DRISHTI

A Revolutionary Concept

DIAGRID STRUCTURAL SYSTEM

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1st-year 2nd year

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To study, analyze and design a diagrid structural system

❖ Abstract :

Diagrid structure represents the latest mutation of tubular structures, plays a significant role due to their inherent aesthetic view, and provides structural efficiency and geometrical versatility. Diagrid structures are used to overcome gravitational force, wind force, and seismic load. To find forces in each member of the building, mainly three methods are used. These are the method of joints, section, and tension coefficient. STAAD pro was used to perform an analysis of the structure.

❖ Motivation :

The main point which motivated engineers to develop massive structures like Diagrid is to overcome difficulties like an earthquake, wind force, etc. To construct high rise buildings is not a simple task. To bear lateral forces such as wind force, to make it earthquake resistance up to some extent taking earthquake zone into a picture of that particular area, Diagrid structure came into existence. Due to the exponential growth of the population, we required more amenities and shelter. Hence less land and more accommodation are feasible. To utilize less land and accommodate more homo-sapiens, the idea of high rise buildings came into existence. Not only from overpopulation had the expansion of the concept to a system without vertical columns led to the birth of the Diagrid structure. There are many benefits of placing diagonal members on the perimeter of the building. Still, certainly, the most important one is the efficiency of the system is far greater than a system where a lateral bearing structure is confined in the narrow core. For mainly these reasons, only Diagrid structures have attracted the interest of architectural and engineers.

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1.0 Introduction:

- Diagrid (a portmanteau of the diagonal grid) is a framework of diagonally intersecting metal, concrete or wooden beams that are used in the construction of buildings and roofs.

- In layman language, it can be said that Diagrid is the structure that provides strength to the building to resist lateral forces by its process of transferring the load to the foundation through its diagonal members.

- Diagrid structures of the steel members are efficient in providing the solution, both in terms of strength and stiffness.

Figure 1

2.0 Members of the Diagrid structural system.

There are mainly six components used in Diagrid structural system. They are as follows.

1. Node :

2. Diagonal members:

- Members that transfer both axial and gravity loads through axial action.
- It can be made of steel, concrete, and composite materials.
- Usually, diagonal steel members are used.

3. Ring beam :

- They comprise of the ring structure at the periphery of the building connected at the nodes, which are further connected at the Diagrid members.
- They are essential in maintaining the stability of the system.

4. Tie beams :

- It has the function to transfer load from RC core to Diagrid structure.
- Tie beams and ring beams can balance unbalanced forces.

5. Core :

- The primary function is to carry gravity loads.
- To break up the span of the floor beams.

6. Triangular Diagrid module :

Each Diagrid module is defined by a single level of diagonals that extend over ‘n.’ The geometry of the single module plays a significant role in the internal axial force distribution, as well as in conferring shear and bending rigidity to the building structure.

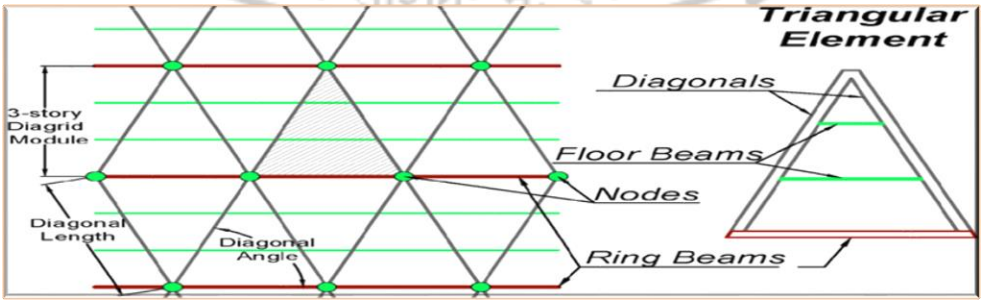


Figure 2

3.0 Methods of solving truss:

- Method of joints
- Method of section
- Method of tension coefficient

4.0 Different materials:

Many materials could be taken into account. The materials which we rejected were as follows: cardboard, wood, steel, timber, ice-cream sticks, teakwood, composite, and many more.

- Cardboard: It cannot resist much load, and the structure may collapse.

- Wood: it can be easily damaged by moisture.

- Steel: it is expensive, and it's not easy to work upon it.

- Composite: it cannot be bent easily, and hence it’s hard to use it during the construction of the model.

- Aluminum: it is light in weight, malleable, easy to work with, inexpensive. Hence, aluminum was selected as our material.

- There were many factors behind this selection, such as strength, availability, expense, ease of construction, feasibility, etc.

5.0 Advantages of Diagrid structure:

- Diagrid structures are mostly exterior and interior; hence free and clear, unique floor plans are possible.
- The glass facades and dearth of interior columns allow generous amounts of day lightning into the structure.
- Diagrid mainly mitigates the use of steel by 21% as compared to braced free structures.
- Diagrid makes maximum exploitation of structural material.
- Diagrid structures are aesthetically dominant and eye-catching.
- Redundancy in the Diagrid design is obvious. Redundancy means if a small part of the structure gets damaged, then it does not result in collapse or demolishment.
- Also, failures of skyscrapers as they could not withstand gravity load and other lateral loads resulted in the development of Diagrid structures.

6.0 Disadvantages of Diagrid structure:

- The number of storeys directly depends on the primary module height,
- This construction needs skilled labour, and the present crew has no idea or experience in installing Diagrid.
- Only high rise buildings can install Diagrid
- If Diagrid is not adequately designed or installed, it affects the economy and safety of the structure.
- The erection of nodes is a complicated process.
- As of yet, the Diagrid construction techniques are not thoroughly explored.

7.0 Types of Sections:

There are mainly four types of sections. They are as follows
1. L-section
2. C-Section
3. Box section
4. Hollow shaft

Among them, we choose a hollow shaft to build our Diagrid. The other three were rejected because

a. In the box section, we need to cut more surfaces as there are 4 in total. So using the box section would consume a lot amount of time.
b. In C-Section, as compared to L-Section, it would be a tacky task to cut surfaces but was more feasible as compared to the box section.
c. In L-Section, there would be no problem faced in cutting phases as compared to the other two, but to shape it at an optimum angle will be a difficult task.
d. Hence, facing difficulties in the above three sections, we ended up using a hollow shaft because it was easy to mould it in needed angle, and also no concept of cutting phases is there in a hollow shaft.

8.0 Designs:

STAAD PRO (software used for the analytical purpose):

- How to build the structure
- Material specification
- Dimensioning.
- Loading
- 3D view
- Analysis

Design: 1

Pros:

- It is pretty good from an aesthetic point of view.
- It can carry the right amount of load.

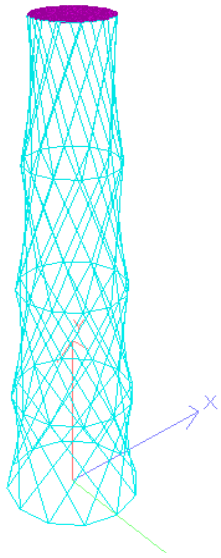


Figure 3

Cons:

- It is challenging from the perspective of manufacturing.
- To manufacture each strut in horizontal as well as the vertical angle is a huge task.
- Angle was not falling in the range of optimum angle.
- Hence this design was rejected.

Design: 2

Pros:

- Angle was lying in an optimum range.
- The design was under specified conditions like base area and height.

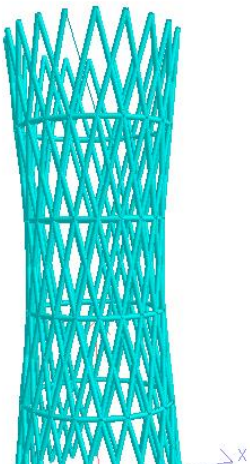


Figure 4

Cons:

- The number of members used was very large and not economic.
- The design has reached its peak of complexity.

Design: 3

Pros:

- Two different lengths of Diagrid members were used in construction. Moving up reduces the length of the diagonal members so that is can carry enough amount of load.
- Several members and nodes used were up to the manufacturing limit.

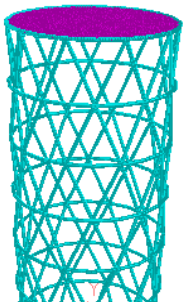
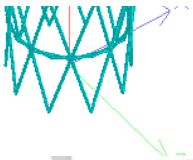


Figure 6



Cons:

- The diagrid angle was not falling in the optimum angle range.

Design: 4

Pros:

- As it is aerodynamic in shape, wind can just pass through it rather than transferring its load to the foundation.
- Upper Diagrid used is kept at a small angle so that it can carry more wind load while lower Diagrid has a higher angle to resist the gravitational load.

Cons:

- The number of members used was more, which increases the level of difficulty in construction.
- Angle doesn't fall under the optimum range.

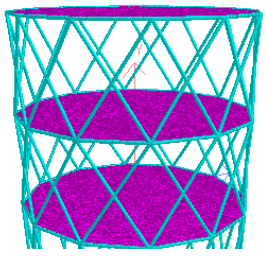


Figure 5

Design: 5 – Final Design:

Pros:

- Diagrid angle lies in optimum angle range, i.e., 69`
- Simple and easy to manufacture.
- It is symmetric. Hence, the load distribution will be more efficient.

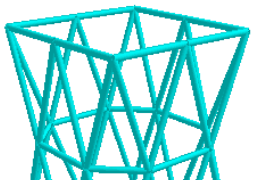
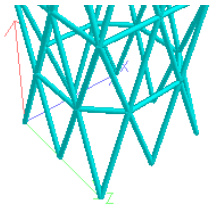


Figure 7



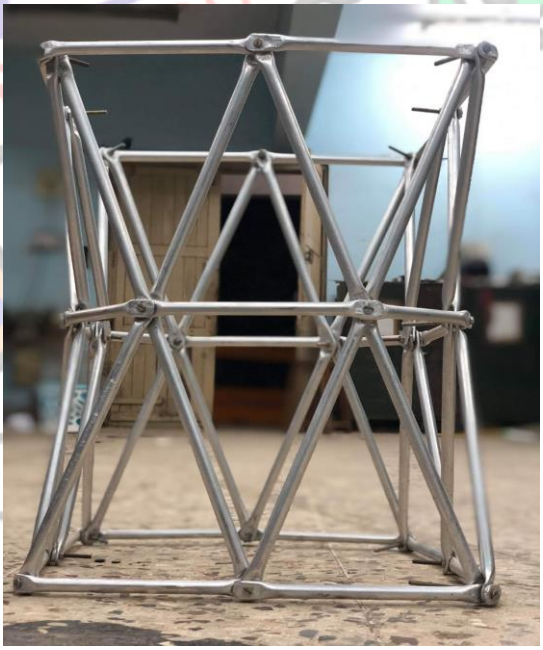
Cons:

- Two different types of slabs were form. One octagon and another square.
- Not aerodynamic as its front surface is plane.

9.0 Manufacturing:

Steps:

- Initially, a square of 30x30 cm on plywood was made.
- Around that, eight struts of 15cm each were kept.
- After construction of diagonal members of length 21.4 cm, joining them with octagon of 4 struts measuring 10.6 and other four measuring 15cm.
- It was then followed by constructing another floor having diagonal members, which then combined at the top to form a square of 30x30 again.



10.0 Problems faced:

STAAD PRO: learning new software took a significant amount of time. Also, initially, it took load up to 30,000kg, which can be considered as it's over efficiency. Also, at times, no displacement was shown. Joining members at an angle was difficult.

11.0 Bibliography:

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