Ministry of Higher Education

The Higher Institute of Engineering & Technology

New-Damietta

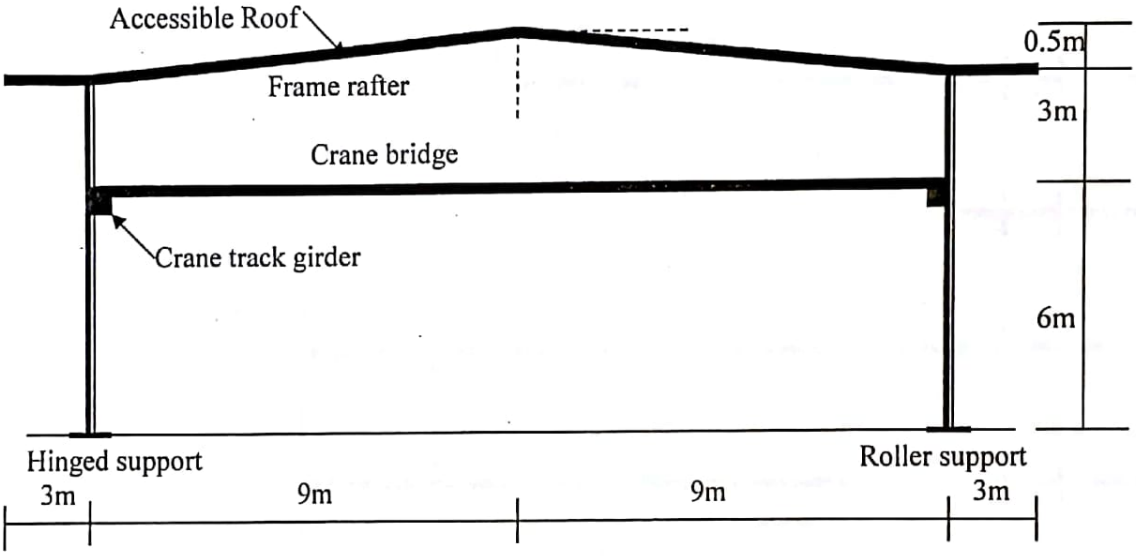
Department: Civil Engineering
Level: Four
Summer Semester 2017/2018
Subject: Steel constructions (II), Code: CIE407

Date: July-2018
Time allowed: 90 Min.
Full marks: 20
No. of pages: one

- Any missing data may be reasonably assumed. Any sketch may be neat and drawn to scale.

Question No. One (20marks):

It is required to construct a steel storage building on an area of (24m width × 55m length). The main supporting element is a **hinged-roller frame** shown in figure with double cantilevers 3m each, taken from the width of the area. The spacing between frames is 5.5m. Secondary beams are arranged above the frame rafter at 3m apart. The clear height of the frame is not less than 6m. A crane girder is provided in the hall as illustrated.



Data:

- Secondary beams of the roof support an R.C. slab of 15cm thickness with floor covering weighs 150kg/m^2.
- L. L. on the roof of the frame is calculated according to the Egyptian Code for the accessible roof.
- Maximum crane wheel loads are two loads of 16 ton each spaced at 2.5m. The lateral shock effect is 10%. The crane type is electric.

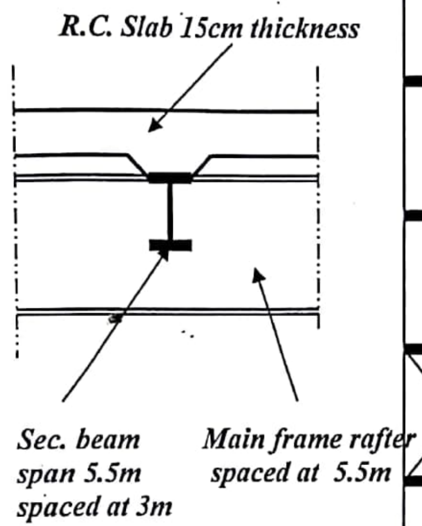
Requirements:

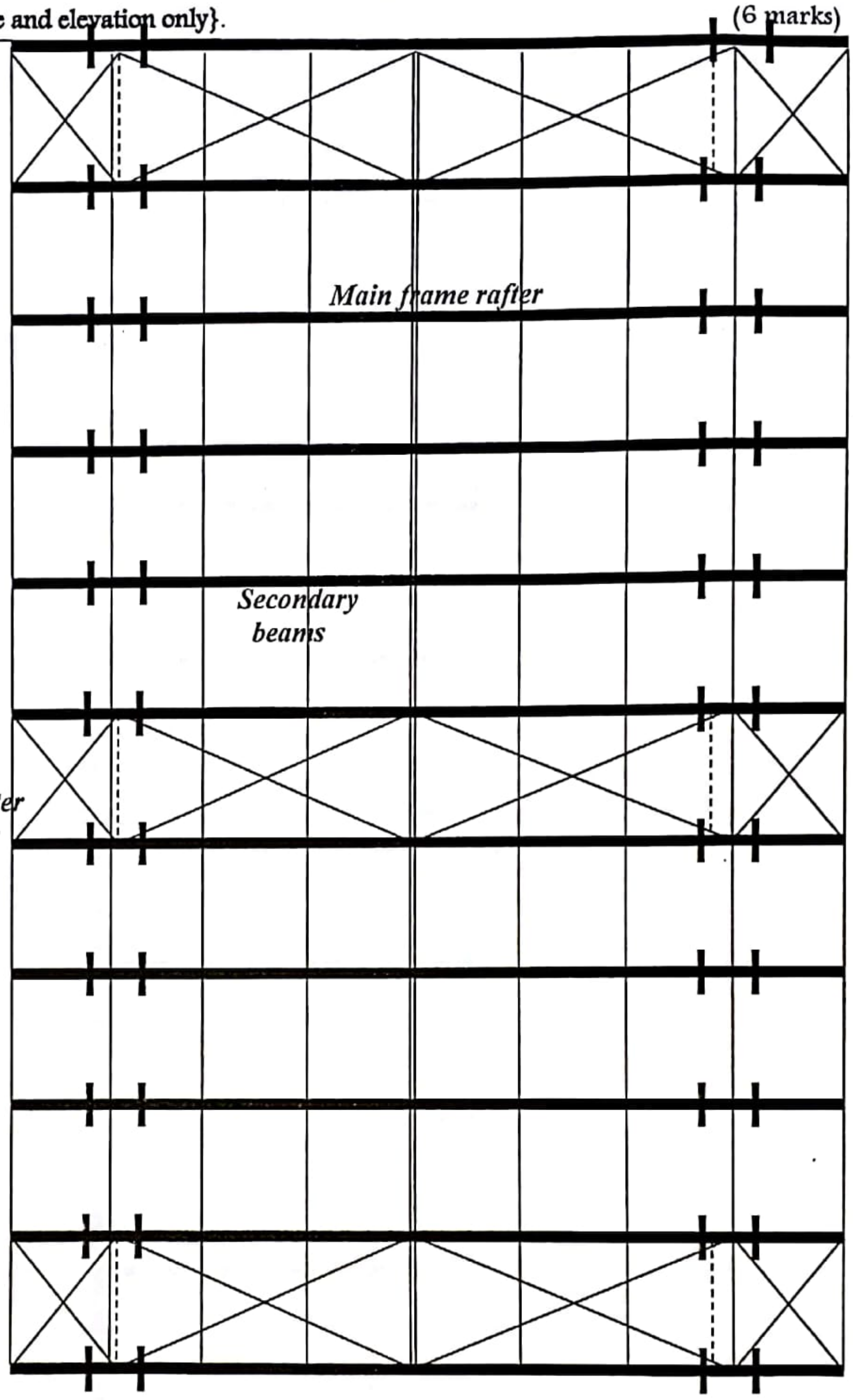
1. Draw to a convenient scale the general layout of the storage showing the distribution of the selected secondary beams and the main frames, **{plane and elevation only}**. (6 marks)
2. Draw the B.M.D. of the main frame due to the applied loads then design the main beam (rafter) of the frame. (8 marks)
3. Design the crane track girder as a built-up section. (6 marks)

Good luck

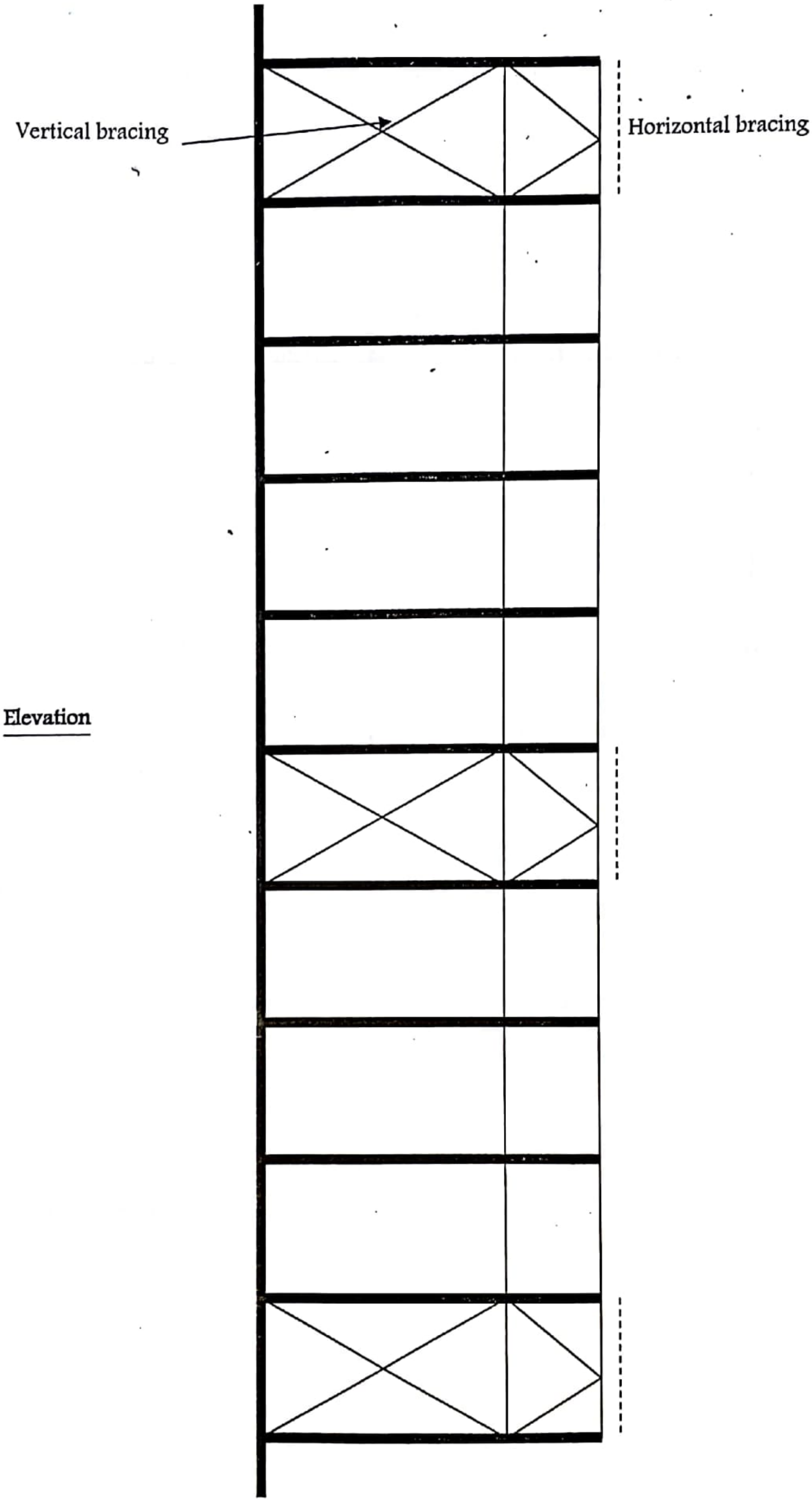
Model Answer

1- Draw to a convenient scale the general layout of the storage showing the distribution of the selected secondary beams and the main frames, **{plane and elevation only}**. (6 marks)





Structural plan of the frame roof

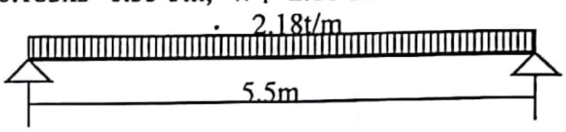


Elevation

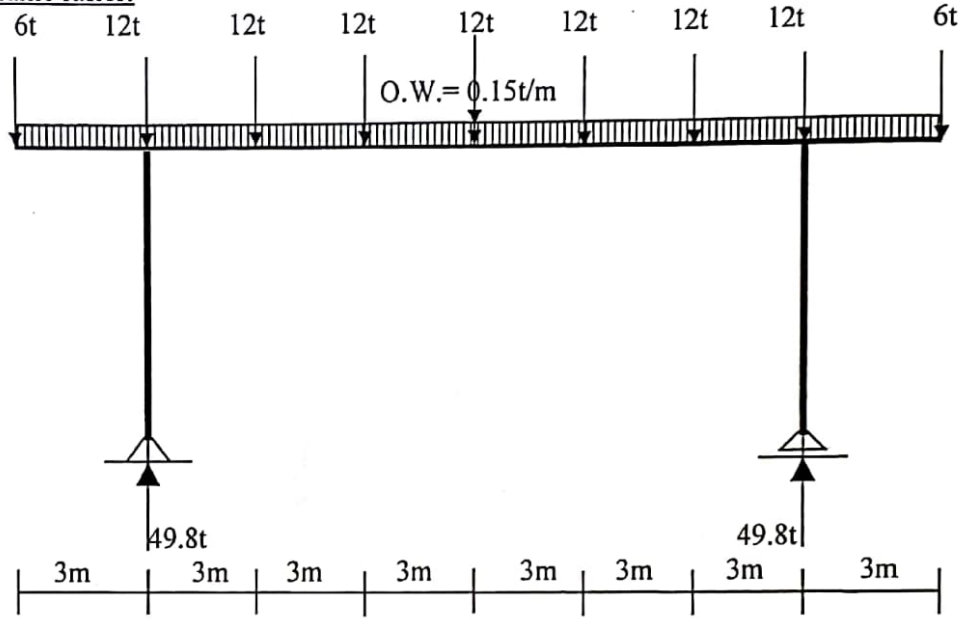
2- Draw the B.M.D. of the main frame due to the applied loads then design the rafter of the frame. (8marks)

For the secondary beam:

$W_{D.L.}$=0.15x2.5x3+0.15x3+0.05=1.63 t/m, $W_{L.L.}$=0.183x3=0.55 t/m, W_T=2.18 t/m
Reaction =12t



For an intermediate frame rafter:



Mmax.+ve at c= 149mt
Qmax. = 38t

Design of section:

F = M / S_x

Assume compact section therefore, F=0.64Fy=1.54t/cm² & Mmax. = 38.76mt,
Thus S_x =9675cm³ Choose (B.F.I.B. 800 , S_x =9890cm³)

Check of section class:

Check of stresses:

Check of normal stress:

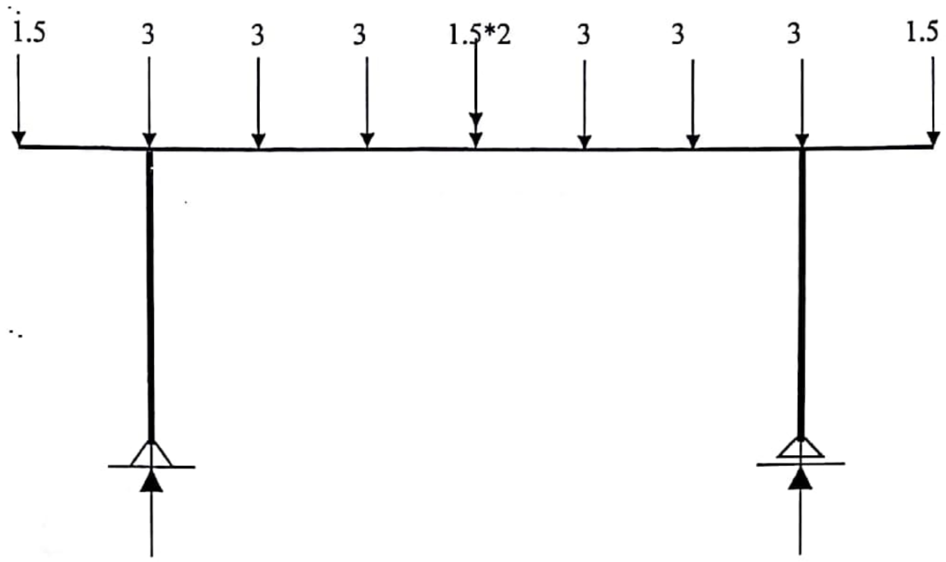
Fact= M / S_x = (149x100) / 9890 =1.51t/cm² **Safe O.K.**

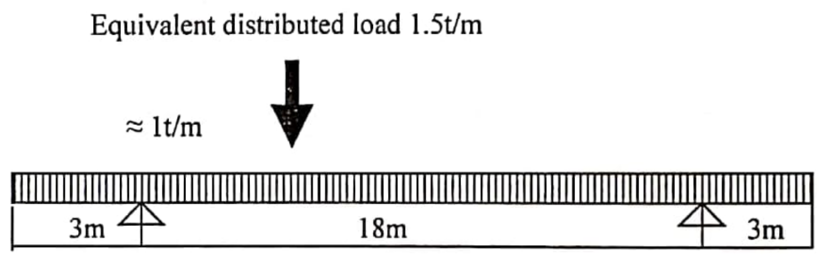
Check of shear stress:

q = 38/(80x1.75) = 0.27 t/cm² less than 0.84 t/cm² **Safe O.K.**

Check of deflection:

Due to L.L. on the main beam only is:



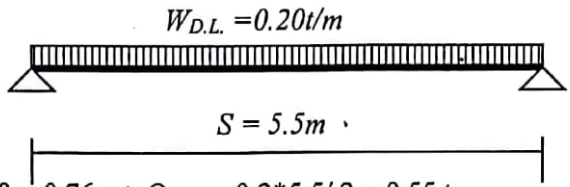


Therefore, $\delta_{L.L.}$ is calculated

3- Design the crane track girder as a built-up section. (6 marks)

1- Dead load:

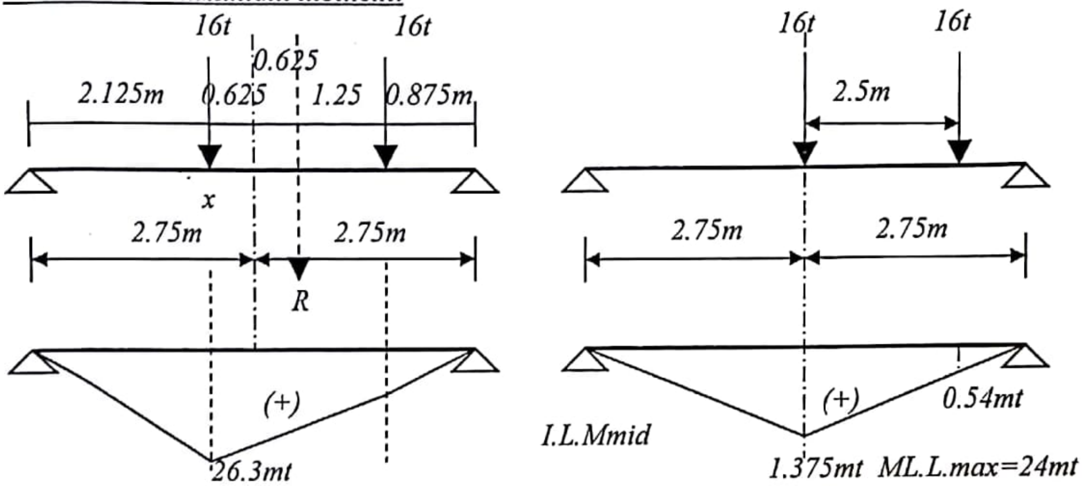
Assume O.W. of the crane girder = 0.20t/m.



$M_{D.L.} = 0.2*5.5^2/8 = 0.76$ mt, $Q_{D.L.} = 0.2*5.5/2 = 0.55$ t.

2- Live load and impact:

Calculate the maximum moment:



Case one

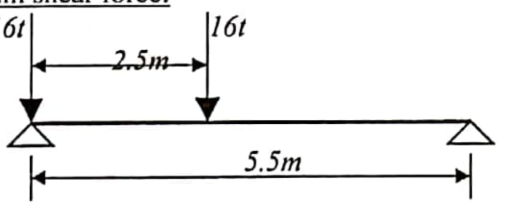
Case Two

Cases of maximum moments

Therefore:

$M_{L.L.} = 26.3$ mt., $M_{L.L.+I} = 26.3*(1+0.25) = 32.9$mt.

Calculate the maximum shear force:



Case of maximum shear

$Q_{L.L.} = 24.73$t, $Q_{L.L.+I} = 26.3*(1+I) = 24.73*(1+0.25) = 30.9$t

Design values on the crane girder are:

$M_x = M_{D.L.} + M_{L.L.+I} = 33.7$mt, $M_y = M_{L.L.}/10 = 3.37$mt and $Q_{max} = Q_{D.L.} + Q_{L.L.+I} = 31.5$t.

Choice of section as a hot rolled section

Assume the section is non – compact, therefore $F_b = 0.58F_y = 1.4$ t/cm².

$$S_x required = \frac{(33.7 + 8*3.37)*100}{1.4*1.2} = 3610 cm^3$$

Note that the stress is increased by 20% due to case II (lateral shock effect).

Choose ***BFIB No.550*** {55*30/1.6*3}, r=2.4cm.............. $S_x = 5100 cm^3$.

a- Check of the class of section

$\frac{c}{t_f} = \frac{16.6}{3} = 5.53 \le \frac{16.9}{\sqrt{F_y}} = 10.9$, the flange is compact.

$\frac{d_w}{t_w} = \frac{44.2}{1.6} = 27.6 \le \frac{127}{\sqrt{F_y}} = 82$, the web is compact.

Therefore, the section is fully compact.

b- Check of the lateral torsional buckling of compression flange

$L_{u\ act} = S = 550cm$

$L_{u\ max}$ = the least of $\left[\begin{array}{l} \ldots \frac{20b_f}{\sqrt{F_y}} = \frac{20*30}{\sqrt{2.4}} = 387.3cm \\ \ldots \frac{1380A_f}{d \times F_y} C_b = \frac{1380*30*3}{60*2.4} *1.35 = 1164.38cm \end{array}\right] = 387.3cm$

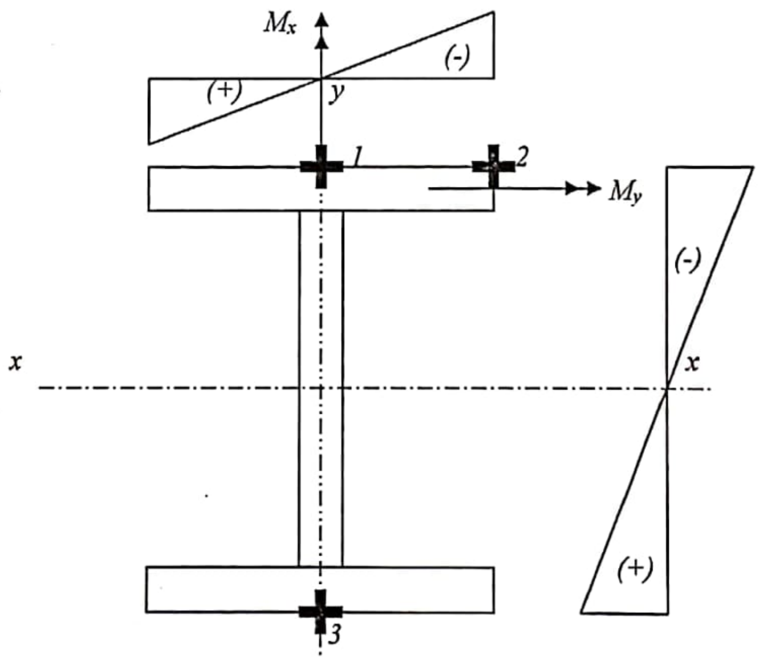
$L_{u\ act} > L_{u\ max}$

$F_{ltb1} = \frac{800A_f}{L_u d} C_b = \frac{800(30*3)}{700*60} 1.35 = 2.31t/cm^2 \ge 0.58F_y$

Therefore, $F_{ltb} = 0.58F_y = 1.4t/cm^2$

2- Check of stresses:

a- Check of bending stress:



Point 1,3:

$f_1 = \frac{M_x}{S_x} = \frac{33.7*100}{5100} = 0.7 \le 1.4t/cm^2$. **Safe O.K.**

Point 2:

$f_2 = \frac{M_x}{S_x} + \frac{M_x}{0.5S_y} = \frac{33.7*100}{5100} + \frac{3.37*100}{0.5*902} = 1.4 \le 1.4*1.2t/cm^2 = 1.68t/cm^2$.

Safe O.K.

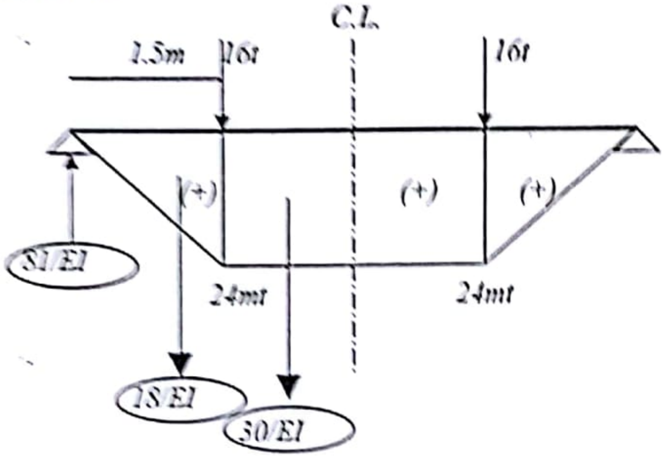
2- Check of shear stress

$q_{act} = 31.5/(55*1.7) = 0.34\ t/cm^2 \le 0.35F_y = 0.84\ t/cm^2$ **Safe O.K.**

3- Check of fatigue:

$f_{sr\ act} = f_{max} - f_{min} = (33.7-0.55)*100/5100 = 0.65\ t/cm^2 \le F_{sr\ allowable} = 1.68\ t/cm^2$ **Safe O.K.**

4- Check of deflection:



$$\delta_{act} = \frac{M_{mid-point}}{EI} = \frac{[81*2.75-18*1.75-30*0.625]*10^6}{2100*136700} = 0.6cm \le L/800 = 550/800 = 0.69cm$$

Safe O.K.