

TBA 4125 - Main project - Konstruksjon

Jochen Köhler

Institute of Structural Engineering, NTNU

Version 12.02.2024

Deadline 15.03.2024.

1 Introduction

A new office building is to be built, and you are the engineers tasked with carrying out the preliminary design of the structure. A 3D-model of the structure is provided as an **IFC-model**, see also Figure (1)¹. Your job is to create technical drawings, calculate relevant loads, load combinations, and use simplified analysis to assess the feasibility of the structure before it enters the detailed design phase.

¹There are many IFC-viewers free and online on the www. A recommendation is the one from [Autodesk](#).

Alternatively try the following options:

1. Go to: <https://apps.ntnu.no/apps/all> - no sign up and no download required, works for both MAC and Windows. Follow online instructions to install AppsAnywhere get access to software licenses. Then:
 - a. Search for ArchiCAD and press Start. File > Open > select file type IFC and open where file is saved. OR
 - b. Search for SketchUp Pro and press Start. File > Import > select file type IFC and open where file is saved.
2. Go to: Autodesk Viewer – online viewer only - online sign up required. No license required.
3. Go to: Autodesk Revit – local viewing and drawing - online sign up and download required. Free educational license available for students.

- Columns have a diameter of 300 mm , beams are $300\text{ mm} \times 300\text{ mm}$. Slabs are 180 mm thick.

Loads (characteristic values):

- Self-weight of the RC structure. Density of reinforced concrete is 26 kN/m^3
- Weight of the permanent installation – 2.1 kN/m^2
- Variable imposed load – 3.5 kN/m^2
- Snow loads - according to NS-EN 1991-1-3
- Wind loads - according to NS-EN 1991-1-4

2 Tasks

Task 1 - Technical drawings: Produce the necessary drawings required to build this structure. Label the structure with axes ranging from A to C in the Y- direction, and 1 to 4 in the X- direction.

Task 2 - Snow loads: Calculate the characteristic snow load on the roof according to NS-EN 1991-1-3 and provide a clear overview of all loads based on a table and sketches.

Task 3 - Wind loads: Calculate the characteristic wind loads acting on the walls and roofs of the structure according to NS-EN 1991-1-4. Provide a clear overview of all loads based on a table and sketches.

Task 4 - Horizontal load transfer:

1. Is the structure stable when subject to horizontal loads as it is? What is required to make it stable? (Hint: consider the properties of the connections)
2. How can we ensure structural stability without putting any requirements to the connections of the beam-column frame?
3. In a plan view, sketch different 3 shear wall arrangements for the structure that will ensure its stability. Give your reasoning for choosing a certain arrangement (number of walls, their placement, etc), and decide which arrangement you think is the best.

Task 5 - Structural analysis:

1. Consider the column in axis B-2, at the level of the foundation.
 - (a) Sketch the load areas of the roof and the two floors that is supported by the column.
 - (b) What is the dead load, N_g , in the column in kN?
 - (c) What is the variable imposed load, N_q , in the column in kN?

- (d) Using the snow load results from task 2, what is the snow load, N_s , in the column, in kN?
 - (e) Using the wind load results from task 3, what is the wind load, N_w , in the column, in kN?
 - (f) Using the loads you calculated in (b), (c), (d) and (e), calculate the design load, N_d , in the column using equations 6.10 a) and b) from Eurocode 1. Remember to consider both the snow load or the variable load as the leading variable load.
 - (g) What is the final design load for the column, N_d ?
 - (h) To calculate this design load, the variable imposed load is assumed to act on all floors simultaneously. Is this realistic?
2. Consider the continuous beam on the first floor in axis 2 A-C. Calculate the relevant load combinations (see [Link](#) for hints) for the positive and negative bending moments in the beam. Consider only dead load and variable imposed load, not snow.
 3. Now imagine that the column in axes B were removed, and the concrete beam is replaced by a steel beam. Calculate the bending moment now, and suggest a suitable steel profile from the table below. The steel beam should be of S355 steel with a design value for the yield strength of $f_{y,d} = 338 \text{ MPa}$.
 4. Do we save money on materials by doing this? Assuming the price of reinforced concrete is 3000 NOK per m^3 and the price of S355 steel is 6000 NOK per t .
 5. Comment on the results in the previous two exercises. What other factors affect cost as well as just material cost? Will these factors change which option is cheapest or not?
 6. How will removing the columns in axes B affect the rest of the structure? Answer qualitatively.

Task 6 (not compulsory) - Forensic Engineering: When structures fail, people can get hurt and these cases are often considered in the light of legal justice. In these cases, structural engineers are consulted to analyse the structural failure ex post facto.

A very recent and spectacular case is reported [here](#).

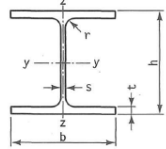


Figure 2: Building exposed to wind.

1. Collect information and make some reasonable assumptions about the geometry of the building and the self weight. (note that the self weight is characterised by the mean value - make a “fair guess”),
2. Characterise the wind pressure on the building for the corresponding site according EN1991-1-4.
3. Analyse whether the building is in Equilibrium by utilising EN1990 Eq.6.10.
4. Design the necessary anchorage resistance for the building. Where would you place the anchorage?

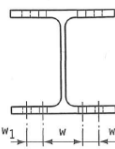
Appendix

L 13 VARMVALSEDE HE-B - BJELKER



Dimensjoner etter NS-EN 10 034
Materiale etter NS-EN 10 025

Betegnelse f.eks.: Bjelke NS-EN 10 034 HE 360 B
Stål NS-EN 10 025



Dimensjoner (mål i mm)						Masse kg/m	A ·10 ⁻³ mm ²	y - y			z - z			I _T ·10 ⁻³ mm ⁴	S _y ·10 ³ mm ³	C _w ·10 ⁹ mm ⁶	Hullavstand / hulldiam.(i mm)		
h	b	s	t	r	I·10 ⁶ mm ⁴			W·10 ³ mm ³	i mm	I·10 ⁶ mm ⁴	W·10 ³ mm ³	i mm	w				w ₁	d	
100	100	6	10	12	20,4	2,60	4,50	88,9	41,6	1,67	33,5	25,3	92,9	52,1	3,375	56	-	13	
120	120	6,5	11	12	26,7	3,40	8,64	144	50,4	3,18	52,9	30,6	139	82,6	9,410	66	-	17	
140	140	7	12	12	33,7	4,30	15,1	216	59,3	5,50	78,5	35,8	201	123	22,48	76	-	21	
160	160	8	13	15	42,6	5,43	24,9	311	67,8	8,89	111	40,5	314	177	47,94	86	-	23	
180	180	8,5	14	15	51,2	6,53	38,3	426	76,6	13,6	151	45,7	423	241	93,75	100	-	25	
200	200	9	15	18	61,3	7,81	57,0	570	85,4	20,0	200	50,7	595	321	171,1	110	-	25	
220	220	9,5	16	18	71,5	9,10	80,9	736	94,3	28,4	258	55,9	768	414	295,4	120	-	25	
240	240	10	17	21	83,2	10,6	112,6	938	103	39,2	327	60,8	1030	527	486,9	96	35	25	
260	260	10	17,5	24	93,0	11,8	149,2	1150	112	51,3	395	65,8	1240	641	753,7	106	40	25	
280	280	10,5	18	24	103	13,1	192,7	1380	122	65,9	471	70,9	1440	767	1130	110	45	25	
300	300	11	19	27	117	14,9	251,7	1680	130	85,6	571	75,8	1860	934	1688	120	45	28	
320	300	11,5	20,5	27	127	16,1	308,2	1930	138	92,4	616	75,7	2260	1070	2069	120	45	28	
340	300	12	21,5	27	134	17,1	366,6	2160	146	96,9	646	75,3	2580	1200	2454	120	45	28	
360	300	12,5	22,5	27	142	18,1	431,9	2400	155	101,4	676	74,9	2930	1340	2883	120	45	28	
400	300	13,5	24	27	155	19,8	576,8	2880	171	108,2	721	74,0	3570	1620	3817	120	45	28	
450	300	14	26	27	171	21,8	798,9	3550	191	117,2	781	73,3	4420	1990	5258	120	45	28	
500	300	14,5	28	27	187	23,9	1072	4290	212	126,2	842	72,7	5400	2410	7018	120	45	28	
550	300	15	29	27	199	25,4	1367	4970	232	130,8	872	71,7	6020	2800	8856	120	45	28	
600	300	15,5	30	27	212	27,0	1710	5700	252	135,3	902	70,8	6690	3210	10965	120	45	28	
650	300	16	31	27	225	28,6	2106	6480	271	139,8	932	69,9	7410	3660	13363	120	45	28	
700	300	17	32	27	241	30,6	2569	7340	290	144,4	963	68,7	8330	4160	16064	126	45	28	
800	300	17,5	33	30	262	33,4	3591	8980	328	149,0	994	66,8	9490	5110	21840	130	40	28	
900	300	18,5	35	30	291	37,1	4941	10980	365	158,2	1050	65,3	11400	6290	29461	130	40	28	
1000	300	19	36	30	314	40,0	6447	12890	401	162,8	1090	63,8	12600	7430	37637	130	40	28	

Figure 3: Steel beam.

Documentation

The tasks of the project have to be documented in a report that contains all information in a comprehensive and professional layout.

This implies the following recommendations for reporting:

- The report should start with a title page containing the following information:
 - Course name (TBA4125 - Prosj...)
 - Report title

- All names of the group and group number
 - Place and date
- The report should contain a table of content and should be well structured.
- Drawings are attached with their original paper formats, i.e. not shrunk down to A4.
- References to literature and standards should be given, a list of references is added at the end of the report.
- All figures and tables have numbers and captions.
- The report contains a section on summary and a section on conclusions. In the latter you might report also on observations or experiences during the work on the tasks.
- The report should also document how the different tasks have been distributed among the group members.