INTISARI

Penelitian ini mengkaji perilaku termal dan mekanika panel *cross-laminated timber* (CLT) homogen berbahan kayu mahoni (*Swietenia mahagoni*) ketika terpapar kebakaran standar ISO 834 melalui pemodelan numerik berbasis metode elemen hingga (FEM) pada Abaqus. Kajian dilakukan untuk memahami distribusi temperatur, kedalaman arang (*char depth*), penurunan sifat mekanik, deformasi struktural, serta kapasitas residual panel setelah paparan kebakaran. Pendekatan ini diperlukan mengingat karakteristik kayu tropis belum banyak direpresentasikan dalam standar desain ketahanan api internasional.

Analisis dilakukan secara *sequentially coupled* melalui dua tahap: *transient heat transfer* untuk mendapatkan distribusi temperatur tiga dimensi, kemudian pemetaan temperatur tersebut ke analisis mekanik *static general*. Sifat termal dan mekanik kayu dimodelkan sebagai *temperature-dependent* sesuai Eurocode 5 dan literatur kayu tropis. Uji konvergensi mesh diterapkan untuk memastikan kestabilan dan akurasi numerik model. Pendekatan ini digunakan untuk mengevaluasi pembentukan gradien temperatur, lokasi front pirolisis, penurunan modulus elastisitas, deformasi struktural, dan bagian penampang yang masih mampu menopang beban.

Hasil simulasi menunjukkan bahwa permukaan panel mencapai temperatur sekitar ~1000 °C pada 90 menit, sedangkan zona terdalam tetap berada di bawah 150 °C. Kedalaman arang mencapai 57 mm dengan laju pengarangan rata-rata 0,63 mm/menit, konsisten dengan ketentuan Eurocode 5. Degradasi modulus elastisitas signifikan terjadi pada zona panas, sehingga hanya sekitar 24% ketebalan panel yang mempertahankan kekakuan mendekati nilai awal. Deformasi menunjukkan mekanisme *thermo-mechanical bending*, namun tidak terjadi kegagalan struktural karena lapisan terdalam tetap kaku. Validasi terhadap studi Khelifa dkk. (2024)menunjukkan kesesuaian pola temperatur dan respons tegangan, sehingga model dinyatakan reliabel. Penelitian ini memberikan pemahaman komprehensif mengenai perilaku CLT kayu mahoni pada suhu tinggi dan menjadi dasar penting bagi perancangan ketahanan api panel kayu tropis.

Kata kunci: CLT, kayu mahoni, ISO 834, analisis termal, kapasitas residual

ABSTRACT

This research examines the thermal behavior and mechanics of homogeneous cross-laminated timber (CLT) panels made from mahogany wood (Swietenia mahagoni) when exposed to the ISO 834 standard fire thru numerical modeling based on the finite element method (FEM) in Abaqus. The study was conducted to understand the temperature distribution, *char* depth, reduction in mechanical properties, structural deformation, and residual capacity of the panel after fire exposure. This approach is necessary considering that the *char*acteristics of tropical wood are not yet widely represented in international fire resistance design standards.

The analysis was performed sequentially thru two stages: transient heat transfer to obtain the three-dimensional temperature distribution, followed by mapping this temperature distribution to static general mechanical analysis. The thermal and mechanical properties of wood are modeled as temperature-dependent according to Eurocode 5 and tropical wood literature. Mesh convergence tests were applied to ensure the numerical stability and accuracy of the model. This approach is used to evaluate the formation of temperature gradients, the location of the pyrolysis front, the decrease in elastic modulus, structural deformation, and the cross-sectional area still capable of supporting a load.

The simulation results show that the panel surface reaches a temperature of approximately ~1000 °C at 90 minutes, while the deepest zone remains below 150 °C. The *char* depth reached 57 mm with an average *charring* rate of 0.63 mm/minute, consistent with Eurocode 5 provisions. Significant degradation of the elastic modulus occurs in the hot zone, with only about 24% of the panel thickness retaining stiffness close to its initial value. Deformation indicates a thermo-mechanical bending mechanism, but structural failure did not occur because the innermost layer remained rigid. Validation of the study by Khelifa et al. (2024) showed consistency in temperature patterns and voltage response, thus the model was declared reliable. This research provides a comprehensive understanding of the behavior of mahogany CLT at high temperatures and serves as an important foundation for the design of fire resistance in tropical wood panels.

Keywords: CLT, mahogany, ISO 834 fire curve, thermal analysis, residual capacity