UNIVERSITI TEKNOLOGI MARA

DEVELOPMENT OF CHARACTERISTIC VALUE FOR COMPRESSIVE STRENGTH PROPERTIES OF SELECTED MALAYSIAN TROPICAL HARDWOOD TIMBER

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ABSTRACT

Currently, structural design of timber in Malaysia is still making reference to Malaysia Standard MS 544: Part 2 and MS 544: Part 3, which are based on permissible (working) stress and the strength data such as bending, compression and tensile strength in those standards were derived from data obtained from testing small clear specimens. However, the mechanical behaviour of timber cannot be derived with any reliability from properties of clear wood which is considered defect-free and usually only suitable for laboratory test. Strength data from small clear specimen still imposed inaccuracies as it does not represent actual strength of structural size of timber in order to correctly and economically design structural elements. The introduction of the limit states code principles of Eurocode 5: Design of Timber Structures presents opportunities for engineers to optimize the design of timber structures and get the best out of the material. However the reference strength data expressed as characteristic values which provided in EN 338: 2016 are based on European softwood and a few of hardwood species with none from Malaysian hardwood timber. Those values were derived from the strength data of structural size specimens. Therefore, there is a need to establish the strength data from structural size specimens from Malaysian Tropical timber if the design needs to be changed into limit state design as in Eurocode 5. This study only reports on the determination and derivation of compressive strength of selected Malaysian Tropical hardwoods namely Balau, Kempas, Kelat, Kapur, Resak, Keruing, Mengkulang, Light Red Meranti and Acacia. All of these species were tested in structural size and small clear specimen according to EN 408: 2010 and BS 373: 1957 respectively. Specimens of each species were collected from four different regions in Malaysia which are from Kelantan, Pahang, Johor and Sarawak. A moderate to strong correlation between compressive strength, density and modulus of elasticity were observed for all species. In general, the results show that compressive strength parallel to the grain of small clear specimens are higher than those obtained from structural size specimens. The grade stresses for small clear and structural size specimens of compression parallel to the grain are found to be higher than MS 544 but shows inconsistent trend for compressive strength grade stresses perpendicular to the grain compared to the MS 544. Furthermore, Kempas (43.9 MPa) and Balau (8.9 MPa) show highest characteristic value for compressive parallel and perpendicular to the grain respectively. The derived characteristic values are also higher when compared to the respective strength class in EN 338: 2016 especially for heavy and medium hardwood which have density over than 700 kg/m^3 while for lower density hardwood it show close value to the one stipulated in EN 338: 2016. Through the correlation of mean compressive strength small clear and characteristic value of structural size specimens, the equation to determine characteristic value for density ranging between 800 kg/m^3 to 900 kg/m^3 is $f_{c,0,k=}\ 0.56x \times 0.8$. A verification of equation to determine compressive strength characteristic values give a different equation which is $f_{c,0,k} =\ 1.91(f_{m,k})^{0.7}$ which indicates that the equation in EN 384: 2016 only suitable for hardwood timber with the density lower than 700 kg/m^3.

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CHAPTER ONE
INTRODUCTION

1.1 Background of Study

Timber is one of the renewable and recyclable natural resource and commonly used in structural, outdoor, indoor equipment and furniture industry. It is not only a renewable and recyclable resource but also energy-efficient compared to other materials such as steel and concrete in term of material production, thus making it as a lowest embodied energy material. Essentially, timber plays an important role that acts as carbon sink in order to reduce carbon emission. In construction industry, timber often is used as trusses, beams, joists and many others. Usage of timber as structural material is not new, in fact it was used over centuries ago. As time passes, developments in timber engineering are expanding rapidly with various types of new innovation timber components as a structural material that enabling timber to compete with other engineering material in building forms.

Structural use of sawn timber and engineered wood products that emphasize on performance-based design has a critical matter which is the uncertainty in strength of timber and timber based elements (Leicester, 2002). There are thousands of species of tree which each species has different growth rates, degrees of durability and structural properties. Timbers are naturally grown thus making them difficult materials to characterize with extensive variation of strength not only between different species but also between timber of the same species and even from the same log (Chu, Ho, Midon & Malik, 1997). Because of its extensive use in construction as structural form for example beams, trusses, columns and joists, determining strength properties of solid timber is very important to ensure the safety and ability of the material to withstand external loads as timber is weak in tension (Faherty & Willionson, 1999). So, the suitability of this source for particular purpose depends on its physical and mechanical properties. In determining the physical and mechanical properties of timber to be used in design, there are many factors to be considered such as, loading criteria, moisture content, natural and non-natural defects and many others.

Currently, in Malaysia, the structural design of timber is still based on the permissible stress design as given in MS 544 Part 2: 2001: Code of practice for