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Software Development for Cold-formed Steel Elements

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SOFTWARE DEVELOPMENT FOR COLD-FORMED STEEL ELEMENTS

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Abstract

The great acceptance of steel structures and specifically cold formed steel elements in Colombia and other countries around the world, makes companies like Acerías de Colombia - ACESCO develop new tools to help their clients. This tool was developed with the assistance of "Diseño de Soluciones", with enginner Oscar Betancurt who was incharge of programming with the supervision and assistance of ACESCO's technical department. As a consequence, Acesco created a Design Software for their products, based on the AISI – Cold Formed Steel Design Manual – 1991 and 1996 editions.
The result is a software containing six different modules: graphics and tables - calculates and shows graphics and tables for different stresses for specific C and Z shapes; technical manuals - digitalized manuals edited by ACESCO; Metaldeck (Steel deck) design - calculates steel deck slabs; profiles for floor structures - designs profiles to be used as floor beams, with or without the use of steel deck; purlins - designs elements as support for any roof type; trusses and rigid frames - designs the most cost-effective structure using the information the designer provides.
With this kind of tools more people are using steel, and specifically cold-formed steel elements to build structures of different types. Engineering companies, especially the ones who build steel structures, are using the software to generate reports and budgets faster and easier.

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Design software

Acerías de Colombia S. A. - ACESCO trying to help the clients, developed a design software for their products. The software is divided into six modules, each one oriented in helping the designer in a different way.
There is a common screen for all the modules, called prices screen. This screen allows the user to change the prices for all the products included in the software. The idea of including prices in the software is to create not only analysis but also budgets in a very short time. This helps the companies respond to their clients in a fast and accurate way. The price is done in the software once the design module has performed the calculations and defined the reference for the purlin, the program searches for the reference in the database, which contains the price per meter of every reference of purlins. The program multiplies that value by the amount of meters, calculating the total value of the materials for the structure. To change the prices ACESCO has a link on its website (www.acesco.com). Here you can find the explanation on how to change the price database on the program so you can adjust them to your needs. However this link is, for the moment, only in Spanish. If you want the full information about it, we can provide it to you in English.

All the procedures and results involved in the program were evaluated and accepted by the Civil Engineering Department of the Universidad de Los Andes. The evaluation verifies the software procedures and routines and approves them.

1.1. Overview

In Colombia, construction and design is regulated by the *Norma Colombiana de Diseño y Construcción Sismo Resistente - NSR 98 (AIS 1998)*. Chapter 6 of this book is dedicated to cold formed steel design and it is based on the *Cold Formed Steel Design Manual - 1991 (AISI - 1991)*. When Acesco released the software, the latest version of the *Cold Formed Steel Design Manual* was the 1996 edition. For this reason the software has the possibility to handle designs selecting one of the two editions, the 1991 edition or the 1996 edition. Acesco is now developing a new version of the program to comply with the North American Specification for the Design of Cold-Formed Steel Structural Members – 2001 edition.

1.2. Graphics and Tables Module

This is the most important module of the software. Using equations and methodology proposed by the *AISI*, it calculates and shows graphics and tables for different stresses for C and Z shapes. It also considers some combinations of C shapes to generate Box shapes and I shapes. The strengths founded in this module are used in all the other modules, being the base for the entire program. ACESCO produces purlins in 6 different heights, going from 2.36in (60mm.) to 13.97in (355mm.) in C shapes and from 6.3in (160mm.) to 12in (305mm.) in Z shapes. They are manufactured in 5 different thicknesses from 0.0472in (1.2mm.) to 0.118in (3.0mm.) according to dimensional limits imposed by the *AISI-96*. The software lets the user select the desire shape, height and thickness from a list of standard ACESCO references. Figure 1 shows the different purlin options available in the program.

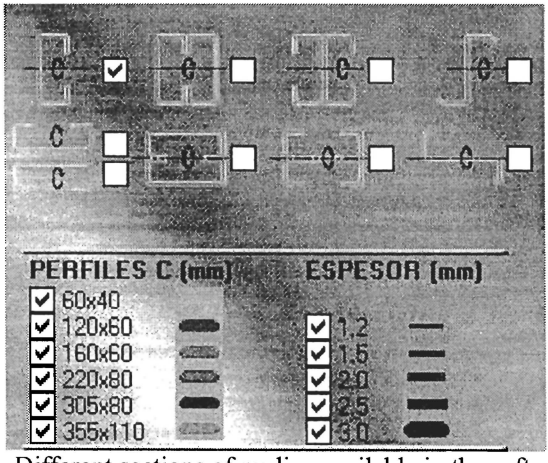


Figure 1 – Different sections of purlins available in the software.

For the selected purlins, the software can display 8 different graphs, 5 to show nominal strength for different kind of stresses, and 3 to show stress combinations. The available graphs are: compression strength, flexural strength, shear strength, tension strength, web crippling strength, combined shear and

bending, combined web crippling and bending and combined compression and bending. This graphs are very useful to understand the general behavior of the purlins. Figure 2 shows an example of the flexural strength behavior of a C-120x60 shape in three different thicknesses.
Two additional options are available in this module: the software can calculate using galvanized purlins or non-galvanized purlins.

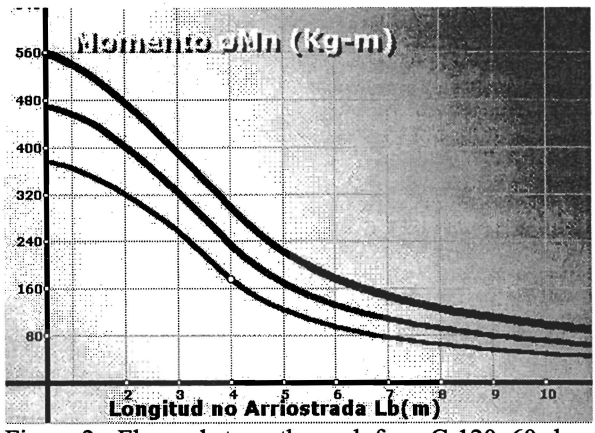


Figure 2 - Flexural strength graph for a C-120x60 shape.

1.3. Technical manuals

This module presents the digitalized version in PDF format of the manuals edited by ACESCO. These manuals are: *Manual de diseño de perfiles (Acesco 2002), Manual Técnico Metaldeck (Acesco 2001)* and *Manual de Instalación de Metaldeck (Acesco 2001).*
The first manual is a book containing some theory about cold-formed steel design and a variety of tables presenting the load capacities for all the purlins manufactured by ACESCO. The second manual is a technical book for the product *Metaldeck*; this is the name of the steel deck ACESCO produces. The last one is a small book specifically oriented on installation of Metaldeck.

1.4. Metaldeck (Steel Deck) Design

The design method used to develop this module is based on the equations published in the *Composite Deck Design Book (SDI 1991)*. This methodology analyzes the deck initially as a working platform and then as a composite deck. ACESCO manufactures steel deck in two shapes called Metaldeck 2" and Metaldeck 3". The name indicates the total steel deck profile depth.
In this module the user has to select between two options, practical design and detailed design, both let the user design a Metaldeck slab. The first is easier to handle but it has less options. The second one is a lot more flexible but a little more complicated.

1.4.1. Practical design

This part of the program needs only three variables to specify a Metaldeck slab. These variables are: dead load, live load and the clear span. The idea of this module is to obtain a general pre-dimension for a construction project. It is assumed that the slab is in a simply supported condition and it is not possible to apply concentrated loads to the problem. As a result the program indicate the steel deck geometry, thickness and a slab depth. Figure 3 presents the screen where the user inputs the variables and figure 4 shows the results screen, with different solutions for the problem.

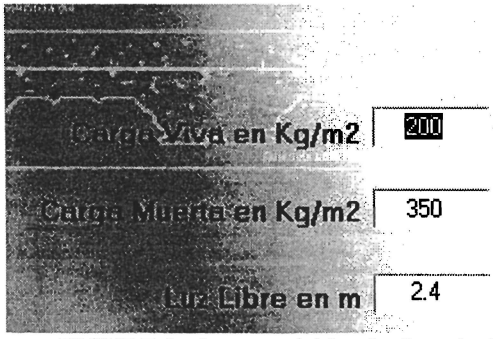
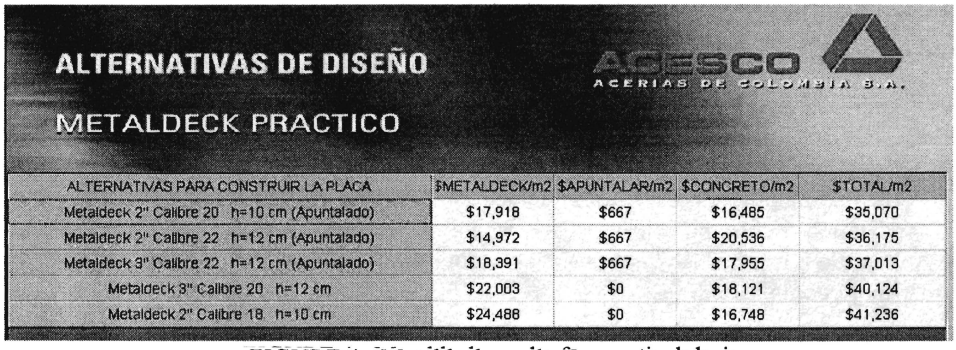


FIGURE 3 - Input variables for Practical design



ALTERNATIVAS PARA CONSTRUIR LA PLACA	$METALDECK/m2	$APUNTALAR/m2	$CONCRETO/m2	$TOTAL/m2
Metaldeck 2" Calibre 20 h=10 cm (Apuntalado)	$17,918	$667	$16,485	$35,070
Metaldeck 2" Calibre 22 h=12 cm (Apuntalado)	$14,972	$667	$20,536	$36,175
Metaldeck 3" Calibre 22 h=12 cm (Apuntalado)	$18,391	$667	$17,955	$37,013
Metaldeck 3" Calibre 20 h=12 cm	$22,003	$0	$18,121	$40,124
Metaldeck 2" Calibre 18 h=10 cm	$24,488	$0	$16,748	$41,236

FIGURE 4 - Metaldeck results for practical design

1.4.2. Detail design

The user can establish a problem using from one to five spans, with the possibility of simply supported spans or continuous spans. If needed, it is possible to apply a concentrated load in any span. Additionally, the module lets the user select the design maximum deflection of the slab and construction loads.

The software analyzes and presents the moment, shear and displacement diagrams for different solutions to the problem. The results screen is similar to the one showed on the practical design. Figures 5 and 6 show different screens of this module.

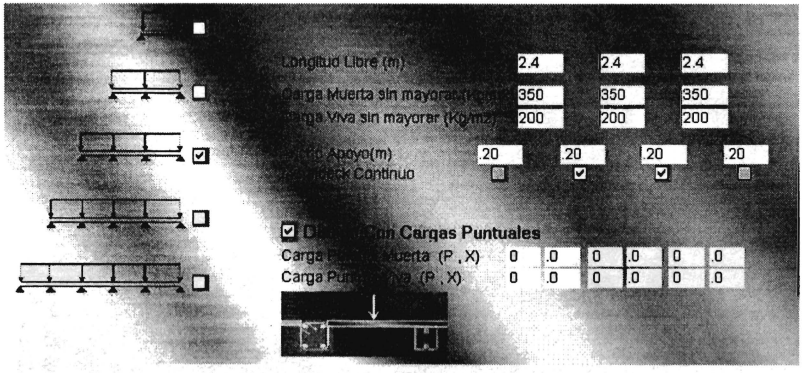
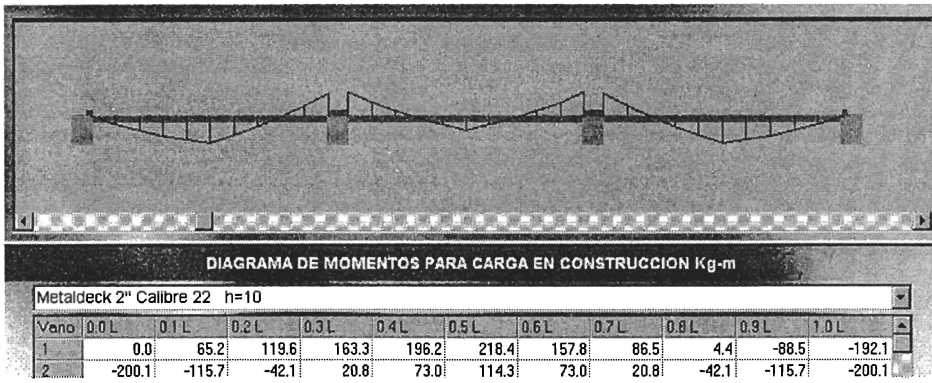


FIGURE 5 - First screen in detail design



Vano	0.0 L	0.1 L	0.2 L	0.3 L	0.4 L	0.5 L	0.6 L	0.7 L	0.8 L	0.9 L	1.0 L
1	0.0	65.2	119.6	163.3	196.2	218.4	157.8	86.5	4.4	-88.5	-192.1
2	-200.1	-115.7	-42.1	20.8	73.0	114.3	73.0	20.8	-42.1	-115.7	-200.1

FIGURE 6 - Moment diagram for a selected load case

1.5. Purlins For Floor Structures

The module designs C shapes, or combinations of C shapes, to be used as support for any kind of floor. If the designer wants Metaldeck slab, it can be designed to work supported by the designed purlins. Another option available is to design purlins working as a compound cross section with the Metaldeck slab.
For any of the options above, the input data are live load, dead load and the geometric dimensions of the floor. There is a separate screen that lets the designer change some variables as moment factor, load combinations, maximum and minimum profile separations and some others.
The software analyzes the problem and shows different solutions, always trying to present the most cost-effective one. Figure 7 shows the main screen of the module and figure 8 shows a screen with some variables the designer can change.

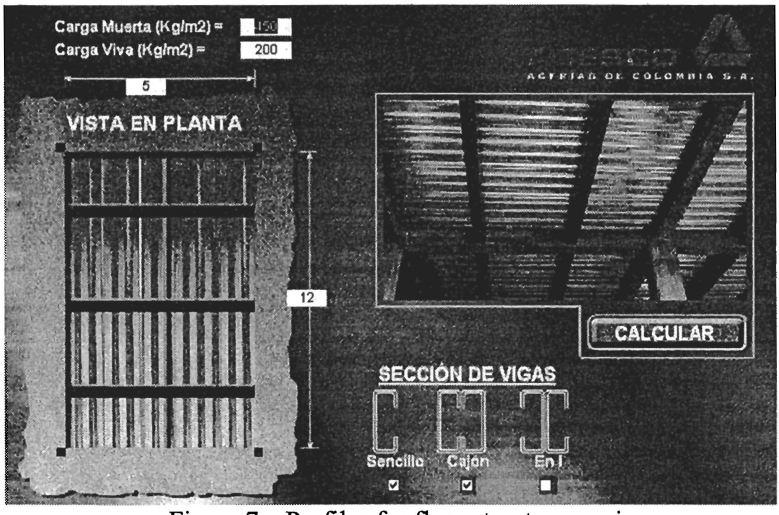


Figure 7 – Profiles for floor structures main screen

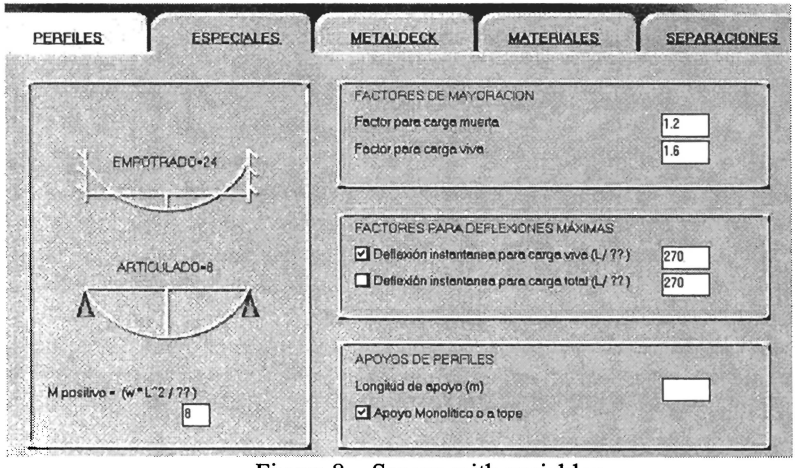


Figure 8 – Screen with variables.

1.6. Purlins

It designs elements to support any roof type. The design is based on flexure, lateral buckling, web crippling and deflections. The input variables are dead load, live load, wind load and other load (snow, rain, etc.). The designer has to determine the roof's slope, distance between purlins and clear span or spans (up to 5 spans allowed), depending on the problem. If the designer wants, web-crippling analysis can be selected; in this case it is important to establish a bearing length for the elements.
The user can select different shapes to design the purlins (C shape, Z shape or combinations of C Shapes) and determine if they are laterally braced or not. Figure 9 shows the general screen used to input the different variables.

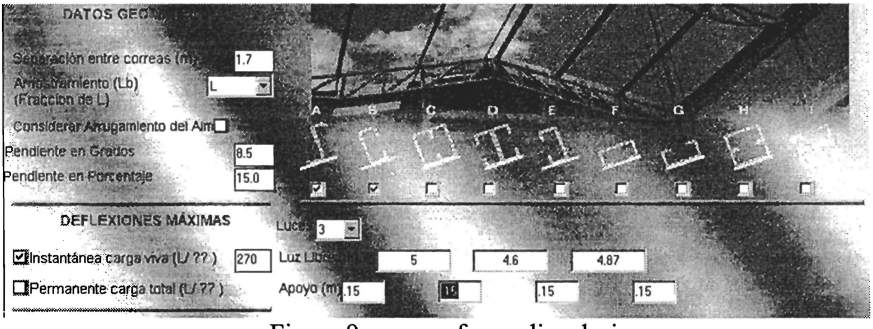


Figure 9 - screen for purlins design.

1.7. Trusses and Rigid Frames

This module presents several pre-established geometries of different trusses and rigid frames. The engineer selects one of them and works with it or modifies it according to the problem that has to be solved. Dead, live, earthquake and wind loads can be applied to any node or element of the structure.
Elements can be moved, deleted, divided, or grouped to accommodate the structure to the engineers needs.

The result is a design of the most economical structure, using different type of purlins ACESCO produces. It shows compression, moment and shear diagrams for the designed structure, for each load combination available. Figures 10 and 11 show two different screens of the design process.

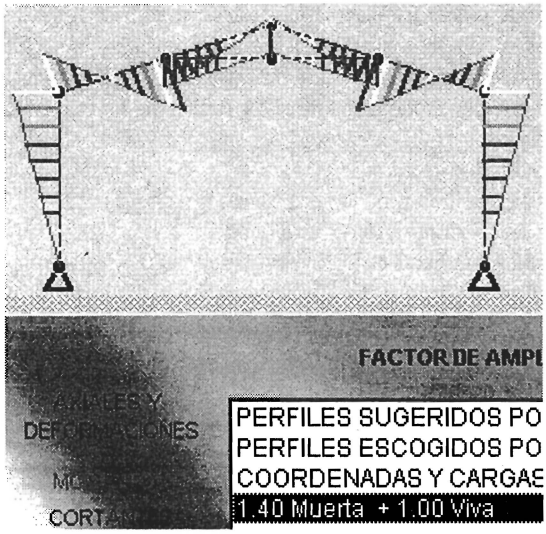


Figure 10 - Elements being grouped

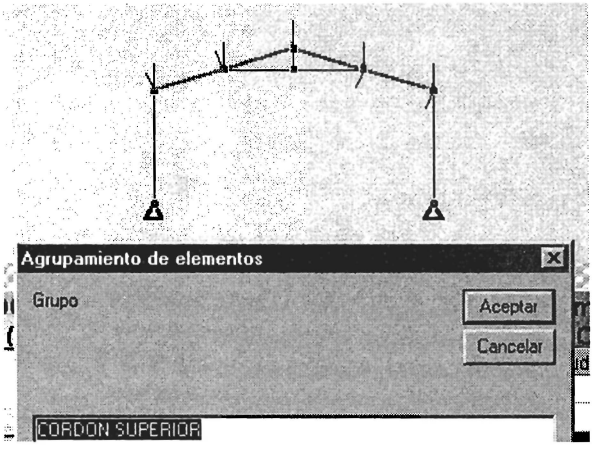


Figure 11 – Moment diagram for a selected load case

2. CONCLUSIONS

This tool is promoting the use of steel structures, using specifically Cold-formed steel products. A lot of architecture and engineer departments are interested in the software, because it is a perfect way to introduce Cold-formed steel structures to their students.
The software is not only used to design structures, it is also used to generate budgets faster and easier than before. Many engineering companies, specially the ones who build steel structures are using the software to calculate and specify ACESCO's products in their projects. They are using it also to generate reports and budgets in a very short time, allowing the companies to present projects faster than before. The execution on different modules is almost instantaneous, but speed may change depending on the amount of elements selected. Execution may take a few seconds when you are running "trusses" and "rigid frames" modules.

Today the software is designed only for purlins manufactured by ACESCO with the technical specification required for Colombia. It could be modified depending on other minimum specification required by other countries.

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