.

2.2 Research Setting

This research will involve selecting a case study that exhibits specific features indicating that the structure is being compromised by an insect, resulting in structural defects. The researcher will select an appropriate case study to investigate a structure that experiences a decrease in strength because of insect infestation. In this case study, the researcher will undertake observations by examining the

flaws present in the chosen residence. Researchers will employ visual inspection and utilize appropriate diagnostic tools, such as moisture meter, borescope, infrared camera, ultrasonic testing equipment, hammer, and flashlight, to immediately observe and diagnose flaws resulting from insect bites. Furthermore, the researcher employed the literature review approach to gather data from many sources like journals, papers, the internet, and previous research projects to determine the flaw in the house. A literature review is a crucial step in research that serves to uncover issues within a certain field of study and establish comparisons with pre-existing theories. Using this approach, the researcher will collect data to acquire a deeper comprehension prior to undertaking an inquiry about structural weaknesses caused by insect infestations with varying attributes. By employing this approach, the researcher can detect multiple flaws in the structure.

2.3 Data Collection Method

2.3.1 Literature review

In this approach, the researcher will gather data by examining various sources of prior knowledge, including journals, articles, online publications, websites, and relevant books. These supplementary resources offer valuable data gathering and the necessary information to address certain research difficulties, all of which will be documented by the researcher. Thus, this secondary data collection will serve as a standard against which the initial data collection will be measured. An essential step in conducting a research study involves acquiring information by thoroughly reviewing the existing literature on the research topic.

It is noteworthy that academics generally perceive undertaking literature research as demanding, time-consuming, and difficult. However, it can yield immensely rewarding results. The literature review is an essential and influential stage in the research process that has a major impact on the subsequent stages. Furthermore, the literature review had been analyzed and contrast the outcomes of previous study to ensure that no same results are obtained by the end of the studies.

2.3.2 Case study

Observation is an essential technique for detecting and evaluating architectural flaws. Building defects involve a wide range of problems, such as poor craftsmanship, decaying materials, structural difficulties, design flaws, and maintenance issues. To precisely detect and rectify these flaws, a comprehensive and methodical procedure of observation is required. A qualitative research methodology was employed. A crucial aspect of this research involves assessing the present state of the facility using a building condition survey.

A comprehensive analysis of the various types of flaws that can be identified in wooden structures was generated. Inspections are conducted using Visual Inspection or Condition Survey Protocol 1 to identify flaws in the construction of conventional timber buildings. During the examination, various significant details regarding the history of the structure were considered. These included the ownership of the structure, the dates of its construction and completion, the type of wood used in its construction, any information regarding the maintenance of the property, and any other pertinent data collected.

3. Agent of Insect Defects

Insect attacks are a prevalent issue that typically affects both the structural and non-structural components of timber structures. The insect attacks, commonly referred to as woodworm, are agents

that pose a threat to timber by causing it to lose strength and decay. The majority of beetles can be located within the cavities of timber. The larvae that burrow into the wood in their quest for nourishment upon hatching are the primary source of damage. The following insects provide a threat to timber: termites, wood-boring beetles, and carpenter ants.

3.1 Termites

Termites (Figure 1) also referred to as 'white ants' are highly organized insects that establish complex social structures. In fact, they have no connection whatsoever to ants. Two termite species that are of conservation significance are soil termites and dry wood termites. One species constructs its nests at ground level, whereas another species is capable of flight. Termites pose a significant threat to timber structures. If not controlled, they have the potential to cause significant harm due to their consumption of cellulose, a substance found in wood. Termites have the ability to excavate the interior of beams, posts, and other wooden components of a log structure, thereby diminishing its structural integrity. Termites are prone to tunnelling through aged or untreated wood, creating holes and using them as pathways, particularly within walls. Furthermore, termites also migrated between the inadequately constructed foundations. Termites have the ability to infiltrate gaps between the foundation and walls of buildings, even when these areas are not suitable for them to feed on. Termites will significantly weaken the structural integrity of the wood. Signs of termite infestation are visible on the extensions of foundations, walls, timber columns, rafters, beams, and other structural elements [14].

Fig. 1. Termites

Furthermore, an additional consequence of termite infestation is the production of a noxious odour in both the load-bearing and non-load-bearing components of structures, resulting in the formation of blisters or discoloration on walls, columns, and other surfaces [15, 16]. The reason behind these termite attacks is that once their leaders or colonies discover a location with a potential food source, they gradually consume all the edible wood, leaving only the exterior layers behind [17, 18]. The rationale behind preserving these outer layers is to offer a habitat for the termites residing within the wood. Figure 2 shows the effect of termite attack on wooden flooring while Figure 3 demonstrates termite attack on timber wall. According to Figures 2 and 3, termites mostly remove palatable wood, which will provide space to fill the remaining thin outer layer and maintain its rigidity. The massive number of mound-building termite nests makes their attacks on timber construction extremely destructive. They usually eat the nutrients in wood, which leads to the integrity of the wood itself being low in terms of strength [19, 20].

Fig. 2. Termite attack on wooden flooring

Fig. 3. Termite attack of timber wall

3.2 Wood-Boring Beetles

Wood boring beetles (Figure 4), sometimes known as boring beetles, belong to a genus of insects that feed on wood by burrowing into it. Upon reaching maturity, the larvae of this species undergo a transformation into fully-developed beetles. However, before to this stage, they reside within the wood [21]. The term "woodworms" is the most used word for furniture bugs, however there are other names as well. Several kinds of beetles, such as deathwatch, longhorn, and powder post beetles, tunnel into wood to deposit their eggs [22]. Upon consuming the wood, the larvae undergo metamorphosis and mature into adults, constructing galleries and tunnels. Over a period of time, this activity might potentially compromise the strength of the wood and lead to structural issues [23]. The beetles excrete frass through the holes they bore into the affected wood. This material commonly accumulates in fissures or below fissures in structures. Frass can vary in texture from exceedingly fine to rough.

According to Figure 5, wood-boring beetles typically infest structural softwoods. Contrary to its name, it is often a concern with newer projects that utilize wood that is contaminated. Wood that is not properly treated, kiln-dried, or stored for a long time becomes susceptible to damage. This insect readily infests structural timbers. Most wood borers typically produce raised, circular holes, however they may occasionally make oval or semicircular holes. The dimensions and morphology of the cavities that appear can aid in distinguishing clusters of beetles. Wood boring beetles specifically target subflooring, hardwood floors, interior trim, joists, sills, and beams for their assaults. Potential targets may encompass tool holders, hardwood furniture, staircases, and other wooden objects.

Fig. 4. Wood-boring beetles

Fig. 5. Bore-holes defects

3.3 Carpenter Ants

Carpenter ants (Figure 6) are insects that primarily inhabit and construct their nests in wooden structures, both outdoors and indoors. These ants destroy wood to create empty spaces where they can construct their nests. Carpenter ants, unlike other insects, often do not actively attack or consume wood. Instead, they tend to undermine the structural integrity of wood and mostly infest trees that are already damaged. Carpenter ants construct colonies on the property when they discover a source of food. If this incursion is not swiftly dealt with, it rapidly escalates into a major infestation [24]. After excavating holes in a direction opposite to the natural pattern of the wood, they transport the wood shavings to a separate location that is not near the wooden tunnels. Homeowners may find it more challenging to locate their nest following the removal of wood chips, since only a little oval hole remains within the wood.

According to Figure 7, carpenter ants will exploit any opening in the structure. Carpenter ants have the potential to significantly compromise the structural integrity of buildings. Long-standing infections might lead to significant repercussions. While termite infestations are more destructive than ant infestations, it is still essential to take preventive steps to prevent structural collapse caused by the ants' tunnels in our homes [25]. These critters possess the capability to cause significant damage to structures, however they are typically more of a nuisance than a structural concern.

Fig. 6. Carpenter ant

Fig. 7. Damage due to carpenter-ant attack

4. Origin Defects and Practical Corrective Measures

4.1 Termites

Termites gnaw on wooden structures like posts, beds, and other structures to destroy them year after year. They live in colonies and individuals cannot exist without contact with the colony. Some species have nests made of wood, while others build mound-like structures on the ground or underground [26]. Almost all species of subterranean creatures that attack tall trees are susceptible to termite damage, and wood in contact with the ground is most vulnerable. Termites are attracted to moisture and cellulose-based materials such as wood. Buildings are often penetrated by cracks or contact with the ground wood.

Foundations are built using resistant materials such as brick, steel or concrete slabs to make termite tunnels visible. All foundation walls and columns must be installed with termite shields (Figure 8) made of durable materials such as crushed stone, steel casing or stainless-steel mesh. Termite shields should be installed with a protrusion of 2 to 3 inches beyond the wall on all sides as shown in Figure 9. Soil treatment can result in the concentration of toxic materials in the soil

surrounding the foundation and columns [27]. Durable chemicals are no longer registered for such uses, so modern chemicals must be reused to maintain protection. A network system or hand-sprayed chemicals can be used to reapply, with special pipes hidden inside the building for reinforcement.

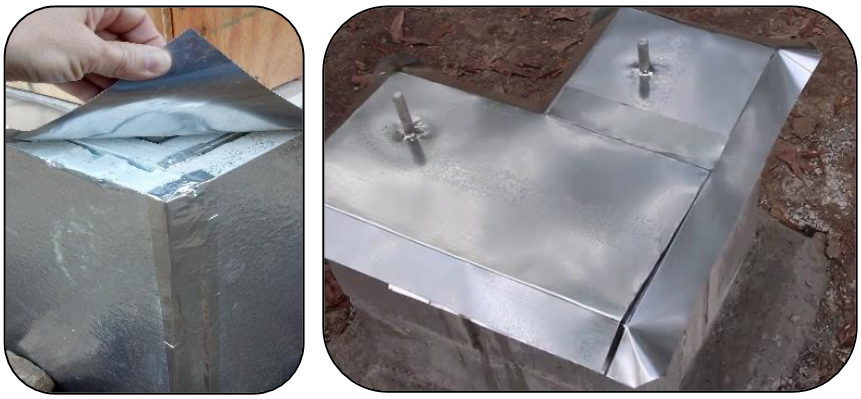

Fig. 8. Termite shields

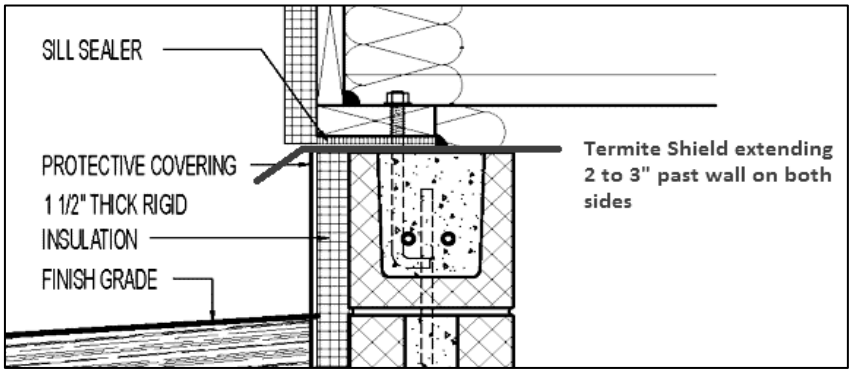

Fig. 9. Installation of terminate shield

4.2 Wood-Boring Beetles

Wood beetles can cause damage, resulting in the formation of numerous "bag holes" on the top of the wood surface. Small pieces of sawdust created by the larvae in the tunnels can be filtered out of the holes by hitting or disturbing the wood. Cutting down an infected tree frequently reveals many tunnels filled with debris. Subfloors, hardwood floors, interior trim, joists, sills, and particularly joists are susceptible to attack [28]. Attacking hardwood furniture, tool handles, ladders and other wood products is another issue that can be attacked. Log houses are particularly vulnerable. The higher wood moisture content in vacation or recreational areas, caused by intermittent heating or poor ventilation, makes them more susceptible to beetles [29]. Wood beetles deposit their eggs into wood and then consume them to feed on their larvae, resulting in structural damage.

Wood beetle attacks are not always prevented by the concealed feeding behaviour of larvae. This is a risky practice [30]. The risk of infection can be reduced by using seasoned wood in construction and inspecting the wood as well as other types of wood before buying. Sealing exposed wood surfaces with a protective layer of polyurethane (Figure 10), varnish or paint also prevents species that can re-contaminate the structural wood from spawning. Additionally, firewood must be debarked, stored outside, and brought home only immediately before use.

Fig. 10. Protective layer of polyurethane

4.3 Carpenter Ants

Carpenter ants are common home pests. Carpenter ants help break down dead and decaying wood in their natural habitat. They usually nest in hollow trunks, stumps, and trees. However, the large, dark-coloured workers often attack homes in search of food [31]. Although these ants do not usually dig holes in dry solid wood, they can create satellite nests by digging into damp, rotting wood and soft materials such as foam insulation boards. it is rare for structural timbers to suffer damage from expansion in sockets [32]. Houses built in the forest are particularly vulnerable to attack. Nests are made by digging wood by carpenters, which can cause damage to buildings over time.

Remove stumps, logs and wood waste from buildings less than 100 meters away. Don't allow plants, especially shrubs and evergreens, to contact the house. Leave the house and keep firewood away from the house, bring it inside only when needed. Keep the woodwork and other structures of the house dry by making necessary repairs to the roof, rafters, gutters and water lines. Repairing damage caused by water and rotting wood. Generally, carpenter ants do not attack solid wood with less than 15 percent moisture content. Make sure the exterior of the wood is painted and sealed. Cover the holes where pipes and wires enter the house. For structural parts in ground contact, use pressure treated lumber. Provide adequate ventilation and install plastic sheeting moisture barriers under crawl spaces and wood porches as shown in Figure 11. Alternatively, cover the area with water.

Fig. 11. Vapour barrier and insulation to crawl space

5. Procedure for Conducting Defect Evaluation

5.1 Visual Inspection

Begin by conducting a visual inspection of the timber. Look for small, round exit holes in the surface of the wood. These holes are usually left by adult insects when they emerge from wood. Check for tunnels or galleries in the woods. These are the pathways created by the larvae as they feed and move through the wood. The pattern and size of the tunnel can vary depending on the type of insect. Check for any surface damage such as irregularities, cracks, or weak areas that may indicate subsurface insect activity.

5.2 Identify the Insects

Try to identify the type of insect that is responsible for the damage. Different insects can cause specific types of damage, so knowing the cause can help determine the extent of the infestation and appropriate treatment. For example, small beetles are insects that lay their eggs in the cracks and crevices of wood. Larvae burrow into the wood, creating tunnels filled with fine powder. The exit hole is usually round and about the size of a pinhead.

5.3 Assess the Damage

Check if the infestation is active or if the insects have left the wood. Assess the structural integrity of the wood and whether any repairs or replacements are necessary Determine the scope of the infestation by identifying areas of the wood that show signs of insect activity, such as exit holes, tunnels, frass, or discoloration of the wood. Assess whether the infestation is localized or widespread throughout the wood. Evaluate the structural integrity of the wood by checking for signs of weakness, rot or holes caused by insect damage. Pay attention to any soft or spongy areas, as well as cracks or splits that can affect the wood's strength.

5.4 Probe the Timber

When surveying wood for signs of insect damage, it is important to follow a systematic approach to assessing the extent of infestation. Use sharp tools like screwdrivers, awls or knives to probe the wood. Make sure the tool is clean and sharp to easily penetrate the wood and locate any soft or hollow areas. Identify areas of wood showing visible signs of insect activity, such as holes, splinters, or discoloration. Focus on this area to research, as well as any spots that feel weak or damaged. Slowly insert the probing tool into the wood at a slight angle to prevent additional damage. Gradually push the tool into the wood, feeling for resistance that may indicate insect tunnels.

5.5 Measure the Depth of Damage

Measuring the depth of damage caused by insects involves assessing the extent to which insects have penetrated or affected a substrate, such as plant tissue, wood or stored products. The depth of damage can vary depending on the type of insect, its feeding habits, the composition of the substrate, and the duration of the attack. Visually inspect the surface of the substrate for signs of insect feeding, boring or tunnelling. Use a probe or knife to gently probe the substrate and determine the depth of the damage. The probe will encounter resistance when it reaches an undamaged substrate, or a different texture caused by insect activity. In addition, take a cross- sectional sample of the substrate

and examine it under a microscope to assess the extent of damage and visualize insect galleries, tunnels or frass.

5.6 Consider Treatment Options

Based on the type of insect infestation and the extent of damage, consider your options for treating the timber. This could include chemical treatments, heat treatment, fumigation or physical removal of the affected areas. For example, apply insecticidal compounds, such as botanicals, synthetic chemicals, or microbial agents, to directly target and kill pest insects responsible for damage. Treat affected materials or structures with gaseous insecticides to penetrate crevices and inaccessible areas and eliminate hidden insect infestations and physically destroy insect-infested materials or structures to eliminate pests and prevent further damage spread.

5.7 Monitor and Prevent Future Infestations

After treating the timber, monitor it regularly to ensure the effectiveness of the treatment. Take preventive measures such as storing timber in dry, well-ventilated area, applying protective coatings, or using insect-resistant wood species to prevent future infestations. Such as, setting up a routine schedule to check structures, materials or plants that are exposed to insect stings. Additionally, conduct a thorough inspection, focusing on potential entry points, hidden areas and signs of insect activity, such as damage, frass, or pest sightings. Use sticky traps, pheromone traps or light traps to capture adult insects and monitor population levels.

6. Propose an Action Plan for Insect Attack Avoidance

As for the remedies to reduce or mitigate the insect attacks in the future, we can do the action plan on our own, or call pest management to do some remediation purpose to our home. Insect attacks as mentioned have many ways of weakening the strength of the structural and non-structural elements of our timber building.

6.1 Moisture Content Prevention

As with rot, the best long-term approach to managing an infestation is to eliminate the initial environmental factors that support insect growth. Lowering the moisture level of the wood and the surrounding area is the easiest method to achieve this modification. The insects will be born inside our buildings if they see or feel a wet area around them. The wet area inside our buildings usually happens after the leakage spreads to our structural elements, and if there’s no immediate action taken to that defect, the moisture will come out and it will invite insects to spread. By that, the best we can do is to do an immediate maintenance to the defects that will make a leakage spread inside our buildings. We can take immediate action by doing a replacement for improper ceiling placement that makes the leak spread after the heavy rain. Maintaining the integrity and waterproofness of the roof, particularly where the roof levels change, at the vents, and at the chimney flashing. include vapor barrier installation, and checking for leaks in plumbing, and heating pipes.

6.2 Chemical Control

Apply chemical treatments to prevent long-standing insect pests from inflicting more harm and to aid in the initial eradication of infestations. This method usually involves the use of chemical elements which is for kill the pest or other essential behaviour. Natural items, synthetic materials that approximate natural things, or entirely synthetic materials can all be utilized as chemicals in chemical management. When applying, precaution should be taken to make sure the treatment comes into contact with the insect long enough to kill enough of it to render the colony non-viable. Synthetic chemical pesticides play a major role in the majority of integrated pest management approaches. Chemical treatments are effective because they may swiftly bring big pest populations down to manageable levels and are often simple to administer.

6.3 Spraying

Furniture beetles will react more favourably to the agent's application on wood surfaces than other pest species. To help the sprayed treatment stick to the wood, keep the applicator nozzle close to the wood and apply the chemical at a low pressure. Whilst the termites have colonies inside the timber elements, we should do an inspection which is to locate the exact location of their lives or colonies. After that, the EPA-approved insecticide formulations can be applied to spraying through the termite colonies. Depending on the substance applied, the pesticide may go deeper or stay close to the surface. Only adult insects emerging from wood or trying to re- enter wood are affected by insecticides that stay close to the surface. Below the wood's surface, larval growth is frequently ongoing. Intense infestations of wood-boring beetles are typically uncontrollable by non-penetrating surface treatments.

6.4 Fogging

Chemical fogging treatments are especially helpful when treating wide regions since they target the eggs. While misting might be effective in some circumstances, it is unlikely to reach eggs kept in difficult-to-reach locations, necessitating repeated treatments. Misting and smoke treatments have the drawback of being far less targeted than spray or injection techniques.

6.5 Immediate Control Treatment

If we as an occupancy see the insect colony, we must immediately take action to eliminate their colonies. For example, we need to use a wood treatment or related to that to apply on our timber structures if termites are seen indoors. In addition, the control is by far the most effective way, which is we will ensure to prevent the spreading of insects around the timber structure. As occupancy in our houses, we need to ensure and prepare for insect attacks, which means we also need to inspect our buildings for at least one month which is to see through our structural members if there’s a colony of insects to grow.

6.6 Replacement of New Structures

The most widely used methods to control beetle infestations in wood include temperature treatment, fumigation, surface chemical application, and replacing infested wood. If the infestation is under control, replacing the contaminated wood is often a wise choice. Any wooden furniture or

structure should be removed or replaced when it makes sense. Replacement reduces the chance of infection spreading or recurring and eliminates any obvious major damage in the finished building. This method is the best way to prevent any continuous damage occur in the wood. This method is also used by the occupancy if there's no other way to prevent or repair the physical damage of the structural members. The only choice is to replace them with new structural members which will take a higher cost. For the replacement of new timber elements, it is advised to the contractor to buy high-graded timber and ensure the timber elements are in good condition which means there are no minor or major defects to the timber that may be caused spreading of insects.

6.7 Coating

Another prevention method to apply is coating the buildings with the coating insect product or painting. Ensure that all your furniture's exposed wood and paint have a fresh layer of varnish or paint on it. Once the wood has been finished painted, coated, waxed, or covered with other materials most wood-boring beetle species will not re-enter it. Be clear of using firewood or any new wood insect sources [33]. Adult beetles and other pests may emerge from wood temporarily stored indoors and cause damage to wood, structural furniture, or general annoyance. Usually, applications consist of applying a water emulsion twice, with the second application occurring before the first one dries entirely. Applications made to unpainted wood surfaces will permit some wood penetration.

6.8 Post Treatment Action

Post-treatment action on the new timber structure is one of the important steps to consider ensuring the longevity of the structure [34]. By implementing the coating, spraying, painting, etc, it is important to take certain remedial action to ensure re-infestation does not occur. These steps include:

i. Ensure all decayed timber replaced: The most important part is to ensure the decayed timber is already replaced with a new one. It is an important part to consider since insect attacks are more likely to spread in the decayed timber itself. The replacement is not only to maintain the strength of a building, but it is also to prevent any possibility of insect attacks in the future.
ii. Resource of moisture removed: Another benefit is that this will enhance a building's general health and reduce the possibility of re-infestation [35]. Long-term success with pest management is uncertain if sufficient corrective action is not taken to address moisture and damp infiltration [36-38].
iii. Continued monitoring: To make sure the pest has been eradicated entirely, it's critical to continue keeping monitoring on the area that was afflicted before treatment [39]. Further environmental controls or the application of cost-effective chemical treatments may be required if there is ongoing evidence of insect activity [40-42].

6.9 Crawlspace Foundations

Thoroughly considering the building of foundations is crucial in safeguarding against termites and should be given significant attention [43, 44]. It is imperative to construct all foundations with maximum resistance against termites [45]. Additionally, it is advisable to employ lightweight foamed concrete as the crawlspace foundation [46-50]. The most resilient foundations are those made of poured concrete walls and piers that are adequately strengthened to prevent significant shrinkage

or settlement fractures [51-54] as illustrated in Figure 12. Termites are capable of exploiting fissures with a minimum width of 0.8 mm. The most durable specimens of this variety are topped with fortified poured concrete measuring a minimum of 10 cm in thickness as shown in Figure 13. Substitute extensively deteriorated (structurally compromised) sills, joists, flooring, etc., with solid wood [55-57]. Whenever feasible, eliminate all dirt within 46 cm from joists and 30 cm from girders.

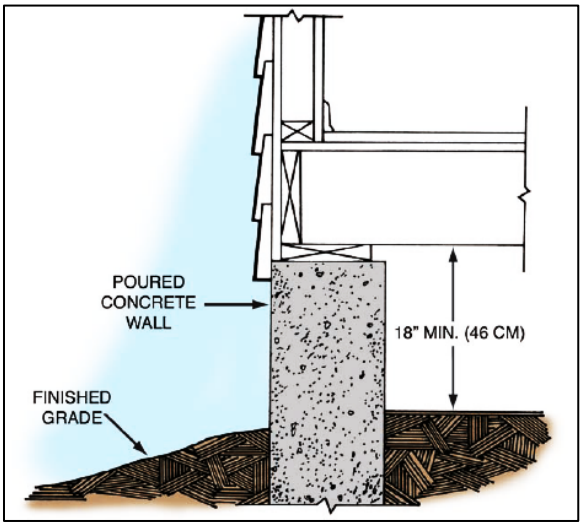

Fig. 12. Concrete walls and piers can be readily examined for concealed termite incursions [58]

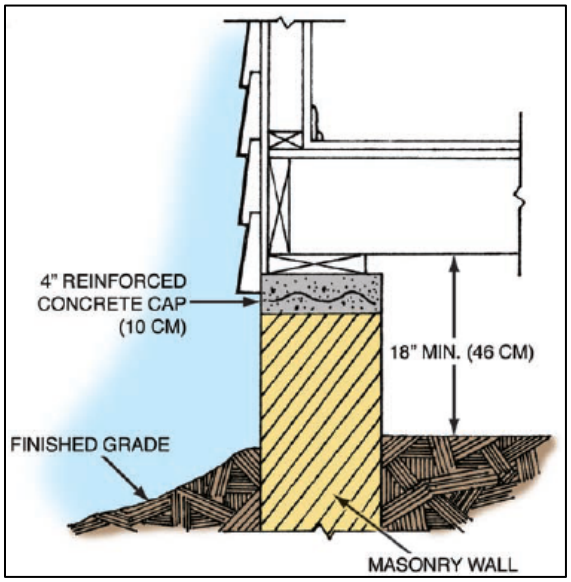

Fig. 13. Use of a concrete covering on masonry walls serve as a preventive measure against covert termite infestations [58]

7. Conclusions

Timber structures can experience a decrease in strength due to faults caused by insect assaults. These insects use the minerals found in wood and establish their colonies within it. Building faults and damage can be classified into two categories: structural and non-structural. Structural damage occurs when the load-bearing components of a structure fail, causing the structure to become unsafe and unable to support its prescribed load. Subsequently, a multitude of insect infestations can be observed in our lumber. These insects not only do harm to the integrity of our building structure but also result in a decrease in the strength of our timber. Termites are the predominant insects that provide a significant issue due to their capacity to consume the nutrients present in wood, unlike carpenter ants. Wood-boring beetles are another type of insect that might be found in our building. It can be inferred that insects are prone to inhabit their colonies within decaying or fractured timber. Ultimately, they will utilize that location as their primary domain. The inspection can be conducted using a range of tools, such as a moisture meter, borescope, flashlight, hammer, infrared camera, and ultrasonic testing equipment. The occupants can implement multiple measures to ensure the long-term durability of their structure. The process involves doing a visual examination to identify any existing flaws or imperfections in the structure of the building. If the damage is caused by insect infestation, proceed to the subsequent stage, which involves identifying the specific bug species inhabiting the building structure.

The next stage is to assess the extent of the damage, determining if the infestation is confined to a specific area or has spread across the entire wooden structure. Assess the structural soundness of the wood by examining for indications of weakening, decay, or perforations resulting from insect infestation. The subsequent stages involve examining the timber, assessing the extent of the damage,

evaluating treatment options, and finally, monitoring and preventing future infestations. Finally, the occupation must also consider the measures performed after all insect attacks have occurred in the structure. To maintain the integrity of their construction, the most effective method is to prevent moisture content. This procedure is commonly employed to eliminate the potential for insect infestation in a specific section of the wooden framework. By consistently addressing any problems that could cause the propagation of leaks within our facilities through regular maintenance. To address the issue of water leakage caused by inappropriate ceiling placement, we should promptly replace the affected areas to prevent further spread of the leak following severe rainfall. Additionally, alternative techniques can be employed, including chemical control, spraying, fogging, immediate control treatment, coating, replacement of the existing structure, and finally, post-treatment measures should be considered by the occupants.

Acknowledgment

The authors thank the financial support provided by the Ministry of Higher Education, Malaysia, for this research work through the Fundamental Research Grant Scheme Grant Ref. No. FRGS/1/2022/TK01/USM/02/3.

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