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COMPARATIVE STUDY OF PERFORMANCE OF 60 STOREY STEEL BUILDINGS WITH EXO-SKELETON, FRAMED TUBE AND CONVENTIONAL STRUCTURAL SYSTEMS UNDER DYNAMIC LOADING

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Abstract - *High rise steel buildings with Exoskeleton structural system, Framed tube structure system and Conventional structure system under dynamic loading for 60 storey are taken for the analysis. Earthquake zone III (Kolkata) & zone V (Darbhang) and all soil conditions are considered to compare the results in terms of time period, storey displacement, storey drift and storey shear. For dynamic earthquake and dynamic wind analysis response spectrum method (IS 1893-2002) and gust factor method (IS 875-1987 part 3)are used respectively in ETABS V16 software. For steel design IS 800-2007 is considered.*

Key Words: **Exoskeleton system, Framed Tube system, Conventional system, Dynamic analysis, Gust Factor method, Response spectrum method, Time period, Storey displacement, Storey drift, Storey shear , ETABS.**

1. INTRODUCTION

The nature of building perimeters has more structural significance in tall buildings than in any other building type due to their tallness, greater vulnerability to lateral forces occurs. Thus, it is quite desirable to concentrate on lateral load-resisting systems on the perimeter of tall buildings to increase their structural depth and resistance to lateral loads.

An "exoskeleton" is basically a Greek word, meaning "outer skeleton". It is the external skeleton that protects an animal's body as per zoology. In civil engineering, it is an external supporting structure that resist lateral loading.

(a) (b) (c)

Fig -1: Exoskeleton structure (a) Hotel De Las Artes, Spain (b) Hotel Burj Al Arab, Dubai (c) O-14Business Bay, Dubai

In Framed tube structure system columns are closely spaced at the perimeter and columns joined by beams which resist lateral loads. This creates tube as continues perforated chimney. This type of structure is constructed up to 100 stories.

Fig -2: Framed Tube structure (a) Brunswick Building, Chicago (b) De Witt Chestnut Apartment, Chicago (c) World Trade Centre (1973-2001)

2. Research Significance

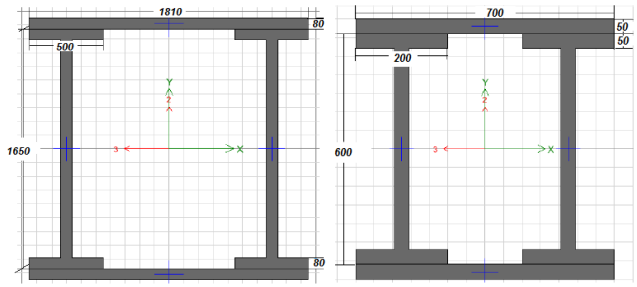
In high rise buildings it is necessary to analyze dynamic loads. As the height of the building increases, lateral loads like earthquake and wind loads acting on building become more venerable so it is necessary to analyze the lateral loads.

In this paper three systems are compared in terms of time period, displacement, drift, and shear. To analyze the lateral loading two locations Kolkata and Darbhang are considered. The objective of this study is to find out which system is better to resist dynamic earthquake and dynamic wind load

3. Modelling and Analysis

3.1 Building Configuration

For the comparison of exoskeleton, framed tube and conventional structure systems a square plan of 36 x 36 m having typical storey height and bottom storey height of 3m is considered. The total structure height is 180 m. Fe 345 material having weight density 76.9729 kN/m^3 is selected. Typical floor slab thickness is 120mm having M30 grade of concrete is considered. In Exoskeleton system, exoskeleton members are provided at 1m outside the plan in all direction. In all systems main beams, secondary beams and exoskeleton members named B1, B3 and E3 respectively are of ISMB 550 with top and bottom cover plate of 220 x 50 mm and inclined beams in plan named B2 is of ISMB 600 with top and bottom cover plate of 250 x 50 mm are considered.



(a) (b)

Fig -1: Column details (a) Interior column C1,(b) Exterior column C2

3.2 Model Preparation

Modelling is done using ETABS v16 software.

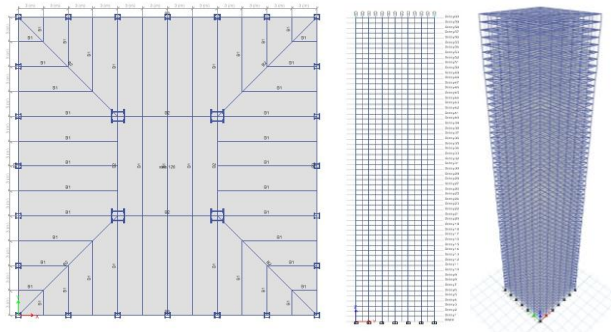


Fig -2: Plan, Elevation & 3D view of Conventional system

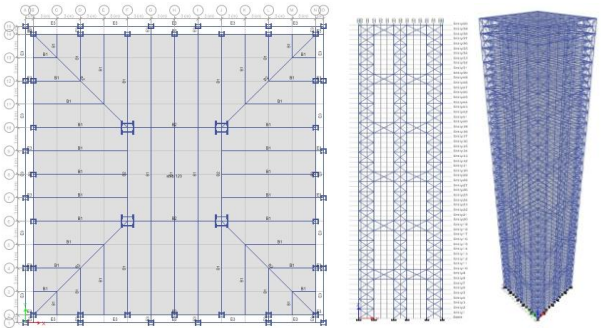


Fig -3: Plan, Elevation & 3D view of Exoskeleton system

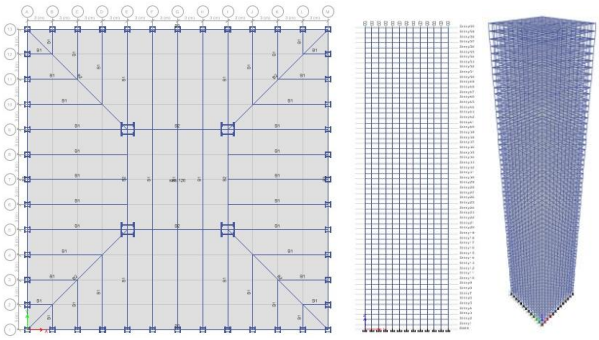


Fig -4: Plan, Elevation & 3D view of Framed tube System

3.3 Dynamic analysis methods and Loading Data

Dead Load = 1.5 kN/m^2

Live Load = 2.5 kN/m^2

Cladding Load = 0.108 kN/m^2

3.3.1 Response spectrum method

A response spectrum method is straight forward graphical portrayal of unfaltering state reaction for dislodging, speed or quickening of oscillators of fluctuating normal response that are forced into motion by the same base vibration. In this method response of multiple modes of a building is consider for the analysis. The response of a structure can be defined as a combination of modes that in a vibrating string correspond to the "harmonic". To perform response spectrum analysis, it is necessary to know the earthquake intensity at zone on which the building.

Table -1: Earthquake Loading data

Location	Kolkata	Darbhang
Zone	3	5
Zone Factor, Z	0.16	0.36
Importance Factor, I	1.2	1.2
Response reduction Factor, R	5	5
Soil Type	I,II & III	I,II & III

3.3. Gust Factor method

Gust factor method is rational and realistic and it is considered for the computation of dynamic wind loads in the case of very tall frames and structures. It becomes necessary to study the criticality of wind forces in the case of multi-storied frames particularly on more serve wind zones. Here, basic wind speed for Kolkata and Darbhang is 50m/s and 55 m/s respectively. For the dynamic wind analysis terrain category III and class C is consider.

3.3.2.1 Calculation of dynamic wind load

Criteria to satisfy for the requirement of dynamic analysis as per IS 875-1987 part 3

Case1: If height to least lateral dimension ratio > 5.

Table -2: Dynamic wind analysis check case-1

System	H (m)	D (m)	H/D	Dynamic analysis
Conv. & Fram.	180	36	5	= 5 Not Required
Exoskeleton	180	38	4.73	< 5 Not Required