10th International Congress on Civil Engineering, 5-7 May 2015
University of Tabriz, Tabriz, Iran

Evaluating optimum topology of braced-tube tall steel structures using non-linear time-history analysis

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Abstract

One of the common structural systems for tall buildings is braced-tube frames. These frames provide massive lateral stiffness and enable the engineers to design structures with considerable heights. Key point while deigning these structures is to obtain number of braced stories and the angle of diagrids. In this paper, optimum angle of diagrids is investigated. Optimum angle will yield the minimum lateral displacement and inter-story drift. Also, minimization of shear lag phenomenon is considered. Cares should be taken while analyzing tall buildings. Hence, non-linear response-history analysis is performed to achieve the optimum design. Examples with different height are assessed to obtain the contribution of the height to the optimum design.

Keywords: Tall buildings, Braced-tube structures, Shear-lag phenomenon, non-linear response-history analysis.

1. INTRODUCTION

Tall buildings are symbols of city's economic stature. Hence, building such structures not only provides massive amount of accommodation space, but also contributes to atheistic criteria. Constructing a tall structure is essential due to high price of land in metropolitan cities. Structural systems for tall structures are categorized into two main groups: Interior and exterior lateral load resisting frames. Interior frames are optimized version of well-known moment resisting frames. Moment resisting frames are appropriate for the structures up to 30 stories. Placing a shear wall or truss core will significantly increase lateral load resisting capacity of moment frames.

To achieve a better performance an outrigger is added to a specific story. This will form a new structural system called "outrigger-braced structure". Being cheap to construct is main feature of this structural system. However, one or more stories are ruined due to the placement of outriggers and belt trusses. In order to conserve more internal space, exterior lateral load resisting frames are proposed by Fazlur Khan[1]. This structure's (also known as tubular systems) main lateral load resisting frame is built on exterior layer of structure. Tubular frames provide massive lateral stiffness while preserving amazing interior space. This characteristic is significantly appropriate for tall buildings.

Shear-lag phenomenon is one of the key factors to be considered while designing framed-tube buildings. Most of the earlier researches regarding framed-tube buildings are devoted to the shear-lag phenomenon investigation [2], [3], [4], [5], [6] and [7]. Assessment of shear-lag phenomenon is due to lowering the amount of damage to the non-structural elements. Main reason for the occurrence of the shear-lag is rigidity of spandrel beams. The whole concept of framed tube building is to construct the outer frame as rigid as possible to from a hollow box type cantilever to resist the lateral loads. However in the real-world designs this is quite impossible. Also, scientists have lately contributed a lot to decrease the effect of shear-lag by proposing different methods. Utilizing braces is one of the common ways to decrease the effect of shear-lag. Framed-tube buildings which are stiffened by braces are braced-tube frames. Results of some researches suggest that using diagrids will reduce the effect of shear lag. However due to massive computational cost utilizing non-linear response history analysis and considering effect of diversity in ground motions is neglected. Thus, in the present study 3 different ground motions are assigned to the models utilizing provisions of ASCE 7-10 [8].