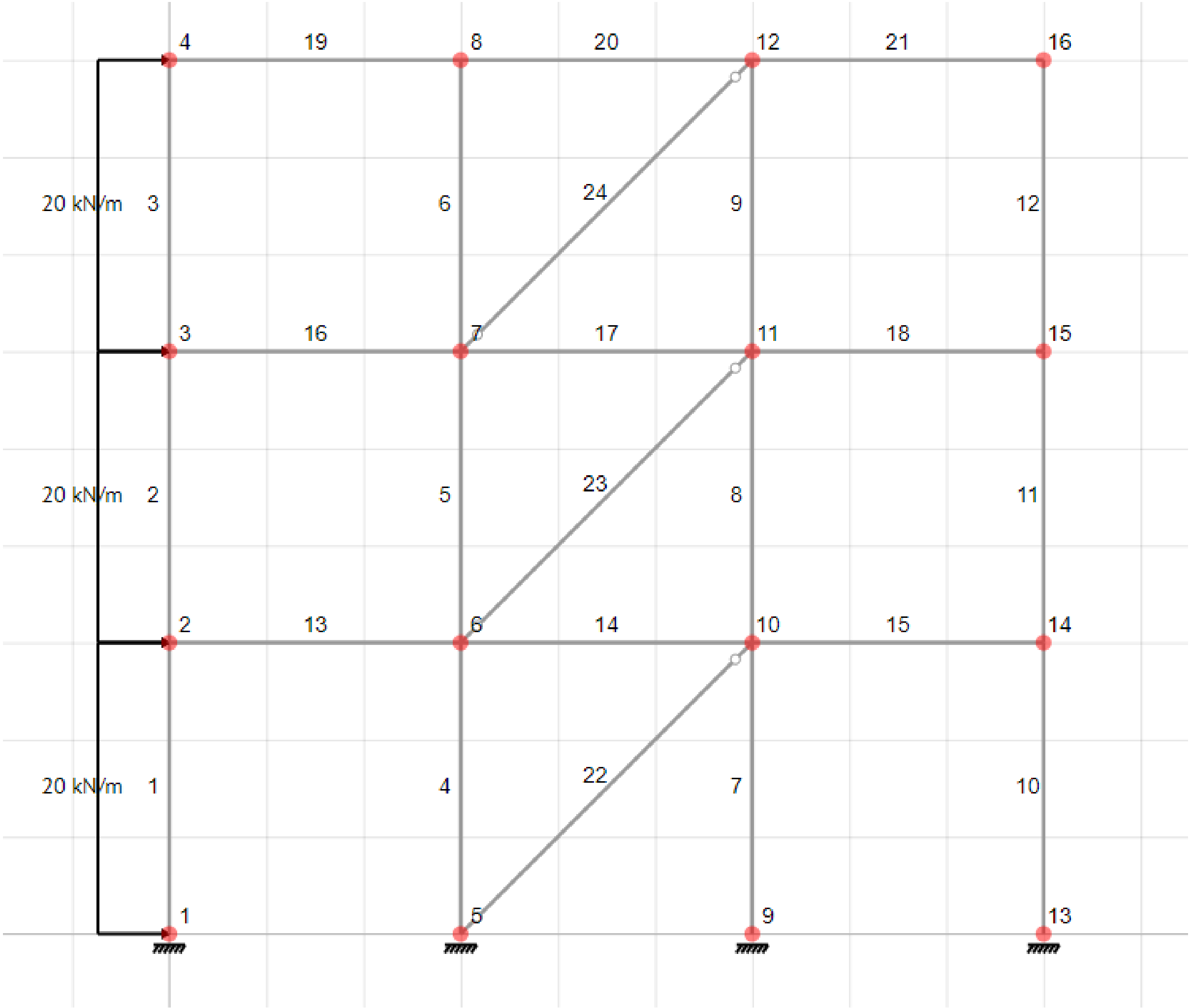


<u>**General Information**</u>

- Height of structure is 18 metres.
- Width of Structure is 18 metres.
- Beams and columns are each 6 metres.
- Diagonals are 8.485 metres long.
- A horizontal uniformly distributed load of 20 kN/m is applied to the left side of the structure.
- Modulus of elasticity is 2.1×10^{8} kN/m^{2}.
- Second moment of area of the beams and columns are 2.94×10^{-4} m^{4}.
- Cross-sectional area of the members is 8.55×10^{-3} m^{2}

The braced frame and the portals will be analysed separately and then combined to get the overall deflection of the structure.

Equations provided by Stafford-Smith and Coull, (1991) and Zalka (2020) will be used.

First consider the braced frame section:

The shear deflection of a single storey at the top of the braced bay according to Stafford-Smith and Coull is given by:

$$\delta^s = \frac{Q}{E}\left(\frac{d^3}{L^2 A} + \frac{L}{A}\right)$$

Where Q is the storey shear.

d is the length of the diagonal

L is the length of the bay

A is the cross-sectional area of the diagonal

E is the modulus of elasticity

The shear at each storey from the top of the structure to the bottom is:

$$Q_1 = 6 \cdot 20 = 120\ kN$$
$$Q_2 = 120 + 6 \cdot 20 = 240\ kN$$
$$Q_3 = 240 + 6 \cdot 120 = 360\ kN$$

Therefore, the shear deflection is:

$$\delta_1 = \frac{120}{2.1 \cdot 10^8} \cdot \left(\frac{8.485^3}{6^2 \cdot 8.55 \cdot 10^{-3}}\right) = 0.001352\ m$$

$$\delta_2 = \frac{240}{2.1 \cdot 10^8} \cdot \left(\frac{8.485^3}{6^2 \cdot 8.55 \cdot 10^{-3}}\right) = 0.003070\ m$$

$$\delta_3 = \frac{360}{2.1 \cdot 10^8} \cdot \left(\frac{8.485^3}{6^2 \cdot 8.55 \cdot 10^{-3}}\right) = 0.004606\ m$$

Total shear deflection is the sum of the these, which gives:

$$\delta^s = 0.009211\ m$$

Using still Stafford-Smith and Coull (1991) and moving on to the flexural component we must compute the external moments at each mid-storey level. Going from top to bottom we get:

$$M_3 = 3m \cdot 120\ kN = 360\ kNm$$
$$M_2 = 9m \cdot 120\ kN = 1080\ kNm$$
$$M_1 = 15m \cdot 120\ kN = 1800\ kNm$$

To obtain the rotation at each storey we compute:

$$\sum_{1}^{3} h \cdot \left(\frac{M}{E \cdot I}\right)$$

Which is:

$$\sum_{1}^{3} h \cdot \left(\frac{M}{E \cdot I}\right) = \left(\frac{6 \cdot 360}{2.1 \cdot 10^8 \cdot 0.1539} + \frac{6 \cdot 1080}{2.1 \cdot 10^8 \cdot 0.1539} + \frac{6 \cdot 1800}{2.1 \cdot 10^8 \cdot 0.1539}\right) = 0.003609\ m$$

Summing the shear and flexure for the braced frame gives the answer of:

$$\delta_{total} = 0.009211 + 0.003609 = 0.01282\ m$$

Next moving on to the portal frames. This time using Zalka (2020).

Zalka gives the stiffness of a frame as:

$$K_{frame} = \left(\frac{1}{K_c} + \frac{1}{K_b}\right)^{-1}$$

Where Kc is the stiffness of the columns and Kb is the stiffness of the beams. These are both computed by:

$$K_c = \sum \frac{12 \cdot E \cdot Ic}{h^2} = 4 \cdot \frac{12 \cdot 2.1 \cdot 10^8 \cdot 2.94 \cdot 10^{-4}}{6^2} = 82320\ kN$$

$$K_b = \sum \frac{12 \cdot E \cdot Ib}{L \cdot h} = 3 \cdot \frac{12 \cdot 2.1 \cdot 10^8 \cdot 2.94 \cdot 10^{-4}}{6 \cdot 6} = 61740\ kN$$

Therefore:

$$K_{frame} = \left(\frac{1}{82320} + \frac{1}{61740}\right)^{-1} = 35280\ kN$$

Zalka computes the deflection at the top of the structure as:

$$\delta^s = \frac{w \cdot H^4}{8 \cdot E \cdot I} + \frac{w \cdot H^2}{2 \cdot K_{frame}}$$

The second moment of area is:

$$I = \sum A \cdot t^2 = 2 \cdot \left(8.55 \cdot 10^{-3} \cdot 3^2 + 8.55 \cdot 10^{-3} \cdot 9^2\right) = 1.5390\ m^4$$

Therefore:

$$\delta^s = \frac{20 \cdot 18^4}{8 \cdot 2.1 \cdot 10^8 \cdot 1.5390} + \frac{20 \cdot 18^2}{2 \cdot 35280} = 0.092648\ m$$

Zalka uses the method of dividing the stiffness between the two elements – the braced frame and the portal frame:

The stiffness is computed as:

$$S_{xi} = \frac{1}{\delta(H)}$$

Because we have the deflections, we can compute the stiffness. For the braced frame as:

$$S_1 = \frac{1}{(0.01282)} = 78.003\ \frac{1}{m}$$

The portal frames.

$$S_2 = \frac{1}{(0.09266)} = 10.792\ \frac{1}{m}$$

Now proportioning the stiffnesses:

Braced Frame:

$$q_1 = \frac{S_1}{S_1 + S_2} = \frac{78.003}{78.003 + 10.792} = 0.878$$

Portal Frames:

$$q_2 = \frac{S_2}{S_1 + S_2} = \frac{10.792}{78.003 + 10.792} = 0.1216$$

It makes sense that the braced frame has the highest distribution of stiffness.

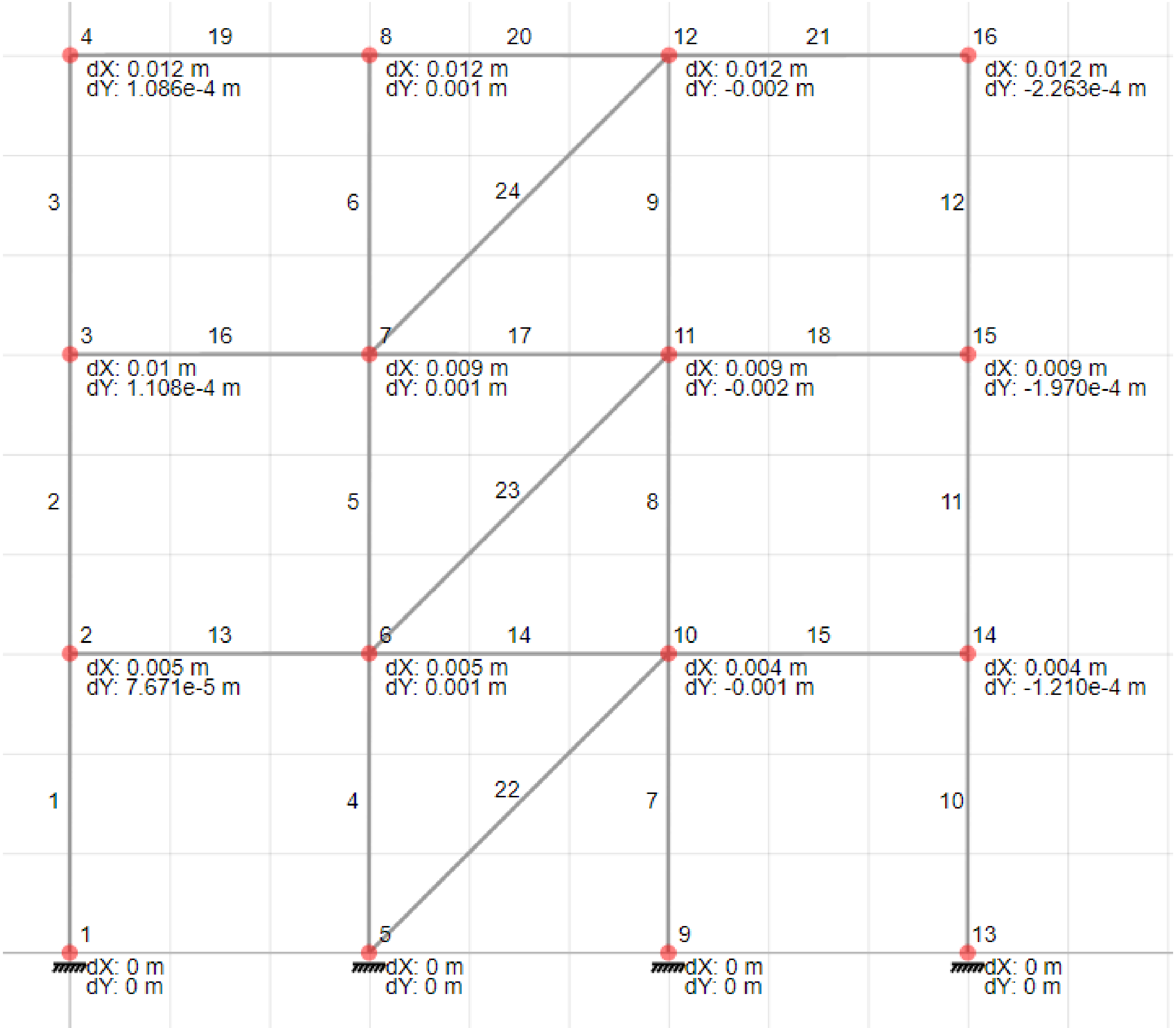
Now, Zalka says to apply these factors the previous equations for displacement.

$$\delta\ = \delta_{bf} \cdot q_1\ +\ \delta_{pf} \cdot q_2$$

Which gives:

$$\delta\ = 0.0128 \cdot 0.878\ +\ 0.0926 \cdot 0.1216 = 0.0225\, m$$

This value for the total displacement is nearly twice as high as the software as shown below. The software computes the displacement at the top storey as 0.012 metres.



As you have seen I have combined methods from Stafford-Smith and Coull with Zalka. I am not sure if I am on the right track, and I am hoping someone can give me a better understanding of problems such as these.

Many thanks,

Tygra