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Life Cycle Assessment of Timber Components in Taiwan Traditional Temples

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Abstract

For years, research on the life cycle of conventional building materials (e.g. reinforced concrete and metal structures) has been studied; however very little literature can be found in non-conventional materials such as timber. Ever since the 1999 Chi-Chi earthquake that happened in Taiwan, many traditional timber framework buildings were destroyed or severely damaged. For the past decade, enormous amount of resources have been invested by the Taiwanese government to begin various studies on traditional timber building techniques, timber material testing etc. Although correct building technique or proper use of building material are crucial towards establishing a structurally-sound timber framework, without proper building maintenance, the structural integrity will also be jeopardised in future. With the continual decline of timber supply, re-using existing timber materials becomes especially important in building conservation. In this paper, eight Taiwanese traditional temples are used to study the life cycle of historic timber framework. Based on past records of each building's restoration process, statistical calculations of various timber components at different repair stages and oral interviews with the traditional master carpenters, architects and timber surveying units, results shown that alteration design during repair stage is recommended as it enables architects to give more informed repair advice. However if improper or unsuitable measures are carried out during emergency rescue work, timber deterioration will only aggravate further instead of being salvaged. Lastly, a theoretical calculation method for timber framework life span is proposed by using 50% as the critical point for overall structural failure.

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1. Introduction

This paper arises from a joint collaboration with the Architecture and Building Research Institute (ABRI) of the Ministry of Interior in Taiwan where a series of research projects on the conservation of historic buildings and recent scientific technology have been carried out. As part of the project, the life cycle of historic timber buildings was studied by using eight Taiwanese traditional temples case study. Besides reviewing past literature records of each building's restoration process, statistical compilations and calculations of the main structural timber components at different repair stages were also carried out. To have a better understanding on how the conditions of the timber components are being assessed, oral interviews were conducted with the traditional master carpenters, conservation architects and timber structure surveying organizations involved in each temple's repair stage. This study seeks to find a proper procedure and method to evaluate the life cycle of Taiwan historic timber buildings in future.

2. Research Methods

Sample Criteria

Eight traditional Chinese temples with the following criteria were selected:

- Sample must be a national monument status;
- Sample should at least has completed, or is currently undergoing one major repair work;
- Only the main timber structural members of the Die-dou (疊斗) style timber roof framework will be studied (Figure 1).

Research Methodology

Generally, the research methodology is divided into the following three sections:

- Field investigation and oral interviews;
- Statistical calculations;
- Review on the environmental indicators that lead to the damage of timber framework;

In this paper, only section 1 and 2 will be covered in more detail. An overview of the above research procedures are summarised into a flowchart as shown in Figure 2.

2.1. Field investigation and oral interviews

During the investigation and repair stage, each members of the timber framework are examined by the master carpenters and architects. The extent of timber damage is usually classified into three levels – (1) slight damage; (2) moderate damage and (3) severe damage. Timber members that fall under Level 1 and 2 are considered repairable cases, whilst Level 3 is usually either beyond repair

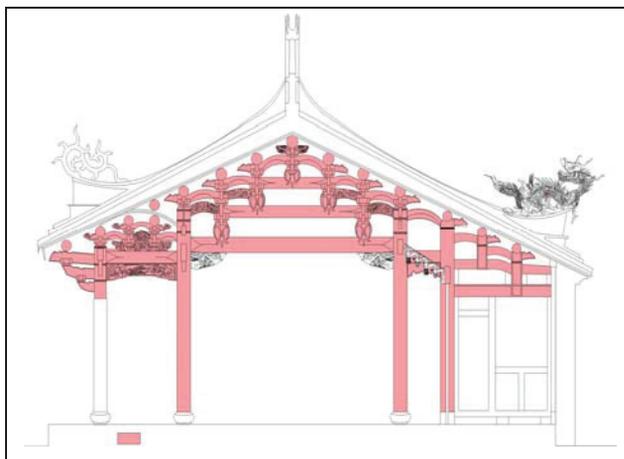


Figure 1: Main structural members of the *Die-dou* style timber framework.

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