

Comparative Structural Analysis Of G+11 Residential Building Using Glass Fiber Reinforced Concrete and Conventional Concrete by Using Staad Pro

G.V.Bhadra Charyulu¹, D.Appannar²

¹ P.G. Student, Kakinada Institute of Technology & Science (Autonomous), Divili

² Assistant Professor, Kakinada Institute of Technology & Science (Autonomous), Divili

Abstract— The rapid development of urban infrastructure has increased the demand for high-performance, sustainable, and durable construction materials. Glass Fiber Reinforced Concrete (GFRCC) has emerged as a promising alternative to conventional concrete due to its superior tensile strength, crack resistance, reduced brittleness, and enhanced durability. This project presents a comparative structural analysis of a G+11 Residential building designed using both GFRCC and traditional Reinforced concrete, employing STAAD.Pro as the primary modelling and structural analysis tool.

The core objective of this study is to evaluate the behaviour and performance of GFRCC-based structural components under gravity and lateral loads, including dead load, live load, wind load, and earthquake forces, as per relevant design codes (IS 456:2000, IS 875 Part 1–5, and IS 1893:2016). The material properties for GFRCC, including Elastic modulus, tensile strength, density, and strain capacity, are defined based on established literature and manufacturer data. The building is modelled with identical geometry, load distribution, and boundary conditions, allowing an objective comparison between the two material systems.

Key structural responses investigated in this project include deflection, bending moment, shear forces, axial forces, crack resistance, and overall lateral stability. Serviceability and ultimate performance criteria are evaluated to assess the efficiency, safety, and practicality of incorporating GFRCC in high-rise structures. Additionally, construction feasibility and economic implications are examined to highlight the potential cost-benefit relationship of GFRCC compared to conventional concrete.

The study aims to demonstrate the viability of GFRCC as a sustainable alternative in multi-storey building construction, offering improved structural performance,

enhanced durability, and potential reductions in maintenance demands. The results of this analysis are expected to provide valuable insights for structural engineers and practitioners seeking innovative materials for modern construction, and to support the integration of GFRCC technology within STAAD.Pro-based design workflows for future infrastructure development.

Keywords: Glass Fiber Reinforced Concrete (GFRCC), STAAD.Pro, Elastic modulus, Tensile strength.

I. INTRODUCTION

Concrete is widely used construction material in high-rise buildings, owing to its durability, economy, and favorable structural properties. However, conventional reinforced concrete faces persistent challenges such as cracking, reduced tensile resistance, and long-term durability concerns—especially in seismic, coastal, or aggressive environmental conditions. To enhance performance and service life, modern construction research has shifted toward composite concrete technologies, particularly GFRCC.

GFRCC incorporates alkali-resistant glass fibers into cementitious matrices, significantly improving tensile strength, shrinkage control, crack resistance, and ductility. Such improvements are crucial for high-rise buildings, where both serviceability and structural integrity under lateral and gravity loads are critical (Zia et al., 2019; Thomas & Ramaswamy, 2021). As urban infrastructure expands vertically, innovative concrete systems are necessary to reduce maintenance demands and enhance life-cycle performance.

Motivated by sustainability, improved durability, and increasing demand for resilient structural systems, this study investigates the performance of a G+11 residential building designed using GFRCC and compares it with conventional RCC using STAAD.Pro.

II. LITERATURE REVIEW

1. Farhaz Ahmed (2018) - Properties of Glass Fiber Reinforced Concrete

A comprehensive review on GFRC highlighted improvements in tensile strength, ductility, and post-crack energy absorption when glass fibers are integrated into concrete. The study emphasized that optimized fiber content and matrix compatibility are crucial for performance, while excessive fiber addition compromises workability and compaction. This review highlights the requirements for alkali-resistant fibers as well as the role played by supplementary cementitious materials in improving durability. This paper acts as a basic resource that aids in establishing the material properties of GFRC in structural programs.

2. Experimental and Material Data for GFRC (2018-2020)

The uploaded studies provide validated physical and mechanical property data for GFRC mixes, including fiber composition, mechanical behavior, and durability characteristics. Key findings note that:

- AR-glass fibers improve tensile response and crack control,
- Compressive strength gains are modest but serviceability enhancements are significant, and
- Fiber compatibility with the cement matrix governs long-term durability. These datasets are used to define equivalent elastic modulus, tensile behavior, and material parameters for GFRCC in STAAD.Pro modeling.

3. Zia et al. (2019) – Mechanical Behavior of Glass Fiber Reinforced Concrete

According to Zia et al. (2019), studies have been conducted to show how alkali-resistant glass fiber can alter the mechanical properties of concrete, particularly focusing on compressive strength, split tensile strength, and post-cracking behavior. As found

by the researchers, there was a considerable improvement in crack-resistance and ductility with the addition of glass fibers in concrete, which shows that the GFRCC behaves as micro-reinforcement and changes the modes of failure. The increment in compressive strength is insignificant; however, there is a significant increase in tensile and flexural behavior. Thus, the GFRCC is better suited for serviceability and durability rather than just pure strength.

4. Subash Singh et al. (2020) - Study on GFRC with Replacement of Fine Aggregate by M.Sand

Experimental study considered the GFRC mixture, which uses M-Sand as a replacement for natural sand, with the quantity of glass fiber being systematically varied. It was found that the compressive strength and split tensile strength increased with increasing fiber percentage, until it reached its optimum at about 1%, after which the mechanical properties started deteriorating because of fiber balling and poor workability. These results emphasize the importance of fiber dosage control for achieving optimal mechanical response. The findings directly support this project's material modeling inputs, demonstrating realistic strength improvements and the need to calibrate fiber content based on structural requirements.

III. OVERVIEW ON STAAD.Pro

In recent years, the integration of structural engineering software in the construction industry has revolutionized design and analysis practices. Structural software has replaced manual calculations, allowing for faster, more accurate, and efficient modeling. One of the most widely adopted software platforms in this domain is STAAD.Pro, developed by Bentley Systems. STAAD.Pro has become a cornerstone for engineers in consulting, contracting, and government authorities due to its versatility, robustness, and user-friendly interface.

The program STAAD.Pro is widely used around the globe in the field of engineering analysis and structural designs. It supports both 2D and 3D designs and integrates flawlessly into international standards of design codes with a wide variety of structural elements

and loadings. The engineers have the facility to construct, analyze, and design structures with the finite element method, which leads to more accurate and economical designs.

This study emphasizes the usage patterns of structural engineering software, particularly STAAD.Pro, and compares its functionality and frequency of use with other popular tools such as ESTEEM, PROKON, ORION, Excel, and SAP2000. Data was gathered through literature review and field surveys conducted among practitioners in the Ipoh region, Malaysia. The results confirm that STAAD.Pro holds the highest preference among engineers due to its analytical depth and efficiency in steel and RCC design, especially where detailing is not a primary requirement.

IV. DESIGN PREREQUISITES

This chapter presents the fundamental assumptions, codal guidelines, and design parameters adopted for the structural analysis and comparison of a G+11 residential building constructed using GFRC and RCC in STAAD.Pro. These prerequisites ensure accuracy, consistency, and compliance with relevant standards for evaluating the performance of both construction systems.

The location of site situated near Kakinada, Kakinada District, Andhra Pradesh with a well scattered obstructions height not exceeding 10 meters to the proposed construction and the Hard soil type which is available for foundation at the proposed construction site. The measurements of the proposed construction are

- Length dimension : 40 feet or 12.192 mts
- Width Dimension : 91 feet or 27.736
- Front Setback : 3 mts
- Back Setback : 3 mts
- Rear setbacks : 3 mts

Height of the structure : 36 mts

(as per the G.O.Ms.119 Andhra Pradesh Building Rules 2017, dated 28.03.2017 and all amendments up to 2025 rules in vogue)

The Dimensions of each room in Flat –I, II, III & IV are listed as below.

FLAT -1		
ROOM NAME	LENGTH (FT)	WIDTH (FT)
Hall/Living	19'-10"	10'-0"
Dining	12'-6"	10'-4"
Kitchen	10'-6"	5'-9"
M. Bedroom	15'-0"	10'-0"
C. Bedroom	12'-0"	10'-4"
Toilet	7'-0"	4'-7"
FLAT -2		
ROOM NAME	LENGTH (FT)	WIDTH (FT)
Hall/Dining	19'-10"	11'-2"
Kitchen	10'-6"	6'-7"
M. Bedroom	11'-3"	10'-0"
C. Bedroom	11'-0"	10'-0"
Toilet	5'-0"	6'-1"
FLAT -3		
ROOM NAME	LENGTH (FT)	WIDTH (FT)
Hall/Dining	19'-10"	11'-2"
Kitchen	9'-0"	6'-7"
M. Bedroom	14'-9"	10'-0"
C. Bedroom	13'-8"	10'-0"
Toilet	6'-1"	4'-7"
FLAT -4		
ROOM NAME	LENGTH (FT)	WIDTH (FT)
Hall	12'-0"	10'-4"
Dining	12'-6"	14'-3"
Kitchen	10'-6"	5'-9"

4.1 Design Philosophy & Governing Codes

The structural design follows the Limit State Method, satisfying both:

- ULS → safety against collapse under maximum loads
- Serviceability Limit State (SLS) → acceptable deflection, cracking, vibration, and comfort

The following codes and guidelines are adopted:

Table 4.1: code books for different type of loading's

Purpose	Code / Standard Used
RCC structural design	IS 456:2000
Seismic analysis	IS 1893 (Part-1): 2016
Wind loads	IS 875 (Part-3): 2015
Dead loads	IS 875 (Part-1): 1987
Live loads	IS 875 (Part-2): 1987
Concrete mix & material	SP-23 & IS 10262:2019
GFRC material parameters	Validated experimental values & published research data (uploaded studies)

4.2 Load Calculations

The building is analysed for gravity and lateral loads using codal load combinations, consistent for both GFRC and RCC cases.

4.2.1 Dead Load Calculations:

Based on member self-weight & finishes per IS 875-Part 1

- Beams weight: Area of cross-section X unit weight of material
- Columns weight: Area of cross-section X unit weight of material
- Outer walls weight: Thickness of wall X height of wall X unit weight of material
- Inner walls weight: Thickness of wall X height of wall X unit weight of material
- Parapet wall weight: Thickness of wall X height of wall X unit weight of material
- Slab weight: Thickness of slab X unit weight of material

1. Dead load calculations for Conventional Concrete:

- Beams weight: $0.3 \times 0.45 \times 25 = 3.375 \text{ kN/m}$
- Columns weight: $0.3 \times 0.45 \times 25 = 3.375 \text{ kN/m}$
- Outer walls weight: $0.3 \times 3.0 \times 20 = 18.0 \text{ kN/m}$
- Inner walls weight: $0.15 \times 3.0 \times 20 = 9.0 \text{ kN/m}$
- Parapet wall weight: $0.1 \times 1.2 \times 20 = 2.4 \text{ kN/m}$
- Slab weight: $0.125 \times 25 = 3.125 \text{ kN/m}^2$

2. Dead load calculations for GFRC:

- Beams weight: $0.3 \times 0.45 \times 24 = 3.24 \text{ kN/m}$
- Columns weight: $0.3 \times 0.45 \times 24 = 3.24 \text{ kN/m}$
- Outer walls weight: $0.3 \times 3.0 \times 20 = 18.0 \text{ kN/m}$
- Inner walls weight: $0.15 \times 3.0 \times 20 = 9.0 \text{ kN/m}$
- Parapet wall weight: $0.1 \times 1.2 \times 20 = 2.4 \text{ kN/m}$
- Slab weight: $0.125 \times 24 = 3.0 \text{ kN/m}^2$

4.2.2 Live Load (LL)

As per IS 875-Part 2 (residential building values)
Live loads on the floors for residential buildings = 2 kN/m²

Live loads on the terrace floor for residential buildings = 1.5 kN/m²

4.2.3 Earthquake Load (EL)

As per IS: 1893-2016 the seismic loads are automatically calculating the base shear in Staad pro. For that we have to enter zone factor, importance factor, etc.... Now, we have to consider the seismic parameters which are required to calculation of seismic loads acting upon to structure.

$$\text{Design seismic co-efficient } (A_h) = \frac{Z \cdot I (S_a/g)}{2R}$$

Where, Z = zone factor

(for zone factor we have to go for the table 2 of IS1893-2016) = 0.16

I = Importance factor

(for importance factor we have to go for the table 6 of IS1893-2016) = 1.5

R = Response Reduction factor

(for Response reduction factor we have to go for the table 6 of IS1893-2016) = 5.0

(S_a/g) = Average response acceleration co-efficient

(To obtain acceleration co-efficient from figure 2 of IS: 1893-2016) = 2.5

4.2.4 Wind Load (WL)

As per IS: 875-part III the wind load calculations are clearly listed as below.

- Basic wind speed (V_b) = 50 m/s (wind zonal map of India of IS:875-part III)
- k₁ = probability factor (risk coefficient) = 1.08
- k₂ = Terrain, height and structure size factor.

Here in this Terrain Category-II, Class-B as per the structure measurements & location.

- k₃ = topography factor = 1.0 (from clause 5.3.3 of IS: 875 (Part-3)-2015)

Table 4.2 : Calculated Values of Design Wind Intensities

ALONG DIRECTION	Height	Design wind speed (V _z) (m/s)	Design wind Pressure (P _z) (N/m ²)	Design wind intensity W _i (N/m ²)
X	10	52.92	1680.315	2016.378
	15	55.08	1820.283	2184.34
	20	56.70	1928.934	2314.72
	30	59.40	2117.016	2540.419
	36	60.75	2214.337	2657.205
Z	10.000	52.92	1680.315	2100.393
	15	55.08	1820.283	2275.353
	20	56.70	1928.934	2411.167
	30	59.40	2117.016	2646.270
	36	60.75	2214.337	2767.927

4.3 Material Properties

Accurate material modeling is essential to compare GFRC and RCC behavior in STAAD.Pro.

GFRC Material Properties (from uploaded experiment data & literature)

- Grade Equivalent: ~M30
- Compressive Strength (f_{ck}): 30 MPa
- Elastic Modulus (E_c): ~28,000–30,000 MPa (adjusted based on fiber content)
- Tensile Strength: improved vs RCC (based on fiber addition)
- Density: ~24 kN/m³ (slightly lower than RCC)
- Fiber Dose: 0.5% to 1% by volume (experiment-verified optimum)

GFRC modeled as linear-elastic concrete with enhanced tensile performance & reduced cracking tendency.

Conventional RCC Properties

- **Concrete Grade:** M30
- **Modulus of Elasticity (E_c):** $5000 \sqrt{f_{ck}} = 27,386 \text{ MPa}$
- **Density:** 25 kN/m³

Reinforcement Steel

- Grade: Fe-500
- Yield Strength: 500 MPa
- Elastic Modulus: $2 \times 10^5 \text{ MPa}$
- Density: 78.5 kN/m³

4.4 Structural System & Section Properties

- Building Type: G+11 framed RCC structure
- Floor Height: Typical 3.0 m
- Beams & Columns: Rectangular sections (same dimensions in both models)
- Slab Thickness: Uniform (as per IS slab design norms)
- Staircase & Lift Core: Included
- Shear Walls: Not used — column-beam moment frame system to highlight concrete performance difference

V. METHODOLOGY

This chapter describes the systematic methodology adopted for the analysis and comparison of a G+11 residential building constructed using GFRC and RCC in STAAD.Pro. The workflow includes model development, material definition, load application, and performance evaluation to ensure a scientific and

accurate comparison between the two structural systems.

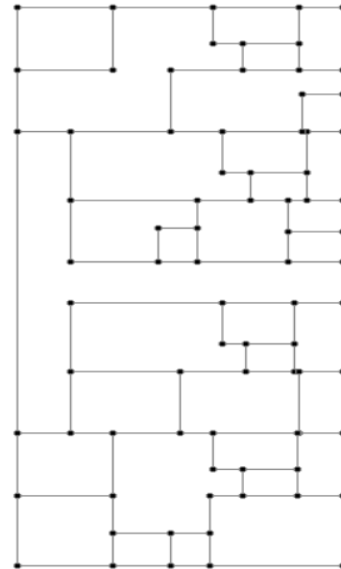


Figure 5.1: showing Typical plan of G+11 building (RCC) in Staad Pro

5.2 Material, Properties Generation in STAAD Pro

Once the Model in Staad Pro Software is created successfully, the next step involves defining the material properties for the sections of the beams, columns, and slab panels based on the National Building Code criteria. After defining the properties, we shall assign these properties to each section, as shown in the diagrams below.



Figure 5.4: Material Property Definition in STAAD.Pro

5.3 Loads Generation in STAAD Pro

Once the structure's supports are in place, we must apply several types of loads, including dead, live, wind, earthquake, and combination loads.

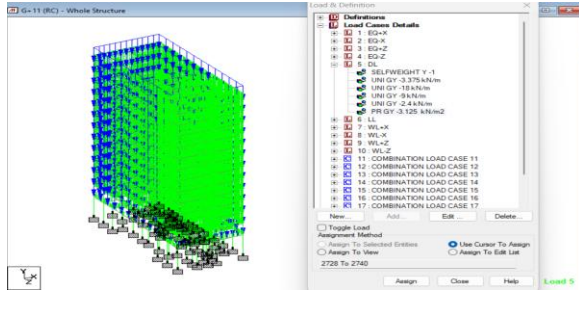


Figure 5.9: Assignment of Dead Load – G+11(RCC)

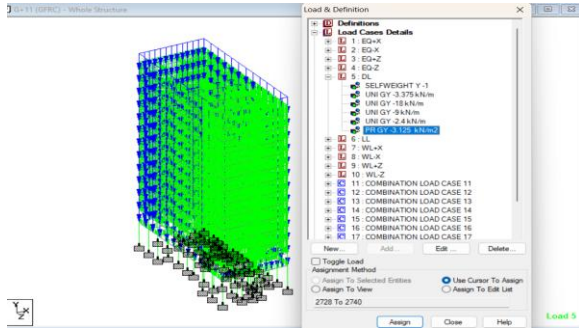


Figure 5.10: Assignment of Dead Load – G+11(GFRC)

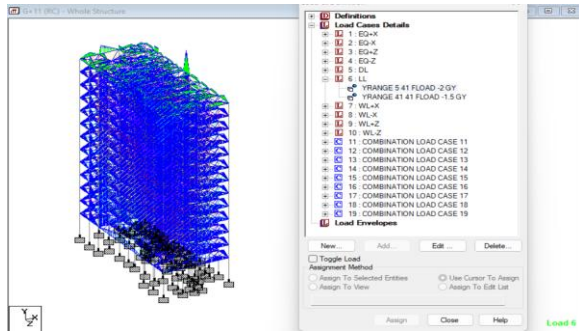


Figure 5.11: Assignment of Live Load – G+11(RCC)

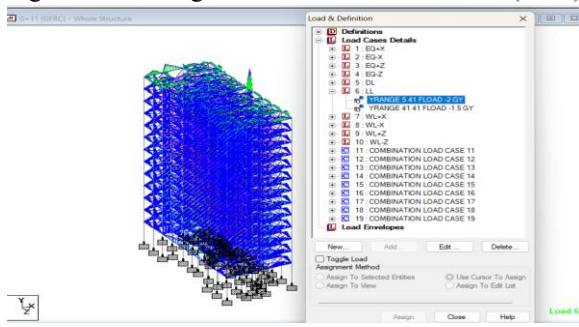


Figure 5.12: Assignment of Live Load – G+11(GFRC)

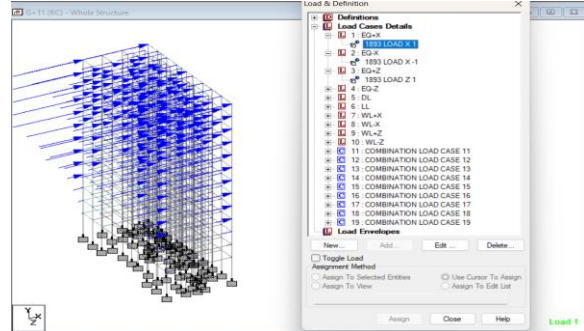


Figure 5.13: Assignment of Earthquake Loads – G+11(RCC)

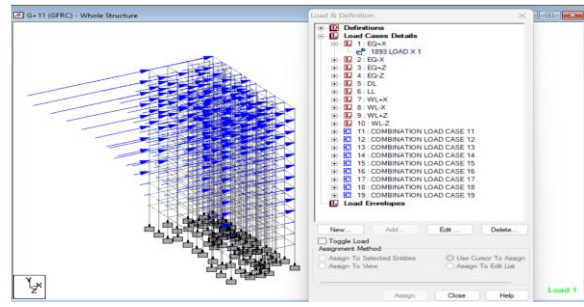


Figure 5.14: Assignment of Earthquake Loads – G+11(GFRC)

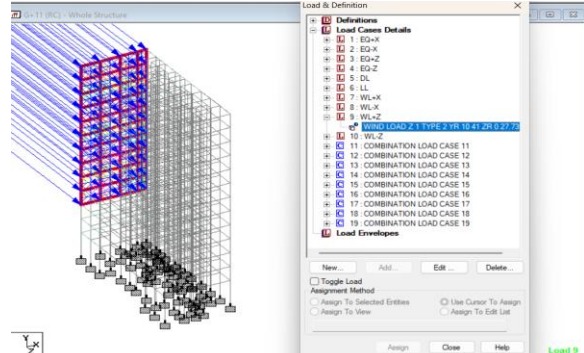


Figure 5.15: Assignment of Wind Loads – G+11(RCC)

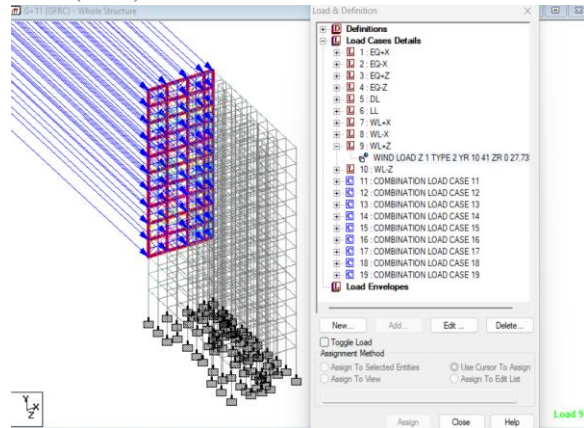


Figure 5.16: Assignment of Wind Loads – G+11(GFRC)

VI. RESULTS AND DISCUSSION

6.1 Results

The structural analysis of the G+11 residential building using STAAD.Pro yielded the following key results for both Normal Concrete and Glass Fiber Reinforced Concrete (GFRC) models. The values represent the maximum observed forces and displacements under the applied loading conditions.

6.2 Beam Design Results

BEAM NO. 233 DESIGN RESULTS (Beam in Ground Floor G+11 RC Building)

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 3657.0 mm SIZE: 300.0 mm X 450.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION 0.0 mm 914.2 mm 1828.5 mm 2742.8 mm 3657.0 mm

TOP 582.24 308.04 256.23 388.98 979.20
REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

BOTTOM 930.37 539.13 255.00 255.00 492.20
REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION 0.0 mm 914.2 mm 1828.5 mm 2742.8 mm 3657.0 mm

TOP 3-25i 3-25i 3-25i 3-25i 3-25i
REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

BOTTOM 3-20i 3-20i 3-20i 3-20i 3-20i
REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

SHEAR 2 legged 8i 2 legged 8i 2 legged 8i 2 legged 8i 2 legged 8i
REINF. @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 565.0 mm AWAY FROM START SUPPORT
VY = -54.46 MX = -2.58 LD= 16
Provide 2 Legged 8i @ 150 mm c/c

SHEAR DESIGN RESULTS AT 565.0 mm AWAY FROM END SUPPORT
VY = -81.54 MX = -2.58 LD= 16
Provide 2 Legged 8i @ 150 mm c/c

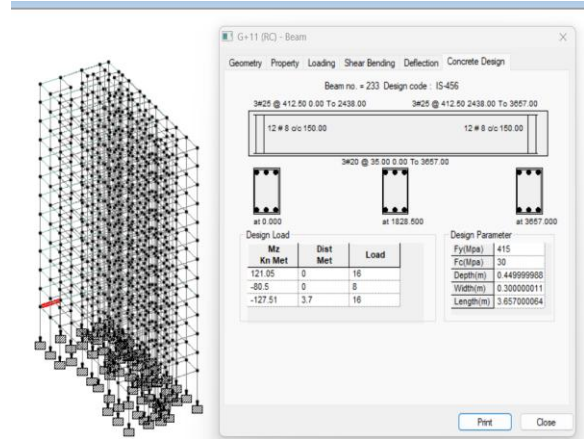


Figure 6.1: Detailing Diagram of beam in Ground Floor – G+11(RCC)

BEAM NO. 233 DESIGN RESULTS (for G+11 GFRC Building)

M30 Fe415 (Main) Fe415 (Sec.)
LENGTH: 3657.0 mm SIZE: 300.0 mm X 450.0 mm COVER: 25.0 mm

SUMMARY OF REINF. AREA (Sq.mm)

SECTION 0.0 mm 914.2 mm 1828.5 mm 2742.8 mm 3657.0 mm

TOP 588.00 310.43 255.00 389.56 986.30
REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

BOTTOM 925.80 534.91 255.00 255.00 490.26
REINF. (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm) (Sq. mm)

SUMMARY OF PROVIDED REINF. AREA

SECTION 0.0 mm 914.2 mm 1828.5 mm 2742.8 mm 3657.0 mm

TOP 3-16i 3-16i 3-16i 3-16i 5-16i
REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)

BOTTOM 3-20i 3-20i 3-20i 3-20i 3-20i

REINF. 1 layer(s) 1 layer(s) 1 layer(s) 1 layer(s)
1 layer(s)

SHEAR 2 legged 8i 2 legged 8i 2 legged 8i 2 legged 8i 2 legged 8i

REINF. @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c @ 150 mm c/c

SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT

SHEAR DESIGN RESULTS AT 565.0 mm AWAY FROM START SUPPORT

VY = -54.46 MX = -2.27 LD= 16
Provide 2 Legged 8i @ 150 mm c/c

SHEAR DESIGN RESULTS AT 565.0 mm AWAY FROM END SUPPORT

VY = -81.31 MX = -2.27 LD= 16
Provide 2 Legged 8i @ 150 mm c/c

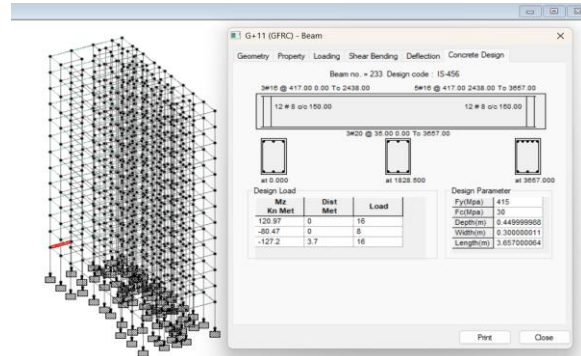


Figure 6.2: Detailing Diagram of beam – G+11(GFRC)

6.3 Column Design Results

COLUMN NO. 214 DESIGN RESULTS (for G+11 RC Building)

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 5000.0 mm CROSS SECTION: 450.0 mm X 300.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 16 BRACED LONG(Z) /SHORT(Y)

REQD. STEEL AREA : 4691.93 Sq.mm.
REQD. CONCRETE AREA: 130308.08 Sq.mm.

MAIN REINFORCEMENT : Provide 16 - 20 dia. (3.72%, 5026.55 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 3219.52 Muz1 : 106.08 Muy1 : 176.16
INTERACTION RATIO: 0.97 (as per Cl. 39.6, IS456:2000)

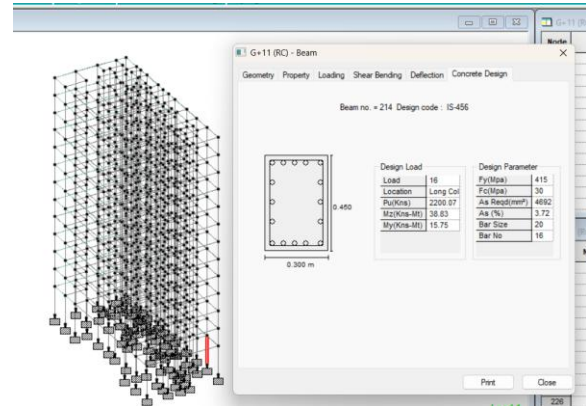


Figure 6.3: Detailing Diagram of Column – G+11(RCC)

COLUMN NO. 214 DESIGN

RESULTS (for G+11 GFRC Building)

M30 Fe415 (Main) Fe415 (Sec.)

LENGTH: 5000.0 mm CROSS SECTION: 450.0 mm X 300.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 16 BRACED LONG(Z) /SHORT(Y)

REQD. STEEL AREA : 4674.95 Sq.mm.
REQD. CONCRETE AREA: 130325.05 Sq.mm.

MAIN REINFORCEMENT : Provide 16 - 20 dia. (3.72%, 5026.55 Sq.mm.)

(Equally distributed)

TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)

Puz : 3214.47 Muz1 : 105.76 Muy1 : 175.59
INTERACTION RATIO: 0.98 (as per Cl. 39.6, IS456:2000)

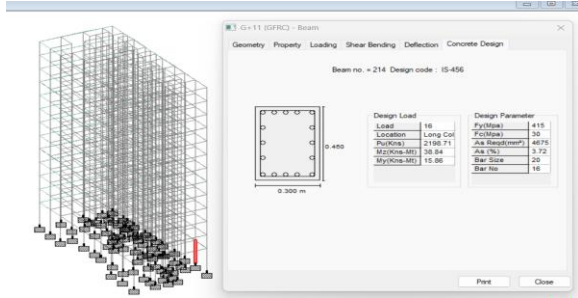


Figure 6.4: Detailing Diagram of Column – G+11(GFRC)

VII. CONCLUSIONS

Based on the comprehensive modelling, analysis, and comparison of the G+11 Residential building using STAAD.Pro the following conclusions are drawn:

- **Superior Structural Performance:** GFRC significantly enhances structural stiffness, reducing maximum resultant displacement by 22.8% compared to normal concrete. This demonstrates GFRC's ability to provide superior serviceability and reduced cracking under load.
- **Enhanced Deflection Control:** The material shows excellent deflection control capabilities with 23.3% reduction in vertical displacement. This indicates GFRC's superior performance in managing deformations under gravity loads and improving overall structural stability.
- **Reduced Internal Forces:** Analysis reveals consistently lower internal forces in GFRC structure with 1.2% reduction in both bending moment and shear forces. This reduction suggests potential for optimizing reinforcement requirements while maintaining structural safety.
- **Efficient Load Distribution:** GFRC demonstrates more efficient load distribution throughout the structural system, evidenced by reduced axial forces (0.7%) and more balanced force transmission. This leads to better utilization of material capacity.
- **Viable Construction Alternative:** The study confirms GFRC as a viable and competitive alternative to conventional concrete for high-rise buildings. Its enhanced properties offer opportunities for more durable and efficient structural designs in modern construction.

- **Software Validation:** The research validates STAAD.Pro effectiveness in analysing composite materials like GFRC, providing reliable results that can support structural decision-making and innovation in concrete technology.
- **Sustainable Solution:** GFRC's improved performance characteristics, combined with its potential for reduced material usage, position it as a sustainable construction solution that aligns with modern environmental and efficiency requirements.

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