

Study on Physical and Mechanical Properties of Historical Timber Building in Myanmar: (A Case Study of Pyay Hostel in Yangon University Campus)

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ABSTRACT

The assessment of existing timber structures requires the determination of the physical and mechanical properties of the individual timber members, which is often obtained by visual grading combined with information of small clear wood specimens. This study aims to investigate the properties of timber members for the seismic safety assessment and evaluation of existing timber building, Pyay Hostel situated in Yangon University. Because this building has been established in 1924, its life time is near 100 years and has some circumstances such as alteration of uses and detection of deterioration. The physical and mechanical properties of existing timber members such as moisture content, specific gravity, static bending, compression parallel to grain, compression perpendicular to grain, tension parallel to grain and shear parallel to grain are determined by experiment in the Structural Laboratory, Civil Engineering Department, YTU. According to the experimental results, it is found that the physical properties of teak and pyingado used in this building are 10% and 14% of moisture content, and 0.56 and 0.8 for specific gravity. In the mechanical properties of timber members, the modulus of elasticity values for Teak and Pyingado are obtained 2.79×10^6 psi and 3.88×10^6 psi, and the modulus of rupture values of Teak and Pyingado are 1.94×10^4 psi and 2.81×10^4 psi respectively. On the other hand, it is found that the compressive strength of Teak and Pyingado are 636.69 psi and 1210.75 psi respectively. This investigation results are reasonable and applicable to use seismic safety assessment and evaluation of existing timber building.

KEYWORDS: Timbers from Existing Building, Experiments, Physical Properties, Mechanical Properties.

I. INTRODUCTION

In Myanmar, timber used as a structural material, is associated mainly as a historical building material for the construction of wooden houses, religious facilities as well as engineering structures such as small bridges or footbridges. Timbers are renewable and natural resources for construction processes. Timber has many properties such as workability, durability, treatability and satisfactory. According to the Myanmar Census data in 2014, among buildings in Myanmar, 82% of buildings are made of timber and bamboo. Due to the lack of maintenance, most of the timber buildings in Myanmar may be needed to rehabilitation of existing conditions. When renovating buildings it is necessary to assess the physical condition and strength of timber structures. Physical properties are the quantitative characteristics of wood and its behavior to external influences other than applied forces. Familiarity with physical properties is important because they can significantly influence the performance and strength of wood used in structural applications. The most accurate way of determining the mechanical properties is by destructive methods, the most relevant results being usually obtained from compression, tension and bending tests. Mechanical properties are the characteristics of a material in response to externally applied forces. They include elastic properties, which characterize resistance to deformation and distortion, and strength properties, which characterize resistance to

applied loads. Mechanical property values are given in terms of stress (force per unit area) and strain (deformation resulting from the applied stress). The mechanical property values of wood are obtained from laboratory tests of lumber of straight-grained clear wood samples (without natural defects that would reduce strength, such as knots, checks, splits, etc). The destructive techniques can be used to predict modulus of rupture (MOR) and modulus of elasticity (MOE) of wood in existing timber building. In reality, it is not impossible to test some properties like that physical and mechanical properties regenerating from all timbers sustained from entire building. Therefore, some of the timber members are collected as a specimen from existing building and conducted laboratory testing. [6]

II. OBJECTIVE

The main objective of this study is to investigate physical and mechanical properties of timber members for the safety assessment and evaluation of Pyay Hostel in Yangon University.

III. OVERVIEW OF THE CASE STUDY BUILDING

Rangoon College buildings were started building in 1900 and added chemistry labs in 1913, physics labs in 1915. Later, in 1920, when established the Yangon University under British rule, these building became part of the university' property. Total area of the campus, which now calls Yangon University,

is over 400 acres wide and the central Government gave the budget to buy the land. After the establishment of the university, The Sub- committee hired T.O Foster, who visited England and hired required staffs to build the buildings, prepared the buildings plans. As the British Government’s financial support was very limited about 100, 000 (one lakh kyat) per year, Governor SaharKoteButtlar opened Arwady which are gambling houses to prepare capitalized money for the construction of the buildings. Two years later, in 1922, December 2nd, Governor Sir Regi Henery Chirsdought, the principle of Yangon University placed the foundation brick for the convocation building and finished construction in 1931. As a result of gradually increased students, two timber hostel buildings were built which can accommodate 224 students. These buildings were finished construction in 1924 June and named one as Pyay and other as Tagung. Pyay Hostel in Yangon University is now utilized for 111 female students from the Yangon Education University. As the building was constructed on isolated reinforced concrete footings with timber post and beam structural system, the building’s timber members lasted nearly a hundred years old. Pyay hostel (two-storey timber building) in Yangon University has been established since 1924 and life time is near 100 years. The dimensions of the building are 481ft. long, 52 ft. wide, 29 ft. height and the each of the floor area is about 25000 sq.ft. This building is composed of timbers, such as Pyinkado (ironwood) and Teak as shown in Figure 1.



Fig.1 Location Map and Photo of Pyay Hostel in Yangon University

IV. EXPERIMENTAL STUDY ON PROPERTIES OF TIMBER

Wood is an extremely versatile material with a wide range of physical and mechanical properties among the many species of wood. It is also a renewable resource with an exceptional strength-to-weight ratio. Wood is a desirable construction material because the energy requirements of wood for producing a usable end-product are much lower than those of competitive materials, such as steel, concrete, or plastic. The case study building had been constructed using the valuable wood species of Myanmar forestry such as Teak and Pyingado and old enough to assess for the safety. Therefore, the determination of the properties of timbers should be carried out for the safety assessment. Therefore, experimental studying on properties of timber member is presented in this section. Pyingado and Teak samples used in this building are collected in some place of existing building as shown in Figure 2.



Fig. 2 Collection of Wood Species

Two specimens are prepared for each test as shown in Figure 3. To obtain the required physical and mechanical properties of existing timbers (Pyay Hostel), the following laboratory testing was done. They are:

1. Moisture Content
2. Specific Gravity
3. Static Bending
4. Compression parallel to grain
5. Compression perpendicular to grain
6. Tension parallel to grain and
7. Shear Parallel to grain



Fig. 3 Prepared of Test Specimens

The preparation of test samples and methods of test were based on American Standard Methods of Testing Small Clear Specimens of Timber (ASTM.D 143-09). The obtained samples informed to be air-dried and test samples were prepared at the Yangon Technological University structural laboratory. Depending upon the availability of wood, six numbers of samples for each test were made.

A. Determination of Physical Properties

Moisture content (MC) and specific gravity (SG) are determined as the physical properties. The green weight of the samples was weighed with a digital weighing balance as shown in Figure 4. The samples were dried in an oven at initial temperature of 70°C for 6 hours and thereafter increased to 100 ±2° C to complete 24hours as shown in Figure 5. The loss in weight expressed as a percentage of the final oven dry weight was taken as the moisture content of the test piece. This procedure was repeated until a substantially constant weight was obtained. And then, the swelling and shrinkage was determined by soaking the oven dried sample for 24 hours, and thereafter re-oven dried again to a constant weight. The basic density determination based on the green volume and oven-dry weight using a water displacement method was use in the measurement of density. By using equations (1) and (2), the moisture content and specific gravity can be obtained.

$$MC (\%) = \frac{\text{Initial weight} - \text{Oven dry weight}}{\text{Oven dry weight}} \times 100 \quad (1)$$

$$SG = \frac{\text{Oven dry weight of sample}}{\text{Volume of sample} \times \text{Density of water}} \quad (2)$$

According to the experimental results, the mean values of moisture content and specific gravity of Teak and Pyingado in existing condition is shown in Table 1.



Fig. 4 Weighting Specimen



Fig. 5 Test Samples in the oven



Fig. 6 Shimadzu Autograph Universal Testing Machine, Y.T.U

Table 1 Moisture Content and Specific Gravity Results of Teak and Pyingado

Species	MC (%)	Specific Gravity
Teak	14%	0.56
Pyingado	10%	0.8

B. Determination of Mechanical Properties

Mechanical properties most commonly measured and represented as “strength properties” for design include modulus of rupture (MOR) and modulus of elasticity (MOE) in bending, maximum stress in compression parallel to grain, compressive stress perpendicular to grain, and shear strength parallel to grain. Statics bending is a measure of the strength of a material as a beam. Compression parallel to grain test is a measure of the strength value of member subjected to compression such as columns, post and props. Compression perpendicular to grain test is a measure of the bearing strength values of member subjected to compression such as beams, sleepers and joints. Tension parallel to grain test is a measure of the strength values of member in parallel to grain direction subjected to the simply supported trusses. Shear parallel to grain test is a measure of the strength values of member in parallel to grain direction subjected to the bolted timbers, notched timber, rollers and sheaves. According to ASTM.D-143-09, for statics bending test, the modulus of rupture and the modulus of elasticity were determined six samples sized 1.in x 1.in x 16 .in as shown in Figure 7. For compression strength parallel to the grain and perpendicular to the grain were determined according to ASTM.D-143-09. Size of specimen of both tests was determined 1.in x 1.in x 4.in for parallel to grain as shown in Figure 8 and 2.in x 2.in x 6.in for perpendicular as shown in Figure 9. For tension parallel to grain test were determined 18 in length, 1 in x 1in at the ends, 1 in x 3/8 in in the middle as shown in Figure 10. For shear parallel to grain test was determined 1.in x 1.in x 1.in as shown in Figure 11. The mechanical properties were tested using Shimadzu Autograph Universal Testing Machine at Yangon Technological University as shown in Figure 6.



Fig. 7 Experimental Set-up of Static Bending Test

The values obtained for the modulus of rupture (MOR) and modulus of elasticity (MOE) from Pyingado and Teak in existing condition is shown in Table 2.

Table 2 Static Bending Test Results of Teak and Pyingado

Species	MOR (psi)	MOE (psi)
Teak	19484.05	2.79x 10 ⁶
Pyingado	28127.9	3.88x 10 ⁶



Fig.8 Experimental Set-up of Compression Parallel to Grain



Fig.9 Experimental Set-up of Compression Perpendicular to Grain

Test The values obtained for the maximum crushing stress and compressive stress at proportional limit in compression perpendicular to grain test and compressive stress at proportional limit in compression parallel to grain test from Teak and Pyingado in existing condition is presented in Table 3.

Table 3 Compression Test Results of Teak and Pyingado

Species	$f_{c\perp}$ (psi)	$f_{c\parallel}$ (psi)
Teak	636.69	1541.4
Pyingado	1210.75	5305.65



Fig. 10 Experimental Set-up of Tension Parallel to Grain



Fig. 11 Experimental Set-up of Shear Parallel to Grain

The values obtained for the maximum tensile stress in tension parallel to grain and maximum shear stress in shear parallel to grain test from Teak and Pyingado in existing condition is shown in Table 4. Table 4 Tension and Shear Test Results of Teak and Pyingado

V. CONCLUSION

According to the experimental results, it is found that the physical properties of teak and pyingado used in this building are 10% and 14% of moisture content, and 0.56 and 0.8 for specific gravity. In the mechanical properties of timber members, the modulus of elasticity values for teak and pyingado are obtained 2.79x106 psi and 3.88x106 psi, and the modulus of rupture values of teak and pyingado are 1.94x104 psi and 2.81x104 psi respectively. On the other hand, it is found that the compressive strength of teak and pyingado are 636.69 psi and 1210.75 psi respectively. Finally, it can be concluded that the investigation results are reasonable and applicable to use seismic safety assessment and evaluation of existing timber building.

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