Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 83 (1999)

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DOI: https://doi.org/10.5169/seals-62936

An Integrated Steel Design System Developed for Educational Purposes

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Summary

The main goal of this paper is to present an educational software for an integrated analysis and design of steel structures. The system provides structural engineering students and designers with a graphical tool to speed up the assessment of various structural systems. The motivation created with this fast and user-friendly design process improves the students ability to obtain more suitable structural solutions. The member structural strength design checks are performed according to ultimate and serviceability limit states necessary to insure an adequate structural safety. The program displays, in an suitable graphical way, all the members designed together with their strength design ratios. The flexibility of the system enable users to change on the fly the suggested steel sections according to fabrication needs or any other constraints.

Keywords: Structural Design, Automated Design of Steel Structures, Interactive Design of Structures, Structural Engineering Education.

Abstract

Structural steel design programs are very powerful tools not only for the daily use of structural engineers, but also to help undergraduate and graduate students to learn and understand the structural behaviour. Unfortunately, these programs are very expensive and, in the great majority of cases, not suitable for an efficient educational use.

Students in regular courses spend much time exercising theoretical aspects of structural behaviour without exploring concurrent issues such as connection rigidity, sideway displacements, deflections; member resistance, fabrication and erection costs, fire resistance and others.

Regretfully, this design knowledge often will be acquired only after some years of experience. On the other hand, the fast development of computational resources and graphical interfaces allows a more active participation of users in the steel structures design process which provided the major motivation for this work. The idea is to develop a teaching tool to increase the understanding of the global structural behaviour and a well as providing a controlled design procedure.

This paper also presents a brief overview of the portal frame design process. The sway frame design methods were summarised and included: a linear first order analysis, an approximated P-Delta method and a second order analysis. The complete structural design of a non sway system is proposed with the aid of the developed software. This method can detect, by means of a fast structure reanalysis, if the structure has any potentially underdesigned members.

The software FTOOL (Bidimensional Portal Frame Structural Analysis), developed at PUC/RIO was further expanded to include the steel structure design. Limits states design philosophy was implemented in the program, taking into account serviceability and resistance requirements used in the Canadian Code ,CAN/CSA-S16.1-94, [1].

A brief description of the program FTOOL in found elsewhere [2], [3]. The program has been used for teaching undergraduate students and was recently converted to the Windows environment. Extra modules as well as modification in others programs procedures had to be implemented in FTOOL to make the steel structure design user-friendly. A steel section data bank with a comprehensive set of information on standardised profiles was created to facilitate the structure input phase. A graphical interface based on IUP/LED, [4], a portable system user interface and CD, [5], Canvas Draw developed at the TECGRAF/PUC/RIO form the basis for input and output visualisation. The program developed is fully portable and can run on IBM-PC environments, or X-Windows based systems. The main modifications performed in data structure of the FTOOL program, were implemented to include geometric, material and design properties, required for the structural design [6].

The graphic interface used in the program FTOOL was created with the objective of assisting the user's needs and simplifying, as much possible, the data input generation. The menus and submenus implemented consisted in: pre-processing, post-processing and structural design. The structural design checks for a given member included: cross section capacity, overall member capacity, lateral torsional capacity, shear capacity, vertical and lateral displacements assessment.

The full interaction of the implemented module of: pre-processing, post-processing, structural analysis and structural design is achieved through an user-friendly interface. A flexible environment is created enabling designers and students to use the results obtained in one module as input requirement for others. This strategy induces a step by step procedure very efficient for teaching structural design and analysis. The possibility of using different structural sections can also improve the students learning ability on structural analysis and steel structures behaviour.

The program FTOOL serves as an useful tool to speed up the design process. A cost reduction investigation can be performed for a given structure through the design of alternative structural solutions. The program also enables the selection of a roll of sections according to fabrication or any other design requirements. This feature can significantly reduce the structure's fabrication and erection

References

[1] Canadian Standards Association, *Limit States Design of Steel Structures*, National Standard of Canada, Rexdale, Ontario, 1994.

[2] Grupo de Tecnologia em Computação Gráfica - TecGraf, *FOOL User Manual*, version 1.0, PUC-Rio, Rio de Janeiro, 1994. (in portuguese)

[3] Cavalcanti, P.R., *Criação e Manutenção de Subdivisões do Espaço, Ph.D. Thesis*, Computer Science Department, PUC-Rio, 1992. (in portuguese)

[4] Grupo de Tecnologia em Computação Gráfica - TecGraf, *IUP/LED – Sistema Portátil de Interface com o Usuário, Reference Manual*, Rio de Janeiro, 1996. (in portuguese)

[5] Grupo de Tecnologia em Computação Gráfica - TecGraf, *CD – Canvas Draw – A 2D Graphics Library , Thecnical report*, PUC-Rio, Rio de Janeiro, 1997. (in portuguese)

[6] Peixoto, R.H, *Um Sistema Integrado para Análise e Projeto de Estruturas de Aço, M.Sc. Dissertation*, PUC-Rio, Rio de Janeiro, 1999. (in portuguese)