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# Designing Against the Wind

## Simulation helps develop screen enclosures that can better withstand hurricane-force winds.

Photo courtesy Richard Graulich/*The Palm Beach Post.*

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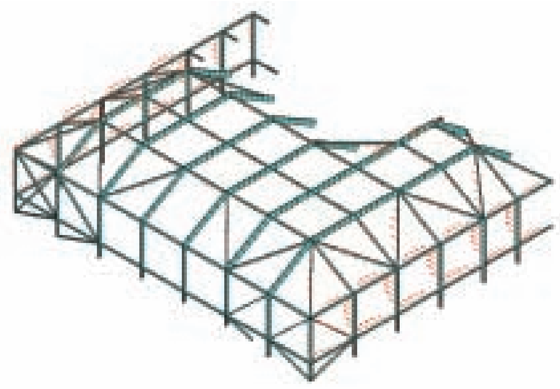
One of the most popular residential structures in Florida is the screen enclosure (or screen room), consisting of an extruded aluminum frame covered with screen. These structures are primarily intended to keep debris and insects out of swimming pools and to increase living space to include an outdoor environment. Even so, they must be designed to resist hurricane-force winds ranging from 100 mph inland to 150 mph in coastal areas, depending on building code requirements.

Recent hurricanes have revealed shortcomings in these designs. Most are developed by contractors or enclosure fabricators based on oversimplified analytical assumptions. Components typically are sized without regard to the *Aluminum Design Manual* (ADM), *Specifications and Guidelines for Aluminum Structures* as specified by the Florida Building Code (FBC). Moreover, fasteners and fastening methods typically are selected for ease of fabrication or accepted convention rather than suitability for the high wind loads.

Using ANSYS Mechanical software, Optimization Analysis Associates, Inc. — an engineering consulting firm specializing in mechanical analysis and design simulation — performed analytical studies of existing screen enclosure designs using FBC wind loads. The company found that the simplified methods failed to accurately calculate forces and moments. Thus, the complex interactions among structural members were not adequately accounted for in the designs.

Finite element analysis (FEA) provides the most accurate method of determining such loads and interactions. Most engineers in the screen enclosure industry do not have a background in FEA, however, and those with such expertise often forgo these studies due to time and cost constraints. The answer is an automated FEA-based screen enclosure design tool — one that is fast, is accurate and requires no FEA skills.

A perfect platform for this task is ANSYS Parametric Design Language (APDL) — a scripting language for automating common analysis tasks or even building models in terms of user-specified input variables. This adaptive software architecture enabled Optimization Analysis Associates to create a web-based solution with a graphical interface through which screen enclosure designs could be conveniently specified and automatically evaluated.



APDL is used to automatically create, load and solve a full-frame model of a screen enclosure from parameters entered by the user describing the structure.

Users are required to enter only minimal input data, including basic geometry information of the frame, wind load criteria, a sketch of the plan view (to provide x and y coordinates for each corner), wall height, roof style, density of structural members (number of columns to be used on a wall, for instance) and sizes of the structural members. From this input data, three APDL macros then automatically perform an analysis, check results against guidelines and generate layout drawings — all completed in less than three minutes and requiring no user intervention.

The first APDL macro reads in the data to create, load and solve the full frame model. Beam elements represent the structural members, which are coupled in the model to simulate hinged or rigid connections as necessary according to the type of connections used. Shell elements represent the screen in a proprietary method that determines the load distribution on structural members. Solutions are obtained for the eight wind-load cases prescribed by the FBC.

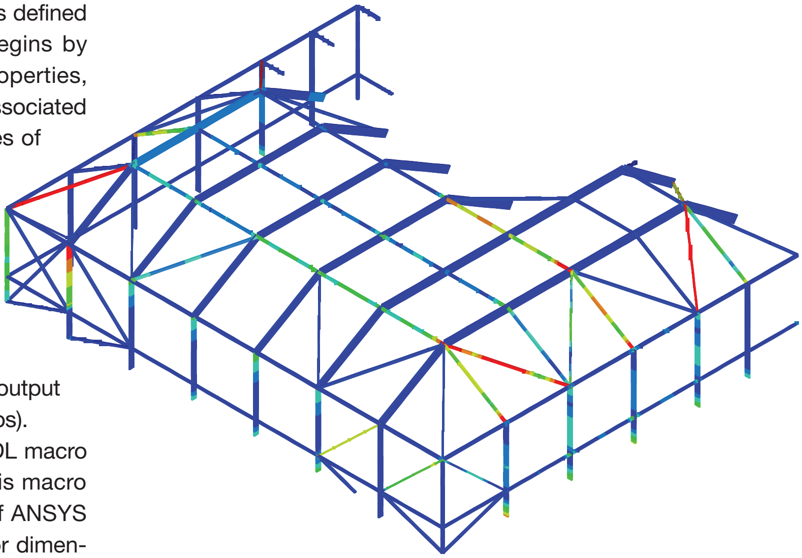
A second macro performs all required checks defined by ADM criteria. This complicated process begins by accessing external files containing section properties, material characteristics and other parameters associated with extrusions used in the design. Then a series of nested APDL do-loops performs the ADM calculations for all nodes on every structural member for each load case. The macro enters this data into arrays and sorts through them to determine the limiting members. The limiting members are written to a summary report text file, which is accessed by the web-based interface. The report provides a simple pass/fail output with percent overstress values (or interaction ratios).

If the user has a passing design, a third APDL macro produces a layout drawing of the structure. This macro takes advantage of the graphical capabilities of ANSYS Mechanical software in generating annotation for dimensions and labels on screen enclosure 2-D layout drawings. If the user does not have a passing design (or if the design is too conservative), parameters may be revised and another iteration may be performed.

Optimization Analysis Associates has written programs for more specialized work as well. A version of the model-building macro allows experienced users of software from ANSYS to create customized structures with nontypical shapes and/or nonstandard bracing configurations. Another macro uses the ADM data to produce color contour plots of interaction ratios, a calculated value of allowable stress ratio not existing in the results file. Locations of failure to meet the ADM criteria give a quick visual indication of problem areas. In addition, these allowable stress ratio plots can be animated with a modified version of the animation macro ANCNTR.MAC and overlaid on 3-D models showing deformed structural geometry.

One final specialized macro provides a cost estimate for the construction of the design. This macro interrogates the model to determine the length of each extrusion required along with the square footage of screen and number of fasteners, brackets, etc. It accesses an external price list file for each item, as well as factors for items such as labor, scrap, overhead and profit to determine the total cost. The final output includes a complete parts list and a breakdown of all cost components.

The automation of the modeling and simulation-based evaluation using APDL provides a fast, easy-to-use and extremely accurate method of structural frame designs. The screen enclosure industry now has the potential to produce hurricane-resistant structures, to significantly improve design productivity, and to improve cost estimating and profit margins of contractors and fabricators who use engineering simulation for their designs. ■



Color contour plots of interaction ratios show locations' potential wind-force failure in red.