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Effect of Non-Structural Elements on High Rise Structure

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ABSTRACT:*A high-rise building is typically thought of as a grouping of various structural and non-structural components. The architectural, mechanical, and electrical components of a building that directly serve human needs are referred to as non-structural elements. These are not a part of the building's main load-resisting system. As a result, they are frequently overlooked in structural design. The behavior of past seismic events clearly illustrated that lack of adequate of design provisions for non-structural elements and their attachments resulted in poor performance of several life line buildings. The goal of this research is to learn more about NSEs and to examine the impact of non-structural elements on high-rise (G+20) buildings in Seismic zone 4. For achieving our objective, we use IS Code 16700:2017 as designing purpose and for modelling Tekla Structural Designer as a software tool*.

KEYWORDS -*Non-structural elements, High rise building, IS 16700:2017, Tekla Structural Designer, Seismic Safety*

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I. INTRODUCTION

The An earthquake is a natural dreaded calamity that results from a sudden discharge of energy beneath the earth. It is regarded as one of the worst natural disasters, shaking up a portion of the earth's surface as well as all manmade objects, living and non-living things on it.[1] Rapid urban population growth and the resulting pressure on limited space have significantly impacted city residential development. The high cost of land, the desire to avoid continuous urban sprawl, and the need to preserve vital agricultural production have all contributed to the upward trend in residential construction. As a building's height increases, the lateral load-resisting system takes precedence over the structural system that resists gravitational loads.[2]

A building's behavior during an earthquake is determined by its general shape, size, and geometry. The seismic performance of both regular and irregular shape structures is affected by the building's height as well as other essential structural characteristics. Non-structural features in buildings such as ceilings, panels, windows, and doors, as well as equipment, mechanical, and sanitary facilities, should be considered in the design of any structure vulnerable to seismic movement.[3]

A building is considered safe when both of the following can withstand earthquake ground motions at its base without damage:

a). people in the building, and

b). the building's contents, appendages, and services and utilities in the building.

Safety of people means no collapse of the whole or part of the building that endangers life, and safety of contents means the contents, appendages to structures, and services & utilities can continue to function as expected even after the earthquake.[4] Non-structural elements are those that are attached to or housed in a building or building system but are not part of the building's main load-bearing structural system. Depending on their nature, the aforementioned elements are subjected to substantial inertia forces and/or relative displacements during an earthquake. There are three types of risk associated with earthquake damage to non-structural elements: loss of life or injury to building occupants, loss of property, particularly in commercial buildings where the cost of non-structural elements can be as high as 75% of the total cost of the building, and impairment or loss of function of an important building or lifeline structure, such as a fire fighting system, communication facilities, or a telecom center.[6]Several water tanks and sign boards on top of buildings in India toppled after the 2001 Bhuj earthquake. Unfortunately, the loss of human life and structure was so pervasive that non-structural damage was overlooked.[6]

Fig 1. Failure of overhead tank in Bhuj earthquake, 2001

Fig 2. Failure of signboard in Bhuj earthquake, 2001

II. RELATED WORK

[3]**Aarti Kishor Shahane et.al (2021)** In this paper they used a solved example to demonstrate the use of a displacement-sensitive element such as a sign board. Utilizing Staad software, it displays many factors such as base shear, displacement, mass participation, period, node displacement, beam displacement, and effect of nonstructural elements (Signboard) of the building.

[7]**Prof. Kavita K. Ghogare et.al (2016)** Their work investigates the response of non-structural elements during an earthquake. Where they concluded that the provisions of the IS Code for non-structural elements are the most critical. The highest seismic force causes the most damage. The effects of non-structural factors on structure are more pronounced.

[6]**Goutam Mondal (2005)** The study examines the design lateral forces proposed in several worldwide seismic codes, as well as their design philosophy and design requirements. Non-structural damage is frequently reported in earthquakes in India but is often missed due to the obvious focus on the massive loss of human lives and structural damage.

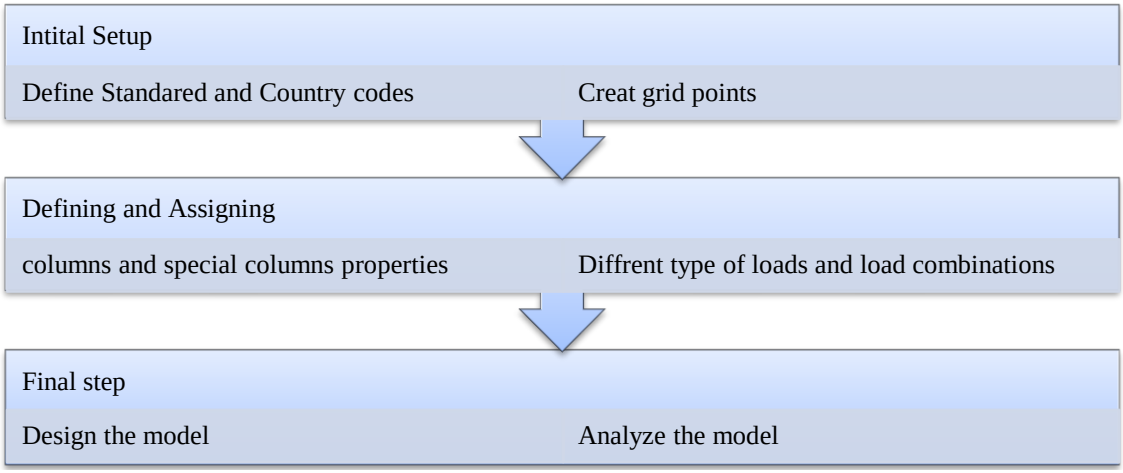
[7] Amit Bose at.el. [2004], Following the Kutch earthquake, the focus of most studies and solutions linked to earthquake-safe habitats in India has shifted to structural engineering components of the built form. This research focuses on the behavior of non-structural components in buildings as a result of the Kutch earthquake, and how they were responsible for causing damage to the building's and structural system's functionality. The research will be valuable in catastrophe mitigation, particularly in terms of non-structural component damage to buildings. It makes recommendations for future actions in the fields of needed research and the establishment of new codes and guidelines.

III. OBJECTIVES

1. The To evaluate the seismic performance of a High-rise building (G+20) in seismic zone 4 for under vertical and earthquake loads.
2. To study the seismic behavior of non-structural elements (NSE) in High-rise building(G+20)in seismic zone 4 of medium soil conditions using IS 16700:2017
3. To evaluate the seismic parameters storey displacement, base shear, Seismic weight in a (G+20) High-rise building as per Indian standards

IV. METHODOLOGY

The current thesis study involves modelling and analysis of a rectangular-shaped building. We modelled two buildings, one without NSCs and the other with NSCs, and then used Tekla structural designer to complete the modelling.



V. Models

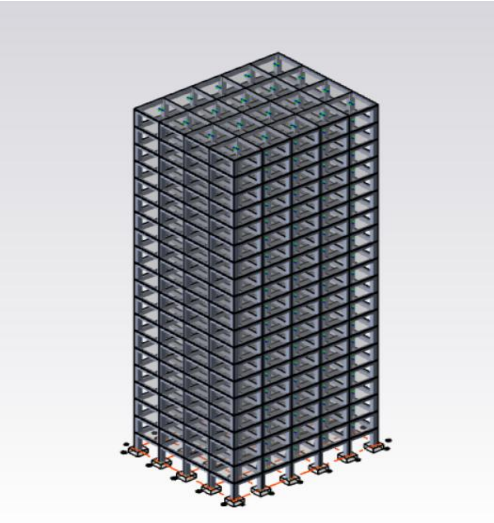


Fig 1. Model without NSEs

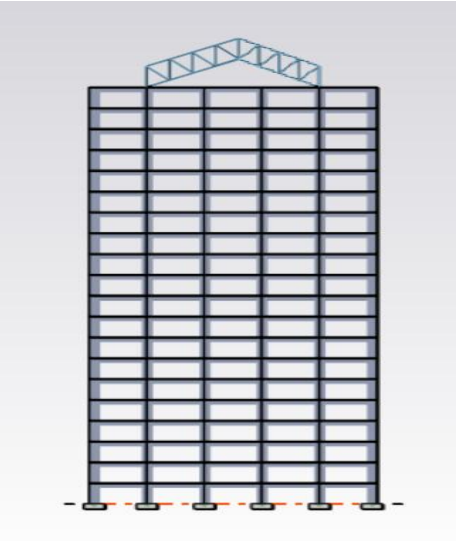


Fig 2. Model with NSEs

VI. Building Parameters

Table 1: - Parameters of models

Area of building	$20*25\ m^2$	
Height of building	60 m	
Shape of building	Rectangular	
Seismic zone	IV	
Zone factor	0.240	
Soil type	Medium (II)\	
Importance Factor, I (As per IS 1893:2016)	1.2	
R, Response factor (As per IS 1893:2016)	5	
IS Codes adopt for research	IS 1893:2016 (part1), IS 16700:2017	
Member	Dimensions	Grade
Slab	150mm	M30

Column	650*700	M30
Beam	450*550	M30

VII. ANALYSIS AND RESULTS

1. :-Design of NSEs

Non-structural elements (NSEs) of tall buildings must adhere to all applicable current national standards and guidelines established by various statutory and non-statutory authorities, as well as the building's client/owner.

$$\mathbf{Fp} = \boldsymbol{Z}\left(1 + \frac{\boldsymbol{x}}{\boldsymbol{h}}\right)\frac{\boldsymbol{ap}}{\boldsymbol{Rp}}\boldsymbol{IpWp}$$

Where,
Z = Seismic Zone *factor* [as defined in IS 1893 (Part 1)],
I_p = importance factor of the NSE (*from* Table 10 IS 16700:2017),
R_p = component response modification factor (*From* Table 11 IS 16700:2017),
a_p = component amplification factor (*from* Table 11 IS 16700:2017),
W_p = weight of the NSE,
x = height of point of attachment of the NSE above top of the foundation of the building, and
H = overall height of the building.

In residential buildings there are various types of NSEs applied which were classified into two parts

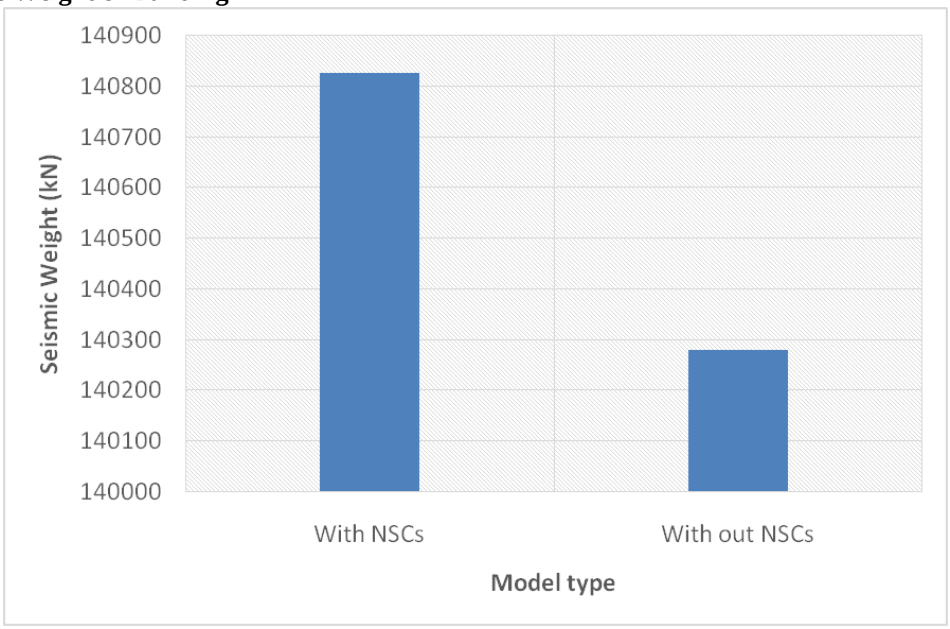
Architectural component or element

- Parapet wall
  Fp=172.8 kN
- Billboards
  Fp=38.4 kN

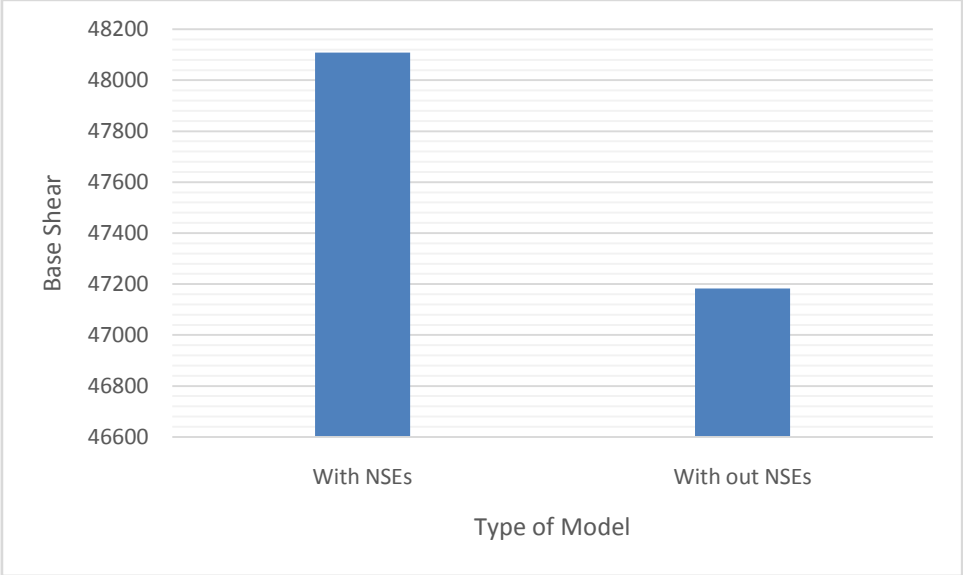
Mechanical and electrical component/elements

- Elevators
  Fp=85.68 kN
- Lighting Fixtures
  Fp=18.16 kN

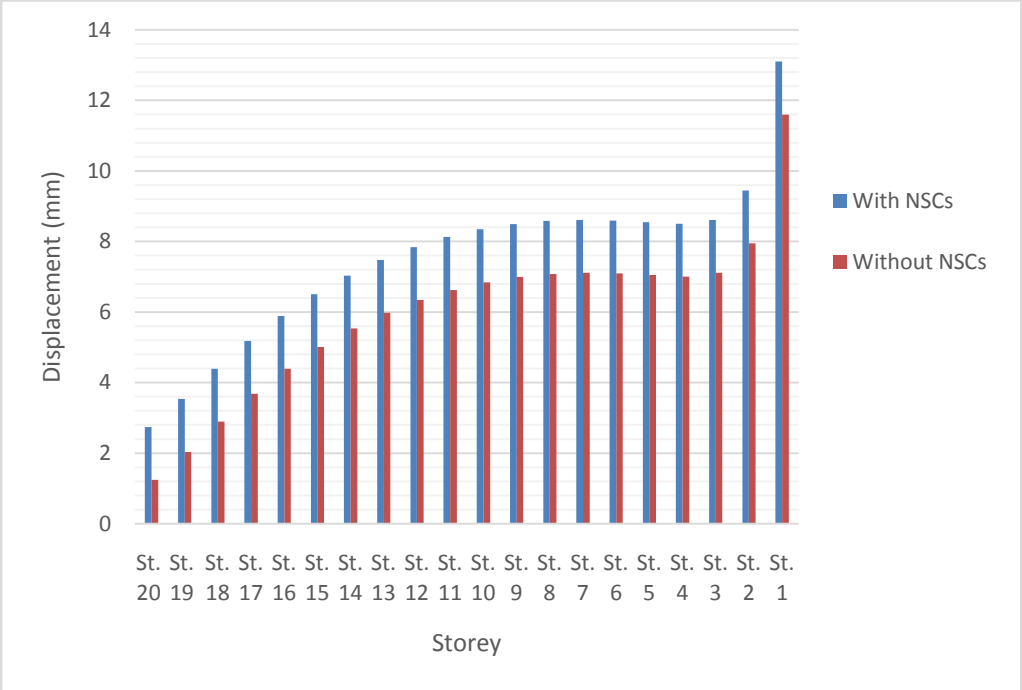
1. Seismic Weight of Building



2. Base shear



3. Displacement



VIII. CONCLUSION

1. IS Code provisions for non-structural elements are most important.
2. Effects of non-structural elements on structure are more.
3. It is observed that deflection in a building without NSEs is minimum where as it is increased in building having NSEs.
4. Local force may be concentrated if non-structural components are rearranged non-uniformly in

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