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Seismic Analysis of Flat Slab Building

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Abstract

Flat slab buildings are the building in which slab without beam directly resting on the column. Flat slab building provides much more advantage over the conventional frame building in terms of appearance, economy, aesthetic and speed of construction practice. However it is subjected to flexure failure of slab, punching shear failure. Out of these failures punching shear failure is brittle failure, catastrophic and the most dangerous type of failure. This dissertation presented herein can be considered into three main aspects. In the first aspect the seismic analysis of flat slab building is considered. As performance of flat slab building is not satisfactory under earthquake loading due to their vulnerability to punching shear failure. In the second aspects as due to large bending moment and shear force at the slab column joints the stresses are developed which brings about the cracks in the concrete and the failure takes place and thus there is a demand to provide the large area at the slab column joint so as to called as column head at the top of the column and drop at the slab and hence one of the most important issue is the brittle punching failure due to the transfer of unbalanced moment and shear force between column and slabs. So punching shear failure in the flat slab building was considered in the second aspect. In the third aspects the cost of different modals is compared.

Keywords: *Seismic Analysis, Flat Slab, Building.*

Introduction

Reinforced concrete flat slab building represent decorous and easy to built floor system. These types of building are preferred by both architects and client because of their aesthetic appearance and other economic advantage. Flat slab building are the building in which slabs is directly supported by columns. The term 'flat slab' means a reinforced concrete slab with or without drops supported generally without beam, by columns with or without flared column head. The column head is sometimes widened so as to reduce the punching shear in the slab. The widened portion is called column head. Moment in the slab is more near the column. Hence the slab is thickened near the columns by providing the drops called as drop panel.

Flat slab are of following types

(a) Slab without drop and column with column head
(b) Slab with drop and column without column head.
(c)Slab with drop and column with column head
(d) Slab without drop and column head.

The behavior of this type of structure systems with flat slab show important drawbacks such as the non dissipative features of their seismic response. Behavior of the flat slab building during earthquake is not satisfactory. Due to their flexibility flat slab building shows large deformation under lateral loading. The most important determinant effect on the structure caused by lateral component of the earthquake. As compared to gravity load effect, earthquake load effects on buildings are quite variable and increase rapidly as the height of building increases. For gravity loads, structure is designed by considering area supported by a column and spans of beam; whereas for earthquake loads, design is a function of total mass, height. It is likely that low and mid rise structures, having good structural form can carry most of earthquake loads. The strength requirement is a dominant factor in the design of structure. As height increases the rigidity (i.e. the resistant to lateral deflection) and stability (i.e. resistant to overturning moments) of structure gets affected.

Hence flat slab structure is common in low to moderate seismic risk where it is used as a lateral load resisting system. This system cannot be used as primary lateral load resisting system for high seismic region. Shear wall or moment frame should be used with flat slab structure as lateral load resisting element for high rise building or in the high seismic region.

Results

Seismic analysis of building is carried out by considering the live load (L.L), dead load (D.L) and the earthquake load in the both direction i.e. sway to left (-EL) and sway to right (+EL) by the software SAP 2000 vs.14 The various load combination which are considered during the analysis are according to cls.6.3 of IS 1893 2001 and are given as:

Different Load Combination

Load Case	Load cases
1	1.5(DL+LL)
2	1.2(DL+LL+EL)
3	1.2(DL+LL-EL)
4	1.5(DL+EL)
5	1.5(DL-EL)
6	0.9DL+1.5 EL
7	0.9DL-1.5EL

Description for Loading

The loading on the buildings is considered as per following calculations

FOR MODAL 1

Calculation of Load

Dead Loads

External wall load = 0.25x (3.35-.45) x 20 = 14.5 kN/m

Internal wall load = 0.15x (3.35-.45) x 20 = 8.7 kN/m

Weight of the slab having thickness 120mm = 25 x 0.12 = 3 kN/m

Self weight of building is automatically considered by the SAP software.

Live Loads

The live load of 3.5 kN/m^2 is considered on the buildings.

Earthquake Forces Data

Earthquake load for the building has been calculated as per IS-1893-2002:
Zone (Z) = II
Response Reduction Factor (RF) = 5 for SMRF. [Table-7 of IS-1893 (Part I):2002]
Importance Factor (I) = 1 [Table-6 of IS-1893 (Part I):2002]
S_a/g = Average response acceleration coefficient for various soil sites as given of IS-1893 (Part I): 2002 based on appropriate natural periods and damping of structures.
Time period of the building from the code has presented in Table-

Time period and horizontal seismic coefficient

Direction	Height (m)	Lateral dimension(m)	Time period (Sec)	S_a/g	A_h
X	14.05	40.70	0.198	2.5	0.06
Y	14.05	11.5	0.373	2.5	0.06

Comparison of Model Time Periods for All 3 Buildings

For model 1

Design Seismic Base Shear:

For 3 storey building with beam $V_b = A_h \times W$ = 0.06x24855.69 kN = 1491.34 kN

Model 1

Time Period for model 1

StepType	StepNum	Period	DampRatio
Text	Unitless	Sec	Unitless
Mode	1	0.9796	0.05
Mode	2	0.855275	0.05
Mode	3	0.705051	0.05
Mode	4	0.317346	0.05
Mode	5	0.275808	0.05
Mode	6	0.224165	0.05
Mode	7	0.189085	0.05
Mode	8	0.163344	0.05
Mode	9	0.147055	0.05
Mode	10	0.129799	0.05
Mode	11	0.126645	0.05
Mode	12	0.105876	0.05

Design Base Shear for modal 1

OutputCase	CaseType	StepType	GlobalFX	GlobalFY	GlobalFZ
Text	Text	Text	KN	KN	KN
EQX	LinRespSpec	Max	1291.53	0.000001535	0.0001122
EQY	LinRespSpec	Max	0.000001081	1286.88	0.0001326

Modal 2

Time Period for model 2

StepType	StepNum	Period
Text	Unitless	Sec
Mode	1	1.201611
Mode	2	1.147218
Mode	3	0.989381
Mode	4	0.367144
Mode	5	0.34066
Mode	6	0.284869
Mode	7	0.202539
Mode	8	0.18262
Mode	9	0.147112
Mode	10	0.145696
Mode	11	0.127931
Mode	12	0.116342

Conclusion

Flat slab building, conventional building and a camouflage model with rectangular plan have been considered and it is found that flat slab building is more flexible and less resistant to lateral loading however conventional building is the best one. Camouflage is the good alternative if it is required the building for good aesthetic and light visibility point of view.

Fundamental period of flat slab building is the maximum among all model considered in this dissertation. However if a flat slab building is designed by different code then it is found that fundamental period calculated by Euro code has the minimum value and ACI code has the maximum one. So it is found that a flat slab building designed by Euro code gives the good result for lateral loading as compared to other code

Based on the comparison of cost of flat slab building with the other buildings it is found that flat slab building being the good in aesthetic and other advantage in terms of architecture point of view is found to be less economical as compare to other models.

In the design example consider in this dissertation it is observed that concrete cost is increased by 1.6 % while that of steel is increased by 13 % as compared to conventional building. Camouflage model designed by euro code serve the purpose if it is required to design the building which is economical and resembles with the flat slab.

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