Earthquake Analysis of Grid Floor And Its Parametric Study

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Abstract- *The various methods of analysis of grid floor is mentioned in my previous research paper .This research paper incorporates the calculation of deflection by using plate cross stiffened case (without considering continuity) and by using Macaulay's Method (considering continuity) for central and multiple column case.*

Along with this Earthquake analysis of the grid floor (with sample problem) is also conducted by equivalent static method as given in the IS code 1893 (Part I): 2002 considering the safety of the structura as a whole for lateral forces.

I. INTRODUCTION

Grid floor is the system in which beams are spaced at closed intervals ,monolithic with a slab. They are generally used where large column free space like auditorium , vestibules, theatre halls, showrooms, banquet halls is the main requirement.

As grid floor is simply supported but the frame is rigid frame so the earthquake analysis for this rigid frame is done by equivalent static method.

GRID SLAB

In this study basically three grid sizes are taken for the comparative analysis they are-

(1)1.47m×1.47m (2)1.47m×1.1m (3)1.47m×0.885m

Along with these grid size variation column positions have also been changed to know the variation of stress parameters such as deflection and its behavior. The three column conditions are-

(1) Simply Supported Case (2)Central Column Case(3)Multiple Column Case

For central and multiple column case deflection is calculated by considering it as simply supported as well as by considering continuity effect and then it is verified with conjugate beam method.

As Jabalpur comes under zone III so its seismic analysis is done for this zone. First the frame analysis is done by Portal Method for the weakest frame (having less supports as compared to length of span), as span is much greater (17.7m) with respect to number of columns. After doing frame analysis seismic analysis of grid beams is done by ***Equivalent Static Method*** as it is two story building which does not get effected by horizontal loads easily. After doing seismic analysis of grid beams. At last the comparative analysis of stress values and other important parameters are done.In this thesis not only the analysis of grid beams is done but also a sample design of square shaped grid 1.47m×1.47m as per IS 456: 2000 is done .

Base Shear, $V_B = A_h W$

The total horizontal load is now distributed along the height of the building as per **clause 7.7.1 of IS:1893 (Part I):2002**.

The design base shear (V_B) distributed along the height of the building is given by

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

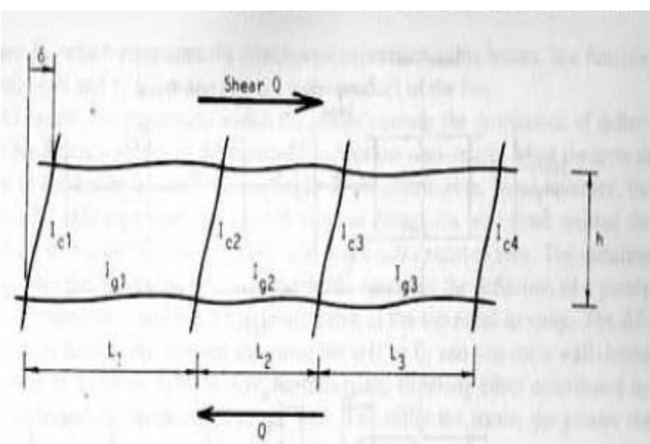
Accidental eccentricity –

Design eccentricity is given by **IS 1893 (Part I) clause 7.9.2** e_{si} -0.05 b_i

Equivalent static method -The maximum horizontal displacement expression is given as $y(z)=\frac{11}{120}\frac{w_1 H^4 k_1}{EI}$ in Bryan Stafford Smith and Alex Coull. k_1 depends on $\alpha H, \alpha = \frac{GJ}{[EI_w]^{\frac{1}{2}}}$

αH characterizes the behavior of rigid wall – frames such that wall - frame structures with similar value of αH have similar deflection profiles and internal forces distribution for similar distribution of applied loading.

Shear rigidities (G_A) – It is defined as the shear force required to cause unit horizontal displacement per unit height. $G_A = \frac{Qh}{\delta}$



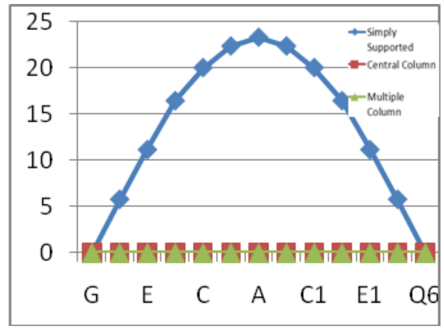
Typical story of rigid frame subjected to shear

For a typical story of rigid frame $G_A = \frac{12E}{h\left[\frac{1}{G}+\frac{1}{C}\right]}$ where $G=\frac{\sum I_g}{L}$ for the girders across one floor level of a bent , $C=\frac{\sum I_c}{h}$ for the columns in one story of the bent.

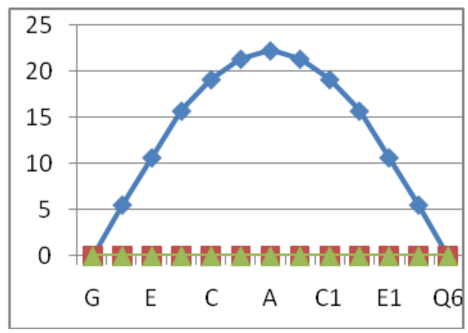
II. RESULTS AND DISCUSSION

The calculation of deflection calculation done by using Plate cross-stiffened case and by considering continuity effect for central and multiple column case is presented below through representative graphs using excel worksheet.

Deflection along G - Q_6 (by Plate Theory)

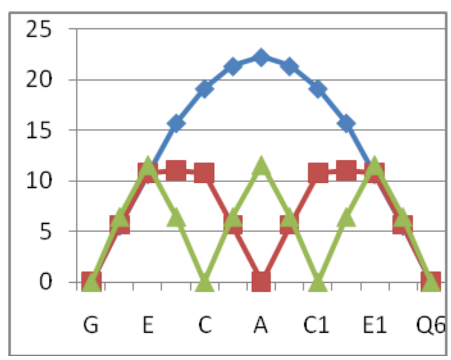


Top Story



Bottom Story

Deflection along G - Q_6 (by using Continuity Effect)



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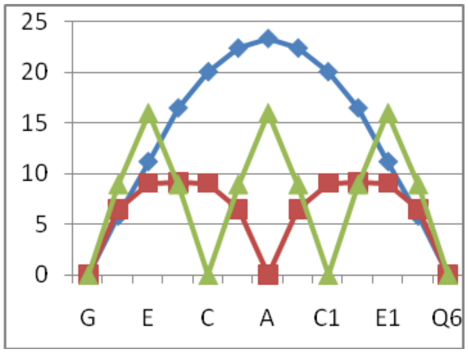
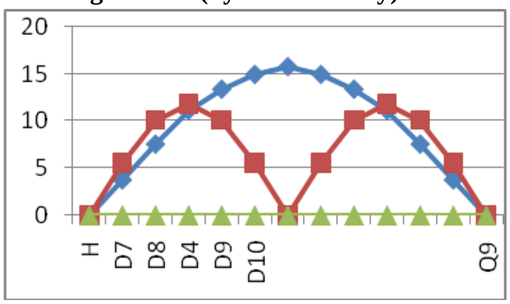
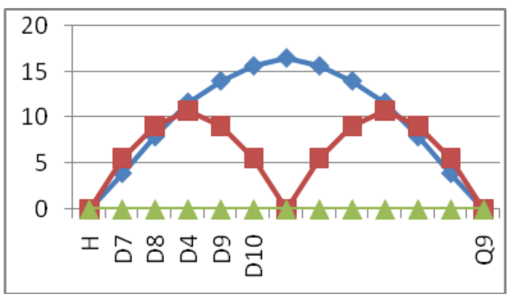


Bottom story

Deflection along H - Q_9 (by Plate Theory)

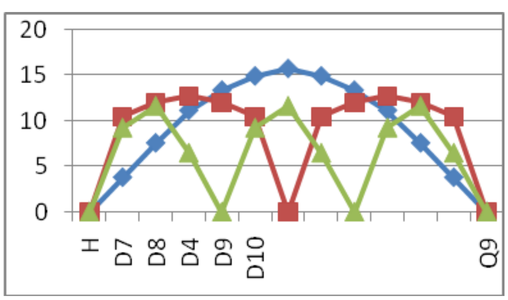


(Top Story)

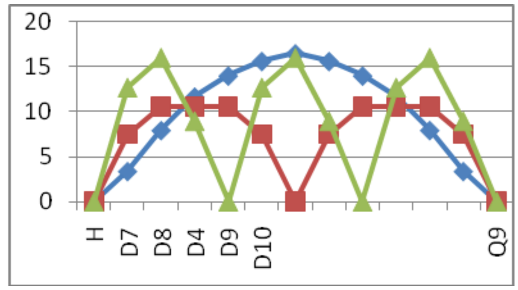


(Bottom Story)

Deflection along H - Q_9 (by using Continuity Effect)

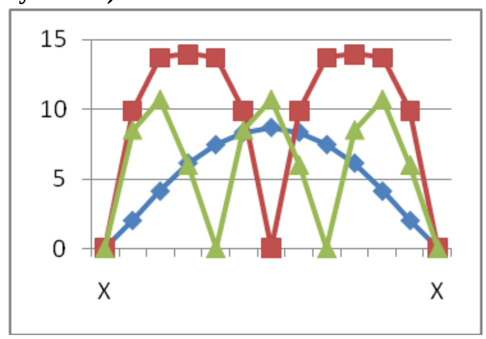


Top story

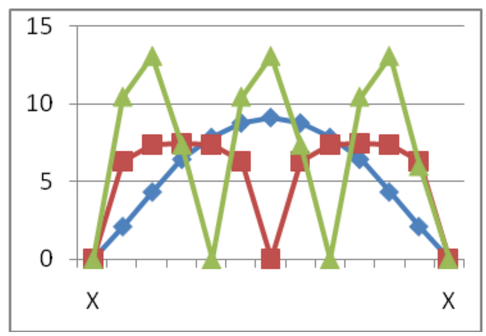


Bottom story

Deflection along X –X for grid size 1.47x1.47m (by using Continuity Effect)



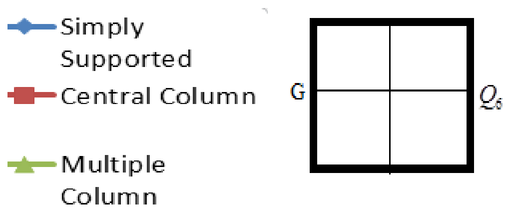
Top story

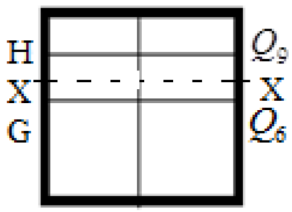


Bottom story

Note :

- In the central column case the deflection is zero at edges since the plate theory assumes the plate size 8.85x8.85m, analyzed as per previously published research papers by **Dr. S. A. Halkude**,**Anitha.K**and other researchers **.**And in multiple column case the deflection is zero at edges since the plate theory assume the plate size 5.9x4.425m which is analyzed as per previously published research papers.
- The value of maximum deflection calculated by Plate theory is higher than the value calculated by considering continuity effect (Macaulay's Method).
- Co-ordinates are mentioned with respect to grid plan of grid size 1.47x1.47m.





- Stress parameter value comparison for different column conditions is shown mentioned below in the table-

GRID SIZE(1.47 x1.47m)	SIMPLY SUPPORTED CASE (1)	CENTRAL COLUMN CASE(2)	MULTIPLE COLUMN CASE(3)	(2)/(1)*100 (%)	(3)/(1)*100 (%)	(3)/(2)*100 (%)	STRESS PARAMETER
Bottom story	493.68	65.19	10.5	86.8	97.88	83.89	Mx
	493.68	65.19	10.5	86.8	97.88	83.89	My
	65.18	5.41	0.76	91.7	98.84	85.95	Mxy
	65.18	5.41	0.76	91.7	98.84	85.95	Myx
	99.19	25.22	6.14	74.58	93.8	75.65	Qx
	99.19	25.22	13.66	74.58	86.23	45.83	Qy
	23.32	10.71	4.92	54.08	78.91	54.06	Deflection
	181.18	107.43	44.72	40.71	75.32	58.37	Lateral loads
	627.85	274.14	160.45	40.95	74.45	41.47	Base Shear
	160.34	95.07	39.57	40.71	75.33	58.37	Seismic Moments
Top story							
	390.60	46.02	7.6	88.22	98.1	83.49	Mx
	390.60	46.02	7.6	88.22	98.1	83.49	My
	48.31	2.8	0.55	94.21	98.86	80.36	Mxy
	48.31	2.8	0.55	94.21	98.86	80.36	Myx
	77.90	17.32	4.45	78	87.28	74.30	Qx
	77.90	17.32	9.91	78	87.28	42.78	Qy
	22.26	11.8	3.57	47	83.97	69.74	Deflection
	446.67	166.71	115.73	62.68	74	30.58	Lateral loads
	181.18	107.43	44.72	56.34	75.32	58.37	Base Shear
	395.30	147.54	102.42	62.28	74	30.58	Seismic Moments

Horizontal Deflection due to Earthquake in grid floor size 1.47x1.47 for different column position condition –

S No.	Story	Simply Supported	Central Column	Multiple Column
1	2	7.7	9.43	13.8
2	1-2	6.6	7.02	9.66
3	1	4.4	4.13	5.29
4	0-1	1.65	1.24	1.61

III. CONCLUSION

This paper not only deals with analysis of grid floorbut also static analysis .As it is only single story building so dynamic analysis is not important as mentioned in Bryan Stafford Smith and Alex Coull book. The conclusion is mentioned below:

1) As the number of column is increased lateral forces acting on the grid reduces on contrary horizontal deflection due to earthquake is experienced to be more in case of simply supported case then central column case.
2) Deflection can be obtained point to point by using interpolation manually.

IV. SCOPE FOR FUTURE STUDY

- Deflection distribution in both directions for different grid sizes.
- To analyze the grid floor for multiple column case for grid sizes 1.47x1.1m and 1.47x0.885m and its horizontal deflection calculation due to earthquake.

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[9] Bryan Stafford Smith and Alex Coull, " Tall Building Structures Analysis and design"

[10] **Prof. Dr. S. A. Halkude**,**ComparisonofVarious Methods of Analysis of Grid Floor Frame,** In this paper comparison of parameters calculated based on flexural parameters are done by using various methods . Plate theory and RankineGrashoff's method are used for simple support condition whereas Stiffness method can be used for rigid supports as well.

[11] **CH.RAJKUMAR ,Analysis and Design of Multistory Building with Grid Slab Using ETABS,** In the present problem G+ Building is considered and analysis and design is done for both seismic and non -seismic loads and then it is compared with the flat slab.

[12] **Anitha.K, Design And Analysis Of Grid Floor Slab,** This paper deals with the sway of various variables on the economical spacing of the transverse beams in grid floor.The parametric study is carried out using the model proposed by ANSYS 12.0 software

[13] **Sudhir Singh Bhadauriya, Comparative Analysis and Design of Flat and Grid slab system with conventional slab system,** In this paper slab system design and analysis for G+10 building for seismic zone III having medium soil condition using STAAD Pro V8i is done considering plan area or grid size/ spacing of the column to know the suitability of slab system corresponding to plan area.

[14] **Mohammed Fatir, Relative Study Of Seismic Analysis Between Flat Slab And Grid Slab Of RCC Structures With Different Masonry Infills In Two DifferentZones,**This paper present the comparison of multi-story buildings having flat slabs withdrops with that of conventional beam column framing so called grid slab system under linear dynamic analysis (Response spectrum analysis) in two differentzones III and zone IV with medium soil type conditions. ETABS software which came to conclusion that grid slab structures with infill shows better performance as compared to without infill structures. In addition to this the structurewith shear wall reduced max displacement and storydrift and time period incomparison with structure with concrete bracing.

[15] **Harish M K.,Analysis and Design of Grid Slab in Building Using Response Spectrum Method,** In this study analysis and design is done for both gravity, seismic and wind loading conditions as per IS codes by considering G+4 building. ETAB software is used for analysis and manual calculation is done for design.