ABSTRAK

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Judul Tesis : Pengaruh Bentuk dan Jarak Purlin Terhadap Stabilitas Lateral Rafter Struktur Portal Baja via Analisis Elemen Hingga 3 Dimensi

Stabilitas lateral rafter baja sangat dipengaruhi oleh keberadaan elemen pengekang seperti purlin dalam mencegah tekuk torsi lateral (*Lateral Torsional Buckling* – LTB). Namun, praktik perancangan rafter baja umumnya mengabaikan kontribusi kekakuan purlin dan hanya memperhitungkannya sebagai beban. Penelitian ini bertujuan untuk memperoleh informasi pengaruh bentuk dan jarak purlin sebagai *lateral bracing* pada *top flange* rafter terhadap peningkatan momen kritis elastik (M_{cr}) melalui pendekatan numerik analisis elemen hingga, serta membandingkan nilai M_{cr} hasil analisis dengan prediksi beberapa ketentuan desain.

Pemodelan dilakukan pada portal *monoslope* yang terdiri dari kolom, rafter, dan purlin menggunakan perangkat lunak ANSYS dengan elemen SHELL181. Analisis membandingkan kondisi rafter tanpa purlin (*unbraced*) dan dengan purlin (*braced*) pada variasi jarak purlin (L_b) serta dua tipe purlin, yaitu C150×50×20×3 mm dan Z150×50×20×3 mm. Hasil numerik kemudian dibandingkan dengan perhitungan berbasis SNI 1729:2020, AISC 360, dan EN 1993-1-1:2005.

Hasil penelitian menunjukkan bahwa pemasangan purlin meningkatkan M_{cr} rafter secara signifikan sebesar 321,37% – 444,68% dibandingkan kondisi *unbraced*, dan nilai M_{cr} meningkat seiring semakin rapatnya jarak purlin. Purlin tipe Z150×50×20×3 mm menghasilkan M_{cr} lebih tinggi sebesar 1,776% – 2,846% dibanding purlin tipe C150×50×20×3 mm karena memiliki *section properties* yang lebih besar, meskipun luas dan berat penampang sama. Pada kondisi *unbraced*, M_{cr} jauh lebih kecil daripada momen plastis (M_p) berdasarkan SNI 1729:2020 sehingga LTB elastik berpotensi terjadi sebelum leleh.

Sedangkan pada kondisi *braced* M_{cr} melampaui M_p sebesar 18,082%–52,638% sehingga mekanisme pengendali bergeser dari LTB menuju leleh (*yield*). Dari sisi perbandingan ketentuan desain, EN 1993-1-1:2005 memberikan hasil M_{cr} yang paling mendekati analisis numerik, dengan deviasi sekitar −15,277% (posisi beban pada *top flange*) dan −5,850% (posisi beban pada *shear centre*), serta +8,354% untuk posisi beban pada *bottom flange*. Sementara itu, AISC 360 cenderung memberikan hasil M_{cr} *overpredict* sekitar 20,624% dibandingkan hasil FEA, yang diakibatkan tidak dipertimbangkannya pengaruh posisi beban secara eksplisit, sehingga penggunaannya memerlukan kehati-hatian.

Kata kunci: lateral torsional buckling, momen kritis elastik (M_{cr}), metode elemen hingga, rafter, purlin, panjang tak terkekang (L_b).

ABSTRACT

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Study Program : Master of Civil Engineering

Title of Thesis : The Effect of the Shape and Spacing of Purlins on Lateral Stability of Rafters Steel Portal Structures via 3-Dimensional Finite Element Analysis

The lateral stability of steel rafters is strongly influenced by the presence of restraining members such as purlins in preventing lateral–torsional buckling (LTB). However, in common design practice, the stiffness contribution of purlins is often neglected, and purlins are treated only as gravity loads. This study aims to provide insight into the effects of purlin type and spacing, acting as lateral bracing at the rafter top flange, on the increase in the elastic critical moment (M_{cr}) using a finite element (FE) numerical approach, and to compare the FE-based M_{cr} with predictions from selected design provisions.

A monoslope portal frame consisting of columns, rafters, and purlins was modelled in ANSYS using SHELL181 elements. The analysis compares an unbraced rafter (without purlins) and braced rafters (with purlins) for varying purlin spacing (L_b) and two purlin sections, namely C150×50×20×3 mm and Z150×50×20×3 mm. The numerical results are subsequently benchmarked against code-based calculations in SNI 1729:2020, AISC 360, and EN 1993-1-1:2005.

The results indicate that installing purlins increases the rafter M_{cr} substantially by 321.37%–444.68% relative to the unbraced condition, and that M_{cr} increases as purlin spacing becomes closer. The Z150×50×20×3 mm purlin yields an M_{cr} that is 1.776%–2.846% higher than that of the C150×50×20×3 mm purlin due to larger section properties, despite having the same cross-sectional area and weight. In the unbraced condition, M_{cr} is much lower than the plastic moment capacity (M_p) according to SNI 1729:2020, indicating that elastic LTB may occur prior to yielding.

In contrast, under braced conditions M_{cr} exceeds M_p by 18.082%–52.638%, shifting the governing limit state from LTB to yielding. In the code comparison, EN 1993-1-1:2005 provides the closest agreement with the FE results, with deviations of approximately −15.277% for loading at the top flange and −5.850% for loading at the shear centre, and +8.354% for loading at the bottom flange. Meanwhile, AISC 360 tends to overpredict M_{cr} by about 20.624% compared with the FE results, primarily because the influence of load application position is not explicitly considered; therefore, caution is required when applying this provision.

Keywords: lateral–torsional buckling, elastic critical moment (M_{cr}), finite element method, rafter, purlin, unbraced length (L_b).