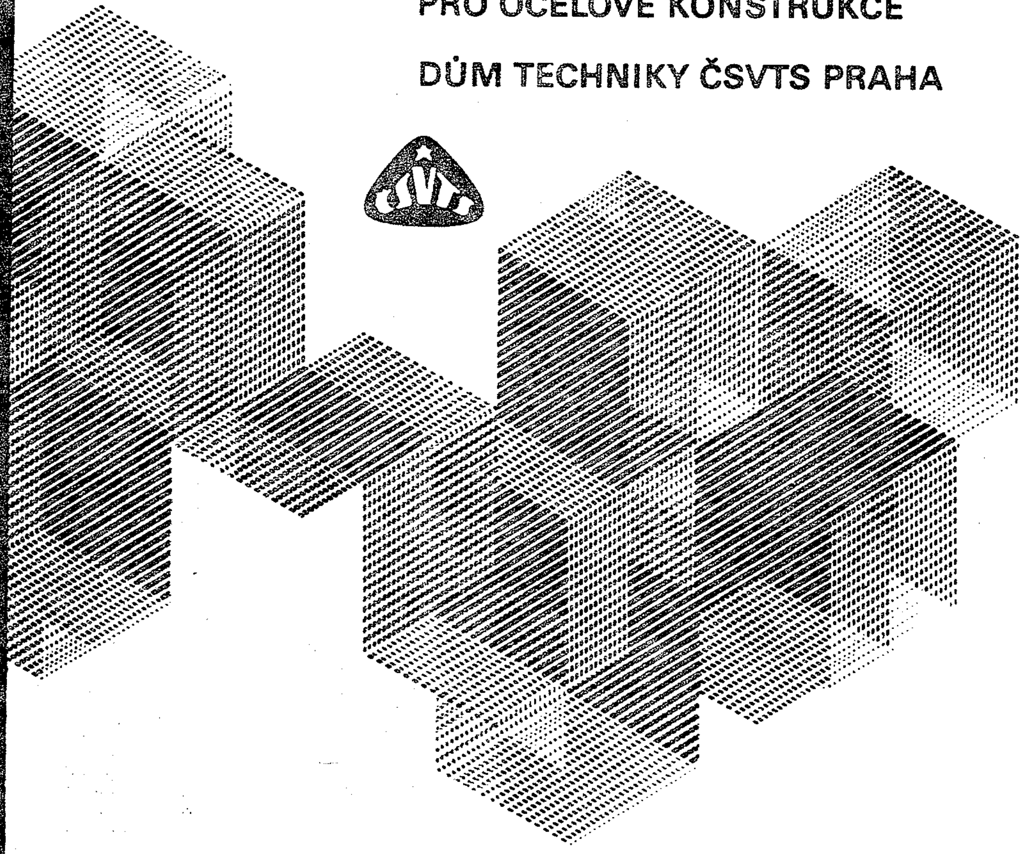
díl 2.

KOMISE ČESKÉ RADY ČSVTS
PRO OCELOVÉ KONSTRUKCE

KOMISE SLOVENSKÉ RADY ČSVTS
PRO OCELOVÉ KONSTRUKCE

DŮM TECHNIKY ČSVTS PRAHA



15. CELOSTÁTNÍ OCELÁŘSKÁ KONFERENCE

závazná přihláška

současnost a budoucnost ocelových konstrukcí

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OPTIMUM DESIGN OF PLANE FRAMES USING THE FEM IN PERSONAL COMPUTERS

The design of a safe and economical structure is one of the main concerns of structural engineers. The finite element method presents a powerful tool for analysis of many engineering problems and it is extensively used in stress analysis.
The coupling of these two methods results in an efficient procedure to find the optimum design of a plane frame constructed from welded I-beams.

The computer program consists of three parts:

1. The menu and the data input: the main sizes of the structure and the loading cases.
2. Analysis using FEM: both at columns and rafters the heights of webs are linearly increasing or decreasing (see. Fig. 1.).
3. Optimization: using the Rosenbrock's Hillclimb procedure, where, for the stress and displacement constraints, the FEM procedure is a subprogram. The program finds the minimum of the merit function while the various constraints are satisfied.

<u>The unknown variables are</u>:

at columns:
- height of web at pinned base
- thickness of web
- width of flange (constant for a frame)
- thickness of flange
- height of web at the eaves points of frame

at rafters:
- height of web at the eaves points
- thickness of web

- thickness of flange
- height of web at apex

The merit function is the mass of the structure to be minimized. The quantity is computed as a sum of member masses.

$$y(x_i) = \sum_{i=1}^{N} \rho A_i \ell_i$$

where A_i and ℓ_i are the area and length of the i th member, respectively and ρ is the material density.

The design constraints are as follows:

1. Statical stress constraints
   Maximum elastic stresses in the columns and rafters due to bending and compression must be lower than the admissible stress.
   Number of constraints is four.
2. Local web and flange buckling constraints both at columns and rafters.
   Number of constraints is six.
3. Lateral buckling constraint for the compressed flange of rafter.
   Number of constraint is one.
4. Vertical and horizontal displacement constraints for the apex and eaves points of the frame.
   Number of constraints is two.
5. Size constraints; the upper and lower limits for the unknown variables, according to the demand of the factory.
   Number of constraints is nine.
   Constraints No. 1-5. are defined according to the Hungarian Standard for Steel Structures MSZ 15024/85.
6. Elastic lateral buckling for the tension flange both

at columns and rafters.
Number of constraints is two, according to the British Standard BS 5940.

The total number of constraints is 24.
All the constraints are as follows:

$$x_i^L \leq x_i \leq x_i^U \qquad i = 1, \ldots, 24 .$$

Where x_i is the i th variable, x_i^L the lower and x_i^U is the upper limit.

Design data

The loading conditions are also shown in Fig. 1.
Uniformly distributed loads at bars, concentrated loads and bending moments can be applied at nodes.
Material: steel Fe 360 or Fe 520 can be used.

The optimization procedure

The description and flow chart of the multivariable, constrained, direct search method "Hillclimb" can be found in references [1, 2]. It was complemented to find discrete values.

The finite element analysis

We used linearly elastic frame members, axial and transversal forces as well as bending moment can be accured at nodal points. Number of nodes is 29.

Computer

An IBM PC/AT compatible type computer has been used, with EGA card and mathematical coprocessor. The main memory of the computer is 1 MBytes and there is a built-in Winchenster disk with 20 MBytes.
We used the BASIC language with compiler.

Numerical example:

Distance of columns	:24000 mm
Height of eaves points	: 6000 mm
Height of apex	: 8400 mm
Distances between frames	: 5000

The length of the haunch
from the eaves point : 3000
Distance of purlins : 2000
The uniformlydistributed vertical load: 0.4 kN/m^2
Shape constants for wind load: 0.8, 0.4, 0, -0.4

Results:

	Column		rafter	
	web	flange	web	flange
height width	230/640 (mm)	200	560/230	200
thickness	6	12	8	16

Total mass of the plane frame is: 2466 kg
The nearly active constraints were as follows:

- stress in rafter at the eaves point,
- web buckling in column at the eaves points

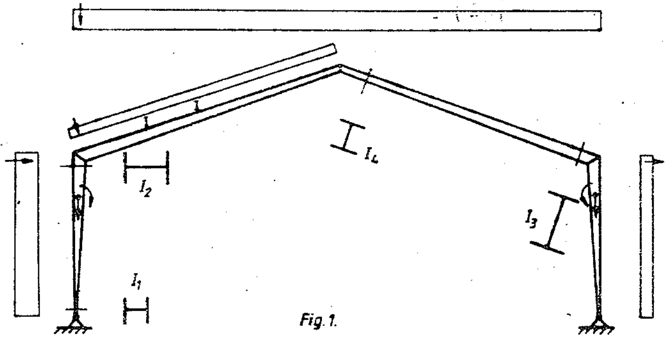

Fig.1.

References

[1] Rosenbrock H.H.: An automatic method for finding the greatest or least value of a function. Computer Journal 3 (1960) p. 175-184.

[2] Bykovskii S., Jármai K.: Cost optimization of welded steel beams. Publ. of the Techn. Univ. Miskolc, 41 (1987) p. 241-254.

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CAD OF SPACE STEEL STRUCTURES

This paper is concerned with the prerequisites, theoretic basis, program realization and implemention of a set of programs for computer aided design of multi-purpose buildings with steel space structure /SSS/ roofings. It is developed by a team from KNIPIOIUS - Sofia, working in close collaboration with a team from the plant for fabrication, assembly and erection of SSS similar to the systems MERO and MARHI.

GENERAL DESCRIPTION

For the last 10 years a considerable growth in designing and erecting tube SSS has been noted in Bulgaria.

This type of structures is assembled from uniformly long tube rods connected by an axial bolted joint in nodes with prefabricated threaded openings.

The rapid spread as well as the necessity of computerizing the design process is grounded on the specific features of SSS such as:

- high degree of internal and external redundancy leading to impossibility of a precise manual analysis,
- lightweight, due to correct selection and distribution of the appropriate type of rod sections, could only be achieved by several iterative computations,
- unification of elements allowing the set up of a data base, thus contributing to the speed and efficiency of CAD.

The rapid advance in computer technology and capacity enables the analysis of still larger span SSS with most arbitrary layout and elevation.

THEORETIC BASIS

The structure is considered as a combination of a space truss and space frame elements. The static analysis is