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SHOPPING MALL CONSTRUCTION IN SURGUJA SEISMIC ZONE III USING COMPUTERIZED ANALYSIS METHOD

Adhyatma Khare[1], Dr Ram Narayan Khare[2],Nishant Karsh[3]

[1]*(M.Tech Student, IIT Hyderabad, Telangana, India)*

[2]*(Principal, Vishwavidyalaya Engineering College Ambikapur, Surguja, Chhattisgarh, India)*

[4]*(M.Tech Student, Vishwavidyalaya Engineering College Ambikapur, Surguja, Chhattisgarh, India)*

ABSTRACT

Flat Slabs are provided in order to increase the clearance of room and also when we have to place the column apart without any bracing. This system is quite beneficial as they reduce the dead load of building. For mall, airports, shopping complexes, marriage hall , hospitals we need large space at that place we can provide the flat slab so that it reduces the area covered by building component and provide space for circulation. Here we are going to design the commercial complex that is to be constructed in the Ambikapur for shopping mall. .

Keywords **:**Etabs Software, Sesimic Analysis , Commercial building, Flat Slab

I. INTRODUCTION

Recently Surguja has witnessed two earthquake of magnitude nearly 4.9 on richer scale thus converting the area into Seismic Zone III acc to IS Code 1893:2016.

It is highly recommended to design the building that is to be constructed in the area with this recent seismic effect because the earthquake will surely damage the structure if not made acc to the building rules and following the codes. Ductile detailing of building is must in now a days because this place is developing very fast were various multistory apartments are now under construction due to increase in population of the city. Surguja District headquarter Ambikapur is the new emerging City of Chhattisgarh and we as a civil engineers have implement the latest technologies in the area for structure designing so that the building can withstand the current seismic activities of the area.

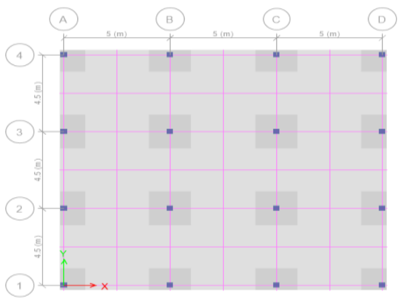
The paper deals with the designing of flat slab with seismic effect

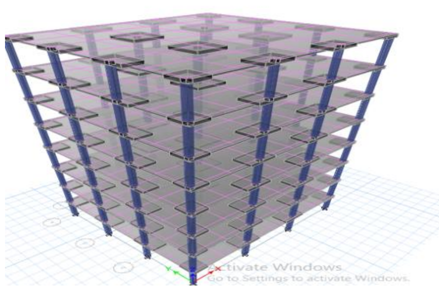
The objectives of the present study are:

1. Modeling and Analysis of G+ 8 flat slab buildings under Dead Load, Live Loads And Lateral Seismic loads Using ETAB software
2. Designing the Column, Slab and Drop of Building using ETAB
3. Checking punching shear for the building
4. Generating Crack width of building
5. To get Storey drift, displacement shears force, joint reaction and bending moment of structure.

Earthquake latest design code 1893:2016 using strip based design technique for only drop flat slab is used for analysis and design with all the load combos were taken by software itself.

II. MODELLING AND ANALYSISIN ETAB SOFTWARE





The structure is modeled in the Etab software and then analysis is performed

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQX according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = X

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Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] $Z = 0.36$

Response Reduction Factor, R [IS Table 9] $R = 5$

Importance Factor, I [IS Table 8] $I = 1$

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS 6.4.2] $\frac{S_a}{g} = \frac{1.36}{T}$ $\frac{S_a}{g} = 1.661115$

Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Table 2Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	0.819	11623.0668	695.061

Table 3 Loads of Storey's

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story8	23.5	186.8744	0
Story7	20.5	181.368	0
Story6	17.5	132.1689	0
Story5	14.5	90.738	0
Story4	11.5	57.0754	0
Story3	8.5	31.1811	0
Story2	5.5	13.055	0
Story1	2.5	2.6003	0
Base	0	0	0

Applied Story Forces

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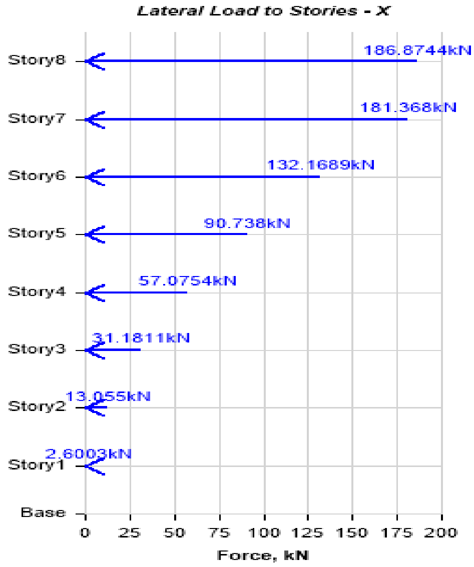

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQY according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = Y

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] $Z = 0.36$

Response Reduction Factor, R [IS Table 9] $R = 5$

Importance Factor, I [IS Table 8] $I = 1$

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS 6.4.2] $\frac{S_a}{g} = \frac{1.36}{T}$ $\frac{S_a}{g} = 1.587836$

Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Table 4 Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	0.857	11623.0668	664.399

Table 5 Load in Y Axis

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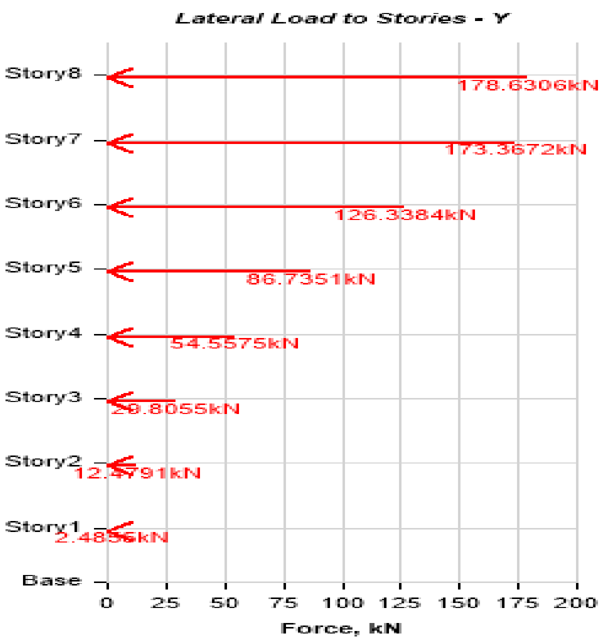
Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
Story8	23.5	0	178.6306
Story7	20.5	0	173.3672
Story6	17.5	0	126.3384
Story5	14.5	0	86.7351
Story4	11.5	0	54.5575
Story3	8.5	0	29.8055
Story2	5.5	0	12.4791
Story1	2.5	0	2.4855
Base	0	0	0

Applied Story Forces



Functions

Response Spectrum Functions

Table 6 Functions - Response Spectrum - User Defined

Name	Period sec	Value	Damping Ratio
UnifRS	0	1	0.05
UnifRS	1	1	

Load Cases

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Table 7Load Case Definitions - Summary

Name	Type
Dead	Linear Static
Live	Linear Static
Modal	Modal - Eigen
EQX	Linear Static
EQY	Linear Static
EQ-Y	Linear Static
EQ-X	Linear Static
EQ+X	Linear Static
EQ+Y	Linear Static

Analysis Results

Table 8 Centers Of Mass And Rigidity

Story	Diaphragm	Mass X kg	Mass Y kg	XCM m	YCM m	Cum Mass X kg	Cum Mass Y kg	XCCM m	YCCM m	XCR m	YCR m
Story8	D1	119940.56	119940.56	7.5	6.75	119940.56	119940.56	7.5	6.75		
Story7	D1	152969.6	152969.6	7.5	6.75	272910.16	272910.16	7.5	6.75		
Story6	D1	152969.6	152969.6	7.5	6.75	425879.76	425879.76	7.5	6.75		
Story5	D1	152969.6	152969.6	7.5	6.75	578849.37	578849.37	7.5	6.75		
Story4	D1	152969.6	152969.6	7.5	6.75	731818.97	731818.97	7.5	6.75		
Story3	D1	152969.6	152969.6	7.5	6.75	884788.58	884788.58	7.5	6.75		
Story2	D1	152969.6	152969.6	7.5	6.75	1037758.18	1037758.18	7.5	6.75		
Story1	D1	147464.76	147464.76	7.5	6.75	1185222.94	1185222.94	7.5	6.75		

Modal Results

Table 9Modal Periods And Frequencies

Case	Mode	Period sec	Frequency cyc/sec	CircFreq rad/sec	Eigenvalue rad2/sec2
Modal	1	0.857	1.168	7.3358	53.8138
Modal	2	0.819	1.221	7.6743	58.8954
Modal	3	0.741	1.349	8.4762	71.8457
Modal	4	0.251	3.988	25.0552	627.7613
Modal	5	0.219	4.574	28.739	825.9323
Modal	6	0.209	4.775	30.002	900.1202
Modal	7	0.124	8.093	50.8516	2585.8818
Modal	8	0.098	10.195	64.058	4103.4327
Modal	9	0.097	10.321	64.849	4205.3961
Modal	10	0.073	13.782	86.5948	7498.668
Modal	11	0.056	17.942	112.731	12708.2889
Modal	12	0.054	18.631	117.0639	13703.9563

Table 10 Modal Participating Mass Ratios (Part 1 of 2)

Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX
Modal	1	0.857	0	0.7529	0	0	0.7529	0	0.2816	0	0	0.2816
Modal	2	0.819	0.7201	0	0	0.7201	0.7529	0	0	0.3183	0	0.2816
Modal	3	0.741	0	0	0	0.7201	0.7529	0	0	0	0.7372	0.2816
Modal	4	0.251	0	0.1133	0	0.7201	0.8662	0	0.4089	0	0	0.6905
Modal	5	0.219	0.1337	0	0	0.8538	0.8662	0	0	0.3466	0	0.6905
Modal	6	0.209	0	0	0	0.8538	0.8662	0	0	0	0.1221	0.6905
Modal	7	0.124	0	0.0506	0	0.8538	0.9168	0	0.0843	0	0	0.7748
Modal	8	0.098	0	0	0	0.8538	0.9168	0	0	0	0.0551	0.7748
Modal	9	0.097	0.0586	0	0	0.9124	0.9168	0	0	0.1054	0	0.7748
Modal	10	0.073	0	0.0296	0	0.9124	0.9465	0	0.082	0	0	0.8568

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Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX
Modal	11	0.056	0	0	0	0.9124	0.9465	0	0	0	0.0314	0.8568
Modal	12	0.054	0.0328	0	0	0.9452	0.9465	0	0	0.083	0	0.8568

Table 11 Modal Participating Mass Ratios (Part 2 of 2)

Case	Mode	SumRY	SumRZ
Modal	1	0	0
Modal	2	0.3183	0
Modal	3	0.3183	0.7372
Modal	4	0.3183	0.7372
Modal	5	0.6649	0.7372
Modal	6	0.6649	0.8593
Modal	7	0.6649	0.8593
Modal	8	0.6649	0.9143
Modal	9	0.7702	0.9143
Modal	10	0.7702	0.9143
Modal	11	0.7702	0.9457
Modal	12	0.8532	0.9457

Table 12 Modal Load Participation Ratios

Case	ItemType	Item	Static %	Dynamic %
Modal	Acceleration	UX	99.99	94.52
Modal	Acceleration	UY	99.99	94.65
Modal	Acceleration	UZ	0	0

Table 13 Modal Direction Factors

Case	Mode	Period sec	UX	UY	UZ	RZ
Modal	1	0.857	0	1	0	0
Modal	2	0.819	1	0	0	0
Modal	3	0.741	0	0	0	1
Modal	4	0.251	0	1	0	0
Modal	5	0.219	1	0	0	0
Modal	6	0.209	0	0	0	1
Modal	7	0.124	0	1	0	0
Modal	8	0.098	0	0	0	1
Modal	9	0.097	1	0	0	0
Modal	10	0.073	0	1	0	0
Modal	11	0.056	0	0	0	1
Modal	12	0.054	1	0	0	0

Table 14 Column Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story8	C4	4	COLUMN	UDConS7	3000	3000	1	Ductile Frame

Table 15 Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
600	900	60	30

Table 16 Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	415	415

Table 17 Design Code Parameters

γ_C	γ_S
1.5	1.15

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Table 18 Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
125.7933	-102.6638	96.2986	3.2706	4.5286	4320	0.8

Table 19 Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	1	3000	38.5194	0	4.5286
Minor Bend(M2)	1	3000	-53.487	0	3.2706

Table 20 Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	54.1203	238.7145	201.6005	0	665.06
Minor, V_{u3}	40.9807	234.2941	194.4007	0	997.59

Table 21 Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	N/N	N/N	N/N	N/N	N/N	N/N
Minor Shear, V_{u3}	N/N	N/N	N/N	N/N	N/N	N/N

Table 22 Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
N/N	N/N

Table 23 Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
5400	43.2	8634.6	3866.19	125.7933	1

Table 24 Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	1	900	3.333	12	No	0
Minor Bending (M_2)	Yes	1	600	5	12	No	0

IS 456:2000 + IS 13920:2016 Column Section Design (Flexural Details)

Table 25 Factored & Minimum Biaxial Moments

	NonSwayM_{ns} kN-m	Sway M_s kN-m	Factored M_u kN-m
Major Bending(M_{u3})	90.7903	5.5082	96.2986
Minor Bending(M_{u2})	-75.3002	-27.3636	-102.6638

Table 26 Slenderness Effects (IS 39.7.1) and Minimum Biaxial Moments (IS 39.2, 25.4)

	End Moment M_{u1} (kN-m)	End Moment M_{u2} (kN-m)	Initial Moment (kN-m)	k*M_a Moment (kN-m)	Minimum Moment (kN-m)	Minimum Eccentricity (mm)
Major Bending (M_3)	-66.0624	96.2986	38.5194	0	4.5286	36
Minor Bending (M_2)	20.2782	-102.6638	-53.487	0	3.2706	26

Table 27 Effective Length Factors (IS 25.2, Annex E)

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	K Sway	K Non-Sway	Framing Type	P-Delta Done?	Q Factor	K Used
Major Bend(M_3)	1	1	Ductile Frame	No	0.01783	1
Minor Bend(M_2)	1	1	Ductile Frame	No	0.013522	1

IS 456:2000 + IS 13920:2016 Column Section Design (Shear Details)

Table 28 Shear Design for V_{u2}, V_{u3}

	Rebar A_v /s mm²/m	Design V_u kN	Design P_u kN	Design M_u kN-m	V_c kN	V_s kN	V_n kN
Major Shear(V_2)	665.06	54.1203	125.7933	96.2986	238.7145	201.6005	440.315
Minor Shear(V_3)	997.59	40.9807	125.7933	-102.6638	234.2941	194.4007	428.6947

Table 29 Design Forces

	Factored V_u kN	Factored P_u kN	Factored M_u kN-m	Capacity V_p kN
Major Shear(V_2)	54.1203	125.7933	96.2986	0
Minor Shear(V_3)	40.9807	125.7933	-102.6638	0

Table 30 Capacity Shear

	Shear V_p kN	Long.Rebar $A_{s(Bot)}$ %	Long.Rebar $A_{s(Top)}$ %	Cap.Moment M_{posBot} kN-m	Cap.Moment M_{negTop} kN-m	Cap.Moment M_{negBot} kN-m	Cap.Moment M_{posTop} kN-m
Major Shear(V_2)	0	0	0	0	0	0	0
Minor Shear(V_3)	0	0	0	0	0	0	0

Table 31 Design Basis

ShrReduc Factor Unitless	Strength f_{ys} MPa	Strength f_{ck} MPa	Area A_g cm²
1	415	30	5400

Table 32 Concrete Shear Capacity

	Conc.Area A_c cm²	A_{st} %	Basic τ_c MPa	CompFactor δ Unitless	DepthFactr k Unitless	Strengh Factor Unitless
Major Shear(V_2)	5040	0.429	0.463	1.023	1	1
Minor Shear(V3)	4860	0.444	0.471	1.023	1	1

Table 33 Shear Rebar Design

	Design V_u kN	Stress τ MPa	Concrete τ_{cd} MPa	Limit $\tau_{c,max}$ MPa	Rebar Area A_{sv} /s mm²/m
Major Shear(V_2)	54.1203	0.11	0.47	3.5	665.06
Minor Shear(V_3)	40.9807	0.08	0.48	3.5	997.59

IS 456:2000 + IS 13920:2016 Column Section Design (Beam/Column Capacity Ratio)

Table 34Dimensions of the Beams At the Joint (Part 1 of 2)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	1	900	3.333	12	No	0
Minor Bending (M_2)	Yes	1	600	5	12	No	0

Table 35 Longitudinal Reinforcement Design for P_u - M_{u2} - M_{u3} Interaction

Column End	Rebar Area mm²	Rebar %
Top	4320	0.8
Bottom	4320	0.8

Table 36 Design Axial Force & Biaxial Moment for P_u - M_{u2} - M_{u3} Interaction

Column End	Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Station Loc mm	Controlling Combo
Top	125.7933	-102.6638	96.2986	3000	UDConS7
Bottom	198.7858	40.781	-103.4782	0	UDConS11

Table 37 Shear Reinforcement for Major Shear, V_{u2}

Column End	Rebar A_{sv} /s mm²/m	Design V_{u2} kN	Station Loc mm	Controlling Combo
Top	665.06	19.3924	3000	UDConS38
Bottom	665.06	19.3924	0	UDConS38

Table 38 Shear Reinforcement for Minor Shear, V_{u3}

Column End	Rebar A_{sv} /s mm²/m	Design V_{u3} kN	Station Loc mm	Controlling Combo
Top	997.59	20.065	3000	UDConS38
Bottom	997.59	20.065	0	UDConS38

III. CONCLUSION

The design of G + 8 Story building using Etab Software by application of IS Code 1893:2016 for earthquake design, IS 456:2000 for concrete design shows that for FE415 and M30 the column size 600*900 mm , slab size 125 mm and drop size 300 mm is sufficient for the building geometry .

The design is safe in punching shear. And the amount of steel required for column=4320 mm^2 for all Columns. The Structure does not fail for seismic zone II.

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