

REGIONE ABRUZZO

Programma di riqualificazione e di sviluppo sostenibile nel territorio

P.R.U.S.S.T.

La città lineare della costa

ente proponente

COMUNE DI CHIETI - COMUNE DI CEPAGATTI

committente

SIRECC S.r.l. - SILE COSTRUZIONI S.r.l.

progetto

Opere di messa in sicurezza ai fini idraulici
dell'area P.R.U.S.S.T. 7-93
e modifica planimetrica
dell'intervento edilizio a completamento con la
realizzazione di edifici commerciali - no food -

il progettista

Dott. Ing. Domenico Merlino

Variante a Giudizio V.I.A. n. 1925 del 10.04.2012



elaborato

S.I.A. ALLEGATO 03:

Relazione di Calcolo

Palancolata metallica per completamento argine fluviale

tavola n.

05

commessa n.

7.023

livello progettuale

Definitivo

settore

ARC

particolare

--

scala

--

project manager

DM

work manager

EL

00	Luglio 2016	Emesso per definizione	XX
REV.	DATA	DESCRIZIONE	DISEGNATORE

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Azienda con Sistema di Gestione Qualità certificato UNI EN ISO 9001 da ABICert s.a.s. - Certificato n°QBC434

COMUNE di CHIETI e CEPAGATTI

Province di Chieti e Pescara

COMMITTENTE

SIRECC S.R.L.

OGGETTO

**ACCORDO DI PROGRAMMA P.R.U.S.S.T 7-93
ARGINE FLUVIALE A PROTEZIONE DELL'AREA
MEGALÒ IN OTTEMPERANZA AI DETTAMI
DELL'ORDINANZA DEL SERVIZIO DEL GENIO CIVILE
REGIONALE DI PESCARA PROT. RA 312705**

RELAZIONE DI CALCOLO (Palancolata)



TECNOSOIL
ENGINEERING s.r.l.

Il Relatore
Dott. Ing. Pietromartire Lorenzo

Prof. Nicola Sciarra

RIFERIMENTO ELABORATO:

DATA

File					N. prog.				
0	0	2	1	4	0	0	3	0	1

FEBBRAIO, 2014

Calcolo Palancolata

Technical Report

2014. 2. 13.

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1. Modello Geometrico

(1) The model's width is 23.477 m and the height is 12.25 m.

(2) In this Analysis model (Total 5451 elements): Ground elements (155) and Structural elements (5606).

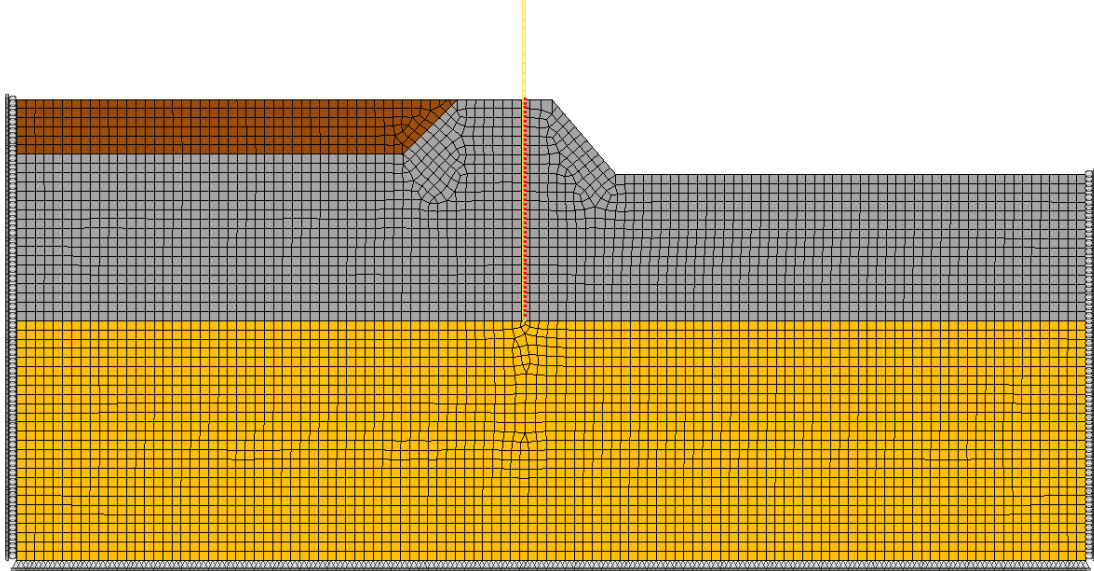


Figura 1 Modello geometrico

Piano campagna

X= 0.0000 Y= 31.8500 X= 9.6771 Y= 31.8500 X= 11.1750 Y= 31.8500 X= 11.7500 Y= 31.8500
X= 13.1592 Y= 30.2000 X= 23.4771 Y= 30.2000

Sottofondo stradale

X= 0.0000 Y= 31.8500 X= 9.6771 Y= 31.8500 X= 8.4771 Y= 30.6500 X= 0.0000 Y= 30.6500
X= 0.0000 Y= 31.8500

Limo sabbioso

X= 0.0000 Y= 30.6500 X= 8.4771 Y= 30.6500 X= 9.6771 Y= 31.8500 X= 11.7500 Y= 31.8500
X= 13.1592 Y= 30.2000 X= 23.4771 Y= 30.2000

X= 23.4771 Y= 27.0000 X= 0.0000 Y= 27.0000 X= 0.0000 Y= 30.6500

Ghiaie

X= 0.0000 Y= 27.0000 X= 23.4771 Y= 27.0000 X= 23.4771 Y= 21.7500 X= 0.0000 Y= 21.7500
X= 0.0000 Y= 27.0000

Palancolata

X= 11.1750 Y= 34.0000 X= 11.1750 Y= 27.0000

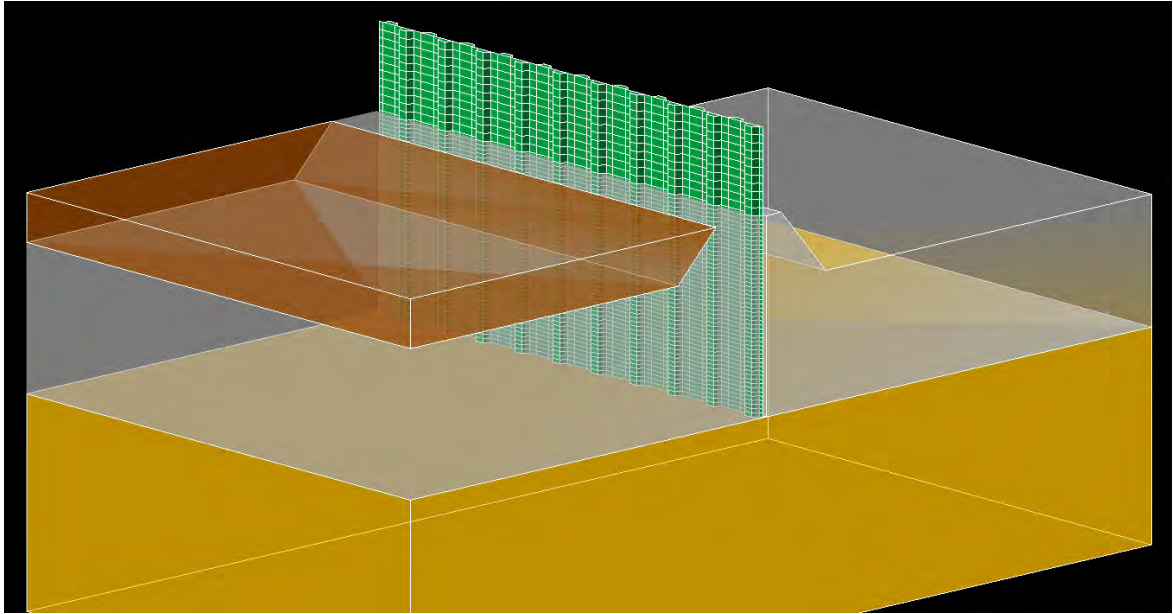


Figura 2 Modello geometrico tridimensionale

2. Proprietà dei terreni e degli elementi strutturali

(1) Ground Material data entered in this Analysis model is as follows:

ID	Name	Model Type	Modulus of Elasticity (kN/m ²)	Wet Unit Weight (kN/m ³)	Saturated Unit Weight (kN/m ³)	Poisson's Ratio	Cohesion (kN/m ²)	Internal Friction Angle ([deg])
1	Limo sabbioso	Mohr-Coulomb	3200	16.2	19.5	0.36	3	23
2	Ghiaie	Mohr-Coulomb	21600	19.5	22	0.31	0	35
4	Sottotondo stradale	Mohr-Coulomb	30000	19	19.5	0.33	0	33

(2) The Structural Property data is as follows:

ID	Name	Member Type	Modulus of Elasticity (kN/m ²)	Poisson's Ratio	Unit Weight (kN/m ³)	Horizontal Spacing (m)	Section Shape
1	Palancola	Beam	2.1e+008	0.3	80	0.6	Sheet Pile

ID	Name	Member Type	Normal Stiffness Modulus (kN/m ³)	Shear Stiffness Modulus (kN/m ³)	Cohesion (kN/m ²)	Internal Friction Angle ([deg])	Tension Cut-off	Tensile Strength (kN/m ²)
2	Property of Interface Elements (Palancola)	Interface	2200	220	3	23	Not considered	-

Stiffness

Normal Stiffness Coeff. (Kn)

It represents the normal stiffness for an Interface element.

Shear Stiffness Coeff. (Kt)

It represents the shear stiffness for an Interface element.

Cohesion (c)

It is the measure of the cohesion at the interface.

Internal Friction Angle

It is the measure of internal friction angle at the interface.

Dilatancy Angle

It represents the ratio between a volumetric strain and a shear strain rate. If un-checked, the same value as the Internal Friction Angle is reflected in analysis.

Tension Cut-off

Check in when tension cut-off is considered. It is used to model the soil behavior as it can sustain no or small tensile stress.

Tensile Strength

Input tensile strength at the interface.

ID	Name	Member Type	DX	DZ	RY
3	Rigid Link of Interface Elements on both sides.	Rigid Link	Fixed	Fixed	Fixed

General

ID Name Palancola Larsen 600

Element Type

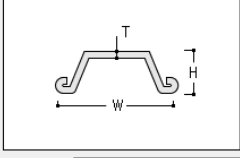
Standard

Horizontal Spacing m

Section

Shape ☐ Tapered Section

Sub-Shapes



Section

Section-2

Material

Material Type

Concrete

Steel Grade

Section Data

Material Data

Section

H	0.075	m
W	0.6	m
T	0.0095	m

Stiffness

Area	0.00583	m ²
I _y	0.000038	m ⁴
Z _y	0.000077	m ³
R _y	0.08116	m

Add Modify Delete Close

Figura 3 Geometria della sezione

Stiffness Calculation

Area

Cross-sectional area.

I_y

Moment of inertia about the local y-axis.

Z_y

Effective shear area in the local y-direction.

R_y

Radius of gyration about the local y-axis.

General

ID Name Palancola

Element Type

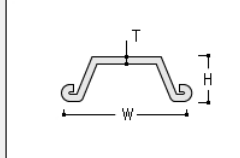
Standard

Horizontal Spacing m

Section

Shape ☐ Tapered Section

Sub-Shapes



Section

Section-2

Material

Material Type

Concrete

Steel Grade

Section Data

Material Data

Concrete Sheet Pile

Properties

Modulus of Elasticity	210000000	kN/m ²
Poisson's Ratio	0.3	
Unit Weight	80	kN/m ³
Thermal Coefficient	0.000012	

Design Strength

Yield Strength	400000	kN/m ²
----------------	--------	-------------------

Figura 4 Proprietà dei materiali strutturali

Properties

Modulus of Elasticity

The slope of the stress-strain line for a linear isotropic material.

Poisson's Ratio

The ratio of the radial (or lateral) strain to the vertical strain.

Unit Weight

The weight of material per unit volume.

Thermal Coefficient

The relative change of a physical property when the temperature is changed by 1 K.

3. Condizioni al contorno

- The Boundary Condition defined in this model is as follows:

(1) Boundary Sets: Condizioni al bordo

- Support (Fixed: 0 Node(s), Hinge: 235 Node(s), Roller(X-direction): 184 Node(s), Roller(Z-direction): 0 Node(s), Rotation: 0 Node(s))

4. Condizioni di carico

- The Load Set assigned to this model is as follows:

(1) Load Set: Peso proprio

- Self Weight (X-direction: 0, Z-direction: -1)

- The direction of Self Weight in general case is the gravity direction (Z-direction) in which -1 is entered.

(2) Load Set: 1_Result - Filtrazione DEF palancola_spb_Analisi di filtrazione stazionaria

- Results from Other Cases (Stress results: 0, Seepage results: 21975)

(3) Load Set: Carico idrostatico

Tabella 1 Carico idrostatico

	Load Set	Element	Load Type	Loading Type	Direction	Projection	X1	X2	P1	P2
	Carico idrostatico	5452	Force	Distributed	0	False	0.0000	1.0000	0.0000	-2.9318
	Carico idrostatico	5453	Force	Distributed	0	False	0.0000	1.0000	-2.9318	-5.8636
	Carico idrostatico	5454	Force	Distributed	0	False	0.0000	1.0000	-5.8636	-8.7955
	Carico idrostatico	5455	Force	Distributed	0	False	0.0000	1.0000	-8.7955	-11.7273
	Carico idrostatico	5456	Force	Distributed	0	False	0.0000	1.0000	-11.7273	-14.6591
	Carico idrostatico	5457	Force	Distributed	0	False	0.0000	1.0000	-14.6591	-17.5909
	Carico idrostatico	5458	Force	Distributed	0	False	0.0000	1.0000	-17.5909	-20.5227
	Carico idrostatico	5459	Force	Distributed	0	False	0.0000	1.0000	-20.5227	-23.4545
	Carico idrostatico	5460	Force	Distributed	0	False	0.0000	1.0000	-23.4545	-26.3864
	Carico idrostatico	5461	Force	Distributed	0	False	0.0000	1.0000	-26.3864	-29.3182
	Carico idrostatico	5462	Force	Distributed	0	False	0.0000	1.0000	-29.3182	-32.2500

*I carichi sono stati moltiplicati per il coefficiente 1.5 in accordo con la normativa attuale (cfr. comb.

A1+M1tab. 6.2.1 Coefficienti parziali per le azioni NTC 2008)

5. Tipologia di analisi

- Analysis Cases defined in this model are as follows:

(1) Calcolo palancola [Static Nonlinear Analysis]

- Number of Mesh Sets to be used in the Analysis model: 11
- Number of Boundary Sets to be used in the Analysis model: 1
- Number of Load Sets to be used in the Analysis model: 3

6. Risultati dell'analisi

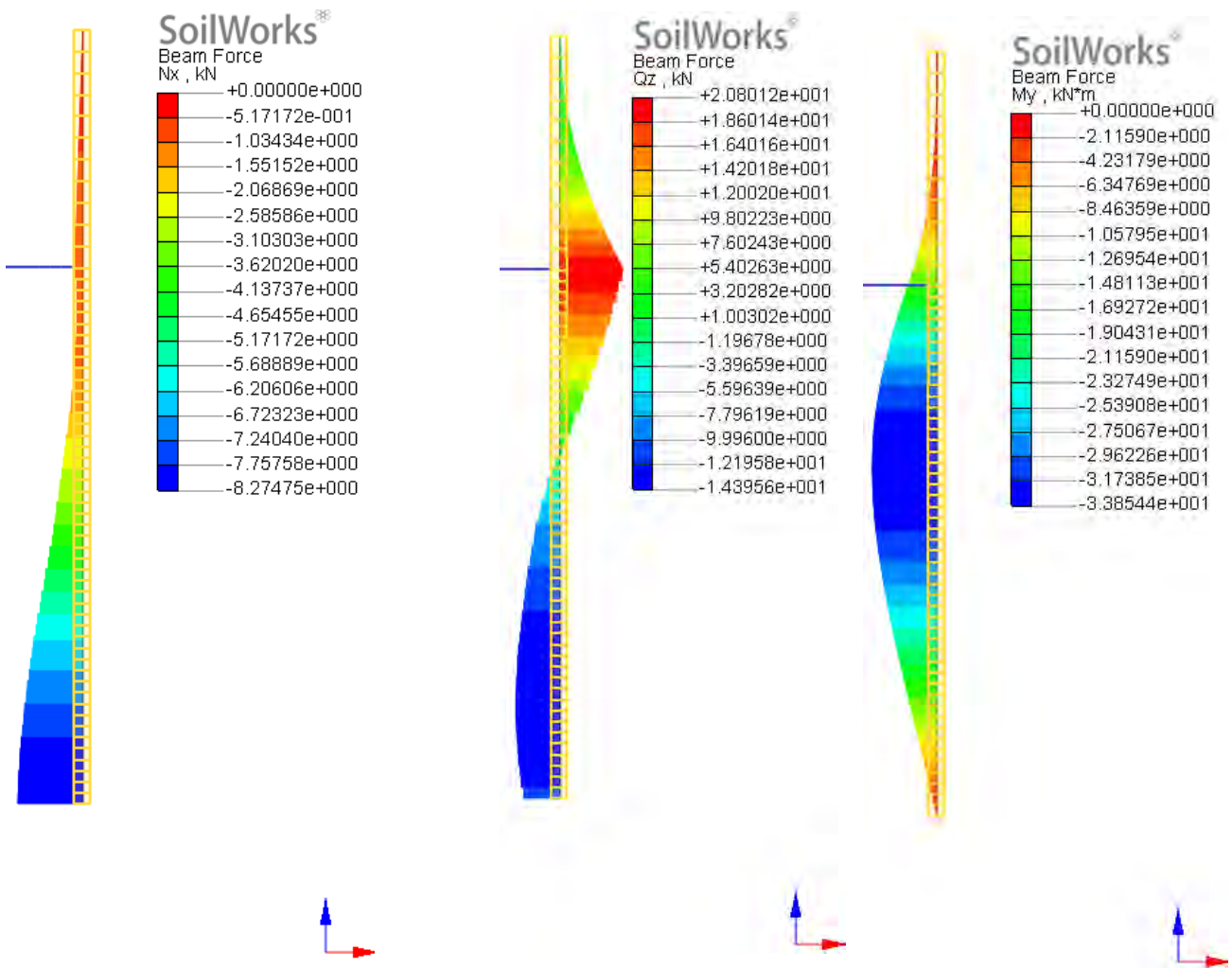


Figura 5 Diagrammi dello sforzo normale, taglio e momento

Tabella 2 Azioni interne

Elem				Nx	Qz	My
ID	X (m)	Z (m)	Part			
Analysis Case: Calcolo palancola						
5452	11.18	34	i	-1.192E-012	-5.749E-011	-4.687E-011
5453	11.18	33.8	i	-9.116E-002	1.719E-001	-1.120E-002
5454	11.18	33.61	i	-1.823E-001	6.876E-001	-8.960E-002
5455	11.18	33.41	i	-2.735E-001	1.547E+000	-3.024E-001
5456	11.18	33.22	i	-3.646E-001	2.751E+000	-7.168E-001
5457	11.18	33.02	i	-4.558E-001	4.298E+000	-1.400E+000
5458	11.18	32.83	i	-5.470E-001	6.189E+000	-2.419E+000
5459	11.18	32.63	i	-6.381E-001	8.424E+000	-3.842E+000
5460	11.18	32.44	i	-7.293E-001	1.100E+001	-5.735E+000
5461	11.18	32.24	i	-8.204E-001	1.392E+001	-8.165E+000
5462	11.18	32.05	i	-9.116E-001	1.719E+001	-1.120E+001

5463	11.18	31.85	i	-9.085E-001	2.035E+001	-1.491E+001
5464	11.18	31.75	i	-7.233E-001	1.897E+001	-1.696E+001
5465	11.18	31.65	i	-7.003E-001	1.838E+001	-1.888E+001
5466	11.18	31.55	i	-6.665E-001	1.708E+001	-2.074E+001
5467	11.18	31.45	i	-6.928E-001	1.638E+001	-2.246E+001
5468	11.18	31.34	i	-7.255E-001	1.493E+001	-2.412E+001
5469	11.18	31.24	i	-7.782E-001	1.417E+001	-2.563E+001
5470	11.18	31.14	i	-8.590E-001	1.260E+001	-2.706E+001
5471	11.18	31.04	i	-9.329E-001	1.180E+001	-2.833E+001
5472	11.18	30.94	i	-1.055E+000	1.014E+001	-2.952E+001
5473	11.18	30.84	i	-1.150E+000	9.272E+000	-3.055E+001
5474	11.18	30.74	i	-1.319E+000	7.443E+000	-3.149E+001
5475	11.18	30.64	i	-1.439E+000	6.477E+000	-3.224E+001
5476	11.18	30.54	i	-1.658E+000	4.432E+000	-3.289E+001
5477	11.18	30.44	i	-1.802E+000	3.378E+000	-3.334E+001
5478	11.18	30.33	i	-2.053E+000	1.338E+000	-3.368E+001
5479	11.18	30.23	i	-2.203E+000	3.758E-001	-3.382E+001
5480	11.18	30.13	i	-2.456E+000	-1.433E+000	-3.385E+001
5481	11.18	30.03	i	-2.606E+000	-2.280E+000	-3.371E+001
5482	11.18	29.93	i	-2.857E+000	-3.869E+000	-3.348E+001
5483	11.18	29.83	i	-3.005E+000	-4.615E+000	-3.309E+001
5484	11.18	29.73	i	-3.250E+000	-6.013E+000	-3.262E+001
5485	11.18	29.63	i	-3.395E+000	-6.670E+000	-3.201E+001
5486	11.18	29.53	i	-3.633E+000	-7.912E+000	-3.134E+001
5487	11.18	29.43	i	-3.828E+000	-8.378E+000	-3.054E+001
5488	11.18	29.32	i	-4.169E+000	-9.250E+000	-2.969E+001
5489	11.18	29.22	i	-4.362E+000	-9.659E+000	-2.876E+001
5490	11.18	29.12	i	-4.698E+000	-1.043E+001	-2.778E+001
5491	11.18	29.02	i	-4.887E+000	-1.079E+001	-2.673E+001
5492	11.18	28.92	i	-5.212E+000	-1.148E+001	-2.564E+001
5493	11.18	28.82	i	-5.395E+000	-1.180E+001	-2.448E+001
5494	11.18	28.72	i	-5.707E+000	-1.242E+001	-2.329E+001
5495	11.18	28.62	i	-5.884E+000	-1.271E+001	-2.203E+001
5496	11.18	28.52	i	-6.184E+000	-1.325E+001	-2.075E+001
5497	11.18	28.41	i	-6.351E+000	-1.348E+001	-1.941E+001
5498	11.18	28.31	i	-6.623E+000	-1.386E+001	-1.805E+001
5499	11.18	28.21	i	-6.776E+000	-1.402E+001	-1.665E+001
5500	11.18	28.11	i	-7.021E+000	-1.425E+001	-1.523E+001
5501	11.18	28.01	i	-7.159E+000	-1.433E+001	-1.379E+001
5502	11.18	27.91	i	-7.373E+000	-1.440E+001	-1.234E+001
5503	11.18	27.81	i	-7.495E+000	-1.439E+001	-1.089E+001
5504	11.18	27.71	i	-7.676E+000	-1.427E+001	-9.435E+000
5505	11.18	27.61	i	-7.781E+000	-1.415E+001	-7.994E+000
5506	11.18	27.51	i	-7.923E+000	-1.380E+001	-6.563E+000
5507	11.18	27.4	i	-8.007E+000	-1.356E+001	-5.169E+000
5508	11.18	27.3	i	-8.104E+000	-1.298E+001	-3.799E+000
5509	11.18	27.2	i	-8.165E+000	-1.265E+001	-2.487E+000
5510	11.18	27.1	i	-8.228E+000	-1.196E+001	-1.209E+000

Tabella 3 Deformazioni elastiche

No	1	1	1
Step	Total Displacement (DXZ(V)) (cm.)	Horizontal Displacement (DX(V)) (cm.)	Vertical Displacement (DZ(V)) (cm.)
Node:16669	13.8757	-13.7739	-1.67793
Node:16670	13.3701	-13.2644	-1.67793
Node:16671	12.8648	-12.7549	-1.67792
Node:16672	12.3599	-12.2455	-1.67792
Node:16673	11.8555	-11.7362	-1.67792
Node:16674	11.3519	-11.2273	-1.67791
Node:16675	10.8495	-10.719	-1.6779
Node:16676	10.3488	-10.2119	-1.67789
Node:16677	9.8506	-9.70665	-1.67788
Node:16678	9.35581	-9.20413	-1.67787
Node:16679	8.86572	-8.7055	-1.67786
Node:1	8.38185	-8.21221	-1.67784
Node:51	8.13476	-7.95985	-1.67783
Node:2	7.89009	-7.70963	-1.67783
Node:55	7.64811	-7.46181	-1.67782
Node:3	7.40908	-7.21661	-1.67781
Node:58	7.17322	-6.97425	-1.67781
Node:4	6.94078	-6.73494	-1.6778
Node:61	6.71195	-6.49887	-1.6778
Node:5	6.48695	-6.26623	-1.67779
Node:64	6.26597	-6.03717	-1.67778
Node:6	6.04917	-5.81185	-1.67777
Node:67	5.83672	-5.59039	-1.67776
Node:7	5.62877	-5.37291	-1.67775
Node:70	5.42544	-5.15951	-1.67774
Node:8	5.22685	-4.95028	-1.67772
Node:73	5.03311	-4.74526	-1.67771
Node:9	4.84429	-4.5445	-1.67769
Node:76	4.66046	-4.34802	-1.67767
Node:10	4.48168	-4.15583	-1.67765
Node:79	4.30797	-3.9679	-1.67763
Node:11	4.13939	-3.7842	-1.67761
Node:82	3.97594	-3.60469	-1.67758
Node:12	3.81764	-3.42931	-1.67756
Node:85	3.6645	-3.25798	-1.67753
Node:13	3.51652	-3.09062	-1.6775
Node:88	3.37371	-2.92712	-1.67747
Node:14	3.23607	-2.76738	-1.67743
Node:91	3.10362	-2.61128	-1.6774
Node:15	2.97636	-2.4587	-1.67736
Node:94	2.85432	-2.30949	-1.67732
Node:97	2.62607	-2.02068	-1.67723
Node:16	2.73754	-2.16354	-1.67727
Node:17	2.51997	-1.88077	-1.67718
Node:100	2.41931	-1.74365	-1.67713
Node:18	2.32421	-1.60915	-1.67708
Node:103	2.23479	-1.47711	-1.67703
Node:19	2.15119	-1.34736	-1.67697

Node:106	2.07358	-1.21971	-1.67692
Node:20	2.00217	-1.09399	-1.67686
Node:109	1.93716	-0.970017	-1.6768
Node:21	1.8788	-0.847606	-1.67674
Node:112	1.82733	-0.726573	-1.67668
Node:22	1.78302	-0.606735	-1.67661
Node:115	1.7461	-0.48791	-1.67655
Node:23	1.71681	-0.369916	-1.67648
Node:118	1.69534	-0.252577	-1.67642
Node:24	1.68183	-0.13572	-1.67635
Node:121	1.67639	-0.0191784	-1.67628
Node:25	1.67903	0.0972084	-1.67621

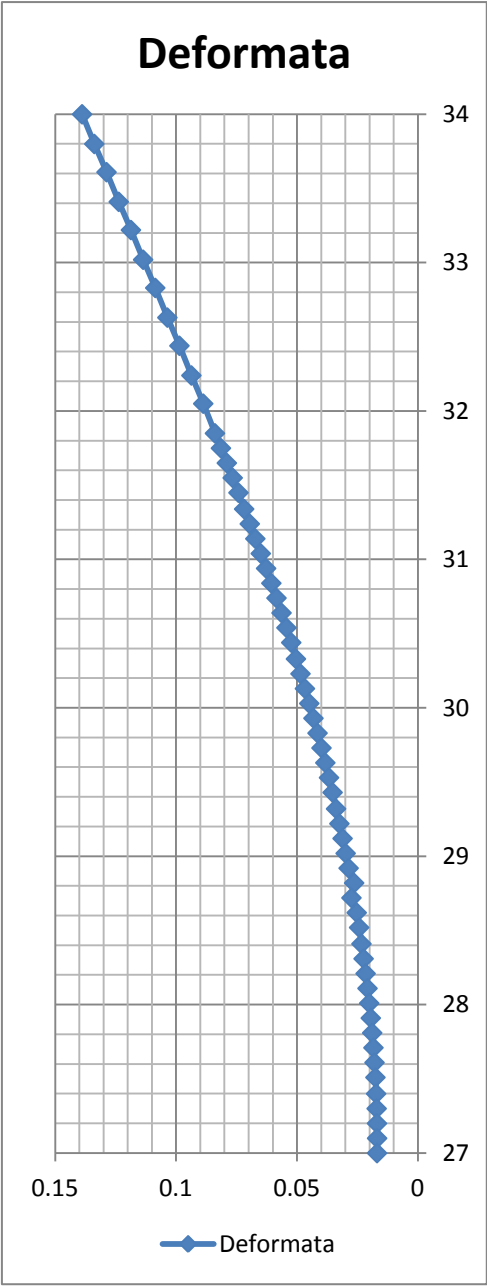


Figura 6Deformata elastica

7. Verifiche strutturali

LARSEN 600			Section width per D = 1200 mm			
		Unit	Per m wall	Single pile	Double pile	Triple pile
Elastic section modulus ¹⁾	W_y	cm ³	510	E	D	Dr
	W_x	cm ³	—	109	614	705
Plastic section modulus ¹⁾	W_{py}	cm ³	558	920	—	—
Weight		kg/m	94.0	—	—	—
Cross sectional area		cm ²	119.7	56.4	112.8	169.2
Circumference ²⁾		cm	225	71.8	143.6	215.4
Coating area ³⁾		m ² /m	2.25	156	291	426
Static moment	S_y	cm ³	279	1.44	2.79	4.14
Second moment of inertia	I_y	cm ⁴	3840	—	—	—
	I_z	cm ⁴	—	736	4610	6370
Radius of gyration	i_y	cm	5.66	29300	—	—
				3.20	5.66	5.44

¹⁾ Section modulus referred:

E and Dr – the heavy axis of the respective element; D and per m wall – the wall axis y-y.
The section modulus of D, Dr u. per m wall requires locking of the factory-cripped interlocks to accommodate the shear forces.

²⁾ Including the internal surface of free interlocks of single, double and triple piles.

³⁾ Without interlock interior – two-side coating.

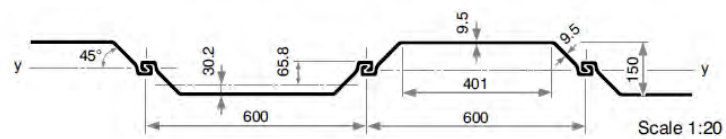


Figura 7 Tabella illustrativa Sezione Larsenn 600

Acciaio S430GP $f_y = 540000 \text{ kN/m}^2$

Modulo di resistenza elastico 0.00051 m^3

Momento flettente massimo 34 kNm

Modulo di design $M/f_y = 0.000079069 \text{ m}^3$

$M_d < M_r$ OK!!!!