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Conservation and Repair Works for Traditional Timber Mosque in Malaysia: A Review on Techniques

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***Abstract*—**Building life cycle will never be excused from the existence of defects and deterioration. They are common problems in building, existed in newly build or in aged building. Buildings constructed from wood are indeed affected by its agent and serious defects and damages can reduce values to a building. In repair works, it is important to identify the causes and repair techniques that best suites with the condition. This paper reviews the conservation of traditional timber mosque in Malaysia comprises the concept, principles and approaches of mosque conservation in general. As in conservation practice, wood in historic building can be conserved by using various restoration and conservation techniques which this can be grouped as Fully and Partial Replacement, Mechanical Reinforcement, Consolidation by Impregnation and Reinforcement, Removing Paint and also Preservation of Wood and Control Insect Invasion, as to prolong and extended the function of a timber in a building. It resulted that the common techniques adopted in timber mosque conservation are from the conventional ways and the understanding of the repair technique requires the use of only preserve wood to prevent the future immature defects.

***Keywords*—**Building conservation, conservation principles, repair works, traditional timber mosque

I. Introduction

BUILDING conservation has long been of concern, although its popular application is relatively recent in origin, particularly in Malaysia [1]. The field of conservation had gained place in 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 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. For heritage 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 buildings' heritage value [2].

Malaysia enriched with various and unique building design indicates the existing multi culture nation. Mosque, as one of the local architectural heritage had contributed for the sustainability of architecture in this country. The conservation of old mosques particularly with traditional vernacular design is as important as conserving other historic buildings. Some of the old mosques had transformed the building materials, some of it had been neglected but mostly they retain the originality of its structure. The old mosques, built using famous local hardwood, undeniable for its unique and displaying fine carpentry skills are rarely seen today.

Mosques, as with the other older building are also affected to defects and deteriorations, due to 'wear and tear' process. The problems can be seen seriously found in a building with no maintenance carried in such a way. Typically, defects that often struck wood buildings, especially in tropical country mainly caused by moisture problems and biological attack, such as termite and decay fungus. A continuous exposure to these environmental agents and pests without proper preventive measures will rapidly dilapidated buildings [3] and [4]. In carrying out a repair work, it is crucial to understanding the cause of defects as to ensure the best way to achieve improvement. In fact, understanding the causes and agents of defects can reduce the risk of greater damage [3]. Building defects must be viewed comprehensively and failing to identify building defects can cause a wrong repair selection [5] and [6]. Repair works should be carried accurately with the kind of defects and it must not intervene the values of the cultural heritage [7].

In any conservation program, authenticity of a cultural heritage had always been emphasized. To maintain the originality of materials, the architecture, history and its characteristics are some aspects that often emphasized in building conservation projects. It is important to best select the repair and conservation technique particularly for wood

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structure as to met with the conservation objective thus prolong the usage and retain the heritage value of the material.

II. Conservation And The Concept

Growing concern for a sustainable building conservation, one should realize the outcomes of preserving the historical building stock. Highlighted in [8], it contains two activities; to care and safe guard from being destroyed or changed without careful planning. Thus, conservation work is one of the historical resources medium which keeping up the physical evidence for our future generation.

According to [7], conservation practice requires technically and scientifically knowledge of how decay occur and how to eliminate decay. The definition broaden from technical aspects to the dynamically planning and management process to prolong life of the historic buildings.

Conservation must preserve and if possible enhance the messages and values of cultural property. These values help systematically to set overall priorities in deciding proposed interventions, as well as to establish the extent and nature of the individual treatment [7]. The authenticity is highly emphasized to ensure a cultural property is worthy to conserve. Emphasized by [9], a heritage must be restored to its actual or original historical evidence as it is part of materials documentation that allow an assumption about the past. According to [10], four (4) authenticity aspects in conservation practice that need to be considered outlined by ICCROM (International Center for Study on Preservation and Restoration of Cultural Property) which is material, design and architectural, the quality of workmanship and manufacturing technique and the originality of layout and construction. Materials from the past contained undocumented information and technology thus assessing its authenticity are important in conservation. This was stated by [11], in which, the conservation practice should be based on authenticity, thus preserving of material should be made according to its original material which includes the type, color and texture. As to [7], a cultural property may experienced a diversity of transformation hence, requires the concept of authenticity in design and architectural. This contains the study to identify the original structure, design and architecture and the relation with the environment. Authenticity in layout and construction needs to give a true picture of its original form and experience relations with the historical events. The authenticity in this term determined through an archaeological research [8]. Meanwhile, the authenticity in workmanship is to preserve the originality of craftsmanship and manufacturing technique which are in scarce in number.

III. Principles And Approaches Of Mosques Conservation

The key element of conservation activity will never escape with repair and maintenance work. As in [12], revealed that there is lack of technical knowledge in repairing and maintaining historic buildings. This is a major problem because almost all conservation jobs involve both repair and maintenance stages requiring an understanding of and analysis of building defect diagnoses.

The life cycle of historic building justifies its historical values. Thus, intervention is required to be at minimal and controlled as it would lead to the loss of its original values in cultural property. Highlighted in the [13], six principles of high quality building conservation explain as:

1) Retain cultural heritage significance
2) Use traditional techniques and materials
3) Use appropriately experienced and skilled contractors
4) Do only what is necessary
5) Retain repair authentic fabric
6) Readily identify new work

The principles are uniquely reflected to the aim of the conservation work which is to retain the significance of places. Heritage places should be accorded the utmost care to protect their understanding values [13]. As explained by [14], a conservation work successfully carried if it complied with the basic principles of conservation. Therefore, conserving a heritage should always apply with the right techniques and conservation methods. [14] also suggests four (4) key principles that should always practiced in conservation work in Malaysia, which is:

1) Minimal intervention. As in (Burra Charter Article 3, 1979) sets out ".... *the Conservation* is based on a respect for the existing *fabric, use, associations and meanings. It requires a cautious approach of changing as much as necessary but as little as possible…".*
2) Conducting scientific research and laboratories testing. As contained in the ICOMOS, Article 12, 1998 that outlined ".. *conservation should be based on appropriate research and physical investigation which should as far as possible, a non destructive..*" and Article 10 (e) .. ".. *intervention should always be preceeded by appropriate research, investigation and recording* ".
3) Documentation of conservation work. This is contained in Article 10 (f), ICOMOS 1998 which outlines .. ".. *Conservation records should always be maintained, kept with the documentation of the building or site and deposited in an appropriate archive..".*
4) Applying effective methods and techniques. In Clause 4, Article 4.1 and 4.2, outline in Burra Charter ".. *Conservation should make use of all the knowledge, skills and disciplines which can contribute to the study and care of the place..*" and ".. *Traditional techniques and materials are preferred for the conservation of significant fabric. In some circumstances modern techniques and materials which offer substantial conservation benefits may be appropriate....* ".

In principle, the existing condition of the mosque should technically be inspected before any further remedial work for conservation takes place. Once the affected condition is identified, the underlying judgment will be drawn precisely. Generally, there are seven (7) approaches in a conservation program, used individually or combined, depend on the circumstances and objectives of a conservation project. The approaches are conservation, preservation, restoration, maintenance, redevelopment, rehabilitation and consolidation [15] - [17].

There are several approaches used in preserving religious buildings. The most common approach used particularly for mosques are conservation, preservation, restoration and

maintenance. Experienced from the Old Tinggi Mosque in Bagan Serai, Perak, the conservation work was successfully restored to its original features which include the building material, design and location. In some cases, the environmental aspect had contributed to the improvement of the mosque as well, for example the Kampung Laut Mosque in Nilam Puri, Kelantan which had undergone for restoration work and relocation due to the threat of natural disasters (See Fig. 1and 2).

It is not simply 'putting the principles into practice' as some approaches are inapplicable in conserving a mosque. The restoration approach as referred in Article 1.7, Burra Charter (1999) ".. means returning the existing fabric of a place to a known earlier state by removing accretions or by reassembling existing components without the introduction of new material…". In accordance to [18], the restoration is defines as an effort to obtain an accurate forms and details of an object through dismantling or replacement of lost with new material. Diversely in conserving old mosque which still in use, particularly, the additional space and structure can be seen clearly as the concept of a mosque is to invite and encourage the presence of congregation. Structures mostly in the permanently form are discouraged to remove and demolition will affect the concept of a mosque. However, its applicable if a justification considered; in which building a new mosque, or it is no longer used or using material which can be differentiate from the original. Meanwhile rebuilding defines as a new construction of what has been lost or destroyed, in the form of the original conditions in terms of its building materials and the details from the original. Any replacement of the missing elements or experiencing severe deterioration must be able to look unite and harmoniously with the overall condition and can be differentiated between the new and original material or elements through a thorough inspection [18].

Fig. 1The conservation of Old Tinggi Mosque, in Bagan Serai

Fig. 2: Renovations and additional structure were supported to the Old Mosque of Kg. Mendun, in Negeri Sembilan.

[19] explained that as conserving on other older buildings, the methods of repair and replacement of lost or seriously damaged of a building elements in a mosque should based on appropriate approach. For replacing a seriously decay timber element, it should be replaced with the same kind of its original material. If insufficient source encountered, replacement by using similar character can be applied. The reproduction concept are use in such if an element had been lost by imitate the design, the character and its material. In consistent with the concept of reconstruction according to Article 1.8, Charter Burra (1999) by returning to a known earlier state and is distinguished from restoration by the introduction of new material into the fabric. Such understanding will come by adopting the nature of the conservation work as our norm.

IV. **R**EPAIRING **T**IMBER **B**UILDING

In any building works, an accurate outcomes are depends on the correct selection of techniques. Appropriate selection of techniques, by considering the basic principle of conservation is a way for a good conservation practice. Conservation work concerned on the preservation of authenticity in a cultural property. To meet the aspects, basic principles have been recognized for any intervention or work carried in such a manner. [20] highlighted the working principles of repairing timber structure, which are as follows:

1) Find and remove the source of problems. The main sources which cause serious defects in wood is moisture [21]. Any severe part affected by defects, probably cause by highly presence of humidity must look on the source of causes. Reseal the leaking roof, gutter, eaves-through or ventilate space, or change according to the condition of the defects.
2) Retain as many original works of old.
3) When repairing roof or floors, pay special attention to the effects of the ceiling's beneath, especially plaster ones.
4) Approach of strengthening of deformed structure with great care. It is too easy to snap, shear, or deform joints, dowels, pegs and so on without

knowing. Securing or stabilizing may be all that is required.

5) Make sure that the timbers which are leaving exposed were meant to be exposed. Many subsequent problems have been caused by the stripping of exterior boards stucco and paint from timbers. Often the stripping is done in the mistaken belief that this was how "the original was supposed to be seen".

As for a basic guidance, the principles are to ensure any repairing works as stayed within the main aim in conservation. Stressed on minimal intervention, hence not all condition required for major replacement by using new materials. Four (4) techniques proven used for repairing timber buildings; a singular or combined technique appropriates to be used in one particular conservation project. The methods are (1) fully or partial replacement techniques, (2) mechanical reinforcement techniques, (3) consolidation by impregnation, and (4) consolidation and reinforcement [20]-[22].

A. Fully and Partial Replacement

Reuse is one of a popular concept used in wood restoration. This can be made in fully or partial replacement. If a structure severely damage by decay, they can be totally replaced or, if some part are still enough these may be retained and patches inserted. The guiding principle should be retained as much original material as possible. Partial replacement is best selected when only certain areas need an improvement The replacement should meet that new and old wood accurately matched according to its species, color, grain direction, and quality of workmanship. Where wood is being partially replaced with new wood, carefully inset into the old where the unsound wood have been chiseled away. Synthetic resin adhesives are frequently used to secure a new piece in place [20].

B. Mechanical Reinforcement System

The technique is to restore the wood by using mechanical connection system. Severely deteriorate wood replaced with a sound new wood and secured with dowels of wood, metal or glass fiber reinforcement plastic. Failed or weak connections can be or replaced by special brackets, angle irons, stirrups and hangers. Missing areas of wood are filled with filler or plastic repair consisting of synthetic resin.

C. Consolidation By Impregnation

Where woods become powdery or friable cause by insects or fungal attacks, the remaining material can be bonded together again by impregnating the wood with synthetic resins. The remaining gap or spaces are also injected with the material. The resins are inserted via drilled holes using large hypodermic syringes or by using bulk loading guns.

D. Consolidation and Reinforcement

The method used synthetic resins with steel reinforcement to reinstate old structural timbers and enable them to carry load, known as BETA system generated from Netherlands [20]. By removing severely deteriorate area, the space if filled with epoxy resin and secure by connected to sound wood using the reinforcement. The method recommended if a timber member is in seriously deteriorate and replacement with new material it will affect its significant and historic values (See Fig. 3 and Diagram 1).

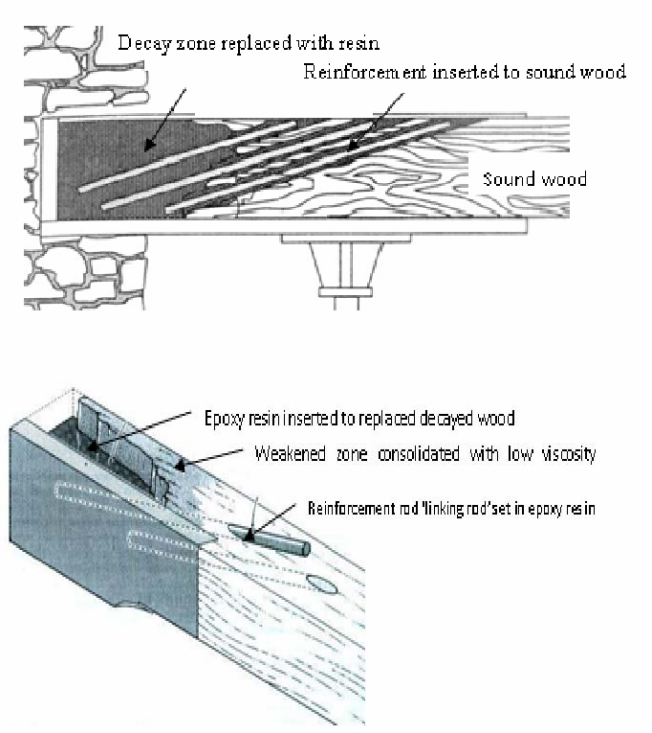

Fig.3: BETA method using wood epoxy reinforcement in restoring and repairing decayed timber beam
(Source: Weaver, 1999 & Ashurt, J, 1989)

There are two following techniques of finishing work for timber repair that are:

E. Removing Paint

Paint has been a popular finishing material used in timber building in Malaysia. In restoring back to its original features, the conservation works need to remove the layers and this can be done through three (3) available techniques which is using paint remover, heat and sander machine (See Diagram 1).

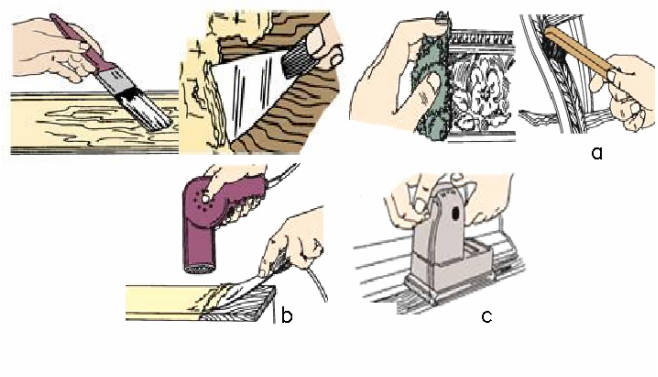

Diagram 1: Removal paint method, (a) using paint remover before any scraping off paint brushing technique; (b) remove by using heat (c) using sander machine (Source: DoItYourself, 1995)

F. Preservation of wood and Control Insect Invasion

Wood preservation frequently used as a protection for woods from being attacked by its biological agents. Three (3) types of preservatives in which are oil-based tar (coal-tar creosote); based on organic solvent (Pentachlorophenol, Naphthenate, Tributyl tin oxide, Organo boron compounds, synthetic pyrethroids); and water based material (copper, zinc, chromium and arsenic, CCA). Copper, chromium arsenic salts (CCA) are the common used in the industry [23].

In preservation techniques, preservative absorption to wood is important thus section with good absorption are usually in good protection. Only affected areas are protected from decay agent. Hence, wood selection should consider the rate of absorption. Preservation process can be done in two ways, either using pressure or non-pressure method through infusion, dipping or brushing. A non–pressure method is commonly a surfaces protection, absorb at certain depth. It will not result for deeper preservatives absorption but mostly used to protect exposed surface from biological attack. It is a mistake, of using brushing techniques applied after a wood member has been erected. Joining area are most affected by the decay agent, therefore protection by applying preservatives to this section should be made first before any erection is made. This should reduce the risk of decay due to the moisture problems that may exist. Where parts or element are exposed to environmental conditions, though technically are directly exposed to rain, the problem reduce by drying process assist by sunlight and wind. Diversely from those hidden parts, protecting from moisture are difficult and usually slowly to dry. Hence, applying preservative to this part is crucial before any erection especially on the connection part. The brushing techniques is a temporarily method as it only last for several years due to continuous exposure to weather and the environment. Hence, preservation methods, combined with from various techniques enable for long lasting protection.

Pest control especially on preserving wood from termites and fungi are not particularly focused to wood, but can be done to the surroundings. The use of pesticide injected to soil at a certain depth or on wooden blocks or bait are another method to eliminate termites attack. Insects such as beetles, removed by using spraying, injection and fogging techniques which this are usually kill the larva. Pesticide from spraying process will absorb to the wood, and larva became less interest to have sap wood as food and eventually died. The techniques for the pest control especially to insects depend on the conditions and location in which appropriately for unreachable space [21].

V. REPAIR TECHNIQUE FOR TRADITIONAL TIMBER MOSQUE

Generally, no special techniques have been documented for repairing mosques. Basically, the timber is restored back to its original condition by removing decayed section and replacement is made by using new sound timber. Each of the conservation for timber buildings are differ in which the selection of techniques depended on the cost, the selected approaches, total building condition and deteriorations and the availability of resources.

A field study has been conducted in identifying the repair techniques and conservation of timber mosques in Malaysia. In the study, six (6) old timber mosques were selected based on the building material and accessibility of getting technical information (see Table 1). Applied repair techniques reviewed and determined the application of conservation principles for such works. Generally, the partial and fully replacement is the common techniques used in the conservation, which is easier to synchronize with the conservation principle; to carry as near as possible of the significance of an element.

TABLE I
THE APPLICATION OF REPAIR TECHNIQUES IN THE CONSERVATION OF TIMBER MOSQUE IN MALAYSIA

Name Of Timber Mosque / Year Built	Repair Techniques			
	Fully And Partial Replace-ment	Mechanical Reinforce-ment System	Consolidation by Impregnation	Consolidation and Reinforcement
1. Masjid Lama Mulong, Kelantan - yr built **1958**	√	√		
2. Masjid Lama Kg. Kuala Dal, Kuala Kangsar, Perak - yr built **1936**	√			
3. Masjid Lama Kg. Jerang, Negeri Sembilan - yr built **1922**	√	√		
4. Masjid Lama Kg. Sungai Relai, Negeri Sembilan - yr built **1929**	√			
5. Masjid Tinggi Lama, Bagan Serai - yr built **1940**	√	√		
6. Masjid Kg. Laut, Kelantan - yr built **1730's**	√		√	

Mechanical reinforcement technique is mainly to provide adequate support to the building structures. This method applies particularly on the preserved timber roof structures which require extra supporting system to strengthen and withstand loads. For removing previous paint work, several techniques should be selected carefully and this must be based on the condition and character of the surface. Some techniques can clearly harm the character of the unique elements. For example, using sander machine is not applicable or unsuitable to remove paint on the craved surfaces, which this should be

replaced by using paint remover. This process requires a careful and thorough cleaning work as to preserve and maintain the significant and the originality of the elements.

In every timber building including the timber mosque, wood preservation are important part to prolong the usage of this material. Using treated wood is highly recommended in the conservation of timber buildings. Future immature defects caused by bio-deterioration agents such as the termites, beetles and fungi agent can be control through these rules. In any cut-section, the surface should be protected with protective layer or timber preservatives coats that contain chemical for anti termites and wood boring insects. This should be applied before the parts joined or connected to the other building structures. The application of timber coat and shield neither helps to protect building form decay but also to maintain the aesthetic features of the natural materials in use. The main factor which applies for repair work should retain the originality of the material used, authenticity of design and the art of woodcarving works. [24] revealed that timber mosque is a nucleus for Malay rural communities of the region stretching from the northern states of Peninsular Malaysia to the southern province of Thailand. The state of arts of the architectural merits shown in the design of timber mosque illustrated in the woodcarving works and the type of connection applied in the timber structures. The carving is part of the mosque's architecture that without it the building may consider as incomplete to be categorized as vernacular architecture of the region [24].

Conservation in general focuses towards the historical rights and originality contradict with the refurbishment work in which the aims of conducting both works are heading to different objective and goal. [25] pointed that the reasons for building refurbishment can vary in some cases because it is so extensive that only the original facade remains and the interior being totally reconstructed. Hence it contributes to a brand new look for the specified building whereas conservation retains all building aspects to its existing function but requires cycle of improvement.

VI. CONCLUSION

For best conservation practice it is necessary to determine appropriates techniques available in protecting a cultural heritage. Understanding of building defects and deterioration are important factors in any conservation work as to minimize the cost of restoration and to protect the buildings from being lost forever. Defects can be repaired satisfactorily only if the causes have been correctly diagnosed. The technique of repair should always consider the kind of defects thus help to reduce the risk of further deterioration. Hence, to prolong a historic timber building, it is important to understand the techniques available and best practice with the principles of repair in securing for optimal conservation works.

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