International
Journal
Of Advanced Research in Engineering & Management (IJAREM)
ISSN: 2456-2033 || PP. 43-65

Analysis and Design of Pre - Engineered Building for Vehicle Parking Shed

[1]Dr. S. Vimala, [2]Vijayalakshmi. A, [3]Anitha.V, [4]Idhayaarasi.G, [5]Amaravathi. V, [6]Birundha Devi. M

[1]M.E., Phd. Professor, Dept. of Civil Engineering
PSNA College of Engineering and Technology, Dindigul
[2,3,4,5,6]Student
PSNA College of Engineering and Technology, Dindigul

Introduction

1.1 GENERAL

India being a developed country massive house building construction is taking place in various parts of the country. Since 30% of Indian population lives in towns and cities, hence construction is more in the urban places. The requirement of housing is tremendous but there will always be a shortage of house availability as the present masonry construction technology cannot meet the rising demand every year. Hence one has to think for alternative construction system for steel or timber buildings, but timber is anyway not suitable to tropical countries like India.

1.2 CONCEPT OF PRE ENGINEERED BUILDING

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

In pre-engineered building concept the complete designing is done at the factory and the building components are brought to the site in CKD (Completely Knock Down condition). These components are then fixed / jointed at the site and raised with the help of cranes. The pre-engineered building calls for very fast construction of buildings and with good aesthetic looks and quality construction. Pre-engineered buildings can be used extensively for construction of industrial and residential buildings. The buildings can be multi storied (4-6 floors). These buildings are suitable to various environmental hazards. An efficiently designed pre-engineered building can be lighted than the conventional steel buildings by up to 30%. Lighter weight equates to less steel and a potential price savings in structural form work.

1.3ADVANTAGES OF PRE ENGINEERED BUILDING

- Reduction in Construction Time
- Lower Cost
- Flexibility of Expansion
- Larger Spans
- Quality Control
- Low Maintenance
- Energy Efficient Roofing and Wall systems
- Architectural Versatility

1.4BENEFITS OF PRE ENGINEERED BUILDING

- Easy future expansion/modification
- Weather proof and fire hazards

- Optimized design of steel reducing weight
- International quality standards
- Seismic & wind pressure resistant
- Quality design, manufacturing and erection, saving around 30-40% of project time
- Quick delivery and Quick turn-key construction
- Erection of the building is fast
- The building can be dismantled and relocated easily
- Suitability for hilly regions and other geographically difficult areas

1.5APPLICATIONS OF PREENGINEERED BUILDING

Almost every conceivable building use has been achieved with PEB; the most common applications are industrial, institutional and commercial.

In India, Pre-engineered building systems find applications primarily in the construction of Warehouses, & Industrial sheds & Buildings. The recent focus has also shifted to cover rural as well as urban, individual and mass housing project, farm houses, slum re-organisation projects and rehabilitation projects, amenity structures like health centres, kiosks, primary schools, panchayatghars etc.

Applications of Pre Engineered steel buildings include

- House & Living Shelters
- Factories
- Warehouses
- Sport halls (Indoor and Outdoor)
- Aircraft Hangers
- Supermarkets
- Workshops
- Office Buildings
- Labour Camps
- Petrol Pumps/Service Buildings

Table1.1 Comparsion of Pre Engineered Building and Conventionl Building

Properties	**Pre- engineered building**	**Conventional building**
Design	Requires specialized computer design	Requires heavy detailing with modification
Structural weight	Efficient use of steel at different components of section which reduces the weight from 20% - 40%	Conventional steel section are used which are heavier than pre engineered section
Erection	Pre casted sections are designed as per the site necessity	Sections are need to be modified as per site condition
Performance	Higher performance due to efficient bracing system	Faulty connections may leads to poor performance
Safety and responsibility	Order is fulfilled by a single supplier leads o better management of materials and section	Multiple supplier units results in inefficient management of building materials and sections
Economy	Economical in terms of erection time and economy	Economical in terms of cost but uneconomical in terms of erection time

Component of Pre-Engineered Building

- Primary components
- Secondary components
- Sheeting (or) cladding

2.1 PRIMARY COMPONENTS

Main framing:

Main framing basically includes the rigid steel frames of the building. The PEB rigid frame comprises of tapered columns and tapered columns and tapered beam (the fabricated tapered sections are referred to 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.

All rigid frames shall be welded built-up "I" sections or hot rolled sections. The columns and the rafters may be either uniform depth or tapered. Flanges shall be connected to webs by means of a continuous fillet weld on one side. All end wall roof and end wall columns shall be cold- formed "C" sections, mill-rolled sections, or built-up "I" sections depending on design requirements. Plates, Stiffeners, etc. all base plates splice plates, cap plates, and stiffeners shall be factory welded into place on the structural members.Built-up I section to build primary structural framing members (Columns and Beams)

Columns:

The main purpose of the columns is to transfer the vertical loads to the foundations. However a part of the horizontal actions (wind action) is also transferred through the columns.

Basically in pre-engineered buildings columns are made up of I sections which are most economical than others. The width and breadth will go on increasing from bottom to top of the column. I section consists of flanges and web are made from plates by welding.

Tapered beams:

A tapered beam is one of series of sloped structural members (beams) that extend from the ridge or hip to the wall-plate down slope perimeter or eave, and that are designed to support the roof deck and its associated loads.

2.2 SECONDARY COMPONENTS

Purlins:

Purlins shall be roll formed Z sections, 200 mm deep with 64 mm flanges shall have a 16 mm stiffening lip formed at 45 to the flange. Purlins and girts shall be cold-formed "Z" sections with stiffened flanges. Flange stiffeners shall be sized to comply with the requirements of the latest edition of AISC. Purlin and girt flanges shall be unequal in width to allow for easier nesting during erection. They shall be pre punched at the factory to provide for field bolting to the rigid frames. They shall be simple or continuous span as required by design. Connection bolts will install through the

2.3 SHEETING OR CLADDING

The sheets used in the construction of pre-engineered buildings are composed of the following:

Base metal of either Galvalume coated steel conforming to ASTM B 209M. Galvalume coating is 55% Aluminium and about 45% Zinc by weight. An exterior surface coating on painted sheets of 25 microns of epoxy primer with a highly durable polyester finish.

An interior surface coating on painted sheets of 12 microns of epoxy primer and modified polyester or foam. The sheeting material is cold-rolled steel, high tensile 550 MPA yield stress, with hot dip metallic coating of Galvalume sheet.

Vehice Parking Shed

3.1 Introduction

A Vehicle parking shed is opened structure to hold the bikes, cars, in a protective storage. The main speciality of these vehicle parking shed is they consists of tapered steel beams, steel, columns, purlins. A pre-engineered vehicle parking shed is the perfect solution for safe, secure and storage of all bikes and cars.

Area of Vehicle parking shed is 928.93m^2.First half of distance is allotted for parking cars, and the second half of the distrance is allotted for bike. Its very free space to turn and parking all the vehicles in a free manner. No disturbance and traffic occurred while entry and exit of vehicles in a peak hour.

The pre-engineered building market is very homogeneous. Although most metal buildings may look the same from outside, unless you really inspect each manufacturers product, it will be difficult to determine the quality differences between products. As with most purchases, it pays to understand the differences. Once the product (tapered steel beam, steel columns, purlins, base plate, end plate) is made, any sacrifice in quality becomes apparent and lives on throughout the life of the product. Making the right choice returns dividends for many years through reliability, product longevity and ease of operation.

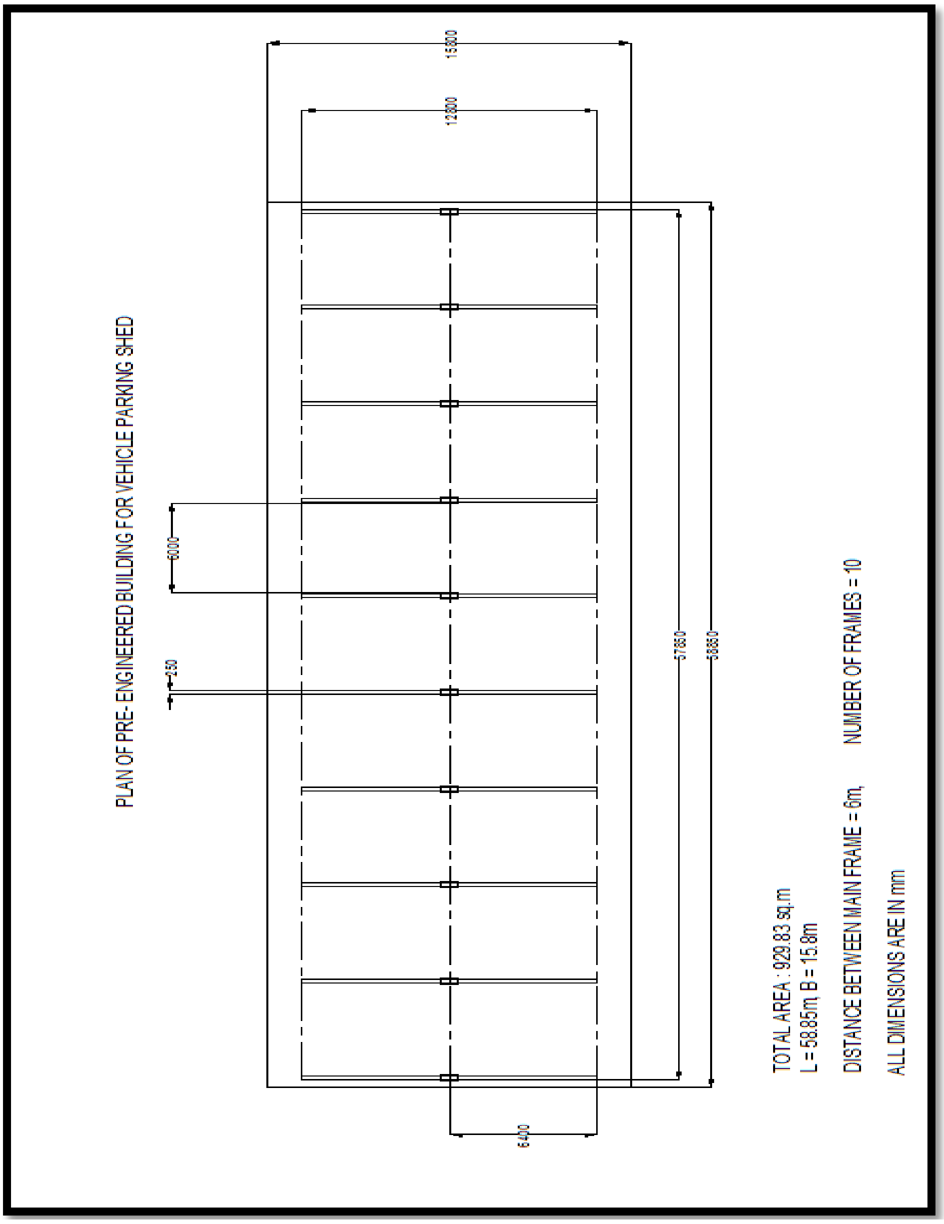

Figure 3.1 Plan of Pre Engineered Building for Vehicle Parking Shed

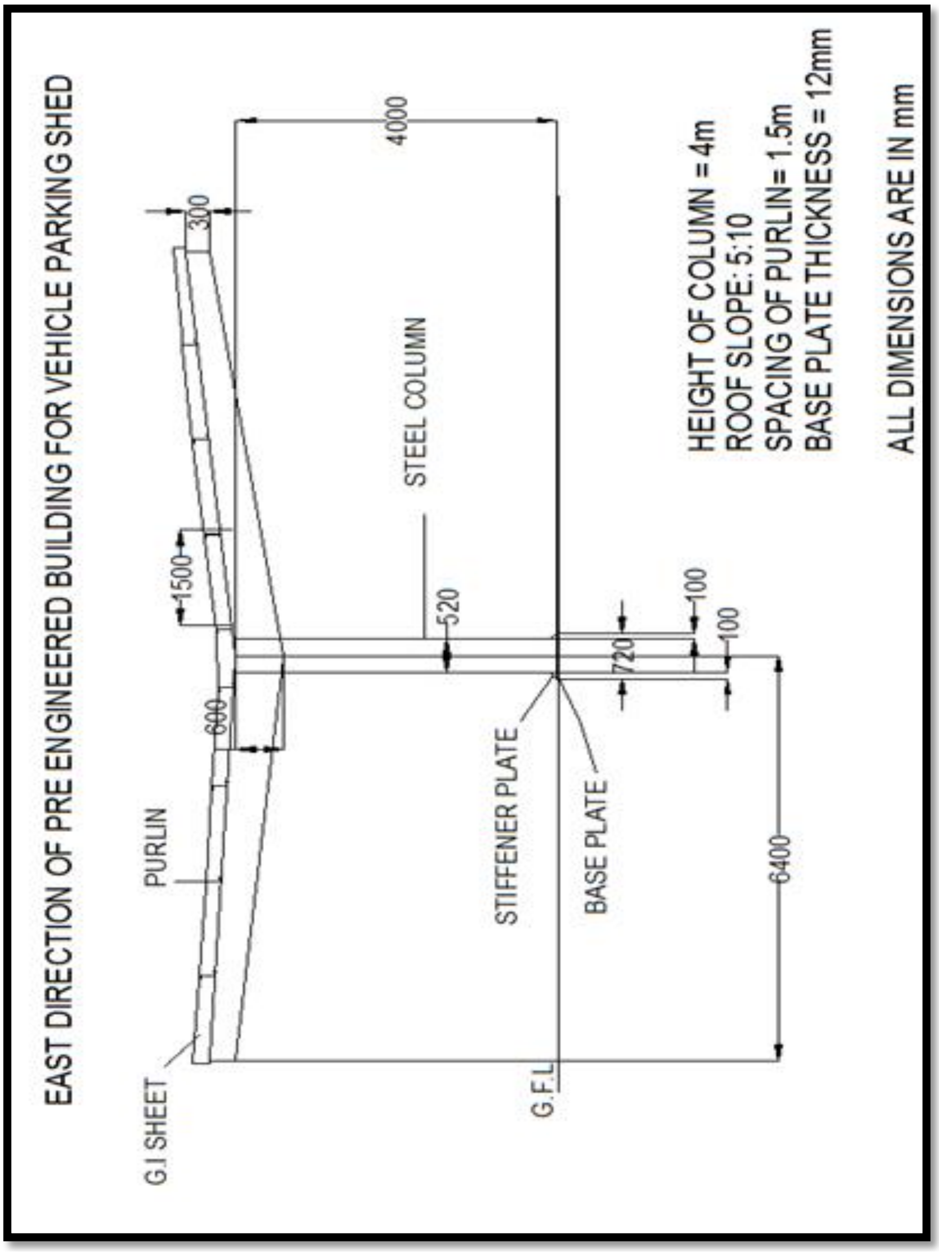

Figure 3.2 East Direction View of Pre Engineered Building for Vehicle Parking Shed

Analysis of a Vehicle Parking Shed

4.1 Main Frame Design Load Calculation

Table4.1 Properties of the Member of Frame:

Member No.	Depth of start node (mm)	Depth of end node (mm)	Width of flange (mm)	Thickness of flange (mm)	Thickness of web (mm)
1	624	324	250	5	12
2	624	324	250	5	12
3	520	520	200	5	10

DEAD LOAD: (referIS 875 – 2000 PART 1)
Self weight of G.I sheet = 0.12kN/m^2
Dead load D.L = 0.12 X 6 = 0.72kN/m^2
LIVE LOAD: (referIS 875 – 2000 PART 2)
Live load = 0.75kN/m^2
= 0.75 X 6 = 4.5kN/m
COLLATERAL LOAD:
Collateral load = 0.2 X 6 = 1.2kN/m

WIND LOAD: (refer IS 875 – 2000 PART3)
Basic wind velocity = V_b =39m/s(Zone II)
Risk coefficient, k1= 1
Terrain factor, k2 = 1.05
Topography factor, k3= 1.36
Calculation of wind speed, Vz= V_b X k1 Xk2 Xk3
= 39 X1 X 1.05 X1.36
= 55.692m/s
Calculation of design wind pressure (pd)= 0.6 Vz^2 = 0.6 X 55.6922
= 1.8kN/m^2
Coefficient of air pressure, C_p= 0.9
CALCULATION OF WIND LOAD:
Wind load = C_p X pd X A = 0.9 X1.8 X4 X 13 = 81kN
Wind load per unit length = 81/2 =13.5kN/m
LOAD COMBINATION:
LOAD COMBINATION OF STRENGTH
1. 1.5 DL + 1.5 CL + 1.5 LL
2. 1.5 DL + 1.5 CL + 1.5 WLP
3. 1.5 DL + 1.5 CL + 1.5 WRP
4. 1.5 DL + 1.5 CL + 1.5 WLS
5. 1.5 DL + 1.5 CL + 1.5 WRS
6. 1.5 DL + 1.5 CL + 1.5 WPP
7. 1.5 DL + 1.5 CL + 1.5 WPS
8. 1.5 DL + 1.5 CL + 1.5 EQ1
9. 1.5 DL + 1.5 CL + 1.5 EQ2
10. 0.9 DL + 0.9 CL + 1.5 WLP
11. 0.9 DL + 0.9 CL + 1.5 WRP
12. 0.9 DL + 0.9 CL + 1.5 WLS
13. 0.9 DL + 0.9 CL + 1.5 WRS
14. 0.9 DL + 0.9 CL + 1.5 WPP
15. 0.9 DL + 0.9 CL + 1.5 WPS
16. 0.9 DL + 0.9 CL + 1.5 EQ1
17. 0.9 DL + 0.9 CL + 1.5 EQ2
18. 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WLP
19. 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WRP
20. 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WLS
21. 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WRS
22. 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WPP
23. 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WPS
24. 1.2 DL + 1.2 CL + 1.2 LL + 0.6 EQ1
25. 1.2 DL + 1.2 CL + 1.2 LL + 0.6 EQ2
26. 0.9 DL + 0 CL + 1.5 WLP
27. 0.9 DL + 0 CL + 1.5 WRP
28. 0.9 DL + 0 CL + 1.5 WLS
29.0.9 DL + 0 CL + 1.5 WRS

30. 0.9 DL + 0 CL + 1.5 WPP
31. 0.9 DL + 0 CL + 1.5 WPS

LOAD COMBINATION OF SERVICEABILITY

1. 1 DL + 1 CL + 1 LL
2. 1 DL + 1 CL + 1 WLP
3. 1 DL + 1 CL + 1 WRP
4. 1 DL + 1 CL + 1 WLS
5. 1 DL + 1 CL + 1 WRS
6. 1 DL + 1 CL + 1 WPP
7. 1 DL + 1 CL + 1 WPS
8. 1 DL + 1 CL + 1 EQ1
9. 1 DL + 1 CL + 1 EQ2
10. 1 DL + 1 CL + 0.8 LL + 0.8 WLP
11. 1 DL + 1 CL + 0.8 LL + 0.8 WRP
12. 1 DL + 1 CL + 0.8 LL + 0.8 WLS
13. 1 DL + 1 CL + 0.8 LL + 0.8 WRS
14. 1 DL + 1 CL + 0.8 LL + 0.8 WPP
15. 1 DL + 1 CL + 0.8 LL + 0.8 WPS
16. 1 DL + 1 CL + 0.8 LL + 0.8 EQ1
17. 1 DL + 1 CL + 0.8 LL + 0.8 EQ2

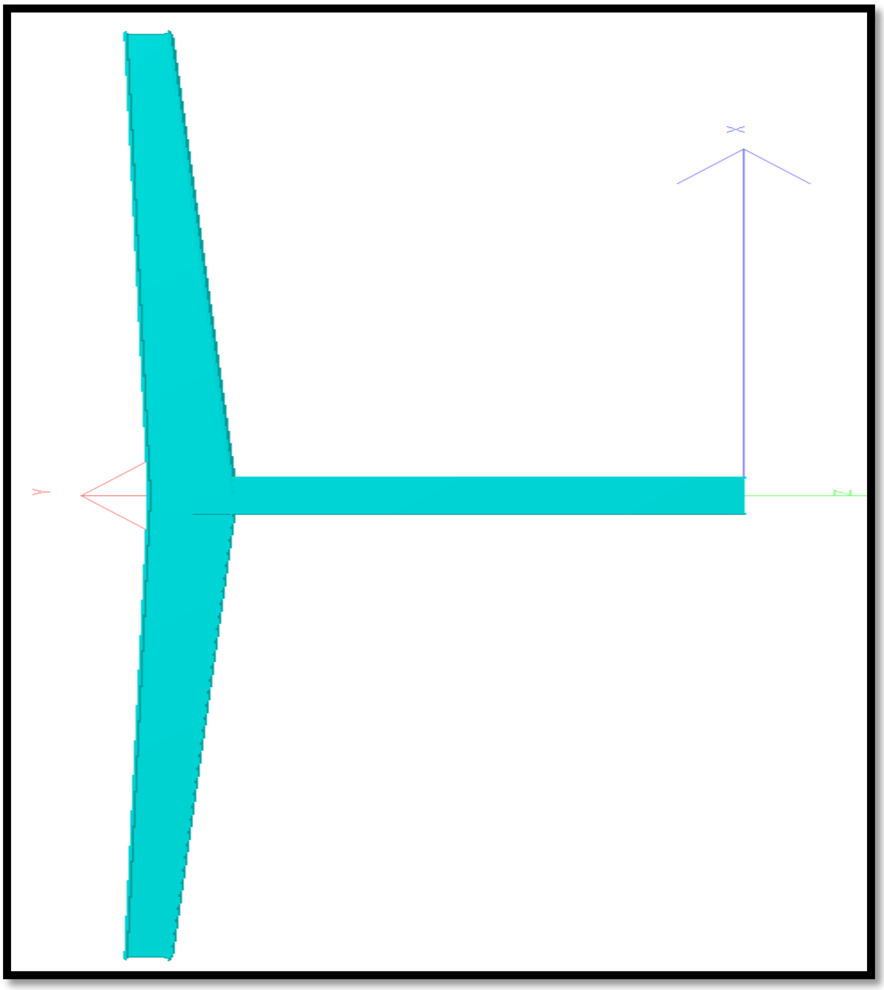

Figure 4.1 3d Modelling of Vehicle Parking Shed

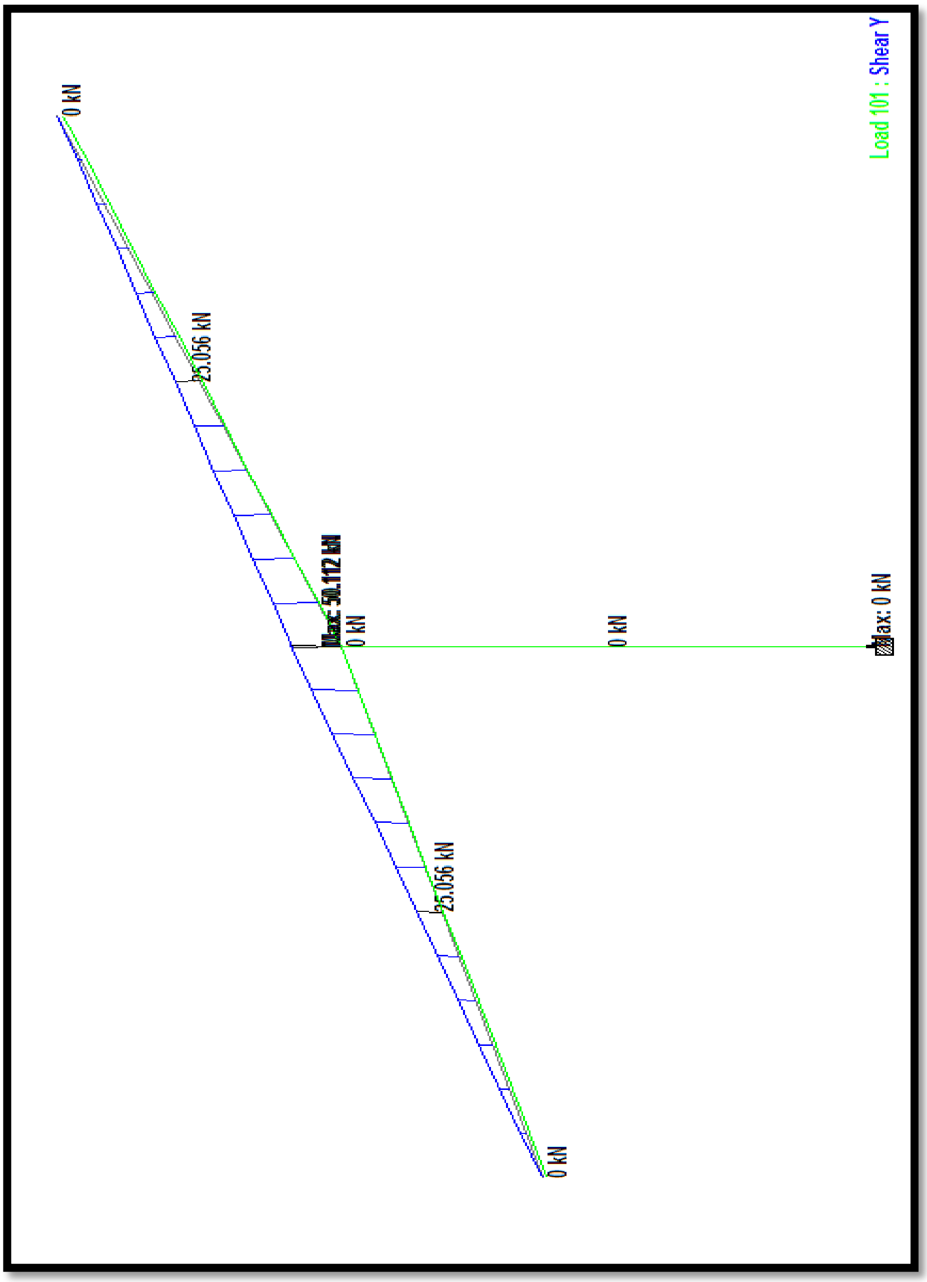

Figure 4.2 Shear Force Diagram

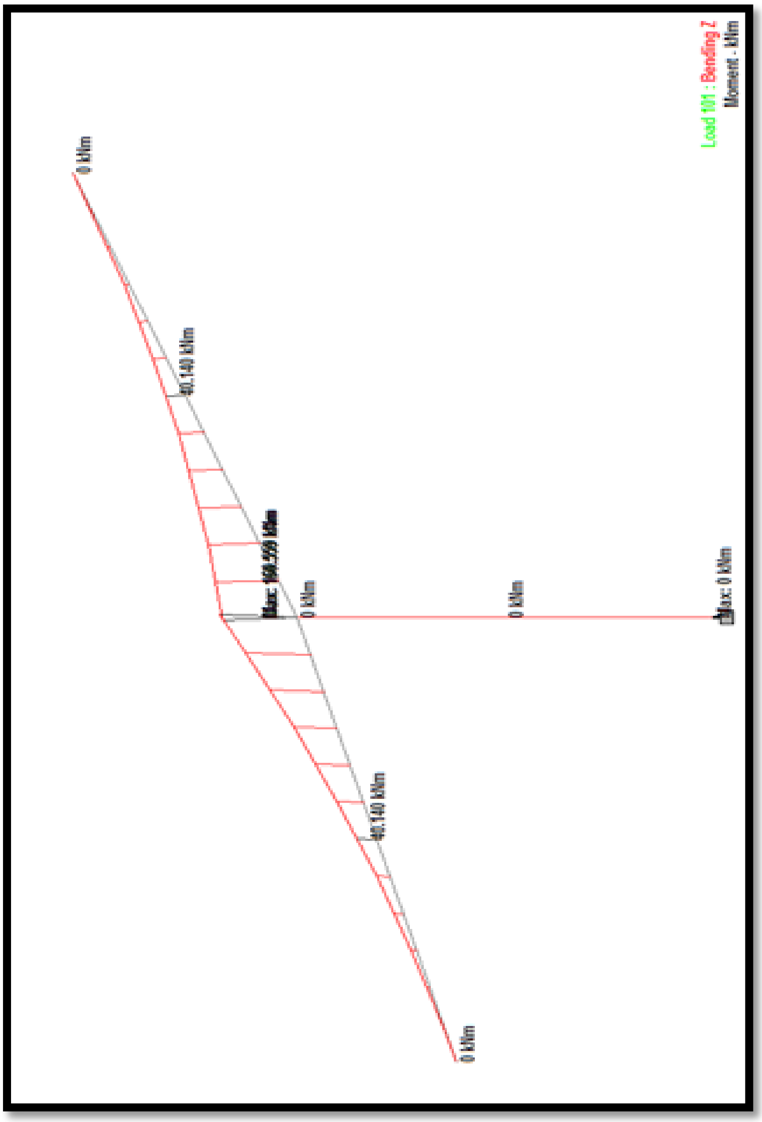

Figure 4.3 Bending Moment Diagram

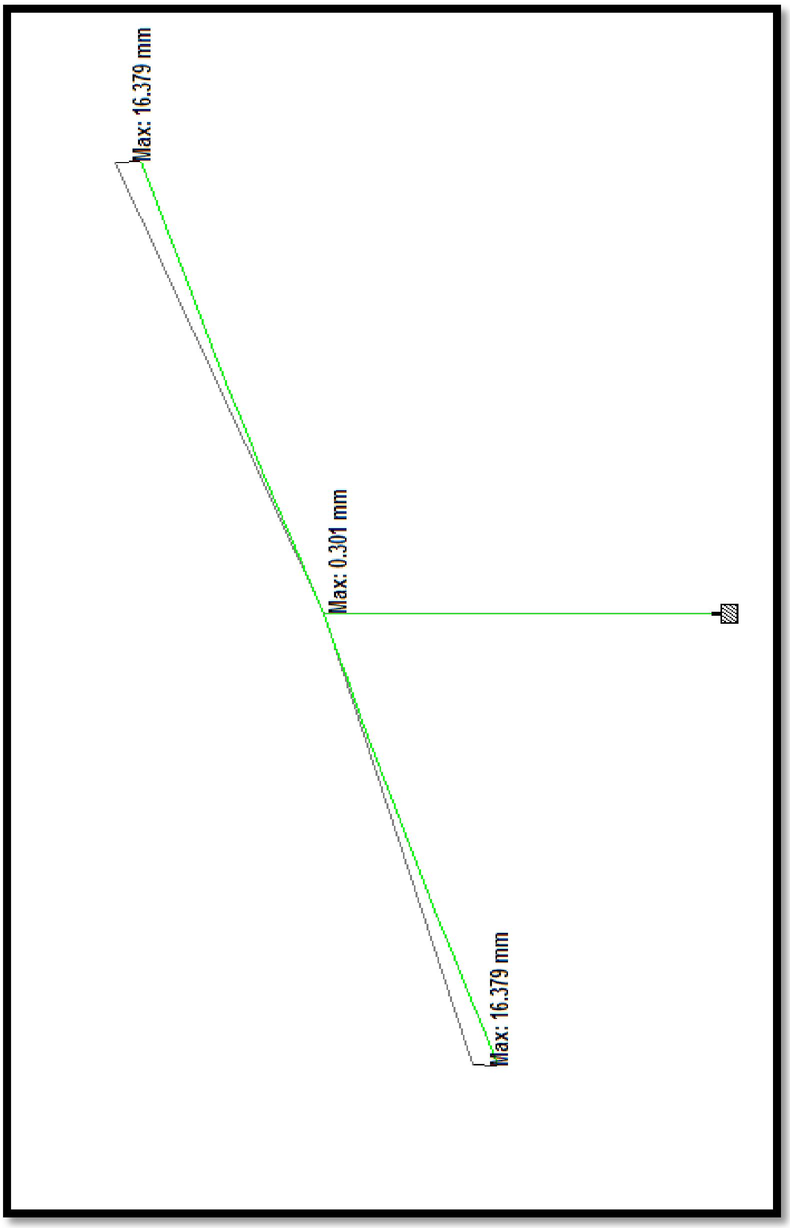

Figure 4.4 Deflection Diagram

4.2 DESIGN OF COLD FORMED Z – PURLIN

Spacing of purlin = 1.5m
Roof slope = 5:10
Distance between main frame = 6m

DEAD LOAD (refer IS 875 – 2000 PART – 1):

Unit weight /m of sheeting= 0.12kN/m^2
= 0.12 x 1.5 = 0.18kN/m
Self weight of Purlin = 0.07kN/m
Total Dead load per metre on each purlin = 0.07 + 0.18 = 0.25kN/m

LIVE LOAD (referIS 875- 2000 PART – 2):
Live load intensity on purlin = 0.75kN/m^2
Total live load per metre on each purlin = 0.75 X 1.5 = 1.125kN/m

WIND LOAD(refer IS 875 – 2000 PART – 3):
Maximum wind load per metre on each purlin = (1+0.2) X 1.161 X 1.5
= 1.62kN/m

PROPERTIES OF Z SECTION (refer BS: 5950 PART 5 -1998):
Area = 8.37 m^2
Thickness t = 2.5mm
w= 6.57kg/m
Ixx = 439cm^4
Iyy = 58.4 cm^4
Zxx = 46.21cm^3
Zyy = 10.01cm^3

OVER ALL DEPTH:
190mm < 100t=100(2.5)
190mm < 255mm
Hence ok

OVER ALL WIDTH OF COMPRESSION FLANGE AND THICKNESS:
B/t < 35
60/2.55 = 23.52mm < 35mm
Hence ok
Width of lip > B/5
20mm > 60/5
20mm >12mm
Check the above section based on IS 801 – 1975
w/t = (60 – 2X 2.55)/2.55 = 21.52
Minimum over all depth required as cl.No. 5.2.2.1 of IS 801 – 1975

$$= 2.8t\sqrt[6]{(w/t)^2 - 281200/fy}$$

fy = 3450 kg/cm^2

$$= 2.8 \text{ X } 2.55\sqrt[6]{}\text{ X}\sqrt{21.52^2 - 281200/3450}$$

= 14.9 = 15mm < 20mm
4.8 t = 4.8 X 2.55 = 12.24 < 15mm
Hence ok

CALCULATION OF EFFECTIVE DESIGN WIDTH OF COMPRESSIVE ELEMENT (refer Cl.NO. 5.2.2.1 OF IS 801 – 1975):
w = 60 – 2(2.55) = 54.9mm

$$(w/t)_{lim} = \frac{1435}{\sqrt{f}}$$

f = 0.75 X 1600kg/cm^2

$$= \frac{1435}{\sqrt{0.75 \text{ X}1600}}$$

= 41.4 X 2.55= 105.57mm
105.57 > 54.9

Hence ok

CHECK FOR DEFLECTION (refer BS 5950PART 5 -1998):

a) Permissible deflection due to live load on purlin as per BS 5950
δ permissible = Span / 240 = 6000/240 = 25mm
Load due to live load = 1.125 X 6 = 6.75kN

b) Calculate deflection due to live load on purlin
$\delta = 5wl^3/384EI$
$= \dfrac{5 \times 6.75 \times 10^3 \times 6000^3}{384 \times 2 \times 10^5 \times 439 \times 10^4}$
= 21.6mm < 26.04mm
Hence found safe when checked for deflection

c) Calculate for shear stress in web referring cl.No. 6.4 of IS 801 -1975
h = 190 – (2 X2.55) = 178.9mm
h/t = 178.9/2.55 = 70.15
4590/fy = 4590/3450 = 78.14 > 70.15
Hence maximum average permissible shear stress
fv = 1275 X fy/(h/t)= 1275 X fy/70.15
fy = 0.4 fy = 0.4 X 3450 = 1380 kg/cm^2
fv = 1275 x 1380/70.15 = 67.51N/mm^2
Actual shear stress for Dead load + wind load = 1.87kN/m
Actual shear stress = (1.87 X 10^3 X 6)/(178 X 2.55) = 24.71N/mm^2
= 24.71N/mm^2< 67.51N/mm^2
F_v = 67.51 X 1.33 = 89.78MPa

CHECK FOR COMBINE SHEAR(refer to cl No. 6.4.2 and 6.4.3 of IS 801 – 1975
$F_{bw} = 36560000/(h/t)^2 = 36560000/70.15^2 = 742.39$N/mm^2
F = 0.6 X 3450 = 2076 kg/cm^2 = 207 N/mm^2
$\sqrt{(f_{bw}/F_{bw})^2 + (f_v/F_v)^2} < 1$
$F_{bw} = M/Z_{xx} = 5.84 \times 10^6/46.21 \times 10^3 = 126.37$ N/mm^2
126.37/207 2 + 24.71/89.78 2 < 1
0.66 <1
Hence safe

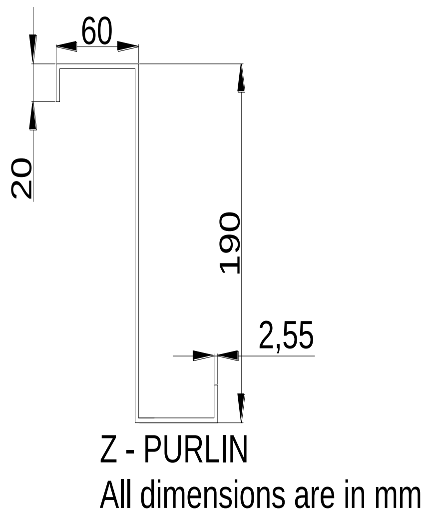

Figure 4.5 Cold Formed Z - Purlin

Design of Connections

5.1 DESIGN OF COLUMN BASE PLATE CONNECTION

BUILT UP I-SECTION COLUMN:

Depth of the I- Section = 520mm
Thickness of the web t_w = 5mm
Thickness of the flange t_f = 10mm
Width of the flange b_f = 200mm
Adopt M25 concrete, Fe410 grade steel
Axial load = 100kN

CALCULATE THE BEARING STRENGTH OF CONCRETE:

Bearing strength of concrete = 0.45 X 25
= 11.25N/mm^2

Assume Projection = 100mm will be on each side

CALCULATE THE EDGE DISTANCE:

Diameter of the bolt = 20mm
e = 1.5d = 1.5X20 = 30mm

NUMBER OF BOLT:

Provide 8 number of bolt 20mm diameter, 300mm long anchor bolt to connect the base plate to the foundation of concrete

CHECK THE REQUIRED AREA OF BASE PLATE:

Base plate size = 720 X 400mm = 2,88,000mm^2
Factor load = 1.5 X 100 = 150kN

Required area of base plate $= \dfrac{150 \text{ X } 10^3}{11.25}$

$= 13{,}333\text{mm}^2$

13,333 mm^2< 2, 88, 000mm^2

Hence ok

CALCULATE THE THICKNESS OF BASE PLATE:

$W = P/A = \dfrac{150 \text{ X } 10^3}{720 \text{ X } 400}$

W = 0.52kN/mm^2

$$ts = \sqrt{\left[\frac{2.5W(a^2-0.3b^2)\gamma_{mo}}{fy}\right]}$$

$$ts = \sqrt{\frac{2.5X0.52X(100^2-0.3(100^2)X1.1}{250}}$$

ts = 6mm
Flange thickness = 10mm
Thickness of base plate greater than flange thickness, so adopt thickness of base plate is 12mm

WELD CONNECTING BASE PLATE TO COLUMN:

Use a 6mm fillet weld all round the column section to hold the base plate in place
Total length available for welding = 2(200 +400 – 5 – 10 + 520)
L = 2200mm

CALCULATE THE STRENGTH OF WELD:

Strength of weld = $f_{\omega n} = \dfrac{\sqrt{fu}/3}{\gamma_{m\omega}} = \dfrac{\sqrt{4103}}{1.25}$

= 189 N/mm^2

After deducting end returns of the weld, at the rate of two times the size of weld at each end ,
L_{eff} = 2200 – 2 X 2 X 6 X 6 = 2056mm
Capacity of weld = 0.7 X6 X 189 = 0.7938kN/mm
Required length of weld = 150/0.7938 = 188.96mm
188. 96mm < 2056mm
Hence a 6mm weld is adequate
This is a fillet weld on the edge and not on the rounded ends of the member
Provide stiffener plate on each side of the column, adopt 100mm and 50mm depth of the stiffener plate and 8mm thickness of the stiffener plate.

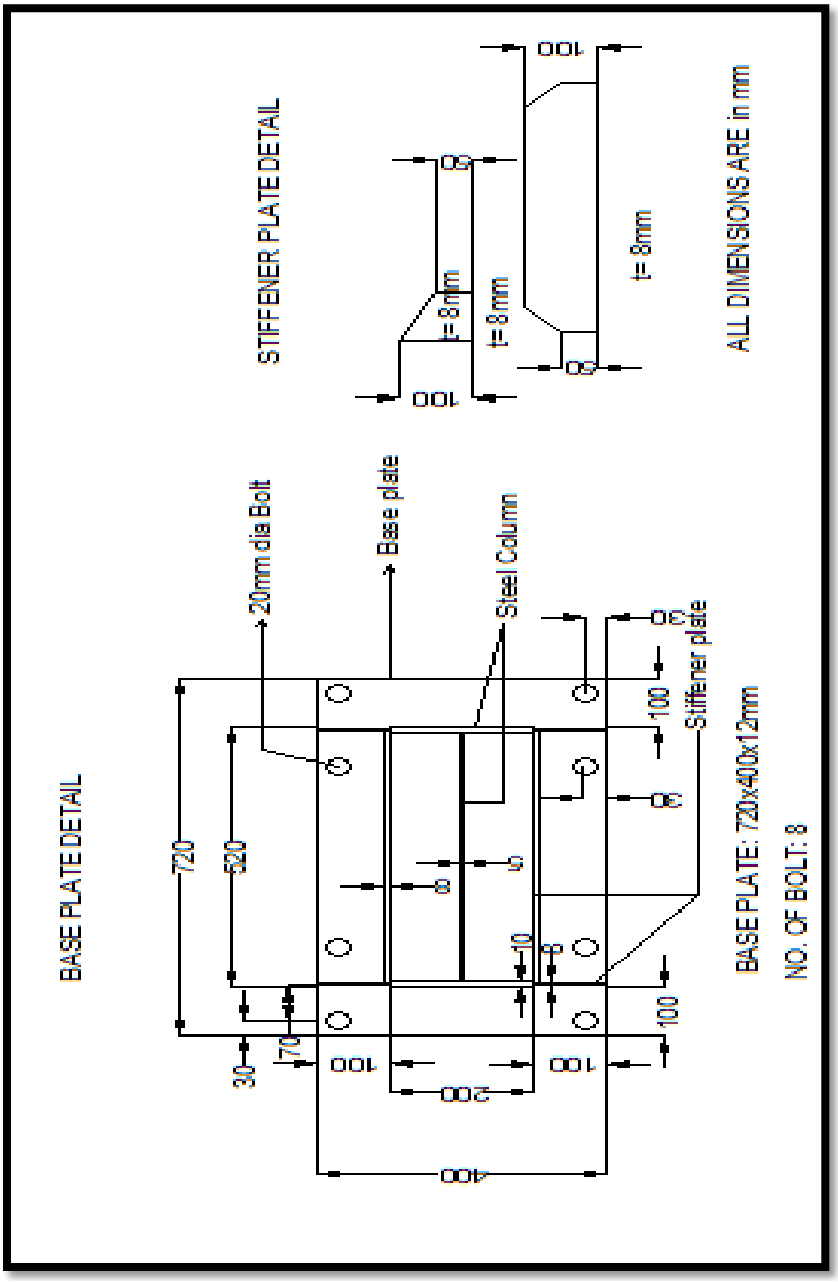

Figure 5.1 Base Plate Connection

5.2 DESIGN OF COLUMN BEAM END PLATE CONNECTION
BUILT UP I – SECTION BEAM:

Thickness of the flange = 12mm
Width of the flange, b_f = 250mm
Thickness of the web, t_w = 5mm
Depth of section at start node= 624mm
Depth of section at each node = 324mm
Diameter of the bolt, d_b= 20mm
Thickness of end plate, t_b= 12mm
Thickness of stiffener plate = 8mm
Pitch inside distance, p_i = 50mm
Pitch outside distance, p_o = 50mm
Pitch distance, p = 100mm
Gauge distance, g = 100mm
Applied moment = 402kNm

CALCULATE THE PLATE STRENGTH (M_{pl})

$$M_{pl} = \frac{fy\ tp^2 dK_{pl}}{4}$$

TO FIND K_{pl}:

Multiple row extended end plate – stiffened
50mm < 100/2
50mm < 70.7mm
Use

$$K_{pl} = \frac{2bp}{p_o - 2b/2} + \frac{2bp}{p_i - db/2} + 2\left[\frac{2(p_i + p_o + p + de + g\sqrt{2}}{g/2 - db/2}\right]$$

$$K_{pl} = \frac{2(250)}{50-20/2} + \frac{2(250)}{50-20/2} + 2\left[\frac{2(50 + 50 + 100 + 50 + 70.7)}{50 - 25/2}\right]$$

K_{pl}= 188.32
M_{pl} = 250 X (12^2/4) X 624 (188.32)
M_{pl} = 1057.6kNm

TO FIND THE BOLT STRENGTH:

Mb = n(Fub As) $h1^2$/ho
Provide number of bolt = 12
As = π/4 X 20^2 = 314mm^2
M_b = 12 X 400 X 314 X 562^2/662
M_b = 719.09kNm
The connection nominal moment (M_n) is the minimum of both the plate strength (M_{pl}) and Bolt design(M_b)
$M_n < M_{pl}$
270kNm < 1056kNm
$M_n < M_b$
270kNm < 719.09kNm
Hence satisfied

CALCULATE THE BOLT FORCE:

By taking moment about the centre of top flange
125 X 10^3 + 20(624/2- 12/2) = (2F1/612) X ((2 X 612^2) + 462^2)
131120 = 3145.5 F1
F1 = 42kN
F1 = F2 = 42kN
F3 = 462/612 X 42= 30.9kN
Reaction at top flange
Fc = 2(42 + 42 + 30.9) – 20
Fc = 209.8kN

Capacity of beam flange = fy/8moX A
= 250/1.1 X (12 X 250) X 10-3
= 681.8kN

209.8kN < 681.8kN
Hence the connection is safe

END PLATE AND BOLT:
Assume 10mm fillet weld to flange
Distance from the centre line of the bolt to the toe of fillet weld
lv = 50 – 10 = 40mm
Adopt end distance le = 50mm
Effective length of end plate per bolt = 250/2 =125mm
Tension capacity of M20 bolt = 141kN
Allowable prying load Q = 141 – 42 = 99kN
Moment at the toe of the weld= 99 X 50 – 42 X 40 = 3270kNm
Moment capacity of the plate = fy/1.1 X($wT^2/4$)

$$T = \sqrt{\frac{3270 \times 10^3 \times 1.1 \times 4}{250 \times 125}}$$

T= 20mm

β = 2 (non pre loaded), γ = 1.5 (factor load)
Proof stress fo =0.7fub = 0.7 X 400/1000 = 0.28kN/mm^2

$$Q = \left[\frac{lv}{2le}\right] \times \left[Te - \frac{\beta\ 8\ fo\ be\ t^4}{27\ le\ lv^2}\right]$$

$$= \frac{40}{2 \times 50} \times \left[42 - \frac{2 \times 1.5 \times 0.28 \times 125 \times 20^4}{27 \times 50 \times 40^2}\right]$$

Q = 13.6kN < 99kN
Check for combined shear and tension
Shear capacity of M20 bolt = 52.6kN
Shear per bolt = Pu/ No. of bolt = 125/12 = 10.41kN
Tensile capacity of the bolt = 141kN
$(10.41/52.6)^2 + ((42 + 13.6)/141)^2 < 1$
0.039 + 0.155 < 1
0.19 < 1
Hence the connection is safe
Provide stiffener plate adopt 100mm and 50mm depth of the stiffener plate and 8mm thickness of the stiffener plate

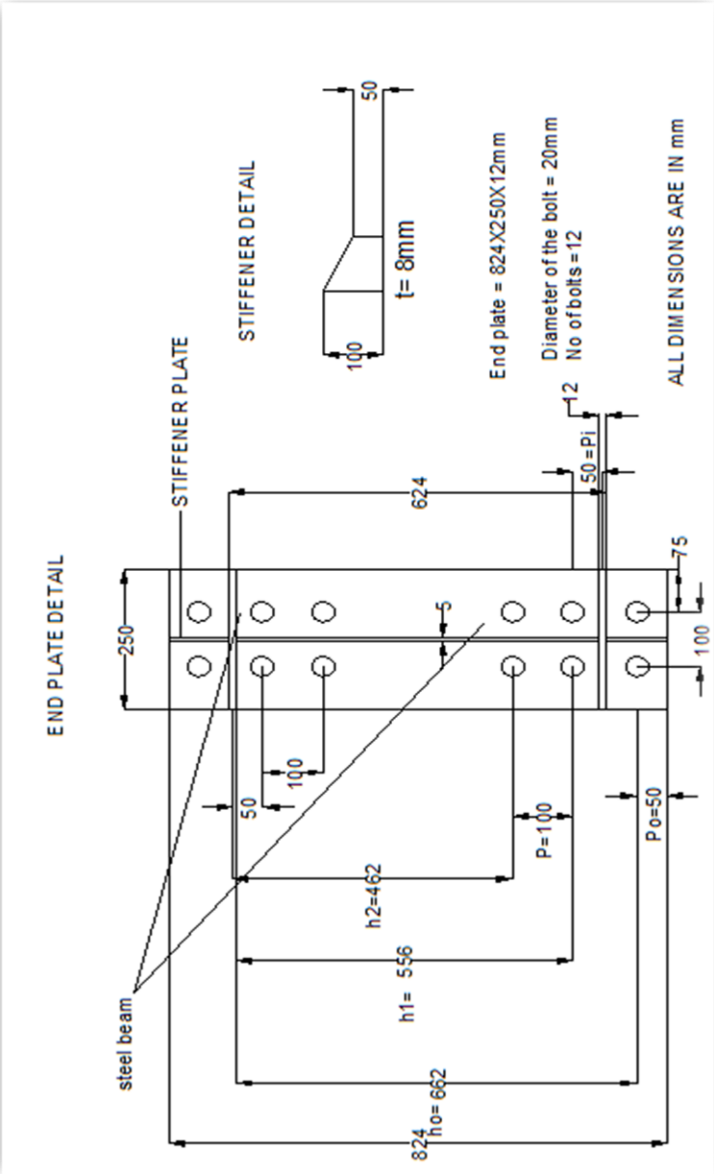

Figure 5.2 Column Beam End Plate Connection

Conclusion

Pre –engineered buildings are more advantageous over conventionally designed buildings in terms of cost effectiveness, time saving, future scope, and economy. Cold formed sections are more advantageous over hot rolled sections in terms of consistency, best suited for site erection, versatility of profile shape, pre galvanized and minimization of material. Pre –engineered building for vehicle parking shed gives the users much more economical and better solution for long span structures where large column free areas easy way to park a lot of vehicles

Appendices

Staad Pro. Output
The input given to the Staad is read from the Staad Editor. The input for the extraction of the design is as
STAAD PLANE
START JOB INFORMATION

```
JOB NAME VEHICLE PARKING SHED
JOB NO 01
JOB COMMENT 2 D FRAME VEHICLE PARKING SHED
ENGINEER DATE 05-Sep-17
END JOB INFORMATION
INPUT WIDTH 79
*******************************************************
*******************************************************
UNIT METER KN
JOINT COORDINATES
1 0 0 0; 2 0 4 0; 3 6.4 4.32 0; 4 -6.4 4.32 0;
MEMBER INCIDENCES
1 2 4; 2 2 3; 3 1 2;
*START GROUP DEFINITION
*MEMBER
*END GROUP DEFINITION
DEFINE MATERIAL START
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005
DAMP 0.03
END DEFINE MATERIAL
*******************************************************
MEMBER PROPERTY AMERICAN
1 2 TAPERED 0.624 0.005 0.324 0.25 0.012
3 TAPERED 0.52 0.005 0.52 0.2 0.01
**
CONSTANTS
MATERIAL STEEL ALL
SUPPORTS
1 FIXED
LOAD 1 EQ1
JOINT LOAD
2 FX 2
*******************************************************
*******************************************************
LOAD 2 EQ2
JOINT LOAD
2 FX -2
*******************************************************
*******************************************************
LOAD 3 LOADTYPE None  TITLE DL
MEMBER LOAD
1 2 UNI GY -0.72

*******************************************************
LOAD 4 LOADTYPE None  TITLE LL

MEMBER LOAD
1 2 UNI GY -4.5
*******************************************************
LOAD 5 LOADTYPE None  TITLE CL
```

International
Journal
Of Advanced Research in Engineering & Management (IJAREM)
ISSN: 2456-2033 || PP. 43-65

```
******************************************************
*** CL = 0.2 x 6 = 0.12 kN/m
******************************************************
*** WIND LOAD CALCULATION
******************************************************
***************************************************************************
** WLP=> WIND LEFT PERPENDICULAR TO RIDGE PRESSURE
***************************************************************************
** WLP=> WIND LEFT PERPENDICULAR TO RIDGE PRESSURE
LOAD 6 LOADTYPE Wind  TITLE WLP
MEMBER LOAD
1 2 UNI GY 13.5
**************************************************************************
** WRP=> WIND RIGHT PERPENDICULAR TO RIDGE PRESSURE
LOAD 7 LOADTYPE Wind  TITLE WRP
MEMBER LOAD
1 2 UNI GY 13.5
**************************************************************************
** WLS=> WIND LEFT PERPENDICULAR TO RIDGE SUCTION
LOAD 8 LOADTYPE Wind  TITLE WLS
MEMBER LOAD
1 2 UNI GY 13.5
***************************************************************************
** WRS=> WIND RIGHT PERPENDICULAR TO RIDGE SUCTION
LOAD 9 LOADTYPE Wind  TITLE WRS
MEMBER LOAD
1 2 UNI GY 13.5
***************************************************************************
** WPP=> WIND PARALLEL TO RIDGE PRESSURE
LOAD 10 LOADTYPE Wind  TITLE WPP
***************************************************************************
** WPS=> WIND PARALLEL TO RIDGE SUCTION
LOAD 11 LOADTYPE Wind  TITLE WPS
********************************
******************************************************
******************************************************
*** DESIGN LOAD COMBINATION WITHOUT CRANE
******************************************************
*** 1.5 (DL + CL + LL)
LOAD COMB 101 1.5 DL + 1.5 CL + 1.5 LL
3 1.5 5 1.5 4 1.5
******************************************************
*** 1.5 (DL + CL +  WL)
LOAD COMB 102 1.5 DL + 1.5 CL + 1.5 WLP
3 1.5 5 1.5 6 1.5
LOAD COMB 103 1.5 DL + 1.5 CL + 1.5 WRP
3 1.5 5 1.5 7 1.5
LOAD COMB 104 1.5 DL + 1.5 CL + 1.5 WLS
3 1.5 5 1.5 8 1.5
LOAD COMB 105 1.5 DL + 1.5 CL + 1.5 WRS
3 1.5 5 1.5 9 1.5
LOAD COMB 106 1.5 DL + 1.5 CL + 1.5 WPP
3 1.5 5 1.5 10 1.5
LOAD COMB 107 1.5 DL + 1.5 CL + 1.5 WPS
```

3 1.5 5 1.5 11 1.5
****
*** 1.5 (DL + CL + EQ)
LOAD COMB 108 1.5 DL + 1.5 CL + 1.5 EQ1
3 1.5 5 1.5 1 1.5
LOAD COMB 109 1.5 DL + 1.5 CL + 1.5 EQ2
3 1.5 5 1.5 2 1.5
****
*** 0.9 (DL + CL) + 1.5 WL
LOAD COMB 110 0.9 DL + 0.9 CL + 1.5 WLP
3 0.9 5 0.9 6 1.5
LOAD COMB 111 0.9 DL + 0.9 CL + 1.5 WRP
3 0.9 5 0.9 7 1.5
LOAD COMB 112 0.9 DL + 0.9 CL + 1.5 WLS
3 0.9 5 0.9 8 1.5
LOAD COMB 113 0.9 DL + 0.9 CL + 1.5 WRS
3 0.9 5 0.9 9 1.5
LOAD COMB 114 0.9 DL + 0.9 CL + 1.5 WPP
3 0.9 5 0.9 10 1.5
LOAD COMB 115 0.9 DL + 0.9 CL + 1.5 WPS
3 0.9 5 0.9 11 1.5
****
*** 0.9 (DL + CL) + 1.5 EQ
LOAD COMB 116 0.9 DL + 0.9 CL + 1.5 EQ1
3 0.9 5 0.9 1 1.5
LOAD COMB 117 0.9 DL + 0.9 CL + 1.5 EQ2
3 0.9 5 0.9 2 1.5
****
*** 1.2 (DL + CL + LL) + 0.6 WL
LOAD COMB 118 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WLP
3 1.2 5 1.2 4 1.2 6 0.6
LOAD COMB 119 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WRP
3 1.2 5 1.2 4 1.2 7 0.6
LOAD COMB 120 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WLS
3 1.2 5 1.2 4 1.2 8 0.6
LOAD COMB 121 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WRS
3 1.2 5 1.2 4 1.2 9 0.6
LOAD COMB 122 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WPP
3 1.2 5 1.2 4 1.2 10 0.6
LOAD COMB 123 1.2 DL + 1.2 CL + 1.2 LL + 0.6 WPS
3 1.2 5 1.2 4 1.2 11 0.6
****
*** 1.2 (DL + CL + LL) + 0.6 EQ
LOAD COMB 124 1.2 DL + 1.2 CL + 1.2 LL + 0.6 EQ1
3 1.2 5 1.2 4 1.2 1 0.6
LOAD COMB 125 1.2 DL + 1.2 CL + 1.2 LL + 0.6 EQ2
3 1.2 5 1.2 4 1.2 2 0.6
****
****
****
*** 0.9 (DL) + 1.5 WL
LOAD COMB 126 0.9 DL + 0 CL + 1.5 WLP
3 0.9 5 0.0 6 1.5
LOAD COMB 127 0.9 DL + 0 CL + 1.5 WRP

3 0.9 5 0.0 7 1.5
LOAD COMB 128 0.9 DL + 0 CL + 1.5 WLS
3 0.9 5 0.0 8 1.5
LOAD COMB 129 0.9 DL + 0 CL + 1.5 WRS
3 0.9 5 0.0 9 1.5
LOAD COMB 130 0.9 DL + 0 CL + 1.5 WPP
3 0.9 5 0.0 10 1.5
LOAD COMB 131 0.9 DL + 0 CL + 1.5 WPS
3 0.9 5 0.0 11 1.5
****
****
*** DEFLECTION LOAD COMBINATION WITHOUT CRANE
****
*** DL + CL + LL
LOAD COMB 1101 1 DL + 1 CL + 1 LL
3 1.0 5 1.0 4 1.0
****
*** (DL + CL + WL)
LOAD COMB 1102 1 DL + 1 CL + 1 WLP
3 1.0 5 1.0 6 1.0
LOAD COMB 1103 1 DL + 1 CL + 1 WRP
3 1.0 5 1.0 7 1.0
LOAD COMB 1104 1 DL + 1 CL + 1 WLS
3 1.0 5 1.0 8 1.0
LOAD COMB 1105 1 DL + 1 CL + 1 WRS
3 1.0 5 1.0 9 1.0
LOAD COMB 1106 1 DL + 1 CL + 1 WPP
3 1.0 5 1.0 10 1.0
LOAD COMB 1107 1 DL + 1 CL + 1 WPS
3 1.0 5 1.0 11 1.0
****
*** (DL + CL + EQ)
LOAD COMB 1108 1 DL + 1 CL + 1 EQ1
3 1.0 5 1.0 1 1.0
LOAD COMB 1109 1 DL + 1 CL + 1 EQ2
3 1.0 5 1.0 2 1.0
****
*** (DL + CL) + 0.8 (LL + WL)
LOAD COMB 1110 1 DL + 1 CL + 0.8 LL + 0.8 WLP
3 1.0 5 1.0 4 0.8 6 0.8
LOAD COMB 1111 1 DL + 1 CL + 0.8 LL + 0.8 WRP
3 1.0 5 1.0 4 0.8 7 0.8
LOAD COMB 1112 1 DL + 1 CL + 0.8 LL + 0.8 WLS
3 1.0 5 1.0 4 0.8 8 0.8
LOAD COMB 1113 1 DL + 1 CL + 0.8 LL + 0.8 WRS
3 1.0 5 1.0 4 0.8 9 0.8
LOAD COMB 1114 1 DL + 1 CL + 0.8 LL + 0.8 WPP
3 1.0 5 1.0 4 0.8 10 0.8
LOAD COMB 1115 1 DL + 1 CL + 0.8 LL + 0.8 WPS
3 1.0 5 1.0 4 0.8 11 0.8
****
*** (DL + CL) + 0.8 (LL + EQ)
LOAD COMB 1116 1 DL + 1 CL + 0.8 LL + 0.8 EQ1
3 1.0 5 1.0 4 0.8 1 0.8

```
LOAD COMB 1117 1 DL + 1 CL + 0.8 LL + 0.8 EQ2
3 1.0 5 1.0 4 0.8 2 0.8
******************************************************
*** FOR SIESMIC MASS FENERATION
******************************************************
**** DL + CL + DL OF CRANE
*LOAD COMB 2000 1 DL + 1 CL + 1 CL
*3 1.0 5 1.0 52 1.0
*****************************************************
PERFORM ANALYSIS
DEFINE ENVELOPE
101 TO 131 ENVELOPE 1 TYPE STRENGTH
1101 TO 1117 ENVELOPE 2 TYPE SERVICEABILITY
END DEFINE ENVELOPE
*****************************************************
LOAD LIST 101 TO 131
*****************************************************
PERFORM ANALYSIS
*****************************************************
************************************************
PARAMETER 1
CODE IS800 LSD
FYLD 345000 ALL
BEAM 1 ALL
CAN 1 MEMB 1 2
MAIN 0 ALL
TST 0 ALL
LAT 0 ALL
LST 0 ALL
STP 2 ALL
**
LY 1.5 MEMB 1 2
LX 1.5 MEMB 1 2
LZ 12.82 MEMB 1 2
**
LZ 6 MEMB 3
**
CHECK CODE ALL
**************************
*STEEL MEMBER TAKE OFF ALL
FINISH
****************************************************
```

References

[1]. Abdelrahim KhalilDessouki, Ahmed Hassan Youssef and Mohammed Mostafa Ibrahim.(2013) 'Behaviour of I- beam bolted extended end plate moment connections', Ains Shams Engineering Journal Vol.4, pp. 685-699.

[2]. BS: 5950 – part- 5,(1998) 'Code of practice for design of cold formed thin gauge section', United Kingdom.

[3]. IS: 875 – part – 1, (1987) 'Code of practice for design loads (other than earthquake) for building structures', Dead loads, New Delhi.

[4]. IS: 875 -part -2,(1987) 'Code of practice for design loads (other than earthquake) for building structures', Imposed loads, New Delhi

[5]. IS: 875 - part –3, (1987) 'Code of practice for design loads (other than earthquake) for building structures', Wind loads, New Delhi.

[6]. IS: 801- (1987) 'Code of practice for use of Cold – formed light gauge steel structure members general building construction', New Delhi

[7]. IS: 800-(1984)'Code of practice for general construction in steel', New Delhi,

[8]. KanakambaraRao,S. and Sarah Chandra Kumar, B.and Syed Firoz. (2012)'Design Concept of Pre-Engineered building', International Journal of Engineering Research and Application, Vol.2, pp.267 - 272.

[9]. RoshanSatputeValsson Varghese.(2012) 'Building design using Cold formed section', International referred Journal of Engineering and Science, Vol.1, pp. 01-16.

[10]. SubramanianN. (2008) Design of steel structures,Oxford University press, New Delhi.

[11]. Swathi D V.(2014) 'Design and analysis of Pre – engineered Steel frame', International Journal of Research Sciences and Advanced Engineering, Vol.2, pp.250 – 255.