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Seismic Response of R.C.C Low Rise Frame Structure with Soft Story Effects using E-Tabs: A Case Study

Preeti[1],
[1]Department of Civil Engineering Department
GITAM Kablana, India

Amit Singhal[2],
[2]Department of Civil Engineering Department
GITAM Kablana, India

Neeraj Kumar[3]
[3]Department of Civil Engineering Department
GITAM Kablana, India

The increase in urban population in recent times has raised the requirements of vehicle parking as a major problem, & to resolve this matter first storey of the apartments are generally kept open& hence used for parking purpose .Buildings are classified as "soft storey" if that level is less than 70% as stiff as the floor immediately above it, or less than 80% as stiff as the average stiffness of the floors above it.A building with soft storey inherently vulnerable to collapse during earthquake due to its reduced stiffness infill walls in frame building provides stiffness & alters the behavior of building under lateral loads.A Soft Storey is a Building in which one or more floors have windows, wide doors, large unobstructed commercial spaces, or other openings in place where shear wall or any other arrangement normally be required for providing stability as a matter of safe structural design.In this paper different iterations are done with programs E-tabs,to study the seismic behavior of soft storey buildings with different arrangements,Parameters discussed here include the comparative study of Stiffness, Design Seismic base shear, fundamental natural time period, lateral displacement.

Index Terms—wall-strut, E-tabs , Shear walls, Seismic analysis.

I. INTRODUCTION

A soft story building is building with one or more floors which are "soft" due to structural design [1]. These floors can be especially dangerous in earthquakes, because they cannot cope with the lateral forces caused by the swaying of the building during a quake. As a result, the soft story may fail, causing what is known as a soft story collapse.

A soft story collapse is one of the leading causes of damage to private residences .Soft story buildings are characterized by having a story which has a lot of open space. Parking garages, for example, are often soft stories, as are large retail spaces or floors with a lot of windows. While the unobstructed space of the soft story might be aesthetically or commercially desirable, it also means that there are less opportunities to install shear walls, specialized walls which are designed to distribute lateral forces so that a building can cope with the swaying characteristic of an earthquake [2].

As the population is increasing day by day in the past few years the trend to utilize in all over world to have one open storey concept in the building but at the same time it is of prime importance to make such buildings earthquake resistant. A soft storey is the one in which the rigidity is lesser than other storey above it because of not containing any brick walls of any property which rest of the floors of the same building contains.

Earthquakes of different intensities produce low-high waves which tend to vibrate & effect the base of the building so due to this some lateral forces generates in the building which bring variations & Complications in structure especially in the open storey. Following is some diagrammatic representation of building showing distribution of displacement in a regular & in a soft storey building [4].

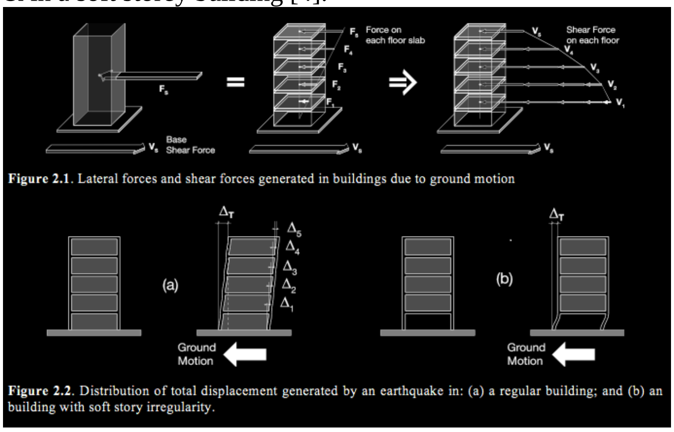

Figure 2.1. Lateral forces and shear forces generated in buildings due to ground motion

Figure 2.2. Distribution of total displacement generated by an earthquake in: (a) a regular building; and (b) an building with soft story irregularity.

A. Elevational View Of The Site

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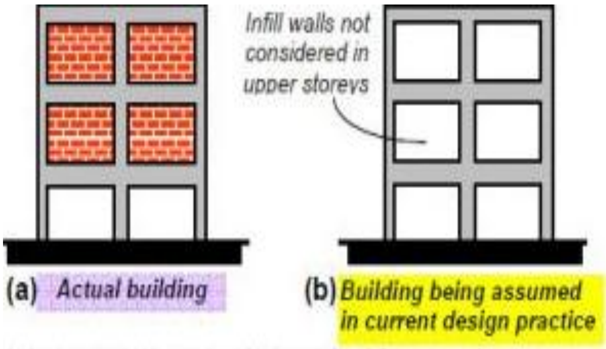


Figure showing Open storey building:- Assumptions made in Current design practice are not consistant with the actual structure.

II. ANALYSIS OF BUILDING FOR DIFFERENT ARRANGEMENTS

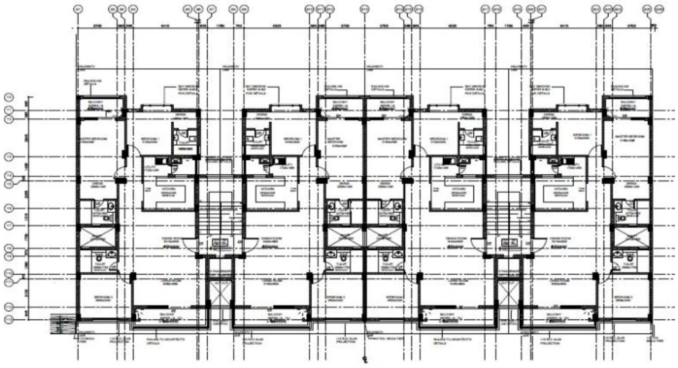
In this study R.C.C Building is modeled & analyzed in three different arrangements using the same configurations:-

1. CASE I :- Model with bare frame.
2. CASE II :- Model with wall-strut above Stilt roof Level
3. CASE III :- Model with shear walls upto Stilt floor Roof Level.
4. CASE IV :- Model with Wall-Strut at all Storey.

A. STRUCTURAL CONFIGURATION OF BUILDING

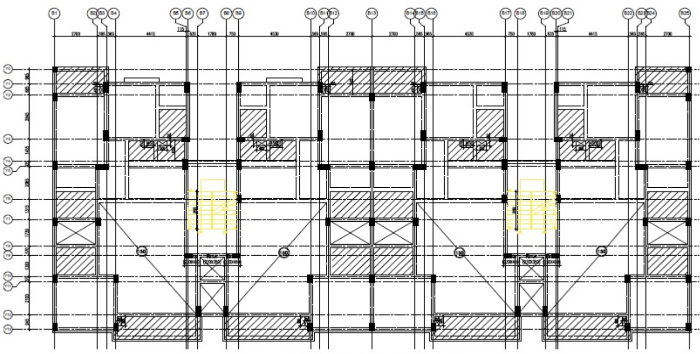
S.no	Description	Information
1.	No. of upper storeys above stilt	4
2.	Type of frame	RCC Frame with Stilt/Ground open
3.	Height of Upper floors	3.0 m
4.	Beam sizes	230x450
5.	Soil type/Support conditions	Medium
6.	Self weight of Building	1.0
7.	Grade of concrete/Steel	Slab-M25,Beam-M25,Column-M30 Reinforcement: Fe500/Fe415
8.	Minimum cover	Slab-25mm Beam-25mm Column-40mm Shear wall-25mm
9.	Mass Sources	DL+25%LL
10.	Thickness of slab/shear wall	Slab-125/150mm,shear wall-230mm
11.	Thickness of partions& brick /block used	230mm/115mm
12.	Dead Loads/Density of different material	RCC-25Kn/m^3 Brickwork-18.0 Kn/m^3
13.	Imposed load	2/3 Kn/m^3
14.	Floor finish	1.35 Kn/m^3
15.	Importance Factor	1.0
16.	Seismic Zone	Z-4
17.	Response reduction factor	5

III. DESCRIPTIONS OF STRUCTURAL MODELS WITH ARCHITECTURAL AND STRUCTURAL DRAWING [5]



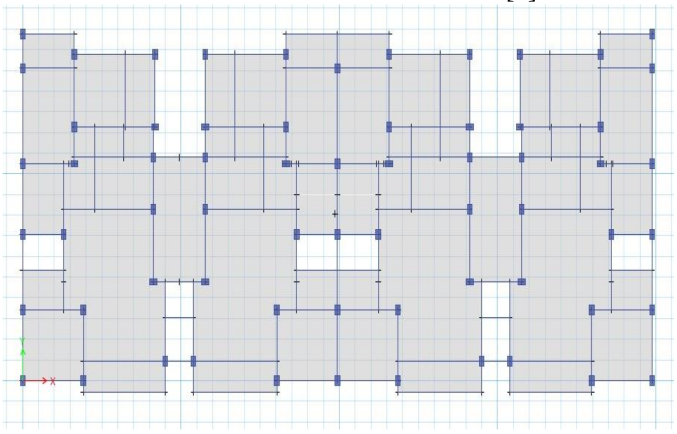
TYPICAL FLOOR PLAN

II. ARCHITECTURAL TYPICAL FLOOR PLAN



STRUCTURALTYPICAL FLOOR PLAN

B. CASE I :- MODEL WITH BARE FRAME [5]



TYPICAL FLOOR PLAN IN E-TABS

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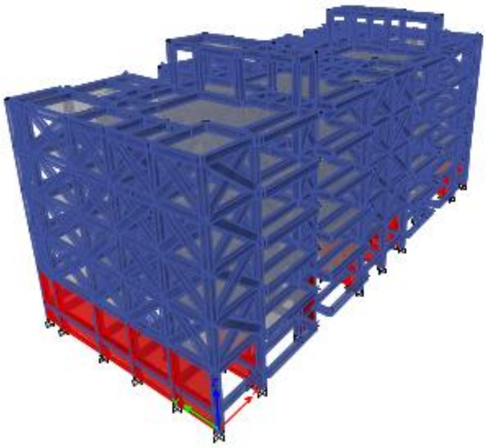
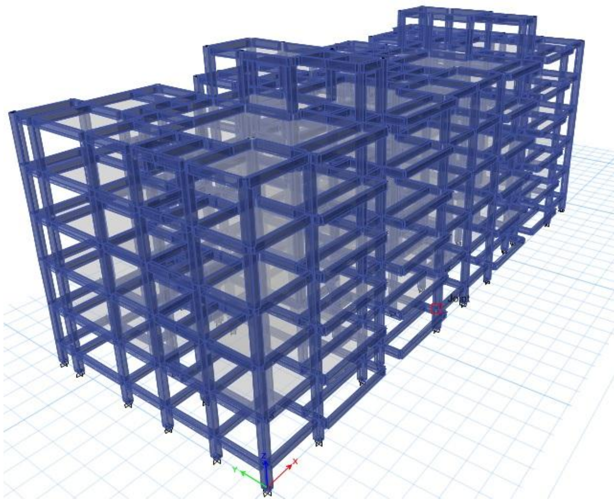
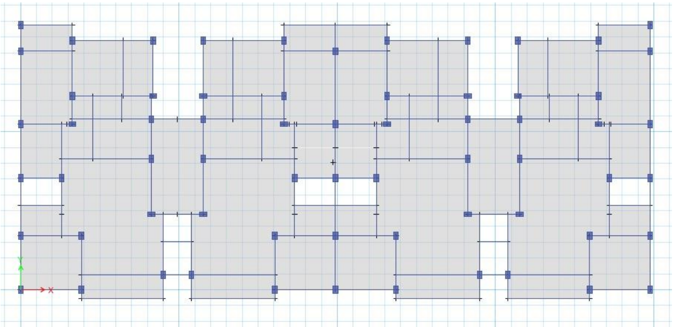


ISOMETRIC VIEW OF CASE III

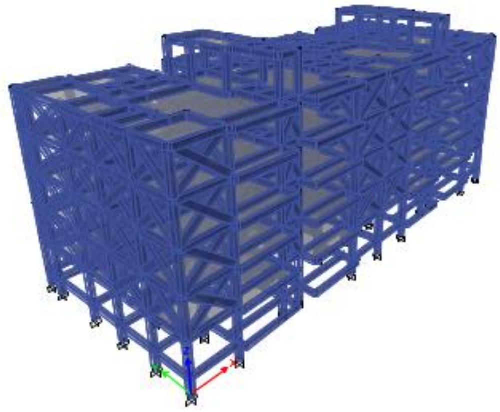


ISOMETRIC VIEW OF CASE I

C. CASE II:- MODEL WITH WALL-STRUT BOVE STILT ROOF LEVEL [5]

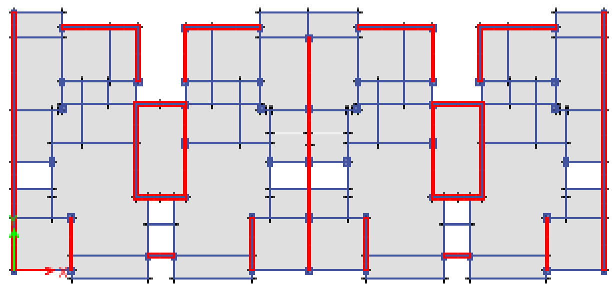


TYPICAL FLOOR PLAN IN E-TABS



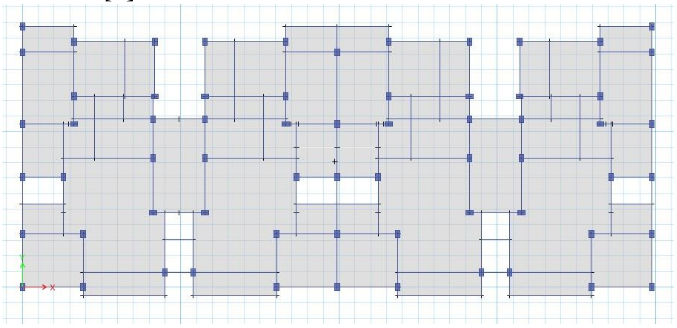
ISOMETRIC VIEW OF CASE II

D. CASE III:-MODEL WITH SHEAR WALLS UPTO STILT FLOOR ROOF LEVEL [5]



TYPICAL FLOOR PLAN IN E-TABS

E. CASE IV:- MODEL WITH WALL-STRUT AT ALL STOREY [5]



TYPICAL FLOOR PLAN IN E-TABS

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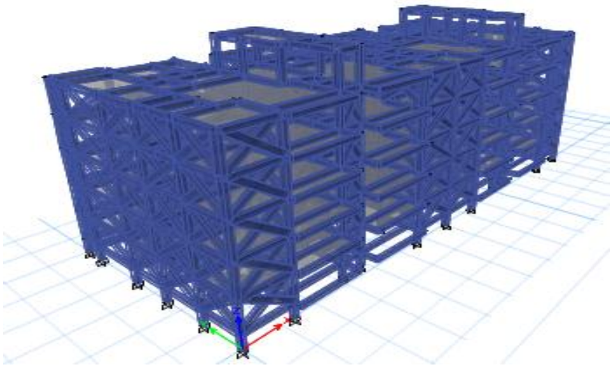


ISOMETRIC VIEW OF CASE IV

IV. ANALYSIS RESULT AND DISCUSSION

A. Storey Stiffness

.It is the rigidity of an object – the extent to which it resists deformation in response to the applied force.

$$K = P/\Delta$$

Hence after analyzing the Building the results obtained maximum of both longitudinal and transverse direction comparisons are presented in tabular form.

CASEI -Calculation of stiffness for bare frame model:-

Storey No.	Load(KN)	Stiffness(KN/M)
Roof	861	443368
4th	1547	496057
3rd	1958	505674
2nd	2165	523705
1st	2236	684561
Stilt	2238	3349887

CASE-II: Calculation of stiffness with wall strut above stilt roof level :-

Storey No.	Load(KN)	Stiffness(KN/M)
Roof	962	2332499
4th	1783	7014699
3rd	2275	9081545
2nd	2523	11067384
1st	2601	940321
Stilt	2603	3666969

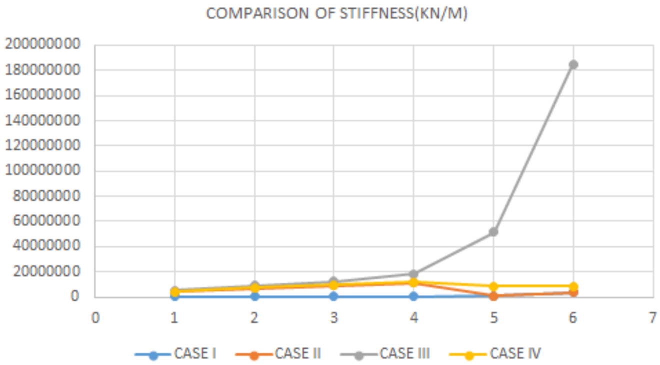
CASE-III :Calculation of stiffness with shear wall upto stilt roof level:-

Storey No.	Load(KN)	Stiffness(KN/M)
Roof	1013	5245846
4th	1877	9216545
3rd	2395	12477596
2nd	2655	18490000
1st	2748	51476334
Stilt	2750	185096979

CASE-IV: Calculation of stiffness with wall strut at all storey:-

Storey No.	Load(KN)	Stiffness(KN/M)
Roof	992	4128167
4th	1840	7287135
3rd	2345	9621057
2nd	2600	11622938
1st	2686	8573513
Stilt	2690	8737476

Fig1:-Showing stiffness comparison of all four cases



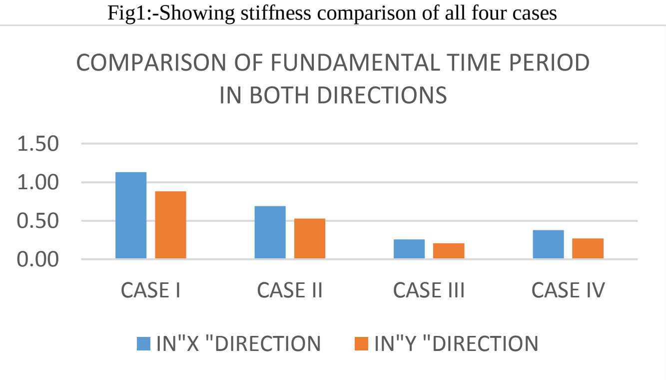
B. Fundamental Natural Period (Ti) [8]

The Analysis as per code (IS :1893-1984) and analysis as per (E-TABS) natural periods of the building models is seen that the analytical natural periods do not match with the natural periods extracted from the empirical formula in the code. It is the first modal time period of vibration The Lower the time period estimated imposes larger base shear in the building .As we have introduced infill in models the time period get reduced .Hence after analyzing the Building the results obtained for three models in both longitudinal and transverse direction and there comparisons are presented in tabular form

Table 1. Showing Time Period Comparison of all four cases

Storey No.	Case I (Sec)	Case II (Sec)	Case III (Sec)	Case IV (Sec)
IN "X" Direction	1.13	0.69	0.26	0.38
IN "Y" Direction	0.88	0.53	0.21	0.27

Fig1:-Showing stiffness comparison of all four cases



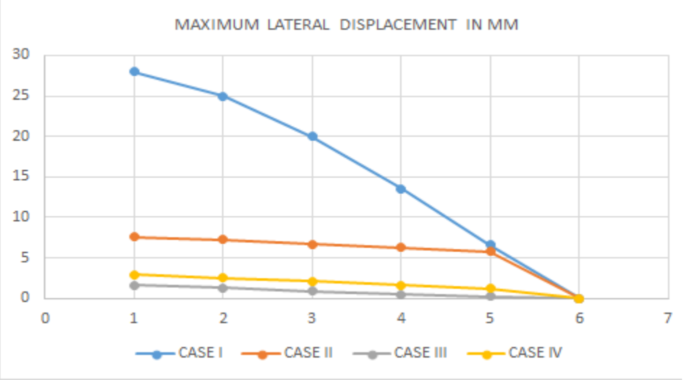
C. Lateral Displacements [6]

Lateral displacement is caused due to the Lateral Force on the each storey level of building. Lateral displacement will be higher on top storey. Hence after analyzing the Building the results obtained for four models are below in the table.

Kindly Note:-Maximum Displacement of both longitudinal and transverse direction are observed for comparison

Table 1. Showing Lateral Displacement comparisons of all four cases

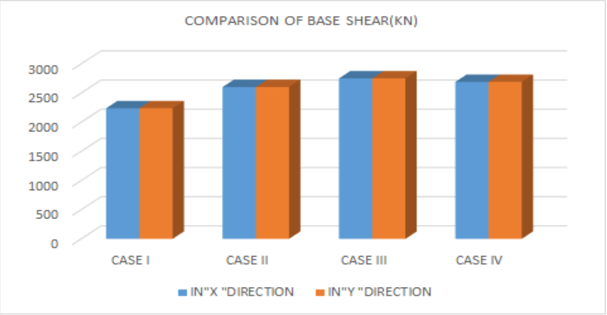
STOREY NO	Case I (MM)	Case II (MM)	Case III (MM)	Case IV (MM)
roof	28	7.6	1.6	3.0
4th	25	7.2	1.3	2.5
3rd	20	6.7	0.9	2.1
2nd	13.5	6.3	0.5	1.6
1st	6.6	5.8	0.2	1.2
Stilt	0	0	0	0



V. DESIGN SEISMIC BASE SHEAR (VB)

It is the total design lateral force at the base of a structure. Hence after analyzing the Building the results obtained for four models in both longitudinal and transverse direction. The comparisons are presented in tabular for

	Case I (KN)	Case II (KN)	Case III (KN)	Case IV (KN)
IN "X" Direction	2238	2603	2751	2690
IN "Y" Direction	2238	2603	2751	2690



VI. RESULT AND CONCLUSSION

RCC Frame building with open at stilt will to perform poorly during in strong earthquake shaking .In this paper ,the seismic vulnerability of buildings with soft storey is shown through an example building .The strength demands in first storey building is very large for buildings with soft stilt storey .It is not feasible to provide such large column sizes at stilt storey level.

The lateral displacement of the bare frame model is on the higher side as no infill are modelled in it ,hence gives less resistance to lateral forces and less stiffness of storey.

In case III by using diagonal wall strut at specific locations it significantly increases the stiffness of the building and also reduces the lateral displacement,it also reduces the Fundamental time period of the building.

The analysis result shows some observations:-

- The Fundamental time period of the model with bare frame gives 2.97 times more time period than the model with infill effect.
- The base shear lateral forces of the model with wall strut modelled is 20% higher then the bare frame modal
- The lateral displacement of the bare frame modal are almost 8 times then the modal with infill effect

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