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Seismic Behavior of Soft Storey Effect in RC Structure by ETABS Analysis

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Abstract - *Soft storey is a typical feature in the modern multi-storey construction. Soft storey reduce the stiffness of the lateral load resisting system and a progressive collapse become unavoidable in severe earthquake. Soft storey behaviour exhibit higher stresses at the columns and the columns fail as the plastic hinges are not formed on predetermined positions. Dynamic analysis of the building model is performed in ETABS. The performance of structure is evaluated in terms of displacement and acceleration. Different cases are analysed by ETABS for models Change in Height, Change in Location of soft storey and Provision of shear wall. The models are tested for displacement, fundamental time period, natural frequency, acceleration. It is observed that, Providing of shear wall improves resistant behaviour of the structure when compared to soft storey provided. All storey wall structure behaves very well in dynamic analysis as compare to the soft storey at various floor model*.

Key Words: Soft storey, ETABS, displacement, fundamental time period, natural frequency, acceleration, Free Vibration.

1. INTRODUCTION

Soft storey is a storey having the lateral stiffness less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storey above (IS1893:2002).when a sudden change in stiffness takes place along the building height, the storey at which this drastic change of stiffness occurs is called a soft storey. "Soft story" and "weak story" are irregular building configurations that are a significant source of serious earthquake damage. Many building structure having parking or commercial areas in their first stories, suffered major structural damages and collapsed in the recent earthquakes. Large open areas with less infill and exterior walls and higher floor levels at the ground level result in soft stories and hence damage. In such buildings, the stiffness of the lateral load resisting systems at those stories is quite less than the stories above or below.

1.1 Objectives

1. To study the soft storey effect.
2. To study the seismic response of soft storey structure.
3. To give guideline for elimination of soft storey effect.

1.2 Methodology

1. Selection of model configuration in software.
2. Analysis of structure with software for all cases.
3. Comparative study on results under
    i. Relative Deflection
    ii. Acceleration
    iii. Time period

2. Geometric Definition

Paper deals with the analysis of R.C.C framed structure is carried out by E-TAB software by considering parameters as follows

Table -1: RCC Frame Structure Parameters

1	Type of structure	OMRF
2	Seismic zone	5
3	Number of storey	G+7
4	Infill wall size	230 mm
5	Imposed load	3 KN/m2
6	Concrete grade	M25
7	Steel	Fe 415
8	Beam size	230*350
9	Column size	230*400
10	Slab thickness	150 mm
11	Type of soil	Medium soil strata
12	Damping	5 %
13	Height of ground storey	3.5 m
14	Height of other storey	3.5 m
15	Plan dimensions	9 m *7 m

2.1 Model considered for free vibration analysis

1. G+7 storey bare frame model (without any external wall at any storey)
2. G+7 storey model with external wall at all story
3. G+7 storey model with external wall at all storey except ground storey
4. G+7 storey model with increase of ground storey (4m) and all other storey remains unchanged with wall
5. G+7 storey model with shear wall at base only and all other floor contains brick wall

3. RESULT

1) Bare frame

Storey Number	Fundamental time period (sec)	Fundamental frequency(sec-1)	Base shear (KN)	Mass Participation (%)	Displacement (mm)
1	2.521592	0.396	4344.	97.43	13
2					32.7
3					50.5
4					65.4
5					77.7
6					86.9
7					92.8
8					96.1

From Eigen value analysis of bare frame model for displacement it is observed that the displacement at ground storey starts from 13mm and max displacement is 96.1 mm occurs at 8th storey. The base shear of bare frame model is 4344.47 KN. All floor doesn't contains any external wall so change in displacement is a uniform. The building behaves very flexible.

2) All storey wall

Storey Number	Fundamental time period (sec)	Fundamental frequency(sec-1)	Base shear (KN)	Mass Participation (%)	Displacement (mm)
1	0.571857	1.748	9290.	98.74	6.2
2					14.3
3					24.3
4					36
5					48.4
6					60.9
7					73.1
8					84.6

It is observed that the displacement at ground storey starts from 6.2 mm and max displacement is 84.6 mm occurs at 8th storey. The base shear of building model (all floor walls) is 9290.24 and it is more than the bare frame model. Displacement of ground storey is decreased and building behaves stiff as compare to bare frame model. Design philosophy of earthquake implies that the displacement with respect to storey height should be linear.

3) No wall at bottom storey (ground storey)

Storey Number	Fundamental time period (sec)	Fundamental frequency(sec-1)	Base shear (KN)	Mass Participation (%)	Displacement (mm)
1	1.486182	0.672	8672.	87.71	70.8
2					75.7
3					80.7
4					86.1
5					91.6
6					97.2
7					102.7
8					107.9

When all story contains external wall except the ground storey the displacement of ground storey is 70.8 mm and max displacement occurs at 8th storey is 107.9 mm. As compare to case b (all storey walls) the displacement of bottom storey and top storey is tremendously increased .The base shear is also decreased as compare to case b (all storey wall). Sudden increase in the displacement may cause more damage to the column of bottom storey.

4) G increased ht (4m)

Storey Number	Fundamental time period (sec)	Fundamental frequency(sec-1)	Base shear (KN)	Mass Participation (%)	Displacement (mm)
1	1.754617	0.569	8684.	86.75	47.1
2					49.3
3					51.2
4					53.3
5					55.4

6					57.5
7					59.5
8					61.4

It is observed that the displacement at first storey level is very large that is 47.1mm as compare to normal structure. That means for soft storey at ground floor increases the drift and displacement. Also for 1st storey the displacement is very large as compare to case b (all storey wall), which may be disasters.

5) Shear wall at bottom

Storey Number	Fundamental time period (sec)	Fundamental frequency(sec-1)	Base shear (KN)	Mass Participation (%)	Displacement (mm)
1	0.497508	2.010	9444.	97.31	1
2					4.9
3					9.3
4					13.7
5					18.7
6					25.6
7					33.1
8					40.4

When application of shear wall at periphery of bottom storey the displacement of that storey reduces tremendously and it becomes nearly 1mm. As well as less displacement occurs at top storey i.e. 40.4mm which is in the range of safe displacement. After the application of shear wall the building behaves like very more rigid this is good as concern to soft storey effect.

4. CONCLUSIONS

From free vibration analysis results it is observed that a structure with wall at all storey have uniform displacement at each storey. The displacement variation w.r.t storey is linear. There is abrupt increase in displacement at the soft storey floor level. Whereas shear wall at bottom structure is more rigid as compared to all cases and having lesser variation in displacement. Thus provision of shear wall at bottom storey is advisable.

The storey drift in case of building with soft storey is very large as compare to normal structure. Large changes in relative storey drift are observed across the soft storey. These large drift leads to undesirable bending moments in column which leads to failure of structure as whole.

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