Universitat Politécnica de Valencia
Facultad de Ingeniería
Escuela Técnica Superior de Edificación

Structural design works of a olympic swimming-pool and study of the relationship of the structural model with the architectural design

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SUMMARY

PART I : ARCHITECTURAL DESIGN

PART II : STRUCTURAL DESIGN

EXTERNAL ATTACHEMENT:

i. ***Graphic work T1 :*** Floor type 1: Furnished plan

ii. ***Graphic work T2 :*** Floor type 1: Floor slab reinforcement and rafters reinforcement;

iii. ***Graphic work T3 :*** Floor type 2: Floor slab reinforcement and rafters reinforcement;

iv. ***Graphic work T4 :*** Reinforcement board beam “B”, Building 1;

v. ***Graphic work T5 :*** Reinforcement board beam “C”, Building 1;

vi. ***Graphic work T6 :*** Reinforcement board building beam “B”, Building 2;

vii. ***Graphic work T7 :*** Reinforcement columns “B”, Building 2;

INTRODUCTION

The following thesis has been written in a range of an interchange “Erasmus” program between the University Politecnic of Marche and the University Politecnic of Valencia. The topic object of study is based on the development of a Project concerning to a sports building. This study has to touch both the architectural aspect and the structural aspect of the building design.

The first part comprends the feasibility study evaluating the set up of the functional areas in relaction to the use classifications, with particolar attention to satisfy the normatives prescription in regards both the accessibility and the fire prevention.
The main part of the relationship is the second one, based on the development of a structural model, evaluating an over all view of the behaviour and designing all the structural elements among wich roof, beams, columns, floor slabs.

Is decided to develop the study of a Building with a purpose of Olypic Swimming-pool with vase dimensions of 50x25m, setted in Valencia. This choice has undoubtedly inposed to design spaces with opening considerables and, precisely in this direction has been tried to develop solutions as well as on functionality and with remarkable architectonic quality.
This choices, for example the design of embossed roof , in some cases moved in damage of the structural regolarity and , for this reason, have been studied soluctions that permits to minimize the irregularities generated.
It’s important underline that almost everything the Spanish Land is subjected to a seismic accellerations with a really low intensity. Indeed, contrary to the Italian territory where in the mayority of it the eartquake loads are dimensioning, in Spain is possible to design almost all the structures dimensioning only for vertical loads.
This peculiarity is present also in the Valencian area and it has permitted so, to carry forward Architectonics choices not conventionals in the Italian area. It’s important to underline that despite that, the spanish low in the field of building “Codigo Tecnico” provide seismic verifications for building with a particular and strategic importance (Class III-IV).
Considering the surface and the capacity of the building is possible to fill it in the Class III, so to the dimensioning only for vertical loads is followed by the seismic verification, that in the mayority of cases ,seeing the low accelleration of the ground , is fully satisfied.

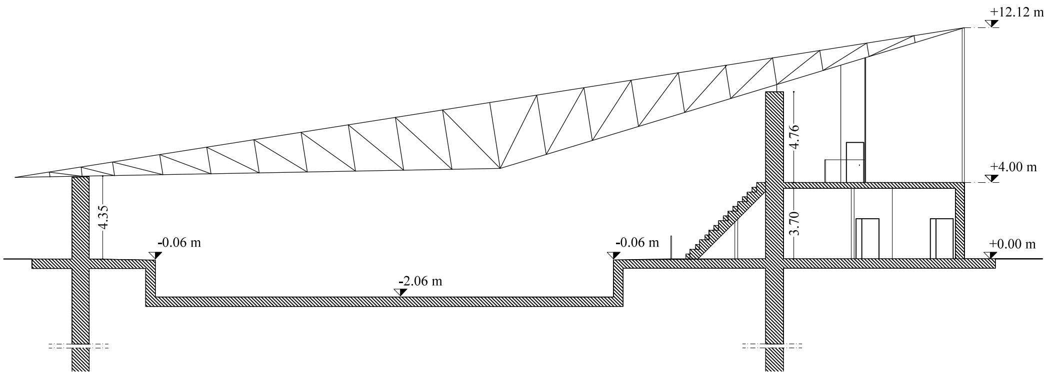
PART I
ARCHITECTURAL DESIGN

1 GENERALITIES

1.1 HEADROOM

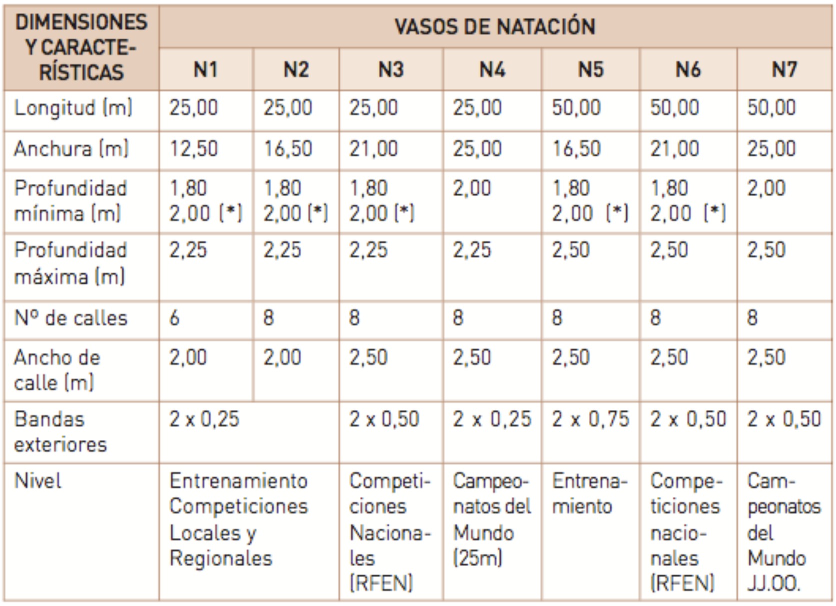
“La altura mínima libre que deben de tener los locales destinados a espectáculos públicos, no será inferior a 3,20 m, medidos desde el suelo de la sala al techo.Si existieran elementos escalonados o decorativos en algún punto de la sala, su altu- ra libre no será en ningún caso inferior a 2,80 m.”

In our case the minimum headroom is of 3,70 m, with a maximum of 4,76 in the second floor.



1.2 VASE CHARACTERISTICS

1.2.1 DIMENSIONAL CHARACTERISTICS



DIMENSIONES Y CARACTERÍSTICAS	VASOS DE NATACIÓN						
	N1	N2	N3	N4	N5	N6	N7
Longitud (m)	25,00	25,00	25,00	25,00	50,00	50,00	50,00
Anchura (m)	12,50	16,50	21,00	25,00	16,50	21,00	25,00
Profundidad mínima (m)	1,80 2,00 (*)	1,80 2,00 (*)	1,80 2,00 (*)	2,00	1,80 2,00 (*)	1,80 2,00 (*)	2,00
Profundidad máxima (m)	2,25	2,25	2,25	2,25	2,50	2,50	2,50
Nº de calles	6	8	8	8	8	8	8
Ancho de calle (m)	2,00	2,00	2,50	2,50	2,50	2,50	2,50
Bandas exteriores	2 x 0,25		2 x 0,50	2 x 0,25	2 x 0,75	2 x 0,50	2 x 0,50
Nivel	Entrenamiento Competiciones Locales y Regionales		Competiciones Nacionales (RFEN)	Campeonatos del Mundo (25m)	Entrenamiento	Competiciones nacionales (RFEN)	Campeonatos del Mundo JJ.OO.

The project swimming pool is an Olimpic – N7 that can be used for World Championship JJ.OO. It has the following characteristics:

1.2.1.1 *Swimming lanes*

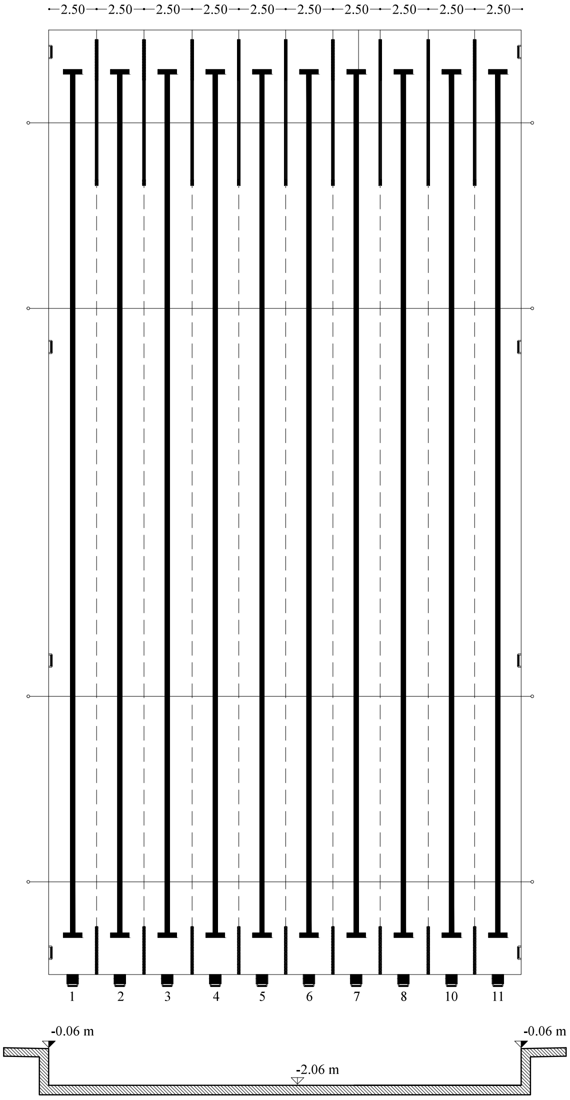
“Las calles tendrán una anchura mínima de 2,00 m y recomendada de 2,50 m. En vasos de 25 m y de 50 m para Competiciones Nacionales, el no de calles será de 8, el ancho de calle será de 2,50 m con dos bandas exteriores de 0,50 m. En va- sos de 25 m y de 50 m para Campeonatos del Mundo y Juegos Olímpicos, el no de calles será de 8, el ancho de calle será de 2,50 m con dos bandas exteriores de 2,50 m.”

In our case there are 10 swimming lanes ond theyr width is of 2,50 m each.

1.2.1.2 *Depth of the vase*

“La profundidad mínima requerida es de 1,80 m y recomendada de 2,00 m. En Cam- peonatos del Mundo y Juegos Olímpicos la profundidad mínima será de 2,00 m.”

The depth of the vase is of 2,00 m in for all the plane surface



1.2.1.3 *Platform*

“Las anchuras mínimas de playas ó andenes serán como mínimo de 2,00 m (3,50 m recomendado) y de 5,00 m en el extremo de las plataformas de salidas en piscinas donde se celebren Competiciones Nacionales.

La superficie de las playas será plana, sin que se formen charcos y con pendiente de, al menos, 2% en dirección perpendicular y opuesta al vaso hacia canaleta de recogida de agua perimetral, independiente y alejada de la del vaso.”

For this reason are designed sidewalk with minimum width of 3,00 m next to the long side of the vase and with 5,00 m of width on the short side of the vase just in front of the dressing rooms exities.
All the surfaces close to the pool are with a slope of 2% to guarantee the water flow.

1.2.1.4 *Swimming vase access*

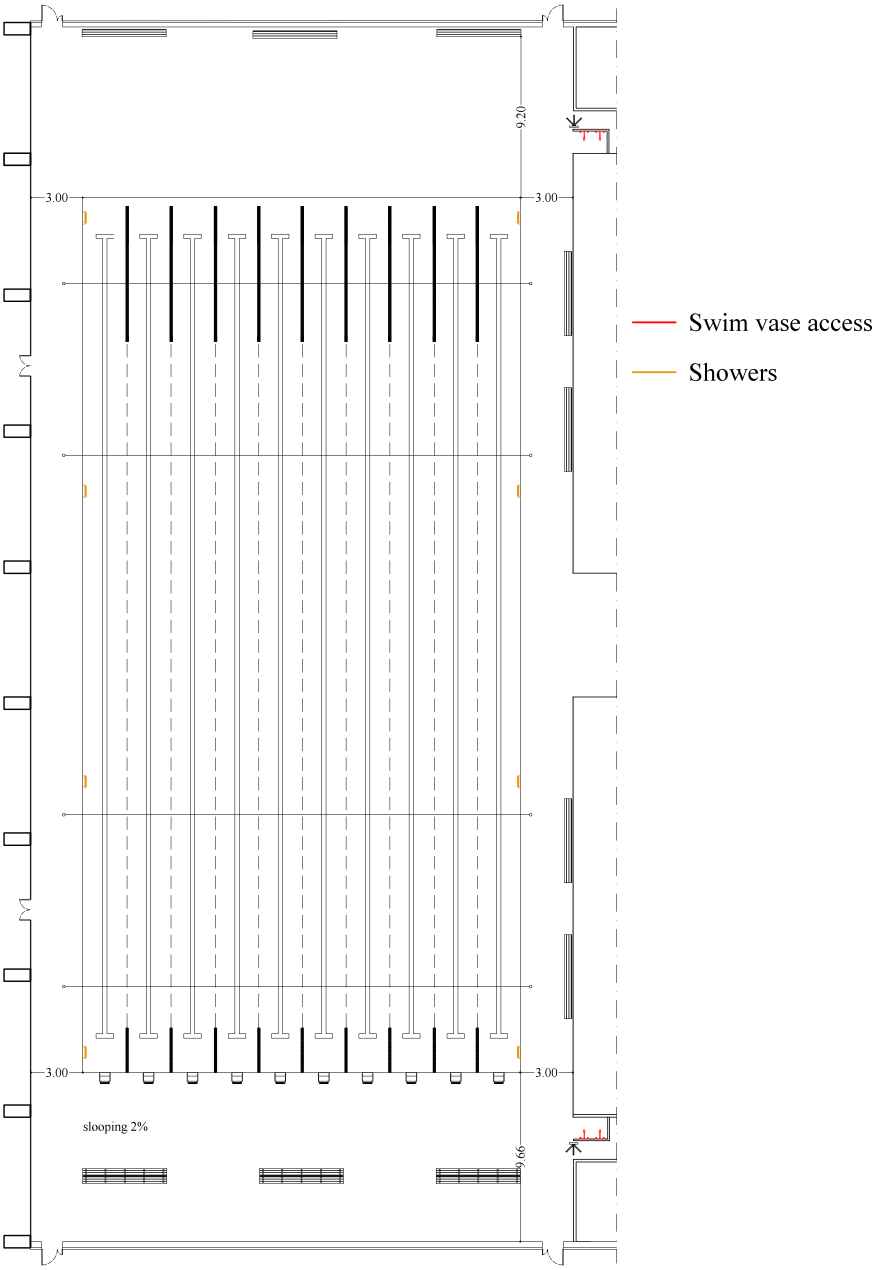
“Se dispondrán accesos al vaso mediante escaleras verticales en las esquinas de los lados laterales y cuando sea necesario otras a distancias no superior a 20 m entre escaleras, excepto en los vasos de chapoteo.”

Are disposed 4 ladder in each side of the swimming pool both disposed within a distance of 17m from the others.

1.2.1.5 *Showers*

“Se dispondrán duchas en el espacio de playas, al menos 4, junto al acceso a las mis- mas desde el pasillo de pies descalzos, se podrán también disponer duchas alrededor de los vasos próximas a los accesos o escaleras a dichos vasos. El agua se recogerá mediante canaleta perimetral alejada del vaso.”

Are disposed 4 shower at the entrances of the swimming area: two in front of the women dressing room and two in front of the men dressing room.



1.3 FUNCTIONALITY DESIGN

1.3.1 DRESSING ROOM

1.3.1.1 *Surface*

“A los vestuarios se accederá desde la zona de pies calzados y desde ellos a través de la zona de pies descalzos se accederá al recinto de piscinas. El no mínimo de vestuarios es de 2, uno para cada sexo. Los vestuarios se dimensionarán para un n° de usuarios en función del aforo, el cual es proporcional a los m^2 de lámina de agua, el aforo se fija en 1 usuario / 3m^2 lamina de agua (Aforo: m^2 lamina agua/3), considerando que no usan los vestuarios a la vez todos los usuarios, establecemos 1/2 del total del aforo (N^o usuarios de vestuarios simultáneos: m^2 lamina agua/6) el no

de usuarios simultáneos obtenido se repartirá al 50% en vestuarios masculinos y femeninos y se dispondrá de una superficie por cada vestuario de 1 m^2/usuario."

Are designed 2 dressing room for the pubblic.Both ae disposed on the edge of the building.
To evaluate the minimum capacity of them are considered:

$$Water\ surface\ = 50m\ x25\ m\ = 1250\ m^{\ 2}$$

$$N°\ Users_{\ tot} = \frac{1250\ m^2}{6} = 209\ m^2$$

considering that there are 2 dressing rooms, they have the following N° each:

$$N°\ Users_{\ man/woman} = \frac{209\ m^2}{2} = 104{,}5\ m^2$$

In our case are designed two dressing room with a surface of 191,00 m^2 each, and the prescriptive requestion is widely satisfied.

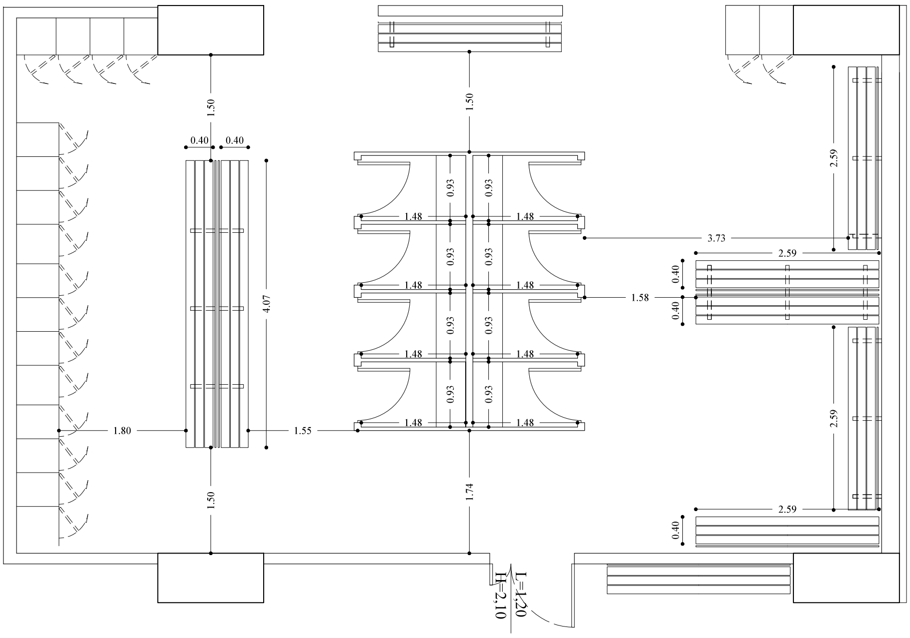
1.3.1.2 *Height*

"La altura recomendada de vestuarios y aseos será de 3,00 m y la altura libre mínima entre el pavimento y el obstáculo más próximo, luminaria, conducto de instalaciones, etc. será de 2,80 m."

The dressing room minimum height is of 3,50 m in correspondance of the high deep beam of 50 cm (interfloor height =4,00 m)

1.3.1.3 *Fornitures*

"Para el cambio de ropa en vestuarios, se colocarán bancos fijos con una longitud mínima 0,60 m/usuario (0,50 m/usuario para escolares), ancho entre 0,40 m 0,45 m y una altura de 0,45 m. La separación libre mínima entre dos bancos ó entre banco y paramento ó taquilla será de 1,5 m. Los bancos estarán sujetos a los muros mediante escuadras o elementos similares y sin patas para favorecer la limpieza ó serán de fábrica. Se dispondrán percheros resistentes sobre los bancos, 2 Uds./usuario a una altura de 1,65 m y de 1,40 m para escolares, no son admisibles ganchos por seguridad. "



1.3.1.4 *Showers*

“Próximo a los vestuarios se dispondrán como mínimo dos zonas de duchas colecti- vas, una para cada sexo, con espacio para secado, así como dos zonas de aseos y lavabos, una para cada sexo, las zonas de duchas y las zonas de aseos y lavabos no serán de paso una para la otra, tendrán acceso directo desde el pasillo de pies des- calzos o desde el vestuario y estarán protegidas de vistas desde los pasillos de circulación.
Se dispondrán duchas en proporción de 1ducha/20 usuarios, con un mínimo de 5 y 1 en vestuarios de árbitros, profesores. Las duchas serán preferentemente colectivas. Cada ducha dispondrá de una superficie de 0,90 x 0,90 m, el paso mínimo entre duchas será de 0,80 m y entre duchas y pared de 1m.”

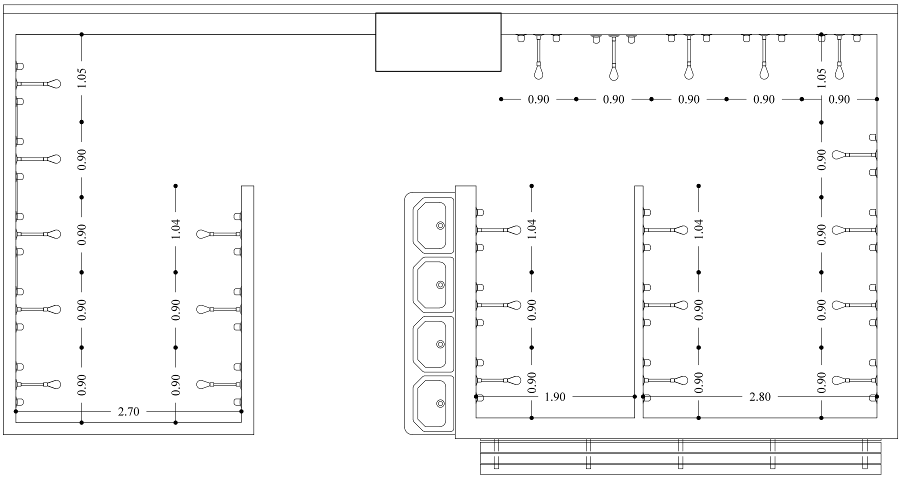
Are disposed 23 showers in each dressing room. The minimum precriptive requested is of:

$$\frac{1\,shower}{20\,users}$$

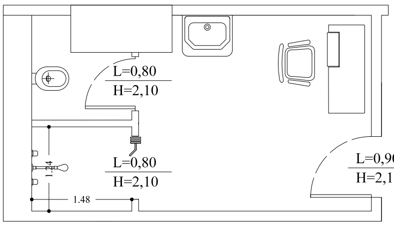
considering that we have 104 users in each dressing room,the minimum nuber of showers is :

$$\frac{104}{20} \approx 4$$

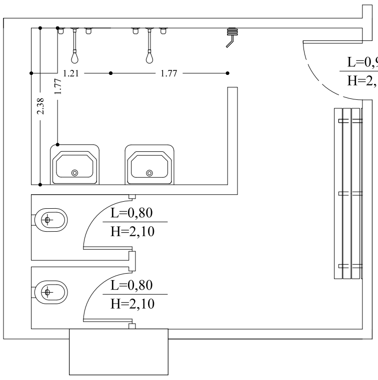
the showers used are 23 anf the prescription is largely satisfied.



the Arbiters dressing room with 1 shower:



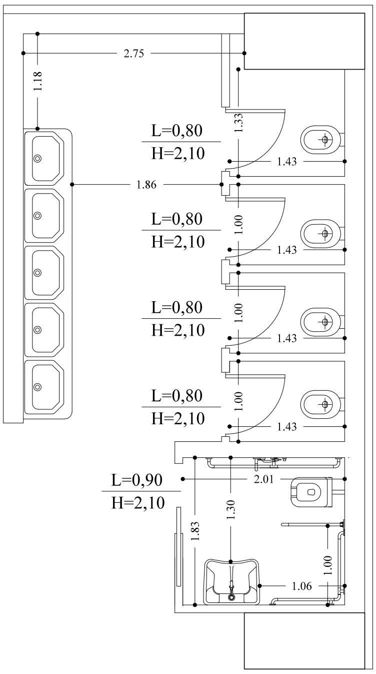
the instructor dressing room with 2 showers



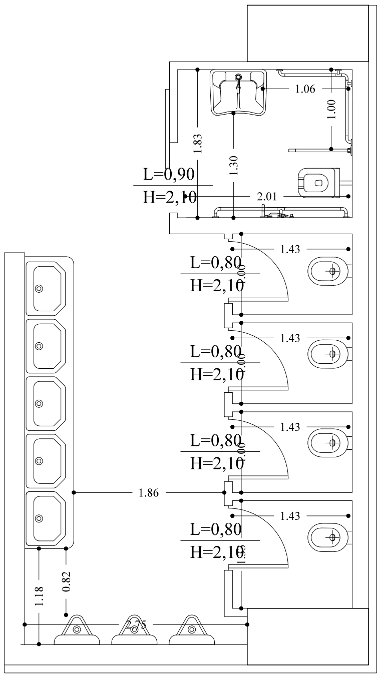
1.3.2 BATHROOM

"Cada zona de aseos, masculina y femenina, dispondrá de cabinas de inodoros y lavabos, en proporción de 1 por cada 50 usuarios con un mínimo de cuatro cabinas y 2 lavabos en los aseos masculinos se sustituirá la mitad de inodoros por urinarios, con un mínimo con dos urinarios. Las cabinas de inodoro tendrán una anchura mínima de 1 m y una de ellas adaptada para minusválidos. Los vestuarios de árbitros, profesores tendrán como mínimo una cabina y un lavabo."

The women bathrooms are provided with 5 bathroom and one of these is for people with physical didability. There are 4 washbasin close to the bathroom area and 4 washbasin in the shower area.



The men bathrooms are provided with 5 bathroom. One of these is for people with physical disability. Are supplied also 3 urinal.
There are 4 washbasin close to the bathroom area and 4 washbasin in the shower area.



1.3.1 INFIRMARY

"Estará bien comunicado con el recinto de piscinas y tendrá una fácil salida hacia el exterior para evacuación de accidentados.
Dispondrá como mínimo de lavabo, inodoro, ducha, espacio de cambio de ropa, es- pacio para camilla, mesa y silla, teléfono y estará dotado con equipos de primeros auxilios y material de cura."

The infirmary is placed close tho the main entrace of the swimming pool, with a surface of 36,81 m and fully equipped with first-emergency material.

1.3.2 ENGINE ROOM

1.3.2.1 *Dimensions*

"Las instalaciones térmicas deberán ser perfectamente accesibles en todas sus partes de forma que puedan realizarse adecuadamente y sin peligro todas las operaciones de mantenimiento, vigilancia y conducción.
La altura mínima de la sala será de 2,50 m, respectándose una altura libre de tube- rías y obstáculos sobre la caldera de 0,5 m."

1.3.2.2 *Ventilation*

"Toda sala de máquinas cerrada debe disponer de medios suficientes de ventilación. El sistema de ventilación podrá ser del tipo:

— Natural directa por orificios.
— Natural directa por conductos.
— Ventilación forzada.

Se recomienda adoptar, para mayor garantía de funcionamiento, el sistema de venti- lación directa por orificios.

La ventilación natural directa al exterior puede realizarse, para las salas contiguas a zonas al aire libre, mediante aberturas de área libre mínima de 5 cm2/kW de potencia térmica nominal."

The engine room is organized in an external area not connected with the main building. The total surface is of 22,39 m^2 with an interfloor height of 4,00 m.
The surface of ventilation is of 2,34 m^2.
The roof of the engineer room has an additional features because is used like a support for the stairs of the emergency exit on the south side.

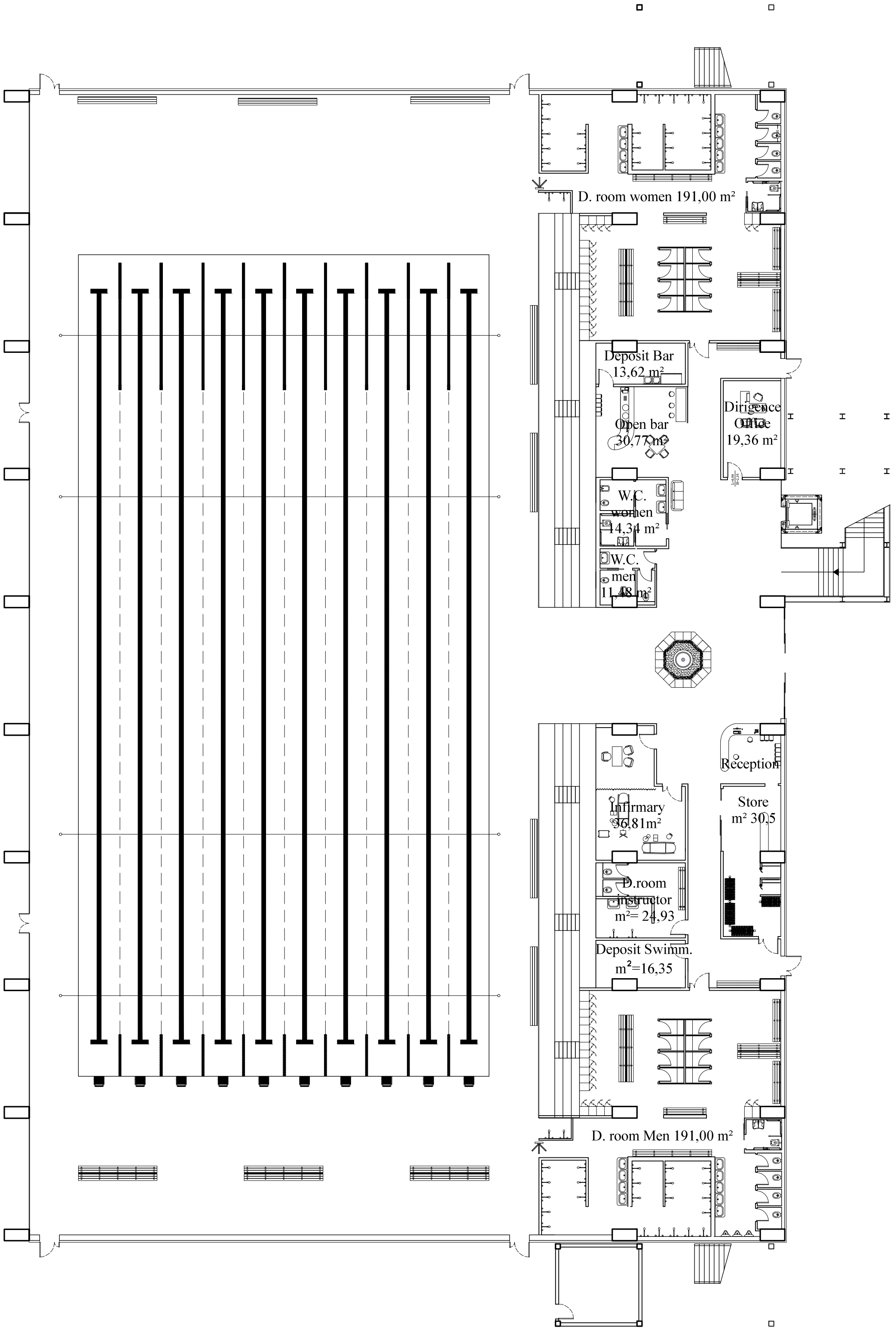
1.3.3 TERRACES

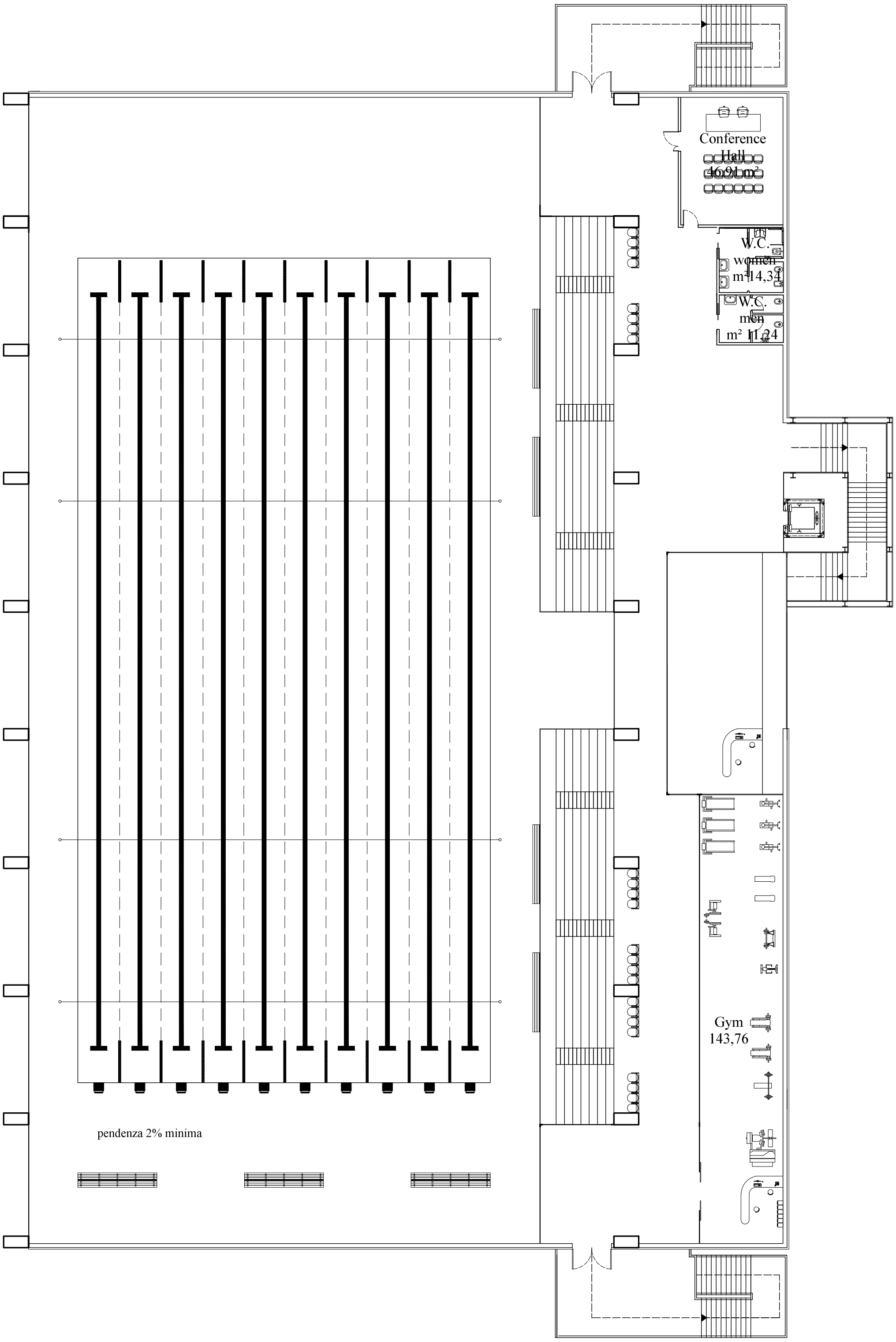
"Las graderías dispondrán de amplias salidas con escaleras suaves o rampas de 1,20 m de ancho por cada 200 espectadores o fracción y en número proporcional a su aforo. Cada 14 m de gradería habrá un paso de un metro que no podrá ocuparse durante el espectáculo. Las localidades deberán estar separadas de la cancha, terreno de juego o circuito, con una barandilla o cerramiento debiendo estar esta separación a una distancia mínima de 2,50 m."

For this reason are designed stairs upon the terraces every 7,70 m with 1,20 m of width. The grandstanding capacity is of 500 person and are designed 6 stairs upon the terraces every 7,70 m with 1,20 m of width. The total oblique lenght of the terraces stairs is of 5m and is not necessary to dispose a free stair step of 1 m.

1.4 FUNCTIONALITY DESIGN OUTPUT

Following the resume of the functionality design with the planimetric disposal of all the spaces:


D. room women 191,00 m²
Deposit Bar
13,62 m²
Open bar
30,77 m²
Dirigence
Office
19,36 m²
W.C.
women
14,34 m²
W.C.
men
11,48 m²
Reception
Store
m² 30,5
Infirmary
36,81m²
D.room
instructor
m²= 24,93
Deposit Swimm.
m²=16,35
D. room Men 191,00 m²


Conference
Hall
46,91 m²
W.C.
women
m² 14,34
W.C.
men
m² 11,24
Gym
143,76
pendenza 2% minima

2 FIRE PREVENTION DESIGN

2.1 BUILDING CAPACITY EVALUATION

Following the resume of the zones that have to be considered for the evaluation of the building capacity.

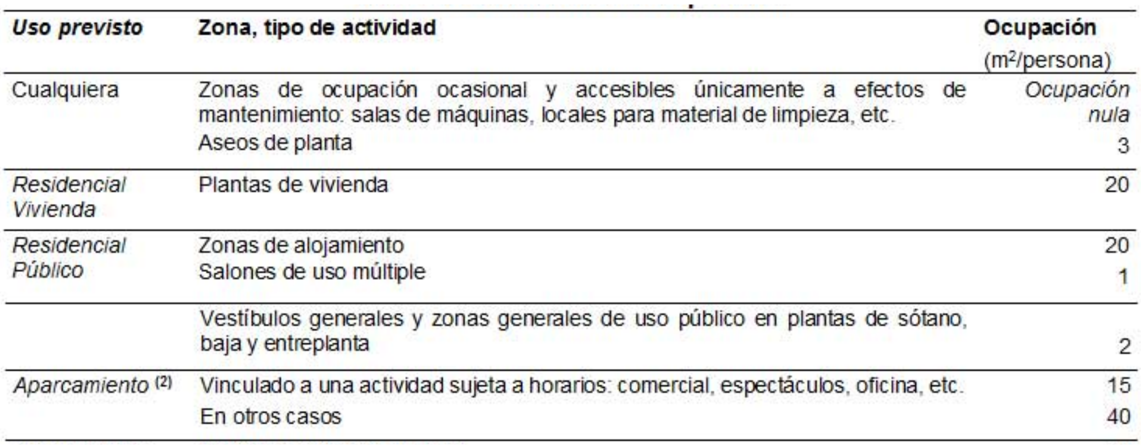
First floor

1. *Dressing rooms tot = 406,93* m^2
2. *Atrium tot = 135,77* m^2
3. *Store tot = 30,5* m^2
4. *Bar tot = 30,77* m^2
5. *Office tot = 19,36* m^2
6. *Wc tot = 25,58* m^2
7. *Deposit tot = 29,97* m^2
8. *Swimming pool area = 1250* m^2

Second floor

1. *Conference hall tot = 46,91* m^2
2. *Stand seats tot = 258,3* m^2
3. *Gym tot = 143,76* m^2
4. *Wc tot = 25,58* m^2

To evaluate the building capacity is necessary to considerate the density values of the following table, in function of the utile surface of each zone.



Uso previsto	**Zona, tipo de actividad**	**Ocupación** (m^2/persona)
Cualquiera	Zonas de ocupación ocasional y accesibles únicamente a efectos de mantenimiento: salas de máquinas, locales para material de limpieza, etc.	*Ocupación nula*
	Aseos de planta	3
Residencial Vivienda	Plantas de vivienda	20
Residencial Público	Zonas de alojamiento	20
	Salones de uso múltiple	1
	Vestíbulos generales y zonas generales de uso público en plantas de sótano, baja y entreplanta	2
Aparcamiento (2)	Vinculado a una actividad sujeta a horarios: comercial, espectáculos, oficina, etc.	15
	En otros casos	40

Administrativo	Plantas o zonas de oficinas	10
	Vestíbulos generales y zonas de uso público	2
Docente	Conjunto de la planta o del edificio	10
	Locales diferentes de aulas, como laboratorios, talleres, gimnasios, salas de dibujo, etc.	5
	Aulas (excepto de escuelas infantiles)	1,5
	Aulas de escuelas infantiles y salas de lectura de bibliotecas	2
Hospitalario	Salas de espera	2
	Zonas de hospitalización	15
	Servicios ambulatorios y de diagnóstico	10
	Zonas destinadas a tratamiento a pacientes internados	20
Comercial	En *establecimientos* comerciales:	
	áreas de ventas en plantas de sótano, baja y entreplanta	2
	áreas de ventas en plantas diferentes de las anteriores	3
	En zonas comunes de centros comerciales:	
	mercados y galerías de alimentación	2
	plantas de sótano, baja y entreplanta o en cualquier otra con acceso desde el espacio exterior	3
	plantas diferentes de las anteriores	5
	En áreas de venta en las que no sea previsible gran afluencia de público, tales como exposición y venta de muebles, vehículos, etc.	5
Pública concurrencia	Zonas destinadas a espectadores sentados:	
	con asientos definidos en el proyecto	1pers/asiento
	sin asientos definidos en el proyecto	0,5
	Zonas de espectadores de pie	0,25
	Zonas de público en discotecas	0,5
	Zonas de público de pie, en bares, cafeterías, etc.	1
	Zonas de público en gimnasios:	
	con aparatos	5
	sin aparatos	1,5
	Piscinas públicas	
	zonas de baño (superficie de los vasos de las piscinas)	2
	zonas de estancia de público en piscinas descubiertas	4
	vestuarios	3
	Salones de uso múltiple en edificios para congresos, hoteles, etc.	1
	Zonas de público en restaurantes de "comida rápida", (p. ej: hamburgueserías, pizzerías...)	1,2
	Zonas de público sentado en bares, cafeterías, restaurantes, etc.	1,5
	Salas de espera, salas de lectura en bibliotecas, zonas de uso público en museos, galerías de arte, ferias y exposiciones, etc.	2
	Vestíbulos generales, zonas de uso público en plantas de sótano, baja y entreplanta	2
	Vestíbulos, vestuarios, camerinos y otras dependencias similares y anejas a salas de espectáculos y de reunión	2
	Zonas de público en terminales de transporte	10
	Zonas de servicio de bares, restaurantes, cafeterías, etc.	10

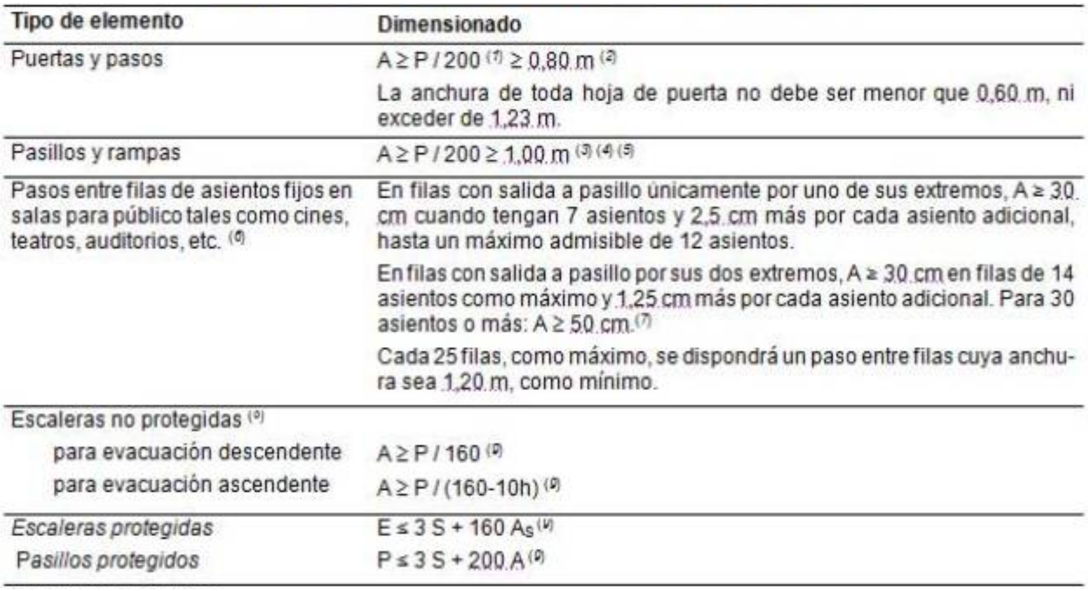
And we obtain the following values:

First floor	*Suface*	*Occupation*	*N° People*
	m^2	*m^2/per*	
Dressing rooms	*406,93*	*2*	*203,47*
Atrium	*135,77*	*2*	*67,89*
Store	*30,5*	*2*	*15,25*
Bar	*30,77*	*1,5*	*20,51*
Office	*19,36*	*10*	*1,94*
Wc	*25,58*	*3*	*8,53*
Deposit tot	*29,97*	*-*	*0,00*
Swimming pool area	*1250*	*4*	*312,50*
		tot	***322,96***

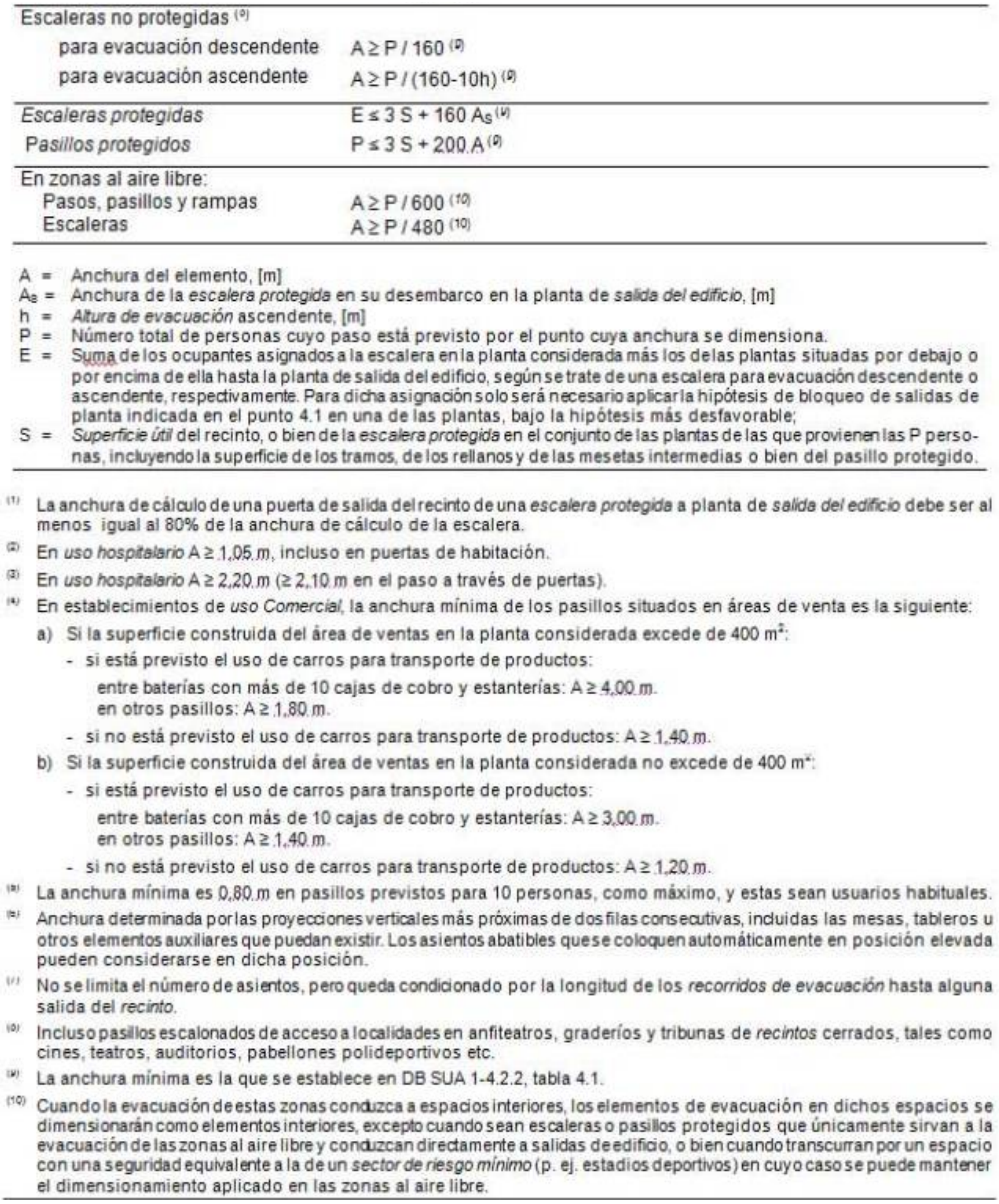
Second Floor	*Surface*	*Occupation*	*N° People*
	m^2	*m^2/per*	
Conference hall	*46,91*	*2*	*23,46*
Stand seats	*258,3*	*0,5*	*516,60*
Gym	*143,76*	*5*	*28,75*
Wc	*25,58*	*3*	*8,53*
		tot	***577,33***

2.2 WAY OUT DESIGN

***A**re evaluate building way-out that enable people to exit in safe places, in this case the open space outwards.*



Tipo de elemento	Dimensionado
Puertas y pasos	$A \geq P / 200$ (1) $\geq 0{,}80$ m (2) La anchura de toda hoja de puerta no debe ser menor que 0,60 m, ni exceder de 1,23 m.
Pasillos y rampas	$A \geq P / 200 \geq 1{,}00$ m (3) (4) (5)
Pasos entre filas de asientos fijos en salas para público tales como cines, teatros, auditorios, etc. (6)	En filas con salida a pasillo únicamente por uno de sus extremos, $A \geq 30$ cm cuando tengan 7 asientos y 2,5 cm más por cada asiento adicional, hasta un máximo admisible de 12 asientos. En filas con salida a pasillo por sus dos extremos, $A \geq 30$ cm en filas de 14 asientos como máximo y 1,25 cm más por cada asiento adicional. Para 30 asientos o más: $A \geq 50$ cm. (7) Cada 25 filas, como máximo, se dispondrá un paso entre filas cuya anchura sea 1,20 m, como mínimo.
Escaleras no protegidas (8)	
para evacuación descendente	$A \geq P / 160$ (9)
para evacuación ascendente	$A \geq P / (160-10h)$ (9)
Escaleras protegidas	$E \leq 3 S + 160 A_S$ (9)
Pasillos protegidos	$P \leq 3 S + 200 A$ (9)



Escaleras no protegidas (8)	
para evacuación descendente	$A \geq P / 160$ (9)
para evacuación ascendente	$A \geq P / (160-10h)$ (9)
Escaleras protegidas	$E \leq 3\,S + 160\,A_S$ (9)
Pasillos protegidos	$P \leq 3\,S + 200\,A$ (9)
En zonas al aire libre:	
Pasos, pasillos y rampas	$A \geq P / 600$ (10)
Escaleras	$A \geq P / 480$ (10)

A = Anchura del elemento, [m]
A_S = Anchura de la *escalera protegida* en su desembarco en la planta de *salida del edificio*, [m]
h = *Altura de evacuación* ascendente, [m]
P = Número total de personas cuyo paso está previsto por el punto cuya anchura se dimensiona.
E = Suma de los ocupantes asignados a la escalera en la planta considerada más los de las plantas situadas por debajo o por encima de ella hasta la planta de salida del edificio, según se trate de una escalera para evacuación descendente o ascendente, respectivamente. Para dicha asignación solo será necesario aplicar la hipótesis de bloqueo de salidas de planta indicada en el punto 4.1 en una de las plantas, bajo la hipótesis más desfavorable;
S = *Superficie útil* del recinto, o bien de la *escalera protegida* en el conjunto de las plantas de las que provienen las P personas, incluyendo la superficie de los tramos, de los rellanos y de las mesetas intermedias o bien del pasillo protegido.

(1) La anchura de cálculo de una puerta de salida del recinto de una *escalera protegida* a planta de *salida del edificio* debe ser al menos igual al 80% de la anchura de cálculo de la escalera.

(2) En *uso hospitalario* $A \geq 1{,}05$ m, incluso en puertas de habitación.

(3) En *uso hospitalario* $A \geq 2{,}20$ m ($\geq 2{,}10$ m en el paso a través de puertas).

(4) En establecimientos de *uso Comercial*, la anchura mínima de los pasillos situados en áreas de venta es la siguiente:
a) Si la superficie construida del área de ventas en la planta considerada excede de 400 m^2:
- si está previsto el uso de carros para transporte de productos:
  entre baterías con más de 10 cajas de cobro y estanterías: $A \geq 4{,}00$ m.
  en otros pasillos: $A \geq 1{,}80$ m.
- si no está previsto el uso de carros para transporte de productos: $A \geq 1{,}40$ m.

b) Si la superficie construida del área de ventas en la planta considerada no excede de 400 m^2:
- si está previsto el uso de carros para transporte de productos:
  entre baterías con más de 10 cajas de cobro y estanterías: $A \geq 3{,}00$ m.
  en otros pasillos: $A \geq 1{,}40$ m.
- si no está previsto el uso de carros para transporte de productos: $A \geq 1{,}20$ m.

(5) La anchura mínima es 0,80 m en pasillos previstos para 10 personas, como máximo, y estas sean usuarios habituales.

(6) Anchura determinada por las proyecciones verticales más próximas de dos filas consecutivas, incluidas las mesas, tableros u otros elementos auxiliares que puedan existir. Los asientos abatibles que se coloquen automáticamente en posición elevada pueden considerarse en dicha posición.

(7) No se limita el número de asientos, pero queda condicionado por la longitud de los *recorridos de evacuación* hasta alguna salida del *recinto*.

(8) Incluso pasillos escalonados de acceso a localidades en anfiteatros, graderíos y tribunas de *recintos* cerrados, tales como cines, teatros, auditorios, pabellones polideportivos etc.

(9) La anchura mínima es la que se establece en DB SUA 1-4.2.2, tabla 4.1.

(10) Cuando la evacuación de estas zonas conduzca a espacios interiores, los elementos de evacuación en dichos espacios se dimensionarán como elementos interiores, excepto cuando sean escaleras o pasillos protegidos que únicamente sirvan a la evacuación de las zonas al aire libre y conduzcan directamente a salidas de edificio, o bien cuando transcurran por un espacio con una seguridad equivalente a la de un *sector de riesgo mínimo* (p. ej. estadios deportivos) en cuyo caso se puede mantener el dimensionamiento aplicado en las zonas al aire libre.

On the ground floor are projected simmetrically 8 emergencies exits to guarantee a maximum escape hatch length of 32 m that satisfy the prescription request of :

$$l < 50\ m$$

On the first floor are projected 3 emergencies exits; two on the extremities and one on the centre.
The maximum escape hatch length is of 44 m and is satisifed the prescription request.

2.3 VOIDING ELEMENTS DESIGN

For the dimensioning of emergency doors and emergency ladder is necessary to consider the following parameters:

2.3.1 DOORS DIMENSIONING

For the door predimensioning we consider the minimum width of a door evaluate with :

First floor:

$$W_m = \frac{P}{200}$$

First floor	*N° People*	*Flow capacity requested*
		m
Dressing rooms	*203,47*	*1,017*
Atrium	*67,89*	*0,339*
Store	*15,25*	*0,076*
Bar	*20,51*	*0,103*
Office	*1,94*	*0,010*
Wc	*8,53*	*0,043*
Deposit tot	*0,00*	*0,000*
Swimming pool area	*625,00*	*3,125*
tot	*942,58*	***4,713***

We choose to dispose simmetrically 8 emercency exits (1,20m each) to guarantee a width of 9,60 m.

Second floor:

In this case to dimensioning the emergency doors we consider the minimum dimensioning value of the stairs because each person located on the first floor has to use them to reach the safe places externally:

$$W_m = \frac{P}{160}$$

Second Floor	*N° People*	*Flow capacity requested*
		m
Conference hall	*23,46*	*0,147*
Stand seats	*516,60*	*3,229*
Gym	*28,75*	*0,180*
Wc	*8,53*	*0,053*
tot	*577,33*	***3,608***

The second floor is provided with 3 emergencies way. Two of them are emergencies doors that guarantee a width of 2,40 m , the third one is a ladder (width 2,40m) placed centrally that connect the first floor whit the ground. They guarantee total width of 7,20m.

2.3.2 STAIRS DIMENSIONING

2.3.2.1 *Width dimensionig*

The stairs dimensioning are made only for the second floor. In this case we have 3 stairs:

- *Two external stairs:*

$$W_m = \frac{P}{480}$$

P is considered P/2 because in the most unfavorable case the fire is on the centre of the building and the emergencies exits used are on the extremities.

$$W_m = \frac{288{,}5}{480} = 0{,}60m$$

And in our case are choosen two ladder of 2,40 m.

- *One stair not protected:*

$$W_m = \frac{P}{160}$$

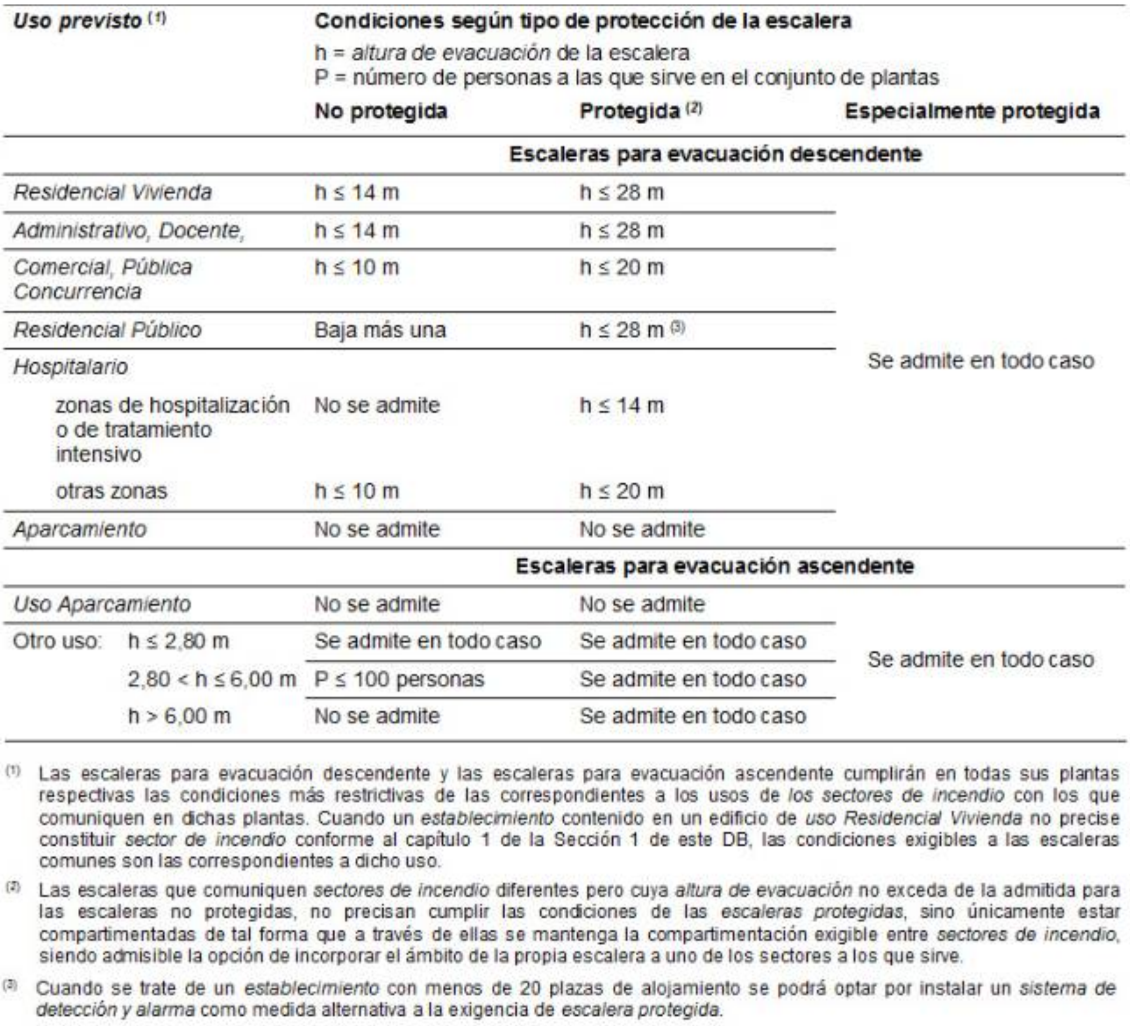
P is considered P/2 because in the most unfavorable case the fire is on one extremities and the emergencies used are on the opposite extremity and on the centre.

$$W_m = \frac{288{,}5}{160} = 1{,}80m$$

And in our case is choosen a stair width of 2,40 m.

2.3.2.2 *Stairs protections*

Following the CTE in our case we can not protect internally ladders against fire/smoke. As a matter of fact ,the building has just one upper-ground level with a height of 4 m.



Uso previsto (1)	**Condiciones según tipo de protección de la escalera** h = *altura de evacuación* de la escalera P = número de personas a las que sirve en el conjunto de plantas		
	No protegida	**Protegida** (2)	**Especialmente protegida**
	Escaleras para evacuación descendente		
Residencial Vivienda	h ≤ 14 m	h ≤ 28 m	Se admite en todo caso
Administrativo, Docente,	h ≤ 14 m	h ≤ 28 m	
Comercial, Pública Concurrencia	h ≤ 10 m	h ≤ 20 m	
Residencial Público	Baja más una	h ≤ 28 m (3)	
Hospitalario			
zonas de hospitalización o de tratamiento intensivo	No se admite	h ≤ 14 m	
otras zonas	h ≤ 10 m	h ≤ 20 m	
Aparcamiento	No se admite	No se admite	
	Escaleras para evacuación ascendente		
Uso Aparcamiento	No se admite	No se admite	Se admite en todo caso
Otro uso: h ≤ 2,80 m	Se admite en todo caso	Se admite en todo caso	
2,80 < h ≤ 6,00 m	P ≤ 100 personas	Se admite en todo caso	
h > 6,00 m	No se admite	Se admite en todo caso	

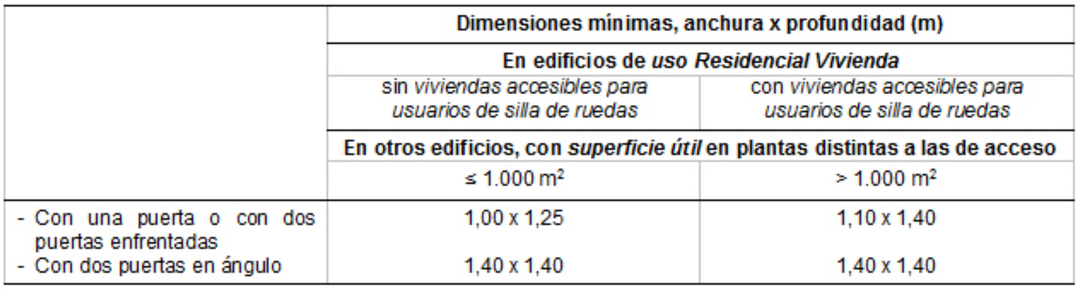
(1) Las escaleras para evacuación descendente y las escaleras para evacuación ascendente cumplirán en todas sus plantas respectivas las condiciones más restrictivas de las correspondientes a los usos de *los sectores de incendio* con los que comuniquen en dichas plantas. Cuando un *establecimiento* contenido en un edificio de *uso Residencial Vivienda* no precise constituir *sector de incendio* conforme al capítulo 1 de la Sección 1 de este DB, las condiciones exigibles a las escaleras comunes son las correspondientes a dicho uso.

(2) Las escaleras que comuniquen *sectores de incendio* diferentes pero cuya *altura de evacuación* no exceda de la admitida para las escaleras no protegidas, no precisan cumplir las condiciones de las *escaleras protegidas*, sino únicamente estar compartimentadas de tal forma que a través de ellas se mantenga la compartimentación exigible entre *sectores de incendio*, siendo admisible la opción de incorporar el ámbito de la propia escalera a uno de los sectores a los que sirve.

(3) Cuando se trate de un *establecimiento* con menos de 20 plazas de alojamiento se podrá optar por instalar un *sistema de detección y alarma* como medida alternativa a la exigencia de *escalera protegida*.

2.3.3 EMERGENCY LIFT

The minimum requirement for the lift are:



	Dimensiones mínimas, anchura x profundidad (m)	
	En edificios de *uso Residencial Vivienda*	
	sin *viviendas accesibles para usuarios de silla de ruedas*	con *viviendas accesibles para usuarios de silla de ruedas*
	En otros edificios, con *superficie útil* en plantas distintas a las de acceso	
	≤ 1.000 m^2	> 1.000 m^2
- Con una puerta o con dos puertas enfrentadas	1,00 x 1,25	1,10 x 1,40
- Con dos puertas en ángulo	1,40 x 1,40	1,40 x 1,40

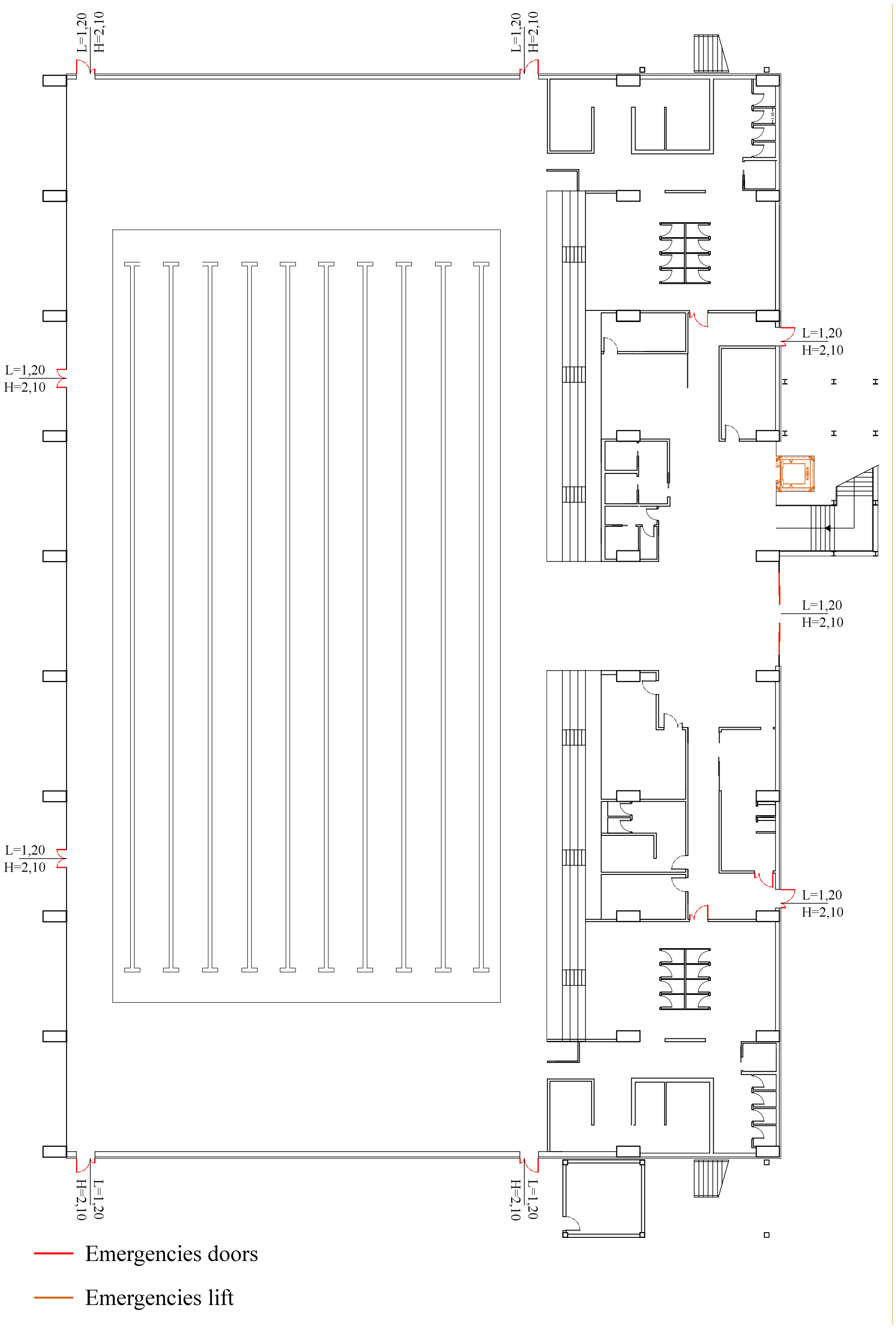
The upper floor served by the lift has a surface of $1025m^2$. Is choosen a two shutters "Kone" lift.

In that case the minimum admissible dimensions are 1,10 m x1,40 m.

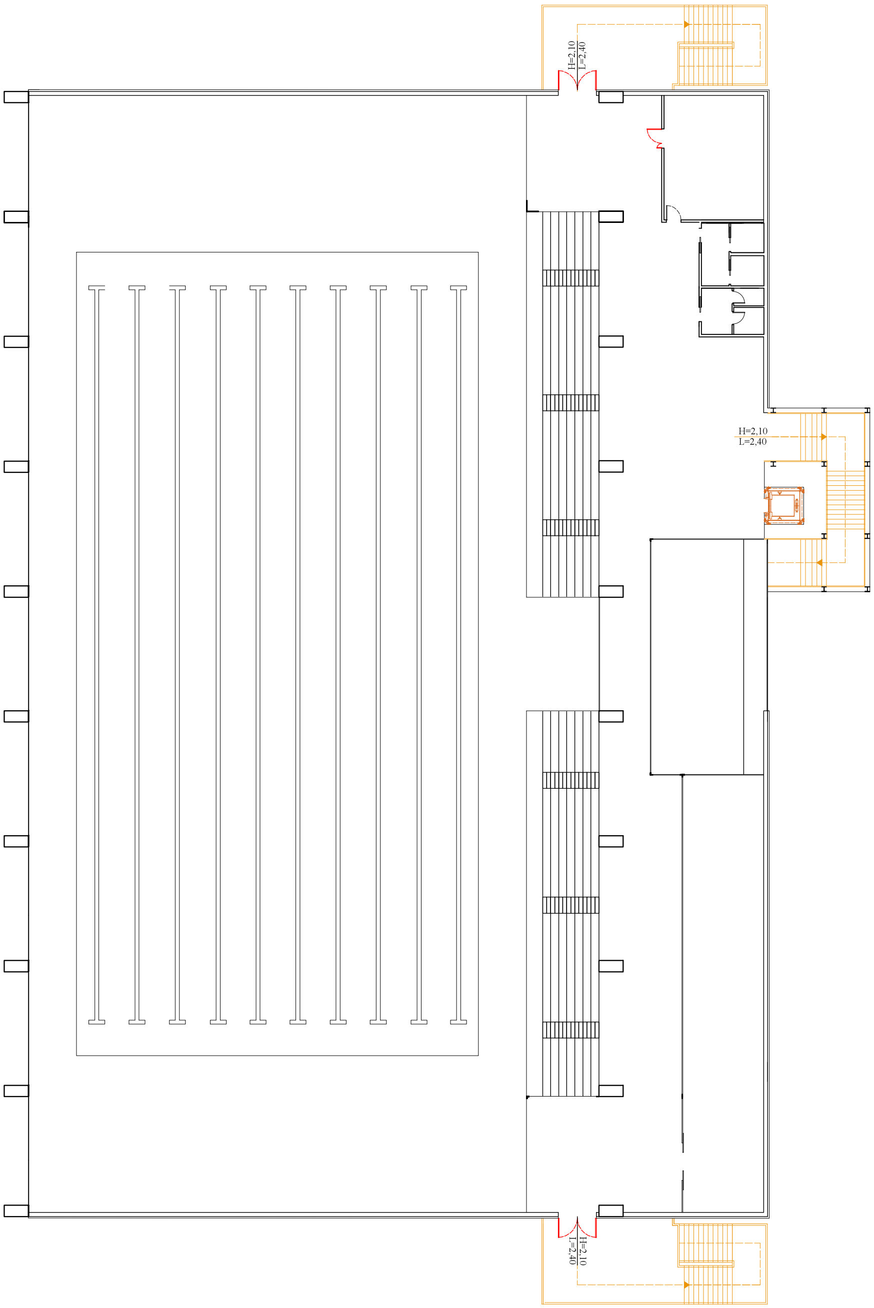
For that reason is selected a "Kone Steel" lift with internal box dimensions of 1,40 m x 1,40m and a load capacity of 800 Kg.

2.4 FIRE PREVENTION DESIGN OUTPUT

First floor:



Second floor:



— Emergencies doors

— Emergencies lift

— Emergencies ladder

3 ACCESSIBILITY

3.1 ACCESSIBILITY DESIGN

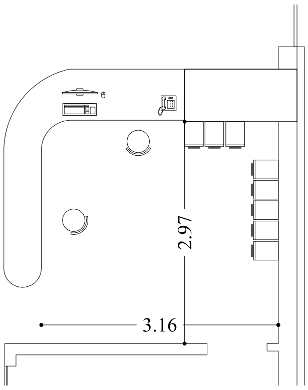
3.1.1 MAIN ENTRANCE

The main eintrance is projected centralized respect the planimetric provision of the building.

3.1.2 RECEPTION

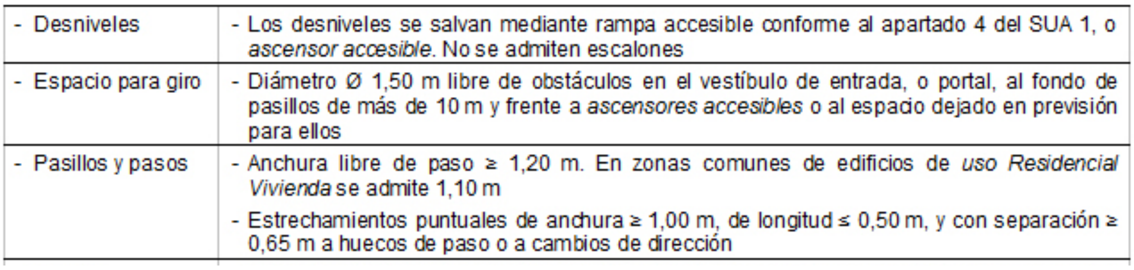
"Su plano de trabajo tiene una anchura de 0,80 m, como mí- nimo, está situado a una altura de 0,85 m, como máximo, y tiene un espacio libre inferiorde70x80x50cm(al- tura x anchura x profundidad), como mínimo. "

The reception is projected "open air" with the following dimensions: 3,65 mx 3,0 m. The worktop is designed with a ground elevation of 1,00 m without difference gap with the ground level.

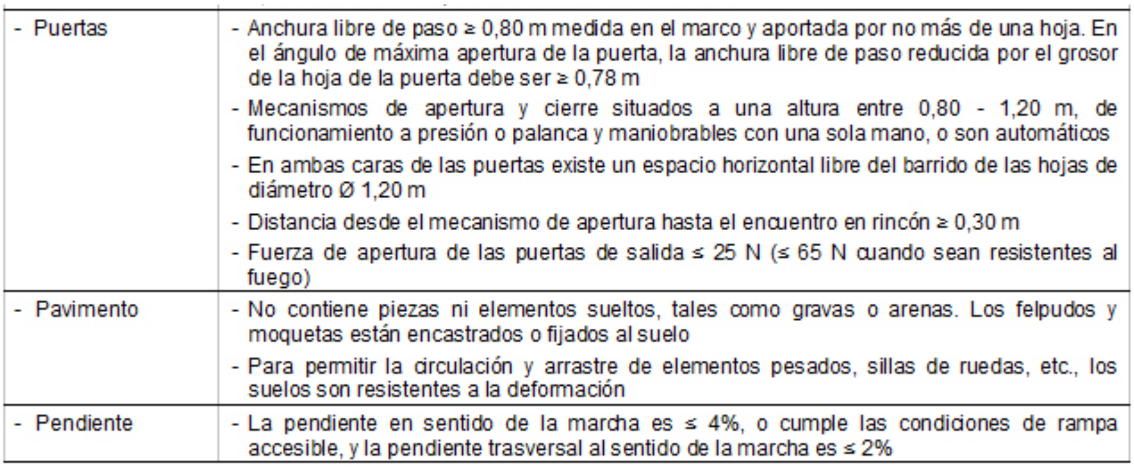


3.1.3 PATH

For the design of all the pathways are considered the following precriptions.



- Desniveles	- Los desniveles se salvan mediante rampa accesible conforme al apartado 4 del SUA 1, o *ascensor accesible*. No se admiten escalones
- Espacio para giro	- Diámetro Ø 1,50 m libre de obstáculos en el vestíbulo de entrada, o portal, al fondo de pasillos de más de 10 m y frente a *ascensores accesibles* o al espacio dejado en previsión para ellos
- Pasillos y pasos	- Anchura libre de paso ≥ 1,20 m. En zonas comunes de edificios de *uso Residencial Vivienda* se admite 1,10 m - Estrechamientos puntuales de anchura ≥ 1,00 m, de longitud ≤ 0,50 m, y con separación ≥ 0,65 m a huecos de paso o a cambios de dirección

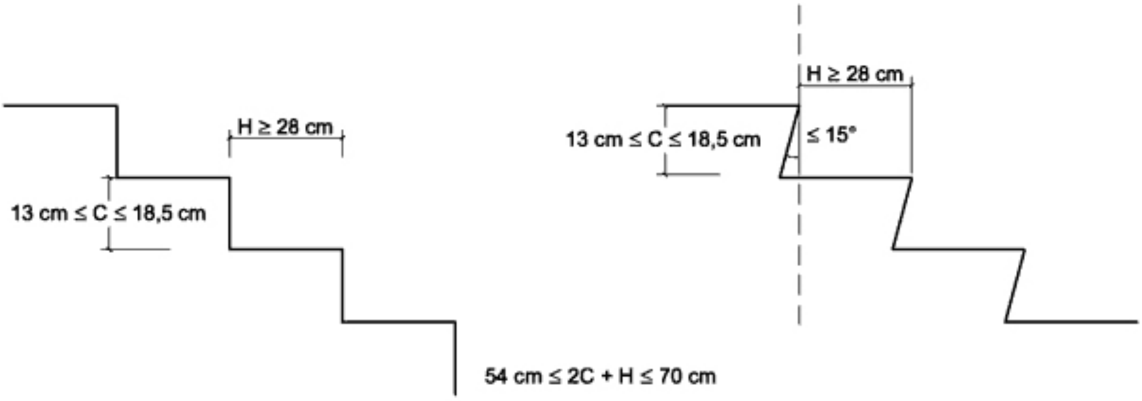


- Puertas	- Anchura libre de paso ≥ 0,80 m medida en el marco y aportada por no más de una hoja. En el ángulo de máxima apertura de la puerta, la anchura libre de paso reducida por el grosor de la hoja de la puerta debe ser ≥ 0,78 m - Mecanismos de apertura y cierre situados a una altura entre 0,80 - 1,20 m, de funcionamiento a presión o palanca y maniobrables con una sola mano, o son automáticos - En ambas caras de las puertas existe un espacio horizontal libre del barrido de las hojas de diámetro Ø 1,20 m - Distancia desde el mecanismo de apertura hasta el encuentro en rincón ≥ 0,30 m - Fuerza de apertura de las puertas de salida ≤ 25 N (≤ 65 N cuando sean resistentes al fuego)
- Pavimento	- No contiene piezas ni elementos sueltos, tales como gravas o arenas. Los felpudos y moquetas están encastrados o fijados al suelo - Para permitir la circulación y arrastre de elementos pesados, sillas de ruedas, etc., los suelos son resistentes a la deformación
- Pendiente	- La pendiente en sentido de la marcha es ≤ 4%, o cumple las condiciones de rampa accesible, y la pendiente trasversal al sentido de la marcha es ≤ 2%

3.1.4 STAIRS

3.1.4.1 *Stair-step design*

"En tramos rectos, la huella medirá 28 cm como mínimo. En tramos rectos o curvos la contrahuella medirá 13 cm como mínimo y 18,5 cm como máximo, excepto en zonas de uso público, así como siempre que no se disponga ascensor como alternativa a la escalera, en cuyo caso la contrahuella medirá 17,5 cm, como máximo. La huella H y la contrahuella C cumplirán a lo largo de una misma escalera la relación siguiente: 54 cm ² 2C + H ² 70 cm."



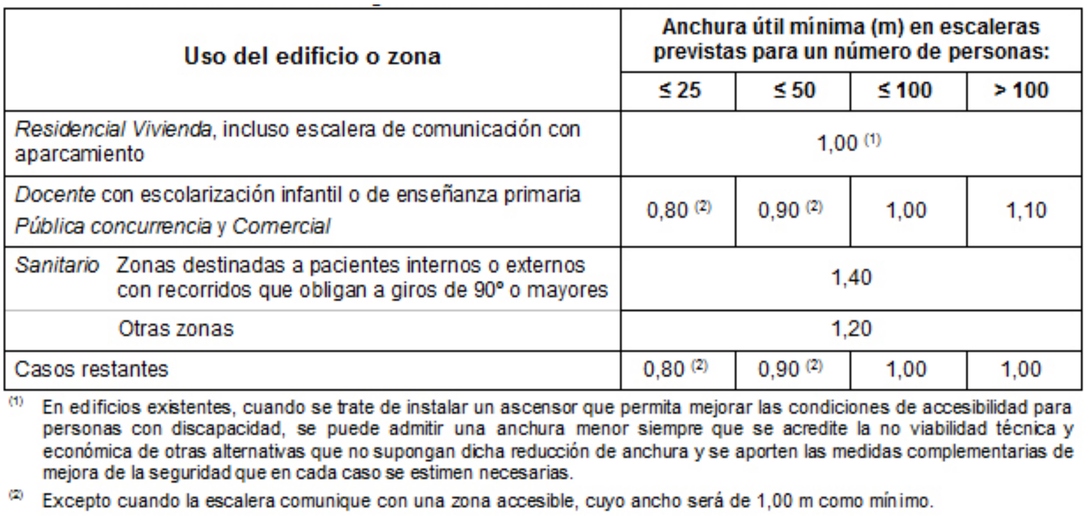
In our case the stair are designed with a tread of 30cm and a riser of 17,5cm and the verification:

$$2C + H = 65cm \leq 70cm$$

is satisfied.

3.1.4.2 *Flight stair design*

"La máxima altura que puede salvar un tramo es 2,25 m, en zonas de uso público, así como siempre que no se disponga ascensor como alternativa a la escalera, y 3,20 m en los demás casos."



Uso del edificio o zona	Anchura útil mínima (m) en escaleras previstas para un número de personas:			
	≤ 25	≤ 50	≤ 100	> 100
Residencial Vivienda, incluso escalera de comunicación con aparcamiento	1,00 (1)			
Docente con escolarización infantil o de enseñanza primaria *Pública concurrencia* y *Comercial*	0,80 (2)	0,90 (2)	1,00	1,10
Sanitario Zonas destinadas a pacientes internos o externos con recorridos que obligan a giros de 90° o mayores	1,40			
Otras zonas	1,20			
Casos restantes	0,80 (2)	0,90 (2)	1,00	1,00

(1) En edificios existentes, cuando se trate de instalar un ascensor que permita mejorar las condiciones de accesibilidad para personas con discapacidad, se puede admitir una anchura menor siempre que se acredite la no viabilidad técnica y económica de otras alternativas que no supongan dicha reducción de anchura y se aporten las medidas complementarias de mejora de la seguridad que en cada caso se estimen necesarias.

(2) Excepto cuando la escalera comunique con una zona accesible, cuyo ancho será de 1,00 m como mínimo.

For that reason are designed ladder with maximum elevation of 2,00 m and minimum width of 2,40 m

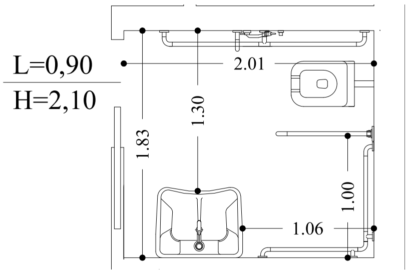
3.1.5 DRESSING ROOM

All the dressing room respect the minimum charactheristics of accessibilities.
The width of the path in front of the lavabos is of 1,50 m. The dressing room is connecteed with the main area with a fireproof door 1,20x 2,10 m.
All the shower are open air, with no gap and with free space between partitions walls of 1,90 m.

3.1.6 BATHROOMS

"Se establecerán retretes, urinarios y lavabos en cada planta a razón de 4 plazas de urinarios, 2 inodoros y 2 lavabos para caballeros y 6 inodoros y 2 lavabos para señoras por cada 500 espectadores o fracción reduciéndose aquellas cifras a la mitad en el caso de que el aforo de cada piso sea inferior a 30"

Are designed 3 bathroom for people with physic disabilities on the ground floor and one on the first floor.
On the ground floor two of them are disposed respectively in girl and man dressing room and one of them is disposed in a central area acailable for the main pubblic.
All off them are communicating with accesibles pathways,they have free space to turn the weelchair of 1,50 m and all the door with is 0,90 m.
Are disposed support plank on the wal close to the wc with a height from the ground of 0,90 m.



3.1.6.1 *Toilets*

"Espacio de transferencia lateral de anchura 80 cm y 75 cm de fondo hasta el borde frontal del inodoro. En uso público, espacio de transferencia a ambos lados. Altura del asiento entre 45 50 cm."

3.1.6.2 *Washbasin*

"Espacio libre inferior mínimo de 70 (altura) x 50 (profundidad) cm. Sin pedestal. Altura de la cara superior 85 cm."

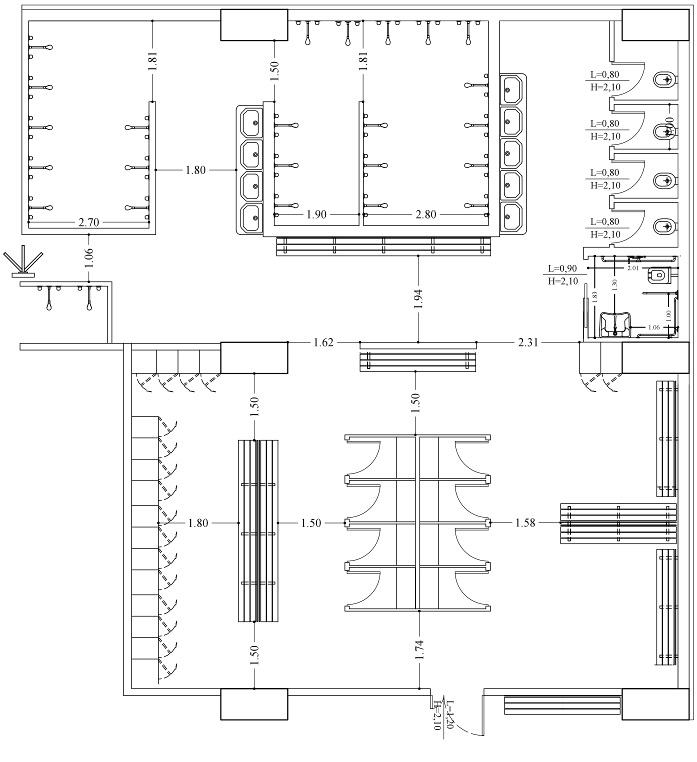
3.1.6.3 *Showers*

"Espacio de transferencia lateral de anchura 80 cm al lado del asiento. Suelo enrasado con pendiente de evacuación 2%."

3.1.6.4 *Seating*

"Dispondrán de asiento de 40 (profundidad) x 40 (anchura) x 45-50 cm (altura), abati- ble y con respaldo.Espacio de transferencia lateral 80 cm a un lado."

LAYOUT OF THE DRESSING ROOMS DESIGN



PART II
STRUCTURAL DESIGN

1 MATERIALS REPORT

1.1 CONCRETE

Concrete is a composite construction material composed primarily of aggregate, cement, and water that influence the fisics and chymics characteristics of the wet or dry concrete.

The cement, commonly Portland cement, and other cementitious materials such as fly ash and slag cement, serve as a binder for the aggregate. Various chemical admixtures are also added to achieve varied properties. Water is then mixed with this dry composite, which enables it to be shaped (typically poured) and then solidified and hardened into rock-hard strength through a chemical process called hydration.

Concrete is strong in compression, as the aggregate efficiently carries the compression load. However, it is weak in tension as the cement holding the aggregate in place can crack, allowing the structure to fail.

Reinforced concrete solves these problems by adding either steel reinforcing bars, steel fibers, glass fiber, or plastic fiber to carry tensile loads. Thereafter the concrete is reinforced to withstand the tensile loads upon it.

1.1.1 BINDER

A binder is a dry substance added to a liquid in order to draw it together in such a way that it maintains a uniform consistency. In the most general sense of the word, a cement is a binder, a substance that sets and hardens independently, and can bind other materials together.

These substances are used in construction for the packing of artificial conglomerate,like concrete and mortar.

The process of strength growth is called "hardening".This is often confused with "setting", but setting is not the same:

- *Setting: is the stiffening of the concrete after it has been placed.A concrete can be "set" in that it is no longer fluid , but it may still be very weak;you may not be able to walk on it ,for example. Setting is early-stage calcium silicate hydrate formation and ettringite formation. The terms "initial set" and "final set" are arbitrary definitions of early and later set; there are laboratory procedures for determining the using weighted neeles penetrating into cement paste.*

- *Hardening: is the process of strenght growth and may continue for weeks or months after the concrete been mixed and placed. Hardening is due largely to the .formation of calcium silicate hydrate as te cement contiunes to hydrate.*

The rate at wich concrete sets is independent of the rate at wich it hardens. Rapid Harden-cement may have similar setting times to ordinary Portland Cement.

Portland cement is a basic ingredient of concrete, mortar and most non-specialty grout. The most common use for Portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water.

As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be grey or white.

1.1.1.1 *Binder Classification*

Binders can be divided in two categories:

- *Aerial binder: setting and hardening with air contact. Some of aerial binder are: lime and gypsum.*

- *Hydraulic Binder: hydraulic binder, like the cement, are inorganic materials fine grinded,that mixed with wather and air start the setting and then the hardening phases. This capacity is due to the presence of some fine compound (silicate,calcium ferrite, alluminate) both able to react with wather, depeloping hydrates insoluble products and or poorly soluble with hydraulic propriety.*

1.1.2 CONSTRUCTION AGGREGATE

Construction aggregate, or simply "aggregate", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates.

Aggregates are the most mined material in the world. Fine aggregate makes up the bulk of masonry mortars, renders and screeds, therefore it has a significant effect upon the properties of the product in both its fresh and hardened state.

The selection of suitable aggregates, which are capable of producing a product with the optimum properties, is most important. The design of mortar mixes is based on the concept that the voids in the fine aggregate, which are generally in the range 25-40%, will be filled with binder.

Sources for these basic materials can be grouped into three main areas: Mining of mineral aggregate deposits, including sand, gravel, and stone; use of waste slag from the manufacture of iron and steel; and recycling of concrete, which is itself chiefly manufactured from mineral aggregates.

In addition, there are some (minor) materials that are used as specialty lightweight aggregates: clay, pumice, perlite, and vermiculite.

The EN 12620 define a classification of aggregate based on minimum diameter(d) and maximum (D) of a aggregates fraction, in the following classes:

- *Big aggregate: d ≥ 2 mm; D ≥ 4 mm*
- *Fine aggregate (sand): d = 0; D ≤ 4 mm*
- *Coarse aggregate: 0/8: d = 0; D ≤ 8 mm*
- *All in aggregate : d = 0; D ≤ 45 mm*
- *filler: ≤ passante al settaccio 0,063 mm*

1.1.2.1 *Granulometric analisys*

Testing is the means by which the properties of a material are routinely evaluated and compared with the appropriate specification requirements.

The type of material that the aggregate is going to be used in may well lead to different specification requirements. Test results also provide a historic record of how the properties of a material vary with tim.

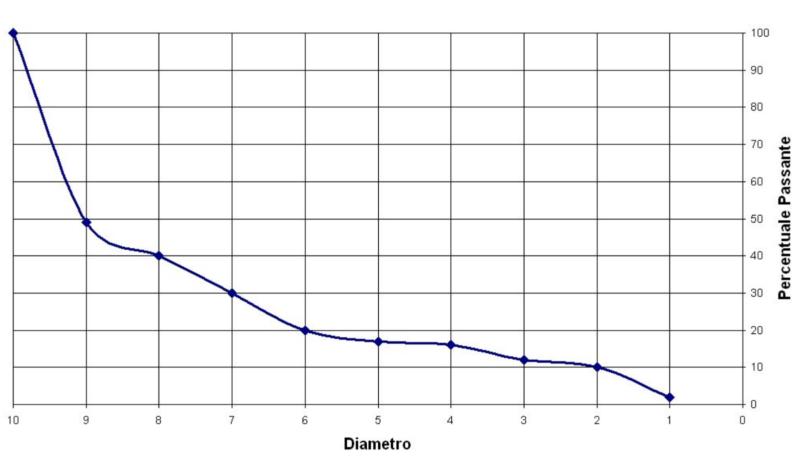
The objective of sampling is to obtain a bulk sample that is representative of the average properties of the batch, it is important to remember that information obtained *from test samples is only as representative of the material as the samples on which the tests are undertaken.*

Bulk samples can be reduced to sample sizes suitable for testing by using a riffle box or by coning and quartering. There are several sizes of riffle box to suit different sizes of aggregate. The box consists of an even number of chutes discharging in alternate directions.

The material is passed through the riffle box, which divides it into two portions, one of which is discarded. The other portion is passed through again and the process repeated until the sample has been reduced to the required size.
It should be noted that a riffle box can only be used on dry material.

At the end we weigh the material fraction in each single sieve obtaining the weight of the passing material comparing it with the total weight of the total sample.

The results of a sieve analysis are plotted on a log scale to produce a particle size distribution chart (granulometric curve).On the x-axis we have the sieve opening (mm) and on the y–axis the passant percent of aggregate.



To realise a concrete with the maximum density, we use the Fueller rule:

$$P = 100\sqrt{\left(\frac{d}{D}\right)}$$

Where:

- *P percent of materials pass through a sieve of d diameter (mm);*
- *D is a maximum diameter of the aggregate (mm).*

Bolomey has modified the Fueller formulas , considering only the aggregate granulometry, adding a A coefficient that consider the requested lavorability and the taggregate tipology (alluvial or crashed):

$$P = A + (100 - A)\sqrt{\frac{d}{D}}$$

Where:

- *For "A" we adopt the following values: more the real curve is close to the ideal curve, more the concrete will be compact.*
-

Tipology	*Consistent class for Abrams*	***A***
alluvial	*S1*	*4-8*
alluvial	*S2-S3-S4*	*8-10*
alluvial	*S5*	*10-12*
crashed	*S1*	*6-10*
crashed	*S2-S3-S4*	*12-14*
crashed	*S5*	*14-16*

1.1.2.2 *Maximum diameter of the aggregate*

Following the Eurocodes, the maximum diameter of the aggregates has to be:

- *Dmax < 1/4 of the minimum structural element dimension to prevent the eterogenity increase of the material;*

- *Dmax < air-gap between the bars(mm) - 5 mm to prevent that the bulk aggreagate block the concrete flow through the stell bars reinforcement;*

- *Dmax < 1,3[2] of the concrete cover weight , to prevent that between the formwork and the bars the bulk aggregate block the concrete flow.*

1.1.3 CHEMICAL ADMIXTURES

Chemical admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement and are added to the concrete at the time of batching/mixing.

On the concrete wet they can influence the water request, the air content, the lavorability and it's mainteining, on bleeding (water on the surface), on setting time.
On the hard concrete they can influence:

- *Mechanic characteristics*
- *Elastic modulus*
- *durability*
- *impermeability*
- *fairfaced conrete*
- *freeze strength*
- *chimic strenght*

1.1.3.1 *Classification*

The most important types of chemical admixtures used are the following:

- *Accelerators speed up the hydration (hardening) of the concrete. Typical materials used are CaCl2, Ca(NO3)2 and NaNO3. However, use of chlorides may cause corrosion in steel reinforcing and is prohibited in some countries, so that nitrates may be favored.*

- *Retarders slow the hydration of concrete and are used in large or difficult pours where partial setting before the pour is complete is undesirable. Typical polyol retarders are sugar, sucrose, sodium gluconate, glucose, citric acid, and tartaric acid.*

- *Air entrainments add and entrain tiny air bubbles in the concrete, which will reduce damage during freeze-thaw cycles, thereby increasing the concrete's durability. However, entrained air entails a trade off with strength, as each 1% of air may result in 5% decrease in compressive strength.*

- *Plasticizers increase the workability of plastic or fresh"concrete, allowing it be placed more easily, with less consolidating effort. A typical plasticizer is lignosulfonate. Plasticizers can be used to reduce the water content of a concrete while maintaining workability and are sometimes called water-reducers due to this use. Such treatment improves its strength and durability characteristics. Superplasticizers (also called high-range water-reducers) are a class of plasticizers that have fewer deleterious effects and can be used to increase workability more than is practical with traditional plasticizers. Compounds used as superplasticizers include sulfonated naphthalene formaldehyde condensate, sulfonated melamine formaldehyde condensate, acetone formaldehyde condensate and polycarboxylate ethers.*

- *Pigments can be used to change the color of concrete, for aesthetics.*

- *Corrosion inhibitors are used to minimize the corrosion of steel and steel bars in concrete.*

- *Bonding agents are used to create a bond between old and new concrete (typically a type of polymer) .*

- *Pumping aids improve pumpability, thicken the paste and reduce separation and bleeding.*

1.1.4 MIXTURE COMPOSITION

The concrete used to carry out the building is a C25/30, with:

- *Rck 30*
- *Stifness class S4*
- *Ratio W/C =0,53*
- *Dmax = 25 mm*
- *Cement class 32,5 II/III*

- *Exposition class XC1*
- *Additivo superfluidificante = 0,8%*

The m^3 *dose of mixuture is the following:*

<table>
<tr><td colspan="5"><i>Formula base:</i> <i>R_{ck} 30 S4 D_{max} 25mm 32,5 R XC1</i></td></tr>
<tr><td colspan="5"><i>Standard production :1 m³</i></td></tr>
<tr><td><i>Cement 32,5R</i></td><td><i>320</i></td><td><i>Kg</i></td><td><i>Chemical mix-Creative</i></td><td><i>0,80%</i></td></tr>
<tr><td><i>Water</i></td><td><i>169</i></td><td><i>l</i></td><td><i>Sand 0/5</i></td><td><i>60%</i></td></tr>
<tr><td><i>Filler</i></td><td><i>20</i></td><td><i>Kg</i></td><td><i>Rubble 8/15</i></td><td><i>12%</i></td></tr>
<tr><td><i>Rate W/C</i></td><td><i>0,53</i></td><td></td><td><i>Rubble 17/25</i></td><td><i>28%</i></td></tr>
</table>

1.1.5 MECHANICAL CHARACTERISTICS

To evaluate the structure strenght with the limited state method we consider the following parameters:

- *Cubic compression strenght:*

$$R_{ck} = 30,00 \ MPa$$

- *Cilindric compression strenght:*

$$f_{ck} = 0,83 \bullet Rck = 24,90 \ MPa$$

- *Cilindric medium compression strenght:*

$$f_{cm} = f_{ck} + 8 \ MPa = 32,90 \ MPa$$

- *Characteristic tensile strenght:*

$$f_{ctk} = 0,70 \bullet 0,30 \bullet f_{ck2/3} = 1,80 \ MPa$$

- *Elastic module :*

$$E_{cm} = 22000 \bullet (f_{cm}/10)_{0,3} = 31446 \ MPa$$

- *Reduced elastic module due the concrete cracking:*

$$E_{red} = 0,5 \bullet E_{cm} = 15723$$

- *Poisson ratio:*

$$\nu = 0,20$$

- *Thermic dilatation coefficient:*

$$\alpha = 1 \bullet 10^{-5} \ ° C^{-1}$$

- *Material factor SLU:*

$$\gamma_c = 1,50$$

- *Progectual strenght SLU:*

$$f_{cd} = 0{,}85\, f_{ck} / \gamma_c = 14{,}11 MPa$$

- *Coefficiente materiale allo SLE:*

$$\gamma_c = 1{,}0$$

- *Maximum progectual strain SLE (combo1):*

$$\sigma_x \leq 0{,}45\, f_{ck} = 11{,}20\ MPa$$

- *Maximum progectual strain SLE (combo2)::*

$$\sigma_x \leq 0{,}60\, f_{ck} = 14{,}94\ MPa$$

1.2 STEEL

Steel is an alloy made by combining iron and other elements, the most common of these being carbon. Varying the amount of alloying elements and the form of their presence in the steel (solute elements, precipitated phase) controls qualities such as the hardness, ductility, and tensile strength of the resulting steel.

Steel with increased carbon content can be made harder and stronger than iron, but such steel is also less ductile than iron.

Alloys with a higher than 2.1% carbon content are known as cast iron because of their lower melting point and good castability.

Steel is also distinguishable from wrought iron, which can contain a small amount of carbon, but it is included in the form of slag inclusions. Two distinguishing factors are steel's increased rust resistance and better weldability

.

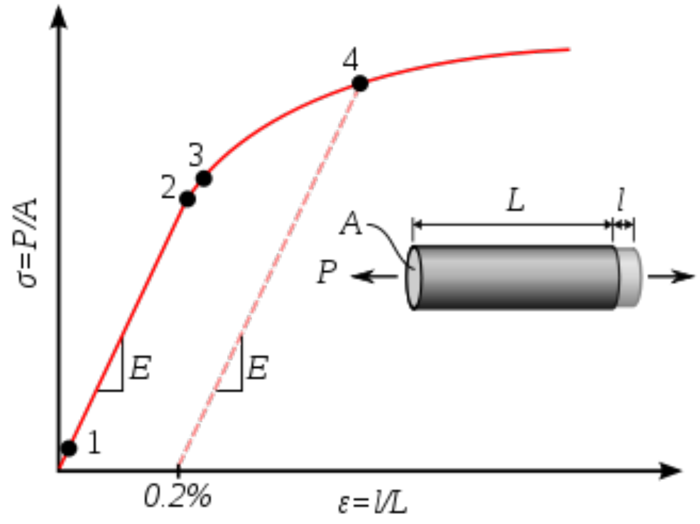
Steel used in reinforced concrete is made principally by round bars, with standard lenght of 12 m,it's usally named mild steel, due his ductility characteristics that is usefull in sismic projectations.

Is possible to distinguish the steel in:

- *Not alloyed steel: carbon steel, black steel.*
- *Alloy steel: low alloy steel or high alloy steel.*

1.2.1 STRAIN-DEFORMABILITY DIAGRAM

The distinction between hard-steel and mild-steel is underlined on the following diagram σ-ε of a steel-sample under tensile stress.



a) ***Mild steel:***

- *The first part is with a rectilinear trend,following the linear law:*

$$\sigma = E\,\varepsilon,$$

Therefore material trend is elastyc-linear. This behaviour is right untill the tensile proportionality achievement σ_p.

- *The following phase is elastic, but not linear (the diagram start to bend), untill reach the elastic state limite* σ_e.

- *After* σ_e *the material get in an elasto-plastic phase untill reacheing the yeld point stress* σ_y. *Unload the sample in this phase can give up permanent deformations.*

- *After the yeld point stress, the sample has an internal insability state, with a plastic phase characterised by heavy deformability with constant stress and diagram line almost horyzontal.The lenght of this phase depends by the steel considered.*

- *The last phase, the sample is estabilished, following a new stress grow, untill the achievement the maximum value* σ_r.□*In this phase the material is hardened. After* σ_r *the sample has a necking with stress decrease untill the physic brocking of it.*

The value of σ_p, σ_e *e* σ_y *are really close to each other, so it's possible to consider both overlapping, and the elastic beahaviour untill the yeld point.*

B) ***Hard steel**:*

- *Due the young factor is the same for all the stell, the first stroke of the strain deformability diagram coincide with that of mild steel.*

- *After the elastic limite, the plastic phase is really short and some hard steels don't have it. In fact overtaked the elastic limite, the sample reach the value of yeld point broking without necking.*
  Frequently is not possible to evaluate the yeld point in the diagrams strain-deformability of hard steel; in these case it is considered that stress value that entail the 0,2% of residual deformation after unload the sample. The point yeld stress in named $\sigma_{y,0,2}$.

1.2.2 STEEL REINFORCEMENT CLASSIFICATION

Considering the steel bars for normal concrete , the Ministerial Decree 14 january 2008, in force since 1 july 2009, is possible to use the following classes of ribbed steel:

- *B 450 C (hot rolled steel): characterised by a broking stress not less than 540* N/mm^2*; by yeld point not less than 450* N/mm^2 *and total stretch with maximum load not less than 7%;*

- *B 450 A (drawn steel): characterised by a broking stress not less than 540* N/mm^2*; by yeld point not less than 450* N/mm^2 *and total stretch with maximum load not less than 3% (less ductility than the B450C).*

The normative allow to project with the steel B 450 A with a project stress less than the steel B 450 C, therefore for the second one the yeld point f_{yk} *is divided by the security partial factor* γ_{ms} *=1,15 following the formula:*

$$f_{yd} = \frac{f_{yk}}{\gamma_{ms}}$$

while the second one as well by a further model factor γ_e *= 1,20 following the formula:*

$$f_{yd} = \frac{f_{yk}}{\gamma_{ms} \cdot \gamma_c}$$

NB: *<u>The steel B 450 C is the most ductile and the one admitted in seismic zone.</u>*

1.2.3 MECHANICAL CHARACTERISTICS OF THE REINFORCEMENT BARS

The steel used for the built of the reinfoced concrete is the B450C ,with the following characteristics:

- *Elastyc module :*

$$E_s = 206000 MPa$$

- *Characterisitc broken stress:*

$$f_{tk(min)} = 540\ MPa$$

- *Characterisitc yeld point stress:*

$$f_{yk(min)} = 450\ MPa$$

- *Minimum broken extension:*

$$\otimes t \geq 8\%$$

- *Minimum Rate:*

$$f_t/f_y \geq 1,15$$

- *Maximum Rate:*

$$f_t/f_y \leq 1,35$$

- *Maximum Rate:*

$$f_{y,eff}/f_{y,nom} \leq 1,35$$

- *Material coefficient SLU:*

$$\gamma s = 1,15$$

- *Projectual strenght SLU:*

$$f_{yd} = f_{yk}/\gamma_s = 391,30\ MPa$$

- *Material coefficient SLE:*

$$\gamma_s = 1,00$$

- *Maximum projectual stress SLE:*

$$\sigma_s \leq 0,80\, f_{yk} = 360\ MPa$$

1.2.4 STRUCTURAL STEEL CLASSIFICATION

The most common shapes available in European countries are:

- *I-beam: I-shaped cross-section - in Britain these include Universal Beams (UB) and Universal Columns (UC); in Europe it includes the IPE, HE, HL, HD and other sections; in the US it includes Wide Flange (WF) and H sections;*
- *Z-Shape: half a flange in opposite directions;*
- *HSS-Shape: Hollow structural section also known as SHS (structural hollow section) and including square, rectangular, circular (pipe) and elliptical cross sections;*
- *Angle: L-shaped cross-section;*
- *Channel, or C section: shaped cross-section;*
- *Tee: T-shaped cross-section;*
- *Bar, a piece of metal, rectangular cross sectioned (flat) and long, but not so wide so as to be called a sheet;*
- *Rod, a round or square and long piece of metal or wood, see also rebar and dowel.*
- *Plate, metal sheets thicker than 6 mm or 1/4 in.*
- *Open web steel joist*

Most steels used throughout Europe are specified to comply with the European standard EN 10025.

Typical grades are described as "S275J2" or "S355K2W",where:

- *S : denotes structural rather than engineering steel;*

- *275 or 355 denotes the yield strength in newtons per square millimetre or the equivalent megapascals;*

- *J2 or K2 denotes the materials toughness by reference to Charpy impact test values;*

- *W denotes weathering steel.*

Further letters can be used to designate fine grain steel ('N' or 'NL'); quenched and tempered steel ('Q' or 'QL'); and thermomechanically rolled steel ('M' or 'ML').

The normal yield strength grades available are 195, 235, 275, 355, 420, and 460, , almost all structural steel is grades S275 and S355.

Higher grades are available in quenched and tempered material (500, 550, 620, 690, 890 and 960 - although grades above 690 receive little if any use in construction at present).

A set of euronorms define the shape of a set of standard structural profiles:

- *European I-beam: IPE - Euronorm 19-57*
- *European I-beam: IPN - DIN 1025-1*
- *European flange beams: HE - Euronorm 53-62*
- *European channels: UPN - DIN 1026-1*

1.2.5 MECHANICAL CHARACTERISTICS OF THE STRUCTURAL STELL

The steel used for the built of roof is Steel S235 with the following charatheristic:

- *Elastyc module :*

$$E_s = 206000MPa$$

- *Characterisitc broken stress:*

$$f_{tk(min)} =360MPa$$

- *Characterisitc yeld point stress:*

$$f_{yk(min)} = 235\ MPa$$

- *Minimum broken extension:*

$$\otimes t \geq 8\%$$

- *Minimum Rate:*

$$f_t/f_y \geq 1,15$$

- *Maximum Rate:*

$$f_t/f_y \leq 1,35$$

- *Maximum Rate:*

$$f_{y,eff}/f_{y,nom} \leq 1,35$$

- *Material coefficient SLU:*

$$\gamma s = 1,15$$

- *Projectual strenght SLU:*

$$f_{yd} = f_{yk}/\gamma_s = 204\ MPa$$

- *Material coefficient SLE:*

$$\gamma_s = 1,00$$

- *Maximum projectual stress SLE:*

$$\sigma_s \leq 0,80\, f_{yk} = 188\ MPa$$

2 STATIC CALCULATION REPORT

2.1 LOADS CONSIDERED

A correct loads evaluation is extremely important for the evaluation and the design of all the structure.
Following a resume of the load calculation evaluated.

2.1.1 DEAD LOADS

The dead loads that have to be considered are the following:

1. *G1: structural weight;*
2. *G2: permanent non-structural loads*
3. *Precompression and pretension – not considered*
4. *Viscosity – not considered*

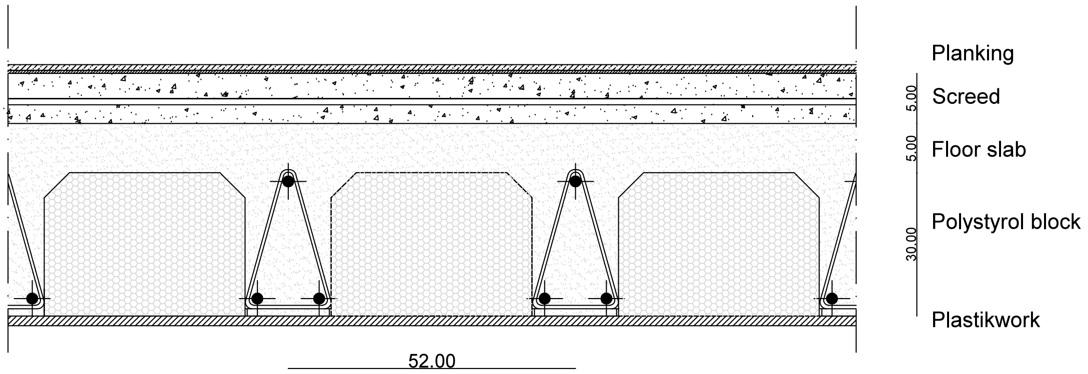
2.1.1.1 *Roof*

For what concern the weight of the roof we consider its structure built with woodden strips 5cm x 5 cm with an axile base of 50 cm.
The next layer is a woodden panel h 4 cm. This layer is the basement for the impermeabil Bituminous waterproof (dump-proof) sheeth.
The last layer is the copper finiture with an height of 0,5 mm.

For the roof package we have the following loads:

Non-accesible roofing					
Non permanent loads	*Typology*	*Weight KN/m^3*	*Height (m)*	*Width (m)*	*Weight KN/m^2*
G2	*copper layer*	*89,3*	*0,0005*		*0,045*
	insulating layer	*16*	*0,008*		*0,128*
	woodden panel	*5*	*0,05*		*0,250*
	woodden strips	*5*	*0,05*	*0,05*	*0,025*
Totale G2					***0,423***

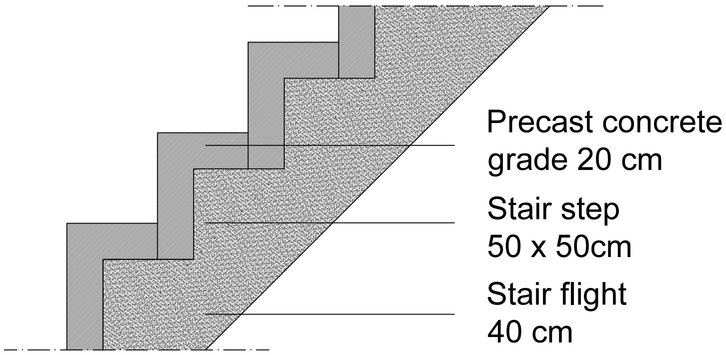
2.1.1.2 *Internal slab floor*



Slab Floor					
Action	*Tipology*	*Weight (KN/m^3)*	*Height (m)*	*Width (m)*	*Weight (KN/m^2)*
G1	*rafters*	*25*	*0,3*	*0,12 x 2*	*2*
	Floor slab	*25*	*0,05*	*1*	*1,25*
Total G1					*3,25*
G2	*Planking*		*0,02*		*0,4*
	Screed	*16*	*0,05*		*0,8*
	Plasterwork		*0,02*		*0,3*
	Partition				*1,2*
Total G2					*2,7*

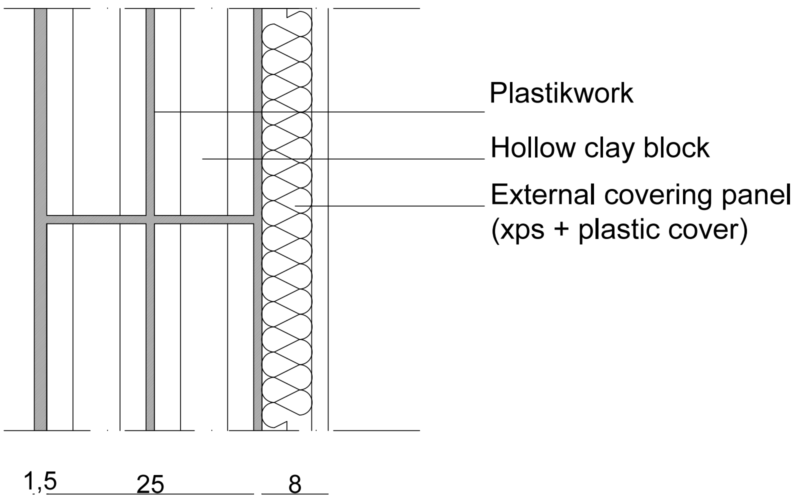
2.1.1.3 *Tribune beam structure*

The tribune structure is made with prebuilts concrete elements placed on the oblique beams.



Stairs					
Action	*Tipology*	*Weight (KN/m^3)*	*Height (m)*	*Width (m)*	*Weight (KN/m^2)*
G2	*riser*	*25*	*0,5*	*0,5*	*3,13*
	tread	*25*	*0,35*		*10*
Total G2					*10*

2.1.1.4 *External wall*



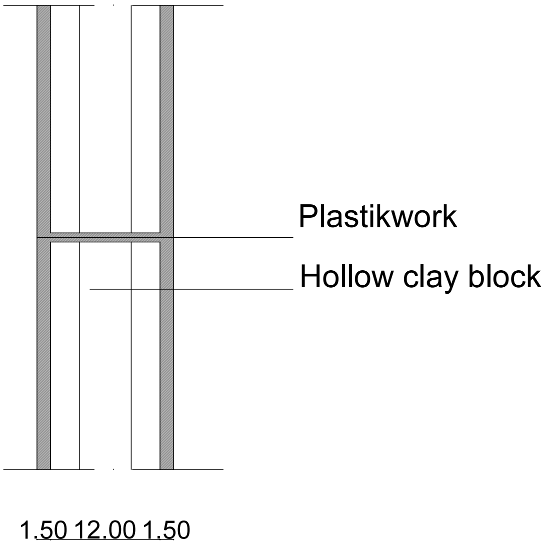
External wall				
Action	*Tipology*	*Weight (KN/m^3)*	*Height (m)*	*Weight (KN/m^2)*
G2	*Plastik work*		*0,1*	*0,6*
	Hollow clay bloc 2	*6*	*0,24*	*1,44*
	Piz			*0,2*
Totale G2				*2,24*

2.1.1.5 *Face work glass wall*

The value of the face work glass wall is provided by the company that produce the system.

Face work glass				
Action	*Tipology*	*Weight (KN/m^3)*	*Height (m)*	*Weight (KN/m^2)*
G2	*Stratified glass*			*0,2*
	Alluminium structure			*0,65*
Totale G2				*0,85*

2.1.1.6 *Internal wall*



Internal walls				
Action	*Tipology*	*Weight (KN/m^3)*	*Height (m)*	*Weight (KN/m^2)*
G2	*Plastik work*		*0,1*	*0,3*
	Hollow clay bloc 2	*6*	*0,12*	*0,77*
	Plastik work		*0,1*	*0,3*
Totale G2				*1,37*

2.1.1.7 *Self weight concrete elements*

G1 is evaluated considering the concrete density of $\gamma_c = 25\ kN/m^3$.

2.1.2 VARIABLE LOADS

The variable loads that have to be considered are:

1. *Snow loads;*
2. *Wind action;*
3. *Seismic action;*

2.1.2.1 *Snow loads*

$$q_s = \mu \cdot S_k$$

where

μ = cover coefficient. With inclination of the cover $0 < \alpha < 30°$ $\mu = 1$;
S_k = feature value of the snow loads on horizzontal ground; depends by the following table:

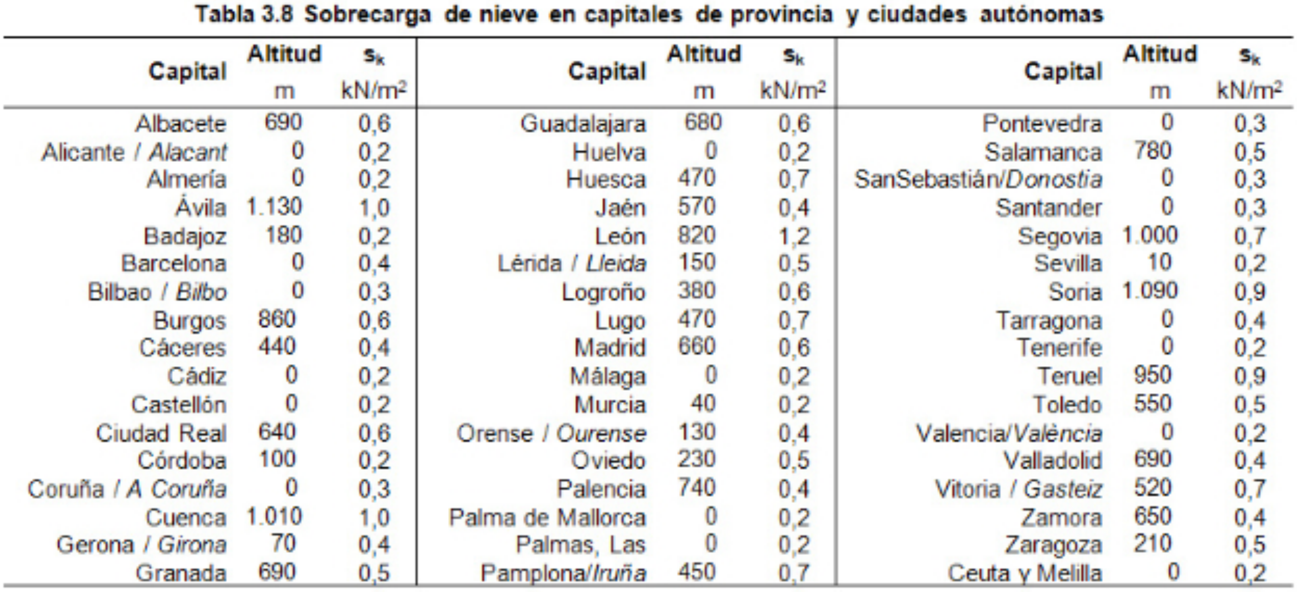


Tabla 3.8 Sobrecarga de nieve en capitales de provincia y ciudades autónomas

Capital	Altitud	s_k	Capital	Altitud	s_k	Capital	Altitud	s_k
	m	kN/m²		m	kN/m²		m	kN/m²
Albacete	690	0,6	Guadalajara	680	0,6	Pontevedra	0	0,3
Alicante / *Alacant*	0	0,2	Huelva	0	0,2	Salamanca	780	0,5
Almería	0	0,2	Huesca	470	0,7	SanSebastián/*Donostia*	0	0,3
Ávila	1.130	1,0	Jaén	570	0,4	Santander	0	0,3
Badajoz	180	0,2	León	820	1,2	Segovia	1.000	0,7
Barcelona	0	0,4	Lérida / *Lleida*	150	0,5	Sevilla	10	0,2
Bilbao / *Bilbo*	0	0,3	Logroño	380	0,6	Soria	1.090	0,9
Burgos	860	0,6	Lugo	470	0,7	Tarragona	0	0,4
Cáceres	440	0,4	Madrid	660	0,6	Tenerife	0	0,2
Cádiz	0	0,2	Málaga	0	0,2	Teruel	950	0,9
Castellón	0	0,2	Murcia	40	0,2	Toledo	550	0,5
Ciudad Real	640	0,6	Orense / *Ourense*	130	0,4	Valencia/*València*	0	0,2
Córdoba	100	0,2	Oviedo	230	0,5	Valladolid	690	0,4
Coruña / *A Coruña*	0	0,3	Palencia	740	0,4	Vitoria / *Gasteiz*	520	0,7
Cuenca	1.010	1,0	Palma de Mallorca	0	0,2	Zamora	650	0,4
Gerona / *Girona*	70	0,4	Palmas, Las	0	0,2	Zaragoza	210	0,5
Granada	690	0,5	Pamplona/*Iruña*	450	0,7	Ceuta y Melilla	0	0,2

Then the snow load is:

$$q_s = 1 \cdot 0{,}2 = \mathbf{0{,}2}\ KN/m^2$$

2.1.2.2 *Wind loads*

$$q_w = q_b \cdot C_e \cdot C_p$$

where

q_b = dinamic wind pressure. In a semplified way is adopted 0,5 KN/m^2 for all the Spain;

C_e = exposure coefficient, depends by the height of the building according with the degree of coarseness.

It's possible to calcol it with the following table, where the height is the medium between the ground level ant the point considered.

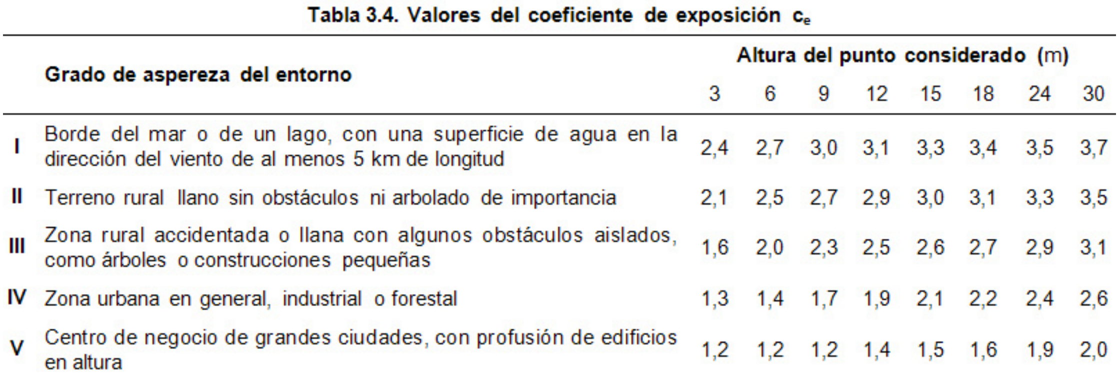


Tabla 3.4. Valores del coeficiente de exposición c_e

	Grado de aspereza del entorno	Altura del punto considerado (m)							
		3	6	9	12	15	18	24	30
I	Borde del mar o de un lago, con una superficie de agua en la dirección del viento de al menos 5 km de longitud	2,4	2,7	3,0	3,1	3,3	3,4	3,5	3,7
II	Terreno rural llano sin obstáculos ni arbolado de importancia	2,1	2,5	2,7	2,9	3,0	3,1	3,3	3,5
III	Zona rural accidentada o llana con algunos obstáculos aislados, como árboles o construcciones pequeñas	1,6	2,0	2,3	2,5	2,6	2,7	2,9	3,1
IV	Zona urbana en general, industrial o forestal	1,3	1,4	1,7	1,9	2,1	2,2	2,4	2,6
V	Centro de negocio de grandes ciudades, con profusión de edificios en altura	1,2	1,2	1,2	1,4	1,5	1,6	1,9	2,0

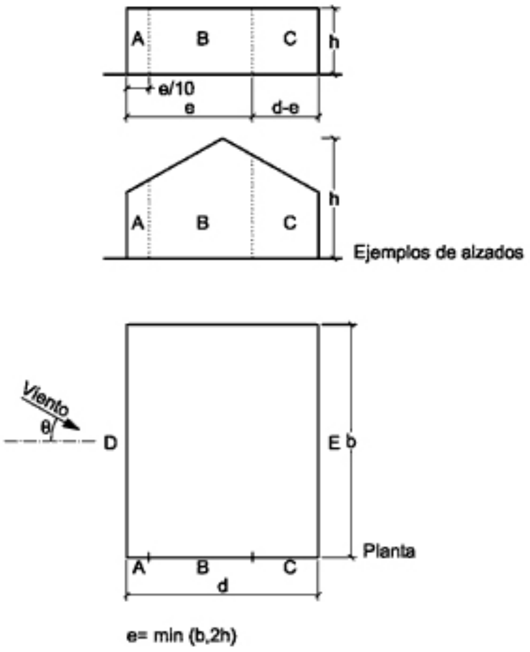
We are en Class III, and the height of the considered point is :

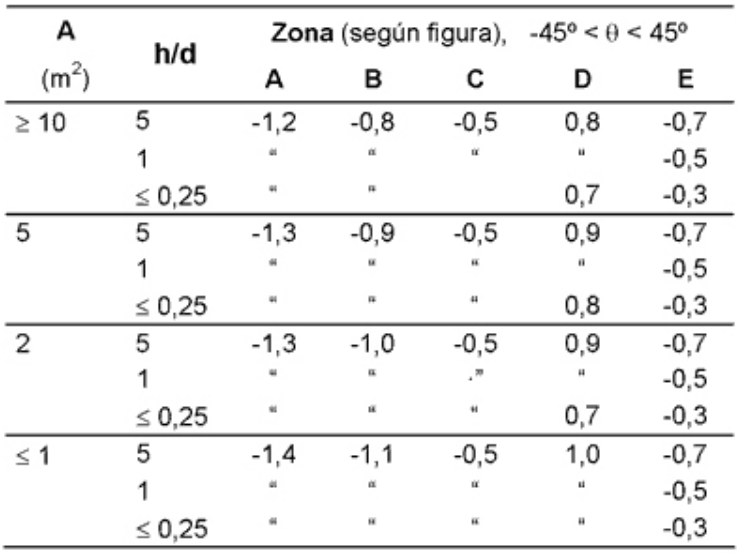
$$(0 + 13)/2 = 6{,}5 \text{ m}$$

C_p = eolic coefficient, depends by the shape and the orientation of the surface respect the wind

In the following tables we have the value of C_p for the case with a pent roof.

Tabla D.3 Paramentos verticales





A (m^2)	h/d	Zona (según figura), -45° < θ < 45°				
		A	B	C	D	E
≥ 10	5	-1,2	-0,8	-0,5	0,8	-0,7
	1	"	"	"	"	-0,5
	≤ 0,25	"	"		0,7	-0,3
5	5	-1,3	-0,9	-0,5	0,9	-0,7
	1	"	"	"	"	-0,5
	≤ 0,25	"	"	"	0,8	-0,3
2	5	-1,3	-1,0	-0,5	0,9	-0,7
	1	"	"	.”	"	-0,5
	≤ 0,25	"	"	"	0,7	-0,3
≤ 1	5	-1,4	-1,1	-0,5	1,0	-0,7
	1	"	"	"	"	-0,5
	≤ 0,25	"	"	"	"	-0,3

In our case :
$h_{max} = 13,4\ m$
$d_1 = 48,33\ m$
$d_2 = 70,00\ m$

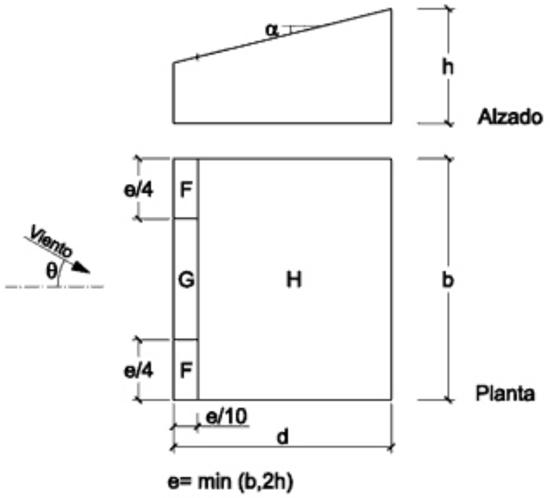
$$\frac{h}{d_1} \approx \ 0{,}25$$
$$\frac{h}{d_2} \approx \ 0{,}18$$

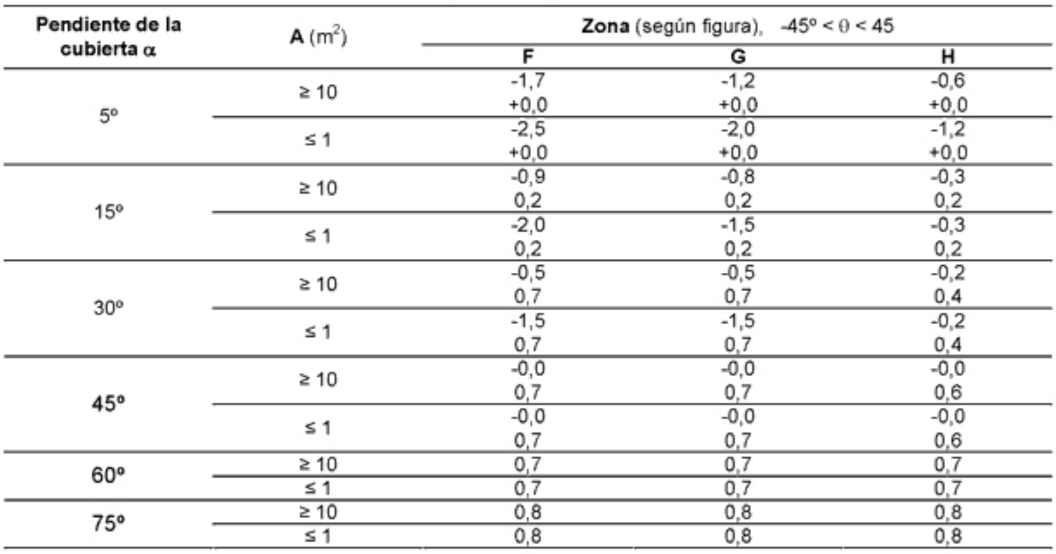
In both cases we have to consider the same values for vertical walls :

D = 0,7
E = -0,3

Tabla D.5 Cubiertas a un agua.

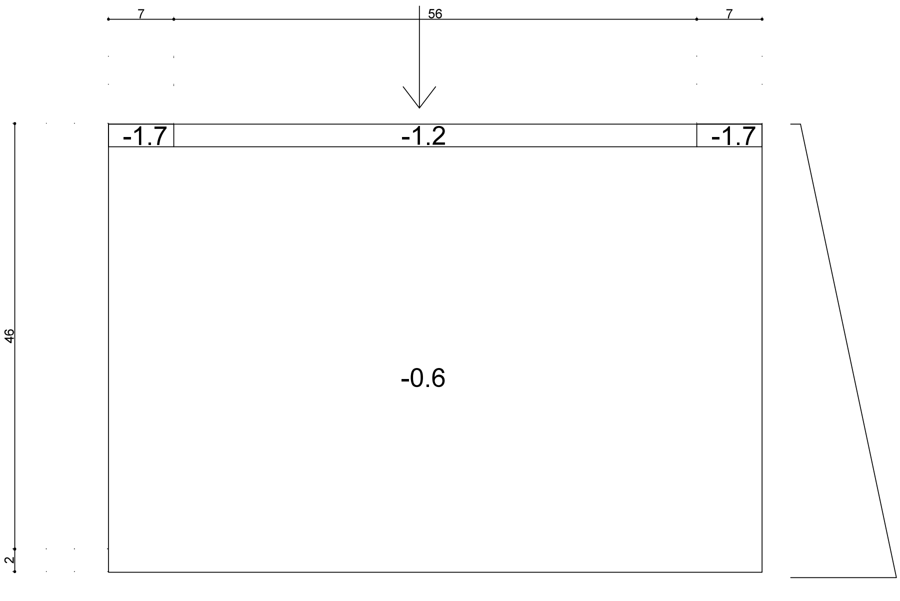
a) Dirección del viento -45º ≤ θ ≤ 45º



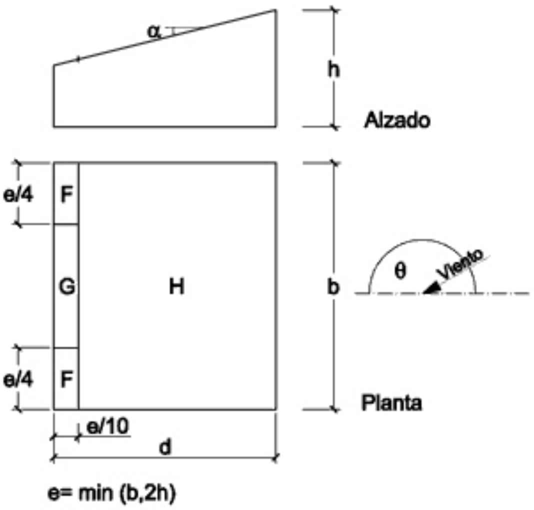


Pendiente de la cubierta α	A (m²)	Zona (según figura), -45º < θ < 45		
		F	G	H
5º	≥ 10	-1,7 +0,0	-1,2 +0,0	-0,6 +0,0
	≤ 1	-2,5 +0,0	-2,0 +0,0	-1,2 +0,0
15º	≥ 10	-0,9 0,2	-0,8 0,2	-0,3 0,2
	≤ 1	-2,0 0,2	-1,5 0,2	-0,3 0,2
30º	≥ 10	-0,5 0,7	-0,5 0,7	-0,2 0,4
	≤ 1	-1,5 0,7	-1,5 0,7	-0,2 0,4
45º	≥ 10	-0,0 0,7	-0,0 0,7	-0,0 0,6
	≤ 1	-0,0 0,7	-0,0 0,7	-0,0 0,6
60º	≥ 10	0,7	0,7	0,7
	≤ 1	0,7	0,7	0,7
75º	≥ 10	0,8	0,8	0,8
	≤ 1	0,8	0,8	0,8

in the specific case:

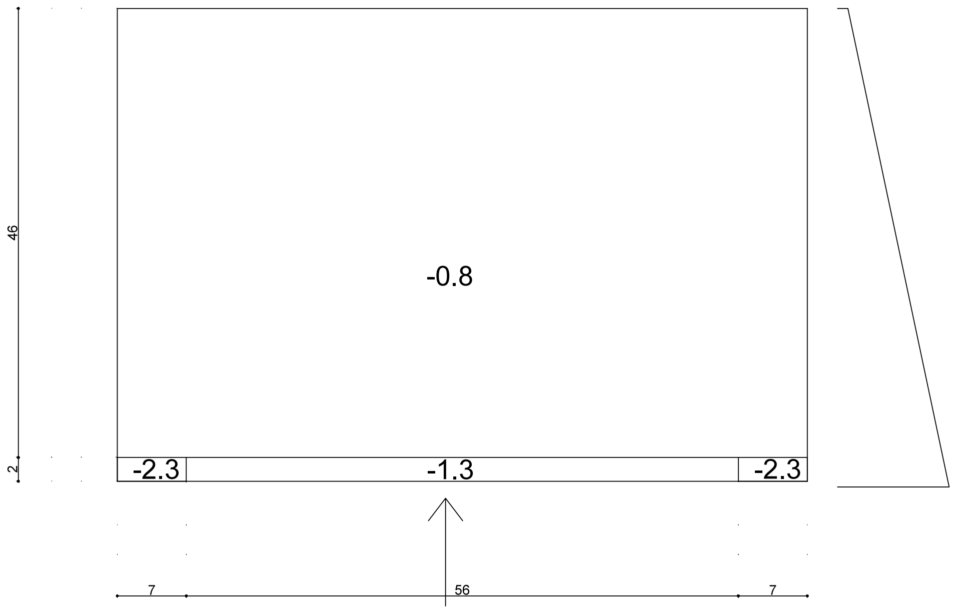


b) Dirección del viento 135º ≤ θ ≤ 225º

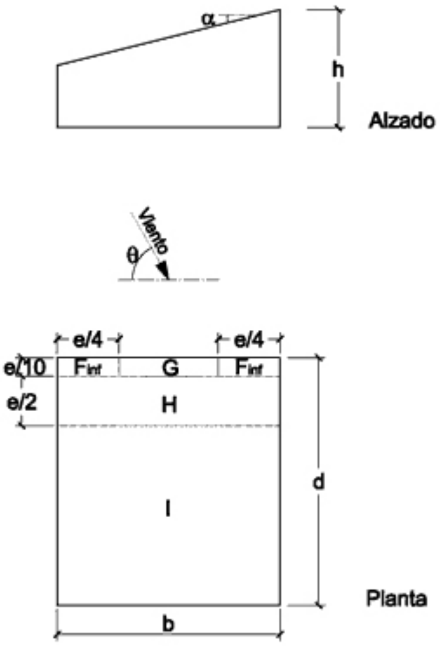


Pendiente de la cubierta α	A (m²)	Zona (según figura), 135º ≤ θ ≤ 225º		
		F	G	H
5º	≥ 10	-2,3	-1,3	-0,8
	≤ 1	-2,5	-2,0	-1,2
15º	≥ 10	-2,5	-1,3	-0,9
	≤ 1	-2,8	-2,0	-1,2
30º	≥ 10	-1,1	-0,8	-0,8
	≤ 1	-2,3	-1,5	-0,8
45º	≥ 10	-0,6	-0,5	-0,7
	≤ 1	-1,3	-0,5	-0,7
60º	≥ 10	-0,5	-0,5	-0,5
	≤ 1	-1,0	-0,5	-0,5
75º	≥ 10	-0,5	-0,5	-0,5
	≤ 1	-1,0	-0,5	-0,5

in the specific case:



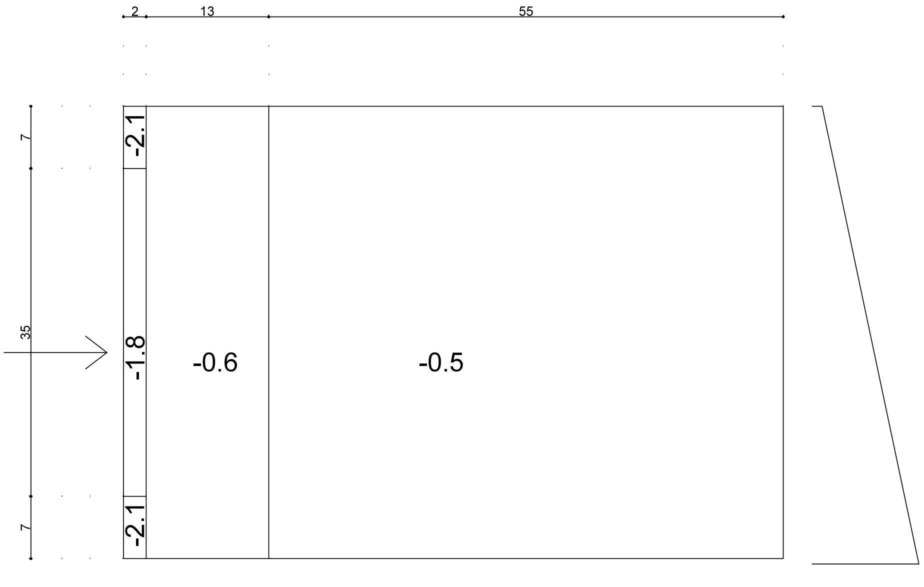
c) Dirección del viento 45º ≤ θ ≤ 135º



e= min (b,2h)

Pendiente de la cubierta α	A (m^2)	Zona (según figura), 45º ≤ θ ≤ 135º				
		F_{inf}	F_{sup}	G	H	I
5º	≥ 10	-2,1	-2,1	-1,8	-0,6	-0,5
	≤ 1	-2,4	-2,6	-2,0	-1,2	-0,5
15º	≥ 10	-1,6	-2,4	-1,9	-0,8	-0,7
	≤ 1	-2,4	2,9	-2,5	-1,2	-1,2
30º	≥ 10	-1,3	-2,1	-1,5	-1,0	-0,8
	≤ 1	-2,0	-2,9	-2,0	-1,3	-1,2
45º	≥ 10	-1,3	-1,5	-1,4	-1,0	-0,9
	≤ 1	-2,0	-2,4	-2,0	-1,3	-1,2
60º	≥ 10	-1,2	-1,2	-1,2	-1,0	-0,7
	≤ 1	-2,0	-2,0	-2,0	-1,3	-1,2
75º	≥ 10	-1,2	-1,2	-1,2	-1,0	-0,5
	≤ 1	-2,0	-2,0	-2,0	-1,3	-0,5

in the specific case:



The wind loads is:
On the walls:

$$q_{w1} = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 0{,}3 = \mathbf{0{,}276}\ KN/m^2$$

$$q_{w2} = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 0{,}7 = \mathbf{0{,}64}\ KN/m^2$$

On the roof:

CASE1:

$$q_1 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 0{,}6 = \mathbf{0{,}552}\ KN/m^2$$

$$q_2 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 1{,}2 = \mathbf{1{,}104}\ KN/m^2$$

$$q_3 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 1{,}7 = \mathbf{1{,}56}\ KN/m^2$$

CASE2:

$$q_1 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 0{,}8 = \mathbf{0{,}736}\ KN/m^2$$

$$q_2 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 2{,}3 = \mathbf{2{,}16}\ KN/m^2$$

$$q_3 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 1{,}3 = \mathbf{1{,}19}\ KN/m^2$$

CASE3:

$$q_1 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 0{,}5 = \mathbf{0{,}46}\ KN/m^2$$

$$q_2 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 0{,}6 = \mathbf{0{,}552}\ KN/m^2$$

$$q_3 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 2{,}1 = \mathbf{1{,}93}\ KN/m^2$$

$$q_3 = q_b \cdot C_e \cdot C_p = 0{,}46 \cdot 2 \cdot 1{,}8 = \mathbf{1{,}65}\ KN/m^2$$

2.1.2.3 *Use loads*

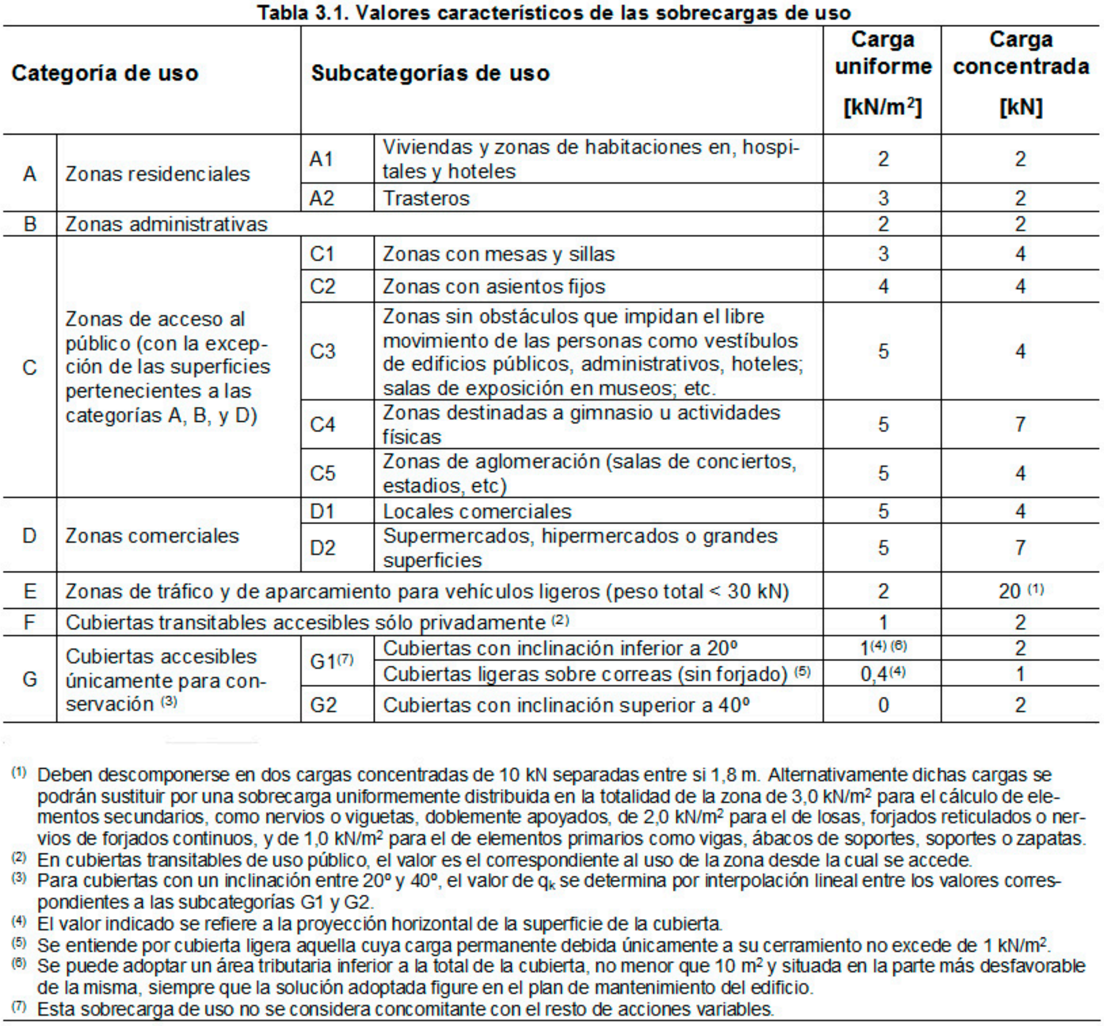


Tabla 3.1. Valores característicos de las sobrecargas de uso

Categoría de uso		Subcategorías de uso		Carga uniforme [kN/m^2]	Carga concentrada [kN]
A	Zonas residenciales	A1	Viviendas y zonas de habitaciones en, hospitales y hoteles	2	2
		A2	Trasteros	3	2
B	Zonas administrativas			2	2
C	Zonas de acceso al público (con la excepción de las superficies pertenecientes a las categorías A, B, y D)	C1	Zonas con mesas y sillas	3	4
		C2	Zonas con asientos fijos	4	4
		C3	Zonas sin obstáculos que impidan el libre movimiento de las personas como vestíbulos de edificios públicos, administrativos, hoteles; salas de exposición en museos; etc.	5	4
		C4	Zonas destinadas a gimnasio u actividades físicas	5	7
		C5	Zonas de aglomeración (salas de conciertos, estadios, etc)	5	4
D	Zonas comerciales	D1	Locales comerciales	5	4
		D2	Supermercados, hipermercados o grandes superficies	5	7
E	Zonas de tráfico y de aparcamiento para vehículos ligeros (peso total < 30 kN)			2	20 (1)
F	Cubiertas transitables accesibles sólo privadamente (2)			1	2
G	Cubiertas accesibles únicamente para conservación (3)	G1 (7)	Cubiertas con inclinación inferior a 20º	1 (4) (6)	2
			Cubiertas ligeras sobre correas (sin forjado) (5)	0,4 (4)	1
		G2	Cubiertas con inclinación superior a 40º	0	2

(1) Deben descomponerse en dos cargas concentradas de 10 kN separadas entre si 1,8 m. Alternativamente dichas cargas se podrán sustituir por una sobrecarga uniformemente distribuida en la totalidad de la zona de 3,0 kN/m^2 para el cálculo de elementos secundarios, como nervios o viguetas, doblemente apoyados, de 2,0 kN/m^2 para el de losas, forjados reticulados o nervios de forjados continuos, y de 1,0 kN/m^2 para el de elementos primarios como vigas, ábacos de soportes, soportes o zapatas.

(2) En cubiertas transitables de uso público, el valor es el correspondiente al uso de la zona desde la cual se accede.

(3) Para cubiertas con un inclinación entre 20º y 40º, el valor de q_k se determina por interpolación lineal entre los valores correspondientes a las subcategorías G1 y G2.

(4) El valor indicado se refiere a la proyección horizontal de la superficie de la cubierta.

(5) Se entiende por cubierta ligera aquella cuya carga permanente debida únicamente a su cerramiento no excede de 1 kN/m^2.

(6) Se puede adoptar un área tributaria inferior a la total de la cubierta, no menor que 10 m^2 y situada en la parte más desfavorable de la misma, siempre que la solución adoptada figure en el plan de mantenimiento del edificio.

(7) Esta sobrecarga de uso no se considera concomitante con el resto de acciones variables.

The use loads evaluated are the following

- *C4 = Gym zones or phisic activities zones:*

$$q_{c4} = 5\ kN/m^2$$

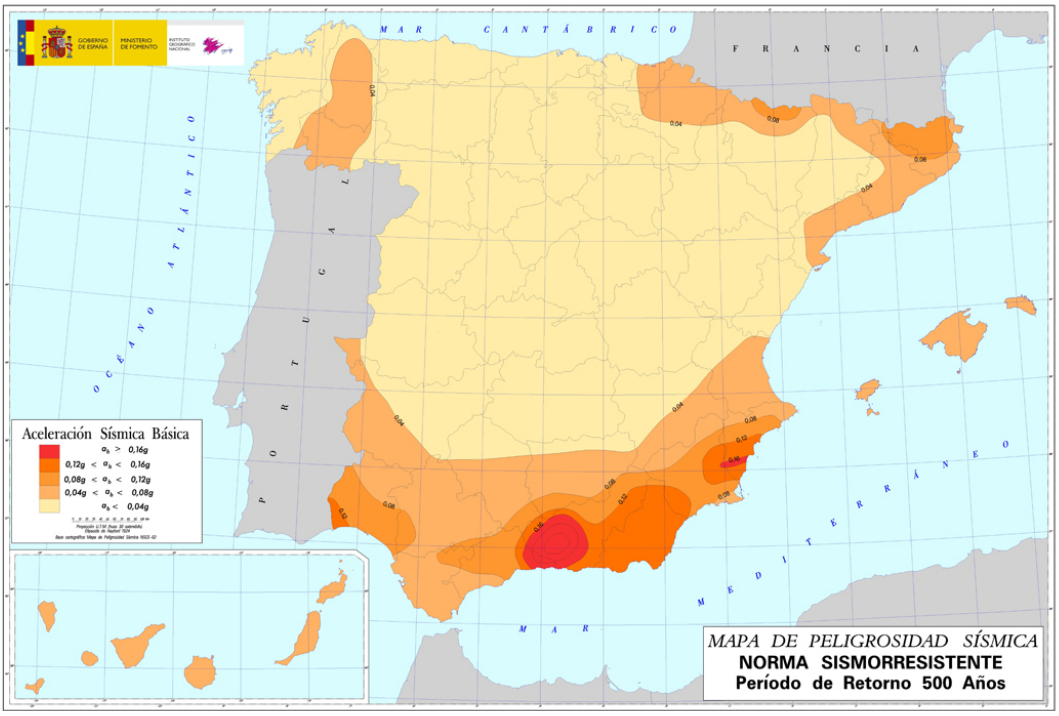
- *C5 = Agglomeration zones:*

$$q_{c5} = 5\ kN/m^2$$

- *F = Roof accesible only for conservations works:*

$$q_F = 5\ kN/m^2$$

2.1.2.4 *Seismic Actions*



The seismic project actions, are definied starting from the seismic risk of the construction site. This element is of foundamental importance to determinate the seismic actions.
They are evaluated in relation with a "reference period" Vr obtained, depending by the typology of building, amplified with the Use coefficient CU:

$$V_r = V_n \cdot C_u$$

V_n*= is the nominal life of a building meaning the number of years in wich can be used following the scope whereby is destined. In our case.*

$$V_n = 50$$

"Ordinary building with normal importance"

C_u *= depends by the use of the building during his life. In our case*

$$C_u = 1{,}5$$

"Buildings which use provide for significative crowd. Factories with dangerous activities for the ambient."

So

$$V_r = 75$$

spettro di risposta elastico

It permit to obtain the answer in terms of accelerations (velocity and displacement) of a simple oscillator with a damping factor of 5% exposed to a seismic accelerogram, on varying the self frequency (or periode).

The analitic description of the response spectrum depends by:

- a_g *maximum horyzontal acelleration of the site;*
- *Fo maximum value of amplification of the response spectrum in horyzontal acceleration;*
- *TC* period in wich start the constant speed of the spectrum in horyzontal accelleration.*

To the four limite estate (SLO,SLD,SLV,SLC) are assigned value of the PVR of 81%, 63%, 10% e 5% , and they remain unchanged respect the use class considered.

This probabilities, evaluated in the reference period of the considered building, permit to individuate the return time TR with the following formula:

$$Tr = \frac{-V_r}{ln(1 - PVR)}$$

obtaining the values of TR according to VR and PVR.

In our case considering the SLD state limite the return time will be:

- *SLE→SLD→PVR=63%→VR=50anni→TR=75years;*
- *SLU→SLV→PVR=10%→VR=50anni→TR=711years.*

The conditions of the reference sitium usually are not the same that the really conditions. Is necessary ,hence ,to consider:

1) *Topographic conditions of the sitium, in our case:*

$$S_t = 1$$

"T1 Flat surface, gentle slope with a medium inclination i ≤ 15°";

2) *Stratigraphic conditions of the sitium, in our case:*

"C) Coarse grained deposit, on average thicken or fine grained on average consistent with minimum width of 30 m, charachterised with a gradual improvement of the mechanical charactheristics in depth."

Both factors contributes to modify the seismic action in width, durate ,frequency containing.

So the response spectrum is definied with the following expressions:

$$0 \le T < T_B \qquad S_e(T) = a_g \cdot S \cdot \eta \cdot F_O \cdot \left[\frac{T}{T_B} + \frac{1}{\eta \cdot F_O}\left(1 - \frac{T}{T_B}\right)\right]$$

$$T_B \le T < T_C \qquad S_e(T) = a_g \cdot S \cdot \eta \cdot F_O$$

$$T_C \le T < T_D \qquad S_e(T) = a_g \cdot S \cdot \eta \cdot F_O \cdot \left(\frac{T_C}{T}\right)$$

$$T_D \le T \qquad S_e(T) = a_g \cdot S \cdot \eta \cdot F_O \cdot \left(\frac{T_C \cdot T_D}{T^2}\right)$$

Where:

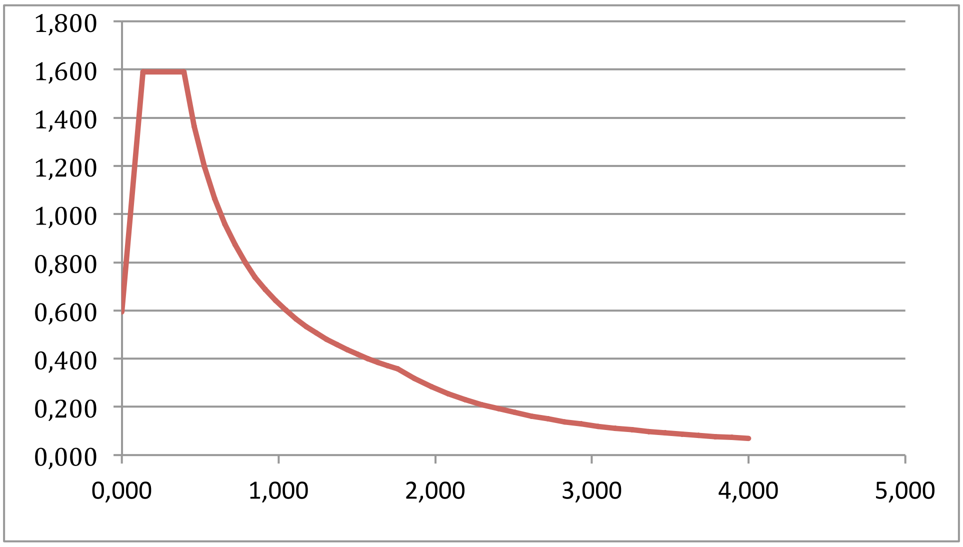
- *T = vibrational period;*
- *S_e =spectral acceleration ;*
- *S =coefficent that consider the stratigraphic conditions and the topographic conditions with the following formula:*

  $$S = S_S \cdot S_T$$

  With S_S stratigraphic amplification factor and ST topographic aplification factor;
- *η = factor that modify the elastic spectrum with damping factor ξ different to the 5%,*
- *F_o = factor that quantifiy the maximum spectral amplification, on the reference horyzontal sitium;*
- *TC =period corresponding to the begininning of the constant speed on the response spectrum: TC = CC ·TC*;*
- *TB =period corresponding to the beginning of the constant accelleration on the response spectrum: TB = TC /3;*
- *TD =period corresponding to the beginning of the constant displacement on the response spectrum: 4,00·(ag/g) + 1,60.*

2.1.2.4.1 Exercise Response spectrum

This spectrum is evaluated for the city of Valencia, with a stratigraphic condition of the ground "C" and topographic condition of the ground "T1", probability PVR=63% and reference life Tr =75 years.

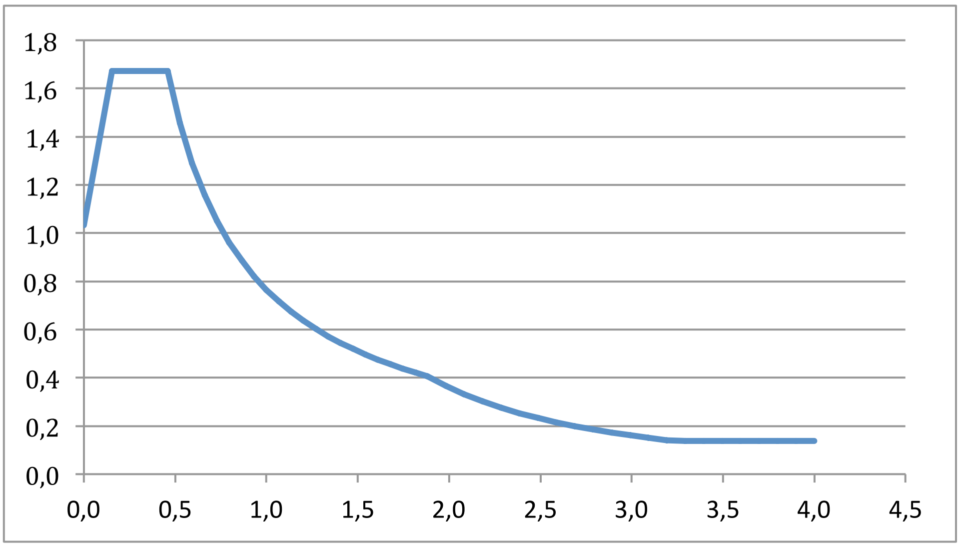


T_s	S_a/g	S_a	
0,000	0,061	0,594	$0<T<T_B$
0,132	0,162	1,590	$T_B<T<T_C$
0,395	0,162	1,590	
0,460	0,139	1,366	$T_C<T<T_D$
0,525	0,122	1,196	
0,590	0,109	1,065	
0,655	0,098	0,959	
0,720	0,089	0,872	
0,786	0,082	0,800	
0,851	0,075	0,739	
0,916	0,070	0,686	
0,981	0,065	0,641	
1,046	0,061	0,601	
1,111	0,058	0,566	
1,176	0,054	0,534	
1,241	0,052	0,506	
1,306	0,049	0,481	
1,371	0,047	0,458	
1,436	0,045	0,438	
1,501	0,043	0,419	
1,566	0,041	0,401	
1,631	0,039	0,385	
1,696	0,038	0,370	
1,761	0,036	0,357	

T_s	S_a/g	S_a	
1,868	0,032	0,317	$T_D<T$
1,975	0,029	0,284	
2,081	0,026	0,256	
2,188	0,024	0,231	
2,294	0,021	0,210	
2,401	0,020	0,192	
2,508	0,018	0,176	
2,614	0,017	0,162	
2,721	0,015	0,150	
2,827	0,014	0,138	
2,934	0,013	0,129	
3,041	0,012	0,120	
3,147	0,011	0,112	
3,254	0,011	0,105	
3,360	0,010	0,098	
3,467	0,009	0,092	
3,574	0,009	0,087	
3,680	0,008	0,082	
3,787	0,008	0,077	
3,893	0,007	0,073	
4,000	0,007	0,069	

2.1.2.4.2 Exercise Response spectrum

This spectrum is evaluated for the city of Valencia, with a stratigraphic condition of the ground "C" and topographic condition of the ground "T1", probability PVR=10% and reference life Tr =711 years.



T_s	S_a/g	S_a		T_s	S_a/g	S_a	
0,000	0,086	0,844	$0<T<T_B$	1,933	0,048	0,470	$T_D<T$
0,148	0,221	2,165	$T_B<T<T_C$	2,036	0,043	0,424	
0,443	0,221	2,165		2,139	0,039	0,384	
0,509	0,192	1,884	$T_C<T<T_D$	2,243	0,036	0,349	
0,575	0,170	1,668		2,346	0,033	0,319	
0,641	0,153	1,496		2,450	0,030	0,293	
0,707	0,138	1,357		2,553	0,027	0,269	
0,773	0,127	1,241		2,656	0,025	0,249	
0,839	0,117	1,143		2,760	0,024	0,231	
0,905	0,108	1,060		2,863	0,022	0,214	
0,971	0,101	0,988		2,966	0,020	0,200	
1,037	0,094	0,925		3,070	0,019	0,186	
1,103	0,089	0,870		3,173	0,018	0,174	
1,169	0,084	0,821		3,276	0,017	0,164	
1,235	0,079	0,777		3,380	0,016	0,154	
1,301	0,075	0,738		3,483	0,015	0,145	
1,367	0,072	0,702		3,587	0,014	0,136	
1,433	0,068	0,670		3,690	0,013	0,129	
1,499	0,065	0,640		3,793	0,012	0,122	
1,565	0,062	0,613		3,897	0,012	0,116	
1,631	0,060	0,588		4,000	0,011	0,110	
1,697	0,058	0,565					
1,763	0,055	0,544					
1,829	0,053	0,525					

2.2 PREDIMENSIONING OF THE STRUCTURE

Considering that the building has to be provided with structural systems capable, whit accetable prices, to satisfy the security requirement towards to verticals loads and horyzontal loads.

The construction is provided with resistant systems along two principal directions able to guarantee rigidity and adeguate resistence act toward traslational motion and torsional motion originate by the eccentricity between mass center and rigidity center of the building.

This torsional motions tend to stress the structural elements in a non-uniform way. For that reason is necessary to design the structure, when possible , with structural elements allocated on the periferic zones of the building to minimize the eccentricity between mass center and rigidity center in both levels of the construction. To maximize the torsional rigidity is necessary that the floor slab operate like a rigid diaphram to correctly distribuite loads on vertical support elements.

In our case the planimetric shape of the building doesn't allow to distribuite the rigidities in an usual manner.
For that reason is possible to take some considerations:

- *On the long side of the building we have deep beams to guarantee the rigidity in that direction ,moreover are projected three expansion joint to divide the structure in 3 different building with reduced lenght.*
  In each structure are introduced wind-braced concentric in each level of support of the roof to improve the rigidity in this direction,

- *On the short side of the building we have strong column to guarantee the rigidity in this direction , moreover is projected a shear link on the head of the higher column to separate the concrete building with the steel roof , allowing them to a free displacement behaviour.*
  The shear link is provided on the higher column because the low column can contraste the horyzontal loads better;

- *The three separated building are projected with the same structural rigidity, same number of columns , same planimetric surface along same beams charactheristics,*

- *The truss steel cover is made with a double orditure to move his behaviour close to a rigid element and to assimilate the plane diaphram;*

The roof in esame is a typical roof framework made with steel. Are created two typologies of struts:

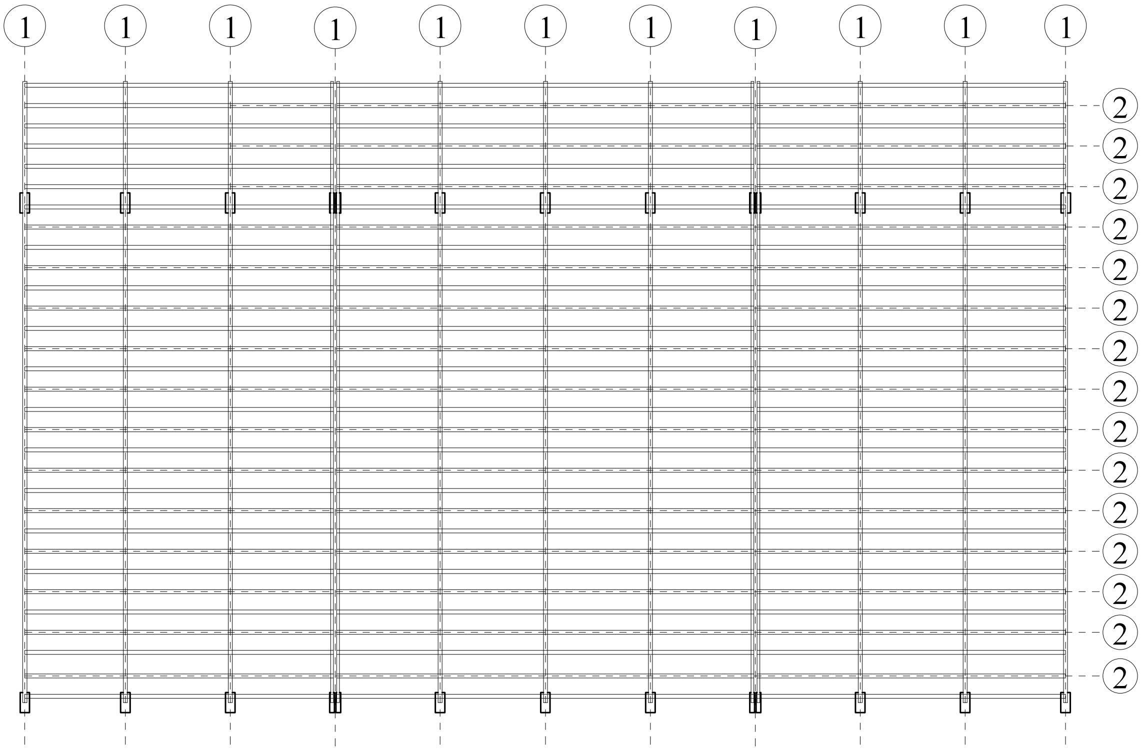
1. *1)Primary struts beam ;*
2. *2) Secondary struts beam.*

The double orditure is made to guarantee a rigid behaviour of the structure under the effects of horyzontal loads. Moreover are introduced wind-brace on the upper layer to distribuite the loads in as a rigid diaphram.

The plane diaphram is necessary to assure an adeguate answer during seismic action,enabling his distribution on the different seismic elements and preventing the incoherent vibration between different elements of the same structure.
An incoherent answer lead to relevant joint distorsion and on a non structural elements.

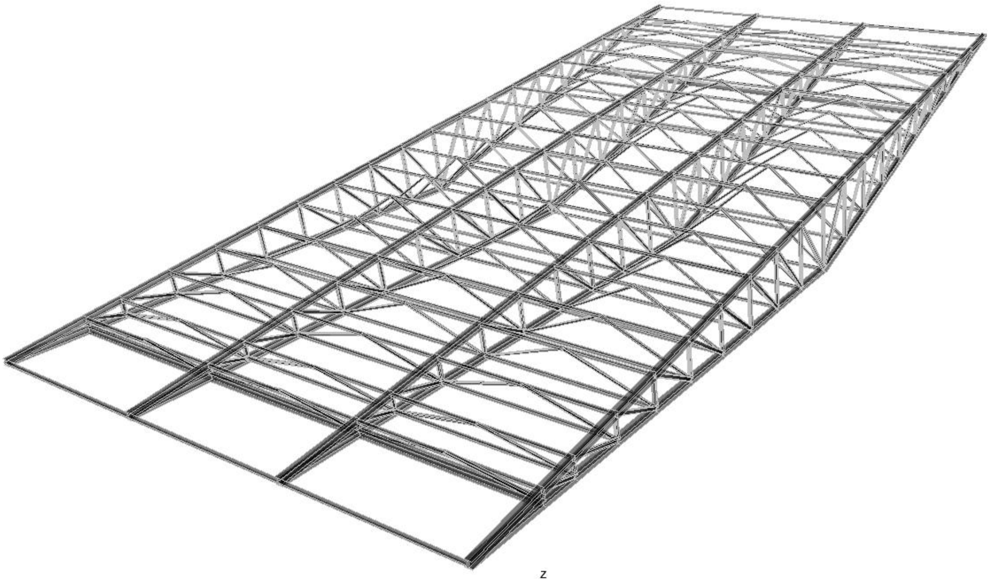
In absence of a rigid diafram the horizontal structure must be projected with stiffening element to assure a sufficient deformative coerence under seismic action.

In our case the complete building is made with 3 coupling joint and the structural roof is the same for the 3 buildings evaluated.
Following the planimetry disposal of the two different struts:

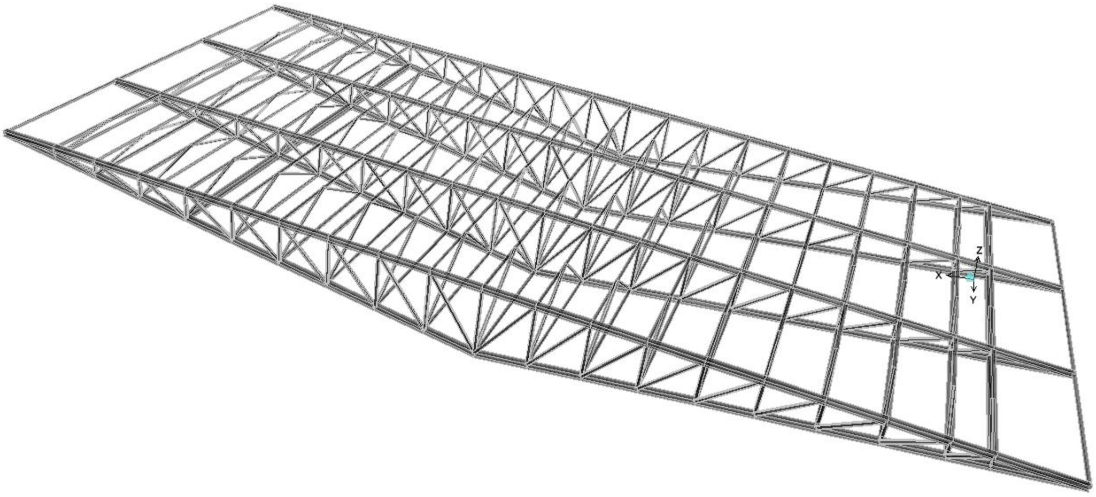


Following the resume of the structural roof for one of the principal buildings:

Right view



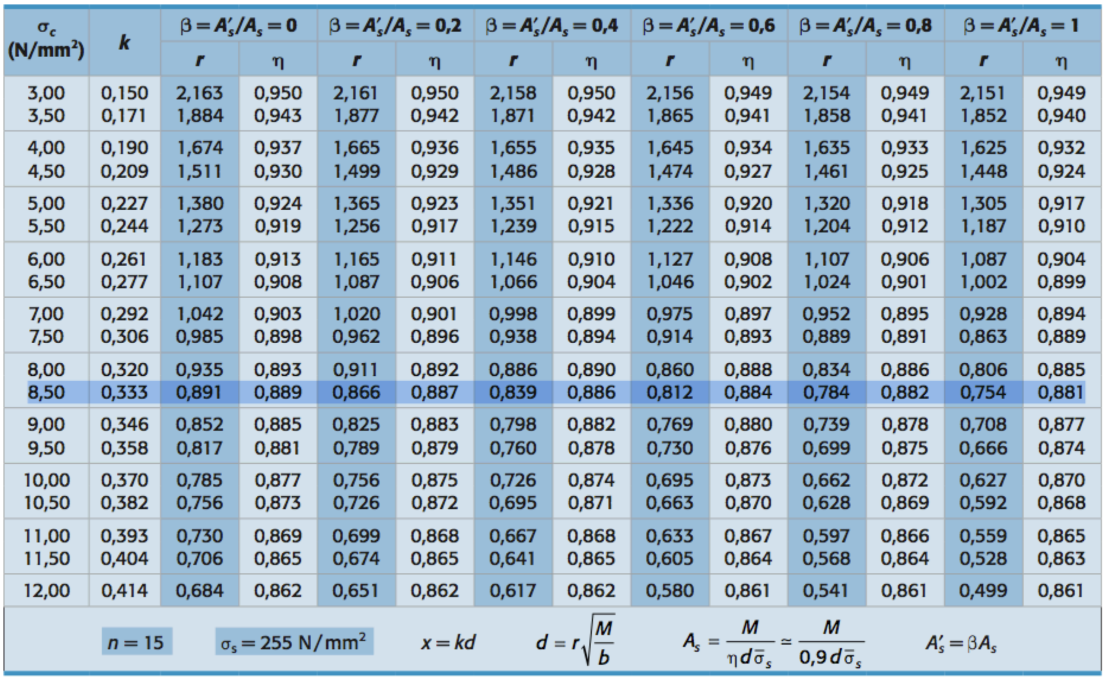
left view



2.2.1 PREDIMENSIONING OF THE BEAM

For the predimensioning of the Beam we consider the tabular method for inflected sections. Considering a Concrete Sections, with one of the dimension known (b), is possible to evaluate the minimum lenght of the other dimension fixing:

- $\beta = A_s'/A_s$
- *Concrete Class C 25/30* $= \sigma_c = 9{,}7\ N/mm^2$
- *Steel class* $\sigma_c = 255\ N/mm^2$



σ_c (N/mm²)	k	$\beta = A_s'/A_s = 0$		$\beta = A_s'/A_s = 0{,}2$		$\beta = A_s'/A_s = 0{,}4$		$\beta = A_s'/A_s = 0{,}6$		$\beta = A_s'/A_s = 0{,}8$		$\beta = A_s'/A_s = 1$	
		r	η	r	η	r	η	r	η	r	η	r	η
3,00	0,150	2,163	0,950	2,161	0,950	2,158	0,950	2,156	0,949	2,154	0,949	2,151	0,949
3,50	0,171	1,884	0,943	1,877	0,942	1,871	0,942	1,865	0,941	1,858	0,941	1,852	0,940
4,00	0,190	1,674	0,937	1,665	0,936	1,655	0,935	1,645	0,934	1,635	0,933	1,625	0,932
4,50	0,209	1,511	0,930	1,499	0,929	1,486	0,928	1,474	0,927	1,461	0,925	1,448	0,924
5,00	0,227	1,380	0,924	1,365	0,923	1,351	0,921	1,336	0,920	1,320	0,918	1,305	0,917
5,50	0,244	1,273	0,919	1,256	0,917	1,239	0,915	1,222	0,914	1,204	0,912	1,187	0,910
6,00	0,261	1,183	0,913	1,165	0,911	1,146	0,910	1,127	0,908	1,107	0,906	1,087	0,904
6,50	0,277	1,107	0,908	1,087	0,906	1,066	0,904	1,046	0,902	1,024	0,901	1,002	0,899
7,00	0,292	1,042	0,903	1,020	0,901	0,998	0,899	0,975	0,897	0,952	0,895	0,928	0,894
7,50	0,306	0,985	0,898	0,962	0,896	0,938	0,894	0,914	0,893	0,889	0,891	0,863	0,889
8,00	0,320	0,935	0,893	0,911	0,892	0,886	0,890	0,860	0,888	0,834	0,886	0,806	0,885
8,50	0,333	0,891	0,889	0,866	0,887	0,839	0,886	0,812	0,884	0,784	0,882	0,754	0,881
9,00	0,346	0,852	0,885	0,825	0,883	0,798	0,882	0,769	0,880	0,739	0,878	0,708	0,877
9,50	0,358	0,817	0,881	0,789	0,879	0,760	0,878	0,730	0,876	0,699	0,875	0,666	0,874
10,00	0,370	0,785	0,877	0,756	0,875	0,726	0,874	0,695	0,873	0,662	0,872	0,627	0,870
10,50	0,382	0,756	0,873	0,726	0,872	0,695	0,871	0,663	0,870	0,628	0,869	0,592	0,868
11,00	0,393	0,730	0,869	0,699	0,868	0,667	0,868	0,633	0,867	0,597	0,866	0,559	0,865
11,50	0,404	0,706	0,865	0,674	0,865	0,641	0,865	0,605	0,864	0,568	0,864	0,528	0,863
12,00	0,414	0,684	0,862	0,651	0,862	0,617	0,862	0,580	0,861	0,541	0,861	0,499	0,861

$n = 15$ $\quad \sigma_s = 255\ N/mm^2$ $\quad x = kd$ $\quad d = r\sqrt{\frac{M}{b}}$ $\quad A_s = \frac{M}{\eta d \bar{\sigma}_s} \simeq \frac{M}{0{,}9 d \bar{\sigma}_s}$ $\quad A_s' = \beta A_s$

Knowing the value of the bending moment evaluated is possible to evaluate the minimum lenght of the other dimension with the following:

$$d = r\sqrt{\frac{M}{b}}$$

Beam	Lenght	G_{floor}	Gt_{amp}	Q_k	G_{floor}	Gt_{amp}	Q_k	q_{tot}	M	b	r	h	Concrete cover
	(m)	kN/m^2	kN/m^2	kN/m^2	kN/m	kN/m	kN/m	kN/m	kN m	mm	mm	mm	mm
A 1-2	7,53	5,95	0	5	5,6	0	4,7	10,3	48,7	300	0,817	359,2	30
B 1-2	7,53	5,95	0	5	11,2	0	9,4	20,6	97,4	300	0,817	495,5	30
B 2-3	7,7	5,95	0	5	5,7	0	4,8	10,5	52,1	300	0,817	370,4	30
B 3-4	7,6	5,95	0	5	5,7	0	4,8	10,5	50,7	300	0,817	366,0	30
B 5-5'	4,1	5,95	0	5	7,4	0	4,8	12,3	17,2	300	0,817	225,4	30
B 5'-6	3,45	5,95	0	5	7,4	0	4,8	12,3	12,2	300	0,817	194,4	30
B 6-7	7,7	5,95	0	5	14,9	0	4,8	19,7	97,3	300	0,817	495,2	30
B 7-7'	3,45	5,95	0,2	5	7,4	0,2	4,8	12,5	12,3	300	0,817	195,8	30
B 7'-8	4,1	5,95	0	5	7,4		4,8	12,3	17,2	300	0,817	225,4	30
B 9-10	7,6	5,95	0	5	5,7	0	4,8	10,5	50,7	300	0,817	366,0	30
B 10-11	7,7	5,95	0	5	5,7	0	4,8	10,5	52,1	300	0,817	370,4	30
B 11-12	7,53	5,95	0	5	11,2	0	9,4	20,6	97,4	300	0,817	495,5	30
A 11-12	7,53	5,95	0	5	5,6	0	4,7	10,3	48,7	300	0,817	359,2	30
D 5-5'	4,1	5,95	0	5	26,5	0	22,3	48,7	68,3	300	0,817	419,7	30
D 5'-6	3,45	5,95	0,2	5	7,4	0,2	6,3	13,9	13,8	300	0,817	205,1	30
D 6-7	7,7	5,95	0,2	5	7,4	0,2	6,3	13,9	68,6	300	0,817	420,7	30
D 7-7'	3,45	5,95	0,2	5	7,4	0,2	6,3	13,9	13,8	300	0,817	205,1	30
D 7'-8	4,1	5,95	0	5	26,5	0	22,3	48,7	68,3	300	0,817	419,7	30
C 1-2	7,53	5,95	0,85	5	5,6	6,8	4,7	17,1	80,8	300	0,817	454,1	30
C 2-3	7,7	5,95	0,85	5	5,7	6,8	4,8	17,3	85,7	300	0,817	466,6	30
C 3-4	7,6	5,95	0,85	5	5,7	6,8	4,8	17,3	83,5	300	0,817	460,9	30
C 5-5'	4,1	5,95	0,85	5	19,0	6,8	16,0	41,8	58,6	300	0,817	391,1	30
C 5'-6	3,45	0	0,85	0	0,0	6,8	0,0	6,8	6,7	300	0,817	152,5	30
C 6-7	7,7	0	0,85	0	0,0	6,8	0,0	6,8	33,6	300	0,817	303,4	30
C 7-7'	3,45	0	0,85	0	0,0	6,8	0,0	6,8	6,7	300	0,817	152,5	30
C 7'-8	4,1	0	0,85	0	0,0	6,8	0,0	6,8	9,5	300	0,817	175,6	30
C 9-10	7,6	5,95	0,85	5	5,6	6,8	4,7	17,1	82,3	300	0,817	458,0	30
C 10-11	7,7	5,95	0,85	5	5,7	6,8	4,8	17,3	85,7	300	0,817	466,6	30
C 11-12	7,53	5,95	0,85	5	5,7	6,8	4,8	17,3	81,9	300	0,817	457,0	30

Beam	**Lenght**	**G_{floor}**	**Gt_{amp}**	**Q_k**	**G_{floor}**	**Gt_{amp}**	**Q_k**	**q_{tot}**	**M**	**b**	**r**	**h**	**Concrete cover**
	(m)	kN/m^2	kN/m^2	kN/m^2	kN/m	kN/m	kN/m	kN/m	kN m	mm	mm	mm	mm
1 A-B	5	5,95	0,5	5	16,8	3,0	14,1	33,9	70,7	600	0,8	310,4	30,0
1 B-C	9	5,95	0,5	5	16,8	3,0	14,1	33,9	229,0	600	0,8	534,7	30,0
2 A-B	5	5,95	0	5	16,8	0,0	14,1	30,9	64,4	600	0,8	297,7	30,0
2 B-C	9	5,95	0	5	34,0	0,0	28,6	62,5	422,1	600	0,8	715,3	30,0
3 B-C	9	5,95	0	5	34,1	0,0	28,7	62,8	424,1	600	0,8	716,9	30,0
4 B-C	9	5,95	0	5	17,0	0,0	14,3	31,2	210,7	600	0,8	514,1	30,0
5 B-C	9	0	0	0	0,0	0,0	0,0	0,0	0,0	600	0,8	30,0	30,0
6 B-C	9	0	0	0	0,0	0,0	0,0	0,0	0,0	600	0,8	30,0	30,0
7 B-C	9	0	0	0	0,0	0,0	0,0	0,0	0,0	600	0,8	30,0	30,0
8 B-C	9	0	0	0	0,0	0,0	0,0	0,0	0,0	600	0,8	30,0	30,0
9 B-C	9	5,95	0	5	17,0	0,0	14,3	31,2	210,7	600	0,8	514,1	30,0
10 B-C	9	5,95	0	5	34,1	0,0	28,7	62,8	424,1	600	0,8	716,9	30,0
11 A-B	5	5,95	0	5	16,8	0,0	14,1	30,9	64,4	600	0,8	297,7	30,0
11 B-C	9	5,95	0	5	34,0	0,0	28,6	62,5	422,1	600	0,8	715,3	30,0
12 A-B	5	5,95	0,5	5	16,8	3,0	14,1	33,9	70,7	600	0,8	310,4	30,0
12 B-C	9	5,95	0,5	5	16,8	3,0	14,1	33,9	229,0	600	0,8	534,7	30,0

2.2.1.1 *Prototypes definition*

We pick for the following section, depending by the minimum value h evaluated with the tabular method.

ALPHABETIC FRAMES:

Beam	***b (cm)***	h_{min}	h_{choose}	***Misure Units***
A 1-2	*300*	*350,7*	*400,0*	*cm*
A 11-12	*300*	*301,9*	*400,0*	*cm*
B 1-2	*300*	*483,5*	*500,0*	*cm*
B 2-3	*300*	*361,6*	*500,0*	*cm*
B 3-4	*300*	*357,3*	*500,0*	*cm*
B 5-6	*300*	*723,4*	*750,0*	*cm*
B 6-7	*300*	*476,3*	*600,0*	*cm*
B 7-8	*300*	*723,4*	*750,0*	*cm*
B 9-10	*300*	*357,3*	*500,0*	*cm*
B 10-11	*300*	*361,6*	*500,0*	*cm*
B 11-12	*300*	*483,5*	*500,0*	*cm*
C 1-2	*300*	*437,7*	*500,0*	*cm*
C 2-3	*300*	*449,8*	*500,0*	*cm*
C 3-4	*300*	*444,4*	*500,0*	*cm*
C 5-6	*300*	*530,3*	*550,0*	*cm*
C 6-7	*300*	*287,5*	*550,0*	*cm*
C 7-8	*300*	*530,3*	*550,0*	*cm*
C 9-10	*300*	*441,5*	*500,0*	*cm*
C 10-11	*300*	*449,8*	*500,0*	*cm*
C 11-12	*300*	*440,6*	*500,0*	*cm*

NUMBER FRAMES

Beam	***b***	h_{min}	h_{choose}	***Misure Units***
1 A-B	*600*	*302,4*	*350,0*	*cm*
1 B-C	*600*	*520,3*	*550,0*	*cm*
2 A-B	*600*	*290,8*	*350,0*	*cm*
2 B-C	*600*	*697,6*	*750,0*	*cm*
3 B-C	*600*	*699,2*	*750,0*	*cm*
4 B-C	*600*	*501,6*	*550,0*	*cm*
5 B-C	*600*	*30,0*	*350,0*	*cm*
6 B-C	*600*	*30,0*	*350,0*	*cm*
7 B-C	*600*	*30,0*	*350,0*	*cm*
8 B-C	*600*	*30,0*	*350,0*	*cm*
9 B-C	*600*	*501,6*	*550,0*	*cm*
10 B-C	*600*	*699,2*	*750,0*	*cm*
11 A-B	*600*	*290,8*	*350,0*	*cm*
11 B-C	*600*	*697,6*	*750,0*	*cm*
12 A-B	*600*	*302,4*	*350,0*	*cm*
12 B-C	*600*	*520,3*	*550,0*	*cm*

The prototypes evaluated are the following:

Name	**b**	**h_{pick}**	**Misure Units**
Prototype 1	*300*	*400*	*cm*
Prototype 2	*300*	*500*	*cm*
Prototype 3	*300*	*750*	*cm*
Prototype 4	*300*	*600*	*cm*
Prototype 5	*300*	*550*	*cm*
Prototype 6	*600*	*350*	*cm*
Prototype 7	*600*	*550*	*cm*
Prototype 8	*600*	*800*	*cm*

2.2.2 PREDIMENSIONING OF THE COLUMN

To predimensioning the column is necessary know what is the most loaded. Following is possible to evaluate wich is the minimum Surface of concrete to contrast the applied strain.
Is used the following formula:

$$\sigma = \frac{N}{A}$$

therefore

$$A = \frac{N}{\sigma}$$

Name	*Station*	*OutputCase*	*P*	*Name*	*Station*	*OutputCase*	*P*
	m		*kN*		*m*		*kN*
B 5	*0*	*COMBO2-USE*	*-1079,7*	*B 2*	*0,0*	*COMBO2-USE*	*-1592,4*
B 5	*4*	*COMBO2-USE*	*-1189,9*	*B 2*	*4,0*	*COMBO2-USE*	*-1702,6*
B 6	*0*	*COMBO2-USE*	*-1384,0*	*B 3*	*0,0*	*COMBO2-USE*	*-1703,6*
B 6	*4*	*COMBO2-USE*	*-1494,2*	*B 3*	*4,0*	*COMBO2-USE*	*-1813,8*
B 7	*0*	*COMBO2-USE*	*-1393,4*	*B 4*	*0,0*	*COMBO2-USE*	*-967,5*
B 7	*4*	*COMBO2-USE*	*-1503,7*	*B 4*	*4,0*	*COMBO2-USE*	*-1077,8*
B 8	*0*	*COMBO2-USE*	*-781,1*	*C 1*	*0,0*	*COMBO2-USE*	*-419,8*
B 8	*4*	*COMBO2-USE*	*-891,4*	*C 1*	*4,0*	*COMBO2-USE*	*-530,1*
K 5	*0*	*COMBO2-USE*	*-287,2*	*C 2*	*0,0*	*COMBO2-USE*	*-803,6*
K 5	*4,37548*	*COMBO2-USE*	*-407,9*	*C 2*	*4,0*	*COMBO2-USE*	*-913,8*
K 6	*0*	*COMBO2-USE*	*-465,9*	*C 3*	*0,0*	*COMBO2-USE*	*-806,0*
K 6	*4,37548*	*COMBO2-USE*	*-586,5*	*C 3*	*4,0*	*COMBO2-USE*	*-916,3*
K 7	*0*	*COMBO2-USE*	*-465,2*	*C 4*	*0,0*	*COMBO2-USE*	*-421,8*
K 7	*4,37548*	*COMBO2-USE*	*-585,8*	*C 4*	*4,0*	*COMBO2-USE*	*-532,1*
K 8	*0*	*COMBO2-USE*	*-287,1*	*K 1*	*0,0*	*COMBO2-USE*	*-288,2*
K 8	*4,37548*	*COMBO2-USE*	*-407,7*	*K 1*	*4,4*	*COMBO2-USE*	*-408,8*
B 5.1	*0*	*COMBO2-USE*	*-439,7*	*K 2*	*0,0*	*COMBO2-USE*	*-464,7*
B 5.1	*5,1853*	*COMBO2-USE*	*-582,6*	*K 2*	*4,4*	*COMBO2-USE*	*-585,3*
B 6.1	*0*	*COMBO2-USE*	*-732,5*	*K 3*	*0,0*	*COMBO2-USE*	*-462,7*
B 6.1	*5,1853*	*COMBO2-USE*	*-875,4*	*K 3*	*4,4*	*COMBO2-USE*	*-583,3*
B 7.1	*0*	*COMBO2-USE*	*-718,9*	*K 4*	*0,0*	*COMBO2-USE*	*-285,5*
B 7.1	*5,1853*	*COMBO2-USE*	*-861,8*	*K 4*	*4,4*	*COMBO2-USE*	*-406,2*
B 8.1	*0*	*COMBO2-USE*	*-439,9*	*B1-2*	*0,0*	*COMBO2-USE*	*-438,7*
B 8.1	*5,1853*	*COMBO2-USE*	*-582,8*	*B1-2*	*5,2*	*COMBO2-USE*	*-581,7*
A 1	*0*	*COMBO2-USE*	*-192,4*	*B 2-1*	*0,0*	*COMBO2-USE*	*-733,7*
A 1	*4*	*COMBO2-USE*	*-214,5*	*B 2-1*	*5,2*	*COMBO2-USE*	*-876,6*
A 2	*0*	*COMBO2-USE*	*-166,9*	*B 3-1*	*0,0*	*COMBO2-USE*	*-721,4*
A 2	*4*	*COMBO2-USE*	*-188,9*	*B 3-1*	*5,2*	*COMBO2-USE*	*-864,4*
B 1	*0*	*COMBO2-USE*	*-1199,8*	*B 4-1*	*0,0*	*COMBO2-USE*	*-441,4*
B 1	*4*	*COMBO2-USE*	*-1310,1*	*B 4-1*	*5,2*	*COMBO2-USE*	*-584,4*

2.2.2.1 *Prototypes definition*

Are choosen 4 prototypes of column due the plant disposal of them.

- *Prototype A : part of the A Frame;*
- *Prototype B : part of the B Frame;*
- *Prototype C : part of the C Frame;*
- *Prototype K : part of the K Frame;*

Both of them are calculated considering the most stressed column in each frame.

Name	**N**	σ_{cls}	**Area**	h_{choose}	**b**
	kN	N/mm^2	mm^2	mm	**mm**
Prototype A	-214,5	9,7	22108,9	600	55,27216495
Prototype B	-1813,8	9,7	186992,4	600	311,6539519
Prototype C	-916,3	9,7	94464,2	600	157,440378
Prototype K	-583,3	9,7	60131,9	600	100,2197595

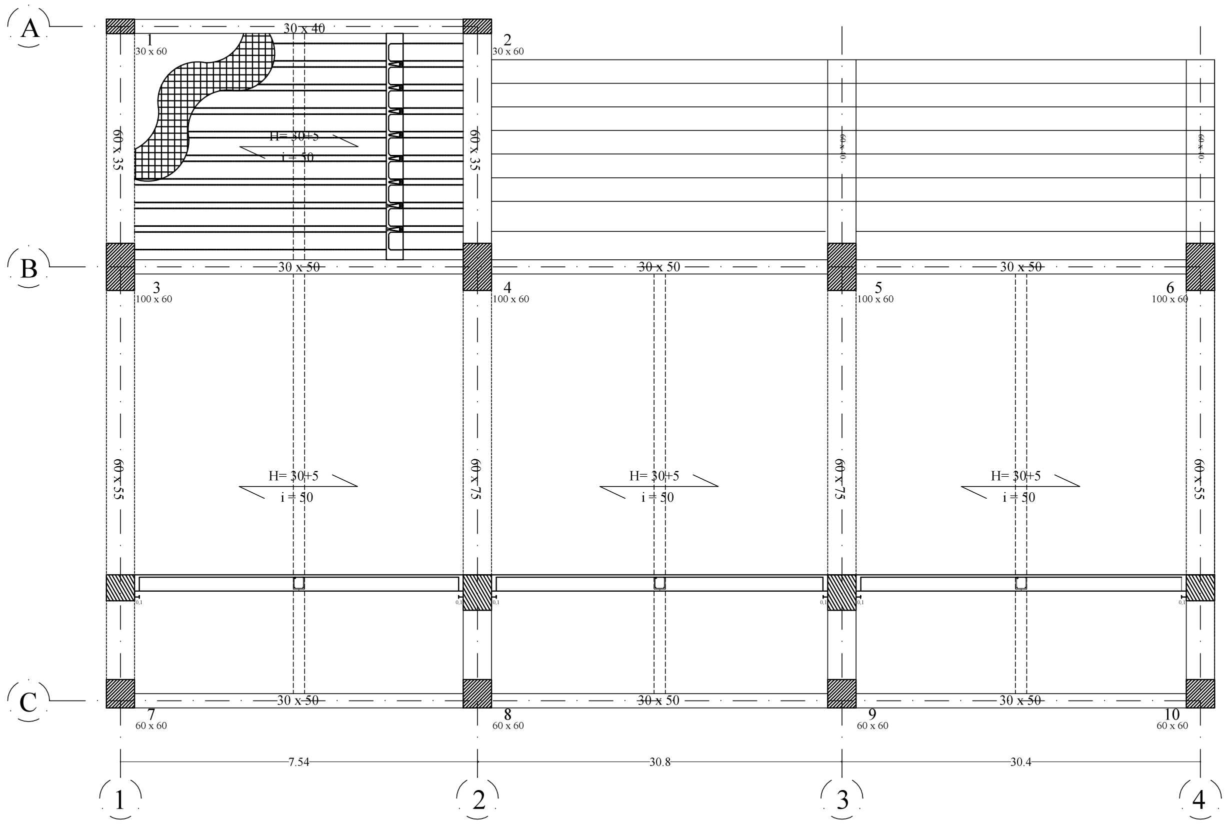
Considering the hierarchy of resistances we choose sections with b value increased respect the minimum requested.

Name	h_{choose}	**b**
	mm	**mm**
Prototype A	600	400
Prototype B	600	900
Prototype C	600	600
Prototype K	600	1000

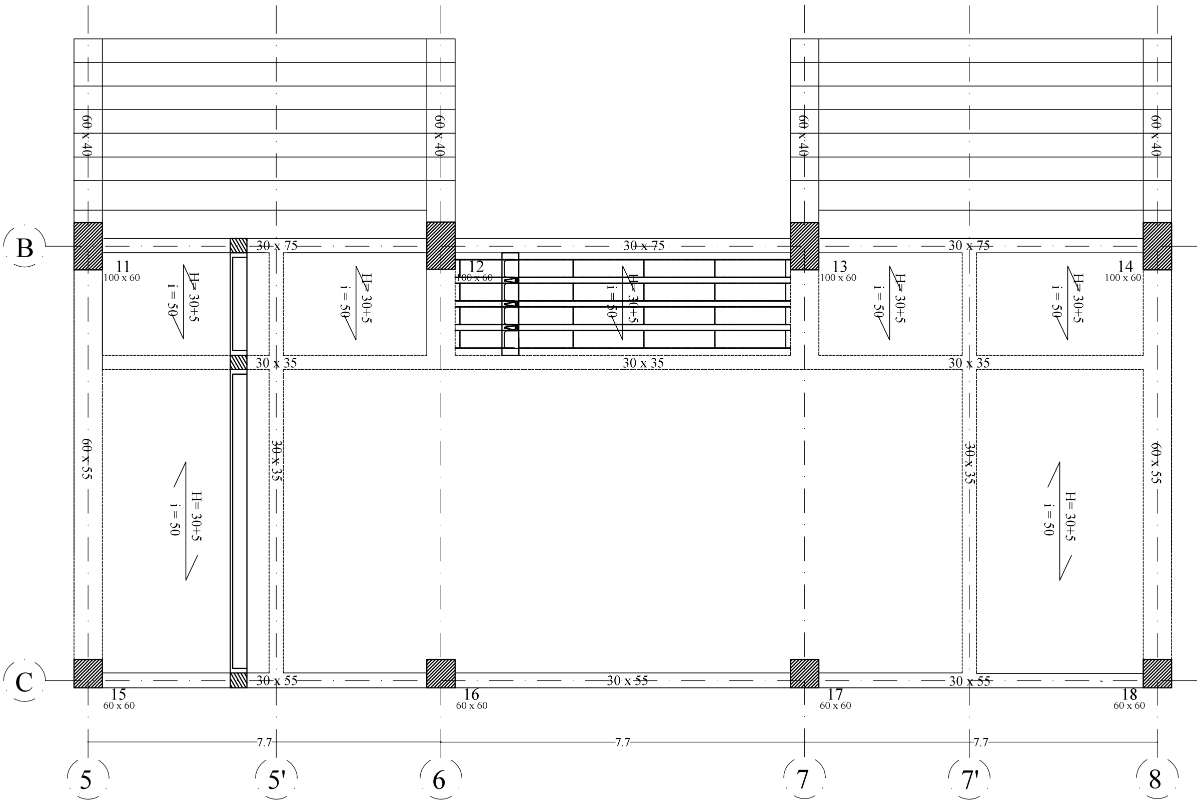
2.2.3 LAYOUT OF THE PREDIMENSIONING

After the predimensioning of column and beams we obtain the following layout of the 3 different structure:

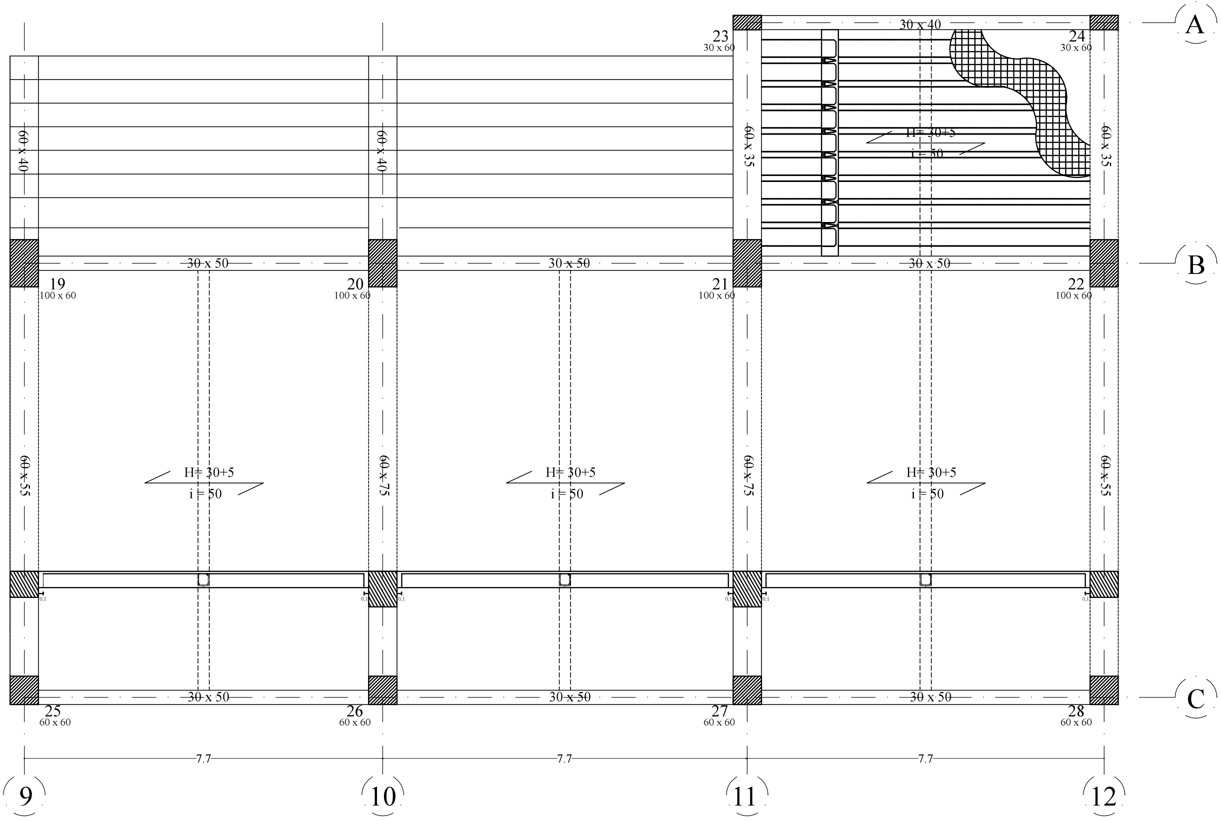
Building 1



Building 2



Building 3



2.3 MODELATION OF THE STRUCTURE

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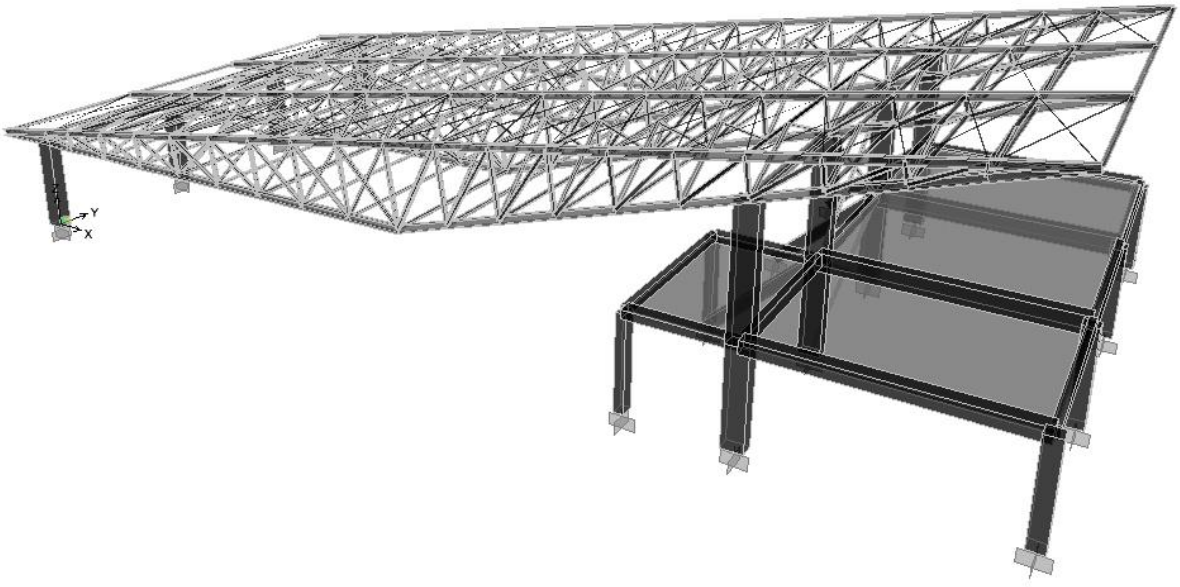
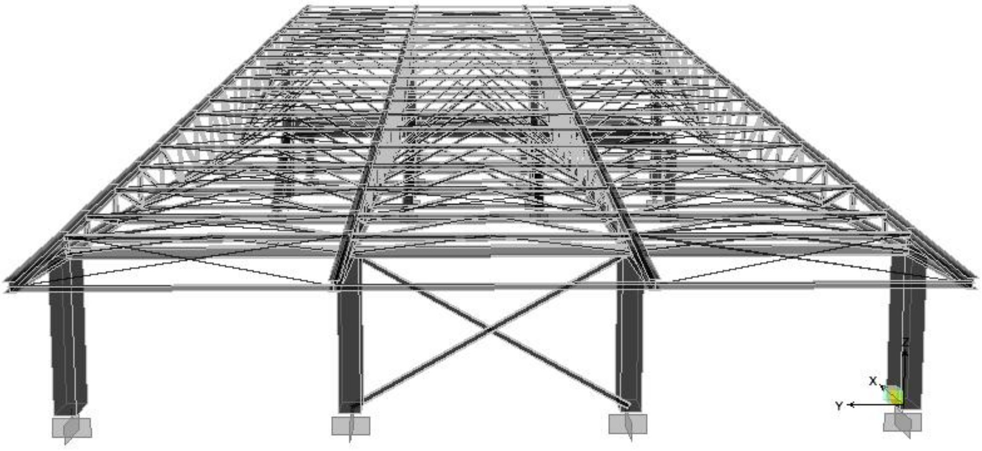
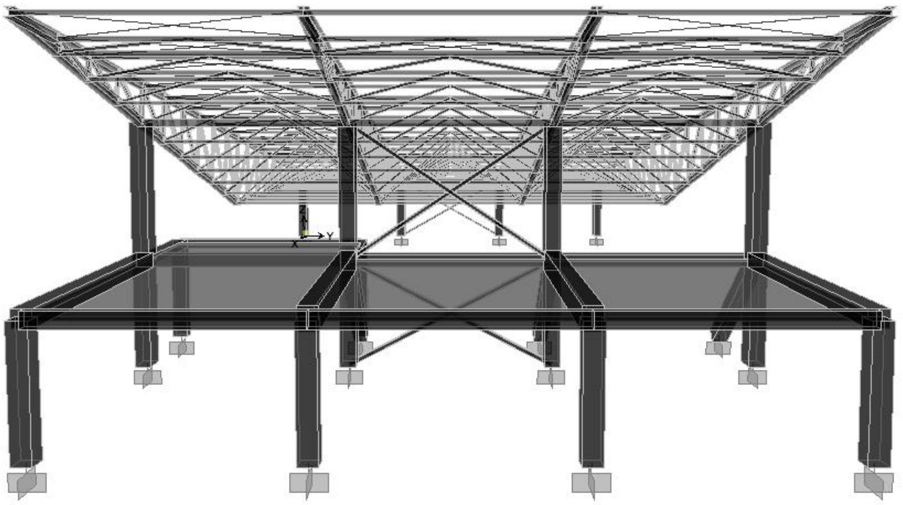
MODEL 1 –Side A prospect



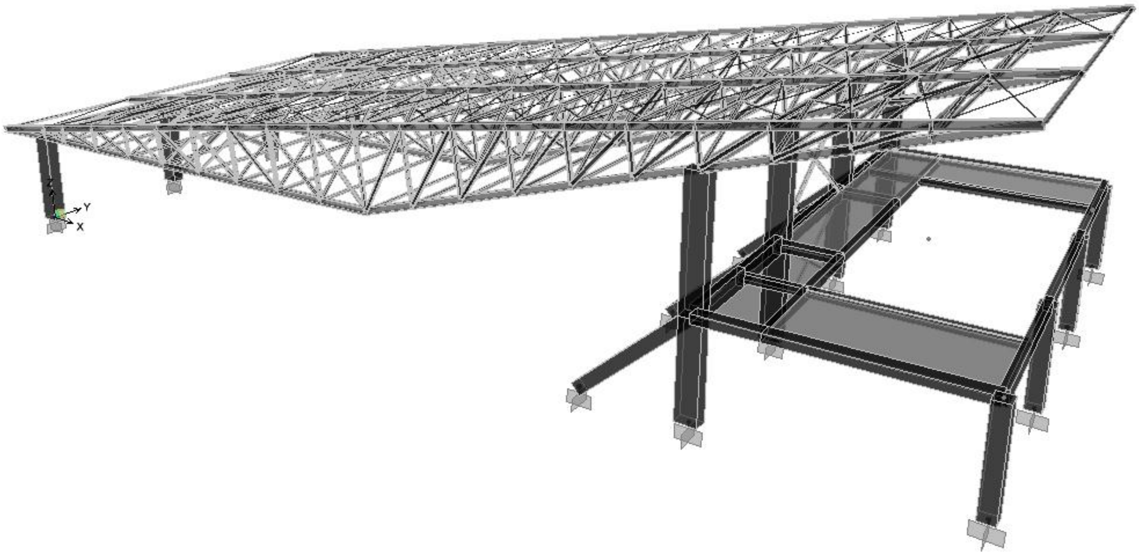
<u>Side B prospect</u>



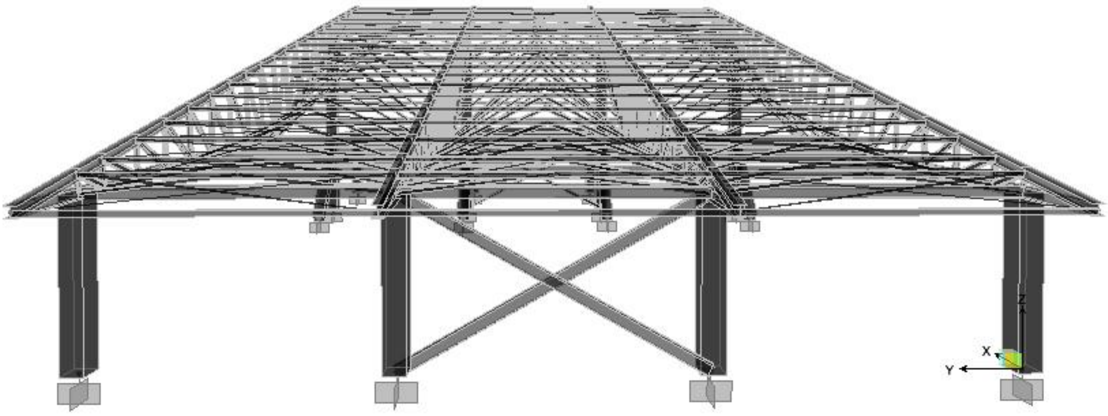
<u>Side C prospect</u>



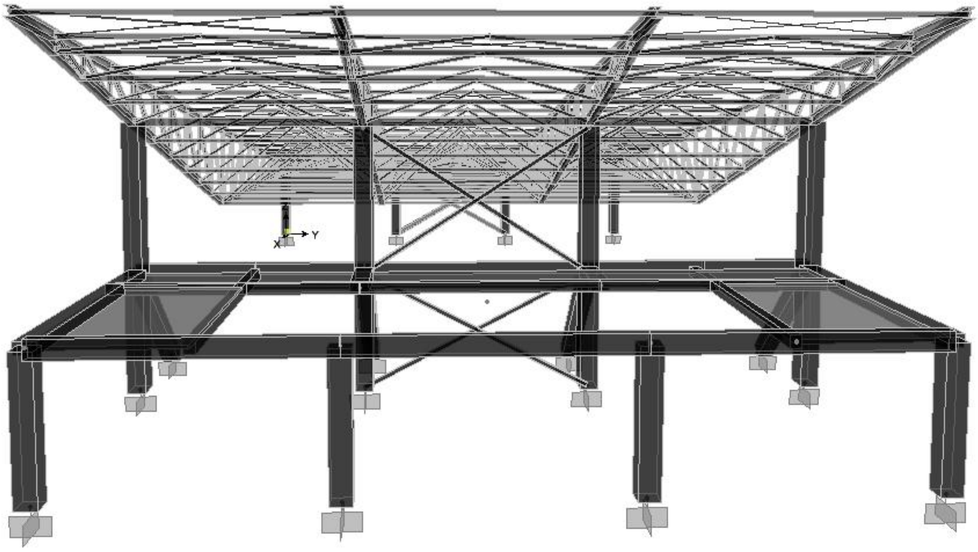
MODEL 2 –Side A prospect



Side B prospect



Side C prospect



2.3.1 SECTIONS DEFINITION

SectionName	***Material***	***Shape***	***t3***	***t2***	***Area***
Quadre 140	*steel fe360*	*Quadre Cave*	*0,14*	*0,14*	*0,002*
HEB280	*steel fe360*	*I/Wide Flange*	*0,28*	*0,28*	*0,013*
T	*steel fe360*	*T/wide flange*	*0,05*	*0,05*	*0,007*
Quadre 50	*steel fe360*	*Quadre Cave*	*0,05*	*0,05*	*0,0005*
PIL 60x40	*Concrete C25/30*	*Rectangular*	*0,4*	*0,6*	*0,18*
PIL60x90	*Concrete C25/30*	*Rectangular*	*0,9*	*0,6*	*0,9*
PIL60x60	*Concrete C25/30*	*Rectangular*	*0,6*	*0,6*	*0,36*
PROT 1	*Concrete C25/30*	*Rectangular*	*0,4*	*0,3*	*0,12*
PROT 2	*Concrete C25/30*	*Rectangular*	*0,5*	*0,3*	*0,15*
PROT 3	*Concrete C25/30*	*Rectangular*	*0,5*	*0,3*	*0,15*
PROT 4	*Concrete C25/30*	*Rectangular*	*0,35*	*0,6*	*0,21*
PROT 5	*Concrete C25/30*	*Rectangular*	*0,55*	*0,6*	*0,33*
PROT 6	*Concrete C25/30*	*Rectangular*	*0,55*	*0,6*	*0,33*
PROT 7	*Concrete C25/30*	*Rectangular*	*0,75*	*0,6*	*0,45*
PROT 8	*Concrete C25/31*	*Rectangular*	*0,3*	*0,35*	*0,105*
PROT 9	*Concrete C25/32*	*Rectangular*	*0,3*	*0,35*	*0,105*
PROT 10	*Concrete C25/33*	*Rectangular*	*0,3*	*0,35*	*0,105*
PROT 11	*Concrete C25/33*	*Rectangular*	*0,3*	*0,35*	*0,105*
PROT 12	*Concrete C25/33*	*Rectangular*	*0,3*	*0,35*	*0,105*
PROT 13	*Concrete C25/30*	*Rectangular*	*0,75*	*0,3*	*0,225*
PROT 14	*Concrete C25/30*	*Rectangular*	*0,75*	*0,3*	*0,225*
PROT 15	*Concrete C25/30*	*Rectangular*	*0,6*	*0,35*	*0,21*
PROT 16	*Concrete C25/30*	*Rectangular*	*0,6*	*0,35*	*0,21*

2.3.2 FRAMES DEFINITION

The calcol code assign automatically a frames numeration, consequently it ha been changed acording with the frame name used before:

MODEL 1 – concrete beam

Frame	**SectionType**	**AnalSect**
Text	Text	Text
A 1	Rectangular	PIL 40x60
A 2	Rectangular	PIL 40x60
B 1	Rectangular	PIL60x90
B 2	Rectangular	PIL60x90
B 3	Rectangular	PIL60x90
B 4	Rectangular	PIL60x90
C 1	Rectangular	PIL60x60
C 2	Rectangular	PIL60x60
C 3	Rectangular	PIL60x60
C 4	Rectangular	PIL60x60
K 1	Rectangular	PIL60x90
K 2	Rectangular	PIL60x90
K 3	Rectangular	PIL60x90
K 4	Rectangular	PIL60x90
B1-2	Rectangular	PIL60x90
1 A-B	Rectangular	PROT4
1 B-C	Rectangular	PROT5
2 A-B	Rectangular	PROT4
2 B-C	Rectangular	PROT7
3 B-C	Rectangular	PROT7
4 B-C	Rectangular	PROT5
A 1-2	Rectangular	PROT1
B 1-2	Rectangular	PROT3
B 2-1	Rectangular	PIL60x90
B 2-3	Rectangular	PROT2
B 3-1	Rectangular	PIL60x90
B 3-4	Rectangular	PROT2
B 4-1	Rectangular	PIL60x90
C 1-2	Rectangular	PROT2
C 2-3	Rectangular	PROT2
C 3-4	Rectangular	PROT2

MODEL 2– concrete beam

Frame	*SectionType*	*AnalSect*
Text	*Text*	*Text*
B 5	*Rectangular*	*PIL60x90*
B 6	*Rectangular*	*PIL60x90*
B 7	*Rectangular*	*PIL60x90*
B 8	*Rectangular*	*PIL60x90*
C-5	*Rectangular*	*PIL60x60*
C-6	*Rectangular*	*PIL60x60*
C-7	*Rectangular*	*PIL60x60*
C-8	*Rectangular*	*PIL60x60*
5 B-D	*Rectangular*	*PROT15*
5 D-C	*Rectangular*	*PROT15*
B 5-6	*Rectangular*	*PROT14*
B 6-7	*Rectangular*	*PROT13*
C 5-6	*Rectangular*	*PROT13*
C 6-7	*Rectangular*	*PROT14*
C 7-8	*Rectangular*	*PROT15*
D 6-7	*Rectangular*	*PROT12*
5' B-D	*Rectangular*	*PROT8*
5' D-C	*Rectangular*	*PROT9*
B 5-5'	*Rectangular*	*PROT14*
B 7'-8	*Rectangular*	*PROT14*
B 7-7'	*Rectangular*	*PROT14*
D 5'-6	*Rectangular*	*PROT11*
D 5-5'	*Rectangular*	*PROT10*
D 7'-8	*Rectangular*	*PROT10*
D 7-7'	*Rectangular*	*PROT11*
5 B inclin	*Rectangular*	*PROT15*
6 B inclin	*Rectangular*	*PROT16*
7 B inclin	*Rectangular*	*PROT16*
8 B inclin	*Rectangular*	*PROT15*
B 5.1	*Rectangular*	*PIL60x90*
B 6.1	*Rectangular*	*PIL60x90*
B 7.1	*Rectangular*	*PIL60x90*
B 8.1	*Rectangular*	*PIL60x90*
K 5	*Rectangular*	*PIL60x90*
K 6	*Rectangular*	*PIL60x90*
K 7	*Rectangular*	*PIL60x90*
K 8	*Rectangular*	*PIL60x90*

For the sections assignement on the roof see the ***ATTACHEMENT A.***

2.3.3 LOADS ASSIGNEMENT

The loads are assigned considering the self weight (G1+ G2) of the roof, and of variable loads descript on national regulations.
These loads are assigned directly on the beam, linearly.
The weight of beams and columns has been self evaluated by the calcul program including in the voice "Self weight elements".

MODEL 1 – X direction

Beam	*Lenght (m)*	*G2 kN/m*	*Qk kN/m*
A 1-2	*7,53*	*5,6*	*4,7*
B 1-2	*7,53*	*11,2*	*9,4*
B 2-3	*7,7*	*5,7*	*4,8*
B 3-4	*7,6*	*5,7*	*4,8*
C 1-2	*7,53*	*10,8*	*4,7*
C 2-3	*7,7*	*10,9*	*4,8*
C 3-4	*7,6*	*10,9*	*4,8*

MODEL 2 – X direction

Beam	*Lenght (m)*	*G2 kN/m*	*Qk kN/m*
B 5-5'	*4,1*	*7,4*	*4,8*
B 5'-6	*3,45*	*7,4*	*4,8*
B 6-7	*7,7*	*14,9*	*4,8*
B 7-7'	*3,45*	*7,6*	*4,8*
B 7'-8	*4,1*	*7,4*	*4,8*
D 5-5'	*4,1*	*26,5*	*22,3*
D 5'-6	*3,45*	*7,6*	*6,3*
D 6-7	*7,7*	*7,6*	*6,3*
D 7-7'	*3,45*	*7,6*	*6,3*
D 7'-8	*4,1*	*26,5*	*22,3*
C 5-5'	*4,1*	*24,2*	*16*
C 5'-6	*3,45*	*5,2*	*0*
C 6-7	*7,7*	*5,2*	*0*
C 7-7'	*3,45*	*5,2*	*0*
C 7'-8	*4,1*	*5,2*	*0*

MODEL 1 – Y direction

Beam	*Lenght (m)*	*G2 kN/m*	*Qk kN/m*
1 A-B	*5*	*19,8*	*14,1*
1 B-C	*9*	*19,8*	*14,1*
2 A-B	*5*	*16,8*	*14,1*
2 B-C	*9*	*34*	*28,6*
3 B-C	*9*	*34,1*	*28,7*
4 B-C	*9*	*17*	*14,3*

MODEL 2 – Y direction

Beam	*Lenght (m)*	*G2 kN/m*	*Qk kN/m*
5 B-C	*9*	*0*	*0*
6 B-C	*9*	*0*	*0*
7 B-C	*9*	*0*	*0*
8 B-C	*9*	*0*	*0*

For the loads assignement on the roof see the ***ATTACHEMENT B.***

2.3.4 LOAD COMBINATIONS

2.3.4.1 *Load patterns definition*

To obtain the LOADS COMBINATIONS on the building is essential made on the calcol model the following Loads Patterns.
They are fondametally because every time that has to be assigned a load (distribuited or punctual) to a frame or a joint, has to be specified on the Calcol Code in what of the following Patterns Loads fall the value.

Case	***Type***	***InitialCond***	***Analysis modal case***
DEAD	*LinStatic*	*Zero*	
MODAL	*LinModal*	*Zero*	
G1	*LinStatic*	*Zero*	
G2	*LinStatic*	*Zero*	
SNOW	*LinStatic*	*Zero*	
ACC USO	*LinStatic*	*Zero*	
WIND CASE1	*LinStatic*	*Zero*	
WIND CASE 2	*LinStatic*	*Zero*	
WIND CASE 3	*LinStatic*	*Zero*	
SPETTX_SLD	*response spectrum*		*MODAL*
SPETTY_SLD	*response spectrum*		*MODAL*
SPETTX_SLV	*response spectrum*		*MODAL*
SPETTY_SLV	*response spectrum*		*MODAL*

2.3.4.2 *Load Cases Definition*

It is possible to deifine the following Load Cases.

LoadPat	**DesignType**	**SelfWtMult**
DEAD	DEAD	1
G1	DEAD	0
G2	DEAD	0
SNOW	DEAD	0
ACC USO	DEAD	0
ACC ROOF	DEAD	0
WIND CASE 1	DEAD	0
WIND CASE 2	DEAD	0
WIND CASE 3	DEAD	0

It has to pay attention to the following load case "spectrum" that are based on the vibrations modes and mix them with a modal combination CQC type and with a directional combination ordering from the ABS scale factor "1".
The following table define in a detailled way the parameters used:

Load case	Load Type	Direction	Spectral function	Scale factor	Modal Combination	Scale factor	ABS scale factor
SPETTX_SLD	Acceleration	U1	spettro allo Sld	9,81	CQC	ABS	1
	Acceleration	U2	spettro allo Sld	2,94			
SPETTY_SLD	Acceleration	U2	spettro allo Sld	9,81	CQC	ABS	1
	Acceleration	U1	spettro allo Sld	2,94			
SPETTX_SLV	Acceleration	U1	spettro allo Slv	9,81	CQC	ABS	1
	Acceleration	U2	spettro allo Slv	2,94			
SPETTY_SLV	Acceleration	U2	spettro allo Slv	9,81	CQC	ABS	1
	Acceleration	U1	spettro allo Slv	2,94			

2.3.4.3 *Loads combinations*

Now is possible to define the following loads combinations:

ComboName	***ComboType***	***CaseType***	***CaseName***	***ScaleFactor***
COMB1 SLU NEVE+WIND1	*Linear Add*	*Linear Static*	*G1*	*1,35*
		Linear Static	*G2*	*1,35*
		Linear Static	*SNOW*	*1,5*
		Linear Static	*DEAD*	*1,35*
		Linear Static	*WIND CASE1*	*0,75*
		Linear Static	*ACC ROOF*	*0,75*
COMB1 SLU NEVE+WIND2	*Linear Add*	*Linear Static*	*G1*	*1,35*
		Linear Static	*G2*	*1,35*
		Linear Static	*SNOW*	*1,5*
		Linear Static	*DEAD*	*1,35*
		Linear Static	*WIND CASE 2*	*0,75*
		Linear Static	*ACC ROOF*	*0,75*
COMB1 SLU NEVE+WIND3	*Linear Add*	*Linear Static*	*G1*	*1,35*
		Linear Static	*G2*	*1,35*
		Linear Static	*SNOW*	*1,5*
		Linear Static	*DEAD*	*1,35*
		Linear Static	*WIND CASE 3*	*0,75*
		Linear Static	*ACC ROOF*	*0,75*
COMB2.1-CATEGORIA+WIND1	*Linear Add*	*Linear Static*	*DEAD*	*1,35*
		Linear Static	*G1*	*1,35*
		Linear Static	*ACC ROOF*	*1,5*
		Linear Static	*G2*	*1,35*
		Linear Static	*ACC USO*	*1,5*
		Linear Static	*WIND CASE1*	*0,9*
		Linear Static	*SNOW*	*0,75*
COMB2.2-CATEGORIA+WIND2	*Linear Add*	*Linear Static*	*DEAD*	*1,35*
		Linear Static	*G1*	*1,35*
		Linear Static	*ACC ROOF*	*1,5*
		Linear Static	*G2*	*1,35*
		Linear Static	*ACC USO*	*1,5*
		Linear Static	*WIND CASE 2*	*0,9*
		Linear Static	*SNOW*	*0,75*
COMB2.3-CATEGORIA+WIND3	*Linear Add*	*Linear Static*	*DEAD*	*1,35*
		Linear Static	*G1*	*1,35*
		Linear Static	*ACC ROOF*	*1,5*
		Linear Static	*G2*	*1,35*
		Linear Static	*ACC USO*	*1,5*
		Linear Static	*WIND CASE 3*	*0,9*
		Linear Static	*SNOW*	*0,75*
COMB3.1-WIND 1	*Linear Add*	*Linear Static*	*G1*	*1,35*
		Linear Static	*G2*	*1,35*
		Linear Static	*WIND CASE1*	*1,5*
		Linear Static	*DEAD*	*1,35*
		Linear Static	*ACC USO*	*0,75*

COMB 3.2 -WIND 2	*Linear Add*	*Linear Static*	*G1*	*1,35*
		Linear Static	*G2*	*1,35*
		Linear Static	*WIND CASE 2*	*1,5*
		Linear Static	*DEAD*	*1,35*
		Linear Static	*ACC USO*	*0,75*
		Linear Static	*SNOW*	*0,75*
COMB3.3-WIND3	*Linear Add*	*Linear Static*	*G1*	*1,35*
		Linear Static	*G2*	*1,35*
		Linear Static	*WIND CASE 3*	*1,5*
		Linear Static	*DEAD*	*1,35*
		Linear Static	*ACC USO*	*0,75*
		Linear Static	*SNOW*	*0,75*
ENVELOPE	*Envelope*	*Response Combo*	*COMB1 SLU NEVE+WIND1*	*1*
		Response Combo	*COMB1 SLU NEVE+WIND1*	*1*
		Response Combo	*COMB1 SLU NEVE+WIND2*	*1*
		Response Combo	*COMB1 SLU NEVE+WIND3*	*1*
		Response Combo	*COMB2.1-CATEGORIA+WIND1*	*1*
		Response Combo	*COMB2.2-CATEGORIA+WIND2*	*1*
		Response Combo	*COMB2.3-CATEGORIA+WIND3*	*1*
		Response Combo	*COMB 3.1-WIND1*	*1*
		Response Combo	*COMB 3.2-WIND2*	*1*
		Response Combo	*COMB 3.3-WIND3*	*1*

And the seismic combinations evaluated are the following:

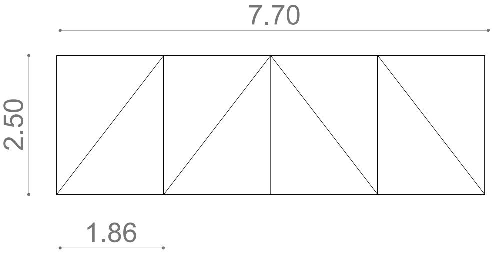
ComboName	***ComboType***	***CaseType***	***CaseName***	***ScaleFactor***
SLDX	*Linear Add*	*Linear Static*	*DEAD*	*1*
		Linear Static	*G1*	*1*
		Linear Static	*G2*	*1*
		Response Spectrum	*SPETTSLD_X*	*1*
		Linear Static	*ACC USO*	*0,3*
		Linear Static	*ACC ROOF*	*0,3*
SLDY	*Linear Add*	*Linear Static*	*DEAD*	*1*
		Linear Static	*G1*	*1*
		Linear Static	*G2*	*1*
		Response Spectrum	*SPETTSLD_Y*	*1*
		Linear Static	*ACC USO*	*0,3*
		Linear Static	*ACC ROOF*	*0,3*
SLVX	*Linear Add*	*Linear Static*	*DEAD*	*1*
		Linear Static	*G1*	*1*
		Linear Static	*G2*	*1*
		Response Spectrum	*SPETTSLV_X*	*1*
		Linear Static	*ACC USO*	*0,3*
		Linear Static	*ACC ROOF*	*0,3*

ComboName	***ComboType***	***CaseType***	***CaseName***	***ScaleFactor***
SLVY	*Linear Add*	*Linear Static*	*DEAD*	*1*
		Linear Static	*G1*	*1*
		Linear Static	*G2*	*1*
		Response Spectrum	*SPETTSLV_Y*	*1*
		Linear Static	*ACC USO*	*0,3*
		Linear Static	*ACC ROOF*	*0,3*
SXSLV_TP	*Linear Add*	*Linear Static*	*TORCX_SLV*	*1*
		Response Spectrum	*SPETTSLV_X*	*1*
SXSLV_TN	*Linear Add*	*Linear Static*	*TORCX_SLV*	*-1*
		Response Spectrum	*SPETTSLV_X*	*1*
SYSLV_TP	*Linear Add*	*Linear Static*	*TORCY_SLV*	*1*
		Response Spectrum	*SPETTSLV_Y*	*1*
SYSLV_TN	*Linear Add*	*Linear Static*	*TORCY_SLV*	*-1*
		Response Spectrum	*SPETTSLV_Y*	*1*

2.4 SECONDARY TRUSS STEEL DESIGN

The secondary truss is connected to the primary in correspondance of the risers and his height depends by theyr length. In favour of security we consider the most unfavorable case with the maximum height of the secondary struts corresponding to the longer riser on the primary truss (3,50 m).

The secondary truss steel has the following charactherisitcs:



2.4.1 LOAD COMBINATIONS

The loads that have to be considered for the predimensioning of the purlin are the following:

q_c = *weight roof* = $0{,}423\ KN/m^2$
q_s= *snow loads* = $0{,}2\ KN/m^2$
q_{w1} = *wind loads* = $0{,}736\ KN/m^2$
q_e = *exercise load* = $1\ KN/m$
q_p = *weight purlin (unknoun)*

The influence area of a single purlin, egual at the axile base, is of 1,86 m.

For the predimensioning we consider the combination SLU/SLE corrispondent to the worst operating conditions.

Then: q_c = *weight roof* = $(0{,}423\ KN/m^2 \cdot 1{,}86\ m) / \cos 6 = 0{,}76\ KN/m$
q_s= *snow loads* = $0{,}2\ KN/m^2 \cdot 1{,}86\ m = 0{,}37\ KN/m$
q_e = *exercise load* = $(1\ KN/m^2 \cdot 1{,}86\ m) = 1{,}86\ KN/m$
q_p = *weight purlin (unknoun)*
q_{w1} = *wind loads* = $(0{,}736\ KN/m^2\ 1{,}86\ m)/\cos 6 = 1{,}36\ KN/m$

ULS: characteristic combination

ULS: comb. 1 (Q_k snow):

$$F_d = 1.3 \cdot (0{,}76) + 1.5 \cdot (0{,}37) = 1{,}54\ kN/m$$

ULS :comb. 2(Q_k exerc.):

$$F_d=1.3\cdot(0{,}76)+1.5(1{,}86\,)=3{,}77\ kN/m$$

ULS:comb. 3 (Q_k wind):

$$F_d = 1{,}3 \cdot (0{,}76) + 1.5 \cdot (-1{,}36) +1{,}5*(0{,}5*0{,}37) = -0{,}77\ kN/m$$

ELS: characteristic combination

ELS – comb. 1 (Q_k pred. snow):

$$F_d = 1 \cdot (0{,}76) + 1 \cdot (0{,}37) = 1{,}13\ kN/m$$

ELS – comb. 2 (Q_k pred. exerc.):

$$F_d = 1 \cdot (0{,}76) + 1 \cdot (1{,}86) =2{,}62\ kN/m$$

ELS – comb. 2 (Q_k pred. wind):

$$F_d = 1 \cdot (0{,}76) + 1 \cdot (-1{,}36) +(0{,}5*0{,}37)= -0{,}41\ kN/m$$

The first two combination are used to evaluate the maximum loads directed downwards.

The third combination maximize the loads upwards; this one in particolar it's useful to evaluate if ,the wind action, can originate a force invertion, causing tensile stress on elements before compressed and the other way round.

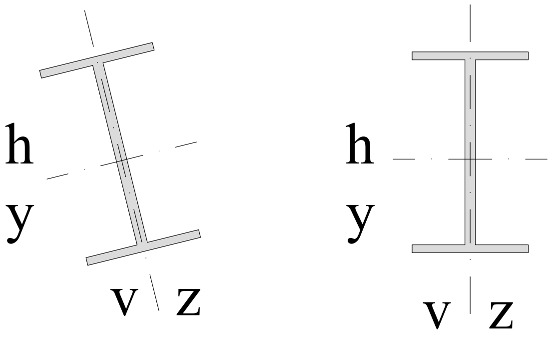
We consider the worst load combination:

ULS- comb.2
ELS – comb.2

2.4.2 DESIGN AND VERIFICATION OF THE PURLIN

2.4.2.1 ***Predimensioning of the purlin***

On first approximation and for semplicity we consider that the purlin have one of the two principal axis parallel to the terrain.



Considering the purlin like a simply supported beam on a light of L= 2,5 m , the maximum moment in the middle is :

$$M_{ed} = F_d \cdot \frac{L^2}{8} = 3{,}77\ \frac{KN}{m} \cdot \frac{(2{,}5m)^2}{8} = 2{,}94\ KN\ m$$

Considering the verific of the bending elements:

$$\frac{M_{ed}}{M_{c,rd}} \leq 1$$

where $M_{c,rd} = \frac{W \quad f_{yk}}{\gamma_{MO}}$ *(Plastic Moment class 1-2)*

so : $W_y \geq \frac{\gamma_{MO} \cdot M_{ed}}{f_{yk}} = \frac{1{,}05 \cdot 2940000}{235} = 13136{,}1\ mm^3 = 13{,}13\ cm^3$

We choose an HEA 100 with :

Wy =26,7 cm^3

For the ESL the "Codigo Tecnico" provides one value for the maximum deformation:

$$f \leq L/300$$

considering that:

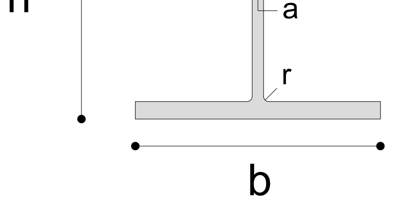
$$f = \frac{5 \cdot F_d \cdot L^4}{384 \cdot E \cdot J_x}$$

by inverting the equation:

$$J_x = \frac{5 \cdot F_d \cdot L^4 \cdot 300/L}{384 \cdot E} = \frac{5 \cdot 2{,}62\ KN/m \cdot (2{,}5m)^4 \cdot \frac{300}{2{,}5} mm}{384 \cdot 210000} =$$

$$J_x = 7641486{,}2\ mm^4$$

We choose therefore an HEA 100 section with the following characteristics:



Name HEA	**b (mm)**	**h (mm)**	**a (mm)**	**e (mm)**	**r (mm)**	**Weight (Kg/m)**	**Section (cm^2)**	**Jx (cm^4)**	**Jy (cm^4)**	**Wx (cm^3)**	**Wy (cm^3)**	**Ix**	**Iy**
100	100	96	5	8	12	16,7	21,24	349,2	133,8	72,6	26,7	4,06	2,51

2.4.2.1.1 Excercise state limite verifications

We start with the ELS beacuse is more burdensome than the ultimate limited state.

ELS – comb. 2 (Q_k pred. exerc.) $F_d = 1 \cdot (0,76+0,16) + 1 \cdot (1,86) = 2,78$ *kN/m*

Decomposing the force following the direction of principal axis, we obtain:

ELS – comb. 1 (Q_k pred. snow) $F_{dz} = 2,78$ *kN/m* $\cdot \cos 6° = 2,76$ *KN/m*

$F_{dy} = 2,78$ *kN/m* $\cdot$ *sen* $6° = 0,29$ *KN/m*

The downward deformation is :

$$f_z = \frac{5 \cdot F_{dz} \cdot L^4}{384 \cdot E \cdot J_y} = \frac{5 \cdot 2,76\, KN/m \cdot (2500m)^4}{384 \cdot 210000 \cdot 3492000} = 1,91\, mm$$

$$f_y = \frac{5 \cdot F_{dy} \cdot L^4}{384 \cdot E \cdot J_z} = \frac{5 \cdot 0,29\, KN/m \cdot (2500m)^4}{384 \cdot 210000 \cdot 1330000} = 0,52\, mm$$

$$f = \sqrt{f_z^2 + f_y^2} = 1,98\, mm < \frac{2500mm}{300} = 8,33\, mm$$

the verific is satisfied.

2.4.2.1.2 Ultime state limite verification

For the purlin verific at USL we consider the COMBO2 predominant because is the most unfavorable.
At the load combination we add the weight of the HEB200 section:

ULS :comb. 2(Q_k exerc.):

$F_d = 1.3 \cdot (0,76+0,16) + 1.5(1,86) = 3,98$ *kN/m*

Decomposing the force following the direction of principal axis, we obtain:

ULS :comb. 2(Q_k exerc.):

F_{dz} = 6,20 kN/m · cos 6° =3,86 KN/m

F_{dy} = 6,20 kN/m · sen 6° =0,41 KN/m

2.4.2.2 *ULS verification of the purlin*

2.4.2.2.1 Evaluation of the shear stress project

Considering the purlin like a simply supported beam on a light of L =2,5 m , the maximum values of shear stress are on the edge section:

$$V_z = F_{dz} \cdot \frac{L}{2} = 3{,}86\ \frac{KN}{m} \cdot \frac{2{,}5\ m}{2} = 4{,}82\ KN$$

$$M_z = 0$$

$$V_y = F_{dy} \cdot \frac{L}{2} = 0{,}41\ \frac{KN}{m} \cdot \frac{2{,}5\ m}{2} = 0{,}51\ KN$$

$$M_y = 0$$

2.4.2.2.2 Shear verification

Is made on the edges where the shear is maxim; we have the following load stress:

$$V_z = 4{,}82\ KN$$

$$V_y = 0{,}51\ KN$$

The verific consist in the control that the following relationship is satisfied:

$$\frac{V_{ed}}{V_{rd}} \leq 1$$

where :

$$V_{z,rd} = \frac{A_{VZ} \cdot f_{yk}}{\sqrt{3} \cdot \gamma_{M0}} = \frac{372 \cdot 235}{\sqrt{3} \cdot 1{,}05} = 48068{,}7N$$

$$\frac{V_z}{V_{rd,z}} = 0{,}1 \leq 1$$

$$V_{y,rd} = \frac{A_{Vy} \cdot f_{yk}}{\sqrt{3} \cdot \gamma_{M0}} = \frac{1404 \cdot 235}{\sqrt{3} \cdot 1{,}05} = 181419\ N$$

$$\frac{V_y}{V_{rd,y}} = 0{,}002 \leq 1$$

where for I and H section is possible to assume like a resistant surface at shear stress the value calcolable with the following formulas:
Z direction:

$$A_{vz} = (\,A - 2 \cdot b\ \cdot\ e\,) + (a - 2r) \cdot e = (\,2124 - 2 \cdot 100\ \cdot\ 8\,) + (5 - 24) \cdot 8 \\ = 372\,mm^2$$

Y direction :

$$A_{vy} = A - \sum(e \cdot (h - 2a) = 2124 - \sum(8 \cdot (100 - 10) = \ 1404\,mm^2$$

2.4.2.2.3 Evaluation of the moment project stress

Considering the purlin like a simply supported beam on a light of L =2,5 m , the maximum values of bending moment are in the Middle section:

$$V_z = \ 0$$

$$M_z = F_{dy}\ \cdot \frac{L^2}{8} = 3{,}86\frac{KN}{m} \cdot \frac{(2{,}5m)^2}{8} = 3{,}01\ KN\ m$$

$$V_y = \ 0$$

$$M_y = F_{dy}\ \cdot \frac{L^2}{8} = 0{,}41\frac{KN}{m} \cdot \frac{(2{,}5m)^2}{8} = 0{,}32\ KN\ m$$

2.4.2.2.4 Bending moment verification

Is made on the middle section where the bending moment is maxim; we have the following load stress:

$$M_z = 3{,}01\ KN\ m$$

$$M_y = 0{,}32\ KN\ m$$

In the biaxal verific for section I we have to control that:

$$\left(\frac{M_y}{M_{y,rd}}\right) + \left(\frac{M_z}{M_{z,rd}}\right) \leq 1$$

with

$$M_{y,rd} = \frac{W_y \cdot f_{yk}}{\gamma_{M0}} = \frac{26760mm \cdot 235}{1{,}05} = 5{,}98\ KN\ m$$

$$M_{Z,rd} = \frac{W_Z \cdot f_{yk}}{\gamma_{M0}} = \frac{72760mm \cdot 235}{1{,}05} = 17{,}2\ KN\ m$$

so

$$\left(\frac{0{,}32\ KN\ m}{5{,}98\ KN\ m}\right) + \left(\frac{3{,}01KN\ m}{17{,}2\ KN\ m}\right) = 0{,}22 \leq 1$$

2.4.3 DESIGN AND VERIFICATION OF THE TRUSS ELEMENT

2.4.3.1 *Predimensioning of the truss struts*

The maximum value of axial force on slash evaluated is:

$N_{max} = 10{,}91\ KN$

Considering that :

$$\frac{N_{max}}{N_{rd}} \leq 1$$

where :

$$N_t = \frac{A \cdot f_{yk}}{\gamma_{mo}}$$

we obtain:

$$A = \frac{N_{ed} \cdot \gamma_{MO}}{f_{yk}} = \frac{10910N \cdot 1.05}{235} = 48{,}74\ mm^2$$

we choose a cave section with the following characteristics each:

Cave section	***b (mm)***	***h (mm)***	***r_0 (mm)***	***r_i (mm)***	***e***	***Section (cm^2)***	***Weight (Kg/m)***	***J (cm^4)***	***W (cm^3)***	***I (mm)***
50x50	*50*	*50*	*10*	*5*	*5*	*835,62*	*6,56*	*27,04*	*10,82*	*17,99*

Axial surface provided:

$$A = 578{,}05\ mm^2$$

2.4.3.2 *Predimensioning of the chord*

For the predimensioning of chord we consider the following maximum forces:
$N_{max,compr} = 1,5\ KN$

The estabilty verific for the compressed beam is the most burdensome.

$$\frac{N_{max,compr}}{N_{est,rd}} \leq 1$$

where

$$N_{est,rd} = \frac{x \cdot A \cdot f_{yk}}{\gamma_{M!}}$$

For first approximation we consider x = 0,8, to get A like single unknown quantity. Inverting it we obtain:

$$A = \frac{N_{max,compr} \cdot \gamma_{M1}}{x \cdot f_{yk}} = \frac{1500\,N \cdot 1,05}{235\,N/mm^2 \cdot 0,8} = 8,37\,mm^2$$

consequently we choose an T 50x50x7 section with the following characteristics:

Name T	b (mm)	h (mm)	a (mm)	Weight (Kg/m)	Section (cm^2)	Jx (cm^4)	Jy (cm^4)	Wx (cm^3)	Wy (cm^3)	Ix	Iy
50x50	*50*	*50*	*7*	*5,1*	*6,51*	*14,9*	*7,41*	*4,26*	*2,97*	*1,51*	*1,07*

Axial surface provided:

$$A = 651\ mm^2$$

Now we have to verific if the "x" value corresponding to the choosen profiles is ≥ 0,8

$$x = \frac{1}{\phi + \sqrt{\phi^2 - \lambda}} \leq 1\,mm^2$$

where:

$$\bar{\lambda} = \frac{\lambda}{\pi \cdot \sqrt{\frac{E}{f_{yk}}}} = \frac{88,15}{3,14 \cdot \sqrt{\frac{210000}{235}}} = 0,94$$

with:

$$\lambda = \frac{1}{\rho_{min}} = \frac{i}{cos\alpha} \cdot \frac{1}{\rho_z} = \frac{1860}{cos6} \cdot \frac{1}{21,1} = 88,15$$

$$\phi = 0,5 \cdot [1 + \alpha \cdot (\lambda - 0,2) + \lambda^2] = 0,5 \cdot [1 + 0,49 \cdot (0,94 - 0,2) + 0,94^2]$$

$$\phi = 1{,}12$$

α *= amplification factor due to lamined section and inflection on the z-axis.*

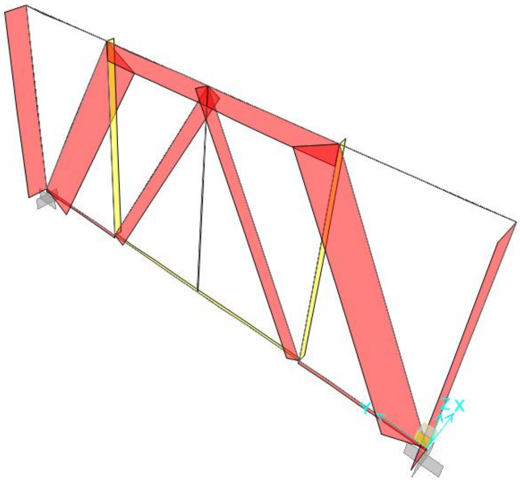
At the end we obtain:

$$x = \frac{1}{1{,}12 + \sqrt{(1{,}12)^2 - (0{,}94)^2}} = 0{,}78$$

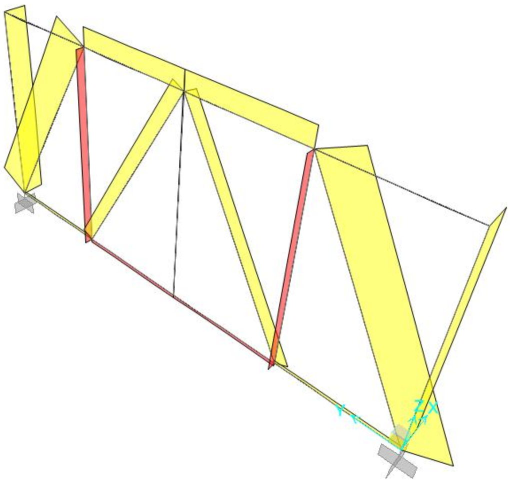
2.4.3.3 *Evaluation of the Project strains*

The evaluation of the project strains is made considering the following cases:

ULS :comb. 2(Q_k *exerc.):* F_d *=7,01 kN*



ULS:comb. 3 (Q_k *wind):* F_d *=-1,43 kN*



2.4.3.4 *ULS verification of the struts*

The struts are set up with cave quadre section 50x50 mm with the following characteristics:

Cave section	***b (mm)***	***h (mm)***	***r_0 (mm)***	***r_i (mm)***	***e***	***Section (cm^2)***	***Weight (Kg/m)***	***J (cm^4)***	***W (cm^3)***	***I (mm)***
50x50	*50*	*50*	*10*	*5*	*5*	*835,62*	*6,56*	*27,04*	*10,82*	*17,99*

The compression verific is made considering that :

$$\frac{N_{max,compr}}{N_{rd}} \leq 1$$

where :

$$N_{rd} = \frac{A \cdot f_{yk}}{\gamma_{mo}}$$

The tenisile stress verific is made considering that

$$\frac{N_{max,tens}}{N_{rd}} \leq 1$$

And the estabilty verific is made considering:

$$\frac{N_{max,compr}}{N_{est,rd}} \leq 1$$

where

$$N_{est,rd} = \frac{x \cdot A \cdot f_{yk}}{\gamma_{M1}}$$

$$x = \frac{1}{\phi + \sqrt{\phi^2 - \lambda}} \leq 1\, mm^2$$

where:

$$\bar{\lambda} = \frac{\lambda}{\pi \cdot \sqrt{\frac{E}{f_{yk}}}}$$

with:

$$\lambda = \frac{1}{\rho_{min}} = l\,\frac{1}{\rho_z}$$

$$\phi = 0{,}5 \cdot [1 + \alpha \cdot (\lambda - 0{,}2) + \lambda^2]$$

α = amplification factor due to lamined section and inflection on the z-axis.

Following the verific for all the struts:

Strut	**Lenght**	**Section**	**Area**	i_y	λ_{adim}	λ =	α	Φ	χ	$N_{b,Rd}$	$N_{t,rd}$
11	3963,53	L	835,62	17,99	220,32	2,35	0,49	3,78	0,15	27,73	187,02
11	3963,53	L	835,62	17,99	220,32	2,35	0,49	3,78	0,15	27,73	187,02
12	3963,53	L	835,62	17,99	220,32	2,35	0,49	3,78	0,15	27,73	187,02
12	3963,53	L	835,62	17,99	220,32	2,35	0,49	3,78	0,15	27,73	187,02

Beam	$N_{b,Rd}$	$N_{t,rd}$	**COMBO2**	**COMBO3**	*Estability Verific*	*Tensile stress Verific*
					$N_{ed}/N_{b,rd}$	$N_{ed}/N_{t,rd}$
11	27,73	187,02	-12,417	2,627	0,448	0,014
20	27,73	187,02	-5,344	1,184	0,193	0,006
27	27,73	187,02	-5,344	1,184	0,193	0,006
41	27,73	187,02	-12,417	2,627	0,448	0,014

2.4.3.5 *ULS verification of the chords*

The chords have the following geometric characteristics:

Name T	***b (mm)***	***h (mm)***	***a (mm)***	***Weight (Kg/m)***	***Section*** (cm^2)	***Jx*** (cm^4)	***Jy*** (cm^4)	***Wx*** (cm^3)	***Wy*** (cm^3)	***Ix***	***Iy***
50x50	*50*	*50*	*7*	*5,1*	*6,51*	*14,9*	*7,41*	*4,26*	*2,97*	*1,51*	*1,07*

The compression verific is made considering that :

$$\frac{N_{max,compr}}{N_{rd}} \leq 1$$

where :

$$N_{rd} = \frac{A \cdot f_{yk}}{\gamma_{mo}}$$

The tenisile stress verific is made considering that

$$\frac{N_{max,tens}}{N_{rd}} \leq 1$$

And the estabilty verific is made considering:

$$\frac{N_{max,compr}}{N_{est,rd}} \leq 1$$

where

$$N_{est,rd} = \frac{x \cdot A \cdot f_{yk}}{\gamma_{M1}}$$

$$x = \frac{1}{\phi + \sqrt{\phi^2 - \lambda}} \leq 1\, mm^2$$

where:

$$\bar{\lambda} = \frac{\lambda}{\pi \cdot \sqrt{\frac{E}{f_{yk}}}}$$

with:

$$\lambda = \frac{1}{\rho_{min}} = l\,\frac{1}{\rho_z}$$

$$\phi = 0{,}5 \cdot [1 + \alpha \cdot (\lambda - 0{,}2) + \lambda^2]$$

α = amplification factor due to lamined section and inflection on the z-axis =0,34.

Following the verific for all the chords:

Chord	**Lenght**	**Section**	**Area**	i_y	λ_{adim}	$\lambda =$	α	Φ	χ	$N_{b,Rd}$	$N_{t,rd}$
1	1860	T	651	10,7	173,83	1,85	0,34	2,62	0,22	32,58	145,70
2	1860	T	651	10,7	173,83	1,85	0,34	2,62	0,22	32,58	145,70
3	1860	T	651	10,7	173,83	1,85	0,34	2,62	0,22	32,58	145,70
4	1860	T	651	10,7	173,83	1,85	0,34	2,62	0,22	32,58	145,70
5	1860	T	651	10,7	173,83	1,85	0,34	2,62	0,22	32,58	145,70
6	1860	T	651	10,7	173,83	1,85	0,34	2,62	0,22	32,58	145,70
7	1860	T	651	10,7	173,83	1,85	0,34	2,62	0,22	32,58	145,70
8	1860	T	651	10,7	173,83	1,85	0,34	2,62	0,22	32,58	145,70

Beam	$N_{b,Rd}$	$N_{t,rd}$	**COMBO2**	**COMBO3**	Estability Verific	Tensile stress Verific
					$N_{ed}/N_{b,rd}$	$N_{ed}/N_{t,rd}$
1	32,58	145,70	-0,0037	0,0007548	0,000	0,000
2	32,58	145,70	-5,137	1,048	0,158	0,007
3	32,58	145,70	-5,137	1,048	0,158	0,007
4	32,58	145,70	-0,0037	0,0007548	0,000	0,000
5	32,58	145,70	-0,955	0,195	0,029	0,001
6	32,58	145,70	0,955	-0,195	0,006	0,007
7	32,58	145,70	0,955	-0,195	0,006	0,007
8	32,58	145,70	-0,955	0,195	0,029	0,001

2.4.3.6 *ELS verification*

Considering the integrity of constructiv elements, is admitted that the roof is suficient rigid if, for all his parts, the deformability arrow is lowest than:

$$a < \frac{1}{300} \cdot l$$

Where:

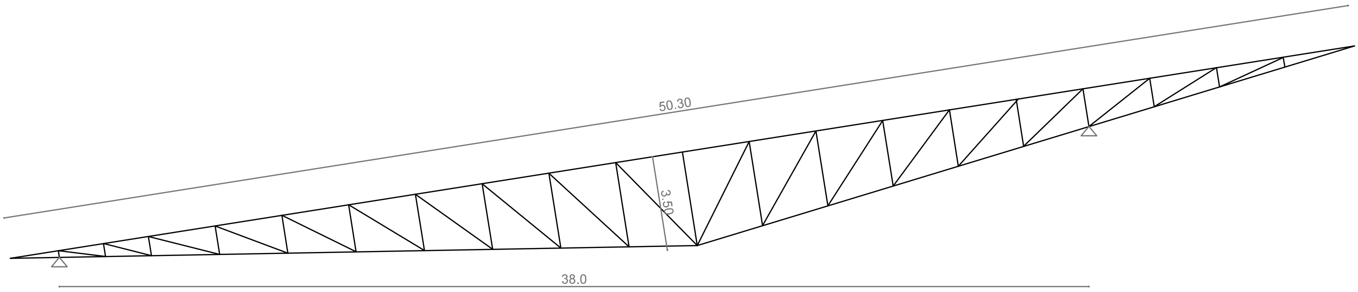
$l = 38{,}9\ m$

ELS – comb. 1 (Q_k pred. EXERC) $F_d = 1 \cdot (1{,}48) + 1 \cdot (1) = 2{,}48\ kN/m$

COMBINATION	***Displacements***		***Real Displacement***	***Admisible Displacement***	***Verific R/A***
	U1 (mm)	*U2 (mm)*			
SLE	*4,280*	*-19,804*	*20,261*	*129,666*	*0,156*

2.5 PRIMARY TRUSS STEEL DESIGN

The primary truss steel has the following charactherisitcs:



To set the height of the truss steel we use the following pratic rule:

$$\frac{L}{15} \leq h \leq \frac{L}{10}$$

so

$$3{,}32\ m \leq h \leq 4{,}92\ m$$

we choose h = 3,50 m.
The struts width is of 50,30 m, with a maximum height of 3,50. Are built on column wit disposed with a structural mesh of 38 m x 7,70m.
The secondary beams are connected to the primary every 2,50 m in correspondace of the risers of the struts.

2.5.1 LOAD COMBINATIONS

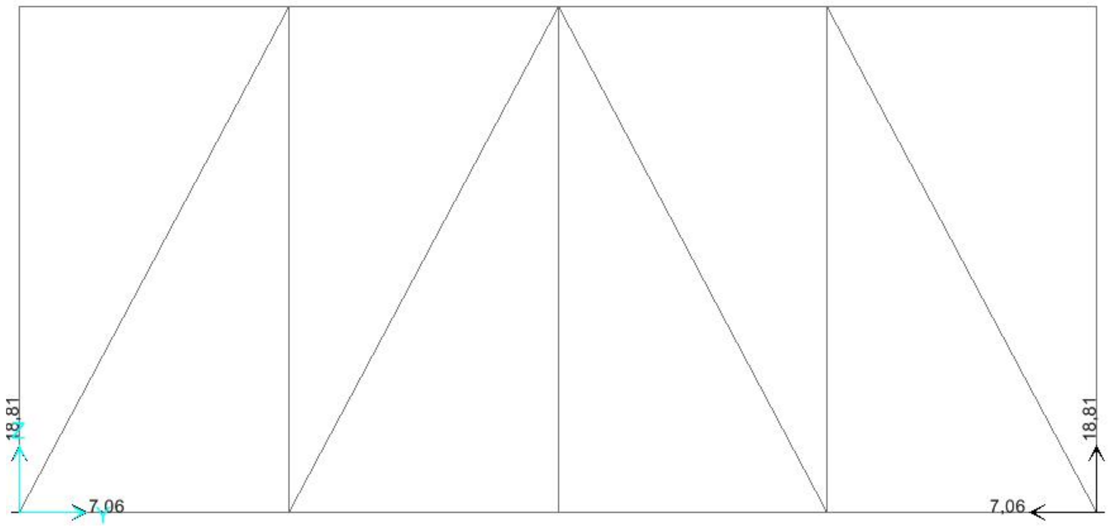
The loads that have to be considered for the predimensioning of the purlin are the following:

q_c = *weight roof = 0,423 KN/*m^2
q_s= *snow loads = 0,2 KN/*m^2
q_{w1} = *wind loads = 0,736 KN/*m^2
q_e = *exercise load = 1 KN/m*
q_p = *weight purlin (unknoun)*

The concentrate load applied on the joints of the principal struts are evaluated considering the reaction forces on the foot anchorage of the secondary struts.
We obtain the following loads:

ULS: characteristic combination

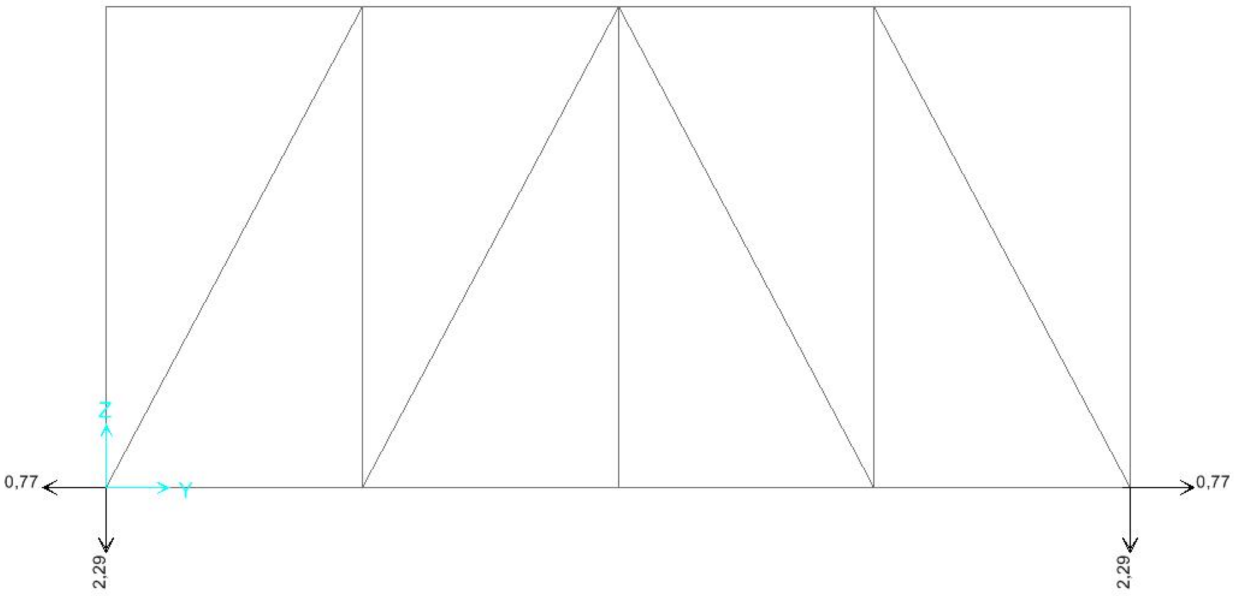
ULS:comb. 2(Q_k exerc.):



$F_{d,x}$ =0 kN

$F_{d,z}$ =36,62 kN

ULS:comb. 3 (Q_k wind):



$F_{d,x}$ =0 kN

$F_{d,z}$ =-4,58 kN

The value obtained are duplicated because on each primaries struss are connected two secondaries struts.

2.5.2 DESIGN AND VERIFICATION OF THE TRUSS ELEMENT

2.5.2.1 *Predimensioning of the truss struts*

The maximum value of axial force on slash evaluated is:

$N_{max} = 552\ KN$

Considering that :

$$\frac{N_{max}}{N_{rd}} \leq 1$$

where :

$$N_t = \frac{A \cdot f_{yk}}{\gamma_{mo}}$$

we obtain:

$$A = \frac{N_{ed} \cdot \gamma_{MO}}{f_{yk}} = \frac{552000KN \cdot 1.05}{235} = 2466\ cm^2$$

we choose cave quadre section with the following characteristics:

Cave section	b (mm)	h (mm)	r_0 (mm)	r_i (mm)	e	Section (cm^2)	Weight (Kg/m)	J (cm^4)	W (cm^3)	I (mm)
140x140	140	140	17,5	10,5	7	3123,29	24,52	920,4	155,3	54,29

Axial surface provided:

$$A = 3123{,}29\ mm^2$$

2.5.2.2 *Predimensioning of the chord*

For the predimensioning of chord we consider the following maximum forces:
$N_{max,compr} = 925\ KN$
$N_{max,traz} = 1004\ KN$

The estabilty verific for the compressed beam is the most burdensome.

$$\frac{N_{max,compr}}{N_{est,rd}} \leq 1$$

where

$$N_{est,rd} = \frac{x \cdot A \cdot f_{yk}}{\gamma_{M!}}$$

For first approximation we consider x = 0,8, to get A like single unknown quantity. Inverting it we obtain:

$$A = \frac{N_{max,compr} \cdot \gamma_{M1}}{x \cdot f_{yk}} = \frac{925000\, N \cdot 1{,}05}{235\, N/mm^2 \cdot 0{,}8} = 5166\, mm^2$$

consequently we choose an HEB280 section with the following characteristics:

Name HEB	***b (mm)***	***h (mm)***	***a (mm)***	***e (mm)***	***r (mm)***	***Weight (Kg/m)***	***Section (cm^2)***	***Jx (cm^4)***	***Jy (cm^4)***	***Wx (cm^3)***	***Wy (cm^3)***	***Ix***	***Iy***
280	*280*	*180*	*10,5*	*18*	*24*	*103,0*	*131,4*	*19270*	*6595*	*1376*	*471*	*12,1*	*7,09*

Axial surface provided:

$$A = 13140\ mm^2$$

Now we have to verific if the "x" value corresponding to the choosen profiles is ≥ 0,8

$$x = \frac{1}{\phi + \sqrt{\phi^2 - \lambda}} \leq 1\, mm^2$$

where:

$$\bar{\lambda} = \frac{\lambda}{\pi \cdot \sqrt{\frac{E}{f_{yk}}}} = \frac{35{,}4}{3{,}14 \cdot \sqrt{\frac{210000}{235}}} = 0{,}37$$

with:

$$\lambda = \frac{1}{\rho_{min}} = \frac{i}{cos\alpha} \cdot \frac{1}{\rho_z} = \frac{2500}{cos6} \cdot \frac{1}{70{,}9} = 35{,}4$$

$$\phi = 0{,}5 \cdot [1 + \alpha \cdot (\lambda - 0{,}2) + \lambda^2] = 0{,}5 \cdot [1 + 0{,}49 \cdot (0{,}37 - 0{,}2) + 0{,}37^2]$$

$$\phi = 0{,}61$$

α = amplification factor due to lamined section and inflection on the z-axis.

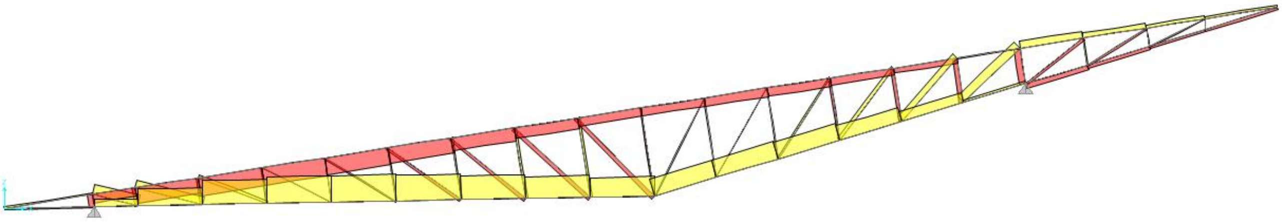
At the end we obtain:

$$x = \frac{1}{061 + \sqrt{(0{,}61)^2 - (0{,}37)^2}} = 0{,}91 \geq 0{,}8$$

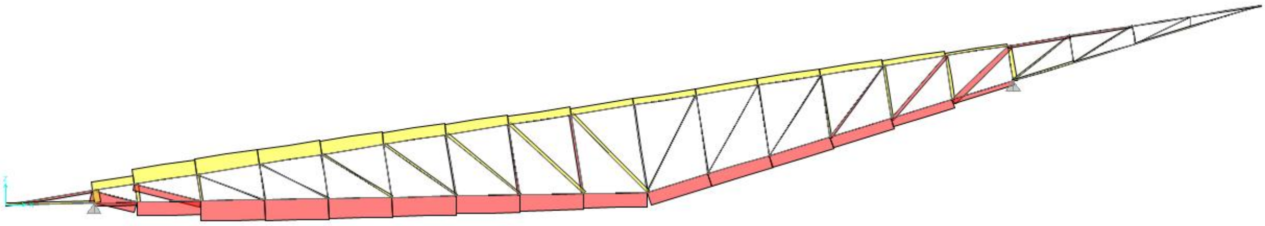
2.5.2.3 *Evaluation of the Project strains*

To resolve the truss steel and obtain the beams strain we use the software SAP2000 (program for the structural analisis), considering also the self weight of the beams determined with the predimensioning.
All the loads are positioned on the joint, exept the self weight of the structure (DEAD) that is computable automatically from the resolving software.

ULS :comb. 2(Q_k *exerc.):* F_d *=36,62 kN*



ULS:comb. 3 (Q_k *wind):* F_d *=- 4,58 kN*



2.5.2.4 *ULS verification of the struts*

The struts are set up with cave quadre section with the following characteristics:

Cave section	***b (mm)***	***h (mm)***	***r_0 (mm)***	***r_i (mm)***	***e***	***Section (cm^2)***	***Weight (Kg/m)***	***J (cm^4)***	***W (cm^3)***	***I (mm)***
140x140	*140*	*140*	*17,5*	*10,5*	*7*	*3123,29*	*24,52*	*920,4*	*155,3*	*54,29*

The compression verific is made considering that :

$$\frac{N_{max,compr}}{N_{rd}} \leq 1$$

where :

$$N_{rd} = \frac{A \cdot f_{yk}}{\gamma_{mo}}$$

The tenisile stress verific is made considering that

$$\frac{N_{max,tens}}{N_{rd}} \leq 1$$

And the estabilty verific is made considering:

$$\frac{N_{max,compr}}{N_{est,rd}} \leq 1$$

where

$$N_{est,rd} = \frac{x \cdot A \cdot f_{yk}}{\gamma_{M1}}$$

$$x = \frac{1}{\phi + \sqrt{\phi^2 - \lambda}} \leq 1\, mm^2$$

where:

$$\bar{\lambda} = \frac{\lambda}{\pi \cdot \sqrt{\frac{E}{f_{yk}}}}$$

with:

$$\lambda = \frac{1}{\rho_{min}} = l\, \frac{1}{\rho_z}$$

$$\phi = 0{,}5 \cdot [1 + \alpha \cdot (\lambda - 0{,}2) + \lambda^2]$$

α = amplification factor due to lamined section and inflection on the z-axis.

Following the verific for all the struts:

Strut	**Lenght**	**Sezione**	**Area**	i_y	λ_{adim}	$\lambda =$	α	Φ	χ	$N_{b,Rd}$	$N_{t,rd}$
2	3152,36	Cave 140x140	3123	54,29	58,07	0,62	0,34	0,76	0,83	578,47	698,96
3	2804,72	Cave 140x140	3123	54,29	51,66	0,55	0,34	0,71	0,86	601,94	698,96
4	2457,08	Cave 140x140	3123	54,29	45,26	0,48	0,34	0,66	0,89	623,49	698,96
5	2109,44	Cave 140x140	3123	54,29	38,86	0,41	0,34	0,62	0,92	643,39	698,96
6	1761,8	Cave 140x140	3123	54,29	32,45	0,35	0,34	0,58	0,95	661,97	698,96
7	1414,16	Cave 140x140	3123	54,29	26,05	0,28	0,34	0,55	0,97	679,60	698,96
8	1066,52	Cave 140x140	3123	54,29	19,64	0,21	0,34	0,52	1,00	696,66	698,96
9	718,88	Cave 140x140	3123	54,29	13,24	0,14	0,34	0,50	1,02	713,55	698,96
10	3271,05	Cave 140x140	3123	54,29	60,25	0,64	0,34	0,78	0,82	569,99	698,96
12	3152,36	Cave 140x140	3123	54,29	58,07	0,62	0,34	0,76	0,83	578,47	698,96
13	2804,72	Cave 140x140	3123	54,29	51,66	0,55	0,34	0,71	0,86	601,94	698,96
14	2457,08	Cave 140x140	3123	54,29	45,26	0,48	0,34	0,66	0,89	623,49	698,96
15	2109,44	Cave 140x140	3123	54,29	38,86	0,41	0,34	0,62	0,92	643,39	698,96
16	1761,8	Cave 140x140	3123	54,29	32,45	0,35	0,34	0,58	0,95	661,97	698,96
17	1414,16	Cave 140x140	3123	54,29	26,05	0,28	0,34	0,55	0,97	679,60	698,96
18	1066,52	Cave 140x140	3123	54,29	19,64	0,21	0,34	0,52	1,00	696,66	698,96
19	718,88	Cave 140x140	3123	54,29	13,24	0,14	0,34	0,50	1,02	713,55	698,96
21	3500	Cave 140x140	3123	54,29	64,47	0,69	0,34	0,82	0,79	552,95	698,96
22	2424,05	Cave 140x140	3123	54,29	44,65	0,48	0,34	0,66	0,89	625,45	698,96
23	4301,16	Cave 140x140	3123	54,29	79,23	0,84	0,34	0,97	0,70	487,12	698,96
24	4023,35	Cave 140x140	3123	54,29	74,11	0,79	0,34	0,91	0,73	510,87	698,96
25	3757,19	Cave 140x140	3123	54,29	69,21	0,74	0,34	0,86	0,76	532,77	698,96
26	3505,32	Cave 140x140	3123	54,29	64,57	0,69	0,34	0,82	0,79	552,54	698,96
28	3058,42	Cave 140x140	3123	54,29	56,33	0,60	0,34	0,75	0,84	585,01	698,96
29	2872,26	Cave 140x140	3123	54,29	52,91	0,56	0,34	0,72	0,85	597,54	698,96
30	2717,99	Cave 140x140	3123	54,29	50,06	0,53	0,34	0,70	0,87	607,49	698,96
31	4301,16	Cave 140x140	3123	54,29	79,23	0,84	0,34	0,97	0,70	487,12	698,96
32	4023,35	Cave 140x140	3123	54,29	74,11	0,79	0,34	0,91	0,73	510,87	698,96
33	3757,19	Cave 140x140	3123	54,29	69,21	0,74	0,34	0,86	0,76	532,77	698,96
34	3505,32	Cave 140x140	3123	54,29	64,57	0,69	0,34	0,82	0,79	552,54	698,96
35	3271,05	Cave 140x140	3123	54,29	60,25	0,64	0,34	0,78	0,82	569,99	698,96
36	3058,42	Cave 140x140	3123	54,29	56,33	0,60	0,34	0,75	0,84	585,01	698,96
37	2872,26	Cave 140x140	3123	54,29	52,91	0,56	0,34	0,72	0,85	597,54	698,96
38	2717,99	Cave 140x140	3123	54,29	50,06	0,53	0,34	0,70	0,87	607,49	698,96
39	1832,05	Cave 140x140	3123	54,29	33,75	0,36	0,34	0,59	0,94	658,31	698,96
40	484,56	Cave 140x140	3123	54,29	8,93	0,10	0,34	0,49	1,04	725,07	698,96
60	412,92	Cave 140x140	3123	54,29	7,61	0,08	0,34	0,48	1,04	728,63	698,96

Strut	$N_{b,Rd}$	$N_{t,rd}$	***COMBO1***	***COMBO2***	***COMBO3***	*Estability Verific*	*Tensile stress Verific*
						$N_{ed}/N_{b,rd}$	$N_{ed}/N_{t,rd}$
2	0,28	0,14	-10,345	-28,085	1,038	0,049	0,001
3	0,37	0,12	-34,863	-70,252	1,737	0,117	0,002
4	0,43	0,11	-75,472	-138,723	3,365	0,222	0,005
5	0,46	0,09	-121,469	-216,777	5,322	0,337	0,008
6	0,46	0,08	-164,848	-289,944	7,422	0,438	0,011
7	0,43	0,06	-244,425	-426,205	10,976	0,627	0,016
8	0,37	0,05	11,061	25,991	3,948		0,037
9	0,28	0,03	7,159	19,012	5,298		0,027
10	1,44	0,14	236,589	416,344	-4,318	0,008	0,596
12	1,66	0,14	89,784	147,578	-2,971	0,005	0,211
13	1,60	0,12	78,932	129,579	-3,027	0,005	0,185
14	1,51	0,11	52,802	86,693	-2,175	0,003	0,124
15	1,39	0,09	26,465	43,343	-1,23	0,002	0,062
16	1,24	0,08	-3,722	-6,429	-0,051	0,010	
17	1,06	0,06	-39,861	-66,104	2,134	0,097	0,003
18	0,84	0,05	-77,015	-127,57	11,948	0,183	0,017
19	0,60	0,03	-106,5	-177,139	20,057	0,248	0,029
21	3,23	0,15	-38,696	-67,05	6,19	0,121	0,009
22	2,34	0,11	-39,23	-104,999	-8,404	0,168	
23	4,34	0,19	-20,635	-23,874	4,6	0,049	0,007
24	4,24	0,18	6,054	22,503	4,038		0,032
25	4,13	0,17	61,249	116,264	2,228		0,166
26	4,00	0,15	130,944	235,209	-0,298	0,001	0,337
28	3,76	0,13	320,948	558,258	-8,22	0,014	0,799
29	3,66	0,13	-71,562	-140,73	2,263	0,236	0,003
30	3,58	0,12	-76,209	-166,727	-2,597	0,274	
31	5,86	0,19	-148,431	-247,942	9,574	0,509	0,014
32	5,65	0,18	-138,481	-231,223	9,996	0,453	0,014
33	5,45	0,17	-113,747	-190,429	8,897	0,357	0,013
34	5,23	0,15	-82,875	-140,046	8,416	0,253	0,012
35	5,03	0,14	-42,011	-73,675	8,123	0,129	0,012
36	4,84	0,13	16,626	22,431	6,709		0,032
37	4,67	0,13	119,946	191,933	0,4		0,275
38	4,54	0,12	268,698	436,833	-27,383	0,045	0,625
39	3,14	0,08	315,047	515,438	-46,035	0,070	0,737
40	0,85	0,02	-197,943	-332,474	40,817	0,459	
60	1,09	0,02	0,408	-11,194	0,251	0,015	

2.5.2.5 *ULS verification of the chords*

The chord have the following geometric characteristics:

Name HEB	***b (mm)***	***h (mm)***	***a (mm)***	***e (mm)***	***r (mm)***	***Weight (Kg/m)***	***Section (cm^2)***	***Jx (cm^4)***	***Jy (cm^4)***	***Wx (cm^3)***	***Wy (cm^3)***	***Ix***	***Iy***
280	*280*	*180*	*10,5*	*18*	*24*	*103,0*	*131,4*	*19270*	*6595*	*1376*	*471*	*12,1*	*7,09*

First we consider the chord with the maximum axial stress.

$N_{max,compr}$ *=1152 KN*

Considering that :

$$\frac{N_{max,compr}}{N_{rd}} \leq 1$$

where :

$$N_{rd} = \frac{A \cdot f_{yk}}{\gamma_{mo}} = \frac{13140 \cdot 235}{1{,}05} = 2940{,}8\ KN$$

we obtain:

$$\frac{1152KN}{2940{,}8\ KN} = 0{,}39\ \leq 1$$

Now we consider the CORRENTE with the maximum tensile stress.

$N_{max,tens}$ *=1704 KN*

Considering that :

$$\frac{N_{max,tens}}{N_{rd}} \leq 1$$

where :

$$N_{rd} = \frac{A \cdot f_{yk}}{\gamma_{mo}} = \frac{13140 \cdot 235}{1{,}05} = 2940{,}8\ KN$$

we obtain:

$$\frac{1704\ KN}{2940{,}8\ KN} = 0{,}57\ \leq 1$$

For the estability verific we consider:

N

$N_{max,compr} = 1152\ KN$

$$\frac{N_{max,compr}}{N_{est,rd}} = \frac{1152KN}{2676{,}18\ KN} = 0{,}43 \leq 1$$

where

$$N_{est,rd} = \frac{x \cdot A \cdot f_{yk}}{\gamma_{M1}} == \frac{0{,}91 \cdot 13140 \cdot 235}{1{,}05} = 2676{,}18KN$$

$$x = \frac{1}{\phi + \sqrt{\phi^2 - \lambda}} = \frac{1}{061 + \sqrt{(0{,}61)^2 - (0{,}37)^2}} = 0{,}91 \leq 1\ mm^2$$

where:

$$\bar{\lambda} = \frac{\lambda}{\pi \cdot \sqrt{\frac{E}{f_{yk}}}} = \frac{35{,}4}{3{,}14 \cdot \sqrt{\frac{210000}{235}}} = 0{,}37$$

with:

$$\lambda = \frac{1}{\rho_{min}} = \frac{i}{cos\alpha} \cdot \frac{1}{\rho_z} = \frac{2500}{cos6} \cdot \frac{1}{70{,}9} = 35{,}4$$

$$\phi = 0{,}5 \cdot [1 + \alpha \cdot (\lambda - 0{,}2) + \lambda^2] = 0{,}5 \cdot [1 + 0{,}49 \cdot (0{,}37 - 0{,}2) + 0{,}37^2]$$

$$\phi = 0{,}61$$

α = amplification factor due to lamined section and inflection on the z-axis.

Following the verific for all the chords:

Chord	***Lenght***	***Sezione***	***Area***	i_y	λ_{adim}	λ =	α	Φ	χ	$N_{b,Rd}$	$N_{t,rd}$
11	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
20	*3518,18*	*HEB280*	*13140*	*70,9*	*49,62*	*0,53*	*0,49*	*0,72*	*0,83*	*2431,60*	*2940,86*
27	*3484,65*	*HEB280*	*13140*	*70,9*	*49,15*	*0,52*	*0,49*	*0,72*	*0,83*	*2440,02*	*2940,86*
41	*1701,33*	*HEB280*	*13140*	*70,9*	*24,00*	*0,26*	*0,49*	*0,55*	*0,97*	*2857,66*	*2940,86*
42	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
43	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
44	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
45	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
46	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
47	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
48	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
49	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
50	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
51	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
52	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
53	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
54	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
55	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
56	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
57	*1685,11*	*HEB280*	*13140*	*70,9*	*23,77*	*0,25*	*0,49*	*0,55*	*0,97*	*2861,30*	*2940,86*
58	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
59	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
61	*2949,17*	*HEB280*	*13140*	*70,9*	*41,60*	*0,44*	*0,49*	*0,66*	*0,87*	*2571,05*	*2940,86*
62	*2270,35*	*HEB280*	*13140*	*70,9*	*32,02*	*0,34*	*0,49*	*0,59*	*0,93*	*2729,24*	*2940,86*
63	*2857,64*	*HEB280*	*13140*	*70,9*	*40,31*	*0,43*	*0,49*	*0,65*	*0,88*	*2592,84*	*2940,86*
64	*2312,15*	*HEB280*	*13140*	*70,9*	*32,61*	*0,35*	*0,49*	*0,60*	*0,92*	*2719,70*	*2940,86*
69	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
70	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
71	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
72	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
73	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
74	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
76	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
75	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
77	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
78	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
79	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
80	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
81	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*
82	*2500*	*HEB280*	*13140*	*70,9*	*35,26*	*0,38*	*0,49*	*0,61*	*0,91*	*2676,54*	*2940,86*

chord	$N_{b,Rd}$	$N_{t,rd}$	**COMBO1**	**COMBO2**	**COMBO3**	*Estability Verific*	*Tensile stress Verific*
						$N_{ed}/N_{b,rd}$	$N_{ed}/N_{t,rd}$
11	*0,92*	*0,08*	*204,321*	*455,992*	*19,026*		*0,155*
20	*2,37*	*0,12*	*-18,567*	*-41,431*	*7,344*	*0,017*	*0,002*
27	*3,16*	*0,12*	*20,501*	*44,487*	*-7,337*	*0,003*	*0,015*
41	*2,35*	*0,06*	*325,282*	*545,895*	*-10,684*	*0,004*	*0,186*
42	*3,53*	*0,08*	*269,092*	*584,308*	*18,106*		*0,199*
43	*3,62*	*0,08*	*-4,307*	*108,527*	*26,089*	*0,002*	*0,037*
44	*3,70*	*0,08*	*-199,03*	*-234,449*	*30,741*	*0,088*	*0,010*
45	*3,78*	*0,08*	*-300,444*	*-416,748*	*32,129*	*0,156*	*0,011*
46	*3,87*	*0,08*	*-347,042*	*-504,863*	*31,763*	*0,189*	*0,011*
47	*3,95*	*0,08*	*-355,445*	*-527,511*	*30,337*	*0,197*	*0,010*
48	*4,04*	*0,08*	*-347,718*	*-521,589*	*28,748*	*0,195*	*0,010*
49	*4,12*	*0,08*	*-353,006*	*-530,892*	*29,63*	*0,198*	*0,010*
50	*4,20*	*0,08*	*-446,657*	*-687,418*	*35,797*	*0,257*	*0,012*
51	*4,29*	*0,08*	*-540,541*	*-844,297*	*42,687*	*0,315*	*0,015*
52	*4,37*	*0,08*	*-623,284*	*-983,392*	*49,833*	*0,367*	*0,017*
53	*4,46*	*0,08*	*-689,332*	*-1095,498*	*57,093*	*0,409*	*0,019*
54	*4,54*	*0,08*	*-728,402*	*-1163,787*	*64,206*	*0,435*	*0,022*
55	*4,62*	*0,08*	*-719,444*	*-1153,775*	*70,74*	*0,431*	*0,024*
56	*4,71*	*0,08*	*-607,478*	*-975,378*	*72,344*	*0,364*	*0,025*
57	*3,23*	*0,06*	*-316,504*	*-503,728*	*42,574*	*0,176*	*0,014*
58	*4,88*	*0,08*	*662,099*	*1095,619*	*-59,109*	*0,022*	*0,373*
59	*4,96*	*0,08*	*922,96*	*1518,969*	*-84,759*	*0,032*	*0,517*
61	*6,05*	*0,10*	*-78,153*	*-152,297*	*-3,836*	*0,059*	
62	*4,73*	*0,08*	*-96,619*	*-199,106*	*-7,84*	*0,073*	
63	*6,05*	*0,10*	*73,591*	*144,88*	*3,088*		*0,049*
64	*4,98*	*0,08*	*128,915*	*285,926*	*14,294*		*0,015*
69	*5,80*	*0,08*	*1029,448*	*1688,808*	*-83,805*	*0,031*	*0,574*
70	*5,89*	*0,08*	*1041,906*	*1704,792*	*-77,672*	*0,029*	*0,580*
71	*5,97*	*0,08*	*1007,683*	*1644,598*	*-70,879*	*0,026*	*0,559*
72	*6,05*	*0,08*	*946,579*	*1540,695*	*-63,881*	*0,024*	*0,524*
73	*6,14*	*0,08*	*868,98*	*1410,093*	*-56,968*	*0,021*	*0,479*
74	*6,22*	*0,08*	*778,594*	*1259,036*	*-50,192*	*0,019*	*0,428*
76	*6,39*	*0,08*	*704,358*	*1127,826*	*-46,178*	*0,017*	*0,384*
75	*6,31*	*0,08*	*703,597*	*1117,691*	*-47,923*	*0,018*	*0,380*
77	*6,47*	*0,08*	*663,087*	*1039,646*	*-48,565*	*0,018*	*0,354*
78	*6,56*	*0,08*	*568,508*	*868,728*	*-47,51*	*0,018*	*0,295*
79	*6,64*	*0,08*	*383,095*	*541,489*	*-43,298*	*0,016*	*0,184*
80	*6,73*	*0,08*	*113,17*	*71,06*	*-35,609*	*0,013*	*0,038*
81	*6,81*	*0,08*	*-225,218*	*-498,294*	*-19,892*	*0,186*	
82	*6,89*	*0,08*	*-144,431*	*-324,96*	*-16,913*	*0,121*	

2.5.2.6 *ELS verification*

Considering the integrity of constructiv elements, is admitted that the roof is suficient rigid if, for all his parts, the deformability arrow is lowest than:

$$a < \frac{1}{300} \cdot l$$

Where:

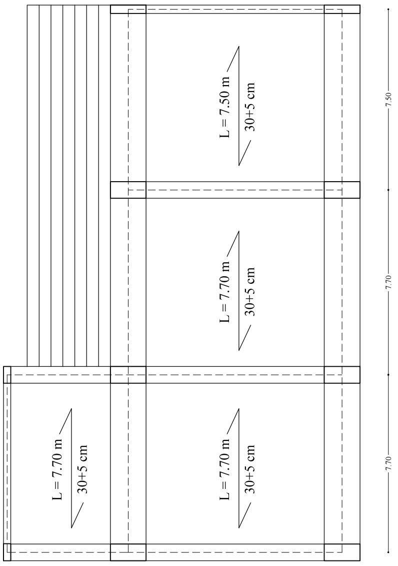
$l = 38{,}9\ m$

First Verific

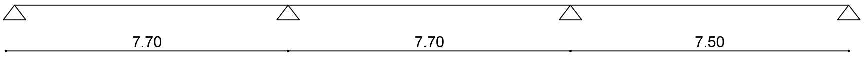
ELS – comb. 1 (Q_k pred. snow) $F_d = 1 \cdot (1{,}48) + 1 \cdot (0{,}5) = 1{,}98\ kN/m$

COMBINATION	***Displacements***		***Real Displacement***	***Admisible Displacement***	***Verific R/A***
	U1 (mm)	*U2 (mm)*			
SLE	*4,280*	*-19,804*	*20,261*	*129,666*	*0,156*

2.6 FLOOR TIPE 1 DESIGN



For the predimensioning of the floor we consider it like a continue beam with the following characteristics:



$$h_{min} > l_{max} / 25 = 770 \text{ cm} /25 = 30{,}8 \text{ cm}$$

Our structural package is 35 cm and the verific is satisified.

2.6.1 LOAD COMBINATIONS

The influence area of a single rafters, egual at the axile base, is of 0,52 m.

Then: G_1 = structural roof = $(3{,}25\ KN/m^2 \cdot 0{,}52\ m) = 1{,}73\ KN/m$
G_2= non structural elements $=1{,}58\ KN/m^2 \cdot 0{,}52\ m=0{,}82KN/m$
G_{2a} =partition = $1{,}20\ KN/m^2 \cdot 0{,}52\ m = 0{,}62\ KN/m$
q_e = exercise load = $(5\ KN/m^2 \cdot 0{,}52\ m) =2{,}60\ KN/m$

ULS: characteristic combination

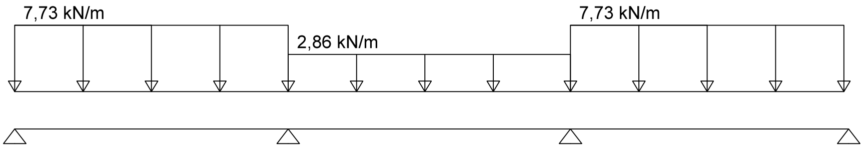
ULS: – comb. 1 $F_d = 1.35 \cdot (1,73+0,82) + 1.5 \cdot (0,26+2,6) = 7,73$ *kN/m*

ULS – comb. 2 $F_d = 1 \cdot (2,86) = 2,86$ *kN/m*

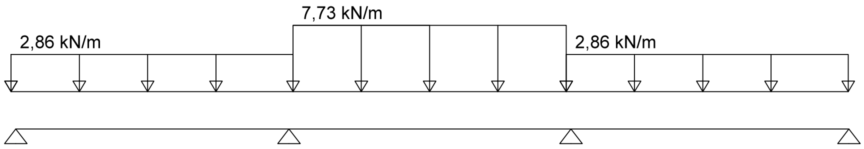
To obtain the floor strain we use the software SAP2000 (program for the structural analisis).
All the loads are positioned on the joint, exept the self weight of the structure (DEAD) that is computable automatically from the resolving software.

The load combination evaluated at USL are the following:

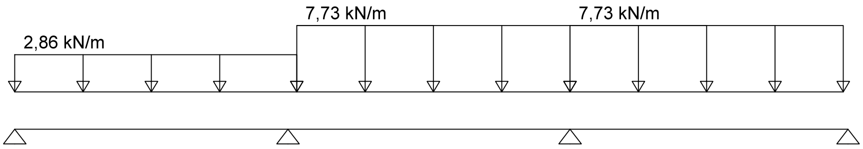
COMBO1



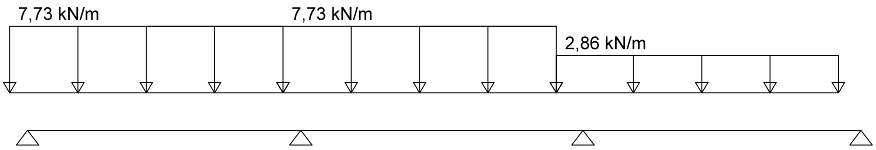
COMBO2



COMBO3



COMBO4



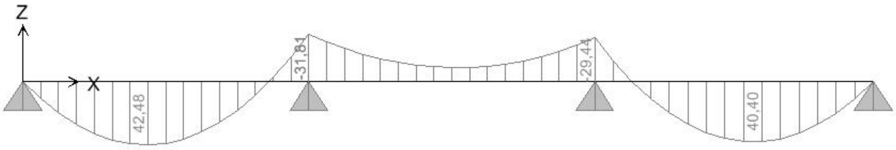
2.6.2 DESIGN AND VERIFICATIONS LONGITUDINAL REINFORCEMENT

2.6.2.1 *Evaluation of the Project strains*

The load stress evaluated with the SAP2000 program are:

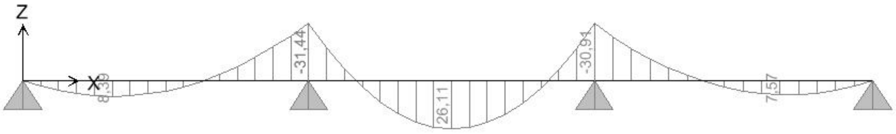
COMBO1

Moment



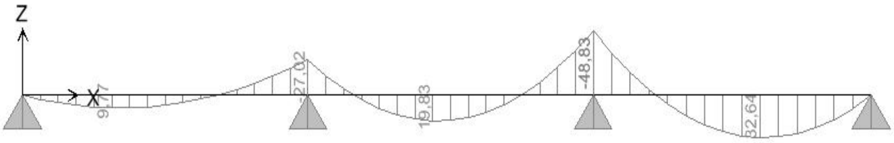
COMBO2

Moment



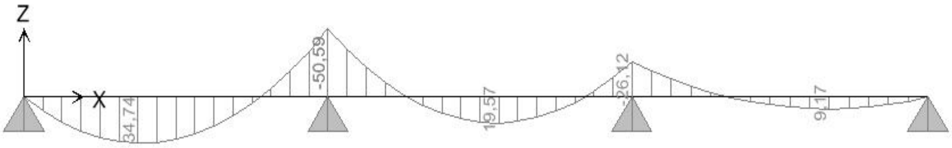
COMBO3

Moment



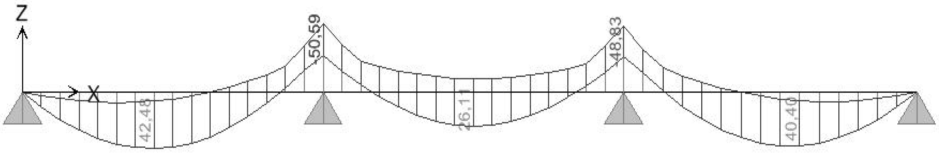
COMBO4

Moment



ENVELOPE

Moment



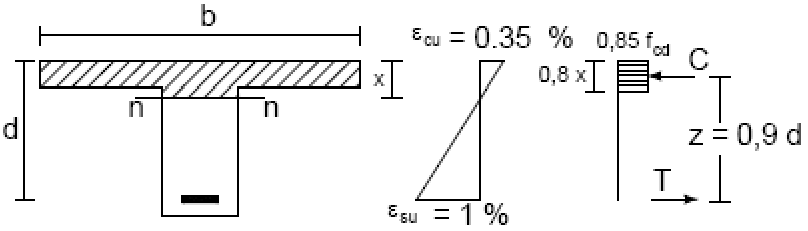
We have to translate horizzontally the bending moment of:

$$0.9d=0.9x35=31.5\ cm$$

2.6.2.2 *Longitudinal reinforcement design of the middle sections*

On the assist we consider the following situation:

Section 1		
B	*0,12*	*m*
h	*0,35*	*m*
c	*0,03*	*m*
d	*0,32*	*m*
x_{lim}	*0,14*	*m*
f_{cd}	*16,6*	*kN*
$\boldsymbol{M_{lim}}$	***51,18***	*kN m*



Where :

$$M_{lim} = 0{,}8 \cdot x_{lim} \cdot b \cdot 0{,}85 \cdot f_{cd} \cdot (d - 0{,}4x_{lim})$$

and

x_{lim} = *0,45 d (between the elastic and the plastic limit of the steel)*

	Middle section 1	***Middle section 2***	***Middle section 3***
M_{ed}	*44,99*	*27,98*	*42,76*
M_{lim}	*51,18*	*51,18*	*51,18*
M_{ed}/m_{lim}	*0,26*	*0,16*	*0,25*

In both of cases we can project them with concrete reinforcement only for tensile stress.

So:

$$A_s = \frac{M_{sd}}{(0{,}9 \cdot f_{yd} \cdot d)}$$

Middle section 1:

$$A_{s1} = \frac{4499000\ N\ mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32\ mm)} = 400{,}8\ mm^2 = 4{,}008\ cm^2$$

Middle section 2:

$$A_{s2} = \frac{2798000\ N\ mm}{(0{,}9\ \cdot\ 391\frac{N}{mm} \cdot 32\ mm)} = 2{,}48\ cm^2$$

Middle section 3:

$$A_{s3} = \frac{4278000\ N\ mm}{(0{,}9\ \cdot\ 391\frac{N}{mm} \cdot 32\ mm)} = 3{,}80\ cm^2$$

the concrete renforcement for those section is:

	Middle section 1	***Middle section 2***	***Middle section 3***
A_{smin}	*4,00*	*2,48*	*3,80*
A_s	*2Φ16*	*1Φ8+1Φ16*	*2Φ16*
$A_{sfornited}$	*4,02*	*2,5*	*4,02*

And to evaluate the resistance of the section we use:

$$0{,}8\, x\ (0{,}8\, f_{cd}\ ) \cdot b -\ A_s f_{yd} = 0$$

so:

$$x = \frac{A_s f_{yd}}{0{,}8(0{,}8\, f_{cd}\ ) \cdot b}$$

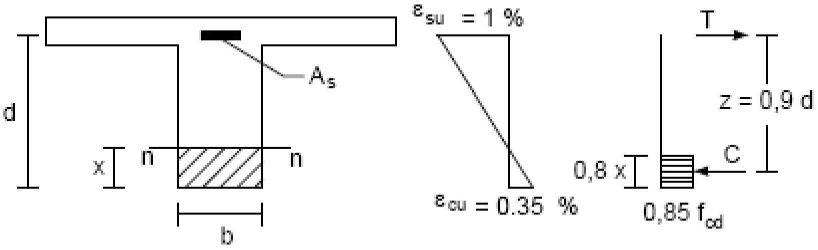
and the resistent moment is:

$$M_{rd} =\ A_s \cdot f_{vd} \cdot (d - 0{,}4\, x)$$

		Middle section 1	***Middle section 2***	***Middle section 3***
f_{yd}	*N/mm²*	*391,3*	*391,3*	*391,3*
f_{cd}	*N/mm²*	*16,6*	*16,6*	*16,6*
b	*mm*	*120*	*120*	*120*
A_s	*mm*	*4,02*	*2,5*	*4,02*
x	*mm*	*98,71*	*61,39*	*98,71*
M_{rd}	*kN m*	*44,13*	*28,90*	*44,13*

2.6.2.3 *Longitudinal reinforcement design of the assists*

Section 1		
B	*0,12*	*m*
h	*0,35*	*m*
c	*0,03*	*m*
d	*0,32*	*m*
x_{lim}	*0,14*	*m*
f_{cd}	*16,6*	*kN*
$\boldsymbol{M_{lim}}$	***51,18***	*kN m*



Where :

$$M_{lim} = 0{,}8 \cdot x_{lim} \cdot b \cdot 0{,}85 \cdot f_{cd} \cdot (d - 0{,}4x_{lim})$$

and

$x_{lim} = 0{,}45\ d$ *(between the elastic and the plastic limit of the steel)*

At the assits 1 and 4 we have to add a bending moment due to the torsional rigidity of the beam. His calculation is made considerig the 25% of the maximum bending moment on the adjoining beam.

$$M_1 = \frac{M_{ed1}}{4} = \frac{44{,}99KN\ m}{4} = 11{,}25\ kN\ m$$

$$M_4 = \frac{M_{ed1}}{4} = \frac{42{,}78KN\ m}{4} = 10{,}69\ kN\ m$$

	Assist 1	*Assist 2*	*Assist 3*	*Assist 4*
M_{ed}	*11,25*	*50,68*	*48,8*	*10,69*
M_{lim}	*51,18*	*51,18*	*51,18*	*51,18*
M_{ed}/m_{lim}	*0,22*	*0,99*	*0,95*	*0,21*

The verific is satisfied and we can project both with concrete reinforcement only for tensile stress.

So:

$$A_s = \frac{M_{sd}}{(0{,}9 \cdot f_{yd} \cdot d)}$$

Assist 1:

$$A_{s1} = \frac{1125000\, N\, mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32\, mm)} = 100\, mm^2 = 1{,}00 cm^2$$

Assist 2:

$$A_{s2} = \frac{5068000\, N\, mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32 mm)} = 4{,}50\, cm^2$$

Assist 3:

$$A_{s3} = \frac{4880000\, N\, mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32\, mm)} = 4{,}33\, cm^2$$

Assist 4:

$$A_{s4} = \frac{1069000\, N\, mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32\, mm)} = 0{,}95\, cm^2$$

the concrete renforcement for those section is:

	Assist 1	**Assist 2**	**Assist 3**	**Assist 4**
A_{smin}	2,54	4,50	4,33	2,41
A_s	2Φ12+1Φ8	3Φ12+1Φ16	2Φ16+1Φ8	2Φ12+1Φ8
$A_{sfornited}$	2,76	5,4	4,52	2,76

And to evaluate the resistance of the section we use:

$$0{,}8\, x\, (0{,}8\, f_{cd}) \cdot b - A_s f_{yd} = 0$$

so:

$$x = \frac{A_s f_{yd}}{0{,}8(0{,}8\, f_{cd}) \cdot b}$$

and the resistent moment is:

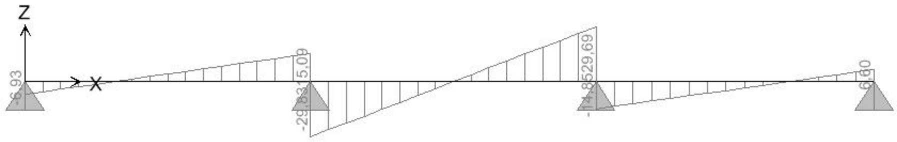
$$M_{rd} = A_s \cdot f_{vd} \cdot (d - 0{,}4\,x)$$

		Assist 1	**Assist 2**	**Assist 3**	**Assist 4**
f_{yd}	N/mm^2	391,3	391,3	391,3	391,3
f_{cd}	N/mm^2	16,6	16,6	16,6	16,6
b	mm	120	120	120	120
A_s	mm	1,13	5,4	4,52	1,13
x	mm	27,75	132,59	110,99	27,75
M_{rd}	kN m	13,66	56,41	48,75	13,66

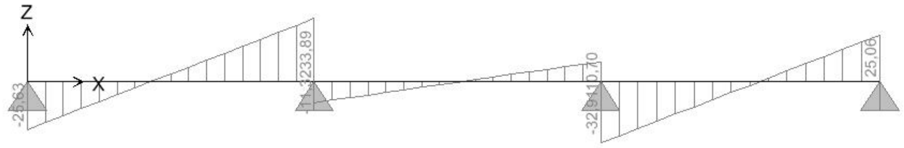
2.6.3 DESIGN AND VERIFICATIONS SHEAR REINFORCEMENT

2.6.3.1 *Evaluation of the Stress shear Projects*

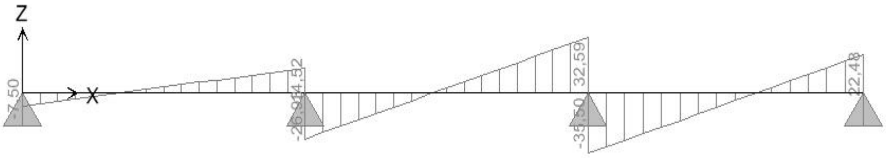
COMBO1
Shear



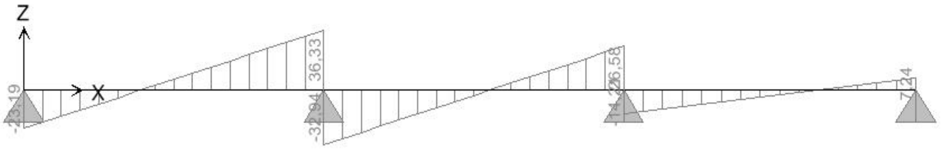
COMBO2
Shear



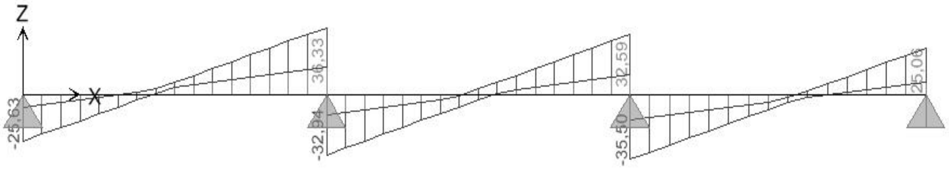
COMBO3
Shear



COMBO4
Shear



ENVELOPE
Shear



2.6.3.2 *Evaluation of the shear breaking point on the concrete side*

Is possible evaluate the shear breaking stress on the concrete side considering the following formula:

$$V_{rcd} = 0{,}3 \cdot d \cdot b_0 \cdot \alpha_c \ \cdot \ f'_{cd} \cdot \frac{\cot\alpha \ + \cot\theta}{1 + \ \cot^2\theta} = 230{,}4kN$$

where:

- *d : widht utile of the section along the shear direction;*
- *b :base corresponding to the shear stress direction;*
- *f'cd :breaking stress on concrete reduced due the axial anime compression (f'cd=0,6×fcd)*
- *α :inclination angle of stirrups (α=90°)*
- *θ inclination angle of the concrete struts*

(1 ≤ ctgθ ≤ 2,5) (21.8° ≤ θ ≤ 45°)

The inclination angle of the concrete struts is evaluated of θ = 45° in safety favour;

And the project shear strass that has to be used for the verific is V_{ed} is evaluated on the edge of the beam :

$$V_{ed} = |V_{max} - q \cdot x| = 36{,}33kN - 7{,}73 \cdot 0{,}35m = 33{,}62kN$$

2.6.3.3 *Shear verification on the concrete side*

The shear verifications con concrete are made evaluating the piston road compressed and the tensile stress on the concrete.
The first verific is made evaluating:

$$\frac{V_{ed,y}}{V_{rcd,y}} < 1$$

So :

$$\frac{33{,}6kN}{230{,}4kN} = 0{,}14 < 1$$

The verific of the tensile stress is made evaluating the concrete contribution to the shear with the following:

$$V_{rd1} = \left(\frac{0{,}18}{g_c} \cdot k \cdot (100\rho_1 \cdot f_{ck})^{\frac{1}{3}}\right) b_w \cdot d$$

Where :

$$K = 1 + \sqrt{\left(\frac{200}{d}\right)} = 1 + \sqrt{\left(\frac{200}{290}\right)} = 1{,}83$$

$$\rho_1 = \frac{A_{s1}}{(b_w \cdot d)} = \frac{3{,}87\ cm^2}{(12\ cm \cdot 29\ cm)} = 0{,}011$$

so

$$V_{rd1} = \frac{\left(\frac{0{,}18}{1{,}5} \cdot 1{,}83 \cdot \left(100 \cdot 0{,}011 \cdot 25\frac{N}{mm}\right)^{\frac{1}{3}}\right) 120\ mm \cdot 290\ mm}{1000} = 23{,}06\ kN$$

moreover the value of V_{min} *is the following:*

$$V_{min} = 0{,}05 \ \cdot \ K^{\frac{3}{2}} \ \cdot f_{ck}{}^{\frac{1}{2}} \cdot b_w \cdot d = 22{,}3\ KN$$

$$V_{rd1} \geq (V_{min})$$

Considering that the verific is satisfied we introduce only a minimum full concrete band.

2.6.3.4 *Shear reinforcement design*

On the assits we have to add a concrete reinforcement following the scheme of simply supported beam we have:

$V_{max} = 36,33\ kN$

$$A_{shear} = \frac{V_{max}}{f_{yd}} = \frac{(36330\ N\ )}{(\ 391,3\frac{N}{mm})} = 96,70\ mm^2 = 0,967\ cm^2$$

We use 2 $\phi 8$ with a correspondent Air of 1 cm^2.

2.6.4 VERIFICATIONS OF THE EXERCISE STRAIN

The section that could have problems are the two sections in correspondance of the central assits, where the copressed zone (on the bottom) have a width of 12 cm.
We consider the following two combinations:

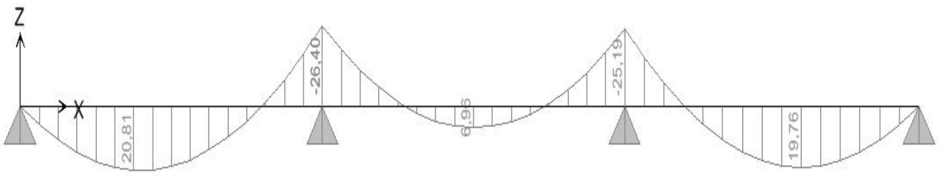
ELS: exercise state limite

ELS: – comb. 1 $F_d = 1\ (1,84+1,02\ )+ 1\ (0,26\ +2,6) = 5,72\ kN/m$

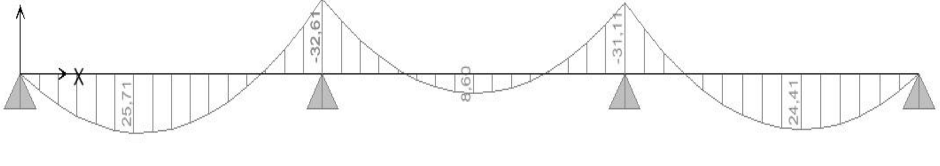
ELS: – comb. 2 $F_d =1\cdot (1,84+1,02\ )+ 0,6\ (0,26\ +2,6) =4,57\ kN/m$

The loads stress evaluated are the following:

ELS - COMBO1



ELS – COMBO2



We have to control that:

ELS-COMBO1

$$\sigma_c < 0{,}6\ f_{ck}$$

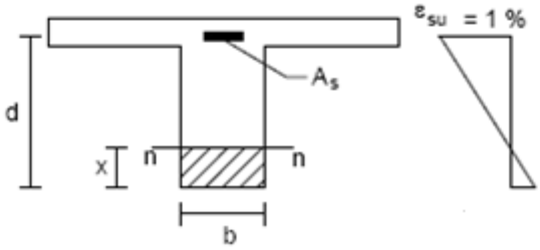
$$\sigma_s < 0{,}8\ f_{vk}$$

ELS-COMBO2

$$\sigma_c < 0{,}45\ f_{ck}$$

2.6.4.1 *Verification of assist*

b	*m*	*0,12*
h	*m*	*0,35*
c	*m*	*0,03*



We can calculate the profondity of neutral axis with the following formula:

$$\frac{bx^2}{2} - A_s\,(d-x) = 0$$

for the Evaluations of the neutral axis see the ***ATTACHEMENT C.***

The moment of inertia can be evaluated with
:

$$I_d = \frac{b\,x^3}{3} + A_s\,(d-x)^2$$

						Med	$\sigma_{c,max}$	$\sigma_{s,max}$	Med	$\sigma_{c,max}$
	b	d	As	x	Id	Combo 1	Combo 1	Combo 1	Combo 2	Combo 2
	mm	mm	mm^2	mm	mm^4	N mm	N/mm^2	N/mm^2	N mm	N/mm^2
ASSIST1	120	320	276	78,4	35385886,7	640000	1,42	65,54	520000	1,15
ASSIST2	120	320	540	153,5	159642230,0	3260000	3,13	51,00	2640000	2,54
ASSIST3	120	320	452	128,5	101448822,0	3110000	3,94	88,06	2520000	3,19
ASSIST4	120	320	276	78,4	35385886,7	610000	1,35	62,47	470000	1,04

Considering the COMBO1 the maximum stress on the concrete and on the steel are:

$$\sigma_{c,max} = \left(\frac{M}{I_{id}}\right) x$$

$$\sigma_{s,max} = n\left(\frac{M}{I_{id}}\right)(d - x)$$

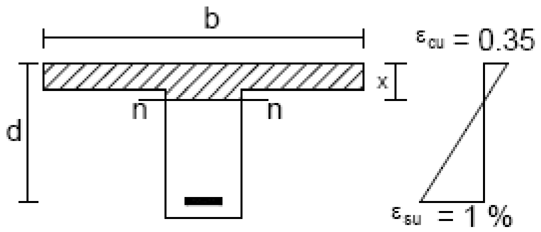
Considering the COMBO2 the maximum stress on the concrete is:

$$\sigma_{c,max} = \left(\frac{M}{I_{id}}\right) x$$

At the verific we have:

	Combo1						*Combo 2*		
	$\sigma_{c,amm}$ $=0{,}6f_{ck}$	$\sigma_{s,amm}$ $=0{,}8f_{yk}$	$\sigma_{c,max}$	$\sigma_{s,max}$	$\sigma_{c,max}/\sigma_{c,amm}$	$\sigma_{s,max}/\sigma_{s,amm}$	$\sigma_{c,amm}$ $=0{,}45f_{ck}$	$\sigma_{c,max}$	$\sigma_{c,max}/\sigma_{c,amm}$
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	-	-	N/mm^2	N/mm^2	N/mm^2
ASSIST1	*15*	*364*	*1,42*	*65,54*	*0,095*	*0,180*	*11,25*	*1,15*	*0,102*
ASSIST2	*15*	*364*	*3,13*	*51,00*	*0,209*	*0,140*	*11,25*	*2,54*	*0,226*
ASSIST3	*15*	*364*	*3,94*	*88,06*	*0,263*	*0,242*	*11,25*	*3,19*	*0,284*
ASSIST4	*15*	*364*	*1,35*	*62,47*	*0,090*	*0,172*	*11,25*	*1,04*	*0,093*

2.6.4.2 *Verification of the middle section*



						Med	$\sigma_{c,max}$	$\sigma_{s,max}$	*Med*	$\sigma_{c,max}$
	b	*d*	*As*	*x*	*Id*	*Combo 1*	*Combo 1*	*Combo 1*	*Combo 2*	*Combo 2*
	mm	*mm*	mm^2	*mm*	mm^4	*N mm*	N/mm^2	N/mm^2	*N mm*	N/mm^2
MID 1	*120*	*320*	*402*	*74,6*	*18070061,8*	*2570000*	*10,61*	*523,53*	*2081000*	*8,59*
MID 2	*120*	*320*	*205*	*42,7*	*6042996,4*	*860000*	*6,08*	*591,95*	*696000*	*4,92*
MID 3	*120*	*320*	*402*	*74,6*	*18070061,8*	*2440000*	*10,07*	*497,05*	*1976000*	*8,16*

And the verification is:

	Combo1						Combo 2		
	$\sigma_{c,amm}$ $=0,6f_{ck}$	$\sigma_{s,amm}$ $=0,8f_{yk}$	$\sigma_{c,max}$	$\sigma_{s,max}$	$\sigma_{c,max}/\sigma_{c,amm}$	$\sigma_{s,max}/\sigma_{s,amm}$	$\sigma_{c,amm}$ $=0,45f_{ck}$	$\sigma_{c,max}$	$\sigma_{c,max}/\sigma_{c,amm}$
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	-	-	N/mm^2	N/mm^2	N/mm^2
MID 1	15	364	6,58	324,63	0,439	0,892	11,25	5,33	0,474
MID 2	15	364	6,08	592,09	0,405	1,627	11,25	4,92	0,437
MID 3	15	364	6,25	308,21	0,416	0,847	11,25	5,06	0,450

In the mid section 2 the verific is not satisfied so it is increased the longitudinal reinforcement using : 1f16 +1f12 with A_s=314 mm^2.
The new value are:

	b	d	As	x	Id	Med Combo 1	$\sigma_{c,max}$ Combo 1	$\sigma_{s,max}$ Combo 1	Med Combo 2	$\sigma_{c,max}$ Combo 2
	mm	mm	mm^2	mm	mm^4	N mm	N/mm^2	N/mm^2	N mm	N/mm^2
MID 2	120	320	314	53,8	11634808,4	860000	3,98	295,15	696000	3,22

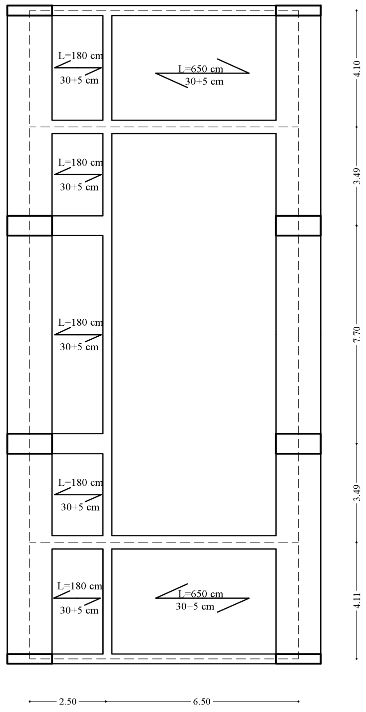
And the verific is:

	Combo1						Combo 2		
	$\sigma_{c,amm}$ $=0,6f_{ck}$	$\sigma_{s,amm}$ $=0,8f_{yk}$	$\sigma_{c,max}$	$\sigma_{s,max}$	$\sigma_{c,max}/\sigma_{c,amm}$	$\sigma_{s,max}/\sigma_{s,amm}$	$\sigma_{c,amm}$ $=0,45f_{ck}$	$\sigma_{c,max}$	$\sigma_{c,max}/\sigma_{c,amm}$
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	-	-	N/mm^2	N/mm^2	N/mm^2
MID 2	15	364	3,98	295,15	0,265	0,811	11,25	3,22	0,286

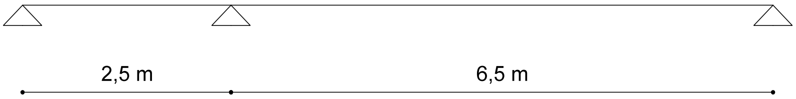
2.6.5 FLOOR SLAB DESIGN OUTPUT

*For the floor-1 reinforcement design see the **EXTERNAL ATTACHEMENT – graphic work T1.***

2.7 FLOOR TIPE 2 DESIGN



For the predimensioning of the floor we consider it like a continue beam with the following characteristics:



$$h_{min} > l_{max} / 25 = 770 \text{ cm} /25 = 30{,}8 \text{ cm}$$

Our structural package is 35 cm and the verific is satisified.

2.7.1 LOAD COMBINATIONS

The influence area of a single rafters, egual at the axile base, is of 0,52 m.

Then: G_1 *= structural roof =* $(3{,}25\ KN/m^2 \cdot 0{,}52\ m) = 1{,}64\ KN/m$

G_2*= non structural elements =*$1{,}98\ KN/m^2 \cdot 0{,}52\ m = 1{,}02 KN/m$

G_{2a} *=partition =* $1{,}20\ KN/m^2 \cdot 0{,}52\ m = 0{,}62\ KN/m$

q_e *= exercise load =* $(5\ KN/m^2 \cdot 0{,}52\ m) = 2{,}60\ KN/m$

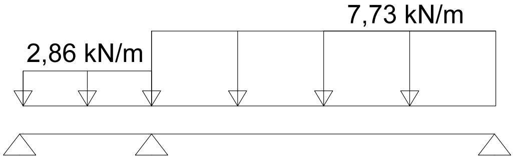
ULS: characteristic combination

ULS: – comb. 1 $F_d = 1.35 \cdot (1{,}64+1{,}02) + 1.5 \cdot (0{,}26 + 2{,}6) = 7{,}73$ *kN/m*

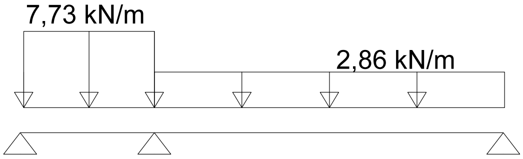
ULS – comb. 2 $F_d = 1 \cdot (2{,}86) = 2{,}86$ *kN/m*

We pick for this floor the same structural package of the BUILDING 2 due to guarantee the same stifness behaviour in the plane.
The load combination evaluated at USL are the following:

COMBO1



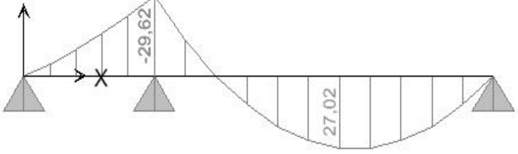
COMBO2



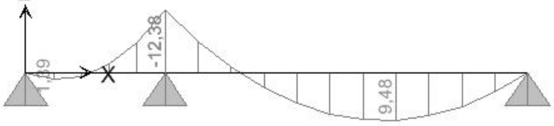
2.7.2 DESIGN AND VERIFICATIONS LONGITUDINAL REINFORCEMENT

2.7.2.1 *Evaluation of the Project strains*

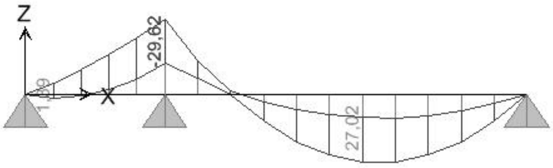
The load stress evaluated with the SAP2000 program are:
COMBO1
Moment



COMBO2
Moment



ENVELOPE
Moment



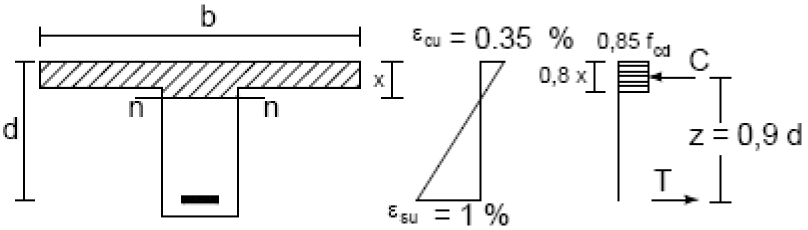
We have to translate horizzontally the bending moment of:

$$0.9d=0.9x35=31.5\ cm$$

2.7.2.2 *Longitudinal reinforcement design of the middle sections*

On the middle of the beam we consider the following situation:

Section 1		
B	*0,12*	*m*
h	*0,35*	*m*
c	*0,03*	*m*
d	*0,32*	*m*
x_{lim}	*0,14*	*m*
f_{cd}	*16,6*	*kN*
$\boldsymbol{M_{lim}}$	***51,18***	*kN m*



Where :

$$M_{lim} = 0{,}8 \cdot x_{lim} \cdot b \cdot 0{,}85 \cdot f_{cd} \cdot (d - 0{,}4x_{lim})$$

and

x_{lim} *= 0,45 d (between the elastic and the plastic limit of the steel)*

	Middle section 1	Middle section 2
M_{ed}	27,09	1,99
M_{lim}	51,18	51,18
M_{ed}/m_{lim}	0,52	0,03

In both of cases we can project them with concrete reinforcement only for tensile stress.
So:

$$A_s = \frac{M_{sd}}{(0{,}9 \cdot f_{yd} \cdot d)}$$

Middle section 1:

$$A_{s1} = \frac{2709000\,N\,mm}{(0{,}9 \cdot 391\frac{N}{mm} \cdot 32\,mm)} = 241{,}8\,mm^2 = 2{,}41\,cm^2$$

Middle section 2:

$$A_{s2} = \frac{199000\,N\,mm}{(0{,}9 \cdot 391\frac{N}{mm} \cdot 32\,mm)} = 0{,}18\,cm^2$$

the concrete renforcement for those section is:

	Middle section 1	Middle section 2
A_{smin}	2,41	0,18
A_s	1Φ16+1Φ8	1Φ8
$A_{sfornited}$	2,51	0,51

In the middle sections we have only concrete reinforcement for tensile stress consequentely the neutral axis could be evaluated with the following formula:

$$0{,}8\,x\,(0{,}8\,f_{cd}) \cdot b - A_s f_{yd} = 0$$

so:

$$x = \frac{A_s f_{yd}}{0{,}8(0{,}8\,f_{cd}) \cdot b}$$

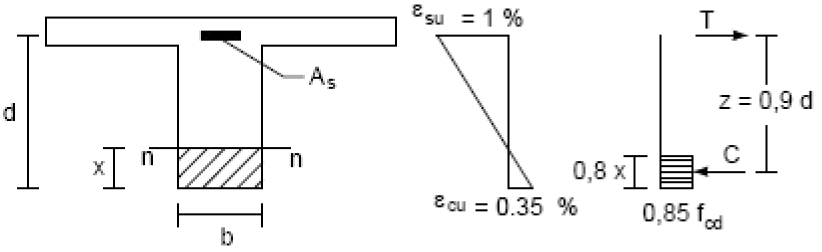
and the resistent moment is:

$$M_{rd} = A_s \cdot f_{vd} \cdot (d - 0{,}4\,x)$$

		Middle section 1	***Middle section 2***
f_{yd}	N/mm^2	*391,3*	*391,3*
f_{cd}	N/mm^2	*16,6*	*16,6*
b	*mm*	*120*	*120*
A_s	*mm*	*2,51*	*0,5*
x	*mm*	*61,63*	*12,28*
M_{rd}	*kN m*	*29,01*	*6,16*

2.7.2.3 *Longitudinal reinforcement design of the assists*

Section 1		
B	*0,12*	*m*
h	*0,35*	*m*
c	*0,03*	*m*
d	*0,32*	*m*
x_{lim}	*0,14*	*m*
f_{cd}	*16,6*	*kN*
$\mathbf{M_{lim}}$	***51,18***	*kN m*



Where :

$$M_{lim} = 0{,}8 \cdot x_{lim} \cdot b \cdot 0{,}85 \cdot f_{cd} \cdot (d - 0{,}4x_{lim})$$

and

$x_{lim} = 0{,}45\ d$ *(between the elastic and the plastic limit of the steel)*

At the assits 1 and 4 we have to add a bending moment due to the torsional rigidity of the beam. His calculation is made considerig the 25% of the maximum bending moment on the adjoining beam.

$$M_1 = \frac{M_{ed1}}{4} = \frac{27{,}09KN\ m}{4} = 6{,}77\ kN\ m$$

$$M_3 = \frac{M_{ed1}}{4} = \frac{1{,}99KN\ m}{4} = 0{,}49\ kN\ m$$

	Assist 1	*Assist 2*	*Assist 3*
M_{ed}	*6,77*	*29,62*	*0,49*
M_{lim}	*51,18*	*51,18*	*51,18*
M_{ed}/m_{lim}	*0,13*	*0,58*	*0,01*

The verific is satisfied and we can project both with concrete reinforcement only for tensile stress.
So:

$$A_s = \frac{M_{sd}}{(0{,}9 \cdot f_{yd} \cdot d)}$$

Assist 1:

$$A_{s1} = \frac{677000\, N\, mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32\, mm)} = 60mm^2 = 0{,}60cm^2$$

Assist 2:

$$A_{s2} = \frac{2962000\, N\, mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32mm)} = 2{,}63\ cm^2$$

Assist 3:

$$A_{s3} = \frac{490000\, N\, mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32\, mm)} = 0{,}04\ cm^2$$

the concrete renforcement for those section is:

	Assist 1	*Assist 2*	*Assist 3*
A_{smin}	*0,60*	*2,63*	*0,04*
A_s	*1Φ12*	*2Φ12+1Φ8*	*1Φ8*
$A_{sfornited}$	*1,13*	*2,78*	*0,51*

on the edge of the bay we have only concrete reinforcement for tensile stress consequentely the neutral axis could be evaluated with the following formula:

$$0{,}8\, x\, (0{,}8\, f_{cd}) \cdot b - A_s f_{yd} = 0$$

so:

$$x = \frac{A_s f_{yd}}{0{,}8(0{,}8\ f_{cd}\ ) \cdot b}$$

and the resistent moment is:

$$M_{rd} = A_s \cdot f_{vd} \cdot (d - 0{,}4\ x)$$

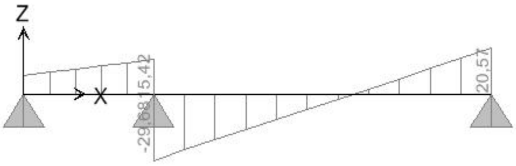
		Assist 1	*Assist 2*	*Assist 3*
f_{yd}	N/mm^2	391,3	391,3	391,3
f_{cd}	N/mm^2	16,6	16,6	16,6
b	mm	120	120	120
A_s	mm	1,13	2,78	0,51
x	mm	27,75	68,26	12,52
M_{rd}	kN m	13,66	31,84	6,29

2.7.3 DESIGN AND VERIFICATIONS SHEAR REINFORCEMENT

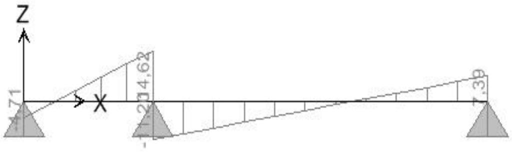
2.7.3.1 *Evaluation of the Stress shear Projects*

The load stress evaluated with the SAP2000 program are:

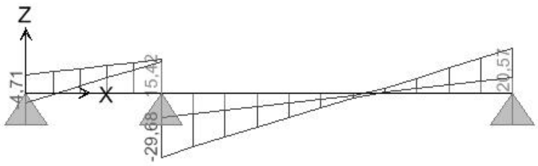
COMBO1
Shear



COMBO2
Shear



ENVELOPE
Shear



2.7.3.2 *Evaluation of the shear breaking point on the concrete side*

Is possible evaluate the shear breaking stress on the concrete side considering the following formula:

$$V_{rcd} = 0{,}3 \cdot d \cdot b_0 \cdot \alpha_c \cdot f'_{cd} \cdot \frac{\cot\alpha + \cot\theta}{1 + \cot^2\theta} = 230{,}4kN$$

where:

- *d : widht utile of the section along the shear direction;*
- *b :base corresponding to the shear stress direction;*
- *f'cd :breaking stress on concrete reduced due the axial anime compression (f'cd=0,6×fcd)*
- *α :inclination angle of stirrups (α=90°)*
- *θ inclination angle of the concrete struts*
  (1 ≤ ctgθ ≤ 2,5) (21.8° ≤ θ ≤ 45°)

The inclination angle of the concrete struts is evaluated of θ = 45° in safety favour;

And the project shear strass that has to be used for the verific is V_{ed} is evaluated on the edge of the beam :

$$V_{ed} = |V_{max} - q \cdot x| = 36{,}33kN - 7{,}73 \cdot 0{,}35m = 17{,}86kN$$

2.7.3.3 *Shear verification on the concrete side*

The shear verifications con concrete are made evaluating the piston road compressed and the tensile stress on the concrete.
The first verific is made evaluating:

$$\frac{V_{ed,y}}{V_{rcd,y}} < 1$$

So :

$$\frac{17{,}86kN}{230{,}4kN} = 0{,}077 < 1$$

The verific of the tensile stress is made evaluating the concrete contribution to the shear with the following:

$$V_{rd1} = \left(\frac{0{,}18}{g_c} \cdot k \cdot (100\rho_1 \cdot f_{ck})^{\frac{1}{3}}\right) b_w \cdot d$$

Where :

$$K = 1 + \sqrt{\left(\frac{200}{d}\right)} = 1 + \sqrt{\left(\frac{200}{290}\right)} = 1{,}83$$

$$\rho_1 = \frac{A_{s1}}{(b_w \cdot d)} = \frac{3{,}87\ cm^2}{(12\ cm \cdot 29\ cm)} = 0{,}011$$

so

$$V_{rd1} = \frac{\left(\frac{0{,}18}{1{,}5} \cdot 1{,}83 \cdot \left(100 \cdot 0{,}011 \cdot 25\frac{N}{mm}\right)^{\frac{1}{3}}\right) 120\ mm \cdot 290\ mm}{1000} = 23{,}06\ kN$$

moreover the value of V_{min} is the following:

$$V_{min} = 0{,}05 \ \cdot \ K^{\frac{3}{2}} \ \cdot f_{ck}{}^{\frac{1}{2}} \cdot b_w \cdot d = 22{,}3\ KN$$

$$V_{rd1} \geq (V_{min})$$

Considering that the verific is satisfied we introduce only a minimum full concrete band.

2.7.3.4 *Shear reinforcement design*

On the assits we have to add a concrete reinforcement following the scheme of simply supported beam we have:

$V_{max} = 20{,}57\ kN$

$$A_{shear} = \frac{V_{max}}{f_{yd}} = \frac{(20570\ N\ )}{(\ 391{,}3\frac{N}{mm})} = 52{,}56\ mm^2 = 0{,}525\ cm^2$$

We use 2 $\phi 8$ with a correspondent Air of 1 cm^2.

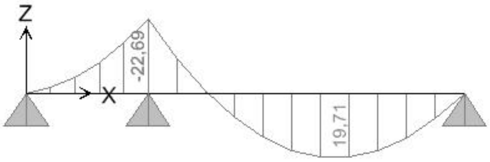
2.7.4 EXERCISE STATE LIMITE VERIFICATION

The section that could have problems are the two sections in correspondance of the central assits, where the copressed zone (on the bottom) have a width of 12 cm.
We consider the following two combinations:

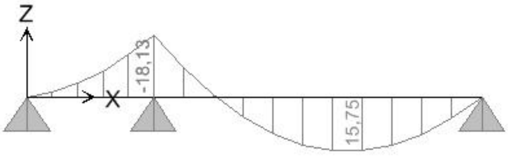
ELS: exercise state limite
ELS: – comb. 1 $F_d = 1\ (1{,}84+1{,}02\ )+ 1\ (0{,}62\ +2{,}6) = 5{,}72\ kN/m$
ELS: – comb. 2 $F_d =1\cdot (1{,}84+1{,}02\ )+ 0{,}6\ (0{,}62\ +2{,}6) =4{,}57\ kN/m$

The loads stress evaluated are the following:

ELS - COMBO1



ELS – COMBO2



We have to control that:

ELS-COMBO1

$$\sigma_c < 0{,}6\ f_{ck}$$

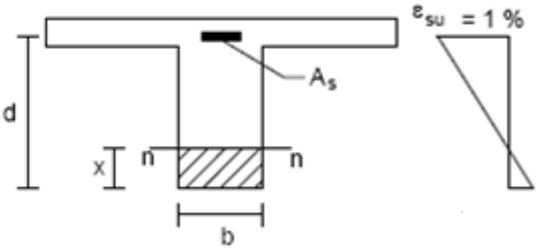
$$\sigma_s < 0{,}8\ f_{vk}$$

ELS-COMBO2

$$\sigma_c < 0{,}45\ f_{ck}$$

2.7.4.1 *Verification of assist*

b	*m*	*0,12*
h	*m*	*0,35*
c	*m*	*0,03*



We can calculate the profondity of neutral axis with the following formula:

$$\frac{bx^2}{2} - A_s\,(d - x) = 0$$

for the Evaluations of the neutral axis see the ***ATTACHEMENT C.***
The moment of inertia can be evaluated with:

$$I_d = \frac{b\,x^3}{3} + A_s\,(d - x)^2$$

						Med	$\sigma_{c,max}$	$\sigma_{s,max}$	*Med*	$\sigma_{c,max}$
	b	*d*	*As*	*x*	*Id*	*Combo 1*	*Combo 1*	*Combo 1*	*Combo 2*	*Combo 2*
	mm	*mm*	*mm*^{2}	*mm*	*mm*^{4}	*N mm*	*N/mm*^{2}	*N/mm*^{2}	*N mm*	*N/mm*^{2}
ASSIST1	*120*	*320*	*113*	*32*	*10683392,0*	*70000*	*0,21*	*28,31*	*140000*	*0,42*
ASSIST2	*120*	*320*	*278*	*78,4*	*35502627,8*	*2240000*	*4,95*	*228,65*	*1811000*	*4,00*
ASSIST3	*120*	*320*	*102*	*28,6*	*9596970,2*	*492000*	*1,47*	*224,08*	*390000*	*1,16*

Considering the COMBO1 the maximum stress on the concrete and on the steel are:

$$\sigma_{c,max} = \left(\frac{M}{I_{id}}\right) x$$

$$\sigma_{s,max} = n\left(\frac{M}{I_{id}}\right)(d - x)$$

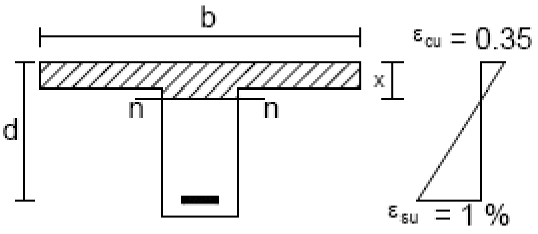
Considering the COMBO2 the maximum stress on the concrete is:

$$\sigma_{c,max} = \left(\frac{M}{I_{id}}\right) x$$

At the verific we have:

	Combo1						Combo 2		
	$\sigma_{c,amm}$ $=0,6f_{ck}$	$\sigma_{s,amm}$ $=0,8f_{yk}$	$\sigma_{c,max}$	$\sigma_{s,max}$	$\sigma_{c,max}/\sigma_{c,amm}$	$\sigma_{s,max}/\sigma_{s,amm}$	$\sigma_{c,amm}$ $=0,45f_{ck}$	$\sigma_{c,max}$	$\sigma_{c,max}/\sigma_{c,amm}$
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	-	-	N/mm^2	N/mm^2	N/mm^2
ASSIST1	15	364	0,21	28,31	0,014	0,078	11,25	0,42	0,037
ASSIST2	15	364	4,95	228,65	0,330	0,628	11,25	4,00	0,355
ASSIST3	15	364	1,47	224,08	0,098	0,616	11,25	1,16	0,103

2.7.4.2 *Verification of the middle section*



	b	d	As	x	Id	Med Combo 1	$\sigma_{c,max}$ Combo 1	$\sigma_{s,max}$ Combo 1	Med Combo 2	$\sigma_{c,max}$ Combo 2
	mm	mm	mm^2	mm	mm^4	N mm	N/mm^2	N/mm^2	N mm	N/mm^2
MID 1	120	320	251	42,7	6232912,3	1971000	13,50	1315,34	2081000	14,26
MID 2	120	320	51	19,1	669251,6	70000	2,00	472,09	696000	19,86

And the verification is:

	Combo1						Combo 2		
	$\sigma_{c,amm}$ $=0,6f_{ck}$	$\sigma_{s,amm}$ $=0,8f_{yk}$	$\sigma_{c,max}$	$\sigma_{s,max}$	$\sigma_{c,max}/\sigma_{c,amm}$	$\sigma_{s,max}/\sigma_{s,amm}$	$\sigma_{c,amm}$ $=0,45f_{ck}$	$\sigma_{c,max}$	$\sigma_{c,max}/\sigma_{c,amm}$
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	-	-	N/mm^2	N/mm^2	N/mm^2
MID 1	15	364	13,50	1315,04	0,900	3,613	11,25	14,25	1,267
MID 2	15	364	1,92	454,78	0,128	1,249	11,25	19,14	1,701

Both the sections are not satisfied so it is increased the longitudinal reinforcement to:

- *Mid section 1: new reinforcement 2*ϕ*16,* A_s*=402* mm^2*;*
- *Mid section 2: new reinforcement 1*ϕ*12+1*ϕ*8,* A_s*=163* mm^2

The new values evaluated are:

						Med	$\sigma_{c,max}$	$\sigma_{s,max}$	Med	$\sigma_{c,max}$
	b	d	As	x	Id	Combo 1	Combo 1	Combo 1	Combo 2	Combo 2
	mm	mm	mm^2	mm	mm^4	N mm	N/mm^2	N/mm^2	N mm	N/mm^2
MID 1	120	320	402	74,6	29141020,1	1971000	5,05	248,97	2081000	5,33
MID 2	120	320	163	27,7	2131602,4	70000	0,91	143,98	696000	9,04

And both the verifics are satisfied:

	Combo1						Combo 2		
	$\sigma_{c,amm}$ $=0,6f_{ck}$	$\sigma_{s,amm}$ $=0,8f_{yk}$	$\sigma_{c,max}$	$\sigma_{s,max}$	$\sigma_{c,max}/\sigma_{c,amm}$	$\sigma_{s,max}/\sigma_{s,amm}$	$\sigma_{c,amm}$ $=0,45f_{ck}$	$\sigma_{c,max}$	$\sigma_{c,max}/\sigma_{c,amm}$
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	-	-	N/mm^2	N/mm^2	N/mm^2
MID 1	15	364	5,05	248,97	0,336	0,684	11,25	5,33	0,474
MID 2	15	364	0,91	143,98	0,061	0,396	11,25	9,04	0,804

2.7.5 FLOOR SLAB DESIGN OUTPUT

For the floor-1 reinforcement design see the ***EXTERNAL ATTACHEMENT – graphic work T2.***

2.8 FLOOR TIPE 3 DESIGN

2.8.1 LOAD COMBINATIONS

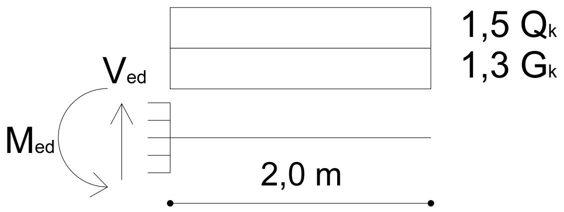
The influence area of a single rafters, egual at the axile base, is of 0,52 m.

Then: G_1 = structural roof = $(3,25\ KN/m^2 \cdot 0,52\ m) = 1,64\ KN/m$
G_2= non structural elements $=1,98\ KN/m^2 \cdot 0,52\ m=1,02KN/m$
G_{2a} =partition = $1,20\ KN/m^2 \cdot 0,52\ m = 0,62\ KN/m$
q_e = exercise load = $(5\ KN/m^2 \cdot 0,52\ m) =2,60\ KN/m$

ULS: characteristic combination

ULS: – comb. 1 $F_d = 1.35 \cdot (1,64+1,02) + 1.5 \cdot (0,26+2,6) = 7,35\ kN/m$

The load combination evaluated at USL are the following:
COMBO1



For the predimensioning of the embossed insoled we consider it like a continue beam with on a edge a rigid joint (shelf) due to the rotational rigidity of the beam (the size of the column on the assists of the beam can guarantee it).
The load combination evaluated is the Combo1.

On the middle section we have:

$$M_{ed} = \frac{q \cdot l^2}{2} = \frac{7{,}35\ kN/m \cdot (2{,}5\ m)^2}{2} = 9{,}18\ kN\ m$$

and the shear on the edge is :

$$V_{sd} = q \cdot l = \ 7{,}35\ kN/m\ \cdot 2{,}5m = 18{,}37\ kN$$

2.8.2 DESIGN AND VERIFICATIONS LONGITUDINAL REINFORCEMENT

2.8.2.1 *Evaluation of the Project strains*

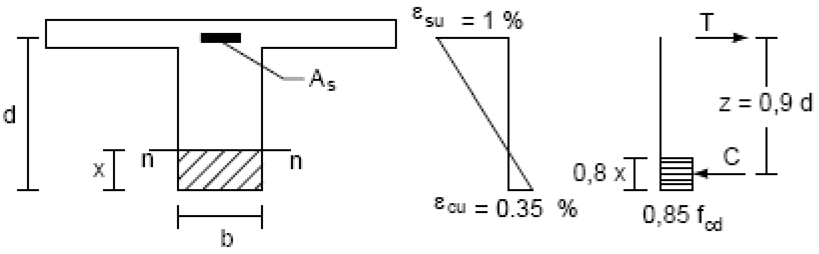
On the middle section we have:

$$M_{ed} = \frac{q \cdot l^2}{2} = \frac{7{,}35\ kN/m \cdot (2{,}5\ m)^2}{2} = 9{,}18\ kN\ m$$

2.8.2.2 *Longitudinal reinforcement design of the middle sections*

On the middle of the beam we consider the following situation:

Section 1		
B	*0,12*	*m*
h	*0,35*	*m*
c	*0,03*	*m*
d	*0,32*	*m*
x_{lim}	*0,14*	*m*
f_{cd}	*16,6*	*kN*
$\boldsymbol{M_{lim}}$	***51,18***	*kN m*



Where :

$$M_{lim} = 0{,}8 \cdot x_{lim} \cdot b \cdot 0{,}85 \cdot f_{cd} \cdot (d - 0{,}4x_{lim})$$

$$M_{sd} = 9{,}18 \frac{kN}{m} < M_{lim} = 51{,}18 \frac{kN}{m}$$

We can project them with concrete reinforcement only for tensile stress.
So:

$$A_s = \frac{M_{sd}}{(0{,}9 \cdot f_{yd} \cdot d)}$$

Middle section:

$$A_{s1} = \frac{918000\, N\, mm}{(0{,}9 \cdot 391 \frac{N}{mm} \cdot 32\, mm)} = 81{,}52\, mm^2 = 0{,}81\, cm^2$$

the concrete renforcement for those section is:

	Assist 1
A_{smin}	*0,81*
A_s	*2Φ8*
$A_{sfornited}$	*1,02*

On the middle section the reinforcement for tensile stress consequentely the neutral axis could be evaluated with the following formula:

$$0{,}8\, x\, (0{,}8\, f_{cd}) \cdot b - A_s f_{yd} = 0$$

so:

$$x = \frac{A_s f_{yd}}{0{,}8(0{,}8\, f_{cd}) \cdot b}$$

and the resistent moment is:

$$M_{rd} = A_s \cdot f_{vd} \cdot (d - 0{,}4\, x)$$

		Middle section 1
f_{yd}	*N/mm^2*	*391,3*
f_{cd}	*N/mm^2*	*16,6*
b	*mm*	*120*
A_s	*mm*	*1,01*
x	*mm*	*24,80*
M_{rd}	*kN m*	*12,25*

2.8.2.3 *Longitudinal reinforcement design of the assists*

In the edge of the bay we have only concrete reinforcement for tensile stress consequentely the neutral axis could be evaluated with the following formula:

$$0{,}8\, x\ (0{,}8\, f_{cd}\ ) \cdot b - \ A_s f_{yd} = 0$$

so:

$$x = \frac{A_s f_{yd}}{0{,}8(0{,}8\, f_{cd}\ ) \cdot b}$$

and the resistent moment is:

$$M_{rd} = \ A_s \cdot f_{vd} \cdot (d - 0{,}4\, x)$$

		Middle section 1
f_{yd}	*N/mm^2*	*391,3*
f_{cd}	*N/mm^2*	*16,6*
b	*mm*	*120*
A_s	*mm*	*1,01*
x	*mm*	*24,80*
M_{rd}	*kN m*	*12,25*

2.8.3 *DESIGN AND VERIFICATIONS SHEAR REINFORCEMENT*

2.8.3.1 *Evaluation of the Stress shear Projects*

The shear stress evaluated is:

$$V_{sd} = q \cdot l = \ 7{,}35\ kN/m\ \cdot 2{,}5m = 18{,}37\ kN$$

2.8.3.2 *Evaluation of the shear breaking point on the concrete side*

Is possible evaluate the shear breaking stress on the concrete side considering the following formula:

$$V_{rcd} = 0{,}3 \cdot d \cdot b_0 \cdot \alpha_c \cdot f'_{cd} \cdot \frac{cot\,\alpha\ + cot\,\theta}{1 +\ cot^2\,\theta} = 230{,}4kN$$

where:

- *d : widht utile of the section along the shear direction;*
- *b :base corresponding to the shear stress direction;*
- *f'cd :breaking stress on concrete reduced due the axial anime compression (f'cd=0,6×fcd)*
- *α :inclination angle of stirrups (α=90°)*
- *θ inclination angle of the concrete struts*
  (1 ≤ ctgθ ≤ 2,5) (21.8° ≤ θ ≤ 45°)

The inclination angle of the concrete struts is evaluated of θ = 45° in safety favour;

And the project shear strass that has to be used for the verific is V_{ed} *is evaluated on the edge of the beam :*

$$V_{ed} = |V_{max} - q \cdot x| = 18{,}33kN - 7{,}73 \cdot 0{,}35m = 15{,}6\ kN$$

2.8.3.3 *Shear verification on the concrete side*

The shear verifications con concrete are made evaluating the piston road compressed and the tensile stress on the concrete.
The first verific is made evaluating:

$$\frac{V_{ed,y}}{V_{rcd,y}} < 1$$

So :

$$\frac{15{,}6kN}{230{,}4kN} = 0{,}06 < 1$$

The verific of the tensile stress is made evaluating the concrete contribution to the shear with the following:

$$V_{rd1} = \left(\frac{0{,}18}{g_c} \cdot k \cdot (100\rho_1 \cdot f_{ck})^{\frac{1}{3}}\right) b_w \cdot d$$

Where :

$$K = 1 + \sqrt{\left(\frac{200}{d}\right)} = 1 + \sqrt{\left(\frac{200}{290}\right)} = 1{,}83$$

$$\rho_1 = \frac{A_{s1}}{(b_w \cdot d)} = \frac{3{,}87\ cm^2}{(12\ cm \cdot 29\ cm)} = 0{,}011$$

so

$$V_{rd1} = \frac{\left(\frac{0{,}18}{1{,}5} \cdot 1{,}83 \cdot \left(100 \cdot 0{,}011 \cdot 25 \frac{N}{mm}\right)^{\frac{1}{3}}\right) 120\ mm \cdot 290\ mm}{1000} = 23{,}06\ kN$$

moreover the value of V_{min} is the following:

$$V_{min} = 0{,}05\ \cdot\ K^{\frac{3}{2}}\ \cdot f_{ck}{}^{\frac{1}{2}} \cdot b_w \cdot d = 22{,}3\ KN$$

$$V_{rd1} \geq (V_{min})$$

Considering that the verific is satisfied we introduce only a minimum full concrete band.

2.8.3.4 *Shear reinforcement design*

On the assits we have to add a concrete reinforcement following the scheme of simply supported beam we have:

Vmax =18,37 kN

$$A_{shear} = \frac{V_{max}}{f_{yd}} = \frac{(18370\ N\ )}{(\ 391{,}3 \frac{N}{mm})} = 46{,}94\ mm^2\ = 0{,}46\ cm^2$$

We use 1 ϕ8 with a correspondent Air of 0,51 cm^2.

2.8.4 VERIFICATIONS OF THE EXERCISE STRAIN

The section that could have problems are the one sections in correspondance of the central assits, where the copressed zone (on the bottom) have a width of 12 cm.
We consider the following two combinations:

ELS: exercise state limite

ELS: – comb. 1 *F_d = 1 (1,64+1,02)+ 1 (0,26 +2,6) = 5,72 kN/m*

ELS: – comb. 2 *F_d =1· (1,64+1,02)+ 0,6 (0,26 +2,6) =4,57 kN/m*

The loads stress evaluated are the following:

ELS - COMBO1

$$M_{ed} = \frac{q \cdot l^2}{2} = \frac{5{,}72\ kN/m \cdot (2{,}5\ m)^2}{2} = 17{,}8\ kN\ m$$

ELS – COMBO2

$$M_{ed} = \frac{q \cdot l^2}{2} = \frac{7{,}35 \frac{kN}{m} \cdot (2{,}5\ m)^2}{2} = 14{,}28\ kN\ m$$

We have to control that:

ELS-COMBO1

$$\sigma_c < 0{,}6\ f_{ck}$$

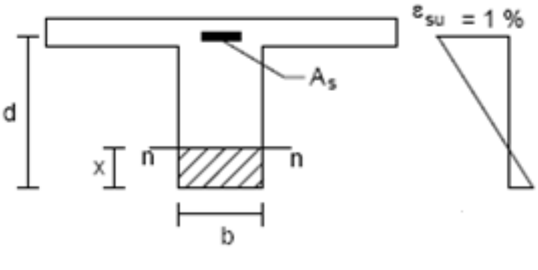
$$\sigma_s < 0{,}8\ f_{vk}$$

ELS-COMBO2

$$\sigma_c < 0{,}45\ f_{ck}$$

2.8.4.1 *Verification of assist*

b	*m*	*0,12*
h	*m*	*0,35*
c	*m*	*0,03*



We can calculate the profondity of neutral axis with the following formula:

$$\frac{bx^2}{2} - A_s\,(d - x) = 0$$

for the Evaluations of the neutral axis see the ***ATTACHEMENT C.***
The moment of inertia can be evaluated with:

$$I_d = \frac{b\,x^3}{3} + A_s\,(d - x)^2$$

						Med	$\sigma_{c,max}$	$\sigma_{s,max}$	Med	$\sigma_{c,max}$
	b	d	As	x	Id	Combo 1	Combo 1	Combo 1	Combo 2	Combo 2
	mm	mm	mm^2	mm	mm^4	N mm	N/mm^2	N/mm^2	N mm	N/mm^2
ASSIST1	120	320	102	28,6	9596970,2	178000	0,53	81,07	1480000	4,41

Considering the COMBO1 the maximum stress on the concrete and on the steel are:

$$\sigma_{c,max} = \left(\frac{M}{I_{id}}\right) x$$

$$\sigma_{s,max} = n\left(\frac{M}{I_{id}}\right)(d - x)$$

Considering the COMBO2 the maximum stress on the concrete is:

$$\sigma_{c,max} = \left(\frac{M}{I_{id}}\right) x$$

At the verific we have:

	Combo1						Combo 2		
	$\sigma_{c,amm}$ $=0,6f_{ck}$	$\sigma_{s,amm}$ $=0,8f_{yk}$	$\sigma_{c,max}$	$\sigma_{s,max}$	$\sigma_{c,max}/\sigma_{c,amm}$	$\sigma_{s,max}/\sigma_{s,amm}$	$\sigma_{c,amm}$ $=0,45f_{ck}$	$\sigma_{c,max}$	$\sigma_{c,max}/\sigma_{c,amm}$
	N/mm^2	N/mm^2	N/mm^2	N/mm^2	-	-	N/mm^2	N/mm^2	N/mm^2
ASSIST1	15	364	0,53	81,07	0,035	0,223	11,25	4,41	0,392

2.9 BEAMS DESIGN

2.9.1 STATUTORY PROVISIONS FOR CIVIL BUILDINGS

To reach the minimum characteristics of ductility Globals and locals, distinguished by the Duttility class adopted, is necessary the respect of some conditions reguarding the geometry and the concrete bars reinforcement details of the elements.

2.9.1.1 *Geometric limitation*

- *The width of the beam, **b**, have not to be less than 20 cm and, for low tide beam, have not to be bigger than the width of the column increased in both sides with half of the cross section of the beam, resulting in any case not bigger than 2 b_c, where b_c is the width of the column orthogonal at the axis of the beam;*

Deep beam	*b*	*b_{min}*	***Verific***
	cm	*cm*	
Prototype 6	*300*	*200*	*Verified*
Prototype 7	*300*	*200*	*Verified*
Prototype 8	*300*	*200*	*Verified*

- *The relation b/h have not to be less than 0,3 so:*

Low tide Beams	*h*	*b*	*b/h*	*b/h_{min}*	***Verific***
	cm	*cm*	*cm*	*cm*	
Prototype 6	*600*	*350*	*0,6*	*0,3*	*Verified*
Prototype 7	*600*	*550*	*0,9*	*0,3*	*Verified*
Prototype 8	*600*	*800*	*1,3*	*0,3*	*Verified*

2.9.1.2 *Prescription on Longitudinal reinforcement*

In all the beams have to be present at least 2 bars Ø 14 on the top and on the bottom

The shares depends by the yeld and permissible stress of the steal. The relationship between top reinforcement and bottom is moderate by the following limites:

<u>High ductility</u>

$$\rho_{max} < \rho' + \frac{72 \cdot f_{yd}}{f_{yk}}$$

Very High ductility

$$\rho_{max} < \rho' + \frac{50 \cdot f_{yd}}{f_{yk}}$$

Where:

- ρ_{max} *is the geometric ratio between tensile reinforcement and concrete* $= A_s / (b \cdot h)$ *or* $A_i / (b \cdot h)$;
- ρ' *is the geometric ratio between concrete and compressed reinforcement;*
- A_s *e* A_i *rappresents the area of longitudinal reinforcement on the top and on the bottom respectively;*

The reinforcement on the top, evaluated with the nevgative bending moment on the edge,has to be contained, for at least the 75% ,whitin the web width and, for section T or L, in any case in a slab zone equal rispectively to a:

- *Width of the column or*
- *The Width of the column increased of 2 times with the height of the slab in both sides of the column (depends if the joint is completely confined or not);*
- *At least ¼ of this reinforcement have to be contained for all the lenght of the beam;*

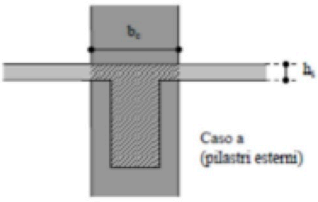
So:

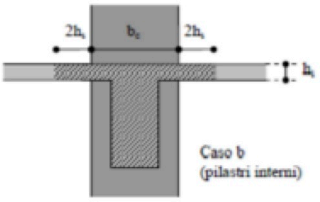
- *Critic zones* $\rho_{comp} > 50\% \rho$
- *Other zones* $\rho_{comp} > 25\% \rho$

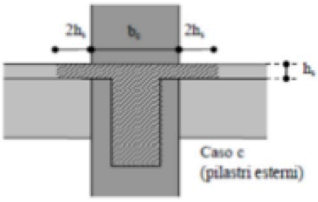
2.9.1.3 *Shear reinforcement high ductility*

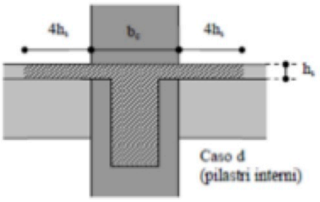
The critic zones are extended for "CDA" and "CDMA",for a lenght respectively of 1 and 1,5 the height of the beam section, misured from the surface joint-column or form both sides considering the prime plasticization section.

With beams that substain a column we absume a lenght of 2 height of the section misured from both column faces.









The stirrupe reinforcement is a circular, rectangular or spiral bar, with the minimum diameter of 6mm,with 135°hook extended at least for 10 diameters on the extremities. The hooks have to be assured on the longitudinal bars.

For structure projected in ***CD"A"****, the respect of the normative pass has to be extended for a lenght of 1,5 times the height of the trasversal section (2 H = critic zone) for example the corresponding critic zone of a beam 30x50 is 100 cm. The first containing clamp has to be positioned not more than 5 cm from the column section; the following have to be positioned with a pass less than the minimum of the following sizes:*

- *d/4 utile height of trasversal section;*
- *20 cm;*
- *6* ϕ_{lon} *;*
- *24* ϕ_{trasv} *;*

While, for structure projected in ***CD"MA",*** *the respect of the normative pass has to be extended for a lenght of 1 times the height of the trasversal (2 H = critic zone). The first containing clamp has to be positioned not more than 5 cm from the column section; the following have to be positioned with a pass less than the minimum of the following sizes:*

- *d/4 utile height of trasversal section;*
- *20 cm;*
- *8* ϕ_{lon} *;*
- *24* ϕ_{trasv} *;*

In central zones, out from critic zone, the stirrups are evaluated respecting the shear verification. The minimum shear reinforcement has minimum to be has to be less than 0,5 utile height of the section

2.9.1.4 *Anchorage*

The longitudinals bars, both on the bottom and on the top, have "as a role" to cross the joint without anchor or splice on them.

If it is impossible to satisfy, the following rooles have to be respected:

- *The bars have to be anchored on the opposite face of the intersection with the joint,or have to be turned upon vertically in corrispondance of that face , to containing the joint;*
- *The anchor lenght of stretched bars have to be evaluated in way that is possible to develop a bars tensile stress of 1,25 fyk, evaluated from a distance of 6 diameters from the column face on the internal face*

The longitudinal part of the beam that anchor on the joint can not terminate inside a critic zone, but has to end beyond; furthermore has to be situated inwards stirrups reinforcement.

To prevent the withdrawl of those reinforcement bars, the diameters of not inclined bars has to be $\leq \alpha_{bL}$ *height of the column section, being:*

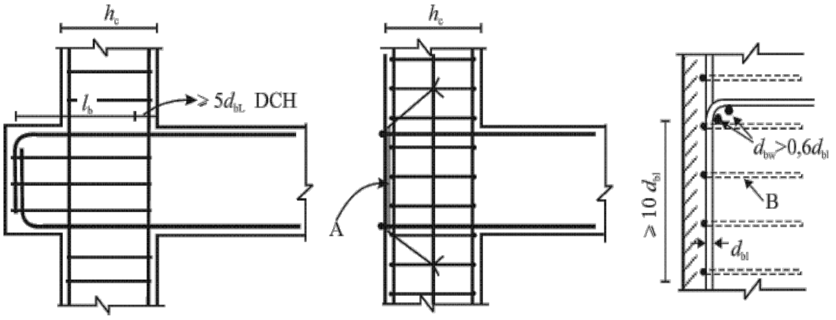
$$\alpha_{bL} = \begin{cases} \dfrac{7,5 \cdot f_{ctm}}{\gamma_{Rd} \cdot f_{yd}} \cdot \dfrac{1+0,8\nu_d}{1+0,75k_D \cdot \rho_{comp}/\rho} & \text{per nodi interni} \\ \dfrac{7,5 \cdot f_{ctm}}{\gamma_{Rd} \cdot f_{yd}} \cdot \left(1+0,8\nu_d\right) & \text{per nodi esterni} \end{cases}$$

where:

- ν_d *axial project stress normalized;*
- K_d *is 1 in CDMA o 2/3 in CDA;*
- γ_{rd} *is 1,2 in CDMA o 1 in CDA;*

Considering the external joint, it is possible that this limitation might not satisfied so:

a) *It's possible to extend the beam beyond the pilar end,*
b) *It's possible to use steel plate welded on the end of the bars , e*
c) *It's possible to fold the bars for a minimum length equal to 10 times the bars diameter setting an apposite cross reinforcement behind the bending.*



a) b) c)

2.9.2 DESIGN AND VERIFICATIONS LONGITUDINAL REINFORCEMENT

2.9.2.1 *Evaluation of the Project strains*

Using the finite element modeling program (csi sap 2000) are determined the bending moment diagrams relatively on a each single load combination. Overlapping it is determined the ENVELOPE combination of all the flexile stress operating on the entire frame.

In particolar the bending moment diagram consider the EnvelopeSLU combination, thereby is possible to obtain the maximum stress conditions.

On the diagram have to make the following corrections:

- *Translation of the diagram of a quantity 0,9d, where "d" rapresent the utile height of the section. In this way is possible to obtain the shear broke mechanism.*

The bending moment obtained grafic has been translated of a quantity:

Name	***b***	h_{pick}	***0,9 x h***	***Misure Units***
Prototype 1	*300*	*400*	*360*	*cm*
Prototype 2	*300*	*500*	*450*	*cm*
Prototype 3	*300*	*750*	*675*	*cm*
Prototype 4	*300*	*600*	*540*	*cm*
Prototype 5	*300*	*550*	*495*	*cm*
Prototype 6	*600*	*350*	*315*	*cm*
Prototype 7	*600*	*550*	*495*	*cm*
Prototype 8	*600*	*750*	*720*	*cm*

The translation towards is where increase the maximum value of bending moment (favour of security), both for considering the beam dimension and to cover with the longitudinal reinforcement the shear stress part;

In favour of security the bending moment diagram is not blunt in the proximity of the joint beam-column. In fact the support is considered punctual by the calcol program.. The flexile strain (direction 2) and the shear strain (direction 3) are considered null due the rigidity of the floor. Is possible to note that thanks to the rigid diafram, the axile stress are null, to demonstrate the rigidity of the floor requested by the normative.

To respect the Hyerarchy of resistances,each section has to be projected with the resisten moment bigger/equal than the stimulate bending moment stress.

The reinforcements are evaluated considering the Bending Moment admissible og the section:

$$M_{lim} = 0{,}8 \cdot x \cdot f_{cd} \cdot b \cdot \left(d - \frac{0{,}8\, d}{2}\right)$$

Considering the bilanced breaking line:

$$X = 0{,}45\, d$$

Name	***b***	***h***	***fcd***	***d***	***x***	M_{lim}	M_{ed}
	mm	*mm*	*N mm*	*mm*	*mm*	*kN*	*kN*
Prototype 1	*300*	*400*	*15,9*	*370*	*95,94*	*121,91*	*45,46*
Prototype 2	*300*	*500*	*15,9*	*470*	*121,87*	*196,72*	*108,10*
Prototype 3	*300*	*750*	*15,9*	*720*	*186,70*	*461,66*	*428,50*
Prototype 4	*300*	*600*	*15,9*	*570*	*147,80*	*289,34*	*198,40*
Prototype 5	*300*	*550*	*15,9*	*520*	*134,84*	*240,80*	*233,60*
Prototype 6	*600*	*350*	*15,9*	*320*	*82,98*	*182,38*	*120,70*
Prototype 7	*600*	*550*	*15,9*	*520*	*134,84*	*481,60*	*364,30*
Prototype 8	*600*	*800*	*15,9*	*770*	*199,66*	*1056,00*	*1005,20*

Comparing the Bending limite moment with the stimulate strain , is possible to notice that, in every section of the construction beam , the limite moment is higher than the stimulate :

$$M_{sd} \leq M_{lim}$$

It is possible therefore proceding with the project of reinforcement longitudinals bars, considering them with simple flexion:

$$As = \frac{Msd}{0{,}9\, d\, fyd}$$

To evaluate the reinforcement bars quantity is necessary to go ahead considering the Resistent moment for differents bars diameter using the following formula:

$$M_{rd} = A_s \cdot 0{,}9 \cdot d \cdot f_{yd}$$

2.9.2.2 *Longitudinal reinforcement design*

Building 1

Reinforcement Assist A 1					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	*N mm^2*	$As^{(-)}$ *min*	*6,22*	*cm^2*
fcd	*14,17*	*N mm^2*		*3φ 16 +1φ 12*	
Es	*200000*	*N mm^2*	*Project* $As^{(-)}$	*7,16*	*cm^2*
Ec	*15000*	*N mm^2*	*0,5* $As^{(-)}$	*3,58*	*cm^2*
Stress			*Project* $As^{(+)}$	*2 φ16*	
$M_{ed}^{(+)}$	*0*	*KN m*		*4,02*	*cm^2*
$M_{ed}^{(-)}$	*81*	*KN m*			
Geometric Characteristic					
h = high			*40*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*37*		*cm*
Resistance evaluation					
Negative bending Moment					
	ρ_{max} =	*0,0060*	≤	$\rho' + 50fcd/fyd^2$	*0,0064*
Mrdu(-)		*93,30*			*KN m*

Reinforcement of the middle of the section A 1-2					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	*N mm^2*	$As^{(-)}$ *min*	*2,53*	*cm^2*
fcd	*14,17*	*N mm^2*		*2φ 12+1 φ16*	
Es	*200000*	*N mm^2*	*Project* $As^{(-)}$	*4,27*	*cm^2*
Ec	*15000*	*N mm^2*	*0,25* $As^{(-)}$	*1,07*	*cm^2*
Stress				*2φ 12*	
$M_{ed}^{(+)}$	*33*	*KN m*	*Project* $As^{(+)}$	*2,26*	*cm^2*
$M_{ed}^{(-)}$	*0*	*KN m*			
Geometric Characteristic					
h = high			*40*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*37*		*cm*
Resistance evaluation					
Positive bending Moment					
	ρ_{max} =	*0,0036*	≤	$\rho' + 50fcd/fyd^2$	*0,0065*
Mrdu(+)		*55,64*			*KN m*

Reinforcement Assist A2					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	$N\ mm^2$	$As^{(-)}$ *min*	*6,45*	cm^2
fcd	*14,17*	$N\ mm^2$		*3φ 16 +1φ 12*	
Es	*200000*	$N\ mm^2$	*Project* $As^{(-)}$	*7,16*	cm^2
Ec	*15000*	$N\ mm^2$	*0,5* $As^{(-)}$	*3,58*	cm^2
Stress			*Project* $As^{(+)}$	*2 φ16*	
$M_{ed}^{(+)}$	*0*	*KN m*		*4,02*	cm^2
$M_{ed}^{(-)}$	*84*	*KN m*			
Geometric Characteristic					
h = high			*40*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*37*		*cm*
Resistance evaluation					
Negative bending Moment					
	ρ_{max}	=	*0,0060*	≤	$\rho'+50fcd/fyd^2$ *0,0064*
Mrdu(-)			*93,30*		*KN m*

Reinforcement Assist B1					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	$N\ mm^2$	$As^{(-)}$ *min*	*9,36*	cm^2
fcd	*14,17*	$N\ mm^2$		*5φ 16*	
Es	*200000*	$N\ mm^2$	*Project* $As^{(-)}$	*10,05*	cm^2
Ec	*15000*	$N\ mm^2$	*0,5* $As^{(-)}$	*5,025*	cm^2
Stress			*Project* $As^{(+)}$	*2φ16+1φ12*	
$M_{ed}^{(+)}$	*0*	*KN m*		*5,15*	cm^2
$M_{ed}^{(-)}$	*155*	*KN m*			
Geometric Characteristic					
h = high			*50*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*47*		*cm*
Resistance evaluation					
Negative bending Moment					
	ρ_{max}	=	*0,0067*	≤	$\rho'+50fcd/fyd^2$ *0,0064*
Mrdu(-)			*166,35*		*KN m*

Reinforcement of the middle of the section B 1-2					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	$N\ mm^2$	$As^{(-)}$ *min*	*3,32*	cm^2
fcd	*14,17*	$N\ mm^2$		*2φ16+1φ12*	
Es	*200000*	$N\ mm^2$	*Project* $As^{(-)}$	*5,15*	cm^2
Ec	*15000*	$N\ mm^2$	*0,25* $As^{(-)}$	*1,29*	cm^2
Stress				*2φ 16*	
$M_{ed}^{(+)}$	*55*	*KN m*	*Project* $As^{(+)}$	*4,02*	cm^2
$M_{ed}^{(-)}$	*0*	*KN m*			
Geometric Characteristic					
h = high			*50*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*47*		*cm*
Resistance evaluation					
Positive bending Moment					
ρ_{max}	=	*0,0034*	≤	$\rho' + 50fcd/fyd^2$	*0,0073*
Mrdu(+)			*85,24*		*KN m*

Reinforcement Assist B2-right					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	$N\ mm^2$	$As^{(-)}$ *min*	*7,44*	cm^2
fcd	*14,17*	$N\ mm^2$	*Project* $As^{(-)}$	*4φ 16*	
Es	*200000*	$N\ mm^2$		*8,04*	cm^2
Ec	*15000*	$N\ mm^2$	*0,5* $As^{(-)}$	*4,02*	cm^2
Stress			*Project* $As^{(+)}$	*2 φ16*	
$M_{ed}^{(+)}$	*0*	*KN m*		*4,02*	cm^2
$M_{ed}^{(-)}$	*97*	*KN m*			
Geometric Characteristic					
h = high			*40*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*37*		*cm*
Resistance evaluation					
Negative bending Moment					
ρ_{max}	=	*0,0067*	≤	$\rho' + 50fcd/fyd^2$	*0,0064*
Mrdu(-)			*104,76*		*KN m*

Reinforcement of the middle of the section B2-3						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		1,81	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	2 φ16		
Es	200000	N mm^2			4,02	cm^2
Ec	15000	N mm^2	0,25 $As^{(-)}$		1,01	cm^2
Stress			Project $As^{(+)}$	2φ 12		
$M_{ed}^{(+)}$	30	KN m			2,26	cm^2
$M_{ed}^{(-)}$	0	KN m				
Geometric Characteristic						
h = high			50			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			47			cm
Resistance evaluation						
Positive bending Moment						
	ρ_{max}	=	0,0027	≤	$\rho' + 50fcd/fyd^2$	0,0061
Mrdu(+)			66,54			KN m

Reinforcement Assist B3-left						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		5,68	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	4φ 16		
Es	200000	N mm^2			8,04	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		4,02	cm^2
Stress			Project $As^{(+)}$	2 φ16		
$M_{ed}^{(+)}$	0	KN m			4,02	cm^2
$M_{ed}^{(-)}$	94	KN m				
Geometric Characteristic						
h = high			50			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			47			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0054	≤	$\rho' + 50fcd/fyd^2$	0,0064
Mrdu(-)			133,08			KN m

Reinforcement Assist B3-right						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		7,21	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	4φ 16		
Es	200000	N mm^2			8,04	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		4,02	cm^2
Stress			Project $As^{(+)}$	2 φ16		
$M_{ed}^{(+)}$	0	KN m			4,02	cm^2
$M_{ed}^{(-)}$	94	KN m				
Geometric Characteristic						
h = high			40			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			37			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0067	≤	$\rho' +50fcd/fyd^2$	0,0064
Mrdu(-)			104,76			KN m

Reinforcement of the middle of the section B 3-4						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		1,87	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	2 φ16		
Es	200000	N mm^2			4,02	cm^2
Ec	15000	N mm^2	0,25 $As^{(-)}$		1,01	cm^2
Stress			Project $As^{(+)}$	2φ 12		
$M_{ed}^{(+)}$	31	KN m			2,26	cm^2
$M_{ed}^{(-)}$	0	KN m				
Geometric Characteristic						
h = high			50			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			47			cm
Resistance evaluation						
Positive bending Moment						
	ρ_{max}	=	0,0027	≤	$\rho' +50fcd/fyd^2$	0,0061
Mrdu(+)			66,54			KN m

Reinforcement Assist B4-left						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	As $^{(-)}$ min		5,56	cm^2
fcd	14,17	N mm^2	Project As$^{(-)}$	4φ 16		
Es	200000	N mm^2			8,04	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$		4,02	cm^2
Stress			Project As$^{(+)}$	2 φ16		
M_{ed} $^{(+)}$	0	KN m			4,02	cm^2
M_{ed} $^{(-)}$	92	KN m				
Geometric Characteristic						
h = high			50			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			47			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0054	≤	ρ' +50fcd/fyd^2	0,0064
Mrdu(-)			133,08			KN m

Reinforcement Assist C1						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	As $^{(-)}$ min		0,06	cm^2
fcd	14,17	N mm^2		4φ 16		
Es	200000	N mm^2	Project As$^{(-)}$		8,04	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$		4,02	cm^2
Stress			Project As$^{(+)}$	2 φ16		
M_{ed} $^{(+)}$	0	KN m			4,02	cm^2
M_{ed} $^{(-)}$	1	KN m				
Geometric Characteristic						
h = high			50			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			47			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0054	≤	ρ' +50fcd/fyd^2	0,0073
Mrdu(-)			133,08			KN m

Reinforcement Assist C1							
Material			**Longitudinal reinforcement**				
fyd	391,3	N mm^2	$As^{(-)}$ min		0,06	cm^2	
fcd	14,17	N mm^2		4φ 16			
Es	200000	N mm^2	Project $As^{(-)}$		8,04	cm^2	
Ec	15000	N mm^2	0,5 $As^{(-)}$		4,02	cm^2	
Stress			Project $As^{(+)}$	2 φ16			
$M_{ed}^{(+)}$	0	KN m			4,02	cm^2	
$M_{ed}^{(-)}$	1	KN m					
Geometric Characteristic							
h = high				50		cm	
b = width				30		cm	
d' =cover reinforcement				3		cm	
d =utile high				47		cm	
Resistance evaluation							
Negative bending Moment							
	ρ_{max}	=	0,0054	≤	ρ' +50fcd/fyd^2	0,0073	
Mrdu(-)			133,08			KN m	

Reinforcement of the middle of the section C 1-2							
Material			**Longitudinal reinforcement**				
fyd	391,3	N mm^2	$As^{(-)}$ min		2,72	cm^2	
fcd	14,17	N mm^2		3φ 12+1 φ16			
Es	200000	N mm^2	Project $As^{(-)}$		5,4	cm^2	
Ec	15000	N mm^2	0,25 $As^{(-)}$		1,35	cm^2	
Stress				2φ 12			
$M_{ed}^{(+)}$	45	KN m	Project $As^{(+)}$		3,08	cm^2	
$M_{ed}^{(-)}$	0	KN m					
Geometric Characteristic							
h = high				50		cm	
b = width				30		cm	
d' =cover reinforcement				3		cm	
d =utile high				47		cm	
Resistance evaluation							
Positive bending Moment							
	ρ_{max}	=	0,0036	≤	ρ' +50fcd/fyd^2	0,0067	
Mrdu(+)			89,38			KN m	

Reinforcement Assist C2-left						
Material			**Longitudinal reinforcement**			
fyd	*391,3*	*N mm²*	*As ⁽⁻⁾ min*		*7,79*	*cm²*
fcd	*14,17*	*N mm²*	*Project As⁽⁻⁾*	*4φ 16*		
Es	*200000*	*N mm²*			*8,04*	*cm²*
Ec	*15000*	*N mm²*	*0,25 As ⁽⁻⁾*		*4,02*	*cm²*
Stress			*Project As⁽⁺⁾*	*2 φ16*		
M_{ed} ⁽⁺⁾	*0*	*KN m*			*4,02*	*cm²*
M_{ed} ⁽⁻⁾	*129*	*KN m*				
Geometric Characteristic						
h = high				*50*		*cm*
b = width				*30*		*cm*
d' =cover reinforcement				*3*		*cm*
d =utile high				*47*		*cm*
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	*0,0054*	≤	*ρ' +50fcd/fyd²*	*0,0073*
Mrdu(-)			*133,08*			*KN m*

Reinforcement Assist C2-right						
Material			**Longitudinal reinforcement**			
fyd	*391,3*	*N mm²*	*As ⁽⁻⁾ min*		*7,84*	*cm²*
fcd	*14,17*	*N mm²*	*Project As⁽⁻⁾*	*4φ 16*		
Es	*200000*	*N mm²*			*8,04*	*cm²*
Ec	*15000*	*N mm²*	*0,5 As ⁽⁻⁾*		*4,02*	*cm²*
Stress			*Project As⁽⁺⁾*	*2 φ16*		
M_{ed} ⁽⁺⁾	*0*	*KN m*			*4,02*	*cm²*
M_{ed} ⁽⁻⁾	*129,8*	*KN m*				
Geometric Characteristic						
h = high				*50*		*cm*
b = width				*30*		*cm*
d' =cover reinforcement				*3*		*cm*
d =utile high				*47*		*cm*
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	*0,0054*	≤	*ρ' +50fcd/fyd²*	*0,0073*
Mrdu(-)			*133,08*			*KN m*

Reinforcement of the middle of the section C2-3

Material			**Longitudinal reinforcement**		
fyd	391,3	$N\,mm^2$	$As^{(-)}$ min	2,63	cm^2
fcd	14,17	$N\,mm^2$	Project $As^{(-)}$	3φ 12+1 φ16	
Es	200000	$N\,mm^2$		4,02	cm^2
Ec	15000	$N\,mm^2$	0,25 $As^{(-)}$	1,01	cm^2
Stress			Project $As^{(+)}$	2φ 12	
$M_{ed}^{(+)}$	43,61	KN m		2,26	cm^2
$M_{ed}^{(-)}$	0	KN m			
Geometric Characteristic					
h = high			50		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			47		cm
Resistance evaluation					
Positive bending Moment					
	ρ_{max} =	0,0027	≤	$\rho' + 50fcd/fyd^2$	0,0061
Mrdu(+)		66,54			KN m

Reinforcement Assist C3-left

Material			**Longitudinal reinforcement**		
fyd	391,3	$N\,mm^2$	$As^{(-)}$ min	7,67	cm^2
fcd	14,17	$N\,mm^2$	Project $As^{(-)}$	4φ 16	
Es	200000	$N\,mm^2$		8,04	cm^2
Ec	15000	$N\,mm^2$	0,5 $As^{(-)}$	4,02	cm^2
Stress			Project $As^{(+)}$	2 φ16	
$M_{ed}^{(+)}$	0	KN m		4,02	cm^2
$M_{ed}^{(-)}$	126,9	KN m			
Geometric Characteristic					
h = high			50		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			47		cm
Resistance evaluation					
Negative bending Moment					
	ρ_{max} =	0,0054	≤	$\rho' + 50fcd/fyd^2$	0,0073
Mrdu(-)		133,08			KN m

Reinforcement Assist C3-right						
Material			***Longitudinal reinforcement***			
fyd	*391,3*	*N mm^2*	*As $^{(-)}$ min*		*8,02*	*cm^2*
fcd	*14,17*	*N mm^2*	*Project As$^{(-)}$*	*4φ 16*		
Es	*200000*	*N mm^2*			*8,04*	*cm^2*
Ec	*15000*	*N mm^2*	*0,5 As $^{(-)}$*		*4,02*	*cm^2*
Stress			*Project As$^{(+)}$*	*2 φ16*		
$M_{ed}^{(+)}$	*0*	*KN m*			*4,02*	*cm^2*
$M_{ed}^{(-)}$	*132,7*	*KN m*				
Geometric Characteristic						
h = high			*50*			*cm*
b = width			*30*			*cm*
d' =cover reinforcement			*3*			*cm*
d =utile high			*47*			*cm*
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	*0,0054*	≤	*ρ' +50fcd/fyd^2*	*0,0073*
Mrdu(-)			*133,08*			*KN m*

Reinforcement of the middle of the section C 3-4						
Material			***Longitudinal reinforcement***			
fyd	*391,3*	*N mm^2*	*As $^{(-)}$ min*		*2,66*	*cm^2*
fcd	*14,17*	*N mm^2*	*Project As$^{(-)}$*	*3φ 12+1 φ16*		
Es	*200000*	*N mm^2*			*5,4*	*cm^2*
Ec	*15000*	*N mm^2*	*0,25 As $^{(-)}$*		*1,35*	*cm^2*
Stress			*Project As$^{(+)}$*	*2φ 12*		
$M_{ed}^{(+)}$	*44*	*KN m*			*2,26*	*cm^2*
$M_{ed}^{(-)}$	*0*	*KN m*				
Geometric Characteristic						
h = high			*50*			*cm*
b = width			*30*			*cm*
d' =cover reinforcement			*3*			*cm*
d =utile high			*47*			*cm*
Resistance evaluation						
Positive bending Moment						
	ρ_{max}	=	*0,0036*	≤	*ρ' +50fcd/fyd^2*	*0,0061*
Mrdu(+)			*89,38*			*KN m*

Reinforcement Assist C4-left						
Material			***Longitudinal reinforcement***			
fyd	391,3	N mm^2	$As^{(-)}$ min		7,24	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	4φ 16		
Es	200000	N mm^2			8,04	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		4,02	cm^2
Stress			Project $As^{(+)}$	2 φ16		
$M_{ed}^{(+)}$	0	KN m			4,02	cm^2
$M_{ed}^{(-)}$	119,8	KN m				
Geometric Characteristic						
h = high			50			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			47			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0054	≤	$\rho' + 50 fcd/fyd^2$	0,0073
Mrdu(-)			133,08			KN m

Reinforcement Assist A 1						
Material			***Longitudinal reinforcement***			
fyd	391,3	N mm^2	$As^{(-)}$ min		6,22	cm^2
fcd	14,17	N mm^2		3φ 16 +1φ 12		
Es	200000	N mm^2	Project $As^{(-)}$		7,16	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		3,58	cm^2
Stress			Project $As^{(+)}$	2 φ16		
$M_{ed}^{(+)}$	0	KN m			4,02	cm^2
$M_{ed}^{(-)}$	81	KN m				
Geometric Characteristic						
h = high			40			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			37			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0060	≤	$\rho' + 50 fcd/fyd^2$	0,0064
Mrdu(-)			93,30			KN m

Reinforcement of the middle of the section A 1-2					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	*N mm^{2}*	*As $^{(-)}$ min*	*2,53*	*cm^{2}*
fcd	*14,17*	*N mm^{2}*		*2φ 12+1 φ16*	
Es	*200000*	*N mm^{2}*	*Project As$^{(-)}$*	*4,27*	*cm^{2}*
Ec	*15000*	*N mm^{2}*	*0,25 As $^{(-)}$*	*1,07*	*cm^{2}*
Stress				*2φ 12*	
$M_{ed}^{(+)}$	*33*	*KN m*	*Project As$^{(+)}$*	*2,26*	*cm^{2}*
$M_{ed}^{(-)}$	*0*	*KN m*			
Geometric Characteristic					
h = high			*40*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*37*		*cm*
Resistance evaluation					
Positive bending Moment					
ρ_{max}	=	*0,0036*	≤	*ρ' +50fcd/fyd^{2}*	*0,0065*
Mrdu(+)		*55,64*			*KN m*

Reinforcement Assist A2					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	*N mm^{2}*	*As $^{(-)}$ min*	*6,45*	*cm^{2}*
fcd	*14,17*	*N mm^{2}*		*3φ 16 +1φ 12*	
Es	*200000*	*N mm^{2}*	*Project As$^{(-)}$*	*7,16*	*cm^{2}*
Ec	*15000*	*N mm^{2}*	*0,5 As $^{(-)}$*	*3,58*	*cm^{2}*
Stress			*Project As$^{(+)}$*	*2 φ16*	
$M_{ed}^{(+)}$	*0*	*KN m*		*4,02*	*cm^{2}*
$M_{ed}^{(-)}$	*84*	*KN m*			
Geometric Characteristic					
h = high			*40*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*37*		*cm*
Resistance evaluation					
Negative bending Moment					
ρ_{max}	=	*0,0060*	≤	*ρ' +50fcd/fyd^{2}*	*0,0064*
Mrdu(-)		*93,30*			*KN m*

Reinforcement Assist 2-A					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	$As^{(-)}$ min	2,04	cm^2
fcd	14,17	N mm^2		2φ 12	
Es	200000	N mm^2	Project $As^{(-)}$	2,26	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$	1,13	cm^2
Stress			Project $As^{(+)}$	2φ 12	
$M_{ed}^{(+)}$	0	KN m		2,26	cm^2
$M_{ed}^{(-)}$	23	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			60		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
Negative bending Moment					
ρ_{max}	=	0,0011	≤	ρ' +72fcd/fyd^2	0,0077
Mrdu(-)		25,47			KN m

Reinforcement of the middle of the section 2-AB					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	$As^{(-)}$ min	4,88	cm^2
fcd	14,17	N mm^2		5φ 12	
Es	200000	N mm^2	Project $As^{(-)}$	5,65	cm^2
Ec	15000	N mm^2	0,25 $As^{(-)}$	1,4125	cm^2
Stress				2φ 12	
$M_{ed}^{(+)}$	55	KN m	Project $As^{(+)}$	2,26	cm^2
$M_{ed}^{(-)}$	0	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			60		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
Positive bending Moment					
ρ_{max}	=	0,0027	≤	ρ' +50fcd/fyd^2	0,0057
Mrdu(+)		63,67			KN m

Reinforcement Assist 2-B left						
Material			**Longitudinal reinforcement**			
fyd	*391,3*	*N mm^2*	*As $^{(-)}$ min*		*5,50*	*cm^2*
fcd	*14,17*	*N mm^2*		*5φ 12*		
Es	*200000*	*N mm^2*	*Project As$^{(-)}$*		*5,65*	*cm^2*
Ec	*15000*	*N mm^2*	*0,5 As $^{(-)}$*		*2,825*	*cm^2*
Stress			*Project As$^{(+)}$*	*3φ 12*		
M_{ed} $^{(+)}$	*0*	*KN m*			*3,39*	*cm^2*
M_{ed} $^{(-)}$	*62*	*KN m*				
Geometric Characteristic						
h = high			*35*			*cm*
b = width			*60*			*cm*
d' =cover reinforcement			*3*			*cm*
d =utile high			*32*			*cm*
Resistance evaluation						
			Negative bending Moment			
	ρ_{max}	*=*	*0,0027*	*≤*	*ρ' +50fcd/fyd^2*	*0,0064*
Mrdu(-)			*63,67*			*KN m*

Reinforcement Assist 2-B right						
Material			**Longitudinal reinforcement**			
fyd	*391,3*	*N mm^2*	*As $^{(-)}$ min*		*27,61*	*cm^2*
fcd	*14,17*	*N mm^2*		*5φ24 +5φ 12*		
Es	*200000*	*N mm^2*	*Project As$^{(-)}$*		*28,27*	*cm^2*
Ec	*15000*	*N mm^2*	*0,5 As $^{(-)}$*		*14,135*	*cm^2*
Stress			*Project As$^{(+)}$*	*3φ 12+1φ16+2φ24*		
M_{ed} $^{(+)}$	*0*	*KN m*			*14,45*	*cm^2*
M_{ed} $^{(-)}$	*700*	*KN m*				
Geometric Characteristic						
h = high			*75*			*cm*
b = width			*60*			*cm*
d' =cover reinforcement			*3*			*cm*
d =utile high			*72*			*cm*
Resistance evaluation						
			Negative bending Moment			
	ρ_{max}	*=*	*0,0063*	*≤*	*ρ' +50fcd/fyd^2*	*0,0064*
Mrdu(-)			*716,82*			*KN m*

Reinforcement of the middle of the section 2 B-C					
Material			**Longitudinal reinforcement**		
fyd	391,3	$N\ mm^2$	$As^{(-)}$ min	20,27	cm^2
fcd	14,17	$N\ mm^2$		3φ 12+4φ24	
Es	200000	$N\ mm^2$	Project $As^{(-)}$	21,48	cm^2
Ec	15000	$N\ mm^2$	0,25 $As^{(-)}$	5,37	cm^2
Stress				5φ 12	
$M_{ed}^{(+)}$	514	KN m	Project $As^{(+)}$	5,65	cm^2
$M_{ed}^{(-)}$	0	KN m			
Geometric Characteristic					
h = high			75		cm
b = width			60		cm
d' =cover reinforcement			3		cm
d =utile high			72		cm
Resistance evaluation					
			Positive bending Moment		
ρ_{max}	=	0,0048	≤	$\rho' +72fcd/fyd^2$	0,0079
Mrdu(+)			544,65		KN m

Reinforcement Assist 2-C left					
Material			**Longitudinal reinforcement**		
fyd	391,3	$N\ mm^2$	$As^{(-)}$ min	23,62	cm^2
fcd	14,17	$N\ mm^2$	Project $As^{(-)}$	5φ 12+4φ 24	
Es	200000	$N\ mm^2$		23,74	cm^2
Ec	15000	$N\ mm^2$	0,5 $As^{(-)}$	11,87	cm^2
Stress			Project $As^{(+)}$	3φ 12+2φ24	
$M_{ed}^{(+)}$	0	KN m		12,44	cm^2
$M_{ed}^{(-)}$	599	KN m			
Geometric Characteristic					
h = high			75		cm
b = width			60		cm
d' =cover reinforcement			3		cm
d =utile high			72		cm
Resistance evaluation					
			Negative bending Moment		
ρ_{max}	=	0,0053	≤	$\rho' +50fcd/fyd^2$	0,0064
Mrdu(-)			601,96		KN m

Reinforcement Assist 3-A							
Material			**Longitudinal reinforcement**				
fyd	391,3	N mm^2	As $^{(-)}$ min		17,90	cm^2	
fcd	14,17	N mm^2		4φ 12+3φ24			
Es	200000	N mm^2	Project As$^{(-)}$		18,09	cm^2	
Ec	15000	N mm^2	0,25 As $^{(-)}$		4,52	cm^2	
Stress				4φ 12			
$M_{ed}^{(+)}$	0	KN m	Project As$^{(+)}$		4,52	cm^2	
$M_{ed}^{(-)}$	454	KN m					
Geometric Characteristic							
h = high				75		cm	
b = width				60		cm	
d' =cover reinforcement				3		cm	
d =utile high				72		cm	
Resistance evaluation							
Negative bending Moment							
	ρ_{max}	=	0,0040	≤	$\rho' + 50fcd/fyd^2$	0,0064	
Mrdu(-)			458,69			KN m	

Reinforcement of the middle of the section 3-AB							
Material			**Longitudinal reinforcement**				
fyd	391,3	N mm^2	As $^{(-)}$ min		20,23	cm^2	
fcd	14,17	N mm^2		4φ 12+1φ 16+3φ 24			
Es	200000	N mm^2	Project As$^{(-)}$		20,3	cm^2	
Ec	15000	N mm^2	0,25 As $^{(-)}$		10,15	cm^2	
Stress				2φ 12+2φ24			
$M_{ed}^{(+)}$	513	KN m	Project As$^{(+)}$		11,31	cm^2	
$M_{ed}^{(-)}$	0	KN m					
Geometric Characteristic							
h = high				75		cm	
b = width				60		cm	
d' =cover reinforcement				3		cm	
d =utile high				72		cm	
Resistance evaluation							
Positive bending Moment							
	ρ_{max}	=	0,0045	≤	$\rho' + 50fcd/fyd^2$	0,0071	
Mrdu(+)			514,73			KN m	

Reinforcement Assist 3-B left						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		23,51	cm^2
fcd	14,17	N mm^2			5φ 12+4φ 24	
Es	200000	N mm^2	Project $As^{(-)}$		23,74	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		11,87	cm^2
Stress			Project $As^{(+)}$		3φ 12+2φ24	
$M_{ed}^{(+)}$	0	KN m			12,44	cm^2
$M_{ed}^{(-)}$	596	KN m				
Geometric Characteristic						
h = high			75			cm
b = width			60			cm
d' =cover reinforcement			3			cm
d =utile high			72			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0053	≤	$\rho' + 50fcd/fyd^2$	0,0064
Mrdu(-)			601,96			KN m

Reinforcement Assist 4-B						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		19,60	cm^2
fcd	14,17	N mm^2			3φ 24+3φ 16	
Es	200000	N mm^2	Project $As^{(-)}$		19,6	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		9,8	cm^2
Stress			Project $As^{(+)}$		5φ 16	
$M_{ed}^{(+)}$	0	KN m			10,05	cm^2
$M_{ed}^{(-)}$	359	KN m				
Geometric Characteristic						
h = high			55			cm
b = width			60			cm
d' =cover reinforcement			3			cm
d =utile high			52			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0059	≤	$\rho' + 50fcd/fyd^2$	0,0064
Mrdu(-)			358,93			KN m

Reinforcement of the middle of the section 4-BC					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	*N mm^2*	*As $^{(-)}$ min*	*14,58*	*cm^2*
fcd	*14,17*	*N mm^2*		*3φ 24+2φ 16*	
Es	*200000*	*N mm^2*	*Project As$^{(-)}$*	*19,6*	*cm^2*
Ec	*15000*	*N mm^2*	*0,25 As $^{(-)}$*	*9,8*	*cm^2*
Stress				*6φ 12*	
M_{ed} $^{(+)}$	*267*	*KN m*	*Project As$^{(+)}$*	*6,78*	*cm^2*
M_{ed} $^{(-)}$	*0*	*KN m*			
Geometric Characteristic					
h = high			*55*		*cm*
b = width			*60*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*52*		*cm*
Resistance evaluation					
Positive bending Moment					
	ρ_{max}	*=*	*0,0059*	*≤ ρ' +50fcd/fyd^2*	*0,0067*
Mrdu(+)			*358,93*		*KN m*

Reinforcement Assist 4-C left					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	*N mm^2*	*As $^{(-)}$ min*	*29,82*	*cm^2*
fcd	*14,17*	*N mm^2*		*7φ 12*	
Es	*200000*	*N mm^2*	*Project As$^{(-)}$*	*7,92*	*cm^2*
Ec	*15000*	*N mm^2*	*0,5 As $^{(-)}$*	*3,96*	*cm^2*
Stress			*Project As$^{(+)}$*	*6φ 12*	
M_{ed} $^{(+)}$	*0*	*KN m*		*6,78*	*cm^2*
M_{ed} $^{(-)}$	*336*	*KN m*			
Geometric Characteristic					
h = high			*35*		*cm*
b = width			*60*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*32*		*cm*
Resistance evaluation					
Negative bending Moment					
	ρ_{max}	*=*	*0,0038*	*≤ ρ' +50fcd/fyd^2*	*0,0064*
Mrdu(-)			*89,25*		*KN m*

Building 2

Reinforcement Assist B5					
Material			**Longitudinal reinforcement**		
fyd	*391,3*	$N\ mm^2$	$As^{(-)}$ *min*	*6,90*	cm^2
fcd	*14,17*	$N\ mm^2$		*3φ 16 +1φ 12*	
Es	*200000*	$N\ mm^2$	*Project* $As^{(-)}$	*7,15*	cm^2
Ec	*15000*	$N\ mm^2$	*0,5* $As^{(-)}$	*3,575*	cm^2
Stress			*Project* $As^{(+)}$	*2 φ16*	
$M_{ed}^{(+)}$	*0*	*KN m*		*4,02*	cm^2
$M_{ed}^{(-)}$	*175*	*KN m*			
Geometric Characteristic					
h = high			*75*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*72*		*cm*
Resistance evaluation					
Negative bending Moment					
	ρ_{max} =	*0,0032*	≤	$\rho' +50fcd/fyd^2$	*0,0064*
Mrdu(-)		*181,30*			*KN m*

Reinforcement of the middle of the section 5' at 4,2m					
Material			**Longitudinal reinforcement**		
fyd	*391,3*	$N\ mm^2$	$As^{(-)}$ *min*	*7,18*	cm^2
fcd	*14,17*	$N\ mm^2$		*4 φ16*	
Es	*200000*	$N\ mm^2$	*Project* $As^{(-)}$	*8,04*	cm^2
Ec	*15000*	$N\ mm^2$	*0,5* $As^{(-)}$	*4,02*	cm^2
Stress				*2φ 16*	
$M_{ed}^{(+)}$	*182*	*KN m*	*Project* $As^{(+)}$	*4,02*	cm^2
$M_{ed}^{(-)}$	*0*	*KN m*			
Geometric Characteristic					
h = high			*75*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*72*		*cm*
Resistance evaluation					
Positive bending Moment					
	ρ_{max} =	*0,0036*	≤	$\rho' +50fcd/fyd^2$	*0,0064*
Mrdu(+)		*203,86*			*KN m*

Reinforcement Assist B6 left					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	As $^{(-)}$ min	6,78	cm^2
fcd	14,17	N mm^2	Project As$^{(-)}$	3φ 16+1φ 20	
Es	200000	N mm^2		9,17	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$	4,585	cm^2
Stress			Project As$^{(+)}$	2 φ16 +1φ 12	
M_{ed} $^{(+)}$	0	KN m		5,15	cm^2
M_{ed} $^{(-)}$	172	KN m			
Geometric Characteristic					
h = high			75		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			72		cm
Resistance evaluation					
Negative bending Moment					
ρ_{max}	=	0,0041	≤	ρ' +50fcd/fyd^2	0,0069
Mrdu(-)			232,52		KN m

Reinforcement Assist B6-right					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	As $^{(-)}$ min	1,62	cm^2
fcd	14,17	N mm^2	Project As$^{(-)}$	3φ 16	
Es	200000	N mm^2		6,03	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$	3,015	cm^2
Stress			Project As$^{(+)}$	2 φ16	
M_{ed} $^{(+)}$	0	KN m		4,02	cm^2
M_{ed} $^{(-)}$	41	KN m			
Geometric Characteristic					
h = high			75		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			72		cm
Resistance evaluation					
Negative bending Moment					
ρ_{max}	=	0,0027	≤	ρ' +50fcd/fyd^2	0,0064
Mrdu(-)			152,90		KN m

Reinforcement of the middle of the section B 6-7

Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		2,92	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	2 φ16		
Es	200000	N mm^2			4,02	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		2,01	cm^2
Stress			Project $As^{(+)}$	2φ 16		
$M_{ed}^{(+)}$	74	KN m			2,26	cm^2
$M_{ed}^{(-)}$	0	KN m				

Geometric Characteristic		
h = high	75	cm
b = width	30	cm
d' =cover reinforcement	3	cm
d =utile high	72	cm

Resistance evaluation						
		Positive bending Moment				
	ρ_{max}	=	0,0018	≤	$\rho' + 50 fcd/fyd^2$	0,0056
Mrdu(+)			101,93			KN m

Reinforcement Assist B7-left

Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		1,85	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	1φ 16 +1φ 24		
Es	200000	N mm^2			6,53	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		3,265	cm^2
Stress			Project $As^{(+)}$	2 φ16		
$M_{ed}^{(+)}$	0	KN m			4,02	cm^2
$M_{ed}^{(-)}$	47	KN m				

Geometric Characteristic		
h = high	75	cm
b = width	30	cm
d' =cover reinforcement	3	cm
d =utile high	72	cm

Resistance evaluation						
		Negative bending Moment				
	ρ_{max}	=	0,0029	≤	$\rho' + 50 fcd/fyd^2$	0,0064
Mrdu(-)			165,58			KN m

Reinforcement Assist B7-right						
Material			***Longitudinal reinforcement***			
fyd	*391,3*	*N* mm^2	$As^{(-)}$ *min*		*9,35*	cm^2
fcd	*14,17*	*N* mm^2	*Project* $As^{(-)}$	*3φ 16 +2φ 24*		
Es	*200000*	*N* mm^2			*15,08*	cm^2
Ec	*15000*	*N* mm^2	*0,5* $As^{(-)}$		*7,54*	cm^2
Stress			*Project* $As^{(+)}$	*4 φ16*		
$M_{ed}^{(+)}$	*0*	*KN m*			*8,04*	cm^2
$M_{ed}^{(-)}$	*237*	*KN m*				
Geometric Characteristic						
h = high			*75*			*cm*
b = width			*30*			*cm*
d' =cover reinforcement			*3*			*cm*
d =utile high			*72*			*cm*
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	*0,0067*	≤	$\rho' + 50fcd/fyd^2$	*0,0082*
Mrdu(-)			*382,37*			*KN m*

Reinforcement of the middle of the section 7'						
Material			***Longitudinal reinforcement***			
fyd	*391,3*	*N* mm^2	$As^{(-)}$ *min*		*7,18*	cm^2
fcd	*14,17*	*N* mm^2	*Project* $As^{(-)}$	*4φ16*		
Es	*200000*	*N* mm^2			*8,04*	cm^2
Ec	*15000*	*N* mm^2	*0,5* $As^{(-)}$		*4,02*	cm^2
Stress			*Project* $As^{(+)}$	*2φ 16*		
$M_{ed}^{(+)}$	*182*	*KN m*			*4,02*	cm^2
$M_{ed}^{(-)}$	*0*	*KN m*				
Geometric Characteristic						
h = high			*75*			*cm*
b = width			*30*			*cm*
d' =cover reinforcement			*3*			*cm*
d =utile high			*72*			*cm*
Resistance evaluation						
Positive bending Moment						
	ρ_{max}	=	*0,0036*	≤	$\rho' + 50fcd/fyd^2$	*0,0064*
Mrdu(+)			*203,86*			*KN m*

Reinforcement Assist B8 left					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	As$^{(-)}$ min	6,90	cm^2
fcd	14,17	N mm^2		3φ 16 +1φ 12	
Es	200000	N mm^2	Project As$^{(-)}$	7,15	cm^2
Ec	15000	N mm^2	0,5 As$^{(-)}$	3,575	cm^2
Stress			Project As$^{(+)}$	2 φ16	
$M_{ed}^{(+)}$	0	KN m		4,02	cm^2
$M_{ed}^{(-)}$	175	KN m			
Geometric Characteristic					
h = high			75		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			72		cm
Resistance evaluation					
Negative bending Moment					
ρ_{max}	=	0,0032	≤	ρ' +50fcd/fyd^2	0,0064
Mrdu(-)		181,30			KN m

Reinforcement Assist D5					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	As$^{(-)}$ min	11,18	cm^2
fcd	14,17	N mm^2		3φ 20 +1φ 16	
Es	200000	N mm^2	Project As$^{(-)}$	11,45	cm^2
Ec	15000	N mm^2	0,5 As$^{(-)}$	5,725	cm^2
Stress			Project As$^{(+)}$	3 φ16	
$M_{ed}^{(+)}$	0	KN m		6,03	cm^2
$M_{ed}^{(-)}$	126	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
Negative bending Moment					
ρ_{max}	=	0,0109	≤	ρ' +50fcd/fyd^2	0,0104
Mrdu(-)		129,04			KN m

Reinforcement of the middle of the section D 5-5' at 2,56 m					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	As $^{(-)}$ min	8,16	cm^2
fcd	14,17	N mm^2		2 φ16+1 φ24	
Es	200000	N mm^2	Project As$^{(-)}$	8,54	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$	4,27	cm^2
Stress				2φ 20	
M_{ed} $^{(+)}$	92	KN m	Project As$^{(+)}$	6,28	cm^2
M_{ed} $^{(-)}$	0	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
Positive bending Moment					
	ρ_{max} =	0,0081	≤	ρ' +50fcd/fyd^2	0,0106
Mrdu(+)		96,24			KN m

Reinforcement Assist D6-left					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	As $^{(-)}$ min	8,70	cm^2
fcd	14,17	N mm^2	Project As$^{(-)}$	2φ 20 +1φ 16 +1φ 12	
Es	200000	N mm^2		9,42	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$	4,71	cm^2
Stress			Project As$^{(+)}$	2 φ16 +1 φ12	
M_{ed} $^{(+)}$	0	KN m		5,15	cm^2
M_{ed} $^{(-)}$	98	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
Negative bending Moment					
	ρ_{max} =	0,0090	≤	ρ' +50fcd/fyd^2	0,0095
Mrdu(-)		106,16			KN m

Reinforcement Assist D6-right					
Material			**Longitudinal reinforcement**		
fyd	391,3	$N\,mm^2$	$As^{(-)}$ min	9,32	cm^2
fcd	14,17	$N\,mm^2$	Project $As^{(-)}$	2φ 20 +1φ 16 +1φ 12	
Es	200000	$N\,mm^2$		9,42	cm^2
Ec	15000	$N\,mm^2$	0,5 $As^{(-)}$	4,71	cm^2
Stress			Project $As^{(+)}$	2 φ16 +1 φ12	
$M_{ed}^{(+)}$	0	KN m		5,15	cm^2
$M_{ed}^{(-)}$	103	KN m			
Geometric Characteristic					
h = high	35	cm			
b = width	30	cm			
d' =cover reinforcement	3	cm			
d =utile high	32	cm			
Resistance evaluation					
Negative bending Moment					
ρ_{max}	=	0,0090	≤	$\rho' +50fcd/fyd^2$	0,0095
Mrdu(-)	106,16	KN m			

Reinforcement of the middle of the section D6-7					
Material			**Longitudinal reinforcement**		
fyd	391,3	$N\,mm^2$	$As^{(-)}$ min	5,06	cm^2
fcd	14,17	$N\,mm^2$	Project $As^{(-)}$	2φ 20	
Es	200000	$N\,mm^2$		6,28	cm^2
Ec	15000	$N\,mm^2$	0,25 $As^{(-)}$	1,57	cm^2
Stress			Project $As^{(+)}$	2φ 12	
$M_{ed}^{(+)}$	57	KN m		2,26	cm^2
$M_{ed}^{(-)}$	0	KN m			
Geometric Characteristic					
h = high	35	cm			
b = width	30	cm			
d' =cover reinforcement	3	cm			
d =utile high	32	cm			
Resistance evaluation					
Positive bending Moment					
ρ_{max}	=	0,0060	≤	$\rho' +50fcd/fyd^2$	0,0068
Mrdu(+)	70,77	KN m			

Reinforcement Assist D7-left					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	$As^{(-)}$ min	9,14	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	2φ 20 +1φ 16 +1φ 12	
Es	200000	N mm^2		9,42	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$	4,71	cm^2
Stress			Project $As^{(+)}$	2 φ16 +1 φ12	
$M_{ed}^{(+)}$	0	KN m		5,15	cm^2
$M_{ed}^{(-)}$	103	KN m			
Geometric Characteristic					
h = high				35	cm
b = width				30	cm
d' =cover reinforcement				3	cm
d =utile high				32	cm
Resistance evaluation					
Negative bending Moment					
	ρ_{max}	=	0,0090	≤ $\rho' + 50fcd/fyd^2$	0,0095
Mrdu(-)			106,16		KN m

Reinforcement Assist D7-right					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	$As^{(-)}$ min	8,70	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	2φ 20 +1φ 16 +1φ 12	
Es	200000	N mm^2		9,42	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$	4,71	cm^2
Stress			Project $As^{(+)}$	2 φ16 +1 φ12	
$M_{ed}^{(+)}$	0	KN m		5,15	cm^2
$M_{ed}^{(-)}$	98	KN m			
Geometric Characteristic					
h = high				35	cm
b = width				30	cm
d' =cover reinforcement				3	cm
d =utile high				32	cm
Resistance evaluation					
Negative bending Moment					
	ρ_{max}	=	0,0090	≤ $\rho' + 50fcd/fyd^2$	0,0095
Mrdu(-)			106,16		KN m

Reinforcement of the middle of the section D7'-8 at 2,56m					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	$As^{(-)}$ min	8,16	cm^2
fcd	14,17	N mm^2		2 φ16+1 φ24	
Es	200000	N mm^2	Project $As^{(-)}$	8,54	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$	4,27	cm^2
Stress				2φ 20	
$M_{ed}^{(+)}$	92	KN m	Project $As^{(+)}$	6,28	cm^2
$M_{ed}^{(-)}$	0	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
Positive bending Moment					
	ρ_{max} =	0,0081	≤	ρ' +50fcd/fyd^2	0,0106
Mrdu(+)		96,24			KN m

Reinforcement Assist D8-left					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	$As^{(-)}$ min	11,18	cm^2
fcd	14,17	N mm^2		3φ 20 +1φ 16	
Es	200000	N mm^2	Project $As^{(-)}$	11,45	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$	5,725	cm^2
Stress			Project $As^{(+)}$	3 φ16	
$M_{ed}^{(+)}$	0	KN m		6,03	cm^2
$M_{ed}^{(-)}$	126	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
Negative bending Moment					
	ρ_{max} =	0,0109	≤	ρ' +50fcd/fyd^2	0,0104
Mrdu(-)		129,04			KN m

Reinforcement Assist C5					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	*N mm^2*	*As $^{(-)}$ min*	*9,34*	*cm^2*
fcd	*14,17*	*N mm^2*		*3φ 16+1φ 24*	
Es	*200000*	*N mm^2*	*Project As$^{(-)}$*	*10,55*	*cm^2*
Ec	*15000*	*N mm^2*	*0,5 As $^{(-)}$*	*5,275*	*cm^2*
Stress			*Project As$^{(+)}$*	*2 φ16+1 φ12*	
$M_{ed}^{(+)}$	*0*	*KN m*		*5,15*	*cm^2*
$M_{ed}^{(-)}$	*171*	*KN m*			
Geometric Characteristic					
h = high			*55*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*52*		*cm*
Resistance evaluation					
Negative bending Moment					
	ρ_{max} =	*0,0064*	≤	*ρ' +50fcd/fyd^2*	*0,0077*
Mrdu(-)		*193,20*			*KN m*

Reinforcement of the middle of the section C 5-5' at 2,56 m					
Material			***Longitudinal reinforcement***		
fyd	*391,3*	*N mm^2*	*As $^{(-)}$ min*	*5,02*	*cm^2*
fcd	*14,17*	*N mm^2*		*3 φ16*	
Es	*200000*	*N mm^2*	*Project As$^{(-)}$*	*6,03*	*cm^2*
Ec	*15000*	*N mm^2*	*0,5 As $^{(-)}$*	*3,02*	*cm^2*
Stress				*2φ 16*	
$M_{ed}^{(+)}$	*92*	*KN m*	*Project As$^{(+)}$*	*4,02*	*cm^2*
$M_{ed}^{(-)}$	*0*	*KN m*			
Geometric Characteristic					
h = high			*55*		*cm*
b = width			*30*		*cm*
d' =cover reinforcement			*3*		*cm*
d =utile high			*52*		*cm*
Resistance evaluation					
Positive bending Moment					
	ρ_{max} =	*0,0037*	≤	*ρ' +50fcd/fyd^2*	*0,0071*
Mrdu(+)		*110,43*			*KN m*

Reinforcement Assist C 6-left

Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	As $^{(-)}$ min		11,36	cm^2
fcd	14,17	N mm^2	Project As$^{(-)}$	2φ 16+1φ 24+1φ 20		
Es	200000	N mm^2			11,68	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$		5,84	cm^2
Stress			Project As$^{(+)}$	3 φ16		
M_{ed} $^{(+)}$	0	KN m			6,03	cm^2
M_{ed} $^{(-)}$	208	KN m				

Geometric Characteristic		
h = high	55	cm
b = width	30	cm
d' =cover reinforcement	3	cm
d =utile high	52	cm

Resistance evaluation						
			Negative bending Moment			
	ρ_{max}	=	0,0071	≤	ρ' +50fcd/fyd^2	0,0083
Mrdu(-)			213,89			KN m

Reinforcement Assist C 6-right

Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	As $^{(-)}$ min		4,91	cm^2
fcd	14,17	N mm^2	Project As$^{(-)}$	2φ 16+1φ 20		
Es	200000	N mm^2			7,14	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$		3,57	cm^2
Stress			Project As$^{(+)}$	2 φ16		
M_{ed} $^{(+)}$	0	KN m			4,02	cm^2
M_{ed} $^{(-)}$	90	KN m				

Geometric Characteristic		
h = high	55	cm
b = width	30	cm
d' =cover reinforcement	3	cm
d =utile high	52	cm

Resistance evaluation						
			Negative bending Moment			
	ρ_{max}	=	0,0043	≤	ρ' +50fcd/fyd^2	0,0071
Mrdu(-)			130,75			KN m

Reinforcement of the middle of the section C 6-7						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		2,18	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	2 φ16		
Es	200000	N mm^2			4,02	cm^2
Ec	15000	N mm^2	0,25 $As^{(-)}$		1,01	cm^2
Stress			Project $As^{(+)}$	2φ 16		
$M_{ed}^{(+)}$	40	KN m			4,02	cm^2
$M_{ed}^{(-)}$	0	KN m				
Geometric Characteristic						
h = high				55		cm
b = width				30		cm
d' =cover reinforcement				3		cm
d =utile high				52		cm
Resistance evaluation						
Positive bending Moment						
	ρ_{max}	=	0,0024	≤	$\rho' + 50fcd/fyd^2$	0,0071
Mrdu(+)			73,62			KN m

Reinforcement Assist C 7-left						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		4,91	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	2φ 16+1φ 20		
Es	200000	N mm^2			7,14	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		3,57	cm^2
Stress			Project $As^{(+)}$	2 φ16		
$M_{ed}^{(+)}$	0	KN m			4,02	cm^2
$M_{ed}^{(-)}$	90	KN m				
Geometric Characteristic						
h = high				55		cm
b = width				30		cm
d' =cover reinforcement				3		cm
d =utile high				52		cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0043	≤	$\rho' + 50fcd/fyd^2$	0,0071
Mrdu(-)			130,75			KN m

Reinforcement Assist C 7-right						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	As $^{(-)}$ min		11,36	cm^2
fcd	14,17	N mm^2	Project As$^{(-)}$		2φ 16+1φ 24+1φ 20	
Es	200000	N mm^2			11,68	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$		5,84	cm^2
Stress			Project As$^{(+)}$		3 φ16	
$M_{ed}^{(+)}$	0	KN m			6,03	cm^2
$M_{ed}^{(-)}$	208	KN m				
Geometric Characteristic						
h = high			55			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			52			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0071	≤	ρ' +50fcd/fyd^2	0,0083
Mrdu(-)			213,89			KN m

Reinforcement of the middle of the section C 7'-8 at 2,56m						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	As $^{(-)}$ min		5,02	cm^2
fcd	14,17	N mm^2	Project As$^{(-)}$		3 φ16	
Es	200000	N mm^2			6,03	cm^2
Ec	15000	N mm^2	0,25 As $^{(-)}$		3,02	cm^2
Stress			Project As$^{(+)}$		2φ 16	
$M_{ed}^{(+)}$	92	KN m			4,02	cm^2
$M_{ed}^{(-)}$	0	KN m				
Geometric Characteristic						
h = high			55			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			52			cm
Resistance evaluation						
Positive bending Moment						
	ρ_{max}	=	0,0037	≤	ρ' +50fcd/fyd^2	0,0071
Mrdu(+)			110,43			KN m

Reinforcement Assist C 8-left						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		9,34	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$	3φ 16+1φ 24		
Es	200000	N mm^2			10,55	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		5,275	cm^2
Stress			Project $As^{(+)}$	2 φ16+1 φ12		
$M_{ed}^{(+)}$	0	KN m			5,15	cm^2
$M_{ed}^{(-)}$	171	KN m				
Geometric Characteristic						
h = high			55			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			52			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0064	≤	$\rho' +50fcd/fyd^2$	0,0077
Mrdu(-)			193,20			KN m

Reinforcement Assist 5 B						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		14,30	cm^2
fcd	14,17	N mm^2		3φ 24 + 1φ 12		
Es	200000	N mm^2	Project $As^{(-)}$		14,68	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		7,34	cm^2
Stress			Project $As^{(+)}$	4 φ16		
$M_{ed}^{(+)}$	0	KN m			8,03	cm^2
$M_{ed}^{(-)}$	287	KN m				
Geometric Characteristic						
h = high			60			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			57			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0082	≤	$\rho' +50fcd/fyd^2$	0,0091
Mrdu(-)			294,68			KN m

Reinforcement of the middle of the section 5 D						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		7,00	cm^2
fcd	14,17	N mm^2	Project $As^{(-)}$		4 φ16	
Es	200000	N mm^2			8,03	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		2,01	cm^2
Stress					3φ 24 + 1φ 12	
$M_{ed}^{(+)}$	140,59	KN m	Project $As^{(+)}$		14,68	cm^2
$M_{ed}^{(-)}$	0	KN m				
Geometric Characteristic						
h = high			60			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			57			cm
Resistance evaluation						
			Positive bending Moment			
	ρ_{max}	=	0,0045	≤	$\rho' +50fcd/fyd^2$	0,0128
Mrdu(+)			161,19			KN m

Reinforcement Assist 5 C						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	$As^{(-)}$ min		6,48	cm^2
fcd	14,17	N mm^2			2φ 24	
Es	200000	N mm^2	Project $As^{(-)}$		9,05	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$		4,525	cm^2
Stress			Project $As^{(+)}$		3 φ16	
$M_{ed}^{(+)}$	0	KN m			6,03	cm^2
$M_{ed}^{(-)}$	130	KN m				
Geometric Characteristic						
h = high			60			cm
b = width			30			cm
d' =cover reinforcement			3			cm
d =utile high			57			cm
Resistance evaluation						
			Negative bending Moment			
	ρ_{max}	=	0,0050	≤	$\rho' +50fcd/fyd^2$	0,0080
Mrdu(-)			181,67			KN m

Reinforcement Assist 5' B					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	$As^{(-)}$ min	6,92	cm^2
fcd	14,17	N mm^2		3φ 16 +1φ 12	
Es	200000	N mm^2	Project $As^{(-)}$	7,16	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$	3,58	cm^2
Stress			Project $As^{(+)}$	2 φ16	
$M_{ed}^{(+)}$	0	KN m		4,02	cm^2
$M_{ed}^{(-)}$	78	KN m			
Geometric Characteristic					
h = high				35	cm
b = width				30	cm
d' =cover reinforcement				3	cm
d =utile high				32	cm
Resistance evaluation					
Negative bending Moment					
	ρ_{max} =	0,0068	≤	$\rho' +50fcd/fyd^2$	0,0085
Mrdu(-)		80,69			KN m

Reinforcement of the middle of the section 5' D					
Material			**Longitudinal reinforcement**		
fyd	391,3	N mm^2	$As^{(-)}$ min	2,93	cm^2
fcd	14,17	N mm^2		2 φ16	
Es	200000	N mm^2	Project $As^{(-)}$	4,02	cm^2
Ec	15000	N mm^2	0,5 $As^{(-)}$	2,01	cm^2
Stress				1φ 12+1φ 16	
$M_{ed}^{(+)}$	33	KN m	Project $As^{(+)}$	3,14	cm^2
$M_{ed}^{(-)}$	0	KN m			
Geometric Characteristic					
h = high				35	cm
b = width				30	cm
d' =cover reinforcement				3	cm
d =utile high				32	cm
Resistance evaluation					
Positive bending Moment					
	ρ_{max} =	0,0038	≤	$\rho' +50fcd/fyd^2$	0,0076
Mrdu(+)		45,30			KN m

Reinforcement Assist 5' C					
Material			**Longitudinal reinforcement**		
fyd	391,3	$N\ mm^2$	$As^{(-)}$ min	7,10	cm^2
fcd	14,17	$N\ mm^2$		$3\varphi\ 16 + 1\varphi\ 12$	
Es	200000	$N\ mm^2$	Project $As^{(-)}$	7,16	cm^2
Ec	15000	$N\ mm^2$	$0,5\ As^{(-)}$	3,58	cm^2
Stress			Project $As^{(+)}$	$2\ \varphi 16$	
$M_{ed}^{(+)}$	0	KN m		4,02	cm^2
$M_{ed}^{(-)}$	80	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			30		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
		Negative bending Moment			
ρ_{max}	=	0,0068	≤	$\rho' + 50fcd/fyd^2$	0,0085
Mrdu(-)			80,69		KN m

Reinforcement Assist 6 B					
Material			**Longitudinal reinforcement**		
fyd	391,3	$N\ mm^2$	$As^{(-)}$ min	35,58	cm^2
fcd	14,17	$N\ mm^2$		$8\varphi\ 24$	
Es	200000	$N\ mm^2$	Project $As^{(-)}$	36,18	cm^2
Ec	15000	$N\ mm^2$	$0,5\ As^{(-)}$	18,09	cm^2
Stress			Project $As^{(+)}$	$8\varphi\ 24$	
$M_{ed}^{(+)}$	0	KN m		36,18	cm^2
$M_{ed}^{(-)}$	401	KN m			
Geometric Characteristic					
h = high			35		cm
b = width			60		cm
d' =cover reinforcement			3		cm
d =utile high			32		cm
Resistance evaluation					
		Negative bending Moment			
ρ_{max}	=	0,0172	≤	$\rho' + 50fcd/fyd^2$	0,0219
Mrdu(-)			407,73		KN m

Reinforcement Assist 6 B						
Material			**Longitudinal reinforcement**			
fyd	391,3	N mm^2	As $^{(-)}$ min		30,77	cm^2
fcd	14,17	N mm^2		8φ 24		
Es	200000	N mm^2	Project As$^{(-)}$		36,18	cm^2
Ec	15000	N mm^2	0,5 As $^{(-)}$		18,09	cm^2
Stress			Project As$^{(+)}$	8φ 24		
$M_{ed}^{(+)}$	0	KN m			36,18	cm^2
$M_{ed}^{(-)}$	401	KN m				
Geometric Characteristic						
h = high			40			cm
b = width			60			cm
d' =cover reinforcement			3			cm
d =utile high			37			cm
Resistance evaluation						
Negative bending Moment						
	ρ_{max}	=	0,0151	≤	$\rho' + 50fcd/fyd^2$	0,0197
Mrdu(-)			471,44			KN m

2.9.2.3 *Longitudinal reinforcemet prototypes updating*

		Prot.1	**Prot.2**	**Prot.3**	**Prot.4**	**Prot.5**	**Prot.6**	**Prot.7**	**Prot.8**	Misure Units
b		300	300	300	600	600	600	600	300	cm
h		400	500	500	350	550	550	750	350	cm
Reinforcement on the Assist 1	top	7,16	8,04	10,05	6,78	31,66	19,6	28,27	7,16	cm^2
	Bottom	4,02	4,02	6,03	4,02	15,83	10,5	14,45	4,02	cm^2
Reinforcement on the Middle of the section	top	**3,08**	**3,08**	**3,08**	**3,08**	3,39	8,04	5,65		cm^2
	Bottom	4,27	5,4	5,4	6,78	11,3	15,13	21,48		cm^2
Reinforcement on the Assist 2	top	7,16	8,04	10,05	11,31	27,14	19,6	23,74	7,16	cm^2
	Bottom	4,02	4,02	6,03	5,65	13,57	10,5	12,44	4,02	cm^2
Beam		A 1-2	B 2-3 B 3-4 C 1-2 C 2-3 C 3-4	B 1-2	1 A-B 2 A-B	1 B-C	4 B-C	2 B-C 3 B-C	5' B-D 7' B-D	

		prot.9	**prot.10**	**prot.11**	**prot.12**	**prot.13**	**prot.14**	**prot.15**	**prot.16**	Misure Units
b		300	300	300	300	300	300	600	600	cm
h		350	350	350	350	750	750	350	350	cm
Reinf. on the Assist 1	top	7,16	11,45	6,28	9,42	6,53	7,15	7,15	36,18	cm^2
	Bottom	4,02	6,03	8,54	5,15	4,02	4,02	4,02	36,18	cm^2
Reinf.on the Middle of the section	top				2,26	2,26	4,02	7,02		cm^2
	Bottom				6,28	4,02	8,04	8,04		cm^2
Reinf.on the Assist 2	top	7,16	6,28	9,42	9,42	6,53	15,08	15,08		cm^2
	Bottom	4,02	8,54	5,15	5,15	4,02	8,04	8,04		cm^2
Beam		5'D-C 7' D-C	D 5-5' D 7'-8	D 5'-6 D 7-7'	D 6-7	B 6-7	B 5-6 B 7-8	5 B-C 8 B-C	7 B-D 6 B-D	

2.9.2.4 *Longitudinal reinforcement anchorage*

Considering the normative prescriptions, is studied the correct reinforcement disposal both in terms of constructive details and optimum cover of bending moment diagrams. Are choosen, for longitudinl rebars reinforcement, the following diameters: φ 12, φ 16, φ 20; while for the shear reinforcement is used a φ 8.
The anchorage on the favourable zones are evaluated with a utile length 36,4 φ :

- *For φ20 reinforcement bars we obtain an anchorage of 36,4 · 2,0 ≅ 62,8 cm;*
- *For φ16 reinforcement bars we obtain an anchorage of 36,4 · 1,6 ≅ 58,24cm;*
- *For φ12 reinforcement bars we obtain an anchorage of 36,4 · 1,4 ≅ 43,68cm;*

The anchorage on the non-favourables zones are evaluated with a utile length of 60φ a evaluated for the critices zones ending:

- *For φ20 reinforcement bars we obtain an anchorage of 60 · 2,0 ≅ 120,0 cm;*
- *For φ16 reinforcement bars we obtain an anchorage of: 60· 1,6 ≅ 96,0 cm;*
- *For φ12 reinforcement bars we obtain an anchorage of: 60 · 1,2 ≅ 72,0cm;*

Internally at joint column-beam, the anchorage is carried out folding the bars for a minimum length of 10 diameters, using the longitudinal bars of the hortogonal beam like a transverse reinforcement, since the rebars typology allows it.

2.9.3 DESIGN AND VERIFICATIONS SHEAR REINFORCEMENT

The shear dimensioning is achieved through the application of resistances hierarchy, because the beam have to reach the flexile breaking point before with a ductile broking before the shear break point. For this reason the shear project has done with an increased shear respect the one evaluated with a linear bending moment diagram, where on the extremities we have the bending moments resistantsof the contigus beams. In particolar the project shear stresse sare obtained adding the shear contribute due to gravitational loads to the resistant bending moment of the extremities sections amplified with the factor:

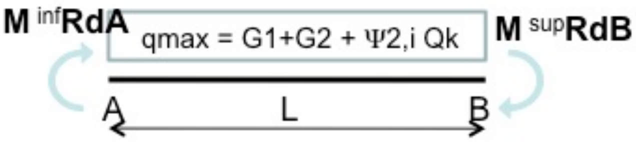
$$\gamma_{rd} = 1{,}35$$

Is the overstrenght Factor that consider the real ultimate strenght of the steel at plastic hardening.

2.9.3.1 *Hierarchy of resistances*

To excluding inhelastic mechanisms due to the shear , we obtain the shear stress adding the gravitational loads on the beam to the shear stress corresponding at the development of plastic hinge on the beam generated by the two resistants bending moments of plasticization section and amplified by the overstrenght factor γ 1,35.
Are obtained the maximum and minimum shear stresses, considering the following cases:

1. *First scheme considered*

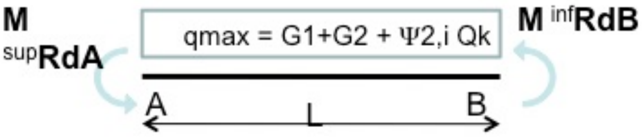


$M^{inf}_{rd,left}$ = Cloakwise bending moment of left section,
$M^{sup}_{rd,right}$ = Cloakwise bending moment of right section,
The shear, on this scheme, could be obtained adding the linear gravitationals loads to the constant shear related to the bending moment on the edge of the beam. The shear diagram obtained has a linear variation on the beam length:

$$V_{sd1}^{max} = -\gamma_{rd}\frac{M_{rd1}^{inf}+M_{rd2}^{sup}}{L}-\frac{q^{max}L}{2}$$

$$V_{sd2}^{max} = -\gamma_{rd}\frac{M_{rd1}^{inf}+M_{rd2}^{sup}}{L}+\frac{q^{max}L}{2}$$

1. *Second scheme considered*



$$V_{sd1}^{max} = +\gamma_{rd}\frac{M_{rd1}^{sup}+M_{rd2}^{inf}}{L}-\frac{q^{max}L}{2}$$

$$V_{sd2}^{max} = +\gamma_{rd} \frac{M_{rd1}^{sup} + M_{rd2}^{inf}}{L} + \frac{q^{max} L}{2}$$

The diagram shell strain will be the envelope of the 4 diagram considered above. The diagram evaluated is increased respect the diagram obtained with the sap modellation.

2.9.3.2 *Evaluation of the Stress shear Projects*

Following the resume table of the developed caltulations:

	$M_{rd,sup}$ left	**$M_{rd,sup}$ right**	**$M_{rd,inf}$ left**	**$M_{rd,inf}$ right**	**Q**	**L**	**V_{SD1}**	**V_{SD2}**	**V_{SD3}**	**V_{SD4}**
	kN m	*kN m*	*kN m*	*kN m*	*kN*	*m*	*kN*	*kN*	*kN*	*kN*
Prot. 1	*93,3*	*93,3*	*52,38*	*52,38*	*14,3*	*7,5*	***-80,0***	*27,7*	*-27,7*	*80,0*
Prot. 2	*104*	*104*	*52,38*	*52,38*	*14,7*	*7,7*	***-84,0***	*29,2*	*-29,2*	*84,0*
Prot. 3	*166*	*166*	*99,81*	*99,81*	*28,7*	*7,5*	***-155,7***	*60,4*	*-60,4*	*155,7*
Prot. 4	*76*	*127*	*45,3*	*63,67*	*46,9*	*5,0*	***-163,8***	*70,7*	*-79,5*	*155,0*
Prot. 5	*579*	*206*	*289,9*	*248,51*	*46,9*	*9,0*	*-285,4*	*136,7*	*-86,9*	***335,2***
Prot. 6	*358*	*89,25*	*184,04*	*76,41*	*43,4*	*9,0*	*-236,3*	*154,3*	*-130,1*	***260,5***
Prot. 7	*716*	*601*	*366,4*	*315,4*	*87*	*9,0*	*-536,6*	*246,4*	*-236,8*	***546,2***
Prot. 8	*80*	*35,3*	*45,3*	*45,3*	*0*	*2,5*	*-43,5*	*-43,5*	*67,7*	***67,7***
Prot. 9	*35,3*	*80*	*45,3*	*45,3*	*0*	*6,4*	***-26,4***	*-26,4*	*17,0*	*17,0*
Prot. 10	*129*	*70,77*	*67,9*	*96,24*	*67,8*	*4,1*	*-184,6*	*93,3*	*-64,8*	***213,2***
Prot. 11	*70,77*	*106,16*	*96,24*	*58,04*	*19,3*	*3,5*	***-112,5***	*-45,9*	*17,1*	*83,7*
Prot. 12	*106*	*106*	*58,04*	*58,04*	*19,3*	*7,7*	***-103,1***	*45,5*	*-45,5*	*103,1*
Prot. 13	*166*	*382*	*101,9*	*165,6*	*26,6*	*7,7*	***-187,2***	*17,6*	*-44,3*	*160,5*
Prot. 14	*181*	*249*	*101,3*	*133,08*	*16,9*	*7,6*	***-126,4***	*2,0*	*-8,4*	*120,0*
Prot. 15	*294*	*181*	*161,19*	*121,04*	*0*	*9,0*	*-51,3*	*-51,3*	*62,3*	***62,3***
Prot. 16	*407,3*	*407,3*	*407,3*	*407,3*	*132,8*	*2,5*			*307,1*	***572,7***

2.9.3.3 *Evaluation of the shear breaking point on the concrete side*

Is possible evaluate the shear breaking stress on the concrete side considering the following formula:

$$V_{rcd} = 0{,}9 \cdot d \cdot b \cdot \alpha_c \cdot f'_{cd} \cdot \frac{\cot \alpha + \cot \theta}{1 + \cot^2 \theta}$$

where:

- *d : widht utile of the section along the shear direction;*
- *b :base corresponding to the shear stress direction;*
- *□f’cd :breaking stress on concrete reduced due the axial anime compression (f'cd=0,6×fcd)*

- *α :inclination angle of stirrups (α=90°)*
- *□θ inclination angle of the concrete struts*

  $(1 \le ctg\theta \le 2{,}5)$ $(21.8° \le \theta \le 45°)$
- *α_c amplification factor of*

1	*with not compressed sections*
$1+\sigma_{cp}/f_{cd}$	*with $0 \le \sigma_{cp} \le 0{,}25\, f_{cd}$*
1,25	*with $0{,}25\, f_{cd} \le \sigma_{cp} \le 0{,}5\, f_{cd}$*
$2{,}5(1-\sigma_{cp}/f_{cd})$	*$0{,}5\, f_{cd} \le \sigma_{cp} \le f_{cd}$*

The inclination angle of the concrete struts is evaluated of θ = 45° in safety favour;

	b_y - h_x	b_x -h_y	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp}/f_{cd}	α_c	f_{cd}'	γ_c	V_{rcd}
	mm	mm	mm	N mm^2	N mm^2	N mm^2	N mm^2	N mm^2	-		N mm^2	-	kN
Prot 1	300	400	50	1,00	25	14,1	7,05	3,53	0,071	1,07	8,46	1,5	428,09
Prot 2	300	500	50	1,00	25	14,1	7,05	3,53	0,071	1,07	8,46	1,5	550,40
Prot 3	300	500	50	1,00	25	14,1	7,05	3,53	0,071	1,07	8,46	1,5	550,40
Prot 4	600	350	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	856,58
Prot 5	600	550	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	1427,63
Prot 6	600	550	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	1427,63
Prot 7	600	550	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	1427,63
Prot 8	300	350	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	428,29
Prot 9	300	350	50	1,00	25	14,1	7,05	3,53	0,071	1,07	8,46	1,5	366,93
Prot 10	300	350	50	1,00	25	14,1	7,05	3,53	0,071	1,07	8,46	1,5	366,93
Prot 11	300	350	50	1,00	25	14,1	7,05	3,53	0,071	1,07	8,46	1,5	366,93
Prot 12	300	350	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	428,29
Prot 13	300	750	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	999,34
Prot 14	300	750	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	999,34
Prot 15	300	350	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	428,29
Prot 16	600	350	50	1,00	25	14,1	7,05	3,53	0,071	1,25	8,46	1,5	856,58

2.9.3.4 *Shear verification on the concrete side*

The shear verifications con concrete are made evaluating:

$$\frac{V_{ed,x}}{V_{rcd,x}} < 1$$

and

$$\frac{V_{ed,y}}{V_{rcd,y}} < 1$$

	$V_{ed,,rigth}^{(-)}$	$V_{ed,left}^{(+)}$	$V_{ed,right}^{(-)}$	$V_{ed,left\ (+)}$	V_{rd}	$V_{ed,rigth}^{(-)}/V_{rd}$	$V_{ed,,left}^{(+)}/V_{rd}$	$V_{ed,,rigth}^{(-)}/V_{rd}$	$V_{ed,,left}^{(+)}/V_{rd}$
	kN	*kN*	*kN*	*kN*	*kN*	-	-	-	-
Prot 1	-80,0	27,7	-27,7	80,0	428,09	0,19	0,06	0,06	0,19
Prot 2	-84,0	29,2	-29,2	84,0	550,40	0,15	0,05	0,05	0,15
Prot 3	-155,7	60,4	-60,4	155,7	550,40	0,28	0,11	0,11	0,28
Prot 4	-163,8	70,7	-79,5	155,0	856,58	0,19	0,08	0,09	0,18
Prot 5	-285,4	136,7	-86,9	335,2	1427,63	0,20	0,10	0,06	0,23
Prot 6	-236,3	154,3	-130,1	260,5	1427,63	0,17	0,11	0,09	0,18
Prot 7	-536,6	246,4	-236,8	546,2	1427,63	0,38	0,17	0,17	0,38
Prot 8	-43,5	-43,5	67,7	67,7	428,29	0,10	0,10	0,16	0,16
Prot 9	-26,4	-26,4	17,0	17,0	366,93	0,07	0,07	0,05	0,05
Prot 10	-184,6	93,3	-64,8	213,2	366,93	0,50	0,25	0,18	0,58
Prot 11	-112,5	-45,9	17,1	83,7	366,93	0,31	0,13	0,05	0,23
Prot 12	-103,1	45,5	-45,5	103,1	428,29	0,24	0,11	0,11	0,24
Prot 13	-140,3	46,8	-46,7	140,4	999,34	0,14	0,05	0,05	0,14
Prot 14	-163,3	38,9	-45,3	156,9	999,34	0,16	0,04	0,05	0,16
Prot 15	-51,3	-51,3	62,3	62,3	428,29	0,12	0,12	0,15	0,15
Prot 16	0,0	0,0	307,1	572,7	856,58	0,00	0,00	0,36	0,67

2.9.3.5 *Shear reinforcement design*

After the shear verification on the concrete side is evaluated the the minimum shear reinforcement with the following formula:

$$V_{rsd} = 0{,}9\, d \left(\frac{A_{sw}}{s}\right) f_{yd}(ctg\alpha + ctg\theta)sin\theta$$

Where :

- f_{yd} *is the breaking project resistance on the steal;*
- A_{sw} *is the Area of the stirrups;*
- *S is the footstep between the stirrups;*

	$V_{ed,max}$	d	(A_{sw}/s)	As $\phi 8$	n	$A_{sw,x}$	S_x
	kN	mm	-	mm	-	mm^2	mm
Prot 1	80,0	400	0,57	50	2	100	209,59
Prot 2	84,0	500	0,48	50	2	100	209,59
Prot 3	155,7	500	0,88	50	2	100	113,08
Prot 4	163,8	350	1,33	50	2	100	75,26
Prot 5	335,2	550	1,73	50	4	200	115,58
Prot 6	260,5	550	1,34	50	4	200	148,73
Prot 7	546,2	750	2,07	50	4	200	96,71
Prot 8	67,7	350	0,55	50	2	100	182,17
Prot 9	26,4	350	0,21	50	2	100	466,35
Prot 10	213,2	350	1,73	50	2	100	57,83
Prot 11	112,5	350	0,91	50	2	100	109,57
Prot 12	103,1	350	0,84	50	2	100	119,59
Prot 13	140,3	750	0,53	50	4	200	376,39
Prot 14	163,3	750	0,62	50	4	200	323,48
Prot 15	62,3	350	0,51	50	2	100	197,99
Prot 16	572,7	350	4,65	50	2	100	21,52

2.9.3.6 *Minimum prescriptive shear reinforcement requested*

For structure projected in ***CD”A”****, the respect of the normative pass has to be extended for a lenght of 1,5 times the height of the trasversal section (2 H = critic zone) for example the corresponding critic zone of a beam 30x50 is 100 cm. The first containing clamp has to be positioned not more than 5 cm from the column section; the following have to be positioned with a pass less than the minimum of the following sizes:*

- *0,25 d;*
- *20 cm;*
- *6* ϕ_{lon} *;*
- *24* $\phi_{stirrup}$ *;*

In central zones, out from critic zone, the stirrups are evaluated respecting the shear verification. The minimum shear reinforcement has to be:

- *0,5 d;*
- *25 cm;*

Beam	PROT1	PROT2	PROT3	PROT4	PROT5	PROT6	PROT7	PROT8	PROT9	PROT 10	PROT 11	PROT 12	PROT 13	PROT 14	PROT 15	PROT 16
	A 1-2	B 2-3/ B 3-4/C 1-2/C 2-3/C 3-4	B 1-2	1 A-B/2 A-B	1 B-C	4 B-C	2 B-C/ 3 B-C	5' B-D/ 7' B-D	5'D-C/ 7' D-C	D 5-5'/ D 7'-8	D 5'-6/ D 7-7'	D 6-7	B 6-7	B 5-6/B 7-8	5 B-C/8 B-C	7 B-D/6 B-D
b	300	300	300	600	600	600	600	300	300	300	300	300	300	300	600	600
h	400	500	500	350	550	550	750	350	350	350	350	350	750	750	350	350
Critic zone	600	750	750	525	825	825	1125	525	525	525	525	525	1125	1125	525	525
Minimum Shear reinforcement critic zones																
Φ_{long}	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
$6\Phi_{long}$	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96
$\Phi_{stirrups}$	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
$24\Phi_{tras}$	192	192	192	192	192	192	192	192	192	192	192	192	192	192	192	192
20 cm	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
0,25 d	10	12,5	12,5	8,75	13,75	13,75	18,75	8,75	8,75	8,75	8,75	8,75	18,75	18,75	8,75	8,75
Minimum Shear reinforcement out of critic zones																
25 cm	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
0,5 d	20	25	25	17,5	27,5	27,5	37,5	17,5	17,5	17,5	17,5	17,5	37,5	37,5	17,5	17,5
Minimum prescriptive values																
Footstep critic zone	10	12,5	12,5	8,75	13,75	13,75	18,75	8,75	10	12,5	12,5	8,75	13,75	13,75	18,75	8,75
out of critic zone	20	25	25	25	25	25	25	25	17,5	17,5	17,5	17,5	37,5	37,5	17,5	17,5

2.9.3.7 *Prototipes Upgrade*

Comparing the minimum prescriptive reinforcement to the minimum evaluated with the project stresses are choosen the following values:

							Project Value			
	$\Phi_{stirrups}$	N arm	S_{calcol}	$S_{prescription}$	$S_{out\ crtic\ zone}$	Hcrit	$S_{crit\ zone}$	$S_{out\ crtic\ zone}$	$V_{rds\ crit}$	$V_{rds\ out\ crit}$
	mm		mm	mm	mm	mm	mm	mm	kN	kN
Prot 1	8,0	2	176,18	100,0	200	600	100	200	140,87	70,43
Prot 2	8,0	2	209,59	125,0	250	750	125	250	140,87	70,43
Prot 3	8,0	2	113,08	125,0	250	750	113	250	155,83	70,43
Prot 4	8,0	2	75,26	87,5	250	525	75	250	164,35	49,30
Prot 5	8,0	4	115,58	137,5	250	825	110	250	352,17	154,95
Prot 6	8,0	4	148,73	137,5	250	825	130	250	297,99	154,95
Prot 7	8,0	4	96,71	187,5	250	1125	90	250	586,95	211,30
Prot 8	8,0	2	182,17	87,5	250	525	80	250	154,07	49,30
Prot 9	8,0	2	466,35	100	175	525	100	175	123,26	70,43
Prot 10	8,0	4	115,65	125	175	525	110	175	224,11	140,87
Prot 11	8,0	2	109,57	125	175	525	100	175	123,26	70,43
Prot 12	8,0	2	119,59	87,5	175	525	80	175	154,07	70,43
Prot 13	8,0	4	376,39	137,5	250	1125	130	250	406,35	211,30
Prot 14	8,0	4	323,48	137,5	250	1125	130	250	406,35	211,30
Prot 15	8,0	2	197,99	187,5	175	525	180	175	68,48	70,43
Prot 16	8,0	4	43,05	87,5	175	525	40	175	616,30	140,87

2.9.3.8 *Longitudinal reinforcement anchorage*

Considering the normative prescriptions, is studied the correct reinforcement disposal both in terms of constructive details and optimum cover of bending moment diagrams. Are choosen, for longitudinl rebars reinforcement, the following diameters: φ 12, φ 16, φ 20; while for the shear reinforcement is used a φ 8.
The anchorage on the favourable zones are evaluated with a utile length 36,4 φ :

- *For $\varphi 20$ reinforcement bars we obtain an anchorage of $36{,}4 \cdot 2{,}0 \cong 62{,}8$ cm;*

- *For $\varphi 16$ reinforcement bars we obtain an anchorage of $36{,}4 \cdot 1{,}6 \cong 58{,}24$cm;*

- *For $\varphi 12$ reinforcement bars we obtain an anchorage of $36{,}4 \cdot 1{,}4 \cong 43{,}68$cm;*

The anchorage on the non-favourables zones are evaluated with a utile length of 60φ a evaluated for the critices zones ending:

- *For $\varphi 20$ reinforcement bars we obtain an anchorage of $60 \cdot 2{,}0 \cong 120{,}0$ cm;*

- *For φ16 reinforcement bars we obtain an anchorage of: $60 \cdot 1{,}6 \cong 96{,}0$ cm;*
- *For φ12 reinforcement bars we obtain an anchorage of: $60 \cdot 1{,}2 \cong 72{,}0$cm;*

Internally at joint column-beam, the anchorage is carried out folding the bars for a minimum length of 10 diameters, using the longitudinal bars of the hortogonal beam like a shear reinforcement, since the rebars typology allows it.

2.9.4 BEAMS DESIGN OUTPUT

The graphic works inherents to the beams design are contained in the following attachements:

viii. ***Graphic work T3 :*** Reinforcement board beam "B", Building 1;

ix. ***Graphic work T4 :*** Reinforcement board beam "C", Building 1;

x. ***Graphic work T5 :*** Reinforcement board building beam "B", Building 2;

2.10 COLUMNS DESIGN

2.10.1 STATUTORY PROVISIONS FOR CIVIL BUILDINGS

2.10.1.1 *Geometric limitation*

The minimum dimension of the trasversal section has not to be less than 25 cm.

The rate between the minimum side and maximum of section has not to be less than 0,25. In other case the pilar has considered like a portant walls.
The width of the critics zone has to be the mayor of the following quantities:

- *Height of the section;*
- *1/6 free height of the column;*
- *45 cm;*
- *free height of the column if minor than 3 times the height of the column section;*

2.10.1.2 *Prescription on Longitudinal reinforcement*

The rate of the longitudinal reinforcement has to be included between:

$$1\% < \frac{A_s}{A_c} < 4\%$$

with:
A_s *= Area of longitudinal reinforcement;*
A_c *= Area of the concrete section.*

Besides the longitudinal reinforcement has to be of more than 3 bars in each side of the section face.

2.10.1.3 *Shear reinforcement high ductility*

The shear reinforcement has to be done with strirrups closed with the minimum diameter of ø8.
In the critics zones has to be disposed a minimum stirrup reinforcement of:

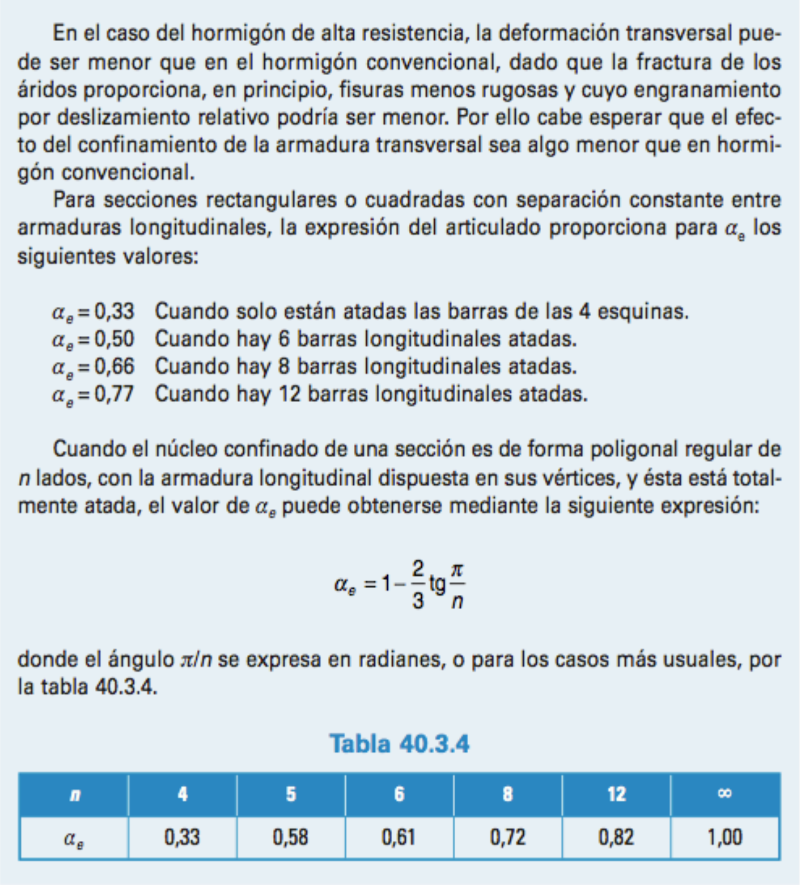
$$\omega_{w,min} = \frac{1}{\alpha}$$
$$\left(\frac{V_d f_{yd} b_c}{1{,}333 b_0} - 0{,}035\right)$$

Where:

$$\omega_{w,min} = \frac{A_{sw}}{b_0 \cdot s} \cdot \frac{f_{yd}}{f_{cd}}$$

$V_d = N_d / A_c f_{cd}$
b_c *=minimum side of the section;*
b_0 *=width of the confined concrete (above the stirrups);*

α = confinement factor:



En el caso del hormigón de alta resistencia, la deformación transversal puede ser menor que en el hormigón convencional, dado que la fractura de los áridos proporciona, en principio, fisuras menos rugosas y cuyo engranamiento por deslizamiento relativo podría ser menor. Por ello cabe esperar que el efecto del confinamiento de la armadura transversal sea algo menor que en hormigón convencional.

Para secciones rectangulares o cuadradas con separación constante entre armaduras longitudinales, la expresión del articulado proporciona para α_e los siguientes valores:

$\alpha_e = 0{,}33$ Cuando solo están atadas las barras de las 4 esquinas.
$\alpha_e = 0{,}50$ Cuando hay 6 barras longitudinales atadas.
$\alpha_e = 0{,}66$ Cuando hay 8 barras longitudinales atadas.
$\alpha_e = 0{,}77$ Cuando hay 12 barras longitudinales atadas.

Cuando el núcleo confinado de una sección es de forma poligonal regular de n lados, con la armadura longitudinal dispuesta en sus vértices, y ésta está totalmente atada, el valor de α_e puede obtenerse mediante la siguiente expresión:

$$\alpha_e = 1 - \frac{2}{3}\,\mathrm{tg}\,\frac{\pi}{n}$$

donde el ángulo π/n se expresa en radianes, o para los casos más usuales, por la tabla 40.3.4.

Tabla 40.3.4

n	4	5	6	8	12	∞
α_e	0,33	0,58	0,61	0,72	0,82	1,00

Besides the maximum footstep of the stirrups in the critics zones has to be the minimum between the following values:

- $b_0/3$
- *15 cm*
- $8\ \phi_{long}$

Oustide the critics zones the mimimum footstep of the stirrups has to be minimum between the following values:

- *20 cm*
- $15\ \phi_{long}$

2.10.2 DESIGN AND VERIFICATIONS LONGITUDINAL REINFORCEMENT

2.10.2.1 *Hierarchy of resistances*

For both the directions and applications verses of the horizontal actions, the columns have to be protected from the premature plastification adopting opportune bending moment stresses. Is possible to achieve that conditions if :

$$\Sigma\, M_{c,Rd} \;\geq \gamma_{rd}\, \Sigma\, M_{b,rd}$$

Where:

- □□$_{rd}$ *= 1,3 (CDA);*
- **Σ**□□$_{□□□□□}$ *= sum of the resistent moment of the beams converging on the joint with the same verse,*
- **Σ**□□$_{□c□□□}$ *= sum of the resistent moment of the columns on the top and on the bottom of the joint ;*

For the basement sections of the column on the ground is adopted the calcol moment major between the one evaluated with the analysis and the $M_{C,Rd}$ *of the top section of the column.*

This hierarchy criteria is not implemented on the upper section of the column in the last floor.

Projecting the longitudinal reinforcement of the beams are note the resistance bending moment (rispettivamente M_{br1} *e* M_{br2}*) of the section converging on a joint. Considering the horizontal loads we have the following situations:*

1. *on the beams ant the column are originate bending moment that respect the equilibrium condition:*

   $$M_{b1} + M_{b2} = M_{c1} + M_{c2}$$

2. *increasing the external actions, the bending moment on the beams (so on the columns) increase untill reaching the maximum admissible value* M_{br1} *e* M_{br2} *corresponding to* M_{cs1} *and* M_{cs2} *calumn value reached;*
3. *for a generic beam is allwais true that:*

   $$M_{br1} / M_{b1} > 1$$

   As the resistance moment is surely major than the bending moment stress. Then when the resistant moment on the beam reach M_{br1}*,the bending moment on the column in turn reach the value* $M_{cs1} > M_{c1}$
4. M_{cs1} *is the maximum value admisible for the column, i fact the bending moment (*M_{br1}*). on the beams can not increase.*

   It's enough to project the column with a resistant moment:

   $$M_{cRd} > M_{cs1}$$

   To guarantee the development of the flexional hinge on the beam before the column.

2.10.2.2 *Method α*

The procedure just mentioned is the base fo the Capacity Design (hierarchy of resistance) and is satisfied if the bending moment of project for the columns are *evaluated with the following formula:*

$$\alpha = \gamma_{rd} \frac{\Sigma M_{b,rd}}{\Sigma M_{c,sd}}$$

where M_c *is the evaluated bending moment of the column with the Sap; the project bending moment can be obtained multiplying* M_c *for the following two terms:*

1. $\gamma_{rd} = 1{,}35$;
2. *the rate between the resistant moment of the beams (numerator) and the bending moment of calcol on the column(common denominator).*
   Remembering that on the joint

   $$\sum M_b = M_{b1} + M_{b2} = M_{c1} + M_{c2} = \sum M_c,$$

   and

   $$\sum M_{b,Rd} > \sum M_b\ ,$$

   is easy to realize that this rate is allways > 1.

Finally:
Each column is projected with a bending moment stress evaluated with the Sap2000 multiply for a sovraresistance of 1,35 (ductilidad alta).

If the bending moment on the column are with opposite sign, only the major value has to be introduced on the common denominator of :

$$\alpha = \gamma_{rd} \frac{\Sigma M_{b,rd}}{\Sigma M_{c,sd}}$$

while the minor has to be added to the resistent moment of the beams on the numerator.

The amplification factor has to be evaluated for both the verses of the horyzontal action, applying the aplification factor at the moment evaluated on the columns with the actions operating on the same direction.

2.10.2.3 *Valutazione sollecitazioni di progetto*

The column project is made following the hyerrchy resistance theory, so that the column resistance is bigger than the beams, are used for the project the fictitious strain that balance the resistant moment on the beams. In a generic joint in fact has to be satisfied the equilibirum between the stimulating strain on the beams (M_{b1} *e* M_{b2}*) and the stimulating strain on the column (*$M_{c1}+M_{c2}$*):*

$$M_{b1} + M_{b2} + M_{c1} + M_{c2} = 0$$

Usually the verse actions on the beams are concorde and the same on the column. Considering the equilibrium we have:

$$M_{b1} + M_{b2} = M_{c1} + M_{c2}$$

And it's possible to define the rate :

$$\alpha_{eq,1} = \frac{M_{b,1} + M_{b,2}}{M_{c,1} + M_{c,2}}$$

that is possible to use like at equilibrium marker, or rather when we have equilibrium on the joint the value $\alpha_{eq}=1$.

The α_{eq} *definiton is not univocal, as it depends by how the bending moments are equilibrate on the joint.*

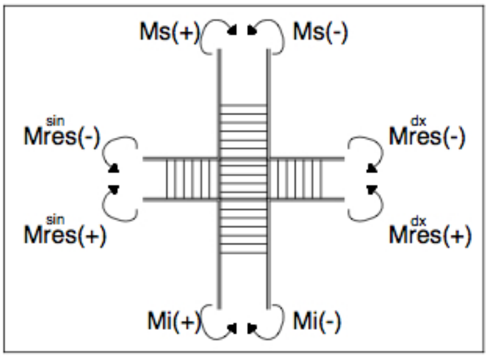
Indeed if one of the moments on the column is cocorde with the one on the beams, the equilibrium change and the bending moment on the column has to be carried on the numerator of the formula:

$$\alpha_{eq,2} = \frac{M_{b,1} + M_{b,2} + M_{c,2}}{M_{c,1}}$$

Or it's possible that the bending Moment on the beams is concorde with that one on the column, therefore it's bending moment has to be carried on the denominator of the formula:

$$\alpha_{eq,3} = \frac{M_{b,1}}{M_{c,1} + M_{c,2} + M_{b,2}}$$

For the equilibrium on the joint the values M_{ps1} *and* M_{ps2} *are the maximum stress values that can be reached on the column, as to be bigger has to increase also the moment on the beams, but this is impossible because they have already reached the resistance plastic point.*



$$\alpha_1 = \gamma_{Rd} \frac{\left| M^{\sin}_{res(-)} + M^{dx}_{res(+)} \right|}{\left| M_{s(+)} + M_{i(-)} \right|}$$

$$\alpha_2 = \gamma_{Rd} \frac{\left| M^{\sin}_{res(+)} + M^{dx}_{res(-)} \right|}{\left| M_{s(-)} + M_{i(+)} \right|}$$

So we use like a project bending moment the following:

$$M^{prog}_{s(+)} = \alpha_1 M_{s(+)} \qquad M^{prog}_{s(-)} = \alpha_2 M_{s(-)}$$

$$M^{prog}_{i(-)} = \alpha_1 M_{i(-)} \qquad M^{prog}_{i(+)} = \alpha_2 M_{i(+)}$$

2.10.2.4 *Evaluation of the Project strains*

With the hyerarchy of resistances are evaluated the value α,consequently the Bending moment stress on the columns increased to reach the sovraresistance on the beams. The hyerarchy is not applied on the top of the structure, indeed we use the stress evvaluated with SAP2000.
On the bottom we use the bending moment stress wich is the major between the calcol moment and the project moment on the top of the first column. Therefore on the base are provided the same reiforcement evaluated on the top of the first column.

Building 1

H= 4m		***P_{inf}***	***$M_{RES,RIGHT}$***	***$M_{RES,LEFT}$***	α
A-1	*X-DIRECTION*	*77,94*	*-93,30*		*1,20*
	Y-DIRECTION	*39,12*	*-76,41*		*1,95*
A-2	*X-DIRECTION*	*82,36*	*-93,30*		*1,13*
	Y-DIRECTION	*35,25*	*-76,41*		*2,17*

	$M_{i,prog\ inf}$	***N_{min}***	***N_{max}***
A-1	*93,30*	*214,47*	*302,86*
	76,41		
A-2	*93,30*	*169,63*	*223,42*
	76,41		

H= 0m		***$M_{i,prog}$***	***N_{min}***	***N_{max}***
B-1	*X-DIRECTION*	*334,23*	*1018,95*	*1388,79*
	Y-DIRECTION	*-89,10*		
B-2	*X-DIRECTION*	*538,19*	*1303,68*	*1875,94*
	Y-DIRECTION	*46,30*		
B-3	*X-DIRECTION*	*469,02*	*1435,23*	*2166,79*
	Y-DIRECTION	*12,88*		
B-4	*X-DIRECTION*	*146,74*	*942,55*	*1315,52*
	Y-DIRECTION	*49,60*		

H= 4m		P_{sup}	P_{inf}	$M_{RES,RIGHT}$	$M_{RES,LEFT}$	α
B-1	*X-DIRECTION*	*-65,02*	*-334,23*	*63,60*	*579,70*	*1,61*
	Y-DIRECTION	*-56,30*	*-89,10*	*0,00*	*166,35*	*1,14*
B-2	*X-DIRECTION*	*-153,18*	*-538,40*	*45,30*	*716,18*	*1,10*
	Y-DIRECTION	*51,14*	*46,30*	*-166,35*	*-66,54*	*2,39*
B-3	*X-DIRECTION*	*-204,88*	*-469,02*	*240,30*	*716,18*	*1,42*
	Y-DIRECTION	*29,40*	*12,88*	*-133,08*	*-85,24*	*5,16*
B-4	*X-DIRECTION*	*-218,57*	*-146,74*	*120,00*	*579,00*	*1,91*
	Y-DIRECTION	*59,75*	*49,60*	*-166,35*		*1,52*

	$M_{i,prog\ sup}$	$M_{i,prog\ inf}$	N_{min}	N_{max}
B-1	-104,76	-538,54	453,90	705,93
	-64,41	-101,94		
B-2	-168,66	-592,82	336,87	587,31
	122,23	110,66		
B-3	-290,79	-665,69	355,74	738,46
	151,81	66,51		
B-4	-418,22	-280,78	356,17	587,75
	90,90	75,45		

H= 13m		$M_{i,prog}$	N_{min}	N_{max}
B-1	X-DIRECTION	-65,02	539,68	791,70
	Y-DIRECTION	0,00		
B-2	X-DIRECTION	-153,17	422,64	673,09
	Y-DIRECTION	0,00		
B-3	X-DIRECTION	-204,88	441,51	824,23
	Y-DIRECTION	0,00		
B-4	X-DIRECTION	-218,57	441,94	673,53
	Y-DIRECTION	0,00		

H= 4m		P_{inf}	$M_{RES,RIGHT}$	$M_{RES,LEFT}$	α
C-1	X-DIRECTION	105,46	-133,08		1,26
	Y-DIRECTION	426,25	-497,01		1,17
C-2	X-DIRECTION	32,82	-133,08	-66,55	6,08
	Y-DIRECTION	606,00	-661,96		1,09
C-3	X-DIRECTION	24,72	-133,08	-66,55	8,08
	Y-DIRECTION	603,60	-661,96		1,10
C-4	X-DIRECTION	119,43	-133,08		1,11
	Y-DIRECTION	415,75	-497,01		1,20

	$M_{i,prog\ inf}$	N_{min}	N_{max}
C-1	133,08	374,40	456,68
	497,01		
C-2	199,63	666,98	821,82
	661,96		
C-3	199,63	666,51	821,27
	661,96		
C-4	133,08	375,32	457,14
	497,01		

H= 0m		$M_{i,prog}$	N_{min}	N_{max}
K-1	*X-DIRECTION*	*219,74*	*193,34*	*302,37*
	Y-DIRECTION	*-7,09*		
K-2	*X-DIRECTION*	*326,80*	*267,59*	*424,64*
	Y-DIRECTION	*12,09*		
K-3	*X-DIRECTION*	*372,62*	*293,84*	*514,12*
	Y-DIRECTION	*12,54*		
K-4	*X-DIRECTION*	*382,79*	*265,42*	*430,19*
	Y-DIRECTION	*13,12*		

H= 4,30m		$M_{i,prog}$	N_{min}	N_{max}
K-1	*X-DIRECTION*	*287,76*	*265,17*	*374,75*
	Y-DIRECTION	*-49,16*		
K-2	*X-DIRECTION*	*336,39*	*339,95*	*497,01*
	Y-DIRECTION	*-53,19*		
K-3	*X-DIRECTION*	*381,28*	*366,21*	*586,49*
	Y-DIRECTION	*-55,04*		
K-4	*X-DIRECTION*	*459,26*	*337,80*	*502,57*
	Y-DIRECTION	*-59,59*		

Building 2

H= 0 m		$M_{i,prog}$	N_{min}	N_{max}
B-5	*X-DIRECTION*	*53,98*	*708,23*	*1137,44*
	Y-DIRECTION	*-149,00*		
B-6	*X-DIRECTION*	*115,21*	*820,76*	*1355,21*
	Y-DIRECTION	*48,79*		
B-7	*X-DIRECTION*	*111,71*	*808,22*	*1480,60*
	Y-DIRECTION	*-27,45*		
B-8	*X-DIRECTION*	*53,37*	*705,02*	*1119,50*
	Y-DIRECTION	*156,15*		

H= 4m		P_{sup}	P_{inf}	$M_{RES,RIGHT}$	$M_{RES,LEFT}$	α
B-5	*X-DIRECTION*	*-169,18*	*-53,98*	*193,20*	*78,57*	*1,22*
	Y-DIRECTION	*-91,71*	*-149,32*	*181,30*		*1,00*
B-6	*X-DIRECTION*	*-173,32*	*-115,40*	*104,76*	*443,20*	*1,90*
	Y-DIRECTION	*47,11*	*48,79*	*-101,93*	*-232,52*	*3,49*
B-7	*X-DIRECTION*	*-177,32*	*-111,40*	*104,76*	*443,20*	*1,90*
	Y-DIRECTION	*-47,34*	*-49,34*	*101,93*	*232,52*	*3,46*
B-8	*X-DIRECTION*	*-169,18*	*-53,98*	*193,20*	*78,57*	*1,22*
	Y-DIRECTION	*92,40*	*154,30*	*181,30*		*1,00*

	$M_{i,prog\ sup}$	$M_{i,prog\ inf}$	N_{min}	N_{max}
B-5	-206,03	-65,74	352,42	550,60
	-91,71	-149,32		
B-6	-328,94	-219,02	376,53	660,85
	164,30	170,15		
B-7	-336,53	-211,43	362,07	735,60
	-163,77	-170,68		
B-8	-206,03	-65,74	350,64	579,91
	92,40	154,30		

H= 13m		$M_{i,prog}$	N_{min}	N_{max}
B-5	X-DIRECTION	-169,17	266,65	464,83
	Y-DIRECTION	0,00		
B-6	X-DIRECTION	-173,54	293,95	628,87
	Y-DIRECTION	0,00		
B-7	X-DIRECTION	-177,64	279,49	606,14
	Y-DIRECTION	0,00		
B-8	X-DIRECTION	-169,87	264,87	494,14
	Y-DIRECTION	0,00		

H= 0m		$M_{i,prog}$	N_{min}	N_{max}
C-5	X-DIRECTION	-139,21	170,36	258,75
	Y-DIRECTION	-231,19		
C-6	X-DIRECTION	-37,20	125,52	179,32
	Y-DIRECTION	92,42		
C-7	X-DIRECTION	-37,06	125,16	178,84
	Y-DIRECTION	93,40		
C-8	X-DIRECTION	-140,02	172,44	261,45
	Y-DIRECTION	241,25		

H= 4m		P_{inf}	$M_{RES,RIGHT}$	$M_{RES,LEFT}$	α
C-5	X-DIRECTION	-139,32	-80,69		1,00
	Y-DIRECTION	-230,32	193,20		1,00
C-6	X-DIRECTION	-37,40			1,00
	Y-DIRECTION	92,42	-130,75	-73,62	2,21
C-7	X-DIRECTION	-38,30			1,00
	Y-DIRECTION	94,36	-130,75	-73,62	2,17
C-8	X-DIRECTION	143,40	-80,69		1,00
	Y-DIRECTION	238,70	193,20		1,00

	$M_{i,prog\ inf}$	N_{min}	N_{max}
C-5	-139,32	214,47	302,86
	-230,32		
C-6	-37,40	169,63	223,42
	204,37		
C-7	-38,30	169,27	222,95
	204,37		
C-8	143,40	216,56	305,56
	238,70		

H= 0m		**$M_{i,prog}$**	**N_{min}**	**N_{max}**
K-5	X-DIRECTION	306,97	209,16	354,52
	Y-DIRECTION	-8,82		
K-6	X-DIRECTION	292,14	232,01	399,31
	Y-DIRECTION	-1,51		
K-7	X-DIRECTION	344,23	237,82	472,74
	Y-DIRECTION	-0,84		
K-8	X-DIRECTION	310,68	210,17	366,14
	Y-DIRECTION	3,77		

H= 4,30m		**$M_{i,prog}$**	**N_{min}**	**N_{max}**
K-5	X-DIRECTION	352,09	281,99	426,90
	Y-DIRECTION	-18,25		
K-6	X-DIRECTION	336,72	304,38	471,70
	Y-DIRECTION	-16,36		
K-7	X-DIRECTION	326,91	310,19	545,18
	Y-DIRECTION	-18,88		
K-8	X-DIRECTION	348,43	282,52	438,51
	Y-DIRECTION	-25,55		

Between the possible combination are evaluated the following:

ENVELOPE			
Combo 1	M_{xmax}	M_{ymax}	N_{min}
Combo 2	M_{xmax}	M_{ymax}	N_{max}

So we have:

Building 1

Superior face				
H= 4m		M_x	M_y	N
B-1	Combo 1	-104,76	-64,41	453,90
	Combo 2	-104,76	-64,41	705,93
B-2	Combo 1	-168,66	122,23	336,87
	Combo 2	-168,66	122,23	587,31
B-3	Combo 1	-290,79	151,81	355,74
	Combo 2	-290,79	151,81	738,46
B-4	Combo 1	-418,22	90,90	356,17
	Combo 2	-418,22	90,90	587,75

Inferior face				
H= 4m		M_x	M_y	*N*
B-1	*Combo 1*	*-538,54*	*-101,94*	*453,90*
	Combo 2	*-538,54*	*-101,94*	*705,93*
B-2	*Combo 1*	*-592,82*	*110,66*	*336,87*
	Combo 2	*-592,82*	*110,66*	*587,31*
B-3	*Combo 1*	*-665,69*	*66,51*	*355,74*
	Combo 2	*-665,69*	*66,51*	*738,46*
B-4	*Combo 1*	*-280,78*	*75,45*	*356,17*
	Combo 2	*-280,78*	*75,45*	*587,75*

Superior face				
H= 4m		M_x	M_y	*N*
B-1	*Combo 1*	*334,23*	*-89,10*	*1018,95*
	Combo 2	*334,23*	*-149,00*	*1388,79*
B-2	*Combo 1*	*538,19*	*46,30*	*1303,68*
	Combo 2	*538,19*	*48,79*	*1875,94*
B-3	*Combo 1*	*469,02*	*12,88*	*1435,23*
	Combo 2	*469,02*	*-27,45*	*2166,79*
B-4	*Combo 1*	*146,74*	*156,15*	*942,55*
	Combo 2	*146,74*	*49,60*	*1315,52*

Inferior face				
H= 13m		M_x	M_y	*N*
B-1	*Combo 1*	*-65,02*	*0,00*	*539,68*
	Combo 2	*-65,02*	*0,00*	*791,70*
B-2	*Combo 1*	*-153,17*	*0,00*	*422,64*
	Combo 2	*-153,17*	*0,00*	*673,09*
B-3	*Combo 1*	*-204,88*	*0,00*	*441,51*
	Combo 2	*-204,88*	*0,00*	*824,23*
B-4	*Combo 1*	*-218,57*	*0,00*	*441,94*
	Combo 2	*-218,57*	*0,00*	*673,53*

H= 0m		M_x	M_y	*N*
C-1	*Combo 1*	*-426,25*	*-105,46*	*330,29*
	Combo 2	*-426,25*	*-105,46*	*412,57*
C-2	*Combo 1*	*-606,65*	*32,82*	*622,87*
	Combo 2	*-606,65*	*32,82*	*777,71*
C-3	*Combo 1*	*-603,60*	*24,87*	*622,39*
	Combo 2	*-603,60*	*24,87*	*777,16*
C-4	*Combo 1*	*-415,75*	*119,43*	*331,21*
	Combo 2	*-415,75*	*119,43*	*413,03*

H= 4m		M_x	M_y	*N*
C-1	*Combo 1*	*133,08*	*497,01*	*214,47*
	Combo 2	*133,08*	*497,01*	*302,86*
C-2	*Combo 1*	*199,63*	*661,96*	*169,63*
	Combo 2	*199,63*	*661,96*	*223,42*
C-3	*Combo 1*	*199,63*	*661,96*	*169,27*
	Combo 2	*199,63*	*661,96*	*222,95*
C-4	*Combo 1*	*133,08*	*497,01*	*216,56*
	Combo 2	*133,08*	*497,01*	*305,56*

Superior face				
H= 0m		M_x	M_y	*N*
K-1	*Combo 1*	*219,74*	*-7,09*	*193,34*
	Combo 2	*219,74*	*-7,09*	*302,37*
K-2	*Combo 1*	*326,80*	*12,09*	*267,59*
	Combo 2	*326,80*	*12,09*	*424,64*
K-3	*Combo 1*	*372,62*	*12,54*	*293,84*
	Combo 2	*372,62*	*12,54*	*514,12*
K-4	*Combo 1*	*310,68*	*382,79*	*265,42*
	Combo 2	*310,68*	*382,79*	*430,19*

Inferior face				
H= 4,30m		M_x	M_y	*N*
K-1	*Combo 1*	*287,76*	*-49,16*	*265,17*
	Combo 2	*287,76*	*-49,16*	*374,75*
K-2	*Combo 1*	*336,39*	*-53,19*	*339,95*
	Combo 2	*336,39*	*-53,19*	*497,01*
K-3	*Combo 1*	*381,28*	*-55,04*	*366,21*
	Combo 2	*381,28*	*-55,04*	*586,49*
K-4	*Combo 1*	*459,26*	*-59,59*	*337,80*
	Combo 2	*459,26*	*-59,59*	*502,57*

Building 2

Superior face				
H= 4m		M_x	M_y	*N*
B-5	*Combo 1*	*-206,03*	*-91,71*	*352,42*
	Combo 2	*-206,03*	*-91,71*	*550,60*
B-6	*Combo 1*	*-328,94*	*164,30*	*376,53*
	Combo 2	*-328,94*	*164,30*	*660,85*
B-7	*Combo 1*	*-336,53*	*-163,77*	*362,07*
	Combo 2	*-336,53*	*-163,77*	*735,60*
B-8	*Combo 1*	*-206,03*	*92,40*	*350,64*
	Combo 2	*-206,03*	*92,40*	*579,91*

Inferior face				
H= 4m		M_x	M_y	*N*
B-5	*Combo 1*	*-65,74*	*-149,32*	*352,42*
	Combo 2	*-65,74*	*-149,32*	*550,60*
B-6	*Combo 1*	*-219,02*	*170,15*	*376,53*
	Combo 2	*-219,02*	*170,15*	*660,85*
B-7	*Combo 1*	*-211,43*	*-170,68*	*362,07*
	Combo 2	*-211,43*	*-170,68*	*735,60*
B-8	*Combo 1*	*-65,74*	*154,30*	*350,64*
	Combo 2	*-65,74*	*154,30*	*579,91*

Superior face				
H= 0m		M_x	M_y	*N*
B-5	*Combo 1*	*53,98*	*-149,00*	*708,23*
	Combo 2	*53,98*	*-149,00*	*1137,44*
B-6	*Combo 1*	*115,21*	*48,79*	*820,76*
	Combo 2	*115,21*	*48,79*	*1355,21*
B-7	*Combo 1*	*111,71*	*-27,45*	*808,22*
	Combo 2	*111,71*	*-27,45*	*1480,60*
B-8	*Combo 1*	*53,37*	*156,15*	*705,02*
	Combo 2	*53,37*	*156,15*	*1119,50*

Inferior face				
H= 13m		M_x	M_y	*N*
B-5	*Combo 1*	*-169,17*	*0,00*	*266,65*
	Combo 2	*-169,17*	*0,00*	*464,83*
B-6	*Combo 1*	*-173,54*	*0,00*	*293,95*
	Combo 2	*-173,54*	*0,00*	*628,87*
B-7	*Combo 1*	*-177,64*	*0,00*	*279,49*
	Combo 2	*-177,64*	*0,00*	*606,14*
B-8	*Combo 1*	*-169,87*	*0,00*	*264,87*
	Combo 2	*-169,87*	*0,00*	*494,14*

H= 0m		M_x	M_y	*N*
C-5	*Combo 1*	*-139,21*	*-231,19*	*170,36*
	Combo 2	*-139,21*	*-231,19*	*258,75*
C-6	*Combo 1*	*-37,20*	*92,42*	*125,52*
	Combo 2	*-37,20*	*92,42*	*179,32*
C-7	*Combo 1*	*-37,06*	*93,40*	*125,16*
	Combo 2	*-37,06*	*93,40*	*178,84*
C-8	*Combo 1*	*-140,02*	*241,25*	*172,44*
	Combo 2	*-140,02*	*241,25*	*261,45*

Inferior face				
H= 4m		M_x	M_y	*N*
C-5	*Combo 1*	*-139,32*	*-230,32*	*214,47*
	Combo 2	*-139,32*	*-230,32*	*302,86*
C-6	*Combo 1*	*-37,40*	*204,37*	*169,63*
	Combo 2	*-37,40*	*204,37*	*223,42*
C-7	*Combo 1*	*-38,30*	*204,37*	*169,27*
	Combo 2	*-38,30*	*204,37*	*222,95*
C-8	*Combo 1*	*-143,40*	*-238,70*	*216,56*
	Combo 2	*-143,40*	*-238,70*	*305,56*

Superior face				
H= 0m		M_x	M_y	*N*
K-5	*Combo 1*	*306,97*	*-8,82*	*209,16*
	Combo 2	*306,97*	*-8,82*	*354,52*
K-6	*Combo 1*	*292,14*	*-1,51*	*232,01*
	Combo 2	*292,14*	*-1,51*	*399,31*
K-7	*Combo 1*	*344,23*	*-0,84*	*237,82*
	Combo 2	*344,23*	*-0,84*	*472,74*
K-8	*Combo 1*	*310,68*	*3,77*	*210,17*
	Combo 2	*310,68*	*3,77*	*366,14*

Inferior face				
H= 4,30m		M_x	M_y	*N*
K-5	*Combo 1*	*352,09*	*-18,25*	*281,99*
	Combo 2	*352,09*	*-18,25*	*426,90*
K-6	*Combo 1*	*336,72*	*-16,36*	*304,38*
	Combo 2	*336,72*	*-16,36*	*471,70*
K-7	*Combo 1*	*326,91*	*-18,88*	*310,19*
	Combo 2	*326,91*	*-18,88*	*545,18*
K-8	*Combo 1*	*348,43*	*-25,55*	*282,52*
	Combo 2	*348,43*	*-25,55*	*438,51*

2.10.2.5 *Longitudinal reinforcemet predimensioning*

According with the normative prescriptions we choose the following reinforcement for the columns:

Column	*PROT1*	*PROT2*	*PROT3*	*Misure Units*
b	*900*	*600*	*600*	*mm*
h	*600*	*600*	*300*	*mm*
Ac	*540000*	*360000*	*180000*	mm^2
As,min	*5400*	*3600*	*1800*	mm^2
As,max	*21600*	*14400*	*7200*	mm^2
Longitudinal reinforcement	***18Φ20***	***12Φ20***	***10Φ16***	**-**
	5652	***3768***	***2010***	mm^2
Project Rate	*1,05*	*1,05*	*1,12*	*%*

2.10.2.6 *Longitudinal reinforcemet Verifications*

*The longitudinal reinforcement verifications are made with the software Gelfi-Vca SLU” **(ATTACHEMENT D).***

2.10.2.7 *Longitudinal reinforcemet prototypes evaluated*

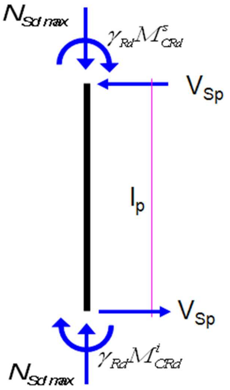
Following the longitudinal verifications, the prototypes evaluated are the following:

Column	*PROT1*	*PROT2*	*PROT3*	*PROT4*	*PROT5*	*PROT6*	*Misure Units*
b	*900*	*600*	*600*	*600*	*600*	*600*	*mm*
b	*600*	*600*	*600*	*600*	*600*	*300*	*mm*
Ac	*540000*	*360000*	*360000*	*360000*	*360000*	*180000*	*mm²*
As,min	*5400*	*3600*	*3600*	*3600*	*3600*	*1800*	*mm²*
As,max	*21600*	*14400*	*14400*	*14400*	*14400*	*7200*	*mm²*
Longitudinal reinforcement	***18Φ20***	***12Φ20***	***18Φ24***	***18Φ24***	***18Φ25***	***10Φ16***	**-**
	5652	***3768***	***8136***	***9040***	***6280***	***2010***	*mm²*
Project Rate	*1,05*	*1,05*	*2,26*	*2,51*	*1,74*	*1,12*	*%*
COLUMNS	*B 1/2/3/4/5/6/7/8* *K 1/2/3/4/5/6/7/8*	*C6-C7*	*C1-C4*	*C2-C3*	*C5-C8*	*A1-A2*	

2.10.3 DESIGN AND VERIFICATIONS SHEAR REINFORCEMENT

2.10.3.1 *Hierarchy of resistances*

Considerind the Hyerarchy resistance, the columns have to reach the bending moment breaking stress before the shear breaking point.
For this reason the shear stress on the columns is incrementated considering the sum of the resistance moments on the edge of the columns,divided the width of the column, increasing it with the amplification factor γ_{RD} =1,35.



$$V_{sp} = \gamma_{rd} \frac{M^{S}_{Crd} + M^{i}_{Crd}}{w_c}$$

2.10.3.2 *Evaluation of the Stress shear Projects*

Considering the resistance moment on the columns we obtain the shear stress:

TOP						
H= 0m		*N*	M_{xrd}	M_{yrd}	V_{edx}	V_{edx}
B-1	*Combo 1*	*1018,95*	*994*	*273*	*501,52*	*210,51*
	Combo 2	*1388,79*	*1063*	*289*	*535,33*	*219,36*
B-2	*Combo 1*	*1303,68*	*1161*	*104,6*	*529,58*	*168,07*
	Combo 2	*1875,94*	*1269*	*111,8*	*570,69*	*178,19*
B-3	*Combo 1*	*1435,23*	*1267*	*40,91*	*590,35*	*128,20*
	Combo 2	*2166,79*	*1384*	*44,8*	*642,91*	*138,52*
B-4	*Combo 1*	*942,55*	*587,3*	*641,5*	*439,96*	*242,51*
	Combo 2	*1315,52*	*629,1*	*674,7*	*469,80*	*254,35*
B-5	*Combo 1*	*708,23*	*278,4*	*706,3*	*269,22*	*347,67*
	Combo 2	*1137,44*	*300,3*	*772,4*	*286,72*	*375,59*
B-6	*Combo 1*	*820,76*	*915,3*	*396*	*351,99*	*296,13*
	Combo 2	*1355,21*	*997*	*426*	*374,90*	*315,39*
B-7	*Combo 1*	*808,22*	*1040*	*243,7*	*483,86*	*216,11*
	Combo 2	*1480,60*	*1160*	*275,7*	*532,16*	*237,39*
B-8	*Combo 1*	*705,02*	*218,5*	*720,1*	*143,89*	*391,32*
	Combo 2	*1119,50*	*206,5*	*606,8*	*147,63*	*368,81*

BOTTOM						
H= 4m		*N*	M_{xrd}	M_{yrd}	V_{edx}	V_{edx}
B-1	*Combo 1*	*453,90*	*750,4*	*459,2*	*501,52*	*210,51*
	Combo 2	*705,93*	*799*	*474*	*535,33*	*219,36*
B-2	*Combo 1*	*336,87*	*681*	*480*	*529,58*	*168,07*
	Combo 2	*587,31*	*716*	*508*	*570,69*	*178,19*
B-3	*Combo 1*	*355,74*	*786,4*	*405*	*590,35*	*128,20*
	Combo 2	*738,46*	*852,2*	*437*	*642,91*	*138,52*
B-4	*Combo 1*	*356,17*	*943*	*202*	*439,96*	*242,51*
	Combo 2	*587,75*	*1005*	*210*	*469,80*	*254,35*
B-5	*Combo 1*	*352,42*	*658*	*503*	*269,22*	*347,67*
	Combo 2	*550,60*	*697*	*534*	*286,72*	*375,59*
B-6	*Combo 1*	*376,53*	*309*	*634*	*351,99*	*296,13*
	Combo 2	*660,85*	*307*	*671*	*374,90*	*315,39*
B-7	*Combo 1*	*362,07*	*643*	*508*	*483,86*	*216,11*
	Combo 2	*735,60*	*691*	*550*	*532,16*	*237,39*
B-8	*Combo 1*	*350,64*	*282*	*641*	*143,89*	*391,32*
	Combo 2	*579,91*	*307*	*676*	*147,63*	*368,81*

TOP						
H= 4m		*N*	M_{xrd}	M_{yrd}	V_{edx}	V_{edx}
B-1	*Combo 1*	*453,90*	*984*	*175*	*369,43*	*37,97*
	Combo 2	*705,93*	*1047*	*191*	*392,82*	*41,44*
B-2	*Combo 1*	*336,87*	*950*	*176*	*357,43*	*38,19*
	Combo 2	*587,31*	*1018*	*183*	*382,00*	*39,71*
B-3	*Combo 1*	*355,74*	*990*	*96*	*366,70*	*20,83*
	Combo 2	*738,46*	*1092*	*108,5*	*404,02*	*23,54*
B-4	*Combo 1*	*356,17*	*919,1*	*245,5*	*351,31*	*53,27*
	Combo 2	*587,75*	*971*	*259*	*371,69*	*56,20*
B-5	*Combo 1*	*352,42*	*282,1*	*641,9*	*259,42*	*139,28*
	Combo 2	*550,60*	*280,1*	*678*	*271,25*	*147,11*
B-6	*Combo 1*	*376,53*	*658*	*503*	*373,64*	*109,14*
	Combo 2	*660,85*	*697*	*534*	*417,47*	*115,87*
B-7	*Combo 1*	*362,07*	*630*	*515*	*367,57*	*111,75*
	Combo 2	*735,60*	*677*	*560*	*413,13*	*121,51*
B-8	*Combo 1*	*350,64*	*829*	*364*	*404,67*	*78,98*
	Combo 2	*579,91*	*867*	*385*	*436,13*	*83,54*

BOTTOM						
H= 13m		*N*	M_{xrd}	M_{yrd}	V_{edx}	V_{edx}
B-1	*Combo 1*	*539,68*	*718,6*	*0*	*369,43*	*37,97*
	Combo 2	*791,70*	*763,4*	*0*	*392,82*	*41,44*
B-2	*Combo 1*	*422,64*	*697,3*	*0*	*357,43*	*38,19*
	Combo 2	*673,09*	*742,5*	*0*	*382,00*	*39,71*
B-3	*Combo 1*	*441,51*	*700*	*0*	*366,70*	*20,83*
	Combo 2	*824,23*	*770*	*0*	*404,02*	*23,54*
B-4	*Combo 1*	*441,94*	*700*	*0*	*351,31*	*53,27*
	Combo 2	*673,53*	*742*	*0*	*371,69*	*56,20*
B-5	*Combo 1*	*266,65*	*913,5*	*0*	*259,42*	*139,28*
	Combo 2	*464,83*	*970*	*0*	*271,25*	*147,11*
B-6	*Combo 1*	*293,95*	*1064*	*0*	*373,64*	*109,14*
	Combo 2	*628,87*	*1227*	*0*	*417,47*	*115,87*
B-7	*Combo 1*	*279,49*	*1064*	*0*	*367,57*	*111,75*
	Combo 2	*606,14*	*1227*	*0*	*413,13*	*121,51*
B-8	*Combo 1*	*264,87*	*1036*	*0*	*404,67*	*78,98*
	Combo 2	*494,14*	*1143*	*0*	*436,13*	*83,54*

TOP						
H= 0m		*N*	M_{xrd}	M_{yrd}	V_{edx}	V_{edx}
C-1	*Combo 1*	*214,47*	*150*	*593*	*173,65*	*205,28*
	Combo 2	*302,86*	*159*	*605*	*192,91*	*211,89*
C-2	*Combo 1*	*169,63*	*254*	*845*	*236,04*	*250,99*
	Combo 2	*223,42*	*255*	*853*	*243,51*	*254,44*
C-3	*Combo 1*	*169,27*	*240*	*851*	*232,30*	*250,13*
	Combo 2	*222,95*	*240*	*859*	*239,49*	*254,44*
C-4	*Combo 1*	*216,56*	*149*	*594*	*173,36*	*205,56*
	Combo 2	*305,56*	*159*	*605*	*179,40*	*211,89*
C-5	*Combo 1*	*170,36*	*268*	*463*	*120,18*	*204,41*
	Combo 2	*258,75*	*279*	*470*	*127,08*	*210,45*
C-6	*Combo 1*	*125,52*	*161*	*389*	*59,51*	*179,69*
	Combo 2	*179,32*	*162*	*400*	*60,66*	*186,59*
C-7	*Combo 1*	*125,16*	*161*	*388*	*59,51*	*179,40*
	Combo 2	*178,84*	*162*	*399*	*60,66*	*186,30*
C-8	*Combo 1*	*172,44*	*276*	*458*	*121,33*	*203,55*
	Combo 2	*261,45*	*279*	*471*	*124,49*	*211,89*

BOTTOM						
H= 4m		*N*	M_{xrd}	M_{yrd}	V_{edx}	V_{edx}
C-1	*Combo 1*	*330,29*	*454*	*121*	*173,65*	*205,28*
	Combo 2	*412,57*	*512*	*132*	*192,91*	*211,89*
C-2	*Combo 1*	*622,87*	*567*	*28*	*236,04*	*250,99*
	Combo 2	*777,71*	*592*	*32*	*243,51*	*254,44*
C-3	*Combo 1*	*622,39*	*568*	*19*	*232,30*	*250,13*
	Combo 2	*777,16*	*593*	*26*	*239,49*	*254,44*
C-4	*Combo 1*	*331,21*	*454*	*121*	*173,36*	*205,56*
	Combo 2	*413,03*	*465*	*132*	*179,40*	*211,89*
C-5	*Combo 1*	*214,47*	*150*	*248*	*120,18*	*204,41*
	Combo 2	*302,86*	*163*	*262*	*127,08*	*210,45*
C-6	*Combo 1*	*169,63*	*46*	*236*	*59,51*	*179,69*
	Combo 2	*223,42*	*49*	*249*	*60,66*	*186,59*
C-7	*Combo 1*	*169,27*	*46*	*236*	*59,51*	*179,40*
	Combo 2	*222,95*	*49*	*249*	*60,66*	*186,30*
C-8	*Combo 1*	*216,56*	*146*	*250*	*121,33*	*203,55*
	Combo 2	*305,56*	*154*	*266*	*124,49*	*211,89*

TOP						
H= 0m		N	M_{xrd}	M_{yrd}	V_{edx}	V_{edx}
K-1	Combo 1	193,34	938	158	501,72	84,51
	Combo 2	302,37	970	157	518,84	83,98
K-2	Combo 1	267,59	964	148	515,63	79,16
	Combo 2	424,64	1005	157	537,56	83,98
K-3	Combo 1	293,84	976	138	522,05	73,81
	Combo 2	514,12	1034	147	553,07	78,63
K-4	Combo 1	265,42	976	118	522,05	63,12
	Combo 2	430,19	1019	128	545,05	68,47
K-5	Combo 1	209,16	964	23	520,71	17,92
	Combo 2	354,52	1007	22	543,71	18,99
K-6	Combo 1	232,01	972	33	524,72	20,59
	Combo 2	399,31	1022	32	551,20	21,66
K-7	Combo 1	237,82	974	15	525,26	17,92
	Combo 2	472,74	1043	17	561,90	19,52
K-8	Combo 1	210,17	965	16	519,37	23,00
	Combo 2	366,14	1011	15,7	544,51	21,85

BOTTOM						
H= 4,3m		N	M_{xrd}	M_{yrd}	V_{edx}	V_{edx}
K-1	Combo 1	265,17	938	158	501,72	84,51
	Combo 2	374,75	970	157	518,84	83,98
K-2	Combo 1	339,95	964	148	515,63	79,16
	Combo 2	497,01	1005	157	537,56	83,98
K-3	Combo 1	366,21	976	138	522,05	73,81
	Combo 2	586,49	1034	147	553,07	78,63
K-4	Combo 1	337,80	976	118	522,05	63,12
	Combo 2	502,57	1019	128	545,05	68,47
K-5	Combo 1	281,99	983	44	520,71	17,92
	Combo 2	426,90	1026	49	543,71	18,99
K-6	Combo 1	304,38	990	44	524,72	20,59
	Combo 2	471,70	1039	49	551,20	21,66
K-7	Combo 1	310,19	990	52	525,26	17,92
	Combo 2	545,18	1058	56	561,90	19,52
K-8	Combo 1	282,52	977	70	519,37	23,00
	Combo 2	438,51	1025	66	544,51	21,85

2.10.3.3 *Evaluation of the shear breaking point on the concrete side*

Is possible evaluate the shear breaking stress on the concrete side consiering the following formula:

$$V_{rcd} = 0{,}9\ d\ b\ \alpha_c 0{,}5 f'_{cd}\ (cotg\alpha + ctg\theta)/(1 + ctg^2\theta)$$

where:

- *d : widht utile of the section along the shear direction;*
- *b :base corresponding to the shear stress direction;*
- *f'cd :breaking stress on concrete reduced due the axial anime compression (f'cd=0,6×fcd)*
- *α :inclination angle of stirrups (α=90°)*
- *θ inclination angle of the concrete struts*
  (1 ≤ ctgθ ≤ 2,5) (21.8° ≤ θ ≤ 45°)
- α_c *amplification factor of*

1	with not compressed sections
$1+\sigma_{cp}/f_{cd}$	with $0 \le \sigma_{cp} \le 0{,}25\, f_{cd}$
1,25	with $0{,}25\, f_{cd} \le \sigma_{cp} \le 0{,}5\, f_{cd}$
$2{,}5(1-\sigma_{cp}/f_{cd})$	$0{,}5\, f_{cd} \le \sigma_{cp} \le f_{cd}$

The inclination angle of the concrete struts is evaluated of θ = 45° in safety favour.

TOP																	
H= 4m		N	b_y - h_x	b_x -h_y	$A_{s,l,min}$	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp}/f_{cd}	α_c	f_{cd}'	γ_c	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)
B-1	Combo 1	453,90	600	900	5652	50	0,85	25	14,1	7,05	3,53	0,0602	1,06	8,46	1,5	1997,99	2058,54
	Combo 2	705,93	600	900	5652	50	1,32	25	14,1	7,05	3,53	0,0937	1,09	8,46	1,5	2061,03	2123,49
B-2	Combo 1	336,87	600	900	5652	50	0,63	25	14,1	7,05	3,53	0,0447	1,04	8,46	1,5	1968,72	2028,38
	Combo 2	587,31	600	900	5652	50	1,10	25	14,1	7,05	3,53	0,0780	1,25	8,46	1,5	2355,58	2426,96
B-3	Combo 1	355,74	600	900	5652	50	0,67	25	14,1	7,05	3,53	0,0472	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	738,46	600	900	5652	50	1,38	25	14,1	7,05	3,53	0,0980	1,25	8,46	1,5	2355,58	2426,96
B-4	Combo 1	356,17	600	900	5652	50	0,67	25	14,1	7,05	3,53	0,0473	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	587,75	600	900	5652	50	1,10	25	14,1	7,05	3,53	0,0780	1,25	8,46	1,5	2355,58	2426,96
B-5	Combo 1	352,42	600	900	5652	50	0,66	25	14,1	7,05	3,53	0,0468	1,05	8,46	1,5	1972,61	2032,39
	Combo 2	550,60	600	900	5652	50	1,03	25	14,1	7,05	3,53	0,0731	1,07	8,46	1,5	2022,18	2083,46
B-6	Combo 1	376,53	600	900	5652	50	0,70	25	14,1	7,05	3,53	0,0500	1,05	8,46	1,5	1978,64	2038,60
	Combo 2	660,85	600	900	5652	50	1,24	25	14,1	7,05	3,53	0,0877	1,25	8,46	1,5	2355,58	2426,96
B-7	Combo 1	362,07	600	900	5652	50	0,68	25	14,1	7,05	3,53	0,0481	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	735,60	600	900	5652	50	1,38	25	14,1	7,05	3,53	0,0976	1,25	8,46	1,5	2355,58	2426,96
B-8	Combo 1	350,64	600	900	5652	50	0,66	25	14,1	7,05	3,53	0,0465	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	579,91	600	900	5652	50	1,09	25	14,1	7,05	3,53	0,0770	1,25	8,46	1,5	2355,58	2426,96

BOTTOM																	
H= 13m		N	b_y - h_x	b_x -h_y	$A_{s,l,min}$	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp} /f_{cd}	α_c	f_{cd}'	γ_c	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)
B-1	Combo 1	539,68	600	900	5652	50	1,01	25	14,1	7,05	3,53	0,072	1,07	8,46	1,5	2019,45	2080,64
	Combo 2	791,70	600	900	5652	50	1,48	25	14,1	7,05	3,53	0,105	1,11	8,46	1,5	2082,48	2145,59
B-2	Combo 1	422,64	600	900	5652	50	0,79	25	14,1	7,05	3,53	0,056	1,06	8,46	1,5	1990,17	2050,48
	Combo 2	673,09	600	900	5652	50	1,26	25	14,1	7,05	3,53	0,089	1,25	8,46	1,5	2355,58	2426,96
B-3	Combo 1	441,51	600	900	5652	50	0,83	25	14,1	7,05	3,53	0,059	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	824,23	600	900	5652	50	1,54	25	14,1	7,05	3,53	0,109	1,25	8,46	1,5	2355,58	2426,96
B-4	Combo 1	441,94	600	900	5652	50	0,83	25	14,1	7,05	3,53	0,059	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	673,53	600	900	5652	50	1,26	25	14,1	7,05	3,53	0,089	1,25	8,46	1,5	2355,58	2426,96
B-5	Combo 1	266,65	600	900	5652	50	0,50	25	14,1	7,05	3,53	0,035	1,04	8,46	1,5	1951,16	2010,28
	Combo 2	464,83	600	900	5652	50	0,87	25	14,1	7,05	3,53	0,062	1,06	8,46	1,5	2000,73	2061,36
B-6	Combo 1	293,95	600	900	5652	50	0,55	25	14,1	7,05	3,53	0,039	1,04	8,46	1,5	1957,99	2017,32
	Combo 2	628,87	600	900	5652	50	1,18	25	14,1	7,05	3,53	0,083	1,25	8,46	1,5	2355,58	2426,96
B-7	Combo 1	279,49	600	900	5652	50	0,52	25	14,1	7,05	3,53	0,037	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	606,14	600	900	5652	50	1,13	25	14,1	7,05	3,53	0,080	1,25	8,46	1,5	2355,58	2426,96
B-8	Combo 1	264,87	600	900	5652	50	0,50	25	14,1	7,05	3,53	0,035	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	494,14	600	900	5652	50	0,92	25	14,1	7,05	3,53	0,066	1,25	8,46	1,5	2355,58	2426,96

TOP																	
H= 0m		N	b_y - h_x	b_x -h_y	$A_{s,l,min}$	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp} /f_{cd}	α_c	f_{cd}'	γ_c	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)
B-1	Combo 1	1018,95	600	900	5652	50	1,91	25	14,1	7,05	3,53	0,135	1,14	8,46	1,5	2139,32	2204,15
	Combo 2	1388,79	600	900	5652	50	2,60	25	14,1	7,05	3,53	0,184	1,18	8,46	1,5	2231,83	2299,46
B-2	Combo 1	1303,68	600	900	5652	50	2,44	25	14,1	7,05	3,53	0,173	1,17	8,46	1,5	2210,54	2277,52
	Combo 2	1875,94	600	900	5652	50	3,51	25	14,1	7,05	3,53	0,249	1,25	8,46	1,5	2355,58	2426,96
B-3	Combo 1	1435,23	600	900	5652	50	2,69	25	14,1	7,05	3,53	0,190	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	2166,79	600	900	5652	50	4,06	25	14,1	7,05	3,53	0,288	1,25	8,46	1,5	2355,58	2426,96
B-4	Combo 1	942,55	600	900	5652	50	1,76	25	14,1	7,05	3,53	0,125	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	1315,52	600	900	5652	50	2,46	25	14,1	7,05	3,53	0,175	1,25	8,46	1,5	2355,58	2426,96
B-5	Combo 1	708,23	600	900	5652	50	1,33	25	14,1	7,05	3,53	0,094	1,09	8,46	1,5	2061,61	2124,08
	Combo 2	1137,44	600	900	5652	50	2,13	25	14,1	7,05	3,53	0,151	1,15	8,46	1,5	2168,96	2234,69
B-6	Combo 1	820,76	600	900	5652	50	1,54	25	14,1	7,05	3,53	0,109	1,11	8,46	1,5	2089,75	2153,08
	Combo 2	1355,21	600	900	5652	50	2,54	25	14,1	7,05	3,53	0,180	1,25	8,46	1,5	2355,58	2426,96
B-7	Combo 1	808,22	600	900	5652	50	1,51	25	14,1	7,05	3,53	0,107	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	1480,60	600	900	5652	50	2,77	25	14,1	7,05	3,53	0,197	1,25	8,46	1,5	2355,58	2426,96
B-8	Combo 1	705,02	600	900	5652	50	1,32	25	14,1	7,05	3,53	0,094	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	1119,50	600	900	5652	50	2,10	25	14,1	7,05	3,53	0,149	1,25	8,46	1,5	2355,58	2426,96

BOTTOM																	
H= 4m		N	b_y - h_x	b_x -h_y	$A_{s,l,min}$	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp}/f_{cd}	α_c	f_{cd}'	γ_c	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)
B-1	Combo 1	453,90	600	900	5652	50	0,85	25	14,1	7,05	3,53	0,060	1,06	8,46	1,5	1997,99	2058,54
	Combo 2	705,93	600	900	5652	50	1,32	25	14,1	7,05	3,53	0,094	1,09	8,46	1,5	2061,03	2123,49
B-2	Combo 1	336,87	600	900	5652	50	0,63	25	14,1	7,05	3,53	0,045	1,04	8,46	1,5	1968,72	2028,38
	Combo 2	587,31	600	900	5652	50	1,10	25	14,1	7,05	3,53	0,078	1,25	8,46	1,5	2355,58	2426,96
B-3	Combo 1	355,74	600	900	5652	50	0,67	25	14,1	7,05	3,53	0,047	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	738,46	600	900	5652	50	1,38	25	14,1	7,05	3,53	0,098	1,25	8,46	1,5	2355,58	2426,96
B-4	Combo 1	356,17	600	900	5652	50	0,67	25	14,1	7,05	3,53	0,047	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	587,75	600	900	5652	50	1,10	25	14,1	7,05	3,53	0,078	1,25	8,46	1,5	2355,58	2426,96
B-5	Combo 1	352,42	600	900	5652	50	0,66	25	14,1	7,05	3,53	0,047	1,05	8,46	1,5	1972,61	2032,39
	Combo 2	550,60	600	900	5652	50	1,03	25	14,1	7,05	3,53	0,073	1,07	8,46	1,5	2022,18	2083,46
B-6	Combo 1	376,53	600	900	5652	50	0,70	25	14,1	7,05	3,53	0,050	1,05	8,46	1,5	1978,64	2038,60
	Combo 2	660,85	600	900	5652	50	1,24	25	14,1	7,05	3,53	0,088	1,25	8,46	1,5	2355,58	2426,96
B-7	Combo 1	362,07	600	900	5652	50	0,68	25	14,1	7,05	3,53	0,048	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	735,60	600	900	5652	50	1,38	25	14,1	7,05	3,53	0,098	1,25	8,46	1,5	2355,58	2426,96
B-8	Combo 1	350,64	600	900	5652	50	0,66	25	14,1	7,05	3,53	0,047	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	579,91	600	900	5652	50	1,09	25	14,1	7,05	3,53	0,077	1,25	8,46	1,5	2355,58	2426,96

TOP																	
H= 0m		N	b_y - h_x	b_x -h_y	$A_{s,l,min}$	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp}/f_{cd}	α_c	f_{cd}'	γ_c	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)
C-1	Combo 1	214,47	600	900	5652	50	0,40	25	14,1	7,05	3,53	0,028	1,03	8,46	1,5	1938,11	1996,84
	Combo 2	302,86	600	900	5652	50	0,57	33,2	14,1	7,05	3,53	0,040	1,04	8,46	1,5	1960,22	2019,62
C-2	Combo 1	169,63	600	900	5652	50	0,32	33,2	14,1	7,05	3,53	0,023	1,02	8,46	1,5	1926,89	1985,28
	Combo 2	223,42	600	900	5652	50	0,42	33,2	14,1	7,05	3,53	0,030	1,25	8,46	1,5	2355,58	2426,96
C-3	Combo 1	169,27	600	900	5652	50	0,32	33,2	14,1	7,05	3,53	0,022	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	222,95	600	900	5652	50	0,42	33,2	14,1	7,05	3,53	0,030	1,25	8,46	1,5	2355,58	2426,96
C-4	Combo 1	216,56	600	900	5652	50	0,41	33,2	14,1	7,05	3,53	0,029	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	305,56	600	900	5652	50	0,57	33,2	14,1	7,05	3,53	0,041	1,25	8,46	1,5	2355,58	2426,96
C-5	Combo 1	170,36	600	900	5652	50	0,32	25	14,1	7,05	3,53	0,023	1,02	8,46	1,5	1927,08	1985,47
	Combo 2	258,75	600	900	5652	50	0,48	33,2	14,1	7,05	3,53	0,034	1,03	8,46	1,5	1949,18	2008,25
C-6	Combo 1	125,52	600	900	5652	50	0,23	33,2	14,1	7,05	3,53	0,017	1,02	8,46	1,5	1915,86	1973,92
	Combo 2	179,32	600	900	5652	50	0,34	33,2	14,1	7,05	3,53	0,024	1,25	8,46	1,5	2355,58	2426,96
C-7	Combo 1	125,16	600	900	5652	50	0,23	33,2	14,1	7,05	3,53	0,017	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	178,84	600	900	5652	50	0,33	33,2	14,1	7,05	3,53	0,024	1,25	8,46	1,5	2355,58	2426,96
C-8	Combo 1	172,44	600	900	5652	50	0,32	33,2	14,1	7,05	3,53	0,023	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	261,45	600	900	5652	50	0,49	33,2	14,1	7,05	3,53	0,035	1,25	8,46	1,5	2355,58	2426,96

BOTTOM																	
H= 4m		N	b_y - h_x	b_x -h_y	$A_{s,l,min}$	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp} /f_{cd}	α_c	f_{cd}'	γ_c	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)
C-1	Combo 1	330,29	600	900	5652	50	0,62	25	14,1	7,05	3,53	0,044	1,04	8,46	1,5	1967,08	2026,68
	Combo 2	412,57	600	900	5652	50	0,77	25	14,1	7,05	3,53	0,055	1,05	8,46	1,5	1987,66	2047,89
C-2	Combo 1	622,87	600	900	5652	50	1,17	25	14,1	7,05	3,53	0,083	1,08	8,46	1,5	2040,26	2102,08
	Combo 2	777,71	600	900	5652	50	1,46	25	14,1	7,05	3,53	0,103	1,25	8,46	1,5	2355,58	2426,96
C-3	Combo 1	622,39	600	900	5652	50	1,16	25	14,1	7,05	3,53	0,083	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	777,16	600	900	5652	50	1,45	25	14,1	7,05	3,53	0,103	1,25	8,46	1,5	2355,58	2426,96
C-4	Combo 1	331,21	600	900	5652	50	0,62	25	14,1	7,05	3,53	0,044	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	413,03	600	900	5652	50	0,77	25	14,1	7,05	3,53	0,055	1,25	8,46	1,5	2355,58	2426,96
C-5	Combo 1	214,47	600	900	5652	50	0,40	25	14,1	7,05	3,53	0,028	1,03	8,46	1,5	1938,11	1996,84
	Combo 2	302,86	600	900	5652	50	0,57	25	14,1	7,05	3,53	0,040	1,04	8,46	1,5	1960,22	2019,62
C-6	Combo 1	169,63	600	900	5652	50	0,32	25	14,1	7,05	3,53	0,023	1,02	8,46	1,5	1926,89	1985,28
	Combo 2	223,42	600	900	5652	50	0,42	25	14,1	7,05	3,53	0,030	1,25	8,46	1,5	2355,58	2426,96
C-7	Combo 1	169,27	600	900	5652	50	0,32	25	14,1	7,05	3,53	0,022	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	222,95	600	900	5652	50	0,42	25	14,1	7,05	3,53	0,030	1,25	8,46	1,5	2355,58	2426,96
C-8	Combo 1	216,56	600	900	5652	50	0,41	25	14,1	7,05	3,53	0,029	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	305,56	600	900	5652	50	0,57	25	14,1	7,05	3,53	0,041	1,25	8,46	1,5	2355,58	2426,96

									TOP								
H= 0m		N	b_y - h_x	b_x -h_y	$A_{s,l,min}$	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp} /f_{cd}	α_c	f_{cd}'	γ_c	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)
K-1	Combo 1	193,34	600	900	5652	50	0,36	25	14,1	7,05	3,53	0,026	1,03	8,46	1,5	1932,82	1991,39
	Combo 2	302,37	600	900	5652	50	0,57	25	14,1	7,05	3,53	0,040	1,04	8,46	1,5	1960,09	2019,49
K-2	Combo 1	267,59	600	900	5652	50	0,50	25	14,1	7,05	3,53	0,036	1,04	8,46	1,5	1951,39	2010,53
	Combo 2	424,64	600	900	5652	50	0,79	25	14,1	7,05	3,53	0,056	1,25	8,46	1,5	2355,58	2426,96
K-3	Combo 1	293,84	600	900	5652	50	0,55	25	14,1	7,05	3,53	0,039	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	514,12	600	900	5652	50	0,96	25	14,1	7,05	3,53	0,068	1,25	8,46	1,5	2355,58	2426,96
K-4	Combo 1	265,42	600	900	5652	50	0,50	25	14,1	7,05	3,53	0,035	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	430,19	600	900	5652	50	0,81	25	14,1	7,05	3,53	0,057	1,25	8,46	1,5	2355,58	2426,96
K-5	Combo 1	209,16	600	900	5652	50	0,39	25	14,1	7,05	3,53	0,028	1,03	8,46	1,5	1936,78	1995,47
	Combo 2	354,52	600	900	5652	50	0,66	25	14,1	7,05	3,53	0,047	1,05	8,46	1,5	1973,14	2032,93
K-6	Combo 1	232,01	600	900	5652	50	0,43	25	14,1	7,05	3,53	0,031	1,03	8,46	1,5	1942,49	2001,36
	Combo 2	399,31	600	900	5652	50	0,75	25	14,1	7,05	3,53	0,053	1,25	8,46	1,5	2355,58	2426,96
K-7	Combo 1	237,82	600	900	5652	50	0,45	25	14,1	7,05	3,53	0,032	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	472,74	600	900	5652	50	0,88	25	14,1	7,05	3,53	0,063	1,25	8,46	1,5	2355,58	2426,96
K-8	Combo 1	210,17	600	900	5652	50	0,39	25	14,1	7,05	3,53	0,028	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	366,14	600	900	5652	50	0,69	25	14,1	7,05	3,53	0,049	1,25	8,46	1,5	2355,58	2426,96

BOTTOM																	
H= 4,3m		N	b_y - h_x	b_x -h_y	$A_{s,l,min}$	c	σ_{cp}	f_{ck}	f_{cd}	0,5 f_{cd}	0,25 f_{cd}	σ_{cp} /f_{cd}	α_c	f_{cd}'	γ_c	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)
K-1	Combo 1	265,17	600	900	5652	50	0,50	25	14,1	7,05	3,53	0,035	1,04	8,46	1,5	1950,79	2009,90
	Combo 2	374,75	600	900	5652	50	0,70	25	14,1	7,05	3,53	0,050	1,05	8,46	1,5	1978,20	2038,14
K-2	Combo 1	339,95	600	900	5652	50	0,64	25	14,1	7,05	3,53	0,045	1,05	8,46	1,5	1969,49	2029,17
	Combo 2	497,01	600	900	5652	50	0,93	25	14,1	7,05	3,53	0,066	1,25	8,46	1,5	2355,58	2426,96
K-3	Combo 1	366,21	600	900	5652	50	0,69	25	14,1	7,05	3,53	0,049	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	586,49	600	900	5652	50	1,10	25	14,1	7,05	3,53	0,078	1,25	8,46	1,5	2355,58	2426,96
K-4	Combo 1	337,80	600	900	5652	50	0,63	25	14,1	7,05	3,53	0,045	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	502,57	600	900	5652	50	0,94	25	14,1	7,05	3,53	0,067	1,25	8,46	1,5	2355,58	2426,96
K-5	Combo 1	281,99	600	900	5652	50	0,53	25	14,1	7,05	3,53	0,037	1,04	8,46	1,5	1955,00	2014,24
	Combo 2	426,90	600	900	5652	50	0,80	25	14,1	7,05	3,53	0,057	1,06	8,46	1,5	1991,24	2051,58
K-6	Combo 1	304,38	600	900	5652	50	0,57	25	14,1	7,05	3,53	0,040	1,04	8,46	1,5	1960,60	2020,01
	Combo 2	471,70	600	900	5652	50	0,88	25	14,1	7,05	3,53	0,063	1,25	8,46	1,5	2355,58	2426,96
K-7	Combo 1	310,19	600	900	5652	50	0,58	25	14,1	7,05	3,53	0,041	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	545,18	600	900	5652	50	1,02	25	14,1	7,05	3,53	0,072	1,25	8,46	1,5	2355,58	2426,96
K-8	Combo 1	282,52	600	900	5652	50	0,53	25	14,1	7,05	3,53	0,037	1,25	8,46	1,5	2355,58	2426,96
	Combo 2	438,51	600	900	5652	50	0,82	25	14,1	7,05	3,53	0,058	1,25	8,46	1,5	2355,58	2426,96

2.10.3.4 *Shear verification on the concrete side*

The shear verifications con concrete are made evaluating:

$$\frac{V_{ed,x}}{V_{rcd,x}} < 1$$

and

$$\frac{V_{ed,y}}{V_{rcd,y}} < 1$$

H= 4m		V_{edx} *(KN)*	V_{edx} *(KN)*	$V_{rcd,x}$ *(KN)*	$V_{rcd,y}$ *(KN)*	$V_{ed,y}/V_{rcd,y}$	$V_{rcd,x}/V_{ed,x}$
B-1	*Combo 1*	*369,43*	*37,97*	*1997,99*	*2058,54*	*0,185*	*0,018*
	Combo 2	*392,82*	*41,44*	*2061,03*	*2123,49*	*0,191*	*0,020*
B-2	*Combo 1*	*357,43*	*38,19*	*1968,72*	*2028,38*	*0,182*	*0,019*
	Combo 2	*382,00*	*39,71*	*2355,58*	*2426,96*	*0,162*	*0,016*
B-3	*Combo 1*	*366,70*	*20,83*	*2355,58*	*2426,96*	*0,156*	*0,009*
	Combo 2	*404,02*	*23,54*	*2355,58*	*2426,96*	*0,172*	*0,010*
B-4	*Combo 1*	*351,31*	*53,27*	*2355,58*	*2426,96*	*0,149*	*0,022*
	Combo 2	*371,69*	*56,20*	*2355,58*	*2426,96*	*0,158*	*0,023*
B-5	*Combo 1*	*259,42*	*139,28*	*1972,61*	*2032,39*	*0,132*	*0,069*
	Combo 2	*271,25*	*147,11*	*2022,18*	*2083,46*	*0,134*	*0,071*
B-6	*Combo 1*	*373,64*	*109,14*	*1978,64*	*2038,60*	*0,189*	*0,054*
	Combo 2	*417,47*	*115,87*	*2355,58*	*2426,96*	*0,177*	*0,048*
B-7	*Combo 1*	*367,57*	*111,75*	*2355,58*	*2426,96*	*0,156*	*0,046*
	Combo 2	*413,13*	*121,51*	*2355,58*	*2426,96*	*0,175*	*0,050*
B-8	*Combo 1*	*404,67*	*78,98*	*2355,58*	*2426,96*	*0,172*	*0,033*
	Combo 2	*436,13*	*83,54*	*2355,58*	*2426,96*	*0,185*	*0,034*

H= 13m		*V_{edx} (KN)*	*V_{edx} (KN)*	*$V_{rcd,x}$ (KN)*	*$V_{rcd,y}$ (KN)*	*$V_{ed,y}/V_{rcd,y}$*	*$V_{rcd,x}/V_{ed,x}$*
B-1	*Combo 1*	*369,43*	*37,97*	*2019,45*	*2080,64*	*0,183*	*0,018*
	Combo 2	*392,82*	*41,44*	*2082,48*	*2145,59*	*0,189*	*0,019*
B-2	*Combo 1*	*357,43*	*38,19*	*1990,17*	*2050,48*	*0,180*	*0,019*
	Combo 2	*382,00*	*39,71*	*2355,58*	*2426,96*	*0,162*	*0,016*
B-3	*Combo 1*	*366,70*	*20,83*	*2355,58*	*2426,96*	*0,156*	*0,009*
	Combo 2	*404,02*	*23,54*	*2355,58*	*2426,96*	*0,172*	*0,010*
B-4	*Combo 1*	*351,31*	*53,27*	*2355,58*	*2426,96*	*0,149*	*0,022*
	Combo 2	*371,69*	*56,20*	*2355,58*	*2426,96*	*0,158*	*0,023*
B-5	*Combo 1*	*259,42*	*139,28*	*1951,16*	*2010,28*	*0,133*	*0,069*
	Combo 2	*271,25*	*147,11*	*2000,73*	*2061,36*	*0,136*	*0,071*
B-6	*Combo 1*	*373,64*	*109,14*	*1957,99*	*2017,32*	*0,191*	*0,054*
	Combo 2	*417,47*	*115,87*	*2355,58*	*2426,96*	*0,177*	*0,048*
B-7	*Combo 1*	*367,57*	*111,75*	*2355,58*	*2426,96*	*0,156*	*0,046*
	Combo 2	*413,13*	*121,51*	*2355,58*	*2426,96*	*0,175*	*0,050*
B-8	*Combo 1*	*404,67*	*78,98*	*2355,58*	*2426,96*	*0,172*	*0,033*
	Combo 2	*436,13*	*83,54*	*2355,58*	*2426,96*	*0,185*	*0,034*

H= 0m		*V_{edx} (KN)*	*V_{edx} (KN)*	*$V_{rcd,x}$ (KN)*	*$V_{rcd,y}$ (KN)*	*$V_{ed,y}$ / $V_{rcd,y}$*	*$V_{rcd,x}$ /$V_{ed,x}$*
B-1	*Combo 1*	*501,52*	*210,51*	*2139,32*	*2204,15*	*0,234*	*0,096*
	Combo 2	*535,33*	*219,36*	*2231,83*	*2299,46*	*0,240*	*0,095*
B-2	*Combo 1*	*529,58*	*168,07*	*2210,54*	*2277,52*	*0,240*	*0,074*
	Combo 2	*570,69*	*178,19*	*2355,58*	*2426,96*	*0,242*	*0,073*
B-3	*Combo 1*	*590,35*	*128,20*	*2355,58*	*2426,96*	*0,251*	*0,053*
	Combo 2	*642,91*	*138,52*	*2355,58*	*2426,96*	*0,273*	*0,057*
B-4	*Combo 1*	*439,96*	*242,51*	*2355,58*	*2426,96*	*0,187*	*0,100*
	Combo 2	*469,80*	*254,35*	*2355,58*	*2426,96*	*0,199*	*0,105*
B-5	*Combo 1*	*269,22*	*347,67*	*2061,61*	*2124,08*	*0,131*	*0,164*
	Combo 2	*286,72*	*375,59*	*2168,96*	*2234,69*	*0,132*	*0,168*
B-6	*Combo 1*	*351,99*	*296,13*	*2089,75*	*2153,08*	*0,168*	*0,138*
	Combo 2	*374,90*	*315,39*	*2355,58*	*2426,96*	*0,159*	*0,130*
B-7	*Combo 1*	*483,86*	*216,11*	*2355,58*	*2426,96*	*0,205*	*0,089*
	Combo 2	*532,16*	*237,39*	*2355,58*	*2426,96*	*0,226*	*0,098*
B-8	*Combo 1*	*143,89*	*391,32*	*2355,58*	*2426,96*	*0,061*	*0,161*
	Combo 2	*147,63*	*368,81*	*2355,58*	*2426,96*	*0,063*	*0,152*

H= 4m		V_{edx} (KN)	V_{edx} (KN)	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)	$V_{ed,y}/V_{rcd,y}$	$V_{rcd,x}/V_{ed,x}$
B-1	Combo 1	501,52	210,51	1997,99	2058,54	0,251	0,102
	Combo 2	535,33	219,36	2061,03	2123,49	0,260	0,103
B-2	Combo 1	529,58	168,07	1968,72	2028,38	0,269	0,083
	Combo 2	570,69	178,19	2355,58	2426,96	0,242	0,073
B-3	Combo 1	590,35	128,20	2355,58	2426,96	0,251	0,053
	Combo 2	642,91	138,52	2355,58	2426,96	0,273	0,057
B-4	Combo 1	439,96	242,51	2355,58	2426,96	0,187	0,100
	Combo 2	469,80	254,35	2355,58	2426,96	0,199	0,105
B-5	Combo 1	269,22	347,67	1972,61	2032,39	0,136	0,171
	Combo 2	286,72	375,59	2022,18	2083,46	0,142	0,180
B-6	Combo 1	351,99	296,13	1978,64	2038,60	0,178	0,145
	Combo 2	374,90	315,39	2355,58	2426,96	0,159	0,130
B-7	Combo 1	483,86	216,11	2355,58	2426,96	0,205	0,089
	Combo 2	532,16	237,39	2355,58	2426,96	0,226	0,098
B-8	Combo 1	143,89	391,32	2355,58	2426,96	0,061	0,161
	Combo 2	147,63	368,81	2355,58	2426,96	0,063	0,152

H= 0m		V_{edx} (KN)	V_{edx} (KN)	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)	$V_{ed,y}/V_{rcd,y}$	$V_{rcd,x}/V_{ed,x}$
C-1	Combo 1	173,65	205,28	1938,11	1996,84	0,090	0,103
	Combo 2	192,91	211,89	1960,22	2019,62	0,098	0,105
C-2	Combo 1	236,04	250,99	1926,89	1985,28	0,122	0,126
	Combo 2	243,51	254,44	2355,58	2426,96	0,103	0,105
C-3	Combo 1	232,30	250,13	2355,58	2426,96	0,099	0,103
	Combo 2	239,49	254,44	2355,58	2426,96	0,102	0,105
C-4	Combo 1	173,36	205,56	2355,58	2426,96	0,074	0,085
	Combo 2	179,40	211,89	2355,58	2426,96	0,076	0,087
C-5	Combo 1	120,18	204,41	1927,08	1985,47	0,062	0,103
	Combo 2	127,08	210,45	1949,18	2008,25	0,065	0,105
C-6	Combo 1	59,51	179,69	1915,86	1973,92	0,031	0,091
	Combo 2	60,66	186,59	2355,58	2426,96	0,026	0,077
C-7	Combo 1	59,51	179,40	2355,58	2426,96	0,025	0,074
	Combo 2	60,66	186,30	2355,58	2426,96	0,026	0,077
C-8	Combo 1	121,33	203,55	2355,58	2426,96	0,052	0,084
	Combo 2	124,49	211,89	2355,58	2426,96	0,053	0,087

H= 4m		*V_{edx} (KN)*	*V_{edx} (KN)*	*$V_{rcd,x}$ (KN)*	*$V_{rcd,y}$ (KN)*	*$V_{ed,y}/V_{rcd,y}$*	*$V_{rcd,x}/V_{ed,x}$*
C-1	*Combo 1*	*173,65*	*205,28*	*1967,08*	*2026,68*	*0,088*	*0,101*
	Combo 2	*192,91*	*211,89*	*1987,66*	*2047,89*	*0,097*	*0,103*
C-2	*Combo 1*	*236,04*	*250,99*	*2040,26*	*2102,08*	*0,116*	*0,119*
	Combo 2	*243,51*	*254,44*	*2355,58*	*2426,96*	*0,103*	*0,105*
C-3	*Combo 1*	*232,30*	*250,13*	*2355,58*	*2426,96*	*0,099*	*0,103*
	Combo 2	*239,49*	*254,44*	*2355,58*	*2426,96*	*0,102*	*0,105*
C-4	*Combo 1*	*173,36*	*205,56*	*2355,58*	*2426,96*	*0,074*	*0,085*
	Combo 2	*179,40*	*211,89*	*2355,58*	*2426,96*	*0,076*	*0,087*
C-5	*Combo 1*	*120,18*	*204,41*	*1938,11*	*1996,84*	*0,062*	*0,102*
	Combo 2	*127,08*	*210,45*	*1960,22*	*2019,62*	*0,065*	*0,104*
C-6	*Combo 1*	*59,51*	*179,69*	*1926,89*	*1985,28*	*0,031*	*0,091*
	Combo 2	*60,66*	*186,59*	*2355,58*	*2426,96*	*0,026*	*0,077*
C-7	*Combo 1*	*59,51*	*179,40*	*2355,58*	*2426,96*	*0,025*	*0,074*
	Combo 2	*60,66*	*186,30*	*2355,58*	*2426,96*	*0,026*	*0,077*
C-8	*Combo 1*	*121,33*	*203,55*	*2355,58*	*2426,96*	*0,052*	*0,084*
	Combo 2	*124,49*	*211,89*	*2355,58*	*2426,96*	*0,053*	*0,087*

H= 0m		*V_{edx} (KN)*	*V_{edx} (KN)*	*$V_{rcd,x}$ (KN)*	*$V_{rcd,y}$ (KN)*	*$V_{ed,y}/V_{rcd,y}$*	*$V_{rcd,x}/V_{ed,x}$*
K-1	*Combo 1*	*501,72*	*84,51*	*1932,82*	*1991,39*	*0,260*	*0,042*
	Combo 2	*518,84*	*83,98*	*1960,09*	*2019,49*	*0,265*	*0,042*
K-2	*Combo 1*	*515,63*	*79,16*	*1951,39*	*2010,53*	*0,264*	*0,039*
	Combo 2	*537,56*	*83,98*	*2355,58*	*2426,96*	*0,228*	*0,035*
K-3	*Combo 1*	*522,05*	*73,81*	*2355,58*	*2426,96*	*0,222*	*0,030*
	Combo 2	*553,07*	*78,63*	*2355,58*	*2426,96*	*0,235*	*0,032*
K-4	*Combo 1*	*522,05*	*63,12*	*2355,58*	*2426,96*	*0,222*	*0,026*
	Combo 2	*545,05*	*68,47*	*2355,58*	*2426,96*	*0,231*	*0,028*
K-5	*Combo 1*	*520,71*	*17,92*	*1936,78*	*1995,47*	*0,269*	*0,009*
	Combo 2	*543,71*	*18,99*	*1973,14*	*2032,93*	*0,276*	*0,009*
K-6	*Combo 1*	*524,72*	*20,59*	*1942,49*	*2001,36*	*0,270*	*0,010*
	Combo 2	*551,20*	*21,66*	*2355,58*	*2426,96*	*0,234*	*0,009*
K-7	*Combo 1*	*525,26*	*17,92*	*2355,58*	*2426,96*	*0,223*	*0,007*
	Combo 2	*561,90*	*19,52*	*2355,58*	*2426,96*	*0,239*	*0,008*
K-8	*Combo 1*	*519,37*	*23,00*	*2355,58*	*2426,96*	*0,220*	*0,009*
	Combo 2	*544,51*	*21,85*	*2355,58*	*2426,96*	*0,231*	*0,009*

H= 4,3m		V_{edx} (KN)	V_{edx} (KN)	$V_{rcd,x}$ (KN)	$V_{rcd,y}$ (KN)	$V_{ed,y}/V_{rcd,y}$	$V_{rcd,x}/V_{ed,x}$
K-1	Combo 1	501,72	84,51	1950,79	2009,90	0,257	0,042
	Combo 2	518,84	83,98	1978,20	2038,14	0,262	0,041
K-2	Combo 1	515,63	79,16	1969,49	2029,17	0,262	0,039
	Combo 2	537,56	83,98	2355,58	2426,96	0,228	0,035
K-3	Combo 1	522,05	73,81	2355,58	2426,96	0,222	0,030
	Combo 2	553,07	78,63	2355,58	2426,96	0,235	0,032
K-4	Combo 1	522,05	63,12	2355,58	2426,96	0,222	0,026
	Combo 2	545,05	68,47	2355,58	2426,96	0,231	0,028
K-5	Combo 1	520,71	17,92	1955,00	2014,24	0,266	0,009
	Combo 2	543,71	18,99	1991,24	2051,58	0,273	0,009
K-6	Combo 1	524,72	20,59	1960,60	2020,01	0,268	0,010
	Combo 2	551,20	21,66	2355,58	2426,96	0,234	0,009
K-7	Combo 1	525,26	17,92	2355,58	2426,96	0,223	0,007
	Combo 2	561,90	19,52	2355,58	2426,96	0,239	0,008
K-8	Combo 1	519,37	23,00	2355,58	2426,96	0,220	0,009
	Combo 2	544,51	21,85	2355,58	2426,96	0,231	0,009

2.10.3.5 *Shear reinforcement design*

After the shear verification on the concrete side is evaluated the prime cracking angle using the following formula:

$$cotg\theta = \sqrt{\frac{1 + |\sigma c|}{f_{ctm}}}$$

with

$$\sigma_c = \frac{N_{ed}}{A_{id}}$$

esabilishing the minimum shear reinforcement with the following formula:

$$V_{rsd} = 0{,}9\ d\ \left(\frac{A_{sw}}{s}\right) f_{yd}(ctg\alpha + ctg\theta) sin\theta$$

Where :

- f_{yd} *is the breaking project resistance on the steal;*
- A_{sw} *is the Area of the stirrups;*
- *S is the footstep between the stirrups;*

Following the evaluation of the minimum shear necessary:

H= 4m		V_{edx}	V_{edx} (KN)	d_x	d_y	$(A_{sw}/s),x$	$(A_{sw}/s),y$	As ϕ8	n_x	n_y	$A_{sw,x}$	$A_{sw,y}$	S_x	S_y
		kN	kN	mm	mm			mm	-	-	mm^2	mm^2	mm	mm
B-1	Combo 1	369,43	37,97	900	600	1,166	0,180	50	6	4	300	200	257,38	1112,94
	Combo 2	392,82	41,44	900	600	1,239	0,196	50	6	4	300	200	242,06	1019,71
B-2	Combo 1	357,43	38,19	900	600	1,128	0,181	50	6	4	300	200	266,02	1106,62
	Combo 2	382,00	39,71	900	600	1,205	0,188	50	6	4	300	200	248,92	1064,29
B-3	Combo 1	366,70	20,83	900	600	1,157	0,099	50	6	4	300	200	259,30	2028,81
	Combo 2	404,02	23,54	900	600	1,275	0,111	50	6	4	300	200	235,35	1795,07
B-4	Combo 1	351,31	53,27	900	600	1,108	0,252	50	6	4	300	200	270,66	793,34
	Combo 2	371,69	56,20	900	600	1,173	0,266	50	6	4	300	200	255,82	751,99
B-5	Combo 1	259,42	139,28	900	600	0,818	0,659	50	6	4	300	200	366,53	303,42
	Combo 2	271,25	147,11	900	600	0,856	0,696	50	6	4	300	200	350,55	287,26
B-6	Combo 1	373,64	109,14	900	600	1,179	0,517	50	6	4	300	200	254,48	387,21
	Combo 2	417,47	115,87	900	600	1,317	0,548	50	6	4	300	200	227,77	364,73
B-7	Combo 1	367,57	111,75	900	600	1,160	0,529	50	6	4	300	200	258,69	378,19
	Combo 2	413,13	121,51	900	600	1,303	0,575	50	6	4	300	200	230,16	347,80
B-8	Combo 1	404,67	78,98	900	600	1,277	0,374	50	6	4	300	200	234,97	535,07
	Combo 2	436,13	83,54	900	600	1,376	0,395	50	6	4	300	200	218,02	505,88

H= 13m		V_{edx}	V_{edx} (KN)	d_x	d_y	(A_{sw}/s),x	(A_{sw}/s),y	As ϕ8	n_x	n_y	$A_{sw,x}$	$A_{sw,y}$	S_x	S_y
		kN	kN	mm	mm			mm	-	-	mm^2	mm^2	mm	mm
B-1	Combo 1	369,43	37,97	900	600	1,166	0,180	50	6	4	300	200	257,38	1112,94
	Combo 2	392,82	41,44	900	600	1,239	0,196	50	6	4	300	200	242,06	1019,71
B-2	Combo 1	357,43	38,19	900	600	1,128	0,181	50	6	4	300	200	266,02	1106,62
	Combo 2	382,00	39,71	900	600	1,205	0,188	50	6	4	300	200	248,92	1064,29
B-3	Combo 1	366,70	20,83	900	600	1,157	0,099	50	6	4	300	200	259,30	2028,81
	Combo 2	404,02	23,54	900	600	1,275	0,111	50	6	4	300	200	235,35	1795,07
B-4	Combo 1	351,31	53,27	900	600	1,108	0,252	50	6	4	300	200	270,66	793,34
	Combo 2	371,69	56,20	900	600	1,173	0,266	50	6	4	300	200	255,82	751,99
B-5	Combo 1	259,42	139,28	900	600	0,818	0,659	50	6	4	300	200	366,53	303,42
	Combo 2	271,25	147,11	900	600	0,856	0,696	50	6	4	300	200	350,55	287,26
B-6	Combo 1	373,64	109,14	900	600	1,179	0,517	50	6	4	300	200	254,48	387,21
	Combo 2	417,47	115,87	900	600	1,317	0,548	50	6	4	300	200	227,77	364,73
B-7	Combo 1	367,57	111,75	900	600	1,160	0,529	50	6	4	300	200	258,69	378,19
	Combo 2	413,13	121,51	900	600	1,303	0,575	50	6	4	300	200	230,16	347,80
B-8	Combo 1	404,67	78,98	900	600	1,277	0,374	50	6	4	300	200	234,97	535,07
	Combo 2	436,13	83,54	900	600	1,376	0,395	50	6	4	300	200	218,02	505,88

H= 0m		V_{edx}	V_{edx} (KN)	d_x	d_y	$(A_{sw}/s),x$	$(A_{sw}/s),y$	As ϕ8	n_x	n_y	$A_{sw,x}$	$A_{sw,y}$	S_x	S_y
		kN	kN	mm	mm			mm	-	-	mm^2	mm^2	mm	mm
B-1	Combo 1	501,52	210,51	900	600	1,582	0,996	50	6	4	300	200	189,60	200,75
	Combo 2	535,33	219,36	900	600	1,689	1,038	50	6	4	300	200	177,62	192,65
B-2	Combo 1	529,58	168,07	900	600	1,671	0,795	50	6	4	300	200	179,55	251,44
	Combo 2	570,69	178,19	900	600	1,801	0,843	50	6	4	300	200	166,62	237,16
B-3	Combo 1	590,35	128,20	900	600	1,863	0,607	50	6	4	300	200	161,07	329,65
	Combo 2	642,91	138,52	900	600	2,028	0,656	50	6	4	300	200	147,90	305,09
B-4	Combo 1	439,96	242,51	900	600	1,388	1,148	50	6	4	300	200	216,12	174,27
	Combo 2	469,80	254,35	900	600	1,482	1,204	50	6	4	300	200	202,39	166,15
B-5	Combo 1	269,22	347,67	900	600	0,849	1,645	50	6	4	300	200	353,20	121,55
	Combo 2	286,72	375,59	900	600	0,905	1,778	50	6	4	300	200	331,63	112,52
B-6	Combo 1	351,99	296,13	900	600	1,111	1,401	50	6	4	300	200	270,14	142,71
	Combo 2	374,90	315,39	900	600	1,183	1,493	50	6	4	300	200	253,63	134,00
B-7	Combo 1	483,86	216,11	900	600	1,527	1,023	50	6	4	300	200	196,51	195,55
	Combo 2	532,16	237,39	900	600	1,679	1,123	50	6	4	300	200	178,68	178,02
B-8	Combo 1	143,89	391,32	900	600	0,454	1,852	50	6	4	300	200	660,81	108,00
	Combo 2	147,63	368,81	900	600	0,466	1,745	50	6	4	300	200	644,08	114,59

H= 4m		V_{edx}	V_{edx} (KN)	d_x	d_y	$(A_{sw}/s),x$	$(A_{sw}/s),y$	As ϕ8	n_x	n_y	$A_{sw,x}$	$A_{sw,y}$	S_x	S_y
		kN	kN	mm	mm			mm	-	-	mm^2	mm^2	mm	mm
B-1	Combo 1	501,52	210,51	900	600	1,582	0,996	50	6	4	300	200	189,60	200,75
	Combo 2	535,33	219,36	900	600	1,689	1,038	50	6	4	300	200	177,62	192,65
B-2	Combo 1	529,58	168,07	900	600	1,671	0,795	50	6	4	300	200	179,55	251,44
	Combo 2	570,69	178,19	900	600	1,801	0,843	50	6	4	300	200	166,62	237,16
B-3	Combo 1	590,35	128,20	900	600	1,863	0,607	50	6	4	300	200	161,07	329,65
	Combo 2	642,91	138,52	900	600	2,028	0,656	50	6	4	300	200	147,90	305,09
B-4	Combo 1	439,96	242,51	900	600	1,388	1,148	50	6	4	300	200	216,12	174,27
	Combo 2	469,80	254,35	900	600	1,482	1,204	50	6	4	300	200	202,39	166,15
B-5	Combo 1	269,22	347,67	900	600	0,849	1,645	50	6	4	300	200	353,20	121,55
	Combo 2	286,72	375,59	900	600	0,905	1,778	50	6	4	300	200	331,63	112,52
B-6	Combo 1	351,99	296,13	900	600	1,111	1,401	50	6	4	300	200	270,14	142,71
	Combo 2	374,90	315,39	900	600	1,183	1,493	50	6	4	300	200	253,63	134,00
B-7	Combo 1	483,86	216,11	900	600	1,527	1,023	50	6	4	300	200	196,51	195,55
	Combo 2	532,16	237,39	900	600	1,679	1,123	50	6	4	300	200	178,68	178,02
B-8	Combo 1	143,89	391,32	900	600	0,454	1,852	50	6	4	300	200	660,81	108,00
	Combo 2	147,63	368,81	900	600	0,466	1,745	50	6	4	300	200	644,08	114,59

H= 0m		V_{edx}	V_{edx} (KN)	d_x	d_y	$(A_{sw}/s),x$	$(A_{sw}/s),y$	As ϕ8	n_x	n_y	$A_{sw,x}$	$A_{sw,y}$	S_x	S_y
		kN	kN	mm	mm			mm	-	-	mm^2	mm^2	mm	mm
C-1	Combo 1	173,65	205,28	600	600	0,822	0,971	50	4	4	200	200	243,37	205,87
	Combo 2	192,91	211,89	600	600	0,913	1,003	50	4	4	200	200	219,07	199,45
C-2	Combo 1	236,04	250,99	600	600	1,117	1,188	50	4	4	200	200	179,04	168,38
	Combo 2	243,51	254,44	600	600	1,152	1,204	50	4	4	200	200	173,55	166,09
C-3	Combo 1	232,30	250,13	600	600	1,099	1,184	50	4	4	200	200	181,92	168,96
	Combo 2	239,49	254,44	600	600	1,133	1,204	50	4	4	200	200	176,46	166,09
C-4	Combo 1	173,36	205,56	600	600	0,820	0,973	50	4	4	200	200	243,77	205,58
	Combo 2	179,40	211,89	600	600	0,849	1,003	50	4	4	200	200	235,57	199,45
C-5	Combo 1	120,18	204,41	600	600	0,569	0,967	50	4	4	200	200	351,66	206,74
	Combo 2	127,08	210,45	600	600	0,601	0,996	50	4	4	200	200	332,56	200,81
C-6	Combo 1	59,51	179,69	600	600	0,282	0,850	50	4	4	200	200	710,11	235,19
	Combo 2	60,66	186,59	600	600	0,287	0,883	50	4	4	200	200	696,65	226,49
C-7	Combo 1	59,51	179,40	600	600	0,282	0,849	50	4	4	200	200	710,11	235,57
	Combo 2	60,66	186,30	600	600	0,287	0,882	50	4	4	200	200	696,65	226,84
C-8	Combo 1	121,33	203,55	600	600	0,574	0,963	50	4	4	200	200	348,32	207,62
	Combo 2	124,49	211,89	600	600	0,589	1,003	50	4	4	200	200	339,48	199,45

H= 4m		V_{edx}	V_{edx} (KN)	d_x	d_y	$(A_{sw}/s),x$	$(A_{sw}/s),y$	As ϕ8	n_x	n_y	$A_{sw,x}$	$A_{sw,y}$	S_x	S_y
		kN	kN	mm	mm			mm	-	-	mm^2	mm^2	mm	mm
C-1	Combo 1	173,65	205,28	600	600	0,822	0,971	50	4	4	200	200	243,37	205,87
	Combo 2	192,91	211,89	600	600	0,913	1,003	50	4	4	200	200	219,07	199,45
C-2	Combo 1	236,04	250,99	600	600	1,117	1,188	50	4	4	200	200	179,04	168,38
	Combo 2	243,51	254,44	600	600	1,152	1,204	50	4	4	200	200	173,55	166,09
C-3	Combo 1	232,30	250,13	600	600	1,099	1,184	50	4	4	200	200	181,92	168,96
	Combo 2	239,49	254,44	600	600	1,133	1,204	50	4	4	200	200	176,46	166,09
C-4	Combo 1	173,36	205,56	600	600	0,820	0,973	50	4	4	200	200	243,77	205,58
	Combo 2	179,40	211,89	600	600	0,849	1,003	50	4	4	200	200	235,57	199,45
C-5	Combo 1	120,18	204,41	600	600	0,569	0,967	50	4	4	200	200	351,66	206,74
	Combo 2	127,08	210,45	600	600	0,601	0,996	50	4	4	200	200	332,56	200,81
C-6	Combo 1	59,51	179,69	600	600	0,282	0,850	50	4	4	200	200	710,11	235,19
	Combo 2	60,66	186,59	600	600	0,287	0,883	50	4	4	200	200	696,65	226,49
C-7	Combo 1	59,51	179,40	600	600	0,282	0,849	50	4	4	200	200	710,11	235,57
	Combo 2	60,66	186,30	600	600	0,287	0,882	50	4	4	200	200	696,65	226,84
C-8	Combo 1	121,33	203,55	600	600	0,574	0,963	50	4	4	200	200	348,32	207,62
	Combo 2	124,49	211,89	600	600	0,589	1,003	50	4	4	200	200	339,48	199,45

H= 0m		V_{edx}	V_{edx} (KN)	d_x	d_y	$(A_{sw}/s),x$	$(A_{sw}/s),y$	As ϕ8	n_x	n_y	$A_{sw,x}$	$A_{sw,y}$	S_x	S_y
		kN	kN	mm	mm			mm	-	-	mm^2	mm^2	mm	mm
K-1	Combo 1	501,72	84,51	900	600	1,583	0,400	50	6	4	300	200	189,52	500,05
	Combo 2	518,84	83,98	900	600	1,637	0,397	50	6	4	300	200	183,27	503,24
K-2	Combo 1	515,63	79,16	900	600	1,627	0,375	50	6	4	300	200	184,41	533,84
	Combo 2	537,56	83,98	900	600	1,696	0,397	50	6	4	300	200	176,88	503,24
K-3	Combo 1	522,05	73,81	900	600	1,647	0,349	50	6	4	300	200	182,14	572,53
	Combo 2	553,07	78,63	900	600	1,745	0,372	50	6	4	300	200	171,92	537,47
K-4	Combo 1	522,05	63,12	900	600	1,647	0,299	50	6	4	300	200	182,14	669,56
	Combo 2	545,05	68,47	900	600	1,720	0,324	50	6	4	300	200	174,45	617,25
K-5	Combo 1	520,71	17,92	900	600	1,643	0,085	50	6	4	300	200	182,61	2358,46
	Combo 2	543,71	18,99	900	600	1,715	0,090	50	6	4	300	200	174,88	2225,59
K-6	Combo 1	524,72	20,59	900	600	1,656	0,097	50	6	4	300	200	181,21	2052,17
	Combo 2	551,20	21,66	900	600	1,739	0,103	50	6	4	300	200	172,51	1950,83
K-7	Combo 1	525,26	17,92	900	600	1,657	0,085	50	6	4	300	200	181,03	2358,46
	Combo 2	561,90	19,52	900	600	1,773	0,092	50	6	4	300	200	169,22	2164,62
K-8	Combo 1	519,37	23,00	900	600	1,639	0,109	50	6	4	300	200	183,08	1837,41
	Combo 2	544,51	21,85	900	600	1,718	0,103	50	6	4	300	200	174,63	1934,11

H= 4,3m		V_{edx}	V_{edx} (KN)	d_x	d_y	$(A_{sw}/s),x$	$(A_{sw}/s),y$	As ϕ8	n_x	n_y	$A_{sw,x}$	$A_{sw,y}$	S_x	S_y
		kN	kN	mm	mm			mm	-	-	mm^2	mm^2	mm	mm
K-1	Combo 1	501,72	84,51	900	600	1,583	0,400	50	6	4	300	200	189,52	500,05
	Combo 2	518,84	83,98	900	600	1,637	0,397	50	6	4	300	200	183,27	503,24
K-2	Combo 1	515,63	79,16	900	600	1,627	0,375	50	6	4	300	200	184,41	533,84
	Combo 2	537,56	83,98	900	600	1,696	0,397	50	6	4	300	200	176,88	503,24
K-3	Combo 1	522,05	73,81	900	600	1,647	0,349	50	6	4	300	200	182,14	572,53
	Combo 2	553,07	78,63	900	600	1,745	0,372	50	6	4	300	200	171,92	537,47
K-4	Combo 1	522,05	63,12	900	600	1,647	0,299	50	6	4	300	200	182,14	669,56
	Combo 2	545,05	68,47	900	600	1,720	0,324	50	6	4	300	200	174,45	617,25
K-5	Combo 1	520,71	17,92	900	600	1,643	0,085	50	6	4	300	200	182,61	2358,46
	Combo 2	543,71	18,99	900	600	1,715	0,090	50	6	4	300	200	174,88	2225,59
K-6	Combo 1	524,72	20,59	900	600	1,656	0,097	50	6	4	300	200	181,21	2052,17
	Combo 2	551,20	21,66	900	600	1,739	0,103	50	6	4	300	200	172,51	1950,83
K-7	Combo 1	525,26	17,92	900	600	1,657	0,085	50	6	4	300	200	181,03	2358,46
	Combo 2	561,90	19,52	900	600	1,773	0,092	50	6	4	300	200	169,22	2164,62
K-8	Combo 1	519,37	23,00	900	600	1,639	0,109	50	6	4	300	200	183,08	1837,41
	Combo 2	544,51	21,85	900	600	1,718	0,103	50	6	4	300	200	174,63	1934,11

2.10.3.6 *Minimum prescriptive shear reinforcement requested*

The width of the critics zone has to be the mayor of the following quantities:

- *Height of the section;*
- *1/6 free height of the column;*
- *45 cm;*
- *free height of the column if minor than 3 times the height of the column section;*

Column	*PROT1*	*PROT2*	*PROT3*	*PROT4*	*PROT5*	*PROT6*	*Misure Units*
	B 1/2/3/4/5/6/7/8	*C6-C7*	*C1-C4*	*C2-C3*	*C5-C8*	*A1-A2*	-
	K 1/2/3/4/5/6/7/8						
b	*900*	*600*	*600*	*600*	*600*	*600*	*mm*
h	*600*	*600*	*600*	*600*	*600*	*300*	*mm*
H_{beam}	*550*	*500*	*500*	*500*	*500*	*400*	mm^2
$H_{interfloor}$	*3450*	*3500*	*3500*	*3500*	*3500*	*3600*	*mm*
$1/6\ H_{interfloor}$	*575,0*	*583,3*	*583,3*	*583,3*	*583,3*	*600,0*	*mm*
$H_{max\ section}$	*900*	*600*	*600*	*600*	*600*	*600*	*mm*
Critic zone	*900*	*600*	*600*	*600*	*600*	*600*	*mm*

Besides the maximum footstep of the stirrups in the critics zones has to be the minimum between the following values:

- $b_0/3$
- *15 cm*
- $8\ \phi_{long}$

Oustide the critics zones the mimimum footstep of the stirrups has to be minimum between the following values:

- *20 cm*
- $15\ \phi_{long}$

X direction	PROT1	PROT2	PROT3	PROT4	PROT5	PROT6	Misure Units	
	B 1/2/3/4/5/6/7/8 K 1/2/3/4/5/6/7/8	C6-C7	C1-C4	C2-C3	C5-C8	A1-A2	-	
b	900	600	600	600	600	600	mm	Column characteristics
h	600	600	600	600	600	300	mm	
ϕ_{lon}	20	20	24	24	24	16	mm	
Ast	300	200	200	200	200	200	mm^2	
fcd	14,1	14,1	14,1	14,1	14,1	14,1	N mm^2	
fyd	391,3	391,3	391,3	391,3	391,3	391,3	N mm^2	
bst	850	550	550	550	550	550	mm	critic zones
$b_0/3$	200	200	200	200	200	100	mm	
150 mm	150	150	150	150	150	150	mm	
$8\phi_{lon}$	160	160	192	192	192	128	mm	
limit 7.4.8	122,4	126,1	126,1	126,1	126,1	126,1	mm	
200 mm	200	200	200	200	200	200	mm	All the column
$15\phi_{lon}$	300	300	360	360	360	240	mm	
Critic Zones	122,4	126,1	126,1	126,1	126,1	126,1	mm	Value choosen
All the column	200	200	200	200	200	200	mm	

Y direction	PROT1	PROT2	PROT3	PROT4	PROT5	PROT6	Misure Units	
	B 1/2/3/4/5/6/7/8 K 1/2/3/4/5/6/7/8	C6-C7	C1-C4	C2-C3	C5-C8	A1-A2	-	
b	900	600	600	600	600	600	mm	Column characteristics
h	600	600	600	600	600	300	mm	
ϕ_{lon}	20	20	24	24	24	16	mm	
Ast	200	200	200	200	200	100	mm^2	
fcd	14,1	14,1	14,1	14,1	14,1	14,1	N mm^2	
fyd	391,3	391,3	391,3	391,3	391,3	391,3	N mm^2	
bst	550	550	550	550	550	250	mm	critic zones
$b_0/3$	200	200	200	200	200	100	mm	
150 mm	150	150	150	150	150	150	mm	
$8\phi_{lon}$	160	160	192	192	192	128	mm	
limit 7.4.8	126,1	126,1	126,1	126,1	126,1	138,8	mm	
200 mm	200	200	200	200	200	200	mm	All the column
$15\phi_{lon}$	300	300	360	360	360	240	mm	
Critic Zones	126,1	126,1	126,1	126,1	126,1	128	mm	Value choosen
All the column	200	200	200	200	200	200	mm	

2.10.4 COLUMNS DESIGN OUTPUT

The graphic works inherents to the beams design are contained in the following attachements:

Graphic work T6 : Reinforcement columns “B”, Building 2;

3 ATTACHEMENTS

3.1 ATTACHEMENT A

Joint	**LoadPat**	**F1**	**F2**	**F3**	**Joint**	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN	Text	Text	KN	KN	KN
81	G1	0	0	-2,02	89	WIND CASE 1	0	0	2,81
81	G2	0	0	-4,07	89	G1	0	0	-2,02
81	ACC USO	0	0	-9,62	89	G2	0	0	-4,07
81	SNOW	0	0	-1,92	89	ACC USO	0	0	-9,62
81	WIND CASE 2	0	0	2,11	89	SNOW	0	0	-1,92
81	WIND CASE 2	4,55	0	0	89	WIND CASE 2	0	0	2,11
81	WIND CASE 3	0	6,35	0	89	WIND CASE 3	0	7,315	0
81	WIND CASE 1	0	0	8,43	91	WIND CASE 1	0	0	2,81
81	WIND CASE 1	-11,09	0	0	91	G1	0	0	-2,02
82	WIND CASE 1	0	0	2,81	91	G2	0	0	-4,07
82	G1	0	0	-2,02	91	ACC USO	0	0	-9,62
82	G2	0	0	-4,07	91	SNOW	0	0	-1,92
82	ACC USO	0	0	-9,62	91	WIND CASE 2	0	0	2,11
82	SNOW	0	0	-1,92	91	WIND CASE 3	0	7,315	0
82	WIND CASE 2	0	0	2,11	93	WIND CASE 1	0	0	2,81
82	WIND CASE 3	0	7,315	0	93	G1	0	0	-2,02
83	WIND CASE 1	0	0	2,81	93	G2	0	0	-4,07
83	G1	0	0	-2,02	93	ACC USO	0	0	-9,62
83	G2	0	0	-4,07	93	SNOW	0	0	-1,92
83	ACC USO	0	0	-9,62	93	WIND CASE 2	0	0	2,11
83	SNOW	0	0	-1,92	93	WIND CASE 3	0	7,315	0
83	WIND CASE 2	0	0	2,11	95	WIND CASE 1	0	0	2,81
83	WIND CASE 3	0	7,315	0	95	G1	0	0	-2,02
85	WIND CASE 1	0	0	2,81	95	G2	0	0	-4,07
85	G1	0	0	-2,02	95	ACC USO	0	0	-9,62
85	G2	0	0	-4,07	95	SNOW	0	0	-1,92
85	ACC USO	0	0	-9,62	95	WIND CASE 2	0	0	2,11
85	SNOW	0	0	-1,92	95	WIND CASE 3	0	7,315	0
85	WIND CASE 2	0	0	2,11	97	G1	0	0	-2,02
85	WIND CASE 3	0	7,315	0	97	G2	0	0	-4,07
87	WIND CASE 1	0	0	2,81	97	ACC USO	0	0	-9,62
87	G1	0	0	-2,02	97	SNOW	0	0	-1,92
87	G2	0	0	-4,07	97	WIND CASE 2	0	0	2,11
87	ACC USO	0	0	-9,62	97	WIND CASE 3	0	6,35	0
87	SNOW	0	0	-1,92	97	WIND CASE 1	0	0	8,43
87	WIND CASE 2	0	0	2,11	100	WIND CASE 1	0	0	2,81
87	WIND CASE 3	0	7,315	0	100	G1	0	0	-2,02

Joint	**LoadPat**	**F1**	**F2**	**F3**	**Joint**	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN	Text	Text	KN	KN	KN
100	ACC USO	0	0	-9,62	109	WIND CASE 2	0	0	2,11
100	SNOW	0	0	-1,92	109	WIND CASE 3	0	7,315	0
100	WIND CASE 3	0	6,35	0	111	WIND CASE 1	0	0	2,81
100	WIND CASE 2	0	0	6,006	111	G1	0	0	-2,02
101	WIND CASE 1	0	0	2,81	111	G2	0	0	-4,07
101	G1	0	0	-2,02	111	ACC USO	0	0	-9,62
101	G2	0	0	-4,07	111	SNOW	0	0	-1,92
101	ACC USO	0	0	-9,62	111	WIND CASE 2	0	0	2,11
101	SNOW	0	0	-1,92	111	WIND CASE 3	0	7,315	0
101	WIND CASE 2	0	0	2,11	113	WIND CASE 1	0	0	2,81
101	WIND CASE 3	0	7,315	0	113	G1	0	0	-2,02
103	WIND CASE 1	0	0	2,81	113	G2	0	0	-4,07
103	G1	0	0	-2,02	113	ACC USO	0	0	-9,62
103	G2	0	0	-4,07	113	SNOW	0	0	-1,92
103	ACC USO	0	0	-9,62	113	WIND CASE 2	0	0	2,11
103	SNOW	0	0	-1,92	113	WIND CASE 3	0	7,315	0
103	WIND CASE 2	0	0	2,11	115	WIND CASE 1	0	0	2,81
103	WIND CASE 3	0	7,315	0	115	G1	0	0	-2,02
105	WIND CASE 1	0	0	2,81	115	G2	0	0	-4,07
105	G1	0	0	-2,02	115	ACC USO	0	0	-9,62
105	G2	0	0	-4,07	115	SNOW	0	0	-1,92
105	ACC USO	0	0	-9,62	115	WIND CASE 2	0	0	2,11
105	SNOW	0	0	-1,92	115	WIND CASE 3	0	7,315	0
105	WIND CASE 2	0	0	2,11	117	WIND CASE 1	0	0	2,81
105	WIND CASE 3	0	7,315	0	117	G1	0	0	-2,02
107	WIND CASE 1	0	0	2,81	117	G2	0	0	-4,07
107	G1	0	0	-2,02	117	ACC USO	0	0	-9,62
107	G2	0	0	-4,07	117	SNOW	0	0	-1,92
107	ACC USO	0	0	-9,62	117	WIND CASE 3	0	6,35	0
107	SNOW	0	0	-1,92	117	WIND CASE 2	0	0	6,006
107	WIND CASE 2	0	0	2,11	118	WIND CASE 1	-0,513	0	0
107	WIND CASE 3	0	7,315	0	118	WIND CASE 2	1,2	0	0
109	WIND CASE 1	0	0	2,81	119	G1	0	0	-2,02
109	G1	0	0	-2,02	119	G2	0	0	-4,07
109	G2	0	0	-4,07	119	ACC USO	0	0	-9,62
109	ACC USO	0	0	-9,62	119	SNOW	0	0	-1,92

Joint	**LoadPat**	**F1**	**F2**	**F3**	**Joint**	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN	Text	Text	KN	KN	KN
119	WIND CASE 2	0	0	2,11	134	G1	0	0	-4,04
119	WIND CASE 3	0	6,35	0	134	G2	0	0	-8,14
119	WIND CASE 1	0	0	8,43	134	SNOW	0	0	-3,85
126	WIND CASE 1	-11,088	0	0	134	ACC USO	0	0	-19,25
126	WIND CASE 2	4,55	0	0	134	WIND CASE 1	0	0	5,66
126	WIND CASE 1	-2,43	0	0	134	WIND CASE 2	0	0	4,23
127	WIND CASE 1	-2,43	0	0	134	WIND CASE 3	0	4,23	0
128	G1	0	0	-4,04	136	G1	0	0	-4,04
128	SNOW	0	0	-1,92	136	G2	0	0	-8,14
128	G2	0	0	-4,071	136	SNOW	0	0	-3,85
128	ACC USO	0	0	-9,625	136	ACC USO	0	0	-19,25
128	WIND CASE 2	0	0	4,23	136	WIND CASE 1	0	0	5,66
128	WIND CASE 2	9,35	0	0	136	WIND CASE 2	0	0	4,23
128	WIND CASE 3	0	4,23	0	136	WIND CASE 3	0	4,23	0
128	WIND CASE 1	0	0	16,86	138	G1	0	0	-4,04
128	WIND CASE 1	-22,18	0	0	138	G2	0	0	-8,14
129	G1	0	0	-4,04	138	SNOW	0	0	-3,85
129	G2	0	0	-8,14	138	ACC USO	0	0	-19,25
129	SNOW	0	0	-3,85	138	WIND CASE 1	0	0	5,66
129	ACC USO	0	0	-19,25	138	WIND CASE 2	0	0	4,23
129	WIND CASE 1	0	0	5,66	138	WIND CASE 3	0	4,23	0
129	WIND CASE 2	0	0	4,23	140	G1	0	0	-4,04
129	WIND CASE 3	0	4,23	0	140	G2	0	0	-8,14
130	G1	0	0	-4,04	140	SNOW	0	0	-3,85
130	G2	0	0	-8,14	140	ACC USO	0	0	-19,25
130	SNOW	0	0	-3,85	140	WIND CASE 1	0	0	5,66
130	ACC USO	0	0	-19,25	140	WIND CASE 2	0	0	4,23
130	WIND CASE 1	0	0	5,66	140	WIND CASE 3	0	4,23	0
130	WIND CASE 2	0	0	4,23	142	G1	0	0	-4,04
130	WIND CASE 3	0	4,23	0	142	G2	0	0	-8,14
132	G1	0	0	-4,04	142	SNOW	0	0	-3,85
132	G2	0	0	-8,14	142	ACC USO	0	0	-19,25
132	SNOW	0	0	-3,85	142	WIND CASE 1	0	0	5,66
132	ACC USO	0	0	-19,25	142	WIND CASE 2	0	0	4,23
132	WIND CASE 1	0	0	5,66	142	WIND CASE 3	0	4,23	0
132	WIND CASE 2	0	0	4,23	144	G1	0	0	-4,04
132	WIND CASE 3	0	4,23	0	144	G2	0	0	-8,14

Joint	**LoadPat**	**F1**	**F2**	**F3**	**Joint**	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN	Text	Text	KN	KN	KN
144	SNOW	0	0	-3,85	154	WIND CASE 1	0	0	5,66
144	ACC USO	0	0	-19,25	154	WIND CASE 2	0	0	4,23
144	WIND CASE 2	0	0	4,23	154	WIND CASE 3	0	4,23	0
144	WIND CASE 3	0	4,23	0	156	G1	0	0	-4,04
144	WIND CASE 1	0	0	16,86	156	G2	0	0	-8,14
147	G1	0	0	-4,04	156	SNOW	0	0	-3,85
147	SNOW	0	0	-1,92	156	ACC USO	0	0	-19,25
147	G2	0	0	-4,071	156	WIND CASE 1	0	0	5,66
147	ACC USO	0	0	-9,625	156	WIND CASE 2	0	0	4,23
147	WIND CASE 1	0	0	5,66	156	WIND CASE 3	0	4,23	0
147	WIND CASE 3	0	4,23	0	158	G1	0	0	-4,04
147	WIND CASE 2	0	0	12,01	158	G2	0	0	-8,14
148	G1	0	0	-4,04	158	SNOW	0	0	-3,85
148	G2	0	0	-8,14	158	ACC USO	0	0	-19,25
148	SNOW	0	0	-3,85	158	WIND CASE 1	0	0	5,66
148	ACC USO	0	0	-19,25	158	WIND CASE 2	0	0	4,23
148	WIND CASE 1	0	0	5,66	158	WIND CASE 3	0	4,23	0
148	WIND CASE 2	0	0	4,23	160	G1	0	0	-4,04
148	WIND CASE 3	0	4,23	0	160	G2	0	0	-8,14
150	G1	0	0	-4,04	160	SNOW	0	0	-3,85
150	G2	0	0	-8,14	160	ACC USO	0	0	-19,25
150	SNOW	0	0	-3,85	160	WIND CASE 1	0	0	5,66
150	ACC USO	0	0	-19,25	160	WIND CASE 2	0	0	4,23
150	WIND CASE 1	0	0	5,66	160	WIND CASE 3	0	4,23	0
150	WIND CASE 2	0	0	4,23	162	G1	0	0	-4,04
150	WIND CASE 3	0	4,23	0	162	G2	0	0	-8,14
152	G1	0	0	-4,04	162	SNOW	0	0	-3,85
152	G2	0	0	-8,14	162	ACC USO	0	0	-19,25
152	SNOW	0	0	-3,85	162	WIND CASE 1	0	0	5,66
152	ACC USO	0	0	-19,25	162	WIND CASE 2	0	0	4,23
152	WIND CASE 1	0	0	5,66	162	WIND CASE 3	0	4,23	0
152	WIND CASE 2	0	0	4,23	164	G1	0	0	-4,04
152	WIND CASE 3	0	4,23	0	164	G2	0	0	-8,14
154	G1	0	0	-4,04	164	SNOW	0	0	-3,85
154	G2	0	0	-8,14	164	ACC USO	0	0	-19,25
154	SNOW	0	0	-3,85	164	WIND CASE 1	0	0	5,66
154	ACC USO	0	0	-19,25	164	WIND CASE 2	0	0	10,24

Joint	**LoadPat**	**F1**	**F2**	**F3**	**Joint**	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN	Text	Text	KN	KN	KN
164	WIND CASE 3	0	4,23	0	177	WIND CASE 2	0	0	4,23
165	WIND CASE 1	-1,026	0	0	177	WIND CASE 3	0	4,23	0
165	WIND CASE 2	2,4	0	0	179	G1	0	0	-4,04
166	G1	0	0	-4,04	179	G2	0	0	-8,14
166	G2	0	0	-4,71	179	SNOW	0	0	-3,85
166	ACC USO	0	0	-19,24	179	ACC USO	0	0	-19,25
166	SNOW	0	0	-3,84	179	WIND CASE 1	0	0	5,66
166	WIND CASE 2	0	0	4,23	179	WIND CASE 2	0	0	4,23
166	WIND CASE 3	0	4,23	0	179	WIND CASE 3	0	4,23	0
166	WIND CASE 1	0	0	16,86	181	G1	0	0	-4,04
168	WIND CASE 1	-1,026	0	0	181	G2	0	0	-8,14
168	WIND CASE 2	2,4	0	0	181	SNOW	0	0	-3,85
173	WIND CASE 1	-22,176	0	0	181	ACC USO	0	0	-19,25
173	WIND CASE 2	9,35	0	0	181	WIND CASE 1	0	0	5,66
173	WIND CASE 1	-4,86	0	0	181	WIND CASE 2	0	0	4,23
174	WIND CASE 1	-4,86	0	0	181	WIND CASE 3	0	4,23	0
175	G1	0	0	-4,04	183	G1	0	0	-4,04
175	SNOW	0	0	-1,92	183	G2	0	0	-8,14
175	G2	0	0	-4,071	183	SNOW	0	0	-3,85
175	ACC USO	0	0	-9,625	183	ACC USO	0	0	-19,25
175	WIND CASE 1	0	0	16,86	183	WIND CASE 1	0	0	5,66
175	WIND CASE 1	-22,176	0	0	183	WIND CASE 2	0	0	4,23
175	WIND CASE 2	0	0	4,23	183	WIND CASE 3	0	4,23	0
175	WIND CASE 2	9,35	0	0	185	G1	0	0	-4,04
175	WIND CASE 3	0	4,23	0	185	G2	0	0	-8,14
176	G1	0	0	-4,04	185	SNOW	0	0	-3,85
176	G2	0	0	-8,14	185	ACC USO	0	0	-19,25
176	SNOW	0	0	-3,85	185	WIND CASE 1	0	0	5,66
176	ACC USO	0	0	-19,25	185	WIND CASE 2	0	0	4,23
176	WIND CASE 1	0	0	5,66	185	WIND CASE 3	0	4,23	0
176	WIND CASE 2	0	0	4,23	187	G1	0	0	-4,04
176	WIND CASE 3	0	4,23	0	187	G2	0	0	-8,14
177	G1	0	0	-4,04	187	SNOW	0	0	-3,85
177	G2	0	0	-8,14	187	ACC USO	0	0	-19,25
177	SNOW	0	0	-3,85	187	WIND CASE 1	0	0	5,66
177	ACC USO	0	0	-19,25	187	WIND CASE 2	0	0	4,23
177	WIND CASE 1	0	0	5,66	187	WIND CASE 3	0	4,23	0

Joint	**LoadPat**	**F1**	**F2**	**F3**	**Joint**	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN	Text	Text	KN	KN	KN
189	G1	0	0	-4,04	199	SNOW	0	0	-3,85
189	G2	0	0	-8,14	199	ACC USO	0	0	-19,25
189	SNOW	0	0	-3,85	199	WIND CASE 1	0	0	5,66
189	ACC USO	0	0	-19,25	199	WIND CASE 2	0	0	4,23
189	WIND CASE 1	0	0	5,66	199	WIND CASE 3	0	4,23	0
189	WIND CASE 2	0	0	4,23	201	G1	0	0	-4,04
189	WIND CASE 3	0	4,23	0	201	G2	0	0	-8,14
191	G1	0	0	-4,04	201	SNOW	0	0	-3,85
191	G2	0	0	-8,14	201	ACC USO	0	0	-19,25
191	SNOW	0	0	-3,85	201	WIND CASE 1	0	0	5,66
191	ACC USO	0	0	-19,25	201	WIND CASE 2	0	0	4,23
191	WIND CASE 1	0	0	16,86	201	WIND CASE 3	0	4,23	0
191	WIND CASE 2	0	0	4,23	203	G1	0	0	-4,04
191	WIND CASE 3	0	4,23	0	203	G2	0	0	-8,14
194	G1	0	0	-4,04	203	SNOW	0	0	-3,85
194	SNOW	0	0	-1,92	203	ACC USO	0	0	-19,25
194	G2	0	0	-4,071	203	WIND CASE 1	0	0	5,66
194	ACC USO	0	0	-9,625	203	WIND CASE 2	0	0	4,23
194	WIND CASE 1	0	0	5,66	203	WIND CASE 3	0	4,23	0
194	WIND CASE 3	0	4,23	0	205	G1	0	0	-4,04
194	WIND CASE 2	0	0	12,01	205	G2	0	0	-8,14
195	G1	0	0	-4,04	205	SNOW	0	0	-3,85
195	G2	0	0	-8,14	205	ACC USO	0	0	-19,25
195	SNOW	0	0	-3,85	205	WIND CASE 1	0	0	5,66
195	ACC USO	0	0	-19,25	205	WIND CASE 2	0	0	4,23
195	WIND CASE 1	0	0	5,66	205	WIND CASE 3	0	4,23	0
195	WIND CASE 2	0	0	4,23	207	G1	0	0	-4,04
195	WIND CASE 3	0	4,23	0	207	G2	0	0	-8,14
197	G1	0	0	-4,04	207	SNOW	0	0	-3,85
197	G2	0	0	-8,14	207	ACC USO	0	0	-19,25
197	SNOW	0	0	-3,85	207	WIND CASE 1	0	0	5,66
197	ACC USO	0	0	-19,25	207	WIND CASE 2	0	0	4,23
197	WIND CASE 1	0	0	5,66	207	WIND CASE 3	0	4,23	0
197	WIND CASE 2	0	0	4,23	209	G1	0	0	-4,04
197	WIND CASE 3	0	4,23	0	209	G2	0	0	-8,14
199	G1	0	0	-4,04	209	SNOW	0	0	-3,85
199	G2	0	0	-8,14	209	ACC USO	0	0	-19,25

Joint	**LoadPat**	**F1**	**F2**	**F3**	**Joint**	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN	Text	Text	KN	KN	KN
209	WIND CASE 1	0	0	5,66	241	WIND CASE 3	0	2,11	0
209	WIND CASE 2	0	0	4,23	242	WIND CASE 1	0	0	2,81
209	WIND CASE 3	0	4,23	0	242	G1	0	0	-2,02
211	G1	0	0	-4,04	242	G2	0	0	-4,07
211	G2	0	0	-8,14	242	ACC USO	0	0	-9,62
211	SNOW	0	0	-3,85	242	SNOW	0	0	-1,92
211	ACC USO	0	0	-19,25	242	WIND CASE 2	0	0	2,11
211	WIND CASE 1	0	0	5,66	242	WIND CASE 3	0	2,11	0
211	WIND CASE 3	0	4,23	0	244	WIND CASE 1	0	0	2,81
211	WIND CASE 2	0	0	12,01	244	G1	0	0	-2,02
212	WIND CASE 1	-1,026	0	0	244	G2	0	0	-4,07
212	WIND CASE 2	2,4	0	0	244	ACC USO	0	0	-9,62
213	ACC USO	0	0	-19,25	244	SNOW	0	0	-1,92
213	WIND CASE 1	0	0	16,86	244	WIND CASE 2	0	0	2,11
213	WIND CASE 2	0	0	4,23	244	WIND CASE 3	0	2,11	0
213	WIND CASE 3	0	4,23	0	246	WIND CASE 1	0	0	2,81
215	WIND CASE 1	-1,026	0	0	246	G1	0	0	-2,02
215	WIND CASE 2	2,4	0	0	246	G2	0	0	-4,07
220	WIND CASE 1	-22,176	0	0	246	ACC USO	0	0	-9,62
220	WIND CASE 2	9,35	0	0	246	SNOW	0	0	-1,92
220	WIND CASE 1	-4,86	0	0	246	WIND CASE 2	0	0	2,11
221	WIND CASE 1	-4,86	0	0	246	WIND CASE 3	0	2,11	0
240	G1	0	0	-2,02	248	WIND CASE 1	0	0	2,81
240	G2	0	0	-4,07	248	G1	0	0	-2,02
240	ACC USO	0	0	-9,62	248	G2	0	0	-4,07
240	SNOW	0	0	-1,92	248	ACC USO	0	0	-9,62
240	WIND CASE 2	0	0	2,11	248	SNOW	0	0	-1,92
240	WIND CASE 2	4,55	0	0	248	WIND CASE 2	0	0	2,11
240	WIND CASE 3	0	2,11	0	248	WIND CASE 3	0	2,11	0
240	WIND CASE 1	0	0	8,43	250	WIND CASE 1	0	0	2,81
240	WIND CASE 1	-11,09	0	0	250	G1	0	0	-2,02
241	WIND CASE 1	0	0	2,81	250	G2	0	0	-4,07
241	G1	0	0	-2,02	250	ACC USO	0	0	-9,62
241	G2	0	0	-4,07	250	SNOW	0	0	-1,92
241	ACC USO	0	0	-9,62	250	WIND CASE 2	0	0	2,11
241	SNOW	0	0	-1,92	250	WIND CASE 3	0	2,11	0
241	WIND CASE 2	0	0	2,11	252	WIND CASE 1	0	0	2,81

Joint	**LoadPat**	**F1**	**F2**	**F3**	**Joint**	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN	Text	Text	KN	KN	KN
252	WIND CASE 1	0	0	2,81	263	WIND CASE 1	0	0	2,81
252	G1	0	0	-2,02	263	G1	0	0	-2,02
252	G2	0	0	-4,07	263	G2	0	0	-4,07
252	ACC USO	0	0	-9,62	263	ACC USO	0	0	-9,62
252	SNOW	0	0	-1,92	263	SNOW	0	0	-1,92
252	WIND CASE 2	0	0	2,11	263	WIND CASE 2	0	0	2,11
252	WIND CASE 3	0	2,11	0	263	WIND CASE 3	0	2,11	0
253	WIND CASE 1	0	0	2,81	267	WIND CASE 2	4,55	0	0
253	G1	0	0	-2,02	267	WIND CASE 1	-11,09	0	0
253	G2	0	0	-4,07	267	WIND CASE 1	-2,43	0	0
253	ACC USO	0	0	-9,62	268	WIND CASE 1	-2,43	0	0
253	SNOW	0	0	-1,92	269	WIND CASE 1	0	0	2,81
253	WIND CASE 2	0	0	2,11	269	G1	0	0	-2,02
253	WIND CASE 3	0	2,11	0	269	G2	0	0	-4,07
255	G1	0	0	-2,02	269	ACC USO	0	0	-9,62
255	G2	0	0	-4,07	269	SNOW	0	0	-1,92
255	ACC USO	0	0	-9,62	269	WIND CASE 2	0	0	2,11
255	SNOW	0	0	-1,92	269	WIND CASE 3	0	2,11	0
255	WIND CASE 2	0	0	2,11	271	WIND CASE 1	0	0	2,81
255	WIND CASE 3	0	2,11	0	271	G1	0	0	-2,02
255	WIND CASE 1	0	0	8,43	271	G2	0	0	-4,07
258	WIND CASE 1	0	0	2,81	271	ACC USO	0	0	-9,62
258	G1	0	0	-2,02	271	SNOW	0	0	-1,92
258	G2	0	0	-4,07	271	WIND CASE 2	0	0	2,11
258	ACC USO	0	0	-9,62	271	WIND CASE 3	0	2,11	0
258	SNOW	0	0	-1,92	273	WIND CASE 1	0	0	2,81
258	WIND CASE 3	0	2,11	0	273	G1	0	0	-2,02
258	WIND CASE 2	0	0	6,006	273	G2	0	0	-4,07
259	WIND CASE 1	-0,513	0	0	273	ACC USO	0	0	-9,62
259	WIND CASE 2	1,2	0	0	273	SNOW	0	0	-1,92
260	WIND CASE 1	0	0	2,81	273	WIND CASE 2	0	0	2,11
260	G1	0	0	-2,02	273	WIND CASE 3	0	2,11	0
260	G2	0	0	-4,07	275	WIND CASE 1	0	0	2,81
260	ACC USO	0	0	-9,62	275	G1	0	0	-2,02
260	SNOW	0	0	-1,92	275	G2	0	0	-4,07
260	WIND CASE 2	0	0	2,11	275	ACC USO	0	0	-9,62
260	WIND CASE 3	0	2,11	0	275	SNOW	0	0	-1,92

Joint	**LoadPat**	**F1**	**F2**	**F3**
Text	Text	KN	KN	KN
275	WIND CASE 2	0	0	2,11
275	WIND CASE 3	0	2,11	0
277	WIND CASE 1	0	0	2,81
277	G1	0	0	-2,02
277	G2	0	0	-4,07
277	ACC USO	0	0	-9,62
277	SNOW	0	0	-1,92
277	WIND CASE 2	0	0	2,11
277	WIND CASE 3	0	2,11	0
279	WIND CASE 1	0	0	2,81
279	G1	0	0	-2,02
279	G2	0	0	-4,07
279	ACC USO	0	0	-9,62
279	SNOW	0	0	-1,92
279	WIND CASE 2	0	0	2,11
279	WIND CASE 3	0	2,11	0
281	WIND CASE 1	0	0	2,81
281	G1	0	0	-2,02
281	G2	0	0	-4,07
281	ACC USO	0	0	-9,62
281	SNOW	0	0	-1,92
281	WIND CASE 3	0	2,11	0
281	WIND CASE 2	0	0	6,006
282	G1	0	0	-2,02
282	G2	0	0	-4,07
282	ACC USO	0	0	-9,62
282	SNOW	0	0	-1,92
282	WIND CASE 2	0	0	2,11
282	WIND CASE 3	0	2,11	0
282	WIND CASE 1	0	0	8,43

3.2 ATTACHEMENT B

Frame	**SectionType**	**AnalSect**	**Frame**	**SectionType**	**AnalSect**
1	*Tee*	*T*	*37*	*Tee*	*T*
2	*Double Channel*	*2 x UPN 140*	*38*	*Tee*	*T*
3	*Double Channel*	*2 x UPN 140*	*39*	*Tee*	*T*
4	*Box/Tube*	*Quadro 50*	*40*	*I/Wide Flange*	*HEB280*
5	*Box/Tube*	*Quadro 50*	*41*	*Tee*	*T*
6	*Box/Tube*	*Quadro 140*	*42*	*Tee*	*T*
7	*Pipe*	*tubolare*	*43*	*Tee*	*T*
8	*Tee*	*T*	*44*	*Tee*	*T*
9	*Pipe*	*tubolare*	*45*	*Tee*	*T*
11	*Pipe*	*tubolare*	*46*	*Tee*	*T*
12	*Double Channel*	*2 x UPN 140*	*47*	*Tee*	*T*
13	*Double Channel*	*2 x UPN 140*	*48*	*Tee*	*T*
14	*Pipe*	*tubolare*	*49*	*Tee*	*T*
15	*Pipe*	*tubolare*	*50*	*Tee*	*T*
16	*Pipe*	*tubolare*	*51*	*Tee*	*T*
17	*Tee*	*T*	*52*	*Tee*	*T*
18	*Tee*	*T*	*53*	*Tee*	*T*
19	*Tee*	*T*	*54*	*Tee*	*T*
20	*Tee*	*T*	*56*	*Pipe*	*tubolare*
21	*Tee*	*T*	*57*	*Pipe*	*tubolare*
22	*Tee*	*T*	*58*	*Pipe*	*tubolare*
23	*Tee*	*T*	*81*	*Box/Tube*	*Quadro 50*
24	*Tee*	*T*	*82*	*Box/Tube*	*Quadro 50*
25	*Tee*	*T*	*84*	*I/Wide Flange*	*HEB280*
26	*Tee*	*T*	*85*	*I/Wide Flange*	*HEB280*
27	*Tee*	*T*	*91*	*Rectangular*	*PIL60x90*
28	*Tee*	*T*	*92*	*Rectangular*	*PIL60x90*
29	*Tee*	*T*	*93*	*Rectangular*	*PIL60x90*
30	*Tee*	*T*	*94*	*Rectangular*	*PIL60x90*
31	*Tee*	*T*	*95*	*Rectangular*	*PIL60x90*
32	*Tee*	*T*	*96*	*Rectangular*	*PIL60x90*
33	*Tee*	*T*	*97*	*Rectangular*	*PIL60x90*
34	*Tee*	*T*	*99*	*Rectangular*	*PIL60x90*
35	*Tee*	*T*	*100*	*Box/Tube*	*Quadro 50*
36	*Pipe*	*tubolare*	*101*	*Box/Tube*	*Quadro 50*
133	*Box/Tube*	*Quadro 140*	*168*	*I/Wide Flange*	*HEB280*
134	*Box/Tube*	*Quadro 140*	*169*	*I/Wide Flange*	*HEB280*
135	*Box/Tube*	*Quadro 140*	*170*	*I/Wide Flange*	*HEB280*
136	*Box/Tube*	*Quadro 140*	*171*	*I/Wide Flange*	*HEB280*
137	*Box/Tube*	*Quadro 140*	*172*	*Box/Tube*	*Quadro 140*
138	*Box/Tube*	*Quadro 140*	*173*	*I/Wide Flange*	*HEB280*
139	*Box/Tube*	*Quadro 140*	*174*	*I/Wide Flange*	*HEB280*

Frame	***SectionType***	***AnalSect***	***Frame***	***SectionType***	***AnalSect***
102	*Box/Tube*	*Quadro 50*	*140*	*Box/Tube*	*Quadro 140*
103	*Box/Tube*	*Quadro 50*	*141*	*Box/Tube*	*Quadro 140*
104	*Box/Tube*	*Quadro 50*	*142*	*Box/Tube*	*Quadro 140*
105	*Box/Tube*	*Quadro 50*	*143*	*Box/Tube*	*Quadro 140*
106	*Box/Tube*	*Quadro 50*	*144*	*Box/Tube*	*Quadro 140*
107	*Box/Tube*	*Quadro 50*	*145*	*Box/Tube*	*Quadro 140*
108	*Box/Tube*	*Quadro 50*	*146*	*Box/Tube*	*Quadro 140*
109	*Box/Tube*	*Quadro 50*	*147*	*Box/Tube*	*Quadro 140*
110	*Box/Tube*	*Quadro 50*	*148*	*Box/Tube*	*Quadro 140*
111	*Box/Tube*	*Quadro 50*	*149*	*Box/Tube*	*Quadro 140*
112	*Box/Tube*	*Quadro 50*	*150*	*Box/Tube*	*Quadro 140*
113	*I/Wide Flange*	*HEB280*	*151*	*Box/Tube*	*Quadro 140*
114	*I/Wide Flange*	*HEB280*	*152*	*Box/Tube*	*Quadro 140*
115	*Box/Tube*	*Quadro 50*	*153*	*Box/Tube*	*Quadro 140*
116	*I/Wide Flange*	*HEB280*	*154*	*Box/Tube*	*Quadro 140*
118	*Box/Tube*	*Quadro 50*	*155*	*I/Wide Flange*	*HEB280*
121	*Box/Tube*	*Quadro 140*	*156*	*I/Wide Flange*	*HEB280*
122	*Box/Tube*	*Quadro 140*	*157*	*I/Wide Flange*	*HEB280*
123	*Box/Tube*	*Quadro 140*	*158*	*I/Wide Flange*	*HEB280*
124	*Box/Tube*	*Quadro 140*	*159*	*I/Wide Flange*	*HEB280*
125	*Box/Tube*	*Quadro 140*	*160*	*I/Wide Flange*	*HEB280*
126	*Box/Tube*	*Quadro 140*	*161*	*I/Wide Flange*	*HEB280*
127	*Box/Tube*	*Quadro 140*	*162*	*I/Wide Flange*	*HEB280*
128	*Box/Tube*	*Quadro 140*	*163*	*I/Wide Flange*	*HEB280*
129	*Box/Tube*	*Quadro 140*	*164*	*I/Wide Flange*	*HEB280*
130	*Box/Tube*	*Quadro 140*	*165*	*I/Wide Flange*	*HEB280*
131	*Box/Tube*	*Quadro 140*	*166*	*I/Wide Flange*	*HEB280*
132	*Box/Tube*	*Quadro 140*	*167*	*I/Wide Flange*	*HEB280*
175	*I/Wide Flange*	*HEB280*	*215*	*Box/Tube*	*Quadro 140*
176	*I/Wide Flange*	*HEB280*	*216*	*Box/Tube*	*Quadro 140*
177	*I/Wide Flange*	*HEB280*	*217*	*Box/Tube*	*Quadro 140*
178	*I/Wide Flange*	*HEB280*	*218*	*Box/Tube*	*Quadro 140*
179	*I/Wide Flange*	*HEB280*	*219*	*Box/Tube*	*Quadro 140*
180	*I/Wide Flange*	*HEB280*	*220*	*Box/Tube*	*Quadro 140*
181	*I/Wide Flange*	*HEB280*	*221*	*Box/Tube*	*Quadro 140*
182	*I/Wide Flange*	*HEB280*	*222*	*Box/Tube*	*Quadro 140*
183	*I/Wide Flange*	*HEB280*	*223*	*Box/Tube*	*Quadro 140*
184	*I/Wide Flange*	*HEB280*	*224*	*Box/Tube*	*Quadro 140*
185	*I/Wide Flange*	*HEB280*	*225*	*Box/Tube*	*Quadro 140*
186	*I/Wide Flange*	*HEB280*	*226*	*Box/Tube*	*Quadro 140*
187	*I/Wide Flange*	*HEB280*	*227*	*Box/Tube*	*Quadro 140*
188	*I/Wide Flange*	*HEB280*	*228*	*Box/Tube*	*Quadro 140*

Frame	***SectionType***	***AnalSect***	***Frame***	***SectionType***	***AnalSect***
189	*I/Wide Flange*	*HEB280*	*229*	*Box/Tube*	*Quadro 140*
190	*I/Wide Flange*	*HEB280*	*230*	*Box/Tube*	*Quadro 140*
191	*I/Wide Flange*	*HEB280*	*231*	*Box/Tube*	*Quadro 140*
192	*Box/Tube*	*Quadro 140*	*232*	*Box/Tube*	*Quadro 140*
193	*Box/Tube*	*Quadro 140*	*233*	*Box/Tube*	*Quadro 140*
194	*I/Wide Flange*	*HEB280*	*234*	*Box/Tube*	*Quadro 140*
195	*I/Wide Flange*	*HEB280*	*236*	*Box/Tube*	*Quadro 140*
196	*I/Wide Flange*	*HEB280*	*237*	*Box/Tube*	*Quadro 140*
197	*I/Wide Flange*	*HEB280*	*238*	*Box/Tube*	*Quadro 140*
198	*Box/Tube*	*Quadro 50*	*239*	*I/Wide Flange*	*HEB280*
201	*Box/Tube*	*Quadro 50*	*240*	*I/Wide Flange*	*HEB280*
205	*Box/Tube*	*Quadro 140*	*241*	*I/Wide Flange*	*HEB280*
206	*Box/Tube*	*Quadro 140*	*242*	*I/Wide Flange*	*HEB280*
207	*Box/Tube*	*Quadro 140*	*243*	*I/Wide Flange*	*HEB280*
208	*Box/Tube*	*Quadro 140*	*244*	*I/Wide Flange*	*HEB280*
209	*Box/Tube*	*Quadro 140*	*245*	*I/Wide Flange*	*HEB280*
210	*Box/Tube*	*Quadro 140*	*246*	*I/Wide Flange*	*HEB280*
211	*Box/Tube*	*Quadro 140*	*247*	*I/Wide Flange*	*HEB280*
212	*Box/Tube*	*Quadro 140*	*248*	*I/Wide Flange*	*HEB280*
213	*Box/Tube*	*Quadro 140*	*249*	*I/Wide Flange*	*HEB280*
214	*Box/Tube*	*Quadro 140*	*250*	*I/Wide Flange*	*HEB280*
251	*I/Wide Flange*	*HEB280*	*293*	*Box/Tube*	*Quadro 140*
252	*I/Wide Flange*	*HEB280*	*294*	*Box/Tube*	*Quadro 140*
254	*I/Wide Flange*	*HEB280*	*295*	*Box/Tube*	*Quadro 140*
255	*I/Wide Flange*	*HEB280*	*296*	*Box/Tube*	*Quadro 140*
256	*Box/Tube*	*Quadro 140*	*297*	*Box/Tube*	*Quadro 140*
257	*I/Wide Flange*	*HEB280*	*298*	*Box/Tube*	*Quadro 140*
258	*I/Wide Flange*	*HEB280*	*299*	*Box/Tube*	*Quadro 140*
259	*I/Wide Flange*	*HEB280*	*300*	*Box/Tube*	*Quadro 140*
260	*I/Wide Flange*	*HEB280*	*301*	*Box/Tube*	*Quadro 140*
262	*I/Wide Flange*	*HEB280*	*302*	*Box/Tube*	*Quadro 140*
263	*I/Wide Flange*	*HEB280*	*303*	*Box/Tube*	*Quadro 140*
264	*I/Wide Flange*	*HEB280*	*304*	*Box/Tube*	*Quadro 140*
265	*I/Wide Flange*	*HEB280*	*305*	*Box/Tube*	*Quadro 140*
266	*I/Wide Flange*	*HEB280*	*306*	*Box/Tube*	*Quadro 140*
267	*I/Wide Flange*	*HEB280*	*307*	*Box/Tube*	*Quadro 140*
268	*I/Wide Flange*	*HEB280*	*308*	*Box/Tube*	*Quadro 140*
269	*I/Wide Flange*	*HEB280*	*309*	*Box/Tube*	*Quadro 140*
270	*I/Wide Flange*	*HEB280*	*310*	*Box/Tube*	*Quadro 140*
271	*I/Wide Flange*	*HEB280*	*311*	*Box/Tube*	*Quadro 140*
272	*I/Wide Flange*	*HEB280*	*312*	*Box/Tube*	*Quadro 140*
273	*I/Wide Flange*	*HEB280*	*313*	*Box/Tube*	*Quadro 140*

Frame	**SectionType**	**AnalSect**	**Frame**	**SectionType**	**AnalSect**
274	*I/Wide Flange*	*HEB280*	*314*	*Box/Tube*	*Quadro 140*
275	*I/Wide Flange*	*HEB280*	*315*	*Box/Tube*	*Quadro 140*
276	*Box/Tube*	*Quadro 140*	*316*	*Box/Tube*	*Quadro 140*
277	*Box/Tube*	*Quadro 140*	*317*	*Box/Tube*	*Quadro 140*
278	*I/Wide Flange*	*HEB280*	*318*	*Box/Tube*	*Quadro 140*
279	*I/Wide Flange*	*HEB280*	*319*	*Box/Tube*	*Quadro 140*
280	*I/Wide Flange*	*HEB280*	*320*	*Box/Tube*	*Quadro 140*
281	*I/Wide Flange*	*HEB280*	*321*	*Box/Tube*	*Quadro 140*
282	*Box/Tube*	*Quadro 50*	*322*	*Box/Tube*	*Quadro 140*
285	*Box/Tube*	*Quadro 50*	*323*	*I/Wide Flange*	*HEB280*
289	*Box/Tube*	*Quadro 140*	*324*	*I/Wide Flange*	*HEB280*
290	*Box/Tube*	*Quadro 140*	*325*	*I/Wide Flange*	*HEB280*
291	*Box/Tube*	*Quadro 140*	*326*	*I/Wide Flange*	*HEB280*
292	*Box/Tube*	*Quadro 140*	*327*	*I/Wide Flange*	*HEB280*
328	*I/Wide Flange*	*HEB280*	*363*	*I/Wide Flange*	*HEB280*
329	*I/Wide Flange*	*HEB280*	*364*	*I/Wide Flange*	*HEB280*
330	*I/Wide Flange*	*HEB280*	*365*	*I/Wide Flange*	*HEB280*
331	*I/Wide Flange*	*HEB280*	*366*	*Box/Tube*	*Quadro 50*
332	*I/Wide Flange*	*HEB280*	*369*	*Box/Tube*	*Quadro 50*
333	*I/Wide Flange*	*HEB280*	*373*	*Box/Tube*	*Quadro 50*
334	*I/Wide Flange*	*HEB280*	*376*	*Box/Tube*	*Quadro 50*
335	*I/Wide Flange*	*HEB280*	*378*	*Box/Tube*	*Quadro 50*
336	*I/Wide Flange*	*HEB280*	*379*	*Box/Tube*	*Quadro 50*
337	*I/Wide Flange*	*HEB280*	*380*	*Box/Tube*	*Quadro 50*
338	*I/Wide Flange*	*HEB280*	*381*	*Box/Tube*	*Quadro 50*
339	*I/Wide Flange*	*HEB280*	*382*	*Box/Tube*	*Quadro 50*
340	*Box/Tube*	*Quadro 140*	*383*	*Box/Tube*	*Quadro 50*
341	*I/Wide Flange*	*HEB280*	*385*	*Box/Tube*	*Quadro 50*
342	*I/Wide Flange*	*HEB280*	*386*	*Box/Tube*	*Quadro 50*
343	*I/Wide Flange*	*HEB280*	*387*	*Box/Tube*	*Quadro 50*
344	*I/Wide Flange*	*HEB280*	*388*	*Box/Tube*	*Quadro 50*
345	*I/Wide Flange*	*HEB280*	*389*	*Box/Tube*	*Quadro 50*
346	*I/Wide Flange*	*HEB280*	*390*	*Box/Tube*	*Quadro 50*
347	*I/Wide Flange*	*HEB280*	*391*	*Box/Tube*	*Quadro 50*
348	*I/Wide Flange*	*HEB280*	*392*	*Box/Tube*	*Quadro 50*
349	*I/Wide Flange*	*HEB280*	*394*	*Box/Tube*	*Quadro 50*
350	*I/Wide Flange*	*HEB280*	*395*	*Box/Tube*	*Quadro 50*
351	*I/Wide Flange*	*HEB280*	*396*	*Box/Tube*	*Quadro 50*
352	*I/Wide Flange*	*HEB280*	*399*	*Tee*	*T*
353	*I/Wide Flange*	*HEB280*	*400*	*Tee*	*T*
354	*I/Wide Flange*	*HEB280*	*401*	*Tee*	*T*
355	*I/Wide Flange*	*HEB280*	*402*	*Tee*	*T*

Frame	**SectionType**	**AnalSect**	**Frame**	**SectionType**	**AnalSect**
351	*I/Wide Flange*	*HEB280*	*396*	*Box/Tube*	*Quadro 50*
352	*I/Wide Flange*	*HEB280*	*399*	*Tee*	*T*
353	*I/Wide Flange*	*HEB280*	*400*	*Tee*	*T*
354	*I/Wide Flange*	*HEB280*	*401*	*Tee*	*T*
355	*I/Wide Flange*	*HEB280*	*402*	*Tee*	*T*
356	*I/Wide Flange*	*HEB280*	*403*	*I/Wide Flange*	*HEB280*
357	*I/Wide Flange*	*HEB280*	*404*	*Tee*	*T*
358	*I/Wide Flange*	*HEB280*	*405*	*Tee*	*T*
359	*I/Wide Flange*	*HEB280*	*406*	*Tee*	*T*
360	*Box/Tube*	*Quadro 140*	*407*	*Tee*	*T*
361	*Box/Tube*	*Quadro 140*	*409*	*Tee*	*T*
411	*Box/Tube*	*Quadro 140*	*446*	*I/Wide Flange*	*HEB280*
412	*Box/Tube*	*Quadro 140*	*447*	*I/Wide Flange*	*HEB280*
413	*Box/Tube*	*Quadro 140*	*448*	*I/Wide Flange*	*HEB280*
414	*Box/Tube*	*Quadro 140*	*449*	*I/Wide Flange*	*HEB280*
415	*Box/Tube*	*Quadro 140*	*450*	*Tee*	*T*
416	*Box/Tube*	*Quadro 140*	*451*	*I/Wide Flange*	*HEB280*
417	*Box/Tube*	*Quadro 140*	*452*	*Tee*	*T*
418	*Box/Tube*	*Quadro 140*	*453*	*Tee*	*T*
419	*Box/Tube*	*Quadro 140*	*455*	*I/Wide Flange*	*HEB280*
420	*Box/Tube*	*Quadro 140*	*456*	*Tee*	*T*
421	*Box/Tube*	*Quadro 140*	*457*	*I/Wide Flange*	*HEB280*
422	*Box/Tube*	*Quadro 140*	*458*	*I/Wide Flange*	*HEB280*
423	*Box/Tube*	*Quadro 140*	*459*	*I/Wide Flange*	*HEB280*
424	*Box/Tube*	*Quadro 140*	*460*	*I/Wide Flange*	*HEB280*
425	*Box/Tube*	*Quadro 140*	*461*	*I/Wide Flange*	*HEB280*
426	*Box/Tube*	*Quadro 140*	*462*	*I/Wide Flange*	*HEB280*
427	*Box/Tube*	*Quadro 140*	*463*	*I/Wide Flange*	*HEB280*
428	*Box/Tube*	*Quadro 140*	*464*	*I/Wide Flange*	*HEB280*
429	*Box/Tube*	*Quadro 140*	*465*	*I/Wide Flange*	*HEB280*
430	*Box/Tube*	*Quadro 140*	*466*	*I/Wide Flange*	*HEB280*
431	*Box/Tube*	*Quadro 140*	*467*	*Box/Tube*	*Quadro 140*
432	*Box/Tube*	*Quadro 140*	*468*	*I/Wide Flange*	*HEB280*
433	*Box/Tube*	*Quadro 140*	*469*	*I/Wide Flange*	*HEB280*
434	*Box/Tube*	*Quadro 140*	*470*	*I/Wide Flange*	*HEB280*
435	*Box/Tube*	*Quadro 140*	*471*	*I/Wide Flange*	*HEB280*
436	*Box/Tube*	*Quadro 140*	*472*	*I/Wide Flange*	*HEB280*
437	*Box/Tube*	*Quadro 140*	*473*	*I/Wide Flange*	*HEB280*
438	*Box/Tube*	*Quadro 140*	*474*	*I/Wide Flange*	*HEB280*
439	*Box/Tube*	*Quadro 140*	*475*	*I/Wide Flange*	*HEB280*
440	*Box/Tube*	*Quadro 140*	*476*	*I/Wide Flange*	*HEB280*
441	*Box/Tube*	*Quadro 140*	*477*	*I/Wide Flange*	*HEB280*

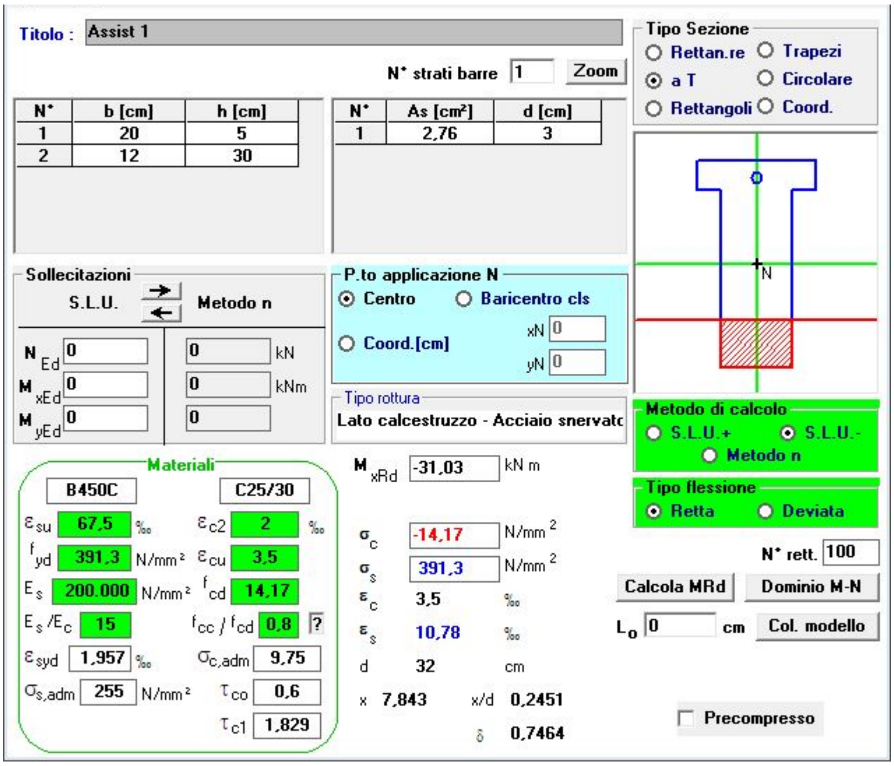
Frame	**SectionType**	**AnalSect**	**Frame**	**SectionType**	**AnalSect**
442	*Box/Tube*	*Quadro 140*	*478*	*I/Wide Flange*	*HEB280*
443	*Box/Tube*	*Quadro 140*	*479*	*I/Wide Flange*	*HEB280*
444	*Box/Tube*	*Quadro 140*	*480*	*I/Wide Flange*	*HEB280*
482	*I/Wide Flange*	*HEB280*	*526*	*Box/Tube*	*Quadro 50*
483	*I/Wide Flange*	*HEB280*	*527*	*Box/Tube*	*Quadro 50*
484	*I/Wide Flange*	*HEB280*	*528*	*Box/Tube*	*Quadro 50*
485	*I/Wide Flange*	*HEB280*	*529*	*Box/Tube*	*Quadro 50*
486	*I/Wide Flange*	*HEB280*	*530*	*Box/Tube*	*Quadro 50*
487	*Box/Tube*	*Quadro 140*	*531*	*Box/Tube*	*Quadro 50*
488	*Box/Tube*	*Quadro 140*	*532*	*Box/Tube*	*Quadro 50*
489	*I/Wide Flange*	*HEB280*	*533*	*Box/Tube*	*Quadro 50*
490	*I/Wide Flange*	*HEB280*	*534*	*Box/Tube*	*Quadro 50*
491	*I/Wide Flange*	*HEB280*	*535*	*Box/Tube*	*Quadro 50*
492	*I/Wide Flange*	*HEB280*	*536*	*Box/Tube*	*Quadro 50*
493	*Tee*	*T*	*537*	*Box/Tube*	*Quadro 50*
494	*Tee*	*T*	*538*	*Box/Tube*	*Quadro 50*
495	*Tee*	*T*	*539*	*Box/Tube*	*Quadro 50*
496	*Tee*	*T*	*540*	*Box/Tube*	*Quadro 50*
498	*Tee*	*T*	*541*	*Box/Tube*	*Quadro 50*
501	*Tee*	*T*	*542*	*Box/Tube*	*Quadro 50*
502	*Tee*	*T*	*543*	*Box/Tube*	*Quadro 50*
503	*Tee*	*T*	*544*	*Box/Tube*	*Quadro 50*
504	*Tee*	*T*	*545*	*Box/Tube*	*Quadro 50*
505	*Tee*	*T*	*546*	*Box/Tube*	*Quadro 50*
506	*Tee*	*T*	*547*	*Box/Tube*	*Quadro 50*
507	*Tee*	*T*	*548*	*Box/Tube*	*Quadro 50*
508	*Tee*	*T*	*549*	*Box/Tube*	*Quadro 50*
509	*Tee*	*T*	*550*	*Box/Tube*	*Quadro 50*
510	*Tee*	*T*	*551*	*Box/Tube*	*Quadro 50*
511	*Tee*	*T*	*552*	*Box/Tube*	*Quadro 50*
512	*Tee*	*T*	*553*	*Box/Tube*	*Quadro 50*
513	*Tee*	*T*	*555*	*Box/Tube*	*Quadro 50*
518	*Tee*	*T*	*556*	*Box/Tube*	*Quadro 50*
519	*Tee*	*T*	*557*	*Box/Tube*	*Quadro 50*
522	*Tee*	*T*	*558*	*Box/Tube*	*Quadro 50*
523	*Tee*	*T*	*559*	*Box/Tube*	*Quadro 50*
524	*Tee*	*T*	*560*	*Box/Tube*	*Quadro 50*
562	*Box/Tube*	*Quadro 50*	*604*	*Tee*	*T*
566	*Tee*	*T*	*605*	*Tee*	*T*
567	*Tee*	*T*	*606*	*Tee*	*T*
568	*Tee*	*T*	*607*	*Tee*	*T*
569	*Tee*	*T*	*608*	*Tee*	*T*

Frame	**SectionType**	**AnalSect**	**Frame**	**SectionType**	**AnalSect**
570	*I/Wide Flange*	*HEB280*	*609*	*Box/Tube*	*Quadro 50*
571	*Tee*	*T*	*610*	*Box/Tube*	*Quadro 50*
572	*Tee*	*T*	*611*	*Box/Tube*	*Quadro 50*
573	*Tee*	*T*	*612*	*Box/Tube*	*Quadro 50*
574	*Tee*	*T*	*615*	*Box/Tube*	*Quadro 50*
575	*Tee*	*T*	*616*	*Box/Tube*	*Quadro 50*
576	*Tee*	*T*	*617*	*Box/Tube*	*Quadro 50*
577	*Tee*	*T*	*618*	*Box/Tube*	*Quadro 50*
578	*Tee*	*T*	*619*	*Box/Tube*	*Quadro 50*
579	*Tee*	*T*	*620*	*Box/Tube*	*Quadro 50*
580	*Tee*	*T*	*621*	*Box/Tube*	*Quadro 50*
582	*Tee*	*T*	*622*	*Box/Tube*	*Quadro 50*
583	*Tee*	*T*	*623*	*Box/Tube*	*Quadro 50*
584	*Tee*	*T*	*624*	*Box/Tube*	*Quadro 50*
586	*Tee*	*T*	*625*	*Box/Tube*	*Quadro 50*
589	*Tee*	*T*	*626*	*Box/Tube*	*Quadro 50*
590	*Tee*	*T*	*627*	*Box/Tube*	*Quadro 50*
591	*Tee*	*T*	*628*	*Box/Tube*	*Quadro 50*
592	*Tee*	*T*	*630*	*Box/Tube*	*Quadro 50*
593	*Tee*	*T*	*631*	*Box/Tube*	*Quadro 50*
594	*Tee*	*T*	*632*	*Box/Tube*	*Quadro 50*
595	*Tee*	*T*	*633*	*Box/Tube*	*Quadro 50*
596	*Tee*	*T*	*634*	*Box/Tube*	*Quadro 50*
597	*Tee*	*T*	*635*	*Box/Tube*	*Quadro 50*
598	*Tee*	*T*	*636*	*Box/Tube*	*Quadro 50*
599	*Tee*	*T*	*637*	*Box/Tube*	*Quadro 50*
600	*Tee*	*T*	*638*	*Box/Tube*	*Quadro 50*
601	*Tee*	*T*	*639*	*Box/Tube*	*Quadro 50*
602	*Tee*	*T*	*640*	*Box/Tube*	*Quadro 50*
525	*Tee*	*T*	*561*	*Box/Tube*	*Quadro 50*
642	*Box/Tube*	*Quadro 50*	*643*	*Box/Tube*	*Quadro 50*
643	*Box/Tube*	*Quadro 50*	*644*	*Box/Tube*	*Quadro 50*
644	*Box/Tube*	*Quadro 50*	*645*	*Box/Tube*	*Quadro 50*
645	*Box/Tube*	*Quadro 50*	*770*	*I/Wide Flange*	*HEB280*
770	*I/Wide Flange*	*HEB280*	*771*	*I/Wide Flange*	*HEB280*
771	*I/Wide Flange*	*HEB280*			

3.3 ATTACHEMENT C

Following the resume of the value x-neutral axis evaluated with the program VCASLU.

ASSIST-FLOOR1



Titolo : Assist 1

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	2,76	3

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni S.L.U. Metodo n

N_{Ed} 0 0 kN

M_{xEd} 0 0 kNm

M_{yEd} 0 0

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Metodo di calcolo: ○ S.L.U.+ ● S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰

f_{yd} 391,3 N/mm² ε_{cu} 3,5

E_s 200.000 N/mm² f_{cd} 14,17

E_s/E_c 15 f_{cc}/f_{cd} 0,8 ?

ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75

$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6

τ_{c1} 1,829

M_{xRd} -31,03 kN m

σ_c -14,17 N/mm²

σ_s 391,3 N/mm²

ε_c 3,5 ‰

ε_s 10,78 ‰

d 32 cm

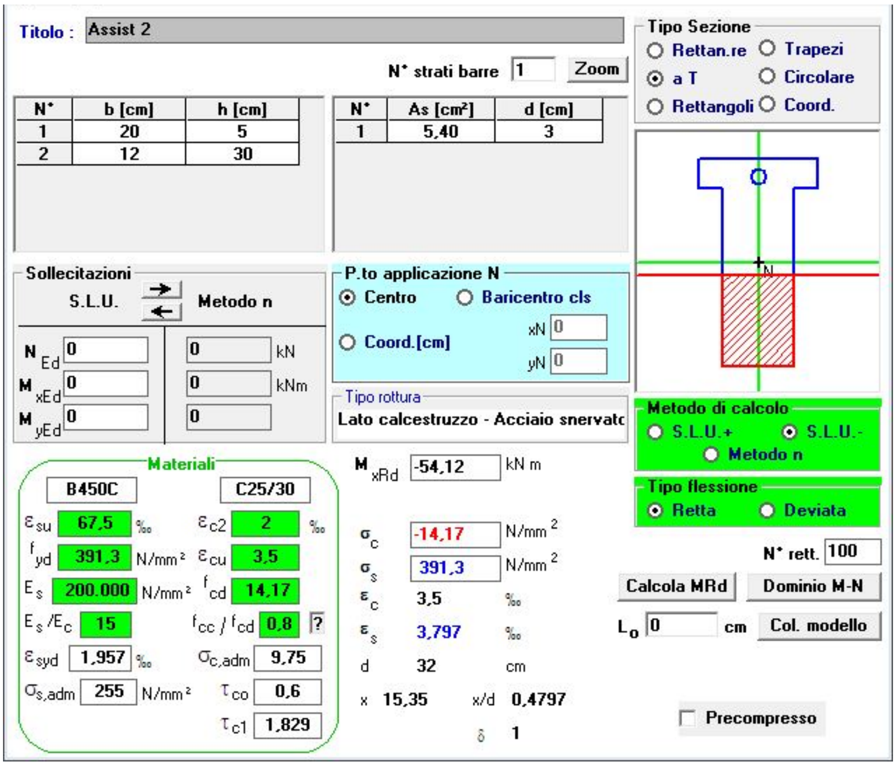
x 7,843 x/d 0,2451

δ 0,7464

N° rett. 100

L_0 0 cm

☐ Precompresso



Titolo : Assist 2

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	5,40	3

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni S.L.U. Metodo n

N_{Ed} 0 0 kN

M_{xEd} 0 0 kNm

M_{yEd} 0 0

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Metodo di calcolo: ○ S.L.U.+ ● S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰

f_{yd} 391,3 N/mm² ε_{cu} 3,5

E_s 200.000 N/mm² f_{cd} 14,17

E_s/E_c 15 f_{cc}/f_{cd} 0,8 ?

ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75

$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6

τ_{c1} 1,829

M_{xRd} -54,12 kN m

σ_c -14,17 N/mm²

σ_s 391,3 N/mm²

ε_c 3,5 ‰

ε_s 3,797 ‰

d 32 cm

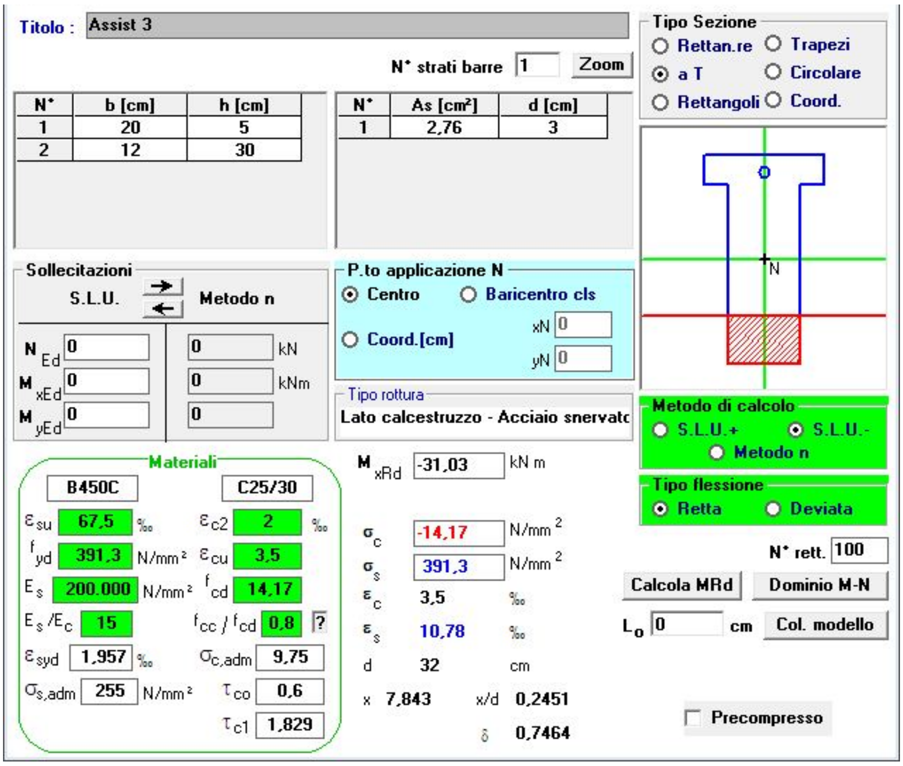
x 15,35 x/d 0,4797

δ 1

N° rett. 100

L_0 0 cm

☐ Precompresso



Titolo : Assist 3

N° strati barre 1 Zoom

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	2,76	3

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni — S.L.U. / Metodo n

	S.L.U.	Metodo n	
N_{Ed}	0	0	kN
M_{xEd}	0	0	kNm
M_{yEd}	0	0	

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Metodo di calcolo: ○ S.L.U.+ ● S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

N° rett. 100

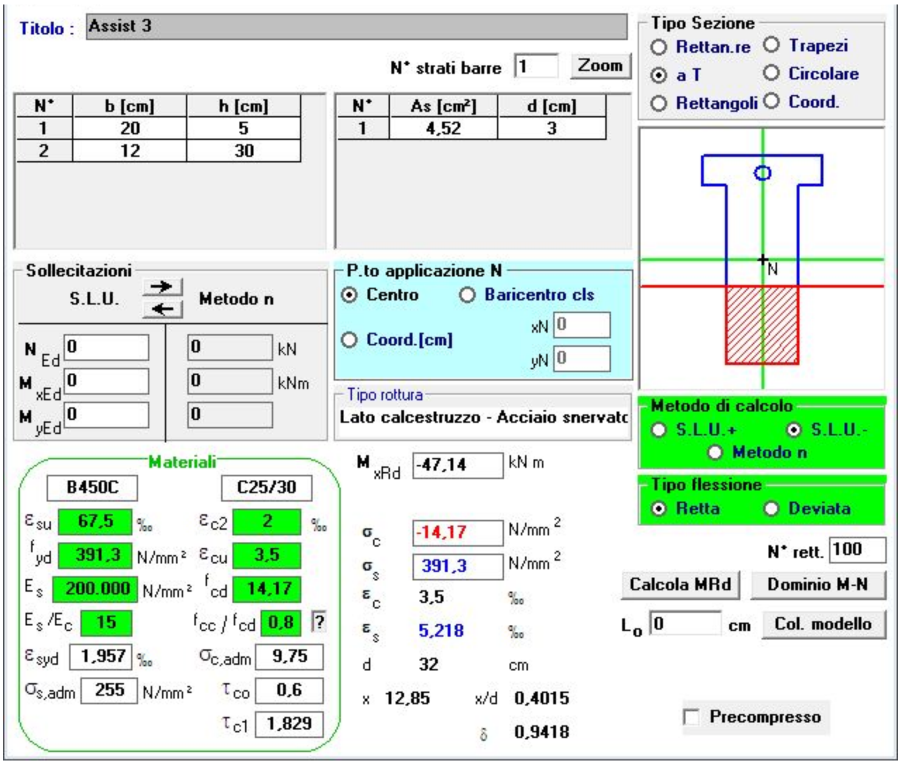
Materiali: B450C C25/30

ε_{su} 67,5 ‰ — ε_{c2} 2 ‰
f_{yd} 391,3 N/mm² — ε_{cu} 3,5
E_s 200.000 N/mm² — f_{cd} 14,17
E_s/E_c 15 — f_{cc}/f_{cd} 0,8
ε_{syd} 1,957 ‰ — $\sigma_{c,adm}$ 9,75
$\sigma_{s,adm}$ 255 N/mm² — τ_{co} 0,6
τ_{c1} 1,829

M_{xRd} -31,03 kN m
σ_c -14,17 N/mm²
σ_s 391,3 N/mm²
ε_c 3,5 ‰
ε_s 10,78 ‰
d 32 cm
x 7,843 x/d 0,2451
δ 0,7464

L_o 0 cm

☐ Precompresso



Titolo : Assist 3

N° strati barre 1 Zoom

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	4,52	3

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni — S.L.U. / Metodo n

	S.L.U.	Metodo n	
N_{Ed}	0	0	kN
M_{xEd}	0	0	kNm
M_{yEd}	0	0	

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Metodo di calcolo: ○ S.L.U.+ ● S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

N° rett. 100

Materiali: B450C C25/30

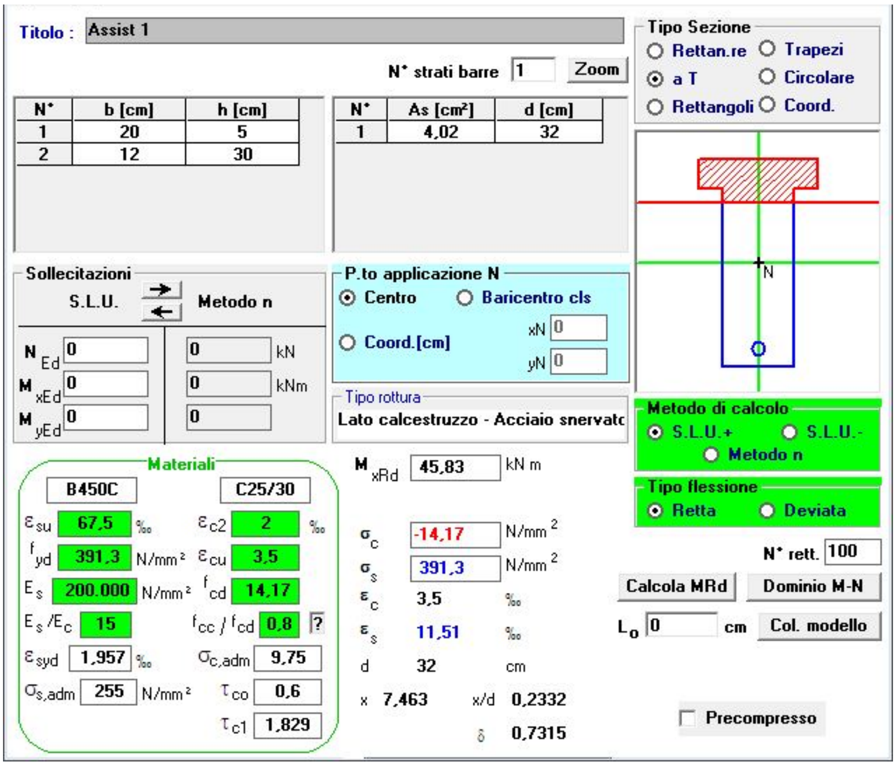
ε_{su} 67,5 ‰ — ε_{c2} 2 ‰
f_{yd} 391,3 N/mm² — ε_{cu} 3,5
E_s 200.000 N/mm² — f_{cd} 14,17
E_s/E_c 15 — f_{cc}/f_{cd} 0,8
ε_{syd} 1,957 ‰ — $\sigma_{c,adm}$ 9,75
$\sigma_{s,adm}$ 255 N/mm² — τ_{co} 0,6
τ_{c1} 1,829

M_{xRd} -47,14 kN m
σ_c -14,17 N/mm²
σ_s 391,3 N/mm²
ε_c 3,5 ‰
ε_s 5,218 ‰
d 32 cm
x 12,85 x/d 0,4015
δ 0,9418

L_o 0 cm

☐ Precompresso

MID SECTION-FLOOR1


Titolo : Assist 1

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	4,02	32

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni S.L.U. / Metodo n

	S.L.U.	Metodo n	
N_{Ed}	0	0	kN
M_{xEd}	0	0	kNm
M_{yEd}	0	0	

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervato

Metodo di calcolo: ● S.L.U.+ ○ S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

N° rett. 100

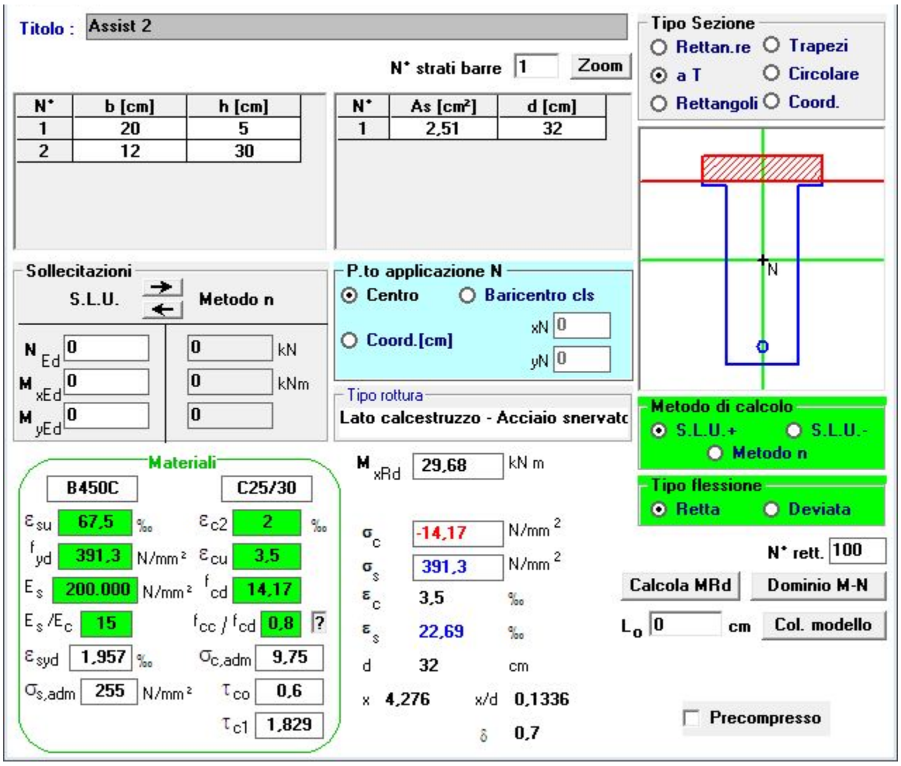
L_o 0 cm

☐ Precompresso

Materiali: B450C, C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰
f_{yd} 391,3 N/mm² ε_{cu} 3,5
E_s 200.000 N/mm² f_{cd} 14,17
E_s/E_c 15 f_{cc}/f_{cd} 0,8
ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75
$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6
τ_{c1} 1,829

M_{xRd} 45,83 kN m
σ_c -14,17 N/mm²
σ_s 391,3 N/mm²
ε_c 3,5 ‰
ε_s 11,51 ‰
d 32 cm
x 7,463 x/d 0,2332
δ 0,7315


Titolo : Assist 2

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	2,51	32

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni S.L.U. / Metodo n

	S.L.U.	Metodo n	
N_{Ed}	0	0	kN
M_{xEd}	0	0	kNm
M_{yEd}	0	0	

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervato

Metodo di calcolo: ● S.L.U.+ ○ S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

N° rett. 100

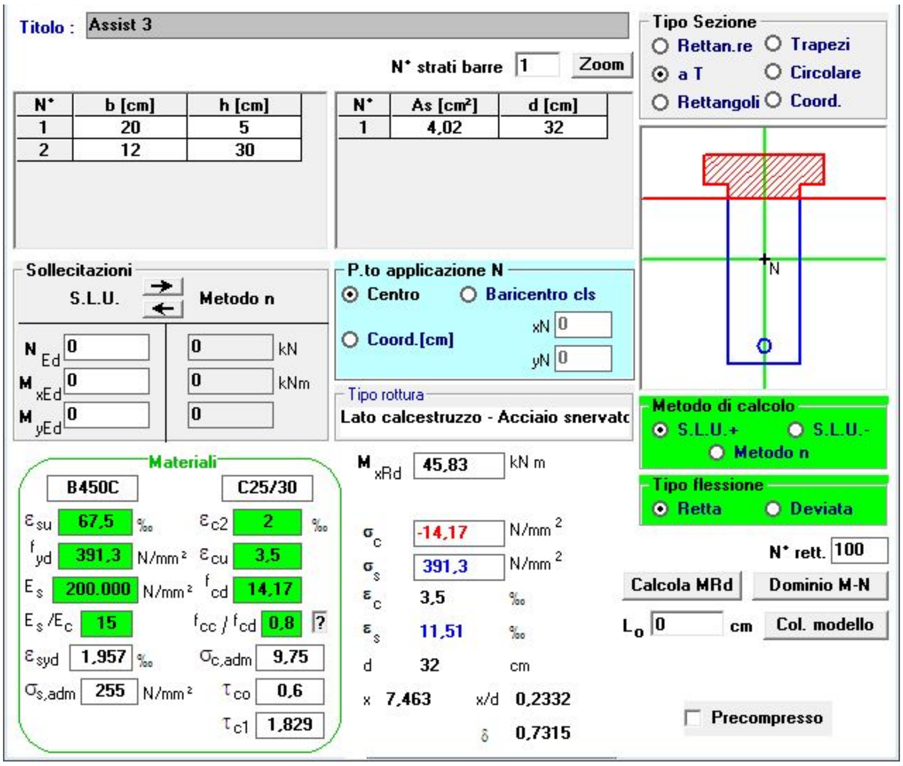
L_o 0 cm

☐ Precompresso

Materiali: B450C, C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰
f_{yd} 391,3 N/mm² ε_{cu} 3,5
E_s 200.000 N/mm² f_{cd} 14,17
E_s/E_c 15 f_{cc}/f_{cd} 0,8
ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75
$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6
τ_{c1} 1,829

M_{xRd} 29,68 kN m
σ_c -14,17 N/mm²
σ_s 391,3 N/mm²
ε_c 3,5 ‰
ε_s 22,69 ‰
d 32 cm
x 4,276 x/d 0,1336
δ 0,7



Titolo : Assist 3

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	4,02	32

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni S.L.U. Metodo n

N_{Ed} 0 0 kN
M_{xEd} 0 0 kNm
M_{yEd} 0 0

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervato

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰
f_{yd} 391,3 N/mm² ε_{cu} 3,5
E_s 200.000 N/mm² f_{cd} 14,17
E_s/E_c 15 f_{cc}/f_{cd} 0,8
ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75
$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6
τ_{c1} 1,829

M_{xRd} 45,83 kN m
σ_c -14,17 N/mm²
σ_s 391,3 N/mm²
ε_c 3,5 ‰
ε_s 11,51 ‰
d 32 cm
x 7,463 x/d 0,2332
δ 0,7315

Metodo di calcolo: ● S.L.U.+ ○ S.L.U.- ○ Metodo n

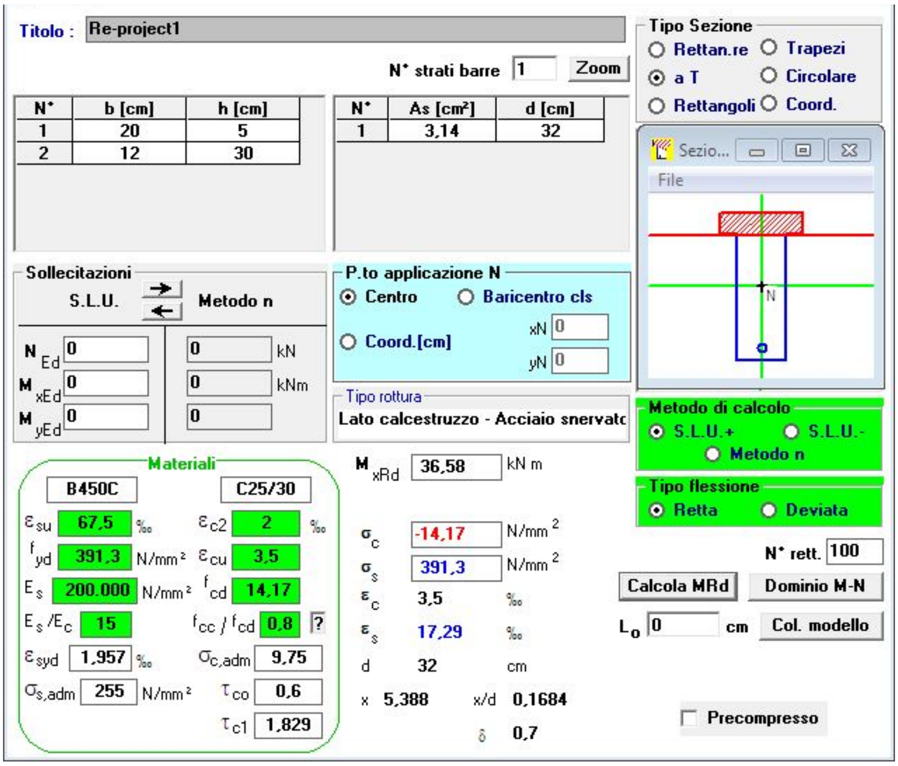
Tipo flessione: ● Retta ○ Deviata

N° rett. 100

L_o 0 cm

☐ Precompresso

Mid section new reinforcements



Titolo : Re-project1

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	3,14	32

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni S.L.U. Metodo n

N_{Ed} 0 0 kN
M_{xEd} 0 0 kNm
M_{yEd} 0 0

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervato

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰
f_{yd} 391,3 N/mm² ε_{cu} 3,5
E_s 200.000 N/mm² f_{cd} 14,17
E_s/E_c 15 f_{cc}/f_{cd} 0,8
ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75
$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6
τ_{c1} 1,829

M_{xRd} 36,58 kN m
σ_c -14,17 N/mm²
σ_s 391,3 N/mm²
ε_c 3,5 ‰
ε_s 17,29 ‰
d 32 cm
x 5,388 x/d 0,1684
δ 0,7

Metodo di calcolo: ● S.L.U.+ ○ S.L.U.- ○ Metodo n

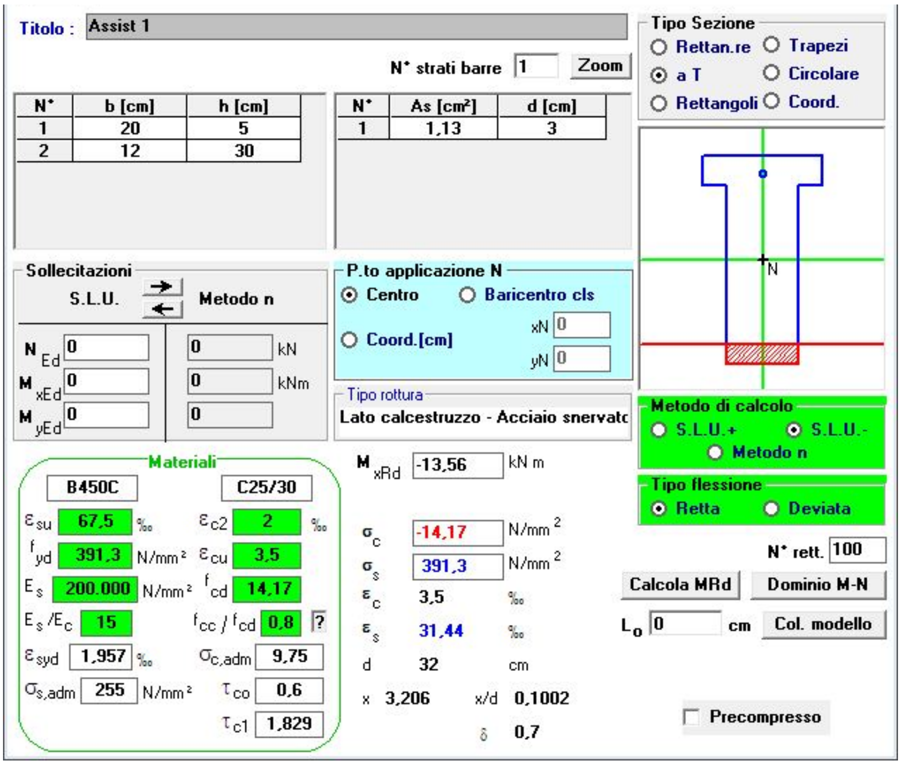
Tipo flessione: ● Retta ○ Deviata

N° rett. 100

L_o 0 cm

☐ Precompresso

ASSIST-FLOOR2



Titolo : Assist 1

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	1,13	3

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni — S.L.U. / Metodo n

N_{Ed} 0 | 0 kN

M_{xEd} 0 | 0 kNm

M_{yEd} 0 | 0

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Materiali: B450C C25/30

ε_{su} 67,5 ‰ — ε_{c2} 2 ‰

f_{yd} 391,3 N/mm² — ε_{cu} 3,5

E_s 200.000 N/mm² — f_{cd} 14,17

E_s/E_c 15 — f_{cc}/f_{cd} 0,8 ?

ε_{syd} 1,957 ‰ — $\sigma_{c,adm}$ 9,75

$\sigma_{s,adm}$ 255 N/mm² — τ_{co} 0,6

τ_{c1} 1,829

M_{xRd} -13,56 kN m

σ_c -14,17 N/mm²

σ_s 391,3 N/mm²

ε_c 3,5 ‰

ε_s 31,44 ‰

d 32 cm

x 3,206 x/d 0,1002

δ 0,7

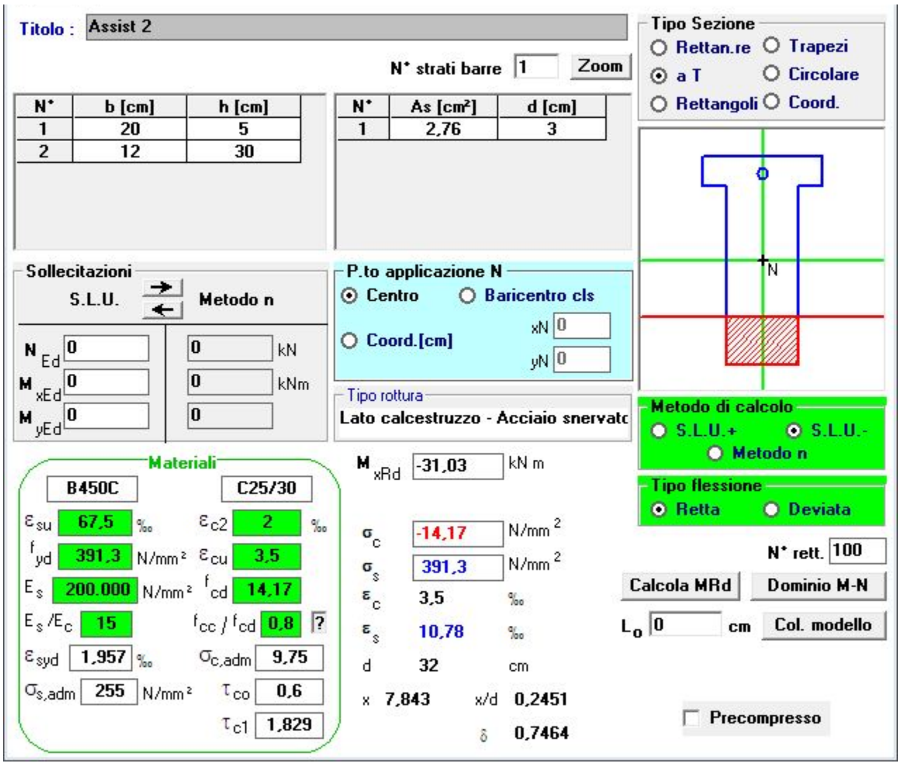
Metodo di calcolo: ○ S.L.U.+ ● S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

N° rett. 100

L_o 0 cm

☐ Precompresso



Titolo : Assist 2

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	2,76	3

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni — S.L.U. / Metodo n

N_{Ed} 0 | 0 kN

M_{xEd} 0 | 0 kNm

M_{yEd} 0 | 0

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Materiali: B450C C25/30

ε_{su} 67,5 ‰ — ε_{c2} 2 ‰

f_{yd} 391,3 N/mm² — ε_{cu} 3,5

E_s 200.000 N/mm² — f_{cd} 14,17

E_s/E_c 15 — f_{cc}/f_{cd} 0,8 ?

ε_{syd} 1,957 ‰ — $\sigma_{c,adm}$ 9,75

$\sigma_{s,adm}$ 255 N/mm² — τ_{co} 0,6

τ_{c1} 1,829

M_{xRd} -31,03 kN m

σ_c -14,17 N/mm²

σ_s 391,3 N/mm²

ε_c 3,5 ‰

ε_s 10,78 ‰

d 32 cm

x 7,843 x/d 0,2451

δ 0,7464

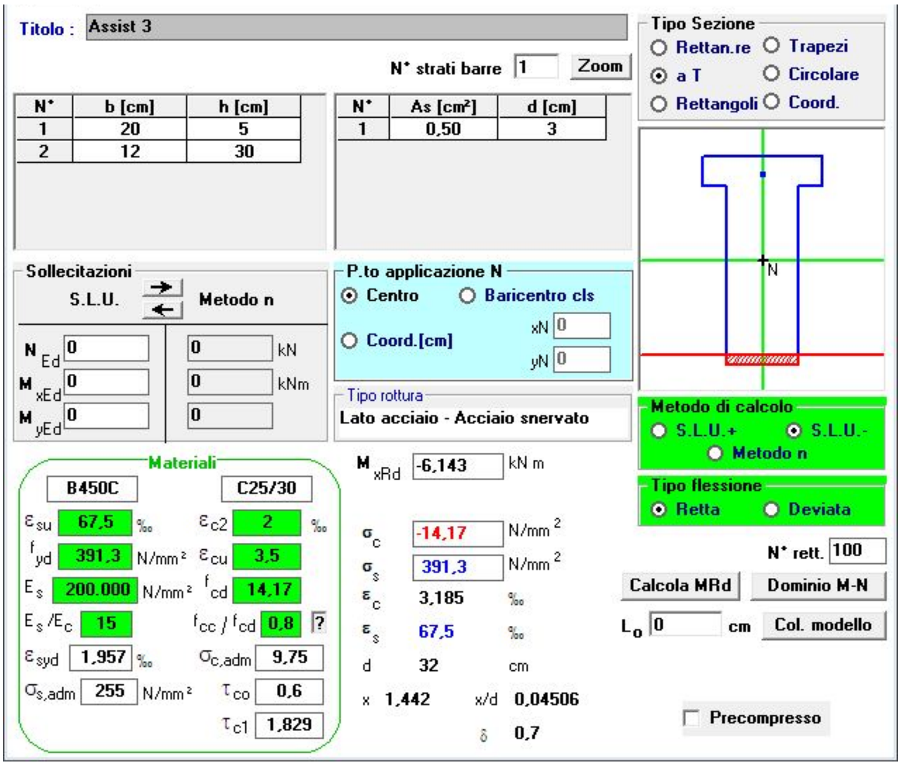
Metodo di calcolo: ○ S.L.U.+ ● S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

N° rett. 100

L_o 0 cm

☐ Precompresso



Titolo : Assist 3

N° strati barre 1

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	0,50	3

Sollecitazioni — S.L.U. / Metodo n

	S.L.U.	Metodo n	
N_{Ed}	0	0	kN
M_{xEd}	0	0	kNm
M_{yEd}	0	0	

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato acciaio - Acciaio snervato

Metodo di calcolo: ○ S.L.U.+ ● S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰
f_{yd} 391,3 N/mm² ε_{cu} 3,5
E_s 200.000 N/mm² f_{cd} 14,17
E_s/E_c 15 f_{cc}/f_{cd} 0,8 ?
ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75
$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6
τ_{c1} 1,829

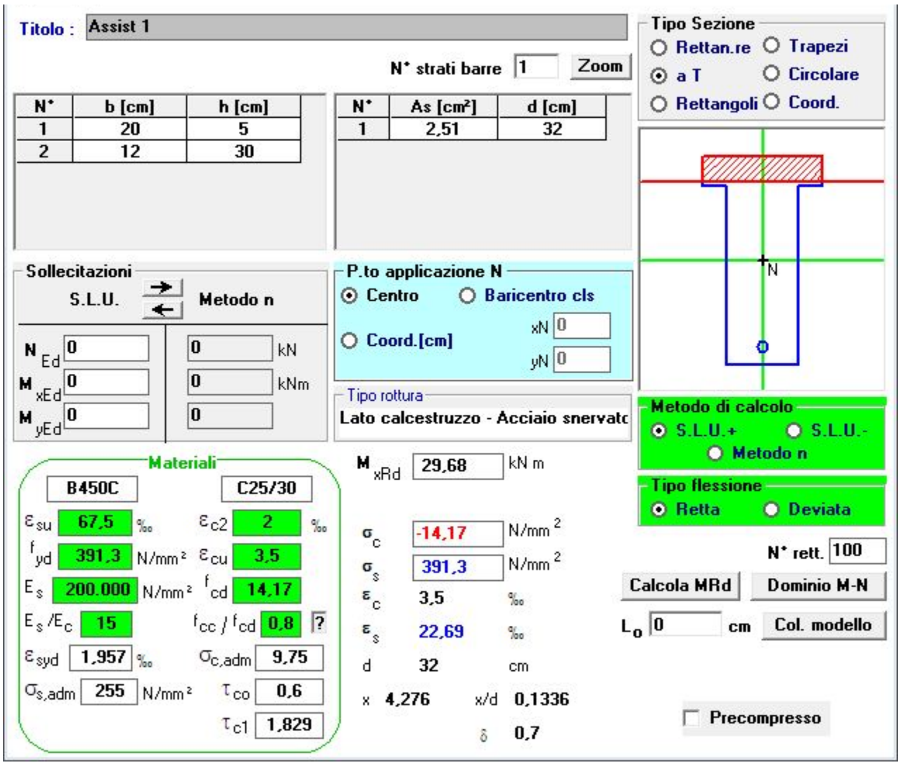
M_{xRd} -6,143 kN m
σ_c -14,17 N/mm²
σ_s 391,3 N/mm²
ε_c 3,185 ‰
ε_s 67,5 ‰
d 32 cm
x 1,442 x/d 0,04506
δ 0,7

N° rett. 100

L_o 0 cm

☐ Precompresso

MID SECTIONS-FLOOR2



Titolo : Assist 1

N° strati barre 1

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	2,51	32

Sollecitazioni — S.L.U. / Metodo n

	S.L.U.	Metodo n	
N_{Ed}	0	0	kN
M_{xEd}	0	0	kNm
M_{yEd}	0	0	

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Metodo di calcolo: ● S.L.U.+ ○ S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

Materiali: B450C C25/30

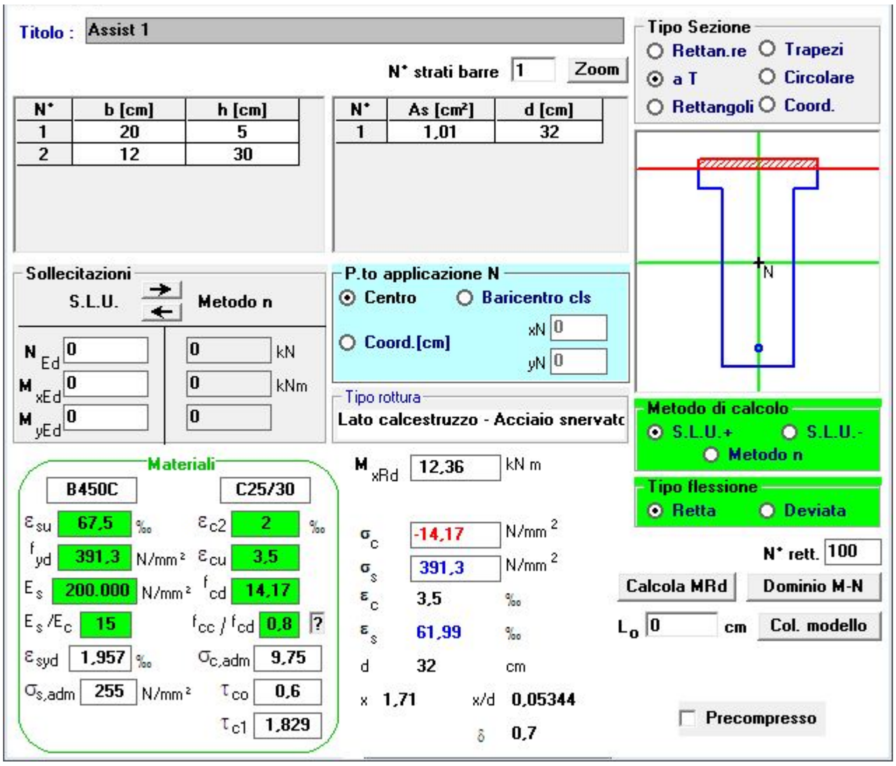
ε_{su} 67,5 ‰ ε_{c2} 2 ‰
f_{yd} 391,3 N/mm² ε_{cu} 3,5
E_s 200.000 N/mm² f_{cd} 14,17
E_s/E_c 15 f_{cc}/f_{cd} 0,8 ?
ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75
$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6
τ_{c1} 1,829

M_{xRd} 29,68 kN m
σ_c -14,17 N/mm²
σ_s 391,3 N/mm²
ε_c 3,5 ‰
ε_s 22,69 ‰
d 32 cm
x 4,276 x/d 0,1336
δ 0,7

N° rett. 100

L_o 0 cm

☐ Precompresso



Titolo : Assist 1

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	1,01	32

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni: S.L.U. Metodo n

N Ed 0 | 0 kN

M xEd 0 | 0 kNm

M yEd 0 | 0

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Metodo di calcolo: ● S.L.U.+ ○ S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰

f_{yd} 391,3 N/mm² ε_{cu} 3,5

E_s 200.000 N/mm² f_{cd} 14,17

E_s/E_c 15 f_{cc}/f_{cd} 0,8

ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75

$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6

τ_{c1} 1,829

M_{xRd} 12,36 kN m

σ_c -14,17 N/mm²

σ_s 391,3 N/mm²

ε_c 3,5 ‰

ε_s 61,99 ‰

d 32 cm

x 1,71 x/d 0,05344

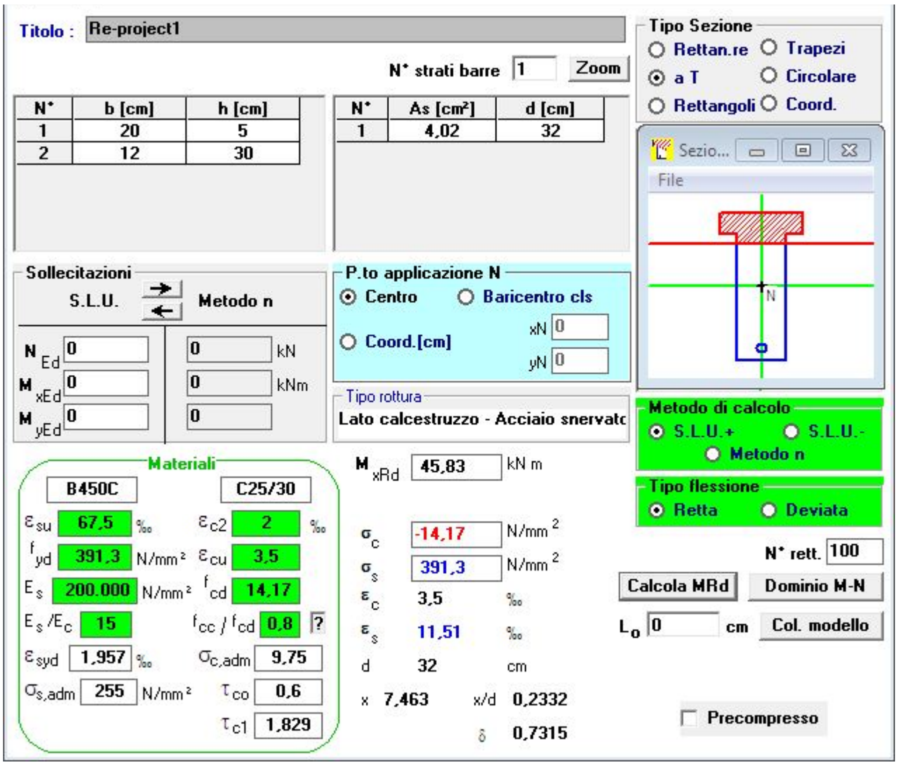
δ 0,7

N° rett. 100

L_o 0 cm

☐ Precompresso

Mid section new reinforcements



Titolo : Re-project1

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	4,02	32

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni: S.L.U. Metodo n

N Ed 0 | 0 kN

M xEd 0 | 0 kNm

M yEd 0 | 0

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervatc

Metodo di calcolo: ● S.L.U.+ ○ S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰

f_{yd} 391,3 N/mm² ε_{cu} 3,5

E_s 200.000 N/mm² f_{cd} 14,17

E_s/E_c 15 f_{cc}/f_{cd} 0,8

ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75

$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6

τ_{c1} 1,829

M_{xRd} 45,83 kN m

σ_c -14,17 N/mm²

σ_s 391,3 N/mm²

ε_c 3,5 ‰

ε_s 11,51 ‰

d 32 cm

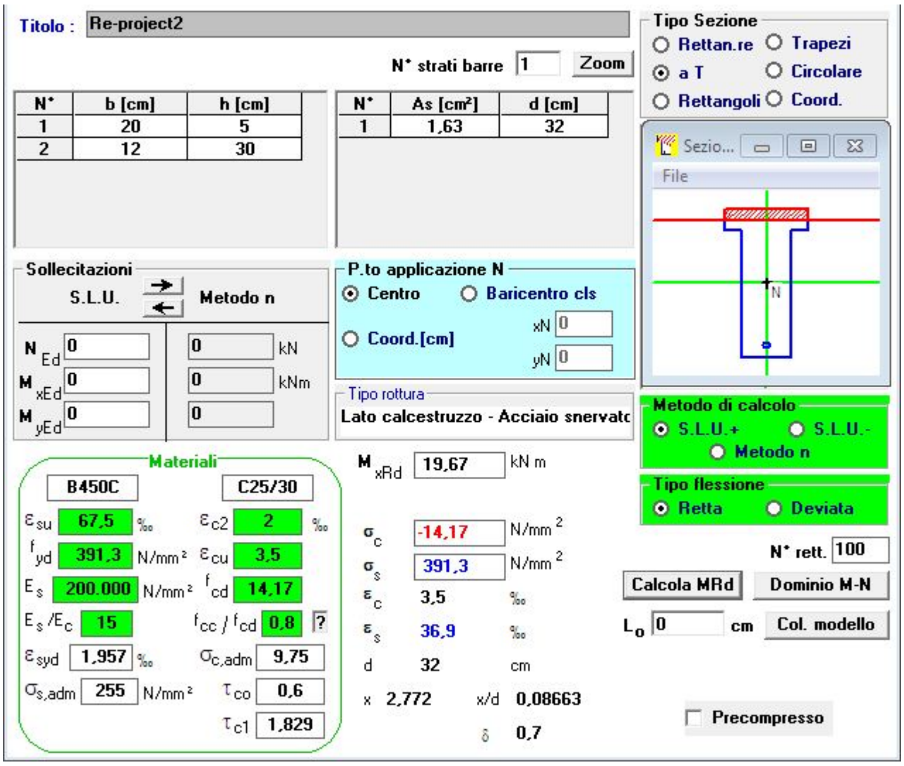
x 7,463 x/d 0,2332

δ 0,7315

N° rett. 100

L_o 0 cm

☐ Precompresso


Titolo : Re-project2

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	1,63	32

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni S.L.U. / Metodo n

	S.L.U.	Metodo n	
N_{Ed}	0	0	kN
M_{xEd}	0	0	kNm
M_{yEd}	0	0	

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervato

Metodo di calcolo: ● S.L.U.+ ○ S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰

f_{yd} 391,3 N/mm² ε_{cu} 3,5

E_s 200.000 N/mm² f_{cd} 14,17

E_s/E_c 15 f_{cc}/f_{cd} 0,8

ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75

$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6

τ_{c1} 1,829

M_{xRd} 19,67 kN m

σ_c -14,17 N/mm²

σ_s 391,3 N/mm²

ε_c 3,5 ‰

ε_s 36,9 ‰

d 32 cm

x 2,772 x/d 0,08663

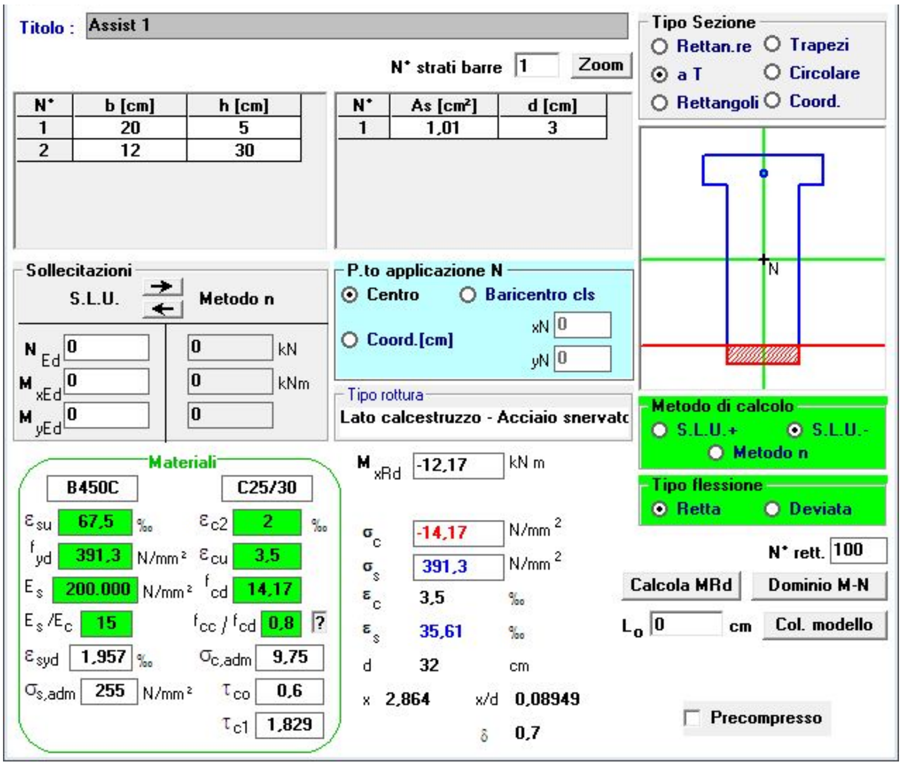
δ 0,7

N° rett. 100

L_0 0 cm

☐ Precompresso

ASSIST-FLOOR3


Titolo : Assist 1

N° strati barre 1

N°	b [cm]	h [cm]
1	20	5
2	12	30

N°	As [cm²]	d [cm]
1	1,01	3

Tipo Sezione: ○ Rettan.re ○ Trapezi ● a T ○ Circolare ○ Rettangoli ○ Coord.

Sollecitazioni S.L.U. / Metodo n

	S.L.U.	Metodo n	
N_{Ed}	0	0	kN
M_{xEd}	0	0	kNm
M_{yEd}	0	0	

P.to applicazione N: ● Centro ○ Baricentro cls ○ Coord.[cm] xN 0 yN 0

Tipo rottura: Lato calcestruzzo - Acciaio snervato

Metodo di calcolo: ○ S.L.U.+ ● S.L.U.- ○ Metodo n

Tipo flessione: ● Retta ○ Deviata

Materiali: B450C C25/30

ε_{su} 67,5 ‰ ε_{c2} 2 ‰

f_{yd} 391,3 N/mm² ε_{cu} 3,5

E_s 200.000 N/mm² f_{cd} 14,17

E_s/E_c 15 f_{cc}/f_{cd} 0,8

ε_{syd} 1,957 ‰ $\sigma_{c,adm}$ 9,75

$\sigma_{s,adm}$ 255 N/mm² τ_{co} 0,6

τ_{c1} 1,829

M_{xRd} -12,17 kN m

σ_c -14,17 N/mm²

σ_s 391,3 N/mm²

ε_c 3,5 ‰

ε_s 35,61 ‰

d 32 cm

x 2,864 x/d 0,08949

δ 0,7

N° rett. 100

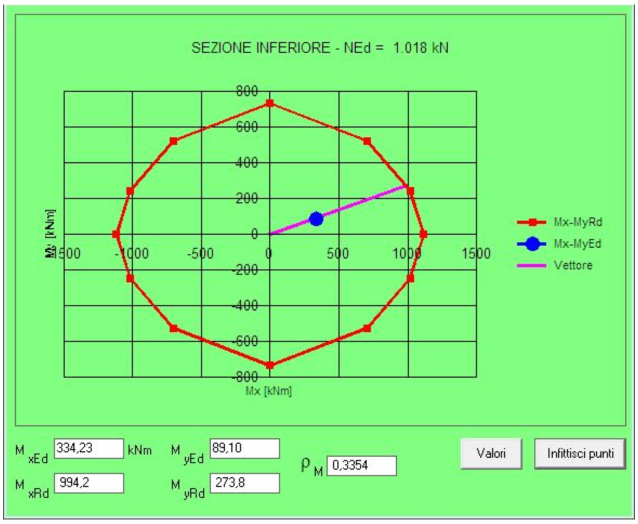
L_0 0 cm

☐ Precompresso

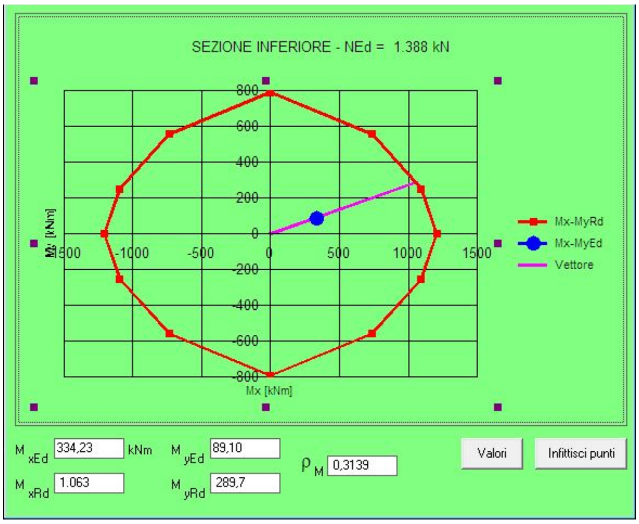
3.4 ATTACHEMENT D

B1 H=0 top

B-1	*Combo 1*	*334,23*	*-89,10*	*1018,95*
	Combo 2	*334,23*	*-89,10*	*1388,79*

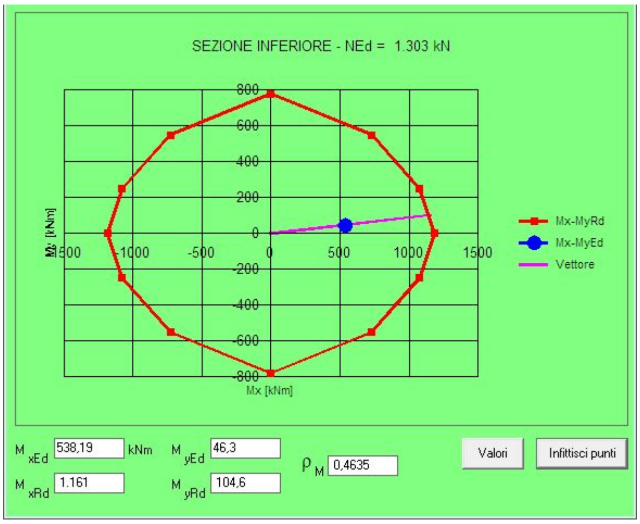


M_{xEd} 334,23 kNm
M_{yEd} 89,10
ρ_M 0,3354
M_{xRd} 994,2
M_{yRd} 273,8

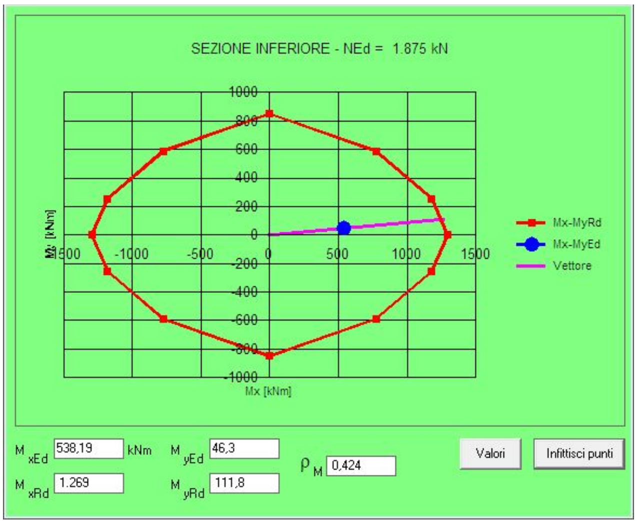


M_{xEd} 334,23 kNm
M_{yEd} 89,10
ρ_M 0,3139
M_{xRd} 1.063
M_{yRd} 289,7

H= 0m		M_x	M_y	*N*
B-2	*Combo 1*	*538,19*	*46,30*	*1303,68*
	Combo 2	*538,19*	*46,30*	*1875,94*

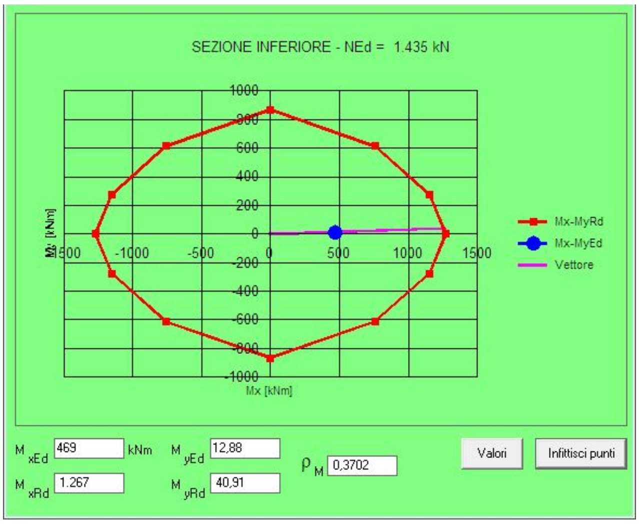


M_{xEd} 538,19 kNm
M_{yEd} 46,3
ρ_M 0,4635
M_{xRd} 1.161
M_{yRd} 104,6



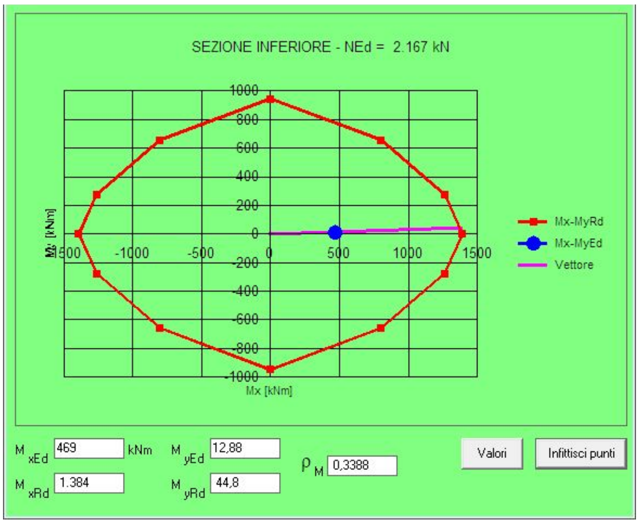
M_{xEd} 538,19 kNm
M_{yEd} 46,3
ρ_M 0,424
M_{xRd} 1.269
M_{yRd} 111,8

H= 0m		M_x	M_y	N
B-3	*Combo 1*	*469,02*	*12,88*	*1435,23*
	Combo 2	*469,02*	*12,88*	*2166,79*



M_{xEd} 469 kNm M_{yEd} 12,88 ρ_M 0,3702

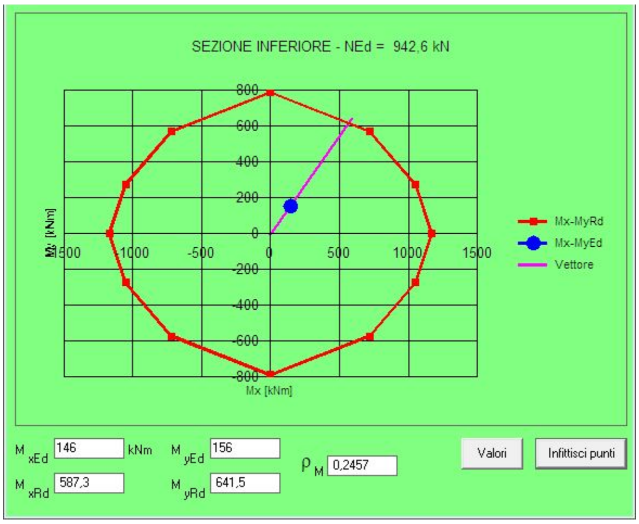
M_{xRd} 1.267 M_{yRd} 40,91



M_{xEd} 469 kNm M_{yEd} 12,88 ρ_M 0,3388

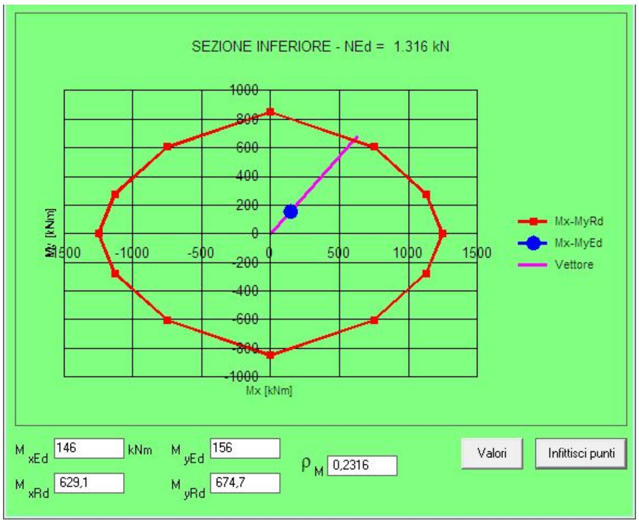
M_{xRd} 1.384 M_{yRd} 44,8

H= 0m		M_x	M_y	N
B-4	*Combo 1*	*146,74*	*156,15*	*942,55*
	Combo 2	*146,74*	*156,15*	*1315,52*



M_{xEd} 146 kNm M_{yEd} 156 ρ_M 0,2457

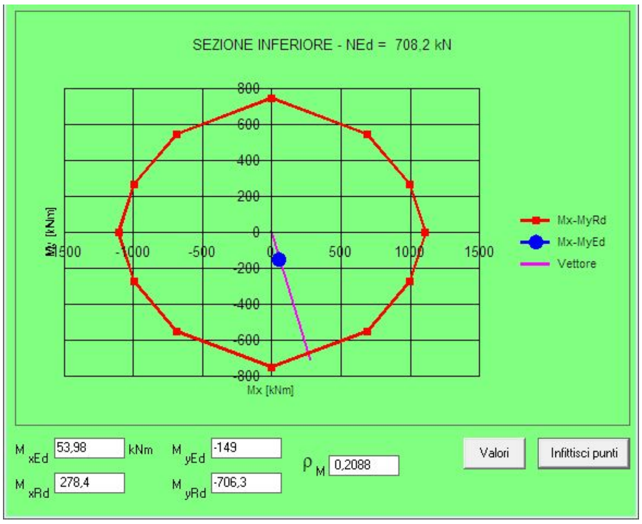
M_{xRd} 587,3 M_{yRd} 641,5



M_{xEd} 146 kNm M_{yEd} 156 ρ_M 0,2316

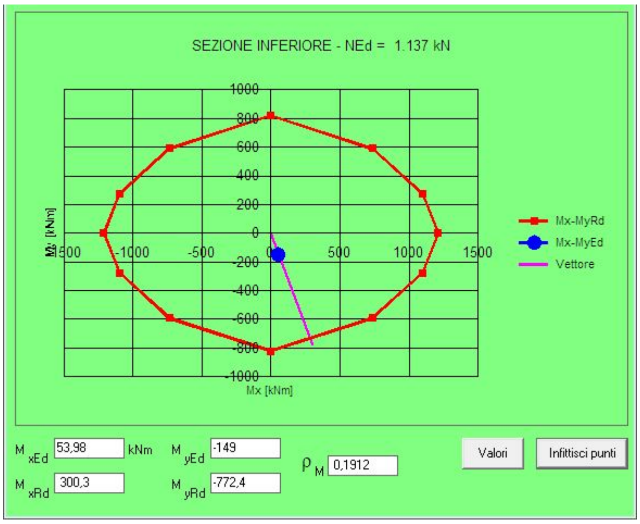
M_{xRd} 629,1 M_{yRd} 674,7

H= 0m		M_x	M_y	N
B-5	*Combo 1*	*53,98*	*-149,00*	*708,23*
	Combo 2	*53,98*	*-149,00*	*1137,44*


SEZIONE INFERIORE - NEd = 708.2 kN

M_{xEd} 53,98 kNm M_{yEd} -149 ρ_M 0,2088

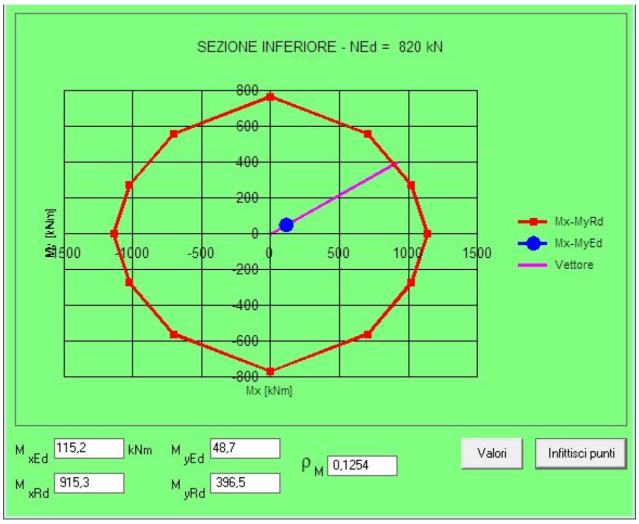
M_{xRd} 278,4 M_{yRd} -706,3


SEZIONE INFERIORE - NEd = 1.137 kN

M_{xEd} 53,98 kNm M_{yEd} -149 ρ_M 0,1912

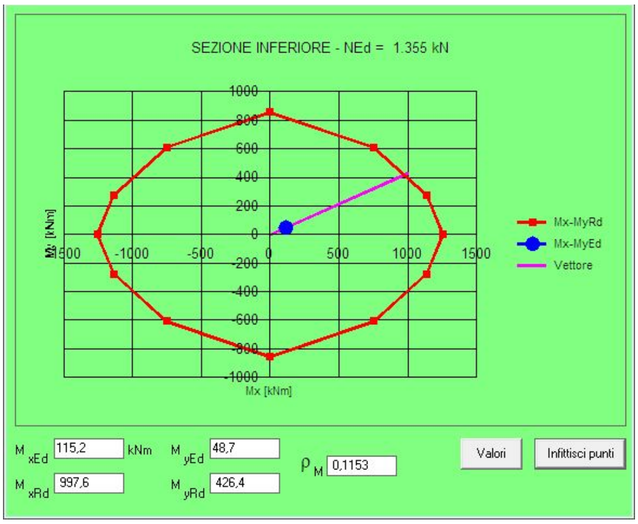
M_{xRd} 300,3 M_{yRd} -772,4

H= 0m		M_x	M_y	N
B-6	*Combo 1*	*115,21*	*48,79*	*820,76*
	Combo 2	*115,21*	*48,79*	*1355,21*


SEZIONE INFERIORE - NEd = 820 kN

M_{xEd} 115,2 kNm M_{yEd} 48,7 ρ_M 0,1254

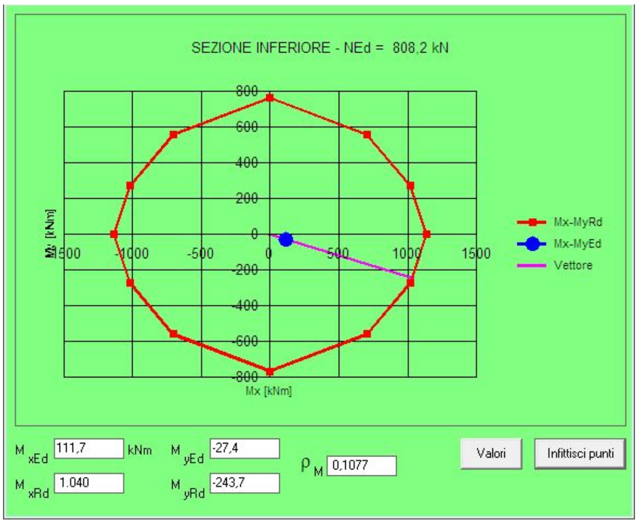
M_{xRd} 915,3 M_{yRd} 396,5


SEZIONE INFERIORE - NEd = 1.355 kN

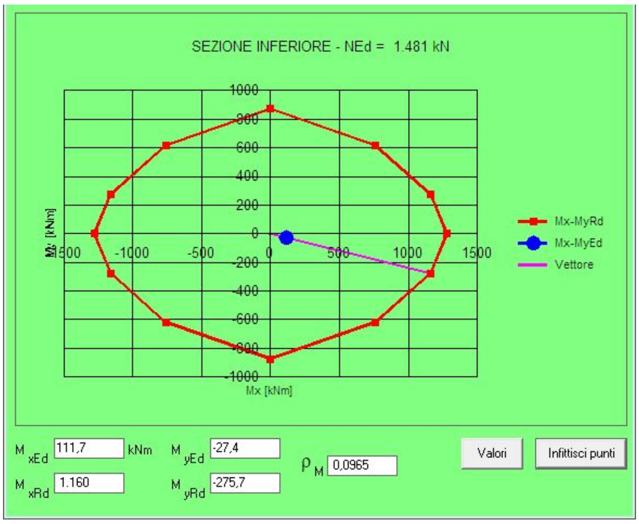
M_{xEd} 115,2 kNm M_{yEd} 48,7 ρ_M 0,1153

M_{xRd} 997,6 M_{yRd} 426,4

H= 0m		M_x	M_y	*N*
B-7	*Combo 1*	*111,71*	*-27,45*	*808,22*
	Combo 2	*111,71*	*-27,45*	*1480,60*

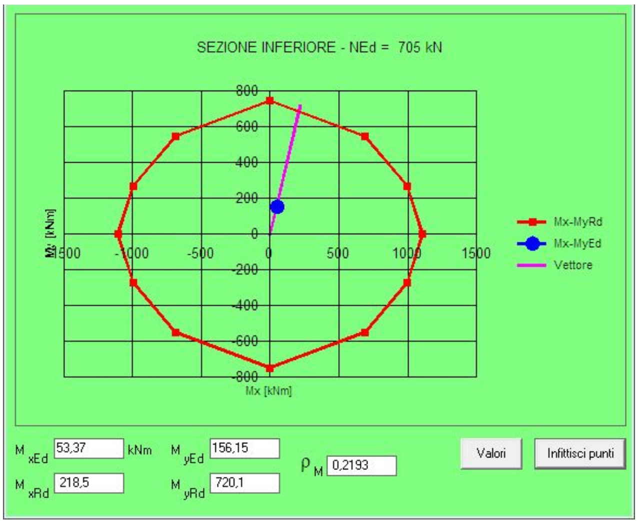


M_{xEd} 111,7 kNm M_{yEd} -27,4 ρ_M 0,1077
M_{xRd} 1.040 M_{yRd} -243,7

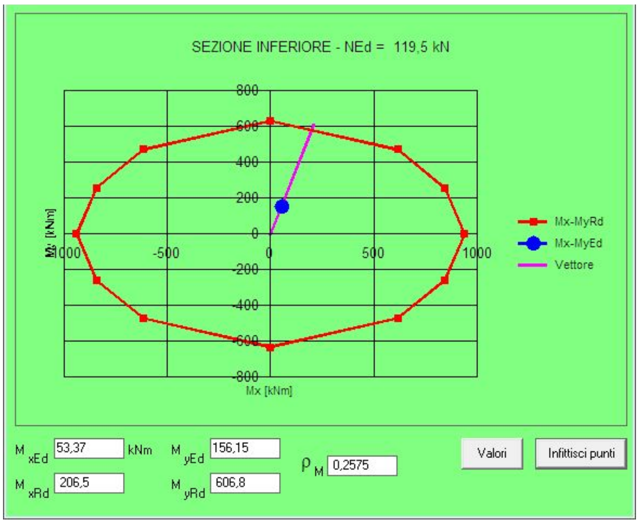


M_{xEd} 111,7 kNm M_{yEd} -27,4 ρ_M 0,0965
M_{xRd} 1.160 M_{yRd} -275,7

H= 0m		M_x	M_y	*N*
B-8	*Combo 1*	*53,37*	*156,15*	*705,02*
	Combo 2	*53,37*	*156,15*	*1119,50*



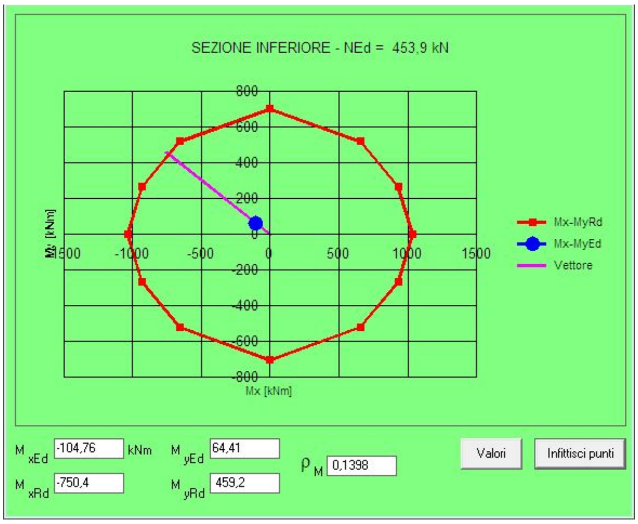
M_{xEd} 53,37 kNm M_{yEd} 156,15 ρ_M 0,2193
M_{xRd} 218,5 M_{yRd} 720,1



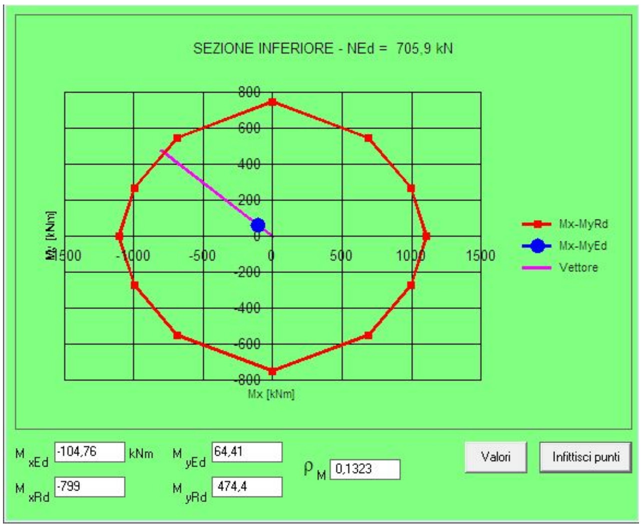
M_{xEd} 53,37 kNm M_{yEd} 156,15 ρ_M 0,2575
M_{xRd} 206,5 M_{yRd} 606,8

B1 H=4 bottom

H= 4m		*M_x*	*M_y*	*N*
B-1	*Combo 1*	*-104,76*	*-64,41*	*453,90*
	Combo 2	*-104,76*	*-64,41*	*705,93*

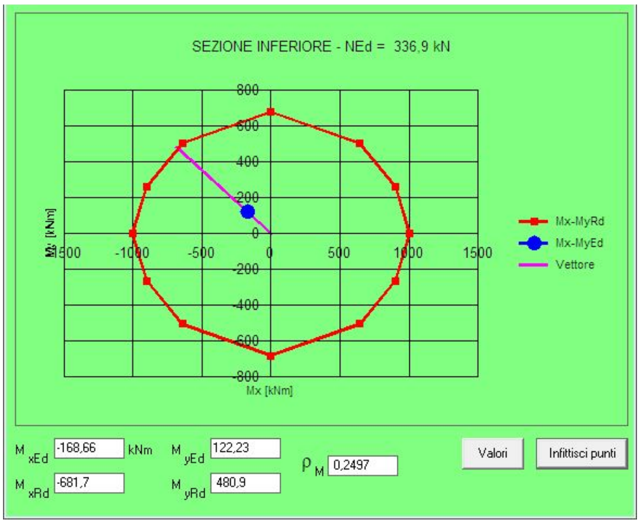


M_{xEd} -104,76 kNm
M_{yEd} 64,41
ρ_M 0,1398
M_{xRd} -750,4
M_{yRd} 459,2

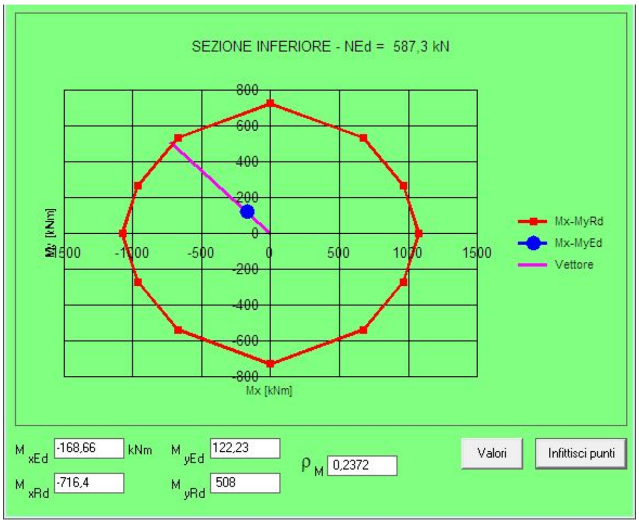


M_{xEd} -104,76 kNm
M_{yEd} 64,41
ρ_M 0,1323
M_{xRd} -799
M_{yRd} 474,4

H= 4m		*M_x*	*M_y*	*N*
B-2	*Combo 1*	*-168,66*	*122,23*	*336,87*
	Combo 2	*-168,66*	*122,23*	*587,31*

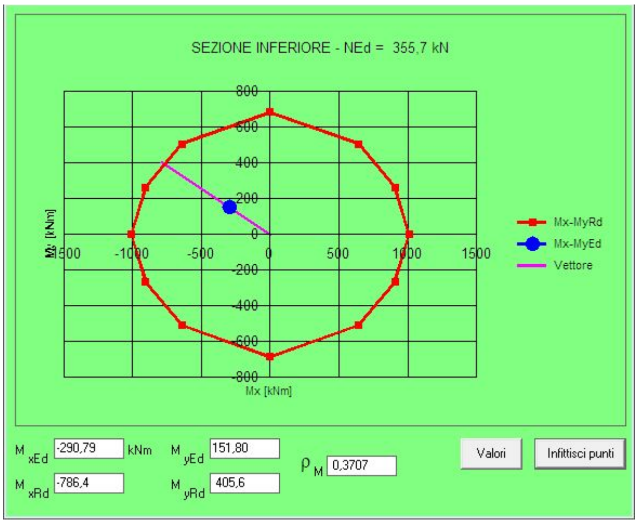


M_{xEd} -168,66 kNm
M_{yEd} 122,23
ρ_M 0,2497
M_{xRd} -681,7
M_{yRd} 480,9



M_{xEd} -168,66 kNm
M_{yEd} 122,23
ρ_M 0,2372
M_{xRd} -716,4
M_{yRd} 508

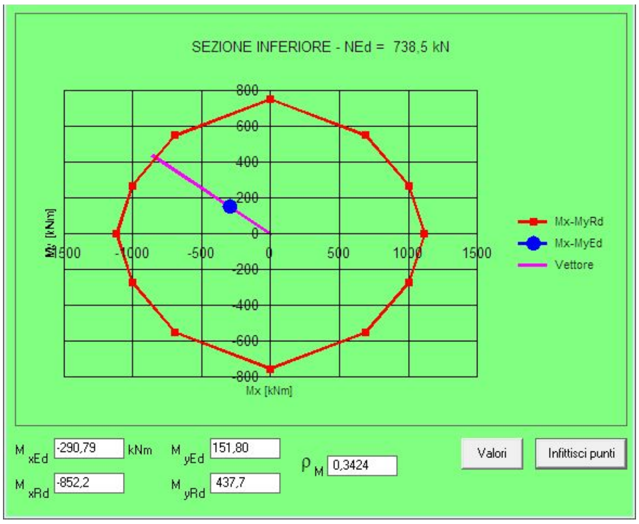
H= 4m		M_x	M_y	N
B-3	*Combo 1*	*-290,79*	*151,81*	*355,74*
	Combo 2	*-290,79*	*151,81*	*738,46*


SEZIONE INFERIORE - NEd = 355,7 kN

M_{xEd} -290,79 kNm M_{yEd} 151,80

M_{xRd} -786,4 M_{yRd} 405,6

ρ_M 0,3707

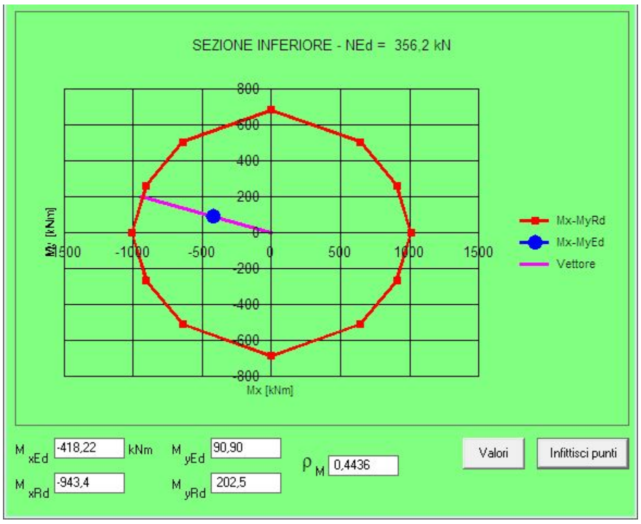

SEZIONE INFERIORE - NEd = 738,5 kN

M_{xEd} -290,79 kNm M_{yEd} 151,80

M_{xRd} -852,2 M_{yRd} 437,7

ρ_M 0,3424

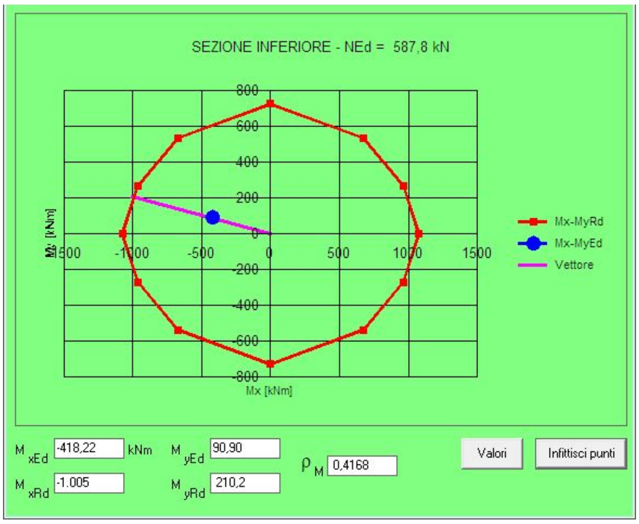
H= 4m		M_x	M_y	N
B-4	*Combo 1*	*-418,22*	*90,90*	*356,17*
	Combo 2	*-418,22*	*90,90*	*587,75*


SEZIONE INFERIORE - NEd = 356,2 kN

M_{xEd} -418,22 kNm M_{yEd} 90,90

M_{xRd} -943,4 M_{yRd} 202,5

ρ_M 0,4436

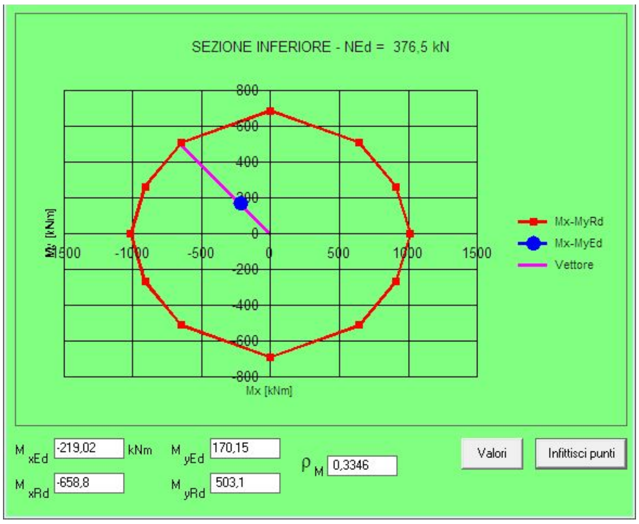

SEZIONE INFERIORE - NEd = 587,8 kN

M_{xEd} -418,22 kNm M_{yEd} 90,90

M_{xRd} -1.005 M_{yRd} 210,2

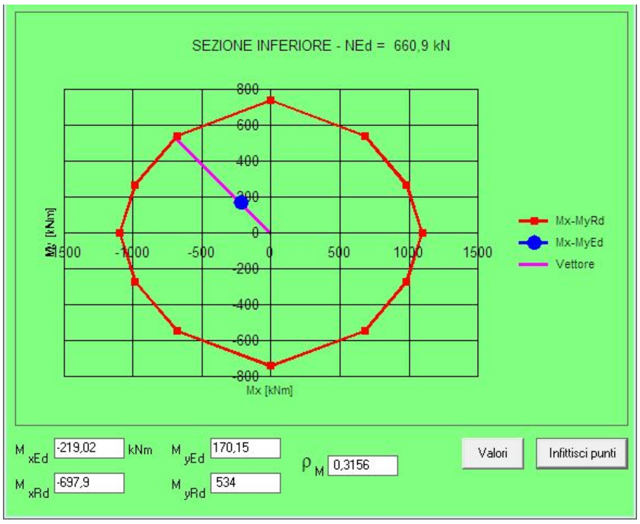
ρ_M 0,4168

H= 4m		M_x	M_y	*N*
B-5	*Combo 1*	*-206,03*	*-91,71*	*352,42*
	Combo 2	*-206,03*	*-91,71*	*550,60*



M_{xEd} -219,02 kNm M_{yEd} 170,15 ρ_M 0,3346

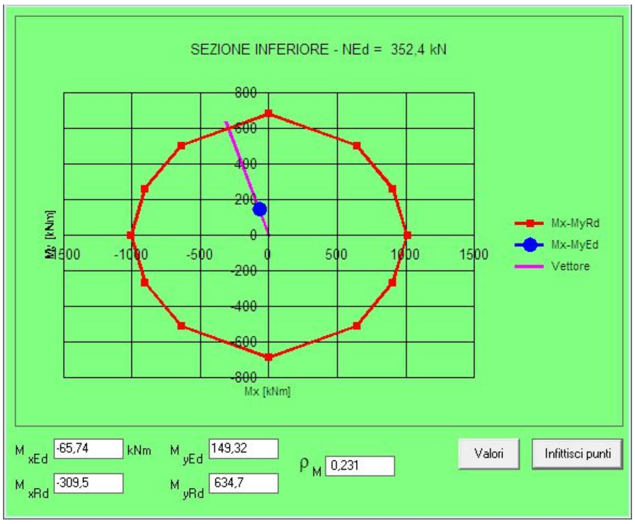
M_{xRd} -658,8 M_{yRd} 503,1



M_{xEd} -219,02 kNm M_{yEd} 170,15 ρ_M 0,3156

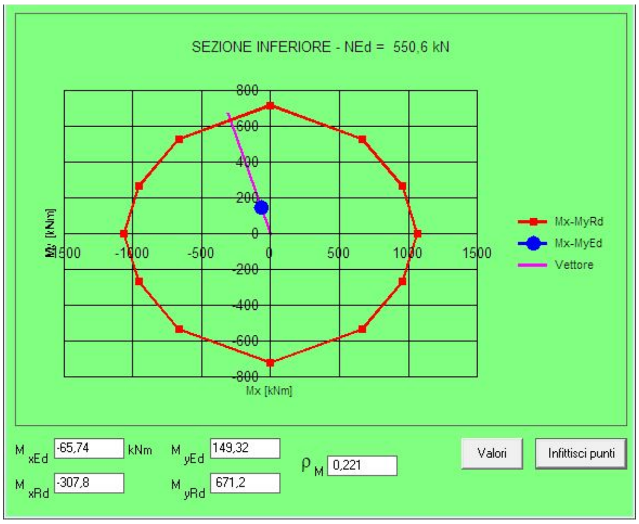
M_{xRd} -697,9 M_{yRd} 534

H= 4m		M_x	M_y	*N*
B-6	*Combo 1*	*-328,94*	*164,30*	*376,53*
	Combo 2	*-328,94*	*164,30*	*660,85*



M_{xEd} -65,74 kNm M_{yEd} 149,32 ρ_M 0,231

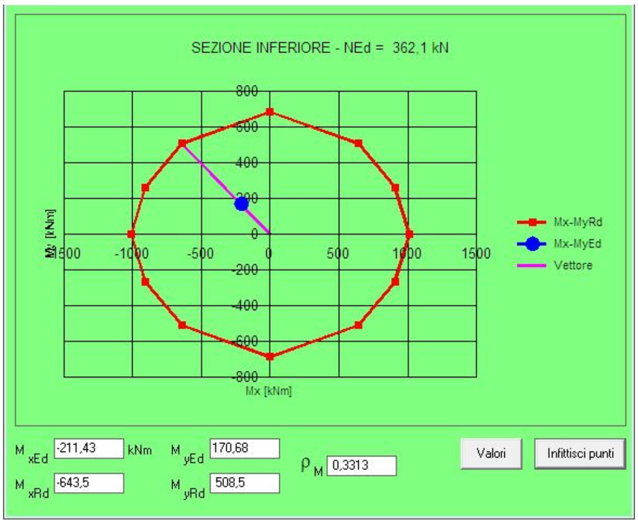
M_{xRd} -309,5 M_{yRd} 634,7



M_{xEd} -65,74 kNm M_{yEd} 149,32 ρ_M 0,221

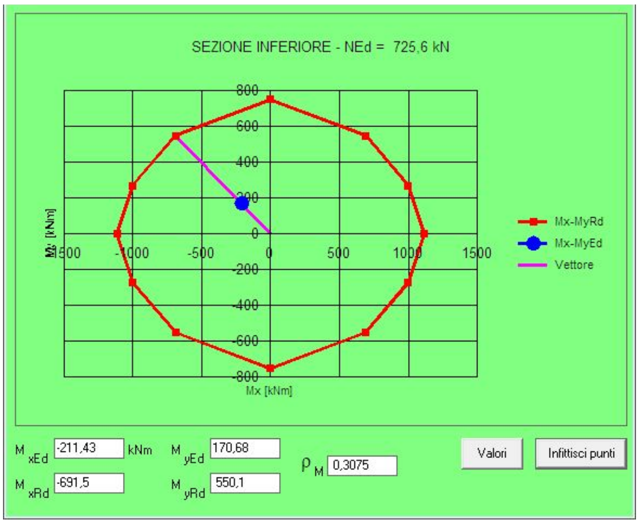
M_{xRd} -307,8 M_{yRd} 671,2

	H= 4m	M_x	M_y	N
B-7	Combo 1	-336,53	-163,77	362,07
	Combo 2	-336,53	-163,77	735,60



M_{xEd} -211,43 kNm M_{yEd} 170,68 ρ_M 0,3313

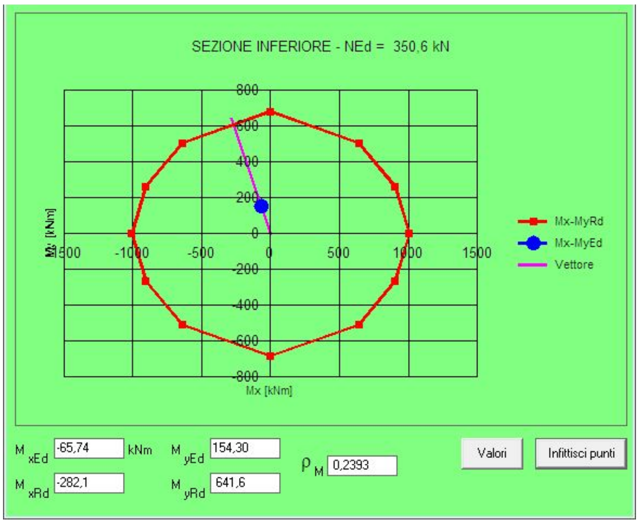
M_{xRd} -643,5 M_{yRd} 508,5



M_{xEd} -211,43 kNm M_{yEd} 170,68 ρ_M 0,3075

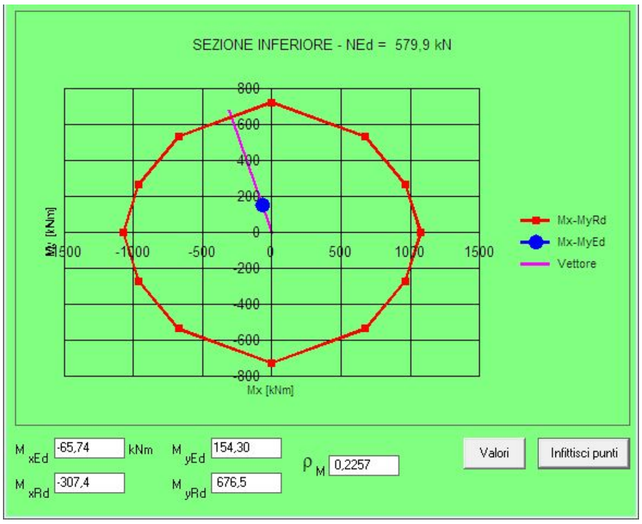
M_{xRd} -691,5 M_{yRd} 550,1

	H= 4m	M_x	M_y	N
B-8	Combo 1	-206,03	92,40	350,64
	Combo 2	-206,03	92,40	579,91



M_{xEd} -65,74 kNm M_{yEd} 154,30 ρ_M 0,2393

M_{xRd} -282,1 M_{yRd} 641,6

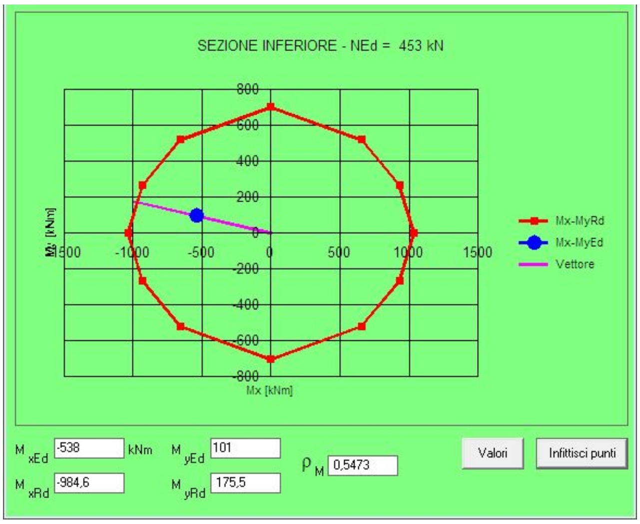


M_{xEd} -65,74 kNm M_{yEd} 154,30 ρ_M 0,2257

M_{xRd} -307,4 M_{yRd} 676,5

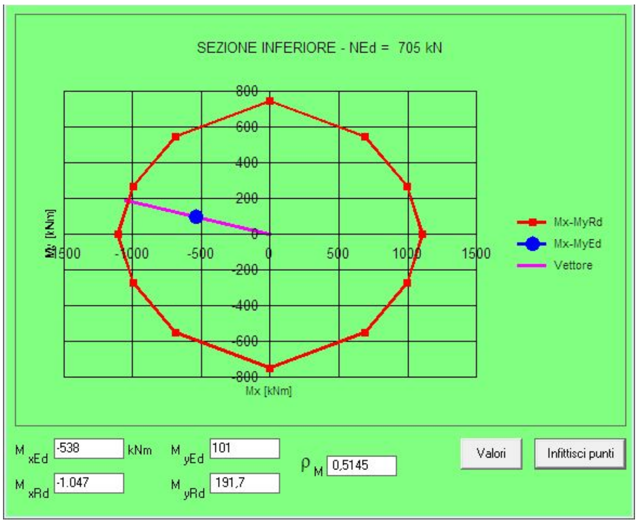
B1 H=4 top

H= 4m		M_x	M_y	*N*
B-1	*Combo 1*	*-538,54*	*-101,94*	*453,90*
	Combo 2	*-538,54*	*-101,94*	*705,93*



M_{xEd} -538 kNm M_{yEd} 101 ρ_M 0,5473

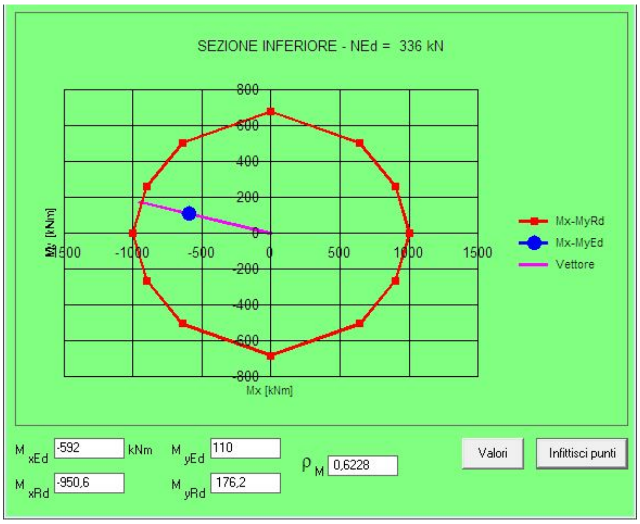
M_{xRd} -984,6 M_{yRd} 175,5



M_{xEd} -538 kNm M_{yEd} 101 ρ_M 0,5145

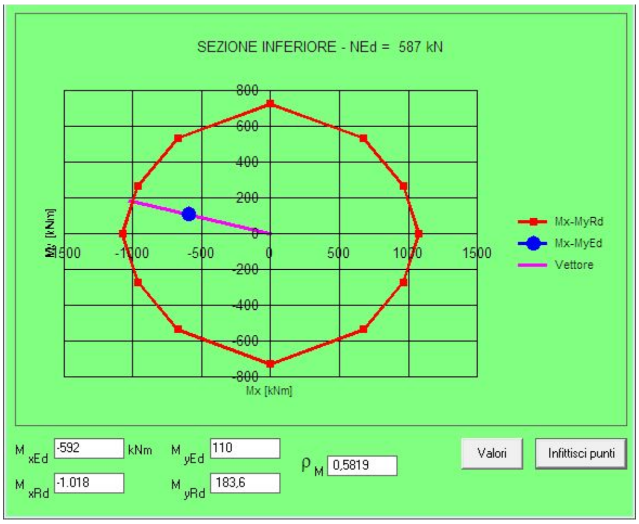
M_{xRd} -1.047 M_{yRd} 191,7

H= 4m		M_x	M_y	*N*
B-2	*Combo 1*	*-592,82*	*110,66*	*336,87*
	Combo 2	*-592,82*	*110,66*	*587,31*



M_{xEd} -592 kNm M_{yEd} 110 ρ_M 0,6228

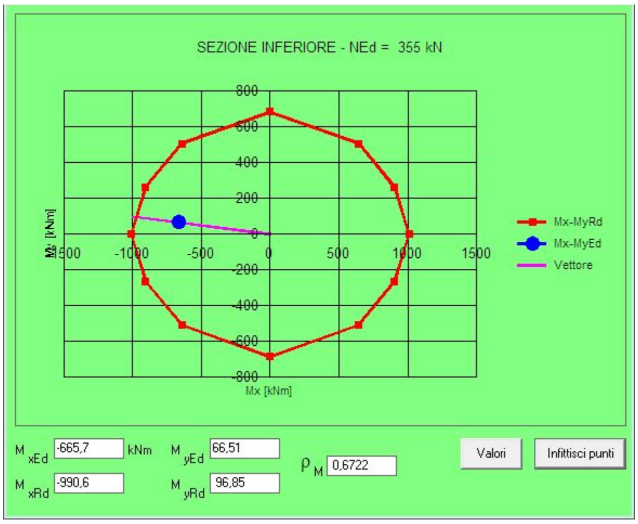
M_{xRd} -950,6 M_{yRd} 176,2



M_{xEd} -592 kNm M_{yEd} 110 ρ_M 0,5819

M_{xRd} -1.018 M_{yRd} 183,6

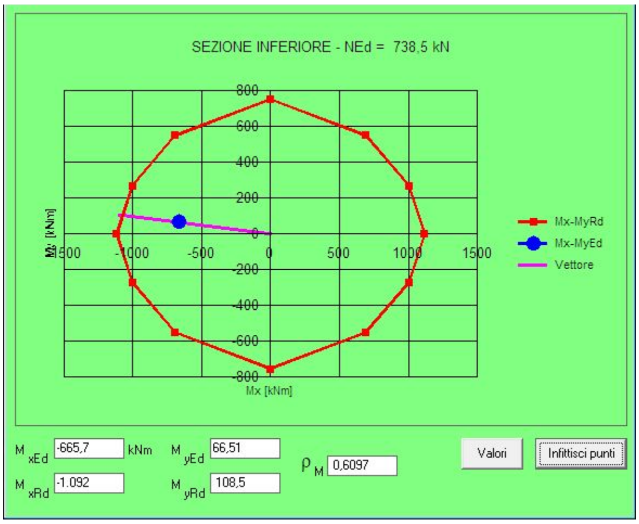
H= 4m		M_x	M_y	N
B-3	Combo 1	-665,69	66,51	355,74
	Combo 2	-665,69	66,51	738,46



M_{xEd} -665,7 kNm M_{yEd} 66,51

M_{xRd} -990,6 M_{yRd} 96,85

ρ_M 0,6722

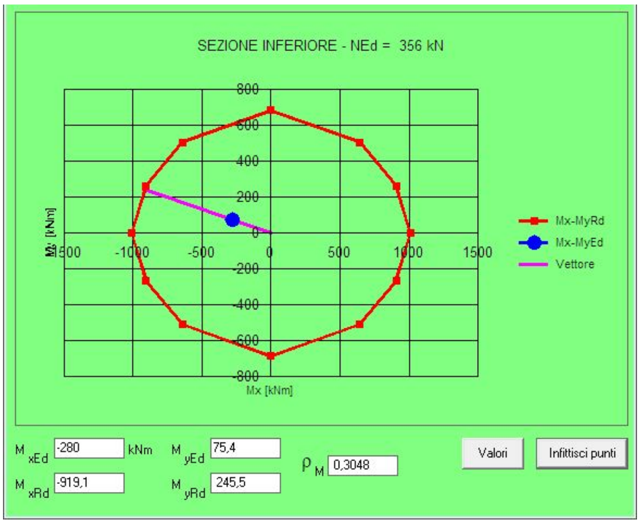


M_{xEd} -665,7 kNm M_{yEd} 66,51

M_{xRd} -1.092 M_{yRd} 108,5

ρ_M 0,6097

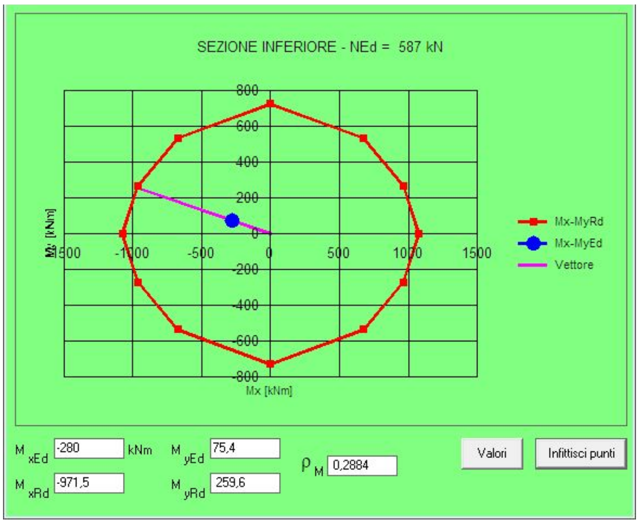
H= 4m		M_x	M_y	N
B-4	Combo 1	-280,78	75,45	356,17
	Combo 2	-280,78	75,45	587,75



M_{xEd} -280 kNm M_{yEd} 75,4

M_{xRd} -919,1 M_{yRd} 245,5

ρ_M 0,3048

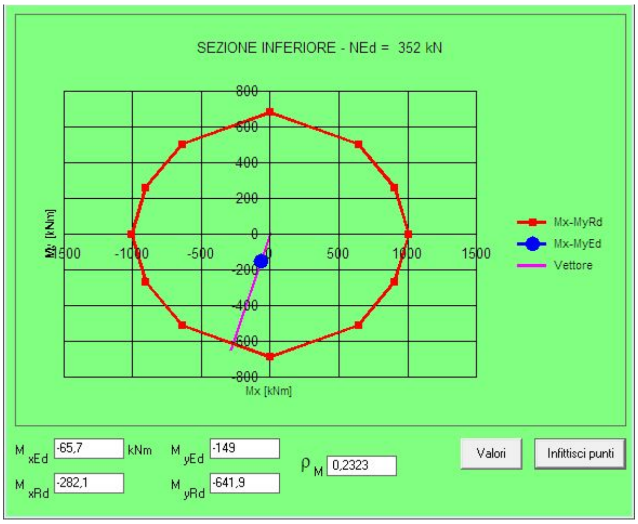


M_{xEd} -280 kNm M_{yEd} 75,4

M_{xRd} -971,5 M_{yRd} 259,6

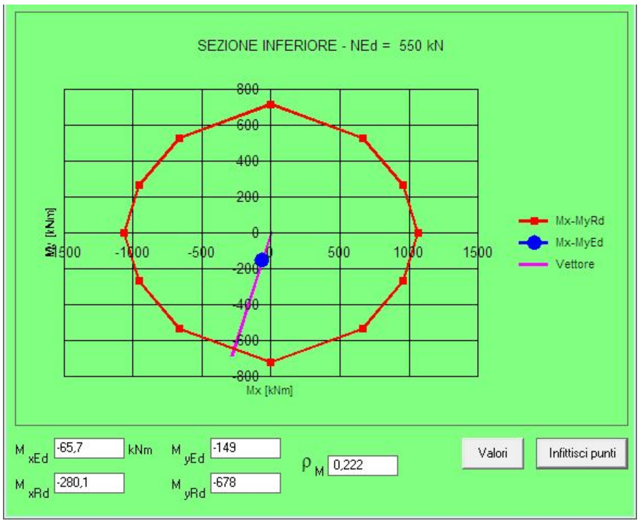
ρ_M 0,2884

H= 4m		M_x	M_y	*N*
B-5	*Combo 1*	*-65,74*	*-149,32*	*352,42*
	Combo 2	*-65,74*	*-149,32*	*550,60*


SEZIONE INFERIORE - NEd = 352 kN

M_{xEd} -65,7 kNm M_{yEd} -149 ρ_M 0,2323

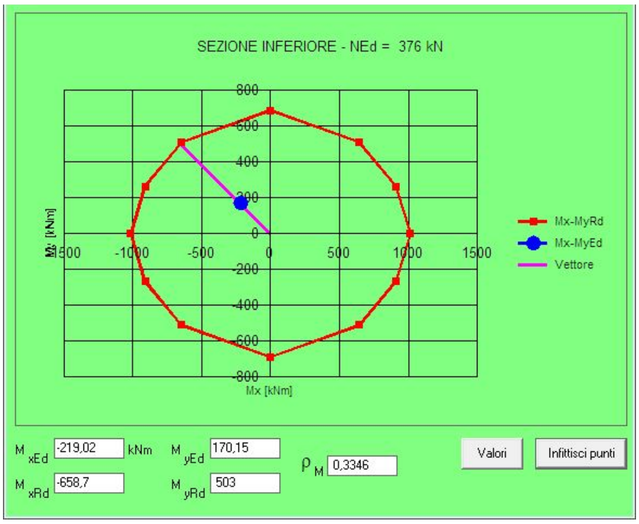
M_{xRd} -282,1 M_{yRd} -641,9


SEZIONE INFERIORE - NEd = 550 kN

M_{xEd} -65,7 kNm M_{yEd} -149 ρ_M 0,222

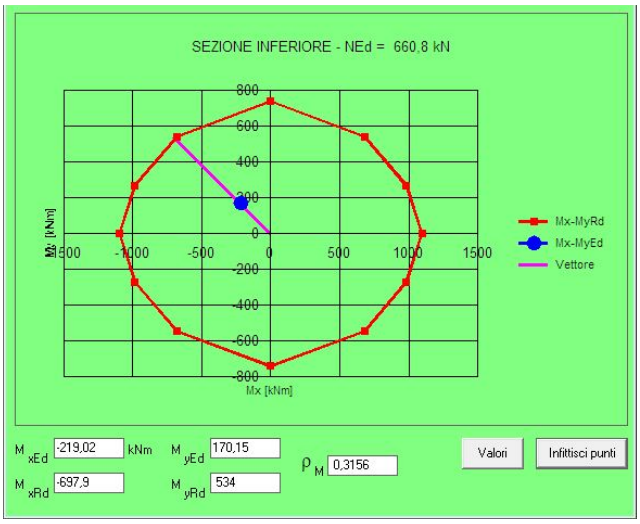
M_{xRd} -280,1 M_{yRd} -678

H= 4m		M_x	M_y	*N*
B-6	*Combo 1*	*-219,02*	*170,15*	*376,53*
	Combo 2	*-219,02*	*170,15*	*660,85*


SEZIONE INFERIORE - NEd = 376 kN

M_{xEd} -219,02 kNm M_{yEd} 170,15 ρ_M 0,3346

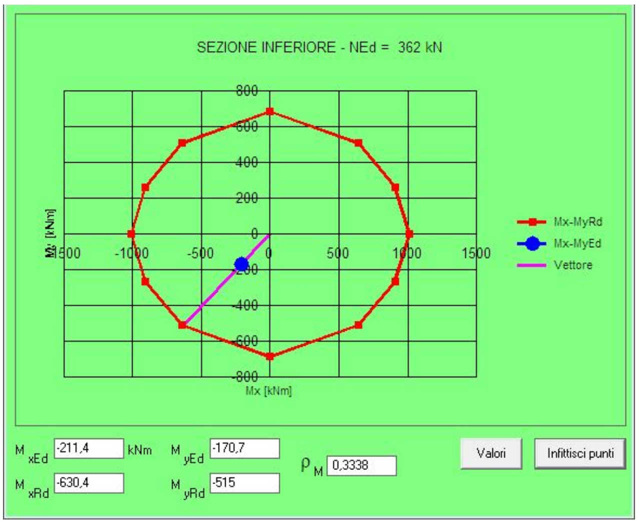
M_{xRd} -658,7 M_{yRd} 503


SEZIONE INFERIORE - NEd = 660,8 kN

M_{xEd} -219,02 kNm M_{yEd} 170,15 ρ_M 0,3156

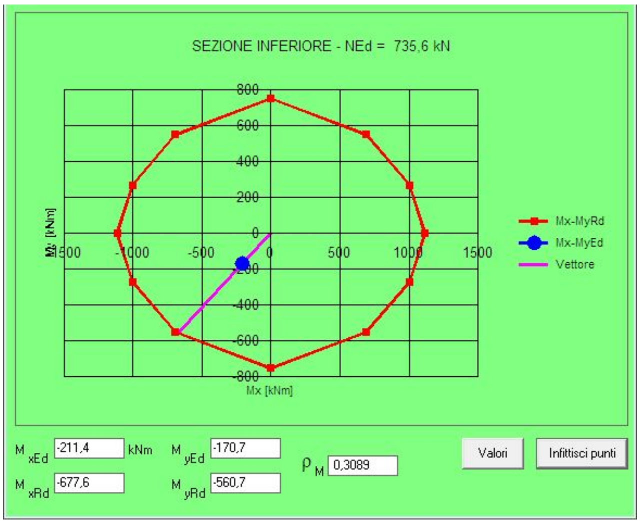
M_{xRd} -697,9 M_{yRd} 534

	H= 4m	M_x	M_y	N
B-7	Combo 1	-211,43	-170,68	362,07
	Combo 2	-211,43	-170,68	735,60



M_{xEd} -211,4 kNm M_{yEd} -170,7 ρ_M 0,3338

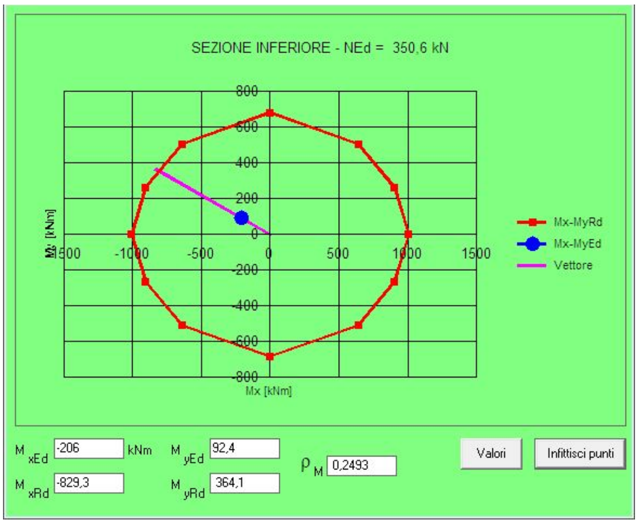
M_{xRd} -630,4 M_{yRd} -515



M_{xEd} -211,4 kNm M_{yEd} -170,7 ρ_M 0,3089

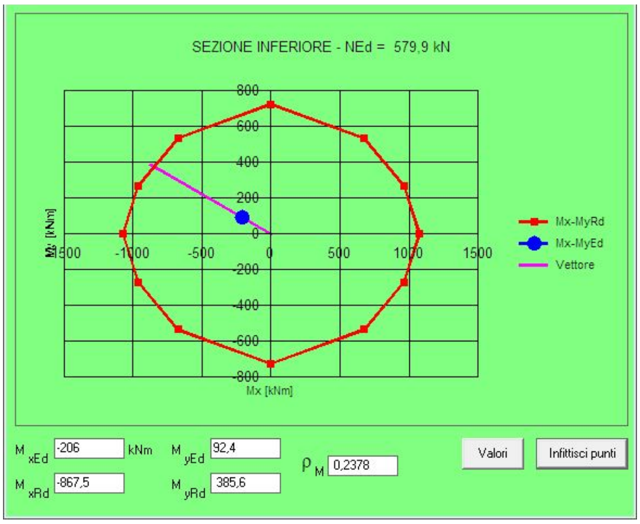
M_{xRd} -677,6 M_{yRd} -560,7

	H= 4m	M_x	M_y	N
B-8	Combo 1	-206,03	92,40	350,64
	Combo 2	-206,03	92,40	579,91



M_{xEd} -206 kNm M_{yEd} 92,4 ρ_M 0,2493

M_{xRd} -829,3 M_{yRd} 364,1

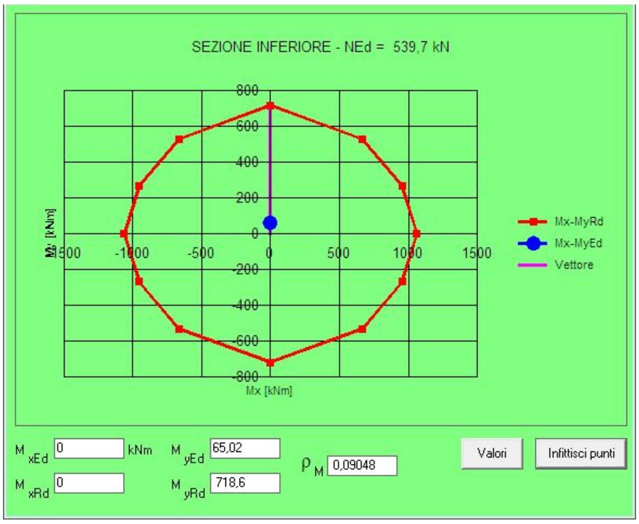


M_{xEd} -206 kNm M_{yEd} 92,4 ρ_M 0,2378

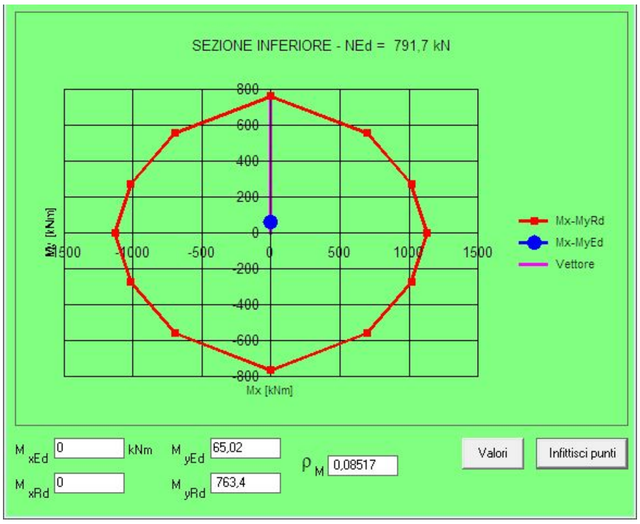
M_{xRd} -867,5 M_{yRd} 385,6

B1 H=13 inferiore

H= 13m		M_x	M_y	*N*
B-1	*Combo 1*	*-65,02*	*0,00*	*539,68*
	Combo 2	*-65,02*	*0,00*	*791,70*

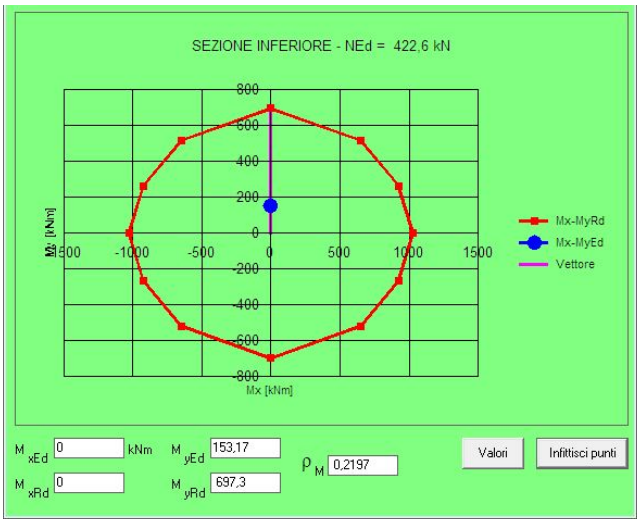


M_{xEd} 0 kNm
M_{xRd} 0
M_{yEd} 65,02
M_{yRd} 718,6
ρ_M 0,09048

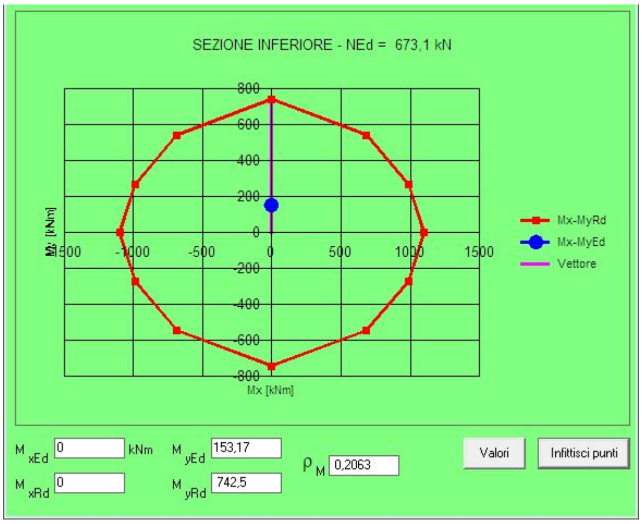


M_{xEd} 0 kNm
M_{xRd} 0
M_{yEd} 65,02
M_{yRd} 763,4
ρ_M 0,08517

H= 13m		M_x	M_y	*N*
B-2	*Combo 1*	*-153,17*	*0,00*	*422,64*
	Combo 2	*-153,17*	*0,00*	*673,09*

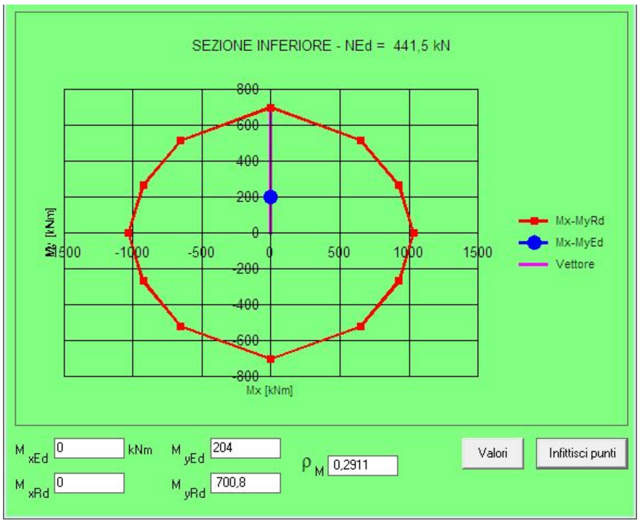


M_{xEd} 0 kNm
M_{xRd} 0
M_{yEd} 153,17
M_{yRd} 697,3
ρ_M 0,2197



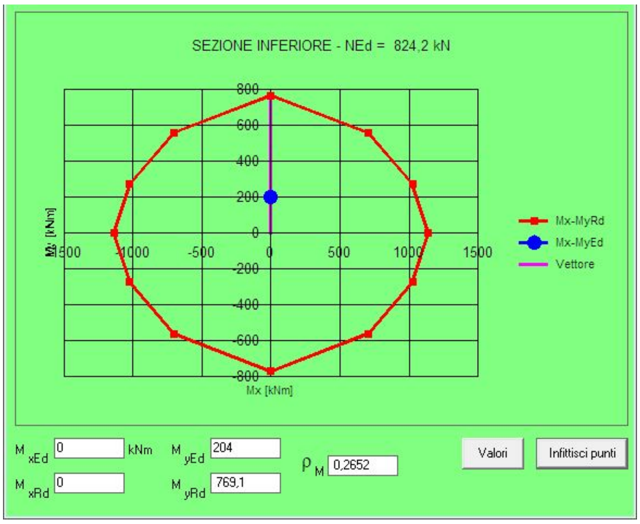
M_{xEd} 0 kNm
M_{xRd} 0
M_{yEd} 153,17
M_{yRd} 742,5
ρ_M 0,2063

H= 13m		M_x	M_y	N
B-3	Combo 1	-204,88	0,00	441,51
	Combo 2	-204,88	0,00	824,23



M_{xEd} 0 kNm M_{yEd} 204 ρ_M 0,2911

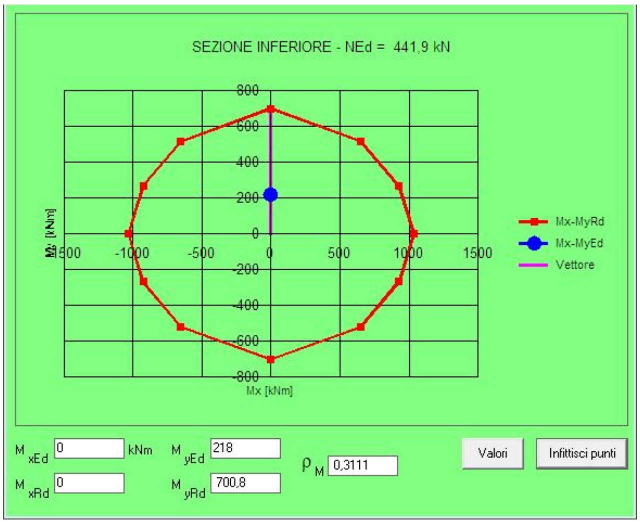
M_{xRd} 0 M_{yRd} 700,8



M_{xEd} 0 kNm M_{yEd} 204 ρ_M 0,2652

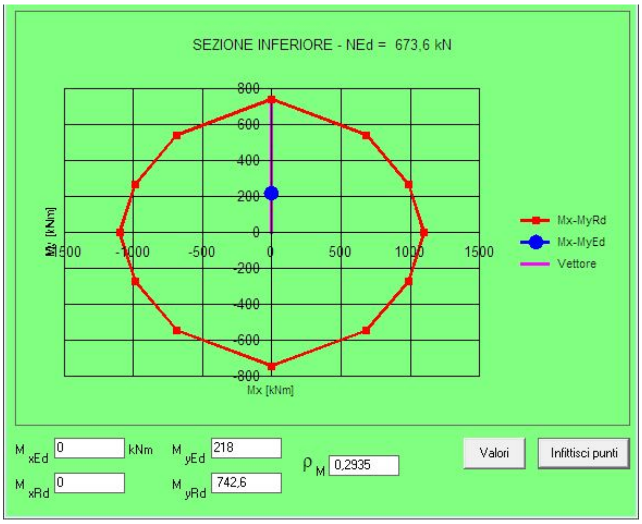
M_{xRd} 0 M_{yRd} 769,1

H= 13m		M_x	M_y	N
B-4	Combo 1	-218,57	0,00	441,94
	Combo 2	-218,57	0,00	673,53



M_{xEd} 0 kNm M_{yEd} 218 ρ_M 0,3111

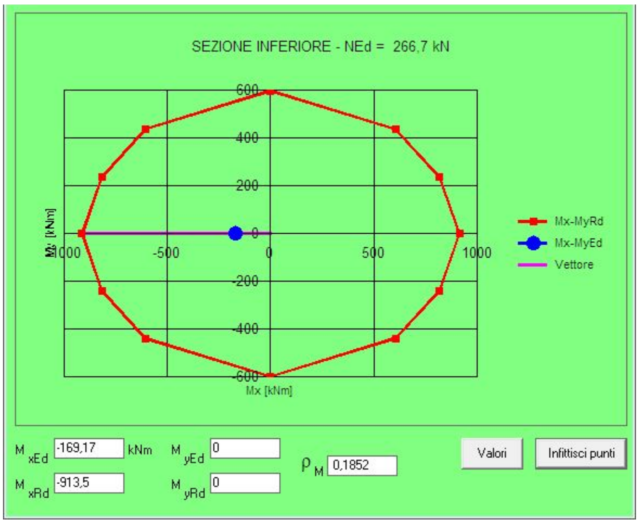
M_{xRd} 0 M_{yRd} 700,8



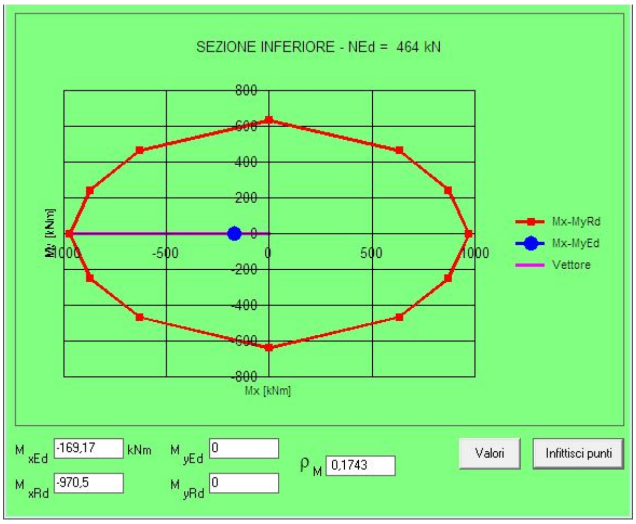
M_{xEd} 0 kNm M_{yEd} 218 ρ_M 0,2935

M_{xRd} 0 M_{yRd} 742,6

H= 13m		M_x	M_y	*N*
B-5	*Combo 1*	*-169,17*	*0,00*	*266,65*
	Combo 2	*-169,17*	*0,00*	*464,83*

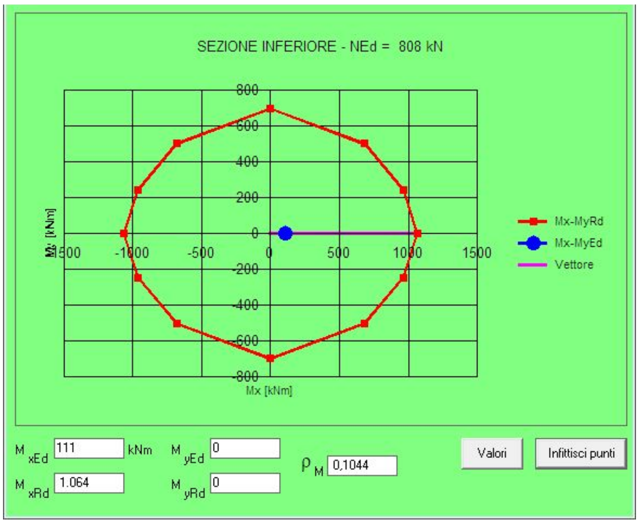


M_{xEd} -169,17 kNm
M_{yEd} 0
M_{xRd} -913,5
M_{yRd} 0
ρ_M 0,1852

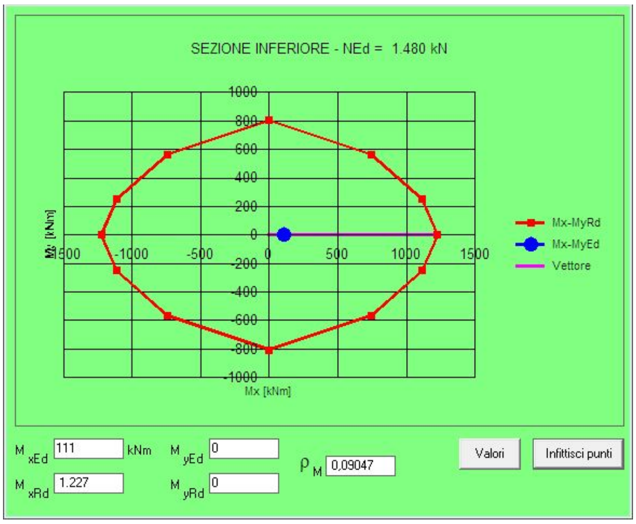


M_{xEd} -169,17 kNm
M_{yEd} 0
M_{xRd} -970,5
M_{yRd} 0
ρ_M 0,1743

H= 0m		M_x	M_y	*N*
B-6	*Combo 1*	*115,21*	*0,00*	*820,76*
	Combo 2	*115,21*	*0,00*	*1355,21*

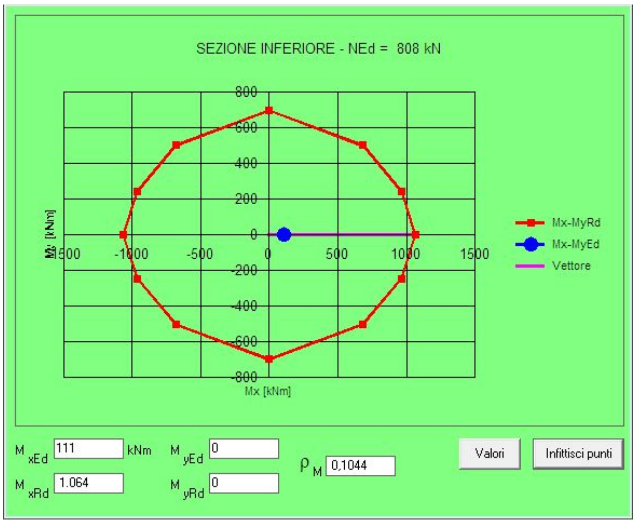


M_{xEd} 111 kNm
M_{yEd} 0
M_{xRd} 1.064
M_{yRd} 0
ρ_M 0,1044



M_{xEd} 111 kNm
M_{yEd} 0
M_{xRd} 1.227
M_{yRd} 0
ρ_M 0,09047

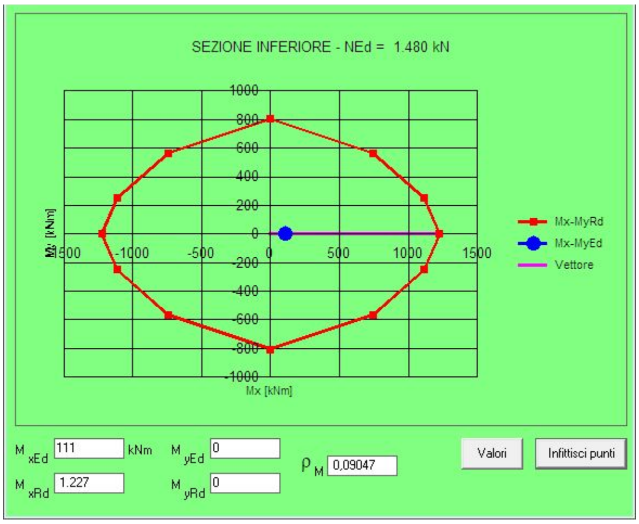
H= 0m		M_x	M_y	N
B-7	Combo 1	111,71	0,00	808,22
	Combo 2	111,71	0,00	1480,60



M_{xEd} 111 kNm M_{yEd} 0

M_{xRd} 1.064 M_{yRd} 0

ρ_M 0,1044

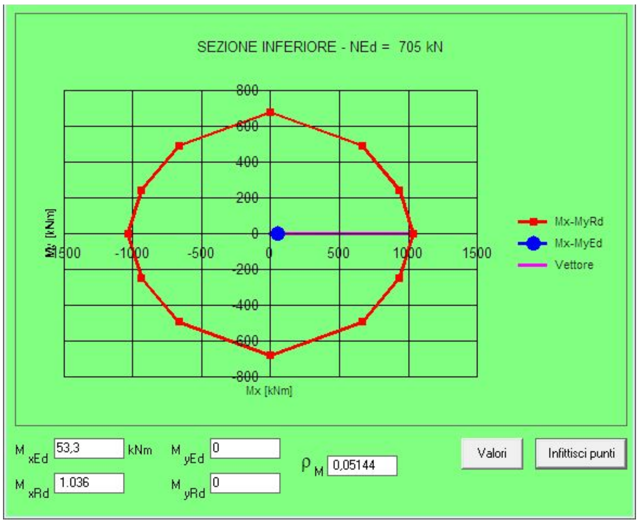


M_{xEd} 111 kNm M_{yEd} 0

M_{xRd} 1.227 M_{yRd} 0

ρ_M 0,09047

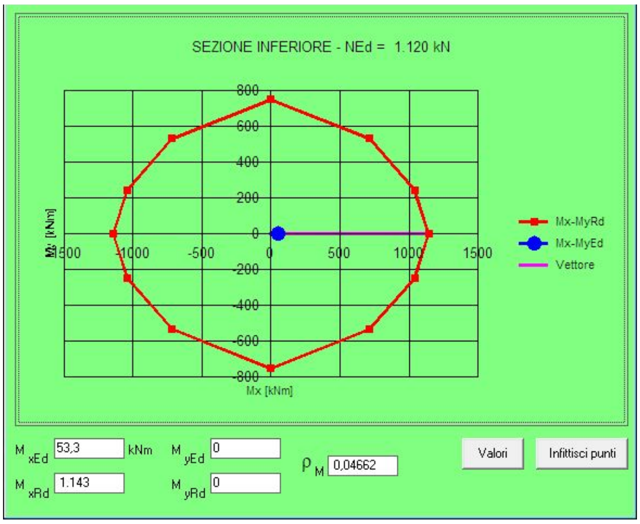
H= 0m		M_x	M_y	N
B-8	Combo 1	53,37	0,00	705,02
	Combo 2	53,37	0,00	1119,50



M_{xEd} 53,3 kNm M_{yEd} 0

M_{xRd} 1.036 M_{yRd} 0

ρ_M 0,05144



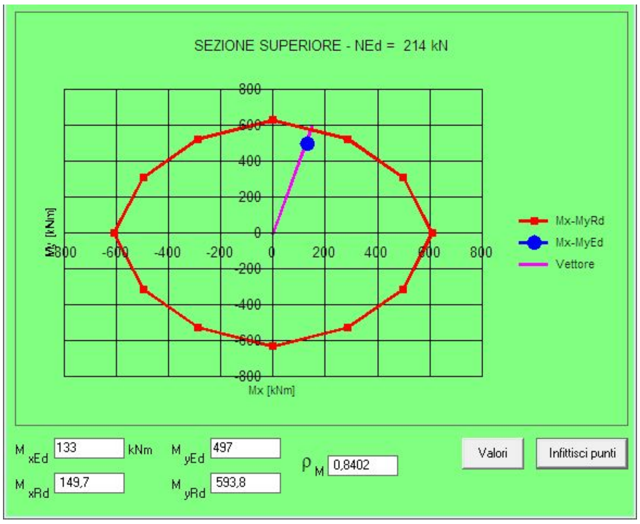
M_{xEd} 53,3 kNm M_{yEd} 0

M_{xRd} 1.143 M_{yRd} 0

ρ_M 0,04662

CH=0 superiore

H= 0m		M_x	M_y	*N*
C-1	*Combo 1*	*133,08*	*497,01*	*214,47*
	Combo 2	*133,08*	*497,01*	*302,86*



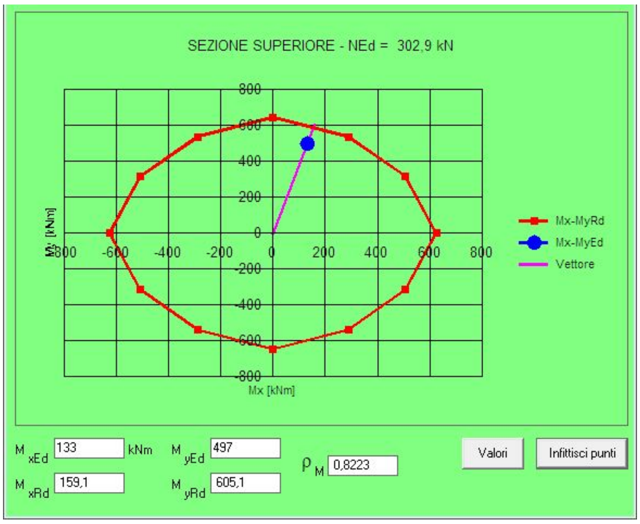
M_{xEd} 133 kNm

M_{yEd} 497

M_{xRd} 149,7

M_{yRd} 593,8

ρ_M 0,8402



M_{xEd} 133 kNm

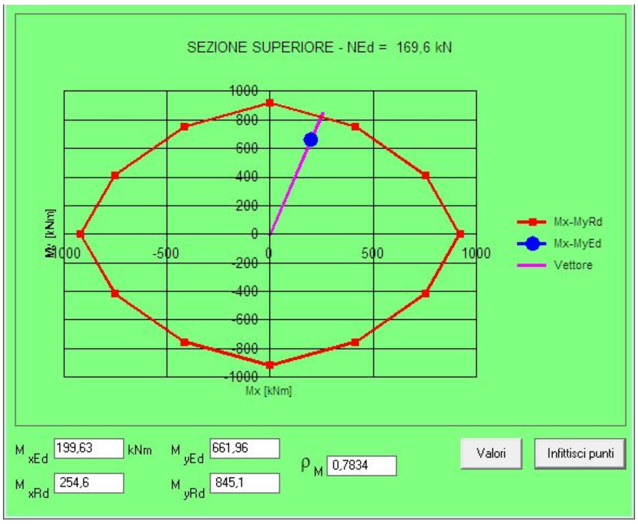
M_{yEd} 497

M_{xRd} 159,1

M_{yRd} 605,1

ρ_M 0,8223

H= 0m		M_x	M_y	*N*
C-2	*Combo 1*	*199,63*	*661,96*	*169,63*
	Combo 2	*199,63*	*661,96*	*223,42*



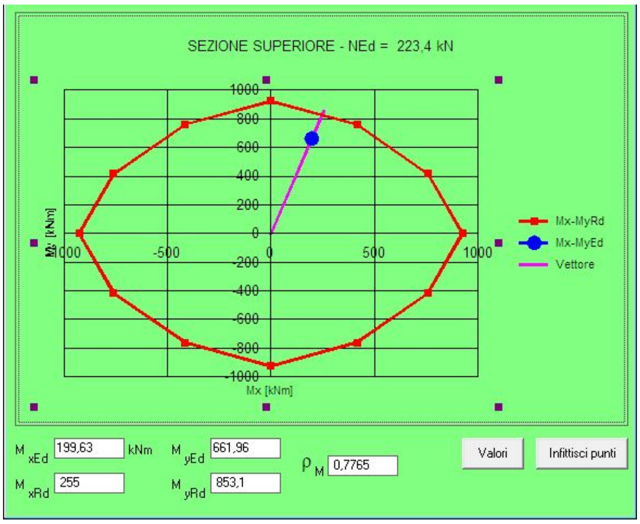
M_{xEd} 199,63 kNm

M_{yEd} 661,96

M_{xRd} 254,6

M_{yRd} 845,1

ρ_M 0,7834



M_{xEd} 199,63 kNm

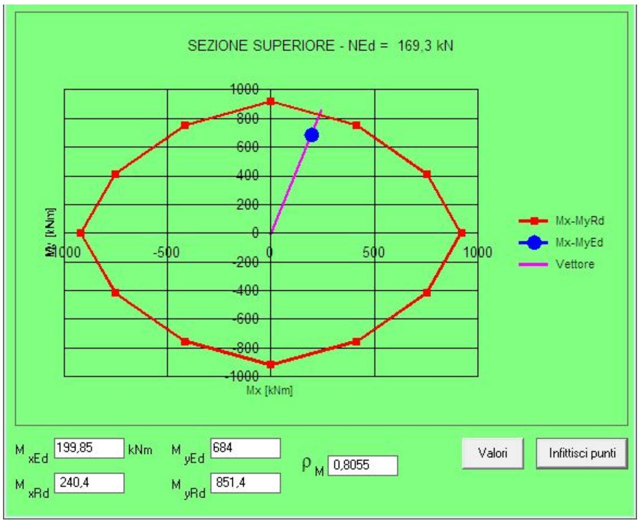
M_{yEd} 661,96

M_{xRd} 255

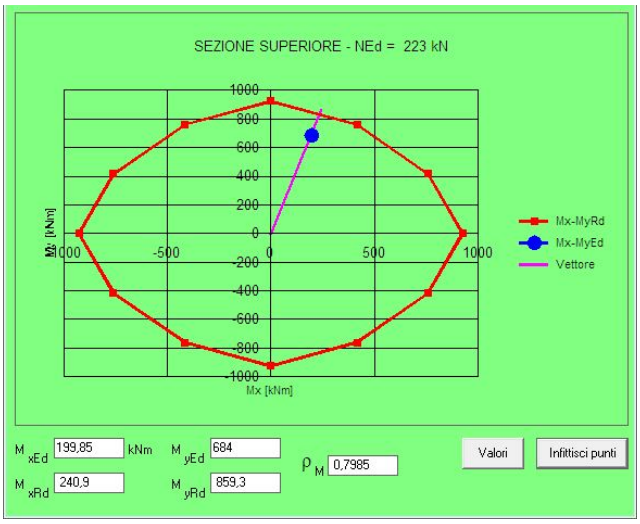
M_{yRd} 853,1

ρ_M 0,7765

H= 0m		*M_x*	*M_y*	*N*
C-3	*Combo 1*	*199,63*	*661,96*	*169,27*
	Combo 2	*199,63*	*661,96*	*222,95*

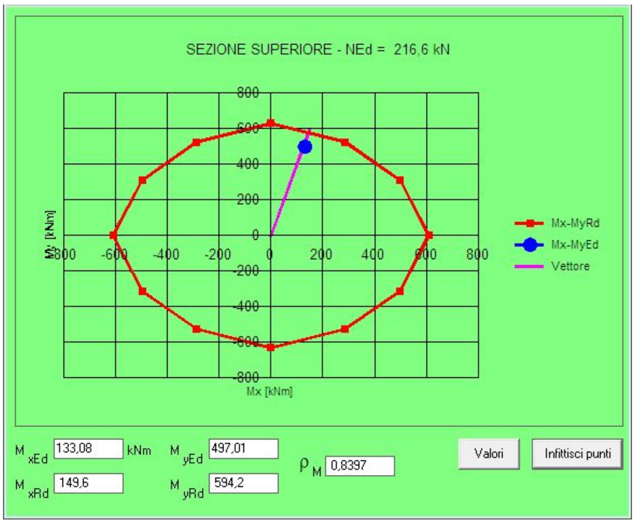


M_{xEd} 199,85 kNm M_{yEd} 684 ρ_M 0,8055
M_{xRd} 240,4 M_{yRd} 851,4

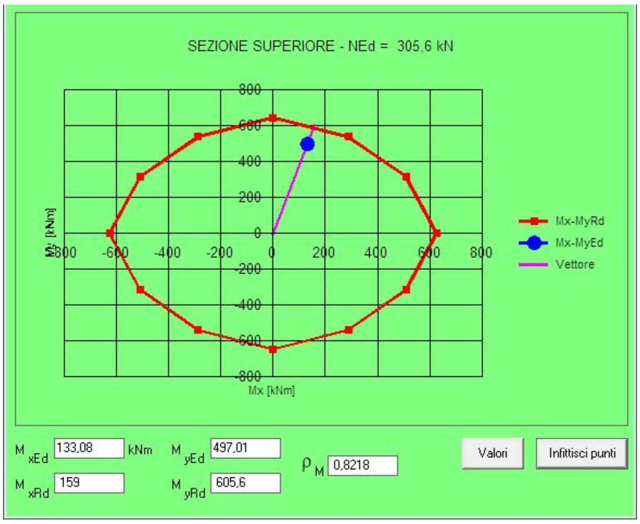


M_{xEd} 199,85 kNm M_{yEd} 684 ρ_M 0,7985
M_{xRd} 240,9 M_{yRd} 859,3

H= 0m		*M_x*	*M_y*	*N*
C-4	*Combo 1*	*133,08*	*497,01*	*216,56*
	Combo 2	*133,08*	*497,01*	*305,56*

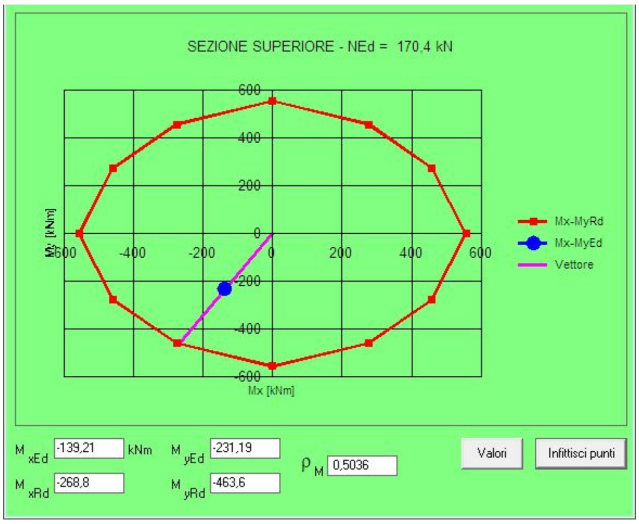


M_{xEd} 133,08 kNm M_{yEd} 497,01 ρ_M 0,8397
M_{xRd} 149,6 M_{yRd} 594,2



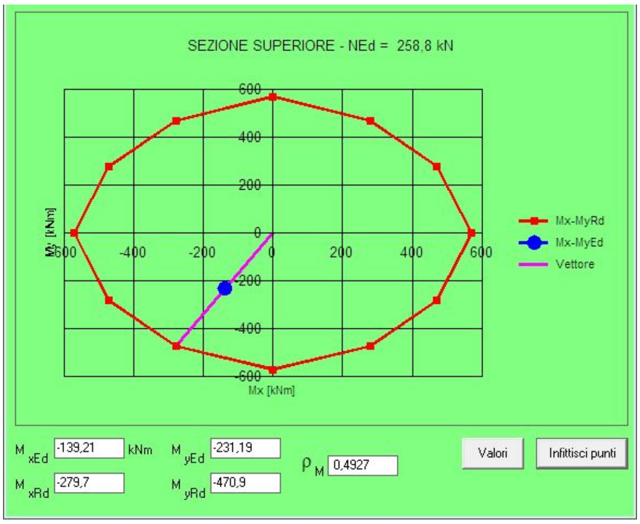
M_{xEd} 133,08 kNm M_{yEd} 497,01 ρ_M 0,8218
M_{xRd} 159 M_{yRd} 605,6

H= 0m		M_x	M_y	*N*
C-5	*Combo 1*	*-139,21*	*-231,19*	*170,36*
	Combo 2	*-139,21*	*-231,19*	*258,75*



M_{xEd} -139,21 kNm M_{yEd} -231,19 ρ_M 0,5036

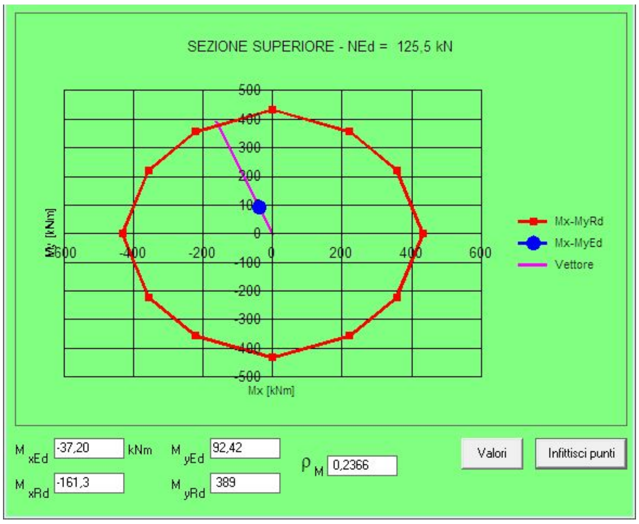
M_{xRd} -268,8 M_{yRd} -463,6



M_{xEd} -139,21 kNm M_{yEd} -231,19 ρ_M 0,4927

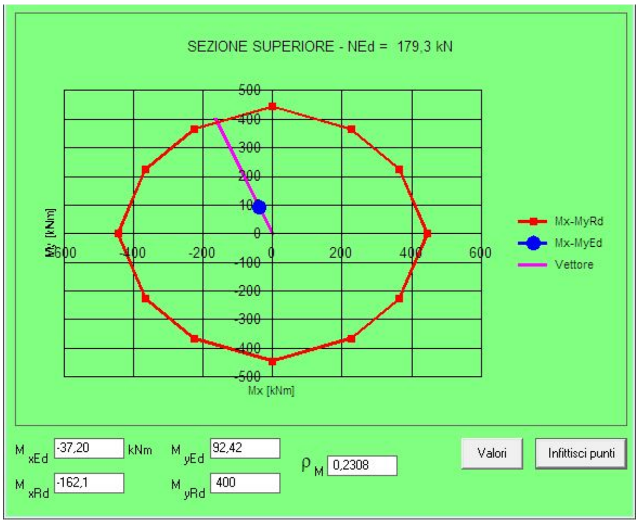
M_{xRd} -279,7 M_{yRd} -470,9

H= 0m		M_x	M_y	*N*
C-6	*Combo 1*	*-37,20*	*92,42*	*125,52*
	Combo 2	*-37,20*	*92,42*	*179,32*



M_{xEd} -37,20 kNm M_{yEd} 92,42 ρ_M 0,2366

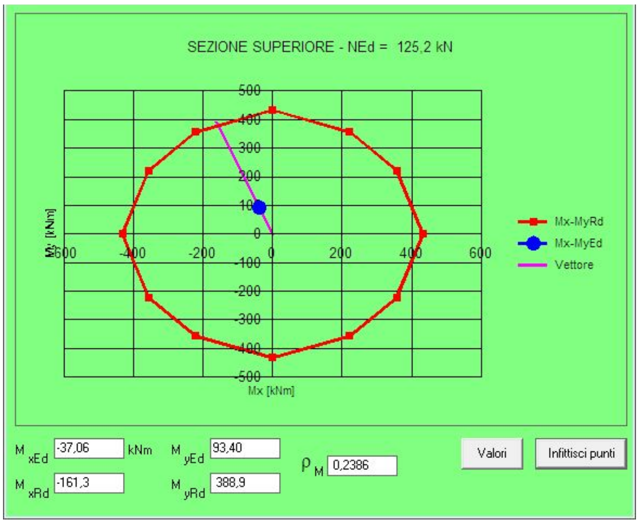
M_{xRd} -161,3 M_{yRd} 389



M_{xEd} -37,20 kNm M_{yEd} 92,42 ρ_M 0,2308

M_{xRd} -162,1 M_{yRd} 400

H= 0m		M_x	M_y	N
C-7	Combo 1	-37,06	93,40	125,16
	Combo 2	-37,06	93,40	178,84



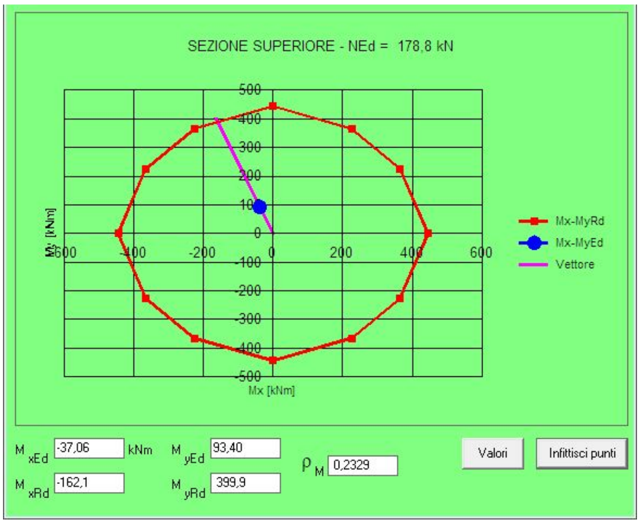
M_{xEd} -37,06 kNm

M_{yEd} 93,40

ρ_M 0,2386

M_{xRd} -161,3

M_{yRd} 388,9



M_{xEd} -37,06 kNm

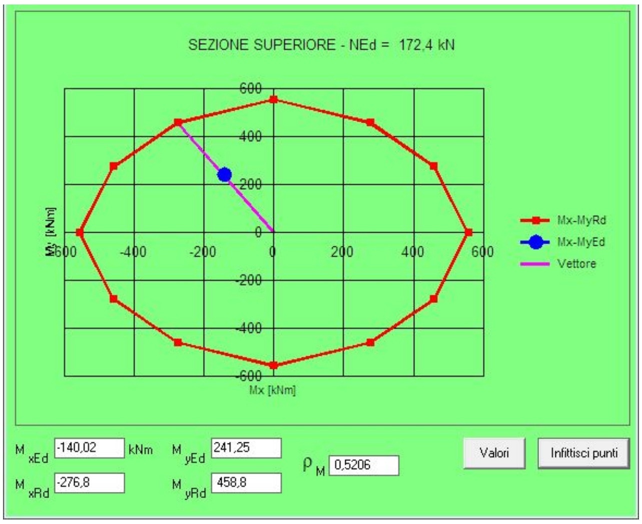
M_{yEd} 93,40

ρ_M 0,2329

M_{xRd} -162,1

M_{yRd} 399,9

H= 0m		M_x	M_y	N
C-8	Combo 1	-140,02	241,25	172,44
	Combo 2	-140,02	241,25	261,45



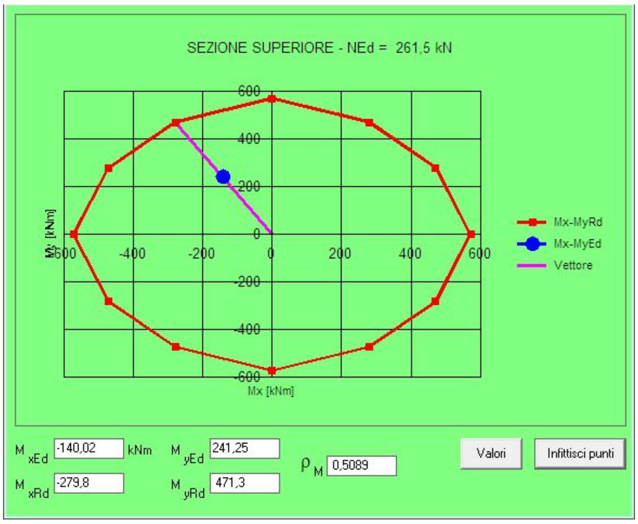
M_{xEd} -140,02 kNm

M_{yEd} 241,25

ρ_M 0,5206

M_{xRd} -276,8

M_{yRd} 458,8



M_{xEd} -140,02 kNm

M_{yEd} 241,25

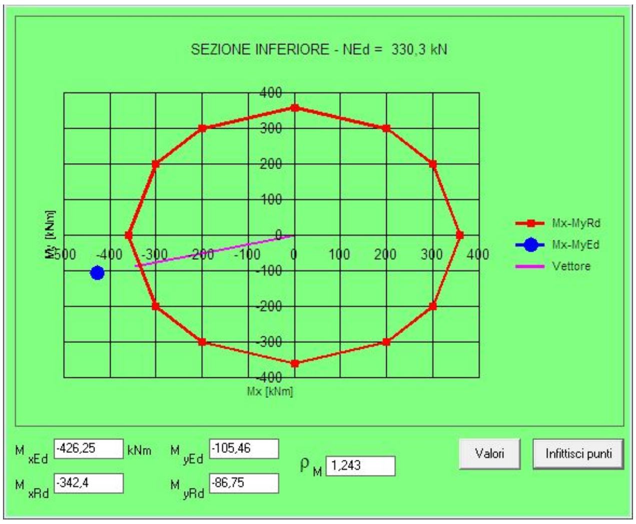
ρ_M 0,5089

M_{xRd} -279,8

M_{yRd} 471,3

C H=4 inferior

H= 4m		*M_x*	*M_y*	*N*
C-1	*Combo 1*	*-426,25*	*-105,46*	*330,29*
	Combo 2	*-426,25*	*-105,46*	*412,57*



M_{xEd} -426,25 kNm M_{yEd} -105,46

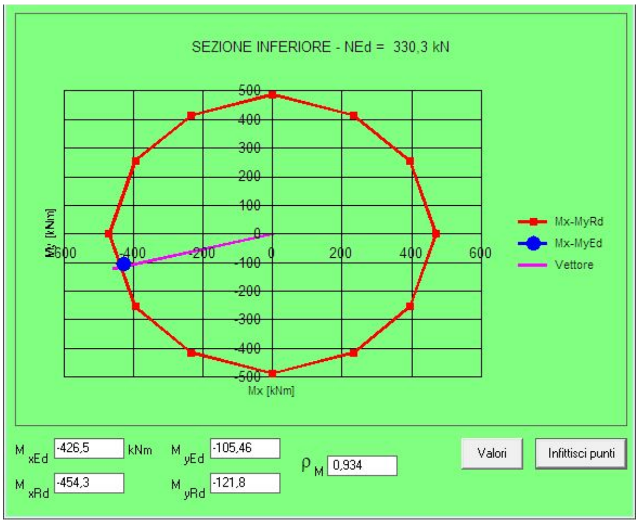
M_{xRd} -342,4 M_{yRd} -86,75

ρ_M 1,243

The verific with the minimum reinforcement is not satisfied, for that reason is increased the number of longitudinal bars:

C1	Dimensions	Misure Units
b	60	cm
h	60	cm
Reinf B	5ϕ24	-
Reinf h	6ϕ24	.

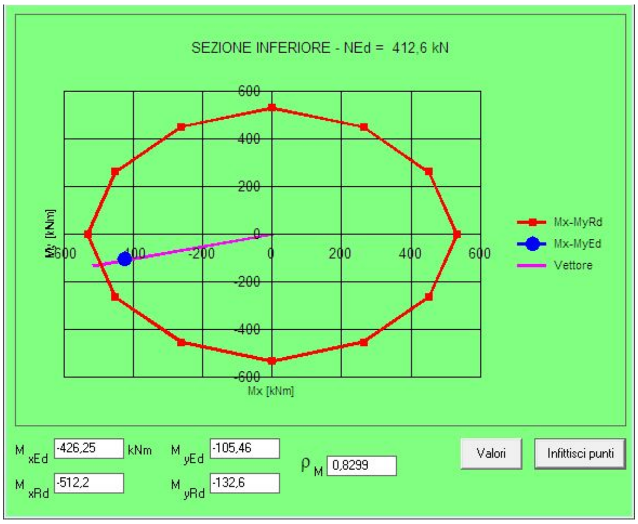
The new verific is:



M_{xEd} -426,5 kNm M_{yEd} -105,46

M_{xRd} -454,3 M_{yRd} -121,8

ρ_M 0,934

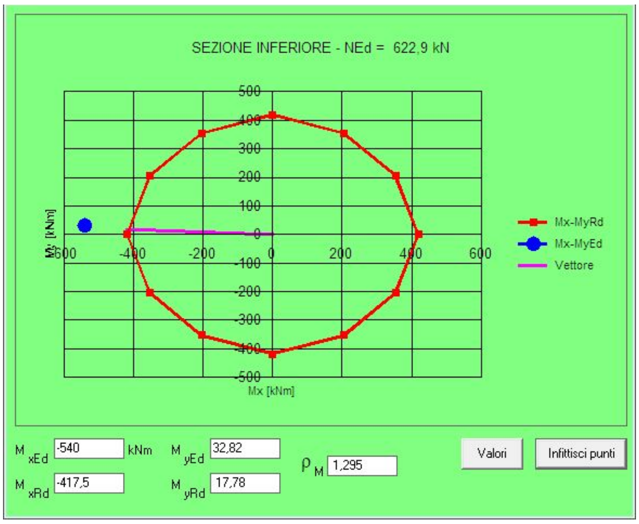


M_{xEd} -426,25 kNm M_{yEd} -105,46

M_{xRd} -512,2 M_{yRd} -132,6

ρ_M 0,8299

H= 4m		M_x	M_y	*N*
C-2	*Combo 1*	*-540,00*	*32,82*	*622,87*
	Combo 2	*-540,00*	*32,82*	*777,71*



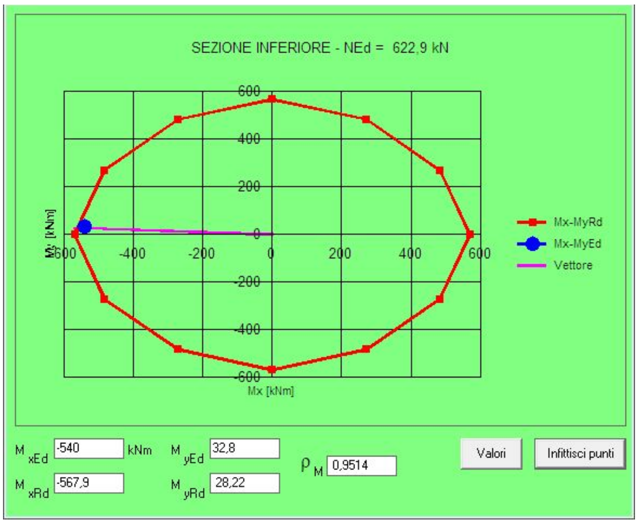
M_{xEd} -540 kNm M_{yEd} 32,82 ρ_M 1,295

M_{xRd} -417,5 M_{yRd} 17,78

The verific with the minimum reinforcement is not satisfied, for that reason is increased the number of longitudinal bars:

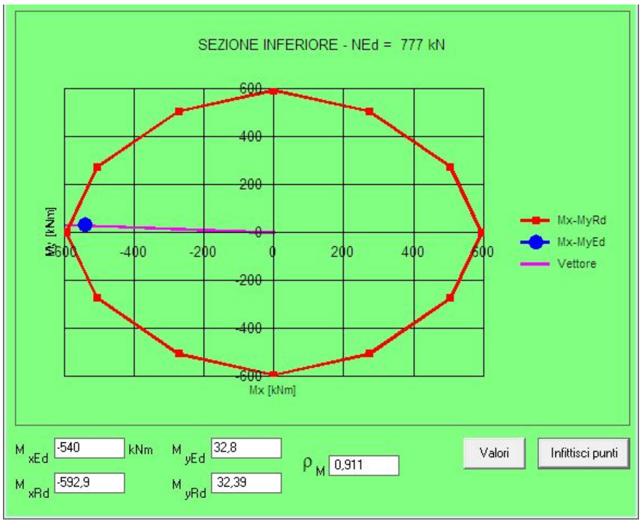
C2	Dimensions	Misure Units
b	60	cm
h	60	cm
Reinf B	6ϕ24	-
Reinf h	6ϕ24	.

The new verific is:



M_{xEd} -540 kNm M_{yEd} 32,8 ρ_M 0,9514

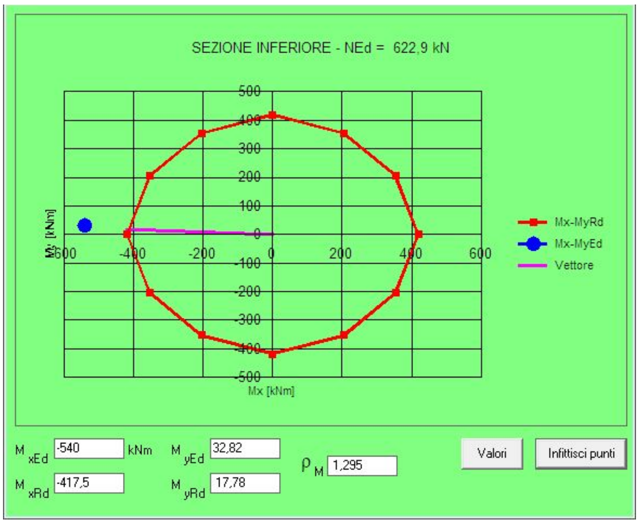
M_{xRd} -567,9 M_{yRd} 28,22



M_{xEd} -540 kNm M_{yEd} 32,8 ρ_M 0,911

M_{xRd} -592,9 M_{yRd} 32,39

H= 4m		*M_x*	*M_y*	*N*
C-3	*Combo 1*	*-555,60*	*24,87*	*622,39*
	Combo 2	*-555,60*	*24,87*	*777,16*



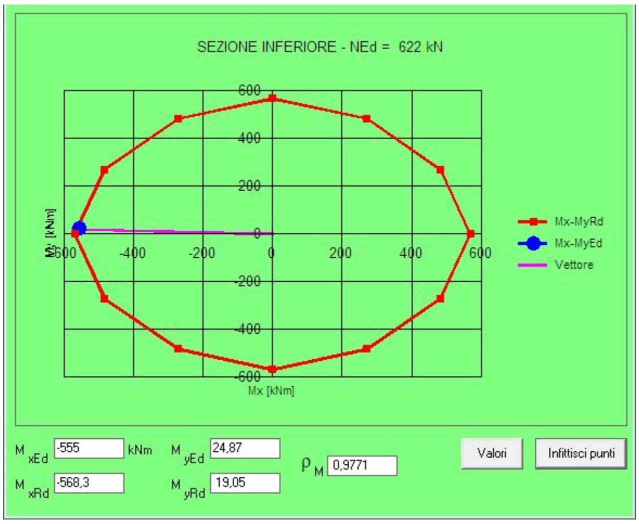
M_{xEd} -540 kNm M_{yEd} 32,82 ρ_M 1,295

M_{xRd} -417,5 M_{yRd} 17,78

The verific with the minimum reinforcement is not satisfied, for that reason is increased the number of longitudinal bars:

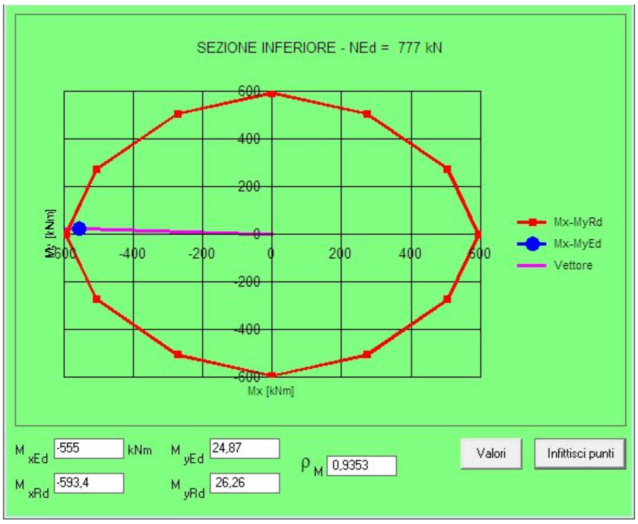
C3	Dimensions	Misure Units
b	60	cm
h	60	cm
Reinf B	6ϕ24	-
Reinf h	6ϕ24	.

The new verific is:



M_{xEd} -555 kNm M_{yEd} 24,87 ρ_M 0,9771

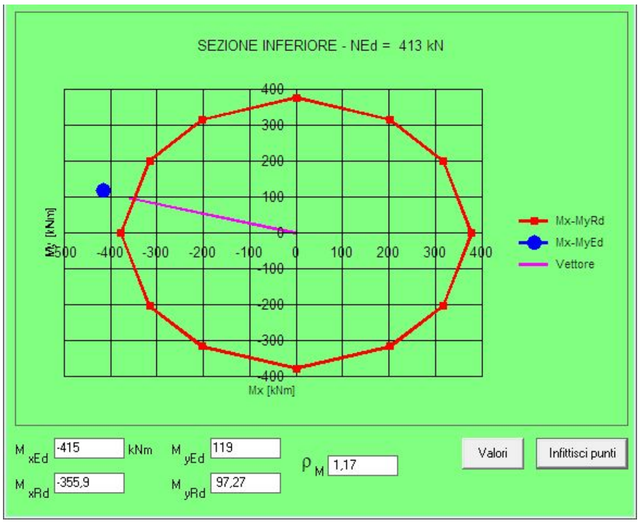
M_{xRd} -568,3 M_{yRd} 19,05



M_{xEd} -555 kNm M_{yEd} 24,87 ρ_M 0,9353

M_{xRd} -593,4 M_{yRd} 26,26

H= 4m		M_x	M_y	N
C-4	*Combo 1*	*-415,75*	*119,43*	*331,21*
	Combo 2	*-415,75*	*119,43*	*413,03*

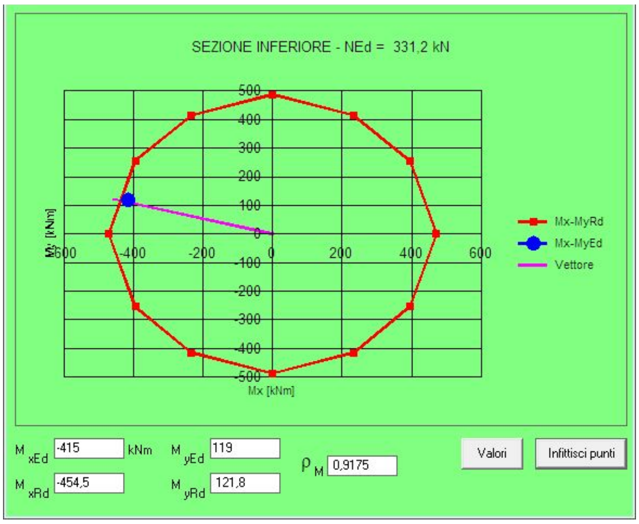


M xEd -415 kNm
M yEd 119
M xRd -355,9
M yRd 97,27
ρ M 1,17

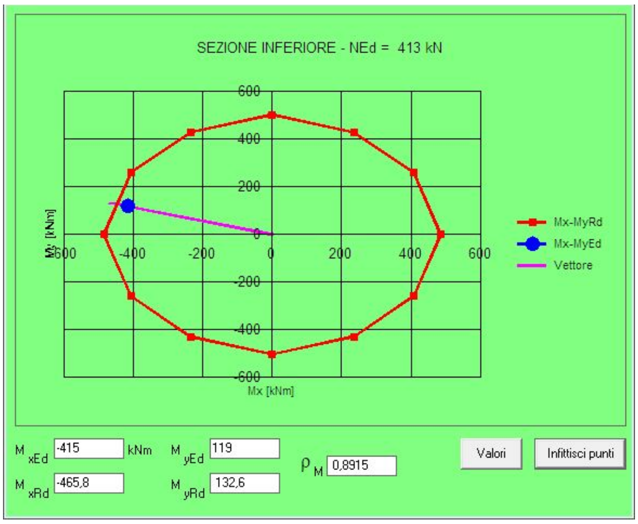
The verific with the minimum reinforcement is not satisfied, for that reason is increased the number of longitudinal bars:

C4	Dimensions	Misure Units
b	60	cm
h	60	cm
Reinf B	5ϕ24	-
Reinf h	6ϕ24	.

The new verific is:

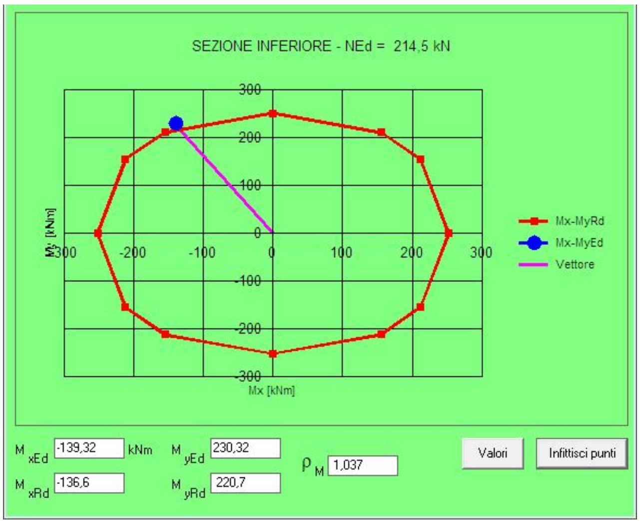


M xEd -415 kNm
M yEd 119
M xRd -454,5
M yRd 121,8
ρ M 0,9175



M xEd -415 kNm
M yEd 119
M xRd -465,8
M yRd 132,6
ρ M 0,8915

H= 4m		M_x	M_y	*N*
C-5	*Combo 1*	*-139,32*	*-230,32*	*214,47*
	Combo 2	*-139,32*	*-230,32*	*302,86*



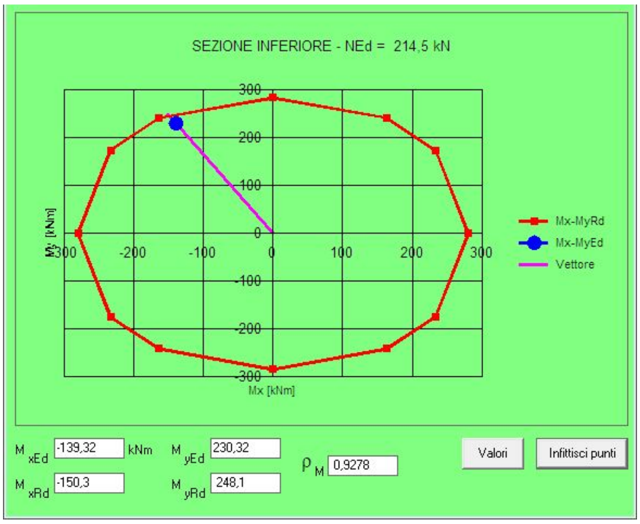
M_{xEd} -139,32 kNm M_{yEd} 230,32 ρ_M 1,037

M_{xRd} -136,6 M_{yRd} 220,7

The verific with the minimum reinforcement is not satisfied, for that reason is increased the number of longitudinal bars:

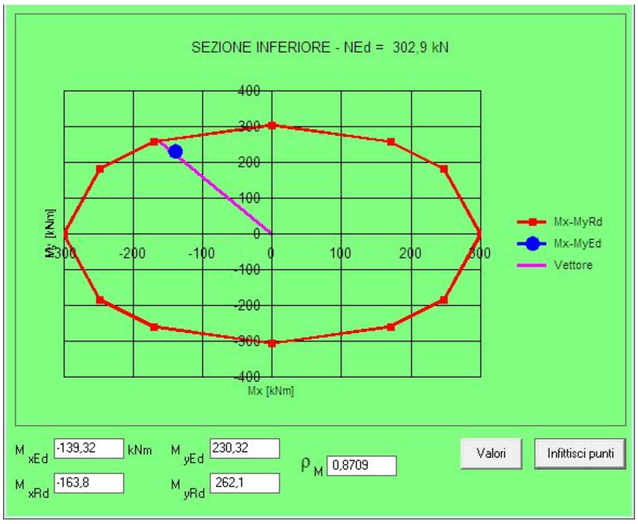
C4	Dimensions	Misure Units
b	60	cm
h	60	cm
Reinf B	5ϕ20	-
Reinf h	6ϕ20	.

And the verific is:



M_{xEd} -139,32 kNm M_{yEd} 230,32 ρ_M 0,9278

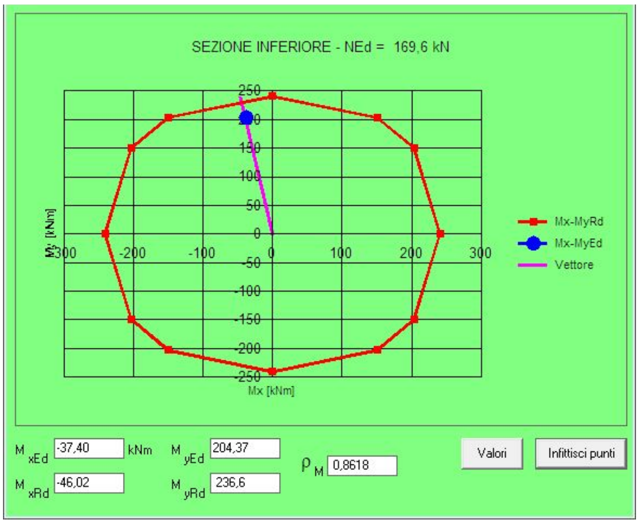
M_{xRd} -150,3 M_{yRd} 248,1



M_{xEd} -139,32 kNm M_{yEd} 230,32 ρ_M 0,8709

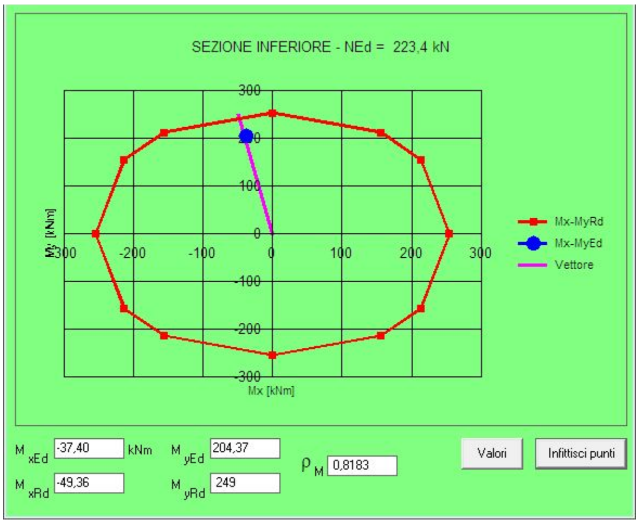
M_{xRd} -163,8 M_{yRd} 262,1

H= 4m		M_x	M_y	N
C-6	Combo 1	-37,40	204,37	169,63
	Combo 2	-37,40	204,37	223,42



M_{xEd} -37,40 kNm M_{yEd} 204,37 ρ_M 0,8618

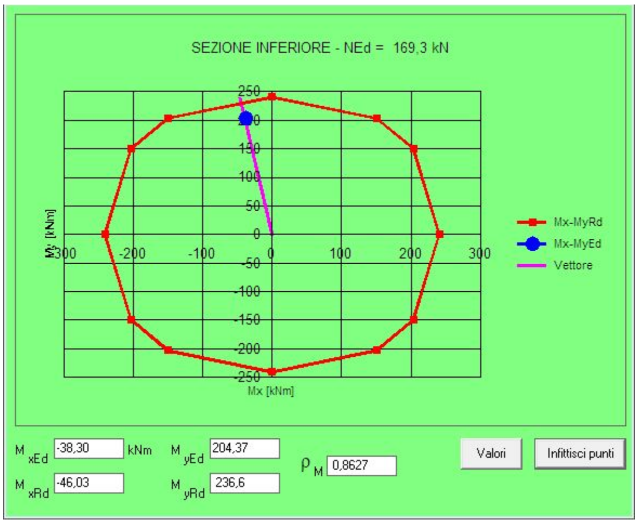
M_{xRd} -46,02 M_{yRd} 236,6



M_{xEd} -37,40 kNm M_{yEd} 204,37 ρ_M 0,8183

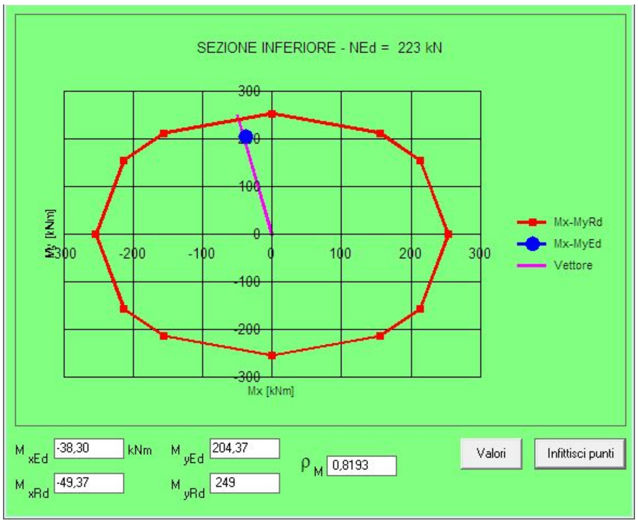
M_{xRd} -49,36 M_{yRd} 249

H= 4m		M_x	M_y	N
C-7	Combo 1	-38,30	204,37	169,27
	Combo 2	-38,30	204,37	222,95



M_{xEd} -38,30 kNm M_{yEd} 204,37 ρ_M 0,8627

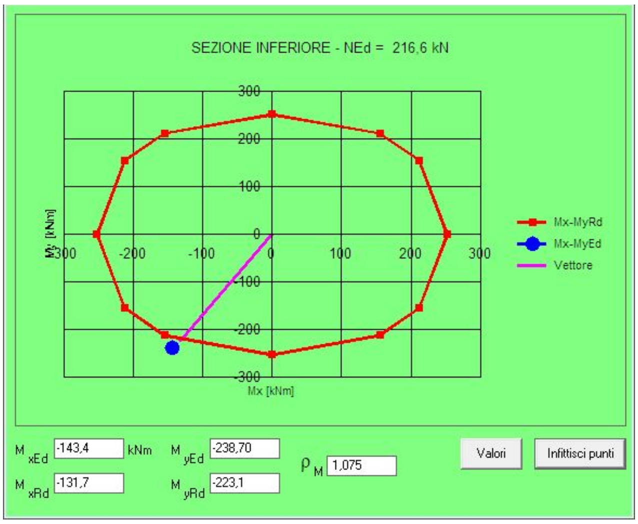
M_{xRd} -46,03 M_{yRd} 236,6



M_{xEd} -38,30 kNm M_{yEd} 204,37 ρ_M 0,8193

M_{xRd} -49,37 M_{yRd} 249

H= 4m		M_x	M_y	*N*
C-8	*Combo 1*	*-143,40*	*-238,70*	*216,56*
	Combo 2	*-143,40*	*-238,70*	*305,56*



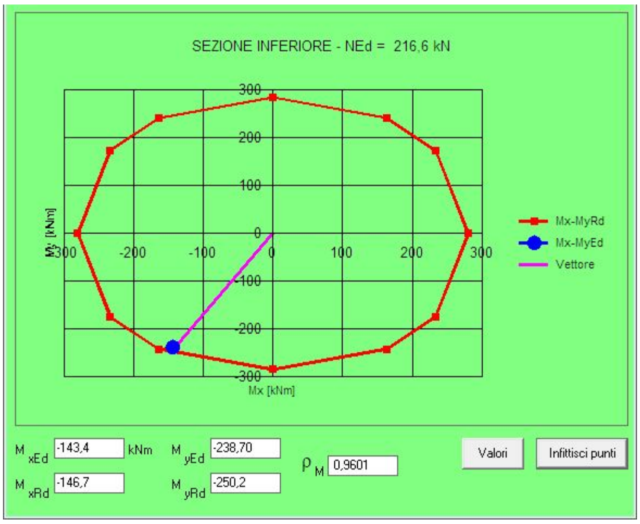
M_{xEd} -143,4 kNm M_{yEd} -238,70 ρ_M 1,075

M_{xRd} -131,7 M_{yRd} -223,1

The verific with the minimum reinforcement is not satisfied, for that reason is increased the number of longitudinal bars:

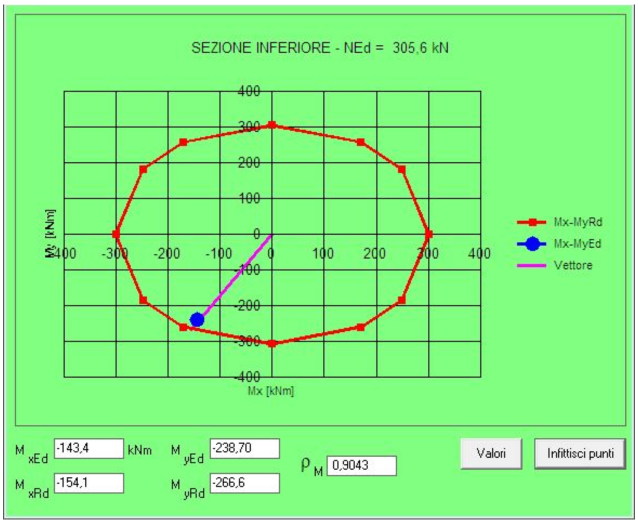
C4	Dimensions	Misure Units
b	60	cm
h	60	cm
Reinf B	5ϕ20	-
Reinf h	5ϕ20	.

And the verific is:



M_{xEd} -143,4 kNm M_{yEd} -238,70 ρ_M 0,9601

M_{xRd} -146,7 M_{yRd} -250,2

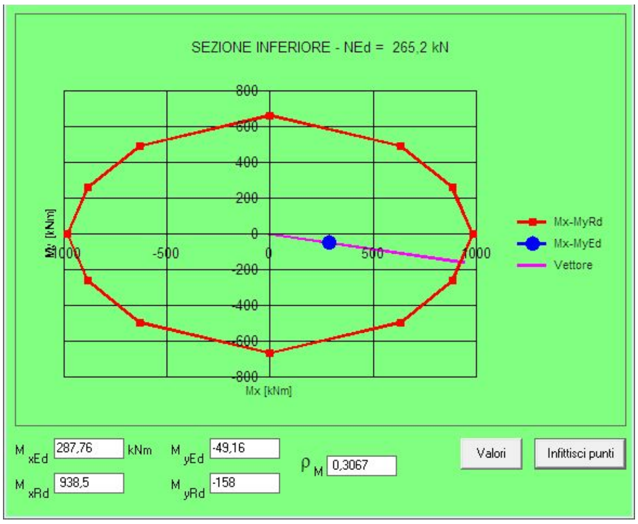


M_{xEd} -143,4 kNm M_{yEd} -238,70 ρ_M 0,9043

M_{xRd} -154,1 M_{yRd} -266,6

K H=0 top

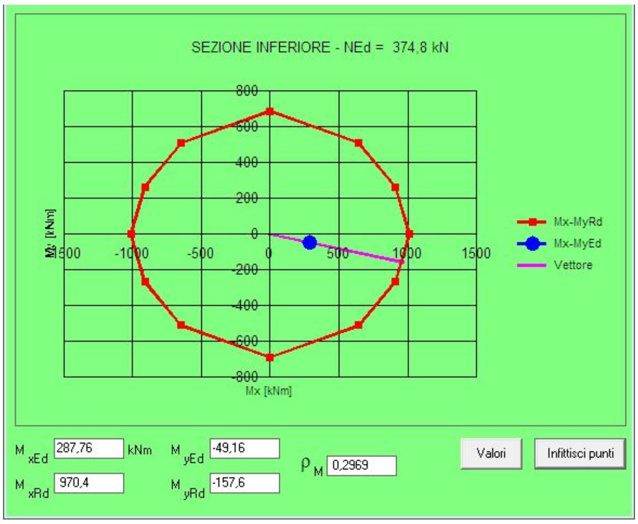
H= 4,30m		M_x	M_y	*N*
K-1	*Combo 1*	*287,76*	*-49,16*	*265,17*
	Combo 2	*287,76*	*-49,16*	*374,75*


SEZIONE INFERIORE - NEd = 265,2 kN

M_{xEd} 287,76 kNm M_{yEd} -49,16

M_{xRd} 938,5 M_{yRd} -158

ρ_M 0,3067

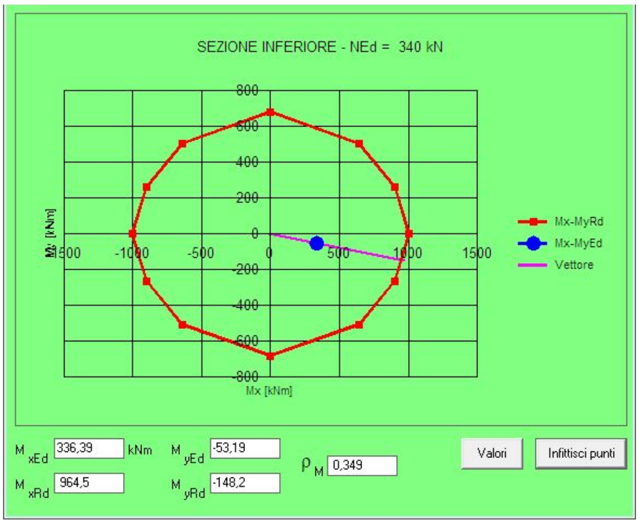

SEZIONE INFERIORE - NEd = 374,8 kN

M_{xEd} 287,76 kNm M_{yEd} -49,16

M_{xRd} 970,4 M_{yRd} -157,6

ρ_M 0,2969

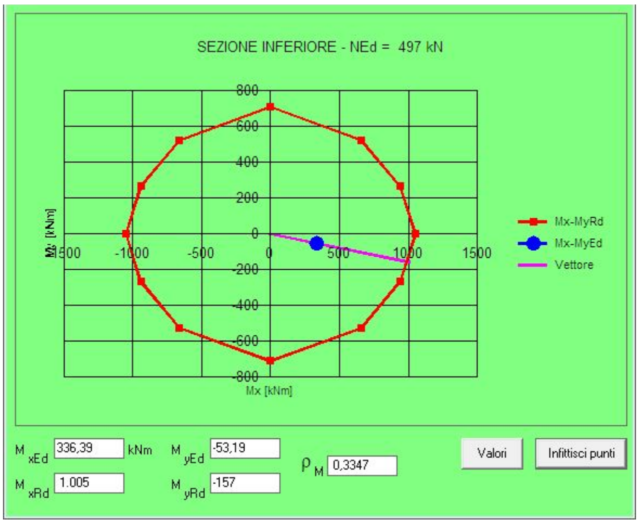
H= 4,30m		M_x	M_y	*N*
K-2	*Combo 1*	*336,39*	*-53,19*	*339,95*
	Combo 2	*336,39*	*-53,19*	*497,01*


SEZIONE INFERIORE - NEd = 340 kN

M_{xEd} 336,39 kNm M_{yEd} -53,19

M_{xRd} 964,5 M_{yRd} -148,2

ρ_M 0,349

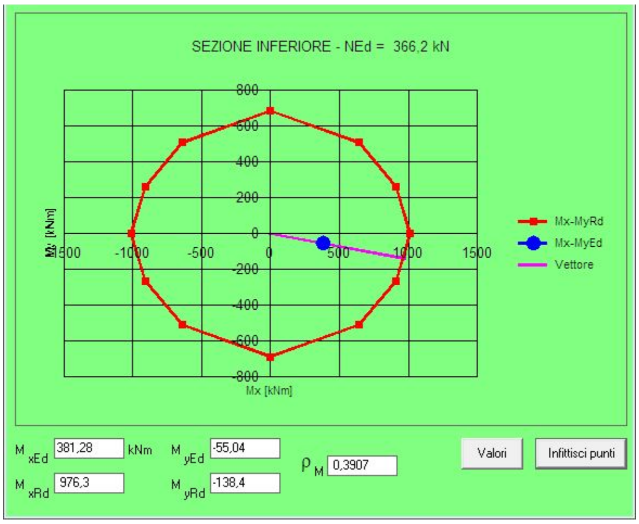

SEZIONE INFERIORE - NEd = 497 kN

M_{xEd} 336,39 kNm M_{yEd} -53,19

M_{xRd} 1.005 M_{yRd} -157

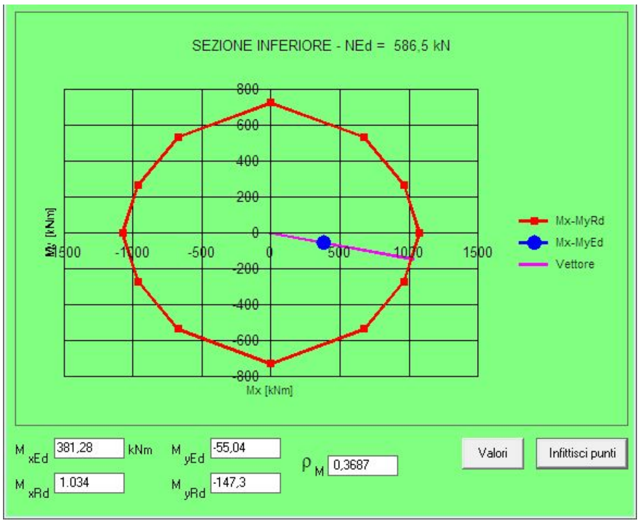
ρ_M 0,3347

H= 4,30m		M_x	M_y	*N*
K-3	*Combo 1*	*381,28*	*-55,04*	*366,21*
	Combo 2	*381,28*	*-55,04*	*586,49*



M_{xEd} 381,28 kNm M_{yEd} -55,04 ρ_M 0,3907

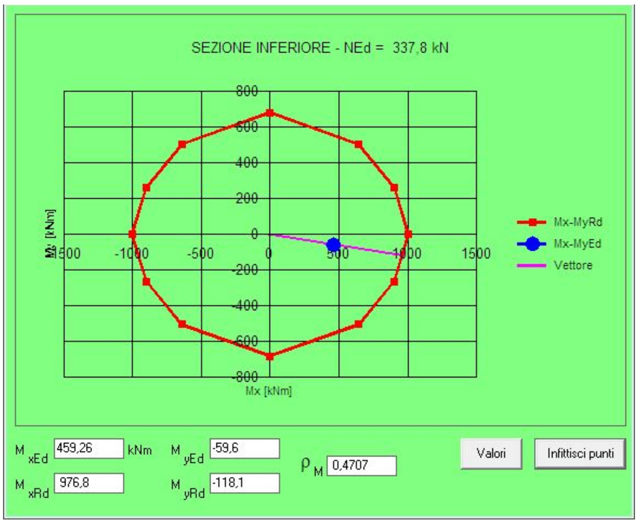
M_{xRd} 976,3 M_{yRd} -138,4



M_{xEd} 381,28 kNm M_{yEd} -55,04 ρ_M 0,3687

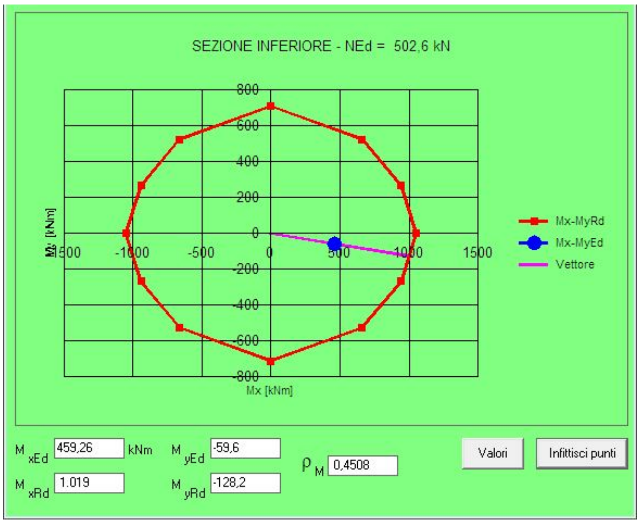
M_{xRd} 1.034 M_{yRd} -147,3

H= 4,30m		M_x	M_y	*N*
K-4	*Combo 1*	*459,26*	*-59,59*	*337,80*
	Combo 2	*459,26*	*-59,59*	*502,57*



M_{xEd} 459,26 kNm M_{yEd} -59,6 ρ_M 0,4707

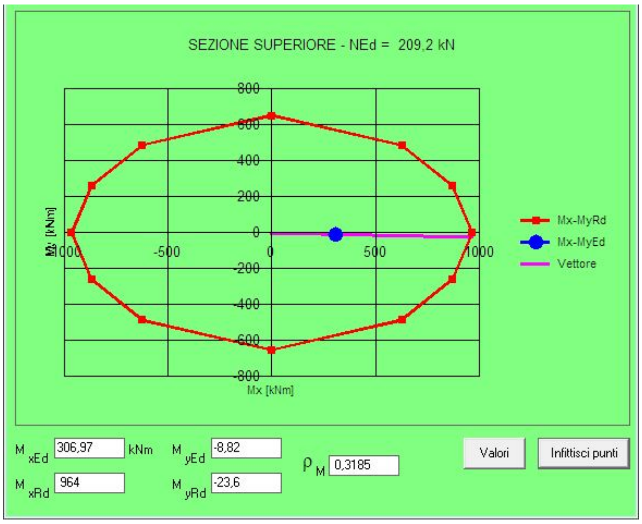
M_{xRd} 976,8 M_{yRd} -118,1



M_{xEd} 459,26 kNm M_{yEd} -59,6 ρ_M 0,4508

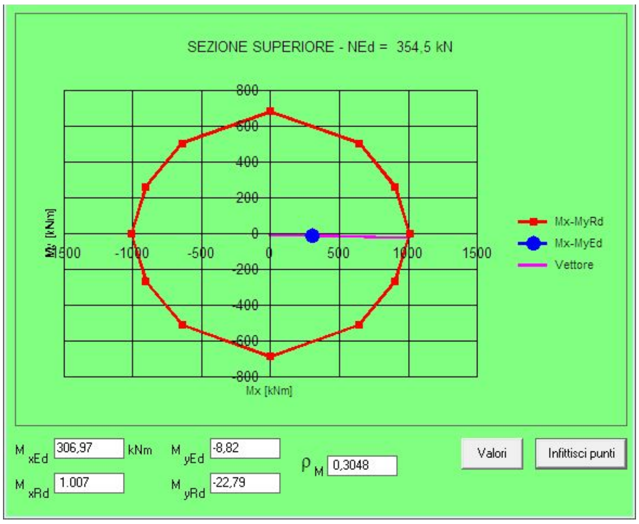
M_{xRd} 1.019 M_{yRd} -128,2

H= 0m		M_x	M_y	N
K-5	Combo 1	306,97	-8,82	209,16
	Combo 2	306,97	-8,82	354,52



M_{xEd} 306,97 kNm M_{yEd} -8,82 ρ_M 0,3185

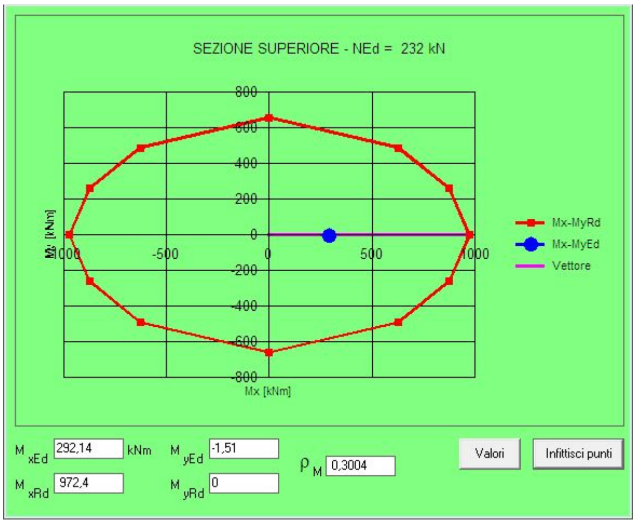
M_{xRd} 964 M_{yRd} -23,6



M_{xEd} 306,97 kNm M_{yEd} -8,82 ρ_M 0,3048

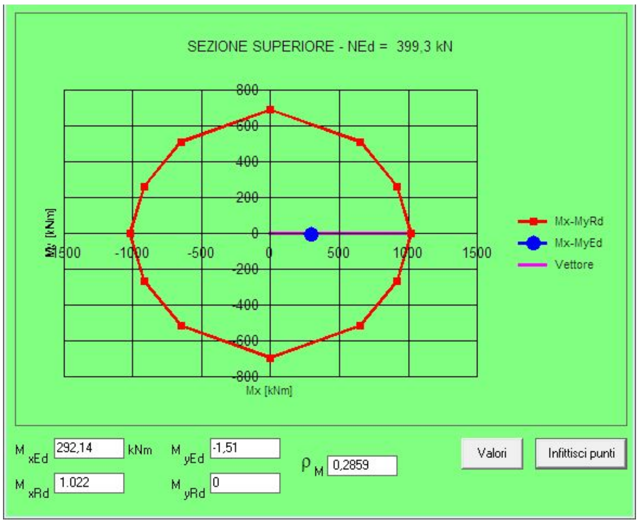
M_{xRd} 1.007 M_{yRd} -22,79

H= 0m		M_x	M_y	N
K-6	Combo 1	292,14	-1,51	232,01
	Combo 2	292,14	-1,51	399,31



M_{xEd} 292,14 kNm M_{yEd} -1,51 ρ_M 0,3004

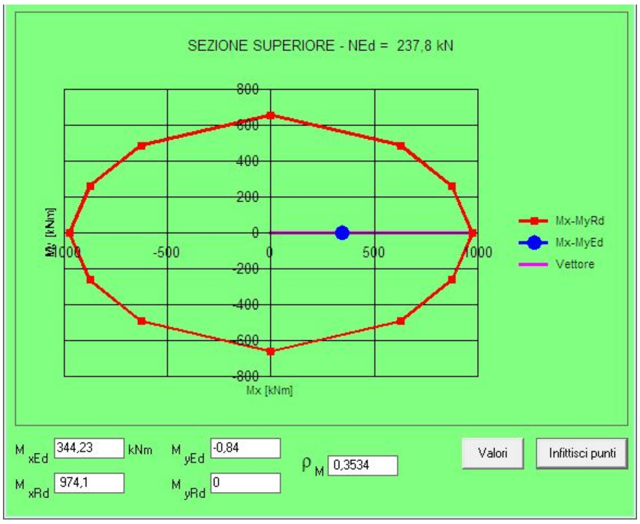
M_{xRd} 972,4 M_{yRd} 0



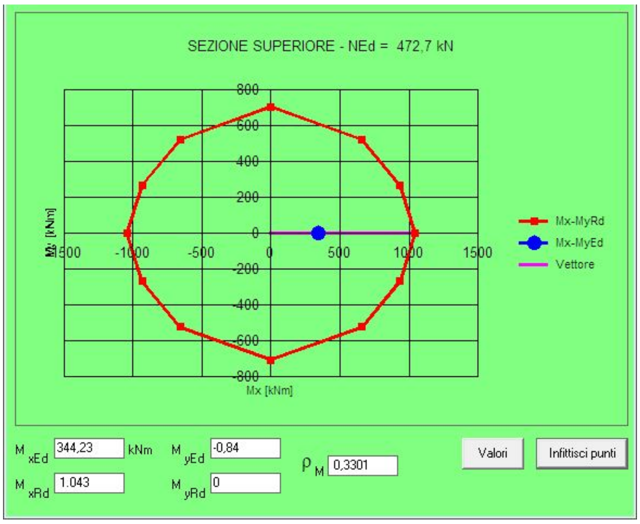
M_{xEd} 292,14 kNm M_{yEd} -1,51 ρ_M 0,2859

M_{xRd} 1.022 M_{yRd} 0

H= 0m		*M_x*	*M_y*	*N*
K-7	*Combo 1*	*344,23*	*-0,84*	*237,82*
	Combo 2	*344,23*	*-0,84*	*472,74*

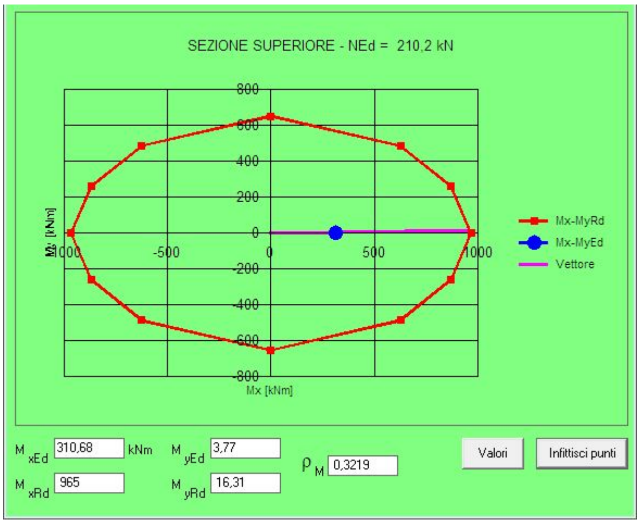

SEZIONE SUPERIORE - NEd = 237,8 kN

M xEd 344,23 kNm
M xRd 974,1
M yEd -0,84
M yRd 0
ρ M 0,3534

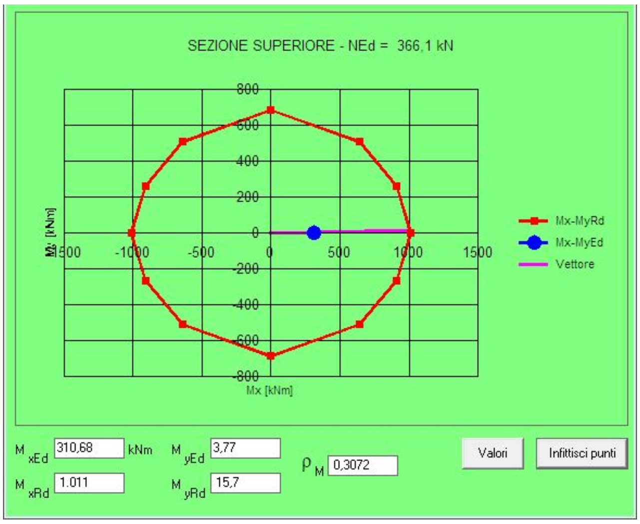

SEZIONE SUPERIORE - NEd = 472,7 kN

M xEd 344,23 kNm
M xRd 1.043
M yEd -0,84
M yRd 0
ρ M 0,3301

H= 0m		*M_x*	*M_y*	*N*
K-8	*Combo 1*	*310,68*	*3,77*	*210,17*
	Combo 2	*310,68*	*3,77*	*366,14*


SEZIONE SUPERIORE - NEd = 210,2 kN

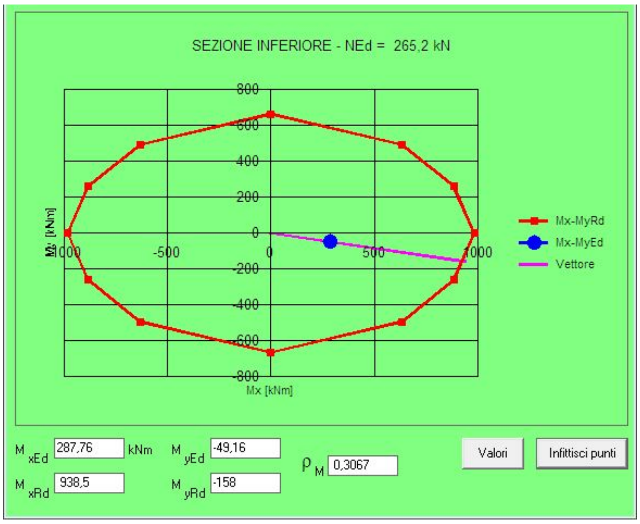
M xEd 310,68 kNm
M xRd 965
M yEd 3,77
M yRd 16,31
ρ M 0,3219


SEZIONE SUPERIORE - NEd = 366,1 kN

M xEd 310,68 kNm
M xRd 1.011
M yEd 3,77
M yRd 15,7
ρ M 0,3072

K H=4,3 bottom

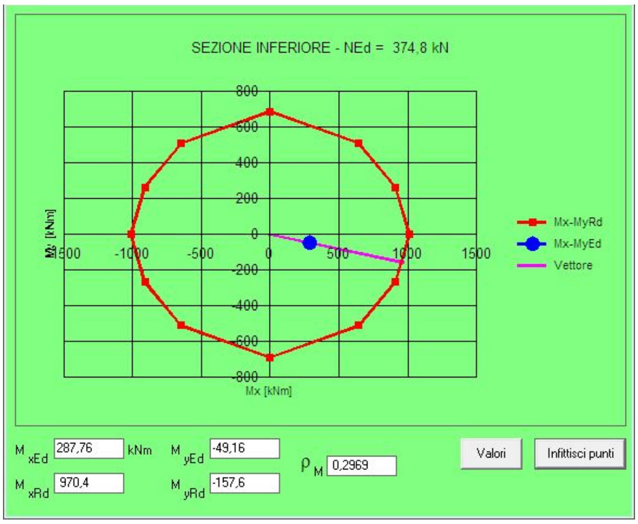
H= 4,30m		M_x	M_y	*N*
K-1	*Combo 1*	*287,76*	*-49,16*	*265,17*
	Combo 2	*287,76*	*-49,16*	*374,75*



M_{xEd} 287,76 kNm M_{yEd} -49,16

M_{xRd} 938,5 M_{yRd} -158

ρ_M 0,3067

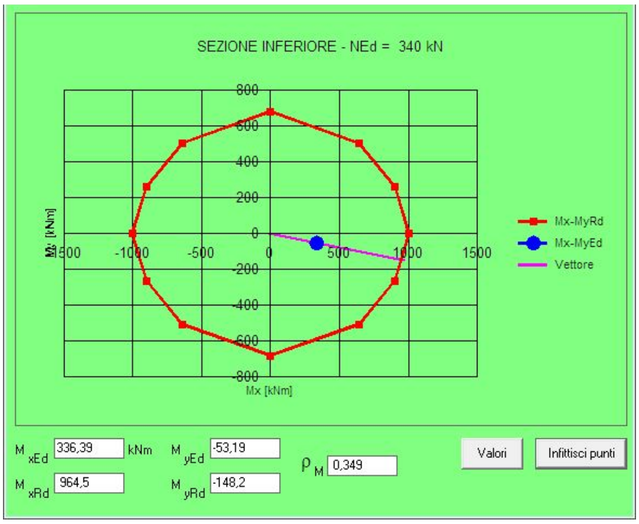


M_{xEd} 287,76 kNm M_{yEd} -49,16

M_{xRd} 970,4 M_{yRd} -157,6

ρ_M 0,2969

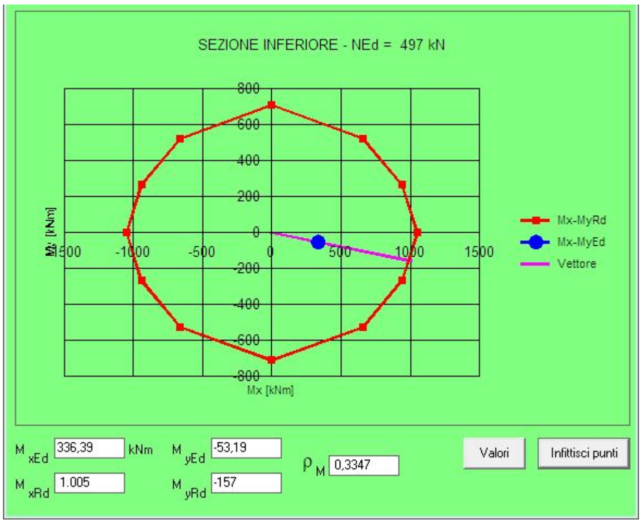
H= 4,30m		M_x	M_y	*N*
K-2	*Combo 1*	*336,39*	*-53,19*	*339,95*
	Combo 2	*336,39*	*-53,19*	*497,01*



M_{xEd} 336,39 kNm M_{yEd} -53,19

M_{xRd} 964,5 M_{yRd} -148,2

ρ_M 0,349

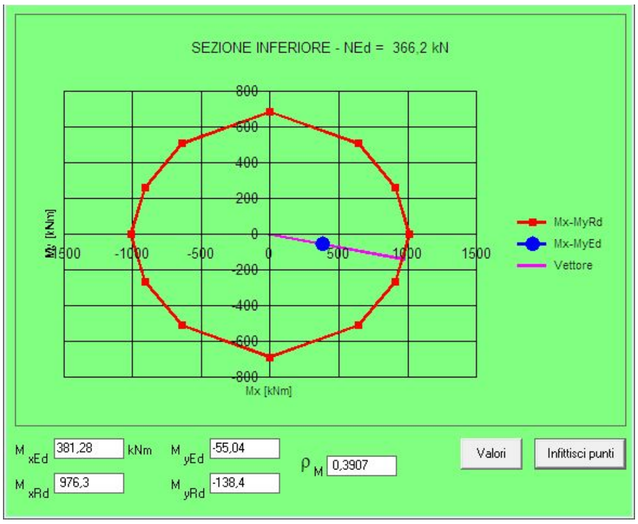


M_{xEd} 336,39 kNm M_{yEd} -53,19

M_{xRd} 1.005 M_{yRd} -157

ρ_M 0,3347

H= 4,30m		M_x	M_y	N
K-3	Combo 1	381,28	-55,04	366,21
	Combo 2	381,28	-55,04	586,49

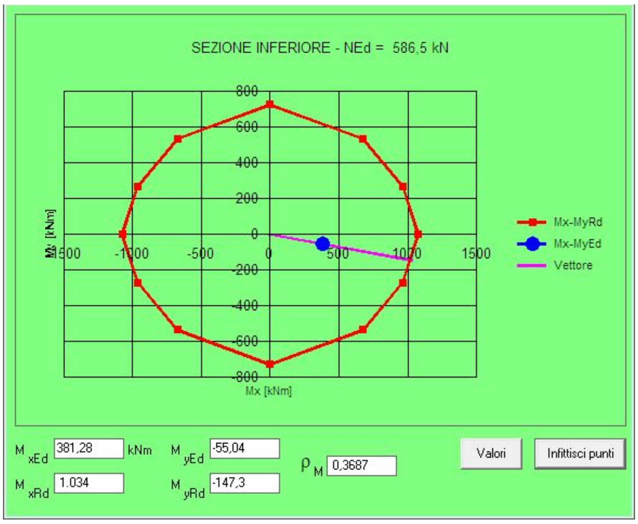


SEZIONE INFERIORE - NEd = 366,2 kN

M_{xEd} 381,28 kNm M_{yEd} -55,04

M_{xRd} 976,3 M_{yRd} -138,4

ρ_M 0,3907



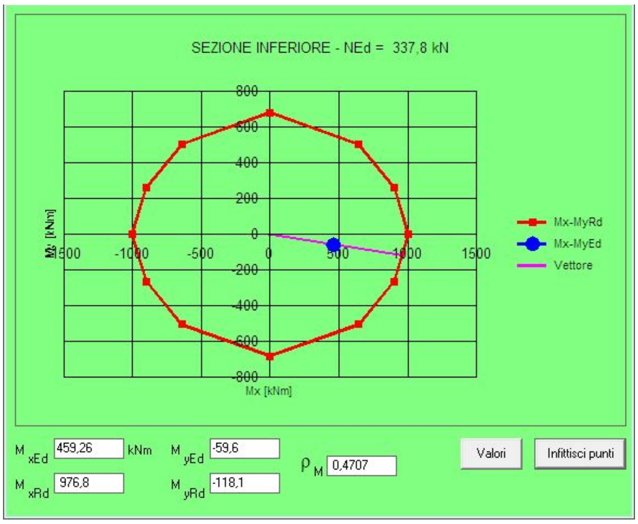
SEZIONE INFERIORE - NEd = 586,5 kN

M_{xEd} 381,28 kNm M_{yEd} -55,04

M_{xRd} 1.034 M_{yRd} -147,3

ρ_M 0,3687

H= 4,30m		M_x	M_y	N
K-4	Combo 1	459,26	-59,59	337,80
	Combo 2	459,26	-59,59	502,57

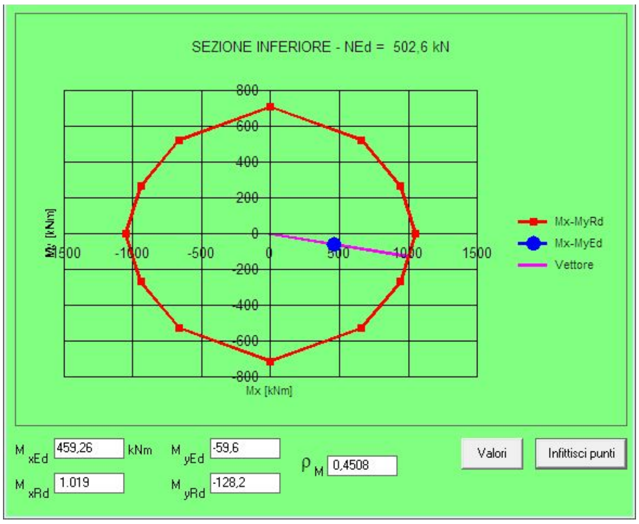


SEZIONE INFERIORE - NEd = 337,8 kN

M_{xEd} 459,26 kNm M_{yEd} -59,6

M_{xRd} 976,8 M_{yRd} -118,1

ρ_M 0,4707



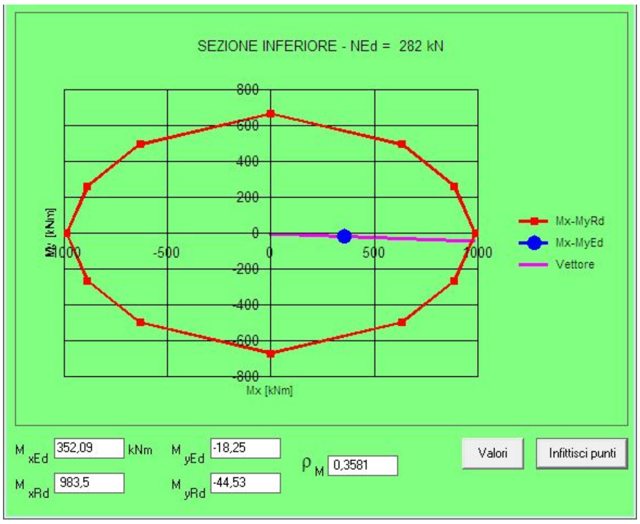
SEZIONE INFERIORE - NEd = 502,6 kN

M_{xEd} 459,26 kNm M_{yEd} -59,6

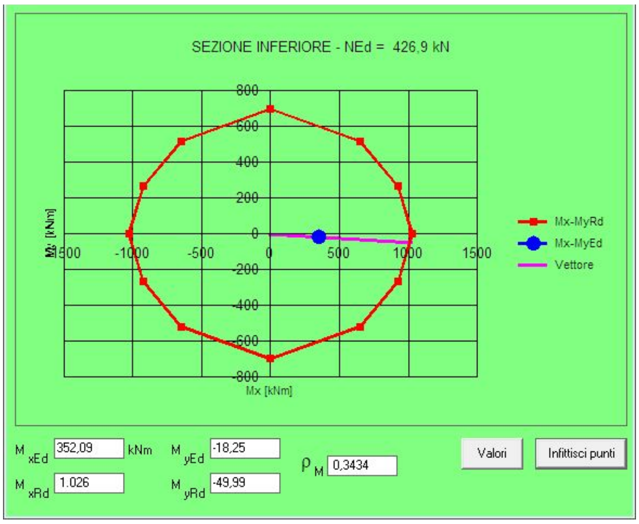
M_{xRd} 1.019 M_{yRd} -128,2

ρ_M 0,4508

H= 4,30m		M_x	M_y	*N*
K-5	*Combo 1*	*352,09*	*-18,25*	*281,99*
	Combo 2	*352,09*	*-18,25*	*426,90*

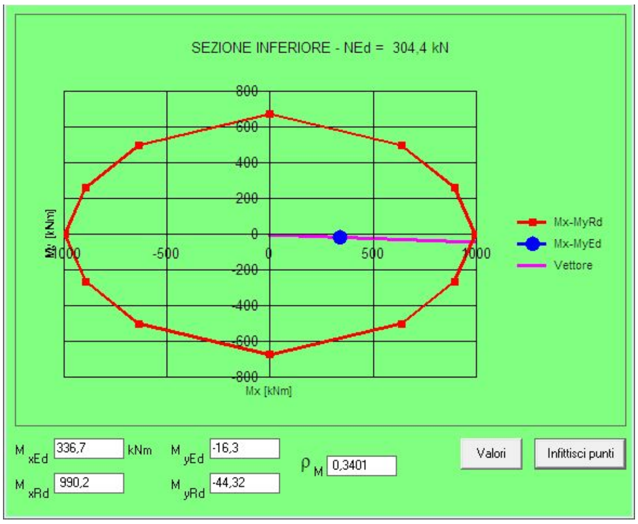


M_{xEd} 352,09 kNm M_{yEd} -18,25 ρ_M 0,3581
M_{xRd} 983,5 M_{yRd} -44,53

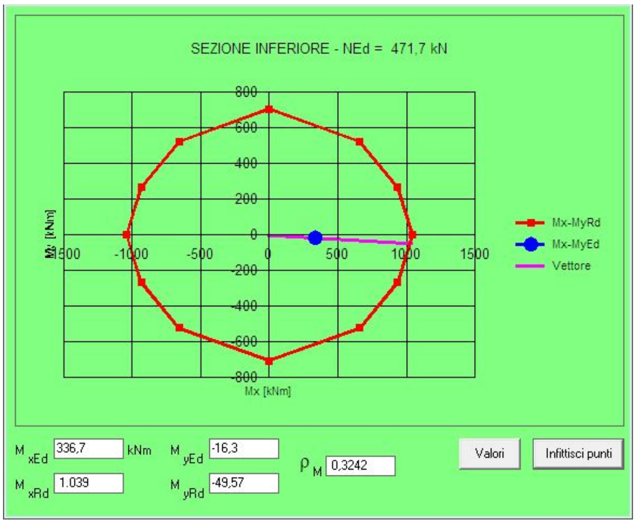


M_{xEd} 352,09 kNm M_{yEd} -18,25 ρ_M 0,3434
M_{xRd} 1.026 M_{yRd} -49,99

H= 4,30m		M_x	M_y	*N*
K-6	*Combo 1*	*336,72*	*-16,36*	*304,38*
	Combo 2	*336,72*	*-16,36*	*471,70*

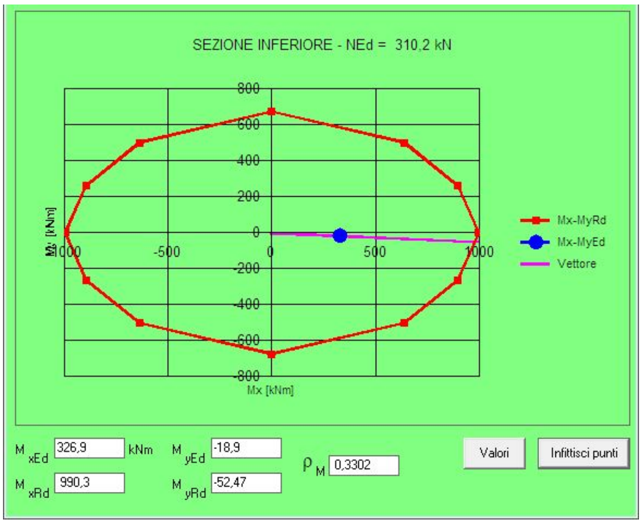


M_{xEd} 336,7 kNm M_{yEd} -16,3 ρ_M 0,3401
M_{xRd} 990,2 M_{yRd} -44,32



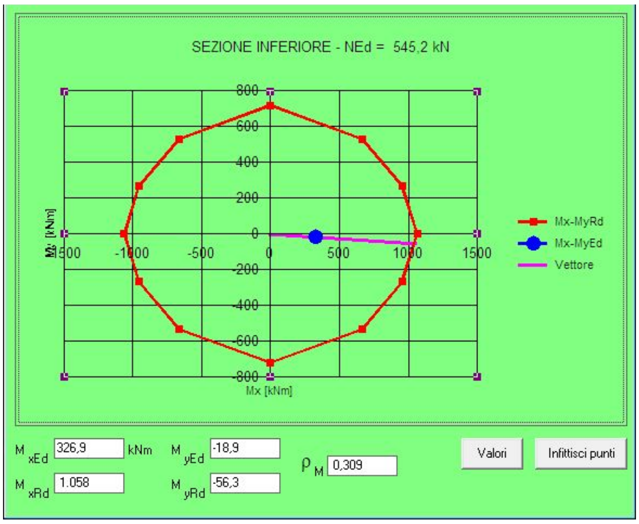
M_{xEd} 336,7 kNm M_{yEd} -16,3 ρ_M 0,3242
M_{xRd} 1.039 M_{yRd} -49,57

H= 4,30m		M_x	M_y	*N*
K-7	*Combo 1*	*326,91*	*-18,88*	*310,19*
	Combo 2	*326,91*	*-18,88*	*545,18*


SEZIONE INFERIORE - NEd = 310,2 kN

M_{xEd} 326,9 kNm M_{yEd} -18,9 ρ_M 0,3302

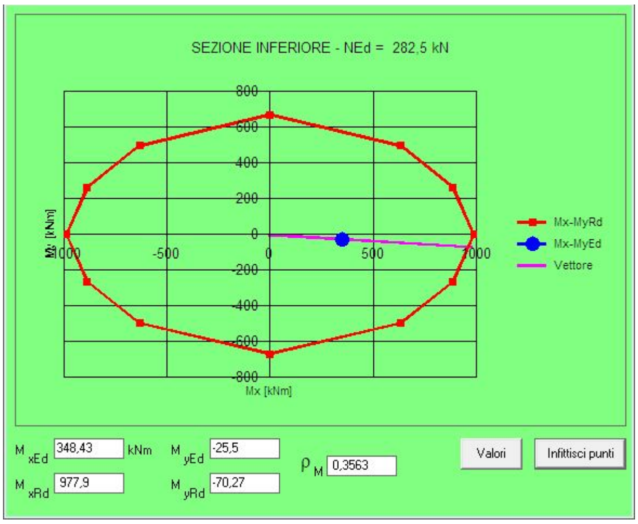
M_{xRd} 990,3 M_{yRd} -52,47


SEZIONE INFERIORE - NEd = 545,2 kN

M_{xEd} 326,9 kNm M_{yEd} -18,9 ρ_M 0,309

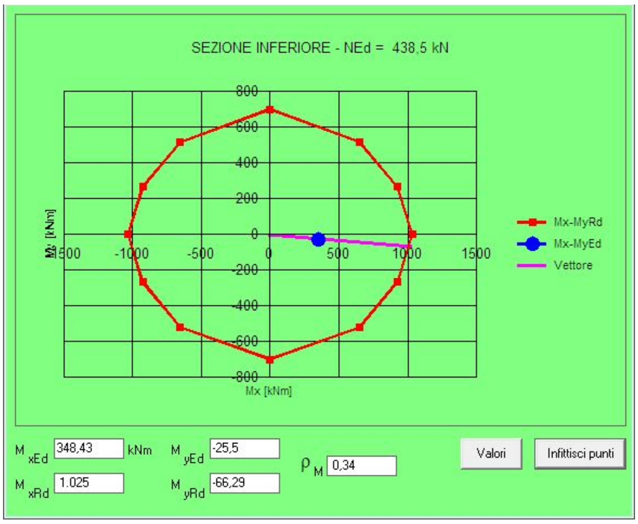
M_{xRd} 1.058 M_{yRd} -56,3

H= 4,30m		M_x	M_y	*N*
K-8	*Combo 1*	*348,43*	*-25,55*	*282,52*
	Combo 2	*348,43*	*-25,55*	*438,51*


SEZIONE INFERIORE - NEd = 282,5 kN

M_{xEd} 348,43 kNm M_{yEd} -25,5 ρ_M 0,3563

M_{xRd} 977,9 M_{yRd} -70,27


SEZIONE INFERIORE - NEd = 438,5 kN

M_{xEd} 348,43 kNm M_{yEd} -25,5 ρ_M 0,34

M_{xRd} 1.025 M_{yRd} -66,29

4 NORMATIVE REFERENCES

[1] *FINA "Normas FINA"* published on the Diario Oficial federacion on 2012.

[2] *RFEN "Normativa general de natacion"* published on the Diario Oficial federacion on 14/12/2012.

[3] *RD 1247/2008 "Instrucciòn de hormigoòn structural EHE08"* published on Boletín Oficial del Estado, n° 203 of *22/08/2008.*

[4] *RD 1371/2007 "Código Técnico de la Edificación"* published on Boletín Oficial del Estado, n° 254 of *19/10/2008.*

[5] *RD 1027/2007 "Reglamento de Instalaciones Térmicas en Edificios 1Boletín Oficial del Estado",* published on Boletín Oficial del Estado, n° 207 of 29/10/2008.

[6] *RD 637/2007* "*Norma de construccion sismoresistente NCSP07" "* published on Boletín Oficial del Estado*,* n° 132 of *22/09/2007.*

[7] *EUROPEAN STANDARD "UNE-EN 13200-1". Spectator facilities - Layout criteria for spectator viewing area",*published on 20/09/2006.

[8] *RD 97/2002 "Norma de construccion sismoresistente NCSE-02"* published on Boletín Oficial del Estado,n° 244 of 11/10/2002.

[9] *EUROPEAN STANDARD " UNE-EN 13451 Swimming pool equipment. specific safety requirements and test methods for lane lines",* published on 2001.

[10] *RD 2816/1982"Reglamento General de Policía de Espectáculos Públicos y Actividades Recreativa*", published on Boletín Oficial del Estado, n° 267 of 6/11/2009.