Aalto University
Department of Civil Engineering
CIV-E1030 Fundamentals of Structural Design **Examination 2 14.12.2016**
Write on each answer sheet Surname, First name and Study ID

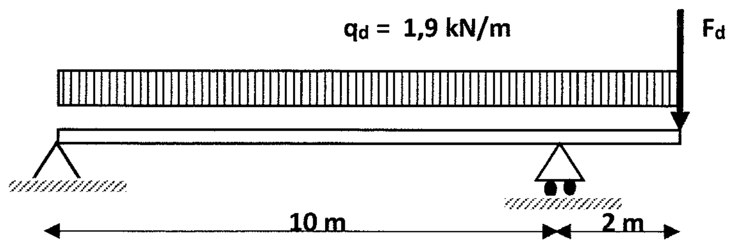
1. Answer to the following questions shortly and use drawings if needed:

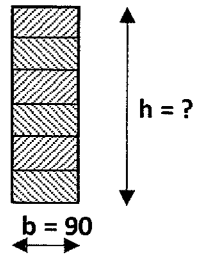
a) What is meant by the term *imposed loads?*
b) Explain typical concrete material composition.
c) Why stirrups are used in concrete beams and columns?
d) What things have to be checked in the design of rigid retaining wall founded on the rock?
e) Why the steel cross-sections are divided to different classes in the design.
f) Explain three basic methods to stabilize building.

2. Glulam timber beam is supported and loaded as shown in the figure. Strength class is GL30c, service class 2; $k_{mod} = 0.8$ and the material factor $\gamma_M = 1.2$.

a) Determinate the minimum height (h) of the beam needed, when the point load $F_d = 0$.
b) What is the maximum point load (F_d), which can be put at the end of the cantilever?

The width of the beam is 90 mm. The height of glulam beams can vary from 90, 135, 180,225…etc. in steps of lamella height of 45 mm.
Note: Use as design criteria only the ultimate bending moment capacity of the beam. Inspections for shear or sideways buckling are not needed.

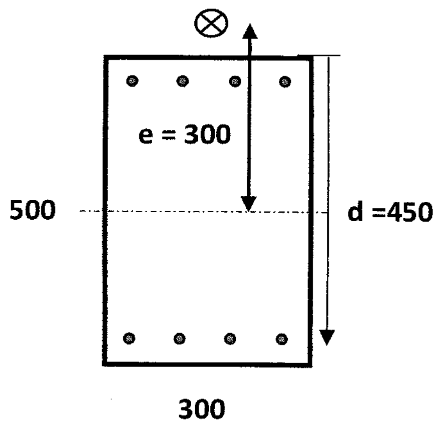




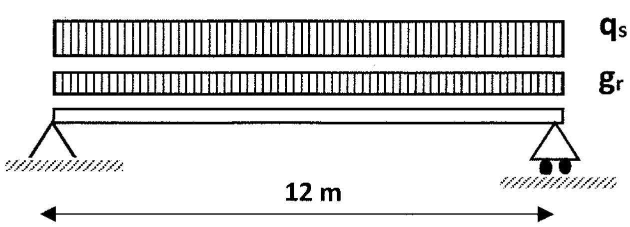
3. Cross-section of symmetrically reinforced concrete column is shown in the figure. Strength class of the concrete is C35 and the quality of steel is B500B. Loading is eccentric (e = 300 mm) compressive load consisting of permanent $N_g = 400$ kN and imposed load $N_q = 700$ kN. Respective load factors are 1.15 and 1.5.
Design required amount of reinforcement at cross-section:

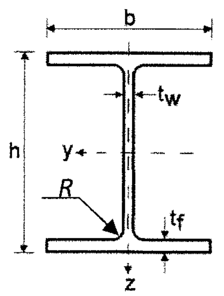
a) By using attached interaction diagram for symmetric section
b) By using equilibrium equations of stress resultants.

Material factors for concrete and reinforcement are 1.5 and 1.15. (CC2).



4. Determine suitable hot rolled IPE –beam, supporting 12 m span roof.
The quality of steel is S275 ($\gamma_M = 1.0$). Spacing between beams is 5 m. Self-weight and section values for IPE profiles are in attached table. Weight of the roof is $g_r = 1{,}2$ kN/m^2 and charakteristik snow load $q_s = 1{,}8$ kN/m^2. Load factors for permanent and live loads are 1.15 and 1.5, respectively. (CC2).
(The beam is prevented against horizontal buckling).





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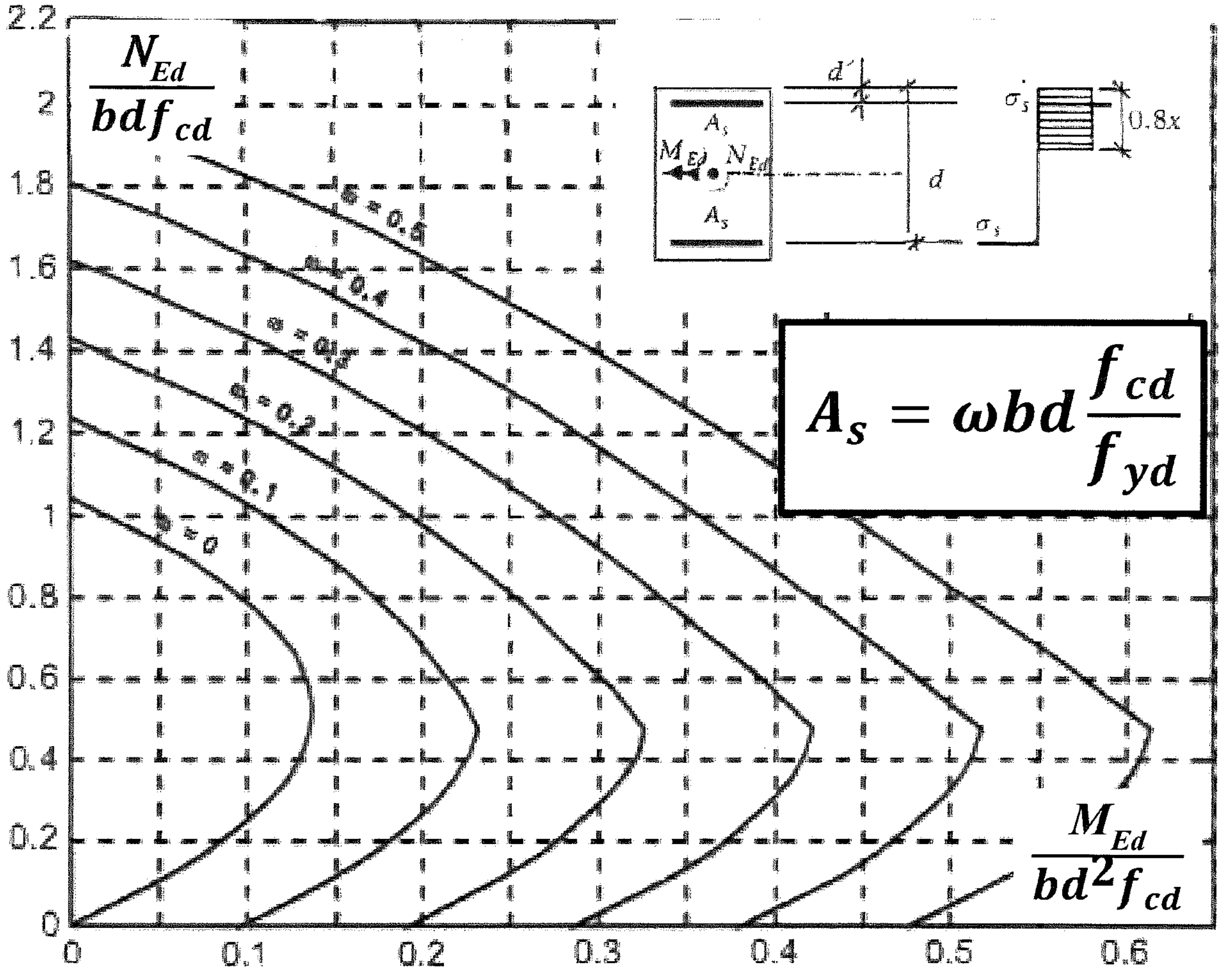
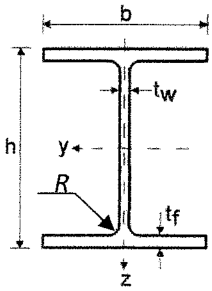
Interaction diagram for RC-column



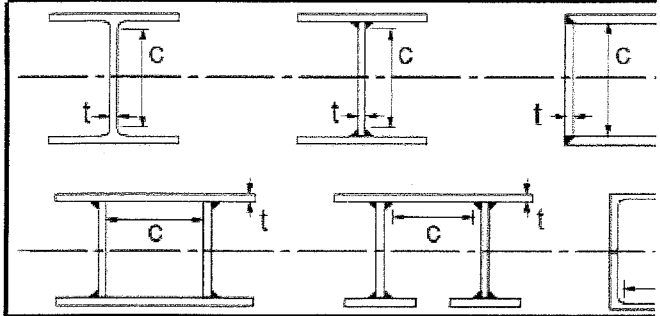
IPE

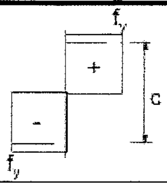
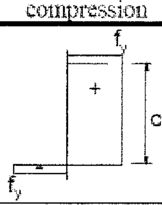
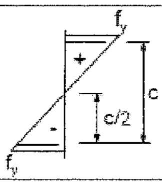
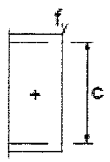
g	mass/m
F	mantel surface area/m cross-
A	section area
A_W	web area
I_y	moment of inertia
W_y	elastic bending resistance W_{el}
Z_y	plastic bending resistance W_{pl}
$i_{y,z}$	radius of inertia



	Areas and mass				Cross-section dimensions					Bending around y-axle			
Dim	g kg/m	F m²/m	A mm²	A_w mm²	h mm	b mm	t_f mm	t_w mm	R mm	I_y mm⁴ x10⁶	W_y mm³ x10³	Z_y mm³ x10³	i_y mm
80	6.0	0.328	764	264	80	46	5.2	3.8	5	0.801	20.0	23.2	32.4
100	8.1	0.400	1032	363	100	55	5.7	4.1	7	1.710	34.2	39.4	40.7
120	10.4	0.475	1321	472	120	64	6.3	4.4	7	3.178	53.0	60.7	49.0
140	12.9	0.551	1643	593	140	73	6.9	4.7	7	5.412	77.3	88.3	57.4
160	15.8	0.623	2009	726	160	82	7.4	5.0	9	8.693	109	124	65.8
180	18.8	0.698	2395	869	180	91	8.0	5.3	9	13.17	146	166	74.2
200	22.4	0.768	2848	1025	200	100	8.5	5.6	12	19.43	194	221	82.6
220	26.2	0.848	3337	1189	220	110	9.2	5.9	12	27.72	252	285	91.1
240	30.7	0.922	3912	1366	240	120	9.8	6.2	15	38.92	324	367	99.7
270	36.1	1.04	4594	1647	270	135	10.2	6.6	15	57.90	429	484	112
300	42.2	1.16	5381	1978	300	150	10.7	7.1	15	83.56	557	628	125
330	49.1	1.25	6261	2303	330	160	11.5	7.5	18	117.7	713	804	137
360	57.1	1.35	7273	2677	360	170	12.7	8.0	18	162.7	904	1020	150
400	66.3	1.47	8446	3208	400	180	13.5	8.6	21	231.3	1160	1310	165
450	77.5	1.61	9882	3956	450	190	14.6	9.4	21	337.4	1500	1700	185
500	90.7	1.74	11550	4774	500	200	16.0	10.2	21	482.0	1930	2190	204
550	106	1.88	13440	5723	550	210	17.2	11.1	24	671.2	2440	2790	223
600	122	2.01	15600	6744	600	220	19.0	12.0	24	920.8	3070	3510	243

EC3 Table 5.2 Sheet 1 Max width to thickness



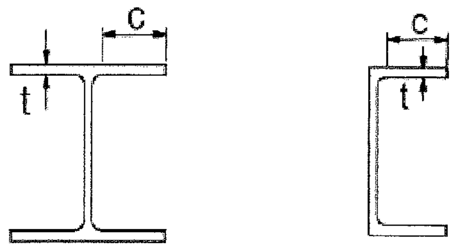
Class	Part subject to bending	Part subject to compression
Stress distribution in parts (compression positive)		
1	$c/t \le 72\varepsilon$	$c/t \le 33\varepsilon$
2	$c/t \le 83\varepsilon$	$c/t \le 38\varepsilon$
Stress distribution in parts (compression positive)		
3	$c/t \le 124\varepsilon$	$c/t \le 42\varepsilon$

$\varepsilon = \sqrt{235/f_y}$	f_y	235	275
	ε	1,00	0,92

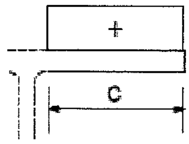
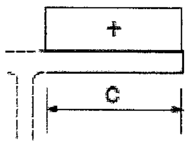
*) $\psi \le -1$ applies where either the compression stress $\sigma \le f_y$ or th

EC3 Table 5.2 sheet 2 Max width to thickness

Outsta



Rolled sections

Class	Part subject to compression
Stress distribution in parts (compression positive)	
1	$c/t \le 9\varepsilon$
2	$c/t \le 10\varepsilon$
Stress distribution in parts (compression positive)	
3	$c/t \le 14\varepsilon$

$\varepsilon = \sqrt{235/f_y}$	f_y	235
	ε	1,00