Evaluation of Response Reduction Factor for Flat Slab Structures

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Abstract – According to Indian Standards while designing any earthquake resisting structure we consider two moment resisting frames i.e. ordinary moment resisting frame (OMRF) having response reduction factor 3 for low design base shear and special moment resisting frame (SMRF) having response reduction factor 5 for high design base shear. The objective of this project is to study the seismic behavior of flat slab system by evaluating 'R' factor and by pushover analysis comparing the results with the frame structure. The parameters like base shear, storey displacement, storey drift, bending and shear stresses in column and slab etc. are studied by STAAD.Pro software in this project. Method of analysis used is Response Spectrum Method.

Index Terms—Static analysis, STAAD. Pro software, Flat Slab, Response Reduction Factor, Seismic loading, Base shear.

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INTRODUCTION

Flat slab systems are more effective than traditional slab-beam-column framed system because of its speedy construction, Easier formwork, use of space and architectural significance. Flat slab system advantageously used where we required large area such as auditorium, theatre halls, showrooms of shops and so on. Flat slab system generally consists of drop panel, column head, column strip and middle strip. In flat slab systems there are generally two types of failures occurs namely flexural failure and punching shear failure. To overcome this problem, we provide drop panel and column head at columns.

Response reduction factor is the ratio of elastic base shear to design base shear. Base shear is generated due to the lateral forces. Response factor denotes the capacity of the frame to dissipate energy through inelastic behavior. 'R' factor depends upon number of stories as the number of stories increases R factor decreases. Response reduction factor is depends upon ductility factor, strength factor, structural redundancy and damping. Actual intensity of earthquake is reduced by response reduction factor 'R'. As flat slab system is not frame system so we cannot use 'R' factor directly without any basis. IS code does not state the 'R' factor for flat slab system. This paper deals with the evaluation of response reduction factor for flat slab at seismic zones IV and comparison of pushover curves by pushover analysis. For that first step is to collect the data for analysis of flat slab and conventional Frame structure modelling of structure on STAAD.Pro Software. Then Design the flat Slab structure by considering R=1,2,3,4,5 & RCC frame structure by considering R=3,5 for different load Combinations.

MODEL ANALYSIS

2.1 Model Description

The plan for the commercial building G+7 with floor to floor height 3.6m is kept for all storey including ground floor for flat slab structure and frame structure. The panel size is 5.1m x5.1m for both the structures. End conditions of all the columns is assigned as fixed support. For partition wall the brick material is siporex block of grade 1 having density $9kN/m^3$. All the model analysis and designed in STAAD.Pro software. Analysis of both the structure by Static method. Grade of the concrete is M25 and steel is Fe415.

2.2 Design data

Total numbers of models are seven created in STAAD.Pro having different response reduction factor for flat slab structure and frame structure. Five models are created for flat slab structure having different response reduction factor (R factor) and two models are created for frame structure of different response reduction factor(R factor) as 3 for ordinary moment resisting frame (OMRF) and 5 for special moment resisting frame (SMRF). Modulus of elasticity of steel is $2x10^5 N/mm^2$.Other remaining basic parameters required for design are mention below in the table as,

Table 1: Loads and Earthquake parameters

Dead load (Floor finished)	- 1 KN/m^2
Dead load (Slab for flat slab)	- 6.5 KN/m^2
Dead load (Slab for frame)	- 3.75 KN/m^2
Dead load (Wall load)	- 2.28 KN/m^2
Dead load (Wall load)	- 2.28 KN/m^2
Dead load (Parapet wall load)	- 0.16 KN/m^2
Live load	- 3 KN/m^2
Soil Type	- Type I
Seismic Zone	- IV
Importance Factor	- 1
Damping Ratio	- 5%
Type of Structure (Frame)	- OMRF& SMRF
Response Reduction Factor (Frame structure)	- 3 & 5
Response Reduction Factor (Flat slab structure)	- 1,2,3,4,5

Table 2: Column Details for Flat slab structure

Column Size (mm)	Column No.
400x400	C9, C16, C21, C28, C32
450x450	C1, C3, C5, C10, C17, C22, C27, C29, C31
500x500	C2, C4, C30
550x550	C12, C24
600x600	C13, C14, C15, C19, C25
650x650	C7, C8, C18, C20, C26
700x700	C11, C23
750x750	C6

Table 3: Column Details for Frame structure

Column Size (mm)	Column No.
450x450	C9, C16, C21, C28
500x500	C5, C10, C22, C29
550x550	C4, C15
600x600	C2, C3, C12, C13, C17, C19, C24, C25, C30, C31
650x650	C1, C7, C14, C18, C26
700x700	C11, C23
800x800	C8, C20, C27, C32
1000x1000	C6

Table 4: Member details

Plinth Beam (Flat slab)	- 300mm X 450mm
Beam (Frame structure)	- 230mmX600mm
Slab Thickness (Flat slab)	- 250mm
Drop size	- 1700mmX1700mm
Drop thickness	- 125mm
Slab thickness (Frame)	- 150mm
Wall thickness	- 150mm
Floor to floor height	- 3.6m
Plinth height above footing top	- 1.8m

2.3 Load Combinations

According to IS: 1893 (Part 1):2002, Load combination used as follows-

- 1.5DL + 1.5LL
- 1.5DL ± 1.5EQx
- 1.5DL ± 1.5EQz
- 1.2DL + 1.2LL ± 1.2EQx
- 1.2DL + 1.2LL ± 1.2EQz
- 0.9 DL ± 1.5EQx
- 0.9 DL ± 1.5EQz

Where, DL is Dead load and LL is Live load, EQX and EQZ are Earthquake loads in the X- and Z- directions, respectively

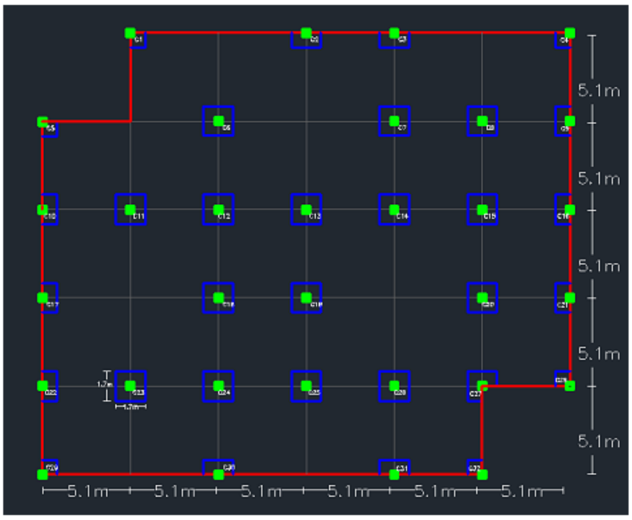

Fig 1: Plan of G+7 storey building of flat slab structure

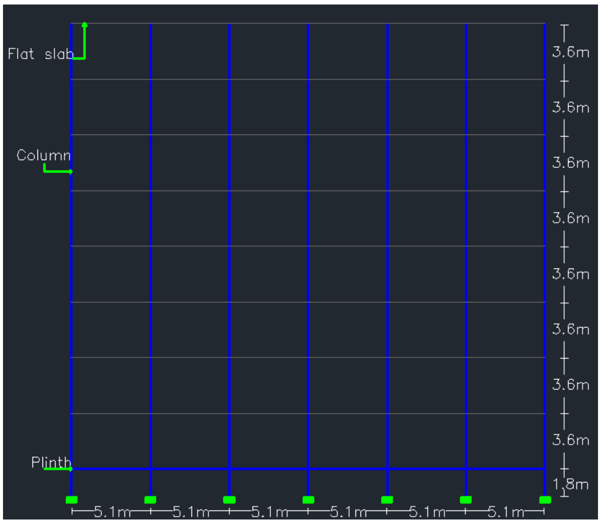

Fig 2: Elevation of G+7 storey building of flat slab structure

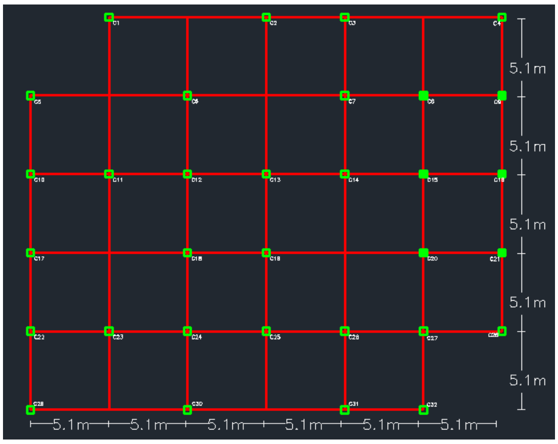

Fig3: Plan of G+7 storey building of frame structure

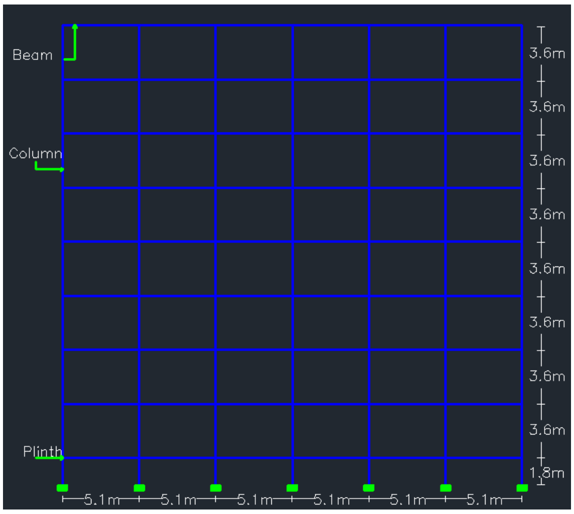

Fig4: Elevation of G+7 storey building of frame structure

Table 5: Design horizontal acceleration spectrum

R factor	Flat slab(A_h)	Frame structure(A_h)
1	0.1230	-
2	0.0651	-
3	0.0410	0.0410
4	0.0307	-
5	0.0246	0.0246

2.4 Design Base shear

Lateral forces applied on building along X & Z direction due to seismic effect or wind at base is known as base shear. Base shear of all models considering different R factor for flat slab structure & frame structure as,

Table 6: Design Base shear with manual validation

R Factor	Base shear(kN) Flat slab		Base shear(kN) Frame structure	
	STAAD Pro	Manual	STAAD Pro	Manual
1	8291.267	8287.58	-	
2	4145.633	4386.35	-	
3	2763.75	2762.52	2722.04	2723.51
4	2072.81	2068.52	-	-
5	1658.253	1657.51	1633.24	1634.10

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