

Committente: **INTERPROGETTI**

**PIATTAFORMA INTERMODALE DI TREMESTIERI IN  
PROVINCIA DI MESSINA**

**CONSULENZA GEOTECNICA**

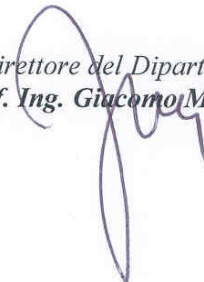
*Relazione n.28 del 14.05.2010*

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# REPORT

agosto 05, 2010

**User:** Università Politecnica delle Marche

**Title:** Banchina di riva

## Table of Contents

1. General Information.....	3
2. Material data .....	4
3. Calculation phases .....	5
4. Results for phase 5 .....	7
5. Results for phase 6 .....	11
6. Results for phase 8 .....	14
7. Results for phase 9 .....	18
8. Results for phase 10 .....	23
9. Results for phase 11 .....	27
10. Results for phase 13 .....	30
11. Results for phase 14 .....	33

## 1. General Information

Table [1] Units

Type	Unit
Length	m
Force	kN
Time	s

Table [2] Model dimensions

	min.	max.
X	-30,000	30,000
Y	-28,000	2,500

Table [3] Model

Model	Plane strain
Element	6-Noded

## 2. Material data

Table [4] Soil data sets parameters

<i>Linear Elastic</i>		<b>2</b>
<b>Type</b>		Drained
$\gamma_{unsat}$	[kN/m <sup>3</sup> ]	25,00
$\gamma_{sat}$	[kN/m <sup>3</sup> ]	25,00
$k_x$	[m/s]	0,000
$k_y$	[m/s]	0,000
$e_{init}$	[-]	0,500
$c_k$	[-]	1E15
$E_{ref}$	[kN/m <sup>2</sup> ]	35000000,00
$\nu$	[-]	0,200
$G_{ref}$	[kN/m <sup>2</sup> ]	14583333,333
$E_{oed}$	[kN/m <sup>2</sup> ]	38888888,889
$E_{incr}$	[kN/m <sup>2</sup> /m]	0,00
$y_{ref}$	[m]	0,000
$R_{inter}$	[-]	1,000
<b>Interface</b>		Neutral

<i>Mohr-Coulomb</i>		<b>1</b>	<b>3</b>	<b>4</b>
<b>Type</b>		Drained	Drained	Drained
$\gamma_{unsat}$	[kN/m <sup>3</sup> ]	19,50	19,00	19,50
$\gamma_{sat}$	[kN/m <sup>3</sup> ]	19,50	19,00	19,50
$k_x$	[m/s]	0,000	0,000	0,000
$k_y$	[m/s]	0,000	0,000	0,000
$e_{init}$	[-]	0,500	0,500	0,500
$c_k$	[-]	1E15	1E15	1E15
$E_{ref}$	[kN/m <sup>2</sup> ]	30000,000	50000,000	30000,000
$\nu$	[-]	0,280	0,200	0,280
$G_{ref}$	[kN/m <sup>2</sup> ]	11718,750	20833,333	11718,750
$E_{oed}$	[kN/m <sup>2</sup> ]	38352,273	55555,556	38352,273
$c_{ref}$	[kN/m <sup>2</sup> ]	0,00	0,00	0,00
$\phi$	[°]	38,00	45,00	32,00
$\psi$	[°]	5,00	0,00	5,00
$E_{inc}$	[kN/m <sup>2</sup> /m]	0,00	0,00	0,00
$y_{ref}$	[m]	0,000	0,000	0,000
$c_{increment}$	[kN/m <sup>2</sup> /m]	0,00	0,00	0,00
$T_{str.}$	[kN/m <sup>2</sup> ]	0,00	0,00	0,00
$R_{inter.}$	[-]	0,50	1,00	0,50
<b>Interface</b>		Neutral	Neutral	Neutral

Table [5] Beam data sets parameters

No.	Identification	EA [kN/m]	EI [kNm <sup>2</sup> /m]	w [kN/m/m]	v [-]	Mp [kNm/m]	Np [kN/m]
1	pali1219-14/6.20m	1,788E6	3,26E5	0,00	0,15	1E15	1E15
2	HZ1080M A-12/AZ13-770	6,174E6	8,485E5	0,00	0,15	1E15	1E15

Table [6] Geotextile data sets parameters

No.	Identification	EA [kN/m]	v [-]
1	6tr+20cm/2.1m	201000,00	0,00

Table [7] Anchor data sets parameters

No.	Identification	EA [kN]	Fmax,com p  [kN]	Fmax,tens  [kN]	L spacing [m]
1	6trefoli/2.1m	81800,00	1E15	1E15	1,00
2	pali1219-14/6.2m	1788000,00	1E15	1E15	1,00

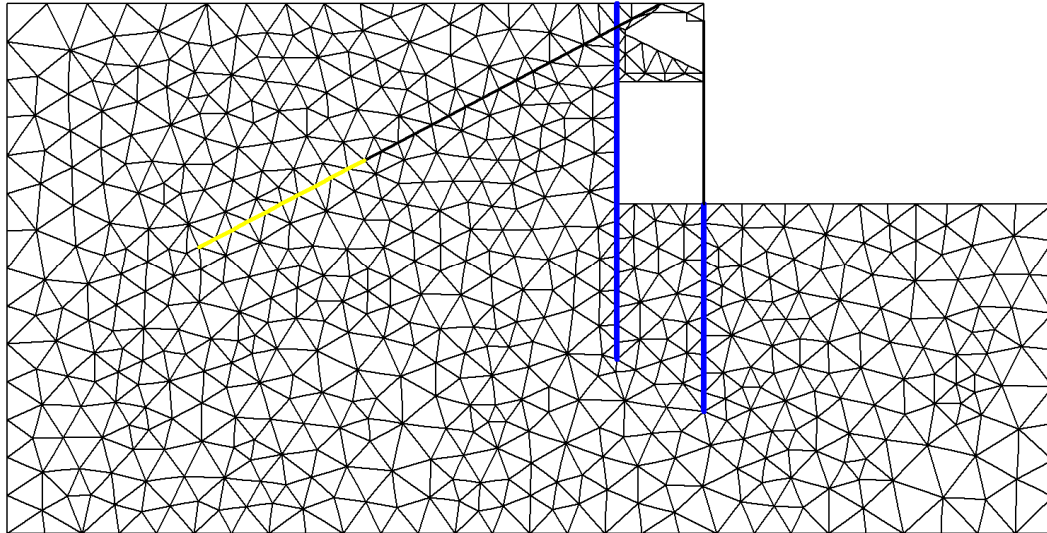
### 3. Calculation phases

Table [8] List of phases

Phase	Ph-No.	Start	Calculation type	Load input	First step	Last step
Initial phase	0	0		-	0	0
palancola+pali	1	0	Plastic	Staged construction	1	2
scavo cella	2	1	Plastic	Staged construction	3	29
cella	3	2	Plastic	Staged construction	30	34
tirante p=300kN	4	3	Plastic	Staged construction	35	41
scavo -9m	5	4	Plastic	Staged construction	42	55
SLE	6	5	Plastic	Staged construction	56	75
west+10kPa	7	6	Plastic	Staged construction	76	82
SLV	8	7	Plastic	Total multipliers	83	114
SLV+fhi rid	9	8	Plastic	Staged construction	115	122
SLU11 Q=46kPa	10	5	Plastic	Staged construction	123	142
SLU12 Q=52kPa	11	10	Plastic	Staged construction	262	269
Q=40kPa+westS	12	6	Plastic	Staged construction	148	153

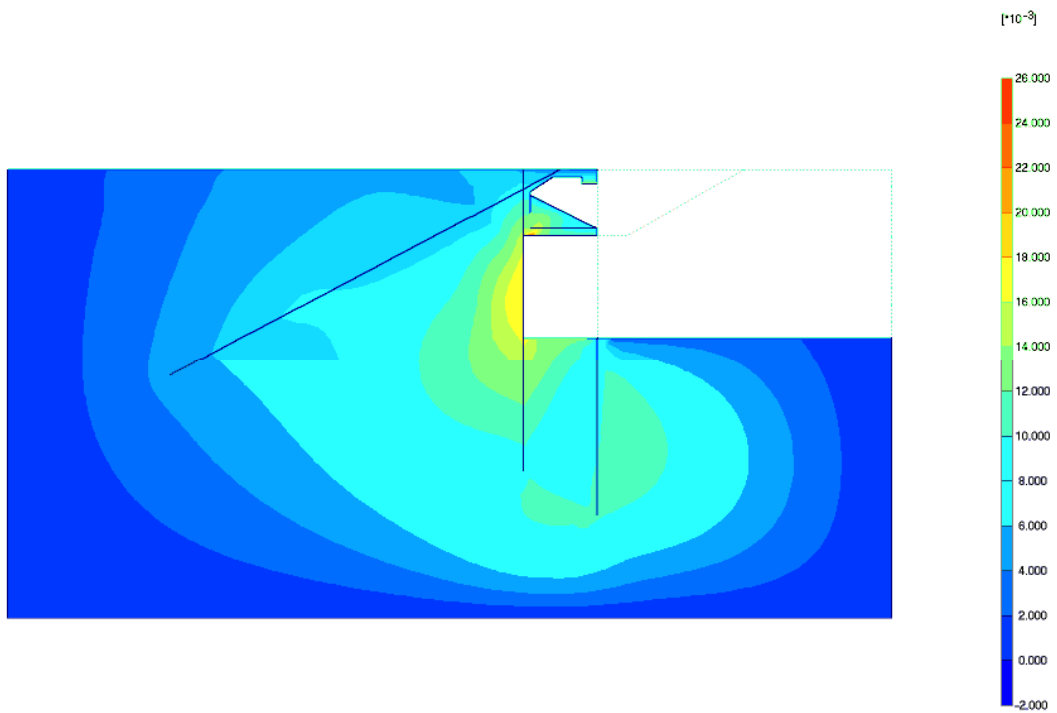
Phase	Ph-No.	Start	Calculation type	Load input	First step	Last step
SLD	13	12	Plastic	Total multipliers	154	161
fhi reduction	14	6	Phi/c reduction	Incremental multipliers	162	261

### 4. Results for phase 5



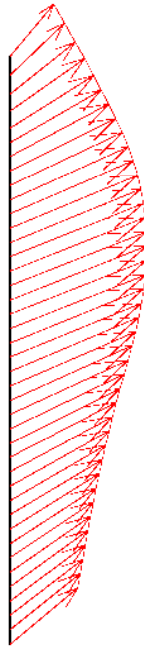
**Fig. 1 Plot of deformed mesh**

- step no: 55 - ( phase: 5 )



**Fig. 2 Plot of horizontal displacements (shadings)**

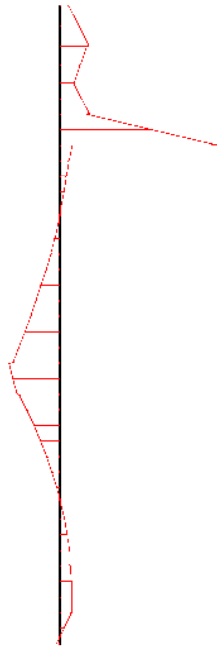
- step no: 55 - ( phase: 5 )



**Fig. 3 Total displacements in beam (plate no: 1)**

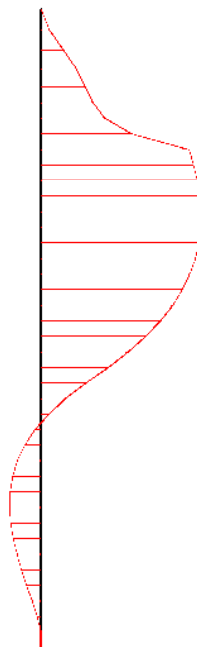
Extreme value  $19,39 \cdot 10^{-3}$  m (phase: 5)





**Fig. 4 Shear forces in beam (plate no: 1)**

Extreme value 321,13 kN/m (phase: 5)



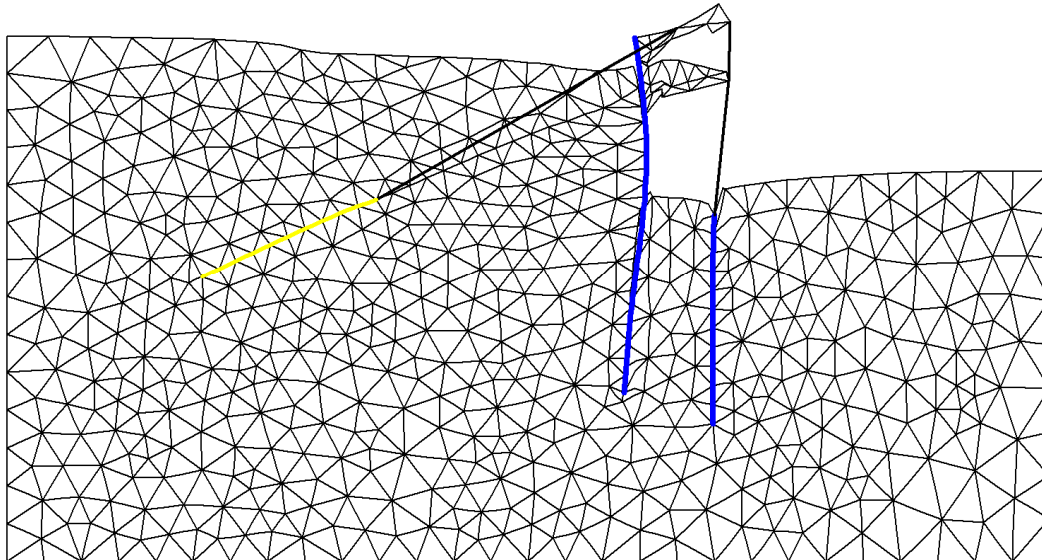
**Fig. 5 Bending moments in beam (plate no: 1)**

Extreme value 353,94 kNm/m (phase: 5)

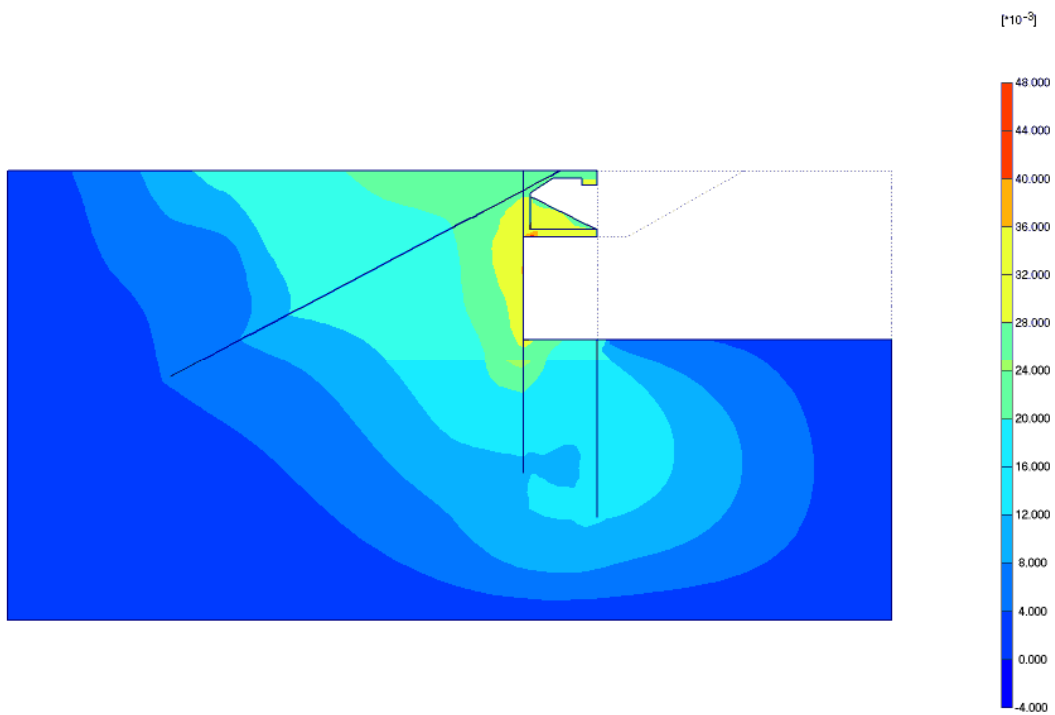
Table [9] Anchors phase no: 5

Anchor no.	Node	x-coord. [m]	y-coord. [m]	F [kN]	Fmax,comp  [kN]	Fmax,tens  [kN]	EA [kN]	Rotation [°]	Le [m]
1	1182	10,000	1,500	-69,353	1E15	1E15	1788000,00	N/A	3,500
	1230	10,000	-2,000						
2	1230	10,000	-2,000	-128,621	1E15	1E15	1788000,00	N/A	7,000
	854	10,000	-9,000						
3	1376	7,500	2,500	159,309	1E15	1E15	81800,00	N/A	19,235
	2184	-9,508	-6,485						

### 5. Results for phase 6

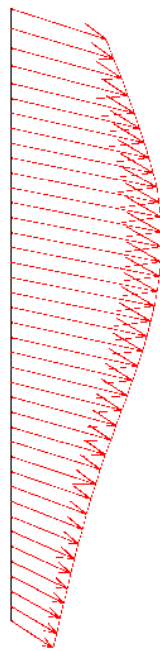


**Fig. 6 Plot of deformed mesh**  
- step no: 75 - ( phase: 6 )



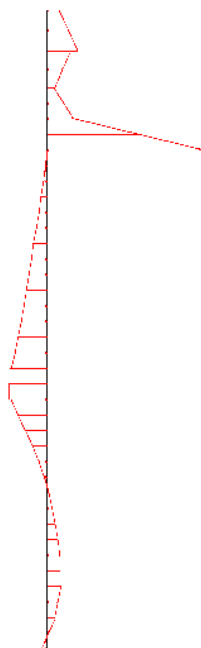
**Fig. 7 Plot of horizontal displacements (shadings)**

- step no: 75 - ( phase: 6 )



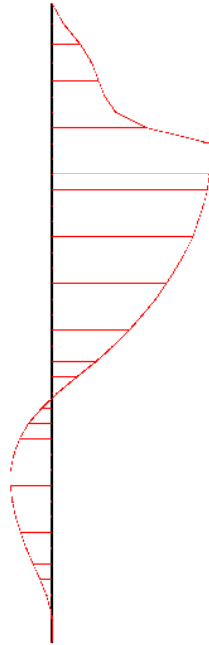
**Fig. 8 Total displacements in beam (plate no: 1)**

Extreme value  $37,01 \cdot 10^{-3}$  m (phase: 6)



**Fig. 9 Shear forces in beam (plate no: 1)**

Extreme value 692,27 kN/m (phase: 6)



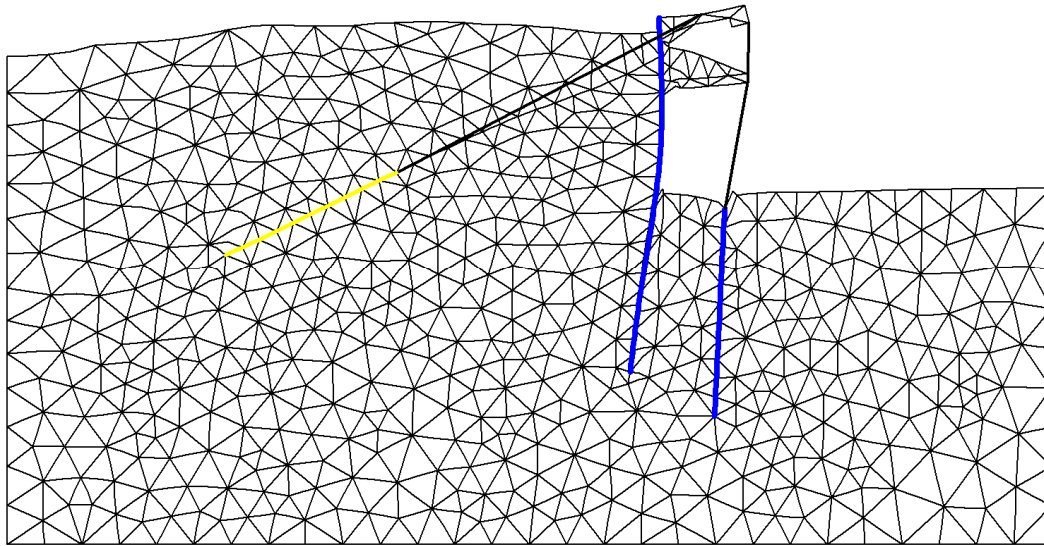
**Fig. 10 Bending moments in beam (plate no: 1)**

Extreme value 681,70 kNm/m (phase: 6)

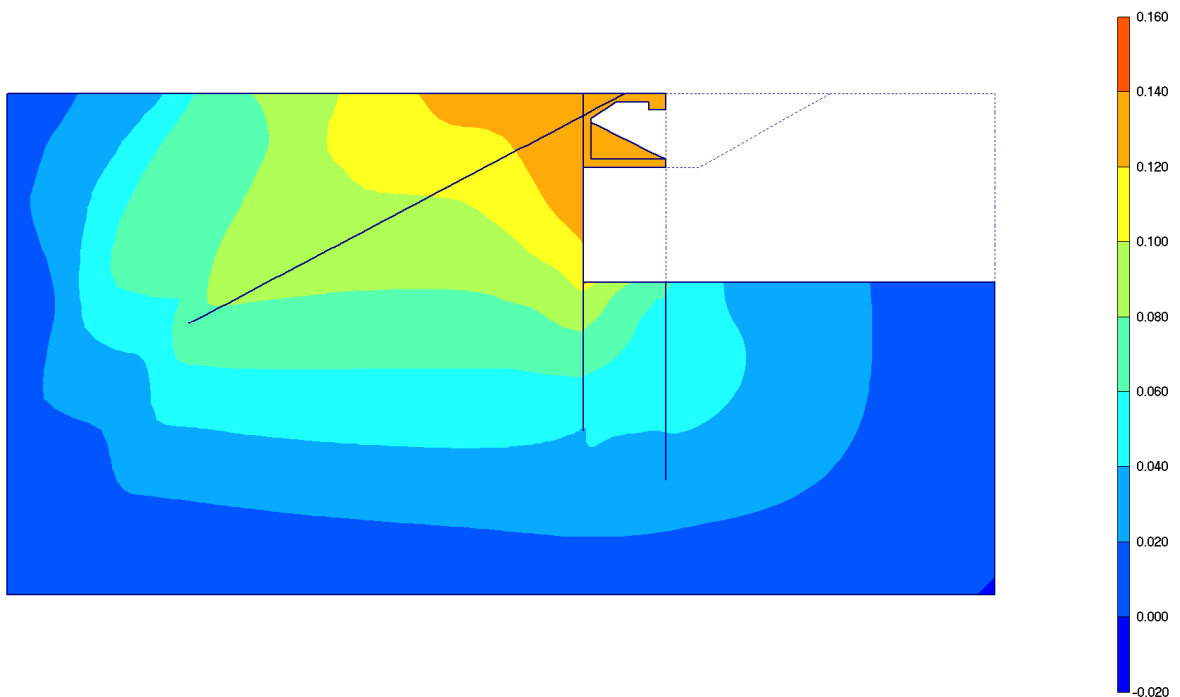
**Table [10] Anchors phase no: 6**

Anchor no.	Node	x-coord. [m]	y-coord. [m]	F [kN]	Fmax,comp  [kN]	Fmax,tens  [kN]	EA [kN]	Rotation [°]	Le [m]
1	1182	10,000	1,500	-213,345	1E15	1E15	1788000,00	N/A	3,500
	1230	10,000	-2,000						
2	1230	10,000	-2,000	-317,789	1E15	1E15	1788000,00	N/A	7,000
	854	10,000	-9,000						
3	1376	7,500	2,500	206,537	1E15	1E15	81800,00	N/A	19,235
	2184	-9,508	-6,485						

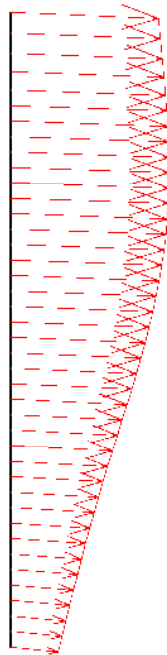
### 6. Results for phase 8



**Fig. 11 Plot of deformed mesh**  
- step no: 114 - ( phase: 8 )

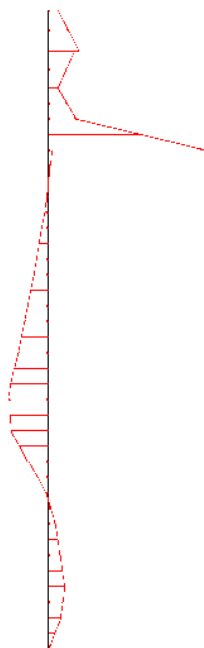


**Fig. 12 Plot of horizontal displacements (shadings)**  
- step no: 114 - ( phase: 8 )



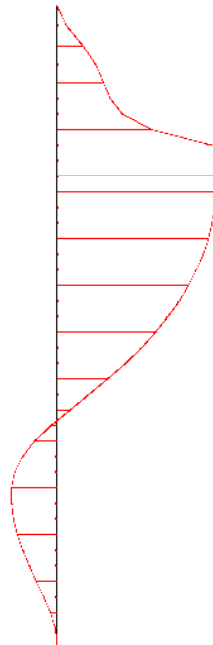
**Fig. 13 Total displacements in beam (plate no: 1)**

Extreme value  $132,06 \cdot 10^{-3}$  m (phase: 8)



**Fig. 14 Shear forces in beam (plate no: 1)**

Extreme value  $1,16 \cdot 10^3$  kN/m (phase: 8)



**Fig. 15 Bending moments in beam (plate no: 1)**

Extreme value  $1,18 \cdot 10^3$  kNm/m (phase: 8)

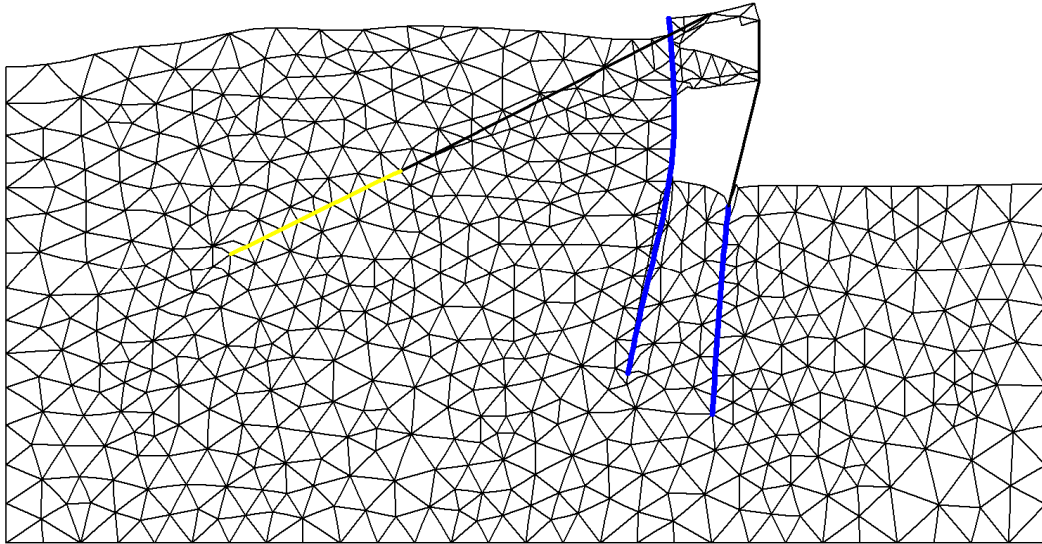
**Table [11] Anchors phase no: 8**

Anchor no.	Node	x-coord. [m]	y-coord. [m]	F [kN]	Fmax,comp  [kN]	Fmax,tens  [kN]	EA [kN]	Rotation [°]	Le [m]
1	1182	10,000	1,500	-166,893	1E15	1E15	1788000,00	N/A	3,500
	1230	10,000	-2,000						
2	1230	10,000	-2,000	-294,587	1E15	1E15	1788000,00	N/A	7,000
	854	10,000	-9,000						
3	1376	7,500	2,500	269,598	1E15	1E15	81800,00	N/A	19,235
	2184	-9,508	-6,485						

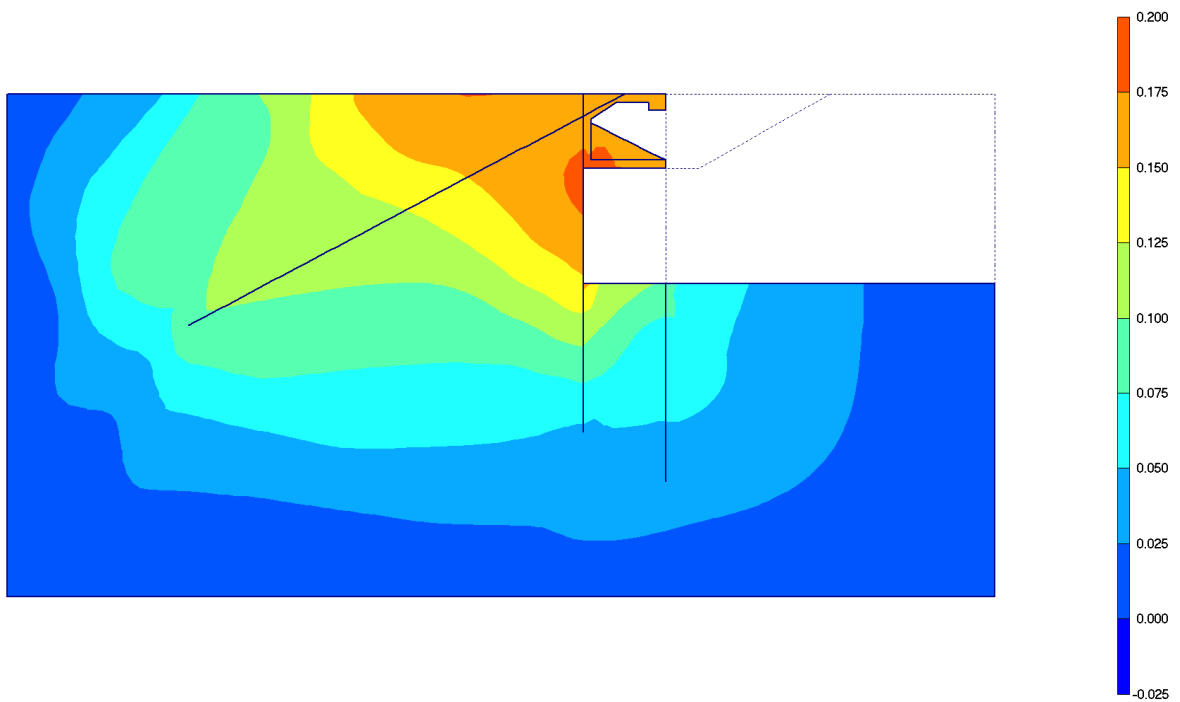




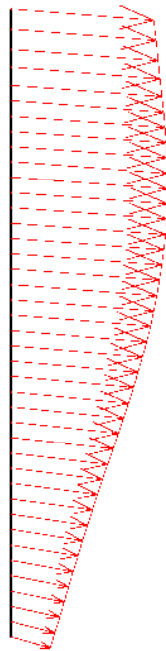
### 7. Results for phase 9



**Fig. 16 Plot of deformed mesh**  
- step no: 122 - ( phase: 9 )

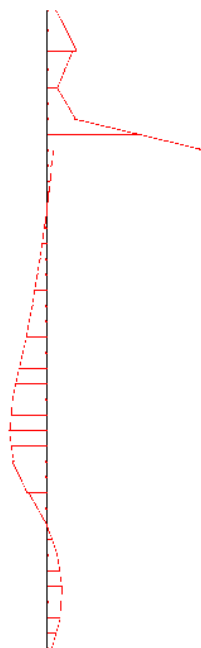


**Fig. 17 Plot of horizontal displacements (shadings)**  
- step no: 122 - ( phase: 9 )



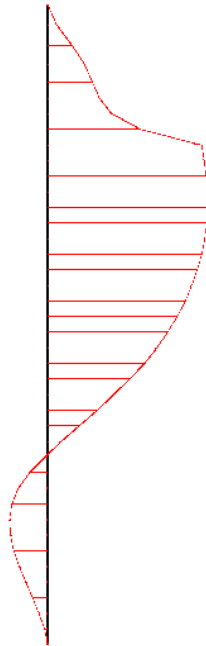
**Fig. 18 Total displacements in beam (plate no: 1)**

Extreme value  $179,35 \cdot 10^{-3}$  m (phase: 9)



**Fig. 19 Shear forces in beam (plate no: 1)**

Extreme value  $1,56 \cdot 10^3$  kN/m (phase: 9)



**Fig. 20 Bending moments in beam (plate no: 1)**

Extreme value  $1,61 \cdot 10^3$  kNm/m (phase: 9)

**Table [12] Anchors phase no: 9**

Anchor	Node	x-coord. [m]	y-coord. [m]	F [kN]	F <sub>max,co</sub> [kN]	F <sub>max,te</sub> [kN]	EA [kN]	Rotation [°]	Le [m]
1	1182	10,000	1,500	-191,853	1E15	1E15	1788000,	N/A	3,500
2	1230	10,000	-2,000	-344,752	1E15	1E15	1788000,	N/A	7,000
3	1376	7,500	2,500	333,057	1E15	1E15	81800,00	N/A	19,235

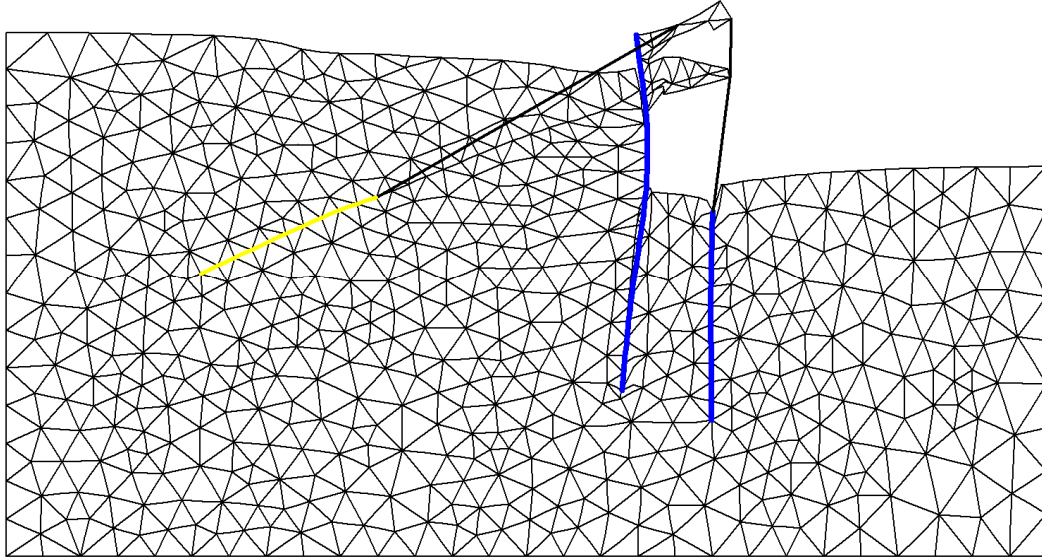
**Table of beam force envelops phase no: 9**

Node no.	x-coord. [m]	y-coord. [m]	N <sub>min</sub> [kN/m]	N <sub>max</sub> [kN/m]	Q <sub>min</sub> [kN/m]	Q <sub>max</sub> [kN/m]	M <sub>min</sub> [kNm/m]	M <sub>max</sub> [kNm/m]
1505	5,000	1,179	-386,957	23,565	-22,140	290,757	-249,358	24,056
1504	5,000	1,840	-182,221	14,297	-18,213	188,800	-91,014	10,731
1503	5,000	2,500	0,000	22,515	-14,287	86,842	0,000	0,000
1187	5,000	-8,000	-289,644	73,286	-213,472	11,654	-	50,894
1186	5,000	-7,500	-285,213	68,924	-183,961	13,659	-	57,223
1217	5,000	-7,000	-280,783	64,563	-154,450	15,664	-	64,553
1217	5,000	-7,000	-280,845	64,532	-154,954	15,531	-	64,553
1218	5,000	-6,500	-276,825	60,709	-129,158	16,742	-	72,621
1325	5,000	-6,000	-272,806	56,887	-106,770	17,954	-	81,296
1325	5,000	-6,000	-272,859	56,894	-107,225	18,187	-	81,296
1326	5,000	-5,500	-269,486	53,641	-87,107	16,857	-	90,055

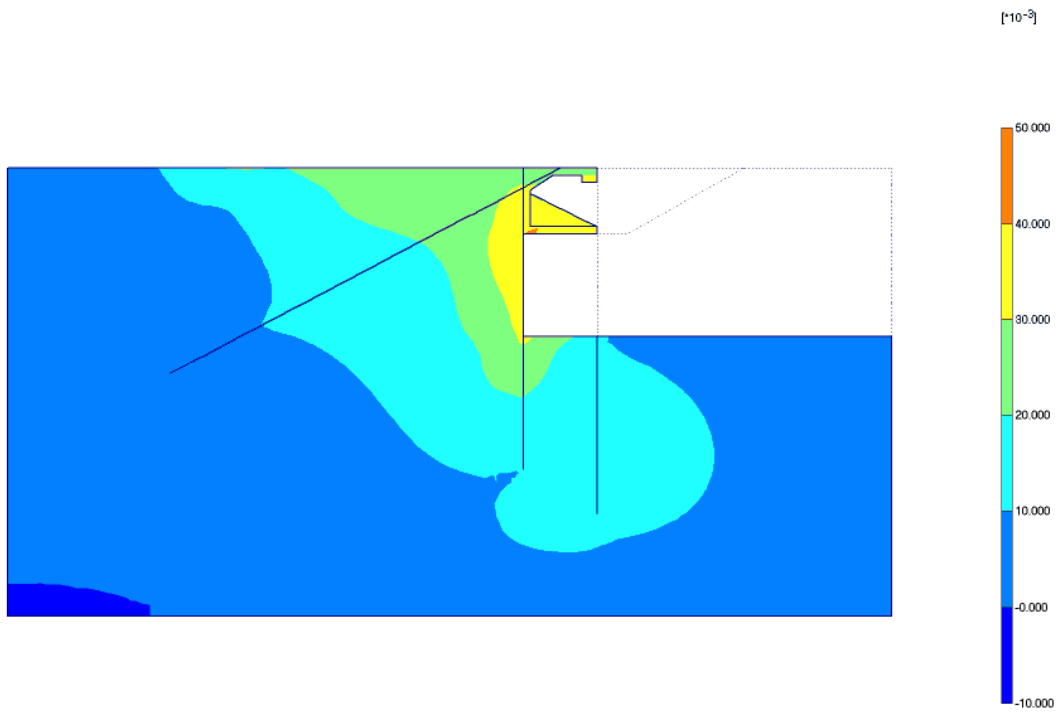
Node no.	x-coord. [m]	y-coord. [m]	N <sub>min</sub> [kN/m]	N <sub>max</sub> [kN/m]	Q <sub>min</sub> [kN/m]	Q <sub>max</sub> [kN/m]	M <sub>min</sub> [kNm/m]	M <sub>max</sub> [kNm/m]
1330	5,000	-5,000	-266,112	50,389	-66,988	16,977	-	98,146
1330	5,000	-5,000	-266,083	50,270	-67,668	16,273	-	98,146
1331	5,000	-4,500	-262,213	47,769	-48,398	13,184	-	104,148
1411	5,000	-4,000	-258,344	45,268	-36,431	18,653	-	107,379
1411	5,000	-4,000	-258,346	45,358	-36,438	18,733	-	107,379
1412	5,000	-3,500	-254,800	43,265	-26,159	34,744	-	106,986
1473	5,000	-3,000	-251,255	41,172	-16,985	50,788	-	101,975
1473	5,000	-3,000	-251,791	42,573	-19,947	49,094	-	101,975
1474	5,000	-2,500	-248,641	39,027	-32,890	62,922	-	89,984
1490	5,000	-2,000	-245,490	35,672	-45,833	76,751	-	71,681
1490	5,000	-2,000	-296,689	0,007	-75,328	1556,917	-	71,681
1491	5,000	-1,500	-415,072	0,007	-44,897	914,660	-938,740	44,958
1499	5,000	-1,000	-533,455	0,008	-27,513	272,403	-641,974	28,305
1499	5,000	-1,000	-612,116	0,006	-32,531	279,470	-641,974	28,305
1500	5,000	-0,500	-641,500	0,004	-25,003	189,030	-524,849	18,083
1501	5,000	0,000	-670,885	0,002	-17,475	98,590	-452,945	12,449
1501	5,000	0,000	-655,986	0,005	-18,774	99,632	-452,945	12,449
1502	5,000	0,590	-604,832	3,370	-9,849	172,641	-372,675	22,640
1505	5,000	1,179	-553,677	40,304	-5,041	245,651	-249,358	24,056
1138	5,000	-9,000	-300,022	79,830	-280,260	7,949	-973,574	41,115
1139	5,000	-8,500	-294,776	76,574	-246,884	9,780	-	45,547
1187	5,000	-8,000	-289,530	73,440	-213,509	11,610	-	50,894
906	5,000	-18,000	-164,085	48,739	-24,604	44,404	0,000	0,000
794	5,000	-17,500	-170,352	52,677	0,000	87,680	-5,170	33,021
796	5,000	-17,000	-176,618	56,615	0,000	130,956	0,000	87,680
796	5,000	-17,000	-178,250	57,268	0,000	121,108	0,000	87,680
795	5,000	-16,500	-186,418	62,250	0,000	134,659	0,000	151,622
839	5,000	-16,000	-194,585	67,327	0,000	148,211	0,000	222,339
839	5,000	-16,000	-195,405	67,369	0,000	139,901	0,000	222,339
838	5,000	-15,500	-204,912	71,095	0,000	120,400	0,000	287,415
850	5,000	-15,000	-214,419	75,027	-0,226	102,774	0,000	342,739
850	5,000	-15,000	-214,581	75,022	-0,226	101,634	0,000	342,739
851	5,000	-14,500	-222,948	77,829	-0,774	66,839	0,000	379,244
880	5,000	-14,000	-231,315	80,725	-4,254	49,393	0,000	389,994
880	5,000	-14,000	-231,393	80,722	-6,479	49,777	0,000	389,994
881	5,000	-13,500	-237,827	82,615	-90,842	22,561	-0,224	367,551
941	5,000	-13,000	-244,261	84,577	-175,206	8,331	-1,210	336,447
941	5,000	-13,000	-243,767	84,583	-194,361	8,271	-1,210	336,447
942	5,000	-12,500	-251,140	85,482	-266,265	4,946	-2,661	312,779
987	5,000	-12,000	-258,512	86,481	-338,168	5,102	-4,499	257,987
987	5,000	-12,000	-258,435	86,489	-328,852	5,179	-4,499	257,987
988	5,000	-11,500	-268,346	86,429	-349,101	5,052	-136,601	166,944
1061	5,000	-11,000	-278,257	86,374	-369,350	4,926	-316,214	101,052
1061	5,000	-11,000	-279,099	86,385	-364,789	4,928	-316,214	101,052
1062	5,000	-10,500	-289,578	85,080	-350,348	5,352	-494,998	46,101
1116	5,000	-10,000	-300,058	83,946	-336,216	5,775	-666,561	34,313

<b>Node no.</b>	<b>x-coord.</b> [m]	<b>y-coord.</b> [m]	<b>N<sub>min</sub></b> [kN/m]	<b>N<sub>max</sub></b> [kN/m]	<b>Q<sub>min</sub></b> [kN/m]	<b>Q<sub>max</sub></b> [kN/m]	<b>M<sub>min</sub></b> [kNm/m]	<b>M<sub>max</sub></b> [kNm/m]
1116	5,000	-10,000	-303,484	83,963	-338,015	5,661	-666,561	34,313
1117	5,000	-9,500	-302,712	81,852	-311,014	6,802	-827,657	37,429
1138	5,000	-9,000	-301,939	79,789	-284,032	7,943	-973,574	41,115
<b>Max:</b>			0,000	86,489	0,000	1556,917	0,000	389,994
<b>Min:</b>			-670,885	0,000	-369,350	0,000	-	0,000

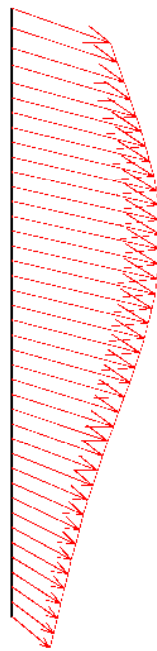
### 8. Results for phase 10



**Fig. 21 Plot of deformed mesh**  
- step no: 142 - ( phase: 10 )

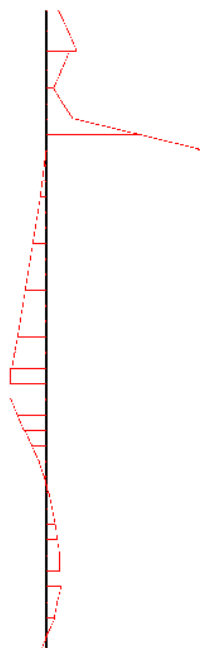


**Fig. 22 Plot of horizontal displacements (shadings)**  
- step no: 142 - ( phase: 10 )



**Fig. 23 Total displacements in beam (plate no: 1)**

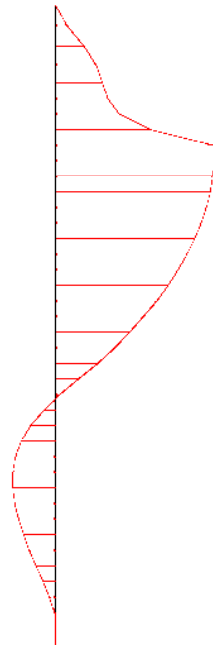
Extreme value  $41,03 \cdot 10^{-3}$  m (phase: 10)





**Fig. 24 Shear forces in beam (plate no: 1)**

Extreme value 754,10 kN/m (phase: 10)



**Fig. 25 Bending moments in beam (plate no: 1)**

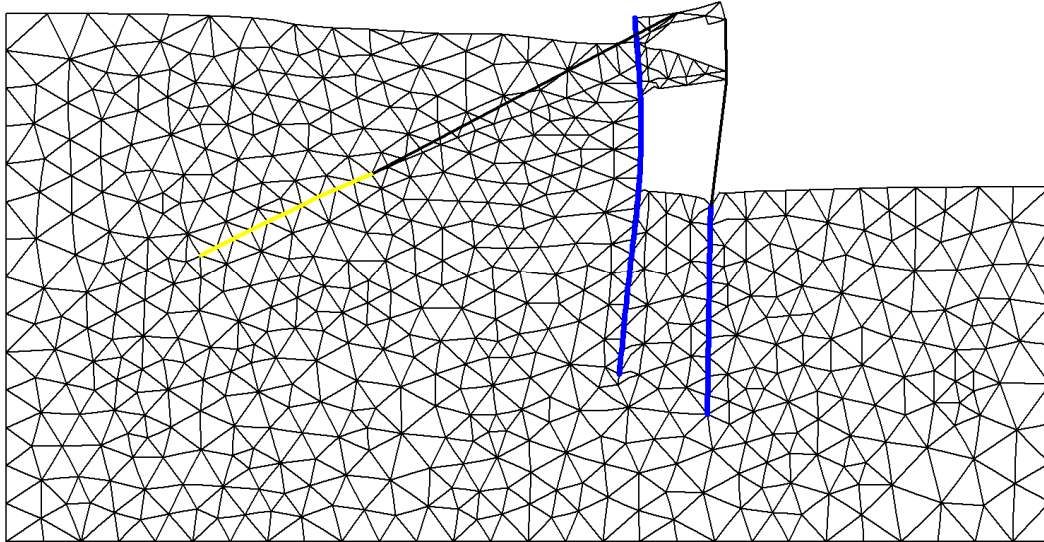
Extreme value 740,09 kNm/m (phase: 10)

**Table [13] Anchors phase no: 10**

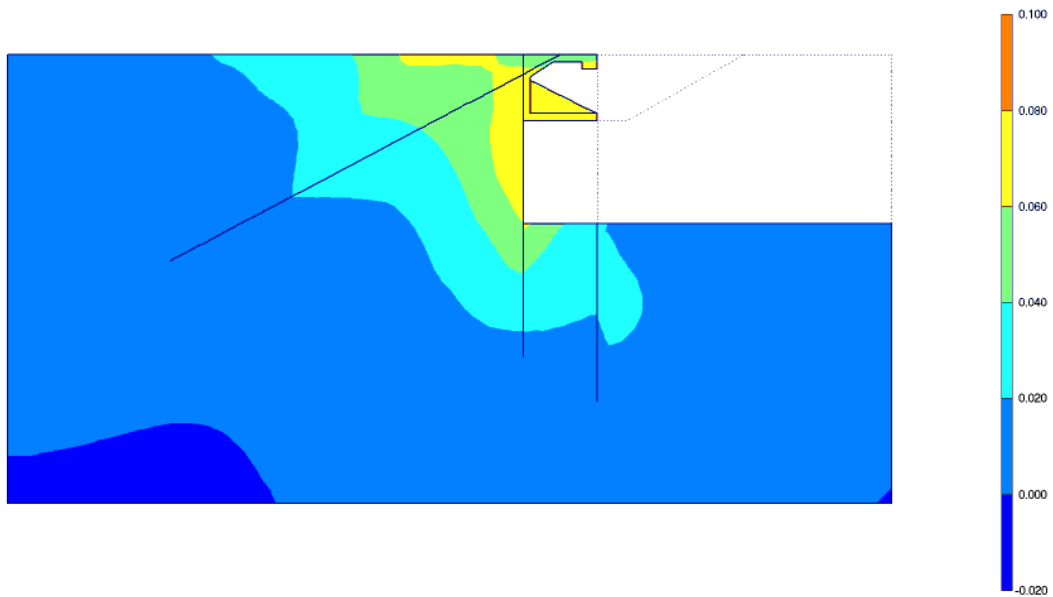
Anchor no.	Node	x-coord. [m]	y-coord. [m]	F [kN]	Fmax,comp  [kN]	Fmax,tens  [kN]	EA [kN]	Rotation [°]	Le [m]
1	1182	10,000	1,500	-235,641	1E15	1E15	1788000,00	N/A	3,500
	1230	10,000	-2,000						
2	1230	10,000	-2,000	-347,098	1E15	1E15	1788000,00	N/A	7,000
	854	10,000	-9,000						
3	1376	7,500	2,500	216,588	1E15	1E15	81800,00	N/A	19,235
	2184	-9,508	-6,485						



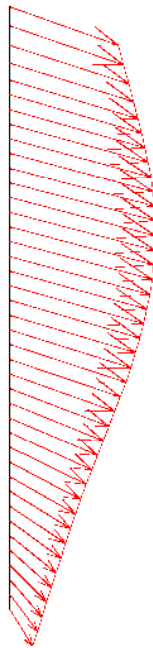
### 9. Results for phase 11



**Fig. 26 Plot of deformed mesh**  
- step no: 269 - ( phase: 11 )

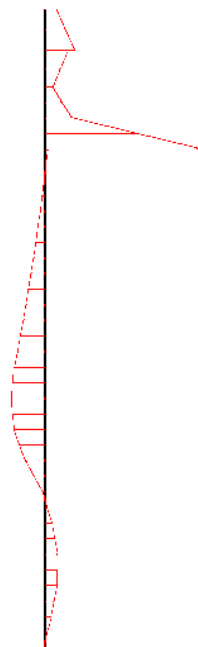


**Fig. 27 Plot of horizontal displacements (shadings)**  
- step no: 269 - ( phase: 11 )



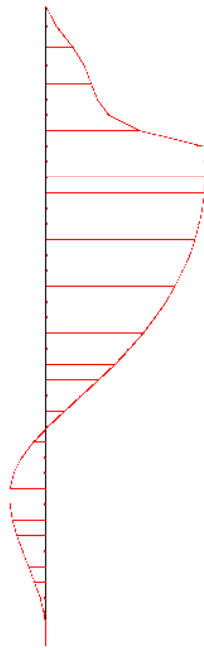
**Fig. 28 Total displacements in beam (plate no: 1)**

Extreme value  $78,06 \cdot 10^{-3}$  m (phase: 11)



**Fig. 29 Shear forces in beam (plate no: 1)**

Extreme value  $1,17 \cdot 10^3$  kN/m (phase: 11)



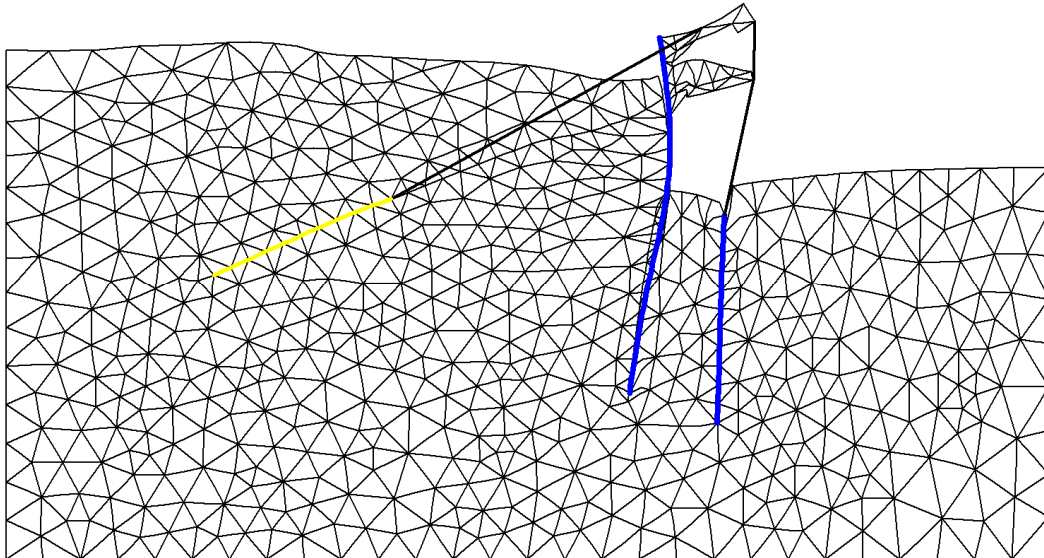
**Fig. 30 Bending moments in beam (plate no: 1)**

Extreme value  $1,15 \cdot 10^3$  kNm/m (phase: 11)

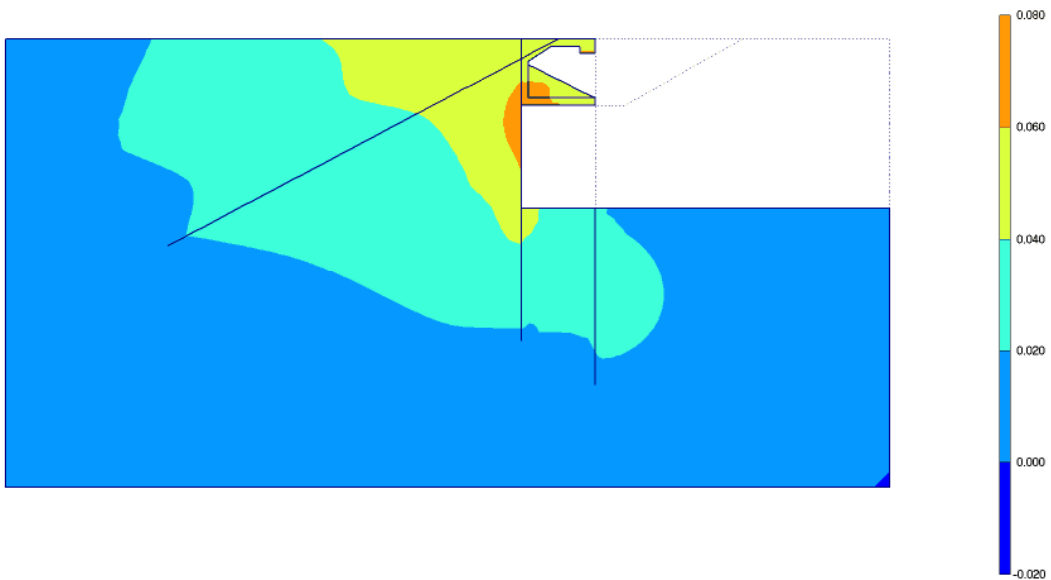
**Table [14] Anchors phase no: 11**

Anchor no.	Node	x-coord. [m]	y-coord. [m]	F [kN]	Fmax,comp  [kN]	Fmax,tens  [kN]	EA [kN]	Rotation [°]	Le [m]
1	1182	10,000	1,500	-287,856	1E15	1E15	1788000,00	N/A	3,500
	1230	10,000	-2,000						
2	1230	10,000	-2,000	-431,410	1E15	1E15	1788000,00	N/A	7,000
	854	10,000	-9,000						
3	1376	7,500	2,500	288,466	1E15	1E15	81800,00	N/A	19,235
	2184	-9,508	-6,485						

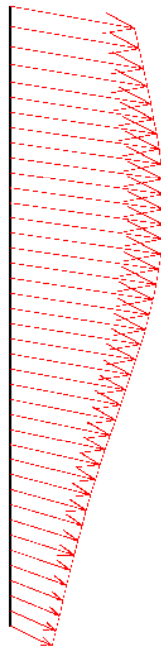
### 10. Results for phase 13



**Fig. 31 Plot of deformed mesh**  
- step no: 161 - ( phase: 13 )

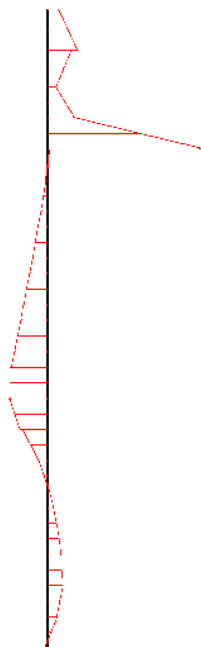


**Fig. 32 Plot of horizontal displacements (shadings)**  
- step no: 161 - ( phase: 13 )



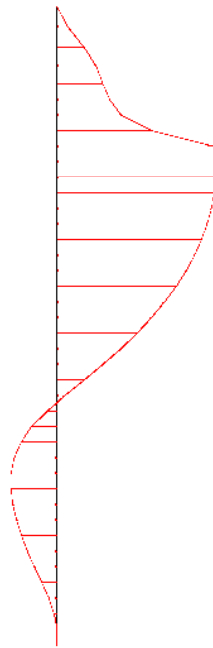
**Fig. 33 Total displacements in beam (plate no: 1)**

Extreme value  $65,15 \cdot 10^{-3}$  m (phase: 13)



**Fig. 34 Shear forces in beam (plate no: 1)**

Extreme value 898,76 kN/m (phase: 13)



**Fig. 35 Bending moments in beam (plate no: 1)**

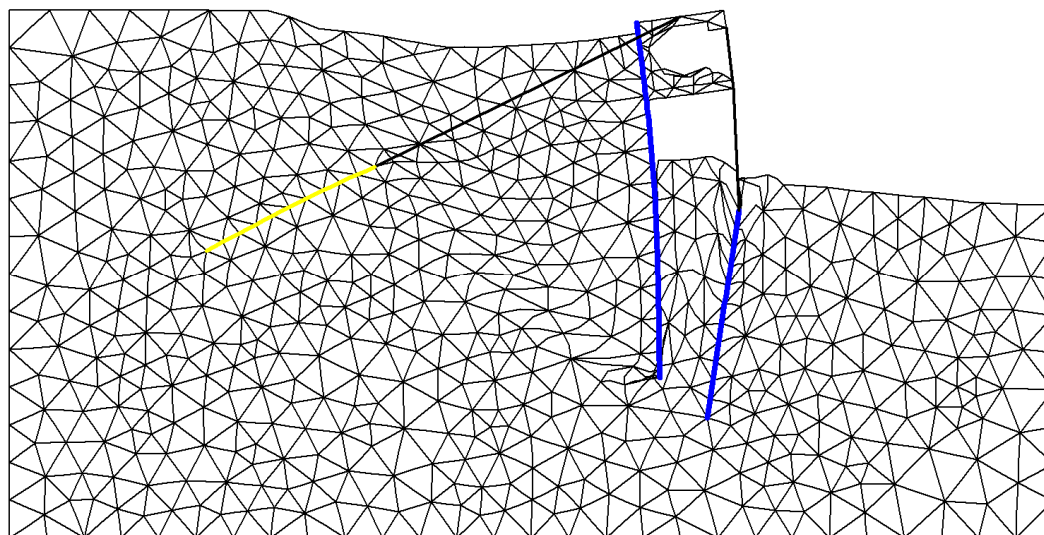
Extreme value 890,70 kNm/m (phase: 13)

**Table [15] Anchors phase no: 13**

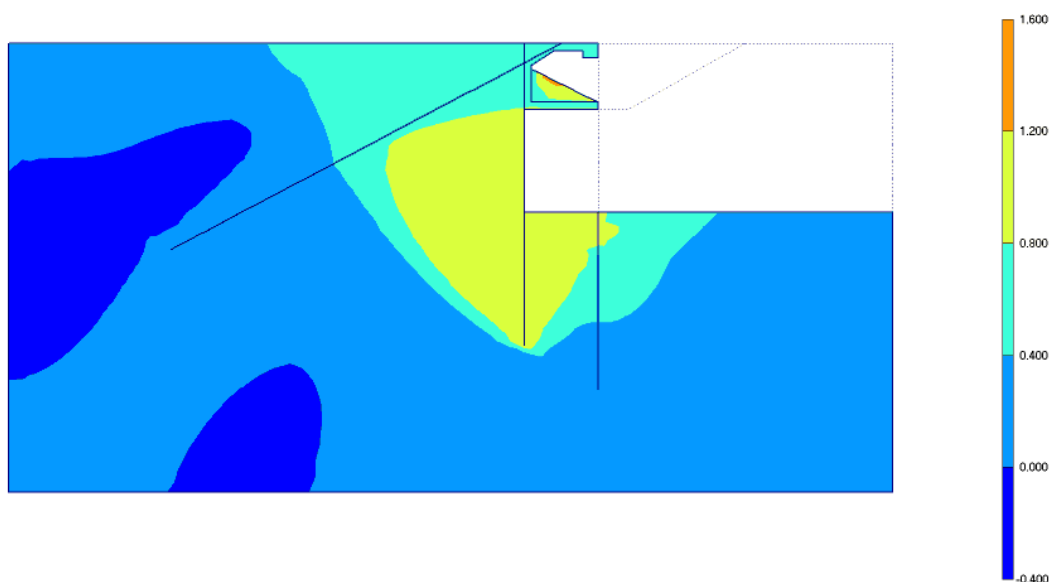
Anchor no.	Node	x-coord. [m]	y-coord. [m]	F [kN]	Fmax,comp  [kN]	Fmax,tens  [kN]	EA [kN]	Rotation [°]	Le [m]
1	1182	10,000	1,500	-228,681	1E15	1E15	1788000,00	N/A	3,500
	1230	10,000	-2,000						
2	1230	10,000	-2,000	-347,383	1E15	1E15	1788000,00	N/A	7,000
	854	10,000	-9,000						
3	1376	7,500	2,500	246,401	1E15	1E15	81800,00	N/A	19,235
	2184	-9,508	-6,485						



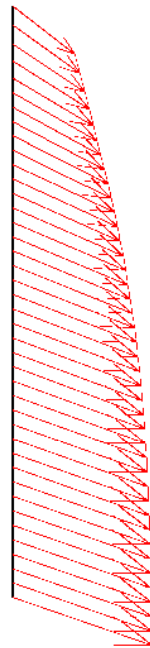
### 11. Results for phase 14



**Fig. 36 Plot of deformed mesh**  
 - step no: 261 - ( phase: 14 )



**Fig. 37 Plot of horizontal displacements (shadings)**  
 - step no: 261 - ( phase: 14 )



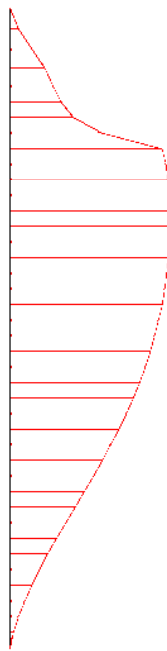
**Fig. 38 Total displacements in beam (plate no: 1)**

Extreme value 1,26 m (phase: 14)



**Fig. 39 Shear forces in beam (plate no: 1)**

Extreme value  $4,15 \cdot 10^3$  kN/m (phase: 14)



**Fig. 40 Bending moments in beam (plate no: 1)**

Extreme value  $4,37 \cdot 10^3$  kNm/m (phase: 14)

**Table [16] Anchors phase no: 14**

Anchor no.	Node	x-coord. [m]	y-coord. [m]	F [kN]	Fmax,comp  [kN]	Fmax,tens  [kN]	EA [kN]	Rotation [°]	Le [m]
1	1182	10,000	1,500	-439,498	1E15	1E15	1788000,00	N/A	3,500
	1230	10,000	-2,000						
2	1230	10,000	-2,000	-766,133	1E15	1E15	1788000,00	N/A	7,000
	854	10,000	-9,000						
3	1376	7,500	2,500	868,408	1E15	1E15	81800,00	N/A	19,235
	2184	-9,508	-6,485						