Simplified Structural Design

by Joe Stoddard

If there is one aspect of building that confounds most contractors, it's properly sizing structural components. Poorly drawn plans, conflicting building codes, confusing span tables, and a lack of understanding of basic principles can add up to sagging roofs, bouncing floors, or even unsafe structures. A computer is no substitute for the knowledge and experience of a good structural engineer, but with software like StruCalc, you can do some of the preliminary work — and chop hours off your engineering bill.

Using StruCalc, a contractor or designer with basic structural knowledge can select component sizes with confidence, or use the program to check pre-drawn plans for accuracy before submitting them to an engineer or building department.

StruCalc 4.0 ships on a single 3 1/2-inch disk, and will work on either Windows 3.1 or Win95/98. Installation went smoothly once I realized that the program is a bit of a throwback and doesn't recognize long file or directory names. This is a minor nuisance that means the installation directory and all saved files have to have a name of eight characters or less. The initial configuration screens ask for the model building code the program should use for analysis. Included are UBC, SBC, BOCA, CABO, and the most recent AISC steel code. The user can change the selected code at any time, and components can be checked against multiple code requirements.

StruCalc Modules

The program's ten modules cover calculations for Square Footing (con-

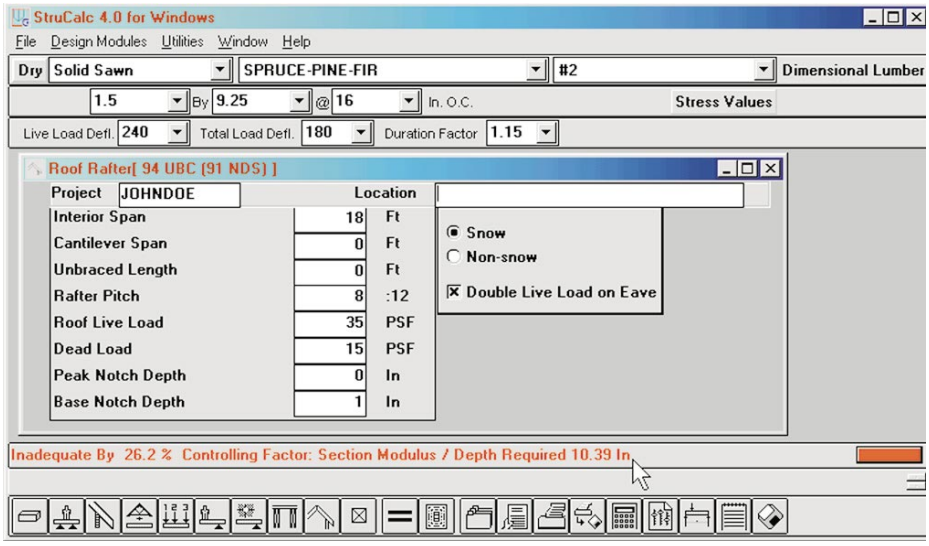

Figure 1. The ten StruCalc design modules are activated either from the menu bar or via buttons at the bottom of the screen. The data shown here are for a UBC analysis of 2x10 S-P-F rafters at 16 inches on-center. According to StruCalc, the rafters are undersized by 26.2%.

crete), Uniformly Loaded Floor Beam, Roof Beam, Combination Roof and Floor Beam, Multi-Loaded Beam, Cantilever Floor Beam, Cantilever Roof Beam, Roof Rafter, Floor Joist, and Columns. The beam modules will calculate solid wood, laminated, and steel beams, and the rafter and joist modules will calculate solid wood and wood I-joists.

After opening the module you want using either the menu bar at the top of the screen or the toolbar buttons at the bottom, you set all the parameters — for example, the length, live and dead loads, pitch (for rafters), depth of footing — for that component. Wood components require you to select the species and grade of lumber you want to work with; steel components require at least the basic shape.

There are two ways to size a component using StruCalc. One way is to take a stab at sizing the component yourself and let StruCalc tell you if your selection will work. This method is handy for checking out as-built conditions and components specified on predrawn plans. For example, a designer may have specified #1 Hem-Fir 2x10 rafters, but all you can get is #2 S-P-F. StruCalc will let you know if you can make the substitution (see Figure 1).

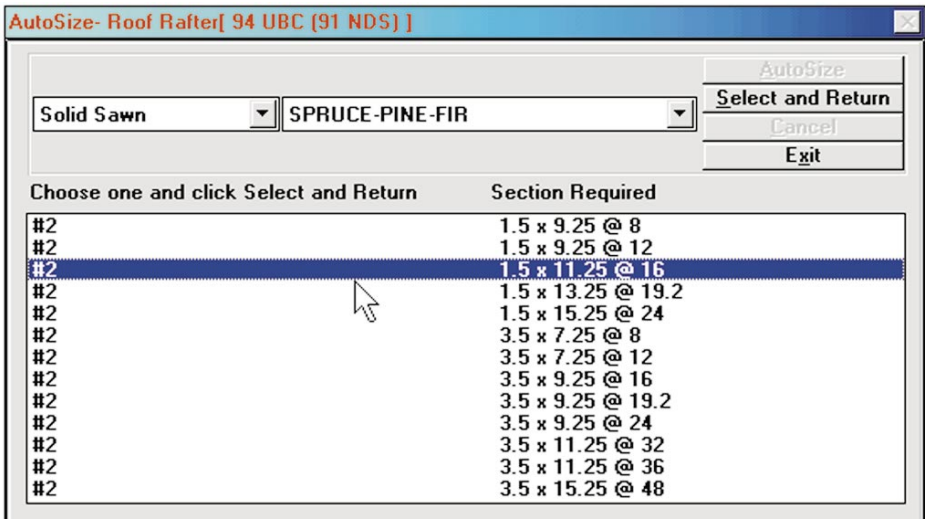

Figure 2. Using AutoSize to analyze the rafter from Figure 1 returns a list of possibilities that includes reduced on-center spacing and increasing the size of the rafter to 2x12. Grade and species can be changed on the fly from drop-down lists at the top of the window.

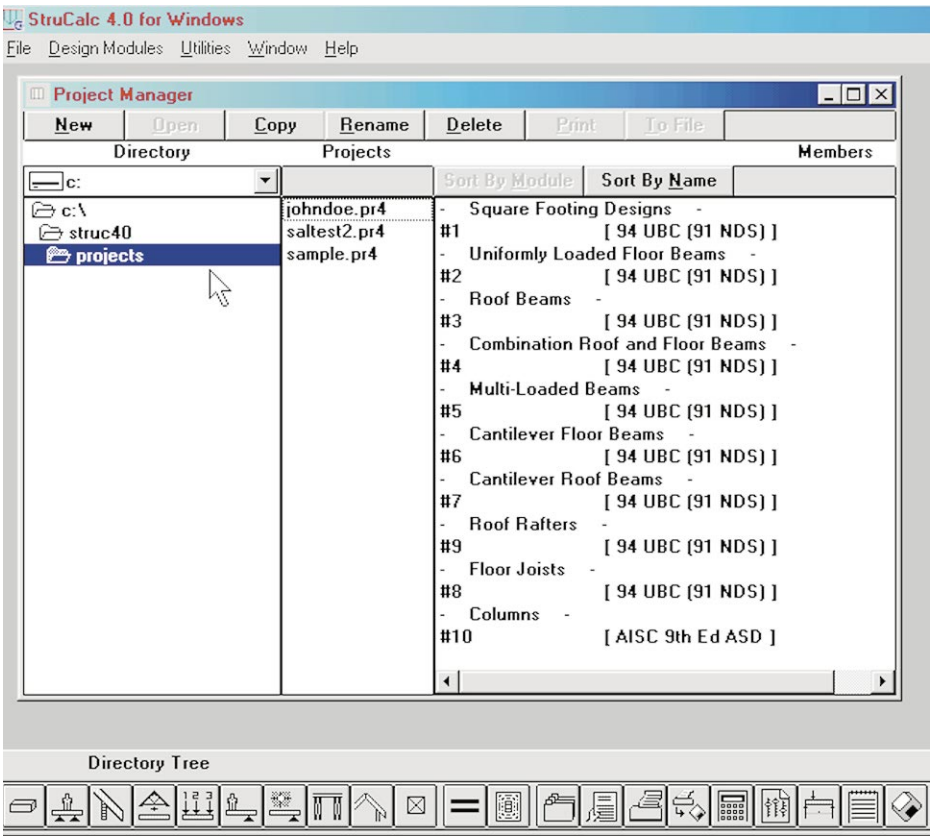

Figure 3. The Project Manager organizes saved analyses, which can be viewed on screen or printed out.

AutoSize. The other way to size a component is to use the AutoSize feature, which will return a list of sizing and spacing options that fit your criteria (Figure 2). For example, a 2x10 rafter might work at 16 inches on-center, but change the spacing to 24 inches and StruCalc says "No way." This is especially useful where space is limited — for instance, a basement where only an 8-inch-deep beam will fit. There are several flavors of 8-inch beams, and StruCalc will let you know which ones work and which ones don't. AutoSize options, such as the species or grade of solid wood or the shape of a steel beam, can also be changed on the fly.

Project Manager. The first time you save an analysis, StruCalc prompts you to name a project and a project folder. Subsequent analyses from the same or other modules are saved there as well, until you change the project name. Each saved analysis is added to a list in the StruCalc Project Manager, which organizes them by component. To re-examine a component, simply open Project Manager and double-click the file you want (Figure 3).

Output. Reports can be printed using any standard Windows printer, or saved to a text file and imported into any Windows word processor. And your engineer will like the shear diagrams generated for beams, joists, and rafters (Figure 4).

Options

StruCalc is preloaded with commonly used structural building materials, section sizes, and stress values, including the following:

- 22 species of solid-sawn lumber
- 5 species-graded glulam types
- 5 LVL manufacturers (Georgia-Pacific, Louisiana-Pacific, Boise-Cascade, Tecton, and Trus Joist-MacMillan)
- 5 common steel beam shapes (W, M, C, S, and MC)
- 4 I-joist manufacturers (G-P, L-P, B-C, and TJM
- 3 steel column cross-sections (square, round, and rectangular)

Species data are kept in a series of text files, and while the selection seemed well thought out and complete, clever users might be able to import their own if needed. This may cause problems with manufacturer-specific engineered products, but where there is enough similarity, one brand might substitute for another.

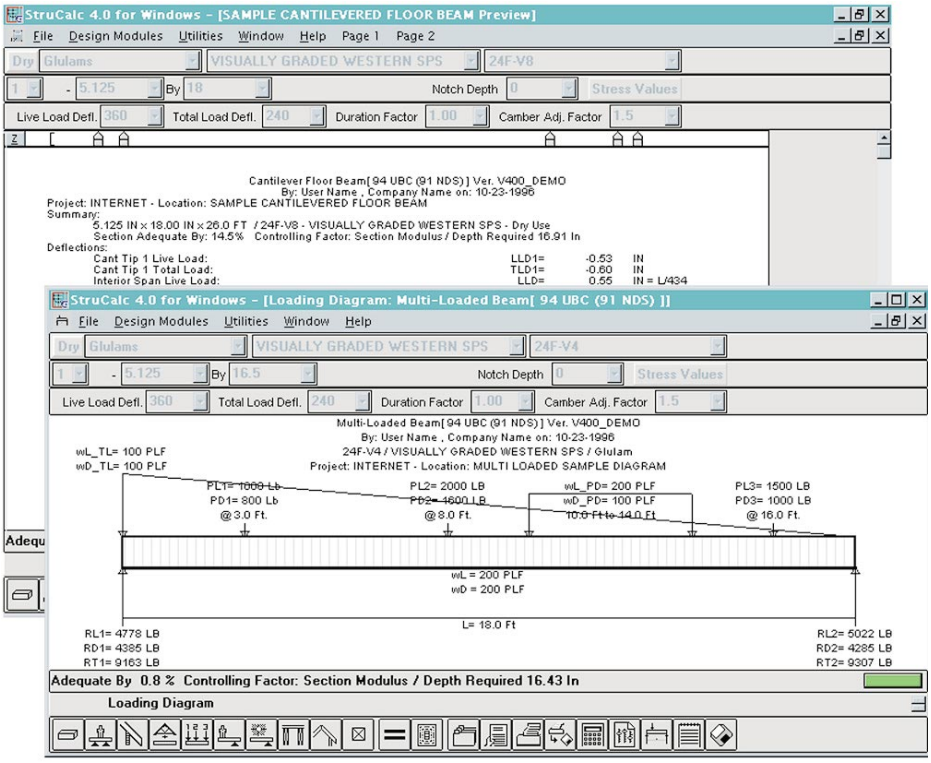

Figure 4. Depending on the component, StruCalc produces either text-based reports or standard engineering shear diagrams. Output can be saved as a text file and imported into your favorite word processor.

Limitations

StruCalc is a worthy tool, but it has limitations. Since the program deals only with individual components, there is no way to analyze load paths, structural systems, or individual connections. It's not enough to design the components; how they are fastened together is equally important. Plus, design of complex assemblies, such as hollow box beams or diaphragms, is beyond the scope of the program. There is also no way to assess how lateral loads, such as wind pressure on a wall or sideways thrust on a beam, will affect the overall design.

Foundations. Except for concrete pier footings, foundation calculations are absent. It would be nice to have a foundation wall and strip footing module, as well as a means to calculate lateral loads on those components from soil pressure.

Column base and cap plates. One curious omission to the footing and column modules is the lack of column base and cap plate design. These components are necessary to spread the load from a column over a larger area of a footing or beam. Fields to hold values for the base plate are included in the footing design module, but not in the column design module. A properly-sized column and footing can still fail if this small but important detail is ignored.

Slabs. Commercial projects employ suspended concrete floors, and even residential work occasionally uses concrete above grade for radiant floors or structural garage slabs. Tools for calculating tensile strength and simple slab cantilevers would be a welcomed addition.

Another minor complaint is the lack of an engineering calculator (StruCalc loads the standard Windows version from the menu). It would also be nice if data could be exported to a spreadsheet or database program for further analysis.

Shortcomings aside, StruCalc is a nicely crafted program that works perfectly for what it was designed to do. In this day of 200MB bloatware, it's proof positive that software can be easy on system resources and still pack a punch. A full installation of StruCalc occupies only 1.2 MB and can run on a 386 PC running Windows 3.1.

Using this or any other structural design program can save time and money, but you will still have to know basic engineering terms and concepts, understand live and dead loads, and be able to calculate tributary loads and load paths. An excellent accompanying manual explains the formulas used in StruCalc, and by itself is a decent reference for the basics of structural design.

StruCalc is available directly from Cascade Consulting Associates (P.O. Box 1617, Corvallis, OR 97339; 800/279-1353). The release version is $295; a limited-function evaluation copy can be downloaded from the company Web site (www.strucalc.com).

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