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COST COMPARISON OF DIFFERENT GRID PATTERNS OF FLOOR SLAB OF SAME SPAN

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Abstract - *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. Grids in addition provide aesthetically pleasing appearance to the roofs. These slabs are most preferred for public assembly halls, theatres, marriage halls, etc as it covers large column free area. This type of structure is monolithic and has more stiffness. 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. It has been constructed in number of areas in India n abroad. In the present study we have considered two types of grid patterns, first is two way grid pattern and second is diagonal grid pattern. The structure is analysed and designed with the help of staad pro software. Design has been checked with respect to IS 456-2000 code.*

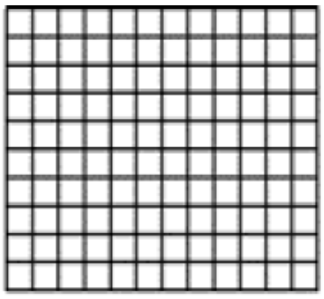
Key Words: **Grids, STAAD PRO, IS 456-2000 Code, Span to depth ratio, monolithic, stiffness.**

1.INTRODUCTION

As we know in India, the structural cost of work is increases time to time due to increase in material & labor cost, which ultimately lead to increase the total cost of building. The structural cost of work is approximately 50% of the total cost of the building. So it is very essential to reduce the structural cost of building. It can be possible by providing safe & economical grid pattern of floors of building. In India it is popular structural configuration often deployed in the construction of hotel porticos, airport terminal buildings, large banquet hall, convention centres and car parks. The rectangular or square voids that are formed in the ceiling is advantageously utilized for concealed architectural lighting. The sizes of beams running in perpendicular directions are generally kept the same. Instead of rectangular beam grid, a diagonal.

1.1 TWO WAY GRIDS:

In two way grid pattern of floor slab the beams are of similar sizes and they intersect each other in both directions and also they are at equally spaced intervals. These structures are rigid planar oten monolithic structures that disperse loads in multi directional pattern, with the loads generally following the shortest stiffest routes to the supports.

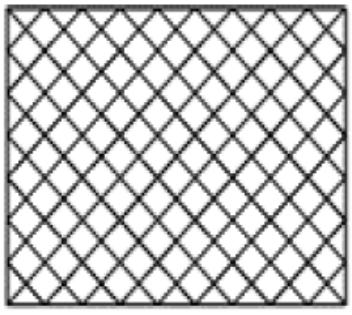


(a) Two-way grid

Fig No.1

1.2 DIAGONAL GRIDS

The construction of egg crate is also not as efficient as diagonal grid system. These grids intersect beams diagonally but they are perpendicular to each other. It is required to support the grid at four points only. The diagonal grid has greater torsional rigidity. The sizes of grid beams are normally similar and are also equally spaced.



(b) Diagonal grid

Fig No.2

2. METHODOLOGY

In this study we have considered three different grid patterns of beams on a floor slab of same area of 12 x 12m span. The grid that we have used are Two way grids and Diagonal. Second step is we have prepared the Models of the all the grid patterns that we have consisdered using STAAD-PRO V8i software. Model is also checked as per checks available in the software. Third step is analysis and design of the structure using STAAD- PRO V8i software. The design is also manually checked and verified as per IS 456- 2000 code for RCC design. The steps for analysis are given as follows,

a) To apply self weight of the structure in the software.
b) To find shear force of the members.
c) To find Bending moments of the members.
d) To find the Displacements of the members.

Fourth step is to estimate the quantity of steel and concrete required for all three structures manually. Final step is to find the Structural cost of the building and respectively find the per square feet cost of the building in terms of structural cost.

A. Grid Patterns:-

Grid A (Two way grid)

Columns:

R1- 300x600 mm

R3- 300x300 mm

Beams:

R3- 300x750 mm

R4- 230x400 mm

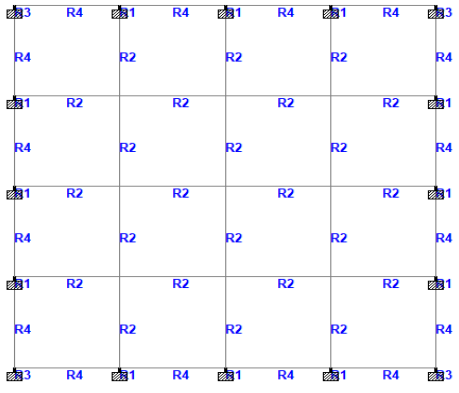


Fig No.5 PATTERN 1

Grid B (Diagonal grid)

Columns:

R1- 400x400 mm

Beams:

R2- 230x450 mm

R3- 300x600 mm

R4- 300x600 mm

R5- 300x600 mm

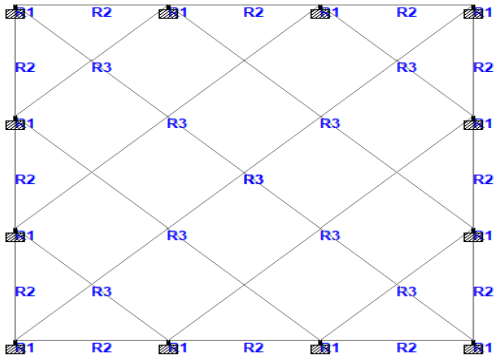


Fig No.6 PATTERN 2

3. LOAD CALCULATIONS

TWO WAY GRID:

DEAD LOADS (IS 875 PART-1)

Dead loads are loads that are permanent on the structure such as construction materials and the materials which are kept permanent on the structure. Also self weight of the structure is considered as dead load.

Self weight :- Selft weight load- Direction Y- Factor = -1

Wall loads:-

Thickness of wall = 230 mm

Floor to floor height = 4m

Height of wall = 3.6m

Load calculation = 0.23 x 20 x 3.6

= 16.56 kN/m

Slab weight calculations :-

Thickness of slab = 125mm

Density of concrete = 25kN/cu.m

Self weight of slab = 0.125 x 25 = 3.125 kN/sq.m

Floor finish = 1.5 kN/sq.m

Total slab weight at floor level = 3.125+1.5= 4.625 kN/sq.m

LIVE LOADS (IS 875 PART 2)

Live loads are produced due to use and occupancy of building. These are normally due to human occupants, storage, furnishings, etc.

Live Load intensity specified = 4 kN/sq.m

LOAD COMBINATIONS:

Type	L/C	Name
Primary	1	DL
Primary	2	LL
Combinations	3	1.5(DL+LL)

DIAGONAL GRIDS :

Wall loads:-

Thickness of wall = 230 mm

Floor to floor height = 4m

Height of wall = 3.55m

Load calculation = 0.23 x 20 x 3.55

= 16.33 kN/m

Slab weight calculations :-

Thickness of slab = 125mm

Density of concrete = 25kN/cu.m

Self weight of slab = 0.125 x 25 = 3.125 kN/sq.m

Floor finish = 1.5 kN/sq.m

Total slab weight at floor level = 3.125+1.5= 4.625 kN/sq.m

LIVE LOADS (IS 875 PART 2)

Live loads are produced due to use and occupancy of building. These are normally due to human occupants, storage, furnishings, etc.

Live Load intensity specified = 4 kN/sq.m

4. ANALYSIS AS PER STAAD PRO

Table -1: Sample Table format

Preparation of Manuscript				
Grids	Size of members(in mm)	Deflection (in mm)	Max B.M (in Kn.m)	Max S.F (in Kn)
G1	Beams:			
	R4- 230x400	0.735	45.453	68.876
	R2- 300x750	15.033	280.806	189.668
	Columns:			
	R3- 300x300		9.234	3.439
	R1- 300x600		275.815	101.185
	Slab thickness= 125mm			
G2	Columns:			
	R1- 400x400 mm		177.43	94.50
	Beams:			
	R2- 230x450 mm	2.40	51.56	65.16
		5.43	193.30	142.10
	R3- 300x600 mm	15.49	226.81	134.87
	R4- 300x600 mm	20.87	167.73	116.82
	R5- 300x600 mm			

5. DESIGN

DESIGN PARAMETERS:

As per IS 456-2000 code these design parameters has been set in STAAD PRO V8i software.

a) **Brace:** Beam/Column braced in both directions
b) **Clear cover:** for column = 40mm
for beam = 30 mm
c) **Ely:** Min length factor about local Y direction = 1
d) **Elz:** Min length factor about local Y direction = 1
e) **Fc:** compressive strength of concrete = 25 N/sq.mm
f) **Fy main:** 500 N/sq.mm
g) **Fy sec:** 500 N/sq.mm
h) **Max main:** 32mm
i) **Min main:** 12mm
j) **Max sec:** 10mm
k) **Min sec:** 8mm
l) **Ratio:** Max percentage of longitudinal reinforcement allowed = 4
m) **R face:** Longitudinal reinforcement in column along four faces
n) **Torsion:** Design for torsion
o) **Track:** Beam and column minimum details are printed
p) **Commands:** Design Beam, Design column.

Two way grid pattern (G1)

Column design:

COLUMN NO.	COLUMN AT GROUND FLOOR		
	SIZE	VERT.BARS	TIES
C1	300x300	8x12 ϕ	8 ϕ @ 150
C2	300x600	6x16 ϕ + 6x12	8 ϕ @ 150

Beam design:

BEAM NO.	SIZE (BxD) (OVERALL)	MID SPAN MAIN BARS		TOP BARS	EXTRA TOP UPTO 0.3xL AT SUPPORT	RING SPACING	REMARKS
		BOTTOM STRT. BARS	BOTM CUT AT MIDDLE 2/3*L				
R4	230x400	2 x 12 ϕ	1 x 12 ϕ	2 x 12 ϕ	1 x 12 ϕ	8 ϕ @ 150	SLAB LEVEL BEAM
R2	300x750	3 x 25 ϕ	3 x 25 ϕ	2 x 25 ϕ	3 x 25 ϕ	10 ϕ @ 150	

2) Diagonal grid pattern (G2):

Schedule of beams:

BEAM NO.	SIZE (BxD) (OVERALL)	MID SPAN MAIN BARS		TOP BARS	EXTRA TOP UPTO 0.3xL AT SUPPORT	RING SPACING	REMARKS
		BOTTOM STRT. BARS	BOTM CUT AT MIDDLE 2/3*L				
SB1	230x450	3 x 16 ϕ		3 x 16 ϕ		8 ϕ @ 150	SLAB LEVEL BEAM
SB2	300x600	3 x 25 ϕ		2 x 25 ϕ		8 ϕ @ 150	
SB3	300x600	4 x 25 ϕ		4 x 25 ϕ		8 ϕ @ 150	
SB4	300x600	3 x 32 ϕ		3 x 32 ϕ		8 ϕ @ 150	

Schedule of columns:

COLUMN NO.	COLUMN AT GROUND FLOOR			REMARKS
	SIZE	VERT.BARS	TIES	
C1	400x400	8x16 ϕ	8 ϕ @ 175 4-LEGD	REGULAR FOOTING

Schedule of slabs:

SLAB NO.	SIZE (OVERALL) IN MM	MID SPAN MAIN BARS		TOP BARS	DISTRIBUTION BARS C/C	EXTRA TOP BARS UPTO 0.3xL AT SUPPORT	REMARKS
		BOTM. BARS	BOTTOM BENT-UP @ L/4				
S1	125 THK.	8 ϕ@ 175	ALT. @ L/4		8 ϕ@ 175	8 ϕ@ 350	TWO WAY

6. ESTIMATION

Grid A: CONCRETE QUANTITY :

Size of members	No.	L (m)	B (m)	D (m)	Qty (cu.m)
Beams					
R2(300x750mm)	6	11.40	0.30	0.625	12.825
R4(230x400mm)	16	10.5	0.23	0.275	10.626
Columns					

R3(300x300mm)	4	3.6	0.3	0.3	1.296
R1(300x600mm)	12	3.6	0.3	0.6	7.776
Slab	1	10.5	10.5	0.125	13.78
Deductions	9		0.3	0.625	1.685
Total qty					44.618

REINFORCEMENT QUANTITY:

FOR COLUMN:

Description	Dia	No.	L(m)	wt/m	Qty (kg)
C1	12	8	4	0.89	28.48
C2	12 16	6 6	4 4	0.89 1.58	21.36 37.92
Lateral ties	8	28	1.040	0.395	11.50
				Total	**99.26**

FOR BEAMS:

For R4: 230x400 mm

Description	Dia	No.	L(m)	wt/m	Qty (kg)	Total Qty(kg)
Bott. Bars	12	2	13.20	0.89	23.49	93.98
Cut at middle 2/3*L	12	1	8	0.89	7.12	28.48
Top bars	12	2	13.20	0.89	23.49	93.98
Extra top	12	1	7.2	0.89	6.408	25.632
Stirrups	8	80	1.112	0.395	35.14	
					Total	**277.212**

For R2: 300x750 mm

Description	Dia	No.	L(m)	wt/m	Qty (kg)	Total Qty(kg)
Bott Bars	25	3	14.5	3.85	55.94x3=167.82	1006.92
Cut at middle 2/3*L	25	3	8	3.85	30.8x3=92.4	554.4
Top bars	25	2	14.5	3.85	55.94x3=167.82	1006.92
Extra top	25	3	3.6	3.85	13.86x3=41.58	249.48
Stirrups	8	120	1.960	0.395	92.91	
					Total	**2910**

For slab:

No. of bars required = 22

Straight bars = 11

Bent up bars = 11

Cutting length of bent up bars = L + 0.42H + Ld – bends

Here, H = D – (2 x clear cover) – diameter of bar

= 125 – (2 x 20) – 8 = 77

Cutting length of bent up bars = 3.34 m

Cutting length of straight bars = L + Ld

= 3000 + (45 x 8)

= 3.36 m

Distribution reinforcement:

No. of bars required = 22

Extra reinforcement = 8

Cutting length = L – (2 x 0.3L) + (2 x spacing)

= 3000 – (2 x 900) + 300

= 1.5 m

Description	Dia	No.	L(m)	wt/m	Qty (kg)	Total Qty(kg)
Bent up bar	8	11	3.34	0.3950	14.51	
Straight bars	8	11	3.36	0.3950	14.6	
Distribution reinforcement	8	22	3.36	0.3950	29.19	
Extra reinforcement	8	8	1.5	0.3950	4.74	
Summation					63.04 x 2	126.08
					Total	**2017.28**

TOTAL QUANTITY OF STEEL = 5303 kg

Grid G2 : CONCRETE QUANTITY

Beam(mm)	No.	L	B	D	Qty.(cu.m)
R2-230x450	4	12.40	0.23	0.325	3.707
R3-300x600	4	5.65	0.3	0.475	3.22
R4-300x600	4	11.31	0.3	0.475	6.44
R5-300x600	2	16.97	0.3	0.475	4.83
Slab	1	12.23	12.23	0.125	18.69
Column-400x400	12	3.55	0.4	0.4	6.816
				Total A	**43.70**
Deductions					
Junction of beams					
R3 & R5	4	0.3	0.3	0.475	0.171
R4 & R4	4	0.3	0.3	0.475	0.171
R4 & R5	4	0.3	0.3	0.475	0.171
R5 & R5	1	0.3	0.3	0.475	0.04275
				Total B	**0.55**

NET

QTY. = 43.15 cum

The steel quantities can be calculated as calculated for Grid pattern G1. So here is the quantity estimate of steel of grid pattern G2,

Dia	Colm. (m)	Beam (m)	Slab (m)	Total (m)	Wt (kg/m)	Total (kg)
8	20.16	1900	3100		0.395	2142
16	345.60	312		657	1.58	1039
25		528.56		528.56	3.58	1894
32		210.24		210.24	6.320	1328
					Total	**6403**

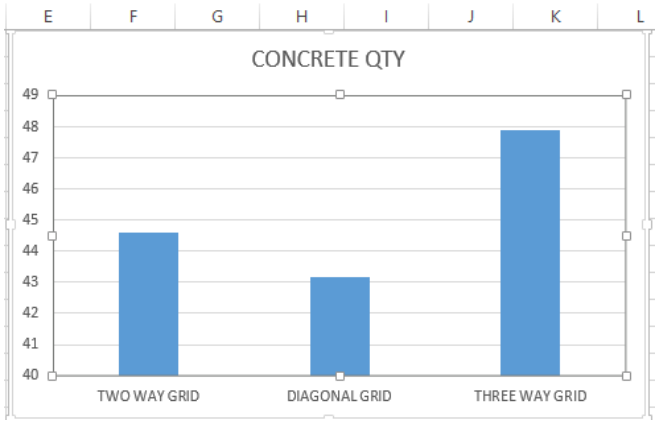
7. CONCLUSION

COST COMPARISON:

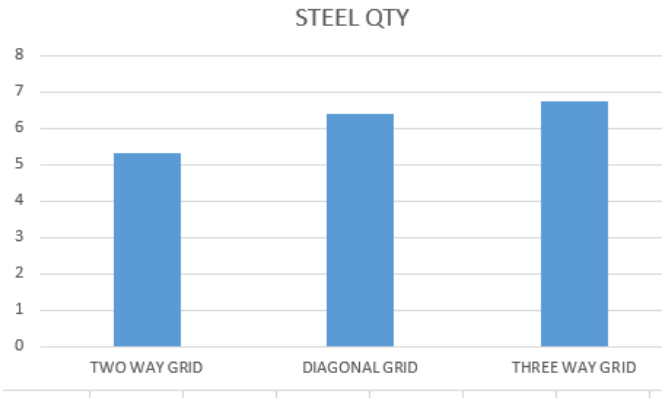
GRID NO.	C.C QTY.	RATE 7200/-	Steel QTY. (M.T)	RATE Rs.60,000/M.T	Total Amount	COST PER SQUARE FEET
1	44.618	3,21,249/-	5.303	3,18,180/-	6,39,429/-	4,440/-
2	43.15	3,10,680/-	6.403	3,84,180/-	6,94,860/-	4,825/-
3	47.90	3,44,880/-	6.727	4,03,620/-	748500/-	5,197/-

- The quantity of concrete required for grid 1 is 44.618 and steel quantity is 5.303 M.T and cost per square feet is 4400/-.
- The quantity of concrete required for grid 2 is 43.15 and steel quantity is 6.403 M.T and cost per square feet is 4825/-.

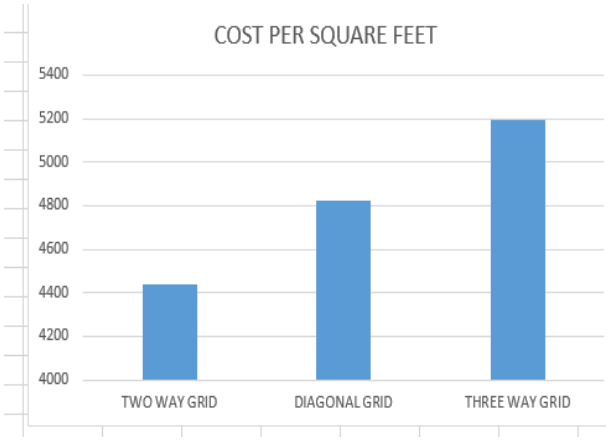
Thus we conclude that **TWO WAY GRID PATTERN** is **economical** cost wise as well as steel and concrete wise as compared to **DIAGONAL GRID.** But for architectural view purpose some may use Diagonal grid pattern as its aappearance is good as compared to two way grid pattern. Torsional rigidity of Diagonal grid pattern is good as compared to two way grids. There sre several grid patterns that can be used and each grid pattern has different significance on the structure. But they are way good compared to Buildings with no. of columns. Thus, We can cut the structural cost of the building by providing grid patterns of floor slabs.



CONCRETE QTY COMPARISON



STEEL QTY COMPARISON



COST COMPARISON

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