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Planning, Design and Analysis of G+3 Hospital Building Provided with Grid Slab

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Abstract - *Grid floor slab consists of beams spaced at regular intervals in perpendicular directions which are monolithic with slab. These slabs are generally used for architectural purpose for large spans such as public assembly halls, auditoriums; show rooms were the slab has to cover a large column free space is required. Since gird slab offers more stiffness the rectangular voided pattern is used in present study. In the present study G+3 building is considered, analyzed and designed is done as per IS codes. The structure is analyzed using ETABS software and design has been done manually.*

Key Words: Grid Slab, Parameters, Spacing and ETABS.

1. INTRODUCTION

Building construction in the engineering deals with the construction of building such as public buildings, residential buildings and commercial buildings. In a simple building can be define as an enclose space by walls with roof, food, cloth and the basic need of human beings. A building is a manmade structure with a roof and walls together standing in one place. Buildings may be of various size, shape and of different functions. A Multi-Storied is a building that has more than one floor above ground in the building. The design process of multi-stored building not only requires imagination and concepts but also with good knowledge structural engineering and also knowledge of practical aspects, such as recent design codes, bye laws, modern methods of constructions. A hospital building are one among the most complex building type. It contains vast range of services with various functional units.

1.1 Grid slab

A grid slab is a type of slab which has two directional reinforcement with monolithic slab at the top, it gives the shape of pockets on a waffle. These slabs are usually used for architectural purpose for large spans with no column interfering at the center such as public assembly halls, auditorium halls cinema theaters. It gives good architectural view with pleasing appearance. Very less maintenance cost. However, construction of the grid slabs is more challenging. By investigation of various parameters, the grid slabs found to be cost effective, for which proper method of analyzing to be done. There are various approximate methods available for analyzing the grid slab system, i.e. as per Is 456-2000 Recommendation or by Rankine Grashoff Method. This are generally used for architectural reasons for large rooms such as Entrance of a hall, Library, cinema theatre, show rooms where large spacing of column is required. The rectangular or square or Dia-grids void formed in the ceiling is has one great advantage that it can be utilized for concealed architectural lighting.

Application of Grid slab

- Grid Floor slabs are built or constructed whenever large column free flat roof is required.
- Grid slabs are light in weight due this it can carry a heavier load at longer span. 6-15m longer span may possible to design with post tensioning.
- It is also cost effective and economical as concrete and steel is reduced to 15% and 10% respectively compared to the normal T beams.
- It has low frequency of vibration and low floor deflections.
- These slabs are often used for architectural purpose such as public assembly halls, auditorium halls cinema theaters, Garages, Airports etc.
- Its strong foundation characteristics of crack and sagging resistance may also be the main purpose of employing this technology. Grid slab can bear a large amount of load compared with other conventional slabs.

Fig -1: Grid floor slab

1.2 LITERATURE REVIEWS

Rangy Jose et.al [1]:

He studied about Structural analysis of G+3 story building and design of this commercial building. Using ETABS. Structural Analysis is a branch of civil engineering which involves in the determination of behavior of structures with different structural components against the effect of loads. Every structure will be subjected to one or the other groups of loads, this are some various kinds of loads which are normally considered i.e., dead load, live load, wind load and earthquake load. ETABS stands Extended Three-Dimensional Analysis of Building System is a CSI software which is take in as part of a whole major analysis engines that is static and dynamic, Linear and non-linear, etc. and this Software especially used to analyze and design of multistory buildings. His project "Analysis and Design of Commercial building using ETABS software" is an attempt to analyze and design a G+3 commercial building using ETABS. A G+3 storey commercial building is taken for his study. Analysis is carried out by static method and design is done as per IS 456:2000 guidelines using software. Also, design the structural elements manually. Drawing and detailing are done using Auto CAD software as per code SP 34.

Navjot Kaur Bhatia [2]:

He made a studies on the dynamic performance of flat slab and grid slab. And compare it with a conventional slab. During the study of the project the author has performed the dynamic analysis for earth quack and wind load of multistory reinforced building with different plan and shapes like square, hexagonal, orthogonal for these flat, grid and conventional slab. The analysis also done for different stories like 10, 20 and 30 and for the different earthquake zone as per the Indian standard code of practice. They had made the relation between earthquake responses and their intensities. About 45-50% increase of cost in conventional slab and about 165% increase in the cost when compared to flat slab.it is also in term of deflection and material cost.

2. METHODOLOGY

1. Modeling in Etabs

2. Analysis &

3. Design

1. Modelling :

Design first step is modelling. In this step we assign a property of structural elements like Slabs, Beams, Columns, Staircase and Shear Walls and modelled. dead load / Self weight are determined based on the dimension of structural elements. Live Load on slabs structure is taken from IS 875-1987 PART II and determined total load.

Example: calculation of loads for analysis

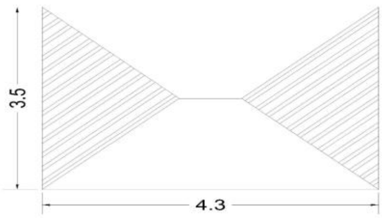

Fig -2: load distribution

Area of left hatched triangle=0.5x3.5x1.75 =3.06m2

Live load on slab=4 KN/m2

Dead load=0.15x1x25=3.75 KN/m

Masonry load=12Kn/m

Load on beam= (3.06x3) + (3.75x3.06) = 20.65KN

Load on beam in KN/m= 20.65/3.5 = 5.90KN/m

Total load on beam = 5.90+12 = 17.90 KN/m

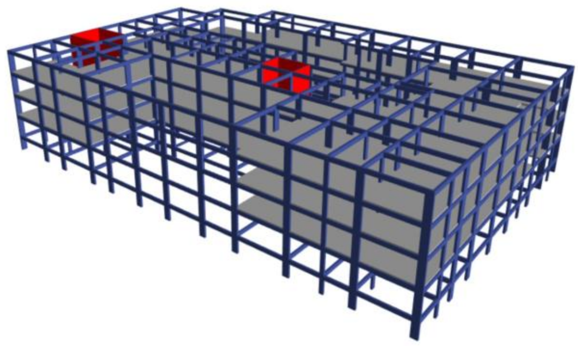

Fig -2: 3D- modelling of structure

2. Analysis:

Analysis is the second step for proceeding design. This step deals with the Loads which are applied on slabs and beams are analyses by using E-tabs. After analyzing the structure we get, bending moment, Shear Force, Axial forces at each and every points of element.

3. Design:

This step is final step from which we obtained detailing of all elements, by using their maximum bending Moment values and Shear Force values within a group for Beams, also based on their spans Slabs are designed. Similarly, Columns and Footings are designed based on Axial Forces and type of bending within group.

A. Design of Slab

Based on their lateral dimensions slabs are classified into two slabs i.e One Way Slab/ One Way Continuous Slab. Two Way Slab/ Two Way Continuous Slab.

- One Way Slab

If ly/lx >2 a Slab is known as One-way slab.

Where ly - Lateral dimension along longer span.

lx - Lateral dimension along shorter span.

- Two Way Slab

If ly/lx <2 a Slab is known as two-way slab. Reinforcement provided in this type of slab is in both x and y direction.

- Grid floor slab (Rankine - Grash off Method)

This method is suitable for small span grids with the spacing of ribs not exceeding 1.50 m. based on equating deflections in either direction at the junctions of ribs. Slab is to be considered as simply supported on edges. In this grid slab the thickness of slab is less compare to conventional slab and flat slab.

Example: Design of grid floor slab slab

Grid floor Hall Size = 11 * 23

Design of Top Slab

Step 1 Dimension

Assume size = 1.5 * 1.5

It is continuous on all four sides

Thickness of slab required = 1500/40 = 37.5 mm

Let thickness selected be (D_f) **90 mm**

Fck = 25 Mpa, Fy = 500 Mpa

Load on slab:

Self-Weight (DL) = .09*1*1*25 = 2.25 KN/m^2

Floor Finish (FF) = 1 KN/m^2

Live Load (LL) = 3 KN/m^2

Factored load (Wu) = 1.5*6.25 = 9.375 KN/m^2

From Table 26 of IS:456-2000

$a_x = a_y = .032$

Mu = $M_x = M_y = a_x$* Wu*l^2 = .032*9.375*1.5^2 = 0.675 KN-m

Assume 8mm dia bar are used

Effective Depth of slab = 90/2 - .5*8 = 41 mm

Calculation of B.M:

$M_{u\ lim}$ = .138*fck*b*d^2 = .138*25*1000*41^2 = 5.7 KN-m

$M_{u\ lim} > M_u$, **therefore thickness selected is sufficient**

Calculation of Ast:

Ast=(0.5*fck/fy)(1-sqrt(1-(4.6*Mu/fck*b*d^2)))bd= 38.59 mm^2

Ast_{min} = .12/100 *1000*90 = 108 mm^2

Using 6 mm bars,

ast = 3.14159*d^2/4 = 28.27 mm^2

Spacing = 1000*ast/Ast = 261.8 mm

therefore provide 6mm dia bar @ 250mm c-c in both direction

Design of Ribs or Grid Beams

Size of Beam

Let Depth be 550 mm

Overall Depth (D) = 600 mm

Depth of Rib (d) = 600-90 = 510 mm

Width of rib not be less than 510/4 = 127.5 mm

Take, Width of rib (b_w) = 150 mm

Distance B/w 2 adjacent beam = 1.5-.15 = 1.35 m

No. of Grids = 11/1.5 * 23/1.5 = 112.44 = 113

Hollow portion Depth = 600-90 = 510mm

Step 2 Load calculation

Self wt = (0.6*11*23-113*1.35*1.35*.51)*25 =1169.23 KN/m^2

Self wt per unit area = 1849.98/11*23 = 4.62 KN/m^2

Floor finish (FF) = 1 KN/m^2

Live Load (LL) = 3 KN/m^2

Factored Load (Wu) = 1.5*(8.62) = 12.93 KN/m^2

From Table 26 in IS 456-2000 for Four edges discontinuous slab with (r) ly/lx = 23/11 = 2.09

Load per unit length in shorter direction = $q_1 = q*r^4/1+r^4 = 2.09^4*12.93 /1+2.09 = 12.29$ KN/m²

$q_2 = q/1+r^2 = 12.93/(1+2.09^2) = 2.41$ KN/m²

Ultimate loads $q_1 = 1.5*12.29 = 18.435$ KN/m²

$q_2 = 1.5*2.41 = 3.615$ KN/m²

Step 3 Calculation of B.M and S.F

Design Moments $(M_{ux}) = q_1*l_x^2/8 = 278.83$ KN-m

$(M_{uy}) = q_2*l_x^2/8 = 239.04$ KN-m

Design Shear $(V_{ux}) = q_1*l_x/2 = 101.4$ KN

$(V_{uy}) = q_2*l_x/2 = 41.57$ KN

Step 4 Reinforcement in shorter span

The beam is of T-section

$l_o = .7*l$, $b_w = 150$ mm, $D_f = 90$mm

Width of flange (B) = $l_o/6+b_w+6D_f = 865$ mm

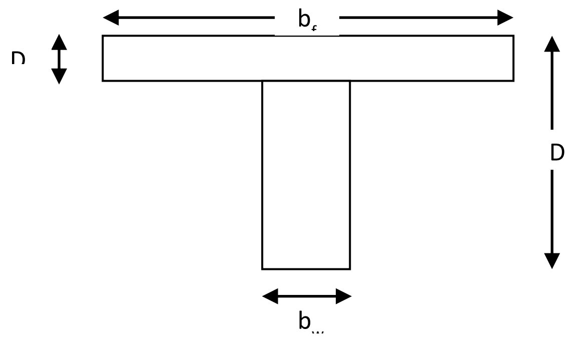

Fig -3: T- Beam

N-A is assumed to be at bottom flange

mu' = $.36*fck*B*D_f*(d-.42D_f) = 330.84$ KN-m > M_{ux}

therefore N-A lies in Flange

Ast=(0.5*fck/fy)(1-sqrt(1-(4.6*Mu/fck*b*d²)))bd=1548.3 mm²

Provide 6 bars of 20mm dia

Reinforcement in longer span

Ast=(0.5*fck/fy)*(1-sqrt(1-(4.6*Mu/fck*b*d*d)))*b*d = 1309.92 mm²

Provide 6 bars of 20mm dia

Design for Shear

In shorter direction, $V_{ux} = V = 101.4$ KN

Check For Shear, Tv = Vu/(b*d) = 1.352 N/mm²

ast provided =1000/100 *((3.14159*d^2)/4 = 804.25 mm²

pt provided (100*ast pro/b*d) = .89 %

Tc = .6092

Tv > Tc

Balanced shear force (Vu-Vc) = V_{us} = 51.14 KN

Provide 2 legged 8mm stirrups,

Asv = 3.14159*2*(8^2)/4 = 100.53 mm²

Spacing .87*fy*Ast*d/sv = Sv = 437 mm

Provide 8mm dia 2 leg verticle stirrup @ 300mm c/c

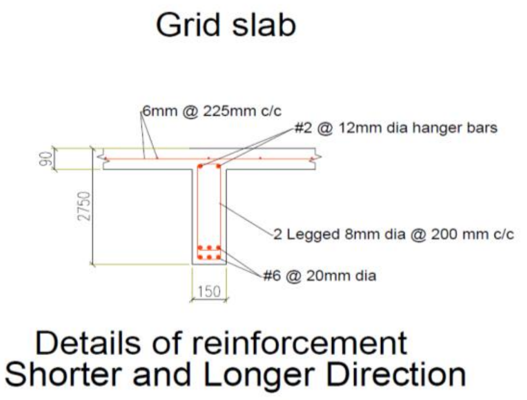

Fig -4: Detailing of grid slab(rib)

2. Design Of Beams

Beam supports Slabs by taking up the load from slab. There are two types of beam i.e Singly Reinforced Sections, Doubly Reinforced Sections.

- Singly Reinforced Sections –The more preferred beam is singly reinforced beam because it provides sufficient warning before the structure collapse. the longitudinal reinforcement will be provided only in tension zone.

- Doubly Reinforced Sections –In this type, longitudinal reinforcement will be provided in both tension and Compression zone.

Example: Design of beam

Design Summary-

Beam size = 230mm x 450mm

Main tensile bars = 6-# 16mm dia bars

Anchor bars = 2- # 12mm dia bars

Stirrups = 8mm dia bar 2LVS

Spacing = 300mm c/c

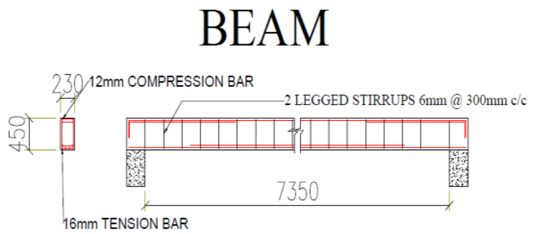

Fig -5: Detailing of beam

3. Design Of Columns

Column supports beam by taking up the load from slab to beam, beam to column. Column is subjected to axial load and It is a Compression member.

Example: Design of column

Design Summary-

column size = 230mm x 750mm

length of column= 3000mm

Main bar- 6 # of 25mm dia

Stirrups = 8mm dia bar 2LVS

Spacing = 150mm c/c

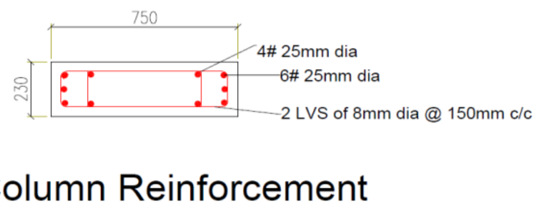

Fig -6: Detailing of column

4. Design Of Footings

footing supports whole structure by taking up the load from slab to beam, beam to column, column to footing. These are flexural member which will be subjected to Bending. There are many types of footing but in our case we considered isolated footing.

Design Summary:

Load from column = 1535 KN

Footing size = 2.5m x 3.5m

Area of reinforcement along x-direction : 12 mm dia @50 mm c/c

Area of reinforcement along y-direction : 12 mm dia @ 75 mm c/c

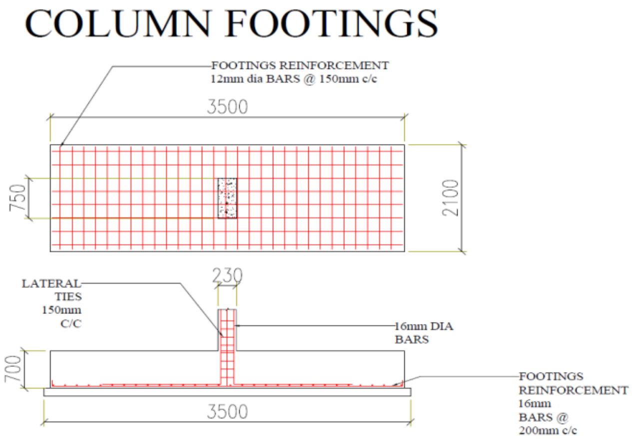

Fig -7: Detailing of footing

3. CONCLUSION

It is increasing overall stiffness of the building thus, reducing the sway problem in the structure. Analysis and design of building using ETABS reduces a lot of time in the work. The software had provide more area of steel in the RCC members as compared to theoretical calculation. This was due to different design approach used in the software. ETABS is more user-friendly and its results and design have a detailed explanation of its derivation. This becomes an invaluable tool which enables us to make last minute changes in load and the designs can be quickly generated. The study of hospital building with grid slab in the this paper shows results are more conservative in Static analysis as compared to the dynamic analysis.

REFERENCES

[1.] IS: 456 (2000) - Plain And Reinforced Concrete Code of Practice

[2.] IS 12433:2001, 'Basic Requirements for Hospital Planning', Bureau of Indian Standards, New Delhi 110002.

[3.] IS 875 (part -2)-1987, 'Code of Practice For Design Loads', Bureau of Indian Standards, New Delhi 110002.

[4.] Structural Design of concrete structure using E-Tabs, Shivam Asawa, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Volume 14, Issue 1 ver. 4 (Jan – Feb 2017).

[5.] Design and analysis of multistoried building under static and dynamic loading Conditions by using E-TABS by Balaji and Selvarasan in International Journal of Technical Research and Applications, Volume 4, Issue 4(July-Aug, 2016).

[6.] Navjot Kaur Bhatia, Volume 3 May 2016 Studying the Response of Flat Slab & Grid Slabs System in Conventional RCC Buildings, International Journal of Trends in Research and Development (IJTRD), pp.335 - 337.

[7.] Ragy Jose, Restina Mathew, Sandra Devan, Sankeerthana Venu, Mohith Y S Volume: 04 Issue 06, June-2017 Analysis and Design of Commercial Building Using E-tabs International Research Journal of Engineering and Technology (IRJET).