Effect of Seismic Retrofitting on R.C. Building with Soft Storey and Floating Column

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Abstract

The objective of this study is to identify an efficient retrofitting method for existing open ground story reinforced concrete frame buildings. This soft storey creates a major weak point in an earthquake. Since soft stories are classically associated with retail spaces and parking garages, they are often on the lower stories of a building, which means that when they collapse, they can take the whole building down with them, causing serious structural damage which may render the structure totally unusable. we are dealing with the comparative study of seismic analysis of multi-storied building with and without floating columns. The analysis is done with Response Spectrum Analysis, as per IS:1893-2002. Various features of lateral stiffness strengthening system, namely lateral bracings, shear walls, increasing the column size in the soft ground storey. the entire project is done with ETABS 3D model and the comparison of these models are been presented with their combinations, and are proposed to reduce the stiffness irregularity and discontinuity in the load path incorporated by the soft ground storey and the floating columns respectively. The results are plotted for both the frames with and without floating column by comparing each other in terms of Story shear, story displacement, story drift and time period.

Keywords*:* *soft storey, floating columns, bracings, shear walls, ETABS.*

I. Introduction

Nowadays, especially after the desolating Nepal earthquake 25 April 2015, there has been a mutual effort throughout India to provide more awareness, especially in practice and education, with respect to earthquake resistant design of structures. The recent example of this category is Bhuj earthquake occurred on Jan.26, 2001. This has created a growing interest and need for earthquake resistant design of structures. Conventional Civil Engineering structures are designed on the basis of strength and stiffness criteria. Most of the multistorey buildings are made of RCC frame building so it's great importance given to make the structure safe against lateral load due to wind and earthquake. The Seismic retrofitting can be done in different ways and to various extents. The purpose should be to certify that the building takes all the damage, but does not collapse when severe earthquake occurs.

This is primarily being adopted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. The floating column is a vertical member which rest on a beam and doesn't have a foundation. The floating column act as a point load on the beam and this beam transfers the load to the columns below it. The floating column is used for the purpose of architectural view and site situations. It can be analysed by using ETABS. The Provision of floating columns can be stated as most of the buildings in India are covering the maximum possible area on a plot within the available bylaws.

For open ground storey frame, retrofitting by means of introducing RC wall in the open ground storey, offers the maximum strength and ductility. Most of the energy developed during earthquake is dissipated by columns of the soft stories. In this process the plastic hinges are formed at the ends of columns, which transform the soft storey into a mechanism. In such case the collapse is unavoidable.

II. METHODOLOGY

A. Modeling of frame structure-

Modelling of structure is done in software ETABS which is based on finite element method. The space frame of multi-storey building is prepared considering special moment resisting frame. Column base are assigned as fixed support, column and beam are model as line element, slab and shear wall are area section but are assigned as membrane.

Model-1A: A multistorey frame building is taken into consideration. Building having a RCC

members like slab, beams, and columns. Building having soft storey at ground floor, also floating columns at 1^{st} floor level.
Model 1B: Building model similar as 1^{st} model with increasing size of column of the soft storey.
Model 1C: Building model similar as 1^{st} model with steel bracings (cross bracings) at perimeter of the soft storey.
Model 1D: Building model similar as 1^{st} model with RCC shear wall at corners of the soft storey.
Model 1E: A multi-Storey frame building is taken into consideration. Building having a RCC members like slab, beams, and columns. Building having soft storey at ground floor.

Following are the data considered for seismic analysis of structure Model 2

Model-2A: A multistory frame building is taken into consideration. Building having a RCC members like slab, beams, and columns. Building having soft storey at ground floor, also floating columns at 1^{st} floor level. Model 2B: Building model similar as 1^{st} model with increasing size of column of the soft storey.
Model 2C: Building model similar as 1^{st} model with steel bracings (cross bracings) at perimeter of the soft storey.
Model 2D: Building model similar as 1^{st} model with RCC shear wall at perimeter of the soft storey.
Model 2E: A multistorey frame building is taken into consideration. Building having a RCC members like slab, beams, and columns. Building having soft storey at ground floor.

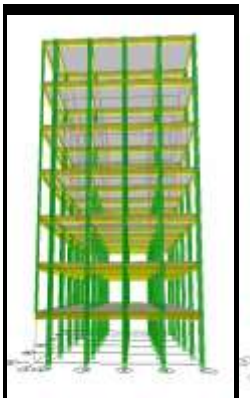

Fig.1 Model 1A

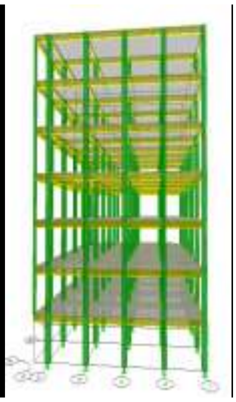

Fig.2 Model 1B

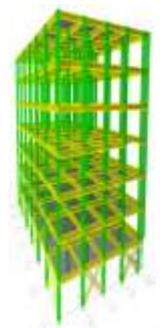

Fig.3 Model 1C

Fig.4 Model 1D

Fig.5 Model 1E

Fig.6 Model 2A

Fig.7 Model 2B

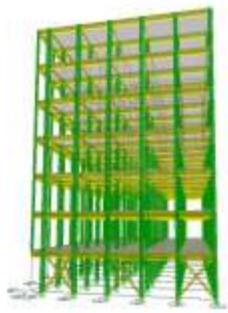

Fig.8 Model 2C

Fig.9 Model 2B

Fig.10 Model 2B

A. Details of multistory frame building :-
Storey of building: G+ 6 storey
Use of building: commercial
Frame type: Special moment resisting frame structure
Floor to floor height : 3 m
Seismic zone: Zone II
Soil type: Medium soil (Type II)
Shear wall: 230 mm thick

Steel bracings; steel cross bracings (ISMB200).

B. Basic load cases used for analysis-

Table -1: Load Cases

Sr.No.	Load cases	Load
1	Dead load	Gravity
2	Live load	Gravity
3	Super imposed DL	Gravity
4	EQX	IS 1893:2002
5	EQY	IS 1893:2002

C. Load consideration-

Live load: 3 KN/m^2
Live load on stair: 4 KN/m^2
Super imposed load: 2KN/m^2
Brick wall load (230mm thick.): 13 KN/m

D. Load combination used as per IS1893 (Part 1):2002 clause6.3.1.2, the following load cases have to be consider for analysis
a) 1.5 (DL + IL)
b) 1.2 (DL ± IL ± EL)
c) 1.5 (DL ± EL)
d) 0.9 DL ± 1.5 EL

E. Section properties -

Preliminary section properties are taken into consideration while modelling the structure, section properties of beam, column and shear walls are as follows.
Beam in X-direction : 230 x 450 mm
Beam in Y-direction : 230 x 450 mm
Column : 450 x 450 mm
Retrofitted column : 750 x 750 mm
RCC slab : 150 mm thick
RCC shear wall : 230 mm thick

III. SEISMIC ANALYSIS OF BUILDING

The recent increase in the speed of computers has made it practical to run much time history analysis in a short period of time. In addition, it is now possible to run design checks as a function of time, which produces superior results, since each member is designed by the response spectrum method.

IV RESULTS AND DISSCUSION

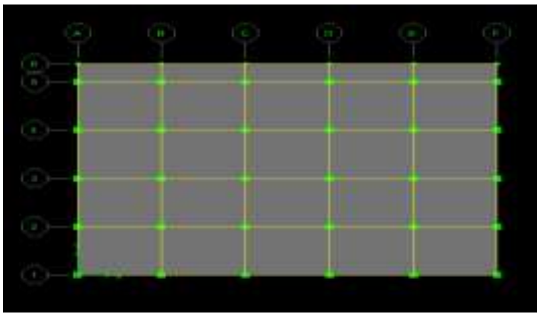

Fig.11 Model of structure1

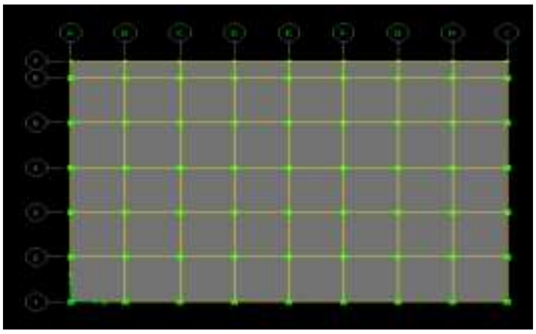

Fig.12 Model of structure2

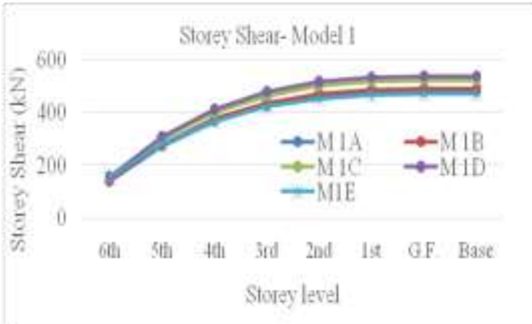

Fig.13 Story Shear (KN)

Fig.14 Story Shear (KN)

For considered G+6 building without retrofit, base shear obtained from earthquake analysis is less than that obtained from retrofit structures.

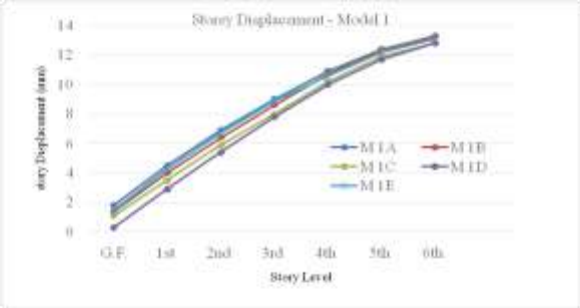

Fig.15 Story Displacement (in mm)

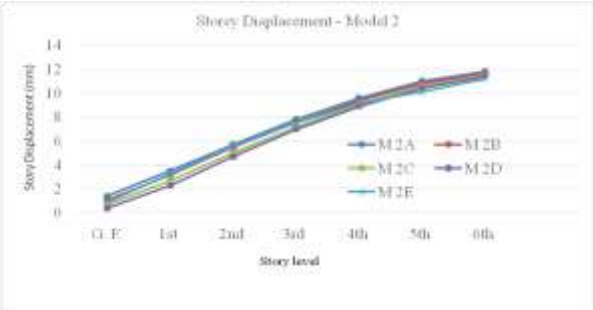

Fig.16 Story Displacement (in mm)

The displacement of without shear wall building is more, and it is not feasible for high rise structure. Displacement can be control by using various retrofitting methods.

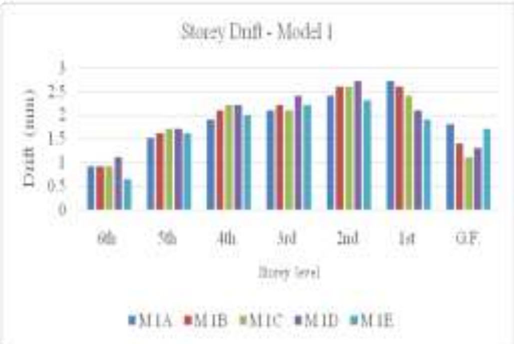

Fig.17 Story Drift

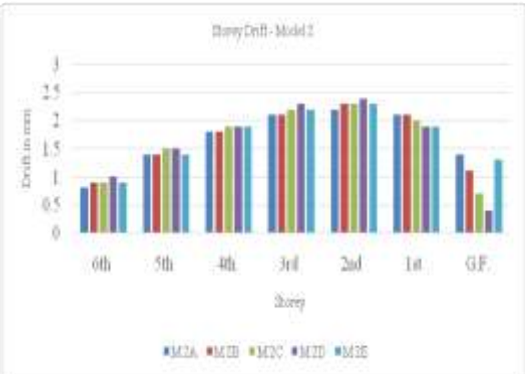

Fig.18 Story Drift

As per IS 1893(part1): 2002 (cl 7.11.1) storey shall not exceed 0.004 times of story height. In this study maximum story height is 3m and as per IS recommendation allowable story drift is 7.2mm

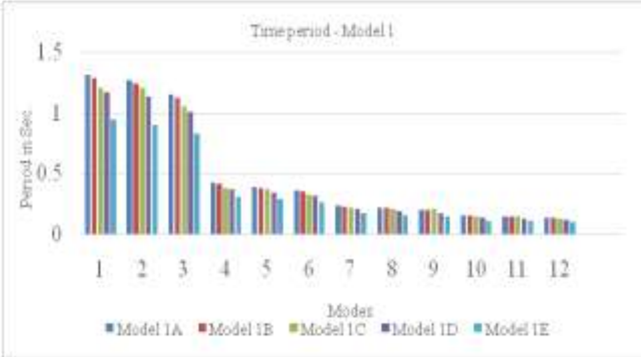

Fig.19 Time Period

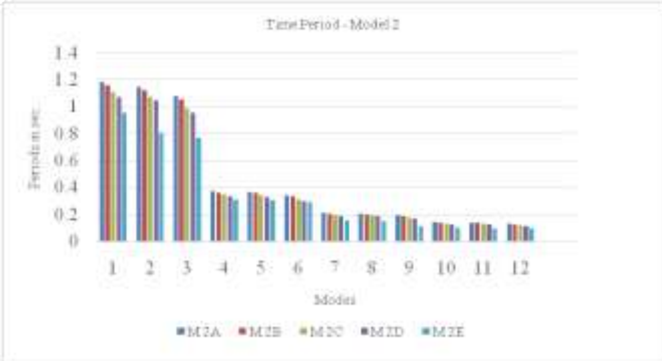

Fig.20 Time Period

Time period of building is more it means the structural damage of the building is minimum. But Deflection is more, so we can control by using various position of shear wall in structure.

IV. CONCLUSIONS

Out of all the three methods used to evaluate base shear, Multi-storey building with shear walls has performed better compared to normal multi-storey building.

1) Storey displacement of 1st structure model 2D is 2 mm at soft Storey which is lesser than the other models. For same model the ground floor displacement is less for shear wall retrofit model which is 3.3mm at top of the retrofit.

2) Storey displacement of the 2nd structure for model 2 is also 2mm at bottom of the soft Storey and for shear wall retrofit it is 3.7mm at the top of retrofit.

3) All the values (Base shear, Storey drift and displacement) are within the permissible limit except the displacement provided by Time history analysis for normal multi-storey building.

4) Provision of floating column is advantageous in increasing FSI of the building but is a risky factor and increases the vulnerability of the building.

5) Time history analysis presents peak value of base shear for multi-storey building with shear walls.

6) So that shear wall retrofit is the best method of retrofit the soft Storey which also reduce the displacement of the whole structure and offers the maximum strength (frequency) and ductility.
7) The steel braced soft story building of base shear increased compared to without steel bracing which indicates that stiffness and ductility of building is increased.
9) For the comparison of overall results for all models, RC structural wall in the open ground storey gives the most desirable behaviour for the framed building from the points of view of strength, stiffness, ductility and frequency profile.

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