Comparative Analysis of Seismic & Wind Load on Soft Storey Building with Equivalent Inclined Column

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Abstract— Providing equivalent inclined column at soft floor will reduces moment, shear force, displacement, storey displacement and drift. The analyses of high rise building with different floor conditions studied under the effect of seismic and wind load condition. So, it is concluded that Equivalent inclined column not only strengthen structure but also provide better stiffness which also justify the purpose of the work. Purpose of preparing this report is to find the soft storey location (level) in a high rise building, so has to have minimum effect of external forces on the structural stability. This study will provide the results against various locations of soft floor with or without placing inclined columns in the building frame. Results are based on the behaviour of building against the lateral forces (Earth quake and wind Forces) as analysed by software Staad pro.

Key words: Soft Story, Weak Floor, Seismic Analysis, Story Drift, Wind Analysis

I. INTRODUCTION

Soft storey is a common building weakness. The term soft storey explains one level of a building that is appreciably more flexible than the stories above it and the floors or the foundation under it.

Buildings are classified as having a soft storey if that level is less than 70% as stiff as the floor instantly above it or less than 80% as stiff as the average stiffness of the three floors above it. Open ground storey buildings are called soft storey building, whereas their ground storey may be weak or weak. The weak or soft storey commonly exists at the ground storey level, but it might be at any other storey level. Soft storey buildings have a lot of open space for example, parking garage, restaurants or floors with lots of windows.

The behaviour of soft storey building in an earthquake is very crucial because the soft storey building is more flexible in seismic condition, vibration is happening in the soft storey building so we provide shear wall in a soft storey building (shear wall resists the effect of an earthquake).

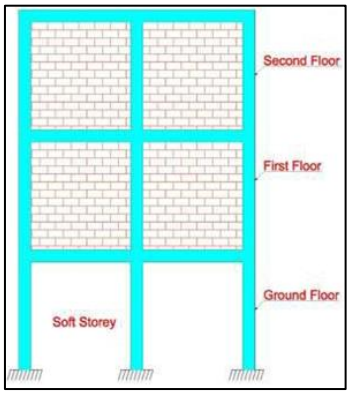

Fig. 2.1: Soft Storey Building
Source:http://www.buildingresearch.com.np/services/erd/erd2.php

Reinforced concrete frame structures have become a common form of construction with masonry infill in urban and semi urban areas in the world. The infill framed structures are made and analyzed by the combination of a moment resisting plane frame and infill masonry walls. The infill masonry may be of brick, concrete blocks, or stones. Ideally in present time the reinforced concrete frame is filled with bricks as non-structural wall of partition of the rooms because of its advantages such as, thermal insulation, durability, cost and simple construction technique.

Nowadays, many buildings are constructed having a unique feature i.e. the ground floor remains open, which means the columns in the ground floor do not have any partition walls between them. This type of structure (Fig. 1.2) having no infill masonry walls in ground floor, but having infill masonry walls in all the upper floors, are called Open Ground Storey (OGS) Buildings. This open ground floor structure is also termed as a structure with 'soft storey at Ground Floor'. OGS buildings are also known as open first storey building (when the floor numbering starts with one from the ground floor itself), pilots, or stilted buildings. Open first storey is nowadays unavoidable feature for the most of the urban multi-storey buildings because social and functional needs for parking, restaurant, commercial use etc. are compelling to provide an open first Storey in high rise structure. Parking has become a necessary feature for the most of urban multistoried buildings as the population is increasing at a very fast rate in urban areas leading to crisis of vehicle parking space. Hence the trend has been to use the ground floor of the building itself for parking purpose.

Fig. 2.2: Model of a Building with Soft Storey at Ground Floor

There is major advantage of this type of buildings functioning, but from the seismic performance point of view, such structures are considered to have increased vulnerability. Though multi-storied buildings with parking floor (soft storey) are vulnerable to collapse dueto seismic forces, their construction is still popular. The OGS buildings are usually designed as framed structures without regard to structural action of wall (masonry infill walls). In India current structural design methods, infill walls are considered as non-structural element and their strength and stiffness are

ignored during analysis and design. The effect of infill panels on RC framed structures if subjected to earthquake is widely accepted and has been subjected to numerous experimental and analytical investigations over last 5 decades.

II. SCOPE OF STUDY

In this work G+5 storey (six stories) building is taken in which floor wise (changing soft storey position from ground to four stories) soft storey is analysed and its contribution in the behaviour of the structure is examined. Soft storey is very flexible so our purpose is to strengthen it by proving equivalent inclined column at the soft floor, and find out the effective equivalent inclined column pattern which stands against the wind and earthquake loading. The investigation is to be carried out by conducting

a) Modelling of building frames with different position of soft floor with and without equivalent inclined column
b) Analysis of frames considering wind and earthquake parameters
c) Critical study of results in term of moments, forces and displacement in the building.
d) Analysis of building frame without considering inclined column.
e) Analysis of building frame considering inclined column at soft floor.

III. METHODOLOGY

The present research work deals with comparative study of behaviour of soft storey building frames, by considering geometrical configurations of building under wind loading and earthquake loading. The framed buildings are subjected to lateral loads and vibrations because of wind and earthquake and therefore lateral load analysis is necessary for these framed structures. The fixed base system is analysed by employing different equivalent inclined column frame structures in seismic and wind loading by means of STAAD Pro software. The responses of the same building frames are studied and evaluated the best geometry which satisfies lateral loadings.

IV. EQUIVALENT INCLINED COLUMN METHOD

The structural frames with unreinforced masonry can be designed as equivalent braced frames by substituting infills with the equivalent inclined columns. Many investigators proposed different approximations for the width of the equivalent inclined column. The width of inclined column depends on the length of contact between the wall & the column (α_h) and between wall & beams (α_L). The formulation for (α_h) & (α_L) on the basis of beam on an elastic foundation was specified by Stafford Smith (1966). Hendry (1998) proposed the following equation to determine effective column width w, where the column is assumed to be subjected to uniform compressive stress.

$$\alpha_h = \frac{\pi}{2}\sqrt[4]{\frac{4E_f I_c h}{E_m t \sin 2\theta}} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\alpha_L = \pi\sqrt[4]{\frac{4E_f I_b L}{E_m t \sin 2\theta}} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$w = \sqrt{\alpha_h^2 + \alpha_L^2} \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where,

- E_m = Elastic Modulus of masonry wall,
- E_f = Elastic Modulus of masonry of frame material,
- t = Thickness of the in-fill wall,
- h = Height of the in-fill wall,
- L = Length of the in-fill wall,
- I_c = Moment of Inertia of the column of the frame,
- $I_b = \tan^{-1}(h/L)$ and
- w = Width of the Equivalent Column.

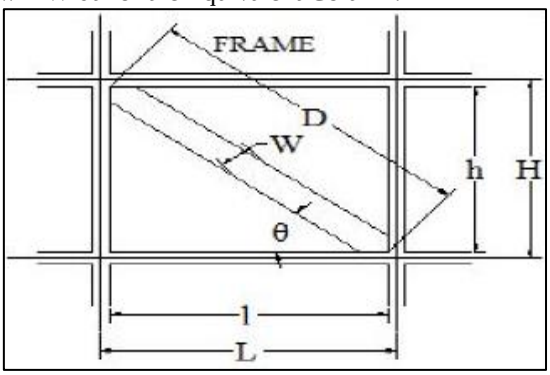

Fig. 3.1: Brick infill as a Diagonal Equivalent Columns

V. EQUIVALENT STATIC METHOD

Equivalent Static method of analysis is a linear static procedure, in which the response of the building is assumed as linear static manner. The analysis is carried out as per IS: 1893-2002 (Part 1).A comparison analysis of results by moments, displacements, shear force, storey displacement and axial force has been done. Following steps are considered

1) Step-1 Selection of building geometry and Seismic zone: The behaviour of all the models is studied for Zone II of Seismic zones of India as per IS code 875 PART II-1987 for which zone factor (Z) is 0.10
2) Step-2 Selecting geometry of 6 stories (G+5) of plan area 15m x 15m

A. Case Details

1) Building without soft story without inclined column.
2) Building with soft story without inclined column.
3) Building with soft story with inclined column.

VI. RESULTS

Following are the salient result discussion of this study

A. Bending Moment

- Considering maximum moment, it is observed that soft storey at ground floor without inclined column is critical in X direction and critical at second floor in Z direction when soft storey is stiffed with inclined column. Equivalent inclined column shows poor performance when 2nd storey is soft floor. So it can be concluded that soft storey at middle floor must be avoided.
- It is seen from the bending moment results that structure is most stable in non-soft floor conditions, but if it is necessary to provide soft floor in high rise building structure must be stiffened at soft floor with the help of inclined column.

B. Shear Force

- Considering shear force, it is observed that soft storey at ground floor without inclined column is critical in X direction and critical at second floor in Z direction when soft storey is stiffed with inclined column. Equivalent inclined column shows poor performance when 2nd storey is soft floor. So it can be concluded that soft storey at middle floor must be avoided.
- It is seen from the bending moment results that structure is most stable in non-soft floor conditions, but if it is necessary to provide soft floor in high rise building structure must be stiffened at soft floor with the help of inclined column

C. Maximum Displacement

- Considering maximum displacement in worst loading combination, maximum displacement is observed in soft storey at second floor without inclined column and minimum when building is without soft storey. But if it is necessary to provide soft storey in the building then it should be placed at higher level of building with inclined column at soft floor.

D. Axial Force

- It is observed that maximum axial force is generated due to worst load combination of earthquake loading or horizontal wind loading case at fourth floor soft storey without inclined column and minimum axial force generation at fourth floor soft storey with inclined column.

E. Storey Displacement

- Storey displacement is maximum when we place soft storey at higher level of building as compared to the bottom floors.
- Result of analysis shows that storey displacement is maximum at case where soft storey at fourth floor without inclined column and it is minimum in a building when building without soft storey and without inclined column.

F. Drift

- Drift is observed maximum in building where soft storey at higher level without inclined column, but if we provide inclined column at same level this means if soft storey is provided at higher level bottom storey of structure will have less drift.

VII. Conclusion

From above results it is observed that equivalent inclined column strengthens the structure from the soft storey. It is clear that CASE-2 (building frame with soft storey and without equivalent inclined column) is most critical and CASE-1 (building without soft storey and without inclined column) is best and efficient one, while CASE-3 (soft storey with inclined column) is second best. Means providing equivalent inclined column at soft floor will reduces moment, shear force, displacement, storey displacement and drift. The analyses of high rise building with different floor conditions studied under the effect of seismic and wind load condition. So, it is concluded that Equivalent inclined column not only strengthen structure but also provide better stiffness which also justify the purpose of the work.

Purpose of preparing this report is to find the soft storey location (level) in a high rise building, so has to have minimum effect of external forces on the structural stability. This study will provide the results against various locations of soft floor with or without placing inclined columns in the building frame. Results are based on the behavior of building against the lateral forces (Earth quake and wind Forces) as analyzed by software Staad pro.

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