# Calculation of buckling load for planar truss structures with multi-symmetry

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**Abstract**

In this paper, the region in which the structural system is situated is divided into four subregions, namely upper, lower, left and right subregions. The stiffness matrix of the entire system is then formed and using the existing direct symmetry and reverse symmetry, the relationships between the entries of the matrix are established. Examples are included to illustrate the steps of the method.
**Keywords: multi-symmetry, trusses, decomposition, buckling load, graph**

## 1. Introduction

Symmetry has been widely used in science and engineering [1-5]. Many eigenvalue problems arise in many scientific and engineering problems [6-8]. While the basic mathematical ideas are independent of the size of matrices, the numerical determination of eigenvalues and eigenvectors becomes more complicated as the dimensions of matrices increase. Special methods are beneficial for efficient solution of such problems, especially when their corresponding matrices are highly sparse.

Methods are developed for decomposing and healing the graph models of structures, in order to calculate the eigenvalues of matrices and graph matrices with special patterns. The eigenvectors corresponding to such patterns for the symmetry of Form I, Form II and Form III are studied in references [9-11], and the applications to vibrating mass-spring systems and frame structures are developed in [12] and [13], respectively. These forms are also applied to calculating the buckling load of symmetric frames [14].

Consider a structural system with two translational degrees of freedom (DOFs) per node which has two axes of symmetry. Suppose each DOF is parallel to one of the axes and is perpendicular to the other axis. For the following three cases one can find matrices in canonical forms, and using the symmetry relationships twice, developed previously [10,15], one can find 4 submatrices. The union of the eigenvalues for these 4 submatrices results in the eigenvalues of the original matrix.

As mentioned before, various symmetries are previously developed. In these symmetries which will be presented in Section 2, a matrix is decomposed two submatrices S and T and the eigenvalues of these submatrices result in the eigenvalues of the main matrix.

In this paper, the region in which the structural system is situated is divided into upper, lower, left and right subregions. The stiffness matrix of the entire system is formed and then using the existing direct and reverse symmetries, relationships between the entries of the matrix are established.

## 2. Single symmetries A and B

As described in reference [15], symmetry of structural systems with each node having two DOFs can be studied in two general forms A and B. These forms are briefly described in the following.

### 2.1. Symmetry of Form A (modified Form II symmetry)

For trusses with axis of symmetry not passing through nodes with active DOFs, we have the Form A symmetry, as shown in Fig. 1.