Analysis and Design of Multistory Building Using STAAD Pro and Modefing It with Manual Calculations

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Abstract: The art and science of designing with affordable, useful, and long-lasting structures is known as structural planning. Generally speaking, this project is built on theoretical design and analysis of a framed structure. The entire planning and design process for structures required creative thought, a solid foundation, and understanding. Using the IS Code approach, analyse and design a G+6 story residential building structure. The entire structure has been painstakingly designed, analysed, and STADD Pro software verified. Using Auto CAD, all of the drafting and detailing was completed. It also served as the foundation for transferring the structure to STAAD Pro for analysis and design. The "Limit State Method" is used in this project to compute the design of the slab, beam, column, staircase, etc. Loads acting on the member are considered according to the IS: 875-1987 (part 1, part2, part3). Thus this building is properly planed in accordance with National Building Code of India.

Keywords* — *Autocad, G+6 Storey residential building,* IS: *875-1987, Staad-pro

I. INTRODUCTION

These days, there is a need to accommodate in multi-story buildings because of the overpopulation in urban areas and the high cost of land. the process of determining general.

The analysis of a structure's shape, particular dimensions, and size ensures that it will serve the purpose for which it was designed and will be able to safely withstand the influences that will be acting on it throughout its useful life. In order to plan and design a structure, it is necessary to have scientific knowledge of structural engineering, as well as understanding of particle aspects like bye-laws and design codes, supported by sample experience and judgement. An effort was made in this project to plan, analyse, and design a residential building. For construction study and design, the plan draught is for building analysis and design.

II. LITERATURE REVIEW

Paper1- ***Ibrahim, et.al (April 2019): Design and Analysis of Residential Building (G+4):***

The structure of the G+4 story residential building was examined, and it was shown to be resilient to loads including dead loads, live loads, wind loads, and seismic loads.

In order to determine the member dimensions (beam, column, slab), the kind and amount of applied loads must be determined.

The length, height, depth, size, and other details of each structural part are provided in detail by Auto CAD.

The programme STADD Pro has the ability to calculate. It includes a number of parameters that were created in accordance with IS 456: 2000. Beams were created with flexure, shear, and stress in mind, and they provide a brief of their number, position, and spacing. [1]

Paper2- ***Dunnala Lakshmi Anuja, et.al (2019): Planning, Analysis and Design of Residential Building (G+5) By using STAAD Pro:***

Slab, Beams, Footing, and Staircase were designed in accordance with IS Code 456-2000 by LSM, and Frame analysis was performed using STAAD-Pro characteristics like sharing deflection torsion, Development time is in accordance with IS code requirements. Column and footing designs were made in accordance with IS 456-2000 and SP-16 design charts. the check specified by the IS Code, such as one- or two-way shear.

The limit state approach is used in the design of the slab, beam, column, rectangular footing, and staircase.

Compared to hand design, drawing, and the STADD Pro geometrical model. [5]

Paper3- ***Mr K. Prabin Kumar, et.al (2018): A Study on Design of Multi-Storey Residential Building:***

To analyse and design every component of the construction and determine how much reinforcement was required for the concrete portion, they used STADD Pro. Different structural actions are members like axial, flexure, shear, and tension are taken into consideration. At the ends, pillars are defined for axial forces and biaxial ends. Building was designed in accordance with IS: 456-2000. [7]

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Paper4- ***Deevi Krishna Chaitanya, et.al (January, 2017): Analysis and Design of a (G+6) Multi-Storey Building Using STAAD Pro:***

To determine the numbers of unknown forces, they used static indeterminacy methods. Distributing well-known fixed and moment values in order to meet the compatibility requirement method of iteration. For the stability of the building structure's members, moments were distributed at successful joints in the frame and continuous beam using Kani's method. They used the design software STADD Pro, which gave precision and greatly reduced design time. [10]

Paper5- ***V S Satheesh1, S. Varna Rao2, Mohammed Salamath3 (June, 2020): Analysis of G+10 Residential Building by STAAD Pro:***

They discovered that it was safe to check for deflection. They used E-Tabs software to carry out the design and study of a G+2 residential structure, and they estimated the size of the building by centre line technique. They used SP-16 to safely design the column, and the interaction formula was tested. [15]

III. METHODOLOGY

- MODELLING- Residential Building
- LOADS
  - Dead load
  - Live load
  - 1.5(Live Load +Dead Load)
- ANALYSIS:
  - Analysis of RCC framed structure.
  - Shear Force and Bending Moment calculations.
- DESIGN:
  - Design of Slab, Beam, Column.
- MANUAL CALCULATION:
  - Bending Moment and Shear Force.
- AUTOCAD DRAWINGS

OBJECTIVE

- Creating the structure's framework.
- Model creation in STAAD PRO.
- Putting loads on the member.
- A layout analysis.
- Create the framework (manual design).

IV. STAAD PRO DESIGN

Table: 1 BASIC DATA

Utility of building	Residential
No of stories	G+6
No of staircases	6
Type of construction	R.C.C framed
Type of wall	Brick wall
Beam	230X300mm & 300X350 mm
Column	300X600mm & 600X300 mm
Slab thickness	125mm
Concrete grade	M30
Steel grade for beam	Fe415
Steel grade for column	Fe500

ANALYSIS OF STRUCTURE IN STAAD-PRO

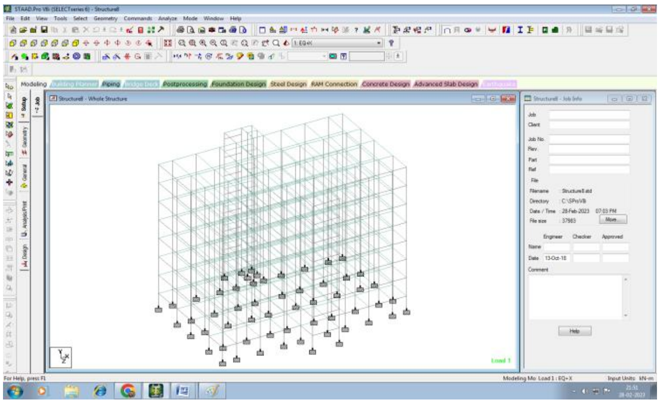

Fig: 1 Modelling

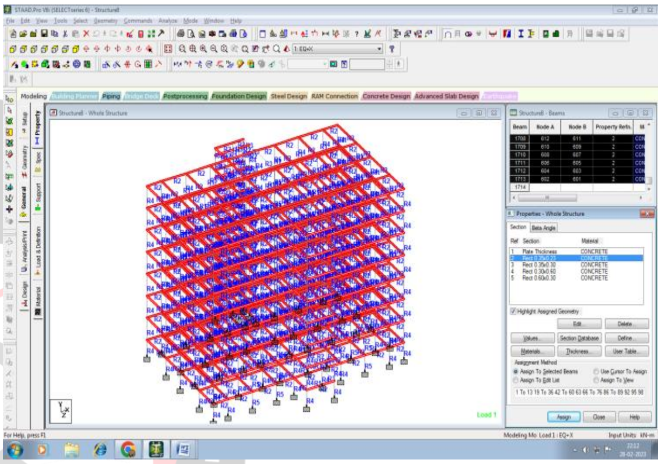

Fig: 2 Assigning Properties on Beams

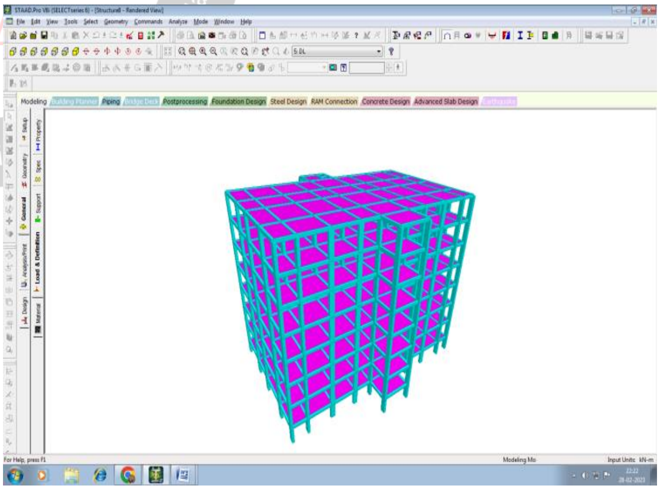

Fig: 3 Model after assigning properties

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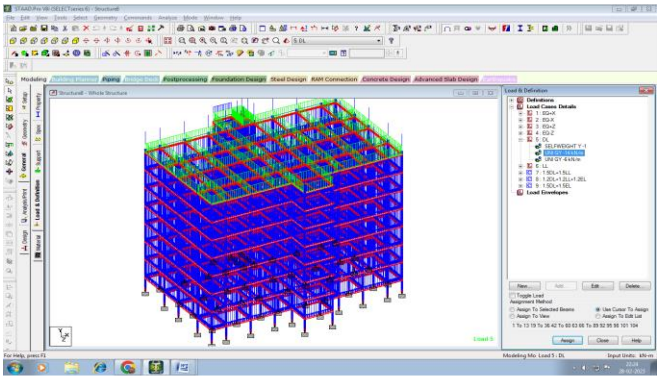

Fig: 4 Assigning Member load

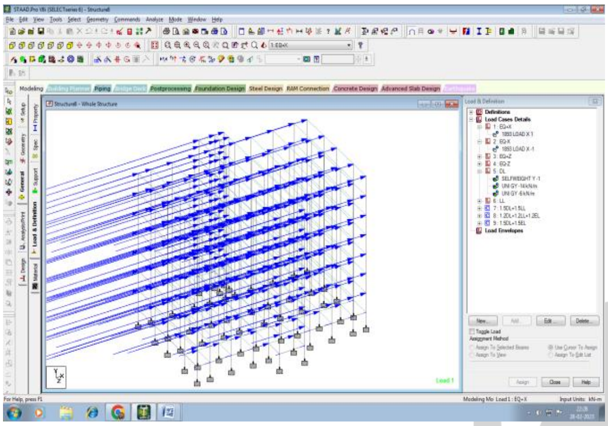

Fig:5 Seismic load from X-axis

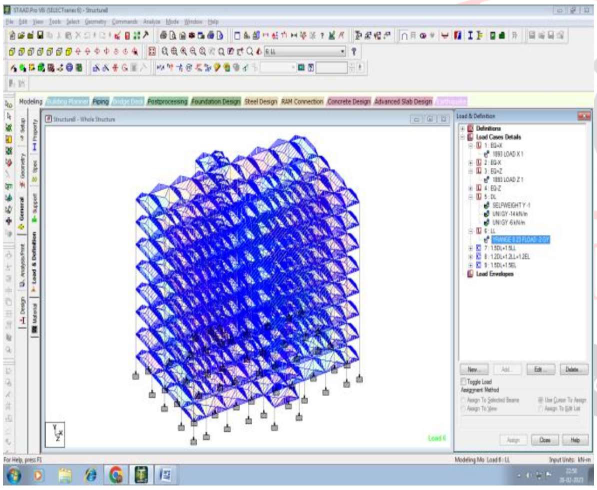

Fig: 6 Assigning live load

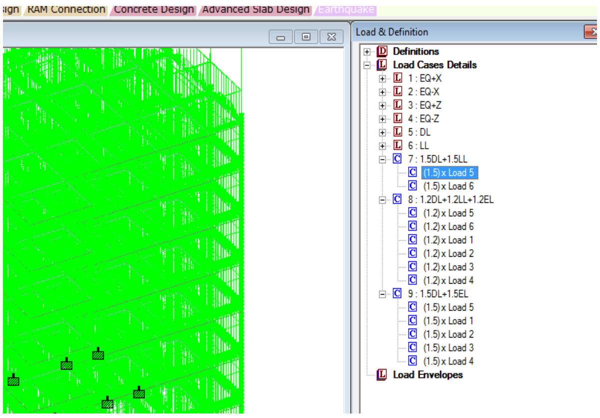

Fig: 7 Assigning load combinations

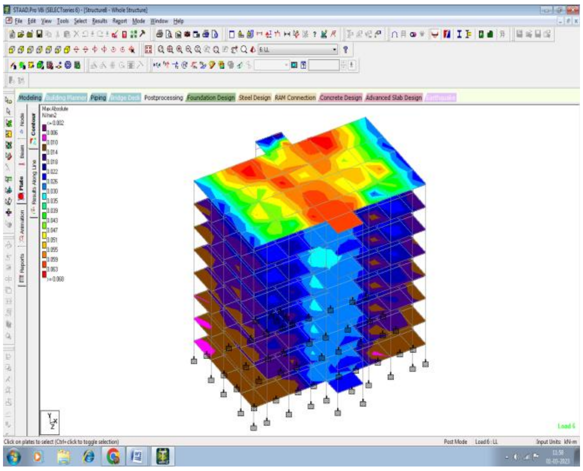

Fig: 8 Intensity of loads

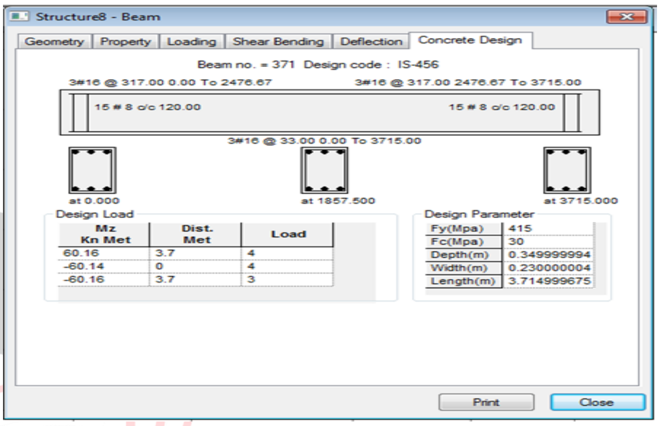

Fig: 9 Design of Beam 371

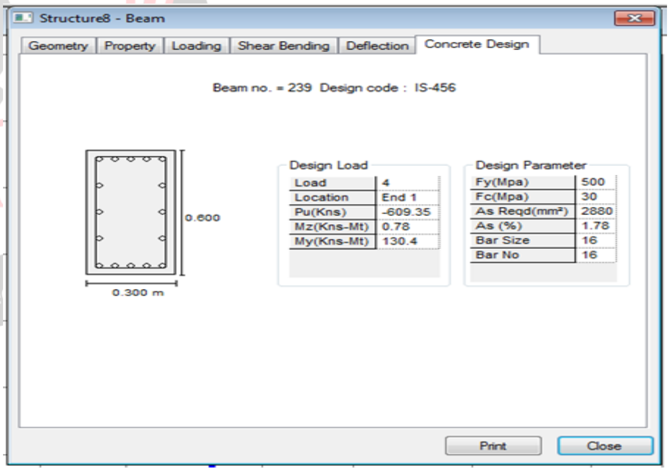

Fig: 10 Design of Column 239

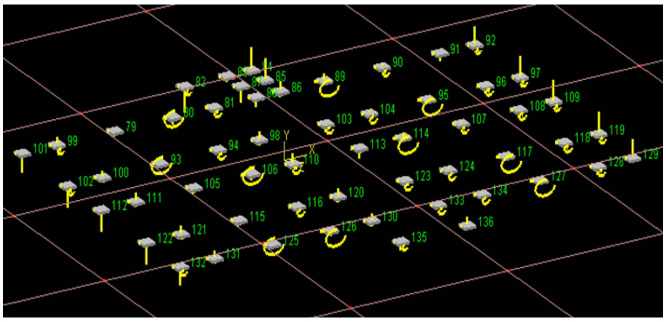

Fig: 11 Footings of structure

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V. STRUCTURE COMPONENTS OF BUILDING AND THEIR MANUAL CALCULATIONS

SLAB

It transmits imposed and dead weight to supports and is a flexible structural member.

Imposed loads include the weights of people, furnishings, equipment, snow, and other materials. Dead loads include the slab's own weight as well as the weight of the flooring slabs for the building's levels and roofs. They are typically thought to transport evenly distributed loads. Slabs are typically only examined for flexure. Slabs are typically horizontal, with the exception of steps and stairs for underground parking. Slabs are held up by walls and beams.

Data

Effective Shorter Span(Lx) = 4.26 m
Effective Longer Span(Ly) = 5.02 m
Width of Support = 0.3m
Fck = 25 N/mm^2
Fy = 415 N/mm^2

Step1: Type of slab

Ly/Lx = 5.02/4.26 <2
Since Ly/Lx ratio is lesser than 2
The slab should be designed as two-way slab

Step2: Depth of slab

Clear cover = 25 mm
Adopt effective depth = 125mm
Over all depth (D) = 150mm

Step3: Loads

Self-weight of slab = 3.125 KN/m2
Live load = 2 KN/m2
Floor finish = 1 KN/m
Total load = 6.125 KN/m2

Factored load

Wu = (1.5 x6.125)
= 9.1875 KN/m2

Step 4: Maximum Bending Moment

From IS 456, Table 26
Short span coefficient
αx(-ve)=0.0418 αx(+ve) = 0.0312
Long span coefficient
αy(-ve)=0.032 αy(+ve) = 0.024
Mux(+ve) = αxWlx^2
= (0.0418× 9.1875× 4.262)

= 6.96 KN-m
Mux(-ve) = αxWlx^2
=(0.0312 × 9.1875 × 4.262)

= 5.20 KN-m

Muy(+ve) = αyWlx^2
= (0.024 × 9.1875 × 4.262)
= 4 KN-m
Muy(-ve) = αyWlx^2
= (0.032 × 9.1875 × 4.262)
= 5.33 KN-m

Step 5: Check for Depth

From IS 456,

$$M_{u,\,lim} = 0.36\frac{x_{u,max}}{d}\left(1-0.42\frac{x_{u,max}}{d}\right)bd^2 f_{ck}$$

=0.36x0.48(1-(0.42x0.48))
x1000x1252x25
Mu, lim = 53.89x106 KN-m
Mu, actual < Mu, lim
Hence section is under reinforced
Hence safe

Step 6: Calculation Of Reinforcement

Shorter span

$$M_u = 0.87\ f_y\ A_{st}\ d\left(1-\frac{A_{st}f_y}{bdf_{ck}}\right)$$

6.96x106 = 0.87x415x Ast x 125x(1-
Astxfy/1000x25x125)
Ast, Req = 158 mm2
Use 10mm ϕ bars,
sv = 78.5/158x1000
= 490 mm
Provide 10mm ϕ bars @490mmc/c
Ast, prov = 160 mm^2

Top of support:

$$M_u = 0.87\ f_y\ A_{st}\ d\left(1-\frac{A_{st}f_y}{bdf_{ck}}\right)$$

5.20x106 = 0.87x415x Ast x 125x(1 –
Astxfy/1000x125x25)
Ast = 117 mm^2
Use 10mm ϕ bars,
sv = 78.5/117x1000
= 650 mm
Provide 10mm ϕ bars @ 650mmc/c
Ast, prov = 121 mm^2

Longer span

$$M_u = 0.87\ f_y\ A_{st}\ d\left(1-\frac{A_{st}f_y}{bdf_{ck}}\right)$$

4 x106 = 0.87x415x Ast x 125x(1 –
Astxfy/1000x25x125)
Ast = 90 mm2
Use 10mm ϕ bars,
sv =78.5/90x1000
= 850 mm
Provide 10mm ϕ bars @ 850 mmc/c
Ast, prov = 92.35 mm2

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Top of support:

$$M_u = 0.87\, f_y\, A_{st}\, d\left(1 - \frac{A_{st} f_y}{b d f_{ck}}\right)$$

5.33 x106 = 0.87x415x Ast x 125x(1
– Astx415/1000x125x25)

Ast = 120 mm2

Use 10mm ϕ bars,

sv = 78.5/120x1000

= 650 mm

Provide 10mm ϕ bars @ 650mmc/c

Ast, prov = 121 mm2

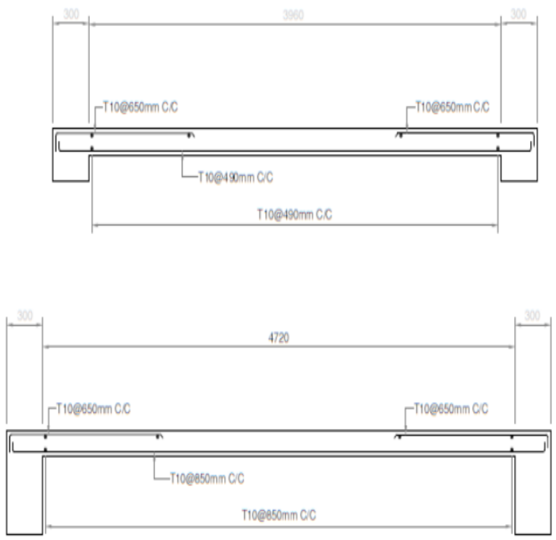

Fig: 12 Slab layouts

BEAM

Concrete structural beam components are made to sustain a specific system of external loads, like walls and the slabs of a roof or floor system. The dimensions of the cross-section are typically presumptive based on serviceability criteria. The depth is chosen to keep deflection within safe, allowable limits, and the width is set based on the thickness of the walls and the housing for the reinforcements.

Data

Effective Length = 4.26 m

Assume b = 230 mm

d = 325 mm

Cover = 25 mm

D = 350 mm

Grade of Concrete = M30

Grade of Steel = Fe415

Load from slab to the beam = 10.04 KN/m

Step1: Load calculation

Dead Load from slab = 1 KN / m2

Wall Load = 0.23 x 20 x 3

= 14 KN/m

Self-Weight of beam = 0.23 x 0.35 x 25

= 2.013 KN/m

Live Load = 2 KN/m

Total Dead Load (Wd) = 28.05 KN/m

Step2: Ultimate Bending moment and shear force

$$M_{u\ support} = 1.5\left(\frac{W_d \times l^2}{12}\right)$$

= 1.5 (28.05 × 4.26^2 /12)

= 60 KN-m

Step3: Check for the depth

$$d = \sqrt{\frac{M_u}{0.138 \times f_{ck} \times b}}$$

d = 253 mm

d, provided > d, required

Hence OK

Step4: Area of steel

At support

$$M_u = 0.87\, f_y\, A_{st}\, d\left(1 - \frac{A_{st} f_y}{b d f_{ck}}\right)$$

Ast req = 572 mm^2

Provide 3 bars of 16 mm dia. bar

Sv = 1000 × $as/\,Ast$

= 1000 × 201/ 603

= 333 mm

Provide 3 nos. of 16 mm dia. bars @ 300 mm c/c

Step5: Check for the shear

Vu = 89.61 KN

$$\tau_v = \frac{V_u}{b \times d}$$

= 1.2 N / mm2

τc = 0.6 N / mm2

τc max = 3.5 N / mm2

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τc max > τv > τc

Provide 10mm dia. of 2 Legged Stirrups @ 400 mm c/c

Step6: Check for spacing

Sv ≤ (0.75 d) = 0.75 x 325

= 244 mm

Sv = 708.2 mm

Sv ≤ 300 mm

Hence ok

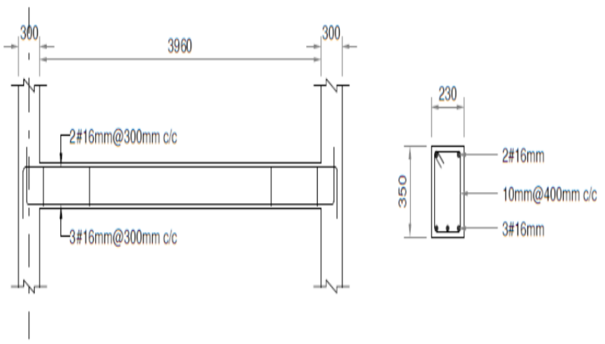

Fig: 13 Beam layouts

3.3 COLUMN

In a structural structure, a column is typically a compression member that supports beams and slabs and has an effective length greater than three times the lateral dimension. A column's ability to support a load depends on its cross-sectional area and longitudinal steel dimensions.

TYPES OF COLUMS

1. Axially loaded column: This type of column has its load acting precisely at the centroid.

2. Uniaxial eccentrically loaded column. A uniaxially loaded column has an axial weight and axial bending moment acting in the same direction.

3. Biaxial eccentrically loaded column- A biaxial loaded column has axial weight and bending moment acting in both directions.

Data:

Use M30 grade concrete and Fe500 grade steel.

Unsupported length, L = 3m

Effective length, leff = 0.65L

= 0.65 x 3000

= 1950 mm

D = 300mm

Dy = 600mm

pu = 1029.752 KN

Mux = 20.59 KN-m

Muy = 22.82 KN-m

leff/D = 1950/300 =6.5 < 12

Hence design it as a short column.

Area of longitudinal reinforcement

p/fck = 1.4/30

= 0.05

d'/D = 50/600

=0.08

Chart of d'/D =0.1 will be used

$pu/(fckbd)$ =1029.75 × 103/30X300X600

= 0.191

$Mu/(fck\ bd^2)$ = 0.09

MUX1 = 291.6 KN-m

MUY1 = 145.8 KN-m

Calculation of Puz

P=1.4; fy = 500 N/mm2; fck =30 N/mm2

Referring to the chart 63 SP-16

PUZ /Ag =18.8

= 3384 KN

PU/PUZ = 1029.75/3384

= 0.3

MUY/MUY1 = 22.82/145.8

= 0.16

MUX/MUX1 = 20.56/291.6

= 0.071

Referring to the Chart 64

MUx /MUx1 =0.9

Hence it is safe

AS = 1.4X300X600/100

= 2520 mm2

AS provided = 2520 mm2

Provide 6 bars of 25 mm dia.

Lateral ties

= 25/4

= 6.25mm,

Where ø is the largest ø used as longitudinal reinforcement.

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The pitch of the lateral ties as per clause 26.5.3.2-C-1 of IS 456, should not be more than the least of,

- Least lateral dimension of column = 300mm.
- Sixteen times the smallest ø of longitudinal reinforcement bar to be tied

  =16x25 = 400mm.
- 300mm.

The pitch of the lateral tie be 300mm.

Provide 10mm dia. @300mm c/c

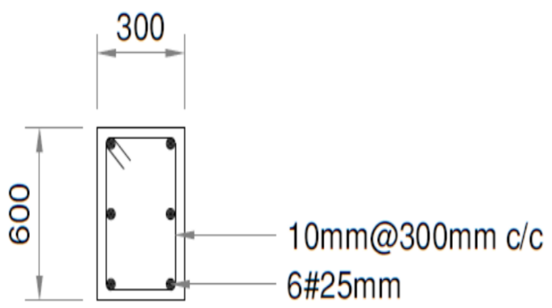

Fig: 14 Column layouts

VI. CONCLUSION

- A comparison of STADD Pro versus manual calculation has shown that there might not be a big difference in final result of manual and software design, but for large scale it creates big difference.
- Compared to manual computation, using STADD Pro made the analysis and design of multi-story buildings go considerably more swiftly, but was not that economical as manual computation is.
- Auto-CAD was used to construct and draught the building plan with the necessary dimensions.
- The G+6 storey residential building's construction can withstand all loads placed on it during design.
- For beam (371) according to software it requires 1186.28 sq.mm of reinforcement but by manual calculation it was found to be 953.33 sq.mm of reinforcement. And for column (239) according to software it requires 2880 sq.mm of reinforcement but by manual calculation it was found to be 2520 sq.mm of reinforcement.

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