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# An Overview Of Connections Of An Industrial Shed With Gantry Girder

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## Abstract

In this paper we shows that design the connections for industrial shed which is Pre Engineering Building (PEB) the new technique of modern construction in steel structures by using IDEA StatiCa software which is design and analyse necessary connections and detail steel connection, very fast and correct, also generate a comprehensive report. Connections are design for providing stability to the structure against maximum forces at that particular point and moment which is generated at point. Design of industrial shed is done by using STAAD Pro software and connections are done IDEA StatiCa . It save the time and complexity in design connection and gives the accurate result.

**Keywords:** Industrial shed, Pre Engineering Building, IDEA StatiCa

## 1. Introduction

A structure needs to be built and designed to securely withstand the applied loads. A building's structural framework must transmit the forces applied to it to the building's foundation and supporting ground. This holds true for both the lateral pressures brought on by winds and earthquakes as well as the vertical forces brought on by the self-weight and occupant loads of the building. The structural framework's design must have a full load path that can move loads from their place of origin to the load-resisting parts in order to produce a stable structure. Additionally, the building needs to be built to withstand the lateral forces' tendency to collapse over. Steel constructions need to be sufficiently ductile for preventing collapse brought on by deformation, as well as sufficiently rigid to control drift and prevent structural damage. Steel constructions with portal frames are the most prevalent kind of industrial buildings. When applied to single-story structures, they are tremendously effective and economical that is, if the design criteria and assumptions are chosen well and the details are kept within budget. A series of parallel portal-shaped frames serving as the main framing elements make up the main parts of a portal framework construction. Every frame is inflexible and can withstand loads from gravity and horizontal lateral forces in the horizontal direction off the frame through flexural action.

In a steel moment-resistant frame, the beam-to-column connection is a traditional rigid connection. Because the rafters are hunched close to the columns to accommodate the peak bending moments at the columns, the columns are often bigger than the rafters. Bolted connections are often utilized for the eaves of the portal frame order to improve the connection design efficiency and locally enhance the depth of the rafter, a haunch can be produced by welding a "cutting" to it. The same steel piece used for the rafter is frequently used for the cutting. In certain instances, the constant depth portion of the beam is attached utilizing an end plate connection, and the column and the hunched portion of the beam are formed as one unit.

The ultimate or strength limit state or the limitation of deflections in the serviceability limit state may be used to guide the choice of member sizes in the design of the rafters and columns in portal frames. Making ensuring that the design bending strength is as near to the section capacity which, for many sections, will be the plastic moment capacity is crucial to obtaining an affordable rafter design. This capacity is often attained by using sufficient constraints, such as fly braces to constrain the lateral column flanges and inner rafter laterally. In the plane of the frames, rafters are subjected to high bending moments that range from the maximum "hogging" moment at the junction with the column to the minimum sagging moment close to the apex.

### 1.1 Pre Engineering Building

Pre engineering building is new and most growing technique in steel industry. Pre-engineered buildings (PEBs) are designed and manufactured by a manufacturer using a predetermined inventory of materials and manufacturing processes that can meet a wide variety of structural and visual design needs. The primary framing structure is an I-shaped member assembly, commonly referred to as an I beam. Tapered sections are also used. In PEBs, the I section beam assembly is typically welded together to form an I section. The I section beams can then be field-assembled, for example by bolted connections, to form the complete frame of the PEB. Cold formed z and c-shaped members can also be used as a secondary structural element for fastening and supporting the exterior cladding. In order to design a prefabricated building, the following factors must be taken into account: Clear span between bearing point Bay spacing Roof slope Live loads, Dead loads, Wind uplift Deflection criteria Internal crane system Maximum practical size .

### 1.2 IDEA StatiCa

Idea Statica is a software solution primarily used in the construction industry for the analysis and design of steel connections. It specializes in providing advanced tools for structural engineers, steel detailers, fabricators, and contractors to optimize and validate their steel connections quickly and efficiently. Here are some key points about Idea Statica:

- Purpose: Idea Statica is used for the analysis, design, and code-checking of various types of steel connections, including joints, beams, columns, and other structural elements.
- Features: The software offers a range of features including 3D modeling of connections, automatic generation of detailed connection reports, code-checking according to international standards (such as Eurocode, AISC, etc.), and the ability to optimize connections for cost-effectiveness and performance.
- Integration: Idea Statica can integrate with various structural analysis and design software packages, such as Autodesk Revit, Tekla Structures, and other CAD/BIM platforms, allowing seamless data exchange and collaboration between different phases of the design process.
- Types of Connections: It covers a wide range of steel connection types, including bolted, welded, and pinned connections, as well as connections involving various geometries and loading conditions.
- Validation and Certification: Idea Statica is developed in accordance with relevant industry standards and undergoes rigorous validation and certification processes to ensure its accuracy and reliability in engineering practice.

- User Interface: The software typically features a user-friendly interface with intuitive tools and workflows, making it accessible to both experienced structural engineers and those new to steel connection design.
- Training and Support: Idea Statica usually offers training programs, tutorials, documentation, and technical support to help users get started with the software and troubleshoot any issues they may encounter.

Overall, Idea Statica is a powerful tool for optimizing and validating steel connections in structural engineering projects, helping to streamline the design process and ensure the safety and efficiency of steel structures.

## 2. Methodology

i] Followings are the technical parameters of Pre-Engineered Buildings:-
span of building*: The centre to centre length from one end wall column to the other end wall column of a frame , The span length of pre engineering shed taken as 36.00 m . Length of shed =38.40 m and Purlin spacing = 1.50 m , the bay spacing for center =6.4 m also Bay spacing for gable end = 9.00m & Clear eave height (h) =8.80m as well as Max. eave height = 10.60 m & Roof slope = 10 degree .
The Design loads: Design loads for pre-engineered buildings are broadly classified into two groups: 1) Dead Loads 2) Live Loads. Other loads considered are wind loads, earthquake loads.

ii].Modelling of Pre-engineered Building*
For basic understanding of the concepts, model of pre engineering building shed is prepared and analysis in STAAD pro software . And further connection design is done by using Idea StatiCa software.

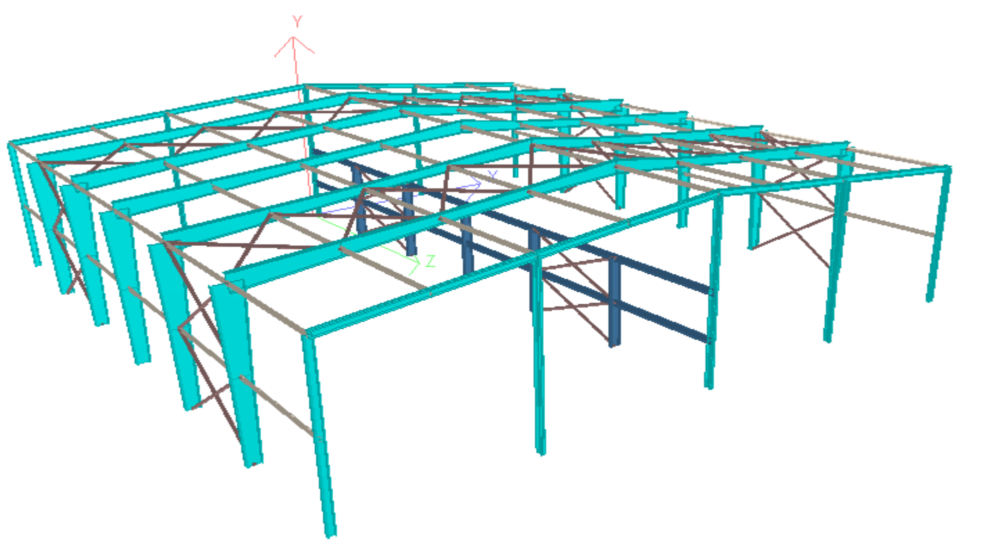


Fig 1. Finale model of PEB on STAAD Pro

iii) Connection design on Idea StataiCa
Bolted connection and welded connection is done for column and rafter joint. 36 mm diameter of bolts are used to stabilized the structure of span is 36 m. Design code is IS. Material used for design is Steel E 250 (Fe 410 W) A, E 300 (Fe 440) & Concrete M30. Analysis is done for Stress, strain/ simplified loading. Also connection design is done for top connection of rafter, gantry connection and base plate connection.

- **Design data of column and rafter**

### Cross-sections

| Name | Material |
|---|---|
| 3 - I1220 | E 250 (Fe 410 W) A |
| 4 - I920 | E 300 (Fe 440) |

### Bolts

| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm$^2$] |
|---|---|---|---|---|
| M36 8.8 | M36 8.8 | 36 | 830.0 | 1017 |

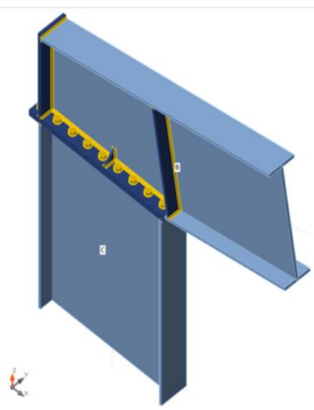
### Load effects (equilibrium not required)

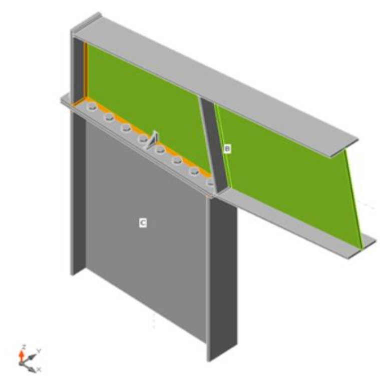
| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| LE1 | B | 0.0 | 0.0 | -250.0 | 0.0 | 1190.0 | 0.0 |

### Design data

| Grade | $T_{db}$ [kN] | $V_{dsb}$ [kN] |
|---|---|---|
| M36 8.8 - 1 | 488.2 | 313.2 |

This data is taken from Idea StatiCa report which is generating after designing process.

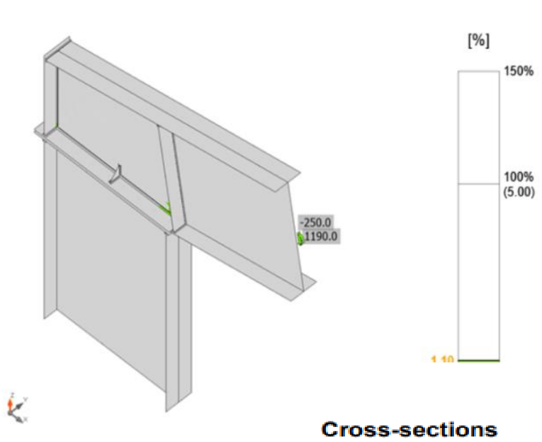


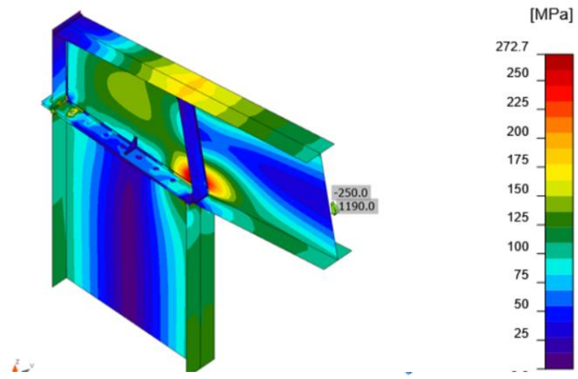


Overall check, LE1

Fig. 2. Bolted connection between rafter and column

This all images are taken from idea static report for overall check, strain check and stress check for load check.




*Strain check, LE1*

**Design**

## Design

Name CC

Description

Analysis Joi

### Cross-sections

| Name | Material |
|---|---|
| 2 - Iw770x250 | E 250 (Fe 410 W) A |

### Bolts

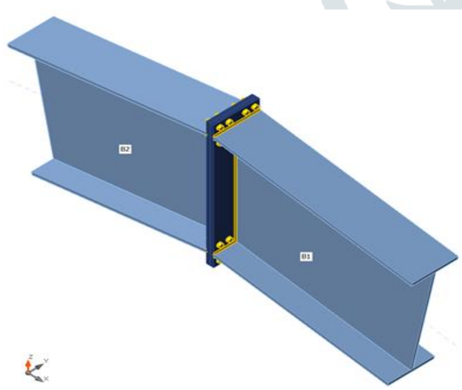
| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm²] |
|---|---|---|---|---|
| M16 8.8 | M16 8.8 | 16 | 800.0 | 201 |

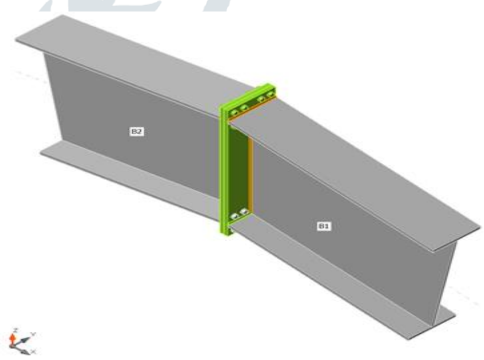
### Beams and columns

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in |
|---|---|---|---|---|---|---|---|---|
| B1 | 2 - Iw770x250 | 0.0 | 10.0 | 0.0 | 0 | 0 | 0 | Node |
| B2 | 2 - Iw770x250 | 180.0 | 10.0 | 0.0 | 0 | 0 | 0 | Node |

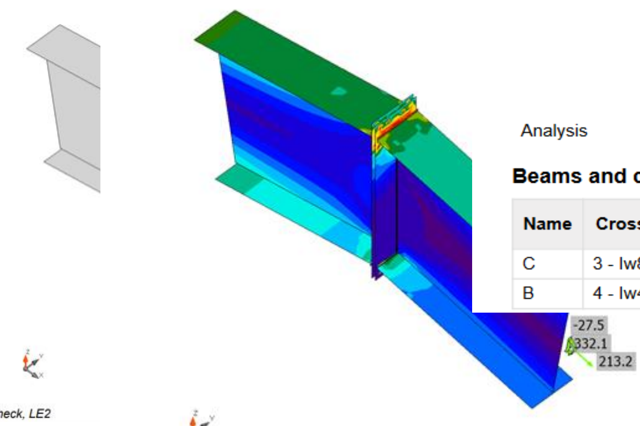
**data for top connection of rafter**

All the figures are taken from idea statica report for overall check for load effect.



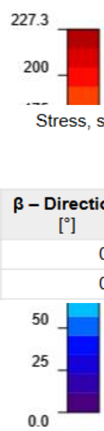


*Overall check, LE2*




Strain check, LE2

Equivalent stress, LE2




- **Data for gantry connection**

| | |
|---|---|
| Analysis | Stress, strain/ simplified loading |

**Beams and columns**

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in | X [mm] |
|---|---|---|---|---|---|---|---|---|---|
| C | 3 - Iw820x250 | 0.0 | -90.0 | 0.0 | 0 | 0 | 0 | Node | 0 |
| B | 4 - Iw400x200 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 | Bolts | 550 |

| Name | Material |
|---|---|
| 3 - Iw820x250 | E 250 (Fe 410 W) A |
| 4 - Iw400x200 | E 250 (Fe 410 W) A |

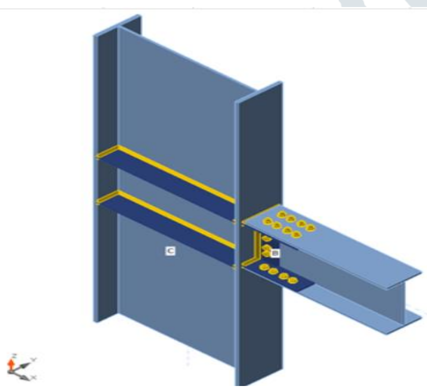
**Bolts**

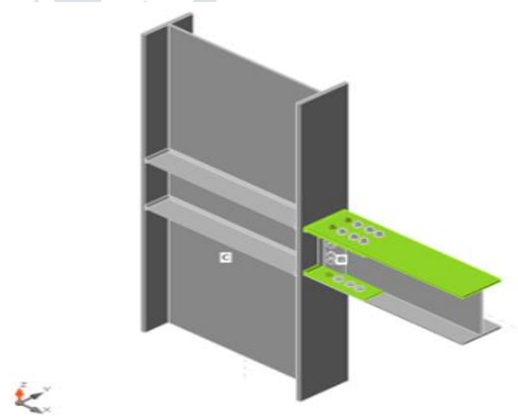
| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm$^2$] |
|---|---|---|---|---|
| M20 8.8 | M20 8.8 | 20 | 830.0 | 314 |

**Load effects (equilibrium not required)**

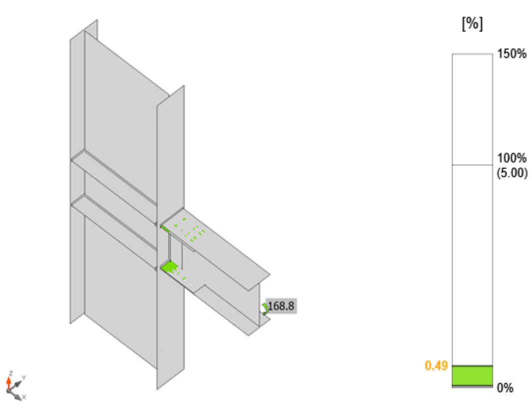
| Name | Member | N [kN] | Vy [kN] |
|---|---|---|---|
| LE1 | B | 0.0 | |

All the images are taken from report

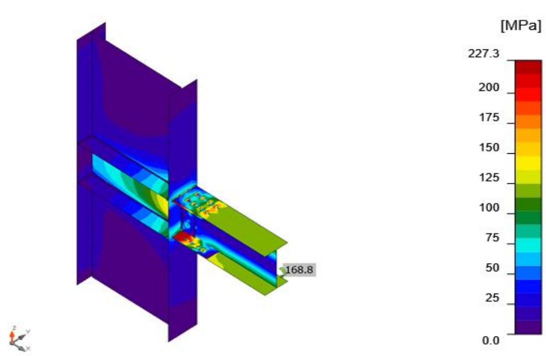




Overall check, LE1




Strain check, LE1




Equivalent stress, LE1

- **Data for**

**Beams and columns**

| Name | Cross-section |
|---|---|
| COL | 2 - Iw620x250 |

**base plate**

### Cross-sections

| Name | Material |
|---|---|
| 2 - Iw620x250 | E 250 (Fe 410 W) A |

### Anchors

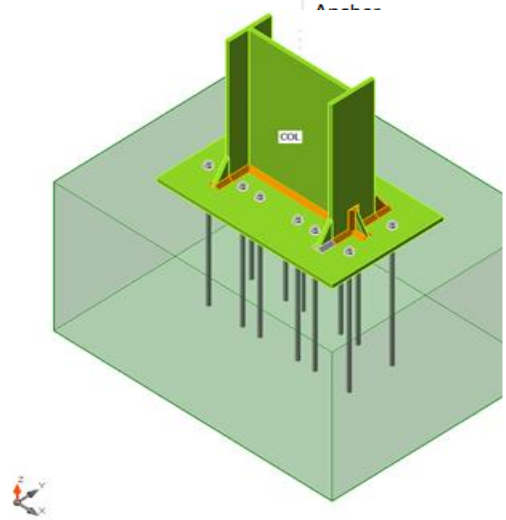
| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm$^2$] |
|---|---|---|---|---|
| M24 8.8 | M24 8.8 | 24 | 830.0 | 452 |

### Load effects (equilibrium not required)

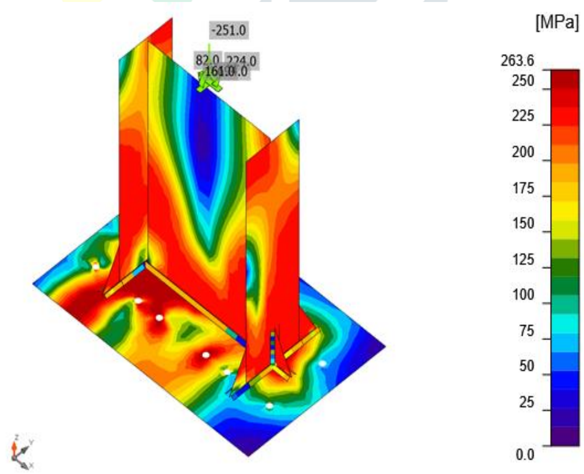
| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| LE1 | COL | -251.0 | 224.0 | 82.0 | 0.0 | 694.0 | 161.0 |

### Foundation block

| Item | Value | Unit |
|---|---|---|
| **CB 1** | | |
| Dimensions | 1250 x 1620 | mm |
| Depth | 1000 | mm |
| [illegible] | M24 8.8 | |
| [illegible] | 900 | mm |
| [illegible] | Friction | |



*Overall check, LE1*




*Equivalent stress, LE1*

## 3). RESULTS AND DISCUSSION

All data is taken from idea static report of design.

1) Data for column and rafter connection

### Check

#### Summary

| Name | Value | Check status |
|---|---|---|
| Analysis | 100.0% | OK |
| Plates | 1.1 < 5.0% | OK |
| Bolts | 56.1 < 100% | OK |
| Welds | 99.5 < 100% | OK |
| Buckling | Not calculated | |

#### Plates

| Nar |
|---|
| C-bfl 1 |
| C-tfl 1 |
| C-w 1 |
| B-bfl 1 |

#### Bolts

| Shape | Item | Loads | $T_b$ [kN] | $V_{sb}$ [kN] | $V_{dpb}$ [kN] | $Ut_t$ [%] | $Ut_s$ [%] | $Ut_{ts}$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|
| | B1 | LE1 | 273.9 | 11.0 | 339.0 | 56.1 | 3.5 | 31.6 | OK |
| | B2 | LE1 | 240.2 | 15.5 | 792.0 | 49.2 | 5.0 | 24.4 | OK |
| | B3 | LE1 | 131.7 | 15.6 | 792.0 | 27.0 | 5.0 | 7.5 | OK |
| | B4 | LE1 | 79.8 | 12.8 | 792.0 | 16.3 | 4.1 | 2.8 | OK |
| | B5 | LE1 | 32.4 | 7.1 | 792.0 | 6.6 | 2.3 | 0.5 | OK |
| | | | | 2.4 | 792.0 | 0.5 | 0.8 | 0.0 | OK |
| | | | | 13.4 | 792.0 | 0.0 | 4.3 | 0.2 | OK |
| | | | | 22.2 | 792.0 | 0.0 | 7.1 | 0.5 | OK |
| | | | | 6.5 | 518.6 | 0.0 | 2.1 | 0.0 | OK |
| | | | | 11.0 | 339.0 | 56.1 | 3.5 | 31.6 | OK |
| | | | | 15.5 | 792.0 | 49.2 | 5.0 | 24.5 | OK |
| | | | | 15.6 | 792.0 | 27.0 | 5.0 | 7.5 | OK |
| | | | | 12.8 | 792.0 | 16.3 | 4.1 | 2.8 | OK |
| | | | | 7.1 | 792.0 | 6.6 | 2.3 | 0.5 | OK |
| | | | | 2.4 | 792.0 | 0.5 | 0.8 | 0.0 | OK |
| | | | | 13.4 | 792.0 | 0.0 | 4.3 | 0.2 | OK |
| | | | | 22.2 | 792.0 | 0.0 | 7.1 | 0.5 | OK |
| | | | | 6.5 | 518.5 | 0.0 | 2.1 | 0.0 | OK |

2) Data for top connection

#### Summary

| Name | Value | Check status |
|---|---|---|
| Analysis | 100.0% | OK |
| Plates | 0.5 < 5.0% | OK |
| Bolts | 61.4 < 100% | OK |
| Welds | 75.9 < 100% | OK |
| Buckling | Not calculated | |

#### Plates

| Name | Material | $f_{yd}$ [MPa] | Thickness [mm] | Loads | $\sigma$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma c_{Ed}$ [MPa] | Check status |
|---|---|---|---|---|---|---|---|---|
| C-tfl 1 | E 250 (Fe 410 W) A | 227.3 | 20.0 | LE1 | 21.2 | 0.0 | 0.0 | OK |
| C-bfl 1 | E 250 (Fe 410 W) A | 227.3 | 20.0 | LE1 | 104.2 | 0.0 | 0.0 | OK |
| C-w 1 | E 250 (Fe 410 W) A | 227.3 | 10.0 | LE1 | 204.2 | 0.0 | 0.0 | OK |
| B-tfl 1 | E 250 (Fe 410 W) A | 227.3 | 16.0 | LE1 | 216.6 | 0.0 | 25.5 | OK |
| B-bfl 1 | E 250 (Fe 410 W) A | 227.3 | 16.0 | LE1 | 193.4 | 0.0 | 21.3 | OK |
| B-w 1 | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE1 | 134.7 | 0.0 | 4.8 | OK |
| STIFF1a | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE1 | 110.1 | 0.0 | 0.0 | OK |
| STIFF1b | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE1 | 114.0 | 0.0 | 0.0 | OK |
| STIFF1c | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE1 | 107.7 | 0.0 | 0.0 | OK |
| STIFF1d | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE1 | 111.6 | 0.0 | 0.0 | OK |
| FP1 | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE1 | 122.9 | 0.0 | 4.8 | OK |
| FP2 | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE1 | 227.6 | 0.2 | 20.4 | OK |
| FP3 | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE1 | 228.3 | 0.5 | 25.6 | OK |

3) Gantry connection

**Summary**

| Name | Value | Check status |
|---|---|---|
| Plates | 0.0 < 5.0% | OK |
| Bolts | 90.5 < 100% | OK |
| Welds | 99.4 < 100% | OK |

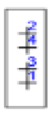
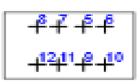
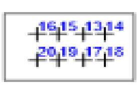
**Plates**

| Name | Material | $f_{yd}$ [MPa] | Thickness [mm] | Loads | $\sigma$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma c_{Ed}$ [MPa] | Check status |
|---|---|---|---|---|---|---|---|---|
| B1-tfl 1 | E 250 (Fe 410 W) A | 227.3 | 20.0 | LE2 | 119.2 | 0.0 | 0.0 | OK |
| B1-bfl 1 | E 250 (Fe 410 W) A | 227.3 | 20.0 | LE2 | 98.7 | 0.0 | 0.0 | OK |
| B1-w 1 | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE2 | 84.6 | 0.0 | 0.0 | OK |
| B2-tfl 1 | E 250 (Fe 410 W) A | 227.3 | 20.0 | LE2 | 120.0 | 0.0 | 0.0 | OK |
| B2-bfl 1 | E 250 (Fe 410 W) A | 227.3 | 20.0 | LE2 | 103.7 | 0.0 | 0.0 | OK |
| B2-w 1 | E 250 (Fe 410 W) A | 227.3 | 12.0 | LE2 | 93.8 | 0.0 | 0.0 | OK |
| PP1a | E 250 (Fe 410 W) A | 227.3 | 20.0 | LE2 | 227.3 | 0.0 | 55.6 | OK |
| PP1b | E 250 (Fe 410 W) A | 227.3 | 20.0 | LE2 | 227.3 | 0.0 | 55.6 | OK |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Plastic strain |
| $\sigma$ | Equivalent stress |
| $f_{yd}$ | Design yield strength |
| $\sigma c_{Ed}$ | Contact stress |

**Bolts**

| Shape | Item | Loads | $T_b$ [kN] | $V_{sb}$ [kN] | $V_{dpb}$ [kN] | $Ut_t$ [%] | $Ut_s$ [%] | $Ut_{ts}$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|
|  | B1 | LE1 | 1.1 | 32.0 | 188.1 | 0.7 | 34.1 | 11.6 | OK |
| | B2 | LE1 | 2.7 | 33.6 | 154.4 | 1.8 | 35.8 | 12.8 | OK |
| | B3 | LE1 | 0.3 | 15.7 | 196.8 | 0.2 | 16.7 | 2.8 | OK |
| | B4 | LE1 | 1.8 | 17.1 | 175.5 | 1.2 | 18.2 | 3.3 | OK |
|  | B5 | LE1 | 2.2 | 55.0 | 129.7 | 1.5 | 58.6 | 34.4 | OK |
| | B6 | LE1 | 1.0 | 56.0 | 99.9 | 0.7 | 59.6 | 35.5 | OK |
| | B7 | LE1 | 1.6 | 55.6 | 99.9 | 1.1 | 59.2 | 35.1 | OK |
| | B8 | LE1 | 14.7 | 57.6 | 133.2 | 10.1 | 61.4 | 38.7 | OK |
| | B9 | LE1 | 2.0 | 55.0 | 129.7 | 1.4 | 58.6 | 34.3 | OK |
| | B10 | LE1 | 1.0 | 55.9 | 99.9 | 0.7 | 59.5 | 35.4 | OK |
| | B11 | LE1 | 1.5 | 55.6 | 99.9 | 1.0 | 59.2 | 35.1 | OK |
| | B12 | LE1 | 14.7 | 57.7 | 133.2 | 10.0 | 61.4 | 38.7 | OK |
|  | B13 | LE1 | 0.0 | 54.8 | 99.9 | 0.0 | 58.4 | 34.1 | OK |
| | B14 | LE1 | 14.6 | 55.0 | 133.2 | 10.0 | 58.6 | 35.3 | OK |
| | B15 | LE1 | 2.2 | 55.5 | 129.7 | 1.5 | 59.1 | 34.9 | OK |
| | B16 | LE1 | 1.6 | 57.2 | 99.9 | 1.1 | 60.9 | 37.0 | OK |
| | B17 | LE1 | 0.0 | 54.7 | 99.9 | 0.0 | 58.2 | 33.9 | OK |
| | B18 | LE1 | 14.6 | 54.9 | 133.2 | 10.0 | 58.4 | 35.1 | OK |
| | B19 | LE1 | 2.4 | 55.4 | 129.7 | 1.6 | 58.9 | 34.8 | OK |
| | B20 | LE1 | 1.5 | 57.0 | 99.9 | 1.0 | 60.7 | 36.9 | OK |

**Design data**

| Grade | $T_{db}$ [kN] | $V_{dsb}$ [kN] |
|---|---|---|
| M20 8.8 - 1 | 146.4 | 93.9 |

4) Base plate

**Summary**

| Name | Value | Check status |
|---|---|---|
| Analysis | 100.0% | OK |
| Plates | 3.9 < 5.0% | OK |
| Anchors | Not calculated | |
| Welds | 98.3 < 100% | OK |
| Concrete block | 83.2 < 100% | OK |
| Buckling | Not calculated | |

# CONCLUSION:

1) From my project work where I compare the PEB and CBS structure with same parameter I conclude that Pre-engineered steel buildings have several advantages, including affordability, robustness, longevity, adaptability, and recycling. The fundamental component of the materials used in pre-engineered steel buildings is steel. As this project demonstrates, pre-engineered buildings are the ideal choice for longer span constructions without internal columns in between. When computers were introduced, the possibilities for design were practically endless. Preservation of Material on the principal frame members' low stress region makes pre-engineered structures more cost-effective.

2) It can be concluded that both bolted and welded connections are excellent choices for stabilizing PEB structures against various loads. Bolted connections offer several advantages in this regard: 1) Strength and Load Transfer: Bolts, typically made from high-strength steel, excel in transferring both tensile and shear loads between structural members. This robustness ensures reliable load distribution within the framework.2) Easy Installation and Assembly: The straightforward installation process of bolted connections involves aligning pre-drilled holes in steel components, simplifying on-site assembly. Unlike welding, no specialized equipment is required, and torque wrenches easily tighten the connections.3) Adjustability and Flexibility: Bolted connections provide adaptability during both installation and future modifications of pre-engineered steel buildings. They allow effortless disassembly and reassembly, enabling alterations to building layouts or the integration of new components without compromising structural integrity. This flexibility is particularly valuable for accommodating building expansions or other adjustments.

3) Idea statica is one of the best and time severs software for accurate design the connection for steel structure.

4) Gantry connection design is crucial for ensuring structural stability, load distribution, and durability in various elevated structures such as bridges and cranes. Well-engineered connections enhance safety, minimize maintenance requirements, and optimize cost-efficiency by distributing loads efficiently and providing resilience against environmental factors. Additionally, thoughtful design considerations allow for adaptability and flexibility to accommodate future modifications while contributing to the overall aesthetic appeal of the structure.

5) Base plates serve as critical components in transferring loads from columns or other structural elements to the foundation. A well-designed base plate ensures stability, distributes loads effectively, and minimizes the risk of settlement or failure. Proper detailing and material selection in base plate design are essential to withstand various forces, including vertical loads, moments, and shear. Additionally, considering factors such as soil conditions, anchor bolt arrangements, and connection details are vital for optimizing performance and ensuring long-term structural integrity. Ultimately, meticulous base plate design is integral to the overall safety, stability, and functionality of any structure.

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