



ABSTRACT

The non linear and non homogenous behavior of glulam bamboo beam-column has not been studied yet. As a result, there is lack of information about its behavior and an analysis method associated to its non linearity and non homogeneity. Hence, the non linear behavior of glulam bamboo beam-column was investigated in this research to find out its analysis method. The research objectives were developing numerical solution to calculate the deflection and maximum bending load of glulam bamboo beam-column either by assuming bamboo as non linear material and a homogenous material or by assuming bamboo as non linear material and a non homogenous material; formulating the proper constitutive equation model of glulam bamboo and finding out the numerical non linear analysis method that able to yield load and deflection closer to the actual behavior of glulam bamboo beam-column.

The experimental and numerical studies were conducted in this research. Tensile and compressive test parallel to grain was conducted based on modified ISO 22157 and ASTM D143-94, respectively. The results were used to formulate the constitutive model of glulam bamboo beam-column. Static bending test was carried out based on ASTM D143-94 to obtain the bending strength. It is used to calculate the deflection and maximum bending load based on linear material and homogenous material assumption. The full scale beam-column test was carried out to validate the formulated numerical calculation result. The numerical study was conducted to find out the numerical solution of non linear behavior of glulam bamboo beam-column. Numerical solution was developed by using finite different method. Newton-Raphson iteration method was applied to obtain neutral axis position and equilibrium deflected shape. Gauss quadrature method was applied to calculate the internal axial forces and internal moments. The stress distribution of glulam bamboo beam-column was defined by referring the tensile and compressive stress-strain relation parallel to grain of glulam bamboo that is represented as constitutive equation. When the numerical solution has been validated, some calculations were conducted by using three different assumptions, *i.e.*, bamboo as a linear and a homogenous material; bamboo as a non linear and a homogenous material; bamboo as a non linear and a non homogenous material.

The research result shows that developed numerical solution can be applied to calculate deflection and maximum bending load by assuming bamboo either as non linear and homogenous material or non linear and non homogenous material. The constitutive equation of glulam bamboo can be modeled as a three linear curve. Numerical calculation by using assumption bamboo as a non linear and non homogenous material yields the lowest relative differences of deflection (8.14%). Under lateral loading 9067 N, it also yields the lowest relative differences of deflection (3%). In the case of maximum tensile and compressive strain, the average relative differences yielded from non linear and non homogenous material assumption (23% and 11%) are the same as those yielded from non linear and homogenous material assumption (23% and 10%). Hence, Numerical calculation by using assumption bamboo as a non linear and non homogenous material is recommended to be used for detail calculation of glulam bamboo beam-column.



INTISARI

Penelitian tentang perilaku non-linier dan non-homogen balok-kolom bambu laminasi belum pernah dilakukan. Sehingga, belum ada informasi mengenai perilaku balok-kolom bambu laminasi beserta metode analisisnya yang sudah mempertimbangkan sifat non-linier dan non-homogen dari bambu. Oleh karena itu, pada penelitian ini, perilaku non-linier bambu laminasi diinvestigasi untuk memperoleh metode analisa yang telah mempertimbangkan sifat non-linier dan non-homogen bambu. Tujuan penelitian ini adalah untuk memperoleh solusi numerik yang digunakan untuk menghitung lendutan dan beban lentur maksimum dengan menggunakan asumsi baik bambu bersifat sebagai bahan non-linier dan homogen maupun bambu bersifat sebagai bahan non-linier dan non-homogen; untuk memformulasikan model persamaan konstitutif bambu laminasi dan untuk memperoleh metode analisis non-linier yang mampu memperoleh hasil perhitungan beban-lendutan yang mendekati dengan kondisi aktualnya.

Penelitian secara eksperimen dan numerik dilakukan. Pengujian tarik dan tekan sejajar serat masing-masing dilakukan berdasarkan ISO 22157 dan ASTM D143-94. Hasil pengujian ini digunakan untuk memformulasikan model konstitutif bambu laminasi. Pengujian lentur statis dilakukan berdasarkan ASTM D143-94 untuk memperoleh tegangan lentur. Tegangan lentur digunakan untuk menghitung defleksi dan beban lentur maksimum berdasarkan asumsi bahwa bambu adalah bahan yang bersifat linier dan homogen. Pengujian skala penuh balok-kolom dilakukan untuk proses validasi hasil analisa numerik. Penelitian secara numerik dilakukan untuk memperoleh solusi numerik perilaku non-linier dan non-homogen bambu laminasi. Solusi numerik dikembangkan dengan menggunakan metode finite different. Metode iterasi Newton-Raphson digunakan untuk memperoleh posisi garis netral dan bentuk lendutan balok-kolom bambu laminasi. Metode Gauss kuadrat digunakan untuk menghitung gaya-gaya dalam. Distribusi tegangan pada potongan melintang balok-kolom ditentukan dengan mengacu hubungan tegangan-regangan tarik dan tekan sejajar serat.

Hasil penelitian menunjukkan bahwa, solusi numerik dapat digunakan untuk menghitung defleksi dan beban lentur maksimum berdasarkan asumsi baik bambu sebagai bahan non-linier dan homogen maupun bambu sebagai bahan non-linier dan non-homogen. Persamaan konstitutif bambu laminasi dapat dimodelkan sebagai kurva three-linear. Ketika dibandingkan dengan hasil eksperimen, perhitungan numerik dengan menggunakan asumsi bahwa bambu sebagai bahan non-linier dan non homogen menghasilkan perbedaan defleksi relatif terkecil (8.14%). Pada pembebanan lentur 9067 N, asumsi tersebut juga menghasilkan perbedaan defleksi relatif terkecil (3%). Perhitungan numerik yang mengasumsikan bambu sebagai bahan non-linier dan homogen menghasilkan perbedaan relative regangan tarik dan tekan maksimum (23% dan 11%) yang hampir sama dengan perhitungan numerik yang mengasumsikan bambu sebagai bahan non-linier dan non homogen (23% dan 10%). Dengan pertimbangan tersebut, perhitungan numerik dengan asumsi bambu sebagai bahan non-linier dan non-homogen direkomendasikan untuk digunakan dalam perhitungan detail balok-kolom bambu laminasi.