Review On
"The Efficient Use of a Outrigger and Belt Truss in Tall Buildings"

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Abstract : The development of tall building, and has been rapidly growing worldwide by introducing new challenges that need to meet by engineering considerations and judgments. In tall buildings generally lateral loads are often resisted by a system of varied sorts of shear or core wall. But when the peak of the building increases and when some irregularities are present in buildings, the stiffness of building is reduced. So the introduction of outrigger beams and its position in tall buildings with shear walls are wont to provide sufficient lateral stiffness to the structure. This paper is about the behaviour of tall buildings with and without outriggers, its location, optimization and the efficiency of outrigger for tall buildings under earthquake load conditions. A g+15 storey with single belt truss, g+30 storeys with two belt trusses and g+40 storey with three belt trusses structure are investigated with three different shape outrigger belt trusses that are X, V and N. From the analysis a comparative study is made with and without variation of shape of outrigger with belt truss with parameters likes storey displacement and storey drift under earthquake loading and get an optimum position of outrigger belt truss by using ETABS Software.

Keywords: Outrigger System, Earthquake load, Optimum shape, and position of belt truss, Storey Drift, Lateral Displacement.

1. INTRODUCTION

1.1 General

Due to increase in demand for living space in developed and developing area leads the way to the development in construction techniques. Hence, tall buildings play an important role in the new generation of structure. The sensitivity of tall buildings against strong earthquakes and wind has increased. This has resulted in understanding the structural behavior of modern tall buildings under lateral loads. When the height of the building increase, the risk of horizontal and vertical forces also increases. The moment resisting frame or braced core wall at a specific height is insufficient to provide stiffness against lateral loads. Outrigger is provided with a shear Or core wall in tall buildings with certain height ratio to increase the stiffness and to decrease deflection against lateral loads. The outrigger and belt truss system is one among the lateral loads resisting system during which the external columns are tied to the central core wall with very stiff outriggers and belt truss at 1 or multi levels. The belt truss tied the exterior column of the building while the outriggers engage them with the main or central shear wall.

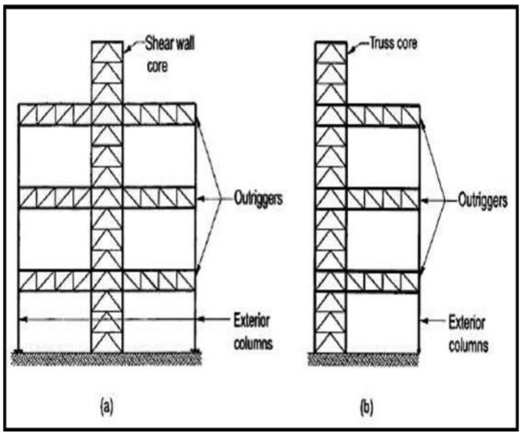


Figure 1: (a) Outrigger with a central core (b) Outrigger system with offset core.

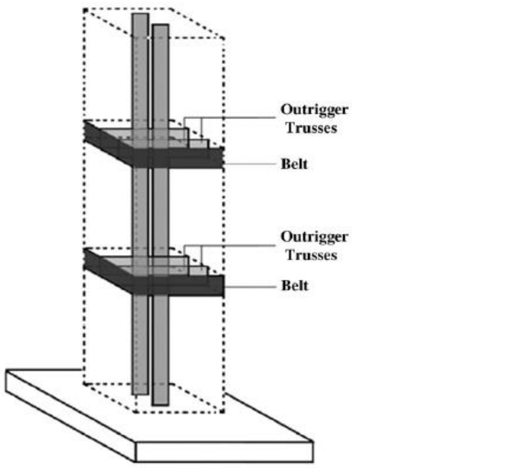


Figure 2: Tall building with conventional outriggers and belt truss.

1.2 Behaviour of Outrigger

The structural arrangement for this technique consists of a main concrete core connected to exterior columns by relatively stiff horizontal members like a 1 or two-story deep walls commonly referred to as outriggers. The core may be centrally located with outriggers extending on both, or it may be located on one side of the building with outriggers extending to the building columns on one side. The basic structural response of the system is sort of simple. Because the outrigger act as a stiff arm engaging exterior columns, when central cores tries to tilt its rotation at outrigger level induced a tension compression couple in exterior columns and acting in opposite to that moment. The result's the sort of restoring moment working on the core at that level. As a result, the effective depth of the structure for resisting bending is increased when the core bends as a vertical cantilever, by the event of tension within the windward columns, and by compression within the leeward columns. In addition to those columns located at the end of the outriggers, it's usual also to mobilize other peripheral columns to help in restraining the rotation of outriggers. This is achieved by tying the outside columns with a one- or two-story deep wall commonly mentioned as a "belt wall," round the building.

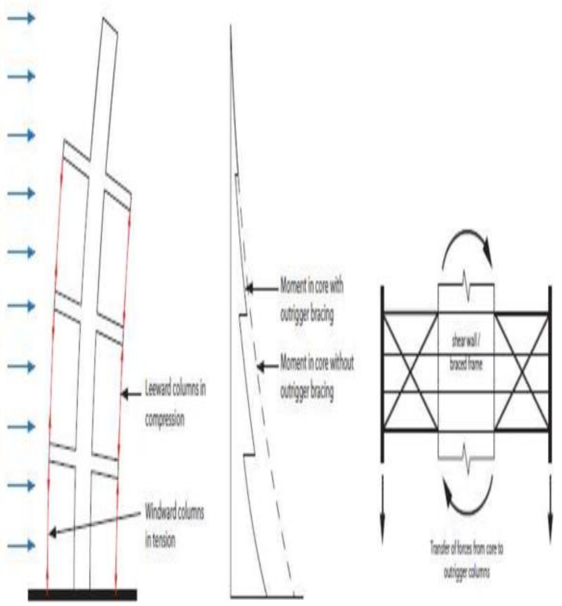


Figure 3: Behaviour of Outrigger Structural system.

1.3 Types Of Outrigger Truss System

On the idea of connectivity of core to exterior columns, this technique may be divided into two types:
Conventional outrigger concept.
Virtual outrigger concept.

1. Conventional outrigger concept

In the conventional outrigger concept, the outrigger trusses or girders are connected directly to shear walls or braced frames at the core and to columns located outboard of the core. Conventional outrigger as shown in Fig.4

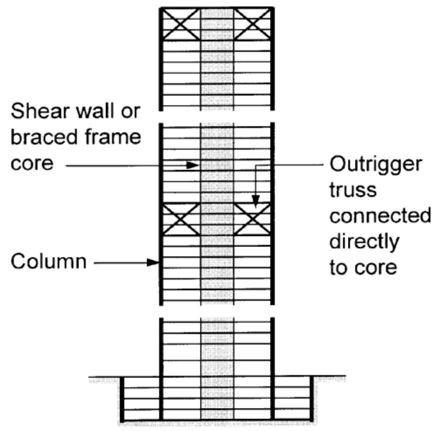


Figure 4: Tall building with conventional outriggers

2. Virtual outrigger concept

In the "virtual" outrigger concept, an equivalent transfer of overturning moment from the core to elements outboard of the core is achieved, but without an immediate connection between the outriggers trusses, and the core. The basic idea behind the virtual outrigger concept is to use floor diaphragms, which are typically very stiff and powerful in their plane.
The use of belt trusses as virtual outriggers avoids many of the issues related to the utilization of conventional outriggers. And the principle is the same as when belt trusses are used as virtual outriggers. Some fractions of the moment in the core are converted into a horizontal couple in the floors at the top and the bottom of the basement. Belt truss as a virtual outrigger as shown in Fig. 5.

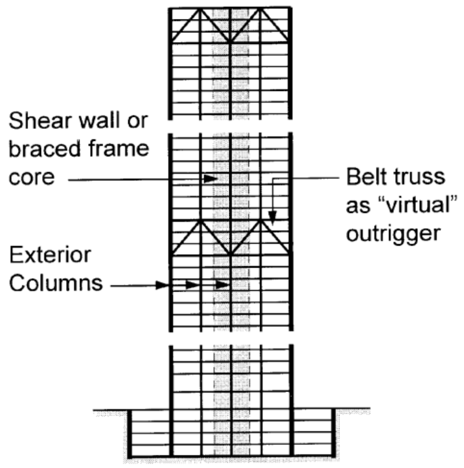


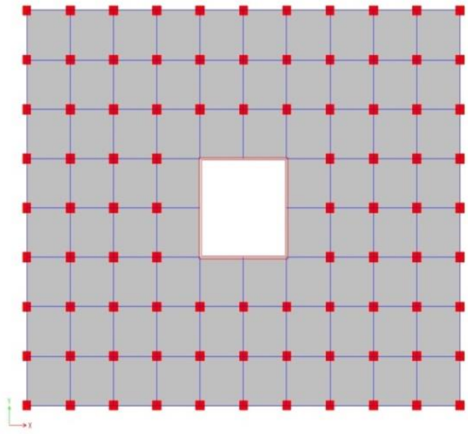
Figure 5: Tall building with belt trusses as "virtual" outriggers.

3. Factors Affecting The Effectiveness Of Outrigger System :

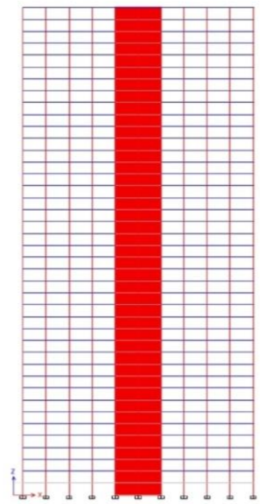
1. The stiffness and location of the outrigger and Belt truss system.
2. Geometry of the tall building.
3. Stiffness of the central core.
4. Floor-to-floor height of the tall building.

2. METHODOLOGY

In the present study a three-dimensional RCC building frame model of 45 m, 90 m & 120 m height having 9 × 8 Bay spacing of 5 m. vertically regular building, having symmetry along X and Y direction and square is considered. RCC building having concrete shear wall as a central core modeled in form of shell-thin with thickness of 400 mm and concrete slab in form of membrane with thickness of 180 mm. For the belt truss using ISA 200 × 200 × 12 steel section for X, V & N type bracing in belt truss. The structure having fixed support, and every one joints designed as perfectly rigid. The floor height is assumed to be 3 m. Structure model having a different size of beams and columns, and other parameters used for the analysis are given in table no. 1 & 2. All the dimensions of the building used as per code IS 456-2000.



(a) Plan View



(b) Without OT Section

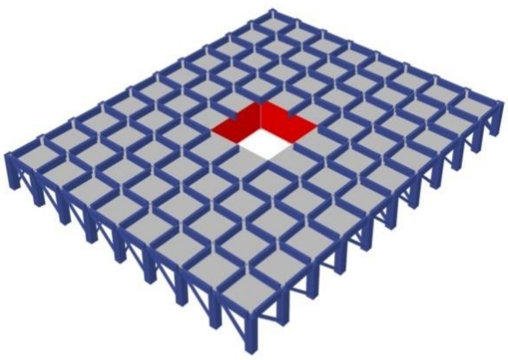
Table 1. Parameters of the Structures

	Parameter	Value		
1	Type of Frame	Building with shear wall		
2	No. of story	G + 15 + Terrace	G + 30 + Terrace	G + 40 + Terrace
3	Floor Height	3 m	3 m	3 m
4	Length of Building	50 m	50 m	50 m
5	Width of Building	40 m	40 m	40 m
6	Column Size	600 × 600 mm	750 × 750 mm	900 × 900 mm
7	Beam Size	230 ×	230 ×	230 ×

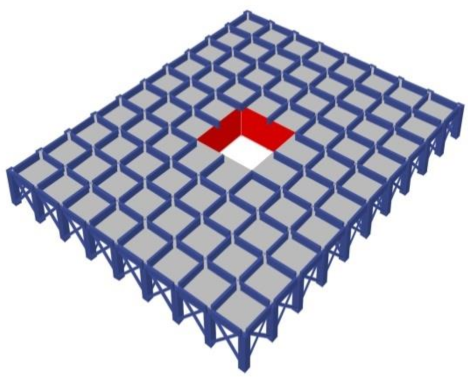
		600 mm	600 mm	600 mm
8	Slab Thickness	150 mm	150 mm	150 mm
9	Concrete Grade			
	Wall & Column	M30	M40	M50
	Beam & Slab	M25	M30	M35
10	Reinforcement Grade	Fe 500	Fe 500	Fe 500

Table 2. Some parameters used for the analysis of building

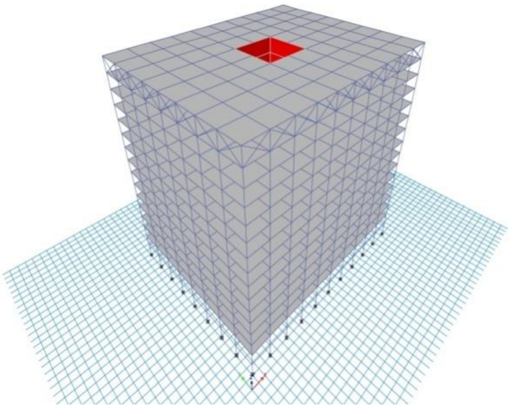
Serial No.	Particulars	Model Data
1.	Analysis Type	Response Spectrum
2.	A Software Selection	ETABs
3.	Data Analysis	Max. Displacement Value, Story Drift Rotation Value
4.	Load Pattern	Live Load, Dead Load, EQx & EQy
5.	Zone Factor	III Zone (Z=0.16)
6.	Importance of Structure	1
7.	Soil Type	II (Medium)
8.	Type of Structure	RC Moment Resisting Building.



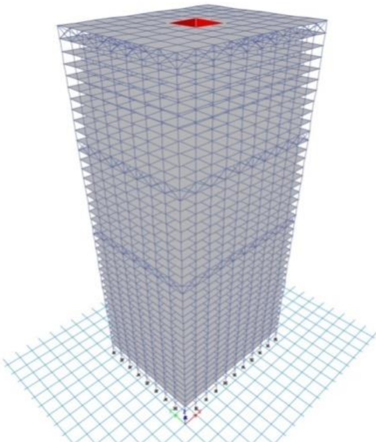
(C) N-Type Belt Truss



(d) X-Type Belt Truss

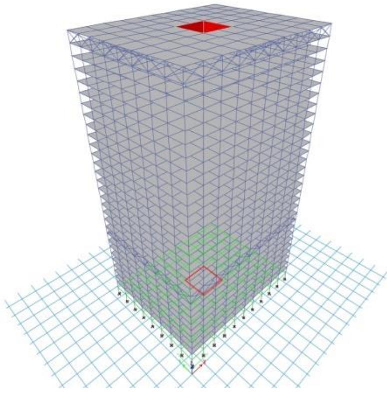


(e) 3D View With OT G+15 Story



(g) 3D View With OT G+40 Story

Figure 6: Building view and story plan with their details



(f)3D View With OT G+30 Story

1.4 Objectives of the Project

Following are the objectives of dissertation work.

1. Analysis of high rise building without the use of outriggers under earthquake loading.
2. To study the effect of the introduction of Outriggers in high rise building subjected to seismic loading.
3. Analysis with the change of shape of outrigger (X, V & N) in building.
4. The results for different outrigger positions are interpreted and conclusions are made as to which condition buildings taken in the consideration are most stable.
5. The results of different parameters such as displacement, drift, Base shears and time period are studied.
6. Reduction in drift, deflections and fundamental time period of the regular and irregular building is studied.

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