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NEW RETROFITTING METHOD FOR SOFT STOREY EFFECT

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Abstract: Now a day the construction of multi storey buildings are increasing day by day. But most of the building lacks structural wall mainly in the ground floor. This is mainly for the purpose of parking area or for making open meeting halls. Even though we have seen such buildings in our locality too. These types of buildings are known as soft storey building or open ground storey building. So we can say that in multi storey buildings or high rise buildings, soft storey is a typical feature because the ground storey is left open for these purposes which has been discussed. These types of building are weaker than the normal regular framed building. And these buildings are more vulnerable even in low intensity earthquakes. Severe collapse of building occurs for soft storey building. Now a day some retrofitting methods for soft storey effect are using during the construction itself. But for already constructed buildings the number of retrofitting methods are low. The commonly used methods are Shear wall and Diagonal bracings. But it has some disadvantages. So here we are trying to develop a new retrofitting method for soft storey effect. The whole analysis is done using ETABS 2019 software.

Index Terms – *Multi storey buildings, retrofitting, earthquakes, High rise buildings, ETABS 2019*

I. INTRODUCTION

Now a days Reinforced concrete (R C) frame buildings are becoming increasingly common in most of the urban areas in India. Most of the buildings constructed in recent times have a special feature – the ground storey or basement is left open for the purpose of parking or meeting halls, i.e, only columns are present in the bottom storey, without infill walls. This feature introduces a special effect called Soft storey effect in the building. Such buildings are called soft storey building or open ground storey buildings and are more weaker than normal regular framed building which has infill walls in all storeys. Open ground storey buildings or soft storey buildings have consistently shown poor performance during past earthquakes across the world, most of them have been collapsed severely. These construction practice of making open ground storey causes structural irregularity in terms of stiffness and strength. Therefore, determination of soft storey effect and its effect on building are essential in the design process to find the seismic performance of high rise buildings. And also it is essential to mitigate the effect of soft storey, it is necessary to analyse the seismic behaviour of RC buildings with soft storey. A number of buildings with open ground storey have been built in India in recent years. For example the city of Ahmedabad alone has about 25000 five storey buildings and about 1500 eleven storey buildings and majority of them have open ground storeys. The situation in Kerala is also not different. We can see so may open ground storey buildings in our locality too. In the last three decades, the country has been experienced one major and several moderate size earthquakes. During earthquake these soft storey buildings are severely collapsed. So it is necessary to retrofit these type of buildings. There are so many retrofitting methods which can be used in the construction stage itself, like base isolation. But it is equally important to retrofit the buildings which have already constructed. The commonly used methods to retrofit already constructed soft storey buildings are shear wall and diagonal bracing. But the main disadvantage of both the method is, it restrict the parking area. So here we are trying to develop a new retrofitting method which will have structural effectiveness and do not restrict parking space. Figure shows a particular open ground storey building which are used for parking area.

II. LITERATURE REVIEW

Samundra Pokhrel and Sailesh Adhikari (2021): Due to the absence of infill walls for the purpose of increasing space for the parking area results in the formation of soft storey effect. Such buildings are vulnerable to collapse due to earthquake load. This paper attempts to solve and evaluate the performance of RC framed building with soft storey and compare seismic response carried out by soft storey buildings at different level with the structure having infill walls at all floors. Storey displacement Storey drift and Storey stiffness are also being investigated and influence of such parameters are noted.

Sakshi A Manchalwar (2021): This journal deals with modelling of friction dampers, infill masonry walls and evaluating strengthened RC frame building. Damper is a energy dissipating passive device which reduces the response of open ground storey building under lateral loading due to earthquake. Dampers are installed in selected bays so that it reduces response. The storey displacement and inner storey drift for all the cases were compared in this study. Cross brace with friction damper and chevron brace with friction damper were modelled using Wen's plastic link element in SAP2000.

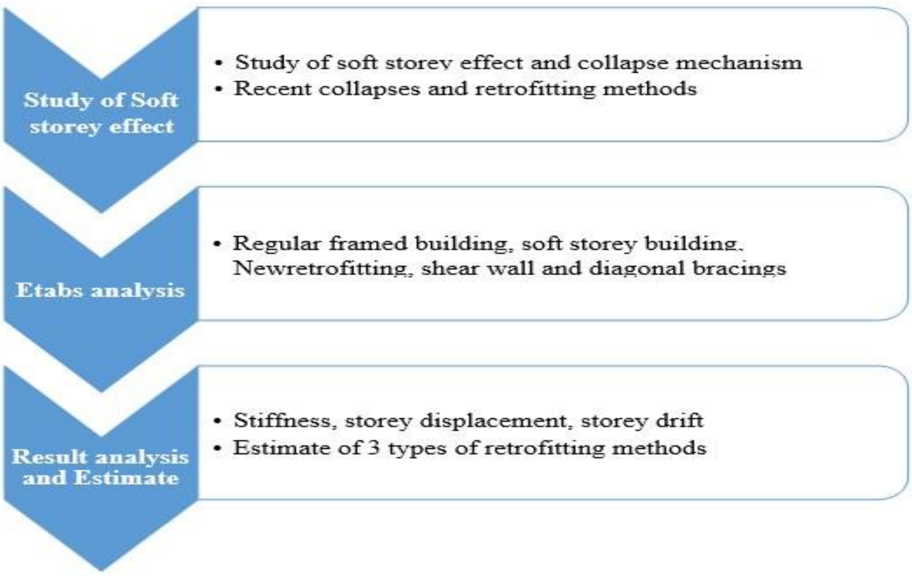
Mariem M. Abd-Alghany, Khaled F. El-Kashif & Hany A. Abdalla (2021): In this study, the seismic performance of RC buildings with soft storey using finite element method is investigated. The parameters considered in this research include the height of soft storey, irregularity in building plan dimensions, and the location of soft storey along the building height and also code provision for soft storey effect is also discussed.

Ashish Kumar Mishra and Gaurav Tanwar (2021): This paper deals with two aspects i.e. the performance of soft storey buildings during the past earthquakes and the previous studies on soft storey buildings.

Dhiraj D Ahiwale and Rushikesh R Khartode (2020): Building collapse because of Soft Storey effect and buildings with open storey buildings are particularly exposed to it. To analyse such buildings a twelve storied building is taken into account and the performance of structure evaluated by using pushover analysis in SAP 2000 software. The main objective of such analysis is to develop design methodologies that produce seismic performance of structures.

Shubham Bujade and Prof. Ishant Dahat (2020): This study the focus is on the seismic design of RC structure with soft storey at various level and finding out the way to optimize it using different models and their comparison.

III. RESEARCH METHODOLGY

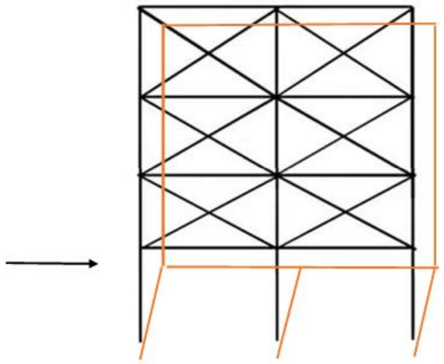


IV. SOFT STOREY COLLAPSE MECHANISM

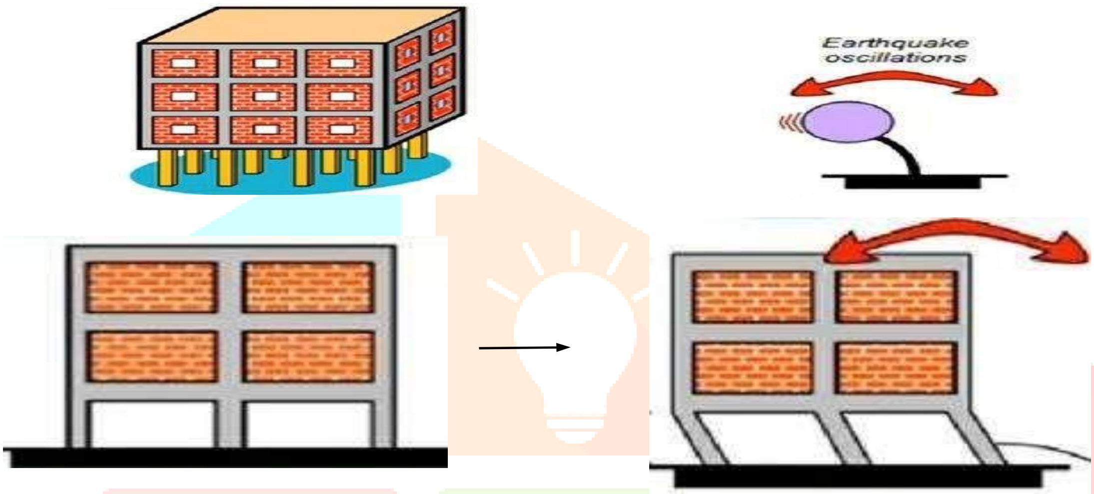
Here explains the mechanism of how soft storey buildings collapse. Before explaining the collapse mechanism, we have to understand some of the terms related to it.

Stiffness : Stiffness is the extent to which an object resists deformation in response to an applied force. The complementary concept is flexibility or pliability: the more flexible an object is, the less stiff it is. It is denoted by the letter K.
K = Force / Deformation

Displacement : It simply change in position of an object. Here we are considering the storey displacement.

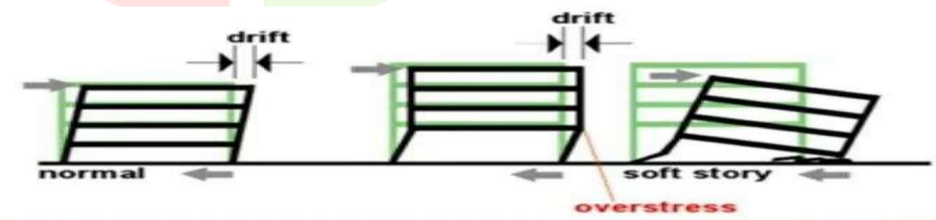


Let us take as an example for the structure. It has bracings at the all levels except at the ground level. The column size is assumed to be uniform throughout the height. From the figure itself, it is clear that the upper storeys have more stiffness. During earthquake vibrationl motions will be induced in the structure. It forms plastic hinges. When it reaches to its ultimate capacity huge chance of collapse occures. The columns will have no stiffness to take additional shear force which have developed. The shear force is highly attracted towards the soft storey. In this way collapse of the structure occures.

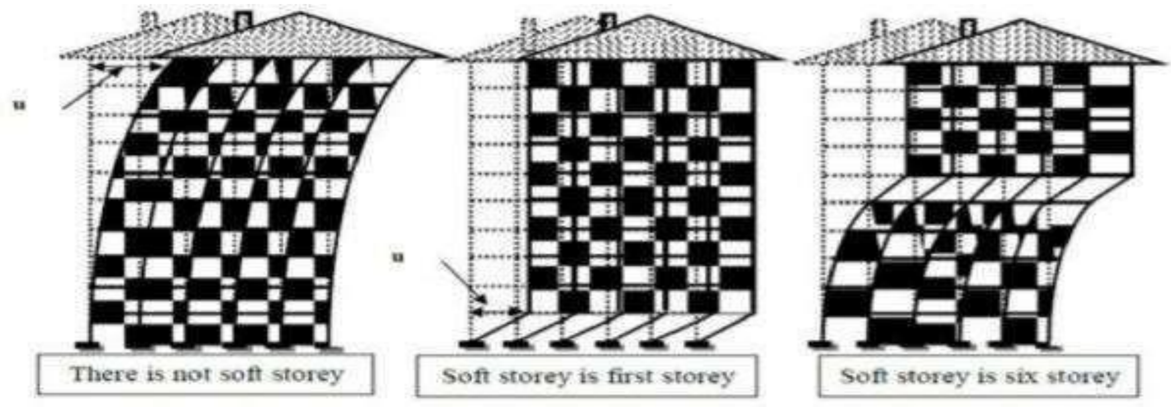


Building with soft storey and collapse mechanism

Consider the fig. below. It shows the stress concentration in collapse mechanism. First figure is of a normal building which hasn't any stiffness irregularity. When earthquake occurs the drift is comparatively small in this case. The second figure is of a soft storey building. During earthquake the drift in upperstorey is approximately same as the first case but in the ground floor the drift is large. So stress concentration occurs in this case and collapse occurs as shown in figure

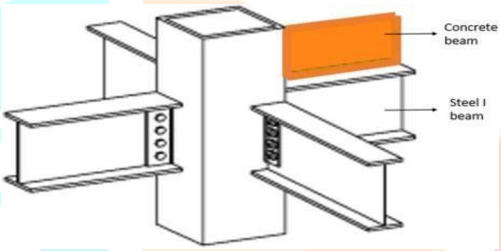


Stress concentration in collapse mechanism



Soft storey at different levels building

A steel I section or I beam is used as the new retrofitting method. The main advantage is it doesn't restrict parking area. Here the I beam is connected just below the concrete beam of bottom storey of soft storey building. It top flange touches the bottom portion of concrete beam od building, i.e, its position is inbetween two columns , just below the concrete beam.



The two ends of the I section is connected to the columns and the top flange is connected to the concrete beam. ISMB 250 or ISHB 150 sections can be used.

VI. DESIGN

STEP-1

Given data from ETABS,

Maximum Bending Moment = 162252.9612 KNm```

Maximum shear force = 7078.7308 KN Plastic section modulus required

STEP -2

$$Z_{pz} \text{ required } = M\,\gamma_{mo} / f_y \quad \gamma_{mo} = 1.1 \text{ (from IS 800 : 2007, Table-5)}$$

Step-3

f_y = 250 N/mm²

Zpz Required = 162252.9612×1.1 / 250

=713.91 cm ^{3}

Selection of suitable section from IS 800 : 2007 , By selecting section with

Zpz Required

Zpz = 731.21 cm 3

So, the section is ISWB 300

Sectional properties for this section are,

Sectional Area = 61.33 cm 2

D = 300 mm

bf = 200 mm

tf = 10.0mm

Tw=7.4

Zez =4.02 cm3

VII. ETABS ANALYSIS

Here the whole analysis is done using ETABS 2019 software. 5 types of building are analysed. They are;

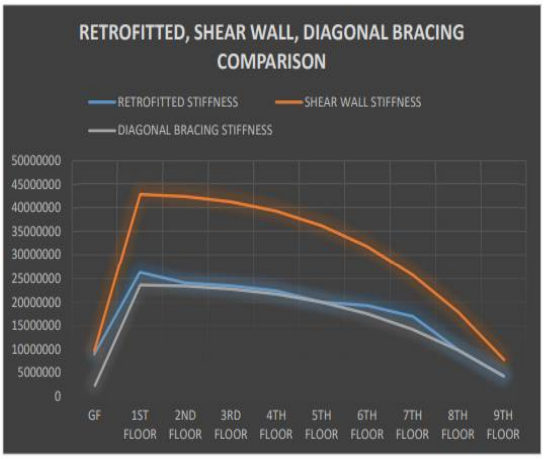
MATERIAL TYPES

Object type	Material	Weight KN
Column	M25	4318.7243
Beam	M25	5878.2637
Wall	Masonry	64687.5
Floor	25	9278.5093

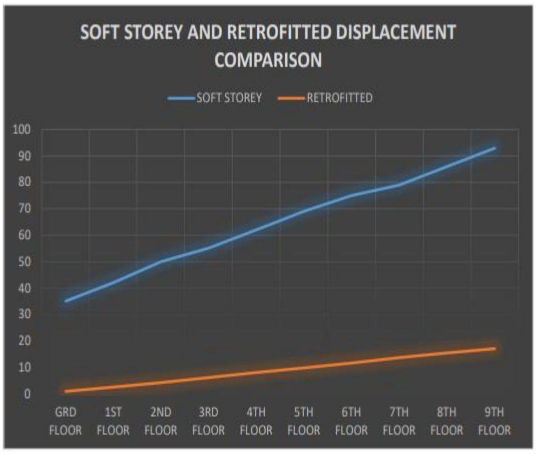
VIII. RESULT COMPARISON

Stiffness comparison of all 5 types of buildings

STOREY	REGULAR FRAMED STIFFNESS	SOFT STOREY STIFFNESS	RETROFITTED STIFFNESS	SHEAR WALL STIFFNESS	DIAGONAL BRACING STIFFNESS
GF	39335195718	1211397.627	3991398.259	9707581.118	2299622.372
1ST FLOOR	27276721538	23298272.3	bhhjhj 26298237.03	42912742.83	23684735.48
2ND FLOOR	21951079215	23028294.97	24028260.15	42405471.27	23408545.64
3RD FLOOR	18641699198	22421110.32	23421076.42	41282204.55	22791393.92
4TH FLOOR	16279676517	21346633.59	22346601.31	39300105.07	21699074.73
5TH FLOOR	14311313397	19670286.56	19990256.82	36211907.75	19995021.38
6TH FLOOR	12394528756	17258021.55	19257995.46	31770560.81	17542922.13
7TH FLOOR	10228895727	13975516.41	16975495.28	25728304.39	14206232.87
8TH FLOOR	7461524413	9688236.58	9888221.932	17836629.68	9848186.471
9TH FLOOR	3562741098	4261384.813	4361378.37	7846143.026	4331746.239



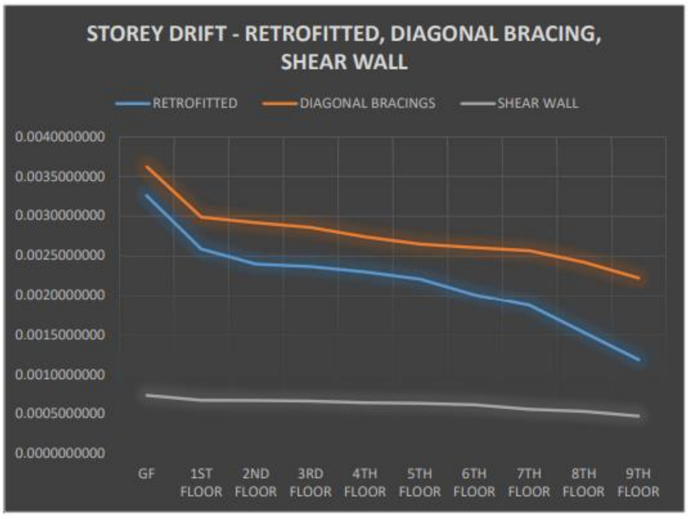
Storey displacement of all five types of building



Drift value comparison of five types of building

STOREY	REGULAR FRAMED	SOFT STOREY	RETROFITTED	SHEAR WALL	DIAGO NAL BRACI NGS
GRD FLOOR	0.001	35.12	0.9	0.003	14.8
1ST FLOOR	0.002	42.004	2.53	0.004	22.6
2ND FLOOR	0.004	50	4.2	0.005	28.2
3RD FLOOR	0.006	55.14	l.ll 6.13	0.007	34.8
4TH FLOOR	0.008	62.01	8	0.009	45.9
5TH FLOOR	).01	59.1	).8	).015	50
6TH FLOOR	0.013	75	11.6	0.017	58.87
7TH FLOOR	0.015	79	13.7	0.019	65.8
8TH FLOOR	0.017	86.005	15.4	0.02	70.8
9TH FLOOR	0.018	93.012	17.1	0.022	75.4

STOREY	REGULAR FRAMED	SOFT STOREY	RETROFITTED	DIAGONAL BRACINGS	SHEAR WALL
GF	0.0001293000	1.948	0.0032600000	0.0036240000	0.0007340000
1ST FLOOR	0.0001623000	0.901	0.0025900000	0.0029840000	0.0006720000
2ND FLOOR	0.0001577000	0.827	0.0024000000	0.0029140000	0.0006680000
3RD FLOOR	0.0001515000	0.8001	0.0023700000	0.0028560000	0.0006601000
4TH FLOOR	0.0001486000	0.762	0.0023010000	0.0027350000	0.0006410000
5TH FLOOR	0.0001417000	0.675	0.0022100000	0.0026450000	0.0006321000
6TH FLOOR	0.0001300000	0.551	0.0020100000	0.0026010000	0.0006140000
7TH FLOOR	0.0001133000	0.468	0.0018750000	0.0025610000	0.0005570000
8TH FLOOR	0.0000922800	0.402	0.0015300000	0.0024150000	0.0005317000
9TH FLOOR	0.0000641700	0.361	0.0011840000	0.0022180000	0.0004730000



IX. CONCLUSION OF ALL THE COMPARISON

Here the conclusions arrived from the comparison of different parameters like stiffness, storey displacement, and drift are discussed.

- We know that shear wall and diagonal bracing are the commonly used retrofitting methods.
- By using I section stiffness increased and a large reduction in storey Displacement and drift has been occurred.
- So I section can be used as an effective retrofitting method.
- And I section is far better than diagonal bracing.
- Out of these three retrofitting method shear wall is the best method But the main disadvantage is it restrict the parking space.
- So by using I section, collapse will be reduced without restricting the parking area.

COST COMPARISON OF BUILDING WITH I SECTION, DIAGONAL BRACING AND SHEAR WALL

METHOD	TOTAL COST (Rs.)
I section	325588.1285
Diagonal bracing	384372.378
Shear wall	488164.01

X. CONCLUSION

Here a detailed study of soft storey effect and commonly used retrofitting methods are carried out. Based on the study we found that the commonly used retrofitting method has a main disadvantage of parking area restriction. So we decided to find a new retrofitting method which will be structurally, economically feasible and do not restrict the building area. So we developed a new retrofitting method, I section. After the analysis using ETABS 2019 soft ware , we proved the structural advantages of this new retrofitting method. And also cost comparison also carried out. It is economically feasible and do not restrict the parking area. After all we can surely say that this I section retrofitting method is a good solution for soft storey effect. If further studies are done in this area it can be developed as an effective soft storey retrofitting method in future.

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