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OPTIMUM COMPRESSIVE PRESSURE AND THERMAL TREATMENT FOR EFFECTIVE MAHANG WOOD DENSIFICATION

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By

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Faculty: Forestry

Wood densification can be done by mechanical means involving heat and moisture. However, mechanically densified wood is dimensionally unstable. Compressive deformation could be fix by applying pressure above the elastic limit but lower than the maximum compression load. Therefore, compressive pressure becomes an important parameter and no stopper's bars or molds are used to limit the compression. Determination of the optimum compressive pressure for densification provides a new innovative way in densifying wood without experiencing compressive failure. Densified wood was successfully produced from ten-year-old mahang wood (*Macarangga gigantea*) having initial density of 274±26 kg/m^3. Transverse compression strength in radial direction of steamed and unsteamed mahang wood was determined prior to calculating the required compression pressure. The steaming duration was 15, 30 and 45 min. After analysis using the stress-strain curve, the compressive strength was converted into compressive pressure. The After pre-steamed in a closed vessel at 130 °C for either 15, 30 or 45 min, all the pre-steamed mahang woods were densified by compressing the wood at a specific pressure that was pre-determined. After cooling and conditioning at dry condition (under silica gel) for two weeks, the densified wood was tested for the dimensional stability and strength properties. The wood was successfully compressed at 75-78% compression ratio without any visual physical defects and springback. Compressive pressures between 0.91 kgf/mm^2 to 2.04 kgf/mm^2 were using for compressing steamed mahang wood (15, 30 and 45 min steaming). The densified mahang wood was tested for bending strength, shear modulus and dimensional stability. The dimensional stability of densified mahang wood was evaluated after conditioning at 45%, 65%, 85% and 100% RH at 25 °C. The maximum thickness swelling was 43.49% after being conditioning in 100% RH at 25 °C until constant reading for 29 days. However, the thickness swelling was less than 3% after conditioning at 45% and 65% RH. Therefore, all densified wood specimens for bending strength and shear modulus were condition at 65% RH. The results showed the bending strength of densified mahang was as high as 137.37 MPa, Modulus of Elasticity (MOE) was 16.80 GPa and shear modulus was 1.13 GPa. The result shows that the approach used in this study is effective for densification of low density (<300 kg/m^3) wood into about 300% of the original density. Although the thickness recovery is still high, higher compressive pressure improved dimensional stability. Thirty minutes steaming pre-treatment at 130 °C provides an optimum condition for densification of mahang wood producing densified mahang of high strength and dimensional stability.

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

TEKANAN MAMPATAN OPTIMUM DAN RAWATAN TERMA UNTUK PENUMPATAN KAYU MAHANG YANG BERKESAN

Oleh

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Penumpatan kayu dapat dihasilkan secara mekanikal dengan kehadiran haba dan kelembapan. Walaubagaimanapun, kayu mampatan yang terhasil adalah tidak stabil dari segi dimensinya. Untuk mencegah pengubahan bentuk dalam kayu, tekanan mampatan semasa dimampat perlu dikenakan dengan syarat melebihi had elastic kayu tetapi lebih rendah daripada daya mampatan maksima kayu tersebut. Oleh itu, tekanan mampatan menjadi satu parameter yang penting dalam proses pemampatan dimana tiada acuan dan 'stopper's bars' digunakan dalam proses pemampatan. Penentuan tekanan mampatan optimum terhadap proses pemampatan ini telah memberi satu cara inovatif yang baru dalam menghasilkan kayu mampatan tanpa masalah atau pengubahan bentuk semasa proses pemampatan, Dalam kajian ini, kayu mampatan telah berjaya dihasilkan daripada kayu mahang (*Maccarangga gigantea*) yang berumur sepuluh tahun ke atas dengan densiti 274±26 kg/m^3. Specimen kayu mahang yang telah kukus dan tanpa kukus telah ditentukan kekuatan mampatan melintang pada arah radial sebelum proses pemampatan untuk mengira

tekanan yang diperlukan untuk memampatkan spesimen kayu mahang. Jangka masa untuk pengukusan spesimen ialah 15, 30 dan 45 minit. Selepas mengaplikasikan teori lengkung tegasan-terikan untuk analisasi, kekuatan mampatan telah ditukar kepada tekanan mampatan. Semua specimen kayu mahang yang telah dikukus di bawah suhu 130 ºC selang janka masa 15, 30 atau 45 minit telah dimampat dengan tekanan yang spesifik yang telah ditentukan. Selepas itu, spesimen kayu mampatan yang telah dihasilkan dibiar sejuk dan dimasukkan ke dalam bekas tertutup yang mengandungi gel silika selama dua minggu untuk tujuan kondisi sebelum ujian kestabilan dimensi dan kekuatan fizikal. Hasil kajian menunjukkan spesimen kayu berjaya dimampat di bawah nisbah mampatan75-78% tanpa kecacatan dan pembidasan di bawah pemerhatian mata kasar. Tekanan mampatan di antara 0.91 kgf/m^2 hingga 2.04 kgf/m^2 telah digunakan untuk memampatkan kayu mahang yang dikukus (dengan masa pengukusan 15, 30 dan 45 minit). Kayu mampatan yang dihasilkan telah diuji kekuatan tegasan, modulus ricihan dan kestabilan dimensinya. Kestabilan dimensi kayu mampatan telah dinilai selepas dikondisi pada RH 45%, 65%, 85% dan 100% pada suhu 25 ºC. Maksimum ketebalan bengkak ialah 43.49% selepas spesimen dikondisi pada RH 100% pada suhu 25 ºC dan mencapai bacaan konstan dalam 29 hari. Walaubagaimanapun, ketebalan bengkak adalah kurang daripada 3% selepas spesimen dikondisi pada RH 45% dan 65%. Sehubungan dengan itu, semua spesimen kayu mampatan yang digunakan dalam ujian kekuatan tegangan dan modulus ricihan adalah spesimen yang dikondisi pada RH 65%. Hasil kajian menunjukkan bahawa kayu mampatan yang dihasilkan mencapai kekuatan tegangan setinggi 137.37 MPa manakala modulus elastisiti (MOE) ialah 16.80 GPa danmodulus ricihan ialah 1.13 GPa. Ini telah menunjukkan bahawa pendekatan yang diaplikasi dalam kajian ini adalah efektif untuk memampatkan kayu yang mempunyai densiti rendah (<300 kg/m^3) kepada densiti yang lebih tinggi sebanyak 300% daripada densiti asalnya. Walaupun pemulihan ketebalan selepas proses pemampatan masih tinggi, tetapi tekanan mampatan yang tinggi telah menambah baik kestabilan dimensi. Pra-rawatan pengukusan selama 30 minit pada suhu 130 ºC adalah kondisi yang optimum untuk menghasilkan kayu mampatan dari kayu mahang dengan kekuatan dan kestabilan dimensi yang lebih tinggi.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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