PREDICTION OF BEAM STIFFNESS FOR STRUCTURAL GLUED-LAMINATED TIMBER

By

ONG CHEE BENG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Dedicated to my mother.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: Wong Ee Ding, Ph.D.

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The objective of the study was made to develop a probabilistic model for predicting the statistical distribution of stiffness properties of some selected Malaysian timbers. In this respect, a three-step experimental approach was adopted before simulated beam stiffness for the species population was derived. Firstly, a number of probability functions representing the actual distribution of selected timber data were examined. Goodness-of-fit (GOF) analysis was then carried out to establish the best fitting distribution function for the experimental data used. Secondly, the modulus of elasticity (MOE) of solid and finger-jointed samples was obtained from non-destructive testing (NDT) using the fundamental vibration frequency methodology. Results from the above method were calibrated against those obtained through static bending test by means of Universal Testing Machine. Finally, glued-laminated timber (glulam) beams were fabricated using laminations with predetermined MOEs by NDT method and the beams were later subjected to 3-point static bending test for MOE determination. In the mean time, finite element method (FEM) coupled with transformed section approach, was also used to simulate the glulam beam tests after experimental length effect was incorporated. The MOE of beams population was then predicted using randomly generated MOE and length data.

The GOF analysis indicates that 3-parameter Weibull distribution best fit the probability distribution of the tested timber. Results from the NDT method also showed a good relationship between the fundamental vibration frequency test and the static bending test conducted with a coefficient of determination of about 0.89. In the simulation of glulam beams, the MOE values of simulated glulam beams are generally higher than the actual tests conducted, particularly in durian hutan, with a percentage difference of about 23%. In the prediction of the MOE glulam beams population, the generated distribution exhibits higher MOE values compared to the average value reported respectively for durian hutan and rubberwood species.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan ijazah Master Sains

FORMULASI KEANJALAN RASUK UNTUK KAYU GLULAM

Oleh

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Kajian dilakukan untuk menghasilkan satu model kebarangkalian dalam menentukan taburan statistik ciri-ciri ketegangan bagi sesetengah kayu Malaysia yang terpilih. Dalam aspek ini, tiga aras kajian akan diketengahkan sebelum penentuan ketegangan rasuk satu populasi spesies melalui simulasi dijalankan. Pertama, beberapa fungsi taburan kebarangkalian akan disiasat bagi mewakili taburan sebenar data kayu yang dipilih. Ujian tahap kesesuaian (GOF) digunakan untuk menguji fungsi taburan yang paling tepat dan sesuai untuk mewakili taburan data eksperimental yang digunakan. Kedua, modulus kekenyalan (MOE) sampel kayu padu dan tanggam jari dikira dengan menggunakan ujian tanpa musnah (NDT) iaitu teknologi frequensi getaran. Keputusan tersebut dipiawaikan dengan keputusan yang diperolehi daripada teknik beban-mati menggunakan "Universal Testing Machine". Akhirnya, rasuk glulam (glued-laminated) dihasilkan dengan menggunakan laminasi yang telah ditentukan MOE dan kemudiannya ujian lenturan 3-

titik dijalankan ke atas rasuk tersebut. Pada masa yang sama FEM (Finite Element Method) bersama analisis "transformed section" juga digunakan untuk mengsimulasikan ujian rasuk glulam tersebut setelah keputusan eksperimen faktor panjang kayu dimasukkan. Akhirnya, MOE populasi rasuk diramal berdasarkan MOE dan data panjang kayu yang dijanakan secara rawak.

Keputusan dalam analisis GOF menunjukkan bahawa taburan Weibull 3-parameter adalah paling sesuai dalam mewakili taburan kebarangkalian kayu-kayu yang diuji. Keputusan daripada ujian NDT juga menunjukkan hubungan yang rapat diantara ujian frekuensi getaran dengan ujian lenturan statik yang telah dijalankan dengan koeffisien sebanyak 0.89. Dalam simulasi ujian rasuk glulam, MOE rasuk glulam yang disimulasikan adalah lebih tinggi daripada ujian makmal yang dijalankan, terutama bagi spesies durian hutan dimana sebanyak 23 peratus perbezaan diperolehi. Dalam ramalan MOE populasi rasuk glulam, taburan yang dijana menunjukkan nilai MOE yang lebih tinggi daripada yang dilaporkan untuk kedua-dua spesies kayu getah dan juga durian hutan.

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I certify that an Examination Committee met on 12th May 2004 to conduct the final examination of Ong Chee Beng on his Master of Science thesis entitled "Prediction of Beam Stiffness for Structural Glued-Laminated Timber" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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ONG CHEE BENG

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