Victoria University

Melbourne Australia

College of Engineering and Science

Vac4191 Structural Engineering Design 2

Assignment 1

Design of Steel Framed Industrial Building

<submitted by>

<Prof Name>

<date>

Introduction: Design brief

We are given that “there is a steel portal frame of an enclosed industrial building. The span of the portal frames is 24 m and the spacing of the portal frames is 5.5 m. The height of the portal frame columns at the eaves is 5.3 m. There are two roller doors (shaded areas) in the two end bays as shown in Figure 1.

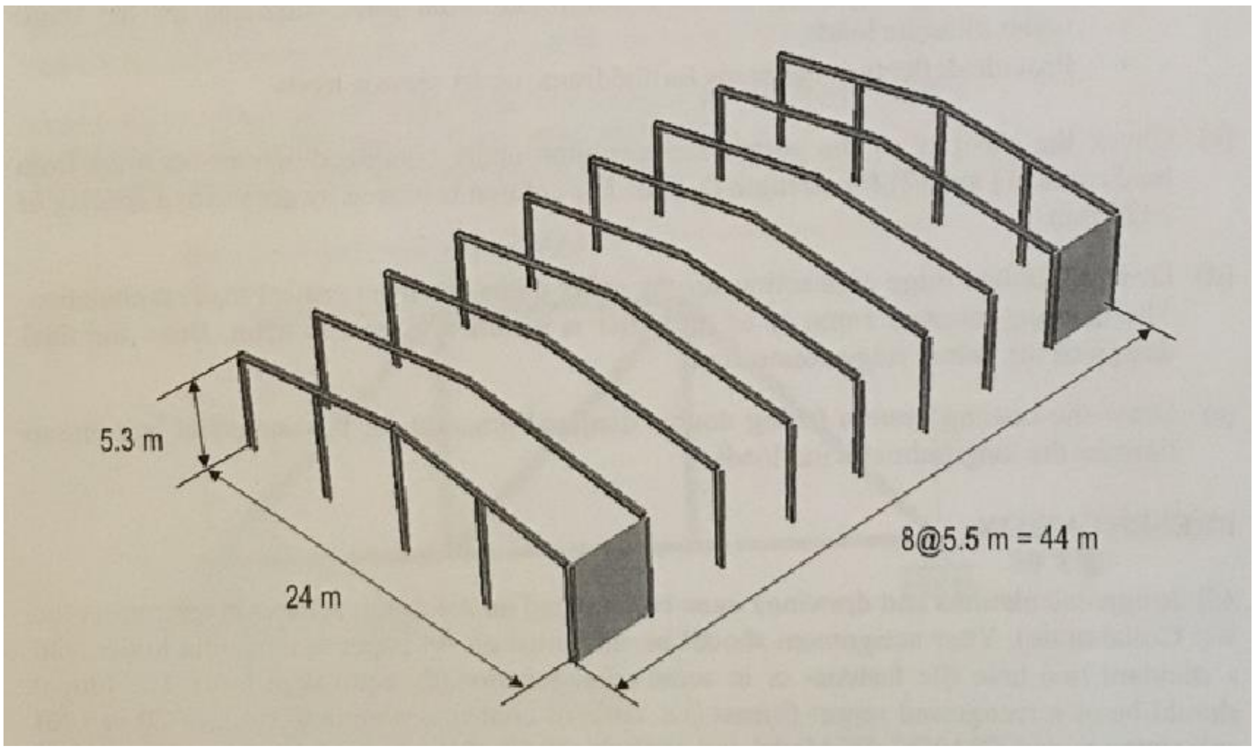


Figure 1: Steel portal frames of an enclosed industrial building

The dimensions of each roller door are 4000 * 3700 mm. The roof pitch is 8.5°. The building, which is a normal structure, is to be located on a flat exposed site in Region A5, Terrain Category 2. There are no surrounding buildings and the orientation of the building has not been finalized. The design working life of this building is 50 years.

Design Requirements

(a) Compute dead loads and live loads on the rafter, and external and internal wind pressure on the roof and walls under cross and longitudinal winds. Draw the line load diagrams the first internal frame under the dead loads, live loads and all wind load cases.

Sol: For dead load, γf = 1.5

Wd = 1.5 * 44 / 8 = 8.25Kn/m

live load:

Angle of rafter = 8.5

From IS: 875 (part 2) – 1987; Table 2 (cl 4.1), For accompanying live load, γf = 1.05

Live load / m run = {0.75-0.02*(8.5-10)}*6 =4.68

Live load on rafter=4.68*5.5 (as spacing of the portal frames is 5.5 m.)

=25.74kn/m

Wind pressure:

Internal pressure coefficient

Assuming buildings with low degree of permeability

Cpi=±0.2

External pressure coefficient

External pressure coefficient for walls and roofs are tabulated in given Tables

For walls

h/w= 6/15=0.4

L/w=30/15=2.0

Exposed area of wall per frame @5.5 m

c/c is A=5.5*6=33m

Wind load on wall/frame, A pd=33*0.96=31.68kN

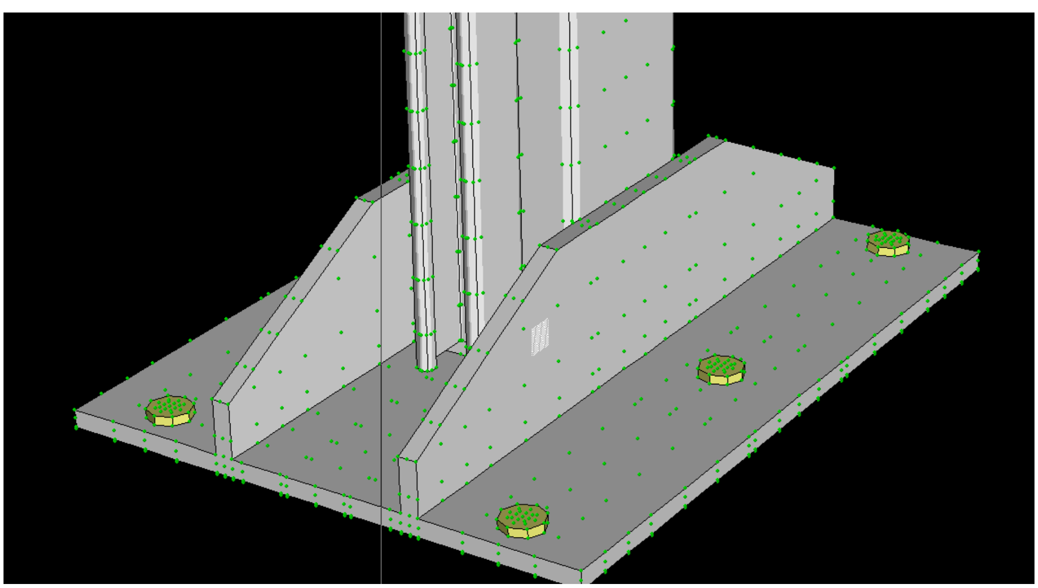
1(b) For roofs

Exposed area of each slope of roof, per frame (5.5m length) is

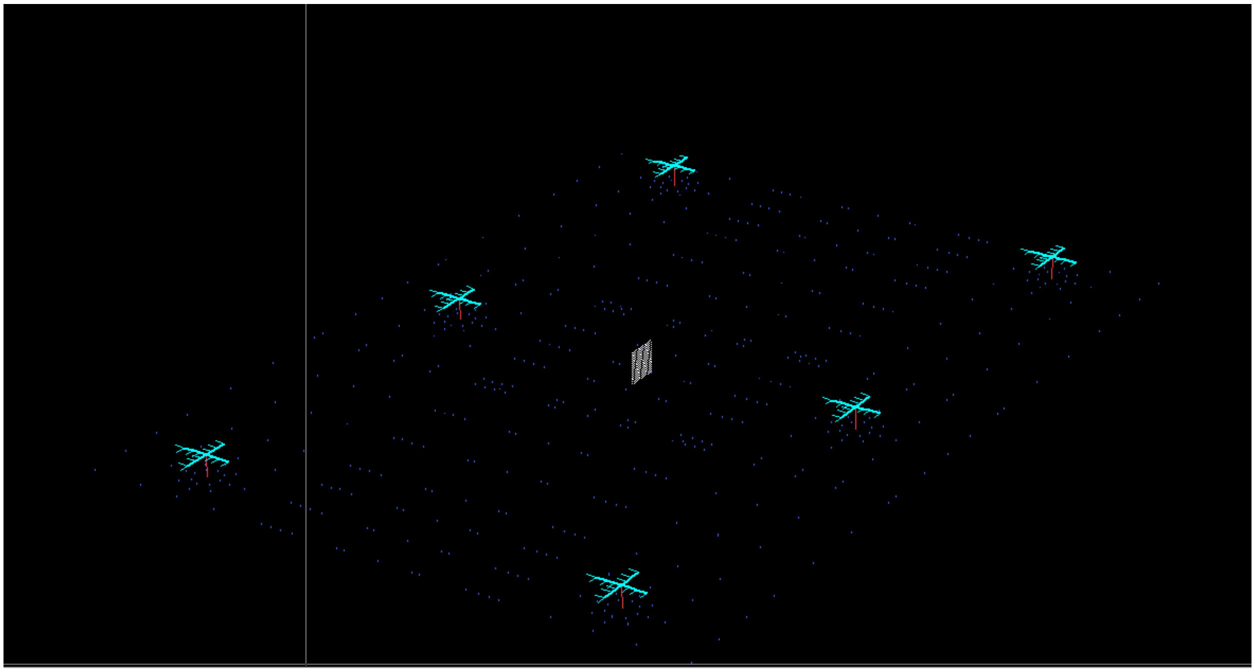
A= 5.5 * SQRT($(3.0)^2 + 7.5^2$) = 44.42 m

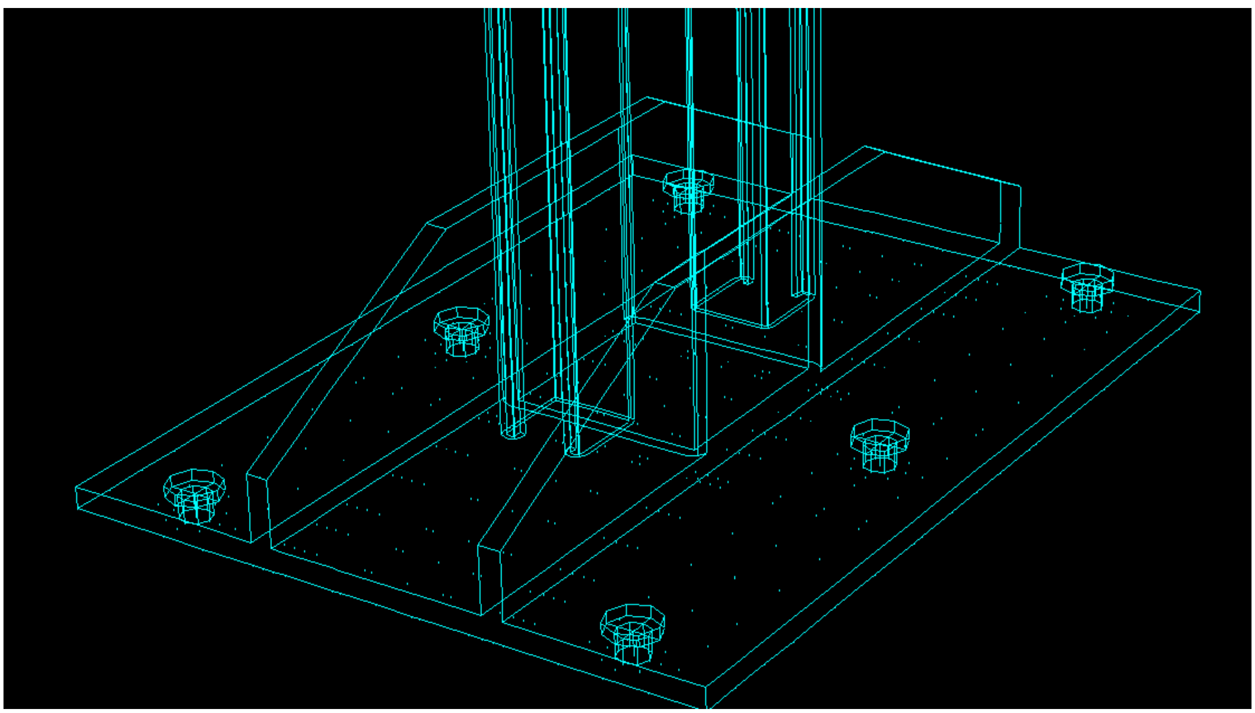
⇨ For roof, Apd=38.7kN

(b) Undertake the second order elastic analyses on the first internal frame under the following load cases using STRAND7. The base of the column is pinned. Select economical column and rafter UB sections for the first internal frame based on serviceability criteria. The vertical deflection limit on rafters is L/360 under dead loads, L/240 under live loads and L/150 under wind loads. The horizontal deflection limit at the eaves level due to wind load is H/150. Load cases: For strength design: (1)1.2G +1.5Q;

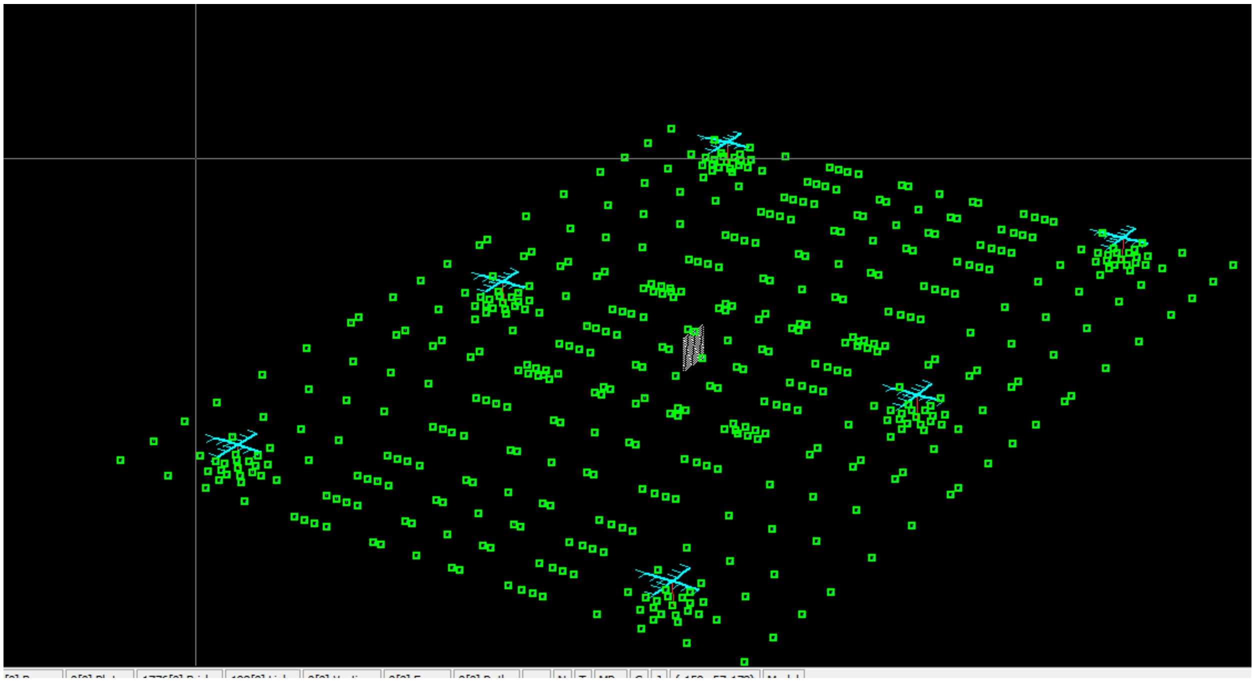


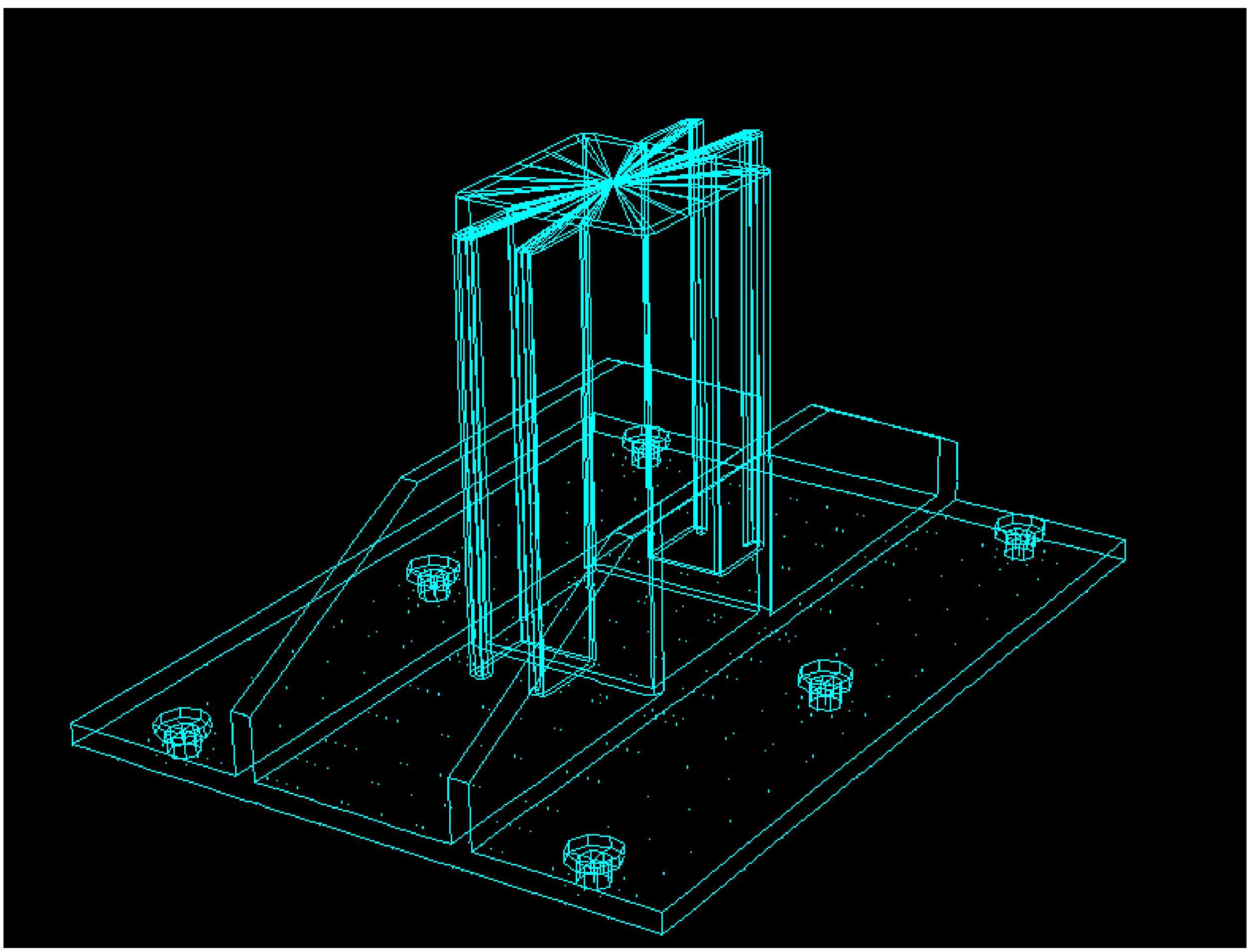
(2) 0.9G + W. (cross wind);



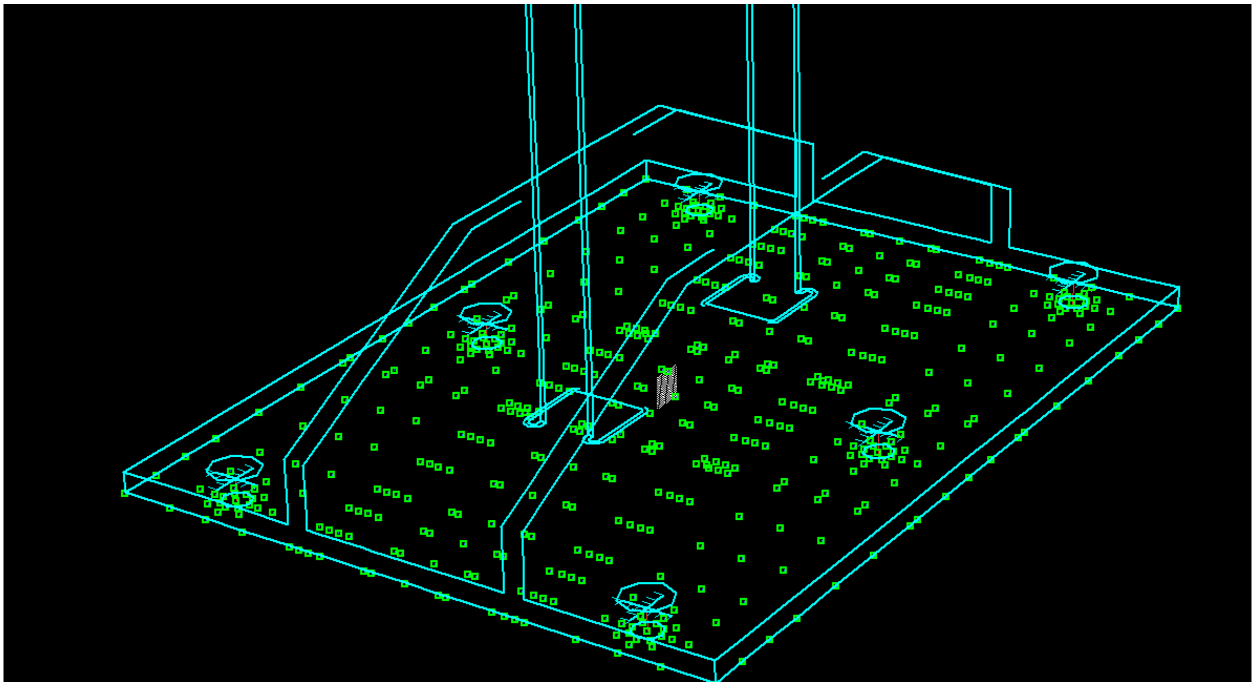


(3) 0.9G +1,,, (longitudinal wind).

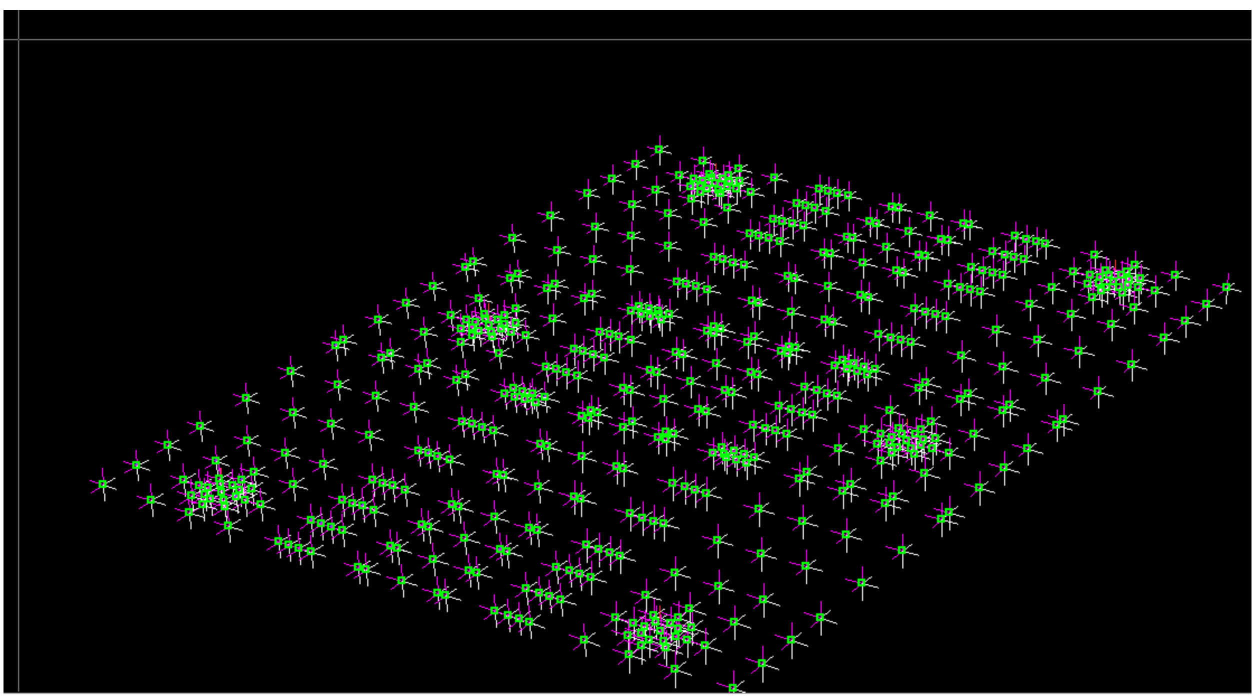




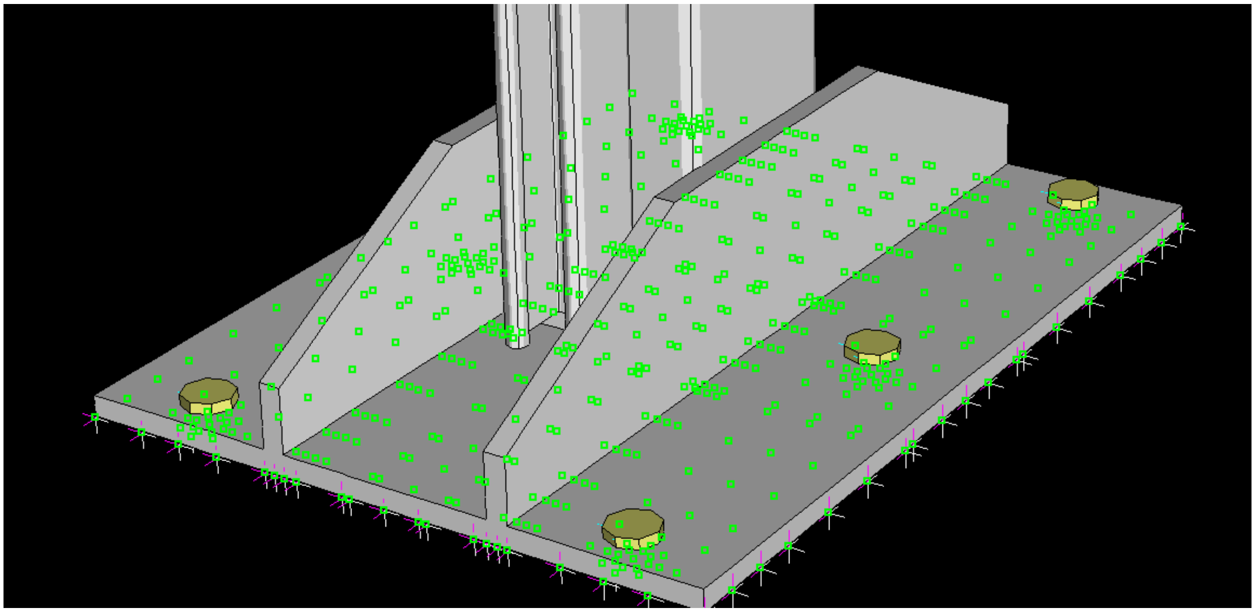
For serviceability: (1) G ; (2) Q;

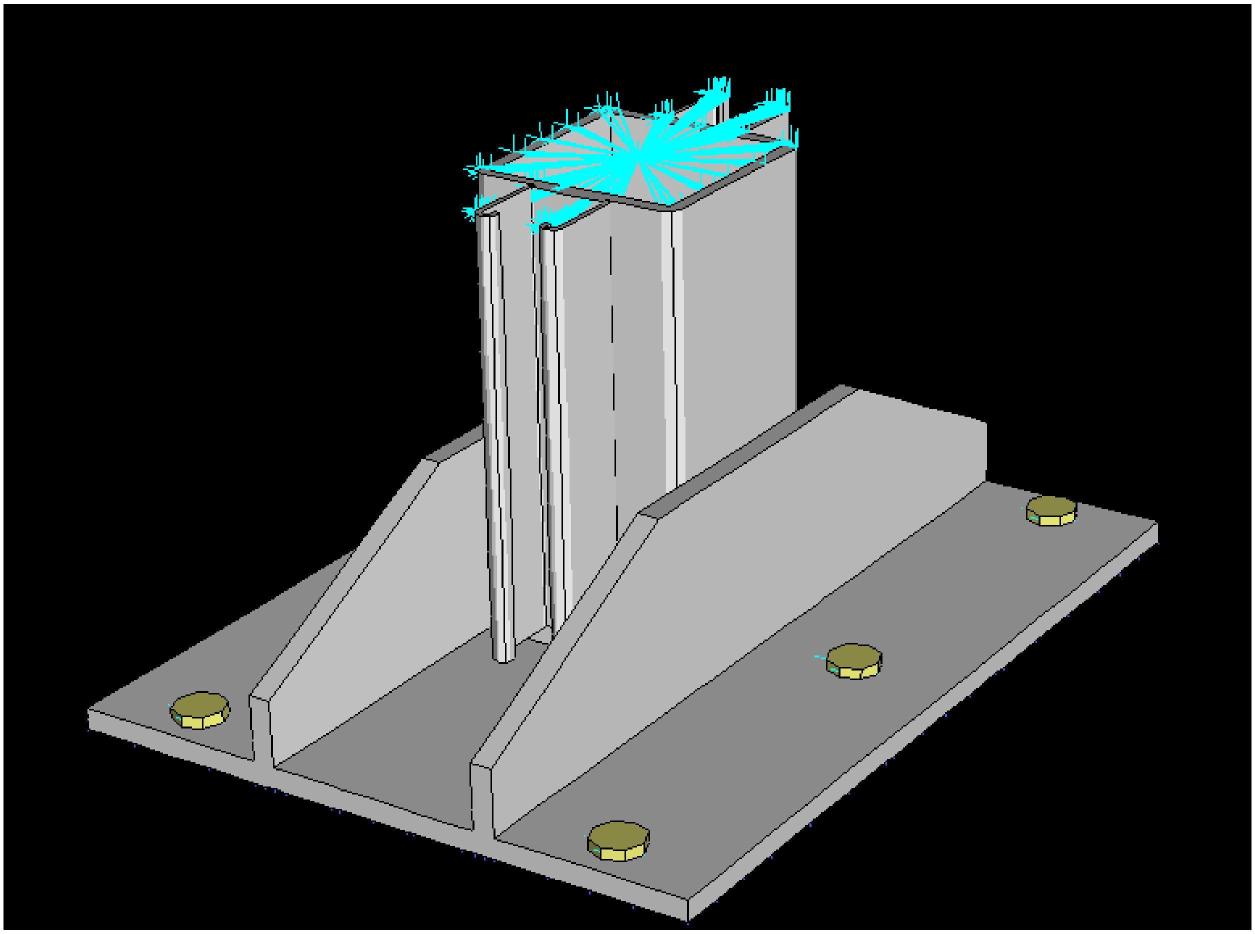


(3) W, (cross wind);



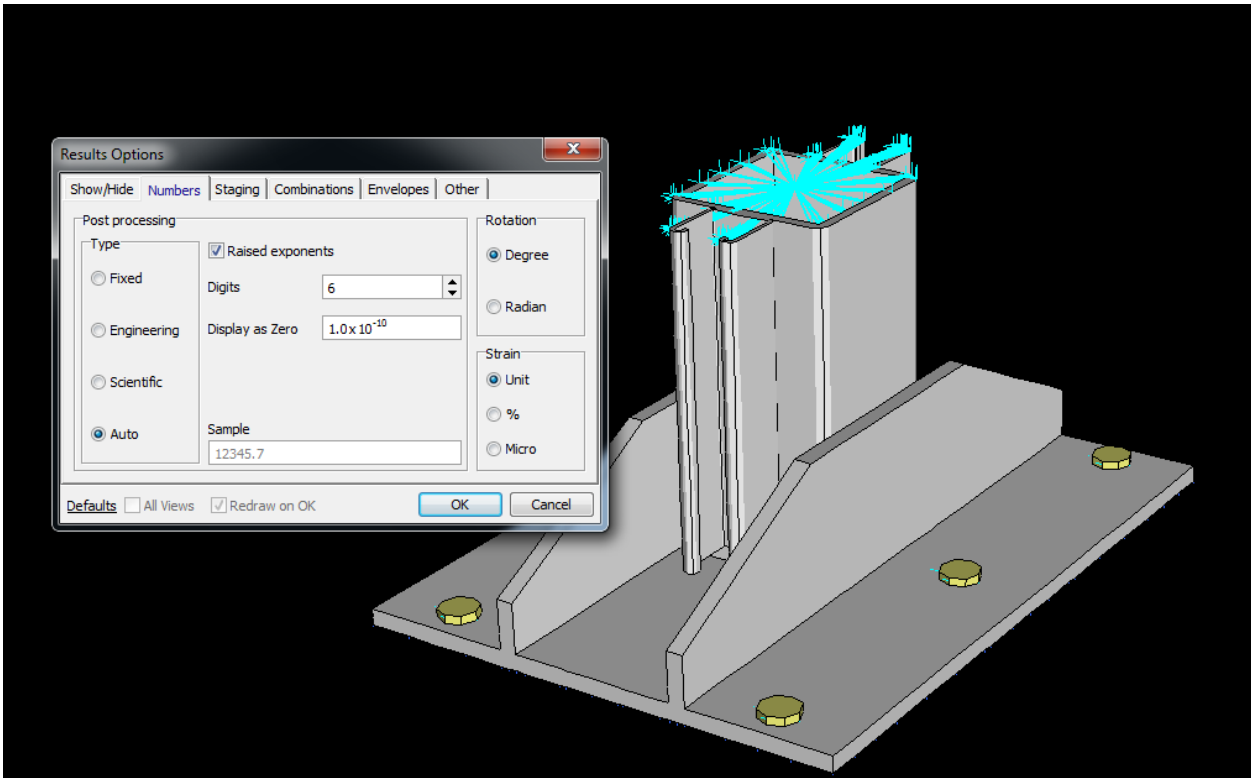
(4) W, (longitudinal wind).



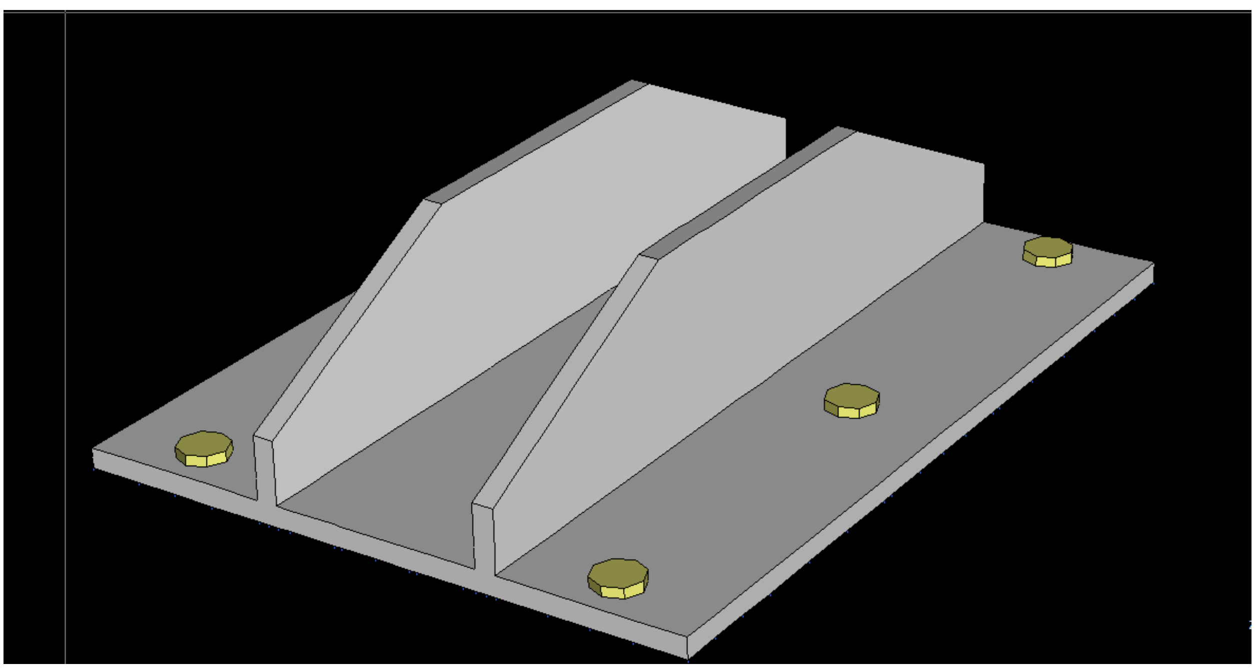


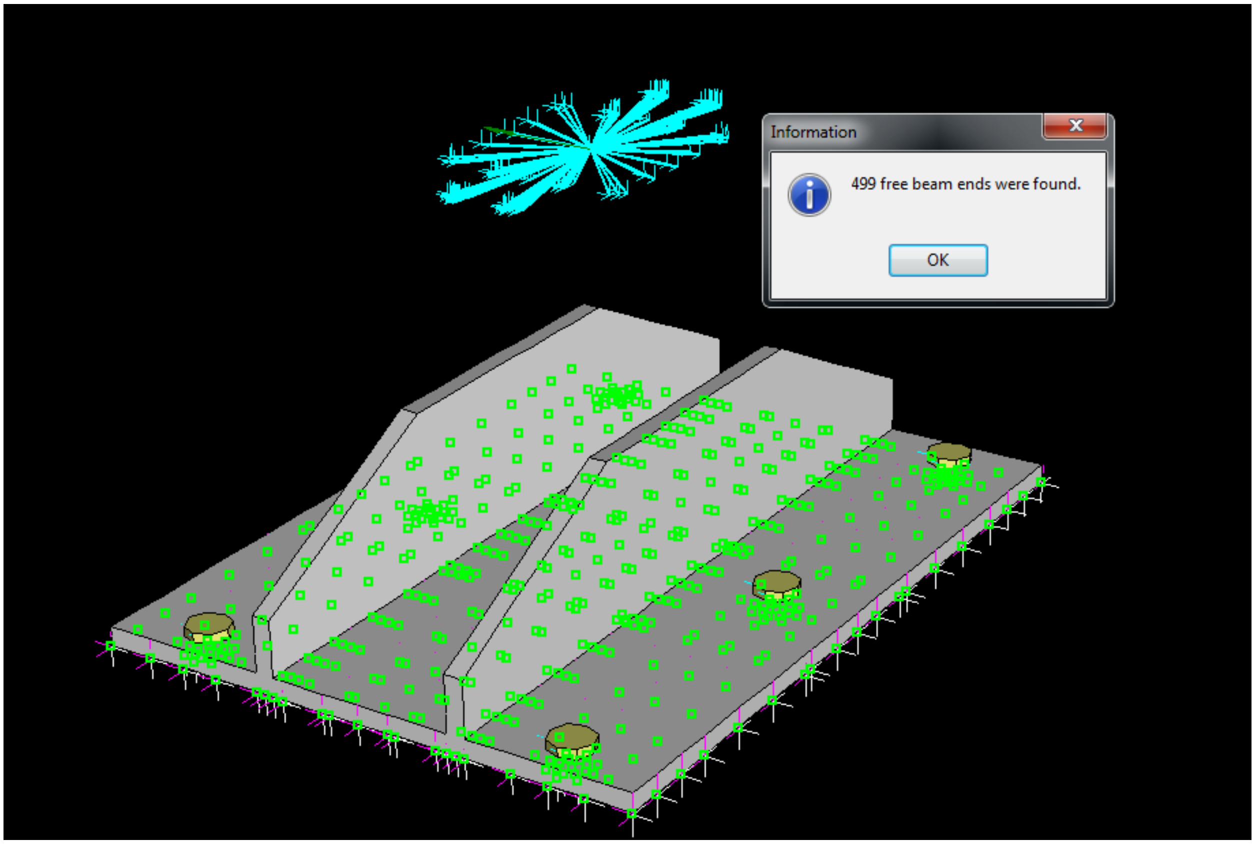
Required outputs: • Provide loading diagram for each load case showing loading values in STRAND7. • Provide bending moment, shear force and axial force diagrams for the frame under ultimate loads. • Provide deflection diagrams for the frame under service loads.

(Diagrams are attached above. The model is also attached herewith)



(c) Check the capacity of the portal frame column under combined actions obtained from load cases (1) and (2) for strength design. The column is braced by gins with a spacing of 1325 mm.





(d) Design a bolted ridge connection for the rafter under the most critical load combination. The bending moment capacity of the rafter is assumed to be 250 kNm. Draw the final design of the bolted ridge connection. (e) Draw the bracing system (using double diagonal bracing) for this industrial building to transfer the longitudinal wind loads.

A bolted ridge connection in a steel portal frame is subjected to a design bending moment M* = 250 kNm.

Assumptions:

Design axial tension force N=68kN

Design shear force V*= -7.5kN.

The rafter of the ridge connection is a Grade 300 steel section 360UB56.7.

The rafter slope is 8°. The design bending moment capacity of the rafter is 250 kN m. Design this bolted ridge connection.

Design actions

a. Minimum design actions

The minimum design bending moment is taken as Mmin=0.3Mb=0.3*250=75kNm

M =160kN m

Thus, M=160kNm is used in the design of the connection.

The design shear force IV1<40 kN

Thus, V is taken as V=-40kN acting in the same direction of the shear force.

b. Design actions for the design of bolts and end plate The dimensions of 360UB56.7 steel section are: d=359mm, bf =172mm, tf=13mm

Design forces at the flanges and shear force are calculated as follows:

$$N^*_{ft} = \frac{M^*}{d - t_f}\cos\theta + \frac{N^*}{2}\cos\theta - \frac{V^*}{2}\sin\theta$$

$$= \frac{160 \times 10^3}{359 - 13}\cos 8° + \frac{68}{2}\cos 8° - \frac{-40}{2}\sin 8° = 494.4 \text{ kN}$$