Dynamic Behaviour of Grid Pattern on Concrete Floors

Vipul R. Meshram[1] Dr. Valsson Varghese[2]
[1]M.tech scholar [2]Professor & Head
[1,2]Department of Civil Engineering
[1,2]K. D. K. C. E Nagpur

Abstract— In the present study, an attempt is made to compare the base reactions, bending moment and shear force obtained from the dynamic analysis using STAAD Pro software for various grid patterns. The size of grid patterns are 18mx18m and four basic grid patterns are selected which are varied by increasing the intermediate beams. It is important to note that the grids are analyzed for G+3 building. IS 1893:2002 is referred to apply dynamic loading on the grids and Equivalent static analysis (ESA) or seismic coefficient method (SCM) is followed to apply the dynamic loading on the grids. The main aim of the study is to compare the above mentioned results obtained from the dynamic analysis of various grid patterns and study the behavior of various grids under dynamic loading. It is important to note that the comparison of results is studied for the various load combinations specified in IS 1893:2002. The study also evaluates the storey shear for various grid patterns.

Key words: Bending moment, Base shear, Grid patterns, IS 1893:2002, STAAD software.

I. Introduction

The principal decisions regarding structure relate to column layout, foundation conditions, integration of building services, and external wall construction. The role of a multi-storey building structure is to transmit the applied loads to the foundations. The principal loads on a multi-storey building are those due to gravity and wind. These are applied at every floor level. The structural frame transmits these from their point of application to the foundations. Ideally it should combine structural efficiency with minimum impact on the economy and function of the other elements of the building.

The choice of structural grid defines column positions and is a very important design decision. The structural grid is defined principally by column positions and the main beams spanning between them. This defines on plan two sets of grid lines which are normally perpendicular. The establishment of this structural grid is a very important design decision and the following points should be considered:

(1) A column should normally be positioned at every intersection of two grid lines
(2) A main beam should normally be positioned along every grid line
(3) Ideally grid lines should be orthogonal (the two sets of parallel lines forming a rectangular grid, and the spacing between grid lines should be regular (for circular buildings radial and circumferential grids are often used)
(4) In practice the shape of the building and/or site may require some variation from this, and irregular spacing or skewed grid lines cannot be avoided. However, these can generally be concentrated in small areas, allowing the main part of the building to be set out in accordance with a regular orthogonal grid.

The omission of a column at a grid intersection has enormous structural implications unless the supporting beams and columns above are also omitted. A grid is a planar structural system composed of continuous members that either intersect or cross each other. Grids are used to cover large column free areas and are subjected to loads applied normally to its plane. It is beneficial over normal beams as it has a better load dispersing mechanism and also this system reduces the normal span to depth ratio which helps in reducing the height of the building. A grid is a planar structural system composed of continuous members that either intersect or cross each other. Grids are used to cover large column free areas and have been constructed in number of areas in India and abroad. If it is subjected to loads applied normally to its plane; the structure is referred as Grid. It is composed of continuous member that either intersect or cross each other .Grids in addition to their aesthetically pleasing appearance, provide a number of advantages over the other types of roofing systems.

II. Dynamic Analysis

In India, IS 1893(Part 1): 2002, is used to calculate earthquake loads on the structures. In this Indian Standard, three methods of analysis are given. In the first method, which is used for most of the buildings, static earthquake loads are obtained at each floor of building using empirical time period. This method is termed as Equivalent Static Analysis (ESA) or Seismic Coefficient Method (SCM), it is very easy to use and is based on empirical time period and empirical distribution of earthquake loads on each floor along the height of the building. Next method given in IS 1893 is Response Spectrum Analysis (RSA), wherein, from the structural model of building, natural frequencies and natural modes are obtained. For this purpose, free vibration analysis is performed, wherein mass of structure is to be properly modeled. The mass of slab and mass corresponding to appropriate amount of imposed load are considered along with the mass of beam and column. Using natural frequencies and mode shapes, static earthquake loads and response in each mode are obtained. These modal responses are combined using any one modal combination rules, i.e. Sum of Square Root of Squares (SRSS), Combined Quadratic Combination (CQC) and Absolute Sum (ABS). The third method given in IS 1893 is Time History Analysis (THA). In the time history analysis (THA), dynamic response is obtained by using either modal superposition method or numerical integration method. Here time history of ground acceleration is used and dynamic response in the form of time history of response is obtained. It is to be notedthat if modal superposition method is used to obtain dynamic response, then modal responses are combined using algebraic sum.

RSA uses modal quantities such as modal frequencies, modal mass etc. Response spectrum is more rigorous than equivalent static analysis. Due to combination of modes by different methods one can get good results while performing response spectrum analysis. In the RSA also static loads are calculated, which are obtained using modal properties of structure. The modal combination rules have a very peculiar property i.e. in these combinations; sign of modal response is lost. The modal combination rules, wherein maximum modal responses are considered are used only in RSA.

A. ANALYSIS PARAMETERS CONSIDERED

Type of building	Commercial building (G+3)
Span @ X & Y direction	18 x 18 m
Size of Beam	0.6 x 0.75 m
Size of Column	0.6 x 1 m
Floor to Floor height	3.6 m
Column height below plinth	2 m

B. SEISMIC PARAMETERS CONSIDERED (AS PER 1893: 2002)

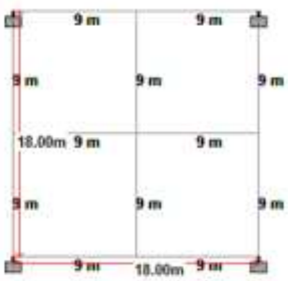
Zone	II
Importance factor	1.5
Response reduction factor (as OMRF)	3
Soil	Medium
Damping	5%

C. PRIMARY AND LOAD COMBINATIONS

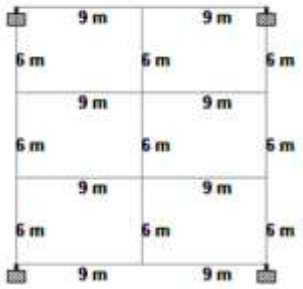
Type	L/C	Name
Primary	1	DL
Primary	2	LL
Primary	3	EQX+
Primary	4	EQX-
Primary	5	EQZ+
Primary	6	EQZ-
Combination	7	1.5(DL+LL)
Combination	8	1.5(DL+EQX+)
Combination	9	1.5(DL+EQX-)
Combination	10	1.5(DL+EQZ+)
Combination	11	1.5(DL+EQZ-)
Combination	12	1.2(DL+LL+EQX+)
Combination	13	1.2(DL+LL+EQX-)
Combination	14	1.2(DL+LL+EQZ+)
Combination	15	1.2(DL+LL+EQZ-)
Combination	16	0.9DL+1.5EQX+
Combination	17	0.9DL+1.5EQX-
Combination	18	0.9DL+1.5EQZ+
Combination	19	0.9DL+1.5EQZ-

III. GRID PATTERNS

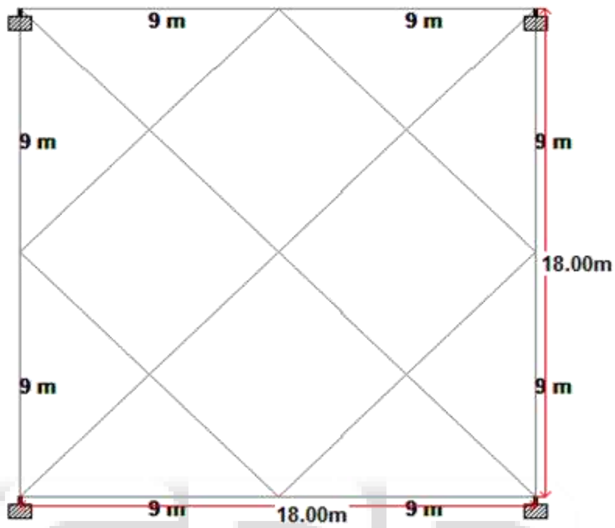
The grid patterns taken for dynamic analysis in STAAD PRO are as follows and the size of grid is 18m x 18m:



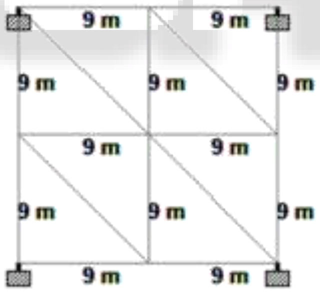
Square 9x9m grid

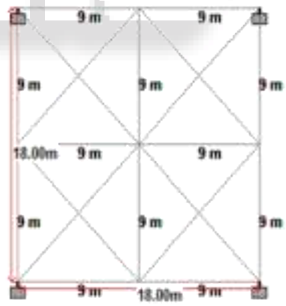


Rectangle 9x6m grid



Diagonal 9x9m grid



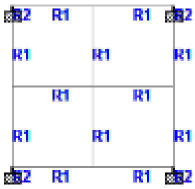
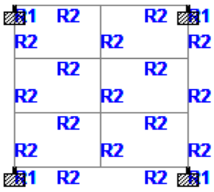
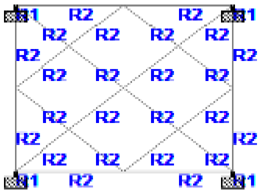
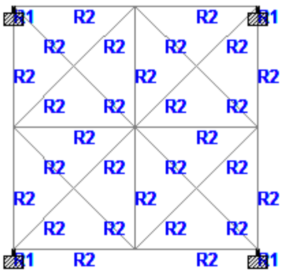


Three way 9x9m grid

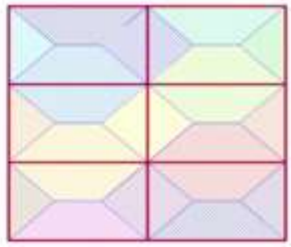
Four way 9x9m grid

A. Properties of Grid Patterns

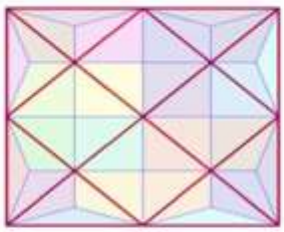
Size of Members	Beams: R1= (600x750) mm Columns: R2= (1350x1350) mm Slab Thickness= 125mm
Loads	Dead Load: Slab Weight=4.625kN/m^2 Wall Weight=8.55kN/m (Outer) Parapet Load= 3kN/m Live Load: At Floor= 4 kN/m^2 At roof level =4 kN/m^2

S 9X9	
R 9X6	
D 9X9	
T 9X9	
F 9X9	

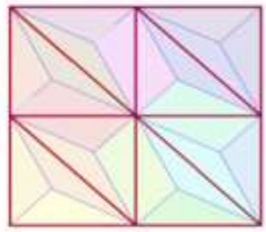
Square 9x9m grid



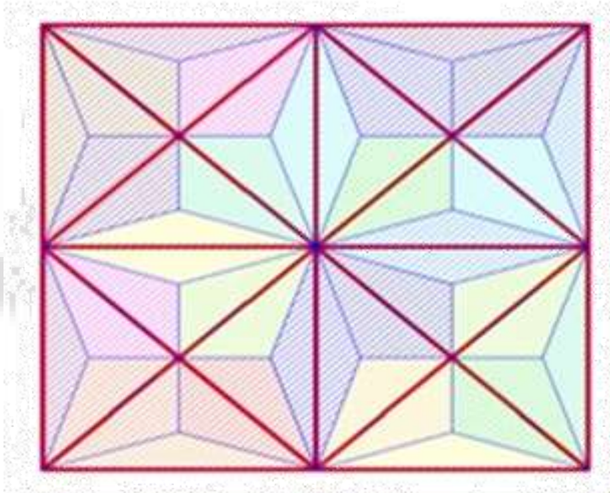
Rectangle 9x6m grid



Diagonal 9x9m grid



Three way 9x9m grid



Four way 9x9m grid

IV. SEISMIC ANALYSIS OF GRID PATTERNS

Using STAAD PRO software grid patterns are selected as discussed in introduction. The size of the grid patterns is 18mx18m. The member properties along with the loads assigned to each of the grid patterns. Load dispersion diagram for various grid patterns.

V. RESULT

CRITICAL VALUES FOR BEAMS						
Span	Load case no	S 9X9	R 9X9	D 9X9	T 9X9	F 9X9
Beam nos.	1.5(DL+ LL)	25	35	49	33	57
Shear force on ff (kn)	7	867	793	597	784	639
Torsion on ff (kn-m)	7	559	510	251	342	270

Bending moment on ff (kn-m)	7	3146	2860	2157	2922	2347
Base shear (kn)	-	730	744	853	825	921
Drift @ top floor (mm)	-	24	27	20	22	22
Maximum displacement@ center ff (mm)	7	90	84	22	40	19
Concrete qty per floor grid (cu.m)	-	85	91	107	102	117
Aproximate steel qty (m.t)	-	1.28	1.37	1.61	1.53	1.76

CRITICAL VALUES FOR COLUMNS						
SPAN	LOAD CASE NO	S 9X9	R 9X9	D 9X9	T 9X9	F 9X9
BEAM NOS.	1.5(DL +LL)	61-65	86-102	121-137	81-97	141-157
AXIAL FORCE ON BOTTOM (KN)	7	9412	9574	10800	12047	11560
SHEAR FORCE TOP FLOOR (KN)	7	1315	1434	1800	2080	1927
BENDING MOMENT TOP FLOOR (KN-M)	7	3430	3748	4493	5213	4813
CONCRETE QTY PER FLOOR GRID (CU.M)	-	20.7	20.7	20.7	20.7	20.7
APROXIMATE STEEL QTY (M.T)	-	0.312	0.312	0.312	0.312	0.312

VI. Conclusion

Based on the Results presented above, the following conclusions can be drawn:

(1) The worst load case of all the grid patterns is found out to be 1.2(DL+LL+EQX-/+) i.e:, load case no.7 .

(2) Loads assigned to each of the grid patterns shows different Load dispersion diagram for various grid patterns.

(3) Diagonal 9x9m grid & Four way 9x9m grid having least affected as compare to other grids. But concrete consume in these grids are more as compare to other grids.

(4) Square, rectangle & three way 9x9m grids are not sustaining due to heavy moments, shear force & torsional moments etc.

(5) Whereas Diagonal 9x9m grid & Four way 9x9m grid are ready to sustain above moments and forces.

Thus Dynamic Behaviour of Grid Pattern on Concrete Floors shows Diagonal 9x9m grid & Four way 9x9m grid are best grid for 18mx18m.

References

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