CHAPTER I

INTRODUCTION

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1.1 General and Statement of Problem

The framed-tube structural system is known to be highly efficient and economical for extra high-rise buildings. Basically the structural system consists of closely spaced exterior columns connected at each floor level by deep spandrel beams to form a structure of rigidly jointed framed panels, which possesses great rigidity against lateral and torsional loadings. Fig. 1 depicts one such structure. In the design of tall buildings to resist wind or seismic loadings, twisting of the structure which may occur due to eccentricity of loading has to be considered. The resulting member forces due to the effects of twisting and axial restraint at the base of the structure may be quite significant, especially when the aspect ratio of the structure increases. The analysis of such a highly redundant structure by treating it as a space frame or even by using an equivalent plane frame technique is too costly at a preliminary design stage. In recent years a number of approximate methods have been suggested for the analysis of symmetrical rectangular framed-tubes under symmetrical lateral loads. Investigation of the torsion problem, on the other hand, is scarce and has been conducted for a special case of a framed-tube of uniform properties. Therefore, there is a need to develop an approximate method which can quickly predict the torsional behavior of framed-tubes of variable story properties with sufficient accuracy for use at a preliminary design stage.

1.2 Literature Review

A three-dimensional analysis of framed-tubes commonly falls into one of the two categories. In the discrete approach the structural force-displacement characteristic is synthesized from those of individual members. The displacement method is commonly employed, and a large computer system is generally needed due to the large number of degrees of freedom involved. In the second approach the discrete structure is first replaced by a statically equivalent continuum and is known as the continuous approach. By using the equilibrium and compatibility conditions, the governing differential equations can be set up and solved manually.

Coull and Subedi (1) proposed a discrete method in which the three-dimensional rectangular framed-tube is reduced to an equivalent plane frame by recognizing the dominant mode of deformation of the structure. Similar studies have been reported by Schwaighofer and Ast. (2) and Naka, et al. (3). However, only the case of the cantiliver bending actions were considered.

A study including both bending and torsional deformations of framed-tubes was made by Rutenberg, A. (4).

Based on results of 10-story framed-tube analyses using the equivalent plane frame method, Khan and Amin (5) presented the influence curves for the approximate analyses of rectangular framed-tubes under uniform lateral loading. By making simplifying assumptions regarding the deformation of the structure, and employing an energy approach Watanavong,S. (6) proposed an approximate method for the analyses of framed-tubes which may possess variable story properties along the height.

The continuous approach was employed by Coull and Bose (7, 8) to analyse rectangular framed-tubes under bending (7) and torsion (8). In this approach the discrete structure is first replaced by an equivalent uniform orthotropic plate to form a substitute closed-tube structure. The properties of the orthotropic plate are chosen so that the two elastic moduli in the horizontal and vertical directions respresent the stiffness of spandrel beams and columns, respectively, and the shear modulus respresents the shear stiffness of the framework panel. By making simplifying assumptions regarding the stress distributions in the structure, and applying the principle of complementary energy, an approximate solution was presented for tubes of uniform property. However, shear deformations were neglected in evaluating the equivalent shear modulus, G_{zs}, and the effect of finite size joints were not accounted for in evaluating the elastic moduli, E_z. Consequently G_{zs} was overestimated and E_z was underestimated (9). Moreover, the method becomes much difficult to apply when the spacings and properties of both beams and columns are not uniform throughout the height of the structure as might be the case in practice.

1.3 Objective and Scope of Study

The objective of the study is to develop a simplified and approximate method for the elastic analysis of symmetrical rectangular framed-tube structures subjected to torsional loading and to compare the results with the solutions obtained by a general space frame program. The proposed method is to be simple and general enough so that framed-tubes with different framework panel properties or any variation of the story properties along the height of the structures can be solved manually with the aid of electronic calculators. Only uniformly distributed static torsional loading is considered, and small deformation is assumed.