

Automating Lifting and Bracing Analysis

Software for precast and tilt-up wall panels also speeds shop drawing production

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To streamline lifting and bracing design, INDUCTA Engineering has created PanelsPlus, a software program that also automates the production of shop drawings for precast and tilt-up concrete panels. It was developed to totally eliminate the process of manually entering the data that defines the geometry of each panel. All data entry is automated by importing information from an AutoCAD® DWG or DXF file.

The software can be used by structural engineers who undertake projects incorporating precast or tilt-up panels and also by drafters who produce detailed shop drawings. A PanelsPlus data file consists of a project containing all the elevations that make up the structure (Fig. 1). The individual panels are contained within each elevation. Each project can contain hundreds of panels that are systematically managed by the software.

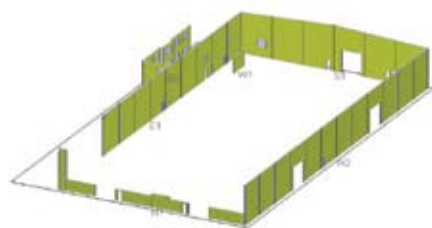


Fig. 1: All of the CAD elevations for a structure are brought directly into a single PanelsPlus data file, eliminating the need to duplicate input of dimensions for individual panels

The algorithm for performing lifting and bracing analysis is based on finite element linear-elastic plate theory and automatically performs a two-way analysis. The finite element mesh is automatically generated by the software for any panel shape.

To speed the production of shop drawings, the program also includes several time-saving drafting tools. These include automatic dimensioning of the panel and associated components, custom user-defined symbols, and user-defined shop drawing templates.

FEATURES

Generating a project starts by importing information from computer-aided design (CAD) files that are produced as either DWG or DXF files. PanelsPlus is a stand-alone program that does not require a CAD program to operate. It only uses the DWG or DXF files that are produced by a CAD program. There are no strict requirements for preparing the CAD drawing prior to import. The only limitation is that the lines defining the perimeter of a panel must be created as a continuous line or a series of line segments that form a closed shape. Cutouts or voids within a panel follow the same requirements as for the panel perimeter. Recessed areas within a panel can be made of many lines forming any shape, provided the lines

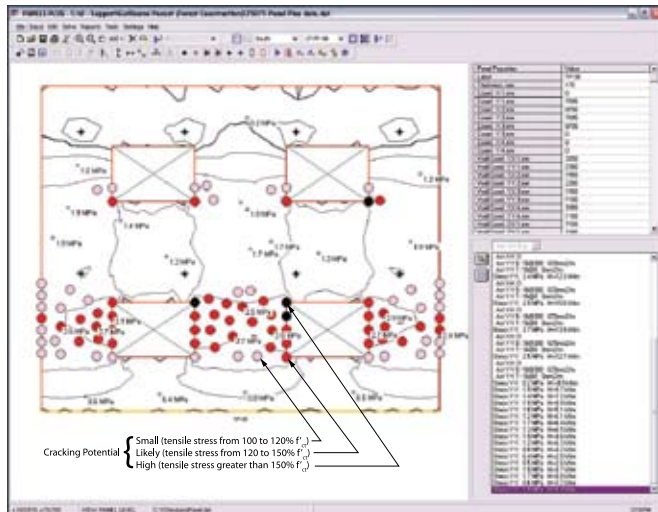


Fig. 2: Stress envelopes for the lifting and rotating analyses are automatically generated from the finite element analysis results. Cracking potential is highlighted using color-coded circles

form a closed outline. Other elements that can be directly imported include ferrules, feature lines, grooves, grout tubes, and cast-in plates. These elements can be positioned on both the near and far face of any panel.

A default panel thickness is specified for all panels contained in each elevation during the importing process. Based on this data and the panel geometry that was read from the CAD file, the software automatically calculates the area, volume, and weight of the panel, along with the coordinates for the center of mass.

From this point, users can perform specific design tasks for each individual panel such as defining lifting points on the face or edge and bracing points, followed by an analysis of the stresses and bending moments in both principal directions. Special loading, such as the weight of the facing layer in a noncomposite sandwich panel, can be included by prorating the unit weight of the concrete. During the analysis of tilt-up panels, the stresses developed during lifting and rotation are calculated, combined, and presented to the user as an envelope (Fig. 2). Reactions at each of the lifting points are calculated for the worst case between the load at lift off (that includes suction) and the load during rotation.

Once results are available, the engineer can choose to refine the position of lifting or bracing points, material properties, or panel thickness to optimize the efficiency of the design. Bending moment diagrams about either of the principal axes can be easily extracted at any section of a panel.

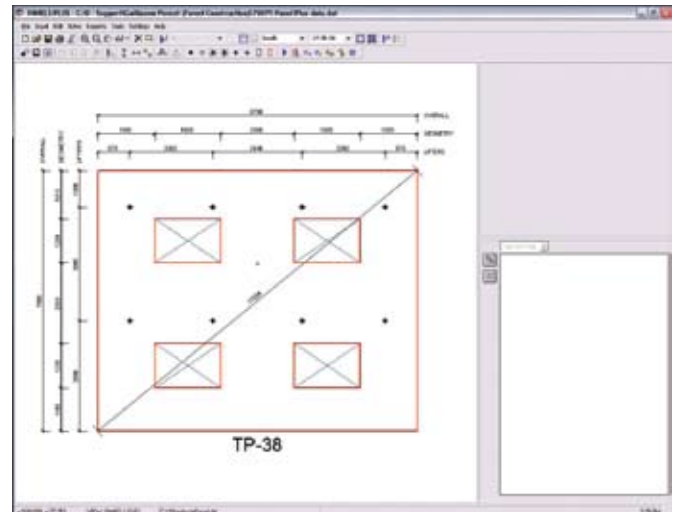


Fig. 3: Dimension lines created in PanelsPlus can be easily formatted to match a company standard in the CAD program

OUTPUT

A one-step DXF export feature has replaced the tedious exercise of extracting basic quantities and output for each panel. Users can take full advantage of the DXF export efficiency by merging an existing, blank shop-drawing template with a range of available results from within PanelsPlus.

The major concept of the drafting features was not to try to replicate a CAD drawing program, but rather to export information from PanelsPlus that can be easily formatted once the DXF file is opened in a CAD program. For example, instead of providing complex options to format the dimension lines and styles shown in Fig. 3, the dimensions that are produced by PanelsPlus are “true” dimensions when formatted in AutoCAD. This allows a drafter to simply apply a dimension style to the DXF output, reducing the time needed to finalize the shop drawing.

USER REPORT

Forest Construction Pty, Ltd., a company based in Queensland, Australia, that designs, manufactures, and installs precast concrete products, recently started using PanelsPlus to design precast wall panels and slabs for buildings like the one shown in Fig. 4. After using the software for 6 months, they felt that it improved the technical quality of their designs in addition to their design production efficiency. Additionally, they could rely on technical support help that answered queries typically within 48 hours.

Three key features of the program particularly impressed the principals of Forest Construction:

Fig. 4: Companies can use the software to improve the quality and efficiency of precast or tilt-up structures like the building shown here (Photo courtesy of Forest Construction Pty, Ltd.)



- First, the finite element analysis takes the guesswork out of lifting design. This analysis used to involve the selection of bands to carry the lifting forces. Through the use of finite element analysis, the design becomes safer and more accurate. They have already noted a reduction in the amount of cracking that occurs due to lifting;
- A second ease-of-use benefit of the software is its visual interface. It facilitates the work of the design engineer, who is now able to see the position and the stress envelope within the elements. Improving the efficiency of the design by moving the lifting points and changing the lifting configuration to reduce the stress in the precast element and the amount of lifting steel required becomes much easier; and
- The third feature is the input and output format that uses standard DWG and DXF files. The input is very easy and less time consuming for the design engineer, and the output is easier for the drafters to use.

Selected for reader interest by the editors.

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