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Study On Effect Of Grid Patterns On Overall Cost Of Structure

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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 and is subjected to loads applies 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. As we know, the structural cost of work increases from time to time due to increase in material & labor cost, which ultimately lead to increase in 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.

The aim of present study is to analyze & design the floor by using the several grid patterns with the help of STAAD (Structural Technique of Analysis and design) software. Quantity of concrete and steel required for building is obtained and finally the total structural cost of building is found out for several grid patterns of floor slab. The aim also includes determining the most economical grid pattern from the results obtained from STAAD software. Quantity of steel and concrete for different grid patterns are compared with the help of bar charts.

KEYWORDS: -*Grid Pattern, floor slab, cost effectiveness, STAAD software*.

1. INTRODUCTION

A structure can be defined as a body which can resist the applied loads without appreciable deformations. Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc. in a safe and economical way. A structure is an assemblage of individual elements like pinned elements (truss elements), beam element, column, shear wall slab cable or arch. Structural engineering is concerned with the planning, designing and the construction of structures. Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Analysis is performed to predict the response of a structure to applied external loads. Real world structural problems are very complex in nature. Analysis of these problems requires idealization. Design process in selection and detailing of the components that make up the structural system. The main object of reinforced concrete design is to achieve a structure that will result in a safe and economical structure. The structural cost of work increases from time to time due to increase in material & labor cost, which ultimately leads to increase in 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. The grid patterns selected for analysis are shown by figure1

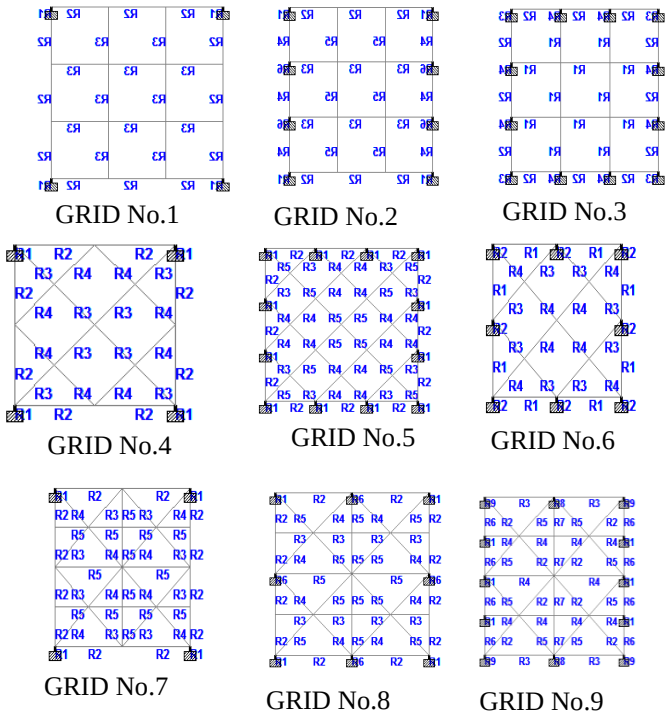


Figure 1 Grid Pattern selected for analysis and design.

2. Aim of this study:

This study aims to determine the most economical grid pattern from the selected nine grid patterns. The grid patterns are analyzed using STAAD software and the analysis results are used to design the grid patterns. The design results are further used to determine the quantity of concrete and steel required. Finally the total cost of grids is evaluated and cost comparison of grids is presented.

3. Objectives of this study:

- To analyze & design the floor for several grid patterns. (Using Software)
- To find the quantity of concrete & steel required for building
- To find the structural cost of the building with several grid patterns of floor slab.

4. Grid Patterns

The nine grids selected for analysis and design are discussed in this section. It is important to note that all the grids have same outer dimension i.e. 12m x 12m. The grids vary with number and position of columns. Moreover the internal beams of grids are also varied.

Grid 1 consists of transverse and longitudinal beams supported by four columns at the four corners as shown in figure 3.01. The sizes of beams and columns are as follows:
Beams:
R2= (500x750) mm
R3 = (300x750) mm
Columns:
R1= (500x500) mm
Slab Thickness= 125 mm
Floor Height=3.6m

Grid 2 also consists of transverse and longitudinal beams but is supported by eight columns in the transverse ends only as shown in figure1. The sizes of beams and columns are as follows:
Beams:
R2= (300x750) mm
R3 = (300x750) mm
R4= (230x450) mm
R5 = (300x750) mm
Columns:
R1= (350x600) mm
R6= (350x600) mm
Slab Thickness= 125 mm

Grid 3 consists of transverse and longitudinal beams but is supported by twelve columns in the transverse and longitudinal ends i.e. at each and every outer joint as shown in figure1. The sizes of beams and columns are as follows:
Beams:
R1= (300x750) mm
R2 = (230x450) mm
Columns:
R3= (300x500) mm
R4= (300x400) mm
Slab Thickness= 125 mm

Grid 4 consists of transverse, longitudinal and diagonal beams and is supported by four columns at the corner joints as shown in figure 1. The sizes of beams and columns are as follows:
Beams:
R2 = (300x600) mm
R3 = (230x600) mm
Columns:
R1= (450x450) mm
Slab Thickness= 120 mm

Grid 5 consists of transverse, longitudinal and diagonal beams and is supported by eight columns as shown in figure 1. The sizes of beams and columns are as follows:
Beams:
R1= (230x600) mm
R3 = (300x750) mm
R4 = (300x750) mm
Columns:
R2= (450x450) mm
Slab Thickness= 120 mm

Grid 6 consists of transverse, longitudinal and diagonal beams and is supported by twelve columns as shown in figure 1. The sizes of beams and columns are as follows:
Beams:
R2= (230x450) mm
R3 = (300x600) mm
R4 = (300x600) mm
R5 = (300x600) mm
Columns:
R1= (400x400) mm
Slab Thickness= 100 mm

Grid 7 is combination of **Grid 1** and **Grid 4** and is supported by four columns as shown in figure 1. The sizes of beams and columns are as follows:

Beams:
R2 = (500x750) mm
R3 = (300x750) mm
R4 = (300x750) mm
R5 = (300x750) mm
Columns:
R1= (500x500) mm
Slab Thickness= 100 mm

Grid 8 is also a combination of **Grid 1** and **Grid 4** but is supported by eight columns as shown in figure 1. The sizes of beams and columns are as follows:
Beams:
R2 = (300x350) mm
R3 = (230x600) mm
R4 = (300x750) mm
R5 = (300x750) mm
Columns:
R1= (300x350) mm
R6= (500x500) mm
Slab Thickness= 100 mm

Grid 9 is also a combination of **Grid 1** and **Grid 4** but is supported by twelve columns as shown in figure 1. The sizes of beams and columns are as follows:
Beams:
R2= (300x750) mm
R3 = (230x600) mm
R4 = (300x750) mm
R5 = (300x750) mm
R6 = (230x450) mm
R7= (300x750) mm
Columns:
R1= (300x450) mm
R8= (450x600) mm
R9= (300x300) mm
Slab Thickness= 100 mm

5. Static Analysis using STAAD

To perform static analysis in STAAD following steps must be followed:

i. Geometric Modeling
ii. Sectional Properties
iii. Material Properties
iv. Supports : Boundary Conditions (Static)
v. Loads & Load combinations
vi. Special Commands
vii. Analysis Specification
viii. Design command

Geometric Modeling

To model any structure in STAAD the first step is to specify the nodal co-ordinate data followed by selection of elements from element library.

Sectional & Material Properties

The element selected for modeling is then assigned the properties if the element is beam the cross section of beam is assigned. For plate elements thickness is assigned. After assigning the sectional property to the member it is important to assign it with member properties. Material properties include modulus of elasticity, poisson's ratio; weight density, thermal coefficient, damping ratio and shear modulus

Support and boundary condition

After assigning the sectional and material properties, boundary condition is assigned to the structure in form of fixed, hinged and roller support to structure. In the present work boundary condition is assigned in form of fixed support.

Load and load combination

Loads are a primary consideration in any building design because they define the nature and magnitudes of hazards are external forces that a building must resist to provide a reasonable performance (i.e., safety and serviceability) throughout the structure's useful life. The anticipated loads are influenced by a building's intended use (occupancy and function), configuration (size and shape) and location (climate and site conditions). In the presents study following loads are considered for analysis.

Dead Loads (IS- 875 PART 1):

Dead loads consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, including claddings, finishes and fixed equipment. Dead load is the total load of all of the components of the components of the building that generally do not change over time, such as the steel columns, concrete floors, bricks, roofing material etc.. In the study the following loads are taken under dead load:
Slab Weight
Σ Loads on beams of walls

Slab Weight calculation:
Thickness of slab=0.125m (Grid 1)
Density of concrete= 25kN/m^3
Self Weight of slab= Density of concrete x Thickness of slab
= 25x0.125
= 3.125kN/m^2
Floor Finish at floor level = 1.5 kN/m^2
Total Slab Weight at floor level= 4.625 kN/m^2

Wall load calculation:

Width of the wall=230mm
Beam size=500x750mm
Height of the wall=3.6m
Wall Weight = Thickness of wall x Height of wall x Density of brick wall
= 0.23 x (3.6-0.75) x 20
= 13.11kN/m

Live Loads (IS 875 PART 2):

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. The uniform and concentrated live loads should not be applied simultaneously on a structural evaluation. Concentrated loads should be applied to a small area or surface consistent with the application and should be located or directed to give the maximum load effect possible in end- use conditions. In staad we assign live load in terms of U.D.L .we has to create a load case for live load and select all the beams to carry such load. The following loads come under live loads

Σ Floor load

Floor load:

Live Load Intensity specified = 4 kN/m^2

Live Load at roof level =1.5 kN/m^2

The results obtained from the analysis of the above mentioned grids are summarized as shown in table 1:

Table 1 Summary of results of nine grids.

Type of Grid	Size of Members	Loads	Deflection. mm	Max Bending Moment Values (kNm)	Max Shear Force Values (kN)
G 1	Beams: B1= (500x750) mm B2 = (300x750) mm Columns: C1= (500x500) mm Slab Thickness= 125mm	Dead Load: Slab Weight=4.625kN/m^2 Wall Weight=14.49kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 23.12 44.96 ------	 936.56 205.97 743.84	 498.49 157.31 385.74
G 2	Beams: B1= (300x750) mm B2 = (300x750) mm B3=(230x450) mm B4=(300x750) mm Columns: C1= (350x600) mm C2=(350x600) mm Slab Thickness= 125 mm	Dead Load: Slab Weight=4.625 kN/m^2 Wall Weight=14.49kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 20.37 23.60 2.24 20.13	 645.92 718.83 60.00 60.27 518.75 490.80	 325.84 344.57 80.96 70.07 264.49 243.06
G3	Beams: B1= (230x450) mm B2 = (300x750) mm Columns: C1= (300x500) mm C2= (300x400) mm Slab Thickness= 125mm	Dead Load: Slab Weight=4.625 kN/m^2 Wall Weight=14.49 kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 2.70 20.51 	 61.64 326.52 49.19 195.96	 81.82 221.08 24.16 106.31
G 4	Beams: B1 = (500x750) mm B2 = (450x750) mm B3=(300x750) mm Columns: C1= (500x500) mm Slab Thickness=120mm	Dead Load: Slab Weight=4.5 kN/m^2 Wall Weight=14.49 kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 24.93 49.10 33.02 	 825.56 778.7 228.96 784.91	 366.64 334.28 113.60 411.59
G 5	Beams: B1= (230x600) mm B2 = (300x750) mm B3=(300x750) mm Columns: C1= (450x450) mm Slab Thickness= 120mm	Dead Load: Slab Weight=4.5 kN/m^2 Wall Weight=14.49 kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 3.37 17.75 9.95 	 114.58 178.53 310.79 292.02	 107.61 150.55 222.71 155.67
G 6	Beams: B1= (230x450) mm B2 = (300x600) mm B3= (300x600) mm B4= (300x600) mm Columns: C1= (400x400) mm Slab Thickness= 100mm	Dead Load: Slab Weight=4.0 kN/m^2 Wall Weight=14.49 kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 2.40 5.23 15.49 20.87 	 51.56 193.30 226.81 167.73 177.34	 65.16 142.10 134.87 116.82 94.50

G 7	Beams: B1 = (500x750) mm B2 = (300x750) mm B3= (300x750) mm B4= (300x750) mm Columns: C1= (500x500) mm Slab Thickness= 100mm	Dead Load: Slab Weight=4 kN/m^2 Wall Weight=14.49 kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 26.17 34.22 48.18 48.18	 841.11 212.05 636.71 427.0 754.45	 456.71 63.47 288.72 142.87 393.17
G 8	Beams: B1 = (230x600) mm B2 = (300x750) mm B3= (300x750) mm B4= (300x750) mm Columns: C1=(300x350) C2= (500x500) mm Slab Thickness= 100mm	Dead Load: Slab Weight=4 kN/m^2 Wall Weight=14.49 kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 3.70 10.0 8.62 13.41	 172.75 92.31 332.49 293.92 43.00 380.60	 144.02 49.20 182.20 191.66 23.42 201.60
G 9	Beams: B1 = (230x600) mm B2 = (300x750) mm B3= (300x750) mm B4= (300x750) mm B5= (230x450) mm B6= (500x750) mm Columns: C1=(300x300) mm C2= (300x450) mm C3= (450x600) mm Slab Thickness= 100mm	Dead Load: Slab Weight=4 kN/m^2 Wall Weight=14.49 kN/m Live Load: At Floor= 4 kN/m^2 At roof level =1.5 kN/m^2	 3.60 12.68 7.21 12.68 1.85 12.68	 130.26 219.24 170.81 248.33 39.57 345.47 33.03 182.86 354.46 (Mz=0.0)	 114.02 172.64 138.86 97.50 61.86 233.63 17.92 98.88 189.65 (Fz=0.0)

6. Quantitative comparison of grid patterns

Figure 2 shows structural components of Grid1 for which the quantity of concrete and steel is evaluated manually. Table 2 shows the concrete quantity of grid 1 whereas table 3 shows the reinforcement quantity required in construction of grid 1.

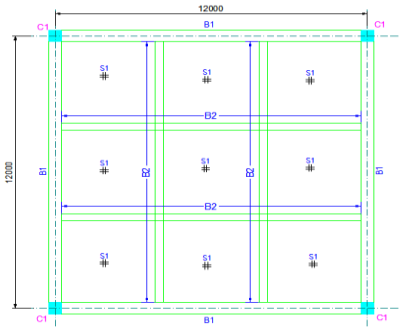


Figure 2 Structural component of Grid 1

Table 2 Concrete Quantity for Grid No.1

Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1(500 x 750)	2	12.50	0.50	0.625	7.81
	2	11.50	0.50	0.625	7.19
B2(300 x 750)	4	11.50	0.30	0.625	8.63
Slab	1	13.00	13.00	0.125	21.13
Column	4	0.50	0.50	3.600	3.60
				Total A	48.35
Deduction					
Junction of Beam B2 & B2	4	0.30	0.30	0.625	0.23
				Total B	0.23
			Net Quantity A-B		48.13

Table 3 Reinforcement Quantity of Grid 1

Diameter in mm	Column (Rmt.)	Beam. (Rmt.)	Slab (Rmt.)	Total (Rmt.)	Wt. (Kg/Rmt)	Total (Kg)
8	503.55	2582.40	2865.20	5951.15	0.395	2350.70
12	------	------	------	------	0.890	------
16	172.80	------	------	172.80	1.580	273.024
20	------	------	------	------	2.469	------
25	------	1015.60	------	1015.60	3.585	3640.926
32	------	------	------	------	6.320	------
					TOTAL (Kg)	6264.65
					M.T.	6.264

Figure 3 shows structural components of Grid 2 for which the quantity of concrete and steel is evaluated manually. Table 4 shows the concrete quantity of grid 2 whereas table 5 shows the reinforcement quantity required in construction of grid 2.

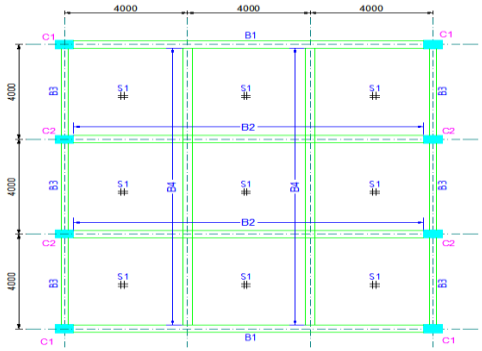


Figure3 Structural component of Grid 2

Table 4 Concrete Quantity for Grid No.2

Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1 (300 x 750)	2	12.60	0.30	0.625	4.73
B2 (300 x 750)	2	12.60	0.30	0.625	4.73
B3 (230 x 450)	6	3.70	0.23	0.325	1.66
B4 (300 x 750)	2	11.70	0.30	0.625	4.39
Slab	1	12.23	12.30	0.125	18.80
Colum C1	4	0.30	0.60	3.600	2.59
Colum C2	4	0.35	0.60	3.600	3.02
				Total A	39.92
Deduction					
Junction of Beam B2 & B4	4	0.30	0.30	0.625	0.23
				Total B	0.23
			Net Quantity A-B		39.69

Table 5 Reinforcement Quantity of Grid 2

8	724.642	1588.31	2865.20	5178.152	0.395	2045.37
12	------	60.84	------	60.84	0.890	54.15
16	316.80	------	------	316.80	1.580	500.544
20	------	------	------	------	2.469	------
25	------	637.20	------	637.20	3.585	2284.36
32	------	------	------	------	6.320	------
8	724.642	1588.31	2865.20	5178.152	0.395	2045.37
					TOTAL (Kg)	4884.424
					M.T.	4.884

Figure 4 shows structural components of Grid 3 for which the quantity of concrete and steel is evaluated manually. Table 6 shows the concrete quantity of grid 3 whereas table 7 shows the reinforcement quantity required in construction of grid 2.

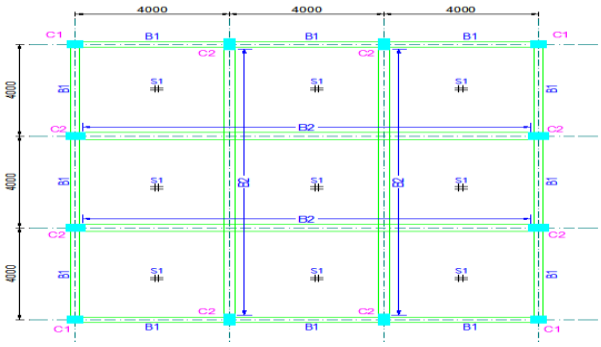


Figure4 Structural component of Grid 3

Table 6 Concrete Quantity for Grid No.3

Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1 (230 x 450)	2	12.50	0.23	0.325	1.87
	6	3.70	0.23	0.325	1.66
B3 (300 x 750)	2	12.40	0.30	0.625	4.65
	2	11.77	0.30	0.625	4.41
Slab	1	12.23	12.23	0.125	18.70
Colum C1	4	0.30	0.50	3.60	2.16
Colum C2	4	0.30	0.40	3.60	3.46
				Total A	36.90
Deduction					
Junction of Beam B2 & B4	4	0.30	0.30	0.625	0.23
				Total B	0.23
			Net Quantity A-B		36.68

Table 7 Reinforcement Quantity of Grid 3

8	836.856	1562.39	2856.20	5255.45	0.395	2075.902
12	------	301.66	------	301.66	0.890	268.480
16	374.40	------	------	374.40	1.580	591.552
20	------	------	------	------	2.469	------
25	------	333.60	------	333.60	3.585	1195.96
32	------	------	------	------	6.320	------
8	836.856	1562.39	2856.20	5255.45	0.395	2075.902
					TOTAL (Kg)	4131.894
					M.T.	4.131

Figure 5 shows structural components of Grid 4 for which the quantity of concrete and steel is evaluated manually. Table 8 shows the concrete quantity of grid 4 whereas table 9 shows the reinforcement quantity required in construction of grid 4.

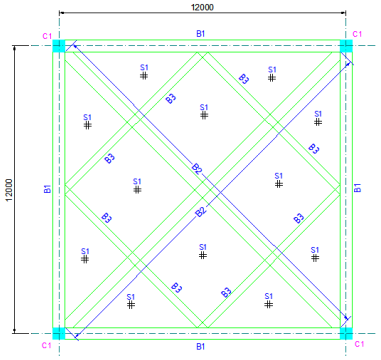


Figure5 Structural component of Grid 4

Table 8 Concrete Quantity for Grid No.4

Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1 (500 x 750)	2	13.00	0.50	0.630	8.19
	2	11.00	0.50	0.63	6.93
B2 (450 x 750)	2	15.556	0.45	0.63	8.82
B3 (300 x 750)	4	7.78	0.30	0.63	5.88
Slab	1	13.00	13.00	0.12	20.28
Colum	4	0.50	0.50	3.60	3.60
				Total A	53.70
Deduction					
Junction of Beam					
B2 & B2	1	0.45	0.45	0.630	0.13
B2 & B3	4	0.45	0.30	0.630	0.34
				Total B	0.47
			Net Quantity A-B		53.23

Table 9 Reinforcement Quantity of Grid 4

Dia. (mm)	Column (Rmt.)	Beam. (Rmt.)	Slab (Rmt.)	Total (Rmt.)	Wt. (Kg/Rmt)	Total (Kg)
8	503.55	3345.11	3385.6	7234.26	0.395	2857.532
12	------	------	------	------	0.890	------
16	------	------	------	------	1.580	------
20	172.80	------	------	172.80	2.469	426.643
25	------	845.24	------	845.24	3.585	3030.185
32	------	350.40	------	350.40	6.320	2214.528
					TOTAL (Kg)	8528.89
					M.T.	8.528

Figure 6 shows structural components of Grid 5 for which the quantity of concrete and steel is evaluated manually. Table 10 shows the concrete quantity of grid 5 whereas table 11 shows the reinforcement quantity required in construction of grid 5.

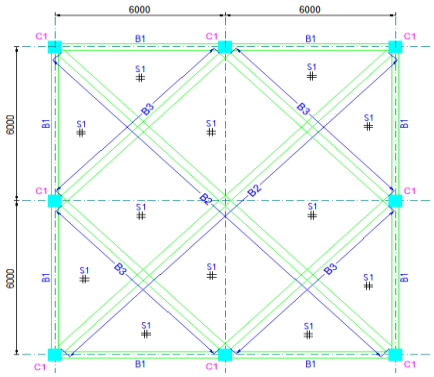


Figure6 Structural component of Grid 5

Table 10 Concrete Quantity for Grid No.5

Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1 (230 x 600)	2	12.45	0.23	0.480	2.75
	2	11.77	0.23	0.48	2.60
B2 (300 x 750)	2	15.556	0.30	0.63	5.88
B3 (300 x 750)	4	7.778	0.30	0.63	5.88
Slab	1	12.23	12.23	0.12	17.95
Column	8	0.45	0.45	3.60	5.83
				Total A	40.89
Deduction					
Junction of Beam					
B2	1	0.30	0.30	0.630	0.06
B2 & B3	4	0.30	0.30	0.630	0.23
				Total B	0.28
			Net Quantity A-B		40.61

Table 11 Reinforcement Quantity of Grid 5

Dia. (mm)	Column (Rmt.)	Beam. (Rmt.)	Slab (Rmt.)	Total (Rmt.)	Wt. (Kg/Rmt)	Total (Kg)
8	1353.41	2241.75	3385.6	6980.76	0.395	2757.4
12	------	------	------	------	0.890	------
16	345.60	398.40	------	744.00	1.580	1175.52
20	------		------	------	2.469	------
25	------	298.12	------	289.12	3.585	1036.495
32	------	210.24	------	210.24	6.320	1328.716
					TOTAL (Kg)	6298.131
					M.T.	6.298

Figure 7 shows structural components of Grid 6 for which the quantity of concrete and steel is evaluated manually. Table 12 shows the concrete quantity of grid 6 whereas table 13 shows the reinforcement quantity required in construction of grid 6.

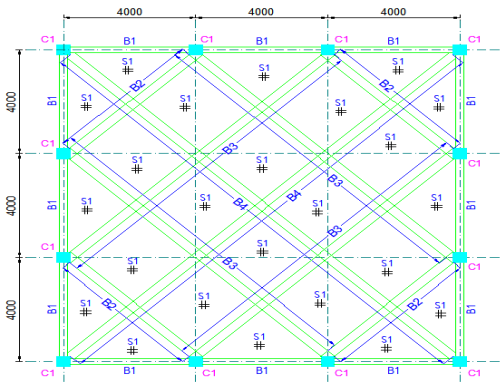


Figure7 Structural component of Grid 6

Table 12 Concrete Quantity for Grid No.6

Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1 (230 x 450)	2	12.45	0.23	0.350	2.00
	2	11.77	0.23	0.35	1.89
Beam B2 (300 x 600)	4	5.650	0.30	0.50	3.39
B3 (300 x 600)	4	11.313	0.30	0.50	6.79
B4 (300 x 600)	2	16.970	0.30	0.50	5.09
Slab	1	12.23	12.23	0.10	14.96
Colum	12	0.40	0.45	3.60	7.78
				Total A	41.90
Deduction					
Junction of Beam					
B2 & B4	4	0.30	0.30	0.500	0.18
B3 & B4	4	0.30	0.30	0.500	0.18
B3 & B3	4	0.30	0.30	0.500	0.18
B4 & B4	1	0.30	0.30	0.500	0.05
				Total B	0.59
			Net Quantity A-B		41.32

Table 13 Reinforcement Quantity of Grid 6

Dia. (mm)	Column (Rmt.)	Beam. (Rmt.)	Slab (Rmt.)	Total (Rmt.)	Wt. (Kg/Rmt)	Total (Kg)
8	862.85	2304.43	3137.4	6304.68	0.395	2490.348
12	------	------	------	------	0.890	------
16	345.60	312.00	------	657.60	1.580	1039.00
20	------	------	------	------	2.469	------
25	------	528.56	------	528.56	3.585	1894.887
32	------	210.24	------	210.24	6.320	1328.716
					TOTAL (Kg)	6752.951
					M.T.	6.752

Figure 8 shows structural components of Grid 7 for which the quantity of concrete and steel is evaluated manually. Table 14 shows the concrete quantity of grid 7 whereas table 15 shows the reinforcement quantity required in construction of grid 2.

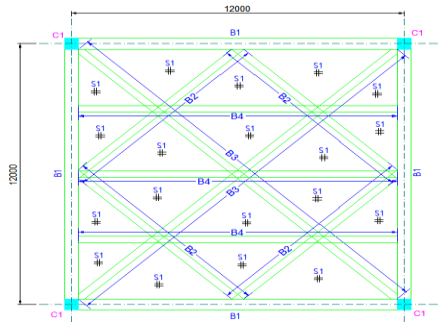


Figure8 Structural component of Grid 7

Table 14 Concrete Quantity for Grid No.7

Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1 (500 x 750)	2	12.50	0.50	0.650	8.13
	2	11.00	0.50	0.65	7.15
Beam B2 (300 x 750)	4	7.778	0.30	0.65	6.07
B3 (300 x 750)	2	15.556	0.30	0.65	6.07
B4 (300 x 750)	3	11.000	0.30	0.65	6.44
Slab	1	12.50	12.50	0.10	15.63
COLUM	4	0.50	0.50	3.60	3.60
				Total A	53.07
Deduction					
Junction of Beam					
B2 & B3, B4	2 x 4	0.30	0.30	0.650	0.47
B3, B3 & B4	2	0.30	0.30	0.650	0.12
				Total B	0.59
			Net Quantity A-B		52.48

Table 15 Reinforcement Quantity of Grid 7

Dia. (mm)	Column (Rmt.)	Beam. (Rmt.)	Slab (Rmt.)	Total (Rmt.)	Wt. (Kg/Rmt)	Total (Kg)
8	503.55	4206.60	3137.40	7847.55	0.395	3099.782
12	------	------	------	------	0.890	------
16	------	------	------	------	1.580	------
20	172.80	------	------	172.80	2.469	426.643
25	------	1158.84	------	1158.84	3.585	4154.441
32	------	280.32	------	280.32	6.320	1771.622
					TOTAL (Kg)	9452.488
					M.T.	9.452

Figure 9 shows structural components of Grid 8 for which the quantity of concrete and steel is evaluated manually. Table 16 shows the concrete quantity of grid 8 whereas table 17 shows the reinforcement quantity required in construction of grid 2.

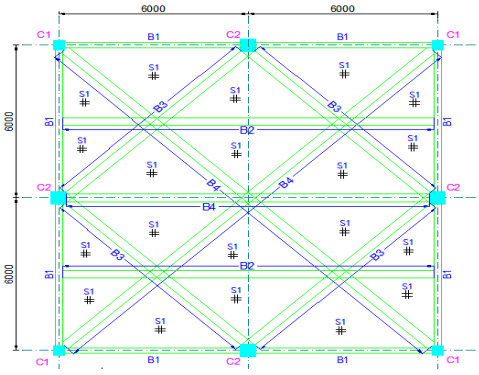


Figure9 Structural component of Grid 8

Table 16 Concrete Quantity for Grid No.8

Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1 (230 x 600)	2	12.35	0.23	0.500	2.84
Beam B1	2	11.77	0.23	0.50	2.71
Beam B2 (300 x 750)	2	11.770	0.30	0.65	4.59
B3 (300 x 750)	4	7.778	0.30	0.65	6.07
B4 (300 x 750)	1	11.77	0.30	0.65	2.30
	2	15.56	0.30	0.65	6.07
Slab	1	12.23	12.23	0.10	14.96
COLUMN C1	4	0.35	0.35	3.60	1.76
C2	4	0.50	0.50	3.60	3.60
				Total A	44.89
Deduction					
Junction of Beam					
B2 & B3, B4	2 x 4	0.30	0.30	0.650	0.47
B4, B4 & B4	2	0.30	0.30	0.650	0.12
				Total B	0.59
			Net Quantity A-B		44.30

Table 17 Reinforcement Quantity of Grid 8

Dia. (mm)	Column (Rmt.)	Beam. (Rmt.)	Slab (Rmt.)	Total (Rmt.)	Wt. (Kg/Rmt)	Total (Kg)
8	753.20	2724.45	3137.40	6615.05	0.395	2612.944
12	------	------	------	------	0.890	------
16	288.00	------	------	288.00	1.580	455.04
20	------	309.60	------	309.60	2.469	764.402
25	------	442.48	------	442.48	3.585	1586.29
32	------	288.54	------	288.54	6.320	1823.572
					TOTAL	7242.248
					M.T.	7.242

Figure 10 shows structural components of Grid 9 for which the quantity of concrete and steel is evaluated manually. Table 18 shows the concrete quantity of grid 9 whereas table 19 shows the reinforcement quantity required in construction of grid 2.

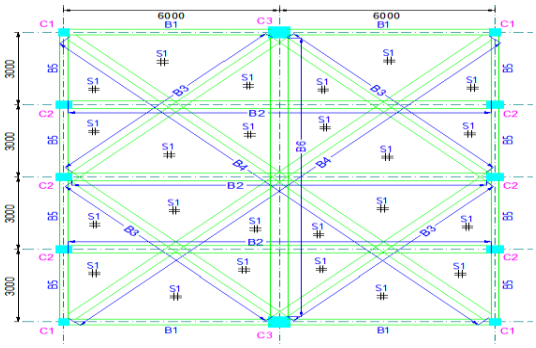


Figure10 Structural component of Grid 9

Table 18 Concrete Quantity for Grid No.9

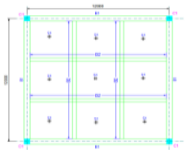
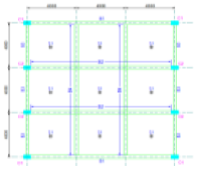
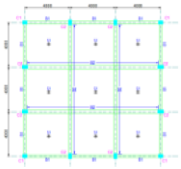
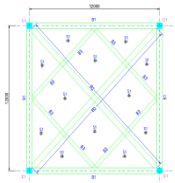
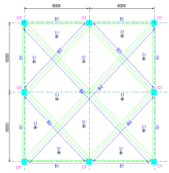
Beam	Number of beam	Length of beam (L)	Width of beam (B)	Clear depth of beam (d)	Quantity in m^3
B1 (230 x 600)	2	12.30	0.23	0.50	2.83
B2 (300 x 750)	3	11.77	0.30	0.65	6.89
Beam B3 (300 x 750)	4	7.778	0.30	0.65	6.07
B4 (300 x 750)	2	15.556	0.30	0.65	6.07
B5 (230 x 450)	2	11.77	0.23	0.35	1.89
B6 (500 x 750)	1	11.77	0.50	0.65	3.83
Slab	1	12.23	12.23	0.10	14.96
Column C1	4	0.30	0.30	3.60	1.30
C2	6	0.30	0.45	3.60	2.92
C3	2	0.45	0.60	3.60	1.94
				Total A	48.68
Deduction					
Junction of Beam					
B2 & B3, B4	2 x 4	0.30	0.30	0.65	0.47
B2 & B6	2	0.30	0.50	0.65	0.20
B2, B4&B4	2	0.30	0.30	0.650	0.12
				Total B	0.78
			Net Quantity A-B		47.90

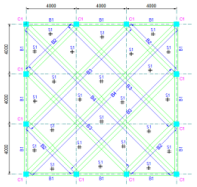
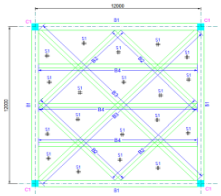
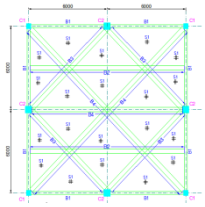
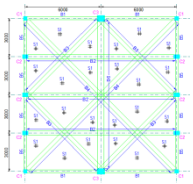
Table 19 Reinforcement Quantity of Grid 9

Dia. (mm)	Column (Rmt.)	Beam. (Rmt.)	Slab (Rmt.)	Total (Rmt.)	Wt. (Kg/Rmt)	Total (Kg)
8	812.56	3182.32	3137.4	7132.28	0.395	2817.25
12	------	------	------	------	0.890	------
16	331.20	102.80	------	434.00	1.580	685.72
20	86.40	683.04	------	769.44	2.469	1899.747
25	------	369.44	------	369.44	3.585	1324.442
32	------	------	------	------	6.320	------
					TOTAL (Kg)	6727.159
					M.T.	6.727

The above results are complied and a cost comparison of all nine grids are presented in table 20

Table 20 Cost comparison of nine grids

1	2	3	4	5	6	7	8
Grid No.	C.C. Qty. (Cum)	Rate (Rs.6010/cum)	Steel Qty (M.T.)	Rate (Rs.54680/M.T.)	Total Amount (Rs.) (3+5)	Cost/Sq. mtr (12x12)m (Rs.)	Size
1	48.13	2,89,261/-	6.264	3,42,516/-	6,31,777/-	4,387/-	
2	39.69	2,38,537/-	4.884	2,67,057/-	5,05,594/-	3,511/-	
3	**36.68**	**2,20,447/-**	**4.131**	**2,25,883/-**	**4,46,330/-**	**3,100/-**	
4	53.23	3,19,912/-	8.528	4,66,311/-	7,86,223/-	5,460/-	
5	40.61	2,44,066/-	6.298	3,44,375/-	5,88,441/-	4,086/-	

6	41.32	2,48,333/-	6.752	3,69,199/-	6,17,532/-	4,288/-	
7	52.48	3,15,405/-	9.452	5,16,835/-	8,32,240/-	5,779/-	
8	44.30	2,66,243/-	7.242	3,95,993/-	6,62,236/-	4,599/-	
9	47.90	2,87,879/-	6.727	3,67,832/-	6,55,711/-	4,554/-	

The above mentioned values of concrete quantity and steel along with their cost results are used to prepare bar charts which give a clear picture of which of grid patterns is economical. Figure 11 shows the cost comparison of different grids. The concrete quantity and steel quantity of different grids is as shown by figure 12 and figure 13 respectively.

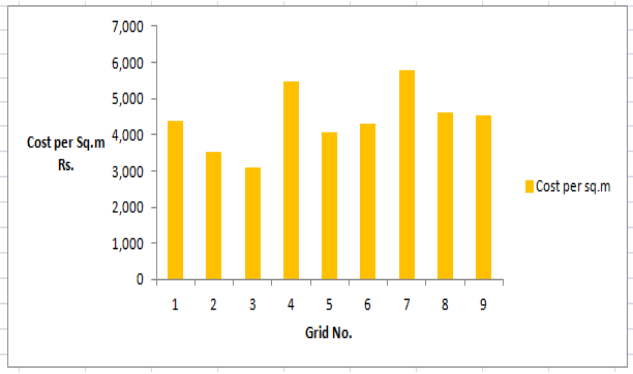


Figure 11 Cost Comparison of different Grids

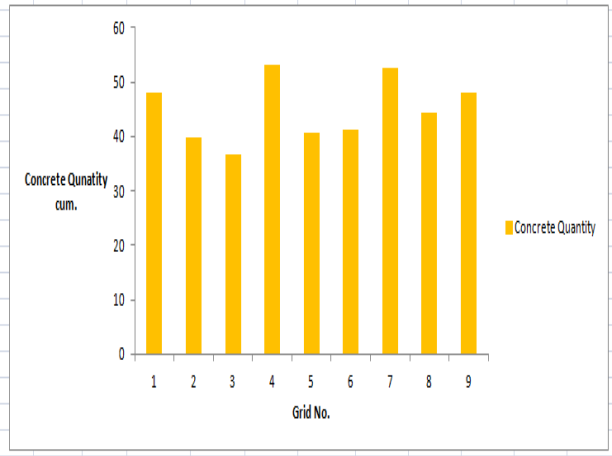


Figure 12 Concrete Quantity of different Grids

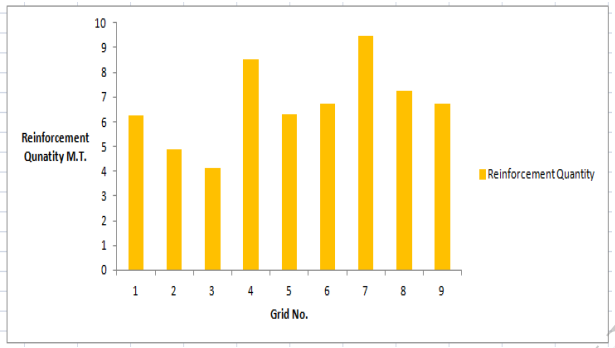


Figure 13 Reinforcement Quantity of different Grids

7. Summary

In the present study, an attempt is made to study the cost effectiveness of building by using nine grid patterns. The study has been divided into three main parts. First part included the static analysis of building. The results in form of S.F.D, B.M.D and deflection were obtained. A comparative table of these results for all the grids has also been presented. In the next section design of these grid patterns from the static results has also been discussed. In the third a cost comparison of the grid patterns has been discussed. The quantity of building materials such as concrete and steel is also evaluated. From the evaluated quantity of steel and concrete, the cost of each and every grid is presented. In the next section conclusions obtained from the study is presented.

8. Conclusions

The major conclusions drawn from the present study are as follows:

1. The quantity of concrete required for grid no. 1 is 48.31 m^3 whereas the steel requirement is 6.26 metric tons. The total cost per square m required in construction of grid no.1 is 4387/-
2. The quantity of concrete required for grid no. 2 is 39.69 m^3 whereas the steel requirement is 4.88 metric tons. The total cost per square m required in construction of grid no.2 is 3511/-
3. The quantity of concrete required for grid no. 3 is 36.68 m^3 whereas the steel requirement is 4.13 metric tons. The total cost per square m required in construction of grid no.3 is 3100/-
4. The quantity of concrete required for grid no. 4 is 53.23 m^3 whereas the steel requirement is 8.53 metric tons. The total cost per square m required in construction of grid no.4 is 5460/-
5. The quantity of concrete required for grid no. 5 is 40.61 m^3 whereas the steel requirement is 6.30 metric tons. The total cost per square m required in construction of grid no.5 is 4086/-
6. The quantity of concrete required for grid no. 6 is 41.32 m^3 whereas the steel requirement is 6.75 metric tons. The total cost per square m required in construction of grid no.6 is 4288/-
7. The quantity of concrete required for grid no. 7 is 52.48 m^3 whereas the steel requirement is 9.45 metric tons. The total cost per square m required in construction of grid no.7 is 5779/-
8. The quantity of concrete required for grid no. 8 is 44.30 m^3 whereas the steel requirement is 7.24 metric tons. The total cost per square m required in construction of grid no.8 is 4599/-
9. The quantity of concrete required for grid no. 9 is 47.90 m^3 whereas the steel requirement is 6.73 metric tons. The total cost per square m required in construction of grid no.9 is 4554/-
10. The **grid no 3** is **most economical grid** cost wise as well as steel and concrete quantity wise.
11. The **grid no.7** is the **most uneconomical cost** and steel quantity wise whereas grid no.4 is the most uneconomical concrete quantity wise.

9. References

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