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TRANSFER MATRIX METHODS FOR STRUCTURAL STABILITY: FROM MATHEMATICAL THEORY TO ENGINEERING APPLICATIONS

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ABSTRACT

The evaluation of critical buckling loads is one of the fundamental problems in the stability analysis of slender structural elements, particularly in applications related to earthquake engineering, structural design, and computational mechanics. This work presents the application of the Transfer and Transport Matrix Method (TMM) as an analytical and numerical approach for determining critical buckling loads in bars subjected to axial forces under different boundary conditions, including restrains, free and sliding supports. The method has recently been successfully applied in other fields of engineering [1].

This article aims to present a methodology based on the classical differential formulation of elastic stability, incorporating matrix techniques to describe the buckling modes of the structural element. Transfer matrices establish relationships between displacements, rotations, and internal force at different stations of the bar. The generation and plotting of buckling modes are performed using the kinematic variables of the station vectors.

Although methods such as the Finite Element Method (FEM) and the Direct Strength Method (DSM) have become standard tools in structural analysis due to their versatility and computational implementation. Transfer matrix formulations have experienced renewed interest due to mathematical elegance, reduced computational cost, and suitability for parametric and segmented structural systems [2]. Particularly, the TMM provides a natural and efficient framework for the stability analysis of slender members.

The research also considers the implementation of the methodology within scientific programming environments to automate calculation procedures and support parametric simulations. From an interdisciplinary perspective, the method combines concepts from differential equations, matrix algebra, and structural stability theory with applications relevant to modern engineering and seismic-resistant design.

The expected results aim to contribute to the development of advanced computational methodologies for structural stability assessment and to promote the integration of matrix-based approaches into research, teaching, and technological applications in civil and computational mechanical engineering.

REFERENCES

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