

UNIVERSITI TEKNOLOGI MARA

**DEVELOPMENT OF
CHARACTERISTIC VALUE OF
BENDING STRENGTH PROPERTIES
FOR SELECTED MALAYSIAN
TROPICAL HARDWOOD TIMBER
IN ACCORDANCE WITH
EUROCODE 5**

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PhD

November 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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Faculty : Civil Engineering

Thesis Title : Development of Characteristic Value of Bending
Strength Properties for Selected Malaysian Tropical
Hardwood Timber in Accordance with Eurocode 5

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ABSTRACT

Timber structural design 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, there is some weaknesses arise as the data derived from the small clear specimen is not represents the true strength properties and imposed to inaccuracies when it comes to design the structural size timber that are surely contain some defects. This issues lead to the insecurity of the engineers to widely use the timber material safely in construction industries. 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 Hardwood timber if the design needs to be changed into limit state design as in Eurocode 5. The aims of this study are to determine the bending strength properties, to evaluate the characteristic value for bending strength properties to form strength class for selected Malaysian hardwood timber based on the EN 384:2016 and BS EN 338:2016 and to develop correlation based on small clear specimens and structural size specimen. In this study, there are 10 timber species were selected namely Balau, Kempas, Kelat, Resak, Kapur, Keruing, Mengkulang, Light red meranti, Geronggang 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. There were in total 3225 specimens tested. The outcome of this study reveals that the bending strength characteristic value results is in the order of Balau (55.2 N/mm²), Kempas (49.7 N/mm²), Resak (49.5 N/mm²), Mengkulang (47.6 N/mm²), Kapur (46.8 N/mm²), Keruing (44.9 N/mm²), Kelat (44.7 N/mm²), Light red meranti (26.1 N/mm²) and Geronggang (21.9 N/mm²). In order to fit the strength classes system there are a lot of sacrifices needed in term of reducing the strength, modulus of elasticity and density. The strength are reduces compared to the actual strength such as Mengkuang and Light red meranti from strength 47.6 N/mm² and 26.1 N/mm² to 40 N/mm² and 20 N/mm² respectively. The highest strength class are placed in DM55 which is Balau and the lowest are placed in C20 which is Light Red Meranti. The strength class shows upgrades for Balau and downgrades for Kempas, Kapur and Keruing compared to the strength classes published in EN338:2016. From the derivation of strength class a new equation to determine characteristic MOE, $E_k = 0.70E_{\text{mean}}$ and mean density, $\rho_{\text{mean}} = 1.0899\rho_k + 104.41$ were establish. Through the correlation of mean bending strength small clear and characteristic value of structural size specimens, the equation to determine characteristic value for density ranging between 900 kg/m³ to 1000 kg/m³ is $f_k = 0.48x \times 0.8$.

ACKNOWLEDGEMENT

Alhamdulillah, with the name of Allah S.W.T, the Most Beneficent and Most Merciful, all praise be to Allah S.W.T, Lord of the Universe. Blessings and peace be upon His Final Prophet Muhammad S.A.W. This challenging journey wouldn't be completed without His Merciful for given me the patience and strength throughout my ups and downs.

First of all, I would like to express my deepest gratitude to my supervisor, Professor Dr. Zakiah Ahmad, Dean of Faculty of Civil Engineering for great guidance, continuous support, motivation and encouragement. Without her support, I might still be lost in my difficult journey and my thesis might be still incomplete. Her full dedication and commitment in supervising me will always be treasured and remembered. May you be love and granted with health and happiness always.

I would like to express my gratitude to my co- supervisor, Dr Simon Aicher from university of Stuttgart, Germany for his knowledge, excellent guidance, motivation, professional critique and efforts on my research work and thesis. My appreciation also goes to all the technicians' team such as Muhammad Tarmizi and Azri Syafiq from heavy structure laboratory, without them I could never have completed my experimental work. I would also like to acknowledge the Malaysian Timber Industry Board (MTIB) for funding this research study and Woodfield factory for supplying the Timber material for this study. Big thanks to my team mates Anis Azmi and Nurul Izzatul Lydia Za'aba for always encourage and support me to complete this journey together and also Dr. Lum Wei Chen for great advice and good mentor.

Special thanks go to my beloved family and friends. Without the love and support from them, this journey might not have beautiful ending as it is. Thank to my siblings, Aida Shamrina, Ain Abyan and Mohd An'Am for always believing in me. Thank you to my parents in law, Norizan Awang and Zaidi Mohamad and my sisters in law for always supporting me especially to taking care of the baby when I was away.

I owe a special thanks to an important person in my life, my husband, my pillar of strength, Azmi Adnan for his unconditional love, support and deepest understanding during this journey of PhD degree that made the thesis are possible to complete. He always been positive and remind me to always be in track no matter how hard the circumference that I faced. All the beautiful words are not enough for me to express my grateful and lucky I am to have him by my side. To my dearest son, Aydan Nuh thanks you for being a very good boy and I love you to the moon and back.

Finally, this thesis is dedicated to my dearest and strongest mother, Muzaidah Daud and my beloved father, Baharin Ismail. Thank you Ma and Abah for always giving me support, advice, life lesson and truly believe in me. This success is only because of your selfless love, care, and sacrifice that you have made my entire life. Hopefully I could return the favour in the near future. May both of you be rewarded immensely here and in the hereafter.

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