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# Analysis and Design of (G+3) Hospital Building by Using Staad.Pro

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**ABSTRACT:**

This paper presents the analysis and design of a G+3 hospital building using STAAD.Pro software. The architectural plan was developed in AutoCAD, and structural analysis was carried out to determine bending moments, shear forces, and support reactions. The design follows IS codes, including IS 456:2000 for RCC elements, IS 875 (Part 1-3):2007 for dead, live, and wind loads, and IS 1893:2002 (Part 1) for seismic loads. STAAD.Pro's tools, which support Building Information Modelling (BIM) workflows, were used to design slabs, beams, and columns, ensuring efficient and code-compliant structural performance.

**Keywords**:- Analysis and design, AutoCAD software, STAADPRO, IS Standards

## INTRODUCTION

Hospitals are universally recognized as vital infrastructure for improving public health, particularly in maternal, child, and infant care. The Alma-Ata Declaration (1978) and India's National Health Policy (1983) emphasize health care as a strategic priority for achieving universal health access. Depending on the scale of a city or town, hospital types and sizes vary, encompassing facilities like dispensaries, clinics, maternity and nursing homes, laboratories, and general hospitals. This study focuses on the structural design and analysis of a G+3 hospital building located in Krishnagiri. The design incorporates all essential departments and amenities, with a layout that emphasizes ease of access, public comfort, and efficient circulation. Each wing is strategically oriented to minimize internal disruptions, promoting both patient comfort and operational efficiency.

Using STAAD.Pro and AutoCAD, the building was structurally analyzed for dead, live, wind, and seismic loads in compliance with are 456:2000, IS 875 (Parts 1-3):2007, and IS 1893:2002 standards. The study also reviews and compares previous designs and case studies to effectively implement evidence-based strategies for improved hospital planning. Research increasingly highlights that the physical environment of healthcare settings directly impacts outcomes, including patient recovery, staff performance, infection rates, and safety incidents. Poorly designed spaces can lead to medical errors, falls, and inefficiencies. Conversely, well-designed healthcare facilities support healing, reduce risk, and improve overall care delivery. This paper underscores the importance of integrating thoughtful architectural planning with structural safety and regulatory compliance to build hospitals that are both resilient and patient-centered.

## LITERATURE REVIEW

**MVK. Satish et.al (2017)** he examined and designed a G+3 hospital building and its facility arrangement reaction to seismic load were studied using STAAD.Pro and after were investigated through a 3Dnon linear reaction history examination and corrected with non-linear static working methodology (NSP), this study recommends utilization of modular NSP rather than first mode NSP as it gives better result while comparing building structures.

**Safwanahmad et.al (2017)** designed a G+2 hospital building using STAAD.Pro by applying suitable loads and sectional details to component within the main aim of this factor was to study the extent of credibility of using STAAD.Pro for analysis.

**Dr.Ashokkumar et.al (2017)** designed a G+3 hospital building using substitute frame method in STAAD.Pro the efficiency of analyzing using software over manual method was analyzed and a comparative analysis was carried out.

## METHODOLOGY

### Introduction to AutoCAD:

AutoCAD is a computer-aided design (CAD) software developed by Autodesk, widely used in architecture, engineering, and construction industries. It allows users to create precise 2D drawings and 3D models for various design and drafting applications.

**Benefits of AutoCAD:**

- **Precision and Accuracy:** Enables highly accurate design with exact dimensions and coordinates.
- **Time Efficiency:** Speeds up the drafting process with tools for copying, mirroring, and editing.
- **Modifications and Revisions:** Easy to update designs without starting from scratch.
- **Layer Management:** Allows organization of different elements (e.g., walls, furniture, electrical) into layers for better control and clarity.
- **Compatibility:** Supports multiple file formats and integrates with other design and analysis software.
- **Visualization:** 3D modeling and rendering features help visualize the final structure before construction.

**Introduction to STAAD.Pro :**

STAAD.Pro is a widely used structural analysis and design software developed by Bentley Systems. It is primarily used by civil and structural engineers to analyze and design buildings, bridges, towers, and other structures under various loading conditions.

**Benefits of STAAD.Pro:**

- **Accurate Structural Analysis:** Allows analysis of structures under different loads including dead, live, wind, and seismic.
- **Code Compliance:** Supports design as per multiple international standards, including IS, ACI, Eurocode, and more.
- **Time Efficiency:** Automates complex calculations, reducing manual effort and time.
- **Design Versatility:** Supports steel, concrete, timber, aluminium, and cold-formed steel designs.
- **Visualization and Reporting:** Provides graphical representations and detailed output reports for better understanding and documentation.
- **Integration:** Can be integrated with other tools like AutoCAD, Revit, and BIM software for a seamless design workflow.

## Load Considerations

***Dead Loads:***

Dead loads include all permanent components such as walls, floor finishes, ceilings, and structural elements. These are calculated based on material dimensions and unit weights. For design purposes, unit weights of plain and reinforced concrete are taken as 24 kN/m³ and 25 kN/m³, respectively.

***Imposed Loads:***

Imposed (live) loads result from building occupancy and include movable partitions, furniture, vibrations, and equipment. These do not account for environmental loads like wind, seismic, or thermal effects.

***4.3 Wind Loads:***

Wind load is a horizontal force acting on structures due to natural airflow. The design wind speed (V) is calculated using the formula:

$V = Vb \times k1 \times k2 \times k3$,

Where,

- Vb is basic wind speed,
- k1 is the risk coefficient,
- k2 is terrain and height factor,
- k3 is topography factor.

Wind pressures are applied to entire buildings, components, and cladding units using pressure coefficients and design wind pressure (Pd):

$F = (Cpe - Cpi) \times A \times Pd$

***Seismic Loads:***

Seismic analysis follows IS 1893:2002. The design base shear **Vb = Ah × W**, where *Ah* is the horizontal acceleration coefficient and *W* is the seismic weight. The building's fundamental period is estimated using:

**Ta = 0.075h*0.75** for RC frames and

**Ta = 0.085h*0.75** for steel frames.

Base shear is distributed vertically using:

**Qi = (Wi × Hi) / Σ(Wi × Hi)**

For structures with rigid diaphragms, lateral forces are distributed based on diaphragm stiffness. Flexible diaphragms require distribution based on in-plane flexibility.

## Analysis of G+3 Hospital Building

**Building Dimensions**:

- Plan: 61.4 m × 61.43 m
- Total Height: 12 m (Each floor: 4 m)
- Loads considered: Dead, Live, Wind, Seismic

**Structural Details & Load Calculations:**

- Floor Finish Load: 1.5 kN/m² (4–12 m)
- Live Load: 5 kN/m² (4–12 m)
- Wall Loads: External – 16.56 kN/m, Internal – 8.2 kN/m, Parapet – 2.3 kN/m
- Wind Load: As per IS 875 (Pz = 1.1 kN/m² using Vz = 43.2 m/s)
- Seismic Load: As per IS 1893:2002, Zone II
- Bearing Capacity: 200 kN/m²

**Structural Member Sizes**:

- Slab Thickness: 0.15 m
- Beams: 0.6×0.35 m (GF & 1F), 0.45×0.35 m (2F & 3F)
- Columns: 0.6×0.45 m (Plinth), 0.5×0.35 m (GF & 1F), 0.45×0.35 m (2F & 3F)

**Supports:**

All base supports are fixed, assigned using STAAD.Pro.

6.4 Load Assignments:

Generated using STAAD.Pro with both manual input and automated load generators.

- **Dead Load:** Auto-calculated using self-weight command.
- **Live Load:** Assigned as 5 kN/m² per floor.
- **Wind Load:**
    - ➢ Basic wind speed (Vb) = 50 kmph
    - ➢ Factors: k1 = 1.08, k2 = 0.8, k3 = 1.0
    - ➢ Design speed Vz = 43.2 m/s, Pressure Pz = 1.1 kN/m²
    - ➢ Wind Load: F = Ae × Pd × Cf = 4.71 kN/m
- **Seismic Load:**

➢ Zone Factor (Z) = 0.1, Importance Factor (I) = 1

➢ Time Period (T) = 0.075h^0.75

➢ Base Shear: Vb = Ah × W

➢ Lateral forces distributed as per stiffness and mass distribution at each floor.

## Design of G+3 Hospital Building Using STAAD.Pro

The structural design of the G+3 hospital building was carried out using STAAD.Pro, adhering to IS:456-2000 for RCC design. Member properties such as clear cover, material strengths (fck, fy), and support conditions were defined within the software. Elements were identified as beams or columns and designed accordingly.

**7.1 Design of Columns**

Columns are vertical compression members critical for load transfer. The failure of a column can lead to structural collapse. Classification is based on:

- **Shape**: Rectangular, Circular, Polygonal
- **Slenderness**: Short (Leff/D < 12), Long (Leff/D > 12)
- **Loading**: Axial, Uniaxial, Biaxial
- **Reinforcement Type**: Tied or Spiral

**IS Code Provisions:**

- **Minimum eccentricity**: *e* > (l/500 + D/30) or 20 mm
- **Longitudinal Steel**: 0.8%–6% of gross area, minimum 12 mm dia, spacing ≤ 300 mm
- **Lateral Ties**: Dia ≥ 6 mm or 1/4th of largest longitudinal bar; pitch ≤ least lateral dimension or 16 × dia of smallest longitudinal bar or 300 mm

**Design of Beams**

Beams resist bending, shear, and axial loads. Types include:

- **Singly Reinforced**: Tension reinforcement only
- **Doubly Reinforced**: Compression and tension steel
- **Flanged Beams**: T-beams with slab acting in compression

**IS Code Provisions (IS:456-2000):**

- **Flexural Reinforcement**:
  - Min: Ast/bd = 0.87/fy
  - Max: 0.04 × bd
- **Shear Reinforcement**:
  - Nominal shear stress: $\tau v = Vu/bd$
  - Provide stirrups when $\tau v < \tau c$
  - Stirrups spacing ≤ 0.75d or 300 mm
  - Vs = (0.87 × fy × Asv × d)/Sv
- **Curtailment and Anchorage**: Ld/3 extension into supports; development length per IS 456
- **Cover**: Minimum 25 mm or equal to bar diameter

## Design of Slabs

Slabs distribute loads primarily through flexure and are categorized as:

- **One-Way Slabs**: Supported on two opposite sides (ly/lx > 2)
- **Two-Way Slabs**: Supported on all four sides (ly/lx < 2)

**Design Considerations**:

- **Main Reinforcement**: Along the span direction (based on max bending moment)
- **Distribution Reinforcement**: For shrinkage and temperature effects

- **Minimum Steel**: As per IS 456 requirements
- Slabs may act monolithically with beams as flanged sections in case of T-beams.

To minimize the input for paper publication while retaining key technical aspects, it is essential to focus on simplifying and condensing the data. Below is a streamlined version of the provided STAAD input, which focuses on the essential parameters while removing redundant or overly detailed information:

## STAAD.PRO INPUT

STAAD SPACE DXF IMPORT - Simplified Input for Paper Publication

**Job Information**

Engineer: [Name]

Date: 26-Feb-25

Units: Meter, kN

**Material Definitions**

Material: Concrete

Elastic Modulus (E): 2.17185e+007 kN/m²

Poisson's Ratio: 0.17

Density: 23.5616 kN/m³

Strength (fcu): 27579 kN/m²

Thermal Coefficient: 1e-005

Damping: 0.05

**Joint Coordinates**

Joint 1: X = -1464.69

**Member Properties**

Beam Sections: Prismatic sections (YD = 0.35 m, ZD = 0.35 m)

Column Sections: Prismatic sections (YD = 0.6 m, ZD = 0.35 m)

**Support Conditions**

Fixed supports at joints: 272 to 455

**Loads**

- Self-weight: Activated

**Wind Load:**

- Type 1 (X Direction)
- Type 2 (Leeward X)
- Type 3 (Side Wall X)
- Type 4 (Y Direction)
- Type 5 (Leeward Y)
- Type 6 (Side Wall Y)

**Seismic Loads:**

- EQX (X Direction)
- EQZ (Z Direction)

Dead Load (DL):Uniform GY = -16.56 kN

Live Load (LL): Uniform FLOAD = -5 kN

**Load Combinations**

- Combinations based on Indian code general structures, e.g., Load Combination 6: 4 1.5, 5 1.5

**Concrete Design**

- Beam Design: Members 1 to 3, 5 to 122, 124 to 238, 240 to 428, 614 to 734
- Column Design: Members 430 to 613, 1041 to 1224, 1652 to 1835
- Element Design: Members 4175 to 4814, 4819, 4824 to 4827

**Analysis and Result**

- Analysis Type: Linear static analysis
- Output: Full results including stresses and deflections

## RESULTS

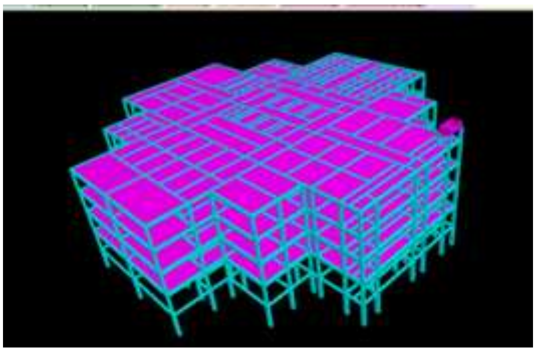


Fig-1 :- Rendering View

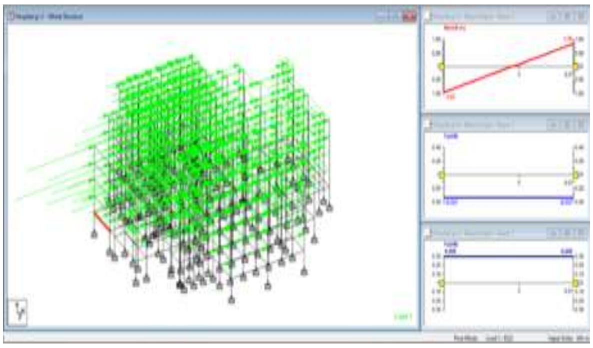


Fig-2 :- Beam Stress Graphs

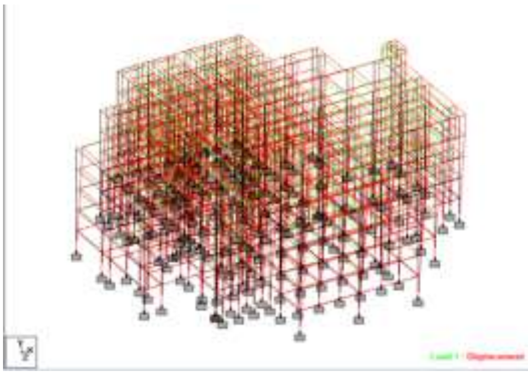
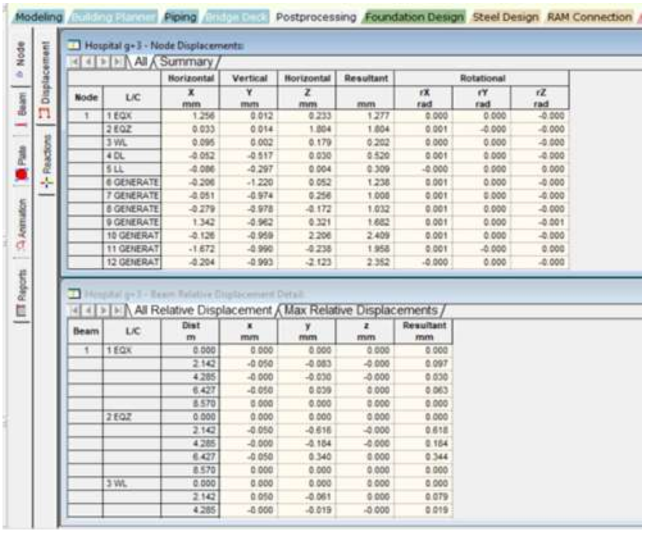


Fig-3:- Beam Displacement Diagram Graphs




| Node | L/C | Horizontal X mm | Vertical Y mm | Horizontal Z mm | Resultant mm | Rotational rX rad | rY rad | rZ rad |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 EQX | 1.256 | 0.012 | 0.233 | 1.277 | 0.000 | 0.000 | -0.000 |
| | 2 EQZ | 0.033 | 0.014 | 1.804 | 1.804 | 0.001 | -0.000 | -0.000 |
| | 3 WL | 0.095 | 0.002 | 0.179 | 0.202 | 0.000 | 0.000 | -0.000 |
| | 4 DL | -0.052 | -0.517 | 0.030 | 0.520 | 0.001 | 0.000 | -0.000 |
| | 5 LL | -0.086 | -0.297 | 0.004 | 0.309 | -0.000 | 0.000 | 0.000 |
| | 6 GENERATE | -0.206 | -1.220 | 0.052 | 1.238 | 0.001 | 0.000 | -0.000 |
| | 7 GENERATE | -0.051 | -0.974 | 0.256 | 1.008 | 0.001 | 0.000 | -0.000 |
| | 8 GENERATE | -0.279 | -0.978 | -0.172 | 1.032 | 0.001 | 0.000 | -0.000 |
| | 9 GENERATE | 1.342 | -0.962 | 0.321 | 1.682 | 0.001 | 0.000 | -0.001 |
| | 10 GENERAT | -0.126 | -0.959 | 2.206 | 2.409 | 0.001 | 0.000 | -0.000 |
| | 11 GENERAT | -1.672 | -0.990 | -0.238 | 1.958 | 0.001 | -0.000 | 0.000 |
| | 12 GENERAT | -0.204 | -0.993 | -2.123 | 2.352 | -0.000 | 0.000 | -0.000 |

| Beam | L/C | Dist m | x mm | y mm | z mm | Resultant mm |
|---|---|---|---|---|---|---|
| 1 | 1 EQX | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | 2.142 | -0.050 | -0.083 | -0.000 | 0.097 |
| | | 4.285 | -0.000 | -0.030 | -0.000 | 0.030 |
| | | 6.427 | -0.050 | 0.039 | 0.000 | 0.063 |
| | | 8.570 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 2 EQZ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | 2.142 | -0.050 | -0.616 | -0.000 | 0.618 |
| | | 4.285 | -0.000 | -0.184 | -0.000 | 0.184 |
| | | 6.427 | -0.050 | 0.340 | 0.000 | 0.344 |
| | | 8.570 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 3 WL | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | 2.142 | 0.050 | -0.061 | 0.000 | 0.079 |
| | | 4.285 | -0.000 | -0.019 | -0.000 | 0.019 |

Fig-4 :- Nodes & Beams Displacement Values

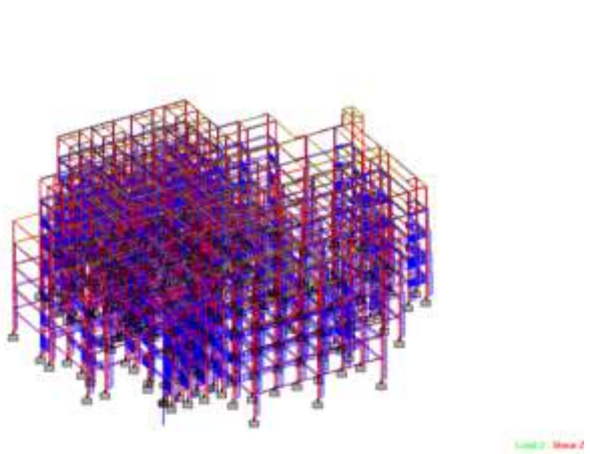


Fig-5:- Shear Force Diagram

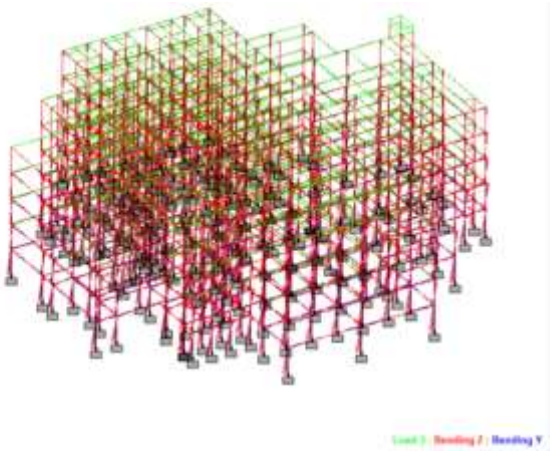


Fig- 6 :- Bending Moment Diagram

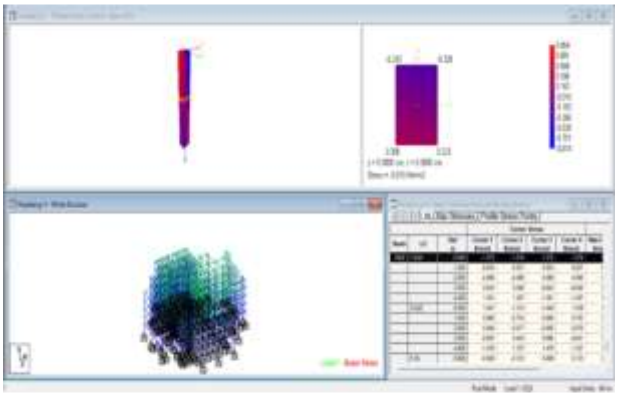


Fig-7:- Stress Distribution in Column

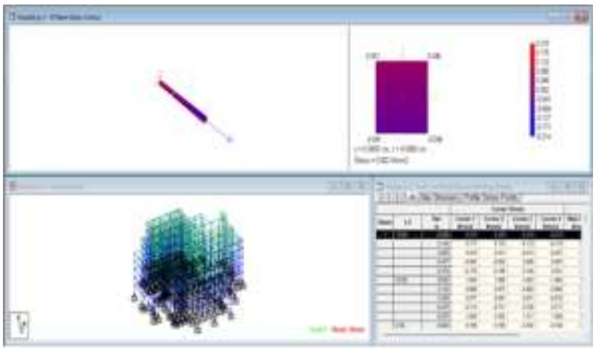


Fig-8:- Stress Distribution in Beam

| | Beam | L/C | Node | Fx kN | Fy kN | Fz kN | Mx kN-m | My kN-m | Mz kN-m |
|---|---|---|---|---|---|---|---|---|---|
| Max Fx | 523 | 6 GENERATE | 118 | **2624.213** | -0.482 | -2.979 | 0.012 | 7.495 | 1.076 |
| Min Fx | 466 | 1 EQX | 40 | **-112.469** | 13.138 | 0.800 | -0.138 | -1.014 | 7.313 |
| Max Fy | 775 | 6 GENERATE | 467 | -15.301 | **361.349** | 0.015 | 1.008 | -0.062 | 689.752 |
| Min Fy | 1386 | 6 GENERATE | 747 | 4.542 | **-356.651** | 0.004 | -0.482 | 0.010 | 705.881 |
| Max Fz | 2919 | 6 GENERATE | 1309 | 286.785 | -0.537 | **78.456** | -0.120 | -164.275 | 0.457 |
| Min Fz | 453 | 18 GENERAT | 27 | 957.455 | -4.196 | **-73.169** | -0.302 | 163.927 | -10.840 |
| Max Mx | 647 | 16 GENERAT | 516 | -3.345 | 99.198 | -2.034 | **73.203** | 0.020 | 35.530 |
| Min Mx | 772 | 6 GENERATE | 501 | -17.621 | 202.150 | -3.549 | **-70.132** | 2.735 | 179.246 |
| Max My | 453 | 18 GENERAT | 27 | 957.455 | -4.196 | -73.169 | -0.302 | **163.927** | -10.840 |
| Min My | 431 | 18 GENERAT | 2 | 724.906 | -3.479 | 52.924 | 0.048 | **-176.087** | -10.595 |
| Max Mz | 1997 | 6 GENERATE | 1016 | -4.386 | -355.797 | -0.003 | -0.652 | -0.009 | **726.359** |
| Min Mz | 2885 | 6 GENERATE | 1005 | 372.839 | 147.997 | 52.985 | 0.055 | 104.274 | **-293.677** |

Fig-9:- Summary of Shear Force & Bending Moment Values

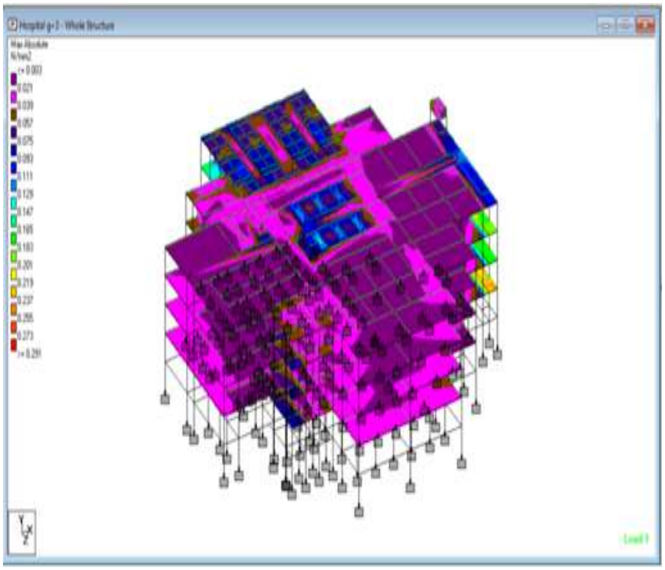


Fig-10:- Plate Stresses

| | | | Shear | | Membrane | | | Bending Moment | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Plate | L/C | SQX (local) N/mm2 | SQY (local) N/mm2 | SX (local) N/mm2 | SY (local) N/mm2 | SXY (local) N/mm2 | Mx kN-m/m | My kN-m/m | Mxy kN-m/m |
| Max Qx | 4178 | 22 GENERAT | **0.102** | 0.008 | 0.001 | -0.002 | -0.010 | 0.499 | -0.130 | -0.030 |
| Min Qx | 4178 | 16 GENERAT | **-0.104** | 0.013 | 0.002 | -0.002 | 0.006 | 0.815 | -0.413 | -0.021 |
| Max Qy | 4540 | 6 GENERATE | 0.011 | **0.139** | 0.003 | 0.005 | -0.002 | -0.100 | 2.956 | 0.405 |
| Min Qy | 4587 | 6 GENERATE | 0.077 | **-0.083** | -0.001 | -0.004 | -0.001 | 1.840 | 0.697 | 0.232 |
| Max Sx | 4826 | 17 GENERAT | 0.023 | -0.032 | **0.095** | -0.007 | 0.023 | 0.513 | 0.502 | -0.649 |
| Min Sx | 4666 | 6 GENERATE | -0.045 | 0.000 | **-0.174** | 0.010 | 0.096 | 0.701 | -0.842 | 1.227 |
| Max Sy | 4827 | 6 GENERATE | -0.008 | 0.001 | 0.046 | **0.076** | -0.061 | 0.147 | -0.076 | -0.029 |
| Min Sy | 4655 | 6 GENERATE | -0.005 | 0.002 | -0.075 | **-0.146** | -0.000 | -3.737 | -3.351 | -0.459 |
| Max Sx | 4824 | 6 GENERATE | 0.066 | 0.006 | 0.071 | -0.033 | **0.198** | 0.190 | -0.025 | -1.067 |
| Min Sx | 4827 | 17 GENERAT | 0.020 | 0.009 | -0.006 | 0.043 | **-0.112** | -0.070 | -0.115 | 0.232 |
| Max Mx | 4676 | 6 GENERATE | 0.001 | -0.000 | -0.090 | -0.122 | -0.005 | **4.851** | 1.550 | 0.055 |
| Min Mx | 4612 | 6 GENERATE | -0.005 | 0.045 | -0.003 | 0.003 | -0.004 | **-5.617** | -0.374 | 0.978 |
| Max My | 4661 | 6 GENERATE | -0.001 | 0.030 | -0.047 | -0.013 | -0.008 | -2.035 | **3.683** | -0.672 |
| Min My | 4655 | 6 GENERATE | -0.005 | 0.002 | -0.075 | -0.146 | -0.000 | -3.737 | **-3.351** | -0.459 |
| Max Mx | 4506 | 6 GENERATE | -0.090 | 0.014 | 0.027 | 0.004 | -0.024 | 3.952 | -0.722 | **2.155** |
| Min Mx | 4523 | 6 GENERATE | -0.062 | 0.015 | 0.001 | 0.001 | 0.000 | -4.141 | -2.865 | **-2.655** |

Fig-11:- Summary of Shear, Membrane & Bending Moment Results of Plates

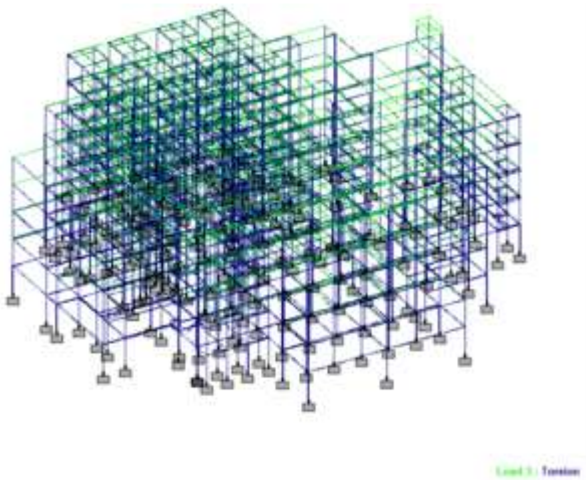


Fig-12:- Torsional Moment Diagram

Fig-13:- Column Reinforcement

Fig-14:- Beam Reinforcement

Fig-15:- Slab Results

## CONCLUSION

**Beam Design:**

- **Flexure**: Calculates sagging and hogging moments, designing for both.
- **Shear**: Calculates shear reinforcement, using two-legged stirrups for balance.

**Column Design:**

- **Axial & Biaxial Moments**: Designs for square columns under axial forces and biaxial moments, with reinforcement based on the critical load.

**Slab Design:**

- **One-**Way & Two-Way: Designs reinforcement based on load configuration, ensuring strength and serviceability with checks for deflection and cracking.

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