ON THE SEISMIC PERFORMANCE EVALUATION OF OUTRIGGER AND BELT TRUSS SYSTEMS FOR STEEL HIGH-RISE BUILDINGS

Mohammad Hosein MOHAMMADKHANI
M.Sc. Student, University of Kashan, Kashan, Iran
hosein_mohammadkhani@yahoo.com

Hossein TAHGHIGHI
Assistant Professor, University of Kashan, Kashan, Iran
tahghighi@kashanu.ac.ir

Keywords: Tall Building, Outrigger System, Response Spectrum Analysis, Time History Analysis, Top Displacement

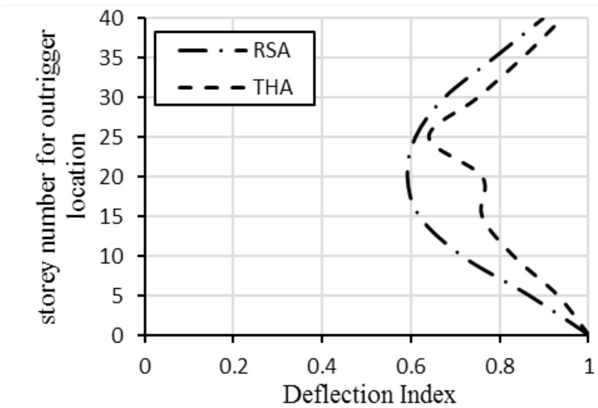
Tall building development has been rapidly increasing worldwide introducing challenges of controlling lateral deflection that need to be solved by structural engineers. In modern tall buildings, lateral loads induced by wind or earthquake are often resisted by a system of central resistant core. But when the building increases in height, the stiffness of the structure becomes more important and the use of outrigger beams between the shear core and external columns can provide sufficient lateral stiffness to the structure. It is also usual to mobilize other peripheral columns to assist in restraining the rotation of outriggers. This is achieved by tying the exterior columns with braced frames commonly referred to as a "belt truss" around the building. The outrigger and belt truss system is commonly used as one of the structural system to effectively control the excessive lateral deflection and storey drifts in high-rise buildings due to either wind or earthquake loads, so that the risk of structural and non-structural damages can be minimized (Bungale, 2010; Jahanshahi and Rahgozar, 2013; Nanduri et al., 2013; Stafford and Coull, 1991).

The present paper attempts to further investigate the seismic behavior of outrigger and belt truss systems. We examine various alternative 3D models using SAP2000 software for a 40-storey steel building with central core braced with outrigger and without outrigger effects. Material properties for steel and concrete in the building are given in Table 1. The structural model with one and two outrigger levels has been analyzed against three sets of ground motion records. The aim of this study is to find and compare optimum outrigger locations in height using response spectrum analysis (RSA) and linear time history analysis (THA). Moreover, the reductions in lateral displacement are compared to model without any outrigger and belt truss system.

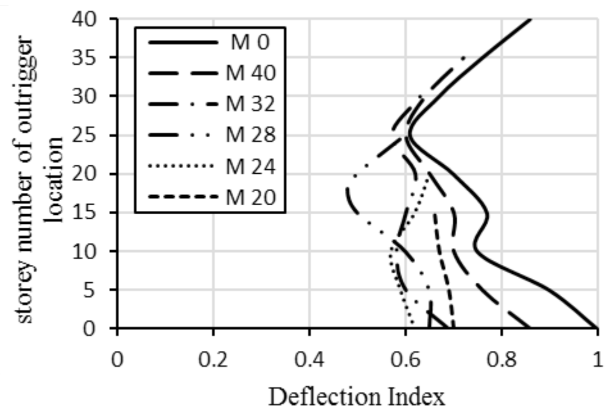
Some representative numerical results are shown in Figure 1. Deflection index is defined as the ratio of deflection with outrigger to deflection without outrigger. As Figure 1a shows, it is found that the optimum location for one outrigger level occurs at storey 20 and 23 from RSA and THA methods respectively. For the case of two outrigger levels, the optimum locations occur at stories 16 and 28 from THA and for RSA, the optimum locations occur at stories 13 and 26 (Figure 1b). Note that in Figure 1b, M0 means model with single varied outrigger and for example M20 shows model with double outriggers, in which one outrigger fixed at storey 20 and the other outrigger level is varied. These findings indicate that the optimized location of outrigger using THA is occurred in upper levels compared with RSA method. In addition, the use of outrigger and belt truss has improved the serviceability of the structure. According to Figure 1, the results show significant decline in the deflection with the use of outrigger system. There is 40% and 35% reduction by the use of one outrigger at the optimum level from RSA and THA respectively, while, 60% and 50% reduction is achieved by the use of two outriggers levels from RSA and THA, respectively.

Table 1. Material properties

Concrete(C35)	
Density	2500 Kg/m³
Compressive Strength	350 Kg/cm²
Modulus of Elasticity	295800 Kg/cm²
Poisson's Ratio	0.2
Steel(ST52)	
Density	7850 Kg/m³
Yield Stress	2800 Kg/cm²
Failure Stress	5200 Kg/cm²
Modulus of Elasticity	2100000 Kg/cm²
Poisson's Ratio	0.3



(a)



(b)

Figure 1. Deflection index verses outrigger and belt truss location, (a) Models with one outrigger level (b) Models with two outrigger levels from THA

REFERENCES

Bungale ST (2010) Reinforced Concrete Design of Tall Buildings, CRC Press

Jahanshahi MR and Rahgozar R (2013) Optimum location of outrigger-belt truss in tall buildings based on maximization of the belt truss strain energy, *International Journal of Engineering*, 26(7): 693-700

Nanduri R, Suresh B and Hussain I (2013) Optimum Position of Outrigger System for High-Rise Reinforced Concrete Buildings under Wind and Earthquake Loadings, *American Journal of Engineering Research (AJER)*, 2(8): 76-89

Stafford SB and Coull A (1991) Tall building structures; analysis and design ,1st Ed, Wiley, New York