A Comparative Study of Seismic Behavior of Flat Slab Structure and Conventional Framed Structure

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Abstract -- Flat slabs is system of construction is one in which the beams used in the conventional methods of constructions are eliminated or provided at perimeter to increase the rigidity. Flat slab structure have been widely used in building construction due to their advantages over conventional framed structure such as economy in construction, its architectural appearance, flexibility, reducing storey height and speed of the construction. Due to absence of beams in flat slab, lateral stiffness is considerably reduced hence flat slab structure more flexible to seismic loading as compare with conventional framed structure. This objective of this work is to compare the seismic behavior of flat slab structure with conventional R.C.C. Structure. This work also study presence of opening on performance of flat slab structure.

Index Terms: Flat slab RC structure, Seismic response, Static analysis, Dynamic analysis.

I. INTRODUCTION

Flat slabs is system of construction is one in which slab is directly rest on the column. The slab directly rests on the column and load from the slab is directly transferred to the columns and then to the foundation. To support heavy loads the thickness of slab near the support with the column is increased and these are called drops, or columns are generally provided with enlarged heads called column heads or capitals. These increasing thickness of flat slab in the region supporting columns provide adequate strength in shear and to increase the amount perimeter of the critical section, for shear and hence, increasing the capacity of the slab for resisting two-way shear and to reduce negative bending moment at the support. Flat slabs have been widely used in building construction due to their advantages in reducing storey height and construction period as compared with conventional structure, leading to a reduction of construction costs. Provision of the flat slab building in which slab is directly rested on columns, have been adopted in many buildings constructed recently due to the advantage of reduced floor to floor heights to meet the economical and architectural demands.

Because of absence of deep beam Flat slab building structures which are more significantly flexible than conventional framed structures, thus becoming more vulnerable to seismic loading. Thus the seismic analysis of these structures is necessary to know the vulnerability of these structures to seismic loading.

II. METHODS OF DESIGN OF FLAT SLAB

Following are the methods used for analysis

1. The direct design method
2. The equivalent frame method

Methods of Seismic Analysis

A. Linear static analysis
B. Linear dynamic analysis

III. PROBLEM FORMULATION, MODELLING AND ANALYSIS

Following are the models used for analysis

Case 1)-

i. 8 storey Flat Slab RC structure having plan dimensions 30 m x36 m.
ii. 8 storey conventional RC Framed structure having plan dimensions 30 m x36 m.
iii. 8 storey flat slab structure with central opening (10m x10m) having plan dimensions 30 m x36 m.

Case 2)-

i. 12 storey Flat Slab RC structure having plan dimensions 30 m x36 m.
ii. 12 storey conventional RC Framed structure having plan dimensions 30 m x36 m.
iii. 12 storey flat slab structure with central opening (10m x10m) having plan dimensions 30 m x36 m.

Case 3)-

i. 18 storey Flat Slab RC structure having plan dimensions 30 m x36 m.
ii. 18 storey conventional RC Framed structure having plan dimensions 30 m x36 m.

iii. 18 storey flat slab structure with central opening (10m x10m) having plan dimensions 30 m x36 m.

All above model are analyzed and comparison is made between these analyses. To know vulnerability of the structure to seismic loading.

Details of Modelling:

i. Storey height -3.2m
ii. Plinth level-0.8m
iii. Thickness of flat slab- 220mm
iv. Thickness of drop is -270mm.
v. Thickness of shear wall is- 150mm.
vi. Size of column -0.45m to 1.2m.
vii. Size of beam -300mm to 600mm.

Loading Details:

1. Gravity loads-

i. Live load at typical floor-4 kN/m2
ii. Live load at top floor -2 kN/m2
iii. Floor finish load at typical floor -1.0 kN/m2
iv. Floor finish load at top floor -2.0 kN/m2

2. Detail of Earthquake loading-

1. Static analysis

a. Location of zone- III.
b. The direction of excitation -X.
c. Importance factor -1
d. Response reduction factors- 5

2. Dynamic analysis-

a. Location of zone- III.
b. The direction of excitation -X.
c. Damping-5%.

IV. RESULTS

Base shear - Base shear is the total design lateral force (VB) along any principal direction, which is determined by following expression

$VB = Ah*W$

Where

Ah = Design horizontal acceleration spectrum

W = Seismic weight of building.

Table 1. Base Shear Comparison Of Above Models

Model	Linear static analysis	Response spectrum analysis
Case 1- 8 storey Structure		
Flat slab structure	1095.61	1015.73
Conventional Structure	2239.58	2053.48
Flat slab structure with opening	1011.93	940.48
Case 2- 12 storey Structure		
Flat slab structure	1467.99	1233.86
Conventional Structure	2650.81	2354.20
Flat slab structure with opening	1371.41	1149.08
Case 3- 18 storey Structure		
Flat slab structure	2253.82	1769.67
Conventional Structure	3175.29	2852.77
Flat slab structure with opening	2109.08	1647.69

From above result it is observe that flat slab structure are more flexible than conventional structure. The presence of opening to flat slab structure increase the flexibility of structure.

1. Storey drift-

Storey drift is the total lateral displacement that met in a single storey of a high-rise building. The drift in a storey is computed as a difference of deflections of the floors at the top and the bottom of the storey under consideration. It is one of the predominantly important engineering response quantity and indictor of structural performance, in particular for multi-storey buildings. Storey drift is considered as unique standard for structural behaviour conclusion.

According IS 1893 (Part 1): 2002 maximum allowable storey drift should not be exceed shall 0.004 times the storey height under consideration. For all the analysis of the above model storey drift should not exceed 12.8mm.

Comparison of Storey Drift for different cases

Case 1- 8 storey structure

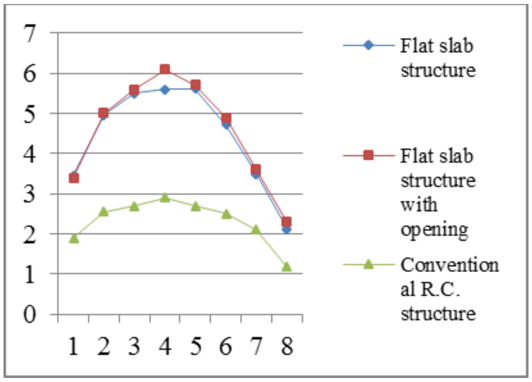

Figure 1. Linear Static Analysis

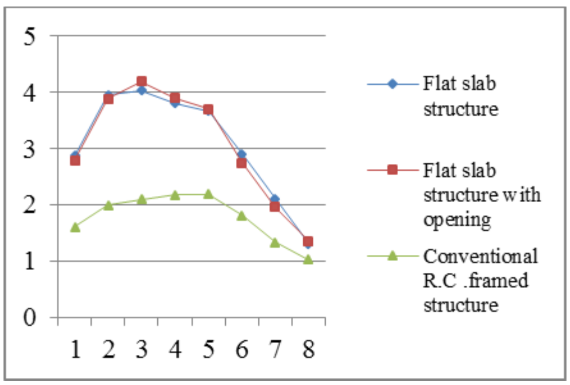

Figure 2. Linear Dynamic Analysis

The plot of drift values shows that in case of 8 storey structure, drift values does not vary much from conventional RC framed structure and does not tend to exceed permissible limit.

Case 2- 12 storey structure

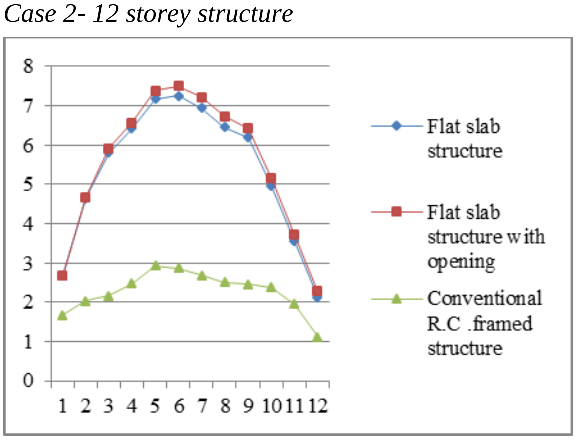

Figure 3.Linear Static Analysis.

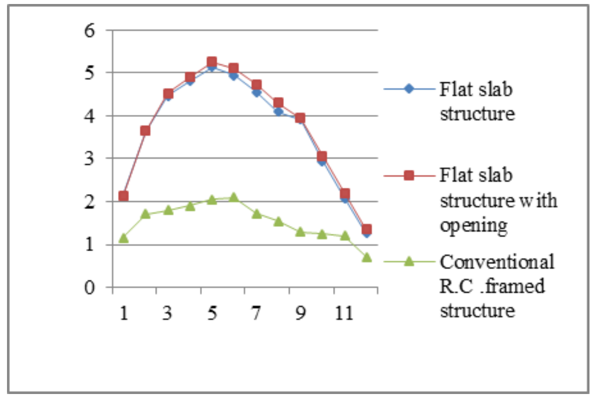

Figure 4.Linear Dynamic Analysis

Figure 3 and 4 shows variation of storey drift for all 3 cases considered above, it is found that drift values are within permissible limits.

Case 3- 18 story structure

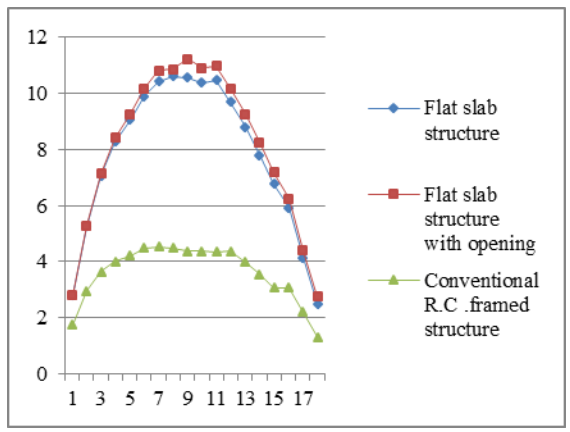

Figure5. Linear Static Analysis

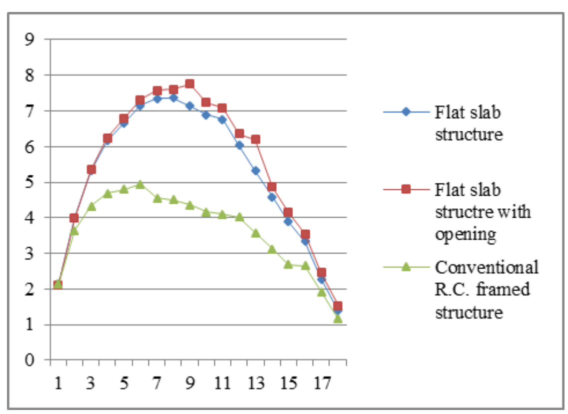

Figure 6. Linear Dynamic Analysis

The plot of drift values shows that for all 3 cases considered above, drift values are within permissible limits but for flat slab structure and flat slab structure with opening drift values are closer to the permissible values.

Comparison of Displacement for different cases

Case 1 -8 storey structure

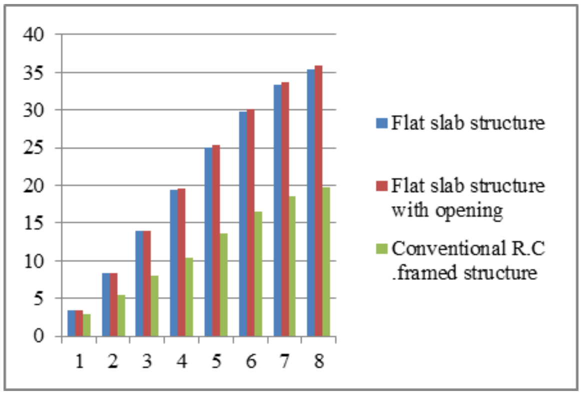

Figure 7. Linear Static Analysis.

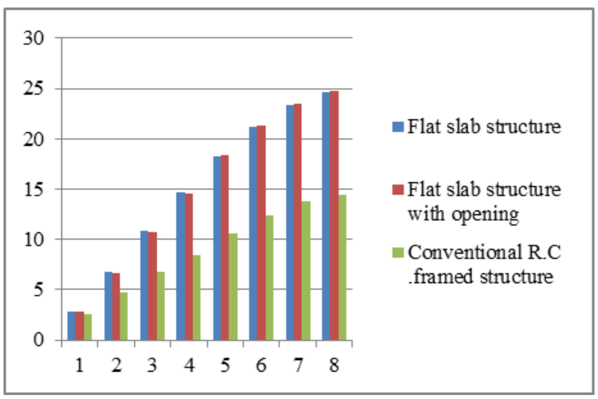

Figure 8. Linear Dynamic Analysis

Maximum displacement attained by conventional structure is much lesser than that in case of flat slab structure and flat slab structure with opening by both the analysis viz. linear static analysis and linear dynamic analysis.

Case 2-12 storey structure

In case of 12 storey structure, flat slab and conventional framed structure does not exceed the maximum permissible value. Also, flat slab structure with opening does not undergo significant displacement as compared flat slab structure without opening.

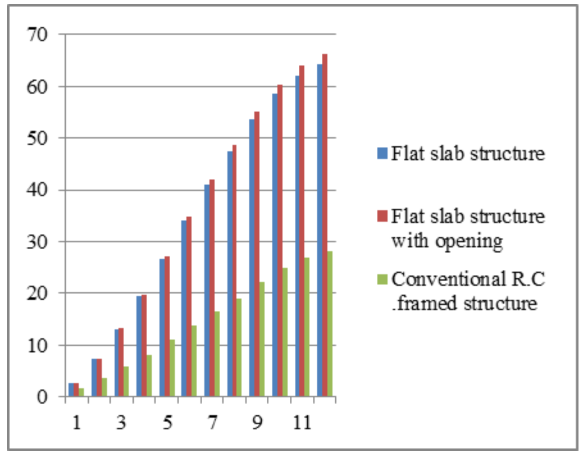

Figure 9. Linear Static Analysis

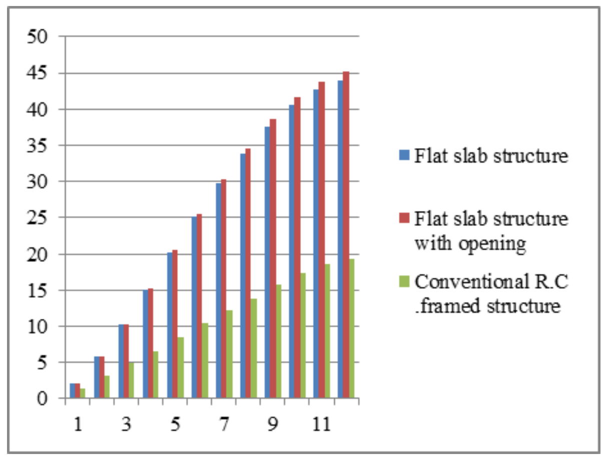

Figure10. Linear Static Analysis.

Case 3- 18 storey structure

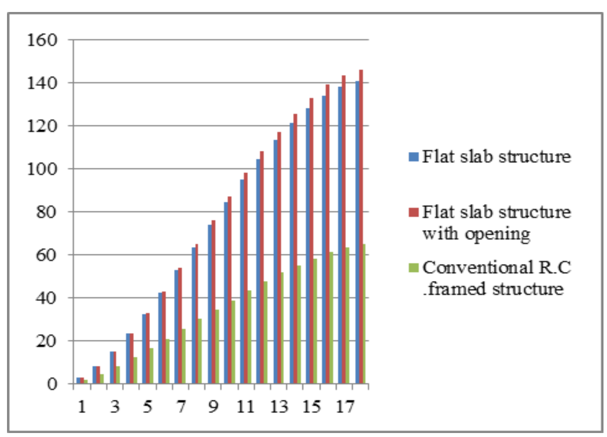

Figure11. Linear Static Analysis

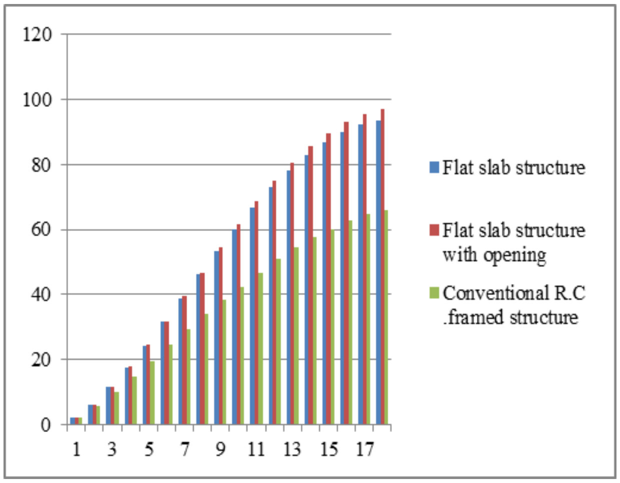

Figure12. Linear Dynamic Analysis

In case of 18 storey structure too, flat slab structure with opening does not undergo significant displacement as compared flat slab structure without opening.

IV. CONCLUSION

1. For all case, flat slab structure design base shear less as compare with conventional structure which is due to the flexibility of flat slab structure.
2. In case of flat slab storey drift is more as compare with conventional RC framed structure. This storey drift found to be maximum at middle storey and minimum at top and bottom storey.
3. From analysis result it seen that displacement of the flat slab structure is more as compare with conventional structure.
4. The presence of opening in flat slab structure does not make appreciable difference in results (maximum displacement and drift) when compared with flat slab structure without opening.

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