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Influence of Different Lateral Load Resisting Structural Systems on Seismic Performance

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ABSTRACT
A natural hazard like earthquake causes damage or collapse of buildings if not designed for lateral loads resulting due to earthquake. Hence to resist the lateral loads in high rise structures it is important to provide exclusive Lateral Load Resisting System (LLRS) which will improve the behaviour of moment resisting frames. Using an appropriate Lateral Load Resisting system is critical to ensure good seismic performance of buildings. In present study, a square plan of 160m tall building with 40m each plan side, having 40 storeys, each storey height is 4m is considered. The analysis has been carried out using software ETAB-2015. In present work, analysis is carried out to study the influence of different lateral load resisting systems i.e. Traditional system, Tube system, Tube-in-Tube System and Bundled system. The modelling is done to examine influence of different lateral load resisting systems on seismic parameters like shear lag effect (difference in column axial forces), maximum lateral displacements, maximum lateral drifts ratio and fundamental natural time period.

Keywords – Traditional system, Tube system, Tube-in-Tube System and Bundled system.

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I. INTRODUCTION

Using an appropriate structural system is critical to good seismic performance of buildings. While moment-frame is the most commonly used lateral load resisting structural system, other structural systems also are commonly used like structural walls, frame-wall system, and braced-frame system. Sometimes, even more redundant structural systems are necessary, e.g., Tube, Tube-in-Tube and Bundled Tube systems are required in many buildings to improve their earthquake behavior. These structural systems are used depending on the size, loading, and other design. Different Lateral Load Resisting Systems are mentioned below.

(1.1) Traditional System: Special Moment Resisting frames consist of a grid of vertical (*i.e.,* columns) and horizontal (*i.e.,* beams) Members. They resist lateral loads through axial forces, bending moment and shear force generated in both beams and columns. In the traditional frame building with the central core (figure 1), most of the lateral forces are carried by the central reinforced concrete core. The load transfer path carries the forces to the concrete core. As the lateral force travels down towards the base of the building, the force flows towards the more stiffened corners of the core in the form of axial tension and compression. Thus, the corners of the core at the base of the building carry larger axial force than the mid sides of the core.

(1.2) Tube System: Closely-spaced heavy columns forming a closed loop inter-connected with beams, together called the tube (figure 2), and forms the first part of the lateral load resisting system. Heavy reinforced concrete structural walls together creating a closed shaft, called as the core, form the other part. The Tube System consists of one perimeter tube with a central core. The inter-connection is important between the perimeter tube and the central core. For smooth and uniform transition of lateral forces to the peripheral frame, a grid of stiff and strong beams and columns is required. The perimeter tube helps to carry lateral forces away from the central core to the perimeter tube.

(1.3) Tube-in-Tube System: When the plan size of the building increases, additional columns may be required to support the gravity loads between the outer tube and inner core, and prevent the slab from bending too much. These columns are not part of the main lateral load resisting system, and therefore are not intended to carry any lateral loads; they are called gravity columns. When the building plan is large, sometimes, many columns may be required to support the gravity loads. Then, it may be beneficial to create a second tube of columns interconnected with beams inside the perimeter tube of columns interconnected with beams. This system is called the Tube-in-Tube System (Figure 3).

(1.4) Bundled System: In large plan area buildings, when even the Tube-in-Tube system fails to control the lateral deformation of the building, an even stiffer lateral force resisting system is required. One system that can offer this is the Bundled-Tubes System; as the name goes, here a set of Tube Systems are stacked together to form the overall lateral load resisting system (Figure 4). The closely-spaced columns of the different tubes are placed in line to form an overall tube system. The RC cores of the tubes are connected to each other with beams that span directly between these stiff vertical elements; these beams are called primary beams.

II. OBJECTIVES OF WORK

To study the difference in the structural behavior of different types of Lateral Load Resisting Systems (LLRS) i.e.

1) Traditional system,
2) Tube system,
3) Tube in tube system,
4) Bundled system.

The equivalent static lateral load method is used to determine earthquake load. The analysis of building models is done using ETAB-2015 to examine the effect of different lateral load resisting systems on seismic parameters like fundamental time period, maximum lateral displacements, maximum lateral drift ratio and shear lag effect (difference in column axial forces).

III. PROBLEM FORMULATION

3.1 General configuration of the building

- Plan Geometry= 40m x 40 m

(5 Bay in X-direction & 5 Bay in Y-directions)

- Typical storey height =4m

3.2 Seismic consideration (IS1893:2002 Part-I)

- Importance factor =1
- Seismic zone=zone(v)
- Zone factor, Z=0.36
- Soil Type: Medium
- Response reduction factor, R=5

3.3 Material Properties

- Grade of Concrete=M30
- Grade of Steel=HYSD500

3.4 Loading

- Dead load of outer infill wall on beam= 12 kN/m
- Dead load of interior wall on beam= 6 kN/m
- Live load on floor = 2 kN/m^2
- Floor Finish on floor =1 kN/m^2

3.5 Load Combinations

The following load combinations (IS1893:2002 Part-1,clause no.6.3.1.2) considered

1.5 (DL+LL)	1.5 (DL+EQY)
1.2 (DL+LL+EQX)	1.5 (DL-EQY)
1.2 (DL+LL-EQX)	0.9DL+1.5EQX
1.2 (DL+LL+EQY)	0.9DL-1.5EQX
1.2 (DL+LL-EQY)	0.9DL+1.5EQY
1.5 (DL+EQX)	0.9DL-1.5EQY
1.5 (DL-EQX)	

3.6 Structural Sizes

Parameter	Traditional system	Tube system	Tube in tube system	Bundled system
Size of column(mmxmm)	1500x1500	1200x1200	1200x1200	1200x1200
Size of beam (mmxmm)	1000x1400	300x800	300x800	300x800
Thickness of RC core(mm)	1500	1200	1200	1200
Slab thickness, mm	150	150	150	150

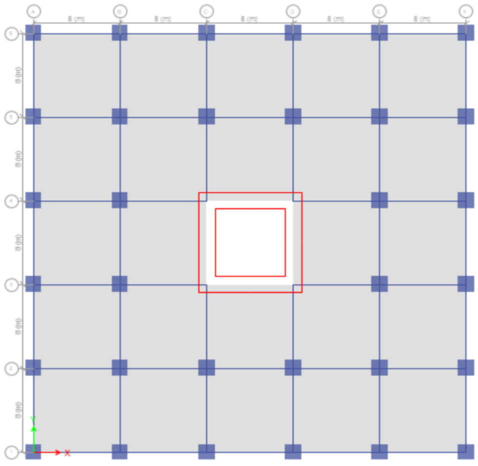

Figure 1 Plan of Traditional System
[In Tube system, in perimeter tube closely spaced columns are provided (2m centre to centre)]

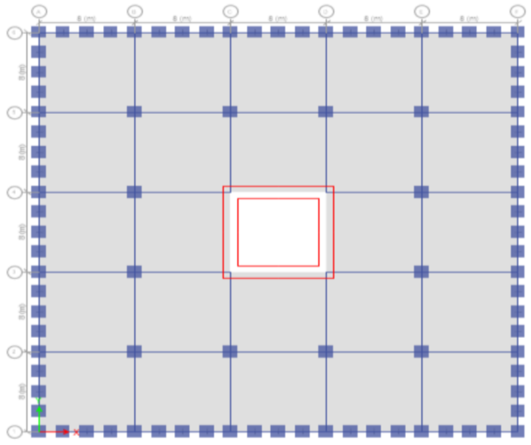

Figure 2 Plan of Tube System

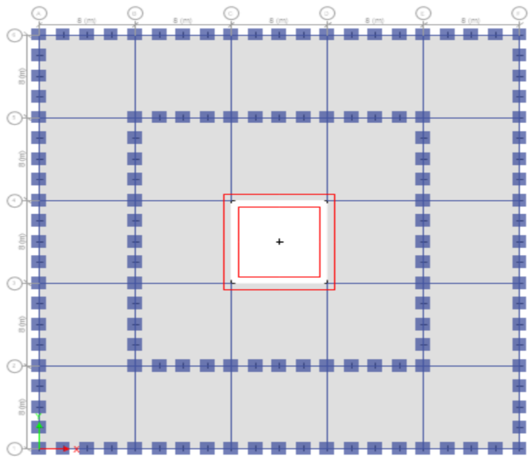

Figure 3 Plan of Tube-in-Tube System

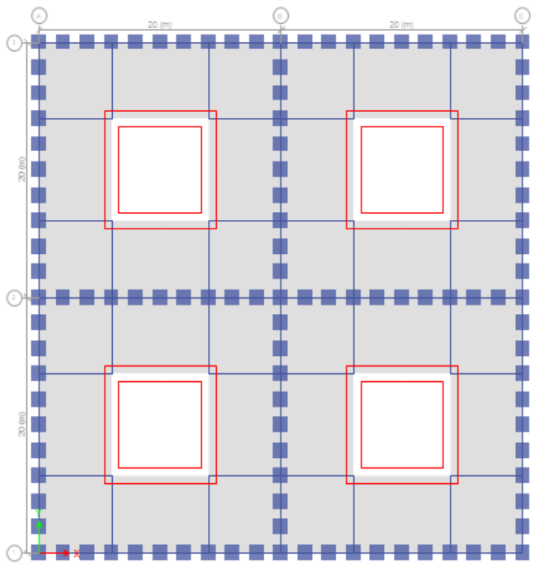

Figure 4 Plan of Bundled System

IV. RESULT ANALYSIS

4.1 Fundamental Time Period

Lateral Load Resisting Systems (LLRS)	Fundamental Time Period, sec
Traditional System	2.876
Tube System	3.635
Tube-in-Tube System	3.482
Bundled System	3.137

4.2 Maximum Story Displacement

Lateral Load Resisting Systems (LLRS)	Maximum Story Displacement, mm
Traditional System	120.91
Tube System	97.21
Tube-in-Tube System	93.12
Bundled System	88.36

4.3 Maximum Story Drift ratio

Lateral Load Resisting Systems (LLRS)	Maximum Story Drift ratio, unitless
Traditional System	0.000918
Tube System	0.000781
Tube-in-Tube System	0.000746
Bundled System	0.000692

4.4 Shear Lag Effect

Lateral Load Resisting Systems (LLRS)	Shear Lag effect (difference in column axial forces on leeward and windward faces), kN
Traditional System	19651.25
Tube System	4713.26
Tube-in-Tube System	4660.02
Bundled System	4473.04

In traditional system, a column with centre to centre spacing 8m are used and in later type closely spaced columns with centre to centre spacing 2m is used.

V. CONCLUSIONS

- Increasing in the number of columns/column sizes, increases both stiffness and mass of buildings. But, when the percentage increase in stiffness as a result of increase in number of columns/column sizes is larger than the percentage increase in mass, the fundamental natural period reduces.
- In comparison of tube system, tube in tube system and bundled systems, fundamental time period of bundled system is less.

- Maximum Story Displacement is found to be less in bundled system.
- The maximum storey drift ratio is found to be less in Bundled system.
- Traditional system has large difference in column axial forces on leeward and windward faces
- Bundled system has smaller difference in column axial forces on leeward and windward faces.

REFERENCES

[1]. C.V.R Murthy, Some Concepts in Earthquake Behaviour of Buildings, GSDMA, Sept-2012.
[2]. IS 1893 (Part-1): 2002 Indian Standard "Criteria for Earthquake Resistant Design of Structures"
[3]. ACI 318-08, (2008), Building Code Requirements for Structural Concrete and Commentary, American Concrete Institude, Farmington Hill, USA

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