Pengembangan metode evaluasi kekuatan dari profil baja persegi (square hollow section/shs) dengan menggunakan teori gabungan pendekatan mekanisme plastis dan elastis = Development of strength evaluation method of a square hollow steel section by the application of combined theories of plastic mechanisms and elastic approach

Andi Muhdiar Kadir, author

Abstrak

[Teknologi struktur berdinding tipis banyak digunakan pada desain struktur automotif, pesawat terbang, kapal laut, gerbong kereta api, bangunan gedung dan industri, dan lain-lain. Salah satu grup struktur berdinding tipis adalah struktur baja ringan dimana tebalnya sekitar 0.373 mm sampai 6.35 mm. Umumnya rasio lebar terhadap tebal disetiap bagian elemennya sangat besar. Kelompok baja ini sering disebut group cold-formed steel section. Ide dari suatu struktur dengan menggunakan baja ringan adalah mendapatkan kekuatan maksimum dari berat material seminimum mungkin dan bila digabungkan dengan strategi perencanaan yang inovatif dan tepat maka dapat diwujudkan untuk berbagai keperluan. Pengaruh bentuk geometri penampang sangat besar pengaruhnya terhadap perilaku dan kekuatannya dalam mendukung beban. Adanya perubahan bentuk sedikit saja dari penampangnya maka kekuatan elemen struktur tersebut akan berbeda sama sekali termasuk juga perilaku tekuknya. Keuntungan penggunaan cold-formed steel section meliputi antara lain desain yang lebih ekonomis dapat dicapai untuk beban yang relatif ringan dan bentangan pendek, pengurangan berat struktur sehingga diperoleh perbandingan kekuatan dengan berat yang tinggi serta dapat digunakan langsung sebagai lantai, atap, dinding, conduit, dan lain-lain. Model kerusakan yang dialami oleh struktur berdinding tipis khususnya dibagian yang tertekan adalah mengalami kerusakan berupa tekuk setempat (local bukcling) kemudian akan berkembang menjadi local plastic hinge failure mechanisms (plastic collapse).

Secara teknis pengembangan model analisis kekuatan struktur baja ringan yang dibuat dengan proses pembentukan dingin ini dapat diarahkan untuk memperkecil kelemahan disain metode konvensional pada struktur baja dimana dalam metode konvensional, disain kekuatan struktur baja biasanya ditentukan dengan memanfaatkan faktor keamanan (safety factor) sehingga besar kecilnya faktor keamanan yang digunakan dalam disain akan berpengaruh pada berat disain struktur baja yang dihasilkan. Untuk mengurangi ketergantungan penggunaan faktor keamanan dalam disain, maka perlu dikaji dan dikembangkan suatu metode evaluasi kekuatan yang tidak tergantung pada penggunaan faktor keamanan. Metode analisis disain yang dikembangkan didalam penelitian ini tidak menggunakan faktor keamanan sehingga dapat digunakan untuk mendisain struktur baja yang mampu mendukung beban kerja dengan berat yang seringan mungkin sehingga diperoleh struktur yang efektif dan efisien dari segi teknis dan ekonomi.

Dalam penelitian ini, suatu metode cut-off strength digunakan sebagai dasar untuk memprediksi kekuatan profil baja ringan berpenampang persegi (SHS) akibat interaksi beban tekan memusat dan momen lentur. Metode cut-off strength diilustrasikan dalam bentuk dua kurva beban-defleksi plastis dan elastis, dimana nilai beban diperpotongan kedua kurva tersebut diasumsikan sebagai kekuatan teoritis profil baja SHS terhadap interaksi tekan memusat dan momen lentur. Kurva plastis dibentuk berdasarkan persamaan beban-defleksi yang dikembangkan melalui analisis kesetimbangan energi model mekanisme kerusakan plastis

profil baja SHS. Sementara itu, kurva elastis dibentuk berdasarkan persamaan beban-defleksi yang dikembangkan melalui analisis non-linear elastic profil baja SHS dengan mempertimbangkan efek local buckling pada penampang profil yang tertekan. Metode analisis ini diimplementasikan dengan menggunakan perangkat lunak (software) komputer. Untuk mengukur ketelitian model analisis disain yang dikembangkan dalam penelitian ini, hasil prediksi kekuatan profil baja SHS diverifikasi menggunakan data kekuatan aktual yang dihasilkan melalui pengujian sejumlah profil baja SHS akibat interaksi beban tekan memusat dan momen lentur sampai rusak. Hasil verifikasi menunjukkan bahwa rasio data prediksi analitis dan eksperimental masih tersebar dalam batas-batas toleransi yang umum digunakan yaitu ± 20 %.
Dalam penelitian ini juga dipelajari parameter dimensi dan material dasar profil baja SHS yang dapat mempengaruhi kekuatannya, dimana parameter tersebut terdiri dari variasi rasio lebar tumpuan beban, tinggi web dan radius kelengkungan terhadap tebal (n/t, hw/t dan r/t), panjang bentang profil (l) dan tegangan yield material (σyield). Hasil kajian menunjukkan bahwa profil baja SHS lebih kuat mendukung interaksi beban tekan memusat dan momen lentur sejalan dengan peningkatan parameter rasio n/t dan hw/t sedangkan akibat peningkatan parameter r/t dan panjang bentang (l) menyebabkan kekuatan profil baja SHS dalam menerima interaksi beban tekan memusat dan momen lentur akan lebih melemah. Disamping itu terindikasi bahwa pengaruh variasi tegangan yield terhadap kekuatan profil baja SHS akibat interaksi beban tekan memusat dan momen lentur tidak terlalu berarti.;
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Thin-walled structure technology is often used in structural design of aircraft, automotive, ship, train, building of industries, etc. A light weight steel structure is one of thin-walled structure group where its thickness ranges inbetween 0.373 mm to 6,35 mm. Generally speaking that the ratio of width to thickness is very large and this group of steel is called cold-formed steel section. The idea of using this light weight steel section in the design is to obtain a high strength to weight ratio and an innovative design strategy, which can be used in various needs.The form of geometry and cross section of the light weight steel structures affects significantly to the strength and local buckling behavior.
The adventage of using the cold-formed steel sectionc is to obtain the economical design and reducing of structural weight. The economical design can be obtained especially for the relative minimum weight and short span. Effect of reducing weight can result in high strength to weight ratio. With reference to this advantages, the light weight steel structures can also directly be used for the design of floor, roof, wall, conduit, etc. In the design of light weight steel structure, its compressive elements tend to undergo local buckling that can be subsequently develop to local plastic hinge failure mechanisms, at collapse.
Technically, the development of strength analytical model of a thin-walled steel structure produced by cold-forming process in this research is aimed at reducing the weakness of a conventional method to analyze the strength of the structure. In the conventional method, the strength design of the steel structure is usually determined using a safety factor where the value of this safety factor will affect the weight of the steel tructure. In order to reduce the dependency of using safety factor in the design, it has been attempted to develop another method of designing the strength of the steel structure, which does not depend on the application of a safety factor. Based on this method, the strength analysis used can certainly result in the design steel structure, which is lighter and still able to carry applied loads. Thus, the main objective of developing this analytical method is intended to obtain the steel structural design, which is still effective and efficient in terms of technical and economical points of view.
In this research program, a method of cut-off strength is used as a basis of predicting the strength of a square

hollow steel section affected by the interaction of concentrated-compressive load and bending moment. The method cut-off strength is illustrated in the form of two plastic and elastic curves of load-deflection, where the value of load at an intersection of these curves is assumed to be the theoretical strength of the steel section with respect to the interaction of concentrated-compressive load and bending moment. The plastic curve is established according to a load-deflection equation that is developed through the analysis of energy equilibrium on the plastic failure mechanisms model of the steel section. Meanwhile, the elastic one is established according to another load-deflection curve that is developed through the analysis of non linear elastic concept of the steel structure. This analytical method is implemented by using computer software. In order to measure the accuracy of the design of this analytical model developed in this program, its predicted results are verified using actual strength data obtained from a number of tests on the square hollow steel sections subjected to the interaction of concentrated-compressive load and bending moment to failure. Verification results indicate that the ratio of the analytical-predicted data and experimental one is still scattered within tolerable limits of ± 20 %.
This research also studies parameters of dimension and basic material of the steel SHS, which can influence its strength, where these parameters consist of variation of load bearing length, web height and radius with respect to thickness (n/t, hw/t and r/t), span length of the section (l) and yield strength material (σyield). The assesment results show that the steel SHS under insteraction of concentrated-compressive load and bending moment are stronger along with the increasing of the parameter of n/t and hw/t. Meanwhile, due to the increasing steel section of radius ratio (r/t) and span length (l) the strength of steel SHS tend to decrease. Bisides, it has also indicated tha the effect of various yield strength with respect to the strength of the steel SHS under insteraction of concentrated-compressive load and bending momento is not too significant.;Thin-walled structure technology is often used in structural design of aircraft, automotive, ship, train, building of industries, etc. A light weight steel structure is one of thin-walled structure group where its thickness ranges inbetween 0.373 mm to 6,35 mm. Generally speaking that the ratio of width to thickness is very large and this group of steel is called cold-formed steel section. The idea of using this light weight steel section in the design is to obtain a high strength to weight ratio and an innovative design strategy, which can be used in various needs.The form of geometry and cross section of the light weight steel structures affects significantly to the strength and local buckling behavior.
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