INDEX

1.-CRANE SYSTEMS

A crane is a lifting machinery discontinuous movement aimed at raising and distributing loads in space suspended from a hook.

They are usually invents makes with counterweights, simple mechanisms to create mechanical advantage and make moving large loads.

The first cranes were invented in Greece, powered by men or animals. These cranes were used mainly for the construction of tall buildings. Subsequently, larger cranes were developed using pulleys to allow the lifting of heavier weights. In the High Middle Ages were used in ports and shipyards for the construction of berths and ships. Some of them were built with stone towers anchored to provide additional stability. The first cranes were built of wood, but since the advent of the industrial revolution the materials used are cast iron and steel.

The first mechanical energy was provided by steam engines in the s. XVIII. Modern cranes usually use internal combustion engines or electrical systems and hydraulic motor to provide much greater strength, although manual cranes are still used on small jobs or where it is uneconomical to have energy.

There are many different types of cranes, each adapted to a specific purpose. Sizes range from the smallest jib cranes, used inside workshops, tower cranes, used to build tall buildings, until the floating cranes, used to build oil rigs and boats to rescue stranded.

1.1.- Overhead travelling cranes

Overhead crane lift loads up to 100 t, so they are the ideal solution for especially cargo handling very heavy and Craft wide. The range of overhead cranes covers four models of different for different applications and conditions of use:

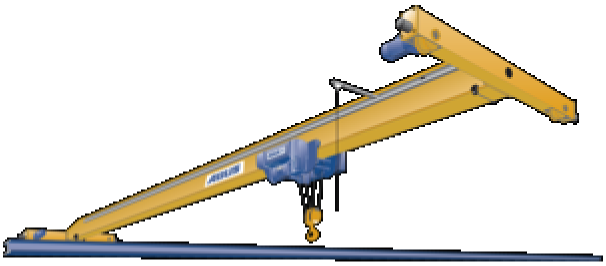


Figure 1.Single-girder overhead travelling crane.

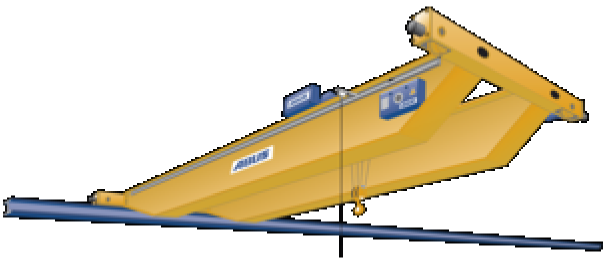


Figure 2. Double-girder overhead travelling crane

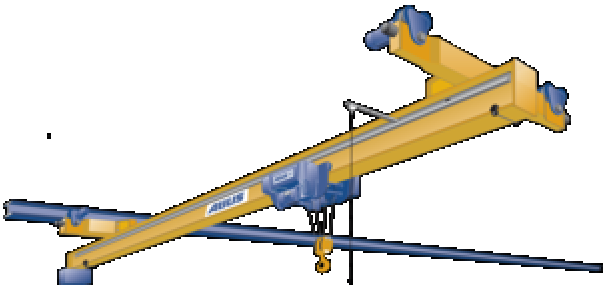


Figure 3. Underslung Overhead Travelling Cranes

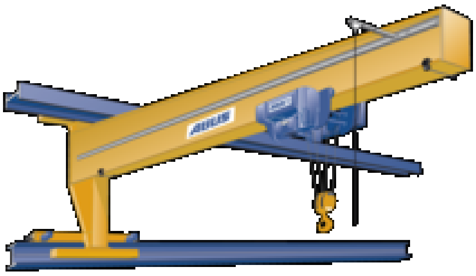


Figure 4. Single-girder wall travelling crane EKL

1.2.- HB system

The crane system suspended is one of the most practical ideas in the technique of lifting and shipping. It has the advantages of a hoist fixed and mobility a bridge crane, although all very economical. canes occur in all conditions necessary for the development characteristic of these systems: the experience lifting and bridges crane, as well as the advanced technique production of high quality and commitment to achieve more comfort and humanity in the workplace.

The has been abused, and is, provide the bridge suspended crane as many benefits as possible without raising the cost of final product. Who needs to raise and transport loads in the workplace, in the warehouse or in production, should be permitted and installed systems

HB bridge suspended crane of abuse. In a matter of technique, profitability, flexibility, quality and adaptability to the job, Hb program offers a wide range of capabilities burden that deserves full recognition market. The recipe for success has been to make in fact the individual wishes of each client.

1.3.- Jib cranes

Jib cranes are powerful and reliable partners, that will facilitate your daily work. With its wide range of cranes pen spinning, jib cranes offers particularly flexible solutions and economic barriers to the flow of materials in the workplace.

Jib cranes fit individually to different needs, from the model hoist up the equipment Additionally, complete with quality of abuse. They operate with only press a button and easily outperform and precision loads up 6.3 t. No matter if they are subject to its own column or a wall or column structure ship. Whether to load machines change tools or heavy placing pieces on desks, boom cranes with lifting work is becomes an easy process, cost and secure

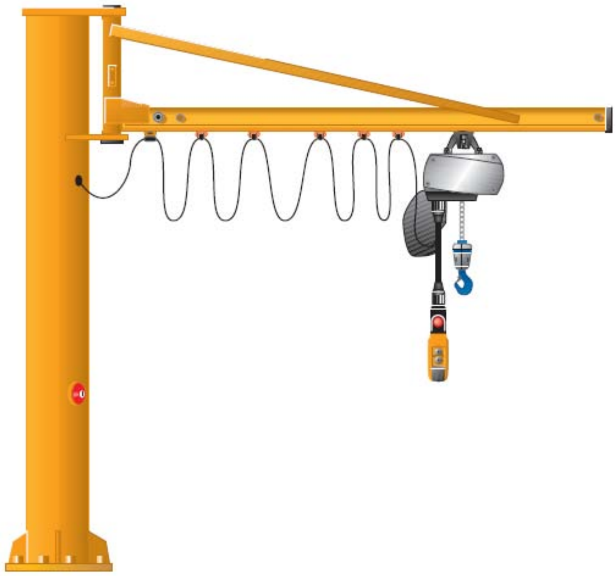


Figure 5. Jib crane system

1.4.- Wire rope hoists

The total availability is the quality more important from a hoist.In order to ensure it under the harsh conditions of daily work we have placed the bar for quality an unusually high level in the manufacture of our systems crane. Electric hoists

Wire rope methods are made most advanced production and demonstrate excellent reliability,safety and durability after many years of use. From the engine to the electronic system, through gears, the brakes and the system electric, everything goes through a strict quality control. The high level of quality must be add flexibility: hoists electrical cover a wide range of capacities, from 1000 kg to 100 tonnes.

With the broad scope of supply, offer electric hoists from the start basic equipment of high quality. For special cases have system components additional. With an electric hoist choose a product with the highest range transport technology materials.

Figure 6. Wire rope hoists

1.5.- Electric Chain Hoists

The new generation of chain hoist Compact are known for their innovative design and its persuasive technology. The four sizes have load capabilities from 80 to 4000 kg, with a three-phase supply of 400 V. The modular engine and transmission opens the stage for a offer varied lifting speeds up to 20 m / min. FEM or with groups of up to 4 m very attractive prices.

With the selection table must be guided by the program Electric chain hoist and take advantage of the major applications achieved with the optional equipment With progressive lifting speed for 100 or 200 kg and supplies ready to be installed in a socket 230 V, this model is the ideal solution for implementing flexible load of a hoist with low weight

Figure 7. Electric chain hoits

1.6.- Ligthweight mobile gantry

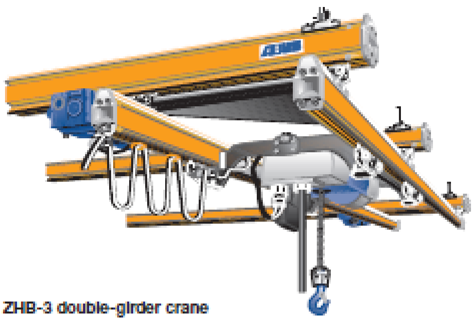
The gantry crane light is the most economical solution in all those places where it is desired or civil works or expensive fixed mount metal structures, and where necessary make loading / unloading on a regular basis and at points different. It is designed for electric chain hoist for loads up to 2000 kg. On its four wheels fitted with brake, two wheels have as standard fasteners to anchor the direction with 90 degrees of rotation, the capable of being moved easily.

Their modular construction allows easy disassembly. Available two heights, allowing its use in multiple applications at adjust its height and width at circunstances.

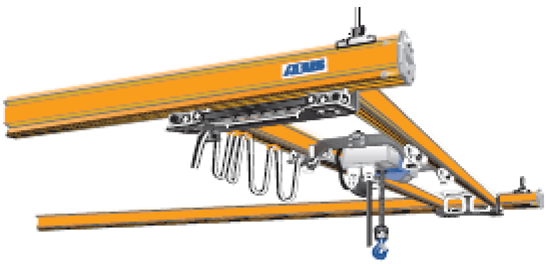
Figure 8. Ligthweight mobile gantry

2.-HB SYSTEM

The HB-System offers tailor-made modular solutions. The components of the system are both practical and cost-effective and can be combined to build just the system which the application demands. All HB-Systems feature an extremely low-build design, ensuring that maximum hook height can be reached in the space which is available. Three types of profiles cover a load capacity range up to 2000 kg. All electrical connections are made using an easy plug-in connector system. And the system can be adapted and individually fitted to almost any type of room or ceiling design.



ZHB-3 double-girder crane



ZHB-X stooled up double-girder crane

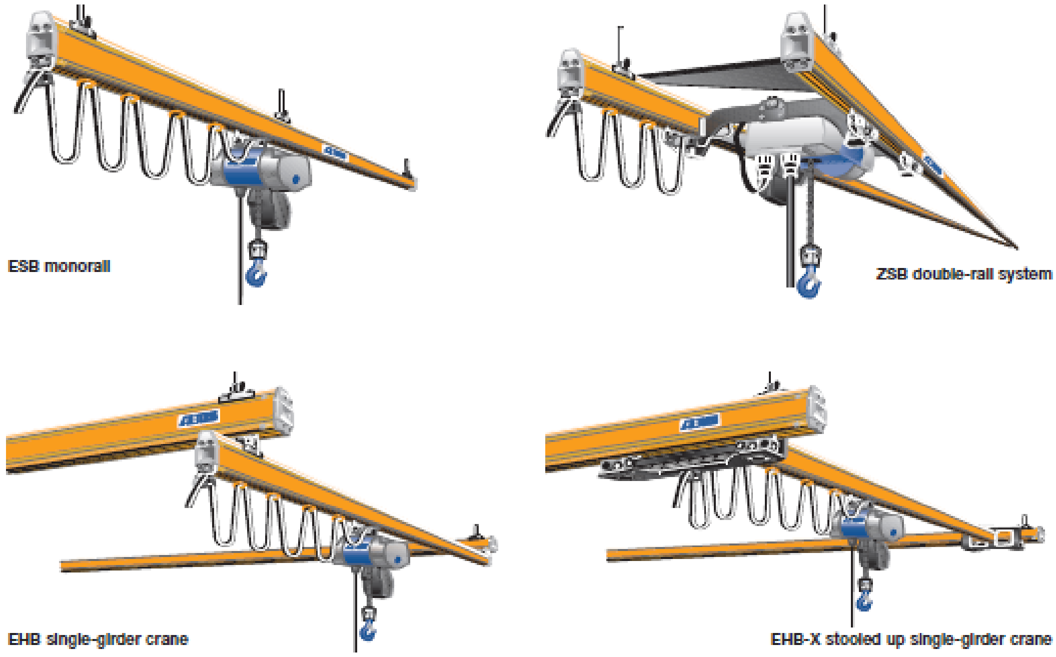


Figure 9. Differents kinds of Abus HB-system

The practical design features of the HB-System bring perceptible benefits for users and their applications:

• With its modular design, the system can simply be tailored to provide cost-effective solutions for users' applications.

• A wide variety of suspension designs are available, permitting installation in conditions which you would scarcely have thought possible.

• Load capacities can be defined in accordance with individual requirements, up to 2000 kg;later extension is often possible.

• The number of component parts is reduced to the bare minimum, simplifying erection, saving time and helping to prevent errors – just what you need if your own specialists are to erect the system. • No special tools are required for erection.

• With the special plug-in connectors typical of systems, electrical installation is also quick and safe.

• Drives and hoists provide a variety of electrical functions for more rational, safer working – with low noise, smooth starting and lifting and smooth switching between speeds. • In addition, all components are designed for optimum interaction. For example, a low headroom electric chain hoist combined with a double rail trolley on an HB-System (types ZSB, ZHB, ZHB-X or ZHB-3) ensures optimum space utilization and maximum hook height. • The fundamental advantages of the HB-System continue to bear fruit in the period following initial investment. The system can be maintained, modified, modernised and uprated efficiently and cost-effectively.

DISTINCTIVE FEATURES: ENCLOSED-TRACK PROFILES

Advanced CAD1) and FEM2) systems were used to design and optimize the track profiles of the HB-System. The results are three types of profile covering the entire load capacity range of the HB-System up to 2000 kg. All the profiles are made from cold-rolled halves welded together to form a high-grade enclosed-track profile, within which the load trolley is housed. ABUS opted for enclosed-track profiles because they effectively protect the trolley running gear and also offer advantages in terms of maintenance.

They also have two additional major advantages. The favourable structural design of the track girder system means that wide suspension spacing is possible, even with high load capacities. And high-grade bolted joints warrant high joint factors and improved load capacity.

In combination, these two features significantly reduce the work involved in installing an HB-System and enhance the productivity of the system. Manual operation of cranes and trolleys is almost effortless.

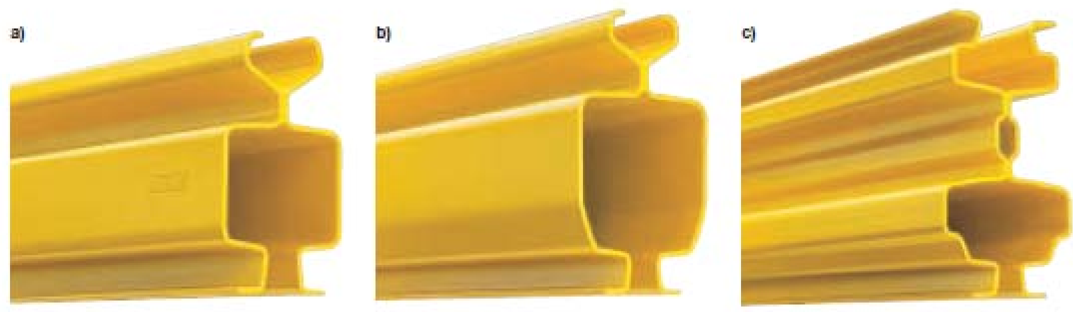


Figure 10. Tracks profiles, a)HB160 b)HB200 c)HB250

The quality of the suspension and connections is an essential feature in ensuring the quality and availability of the entire HB-System. A characteristic feature of the HB-System is a flexible suspension using ball-and-socket joints. These low-build systems are adjustable in height and are therefore particularly versatile. The pendulation motion of the suspension absorbs horizontal forces from the crane system, reducing loads on roof structures and buildings.

HB-system has a whole range of connections for attaching HB-Systems to ceilings or other elements of buildings. Together, the suspension and the ceiling mount ensure that an HB-System can be installed in almost any conditions.

Figure 11. HB system suspension

All HB-Systems are fitted with chain hoists Compact. The new generation of Compact chain hoists feature a fresh new design and convincing technical solutions. The 3 phase 400 volt hoists units are available in three different sizes to reliably handle loads up to 2000 kg with a low-build design for optimum utilisation of the space available and a precision lifting function for the careful lifting and lowering of sensitive goods.

The small GMC hoist rounds off the Compact range. With infinitely variable lifting speed and a load capacity of 100 kg or 200 kg, this unit, supplied ready for connection to a 230 V power socket, is the ideal hoist for flexible and low capacity applications.

The motor and the gear unit are of modular design, allowing us to produce a wide variety of versions for lifting speeds up to 20 m/min and FEM groups up to 4m at attractive prices.

The chain hoists have a number of features which are particularly beneficial in terms of reduced maintenance requirements; long-life brake linings (normally, adjustment is only required after 1 million full-load braking operations); permanently lubricated precision gearbox; adjustable sliding clutch; specially hardened low-wear chain; plug-in connectors for easy installation and maintenance and many other features. Where single girder trolleys are used, the chain hoist is simply suspended from the trolley and is ready for operation as soon as the connectors have been plugged in.

Figure 12. Compact GM4

3.-STRUCTURE 1: FRAME

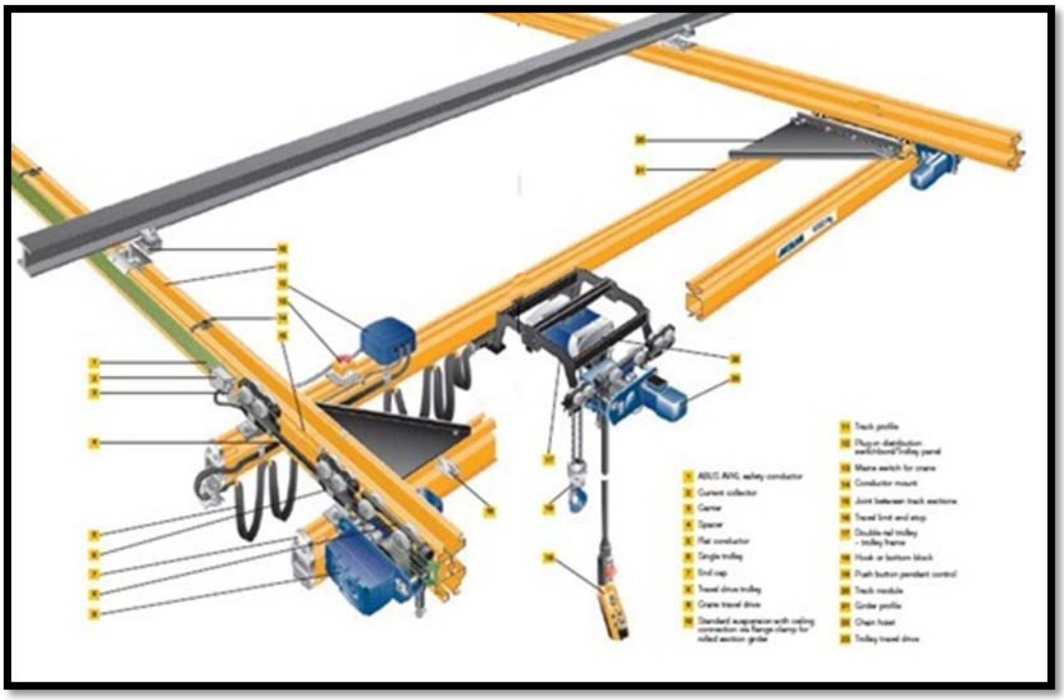


Figure 13. Frame structure

3.1.-Model

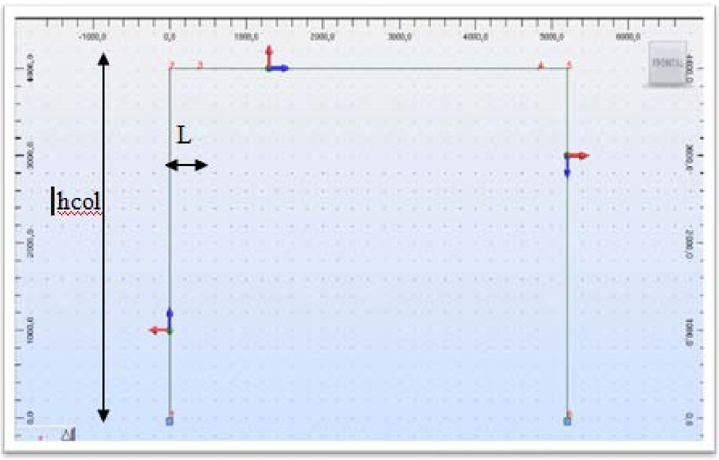


Figure 14. Model

3.2.-Data:

ABUS Single Girder Crane HEB

- Quantity: 2
- Load capacity: 500kg
- Crane girder length: 4445mm
- Projetion: 200/200 mm
- Crane span: 4045mm
- Crane profile: HB160
- Crane travelling: manual
- Hoist travelling: manual
- Hoist power supply: via flat cable along the crane moving on cable slider inside the crane profile

ABUS electric chain hoist

- Quantity: 2
- Load capacity: 500kg
- Type: GM2 500.4-2
- Hook path: 4000mm
- Precis./main lifting: 2-stage, 1.0 / 4.0 m/min
- FEM classification: 2m
- Duty cycle (ED): 60%

Limitations:

- Vertical displacement beam 2: L/500
- Horizontal displacement beam 2: hcol/500

<u>Forces:</u>

The forces that we have to apply are 2,26kN and 8,43kN over the top beam, the beam that is horizontal and support the hoist and the mass. This forces should be verticals in the Z axis, then the forces will be -2,26kN and -8,43 as you can see in the next figure.

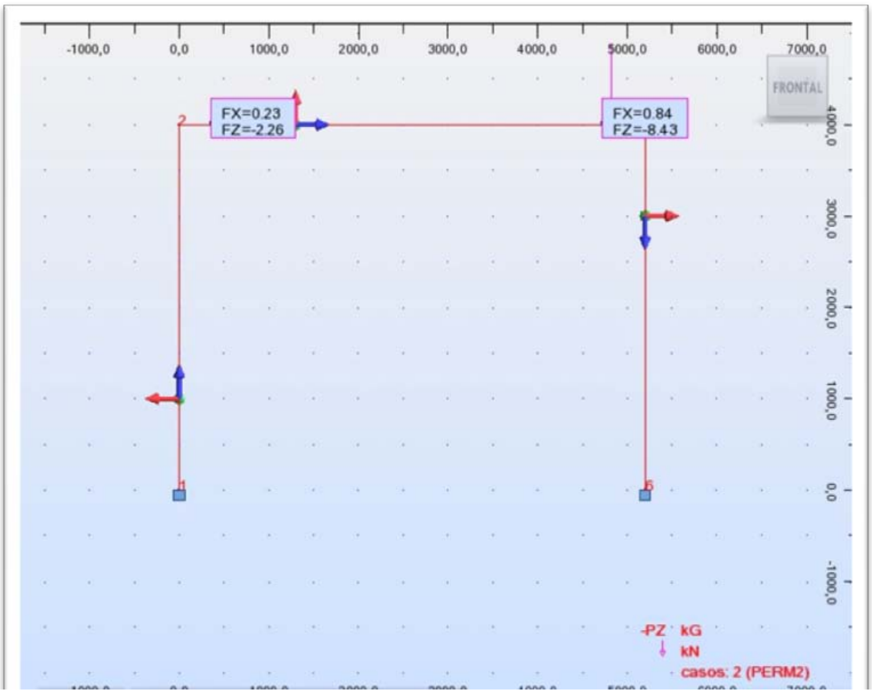


Figure 15. Frame structure data

Therefore, the limitations are:

Limitations:

- Vertical displacement beam 2: $\frac{L}{500} = \frac{377,5mm}{500} = 0,775mm$
- Horizontal displacement beam 2: $\frac{hcol}{500} = \frac{4000mm}{500} = 8mm$

STRUCTURE DATA:

- Project properties: **frame1**

Structure type: Plane frame

Structure gravity center coordinates:

X = 2600.000 *(mm)*

Y = 0.000 *(mm)*

Z = 2787.879 *(mm)*

Central moments of inertia of a structure:

Ix = 388325639.086 *(kg*mm2)*

Iy = 1485502922.041 *(kg*mm2)*

Iz = 1097405437.074 *(kg*mm2)*

3.3.-SOLVE

Forces that are applied.

Bar/Node/Case	FX (kN)	FZ (kN)	MY (kNm)
1/ 1/ 2	3,39	-0,07	-0,29
1/ 2/ 2	2,73	-0,07	-0,58
2/ 2/ 2	0,07	2,73	-0,58
2/ 5/ 2	1,14	-8,81	-2,66
3/ 5/ 2	8,81	1,14	-2,66
3/ 6/ 2	9,46	1,14	1,90

<u>Reactions</u>

Node/Case	FX (kN)	FZ (kN)	MY (kNm)
1/ 2	0,07	3,39	-0,29
6/ 2	-1,14	9,46	-1,90
Case 2	PERM2		
Sum of val.	-1,07	12,85	-2,19
Sum of reac.	-1,07	12,85	-51,40
Sum of forc.	1,07	-12,85	51,40
Check val.	0,00	0,00	0,00
Precision	1,16883e-013	2,16769e-028	

3.3.1.-DIAGRAMS OF FORCES

Fx force

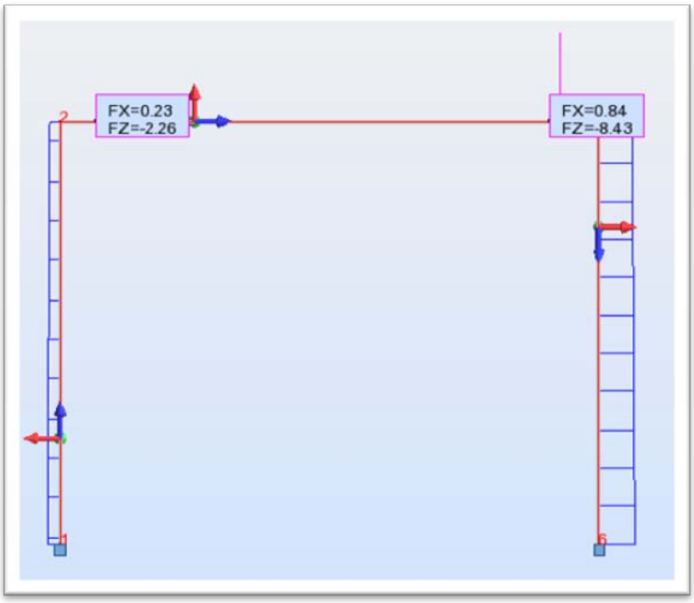


Figure 16. : Frame structure, diagrams of forces. HEA 100

My moment

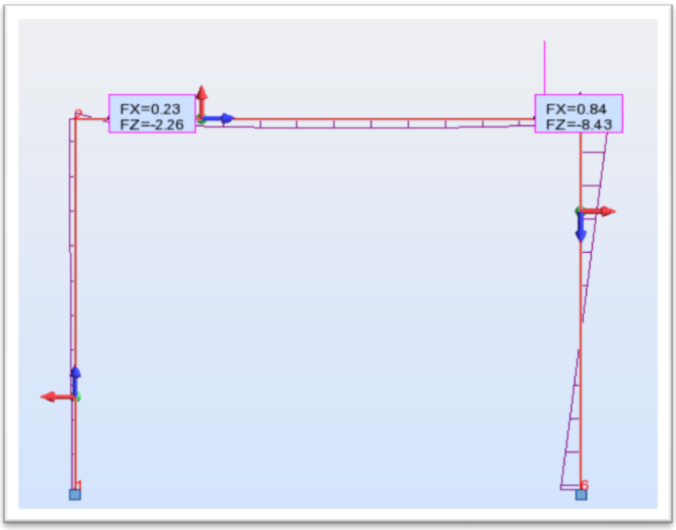
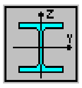


Figure 17. Frame structure, diagrams of moments. HEA 100

The first profile that I have chosen is HEA100, which characteristics you can see in the next table.

ACERO (S235)	fy = 235.00 MPa	fyd,0 = 223.81 MPa	fyd,1 = 223.81 MPa
fu = 360.00 MPa	fud = 288.00 MPa	gM0=1.05	gM1=1.05
gM2=1.25			

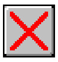


SECTION PARAMETERS: HEA 100

h=9.6 cm	Ay=18.44 cm2	Az=7.56 cm2	Ax=21.24 cm2
b=10.0 cm	Iy=349.22 cm4	Iz=133.81 cm4	Ix=4.69 cm4
tw=0.5 cm	Wply=83.02 cm3	Wplz=41.14 cm3	
tf=0.8 cm			

INTERNAL FORCES AND CAPACITIES:

N,Ed = 8.81 kN	My,Ed = -2.66 kN*m		
Nc,Rd = 475.28 kN	My,pl,Rd = 18.58 kN*m		
Nb,Rd = 122.87 kN	My,c,Rd = 18.58 kN*m		Vz,Ed = 1.14 kN
			Vz,pl,Rd = 97.64 kN
			Class of section = 1



LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis:

Ly = 4000.00 mm   Xy = 0.57

Lk,y = 4000.00 mm   Cm,y = 0.95

Lamy = 98.64   ay = 0.60

Lam_y = 1.05   ky = 1.03

About Z axis:

Lz = 4000.00 mm   Xz = 0.26

Lk,z = 4000.00 mm

Lamz = 159.35

Lam_z = 1.70

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.16 < 1.00   (6.2.8.(1))

Vz,Ed/Vz,pl,Rd = 0.01 < 1.00   (6.2.4.(1))

Global stability check of member:

Lambda,y = 98.64 < Lambda,max = 210.00   Lambda,z = 159.35 < Lambda,max = 210.00
STABLE

N,Ed/(Xy*Ax*fyd,1) + ky*Cm,y*My,Ed/(XLT*Wy*fyd,1) = 0.17 < 1.00   (6.3.4.2.(1))

N,Ed/(Xz*Ax*fyd,1) + ay*ky*Cm,y*My,Ed/(Wy*fyd,1) = 0.16 < 1.00   (6.3.4.2.(1))

Member	Section	Material	Lay	Laz	Ratio	Case
Code group : 1 pilar						
3 Barra_3	HEA 100	ACERO	98.64	159.35	0.17	2 PERM2
	HEA 120		81.78	132.50	0.12	
Code group : 2 viga						
2 Barra_2	HEA 100	ACERO	128.23	207.15	0.15	2 PERM2
	HEA 120		106.31	172.25	0.10	

The displacements of the structure with de forces apply are:

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 2	0,0	0,0	0,0
2/ 2	0,4	-0,0	0,002
3/ 2	0,4	-0,1	0,002
4/ 2	0,4	-0,1	-0,003
5/ 2	0,4	-0,0	-0,002
6/ 2	0,0	0,0	0,0

The following will show the limitations imposed on the structure:

- Vertical displacement beam 2: $\frac{L}{500} = \frac{377,5mm}{500} = 0,775mm$
- Horizontal displacement beam 2: $\frac{hcol}{500} = \frac{4000mm}{500} = 8mm$

We can see in the last table that although the profile HEA100 support the stress, displacements aren´t met, because the vertical displacement beam should be 0,775 and we see that is 1mm, therefore, this profile doesn´t work and should be increased.

The next profile that I will analyze is HEA120

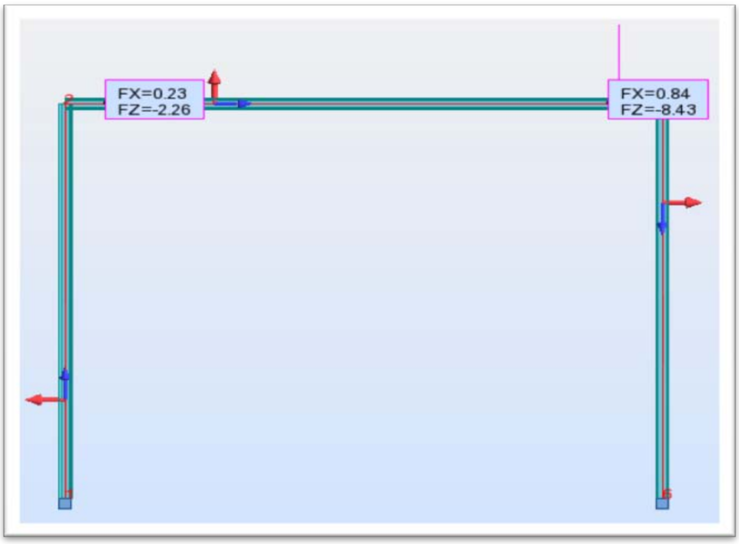


Figure 18. HEA 120 profile

3.4.- PROFILE HEA 120

Fx force

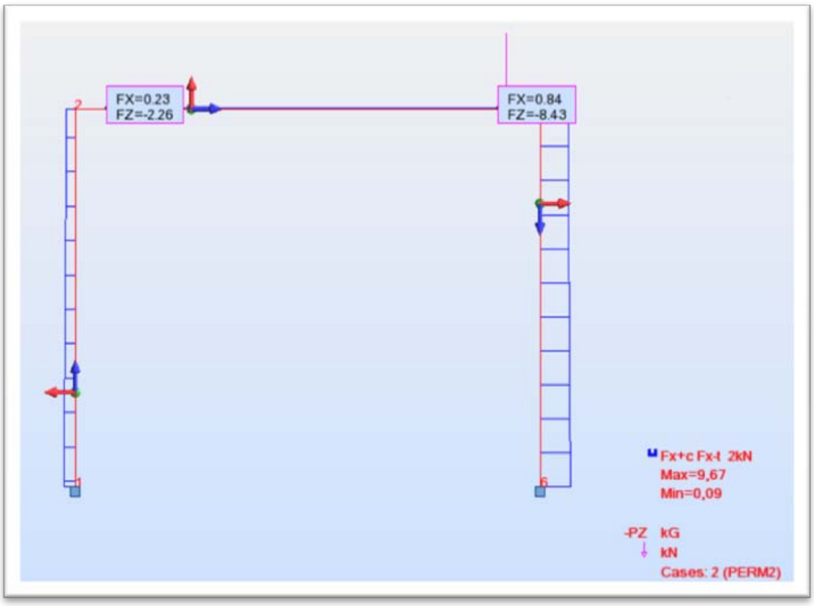


Figure 19. Frame structure, diagrams of forces. HEA 120

My moment

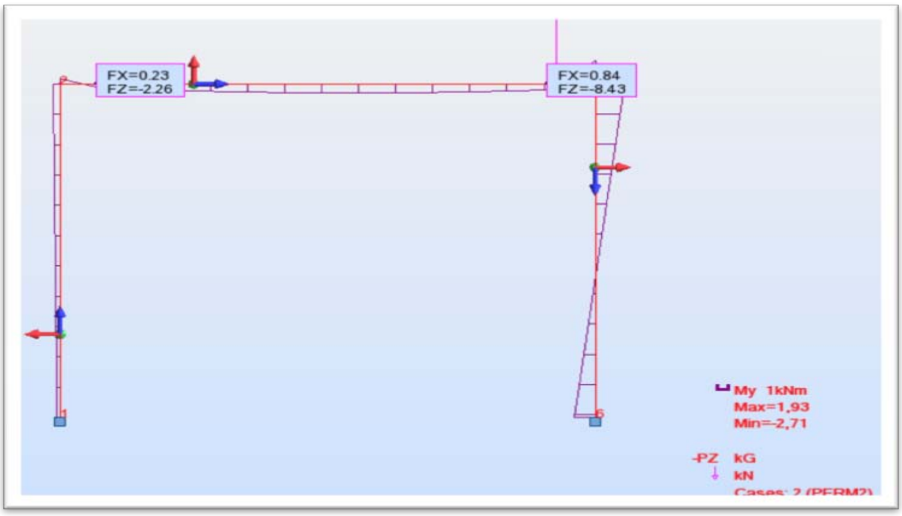


Figure 20. : Frame structure, diagrams of moments. HEA 120

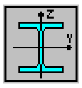
Characteristics of HEA 120

LOADS:

Governing Load Case: 2 PERM2

MATERIAL:

ACERO (S235)	fy = 235.00 MPa	fyd,0 = 223.81 MPa	fyd,1 = 223.81 MPa
fu = 360.00 MPa	fud = 288.00 MPa	gM0=1.05	gM1=1.05
gM2=1.25			



SECTION PARAMETERS: HEA 100

h=9.6 cm	Ay=18.44 cm2	Az=7.56 cm2	Ax=21.24 cm2
b=10.0 cm	Iy=349.22 cm4	Iz=133.81 cm4	Ix=4.69 cm4
tw=0.5 cm	Wply=83.02 cm3	Wplz=41.14 cm3	
tf=0.8 cm			

INTERNAL FORCES AND CAPACITIES:

N,Ed = 8.89 kN	My,Ed = -2.71 kN*m		
Nc,Rd = 475.28 kN	My,pl,Rd = 18.58 kN*m		
Nb,Rd = 122.87 kN	My,c,Rd = 18.58 kN*m		Vz,Ed = 1.16 kN
			Vz,pl,Rd = 97.64 kN
			Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis:

Ly = 4000.00 mm   Xy = 0.57

Lk,y = 4000.00 mm   Cm,y = 0.95

Lamy = 98.64   ay = 0.60

Lam_y = 1.05   ky = 1.03

About Z axis:

Lz = 4000.00 mm   Xz = 0.26

Lk,z = 4000.00 mm

Lamz = 159.35

Lam_z = 1.70

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd + My,Ed/My,c,Rd = 0.16 < 1.00   (6.2.8.(1))

Vz,Ed/Vz,pl,Rd = 0.01 < 1.00   (6.2.4.(1))

Global stability check of member:

Lambda,y = 98.64 < Lambda,max = 210.00   Lambda,z = 159.35 < Lambda,max = 210.00 STABLE

N,Ed/(Xy*Ax*fyd,1) + ky*Cm,y*My,Ed/(XLT*Wy*fyd,1) = 0.18 < 1.00   (6.3.4.2.(1))

N,Ed/(Xz*Ax*fyd,1) + ay*ky*Cm,y*My,Ed/(Wy*fyd,1) = 0.16 < 1.00   (6.3.4.2.(1))

In the next table you can see the displacements

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 2	0,0	0,0	0,0
2/ 2	0,2	-0,0	0,001
3/ 2	0,2	-0,1	0,001
4/ 2	0,2	-0,1	-0,002
5/ 2	0,2	-0,0	-0,001
6/ 2	0,0	0,0	0,0

Vertical displacement beam is 1mm≥ 0,775mm so this profile doesn´t work for the structure that I am calculing.

3.5.-PROFILE HEA 140

Fx force

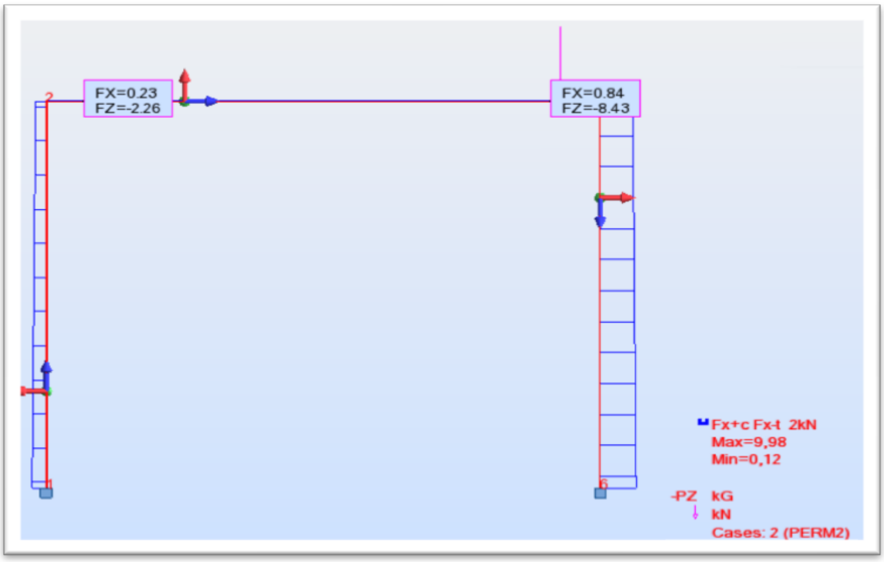


Figure 21. Frame structure, diagrams of forces. HEA 140.

<u>My moment</u>

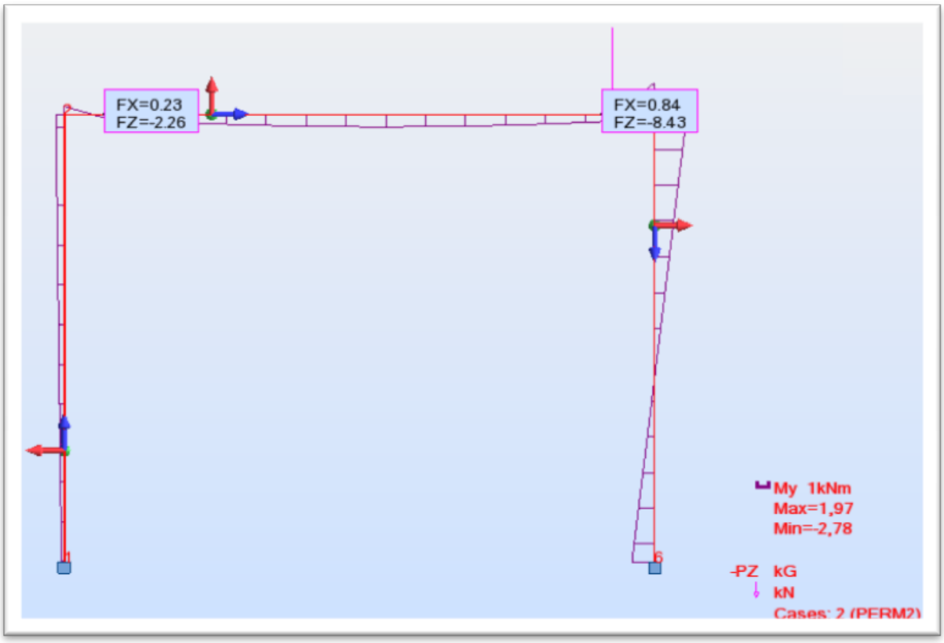


Figure 22. Frame structure, diagrams of moments. HEA 140

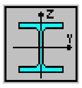
Characteristics of HEA 140

LOADS:

Governing Load Case: 2 PERM2

MATERIAL:

ACERO (S235)	fy = 235.00 MPa	fyd,0 = 223.81 MPa	fyd,1 = 223.81 MPa
fu = 360.00 MPa	fud = 288.00 MPa	gM0=1.05	gM1=1.05
gM2=1.25			



SECTION PARAMETERS: HEA 100

h=9.6 cm	Ay=18.44 cm2	Az=7.56 cm2	Ax=21.24 cm2
b=10.0 cm	Iy=349.22 cm4	Iz=133.81 cm4	Ix=4.69 cm4
tw=0.5 cm	Wply=83.02 cm3	Wplz=41.14 cm3	
tf=0.8 cm			

INTERNAL FORCES AND CAPACITIES:

N,Ed = 9.01 kN	My,Ed = -2.78 kN*m		
Nc,Rd = 475.28 kN	My,pl,Rd = 18.58 kN*m		
Nb,Rd = 122.87 kN	My,c,Rd = 18.58 kN*m		Vz,Ed = 1.19 kN
			Vz,pl,Rd = 97.64 kN

In the next table you can see the displacements

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 2	0,0	0,0	0,0
2/ 2	0,1	-0,0	0,001
3/ 2	0,1	-0,0	0,001
4/ 2	0,1	-0,0	-0,001
5/ 2	0,1	-0,0	-0,001
6/ 2	0,0	0,0	0,0

In the table you can see that the vertical displacement beam is $Uz = 0{,}0mm$ and the limits is 0,775, therefore this profile meets with the requirements.

In the next table is showed the stresses in the beams

Bar/Node/Case	S max (MPa)	S min (MPa)	S max(My) (MPa)	S min(My) (MPa)	Fx/Ax (MPa)
1/ 1/ 2	1,50	0,53	0,49	-0,49	1,02
1/ 2/ 2	3,71	-2,29	3,00	-3,00	0,71
2/ 2/ 2	3,04	-2,96	3,00	-3,00	0,04
2/ 5/ 2	10,34	-9,79	10,07	-10,07	0,28
3/ 5/ 2	12,12	-8,01	10,07	-10,07	2,05
3/ 6/ 2	9,37	-4,65	7,01	-7,01	2,36

And the reactions:

Node/Case	FX (kN)	FZ (kN)	MY (kNm)
1/ 2	0,12	3,90	-0,23
6/ 2	-1,19	9,98	-1,97
Case 2	PERM2		
Sum of val.	-1,07	13,88	-2,20
Sum of reac.	-1,07	13,88	-54,09
Sum of forc.	1,07	-13,88	54,09
Check val.	-0,00	0,00	-0,00
Precision	0,0	2,28154e-028	

With this results we can calculate de anchors of the structure through Hilti PROFIS software.

- Base material: cracked concrete C20/25, compressive strength $25N/mm^2$

- Anchor plate: square, 12mm thickness
- Profile: HEA 140
- Loads: Reactions

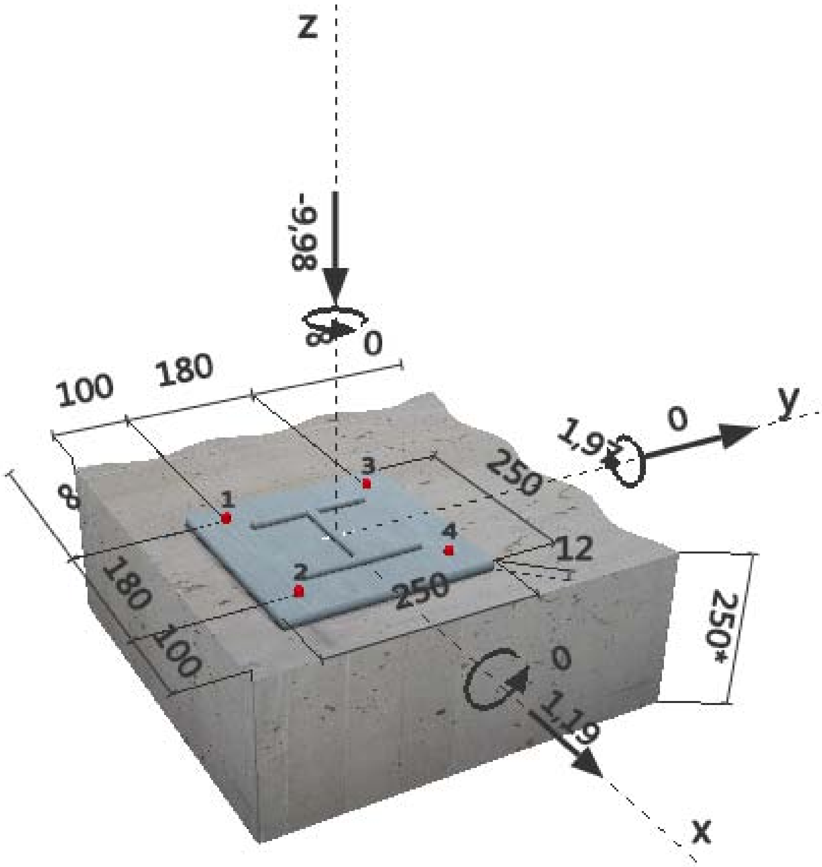


Figure 23. HEA 140 anchors

With this loads and this geometry I have a lot of solutions, but I'll select HSL-3 M8 anchor because is the first anchor that meets. For more information, you can read annex 1, at the end of the document.

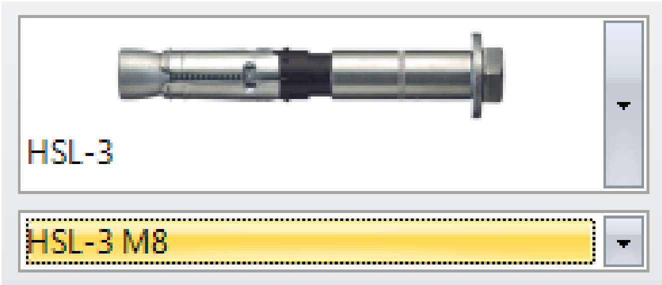


Figure 24. Anchord Bolt

4.-STRUCTURE 2: CANTILEVER

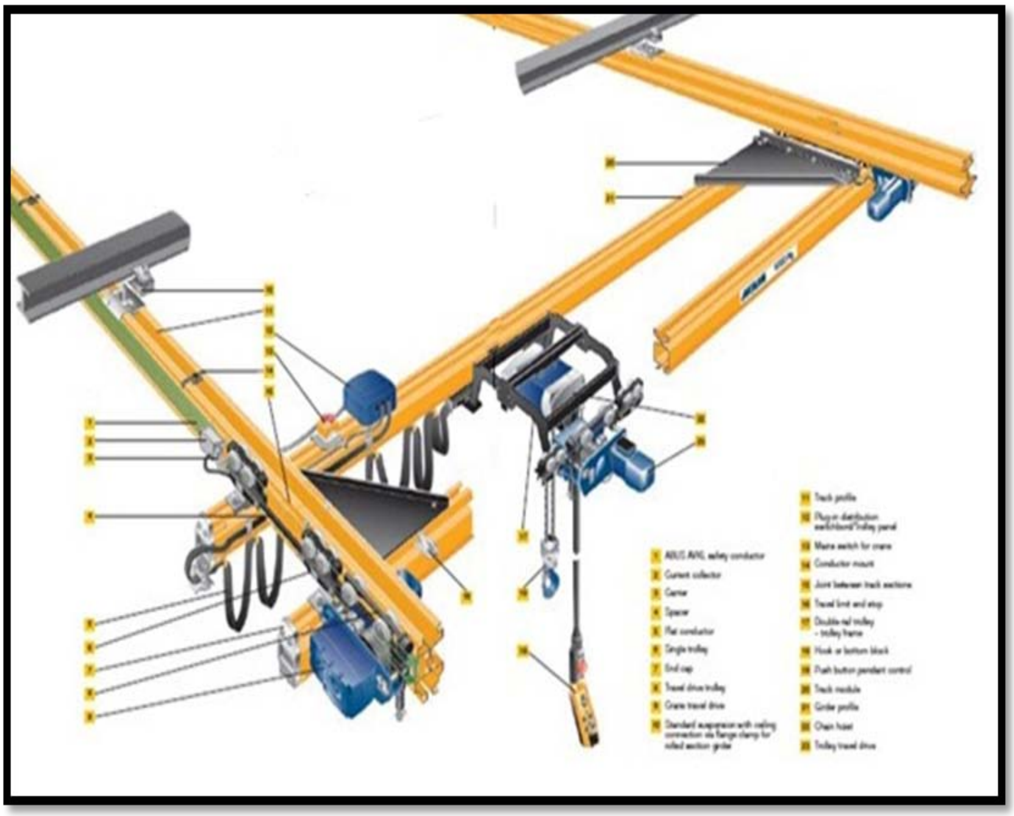


Figure 25. Cantilever structure

4.1.-Model

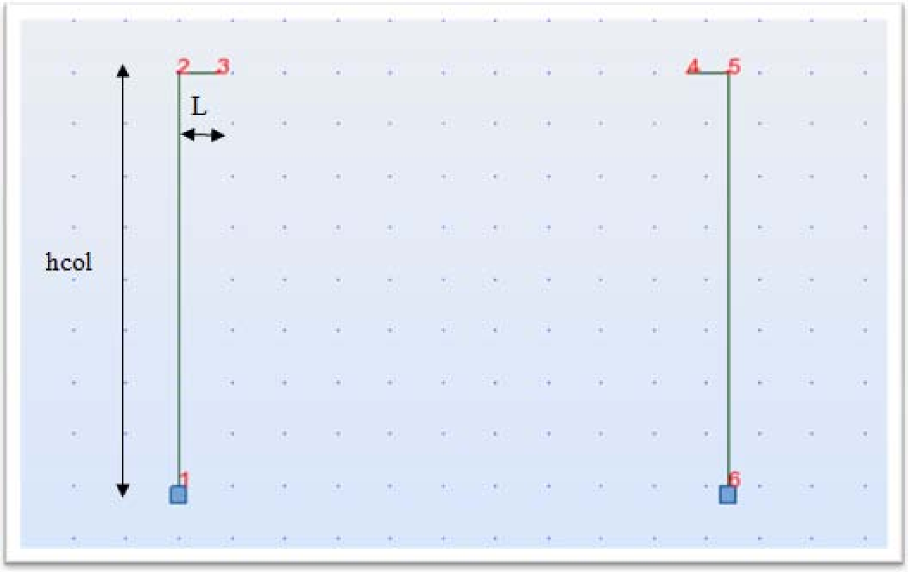


Figure 26. Cantilever structure model

4.2.-Data

ABUS Single Girder Crane HEB

- Quantity: 2
- Load capacity: 500kg
- Crane girder length: 4445mm
- Projetion: 200/200 mm
- Crane span: 4045mm
- Crane profile: HB160
- Crane travelling: manual
- Hoist travelling: manual
- Hoist power supply: via flat cable along the crane moving on cable slider inside the crane profile

ABUS electric chain hoist

- Quantity: 2
- Load capacity: 500kg
- Type: GM2 500.4-2
- Hook path: 4000mm
- Precis./main lifting: 2-stage, 1.0 / 4.0 m/min
- FEM classification: 2m
- Duty cycle (ED): 60%

Limitations:

- Vertical displacement beam 2: L/500
- Horizontal displacement beam 2: hcol/500

Forces:

The forces that we have to apply are 2,26kN and 8,43kN over the top beam, the beam that is horizontal and support the hoist and the mass. This forces should be verticals in the Z axis, then the forces will be -2,26kN and -8,43 as you can see in the next figure.

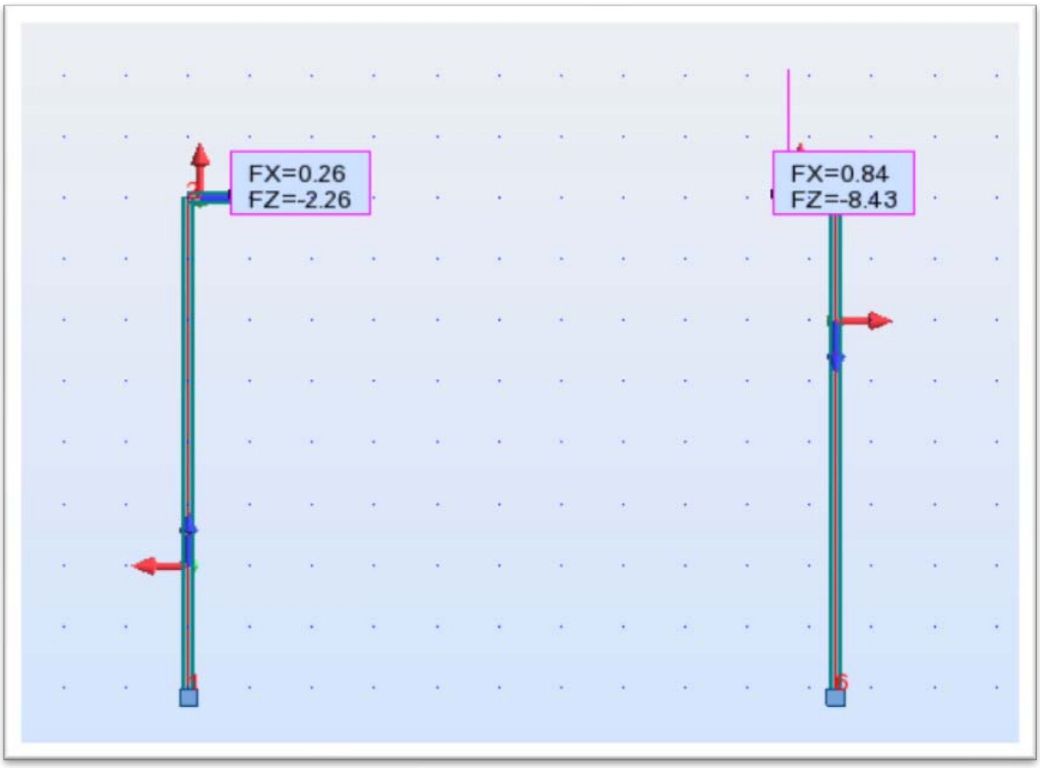


Figure 27. Cantilever structure forces

Limitations:

- Vertical displacement beam 2: $\frac{L}{500} = \frac{377{,}5mm}{500} = 0{,}775mm$
- Horizontal displacement beam 2: $\frac{hcol}{500} = \frac{4000mm}{500} = 8mm$

STRUCTURE DATA

Structure gravity center coordinates:

X = 2600.000 *(mm)*

Y = 0.000 *(mm)*

Z = 2172.473 *(mm)*

Central moments of inertia of a structure:

Ix = 108949109.429 *(kg*mm2)*

Iy = 582917661.031 *(kg*mm2)*

Iz = 474075936.943 *(kg*mm2)*

Mass = 70.974 *(kg)*

Table of load cases / analysis types

Case 1 : PERM1

Analysis type: Static - Linear

4.3.- PROFIL 100

Forces applied:

Bar/Node/Case	FX (kN)	FZ (kN)	MY (kNm)
1/ 1/ 1	2,98	0,26	-1,90
1/ 2/ 1	2,32	0,26	-0,86
2/ 2/ 1	-0,26	2,32	-0,86
2/ 3/ 1	-0,26	2,26	-0,00
3/ 4/ 1	0,84	-8,43	-0,00
3/ 5/ 1	0,84	-8,49	-3,19
4/ 5/ 1	8,49	0,84	-3,19
4/ 6/ 1	9,15	0,84	0,18

Reactions:

Node/Case	FX (kN)	FZ (kN)	MY (kNm)
1/ 1	-0,26	2,98	-1,90
6/ 1	-0,84	9,15	-0,18
Case 1	PERM1		
Sum of val.	-1,10	12,12	-2,08
Sum of reac.	-1,10	12,12	-49,64
Sum of forc.	1,10	-12,12	49,64
Check val.	0,00	0,00	0,00
Precision	1,54684e-013	1,35322e-026	

4.3.1.-DIAGRAMS OF FORCES

Fx force

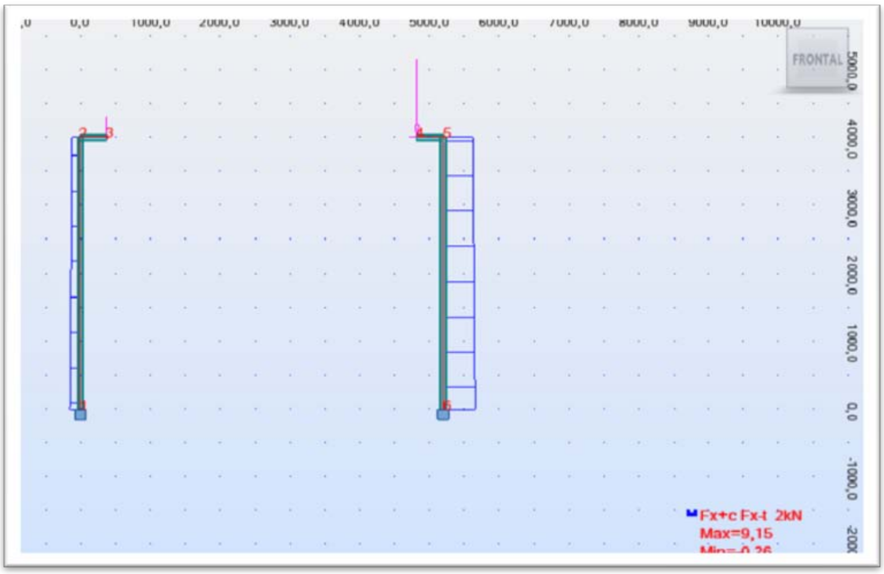


Figure 28. Cantilever structure, diagrams of forces. HEA 100

<u>My moment</u>

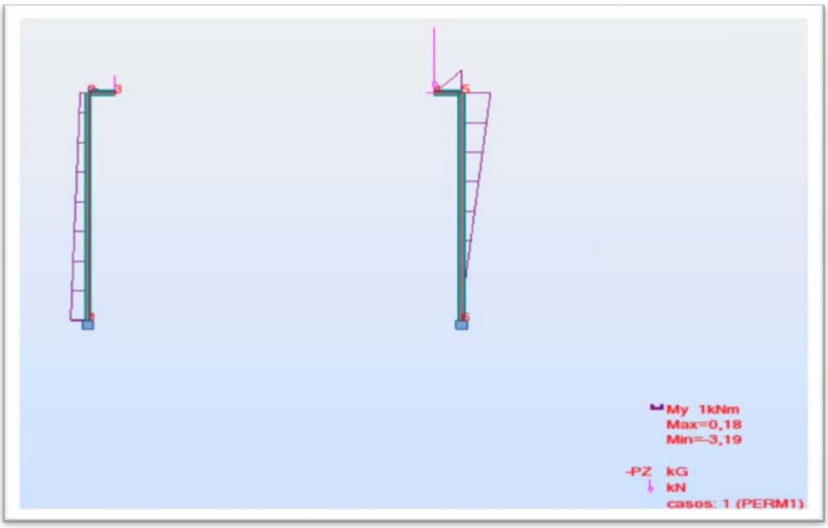


Figure 29. Cantilever structure, diagrams of moments. HEA 100

The first profile that I have chosen is HEA100, which characteristics you can see in the next table.

Member		Section	Material	Lay	Laz	Ratio	Case
Code group : 1 columna							
4 Barra_4	OK	HEA 100	S 235	98.64	159.35	0.16	1 PERM1
	↓	HEA 120		81.78	132.50	0.11	
Code group : 2 viga							
3 Barra_3	OK	HEA 100	S 235	9.31	15.04	0.17	1 PERM1
	↓	HEA 120		7.72	12.50	0.12	

The displacements of the structure with de forces apply are:

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 1	0,0	0,0	0,0
2/ 1	1,7	-0,0	0,008
3/ 1	1,7	-0,3	0,008
4/ 1	-1,0	-0,3	-0,009
5/ 1	-1,0	-0,0	-0,008
6/ 1	0,0	0,0	0,0

The following will show the limitations imposed on the structure:

- Vertical displacement beam 2 and 3: $\frac{L}{500} = \frac{377,5mm}{500} = 0,775mm$

- Horizontal displacement beam 2 and 3: $\frac{hcol}{500} = \frac{4000mm}{500} = 8mm$

The horizontal displacement in nodes 3 and 4 are$\leq$ 8mm, the limit, but vertical displacements are higher than the limit, Uz displacements in nodes 3 and 4 are 3mm and the limitation is 0,775mm

The next profile that I will vanalyze is HEA120

4.4.- PROFILE HEA 120

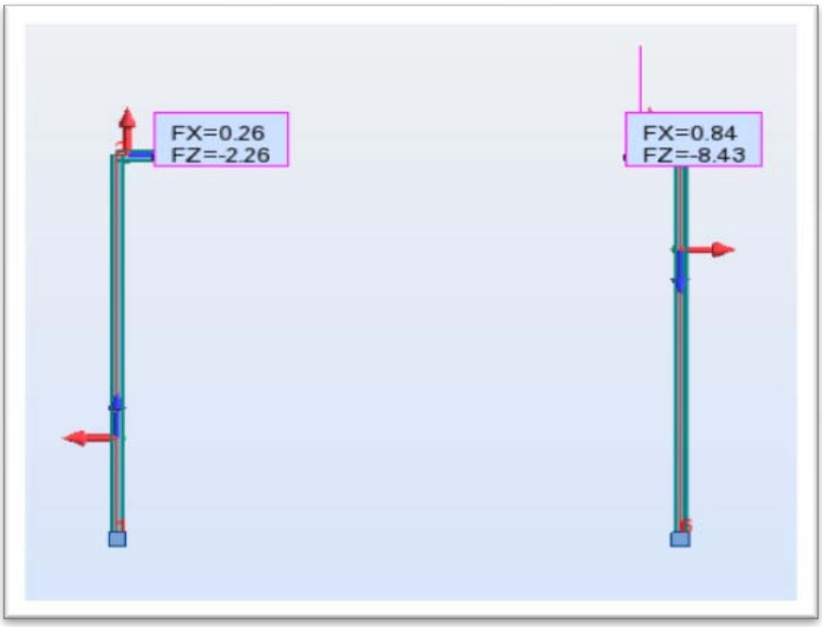


Figure 30. Cantilever structure, HEA 120.

4.4.1.-DIAGRAM OF FORCES

<u>Fx force</u>

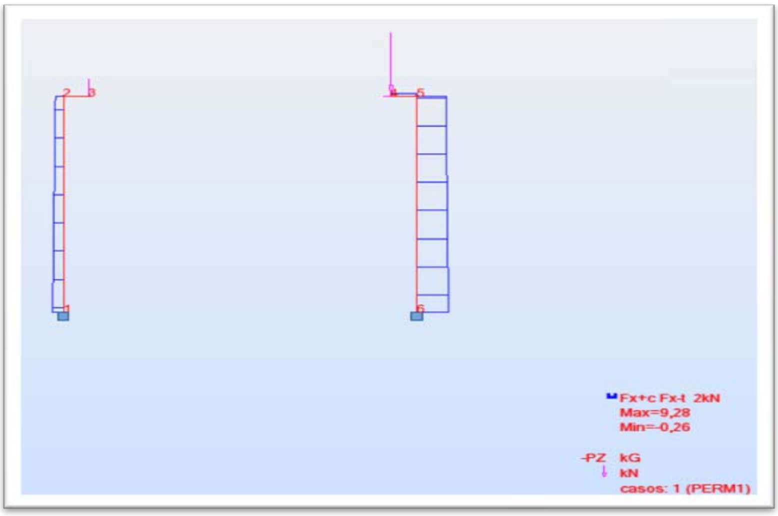


Figure 31. Cantilever structure, diagrams of forces. HEA 120

.My moment

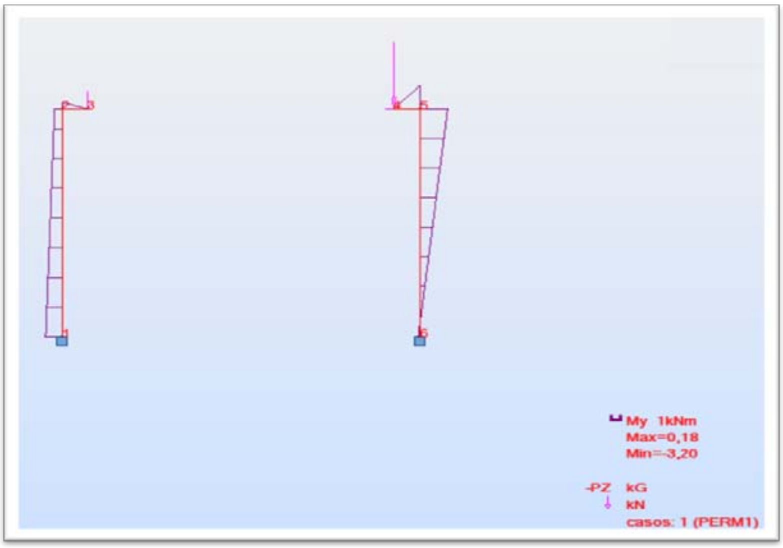


Figure 32. Cantilever structure, diagrams of moments. HEA 120

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.02 < 1.00 (6.2.4.(1))

My,Ed/My,c,Rd = 0.16 < 1.00 (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 98.64 < Lambda,max = 210.00 Lambda,z = 159.35 < Lambda,max = 210.00 STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed/(XLT*My,Rk/gM1) = 0.16 < 1.00 (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed/(XLT*My,Rk/gM1) = 0.13 < 1.00 (6.3.3.(4))

CODE GROUP: 2 viga

MEMBER: 3 Barra_3 **POINT:** 3 **COORDINATE:** x = 1.00

L = 377.50 mm

LOADS:

Governing Load Case: 1 PERM1

MATERIAL:

S 235 (S 235) fy = 235.00 MPa

SECTION PARAMETERS: HEA 100

h=9.6 cm	gM0=1.00	gM1=1.00	
b=10.0 cm	Ay=18.44 cm2	Az=7.56 cm2	Ax=21.24 cm2
tw=0.5 cm	Iy=349.22 cm4	Iz=133.81 cm4	Ix=4.69 cm4
tf=0.8 cm	Wply=83.02 cm3	Wplz=41.14 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 0.84 kN	My,Ed = -3.20 kN*m	
Nc,Rd = 499.05 kN	My,pl,Rd = 19.51 kN*m	
Nb,Rd = 499.05 kN	My,c,Rd = 19.51 kN*m	Vz,Ed = -8.50 kN
	My,N,Rd = 19.51 kN*m	Vz,c,Rd = 102.52 kN

Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis:

Ly = 377.50 mm   Lam_y = 0.10

Lcr,y = 377.50 mm   Xy = 1.00

Lamy = 9.31   kyy = 1.00

About Z axis:

Lz = 377.50 mm   Lam_z = 0.16

Lcr,z = 377.50 mm   Xz = 1.00

Lamz = 15.04

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.00 < 1.00   (6.2.4.(1))

My,Ed/My,c,Rd = 0.16 < 1.00   (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.08 < 1.00   (6.2.6.(1))

Global stability check of member:

Lambda,y = 9.31 < Lambda,max = 210.00   Lambda,z = 15.04 < Lambda,max = 210.00   STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed/(XLT*My,Rk/gM1) = 0.17 < 1.00   (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed/(XLT*My,Rk/gM1) = 0.09 < 1.00   (6.3.3.(4))

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 1	0,0	0,0	0,0
2/ 1	1,0	-0,0	0,004
3/ 1	1,0	-0,2	0,004
4/ 1	-0,6	-0,2	-0,005
5/ 1	-0,6	-0,0	-0,005
6/ 1	0,0	0,0	0,0

As Uz ≥ 1mm, is over the limit, so i have to select the next profile, it is HEA 140

4.5.-PROFILE HEA 140

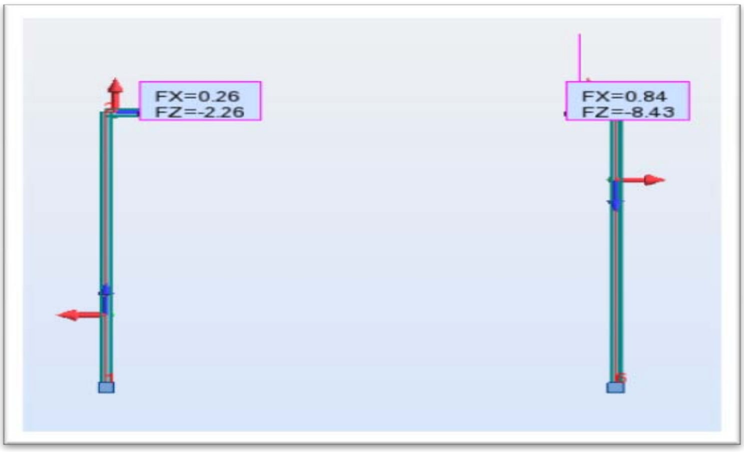


Figure 33. Profile. HEA 140.

4.5.1.-DIAGRAM OF FORCES

<u>Fx force</u>

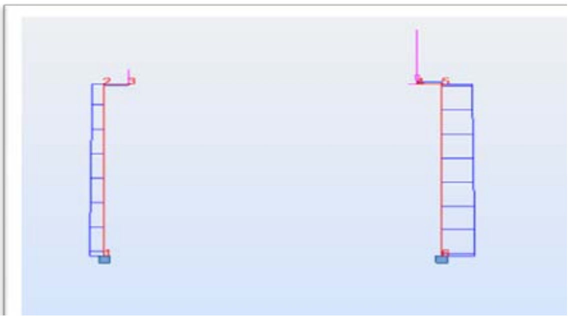


Figure 34. Cantilever structure, diagrams of forces. HEA 140.

<u>My moment</u>

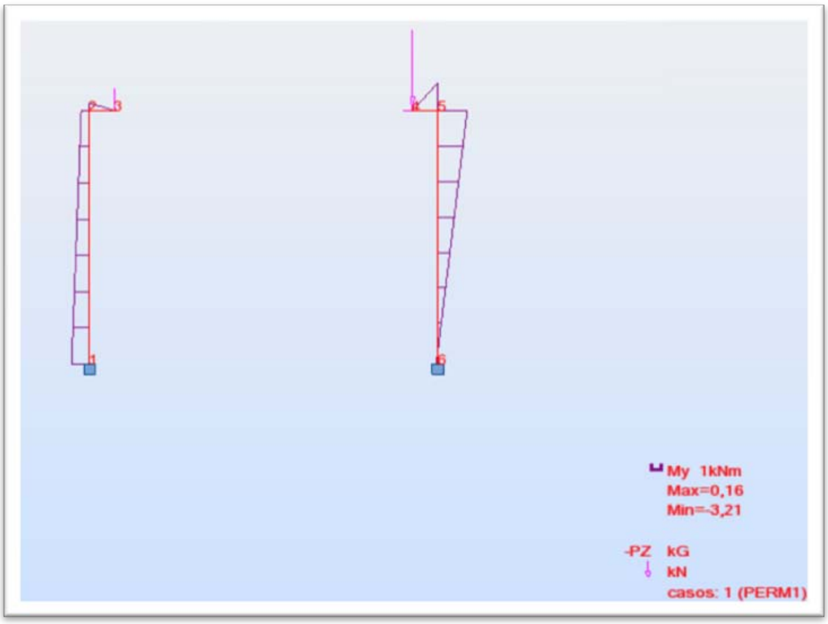


Figure 35. Cantilever structure, diagrams of moments. HEA 140.

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 1	0,0	0,0	0,0
2/ 1	0,6	-0,0	0,003
3/ 1	0,6	-0,1	0,003
4/ 1	-0,4	-0,1	-0,003
5/ 1	-0,4	-0,0	-0,003
6/ 1	0,0	0,0	0,0

Uz ≥ 1mm, is over the limit, so i have to select the next profile, it is HEA 160

4.6.- PROFILE HEA 160

Figure 36. Cantilever structure, profile. HEA 160.

4.6.1.-DIAGRAM OF FORCES

Fx force

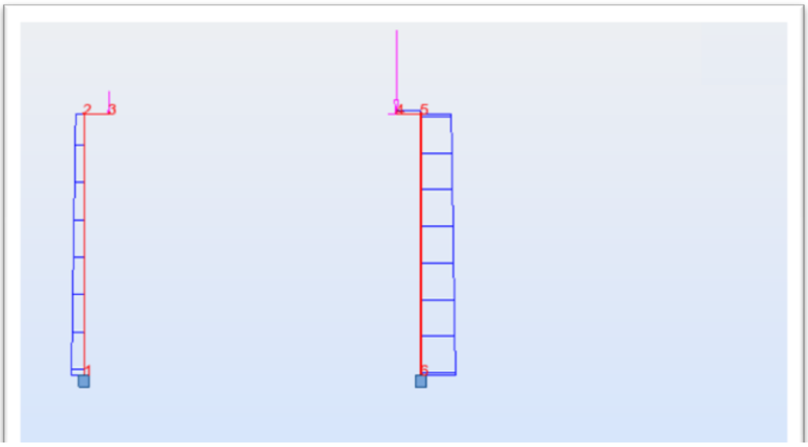


Figure 37. Cantilever structure, diagrams of forces. HEA 160

<u>My moment</u>

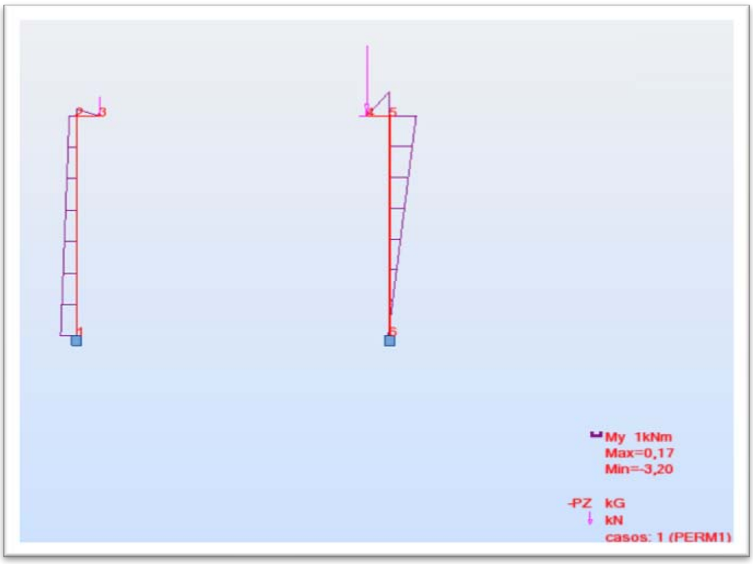


Figure 38. Cantilever structure, diagrams of moments. HEA 160

CODE GROUP: 1 columna

MEMBER: 4 Barra_4 **POINT:** 1 **COORDINATE:** x = 0.00 L = 0.00 mm

LOADS:

Governing Load Case: 1 PERM1

MATERIAL:

S 235 (S 235) fy = 235.00 MPa

SECTION PARAMETERS: HEA 100

h=9.6 cm	gM0=1.00	gM1=1.00	
b=10.0 cm	Ay=18.44 cm2	Az=7.56 cm2	Ax=21.24 cm2
tw=0.5 cm	Iy=349.22 cm4	Iz=133.81 cm4	Ix=4.69 cm4
tf=0.8 cm	Wply=83.02 cm3	Wplz=41.14 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 8.54 kN	My,Ed = -3.20 kN*m		
Nc,Rd = 499.05 kN	My,pl,Rd = 19.51 kN*m		
Nb,Rd = 129.01 kN	My,c,Rd = 19.51 kN*m		Vz,Ed = 0.84 kN
	My,N,Rd = 19.51 kN*m		Vz,c,Rd = 102.52 kN
			Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis:		About Z axis:	
Ly = 4000.00 mm	Lam_y = 1.05	Lz = 4000.00 mm	Lam_z = 1.70
Lcr,y = 4000.00 mm	Xy = 0.57	Lcr,z = 4000.00 mm	Xz = 0.26
Lamy = 98.64	kyy = 0.79	Lamz = 159.35	

-

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.02 < 1.00   (6.2.4.(1))

My,Ed/My,c,Rd = 0.16 < 1.00   (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.01 < 1.00   (6.2.6.(1))

Global stability check of member:

Lambda,y = 98.64 < Lambda,max = 210.00   Lambda,z = 159.35 < Lambda,max = 210.00
STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed/(XLT*My,Rk/gM1) = 0.16 < 1.00   (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed/(XLT*My,Rk/gM1) = 0.13 < 1.00   (6.3.3.(4))

CODE GROUP: 2 viga

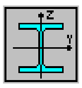
MEMBER: 3 Barra_3   **POINT:** 3   **COORDINATE:** x = 1.00
L = 377.50 mm

LOADS:

Governing Load Case: 1 PERM1

MATERIAL:

S 235 (S 235)   fy = 235.00 MPa



SECTION PARAMETERS: HEA 100

h=9.6 cm	gM0=1.00	gM1=1.00	
b=10.0 cm	Ay=18.44 cm2	Az=7.56 cm2	Ax=21.24 cm2
tw=0.5 cm	Iy=349.22 cm4	Iz=133.81 cm4	Ix=4.69 cm4
tf=0.8 cm	Wply=83.02 cm3	Wplz=41.14 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 0.84 kN	My,Ed = -3.20 kN*m		
Nc,Rd = 499.05 kN	My,pl,Rd = 19.51 kN*m		
Nb,Rd = 499.05 kN	My,c,Rd = 19.51 kN*m		Vz,Ed = -8.54 kN
	My,N,Rd = 19.51 kN*m		Vz,c,Rd = 102.52 kN
			Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis:		About Z axis:	
Ly = 377.50 mm	Lam_y = 0.10	Lz = 377.50 mm	Lam_z = 0.16
Lcr,y = 377.50 mm	Xy = 1.00	Lcr,z = 377.50 mm	Xz = 1.00
Lamy = 9.31	kyy = 1.00	Lamz = 15.04	

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.00 < 1.00 (6.2.4.(1))

My,Ed/My,c,Rd = 0.16 < 1.00 (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.08 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 9.31 < Lambda,max = 210.00 Lambda,z = 15.04 < Lambda,max = 210.00 STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed/(XLT*My,Rk/gM1) = 0.17 < 1.00 (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed/(XLT*My,Rk/gM1) = 0.09 < 1.00 (6.3.3.(4))

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 1	0,0	0,0	0,0
2/ 1	0,4	-0,0	0,002
3/ 1	0,4	-0,1	0,002
4/ 1	-0,2	-0,1	-0,002
5/ 1	-0,2	-0,0	-0,002
6/ 1	0,0	0,0	0,0

Uz ≥ 1mm, is over the limit, so i have to select the next profile, it is HEA 180

4.7.-PROFILE HEA 180

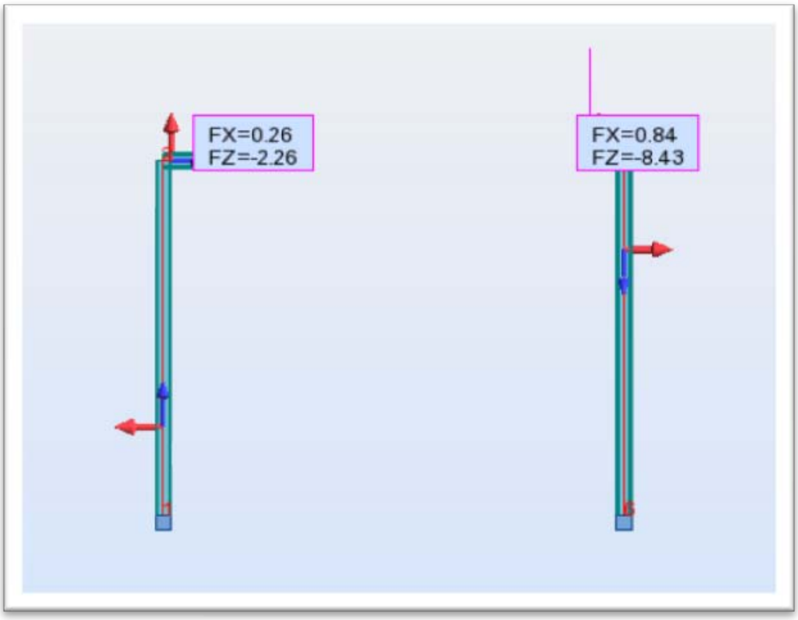


Figure 39. Cantilever structure, profile HEA 180.

4.7.1.-DIAGRAMA OF FORCES

Fx force

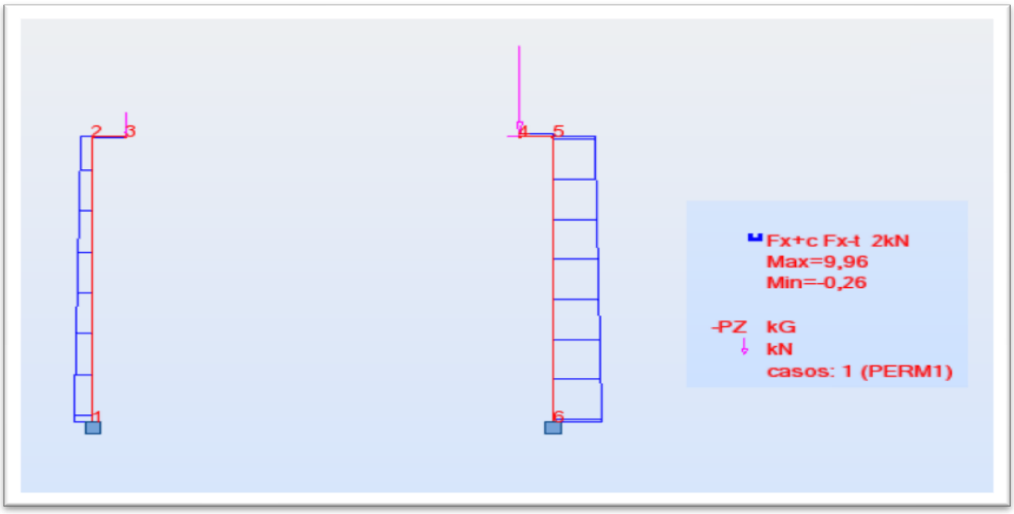


Figure 40. Cantilever structure, diagrams of forces. HEA 180.

<u>My moment</u>

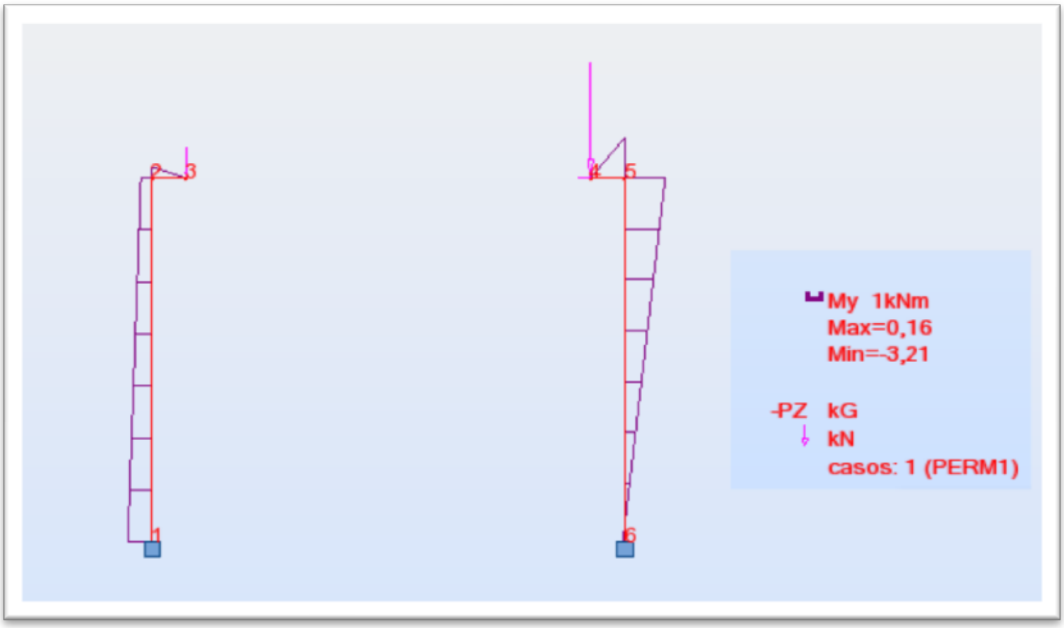


Figure 41. Cantilever structure, diagrams of moments. HEA 180.

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 1	0,0	0,0	0,0
2/ 1	0,2	-0,0	0,001
3/ 1	0,2	-0,0	0,001
4/ 1	-0,1	-0,1	-0,001
5/ 1	-0,1	-0,0	-0,001
6/ 1	0,0	0,0	0,0

Uz ≥ 1mm, is over the limit, so i have to select the next profile, it is HEA 200

4.8.- PROFILE HEA 200

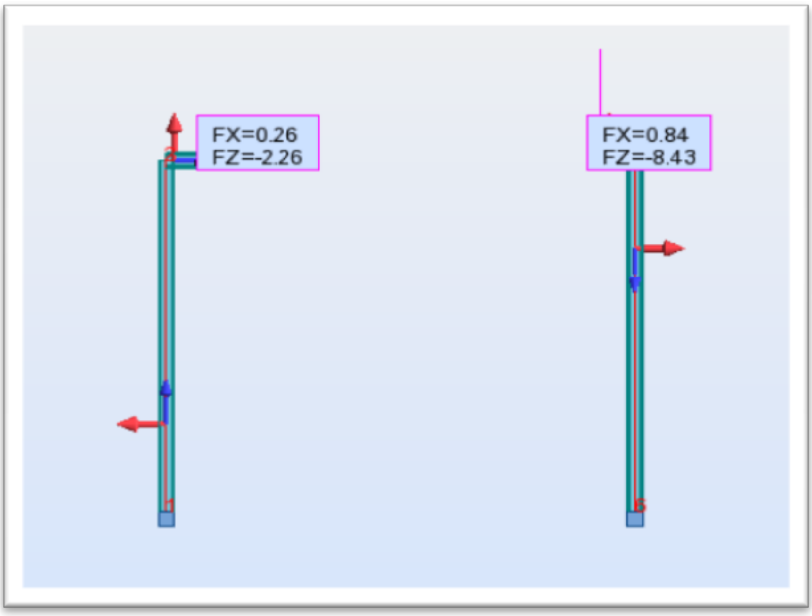


Figure 42. : Cantilever structure, profile HEA 200

4.8.1.-DIAGRAM OF FORCES

<u>Fx force</u>

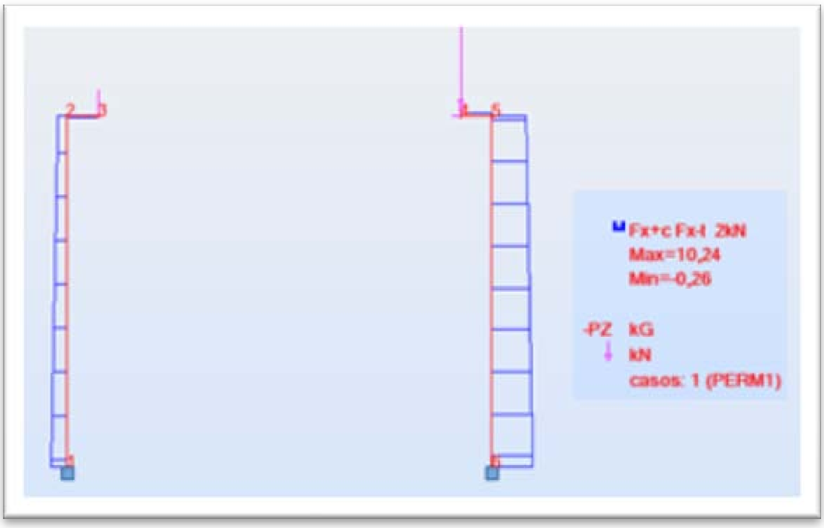


Figure 43. Cantilever structure, diagrams of forces. HEA 200.

My moment

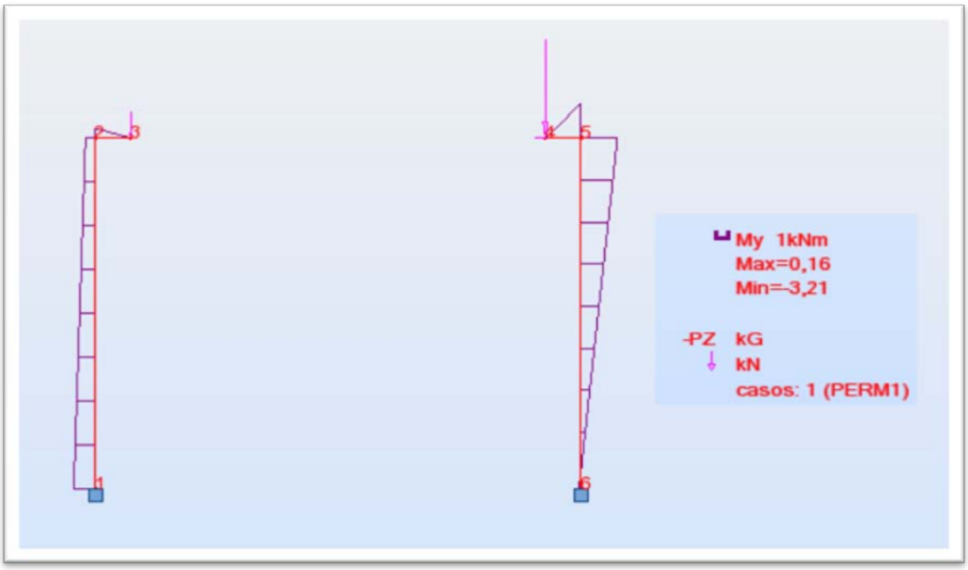
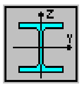


Figure 44. Cantilever structure, diagrams of moments. HEA 200.



SECTION PARAMETERS: HEA 100

h=9.6 cm	gM0=1.00	gM1=1.00	
b=10.0 cm	Ay=18.44 cm2	Az=7.56 cm2	Ax=21.24 cm2
tw=0.5 cm	Iy=349.22 cm4	Iz=133.81 cm4	Ix=4.69 cm4
tf=0.8 cm	Wply=83.02 cm3	Wplz=41.14 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 8.59 kN	My,Ed = -3.21 kN*m
Nc,Rd = 499.05 kN	My,pl,Rd = 19.51 kN*m

Nb,Rd = 129.01 kN My,c,Rd = 19.51 kN*m Vz,Ed = 0.84 kN

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis:		About Z axis:	
Ly = 4000.00 mm	Lam_y = 1.05	Lz = 4000.00 mm	Lam_z = 1.70
Lcr,y = 4000.00 mm	Xy = 0.57	Lcr,z = 4000.00 mm	Xz = 0.26
Lamy = 98.64	kyy = 0.79	Lamz = 159.35	

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.02 < 1.00 (6.2.4.(1))

My,Ed/My,c,Rd = 0.16 < 1.00 (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.01 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 98.64 < Lambda,max = 210.00 Lambda,z = 159.35 < Lambda,max = 210.00 STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed/(XLT*My,Rk/gM1) = 0.16 < 1.00 (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed/(XLT*My,Rk/gM1) = 0.13 < 1.00 (6.3.3.(4))

CODE: *EN 1993-1:2005, Eurocode 3: Design of steel structures.*

ANALYSIS TYPE: Code Group Design with Optimization Options

CODE GROUP: 2 viga

MEMBER: 3 Barra_3 **POINT:** 3 **COORDINATE:** x = 1.00

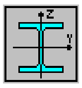
L = 377.50 mm

LOADS:

Governing Load Case: 1 PERM1

MATERIAL:

S 235 (S 235) fy = 235.00 MPa



SECTION PARAMETERS: HEA 100

h=9.6 cm	gM0=1.00	gM1=1.00	
b=10.0 cm	Ay=18.44 cm2	Az=7.56 cm2	Ax=21.24 cm2
tw=0.5 cm	Iy=349.22 cm4	Iz=133.81 cm4	Ix=4.69 cm4
tf=0.8 cm	Wply=83.02 cm3	Wplz=41.14 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 0.84 kN	My,Ed = -3.21 kN*m
Nc,Rd = 499.05 kN	My,pl,Rd = 19.51 kN*m

Nb,Rd = 499.05 kN   My,c,Rd = 19.51 kN*m   Vz,Ed = -8.59 kN

My,N,Rd = 19.51 kN*m   Vz,c,Rd = 102.52 kN

Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis:		About Z axis:	
Ly = 377.50 mm	Lam_y = 0.10	Lz = 377.50 mm	Lam_z = 0.16
Lcr,y = 377.50 mm	Xy = 1.00	Lcr,z = 377.50 mm	Xz = 1.00
Lamy = 9.31	kyy = 1.00	Lamz = 15.04	

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.00 < 1.00   (6.2.4.(1))

My,Ed/My,c,Rd = 0.16 < 1.00   (6.2.5.(1))

Vz,Ed/Vz,c,Rd = 0.08 < 1.00   (6.2.6.(1))

Global stability check of member:

Lambda,y = 9.31 < Lambda,max = 210.00   Lambda,z = 15.04 < Lambda,max = 210.00   STABLE

N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed/(XLT*My,Rk/gM1) = 0.17 < 1.00   (6.3.3.(4))

N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed/(XLT*My,Rk/gM1) = 0.09 < 1.00   (6.3.3.(4))

Node/Case	UX (cm)	UZ (cm)	RY (Rad)
1/ 1	0,0	0,0	0,0
2/ 1	0,2	-0,0	0,001
3/ 1	0,2	-0,0	0,001
4/ 1	-0,1	-0,0	-0,001
5/ 1	-0,1	-0,0	-0,001
6/ 1	0,0	0,0	0,0

In the table you can see that the vertical displacement beam is $Uz = 0,0mm$ and the limits is 0,775, therefore this profile meets with the requirements.

In the next table is showed the stresses in the beams

Bar/Node/Case	S max (MPa)	S min (MPa)	S max(My) (MPa)	S min(My) (MPa)	Fx/Ax (MPa)
1/ 1/ 1	5,70	-4,19	4,95	-4,95	0,76
1/ 2/ 1	2,72	-1,82	2,27	-2,27	0,45
2/ 2/ 1	2,22	-2,32	2,27	-2,27	-0,05
2/ 3/ 1	-0,05	-0,05	0,00	-0,00	-0,05
3/ 4/ 1	0,16	0,16	0,00	-0,00	0,16
3/ 5/ 1	8,42	-8,11	8,26	-8,26	0,16
4/ 5/ 1	9,86	-6,67	8,26	-8,26	1,60
4/ 6/ 1	2,32	1,49	0,41	-0,41	1,90

In the next table you can see the reactions of the cantilever structure:

Node/Case	FX (kN)	FZ (kN)	MY (kNm)
1/ 1	-0,26	4,07	-1,92
6/ 1	-0,84	10,24	-0,16
Case 1	PERM1		
Sum of val.	-1,10	14,32	-2,08
Sum of reac.	-1,10	14,32	-55,36
Sum of forc.	1,10	-14,32	55,36
Check val.	0,00	0,00	0,00
Precision	1,43106e-014	7,44480e-029	

With this results we can calculate de anchors of the structure through Hilti PROFIS software.

- Base material: cracked concrete C20/25, compressive strength $25N/mm^2$
- Anchor plate: square, 12mm thickness
- Profile: HEA 200
- Loads: Reactions

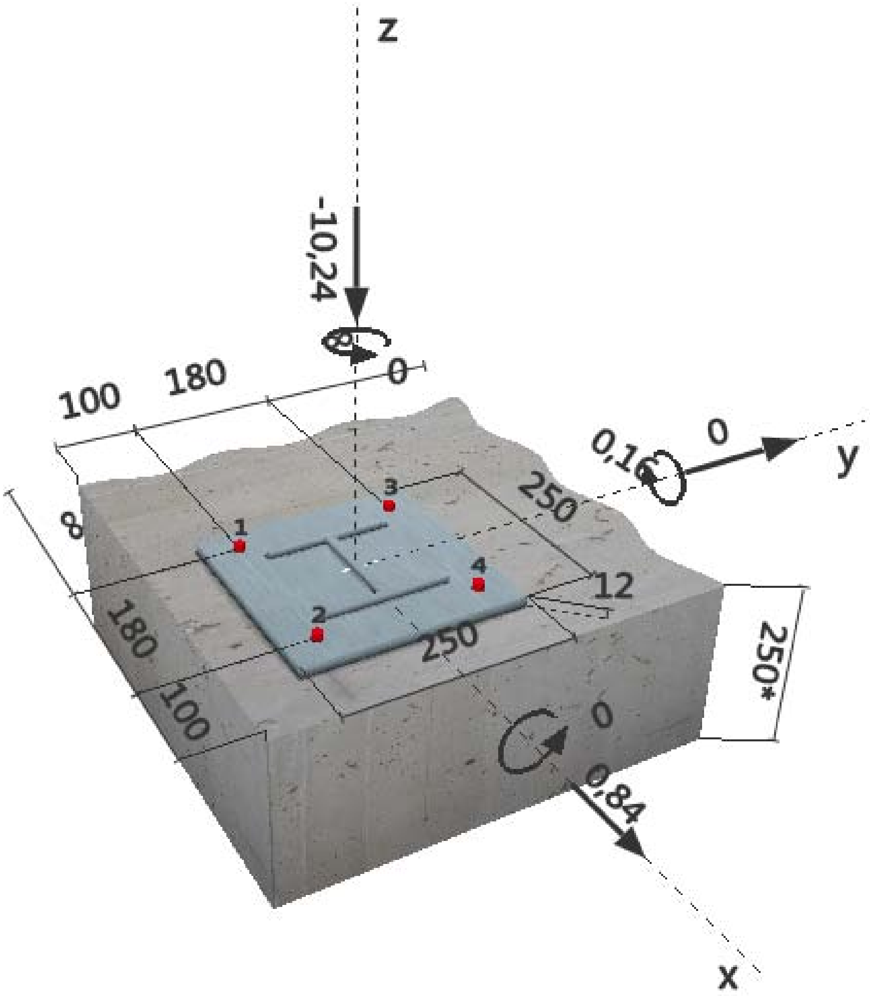


Figure 45. HEA 140 anchors

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Again, the anchors also HSL-3 M8 selected because they are the first type of anchor that meets the minimum requirements. But in this case, one can see that the stresses are lower.

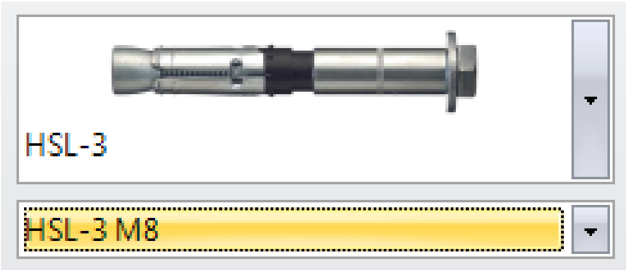


Figure 46. Anchor Bolt

In the next table you can see the stresses

HSL-3	M8	6 %	0 %	6 %	0 %	●	●	●	●	●	60 mm
HSL-3-G	M8	6 %	0 %	6 %	0 %	●	●	●	●	●	60 mm
HSL-3-SK	M8	6 %	0 %	6 %	0 %	●	●	●	●	●	60 mm
HSL-3-SH	M8	6 %	0 %	6 %	0 %	●	●	●	●	●	60 mm
HSL-3	M10	6 %	0 %	6 %	0 %	●	●	●	●	●	70 mm
HSL-3-G	M10	6 %	0 %	6 %	0 %	●	●	●	●	●	70 mm
HSL-3-SK	M10					●	●	●	●	●	
HSL-3-SH	M10					●	●	●	●	●	
HSL-3	M12					●	●	●		●	
HSL-3-G	M12					●	●	●		●	
HSL-3-B	M12					●	●	●		●	
HSL-3-SK	M12					●	●	●		●	
HSL-3-SH	M12					●	●	●		●	
HSL-3	M16					●	●	●		●	
HSL-3-G	M16					●	●	●		●	
HSL-3-B	M16					●	●	●		●	
HSL-3	M20						●	●		●	
HSL-3-G	M20						●	●		●	
HSL-3-B	M20						●	●		●	
HSL-3	M24						●	●			
HSL-3-B	M24						●	●			

5.-CONCLUSIONS

The moments are greater in the cantilever structure, and to comply with the limits is to increase the size of profile, the HEA 200 being the first profile that meets the requirements. On the other hand, we note that as increasing the profile of the structure also increases the size of it and therefore its weight, creating greater efforts.

The biggest problem has been taken in the development of work has been with hosrizontales movements of the structure, which are those that limit the size of the profile.

In the anchorages calculating we see a slight difference: if we compare the two structures when the y-axis is larger in frame structure, but yet when the axis "z" is greater in the cantilever structure.

The structure that I will select to analyze is the frame with HEA 140 profile

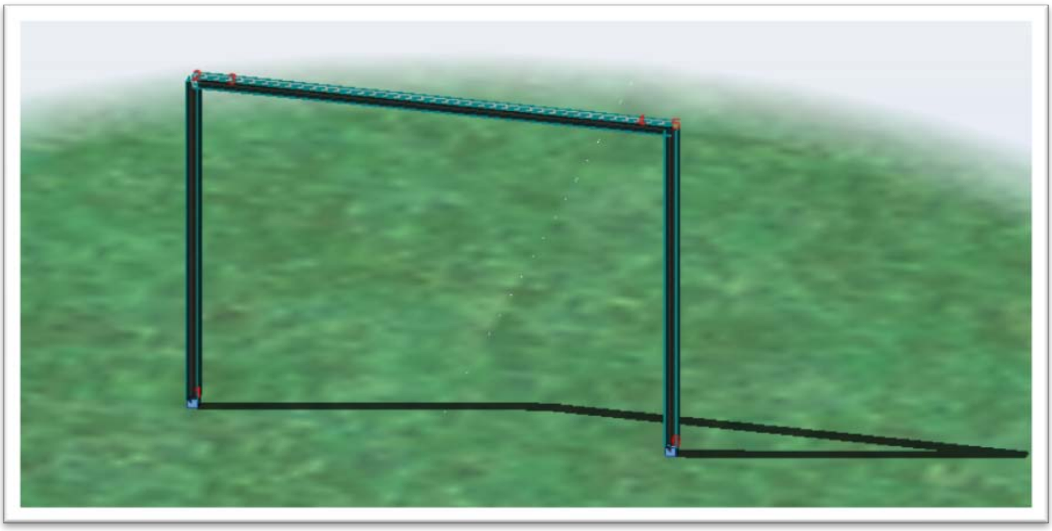
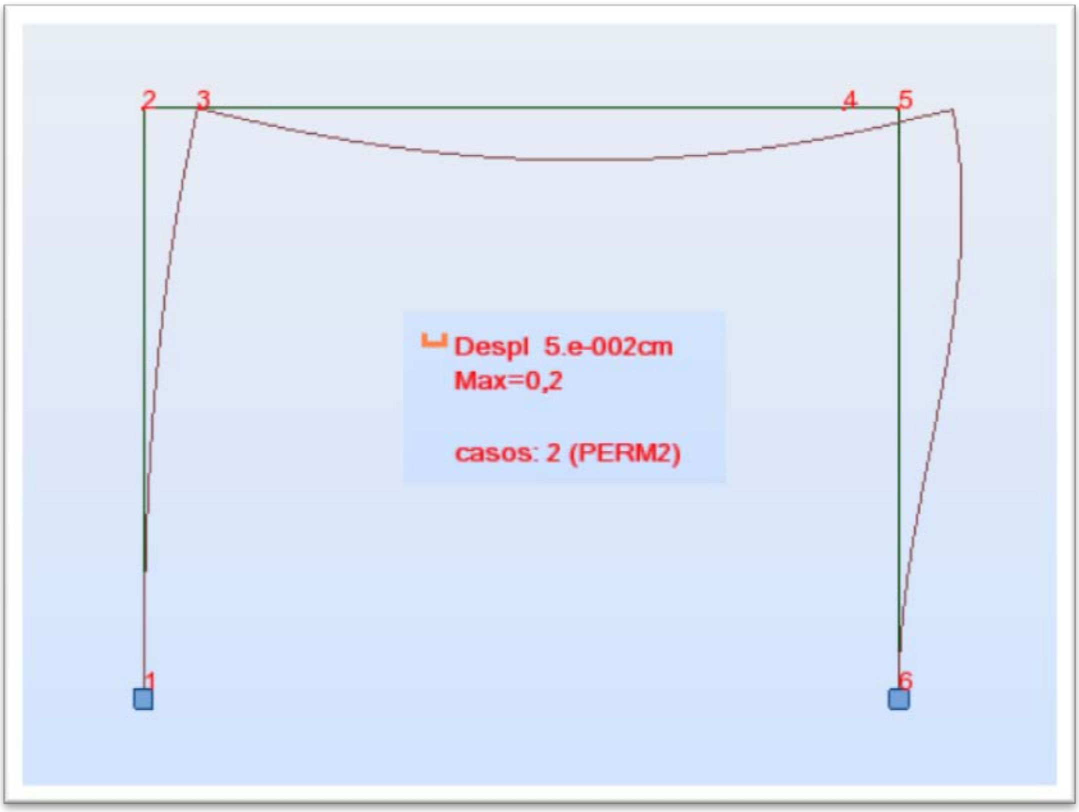


Figure 47. Real view HEA 140 profile

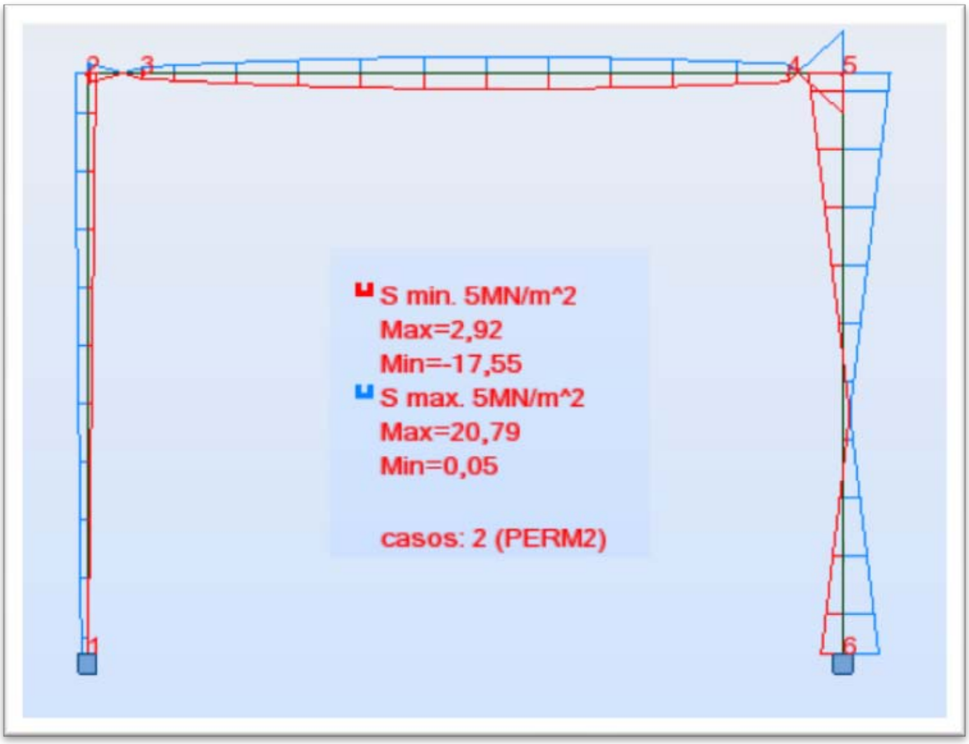
5.1.- RESULTS

Node/Case	FX (kN)	FZ (kN)	MY (kNm)
1/ 2	0,12	3,90	-0,23
6/ 2	-1,19	9,98	-1,97
Case 2	PERM2		
Sum of val.	-1,07	13,88	-2,20
Sum of reac.	-1,07	13,88	-54,09
Sum of forc.	1,07	-13,88	54,09
Check val.	-0,00	0,00	-0,00
Precision	0,0	2,28154e-028	

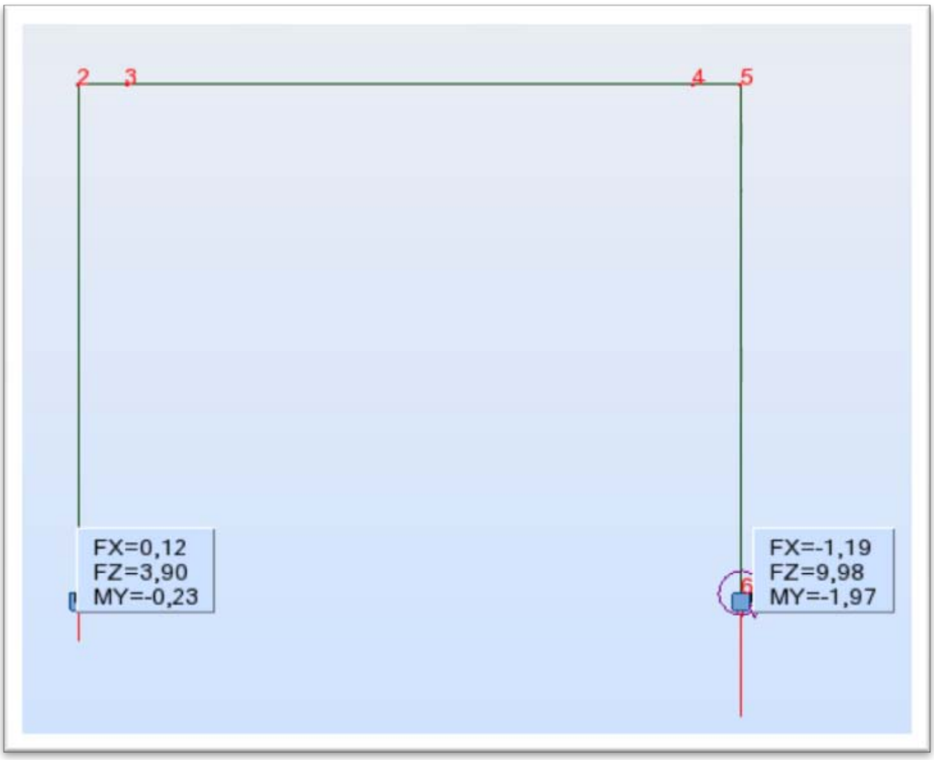
Reaction



Deformation



Stress



Reactions

Bar/Node/Case	S max (MPa)	S min (MPa)	S max(My) (MPa)	S min(My) (MPa)	Fx/Ax (MPa)
1/ 1/ 2	2,70	-0,21	1,46	-1,46	1,24
1/ 2/ 2	5,47	-3,60	4,54	-4,54	0,93
2/ 2/ 2	4,58	-4,50	4,54	-4,54	0,04
2/ 5/ 2	18,30	-17,55	17,92	-17,92	0,38
3/ 5/ 2	20,79	-15,06	17,92	-17,92	2,87
3/ 6/ 2	15,86	-9,50	12,68	-12,68	3,18

6.-ANNEXES

INDEX OF FIGURES