Corresponding Force Matrix: A Bridge Connecting Refined Analysis and Reinforcement Design of Box-section Girders Based on Shells

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Abstract

Benefitting from the development of computing power, box girders can be analysed in a more refined way by discretizing cross-sections into shell elements. However, how to take full advantage of the analysis results in the reinforcement design process remains a problem. To solve this problem, the concept of "corresponding force matrix" is proposed in this paper. The matrix has 6 columns corresponding to the key unit force resultants of a specified location, and 12 rows corresponding to all the possible unfavourable cases. For each row, only one force resultant reaches its maximum (or minimum) under loads while the others take the corresponding values. Then the construction method of the proposed matrix under live loads and load combinations is described, respectively. After that, two reinforcement design methods with the use of the matrix were introduced and compared. Finally, discussions and preliminary conclusions are made.

Keywords: concrete bridges; box-section; shells; reinforcement design; sandwich model; corresponding force matrix.

1 Introduction

The behaviour of box-section bridges is more complicated since the plane section assumption does not strictly apply. To simplify the design process and make it consistent with the current guidelines, several amplification factors are employed to envelop the "spatial effects", such as effective net area of flanges, partial loading amplification factor, etc [1,2]. However, this simplified design method neglects the real structural response of box sections and will potentially result in two extremes, i.e., a significant waste of steel or safety problems [3,4].

Benefitting from the development of finite element theory and computing power, elaborate finite element models such as shell element models can be established for box-section concrete bridges. By performing a linear elastic

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