



Bauherr  
committente

BEZIRKSGEMEINSCHAFT SALTEN - SCHLERN  
COMUNITÀ COMPRENSORIALE DI SALTO - SCILIAR

## AUSFÜHRUNGSPROJEKT

FÜR DIE ERRICHTUNG EINER NEUEN RADWEG- UND FUSSGÄNGERBRÜCKE ÜBER DEN EISACK SOWIE EINER NEUEN RAD- UND FUSSWEGANBINDUNG ZWISCHEN DEN BAUEINHEITEN "KAMPILL CENTER" UND "MILA BOZEN" AUF DEN G.P. 2620/1, 2620/11, 2688/5, 1005/2, 2536/5 UND DER B.P. 4466, KG ZWÖLFMALGREIEN

## PROGETTO ESECUTIVO

PER LA REALIZZAZIONE DI UN NUOVO PONTE PEDOCICLABILE SUL ISARCO E UN NUOVO COLLEGAMENTO PEDOCICLABILE TRA GLI EDIFICI "KAMPILL CENTER" E "MILA BOLZANO" SULLE P.F. 2620/1, 2620/11, 2688/5, 1005/2, 2536/5 E LA P.ED. 4466, CC DODICIVILLE

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A					
B					
C					
D					
E					
F					
Benennung descrizione	<b>STATISCHE BERECHNUNG STAHLKONSTRUKTIONEN</b> <b>RELAZIONE DI CALCOLO COSTRUZIONI IN ACCIAIO</b>				
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## 1. INTRODUZIONE

L'oggetto della presente relazione di calcolo è la progettazione strutturale esecutiva delle esclusive strutture in carpenteria metallica per la realizzazione di un "NUOVO PONTE PEDOCICLABILE SULL'ISARCO TRA GLI EDIFICI "KAMPILL CENTER" E "MILA, BOLZANO" SULLE P.F. 2620/1, 2620/11, 2688/5, 1005/2, 2536/5 E LA P.ED. 4466, CC DODICIVILLE".

Il committente dell'opera è la "COMUNITA' COMPRENSORIALE DI SALTO - SCILIAR, KAMPILL CENTER, Via Innsbruck 29, Bolzano.

Il progettista generale dell'opera è lo studio di architettura "PICHLER ARCHITECTS GmbH Srl, Via T. Edison 15, 39100 Bolzano.

### 1.1. Descrizione delle opere strutturali

La passerella ciclo-pedonale in oggetto è una struttura ad arco a spinta eliminata, in cui l'impalcato metallico stesso assolve la funzione di tirante. La coppia di archi tubolari, che tendono a convergere verso l'apice, è connessa trasversalmente attraverso dei traversi tubolari saldati.

Il sistema di appensione fra archi e impalcato è realizzato mediante profili tubolari inclinati che resistono sia a trazione che a compressione. L'impalcato è costituito da una travatura reticolare piana, in profili tubolari saldati, i cui correnti fungono da tirante per eliminare appunto la spinta degli archi.

La pavimentazione è realizzata mediante una soletta su lamiera grecata collaborante, dello spessore totale di 12 cm, solidarizzata all'impalcato in corrispondenza di ogni traverso grazie a pioli del tipo Nelson. Tale soletta composta assolve la funzione secondaria di trasferire i carichi alla struttura metallica principale, ma non è considerata come collaborante in termini di tirante teso per l'impalcato.

La struttura è costituita da una sola campata, di luce pari a 69,40 m in asse appoggi, mentre gli archi raggiungono un'altezza di 8,25 m rispetto alla quota di imposta degli appoggi. L'impalcato ha una larghezza globale pari 6,40 m in asse e una larghezza calpestabile di 4,40 m.

La passerella poggia sulle due spalle previste sulle due sponde del fiume Isarco. Tali spalle, di cui la presente relazione di calcolo non è oggetto di verifica, sono realizzate in c.a. gettato in opera e micropali. Gli appoggi della passerella sono del tipo da ponte in acciaio e PTFE, fissi, monodirezionali e multi direzionali a seconda dei casi e come indicato nel progetto esecutivo. Sono previsti inoltre dei giunti di espansione alle estremità della passerella, al fine di assorbire gli spostamenti dovuti ai carichi accidentali ed eccezionali (sisma).

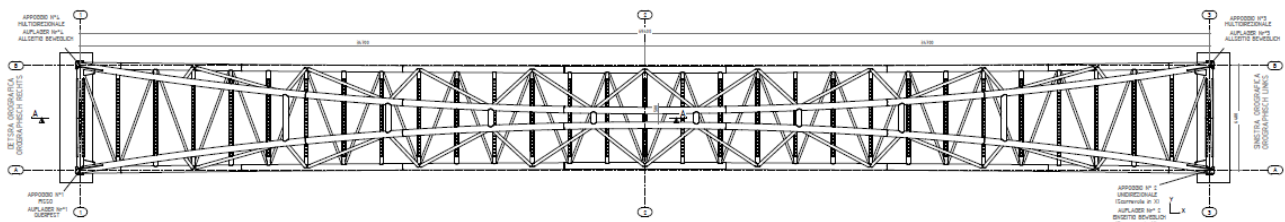
La pavimentazione al di sopra della soletta composta strutturale è realizzata mediante uno strato di impermeabilizzazione, realizzato con una malta cementizia polimerica, sul quale viene posato lo strato d'usura in asfalto drenante.

Al fine di determinare la corretta lunghezza di libera inflessione degli archi da utilizzare nelle verifiche di instabilità, è stata svolta un'analisi di buckling e da questa sono stati estratti i

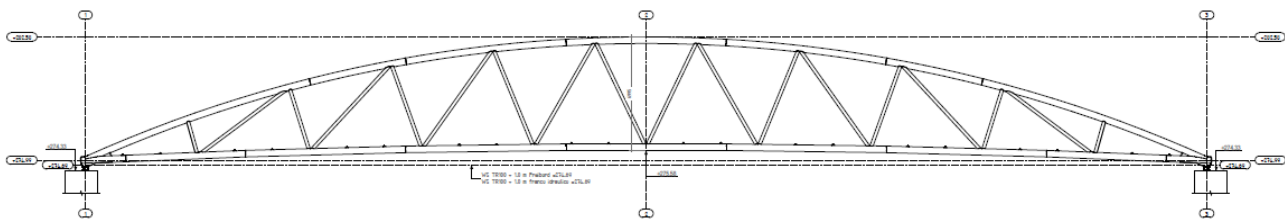
coefficienti moltiplicativi per le lunghezze relative ai due assi principali; la procedura è riportata nel capitolo 10 della presente relazione.

Il risultato dell'analisi di buckling è fortemente influenzato del tipo di connessione tra gli elementi, in particolare tra gli archi ed i relativi traversi; è stata quindi valutata la rigidezza tra questi elementi mediante un'analisi FEM, in modo da poter utilizzare delle molle opportunamente calibrate in corrispondenza delle connessioni. I valori delle rigidezze sono riportati nella tabella 6.15.

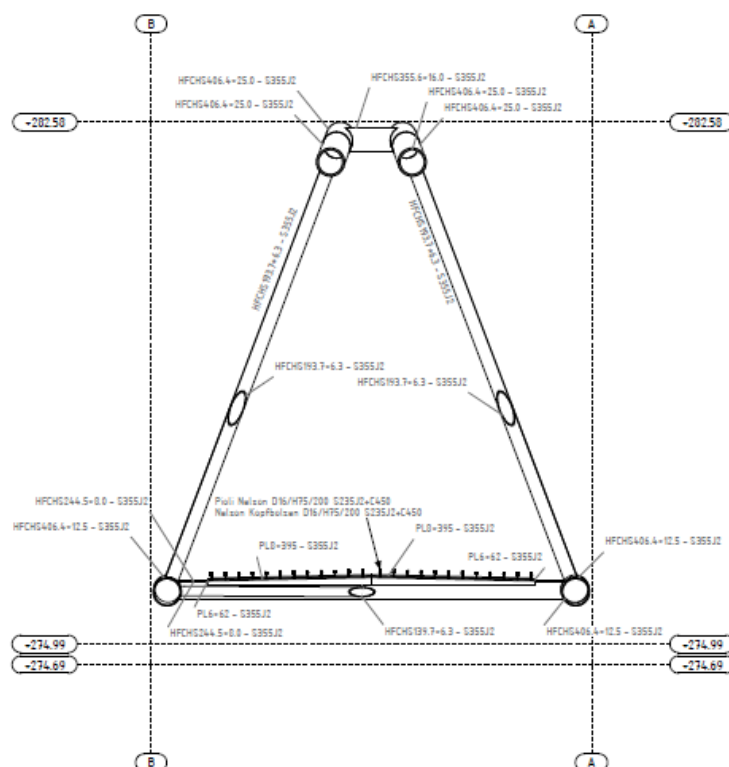
Di seguito si riportano alcune immagini esplicative della struttura in oggetto, tratte dai disegni di progetto esecutivo delle strutture.



*Vista in pianta*

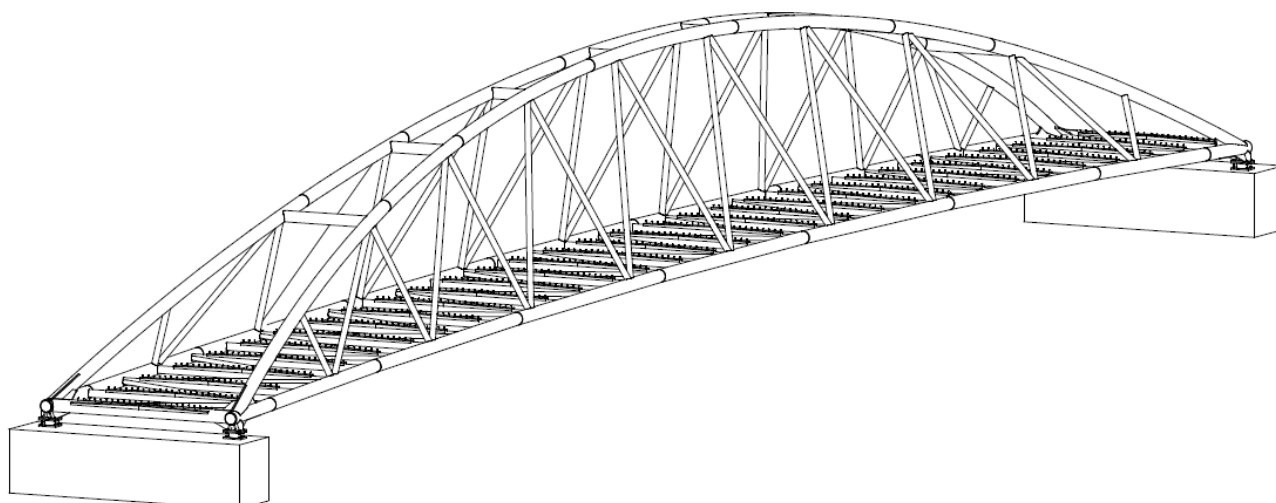


*Prospetto Ovest*

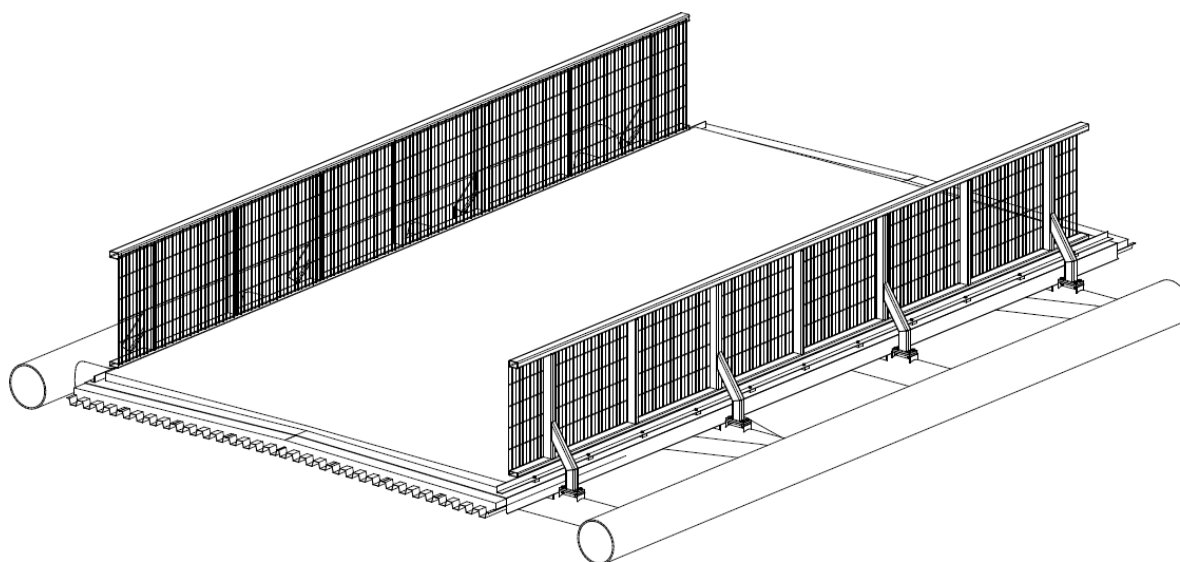




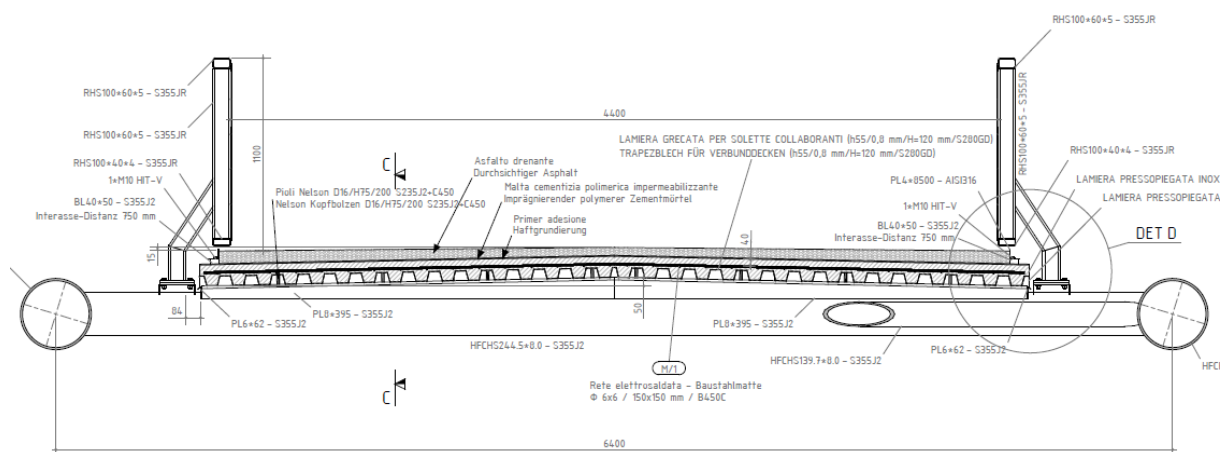
Sezione tipica della parte strutturale



Vista 3D globale



Dettaglio 3D di una porzione tipica di impalcato



Sezione tipica di impalcato

## 2. NORMATIVA DI RIFERIMENTO

Il progetto strutturale è stato condotto nel rispetto delle normative nazionali cogenti e delle normative europee di riferimento elencate di seguito.

### Normativa italiana

- Legge n. 1086 , 05.11.1971  
Norme per la disciplina sulle opere di conglomerato cementizio armato, normale e precompresso ed a struttura metallica.
- Legge n. 64 , 02.02.1974  
Provvedimenti per le costruzioni con particolari prescrizioni per le zone sismiche.
- D.M. 17.01.2018  
Aggiornamento delle <<Norme tecniche per le costruzioni>>.
- CIRCOLARE 21 gennaio 2019 , n. 7 C.S.LL.PP.  
Istruzioni per l'applicazione dell'«Aggiornamento delle "Norme tecniche per le costruzioni"» di cui al decreto ministeriale 17 gennaio 2018.
- UNI 11104:2016  
Calcestruzzo – Specificazione, prestazione, produzione e conformità – Specificazioni complementari per l'applicazione della EN 206.

### Normativa europea

- UNI EN 206:2016  
Calcestruzzo – Specificazione, prestazione, produzione e conformità.
- UNI EN 1990  
Eurocodice – Criteri generali di progettazione strutturale.
- UNI EN 1991-1-1  
Eurocodice 1 – Azioni sulle strutture – Parte 1-1: Azioni in generale – pesi per unità di volume, pesi propri e sovraccarichi per gli edifici.
- UNI EN 1991-1-3  
Eurocodice 1 – Azioni sulle strutture – Parte 1-3: Azioni in generale – carichi da neve.
- UNI EN 1991-1-4  
Eurocodice 1 – Azioni sulle strutture – Parte 1-5: Azioni in generale – Azioni del vento.
- UNI EN 1991-1-5  
Eurocodice 1 – Azioni sulle strutture – Parte 1-5: Azioni in generale – Azioni termiche.
- UNI EN 1991-2  
Eurocodice 1 – Azioni sulle strutture – Parte 2: Carichi da traffico sui ponti.
- UNI EN 1992-1-1  
Eurocodice 2 – Progettazione delle strutture di calcestruzzo – Parte 1-1: Regole generali e regole per edifici.

- UNI EN 1993-1-1  
Eurocodice 3 – Progettazione delle strutture in acciaio – Parte 1-1: Regole generali e regole per edifici.
- UNI EN 1993-1-5  
Eurocodice 3 – Progettazione delle strutture in acciaio – Parte 1-5: Elementi strutturali a lastra.
- UNI EN 1993-1-8  
Eurocodice 3 – Progettazione delle strutture in acciaio – Parte 1-8: Progettazione dei collegamenti.
- UNI EN 1993-1-10  
Eurocodice 3 – Progettazione delle strutture in acciaio – Parte 1-10: Resilienza del materiale e proprietà attraverso lo spessore.
- UNI EN 1993-2  
Eurocodice 3 – Progettazione delle strutture in acciaio – Parte 2: Ponti di acciaio.
- UNI EN 1994-1-1  
Eurocodice 4 – Progettazione delle strutture composte acciaio-calcestruzzo – Parte 1-1: Regole generali e regole per gli edifici.
- UNI EN 1998-1  
Eurocodice 8 – Progettazione delle strutture per la resistenza sismica – Parte 1: Regole generali, azioni sismiche e regole per gli edifici.
- UNI EN 1998-2  
Eurocodice 8 – Progettazione delle strutture per la resistenza sismica – Parte 2: Ponti.

## **Istruzioni e Linee Guida**

- CNR-DT 207/2008  
Istruzioni per la valutazione delle azioni e degli effetti del vento sulle costruzioni.

### 3. SICUREZZA E PRESTAZIONI ATTESE

#### 3.1. Vita nominale di progetto, classi d'uso e periodo di riferimento

Per la passerella ciclopedonale in oggetto si assume una vita nominale di progetto  $V_N = 100$  anni, prevista per costruzioni con livelli di prestazione elevati, come indicato nella tabella seguente:

Tab. 2.4.I – Valori minimi della Vita nominale  $V_N$  di progetto per i diversi tipi di costruzioni

TIPI DI COSTRUZIONI		Valori minimi di $V_N$ (anni)
1	Costruzioni temporanee e provvisorie	10
2	Costruzioni con livelli di prestazioni ordinari	50
3	Costruzioni con livelli di prestazioni elevati	100

Con riferimento alle conseguenze di una interruzione di operatività o di un eventuale collasso, la costruzione in oggetto è associabile alla classe d'uso II, alla quale corrisponde un coefficiente d'uso  $C_u = 1,0$ :

Classe I: Costruzioni con presenza solo occasionale di persone, edifici agricoli.

Classe II: Costruzioni il cui uso preveda normali affollamenti, senza contenuti pericolosi per l'ambiente e senza funzioni pubbliche e sociali essenziali. Industrie con attività non pericolose per l'ambiente. Ponti, opere infrastrutturali, reti viarie non ricadenti in Classe d'uso III o in Classe d'uso IV, reti ferroviarie la cui interruzione non provochi situazioni di emergenza. Dighe il cui collasso non provochi conseguenze rilevanti.

Classe III: Costruzioni il cui uso preveda affollamenti significativi. Industrie con attività pericolose per l'ambiente. Reti viarie extraurbane non ricadenti in Classe d'uso IV. Ponti e reti ferroviarie la cui interruzione provochi situazioni di emergenza. Dighe rilevanti per le conseguenze di un loro eventuale collasso.

Classe IV: Costruzioni con funzioni pubbliche o strategiche importanti, anche con riferimento alla gestione della protezione civile in caso di calamità. Industrie con attività particolarmente pericolose per l'ambiente. Reti viarie di tipo A o B, di cui al DM 5/11/2001, n. 6792, "Norme funzionali e geometriche per la costruzione delle strade", e di tipo C quando appartenenti ad itinerari di collegamento tra capoluoghi di provincia non altresì serviti da strade di tipo A o B. Ponti e reti ferroviarie di importanza critica per il mantenimento delle vie di comunicazione, particolarmente dopo un evento sismico. Dighe connesse al funzionamento di acquedotti e a impianti di produzione di energia elettrica.

Tab. 2.4.II – Valori del coefficiente d'uso  $C_u$

CLASSE D'USO	I	II	III	IV
COEFFICIENTE $C_u$	0,7	1,0	1,5	2,0

Dalle considerazioni di cui sopra si ottiene un periodo di riferimento per l'azione sismica  $V_R = V_N \cdot C_u = 100 \cdot 1,0 = 100$  anni.

### 3.2. Criteri di verifica delle strutture

L'analisi e la verifica di ogni singola struttura è stata condotta con l'ausilio di un programma di calcolo agli elementi finiti, attraverso il quale è stato definito un modello congruente con quanto progettato.

Il progetto e la verifica delle strutture rispetta il metodo semiprobabilistico agli stati limite, come indicato dalle normative cogenti. Le verifiche di sicurezza (resistenza e stabilità) vengono eseguite nei confronti degli stati limite ultimi SLU per le azioni di tipo statico, e di salvaguardia della vita SLV per le azioni di tipo sismico, mentre le verifiche di deformabilità dei singoli elementi e di deformazione globale della struttura vengono eseguite nei confronti degli stati limite di esercizio SLE e di danno SLD. Vengono inoltre eseguite verifiche di comfort di percorrenza della passerella attraverso il calcolo delle accelerazioni indotte dal transito dei pedoni.

L'analisi sismica è stata condotta mediante analisi dinamica modale con spettro di risposta, nell'ipotesi di comportamento strutturale "non dissipativo", come previsto per i ponti. Si rimanda al capitolo specifico sull'analisi dei carichi e successivi per ulteriori approfondimenti sull'analisi dell'evento sismico.

### 3.3. Specifiche di progetto

A seguire le specifiche di progetto di riferimento, con riferimento alle strutture in carpenteria metallica:

Normativa di riferimento per l'esecuzione:	EN 1090-2
Classe di esecuzione secondo EN 1090-2:	EXC3
Classe di tolleranze funzionali secondo EN 1090-2:	Classe 1
Trattamento superficiale:	DUPLEX: zincatura + verniciatura (secondo EN ISO 1461 + EN ISO 12944)
Classe di preparazione delle superfici secondo EN 1090-2:	P2
Categoria di corrosività:	C3 (secondo EN ISO 12944)
Categoria di durabilità:	Zincatura: VH (> 20 anni) Verniciatura: H (> 15 anni)
Ciclo di verniciatura:	A3 (secondo EN ISO 12944)

## 4. CARATTERISTICHE DEI MATERIALI

### 4.1. Calcestruzzo per soletta su lamiera grecata collaborante

Specifiche secondo UNI EN 206:2016, UNI 11104:2016, D.M. 17/01/2018 (NTC 2018) e relativa Circolare Applicativa 21/01/2019 n.7 C.S.LL.PP..

#### Classe di resistenza minima C30/37

Resistenza caratteristica cil. a compressione	$f_{ck} = 30 \text{ N/mm}^2$
Resistenza caratteristica cub. a compressione	$R_{ck} = 37 \text{ N/mm}^2$
Resistenza media a compressione	$f_{cm} = f_{ck} + 8 = 38 \text{ N/mm}^2$
Resistenza media a trazione semplice	$f_{ctm} = 0,30f_{cm}^{2/3} = 2,90 \text{ N/mm}^2$
Resistenza a trazione per flessione	$f_{ctm} = 1,2f_{ctm} = 3,48 \text{ N/mm}^2$
Modulo elastico medio	$E = 22000 (f_{cm}/10)^{0,3} \text{ N/mm}^2 = 32837 \text{ N/mm}^2$
Resistenza di calcolo a compressione	$f_{cd} = \alpha f_{ck} / \gamma_c = 17,00 \text{ N/mm}^2$ ( $\alpha = 0,85$ ; $\gamma_c = 1,5$ )
Coefficiente di Poisson	$\nu = 0,2$ (calcestruzzo non fessurato)
Coefficiente di dilatazione termica	$\alpha = 10 \times 10^{-6}$ (per grado)
Densità	$\rho = 2500 \text{ daN/m}^3$

Classe di esposizione	XC4+XF4
Massimo rapporto a/c	0,45
Minimo contenuto in cemento	360 Kg/m <sup>3</sup>
Aggregati	conformi alla UNI EN 12620 di adeguata resistenza al gelo/disgelo
Diametro massimo dell'inerte	$D_{max} = 16 \text{ mm}$
Contenuto minimo in aria	5% (per $D_{max}=16 \text{ mm}$ )
Copriferro nominale	$c_{nom} = 40 \text{ mm}$ (= S4+2-1 = S5 = 35mm+5mm)
Classe di consistenza (slump)	S4/S5

### 4.2. Acciaio per armatura lenta

#### Classe B450C (per barre, rotoli e reti elettrosaldate)

Tensione caratteristica di snervamento	$f_y = 450 \text{ N/mm}^2$
Tensione caratteristica di rottura	$f_t = 540 \text{ N/mm}^2$

### 4.3. Acciaio per carpenteria metallica

#### Classe S235

Tensione di snervamento	$f_{yk} \geq 235 \text{ N/mm}^2$	( $t \leq 40 \text{ mm}$ )
Tensione di snervamento	$f_{yk} \geq 215 \text{ N/mm}^2$	( $40 \leq t \leq 80 \text{ mm}$ )
Tensione di rottura	$f_{tk} \geq 360 \text{ N/mm}^2$	( $t \leq 40 \text{ mm}$ )
Tensione di rottura	$f_{tk} \geq 360 \text{ N/mm}^2$	( $40 \leq t \leq 80 \text{ mm}$ )



Modulo elastico	$E = 210000 \text{ N/mm}^2$
Coefficiente di Poisson in campo elastico	$\nu = 0.3$
Modulo di elasticità tangenziale	$G = 81000 \text{ N/mm}^2$
Densità	$\rho = 7850 \text{ kg/m}^3$
Coefficiente di dilatazione termica lineare	$\alpha = 12 \times 10^{-6} \text{ per K (per } T \leq 100 \text{ °C)}$

### Classe S275

Tensione di snervamento	$f_{yk} \geq 275 \text{ N/mm}^2$	$(t \leq 40 \text{ mm})$
Tensione di snervamento	$f_{yk} \geq 255 \text{ N/mm}^2$	$(40 \leq t \leq 80 \text{ mm})$
Tensione di rottura	$f_{tk} \geq 430 \text{ N/mm}^2$	$(t \leq 40 \text{ mm})$
Tensione di rottura	$f_{tk} \geq 410 \text{ N/mm}^2$	$(40 \leq t \leq 80 \text{ mm})$
Modulo elastico	$E = 210000 \text{ N/mm}^2$	
Coefficiente di Poisson in campo elastico	$\nu = 0.3$	
Modulo di elasticità tangenziale	$G = 81000 \text{ N/mm}^2$	
Densità	$\rho = 7850 \text{ kg/m}^3$	
Coefficiente di dilatazione termica lineare	$\alpha = 12 \times 10^{-6} \text{ per K (per } T \leq 100 \text{ °C)}$	

### Classe S355

Tensione di snervamento	$f_{yk} \geq 355 \text{ N/mm}^2$	$(t \leq 40 \text{ mm})$
Tensione di snervamento	$f_{yk} \geq 335 \text{ N/mm}^2$	$(40 \leq t \leq 80 \text{ mm})$
Tensione di rottura	$f_{tk} \geq 510 \text{ N/mm}^2$	$(t \leq 40 \text{ mm})$
Tensione di rottura	$f_{tk} \geq 470 \text{ N/mm}^2$	$(40 \leq t \leq 80 \text{ mm})$
Modulo elastico	$E = 210000 \text{ N/mm}^2$	
Coefficiente di Poisson in campo elastico	$\nu = 0.3$	
Modulo di elasticità tangenziale	$G = 81000 \text{ N/mm}^2$	
Densità	$\rho = 7850 \text{ kg/m}^3$	
Coefficiente di dilatazione termica lineare	$\alpha = 12 \times 10^{-6} \text{ per K (per } T \leq 100 \text{ °C)}$	

### Classe di tenacità (secondo UNI EN 1993-1-10)

$$T_{Ed} = T_{md} + \Delta T_r + \Delta T_\sigma + \Delta T_R + \Delta T_\epsilon + \Delta T_{\epsilon f}$$

$$T_{Ed} = -19 \text{ °C} + (-5 \text{ °C}) + 0 \text{ °C} + 0 \text{ °C} + 0 \text{ °C} + 0 \text{ °C} = -24 \text{ °C}$$

Considerando un livello di snervamento proporzionale alla resistenza a snervamento nominale pari a  $\sigma_{Ed} = 0,75 \cdot f_y(t) \text{ [N/mm}^2]$ , si ottengono i seguenti valori massimi ammissibili dello spessore dell'elemento "t":

S235 JR:  $t \leq 33 \text{ mm}$

S235 J0:  $t \leq 46 \text{ mm}$

S235 J2:  $t \leq 69 \text{ mm}$

S275 JR:  $t \leq 28 \text{ mm}$

S275 J0:  $t \leq 41 \text{ mm}$

S275 J2:  $t \leq 61 \text{ mm}$

S355 JR:  $t \leq 18 \text{ mm}$

S355 J0:  $t \leq 31 \text{ mm}$

S355 J2:  $t \leq 46 \text{ mm}$

Di seguito si riporta il calcolo della temperatura  $T_{md}$  (la più bassa temperatura avente un periodo di ritorno specificato, vedi UNI EN 1991-1-5 – Appendice 05-11-2009):



*Mapa delle temperature minime dell'aria all'ombra, al livello del mare ( $T_{min}$ )*

#### 4.4. Bulloni per carpenteria metallica

##### Classe 8.8 SB (EN 15048)

Tensione di snervamento

$$f_{yb} = 640 \text{ N/mm}^2$$

Tensione di rottura a trazione

$$f_{ub} = 800 \text{ N/mm}^2$$

##### Classe 10.9 HV (EN 14399-4)

Tensione di snervamento

$$f_{yb} = 900 \text{ N/mm}^2$$

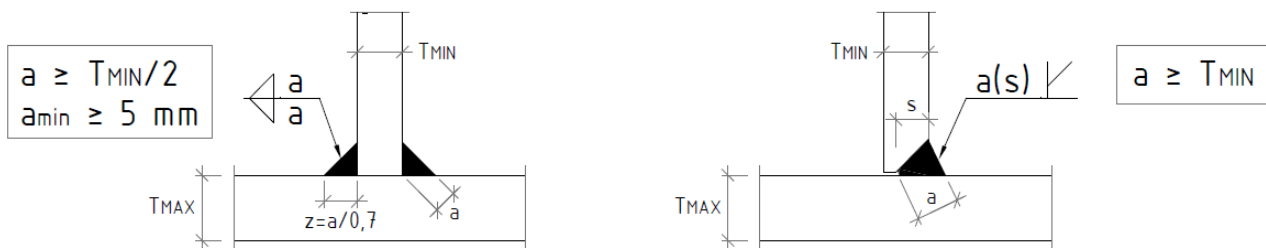
Tensione di rottura a trazione

$$f_{ub} = 1000 \text{ N/mm}^2$$

#### 4.5. Saldature

Livello di qualità **B** per classe di esecuzione **ECX3** (secondo EN 1090-2 e ISO 3834-2).

Se non diversamente specificato, e con riferimento allo spessore minimo collegato " $T_{\text{MIN}}$ ", si prescrivono saldature a cordoni d'angolo (o equivalenti a parziale penetrazione) con gola " $a$ ":



## 5. ANALISI DEI CARICHI

### 5.1. Carichi permanenti

#### ■ Permanenti strutturali

Peso proprio delle strutture in acciaio

$$\gamma = 78,50 \text{ kN/m}^3$$

Peso proprio delle strutture in calcestruzzo armato

$$\gamma = 25,00 \text{ kN/m}^3$$

#### ■ Permanenti non strutturali

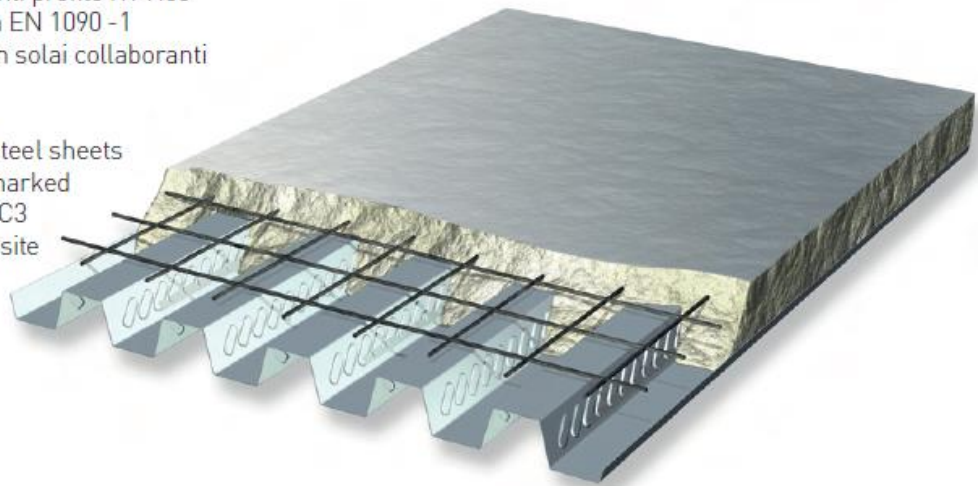
Soletta su lamiera grecata collaborante tipo "Italpannelli ITPH55 a 5 greche"

$$2,50 \text{ kN/m}^2$$

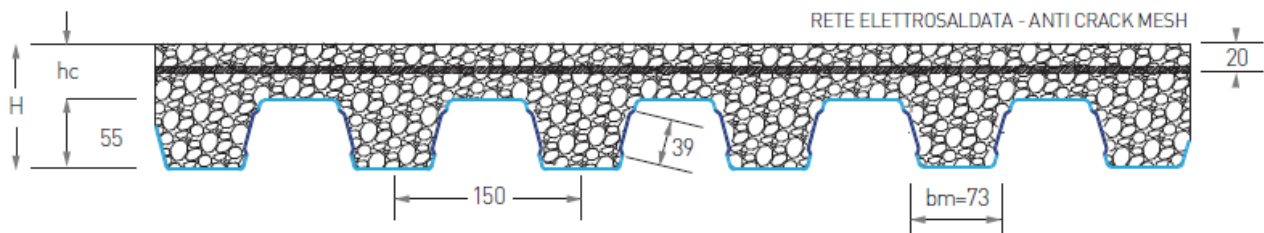
(H=12 cm, spessore lamiera 0,8 mm, luce in asse appoggi= 2,315 m)

Lamiere grecate collaboranti profilo ITPH55  
marcate CE in accordo alla EN 1090 - 1  
Classe EXC3 da utilizzare in solai collaboranti  
acciaio - calcestruzzo

Collaborating trapezoidal steel sheets  
ITP H55 Beton profile CE marked  
according to EN 1090-1 EXC3  
class to be used for composite  
floor steel - concrete.



Passo greche - Ribs step 600 mm - **5 Greche - Ribs**



Pavimentazione e parapetti laterali:

Impermeabilizzazione

$$0,04 \text{ kN/m}^2$$

Manto di usura in conglomerato bituminoso (s=3 cm,  $\gamma=2450 \text{ Kg/m}^3$  compattato)

$$0,75 \text{ kN/m}^2$$

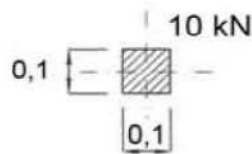
Parapetti laterali (0,50 kN/m x 2, Larghezza impalcato = 4,75 m)

$$0,21 \text{ kN/m}^2$$

$$1,00 \text{ kN/m}^2$$

## 5.2. Azioni variabili da traffico

- **Schema di Carico 4:** è costituito da un carico isolato da 10 kN con impronta quadrata di lato 0,10 m.



Schema di carico 4  
(dimensioni in [m])

- **Schema di Carico 5:** costituito dalla folla compatta, agente con intensità nominale, comprensiva degli effetti dinamici, di 5,00 kN/m<sup>2</sup>, con la disposizione più gravosa per le singole verifiche.

Secondo l'Eurocodice 1 (Rif.: UNI EN 1991-2 § 5.4) bisogna considerare inoltre un'azione distribuita orizzontale, agente lungo l'asse della pavimentazione del ponte pedonale, pari al valore maggiore fra i seguenti:

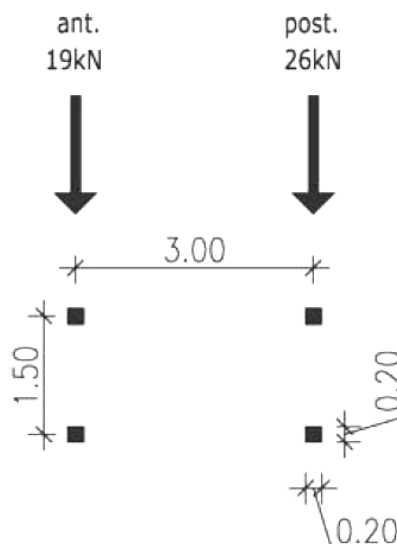
- 10% del carico corrispondente allo schema di carico 5:  $0,1 \cdot 5,00 \text{ kN/m}^2 = 0,50 \text{ kN/m}^2$ ;
- 60% del carico totale corrispondente al veicolo di servizio, se rilevante (vedi definizione del carico dovuto al mezzo di servizio):  $0,6 \cdot (19+26) \text{ kN} = 27 \text{ kN}$ . Tale azione rappresenta la forza di accelerazione e frenamento del mezzo.

Tale azione orizzontale è da considerarsi agente simultaneamente al carico verticale corrispondente (schema di carico 5 e/o carico del veicolo di servizio), ma mai assieme al carico concentrato dello schema di carico 4.

### ▪ Mezzo di servizio

Si considera la possibilità che sul ponte pedonale possa transitare un mezzo di servizio, con la finalità di eseguire operazioni di manutenzione. La scelta del mezzo di servizio è in accordo con le indicazioni del Committente.

- Autocarro leggero a due assi (tipo Daily Iveco) di portata complessiva su due assi 19+26 kN:



**Nota:** L'accesso al ponte pedonale da parte di carichi mobili dovuti a mezzi in transito diversi da quelli di progetto deve essere materialmente impedito.

Il carico dovuto al mezzo di servizio non viene mai considerato simultaneo al carico della folla.

### 5.3. Azioni sui parapetti

I sovraccarichi orizzontali lineari devono essere utilizzati per le verifiche locali dei parapetti laterali e non si combinano con i carichi utilizzati nelle verifiche globali della passerella.

Vanno applicati alla quota minima di 1,10 m dal piano di calpestio e pari al valore di  $H_k = 3,00 \text{ kN/m}$ , secondo la categoria C3 per grandi affollamenti.

### 5.4. Azioni della neve

Il carico neve non deve essere combinato con il carico da folla, e non essendo dimensionante in rapporto a quest'ultimo, va utilizzato esclusivamente per le verifiche in fase di montaggio dell'opera.

Zona	Zona I - Alpina	
Quota del suolo nel sito di realizzazione sul livello del mare	275	m
Carico neve al suolo - $q_{sk}$	1,59	kN/m <sup>2</sup>
Topografia - $C_e$	Normale	1,0
Coefficiente termico - $C_t$	1	
Inclinazione della falda	0	°
Coefficiente di forma - $\mu_1$	0,80	
Coefficiente di forma - $\mu_2$	0,80	
Carico neve sulla copertura - $q_s (\mu_1)$	1,27	kN/m <sup>2</sup>

Nota: poiché la passerella pedonale è costantemente investita dal vento su tutti i lati ed è per natura priva di ostacoli significativi, il coefficiente di forma è assunto pari al valore 0,8 come per le coperture.

### 5.5. Azioni del vento

Nel calcolo delle azioni del vento si farà riferimento di seguito ad un valore dell'altezza della costruzione dal suolo corrispondente al valore medio dell'altezza dell'arco rispetto al pelo libero del fiume Isarco in condizioni di portata normali. Tale valore risulta pari a ca. 10,00 m.



Zona

Zona 1

Periodo di ritorno -  $T_r$  ( $5 \leq T_r \leq 500$  anni -  $T_{r,base} = 50$  anni)

50

Altitudine sul livello del mare del sito ove sorge la costruzione -  $a_s$ 

275

m

Altezza della costruzione -  $z$ 

10,00

m

Coefficiente di topografia (generalmente posto uguale ad 1) -  $c_t$ 

1

Coefficiente dinamico (generalmente posto uguale ad 1) -  $c_d$ 

1

Categoria di esposizione

II

Velocità base di riferimento al livello del mare -  $v_{b,0}$ 

25,0

m/s

Parametro Tab. 3.3.I -  $a_0$ 

1000

m

Parametro Tab. 3.3.I -  $k_s$ 

0,40

Coefficiente di altitudine -  $c_a$ 

1,00

Velocità base di riferimento -  $v_b$ 

25,0

m/s

Coefficiente di ritorno -  $c_r$ 

1,00

Velocità di riferimento -  $v_r$ 

25,0

m/s

Pressione cinetica di riferimento -  $q_r$ 

0,39

kN/m<sup>2</sup>Parametro Tab. 3.3.II -  $k_r$ 

0,19

Parametro Tab. 3.3.II -  $z_0$ 

0,05

m

Parametro Tab. 3.3.II -  $z_{min}$ 

4

m

Coefficiente di esposizione -  $c_e$ 

2,35

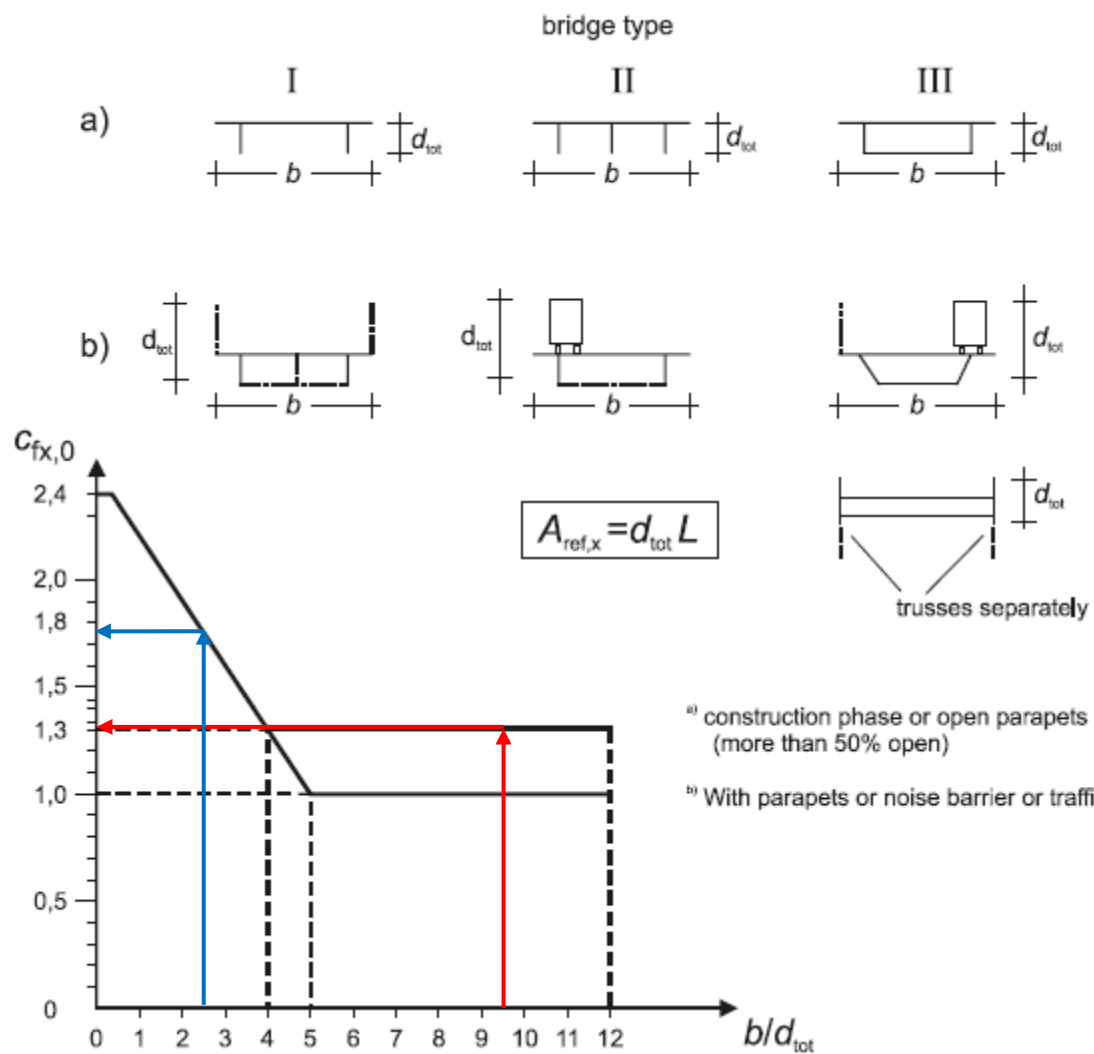
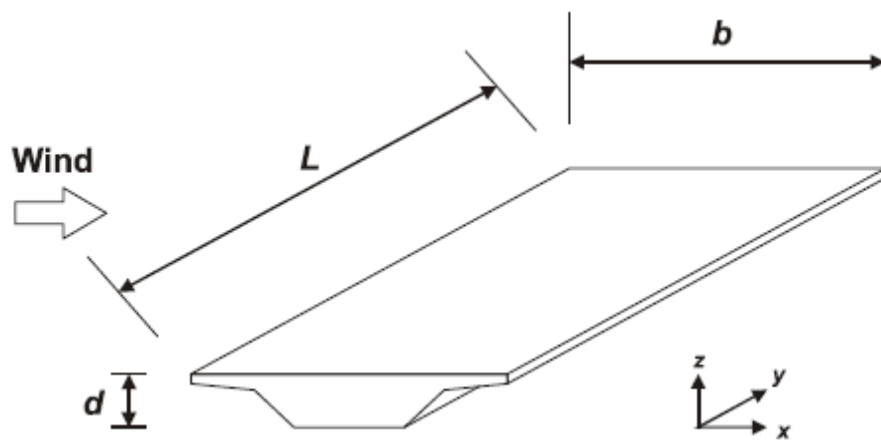
Pressione del vento a meno del coefficiente di forma  $c_p$  -  $p/c_p$ 

0,92

kN/m<sup>2</sup>

▪ Azione del vento sull'impalcato

(Rif.: UNI EN 1991-1-4 § 8)



Vento in direzione X ("drag"):

Caso a)

$$b = 4,75 \text{ m}$$

$$d_{\text{tot}} = 0,50 \text{ m}$$

$$b/d_{\text{tot}} = 9,50$$

$$C_{f,x,0} = 1,30$$

$$p_{x,(a)} = 0,92 \cdot 1,30 = 1,20 \text{ kN/m}^2$$

Caso b)

$$b = 4,75 \text{ m}$$

$$d_{\text{tot}} = 2,00 \text{ m}$$

$$b/d_{\text{tot}} = 2,38$$

$$C_{f,x,0} = 1,75$$

$$p_{x,(b)} = 0,92 \cdot 1,75 = 1,61 \text{ kN/m}^2$$

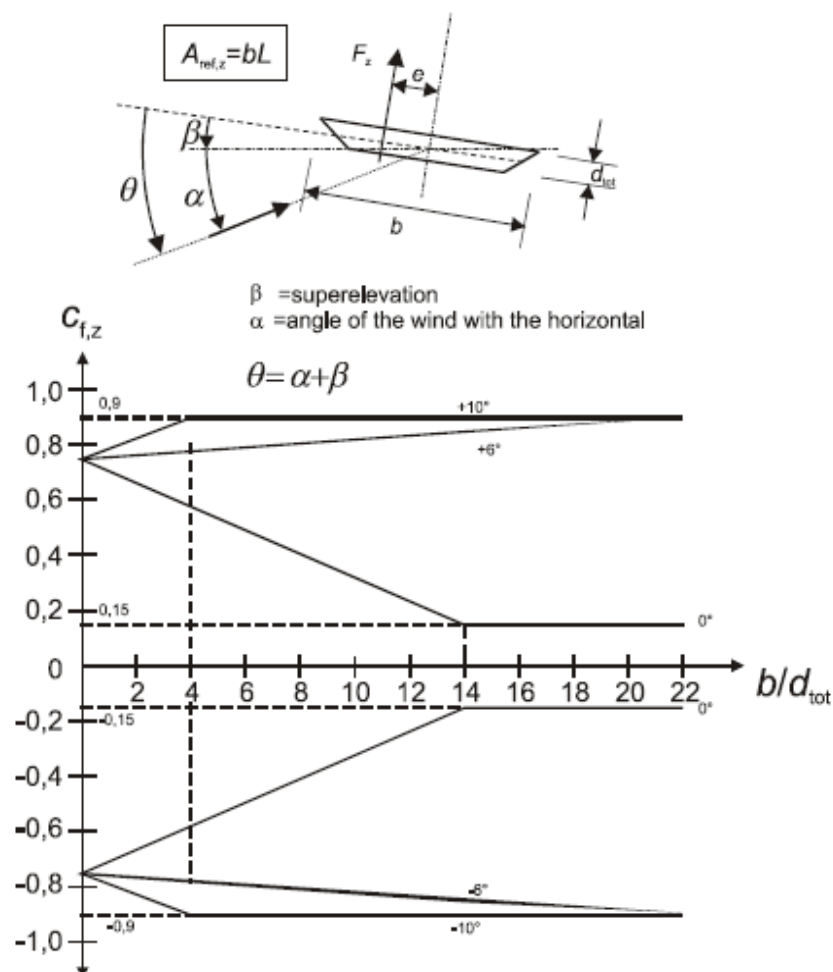
A favore di sicurezza e in mancanza di indicazioni esecutive più precise riguardo alla permeabilità al vento dei parapetti, si adotta il valore di pressione laterale relativa al caso b).

Vento in direzione Z ("lift"):

l'azione del vento in direzione verticale va considerata assumendo, in mancanza di indagini più approfondite, un valore corrispondente ad un coefficiente di forza pari a  $c_{f,z} = \pm 0,90$ .

Tale coefficiente tiene in conto l'effetto di un angolo di attacco del vento rispetto all'impalcato diverso da  $0^\circ$ .

$$p_z = 0,92 \cdot (\pm 0,90) = \pm 0,83 \text{ kN/m}^2$$



Effetti torcenti dovuti al vento ("moment"):

l'azione torcente sull'impalcato dovuta alla componente verticale del vento va considerata assumendo, in mancanza di indagini più approfondite, un'eccentricità pari a  $b/4$ , tale da generare il seguente momento torcente:

$$m_y = (p_z \cdot b) \cdot e = (\pm 0,83 \cdot 4,75) \cdot (4,75/4) = \pm 4,68 \text{ kNm/m} \quad \text{con } e = b/4 = 1,188 \text{ m}$$

▪ Azione del vento su elementi tubolari circolari (archi e diagonali di parete)

(Rif.: UNI EN 1991-1-4 § 7.9)

$$c_{fx0} = \frac{0,11}{(Re/10^6)^{1,4}} \quad (\text{curva A})$$

$$c_{fx0} = 1,2 + \frac{0,18 \cdot \log_{10}(10 \cdot k/b)}{1 + 0,4 \cdot \log_{10}(Re/10^6)} \quad (k/b \geq 10^{-5}) \quad (\text{curva B})$$

$q_p$ [kN/m <sup>2</sup> ]	$v_m(z_e)$ [m/s]	$v$ [m <sup>2</sup> /s]	Diamentro "b" [m]	Re (Reynolds)	Scabrezza k	k/b	Coefficiente di forza ( $c_f = c_{f,0}$ con $\psi_\lambda=1$ )	Forza [kN/m]
0,92	38,37	2E-05	0,193	4,94E+05	0,02	1,04E-04	0,588	0,10
0,92	38,37	2E-05	0,405	1,04E+06	0,02	4,94E-05	0,608	0,23

## 5.6. Azioni della temperatura

Si adotta una variazione termica costante  $\Delta T_u = \pm 25^\circ$ , come indicato per le strutture in acciaio esposte:

Tipo di struttura	$\Delta T_u$
Strutture in c.a. e c.a.p. esposte	$\pm 15^\circ\text{C}$
Strutture in c.a. e c.a.p. protette	$\pm 10^\circ\text{C}$
Strutture in acciaio esposte	$\pm 25^\circ\text{C}$
Strutture in acciaio protette	$\pm 15^\circ\text{C}$

## 5.7. Azione sismica

Ubicazione del sito: Bolzano (BZ)

Vita nominale  $V_N = 100$  anni

Classe d'uso II  $c_u = 1,0$

Vita di riferimento  $V_R = 100$  anni

Categoria di sottosuolo B (come da Relazione Geotecnica a firma Geol. Maria Luise-Goegl)

Categoria topografica T1

Fattore di struttura  $q = 1,00$  (sia per sisma orizzontale che verticale, come prescritto per i ponti)

Di seguito si riportano i parametri e punti degli spettri di risposta per gli stati limite SLD e SLV, sulla base delle ipotesi di progetto di cui sopra e in funzione delle direzioni del moto sismico orizzontale e verticale. Il fattore di struttura è assunto unitario, sia per il moto sismico orizzontale che verticale, nell'ipotesi quindi di struttura "non dissipativa", così come prescritto per i ponti.

SLATO LIMITE	$T_R$ [anni]	$a_g$ [g]	$F_o$ [-]	$T_c^*$ [s]
SLO	60	0,026	2,512	0,196
SLD	101	0,032	2,489	0,231
SLV	949	0,062	2,699	0,380
SLC	1950	0,074	2,791	0,413

## FASE 1. INDIVIDUAZIONE DELLA PERICOLOSITÀ DEL SITO

☒ Ricerca per coordinate
 LONGITUDINE  
11,3346
 LATITUDINE  
46,4936

☒ Ricerca per comune
 REGIONE  
Trentino-Alto Adige
 PROVINCIA  
Bolzano/Bozen
 COMUNE  
Bolzano

Elaborazioni grafiche

Grafici spettri di risposta

Variabilità dei parametri

Elaborazioni numeriche

Tabella parametri

Nodi del reticolo intorno al sito

Reticolo di riferimento
 

Controllo sul reticolo
 

- ☒ Sito esterno al reticolo
- ☐ Interpolazione su 3 nodi
- ☐ Interpolazione corretta

Interpolazione  
superficie rigata

La "Ricerca per comune" utilizza le coordinate ISTAT del comune per identificare il sito. Si sottolinea che all'interno del territorio comunale le azioni sismiche possono essere significativamente diverse da quelle così individuate e si consiglia, quindi, la "Ricerca per coordinate".

INTRO

FASE 1

FASE 2

FASE 3

## FASE 2. SCELTA DELLA STRATEGIA DI PROGETTAZIONE

Vita nominale della costruzione (in anni) -  $V_N$   info

Coefficiente d'uso della costruzione -  $c_U$   info

Valori di progetto

Periodo di riferimento per la costruzione (in anni) -  $V_R$   info

Periodi di ritorno per la definizione dell'azione sismica (in anni) -  $T_R$  info

Stati limite di esercizio - SLE { SLO -  $P_{VR} = 81\%$    
SLD -  $P_{VR} = 63\%$

Stati limite ultimi - SLU { SLV -  $P_{VR} = 10\%$    
SLC -  $P_{VR} = 5\%$

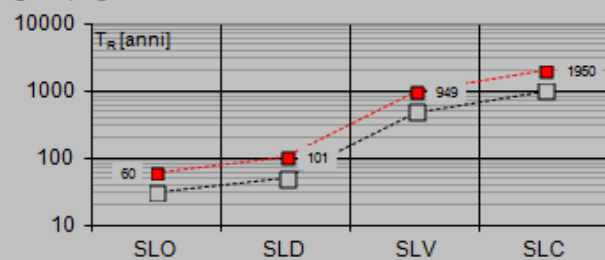
Elaborazioni

Grafici parametri azione

Grafici spettri di risposta

Tabella parametri azione

Strategia di progettazione



LEGENDA GRAFICO

---□--- Strategia per costruzioni ordinarie

---■--- Strategia scelta

INTRO

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## FASE 3. DETERMINAZIONE DELL'AZIONE DI PROGETTO

Stato Limite

Stato Limite considerato  info

Rispostasismica locale

Categoria di sottosuolo  info

Categoria topografica  info

$S_B =$

$C_C =$   info

$h/H =$

$S_T =$   info

( $h$ =quota sito,  $H$ =altezza rilievo topografico)

Compon. orizzontale

☒ Spettro di progetto elastico (SLE)

Smorzamento  $\xi$  (%)

$\eta =$   info

☐ Spettro di progetto inelastico (SLU)

Fattore  $q_c$

Regol. in altezza  info

Compon. verticale

Spettro di progetto

Fattore  $q$

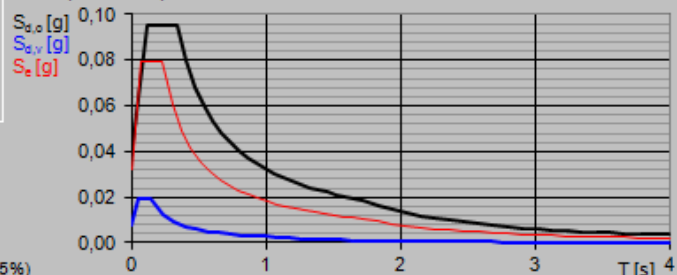
$\eta =$   info

Elaborazioni

Grafici spettri di risposta

Parametri e punti spettri di risposta

Spettri di risposta



— Spettro di progetto - componente orizzontale

— Spettro di progetto - componente verticale

— Spettro elastico di riferimento (Cat. A-T1,  $\xi = 5\%$ )

INTRO

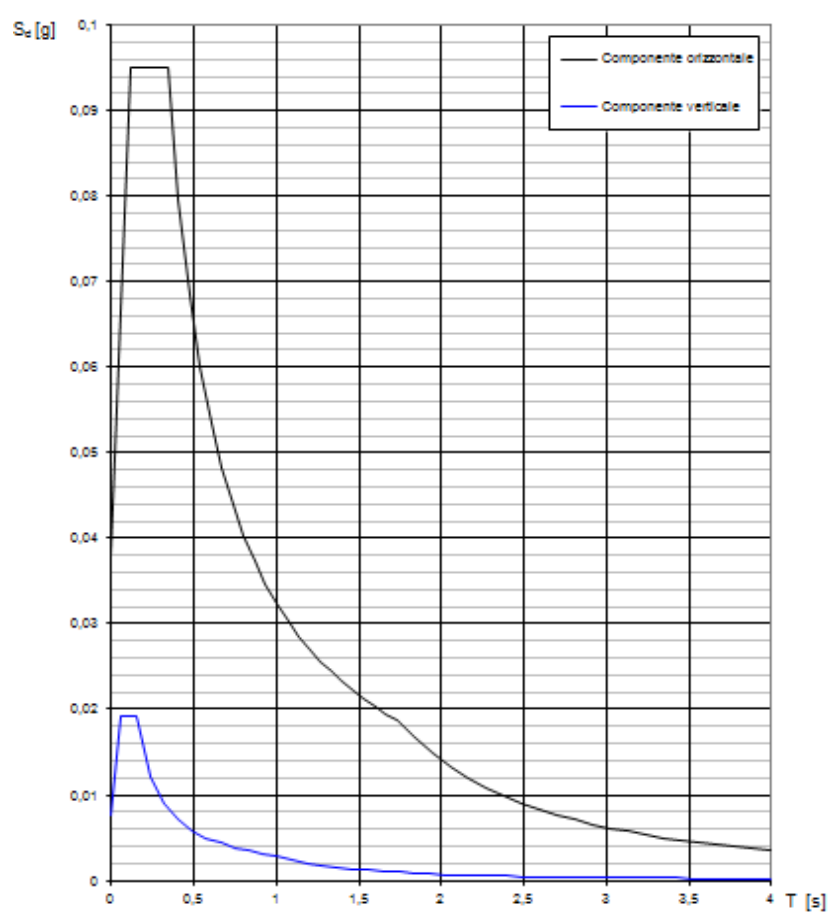
FASE 1

FASE 2

FASE 3



Spettri di risposta (componenti orizz. e vert.) per lo stato lim SLD



## Parametri e punti dello spettro di risposta orizzontale per lo stato limite: SLD

### Parametri indipendenti

STATO LIMITE	SLD
$a_g$	0,032 g
$F_o$	2,489
$T_c^*$	0,231 s
$S_s$	1,200
$C_c$	1,475
$S_T$	1,000
$q$	1,000

### Parametri dipendenti

$S$	1,200
$\eta$	1,000
$T_B$	0,114 s
$T_C$	0,341 s
$T_D$	1,727 s

### Espressioni dei parametri dipendenti

$$S = S_s \cdot S_T \quad (\text{NTC-08 Eq. 3.2.5})$$

$$\eta = \sqrt{10/(5 + \xi)} \geq 0,55; \quad \eta = 1/q \quad (\text{NTC-08 Eq. 3.2.6; §. 3.2.3.5})$$

$$T_B = T_C / 3 \quad (\text{NTC-07 Eq. 3.2.8})$$

$$T_C = C_c \cdot T_c^* \quad (\text{NTC-07 Eq. 3.2.7})$$

$$T_D = 4,0 \cdot a_g / g + 1,6 \quad (\text{NTC-07 Eq. 3.2.9})$$

### Espressioni dello spettro di risposta (NTC-08 Eq. 3.2.4)

$$\begin{aligned}
 0 \leq T < T_B & \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_o \cdot \left[ \frac{T}{T_B} + \frac{1}{\eta \cdot F_o} \left( 1 - \frac{T}{T_B} \right) \right] \\
 T_B \leq T < T_C & \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_o \\
 T_C \leq T < T_D & \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_o \cdot \left( \frac{T_C}{T} \right) \\
 T_D \leq T & \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_o \cdot \left( \frac{T_C T_D}{T^2} \right)
 \end{aligned}$$

Lo spettro di progetto  $S_d(T)$  per le verifiche agli Stati Limite Ultimi è ottenuto dalle espressioni dello spettro elastico  $S_e(T)$  sostituendo  $\eta$  con  $1/q$ , dove  $q$  è il fattore di struttura. (NTC-08 § 3.2.3.5)

### Punti dello spettro di risposta

	T [s]	Se [g]
	0,000	0,038
$T_B \leftarrow$	0,114	0,095
$T_C \leftarrow$	0,341	0,095
	0,407	0,080
	0,473	0,069
	0,539	0,060
	0,605	0,054
	0,671	0,048
	0,737	0,044
	0,803	0,040
	0,869	0,037
	0,935	0,035
	1,001	0,032
	1,067	0,030
	1,133	0,029
	1,199	0,027
	1,265	0,026
	1,331	0,024
	1,397	0,023
	1,463	0,022
	1,529	0,021
	1,595	0,020
	1,661	0,020
$T_D \leftarrow$	1,727	0,019
	1,836	0,017
	1,944	0,015
	2,052	0,013
	2,160	0,012
	2,269	0,011
	2,377	0,010
	2,485	0,009
	2,593	0,008
	2,701	0,008
	2,810	0,007
	2,918	0,007
	3,026	0,006
	3,134	0,006
	3,242	0,005
	3,351	0,005
	3,459	0,005
	3,567	0,004
	3,675	0,004
	3,784	0,004
	3,892	0,004
	4,000	0,003

## Parametri e punti dello spettro di risposta verticale per lo stato limite: SLD

### Parametri indipendenti

STATO LIMITE	SLD
$a_{gv}$	0,008 g
$S_S$	1,000
$S_T$	1,000
$q$	1,000
$T_B$	0,050 s
$T_C$	0,150 s
$T_D$	1,000 s

### Parametri dipendenti

$F_v$	0,600
$S$	1,000
$\eta$	1,000

### Espressioni dei parametri dipendenti

$$S = S_S \cdot S_T \quad (\text{NTC-08 Eq. 3.2.5})$$

$$\eta = 1/q \quad (\text{NTC-08 §. 3.2.3.5})$$

$$F_v = 1,35 \cdot F_o \cdot \left( \frac{a_g}{g} \right)^{0,5} \quad (\text{NTC-08 Eq. 3.2.11})$$

### Espressioni dello spettro di risposta (NTC-08 Eq. 3.2.10)

$$\begin{aligned}
 0 \leq T < T_B & \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_v \cdot \left[ \frac{T}{T_B} + \frac{1}{\eta \cdot F_o} \left( 1 - \frac{T}{T_B} \right) \right] \\
 T_B \leq T < T_C & \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_v \\
 T_C \leq T < T_D & \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_v \cdot \left( \frac{T_C}{T} \right) \\
 T_D \leq T & \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_v \cdot \left( \frac{T_C T_D}{T^2} \right)
 \end{aligned}$$

### Punti dello spettro di risposta

	T [s]	Se [g]
	0,000	0,008
$T_B \leftarrow$	0,050	0,019
$T_C \leftarrow$	0,150	0,019
	0,235	0,012
	0,320	0,009
	0,405	0,007
	0,490	0,006
	0,575	0,005
	0,660	0,004
	0,745	0,004
	0,830	0,003
	0,915	0,003
$T_D \leftarrow$	1,000	0,003
	1,094	0,002
	1,188	0,002
	1,281	0,002
	1,375	0,002
	1,469	0,001
	1,563	0,001
	1,656	0,001
	1,750	0,001
	1,844	0,001
	1,938	0,001
	2,031	0,001
	2,125	0,001
	2,219	0,001
	2,313	0,001
	2,406	0,000
	2,500	0,000
	2,594	0,000
	2,688	0,000
	2,781	0,000
	2,875	0,000
	2,969	0,000
	3,063	0,000
	3,156	0,000
	3,250	0,000
	3,344	0,000
	3,438	0,000
	3,531	0,000
	3,625	0,000
	3,719	0,000
	3,813	0,000
	3,906	0,000
	4,000	0,000

## FASE 3. DETERMINAZIONE DELL'AZIONE DI PROGETTO

Stato Limite

Stato Limite considerato **SLV** ▼ info

Risposta sismica locale

Categoria di sottosuolo **B** ▼ info

Categoria topografica **T1** ▼ info

$S_s = 1,200$

$C_o = 1,335$  ▼ info

$h/H = 0,000$

$S_T = 1,000$  ▼ info

( $h$ =quota sito,  $H$ =altezza rilievo topografico)

Compon. orizzontale

☐ Spettro di progetto elastico (SLE)

Smorzamento  $\xi$  (%) **5**

$\eta = 1,000$  ▼ info

☒ Spettro di progetto inelastico (SLU)

Fattore  $q_o$  **1**

Regol. in altezza **sì** ▼ info

Compon. verticale

Spettro di progetto

Fattore  $q$  **1**

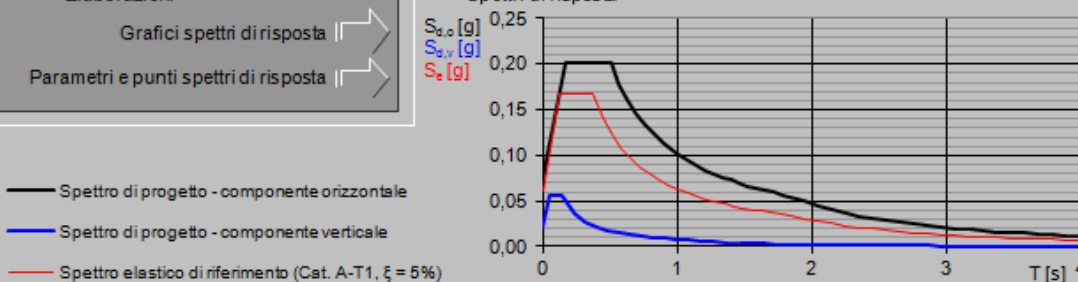
$\eta = 1,000$  ▼ info

Elaborazioni

Grafici spettri di risposta ▶▶

Parametri e punti spettri di risposta ▶▶

Spettri di risposta



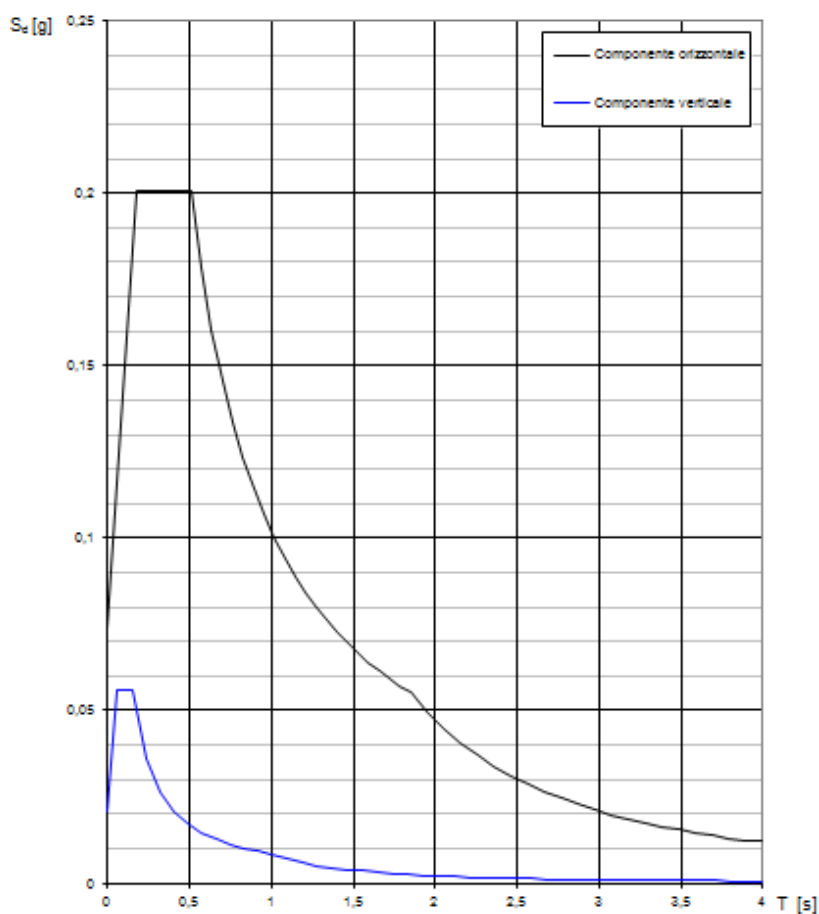
INTRO

FASE 1

FASE 2

**FASE 3**

### Spettri di risposta (componenti orizz. e vert.) per lo stato lim SLV



## Parametri e punti dello spettro di risposta orizzontale per lo stato limite: SLV

### Parametri indipendenti

STATO LIMITE	SLV
$a_g$	0,062 g
$F_o$	2,699
$T_c^*$	0,380 s
$S_s$	1,200
$C_c$	1,335
$S_T$	1,000
$q$	1,000

### Parametri dipendenti

$S$	1,200
$\eta$	1,000
$T_B$	0,169 s
$T_C$	0,508 s
$T_D$	1,848 s

### Espressioni dei parametri dipendenti

$$S = S_s \cdot S_T \quad (\text{NTC-08 Eq. 3.2.5})$$

$$\eta = \sqrt{10/(5 + \xi)} \geq 0,55; \quad \eta = 1/q \quad (\text{NTC-08 Eq. 3.2.6; §. 3.2.3.5})$$

$$T_B = T_C / 3 \quad (\text{NTC-07 Eq. 3.2.8})$$

$$T_C = C_c \cdot T_c^* \quad (\text{NTC-07 Eq. 3.2.7})$$

$$T_D = 4,0 \cdot a_g / g + 1,6 \quad (\text{NTC-07 Eq. 3.2.9})$$

### Espressioni dello spettro di risposta (NTC-08 Eq. 3.2.4)

$$\begin{array}{ll}
 0 \leq T < T_B & S_e(T) = a_g \cdot S \cdot \eta \cdot F_o \cdot \left[ \frac{T}{T_B} + \frac{1}{\eta \cdot F_o} \left( 1 - \frac{T}{T_B} \right) \right] \\
 T_B \leq T < T_C & S_e(T) = a_g \cdot S \cdot \eta \cdot F_o \\
 T_C \leq T < T_D & S_e(T) = a_g \cdot S \cdot \eta \cdot F_o \cdot \left( \frac{T_C}{T} \right) \\
 T_D \leq T & S_e(T) = a_g \cdot S \cdot \eta \cdot F_o \cdot \left( \frac{T_C T_D}{T^2} \right)
 \end{array}$$

Lo spettro di progetto  $S_d(T)$  per le verifiche agli Stati Limite Ultimi è ottenuto dalle espressioni dello spettro elastico  $S_e(T)$  sostituendo  $\eta$  con  $1/q$ , dove  $q$  è il fattore di struttura. (NTC-08 § 3.2.3.5)

### Punti dello spettro di risposta

	T [s]	Se [g]
	0,000	0,074
$T_B \leftarrow$	0,169	0,201
$T_C \leftarrow$	0,508	0,201
	0,572	0,178
	0,635	0,160
	0,699	0,146
	0,763	0,134
	0,827	0,123
	0,891	0,114
	0,954	0,107
	1,018	0,100
	1,082	0,094
	1,146	0,089
	1,210	0,084
	1,273	0,080
	1,337	0,076
	1,401	0,073
	1,465	0,070
	1,529	0,067
	1,593	0,064
	1,656	0,062
	1,720	0,059
	1,784	0,057
$T_D \leftarrow$	1,848	0,055
	1,950	0,049
	2,053	0,045
	2,155	0,041
	2,258	0,037
	2,360	0,034
	2,463	0,031
	2,565	0,029
	2,668	0,026
	2,770	0,025
	2,873	0,023
	2,975	0,021
	3,078	0,020
	3,180	0,019
	3,283	0,017
	3,385	0,016
	3,488	0,015
	3,590	0,015
	3,693	0,014
	3,795	0,013
	3,898	0,012
	4,000	0,012

## Parametri e punti dello spettro di risposta verticale per lo stato limite: SLV

### Parametri indipendenti

STATO LIMITE	SLV
$a_{gv}$	0,021 g
$S_S$	1,000
$S_T$	1,000
$q$	1,000
$T_B$	0,050 s
$T_C$	0,150 s
$T_D$	1,000 s

### Parametri dipendenti

$F_v$	0,907
$S$	1,000
$\eta$	1,000

### Espressioni dei parametri dipendenti

$$S = S_S \cdot S_T \quad (\text{NTC-08 Eq. 3.2.5})$$

$$\eta = 1/q \quad (\text{NTC-08 §. 3.2.3.5})$$

$$F_v = 1,35 \cdot F_o \cdot \left( \frac{a_g}{g} \right)^{0,5} \quad (\text{NTC-08 Eq. 3.2.11})$$

### Espressioni dello spettro di risposta (NTC-08 Eq. 3.2.10)

$$0 \leq T < T_B \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_v \cdot \left[ \frac{T}{T_B} + \frac{1}{\eta \cdot F_o} \left( 1 - \frac{T}{T_B} \right) \right]$$

$$T_B \leq T < T_C \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_v$$

$$T_C \leq T < T_D \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_v \cdot \left( \frac{T_C}{T} \right)$$

$$T_D \leq T \quad S_e(T) = a_g \cdot S \cdot \eta \cdot F_v \cdot \left( \frac{T_C T_D}{T^2} \right)$$

### Punti dello spettro di risposta

	T [s]	Se [g]
	0,000	0,021
$T_B \leftarrow$	0,050	0,056
$T_C \leftarrow$	0,150	0,056
	0,235	0,036
	0,320	0,026
	0,405	0,021
	0,490	0,017
	0,575	0,015
	0,660	0,013
	0,745	0,011
	0,830	0,010
	0,915	0,009
$T_D \leftarrow$	1,000	0,008
	1,094	0,007
	1,188	0,006
	1,281	0,005
	1,375	0,004
	1,469	0,004
	1,563	0,003
	1,656	0,003
	1,750	0,003
	1,844	0,002
	1,938	0,002
	2,031	0,002
	2,125	0,002
	2,219	0,002
	2,313	0,002
	2,406	0,001
	2,500	0,001
	2,594	0,001
	2,688	0,001
	2,781	0,001
	2,875	0,001
	2,969	0,001
	3,063	0,001
	3,156	0,001
	3,250	0,001
	3,344	0,001
	3,438	0,001
	3,531	0,001
	3,625	0,001
	3,719	0,001
	3,813	0,001
	3,906	0,001
	4,000	0,001



## 5.8. Coefficienti di combinazione dei carichi

Si riportano di seguito i coefficienti parziali di sicurezza sulle azioni e i coefficienti  $\Psi_i$  per le combinazioni dei carichi relative ai ponti pedonali.

**Tab. 5.1.V – Coefficienti parziali di sicurezza per le combinazioni di carico agli SLU**

		Coefficiente	EQU <sup>(1)</sup>	A1	A2
Azioni permanenti $g_1$ e $g_3$	favorevoli	$\gamma_{G1} = \gamma_{G3}$	0,90	1,00	1,00
	sfavorevoli		1,10	1,35	1,00
Azioni permanenti non strutturali <sup>(2)</sup> $g_2$	favorevoli	$\gamma_{G2}$	0,00	0,00	0,00
	sfavorevoli		1,50	1,50	1,30
Azioni variabili da traffico	favorevoli	$\gamma_Q$	0,00	0,00	0,00
	sfavorevoli		1,35	1,35	1,15
Azioni variabili	favorevoli	$\gamma_{Qi}$	0,00	0,00	0,00
	sfavorevoli		1,50	1,50	1,30
Distorsioni e presollecitazioni di progetto	favorevoli	$\gamma_{s1}$	0,90	1,00	1,00
	sfavorevoli		1,00 <sup>(3)</sup>	1,00 <sup>(4)</sup>	1,00
Ritiro e viscosità, Cedimenti vincolari	favorevoli	$\gamma_{s2}, \gamma_{s3}, \gamma_{s4}$	0,00	0,00	0,00
	sfavorevoli		1,20	1,20	1,00

**Tab. 5.1.VI – Coefficienti  $\psi$  per le azioni variabili per ponti stradali e pedonali**

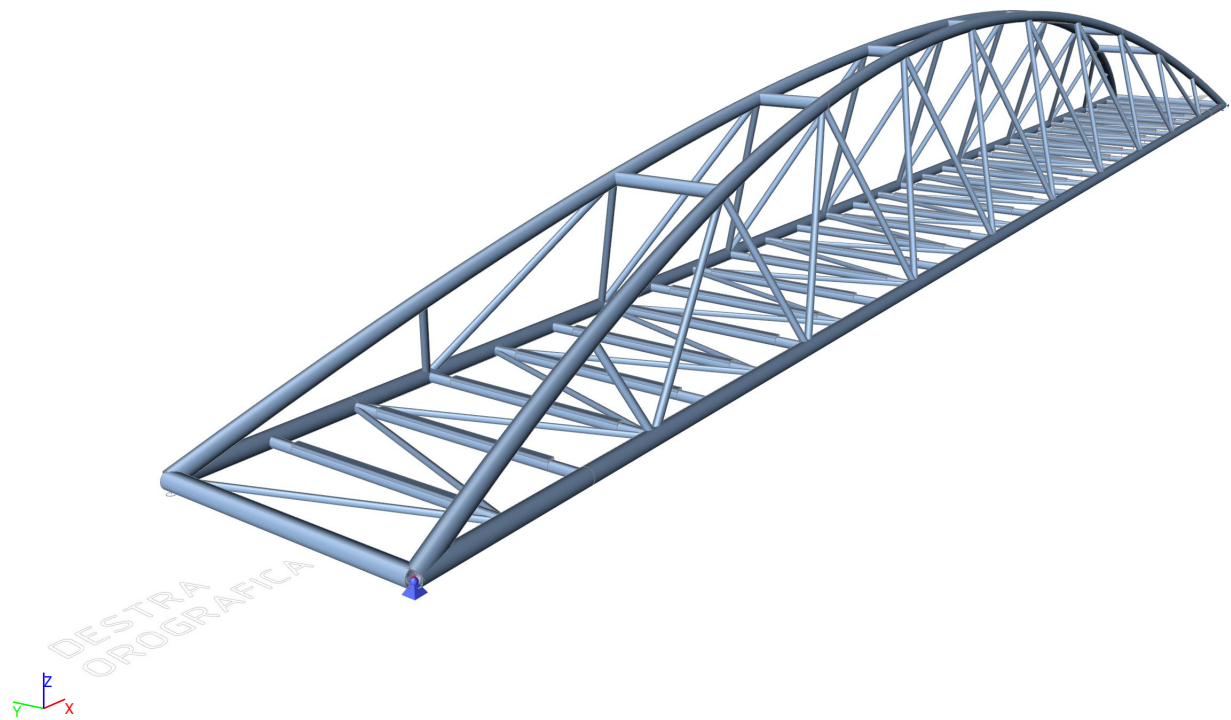
Azioni	Gruppo di azioni (Tab. 5.1.IV)	Coefficiente $\Psi_0$ di combinazione	Coefficiente $\Psi_1$ (valori frequenti)	Coefficiente $\Psi_2$ (valori quasi permanenti)
Azioni da traffico (Tab. 5.1.IV)	Schema 1 (carichi tandem)	0,75	0,75	0,0
	Schemi 1, 5 e 6 (carichi distribuiti)	0,40	0,40	0,0
	Schemi 3 e 4 (carichi concentrati)	0,40	0,40	0,0
	Schema 2	0,0	0,75	0,0
	2	0,0	0,0	0,0
	3	0,0	0,0	0,0
	4 (folla)	--	0,75	0,0
	5	0,0	0,0	0,0
Vento	a ponte scarico SLU e SLE	0,6	0,2	0,0
	in esecuzione	0,8	0,0	0,0
	a ponte carico SLU e SLE	0,6	0,0	0,0
Neve	SLU e SLE	0,0	0,0	0,0
	in esecuzione	0,8	0,6	0,5
Temperatura	SLU e SLE	0,6	0,6	0,5

6. MODELLO DI CALCOLO

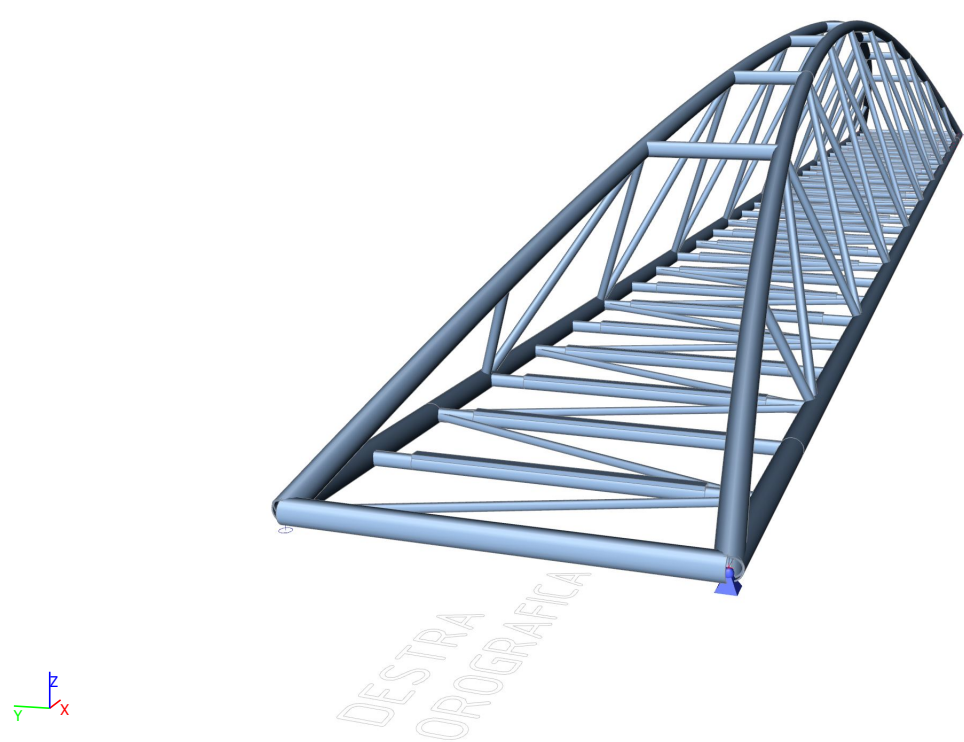
6.1. Project

Licence name	Studio di Ingegneria
Project	Passerella Kampill
Part	-
Description	-
Author	-
Date	29. 03. 2019
Structure	General XYZ
No. of nodes :	155
No. of beams :	175
No. of slabs :	0
No. of solids :	0
No. of used profiles :	10
No. of load cases :	22
No. of used materials :	1
Acceleration of gravity [m/s <sup>2</sup> ]	9,810
National code	EC - EN

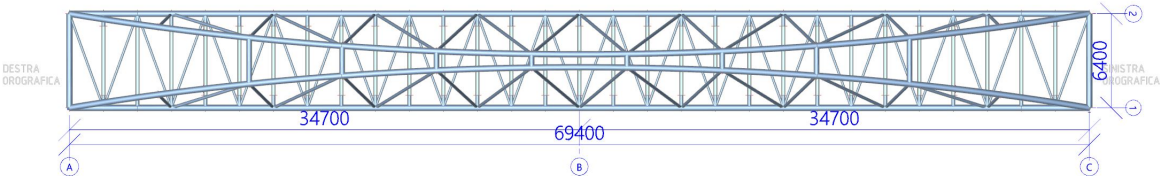
6.2. Rendering strutturale




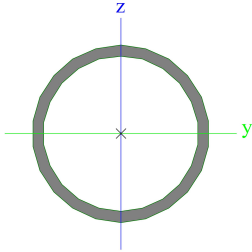

6.3. Rendering strutturale

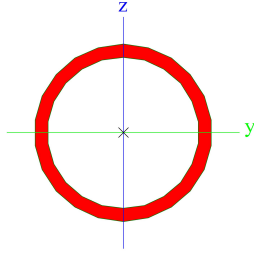

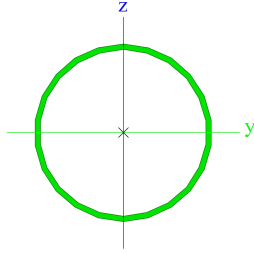



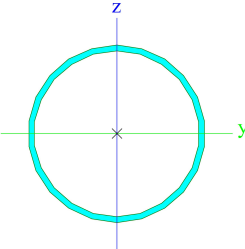
6.4. Rendering strutturale




## 6.5. Profili utilizzati

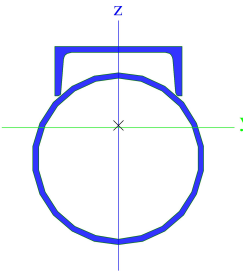
CS1		
Type	CHS406.4/25.0	
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	a	a
A [m <sup>2</sup> ]	3,0000e-02	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	1,9070e-02	1,9070e-02
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	1,2800e+00	2,3963e+00
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	203	203
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	5,4700e-04	5,4700e-04
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	135	135
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	2,6920e-03	2,6920e-03
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	3,5844e-03	3,5844e-03
M <sub>pl,y+</sub> [Nm], M <sub>pl,y-</sub> [Nm]	1,29e+06	1,29e+06
M <sub>pl,z+</sub> [Nm], M <sub>pl,z-</sub> [Nm]	1,29e+06	1,29e+06
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	1,0940e-03	2,2002e-38
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		
CS6		
Type	MSRR406.4x30.0	
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	a	a
A [m <sup>2</sup> ]	3,5500e-02	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	2,2584e-02	2,2584e-02
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	1,2800e+00	2,3649e+00
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	203	203
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	6,3220e-04	6,3220e-04
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	133	133
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	3,1100e-03	3,1100e-03

W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	4,2600e-03	4,2600e-03
M <sub>pl,y+</sub> [Nm], M <sub>pl,y-</sub> [Nm]	1,51e+06	1,51e+06
M <sub>pl,z+</sub> [Nm], M <sub>pl,z-</sub> [Nm]	1,51e+06	1,51e+06
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	1,2640e-03	4,4694e-38
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		
CS2		
Type	CHS406.4/12.5	
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	a	a
A [m <sup>2</sup> ]	1,5500e-02	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	9,8475e-03	9,8475e-03
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	1,2800e+00	2,4748e+00
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	203	203
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	3,0030e-04	3,0030e-04
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	139	139
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	1,4780e-03	1,4780e-03
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	1,9095e-03	1,9095e-03
M <sub>pl,y+</sub> [Nm], M <sub>pl,y-</sub> [Nm]	6,89e+05	6,89e+05
M <sub>pl,z+</sub> [Nm], M <sub>pl,z-</sub> [Nm]	6,89e+05	6,89e+05
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	6,0060e-04	2,6948e-38
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		
CS3		
Type	CHS244.5/8.0	


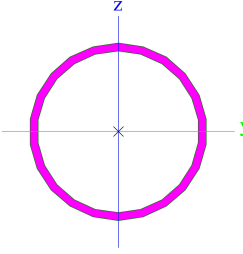
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	a	a
A [m <sup>2</sup> ]	5,9400e-03	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	3,7840e-03	3,7840e-03
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	7,6800e-01	1,4859e+00
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	122	122
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	4,1600e-05	4,1600e-05
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	84	84
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	3,4000e-04	3,4000e-04
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	4,4057e-04	4,4057e-04
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	1,59e+05	1,59e+05
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	1,59e+05	1,59e+05
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	8,3210e-05	1,1027e-39
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		

#### CS4


Type	CHS244.5/8.0 + UNP180	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	general	
Colour		
Flexural buckling y-y, Flexural buckling z-z	d	d
A [m <sup>2</sup> ]	8,7400e-03	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	5,6078e-03	5,0072e-03
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	1,3708e+00	2,0886e+00
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	0	45
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	7,9888e-05	5,5130e-05
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	96	79
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	4,7840e-04	4,5097e-04
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	7,2172e-04	6,2666e-04
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	2,56e+05	2,56e+05
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	2,22e+05	2,22e+05

[Nm]		
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	3
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	1,0992e-04	1,9483e-08
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	-57	0
Picture		

#### CS5

Type	CHS355.6/16.0	
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	a	a
A [m <sup>2</sup> ]	1,7100e-02	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	1,0867e-02	1,0867e-02
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	1,1200e+00	2,1337e+00
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	178	178
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	2,4660e-04	2,4660e-04
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	120	120
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	1,3870e-03	1,3870e-03
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	1,8175e-03	1,8175e-03
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	6,55e+05	6,55e+05
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	6,55e+05	6,55e+05
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	4,9330e-04	6,5073e-39
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		

#### CS7

Type	CHS406.4/16.0	
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling	a	a

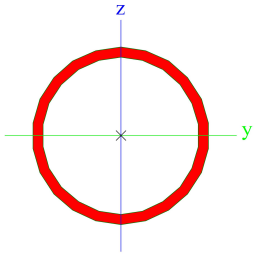
y-y, Flexural buckling z-z		
A [m <sup>2</sup> ]	1,9600e-02	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	1,2493e-02	1,2493e-02
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	1,2800e+00	2,4528e+00
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	203	203
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	3,7450e-04	3,7450e-04
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	138	138
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	1,8430e-03	1,8430e-03
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	2,4015e-03	2,4015e-03
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	8,66e+05	8,66e+05
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	8,66e+05	8,66e+05
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	7,4900e-04	2,7695e-38
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		

<b>D1</b>		
Type	CHS193.7/6.3	
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	a	a
A [m <sup>2</sup> ]	3,7100e-03	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	2,3612e-03	2,3612e-03
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	6,0900e-01	1,1774e+00
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	97	97
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	1,6300e-05	1,6300e-05
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	66	66
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	1,6800e-04	1,6800e-04
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	2,1784e-04	2,1784e-04
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	7,85e+04	7,85e+04
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	7,85e+04	7,85e+04
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	3,2600e-05	3,0347e-40
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0

Picture		
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<b>CV1</b>		
Type	CHS139.7/6.3	
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	a	a
A [m <sup>2</sup> ]	2,6400e-03	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	1,6808e-03	1,6808e-03
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	4,3900e-01	8,3813e-01
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	70	70
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	5,8900e-06	5,8900e-06
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	47	47
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	8,4300e-05	8,4300e-05
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	1,1043e-04	1,1043e-04
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	3,98e+04	3,98e+04
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	3,98e+04	3,98e+04
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	1,1770e-05	3,8075e-41
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		

<b>CV2</b>		
Type	CHS139.7/8.0	
Formcode	3 - Circular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	rolled	
Colour		
Flexural buckling y-y, Flexural buckling z-z	a	a
A [m <sup>2</sup> ]	3,3100e-03	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	2,1072e-03	2,1072e-03

$A_L$ [m <sup>2</sup> /m], $A_D$ [m <sup>2</sup> /m]	4,3900e-01	8,2745e-01
$c_{Y,UCS}$ [mm], $c_{Z,UCS}$ [mm]	70	70
$\alpha$ [deg]	0,00	
$I_y$ [m <sup>4</sup> ], $I_z$ [m <sup>4</sup> ]	7,2000e-06	7,2000e-06
$i_y$ [mm], $i_z$ [mm]	47	47
$W_{el,y}$ [m <sup>3</sup> ], $W_{el,z}$ [m <sup>3</sup> ]	1,0300e-04	1,0300e-04
$W_{pl,y}$ [m <sup>3</sup> ], $W_{pl,z}$ [m <sup>3</sup> ]	1,3674e-04	1,3674e-04
$M_{pl,y,+}$ [Nm], $M_{pl,y,-}$ [Nm]	4,93e+04	4,93e+04
$M_{pl,z,+}$ [Nm], $M_{pl,z,-}$ [Nm]	4,93e+04	4,93e+04
$d_y$ [mm], $d_z$ [mm]	0	0
$I_t$ [m <sup>4</sup> ], $I_w$ [m <sup>6</sup> ]	1,4410e-05	1,4605e-40
$\beta_y$ [mm], $\beta_z$ [mm]	0	0
Picture		


Explanations of symbols	
Formcode	d – Diameter w – Thickness
A	Area
$A_y$	Shear Area in principal y-direction
$A_z$	Shear Area in principal z-direction
$A_L$	Circumference per unit length
$A_D$	Drying surface per unit length
$c_{Y,UCS}$	Centroid coordinate in Y-direction of Input axis system
$c_{Z,UCS}$	Centroid coordinate in Z-direction of Input axis system
$I_{Y,LCS}$	Second moment of area about the YLCS axis
$I_{Z,LCS}$	Second moment of area about the ZLCS axis
$I_{YZ,LCS}$	Product moment of area in the LCS system
$\alpha$	Rotation angle of the principal axis system
$I_y$	Second moment of area about the principal y-axis
$I_z$	Second moment of area about the principal z-axis
$i_y$	Radius of gyration about the principal y-axis

Explanations of symbols	
$i_z$	Radius of gyration about the principal z-axis
$W_{el,y}$	Elastic section modulus about the principal y-axis
$W_{el,z}$	Elastic section modulus about the principal z-axis
$W_{pl,y}$	Plastic section modulus about the principal y-axis
$W_{pl,z}$	Plastic section modulus about the principal z-axis
$M_{pl,y,+}$	Plastic moment about the principal y-axis for a positive $M_y$ moment
$M_{pl,y,-}$	Plastic moment about the principal y-axis for a negative $M_y$ moment
$M_{pl,z,+}$	Plastic moment about the principal z-axis for a positive $M_z$ moment
$M_{pl,z,-}$	Plastic moment about the principal z-axis for a negative $M_z$ moment
$d_y$	Shear center coordinate in principal y-direction measured from the centroid
$d_z$	Shear center coordinate in principal z-direction measured from the centroid
$I_t$	Torsional constant
$I_w$	Warping constant
$\beta_y$	Mono-symmetry constant about the principal y-axis
$\beta_z$	Mono-symmetry constant about the

Explanations of symbols	
	principal z-axis

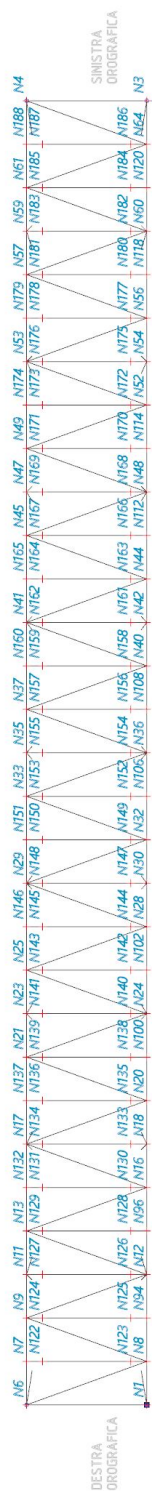
## 6.6. Materiali

Steel EC3

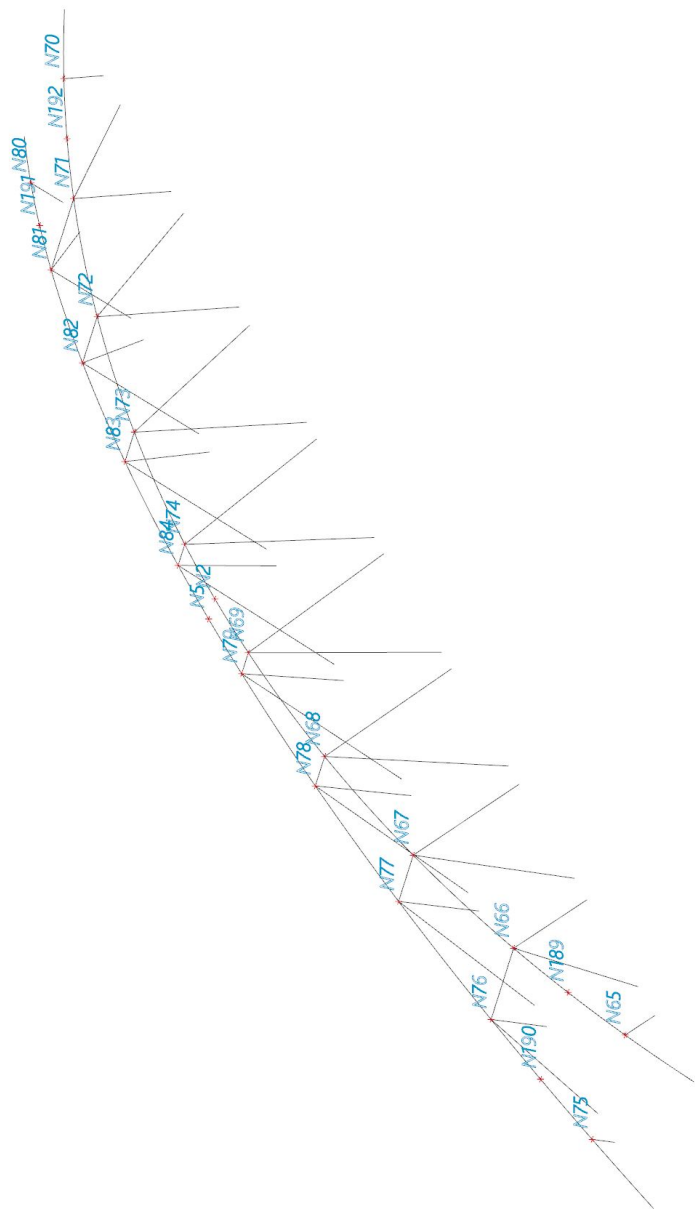
Name	$\rho$ [kg/m <sup>3</sup> ]	$E_{mod}$ [MPa] $G_{mod}$ [MPa]	$\mu$ $\alpha$ [m/mK]	Lower limit [mm]	Upper limit [mm]	$F_y$ [MPa]	$F_u$ [MPa]	Colour
S 355	7850,0	2,1000e+05	0,3	0	40	355,0	490,0	
		8,0769e+04	0,00	40	80	335,0	470,0	



### 6.7. Numerazione nodi impalcato



6.8. Numerazione nodi arco



## 6.9. Nodi

Name	Coord X [m]	Coord Y [m]	Coord Z [m]
N1	0,000	0,000	0,000
N2	34,700	2,760	6,800
N3	69,400	0,000	0,000
N4	69,400	6,400	0,000
N5	34,700	3,640	6,800
N6	0,000	6,400	0,000
N7	2,313	6,400	0,000
N8	2,313	0,000	0,000
N9	4,627	6,400	0,000
N11	6,940	6,400	0,000
N12	6,940	0,000	0,000
N13	9,253	6,400	0,000
N16	11,567	0,000	0,000
N17	13,880	6,400	0,000
N18	13,880	0,000	0,000
N20	16,193	0,000	0,000
N21	18,507	6,400	0,000
N23	20,820	6,400	0,000
N24	20,820	0,000	0,000
N25	23,133	6,400	0,000
N28	25,447	0,000	0,000
N29	27,760	6,400	0,000
N30	27,760	0,000	0,000
N32	30,073	0,000	0,000
N33	32,387	6,400	0,000
N35	34,700	6,400	0,000
N36	34,700	0,000	0,000
N37	37,013	6,400	0,000
N40	39,327	0,000	0,000
N41	41,640	6,400	0,000
N42	41,640	0,000	0,000
N44	43,953	0,000	0,000
N45	46,267	6,400	0,000
N47	48,580	6,400	0,000
N48	48,580	0,000	0,000
N49	50,893	6,400	0,000
N52	53,207	0,000	0,000
N53	55,520	6,400	0,000
N54	55,520	0,000	0,000
N56	57,833	0,000	0,000
N57	60,147	6,400	0,000
N59	62,460	6,400	0,000
N60	62,460	0,000	0,000
N61	64,773	6,400	0,000
N64	67,087	0,000	0,000
N65	6,033	0,904	2,226
N66	12,231	1,633	4,022
N67	18,558	2,183	5,379

Name	Coord X [m]	Coord Y [m]	Coord Z [m]
N68	24,978	2,552	6,287
N69	31,453	2,737	6,743
N70	63,367	0,904	2,226
N71	57,169	1,633	4,022
N72	50,842	2,183	5,379
N73	44,422	2,552	6,287
N74	37,947	2,737	6,743
N75	6,033	5,496	2,226
N76	12,231	4,767	4,022
N77	18,558	4,217	5,379
N78	24,978	3,848	6,287
N79	31,453	3,663	6,743
N80	63,367	5,496	2,226
N81	57,169	4,767	4,022
N82	50,842	4,217	5,379
N83	44,422	3,848	6,287
N84	37,947	3,663	6,743
N85	0,000	5,575	0,000
N86	0,000	3,200	0,000
N87	34,700	3,200	0,000
N88	34,700	5,575	0,000
N89	69,400	3,200	0,000
N90	69,400	5,575	0,000
N91	0,000	0,825	0,000
N92	34,700	0,825	0,000
N93	69,400	0,825	0,000
N94	4,627	0,000	0,000
N96	9,253	0,000	0,000
N100	18,507	0,000	0,000
N102	23,133	0,000	0,000
N106	32,387	0,000	0,000
N108	37,013	0,000	0,000
N112	46,267	0,000	0,000
N114	50,893	0,000	0,000
N118	60,147	0,000	0,000
N120	64,773	0,000	0,000
N122	2,313	5,550	0,000
N123	2,313	0,850	0,000
N124	4,627	5,550	0,000
N125	4,627	0,850	0,000
N126	6,940	0,850	0,000
N127	6,940	5,550	0,000
N128	9,253	0,850	0,000
N129	9,253	5,550	0,000
N130	11,567	0,850	0,000
N131	11,567	5,550	0,000
N132	11,567	6,400	0,000
N133	13,880	0,850	0,000

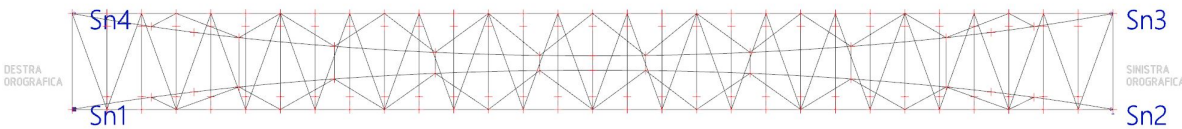
Name	Coord X [m]	Coord Y [m]	Coord Z [m]
N134	13,880	5,550	0,000
N135	16,193	0,850	0,000
N136	16,193	5,550	0,000
N137	16,193	6,400	0,000
N138	18,507	0,850	0,000
N139	18,507	5,550	0,000
N140	20,820	0,850	0,000
N141	20,820	5,550	0,000
N142	23,133	0,850	0,000
N143	23,133	5,550	0,000
N144	25,447	0,850	0,000
N145	25,447	5,550	0,000
N146	25,447	6,400	0,000
N147	27,760	0,850	0,000
N148	27,760	5,550	0,000
N149	30,073	0,850	0,000
N150	30,073	5,550	0,000
N151	30,073	6,400	0,000
N152	32,387	0,850	0,000
N153	32,387	5,550	0,000
N154	34,700	0,850	0,000
N155	34,700	5,550	0,000
N156	37,013	0,850	0,000
N157	37,013	5,550	0,000
N158	39,327	0,850	0,000
N159	39,327	5,550	0,000
N160	39,327	6,400	0,000
N161	41,640	0,850	0,000
N162	41,640	5,550	0,000
N163	43,953	0,850	0,000
N164	43,953	5,550	0,000
N165	43,953	6,400	0,000
N166	46,267	0,850	0,000
N167	46,267	5,550	0,000
N168	48,580	0,850	0,000
N169	48,580	5,550	0,000
N170	50,893	0,850	0,000
N171	50,893	5,550	0,000
N172	53,207	0,850	0,000
N173	53,207	5,550	0,000
N174	53,207	6,400	0,000
N175	55,520	0,850	0,000
N176	55,520	5,550	0,000
N177	57,833	0,850	0,000
N178	57,833	5,550	0,000
N179	57,833	6,400	0,000
N180	60,147	0,850	0,000
N181	60,147	5,550	0,000

Name	Coord X [m]	Coord Y [m]	Coord Z [m]
N182	62,460	0,850	0,000
N183	62,460	5,550	0,000
N184	64,773	0,850	0,000
N185	64,773	5,550	0,000

Name	Coord X [m]	Coord Y [m]	Coord Z [m]
N186	67,087	0,850	0,000
N187	67,087	5,550	0,000
N188	67,087	6,400	0,000
N189	9,114	1,290	3,179

Name	Coord X [m]	Coord Y [m]	Coord Z [m]
N190	9,114	5,110	3,179
N191	60,286	5,110	3,179
N192	60,286	1,290	3,179

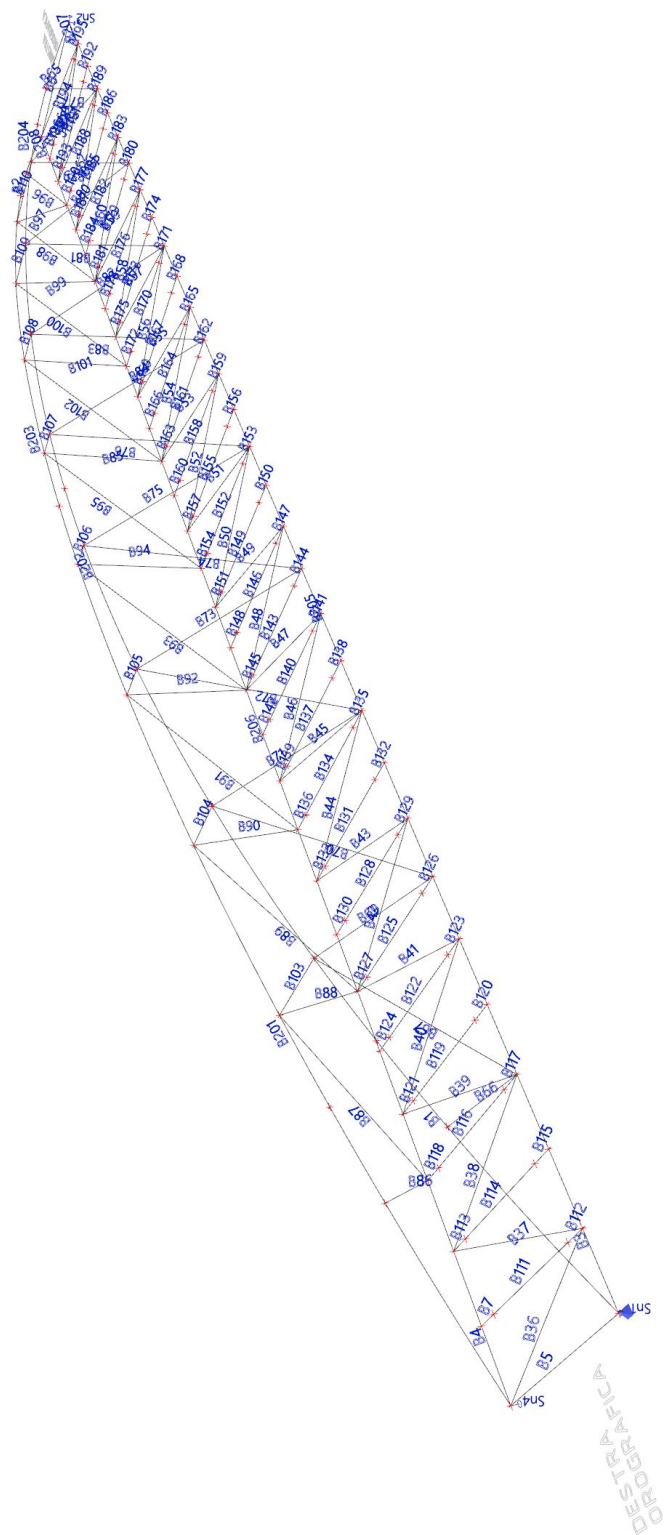
6.10. Numerazione supporti nodali



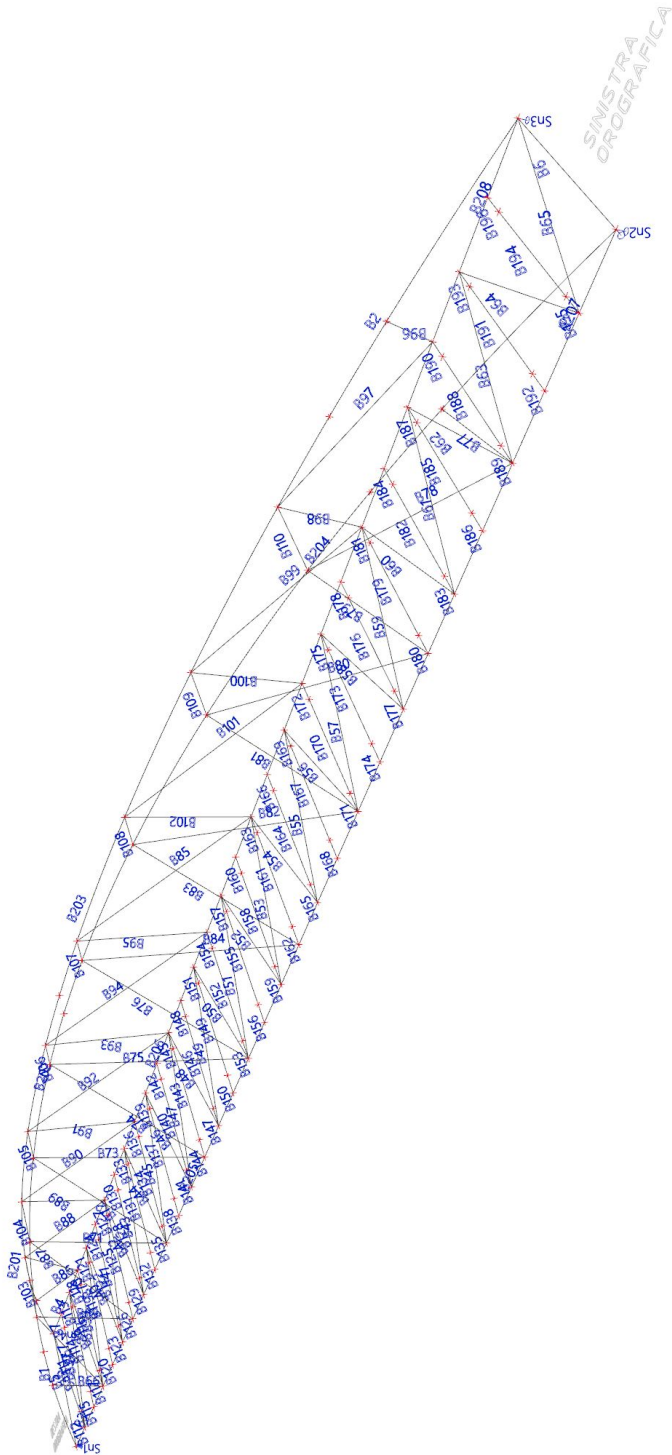
6.11. Supporti nodali

Name	Node	System	Type	X	Y	Z	Rx	Ry	Rz
Sn1	N1	GCS	Standard	Rigid	Rigid	Rigid	Free	Free	Free
Sn2	N3	GCS	Standard	Free	Rigid	Rigid	Free	Free	Free
Sn3	N4	GCS	Standard	Free	Free	Rigid	Free	Free	Free
Sn4	N6	GCS	Standard	Free	Free	Rigid	Free	Free	Free

6.12. Numerazione elementi 1D



6.13. Numerazione elementi 1D



#### 6.14. Elementi 1D

Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B1	CS6 - MSRR406.4x30.0	S 355	19,487	N1	N67	general (0)
B2	CS6 - MSRR406.4x30.0	S 355	19,487	N4	N82	general (0)
B3	CS7 - CHS406.4/16.0	S 355	4,627	N1	N94	general (0)
B4	CS7 - CHS406.4/16.0	S 355	4,627	N6	N9	general (0)
B5	CS7 - CHS406.4/16.0	S 355	6,400	N6	N1	general (0)
B6	CS7 - CHS406.4/16.0	S 355	6,400	N4	N3	general (0)
B7	CS3 - CHS244.5/8.0	S 355	0,850	N7	N122	general (0)
B36	CV2 - CHS139.7/8.0	S 355	6,805	N6	N8	general (0)
B37	CV2 - CHS139.7/8.0	S 355	6,805	N8	N9	general (0)
B38	CV2 - CHS139.7/8.0	S 355	6,805	N9	N12	general (0)
B39	CV1 - CHS139.7/6.3	S 355	6,805	N12	N13	general (0)
B40	CV1 - CHS139.7/6.3	S 355	6,805	N13	N16	general (0)
B41	CV1 - CHS139.7/6.3	S 355	6,805	N16	N17	general (0)
B42	CV1 - CHS139.7/6.3	S 355	6,805	N17	N20	general (0)
B43	CV1 - CHS139.7/6.3	S 355	6,805	N20	N21	general (0)
B44	CV1 - CHS139.7/6.3	S 355	6,805	N21	N24	general (0)
B45	CV1 - CHS139.7/6.3	S 355	6,805	N24	N25	general (0)
B46	CV1 - CHS139.7/6.3	S 355	6,805	N25	N28	general (0)
B47	CV1 - CHS139.7/6.3	S 355	6,805	N28	N29	general (0)
B48	CV1 - CHS139.7/6.3	S 355	6,805	N29	N32	general (0)
B49	CV1 - CHS139.7/6.3	S 355	6,805	N32	N33	general (0)
B50	CV1 - CHS139.7/6.3	S 355	6,805	N33	N36	general (0)
B51	CV1 - CHS139.7/6.3	S 355	6,805	N36	N37	general (0)
B52	CV1 - CHS139.7/6.3	S 355	6,805	N37	N40	general (0)
B53	CV1 - CHS139.7/6.3	S 355	6,805	N40	N41	general (0)
B54	CV1 - CHS139.7/6.3	S 355	6,805	N41	N44	general (0)
B55	CV1 - CHS139.7/6.3	S 355	6,805	N44	N45	general (0)
B56	CV1 - CHS139.7/6.3	S 355	6,805	N45	N48	general (0)
B57	CV1 - CHS139.7/6.3	S 355	6,805	N48	N49	general (0)
B58	CV1 - CHS139.7/6.3	S 355	6,805	N49	N52	general (0)
B59	CV1 - CHS139.7/6.3	S 355	6,805	N52	N53	general (0)
B60	CV1 - CHS139.7/6.3	S 355	6,805	N53	N56	general (0)
B61	CV1 - CHS139.7/6.3	S 355	6,805	N56	N57	general (0)
B62	CV1 - CHS139.7/6.3	S 355	6,805	N57	N60	general (0)
B63	CV2 - CHS139.7/8.0	S 355	6,805	N60	N61	general (0)
B64	CV2 - CHS139.7/8.0	S 355	6,805	N61	N64	general (0)
B65	CV2 - CHS139.7/8.0	S 355	6,805	N64	N4	general (0)
B66	D1 - CHS193.7/6.3	S 355	2,568	N65	N12	general (0)
B67	D1 - CHS193.7/6.3	S 355	6,844	N12	N66	general (0)
B69	D1 - CHS193.7/6.3	S 355	4,644	N66	N18	general (0)
B70	D1 - CHS193.7/6.3	S 355	7,455	N18	N67	general (0)
B71	D1 - CHS193.7/6.3	S 355	6,230	N67	N24	general (0)
B72	D1 - CHS193.7/6.3	S 355	7,958	N24	N68	general (0)
B73	D1 - CHS193.7/6.3	S 355	7,334	N68	N30	general (0)
B74	D1 - CHS193.7/6.3	S 355	8,161	N30	N69	general (0)
B75	D1 - CHS193.7/6.3	S 355	7,969	N69	N36	general (0)
B76	D1 - CHS193.7/6.3	S 355	7,969	N74	N36	general (0)
B77	D1 - CHS193.7/6.3	S 355	2,568	N70	N60	general (0)



Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B78	D1 - CHS193.7/6.3	S 355	6,844	N60	N71	general (0)
B79	D1 - CHS193.7/6.3	S 355	4,644	N71	N54	general (0)
B80	D1 - CHS193.7/6.3	S 355	7,455	N54	N72	general (0)
B81	D1 - CHS193.7/6.3	S 355	6,230	N72	N48	general (0)
B82	D1 - CHS193.7/6.3	S 355	7,958	N48	N73	general (0)
B83	D1 - CHS193.7/6.3	S 355	7,334	N73	N42	general (0)
B84	D1 - CHS193.7/6.3	S 355	8,161	N42	N74	general (0)
B85	D1 - CHS193.7/6.3	S 355	8,161	N41	N84	general (0)
B86	D1 - CHS193.7/6.3	S 355	2,568	N75	N11	general (0)
B87	D1 - CHS193.7/6.3	S 355	6,844	N11	N76	general (0)
B88	D1 - CHS193.7/6.3	S 355	4,644	N76	N17	general (0)
B89	D1 - CHS193.7/6.3	S 355	7,455	N17	N77	general (0)
B90	D1 - CHS193.7/6.3	S 355	6,230	N77	N23	general (0)
B91	D1 - CHS193.7/6.3	S 355	7,958	N23	N78	general (0)
B92	D1 - CHS193.7/6.3	S 355	7,334	N78	N29	general (0)
B93	D1 - CHS193.7/6.3	S 355	8,161	N29	N79	general (0)
B94	D1 - CHS193.7/6.3	S 355	7,969	N79	N35	general (0)
B95	D1 - CHS193.7/6.3	S 355	7,969	N84	N35	general (0)
B96	D1 - CHS193.7/6.3	S 355	2,568	N80	N59	general (0)
B97	D1 - CHS193.7/6.3	S 355	6,844	N59	N81	general (0)
B98	D1 - CHS193.7/6.3	S 355	4,644	N81	N53	general (0)
B99	D1 - CHS193.7/6.3	S 355	7,455	N53	N82	general (0)
B100	D1 - CHS193.7/6.3	S 355	6,230	N82	N47	general (0)
B101	D1 - CHS193.7/6.3	S 355	7,958	N47	N83	general (0)
B102	D1 - CHS193.7/6.3	S 355	7,334	N83	N41	general (0)
B103	CS5 - CHS355.6/16.0	S 355	3,135	N76	N66	general (0)
B104	CS5 - CHS355.6/16.0	S 355	2,034	N77	N67	general (0)
B105	CS5 - CHS355.6/16.0	S 355	1,296	N78	N68	general (0)
B106	CS5 - CHS355.6/16.0	S 355	0,926	N79	N69	general (0)
B107	CS5 - CHS355.6/16.0	S 355	0,926	N84	N74	general (0)
B108	CS5 - CHS355.6/16.0	S 355	1,296	N83	N73	general (0)
B109	CS5 - CHS355.6/16.0	S 355	2,034	N82	N72	general (0)
B110	CS5 - CHS355.6/16.0	S 355	3,135	N81	N71	general (0)
B111	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N122	N123	general (0)
B112	CS3 - CHS244.5/8.0	S 355	0,850	N123	N8	general (0)
B113	CS3 - CHS244.5/8.0	S 355	0,850	N9	N124	general (0)
B114	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N124	N125	general (0)
B115	CS3 - CHS244.5/8.0	S 355	0,850	N125	N94	general (0)
B116	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N127	N126	general (0)
B117	CS3 - CHS244.5/8.0	S 355	0,850	N126	N12	general (0)
B118	CS3 - CHS244.5/8.0	S 355	0,850	N11	N127	general (0)
B119	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N129	N128	general (0)
B120	CS3 - CHS244.5/8.0	S 355	0,850	N128	N96	general (0)
B121	CS3 - CHS244.5/8.0	S 355	0,850	N13	N129	general (0)
B122	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N131	N130	general (0)
B123	CS3 - CHS244.5/8.0	S 355	0,850	N130	N16	general (0)
B124	CS3 - CHS244.5/8.0	S 355	0,850	N132	N131	general (0)
B125	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N134	N133	general (0)
B126	CS3 - CHS244.5/8.0	S 355	0,850	N133	N18	general (0)

Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B127	CS3 - CHS244.5/8.0	S 355	0,850	N17	N134	general (0)
B128	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N136	N135	general (0)
B129	CS3 - CHS244.5/8.0	S 355	0,850	N135	N20	general (0)
B130	CS3 - CHS244.5/8.0	S 355	0,850	N137	N136	general (0)
B131	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N139	N138	general (0)
B132	CS3 - CHS244.5/8.0	S 355	0,850	N138	N100	general (0)
B133	CS3 - CHS244.5/8.0	S 355	0,850	N21	N139	general (0)
B134	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N141	N140	general (0)
B135	CS3 - CHS244.5/8.0	S 355	0,850	N140	N24	general (0)
B136	CS3 - CHS244.5/8.0	S 355	0,850	N23	N141	general (0)
B137	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N143	N142	general (0)
B138	CS3 - CHS244.5/8.0	S 355	0,850	N142	N102	general (0)
B139	CS3 - CHS244.5/8.0	S 355	0,850	N25	N143	general (0)
B140	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N145	N144	general (0)
B141	CS3 - CHS244.5/8.0	S 355	0,850	N144	N28	general (0)
B142	CS3 - CHS244.5/8.0	S 355	0,850	N146	N145	general (0)
B143	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N148	N147	general (0)
B144	CS3 - CHS244.5/8.0	S 355	0,850	N147	N30	general (0)
B145	CS3 - CHS244.5/8.0	S 355	0,850	N29	N148	general (0)
B146	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N150	N149	general (0)
B147	CS3 - CHS244.5/8.0	S 355	0,850	N149	N32	general (0)
B148	CS3 - CHS244.5/8.0	S 355	0,850	N151	N150	general (0)
B149	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N153	N152	general (0)
B150	CS3 - CHS244.5/8.0	S 355	0,850	N152	N106	general (0)
B151	CS3 - CHS244.5/8.0	S 355	0,850	N33	N153	general (0)
B152	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N155	N154	general (0)
B153	CS3 - CHS244.5/8.0	S 355	0,850	N154	N36	general (0)
B154	CS3 - CHS244.5/8.0	S 355	0,850	N35	N155	general (0)
B155	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N157	N156	general (0)
B156	CS3 - CHS244.5/8.0	S 355	0,850	N156	N108	general (0)
B157	CS3 - CHS244.5/8.0	S 355	0,850	N37	N157	general (0)
B158	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N159	N158	general (0)
B159	CS3 - CHS244.5/8.0	S 355	0,850	N158	N40	general (0)
B160	CS3 - CHS244.5/8.0	S 355	0,850	N160	N159	general (0)
B161	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N162	N161	general (0)
B162	CS3 - CHS244.5/8.0	S 355	0,850	N161	N42	general (0)
B163	CS3 - CHS244.5/8.0	S 355	0,850	N41	N162	general (0)
B164	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N164	N163	general (0)
B165	CS3 - CHS244.5/8.0	S 355	0,850	N163	N44	general (0)
B166	CS3 - CHS244.5/8.0	S 355	0,850	N165	N164	general (0)
B167	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N167	N166	general (0)
B168	CS3 - CHS244.5/8.0	S 355	0,850	N166	N112	general (0)
B169	CS3 - CHS244.5/8.0	S 355	0,850	N45	N167	general (0)
B170	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N169	N168	general (0)
B171	CS3 - CHS244.5/8.0	S 355	0,850	N168	N48	general (0)
B172	CS3 - CHS244.5/8.0	S 355	0,850	N47	N169	general (0)
B173	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N171	N170	general (0)
B174	CS3 - CHS244.5/8.0	S 355	0,850	N170	N114	general (0)
B175	CS3 - CHS244.5/8.0	S 355	0,850	N49	N171	general (0)

Name	Cross-section	Material	Length [m]	Beg. node	End node	Type
B176	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N173	N172	general (0)
B177	CS3 - CHS244.5/8.0	S 355	0,850	N172	N52	general (0)
B178	CS3 - CHS244.5/8.0	S 355	0,850	N174	N173	general (0)
B179	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N176	N175	general (0)
B180	CS3 - CHS244.5/8.0	S 355	0,850	N175	N54	general (0)
B181	CS3 - CHS244.5/8.0	S 355	0,850	N53	N176	general (0)
B182	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N178	N177	general (0)
B183	CS3 - CHS244.5/8.0	S 355	0,850	N177	N56	general (0)
B184	CS3 - CHS244.5/8.0	S 355	0,850	N179	N178	general (0)
B185	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N181	N180	general (0)
B186	CS3 - CHS244.5/8.0	S 355	0,850	N180	N118	general (0)
B187	CS3 - CHS244.5/8.0	S 355	0,850	N57	N181	general (0)
B188	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N183	N182	general (0)
B189	CS3 - CHS244.5/8.0	S 355	0,850	N182	N60	general (0)
B190	CS3 - CHS244.5/8.0	S 355	0,850	N59	N183	general (0)
B191	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N185	N184	general (0)
B192	CS3 - CHS244.5/8.0	S 355	0,850	N184	N120	general (0)
B193	CS3 - CHS244.5/8.0	S 355	0,850	N61	N185	general (0)
B194	CS4 - CHS244.5/8.0 + UNP180	S 355	4,700	N187	N186	general (0)
B195	CS3 - CHS244.5/8.0	S 355	0,850	N186	N64	general (0)
B196	CS3 - CHS244.5/8.0	S 355	0,850	N188	N187	general (0)
B201	CS6 - MSRR406.4x30.0	S 355	19,487	N77	N6	general (0)
B202	CS1 - CHS406.4/25.0	S 355	32,478	N67	N72	general (0)
B203	CS1 - CHS406.4/25.0	S 355	32,478	N82	N77	general (0)
B204	CS6 - MSRR406.4x30.0	S 355	19,487	N72	N3	general (0)
B205	CS2 - CHS406.4/12.5	S 355	60,147	N94	N120	general (0)
B206	CS2 - CHS406.4/12.5	S 355	60,147	N9	N61	general (0)
B207	CS7 - CHS406.4/16.0	S 355	4,627	N120	N3	general (0)
B208	CS7 - CHS406.4/16.0	S 355	4,627	N61	N4	general (0)

## 6.15. Cerniere e molle per giunti semirigidi su elementi 1D

Name	Position	Member	ux	uy	uz	fix	fiy	Stiff - fiy [MNm/rad]	fiz	Stiff - fiz [MNm/rad]
H1	Both	B65	Rigid	Rigid	Rigid	Rigid	Free		Free	
H2	Both	B36	Rigid	Rigid	Rigid	Rigid	Free		Free	
H3	Both	B37	Rigid	Rigid	Rigid	Rigid	Free		Free	
H4	Both	B38	Rigid	Rigid	Rigid	Rigid	Free		Free	
H5	Both	B39	Rigid	Rigid	Rigid	Rigid	Free		Free	
H6	Both	B40	Rigid	Rigid	Rigid	Rigid	Free		Free	
H7	Both	B41	Rigid	Rigid	Rigid	Rigid	Free		Free	
H8	Both	B42	Rigid	Rigid	Rigid	Rigid	Free		Free	
H9	Both	B43	Rigid	Rigid	Rigid	Rigid	Free		Free	
H10	Both	B44	Rigid	Rigid	Rigid	Rigid	Free		Free	
H11	Both	B45	Rigid	Rigid	Rigid	Rigid	Free		Free	
H12	Both	B46	Rigid	Rigid	Rigid	Rigid	Free		Free	
H13	Both	B47	Rigid	Rigid	Rigid	Rigid	Free		Free	
H14	Both	B48	Rigid	Rigid	Rigid	Rigid	Free		Free	
H15	Both	B49	Rigid	Rigid	Rigid	Rigid	Free		Free	
H16	Both	B50	Rigid	Rigid	Rigid	Rigid	Free		Free	

Name	Position	Member	ux	uy	uz	fix	fiy	Stiff – fiy [MNm/rad]	fiz	Stiff – fiz [MNm/rad]
H17	Both	B51	Rigid	Rigid	Rigid	Rigid	Free		Free	
H18	Both	B52	Rigid	Rigid	Rigid	Rigid	Free		Free	
H19	Both	B53	Rigid	Rigid	Rigid	Rigid	Free		Free	
H20	Both	B54	Rigid	Rigid	Rigid	Rigid	Free		Free	
H21	Both	B55	Rigid	Rigid	Rigid	Rigid	Free		Free	
H22	Both	B56	Rigid	Rigid	Rigid	Rigid	Free		Free	
H23	Both	B57	Rigid	Rigid	Rigid	Rigid	Free		Free	
H24	Both	B58	Rigid	Rigid	Rigid	Rigid	Free		Free	
H25	Both	B59	Rigid	Rigid	Rigid	Rigid	Free		Free	
H26	Both	B60	Rigid	Rigid	Rigid	Rigid	Free		Free	
H27	Both	B61	Rigid	Rigid	Rigid	Rigid	Free		Free	
H28	Both	B62	Rigid	Rigid	Rigid	Rigid	Free		Free	
H29	Both	B63	Rigid	Rigid	Rigid	Rigid	Free		Free	
H30	Both	B64	Rigid	Rigid	Rigid	Rigid	Free		Free	
H60	Both	B75	Rigid	Rigid	Rigid	Rigid	Free		Free	
H61	Both	B66	Rigid	Rigid	Rigid	Rigid	Free		Free	
H62	Both	B67	Rigid	Rigid	Rigid	Rigid	Free		Free	
H63	Both	B69	Rigid	Rigid	Rigid	Rigid	Free		Free	
H64	Both	B70	Rigid	Rigid	Rigid	Rigid	Free		Free	
H65	Both	B71	Rigid	Rigid	Rigid	Rigid	Free		Free	
H66	Both	B72	Rigid	Rigid	Rigid	Rigid	Free		Free	
H67	Both	B73	Rigid	Rigid	Rigid	Rigid	Free		Free	
H68	Both	B74	Rigid	Rigid	Rigid	Rigid	Free		Free	
H69	Both	B76	Rigid	Rigid	Rigid	Rigid	Free		Free	
H70	Both	B77	Rigid	Rigid	Rigid	Rigid	Free		Free	
H71	Both	B78	Rigid	Rigid	Rigid	Rigid	Free		Free	
H72	Both	B79	Rigid	Rigid	Rigid	Rigid	Free		Free	
H73	Both	B80	Rigid	Rigid	Rigid	Rigid	Free		Free	
H74	Both	B81	Rigid	Rigid	Rigid	Rigid	Free		Free	
H75	Both	B82	Rigid	Rigid	Rigid	Rigid	Free		Free	
H76	Both	B83	Rigid	Rigid	Rigid	Rigid	Free		Free	
H77	Both	B84	Rigid	Rigid	Rigid	Rigid	Free		Free	
H78	Both	B85	Rigid	Rigid	Rigid	Rigid	Free		Free	
H79	Both	B86	Rigid	Rigid	Rigid	Rigid	Free		Free	
H80	Both	B87	Rigid	Rigid	Rigid	Rigid	Free		Free	
H81	Both	B88	Rigid	Rigid	Rigid	Rigid	Free		Free	
H82	Both	B89	Rigid	Rigid	Rigid	Rigid	Free		Free	
H83	Both	B90	Rigid	Rigid	Rigid	Rigid	Free		Free	
H84	Both	B91	Rigid	Rigid	Rigid	Rigid	Free		Free	
H85	Both	B92	Rigid	Rigid	Rigid	Rigid	Free		Free	
H86	Both	B93	Rigid	Rigid	Rigid	Rigid	Free		Free	
H87	Both	B94	Rigid	Rigid	Rigid	Rigid	Free		Free	
H88	Both	B95	Rigid	Rigid	Rigid	Rigid	Free		Free	
H89	Both	B96	Rigid	Rigid	Rigid	Rigid	Free		Free	
H90	Both	B97	Rigid	Rigid	Rigid	Rigid	Free		Free	
H91	Both	B98	Rigid	Rigid	Rigid	Rigid	Free		Free	
H92	Both	B99	Rigid	Rigid	Rigid	Rigid	Free		Free	
H93	Both	B100	Rigid	Rigid	Rigid	Rigid	Free		Free	
H94	Both	B101	Rigid	Rigid	Rigid	Rigid	Free		Free	

Name	Position	Member	ux	uy	uz	fix	fiy	Stiff – fiy [MNm/rad]	fiz	Stiff – fiz [MNm/rad]
H95	Both	B102	Rigid	Rigid	Rigid	Rigid	Free		Free	
H96	Begin	B7	Rigid	Rigid	Rigid	Rigid	Free		Free	
H126	End	B112	Rigid	Rigid	Rigid	Rigid	Free		Free	
H127	Begin	B113	Rigid	Rigid	Rigid	Rigid	Free		Free	
H128	End	B115	Rigid	Rigid	Rigid	Rigid	Free		Free	
H129	End	B117	Rigid	Rigid	Rigid	Rigid	Free		Free	
H130	Begin	B118	Rigid	Rigid	Rigid	Rigid	Free		Free	
H131	End	B120	Rigid	Rigid	Rigid	Rigid	Free		Free	
H132	Begin	B121	Rigid	Rigid	Rigid	Rigid	Free		Free	
H133	End	B123	Rigid	Rigid	Rigid	Rigid	Free		Free	
H134	Begin	B124	Rigid	Rigid	Rigid	Rigid	Free		Free	
H135	End	B126	Rigid	Rigid	Rigid	Rigid	Free		Free	
H136	Begin	B127	Rigid	Rigid	Rigid	Rigid	Free		Free	
H137	End	B129	Rigid	Rigid	Rigid	Rigid	Free		Free	
H138	Begin	B130	Rigid	Rigid	Rigid	Rigid	Free		Free	
H139	End	B132	Rigid	Rigid	Rigid	Rigid	Free		Free	
H140	Begin	B133	Rigid	Rigid	Rigid	Rigid	Free		Free	
H141	End	B135	Rigid	Rigid	Rigid	Rigid	Free		Free	
H142	Begin	B136	Rigid	Rigid	Rigid	Rigid	Free		Free	
H143	End	B138	Rigid	Rigid	Rigid	Rigid	Free		Free	
H144	Begin	B139	Rigid	Rigid	Rigid	Rigid	Free		Free	
H145	End	B141	Rigid	Rigid	Rigid	Rigid	Free		Free	
H146	Begin	B142	Rigid	Rigid	Rigid	Rigid	Free		Free	
H147	End	B144	Rigid	Rigid	Rigid	Rigid	Free		Free	
H148	Begin	B145	Rigid	Rigid	Rigid	Rigid	Free		Free	
H149	End	B147	Rigid	Rigid	Rigid	Rigid	Free		Free	
H150	Begin	B148	Rigid	Rigid	Rigid	Rigid	Free		Free	
H151	End	B150	Rigid	Rigid	Rigid	Rigid	Free		Free	
H152	Begin	B151	Rigid	Rigid	Rigid	Rigid	Free		Free	
H153	End	B153	Rigid	Rigid	Rigid	Rigid	Free		Free	
H154	Begin	B154	Rigid	Rigid	Rigid	Rigid	Free		Free	
H155	End	B156	Rigid	Rigid	Rigid	Rigid	Free		Free	
H156	Begin	B157	Rigid	Rigid	Rigid	Rigid	Free		Free	
H157	End	B159	Rigid	Rigid	Rigid	Rigid	Free		Free	
H158	Begin	B160	Rigid	Rigid	Rigid	Rigid	Free		Free	
H159	End	B162	Rigid	Rigid	Rigid	Rigid	Free		Free	
H160	Begin	B163	Rigid	Rigid	Rigid	Rigid	Free		Free	
H161	End	B165	Rigid	Rigid	Rigid	Rigid	Free		Free	
H162	Begin	B166	Rigid	Rigid	Rigid	Rigid	Free		Free	
H163	End	B168	Rigid	Rigid	Rigid	Rigid	Free		Free	
H164	Begin	B169	Rigid	Rigid	Rigid	Rigid	Free		Free	
H165	End	B171	Rigid	Rigid	Rigid	Rigid	Free		Free	
H166	Begin	B172	Rigid	Rigid	Rigid	Rigid	Free		Free	
H167	End	B174	Rigid	Rigid	Rigid	Rigid	Free		Free	
H168	Begin	B175	Rigid	Rigid	Rigid	Rigid	Free		Free	
H169	End	B177	Rigid	Rigid	Rigid	Rigid	Free		Free	
H170	Begin	B178	Rigid	Rigid	Rigid	Rigid	Free		Free	
H171	End	B180	Rigid	Rigid	Rigid	Rigid	Free		Free	
H172	Begin	B181	Rigid	Rigid	Rigid	Rigid	Free		Free	

Name	Position	Member	ux	uy	uz	fix	fiy	Stiff – fiy [MNm/rad]	fiz	Stiff – fiz [MNm/rad]
H173	End	B183	Rigid	Rigid	Rigid	Rigid	Free		Free	
H174	Begin	B184	Rigid	Rigid	Rigid	Rigid	Free		Free	
H175	End	B186	Rigid	Rigid	Rigid	Rigid	Free		Free	
H176	Begin	B187	Rigid	Rigid	Rigid	Rigid	Free		Free	
H177	End	B189	Rigid	Rigid	Rigid	Rigid	Free		Free	
H178	Begin	B190	Rigid	Rigid	Rigid	Rigid	Free		Free	
H179	End	B192	Rigid	Rigid	Rigid	Rigid	Free		Free	
H180	Begin	B193	Rigid	Rigid	Rigid	Rigid	Free		Free	
H181	End	B195	Rigid	Rigid	Rigid	Rigid	Free		Free	
H182	Begin	B196	Rigid	Rigid	Rigid	Rigid	Free		Free	
H183	Both	B103	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H184	Both	B104	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H185	Both	B105	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H186	Both	B106	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H187	Both	B107	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H188	Both	B108	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H189	Both	B109	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H190	Both	B110	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H191	Both	B5	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H192	Both	B6	Rigid	Rigid	Rigid	Rigid	Flexible	3,8800e+01	Flexible	1,6050e+02
H193	Begin	B1	Rigid	Rigid	Rigid	Rigid	Free		Free	
H194	End	B201	Rigid	Rigid	Rigid	Rigid	Free		Free	
H195	Begin	B2	Rigid	Rigid	Rigid	Rigid	Free		Free	
H196	End	B204	Rigid	Rigid	Rigid	Rigid	Free		Free	

## 7. CARICHI E COMBINAZIONI DI CARICO

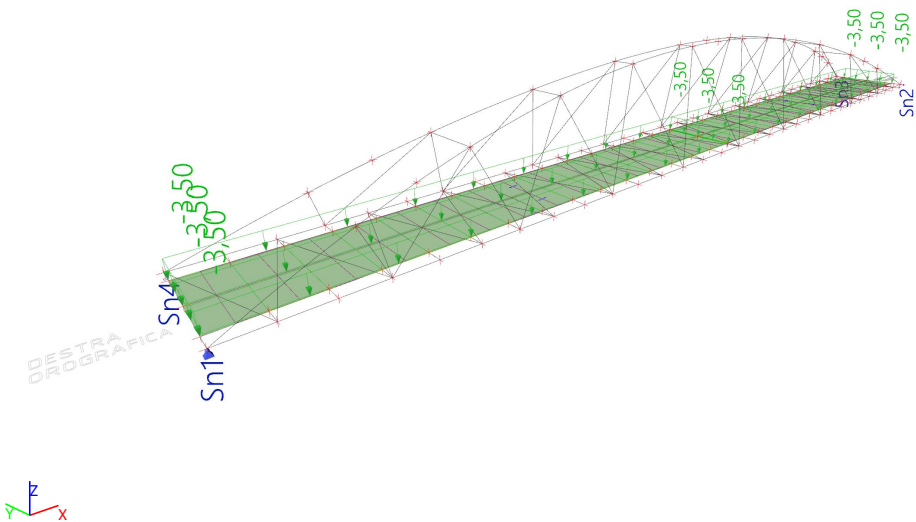
### 7.1. Condizioni di carico

Name	Spec	Description	Load type	Action type	Load group	Direction	Duration	Master load case
G1		Self weight	Self weight	Permanent	PERM	-Z		
G2			Standard	Permanent	PERM			
Q1a	Standard		Static	Variable	VAR1		Short	None
Q1b	Standard		Static	Variable	VAR1		Short	None
Q1c	Standard		Static	Variable	VAR1		Short	None
Q1d	Standard		Static	Variable	VAR1		Short	None
Q2a	Standard		Static	Variable	VAR2		Short	None
Q2b	Standard		Static	Variable	VAR2		Short	None
Q2c	Standard		Static	Variable	VAR2		Short	None
Q2d	Standard		Static	Variable	VAR2		Short	None
Wind A	Standard	(+Y/1)	Static	Variable	WIND		Short	None
Wind B	Standard	(+Y/2)	Static	Variable	WIND		Short	None
Wind C	Standard	(-Y/1)	Static	Variable	WIND		Short	None
Wind D	Standard	(-Y/2)	Static	Variable	WIND		Short	None
Temp A	Standard	(+25°)	Static	Variable	TEMP		Short	None
Temp B	Standard	(-25°)	Static	Variable	TEMP		Short	None
EQ X - SLD	Seismicity		Dynamic	Variable	SEISMIC			None
EQ Y - SLD	Seismicity		Dynamic	Variable	SEISMIC			None
EQ Z - SLD	Seismicity		Dynamic	Variable	SEISMIC			None
EQ X - SLV	Seismicity		Dynamic	Variable	SEISMIC			None
EQ Y - SLV	Seismicity		Dynamic	Variable	SEISMIC			None
EQ Z - SLV	Seismicity		Dynamic	Variable	SEISMIC			None

7.2. Condizioni di carico - Rappresentazione grafica

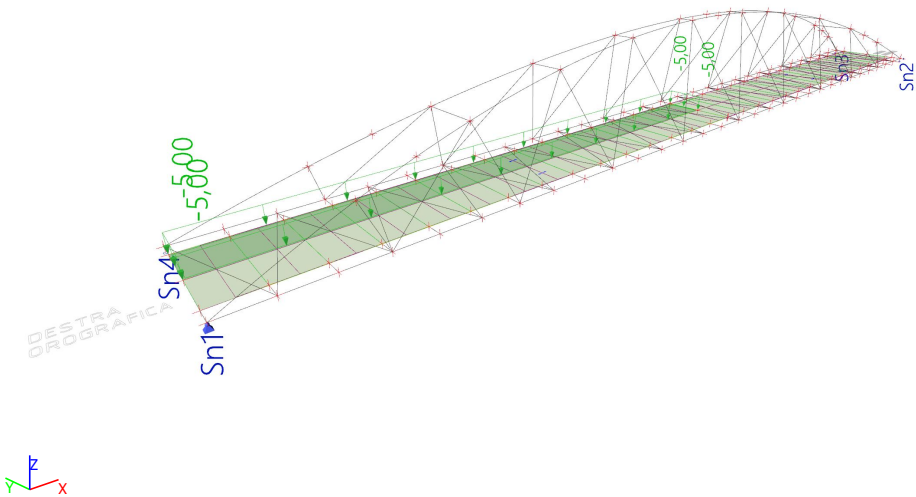
7.2.1. Condizioni di carico - Rappresentazione grafica - G2

Name	Description	Load type	Action type	Load group
G2		Standard	Permanent	PERM



7.2.2. Condizioni di carico - Rappresentazione grafica - Q1a

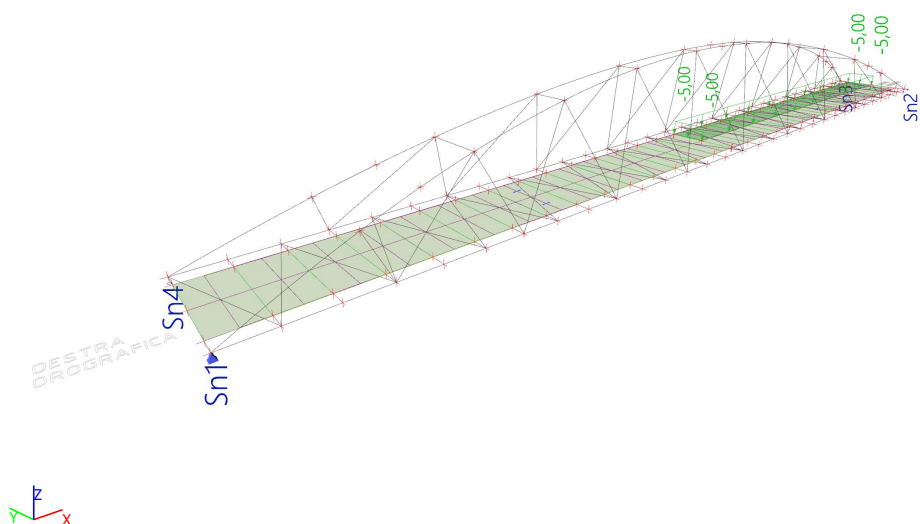
Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Q1a	Standard		Static	Variable	VAR1	Short	None





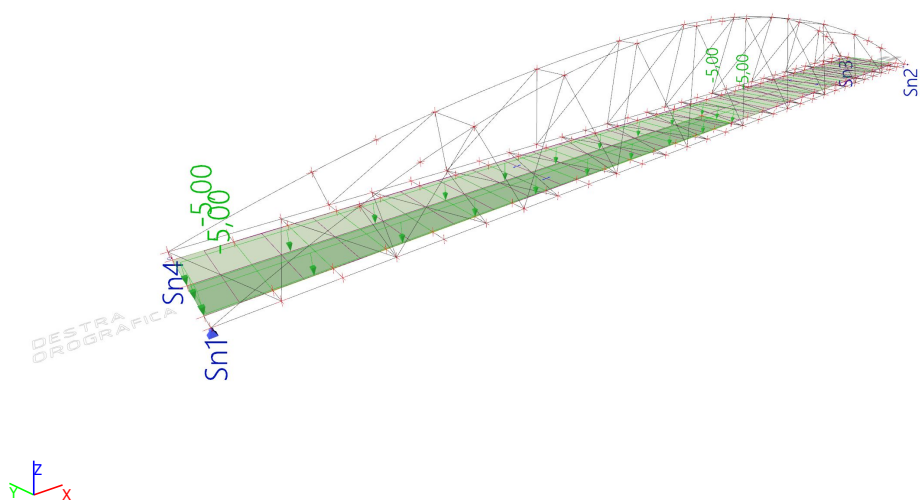
### 7.2.3. Condizioni di carico - Rappresentazione grafica - Q1b

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Q1b	Standard		Static	Variable	VAR1	Short	None



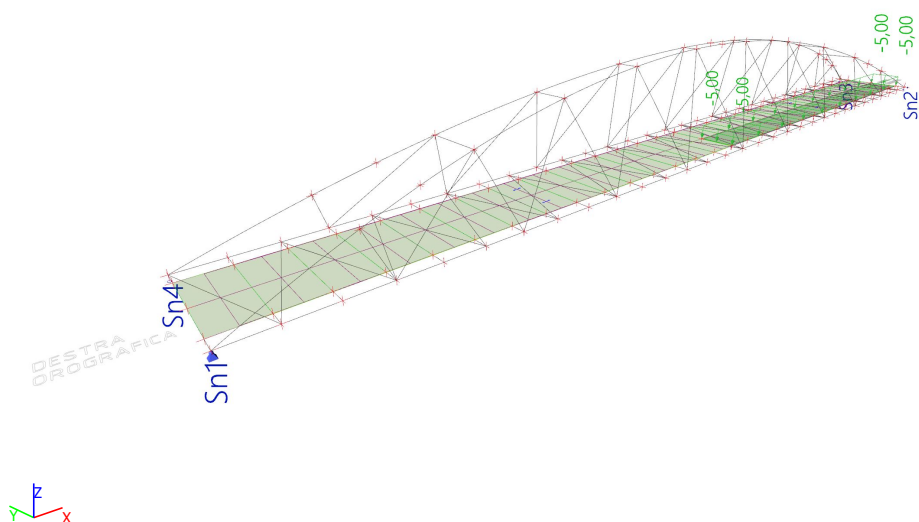
### 7.2.4. Condizioni di carico - Rappresentazione grafica - Q1c

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Q1c	Standard		Static	Variable	VAR1	Short	None



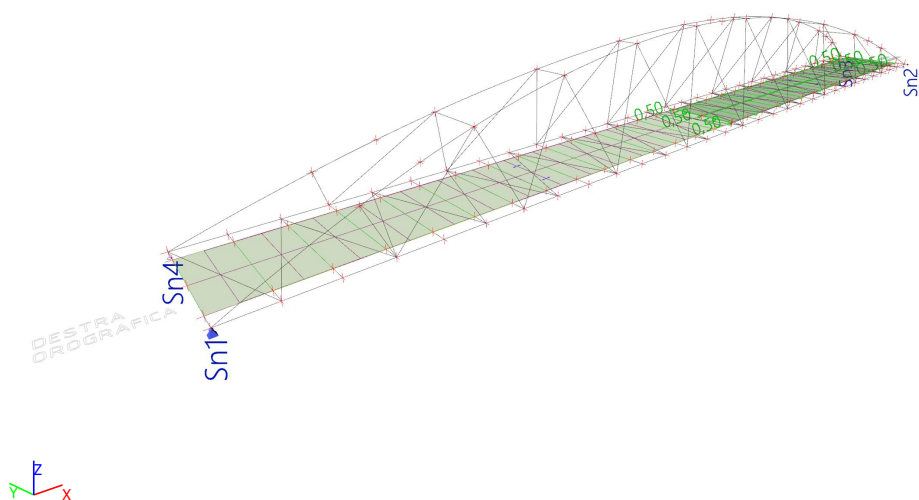
### 7.2.5. Condizioni di carico - Rappresentazione grafica - Q1d

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Q1d	Standard		Static	Variable	VAR1	Short	None



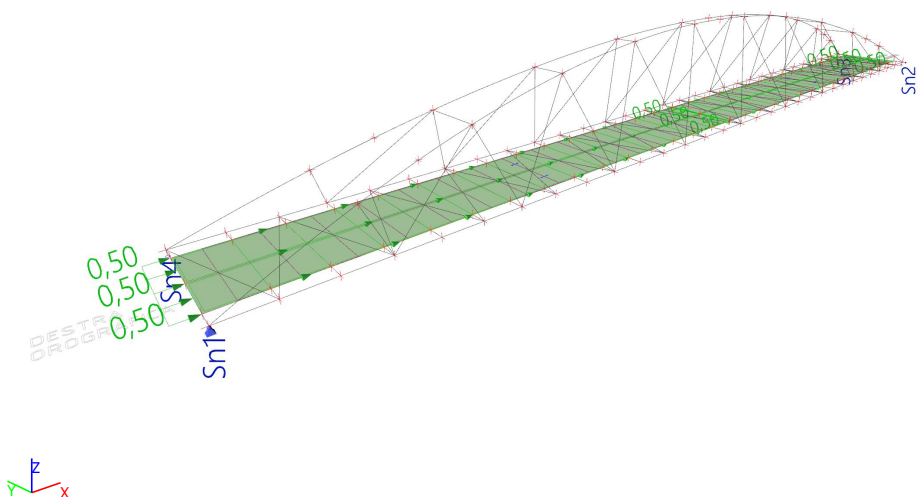
### 7.2.6. Condizioni di carico - Rappresentazione grafica - Q2a

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Q2a	Standard		Static	Variable	VAR2	Short	None



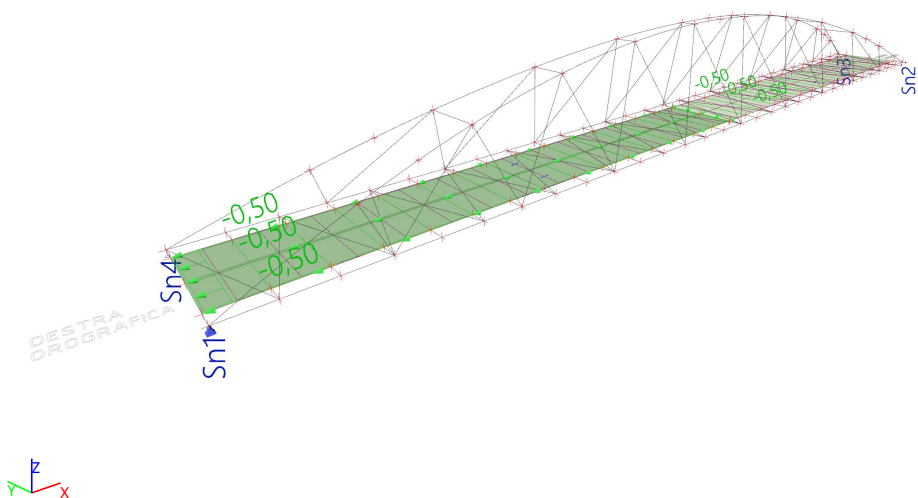
### 7.2.7. Condizioni di carico - Rappresentazione grafica - Q2b

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Q2b	Standard		Static	Variable	VAR2	Short	None



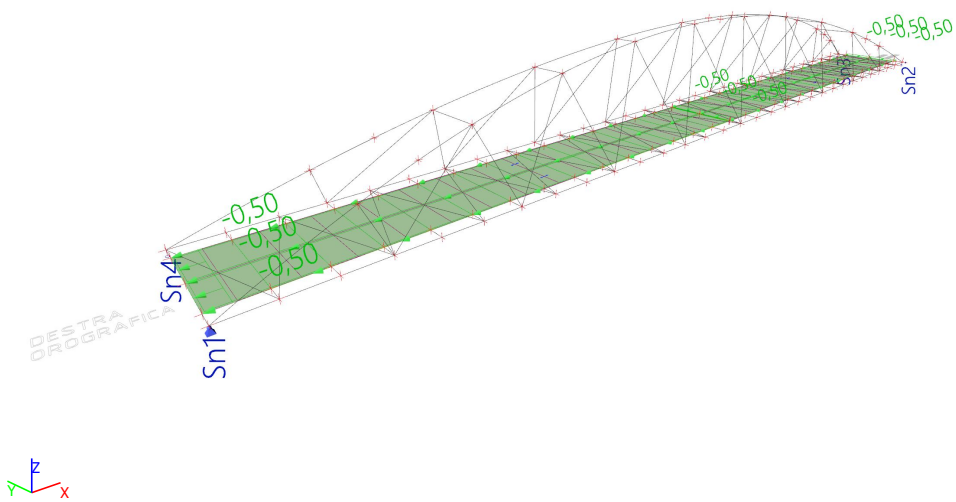
### 7.2.8. Condizioni di carico - Rappresentazione grafica - Q2c

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Q2c	Standard		Static	Variable	VAR2	Short	None



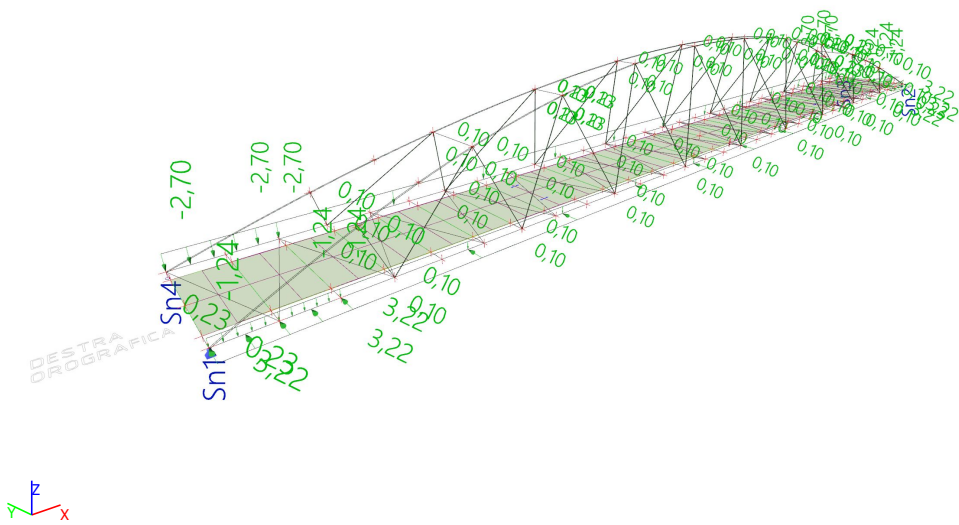
7.2.9. Condizioni di carico - Rappresentazione grafica - Q2d

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Q2d	Standard		Static	Variable	VAR2	Short	None



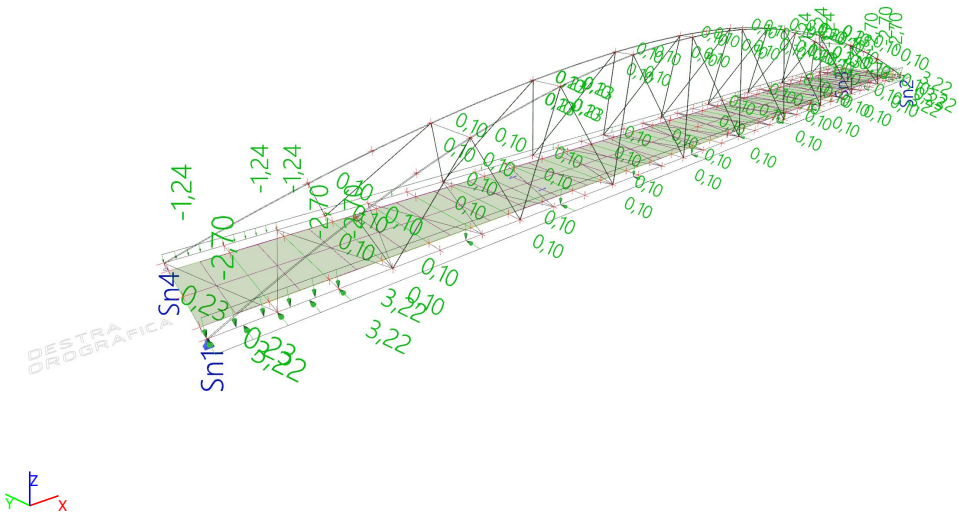
7.2.10. Condizioni di carico - Rappresentazione grafica - Wind A

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Wind A	Standard	(+Y/1)	Static	Variable	WIND	Short	None



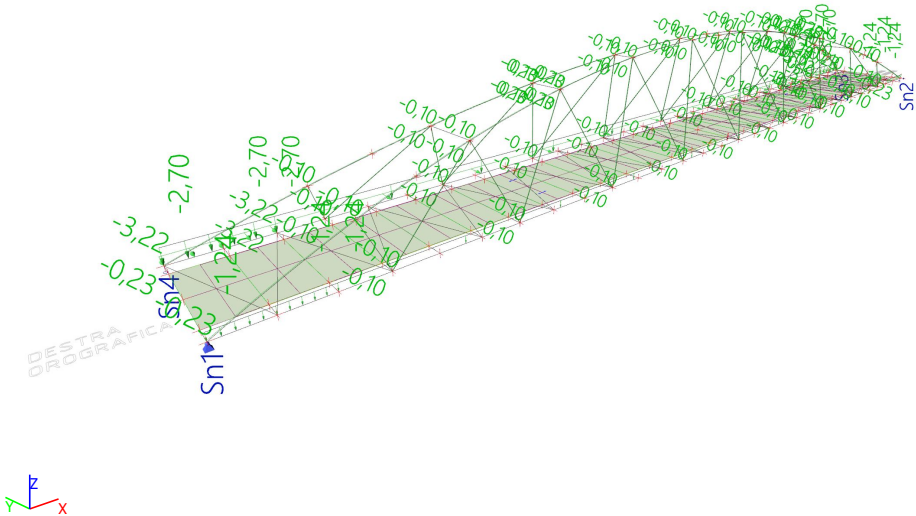
7.2.11. Condizioni di carico - Rappresentazione grafica - Wind B

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Wind B	Standard	(+Y/2)	Static	Variable	WIND	Short	None



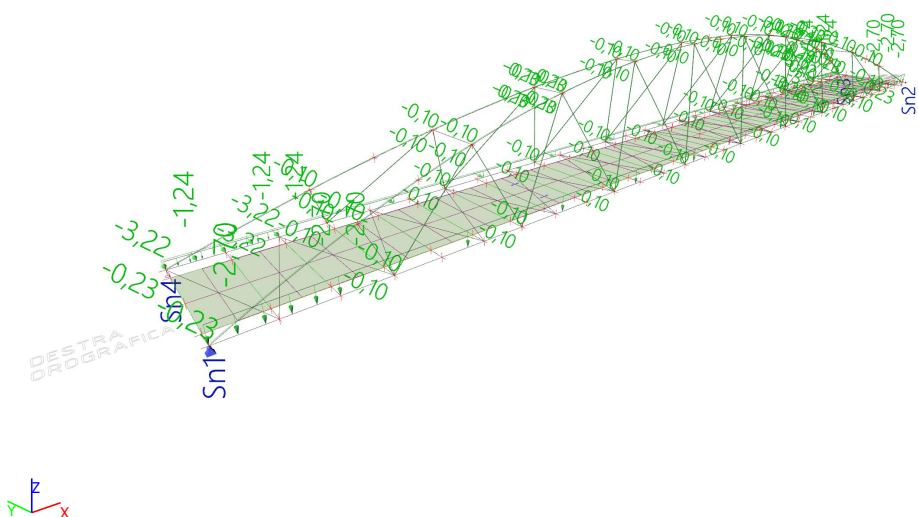
7.2.12. Condizioni di carico - Rappresentazione grafica - Wind C

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Wind C	Standard	(-Y/1)	Static	Variable	WIND	Short	None



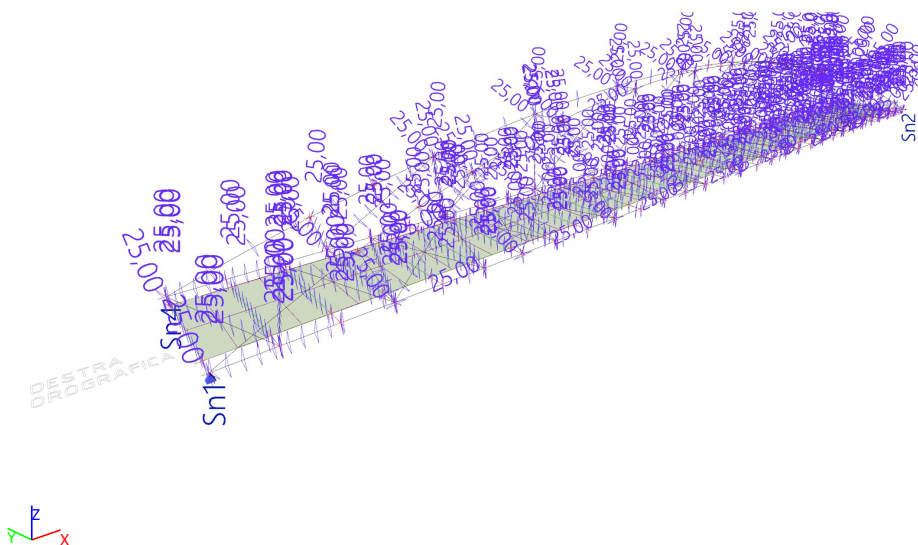
### 7.2.13. Condizioni di carico - Rappresentazione grafica - Wind D

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Wind D	Standard	(-Y/2)	Static	Variable	WIND	Short	None



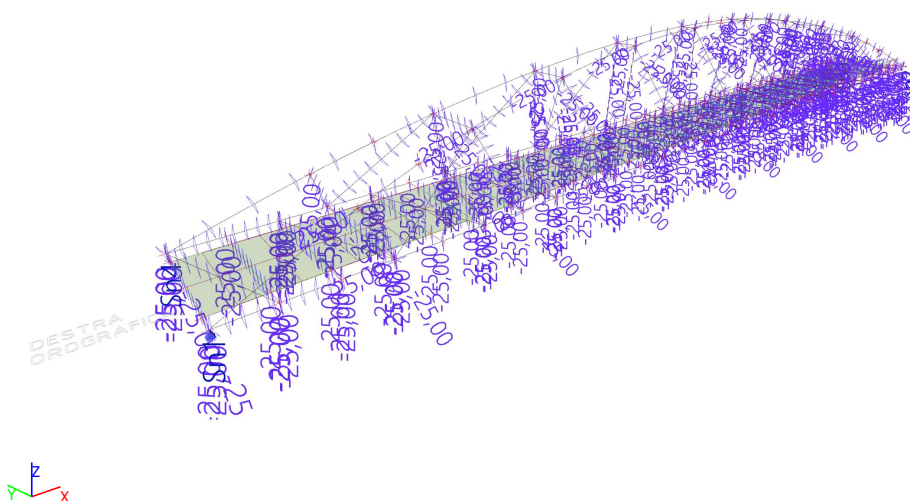
#### 7.2.14. Condizioni di carico - Rappresentazione grafica - Temp A

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Temp A	Standard	(+25°)	Static	Variable	TEMP	Short	None



#### 7.2.15. Condizioni di carico - Rappresentazione grafica - Temp B

Name	Spec	Description	Load type	Action type	Load group	Duration	Master load case
Temp B	Standard	(-25°)	Static	Variable	TEMP	Short	None



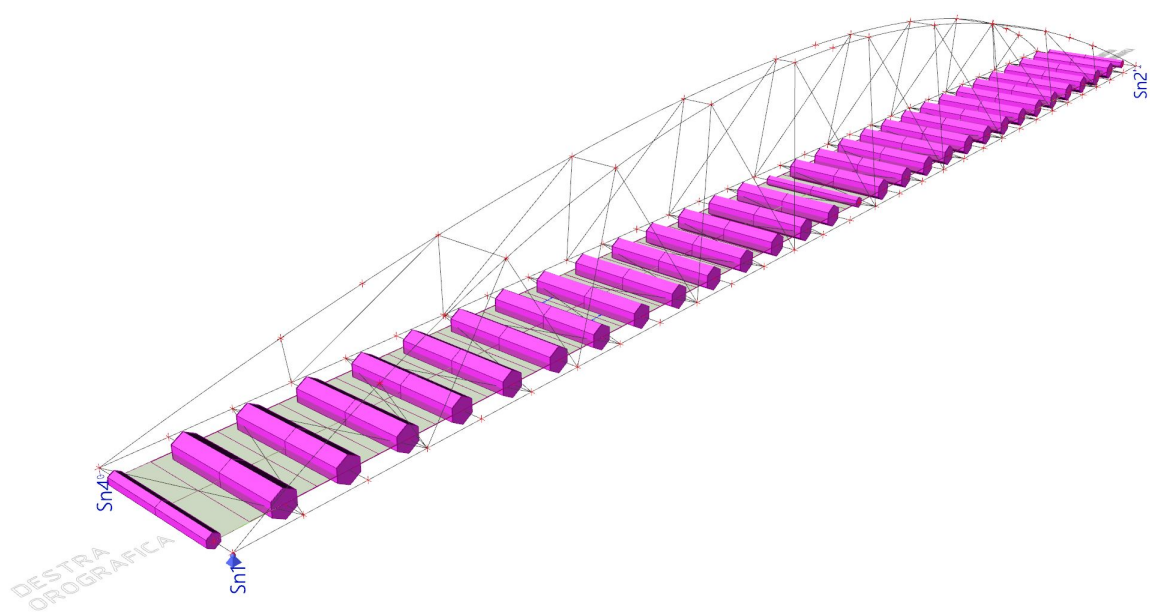
### 7.3. Gruppi di carico

Name	Load	Relation	Type
PERM	Permanent		
VAR1	Variable	Standard	Cat C : Congregation
VAR2	Variable	Exclusive	Cat E : Storage
WIND	Variable	Exclusive	Wind
TEMP	Variable	Exclusive	Temperature
SEISMIC	Seismic	Together	

#### 7.4. Gruppi di massa

Name	Load case
MG1	G2

## 7.5. Rappresentazione grafica gruppo di massa MG1



## 7.6. Combinazione dei gruppi di massa

Name	Mass group	Coeff. [-]
CM1	MG1	1,00
CM1/1 - 1,21		
CM1/2 - 1,93		
CM1/3 - 1,99		
CM1/4 - 2,52		
CM1/5 - 3,46		
CM1/6 - 3,77		
CM1/7 - 3,84		
CM1/8 - 4,24		
CM1/9 - 7,11		
CM1/10 - 7,29		
CM1/11 - 8,04		
CM1/12 - 11,11		



## 7.7. Classi di risultati

Name	List
SLE+SLD	SLD - EN-Seismic
	SLS-Char - EN-SLS Characteristic
SLU+SLV	ULS-Set B - EN-ULS (STR/GEO) Set B
	SLV - EN-Seismic
NL	NC1
	NC2
	NC3

## 7.8. Combinazioni lineari - Involuppi

Name	Description	Type	Load cases	Coeff. [-]
ULS-Set B.1		Envelope - ultimate	G1 - Self weight	1,35
			G2	1,35
ULS-Set B.2		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
ULS-Set B.3		Envelope - ultimate	G1 - Self weight	1,35
			G2	1,35
			Q1a	1,35
			Q1b	1,35
			Q1c	1,35
			Q1d	1,35
			Q2a	1,35
			Q2b	1,35
			Q2c	1,35
			Q2d	1,35
			Wind A - (+Y/1)	0,90
			Wind B - (+Y/2)	0,90
			Wind C - (-Y/1)	0,90
			Wind D - (-Y/2)	0,90
			Temp A - (+25°)	0,90
			Temp B - (-25°)	0,90
ULS-Set B.4		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			Q1a	1,35
			Q1b	1,35
			Q1c	1,35
			Q1d	1,35
			Q2a	1,35
			Q2b	1,35
			Q2c	1,35
			Q2d	1,35
			Wind A - (+Y/1)	0,90
			Wind B - (+Y/2)	0,90
			Wind C - (-Y/1)	0,90
			Wind D - (-Y/2)	0,90
			Temp A - (+25°)	0,90
			Temp B - (-25°)	0,90
ULS-Set B.5		Envelope - ultimate	G1 - Self weight	1,35
			G2	1,35
			Q1a	0,54
			Q1b	0,54
			Q1c	0,54
			Q1d	0,54
			Q2a	1,35
			Q2b	1,35
			Q2c	1,35
			Q2d	1,35
			Wind A - (+Y/1)	0,90

Name	Description	Type	Load cases	Coeff. [-]
			Wind B - (+Y/2)	0,90
			Wind C - (-Y/1)	0,90
			Wind D - (-Y/2)	0,90
			Temp A - (+25°)	0,90
			Temp B - (-25°)	0,90
ULS-Set B.6		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			Q1a	0,54
			Q1b	0,54
			Q1c	0,54
			Q1d	0,54
			Q2a	1,35
			Q2b	1,35
			Q2c	1,35
			Q2d	1,35
			Wind A - (+Y/1)	0,90
			Wind B - (+Y/2)	0,90
			Wind C - (-Y/1)	0,90
			Wind D - (-Y/2)	0,90
			Temp A - (+25°)	0,90
			Temp B - (-25°)	0,90
ULS-Set B.7		Envelope - ultimate	G1 - Self weight	1,35
			G2	1,35
			Q1a	0,54
			Q1b	0,54
			Q1c	0,54
			Q1d	0,54
			Q2a	1,35
			Q2b	1,35
			Q2c	1,35
			Q2d	1,35
			Wind A - (+Y/1)	1,50
			Wind B - (+Y/2)	1,50
			Wind C - (-Y/1)	1,50
			Wind D - (-Y/2)	1,50
			Temp A - (+25°)	0,90
			Temp B - (-25°)	0,90
ULS-Set B.8		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			Q1a	0,54
			Q1b	0,54
			Q1c	0,54
			Q1d	0,54
			Q2a	1,35
			Q2b	1,35
			Q2c	1,35
			Q2d	1,35
			Wind A - (+Y/1)	1,50
			Wind B - (+Y/2)	1,50
			Wind C - (-Y/1)	1,50
			Wind D - (-Y/2)	1,50
			Temp A - (+25°)	0,90
			Temp B - (-25°)	0,90
ULS-Set B.9		Envelope - ultimate	G1 - Self weight	1,35
			G2	1,35
			Q1a	0,54
			Q1b	0,54
			Q1c	0,54
			Q1d	0,54
			Q2a	1,35
			Q2b	1,35

Name	Description	Type	Load cases	Coeff. [-]
			Q2c	1,35
			Q2d	1,35
			Wind A - (+Y/1)	0,90
			Wind B - (+Y/2)	0,90
			Wind C - (-Y/1)	0,90
			Wind D - (-Y/2)	0,90
			Temp A - (+25°)	1,50
			Temp B - (-25°)	1,50
ULS-Set B.10		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			Q1a	0,54
			Q1b	0,54
			Q1c	0,54
			Q1d	0,54
			Q2a	1,35
			Q2b	1,35
			Q2c	1,35
			Q2d	1,35
			Wind A - (+Y/1)	0,90
			Wind B - (+Y/2)	0,90
			Wind C - (-Y/1)	0,90
			Wind D - (-Y/2)	0,90
			Temp A - (+25°)	1,50
			Temp B - (-25°)	1,50
SLS-Char.1		Envelope - serviceability	G1 - Self weight	1,00
			G2	1,00
SLS-Char.2		Envelope - serviceability	G1 - Self weight	1,00
			G2	1,00
			Q1a	1,00
			Q1b	1,00
			Q1c	1,00
			Q1d	1,00
			Q2a	1,00
			Q2b	1,00
			Q2c	1,00
			Q2d	1,00
			Wind A - (+Y/1)	0,60
			Wind B - (+Y/2)	0,60
			Wind C - (-Y/1)	0,60
			Wind D - (-Y/2)	0,60
			Temp A - (+25°)	0,60
			Temp B - (-25°)	0,60
SLS-Char.3		Envelope - serviceability	G1 - Self weight	1,00
			G2	1,00
			Q1a	0,40
			Q1b	0,40
			Q1c	0,40
			Q1d	0,40
			Q2a	1,00
			Q2b	1,00
			Q2c	1,00
			Q2d	1,00
			Wind A - (+Y/1)	0,60
			Wind B - (+Y/2)	0,60
			Wind C - (-Y/1)	0,60
			Wind D - (-Y/2)	0,60
			Temp A - (+25°)	0,60
			Temp B - (-25°)	0,60
SLS-Char.4		Envelope - serviceability	G1 - Self weight	1,00
			G2	1,00
			Q1a	0,40

Name	Description	Type	Load cases	Coeff. [-]
			Q1b	0,40
			Q1c	0,40
			Q1d	0,40
			Q2a	1,00
			Q2b	1,00
			Q2c	1,00
			Q2d	1,00
			Wind A - (+Y/1)	1,00
			Wind B - (+Y/2)	1,00
			Wind C - (-Y/1)	1,00
			Wind D - (-Y/2)	1,00
			Temp A - (+25°)	0,60
			Temp B - (-25°)	0,60
SLS-Char.5		Envelope - serviceability	G1 - Self weight	1,00
			G2	1,00
			Q1a	0,40
			Q1b	0,40
			Q1c	0,40
			Q1d	0,40
			Q2a	1,00
			Q2b	1,00
			Q2c	1,00
			Q2d	1,00
			Wind A - (+Y/1)	0,60
			Wind B - (+Y/2)	0,60
			Wind C - (-Y/1)	0,60
			Wind D - (-Y/2)	0,60
			Temp A - (+25°)	1,00
			Temp B - (-25°)	1,00
PERM.1		Linear - serviceability	G1 - Self weight	1,00
			G2	1,00
VAR.1		Linear - serviceability	Q1a	1,00
			Q1b	1,00
			Q1c	1,00
			Q1d	1,00
SLD.1		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
SLD.2		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			EQ X - SLD	1,00
			EQ Y - SLD	0,30
			EQ Z - SLD	0,30
SLD.3		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			EQ X - SLD	0,30
			EQ Y - SLD	1,00
			EQ Z - SLD	0,30
SLD.4		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			EQ X - SLD	0,30
			EQ Y - SLD	0,30
			EQ Z - SLD	1,00
SLV.1		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
SLV.2		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			EQ X - SLV	1,00
			EQ Y - SLV	0,30
			EQ Z - SLV	0,30

Name	Description	Type	Load cases	Coeff. [-]
SLV.3		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			EQ X - SLV	0,30
			EQ Y - SLV	1,00
			EQ Z - SLV	0,30
SLV.4		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			EQ X - SLV	0,30
			EQ Y - SLV	0,30
			EQ Z - SLV	1,00

### 7.9. Combinazioni non lineari

Name	Type	Load cases	Coeff. [-]
NC1	Ultimate	G1 - Self weight	1,35
		G2	1,35
		Q1a	1,35
		Q1b	1,35
		Q1c	1,35
		Q1d	1,35
NC2	Ultimate	G1 - Self weight	1,35
		G2	1,35
		Q1a	1,35
		Q1c	1,35
NC3	Ultimate	G1 - Self weight	1,35
		G2	1,35
		Q1b	1,35
		Q1d	1,35

### 7.10. Combinazioni analisi di stabilità

Name	Load cases	Coeff. [-]
S1	G1 - Self weight	1,35
	G2	1,35
	Q1a	1,35
	Q1b	1,35
	Q1c	1,35
	Q1d	1,35
S1/1 - 2,28		
S1/2 - 2,42		
S1/3 - 4,47		
S1/4 - 4,47		
S1/5 - 5,36		
S1/6 - 5,43		
S1/7 - 7,99		
S1/8 - 8,12		
S1/9 - 9,00		
S1/10 - 9,41		

## 8. REAZIONI VINCOLARI E SOLLECITAZIONI INTERNE

### 8.1. Protocollo di calcolo - Analisi lineare

#### Linear calculation

Number of 2D elements	0
Number of 1D elements	2256
Number of mesh nodes	2151
Number of equations	12906
Bending theory	Mindlin
Load cases	G1, G2, Q1a, Q1b, Q1c, Q1d, Q2a, Q2b, Q2c, Q2d, Wind A, Wind B, Wind C, Wind D, Temp A, Temp B
Start of calculation	09.04.2019 11:07
End of calculation	09.04.2019 11:07

#### Sum of loads and reactions

Load case	Value	X [kN]	Y [kN]	Z [kN]
G1	loads	0,00	0,00	-798,97
	reaction in nodes	0,00	0,00	798,97
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
G2	loads	0,00	0,00	-1153,78
	reaction in nodes	0,00	0,00	1153,78
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Q1a	loads	0,00	0,00	-412,06
	reaction in nodes	0,00	0,00	412,06
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Q1b	loads	0,00	0,00	-412,06
	reaction in nodes	0,00	0,00	412,06
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Q1c	loads	0,00	0,00	-412,06
	reaction in nodes	0,00	0,00	412,06
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Q1d	loads	0,00	0,00	-412,06
	reaction in nodes	0,00	0,00	412,06
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Q2a	loads	82,41	0,00	0,00
	reaction in nodes	-82,41	0,00	0,00
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Q2b	loads	164,82	0,00	0,00
	reaction in nodes	-164,82	0,00	0,00

Load case	Value	X [kN]	Y [kN]	Z [kN]
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Q2c	loads	-82,41	0,00	0,00
	reaction in nodes	82,41	0,00	0,00
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Q2d	loads	-164,82	0,00	0,00
	reaction in nodes	164,82	0,00	0,00
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Wind A	loads	0,00	280,00	-273,44
	reaction in nodes	0,00	-280,00	273,44
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Wind B	loads	0,00	280,00	-273,44
	reaction in nodes	0,00	-280,00	273,44
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Wind C	loads	0,00	-280,00	-273,44
	reaction in nodes	0,00	280,00	273,44
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Wind D	loads	0,00	-280,00	-273,44
	reaction in nodes	0,00	280,00	273,44
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Temp A	loads	0,00	0,00	0,00
	reaction in nodes	0,00	0,00	0,00
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00
Temp B	loads	0,00	0,00	0,00
	reaction in nodes	0,00	0,00	0,00
	reaction on lines	0,00	0,00	0,00
	contact 1D	0,00	0,00	0,00
	contact 2D	0,00	0,00	0,00

The following dynamic load cases are detailed separately (see below):EQ X - SLD, EQ Y - SLD, EQ Z - SLD, EQ X - SLV, EQ Y - SLV, EQ Z - SLV

Dynamic load case 17 : EQ X - SLD

Mode	Freq. [Hz]	Damp ratio	Damp coef.	Sax [m/s <sup>2</sup> ]	Say [m/s <sup>2</sup> ]	Saz [m/s <sup>2</sup> ]	G(j) [-]	Fx [kN]	Fy [kN]	Mx [kNm]	My [kNm]
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Mode	Freq. [Hz]	Damp ratio	Damp coef.	Sax [m/s <sup>2</sup> ]	Say [m/s <sup>2</sup> ]	Saz [m/s <sup>2</sup> ]	G(j) [-]	Fx [kN]	Fy [kN]	Mx [kNm]	My [kNm]
1	1,21	0,05	1	0,386	0,000	0,000	-0,4593	1,76	-10,63	14,12	-1,61
2	1,93	0,05	1	0,613	0,000	0,000	-0,5125	8,94	1,84	3,27	-7,53
3	1,99	0,05	1	0,634	0,000	0,000	0,0063	0,00	-0,01	-0,71	0,00
4	2,52	0,05	1	0,801	0,000	0,000	0,0597	0,27	0,04	-0,06	-0,20
5	3,46	0,05	1	0,933	0,000	0,000	-0,5523	71,25	12,29	14,77	-35,49
6	3,77	0,05	1	0,933	0,000	0,000	-0,0596	1,18	0,55	3,85	-0,13
7	3,84	0,05	1	0,933	0,000	0,000	0,0089	0,03	-0,05	-0,58	-0,01
8	4,24	0,05	1	0,933	0,000	0,000	0,3281	57,19	3,40	-46,89	-4,07
9	7,11	0,05	1	0,933	0,000	0,000	0,0009	0,00	-0,09	-0,39	-0,16
10	7,29	0,05	1	0,933	0,000	0,000	-0,0031	0,04	0,02	0,06	-0,82
11	8,04	0,05	1	0,933	0,000	0,000	0,0076	0,39	0,07	0,02	-3,20
12	11,11	0,05	1	0,932	0,000	0,000	0,0309	23,91	2,56	-3,88	-88,31
Level=	0,00	0	0	0,000	0,000	0,000	0,0000	94,88	16,91	51,55	-95,63

**Dynamic load case 18 : EQ Y - SLD**

Mode	Freq. [Hz]	Damp ratio	Damp coef.	Sax [m/s <sup>2</sup> ]	Say [m/s <sup>2</sup> ]	Saz [m/s <sup>2</sup> ]	G(j) [-]	Fx [kN]	Fy [kN]	Mx [kNm]	My [kNm]
1	1,21	0,05	1	0,000	0,386	0,000	2,8997	-11,09	67,14	-89,16	10,18
2	1,93	0,05	1	0,000	0,613	0,000	-0,1083	1,89	0,39	0,69	-1,59
3	1,99	0,05	1	0,000	0,634	0,000	-0,0552	-0,01	0,11	6,26	0,01
4	2,52	0,05	1	0,000	0,801	0,000	0,0099	0,05	0,01	-0,01	-0,03
5	3,46	0,05	1	0,000	0,933	0,000	-0,0970	12,51	2,16	2,59	-6,23
6	3,77	0,05	1	0,000	0,933	0,000	-0,0284	0,56	0,26	1,84	-0,06
7	3,84	0,05	1	0,000	0,933	0,000	-0,0172	-0,05	0,10	1,12	0,03
8	4,24	0,05	1	0,000	0,933	0,000	0,0199	3,47	0,21	-2,84	-0,25
9	7,11	0,05	1	0,000	0,933	0,000	-0,0237	-0,09	2,31	9,91	3,98
10	7,29	0,05	1	0,000	0,933	0,000	-0,0017	0,02	0,01	0,04	-0,45
11	8,04	0,05	1	0,000	0,933	0,000	0,0014	0,07	0,01	0,00	-0,59
12	11,11	0,05	1	0,000	0,932	0,000	0,0034	2,61	0,28	-0,42	-9,63
Level=	0,00	0	0	0,000	0,000	0,000	0,0000	-17,39	67,21	-90,04	15,94

**Dynamic load case 19 : EQ Z - SLD**

Mode	Freq. [Hz]	Damp ratio	Damp coef.	Sax [m/s <sup>2</sup> ]	Say [m/s <sup>2</sup> ]	Saz [m/s <sup>2</sup> ]	G(j) [-]	Fx [kN]	Fy [kN]	Mx [kNm]	My [kNm]
1	1,21	0,05	1	0,000	0,000	0,034	0,0044	-0,02	0,10	-0,14	0,02
2	1,93	0,05	1	0,000	0,000	0,054	0,1587	-2,77	-0,57	-1,01	2,33
3	1,99	0,05	1	0,000	0,000	0,056	-0,0158	0,00	0,03	1,79	0,00
4	2,52	0,05	1	0,000	0,000	0,070	0,0029	0,01	0,00	0,00	-0,01
5	3,46	0,05	1	0,000	0,000	0,097	-0,0186	2,40	0,41	0,50	-1,20
6	3,77	0,05	1	0,000	0,000	0,106	-0,0021	0,04	0,02	0,13	0,00
7	3,84	0,05	1	0,000	0,000	0,108	0,0003	0,00	0,00	-0,02	0,00
8	4,24	0,05	1	0,000	0,000	0,120	0,0120	2,10	0,12	-1,72	-0,15
9	7,11	0,05	1	0,000	0,000	0,187	0,0002	0,00	-0,02	-0,08	-0,03
10	7,29	0,05	1	0,000	0,000	0,187	-0,0063	0,09	0,05	0,13	-1,70
11	8,04	0,05	1	0,000	0,000	0,187	0,0000	0,00	0,00	0,00	0,02
12	11,11	0,05	1	0,000	0,000	0,187	0,0009	0,71	0,08	-0,12	-2,64
Level=	0,00	0	0	0,000	0,000	0,000	0,0000	-4,28	-0,73	-2,74	4,09



Dynamic load case 20 : EQ X - SLV

Mode	Freq. [Hz]	Damp ratio	Damp coef.	Sax [m/s <sup>2</sup> ]	Say [m/s <sup>2</sup> ]	Saz [m/s <sup>2</sup> ]	G(j) [-]	Fx [kN]	Fy [kN]	Mx [kNm]	My [kNm]
1	1,21	0,05	1	1,212	0,000	0,000	-1,4184	5,42	-32,84	43,61	-4,98
2	1,93	0,05	1	1,928	0,000	0,000	-1,5937	27,81	5,72	10,18	-23,43
3	1,99	0,05	1	1,969	0,000	0,000	0,0193	0,00	-0,04	-2,18	0,00
4	2,52	0,05	1	1,969	0,000	0,000	0,1459	0,67	0,11	-0,15	-0,50
5	3,46	0,05	1	1,969	0,000	0,000	-1,1639	150,13	25,90	31,12	-74,79
6	3,77	0,05	1	1,969	0,000	0,000	-0,1255	2,48	1,16	8,11	-0,27
7	3,84	0,05	1	1,969	0,000	0,000	0,0187	0,06	-0,11	-1,22	-0,03
8	4,24	0,05	1	1,969	0,000	0,000	0,6915	120,51	7,17	-98,80	-8,58
9	7,11	0,05	1	1,968	0,000	0,000	0,0020	0,01	-0,19	-0,82	-0,33
10	7,29	0,05	1	1,967	0,000	0,000	-0,0064	0,09	0,05	0,14	-1,73
11	8,04	0,05	1	1,966	0,000	0,000	0,0159	0,83	0,15	0,04	-6,73
12	11,11	0,05	1	1,963	0,000	0,000	0,0651	50,29	5,38	-8,17	-185,75
Level=	0,00	0	0	0,000	0,000	0,000	0,0000	201,00	43,17	113,47	-201,97

Dynamic load case 21 : EQ Y - SLV

Mode	Freq. [Hz]	Damp ratio	Damp coef.	Sax [m/s <sup>2</sup> ]	Say [m/s <sup>2</sup> ]	Saz [m/s <sup>2</sup> ]	G(j) [-]	Fx [kN]	Fy [kN]	Mx [kNm]	My [kNm]
1	1,21	0,05	1	0,000	1,212	0,000	8,8183	-33,72	204,17	-271,15	30,94
2	1,93	0,05	1	0,000	1,928	0,000	-0,3334	5,82	1,20	2,13	-4,90
3	1,99	0,05	1	0,000	1,969	0,000	-0,1682	-0,04	0,34	19,05	0,03
4	2,52	0,05	1	0,000	1,969	0,000	0,0240	0,11	0,02	-0,03	-0,08
5	3,46	0,05	1	0,000	1,969	0,000	-0,2041	26,33	4,54	5,46	-13,12
6	3,77	0,05	1	0,000	1,969	0,000	-0,0598	1,18	0,55	3,86	-0,13
7	3,84	0,05	1	0,000	1,969	0,000	-0,0361	-0,11	0,22	2,36	0,05
8	4,24	0,05	1	0,000	1,969	0,000	0,0419	7,29	0,43	-5,98	-0,52
9	7,11	0,05	1	0,000	1,968	0,000	-0,0498	-0,19	4,85	20,83	8,36
10	7,29	0,05	1	0,000	1,967	0,000	-0,0035	0,05	0,03	0,07	-0,94
11	8,04	0,05	1	0,000	1,966	0,000	0,0029	0,15	0,03	0,01	-1,24
12	11,11	0,05	1	0,000	1,963	0,000	0,0071	5,47	0,59	-0,89	-20,22
Level=	0,00	0	0	0,000	0,000	0,000	0,0000	-44,15	204,28	-272,78	40,44

Dynamic load case 22 : EQ Z - SLV

Mode	Freq. [Hz]	Damp ratio	Damp coef.	Sax [m/s <sup>2</sup> ]	Say [m/s <sup>2</sup> ]	Saz [m/s <sup>2</sup> ]	G(j) [-]	Fx [kN]	Fy [kN]	Mx [kNm]	My [kNm]
1	1,21	0,05	1	0,000	0,000	0,100	0,0130	-0,05	0,30	-0,40	0,05
2	1,93	0,05	1	0,000	0,000	0,159	0,4643	-8,10	-1,67	-2,97	6,83
3	1,99	0,05	1	0,000	0,000	0,165	-0,0463	-0,01	0,09	5,25	0,01
4	2,52	0,05	1	0,000	0,000	0,208	0,0086	0,04	0,01	-0,01	-0,03
5	3,46	0,05	1	0,000	0,000	0,286	-0,0545	7,03	1,21	1,46	-3,50
6	3,77	0,05	1	0,000	0,000	0,312	-0,0061	0,12	0,06	0,39	-0,01
7	3,84	0,05	1	0,000	0,000	0,317	0,0008	0,00	-0,01	-0,06	0,00
8	4,24	0,05	1	0,000	0,000	0,351	0,0352	6,14	0,37	-5,03	-0,44
9	7,11	0,05	1	0,000	0,000	0,551	0,0006	0,00	-0,06	-0,25	-0,10
10	7,29	0,05	1	0,000	0,000	0,551	-0,0187	0,26	0,14	0,39	-5,00
11	8,04	0,05	1	0,000	0,000	0,551	-0,0001	-0,01	0,00	0,00	0,05
12	11,11	0,05	1	0,000	0,000	0,551	0,0027	2,10	0,22	-0,34	-7,75
Level=	0,00	0	0	0,000	0,000	0,000	0,0000	-12,54	-2,14	-8,03	12,01

## 8.2. Protocollo di calcolo - Analisi dinamica

### Solution of Free vibration

Number of 2D elements	0
Number of 1D elements	2256
Number of mesh nodes	2151
Number of equations	12906
Combination of mass groups	MC1 CM1
Number of frequencies	12
Method	Lanczos
Bending theory	Mindlin
Type of analysis model	Standard using improved reduced system (IRS)
Start of calculation	09.04.2019 11:07
End of calculation	09.04.2019 11:07

### Sum of masses

	X [kg]	Y [kg]	Z [kg]
1	198838,7	198620,8	198167,4

### Relative modal masses

Mode	mega [rad/]	Period [s]	Freq. [Hz]	Damp ratio	$W_{xi}/W_{xtot}$	$W_{yi}/W_{ytot}$	$W_{zi}/W_{ztot}$	$I_{xi\_R}/W_{xtot\_}$	$I_{yi\_R}/W_{ytot\_}$	$I_{zi\_R}/W_{ztot\_}$
1	7,6155	0,83	1,21	0	0,0218691	0,80238	0,000220511	0,0135928	5,9142e-06	4,70931e-06
2	12,1086	0,52	1,93	0	0,0712439	0,00301767	0,783022	0,00533857	0,000186057	0,000111907
3	12,5152	0,50	1,99	0	1,14239e-05	0,000841559	0,00837066	0,478168	5,68043e-08	1,35367e-08
4	15,8289	0,40	2,52	0	0,00167169	4,37909e-05	0,000474984	1,102e-06	8,18139e-06	0,267932
5	21,7107	0,29	3,46	0	0,37665	0,0112187	0,0372763	0,0767641	0,174209	0,0134473
6	23,7038	0,27	3,77	0	0,00622291	0,00136628	0,000561199	0,0828176	0,512445	0,0313009
7	24,1204	0,26	3,84	0	0,000148476	0,000534855	1,11338e-05	0,0673094	0,00153714	0,319983
8	26,661	0,24	4,24	0	0,302339	0,00107261	0,0238159	0,109419	0,0749502	0,0318121
9	44,6601	0,14	7,11	0	1,90839e-05	0,0119954	2,17169e-05	0,0436228	0,000125798	1,05285e-08
10	45,826	0,14	7,29	0	0,000229437	6,57112e-05	0,0243036	0,000224168	0,000335599	9,74571e-07
11	50,5461	0,12	8,04	0	0,00208251	6,82017e-05	1,28701e-06	0,000251732	0,00262493	1,5597e-05
12	69,7961	0,09	11,11	0	0,126571	0,00145262	0,00277238	0,00683739	0,00829351	0,000199905
0	0	0,00	0,00	0	0,909057	0,834057	0,880852	0,884346	0,774721	0,664808

### Seismicity

Number of 2D elements	0
Number of 1D elements	2256
Number of mesh nodes	2151
Mass in analysis	Missing mass in modes
Signed results	✓
Load case	EQ X - SLD
Combination of mass groups	CM1
Bending theory	Mindlin
Type of analysis model	Standard using improved reduced system (IRS)
Start of calculation	09.04.2019 11:07
End of calculation	09.04.2019 11:07

### Seismicity

Number of 2D elements	0
Number of 1D elements	2256
Number of mesh nodes	2151
Mass in analysis	Missing mass in modes

Signed results	✓
Load case	EQ Y - SLD
Combination of mass groups	CM1
Bending theory	Mindlin
Type of analysis model	Standard using improved reduced system (IRS)
Start of calculation	09.04.2019 11:07
End of calculation	09.04.2019 11:07

#### Seismicity

Number of 2D elements	0
Number of 1D elements	2256
Number of mesh nodes	2151
Mass in analysis	Missing mass in modes
Signed results	✓
Load case	EQ Z - SLD
Combination of mass groups	CM1
Bending theory	Mindlin
Type of analysis model	Standard using improved reduced system (IRS)
Start of calculation	09.04.2019 11:07
End of calculation	09.04.2019 11:07

#### Seismicity

Number of 2D elements	0
Number of 1D elements	2256
Number of mesh nodes	2151
Mass in analysis	Missing mass in modes
Signed results	✓
Load case	EQ X - SLV
Combination of mass groups	CM1
Bending theory	Mindlin
Type of analysis model	Standard using improved reduced system (IRS)
Start of calculation	09.04.2019 11:07
End of calculation	09.04.2019 11:07

#### Seismicity

Number of 2D elements	0
Number of 1D elements	2256
Number of mesh nodes	2151
Mass in analysis	Missing mass in modes
Signed results	✓
Load case	EQ Y - SLV
Combination of mass groups	CM1
Bending theory	Mindlin
Type of analysis model	Standard using improved reduced system (IRS)
Start of calculation	09.04.2019 11:07
End of calculation	09.04.2019 11:07

#### Seismicity

Number of 2D elements	0
Number of 1D elements	2256
Number of mesh nodes	2151
Mass in analysis	Missing mass in modes
Signed results	✓
Load case	EQ Z - SLV
Combination of mass groups	CM1
Bending theory	Mindlin
Type of analysis model	Standard using improved reduced system (IRS)
Start of calculation	09.04.2019 11:07
End of calculation	09.04.2019 11:07

### 8.3. Reazioni vincolari PERM (G1+G2)

Linear calculation

Combination: PERM

System: Global

Extreme: Global

Selection: All

**Nodal reactions**

Name	Case	R <sub>x</sub> [kN]	R <sub>y</sub> [kN]	R <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]	e <sub>x</sub> [mm]	e <sub>y</sub> [mm]
Sn1/N1	PERM/1	0,00	0,00	488,19	0,00	0,00	0,00	0,0	0,0

Name	Combination key
PERM/1	G1 + G2

### 8.4. Reazioni vincolari SLE+SLD

Linear calculation

Class: SLE+SLD

System: Global

Extreme: Global

Selection: All

**Nodal reactions**

Name	Case	R <sub>x</sub> [kN]	R <sub>y</sub> [kN]	R <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]	e <sub>x</sub> [mm]	e <sub>y</sub> [mm]
Sn1/N1	SLS-Char/1	-164,82	-147,60	509,43	0,00	0,00	0,00	0,0	0,0
Sn1/N1	SLS-Char/2	164,82	147,60	553,00	0,00	0,00	0,00	0,0	0,0
Sn3/N4	SLD/3	0,00	0,00	458,97	0,00	0,00	0,00	0,0	0,0
Sn1/N1	SLS-Char/4	164,82	91,60	971,54	0,00	0,00	0,00	0,0	0,0

Name	Combination key
SLS-Char/1	G1 + G2 + Q2b + Wind A
SLS-Char/2	G1 + G2 + Q2d + Wind C
SLD/3	G1 + G2 + EQ X - SLD - 0.30*EQ Y - SLD + 0.30*EQ Z - SLD
SLS-Char/4	G1 + G2 + Q1a + Q1b + Q1c + Q1d + Q2d + 0.60*Wind D

### 8.5. Reazioni vincolari SLU+SLV

Linear calculation

Class: SLU+SLV

System: Global

Extreme: Global

Selection: All

**Nodal reactions**

Name	Case	R <sub>x</sub> [kN]	R <sub>y</sub> [kN]	R <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]	e <sub>x</sub> [mm]	e <sub>y</sub> [mm]
Sn1/N1	SLV/1	236,06	3,86	429,09	0,00	0,00	0,00	0,0	0,0
Sn1/N1	ULS-Set B/2	-222,51	-220,26	691,67	0,00	0,00	0,00	0,0	0,0
Sn1/N1	ULS-Set B/3	222,51	220,26	755,52	0,00	0,00	0,00	0,0	0,0
Sn3/N4	SLV/4	0,00	0,00	421,47	0,00	0,00	0,00	0,0	0,0
Sn1/N1	ULS-Set B/5	222,51	136,26	1321,52	0,00	0,00	0,00	0,0	0,0
Sn1/N1	SLV/6	-236,06	-3,86	547,28	0,00	0,00	0,00	0,0	0,0

Name	Combination key
SLV/1	$G1 + G2 - EQ \cdot X - SLV + 0.30 \cdot EQ \cdot Y - SLV + 0.30 \cdot EQ \cdot Z - SLV$
ULS-Set B/2	$1.35 \cdot G1 + 1.35 \cdot G2 + 1.35 \cdot Q2b + 1.50 \cdot Wind \cdot A$
ULS-Set B/3	$1.35 \cdot G1 + 1.35 \cdot G2 + 1.35 \cdot Q2d + 1.50 \cdot Wind \cdot C$
SLV/4	$G1 + G2 + EQ \cdot X - SLV - 0.30 \cdot EQ \cdot Y - SLV + 0.30 \cdot EQ \cdot Z - SLV$
ULS-Set B/5	$1.35 \cdot G1 + 1.35 \cdot G2 + 1.35 \cdot Q1a + 1.35 \cdot Q1b + 1.35 \cdot Q1c + 1.35 \cdot Q1d + 1.35 \cdot Q2d + 0.90 \cdot Wind \cdot D$
SLV/6	$G1 + G2 + EQ \cdot X - SLV - 0.30 \cdot EQ \cdot Y - SLV - 0.30 \cdot EQ \cdot Z - SLV$

## 8.6. Sollecitazioni interne CS1

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS1 - CHS406.4/25.0

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B202	2,165-	ULS-Set B/1	CS1 - CHS406.4/25.0	<b>-3363,68</b>	-12,29	-37,65	-1,05	-9,27	-19,06
B203	6,496-	SLV/2	CS1 - CHS406.4/25.0	<b>-1103,54</b>	13,90	32,67	-3,28	43,95	3,24
B202	25,982+	ULS-Set B/3	CS1 - CHS406.4/25.0	-3351,20	<b>-51,15</b>	-106,03	2,31	140,11	66,85
B202	32,478	ULS-Set B/4	CS1 - CHS406.4/25.0	-3192,76	<b>51,14</b>	103,73	-3,52	142,86	61,08
B202	0,000	ULS-Set B/5	CS1 - CHS406.4/25.0	-3363,05	-43,85	<b>-109,72</b>	-0,64	150,28	41,70
B202	30,313-	ULS-Set B/6	CS1 - CHS406.4/25.0	-2257,49	19,19	24,43	<b>-9,65</b>	-3,75	-6,81
B203	2,165-	ULS-Set B/7	CS1 - CHS406.4/25.0	-2257,01	-19,20	-24,42	<b>9,68</b>	-3,33	-6,76
B203	32,478	ULS-Set B/8	CS1 - CHS406.4/25.0	-3362,31	43,89	<b>109,78</b>	0,57	<b>151,54</b>	41,95
B202	9,743-	ULS-Set B/9	CS1 - CHS406.4/25.0	-3327,29	-0,30	0,20	-0,22	<b>-34,62</b>	<b>-32,10</b>
B202	25,982+	ULS-Set B/10	CS1 - CHS406.4/25.0	-2851,58	-47,79	-88,90	8,69	117,54	<b>70,69</b>

Name	Combination key
ULS-Set B/1	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2d + 0.90*Wind D + 0.90*Temp B
SLV/2	G1 + G2 + EQ X - SLV - 0.30*EQ Y - SLV + 0.30*EQ Z - SLV
ULS-Set B/3	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp B
ULS-Set B/4	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2d + 0.90*Wind A + 0.90*Temp A
ULS-Set B/5	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2d + 0.90*Wind D + 0.90*Temp A
ULS-Set B/6	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q2d + 0.90*Wind A
ULS-Set B/7	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D
ULS-Set B/8	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind A + 0.90*Temp A
ULS-Set B/9	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2d + 0.90*Wind B + 0.90*Temp A
ULS-Set B/10	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp B

### 8.6.1. Sollecitazione - N

Values: N

Linear calculation

Class: SLU+SLV

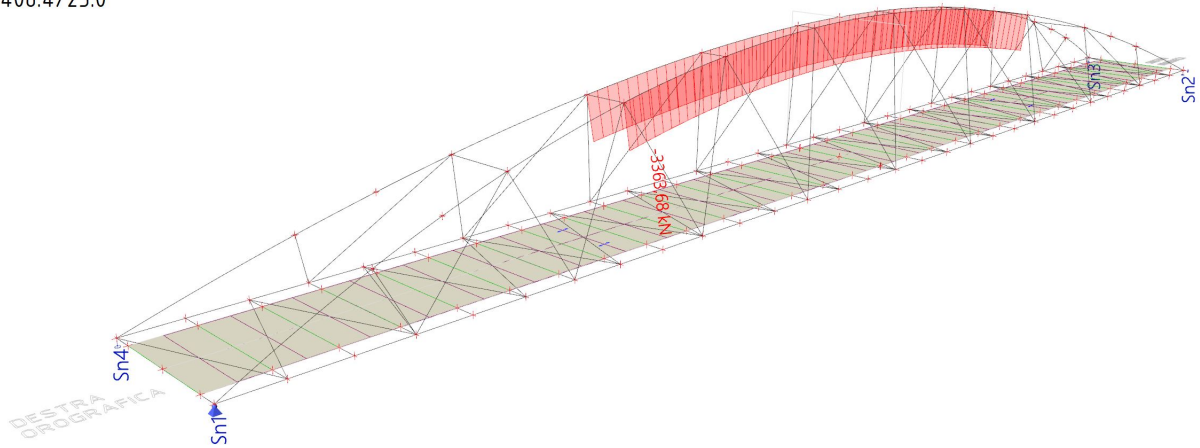
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS1 -

CHS406.4/25.0



## 8.7. Sollecitazioni interne CS6

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS6 - MSRR406.4x30.0

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B1	14,074-	ULS-Set B/1	CS6 - MSRR406.4x30.0	<b>-3412,84</b>	-29,22	-69,20	0,40	41,33	4,04
B2	12,991-	SLV/2	CS6 - MSRR406.4x30.0	<b>-1074,10</b>	15,76	23,58	3,13	38,60	25,52
B204	12,991+	ULS-Set B/3	CS6 - MSRR406.4x30.0	-3382,10	<b>-64,11</b>	-147,23	-2,23	262,41	93,48
B201	12,991+	ULS-Set B/4	CS6 - MSRR406.4x30.0	-3384,66	-63,99	<b>-147,49</b>	-3,29	263,54	92,40
B1	12,991-	ULS-Set B/5	CS6 - MSRR406.4x30.0	-2313,87	32,39	54,17	<b>-16,63</b>	99,33	6,57
B201	6,496+	ULS-Set B/6	CS6 - MSRR406.4x30.0	-2317,03	-32,82	-54,69	<b>17,30</b>	97,34	8,54
B1	2,165-	ULS-Set B/7	CS6 - MSRR406.4x30.0	-3396,11	-2,53	4,24	4,55	<b>-68,22</b>	-41,54
B1	6,496-	ULS-Set B/8	CS6 - MSRR406.4x30.0	-3244,37	58,13	143,73	-7,67	<b>271,03</b>	59,86
B204	9,743-	ULS-Set B/9	CS6 - MSRR406.4x30.0	-2039,48	3,71	13,27	6,12	34,86	<b>-55,18</b>
B2	6,496-	ULS-Set B/10	CS6 - MSRR406.4x30.0	-3382,63	<b>64,18</b>	<b>147,27</b>	1,64	262,49	<b>93,91</b>

Name	Combination key
ULS-Set B/1	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2d + 0.90*Wind D + 0.90*Temp A
SLV/2	G1 + G2 + EQ X - SLV - 0.30*EQ Y - SLV + 0.30*EQ Z - SLV
ULS-Set B/3	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp A
ULS-Set B/4	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind A + 0.90*Temp A
ULS-Set B/5	1.35*G1 + 1.35*G2 + 0.54*Q1c + 0.54*Q1d + 1.35*Q2b + 1.50*Wind B + 0.90*Temp B
ULS-Set B/6	1.35*G1 + 1.35*G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind C
ULS-Set B/7	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2d + 0.90*Wind D + 0.90*Temp B
ULS-Set B/8	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind B + 0.90*Temp A
ULS-Set B/9	1.35*G1 + 1.35*G2 + 0.54*Q1a + 0.54*Q1b + 0.54*Q1c + 1.35*Q2d + 1.50*Wind A + 0.90*Temp B
ULS-Set B/10	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2d + 0.90*Wind A + 0.90*Temp A



### 8.7.1. Sollecitazione - N

Values: N

Linear calculation

Class: SLU+SLV

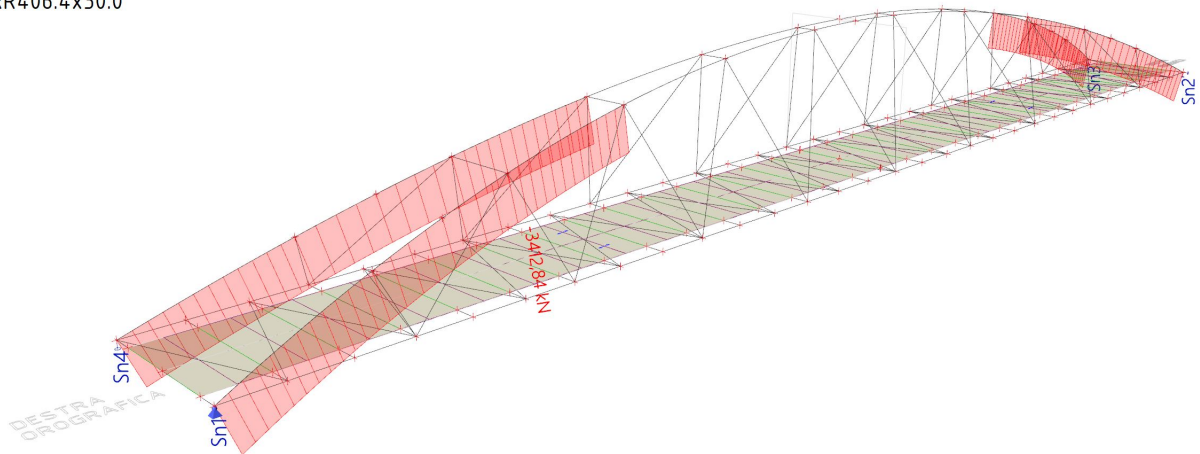
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS6 -

MSRR406.4x30.0



## 8.8. Sollecitazioni interne CS2

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS2 - CHS406.4/12.5

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B205	20,820+	ULS-Set B/1	CS2 - CHS406.4/12.5	<b>776,69</b>	-2,76	-25,81	-0,13	28,42	-7,47
B205	25,447+	ULS-Set B/2	CS2 - CHS406.4/12.5	<b>3661,34</b>	13,78	4,21	-0,09	72,22	-9,07
B205	13,880+	ULS-Set B/3	CS2 - CHS406.4/12.5	3056,15	<b>-20,05</b>	-71,03	-0,83	74,79	17,10
B206	20,820+	ULS-Set B/4	CS2 - CHS406.4/12.5	2875,90	<b>20,04</b>	-70,90	0,46	72,49	-16,01
B206	2,313-	ULS-Set B/5	CS2 - CHS406.4/12.5	2689,79	-9,64	<b>-94,78</b>	0,98	-86,17	-5,30
B206	57,833+	ULS-Set B/6	CS2 - CHS406.4/12.5	2662,06	9,33	<b>94,77</b>	-0,98	-86,68	-5,49
B205	0,000	ULS-Set B/7	CS2 - CHS406.4/12.5	2647,81	-15,58	-66,37	<b>-2,46</b>	100,85	16,78
B205	57,833+	ULS-Set B/7	CS2 - CHS406.4/12.5	2489,58	8,54	76,01	<b>2,47</b>	-64,93	-11,74
B205	23,133-	ULS-Set B/8	CS2 - CHS406.4/12.5	2843,82	5,01	-82,60	-0,73	<b>-112,16</b>	5,56
B206	0,000	ULS-Set B/9	CS2 - CHS406.4/12.5	3214,25	-5,76	-83,92	0,94	<b>124,47</b>	7,82
B206	34,700-	ULS-Set B/10	CS2 - CHS406.4/12.5	3553,66	-13,64	-3,41	-0,04	69,23	<b>-22,34</b>
B205	27,760-	ULS-Set B/4	CS2 - CHS406.4/12.5	3652,38	13,95	-3,62	-0,06	69,20	<b>22,89</b>

Name	Combination key
ULS-Set B/1	G1 + G2 + 1.35*Q2d + 1.50*Wind A + 0.90*Temp A
ULS-Set B/2	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp B
ULS-Set B/3	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind B + 0.90*Temp A
ULS-Set B/4	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind C + 0.90*Temp A
ULS-Set B/5	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind C + 0.90*Temp B
ULS-Set B/6	1.35*G1 + 1.35*G2 + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind C + 0.90*Temp B
ULS-Set B/7	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind B
ULS-Set B/8	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1c + 1.35*Q2d + 0.90*Wind D + 0.90*Temp A
ULS-Set B/9	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind A + 0.90*Temp A
ULS-Set B/10	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2c + 0.90*Wind B + 0.90*Temp A

### 8.8.1. Sollecitazione - N

Values: N

Linear calculation

Class: SLU+SLV

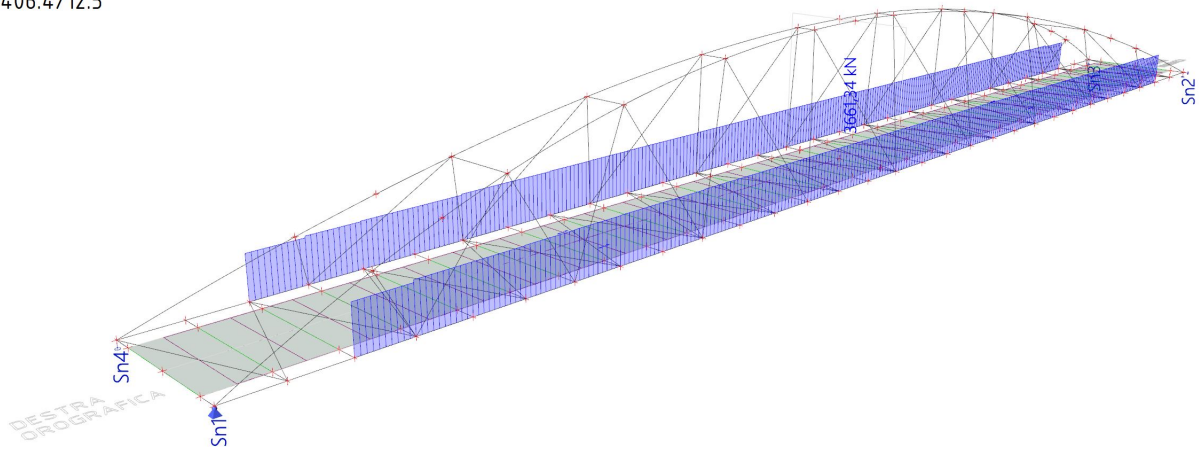
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS2 -

CHS406.4/12.5



## 8.9. Sollecitazioni interne CS3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

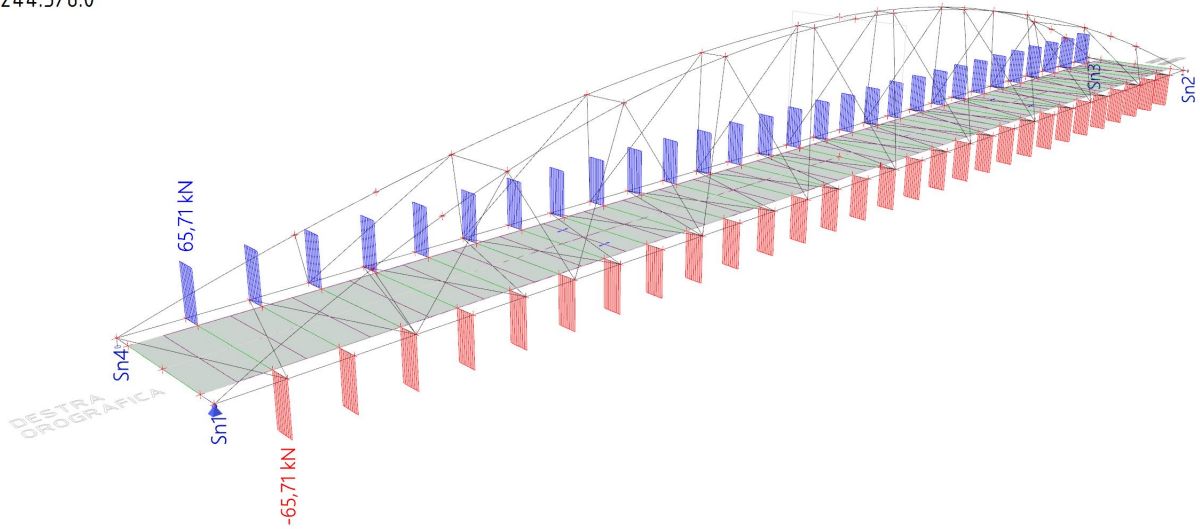
Filter: Cross-section = CS3 - CHS244.5/8.0

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B117	0,000	ULS-Set B/1	CS3 - CHS244.5/8.0	<b>-120,61</b>	3,67	-64,52	-0,10	55,62	<b>-3,15</b>
B196	0,000	SLV/2	CS3 - CHS244.5/8.0	<b>-2,02</b>	0,40	22,69	-0,13	0,00	0,00
B112	0,850	ULS-Set B/3	CS3 - CHS244.5/8.0	-24,89	-3,71	<b>-65,71</b>	0,35	0,00	0,00
B195	0,000	ULS-Set B/4	CS3 - CHS244.5/8.0	-19,74	3,67	-52,86	<b>-2,54</b>	45,71	-3,15
B7	0,000	ULS-Set B/4	CS3 - CHS244.5/8.0	-18,87	<b>-3,71</b>	40,28	<b>2,63</b>	0,00	0,00
B7	0,000	ULS-Set B/3	CS3 - CHS244.5/8.0	-24,89	<b>3,71</b>	<b>65,71</b>	0,35	<b>0,00</b>	0,00
B7	0,850	ULS-Set B/3	CS3 - CHS244.5/8.0	-24,89	3,67	64,52	0,35	<b>55,62</b>	<b>3,15</b>

Name	Combination key
ULS-Set B/1	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind C + 0.90*Temp A
SLV/2	G1 + G2 - 0.30*EQ X - SLV - EQ Y - SLV + 0.30*EQ Z - SLV
ULS-Set B/3	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2c + 0.90*Wind B + 0.90*Temp A
ULS-Set B/4	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D

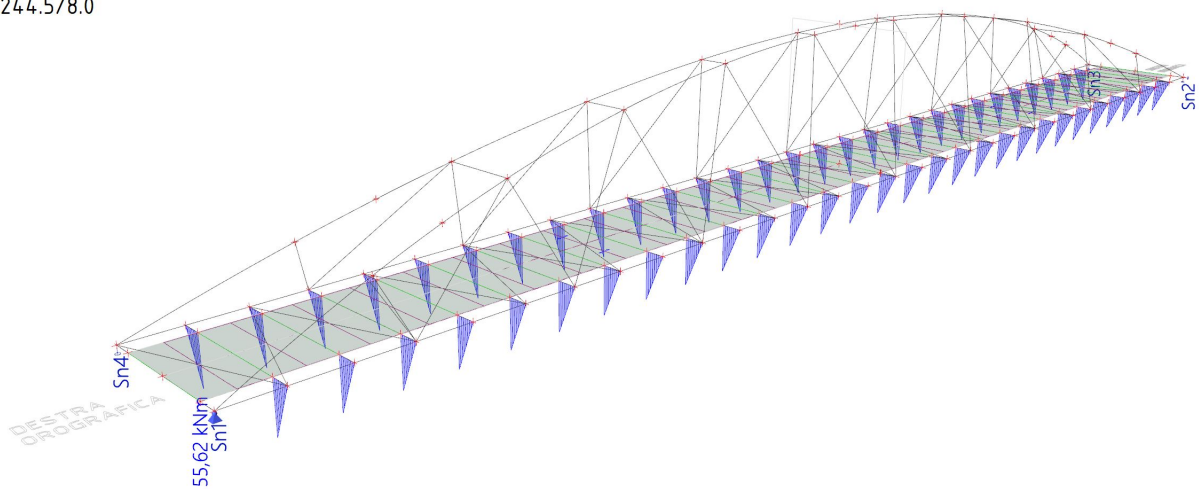
### 8.9.1. Sollecitazione - $V_z$

Values:  $V_z$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS3 -  
CHS244.5/8.0



### 8.9.2. Sollecitazione - $M_y$

Values:  $M_y$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS3 -  
CHS244.5/8.0



## 8.10. Sollecitazioni interne CS4

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

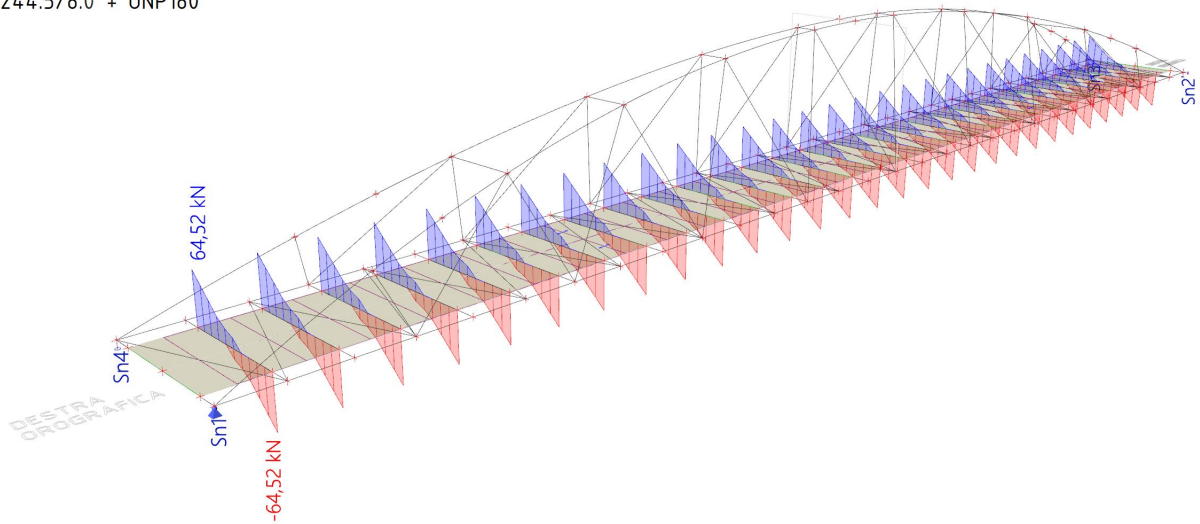
Filter: Cross-section = CS4 - CHS244.5/8.0 + UNP180

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B116	0,000	ULS-Set B/1	CS4 - CHS244.5/8.0 + UNP180	-120,61	-3,67	64,52	-0,10	55,62	-3,15
B194	0,000	SLV/2	CS4 - CHS244.5/8.0 + UNP180	-2,42	0,35	21,88	-0,13	19,11	0,34
B111	4,700	ULS-Set B/3	CS4 - CHS244.5/8.0 + UNP180	-24,89	-3,67	-64,52	0,35	55,62	3,15
B111	0,000	ULS-Set B/3	CS4 - CHS244.5/8.0 + UNP180	-24,89	3,67	64,52	0,35	55,62	3,15
B194	0,000	ULS-Set B/4	CS4 - CHS244.5/8.0 + UNP180	-19,74	-3,67	39,48	-2,54	34,01	-3,15
B194	0,000	SLV/5	CS4 - CHS244.5/8.0 + UNP180	-10,14	-2,43	17,58	-0,33	14,91	-2,34
B111	2,350-	ULS-Set B/4	CS4 - CHS244.5/8.0 + UNP180	-18,87	0,00	11,66	2,63	94,11	-7,46
B111	2,350-	ULS-Set B/3	CS4 - CHS244.5/8.0 + UNP180	-24,89	0,00	0,00	0,35	131,43	7,46

Name	Combination key
ULS-Set B/1	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind C + 0.90*Temp A
SLV/2	G1 + G2 - 0.30*EQ X - SLV - EQ Y - SLV + 0.30*EQ Z - SLV
ULS-Set B/3	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2c + 0.90*Wind B + 0.90*Temp A
ULS-Set B/4	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D
SLV/5	G1 + G2 + EQ X - SLV + 0.30*EQ Y - SLV + 0.30*EQ Z - SLV

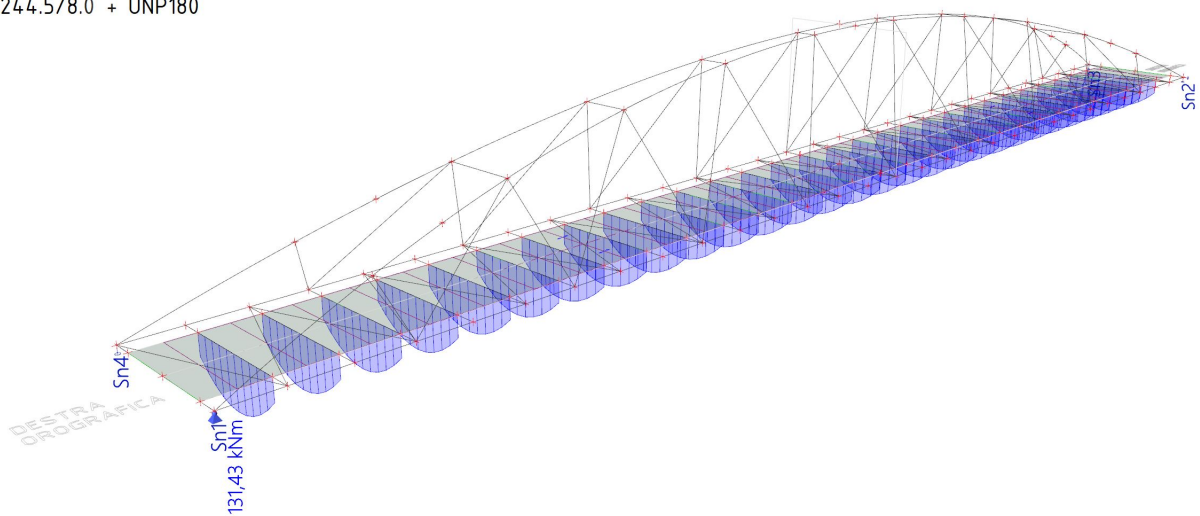
### 8.10.1. Sollecitazione - $V_z$

Values:  $V_z$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS4 -  
CHS244.5/8.0 + UNP180



### 8.10.2. Sollecitazione - $M_y$

Values:  $M_y$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS4 -  
CHS244.5/8.0 + UNP180



## 8.11. Sollecitazioni interne CS5

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS5 - CHS355.6/16.0

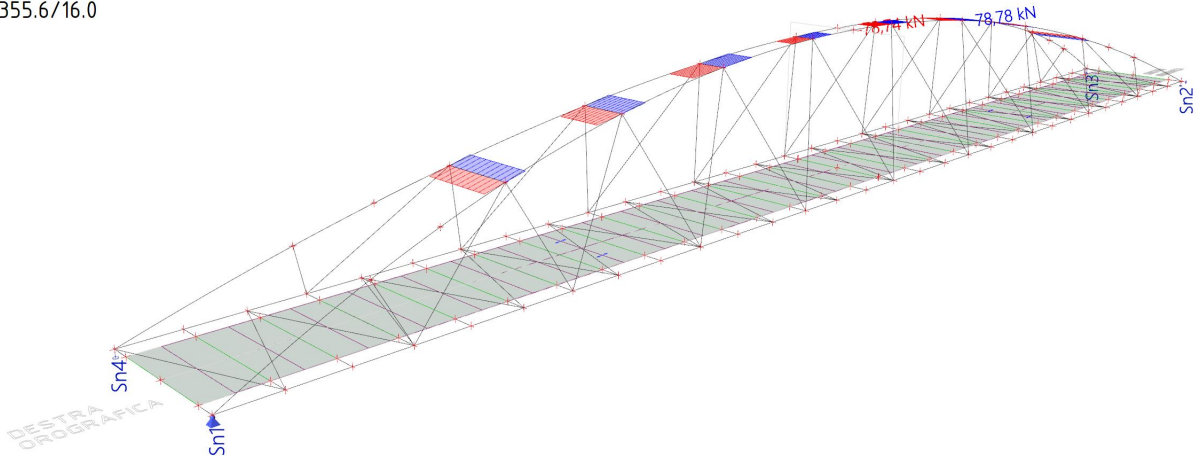
Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B103	0,000	ULS-Set B/1	CS5 - CHS355.6/16.0	<b>-18,81</b>	0,70	2,28	-0,28	2,40	-1,43
B104	0,000	SLV/2	CS5 - CHS355.6/16.0	<b>-4,44</b>	5,38	-6,40	1,80	8,56	-4,56
B108	0,000	ULS-Set B/3	CS5 - CHS355.6/16.0	-10,28	<b>-78,74</b>	-2,13	3,09	2,64	50,38
B108	1,296	ULS-Set B/4	CS5 - CHS355.6/16.0	-10,29	<b>78,78</b>	2,16	-3,09	2,67	50,42
B107	0,926	ULS-Set B/5	CS5 - CHS355.6/16.0	-9,73	-60,14	<b>-11,49</b>	1,71	-4,54	-28,31
B107	0,000	ULS-Set B/6	CS5 - CHS355.6/16.0	-9,73	60,16	<b>11,51</b>	-1,71	-4,54	-28,32
B109	0,000	ULS-Set B/6	CS5 - CHS355.6/16.0	-9,84	52,34	1,32	<b>-5,83</b>	1,94	-54,19
B109	0,000	ULS-Set B/7	CS5 - CHS355.6/16.0	-7,56	-52,97	1,75	<b>5,81</b>	0,76	53,23
B103	3,135	ULS-Set B/8	CS5 - CHS355.6/16.0	-13,42	-34,79	-8,59	0,81	<b>-9,11</b>	-54,07
B110	0,000	ULS-Set B/9	CS5 - CHS355.6/16.0	-17,30	36,02	-3,93	-1,50	<b>12,84</b>	-58,00
B110	3,135	ULS-Set B/10	CS5 - CHS355.6/16.0	-12,77	-40,11	4,61	1,99	11,91	<b>-64,11</b>
B110	0,000	ULS-Set B/11	CS5 - CHS355.6/16.0	-17,62	-41,31	9,30	1,98	-8,34	<b>63,57</b>

Name	Combination key
ULS-Set B/1	1.35*G1 + 1.35*G2 + 1.35*Q2d + 1.50*Temp A
SLV/2	G1 + G2 - EQ X - SLV - 0.30*EQ Y - SLV + 0.30*EQ Z - SLV
ULS-Set B/3	1.35*G1 + 1.35*G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind A
ULS-Set B/4	1.35*G1 + 1.35*G2 + 0.54*Q1c + 0.54*Q1d + 1.35*Q2b + 1.50*Wind D
ULS-Set B/5	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q2d + 0.90*Wind A
ULS-Set B/6	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D
ULS-Set B/7	G1 + G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q2d + 0.90*Wind A
ULS-Set B/8	G1 + G2 + 0.54*Q1d + 1.35*Q2d + 1.50*Wind D + 0.90*Temp A
ULS-Set B/9	1.35*G1 + 1.35*G2 + 0.54*Q1b + 0.54*Q1c + 0.54*Q1d + 1.35*Q2b + 1.50*Wind D
ULS-Set B/10	G1 + G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind A + 0.90*Temp A
ULS-Set B/11	1.35*G1 + 1.35*G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind A + 0.90*Temp B



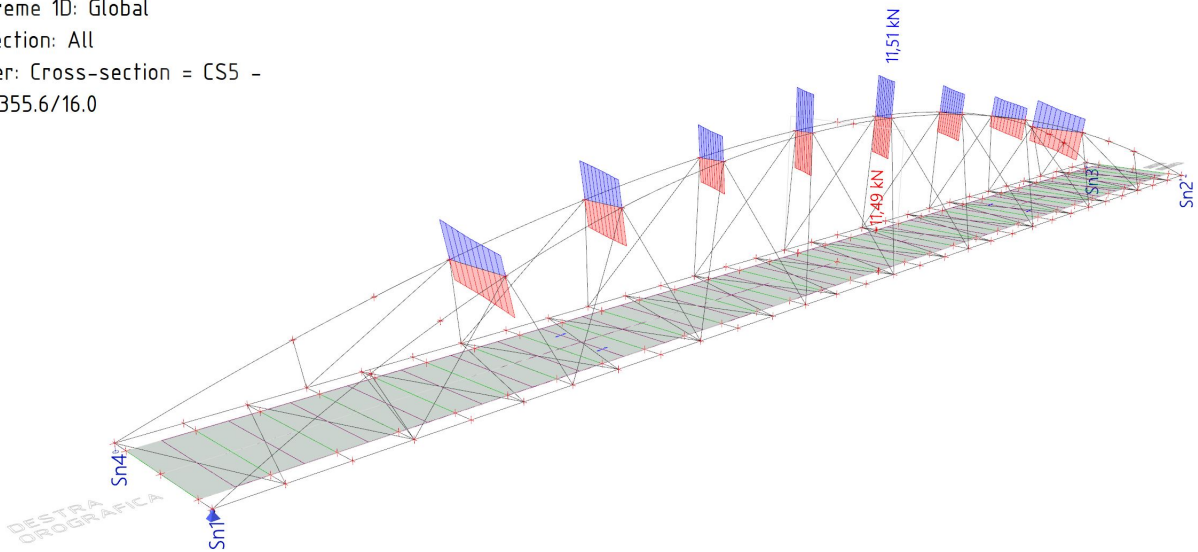
### 8.11.1. Sollecitazione - $V_y$

Values:  $V_y$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS5 -  
CHS355.6/16.0



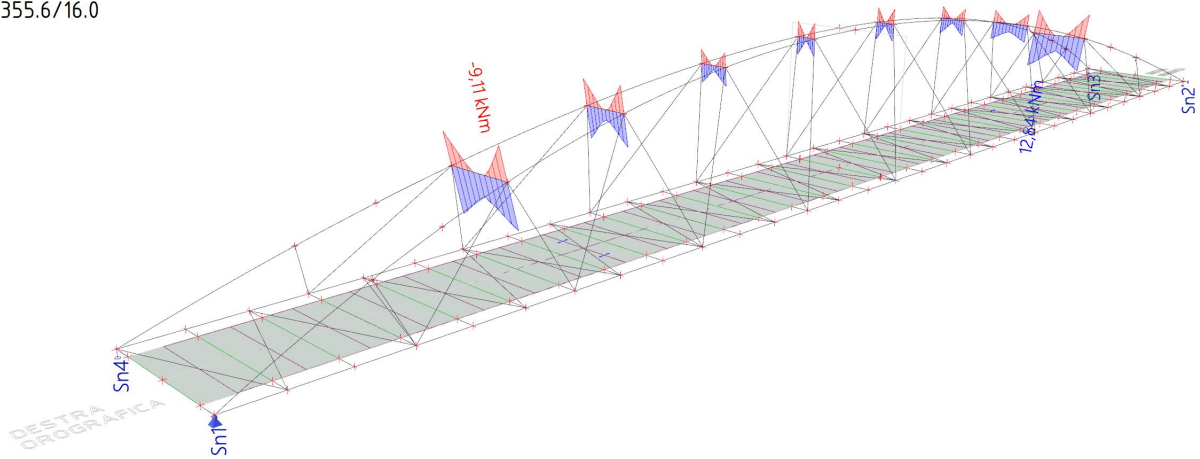
### 8.11.2. Sollecitazione - $V_z$

Values:  $V_z$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS5 -  
CHS355.6/16.0



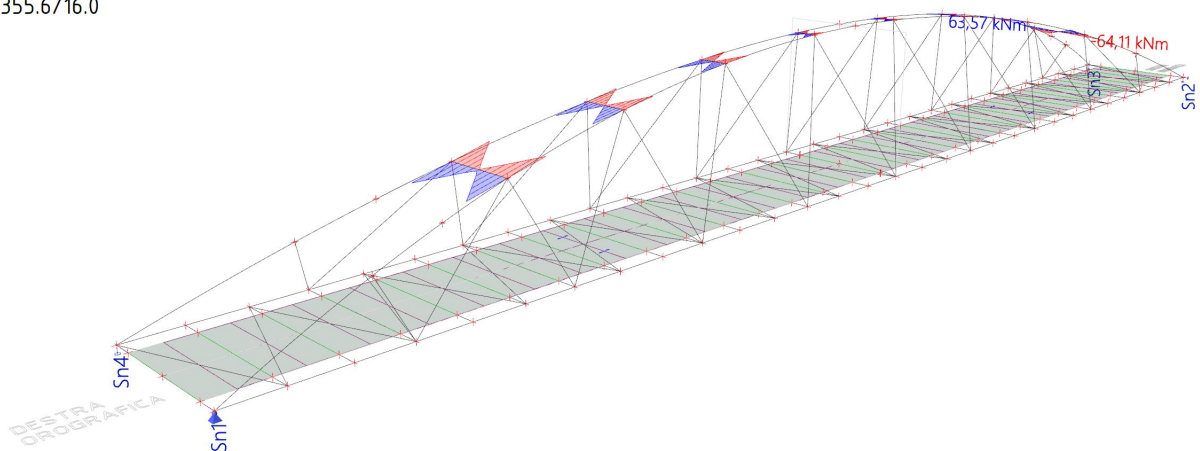
### 8.11.3. Sollecitazione - $M_y$

Values:  $M_y$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS5 -  
CHS355.6/16.0



### 8.11.4. Sollecitazione - $M_z$

Values:  $M_z$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS5 -  
CHS355.6/16.0



## 8.12. Sollecitazioni interne CS7

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

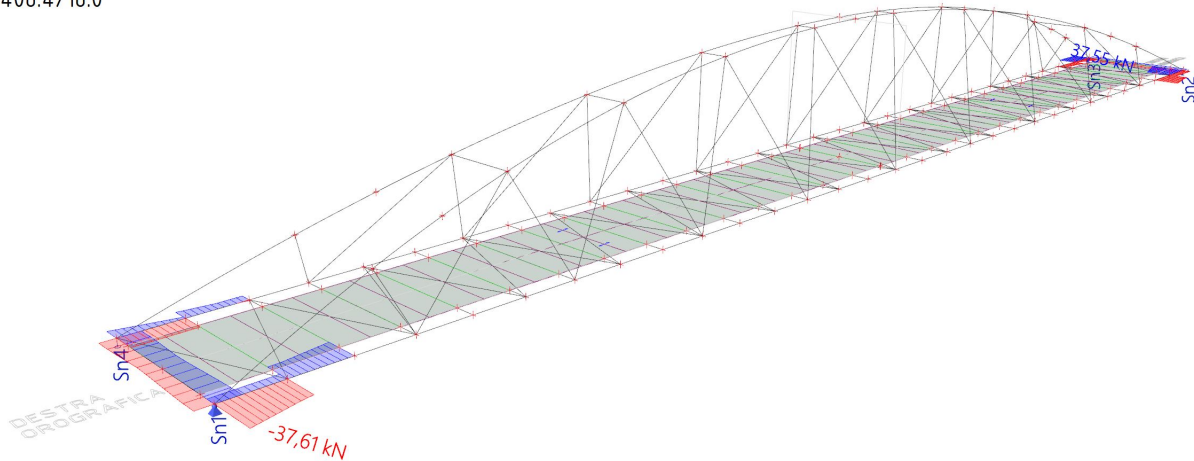
Filter: Cross-section = CS7 - CHS406.4/16.0

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B6	0,000	ULS-Set B/1	CS7 - CHS406.4/16.0	<b>6,97</b>	6,42	16,98	3,37	-7,39	-25,08
B3	2,313+	ULS-Set B/2	CS7 - CHS406.4/16.0	<b>3363,53</b>	21,25	-5,75	-1,28	149,46	-26,41
B3	0,000	ULS-Set B/3	CS7 - CHS406.4/16.0	2477,91	<b>-37,61</b>	58,46	-1,63	-5,57	45,23
B207	4,627	ULS-Set B/4	CS7 - CHS406.4/16.0	2260,17	<b>37,55</b>	-57,84	1,39	-4,20	45,06
B207	4,627	ULS-Set B/5	CS7 - CHS406.4/16.0	3021,30	10,91	<b>-72,55</b>	1,77	-6,79	1,88
B3	0,000	ULS-Set B/6	CS7 - CHS406.4/16.0	3200,59	-13,69	<b>72,84</b>	-1,75	-7,18	7,09
B6	0,000	ULS-Set B/7	CS7 - CHS406.4/16.0	272,72	-4,06	24,00	<b>-17,00</b>	4,37	6,39
B5	0,000	ULS-Set B/7	CS7 - CHS406.4/16.0	284,53	0,97	23,72	<b>17,54</b>	5,29	-4,80
B3	0,000	ULS-Set B/7	CS7 - CHS406.4/16.0	2887,11	-13,67	65,35	-2,03	<b>-17,05</b>	12,10
B3	2,313-	ULS-Set B/8	CS7 - CHS406.4/16.0	3216,29	-27,17	61,68	-1,38	<b>150,96</b>	-34,58
B6	6,400	ULS-Set B/9	CS7 - CHS406.4/16.0	507,45	-15,72	-27,83	-9,47	-9,63	<b>-50,34</b>
B5	6,400	ULS-Set B/10	CS7 - CHS406.4/16.0	507,08	15,95	-28,37	11,08	-11,26	<b>51,07</b>

Name	Combination key
ULS-Set B/1	G1 + G2 + 1.35*Q2b + 1.50*Wind C + 0.90*Temp A
ULS-Set B/2	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp B
ULS-Set B/3	1.35*G1 + 1.35*G2 + 0.54*Q1a + 0.54*Q1c + 0.54*Q1d + 1.35*Q2b + 1.50*Wind B + 0.90*Temp A
ULS-Set B/4	1.35*G1 + 1.35*G2 + 0.54*Q1b + 0.54*Q1c + 0.54*Q1d + 1.35*Q2d + 1.50*Wind B + 0.90*Temp A
ULS-Set B/5	1.35*G1 + 1.35*G2 + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp A
ULS-Set B/6	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp A
ULS-Set B/7	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp A
ULS-Set B/8	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind B + 0.90*Temp A
ULS-Set B/9	1.35*G1 + 1.35*G2 + 0.54*Q1c + 0.54*Q1d + 1.35*Q2d + 1.50*Wind B + 0.90*Temp B
ULS-Set B/10	1.35*G1 + 1.35*G2 + 0.54*Q1c + 0.54*Q1d + 1.35*Q2b + 1.50*Wind B + 0.90*Temp B

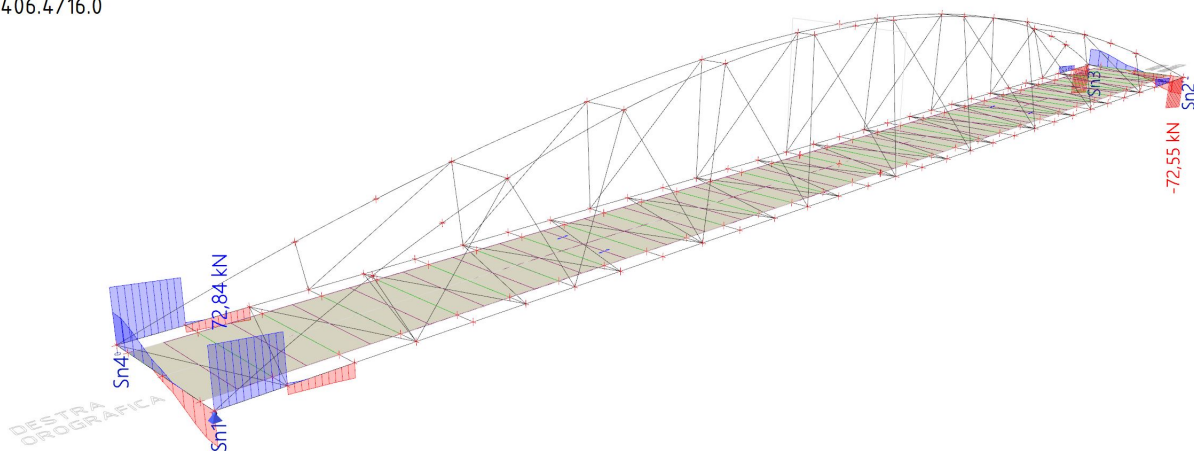
### 8.12.1. Sollecitazione - $V_y$

Values:  $V_y$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS7 -  
CHS406.4/16.0



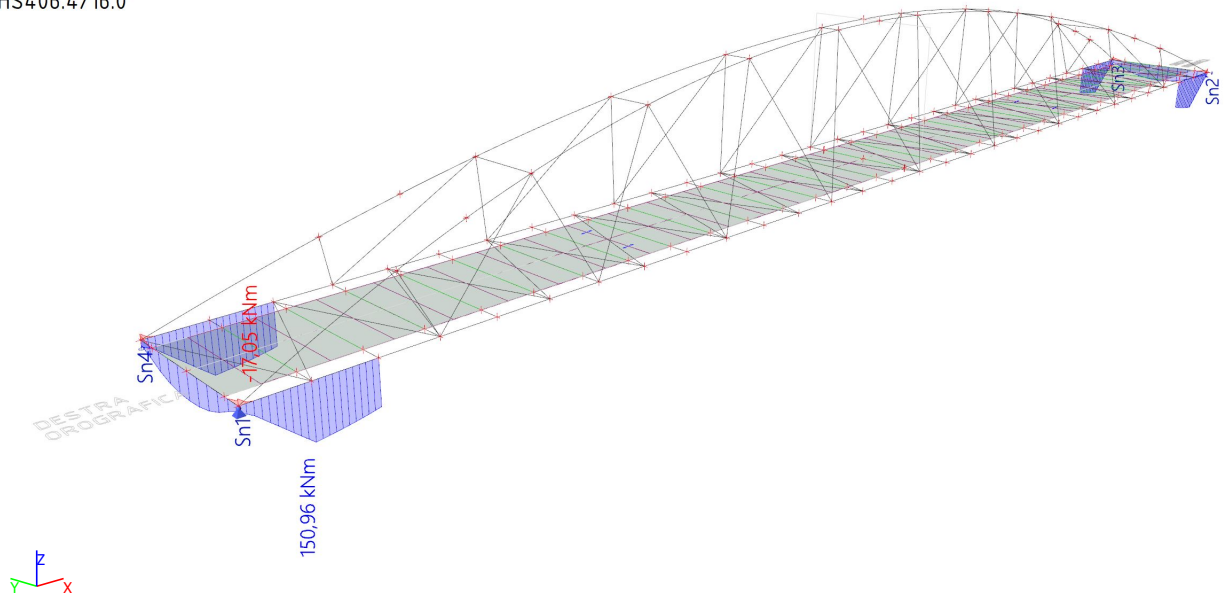
### 8.12.2. Sollecitazione - $V_z$

Values:  $V_z$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS7 -  
CHS406.4/16.0



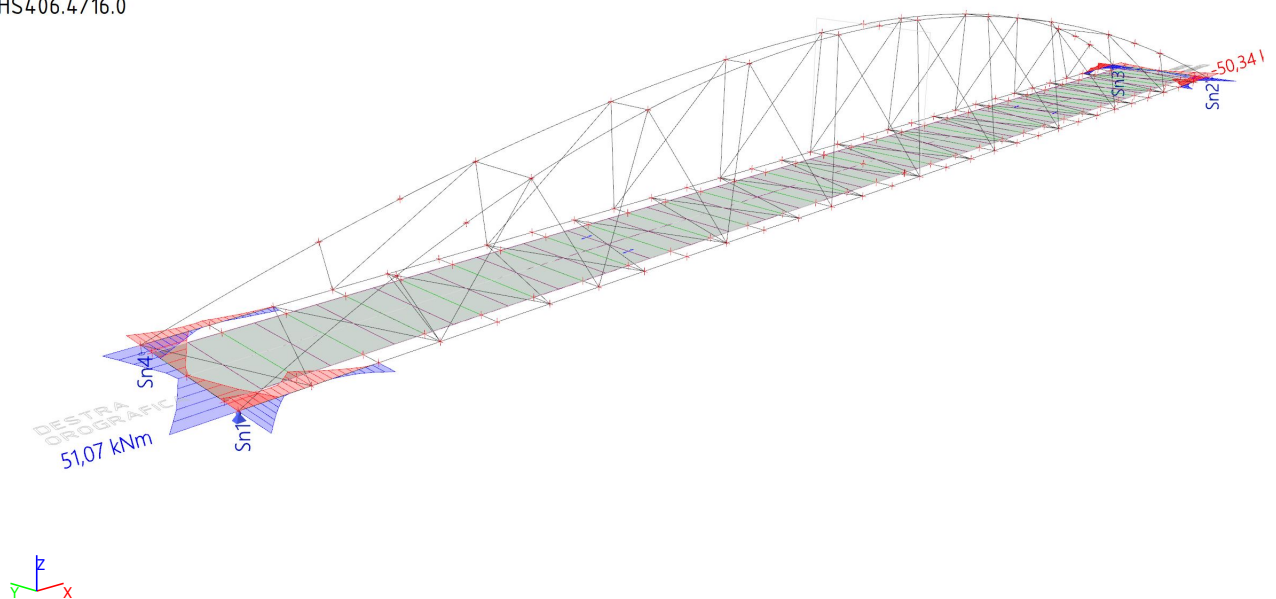
### 8.12.3. Sollecitazione - $M_y$

Values:  $M_y$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS7 -  
CHS406.4/16.0



### 8.12.4. Sollecitazione - $M_z$

Values:  $M_z$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS7 -  
CHS406.4/16.0



### 8.13. Sollecitazioni interne D1

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = D1 - CHS193.7/6.3

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B85	0,000	ULS-Set B/1	D1 - CHS193.7/6.3	<b>-90,30</b>	0,00	0,66	-0,14	0,00	0,00
B86	0,000	ULS-Set B/2	D1 - CHS193.7/6.3	<b>297,70</b>	-0,08	0,18	-0,83	<b>0,00</b>	0,00
B72	0,000	ULS-Set B/3	D1 - CHS193.7/6.3	44,72	<b>-0,51</b>	1,19	-0,01	0,00	0,00
B72	0,000	ULS-Set B/4	D1 - CHS193.7/6.3	39,15	<b>0,51</b>	0,69	0,03	0,00	0,00
B74	8,161	ULS-Set B/3	D1 - CHS193.7/6.3	59,12	0,49	<b>-1,19</b>	-0,03	0,00	0,00
B74	0,000	ULS-Set B/3	D1 - CHS193.7/6.3	56,93	-0,49	<b>1,19</b>	-0,03	0,00	0,00
B77	0,000	ULS-Set B/5	D1 - CHS193.7/6.3	252,24	-0,08	0,18	<b>-1,84</b>	0,00	0,00
B96	0,000	ULS-Set B/6	D1 - CHS193.7/6.3	252,33	0,08	0,18	<b>1,84</b>	0,00	0,00
B74	4,080-	ULS-Set B/3	D1 - CHS193.7/6.3	58,03	0,00	0,00	-0,03	<b>2,42</b>	-1,00
B72	3,979-	ULS-Set B/3	D1 - CHS193.7/6.3	45,74	0,00	0,00	-0,01	2,36	<b>-1,01</b>
B72	3,979-	ULS-Set B/7	D1 - CHS193.7/6.3	30,37	0,00	0,00	0,05	0,90	<b>1,01</b>

Name	Combination key
ULS-Set B/1	G1 + G2 + 1.35*Q1a + 1.35*Q1c + 1.35*Q2d + 0.90*Temp B
ULS-Set B/2	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind A + 0.90*Temp A
ULS-Set B/3	1.35*G1 + 1.35*G2 + 1.50*Wind A
ULS-Set B/4	1.35*G1 + 1.35*G2 + 1.50*Wind C
ULS-Set B/5	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D
ULS-Set B/6	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q2d + 0.90*Wind A
ULS-Set B/7	G1 + G2 + 1.50*Wind C

### 8.13.1. Sollecitazione - N

Values: N

Linear calculation

Class: SLU+SLV

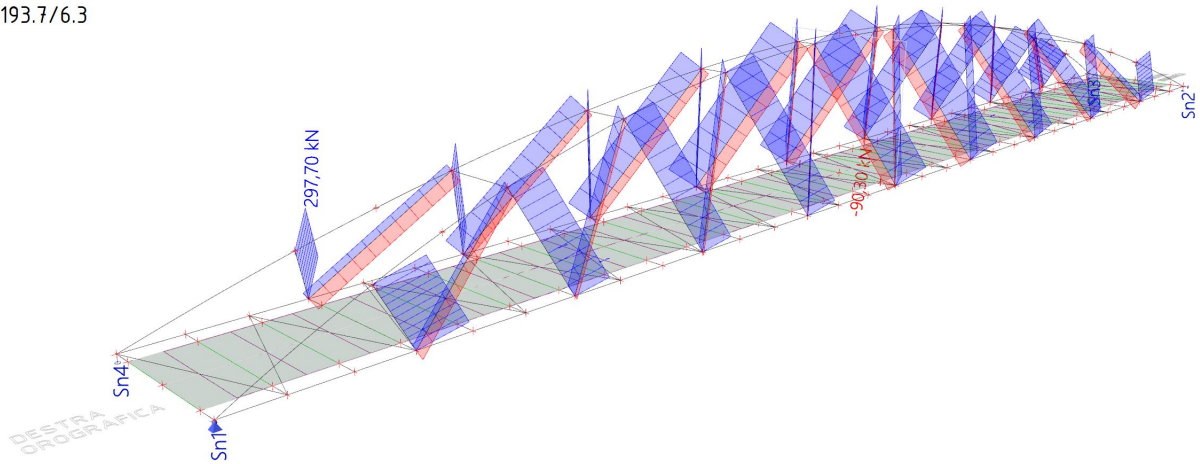
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = D1 -

CHS193.7/6.3



#### 8.14. Sollecitazioni interne CV1

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CV1 - CHS139.7/6.3

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B61	6,125+	SLV/1	CV1 - CHS139.7/6.3	7,49	<b>-0,10</b>	-0,48	0,05	0,38	0,07
B61	6,125+	SLV/2	CV1 - CHS139.7/6.3	13,77	<b>0,10</b>	-0,62	0,11	0,47	-0,07
B39	6,805	ULS-Set B/3	CV1 - CHS139.7/6.3	211,23	0,00	<b>-0,93</b>	0,04	0,00	0,00
B40	0,000	ULS-Set B/4	CV1 - CHS139.7/6.3	144,55	0,00	0,93	<b>-0,31</b>	0,00	0,00
B61	0,000	ULS-Set B/5	CV1 - CHS139.7/6.3	135,73	0,00	<b>0,93</b>	<b>0,31</b>	0,00	0,00
B39	0,000	ULS-Set B/6	CV1 - CHS139.7/6.3	<b>-180,38</b>	0,00	0,69	-0,18	<b>0,00</b>	0,00
B39	3,403-	ULS-Set B/3	CV1 - CHS139.7/6.3	<b>211,23</b>	0,00	0,00	0,04	<b>1,59</b>	0,00
B61	3,403-	SLV/2	CV1 - CHS139.7/6.3	13,73	-0,01	0,01	0,11	1,30	<b>-0,18</b>
B61	3,403+	SLV/1	CV1 - CHS139.7/6.3	7,52	-0,01	0,01	0,05	1,05	<b>0,18</b>

Name	Combination key
SLV/1	G1 + G2 + EQ X - SLV - 0.30*EQ Y - SLV - 0.30*EQ Z - SLV
SLV/2	G1 + G2 - EQ X - SLV + 0.30*EQ Y - SLV + 0.30*EQ Z - SLV
ULS-Set B/3	1.35*G1 + 1.35*G2 + 0.54*Q1c + 0.54*Q1d + 1.35*Q2b + 1.50*Wind B + 0.90*Temp A
ULS-Set B/4	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q2d + 0.90*Wind C
ULS-Set B/5	1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1d + 1.35*Q2d + 0.90*Wind C
ULS-Set B/6	G1 + G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind C + 0.90*Temp B



### 8.14.1. Sollecitazione - N

Values: N

Linear calculation

Class: SLU+SLV

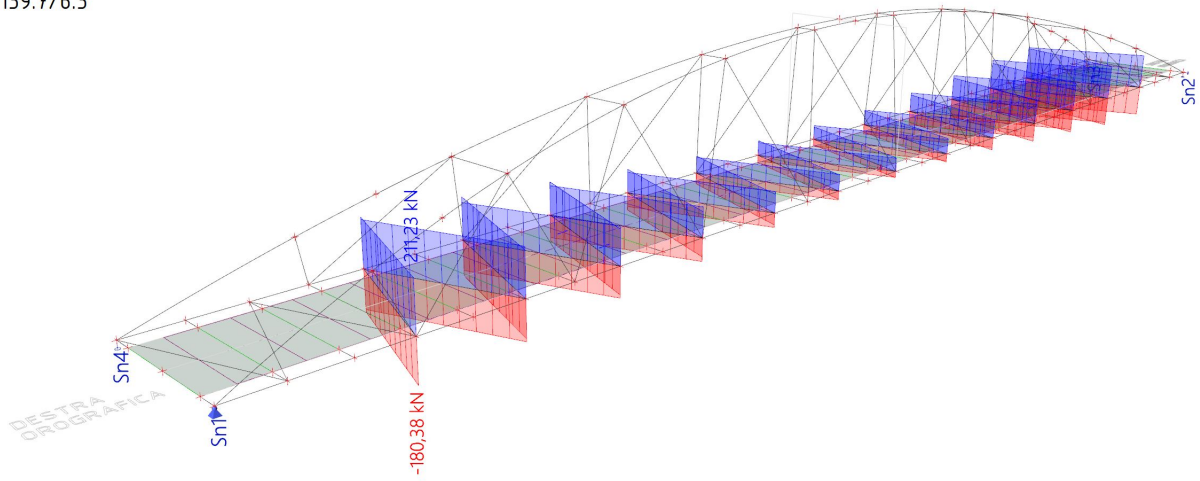
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CV1 -

CHS139.7/6.3



## 8.15. Sollecitazioni interne CV2

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CV2 - CHS139.7/8.0

Name	dx [m]	Case	Cross-section	N [kN]	V <sub>y</sub> [kN]	V <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]
B37	0,000	ULS-Set B/1	CV2 - CHS139.7/8.0	<b>-220,99</b>	0,00	0,87	0,08	0,00	0,00
B37	0,000	ULS-Set B/2	CV2 - CHS139.7/8.0	<b>259,96</b>	0,00	<b>1,17</b>	0,46	<b>0,00</b>	0,00
B65	6,125+	SLV/3	CV2 - CHS139.7/8.0	-3,16	<b>-0,12</b>	-0,58	-0,02	0,46	0,08
B65	6,125+	SLV/4	CV2 - CHS139.7/8.0	26,65	<b>0,12</b>	-0,80	0,09	0,61	-0,08
B36	6,805	ULS-Set B/5	CV2 - CHS139.7/8.0	235,00	0,00	<b>-1,17</b>	-0,27	0,00	0,00
B64	0,000	ULS-Set B/6	CV2 - CHS139.7/8.0	13,99	0,00	1,17	<b>-0,60</b>	0,00	0,00
B37	0,000	ULS-Set B/6	CV2 - CHS139.7/8.0	24,67	0,00	1,17	<b>0,61</b>	0,00	0,00
B36	3,403-	ULS-Set B/5	CV2 - CHS139.7/8.0	235,00	0,00	0,00	-0,27	<b>1,99</b>	0,00
B65	3,403-	SLV/4	CV2 - CHS139.7/8.0	26,58	-0,01	0,01	0,09	1,68	<b>-0,23</b>
B65	3,403+	SLV/3	CV2 - CHS139.7/8.0	-3,10	-0,01	0,01	-0,02	1,27	<b>0,23</b>

Name	Combination key
ULS-Set B/1	G1 + G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind C + 0.90*Temp B
ULS-Set B/2	1.35*G1 + 1.35*G2 + 0.54*Q1c + 0.54*Q1d + 1.35*Q2b + 1.50*Wind B + 0.90*Temp A
SLV/3	G1 + G2 + EQ X - SLV - 0.30*EQ Y - SLV - 0.30*EQ Z - SLV
SLV/4	G1 + G2 - EQ X - SLV + 0.30*EQ Y - SLV + 0.30*EQ Z - SLV
ULS-Set B/5	1.35*G1 + 1.35*G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind C + 0.90*Temp A
ULS-Set B/6	1.35*G1 + 1.35*G2 + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D

### 8.15.1. Sollecitazione - N

Values: N

Linear calculation

Class: SLU+SLV

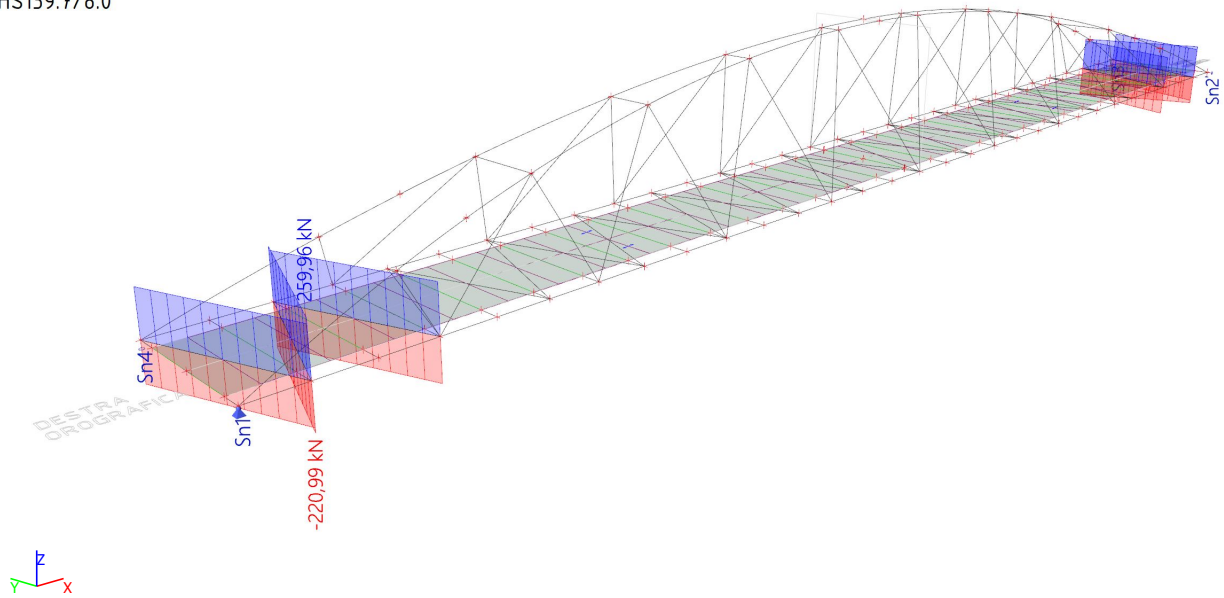
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CV2 -

CHS139.7/8.0



## 9. DEFORMAZIONI

### 9.1. Deformazione globale combinazione PERM (G1+G2)

Values:  $U_{total}$

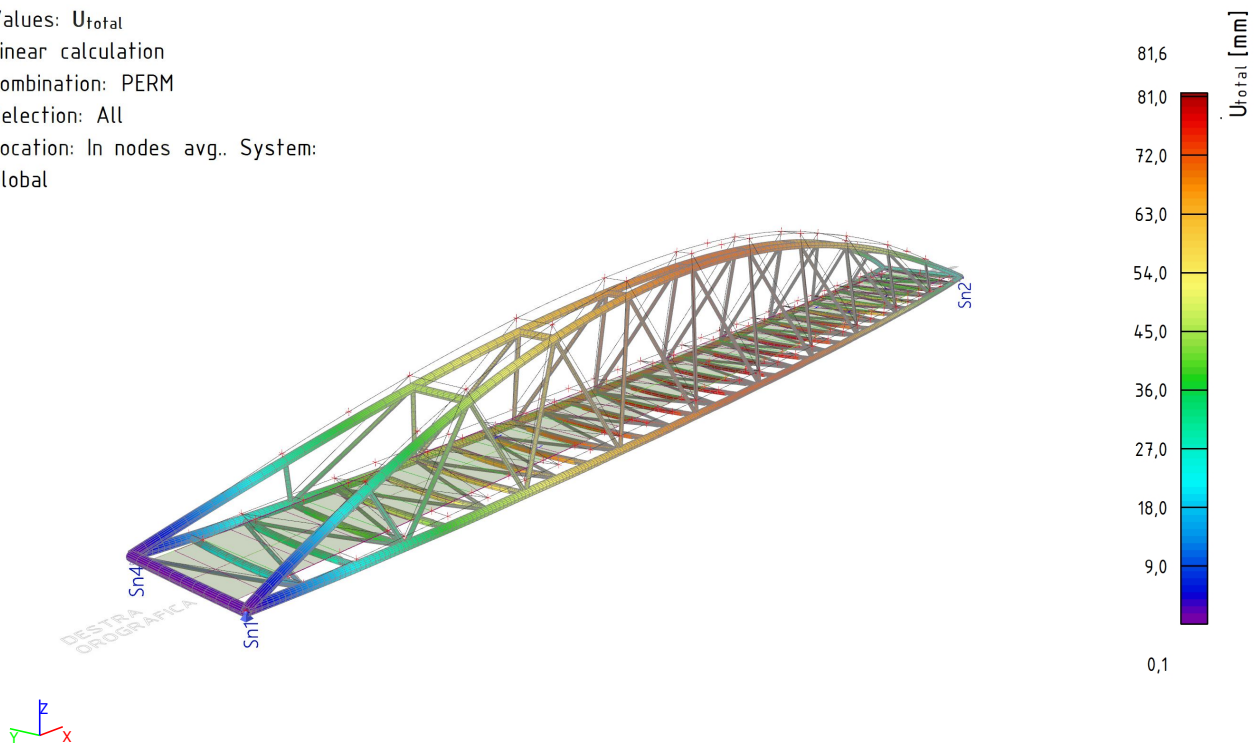
Linear calculation

Combination: PERM

Selection: All

Location: In nodes avg.. System:

Global



### 9.2. Deformazione globale combinazione VAR (Q1+Q2+Q3+Q4)

Values:  $U_{total}$

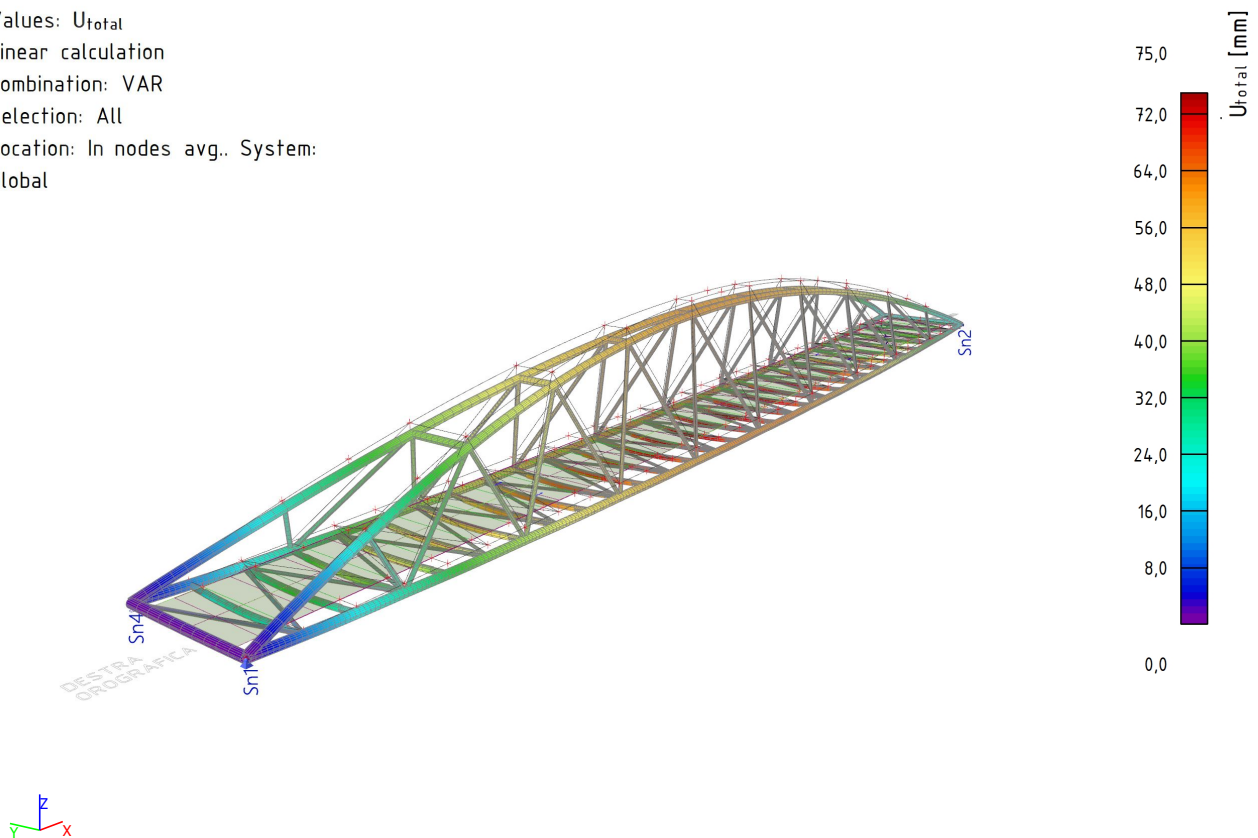
Linear calculation

Combination: VAR

Selection: All

Location: In nodes avg.. System:

Global



### 9.3. Deformazione globale classe SLE+SLD

Values:  $U_{total}$

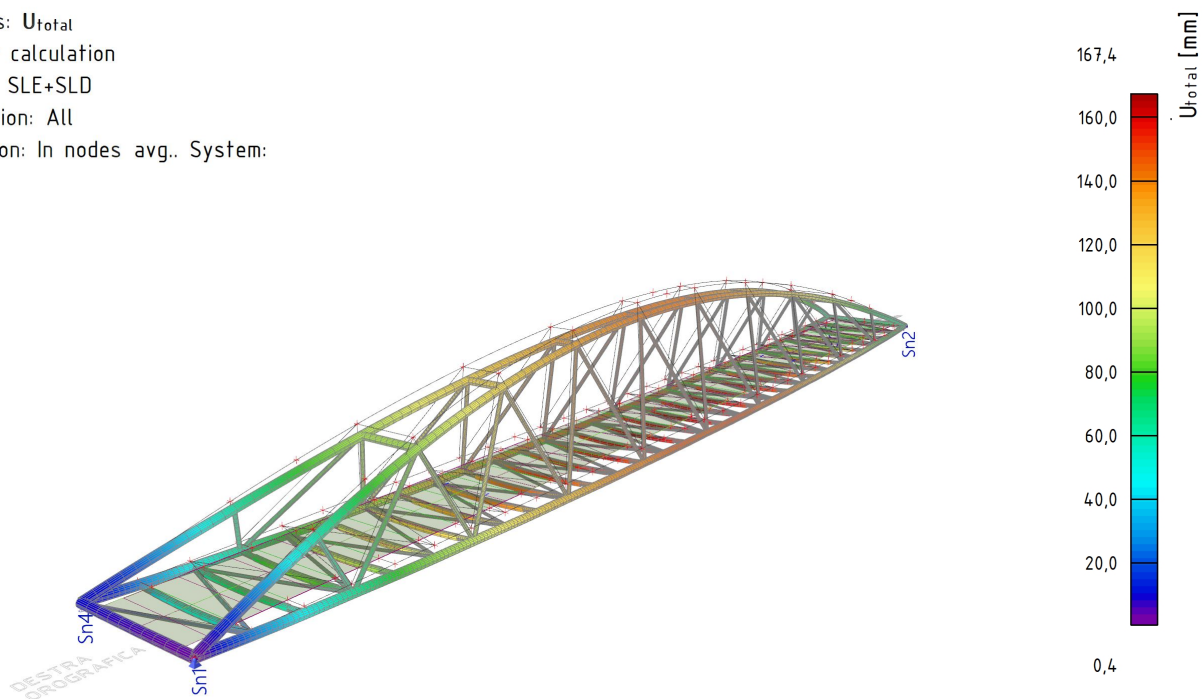
Linear calculation

Class: SLE+SLD

Selection: All

Location: In nodes avg.. System:

Global



### 9.4. Deformazione massima trasversale classe SLE+SLD

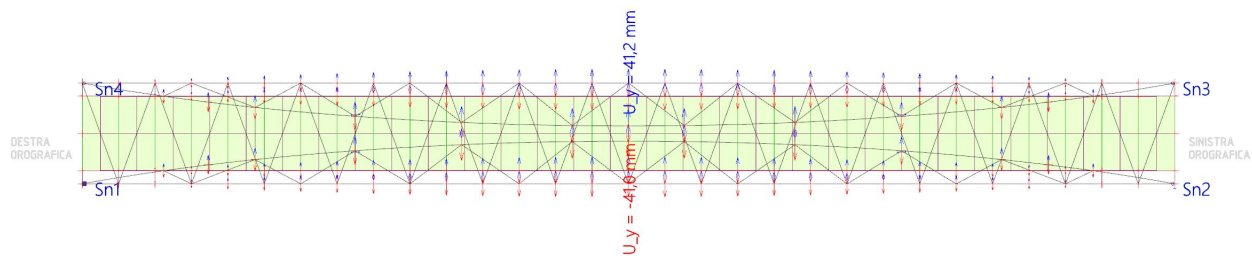
Values:  $U_y$

Linear calculation

Class: SLE+SLD

Extreme: Global

Selection: All



9.5. Deformazione relativa travi impalcato combinazione SLE

Linear calculation  
Combination: SLS-Char  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS4 - CHS244.5/8.0 + UNP180

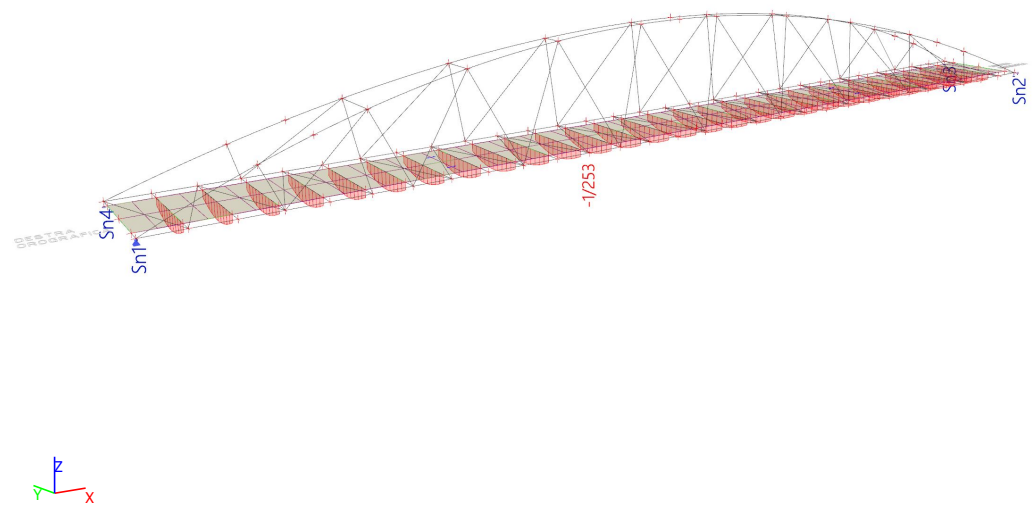
Relative deformations

Name	dx [m]	Case	Cross-section	u <sub>y</sub> [mm]	u <sub>y,rel</sub> [1/xx]	u <sub>z</sub> [mm]	u <sub>z,rel</sub> [1/xx]
B176	2,350-	SLS-Char/1	CS4 - CHS244.5/8.0 + UNP180	-2,0	-1/3136	-18,1	-1/354
B179	2,350-	SLS-Char/2	CS4 - CHS244.5/8.0 + UNP180	2,0	1/3136	-10,9	-1/586
B143	2,350-	SLS-Char/3	CS4 - CHS244.5/8.0 + UNP180	0,0	1/10000	-25,3	-1/253
B149	0,000	SLS-Char/4	CS4 - CHS244.5/8.0 + UNP180	-0,8	-1/7599	-4,6	-1/1391

Name	Combination key
SLS-Char/1	G1 + G2 + Q1a + Q1d + Q2d + 0.60*Wind C
SLS-Char/2	G1 + G2 + 0.40*Q1a + Q2a + Wind C
SLS-Char/3	G1 + G2 + Q1a + Q1c + Q2a + 0.60*Wind D
SLS-Char/4	G1 + G2 + Q1b + Q1d + Q2d + 0.60*Wind A

9.6. Deformazione relativa travi impalcato combinazione SLE

Values: u<sub>z,rel</sub>  
Linear calculation  
Combination: SLS-Char  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS4 -  
CHS244.5/8.0 + UNP180



## 10. ANALISI DI BUCKLING E MODI DI VIBRARE

### 10.1. Coefficienti di buckling

N	f
-	II
Stability combination : S1	
1	2,28
2	2,42
3	4,47
4	4,47
5	5,36
6	5,43
7	7,99
8	8,12
9	9,00
10	9,41

A seguire i due modi di Buckling utilizzati per la determinazione delle lunghezze di libera inflessione degli archi e successivamente inseriti nelle analisi di instabilità.

### 10.2. Primo modo di Buckling

Values:  $u_y$

Stability calculation. Buckling shapes are normalized, so that the maximum nodal displacement resp.

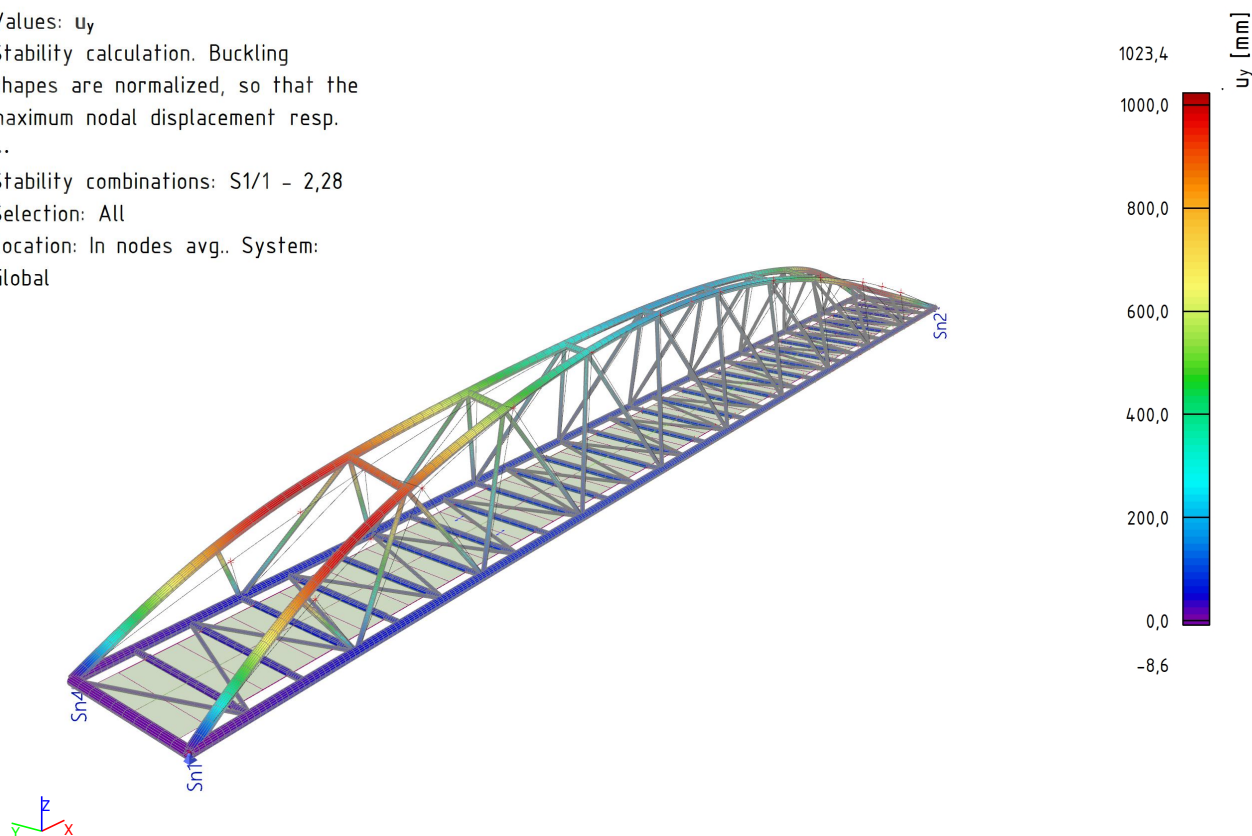
...

Stability combinations: S1/1 - 2,28

Selection: All

Location: In nodes avg.. System:

Global



### 10.3. Nono modo di Buckling

Values:  $u_y$

Stability calculation. Buckling shapes are normalized, so that the maximum nodal displacement resp.

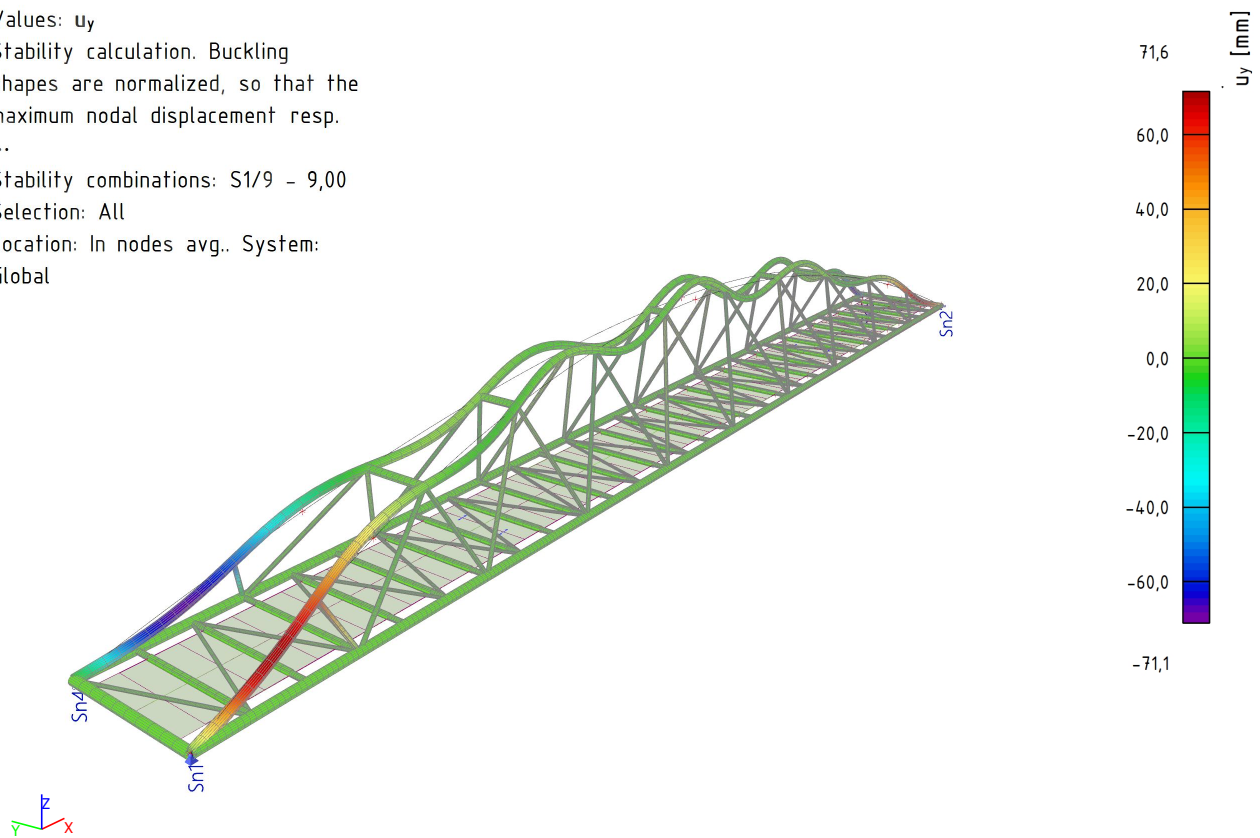
...

Stability combinations: S1/9 - 9,00

Selection: All

Location: In nodes avg.. System:

Global





#### 10.4. Frequenze proprie dell'opera per combinazione di massa MG1

Name	Mass group	Coeff. [-]
CM1	MG1	1,00
CM1/1 - 1,21		
CM1/2 - 1,93		
CM1/3 - 1,99		
CM1/4 - 2,52		
CM1/5 - 3,46		
CM1/6 - 3,77		
CM1/7 - 3,84		
CM1/8 - 4,24		
CM1/9 - 7,11		
CM1/10 - 7,29		
CM1/11 - 8,04		
CM1/12 - 11,11		

#### 10.5. Primo modo di vibrare - Vista in pianta

Values:  $u_y$

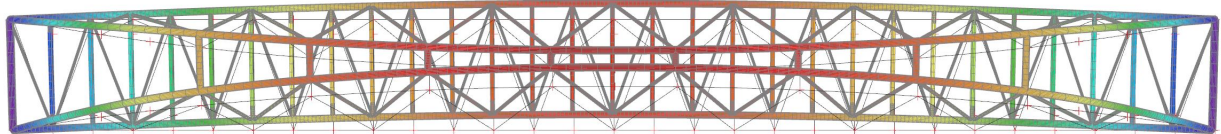
Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.

Mass combination: CM1/1 - 1,21

Selection: All

Location: In nodes avg.. System:

Global



## 10.6. Primo modo di vibrare - Vista frontale

Values:  $u_y$

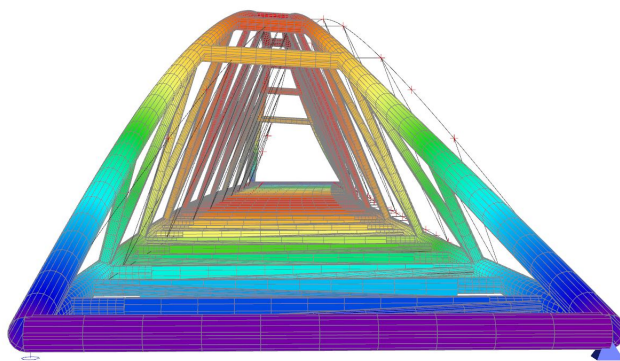
Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.

Mass combination: CM1/1 - 1,21

Selection: All

Location: In nodes avg.. System:

Global



## 10.7. Primo modo di vibrare - Vista 3D

Values:  $u_y$

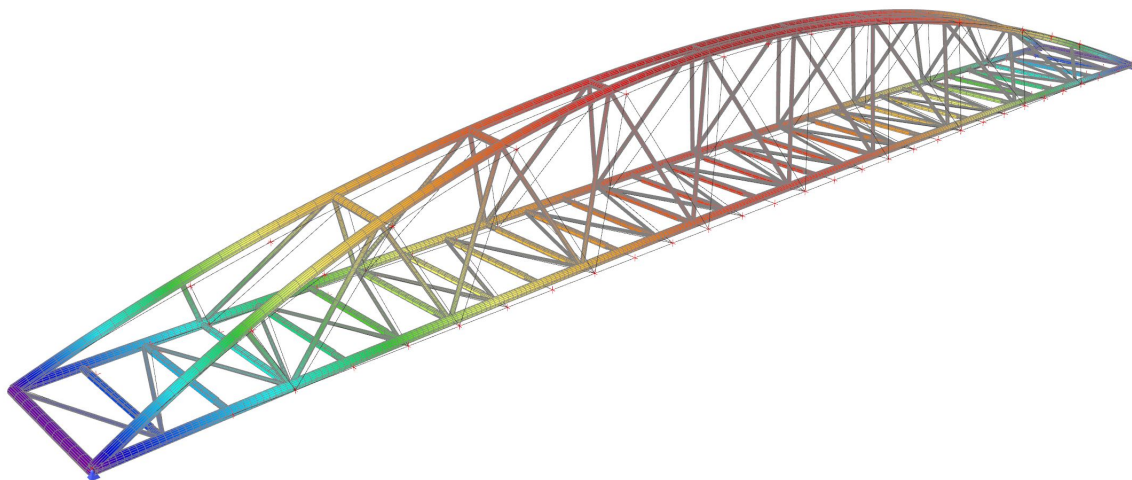
Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.

Mass combination: CM1/1 - 1,21

Selection: All

Location: In nodes avg.. System:

Global



### 10.8. Secondo modo di vibrare - Vista laterale

Values:  $u_y$

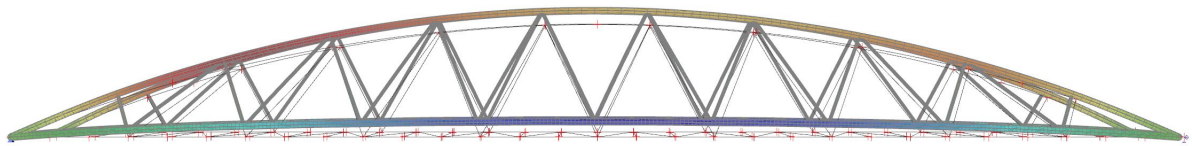
Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.

Mass combination: CM1/2 - 1,93

Selection: All

Location: In nodes avg.. System:

Global



### 10.9. Secondo modo di vibrare - Vista frontale

Values:  $u_y$

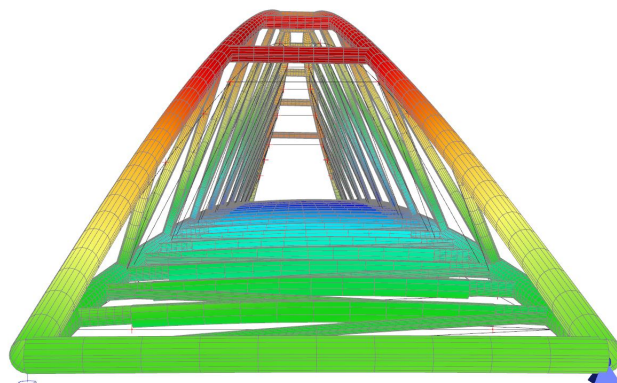
Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.

Mass combination: CM1/2 - 1,93

Selection: All

Location: In nodes avg.. System:

Global



### 10.10. Secondo modo di vibrare - Vista 3D

Values:  $u_y$

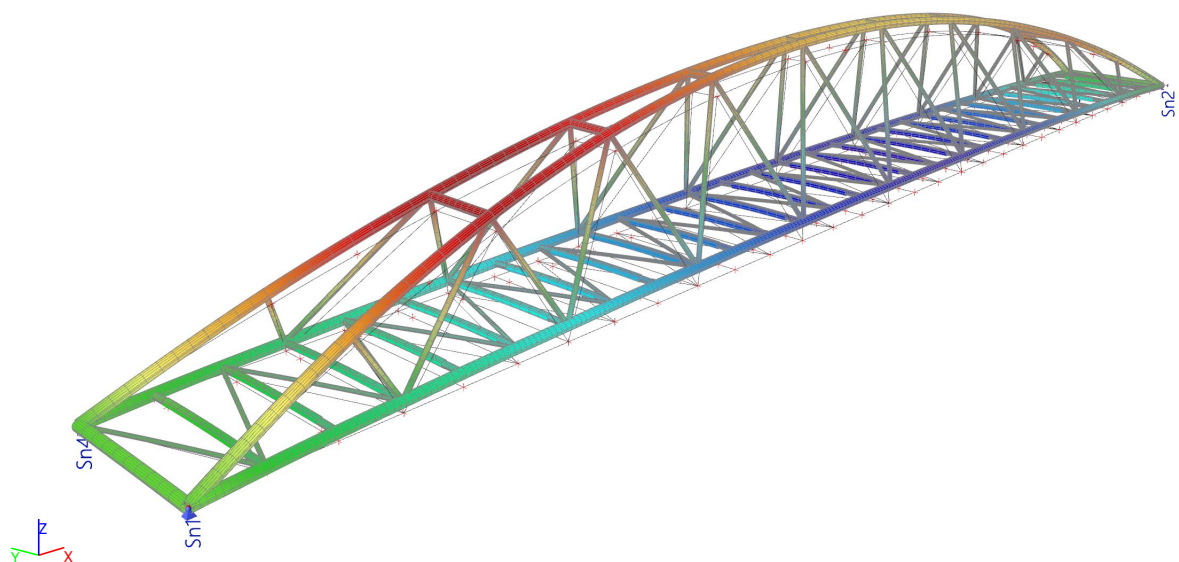
Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.

Mass combination: CM1/2 - 1,93

Selection: All

Location: In nodes avg.. System:

Global



### 10.11. Terzo modo di vibrare - Vista frontale

Values:  $u_y$

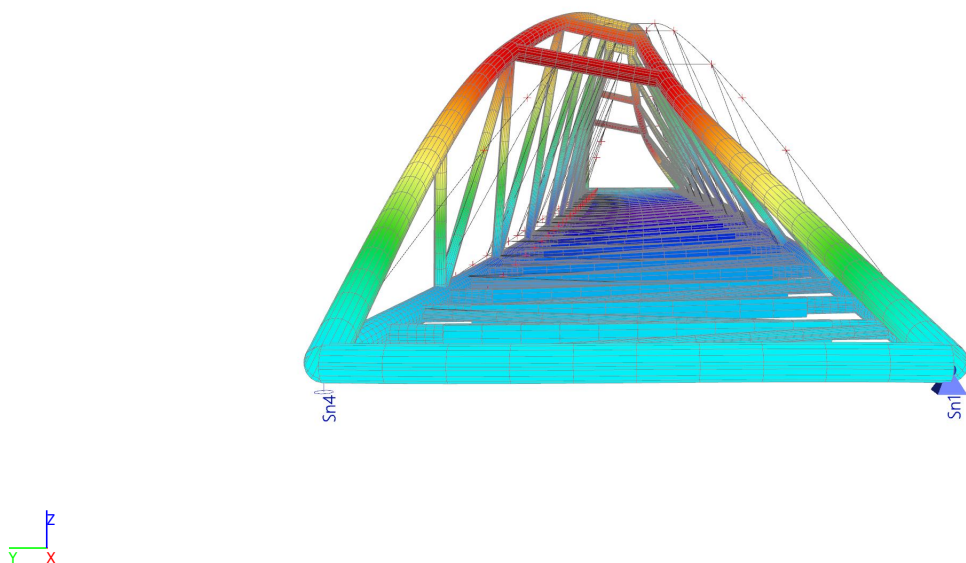
Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.

Mass combination: CM1/3 - 1,99

Selection: All

Location: In nodes avg.. System:

Global



## 10.12. Terzo modo di vibrare - Vista 3D

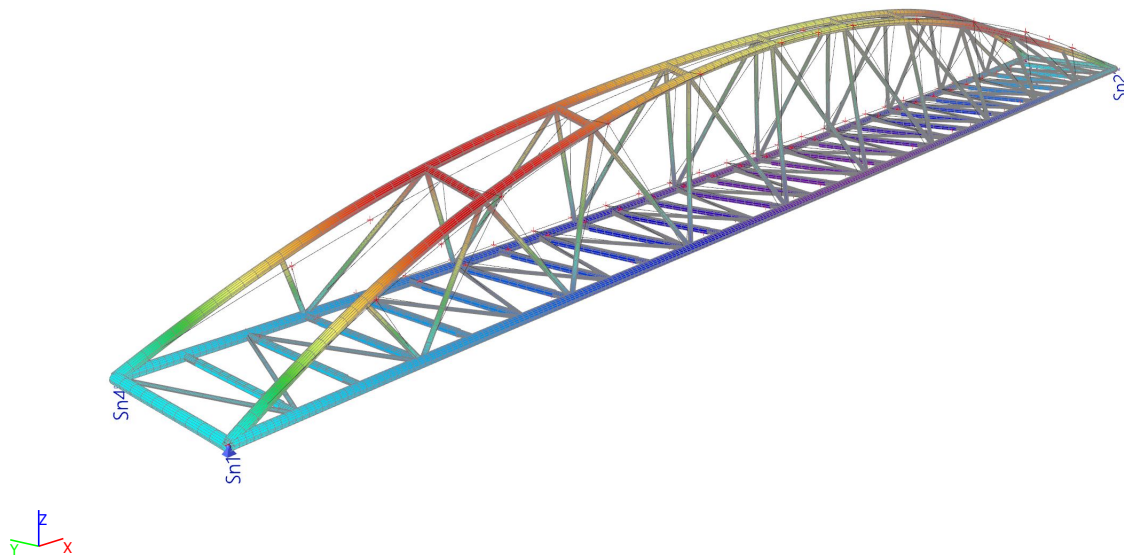
Values:  $u_y$

Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.

Mass combination: CM1/3 - 1,99

Selection: All

Location: In nodes avg.. System: Global



## 11. VERIFICHE DI RESISTENZA ED INSTABILITA'

### 11.1. VERIFICA PROFILO CS1

#### 11.1.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS1 - CHS406.4/25.0

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B202	30,313 / 32,478 m	CHS406.4/25.0	S 355	SLU+SLV	0,76 -
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Combination key
SLU+SLV / $1.35 \cdot G1 + 1.35 \cdot G2 + 1.35 \cdot Q1a + 1.35 \cdot Q1b + 1.35 \cdot Q1c + 1.35 \cdot Q1d + 1.35 \cdot Q2b + 0.90 \cdot \text{Wind D} + 0.90 \cdot \text{Temp A}$

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 30,313 m

Internal forces	Calculated	Unit
$N_{Ed}$	-3354,73	kN
$V_{y,Ed}$	11,75	kN
$V_{z,Ed}$	37,58	kN
$T_{Ed}$	2,07	kNm
$M_{y,Ed}$	-8,14	kNm
$M_{z,Ed}$	-18,58	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
406	25	16,26	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	3,0000e-02	m <sup>2</sup>
$N_{c,Rd}$	10142,86	kN
Unity check	0,33	-

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

I

$W_{pl,y}$	3,5844e-03	m <sup>3</sup>
$M_{pl,y,Rd}$	1211,88	kNm
Unity check	0,01	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	3,5844e-03	m <sup>3</sup>
$M_{pl,z,Rd}$	1211,88	kNm
Unity check	0,02	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	1,9099e-02	m <sup>2</sup>
$V_{pl,y,Rd}$	3728,03	kN
Unity check	0,00	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	1,9099e-02	m <sup>2</sup>
$V_{pl,z,Rd}$	3728,03	kN
Unity check	0,01	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,4	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.31)

$M_{resultant}$	20,29	kNm
$V_{resultant}$	39,37	kN
$M_{N,Rd}$	1027,12	kNm
Unity check	0,02	-

**Note:** The resultant internal forces are used for CHS sections.

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

#### ...:STABILITY CHECK:...

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
406	25	16,26	33,10	46,34	59,58	1

The cross-section is classified as Class 1

### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	6,496	6,496	m
Buckling factor k	1,95	1,95	
Buckling length $l_{cr}$	12,660	12,660	m
Critical Euler load $N_{cr}$	7073,94	7073,94	kN
Slenderness $\lambda$	93,75	93,75	
Relative slenderness $\lambda_{rel}$	1,23	1,23	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	
Buckling curve	a	a	
Imperfection $\alpha$	0,21	0,21	
Reduction factor $\chi$	0,51	0,51	
Buckling resistance $N_{b,Rd}$	5205,31	5205,31	kN

Flexural Buckling verification		
Cross-section area A	3,0000e-02	m <sup>2</sup>
Buckling resistance $N_{b,Rd}$	5205,31	kN
Unity check	0,64	-

### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a CHS section which is not susceptible to Torsional(-Flexural) Buckling.

### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns a CHS section which is not susceptible to Lateral Torsional Buckling.

### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	3,0000e-02	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	3,5844e-03	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	3,5844e-03	m <sup>3</sup>
Design compression force $N_{Ed}$	3354,73	kN
Design bending moment (maximum) $M_{y,Ed}$	151,04	kNm
Design bending moment (maximum) $M_{z,Ed}$	66,85	kNm
Characteristic compression resistance $N_{Rk}$	10650,00	kN
Characteristic moment resistance $M_{y,Rk}$	1272,47	kNm
Characteristic moment resistance $M_{z,Rk}$	1272,47	kNm
Reduction factor $\chi_y$	0,51	
Reduction factor $\chi_z$	0,51	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	0,69	
Interaction factor $k_{yz}$	0,49	
Interaction factor $k_{zy}$	0,44	
Interaction factor $k_{zz}$	0,76	

Maximum moment  $M_{y,Ed}$  is derived from beam B202 position 32,478 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B202 position 25,982 m.



Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	7073,94	kN
Critical Euler load $N_{cr,z}$	7073,94	kN
Elastic critical load $N_{cr,T}$	2423076,92	kN
Plastic section modulus $W_{pl,y}$	3,5844e-03	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	2,6920e-03	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	3,5844e-03	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	2,6920e-03	m <sup>3</sup>
Second moment of area $I_y$	5,4700e-04	m <sup>4</sup>
Second moment of area $I_z$	5,4700e-04	m <sup>4</sup>
Torsional constant $I_t$	1,0940e-03	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	151,04	kNm
Maximum relative deflection $\delta_z$	-0,6	mm
Equivalent moment factor $C_{my,0}$	0,58	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{z,Ed}$	66,85	kNm
Maximum relative deflection $\delta_y$	0,5	mm
Equivalent moment factor $C_{mz,0}$	0,62	
Factor $\mu_y$	0,69	
Factor $\mu_z$	0,69	
Factor $\epsilon_y$	0,50	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	48726,75	kNm
Relative slenderness $\lambda_{rel,0}$	0,16	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,37	
Equivalent moment factor $C_{my}$	0,58	
Equivalent moment factor $C_{mz}$	0,62	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,00	
Factor $w_y$	1,33	
Factor $w_z$	1,33	
Factor $n_{pl}$	0,33	
Maximum relative slenderness $\lambda_{rel,max}$	1,23	
Factor $C_{yy}$	1,10	
Factor $C_{yz}$	1,01	
Factor $C_{zy}$	1,04	
Factor $C_{zz}$	1,08	

Unity check (6.61) =  $0,64 + 0,09 + 0,03 = 0,76$  -

Unity check (6.62) =  $0,64 + 0,06 + 0,04 = 0,74$  -

The member satisfies the stability check.

### 11.1.2. Fattore di utilizzazione

Values:  $UC_{Overall}$

Linear calculation

Class: SLU+SLV

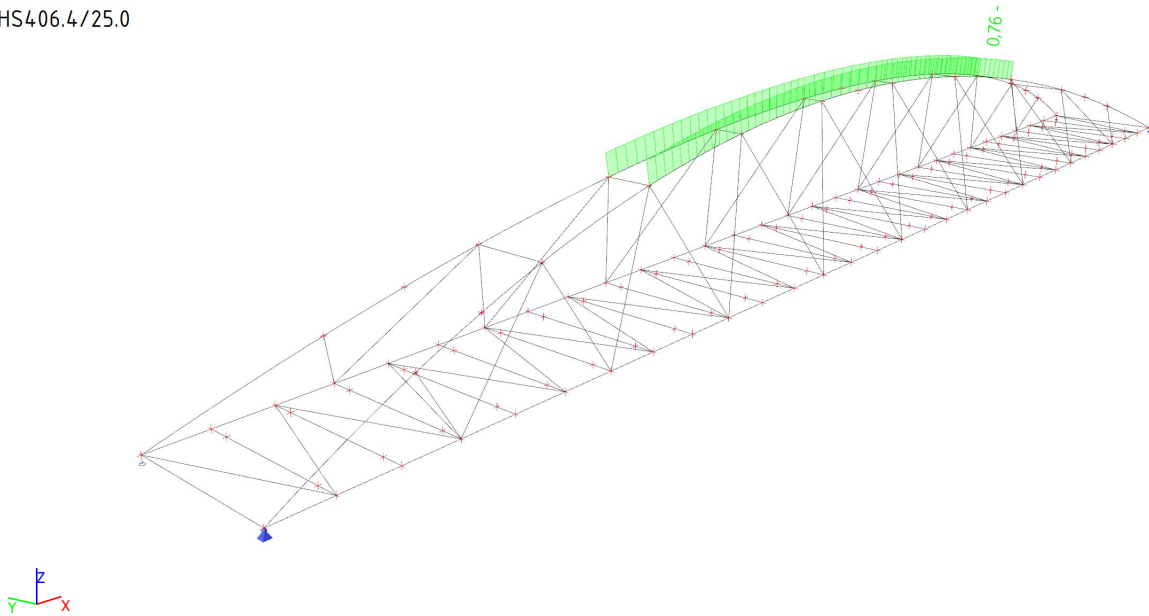
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS1 -

CHS406.4/25.0



## 11.2. VERIFICA PROFILO CS6

### 11.2.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS6 - MSRR406.4x30.0

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B2	0,000 / 19,487 m	MSRR406.4x30.0	S 355	SLU+SLV	0,77 -
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Combination key
SLU+SLV / 1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2d + 0.90*Wind A + 0.90*Temp A

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 0,000 m

Internal forces	Calculated	Unit
$N_{Ed}$	-3394,28	kN
$V_{y,Ed}$	-35,30	kN
$V_{z,Ed}$	-66,67	kN
$T_{Ed}$	2,62	kNm
$M_{y,Ed}$	0,00	kNm
$M_{z,Ed}$	0,00	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
406	30	13,55	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	3,5500e-02	m <sup>2</sup>
$N_{c,Rd}$	12002,38	kN
Unity check	0,28	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
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$A_v$	2,2600e-02	m <sup>2</sup>
$V_{pl,y,Rd}$	44,11,51	kN
Unity check	0,01	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	2,2600e-02	m <sup>2</sup>
$V_{pl,z,Rd}$	44,11,51	kN
Unity check	0,02	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,4	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

The member satisfies the section check.

#### ....STABILITY CHECK....

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
406	30	13,55	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	6,496	6,496	m
Buckling factor k	1,05	2,09	
Buckling length $l_{cr}$	6,835	13,585	m
Critical Euler load $N_{cr}$	28046,36	7099,79	kN
Slenderness $\lambda$	51,22	101,80	
Relative slenderness $\lambda_{rel}$	0,67	1,33	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	
Buckling curve	a	a	
Imperfection $\alpha$	0,21	0,21	
Reduction factor $\chi$	0,86	0,45	
Buckling resistance $N_{b,Rd}$	10336,87	5432,31	kN

Flexural Buckling verification		
Cross-section area A	3,5500e-02	m <sup>2</sup>
Buckling resistance $N_{b,Rd}$	5432,31	kN
Unity check	0,62	-

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a CHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	3,5500e-02	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	4,2600e-03	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	4,2600e-03	m <sup>3</sup>
Design compression force $N_{Ed}$	3394,28	kN
Design bending moment (maximum) $M_{y,Ed}$	262,49	kNm
Design bending moment (maximum) $M_{z,Ed}$	93,91	kNm
Characteristic compression resistance $N_{Rk}$	12602,50	kN
Characteristic moment resistance $M_{y,Rk}$	1512,30	kNm
Characteristic moment resistance $M_{z,Rk}$	1512,30	kNm
Reduction factor $\chi_y$	0,86	
Reduction factor $\chi_z$	0,45	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,10	
Interaction factor $k_{yz}$	0,77	
Interaction factor $k_{zy}$	0,52	
Interaction factor $k_{zz}$	0,82	

Maximum moment  $M_{y,Ed}$  is derived from beam B2 position 6,496 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B2 position 6,496 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	28046,36	kN
Critical Euler load $N_{cr,z}$	7099,79	kN
Elastic critical load $N_{cr,T}$	2866400,60	kN
Plastic section modulus $W_{pl,y}$	4,2600e-03	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	3,1100e-03	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	4,2600e-03	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	3,1100e-03	m <sup>3</sup>
Second moment of area $I_y$	6,3220e-04	m <sup>4</sup>
Second moment of area $I_z$	6,3220e-04	m <sup>4</sup>
Torsional constant $I_t$	1,2640e-03	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	262,49	kNm
Maximum relative deflection $\delta_z$	1,0	mm
Equivalent moment factor $C_{my,0}$	0,89	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{z,Ed}$	93,91	kNm
Maximum relative deflection $\delta_y$	0,9	mm
Equivalent moment factor $C_{mz,0}$	0,67	
Factor $\mu_y$	0,98	
Factor $\mu_z$	0,67	
Factor $\epsilon_y$	0,88	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	56307,45	kNm
Relative slenderness $\lambda_{rel,0}$	0,16	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,34	
Equivalent moment factor $C_{my}$	0,89	

Interaction method 1 parameters		
Equivalent moment factor $C_{mz}$	0,67	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,00	
Factor $w_y$	1,37	
Factor $w_z$	1,37	
Factor $n_{pl}$	0,28	
Maximum relative slenderness $\lambda_{rel,max}$	1,33	
Factor $C_{yy}$	0,91	
Factor $C_{yz}$	0,97	
Factor $C_{zy}$	0,78	
Factor $C_{zz}$	1,04	

Unity check (6.61) =  $0,33 + 0,20 + 0,05 = 0,58$  -

Unity check (6.62) =  $0,62 + 0,10 + 0,05 = 0,77$  -

The member satisfies the stability check.

### 11.2.2. Fattore di utilizzazione

Values:  $UC_{Overall}$

Linear calculation

Class: SLU+SLV

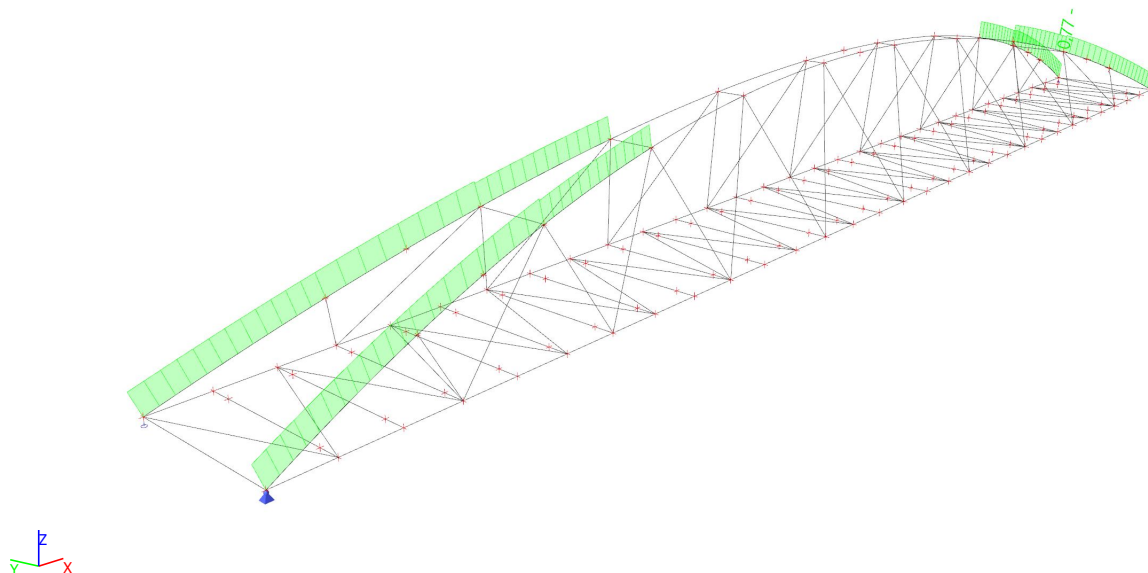
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS6 -

MSRR406.4x30.0



### 11.3. VERIFICA PROFILO CS2

#### 11.3.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS2 - CHS406.4/12.5

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member	B205	25,447 / 60,147 m	CHS406.4/12.5	S 355	SLU+SLV	0,70 -
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Combination key
SLU+SLV / 1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp B

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 25,447 m

Internal forces	Calculated	Unit
$N_{Ed}$	3661,34	kN
$V_{y,Ed}$	13,78	kN
$V_{z,Ed}$	4,21	kN
$T_{Ed}$	-0,09	kNm
$M_{y,Ed}$	72,22	kNm
$M_{z,Ed}$	-9,07	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
406	13	32,51	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Tension check

According to EN 1993-1-1 article 6.2.3 and formula (6.5)

A	1,5500e-02	m <sup>2</sup>
$N_{pl,Rd}$	5240,48	kN
$N_{u,Rd}$	5468,40	kN
$N_{t,Rd}$	5240,48	kN
Unity check	0,70	-

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

I

$W_{pl,y}$	1,9095e-03	m <sup>3</sup>
$M_{pl,y,Rd}$	645,60	kNm
Unity check	0,11	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	1,9095e-03	m <sup>3</sup>
$M_{pl,z,Rd}$	645,60	kNm
Unity check	0,01	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	9,8676e-03	m <sup>2</sup>
$V_{pl,y,Rd}$	1926,15	kN
Unity check	0,01	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	9,8676e-03	m <sup>2</sup>
$V_{pl,z,Rd}$	1926,15	kN
Unity check	0,00	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,0	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.31)

$M_{resultant}$	72,79	kNm
$V_{resultant}$	14,41	kN
$M_{N,Rd}$	294,67	kNm
Unity check	0,25	-

**Note:** The resultant internal forces are used for CHS sections.

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

#### ...:STABILITY CHECK:...

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
406	13	32,51	33,10	46,34	59,58	1

The cross-section is classified as Class 1



### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns a CHS section which is not susceptible to Lateral Torsional Buckling.

The member satisfies the stability check.

### 11.3.2. Fattore di utilizzazione

Values:  $U_{C_{Overall}}$

Linear calculation

Class: SLU+SLV

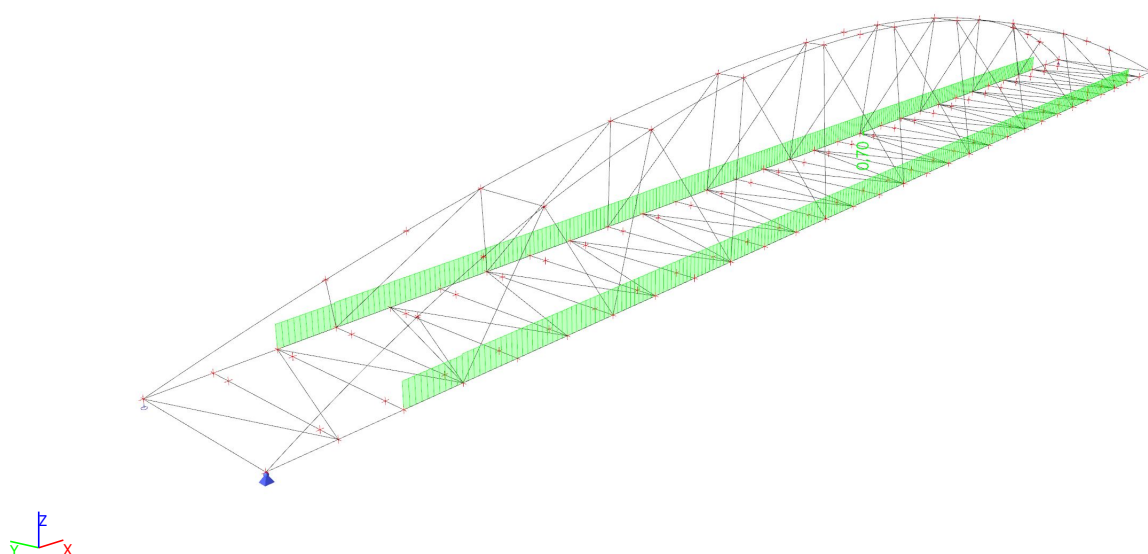
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS2 -

CHS406.4/12.5



## 11.4. VERIFICA PROFILO CS3

### 11.4.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS3 - CHS244.5/8.0

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B117	0,000 / 0,850 m	CHS244.5/8.0	S 355	SLU+SLV	0,50 -
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Combination key
SLU+SLV / 1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind C + 0.90*Temp A

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 0,000 m

Internal forces	Calculated	Unit
$N_{Ed}$	-120,61	kN
$V_{y,Ed}$	3,67	kN
$V_{z,Ed}$	-64,52	kN
$T_{Ed}$	-0,10	kNm
$M_{y,Ed}$	55,62	kNm
$M_{z,Ed}$	-3,15	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
245	8	30,56	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	5,9400e-03	m <sup>2</sup>
$N_{c,Rd}$	2008,29	kN
Unity check	0,06	-

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	4,4057e-04	m <sup>3</sup>
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$M_{pl,y,Rd}$	148,95	kNm
Unity check	0,37	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	4,4057e-04	m <sup>3</sup>
$M_{pl,z,Rd}$	148,95	kNm
Unity check	0,02	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	3,7815e-03	m <sup>2</sup>
$V_{pl,y,Rd}$	738,15	kN
Unity check	0,00	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	3,7815e-03	m <sup>2</sup>
$V_{pl,z,Rd}$	738,15	kN
Unity check	0,09	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,1	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.31)

$M_{resultant}$	55,71	kNm
$V_{resultant}$	64,62	kN
$M_{N,Rd}$	147,71	kNm
Unity check	0,38	-

**Note:** The resultant internal forces are used for CHS sections.

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

#### ...:STABILITY CHECK:...

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
245	8	30,56	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	6,400	6,400	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	6,400	6,400	m
Critical Euler load $N_{cr}$	2105,00	2105,00	kN
Slenderness $\lambda$	76,48	76,48	
Relative slenderness $\lambda_{rel}$	1,00	1,00	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	
Buckling curve	a	a	
Imperfection $\alpha$	0,21	0,21	
Reduction factor $\chi$	0,66	0,66	
Buckling resistance $N_{b,Rd}$	1335,49	1335,49	kN

Flexural Buckling verification		
Cross-section area A	5,9400e-03	m <sup>2</sup>
Buckling resistance $N_{b,Rd}$	1335,49	kN
Unity check	0,09	-

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a CHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns a CHS section which is not susceptible to Lateral Torsional Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	5,9400e-03	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	4,4057e-04	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	4,4057e-04	m <sup>3</sup>
Design compression force $N_{Ed}$	120,61	kN
Design bending moment $M_{y,Ed}$	55,62	kNm
Design bending moment $M_{z,Ed}$	-3,15	kNm
Characteristic compression resistance $N_{Rk}$	2108,70	kN
Characteristic moment resistance $M_{y,Rk}$	156,40	kNm
Characteristic moment resistance $M_{z,Rk}$	156,40	kNm
Reduction factor $\chi_y$	0,66	
Reduction factor $\chi_z$	0,66	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,05	
Interaction factor $k_{yz}$	0,65	
Interaction factor $k_{zy}$	0,65	
Interaction factor $k_{zz}$	1,05	

**Note:** Since this member is non-prismatic the actual moments in the section are being used instead of the maximal moments.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	2105,00	kN
Critical Euler load $N_{cr,z}$	2105,00	kN
Elastic critical load $N_{cr,T}$	479826,90	kN

Interaction method 1 parameters		
Plastic section modulus $W_{pl,y}$	4,4057e-04	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	3,4000e-04	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	4,4057e-04	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	3,4000e-04	m <sup>3</sup>
Second moment of area $I_y$	4,1600e-05	m <sup>4</sup>
Second moment of area $I_z$	4,1600e-05	m <sup>4</sup>
Torsional constant $I_t$	8,3210e-05	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 4 (Line load)	
Equivalent moment factor $C_{my,0}$	1,00	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 4 (Line load)	
Equivalent moment factor $C_{mz,0}$	1,00	
Factor $\mu_y$	0,98	
Factor $\mu_z$	0,98	
Factor $\epsilon_y$	8,06	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	3761,29	kNm
Relative slenderness $\lambda_{rel,0}$	0,20	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,21	
Equivalent moment factor $C_{my}$	1,00	
Equivalent moment factor $C_{mz}$	1,00	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,00	
Factor $w_y$	1,30	
Factor $w_z$	1,30	
Factor $n_{pl}$	0,06	
Maximum relative slenderness $\lambda_{rel,max}$	1,00	
Factor $C_{yy}$	0,99	
Factor $C_{yz}$	0,97	
Factor $C_{zy}$	0,97	
Factor $C_{zz}$	0,99	

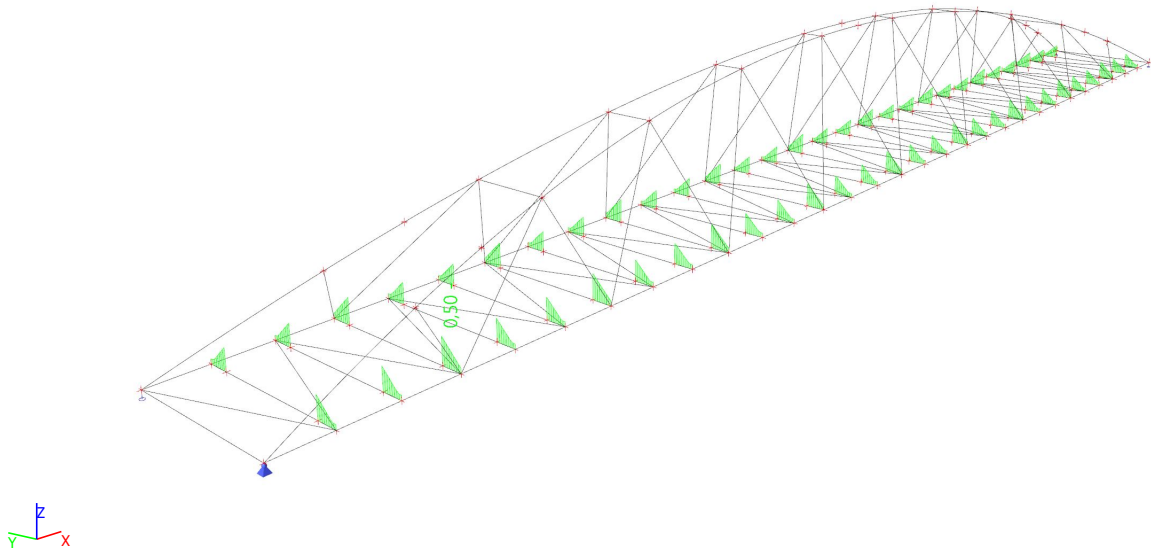
Unity check (6.61) = 0,09 + 0,39 + 0,01 = 0,50 -

Unity check (6.62) = 0,09 + 0,24 + 0,02 = 0,35 -

The member satisfies the stability check.

### 11.4.2. Fattore di utilizzazione

Values:  $UC_{Overall}$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS3 -  
CHS244.5/8.0



## 11.5. VERIFICA PROFILO CS4

### 11.5.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS4 - CHS244.5/8.0 + UNP180

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B116	2,350 / 4,700 m	CHS244.5/8.0 + UNP180	S 355	SLU+SLV	0,65 -
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Combination key
SLU+SLV / 1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind C + 0.90*Temp A

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	General	

....SECTION CHECK:....

The critical check is on position 2,350 m

Internal forces	Calculated	Unit
$N_{Ed}$	-120,61	kN
$V_{y,Ed}$	0,00	kN
$V_{z,Ed}$	0,00	kN
$T_{Ed}$	-0,10	kNm
$M_{y,Ed}$	131,43	kNm
$M_{z,Ed}$	-7,46	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	21	8	1,357e+05	1,300e+05	0,96		1,00	2,58	22,78	27,66	31,38	1
2	I	21	8	1,300e+05	1,185e+05	0,91		1,00	2,58	22,78	27,66	31,90	1
3	I	21	8	1,185e+05	1,015e+05	0,86		1,00	2,58	22,78	27,66	32,54	1
4	I	21	8	1,015e+05	7,956e+04	0,78		1,00	2,58	22,78	27,66	33,42	1
5	I	7	8	7,956e+04	7,057e+04	0,89		1,00	0,88	22,78	27,66	32,18	1
6	I	21	8	5,338e+04	2,372e+04	0,44		1,00	2,58	22,78	27,66	38,30	1
7	I	21	8	2,372e+04	-8,499e+03	-0,36		0,74	2,58	33,62	40,17	58,48	1
8	I	21	8	-8,499e+03	-4,231e+04								
9	I	21	8	-4,231e+04	-7,669e+04								
10	I	21	8	-7,669e+04	-1,106e+05								

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
11	I	21	8	-1,106e+05	-1,430e+05								
12	I	21	8	-1,430e+05	-1,728e+05								
13	I	21	8	-1,728e+05	-1,993e+05								
14	I	21	8	-1,993e+05	-2,216e+05								
15	I	21	8	-2,216e+05	-2,390e+05								
16	I	21	8	-2,390e+05	-2,510e+05								
17	I	21	8	-2,510e+05	-2,572e+05								
18	I	21	8	-2,572e+05	-2,574e+05								
19	I	21	8	-2,574e+05	-2,517e+05								
20	I	21	8	-2,517e+05	-2,401e+05								
21	I	21	8	-2,401e+05	-2,231e+05								
22	I	21	8	-2,231e+05	-2,012e+05								
23	I	21	8	-2,012e+05	-1,750e+05								
24	I	21	8	-1,750e+05	-1,454e+05								
25	I	21	8	-1,454e+05	-1,132e+05								
26	I	21	8	-1,132e+05	-7,935e+04								
27	I	21	8	-7,935e+04	-4,497e+04								
28	I	21	8	-4,497e+04	-1,108e+04								
29	I	21	8	-1,108e+04	2,130e+04	-0,52		0,66	2,58	39,15	46,40	65,42	1
30	I	21	8	2,130e+04	5,119e+04	0,42		1,00	2,58	22,78	27,66	38,77	1
31	I	21	8	5,119e+04	7,767e+04	0,66		1,00	2,58	22,78	27,66	35,07	1
32	I	14	8	7,767e+04	9,230e+04	0,84		1,00	1,69	22,78	27,66	32,72	1
33	I	21	8	9,995e+04	1,173e+05	0,85		1,00	2,58	22,78	27,66	32,59	1
34	I	21	8	1,173e+05	1,293e+05	0,91		1,00	2,58	22,78	27,66	31,94	1
35	I	21	8	1,293e+05	1,355e+05	0,95		1,00	2,58	22,78	27,66	31,42	1
36	I	21	8	1,355e+05	1,357e+05	1,00		1,00	2,58	22,78	27,66	30,94	1
37	I	66	11	9,856e+04	2,083e+05	0,47		1,00	6,00	22,78	27,66	37,83	1
38	I	169	8	2,083e+05	1,856e+05	0,89		1,00	21,12	22,78	27,66	32,13	1
39	I	66	11	1,856e+05	7,589e+04	0,41		1,00	6,00	22,78	27,66	38,90	1
40	I	7	8	9,230e+04	9,995e+04	0,92		1,00	0,88	22,78	27,66	31,76	1
41	I	5	11	9,856e+04	9,230e+04	0,94		1,00	0,45	22,78	27,66	31,61	1
42	I	14	8	7,057e+04	5,338e+04	0,76		1,00	1,69	22,78	27,66	33,77	1
43	I	5	11	7,589e+04	7,057e+04	0,93		1,00	0,45	22,78	27,66	31,69	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	8,7400e-03	m <sup>2</sup>
N <sub>c,Rd</sub>	2954,97	kN
Unity check	0,04	-

#### Bending moment check for M<sub>y</sub>

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

W <sub>pl,y</sub>	7,2172e-04	m <sup>3</sup>
M <sub>pl,y,Rd</sub>	244,01	kNm
Unity check	0,54	-

#### Bending moment check for M<sub>z</sub>

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

!



$W_{pl,z}$	6,2666e-04	m <sup>3</sup>
$M_{pl,z,Rd}$	211,87	kNm
Unity check	0,04	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	4	
$\tau_{Ed}$	0,1	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.1 and formula (6.2)

$N_{pl,Rd}$	2954,97	kN
$M_{pl,y,Rd}$	244,01	kNm
$M_{pl,z,Rd}$	211,87	kNm

Unity check (6.2) = 0,04 + 0,54 + 0,04 = 0,61 -

**Note:** No specific interaction formulae according to EN 1993-1-1 article 6.2.9.1 apply.  
Therefore the plastic linear summation according to EN 1993-1-1 article 6.2.1(7) is verified.

The member satisfies the section check.

#### ...:STABILITY CHECK:...

#### Classification for member buckling design

Decisive position for stability classification: 2,350 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	21	8	1,357e+05	1,300e+05	0,96		1,00	2,58	22,78	27,66	31,38	1
2	I	21	8	1,300e+05	1,185e+05	0,91		1,00	2,58	22,78	27,66	31,90	1
3	I	21	8	1,185e+05	1,015e+05	0,86		1,00	2,58	22,78	27,66	32,54	1
4	I	21	8	1,015e+05	7,956e+04	0,78		1,00	2,58	22,78	27,66	33,42	1
5	I	7	8	7,956e+04	7,057e+04	0,89		1,00	0,88	22,78	27,66	32,18	1
6	I	21	8	5,338e+04	2,372e+04	0,44		1,00	2,58	22,78	27,66	38,30	1
7	I	21	8	2,372e+04	-8,499e+03	-0,36		0,74	2,58	33,62	40,17	58,48	1
8	I	21	8	-8,499e+03	-4,231e+04								
9	I	21	8	-4,231e+04	-7,669e+04								
10	I	21	8	-7,669e+04	-1,106e+05								
11	I	21	8	-1,106e+05	-1,430e+05								
12	I	21	8	-1,430e+05	-1,728e+05								
13	I	21	8	-1,728e+05	-1,993e+05								
14	I	21	8	-1,993e+05	-2,216e+05								
15	I	21	8	-2,216e+05	-2,390e+05								
16	I	21	8	-2,390e+05	-2,510e+05								
17	I	21	8	-2,510e+05	-2,572e+05								
18	I	21	8	-2,572e+05	-2,574e+05								
19	I	21	8	-2,574e+05	-2,517e+05								
20	I	21	8	-2,517e+05	-2,401e+05								
21	I	21	8	-2,401e+05	-2,231e+05								

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
22	I	21	8	-2,231e+05	-2,012e+05								
23	I	21	8	-2,012e+05	-1,750e+05								
24	I	21	8	-1,750e+05	-1,454e+05								
25	I	21	8	-1,454e+05	-1,132e+05								
26	I	21	8	-1,132e+05	-7,935e+04								
27	I	21	8	-7,935e+04	-4,497e+04								
28	I	21	8	-4,497e+04	-1,108e+04								
29	I	21	8	-1,108e+04	2,130e+04	-0,52		0,66	2,58	39,15	46,40	65,42	1
30	I	21	8	2,130e+04	5,119e+04	0,42		1,00	2,58	22,78	27,66	38,77	1
31	I	21	8	5,119e+04	7,767e+04	0,66		1,00	2,58	22,78	27,66	35,07	1
32	I	14	8	7,767e+04	9,230e+04	0,84		1,00	1,69	22,78	27,66	32,72	1
33	I	21	8	9,995e+04	1,173e+05	0,85		1,00	2,58	22,78	27,66	32,59	1
34	I	21	8	1,173e+05	1,293e+05	0,91		1,00	2,58	22,78	27,66	31,94	1
35	I	21	8	1,293e+05	1,355e+05	0,95		1,00	2,58	22,78	27,66	31,42	1
36	I	21	8	1,355e+05	1,357e+05	1,00		1,00	2,58	22,78	27,66	30,94	1
37	I	66	11	9,856e+04	2,083e+05	0,47		1,00	6,00	22,78	27,66	37,83	1
38	I	169	8	2,083e+05	1,856e+05	0,89		1,00	21,12	22,78	27,66	32,13	1
39	I	66	11	1,856e+05	7,589e+04	0,41		1,00	6,00	22,78	27,66	38,90	1
40	I	7	8	9,230e+04	9,995e+04	0,92		1,00	0,88	22,78	27,66	31,76	1
41	I	5	11	9,856e+04	9,230e+04	0,94		1,00	0,45	22,78	27,66	31,61	1
42	I	14	8	7,057e+04	5,338e+04	0,76		1,00	1,69	22,78	27,66	33,77	1
43	I	5	11	7,589e+04	7,057e+04	0,93		1,00	0,45	22,78	27,66	31,69	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	6,400	6,400	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	6,400	6,400	m
Critical Euler load $N_{cr}$	4042,43	2789,66	kN
Slenderness $\lambda$	66,94	80,58	
Relative slenderness $\lambda_{rel}$	0,88	1,05	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	
Buckling curve	d	d	
Imperfection $\alpha$	0,76	0,76	
Reduction factor $\chi$	0,53	0,44	
Buckling resistance $N_{b,Rd}$	1579,20	1300,46	kN

Flexural Buckling verification		
Cross-section area A	8,7400e-03	m <sup>2</sup>
Buckling resistance $N_{b,Rd}$	1300,46	kN
Unity check	0,09	-

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Torsional buckling length $l_{cr}$	6,400	m
Elastic critical load $N_{cr,T}$	574444,89	kN

Elastic critical load $N_{cr,TF}$	2789,65	kN
Relative slenderness $\lambda_{rel,T}$	1,05	
Limit slenderness $\lambda_{rel,0}$	0,20	
Buckling curve	d	
Imperfection $\alpha$	0,76	
Reduction factor $\chi$	0,44	
Cross-section area A	8,7400e-03	m <sup>2</sup>
Buckling resistance $N_{b,Rd}$	1300,46	kN
Unity check	0,09	-

#### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.2 and formula (6.54)

LTB parameters		
Method for LTB curve	General case	
Plastic section modulus $W_{pl,y}$	7,2172e-04	m <sup>3</sup>
Elastic critical moment $M_{cr}$	5656,00	kNm
Relative slenderness $\lambda_{rel,LT}$	0,21	
Limit slenderness $\lambda_{rel,LT,0}$	0,20	

**Note:** The slenderness or bending moment is such that Lateral Torsional Buckling effects may be ignored according to EN 1993-1-1 article 6.3.2.2(4).

Mcr parameters		
LTB length $l_{LT}$	6,400	m
Influence of load position	no influence	
Correction factor k	1,00	
Correction factor $k_w$	1,00	
LTB moment factor $C_1$	1,13	
LTB moment factor $C_2$	0,45	
LTB moment factor $C_3$	0,53	
Shear center distance $d_z$	3	mm
Distance of load application $z_g$	0	mm
Mono-symmetry constant $\beta_y$	-57	mm
Mono-symmetry constant $z_j$	28	mm

**Note:** C parameters are determined according to ECCS 119 2006 / Galea 2002.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	8,7400e-03	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	7,2172e-04	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	6,2666e-04	m <sup>3</sup>
Design compression force $N_{Ed}$	120,61	kN
Design bending moment $M_{y,Ed}$	131,43	kNm
Design bending moment $M_{z,Ed}$	-7,46	kNm
Characteristic compression resistance $N_{Rk}$	3102,72	kN
Characteristic moment resistance $M_{y,Rk}$	256,21	kNm
Characteristic moment resistance $M_{z,Rk}$	222,47	kNm
Reduction factor $\chi_y$	0,53	
Reduction factor $\chi_z$	0,44	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,02	

Bending and axial compression check parameters		
Interaction factor $k_{yz}$	0,61	
Interaction factor $k_{zy}$	0,63	
Interaction factor $k_{zz}$	1,03	

**Note:** Since this member is non-prismatic the actual moments in the section are being used instead of the maximal moments.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	4042,43	kN
Critical Euler load $N_{cr,z}$	2789,66	kN
Elastic critical load $N_{cr,T}$	574444,89	kN
Plastic section modulus $W_{pl,y}$	7,2172e-04	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	4,7840e-04	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	6,2666e-04	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	4,5097e-04	m <sup>3</sup>
Second moment of area $I_y$	7,9888e-05	m <sup>4</sup>
Second moment of area $I_z$	5,5130e-05	m <sup>4</sup>
Torsional constant $I_t$	1,0992e-04	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 4 (Line load)	
Equivalent moment factor $C_{my,0}$	1,00	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 4 (Line load)	
Equivalent moment factor $C_{mz,0}$	1,00	
Factor $\mu_y$	0,99	
Factor $\mu_z$	0,98	
Factor $\epsilon_y$	19,91	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	5018,63	kNm
Relative slenderness $\lambda_{rel,0}$	0,23	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,21	
Equivalent moment factor $C_{my}$	1,00	
Equivalent moment factor $C_{mz}$	1,00	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,00	
Factor $w_y$	1,50	
Factor $w_z$	1,39	
Factor $n_{pl}$	0,04	
Maximum relative slenderness $\lambda_{rel,max}$	1,05	
Factor $C_{yy}$	0,99	
Factor $C_{yz}$	0,98	
Factor $C_{zy}$	1,00	
Factor $C_{zz}$	0,99	

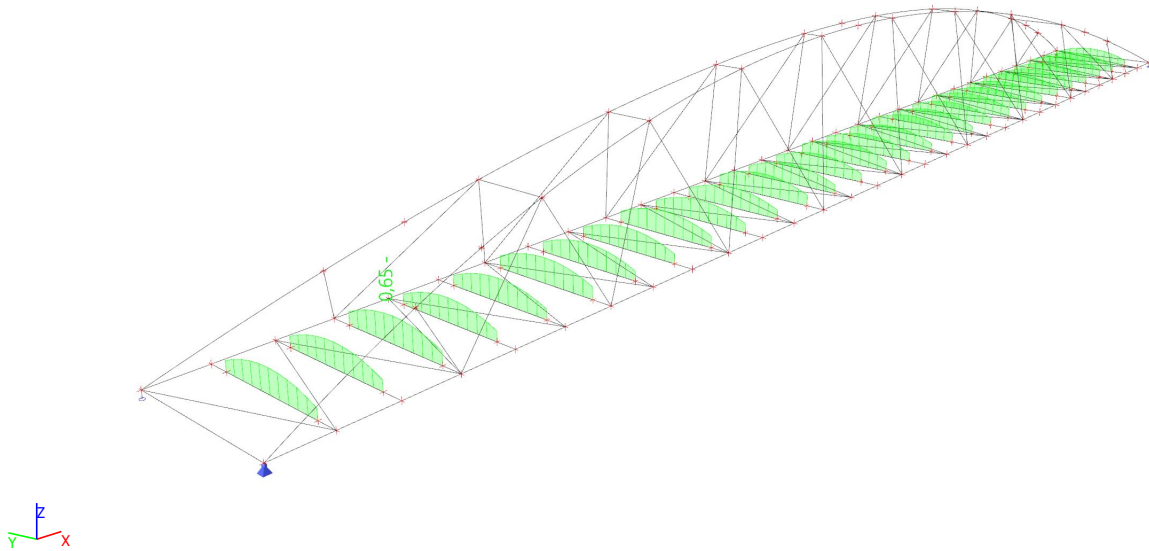
Unity check (6.61) = 0,08 + 0,55 + 0,02 = 0,65 -

Unity check (6.62) = 0,09 + 0,34 + 0,04 = 0,47 -

The member satisfies the stability check.

### 11.5.2. Fattore di utilizzazione

Values:  $UC_{Overall}$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS4 -  
CHS244.5/8.0 + UNP180



## 11.6. VERIFICA PROFILO CS5

### 11.6.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS5 - CHS355.6/16.0

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B110	3,135 / 3,135 m	CHS355.6/16.0	S 355	SLU+SLV	0,11 -
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Combination key
SLU+SLV / G1 + G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind A + 0.90*Temp A

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 3,135 m

Internal forces	Calculated	Unit
$N_{Ed}$	-12,77	kN
$V_{y,Ed}$	-40,11	kN
$V_{z,Ed}$	4,61	kN
$T_{Ed}$	1,99	kNm
$M_{y,Ed}$	11,91	kNm
$M_{z,Ed}$	-64,11	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
356	16	22,23	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	1,7100e-02	m <sup>2</sup>
$N_{c,Rd}$	5781,43	kN
Unity check	0,00	-

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	1,8175e-03	m <sup>3</sup>
------------	------------	----------------

$M_{pl,y,Rd}$	614,49	kNm
Unity check	0,02	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	1,8175e-03	m <sup>3</sup>
$M_{pl,z,Rd}$	614,49	kNm
Unity check	0,10	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	1,0886e-02	m <sup>2</sup>
$V_{pl,y,Rd}$	2124,98	kN
Unity check	0,02	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	1,0886e-02	m <sup>2</sup>
$V_{pl,z,Rd}$	2124,98	kN
Unity check	0,00	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,7	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.31)

$M_{resultant}$	65,20	kNm
$V_{resultant}$	40,37	kN
$M_{N,Rd}$	614,47	kNm
Unity check	0,11	-

**Note:** The resultant internal forces are used for CHS sections.

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

#### ....STABILITY CHECK....

##### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
356	16	22,23	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	3,135	3,135	m
Buckling factor k	10,00	10,00	
Buckling length $l_{cr}$	31,348	31,348	m
Critical Euler load $N_{cr}$	520,12	520,12	kN
Slenderness $\lambda$	261,04	261,04	
Relative slenderness $\lambda_{rel}$	3,42	3,42	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a CHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns a CHS section which is not susceptible to Lateral Torsional Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	1,7100e-02	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	1,8175e-03	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	1,8175e-03	m <sup>3</sup>
Design compression force $N_{Ed}$	12,77	kN
Design bending moment (maximum) $M_{y,Ed}$	11,91	kNm
Design bending moment (maximum) $M_{z,Ed}$	-64,11	kNm
Characteristic compression resistance $N_{Rk}$	6070,50	kN
Characteristic moment resistance $M_{y,Rk}$	645,21	kNm
Characteristic moment resistance $M_{z,Rk}$	645,21	kNm
Reduction factor $\chi_y$	1,00	
Reduction factor $\chi_z$	1,00	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,02	
Interaction factor $k_{yz}$	0,35	
Interaction factor $k_{zy}$	0,62	
Interaction factor $k_{zz}$	0,59	

Maximum moment  $M_{y,Ed}$  is derived from beam B110 position 3,135 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B110 position 3,135 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	520,12	kN
Critical Euler load $N_{cr,z}$	520,12	kN
Elastic critical load $N_{cr,T}$	1381433,89	kN
Plastic section modulus $W_{pl,y}$	1,8175e-03	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	1,3870e-03	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	1,8175e-03	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	1,3870e-03	m <sup>3</sup>
Second moment of area $I_y$	2,4660e-04	m <sup>4</sup>
Second moment of area $I_z$	2,4660e-04	m <sup>4</sup>
Torsional constant $I_t$	4,9330e-04	m <sup>4</sup>



Interaction method 1 parameters		
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	11,91	kNm
Maximum relative deflection $\delta_z$	-0,1	mm
Equivalent moment factor $C_{my,0}$	0,98	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments $\psi_z$	-0,99	
Equivalent moment factor $C_{mz,0}$	0,57	
Factor $\mu_y$	1,00	
Factor $\mu_z$	1,00	
Factor $\epsilon_y$	11,50	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	45523,01	kNm
Relative slenderness $\lambda_{rel,0}$	0,12	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,29	
Equivalent moment factor $C_{my}$	0,98	
Equivalent moment factor $C_{mz}$	0,57	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,00	
Factor $w_y$	1,31	
Factor $w_z$	1,31	
Factor $n_{pl}$	0,00	
Maximum relative slenderness $\lambda_{rel,max}$	3,42	
Factor $C_{yy}$	0,99	
Factor $C_{yz}$	0,99	
Factor $C_{zy}$	0,97	
Factor $C_{zz}$	1,00	

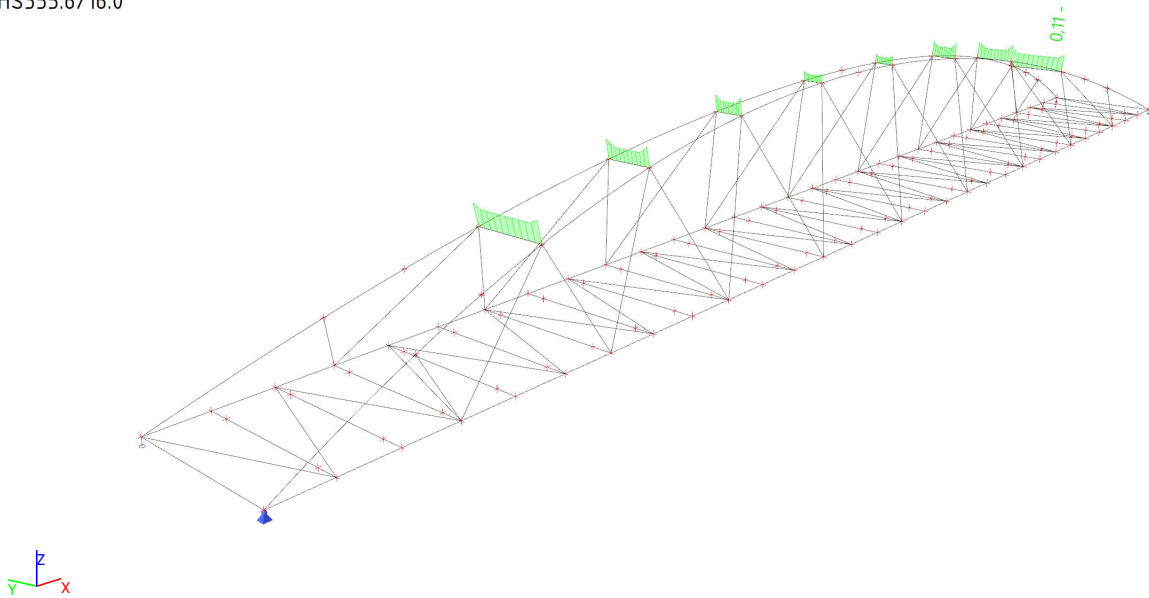
Unity check (6.61) =  $0,00 + 0,02 + 0,04 = 0,06$  -

Unity check (6.62) =  $0,00 + 0,01 + 0,06 = 0,08$  -

The member satisfies the stability check.

### 11.6.2. Fattore di utilizzazione

Values:  $UC_{Overall}$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CS5 -  
CHS355.6/16.0



## 11.7. VERIFICA PROFILO CS7

### 11.7.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS7 - CHS406.4/16.0

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B3	2,313 / 4,627 m	CHS406.4/16.0	S 355	SLU+SLV	0,51 -
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Combination key
SLU+SLV / 1.35*G1 + 1.35*G2 + 1.35*Q1a + 1.35*Q1b + 1.35*Q1c + 1.35*Q1d + 1.35*Q2b + 0.90*Wind D + 0.90*Temp B

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 2,313 m

Internal forces	Calculated	Unit
$N_{Ed}$	3363,53	kN
$V_{y,Ed}$	21,25	kN
$V_{z,Ed}$	-5,75	kN
$T_{Ed}$	-1,28	kNm
$M_{y,Ed}$	149,46	kNm
$M_{z,Ed}$	-26,41	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
406	16	25,40	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Tension check

According to EN 1993-1-1 article 6.2.3 and formula (6.5)

A	1,9600e-02	m <sup>2</sup>
$N_{pl,Rd}$	6626,67	kN
$N_{u,Rd}$	6914,88	kN
$N_{t,Rd}$	6626,67	kN
Unity check	0,51	-

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

I

$W_{pl,y}$	2,4015e-03	m <sup>3</sup>
$M_{pl,y,Rd}$	811,93	kNm
Unity check	0,18	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	2,4015e-03	m <sup>3</sup>
$M_{pl,z,Rd}$	811,93	kNm
Unity check	0,03	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	1,2478e-02	m <sup>2</sup>
$V_{pl,y,Rd}$	2435,65	kN
Unity check	0,01	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	1,2478e-02	m <sup>2</sup>
$V_{pl,z,Rd}$	2435,65	kN
Unity check	0,00	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,3	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.31)

$M_{resultant}$	151,77	kNm
$V_{resultant}$	22,02	kN
$M_{N,Rd}$	555,56	kNm
Unity check	0,27	-

**Note:** The resultant internal forces are used for CHS sections.

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

#### ...:STABILITY CHECK:...:

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
406	16	25,40	33,10	46,34	59,58	1

The cross-section is classified as Class 1

### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns a CHS section which is not susceptible to Lateral Torsional Buckling.

The member satisfies the stability check.

### 11.7.2. Fattore di utilizzazione

Values:  $UC_{Overall}$

Linear calculation

Class: SLU+SLV

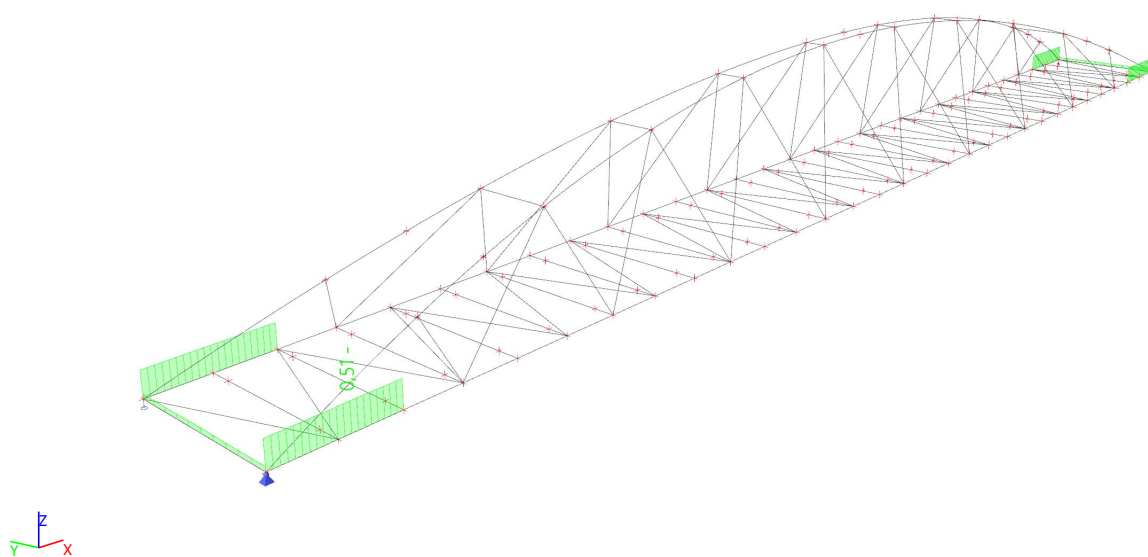
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS7 -

CHS406.4/16.0



## 11.8. VERIFICA PROFILO D1

### 11.8.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = D1 - CHS193.7/6.3

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B85	0,000 / 8,161 m	CHS193.7/6.3	S 355	SLU+SLV	0,24 -
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Combination key
SLU+SLV / G1 + G2 + 1.35*Q1a + 1.35*Q1c + 1.35*Q2d + 0.90*Wind D + 0.90*Temp B

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 0,000 m

Internal forces	Calculated	Unit
$N_{Ed}$	-85,64	kN
$V_{y,Ed}$	-0,30	kN
$V_{z,Ed}$	0,84	kN
$T_{Ed}$	-0,11	kNm
$M_{y,Ed}$	0,00	kNm
$M_{z,Ed}$	0,00	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
194	6	30,75	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	3,7100e-03	m <sup>2</sup>
$N_{c,Rd}$	1254,33	kN
Unity check	0,07	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
--------	------	--

$A_v$	2,3619e-03	m <sup>2</sup>
$V_{pl,y,Rd}$	461,03	kN
Unity check	0,00	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	2,3619e-03	m <sup>2</sup>
$V_{pl,z,Rd}$	461,03	kN
Unity check	0,00	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,3	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

The member satisfies the section check.

#### ....STABILITY CHECK....

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
194	6	30,75	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	8,161	8,161	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	8,161	8,161	m
Critical Euler load $N_{cr}$	507,29	507,29	kN
Slenderness $\lambda$	123,12	123,12	
Relative slenderness $\lambda_{rel}$	1,61	1,61	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	
Buckling curve	a	a	
Imperfection $\alpha$	0,21	0,21	
Reduction factor $\chi$	0,33	0,33	
Buckling resistance $N_{b,Rd}$	412,88	412,88	kN

Flexural Buckling verification		
Cross-section area A	3,7100e-03	m <sup>2</sup>
Buckling resistance $N_{b,Rd}$	412,88	kN
Unity check	0,21	-

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a CHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	3,7100e-03	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	2,1784e-04	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	2,1784e-04	m <sup>3</sup>
Design compression force $N_{Ed}$	85,64	kN
Design bending moment (maximum) $M_{y,Ed}$	1,71	kNm
Design bending moment (maximum) $M_{z,Ed}$	-0,60	kNm
Characteristic compression resistance $N_{Rk}$	1317,05	kN
Characteristic moment resistance $M_{y,Rk}$	77,33	kNm
Characteristic moment resistance $M_{z,Rk}$	77,33	kNm
Reduction factor $\chi_y$	0,33	
Reduction factor $\chi_z$	0,33	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,14	
Interaction factor $k_{yz}$	0,76	
Interaction factor $k_{zy}$	0,76	
Interaction factor $k_{zz}$	1,14	

Maximum moment  $M_{y,Ed}$  is derived from beam B85 position 4,080 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B85 position 4,080 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	507,29	kN
Critical Euler load $N_{cr,z}$	507,29	kN
Elastic critical load $N_{cr,T}$	299653,85	kN
Plastic section modulus $W_{pl,y}$	2,1784e-04	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	1,6800e-04	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	2,1784e-04	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	1,6800e-04	m <sup>3</sup>
Second moment of area $I_y$	1,6300e-05	m <sup>4</sup>
Second moment of area $I_z$	1,6300e-05	m <sup>4</sup>
Torsional constant $I_t$	3,2600e-05	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 4 (Line load)	
Equivalent moment factor $C_{my,0}$	1,01	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 4 (Line load)	
Equivalent moment factor $C_{mz,0}$	1,01	
Factor $\mu_y$	0,88	
Factor $\mu_z$	0,88	
Factor $\epsilon_y$	0,44	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	1155,74	kNm
Relative slenderness $\lambda_{rel,0}$	0,26	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,20	
Equivalent moment factor $C_{my}$	1,01	
Equivalent moment factor $C_{mz}$	1,01	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	



Interaction method 1 parameters		
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,00	
Factor $w_y$	1,30	
Factor $w_z$	1,30	
Factor $n_{pl}$	0,07	
Maximum relative slenderness $\lambda_{rel,max}$	1,61	
Factor $C_{yy}$	0,93	
Factor $C_{yz}$	0,84	
Factor $C_{zy}$	0,84	
Factor $C_{zz}$	0,93	

Unity check (6.61) =  $0,21 + 0,03 + 0,01 = 0,24$  -

Unity check (6.62) =  $0,21 + 0,02 + 0,01 = 0,23$  -

The member satisfies the stability check.

### 11.8.2. Fattore di utilizzazione

Values:  $UC_{Overall}$

Linear calculation

Class: SLU+SLV

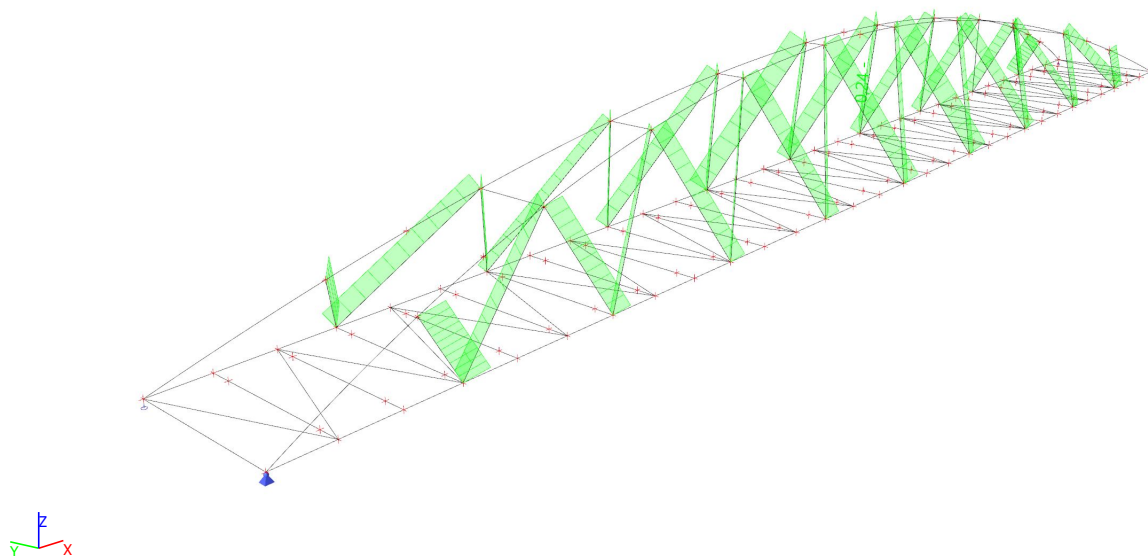
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = D1 -

CHS193.7/6.3



## 11.9. VERIFICA PROFILO CV1

### 11.9.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CV1 - CHS139.7/6.3

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B39	0,000 / 6,805 m	CHS139.7/6.3	S 355	SLU+SLV	0,87 -
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Combination key
SLU+SLV / 1.35*G1 + 1.35*G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind C + 0.90*Temp B

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 0,000 m

Internal forces	Calculated	Unit
$N_{Ed}$	-176,79	kN
$V_{y,Ed}$	0,00	kN
$V_{z,Ed}$	0,93	kN
$T_{Ed}$	-0,20	kNm
$M_{y,Ed}$	0,00	kNm
$M_{z,Ed}$	0,00	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
140	6	22,17	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	2,6400e-03	m <sup>2</sup>
$N_{c,Rd}$	892,57	kN
Unity check	0,20	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
--------	------	--

$A_v$	1,6807e-03	m <sup>2</sup>
$V_{pl,z,Rd}$	328,07	kN
Unity check	0,00	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	1,1	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,01	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

The member satisfies the section check.

....**STABILITY CHECK**....

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
140	6	22,17	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	6,805	6,805	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	6,805	6,805	m
Critical Euler load $N_{cr}$	263,60	263,60	kN
Slenderness $\lambda$	144,08	144,08	
Relative slenderness $\lambda_{rel}$	1,89	1,89	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	
Buckling curve	a	a	
Imperfection $\alpha$	0,21	0,21	
Reduction factor $\chi$	0,25	0,25	
Buckling resistance $N_{b,Rd}$	221,68	221,68	kN

Flexural Buckling verification		
Cross-section area A	2,6400e-03	m <sup>2</sup>
Buckling resistance $N_{b,Rd}$	221,68	kN
Unity check	0,80	-

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a CHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	2,6400e-03	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	1,1043e-04	m <sup>3</sup>
Design compression force $N_{Ed}$	176,79	kN
Design bending moment (maximum) $M_{y,Ed}$	1,59	kNm
Design bending moment (maximum) $M_{z,Ed}$	0,00	kNm
Characteristic compression resistance $N_{Rk}$	937,20	kN
Characteristic moment resistance $M_{y,Rk}$	39,20	kNm
Reduction factor $\chi_y$	0,25	
Reduction factor $\chi_z$	0,25	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,60	
Interaction factor $k_{zy}$	1,60	

Maximum moment  $M_{y,Ed}$  is derived from beam B39 position 3,403 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B39 position 0,000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	263,60	kN
Critical Euler load $N_{cr,z}$	263,60	kN
Elastic critical load $N_{cr,T}$	213049,76	kN
Plastic section modulus $W_{pl,y}$	1,1043e-04	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	8,4300e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	1,1043e-04	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	8,4300e-05	m <sup>3</sup>
Second moment of area $I_y$	5,8900e-06	m <sup>4</sup>
Second moment of area $I_z$	5,8900e-06	m <sup>4</sup>
Torsional constant $I_t$	1,1770e-05	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 4 (Line load)	
Equivalent moment factor $C_{my,0}$	1,02	
Factor $\mu_y$	0,40	
Factor $\mu_z$	0,40	
Factor $\epsilon_y$	0,28	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	500,59	kNm
Relative slenderness $\lambda_{rel,0}$	0,28	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,16	
Equivalent moment factor $C_{my}$	1,02	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $w_y$	1,31	
Factor $w_z$	1,31	
Factor $n_{pl}$	0,20	
Maximum relative slenderness $\lambda_{rel,max}$	1,89	
Factor $C_{yy}$	0,76	
Factor $C_{zy}$	0,46	

Unity check (6.61) = 0,80 + 0,07 + 0,00 = 0,87 -

Unity check (6.62) = 0,80 + 0,07 + 0,00 = 0,87 -

The member satisfies the stability check.

## 11.9.2. Fattore di utilizzazione

Values:  $UC_{Overall}$

Linear calculation

Class: SLU+SLV

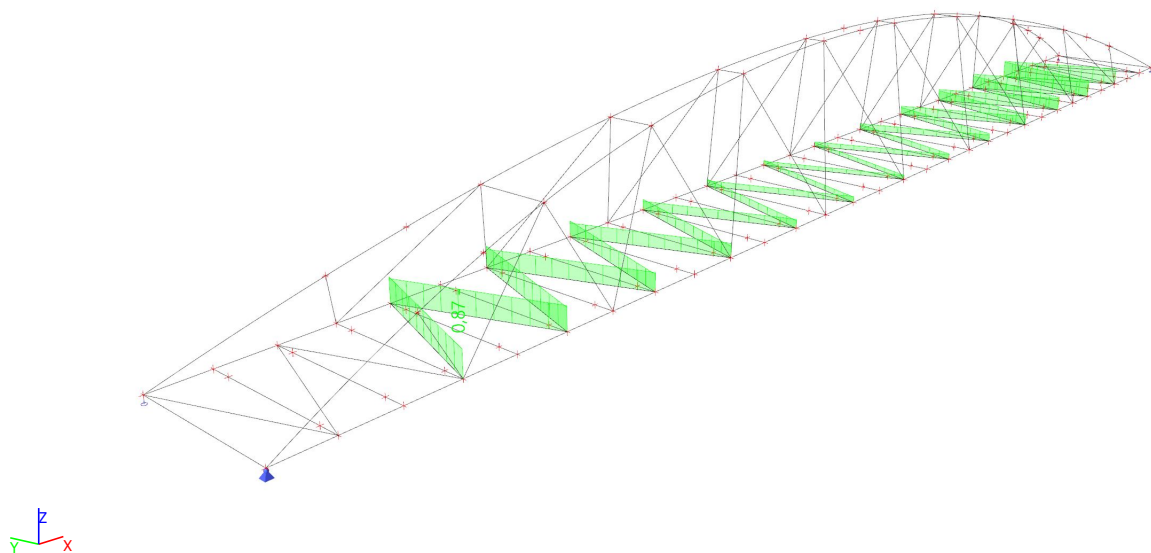
Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CV1 -

CHS139.7/6.3



## 11.10. VERIFICA PROFILO CV2

### 11.10.1. Verifica EC3

Linear calculation

Class: SLU+SLV

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CV2 - CHS139.7/8.0

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B37	0,000 / 6,805 m	CHS139.7/8.0	S 355	SLU+SLV	0,87 -
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Combination key
SLU+SLV / 1.35*G1 + 1.35*G2 + 0.54*Q1a + 0.54*Q1b + 1.35*Q2d + 1.50*Wind C + 0.90*Temp B

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 0,000 m

Internal forces	Calculated	Unit
$N_{Ed}$	-216,54	kN
$V_{y,Ed}$	0,00	kN
$V_{z,Ed}$	1,17	kN
$T_{Ed}$	0,13	kNm
$M_{y,Ed}$	0,00	kNm
$M_{z,Ed}$	0,00	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
140	8	17,46	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	3,3100e-03	m <sup>2</sup>
$N_{c,Rd}$	1119,10	kN
Unity check	0,19	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
--------	------	--

$A_v$	2,1072e-03	m <sup>2</sup>
$V_{pl,z,Rd}$	411,33	kN
Unity check	0,00	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,6	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

The member satisfies the section check.

....**STABILITY CHECK**....

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
140	8	17,46	33,10	46,34	59,58	1

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	6,805	6,805	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	6,805	6,805	m
Critical Euler load $N_{cr}$	322,23	322,23	kN
Slenderness $\lambda$	145,91	145,91	
Relative slenderness $\lambda_{rel}$	1,91	1,91	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	
Buckling curve	a	a	
Imperfection $\alpha$	0,21	0,21	
Reduction factor $\chi$	0,24	0,24	
Buckling resistance $N_{b,Rd}$	271,58	271,58	kN

Flexural Buckling verification		
Cross-section area A	3,3100e-03	m <sup>2</sup>
Buckling resistance $N_{b,Rd}$	271,58	kN
Unity check	0,80	-

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a CHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	3,3100e-03	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	1,3674e-04	m <sup>3</sup>
Design compression force $N_{Ed}$	216,54	kN
Design bending moment (maximum) $M_{y,Ed}$	1,99	kNm
Design bending moment (maximum) $M_{z,Ed}$	0,00	kNm
Characteristic compression resistance $N_{Rk}$	1175,05	kN
Characteristic moment resistance $M_{y,Rk}$	48,54	kNm
Reduction factor $\chi_y$	0,24	
Reduction factor $\chi_z$	0,24	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,62	
Interaction factor $k_{zy}$	1,62	

Maximum moment  $M_{y,Ed}$  is derived from beam B37 position 3,403 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B37 position 0,000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	322,23	kN
Critical Euler load $N_{cr,z}$	322,23	kN
Elastic critical load $N_{cr,T}$	267531,81	kN
Plastic section modulus $W_{pl,y}$	1,3674e-04	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	1,0300e-04	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	1,3674e-04	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	1,0300e-04	m <sup>3</sup>
Second moment of area $I_y$	7,2000e-06	m <sup>4</sup>
Second moment of area $I_z$	7,2000e-06	m <sup>4</sup>
Torsional constant $I_t$	1,4410e-05	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 4 (Line load)	
Equivalent moment factor $C_{my,0}$	1,02	
Factor $\mu_y$	0,39	
Factor $\mu_z$	0,39	
Factor $\epsilon_y$	0,30	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	612,40	kNm
Relative slenderness $\lambda_{rel,0}$	0,28	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,16	
Equivalent moment factor $C_{my}$	1,02	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $w_y$	1,33	
Factor $w_z$	1,33	
Factor $n_{pl}$	0,19	
Maximum relative slenderness $\lambda_{rel,max}$	1,91	
Factor $C_{yy}$	0,75	
Factor $C_{zy}$	0,45	

Unity check (6.61) = 0,80 + 0,07 + 0,00 = 0,87 -

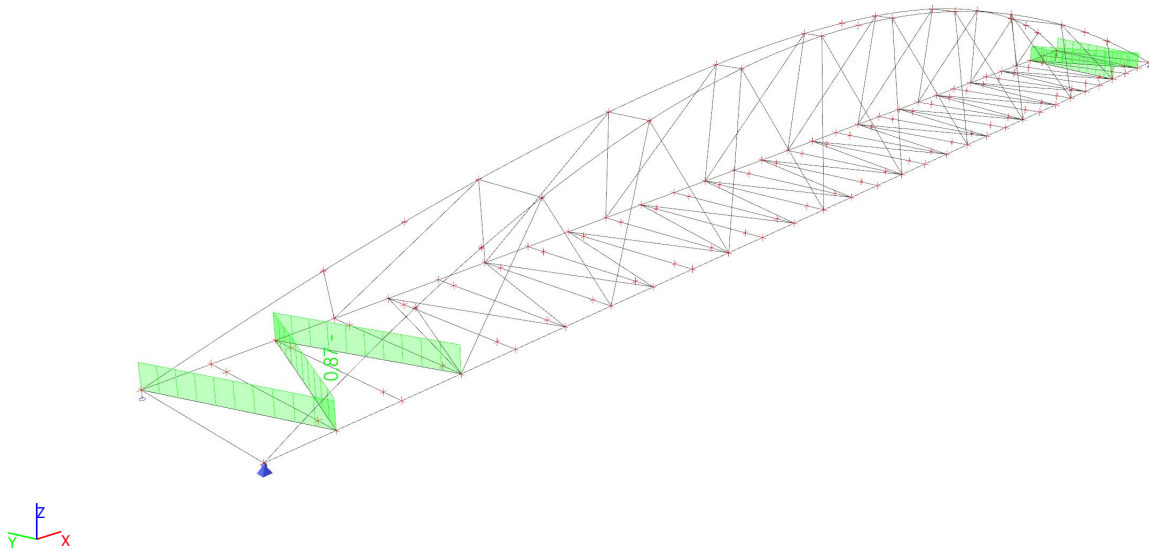
Unity check (6.62) = 0,80 + 0,07 + 0,00 = 0,87 -

The member satisfies the stability check.



### 11.10.2. Fattore di utilizzazione

Values:  $UC_{Overall}$   
Linear calculation  
Class: SLU+SLV  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All  
Filter: Cross-section = CV2 -  
CHS139.7/8.0



## 12. VERIFICA DELLE VIBRAZIONI INDOTTE DAI PEDONI

### 12.1. Introduzione

Nel presente capitolo si tratta la verifica dello Stato Limite di Esercizio relativo al comfort di percorrenza della passerella. Nello specifico trattasi del calcolo delle vibrazioni verticali e laterali indotte dal transito dei pedoni e la relativa verifica di accettabilità in funzione della classe di appartenenza della passerella e di diverse situazioni di progetto.

Il calcolo è effettuato secondo le EUR 23984 EN (2009) "Design of Lightweight Footbridges for Human Induced Vibrations", edito dal Joint Research Center JRC della Commissione Europea.

### 12.2. Situazioni di progetto

La passerella ciclopedonale in esame è situata in zona suburbana, non mette in collegamento aree densamente popolate (vedi centro città), ne si trova in vicinanza di stazioni degli autobus, dei treni ed altro, per cui non risulta soggetta durante la sua vita utile al passaggio frequente di folle di grandi dimensioni.

Per la passerella ciclopedonale in esame si identificano quindi diverse situazioni di progetto (DS), associate a diverse classi di traffico (TC) e classi di comfort (CL), che definiscono i livelli accettabili delle vibrazioni massime, come indicato nella tabella seguente.

Situazione di progetto DS	Classe di traffico TC	Densità pedoni $d [m/s^2]$	Classe di comfort CL
DS1	TC1	0,05	CL1
DS2	TC2	0,2	CL2
DS3	TC3	0,5	CL3
DS4	TC4	1,0	CL3

La struttura in esame, verosimilmente, deve essere quindi verificata alle vibrazioni per una situazione di progetto "caratteristica" DS3, che prevede un massimo di 0,5 pedoni/m<sup>2</sup> (classe di traffico TC3 – traffico denso –), caso in cui bisogna garantire un livello di comfort "minimo" (CL3).

La situazione di progetto più "frequente" di utilizzo della passerella (DS2), prevede un massimo di 0,2 pedoni/m<sup>2</sup> (classe di traffico TC2 – traffico debole –), caso in cui bisognerà quindi garantire un livello di comfort "medio" (CL2).

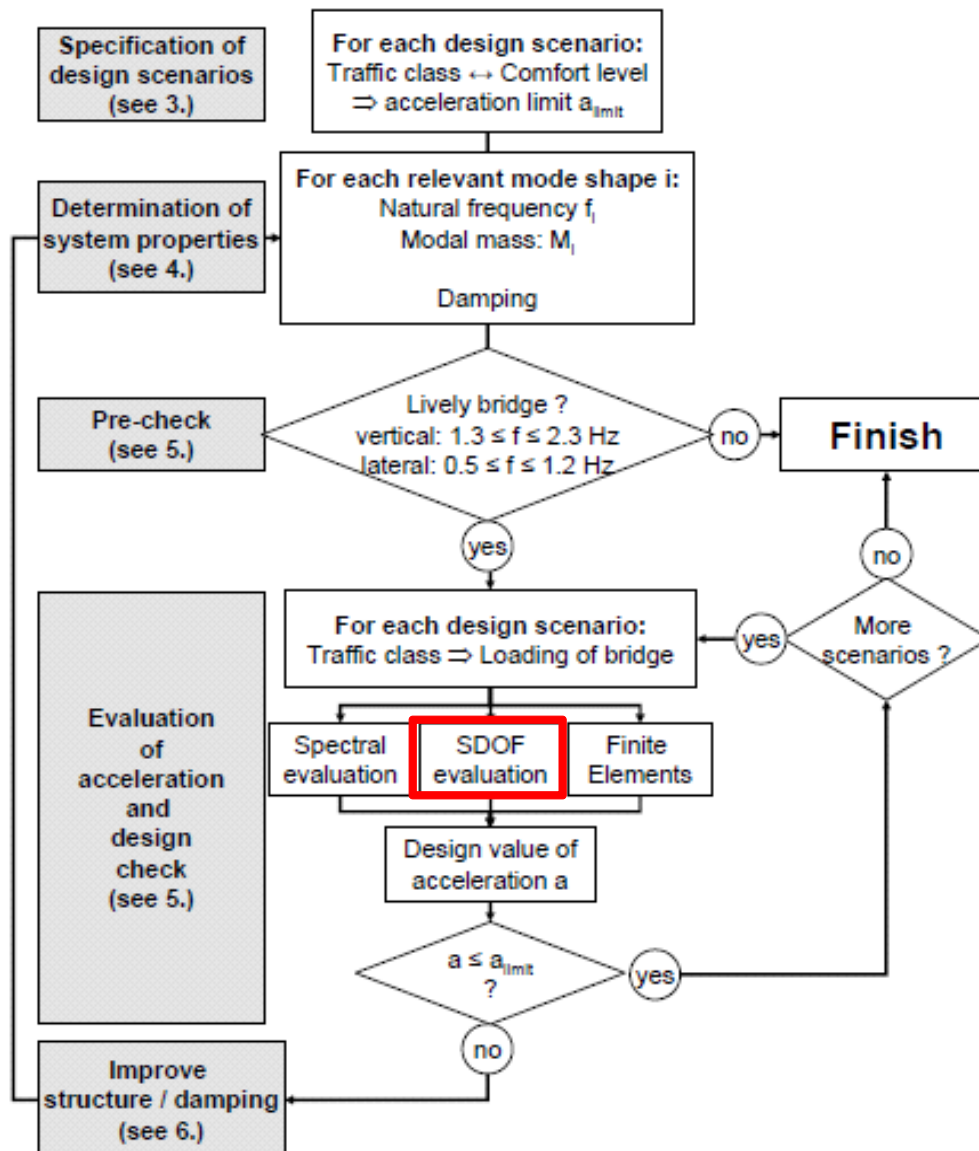
La situazione di progetto che si potrebbe definire invece "quasi-permanente" di utilizzo della passerella (DS1), prevede un massimo di 0,05 pedoni/m<sup>2</sup> (classe di traffico TC1 – traffico molto debole –, corrispondente ad un gruppo di 15 persone presenti sull'impalcato), caso in cui bisognerà quindi garantire un livello di comfort "massimo" (CL1).

Si è infine considerata anche la situazione di progetto DS4, definibile come "eccezionale", che prevede un massimo di 1,0 pedoni/m<sup>2</sup> (classe di traffico TC4 – traffico molto denso –), a cui la passerella sarà verosimilmente soggetta una sola volta nella sua vita utile di progetto, e più precisamente durante l'inaugurazione della stessa, oppure in rare occasioni di grandi eventi.

Nel paragrafo seguente si riporta il calcolo di esempio relativo alla situazione di progetto DS3, riassumendo poi tutti i risultati relativi alle restanti situazioni di progetto in due tabelle finali.

### 12.3. Calcolo e verifica delle vibrazioni

I modi di vibrare della passerella in esame, suscettibili di oscillazioni indotte dai pedoni, sono il 1° modo flessionale verticale ad 1 semionda, con frequenza pari a  $f_{1,v} = 1,93$  Hz e il 1° modo flessionale laterale ad 1 semionda, con frequenza pari a  $f_{1,h} = 1,21$  Hz, rispettivamente per le vibrazioni verticali e orizzontali.



Procedura di calcolo e verifica delle vibrazioni

Classe di traffico		
Classe	Densità d [ped/m <sup>2</sup> ]	Descrizione
TC3 ▼	0,5	traffico intenso

Classe di comfort			
Classe	Grado di comfort	Limite accelerazioni verticali	Limite accelerazioni laterali
CL3 ▼	minimo	1,00 m/s <sup>2</sup> ≤ a <sub>v</sub> ≤ 2,50 m/s <sup>2</sup>	0,30 m/s <sup>2</sup> ≤ a <sub>h</sub> ≤ 0,80 m/s <sup>2</sup>

Nota: i limiti di accelerazione indicati sono solo criteri di comfort; i criteri di "lock-in" per le vibrazioni laterali sono riportati di seguito.

### Caratteristiche geometriche e modali del ponte pedonale

B	6,40 m	larghezza dell'impalcato
B <sub>net</sub>	4,40 m	larghezza netta calpestabile dell'impalcato
L	69,40 m	lunghezza dell'impalcato
S	444,16 m <sup>2</sup>	superficie dell'impalcato (= B*L)
S <sub>net</sub>	305,36 m <sup>2</sup>	superficie netta calpestabile dell'impalcato (= B <sub>net</sub> *L)
M	197000 Kg	massa del ponte
m	2838,62 Kg/m	massa del ponte per unità di lunghezza (= M/B)
f <sub>v,1</sub>	1,93 Hz	frequenza propria del 1° modo di vibrare flessionale verticale
m <sub>v,1</sub>	1	numero di semionde del 1° modo di vibrare flessionale verticale
ξ <sub>v</sub>	0,5 %	coefficiente di smorzamento per oscillazioni verticali
f <sub>h,1</sub>	1,21 Hz	frequenza propria del 1° modo di vibrare flessionale laterale
m <sub>h,1</sub>	1	numero di semionde del 1° modo di vibrare flessionale laterale
ξ <sub>h</sub>	0,5 %	coefficiente di smorzamento per oscillazioni orizzontali
d	0,50 ped/m <sup>2</sup>	densità pedoni scelta in funzione della classe di traffico
N <sub>ped</sub>	152,7 ped	numero totale di pedoni sull'impalcato
M <sub>ped</sub>	10894,6 Kg	massa totale dei pedoni sull'impalcato (= 700[N]*N <sub>ped</sub> )
m <sub>ped</sub>	157,0 Kg/m	massa totale dei pedoni sull'impalcato per unità di lunghezza (= M <sub>ped</sub> /L)
N <sup>*</sup> <sub>ped</sub>	9,44 ped	numero equivalente di pedoni
n <sup>*</sup> <sub>ped</sub>	0,0309 ped/m <sup>2</sup>	numero equivalente di pedoni per unità di superficie (= N <sup>*</sup> <sub>ped</sub> /S <sub>net</sub> )
m <sub>tot</sub>	2995,6 Kg/m	massa totale ponte + pedoni per unità di lunghezza
ρ	1,0553	fattore di influenza delle frequenze per la massa aggiuntiva dei pedoni

### Verifica delle accelerazioni verticali

f <sup>*</sup> <sub>v,1</sub>	1,88 Hz	frequenza propria modificata del 1° modo di vibrare flessionale verticale (= f <sub>v,1</sub> /√ρ)
ψ <sub>v</sub>	1,00	coefficiente di riduzione per modi di vibrare verticali
f <sub>v,ped</sub>	8,65 N/m <sup>2</sup>	forzante verticale dovuta ai pedoni per unità di superficie
F <sub>v,ped</sub>	38,07 N/m	forzante verticale dovuta ai pedoni per unità di lunghezza
a <sub>v,max</sub>	1,62 m/s <sup>2</sup>	<b>accelerazione verticale massima</b>

### Verifica delle accelerazioni laterali

f <sup>*</sup> <sub>h,1</sub>	1,18 Hz	frequenza propria modificata del 1° modo di vibrare flessionale laterale (= f <sub>h,1</sub> /√ρ)
ψ <sub>h</sub>	0,11	coefficiente di riduzione per modi di vibrare laterali
f <sub>h,ped</sub>	0,12 N/m <sup>2</sup>	forzante laterale dovuta ai pedoni per unità di superficie
F <sub>h,ped</sub>	0,53 N/m	forzante laterale dovuta ai pedoni per unità di lunghezza
a <sub>h,max</sub>	0,02 m/s <sup>2</sup>	<b>accelerazione laterale massima</b>

### Verifica del fenomeno di sincronizzazione laterale "lock-in"

a <sub>h,max</sub>	0,02 m/s <sup>2</sup>	≤	a <sub>h,lock-in</sub>	0,125 m/s <sup>2</sup>	(a <sub>h,lock-in</sub> = 0,10÷0,15 m/s <sup>2</sup> )
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Di seguito si riportano le tabelle riassuntive per le diverse situazioni di progetto.

Situazione di progetto DS	Classe di traffico TC	Densità pedoni $d$ [m/s <sup>2</sup> ]	Classe di comfort CL	Smorzamento $\xi_v$ [%]	Accelerazione massima $a_{v,max}$ [m/s <sup>2</sup> ]	Accelerazione limite $a_{v,lim}$ [m/s <sup>2</sup> ]
DS1	TC1	0,05	CL1	0,5	0,54	0,50
DS2	TC2	0,2	CL2	0,5	1,06	1,00
DS3	TC3	0,5	CL3	0,5	1,62	2,50
DS4	TC4	1,0	CL3	0,5	2,17	2,50

*Accelerazioni verticali*

Situazione di progetto DS	Classe di traffico TC	Densità pedoni $d$ [m/s <sup>2</sup> ]	Classe di comfort CL	Smorzamento $\xi_h$ [%]	Accelerazione massima $a_{h,max}$ [m/s <sup>2</sup> ]	Accelerazione limite $a_{h,lim}$ [m/s <sup>2</sup> ] <sup>(1)</sup>
DS1	TC1	0,05	CL1	0,5	0,00	0,10
DS2	TC2	0,2	CL2	0,5	0,00	0,30
DS3	TC3	0,5	CL3	0,5	0,02	0,80
DS4	TC4	1,0	CL3	0,5	0,07	0,80

Nota (1): l'accelerazione laterale limite va comunque contenuta entro il limite di "lock-in"  $0,10 \div 0,15$  m/s<sup>2</sup>

*Accelerazioni laterali*

#### 12.4. Osservazioni

Per quanto riguarda le vibrazioni verticali, la passerella risulta verificata per le situazioni di progetto DS1 e DS2, identificabili rispettivamente come "quasi-permanente" e "frequente", che determinano valori di accelerazione sostanzialmente in accordo con i limiti imposti dalle classi di comfort relative. La situazione "caratteristica" DS3 risulta compresa nei limiti di accettabilità e infine anche la situazione "eccezionale" DS4, in corrispondenza dell'inaugurazione e/o rari eventi, risulta garantire il livello minimo di comfort dei pedoni.

Per quanto concerne le accelerazioni laterali, ogni situazione di progetto è verificata sia con riferimento ai limiti di comfort, sia nei confronti del fenomeno "lock-in", che impone un livello di accelerazione laterale comunque non superiore a  $0,10 \div 0,15$  m/s<sup>2</sup>, valore oltre il quale si innesca un fenomeno di sincronizzazione laterale particolarmente critico nel caso di grandi affollamenti e che genera un aumento repentino delle oscillazioni laterali.

## 13. VERIFICA DELLA SOLETTA SU LAMIERA GRECATA COLLABORANTE

### 13.1. Introduzione

Nel presente capitolo si tratta la verifica agli SLU ed SLE della soletta su lamiera grecata collaborante che costituisce la pavimentazione strutturale dell'impalcato. In particolare si effettuano le verifiche con riferimento alle 3 condizioni di carico variabili da traffico previste da normativa:

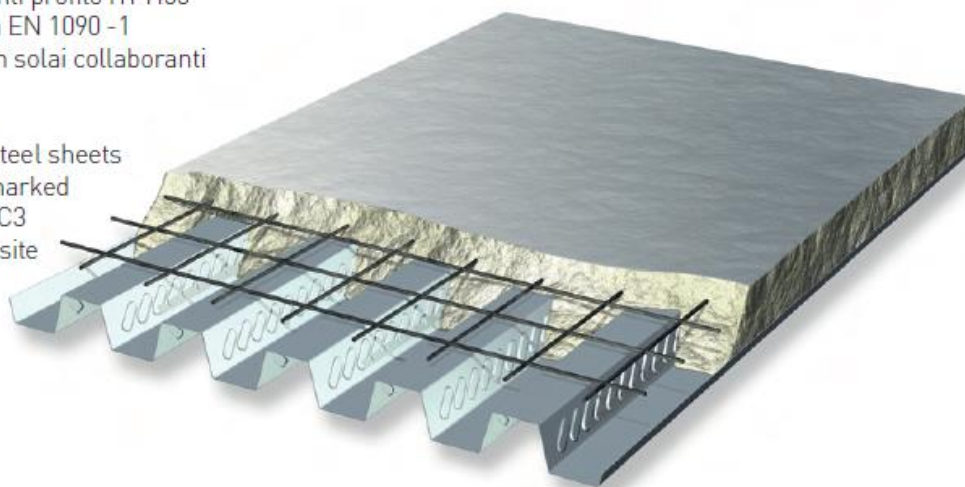
- schema di carico 5: carico da folla compatta uniformemente distribuito;
- schema di carico 4: carico concentrato isolato;
- carico mobile dovuto al mezzo di servizio previsto.

Le caratteristiche geometriche, inerziali e dei materiali della soletta composta sono le seguenti:

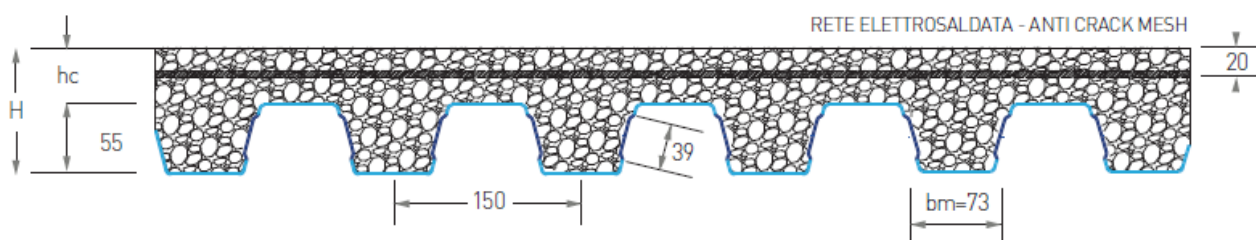
- Lamiera grecata tipo: Italpannelli ITPH55 a 5 greche
- Materiale lamiera: acciaio S280GD / spessore 0,8 mm
- Materiale getto integrativo collaborante: calcestruzzo C30/37
- Materiale rete elettrosaldata: Rete  $\Phi 6$  150x150 in acciaio B450C
- Schema statico: trave in semplice appoggio di luce  $L=2,315$  m

Lamiere grecate collaboranti profilo ITPH55  
marcate CE in accordo alla EN 1090 -1  
Classe EXC3 da utilizzare in solai collaboranti  
acciaio - calcestruzzo

Collaborating trapezoidal steel sheets  
ITP H55 Beton profile CE marked  
according to EN 1090-1 EXC3  
class to be used for composite  
floor steel - concrete.



Passo greche - Ribs step 600 mm - **5 Greche - Ribs**



### 13.2. Schema di carico 5

In funzione delle tabelle di carico fornite dai produttori di lamiera grecate collaboranti, si riporta di seguito la verifica di portanza della soletta su lamiera grecata collaborante per carico distribuito da folla compatta pari a 5,0 kN/m<sup>2</sup>. Le tabelle di portata verificano sia la resistenza agli SLU che le deformazioni agli SLE con il limite di freccia di L/300. La verifica viene eseguita con riferimento allo schema di trave in semplice appoggio.

Per lo S.L.S. elemento appoggiato limitazione 1/300 della freccia - For S.L.S. supported element deflection 1/300 span


- rottura cilindrica / cylinder break  $f_{ck} = 25 \text{ N/mm}^2$
- soletta con calcestruzzo normale / composite floor with normal concrete

Carico permanente / permanent load  $p = 0,00 \text{ KN/m}^2$

(il carico permanente comprende il peso di pavimentazione, sottofondo e impianti fissi)  
(the permanent load includes floor weight, subgrade and fixed equipments)

#### TABELLE PORTATE - LOAD TABLE

Resistenza al taglio longitudinale: metodo di "interazione parziale" / Longitudinal shear resistance: method of partial interaction

H Spessore soletta / Thickness composite floor	S Spessore lamiera / Steel thickness	Peso soletta / Weight composite floor	Luce massima in fase di getto / Max span during concrete casting m			Larghezza efficace appoggio: 50 mm Working width support: 50 mm																					
			q = carico di esercizio variabile / service variable load																								
			mm	Kg./m <sup>2</sup>	2 app	3 app	4 app	l=m	1,50	1,75	2,00	2,25	2,50	2,75	3,00	3,25	3,50	3,75	4,00	4,25	4,50	4,75	5,00	5,25	5,50	5,75	6,00
120 mm	mm	Kg./m <sup>2</sup>	2 app	3 app	4 app	l=m	1,50	1,75	2,00	2,25	2,50	2,75	3,00	3,25	3,50	3,75	4,00	4,25	4,50	4,75	5,00	5,25	5,50	5,75	6,00		
	0,7	234,1	2,00	1,75	1,75		2430	1810	1400	1115	905	745	625	530	445	375	320	275	235	200	170	145	120				
	0,8	235,1	2,25	2,00	2,25		2670	1980	1530	1215	990	810	675	575	485	410	355	300	265	225	190	160	140				
$\tau_{u,Rd}$ 0,091 N/mm <sup>2</sup>	1,0	237,3	2,50	2,50	2,75	$q = Kg./m^2$	2830	2320	1785	1415	1145	950	790	665	565	480	415	355	305	265	235	195	165				
	1,2	239,4	2,75	3,00	3,00		2810	2375	2035	1610	1300	1070	895	755	640	545	475	410	350	305	265	230	195				
	1,5	242,8	3,00	3,50	3,75		2775	2345	2025	1780	1520	1260	1055	890	755	645	555	480	420	365	320	275	235				

Verifica combinata di portanza SLE e freccia SLE:

$$q_k = q_{pp} + q_{Perm} + q_{Folla} = 250 + 100 + 500 = 850 \text{ Kg/m}^2$$

$$L = 2,315 \text{ m} \rightarrow q_{max} = 1156,5 \text{ Kg/m}^2$$

VERIFICATO!

Verifica in fase di getto:

Lamiera grecata non puntellata (-> 2 appoggi)

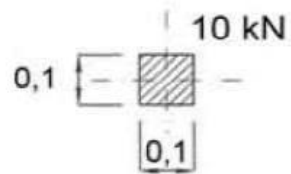
$$L = 2,315 \text{ m} \approx L_{max} = 2,250 \text{ m} (+3\%)$$

VERIFICATO!

Vista la minima differenza fra la luce massima ammissibile in fase di getto e la luce massima in asse appoggi della lamiera grecata, si considera la verifica comunque soddisfatta, anche considerando il fatto che la luce netta fra gli appoggi risulta pari a  $L_{net} = 2,140 \text{ m}$ .

### 13.3. Schema di carico 4

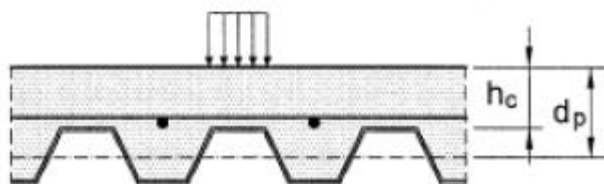
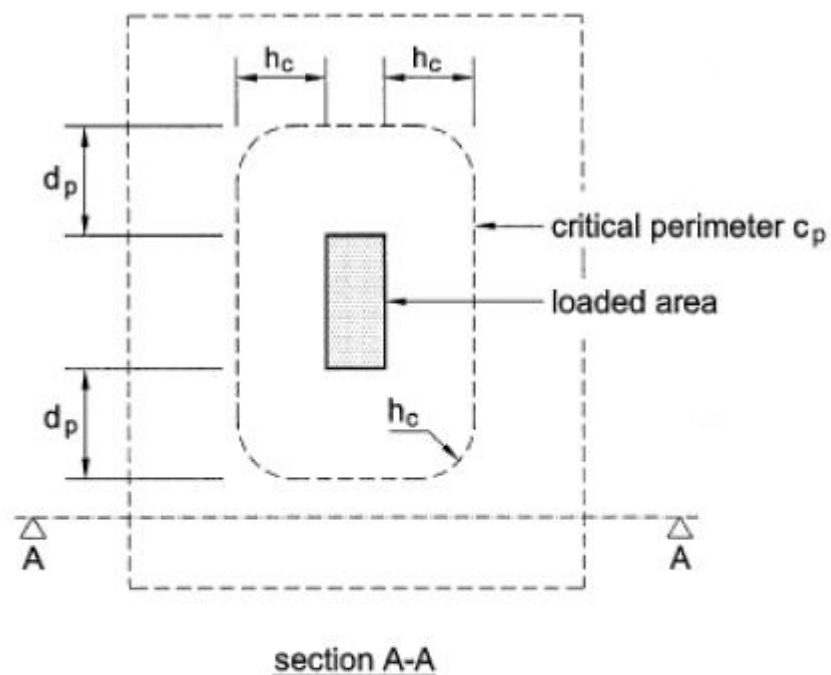
Tale schema di carico, costituito da un carico isolato da 10 kN con impronta quadrata di lato 0,10 m, è finalizzato alla verifica locale di punzonamento della soletta composta.



Schema di carico 4  
(dimensioni in [m])

### Verifica a punzonamento

La verifica a punzonamento, rivolta alla valutazione della massima forza concentrata  $V_{p,Rd}$  applicabile sulla struttura, deve essere condotta in maniera analoga a quanto previsto per le strutture in c.a.. Il perimetro critico deve essere comunque determinato ipotizzando una diffusione degli sforzi a partire dall'area d'impronta per una distanza pari allo spessore minimo del calcestruzzo  $h_c$ .



Perimetro critico per la verifica a punzonamento



### Geometria

$h_p$	55 mm
$h_c$	65 mm
$h_f$	30 mm
$d_p$	87,5 mm
$d_c$	40 mm

altezza lamiera grecata  
altezza soletta al di sopra della lamiera grecata  
altezza finiture  
altezza utile sezione in dir.y (longitudinale)  
altezza utile sezione in dir.z (trasversale)

### Materiali

$f_{ck}$	30 N/mm <sup>2</sup>
$f_{cd}$	17,0 N/mm <sup>2</sup>
$f_{yk}$	450 N/mm <sup>2</sup>
$f_{yd}$	391,3 N/mm <sup>2</sup>

$A_{l,y}$	1253,7 mm <sup>2</sup>	area acciaio lamiera grecata (dir.y)
$A_{s,y}$	188,5 mm <sup>2</sup>	area armatura dir.y
$A_{s,z}$	188,5 mm <sup>2</sup>	area armatura dir.z
$\rho_{l,y}$	0,014328	rapporto geometrico d'armatura in y
$\rho_{l,z}$	0,004713	rapporto geometrico d'armatura in z
$\rho_l$	0,008217 ( $\leq 0,02$ )	rapporto geometrico d'armatura ( $=\sqrt{\rho_x*\rho_y}$ )

### Verifica a punzonamento

$b_p$	100 mm
$a_p$	100 mm
$C_p$	1138,4 mm
$k$	2 ( $\leq 2$ )
$v_{min}$	0,54 N/mm <sup>2</sup>
$v_{Rd}$	1,97 N/mm <sup>2</sup>
$V_{p,Rd}$	145,93 kN

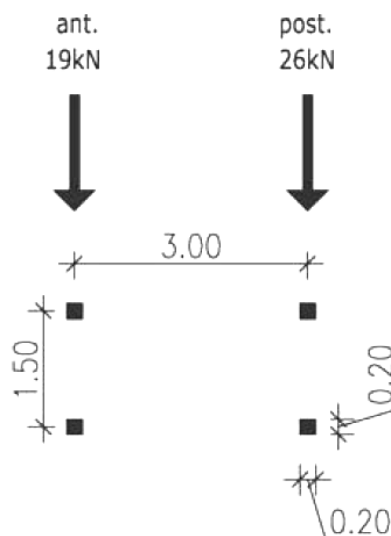
base impronta di carico (dir.z)  
altezza impronta di carico (dir.y)  
perimetro critico

$V_{p,Ed}$	10,00 kN	(6,9%)
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### 13.4. Mezzo di servizio – carico mobile

Si considera la possibilità che sul ponte pedonale possa transitare un mezzo di servizio, con la finalità di eseguire operazioni di manutenzione. La scelta del mezzo di servizio è in accordo con le indicazioni del Committente.

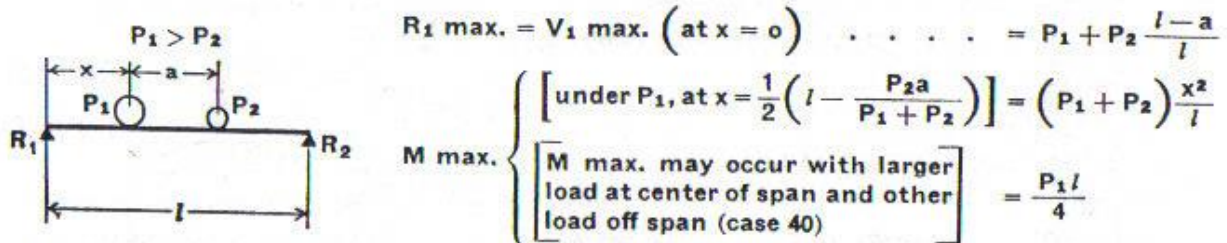
- Autocarro leggero a due assi (tipo Daily Iveco) di portata complessiva su due assi 19+26 kN:



Schema di carico a due assi tandem

Il calcolo del momento e taglio massimi generati dal carico mobile a 2 assi tandem di intensità diversa ( $P_1 > P_2$ ), viene condotto secondo il seguente schema:

#### 42. SIMPLE BEAM—TWO UNEQUAL CONCENTRATED MOVING LOADS



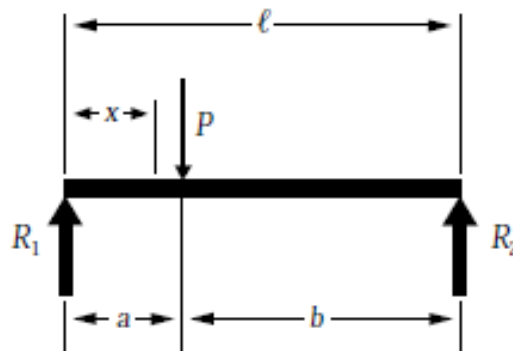
$$P_{1,Ed} = 1,35 \cdot 26 \text{ kN} = 35,1 \text{ kN}$$

$$P_{2,Ed} = 1,35 \cdot 19 \text{ kN} = 25,7 \text{ kN}$$

$$L = 2,315 \text{ m}$$

$$a = 3,00 \text{ m}$$

Essendo però il passo "a" fra gli assi tandem maggiore della luce "L" della soletta con schema a trave in semplice appoggio, il problema si riduce a quello di una trave con un unico asse tandem, quello di maggiore intensità ( $P_1$ ), posizionato in mezzeria e all'appoggio, al fine di ottenere rispettivamente il momento flettente e il taglio massimi.



Taglio massimo all'appoggio:

$$a_p = 0,20 \text{ m}$$

lunghezza dell'impronta di carico

$$a = a_p / 2 = 0,10 \text{ m}$$

$$b = L - a = 2,315 - 0,10 = 2,215 \text{ m}$$

$$R_{1,Ed,max} = V_{1,Ed,max} = P_{1,Ed} \cdot b / L = 33,6 \text{ kN}$$

Momento flettente massimo in mezzeria:

$$a = b = L / 2 = 1,1575 \text{ m}$$

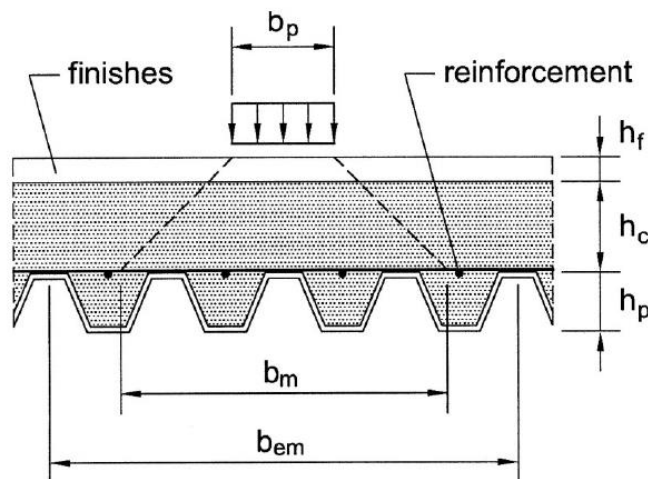
$$M_{1,Ed,max} = P_{1,Ed} \cdot L / 4 = 20,3 \text{ kNm}$$

## Verifica di resistenza della soletta per carico mobile

Nel caso di carico concentrato su un'area " $a_p$ " e " $b_p$ ", posto ad una distanza " $L_p$ " dall'appoggio di una trave con luce " $L$ ", si può assumere che il carico sia in realtà distribuito, per effetto della diffusione all'interno dello spessore, su un'area di dimensioni " $a_m$ " e " $b_m$ ".

Ai fini dell'analisi globale si può definire una larghezza efficace " $b_{em}$ " pari dipendente, oltre che da " $b_m$ ", anche dalla posizione del carico rispetto alla luce della soletta. In definitiva, nel caso di travi in semplice appoggio soggette ad un carico concentrato " $P_p$ " posto a distanza " $L_p$ " dall'appoggio, si può determinare un momento sollecitante per unità di larghezza il cui valore di calcolo è  $m_{Ed}$ .

Infine, la presenza di un carico puntuale determina anche una inflessione in direzione opposta legata alla differenza tra la larghezza " $b_m$ " della zona su cui si considera ripartito il carico e quella efficace  $2b_e$  considerata per le verifiche. In particolare, si può determinare il momento trasversale " $M_{Ed,t}$ " attraverso una relazione semplificata. Per far fronte a questo momento è necessario prevedere la presenza di una opportuna armatura trasversale poiché la lamiera grecata, per ragioni di forma, non ha resistenza in direzione trasversale.



*Larghezza efficace della soletta composta soggetta a carico concentrato*

$$a_m = a_p + 2(h_f + h_c) = 0,39 \text{ m}$$

$$b_m = b_p + 2(h_f + h_c) = 0,39 \text{ m}$$

$$b_{em} = b_m + k * L_p * [1 - L_p / L]$$

con  $k = 2$  per verifiche a flessione e taglio longitudinale

$k = 1$  per verifiche a taglio verticale

$$m_{Ed} = P_p * L_p * [1 - L_p / L] / b_{em}$$

momento flettente longitudinale

$$M_{Ed,t} = P_p * (b_{em} - b_m) / 8$$

momento flettente trasversale

### ▪ Verifica a flessione longitudinale

$$L_p = L / 2 = 1,1575 \text{ m}$$

distanza del carico concentrato dall'appoggio

$$b_{em} = 1,5475 \text{ m}$$

(con  $k = 2$ )

Si noti che essendo l'interasse fra le impronte di carico degli assi tandem pari a  $1,50 \text{ m} < b_{em}$ , la larghezza collaborante totale della soletta per un asse costituito da 2 impronte di carico risulta pari a:

$$b_{em,TOT} = 1,50 + 2 \cdot b_{em} / 2 = 3,05 \text{ m}$$

$$P_p = P_{1,Ed} = 1,35 \cdot 26 \text{ kN} = 35,1 \text{ kN}$$

$$m_{Ed} = 6,67 \text{ kNm/m}$$

Con riferimento alle tabelle di portata del produttore, valide per una larghezza di influenza del carico pari a 1,00 m, si ottengono le seguenti verifiche per analogia di momento flettente:

$$L = 2,315 \text{ m} \quad \rightarrow \quad q_{max} = 1156,5 \text{ Kg/m}^2 = 11,36 \text{ kN/m}^2$$

$$\rightarrow M_{max} = q_{max} \cdot L^2 / 8 = 7,61 \text{ kNm/m} > m_{Ed} = 6,67 \text{ kNm/m} \quad \text{VERIFICATO!}$$

■ Verifica a taglio longitudinale (taglio-scorrimento)

$$v_{Ed} = P_p \cdot (L/2) / b_{em,TOT} = 13,32 \text{ kN/m}$$

$$L_s = \min[L/2 ; m_{Ed} / v_{Ed}] = 0,50 \text{ m}$$

luce di taglio (per carichi distribuiti corrisponde a  $L/4$ , mentre per forze concentrate corrisponde alla distanza minima fra il carico e l'appoggio, oppure come rapporto tra il momento e taglio massimi)

$$V_{1,Rd} = \tau_{u,Rd} \cdot b \cdot L_s \cdot (b_{em,TOT} / b) = 138,8 \text{ kN/m}$$

con  $b = 0,15 \text{ m}$

$$\tau_{u,Rd} = 0,091 \text{ N/mm}^2$$

VERIFICATO!

interasse nervature

resistenza a taglio longitudinale, ottenuta dal produttore mediante prove sperimentali secondo NTC2018 e UNI EN 1994-1-1

Siccome il produttore ha adottato una progettazione della soletta in parziale connessione, bisogna verificare che il valore di " $N_c$ " (risultante delle compressioni - nel calcestruzzo ed armatura compressa -) non superi la corrispondente resistenza allo scorrimento e, dunque, verificare la validità della seguente relazione:

$$N_c(x) = \tau_{u,Rd} \cdot b \cdot L_x \cdot (1/b) \leq N_{cf}$$

$$N_c(L/2) = \tau_{u,Rd} \cdot b \cdot (L/2) \cdot (1/b) = 105,3 \text{ kN/m} \quad (\text{per } L_x = L/2)$$

$$N_{cf} = \min[N_{p,pl,Rd} ; N_{c,pl,Rd}] = 334,7 \text{ kN/m}$$

VERIFICATO!

con  $N_{p,pl,Rd} = A_p \cdot f_{ap} = 334,7 \text{ kN/m}$

con  $A_p = 1253,7 \text{ mm}^2/\text{m}$

$$f_{ap} = f_{ap,k} / \gamma_{M0} = 280 / 1,05 = 267 \text{ N/mm}^2$$

$$N_{c,pl,Rd} = b \cdot h_c \cdot f_{cd} \cdot (1/b) + A_s \cdot f_{sd} = 1178,7 \text{ kN/m}$$

con  $A_s = 188,5 \text{ mm}^2/\text{m}$

$$f_{sd} = f_{s,k} / \gamma_{M0} = 450 / 1,15 = 391 \text{ N/mm}^2$$

$$f_{cd} = \alpha f_{ck} / \gamma_c = 0,85 \cdot 30 / 1,5 = 17,0 \text{ N/mm}^2$$

■ Verifica a taglio verticale

$$L_p = a_p / 2 = 0,10 \text{ m}$$

distanza del carico concentrato dall'appoggio

$$b_{em} = 0,49 \text{ m}$$

(con  $k = 1$ )

Si noti che essendo l'interasse fra le impronte di carico degli assi tandem pari a 1,50 m  $>$   $b_{em}$ , si farà riferimento alla larghezza collaborante della soletta " $b_{em}$ " per una singola impronta di carico:

$$P_p^* = P_{1,Ed} / 2 = 1,35 \cdot 26 / 2 \text{ kN} = 17,6 \text{ kN}$$

$$v_{Ed} = P_p^* \cdot [1 - L_p / L] / b_{em} = 34,37 \text{ kN/m}$$

$$v_{v,Rd} = \max[0,18 \cdot k \cdot (100 \cdot \rho_l \cdot f_{ck})^{1/3} / \gamma_c ; v_{min}] \cdot (b_0 \cdot d_p) \cdot (1/b) = \max[55,2 \text{ kN} ; 23,6 \text{ kN}] = 55,2 \text{ kN VERIFICATO!}$$

$$\text{con } k = 1 + \sqrt{(200/d_p)} = 2 (\leq 2)$$

$$\rho_l = A_p / (b \cdot d_p) = 0,01433$$

$$v_{min} = 0,035 \cdot k^{3/2} \cdot f_{ck}^{1/2} = 0,54 \text{ N/mm}^2$$

$$b_0 = 75 \text{ mm}$$

#### ▪ Verifica per momento flettente trasversale

$$M_{Ed,t} = P_p \cdot (b_{em} - b_m) / 8 = 2,55 \text{ kNm}$$

momento flettente trasversale

$$\text{con } b_{em} = 1,5475 \text{ m}$$

(con  $k = 2$ )

$$b_m = 0,39 \text{ m}$$

$$P_p^* = P_{1,Ed} / 2 = 1,35 \cdot 26 / 2 \text{ kN} = 17,6 \text{ kN}$$

Tale momento flettente va assorbito da una sezione in calcestruzzo armato di dimensioni  $b_{em} \cdot h_c$ :

$$c = 25 \text{ mm}$$

copriferro armatura

$$d = h_c - c = 40 \text{ mm}$$

altezza utile della sezione

$$a_{s,t} = 188,5 \text{ mm}^2/\text{m}$$

armatura trasversale tesa a metro (Rete  $\Phi 6$  150x150)

$$A_{s,t} = a_{s,t} \cdot b_{em} = 291,7 \text{ mm}^2$$

armatura trasversale tesa per sezione di larghezza  $b_{em}$

$$M_{Rd,t} = A_{s,t} \cdot f_{yd} \cdot (0,9 \cdot d) = 4,11 \text{ kNm}$$

VERIFICATO!

#### ▪ Verifica a punzonamento

##### Geometria

$h_p$	55 mm
$h_c$	65 mm
$h_f$	30 mm
$d_p$	87,5 mm
$d_c$	40 mm

altezza lamiera grecata

altezza soletta al di sopra della lamiera grecata

altezza finiture

altezza utile sezione in dir.y (longitudinale)

altezza utile sezione in dir.z (trasversale)

##### Materiali

$f_{ck}$	30 N/mm <sup>2</sup>
$f_{cd}$	17,0 N/mm <sup>2</sup>
$f_{yk}$	450 N/mm <sup>2</sup>
$f_{yd}$	391,3 N/mm <sup>2</sup>

$$A_{l,y} = 1253,7 \text{ mm}^2$$

area acciaio lamiera grecata (dir.y)

$$A_{s,y} = 188,5 \text{ mm}^2$$

area armatura dir.y

$$A_{s,z} = 188,5 \text{ mm}^2$$

area armatura dir.z

$$\rho_{l,y} = 0,014328$$

rapporto geometrico d'armatura in y

$$\rho_{l,z} = 0,004713$$

rapporto geometrico d'armatura in z

$$\rho_l = 0,008217 (\leq 0,02)$$

rapporto geometrico d'armatura ( $= \sqrt{(\rho_{l,y} + \rho_{l,z})}$ )

##### Verifica a punzonamento

$b_l$	200 mm
$a_l$	200 mm
$C_p$	1538,4 mm
$k$	2 ( $\leq 2$ )
$v_{min}$	0,54 N/mm <sup>2</sup>
$v_{Rd}$	1,97 N/mm <sup>2</sup>
$V_{Rd}$	197,20 kN

base impronta di carico (dir.z)

altezza impronta di carico (dir.y)

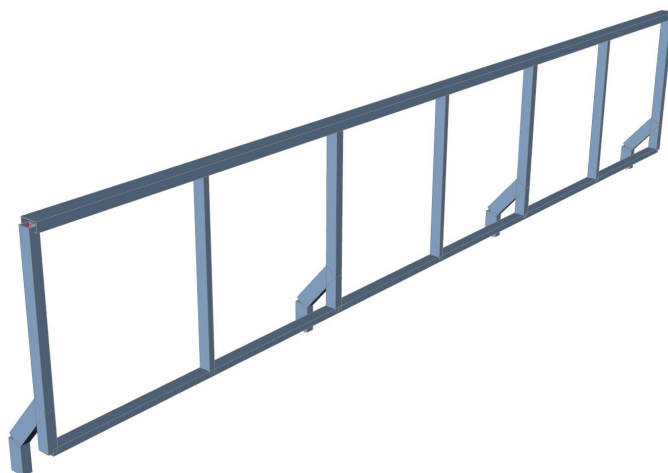
perimetro critico

$$V_{Ed} = 35,10 \text{ kN}$$

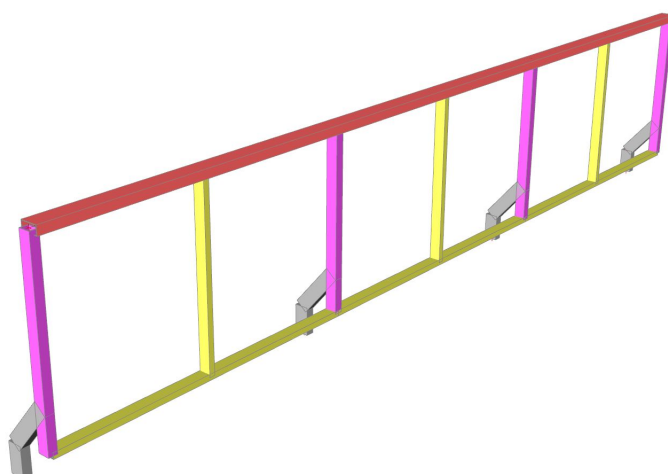
(17,8%)

## 14. VERIFICA PARAPETTO


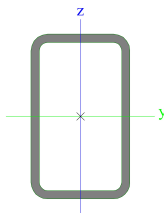
### 14.1. Modello di calcolo




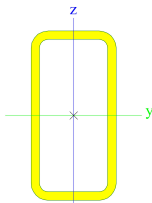

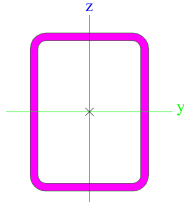

### 14.2. Modello di calcolo - Individuazione profili

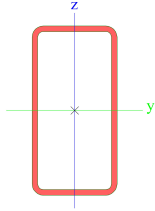


### 14.3. Profili utilizzati

CS1		
Type	CFRHS100X60X5	
Formcode	2 - Rectangular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	cold formed	
Colour		
Flexural buckling y-y, Flexural buckling z-z	c	c
A [m²]	1,4360e-03	
A <sub>y</sub> [m²], A <sub>z</sub> [m²]	5,3791e-04	8,9652e-04
A <sub>L</sub> [m²/m], A <sub>D</sub> [m²/m]	3,0300e-01	5,7413e-01
c <sub>Y,UCS</sub> [mm], c <sub>Z,UCS</sub> [mm]	30	50
α [deg]	0,00	
I <sub>y</sub> [m⁴], I <sub>z</sub> [m⁴]	1,8077e-06	8,0830e-07
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	35	24
W <sub>el,y</sub> [m³], W <sub>el,z</sub> [m³]	3,6150e-05	2,6940e-05
W <sub>pl,y</sub> [m³], W <sub>pl,z</sub> [m³]	4,5590e-05	3,1880e-05
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	1,62e+04	1,62e+04
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	1,13e+04	1,13e+04
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m⁴], I <sub>w</sub> [m⁶]	1,8786e-06	1,2000e-09
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		


CS2		
Type	CFRHS80X40X4	
Formcode	2 - Rectangular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	cold formed	
Colour		
Flexural buckling y-y, Flexural buckling z-z	c	c
A [m²]	8,5500e-04	
A <sub>y</sub> [m²], A <sub>z</sub> [m²]	2,8468e-04	5,6935e-04
A <sub>L</sub> [m²/m], A <sub>D</sub> [m²/m]	2,2600e-01	4,2730e-01
c <sub>Y,UCS</sub> [mm], c <sub>Z,UCS</sub> [mm]	20	40
α [deg]	0,00	
I <sub>y</sub> [m⁴], I <sub>z</sub> [m⁴]	6,4790e-07	2,1490e-07
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	28	16
W <sub>el,y</sub> [m³], W <sub>el,z</sub> [m³]	1,6200e-05	1,0740e-05
W <sub>pl,y</sub> [m³], W <sub>pl,z</sub> [m³]	2,0910e-05	1,2770e-05

M <sub>pl.y.+</sub> [Nm], M <sub>pl.y.-</sub> [Nm]	7,41e+03	7,41e+03
M <sub>pl.z.+</sub> [Nm], M <sub>pl.z.-</sub> [Nm]	4,53e+03	4,53e+03
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	5,5240e-07	2,0480e-10
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		
CS3		
Type	CFRHS80X60X4	
Formcode	2 - Rectangular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	cold formed	
Colour		
Flexural buckling y-y, Flexural buckling z-z	c	c
A [m <sup>2</sup> ]	1,0150e-03	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	4,3459e-04	5,7945e-04
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	2,6600e-01	5,0730e-01
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	30	40
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	8,7920e-07	5,6120e-07
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	29	24
W <sub>el.y</sub> [m <sup>3</sup> ], W <sub>el.z</sub> [m <sup>3</sup> ]	2,1980e-05	1,8710e-05
W <sub>pl.y</sub> [m <sup>3</sup> ], W <sub>pl.z</sub> [m <sup>3</sup> ]	2,6990e-05	2,2120e-05
M <sub>pl.y.+</sub> [Nm], M <sub>pl.y.-</sub> [Nm]	9,57e+03	9,57e+03
M <sub>pl.z.+</sub> [Nm], M <sub>pl.z.-</sub> [Nm]	7,85e+03	7,85e+03
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	1,1312e-06	5,3760e-10
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		
CS4		
Type	CFRHS120X60X4	
Formcode	2 - Rectangular hollow section	
Shape type	Thin-walled	
Item material	S 355	
Fabrication	cold formed	
Colour		

Flexural buckling y-y, Flexural buckling z-z	c	c
A [m <sup>2</sup> ]	1,3350e-03	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	4,4468e-04	8,8935e-04
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	3,4600e-01	6,6730e-01
c <sub>y,UCS</sub> [mm], c <sub>z,UCS</sub> [mm]	30	60
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	2,4074e-06	8,1250e-07
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	42	25
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	4,0120e-05	2,7080e-05
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	5,0490e-05	3,1080e-05
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	1,79e+04	1,79e+04
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	1,10e+04	1,10e+04
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	2,0112e-06	1,5552e-09
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Picture		

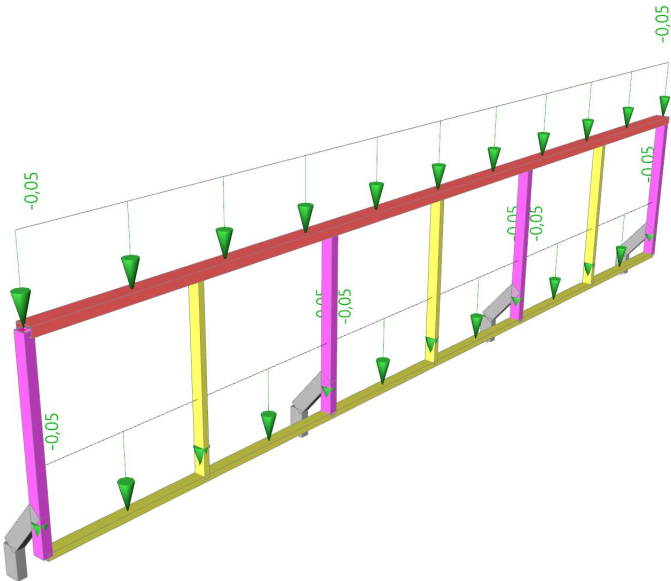
#### 14.4. Materiali

Steel EC3

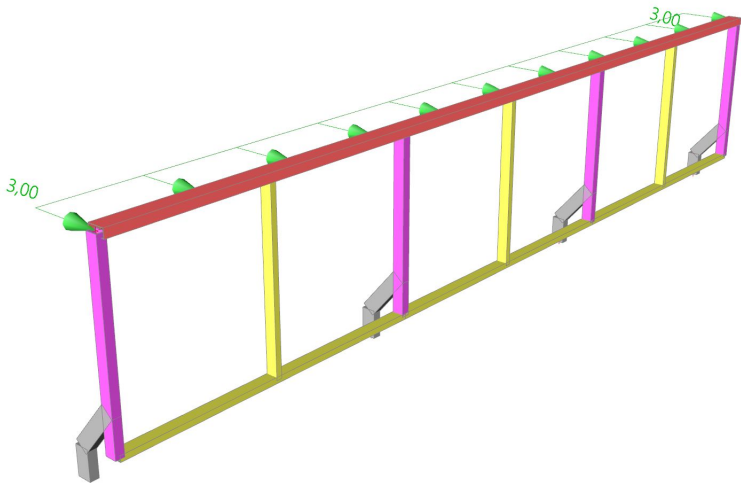
Name	ρ [kg/m <sup>3</sup> ]	E <sub>mod</sub> [MPa] G <sub>mod</sub> [MPa]	μ α [m/mK]	Lower limit [mm]	Upper limit [mm]	F <sub>y</sub> [MPa]	F <sub>u</sub> [MPa]	Colour
S 355	7850,0	2,1000e+05	0,3	0	40	355,0	490,0	
		8,0769e+04	0,00	40	80	335,0	470,0	



14.5. Carico permanente portato - G2



14.6. Carico folla - Q1



#### 14.7. Involuppi combinazioni utilizzate

Name	Description	Type	Load cases	Coeff. [-]
ULS-Set B (auto).1		Envelope - ultimate	G1 - Self weight	1,30
			G2	1,30
ULS-Set B (auto).2		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
ULS-Set B (auto).3		Envelope - ultimate	G1 - Self weight	1,30
			G2	1,30
			Q1	1,50
ULS-Set B (auto).4		Envelope - ultimate	G1 - Self weight	1,00
			G2	1,00
			Q1	1,50
SLS-Char (auto).1		Envelope - serviceability	G1 - Self weight	1,00
			G2	1,00
SLS-Char (auto).2		Envelope - serviceability	G1 - Self weight	1,00
			G2	1,00
			Q1	1,00

#### 14.8. Reazioni vincolari

Linear calculation

Combination: ULS-Set B (auto)

System: Global

Extreme: Global

Selection: All

##### Nodal reactions

Name	Case	R <sub>x</sub> [kN]	R <sub>y</sub> [kN]	R <sub>z</sub> [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	M <sub>z</sub> [kNm]	e <sub>x</sub> [mm]	e <sub>y</sub> [mm]
Sn2/N23	ULS-Set B (auto)/1	-0,28	<b>-10,54</b>	0,60	14,62	-0,07	-0,04	24310,0	-116,9
Sn2/N23	ULS-Set B (auto)/2	0,01	<b>0,01</b>	<b>1,16</b>	0,27	0,00	0,00	229,0	0,7
Sn4/N29	ULS-Set B (auto)/3	0,02	-0,01	<b>0,49</b>	<b>0,13</b>	0,00	0,00	256,6	1,0
Sn2/N23	ULS-Set B (auto)/4	-0,28	-10,53	0,87	<b>14,68</b>	-0,07	-0,04	16896,2	-80,7
Sn1/N19	ULS-Set B (auto)/4	<b>-1,12</b>	-5,06	0,93	8,82	<b>-0,28</b>	-0,20	9517,4	-306,2
Sn4/N29	ULS-Set B (auto)/4	<b>1,12</b>	-5,06	0,93	8,82	<b>0,28</b>	0,20	9517,4	306,2
Sn1/N19	ULS-Set B (auto)/1	-1,11	-5,06	0,78	8,79	-0,28	<b>-0,20</b>	11262,0	-363,7
Sn4/N29	ULS-Set B (auto)/1	1,11	-5,06	0,78	8,79	0,28	<b>0,20</b>	11262,0	363,7

Name	Combination key
ULS-Set B (auto)/1	G1 + G2 + 1.50*Q1
ULS-Set B (auto)/2	1.30*G1 + 1.30*G2
ULS-Set B (auto)/3	G1 + G2
ULS-Set B (auto)/4	1.30*G1 + 1.30*G2 + 1.50*Q1

## 14.9. Verifica profilo CS1

### 14.9.1. EC-EN 1993 Steel check ULS

Linear calculation

Combination: ULS-Set B (auto)

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS1 - CFRHS100X60X5

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B16	0,000 / 0,200 m	CFRHS100X60X5	S 355	ULS-Set B (auto)	0,95 -
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Note: EN 1993-1-3 article 1.1(3) specifies that this part does not apply to cold formed CHS and RHS sections. The default EN 1993-1-1 code check is executed instead of the EN 1993-1-3 code check.

Combination key
ULS-Set B (auto) / 1.30*G1 + 1.30*G2 + 1.50*Q1

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Cold formed	

....SECTION CHECK:....

The critical check is on position 0,000 m

Internal forces	Calculated	Unit
$N_{Ed}$	-0,87	kN
$V_{y,Ed}$	0,28	kN
$V_{z,Ed}$	10,53	kN
$T_{Ed}$	-0,04	kNm
$M_{y,Ed}$	-14,68	kNm
$M_{z,Ed}$	-0,07	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	45	5	3,885e+05	3,846e+05	0,99		1,00	9,00	22,78	27,66	31,03	1
3	I	85	5	3,435e+05	-3,471e+05	-1,01		0,50	17,00	58,88	67,88	101,94	1
5	I	45	5	-3,873e+05	-3,834e+05								
7	I	85	5	-3,423e+05	3,483e+05	-0,98		0,50	17,00	57,79	66,70	99,11	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	1,4360e-03	m <sup>2</sup>
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$N_{c,Rd}$	485,50	kN
Unity check	0,00	-

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	4,5590e-05	m <sup>3</sup>
$M_{pl,y,Rd}$	15,41	kNm
Unity check	0,95	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	3,1880e-05	m <sup>3</sup>
$M_{pl,z,Rd}$	10,78	kNm
Unity check	0,01	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	5,3850e-04	m <sup>2</sup>
$V_{pl,y,Rd}$	105,11	kN
Unity check	0,00	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	8,9750e-04	m <sup>2</sup>
$V_{pl,z,Rd}$	175,19	kN
Unity check	0,06	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	0,8	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,00	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

$M_{N,y,Rd}$	15,41	kNm
$\alpha$	1,66	
$M_{N,z,Rd}$	10,78	kNm
$\beta$	1,66	

Unity check (6.41) = 0,92 + 0,00 = 0,92 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

....**STABILITY CHECK**....

#### Classification for member buckling design

Decisive position for stability classification: 0,000 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	45	5	3,885e+05	3,846e+05	0,99		1,00	9,00	22,78	27,66	31,03	1
3	I	85	5	3,435e+05	-3,471e+05	-1,01		0,50	17,00	58,88	67,88	101,94	1
5	I	45	5	-3,873e+05	-3,834e+05								
7	I	85	5	-3,423e+05	3,483e+05	-0,98		0,50	17,00	57,79	66,70	99,11	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	0,200	0,200	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	0,200	0,200	m
Critical Euler load $N_{cr}$	93666,74	41882,41	kN
Slenderness $\lambda$	5,64	8,43	
Relative slenderness $\lambda_{rel}$	0,07	0,11	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns an RHS section with ' $h / b < 10 / \lambda_{rel,z}$ '.

This section is thus not susceptible to Lateral Torsional Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	1,4360e-03	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	4,5590e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	3,1880e-05	m <sup>3</sup>
Design compression force $N_{Ed}$	0,87	kN
Design bending moment (maximum) $M_{y,Ed}$	-14,68	kNm
Design bending moment (maximum) $M_{z,Ed}$	-0,07	kNm
Characteristic compression resistance $N_{Rk}$	509,78	kN
Characteristic moment resistance $M_{y,Rk}$	16,18	kNm
Characteristic moment resistance $M_{z,Rk}$	11,32	kNm
Reduction factor $\chi_y$	1,00	
Reduction factor $\chi_z$	1,00	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	0,97	
Interaction factor $k_{yz}$	0,48	
Interaction factor $k_{zy}$	0,60	
Interaction factor $k_{zz}$	0,83	

Maximum moment  $M_{y,Ed}$  is derived from beam B16 position 0,000 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B16 position 0,000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	93666,74	kN
Critical Euler load $N_{cr,z}$	41882,41	kN
Elastic critical load $N_{cr,T}$	117422,41	kN
Plastic section modulus $W_{pl,y}$	4,5590e-05	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	3,6150e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	3,1880e-05	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	2,6940e-05	m <sup>3</sup>
Second moment of area $I_y$	1,8077e-06	m <sup>4</sup>
Second moment of area $I_z$	8,0830e-07	m <sup>4</sup>
Torsional constant $I_t$	1,8786e-06	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments $\psi_y$	0,86	
Equivalent moment factor $C_{my,0}$	0,97	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments $\psi_z$	0,21	
Equivalent moment factor $C_{mz,0}$	0,83	
Factor $\mu_y$	1,00	
Factor $\mu_z$	1,00	
Factor $\epsilon_y$	671,17	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	2993,18	kNm
Relative slenderness $\lambda_{rel,0}$	0,07	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,21	
Equivalent moment factor $C_{my}$	0,97	
Equivalent moment factor $C_{mz}$	0,83	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,00	
Factor $w_y$	1,26	
Factor $w_z$	1,18	
Factor $n_{pl}$	0,00	
Maximum relative slenderness $\lambda_{rel,max}$	0,11	
Factor $C_{yy}$	1,00	
Factor $C_{yz}$	1,00	
Factor $C_{zy}$	1,00	
Factor $C_{zz}$	1,00	

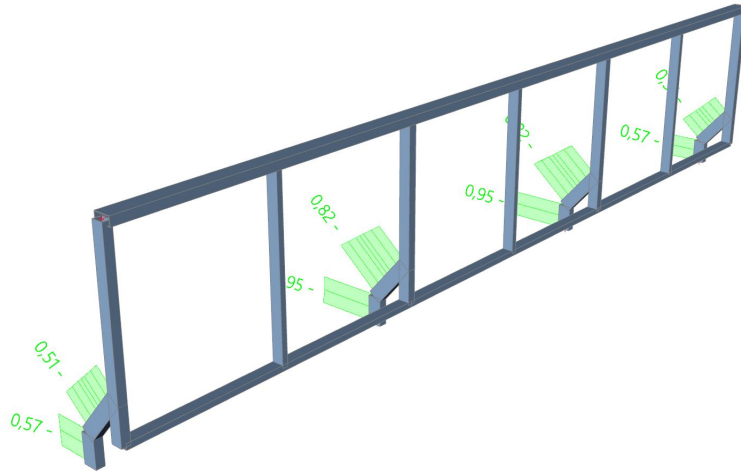
Unity check (6.61) = 0,00 + 0,92 + 0,00 = 0,93 -

Unity check (6.62) = 0,00 + 0,57 + 0,01 = 0,58 -

The member satisfies the stability check.

#### 14.9.2. Sfruttamento profilo

Values:  $UC_{Overall}$   
Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Principal  
Extreme 1D: Member  
Selection: All  
Filter: Cross-section = CS1 -  
CFRHS100X60X5



## 14.10. Verifica profilo CS2

### 14.10.1. EC-EN 1993 Steel check ULS

Linear calculation

Combination: ULS-Set B (auto)

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS2 - CFRHS80X40X4

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B9	0,221 / 1,252 m	CFRHS80X40X4	S 355	ULS-Set B (auto)	0,11 -
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Note: EN 1993-1-3 article 1.1(3) specifies that this part does not apply to cold formed CHS and RHS sections. The default EN 1993-1-1 code check is executed instead of the EN 1993-1-3 code check.

Combination key
ULS-Set B (auto) / G1 + G2 + 1.50*Q1

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Cold formed	

...:SECTION CHECK:...

The critical check is on position 0,221 m

Internal forces	Calculated	Unit
$N_{Ed}$	0,00	kN
$V_{y,Ed}$	-0,17	kN
$V_{z,Ed}$	-0,11	kN
$T_{Ed}$	-0,19	kNm
$M_{y,Ed}$	-0,63	kNm
$M_{z,Ed}$	0,07	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	28	4	3,273e+04	4,145e+04	0,79		1,00	7,00	22,78	27,66	33,35	1
3	I	68	4	3,879e+04	-2,758e+04	-0,71		0,58	17,00	46,30	54,31	76,11	1
5	I	28	4	-3,273e+04	-4,145e+04								
7	I	68	4	-3,879e+04	2,758e+04	-1,41		0,42	17,00	70,48	81,24	143,93	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	2,0910e-05	m <sup>3</sup>
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$M_{pl,y,Rd}$	7,07	kNm
Unity check	0,09	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	1,2770e-05	m <sup>3</sup>
$M_{pl,z,Rd}$	4,32	kNm
Unity check	0,02	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	2,8500e-04	m <sup>2</sup>
$V_{pl,y,Rd}$	55,63	kN
Unity check	0,00	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	5,7000e-04	m <sup>2</sup>
$V_{pl,z,Rd}$	111,26	kN
Unity check	0,00	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	8,6	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,04	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

$M_{N,y,Rd}$	7,07	kNm
$\alpha$	1,66	
$M_{N,z,Rd}$	4,32	kNm
$\beta$	1,66	

Unity check (6.41) = 0,02 + 0,00 = 0,02 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

#### ...:STABILITY CHECK:...

#### Classification for member buckling design

Decisive position for stability classification: 1,252 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	28	4	5,067e+04	3,654e+04	0,72		1,00	7,00	22,78	27,66	34,23	1
3	I	68	4	2,992e+04	-4,825e+04	-1,61		0,38	17,00	76,53	88,22	167,37	1

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
5	I	28	4	-5,083e+04	-3,669e+04								
7	I	68	4	-3,008e+04	4,809e+04	-0,63		0,62	17,00	43,01	50,69	70,91	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	1,252	1,252	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	1,252	1,252	m
Critical Euler load $N_{cr}$	856,26	284,01	kN
Slenderness $\lambda$	45,49	78,99	
Relative slenderness $\lambda_{rel}$	0,60	1,03	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns an RHS section with ' $h / b < 10 / \lambda_{rel,z}'$ .

This section is thus not susceptible to Lateral Torsional Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	8,5500e-04	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	2,0910e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	1,2770e-05	m <sup>3</sup>
Design compression force $N_{Ed}$	0,00	kN
Design bending moment (maximum) $M_{y,Ed}$	-0,74	kNm
Design bending moment (maximum) $M_{z,Ed}$	-0,11	kNm
Characteristic compression resistance $N_{Rk}$	303,52	kN
Characteristic moment resistance $M_{y,Rk}$	7,42	kNm
Characteristic moment resistance $M_{z,Rk}$	4,53	kNm
Reduction factor $\chi_y$	1,00	
Reduction factor $\chi_z$	1,00	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,00	
Interaction factor $k_{yz}$	0,34	
Interaction factor $k_{zy}$	0,62	
Interaction factor $k_{zz}$	0,59	

Maximum moment  $M_{y,Ed}$  is derived from beam B9 position 1,252 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B9 position 1,252 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	856,26	kN
Critical Euler load $N_{cr,z}$	284,01	kN
Elastic critical load $N_{cr,T}$	44481,79	kN
Plastic section modulus $W_{pl,y}$	2,0910e-05	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	1,6200e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	1,2770e-05	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	1,0740e-05	m <sup>3</sup>
Second moment of area $I_y$	6,4790e-07	m <sup>4</sup>
Second moment of area $I_z$	2,1490e-07	m <sup>4</sup>
Torsional constant $I_t$	5,5240e-07	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments $\psi_y$	0,82	
Equivalent moment factor $C_{my,0}$	0,96	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments $\psi_z$	-0,96	
Equivalent moment factor $C_{mz,0}$	0,59	
Factor $\mu_y$	1,00	
Factor $\mu_z$	1,00	
Factor $\epsilon_y$	632189,16	
Factor $a_{LT}$	0,15	
Critical moment for uniform bending $M_{cr,0}$	112,91	kNm
Relative slenderness $\lambda_{rel,0}$	0,26	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,21	
Equivalent moment factor $C_{my}$	1,00	
Equivalent moment factor $C_{mz}$	0,59	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,01	
Factor $w_y$	1,29	
Factor $w_z$	1,19	
Factor $n_{pl}$	0,00	
Maximum relative slenderness $\lambda_{rel,max}$	1,03	
Factor $C_{yy}$	1,00	
Factor $C_{yz}$	1,00	
Factor $C_{zy}$	1,00	
Factor $C_{zz}$	1,00	

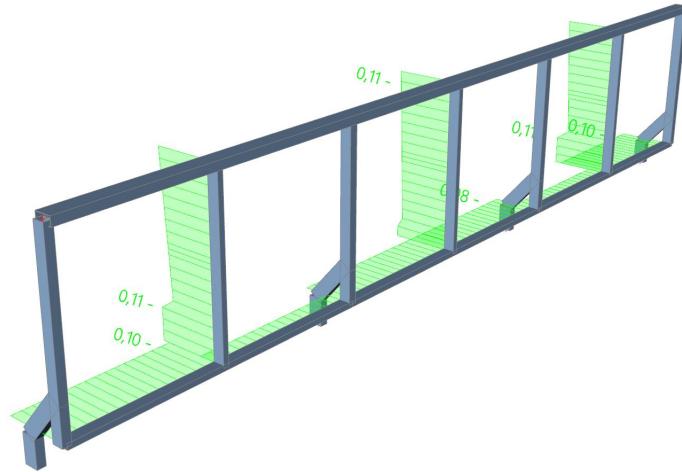
Unity check (6.61) = 0,00 + 0,11 + 0,01 = 0,11 –

Unity check (6.62) = 0,00 + 0,07 + 0,01 = 0,08 –

The member satisfies the stability check.

#### 14.10.2. Sfruttamento profilo

Values:  $UC_{Overall}$   
Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Principal  
Extreme 1D: Member  
Selection: All  
Filter: Cross-section = CS2 -  
CFRHS80X40X4



#### 14.11. Verifica profilo CS3

##### 14.11.1. EC-EN 1993 Steel check ULS

Linear calculation

Combination: ULS-Set B (auto)

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS3 - CFRHS80X60X4

##### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B2	0,272 / 1,252 m	CFRHS80X60X4	S 355	ULS-Set B (auto)	0,96 -
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Note: EN 1993-1-3 article 1.1(3) specifies that this part does not apply to cold formed CHS and RHS sections.  
The default EN 1993-1-1 code check is executed instead of the EN 1993-1-3 code check.

Combination key
ULS-Set B (auto) / G1 + G2 + 1.50*Q1

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Cold formed	

....SECTION CHECK:....

The critical check is on position 0,272 m

Internal forces	Calculated	Unit
$N_{Ed}$	-0,36	kN
$V_{y,Ed}$	-0,14	kN
$V_{z,Ed}$	10,42	kN
$T_{Ed}$	-0,21	kNm
$M_{y,Ed}$	-8,72	kNm
$M_{z,Ed}$	0,04	kNm

##### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	48	4	3,759e+05	3,792e+05	0,99		1,00	12,00	22,78	27,66	31,01	1
3	I	68	4	3,398e+05	-3,352e+05	-0,99		0,50	17,00	57,96	66,87	99,50	1
5	I	48	4	-3,751e+05	-3,785e+05								
7	I	68	4	-3,391e+05	3,359e+05	-1,01		0,50	17,00	58,86	67,85	101,85	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

##### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	1,0150e-03	m <sup>2</sup>
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$N_{c,Rd}$	343,17	kN
Unity check	0,00	-

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	2,6990e-05	m <sup>3</sup>
$M_{pl,y,Rd}$	9,13	kNm
Unity check	0,96	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	2,2120e-05	m <sup>3</sup>
$M_{pl,z,Rd}$	7,48	kNm
Unity check	0,01	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	4,3500e-04	m <sup>2</sup>
$V_{pl,y,Rd}$	84,91	kN
Unity check	0,00	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	5,8000e-04	m <sup>2</sup>
$V_{pl,z,Rd}$	113,22	kN
Unity check	0,09	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	6,1	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,03	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

$M_{N,y,Rd}$	9,13	kNm
$\alpha$	1,66	
$M_{N,z,Rd}$	7,48	kNm
$\beta$	1,66	

Unity check (6.41) = 0,93 + 0,00 = 0,93 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

....**STABILITY CHECK**....

#### Classification for member buckling design

Decisive position for stability classification: 0,272 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	48	4	3,759e+05	3,792e+05	0,99		1,00	12,00	22,78	27,66	31,01	1
3	I	68	4	3,398e+05	-3,352e+05	-0,99		0,50	17,00	57,96	66,87	99,50	1
5	I	48	4	-3,751e+05	-3,785e+05								
7	I	68	4	-3,391e+05	3,359e+05	-1,01		0,50	17,00	58,86	67,85	101,85	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	1,252	1,252	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	1,252	1,252	m
Critical Euler load $N_{cr}$	1161,94	741,68	kN
Slenderness $\lambda$	42,55	53,26	
Relative slenderness $\lambda_{rel}$	0,56	0,70	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns an RHS section with ' $h / b < 10 / \lambda_{rel,z}$ '.

This section is thus not susceptible to Lateral Torsional Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	1,0150e-03	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	2,6990e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	2,2120e-05	m <sup>3</sup>
Design compression force $N_{Ed}$	0,36	kN
Design bending moment (maximum) $M_{y,Ed}$	-7,94	kNm
Design bending moment (maximum) $M_{z,Ed}$	-0,10	kNm
Characteristic compression resistance $N_{Rk}$	360,32	kN
Characteristic moment resistance $M_{y,Rk}$	9,58	kNm
Characteristic moment resistance $M_{z,Rk}$	7,85	kNm
Reduction factor $\chi_y$	1,00	
Reduction factor $\chi_z$	1,00	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,00	
Interaction factor $k_{yz}$	0,59	
Interaction factor $k_{zy}$	0,61	
Interaction factor $k_{zz}$	1,00	

Maximum moment  $M_{y,Ed}$  is derived from beam B2 position 0,348 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B2 position 1,252 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	1161,94	kN
Critical Euler load $N_{cr,z}$	741,68	kN
Elastic critical load $N_{cr,T}$	64883,22	kN
Plastic section modulus $W_{pl,y}$	2,6990e-05	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	2,1980e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	2,2120e-05	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	1,8710e-05	m <sup>3</sup>
Second moment of area $I_y$	8,7920e-07	m <sup>4</sup>
Second moment of area $I_z$	5,6120e-07	m <sup>4</sup>
Torsional constant $I_t$	1,1312e-06	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-7,94	kNm
Maximum relative deflection $\delta_z$	4,4	mm
Equivalent moment factor $C_{my,0}$	1,00	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{z,Ed}$	-0,10	kNm
Maximum relative deflection $\delta_y$	0,0	mm
Equivalent moment factor $C_{mz,0}$	1,00	
Factor $\mu_y$	1,00	
Factor $\mu_z$	1,00	
Factor $\epsilon_y$	1014,36	
Factor $a_{LT}$	0,00	
Critical moment for uniform bending $M_{cr,0}$	261,33	kNm
Relative slenderness $\lambda_{rel,0}$	0,19	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,24	
Equivalent moment factor $C_{my}$	1,00	
Equivalent moment factor $C_{mz}$	1,00	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,00	
Factor $w_y$	1,23	
Factor $w_z$	1,18	
Factor $n_{pl}$	0,00	
Maximum relative slenderness $\lambda_{rel,max}$	0,70	
Factor $C_{yy}$	1,00	
Factor $C_{yz}$	1,00	
Factor $C_{zy}$	1,00	
Factor $C_{zz}$	1,00	

Unity check (6.61) = 0,00 + 0,87 + 0,01 = 0,88 -

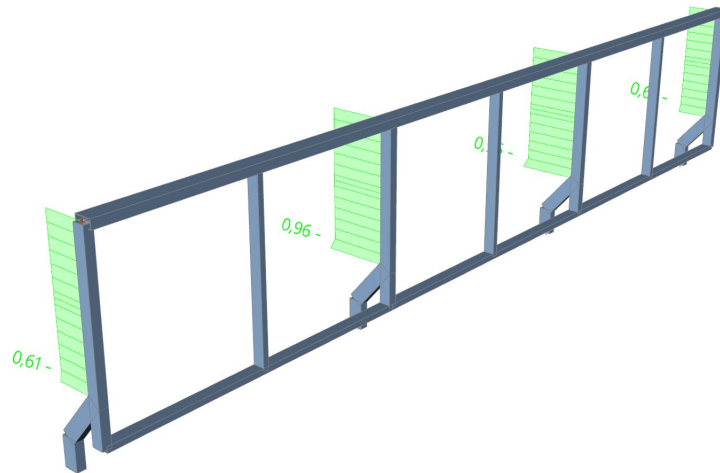
Unity check (6.62) = 0,00 + 0,53 + 0,01 = 0,55 -

The member satisfies the stability check.



#### 14.11.2. Sfruttamento profilo

Values:  $UC_{Overall}$   
Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Principal  
Extreme 1D: Member  
Selection: All  
Filter: Cross-section = CS3 -  
CFRHS80X60X4



## 14.12. Verifica profilo CS4

### 14.12.1. EC-EN 1993 Steel check ULS

Linear calculation

Combination: ULS-Set B (auto)

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = CS4 - CFRHS120X60X4

#### EN 1993-1-1 Code Check

National annex: Italian UNI-EN NA

Member B5	1,155 / 6,930 m	CFRHS120X60X4	S 355	ULS-Set B (auto)	0,15 -
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Note: EN 1993-1-3 article 1.1(3) specifies that this part does not apply to cold formed CHS and RHS sections. The default EN 1993-1-1 code check is executed instead of the EN 1993-1-3 code check.

Combination key
ULS-Set B (auto) / 1.30*G1 + 1.30*G2 + 1.50*Q1

Partial safety factors	
$\gamma_{M0}$ for resistance of cross-sections	1,05
$\gamma_{M1}$ for resistance to instability	1,05
$\gamma_{M2}$ for resistance of net sections	1,25

Material		
Yield strength $f_y$	355,0	MPa
Ultimate strength $f_u$	490,0	MPa
Fabrication	Cold formed	

...:SECTION CHECK:...

The critical check is on position 1,155 m

Internal forces	Calculated	Unit
$N_{Ed}$	-0,26	kN
$V_{y,Ed}$	0,18	kN
$V_{z,Ed}$	0,12	kN
$T_{Ed}$	0,36	kNm
$M_{y,Ed}$	2,45	kNm
$M_{z,Ed}$	0,15	kNm

#### Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	48	4	-6,324e+04	-5,434e+04								
3	I	108	4	-4,953e+04	6,031e+04	-0,82		0,55	27,00	50,76	59,17	84,02	1
5	I	48	4	6,363e+04	5,474e+04	0,86		1,00	12,00	22,78	27,66	32,49	1
7	I	108	4	4,993e+04	-5,992e+04	-1,20		0,45	27,00	64,44	74,28	121,57	1

**Note:** The Classification limits have been set according to Semi-Comp+.

The cross-section is classified as Class 1

#### Compression check

According to EN 1993-1-1 article 6.2.4 and formula (6.9)

A	1,3350e-03	m <sup>2</sup>
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$N_{c,Rd}$	451,36	kN
Unity check	0,00	-

#### Bending moment check for $M_y$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	5,0490e-05	m <sup>3</sup>
$M_{pl,y,Rd}$	17,07	kNm
Unity check	0,14	-

#### Bending moment check for $M_z$

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	3,1080e-05	m <sup>3</sup>
$M_{pl,z,Rd}$	10,51	kNm
Unity check	0,01	-

#### Shear check for $V_y$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	4,4500e-04	m <sup>2</sup>
$V_{pl,y,Rd}$	86,86	kN
Unity check	0,00	-

#### Shear check for $V_z$

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

$\eta$	1,20	
$A_v$	8,9000e-04	m <sup>2</sup>
$V_{pl,z,Rd}$	173,73	kN
Unity check	0,00	-

#### Torsion check

According to EN 1993-1-1 article 6.2.7 and formula (6.23)

Fibre	1	
$\tau_{Ed}$	6,9	MPa
$\tau_{Rd}$	195,2	MPa
Unity check	0,04	-

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

#### Combined bending, axial force and shear force check

According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

$M_{N,y,Rd}$	17,07	kNm
$\alpha$	1,66	
$M_{N,z,Rd}$	10,51	kNm
$\beta$	1,66	

Unity check (6.41) = 0,04 + 0,00 = 0,04 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

....**STABILITY CHECK**....

#### Classification for member buckling design

Decisive position for stability classification: 0,072 m

Classification according to EN 1993-1-1 article 5.5.2

Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

Id	Type	c [mm]	t [mm]	$\sigma_1$ [kN/m <sup>2</sup> ]	$\sigma_2$ [kN/m <sup>2</sup> ]	$\psi$ [-]	$k_\sigma$ [-]	$\alpha$ [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	48	4	1,274e+04	2,959e+03	0,23		1,00	12,00	22,78	27,66	42,15	1
3	I	108	4	1,615e+03	-1,264e+04	-7,82		0,11	27,00	258,45	297,93	1245,00	1
5	I	48	4	-1,235e+04	-2,566e+03								
7	I	108	4	-1,223e+03	1,303e+04	-0,09		0,91	27,00	25,45	30,78	49,83	2

**Note:** The Classification limits have been set according to Semi-Comp+.  
The cross-section is classified as Class 2

#### Flexural Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Buckling parameters	yy	zz	
Sway type	non-sway	non-sway	
System length L	6,930	1,155	m
Buckling factor k	1,00	1,00	
Buckling length $l_{cr}$	6,930	1,155	m
Critical Euler load $N_{cr}$	103,90	1262,35	kN
Slenderness $\lambda$	163,19	46,82	
Relative slenderness $\lambda_{rel}$	2,14	0,61	
Limit slenderness $\lambda_{rel,0}$	0,20	0,20	

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

#### Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

#### Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1

**Note:** The cross-section concerns an RHS section with ' $h / b < 10 / \lambda_{rel,z}$ '.  
This section is thus not susceptible to Lateral Torsional Buckling.

#### Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	1,3350e-03	m <sup>2</sup>
Plastic section modulus $W_{pl,y}$	5,0490e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	3,1080e-05	m <sup>3</sup>
Design compression force $N_{Ed}$	0,26	kN
Design bending moment (maximum) $M_{y,Ed}$	2,43	kNm
Design bending moment (maximum) $M_{z,Ed}$	-0,19	kNm
Characteristic compression resistance $N_{Rk}$	473,93	kN
Characteristic moment resistance $M_{y,Rk}$	17,92	kNm
Characteristic moment resistance $M_{z,Rk}$	11,03	kNm
Reduction factor $\chi_y$	1,00	
Reduction factor $\chi_z$	1,00	
Reduction factor $\chi_{LT}$	1,00	
Interaction factor $k_{yy}$	1,00	
Interaction factor $k_{yz}$	0,57	
Interaction factor $k_{zy}$	0,63	
Interaction factor $k_{zz}$	1,00	

Maximum moment  $M_{y,Ed}$  is derived from beam B5 position 1,083 m.

Maximum moment  $M_{z,Ed}$  is derived from beam B5 position 0,000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	103,90	kN
Critical Euler load $N_{cr,z}$	1262,35	kN
Elastic critical load $N_{cr,T}$	68352,18	kN
Plastic section modulus $W_{pl,y}$	5,0490e-05	m <sup>3</sup>
Elastic section modulus $W_{el,y}$	4,0120e-05	m <sup>3</sup>
Plastic section modulus $W_{pl,z}$	3,1080e-05	m <sup>3</sup>
Elastic section modulus $W_{el,z}$	2,7080e-05	m <sup>3</sup>
Second moment of area $I_y$	2,4074e-06	m <sup>4</sup>
Second moment of area $I_z$	8,1250e-07	m <sup>4</sup>
Torsional constant $I_t$	2,0112e-06	m <sup>4</sup>
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	2,43	kNm
Maximum relative deflection $\delta_z$	-14,7	mm
Equivalent moment factor $C_{my,0}$	1,00	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{z,Ed}$	-0,19	kNm
Maximum relative deflection $\delta_y$	0,0	mm
Equivalent moment factor $C_{mz,0}$	1,00	
Factor $\mu_y$	1,00	
Factor $\mu_z$	1,00	
Factor $\epsilon_y$	308,50	
Factor $a_{LT}$	0,16	
Critical moment for uniform bending $M_{cr,0}$	456,19	kNm
Relative slenderness $\lambda_{rel,0}$	0,20	
Limit relative slenderness $\lambda_{rel,0,lim}$	0,24	
Equivalent moment factor $C_{my}$	1,00	
Equivalent moment factor $C_{mz}$	1,00	
Equivalent moment factor $C_{mLT}$	1,00	
Factor $b_{LT}$	0,00	
Factor $c_{LT}$	0,00	
Factor $d_{LT}$	0,00	
Factor $e_{LT}$	0,03	
Factor $w_y$	1,26	
Factor $w_z$	1,15	
Factor $n_{pl}$	0,00	
Maximum relative slenderness $\lambda_{rel,max}$	2,14	
Factor $C_{yy}$	1,00	
Factor $C_{yz}$	1,00	
Factor $C_{zy}$	1,00	
Factor $C_{zz}$	1,00	

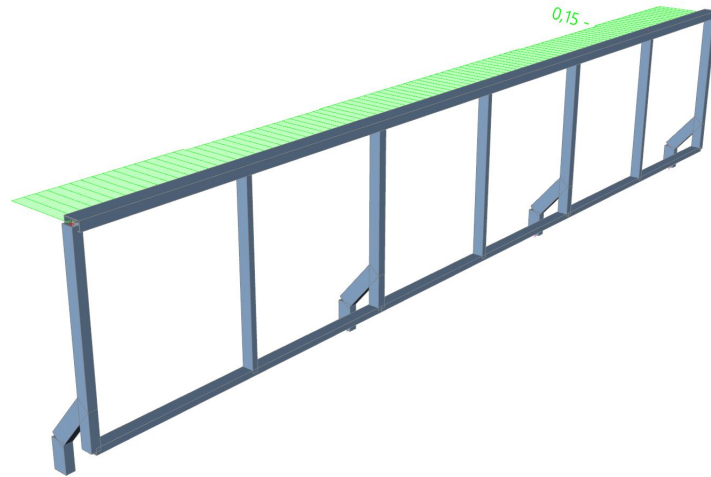
Unity check (6.61) = 0,00 + 0,14 + 0,01 = 0,15 -

Unity check (6.62) = 0,00 + 0,09 + 0,02 = 0,11 -

The member satisfies the stability check.

#### 14.12.2. Sfruttamento profilo

Values:  $UC_{Overall}$   
Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Principal  
Extreme 1D: Member  
Selection: All  
Filter: Cross-section = CS4 -  
CFRHS120X60X4

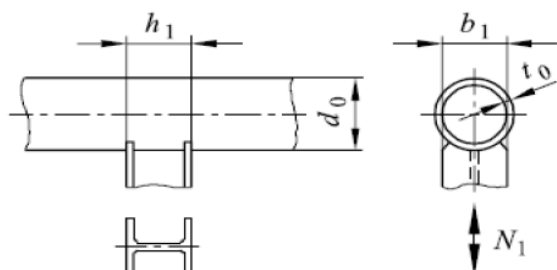


## 15. VERIFICHE NODI PRINCIPALI

### 15.1. Connessione parapetto su traverso

Collegamento saldato tra sezione ad H/I con sezione circolare cava CHS

(UNI EN 1993-1-8 + Errata corrige n°2 26/08/2010 , §7.4.2, Prospetto 7.4)



$$N_{1,Rd} = k_p f_{y0} t_0^2 (4 + 20\beta^2) (1 + 0,25\eta) / \gamma_{M5}$$

$$M_{ip,1,Rd} = h_1 N_{1,Rd} / (1 + 0,25\eta)$$

$$M_{op,1,Rd} = 0,5 b_1 N_{1,Rd}$$

$$\gamma_{M5} = 1,00$$

Materiale profilo CHS

$$f_{yk,0} = 355 \text{ N/mm}^2$$

$$\gamma_{M2} = 1,25$$

$$f_{y0} = 284 \text{ N/mm}^2$$

Materiale profilo H o I

$$f_{yk,1} = 355 \text{ N/mm}^2$$

$$\gamma_{M2} = 1,25$$

$$f_{y1} = 284 \text{ N/mm}^2$$

Geometria profilo CHS

$$d_0 = 244,5 \text{ mm}$$

$$t_0 = 8 \text{ mm}$$

$$d_0/t_0 = 30,56 \text{ classe 1}$$

Geometria profilo H o I

$$h_1 = 210 \text{ mm}$$

$$b_1 = 100 \text{ mm}$$

$$t_{f,1} = 5 \text{ mm}$$

$$A_1 = 2000 \text{ mm}^2$$

$$W_{el,ip,1} = 131825,4 \text{ mm}^3$$

$$W_{el,op,1} = 16708,3 \text{ mm}^3$$

(spessore piattabanda profilo H o I)

Sollecitazioni allo SLU del profilo H o I

$$N_{1,Ed} = 0 \text{ kN}$$

$$M_{ip,1,Ed} = 13,6 \text{ kNm}$$

$$M_{op,1,Ed} = 0 \text{ kNm}$$

Collasso della faccia del corrente del profilo CHS

$$\beta = 0,409 (\geq 0,4) \quad (= b_1/d_0)$$

$$\eta = 0,8589 (\leq 4) \quad (= h_1/d_0)$$

$$\sigma_{0,Ed,CHS} = 0,0 \text{ N/mm}^2 \quad (\text{massima tensione di compressione nel CHS})$$

$$n_p = 0,000 \quad (= (\sigma_{0,Ed}/f_{y0})/\gamma_{M5})$$

$$k_p = 1,000$$

$$N_{1,Rd} = 162,2 \text{ kN} \quad (0,0\%)$$

$$M_{ip,1,Rd} = 28,0 \text{ kNm} \quad (48,5\%)$$

$$M_{op,1,Rd} = 8,1 \text{ kNm} \quad (0,0\%)$$

Punzonamento per taglio del profilo CHS

Per sezioni ad H/I con  $\eta > 2$  (per compressione assiale e flessione fuori dal piano):

$$\eta = 0,86 \leq 2 \quad \text{verifica non necessaria!}$$

$$\sigma_{N,1} = 0,0 \text{ N/mm}^2 \quad (= N_{1,Ed}/A_1)$$

$$\sigma_{M,op,1} = 0,0 \text{ N/mm}^2 \quad (= M_{op,1,Ed}/W_{el,op,1})$$

$$\sigma_{max,op,1} = 0,0 \text{ N/mm}^2 \quad (= N_{1,Ed}/A_1 + M_{op,1,Ed}/W_{el,op,1})$$

$$\sigma_{max,op,1}^{\dagger f,1} = 0,0 \text{ N/mm} \leq 1311,7 \text{ N/mm} \quad (0,0\%)$$

Per tutti gli altri casi:

$$\sigma_{N,1} = 0,0 \text{ N/mm}^2 \quad (= N_{1,Ed}/A_1)$$

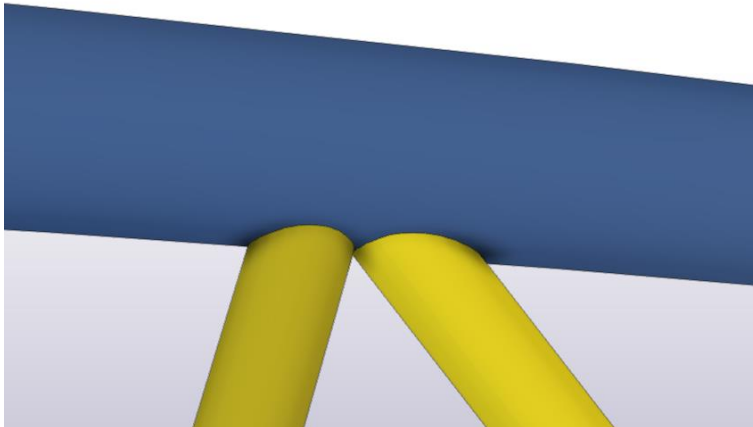
$\sigma_{M,ip,1}$	103,2 N/mm <sup>2</sup>		(= $M_{ip,1,Ed}/W_{el,ip,1}$ )
$\sigma_{max,ip,1}$	103,2 N/mm <sup>2</sup>		(= $N_{1,Ed}/A_1 + M_{ip,1,Ed}/W_{el,ip,1}$ )
$\sigma_{max,ip,1}t_{f,1}$	515,8 N/mm	≤	2623,5 N/mm (19,7%)

Verifica per azioni combinate di momento flettente e sforzo normale

$$N_{1,Ed}/N_{1,RD} + [M_{ip,1,Ed}/M_{ip,1,Rd}]^2 + [M_{op,1,Ed}/M_{op,1,Rd}] = 0,24 \leq 1,00$$



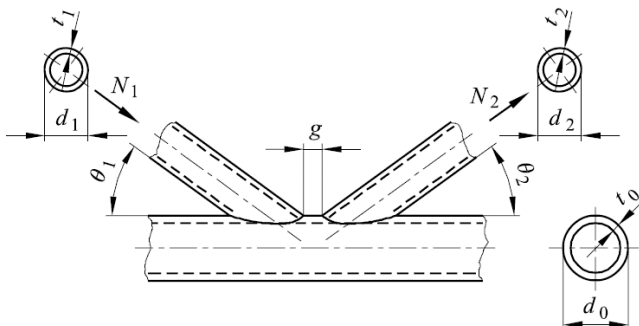
## 15.2. Connessione diagonale di parete su arco



Profilo dell'arco: HFCBS 406,4\*25

Profilo diagonale: HFCBS 193,7\*6,3

Estremi sollecitazioni diagonali: -90,3 kN (compressione)  
+297,7 kN (trazione)



### Dati

Classe acciaio	S 355		
Tensione di snervamento acciaio	$f_{y0}$	355	MPa
Tensione di rottura acciaio	$f_{u0}$	510	MPa
Diametro esterno corrente	$d_0$	406,4	mm
Spessore corrente	$t_0$	25,0	mm
Diametro esterno diagonale	$d_1$	193,7	mm
Spessore diagonale	$t_1$	6,3	mm
Inclinazione diagonale 1	$\theta_1$	82	°
Inclinazione diagonale 2	$\theta_2$	23	°
Coefficiente di sicurezza	$\alpha_{MS}$	1,00	
Gap	$g$	5,00	mm

### Campo di validità

Rapporto spessori tubi ( $0,2 \leq d_1/d_0 \leq 1,0$ )	$d_1/d_0$	0,48	
Classificazione della sezione - corrente "0"	$d_0/t_0$	16,3	classe 1
Classificazione della sezione - diagonale "1"	$d_1/t_1$	30,7	classe 1

### Sollecitazioni di progetto

Azione assiale di progetto	$N_1$	-90,3	kN
	$N_2$	297,7	kN
Sfruttamento del corrente "0" (+ di compressione ; - di trazione)	$n_p$	33,0	%

### Resistenze assiali di progetto

Coefficienti	$\beta$	0,48
	$\gamma$	8,1
	$k_g$	1,87
	$k_p$	0,87

### Collasso della faccia del corrente:

Resistenza assiale di progetto	$N_{1,Rd}$	2423,0	kN
Resistenza assiale di progetto	$N_{2,Rd}$	6141,2	kN

Punzonamento per taglio:

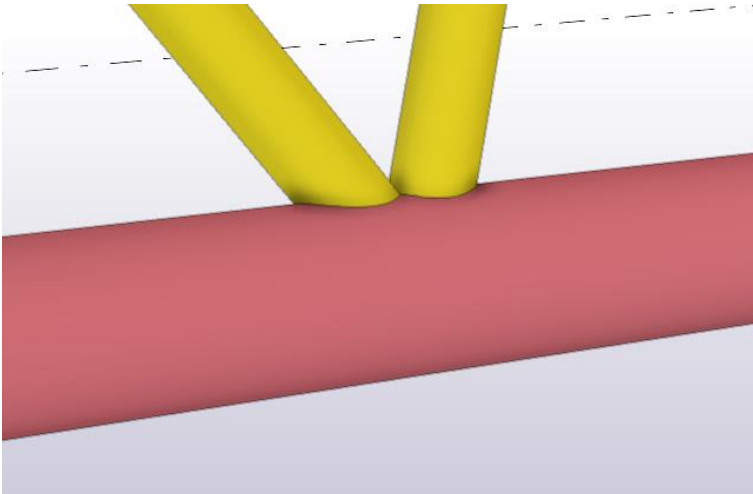
Condizione necessaria per la verifica ( $d_1 \leq d_0 - 2t_0$ )

Verifica necessaria!

Resistenza assiale di progetto diagonale 1	$N_{1,Rd}$	3164,3	kN
Resistenza assiale di progetto diagonale 2	$N_{2,Rd}$	2211,1	kN

Verifica soddisfatta.

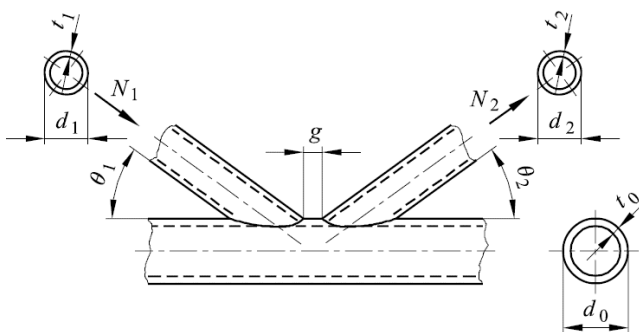
### 15.3. Connessione diagonale di parete su corrente



Profilo del corrente: HFCHS 406,4\*12,5

Profilo diagonale: HFCHS 193,7\*6,3

Estremi sollecitazioni diagonali: -90,3 kN (compressione)  
+297,7 kN (trazione)



#### Dati

Classe acciaio

Tensione di snervamento acciaio

Tensione di rottura acciaio

Diametro esterno corrente

Spessore corrente

Diametro esterno diagonale

Spessore diagonale

Inclinazione diagonale 1

Inclinazione diagonale 2

Coefficiente di sicurezza

Gap

S 355

$f_{y0}$	355	MPa
$f_{u0}$	510	MPa
$d_0$	406,4	mm
$t_0$	12,5	mm
$d_1$	193,7	mm
$t_1$	6,3	mm
$\theta_1$	69	°
$\theta_2$	40	°
$\alpha_{MS}$	1,00	
$g$	5,00	mm

#### Campo di validità

Rapporto spessori tubi ( $0,2 \leq d_1/d_0 \leq 1,0$ )

Classificazione della sezione - corrente "0"

Classificazione della sezione - diagonale "1"

$d_1/d_0$	0,48	
$d_0/t_0$	32,5	classe 1
$d_1/t_1$	30,7	classe 1

**Sollecitazioni di progetto**

Azione assiale di progetto	$N_1$	-90,3	kN
	$N_2$	297,7	kN
Sfruttamento del corrente "0" (+ di compressione ; - di trazione)	$n_p$	-70,0	%

**Resistenze assiali di progetto**

Coefficienti	$\beta$	0,48
	$\gamma$	16,3
	$k_g$	2,65
	$k_p$	1,00

**Collasso della faccia del corrente:**

Resistenza assiale di progetto	$N_{1,Rd}$	1047,4	kN
Resistenza assiale di progetto	$N_{2,Rd}$	1521,3	kN

Punzonamento per taglio:

Condizione necessaria per la verifica ( $d_1 \leq d_0 - 2t_0$ )

Verifica necessaria!

Resistenza assiale di progetto diagonale 1	$N_{1,Rd}$	1729,5	kN
Resistenza assiale di progetto diagonale 2	$N_{2,Rd}$	1469,3	kN

Verifica soddisfatta.