OPTIMIZATION OF HINGED SKELETON STEEL SPACE FRAMES

Prof. P.P.Tapkire[1], Ms. K. J. Narayankar[2]
[1]Professor, [2]Student,
Department of Civil Engineering, NBN Sinhgad Collage of Engineering,Solapur.

ABSTRACT- An act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible is known as optimization.

A space frame is a structural system assembled of linear elements so arranged that the loads are transferred in three dimensional manners. In some cases constituent elements may be two dimensional. Macroscopically a space frame often takes the form of a flat or curved surface. Natural forms of space frames possess exceptional rigidity and use minimum materials to maximum structural advantages.

KEYWORD- Space frame, displacement, member forces, weight of structure, optimization.

I INTRODUCTION

Space frame structures are structural systems with three dimensional assemblies of linear elements, in which the forces are transferred in a three dimensional manner. The classification of space structures is very difficult due to the great variety of possible forms. However, they may be divided into three broad categories such as

(1) skeleton frame work
(2) stressed skin structures and
(3) suspended structures.

The domes, barrel vaults, double and multilayer grids, braced folded plates are few examples of popular skeleton frame works. The stressed skin folded plates, stressed skin domes and barrel vaults are the few examples for the stressed skin systems. The suspended structures are generally known as cables or membrane structures. The behaviour and method of analysis of these three structural classes differ from each other.

II PROPOSED WORK

1. To study the behavior of hinged skeleton steel space frames.
2. To analyze hinged skeleton of different spans using different models with various sizes.
3. To study different parameters influencing design of steel space frame.
4. Applying optimization technique to find optimal design.
5. To develop design chart of steel space frames with or without optimization technique.

III DESIGN CONSIDERATION

In the preliminary stage of planning a space frame to cover a specific building, a number of factors should be studied and evaluated before proceeding to structural analysis and design. These include not only structural adequacy and functional requirements, but also the aesthetic effect desired.

In its initial phase, structural design consists of choosing the general form of the building and the type of space frame appropriate to this form. The geometry of the space frame is an important factor to be planned which will influence both the bearing capacity and weight of the structure.

Method of Support

Ideal double layer grids would be square, circular, or other polygonal shapes with overhanging and continuous supports along the perimeters. This will approach more of a plate type of design which minimizes the maximum bending moment. However, the configuration of the building has a great number of varieties.

Loading Consideration

Dead Load (IS 875 Part 1-1987)

The dead load is established on the basis of the loads which may be expected to act on the structure of constant magnitude. The weight of various accessories such as roof covering, weight of fixture, weight of purlin and purlin support (Stools), space frame joint weight and the self weight of the space frame comprise the total dead load.

Live Load (IS 875 Part 2-1987)

Live load is specified by the local building code and compared with the possible snow or rain load.

Wind Load (IS 875 Part 3-1987)

The wind loads usually represent a significant proportion of the overall forces acting on space frames.

Design Parameters

Types and Geometry

Double layer grids, or flat surface space frames, consist of two planar networks of members forming the top and bottom layers parallel to each other and inter connected by vertical and inclined web members. Double layer grids are characterized by the hinged joints with no moment or torsion resistance; therefore, all members can only resist tension or compression. Even in the case of connection by comparatively rigid joints, the influence of bending or torsion moment is insignificant.

Double layer grids are usually composed of basic elements such as:

- A planar latticed truss
- A pyramid with a square base that is essentially a part of an octahedron

A pyramid with a triangular base (tetrahedron)

Grid Size

By comparing the steel consumption of various types of double layer grids with rectangular plans and supported along perimeters, it was found that the aspect ratio of the plan, defined here as the ratio of a longer span to a shorter span, has more influence than the span of the double layer grids. When the plan is square or nearly square aspect ratio is 1 to 1.5. Therefore, 1.0m and 1.5m grid size has been chosen for study.

Grid Depth

Generally for the analysis, the depth varies between Span/20 to Span/15. However, this ratio depends upon the type of topology, grid size, loading, and support conditions. Grid depth is assumed to be 1.0m.

Support Position

The support condition chosen for the present study is support along perimeter for each case. Also care is taken that the module size of grids matches with the column spacing.

IV THEORETICAL FORMULATION

In the present study Aircraft hanger has been designed for two different type of space grid known as Square on diagonal space grid and Diagonal on square space grid for 30m and 48m span each having grid size as 1.0m x1.0m and 1.5m x 1.5m each and grid depth 1.0 m. Columns with bracing are provided at perimeter having stub column at front side for entrance of Aircraft Hanger.

V STRUCTURAL ANALYSIS OF SPACE FRAME

Various combinations of space frame members are possible with different loading conditions. The researchers have tried these combinations and various parameters were studied.

By understanding suitability two space frame combinations are selected as follows,

1. Square on diagonal space grids
2. Diagonal on square space grids

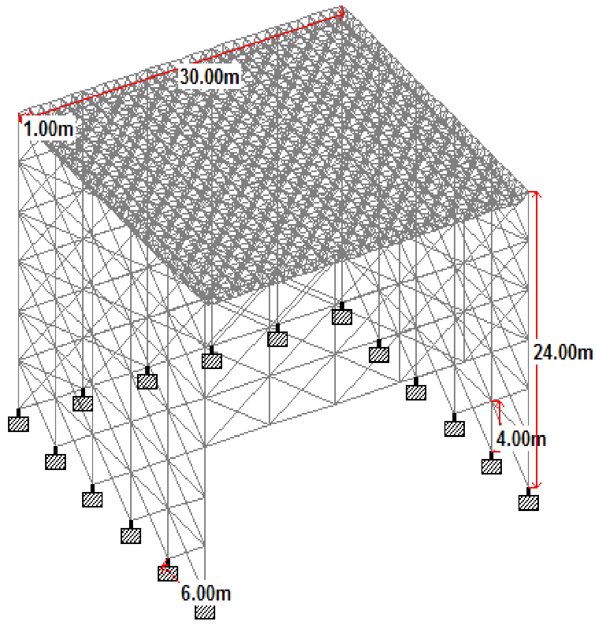

Figure 1: Modelling of Square on diagonal space grid for 30m span, 1.0m x 1.0m grid size

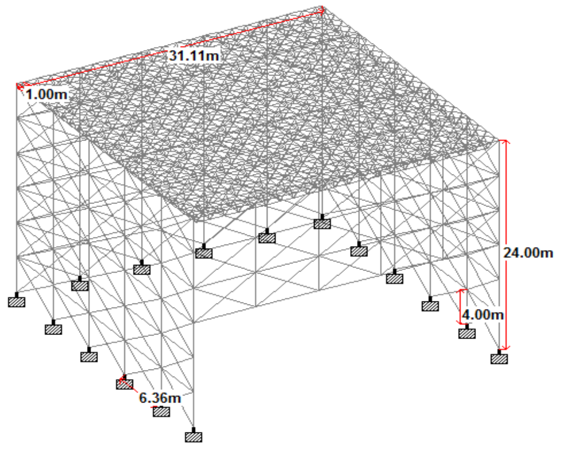

Figure 2: Modelling of Diagonal on Square space grid: 30m span, 1.0m x 1.0m grid size

Considering use of space frame for aircraft hanger spans have been decided. These decided spans are tried with different loading conditions, different grid size and different column sections (Trial cases).

The variation of displacement, axial force in the member and weight of structure are studied and discussed as follows,

- For 1.0x1.0m grid size the maximum displacement up to 40 m span is reach to permissible limit but within the limit.
- For 1.5 x 1.5m grid size diagonal on square shows comparatively less rise than square on diagonals space frame up to midway in between 30 to 48 m span. Square on diagonal space frame shows lower displacement but second half of midway diagonal on square shows better results.
- The variations of displacement are comparatively heavier for 1.5 x 1.5m grid size within permissible limit.
- For 1.0x1.0m grid size of diagonal on square shows almost 6 times reduction in axial force for member for higher span (48 m).
- 1.5 x 1.5m grid comparatively gives reverse results of 1.0x1.0m grid. Diagonal on square shows no variation in axial force of members but square on diagonal space frame shows rise in axial force with almost three times rise.
- For 1.0x1.0m span up to 2/3 times of 30 m square on diagonal is comparatively more preferable then diagonal on square
- It is observed that for 1.0x1.0m grid for diagonal on square shows decreasing weight for increase in span and for square on diagonal weight of structure increases as span increases.
- The percentage of reduction in diagonal on square is negligible as compared to percentage increase in square on diagonal.
- The lowest weight is observed in 1.5 x 1.5m grid for 30 m span with diagonal on square space frame.

By comparing the two types of space frame it is observed that the frame displacement point of view diagonal on square is comparatively better but axial forces are showing different variations as discussed above and weight of structure is significantly on lower side for higher spans for diagonal on square space frame

VI CONCLUSION

Square on diagonal space frame

1. Displacement of square on diagonal space frame increases with increase in span for considered grid size.
2. Variation of displacement for square on diagonal space frame for different size is observed to be same with slight higher values with higher grid size.
3. Axial forces of member for square on diagonal space frame are almost same with increase in span for lower grids.
4. Axial forces of member are observed to be increases with increase in span for higher grid size.
5. Weight of structure of square on diagonal grid size shows higher variation with increase in span for all grid size considered.
6. The increase in variation in weight shows similar rise for grid size considered.

Diagonal on square space frame

1. Displacement variation on diagonal on square space frame shows lower increment for lower size grid and higher increments for increasing span.
2. Displacements are higher for lower span up to certain span which increases for increment in span in comparison with square on diagonal.
3. Axial force of member for diagonal on square space frame shows reduction for lower size grids with increase in span

but remains practically same for higher size grid.

4. The axial forces of member are comparatively lesser than square on diagonal space frame this is true for higher grid size which is considered.
5. Diagonal on square space frame shows a lower weight compared to square on diagonal for increase in span with different grid size.
6. For lower grid size considered the weight of structure decreases with increase in span and for higher grid size considered the increment is observed in weight of structure with increase in span

Square on diagonal comparing mention parameters diagonal on square is preferred with higher grid size for larger span and for lower span lower grid size with square on diagonal is more optimistic than other space frame.

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