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DESIGN OF PRE-ENGINEERED STEEL BUILDING FOR AIR CRAFT HANGAR USING STAAD PRO

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Abstract - *In structural engineering, a pre-engineered building (PEB) is designed by a manufacturer to be fabricated using a pre-determined inventory of raw materials and manufacturing methods that can efficiently satisfy a wide range of structural and aesthetic design requirements. A hangar is a closed structure to hold aircraft or spacecraft in protective storage. Hangars are used for protection from weather, protection from direct sunlight, maintenance, repair, manufacture, assembly and storage of aircraft on airfields, aircraft carriers and ships. Hangars need special structures to be built. The width of the doors is too large and spans from 30 meters to 120 meters, thus enables the aircraft entrance. The bigger the aircraft are to be introduced, the more complex structure is needed. Hence these are specially designed and engineered to fit together to satisfy the unique requirements of specific end-uses.*

Key Words: (Structural, aesthetic design, Hangars, airfield, aircraft, ships, analysis, loads)

1. INTRODUCTION

Buildings & houses are one of the oldest construction activities of human beings. Civil engineering construction has seen a continual economic competition between steel, concrete and other construction materials. A steel building is a metal structure fabricated with steel for the internal support and for exterior cladding, as opposed to steel framed buildings which generally use other materials for floors, walls, and external envelope. Steel buildings are used for a variety of purposes including storage, work spaces and living accommodation.

In structural engineering, a pre-engineered building (PEB) is designed by a manufacturer to be fabricated using a pre-determined inventory of raw materials and manufacturing methods that can efficiently satisfy a wide range of structural and aesthetic design requirements.

Pre-engineered steel buildings use a combination of built-up sections, hot rolled sections and cold formed elements which provide the basic steel frame work with a choice of single skin sheeting with added insulation or insulated sandwich panels for roofing and wall cladding.

Pre-engineered building systems provide real value to clients without sacrificing durability, seismic and wind resistance, or aesthetic appearance. Cost savings begin right at the drawing preparation stage. Systems engineering and fabrication methods help reduce interim financing costs through faster construction and minimized field erection expense. An added benefit is earlier occupancy of the facility and a head start on day-to-day operations by the client.

Apart from costs, there is an assurance of factory-built quality and uniformity in design and fabrication. These systems are also energy efficient; incorporate watertight roofing systems; enable easy disassembly or future expansion and have the lowest life cycle maintenance costs.

Adding to these; there is no mess of sand and cement; power savings; walkable ceilings; progressive and non-progressive panel systems for walls. A poor man can be provided with a home created under strict quality control and having a longer life span, with greater safety against natural disasters like earthquakes and cyclones.

2. RELATED WORK

In structural engineering, a pre-engineered building (PEB) is designed by a manufacturer to be fabricated using a pre-determined inventory of raw materials and manufacturing methods that can efficiently satisfy a wide range of structural and aesthetic design requirements. Within some geographic industry sectors these buildings are also called Pre-Engineered Metal Buildings. Historically, the primary framing structure of a pre-engineered building is an assembly of Ishaped members, often referred as I beam. In PEB, I section beams used are usually formed by welding together steel plates to form of I section. I section beams are then field-assembled (e.g. bolted connections) to form the entire frame of the pre-engineered building. Cold formed Z and C-shaped members may be used as secondary structural elements to fasten and support the external cladding. Roll-formed profiled steel sheet, wood, tensioned fabric, precast concrete, masonry block, glass curtain wall or other materials may be used for the external cladding of the building.

In order to accurately design a pre-engineered building, engineers consider the clear span between bearing points, bay spacing, roof slope, live loads, dead loads, collateral loads, wind uplift, deflection criteria, internal crane system and maximum practical size and weight of fabricated members. Historically, pre-engineered building manufacturers have developed pre calculated tables for different structural elements in order to allow designers to select the most efficient I beams size for their projects.

In pre-engineered building concept the complete designing is done at the factory and the building components are brought to the site in CKD (Completely knock down condition). These components are then fixed / jointed at the site and raised with the help of cranes. The pre engineered building calls for very fast construction of buildings and with good aesthetic looks and quality construction. Pre-engineered Buildings can be used extensively for construction of industrial and residential buildings. The buildings can be multi storied (4-6 floors). These buildings are suitable to various environmental hazards. Pre-engineered buildings can be adapted to suit a wide variety of structural applications; the greatest economy will be realized when utilizing standard details. An efficiently designed pre-engineered building can be lighter than the conventional steel buildings by up to 30%. Lighter weight equates to less steel and a potential price savings in structural framework.

3. AIM OF THE PAPER

Steel is the material of choice for design because it is inherently ductile and flexible. It flexes under extreme loads rather than crushing and crumbling. Structural steel's low cost, strength, durability, design flexibility, adaptability and recyclability continue to make it the material of choice in building construction. Today's structural steel framing is bringing grace, art and function together in almost limitless ways and is offering new solutions and opportunities to create challenging structures, which were once thought impossible. Steel structures have reserve strength. Simple "stick" design in the steel framings allows construction to proceed rapidly from the start of erection.

4. OBJECTIVES

The main objective of the feasibility study is to prepare a report of Pre Engineered steel building for Aircraft Hangar using Staad Pro V8i Software. In general scope of work include the following In the present study, Pre Engineered buildings concept is relatively new technique that are used to design from low rise to high rise multilevel parking and Industrial buildings for manufacturing plants and Aircraft Hangars.

5. METHODOLOGY OF STUDY

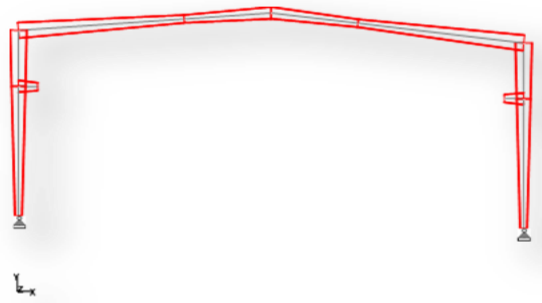

Fig 1: Aircraft Hangar

Width = 60 meters

Length = 120 Meters

Eave Height = 24 Meters

Firstly the information of the project is written after opening the staad.

The model of the framed structure is generated.

After creating the beams and columns we will assign material to them as we require.

Specifying member properties

The supports are first created (as we created fixed supports) and then these are assigned to all the lowermost nodes of structure where we are going to design

Specifying Loads: This is done in following two steps:

a. Firstly creating all the load cases.

b. Then assigning them to respective members and nodes.

The load combinations have been created with the command of auto load combinations. By selecting the Indian code we can generate loads according to that and then adding these loads.

Before doing the analysis for the loads we require specifying analysis command which we need is linear static type. Choosing statics check, we will add this command.

As we require obtaining member end forces and support reactions written in the output file. By clicking on post-analysis a dialog box will open

Run Analysis: The structure will be analyzed to the loads and this command will also show if there is any warning or error.

Post-Processing mode: We can see results in this mode. The deflection, bending moment, shear forces and reactions on supports can been on the structure with values.

6. AIRCRAFT HANGAR

A hangar is a closed structure to hold aircraft or spacecraft in protective storage. Most of the hangars are constructed by using pre-engineered buildings. The main specialty of these hangars is they consist of long spans without any supports or columns.

A pre-engineered steel hangar building is the perfect solution for safe, secure and sturdy storage of private and commercial aircrafts of all sizes. Prefab steel hangars provide the greatest possible storage space to accommodate one or multiple aircraft with a variety of heights and wingspans.

7. TYPES OF AIRCRAFT HANGARS

Group 1 Aircraft Hangars

A hangar having at least one of the following features and operating conditions:
An aircraft access door height over 28 ft. (8.5m).
A single fire area in excess of 40,000 sq. ft (3,716 sq. m).
Provision for housing an aircraft with a tail height over 28 ft. (8.5 m).
Provision for housing strategically important military aircraft as determined by the department of defense.

Group 2 Aircraft Hangars

A hangar having both of the following features:
An aircraft access door height of 28 ft. (8.5 m) or less.
A single fire area not larger than 40,000 sq (3,716 sq. m) per hangar

Group 3 Aircraft Hangars

A Group III hangar may be a freestanding unit for single aircraft, a row hangar housing multiple aircraft that has a common structural wall, roof system and openings for each aircraft or an open bay hangar capable of housing multiple aircraft with the following features:
An aircraft access door height of 28 ft. (8.5 m) or less.
A single fire area that measures up to the maximum square footage permitted for specific types.

8. STAAD PRO

Staad.Pro V8i is the most popular structural engineering software product for 3D model generation, analysis and multi-material design. The basic three activities which are to be carried out to achieve that goal
a) Model generation
b) Calculations to obtain the analytical results
c) result verification - are all facilitated by tools contained in the program's graphical environment.

9. DESIGN PROCESS AND PRINCIPLES

Loads on Structure: The determination of the loads acting on a structure is a complex problem. The nature of the loads varies essentially with the architectural design, the materials, and the location of the structure. Loading conditions on the same structure may change from time to time, or may change rapidly with time.
Dead load: Dead loads shall cover unit weight/mass of materials, and parts or components in a building that apply to the determination of the dead loads in the design of buildings and shall be considered as per IS: 875 (Part 1) - 1987 according to the densities of the possible components. This includes main frames, purlins, girt, cladding, bracing and connections etc.
Live Load: Imposed loads shall be considered as per IS: 875 (Part 2) – 1987. Live load shall be considered as 0.75 KN/sum for the analysis and design.
Wind Load: The basic wind speed and design velocity which shall be modified shall be taken
As per IS: 875 (Part 3) – 1987. The basic wind speed at Hyderabad shall be considered as 44m/sec as per IS: 875 (Part III). This shall be considered for calculating the wind loads. Analysis shall be carried out by considering future expansions if any which has been indicated in the building descriptions and critical forces shall be taken for design.
Seismic Load:
Earthquake loads affect the design of structures in areas of great seismic activity. The proposed structures in this project shall be analyzed for seismic forces. The seismic zone shall be considered as per IS: 1893-2002 (Part 1). For analysis and design, Zone II shall be considered as Mysore region falls under this zone as per IS: 1893-2002 (Part 1).
Earthquake analysis shall be carried out using STAAD PRO 2007 as per the provisions of IS: 1893-2002 (Part 1) & IS: 1893-2005 (part 4). The analysis parameters shall be taken as per the following. The seismic load is considered for Hyderabad location which falls under Zone II.

- Zone Factor: 0.16
- Importance Factor: 1.00
- Response Reduction Factor: 5

10. AIRCRAFT HANGAR DIMENSIONS

The parameters considered for Hangar Design are
Building Input Data
Width = 42 meters
Length = 120 Meters
Eave Height = 24 Meters
Bay Spacing = 7.5 Meters
Brick work = 3 Meters
Roof Slope = 5.71 degrees
Dead Load Calculations:
Sheet weight = 4.57 kg/m2

Purlins = 5 kg
Bracing and Sagging = 9.5 kg
The total load transferring from these components are 1.0 KN/M2
Total Dead load = 1.0x7.5(Bay Spacing) = 7.5 KN/M^2
Live Load Calculations
Live Load is considered from the crane loading and manual loading during erection and is 0.57 according to MBMA code.
Live Load = 0.57x7.5= 4.275 KN/M^2
Wind Load Calculations
Wind Pressure Calculations
Wind Speed Vb = 44 m/sec
Risk coefficient, k1 = 1
Terrain, Ht & size factor, k2 = 1.028
Topography Factor, k3 = 1
Design Wind Speed, Vz= Vbxk1xk2xk3= 44x1x1.028x1 = 45.232 m/s
Design wind pressure, Pz=0.6xVz^2=0.6x45.232^2= 1227.560 N/m^2 = 1.227KN/M/M^2

Seismic Parameters:
HYDERABAD comes under zone –II
Z = seismic zone coefficient = 0.16 (table 2 of IS 1893 PART 1 -2002)
I = depend upon functional use of the structures = 1(from table 6 of IS 1893)
R = response reduction factor = 5 (table 7 of IS 1893 PART 1 -2002)

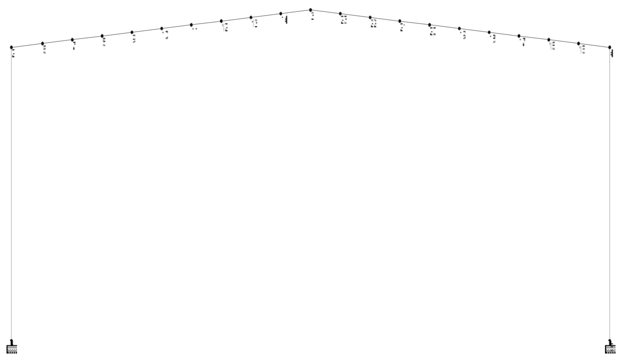

Fig 2: Bending moment for Ideal load

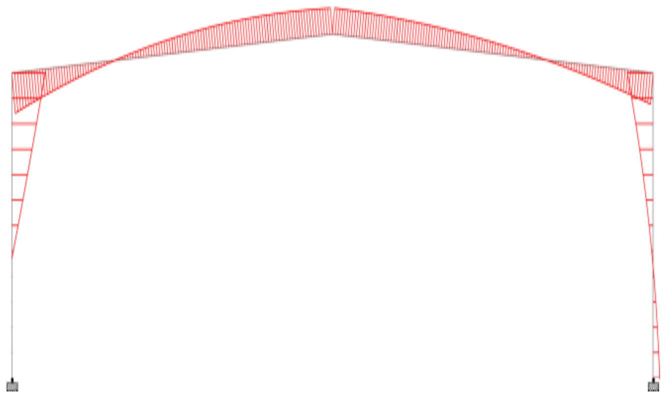

Fig 3: Deflection in Frame

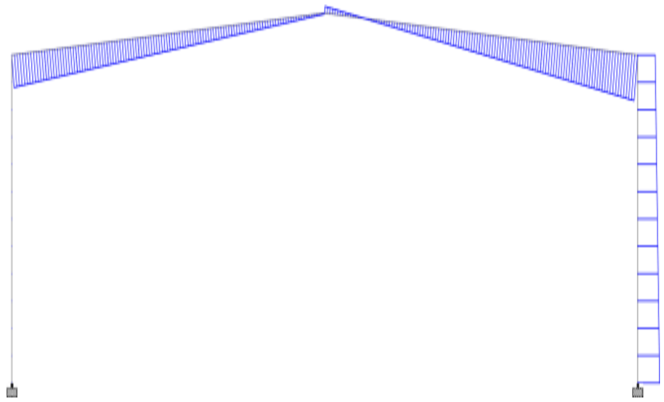

Fig 4: Dead load and Live load acting on frame

10. CONCLUSION

Steel building offers more design and architectural flexibility for unique or conventional styling. Its strength and large clear spans mean the design is not constrained by the need for intermediate support walls. As your requirements changes over the years, you can reuse, relocate, & modify the structure.
Pre-engineered Metal building concept forms an unique position in the construction industry in view of their being ideally suited to the needs of modern Engineering Industry. It would be the only solution for large industrial enclosures having thermal and acoustical features. The major advantage of metal building is the high speed of design and construction for buildings of various categories

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BIOGRAPHIES

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