PRE-ENGINEERED STRUCTURE FOR WARE HOUSE

By

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08MCL002

DEPARTMENT OF CIVIL ENGINEERING

AHMEDABAD-382481

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Major Project

Submitted in partial fulfillment of the requirements

For the degree of

Master of Technology in Civil Engineering
(Computer Aided Structural Analysis And Design)

By

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May 2010

Declaration

This is to certify that

i) The thesis comprises my original work towards the degree of Master of Technology in Civil Engineering at Nirma University (Computer Added Structural Analysis and Design) and has not been submitted elsewhere for a degree.

ii) Due acknowledgement has been made in the text to all other material used.

Bhumir N. Dalal

Certificate

This is to certify that the Major Project entitled "Pre-Engineered Structure For Ware House" submitted by Bhumir N. Dalal (08MCL002), towards the partial fulfillment of the requirements for the degree of Master of Technology in Computer Aided Structural Analysis and Design of Nirma University, Ahmedabad is the record of work carried out by his under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Date of Examination

Abstract

Man has always resorted to innovative means to meet his changing needs. There has been a constant evolution in the construction techniques ever since the time man learnt to hold the spade in his hand. The corporate world, manufacturing sector, residential and institutional sectors, all demand quick construction. The Corporate giants always consider “time” as the prime deciding factor in terms of profitability. For them, earlier construction of commercial buildings means earlier return on investments. Today, there is a dire need of cost effective technology especially in the ever growing field of construction. Pre Engineering is a new construction technology evolved that uses the assembly system, just like a building block game. It comprises of pre designed building components of steel for specific project loading. Connectivity is very simple by just the nut and bolt mechanism minus the welding. This leads to major construction sites to healthy working environment. The concept of PEB is catching up fast in India.

General information regarding pre-engineered structure is described. Landmark achieved by pre-engineered technique is mentioned. It defines the terminology of pre-engineered. Basic parameters, primary members and secondary members explained in detail. Advantage and application of pre-engineered structure for ware house is describe. Difference between pre-engineered Building with conventional steel building is mentioned.

Conventional portal ware house is compared with P.E.B ware house to check in which case it achieve the economy in steel quantity. Ware house is model, analysis and design by STAAD Pro.2006. To compare the results configuration of ware house remain same. Design is done based on IS:800 in STAAD. Yield stress of steel assumes 540 Mpa in P.E.B ware house. Yield stress of Steel assumes 250 Mpa in conventional portal ware house. Application of loading remains same in both cases. D.L, L.L, Wind X (Cpe$\pm$Cpi), Wind -X (Cpe$\pm$Cpi), Wind Z (Cpe$\pm$Cpi), Wind -Z (Cpe$\pm$Cpi) cases

considered in modeling. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Analysis result compared for both warehouses. Steel quantity is observed in both cases.

Spacing of P.E.B portal vary to check in which case it achieve the economy in steel quantity. Ware house is model, analysis and design by STAAD Pro.2006. Configuration of ware house remain same only spacing of portal is vary from 4.5 m, 6 m, 7.5 m, 9 m. Design is done based on IS:800 in STAAD. Yield stress of steel assume 540 Mpa in all cases. D.L, L.L, Wind X (Cpe$\pm$Cpi), Wind -X (Cpe$\pm$Cpi), Wind Z (Cpe$\pm$Cpi), Wind -Z (Cpe$\pm$Cpi) cases considered in modeling. Application of loading remains same in all cases. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Analysis result compared.Steel quantity is observed for mentioned cases.

Width of P.E.B portal vary to check structural behavior of ware house. Ware house is model and analysis by STAAD Pro.2006. Configuration of ware house remains same only width of portal is vary from 25 m two bay to 50 m one bay. Yield stress of steel assume 540 Mpa in both cases. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Analysis result compared for both ware house.

Ware house is design manually based on analysis result given by STAAD Pro.2006. Excel worksheet is prepared for different structural elements like Taper Column, Taper Rafter, Purlin, End Plate Connection, Pedestal, Isolated Footing and Base Plate.

Erection work at site is observed. Snaps of erection work is attached. Drawings for understanding the configuration of ware house is described.

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- Bhumir N. Dalal
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Abbreviations Notations and Nomenclatures

h .... Eave Height of Building
w .... Width of Building
L .... Length of Building
θ .... Angle of Inclination
F .... Wind Force
Cpe .... External Pressure Coefficient
CPi .... Internal Pressure Coefficient
A .... Surface Area of the Element
Pd .... Design Wind Pressure
Vz .... Design Wind Speed
k1 .... risk factor
k2 .... Terrain, Height and Structure Size Factor
k3 .... Topography Factor
Vb .... Basic Wind Speed
A,B,C,D .... Dimension of Building in Plan
E,F,G,H .... Effective Wind Pressure Area
Fy .... Permissible Stress of Steel
D.L .... Dead Load
L.L .... Live Load
W.L .... Wind Load
Fx .... Axial Force
Fy .... Shear Force
Mz .... Moment in Major Axes

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Chapter 1

Introduction

1.1 General

Man has always resorted to innovative means to meet his changing needs. There has been a constant evolution in the construction techniques ever since the time man learnt to hold the spade in his hand!! It is said, "Necessity is the Mother of Invention". Today we find, "Change is Constant", quite an oxymoron though, but truly applicable in the construction world.

The corporate world, manufacturing sector, residential and institutional sectors, all demand quick construction. The Corporate giants always consider "Time" as the prime deciding factor in terms of profitability. For them, earlier construction of commercial buildings means earlier return on investments. Today, there is a dire need of cost effective technology especially in the ever growing field of construction.

The ancient egyptians built the magnificent pyramids. Ever since, nothing so exotic has been done in the world of building construction although civil engineering has adopted new construction techniques in other sectors. Today we still find stone on top of stone and brick by brick construction. In 1889, there came the first use of steel in the construction of the eiffel tower in paris. In 1905 reinforced concrete was used. products began to get manufactured in industries with the start of the industrial revolution in 1780, but today buildings are still done on at site as they were 4,000 years ago.

Pre Engineered Building is a new construction technology evolved that uses the assembly system, just like a Building Block game. Pre-engineered buildings are pre designed, precut and pre manufactured by the building manufacturer. It comprises of pre designed building components of steel for specific project loading. Connectivity is very simple by just the nut and bolt mechanism minus the welding. In this,

- No gas emissions, so making PEB symbiotic with nature.
- No welding electrodes so less accident prone.

1.2 Present Scenario

Time is one of the most important factors which decide the methodology to be selected for doing any task in the world. This is so, as in today's highly commercial and competitive world, time is more important than money as once lost money can be recovered but time consumed can never be regained. Pre-engineered buildings are one such innovation in the field of construction which helps in efficient use of time and money.

Following are now playing major role in design, manufacture, supply and erection of Pre-engineered structure in India.

- Joint ventures like TATA Blue-Scope Steel
- Phenix Varco Pruden
- Reliance - Mammut Group

- Zamil Building Systems
- Kirby Building Systems (India)
- Interarch Building Products Pvt. Ltd
- Tiger Steel Engineering India Pvt ltd
- Punj Lloyd
- Era Buildings Systems
- Multicolor Projects (India) Ltd
- Sarvpriya Industries Ltd (SIL)
- Jindal Mectec
- Cold Steel Building Systems
- Pennar Industries Ltd are playing a major role

In India, the concept of PEB construction started in 1999-2000. In the last fiscal about three lakh tons of materials were produced. The growth rate of PEB construction is 20 percent annually. P.E.B concept has been very successful and well established in North America, Australia and is presently expanding in U.K and European countries.

The much talked about Dynamic Tower of Dubai, the world's first "Building in Motion" of 80 floors (420 m) is the first skyscraper in the world to be constructed as a Pre Engineered Building.

The famous TATA Nano project plant site at Sanand, Gujarat, is to be constructed using PEB components, Phenix Varco Pruden (PVP) being the supplier of P.E.B components for this 50 core project site having 65,000 sq. m.

1.3 Objective of Study

The concept of P.E.B is catching up fast in india. We need an investment of more than 500 billion USD in next few years. In India there is already 40 million tons steel capacity installed. Steel consumption in india is around 27-30 million tons. In india we have surplus capacity of flat steel products available. This attracts its use in the construction of pre-engineered building components. Pre-engineered building is a budding industry, yet growing rapidly. It has current revenue of 400 million USD, approximate 0.35 million tons of steel. The graph below explains this better. fig 1.1

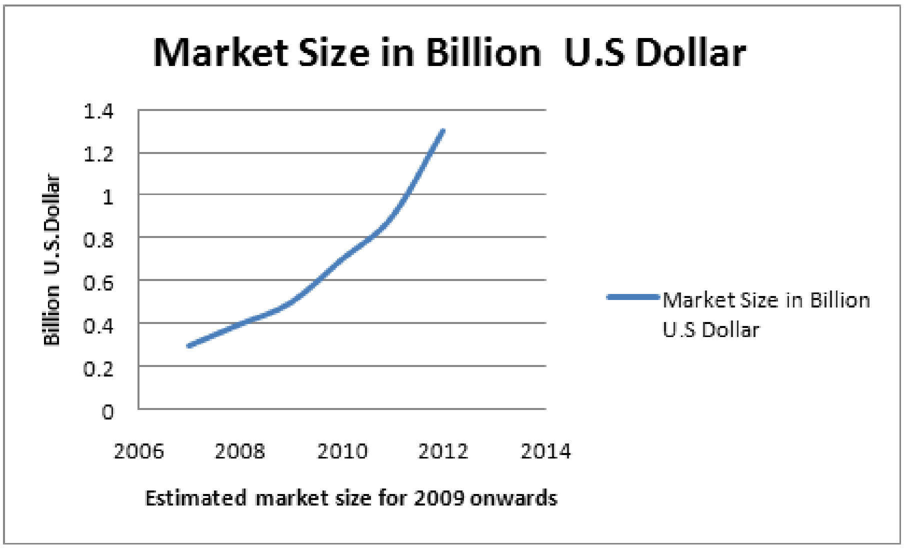


Figure 1.1: Growth of Steel Consumption in India

With so much investment for a building industry, it becomes essential to know the cost effectiveness of PEBs against traditional methods of construction.

The objective of the present work is to understand the phenomena of pre-engineered structure. In other countries like U.S.A, U.K appreciable work has been done. Still in India its new technique. The main objective of present work is as follows:

• Study the behavior of pre-engineered industrial shed structure.

• Understand the basic difference of pre-engineered structure with conventional portal structure.

• critically observe the erection of pre-engineered building. Study the difference in erection point of view.

• Parametric study for the conventional method and pre-engineered method regarding material consumption, Displacement, Column forces, Beam Forces.

• Design primary element of P.E.B and Prepare detailed drawings.

1.4 Scope of Work

• To understand pre-engineering structure and study the behavior of pre-engineering structure. • Analyze different pre-engineering sections prepared by different P.E.B vendors. • Considering same hypothetical data behavior of conventional portal ware house and P.E.B ware house analyzed. • Keeping same configuration of P.E.B ware house only changing spacing of ware house from 4.5 m,6 m,7.5 m,9m. Study the Steel consumption for different portal spacing. • Keeping same configuration of P.E.B ware house changing width of ware house from 25 m two bay to 50 m one bay. Observe the structural behavior of warehouse. • Manually design and detailed the structural component of P.E.B ware house. • Industrial Visit to P.E.B ware house.

1.5 Organization of Major Project

The contents of major project are divided in to various chapters as follows;

Chapter 1 includes introduction. it covers general information regarding pre-engineered building. present scenario, objective of work is mentioned in this chapter. It also includes scope of work.

Chapter 2 includes literature review. It provides an overview of the available books, publications and papers from various journals on the topic of pre-engineered structure. This chapter provides the understanding and importance of pre-engineered structure for ware house.

Chapter 3 includes General information regarding pre-engineered structure. Landmark achieved by pre-engineered technique is mentioned. It defines the terminology of pre-engineered. Basic parameters, primary members and secondary members are explained in detail. Advantage and application of pre-engineered structure for ware house is describe. At last difference between pre-engineered structure with conventional steel structure is mentioned.

Chapter 4. In this chapter conventional portal ware house is compared with P.E.B ware house to check in which case it achieve the economy in steel quantity. Ware house is model, analysis and design by STAAD Pro.2006. To compare the results configuration of ware house remain same. Design is done based on IS-800 in STAAD. Yield stress of steel assume 540 Mpa in P.E.B ware house. Yield stress of steel assume 250 Mpa in conventional portal ware house. Application of loading remains same in both cases. D.L, L.L, Wind X (Cpe±Cpi), Wind -X (Cpe±Cpi), Wind Z (Cpe±Cpi), Wind -Z (Cpe±Cpi) cases considered in modeling. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Comparison of analysis result for different cases is conducted. Steel quantity is observed in both cases.

Chapter 5. In this chapter two aspects considered for ware house. In first aspect spacing of P.E.B portal vary to check in which case it achieve the economy in steel quantity. Ware house is model, analysis and design by STAAD Pro.2006. Configuration of ware house remain same only spacing of portal is vary from 4.5 m, 6 m, 7.5 m, 9 m. In second aspect width of P.E.B vary from 25 m two bay and 50 m width portal to observe the structural behavior of ware house. Design is done based on IS-800 in STAAD. Yield stress of steel assumes 540 Mpa in all cases. D.L, L.L, Wind X (Cpe±Cpi), Wind -X (Cpe±Cpi), Wind Z (C_{pe}±Cpi), Wind -Z (Cpe±Cpi) cases considered in modeling. Application of loading remains same in all cases. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Comparison of analysis result for different cases is conducted. Steel quantity is observed in different cases.

Chapter 6. In this chapter one ware house is design manually based on analysis result given by STAAD Pro.2006. excel worksheet is prepared for different structural elements like Taper Column, Taper Rafter, Purlin, End Plate Connection, Pedestal, Isolated Footing, Base Plate.

Chapter 7 includes Site Visit of P.E.B ware house. Erection work is observed at site. Snaps of erection work, Drawings for understanding the configuration of ware house is prepared in this chapter.

Chapter 8 includes summary of the study, conclusion and future scope of work.

Chapter 2

Litreature Review

2.1 General

The analysis and design of industrial steel structure is discussed by many authors. From the analytical as well as experimental work, they framed some important conclusion for the increasing the efficiency of the structural system. Literature survey is to be carried out to review various criteria which are to be considered for the pre-engineering structure. Survey from various literatures such as different books and research papers has been carried out to support the present work. Relevant information from various research papers, publication from INSDAG, books and codes have been extracted and discussed in this chapter.

2.2 Research Papers and Technical Manual

Tuan Tran, Long-yuan Li [3] incorporates a global optimization method for designing the cross-section of channel beams subjected to uniformly distributed transverse loading. The optimization of the cross-section is performed using the trust-region method (TRM) based on the failure modes of yielding strength, deflection limitation, local buckling, distortional buckling and lateral-torsional buckling. Numerical examples include the comparisons of the optimized sections obtained based on the applications of BS 5950-5 standard.

Upasana Chaudhry [1] explores into the cost effectiveness of P.E.B technology against traditional method of construction. It involves the design of a new P.E.B for an existing conventional steel building and vice versa. Study methodology involved the identification of P.E.B firms in India, collection of primary and secondary data in the form of section properties of tapered sections, structural designs of low rise industrial buildings for case studies, framing configuration details of the main frames, MBMA manual and relevant IS Codes for structurally sound designs, rates of conventional steel sections and PEB tapered sections.

Jyri Outinen [2] explained an overview of the manufacturing, products, materials and structural design of profiled steel sheeting. He has described current research projects.

Basic Detailing Technology Manual [4]This manual gives knowledge of detailing. Various elements of primary members are effectively detailed. Type of bracing system and detailing of each bracing system is cover. Secondary system like roof and purlin, flange brace, purlin brace is detailed. Detailing of roof panel, roof accessories, wall panel are given. Other structural System like canopy, fascia, parapet, building accessories like inspection ladder, ridge ventilator, power ventilator, insulation, fasteners, sealant are explained in this manual.

Low Rise Building Systems Manual-1976 (MBMA) [6] it incorporates the results of research undertaken by MBMA.In many aspects, it reflects refinement and advances in the knowledge of load application methods and design. Every effort has been made in this manual to present accurate and sound engineering and design information.

Metal Building System Manual-2002 (MBSM) [7] it gives Load application on industrial structure and design. Wind, snow, fire-protection preventions are added in this manual.

Metal Building Software (September, 2000) [5] Metal Building Design is a program of Metal Building Software. This program is to serve as a computational aid for the building designer. The building designers should familiarize themselves with the computations used in the program. Every effort has been made to ensure the accuracy of this program.Calculations of building Component and drawing of the member is mentioned in this manual.

W. E.Falby and G. C. Lee [5] explain about formulation of design guides for tapered webs based on post-buckling strength.a) They derived the formulation of necessary modifications to the current AISC "tension-field formula" of prismatic girders for the application to tapered webs.b) They check the adequacy of using the AISC tension-field formula for tapered roof beams in frames.

E.Machaly,S.Safar and A.Ettaf [9]. In this paper, the behavior of tapered-haunched connections was investigated using the finite element method. The general-purpose finite element program, ANSYS was utilized in the analysis incorporating material nonlinearity and geometric imperfections to capture the interaction of yielding and buckling on the different failure modes of such connections.

2.2.1 Technical Manual of P.E.B Vendor

Kirby building system [10] explained basic terminology for pre-engineered structure. Shows standard structural system, special structural system. Determined various engineering data. It presents installation and accessories detail.

Zamil Steel [13] present Company Portfolio. Described the role of the architect and consultant. Explain nomenclature used in the steel structure. Mention basic concept, its merit, demerit, application. Explain various code used in the design.

Fedders Lloyd PEB brochure [12] described the various codes used in Pre-engineered building for India and America.it defines various primary, secondary sections. Determine various system and accessories.

Era Group Technical Detail [11] present Company Portfolio. Quality control and turnkey solutions are explained. Definitions of basic parameters are explained. Various Primary Sections, Secondary Sections and Roofing material are prescribed. Manual mention the material specification.

2.3 Books

S K Duggal (2000) [17] describes basic parameters related industrial steel structures. Different forms of tension, compression and flexure elements are discussed. Different roof supporting tension systems discussed. Information about Gantry Girder also mentioned. This book also gives new trends in industrial building design.

Pasala Dayaratanam (2000) [16] This book includes the design of industrial steel structure. It also includes the design of Gantry Girder. Industrial building design steps are given in depth.

A.S.Arya and J.L.Ajmani, (2007) [15] This book deals with both aspect of design, which are functional design, and structural design. It gives separate design of industrial building in which separate explanation of each and every minor parameter, which is required for design of industrial building. The load calculation for each type of truss and its analysis and design is explained with good illustrative examples. Some other points are also discussed in detail related to industrial buildings that will useful in planning and designing an industrial building.

N Subramanium (2008) [14] this book explain the behavior of various elements of structures and to provide the basic for the Codal rules. It gives the design of the steel structure members (such as gantry girder, compression member, tension members, beams, columns, etc...) as per new codes IS 800-2007.

Advance Analysis and Design of Steel Frames by Guo-Qiang Li and Jin-Jun Li[18] Chapter-3 deals with analysis of Taper beam section. Elastic Stiffness Equation of Taper Beam Element is derived in this book.

2.4 Standards and Codes

IS 800 1984[19] is the Indian code of practice by BIS (Bureau of Indian Standards), for use of structural steel in building construction. Basic standard widely used and accepted by engineers, technical institutions, professional bodies and the industry. In view of the fact that the Code specifies a number of grades of steel with different yield strengths, the design parameter, the geometrical properties and permissible stresses have been expressed to the extent possible in terms of the yield strength of the material. Specific values have also been given for commonly used steels.

IS 801 1975[20] is the Indian code of practice by BIS, for the use of cold-formed light gauge steel sections. It based mainly upon the 1956 edition of AISI's specification for cold formed steel members. Its formulation is based upon the allowable stress design (ASD). It gives brief limitations to be followed in the design of cold-formed steel section. The basic advantage of this code is its simplicity of use. It does not have complicated formulae with too many sub formulae. The limitations are separately mentioned for each type of design requirement.

SP 6(Part-5) [**21**] is the explanatory handbook for engineers to follow the codal requirements of IS-801, 1975. It gives the general understanding of the cold-formed steel, its broad application areas and its usage as structural members in building construction. It explains the basics of the effective width design approach, as adopted in IS 801 formulation. It gives useful tables and curves for effective width calculations and its variation with yield stress or basic design stress.

IS 811 1987 [**22**] is the Indian standard specification for cold-formed light gauge structural steel sections. It is similar to IS 808 for hot-rolled steel section tables or steel tables. It includes section property tables for equal angles, unequal angles, channel without lips-square, channel without lips-rectangular, channel with lips-square, channel with lips-rectangular, hat sections-square, hat sections-rectangular and lipped zed sections-equal flanges.

IS 875 (Part-1,2,3) [**23**] Part-1 gives dead loads unit weight of building materials and stored material.Part-2 gives imposed loads for building and structure.Part-3 gives wind loads for building and structure.

SP-40, Hand book on structural steel with portal frames [**24**] This handbook deals with typification of structures with steel portal frames (without cranes). Typification includes analysis and design of steel portal frames using prismatic hot rolled I-sections. The portal frame has been analyzed and designed for gravity and lateral loads (wind and earthquake forces) using the moment resisting portal frame action, with pinned and fixed support alternatives.

Chapter 3

Pre-Engineered Structure

3.1 Introduction

Pre-engineered building are steel building wherein the framing members and other components are fully fabricated in the factory after designing and brought to the site for assembly, mainly by nut-bolts, thereby resulting into a steel structure of high quality and precision. In conventional steel construction, we have site welding involved, which is not the case in P.E.B using nut-bolt mechanism. These structures use hot rolled tapered sections for primary framing and cold rolled sections (generally "Z "and "C "sections) for secondary framing as per the internal stress requirements, thus reducing wastage of steel and the self-weight of the structure and hence lighter foundations.

International codes are referred in their design as per the MBMA (Metal Building Manufacturers Association) standards which are more flexible allowing the use of built - up sections of minimum 3.5 mm thickness against 6 mm as minimum criteria in conventional steel sections .There is use of steel of high strength (345 MPa) which prominently speaks about greater strength with judicious use of steel as a result of tapered profile. The tapered section concept was first adopted in U.S.A keeping in

Figure 3.1: The Dynamic Tower of Dubai in 5 Different Revolving Stages with Time.

mind the bending moment diagram. At locations of high bending moment values, greater depth is used while less moment encouraged the use of lesser depths. Further unlike the conventional steel sections, where Moment of inertia (I) remains constant, it is not so in case of P.E.B due to varying depths .As per the formula, "I = bd3/12", d (depth) highly affects I value (to the exponential power of 3) and hence to decrease or increase the strength by mere change of depth is quite a logical approach in P.E.B industry and at the same time leading to economical structures.

3.2 Landmarks in P.E.B Technology

The Dynamic Tower of Dubai is the first building in motion to be constructed in the world and that too as a P.E.B .It is the tallest sky scraper in motion consisting of 80 floors (420 m high) with apartment areas ranging from 124 sq mt. to villas of 1200 sq. mt. with parking space inside the apartment.as shown in fig(3.1)

The developer of this project is Rotating Tower Dubai Development Limited of Dynamic Group and the creator of such a concept is Dr. David Fisher. Here each floor rotates independently at different speeds, introducing the fourth dimension - Time. The first 20 floors will be offices, floors 21 to 35 will be a luxury hotel, floors 36 to 70 will be residential apartments and the top 10 floors will be luxury villas. This pre engineered building will require 600 people in the assembly facility and 80 technicians on the construction site instead of 2,000 workers on a similar sized traditional construction site. Construction will be completed by 2010. Such a structure will offer the advantages of any modern industrial product. It saves energy, reduces construction time and dramatically cuts building costs. Each floor of the building can be completed in only seven days!!

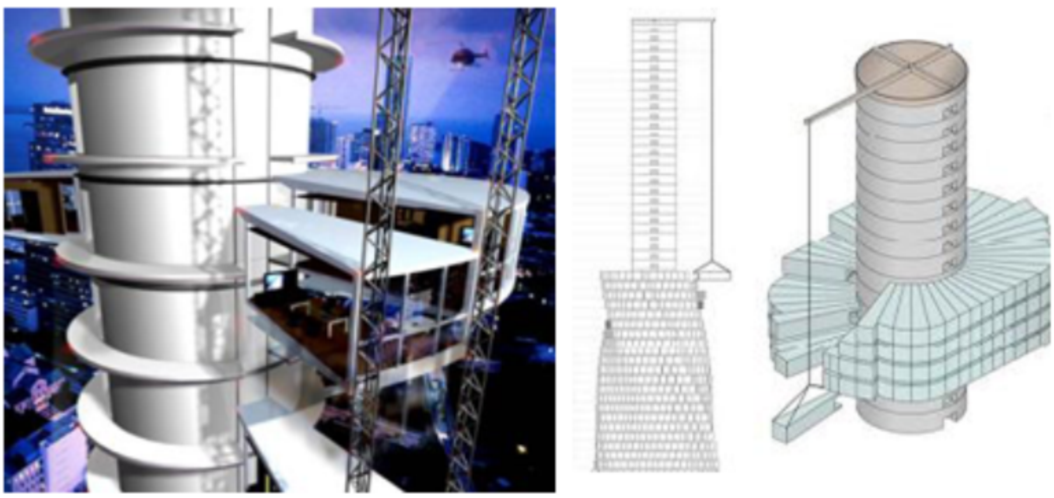


Figure 3.2: Hooked Pre-assembled Units and Construction Method of Dynamic Tower

Two of these 700 million dollar futuristic sky scrapers are planned so far, one each in Dubai and Moscow. Each individual unit will be completely finished at the factory and exported worldwide. It will be equipped with all necessary plumbing and electric systems including all finishing from flooring to ceilings, bathrooms, kitchens, cabinets, lighting and furniture. The preassembled units are simply hooked to each other mechanically, which results in environmentally clean construction sites, avoiding unloading of materials, waste, noise and pollution, there will be less risk of accidents to construction workers, and construction time will be reduced by over 30 percent as shown in fig(3.2). Due to this particular construction method, prefabricated buildings will also be easy to maintain and repair, the building's maintenance facility, type of materials used, and the quality control employed will also make them more durable than any traditional structure.as shown in fig3.2

The Indo Arya warehouse at Hassangarh is India's largest single floor warehouse designed by Tiger Steel Engineering India Pvt. Ltd It is India's largest Regional Distribution Centre (RDC) launched by Indo Arya, at Hassangarh, Haryana and spans over an area of 5,14,000 sq.ft. This PEB is huge enough to shelter 6 of the largest aero planes of the world or accommodate 4 football grounds or 2 Melbourne Cricket Club Grounds. It has a capacity of 85,000 tons of general goods at a time and is equivalent to 36 railway racks and 6 Titanic together! The structure uses galvalume sheets, dock levelers and huge rain shelter canopies. The huge structure was completed within a record time of 6 months (started in December 2006 and completed in May 2007). The maximum height of the structure is 46 ft. It also consists of 49 turbo ventilators and 146 louvers. The warehouse is environment friendly and energy efficient - there is rain water harvesting system to store 2.5 lacs liters of rain water, gravity ventilators that run without electricity and 4percent natural Sky lights to save energy.

3.3 Concept of Pre-engineered Structure

"A Pre-Engineered Steel building is a Shop Fabricated Site bolted Structure"

Engineering includes Designing, Detailing and Manufacturing of the building. The designing and detailing is carried out to ensure that there is no site welding required. The total structure consists of several components fabricated at shop in transportable sizes. These components are assembled and erected at site using structural fasteners. These buildings are called Pre-engineered due to the absence of fabrication activity and less work at site.

A pre-engineered metal building system consists of a series of integrated, often computer-designed, factory-fabricated components that are shipped to the jobsite ready for assembly and erection by a local builder or contractor.

They are quicker, easier and almost less expensive than conventional buildings. Pre-engineering Buildings have become very popular in recent years. They offer affordability and flexibility.

Pre-engineerd building use a combination of built-up sections, hot rolled sections and cold-formed elements, which provide the basic steel frame, framework of primary and secondary members (rigid frame, beams, purlins and girts and columns). They feature a structural steel on which cladding and roofing components are attached.

The complete building system is pre-engineering to facilitate easy production and assembly on site. Pre-engineered steel buildings are designed to suit very specific customer requirements. Upon finalizing the requirements, the primary and secondary structures are prepared in factory and assembled at site.

In conventional steel buildings, mill-produced hot rolled sections (beams and columns)

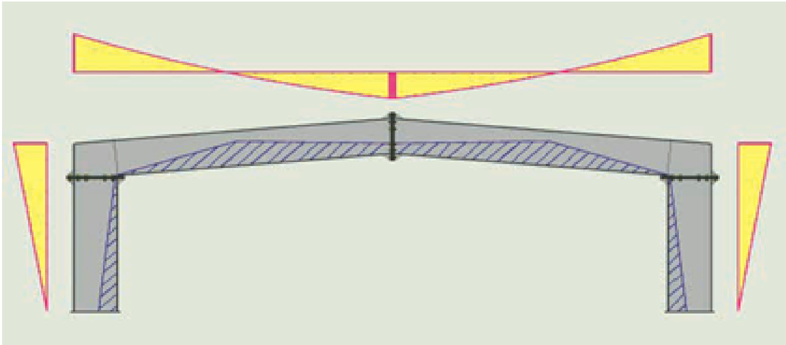


Figure 3.3: Conventional Steel Frame

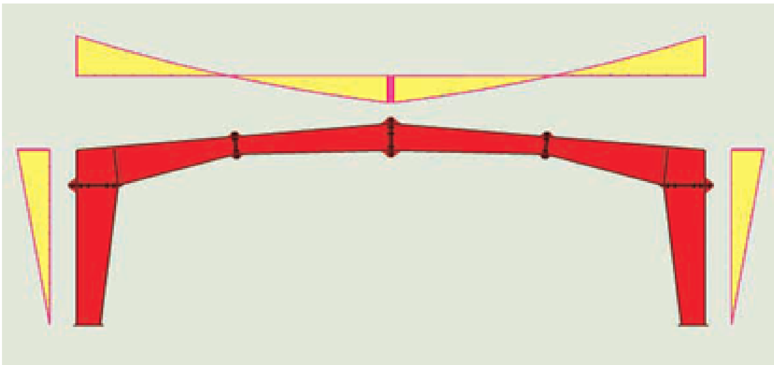


Figure 3.4: Pre-engineered Steel Frame

are used. The size of each member is selected on the basis of the maximum internal stress in the member. Since a hot rolled section has a constant depth, many parts of the member (represented by the hatched area), in areas of low internal stresses, and are in excess or under stressed of design requirements.as shown in fig(3.3))
The Logic behind Pre-engineered steel frame is that the geometry matches the shape of the internal stress (bending moment) diagram thus optimizing material usage and reducing the total weight of the structure as shown in fig(3.4))

3.4 Basic Parameters

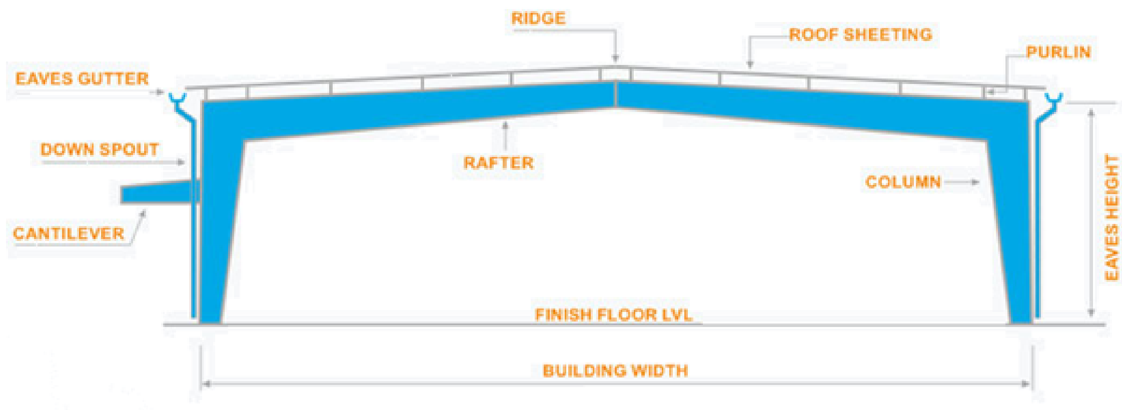


Figure 3.5: Typical Pre-Engineered Frame

Building Width

It is the distance from outside of eave strut of one side wall to outside of eave strut of the opposite side wall.

Building Length

It is the distance between the outside flanges of end wall columns in opposite end walls. The length covers various bay lengths.

End Bay Length

It is the distance from outside of the outer flange of end wall columns to center line of the first interior frame column.

Interior Bay Length

It is the distance between the center lines of two adjacent interior main frame columns. Most common bay spacing range from 6 m to 7.5 m.

Building Height

It is the distance from bottom of the main frame column base plate to the top outer point of the eave strut. When columns are recessed or elevated from finished floor, eave height is the distance from finished floor to top of eave strut.

Bay Spacing

Bay spacing is the distance between two adjacent main frame columns and 7-8 meters are economical.

Roof Slope

The angle of the roof with respect to the horizontal is termed as Roof Slope. The most common roof slope is 1/10. However, Building can be designed with any practical roof slope. Slopes between 1:5 to 1:15 are generally used.

3.5 Main Structural Parts in Pre-engineering System

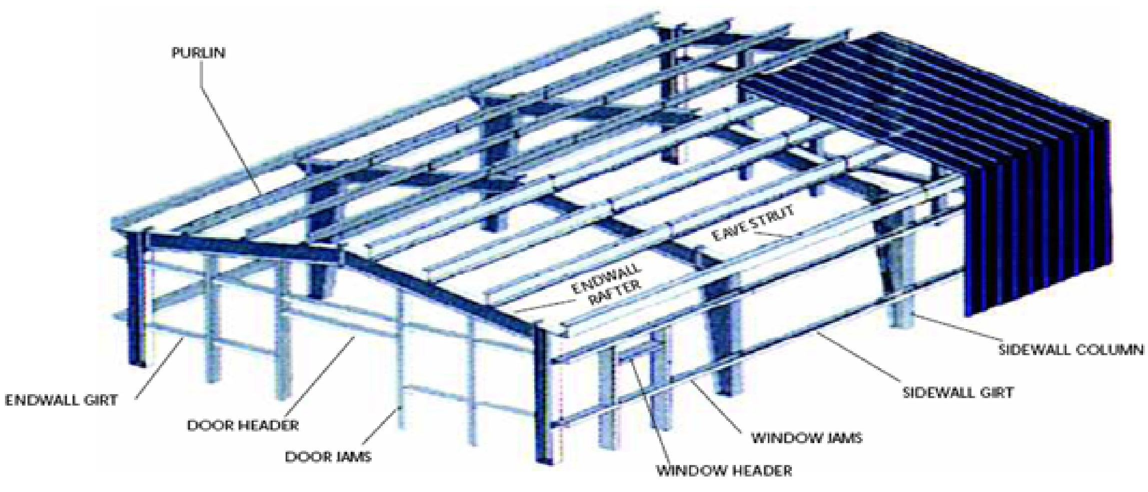


Figure 3.6: Prospective View of Industrial Shed

- Primary Built-up Members
- Secondary Members

3.5.1 Primary Built-up members

Main framing basically includes the rigid steel frames of the building. The P.E.B rigid frame comprises of tapered columns and tapered rafters (The fabricated tapered sections are referred as built-up members). The tapered sections are fabricated using the state of art technology wherein the flanges are welded to the web. Splice plates are welded to the ends of the tapered sections. The frame is erected by bolting the splice plates of connecting sections together. This structure is responsible for transfer of complete building load to the foundations. Primary framing System consists of:

End wall Frames Made of built-up welded hot rolled columns and rafters. The frames of columns and rafters are supported by connection bolts, anchor bolts and wind bracing.

Intermediate Frames Made up of built-up welded hot rolled columns and rafters. The frames of columns and rafters are supported by flange bracing, connection bolts and anchor bolts.

Wind Bracings They provide longitudinal stability to the building. This consists of high grade steel bracing provided in the roof and side walls in one or more bay depending on loading of the building and its length. If necessary, cross bracings can be effectively replaced by wind portal frames or by fixed base wind columns located adjacent and connected to the main frame columns. Main frames are typically constructed from tapered or uniform depth columns and rafters.

As shown in fig(3.7)) are the commonly used primary framing systems. All the primary frames shown herein are symmetrical about the ridge line. Frame asymmetrical about the ridge line, unequal width module and other non-standard frames are also possible.

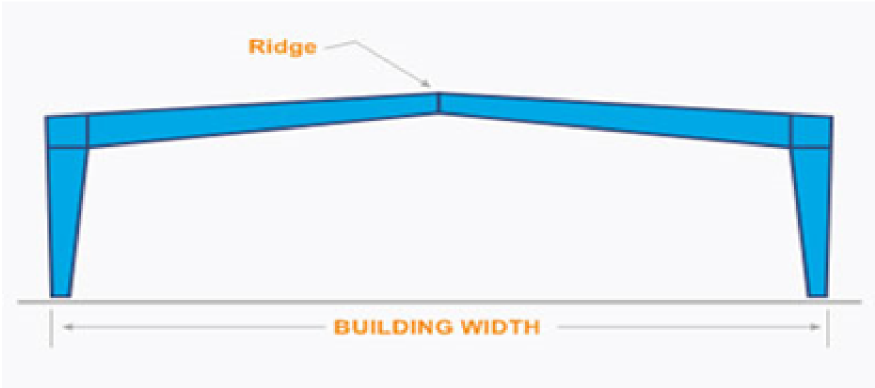


Figure 3.7: Taper Column Clear Span

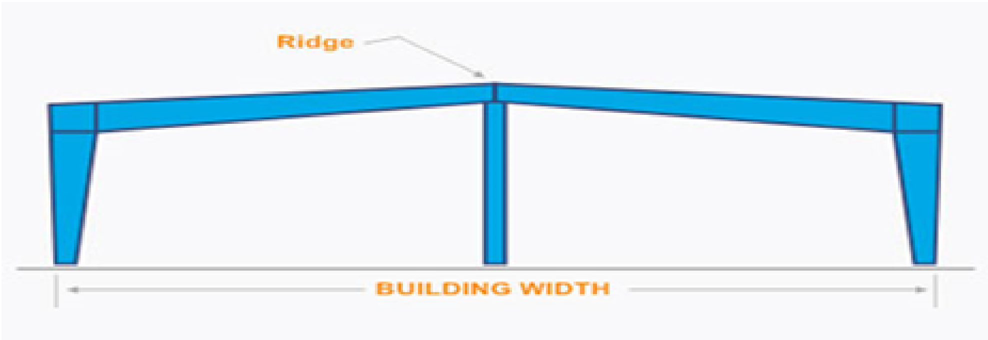


Figure 3.8: Taper Column Multi Span

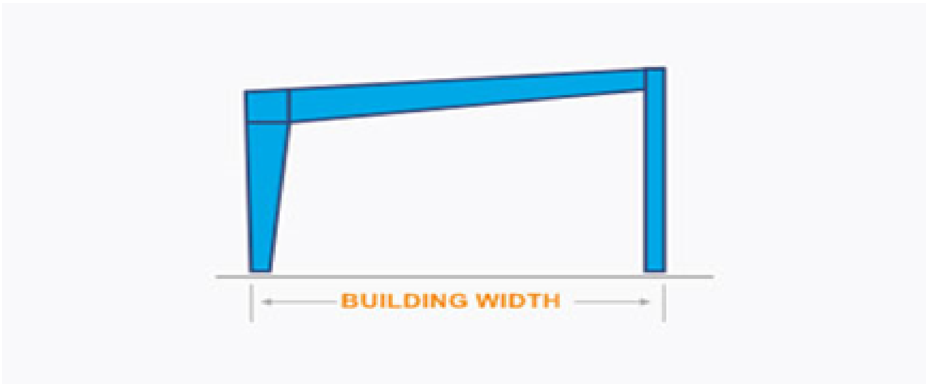


Figure 3.9: Single Slope Clear Span

Crane System

When a crane System is required in ware houses, column or rafter brackets and the crane runway beams that support the crane system are casted at the factories and supplied at the site. Three types of crane systems are frequently used.

- Top Running Crane
- Underhung Crane
- Monorail

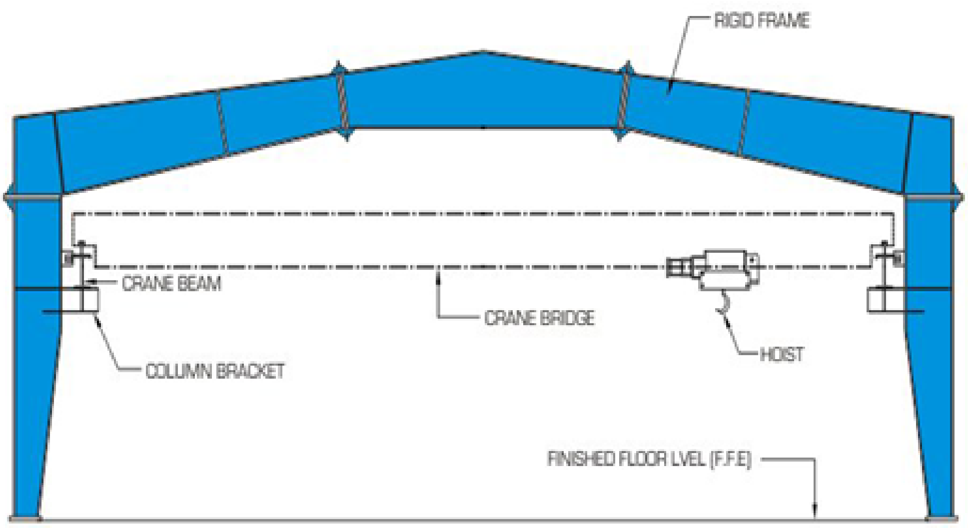


Figure 3.10: Top Running Crane

Mezzanine system

The standard Steel mezzanine framing system consists of a steel deck supported by joists framed onto main mezzanine beams.as shown in fig3.11 , 3.12If required by design loads, the main beams shall also be supported by intermediate columns. The top flange of the joists fits immediately below the top flange of the primary beams.

The economy of a mezzanine system is affected by the applied loads (dead, live and collateral) and mezzanine column spacing. Wherever possible, the primary mezzanine beams should run across the width of the building and be located under the main frame rafters. Joist should run parallel to the roof purlins along the length of the building.

Figure 3.11: Prospective View of Mezzaine System

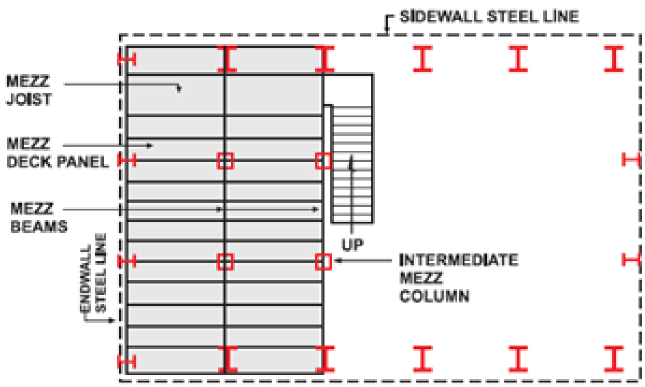


Figure 3.12: Plan of Mezzanine System

3.5.2 Secondary Framing Systems

The Secondary Framing System functions to support and bear the load of Roofing and Cladding and transfer its load to the Primary Framing. The Secondary Framing includes the Roof Purlins, Wall Girts, Clits and miscellaneous items.
Purlins, girts and eave struts are also known as secondary cold-formed members. There is no welding involved in their preparation. They are prepared by just bending the steel coil giving it the desired shape (Z-shape for purlins and girts, and C-shape for eave struts).

Roof Purlins

Purlins are beams which are provided over roof trusses to support the roof coverings. Channels, angle sections, and cold formed C- or Z sections are widely used as purlins.as shown in fig3.13 They are placed in an inclined position over the main rafters of the trusses. To avoid bending in the top chords of roof trusses, it is theoretically desirable to place purlins only at panel points. For larger trusses, however, it is more economical to space purlins at closer intervals. In India, where asbestos cement (AC) sheets are used, the maximum spacing of purlins is also restricted by the length of these sheets. AC sheets provide better insulation to sun's heat (compared to GI sheets), which can be further improved by painting them white on the top surface. The maximum permissible span for these sheets is 1.68 m. Spacing of purlins should be so fixed that the cutting of the sheet is avoided. Hence in practice when AC sheets are used, the Purlin spacing is kept between 1.35 to 1.40 m.

Purlins are the secondary members are for supporting the roof panels and wall cladding. These are cold formed Z profiles generally 200 mm to 300 mm deep made from 1.5 mm to 2.5 mm thick 245 MPa/345 MPa strength steel. Purlins are fixed to the top flange of the rafter with a clip bolted to the rafter and the purlin web bolted to the clip.

Figure 3.13: Different Types of Purlin Sections

Girt

These are beams subjected to unsymmetrical bending. These support vertical dead loads from the sheeting and horizontal wind loads. The main function of girts is to transfer wind loads from wall materials to the primary frame. Girts are positioned horizontally to span between the columns. When the space between primary columns is more than 9m, wind columns may be provided to reduce the girt span.

Sag Rod

Its round section rods and are fastened to the web of the purlins. The roof coverings in industrial buildings are not rigid and do not provide proper support.as shown in fig 3.14

Therefore, sag rods are provided between adjacent purlins to extend lateral support for the purlins in their weaker directions.

A sag rod is designed as a tension member to resist the tangential component of the resultant of the roof load and purlin dead load. The tangential component of the roof load is considered to be acting at the top flange of purlins, whereas the normal

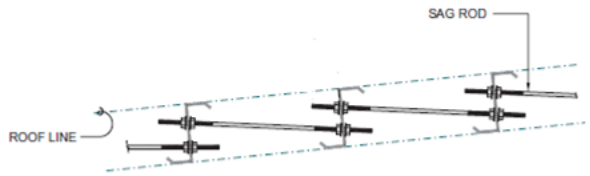


Figure 3.14: Typical Sag rod Connection to Purlin

component and purlins dead load is assumed to act at its centroid. Therefore, the sag rods should be theoretically placed at the point where the resultant of these forces act. But this is not practicable and sag rods are placed at the minimum gauge distance below the top.

3.6 Advantages

- Faster Occupancy
- More Economic than Conventional Structures
- Single Source Responsibility
- Lower Cost
- Flexibility in Expansion
- Large Clear Spans
- Quality Control
- Low Maintenance
- Energy Efficient Roof and Wall Systems
- Architectural Versatility

3.7 Application

- Manufacturing Units / Factories
- Warehousing Units
- Service Stations
- Restaurants
- Sports Complexes
- Shopping Malls
- Exhibition Halls
- Toll Plaza
- Auditoriums
- Aircraft Hangers
- Residential Premises
- Large Factories/Manufacturing Plants
- Gas Stations
- Vehicle Parking Sheds

3.8 Comparision of P.E.B with Conventional Steel Building

Table 3.1: Pre-engineered steel building V/s Conventional Steel building

Case	*Pre-engineered Steel Building*	*Conventional Steel Building*
Structure Weight	Pre-Engineered Buildings are on the average lighter through the efficient use of steel. Primary framing members are tapered (varying depth) built-up sections, with large depths in the areas of highest stress.	Primary steel members are selected from standard hot rolled "I" sections, which are, in many segments of the members, heavier than what is actually required by design. Members have constant cross-sections regardless of the varying magnitude of the local (internal) stresses along the member length.
	Secondary members are light gage (light weight) cold formed (low labour cost) "Z" or "C" shaped members.	Secondary members are selected from standard hot rolled "I" or "C" sections, which are heavier.
Design	Quick and efficient; since PEBs are mainly formed of standard sections and connections, design time is significantly reduced. Basic designs based on international design standards and codes are used over and over.	Each conventional steel structure is designed from scratch by the Consultant, with fewer design aids available to the Engineer.
	Specialized computer analysis and design programs optimize material required. Drafting is also computerized using standard details that minimize the use of project custom details.	Substantial engineering and detailing work is required on every project. Generalized computer analysis programs require extensive input/output and design alterations
	Design, shop detail sketches and erection drawings are supplied free of charge by the manufacturer	Extensive amount of consultant time is devoted to design and drafting, as well as co-ordination and review, often resulting in a significant expense.
	PEB engineers design and detail pre-engineered buildings almost every day throughout the year resulting in faster and more efficient designs.	As each project is a separate case, engineers need more time to develop the designs and details of the unique structure.
	Consultant's in-house design and drafting time is considerably reduced, allowing more time for co-ordination and review, and reduction in design fees.	More complicated design, requiring extensive design and drafting time from Consultants.

Table 3.2: Pre-engineered steel building V/s Conventional Steel building

Case	*Pre-engineered Steel Building*	*Conventional Steel Building*
Erection Simplicity	Since the connections of the components are standard, the learning curve of erection for each subsequent project is faster Periodic free-of-charge erection support at the site is usually provided by PEB manufacturers	The connections are normally complicated and differ from project to project, resulting in longer learning curves of erection for new projects
Erection Cost and Time	Both costs and time of erection are accurately known based upon extensive experience with similar buildings. PEBs are often erected by specialized PEB builders with extensive experience in the erection of similar buildings, offering very competitive rates. PEB builders usually have a stock of standard components; enabling them to complete jobs on time should any shortage or site damage occur to materials. The erection process is easy, fast, step by step and with hardly any requirement for equipment.	Typically, conventional steel buildings are more expensive than PEB. In most of the cases, the erection costs and time are not estimated accurately. Erection is slow and extensive field labour is required. Heavy equipment is often needed.
Seismic Resistance	The low-weight flexible frames offer higher resistance to seismic forces.	Rigid heavy weight structures do not perform well in seismic
Material Required	Material (Steel) per square meter may lower than conventional steel.	” Material (steel) per square meter required is more.
Architecture	Outstanding architectural design can be achieved at low cost using standard architectural features and interface details. Traditional wall and fascia materials, such as concrete, masonry and wood, can be utilized.	Special architectural design and features must be developed for each project, which often require research and thus resulting in much higher costs.
Sourcing and Co-ordination	Building is supplied complete with cladding and all accessories, including erection (if desired), from a single ”one stop” source	Many sources of supply are required. Project management time is required to co-ordinate suppliers and sub-contractors

Table 3.3: Pre-engineered steel building V/s Conventional Steel building

Case	*Pre-engineered Steel Building*	*Conventional Steel Building*
Cost of Change Orders	PEB manufacturers usually stock a large amount of basic raw materials that can be flexibly used in many types of PEB projects. Change orders are easily accommodated at all stages of the order fulfilment process. Little or no material is wasted even if a change order is made after fabrication starts.	Substitution of hot rolled sections that are infrequently rolled by mills is expensive and time consuming. Change orders that are made after hot rolled sections are shipped for fabrication, often result in redundancies to a lot of hot rolled sections, which ultimately result in more cost to the end user
Building Accessories	Designed to fit the system with standardized and interchangeable parts, including pre-designed flashing and trims. Building accessories are mass produced for economy and are available with the building. They have been tried in thousands of existing buildings.	Every project requires special design for accessories and special sourcing for each item Flashing and trims must be uniquely designed and fabricated.
Future Expansions	All project records are safely and orderly kept in electronic format indefinitely, making it easy for the owner or designer to obtain a copy of his building records at any time. Future expansion is simple, easy and cost effective.	It would be difficult to obtain project records, after a long period of time. It is required to contact more than one party, involved in the project, to obtain accurate information Future expansion would be more difficult and, more likely, costlier.
Performance	All components have been specified and designed specifically to act together as a system for maximum efficiency, precise fit, and peak Design and detailing errors are	Components are custom designed for a specific application on a specific job. Design and detailing errors are possible when assembling the diverse components into unique buildings
Foundations	Simple design, easy to construct and light weight.	Extensive, heavy foundations required

Chapter 4

Analysis of Industrial Structure

4.1 General

Frames are mainly subjected to dead load, live load and wind load.

4.1.1 Dead Loads

A load fixed in magnitude and in position is called a dead load.

The dead loads of the frame include the dead load roofing materials, purlins. The unit weight of roofing materials are prescribed by the I.S. 1911. The weight of purlins is known in advance as these are designed prior to the frames.

Determining the dead load of the structure requires the estimation of the weight of the structure together with its associated 'non-structure' components. The dead load of a steel structure is not known before it is design. Normally, an initial value is assumed or estimated based on experience.

The IS 800-2007 states that the self-weight computed on the basis of nominal dimensions and unit weights as given in IS 875 (Part I) may be taken to represent the characteristic dead load.

4.1.2 Live Loads

I.S. 875 specifies the following live loads to be assumed in the analysis of an Industrial Building.

Imposed loads are gravity loads other than dead loads and cover factors such as occupancy by people, movable equipment and furniture within buildings, stored materials such as books, machinery, and snow. Hence, they are different for different types of buildings residential, offices, warehouses, etc.

Imposed loads may be subdivided into two groups:

- Those which are applied gradually, in which case the static equivalent can be used
- Those which are dynamically (for example, repeated loads and impact loads).

~

Imposed loads are specified in the codes based on observation and measurements are generally expressed as static loads for convenience. As per the Indian code [IS 875 (Part 2-Live loads), imposed loads are classified into the following groups:

- Residential (dwelling. hotels. hostels, boarding and lodging houses, clubs, etc.)
- Educational (classrooms, libraries. etc.)
- Institutional (office rooms, bedrooms, kitchens, general storage, etc.)
- Assembly halls (with and without fixed seating, etc.)
- Office and business buildings (rooms with and without separate storage, computer rooms, filing/store rooms, strong rooms, dining rooms, etc.)
- Mercantile buildings (shops)

- Industrial (with light- /medium- /heavy-duty machinery/equipment)
- Storage buildings (warehouses, cold storages)

Though live loads occur at random on any floor, they are often assumed to be uniformly distributed on the floor/roof area. The complete guidelines are given in IS 875 (Part 2). These live loads are assumed to be present on the floors and have to be transmitted to the foundation through beams (cross-beams) and columns.

Live Load on Purlin = [750-20X (θ -10)] N/m2
Live Load on Purlin on Roof = (2/3) X Live Load on Purlin (IS-875, P-2,CL-4.5.1)

4.1.3 Wind Load

The most critical load on an industrial building is the wind load. However for the roofs and walls of an industrial building, consideration must be made for the pressure difference between the opposite faces of such elements to account for external and internal air pressures exerted by the wind blowing against the building. The internal air pressures may be positive or negative depending upon the direction of flow of air with respect to the openings in building. When the negative air pressure is less than the atmospheric pressure it is known as "Suction".

Table 4.1: CPi for Roofs and Walls of an Industrial Building

Permeability	*Openings in relation to wall area %*	*Internal air pressure coefficient(Cpi)*
Zero	0	±0
Normal	5	±0.2
Medium	5-20	±0.5
Large	20	±0.7

The openings in relation to the wall area define the permeability of the building.As shown in table4.1 gives the degree of permeability and corresponding internal air pressure coefficients. For the external air pressure coefficient and coefficients for local effects are given in the I.S. 875(Pqrt-3)-1987.

The wind force F is obtained by

- F= (Cpe±Cpi) X A XPd

Where, Cpe=external pressure coefficient

CPi=internal pressure coefficient

A=surface area of the element under consideration

- Vz=k1Xk2Xk3XVb

Where, Vz=design wind speed

k1=risk factor

k2=terrain, height and structure size factor

k3=topography factor

Vb=basic wind speed in N/m2

- Pd=0.6XVz^2

Pd=design wind pressure

Where, Vz=design wind speed in m/s

All the coefficients are given in the IS 875(part-3):1987

Analysis of ware house is conducted by two methods.

- Conventional Portal Method
- P.E.B Method

4.2 Conventional Portal Method

4.2.1 General

In this method Structure sections used are hot rolled sections. They are uniform through the span. Analysis is carried out by STAAD Pro.2006.Pefomance of Conventional Portal is observed through STAAD analysis. Purlin used in ware house is hot rolled ISMC section.

4.2.2 Configuration of Building

- Width of Structure = 25 m
- Length of Structure = 90m
- Truss Spacing = 7.5 m c/c
- Eave Height = 6 m
- Rise of truss = 3.35 m
- Length of Principle Rafter = 12.94 m
- Angle of truss = 15^o
- Purlin Spacing = 1.44m
- Location = Mudra Port.

4.2.3 Loading

Analysis is carried out in STAAD Pro 2006.

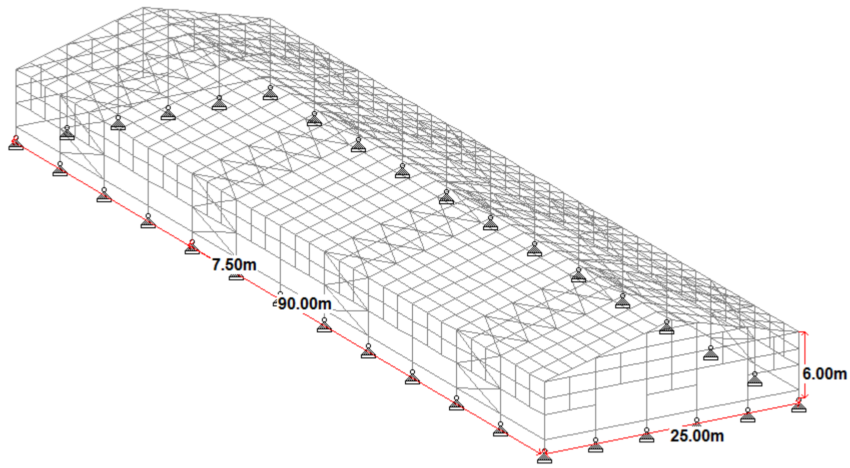


Figure 4.1: Prospective View of Ware house

Dead Load

Loads like Purlin Weight, Sheet Weight and Weight of Rafter are likely to apply on Roof.

But here in STAAD, Modeling only weight of Sheet is applied.

So Weight of other elements like Rafter, Purlin are considered by applying command of Self Weight = 1

Weight of G.I Sheet = 7 kG/smt (IS-875.P-1)

Total Load Acting on Portal = ((12.94X2) +0.15+0.15) X 7.5 X 0.07 = 13.75 kN

Load Acting on Intermediate Point of Rafter = 13.75/18 = 0.76 kN

Load Acting on End Panel Point = 0.76/2 = 0.38 kN

As per the hypothetical data 230 mm thick Brick wall is assumed up to 3 m from base to cladding runner.

Load of wall on plinth beam = 20X0.230X3 = 13.8 kN/m

Live Load

Roof Angle = 15

Live Load Acting on Purlin = 750-20(θ-10) (IS-875 Part-2, T-2)

Where θ = Roof Angle = 15

Live Load on Purlin = 750-20(15-10) = 650 N/smt

Live Load on Rafter = (2/3) of Live Load on Purlin (IS-875 Part-2, CL.4.5.1)

= (2/3) X 650 = 433 N/smt

Live Load on Portal = 0.433 X 25 X 7.5 = 81.19 kN

Load Acting on Intermediate Point of Rafter = 81.19/18 = 4.51 kN

Load Acting on End Panel Point = 4.51/2 = 2.25 kN

Applied as Point Load on Node Point through STAAD

Wind Load

Location of Site = Mudra Port

Basic Wind speed = 50 m/sec

K1= Risk Co-efficient = for all general building = 1.0

K2= Terrain height and structure size, Category-2, Class-B = 0.98

K3 = Topography Factor = 1.0

Vz = VbXK1XK2XK3 = 50x1X0.98x1 = 49 m/sec

Pz = 0.6XVz^2 = 0.6X49^2 = 1440.6 N/smt

Assume wall opening is less than 5 percent

Cpi = $\pm$0.2 (IS-875, Part-3, Cl.6.2.3.1, Pg-27)

Design Pressure on Wall

Length of building A, B = 90 m

Width of Building C, D = 25 m

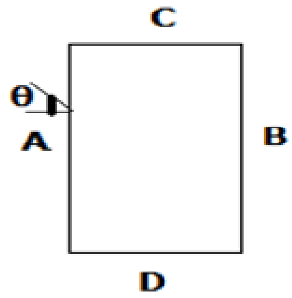


Figure 4.2: Plan of Building

θ= wind angle

Length of Structure, l = 90 m

Width of Structure, w = 25 m

Height of structure, h = 6 m

h/w = 6/25 = 0.24 < 0.5

l/w = 90/25 = 3.6, 1.5 < 3.6 < 4

Table 4.2: Co.eff of Wind on cladding based on IS-875 (P-3) (T-4)

Wind Angle	*A*	*B*	*C*	*D*
0^o	+0.7	-0.25	-0.6	-0.6
90^o	-0.5	-0.5	+0.7	-0.1

Table 4.3: Pressure co-eff. of Wind on Cladding

Wind Angle	*A*	*B*	*C*	*D*
(Cpe+Cpi)				
0^o	+0.9	-0.05	-0.4	-0.4
90^o	-0.3	-0.3	+0.9	+0.1
(Cpe-Cpi)				
0^o	-0.5	-0.45	-0.8	-0.8
90^o	-0.7	-0.7	+0.5	-0.3

Design Pressure on Roof

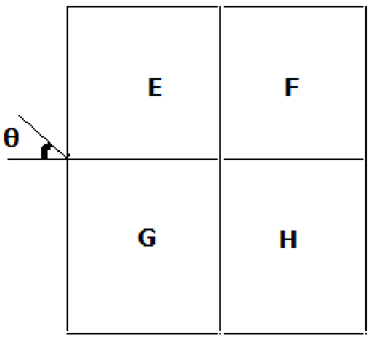


Figure 4.3: Key Plan of Building

θ = wind angle

h/w = 6/25 = 0.24

l/w = 90/25 = 3.6

Table 4.4: Co.eff of Wind on Roof based on IS-875 (P-3) (T-5)

Wind Angle	*E*	*F*	*G*	*H*
0^o	-0.8	-0.8	-0.4	-0.4
90^o	-0.75	-0.6	-0.75	-0.6

Table 4.5: Pressure co-eff. of Wind on Roof

Wind Angle	*E*	*F*	*G*	*H*
(Cpe+Cpi)				
0^o	-0.6	-0.6	-0.2	-0.2
90^o	-0.55	-0.4	-0.55	-0.4
(Cpe-Cpi)				
0^o	-1.0	-1.0	-0.6	-0.6
90^o	-0.95	-0.8	-0.95	-0.8

Based on this co. efficient load is applied on Ware house through STAAD model.

F = (Cpe±Cpi) X A X pd , (IS-875, Part-3, Cl-6.2.1, Pg-13)
Load Combinations as per IS-875, Part-5

- D.L+L.L
- D.L+W.L
- D.L+L.L+W.L

Yield Strength of Steel =250 Mpa is taken.

4.3 Pre-Engineered Building Method

4.3.1 General

A Pre-Engineered metal building system consists of a series of integrated, often computer-designed, factory-fabricated components that are shipped to the jobsite ready for assembly and erection by a local contractor.
Primary components, such as columns, beams, and girders, are typically fabricated from plates, are shop welded, and are optimized for the specified loading conditions. The frames are responsible for transferring the loads from the purlins and girt to the foundations safely.
The framework is done by resting a rafter on the two columns.
The supports are hinged at the bottom of the column.

4.3.2 Configuration of P.E.B Ware house

Configuration of warehouse remains same. Based on bending moment diagrammed section gets taper.
P.E.B structure has higher permissible stress. Consider yield strength of steel = 540 Mpa

4.4 Analysis Result of Both Ware house

Through Analysis, result obtained are detailed below.

Reaction at Base

Base is assumed as Hinge Support. Base reaction of mark circle is taking is consideration.

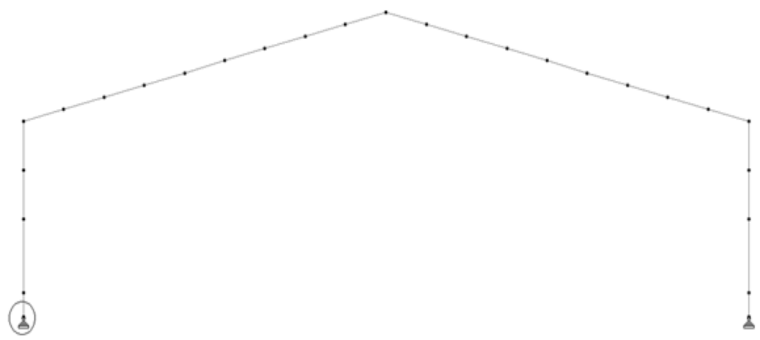


Figure 4.4: Typical Section of Portal for obtaining reaction at base

Table 4.6: Comparision of Vertical Reaction at Base

	Conventional		Pre-engineered	
Load Cases	Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)
Dead Load	17.2	177.6	12.8	252.8
Live Load	19.4	38.7	22.4	41.3
Wind X (Cpe+Cpi)	-64.9	-69.1	-70.5	-80.1
Wind X (Cpe-Cpi)	-24.1	-114.1	-36.7	-133.1
Wind Z (Cpe+Cpi)	-23.5	-76.3	-25.0	-63.2
Wind Z (Cpe-Cpi)	-33.4	-129.8	-40.6	-125.9

Column Forces at Junction

Under the Mark Circle of Beam Column junction forces are obtained.

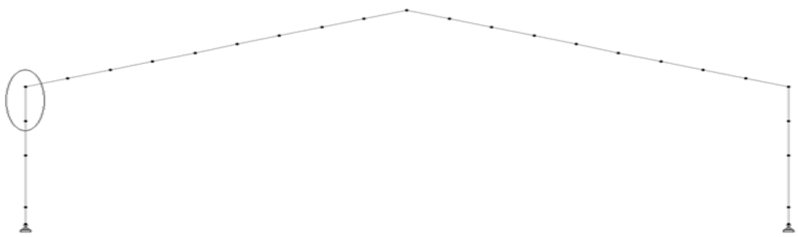


Figure 4.5: Typical Portal Section for obtaining forces in column

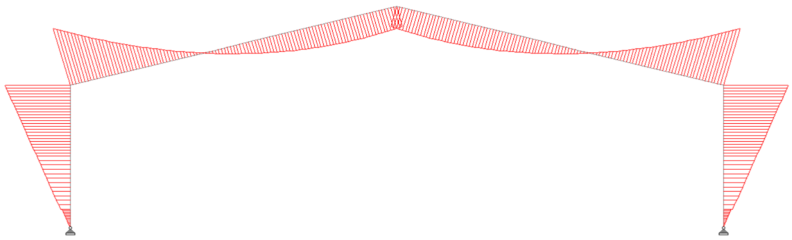


Figure 4.6: Bending Moment Diagram for D.L

Table 4.7: Comparison of Column Forces at Junction

	Conventional			Pre-engineered		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	35.8	-17.6	74.0	23.1	-14.6	46.0
Live Load	38.0	-19.9	84.0	40.4	-26.9	86.4
Wind X (Cpe+Cpi)	-66.2	22.0	-183.5	-69.8	34.5	-178.1
Wind X (Cpe-Cpi)	-109.2	47.3	-158.8	-115.2	59.2	-191.7
Wind Z (Cpe+Cpi)	-74.1	40.1	-136.7	-78.2	51.6	-142.4
Wind Z (Cpe-Cpi)	-125.0	69.4	-220.6	-131.5	87.9	-232.6

Beam Forces at junction

Forces are obtained at beam column junction under mark circle.

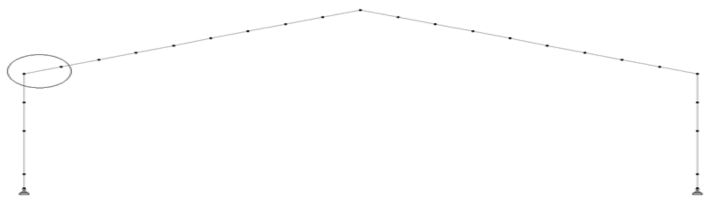


Figure 4.7: Typical Portal Section for obtaining forces in Rafter

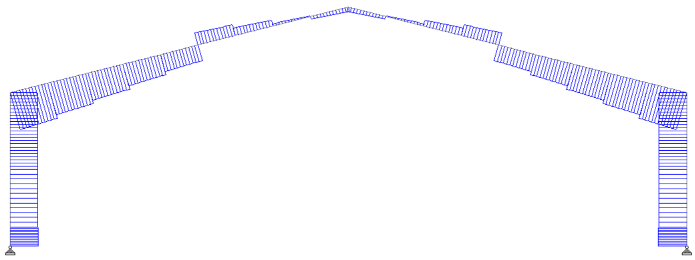


Figure 4.8: Shear Force Diagramme for D.L

Table 4.8: Comparison of Forces in Rafter at Junction

	Conventional			Pre-engineered		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load (kN.m)	24.2	-25.1	63.5	19.0	-15.5	45.0
Live Load (kN.m)	27.5	-29.1	72.1	35.2	-29.7	83.9
Wind X (Cpe+Cpi) (kN.m)	-22.8	56.9	-123.6	-36.3	57.5	-136.2
Wind X (Cpe-Cpi) (kN.m)	-79.5	83.1	-116.3	-94.2	86.6	-162.2
Wind Z (Cpe+Cpi) (kN.m)	-58.5	53.3	-123.9	-71.5	54.2	-145.5
Wind Z (Cpe-Cpi) (kN.m)	-105.2	89.8	-204.1	-126.1	91.6	-241.1

Comparison of Beam forces at Midspan of Rafter

Forces are obtained under mark circle for rafter.

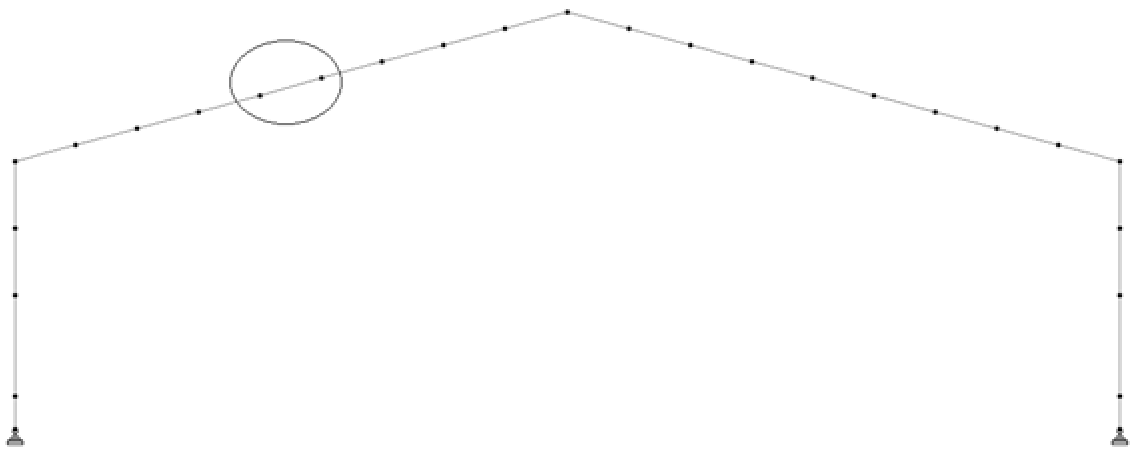


Figure 4.9: Typical Section of Portal for obtained forces at middle of rafter

Table 4.9: Comparison of Forces at Midspan of Rafter

	Conventional			Pre-engineered		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load (kN.m)	17.3	-10.4	-31.1	15.5	-6.4	-13.1
Live Load (kN.m)	18.6	-12.7	-35.2	28.0	-12.6	-25.1
Wind X (Cpe+Cpi) (kN.m)	-16.7	21.5	74.5	-32.3	20.8	62.1
Wind X (Cpe-Cpi) (kN.m)	-71.2	24.8	148.9	-92.1	25.9	116.4
Wind Z (Cpe+Cpi) (kN.m)	-44.9	20.7	64.0	-61.5	20.6	44.9
Wind Z (Cpe-Cpi) (kN.m)	-87.5	33.7	108.0	-114.2	33.5	75.9

Deflection at Ridge

Under the mark circle Displacement of portal is obtained.

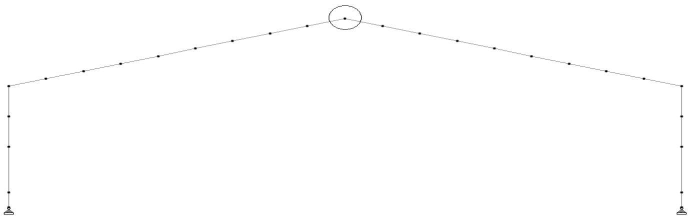


Figure 4.10: Typical Section of Portal for obtained deflection at ridge

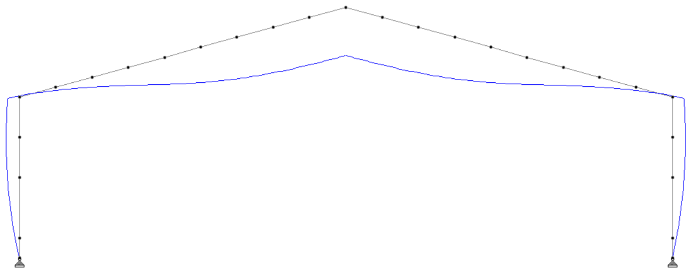


Figure 4.11: Deflection of Portal

Table 4.10: Comparision of Displacement at Ridge of Rafter

	Conventional	Pre-engineered
Load Cases	Vertical (mm)	Vertical (mm)
Dead Load	-27.7	-12.3
Live Load	-31.5	-22.8
Wind X (Cpe+Cpi)	46.3	33.5
Wind X (Cpe-Cpi)	69.8	50.8
Wind Z (Cpe+Cpi)	51.8	37.1
Wind Z (Cpe-Cpi)	83.9	60.5

Deflection at Midpoint of Rafter

Under the mark circle displacement of rafter is obtained.

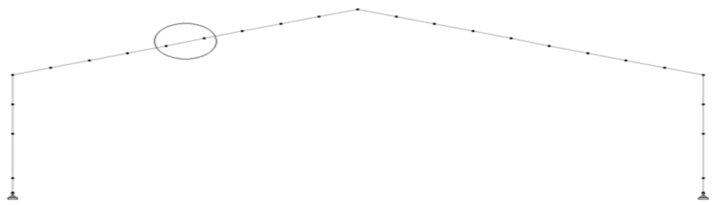


Figure 4.12: Typical Section of Portal for obtained deflection at Midspan of rafter

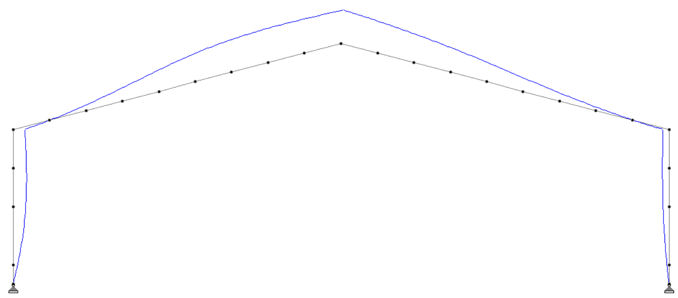
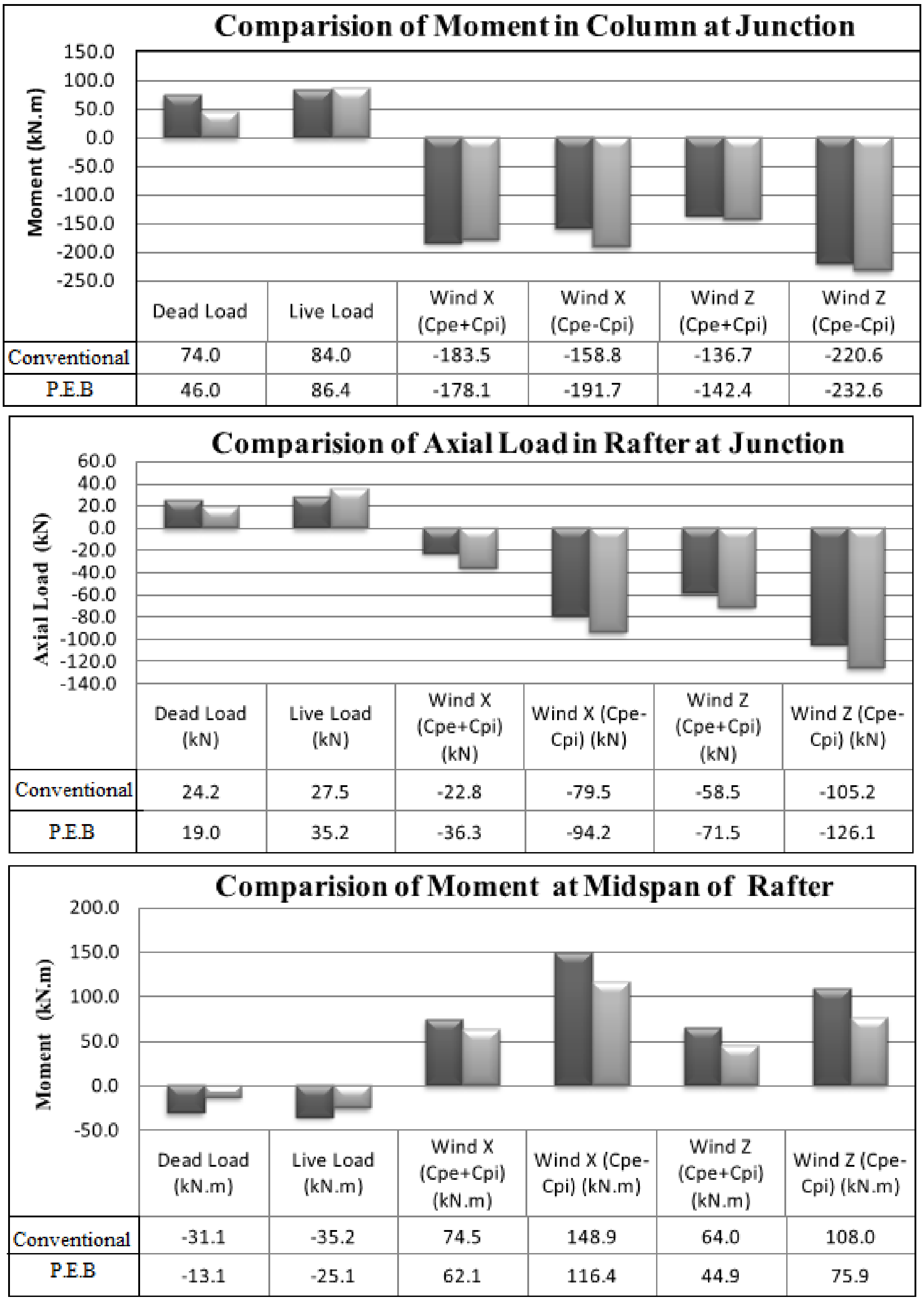


Figure 4.13: Deflection of Portal for Wind Load

Table 4.11: Comparison of Displacement at Midspan of Rafter

	Conventional	Pre-engineered
Load Cases	Vertical (mm)	Vertical (mm)
Dead Load	-19.4	-9.1
Live Load	-22.0	-16.7
Wind X (Cpe+Cpi)	35.5	31.2
Wind X (Cpe-Cpi)	61.7	55.0
Wind Z (Cpe+Cpi)	36.9	27.9
Wind Z (Cpe-Cpi)	60.2	46.0

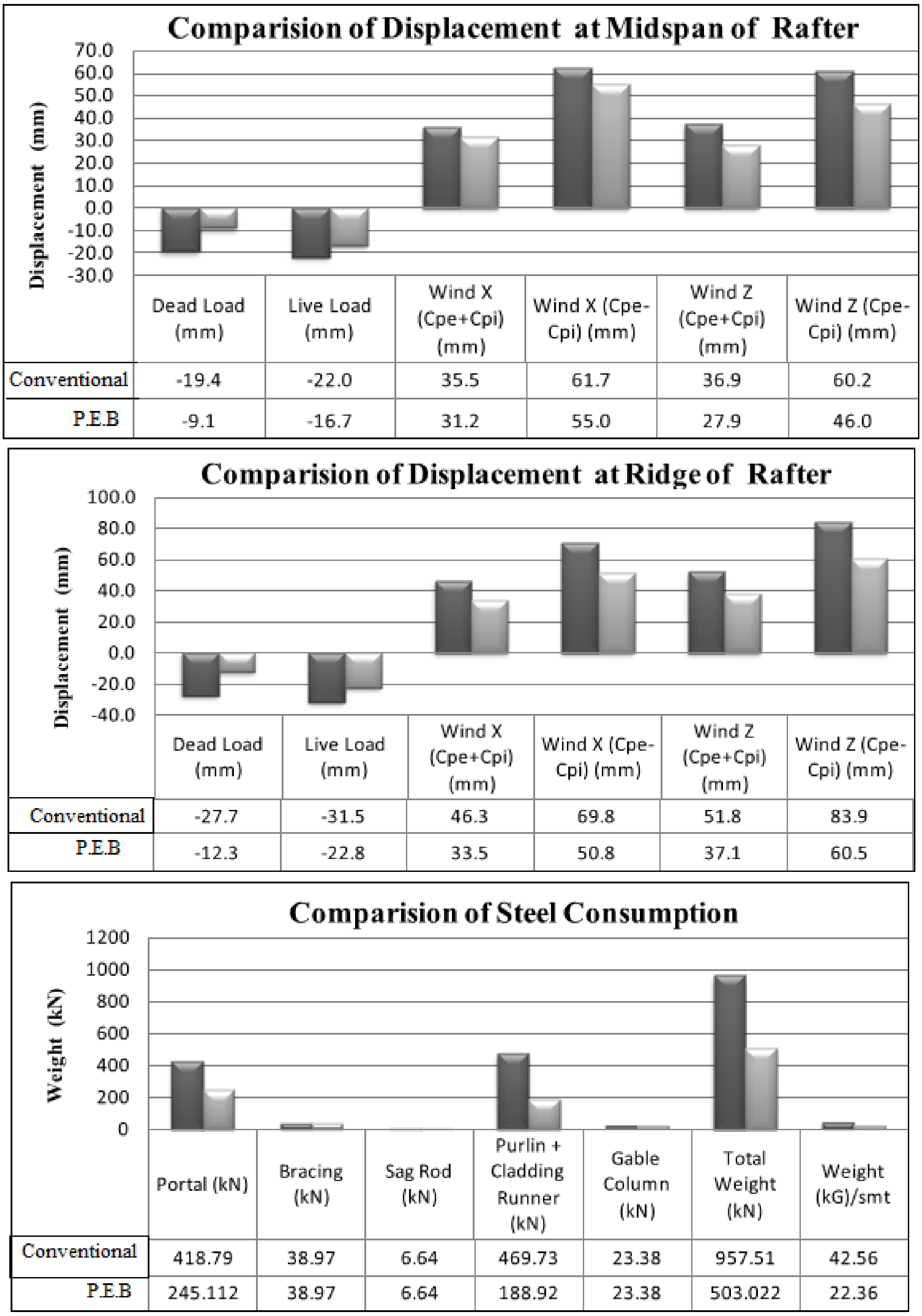


	Dead Load	Live Load	Wind X (Cpe+Cpi)	Wind X (Cpe-Cpi)	Wind Z (Cpe+Cpi)	Wind Z (Cpe-Cpi)
Conventional	74.0	84.0	-183.5	-158.8	-136.7	-220.6
P.E.B	46.0	86.4	-178.1	-191.7	-142.4	-232.6

	Dead Load (kN)	Live Load (kN)	Wind X (Cpe+Cpi) (kN)	Wind X (Cpe-Cpi) (kN)	Wind Z (Cpe+Cpi) (kN)	Wind Z (Cpe-Cpi) (kN)
Conventional	24.2	27.5	-22.8	-79.5	-58.5	-105.2
P.E.B	19.0	35.2	-36.3	-94.2	-71.5	-126.1

	Dead Load (kN.m)	Live Load (kN.m)	Wind X (Cpe+Cpi) (kN.m)	Wind X (Cpe-Cpi) (kN.m)	Wind Z (Cpe+Cpi) (kN.m)	Wind Z (Cpe-Cpi) (kN.m)
Conventional	-31.1	-35.2	74.5	148.9	64.0	108.0
P.E.B	-13.1	-25.1	62.1	116.4	44.9	75.9

Figure 4.14: Comparison of Column Moment at Junction, Axial Force in Rafter at Junction, Moment at Midspan of Rafter



	Dead Load (mm)	Live Load (mm)	Wind X (Cpe+Cpi) (mm)	Wind X (Cpe-Cpi) (mm)	Wind Z (Cpe+Cpi) (mm)	Wind Z (Cpe-Cpi) (mm)
Conventional	-19.4	-22.0	35.5	61.7	36.9	60.2
P.E.B	-9.1	-16.7	31.2	55.0	27.9	46.0

	Dead Load (mm)	Live Load (mm)	Wind X (Cpe+Cpi) (mm)	Wind X (Cpe-Cpi) (mm)	Wind Z (Cpe+Cpi) (mm)	Wind Z (Cpe-Cpi) (mm)
Conventional	-27.7	-31.5	46.3	69.8	51.8	83.9
P.E.B	-12.3	-22.8	33.5	50.8	37.1	60.5

	Portal (kN)	Bracing (kN)	Sag Rod (kN)	Purlin + Cladding Runner (kN)	Gable Column (kN)	Total Weight (kN)	Weight (kG)/smt
Conventional	418.79	38.97	6.64	469.73	23.38	957.51	42.56
P.E.B	245.112	38.97	6.64	188.92	23.38	503.022	22.36

Figure 4.15: Comparison of Displacement at Midspan of Rafter, Displacement at Ridge and Consumption of Steel in Ware house

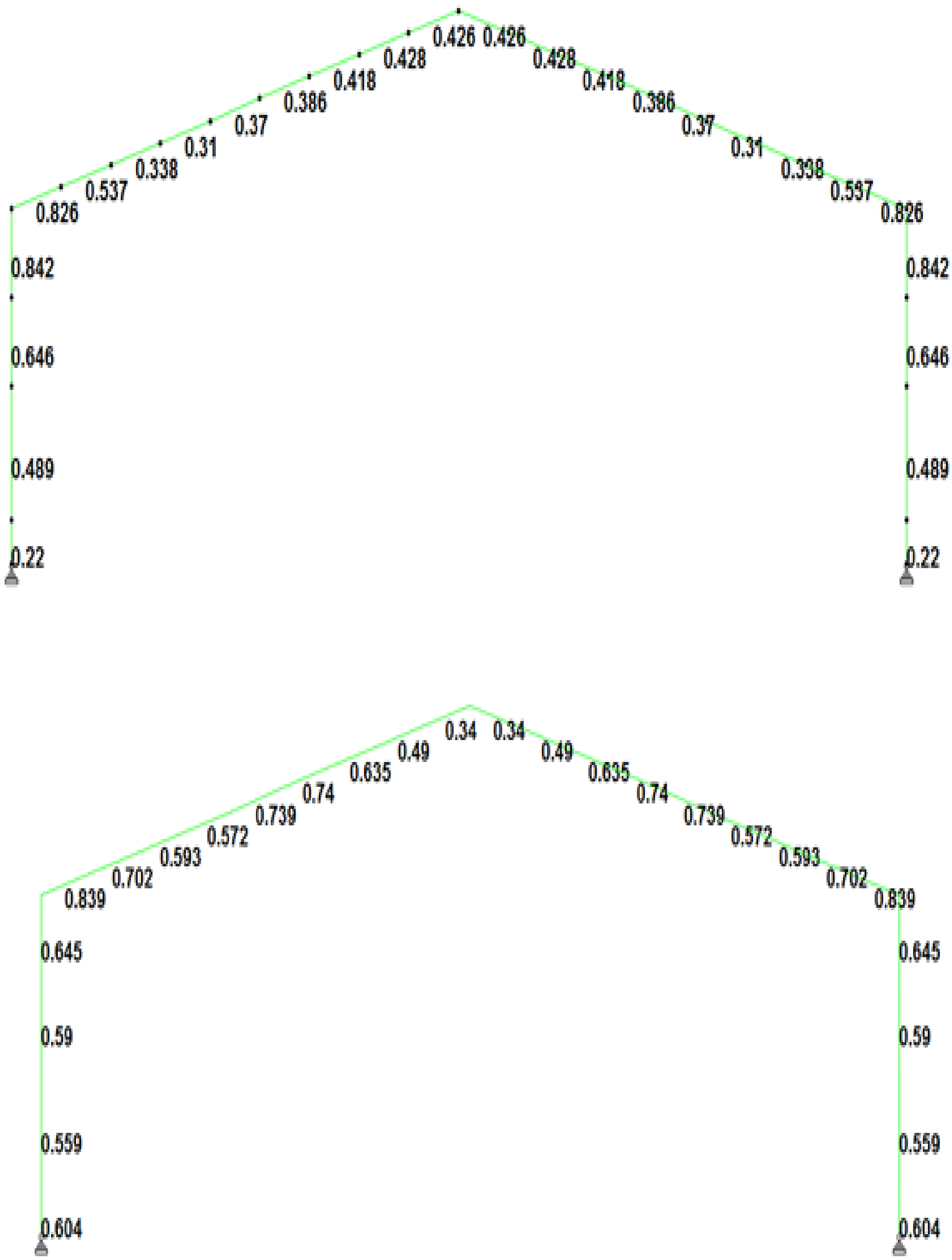


Figure 4.16: Bending Stress Value of Conventional Portal and P.E.B Portal

4.5 Section Property of Conventional Ware house

Section Property obtained through STAAD.

a) Column:- ISMB-500 is used.

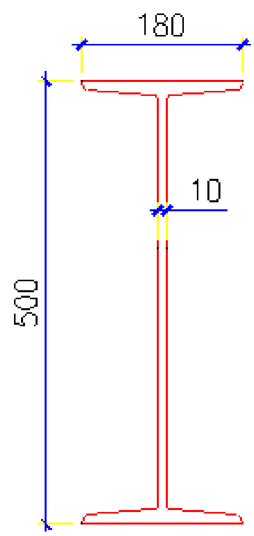


Figure 4.17: Column Section

b) Rafter: - ISMB-500 is used.

c) Purlin: - After analysis and design the section obtained is ISMC-200.

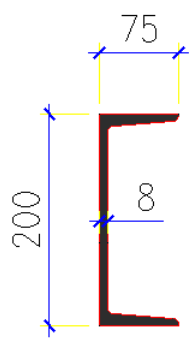


Figure 4.18: Purlin Section

d) Sag Rod: - 12 mm Dia. of Sag rod is provided to break the effective length of Purlin in Minor Axes.

e) Gable Column:-

Spacing of Gable Column is at 5 m c/c

Height of Gable Column is 8.7 m

Provided Gable Column is ISMB-250 at gable end.

f) Bracing: - Along the Wind in X direction Bracing is Provided.

Based on analysis pipe section of external diameter of 75 mm and Internal diameter of 70 mm is provided. Pipe is 2.5 mm thick.

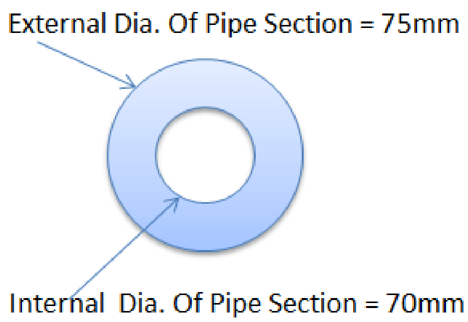


Figure 4.19: Pipe Section for Bracing

g) Cladding Runner Parallel to Purlin:-ISMC-200 Section is provided.

h) Cladding Runner at Gable End:-ISMC-125 Section is provided.

i) Plinth Beam:-R.C.C Beam having Section of 300X600 mm is provided at Plinth Level.

4.6 Section Property of P.E.B Ware house

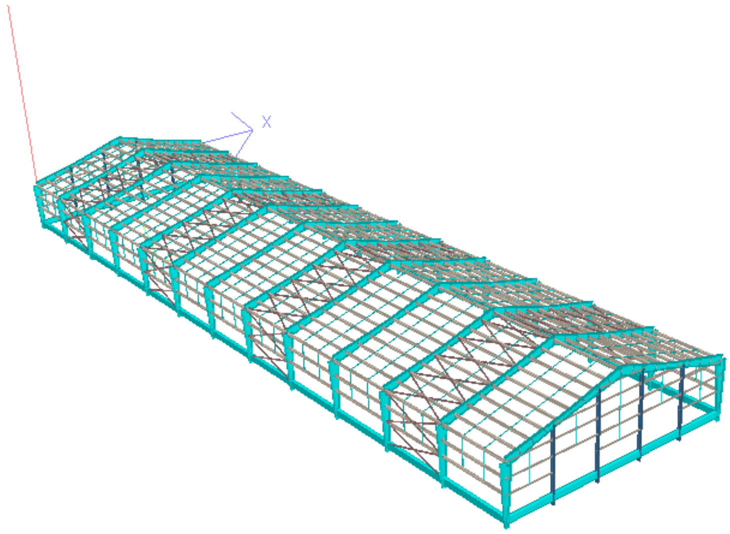


Figure 4.20: P.E.B Ware house

Section Property obtained through STAAD.

a) column Section

Depth of taper section gets vary based on bending moment diagram of Portal.

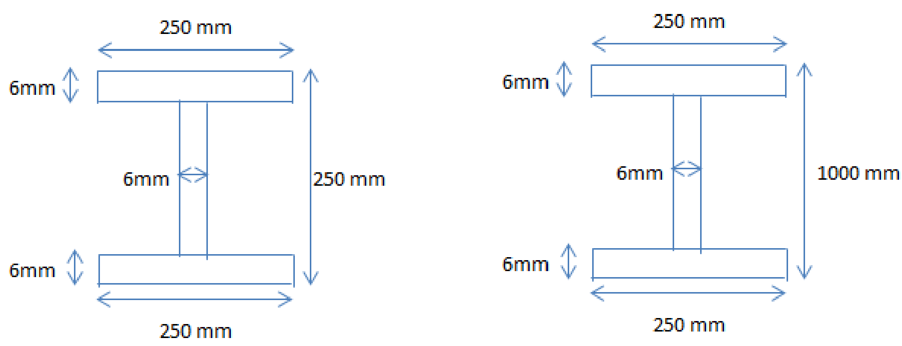


Figure 4.21: Section Property of Column at Base Level and at Top Level

b) Rafter Section

At Mid span the Value of Bending Diagramme is less so based on that section is reduced at midspan. Value of bending moment is maximum at support (Junction) so depth of Web is maximum at junction.

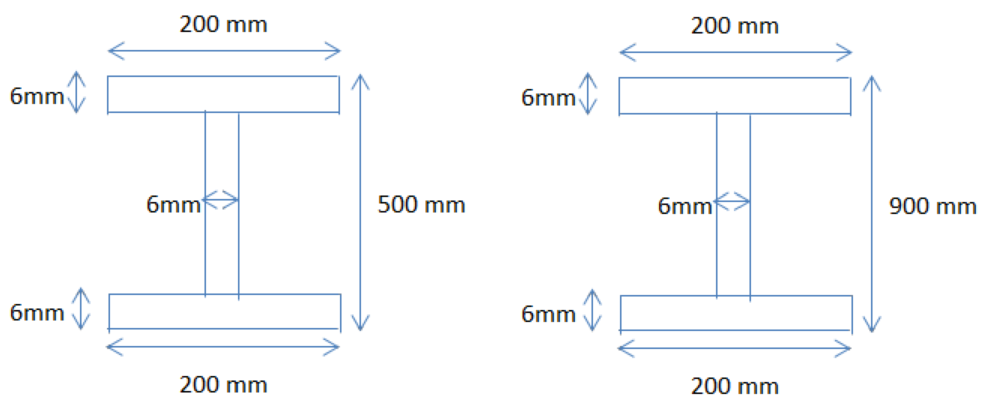


Figure 4.22: Section Property of Column at Midspan and at Junction

c) Purlin:-

After analysis and design the section obtained is Z purlin of 230X75X20X3.15

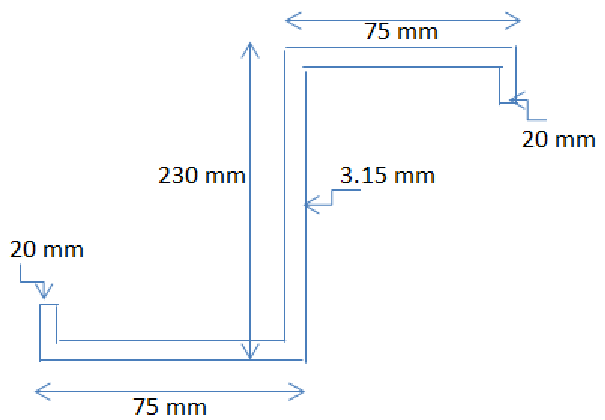


Figure 4.23: Section Property of Cold formed Purlin

f) Cladding Runner Provided Parallel to Purlin is Z-230X75X20X3.15

g) Cladding Runner at Provided at Gable End is Z-180X60X20X3.15

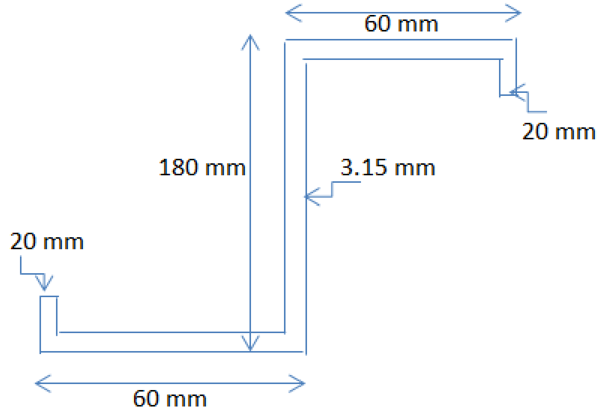


Figure 4.24: Section Property of Cladding Runner

Remaining Properties like Bracings, Gable Column, Sag Rod, and Plinth Beam is remains same as in Conventional Ware house.

4.7 Discussion

Conventional steel portal is compared with P.E.B Portal keeping same configuration of ware house. For designing ware house IS-800 Codal provision is used. STAAD Pro.2006 is used to modeling, analysing and design ware house for both cases. Base is assumed as hinge in both cases. Hypothetical data is assumed such a way that all the parameters in both ware houses remain same only section property gets changed. So that analysis result changes in both cases.

After analysing it observes that base reaction increase from Conventional to Pre-engineered Structure. For wind load suction is taking place while in gravity load compression takes place. Reaction is increased by 42% in Pre-engineered Structure compare to Conventional Structure warehouse.

At beam column junction, moment in column observed in Pre-engineered structure is 60% less compare to Conventional structure in dead load. Shear force in Pre-engineered structure is reduced by 20% compare to conventional structure. Axial force in Pre-engineered structure is reduced by 55% compare to conventional structure. Pre-engineered structure warehouse gives lesser moment, shear and axial forces compare to Conventional structure warehouse in column at beam column junction.

At beam column junction, moment in rafter observed in Pre-engineered structure is 41% less compare to conventional structure in dead load. Shear force in Pre-engineered structure is reduced by 62.2% compare to conventional structure. Axial force in pre-engineered structure is reduced by 27.7% compare to conventional structure. Pre-engineered structure warehouse gives lesser moment, shear and axial forces compare to Conventional Structure ware house in rafter at beam column junction.

In rafter at midspan, moment in rafter observed in conventional structure is 57% more compare to pre-engineered structure in dead load. Shear force in pre-engineered structure is reduced by 63% compare to conventional structure. Axial force in pre-engineered structure is reduced by 11% compare to conventional structure. Pre-engineered structure warehouse gives lesser moment, shear and axial forces compare to Conventional structure warehouse in rafter at midspan.

Displacement at midspan of rafter is less compare to ridge. Maximum displacement is observed in wind-z case. In pre-engineered structure displacement is 30% lesser compare to conventional structure. Pre-engineered structure gives 38% lesser displacement at ridge, compare to conventional structure. Pre-engineered structure warehouse gives lesser displacement at ridge and midspan compare to Conventional structure.

Steel quantity is primarily depending on primary members and purlins. In conventional ware house uniform primary section is used while in P.E.B ware house tapper section is used. In Conventional ware house hot rolled used as purlin while in P.E.B ware house cold formed section used as purlin. This two are the major points to reduce the weight of ware house. For the primary members, pre-engineered structure has reduced weight by 70%. For the purlin members, conventional structure has 59% more weight compare to pre-engineered structure. Total steel quantity for pre-engineered structure is 22.36 kg/smt. Total steel quantity for conventional structure is 42.56 kg/smt. Conventional method ware house has 47% more Steel quantity compare to P.E.B ware house.

Total Area of Ware house = 25X90 = 2250 mtˆ2.

Total Steel in Conventional Ware house = 42.56 X 2250 = 95760 kG = 95.76 MT

Total Steel in P.E.B Ware house = 22.36 X 2250 = 50310 kG = 50.31 MT

So total difference in steel = 95.76 – 50.31 = 45.45 MT

If 1 MT = 52,000 Rs.

Then 45.45 X 52,000 = 23,63,400/- RS can be saved if we used P.E.B ware house.

4.8 Summary

In this chapter Conventional Portal Ware house is compared with P.E.B ware house to check in which case it achieve the economy in steel quantity. Ware house is model, analysis and design by STAAD Pro.2006. To compare the results configuration of ware house remain same. Design is done based on IS-800 in STAAD. Yield Stress of Steel assumes 540 Mpa in P.E.B ware house. Yield Stress of Steel assumes 250 Mpa in Conventional Portal ware house. Application of loading remains same in both cases. D.L, L.L, Wind X (Cpe$\pm$Cpi), Wind -X (Cpe$\pm$Cpi), Wind Z (Cpe$\pm$Cpi), Wind -Z (Cpe$\pm$Cpi) cases considered in modeling. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Comparison of analysis result for different cases is conducted. Steel quantity is observed in both cases. P.E.B ware house is economical compare to Conventional ware house in terms of steel consumption.

Chapter 5

Analysis of P.E.B. Structure

5.1 General

Planning of the PEB buildings (low rise metal buildings) and arranging different building components is a very important step for the designer before proceeding with the design of each component.

The Following building configurations are significantly affecting the building Stability and Cost.

- Main Frame configuration (orientation, type, roof slope, eave height)
- Roof purlins spacing
- End wall system
- Bracing systems arrangement

Some of the above configurations may be governed by customer requirements.

P.E.B Ware house is analysed in terms of varying the spacing of Portal.

- Case-A = 4.5 m Portal Spacing
- Case-B = 6 m Portal Spacing
- Case-C = 7.5 m Portal Spacing
- Case-D = 9 m Portal Spacing

5.2 Changing The Spacing of P.E.B Portal

5.2.1 Configuration of Ware house

- Width of Structure = 50 m
- Length of Structure = 90m
- Truss Spacing = changing from 4.5 m,6 m,7.5 m,9 m
- Eave Height = 6 m
- Length of Principle Rafter = 25.88 m
- Angle of truss = 15^o
- Purlin Spacing = 1.44m
- Location = Mudra Port

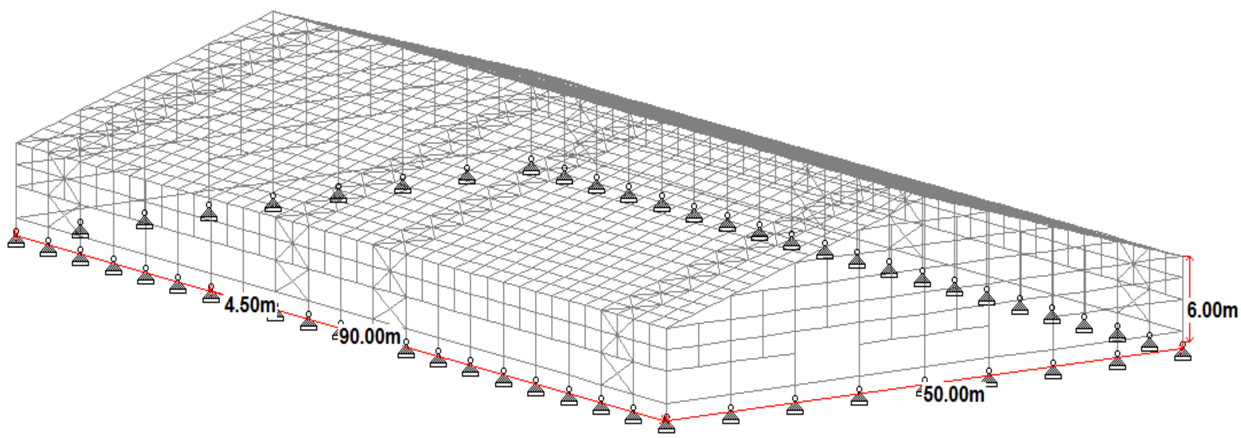


Figure 5.1: Prospective View of 50 m width Ware house

5.2.2 Loading

Loading remain same as mentioned in above case. Analysis is carried out in STAAD Pro 2006.Yield Strength of Steel is assumed as 540 Mpa.

5.2.3 Comparison of Analysis Result

Table 5.1: Reaction at base for Spacing 4.5 m and 6 m

	Spacing 4.5 m		Spacing 6 m	
Load Cases	Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)
Dead Load	30.2	125.9	40.9	164.3
Live Load	40.9	47.1	57.9	63.2
Wind X (Cpe+Cpi)	-71.7	-67.2	-98.8	-96.0
Wind X (Cpe-Cpi)	-82.8	-123.6	-159.1	-179.2
Wind Z (Cpe+Cpi)	-75.0	-122.7	-105.8	-147.6
Wind Z (Cpe-Cpi)	-117.6	-184.4	-165.9	-230.9

Table 5.2: Reaction at base for Spacing 7.5 m and 9 m

	Spacing 7.5 m		Spacing 9 m	
Load Cases	Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)
Dead Load	50.3	202.1	61.9	243.4
Live Load	73.5	78.8	87.9	94.1
Wind X (Cpe+Cpi)	-125.3	-123.3	-149.8	-148.1
Wind X (Cpe-Cpi)	-146.8	-222.4	-175.0	-266.5
Wind Z (Cpe+Cpi)	-132.3	-172.9	-153.4	-196.8
Wind Z (Cpe-Cpi)	-209.1	-277.5	-244.8	-321.5

Table 5.3: Forces in Column at Junction for Spacing 4.5 m and Spacing 6 m

	Spacing 4.5 m			Spacing 6 m		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	36.2	-33.3	132.5	46.6	-42.4	178.0
Live Load	45.9	-44.9	180.7	62.3	-60.0	253.4
Wind X (Cpe+Cpi)	-66.5	42.8	-261.4	-95.0	62.7	-366.9
Wind X (Cpe-Cpi)	-122.1	93.8	-400.9	-176.9	140.4	-664.2
Wind Z (Cpe+Cpi)	-104.988	98.5	-357.0	-132.8	124.0	-487.4
Wind Z (Cpe-Cpi)	-165.4	156.6	-570.0	-214.8	201.8	-784.4

Table 5.4: Forces in Column at Junction for Spacing 7.5 m and Spacing 9 m

	Spacing 7.5 m			Spacing 9 m		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	56.6	-51.1	220.2	69.6	-62.3	273.5
Live Load	78.2	-74.6	323.0	93.6	-88.5	389.1
Wind X (Cpe+Cpi)	-122.5	81.1	-466.8	-147.4	96.9	-557.6
Wind X (Cpe-Cpi)	-220.7	170.3	-716.0	-265.0	203.5	-854.5
Wind Z (Cpe+Cpi)	-160.971	150.4	-611.9	-186.6	172.8	-717.5
Wind Z (Cpe-Cpi)	-264.4	247.5	-991.7	-310.4	288.0	-1173.7

Table 5.5: Forces in Rafter at Junction for Spacing 4.5 m and Spacing 6 m

	Spacing 4.5 m			Spacing 6 m		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	39.7	-22.4	149.2	51.2	-29.6	197.9
Live Load	53.7	-30.9	203.6	72.7	-42.6	282.1
Wind X (Cpe+Cpi)	-49.0	53.0	-242.7	-73.2	75.2	-344.0
Wind X (Cpe-Cpi)	-124.6	88.3	-418.2	-173.6	130.5	-682.4
Wind Z (Cpe+Cpi)	-112.0	62.0	-417.8	-147.7	83.4	-556.5
Wind Z (Cpe-Cpi)	-186.1	102.2	-662.9	-248.2	138.7	-894.5

Table 5.6: Forces in Rafter at Junction for Spacing 7.5 m and 9 m

	Spacing 7.5 m			Spacing 9 m		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	62.1	-36.3	243.2	76.2	-45.1	300.6
Live Load	91.1	-53.9	357.5	108.5	-64.8	428.7
Wind X (Cpe+Cpi)	-95.4	96.8	-438.3	-114.4	116.5	-522.3
Wind X (Cpe-Cpi)	-228.3	159.7	-747.9	-273.6	191.9	-891.0
Wind Z (Cpe+Cpi)	-183.4	104.6	-690.7	-214.0	123.7	-803.2
Wind Z (Cpe-Cpi)	-309.5	174.6	-1120.4	-364.2	207.9	-1317.0

Table 5.7: Forces in Rafter at Midspan for Spacing 4.5 m and 6 m

	Spacing 4.5 m			Spacing 6 m		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	29.0	-7.4	-12.0	41.4	-10.3	-18.5
Live Load	38.7	-10.6	-18.4	58.1	-15.4	-29.0
Wind X (Cpe+Cpi)	-44.9	13.1	101.5	-68.9	19.9	155.8
Wind X (Cpe-Cpi)	-115.4	20.7	148.9	-161.8	36.4	199.8
Wind Z (Cpe+Cpi)	-31.0	22.0	29.2	-88.7	30.3	52.8
Wind Z (Cpe-Cpi)	-96.5	33.4	57.8	-182.2	46.7	96.7

Table 5.8: Forces in Rafter at Midspan for Spacing 7.5 m and 9 m

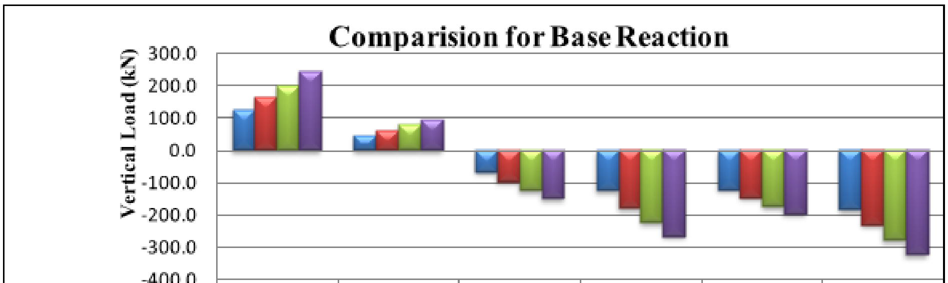
	Spacing 7.5 m			Spacing 9 m		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	52.7	-12.9	-24.9	65.6	-16.0	-31.8
Live Load	76.5	-19.8	-39.5	92.7	-23.7	-48.6
Wind X (Cpe+Cpi)	-92.5	26.1	210.9	-112.5	31.2	258.9
Wind X (Cpe-Cpi)	-221.8	41.1	312.0	-268.5	49.1	381.6
Wind Z (Cpe+Cpi)	-134.9	37.9	75.2	-173.0	43.5	95.1
Wind Z (Cpe-Cpi)	-255.6	59.3	134.2	-318.6	69.1	167.6

Table 5.9: Displacement in Rafter at Midspan

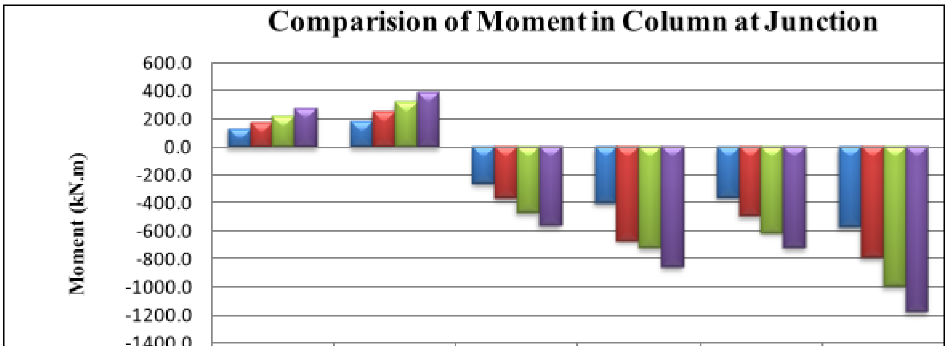
Vertical (mm)	Spacing 4.5 m	Spacing 6 m	Spacing 7.5 m	Spacing 9 m
Dead Load	-16.2	-18.9	-17.4	-16.0
Live Load	-22.4	-27.2	-25.6	-22.8
Wind X (Cpe+Cpi)	79.9	86.1	80.5	71.5
Wind X (Cpe-Cpi)	119.8	119.1	122.8	108.9
Wind Z (Cpe+Cpi)	42.9	52.1	48.6	42.4
Wind Z (Cpe-Cpi)	70.8	84.9	79.7	70.0

Table 5.10: Displacement in Rafter at Ridge

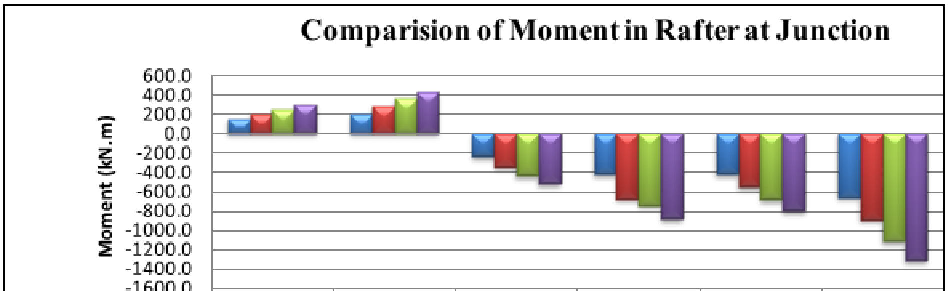
Vertical mm	Spacing 4.5 m	Spacing 6 m	Spacing 7.5 m	Spacing 9 m
Dead Load	-31.7	-29.4	-26.6	-24.4
Live Load	-42.5	-41.3	-38.6	-34.3
Wind X (Cpe+Cpi)	55.8	54.7	51.1	45.3
Wind X (Cpe-Cpi)	96.4	99.9	88.5	78.5
Wind Z (Cpe+Cpi)	89.0	81.4	73.7	62.7
Wind Z (Cpe-Cpi)	135.4	126.5	116.2	100.4



	Dead Load (kN)	Live Load (kN)	Wind X (Cpe+Cpi) (kN)	Wind X (Cpe-Cpi) (kN)	Wind Z (Cpe+Cpi) (kN)	Wind Z (Cpe-Cpi) (kN)
Portal Spacing 4.5 m	125.9	47.1	-67.2	-123.6	-122.7	-184.4
Portal Spacing 6 m	164.3	63.2	-96.0	-179.2	-147.6	-230.9
Portal Spacing 7.5 m	202.1	78.8	-123.3	-222.4	-172.9	-277.5
Portal Spacing 9 m	243.4	94.1	-148.1	-266.5	-196.8	-321.5

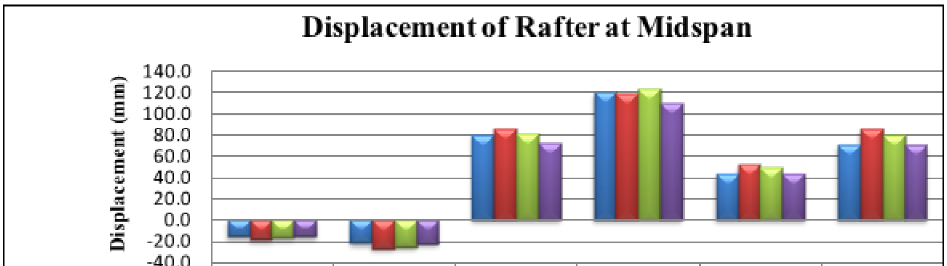


	Dead Load (kN.m)	Live Load (kN.m)	Wind X (Cpe+Cpi) (kN.m)	Wind X (Cpe-Cpi) (kN.m)	Wind Z (Cpe+Cpi) (kN.m)	Wind Z (Cpe-Cpi) (kN.m)
Portal Spacing 4.5 m	132.5	180.7	-261.4	-400.9	-357.0	-570.0
Portal Spacing 6 m	178.0	253.4	-366.9	-664.2	-487.4	-784.4
Portal Spacing 7.5 m	220.2	323.0	-466.8	-716.0	-611.9	-991.7
Portal Spacing 9 m	273.5	389.1	-557.6	-854.5	-717.5	-1173.7

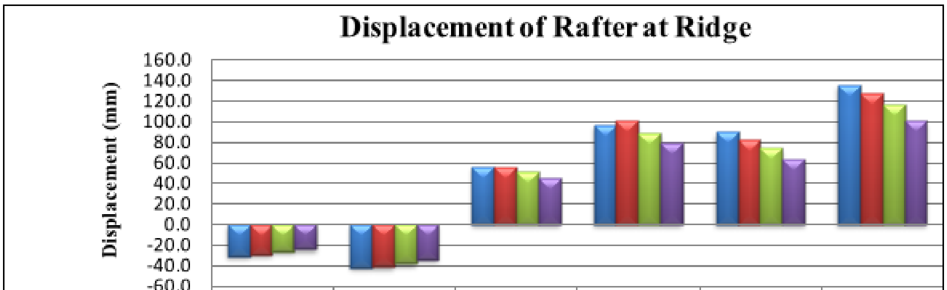


	Dead Load (kN.m)	Live Load (kN.m)	Wind X (Cpe+Cpi) (kN.m)	Wind X (Cpe-Cpi) (kN.m)	Wind Z (Cpe+Cpi) (kN.m)	Wind Z (Cpe-Cpi) (kN.m)
Portal Spacing 4.5 m	149.2	203.6	-242.7	-418.2	-417.8	-662.9
Portal Spacing 6 m	197.9	282.1	-344.0	-682.4	-556.5	-894.5
Portal Spacing 7.5 m	243.2	357.5	-438.3	-747.9	-690.7	-1120.4
Portal Spacing 9 m	300.6	428.7	-522.3	-891.0	-803.2	-1317.0

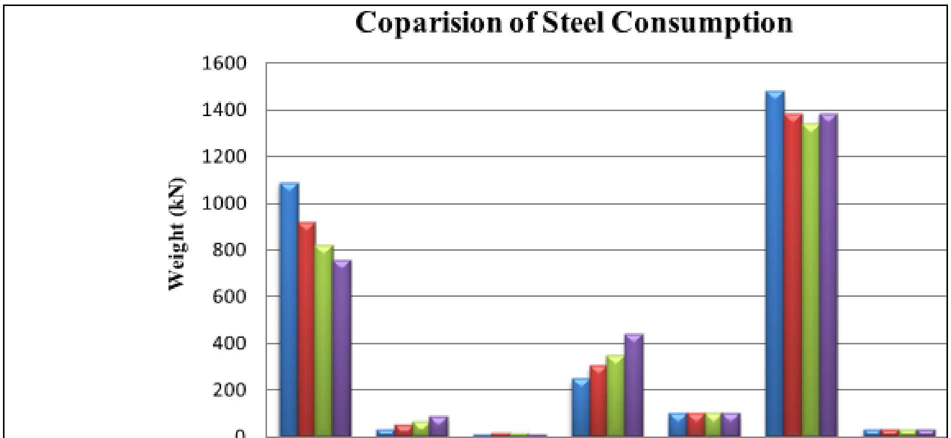
Figure 5.2: Comparision of Reaction at Base, Moment in Column at Junction, Moment in Rafter at Junction



	Dead Load (mm)	Live Load (mm)	Wind X (Cpe+Cpi) (mm)	Wind X (Cpe-Cpi) (mm)	Wind Z (Cpe+Cpi) (mm)	Wind Z (Cpe-Cpi) (mm)
Portal Spacing 4.5 m	-16.2	-22.4	79.9	119.8	42.9	70.8
Portal Spacing 6 m	-18.9	-27.2	86.1	119.1	52.1	84.9
Portal Spacing 7.5 m	-17.4	-25.6	80.5	122.8	48.6	79.7
Portal Spacing 9 m	-16.0	-22.8	71.5	108.9	42.4	70.0



	Dead Load (mm)	Live Load (mm)	Wind X (Cpe+Cpi) (mm)	Wind X (Cpe-Cpi) (mm)	Wind Z (Cpe+Cpi) (mm)	Wind Z (Cpe-Cpi) (mm)
Portal Spacing 4.5 m	-31.7	-42.5	55.8	96.4	89.0	135.4
Portal Spacing 6 m	-29.4	-41.3	54.7	99.9	81.4	126.5
Portal Spacing 7.5 m	-26.6	-38.6	51.1	88.5	73.7	116.2
Portal Spacing 9 m	-24.4	-34.3	45.3	78.5	62.7	100.4



	Portal (kN)	Bracing (kN)	Sag Rod (kN)	Purlin (kN)	Gable Column (kN)	Total Weight (kN)	Weight (kG)/smt
P.E.B Portal Spacing 4.5 m	1087.51	32.47	10.75	247.47	97.56	1475.76	32.79
P.E.B Portal Spacing 6 m	918.84	47.57	15.77	301.04	97.56	1380.78	30.68
P.E.B Portal Spacing 7.5 m	816.96	61.73	12.8	345.7	97.56	1334.75	29.66
P.E.B Portal Spacing 9 m	756.11	82.67	10.75	434.99	97.56	1382.08	30.71

Figure 5.3: Displacement in Rafter at Midspan, Displacement in Rafter at Ridge, Steel Consumption in Ware house for Varying Portal Spacing

Table 5.11: Section Property

	Dimension (mm)	**Portal Spacing**			
Element		4.5m	**6m**	**7.5m**	**9m**
Column at Bottom	Flange Width	300	300	300	300
	Flange Thk.	8	8	8	8
	Web Depth	400	400	400	500
	Web Thk.	8	8	8	8
Column at Top	Flange Width	300	300	300	300
	Flange Thk.	8	8	8	8
	Web Depth	1200	1400	1600	1800
	Web Thk.	8	8	8	8
Rafter at Midspan	Flange Width	250	250	250	250
	Flange Thk.	8	8	8	8
	Web Depth	450	550	650	750
	Web Thk.	8	8	8	8
Rafter at Support	Flange Width	250	250	250	250
	Flange Thk.	8	8	8	8
	Web Depth	1200	1400	1600	1800
	Web Thk.	8	8	8	8
	Cold Form Section	Z-	Z-	Z-	Z-
	Depth	150	180	230	270
	Width	60	60	75	75
	Lips	20	20	20	20
Purlin	Thickness	3.15	3.15	3.15	3.15
Bracing Pipe Section	Outer Dia.	60	70	75	85
	Inner Dia.	55	65	70	80

5.3 Changing The Width of P.E.B Portal

P.E.B Ware house is analysed in terms of varying the Width of Portal. configuration of Ware house remain same only width of Portal is vary from 25 m two bay and 50 m one bay.

5.3.1 Configuration of Ware house

- Width of Structure
  - Case-C 25 m width Two bay.
  - Case-D 50 m Width one Bay.
- Length of Structure = 90m
- Truss Spacing = 7.5 m
- Eave Height = 6 m
- Angle of truss = 15^o
- Purlin Spacing = 1.44m

5.3.2 Loading

Loading remain same as mentioned in above case. Analysis is carried out in STAAD Pro 2006.

5.3.3 Comparison of Analysis Result

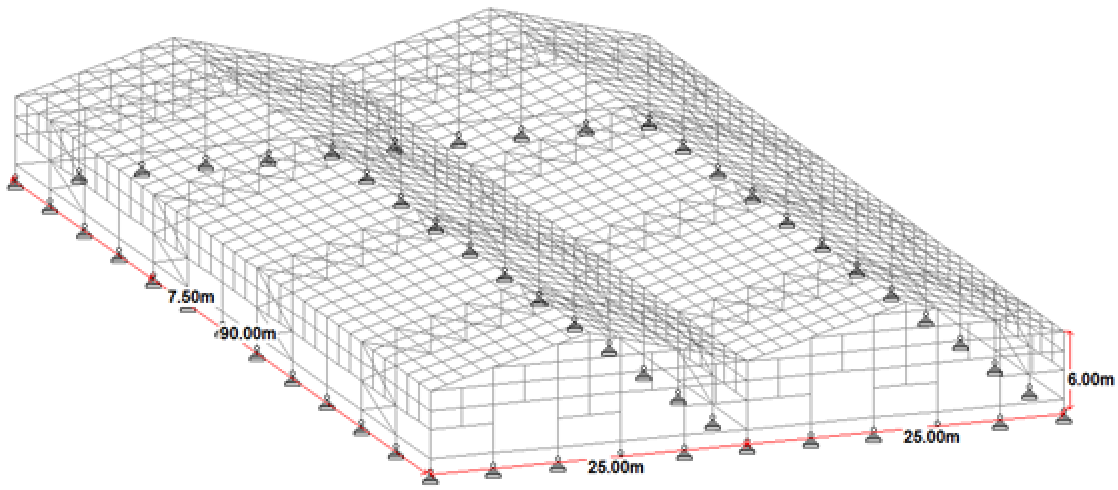


Figure 5.4: 25 m width two bay case,

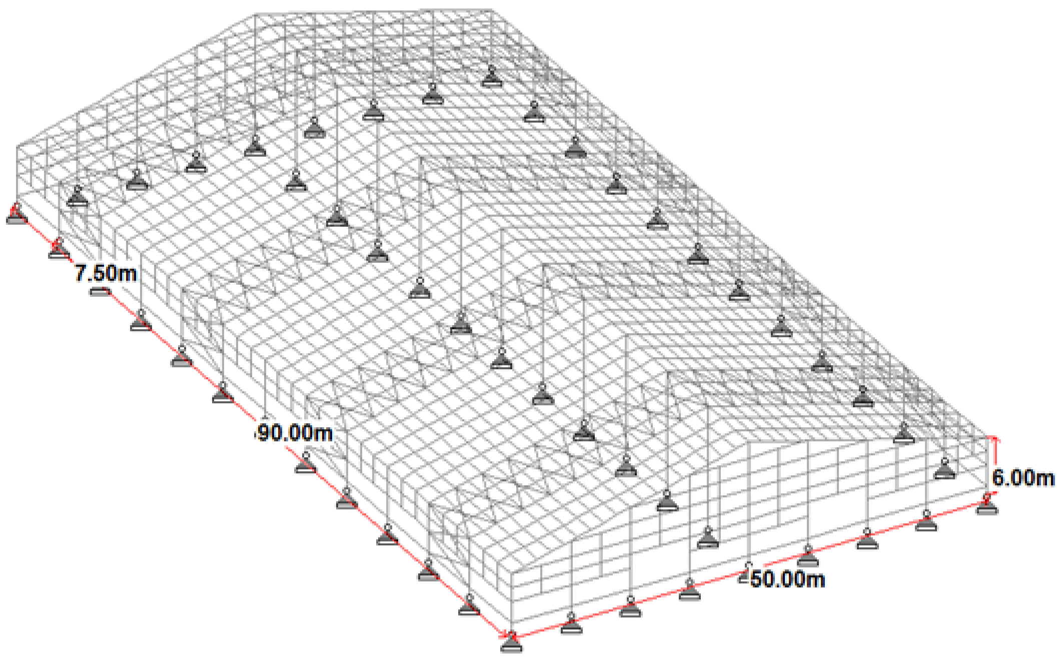


Figure 5.5: 50 m width one bay case-D

Table 5.12: Base Reaction for External Column

	Two Bay		Single Bay	
Load Cases	Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)
Dead Load	13.3	252.9	27.1	200.1
Live Load	23.5	41.9	23.4	41.7
Wind X (Cpe+Cpi)	-91.9	-109.1	-62.1	-67.8
Wind X (Cpe-Cpi)	-56.5	-157.6	-37.0	-128.0
Wind Z (Cpe+Cpi)	-28.0	-61.3	-37.0	-100.4
Wind Z (Cpe-Cpi)	-44.7	-124.6	-57.9	-163.6

Table 5.13: Base Reaction for Internal column

	Two Bay		Single Bay	
Load Cases	Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)
Dead Load	0	164.3	0	84.2
Live Load	0	77.8	0	68.4
Wind X (Cpe+Cpi)	22.794	-109.1	2.2	-87.5
Wind X (Cpe-Cpi)	28.296	-211.1	2.9	-149.5
Wind Z (Cpe+Cpi)	0	-137.3	0	-142.8
Wind Z (Cpe-Cpi)	0	-257.4	0	-214.3

Table 5.14: External Column Forces at Junction

	Two Bay			Single Bay		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	20.1	-15.4	46.9	49.4	-26.9	115.2
Live Load	37.3	-29.7	87.6	41.6	-23.4	101.2
Wind X (Cpe+Cpi)	-69.4	76.1	-223.0	-68.6	14.3	-191.1
Wind X (Cpe-Cpi)	-126.2	100.5	-241.2	-129.1	53.4	-243.1
Wind Z (Cpe+Cpi)	-78.1	55.3	-145.4	-90.2	52.2	-193.2
Wind Z (Cpe-Cpi)	-134.7	92.7	-244.8	-152.7	92.0	-325.7

Table 5.15: Rafter Forces at External Junction

	Two Bay			Single Bay		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	20.1	-15.4	46.9	37.0	-35.9	103.3
Live Load	37.3	-29.7	87.6	32.7	-32.1	90.2
Wind X (Cpe+Cpi)	-69.4	76.1	-223.0	-16.9	63.3	-110.5
Wind X (Cpe-Cpi)	-126.2	100.5	-241.2	-91.5	103.8	-180.0
Wind Z (Cpe+Cpi)	-78.1	55.3	-145.4	-71.7	63.7	-183.5
Wind Z (Cpe-Cpi)	-134.7	92.7	-244.8	-132.4	109.5	-314.8

Table 5.16: Rafter Forces at Internal Junction

	Two Bay			Single Bay		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	17.7	-15.3	45.6	-14.4	42.1	-223.4
Live Load	31.8	-29.4	85.3	-13.7	36.6	-196.0
Wind X (Cpe+Cpi)	-58.7	48.3	-147.2	30.6	-71.0	294.4
Wind X (Cpe-Cpi)	-120.9	78.6	-225.5	111.0	-123.5	571.0
Wind Z (Cpe+Cpi)	-89.7	54.9	-142.1	15.6	-72.4	385.5
Wind Z (Cpe-Cpi)	-140.5	92.0	-239.4	79.6	-123.7	660.5

Table 5.17: Rafter Forces at Midspan

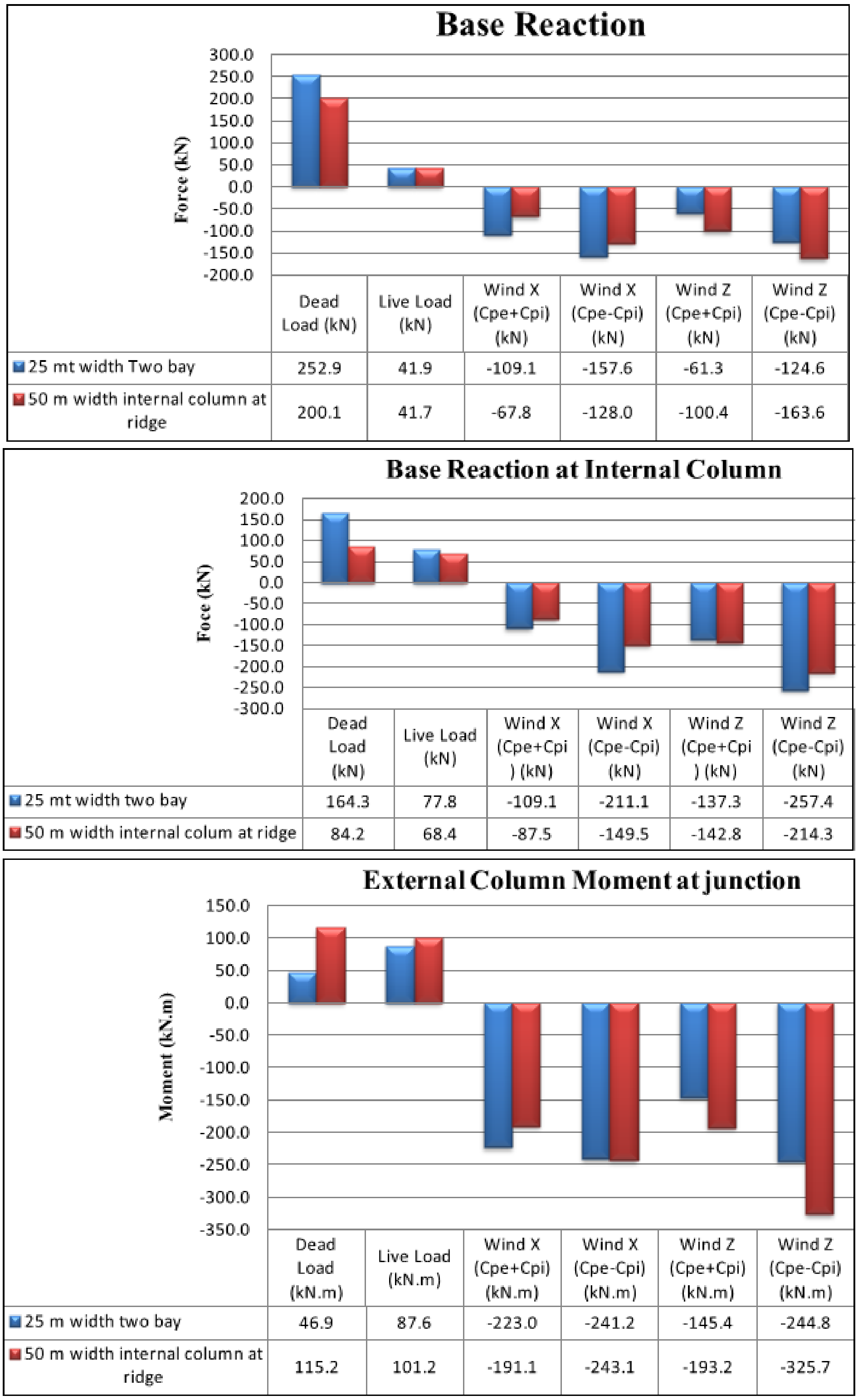
	Two Bay			Single Bay		
Load Cases	Fx kN	Fy kN	Mz kNm	Fx kN	Fy kN	Mz kNm
Dead Load	16.5	-6.3	-10.9	26.2	1.2	-60.8
Live Load	29.9	-12.5	-21.1	23.7	0.6	-54.2
Wind X (Cpe+Cpi)	-61	33.1	59.4	-24.6	-0.6	169.6
Wind X (Cpe-Cpi)	-120.5	33.1	93.7	-102.5	-3.8	262.5
Wind Z (Cpe+Cpi)	-76.2	18.5	39.7	-32.1	-0.9	106.8
Wind Z (Cpe-Cpi)	-130.7	31.3	66.8	-94.7	-1.6	182.7

Table 5.18: Displacement of Rafter Forces at Midspan

	Two Bay	Single Bay
Load Cases	Vertical mm	Vertical mm
Dead Load	-7.2	-43.4
Live Load	-13.2	-38.2
Wind X (Cpe+Cpi)	36.7	155.5
Wind X (Cpe-Cpi)	47.2	231.8
Wind Z (Cpe+Cpi)	21.2	74.7
Wind Z (Cpe-Cpi)	35.9	127.7

Table 5.19: Displacement of Rafter Forces at Ridge

	Two Bay	Single Bay
Load Cases	Vertical mm	Vertical mm
Dead Load	-10.2	-0.9
Live Load	-18.8	-0.8
Wind X (Cpe+Cpi)	50.2	1.0
Wind X (Cpe-Cpi)	54.0	1.6
Wind Z (Cpe+Cpi)	28.3	1.6
Wind Z (Cpe-Cpi)	47.8	2.4

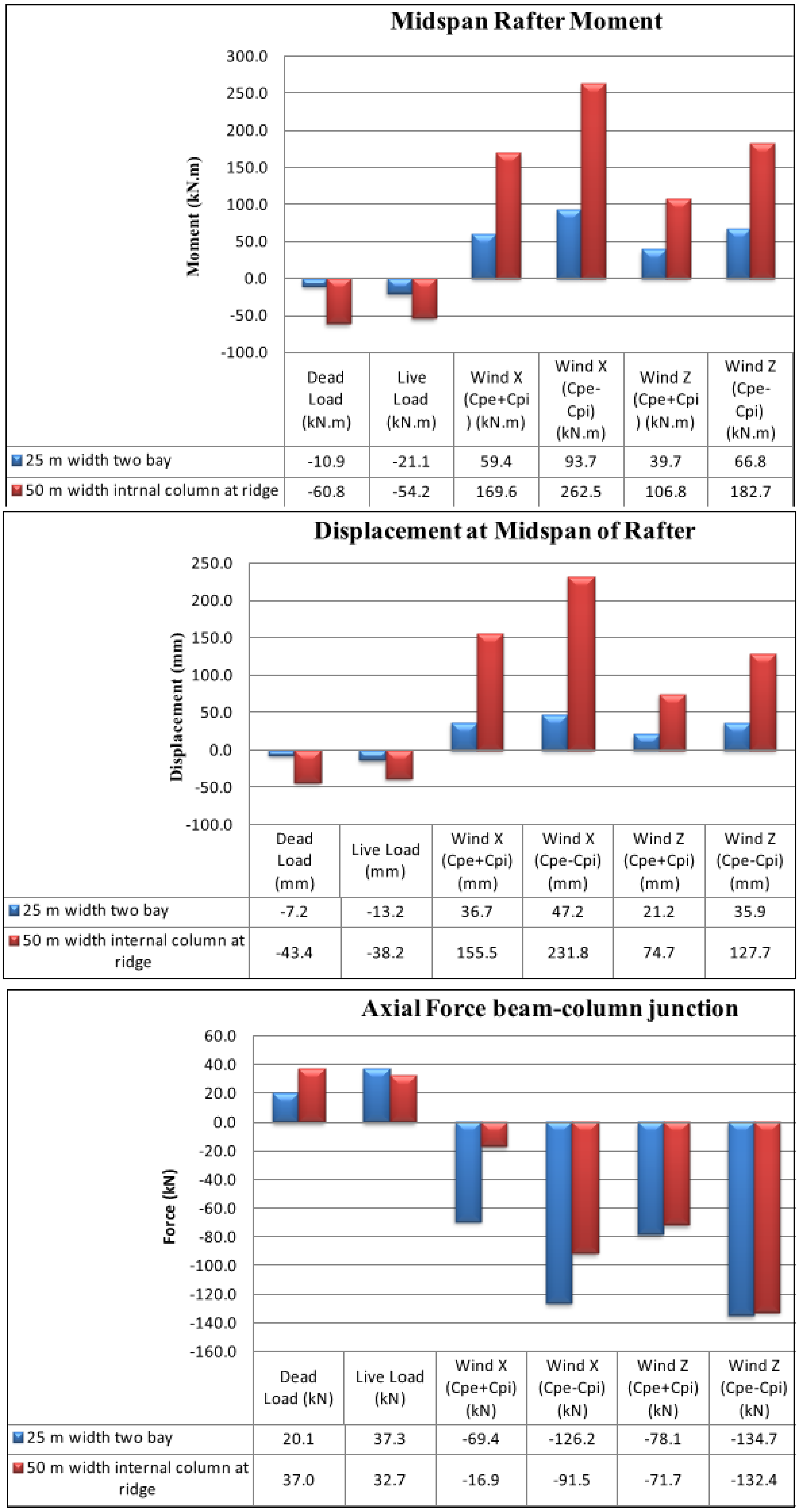


	Dead Load (kN)	Live Load (kN)	Wind X (Cpe+Cpi) (kN)	Wind X (Cpe-Cpi) (kN)	Wind Z (Cpe+Cpi) (kN)	Wind Z (Cpe-Cpi) (kN)
25 mt width Two bay	252.9	41.9	-109.1	-157.6	-61.3	-124.6
50 m width internal column at ridge	200.1	41.7	-67.8	-128.0	-100.4	-163.6

	Dead Load (kN)	Live Load (kN)	Wind X (Cpe+Cpi) (kN)	Wind X (Cpe-Cpi) (kN)	Wind Z (Cpe+Cpi) (kN)	Wind Z (Cpe-Cpi) (kN)
25 mt width two bay	164.3	77.8	-109.1	-211.1	-137.3	-257.4
50 m width internal colum at ridge	84.2	68.4	-87.5	-149.5	-142.8	-214.3

	Dead Load (kN.m)	Live Load (kN.m)	Wind X (Cpe+Cpi) (kN.m)	Wind X (Cpe-Cpi) (kN.m)	Wind Z (Cpe+Cpi) (kN.m)	Wind Z (Cpe-Cpi) (kN.m)
25 m width two bay	46.9	87.6	-223.0	-241.2	-145.4	-244.8
50 m width internal column at ridge	115.2	101.2	-191.1	-243.1	-193.2	-325.7

Figure 5.6: Base Reaction at External Column, Base Reaction at Internal Column, External Column Moment at Junction



	Dead Load (kN.m)	Live Load (kN.m)	Wind X (Cpe+Cpi) (kN.m)	Wind X (Cpe-Cpi) (kN.m)	Wind Z (Cpe+Cpi) (kN.m)	Wind Z (Cpe-Cpi) (kN.m)
25 m width two bay	-10.9	-21.1	59.4	93.7	39.7	66.8
50 m width intrnal column at ridge	-60.8	-54.2	169.6	262.5	106.8	182.7

	Dead Load (mm)	Live Load (mm)	Wind X (Cpe+Cpi) (mm)	Wind X (Cpe-Cpi) (mm)	Wind Z (Cpe+Cpi) (mm)	Wind Z (Cpe-Cpi) (mm)
25 m width two bay	-7.2	-13.2	36.7	47.2	21.2	35.9
50 m width internal column at ridge	-43.4	-38.2	155.5	231.8	74.7	127.7

	Dead Load (kN)	Live Load (kN)	Wind X (Cpe+Cpi) (kN)	Wind X (Cpe-Cpi) (kN)	Wind Z (Cpe+Cpi) (kN)	Wind Z (Cpe-Cpi) (kN)
25 m width two bay	20.1	37.3	-69.4	-126.2	-78.1	-134.7
50 m width internal column at ridge	37.0	32.7	-16.9	-91.5	-71.7	-132.4

Figure 5.7: Midspan Rafter Moment, Displacement at Midspan of Rafter, Axial Forces in Rafter at Junction

5.4 Discussion

- Different P.E.B warehouse has been analysed keeping same configuration of warehouse only changing the spacing of portal. Spacing of portal is varying from 4.5 m, 6 m, 7.5 m and 9 m. For designing ware house IS-800 Codal provision is used.

  – After Analyzing it observes that base reaction for different load cases increase as spacing of portal increased. Value of reaction is gradually increased. For wind load suction is taking place while in gravity load compression takes place. From portal spacing 4.5 m to portal spacing 6 m load is increased by 30%, form portal spacing 6 m to portal spacing 7.5 m load is increased by 22%, from portal spacing 7.5 m to portal spacing 9 m load is increased by 20%.

  – At beam column junction, Moment in column observed in portal spacing 4.5 m is 34% lesser to portal spacing 6 m. Moment observed in portal spacing 6 m is 23.7% lesser than portal spacing 7.5 m. Moment observed in portal spacing 7.5 m is 24% lesser than portal spacing 9 m. So it increment of moment is gradually decreased as spacing of portal increased. Vertical shear observed in portal spacing 4.5 m is 27% lesser than portal spacing 6m. Vertical shear observed in portal spacing 6 m is 20% lesser than portal spacing 7.5 m. Vertical shear observed in portal spacing 7.5 m is 22% lesser than portal spacing 9 m.

  – Moment at midspan of rafter is increased as spacing of portal increased .Moment value is increased by 60% for portal spacing 4.5 m to portal spacing 6 m.it increased by 40% for portal spacing 6 m to portal spacing 7.5 m.it increased by 25% for portal spacing 7.5 m to portal spacing 9 m. Shear force at midspan of rafter is increased as spacing of portal increased. portal spacing 4.5 m to portal spacing 6 m it increased by 40%,portal spacing 6 m to portal spacing 7.5 m it increased by 27%,portal spacing 7.5 m to portal spacing 9 m it increased by 16% .Value of moment and shear is increased as spacing of portal increased but the % of increment is gradually reduced.

- Displacement at midspan of rafter is less comparing to ridge. Maximum displacement is observed in wind-z case. Among all the four cases maximum displacement at midspan of rafter is observed in portal spacing 6 m. Section Property primarily governs the displacement. Value is increased by 16% from portal spacing 4.5 m to portal spacing 6 m. portal spacing 6 m to portal spacing 7.5 m, it reduced to 6%.it reduced to 13% for portal spacing 7.5 m to portal spacing 9 m.

- Steel quantity is primarily depending on primary members and purlins. As spacing of portal increased steel consumption is decreased for primary members. The decrement is 15% for portal spacing 4.5 m to portal spacing 6 m. It decreased by 12.4% for portal spacing 6 m to portal spacing 7.5 m.it decreased by 8% for portal spacing 7.5 m to portal spacing 9 m.but quantity of steel for purlin is gradually increased.it increased by 21% for portal spacing 4.5 m to portal spacing 6 m.it increased by 15% for portal spacing 6 m to portal spacing 7.5 m.it increased by 25% for portal spacing 7.5 m to portal spacing 9 m. So one side steel quantity for primary member is decreased and steel quantity for purlin is increased as spacing of portal increased. For total steel consumption of P.E.B ware house, portal spacing 7.5 m have lesser steel consumption compare to other cases. Total steel quantity for portal spacing 7.5 m is 29.66 kg/smt. portal spacing 4.5 m has 9% more steel consumption than portal spacing 7.5 m.portal spacing 6 m and portal spacing 9 m has 3.5% more steel consumption than portal spacing 7.5m.

- Two P.E.B Warehouse has been analysed keeping same configuration of warehouse only changing the width of portal. Width of one portal kept 25 m but it has two bays. So total width of ware house is 50 m. In second ware house 50 m width is kept but internal column is provided to support the ridge. STAAD Pro.2006 is used to modeling and analyzing the ware house.
  - After analyzing it observes that base reaction of external column in 25 m width Two bay ware house is more compare 50 m width one bay ware house. For dead load its 26.4 % more. Same thing happened with internal column.50 m width two bay ware house has 95% more Base reaction than 50 m width one bay ware house.
  - External Column moment at junction is more in 50 m width one bay ware house.it has 59% more moment than 25 m width two bay ware house at Junction. In the rafter also 50 m width one bay ware house has 54% more moment than 25 m width two bay ware house.
  - Displacement at midspan is more in 50 m width one bay ware house.it has 83% more displacement compare 25 m width two bay ware house.

5.5 Summary

- In this two different aspect take in to consideration. In first aspect, spacing of P.E.B portal vary to check in which case it achieve the economy in steel quantity. Configuration of ware house remains same only spacing of portal is vary from 4.5 m, 6 m, 7.5 m, 9 m. In second aspect, width of portal varies to observe the structural behavior of ware house. Ware house is model, analysis and design by STAAD Pro.2006. Design is done based on IS-800 in STAAD. Yield stress of steel assumes 540 Mpa in all cases. D.L, L.L, Wind X (Cpe$\pm$Cpi), Wind

-X (Cpe±Cpi), Wind Z (Cpe±Cpi), Wind -Z (Cpe±Cpi) cases considered in modeling. Application of loading remains same in all cases. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Analysis results compared.

- for varying the spacing of portal, 7.5 m c/c portal spacing case is economical compare to other spacing.

- for varying width, 25 m width two bay case gives less analysis result compare to 50 m width case.

Chapter 6

Typical Structural Element Design for P.E.B. Unit

6.1 General

Keeping same hypothetical data, conventional ware house and P.E.B ware house is analyzed in STAAD Pro.2006.parametric study is carried out for both ware house.

Changing the spacing of P.E.B portal from 4.5 m,6 m,7.5m,9 m to check the economy and varying the width of portal to observe the structural behavior of ware house is carried out in STAAD Pro.2006.

Design of ware house is carried out in this chapter. Design is done based on IS-800. Analysis results are taken from STAAD Pro.2006. Excel worksheet is prepared for different element. 25 m width Portal spacing 7.5 m c/c STAAD model is considered for detailed design.

6.2 Purlin

Purlin is analyze and design manually. Hot rolled section and cold form section are design in excel worksheet.

if we change the spacing of portal then section property of purlin change. with help of excel sheet varying the spacing of portal, observed section property of purlin is mentioned in table with provision of sag rod and without provision of sag rod.

Table 6.1: Section Property of Hot Rolled Purlin for different Portal Spacing with Sag Rod

Length (m) Stress (Mpa)	Section ISMC	Bending Stress @ major Axes	Perm. Bending Stress @ major Axes	Bending Stress @ Minor Axes	Perm. Bending Stress @ Minor Axes	Comb. Stress check	Actual Deflection (mm)	Perm. Deflection (mm)
4.0	125	40.33	68.93	2.77	165	0.51	5.04	20
4.5	125	51.04	67.09	3.5	165	0.66	8.08	22.5
5.0	125	63.02	64.82	4.32	165	0.85	12.31	25
5.5	150	48.88	64.04	3.53	165	0.67	9.63	27.5
6.0	150	58.17	68.20	1.59	165	0.73	13.64	30
6.5	175	50.74	68.20	1.92	165	0.64	11.97	32.5
7.0	175	58.84	68.56	2.1	165	0.74	16.1	35
7.5	200	51.91	65.58	2.15	165	0.68	14.27	37.5
8.0	200	59.07	68.2	1.38	165	0.74	18.4	40
8.5	200	66.68	68.2	1.56	165	0.84	23.54	42.5
9.0	225	56.78	68.2	1.4	165	0.71	19.97	45
9.5	225	63.26	66.71	1.56	165	0.81	24.79	47.5
10	250	54.99	67.09	1.47	165	0.70	21.49	50

Table 6.2: Section Property of Hot Rolled Purlin for different Portal Spacing without Sag Rod

Length (m) Stress (Mpa)	Section ISMC	Bending Stress @ major Axes	Perm. Bending Stress @ major Axes	Bending Stress @ Minor Axes	Perm. Bending Stress @ Minor Axes	Comb. Stress check	Actual Deflection (mm)	Perm. Deflection (mm)
4.0	125	40.33	55.42	11.07	165	0.68	5.04	20
4.5	125	51.04	51.87	14.01	165	0.91	8.08	22.5
5.0	150	40.39	51.42	11.68	165	0.73	6.58	25
5.5	175	36.33	48.65	12.02	165	0.7	6.14	27.5
6.0	300	14.25	44.33	6.97	165	0.31	1.67	30
6.5	300	16.72	37.74	8.18	165	0.42	2.3	32.5
7.0	350	14.38	38.78	8.7	165	0.36	1.97	35

6.3 Bracing

Since industrial structure are normally light and generally low profile. Wind and seismic forces may be relatively low. Use of X-bracing to develop a horizontal truss system. X bracing loads are transferred to a vertical braces frame, which in turn transfer the loads to the foundation level. In most cases the vertical bracing is located at the perimeter of the structure so as not interfere with plant operations. The vertical bracing configuration most frequently used in an X-braced system using angles or rods designed as tension member.

In STAAD model bracing are defined as truss member.so it can take only axial forces. based on that forces bracing is design for Tension force and check for Compression force. Pipe section is used as bracing member because it consume less steel weight and it has good slenderness property.

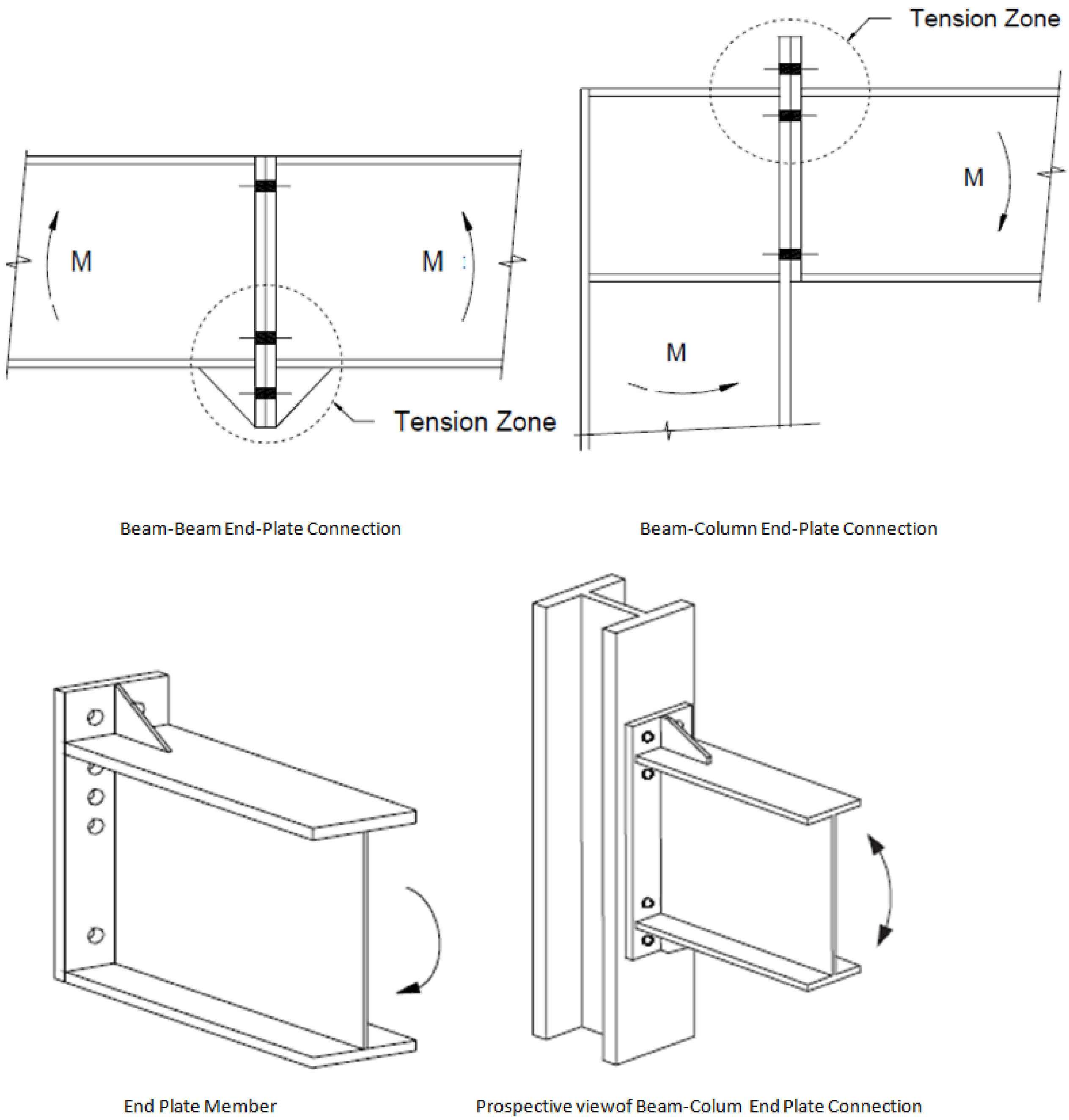
6.4 Taper Primary Member

Members subjected to predominant bending shall have adequate design strength to resist bending moment, shear force, and concentrated forces imposed upon and their combinations. Members shall satisfy the deflection limitation.
In P.E.B taper section is used as primary member.it has high permissible stress. Primary member is design for axial force, Shear force, Moment in major axes and minor axes.

6.5 End Plate Connection

The Low-rise metal building industry has pioneered the use of moment end-plate connections. These bolted connections are used between rafters and columns and to connect two rafter segments in typical gable frames as shown in fig.(6.1)
A typical end-plate moment connection is composed of a steel plate welded to the end of a beam section with attachment to an adjacent member using rows of bolts. End-plate moment connections are classified as either flush or extended, with or without stiffeners. Depending on the direction of the moment and whether the connection will see a moment reversal, the bolted end-plate may be designed to carry tension at top, bottom or both.
A flush connection is detailed such that the end-plate does not appreciably extend beyond the beam flanges with all bolts located between beam flanges. An extended end-plate is one that extends beyond the tension flange a sufficient distance to allow the location of bolts other than between beam flanges. Flush end-plate connections are used in frames subject to light lateral loads. Extended end plates are typically used for beam to column connections as shown in fig (6.1).

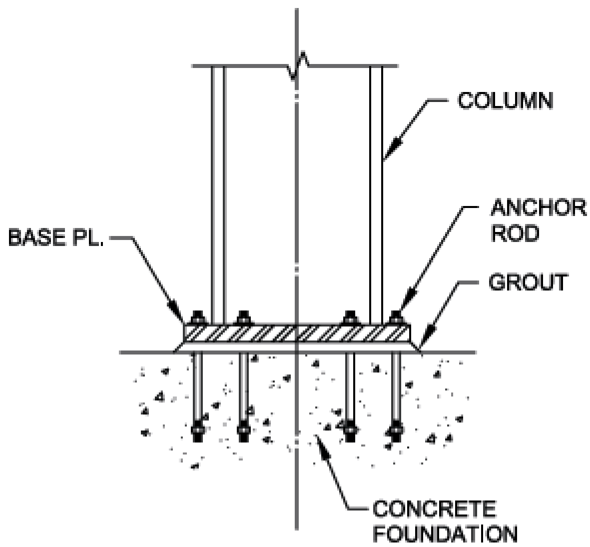
Figure 6.1: End Plate Connection



6.6 Base Plate

Column base plate connections are the critical interface between the steel structure and the foundation as shown in fig(6.2). These connections are used in buildings to support gravity loads and function as part of lateral-load-resisting systems. Base plates and anchor rods are often the last structural steel items to be designed but are the first items required on the jobsite. The schedule demands along with the problems that can occur at the interface of structural steel and reinforced concrete make it essential that the design details take into account not only structural requirements, but also include consideration of constructability issues.

Figure 6.2: Typical Base Plate Detail



6.7 Pedestal

Load is transferred from base plate to pedestal.so pedestal is design for biaxial moment.

6.8 Isolated Footing

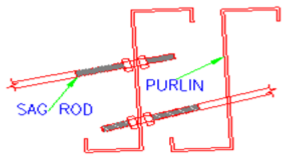
Isolated Footing is provided at base.footing is also design for biaxial moment.

6.9 Summary

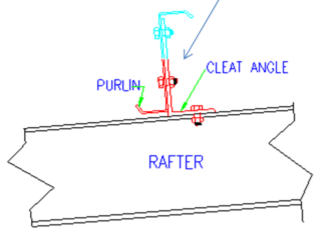
In this chapter various members like Purlin, Bracing, Rafter, Column, Connection, Base Plate, Pedestal, Isolated Footing are design by Excel Worksheet.
Detail drawing is prepared for Plan of ware house, Typical Section of P.E.B portal, End Plate Connection at Beam-Column junction and at ridge, Splice connection, Base Plate, Pedestal, Isolated Footing.

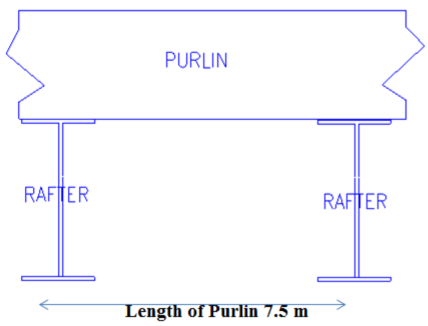
PURLIN DESIGN

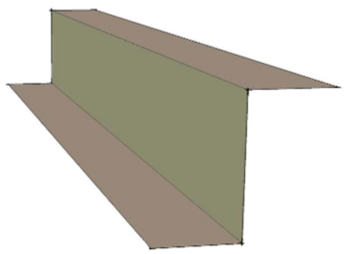
	Input Data	
Project Name	25 m Width Portal Spacing 7.5 m c/c	
Member No.	754	
	Material Property	
Modulus of Elasticity	200000	Mpa
Yeild Stress Of Steel	240	Mpa
	Geometry	
Portal Spacing	7.5	m
Sag Rod Spacing	2.5	m
Purlin Spacing	1.44	m
Angle of Portal / Truss,α	15	deg.
Effective Length in Major Axes	7.5	m
Effective Length in Minor Axes	2.5	m
	Load Calculation	
	1) Dead Load	
Type of Sheet	G.I.Sheet	
Trial Section	260X 75 x20x 3.15	
U.D.L (Sheet + Self wt. of Section + Fixture)	0.22	kN/m
	2) Live Load	
L.L on Purlin (IS-875,PART-2)	0.65	kN/m2
U.D.L on Purlin	0.94	kN/m
	3) Wind Load	
Basic Wind Speed (Vb)	50	m/s
Risk Co-efficient (K1)	1	
Terrain Height and Structure Height (K2)	0.98	
Topography Factor (K3)	1	
Vz=VbXK1XK2XK3	49	m/s
Wind Pressure pZ	1440.6	N/m2
Cpe±Cpi	0.9	
U.D.L on Purlin	-1.87	kN/m
	Moment @ Major Axes	
Moment about Major axis due to D.L	1.17	kN.m
Moment about Major axis due to L.L	5.09	kN.m
Moment about Major axis due to W.L	-10.50	kN.m
	Moment @ Minor Axes	
Moment about Minor axis due to D.L	0.035	kN.m
Moment about Minor axis due to L.L	0.151	kN.m
Moment about Minor axis due to W.L	0.000	kN.m
	Moment For Load Combinaton	
	Major Axes	
D.L+L.L	6.26	kN.m
D.L+W.L	-9.33	kN.m
D.L+L.L+W.L	-4.24	kN.m
	Minor Axes	
D.L+L.L	0.186	kN.m
D.L+W.L	0.035	kN.m
D.L+L.L+W.L	0.186	kN.m
	Load Acting on Purlin	
Load Case For Design	D.L+W.L	
AXIAL FORCE	0	kN
B.Mt @ MAJOR AXES	9.33	kN.m
B.Mt @ MINOR AXES	0.035	kN.m



260X 75 x20x 3.15







3-D view of Purlin

CALCULATION OF ACTUAL STRESS

ACTUAL COMPRESSIVE STRESS (σac,cal=P/Ax)	0	Mpa
ACTUAL BENDING STRESS @ MAJOR AXIS(σbcx,cal=Mx/Zx)	94.61	Mpa
ACTUAL BENDING STRESS @ MINOR AXIS(σbcy,cal=My/Zy)	2.03	Mpa

CALCULATION OF PERMISSIBLE STRESS

AXIAL STRESS

SLENDESNESS RATIO IN MAJOR DIRECTION (λx=lx/rxx)	76.45	Mpa
SLENDESNESS RATIO IN MINO DIRECTION (λy=ly/ryy)	81.22	Mpa
MAXIMUM SLENDERNESS RATIO (λmax) (<250)	**SAFE**	
ELASTIC CRITICAL STRESS IN MAJOR DIRECTION (fcxx=Π^2XE/λx^2)	337.73	Mpa
ELASTIC CRITICAL STRESS IN MINOR DIRECTION (fcyy=Π^2XE/λy^2)	299.20	Mpa
MINIMUN ELASTIC CRITICAL STRESS (fcc)	299.20	Mpa
PERMISSIBLE AXIAL STRESS (σac	5104.51	Mpa
ACTUAL STRESS/PERMISSIBLE STRESS	0.00	

BENDING STRESS

Y = 26.5x100000/{(l/ry)^2}	401.68	Mpa
X = Yx[1+{1/20}*{(l/ryy)*(T/D)}^2]^0.5	411.29	Mpa
k1 (TABLE-6.3)	1	
k2 (YABLE-6.4)	0	
ELASTIC CRITICAL STRESS (fcb)	411.29	Mpa
ELASTIC CRITICAL STRESS ABOUT MAJOR AXES (fcbx) (FROM TABLE)	115	Mpa
PERMISSIBLE STRESS IN BENDING COMPRESSION ABOUT MAJOR AXES (σcbx)	101.72	Mpa
PERMISSIBLE STRESS IN BENDING COMPRESSION ABOUT MINOR AXES (σcby)	165	Mpa

CHECK FOR COMBINED STRESS

Cmx (Cl.7.1.3)	0.85
Cmy (Cl/7.1.3)	0.85
COMBINED STRESS RATIO (Cl.7.1	0.80

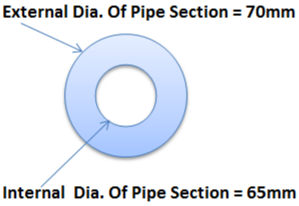
TYPE OF STRESS	UNIT	ACTUAL	PERMISSIBLE	CHECK
AXIAL COMPRESSION CHECK	Mpa	0	5104.51	**SAFE**
BENDING STRESS @ MAOJR AXIS	Mpa	94.61	101.72	**SAFE**
BENDING STRESS @ MINOR AXIS	Mpa	2.03	165	**SAFE**
RATIO OF COMBINED STRESS		0.80	1.33	**SAFE**

Deflection Check for(DL+LL)

Actual Deflection = (5/384) X WL4 / Eixx	18.54	mm	
Permissible Deflection = L/200	37.5	mm	**SAFE**

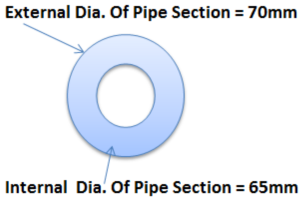
Design for Tension Force

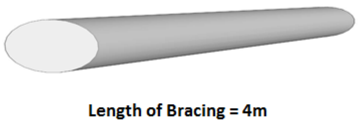
Project name	**25 m Width Portal Spacing 7.5 m c/c**		
Member No.	**2535**		
Location	**Along Wind in X Direction**		
Load Case	**D.L+W.L**		
Axial Load (Tension)	4	kN	
Fy	250	N/mm^2	
Length	4	m	
Permissible Stress(IS-800,1984,P37)	199.5	N/mm^2	
Area Required	20.05	mm^2	
External Dia. of Pipe Section	70	mm	
Internal Dia. of Pipe Section	65	mm	
Area Provided	530.14	mm^2	**SAFE**
Moment of Inertia	302347.61	mm^4	
rmin.	23.88	mm	
Load Capacity of the section	105.76	kN	**SAFE**



Check For Compression Force

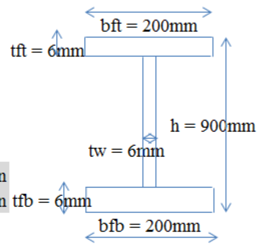
Project Name	**25 m Width Portal Spaced @ 7.5 m c/c**		
Member No.	**2535**		
Location	**Along Wind in X Direction**		
Load Case	**D.L+W.L**		
Axial Load (Compression)	5	kN	
Length	4	m	
Condition	Effectively Held in Position at Both ends, but not Restrained Against Rotation		
Condition for Strut	Use For Battened Strut		
Effective Length Criteria based on Rivet/Bolt	Single Angle Discontinuous Struts Connected by a Two or More Rivet or Bolt		
Fy	250	Mpa	
Outer Diameter	70.0	mm	
Inner Diameter	65.0	mm	
Unit Weight of Section	4.2	Kg/m	
Effective Length	3.7	m	
Gross Area	530.1	mm2	
Moment of Inertia	302347.6	mm4	
rmin	23.9	mm	
λ	156.6	180	**SAFE**
λmin	170.0		
λmax	180.0		
σac	36.0	Mpa	
Max. Allowable Load=Area X σac	19.1	kN	**SAFE**



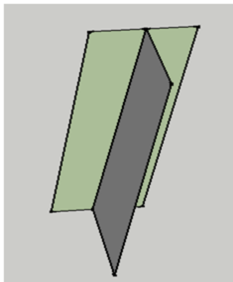


DESIGN OF STEEL BEAM

INPUT DATA		
Project Name	25 m WIDTH PORTAL SPACING 7.5 m c/c	
Member No.	552	
Load Case	D.L+W.L(-Z)	
	LOADING	
Axial Force	80	kN
Moment in Major Axes	240	kN.m
Moment in Minor Axes	0	kN.m
Shear Force	60	kN
Governing Load Case	with Wind	
Member in Major Direction	For members whose ends are restrained against rotation	
Member in Minor Direction	For members whose ends are restrained against rotation	
	GEOMETRY	
Effective length @ Major Axes	1.5	m
Effective length @ Minor Axes	1.5	m
	MATERIAL PROPERTY	
Concrete Mix	M-20	
Yield Stress of Steel	540	Mpa
Modulus of Elasticity of Steel	200000	Mpa
	TRY SECTION	
Depth of Section (h)	900	
Width of Top flange (bft)	200	
Thickness of Top Flange (tft)	6	
Width of Bottom flange (bfb)	200	
Thickness of Bottom Flange (tfb)	6	
Thickness of Web (tw)	6	



Section @ One End



3-D View of Tapper Section

	CALCULATION OF ACTUAL STRESS	
Actual Compressive Stress (σac,cal=P/Ax)	10.35	Mpa
Actual Bending Stress@ Major Axes(σbcx,cal=Mx/Zx)	130.17	Mpa
Actual Bending Stress @ Minor Axes(σbcy,cal=My/Zy)	0.00	Mpa
	CALCULATION OF PERMISSIBLE STRESS	
	1) AXIAL STRESS	
Slenderness Ratio in Major Axes (λx=lx/rxx)	4.58	**SAFE**
Slenderness Ratio in Minor Axes (λy=ly/ryy)	46.57	**SAFE**
Elastic Critical Stress in Major Axes (fcxx=Π^2XE/λx^2)	94184.94	Mpa
Elastic Critical Stress in Minor Axes (fcyy=Π^2XE/λy^2)	909.99	Mpa
Minimum Elastic Critical Stress (fcc)	909.99	Mpa
Permissible Axial Stress (σac)	24617.01	Mpa
Actual Stress/Permissible Stress	0.00042	

2) BENDING STRESS

Y = 26.5x100000/{(l/ry)^2}	1221.67	
X = Yx[1+{1/20}*{(l/ryy)*(T/D)}^{2}]$^{0.5}$	1224.61	
C1	1.00	
C2	1.00	
k1 (TABLE-6.3)	0.50	
k2 (YABLE-6.4)	0.00	
Elastic Critical Stress (fcb)	612.30	Mpa
Elastic Critical Stress @ Major Axes (fcbx) (FROM TABLE)	734.77	Mpa
Permissible Stress in Bending Compression @ Major Axes (σcbx)	249.25	Mpa
Permissible Stress in Bending Compression @ Minor Axes (σcby)	165	Mpa

CHECK FOR COMBINED STRESS

A co-efficient for Sway or non sway frame,Cmx	0.85
A co-efficient for Sway or non sway frame,Cmy	0.85
Combined Stress	0.52

TYPE OF STRESS	ACTUAL	PERMISSIBLE	RATIO	CHECK
Axial Compression	10.35	24617.01	0.00042	SAFE
Bending Stress @ major axis	130.17	249.25	0.52	SAFE
Bending Stress @ minor axis	0.00	165	0.00	SAFE
Ratio of Combined Stress	0.52	1.33		SAFE

CHECK FOR BENDING+AXIAL+SHEAR

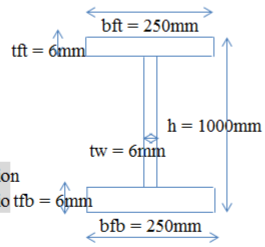
σe,cal=√σa^2,cal+σp^2,cal+σa,cal×σp,cal+3×τvm^2,cal

σa,Axial Stress	10.35	Mpa	
σp,Bending Stress	130.17	Mpa	
τvm,Shear Stress	7.76	Mpa	
σe,cal	136.31	Mpa	
Permissible=0.9XFy	486	Mpa	SAFE

DESIGN OF STEEL COLUMN

INPUT DATA		
Project Name	25 m WIDTH PORTAL SPACING 7.5 m c/c	
Member No.	2449	
Load Case	D.L+W.L(-Z)	

	LOADING	
Axial Force	85	kN
Moment in Major Axes	240	kN.m
Moment in Minor Axes	0	kN.m
Shear Force	60	kN
Governing Load Case	with Wind	
Member in Major Direction	For members whose ends are restrained against rotation	
Member in Minor Direction	For members whose ends are restrained against rotatio	

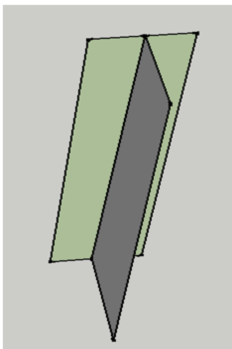


Section @ One End

	GEOMETRY	
Effective length @ Major Axes	6	m
Effective length @ Minor Axes	1.5	m

	MATERIAL PROPERTY	
Concrete Mix	M-20	
Yield Stress of Steel	540	Mpa
Modulus of Elasticity of Steel	200000	Mpa

	TRY SECTION
Depth of Section (h)	1000
Width of Top flange (bft)	250
Thickness of Top Flange (tft)	6
Width of Bottom flange (bfb)	250
Thickness of Bottom Flange (tfb)	6
Thickness of Web (tw)	6



3-D View of Tapper Section

	CALCULATION OF ACTUAL STRESS	
Actual Compressive Stress (σac,cal=P/Ax)	9.52	Mpa
Actual Bending Stress@ Major Axes(σbcx,cal=Mx/Zx)	98.10	Mpa
Actual Bending Stress @ Minor Axes(σbcy,cal=My/Zy)	0.00	Mpa

CALCULATION OF PERMISSIBLE STRESS

	1) AXIAL STRESS	
Slenderness Ratio in Major Axes (λx=lx/rxx)	16.21	SAFE
Slenderness Ratio in Minor Axes (λy=ly/ryy)	35.84	SAFE
Elastic Critical Stress in Major Axes (fcxx=Π^2XE/λx^2)	7512.57	Mpa
Elastic Critical Stress in Minor Axes (fcyy=Π^2XE/λy^2)	1537.12	Mpa
Minimum Elastic Critical Stress (fc	1537.12	Mpa
Permissible Axial Stress (σac)	36251.31	Mpa
Actual Stress/Permissible Stress	0.00026	

2) BENDING STRESS

Y = 26.5x100000/{(l/ry)^2}	2063.59	
X = Yx[1+{1/20}*{(l/ryy)*(T/D)}^2]^0.5	2065.97	
C1	1.00	
C2	1.00	
k1 (TABLE-6.3)	0.50	
k2 (YABLE-6.4)	0.00	
Elastic Critical Stress (fcb)	1032.99	Mpa
Elastic Critical Stress @ Major Axes (fcbx) (FROM TABLE)	1239.58	Mpa
Permissible Stress in Bending Compression @ Major Axes (σcbx)	293.49	Mpa
Permissible Stress in Bending Compression @ Minor Axes (σcby)	165	Mpa

CHECK FOR COMBINED STRESS

A co-efficient for Sway or non sway frame,Cmx	0.85
A co-efficient for Sway or non sway frame,Cmy	0.85
Combined Stress	0.33

TYPE OF STRESS	ACTUAL	PERMISSIBLE	RATIO	CHECK
Axial Compression	9.52	36251.31	0.00026	SAFE
Bending Stress @ major axis	98.10	293.49	0.33	SAFE
Bending Stress @ minor axis	0.00	165	0.00	SAFE
Ratio of Combined Stress	0.33	1.33		SAFE

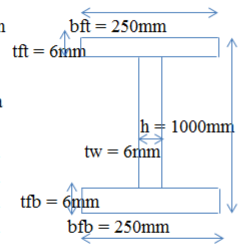
CHECK FOR BENDING+AXIAL+SHEAR

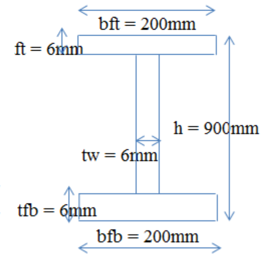
σe,cal=√σa^2,cal+σp^2,cal+σa,cal ×σp,cal+3×τvm^2,cal

σa,Axial Stress	9.52	Mpa	
σp,Bending Stress	98.10	Mpa	
τvm,Shear Stress	6.72	Mpa	
σe,cal	103.84	Mpa	
Permissible=0.9XFy	486	Mpa	SAFE

COLUMN TO RAFTER END PLATE CONNECTION

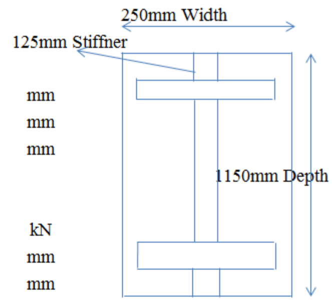
Input Data:-		
Project Name	25 m Width Portal Spacing 7.5 m c/c	
Load Case	D.L+L.L	
Axial Force	80.0	kN
Vertical Shear	60.0	kN
Moment	230.0	kN.m
Property of Primary Member at Junction		
Yeild strength of Steel	540	Mpa
Column		
width of Column flange	250	mm
Thickness of Column Flange	6	mm
Depth of Column Web	1000	mm
Thickness of Column Web	6	mm
Rafter		
Width of Beam Flange	200	mm
Thickness of Beam Flange	6	mm
Depth of Beam Web	900	mm
Thickness of Beam Web	6	mm
Vertical Projection	125.0	mm
Horizontal Projection	25.0	mm
Permissible Stress in Weld	100.0	Mpa
Axial Tension Capacity of Bolt	120.0	Mpa
Pull/Push = (Moment/L.A)	224.4	kN





Weld Thickness

Tension Zone		
Length provided for weld	900	mm
Size of Weld Required	3.5	mm
Provided Weld Thickness	4.5	mm
Shear Zone		
Fy	60	kN
Length provided for weld	1800	mm
Size of Weld Required	0.5	mm
Provided Weld Thickness	4.5	mm



Bolt Design

Bolt Requirement			
Total Tension on Bolt	224.4	kN	
Assume Dia. of Bolt	30	mm	
Tension capacity of bolt	67.9	kN	
Total Bolts Required	3.3		
Provided Bolts	4.0		
4-30 mm Bolts to Resist Direct Tension			
Check Bolt for Direct Tension			
Tension on Bolt	80.0	kN	
No of Bolts Provided to Resist Tensi	4.0		
Tension Capacity of Each Bolt	67.9	kN	
No of Bolts Required	1.2		
Total Tension Capacity of Bolts	271.4	kN	SAFE
4M-30Dia. Bolt Provided to Vertical Shear			
			First Two Rows of Bolt to Resist Direct Shear
Check Bolt for Direct Shear			
Direct Shear on Bolt	60.0	kN	
Bearing Value of Bolt	19.2	kN	Middle Two Rows of Bolt to Resist Vertical Shear
No. of Bolt Required	3.1		
No. of Bolt Provided	4.0		
4M-30Dia. Bolt Provided to Resist Shear			Last Two Rows of Bolt to Resist Direct Shear
Combined Stress Check For Bolt	1.1	>1.4	
	SAFE		

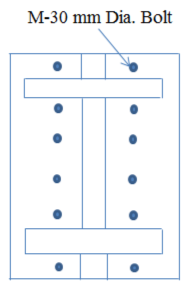
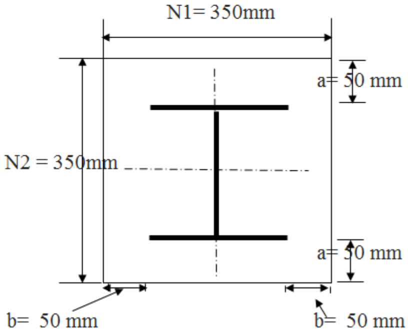
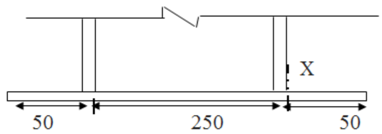


	Plate Thickness	
Total Direct Tension	224.4	kN
Distance between Bolt	150.0	mm
Moment in Plate	4.2	kN.m
Thickness of plate Required	13.7	mm
Thickness of Plate Provided	20.0	mm
End Plate 250X 1150 X 20 mm		
	Compression Zone	
Web Crippling		
Axial Load (Compression)	224.4	kN
Area under web crippling	660.0	mm2
Permissible Stress of Steel	540.0	Mpa
Load Resistion Capacity	356.4	kN
	SAFE	
Web Buckling		
Axial Load (Compression)	224.4	kN
Area under web Buckling	660.0	mm2
Permissible Stress of Steel	540.0	Mpa
Load Resistion Capacity	356.4	kN
	SAFE	

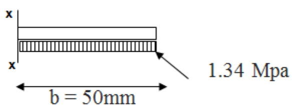
BASE PLATE

Project Name	25 m Width Portal Spacing 7.5 m c/c		
Node No.	43		
	Reactions @ Support		
DL	255.00	kN	
LL	42.00	kN	
WL_H	36.00	kN	
WL_V	133.00	kN	
Moment in Major Axes	0.00	kN.m	
Moment in Minor Axes	0.00	kN.m	
	Load Combination		
Maximum vertical compression (DL+LL+WL)	164.00	kN	
Maximum uplift (Tension) (DL-WL)	122.00	kN	**NO UPLIFT**
Lateral load (Horizontal)	36.00	kN	
	Material Property		
Fck	25	Mpa	
Fy	540	Mpa	
Factor of Safety	4		
Permissible bearing strength of concrete,σb =	6.3	Mpa	
	COLUMN SIZE		
Column Size			
Depth of Section (h)	250	mm	
Width of Top flange (b)	250	mm	
Thickness of Top Flange (tf)	6	mm	
Width of Bottom flange (b)	250	mm	
Thickness of Bottom Flange (tf)	6	mm	
Thickness of Web (tw)	6	mm	
	SIZE OF BASE PLATE		
Area of Base Plate Required, Total Load/σb	26240.0	mm^2	
Extention of Plate at One Side, a	50	mm	
Extention of Plate at Other Side,b	50	mm	
N1	350		
N2	350		
Plate Size	350mm x 350mm		
Area of Base Plate Provided	122500	**SAFE**	
	THICKNESS OF BASE PLATE		
Upward Pressure on Base Plate	1.34	Mpa	
Thickness of Base Plate Required	6.38	mm	
Provided Base plate Thickness	20.00	mm	
		SAFE	





Provide 350mm x 350mmX20mm base plate

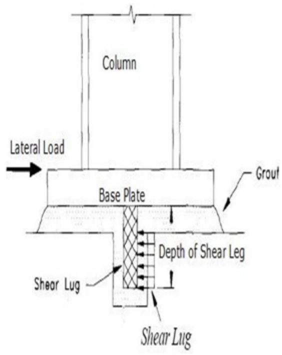


	DESIGN OF ANCHOR BOLT		
Direct Tensile Force	122	kN	
Additional Tensile Force due to Moment in Major Axes	0	kN	
Additional Tensile Force due to Moment in Minor Axes	0	kN	
Diameter of Bolt	20	mm	
No's of Bolt Provide	4		
c/c Distance of Bolt in Major Axes	150	mm	
c/c Distance of Bolt in Minor Axes	100	mm	
Permissible Tensile Capacity of Member	150	Mpa	
Critical Condition,Total Tensile Force Acting on One Bolt	30.50	kN	
Tensile Capacity of One Bolt	47.12	kN	
Total Capacity of Bolt Provided	188.50	kN	
Tensile Capacity Required	122.00	kN	
Provide 4-20 Ø Bolts		**SAFE**	

	LENGTH OF ANCHOR BOLT	
Nominal Diameter of bar, Ø	20.0	mm
Ld = T/π x d x Tbd	431.5	mm
Ld Provided	750.0	mm
Provide750 mm length of bolts		

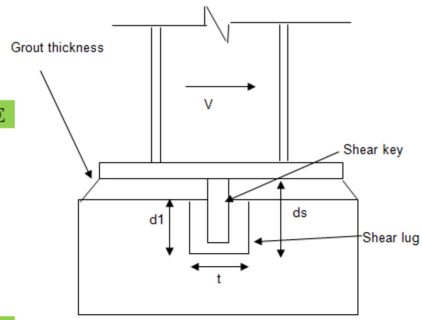
	CHECK BOLT IN SHEAR	
Total Shear at Base	36	kN
No. of Bolts Provided	4	
Shear in Each Bolt	9.00	kN
Shear Stress	28.65	Mpa
Permissible Shear Stress =0.4X fy	216	Mpa
		SAFE

	DESIGN OF SHEAR KEY	
Lateral Force	36	kN
Grout Thickness, G	50	mm
Area of Lug Required, Ag	3200.00	mm^2
Assume Width of Key, b	150	mm
Width of Lug, b1	200	mm
Assume depth of shear key, d=Ag/b	21.3	mm
Provide Depth of Lug, d1	150	mm
Depth of shear key, ds = d1+G	200	mm
Lateral U.D.L. = V/d1	240.00	kN/m
B.Mt = U.D.LXd1X(d1/2+G)	4.50	kN.m
Bending stress	219.45	Mpa
Thickness of plate Required Tp	28.64	mm
Thickness of Plate Provided	30	mm
		SAFE



	CHECK FOR BEARING STRESS	
Actual Bearing stress, W=V/(b*ds/2)	3.20	Mpa
Permissible Bearing Stress	6.25	Mpa
		SAFE

	Size of weld required	
Lateral Force	36	kN
Permissible Stress	108	Mpa
Thickness of Weld, t	6	mm
Length of Weld Required	78.57	mm
Length of Weld Provided	300	mm
		SAFE

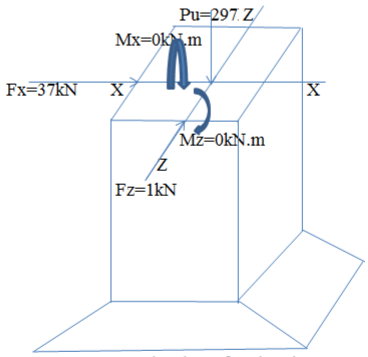


Provide 150mmX150mmX30mm Shear key

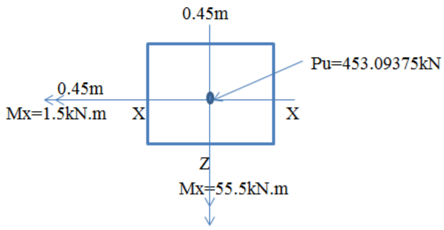
Pedestal Design

Design Data		
Project name	25 mt width Portal Spacing 7.5 m c/c Ware House	
Node No.	73	
Load Case	D.L+L.L	
	Material Property	
Grade of Concrete	M-25	Mpa
Grade of Steel	FE-415	Mpa
S.B.C of Soil	200	kN/m2
Density of concrete	25	kN/m3
	Size of Pedestal	
Height ofPedestal	1	m
Size of Pedestal,L	0.45	m
Width of Pedestal	0.45	m
	Unfactored Loading on Pedestal	
Axial Load	297	kN
Horizontal Force,Fx	37	kN
Horizontal Force,Fz	1	kN
Moment in X	0	kN.m
Moment in Z	0	kN.m
Mx @ base due to Fz	1	kN.m
Mz @ base due to Fx	37	kN.m
Self Weight of Pedestal	5.1	kN
Total Axial Load on Pedestal,P	302.1	kN
Total Mx @ base of Pedestal	1	kN.m
Total Mz @ base of Pedestal	37	kN.m
	Factor Load on Pedestal	
Total Axial Loadon Pedestal,P	453.09	kN.
Total Mx @ base of Pedestal	1.5	kN.m
Total Mz @ base of Pedestal	55.5	kN.m
	For Moment in X dir.	
Cover,d'	0.075	m
D	0.45	m
B	0.45	m
Mx/fckXBXD2	0.00066	
P/fckXBXD	0.0895	
d'/D	0.17	
	From Chart 33 of SP-16:1980	
Pt/fck	0.02	
Pt	0.5	
Pt min	0.8	
Area of Longitudinal Steel in X dir.	1620	mm2
Assume Diameter of Bar	25	mm
No. of Bar Required	4	
Spacing of Bar	115	mm

Provide 25 mm Dia. Bar @ 115 mm c/c along X dir.



Isometric View of Pedestal

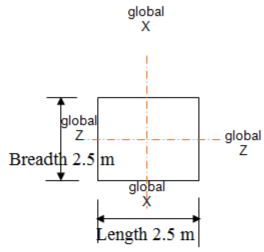


Factor Load @ Bottom of Pedestal Plan

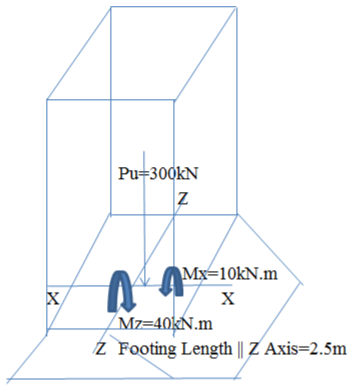
	For Moment in Z dir.	
Cover,d'	0.075	m
D	0.45	m
B	0.45	m
Mz/fckXBXD2	0.02436214	
P/FckXBXD	0.08950	
d'/D	0.1667	
	From Chart 33 of SP-16:1980	
Pt/fck	0.05	
Pt	1.25	
Pt min.	0.8	
Area of Longitudinal Steel in Z dir.	2531.25	mm2
Assume Diameter of Bar	25	mm
No. of Bar Required	6	
Spacing of Bar	115.000	mm
Provide 25 mm Dia. Bar @ 115 mm c/c along Z dir.		
Diameter of Lateral Ties	Lateral Ties	
1) Minimum 5 mm Diameter Bar	5	mm
2) 1/4 of Diameter of main bar	6.25	mm
Provide Lateral Tie Diameter	10	mm
Spacing of Ties,Least of Following		
1) 600 mm	600	mm
2) 16 times Dia. Of main bar	400	mm
3) 48 times Dia. Of Ties	480	mm
Provide Spacing of Lateral Ties	250	mm
Provide 10 mm Dia. Lateral Ties @ 250 mm c/c		

BI-AXIAL FOOTING DESIGN

Input Data		
PROJECT NAME	25 m WIDTH PORTAL SPACING 7.5 m c/c	
Node Point	73	
Load Case	D.L+L.L	
	LOAD APPLICATION ON FOOTING	
Axial Load (Pu)	300	kN
Moment @ X-X Axes	10	kN.m
Moment @ Z-Z Axes	40	kN.m
	COLUMN / PEDESTAL DIMENSION	
Length (l, dim. ‖ Z axis)	0.45	m
Breadth (b, dim. ‖ X axis)	0.45	m
Height of pedestal	1	m
	MATERIAL PROPERTY	
S.B.C. of Soil	200	KN/m2
Unit Weight of Soil	18	kN/m3
Grade of concrete, f_{ck}	25	Mpa
Grade of steel, f_y	415	Mpa
	PROPERTIONING OF FOOTING	
Depth of Top of Footing from F.G.L	2	m
Footing Area Required = Axial Load/S.B.C. of soil	1.5	m2
Equal Length of footing Required	1.22	m
Foot length (L, dim. ‖ Z axis)	2.5	m
Foot Breadth (B, dim. ‖ X axis)	2.5	m
Footing Area Provided	6.25	m2
	SAFE	
	FOOTING DIMENSION	
Foot length (L, dim. ‖ Z axis)	2.5	m
Foot Breadth (B, dim. ‖ X axis)	2.5	m
Edge Thickness	0.3	m
Thickness of Footing @ column Face	0.6	m
Clear Cover	0.075	m
Main Bar Diameter of Footing	12	mm
Effective Depth of Footing	0.519	m
Zxx Provided	2.60	m3
Zzz Provided	2.60	m3
	WEIGHT OF FOOTING	
Weight of Soil Retained Above Footing	151.29	kN
Self Weight of Footing	70.31	kN
Weight of Footing/Pedestal	5.0625	kN
Total Weight of Footing	526.665	kN
	PRESSURE CHECK	
P/A	84.2664	kN/m2
Mx/Zxx	3.84	kN/m2
My/Zyy	15.36	kN/m2
P/A+Mx/Zxx+Mz/Zzz	103.47	kN/m2
P/A+Mx/Zxx-Mz/Zzz	72.75	kN/m2
P/A-Mx/Zxx+Mz/Zzz	95.79	kN/m2
P/A-Mx/Zxx-Mz/Zzz	65.07	kN/m2
Minimum Effective Soil Pressure	65.07	KN/m2 **SAFE**
Maximum Effective Soil Pressure	103.47	KN/m2 **SAFE**



Footing Dimensions



Footing Breadth ‖ X Axis=2.5m

CALCULATION FOR BOTTOM STEEL

A) PARALLEL TO LENGTH OF FOOTING

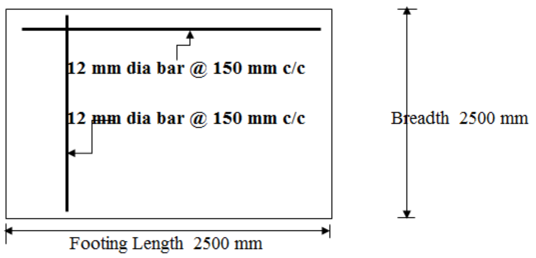
Mu about X1 X1 =(pe max x length2/2)	**54.35**	kN.m
Ast	293	mm2
Min.Ast (0.12 % for Slab, CL 26.5.2.1)	622.8	mm2
Diameter of Bar	12	mm
Spacing of Bar Required	200	mm
Spacing of Bar Provided	150	mm
Ast provided	753.98	mm2
% of Steel Provided	0.15	

Hence provide 12 mm dia bar @ 150 mm c/c parellel to length of footing (‖ to Z) at bottom

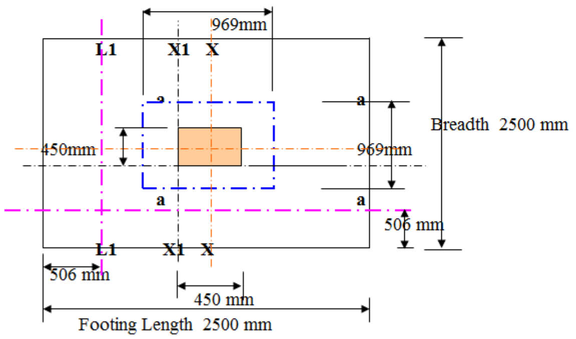
B) PARALLEL TO WIDTH OF FOOTING

Mu about N1 N1= pe max x length2/2	54.35	kN.m
Ast	293	mm2
Min. Ast	622.8	mm2
Diameter of Bar	12	mm
Spacing of Bar Required	200	mm
Spacing of Bar Provided	150	mm
Ast provided	753.98	mm2
% of Steel Provided	0.15	

Hence provide 12 mm dia bar @ 150 mm c/c parellel to length of footing (‖ to X) at bottom



Arrangement of Bottom Reinforcemet

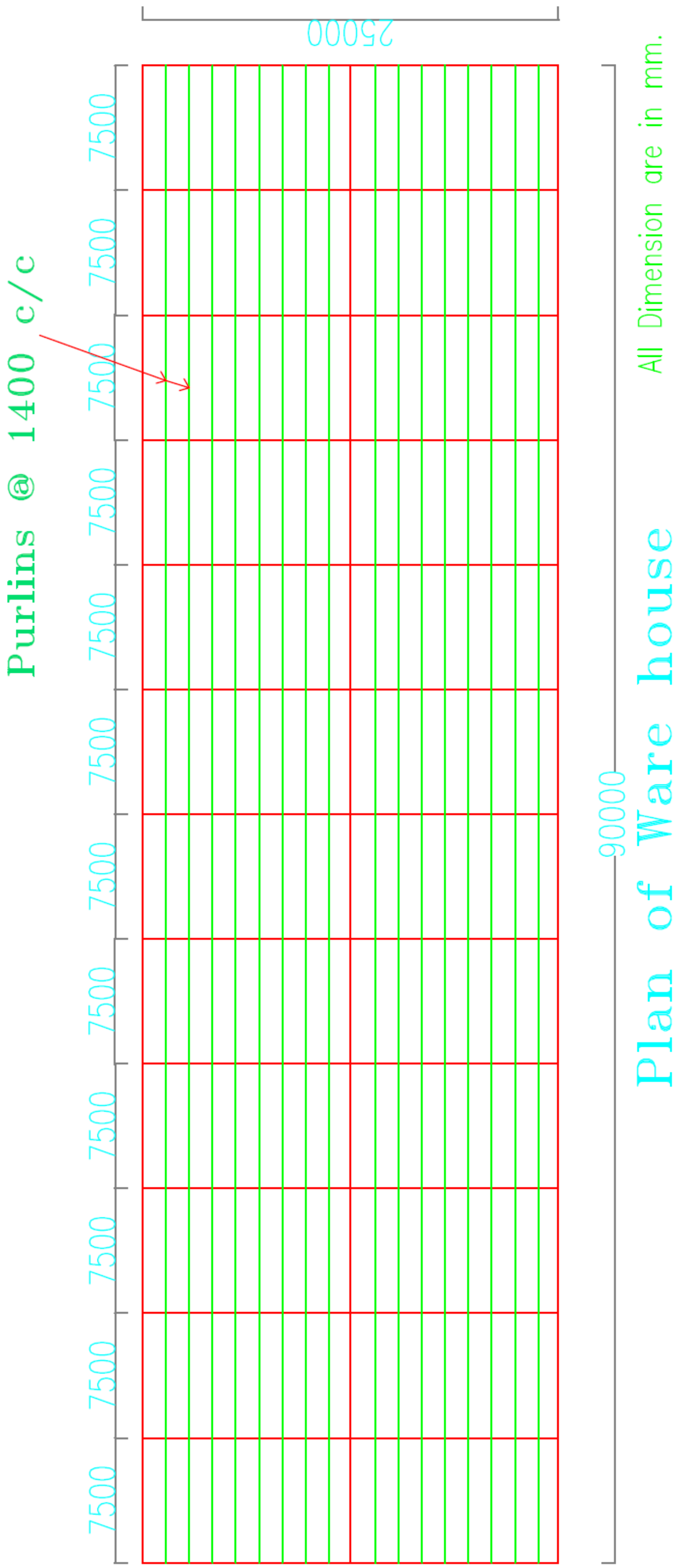


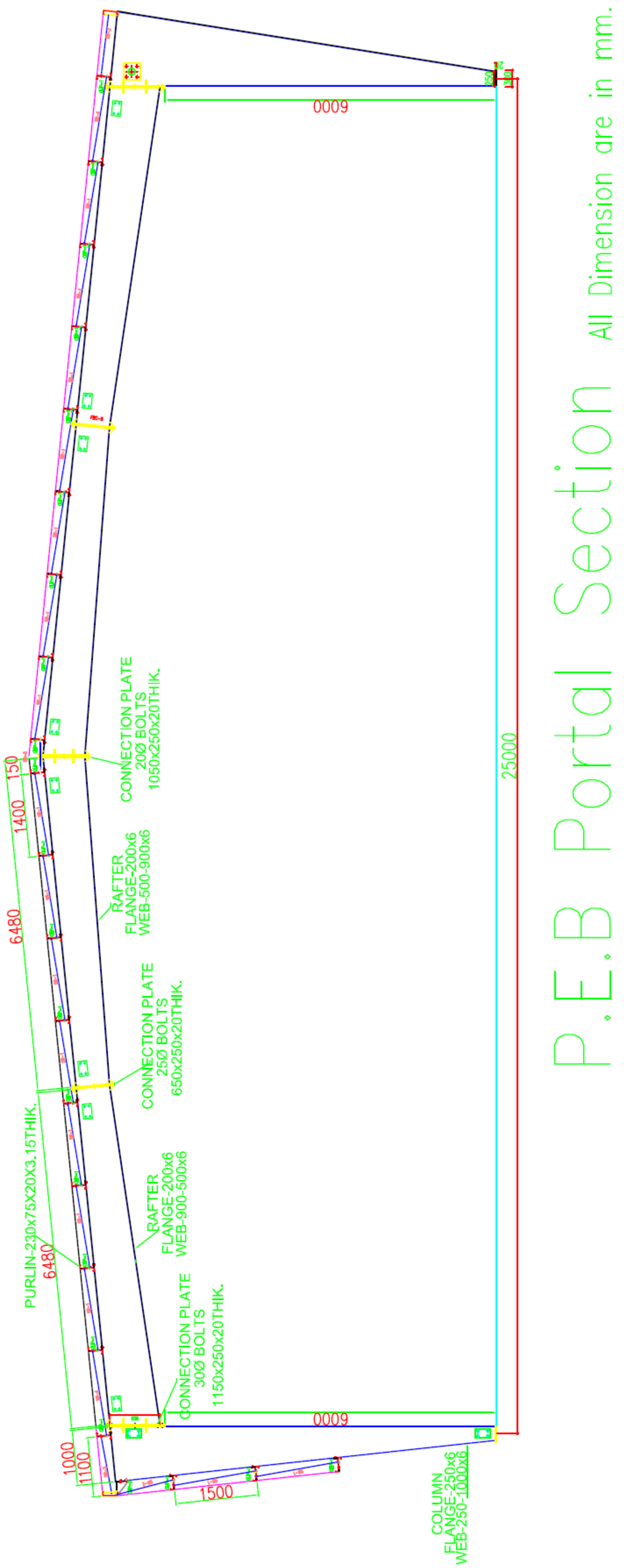
CHECK FOR ONE WAY SHEAR

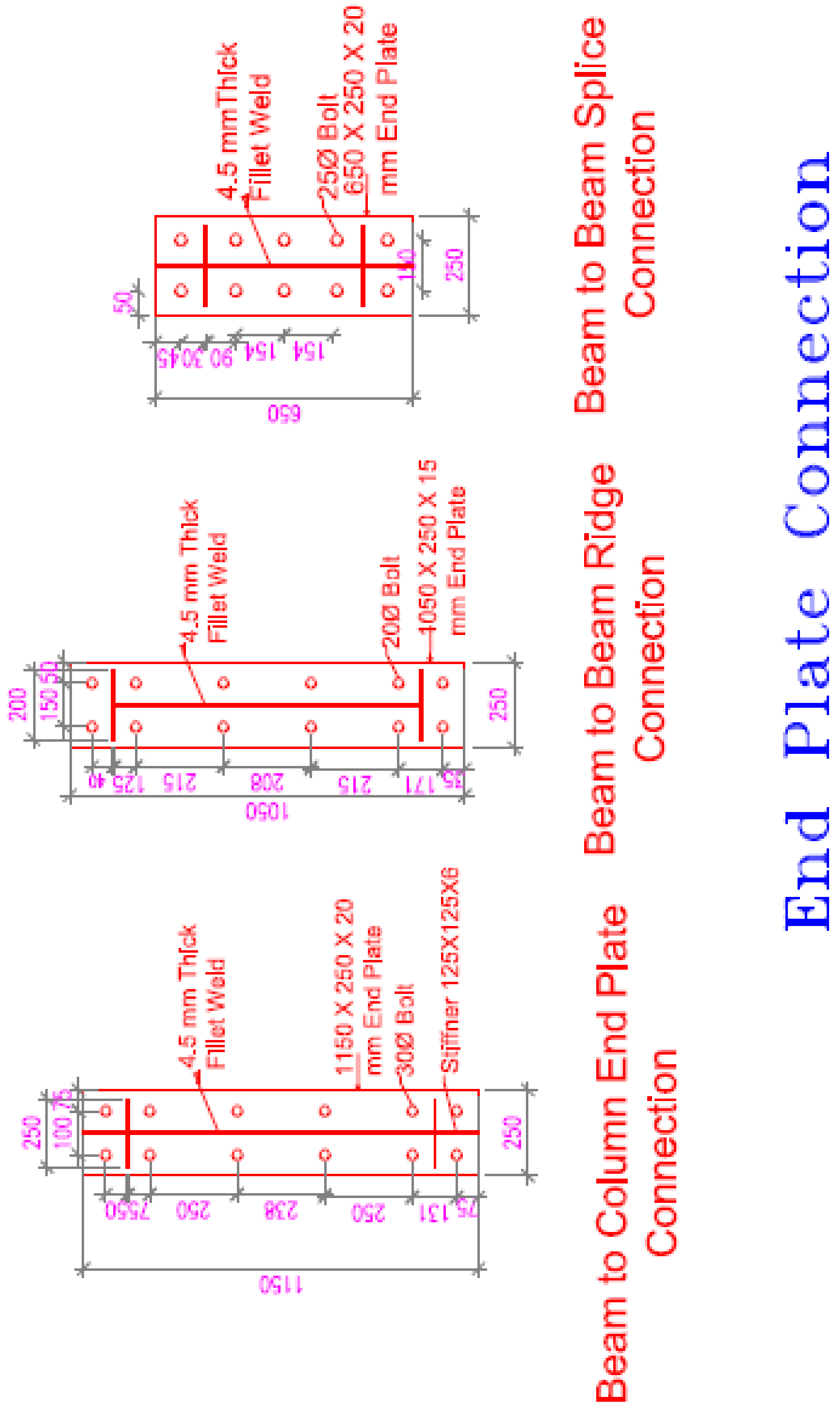
one way shear at critical sec. from edge of footing	506	mm
Shear force Vs=pemax x0.506x1m width of footing	52.35	kN
Shear Stress,τv=V/bd	0.10	Mpa
τc	0.29	Mpa
	τv<τc, HENCE, O.K.	

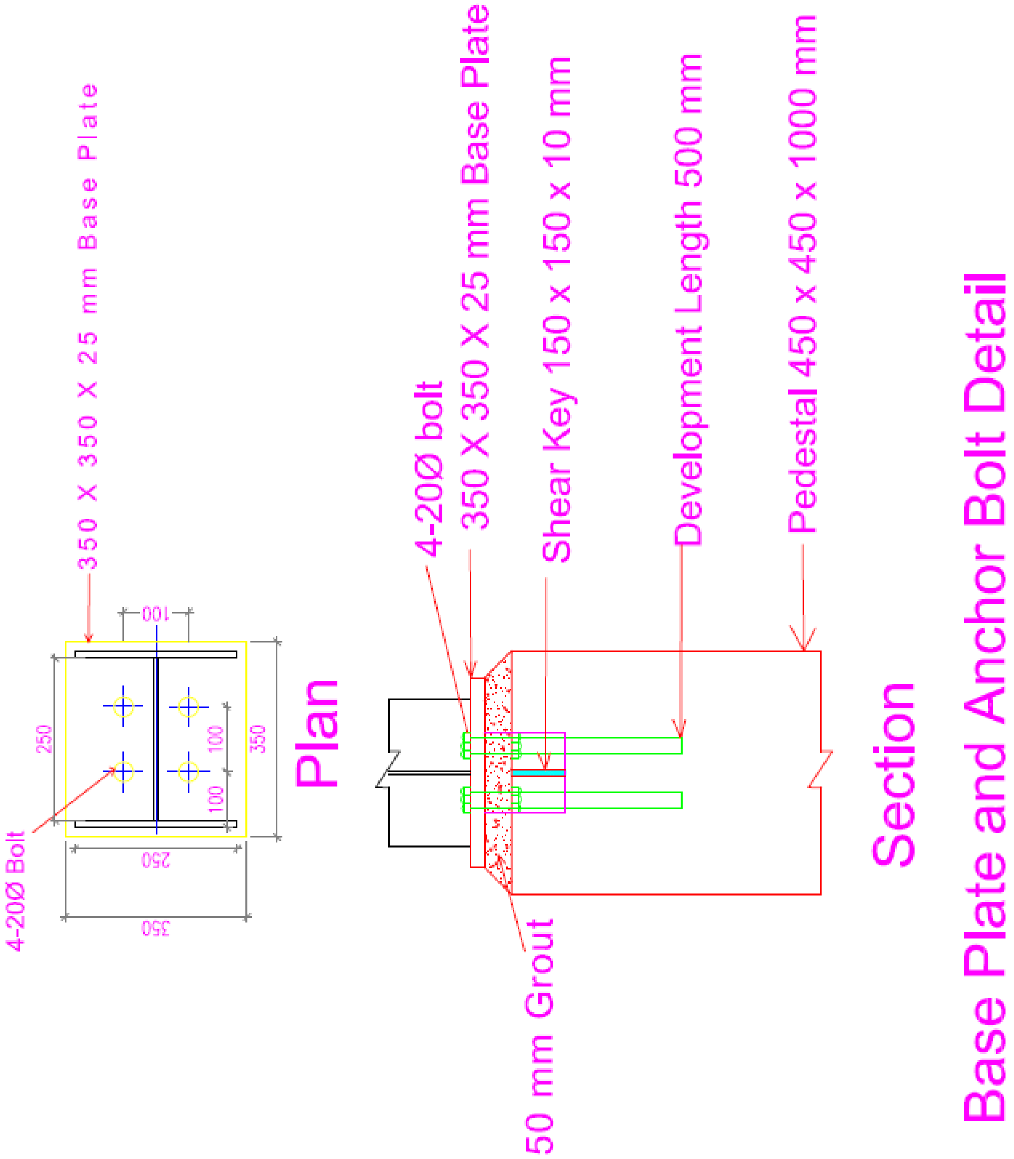
CHECK FOR TWO WAY SHEAR

Allowable Shear Stress, τv Allowable=ks*τc		
ks=(0.5+bc)	1.5	>1
ks	1	
τc=0.25(fck)^0.5	1.25	Mpa
τv Allowable = ks X τc	1.25	Mpa
Shear force Vs=103.466(2.5X2.5-0.969X0.969)	549.51	kN
Length of critical section = 2 X (0.969+0.969)	3876	mm
Area of critical section(Length of critical section X deff.)	2011644	mm2
Shear Stress,τv	0.27	Mpa
	τv<ALLOWABLE, HENCE O.K.	

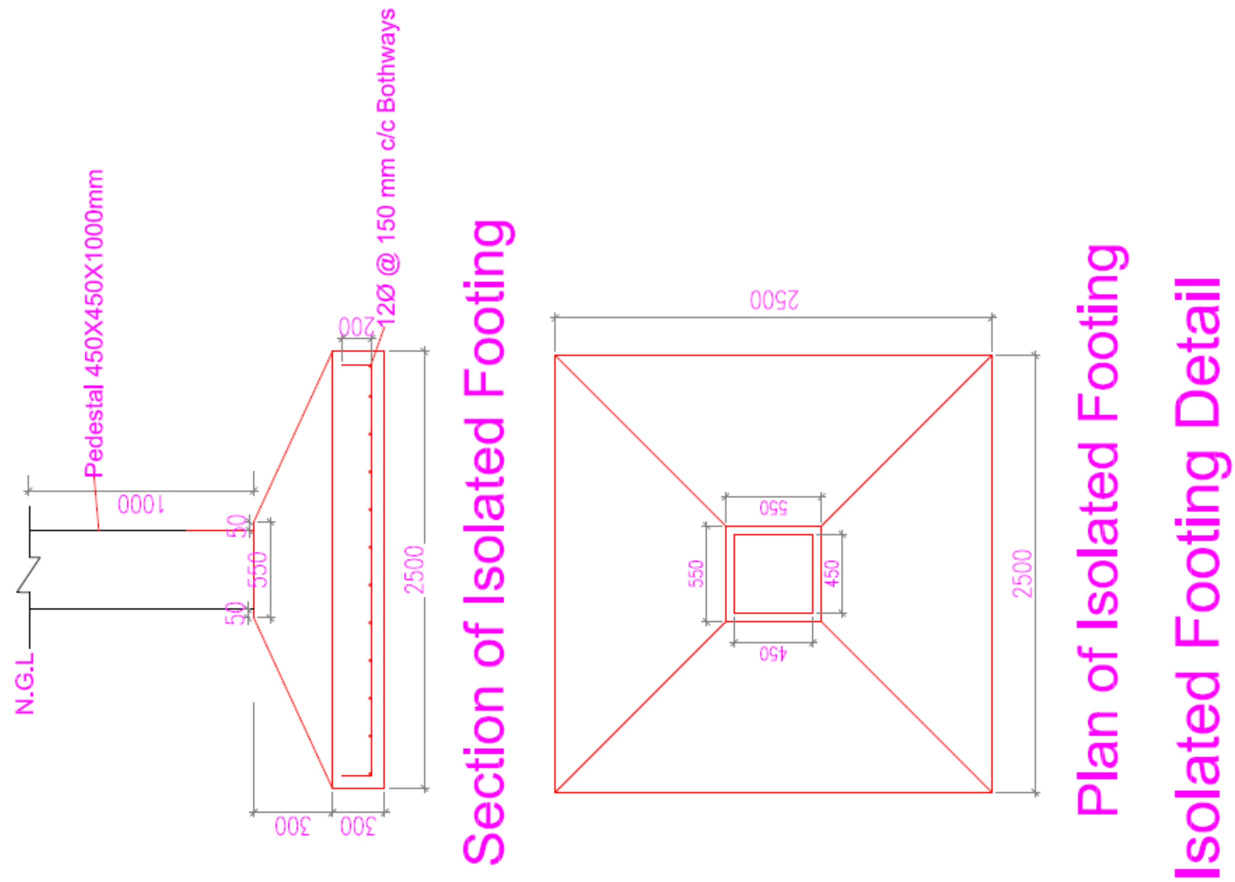

Purlins @ 1400 c/c
25000
7500
7500
7500
7500
7500
7500
7500
7500
7500
7500
7500
7500
90000
Plan of Ware house
All Dimension are in mm.


P.E.B Portal Section
All Dimension are in mm.
CONNECTION PLATE
20Ø BOLTS
1050x250x20THIK.
RAFTER
FLANGE-200x6
WEB-500-900x6
CONNECTION PLATE
25Ø BOLTS
650x250x20THIK.
RAFTER
FLANGE-200x6
WEB-900-500x6
CONNECTION PLATE
30Ø BOLTS
1150x250x20THIK.
PURLIN-230x75X20X3.15THIK.
COLUMN
FLANGE-250x6
WEB-250-1000x6
6000
6000
25000
6480
6480
1400
150
1000
1100
1500


4.5 mm Thick Fillet Weld
25Ø Bolt
650 X 250 X 20 mm End Plate
650
250
Beam to Beam Splice Connection
4.5 mm Thick Fillet Weld
20Ø Bolt
1050 X 250 X 15 mm End Plate
1050
250
Beam to Beam Ridge Connection
4.5 mm Thick Fillet Weld
1150 X 250 X 20 mm End Plate
30Ø Bolt
Stiffener 125X125X6
1150
250
Beam to Column End Plate Connection
End Plate Connection



350 X 350 X 25 mm Base Plate
100
250
350
100
100
250
350
4-20Ø Bolt
Plan
4-20Ø bolt
350 X 350 X 25 mm Base Plate
Shear Key 150 x 150 x 10 mm
Development Length 500 mm
Pedestal 450 x 450 x 1000 mm
50 mm Grout
Section
Base Plate and Anchor Bolt Detail



Pedestal 450X450X1000mm
12Ø @ 150 mm c/c Bothways
N.G.L
1000
50
550
50
200
2500
300
300
Section of Isolated Footing
2500
550
550
450
450
2500
Plan of Isolated Footing
Isolated Footing Detail

Chapter 7

Industrial Visit of P.E.B Ware house

7.1 General

This is the most important element. Industrial visit clears the practical vision of designer.

Various sites are visited during this major project like,

1) Zydus Ware house at matoda, SEZ, Ahmedabad

2) Shivam Estate Ware house, Sarkhej, Ahmedabad

3) Gujarat Exhibition hall, Ahmedabad

4) F.C.C unit, Mundra Port

5) Phenix Varco Prudent Fabrication Plant, Sanand

Two ware house are discretized below.

7.2 Zydus Ware house

The site is located at 20 km from Ahmedabad.

Purpose of this project is to manufacturing medicines.

7.2.1 Configuration of Ware house

- Width of building = 30 m
- Length of building = 113 m
- Portal Spacing = it varies from 5 to 7 m.
- Site Location = Special Economic Zone (SEZ) near Ahmedabad.
- Company = Zydus Technologies Ltd, Matoda, Ahmedabad.
- Purpose = manufacturing
- Architect = Doshi Consultant Pvt Ltd, Indore
- P.E.B Vendor = Everest Industries Limited
- Building is made up of R.C.C and the roof system is made up with
- pre-engineered technique.
- Intermediate column is inserted at 15 m.
- So two successive bays in 30 m width.
- Roof Profile = Pitched Roof

7.2.2 Description of Zydus Ware house

- In the snap two successive bays are seen.one bay of 15 m and another bay of 15 intermediate level. Taper column at intermediate level is seen. Typical rafter profile clearly seen in this snap as shown in fig7.1

- labours transfer the member from basement to first floor. With help of rod, angle welded at flange is pushed and member is transferred from one place to another as shown in fig7.1
- The figure shows that labours are erecting Z-purlin as shown in fig7.1

7.3 F.C.C Unit,Mundra Port

Purpose of this project is to loading and unloading of fertilizer
Fertilizers are imported to India through ship.
Indian Government gives 9 hrs. to loading fertilizer in the train at ware house which is very crucial otherwise fine good penalty
Sometime shortage of man power or chaos of man power Adani has planned to build F.C.C ware house totally equipped so no need for labours for loading and unloading.
Because of shortage of time Adani plan to build Pre-engineered F.C.C Ware house.
Devashish Interiors Pvt ltd is the P.E.B vendor

7.3.1 Configuration of Ware house

- Width of building = 24.5 m
- Length of building = 646 m
- Portal Spacing = 7.25 m.
- Site Location = Mundra Port
- Company = Mundra Port and Special Economic Zone Ltd.
- Purpose = Loading Fertilizer
- Architect = P.M.C Project Pvt Ltd.

- P.E.B Vendor = Devashish Interiors Pvt Ltd, Vadodara.
- Each Portal Spacing at intermediate distance Hoppers are installed.
- Single Bay of 25 m.
- Roof Profile = Pitched Roof

Drawing for the configuration of Ware-house is prepared.

7.3.2 description of Mundra Ware house

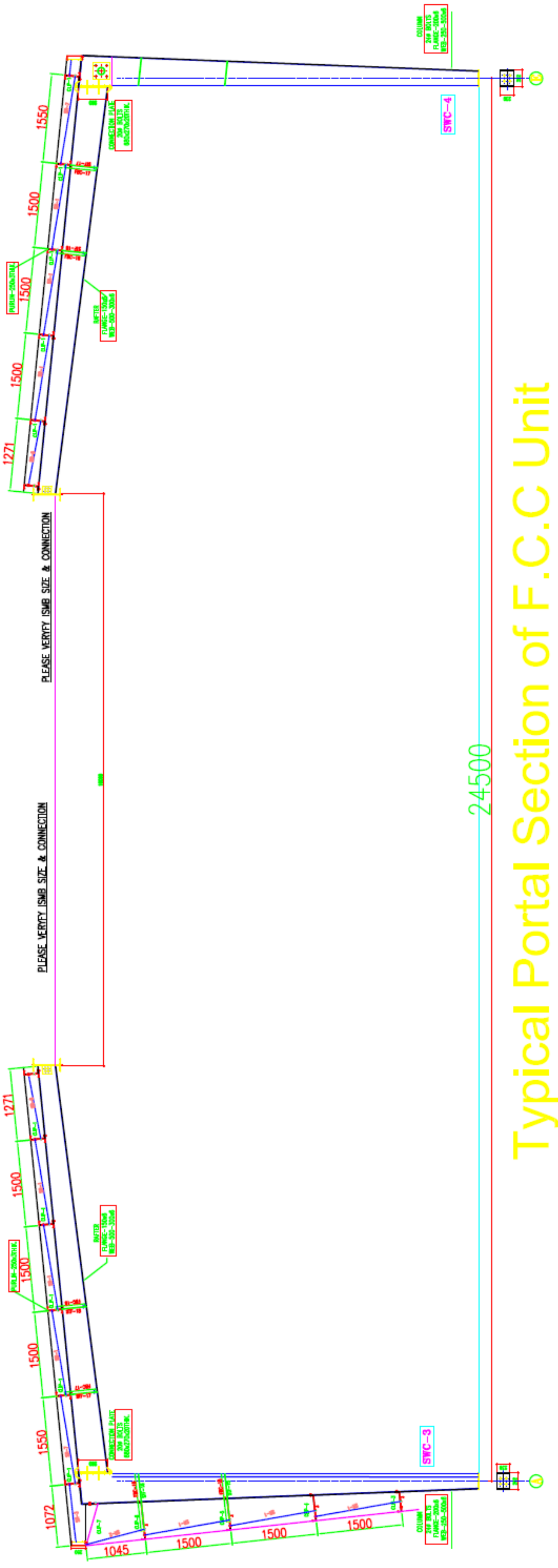
This snap shows Side view of Ware house. In-between hoppers are also seen. On other side road there is a railway track for loading as shown in fig7.2

24.5 m width P.E.B portal is seen in this snap. Pipe bracing used along length. Angle Section is used for Flange bracing. Structural arrangement for hopper is also seen in snap.fig7.2

Pipe Section used as bracing.in the connection plate is used.it breaks all four pipes in equal length. Cladding runner Z-250X60X20X3.15 is used. Flange bracing also seen in snap.fig7.2

7.4 Summary

Various Industrial P.E.B ware house sites are visited. Practical Vision towards P.E.B is clear by this visits. similarity in both discretized ware houses is that client had very less time and P.E.B vendor have to built P.E.B ware house within this short time. This is the Effectiveness of P.E.B Ware house.



Typical Portal Section of F.C.C Unit
24500
PLEASE VERYFY ISMB SIZE & CONNECTION
PLEASE VERYFY ISMB SIZE & CONNECTION
SWC-4
SWC-3
1550
1500
1500
1500
1271
1271
1500
1500
1500
1550
1072
1045
1500
1500
1500

Figure 7.1: Front View of the Building (30m), Transport the section to required location, Placing the Z-Purlin on Rafter

Figure 7.2: Side View of F.C.C ware house, Portal Section, Portal Bracing

Chapter 8

Summary and Conclusion

8.1 Summary

• Pre-engineered building are steel buildings wherein the framing members and other components are fully fabricated in the factory after designing and brought to the site for assembly, mainly by nut-bolts, thereby resulting into a steel structure of high quality and precision.

• Steel is a preferred material for construction, due to its various advantages like quality, aesthetics, economy and environmental conditions. This concept can have lot of scope in India, which can actually fill up the critical shortage of housing, educational and health care institutions, airports, railway stations, industrial buildings & cold storages etc. 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. The major advantage of metal building is the high speed of design and construction for buildings of various categories. Pre-engineered building growing rapidly in India.

• In present study Conventional Portal Ware house is compared with P.E.B ware house to check in which case it achieve the economy in steel quantity. Ware house is model, analysis and design by STAAD Pro.2006. To compare the results configuration of ware house remain same. Design is done based on IS-800 in STAAD. Yield Stress of Steel assumes 540 Mpa in P.E.B ware house. Yield Stress of Steel assumes 250 Mpa in Conventional Portal ware house. Application of loading remains same in both cases. D.L, L.L, Wind X (Cpe±Cpi), Wind -X (Cpe±Cpi), Wind Z (Cpe±Cpi), Wind -Z (Cpe±Cpi) cases considered in modeling. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Comparison of analysis result for different cases is conducted. Steel quantity is observed in both cases.

• Spacing of P.E.B portal vary to check in which case it achieve the economy in steel quantity. Ware house is model, analysis and design by STAAD Pro.2006. Configuration of ware house remain same only spacing of portal is vary from 4.5 m, 6 m, 7.5 m, 9 m. Design is done based on IS-800 in STAAD. Yield stress of steel assumes 540 Mpa in all cases. D.L, L.L, Wind X (Cpe±Cpi), Wind -X (Cpe±Cpi), Wind Z (Cpe±Cpi), Wind -Z (Cpe±Cpi) cases considered in modeling. Application of loading remains same in all cases. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Comparison of analysis result for different cases is conducted.

• Width of P.E.B portal vary to observe structural behavior of ware house. Ware house is model and analyze by STAAD Pro.2006. Configuration of ware house remains same only width of portal is vary from 25m two bay and 50 m one bay. Yield stress of steel assumes 540 Mpa in all cases. Application of loading remains same in all cases. Analysis result observed for base reaction, column moment, rafter moment, displacement at ridge, displacement at midspan. Comparison of analysis result for different cases is conducted.

• In present Study manually one ware house is design based on analysis result. Footing, Pedestal, Base Plate, Taper Column, Taper Rafter, End Plate Connection, Purlin with Sag Rod, Purlin Without Sag Rod, Bracing are design through Excel Worksheet. Industrial Visit to P.E.B ware house is conducted in present study.
1) Zydus Ware house at matoda, SEZ, Ahmedabad
2) Shivam Estate Ware house, Sarkhej, Ahmedabad
3) Gujarat Exhibition hall, Ahmedabad
4) F.C.C unit, Mundra Port
5) Phenix Varco Prudent Fabrication Plant, Sanand

8.2 Conclusion

Analysis of pre-engineered structure is more or less same as typical industrial structure. The difference is that the section gets taper based on bending moment diagram. For secondary members cold form members are used which reduce the weight of structure reduced. In the pre-engineered structure built up sections are prepared with higher grade of steel like 310,510,540 Mpa. So section size get reduced. Due to this reasons material consumption gets reduced compare to conventional structure.

Based on the study carried out in this report the following conclusions can be drawn.

- Modeling, Analysis and Design is carried out to compare conventional ware house to P.E.B ware house
  - After analysing it observes that base reaction increase from Conventional Ware house to P.E.B Ware house.

- P.E.B warehouse gives lesser moment, shear and axial forces compare to Conventional Portal Method in column at beam column junction.

- P.E.B warehouse gives lesser moment, shear and axial forces compare to Conventional Portal Method in rafter at midspan.

- P.E.B warehouse gives lesser displacement at ridge and midspan compare to Conventional Portal Method.

- Steel quantity is primarily depending on primary members and purlins. In conventional ware house uniform primary section is used while in P.E.B ware house tapper section is used. In Conventional ware house hot rolled used as purlin while in P.E.B ware house cold formed section used as purlin. This two are the major points to reduce the weight of ware house. For the primary members, P.E.B ware house has reduced weight by 70%. For the purlin members, Conventional Ware house has 59% more weight compare to P.E.B ware house. Total steel quantity for P.E.B ware house is 22.36 kg/smt. Total steel quantity for Conventional Ware house is 42.56 kg/smt. Conventional method ware house has 47% more Steel quantity compare to P.E.B ware house. So P.E.B ware house is economical compare to conventional ware house.

• Different P.E.B Warehouse has been analyzed keeping same configuration of warehouse only changing the spacing of portal. Spacing of portal is varying from 4.5 m, 6 m, 7.5 m and 9 m.

  - After Analyzing it observes that base reaction for different load cases increase as spacing of portal increased. Value of reaction is gradually increased.

- At beam column junction, Moment in column observed is increased. But increment of moment is gradually decreased as spacing of portal increased. Vertical shear observed in Portal is also increased.

- Moment at midspan of rafter is increased as spacing of portal increased moment. Shear Force at midspan of rafter is increased as spacing of portal increased.

- Displacement at midspan of rafter is less comparing to ridge. Maximum displacement is observed in wind-z case. Among all the four cases maximum displacement at midspan of rafter is observed in Portal Spacing of 6 m.

- Steel quantity is primarily depending on primary members and purlins. As spacing of portal increased steel consumption is decreased for primary members. The decrement is 15% for Portal Spacing of 4.5 m to Portal Spacing of 6 m. It decreased by 12.4% for Portal Spacing of 6 m to Portal Spacing of 7.5 m.it decreased by 8% for Portal Spacing of 7.5 m to Portal Spacing of 9 m. But quantity of steel for purlin is gradually increased.it increased by 21% for Portal Spacing of 4.5 m to Portal Spacing of 6 m.it increased by 15% for Portal Spacing of 6 m to Portal Spacing of 7.5 m.it increased by 25% for Portal Spacing of 7.5 m to Portal Spacing of 9 m. So one side steel quantity for primary member is decreased and steel quantity for purlin is increased as spacing of portal increased. For total steel consumption of P.E.B ware house, Portal Spacing of 7.5 m have lesser steel consumption compare to other cases. Total steel quantity for Portal Spacing of 7.5 m is 29.66 kg/smt. Portal Spacing of 4.5 m has 9% more steel consumption than Portal Spacing of 7.5 m. Portal Spacing of 6 m and Portal Spacing of 9 m has 3.5% more steel consumption than Portal Spacing of 7.5 m. So among this spacing of ware house 7.5 m Portal spacing is economical.

- Two P.E.B warehouse has been analyzed keeping same configuration of warehouse only changing the width of portal. Width of one portal kept 25 m but it has two bays. So total width of ware house is 50 m. In second Ware house 50 m width is kept but internal column is provided to support the ridge. STAAD Pro.2006 is used to modeling and analyzing the ware house.

  - After analysing it observes that base reaction of external column in case 25 m width two bay ware house is more compare to 50 m width one bay ware house.
  - External Column moment at junction, Shear Force, is more in 50 m width one bay ware house compare to 25 m width two bay ware house.
  - In Rafter Moment, Shear Force, Axial Force is more in 50 m width one bay ware house compare to 25 m width two bay ware house.
  - Displacement at midspan rafter is more in 50 m width one bay ware house compare to 25 m width two bay ware house. So 25 m width two bay ware house is economical compare to 50 m width one bay ware house.

8.3 Future Scope

The study in this report is limited to P.E.B Ware house. The present study can be extended to include following aspects.

- P.E.B Technique should be used for Multistory Building.so analysis and design and detailing of such a multistory building can be done.

- P.E.B ware house with crane system, with Gantry girder system can be Analyzed.

- P.E.B System is used in Air-craft hangers.so present study can be extended to that part.

- P.E.B design carried out for Car Parking
- P.E.B design can be carried out for Auditorium.
- P.E.B System use built up sections as primary members it can be further extended to such different section which is economical and have good inertia.
- Present Study can be extended towards the proper detailing of each minute element.

Appendix A

List of Useful Web Sites

- www.sciencedirect.com
- www.asce.com
- www.extremeloading.com
- www.pdf-search-engine.com
- www.zamilsteel.com
- www.everestind.com
- www.eragroup.co.in
- www.scia-online.com
- www.kirbysteel.com
- www.smlpeb.com

Appendix B

List of Paper Present

Presentation Topic:-“Pre-engineered Structure for Ware house”

S.N.Patel Seminar-2010,Department of Civil Engineering,

Birla Vishvkarma Vidyalaya,Vidyanagar.

7 January 2010.

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