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The PLPAK in Concrete international

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Products & Practice Spotlight

A New Tool for Structural Designers

Boundary element modeling software developed for building systems

by Youssef F. Rashed and Mostafa E. Mobasher

In today's design office, building slabs and mat foundations are generally analyzed and designed using software based on the finite element method (FEM). A typical commercial FEM software program allows designers to model the domain of a slab using plate bending elements, for example, and to allow columns or piers to be modeled using beam elements. Automatic mesh generation can simplify modeling, but the analyst may still need to manually adjust the mesh to adequately model slab penetrations or slabs with irregular geometries.

The meshing (discretization) of the slab, combined with centerline modeling of beam elements, however, can lead to geometrical differences between the numerical model and the physical structure. Also, peaking of moments near nodes at idealized supports or connections of plate elements to beam elements may be necessary to average the results in automated design routines. Similar issues arise when a concentrated force must be applied at an FEM node.

The boundary element method (BEM) is an alternative numerical method that overcomes problems presented by FEM. With BEM, domain meshing is no longer required and actual geometries can be accurately modeled in three dimensions.

BEM in Structural Engineering
Our company, Boundary Elements for Engineers (BEE), has developed a plate analysis package called PLPAK. PLPAK is a BEM software program specifically for the analysis and design of building slabs and foundations. The software is based on Reissner's theory for shear-deformable plates in bending.¹ PLPAK can be used for the analysis and design of thick plates, such as mat foundations and transfer slabs. PLPAK is capable of modeling the actual geometry of structural elements, including supporting and loading elements and

openings. The boundaries in the model match the boundaries of the real structure. Characterization of the slab's real geometry. Results at internal points are produced through numerical solutions, as the refined mesh can be adjusted as needed. Because only the boundary system discretization, modeling issues can be minimized. Accurate geometries, modeling issues, clear data exchange between the BEM analysis and structural design and detailing software tools. Making efforts are direct, and, averaging of results isn't needed. Also, for termination can be determined directly, rather than using interpolated data. Finally, the absence of domain discretization simplifies the steps required before performing a meshing-only, stress adjustments are needed for internal details.

Structural Modeling

The steps required for structural analysis (Fig. 1) are:

- Model generation,
- Boundary solution, and
- Calculation and presentation of internal results.

The design, model generation, can be based on a building information model in which structural objects are defined using their engineering attributes. Model generation can also be based on data as CAD files. Figure 2 illustrates the boundary element discretization of a plate. As the figure demonstrates, very few boundary elements are required to obtain detailed results.

The software offers three-dimensional views of the model, and the system provides user-friendly tools for defining boundary attributes and properties in the model. The second step is to run the boundary element analysis. Any number of load conditions can be applied. Values of boundary displacements and reactions, as well as internal support reactions, are compared. The third step comprises determining stress and deflection for internal points and displaying the results. The user can choose how results along lines, spots or at corner nodes (Fig. 3). Depending on the desired end of differences, corner can be generated over the full model or over a set area.

Products & Practice Spotlight

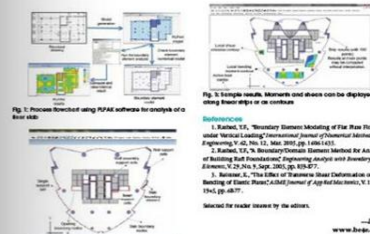


Fig. 1 Process flowchart using PLPAK software for analysis of a floor plate.
Fig. 2 An example of a boundary element model for a complex floor plate. The selection is required only of beams and opening boundaries. Columns, beams, and walls are modeled as required only.
Fig. 3 Sample results. Moments and stress can be displayed along linear strips or at corners.

Youssef F. Rashed is the Principal of BEE and the main developer of the PLPAK software package. He received his PhD in engineering from the University of Illinois at Urbana-Champaign, and is currently a Professor of structural engineering at Cairo University. Dr. Rashed has published numerous research papers and conference presentations in international journals and conferences.

Mostafa E. Mobasher is the Technical Support Director of BEE and also a senior consultant in the development of PLPAK. He received his PhD in engineering from the University of Illinois at Urbana-Champaign and is currently a Professor of structural engineering at Cairo University. Dr. Mobasher has published numerous research papers and conference presentations in international journals and conferences.

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Customer support: support@be4e.com

DEVELOPMENT

The PLPAK software is in constant development to meet the needs of industrial and research purposes. Updates to the software will be posted monthly.

EDITORS

Mostafa E. Mobasher
Mahmoud El Galad
Youssef F. Rashed

Abstract

In today's design office, building slabs and mat foundations are generally analyzed and designed using software based on finite element method (FEM). A typical commercial FEM software program allows designers to model the domain of a slab using plate bending elements, for example, and it allows columns and piers to be modeled using beam elements. Automatic mesh generators can be simplify modeling, but the analysts may still need to manually adjust the mesh to adequately model slab penetrations or slab with irregular geometries.

The meshing (discretization) of the slab, combined with centerline modeling of beam elements, however, can lead to geometrical differences between the numerical model and the physical structure. Also, peaking of moments near nodes at idealized supports or connections of plate elements to beam elements makes it necessary to average the results in automated design routines. Similar issues arise when a concentrated force must be applied at an FEM node.

The boundary element method (BEM) is an alternative numerical method that overcomes problems presented by FEM. With BEM, domain meshing is no longer required, and actual geometries can be accurately modeled. Until recently, however, commercial BEM applications were largely focused on analysis of mechanical or aerospace systems. This article provides a brief introduction to a commercially available BEM software program devoted to building design.

Sinopsis

Una nueva herramienta para diseñadores para diseñadores de estructuras
Rashed, Youssef F., y Mobasher, Mostafa E., Concrete International, V.34, No. 10, octubre de 2012, págs. 54-55

El método de elementos de frontera (boundary element method, BEM) es una alternativa al método de los elementos finitos para el análisis numérico. Con el BEM ya no se requiere la definición de las mallas, de manera que se pueden modelar con exactitud las geometrías reales. Este artículo facilita una breve introducción a PLPAK, un programa informático de BEM disponible a la venta, que se utilice para el análisis y diseño de bloques y cimientos de edificios. El programa incluye módulos para hormigón postensionado y análisis lateral.

New coming: Boundary elements tutorials by Prof. Dr. Youssef F. Rashed

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Using PLPAK in multi-thickness slab

The BE4E consulting services team (services@be4e.com) performed structural analysis and design of a multi-thickness slab (Slab area of 485.0 m2) using the PLPAK & PLDesign. The PLPAK has unique capability of modeling of multi-thickness slabs without the need to use multi-regions. The figures demonstrate the step-by-step analysis and design of the slab. The procedure is initiated by slab model generation on the PLPAK (Figure 1) and completed by the illustration of straining actions (Figure 5). The PLDesign was used as presented in Figures 6 and 7 to perform structural design of the slab.

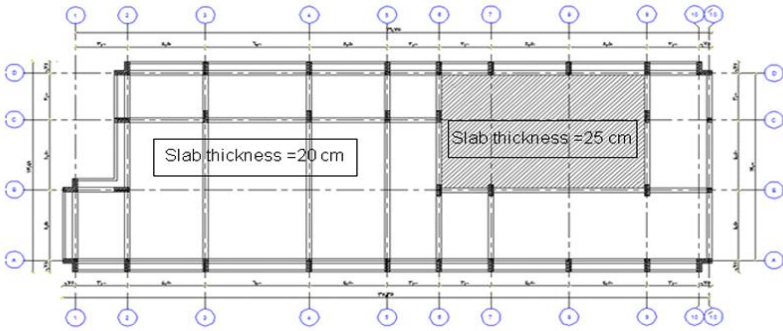


Figure 1: Multi-thickness slab in AutoCAD

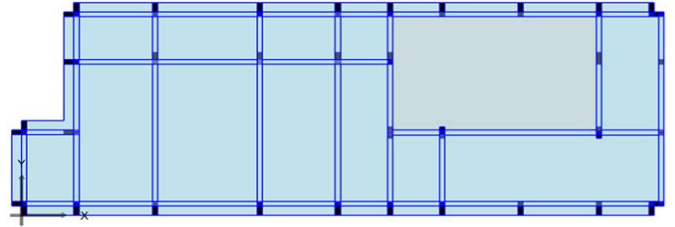


Figure 2: Multi-thickness slab in PLGen

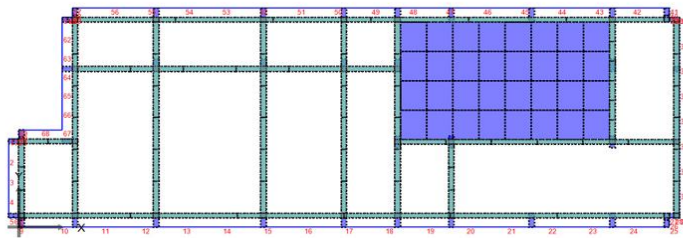


Figure 3: boundary element nodes in PLView

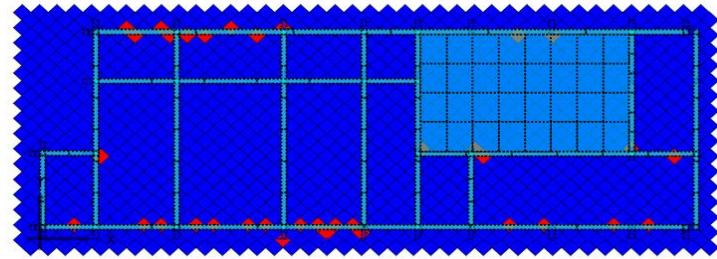


Figure 6: Basic and additional reinforcement in the PLDesign.

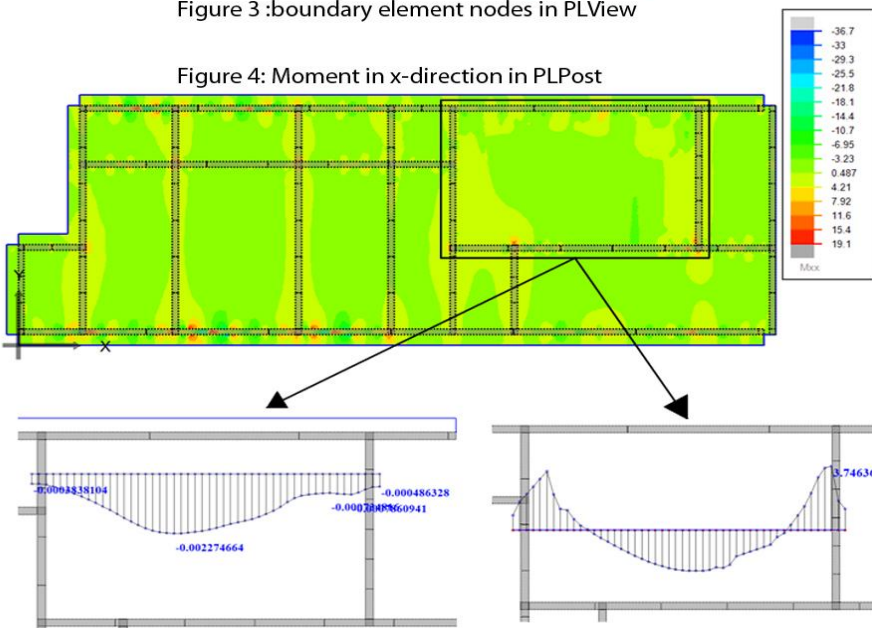


Figure 4: Moment in x-direction in PLPost

Figure 5: two strips showing the deformation & Moment in x-direction

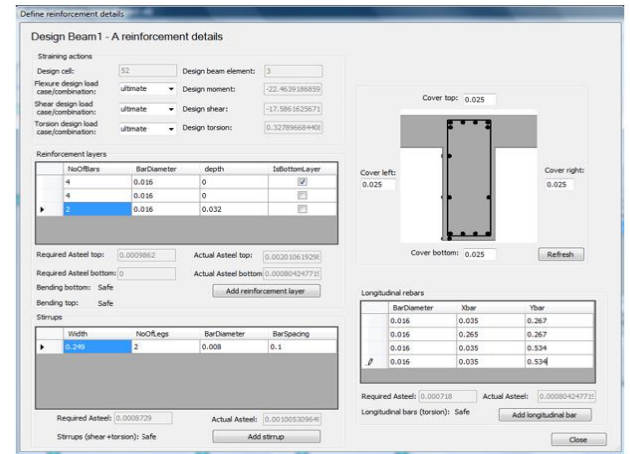


Figure 7: Designing beams in the PLDesign

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