

Third Year Students of Civil Engineering	Course title: Design of Steel structures	Course Code : CES3016
Date : 27-5-2018	Term : Second	Total Assessment Marks : 75 Time Allowed : 4 hours
Steel used is steel 44 ($F_u = 4.4 \text{ t/cm}^2$ and $F_y = 2.8 \text{ t/cm}^2$)	Any missing data may be reasonably assumed. Answer as many questions as you can.	
The exam consists of 3 questions in four pages		

ILOS: A.4, A.12, A.13,A.14, B.3, B.5, B.15,B.17 C.1,C.9, D.3 and D.9

Question (1): (27 marks)

A- Figure (1) illustrates a structural plan for area of 6x12 m². The roof system is reinforced concrete roof of 10cm thickness. If weight of steel structures is 25 kg/m² and live load is 120 kg/m². It is required to carry out the following:

- 1- Calculate loads acting on beam B and Draw straining actions on beam B.
- 2- Design the beam B using HEA sections.

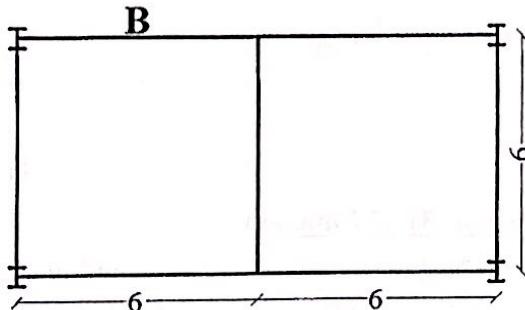


Figure (1)

B- If the designed beam B that shown in figure (1) considered as a composite steel beam under the same loads, calculate the ratio of increase of the beam span. Also calculate number of stud shear connectors of 18mm. The construction method is occurred with shoring.

C- design a crane track girder with 8 m span using HEA sections to carry two reactions of crane bridge spaced 1.5 m. The total capacity of the crane trolley is 14 ton including its own weight. The trolley was moved in 90% of crane bridge span. The crane bridge span is 19m. Consider the dynamic effect (I) = 25 % and lateral shock = 10%, neglect weight of crane bridge.

Question (2): (30 marks)

Figure (2) shows the main structural system covering an industrial area (24.8x30m). The spacing of the steel frames is 6m. The steel frame is roller at A and the frame is hinge at B. It is required to:

A- Draw with a suitable scale elevation, two side views, end gable and plan showing the different arrangement of bracing system.

B- Calculate load distribution of the steel frame due to dead load, live load and left wind load. Draw the BMD and NFD for all load distributions. Determine in table the design values for the critical sections. Consider the given data: live load 120 kg/m², Weight of covering material 40 kg/m², weight of steel structures 35 kg/m² and wind load intensity 90 kg/m²

C- Calculate the buckling length of column BF in the plane of the steel frame and out of plane. Consider the girts that you choice in required A.

D- Design the rigid connection between the rafter and the column at D using high strength bolt M24, grade 8.8 (design= weld + bolts). Also explain with calculations how to check the safety of the column web and flanges at the joint. Consider the straining actions are: M=22 m.t, Q=6 ton and N= -2 ton. for M24 (8.8), $A_s=3.53\text{cm}^2$, $f_{yb}=6.4 \text{ t/cm}^2$, $f_{ub}=8 \text{ t/cm}^2$, case of loading II, st.44, class B surfaces, ordinary steel work.,

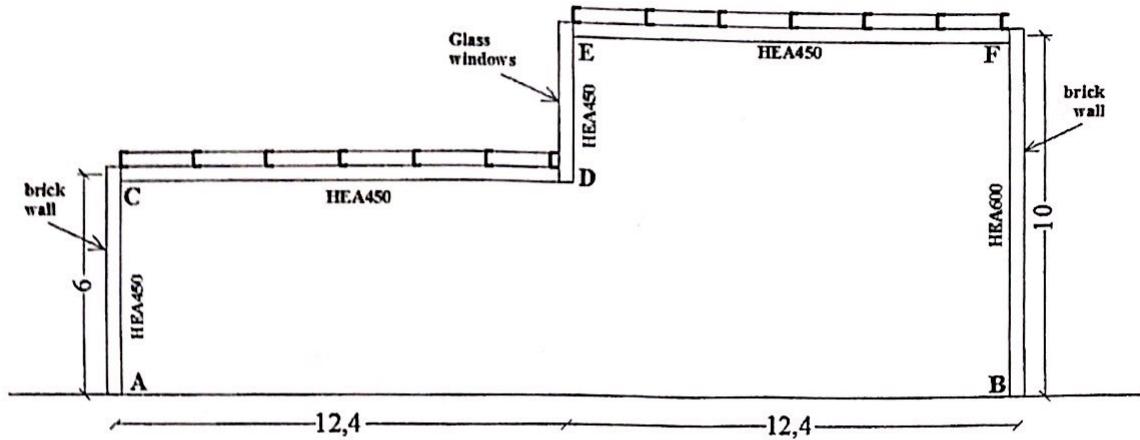


Figure (2)

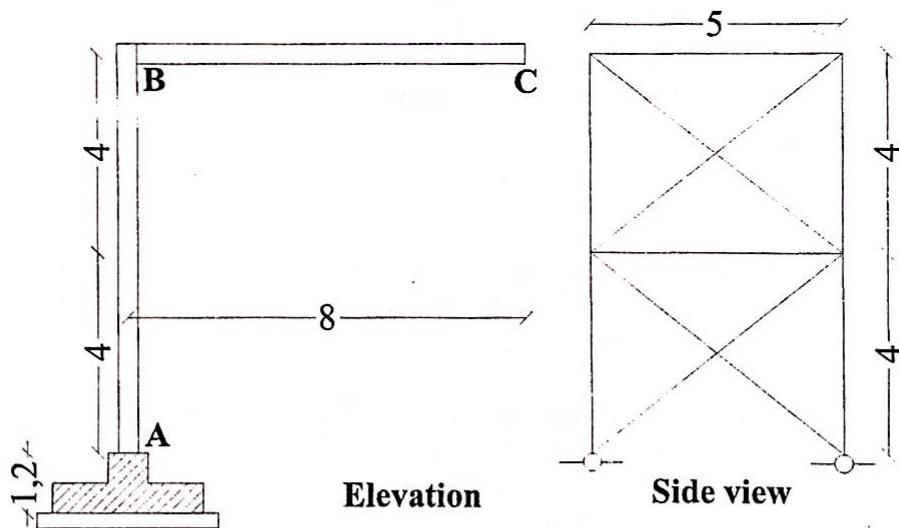
Question (3): (27 marks)

Figure (3) shows an intermediate cantilever frame supported on reinforced concrete footing. The total uniform load acting on the roof is 200 kg/m^2 . It is required to:

A- Design the column AB using steel section HEA.

B- Design the fixed base at A and draw to scale the details of the base in elevation and plan. Assume that the cross section of the column is HEA 450. Let concrete C350.

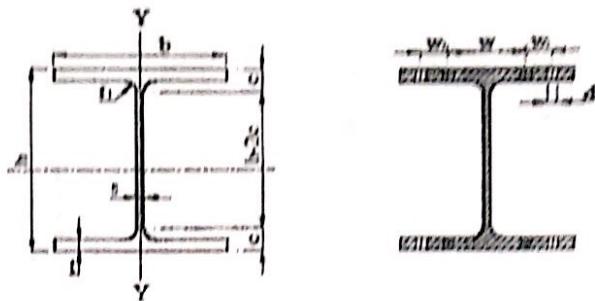
Figure (3)



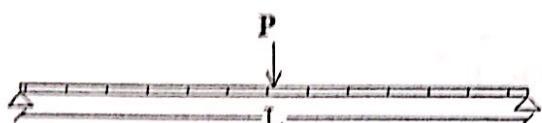
Best wishes

Examiners: Dr/Ali Basha & Dr/Sabry El-Morsy

BROAD FLANGE I - BEAMS (H.E.A.)



Sec. No.	Weight kg/m ³	Area cm ²	A _{web} cm ²	Dimensions							Axis X-X			Axis Y-Y			Details			Surface Area	
				b	b	s	t	r _x	s	h/2a	I _x	S _x	r _y	I _y	S _y	r _x	w	w ₁	d _{ext}	I _x x10 ² m ⁴ /in ⁴	I _y in ²
100	18.7	21.2	4.00	98	100	6.0	6.0	12	20	78	340	73	4.06	134	26.6	2.61	68	H.A.	M12	68.10	22.00
120	16.6	25.3	4.00	114	120	6.0	6.0	12	20	74	608	106	4.06	231	56.5	3.02	68	H.A.	M16	87.70	24.00
140	24.7	31.4	6.38	133	140	6.5	6.5	12	21	91	1030	156	6.73	366	66.6	3.62	76	H.A.	M20	76.40	32.19
160	30.4	39.6	6.04	152	160	6.0	6.0	16	24	104	1670	220	6.57	616	76.9	3.08	86	H.A.	M20	90.60	39.60
180	36.6	46.5	9.12	171	180	6.0	9.5	15	25	121	2510	204	7.45	626	103	4.62	100	H.A.	M24	102.60	29.70
200	42.8	53.6	11.05	190	200	6.5	10.0	18	28	134	3650	300	8.28	1240	134	4.66	116	H.A.	M24	114.00	26.90
220	50.0	64.3	13.18	210	220	7.0	11.0	19	29	152	6410	515	9.17	1650	178	5.61	126	H.A.	M24	126.00	24.20
240	60.3	76.8	15.46	230	240	7.5	12.0	21	31	164	7780	675	10.10	2170	231	6.00	40	M24	137.00	22.70	
260	68.2	86.6	16.66	250	260	7.5	12.5	24	37	176	10450	856	11.00	2670	262	6.66	40	M24	146.00	21.70	
280	76.4	97.3	16.52	270	280	8.0	13.0	24	37	196	13970	1010	11.60	3700	349	7.00	40	M24	160.00	21.00	
300	85.3	113	22.27	290	300	8.5	14.0	27	41	209	18200	1200	12.10	6310	421	7.49	120	59	M27	172.00	19.60
320	97.6	124	25.11	310	309	9.0	15.5	27	43	224	22930	1480	13.00	6000	400	7.49	120	69	M27	176.00	18.70
340	105	139	29.72	330	300	9.5	16.5	27	44	242	27000	1680	14.40	7440	495	7.46	120	59	M27	179.00	17.10
360	112	143	31.60	350	300	10.0	17.5	27	45	260	33090	1860	15.20	7840	520	7.43	120	69	M27	183.00	16.40
400	125	156	36.72	360	300	11.0	16.0	27	46	296	45070	2310	16.80	8560	571	7.34	120	69	M27	191.00	15.30
450	140	176	46.77	440	306	11.5	21.0	27	48	344	63720	2600	16.00	6470	631	7.26	120	69	M27	201.00	14.40
500	165	196	53.26	460	300	12.0	23.0	27	50	340	66970	3550	21.00	10310	601	7.24	120	59	M27	211.00	13.60
550	199	212	61.80	540	300	12.5	24.0	27	51	438	111000	4100	25.00	10820	721	7.16	120	59	M27	221.00	13.30
600	216	226	70.20	590	300	13.0	25.0	27	52	488	141200	4700	25.00	11270	761	7.05	120	69	M27	231.00	13.00
650	100	242	78.38	610	300	13.5	26.0	27	53	534	173200	5140	26.00	11720	782	6.97	120	59	M27	241.00	12.70
700	204	290	92.22	690	300	14.5	27.0	27	54	592	215300	5640	26.00	12180	812	6.84	120	60	M27	250.00	12.30
800	224	288	110.10	700	300	15.0	28.0	30	68	674	303400	7080	32.00	12640	843	6.65	120	60	M27	270.00	12.00
860	262	571	132.60	690	300	16.0	30.0	30	60	770	422100	9480	36.30	13650	903	6.50	120	60	M27	260.00	11.80
1000	272	547	155.12	690	300	16.5	31.0	30	61	656	663800	11100	40.00	14000	934	6.35	120	60	M27	310.00	11.40



$$\Delta = \frac{PL^3}{48EI} + \frac{5wl^4}{385EI}$$

$$Q_{1cm} = \frac{QA_c y_c}{I_v}$$

a- When $L_u/r_T < 84\sqrt{\frac{C_b}{F_y}}$, then:

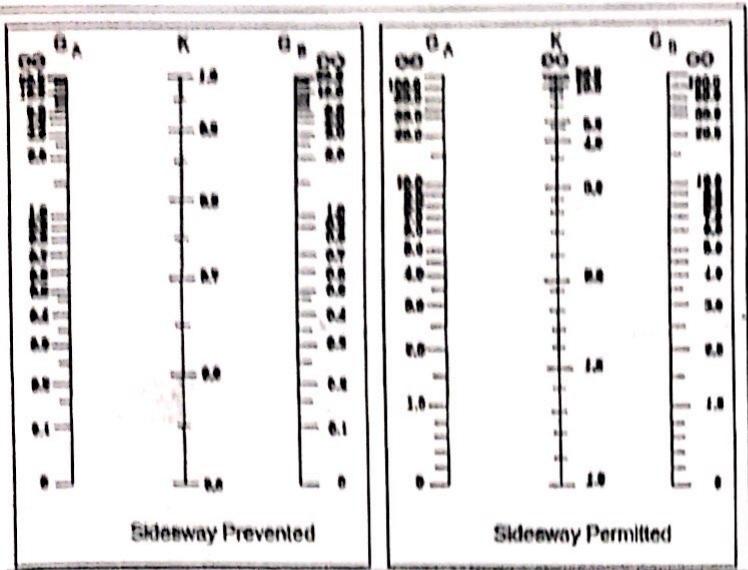
$$F_{lb_2} = 0.68 F_y \dots$$

$$F_{lb_1} = \frac{800}{L_u \cdot d/A_f} C_b \leq 0.58 F_y$$

$$L_u \leq \frac{20b_f}{\sqrt{F_y}} \quad \text{Or} \quad L_u \leq \frac{1380A_f}{dF_y} C_b$$

c- When $L_u/r_T > 188\sqrt{\frac{C_b}{F_y}}$, then:

$$F_{lb_2} = \frac{12000}{(L_u/r_T)^2} C_b \leq 0.58 F_y \dots$$



$\mu = 0.5$ for class A surfaces.
 $\mu = 0.4$ for class B surfaces.
 $\mu = 0.3$ for class C surfaces.

- γ = Safety factor with regard to slip .
 - 1.25 and 1.05 for cases of loading I and II respectively for ordinary steel work.
 - 1.6 and 1.35 for case of loading I and II respectively for parts of bridges, cranes and crane girders which are subjected mainly to dynamic loads.

$$P = \left[\frac{1}{2} + \frac{wt_p^4}{30ab^2A_s} \right] T_{ext,B,M} \text{ or } T_{ext,B} - \left[\left(\frac{3a}{4} \right) \left(\frac{a}{4b} + 1 \right) + \frac{wt_p^4}{30ab^2A_s} \right]$$

$$t_{wc} \geq \frac{b_b t_b}{t_b + 2t_p + 5k}$$

$$2 b_{st} t_{st} \geq b_b t_b - (t_b + 2t_p + 5k) t_{wc}$$

$$b_{st}/t_{st} \leq 25/\sqrt{F_y}$$

$$t_{foot} \geq 0.4 * \sqrt{b_b t_b}$$

$$t_{wc} \geq (M/d_b) / [(0.35 F_y) h_c]$$

$$2b_{st}t_{st} - [(M/d_b) - (0.35 F_y) h_c t_{wc}] / (0.58 F_y \cos \theta) \geq 0$$

$$\alpha = 0.5 \left(\frac{N}{d_w t_w F_y} + 1 \right)$$

$$\text{If } \alpha \leq 0.5, \frac{d_w}{t_w} \leq \left(\frac{63.6/\alpha}{\sqrt{F_y}} \right)$$

$$\text{If } \alpha > 0.5, \frac{d_w}{t_w} \leq \left(\frac{699/\sqrt{F_y}}{13 \alpha - 1} \right)$$

Grade of Steel	$F_e (\text{kg/cm}^2)$	
	$t < 40 \text{ mm}$	$40 \text{ mm} \leq t \leq 100 \text{ mm}$
B137	$F_e = (1.4 - 0.000065\lambda^2)$	$F_e = (1.3 - 0.000065\lambda^2)$
B144	$F_e = (1.6 - 0.000085\lambda^2)$	$F_e = (1.5 - 0.000075\lambda^2)$
B162	$F_e = (2.1 - 0.000135\lambda^2)$	$F_e = (2.0 - 0.000125\lambda^2)$

$$C_b = 1.75 + 1.05 (M_1/M_2) + 0.3 (M_1/M_2)^2 \leq 2.3$$

Allowable Bearing Stress (kg/cm^2)
40
70 for C 250
110 for C 360