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MATHCAD: Teaching and Learning Tool for Reinforced Concrete Design*

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MATHCAD is a sophisticated computation and presentation tool, which is versatile, easy to use, and accessible. It holds strong potential as a learning aid for education and training. This article demonstrates the use of MATHCAD to supplement and enhance traditional teaching and learning methods both inside and outside the classroom. The paper focuses on the topic of reinforced concrete column design. By using the presentation and programming features available in MATHCAD, interactive teaching and learning devices in reinforced concrete design have been produced.

INTRODUCTION

MATHCAD [1] is an efficient learning environment for technical topics such as reinforced concrete design. Its computational and presentation capabilities not only lend themselves to the solution of mathematically-based problems, but also to the effective communication of both problems and solutions. MATHCAD contains powerful presentation capabilities, which include the use of charts, graphic objects, and animation effects. It can also easily import objects from other application programs, such as images and digital photographs. These capabilities offer significant learning enhancements to students of technical subjects.

MATHCAD makes possible new learning strategies for students and teachers. What-if discussions, trend analyses, trial-and-error analyses, and optimization are all valuable learning activities, which take more time than the traditional technical problem solving approach permits. Taking advantage of the computational power and speed of MATHCAD, instructors and students can quickly cycle through problem scenarios, observing trends in the design behavior of reinforced concrete components.

The proposed paper describes the use of the MATHCAD program as a teaching and learning tool in reinforced concrete design courses. A program for the design of reinforced concrete columns is discussed and demonstrated to show the attractive computational environment of MATHCAD and to illustrate its importance as a teaching and learning tool for civil engineering students.

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OVERVIEW OF REINFORCED CONCRETE COLUMN DESIGN

Columns are vertical compression members, which transmit loads from the upper floors to the lower levels and to the soil through the foundations. Based on the position of the load on the cross-section, columns are classified as concentrically loaded, Fig. 1, or eccentrically loaded, Fig. 2. Eccentrically loaded columns are subjected to moment, in addition to axial force. The moment can be converted to a load P and eccentricity e. The moment can be uniaxial, as in the case when two adjacent panels are not similarly loaded, such as columns A and B in Fig. 3. A column is considered biaxially loaded when the bending occurs about the X and Y axes, such as in the case of the corner column C in Fig. 3.

The strength of reinforced concrete columns is determined using the following principles:

1. A linear strain distribution exists across the thickness of the column.
2. There is no slippage between the concrete and the steel.
3. The concrete strain at failure for strength calculations is set equal to 0.003 mm/mm.
4. The tensile resistance of the concrete is negligible and is disregarded.

The strength of reinforced concrete columns is usually expressed using interaction diagrams to relate the design axial load ϕP_n to the design bending moment ϕM_n (Fig. 4). Each point on the curve represents one combination of design axial load ϕP_n and design bending moment ϕM_n corresponding to a particular neutral-axis location. The interaction diagram is separated into a tension control region and a compression control region by the balanced condition at point B. The balanced condition occurs when the failure