International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Sustainable Structural Solution for Commercial Building

Sahil Patil [1] , Amisha Patil [2] , Pooja phadtare [3], and Pratiksha Patole [4]

Abstract - Construction has been an important part of human activity since ancient times. The main goal of construction is to ensure that construction projects are completed within the constraints of the best quality, given period and economically, lighter and less impacting on the environment. Sustainable requirements and to minimize the negative impact on the environment, an ingenious type of material is used which is Light-gauge steel a cold-formed material that is used to make construction process smoother and products stronger. It can be used for roof systems, floor systems, wall systems, roof panels, decks, or entire buildings. This report will help to design sustainable structural solutions for commercial buildings.

***Key Words*:** Sustainable, ingenious, construction, light-gauge stee

1.Introduction

1.1 General

Construction is a key part of the economy as it plays a vital role in the development of a country. It is a source of developing employment and the generation of new incomes. Construction has been an important part of human activity since ancient times. It began as a need for shelter for humans to protect themselves from climate change. It has a wide range of processes which contain planning, surveying, designing, construction, and finishing services. The quality of our buildings has a persistent impact on the welfare of individuals and communities across all regions and sectors. The main goal of construction is to ensure that construction projects are completed within the constraints of the best quality, given period and economically, lighter and less impacting on the environment. Efficiency and productivity are very important in the construction industry; the use of construction technology can be very useful to complete a project productively and efficiently. When creating, designing, or erecting a structure, construction technology can be used to make the work easier.

1.2 Sustainability

Sustainable development has become a leading topic in the construction industry. Sustainable development is defined as development that meets the needs of the present while also making sure that future generations can meet their basic needs.

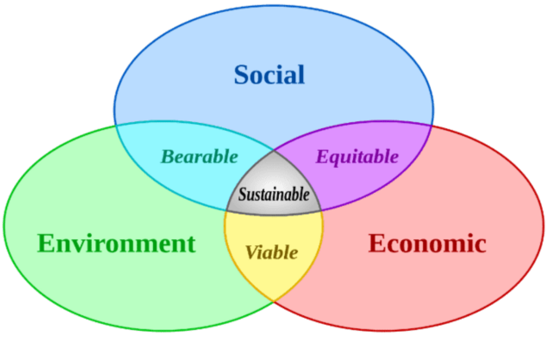


Fig. 1.1 Sustainability cycle

Nowadays a sustainable ecosystem is highly fig 1.1 Sustainability needed but the construction development around us has already caused so much damage to our ecosystem. This increase in urbanization and construction activity will create more waste which eventually destroys natural resources and habitats over 70% of the land surface. This is a major trouble for us as well as for our future generation and hence the requirement for sustainability is especially in the construction industry. For a long period, construction has produced the destruction of our ecosystem. Rectifying this issue has become a top priority in the industry. To resolve this problem the best way is to minimize the consumption of natural resources for the construction sector. To attain this objective some steps are required to be taken while designing, and renovating a structure following environmental rules and energy-saving methods like the use of renewable energy, use of smart technologies, using environmentally friendly materials, etc. Buildings can be classified into different types of construction: fire resistance, non-combustible, ordinary, heavy timber and wood-framed. These include residential building construction, industrial construction, commercial building construction and heavy civil construction.

1.3 Building Materials

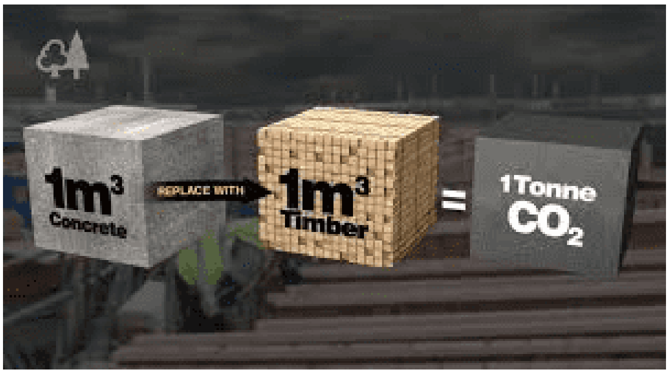


Fig 1.2 CO_2 emission due to concrete and timber

The products/industrial processes of energy-intensive building materials, i.e., cement, lime, steel, bricks and aluminium emit 80% emissions from the construction sector. There are many sorts of building materials used in construction like Concrete, Steel, Wood and Masonry. Every material has various properties like weight, durability, strength, and cost which makes it reasonable for particular kinds of utilizations. The selection of construction materials depends on cost and the capacity to resist stresses acting on the construction units. Building materials can be partitioned into two ways: Natural structure materials like stone and wood, and Man-made structure materials like cement and steel. Processing and transport of the material include energy consumption resulting in carbon emission. To minimize carbon emissions, it will become essential to produce building materials and products with a minimum amount of energy expenditure.

1.4 Cold-Formed Steel

Now to reach the sustainable requirements and to minimize the negative impact on the environment, an ingenious type of material is used which is Light-gauge steel (also known as cold-formed steel and cold-rolled steel) a cold-formed material that is used to make construction processes smoother and products stronger. It does not deteriorate, like wood. It is not bulky, like structural steel. It is not heavy, like concrete. Light Gauge Framing System (LGFS) or Light Gauge Steel Framing (LGSF) is a construction technology using cold-formed steel as the construction material. It can be used for roof systems, floor systems, wall systems, roof panels, decks, or entire buildings. In Site waste is virtually eliminated by the use of prefabricated light steel and modular components compared to the industry average wastage of 10% in construction materials. Use of components rolled to length results in no production waste.

Fig 1.3 LGSF Construction Technology

2.LITERATURE REVIEW

2.1General

The Focus of this project centres around providing a sustainable structural system that will be beneficial for the changing environment. We carried out a detailed study of various research papers which gives us a broader perspective of our focused area i.e. sustainable structures. Our literature study is as follows-

2.2 A Composite Construction study using LGSF

Following are the research papers that help in understanding the composite construction study –

S.vigneshkannan and others reviewed a general study of Light gauge steel structures. the present work details with various CFS sections have been applicable in special features like high fire resistance, min lock buckling, especially CFS hollow section has high loading rates and applicable of infill material bring best results in joints on building elements.

Srushti Bagul and Deepa A Joshi explained composite construction techniques using LGSF and ferrocement for affordable housing. Ferrocement is a composite material used to form thin sections. Elastic and exceptionally strong precast components are 85% recyclable, have low Co2 generation and are energy-efficient. LGSF thin-walled steel members are currently Cold-formed to shape from a steel strip coil. Compared to components made on the site, the industrially manufactured product has low cost, better accuracy in dimensions and quality strength. The technology uses galvanized steel which is rustproof, mould resistant and waterproof and steel carries a 50yrs warranty against any form of corrosion.

Salokhe S. A et.al. (2015) presented a paper that gives a comparative study of the behaviour of hot rolled steel sections and cold-formed steel sections under compressive loading. This research paper shows a comparison of cold-formed and hot-rolled steel sections of equal cross-sectional area. Experimental testing of sections was done in a universal testing machine under axial loading as well as the ultimate compressive strength of both members has been investigated. Different properties of sections are obtained experimentally such as stresses, strain-induced in sections, axial deflection, and lateral deflection. It is observed that hot rolled steel sections have less load carrying capacity than cold-formed steel sections.

Yasar Arafath et.al experimentally investigated the behaviour of cold-formed light gauge steel beams subjected to cyclic loading. CFS members offer one of the highest load capacity-to-weight ratios among the various structural component currently on the market. The design of cold-formed light gauge steel beams was made as per IS 811-1987.

According to a recent study, prefabricated steel construction covers only 25% of the overall Indian real estate market and sums up to about $150 billion. However, industry experts claim that the boom is yet to come for the prefabrication construction method in India and several other neighbouring countries. LGSF is amongst the latest construction concepts that have taken the market by storm, yet there are various misconceptions about prefab structures. Many builders feel that these are still relying on traditional building structures, but as the

market is evolving, the market is getting ready to accept this methodology, and the scenario is changing. Currently, the primary users of the LGSF structures are corporations, but with time these prefab structures are slowly and steadily finding their way into residential real estate.

Hence, there is an immediate need to create more awareness among the common people, popularise the concept and extensively adopt prefabricated structures to increase efficiency. quality, and speed of construction, while reducing cost and additional efforts.

The following can be the conclusions drawn from the above research Composite Construction study

• CFS members offer one of the highest load capacity-to-weight ratios among the various structural components. CFS sections have special features like high fire resistance, and min lock buckling, especially CFS hollow section has high loading rates and the application of infill material bring the best results in joints on building elements

• Cold-formed steel has maximum lateral loading as well as good stiffness value than hot rolled steel. It has more moments of inertia, more stability and section modulus.

• Immediate need to create more awareness among the common people,

• Popularise the concept and extensively adopt prefabricated structures to increase efficiency.

• Quality, and speed of construction, while reducing cost and additional efforts.

2.3 LGSF construction material

Following is the study of LGSF materials to withstand different types of loads-

Building Materials & Technology Promotion Council Ministry of Housing & Urban Poverty Alleviation Government of India. This report gave an in-depth knowledge about the materials used in construction. Though there are very less resources available concerning construction materials of LGSF, this document acted as a huge guide in our design aspects

Summary of literature review

The use of sustainable materials is suggested to have a low impact on the environment and also to use more durable and renewable materials. Composite construction techniques such as LGSF and ferrocement are suggested for having better aesthetic and affordable housing.

CFS members offer one of the highest load capacity-to-weight ratios as they have special features like high fire resistance, min lock buckling and also the hollow sections are more helpful in connecting the building elements.

3.METHODOLOGY

3.1 General

Design of philosophy by which we are going to achieve the objectives for our design and for that we will assign supported characteristic values for material strengths and applied loads (action by force), which will be taken into consideration of the probability of variations in the material strengths and the loads to be supported. The dependability of design is ensured by satisfying the requirement. The following is the methodology proposed

3.2 Design specifications and consideration of RCC

3.2.1 Load selection- The following are the category of design loads considered to be used in the analysis of the structural model of the proposed building:

Dead Loads - These are building loads resulting from the structural elements used in the construction of the proposed structure. They include structural columns, structural beams, structural floors and structural connections. They are also inclusive of other building elements that may not serve a structural purpose such as architectural columns.

Live Loads - These are loads due to the occupancy of the building and are determined based on the building type and intended use.

Seismic Loads - These are externally generated loads applied to a structure as a result of earthquake-generated agitation.

3.2.2 Initial structural element selection- An initial selection of the size ranges of structural elements was chosen for the modelling of the proposed building structure based on its intended purpose and initial designs. These structural elements inclusive of beams, columns, and floor slabs were assessed to determine the best options to meet both structural and economic targets by structural optimization.

The following is a list of structural elements selected for the modelling of the proposed building structure:

- Beams- A Beam is a horizontal structural element that runs horizontally to withstand vertical load coming off the building frame. The beam takes the load & distributes it to ends and transfers it to columns, walls, and posts on both sides of the beam. it only withstands laterally applied loads on the axis of the beam. In the model, the beam size is 500 x300 mm

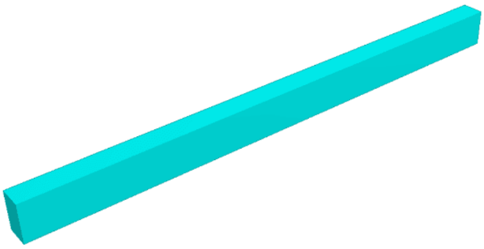


Fig 3.1 Beam

- Column- A column is a vertical structure that transmits the compressive loads. The size of the column in the model is 400 x 500 mm

- Floor - Floors typically consist of a subfloor for support and a floor covering used to give a good walking surface. In modern buildings, the subfloor often has electrical wiring, plumbing, and other services built-in

- Footing- Well-built foundations keep the occupants of the building safe during calamities such as earthquakes, floods, strong winds etc. The foundation must be built such that, it keeps the ground moisture from seeping in and weakening the structure.

Fig 3.2 Column

3.2.3 Design code selection- The local building design codes used in India are the Indian Standard Codes.

Loading- The following structural code was used for the definition and determination of the structural loads used in the analysis of the proposed building as well as the following code was used for the design of the various structural elements in the proposed building

- Indian Standard 456 (2000): Plain and Reinforced Concrete - Code of Practice
- Indian Standard IS 875: 1987 Code of Practice for design loads
- Indian Standard IS 800: 2007 General Construction in Steel Code of Practice.

3.2.4 Construction process of RCC-

A. Pre-Construction Steps

1. To Acquire Land or Plot.
2. To Seek Technical Help.
3. Prepare Estimation and Budgets.
4. Permission from Authorities.
5. Approach a Builder.
6. Superstructure – Column.

B. During Building Construction Steps

1. Site Preparation or Levelling work
2. Excavation and PPC
3. Foundation
4. Plinth Beam or Slab
5. Superstructure – Column
6. Brick Masonry Work
7. The Lintel Over Door Window Gaps
8. Floor Slab or Roof Structure
9. Door Window Framing and Fixations
10. Electrical and Plumbing
11. Exterior Finishing
12. Terrace and Roof Finishing
13. Internal Finishes

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

14. Woodwork and Fixture Fittings
15. Waterproofing
16. Painting Work

3.3 Model creation of RCC building-

Structural physical Model -The figure below represents the structural model of the proposed building structure to be analyzed. The structure consists of a structural reinforced concrete ground floor and three (3) upper structural floors. There are 96 beams and 20 columns in this structural model.

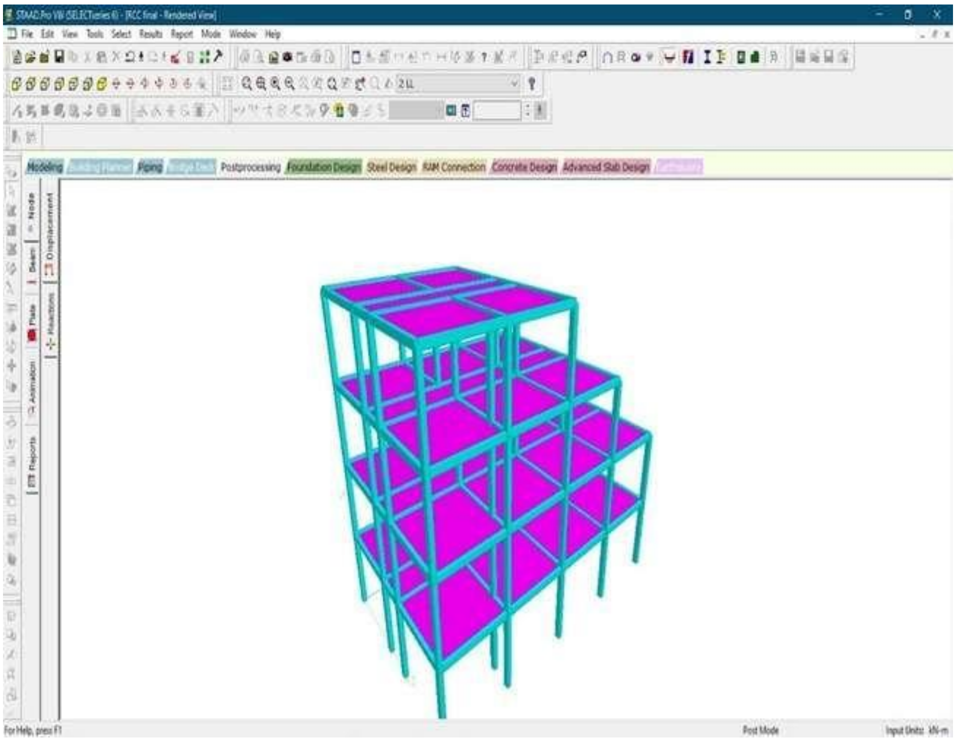


Fig 3.3 Staad Pro RCC

3.4 Input for RCC Building

Following are the values of parameters considered to create the model of a G+3 RCC Commercial building using the software Staadpro.

Table 1 Input file of RCC building

Plan	17x28m
Height	24m
Floor to Floor height	6m
Beam dimensions	0.5x0.3m
Column dimensions	0.5x0.4m
Slab thickness	0.15m
Material	Isotropic concrete
Poisson's ratio	0.17
Density	23.5616 kN/m^3
Strength	40MPa
Dead Load	Self weight factor -1 Floor finish = 1.5kN/m^2 Brick wall = 5kN/m
Live Load	5kN/m^2
Seismic Loads	Zone Factor (III) : 0.16 Performance Factor (k): 1 Soil Interference factor(B): 1
Support	Fixed support
Defined parameters	Compressive strength of concrete(Fc) = 40MPa Yield strength of main steel (fyld) = 500MPa Yield strength of distribution steel (fyld) = 500MPa

	Min. bar diameter = 8mm Max. bar diameter = 20mm
Commands	Design beam Design column Design slab/element Take off
Code of Practice	Indian Standard 456:2000 Plain and Reinforced Concrete Code of Practice

3.5 Output File for RCC Buikding

After performing the analysis on the above model with the help of Staadpro, the output obtained is as follows

Support reactions:

Table 2 Output File, Support Reactions for RCC

	Node	L/C	Horizontal	Vertical	Horizontal	Moment		
			Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	2	3 LL	5.057	339.368	-2.203	-4.2	0.013	-10.124
Min Fx	14	1 SL	-8.199	4.252	-0.271	-0.916	0.084	26.904
Max Fy	8	2 DL	-0.33	1044.938	-5.226	-10.502	-0.012	0.474
Min Fy	3	1 SL	-7.669	-29.764	0.425	1.537	0.07	25.521
Max Fz	9	3 LL	-0.26	506.569	7.86	15.724	0.009	0.463

Min Fz	18	3 LL	0.031	311.188	-7.805	-15.441	0.009	-0.149
Max Mx	9	3 LL	-0.26	506.569	7.86	15.724	0.009	0.463
Min Mx	18	3 LL	0.031	311.188	-7.805	-15.441	0.009	-0.149
Max My	14	1 SL	-8.199	4.252	-0.271	-0.916	0.084	26.904
Min My	6	1 SL	-3.559	1.668	0.245	0.815	-0.329	16.761
Max Mz	14	1 SL	-8.199	4.252	-0.271	-0.916	0.084	26.904
Min Mz	2	3 LL	5.057	339.368	-2.203	-4.2	0.013	-10.124

Beam end forces:

Table 2 Output File, Beam end Forces for RCC

	Beam	**L/C**	**Node**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	37	1 DL	8	1044.938	0.33	-5.226	-0.012	10.502	0.474
Min Fx	186	2 LL	85	-6.399	-9.517	0.344	-0.597	-0.405	-5.199
Max Fy	187	2 LL	86	2.03	69.201	-0.081	0.166	0.224	54.352
Min Fy	155	2 LL	72	-0.959	-62.468	-0.001	-0.076	-0.004	87.284
Max Fz	177	2 LL	72	131.992	1.785	19.486	0.02	-49.757	6.119
Min Fz	176	2 LL	71	184.846	1.788	-16.153	0.025	40.844	6.461
Max Mx	197	1 DL	93	0.303	35.158	-0.001	2.147	0.007	29.367

Min Mx	185	1 DL	84	0.955	34.987	-0.007	-2.389	0.021	29.818
Max My	177	2 LL	89	131.992	1.785	19.486	0.02	67.16	-4.589
Min My	176	2 LL	88	184.846	1.788	-16.153	0.025	-56.071	-4.266
Max Mz	155	2 LL	72	-0.959	- 62.468	-0.001	-0.076	-0.004	87.284
Min Mz	99	2 LL	62	83.78	11.732	5.272	0.021	16.914	-37.493

Nodal Displacement:

Table 2 Output File, Node Displacement for RCC

			Horizontal	**Vertical**	**Horizontal**	**Resultant**	**Rotational**		
	Node	**L/C**	**X mm**	**Y mm**	**Z mm**	**mm**	**rX rad**	**rY rad**	**rZ rad**
Max X	89	1 SL	14.781	-0.01	-0.209	14.783	0	0	0
Min X	58	2 DL	-0.289	-0.564	0.029	0.635	0	0	0.001
Max Y	83	1 SL	14.269	0.094	-0.571	14.28	0	0	0
Min Y	88	2 DL	0.527	-3.543	0.343	3.599	-0.001	0	0
Max Z	81	2 DL	0.485	-1.964	0.391	2.061	0.001	0	-0.001
Min Z	84	1 SL	13.902	0.084	-0.573	13.914	0	0	0
Max rX	89	3 LL	1.102	-1.761	-0.358	2.108	0.001	0	0

Min rX	88	3 LL	1.022	-2.463	-0.362	2.691	-0.001	0	0
Max rY	86	1 SL	13.689	-0.004	-0.209	13.691	0	0	0
Min rY	89	1 SL	14.781	-0.01	-0.209	14.783	0	0	0
Max rZ	80	3 LL	0.181	-1.095	-0.099	1.114	0	0	0.001
Min rZ	82	3 LL	1.027	-1.167	-0.444	1.616	0	0	-0.001
Max Rst	81	1 SL	14.779	0.079	-0.568	14.79	0	0	0

Statics check results:

Table 2 Static check result for RCC

L/C		**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
1	**Loads**	151.78	0	0	0	1227.131	-2910.484
	Reactions	-151.78	0	0	0	-1227.131	2910.484
	Difference	0	0	0	0	0	0
2	**Loads**	0	-15217.33	0	1.30E+05	0	-1.83E+05
	Reactions	0	15217.33	0	-1.30E+05	0	1.83E+05
	Difference	0	0	0	0	0	0

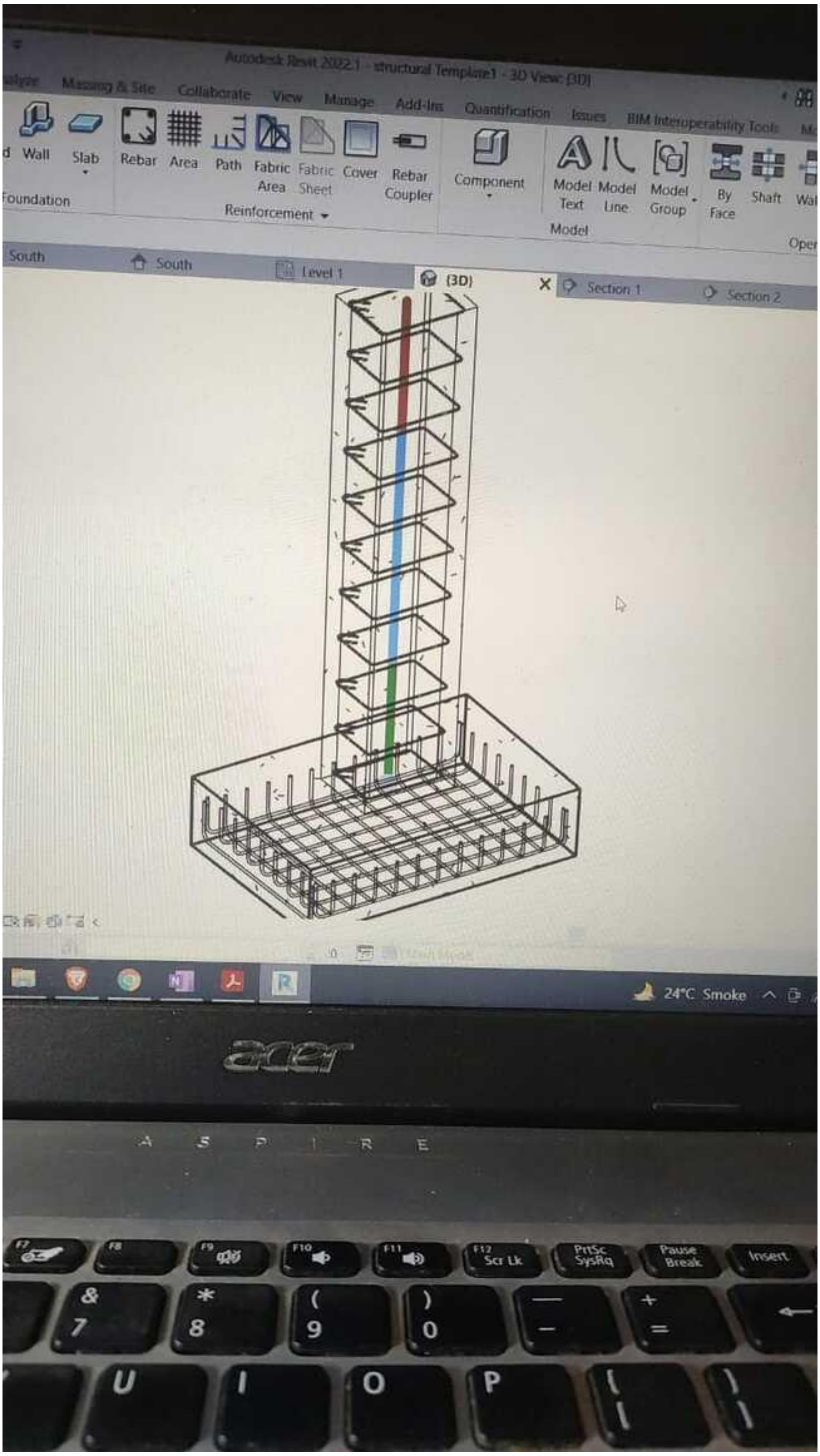
3	**Loads**	0	-7735	0	65747.498	0	-93712.5
	Reactions	0	7735	0	-65747.498	0	93712.5
	Difference	0	0	0	0	0	0

```
         **************  CONCRETE  TAKE OFF  **************
               (FOR BEAMS, COLUMNS AND PLATES DESIGNED ABOVE)
    NOTE: CONCRETE QUANTITY REPRESENTS VOLUME OF CONCRETE IN BEAMS, COLUMNS, AND PLATES DESIGNED ABOVE.
          REINFORCING STEEL QUANTITY REPRESENTS REINFORCING STEEL IN BEAMS AND COLUMNS DESIGNED ABOVE.
          REINFORCING STEEL IN PLATES IS NOT INCLUDED IN THE REPORTED QUANTITY.

         TOTAL VOLUME OF CONCRETE =        362.4 CU.METER

                        BAR DIA          WEIGHT
                        (in mm)         (in New)
                       --------         --------
                            8              61471
                           10              26261
                           12             113333
                           16              18156
                                     ------------
                          *** TOTAL=      219221
```

Fig. Concrete and steel Required for RCC structure


Autodesk Revit 2022.1 - structural Template1 - 3D View: {3D}
Massing & Site
Collaborate
View
Manage
Add-Ins
Quantification
Issues
BIM Interoperability Tools
Wall
Slab
Rebar
Area
Path
Fabric Area
Fabric Sheet
Cover
Rebar Coupler
Component
Model Text
Model Line
Model Group
By Face
Shaft
Foundation
Reinforcement
Model
South
South
Level 1
{3D}
Section 1
Section 2
24°C Smoke
acer

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

Fig 3.3 column and footing

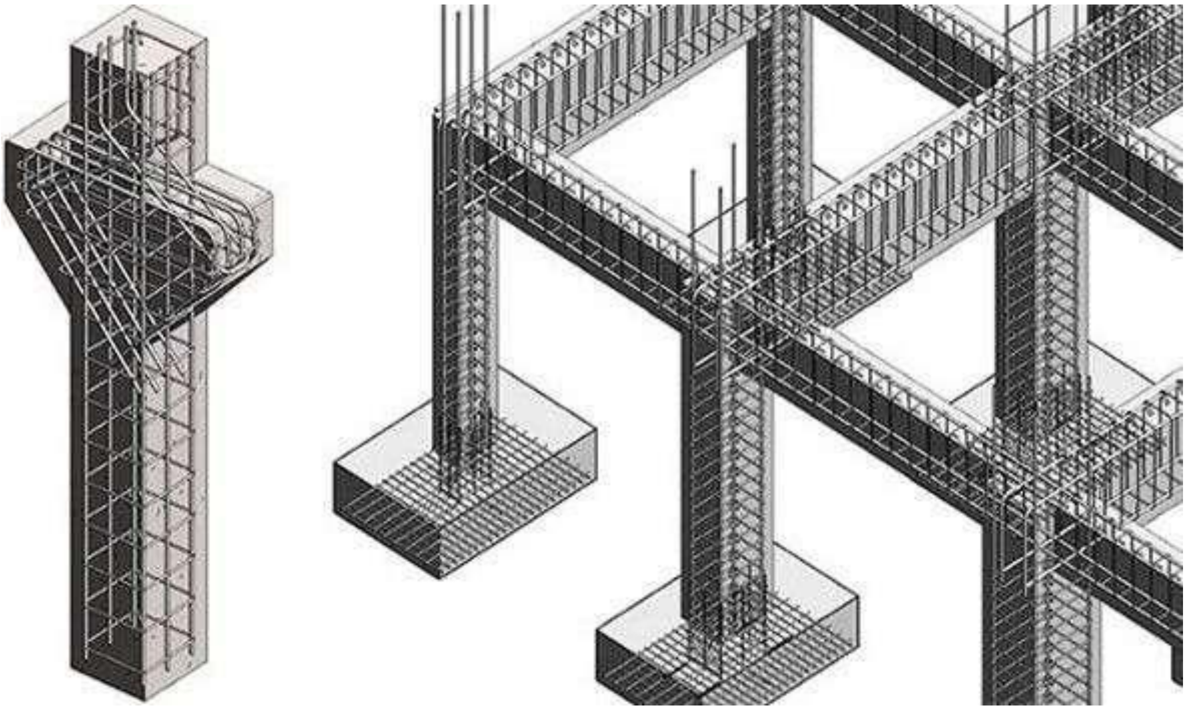


Fig 3.4 Beam Columns connections

Fig 3.5 RCC Staad Pro Design

3.5 Advantages and Disadvantages of RCC

3.5.1Advantages of RCC over other construction materials

1. Strength-In of the price range of RCC, it gives very good strength in both, compression and tension.

2. Durability-RCC structures are enough durable, if they are laid and used properly, they can last up to 100 years.

3. Economy-RCC is cheaper when compared with other construction materials like steel and prestressed concrete. In future, the maintenance cost of RCC is also very low. So, in all aspects, we can say that RCC is an economical construction material.

4. Convenience-RCC can be prepared and moulded easily, at the site of construction. Also, the materials required for preparing RCC can be transported easily.

5. Availability-Raw materials required for preparing RCC (like cement, sand, aggregates, admixtures and steel bars) are easily available everywhere at a fair cost.

6. Mouldability-RCC structures can be moulded in any shape and size as per architectural requirements. For this, it needs good formwork and architectural design.

7. Fire Resistance-RCC structures are more fire-resistant compared to other construction materials like wood, steel, etc.

8. Permeability-RCC structures are impermeable to moisture if some major attempts have been made during their building.

9. Seismic resistance-Properly designed and executed RCC structures are resistant to major vibrations like earthquakes or vibrations produced due to other factors like moving trains etc.

The overall goal is to be able to design reinforced concrete structures that are: • Safe • Economical • Efficient Reinforced concrete is one of the principal building materials used in engineered structures because of • Low cost • Weathering and fire resistance • Good compressive strength • Formability

3.5.2Disadvantages of RCC

Although RCC has various advantages, it has some disadvantages too.

1. RCC sections are heavier compared to the sections made with other construction materials like steel, wood, etc.
2. RCC sections consume more space than other sections made with construction materials like Steel.
3. It requires lots of formwork, centring and shuttering to be fixed. Hence it requires more site space and skilled labour with perfect design and execution.
4. RCC takes time to gain its full strength because cement gains strength very slowly. Thus, it can't be used immediately in the structures. Also, the time taken by the structure for its complete construction is more.
5. RCC needs too much maintenance during its construction, like proper curing, checking of cracks, prevention from direct sunlight, etc.

3.6 Design specifications and consideration of Ligh Gauge Stee Framing Structure

3.6.1Initial Structural Element Selection

1. Structural Section

- STUD: It serves as a general all-purpose framing component used in a variety of applications including external curtain walls, load-bearing walls, headers floors and roof joists, soffits and frame components.
- TRACK: It is used as a closure to stud and joists end as well as head and sill conditions. It is also used for blocking and bridging conditions.
- Load-bearing steel framing members shall be cold-formed to shape from structural quality sheet steel complying with IS801:1975

2. Wall Frame

- Consists of a top trach (U shape configuration) with a depth compatible with that of the studs of the same nominal size. The minimum height of track flanges shall be 19mm.
- Load Bearing Walls – C section studs with depths of 90mm to 250mm and thickness between 2.7mm to 5mm shall be provided at a distance of 300mm to 610mm to ensure the

efficient use of cladding material. Multiple studs are used in heavily loaded applications such as adjacent to openings or in the braced panel.

- Non-load bearing walls – it is similar to that of load-bearing walls except that noggings and diagonal bracing are not required to stabilize the studs.
- Deflection Limit of Walls – Suggested deflection limits for external walls subjected to wind loading are as follows

Full Height glazing	Height/600
Masonry Wall	Height/500
Board/reduced finish	Height/360
Steel Cladding	Height/250
Other Flexible Cladding	Height/360

Table 4 Deflections of wall

3. Wall Cladding

Wall cladding shall be designed to resist wind load. The sheet has to be screwed to the joist/purlin with a maximum spacing of 300mm c/c. all the joints of the sheet in a longitudinal direction require a minimum lap of 150mm to make them leakproof.

4. Bracing

Bracing and bridging shall have configuration and steel thickness to provide secondary support for the studs following the relevant specification for the design of cold-formed steel structure of members. Bracings are provided as rectangular plate section: Plate thickness = 6mm, Width = 140mm

5. Floor Frame

For faster construction, floor joists may be pre-assembled to form floor cassettes. This is good for regular floor places but extra care is required when the geometry of the building required cassettes to vary in size with location or when non-right-angle corners are required. Resistance may be provided to the top flange of the joist by a flooring board. The floor should be designed for the combined effect of dead and imposed load. The construction of a suspended floor comprising cold-formed steel floor joists is similar to that of a floor using timber joists. The strength to weight ratio of light steel joists is higher than that of other materials. steel joists are stable and do not suffer, the long-term problems of drying out, creep and shrinkage, joists are generally positioned at 300-, 400- and 600-mm centres, depending on the spacing capabilities of the floor materials used.

6. Roof Frame

A flat roof is made up of joists. Where steel decking forms a flat roof, a minimum fall of 1:4 should be introduced to ensure that any moisture runs off. to avoid ponding to rainwater, the pitch may need to be increased to overcome the effective reduction in roof angle caused by the deflection of long-span roof purlin or decking.

7. Roof Truss

The use of a light steel roof truss is very economical for larger span buildings, an attic or open roof truss creates usable roof space, uses fewer components than the Fink truss and provides an economical solution since it utilizes the high strength of the steel members. The trusses are placed at 600 mm maximum spacing and are battened and tired conventionally.

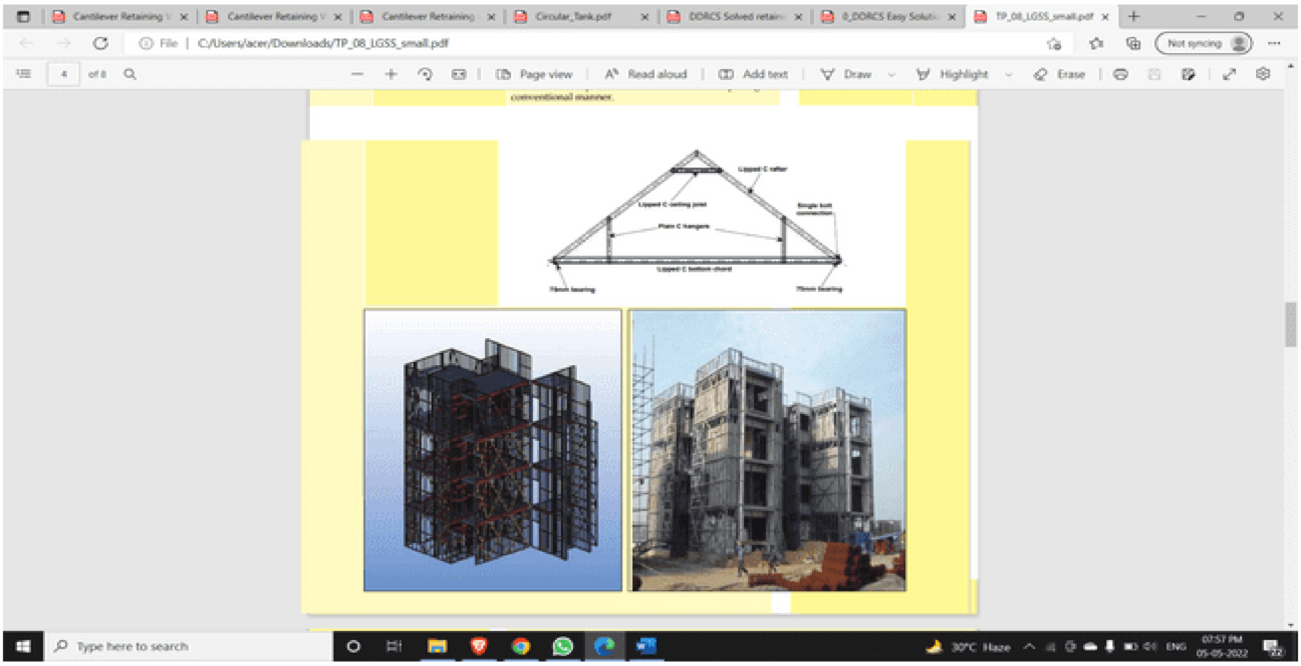


Fig 2.6 Roof Truss

8. Screws

Screws as per details given below shall be used

- Panel assembly – low profile screws
- LGS-LGS Wall Panel to roof cassette – 12-14x15mm

- LGS to concrete – Tapcon screw 14-12x60mm Hex Head
- Wire mesh = EPS Board – SDS Hex Head with Ceresin without the washer
- HRS-LGS – Hex heat
- CP Board 6mm – WT 8 CSK Philips
- Gypsum board – Flat heat self-driven type
- Deck sheet – SDS WT, CSK, Flathead

Fig.3.7 LGSF Construction

3.6.2Design Methodology

The Light Gauge Steel Framing Structure is designed based on provisions of the following standards:

- Indian Standard IS 801: 1975 Code of Practice for use of cold-formed and welded section and light gauge steel structural members in general building construction.
- Indian Standard IS 800: 2007 General Construction in Steel Code of Practice.
- Indian Standard IS 875: 1987 Code of Practice for design loads

Part 1 – Dead Loads – Unit weights of Building Materials and Stored Materials

Part 2 – Imposed Loads

Part 3 – Wind Loads

- IS 1893(Part 1) Criteria for Earthquake Resistant Design of Structures – General Provisions and Buildings.

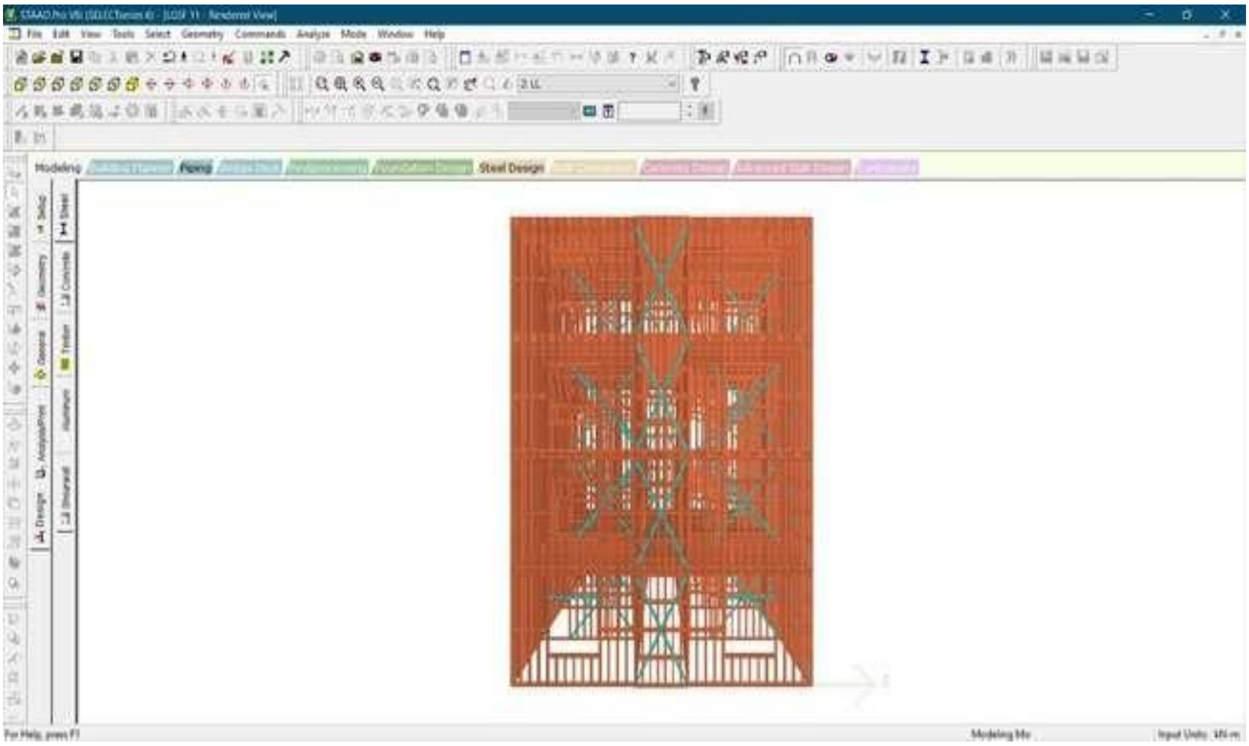
3.7Model Creation

A conceptual and analytical model was created for the proposed building design to better visualize and interpret the design challenges at hand. Autodesk Revit was used to create an architectural model while Bentley Staadpro was used for the analysis and design of the proposed structure.

1. Structural Model

The figure below represents the structural model of the proposed building structure to be analyzed. The structure consists of a steel-framed ground floor and 3 upper framed floors.

Structural element modelling



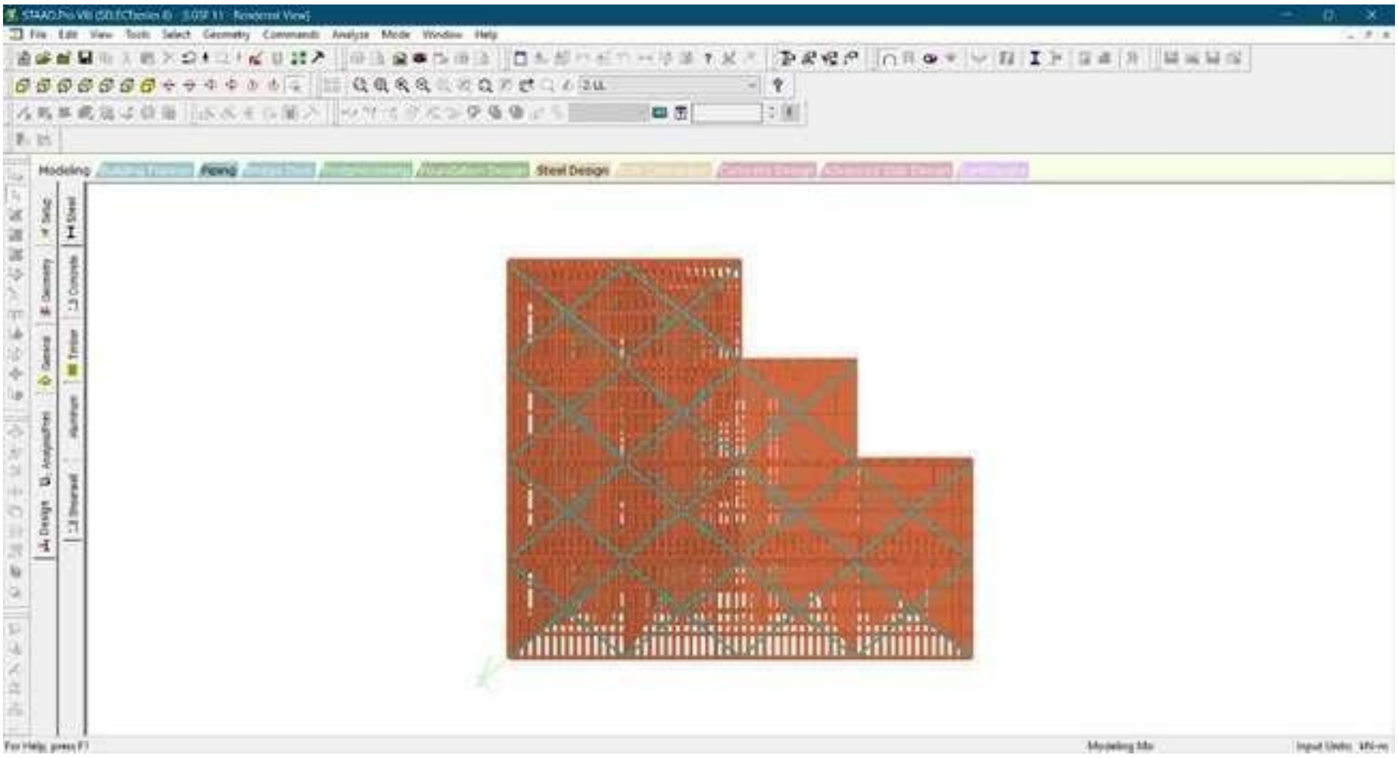


Fig 3.8 LGSF Design Front view *Fig 3.9 LGSF Design Side view*

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

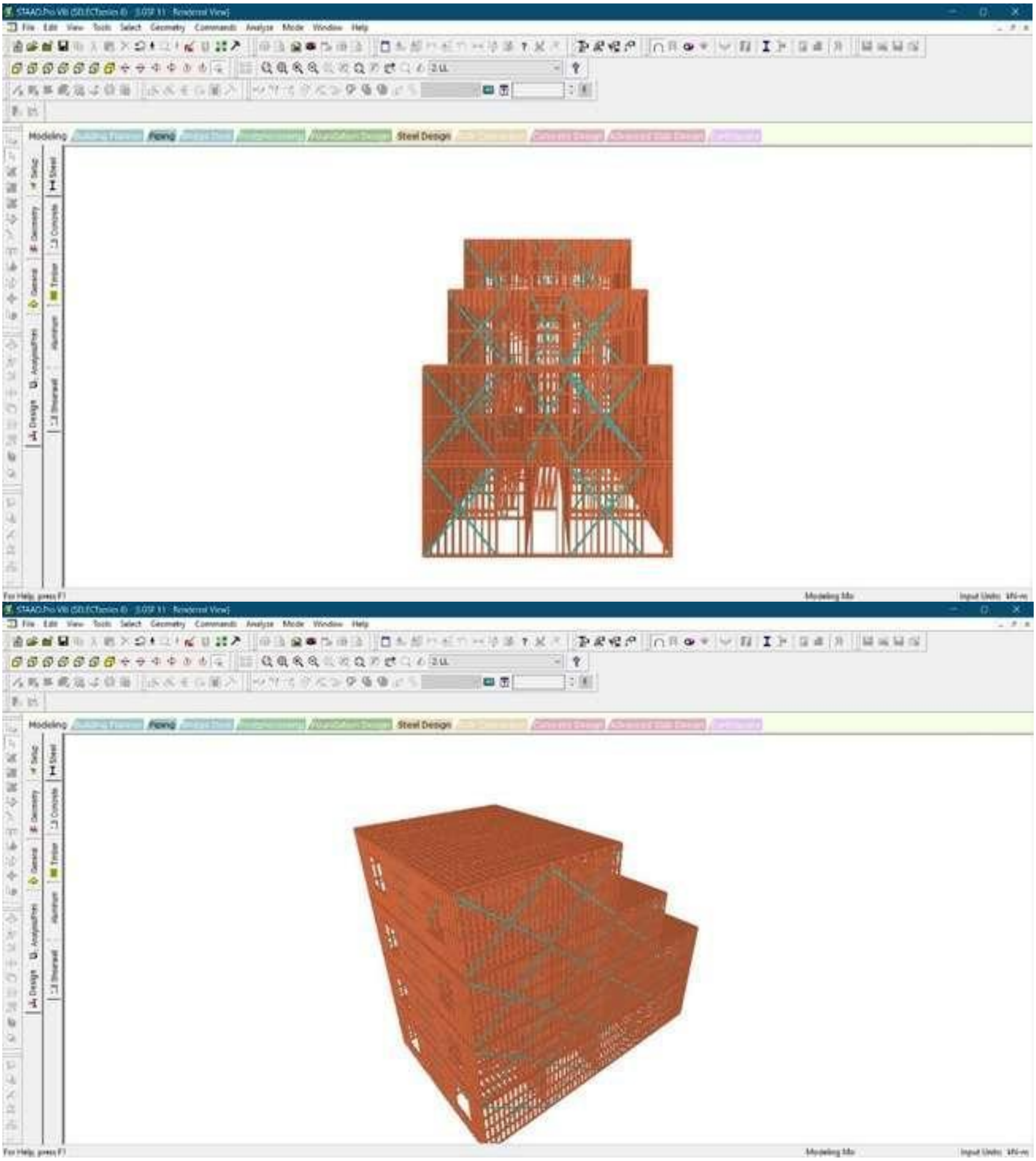


Fig 3.10 Staad Pro LGSD Design

The following figures highlight the modelling of the structural elements used in the design of the proposed building. The modelling of the structural elements was done in Bentley Staadpro.

Table 6 Structural elements dimensions

Sr No	Section	Description	Area (cm^2)	D (mm)	B (mm)	t (mm)	R (mm)	Iz (cm^4)	Iy (cm^4)
1	Channel	200CU80X4	13.7	200	80	4	6	815	83.4
2	Channel	200CU50X4	11.3	200	50	4	6	584	22.1
3	Channel	100CU50X3.15	5.87	100	50	3.15	4.73	90	14.6

Architectural Model

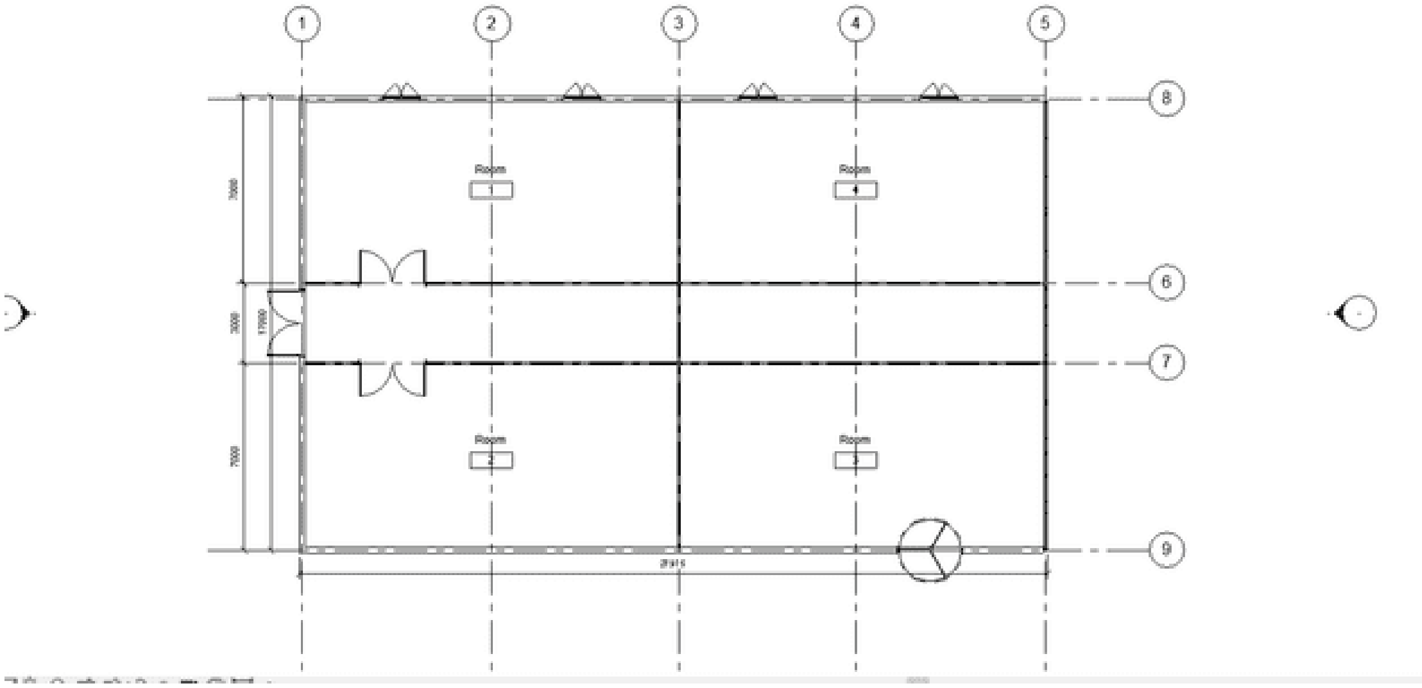


Fig 2.11. Architecture plan

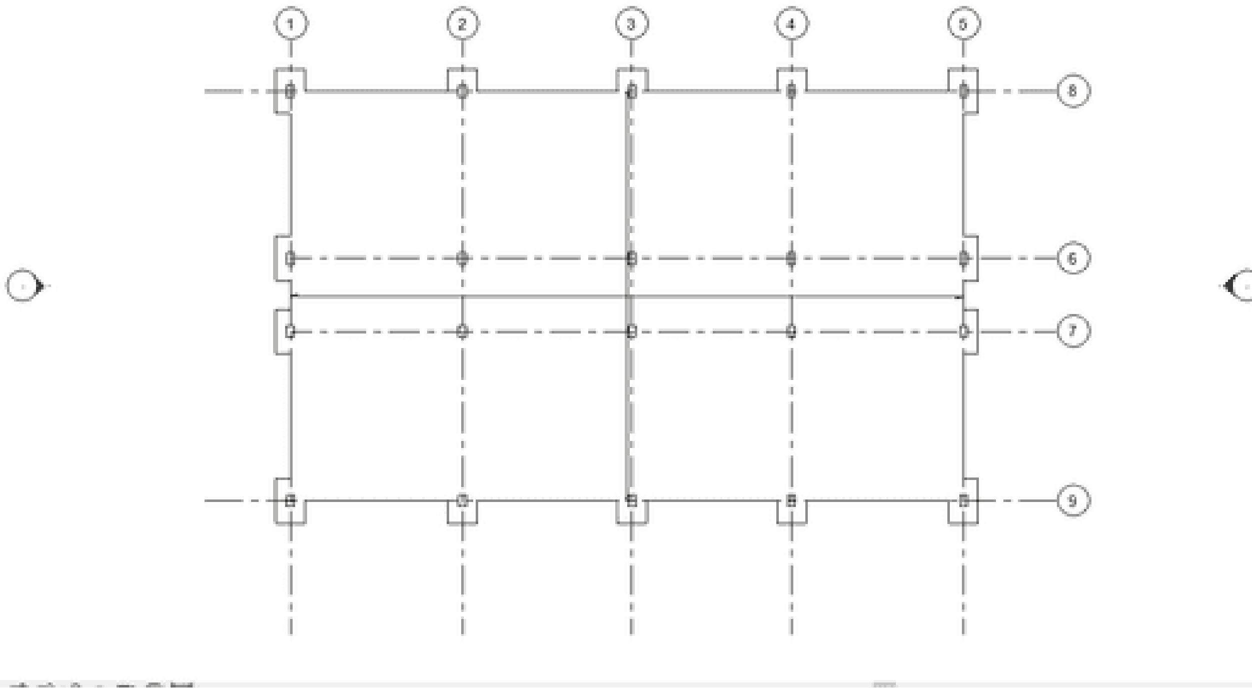


Fig 2.12. Foundation plan

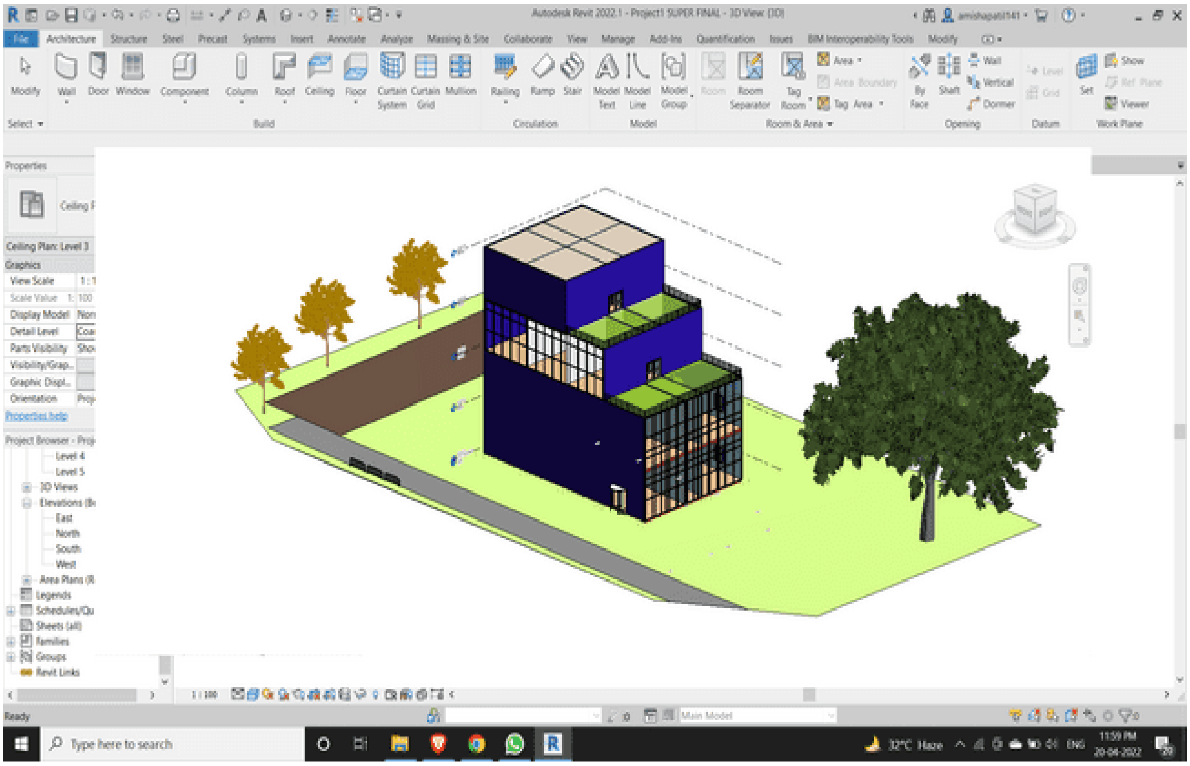


Fig 2.13. Architectural Plan

3.8. Input for LGSF Building

Following are the values of parameters considered to create the model of a G+3 RCC Commercial building using the software Staadpro.

Table 6 Structural elements dimensions

Plan	17x28m
Height	24m
Floor to Floor height	6m
Section Definition	i. Vertical studs and vertical truss members – 200CU80X4 ii. Horizontal noggings and horizontal truss members – 200CU50X4 iii. Inclined truss members – 100CU50X3.15 iv. Bracings – Rect 0.14x0.01
Material	Cold-formed steel
Poisson’s ratio	0.3
Density	76.8195 kN/m^3
Yield stress	253200 kN/m^2
Tensile Strength	407800 kN/m^2
Dead Load	Self weight factor -1 Floor finish = 1.5kN/m^2 Wall cladding = 1.75kN/m
Live Load	5kN/m^2
Seismic Loads	Zone Factor (III) : 0.16

	Performance Factor (k): 1 Soil Interference factor(B): 1
Support	Fixed support
Defined parameters	Yield strength of steel (fyld) = 500MPa
Commands	Member Takeoff Select Take off
Code of Practice	Indian Standard 801:1975 – Code of practice for use of cold-formed light gauge steel structural members in general building construction.

3.9 Output of LGSF Structure

After performing the analysis on the above model with the help of Staadpro, the output obtained is as follows

Support reactions

Table 7 Output Support Reaction

			Horizontal	**Vertical**	**Horizontal**	**Moment**		
	Node	**L/C**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	527	1 DL	38.443	101.843	14.28	-0.197	0	0.289
Min Fx	3233	1 DL	-33.812	185.898	-0.068	-0.146	0	-1.355

Max Fy	1342	1 DL	-0.004	251.439	-0.001	0	0	0.02
Min Fy	922	2 LL	0	2.466	0.002	0.001	0	0
Max Fz	1339	1 DL	-0.004	89.923	21.411	-0.088	0	0.003
Min Fz	3	1 DL	12.073	43.263	-14.256	0.271	0	0.003
Max Mx	875	1 DL	0.035	90.191	0.178	0.349	0	-0.119
Min Mx	28	1 DL	0.051	69.454	-0.222	-0.44	0	-0.134
Max My	15	1 DL	0.881	174.253	0.082	0.145	0.001	-2.919
Min My	2548	1 DL	3.309	48.812	-0.009	-0.019	-0.001	0.307
Max Mz	4458	1 DL	-3.802	77.841	-0.005	-0.014	0	7.883
Min Mz	790	1 DL	-23.547	210.117	-0.067	-0.131	0.001	-2.979

Beam end forces

	Beam		L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm
Max Fx	2878		1 DL	1342	248.186	0.004	0.001	0	0
Min Fx	24624		1 DL	10732	-209.183	27.72	-0.52	0	0.159
Max Fy	3816		1 DL	512	224.389	66.001	0.582	-0.002	-0.173
Min Fy	4413		1 DL	1804	225.636	-67.674	-0.508	0.001	-0.172
Max Fz	21877		1 DL	9918	62.033	0.006	20.435	0	-2.991
Min Fz	23635		1 DL	10673	53.485	0.001	-20.105	0	2.984
Max Mx	33212		1 DL	14877	52.137	-7.404	2.014	0.008	-0.739
Min Mx	33211		1 DL	14876	52.116	7.009	-2.11	-0.008	0.313
Max My	21877		1 DL	9510	62.017	0.006	20.435	0	3.14
Min My	23635		1 DL	10298	53.468	0.001	-20.105	0	-3.048
Max Mz	8027		1 DL	3691	227.063	-67.154	0.714	-0.001	0.255
Min Mz	21032		1 DL	9511	89.537	-38.158	-0.061	0	0.028

NODE DISPLACEMENTS									
			Horizontal	**Vertical**	**Horizontal**	**Resultant**	**Rotational**		
	Node	**L/C**	**X mm**	**Y mm**	**Z mm**	**mm**	**rX rad**	**rY rad**	**rZ rad**
Max X	5733	1 DL	19.403	-11.281	-1.28	22.481	0	- 0.001	- 0.011
Min X	13775	1 DL	-24.88	-17.447	0.566	30.393	0	0.001	- 0.011
Max Y	4308	1 DL	0.891	1.858	0.508	2.123	0	0	0
Min Y	13913	1 DL	-6.88	-44.266	0.215	44.798	-0.001	0	0.001
Max Z	12470	1 DL	6.004	-7.608	22.227	24.248	-0.004	0.005	0
Min Z	5647	1 DL	-12.165	-5.328	-15.055	20.075	0.003	0.003	- 0.002
Max rX	13710	1 DL	-0.017	-6.294	2.029	6.613	0.02	- 0.001	0
Min rX	12971	1 DL	0.049	-6.213	0.237	6.218	-0.02	0.001	0
Max rY	13733	1	0.824	-8.845	0.476	8.896	0.005	0.023	-

		DL							0.001
Min rY	12999	1 DL	-1.946	-9.13	1.158	9.406	0.006	- 0.023	0.001
Max rZ	9424	1 DL	4.002	-11.73	0.307	12.398	-0.001	0	0.019
Min rZ	4985	1 DL	-1.91	-14.205	1.638	14.426	0	0.001	- 0.016
Max Rst	13913	1 DL	-6.88	-44.266	0.215	44.798	-0.001	0	0.001

Table 6 Structural elements dimensions

STATICS CHECK RESULT

L/C		**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
1	Loads	0	-24342.7	0	-36467.2	0	-2.96E+05
	Reactions	0	24342.75	0	36467.2	0	2.96E+05
	Difference	0	0	0	-0.003	0	-0.001
2	Loads	0	-21705	0	-32562	0	-2.65E+05
	Reactions	0	21705	0	32561.99	0	2.65E+05
	Difference	0	0	0	-0.003	0	-0.001

4.MATERIALS USED FOR SUSTAINABLE CONSTRUCTION PURPOSES

4.1GENERAL

It's been just about a decade since brilliant materials have stood out for man. These materials are equipped for answering their general climate and adjusting to it. The improved speed of construction materials has additionally been towards multi-reason and smart materials, which would eventually bring about assembling stage matters. Truth be told, the presence of savvy underlying materials and frameworks plays had a significant influence in fostering the possibility of the shrewd control of a construction. These materials can work on planning strategies and the construction of structures. In the practical structures configuration approach (another way to deal with planning structures which ought to meet an elevated degree of natural principles with an accentuation on the expenses of their valuable life expectancy), such exceptionally productive materials are utilized because they are more versatile to the climate and increment a structure's helpful life expectancy.

4.2 Materials used FOR RCC (REINFORCED CEMENT CONCRETE)

1. 4.2.1. Cement:

There are special varieties of cement such as rapid hardening cement and high alumina cement are used under certain circumstances. Now, most of the cement concrete work in building construction is done with ordinary Portland cement at present.

2. 4.2.2. Aggregates:

These are the inert or chemically inactive materials which form the bulk of cement concrete. These aggregates are bound together utilizing cement. The aggregates are classified into two categories – fine and coarse.

The material which is passed through BIS test sieve no. 480 is termed as a fine aggregate. The material which is retained on BIS test sieve no. 480 is termed as a coarse aggregate. The broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. For thin slabs and walls, the maximum size of coarse aggregate should be limited to one-third the thickness of the concrete section.

The aggregates to be used for cement concrete work should be hard, durable and clean.

(i) Natural aggregates

3. (ii) Artificial aggregates

(i) Natural Aggregates:

The term natural aggregate is used loosely to designate aggregates which need only be removed from their natural deposits as unconsolidated sediments. The aggregates obtained from such deposits are called gravel and sand while those produced from ledge rock, boulders or cobblestones are known as crushed stone. **Thus, the natural aggregates can be divided into the following three types:**

(a) Crushed rock aggregate;

(b) Gravel;

(c) Sand.

(ii) Artificial Aggregates:

The blast furnace slag is perhaps the only artificially prepared aggregate which is used in the construction. It is obtained as a by-product in the manufacture of steel. If slag is specially manufactured under controlled conditions, it can certainly prove to be an excellent aggregate of uniform quality.

4. **4.2.3. Steel:**

The steel reinforcement is generally in the form of round bars of mild steel. The diameters of bars vary from 8 mm to 40 mm. Sometimes the square bars or twisted bars are used as steel reinforcement. For road slabs and other constructions, the reinforcement may also consist of sheets of rolled steel of suitable thickness.

4.2.4 HYSD (High Yielding Strength Deformed)

Ribbed HYSD bars are made of high yield strength steel. Ribs are nothing but projections produced on bars by cold twisting of the bar in hot rolled condition. The twist is made according to the standard requirements.

HYSD bars are important innovation of steel and they are extensively used as the main reinforcement materials in all concrete works like bridges, buildings, precast concrete works, foundations, roads etc.

The reason why these are more famous than any other bars is because of the following advantages:

- HYSD bars can be bent up to 180^o without any cracks.
- High strength and durable.
- 30 to 40% of cost reduced when compared to other round bars.
- Suitable for any type of concrete work.
- Excellent bonding properties with concrete.
- HYSD bars can be welded using electronic flash butt welding or arc welding

2. **4.2.5 Mild Steel**

Ribbed bars can also be produced from mild steel. These are look-alike HYSD ribbed bars but these bars are not recommended by any code and they also have very less strength compared to HYSD bars.

Bar diameters- 8mm, 10mm, 12mm, and 16mm are used in the construction

3. **4.2.6 Rolled Thermo-Mechanically Treated (TMT) Bars**

Thermo-mechanically treated bars or TMT bars are manufactured by a special technique in which the red-hot steel bars are suddenly quenched by spraying water on them. So, the surface of the bar gets cooled down and the inner side or core of the bar is still in hot condition.

The core helps the outer surface to be tempered. With this combination of different temperatures, the bargains more yield strength and exhibits good elongation at ultimate failure.

1. 4.2.7 Water:

This is the least expensive but most important ingredient of concrete. The water, which is used for making concrete, should be clean and free from harmful impurities such as oil, alkali, acid, etc. In general, the water which is fit for drinking should be used for making concrete.

It may be noted that sometimes the ingredients other than the above are added in concrete to give it certain improved qualities or for changing different physical properties in its fresh and hardened stages. These ingredients or substances are known as admixtures. The addition of an admixture may improve the concrete concerning its strength, hardness, workability, water-resisting power, etc.

4. **4.2.8 Mineral admixtures**

These are added to the hardened concrete to reduce possible cracking and improve the workability and sustainability of fresh concrete. They usually affect the properties of concrete through pozzolanic or hydraulic activity. They include silica fume, slags, fly ash, rice husk ash, metakaolin, and natural pozzolans, such as volcanic ash.

Essentially, using mineral admixtures is beneficial in many ways. They can increase concrete strength, reduce permeability, influence specific properties, and make concrete mixtures more economical. You can use these admixtures as blended cement or with Portland cement.

Fly Ash and GGBS(Ground Granulated Blast furnace Slag) are used

5. **4.2.9 Chemical admixtures**

These are added to the concrete mixture to improve its quality during mixing, curing, placement, and transportation. They can also offer high compressive strength, wear resistance, and durability to modern structures.

Ultimately, chemical admixtures improve concrete quality, decrease construction costs, and enhance the properties of hardened concrete.

Pozzolanic Admixtures are used in this construction

4.2.10 Concrete Brickwork

Cement Concrete Solid Rectangular Block bricks are used for sidewalls brickwork of size 12inch * 8inch * 6inch.

Fig 4.1 Concrete Brickwork

6. 4.2.11 Cement Concrete Flooring Material

2. Concrete is the most commonly used flooring material. It is suitable for any type of construction and is cheaper than others and durable. In industrial buildings, a granolithic finish is provided to obtain hard wearing surface. The granolithic finish can be obtained from rich concrete with a tough quality coarse aggregate mix. Polished Concrete Industrial Floor- 48Rs/square feet

Fig 4.2 Flooring Material

4.2.12 Paints

The motivations to utilize paint construction incorporate visual appeal, surface strength, chemical protection, and pest protection. Each type of paint is intended for explicit applications - sufficient paint determination can decrease project costs while further developing execution

The motivations to utilize paint construction incorporate visual appeal, surface strength, chemical protection, and pest protection. Each type of paint is intended for explicit applications - sufficient paint determination can decrease project costs while further developing execution.

4.3 Materials used FOR LGSF G+3 COMMERCIAL BUILDING

4.3.1 Cold Form Steel which is **galvanized light gauge steel** components designed as per codal requirements, produced by cold forming method and assembled as panels at site forming structural steel framework of a building of varying sizes of wall and floor.

4.3.2 Main sections are Studs & Track -

Studs serve as a general all-purpose framing component used in a variety of applications including external curtain walls, load-bearing walls, headers floors & roof joists, soffits and frame components.

The track is used as a closure to stud and joists end as well as head and sill conditions. It is also used for blocking and bridging conditions. Load-bearing steel framing members shall be cold–formed to shape from structural quality sheet steel complying with the requirements of one of the following:


Fig 4.3 Studs and Tracks

4.3.3 Wall Framing-

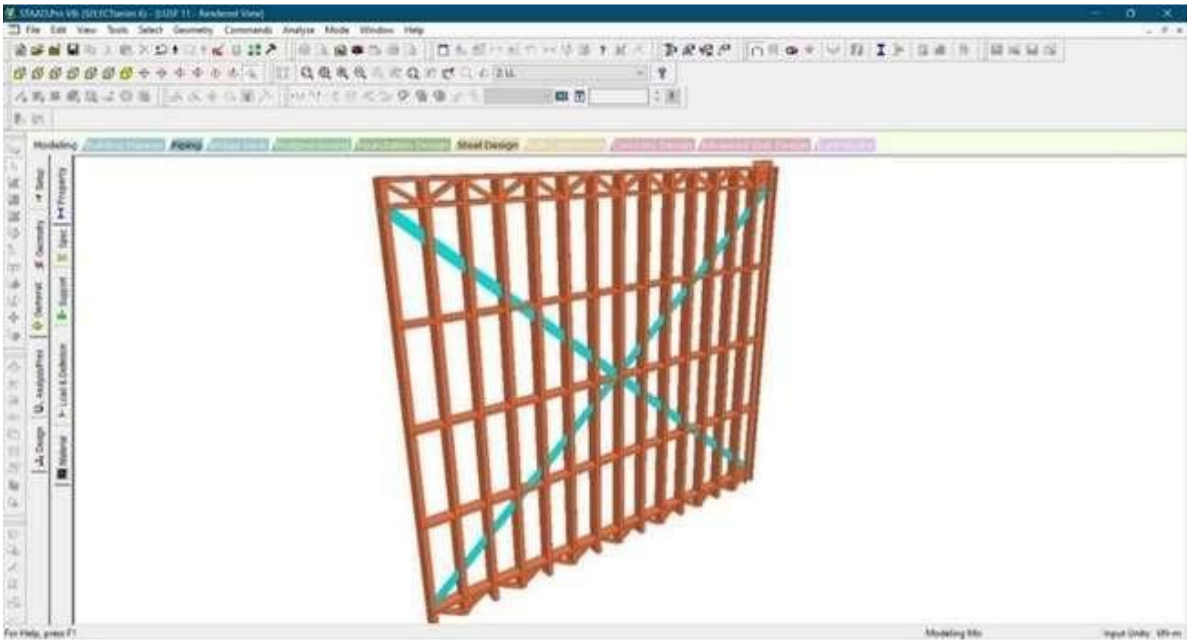


Fig 4.4 Wall Framing

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

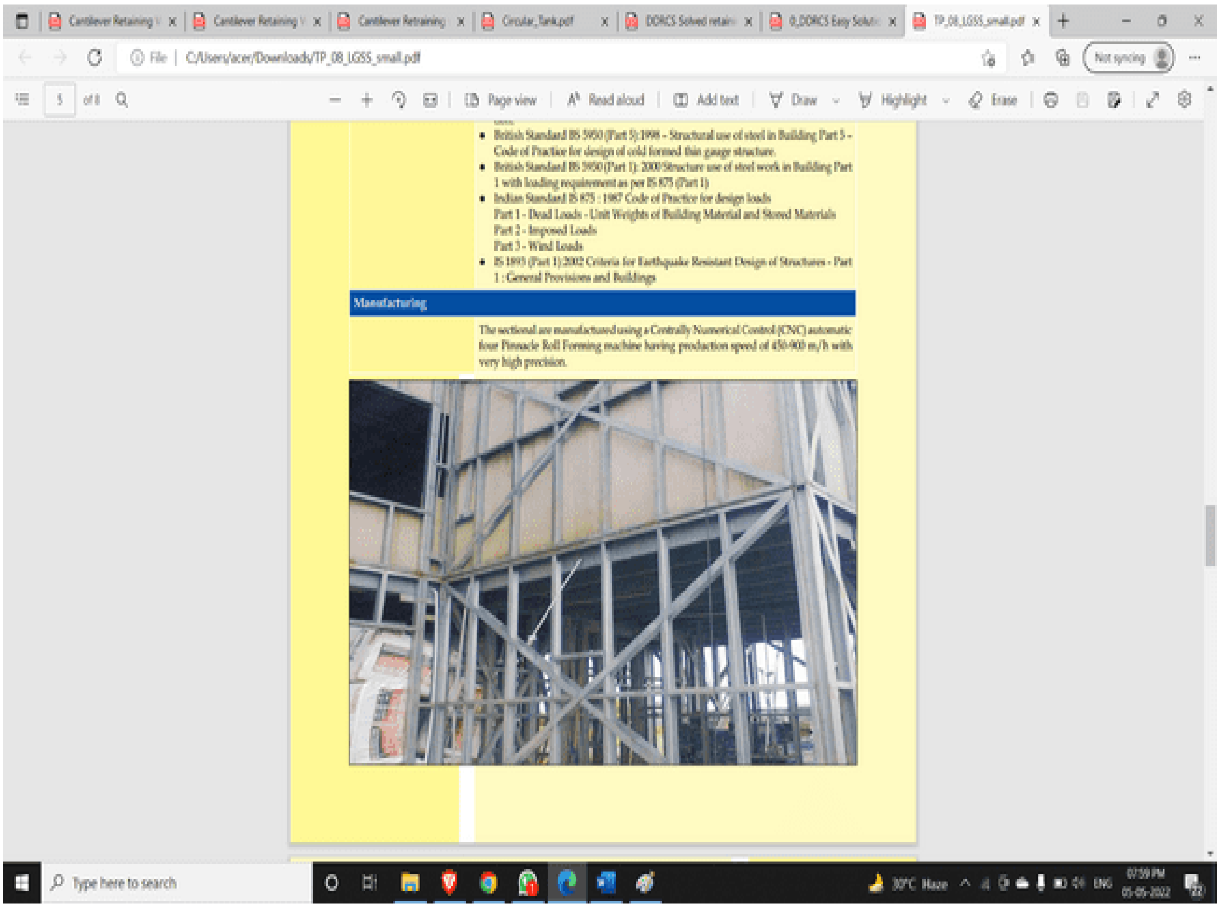


Fig 4.5 Wall Framing

4.3.4 Wall Cladding-

The sheet has to be screwed to the joist/purlin with a maximum spacing of 300 mm c/c. All the joints of the sheet in a longitudinal direction require a minimum lap of 150 mm to make them leakproof. Now, a Gypsum Board of dimension size – (7.31*0.012) m is used

The following materials are generally used on wall cladding:

• Gypsum board conforming to IS 2095 (Pt. 1): 2011

• Heavy duty cement particle board conforming to IS 14862:2000.

Since the Gypsum board is more sustainable material than the heavy-duty cement particle board, so the Gypsum board is used.

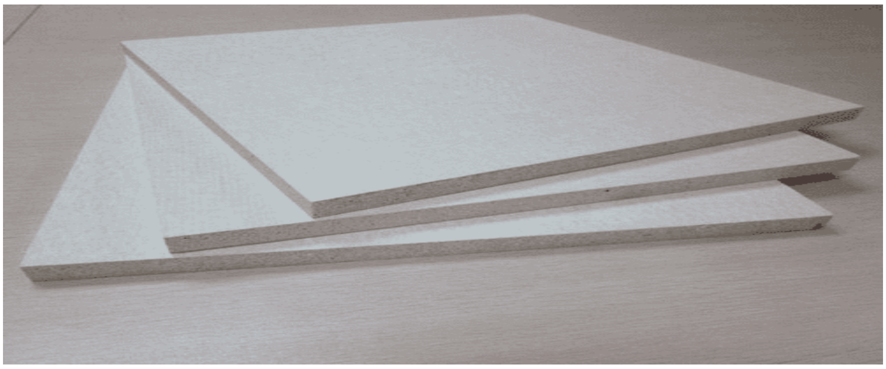


Fig 4.6 Wall Cladding

4.3.5 Bracing-.

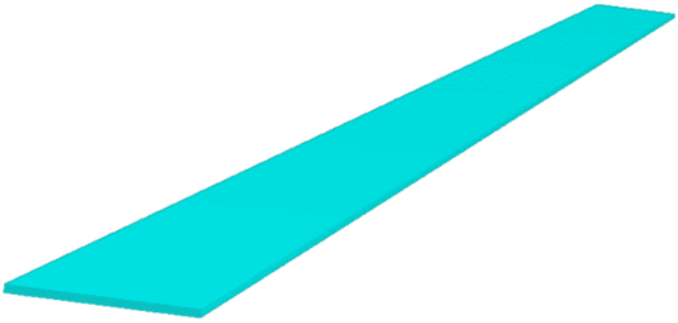


Fig 4.7 Bracing

4.3.6 Roof Frame- Gypsum White False Ceiling is used.

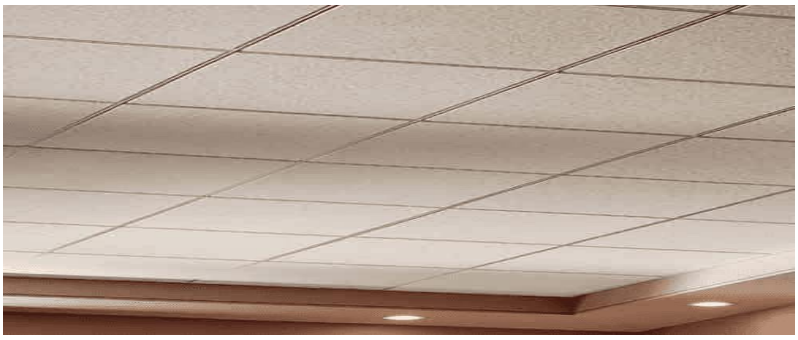


Fig 4.8 Roof Frame

4.3.7 Floor Frame- Brown Engineered Wooden material is used for flooring purposes.

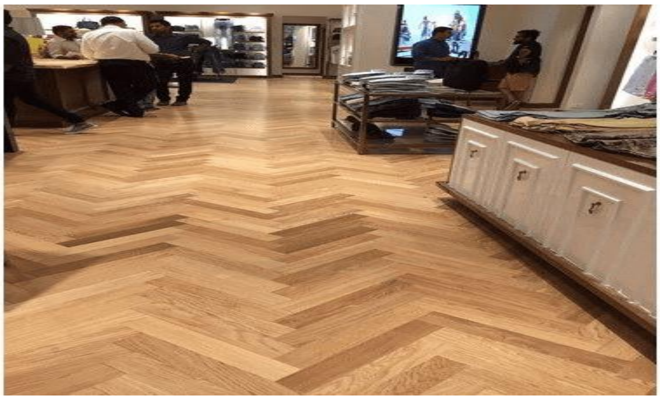


Fig 4.9 Floor Frame

4.3.8 Roof Truss-

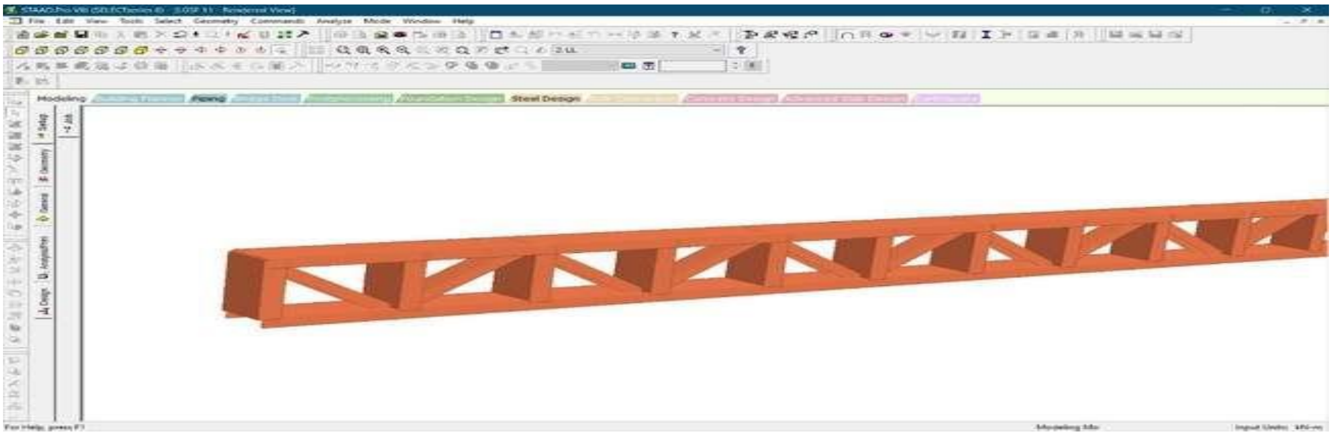
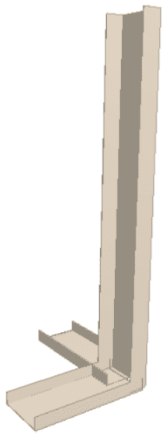


Fig 4.10 Roof Truss

Manufacturing -The sectionals are manufactured using a Centrally Numerical Control (CNC) automatic four Pinnacle Roll Forming machine.



4.3.9 Screws –

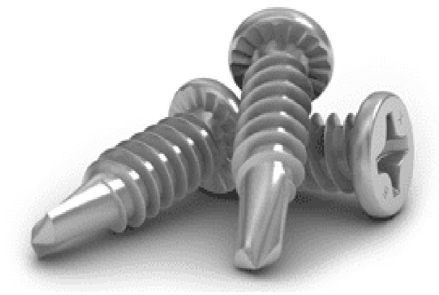


Fig 4.11 Screws

4.3.10.Extended Polystyrene Panel-

Extended Polystyrene Panel Shall be of minimum density – 15 kg/m3.

4.3.11 Wire Mesh-

Wire Mesh Shall be made of 4 mm diameter wire of UTs 480 MPa with spacing 150 mm x 150 mm or 1.4 m diameter of spacing 40 mm x 40 mm.

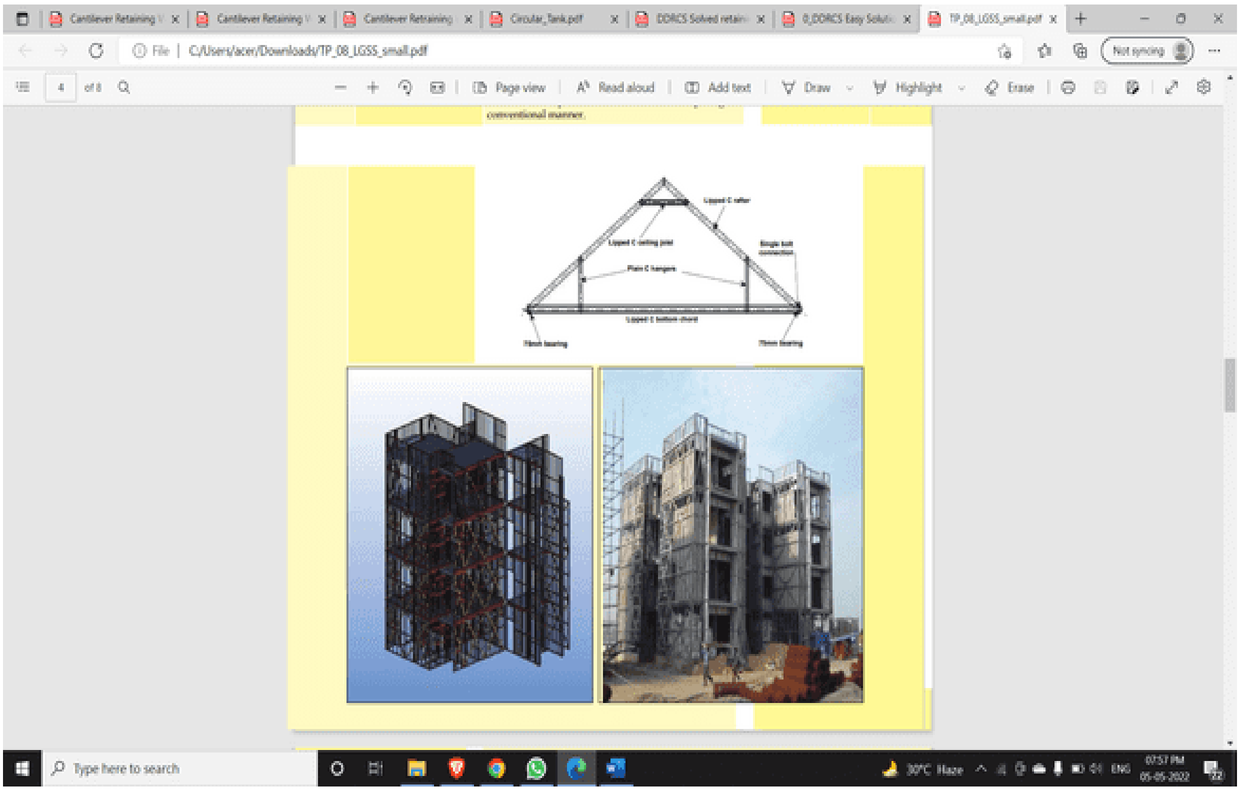


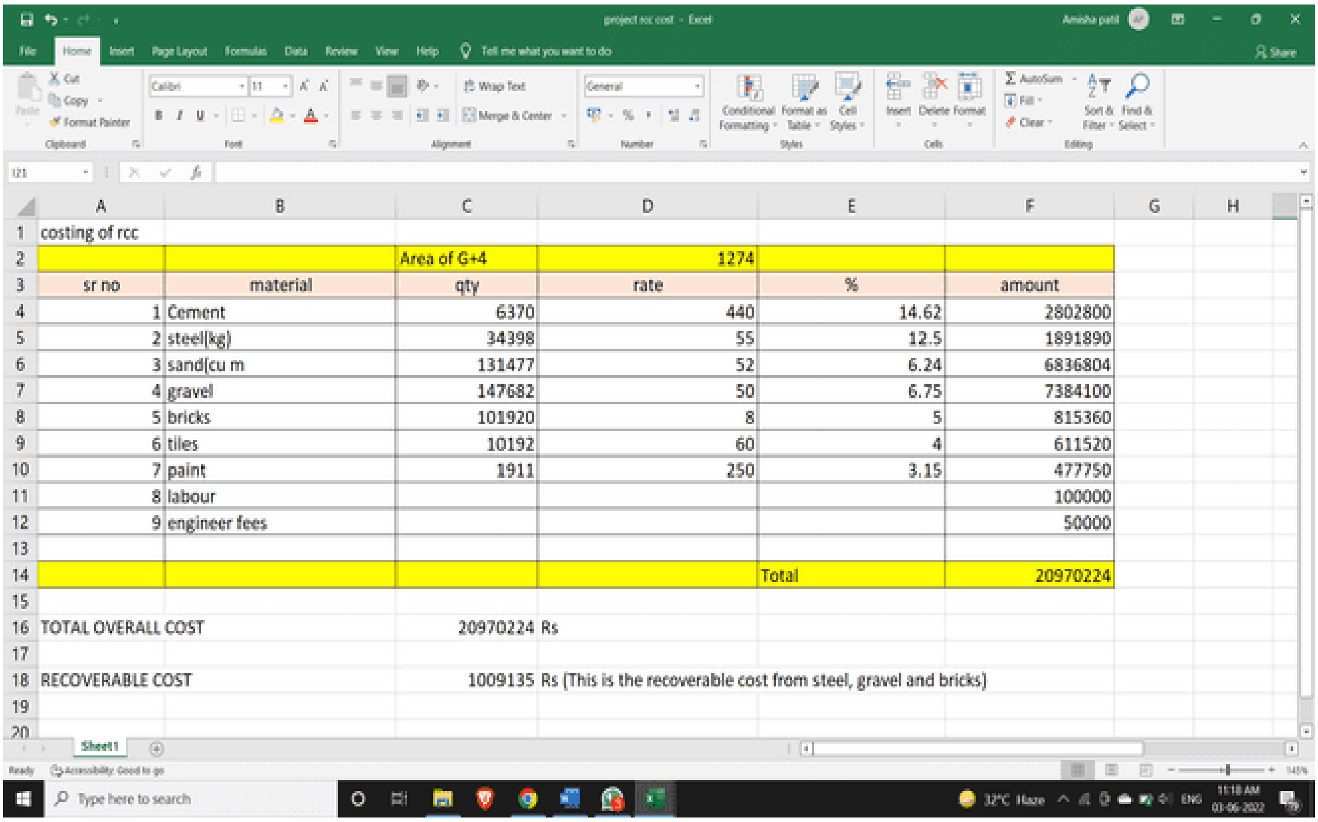
Fig 4.12 LGSF Construction modelling

5.COSTING AND TIME EVALUATION OF G+3 COMMERCIAL BUILDING

5.1 General

Whether a construction project is huge or little, there is just a single goal: to finish the task and accomplish every one of the objectives. However, laying out the objectives is an alternate task, looking at this present reality factors that can represent the deciding moment of your objectives is another. To grasp these elements and mitigate a proper method for finishing the venture, you wantan exact construction cost assessment.

5.2 Costing of RCC Structure-



costing of rcc

sr no	material	qty	rate	%	amount
		Area of G+4	1274		
1	Cement	6370	440	14.62	2802800
2	steel(kg)	34398	55	12.5	1891890
3	sand(cu m	131477	52	6.24	6836804
4	gravel	147682	50	6.75	7384100
5	bricks	101920	8	5	815360
6	tiles	10192	60	4	611520
7	paint	1911	250	3.15	477750
8	labour				100000
9	engineer fees				50000
				Total	20970224

TOTAL OVERALL COST 20970224 Rs

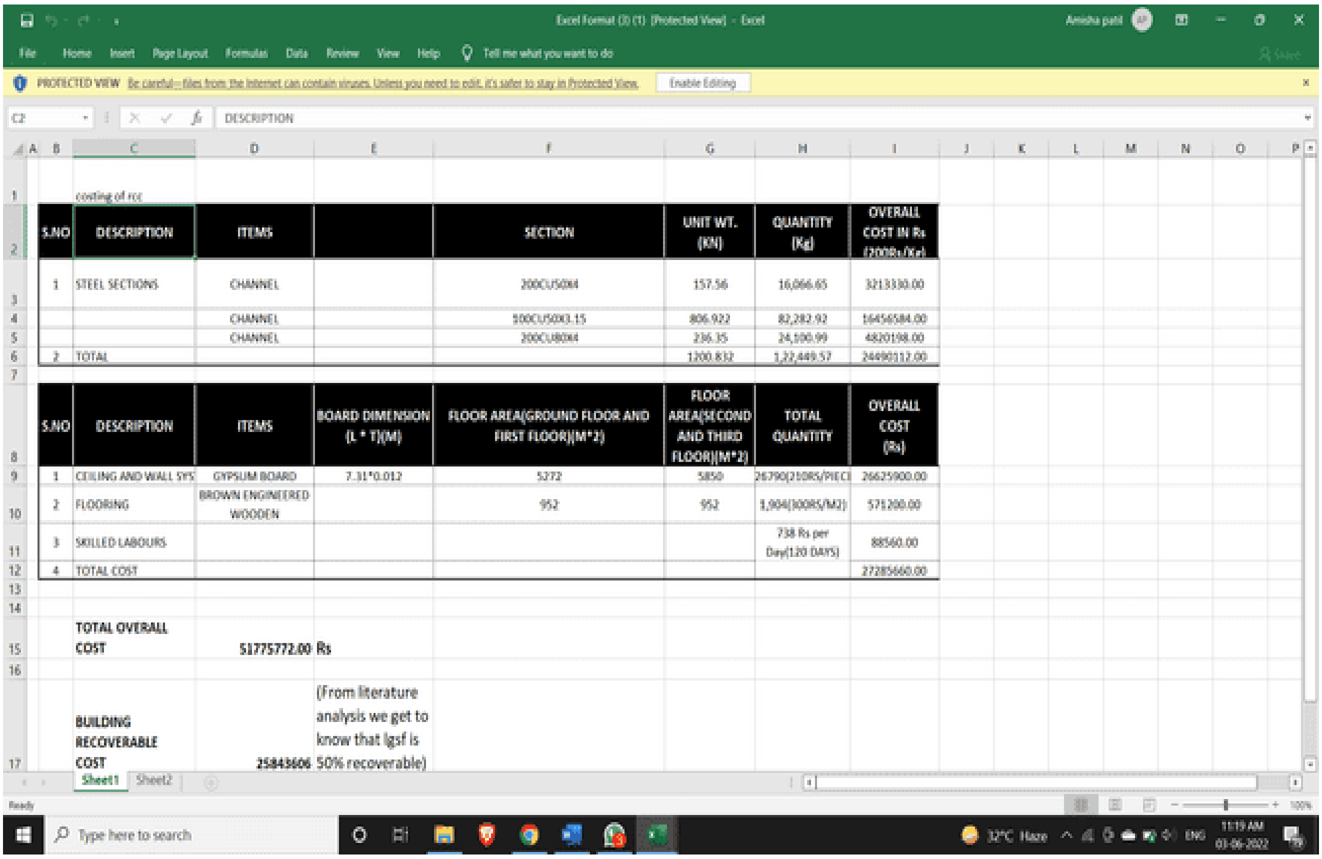
RECOVERABLE COST 1009135 Rs (This is the recoverable cost from steel, gravel and bricks)

Now, from the above given table we approximately calculated the following cost of RCC G+3 Structure. The following costing consists of the materials along with their quantity used for the construction purpose at some particular rate in that location. The cement quantity required for the construction purpose is 6,370 kg with respect to the rate of 440 Rs along with 14.62% which gives us the total Amount of cement which is 28,02,800 Rs. Now the steel required for the structure is 34,398 kg with the rate of 55 Rs with the 12.5%, so the total amount is 18,91,890 Rs. After these 1,31,477 (cum) quantities of sand is required at the rate of 52 Rs of 6.24% of which the total amount is 68,36,804 Rs. The amount of gravel required if of 1,47,682(cum) quantities with the rate of 50 Rs of 12.5%, so the total amount is 73,84,100 Rs. Now, the number of bricks and tiles required is of 1,01,920 and 10,192 (sq m) with the rates of 8 and 60 Rs with the % of 5 and 4 gives us the total amount of 8,15,360 and 6,11,520 Rs respectively. The last material, paint is required is of 1,911 (sq m) with the rate of 250 Rs of 3.15% which gives the total amount of 4,77,750 Rs.Then comes the non-material charges which are of labour and engineer fees which are 1,00,000 and 50,000 Rs respectively.

So, the total final amount required for the whole construction purpose is 2,09,70,224 Rs.

Now the recoverable cost is acquired from steel, gravel and bricks used in the construction and overall, 10% of their cost is taken which we get is 10,09,135 Rs.

5.3 Costing of LGSF structure-



costing of rcc

S.NO	DESCRIPTION	ITEMS		SECTION	UNIT WT. (KN)	QUANTITY (Kg)	OVERALL COST IN Rs (200Rs/Kg)
1	STEEL SECTIONS	CHANNEL		200CU50X4	157.56	16,066.65	3213330.00
		CHANNEL		300CU50X3.15	806.922	82,282.92	16456584.00
		CHANNEL		200CU80X4	236.35	24,100.99	4820198.00
2	TOTAL				1200.832	1,22,449.57	24490112.00

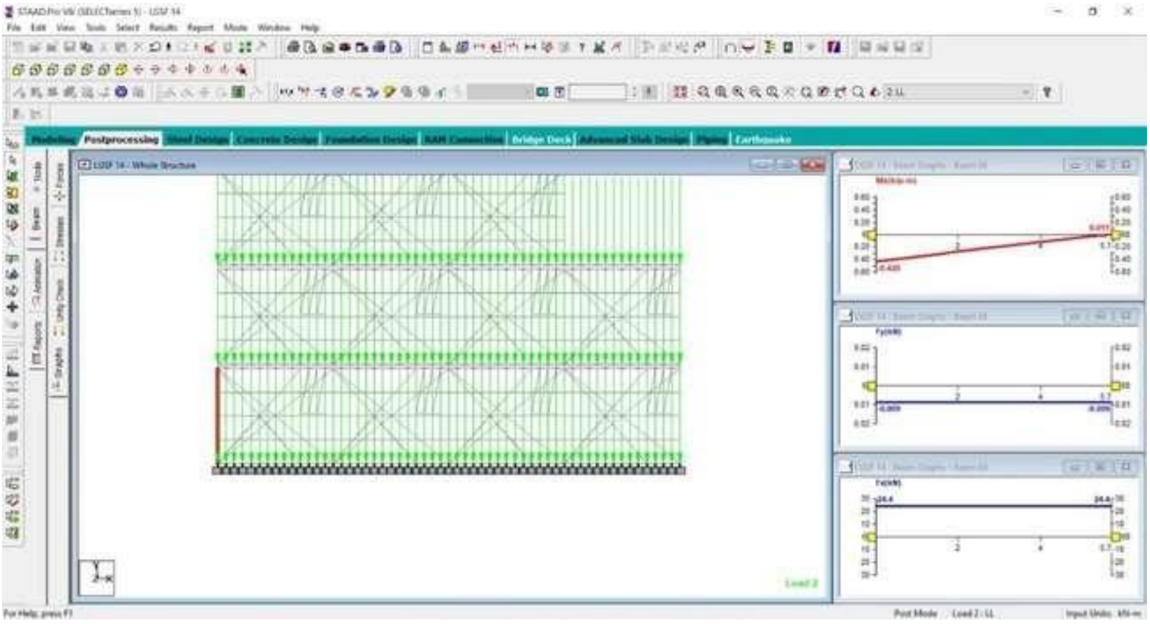
S.NO	DESCRIPTION	ITEMS	BOARD DIMENSION (L * T)(M)	FLOOR AREA(GROUND FLOOR AND FIRST FLOOR)(M^2)	FLOOR AREA(SECOND AND THIRD FLOOR)(M^2)	TOTAL QUANTITY	OVERALL COST (Rs)
1	CEILING AND WALL SYS	GYPSUM BOARD	7.31*0.012	5272	5850	26790(210RS/PIECE	26625900.00
2	FLOORING	BROWN ENGINEERED WOODEN		952	952	1,904(300RS/M2)	571200.00
3	SKILLED LABOURS					738 Rs per Day(120 DAYS)	88560.00
4	TOTAL COST						27285660.00

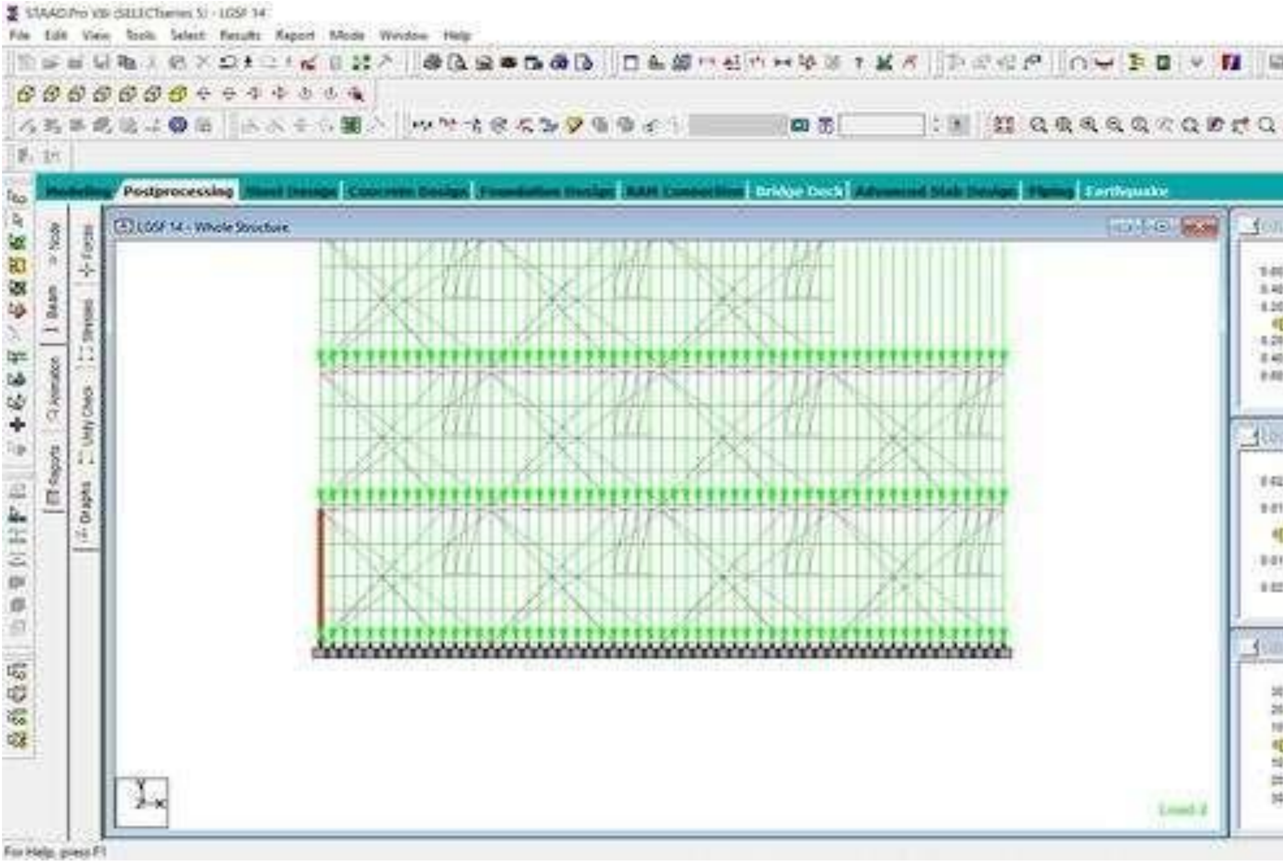
TOTAL OVERALL COST	51775772.00	Rs
BUILDING RECOVERABLE COST	25843606	(From literature analysis we get to know that lgsf is 50% recoverable)

6.RESULTS

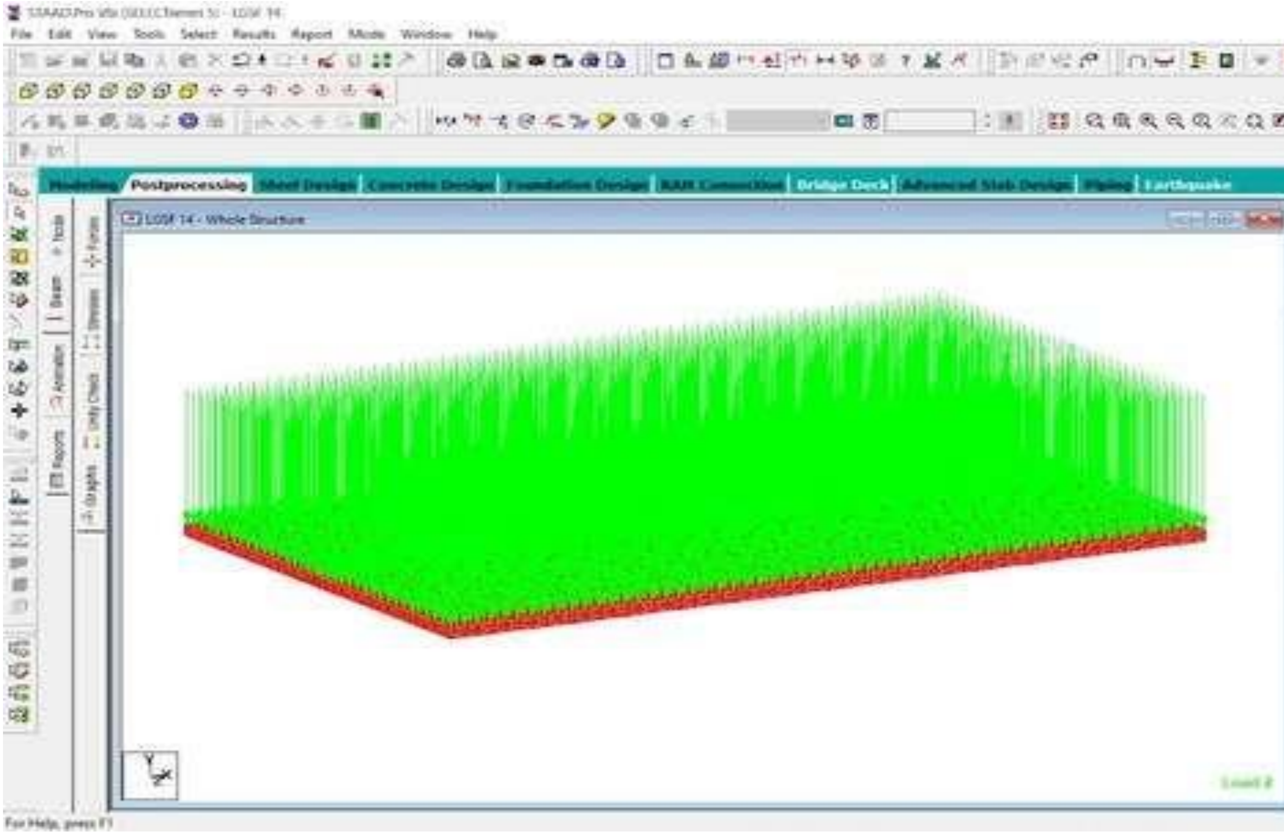
6.1 General

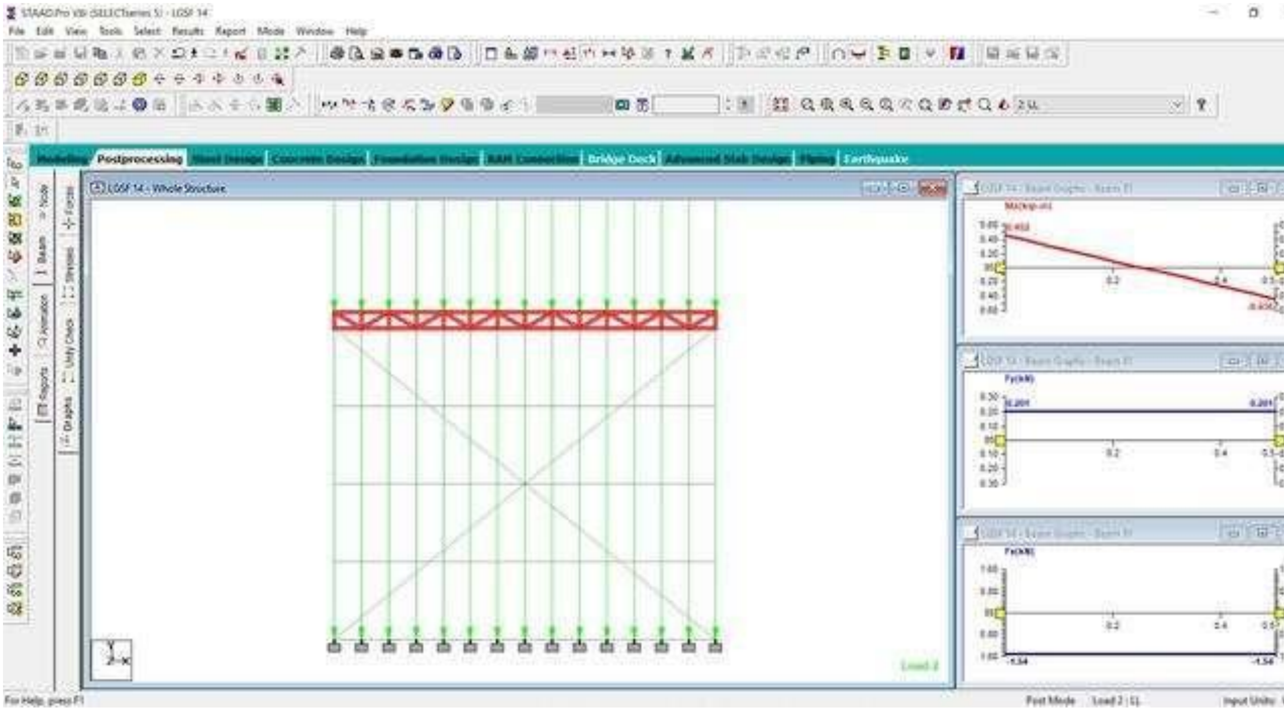
Analysis of RCC and LGSF structural models was performed and compared. Different elements of the two structures showed different values of Maximum Bending Moment, Maximum Shear forces and Maximum Axial Forces. The table below shows the comparison.

	LGSF
Vertical members	 **Stud**

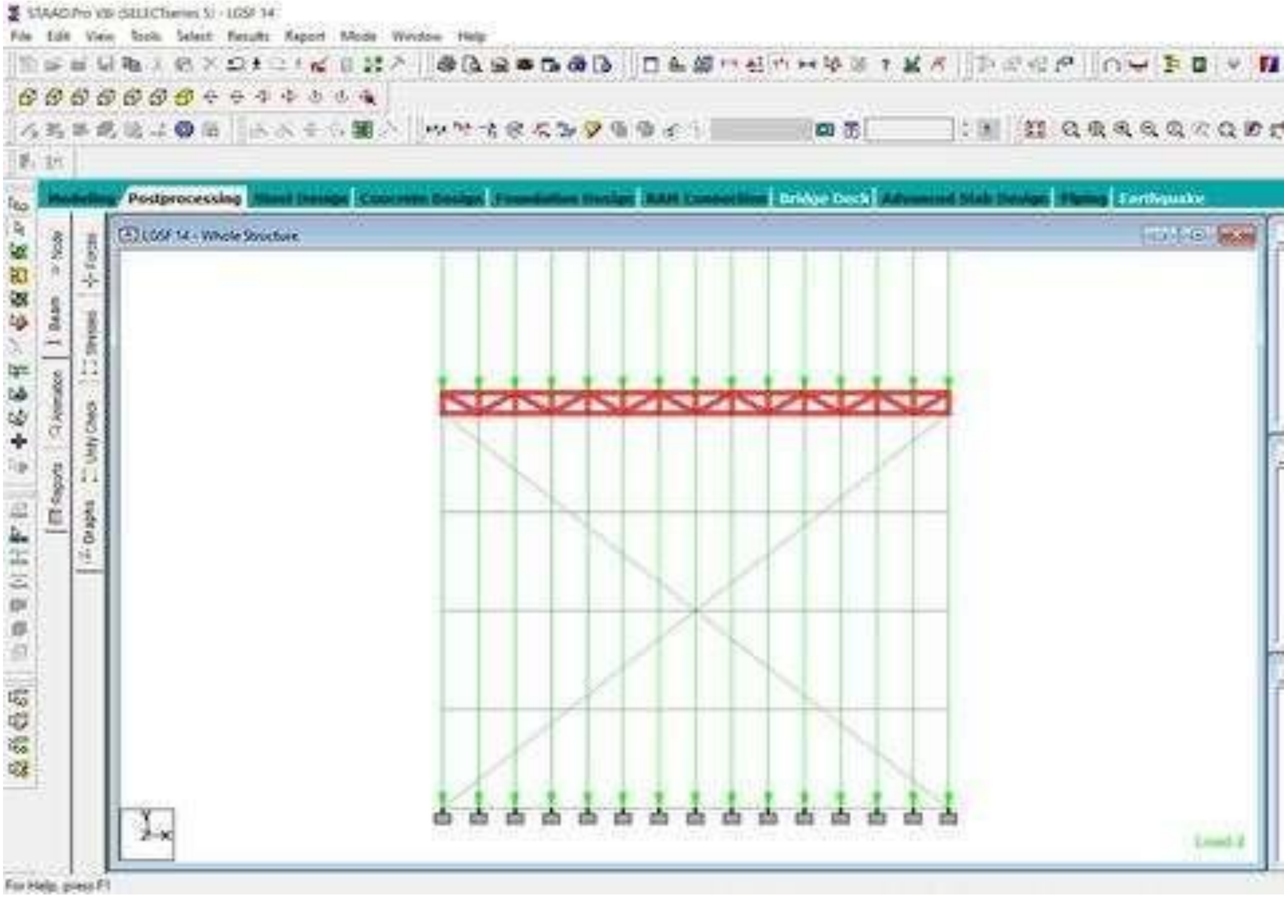
Graphs	

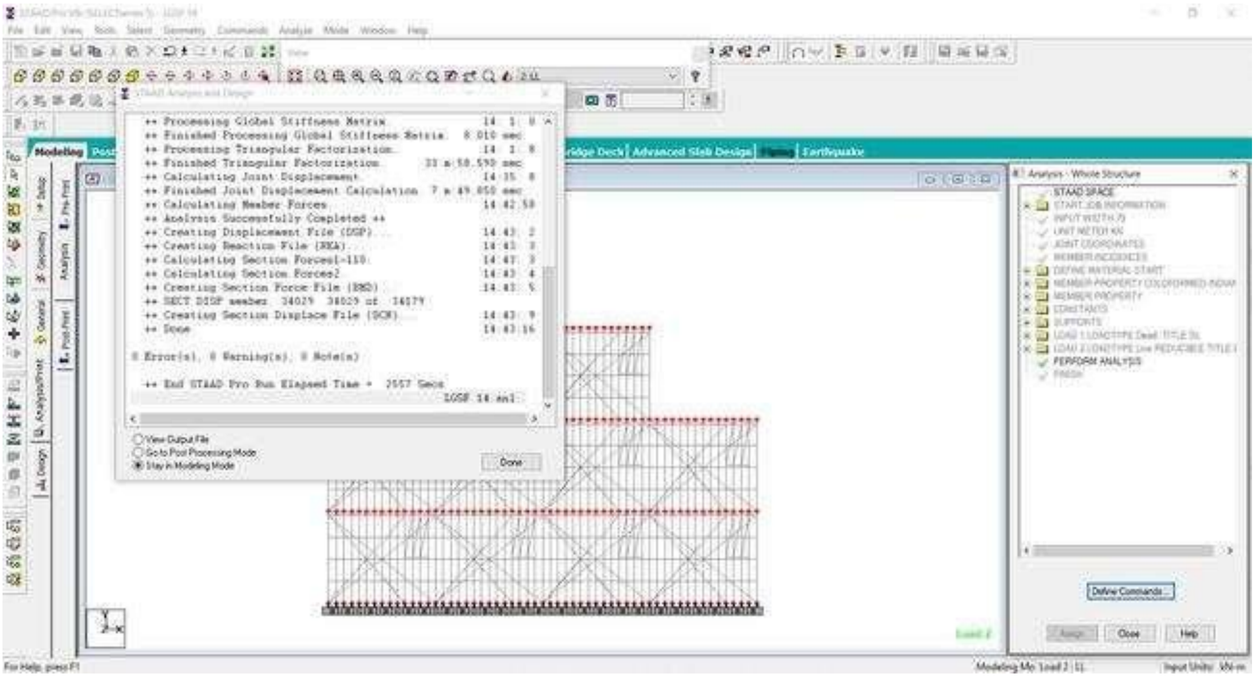
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

	
	LGSF



International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 11 | November - 2023 SJIF Rating: 8.176 ISSN: 2582-3930





7.CONCLUSION

Reinforced Concrete Structure	Light Gauge Steel Framing Structure
Construction is simple.	Construction is cumbersome.
Less Tensile Strength than Steel Structure	More tensile strength than RCC
It is less resistant to earthquake	Framed Structure is more resistant to earthquakes.
Speed of Construction is less.	Speed of Construction is more.
This structure is less prone to corrosion.	Steel is more prone to corrosion.
Skilled as well as non-skilled workers are required during construction.	Only skilled workers are required during construction.
Low Initial Cost as formwork and labour is easily available.	Costly form of construction.
It is brittle as compared to LGSF and hence, failure is sudden and hazardous.	It is ductile. Hence, failure is not sudden
After demolition, a large amount of concrete and steel cannot be reused.	All the steel used is recoverable and can be reused on a different site for the same or different purposes.
Very high Dead Load.	Low Dead Load as compared to RCC.
RCC structures are not portable.	LGSF structures are portable. They can be dismantled and reassembled.
Maximum End forces and Moments are much higher.	Maximum end forces and Moments are low as compared to RCC.
No Bracing System.	A bracing system is Required to resist lateral forces.

REFERENCE

1. *Aniket Sigaria prof. Anubhav rai, prof Y.K. Bajpai (2014)*. Cost comparison between RCC slab & steel composite slab structure of G+5 storied building. The overall plan dimension of the building is 56.3m X 31.94m:- https://www.ijser.org/researchpaper/Cost-Comparison-Between-Rcc-Slab-Steel-Composite-Slab-Structure-Of-G-5-Storied-Building.pdf

2. *Creation Sustainable Building Shell Using Smart Materials* *https://www.scientific.net/AMR.685.240*

3. *G.Hemalatha, Uma. S.G, Muthlakshmi (2020)*. Comparative analysis of steel and RCC frame structure of a commercial building.:-https://www.arcjournals.org/pdfs/ijcrce/v6-i4/2.pdf

4. *Ganesh Jain, Ass. Prof.Vaishant Gupta and Prof.MukeshPandey(2016)* Case Study of Construction Pollution Impact on Environment- The case study done by http://www.ijeter.everscience.org/

5. *Hitesh D. Bambhava, Prof. Jayeshkumar Pitroda, Prof.Jaydev J. Bhavsar(2013)* A Comparative Study On Bamboo Scaffolding And Metal Scaffolding In Construction Industry Using Statistical Methods. The research was done by http://www.ijettjournal.org/
https://studylib.net/doc/18480624/comparative-analysis-and-bending-behavior-of-cold-form-st…
https://www.researchgate.net/publication/223024712_Comparative_experimental_study_of_hot-rolled_and_cold-formed_rectangular_hollow_sections
https://www.researchgate.net/publication/335223704_An_assessment_of_construction_waste_management_in_India_A_statistical_approach
https://www.researchgate.net/publication/342101778_ESTIMATION_OF_CARBON_FOOTPRINT_DURING_CONSTRUCTION_LITERATURE_REVIEW_AND_RESEARCH_AGENDA

6. *Ishwor Thapa*, *Achyut Bhandari*, *Bikash Subbed* Comparative Study of Structural Analysis between Reinforced Cement Concrete Structure and Steel Framed Structure - *I* (International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 07 Issue: 08, Aug 2020 p-ISSN: 2395-0072) (PDF) Comparative Study of Structural Analysis between Reinforced Cement Concrete Structure and Steel Framed Structure (researchgate.net)

7. *Josip Peko, NenoTorić and Ivica Boko(2016)*. COMPARATIVE ANALYSIS OF STEEL AND ALUMINUM STRUCTURES-. https://doi.org/10.13167/2016.13.6

8. *L Gardner, N Saari and F Wang (2010).*Comparative experimental study of hot-rolled and cold-formed rectangular hollow sections https://www.researchgate.net/publication/223024712_Comparative_experimental_study_of_hot-rolled_and_cold-formed_rectangular_hollow_sections

9. *L Gardner, N Saari and F Wang.* Comparative experimental study of hot-rolled and cold-formed rectangular hollow sections

10. *Lakshmipriya M. M., Karthika M. R., Anima P (2020).* COMPARISON STUDY ON LATERAL LOADING BEHAVIOR OF COLD FORM STEEL COLUMNS AND HOT ROLLED STEEL COLUMNS http://ijcrt.org/papers/IJCRT2007427.pdf

11. *Mahesh Suresh Kumawat and L G Kalurkar (ISSN 2319 – 6009 Vol. 3, No. 2, May 2014 IJSCER)* Analysis and design of a multistory building using composite structure - http://www.ijscer.com/uploadfile/2015/0421/20150421032414248.pdf

12. *Metwally, H. Abu-Hamdan Mona M. Abouhamad (2019).*Life cycle cost analysis of light steel-framed building with cement-based walls and floors:- https://www.researchgate.net/publication/339091257_LIFE_CYCLE_COST_ANALYSIS_OF_LIGHT_STEEL_FRAMED_BUILDINGS_WITH_CEMENT-BASED_WALLS_AND_FLOORS

13. *Michael H. Ramagea, Henry Burridgeb and Marta Busse-Wicher et.al (2017).* Renewable and Sustainable Energy Reviews Wood from trees-The uses of timber in construction research done by http://dx.doi.org/10.1016/j.rser.2016.09.107

14. *Mohd Sameer and Hemant.B.Dahake (Volume 2, Issue 4, April– 2017 International Journal of Innovative Science and Research Technology ISSN No: - 2456 - 2165)* Comparative Study of Conventional R.C.C & Composite Structure- https://ijisrt.com/wp-content/uploads/2017/04/Comparative-Study-of-Conventional-R.C.C-Composite-Structure-.pdf

15. *S. Vignesh Kannan. et. a.l(2017)* A general study of light gauge steel structure A review:- https://www.researchgate.net/publication/322384064_A_General_Study_of_Light_Gauge_Steel_Structures_-_A_Review S.vigneshkannan

16. *Salokhe S. A et.al. (2015)*COMPARATIVE STUDY OF BEHAVIOUR OF COLD-FORMED STEEL AND HOT ROLLED STEEL SECTION UNDER COMPRESSIVE LOADING. https://ijret.org/volumes/2015v04/i04/IJRET20150404090.pdf

17. *Sanchita.S.Nawale, Sangram Chalukya, DrS.V.Admane.* Comparative Analysis and Bending Behavior of Cold form Steel with Hot Rolled Steel Section

18. *SrushtiBagul, Deepa A Joshi (2019).* Composite construction technique using LGSF and ferrocement for affordable housing.-https://www.jetir.org/papers/JETIR1906R09.pdf

19. *Suraj Mishra, Suhail Khan, Ravi Singh, Anuj Kumar, Anuj Kumar Sharma, Mukesh Kumar* A Comparative Study on Cost Analysis of RCC and Composite Structures in India - (International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 07 Issue: 06, June 2020 p-ISSN: 2395 0072) https://www.irjet.net/archives/V7/i6/IRJET-V7I6655.pdf

20. Sustainable Design of Deconstructable Steel-Concrete Composite Structures - *AbdolrezaAtaei*a Mark A. Bradford, Hamid Valipourc (Procedia Engineering*

21. *Swarna Swetha Kolaventi, TP Tezeswi and MVN Siva Kumar* An assessment of construction waste management in India: A statistical approach First Published August 17, 019 Research Article https://doi.org/10.1177/0734242X19867754

22. *U. D. Dabhade, N.A.Hedaoo, Dr L. M. Gupta and Dr G. N. Ronghe* Time and Cost Evaluation of Construction of Steel Framed Composite Floor with Precast Concrete Floor Structure (26th International Symposium on Automation and Robotics in Construction (ISARC 2009)) http://www.iaarc.org/publications/fulltext/Time_and_Cost_Evaluation_of_Construction_of_Steel_Framed_Composite_Floor_with_Precast_Concrete_Floor_Structure.pdf
Volume 145, 2016, Pages 1153-1160) https://www.sciencedirect.com/science/article/pii/S1877705816301564

23. *Wang, Eve X. Tan and Patrick X.W. Zou ESTIMATION OF CARBON FOOTPRINT DURING CONSTRUCTION: LITERATURE REVIEW AND RESEARCH AGENDA: 37th Annual Conf. of the Australasian Universities Building Educators Association (AUBEA): Sydney, Australia (July 2012)*

24. *Yasar Arafath (2015).* Experimental investigation on the behaviour of cold-formed light gauge steel beams subjected to cyclic loading. https://www.ijemr.net/DOC/ExperimentalInvestigtionOnTheBehaviourOfColdFormedLightGaugeSteelBeamsSubjectedToCyclicLoading%28768-771%29.pdf