Evaluating optimum location of outrigger for outrigger-braced tall structures utilizing non-linear response-history analysis

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Abstract

Outrigger-braced tall building is considered as one of the most popular and efficient tall building design because they are easier to build, save on costs and provide massive lateral stiffness. Most importantly, outrigger-braced structures can strengthen a building without disturbing its aesthetic appearance and this is a significant advantage over other lateral load resisting systems. Optimum location of outrigger, is an important factor to be considered while designing outrigger-braced structures. To achieve this, scientists utilize different methods including simplified methods. In this paper, optimum location of outriggers is investigated using non-linear response-history analysis. Seven different ground motions are selected to consider the variation of structures responses which are subjected to seismic load cases. Two different examples with zipper-braced steel cores are assessed. 20 and 30 story models are analyzed to consider the effect of height. Results prove, results of simplified methods proposed by previous study are not consistent with actual response of structures and this is because of assumptions of simplified methods.

Keywords: Optimum design, tall buildings, outrigger-braced structures, non-linear response-history analysis.

1. Introduction

Tall building construction is getting more common as cities don't offer enough terrain to construct structures. Hence, engineers tend to design these structures because they provide high ratio of height to the span. This will be beneficial since the investors tend to choose the best design. Also, optimum design of tall structures, mostly in preliminary steps, will contribute to massive saving of money and human resources. To do this, designers try to firstly choose the structural system wisely and secondly try to obtain the most optimum deign for the chosen structural system.

Usually, structural systems for tall buildings are classified into two different group. For the first group, lateral force resisting system is constructed inside of the structural while the second groups lateral load resistance system is built in the outer frame of the structures. Systems of first group is applicable for the structures up to 55 stories [1]. For the taller frames, second type of structural systems is proposed, structural systems like framed-tube and tube in tube structures are categorized in this group. As mentioned, inner lateral force resisting systems are proper for structures with lower height, among these frames outrigger-braced structure is mostly common as it is cheap and easy to construct.

Optimum design of outrigger-braced structures is a major concern in the preliminary steps, because investigating optimum location of outrigger is an arduous effort. Outrigger-braced story is usually supported by the means of belt trusses employing outer columns. To achieve this, researchers employ different methods. Among these methods simplified method proposed by Tarnath [2] is most common method. Tarnath's method yielded the optimum location of first outrigger to be in 0.477 of the total height from the top of the structure. Although, supposition which seriously alter the structural response were made, still the method is popular. Structural properties of the core and columns were assumed to be fixed up height the structure while for the tall frames this is not a wise decision. Static type of analysis for the uniform lateral load was carried out. Ref.s [3] to [7] modified the simplified models of Tarnath. However, still the static type of analysis for the different lateral load distributions were performed.

Simplified method, neglects structural response of beam and columns and only considers contribution of core and outrigger beams to the structural response. In this research, precise modeling of the structure is accomplished using OpenSees [8] program. Results are post processed using Matlab software.