

COMMITTENTE:



ALTA SORVEGLIANZA:



GENERAL CONTRACTOR:



INFRASTRUTTURE FERROVIARIE STRATEGICHE DEFINITE DALLA LEGGE OBIETTIVO N. 443/01

TRATTA A.V. /A.C. TERZO VALICO DEI GIOVI
PROGETTO DEFINITIVO

LINEA III VALICO – GENERALI GALLERIE NATURALI
CUNICOLI ESPLORATIVI VAL LEMME E CASTAGNOLA E
FINESTRA POLCEVERA – RELAZIONE GEOTECNICA, TECNICA,
DI CALCOLO E MONITORAGGIO tomo 2/2

GENERAL CONTRACTOR	ITALFERR S.p.A.
Consorzio Cociv Project Manager (Ing. Guagnozzi) Data:06/11/2012	

COMMESSA	LOTTO	FASE	ENTE	TIPO DOC.	OPERA/DISCIPLINA	PROGR.	REV.
A 3 0 1	0 0	D	C V	R O	G N 0 0 0 X	0 1 2	F

Progettazione :

Rev	Descrizione	Redatto	Data	Verificato	Data	Progettista Integratore	Data	IL PROGETTISTA
B00	Emissione ex art.4 D.lgs 190/02	Fantauzzi	15/06/2005	Bellocchio	15/06/2005	Ognibene	15/06/2005	Ing. E. Ghislandi Data: 06/11/2012
E00	Adeguamento sicurezza in galleria	Ing. M. Frandino	16/03/2012	Ing.F.Colla	20/03/2012	Ing. E. Pagani	23/03/2012	
F00	Rev. per istruttoria ITALFERR A30100D07ISGN0000004A	Ing. M. Frandino	29/10/2012	Ing.F.Colla	31/10/2012	Ing. E. Pagani	05/11/2012	

n. Elab.:

File: A30100DCVROGN000X012F00

CUP: F81H92000000008

Calcolo FLAC – Sezione tipo B2/1

Sezione tipo B2/A - Ap gruppo 2

Input Analisi alle Differenze Finite FLAC

Geometria	
Copertura (m)	500.00
Altezza falda statica (m)	0.00
Coefficiente efficienza drenaggio	0.20
Altezza falda dinamica (m)	0.00
Raggio scavo (m)	5.90

Materiali							
Spitz-beton	f_{cm} (MPa)	s (m)	E_{sp} (MPa)	E_{s2} (MPa)	A_s (cm ²)	E_{ss} (MPa)	I_{sp} (cm ⁴)
	25	0.30	-	28500		2.21E+03	Jox (cm ⁴)
Caroline	tipo	n	p (m)	h (cm)			Jox (cm ⁴)
	HEB200	1.00	1.00	20.00			5696.0
Rivestimenti	R_p (MPa)	S (m)	Armaturo	D			
A.R.	30	1.00	31220	5.0			
Calcoli	30	0.50	31220	9.0			

LEGENDA SIMBOLI

f_{cm} - resistenza media cilindrica a compressione dello spitz-beton
 s - spessore dello spitz-beton
 E_{sp} - moduli elastici intermedi dello spitz-beton
 E_{s2} - modulo elastico finale dello spitz-beton
 A_s - momento di inerzia dello spitz-beton
 n - numero di centine per gruppo
 p - passo centine
 D - area del profilo della singola centina
 h - altezza del profilo centina
 Jox - momento di inerzia del profilo della singola centina
 R_p - resistenza caratteristica cubica a compressione del ole
 S - spessore del rivestimento definitivo
 E_{mat} - modulo elastico del cis maturato
 D - Distanza di getto tra investimenti definitivi e fronte (multiplo del diametro della galleria)
 E_{pr} - modulo elastico del preinvestimento.

Parametri geomecchanici		1° strato		2° strato	
Valori di picco e residui		Picco	Residuo	Picco	Residuo
Peso di volume (kN/m ³)	2.7	33	31		
Angolo attrito (°)	1.10	1.0			
Coesione (MPa)	2.10	2.10			
Modulo elastico (GPa)	0.20	0.30			
Modulo di Poisson	0.30	0.30			
Modulo di deformazione volumetrica (Bulk modulus)(GPa)	1.75	1.75			
Modulo elastico tangenziale (Shear modulus) (GPa)	0.81	0.81			
Modulo costitutivo		Strain-Softening			

Fasi di calcolo (TIME)	x (m)	xPR	RPanet	ROEM	Eprn (MPa)	E _{pr} (MPa)
TIME 1 - Geostatico	∞	∞	0.000	0.000	-	-
TIME 2 - Taratura e scavo	0.00	0.000	0.250	0.349	-	-
TIME 3 - Posa centina e SB	1.00	0.182	0.513	0.959	14.000	-
TIME 4 - Getto Murelle e A.R., maturazione SB	20.00	3.638	0.975	0.983	33200	31220
TIME 5 - Getto calotta	40.00	7.273	0.992	1.000	-	31220
TIME 6 - Decadimento armasso e preinvestimento	∞	∞	1.000	1.000	-	31220

Relazione per il calcolo di RPanet, ROEM:

$$R^* = u_0 + (1-u_0) \left[1 - \frac{x}{1 + 0.84 \cdot Rp} \right]$$

R^* = Convergenza radiale ad una distanza di x metri dal fronte espressa come % di u_0
 u_0 = Convergenza radiale in corrispondenza del fronte espressa come % di u_0
 $1-u_0$ = Convergenza radiale ad una distanza infinita dal fronte
 R_p = Raggio della galleria
 x = distanza tra il fronte e la sezione di calcolo

TIME DI CALCOLO

TIME 1 - Geostatico: Viene applicato il peso proprio del terreno ricorrendo in termini di tensioni litostatiche la situazione preesistente lo scavo della galleria.

TIME 2 - Taratura e scavo: Viene simulato l'arresto del fronte di scavo tenendo in conto il contributo dei consolidamenti al fronte.

TIME 3 - Posa centina e SB: Viene simulata la posa in opera delle centine e dello spitz-beton.

TIME 4 - Getto Murelle e A.R., maturazione SB: Viene simulato il getto delle murelle e dell'arco murella la maturazione dello spitz e l'avanzamento dello scavo.

TIME 5 - Getto calotta: Si simula il getto del rivestimento definitivo di calotta.

TIME 6 - Decadimento armasso e preinvestimento: Si applica un decadimento della caratteristica meccanica del preinvestimento e dell'armasso.

JOB TITLE : Sezioni di verifica - Prerivestimento

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:42

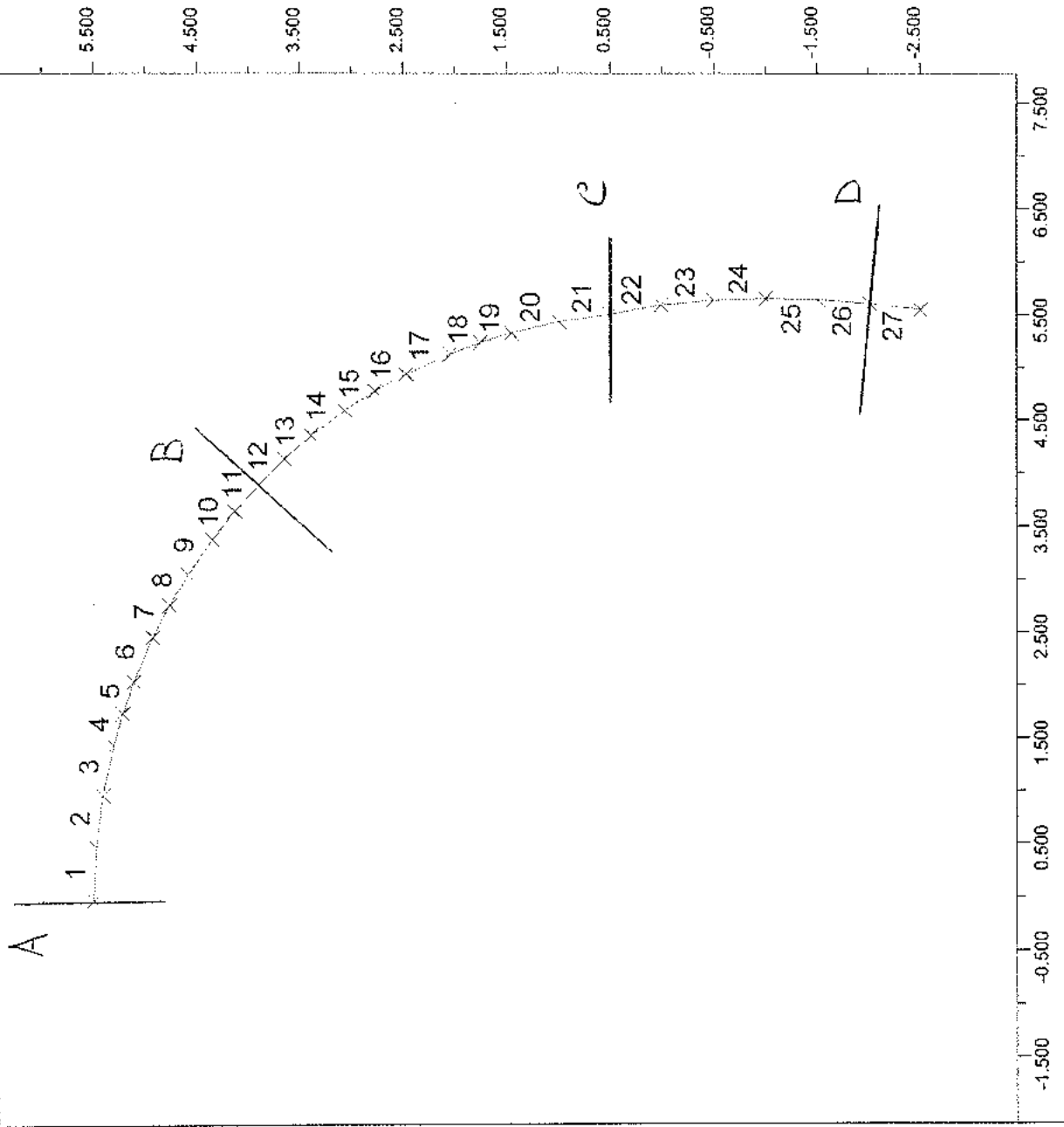
step 20395

-2.121E+00 <x< 7.770E+00

-3.438E+00 <y< 6.454E+00

Beam Plot

Structural Element Numbers



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

Sezione tipo B2/1 - Ap gruppo 2

Verifica del pririvestimento

CARATTERISTICHE GEOMETRICHE E MECCANICHE

MATERIALI	Tipo	σ_{max} (MPa)	H (cm)	Passo (m)	n°	A (cm²)	I (cm⁴)
Spritz-beton	Fcm 25	19.20	30	-	-	3000.0	2250.0
Centine	HEB200	210	20.00	1.00	1.00	78.1	5696.0
Sezione omogeneizzata						4093.4	102027.5

Coefficiente omogeneizzazione m	15	
Baricentro centina d (cm)	10.00	dall'estradosso
Baricentro sezione omogeneiz. Yg (cm)	13.66	dall'estradosso
e'lim,e = I*/(A*Yg) (cm)	1.82	dimensione nocciolo d'inerzia estradosso
e'lim,i = I*/(A*(H-Yg)) (cm)	1.53	dimensione nocciolo d'inerzia intradosso

e = M/N eccentricità

Formule impiegate

$$\sigma_{sb,i} = N/A^* + (M(H-Yg))/I^* \quad \sigma_{sb,e} = N/A^* - (MYg)/I^*$$

$$\sigma_{s,i} = m(N/A^* + M(d+H_s/2-Yg)/I^*)$$

$$\sigma_{s,e} = m(N/A^* - M(d-H_s/2-Yg)/I^*)$$

Tensioni positive se di compressione

Sezione	Elemento	Altezza (m)	N (KN/m)	M (KN*m/m)	e (m)	$\sigma_{sb,i}$ (Mpa)	$\sigma_{sb,e}$ (Mpa)	$\sigma_{s,i}$ (Mpa)	$\sigma_{s,e}$ (Mpa)	
CHIAVE CALOTTA	1	0.30	1041	-2.5	0.00	2.14	2.88	35.82	43.17	TIME 3
RENI	11	0.30	1016	4.4	0.00	3.19	1.89	41.33	28.39	
P.C.	22	0.30	882	-37.6	-0.04	-3.87	7.19	-2.70	107.86	
PIEDE	27	0.30	490	-8.9	-0.02	-0.23	2.39	9.67	35.84	
CHIAVE CALOTTA	1	0.30	1940	-1.2	0.00	4.07	5.30	67.18	79.53	TIME 4
RENI	11	0.30	1974	10.2	0.01	6.46	3.46	81.84	51.84	
P.C.	22	0.30	1813	-66.8	-0.04	-6.27	13.38	4.22	200.63	
PIEDE	27	0.30	1018	-36.8	-0.04	-3.73	7.68	1.09	115.18	

JOB TITLE : Sezioni di verifica - Rivestimento definitivo

FLAC (Version 4.00)

LEGEND

19-Feb-04 10:11

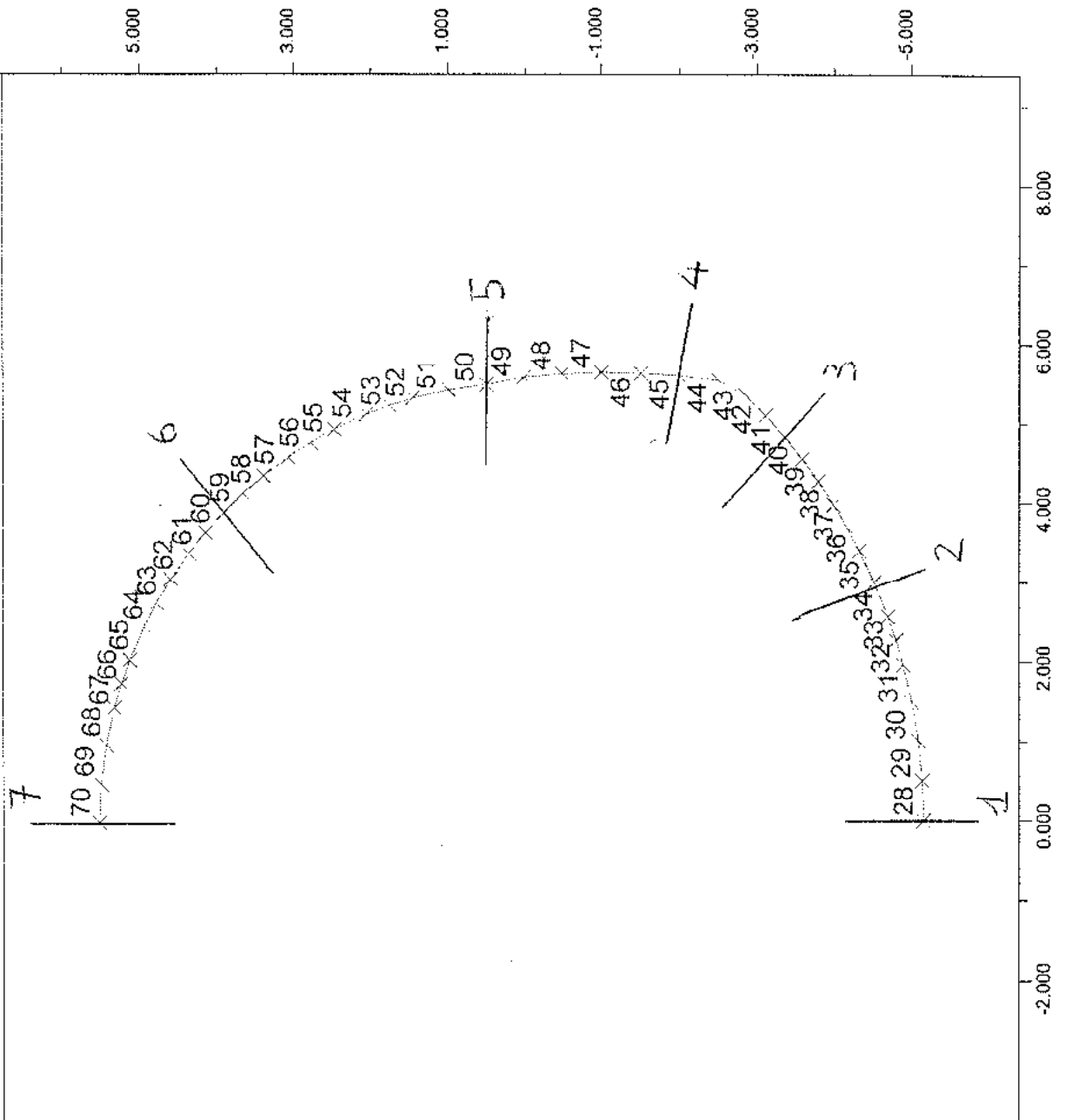
step 26205

-3.755E+00 <x< 9.405E+00

-6.399E+00 <y< 6.761E+00

Beam Plot

Structural Element Numbers



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

Sezione tipo B2/1 - Ap gruppo 2
Verifica del rivestimento definitivo

TIME 4 - Getto Murette e A.R., maturazione SB

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σc (MPa)
CHIAVE A.R.	28	1.00	1246	76.6	0.06	1.7
SEZIONE INTERMEDIA A.R.	34	1.00	1133	102.1	0.09	1.7
ATTACCO A.R. - MURETTA	40	1.00	1078	118.6	0.11	1.8

TIME 5 - Getto calotta

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σc (MPa)
CHIAVE A.R.	28	1.00	1915	-12.2	-0.01	2.0
SEZIONE INTERMEDIA A.R.	34	1.00	1821	-74.9	-0.04	2.3
ATTACCO A.R. - MURETTA	40	1.00	1792	-190.0	-0.11	2.9
ATTACCO CAL. - MURETTA	45	0.80	583	-88.4	-0.15	1.6
PIANO DEI CENTRI	49	0.80	545	100.6	0.18	1.7
RENI	59	0.80	509	-22.6	-0.04	0.8
CHIAVE CALOTTA	70	0.80	484	-1.8	0.00	0.6

TIME 6 - Decadimento ammasso e prlvestimento

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σc (MPa)
CHIAVE A.R.	28	1.00	2386	11.6	0.00	2.5
SEZIONE INTERMEDIA A.R.	34	1.00	2286	-71.9	-0.03	2.7
ATTACCO A.R. - MURETTA	40	1.00	2353	-341.5	-0.15	4.4
ATTACCO CAL. - MURETTA	45	0.80	2658	-260.4	-0.10	5.3
PIANO DEI CENTRI	49	0.80	2893	339.5	0.12	6.8
RENI	59	0.80	2955	-22.0	-0.01	3.9
CHIAVE CALOTTA	70	0.80	2896	-21.0	-0.01	3.8

Sezione tipo B2/1 - Ap gruppo 2

Output Analisi alle Differenze Finite FLAC

TIME	Riduzione forze di scavo [%]	Spostamento y in chiave calotta [cm]	Spostamento x sul piano dei centri [cm]	Spostamento y in chiave A.R. [cm]	Tensioni preriv.		Tensioni Riv. def.
					$\sigma_{SB,max}$ [MPa]	$\sigma_{e,max}$ [MPa]	
TIME 1 - Geostatico	0.0	Nodo i=1 j=68	Nodo i=12 j=57	Nodo i=1 j=47	-	-	-
TIME 2 - Taratura e scavo	94.0	9.4	9.2	8.7	-	-	-
TIME 3 - Posa centina e SB	95.9	9.6	9.5	9.2	7.19	107.86	-
TIME 4 - Getto Murette e A.R., maturazione SB	98.3	9.7	9.7	9.4	13.38	200.63	1.8
TIME 5 - Getto calotta	100.0	9.7	9.7	9.4	-	-	2.9
TIME 6 - Decadimento ammasso e prriverimento	100.0	9.8	9.8	9.4	-	-	6.8

Materiale	Tipo	Tensioni ammissibili [MPa]
Spritz-beton	fcm	$\sigma_{SB,amm}$ 19.20
Centina	Fe	$\sigma_{s,amm}$ 210
Calcestruzzo	Rck	$\sigma_{dis,amm}$ 7.50

Tensioni positive nel cls : compressione

Tensioni positive nell'acciaio : trazione

Spostamenti x positivi verso destra, spostamenti y positivi verso l'alto

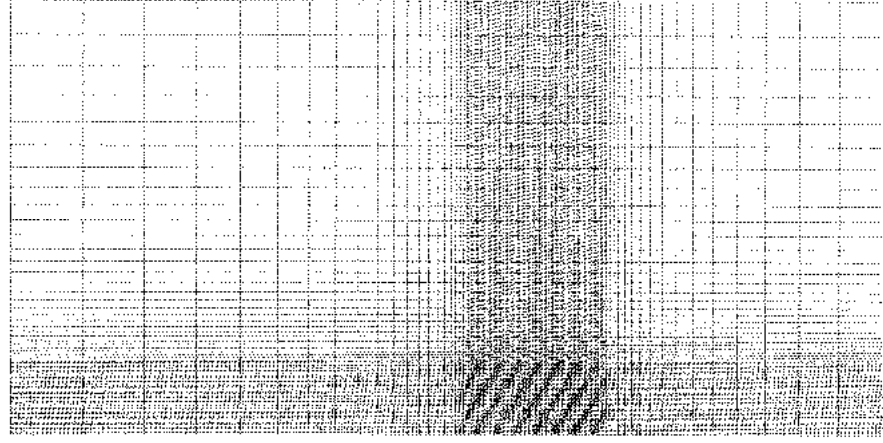
JOB TITLE : Cunicolo Castagnola (Ap gruppo 2) - SEZ. TIPO B2/1

FLAC (Version 4.00)

LEGEND

19-Feb-04 11:52
step 9721
-1.067E+02 <x< 2.267E+02
-1.417E+02 <y< 1.917E+02

MESH DI CALCOLO



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Minneapolis, Minnesota USA

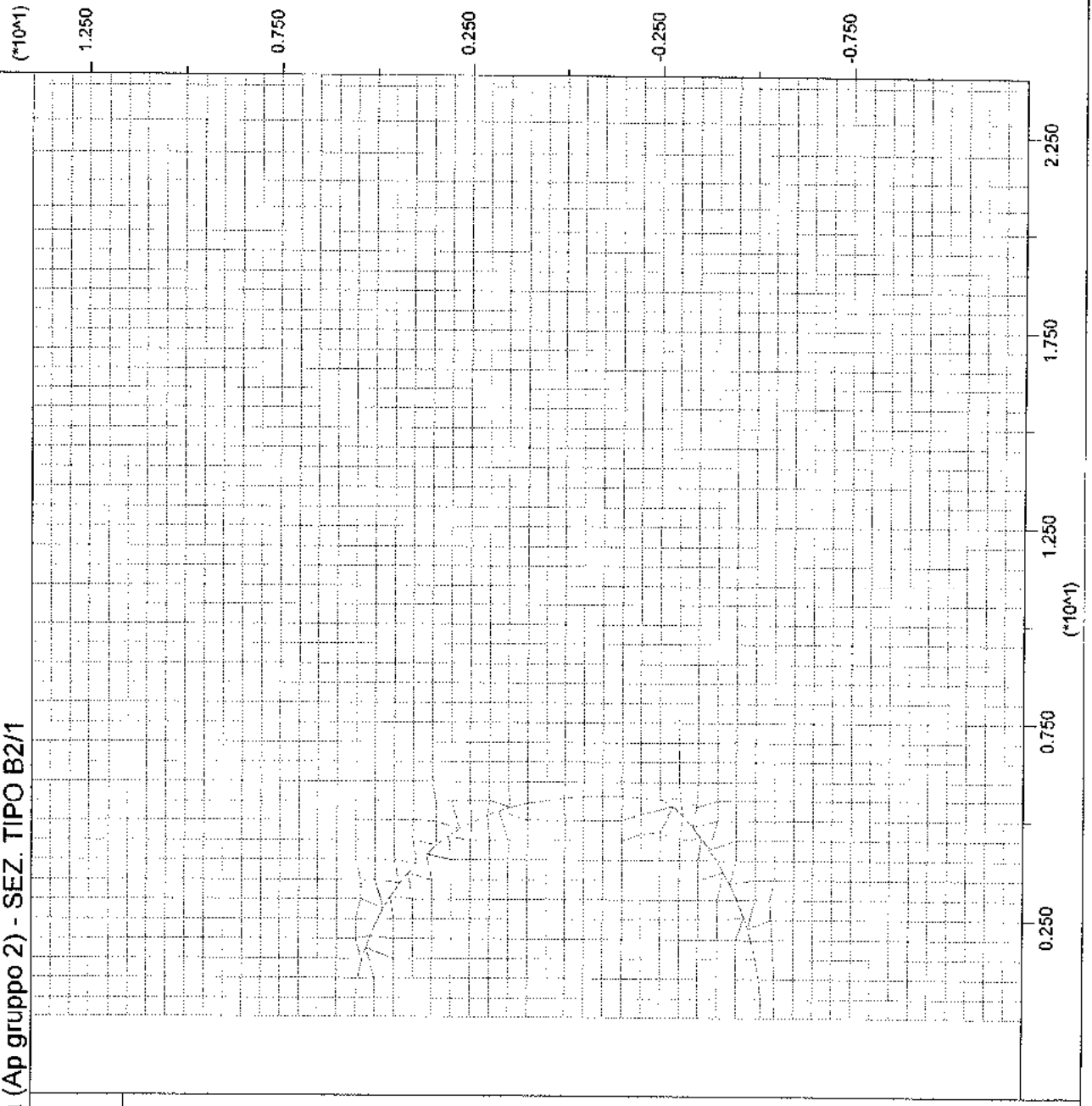
JOB TITLE : Cunicolo Castagnola (Ap gruppo 2) - SEZ. TIPO B2/1

FLAC (Version 4.00)

LEGEND

19-Feb-04 11:52
step 9721
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

MESH DI CALCOLO



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2 - "TIME 1"

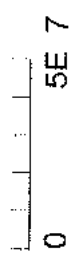
FLAC (Version 4.00)

LEGEND

19-Feb-04 11:52
step 9721
-1.067E+02 <x< 2.267E+02
-1.417E+02 <y< 1.917E+02

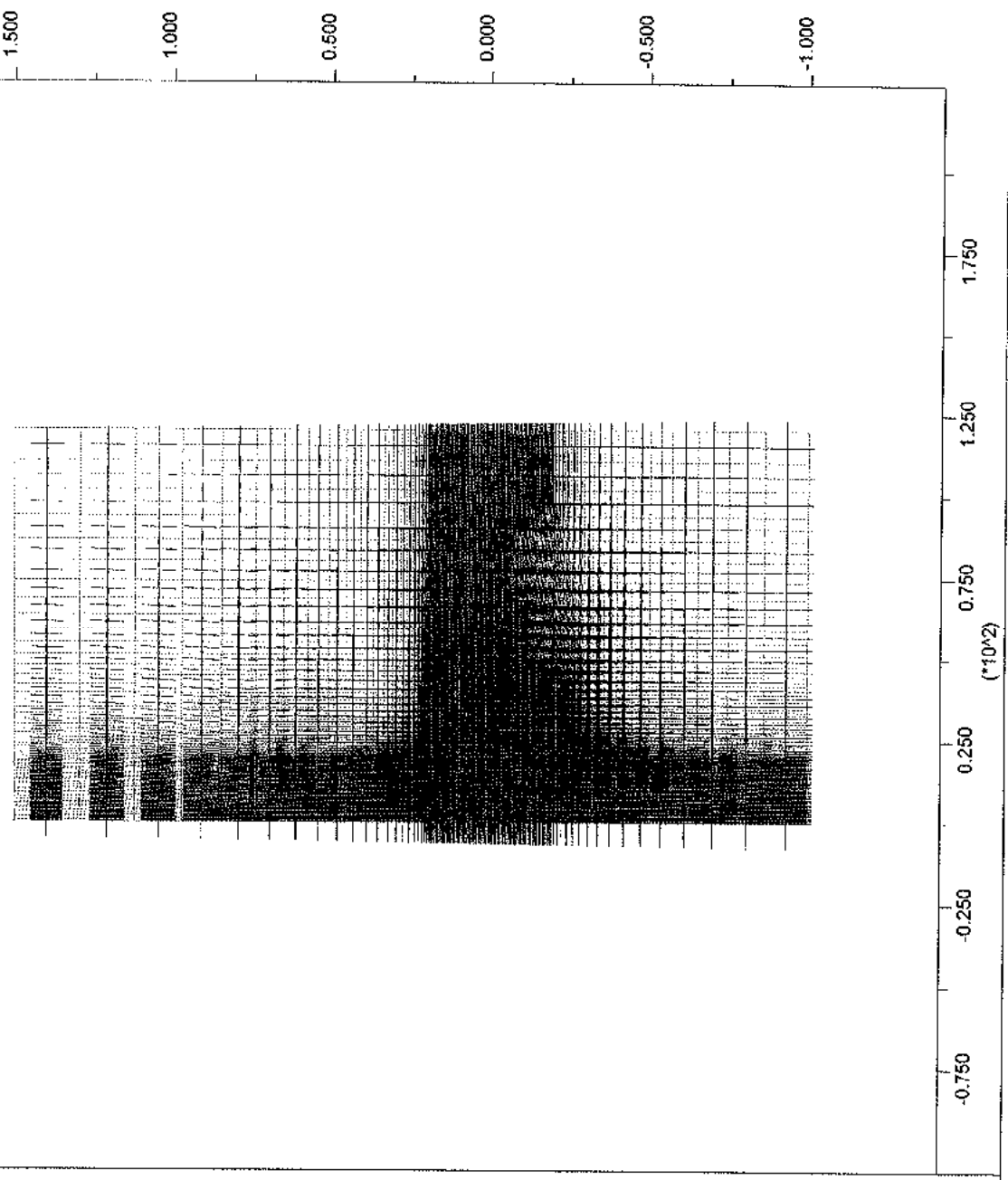
Principal stresses

Max. Value = -9.622E+06
Min. Value = -1.583E+07



Tensioni principali : Pa

0 1E 2



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2 - "TIME 1"

FLAC (Version 4.00)

LEGEND

19-Feb-04 11:52

step 9721

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Principal stresses

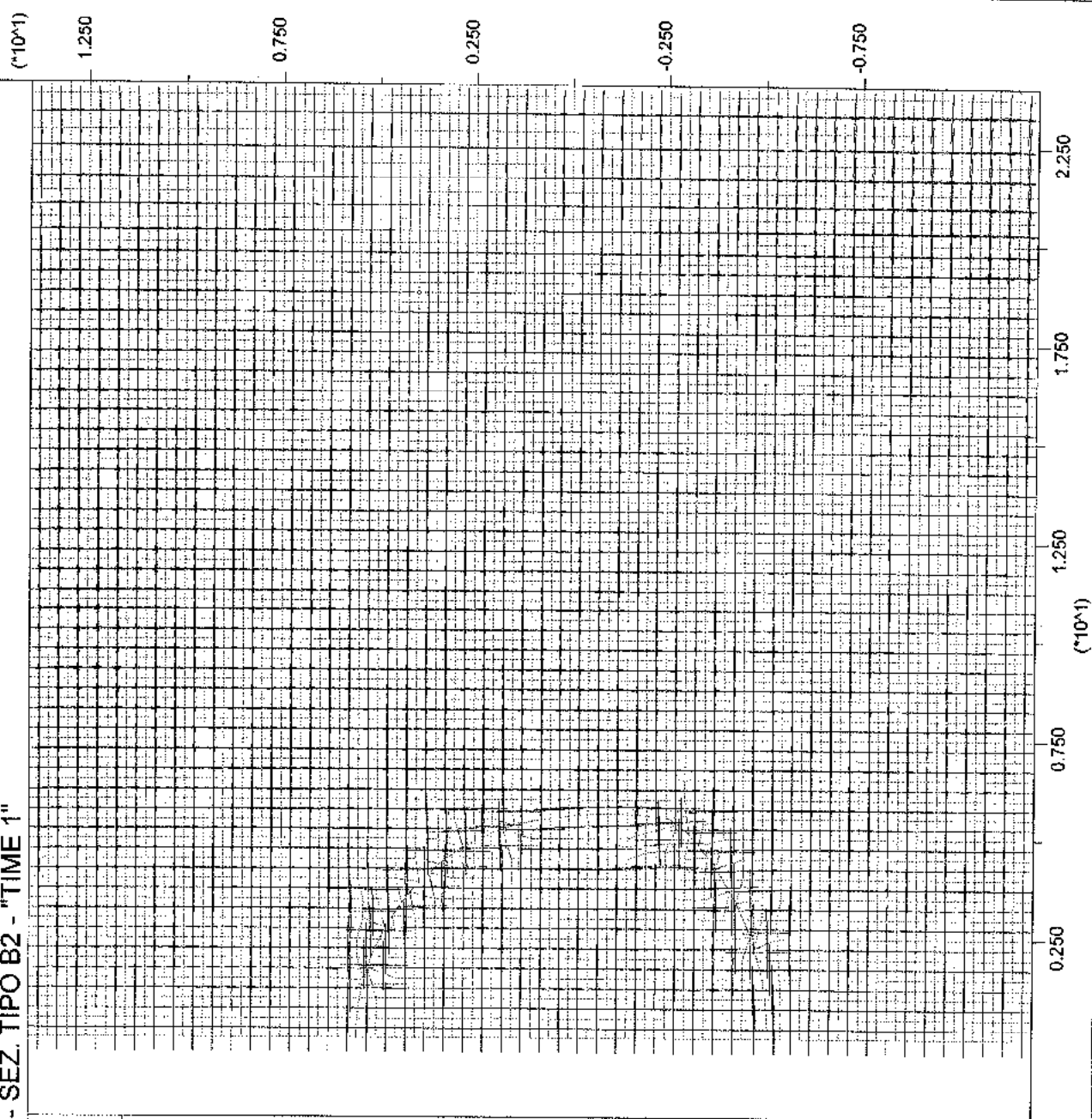
Max. Value = -1.292E+07

Min. Value = -1.371E+07

0 5E 7

Tensioni principali : Pa

0 5E 0



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 2"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:06

step 19152

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -4.943E+05

Min. Value = -2.242E+07

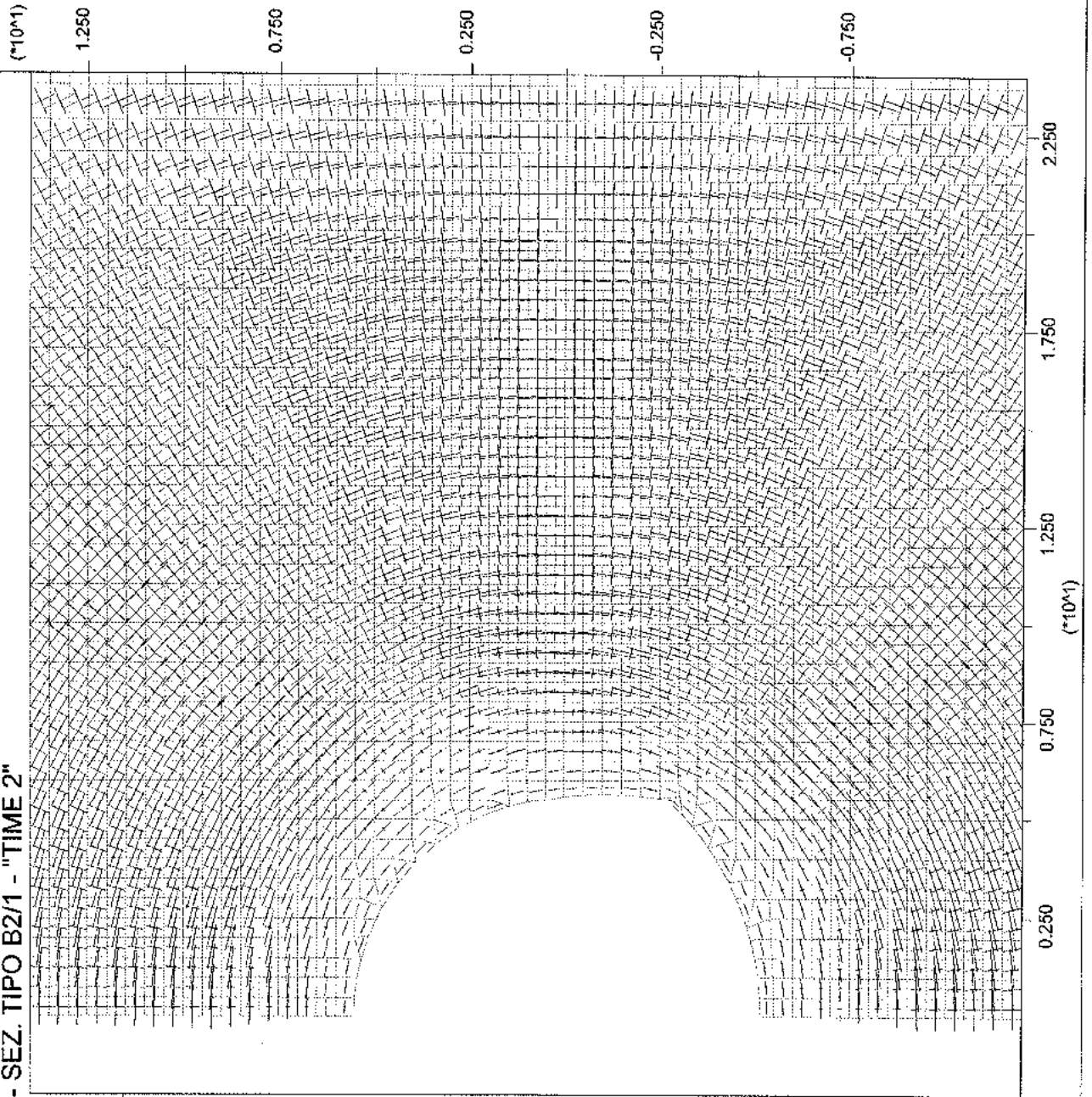


1E 8

Tensioni principali : Pa



5E 0



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 2"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:06

step 19152

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Y-displacement contours

-7.50E-02

-5.00E-02

-2.50E-02

0.00E+00

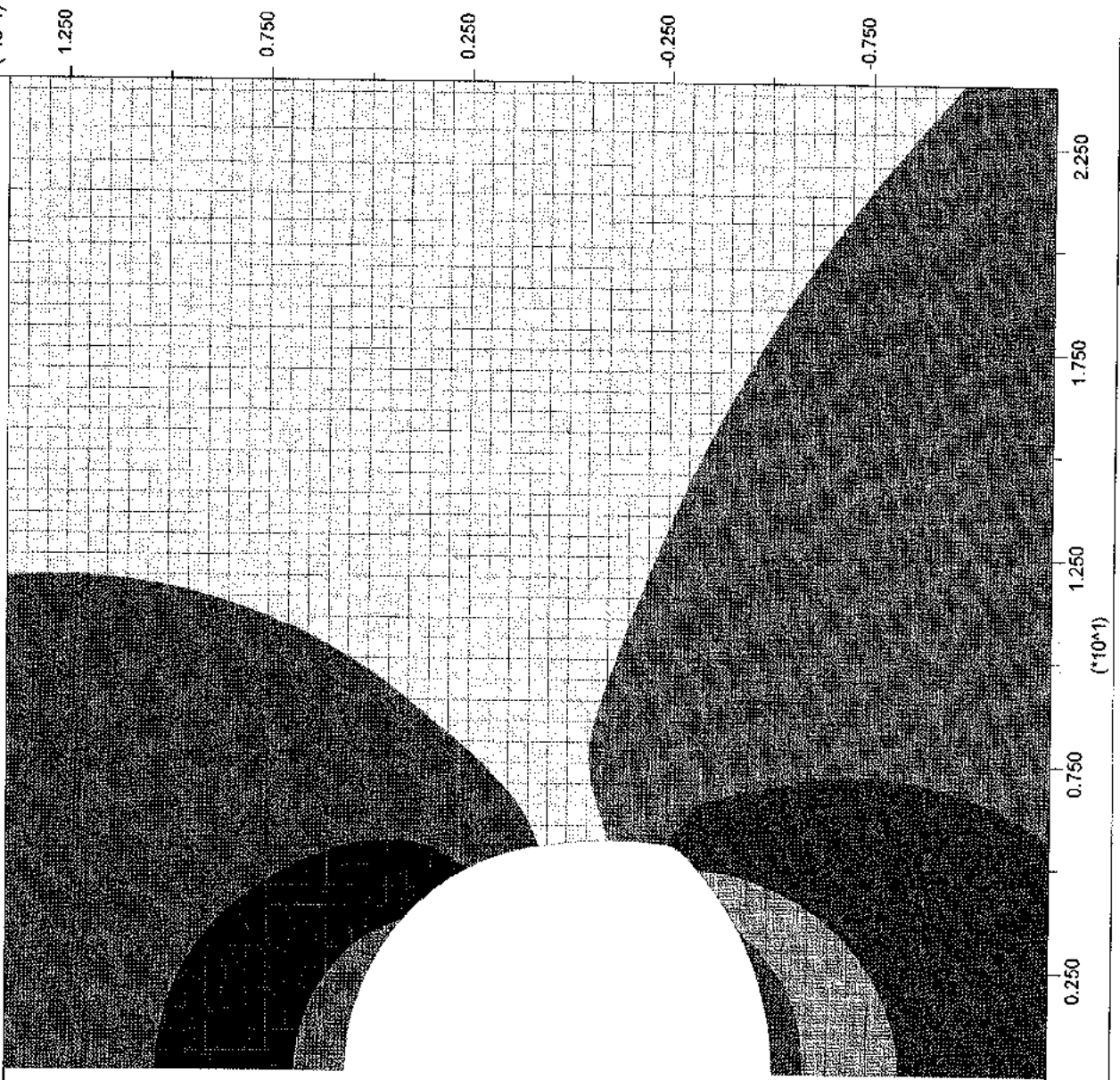
2.50E-02

5.00E-02

7.50E-02

Contour interval= 2.50E-02

Spostamenti verticali



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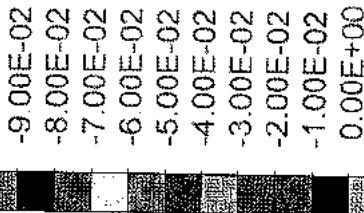
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 2"

FLAC (Version 4.00)

LEGEND

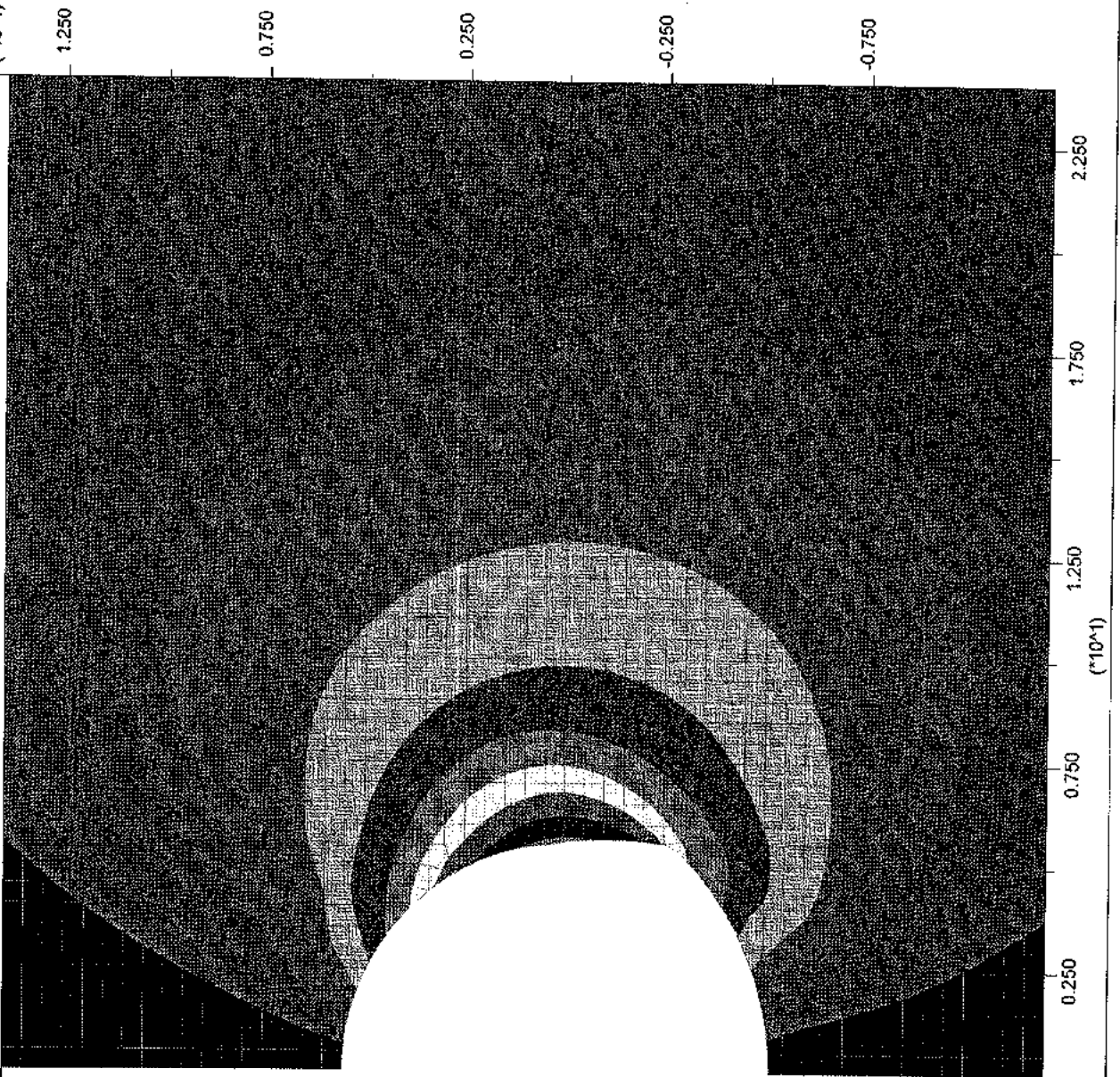
19-Feb-04 12:06
step 19152
-2.00E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 1.00E-02

Spostamenti orizzontali



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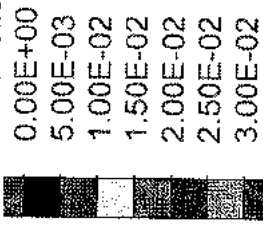
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FLAC (Version 4.00)

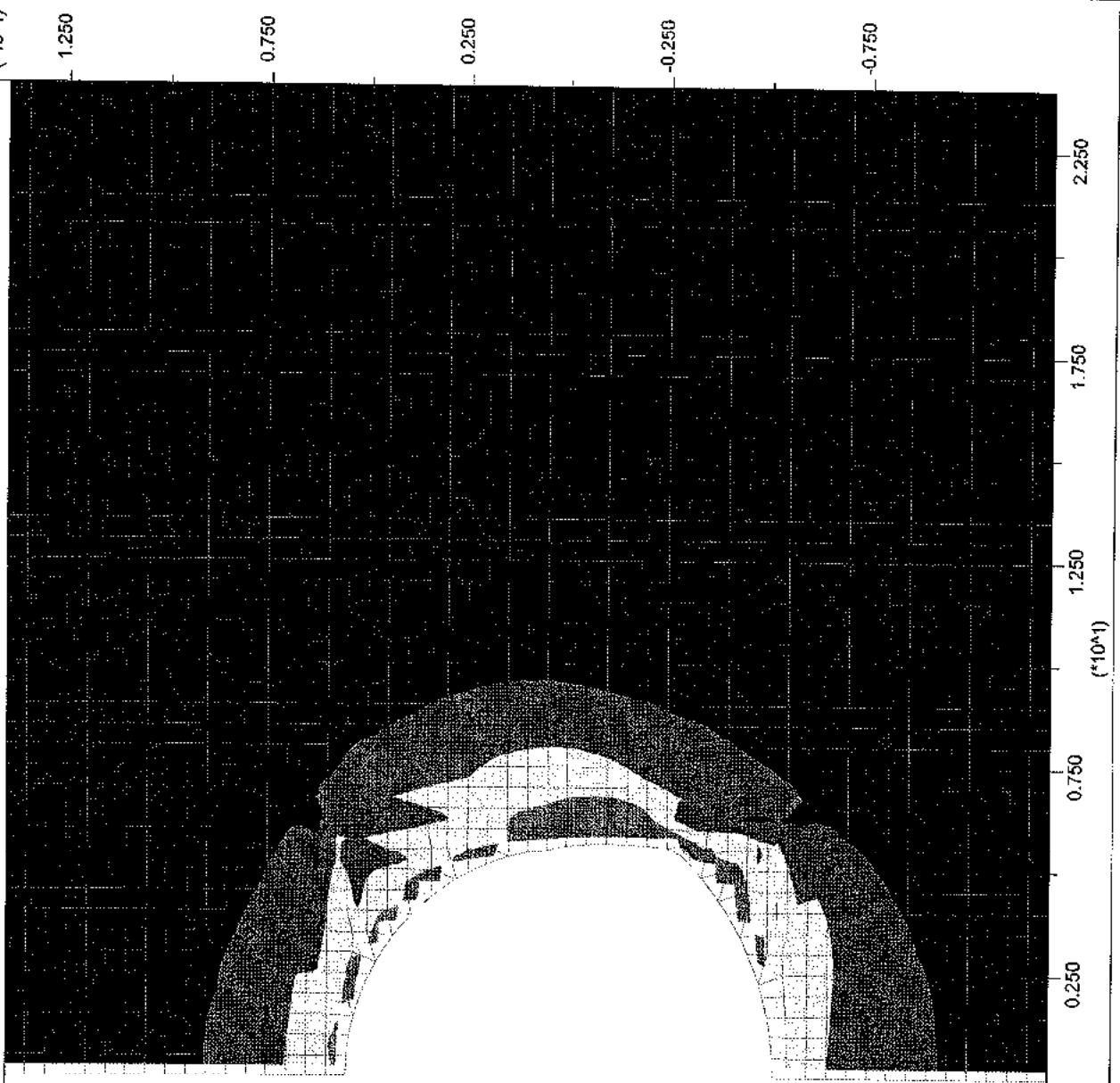
LEGEND

19-Feb-04 12:06
step 19152
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 5.00E-03
Deformazioni plastiche per taglio



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 3"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:11

step 20457

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Principal stresses

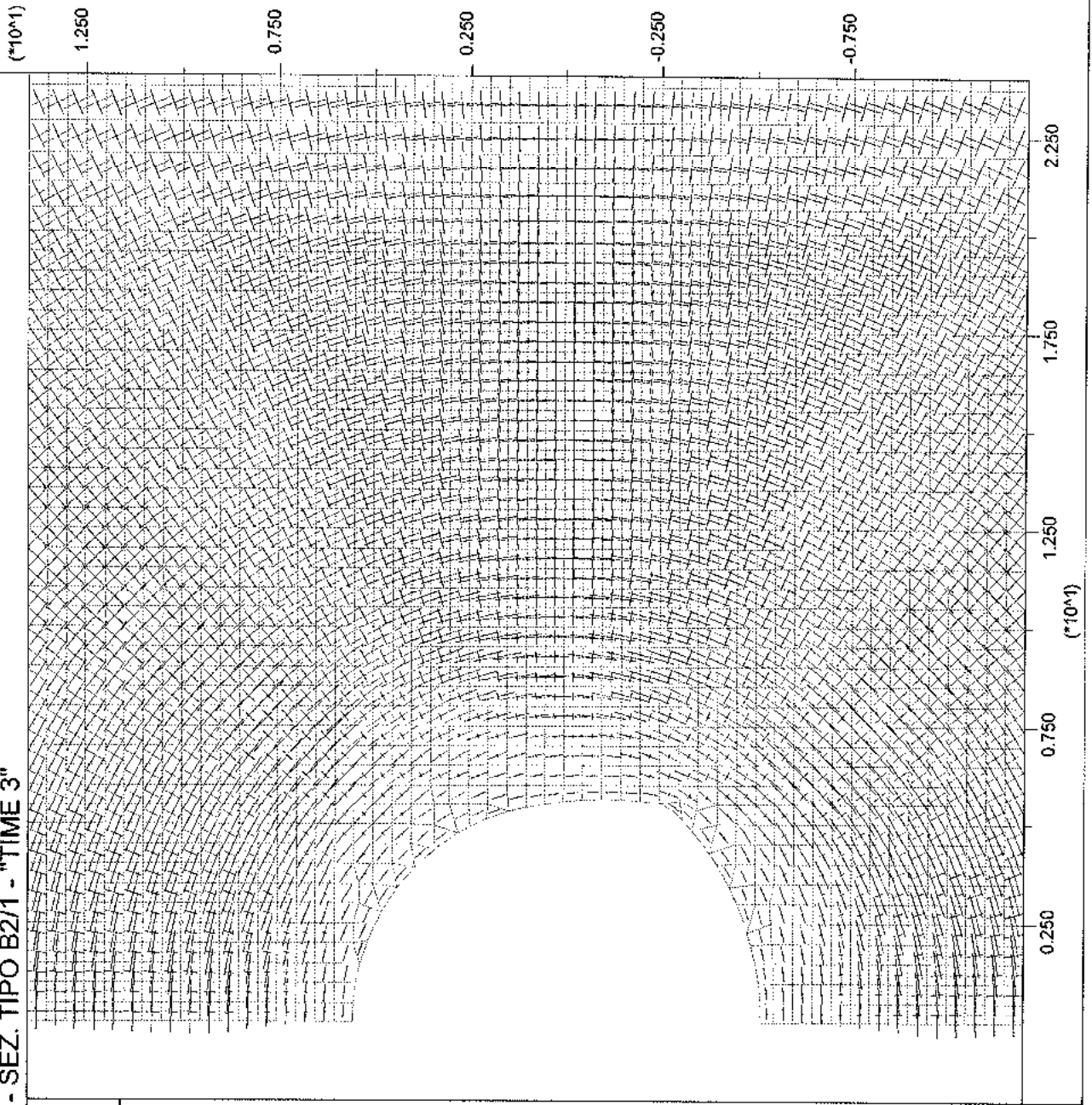
Max. Value = -3.510E+05

Min. Value = -2.218E+07

0 1E 8

Tensioni principali : Pa

0 5E 0



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Minneapolis, Minnesota USA

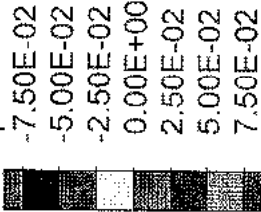
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 3"

FLAC (Version 4.00)

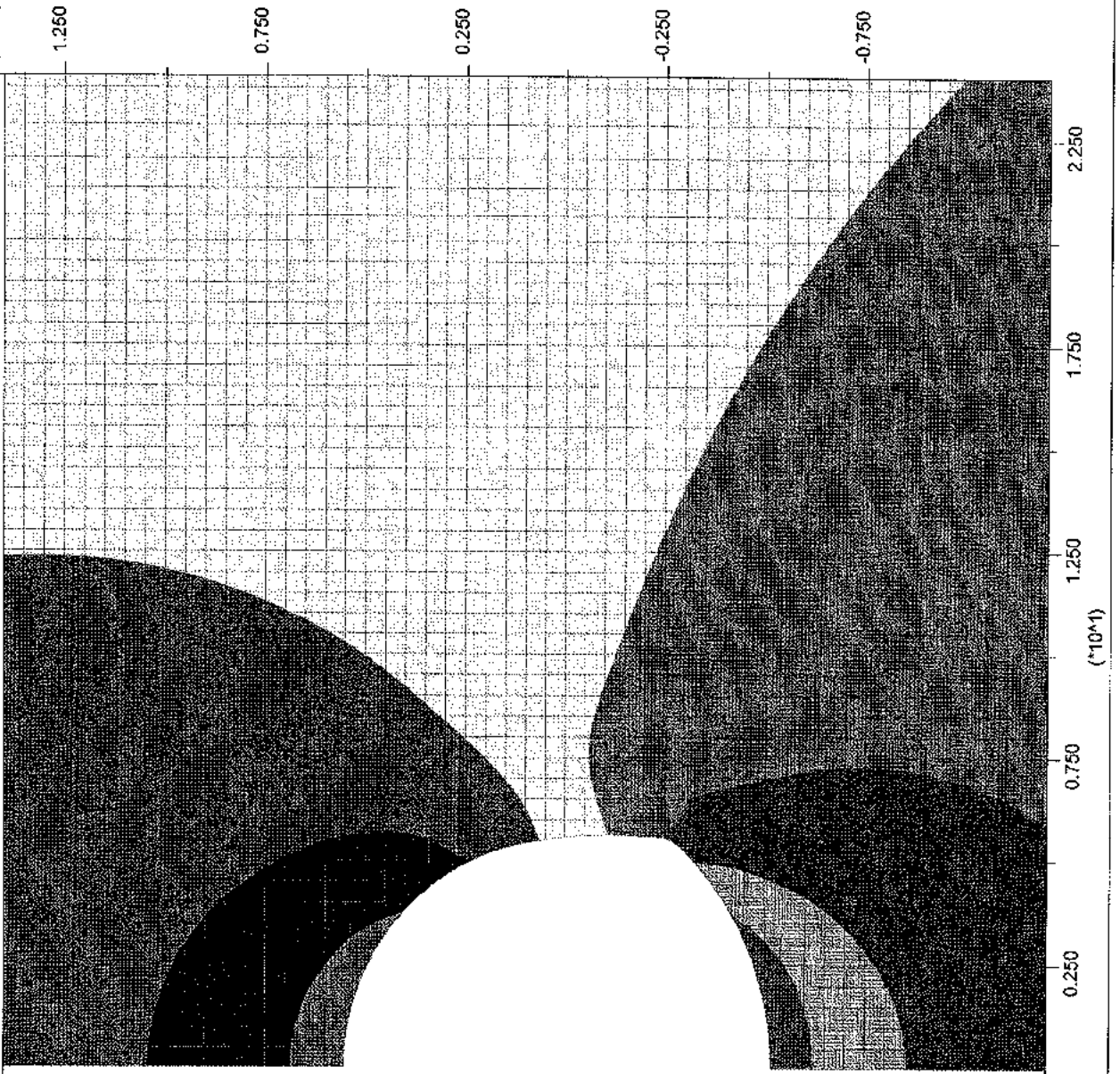
LEGEND

19-Feb-04 12:11
step 20457
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02
Spostamenti verticali



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Minneapolis, Minnesota USA

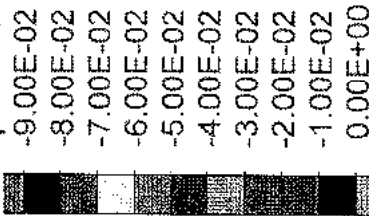
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FLAC (Version 4.00)

LEGEND

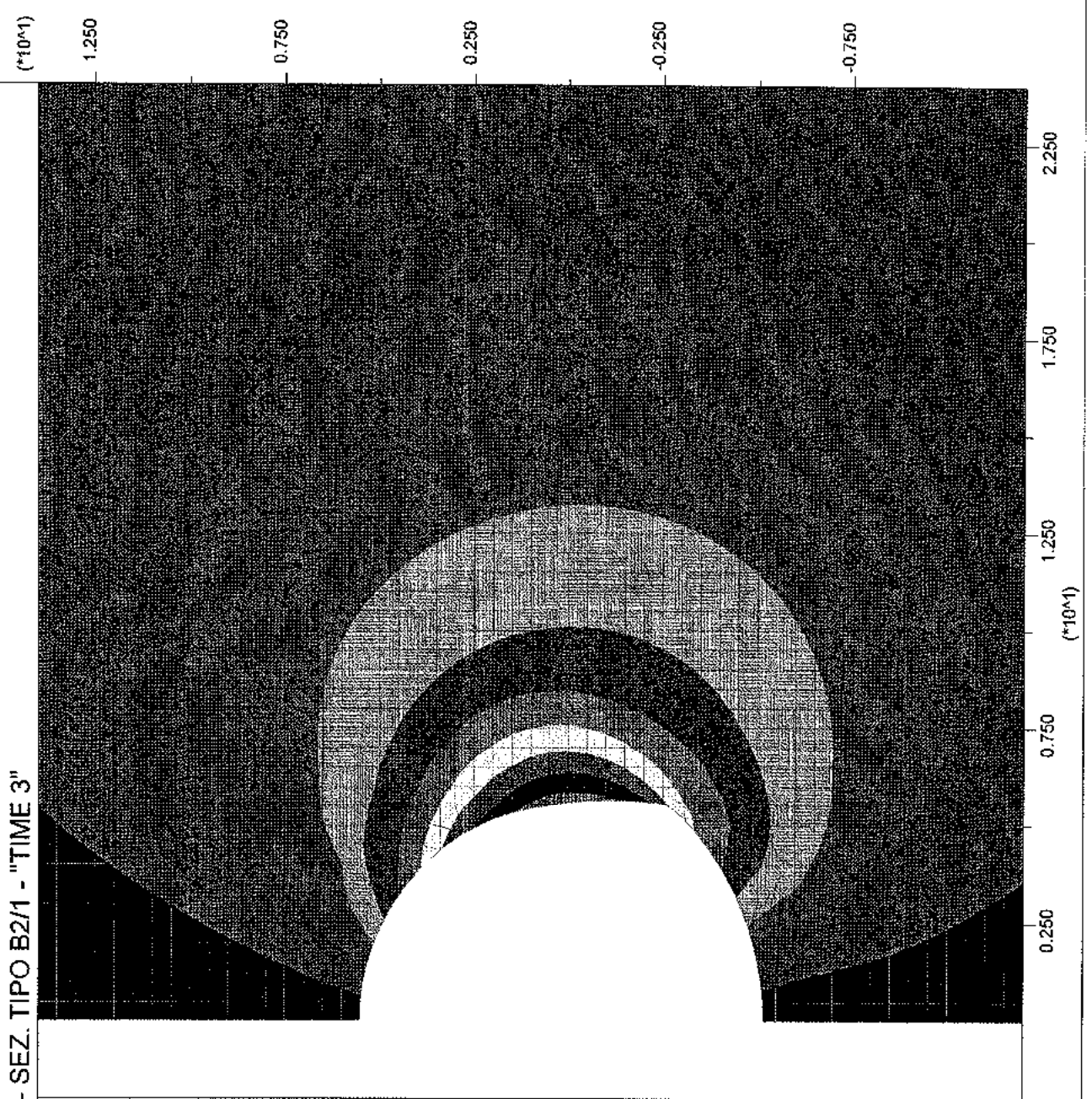
19-Feb-04 12:11
step 20457
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 1.00E-02

Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 3"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:11

step 20457

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

5.00E-03

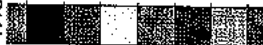
1.00E-02

1.50E-02

2.00E-02

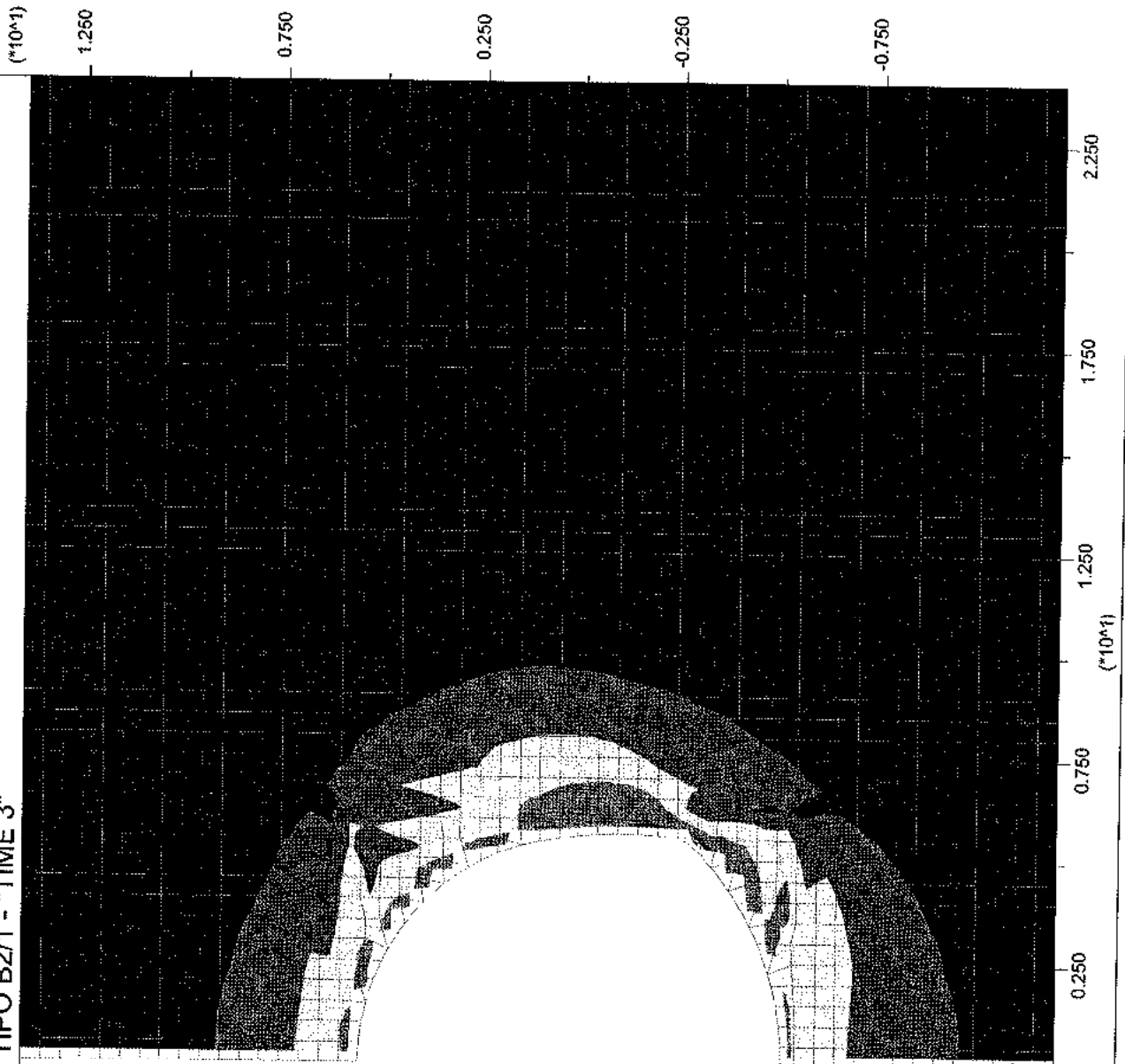
2.50E-02

3.00E-02



Contour interval= 5.00E-03

Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 3"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:11

step 20457

-2.000E+00 <x< 1.400E+01

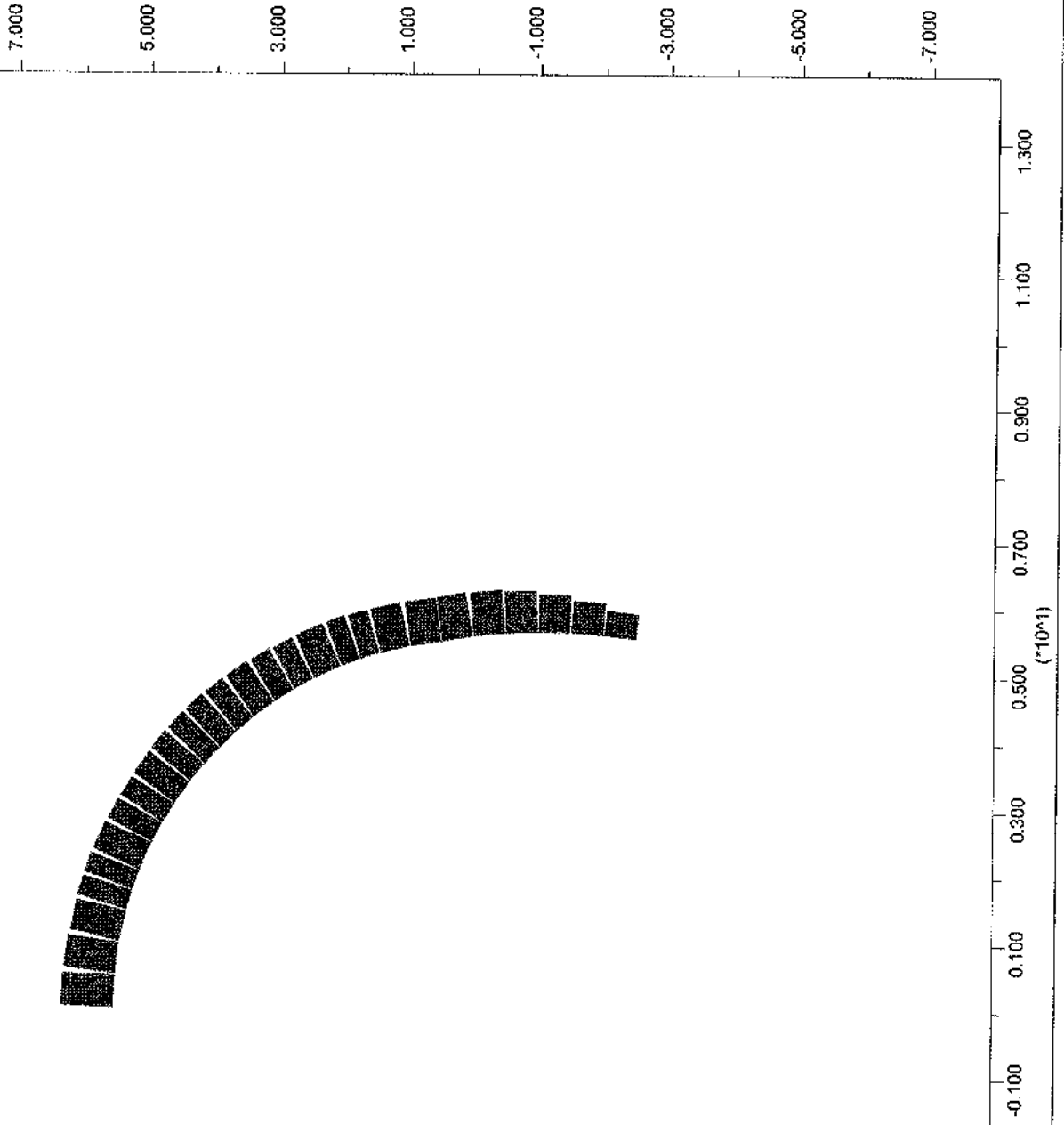
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value

1 (Beam) 1.041E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 3"

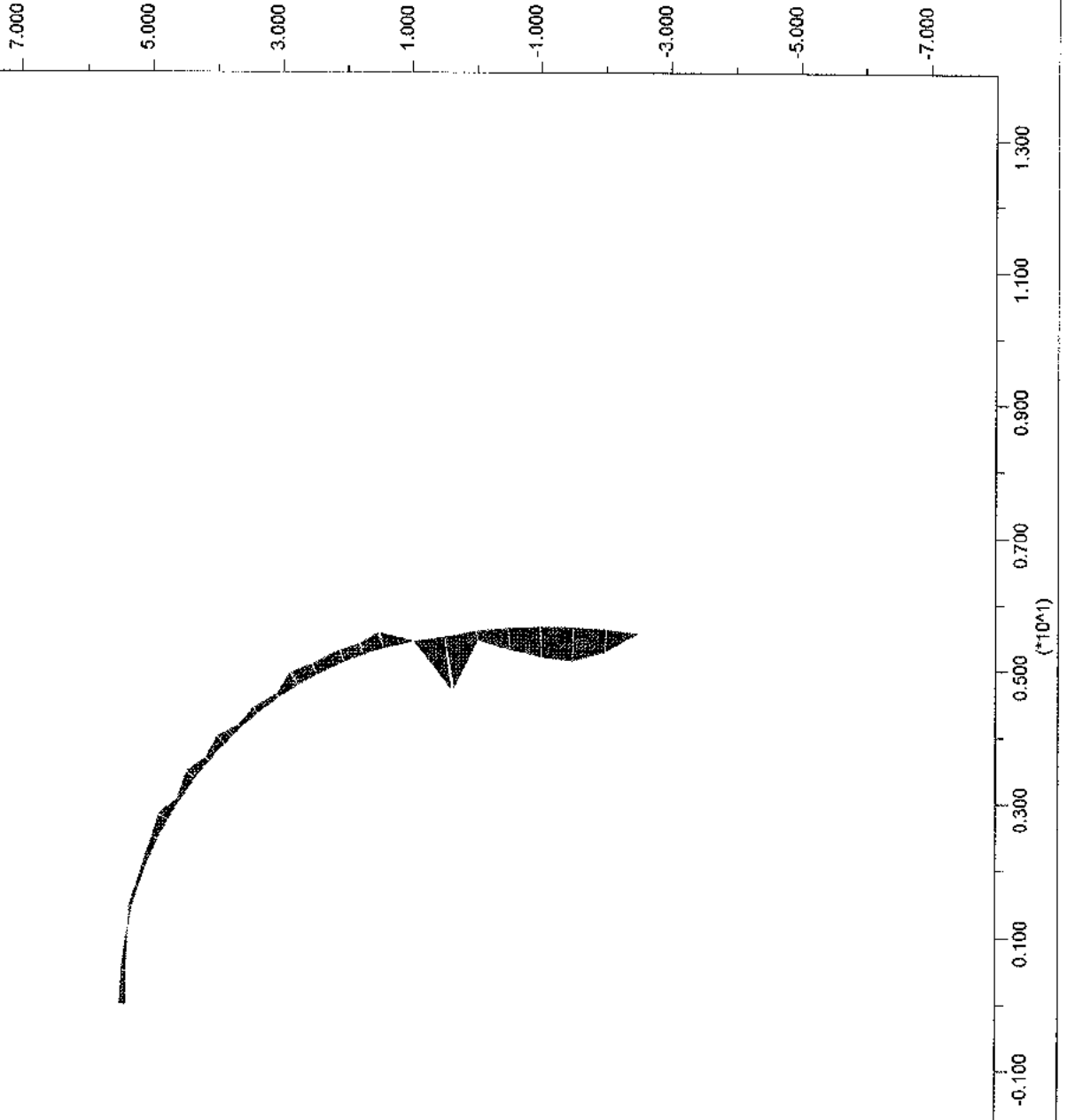
FLAC (Version 4.00)

LEGEND

19-Feb-04 12:11
step 20457
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -2.064E+04



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

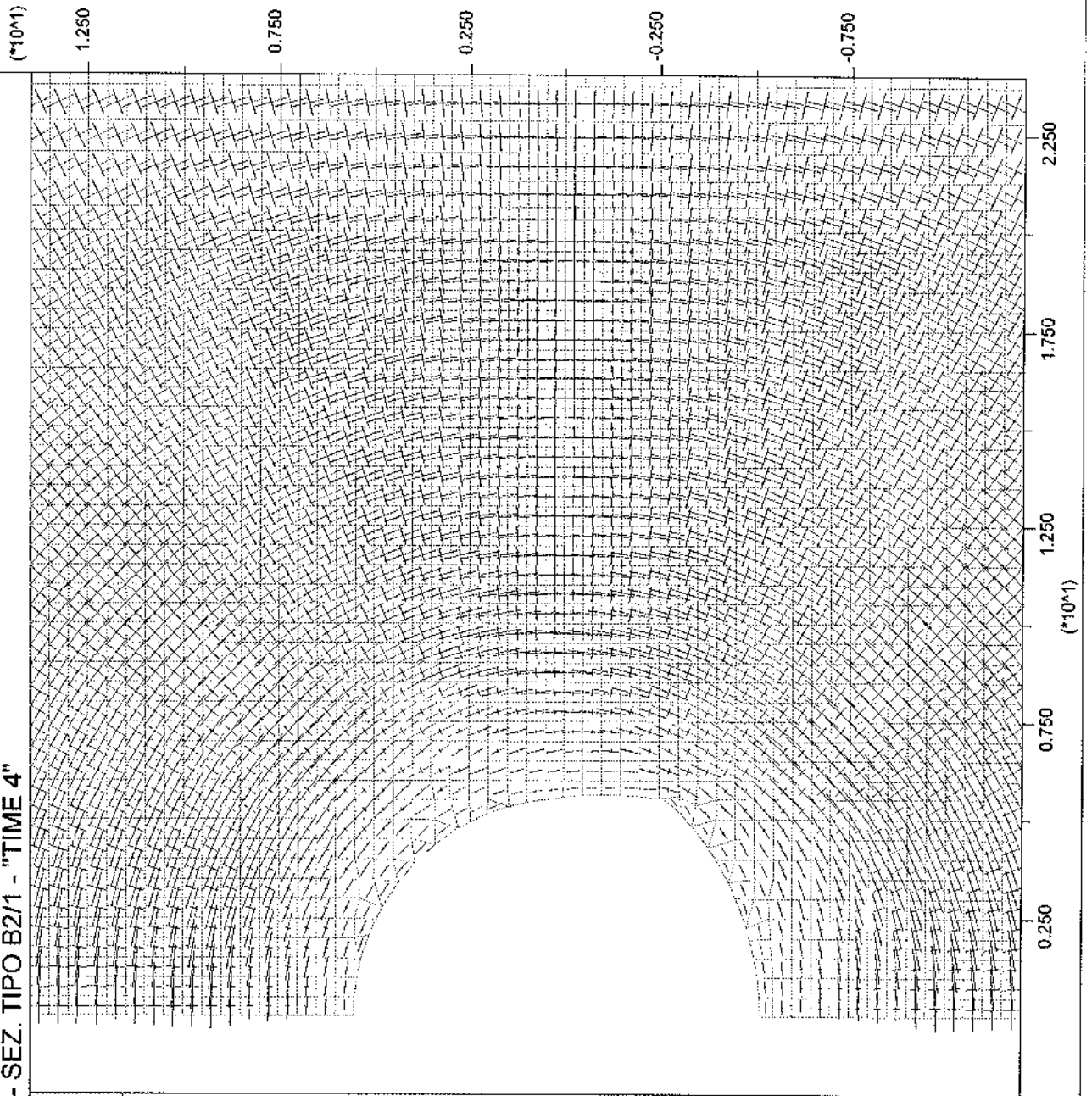
19-Feb-04 12:12
step 24091
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -2.143E+04
Min. Value = -2.236E+07



Tensioni principali : Pa



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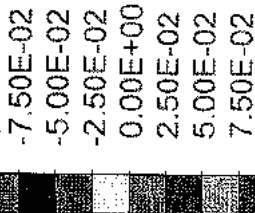
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 4"

FLAC (Version 4.00)

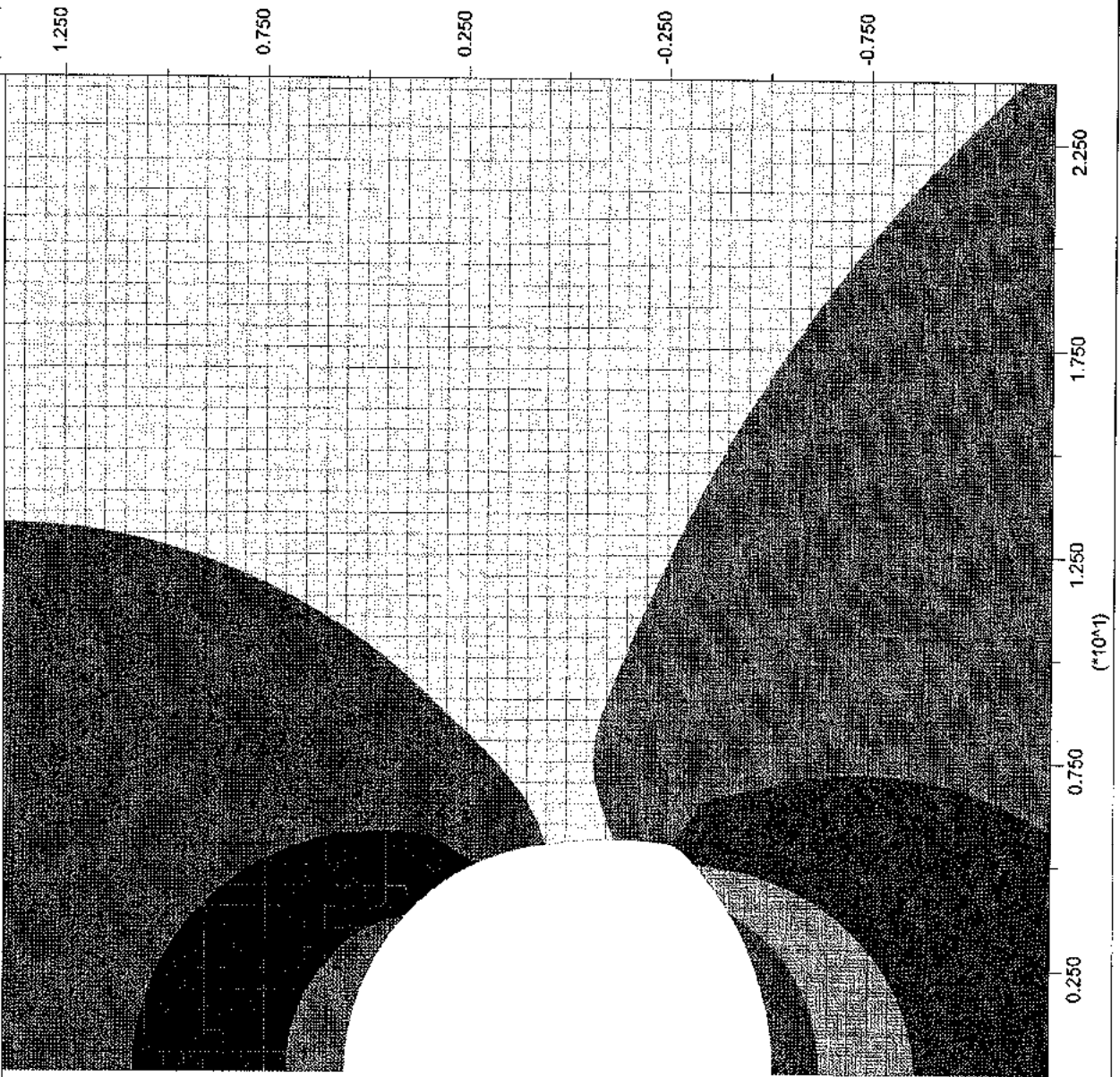
LEGEND

19-Feb-04 12:12
step 24091
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02
Spostamenti verticali



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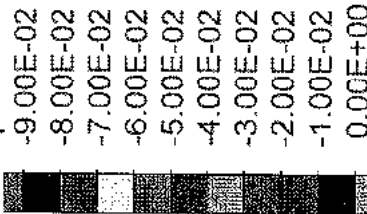
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

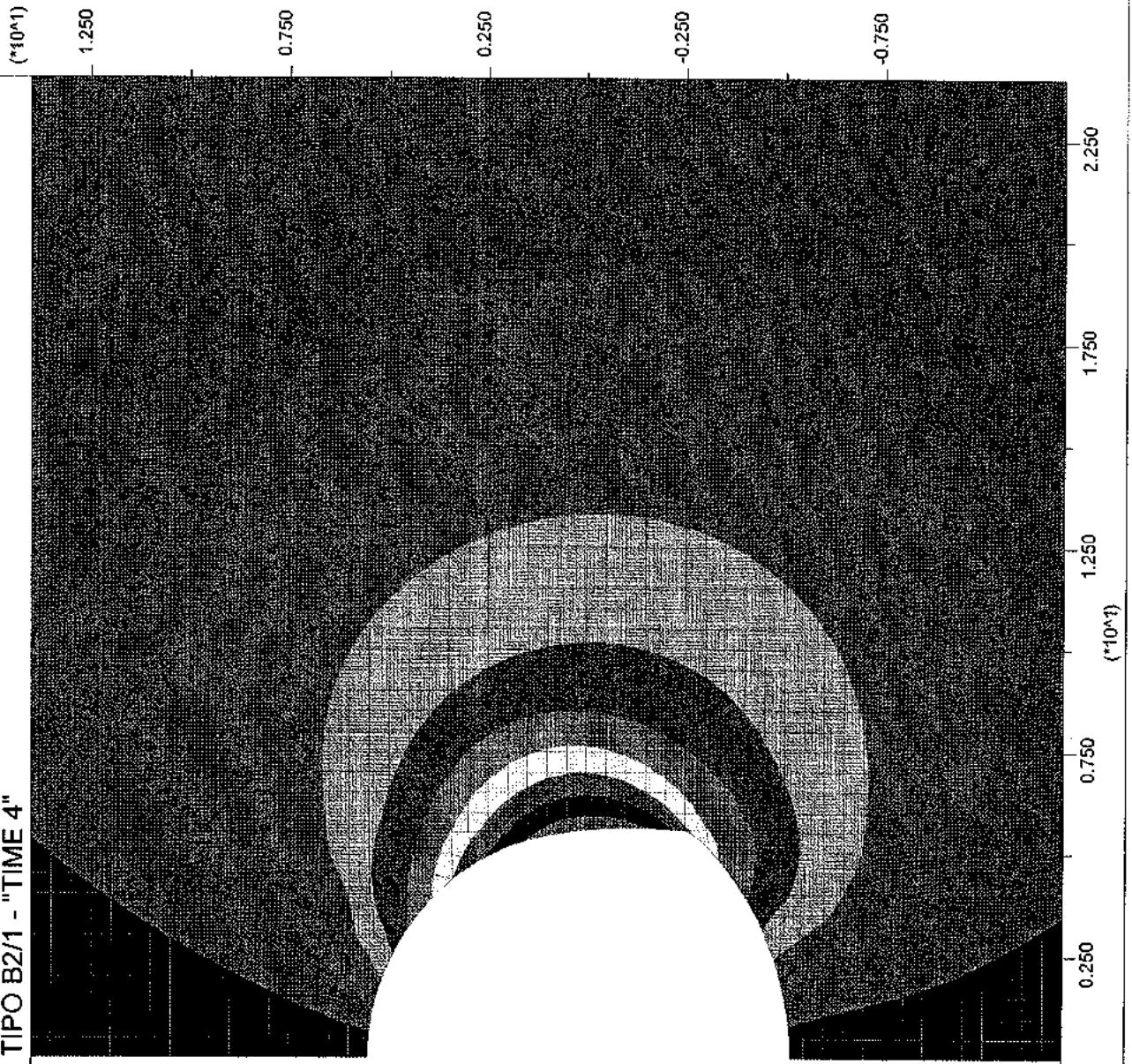
19-Feb-04 12:12
step 24091
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 1.00E-02

Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:12

step 24091

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

5.00E-03

1.00E-02

1.50E-02

2.00E-02

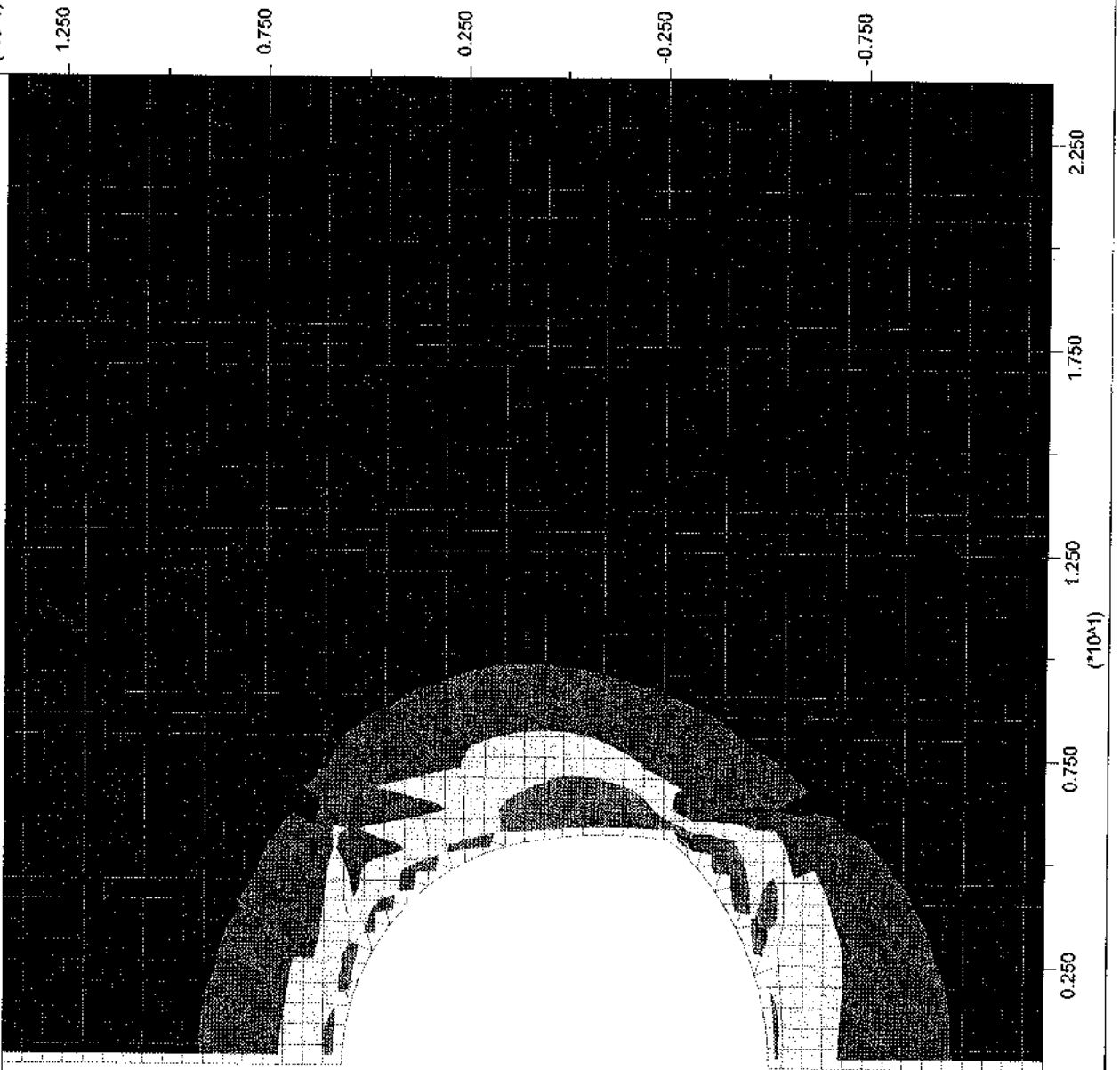
2.50E-02

3.00E-02

3.50E-02

Contour interval= 5.00E-03

Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

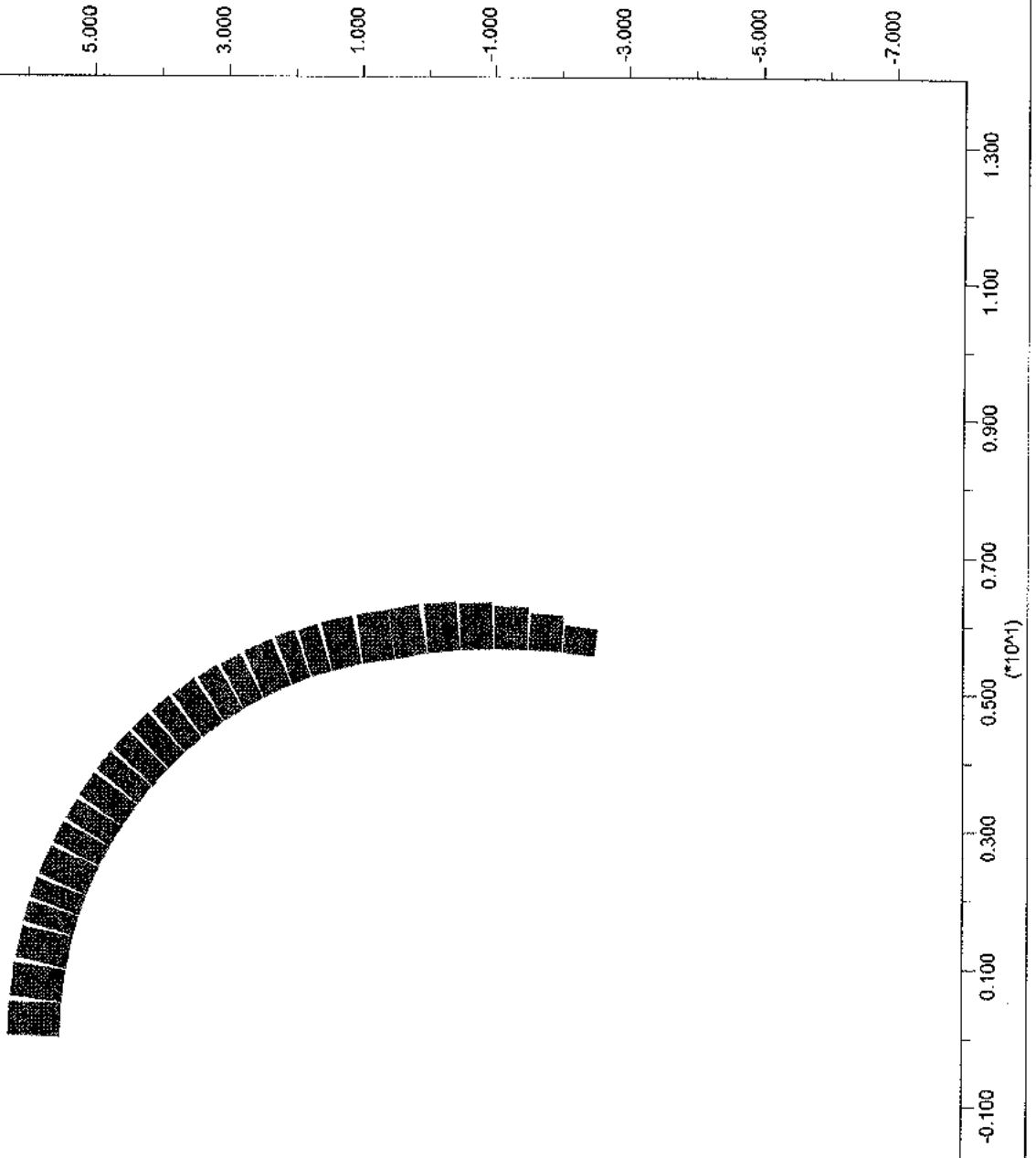
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:12
step 24091
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 1.974E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Curricolo Castagnola - SEZ. TIPO B2/1 - "TIME 4"

FLAC (Version 4.00)

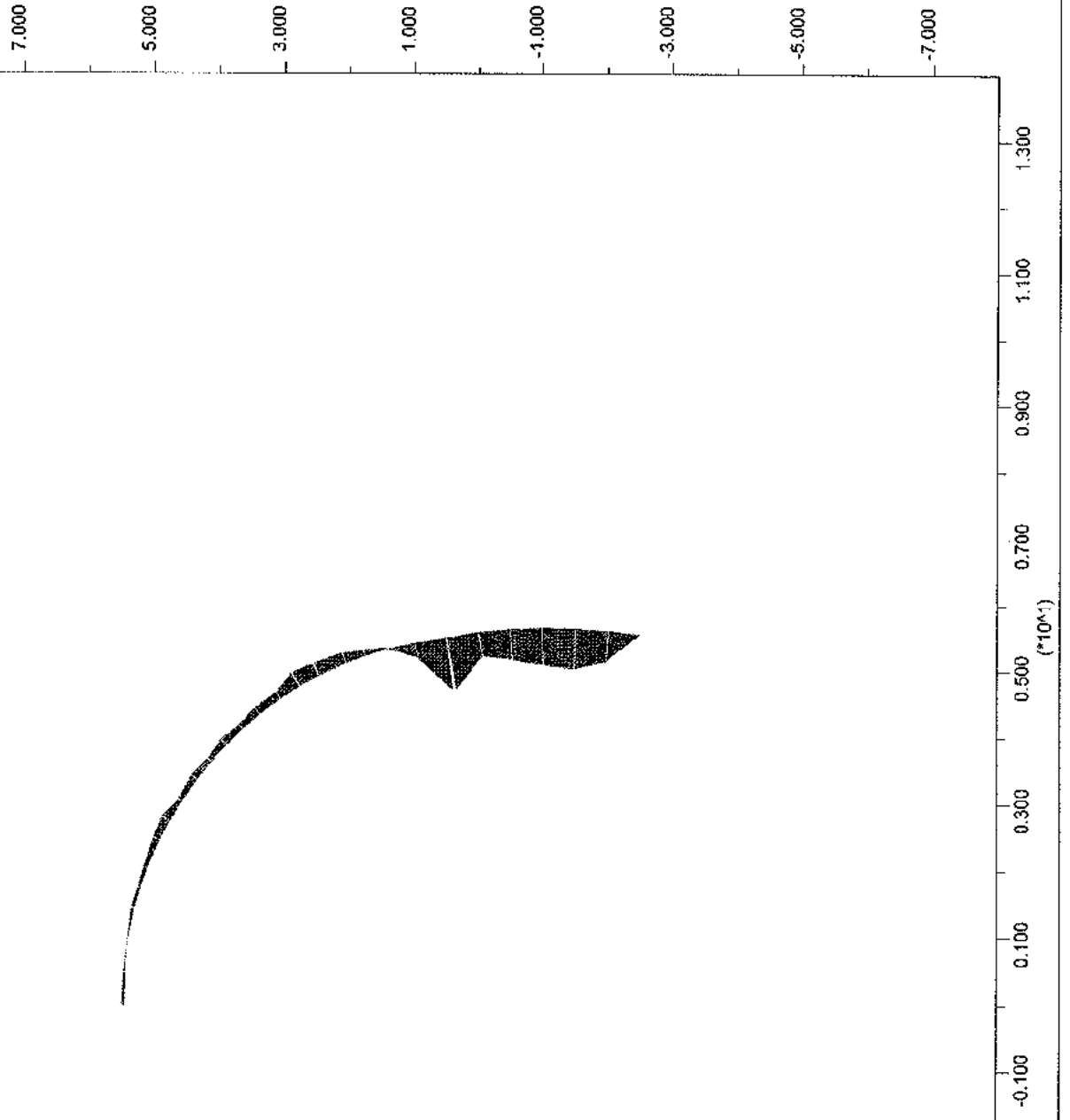
LEGEND

19-Feb-04 12:12
step 24091
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on

Structure Max. Value
1 (Beam) -6.680E+04



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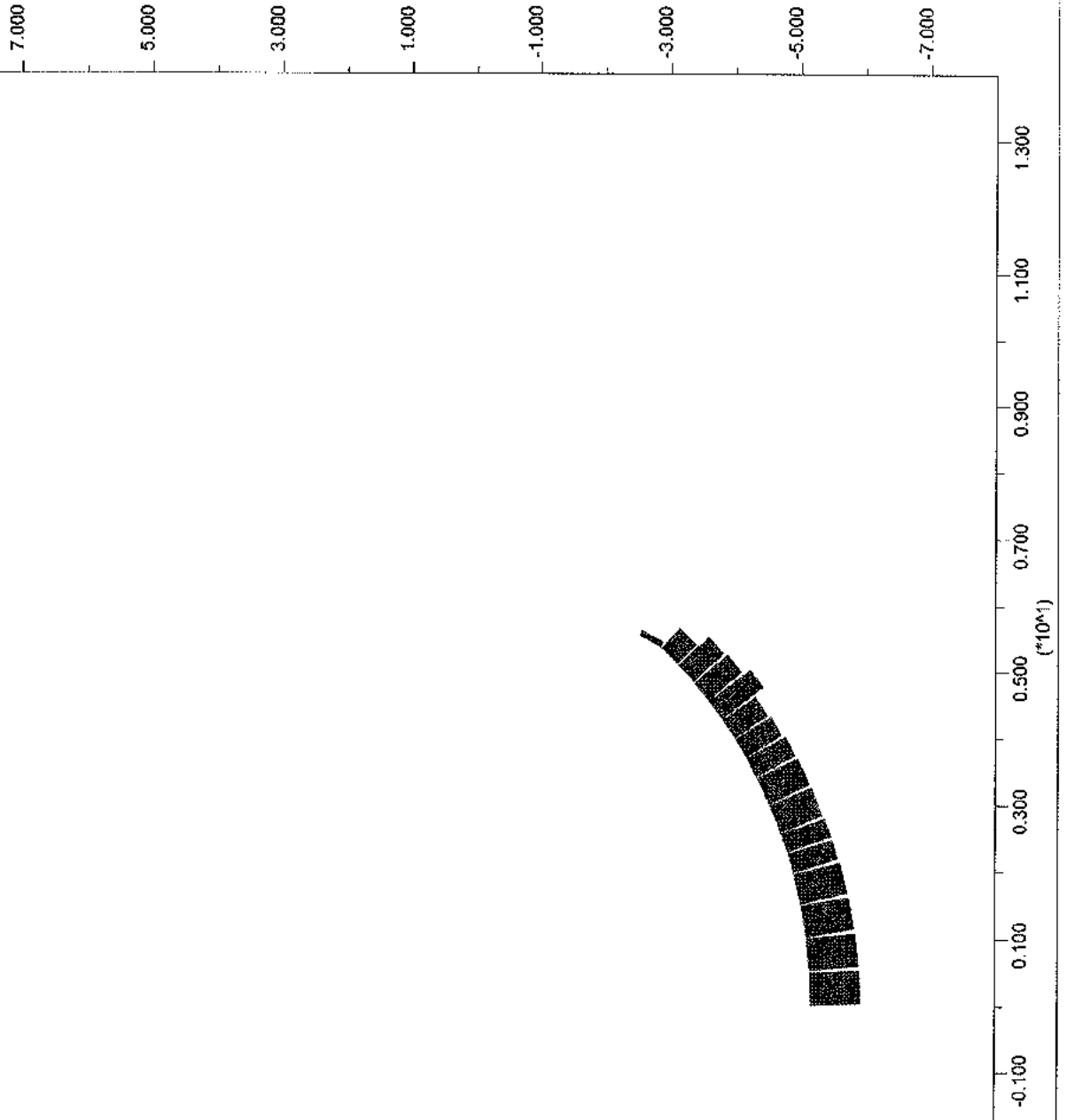
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:12
step 24091
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
2 (Beam) 1.296E+06



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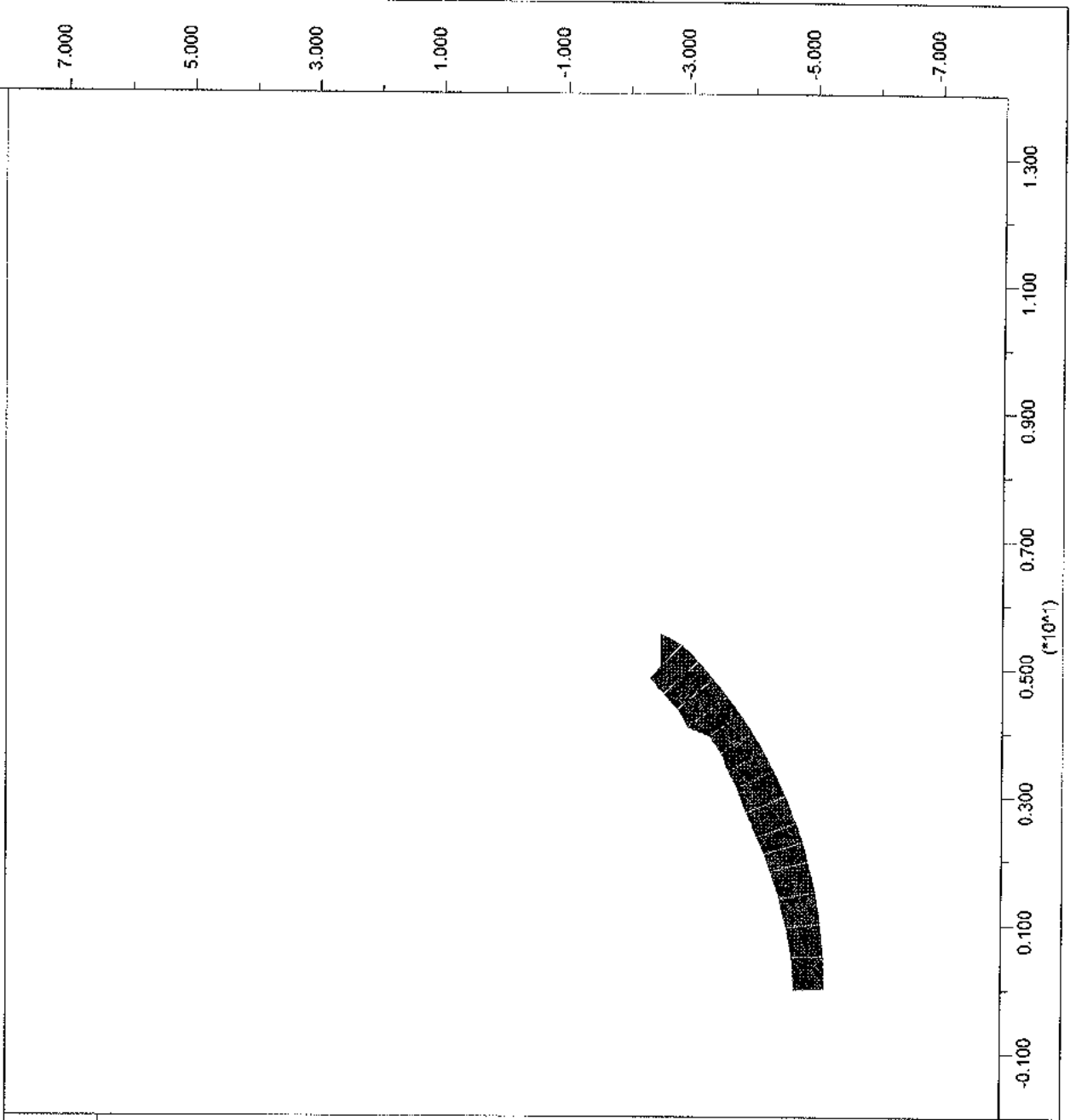
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:12
step 24091
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Momento flettente [N*m/m]
■ Moment on
Structure Max. Value
2 (Beam) -1.188E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 5"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:13

step 24976

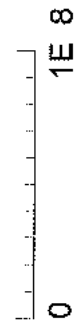
-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

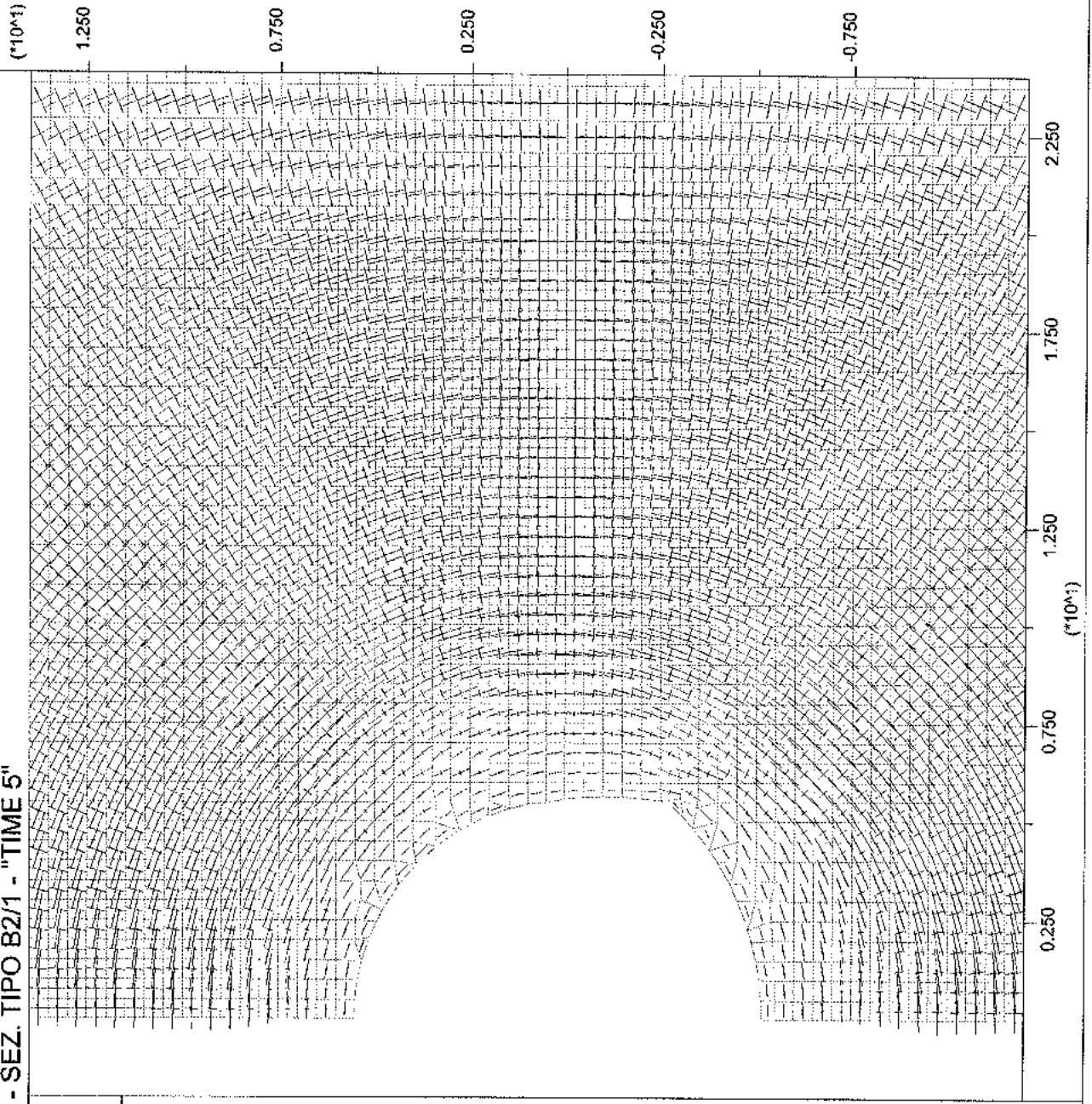
Principal stresses

Max. Value = -6.200E+04

Min. Value = -2.238E+07



Tensioni principali : Pa



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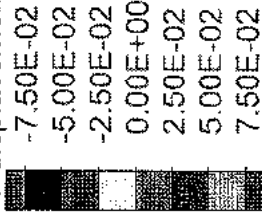
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 5"

FLAC (Version 4.00)

LEGEND

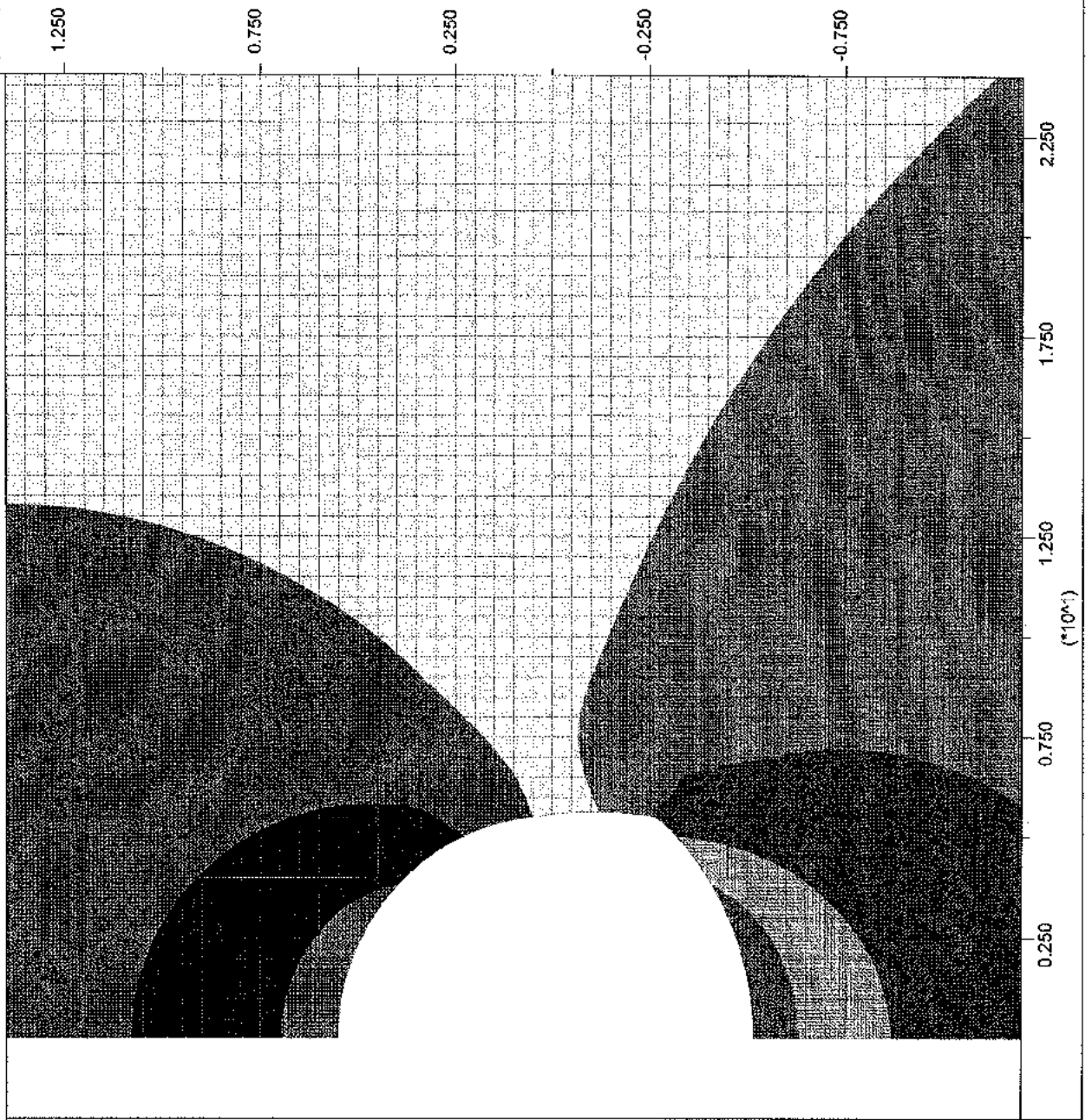
19-Feb-04 12:13
step 24976
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02

Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

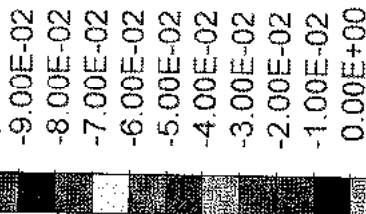
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 5"

FLAC (Version 4.00)

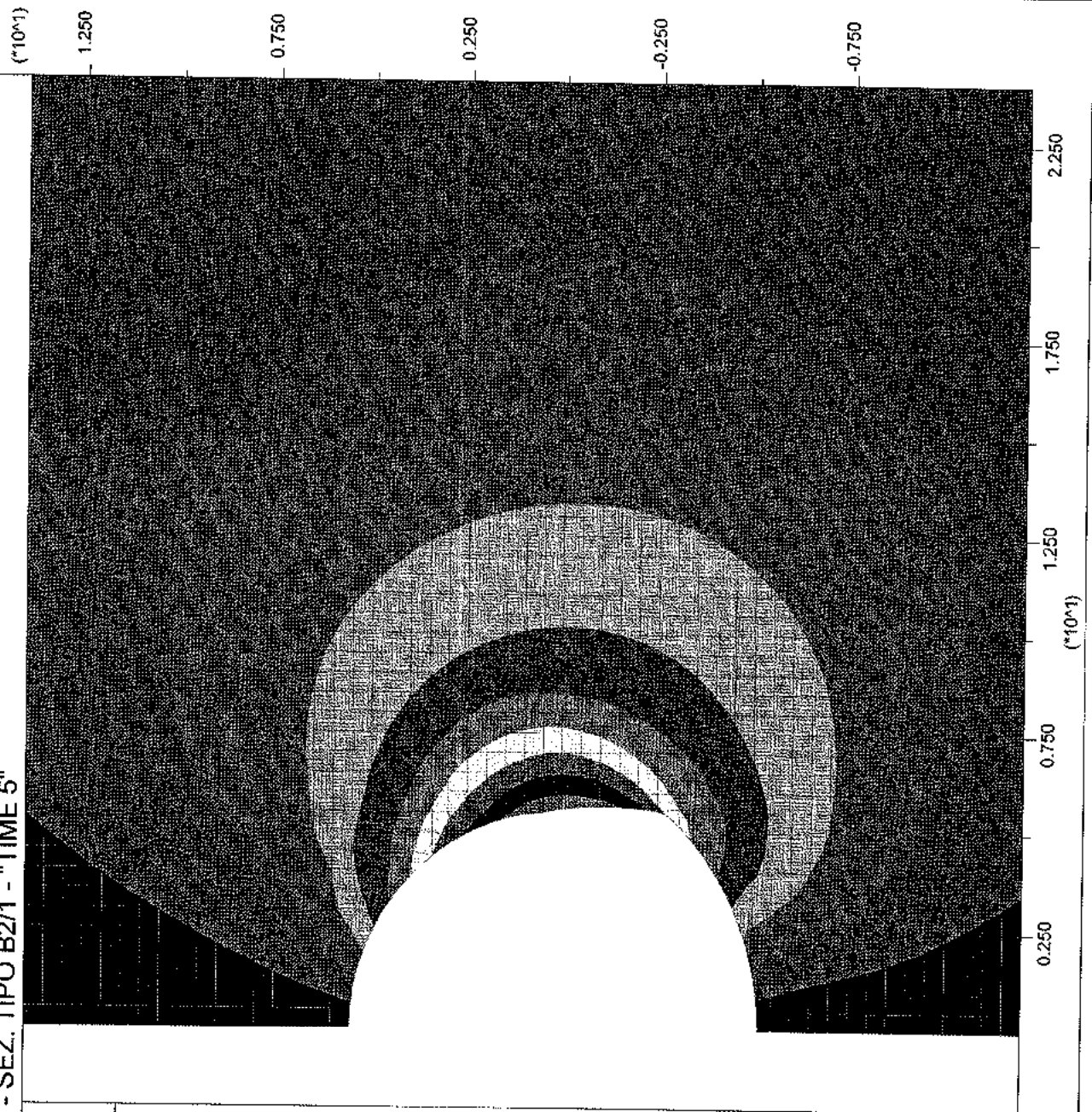
LEGEND

19-Feb-04 12:13
step 24976
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 1.00E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 5"

FLAC (Version 4.00)

LEGEND

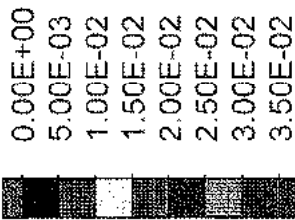
19-Feb-04 12:13

step 24976

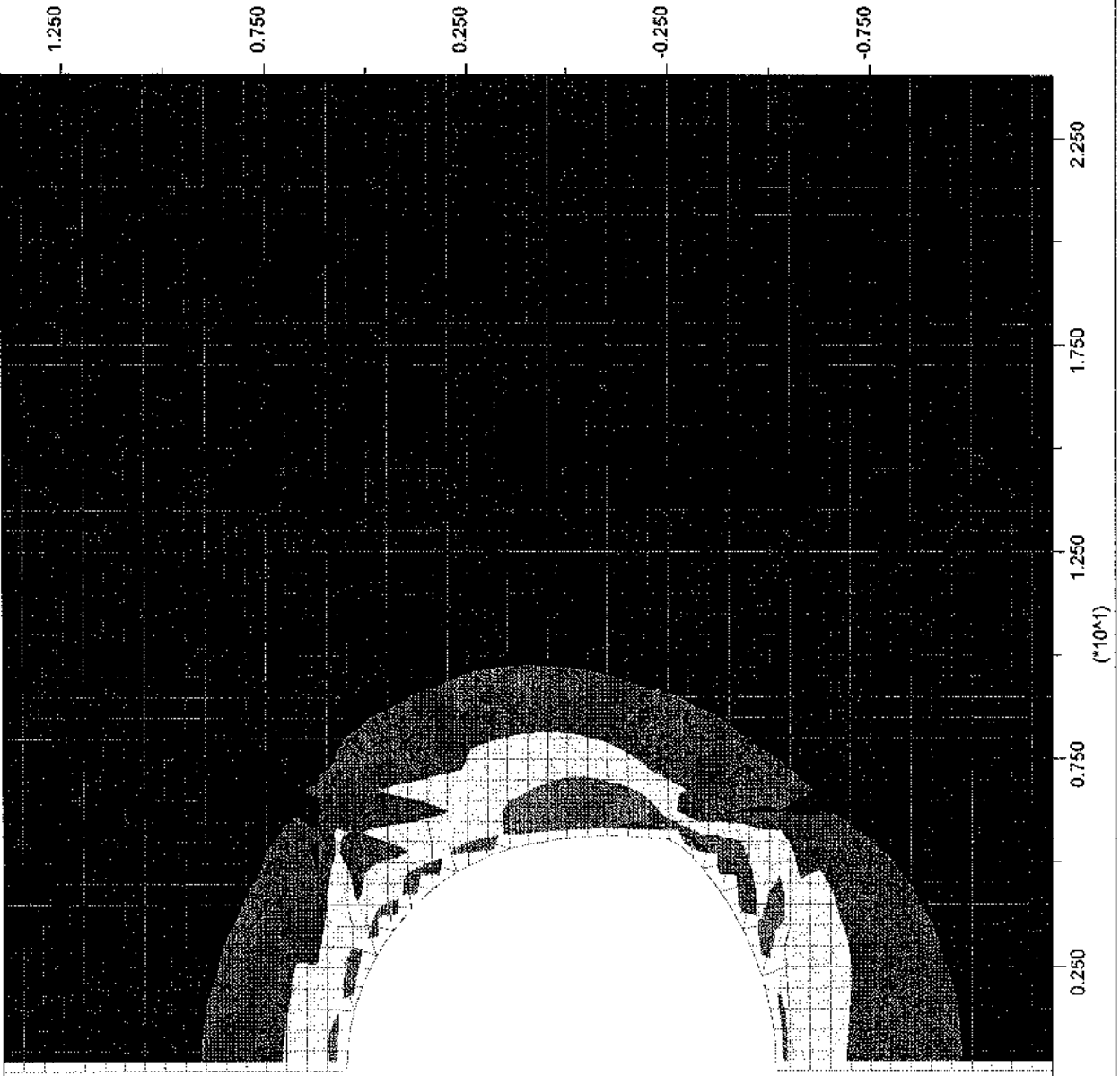
-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 5.00E-03
Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 5"

FLAC (Version 4.00)

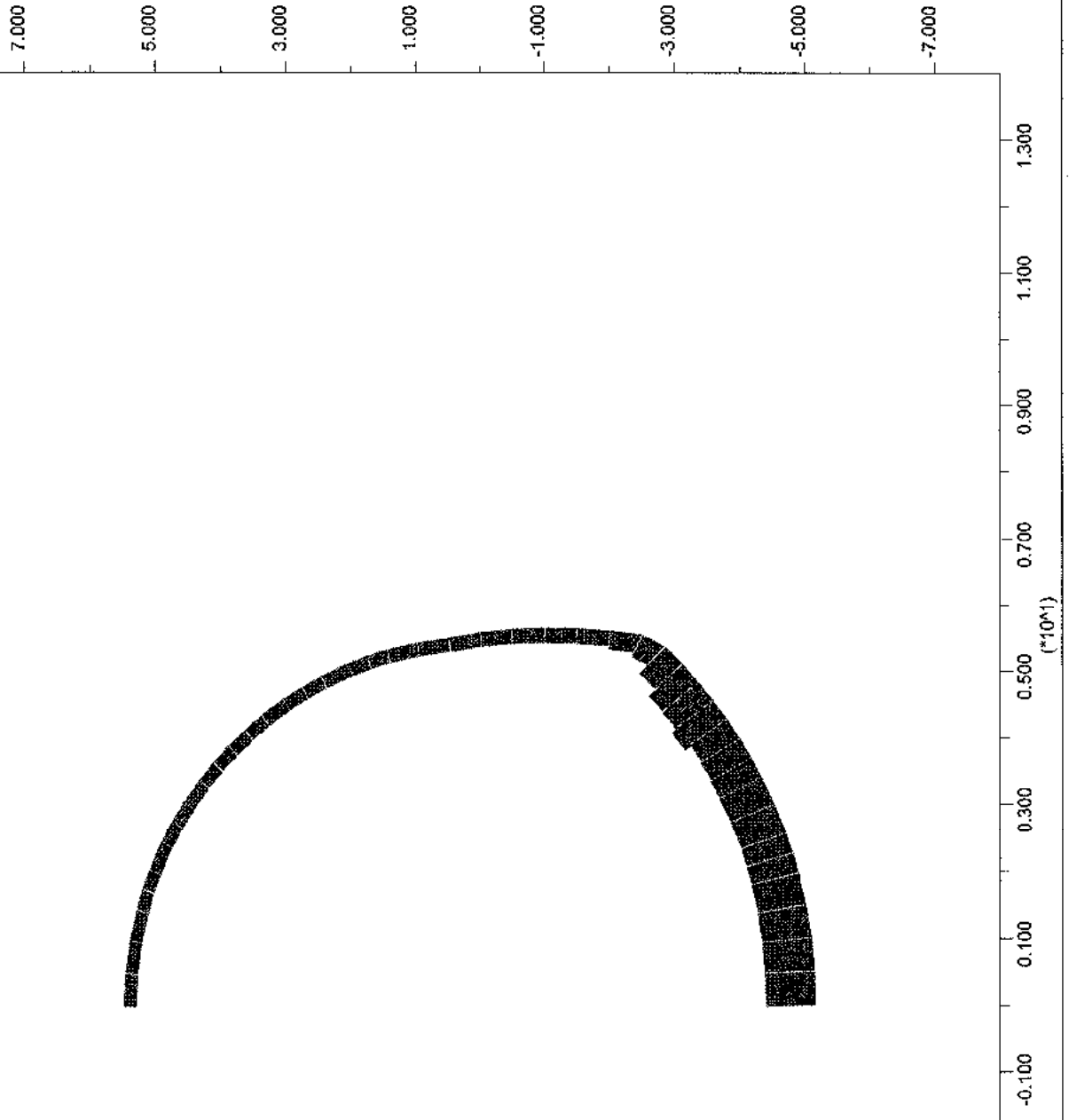
LEGEND

19-Feb-04 12:13
step 24976
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
2 (Beam) 1.994E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 5"

FLAC (Version 4.00)

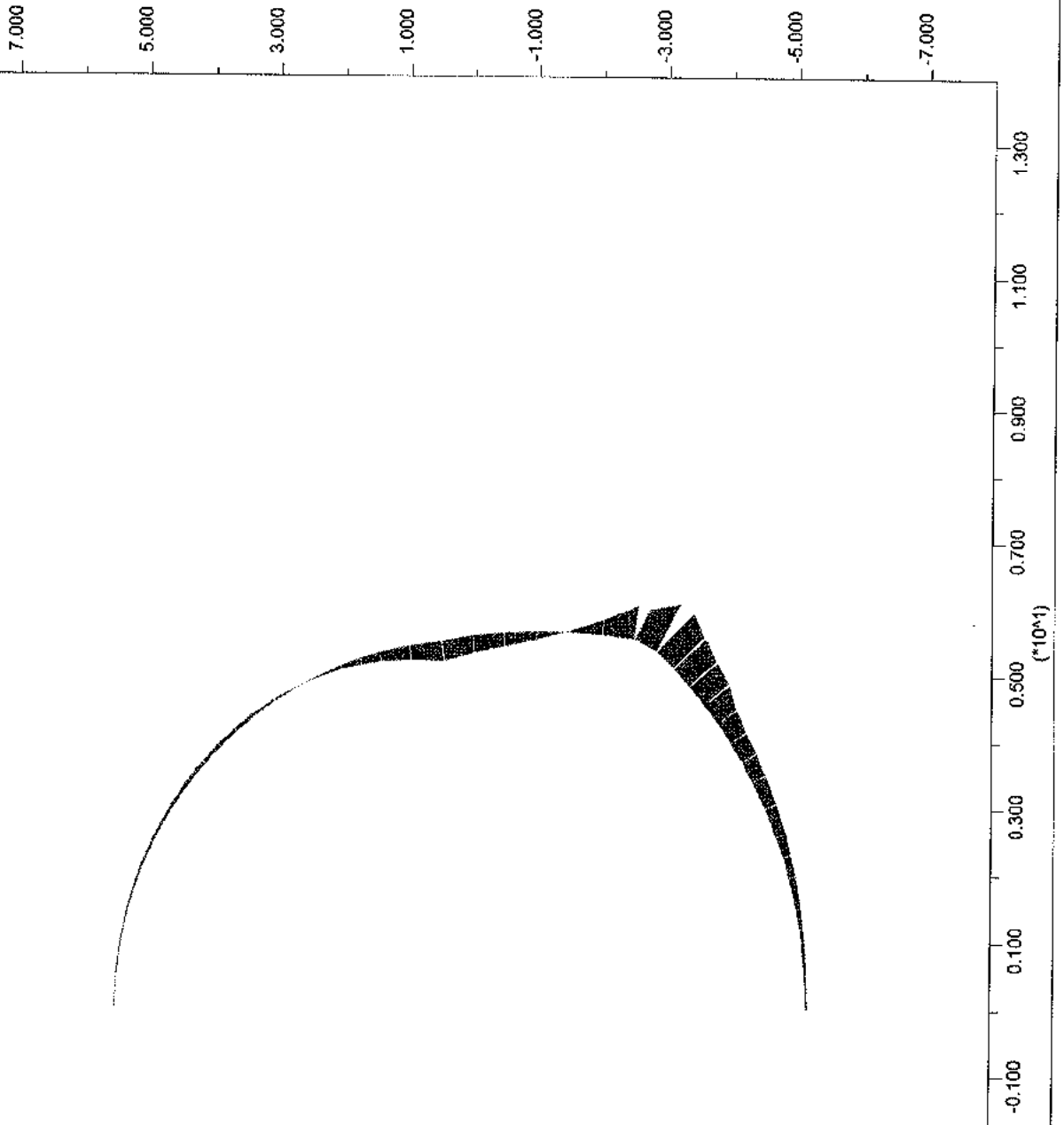
LEGEND

19-Feb-04 12:13
step 24976
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

■ Moment on

Structure Max. Value
2 (Beam) -3.130E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 6"

FLAC (Version 4.00)

LEGEND

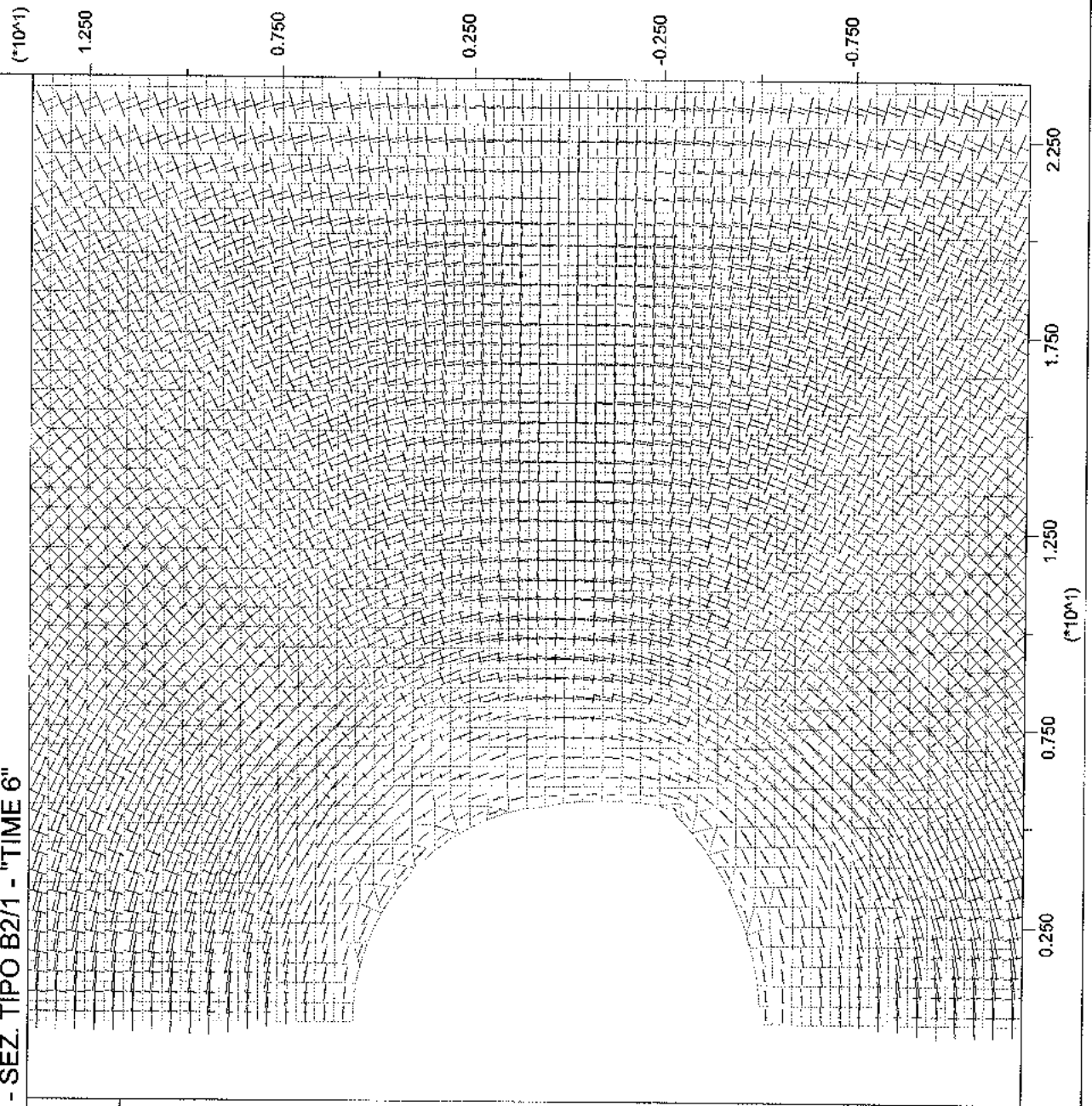
19-Feb-04 12:15
step 25988
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -2.093E+05
Min. Value = -2.244E+07



Tensioni principali : Pa



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Minneapolis, Minnesota USA

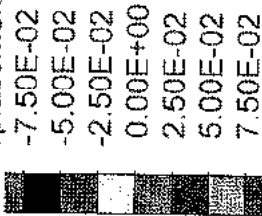
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 6"

FLAC (Version 4.00)

LEGEND

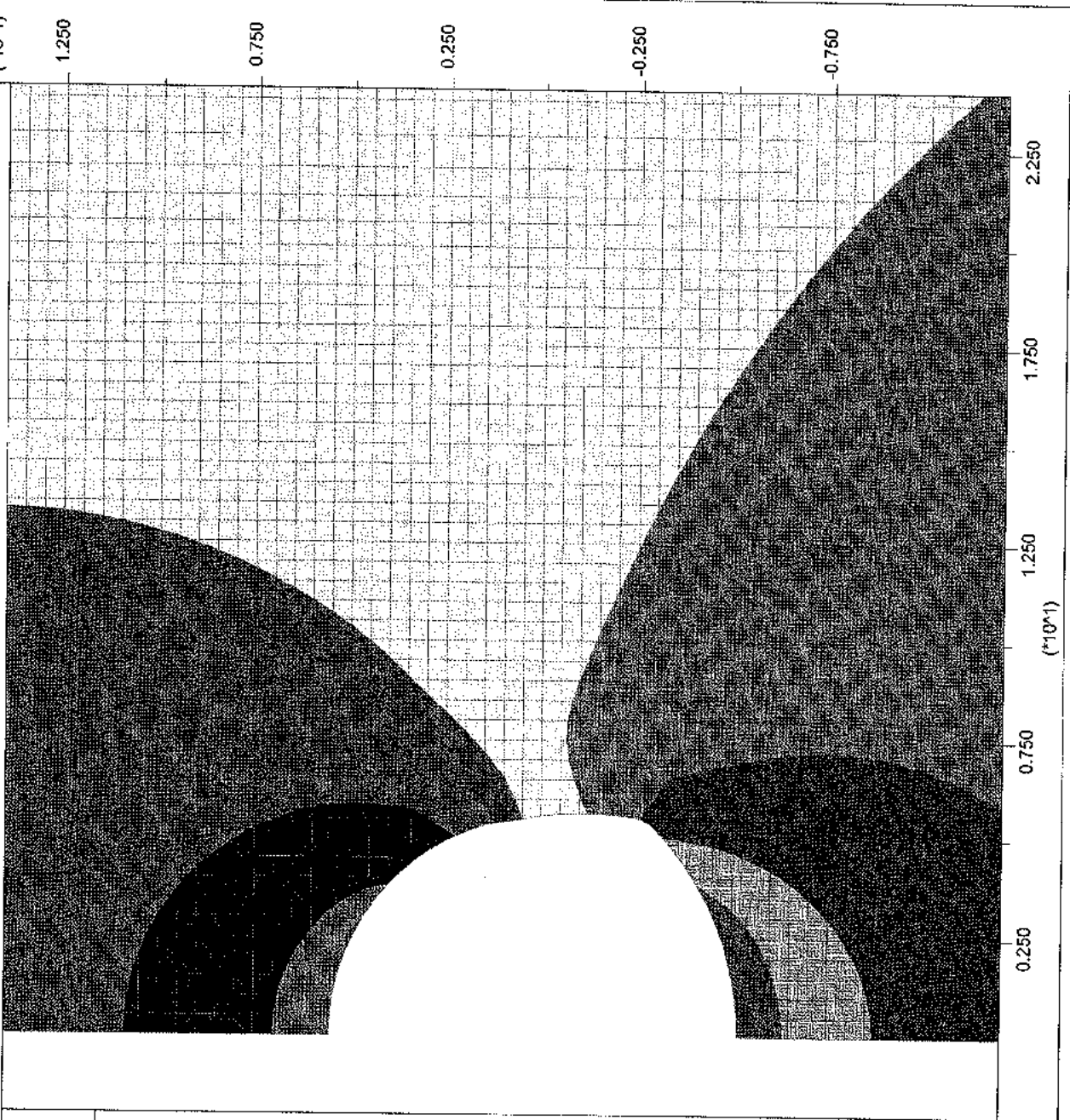
19-Feb-04 12:15
step 25988
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02

Spostamenti verticali



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Minneapolis, Minnesota USA

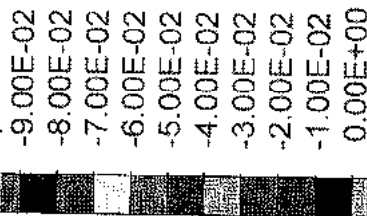
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 6"

FLAC (Version 4.00)

LEGEND

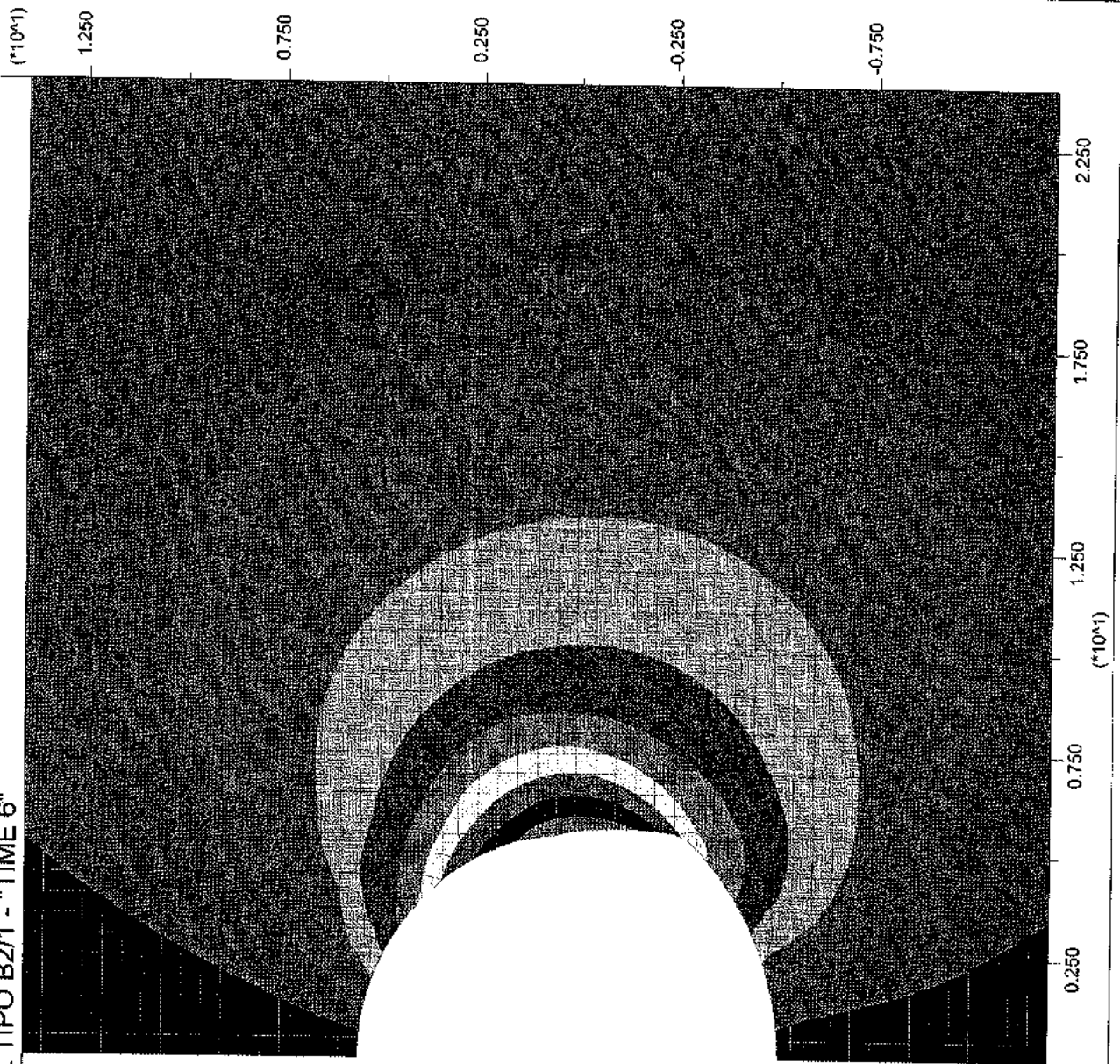
19-Feb-04 12:15
step 25988
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 1.00E-02

Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

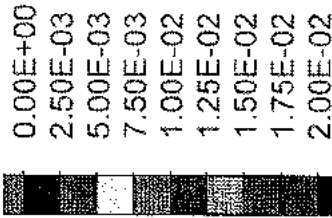
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 6"

FLAC (Version 4.00)

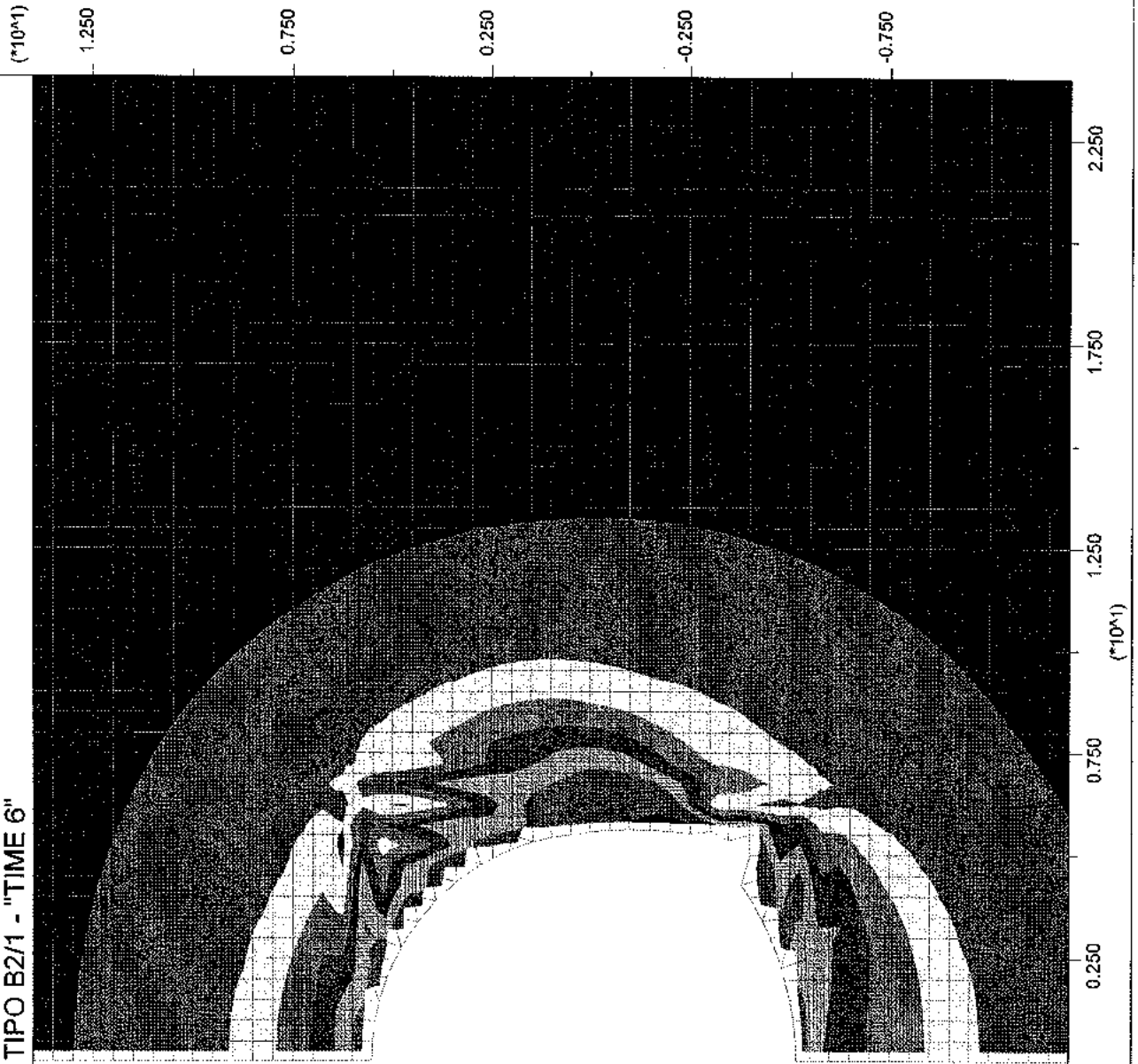
LEGEND

19-Feb-04 12:15
step 25988
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 2.50E-03
Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 6"

FLAC (Version 4.00)

LEGEND

19-Feb-04 12:15

step 25988

-2.000E+00 <x< 1.400E+01

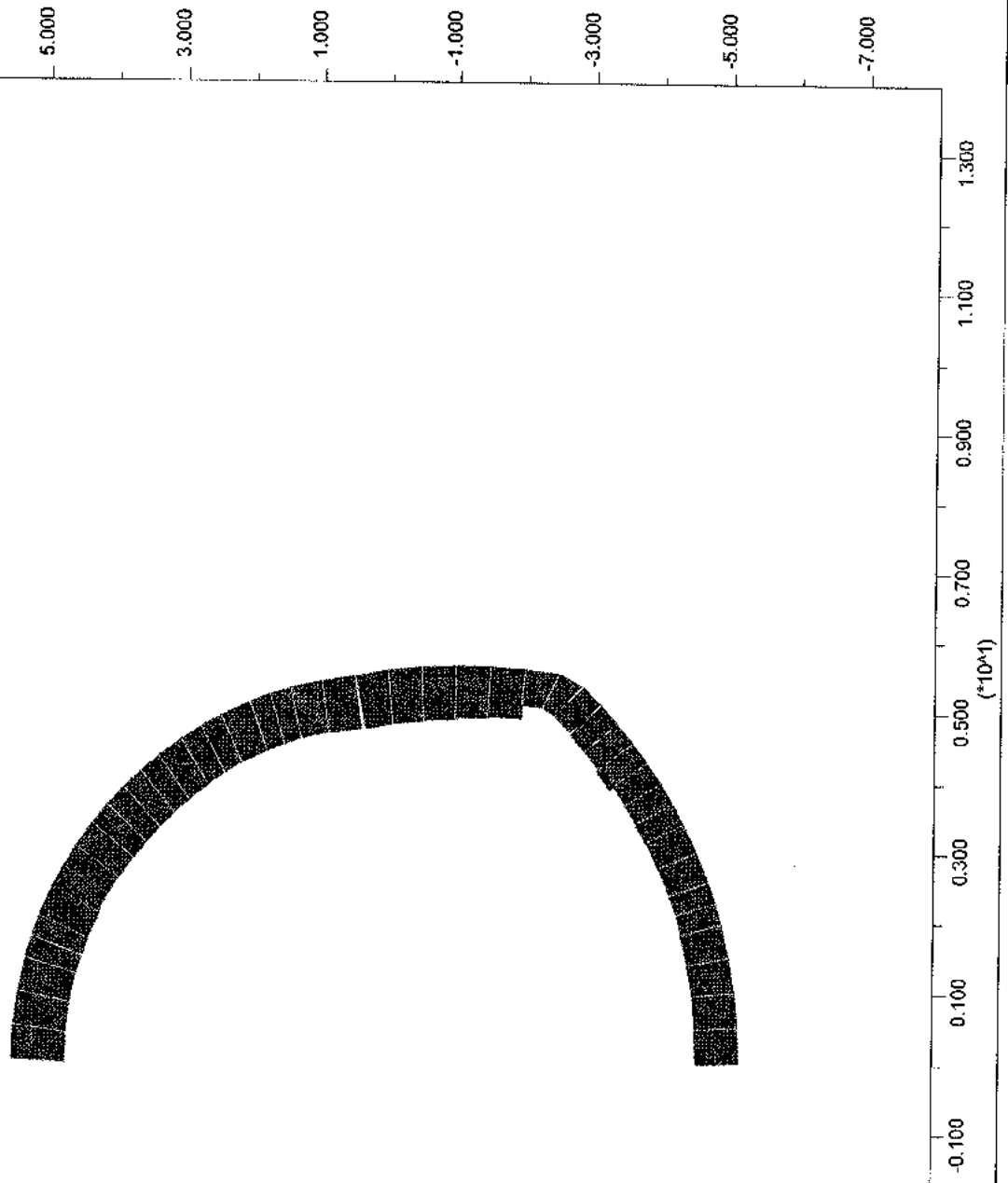
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value

1 (Beam) 2.974E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/1 - "TIME 6"

FLAC (Version 4.00)

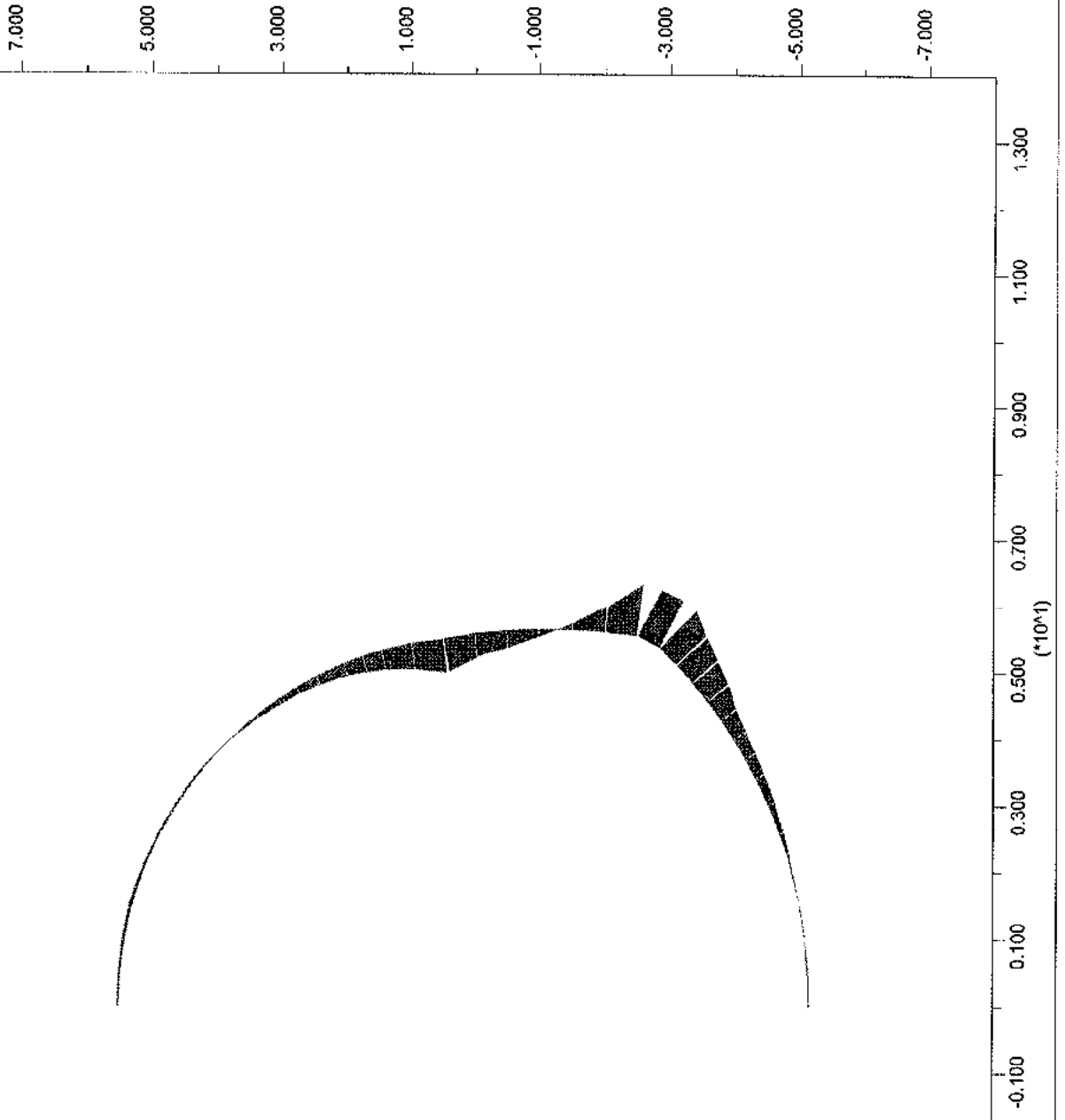
LEGEND

19-Feb-04 12:15
step 25988
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

■ Moment on

Structure Max. Value
1 (Beam) -5.327E+05



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Calcolo FLAC – Sezione tipo B2/2

ANALISI FLAC

Sezione tipo B2/2 - Ap gruppo 2

Input Analisi alle Differenze Finite FLAC

Geometria	
Copertura (m)	600.00
Altezza falda statica (m)	0.00
Coefficiente efficienza di drenaggio	0.20
Altezza falda dinamica (m)	0.00
Raggio scavo (m)	5.00

Parametri geomeccanici	1° strato		2° strato	
	Picco	Residuo	Picco	Residuo
Valori di picco e residuo	2.7	2.7		
Peso di volume (KN/m³)	35	33		
Angolo attrito (°)	1.20	1.1		
Coesione (MPa)	2.10	2.10		
Modulo di Poisson	0.30	0.30		
Modulo di deformazione volumetrica (Bulk modulus) (GPa)	1.75	1.75		
Modulo elastico tangenziale (Shear modulus) (GPa)	0.81	0.81		
Modello costitutivo	Strain-Softening			

Materiali				
Spritz-beeton	E_{sk} (MPa)	E_{sp} (MPa)	E_{sb} (MPa)	ρ (kg/cm³)
	25	28500	28500	2.25E+03
Centine	Tipo	r	A_s (cm²)	h (cm)
	HEB240	1.00	105.0	24.00
Rivestimenti	R_p (MPa)	S (m)	Armato	D
A.R.	30	1.00	31220	5.0
Calotta	30	0.90	31220	9.0

LEGENDA SIMBOLI

- E_m - resistenza media cilindrica a compressione dello spritz-beeton
- s - spessore dello spritz-beeton
- E_{sp} - modulo elastico iniziale dello spritz-beeton
- E_{sb} - modulo elastico finale dello spritz-beeton
- ρ - momento di inerzia dello spritz-beeton
- r - numero di centine per gruppo
- p - passo centine
- A_s - area del profilo della singola centina
- h - altezza del profilo centine
- J_{cx} - momento di inerzia del profilo della singola centina
- R_{cs} - resistenza caratteristica cubica a compressione del cls
- S - spessore del rivestimento definitivo
- E_{mat} - modulo elastico del cls naturale
- D - distanza di getto tra mesuratori definitivi e fronte (multiplo del diametro della galleria)
- E_{pre} - modulo elastico del preinvestimento

Fasi di calcolo (TIME)	x (m)	x/R	RPanet	RDEM	Epre (MPa)	E_{sb} (MPa)
TIME 1 - Geostatico	-∞	-∞	0.000	0.000	-	-
TIME 2 - Taratura e scavo	0.00	0.000	0.280	0.970	-	-
TIME 3 - Posi centine e SB	1.00	0.119	0.510	0.990	14600	-
TIME 4 - Getto Murette e A.R. maturazione SB	20.00	3.974	0.990	0.990	34900	31220
TIME 5 - Getto calotta	40.00	7.143	0.992	1.000	31220	31220
TIME 6 - Decarottamento ammasso e preinvestimento	$x \rightarrow$	$x \rightarrow$	1.000	1.000	-	31220

Relazione per il calcolo di RPanet, RDEM:

$$R^* = u_0 + (h \cos \theta - h(t)) \cdot \left[1 - \frac{x}{1 + \frac{x}{0.84 \cdot R_p}} \right]$$

- R^* = Convergenza radiale ad una distanza di x metri dal fronte espressa come % di u_0
- u_0 = Convergenza radiale in corrispondenza del fronte espressa come % di u_0
- u_0 = Convergenza radiale ad una distanza infinita dal fronte
- R_p = Raggio plastico
- R = Raggio della galleria
- x = distanza tra il fronte e la sezione di calcolo

TIMES DI CALCOLO

TIME 1 - Geostatico	Viene applicato il peso proprio del terreno, ricostruito in termini di tensione litostatica in situazione preesistente in scavo della galleria
TIME 2 - Taratura e scavo	Viene simulato l'arrivo del fronte di scavo tenendo in conto il contributo dei consolidamenti
TIME 3 - Posi centine e SB	Viene simulata la posa in opera delle centine e dello spritz-beeton.
TIME 4 - Getto Murette e A.R. maturazione SB	Viene simulato il getto delle murette e dell'arco rovescio, la maturazione dello spritz e l'accanzamento dello scavo.
TIME 5 - Getto calotta	Si simula il getto del rivestimento definitivo di calotta
TIME 6 - Decarottamento ammasso e preinvestimento	Si applica un accoglimento delle caratteristiche meccaniche del preinvestimento e dell'ammasso

JOB TITLE : Sezioni di verifica - Prerivestimento

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:42

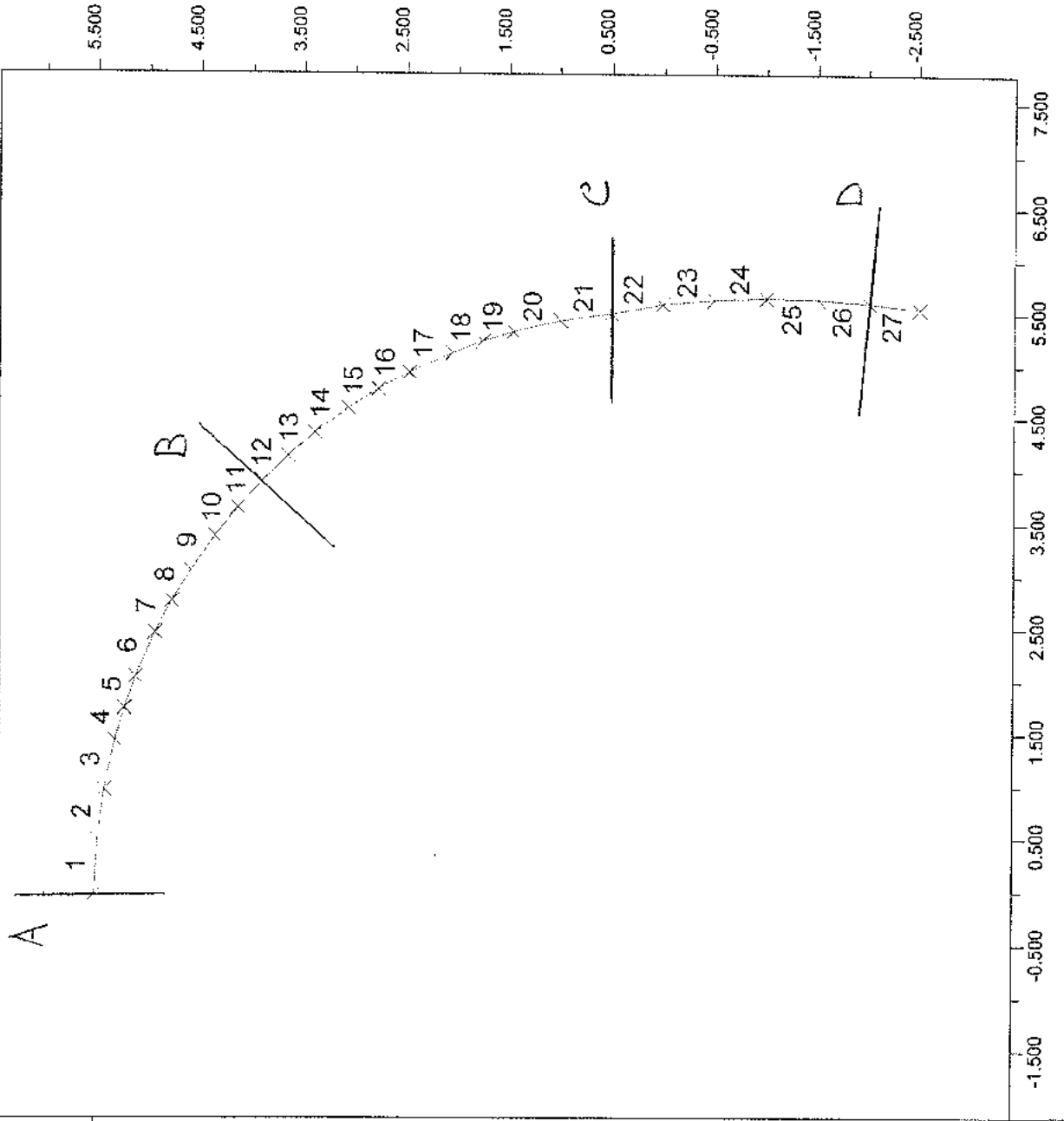
step 20395

-2.121E+00 <x< 7.770E+00

-3.438E+00 <y< 6.454E+00

Beam Plot

Structural Element Numbers



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Sezione tipo B2/2 - Ap gruppo 2

Verifica del pririvestimento

CARATTERISTICHE GEOMETRICHE E MECCANICHE

MATERIALI	Tipo	σ_{max} (MPa)	H (cm)	Passo (m)	n°	A (cm²)	I (cm⁴)
Spritz-beton	Fcm 25	19.20	30		-	3000.0	2250.0
Centine	HEB240	210	24.00	1.00	1.00	106.0	11259.0
Sezione omogeneizzata						4484.0	168811.8

Coefficiente omogeneizzazione m	15	
Baricentro centina d (cm)	12.00	dall'estradosso
Baricentro sezione omogeneiz. Yg (cm)	14.01	dall'estradosso
e*lim,e = I*/(A*Yg) (cm)	2.69	dimensione nocciolo d'inerzia estradosso
e*lim,i = I*/(A*(H-Yg)) (cm)	2.35	dimensione nocciolo d'inerzia intradosso

e = M/N eccentricità

Formule impiegate

$$\sigma_{sb,i} = N/A^* + (M(H-Yg))/I^* \quad \sigma_{sb,e} = N/A^* - (MYg)/I^*$$

$$\sigma_{s,i} = m(N/A^* + M(d+H_g/2-Yg)/I^*)$$

$$\sigma_{s,e} = m(N/A^* - M(d-H_g/2-Yg)/I^*)$$

Tensioni positive se di compressione

Sezione	Elemento	Altezza (m)	N (KN/m)	M (KN*m/m)	e (m)	$\sigma_{sb,i}$ (Mpa)	$\sigma_{sb,e}$ (Mpa)	$\sigma_{s,i}$ (Mpa)	$\sigma_{s,e}$ (Mpa)	
CHIAVE CALOTTA	1	0.30	1265	-3.9	0.00	2.45	3.14	38.85	47.17	TIME 3
RENI	11	0.30	1258	5.9	0.00	3.36	2.32	47.32	34.74	
P.C.	22	0.30	1188	-31.0	-0.03	-0.29	5.22	12.22	78.32	
PIEDE	27	0.30	585	-11.0	-0.02	0.26	2.22	9.80	33.26	
CHIAVE CALOTTA	1	0.30	2335	-6.0	0.00	4.64	5.71	72.78	85.58	TIME 4
RENI	11	0.30	2462	17.7	0.01	7.17	4.02	98.08	60.33	
P.C.	22	0.30	2450	-102.4	-0.04	-4.24	13.96	-8.97	209.41	
PIEDE	27	0.30	1218	-44.4	-0.04	-1.49	6.40	1.32	96.01	

JOB TITLE : Sezioni di verifica - Rivestimento definitivo

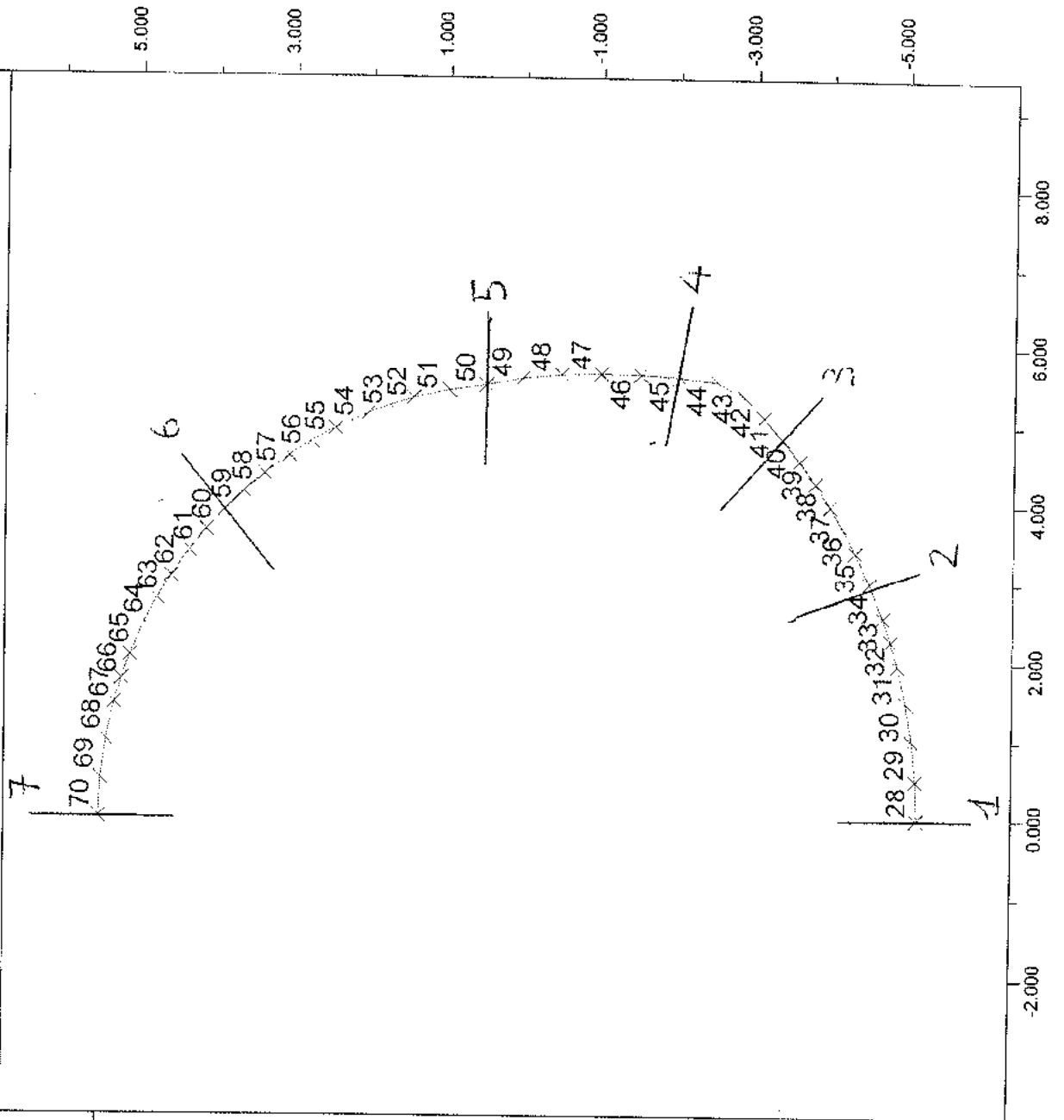
FLAC (Version 4.00)

LEGEND

19-Feb-04 10:11
step 26205
-3.755E+00 <x< 9.405E+00
-6.399E+00 <y< 6.761E+00

Beam Plot
Structural Element Numbers

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Minneapolis, Minnesota USA



Sezione tipo B2/2 - Ap gruppo 2
Verifica del rivestimento definitivo

TIME 4 - Getto Murette e A.R., maturazione SB

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	28	1.00	1480	91.9	0.06	2.0
SEZIONE INTERMEDIA A.R.	34	1.00	1356	123.9	0.09	2.1
ATTACCO A.R. - MURETTA	40	1.00	1319	153.1	0.12	2.3

TIME 5 - Getto calotta

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	28	1.00	2289	-181.8	-0.08	2.4
SEZIONE INTERMEDIA A.R.	34	1.00	2180	-88.4	-0.04	2.8
ATTACCO A.R. - MURETTA	40	1.00	2184	-273.1	-0.13	3.8
ATTACCO CAL. - MURETTA	45	0.90	699	-108.9	-0.16	1.6
PIANO DEI CENTRI	49	0.90	653	145.0	0.22	1.9
RENI	59	0.90	610	-31.6	-0.05	0.9
CHIAVE CALOTTA	70	0.90	578	-1.6	0.00	0.7

TIME 6 - Decadimento ammasso e prerivestimento

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	28	1.00	2847	36.1	0.01	3.1
SEZIONE INTERMEDIA A.R.	34	1.00	2754	-92.3	-0.03	3.3
ATTACCO A.R. - MURETTA	40	1.00	2794	-437.0	-0.16	5.4
ATTACCO CAL. - MURETTA	45	0.90	3178	-290.5	-0.09	5.7
PIANO DEI CENTRI	49	0.90	3624	439.3	0.12	7.3
RENI	59	0.90	3501	-44.8	-0.01	4.2
CHIAVE CALOTTA	70	0.90	3279	-59.1	-0.02	4.1

Sezione tipo B2/2 - Ap gruppo 2

Output Analisi alle Differenze Finite FLAC

TIME	Riduzione forze di scavo [%]	Spostamento y in chiave calotta [cm] Nodo j=1 j=68	Spostamento x sul piano dei centri [cm] Nodo i=12 j=57	Spostamento y in chiave A.R. [cm] Nodo i=1 j=47	Tensioni preriv.		Tensioni Riv. def.
					$\sigma_{SB,max}$ [MPa]	$\sigma_{s,max}$ [MPa]	
TIME 1 - Geostatico	0.0	-	-	-	-	-	-
TIME 2 - Taratura e scavo	94.3	11.0	10.5	10.1	-	-	-
TIME 3 - Posa centina e SB	96.1	11.2	10.9	10.6	5.22	78.32	-
TIME 4 - Getto Murette e A.R., maturazione SB	98.7	11.4	11.2	10.8	13.96	209.41	2.3
TIME 5 - Getto calotta	100.0	11.4	11.2	10.8	-	-	3.8
TIME 6 - Decadimento ammasso e prinvestimento	100.0	11.4	11.3	10.8	-	-	7.3

Materiali	Tipo	Tensioni ammissibili [MPa]
Spritz-beton	fc _m	$\sigma_{SB,amm}$ 19.20
Centina	Fe	$\sigma_{s,amm}$ 210
Calcestruzzo	R _{ck}	$\sigma_{ck,amm}$ 7.50

Tensioni positive nel cis : compressione

Tensioni positive nell'acciaio : trazione

Spostamenti x positivi verso destra, spostamenti y positivi verso l'alto

JOB TITLE : Cunicolo Castagnola (Ap gruppo 2) - SEZ. TIPO B2/2

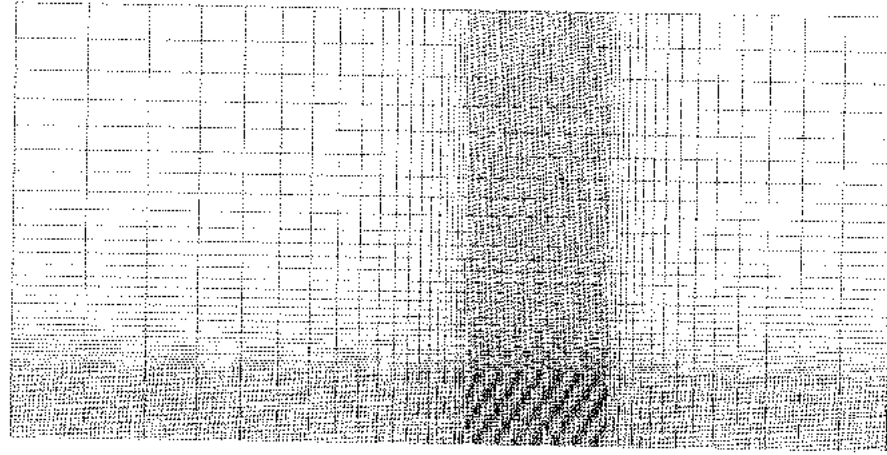
FLAC (Version 4.00)

LEGEND

19-Feb-04 8:58
step 9624
-1.067E+02 <x< 2.267E+02
-1.417E+02 <y< 1.917E+02

MESH DI CALCOLO

0
1E 2



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Minneapolis, Minnesota USA

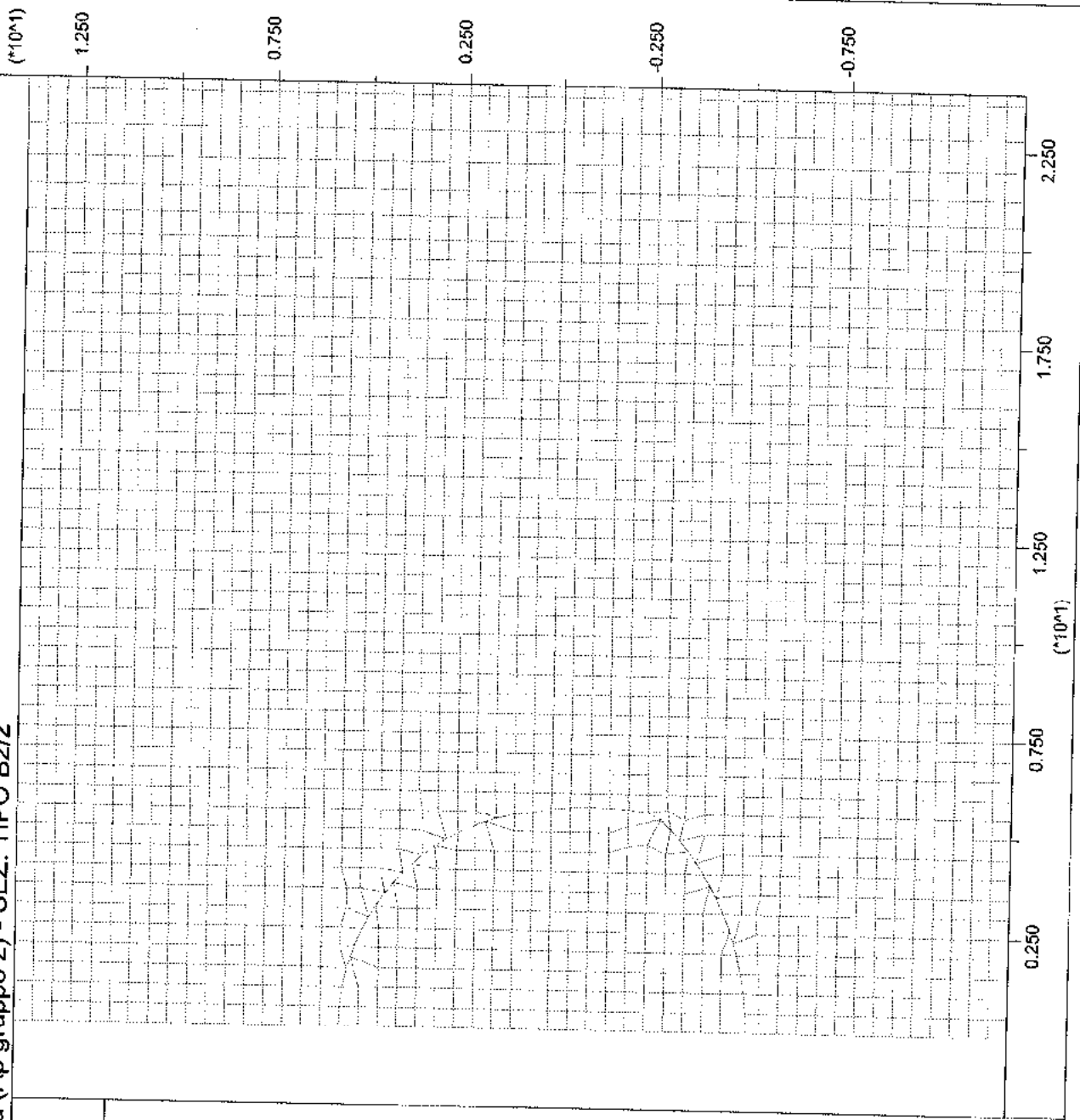
JOB TITLE : Cunicolo Castagnola (Ap gruppo 2) - SEZ. TIPO B2/2

FLAC (Version 4.00)

LEGEND

19-Feb-04 8:58
step 9624
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

MESH DI CALCOLO



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2 - "TIME 1"

FLAC (Version 4.00)

LEGEND

19-Feb-04 8:58
step 9624
-1.067E+02 <x< 2.267E+02
-1.417E+02 <y< 1.917E+02

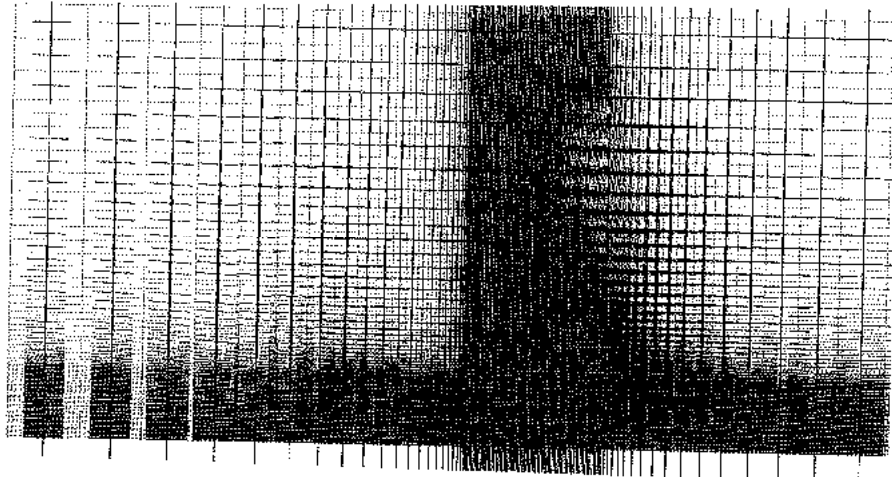
Principal stresses

Max. Value = -1.230E+07
Min. Value = -1.852E+07

0 1E 8

Tensioni principali : Pa

0 1E 2



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2 - "TIME 1"

FLAC (Version 4.00)

LEGEND

19-Feb-04 8:58

step 9624

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Principal stresses

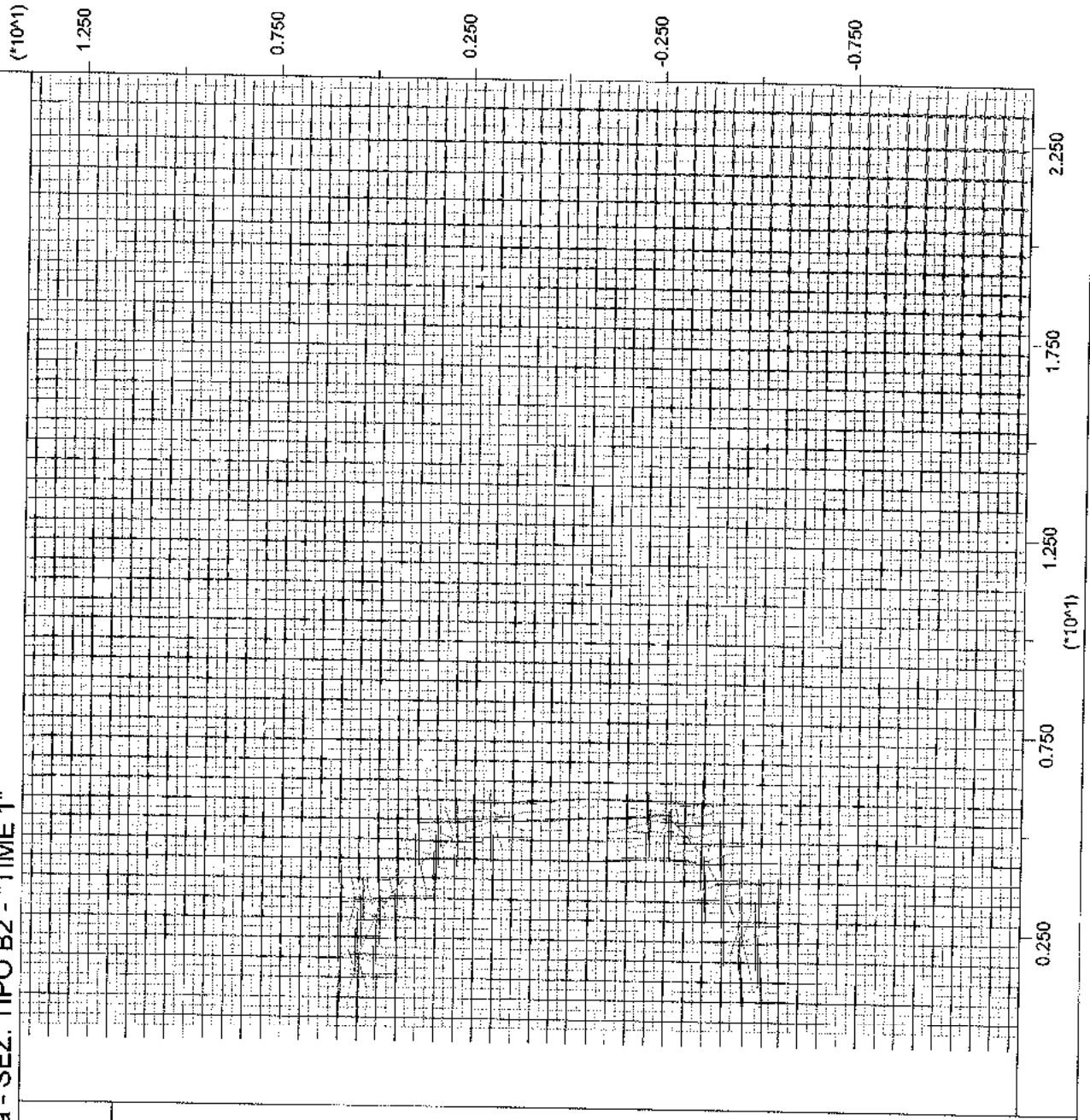
Max. Value = -1.559E+07

Min. Value = -1.639E+07



Tensioni principali : Pa

0 5E 0



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 2"

FLAC (Version 4.00)

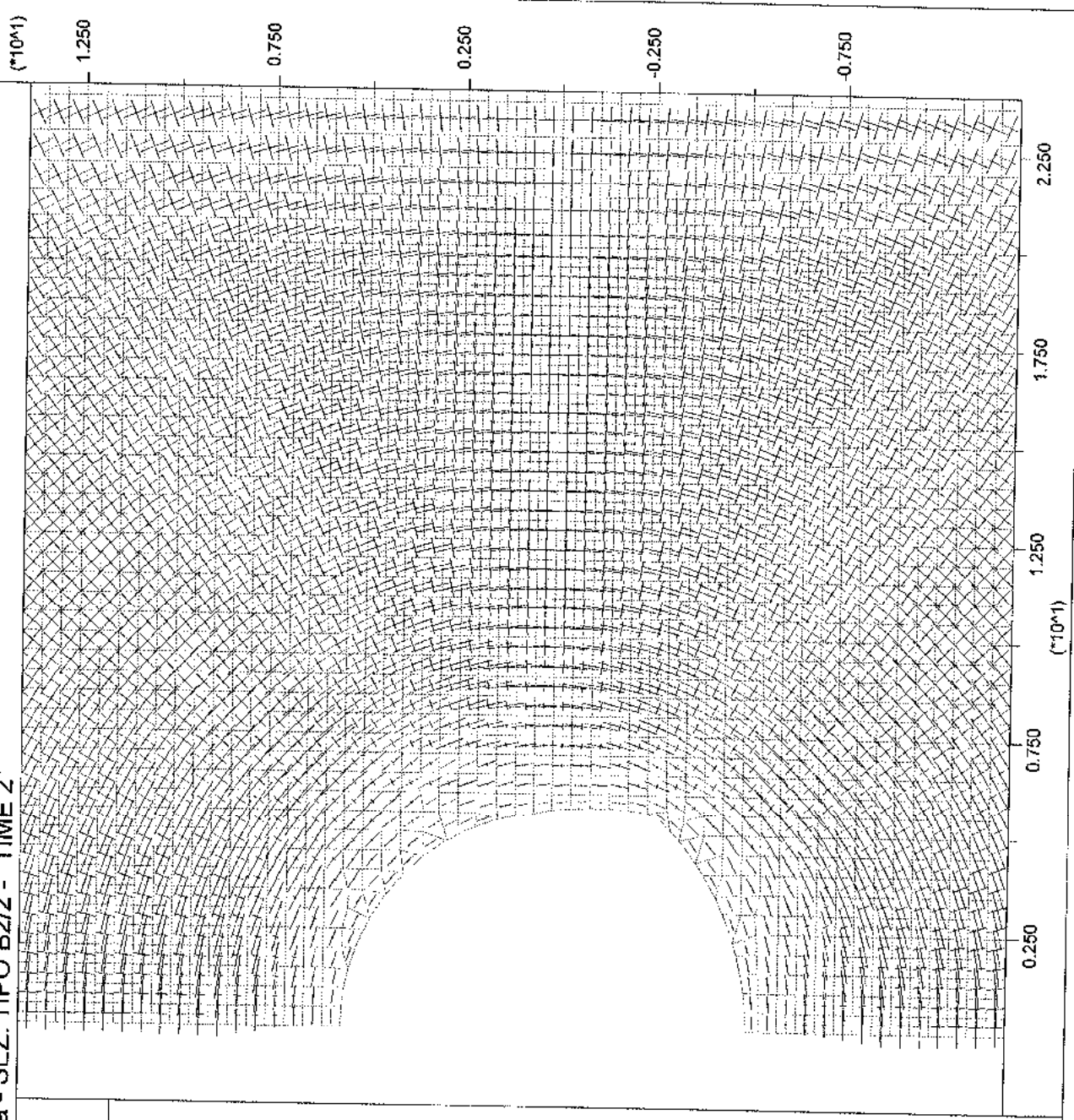
LEGEND

19-Feb-04 9:37
step 19070
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses
Max. Value = -5.891E+05
Min. Value = -2.722E+07



Tensioni principali : Pa



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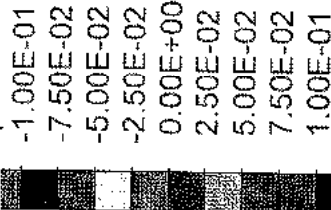
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 2"

FLAC (Version 4.00)

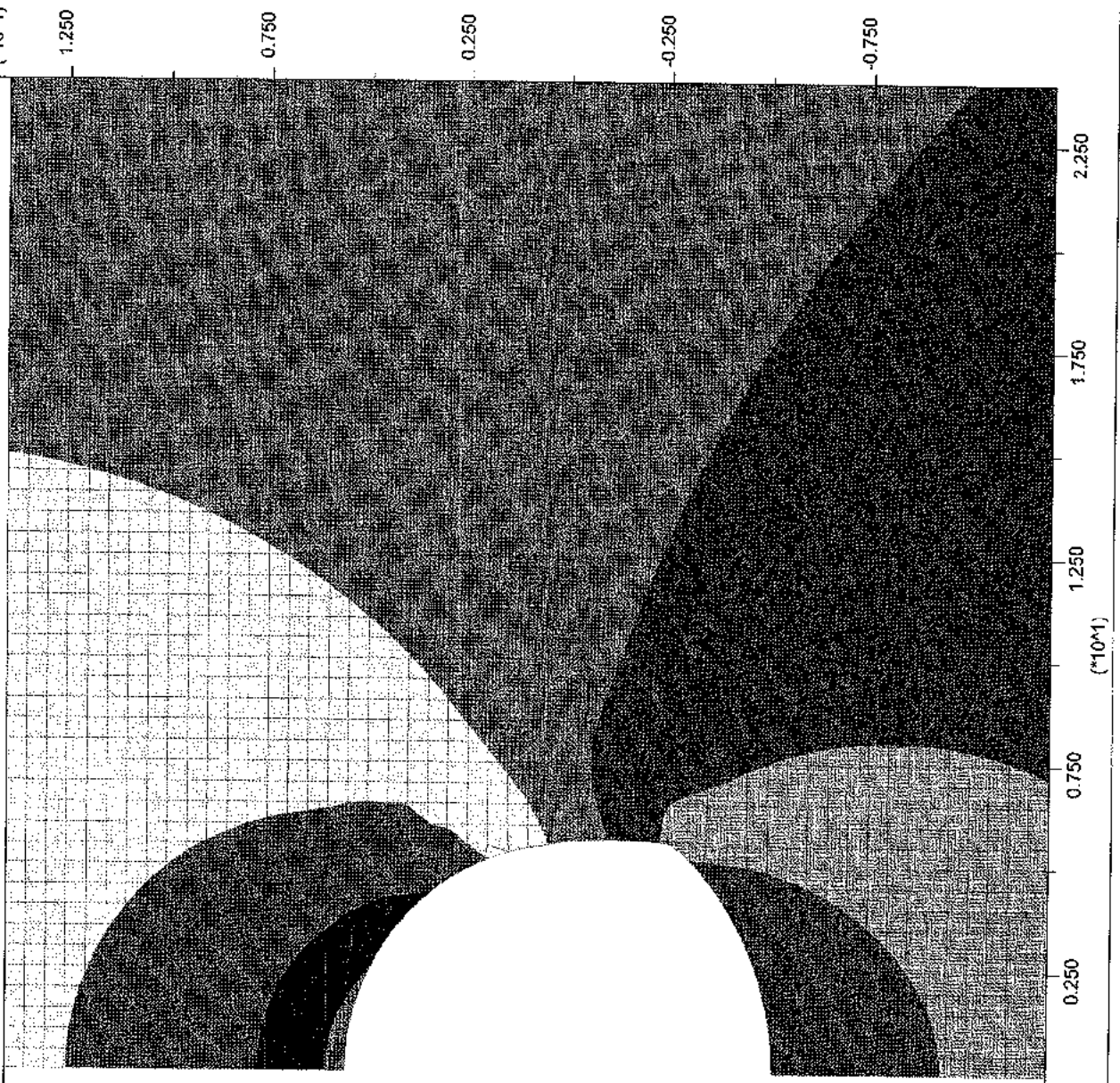
LEGEND

19-Feb-04 9:37
step 19070
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02
Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 2"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:37

step 19070

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-1.00E-01

-8.00E-02

-6.00E-02

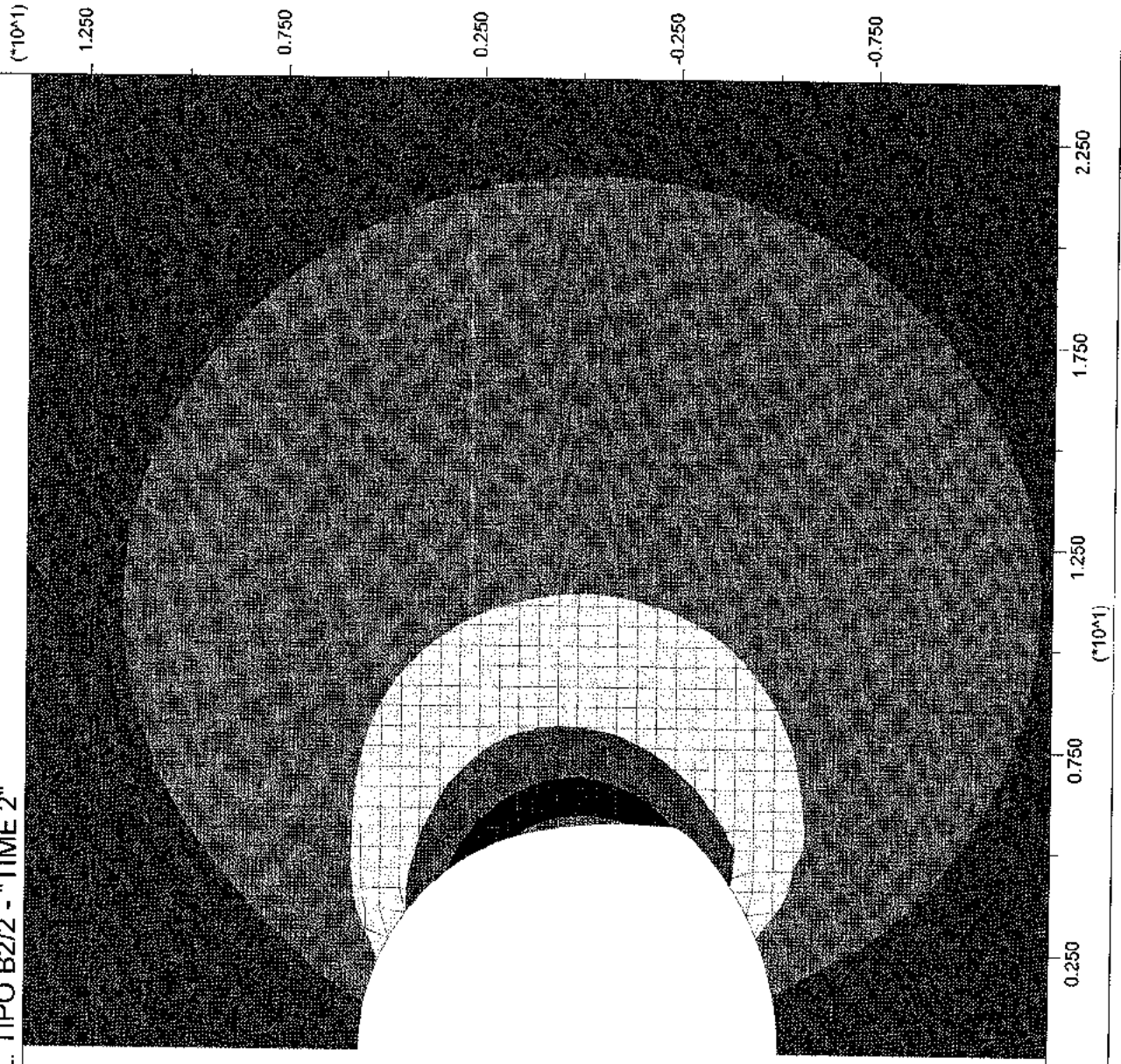
-4.00E-02

-2.00E-02

0.00E+00

Contour interval= 2.00E-02

Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 2"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:37

step 19070

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

5.00E-03

1.00E-02

1.50E-02

2.00E-02

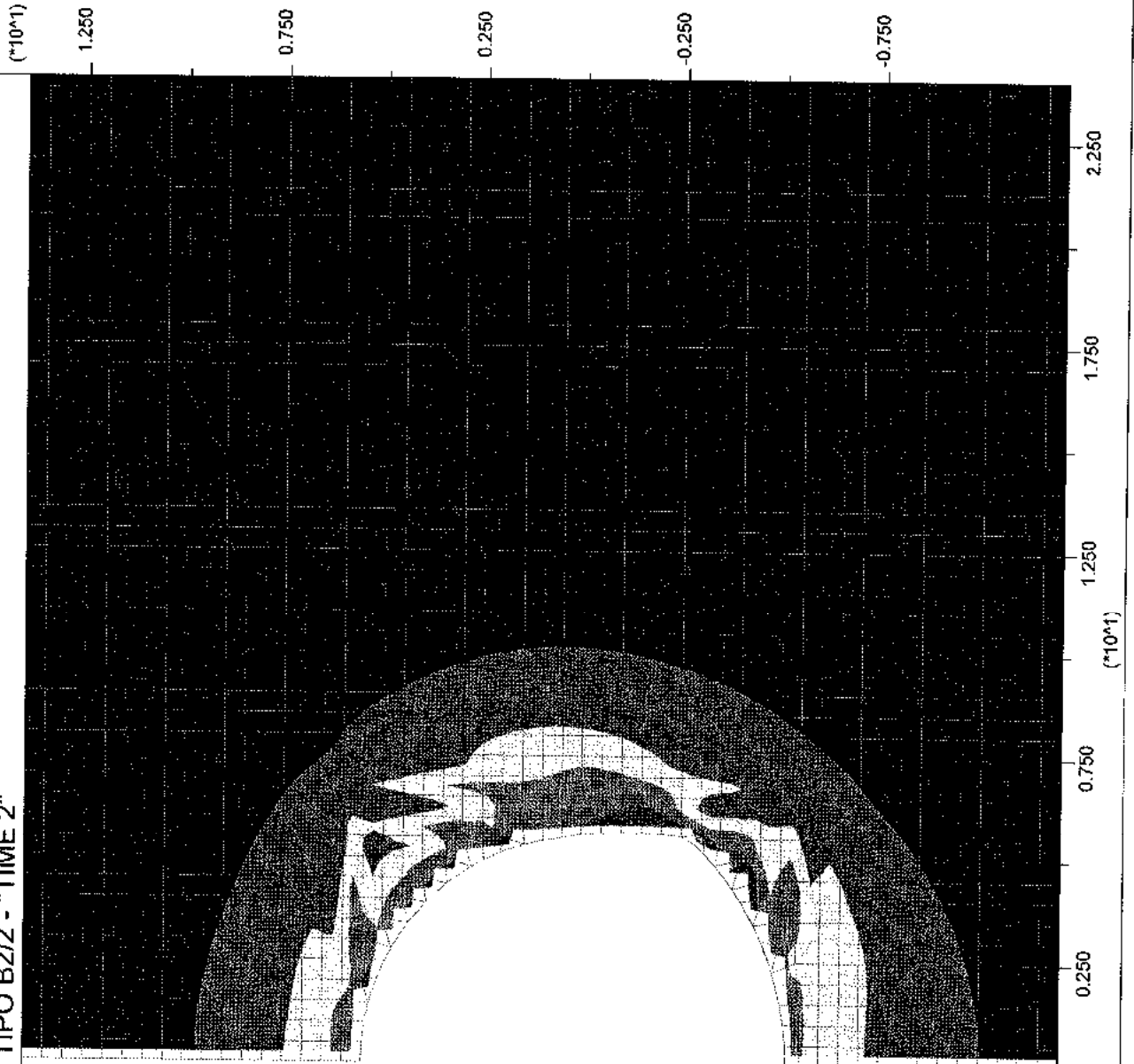
2.50E-02

3.00E-02

3.50E-02

Contour interval= 5.00E-03

Deformazioni plastiche per taglio



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 3"

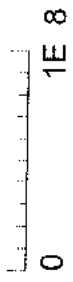
FLAC (Version 4.00)

LEGEND

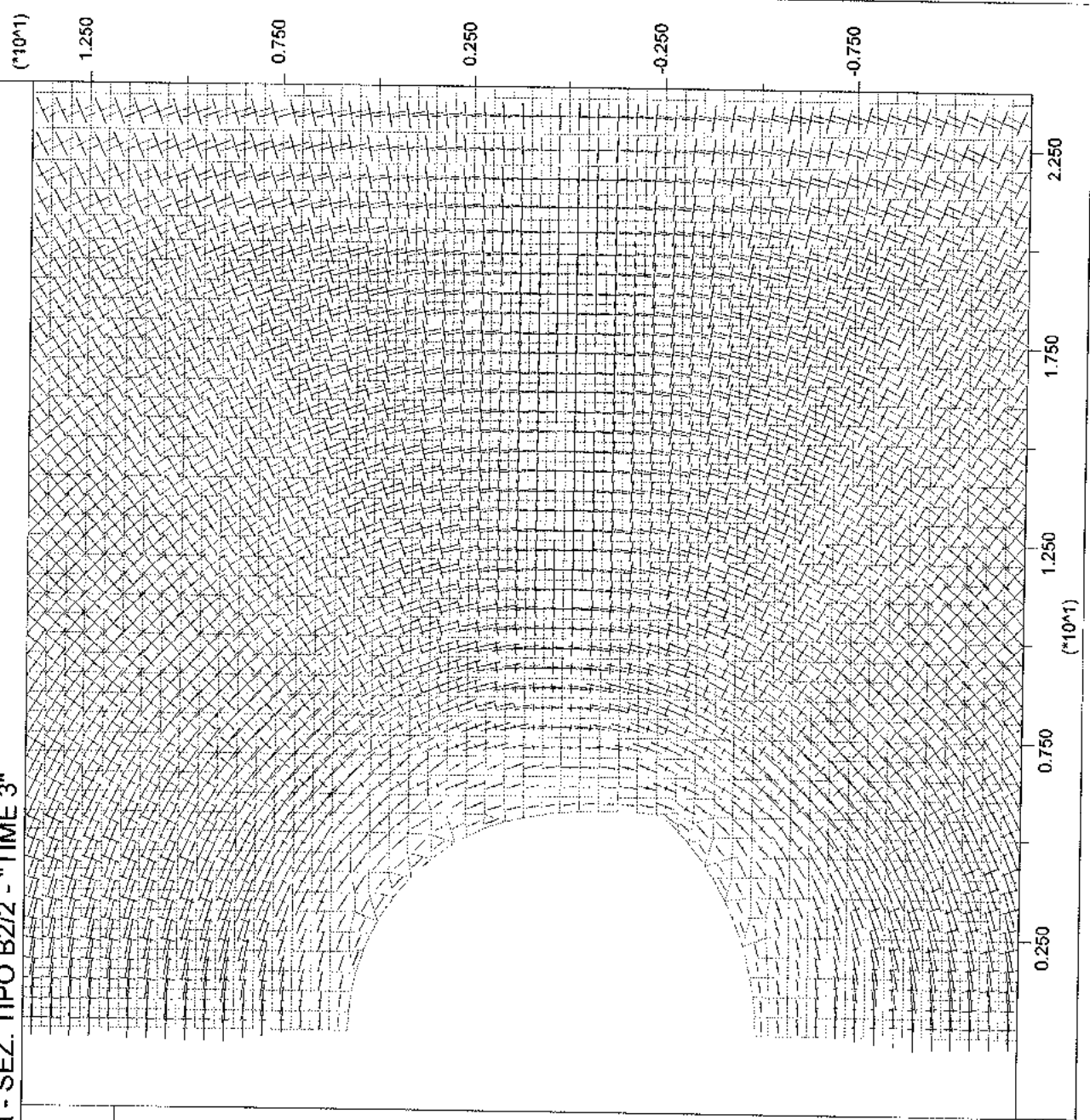
19-Feb-04 9:42
step 20395
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -4.186E+05
Min. Value = -2.731E+07



Tensioni principali : Pa



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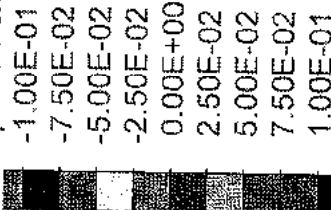
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

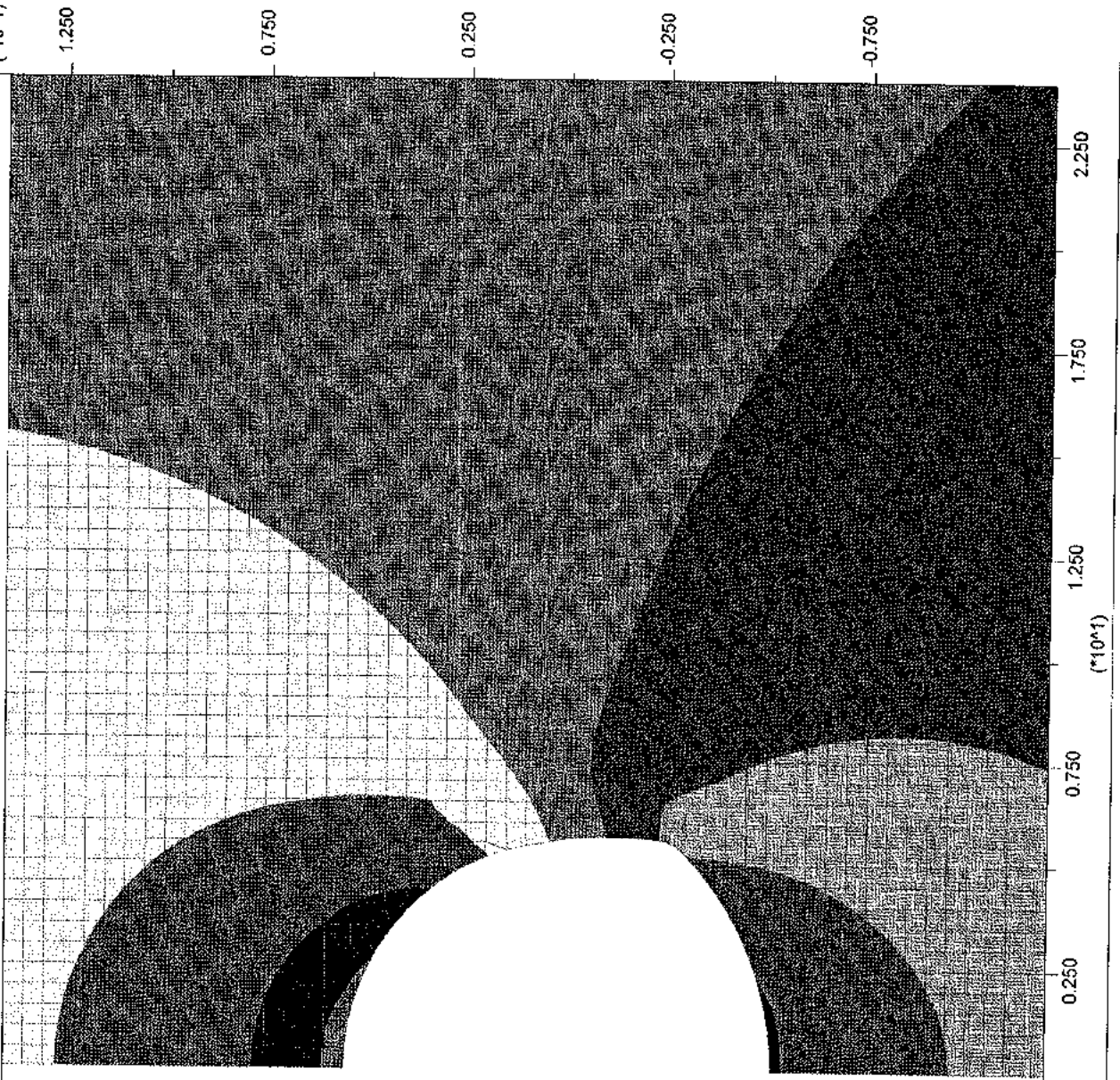
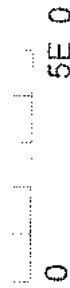
19-Feb-04 9:42
step 20395
-2.00E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02

Spostamenti verticali



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:42

step 20395

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-1.00E-01

-8.00E-02

-6.00E-02

-4.00E-02

-2.00E-02

0.00E+00



Contour interval= 2.00E-02

Spostamenti orizzontali

0

5E 0

(*10^1)

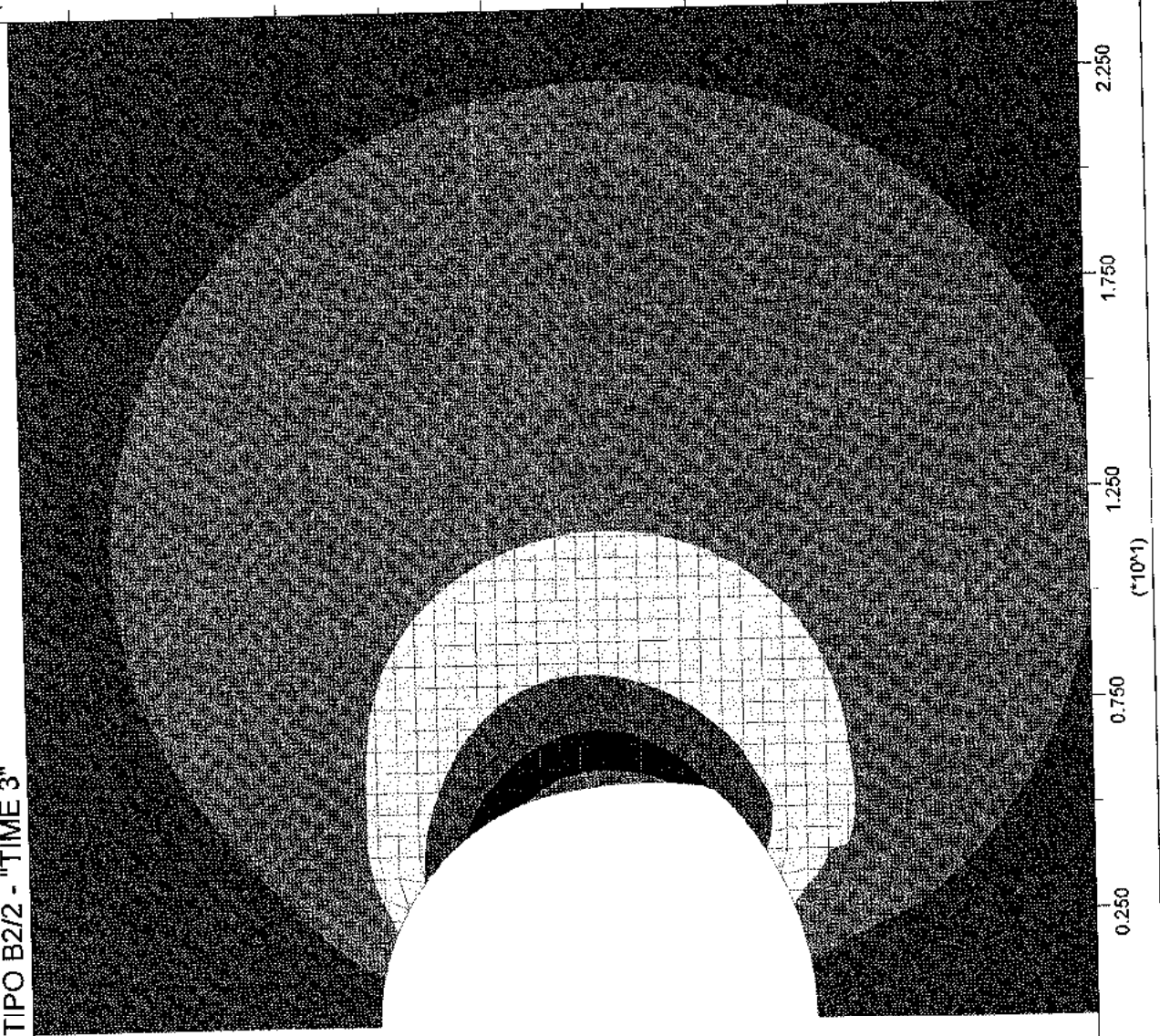
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:42

step 20395

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

5.00E-03

1.00E-02

1.50E-02

2.00E-02

2.50E-02

3.00E-02

3.50E-02

Contour interval= 5.00E-03

Deformazioni plastiche per taglio



(*10⁻¹)

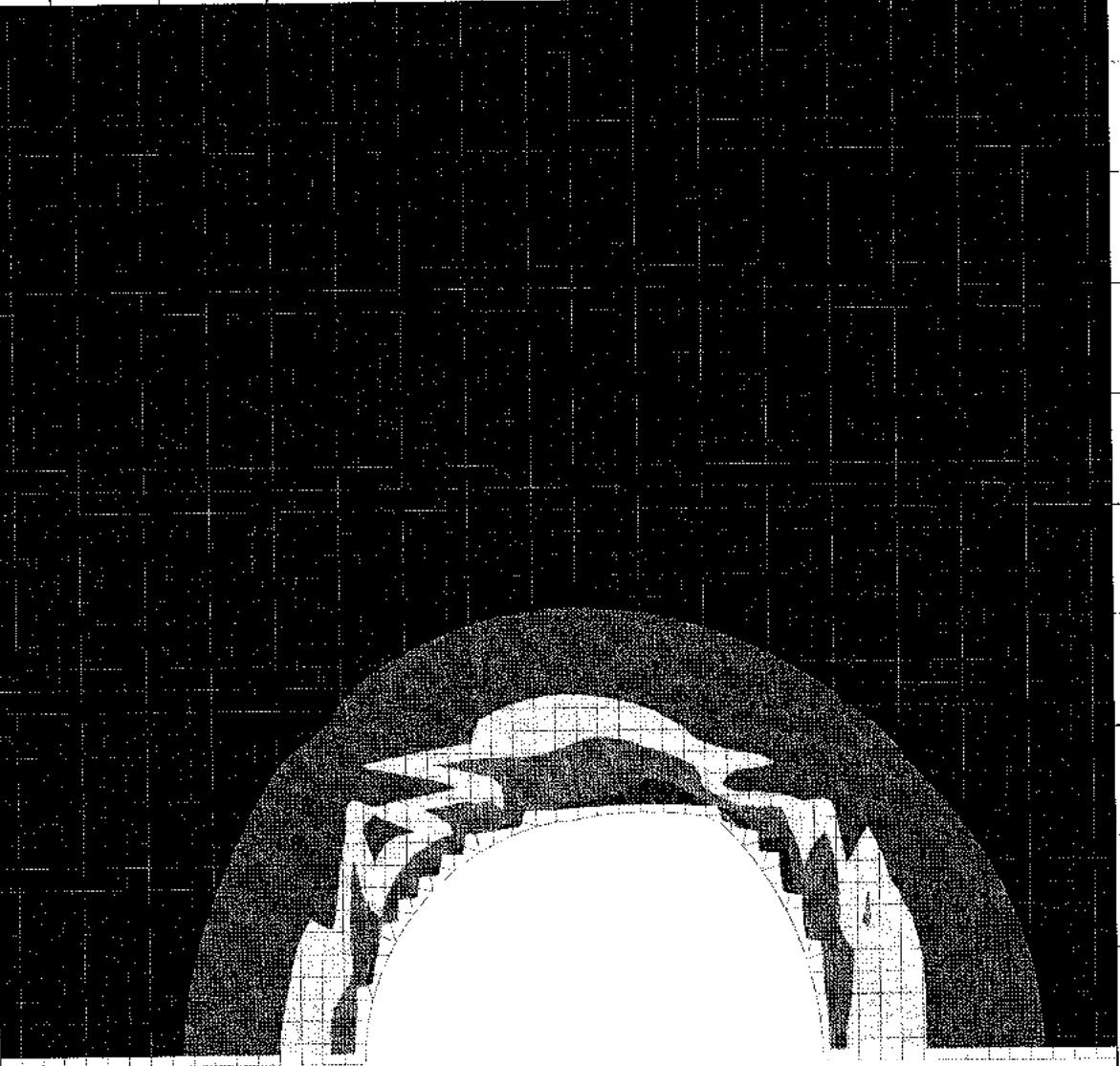
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

(*10⁻¹)

0.750

0.250

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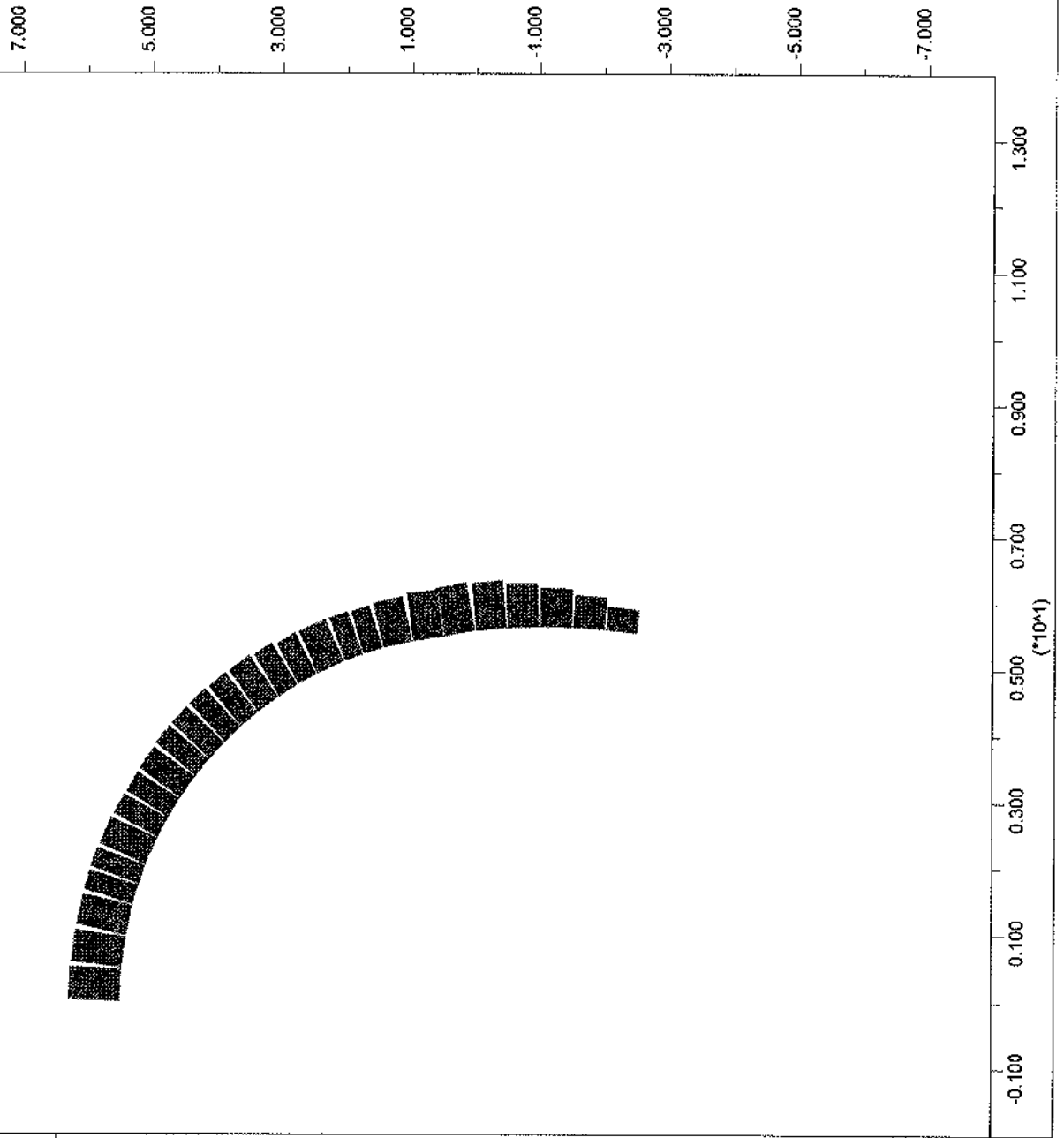
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:42
step 20395
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 1.265E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 3"

FLAC (Version 4.00)

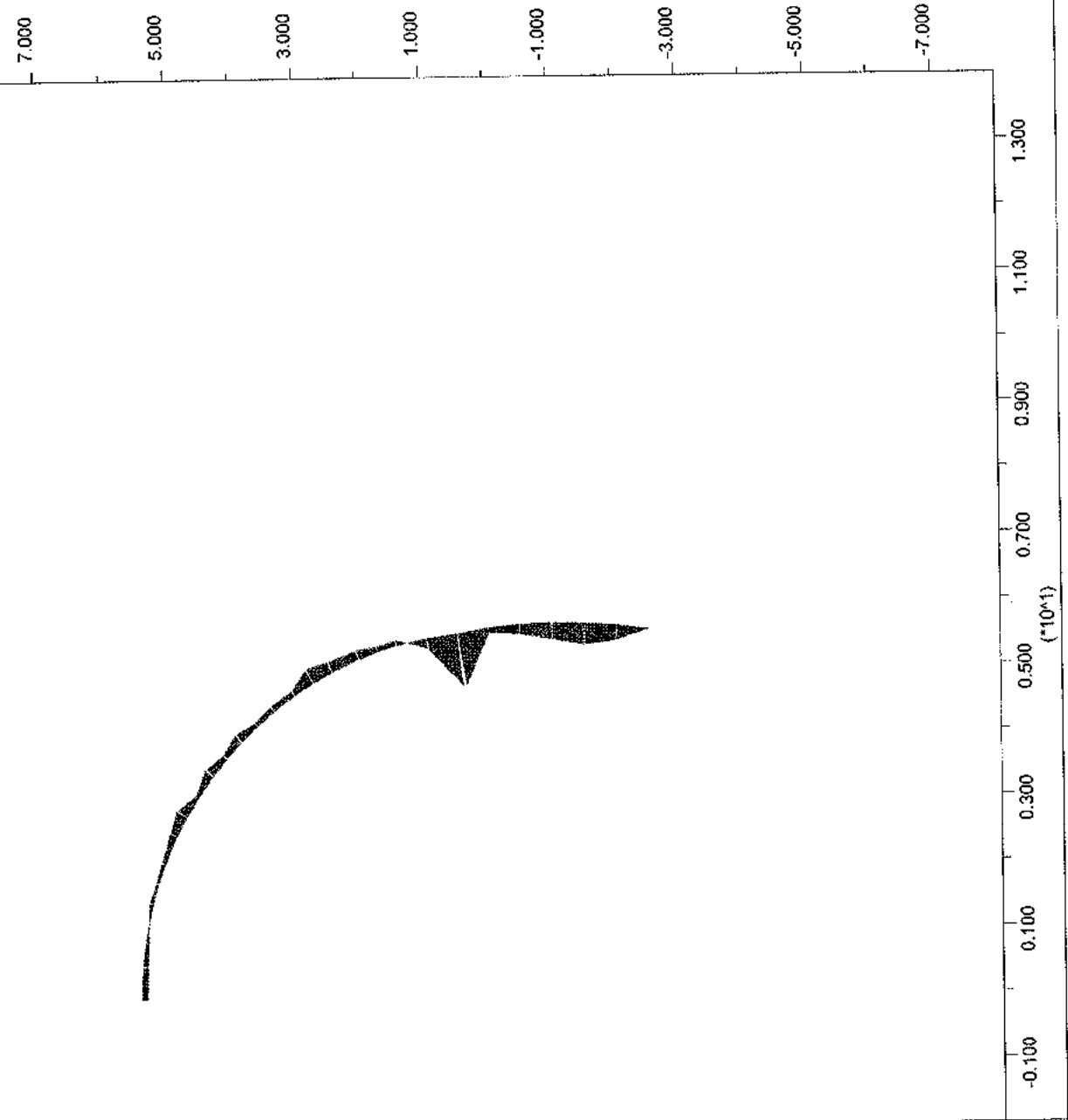
LEGEND

19-Feb-04 9:42
step 20395
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on

Structure Max. Value
1 (Beam) -3.103E+04



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 4"

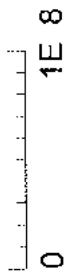
FLAC (Version 4.00)

LEGEND

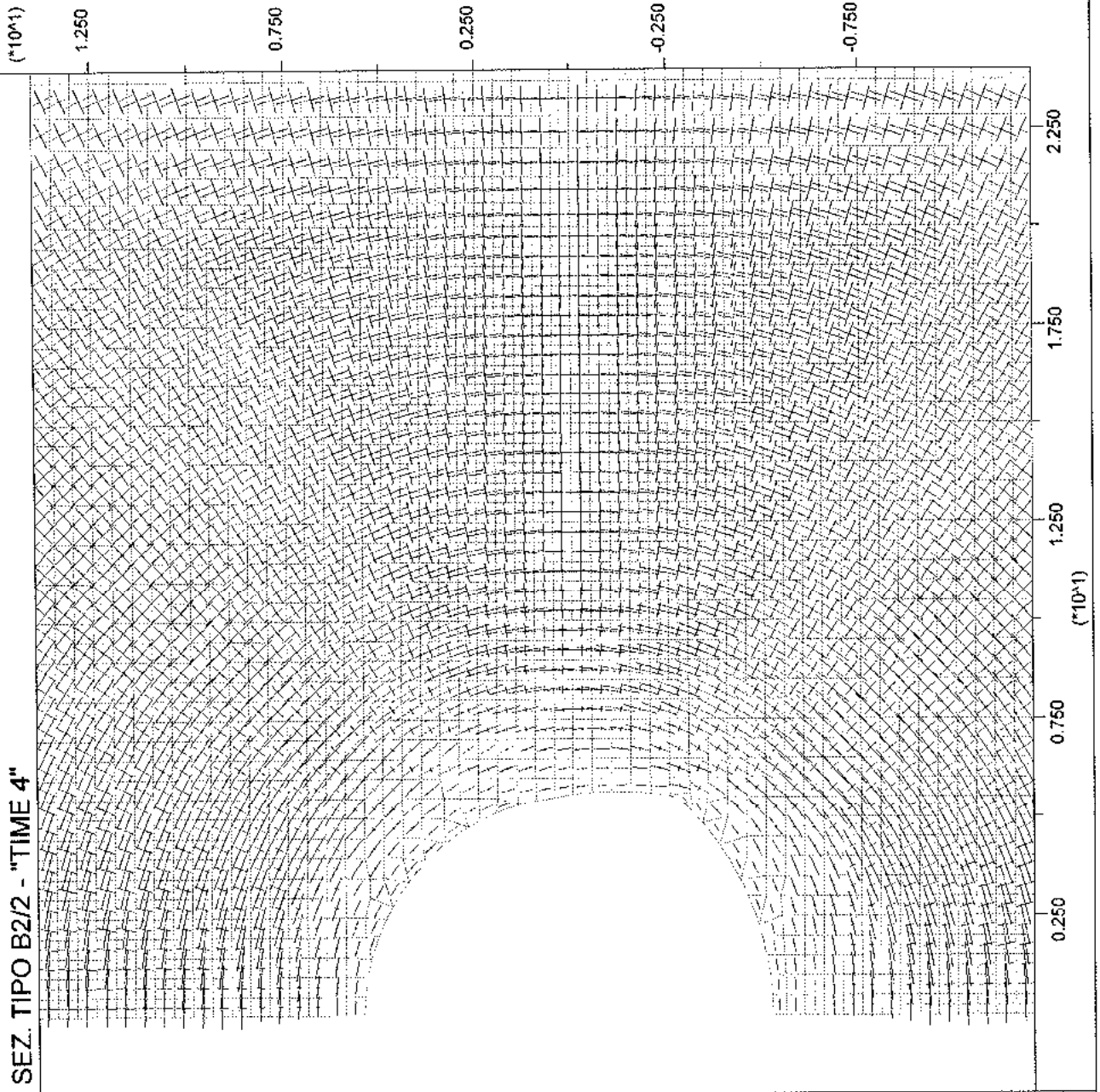
19-Feb-04 9:43
step 24089
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -2.540E+04
Min. Value = -2.750E+07



Tensioni principali: Pa



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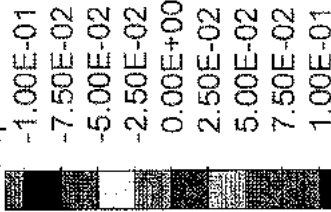
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 4"

FLAC (Version 4.00)

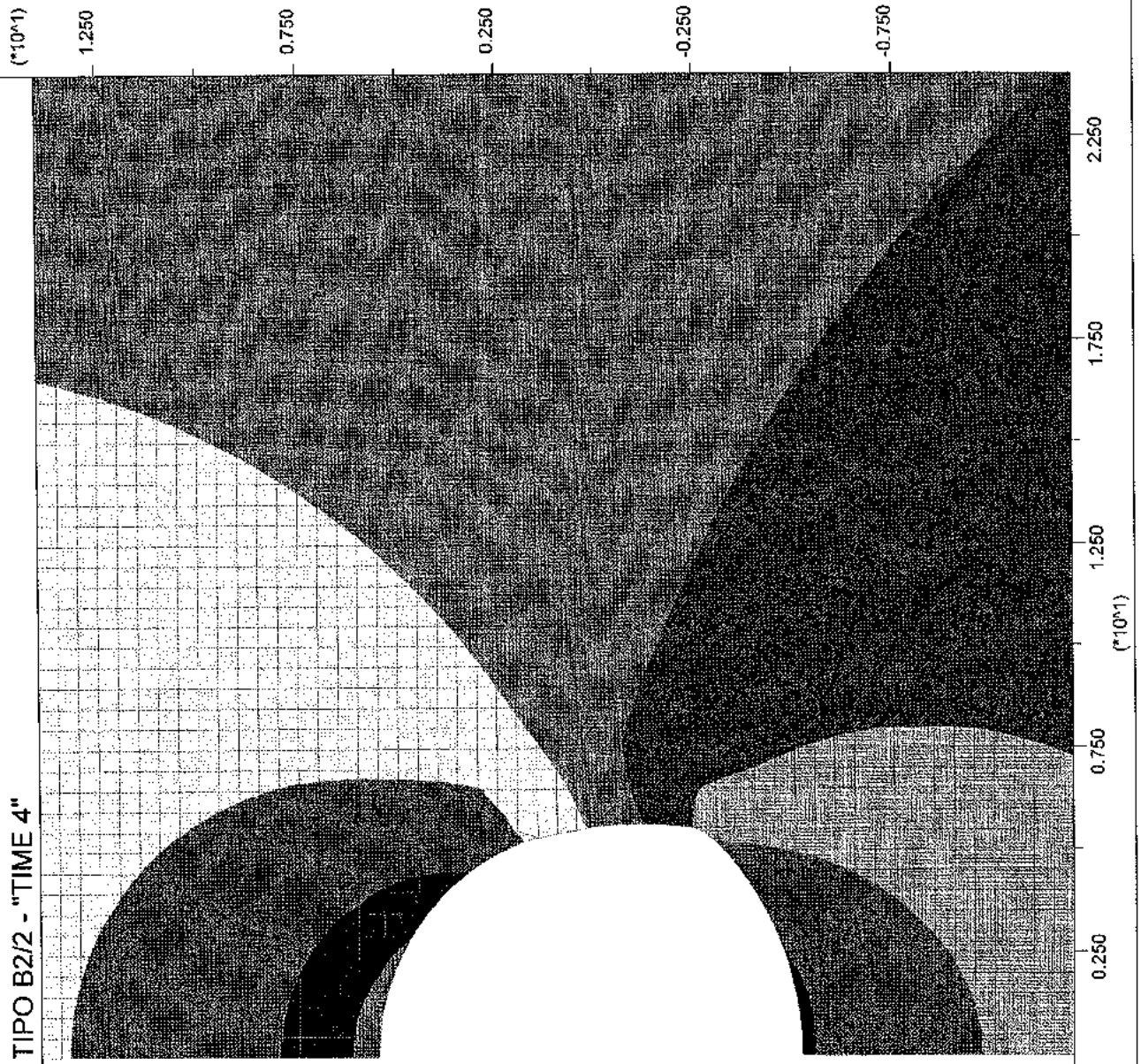
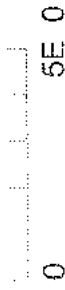
LEGEND

19-Feb-04 9:43
step 24089
-2.00E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02
Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:43

step 24089

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-1.00E-01

-8.00E-02

-6.00E-02

-4.00E-02

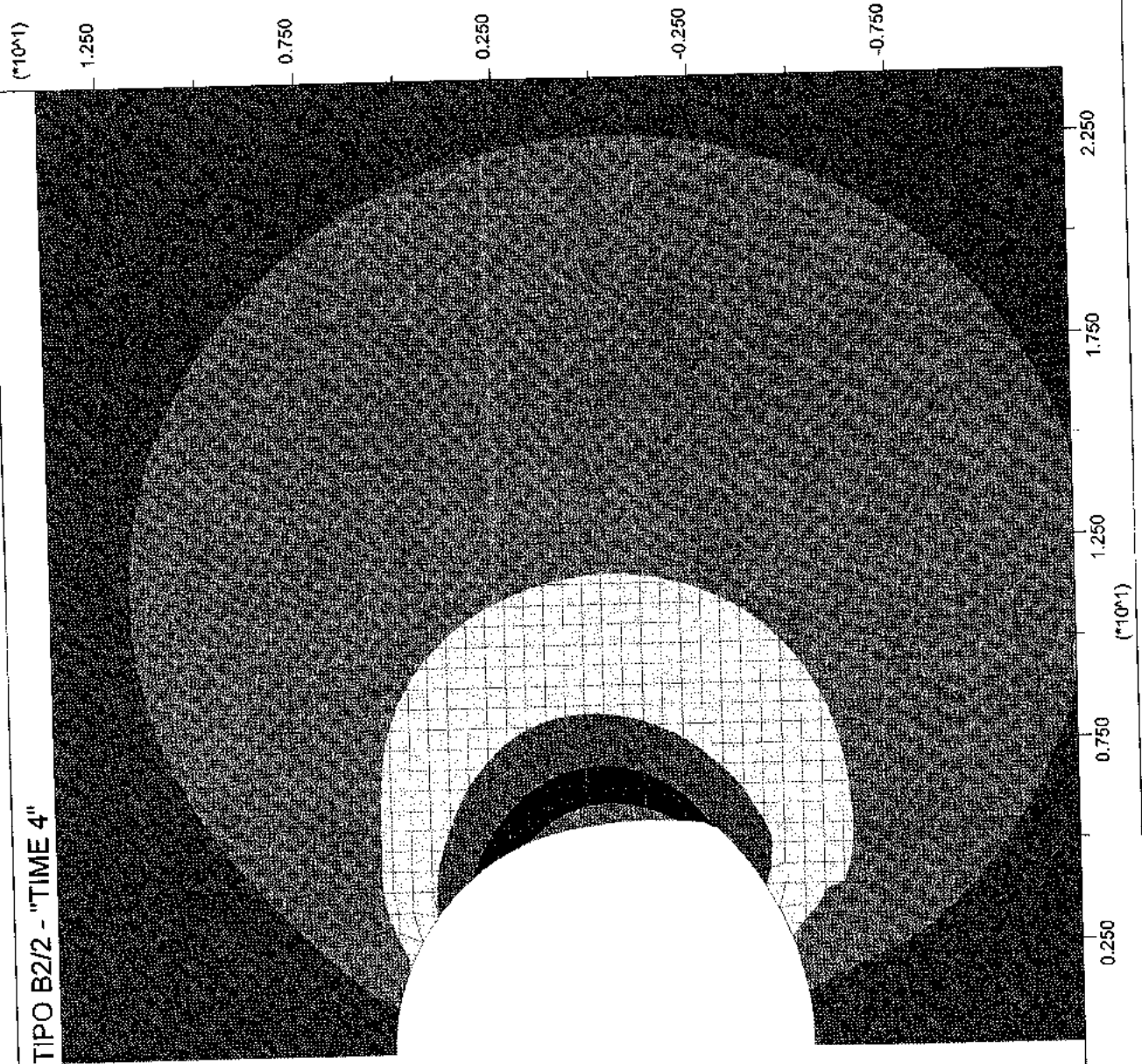
-2.00E-02

0.00E+00



Contour interval= 2.00E-02

Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:43

step 24089

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

5.00E-03

1.00E-02

1.50E-02

2.00E-02

2.50E-02

3.00E-02

3.50E-02

4.00E-02



Contour interval= 5.00E-03

Deformazioni plastiche per taglio



(*10^1)

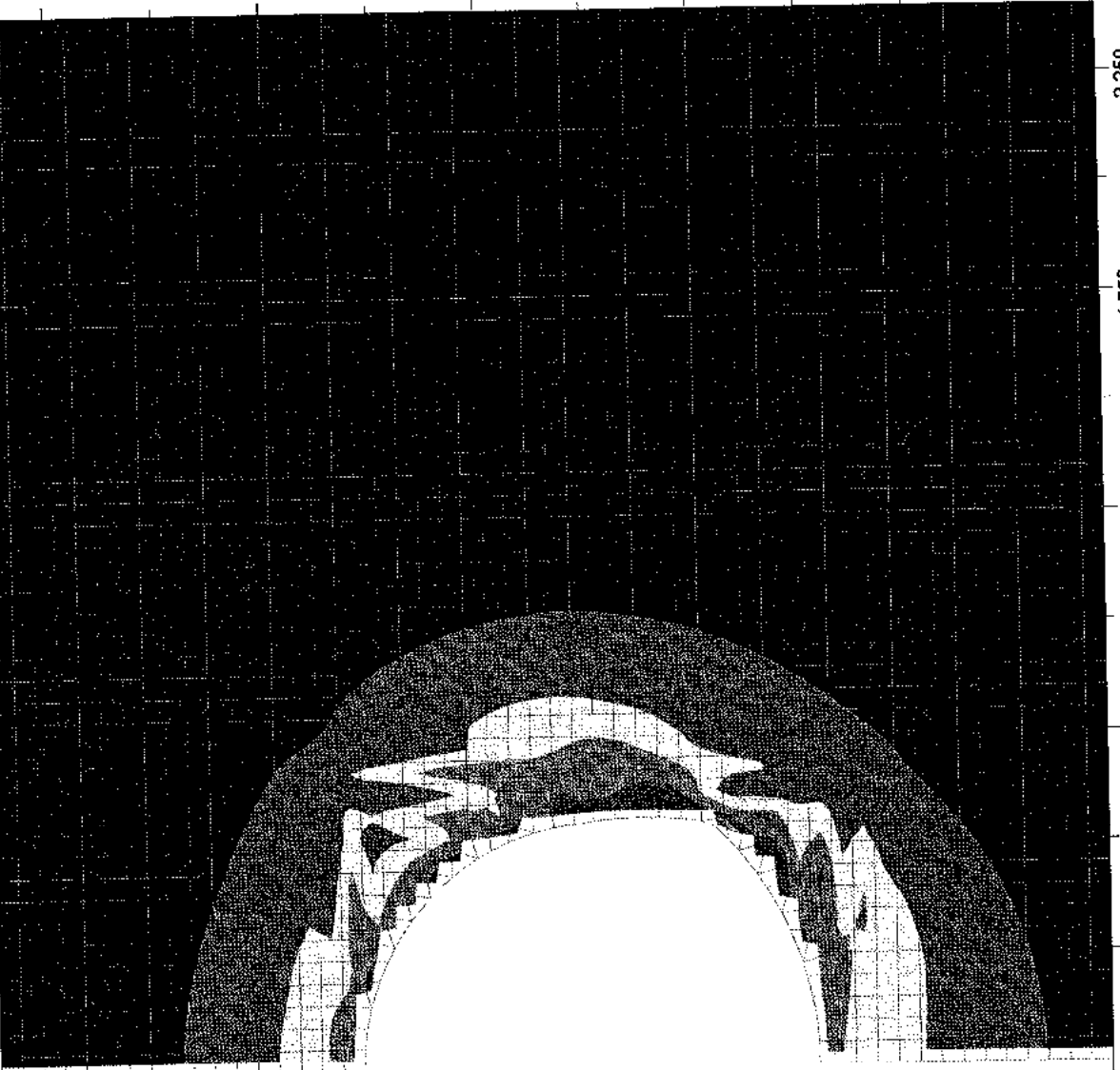
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:43

step 24089

-2.000E+00 <x< 1.400E+01

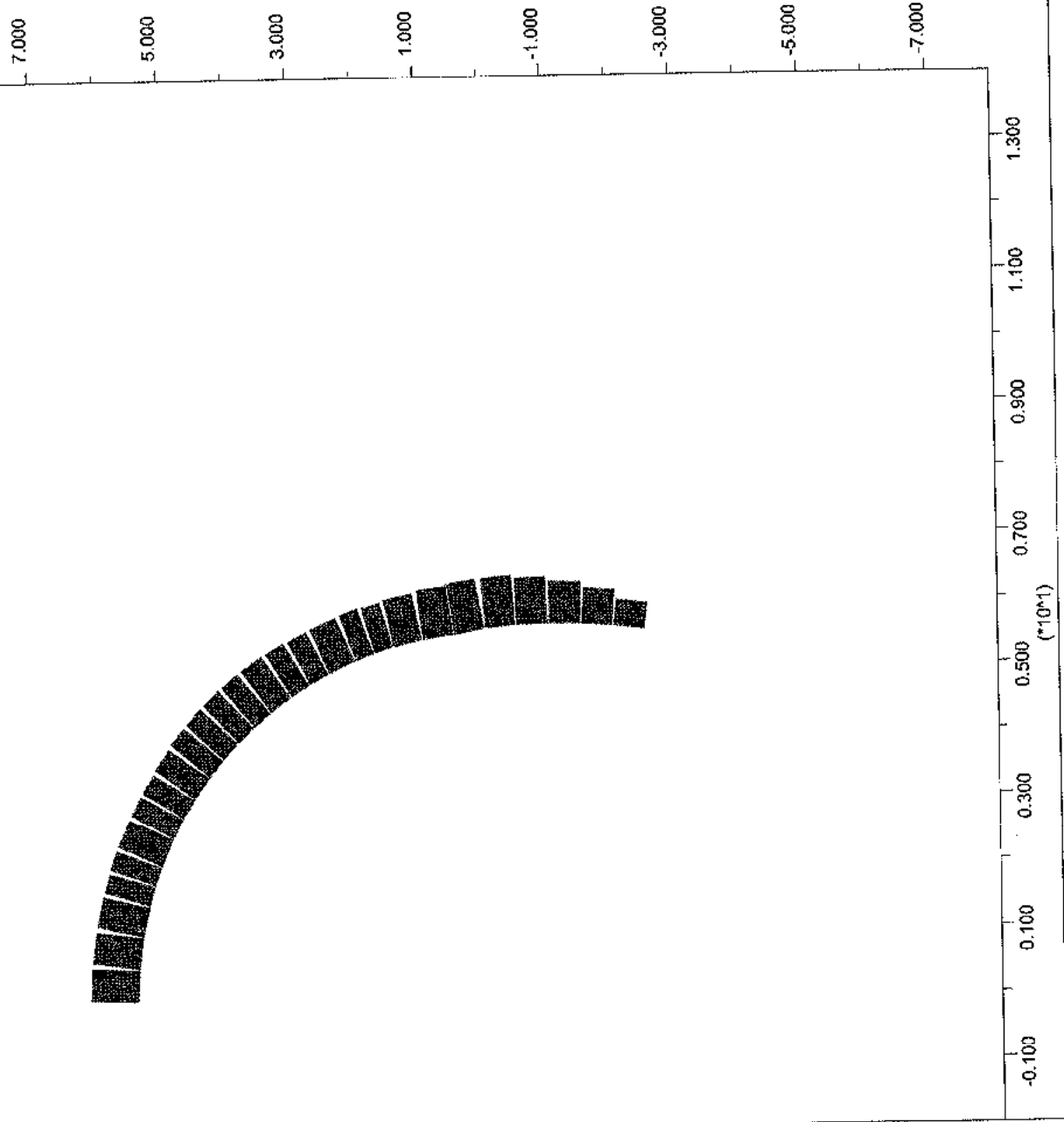
-8.000E+00 <y< 8.000E+00

Priniv. Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value

1 (Beam) 2.474E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:43

step 24089

-2.000E+00 <x< 1.400E+01

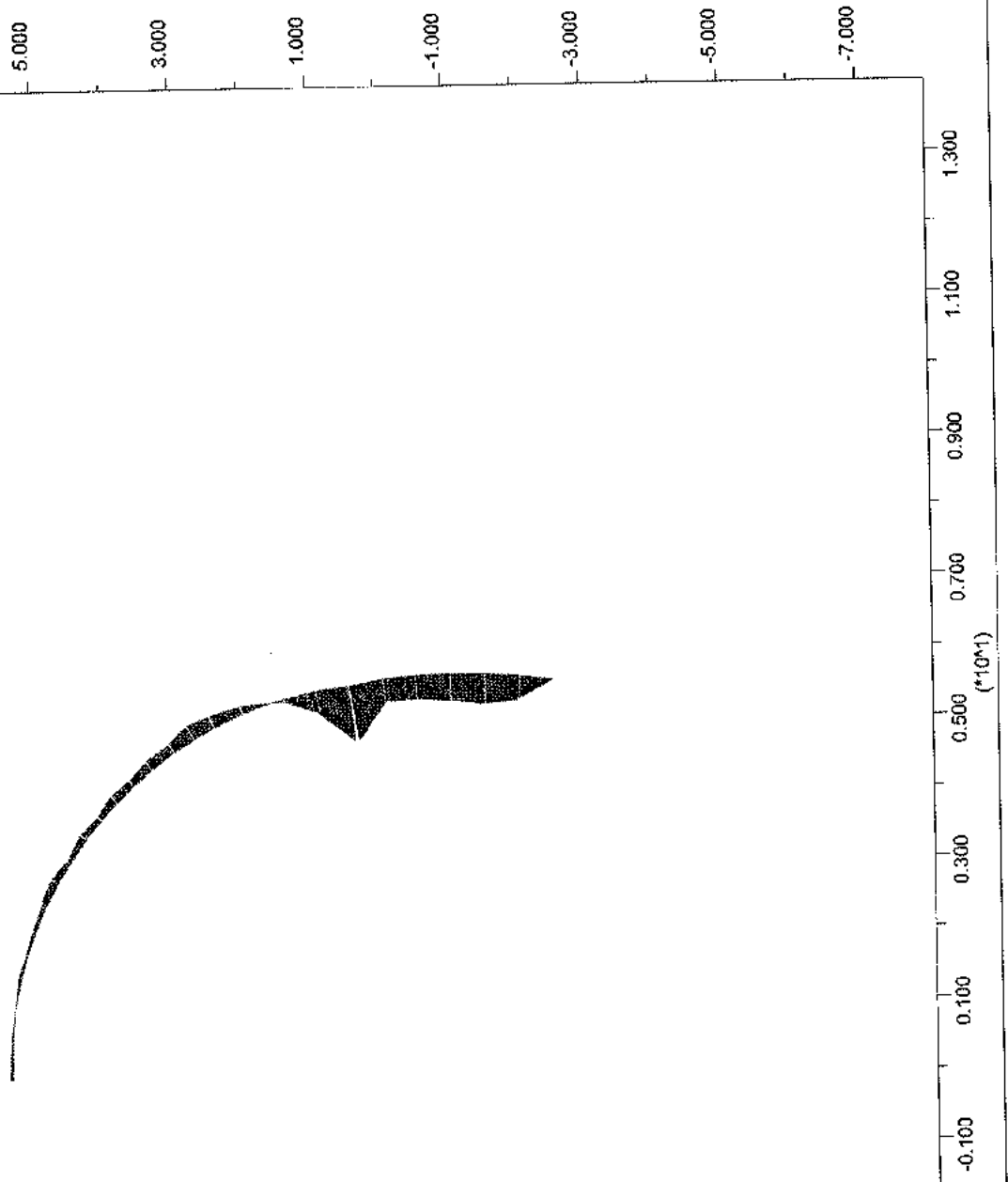
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on

Structure Max. Value

1 (Beam) -1.024E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 4"

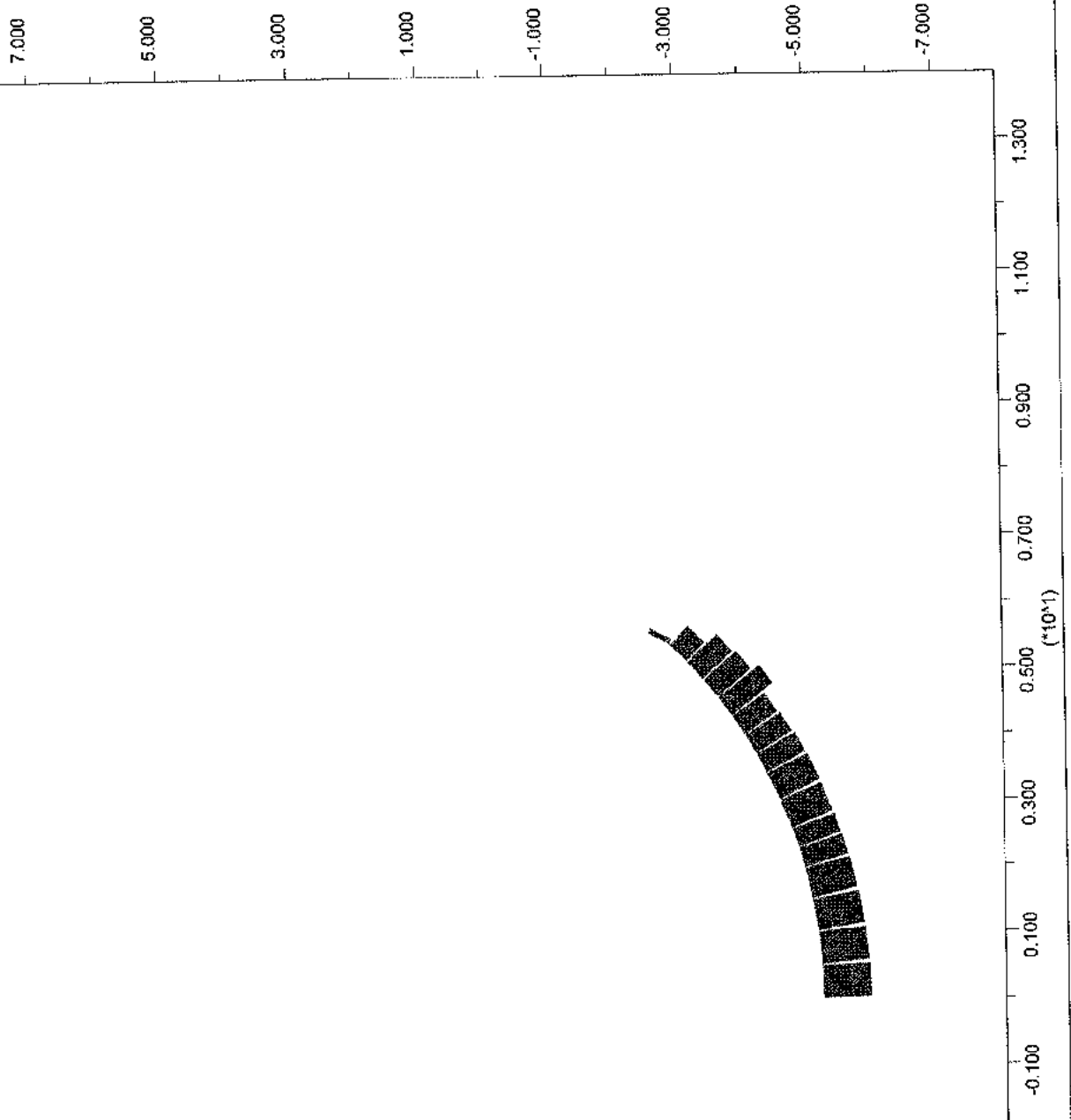
FLAC (Version 4.00)

LEGEND

19-Feb-04 9:43
step 24089
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
2 (Beam) 1.591E+06

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA




JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 4"

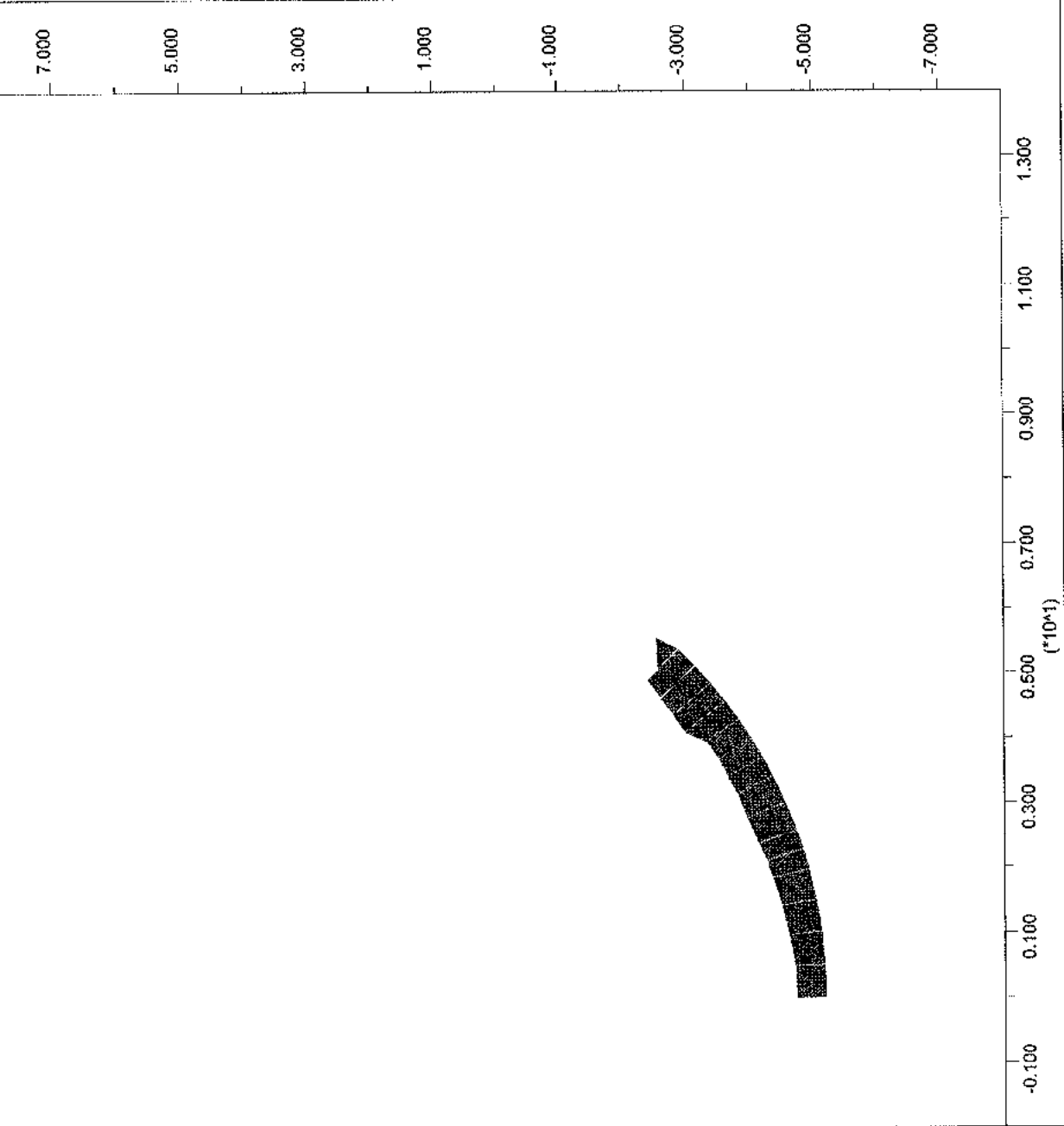
FLAC (Version 4.00)

LEGEND

19-Feb-04 9:43
step 24089
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Momento flettente [N*m/m]

 Moment on
Structure Max. Value
2 (Beam) -1.531E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:47

step 25121

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

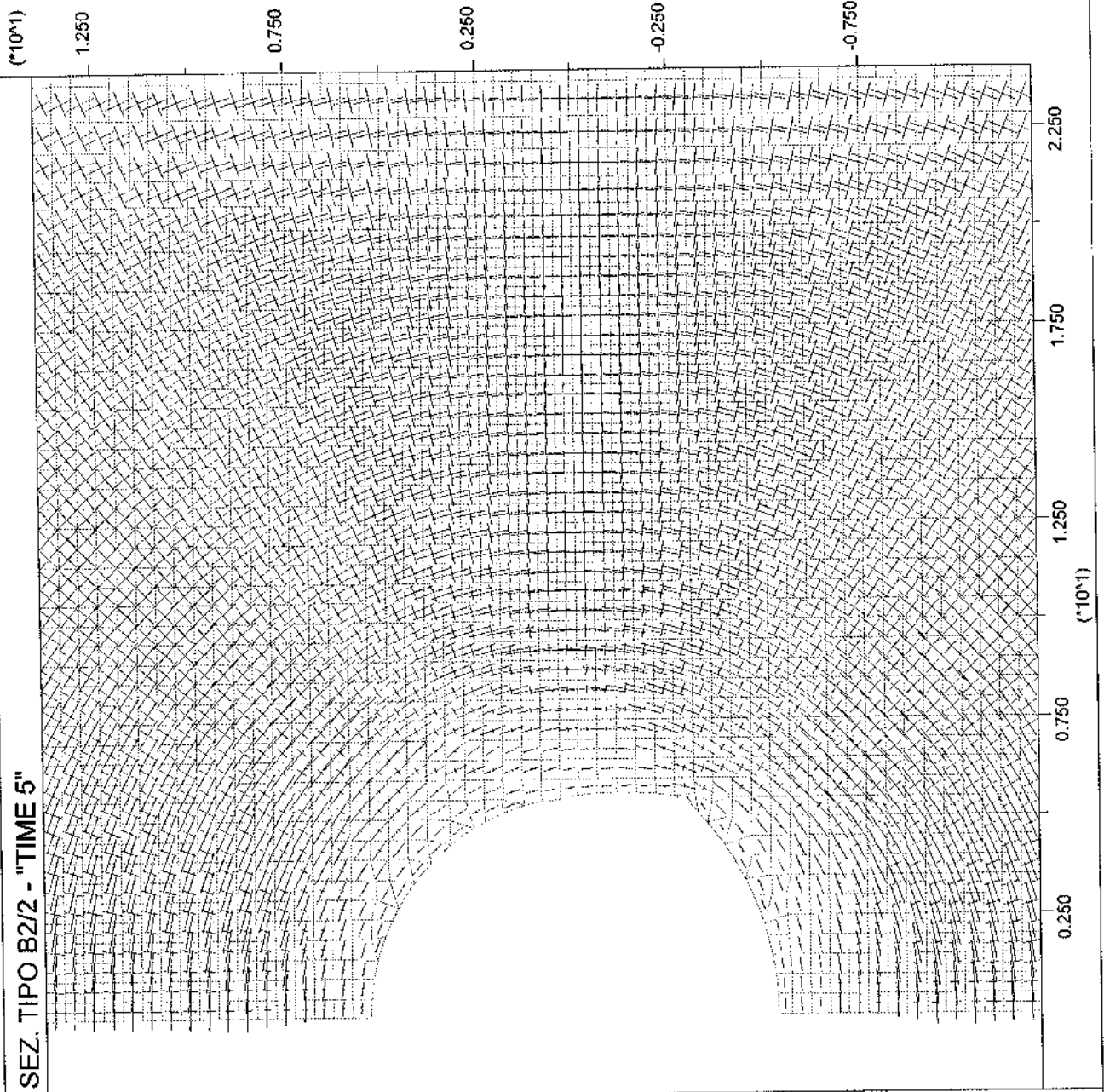
Principal stresses

Max. Value = -7.318E+04

Min. Value = -2.752E+07



Tensioni principali : Pa



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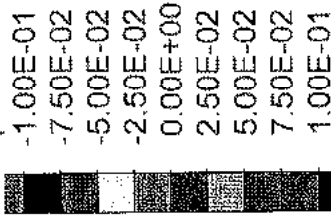
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 5"

FLAC (Version 4.00)

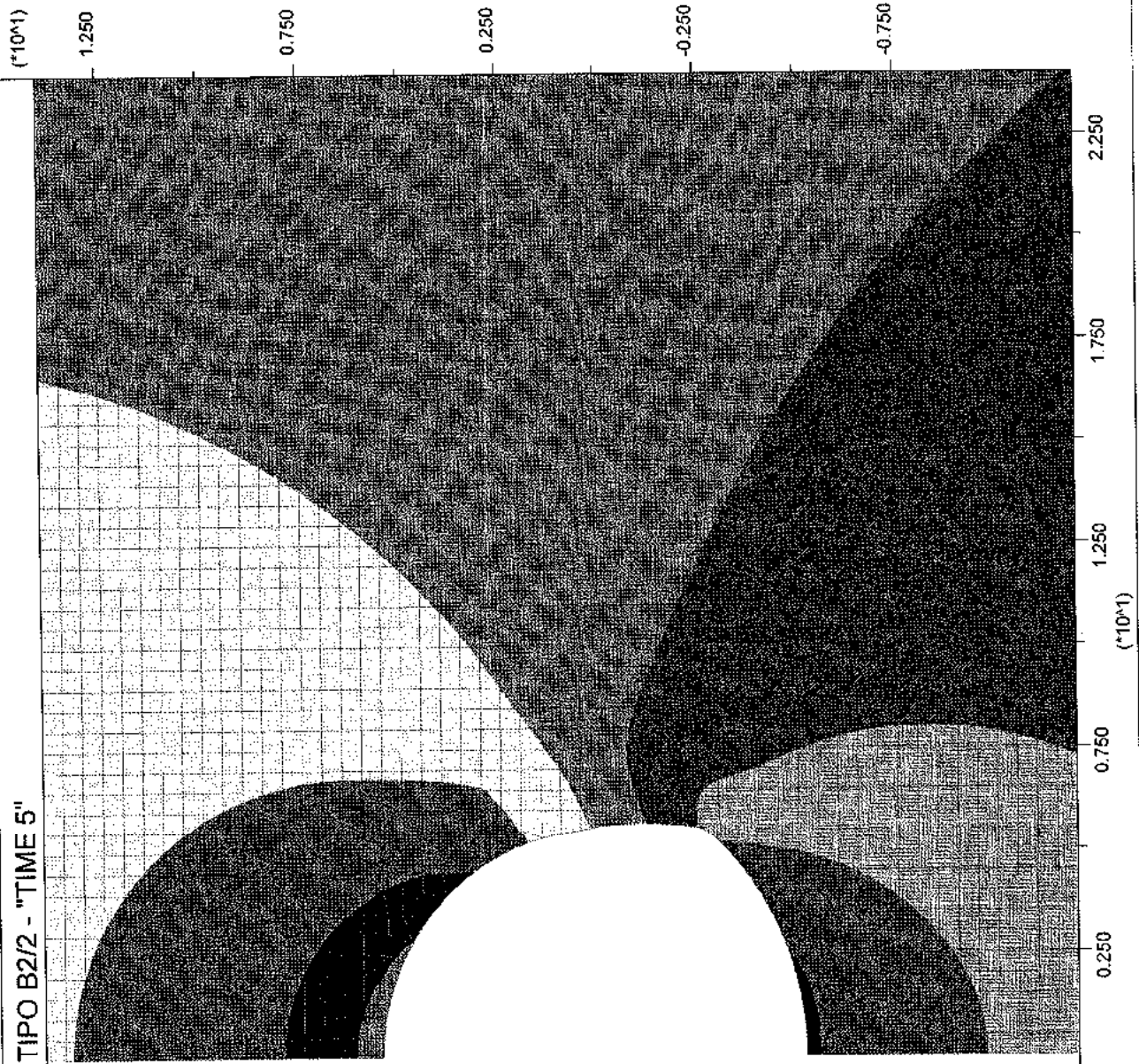
LEGEND

19-Feb-04 9:47
step 25121
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02
Spostamenti verticali



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:47
step 25121
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.00E-02

Spostamenti orizzontali



(*10^1)

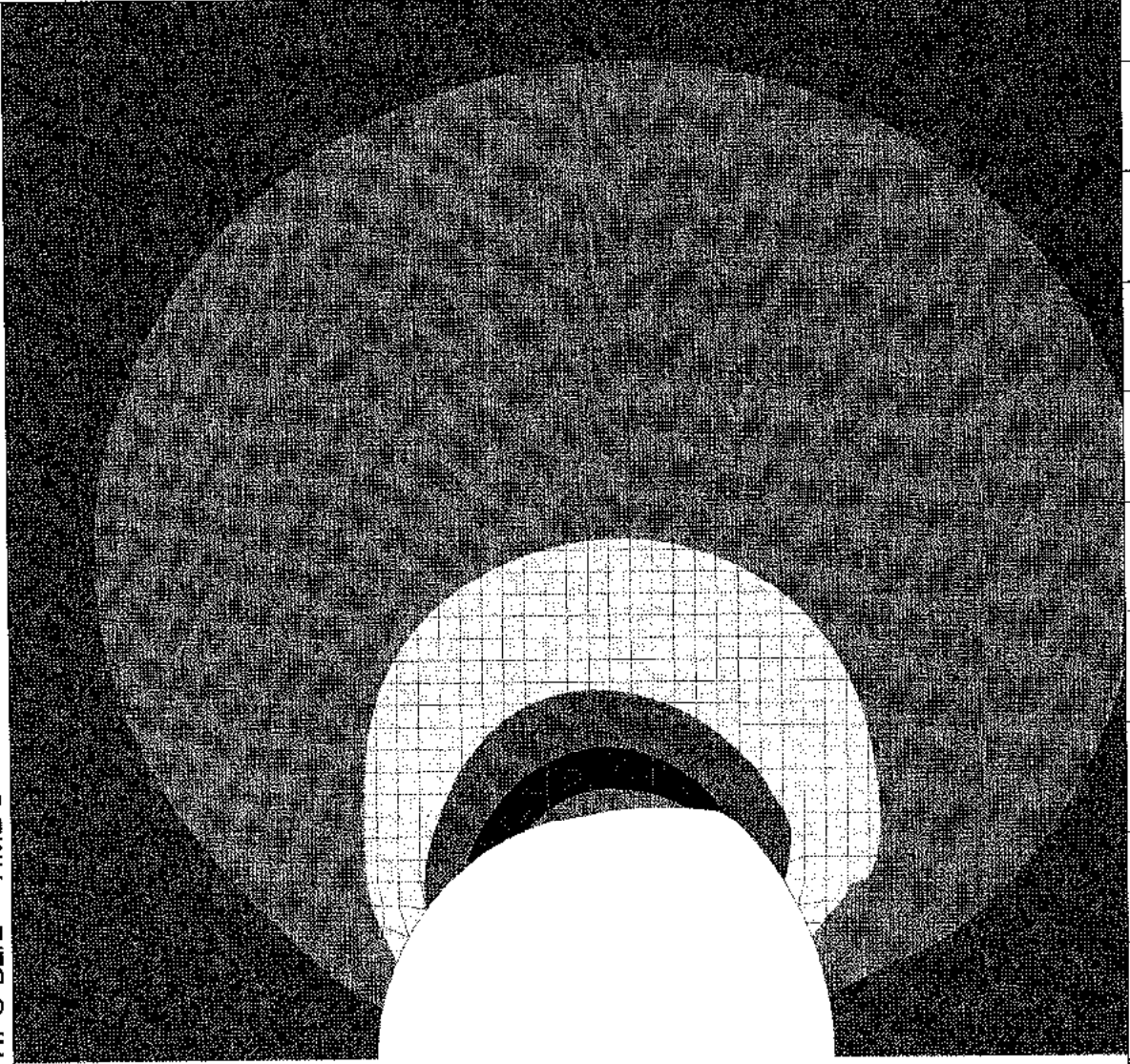
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

19-Feb-04 9:47

step 25121

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

5.00E-03

1.00E-02

1.50E-02

2.00E-02

2.50E-02

3.00E-02

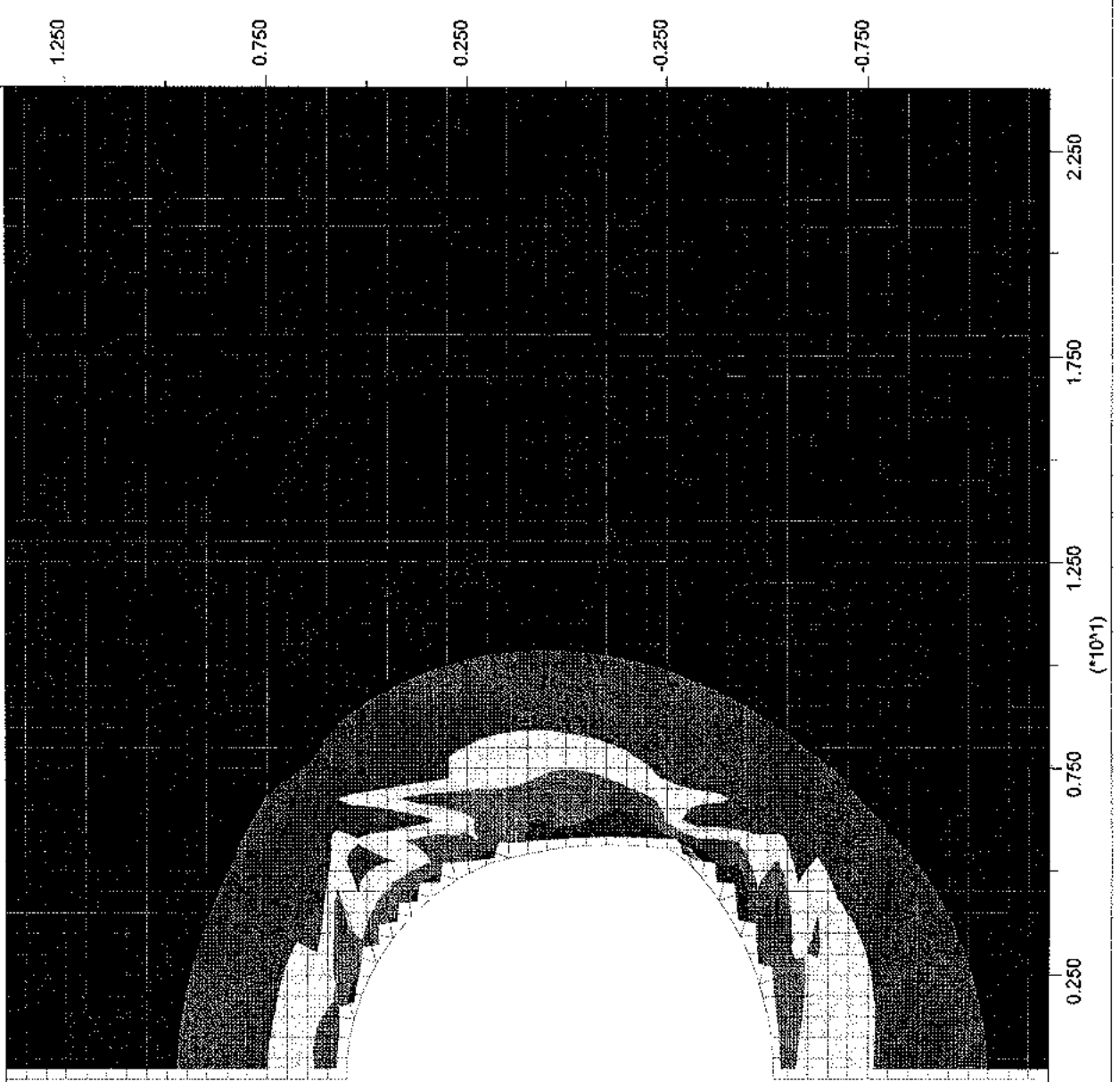
3.50E-02

4.00E-02



Contour interval= 5.00E-03

Deformazioni plastiche per taglio



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 5"

FLAC (Version 4.00)

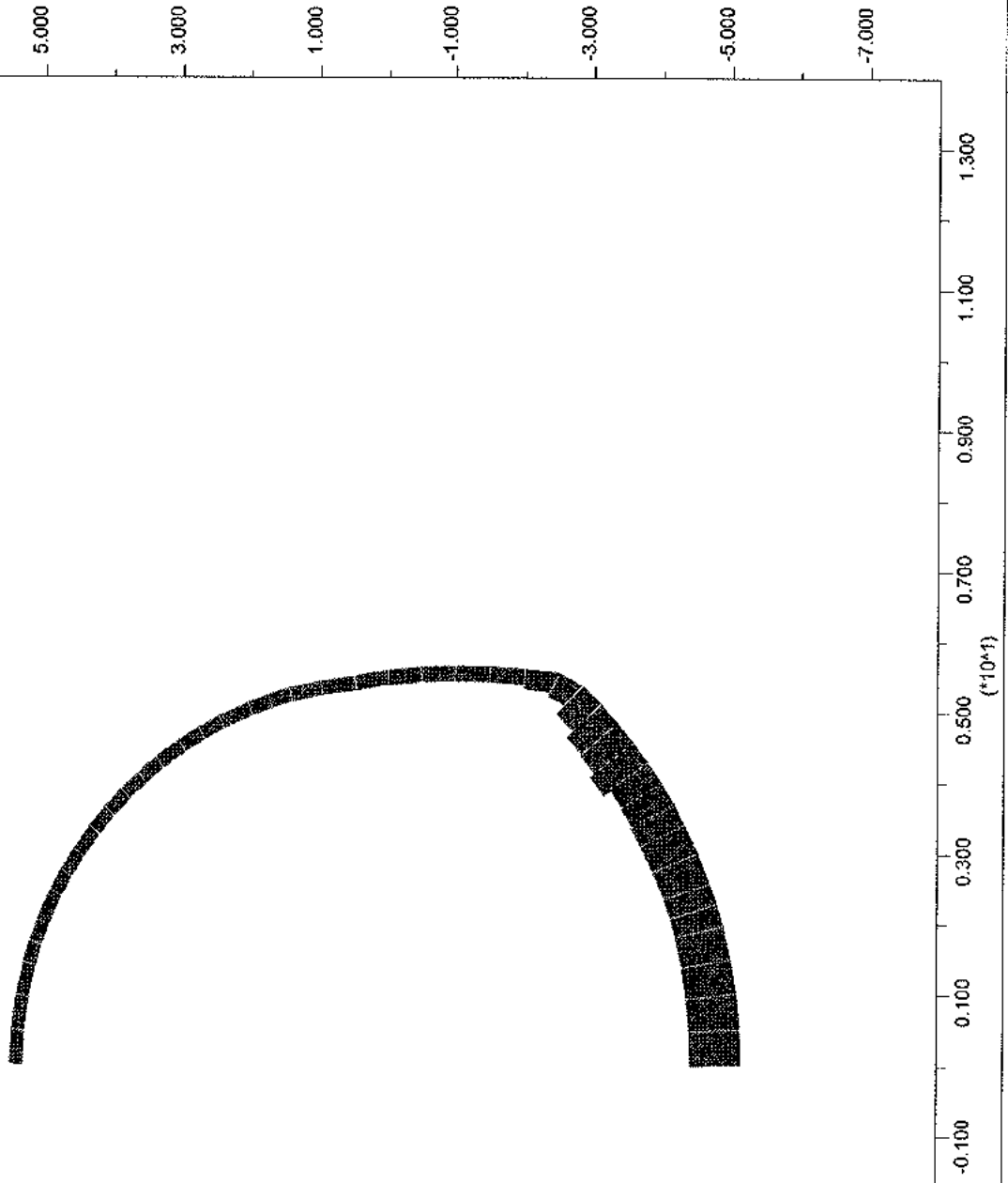
LEGEND

19-Feb-04 9:47
step 25121
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
2 (Beam) 2.436E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

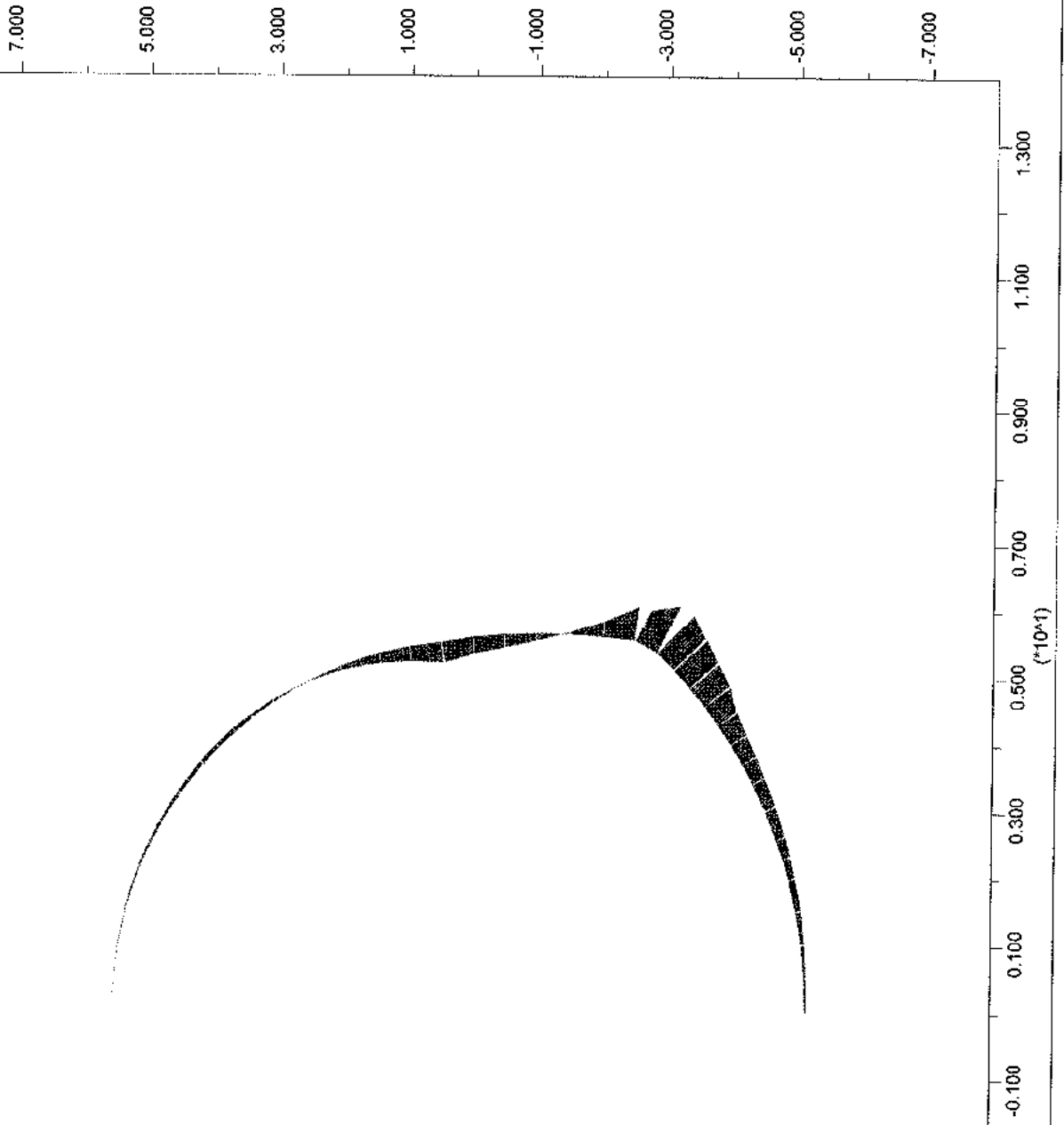
19-Feb-04 9:47
step 25121
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

■ Moment on

Structure Max. Value

2 (Beam) -3.786E+05



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 6"

FLAC (Version 4.00)

LEGEND

19-Feb-04 10:11

step 26205

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

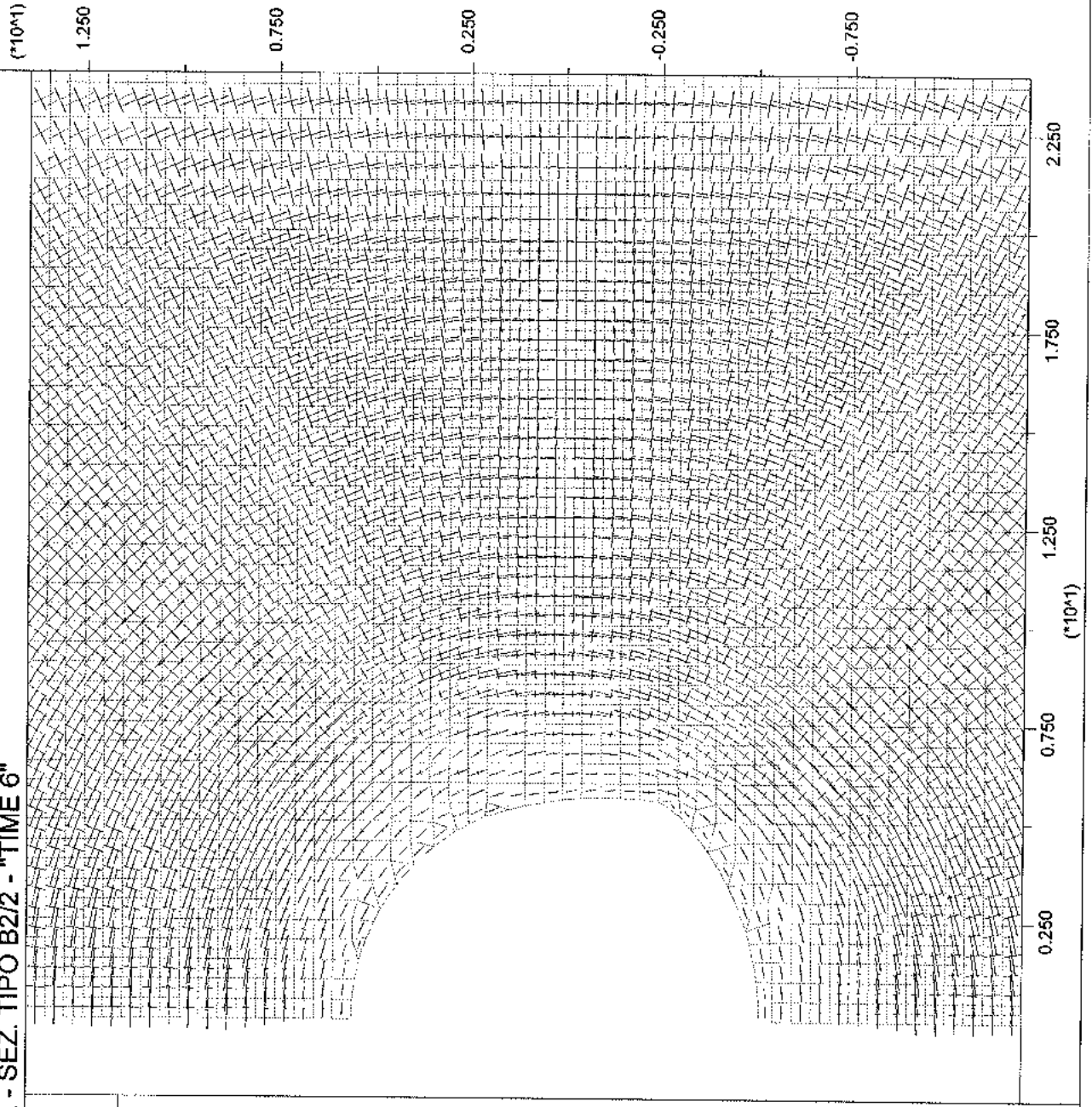
Principal stresses

Max. Value = -2.381E+05

Min. Value = -2.756E+07



Tensioni principali : Pa



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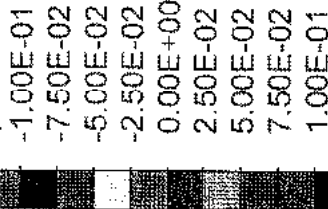
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 6"

FLAC (Version 4.00)

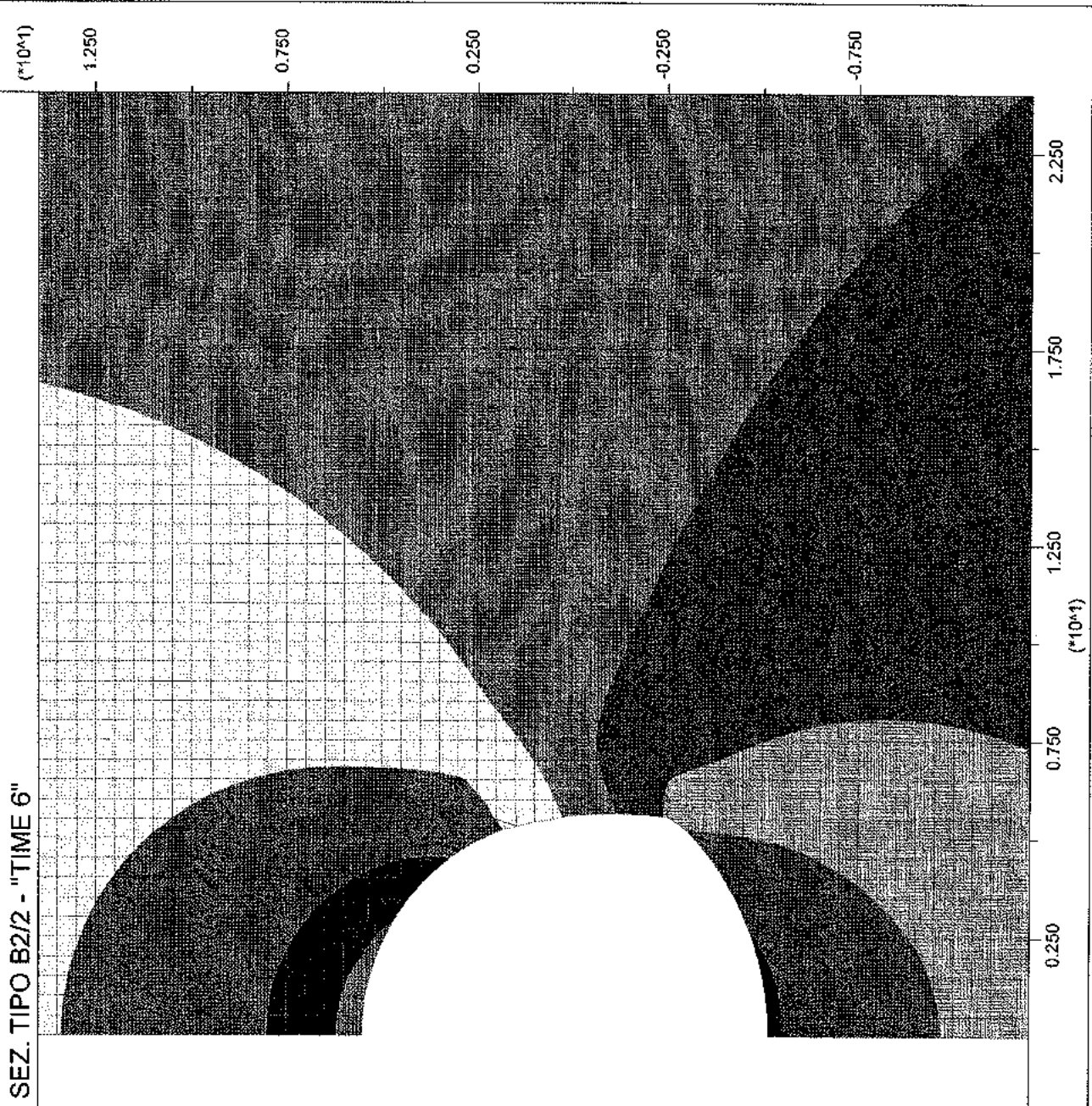
LEGEND

19-Feb-04 10:11
step 26205
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 2.50E-02
Spostamenti verticali



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 6"

FLAC (Version 4.00)

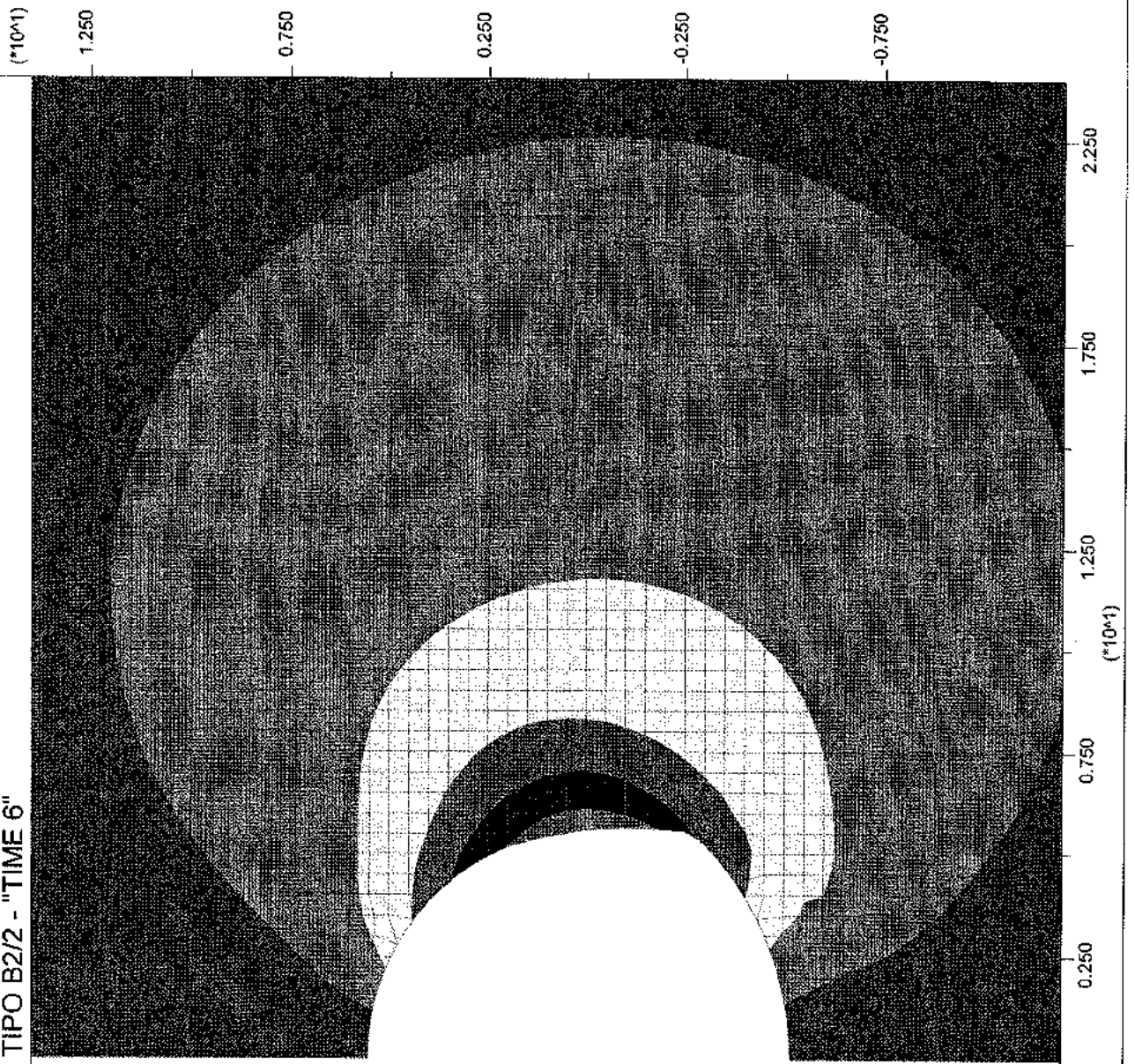
LEGEND

19-Feb-04 10:11
step 26205
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.00E-02
Spostamenti orizzontali



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 6"

FLAC (Version 4.00)

LEGEND

19-Feb-04 10:11

step 26205

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

5.00E-03

1.00E-02

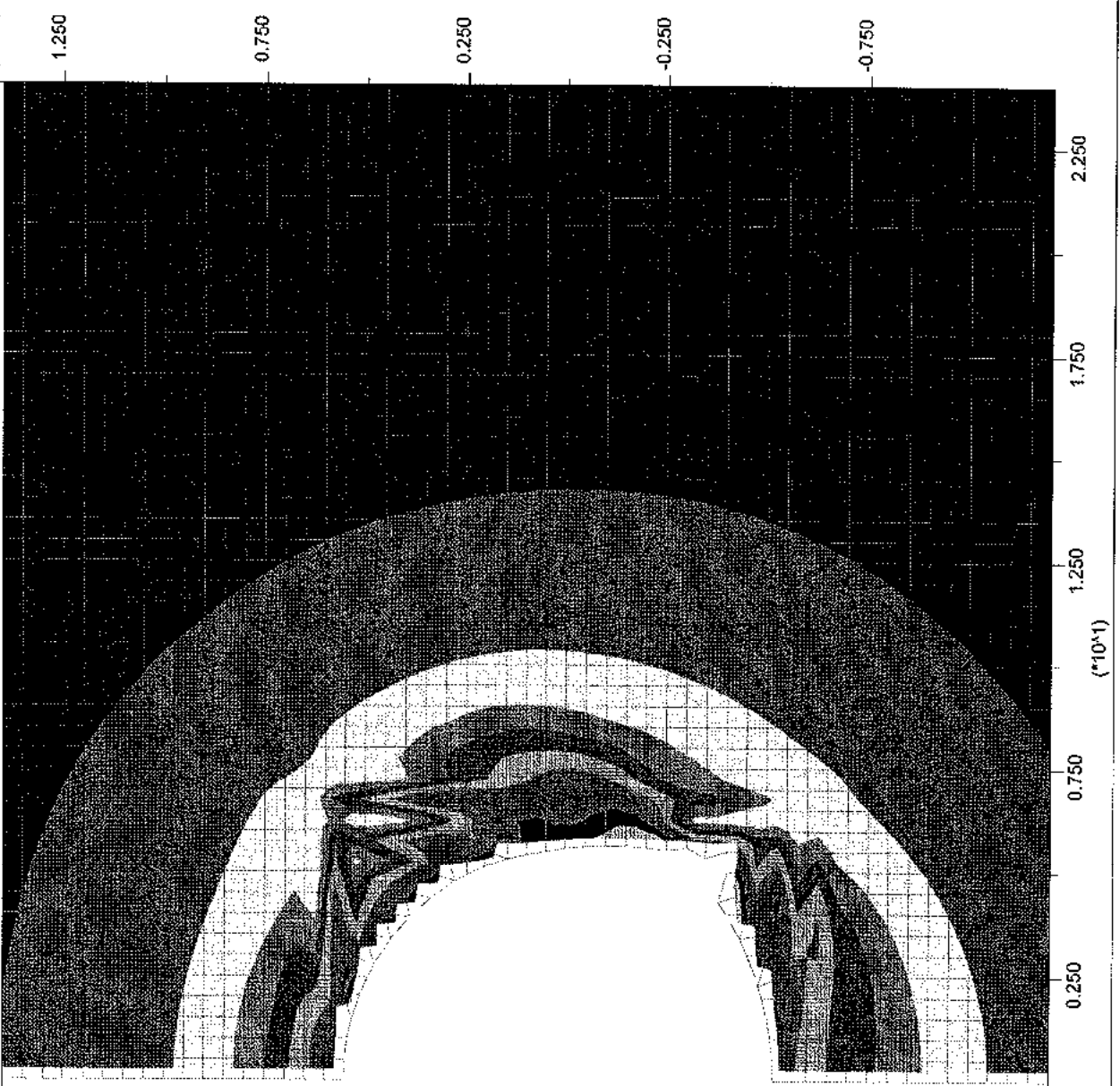
1.50E-02

2.00E-02

2.50E-02

Contour interval= 2.50E-03

Deformazioni plastiche per taglio



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 6"

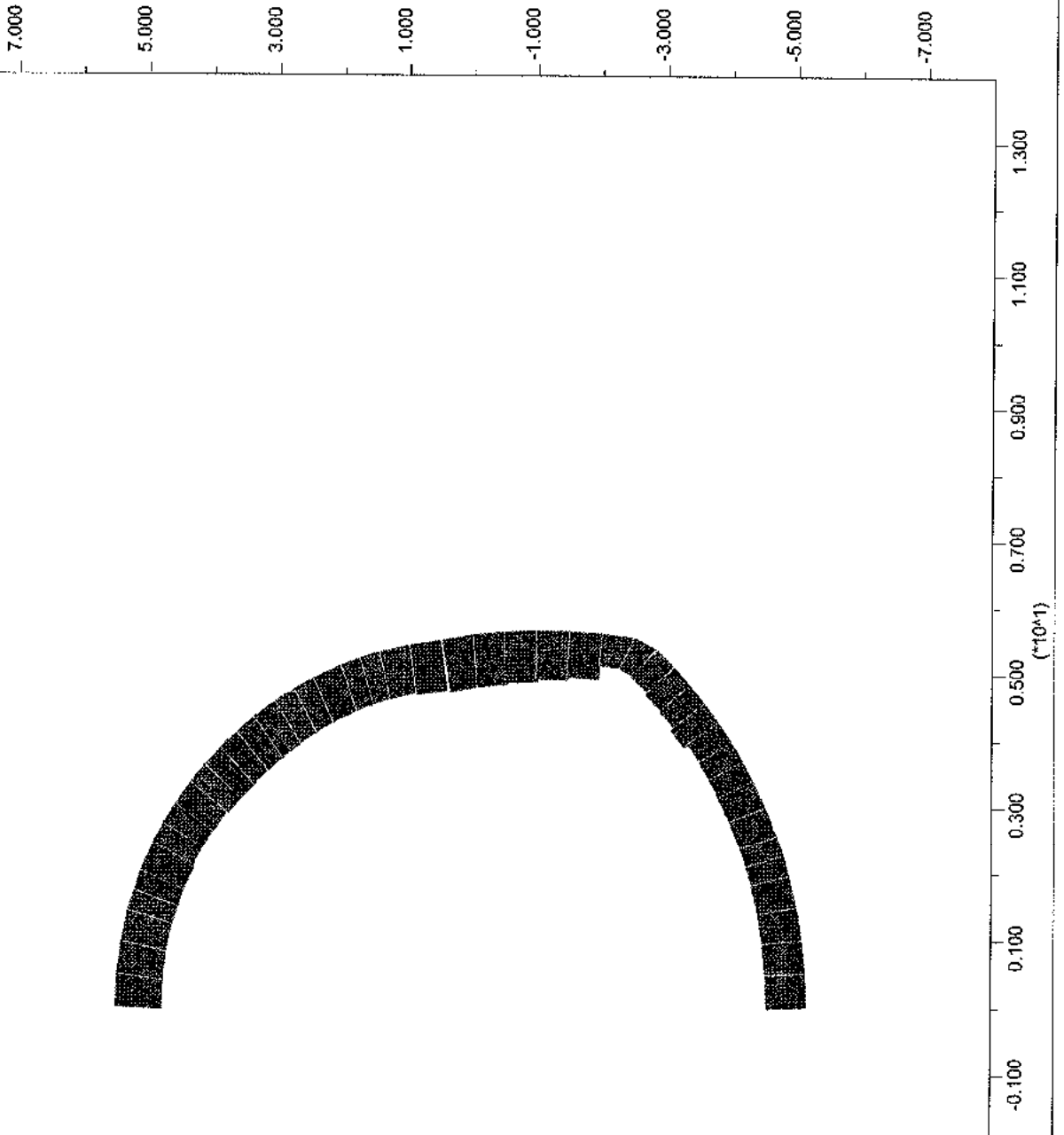
FLAC (Version 4.00)

LEGEND

19-Feb-04 10:11
step 26205
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on
Structure Max. Value
1 (Beam) 3.647E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B2/2 - "TIME 6"

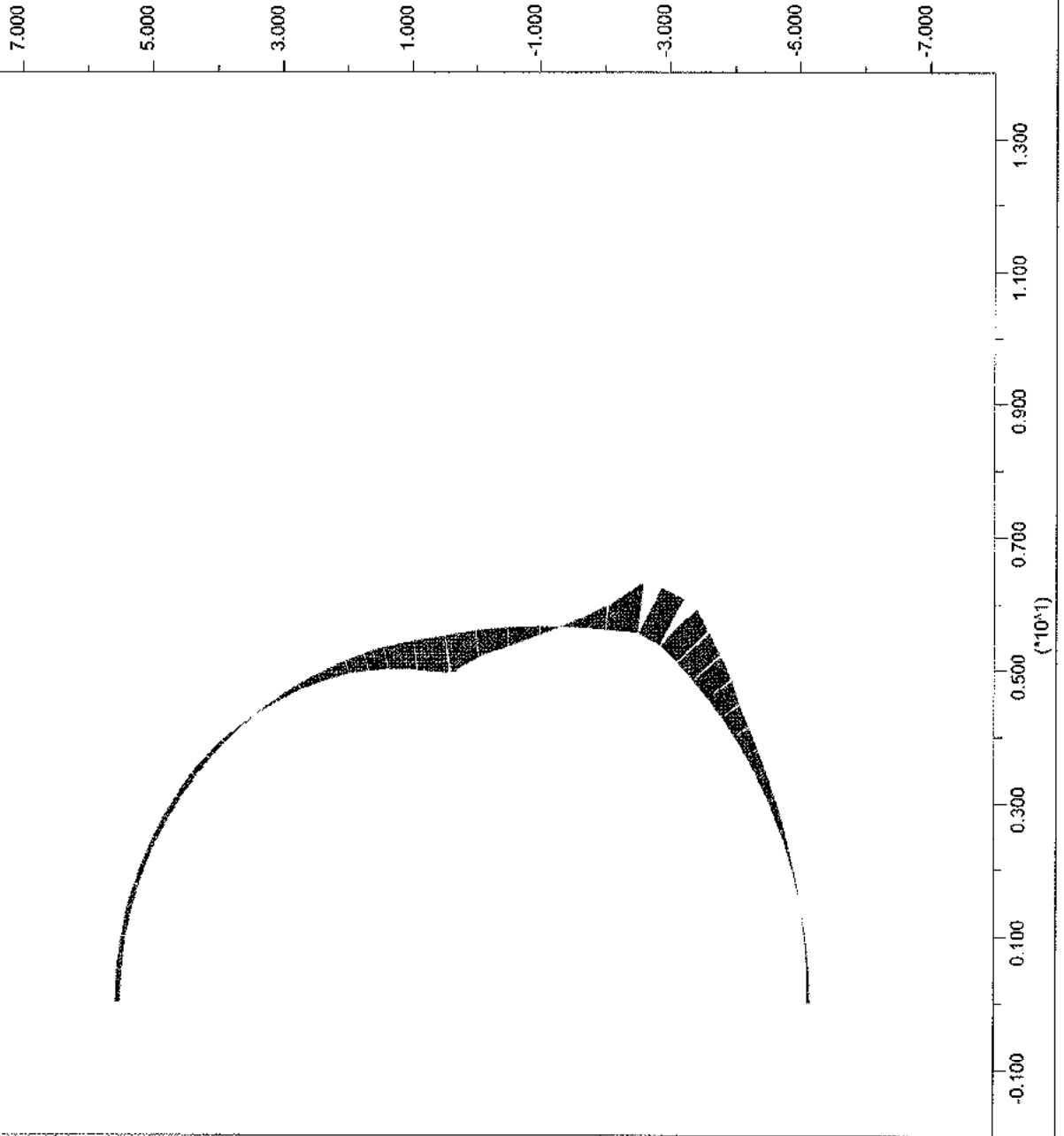
FLAC (Version 4.00)

LEGEND

19-Feb-04 10:11
step 26205
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

 **Moment** on
Structure Max. Value
1 (Beam) -6.226E+05



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Calcolo FLAC – Sezione tipo B4/1

ANALISI FLAC

Sezione tipo B4/1 - Ap gruppo 2

Input Analisi alle Differenze Finite FLAC

Geometrie	
Copertura (m)	500.00
Altezza falda sinistra (m)	0.00
Coefficiente efficienza drenaggio	0.20
Altezza falda dinambica (m)	0.00
Raggio scavo (m)	5.90

Materiali			
Spritz-beton	E_{sb} (MPa)	E_{sb} (MPa)	ν_{sb} (cm)
25	14000	28500	2.28E+03
Centine	h (cm)	A_c (cm ²)	ν_{cc} (cm)
IPN240	2.00	46.1	4239.0
Investimenti	S (m)	Armato	D
A.R.	30	31220	5.8
Calotta	0.80	31220	9.0

Parametri geommeccanici	
Valori di picco e residui	
Picco	Residuo
2.7	2.7
30	28
Angolo attrito (°)	0.90
Costante (MPa)	0.85
Modulo elastico (GPa)	1.65
Modulo di Poisson	0.30
Modulo di deformazione volumetrica (bulk modulus) (GPa)	1.36
Modulo elastico tangenziale (Shear modulus) (GPa)	0.63
Modello costitutivo	Strain-Softening

Fasi di calcolo (TIME)					
TIME 1 - Geostatico	x (m)	xR	PP_{anet}	$RDEM$	E_{sb} (MPa)
TIME 2 - Taratura e scavo	∞	∞	0.000	0.000	-
TIME 3 - Posa centine e pre-spritz	0.80	0.000	0.260	0.370	-
TIME 4 - Installazione bulloni e completamento spritz	1.00	0.182	0.510	0.374	14000
TIME 5 - Getto Murate e A.R., maturazione SB	6.00	1.091	0.864	0.980	14000
TIME 6 - Getto calotta	20.00	3.936	0.975	0.990	31220
TIME 7 - Decadimento ammasso e preinvestimento	40.00	7.273	0.992	1.000	31220

Relazione per il calcolo di PP_{anet} , $RDEM$:

$$R^2 = n \cdot 0 \cdot (x \cdot \omega - n \cdot 0) \cdot \left[1 - \frac{1}{1 + \frac{x}{0.84 \cdot R_p}} \right]$$

R = Convergenza radiale ad una distanza di x metri dal fronte espressa come % di ω
 ω = Convergenza radiale in corrispondenza del fronte espressa come % di ω
 n = Convergenza radiale ad una distanza infinita dal fronte
 PP = Raggio plastico
 R = Raggio della galleria
 x = distanza tra il fronte e la sezione di calcolo

LEGENDA SIMBOLI

- E_{sb} - resistenza media cilindrica a compressione dello spritz-beton
- s - spessore dello spritz-beton
- E_{acc} - moduli elastici armati dello spritz-beton
- E_{acc} - modulo elastico finale dello spritz-beton
- h - momento di inerzia dello spritz-beton
- n - numero di centine per gruppo
- p - passo centine
- A_c - area del profilo della singola centina
- h - altezza del profilo centina
- J_{cc} - momento di inerzia del profilo della singola centina
- R_{cc} - resistenza caratteristica cubica a compressione del cis
- S - spessore del rivestimento definitivo
- E_{mat} - modulo elastico del cis maturato
- D - Distanza di getto tra investimenti definitivi e fronte (multiplo del diametro della galleria)
- E_{pre} - modulo elastico del preinvestimento

TIME DI CALCOLO

TIME 1 - Geostatico	Viene applicato il peso proprio del terreno, ricostruito in termini di sezioni Mostabele la situazione preesistente lo scavo della galleria.
TIME 2 - Taratura e scavo	Viene simulato il fronte di fronte di scavo tenendo in conto il contributo dei consolidamenti
TIME 3 - Posa centine e pre-spritz	Viene simulata la posa in opera delle centine e dello strato di 5 cm di spritz-beton
TIME 4 - Installazione bulloni e completamento spritz	Viene simulata la posa in opera dei bulloni ed il completamento dello spritz-beton
TIME 5 - Getto Murate e A.R., maturazione SB	Viene simulato il getto delle murate e dell'arco rovescio, la maturazione dello spritz e l'avanzamento dello scavo.
TIME 6 - Getto calotta	Si simula il getto del rivestimento definitivo di calotta
TIME 7 - Decadimento ammasso e preinvestimento	Si applica un decadimento delle caratteristiche meccaniche del preinvestimento e dell'ammasso

JOB TITLE : Sezioni di verifica - Prerivestimento

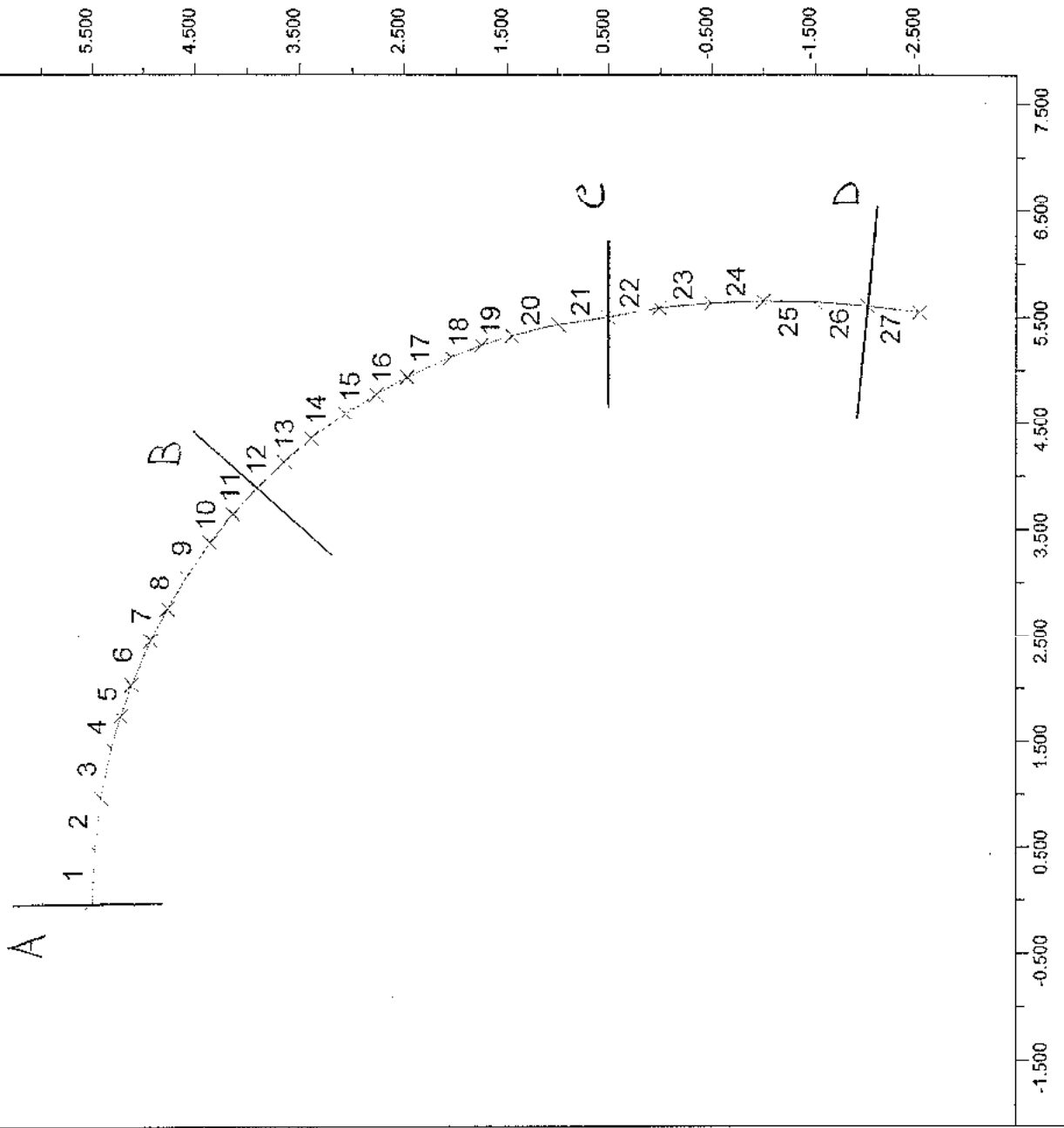
FLAC (Version 4.00)

LEGEND

19-Feb-04 9:42
step 20395
-2.121E+00 <x< 7.770E+00
-3.438E+00 <y< 6.454E+00

Beam Plot
Structural Element Numbers

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



Sezione tipo B4/1 - Ap gruppo 2

Verifica del pririvestimento

CARATTERISTICHE GEOMETRICHE E MECCANICHE

MATERIALI	Tipo	σ_{max} (MPa)	H (cm)	Passo (m)	n°	A (cm²)	I (cm⁴)
Spritz-beton	Fcm 25	19.20	30	-	-	3000.0	2250.0
Centine	IPN240	210	24.00	1.00	2.00	46.1	4239.0
Sezione omogeneizzata						4290.8	129064.4

Coefficiente omogeneizzazione m 15
 Baricentro centina d (cm) 12.00 dall'estradosso
 Baricentro sezione omogeneiz. Yg (cm) 14.10 dall'estradosso
 $e^{lim,e} = I^*/(A \cdot Yg)$ (cm) 2.13 dimensione nocciolo d'inerzia estradosso
 $e^{lim,i} = I^*/(A \cdot (H - Yg))$ (cm) 1.89 dimensione nocciolo d'inerzia intradosso

$e = M/N$ eccentricità

Formule impiegate Tensioni positive se di compressione

$$\sigma_{sb,i} = N/A^* + (M \cdot (H - Yg))/I^* \quad \sigma_{sb,e} = N/A^* - (M \cdot Yg)/I^*$$

$$\sigma_{s,e} = m(N/A^* + M \cdot (d + H_s/2 - Yg))/I^*$$

$$\sigma_{s,i} = m(N/A^* - M \cdot (d - H_s/2 - Yg))/I^*$$

Sezione	Elemento	Altezza (m)	N (KN/m)	M (KN*m/m)	e (m)	$\sigma_{sb,i}$ (Mpa)	$\sigma_{sb,e}$ (Mpa)	$\sigma_{s,i}$ (Mpa)	$\sigma_{s,e}$ (Mpa)	
CHIAVE CALOTTA	1	0.30	1215	3.3	0.00	3.24	2.47	46.27	37.07	TIME 4
RENI	11	0.30	1147	3.4	0.00	3.09	2.30	44.01	34.53	
P.C.	22	0.30	960	-18.0	-0.02	0.02	4.20	12.84	63.05	
PIEDE	27	0.30	455	0.3	0.00	1.10	1.03	16.25	15.41	
CHIAVE CALOTTA	1	0.30	2382	8.9	0.00	6.65	4.58	93.51	68.69	TIME 5
RENI	11	0.30	2228	15.1	0.01	7.05	3.54	95.27	53.15	
P.C.	22	0.30	1722	-63.7	-0.04	-3.84	10.97	-13.11	164.57	
PIEDE	27	0.30	779.4	-31.4	-0.04	-2.05	5.25	-8.89	78.69	

JOB TITLE : Riv. definitivo - Sezioni di verifica

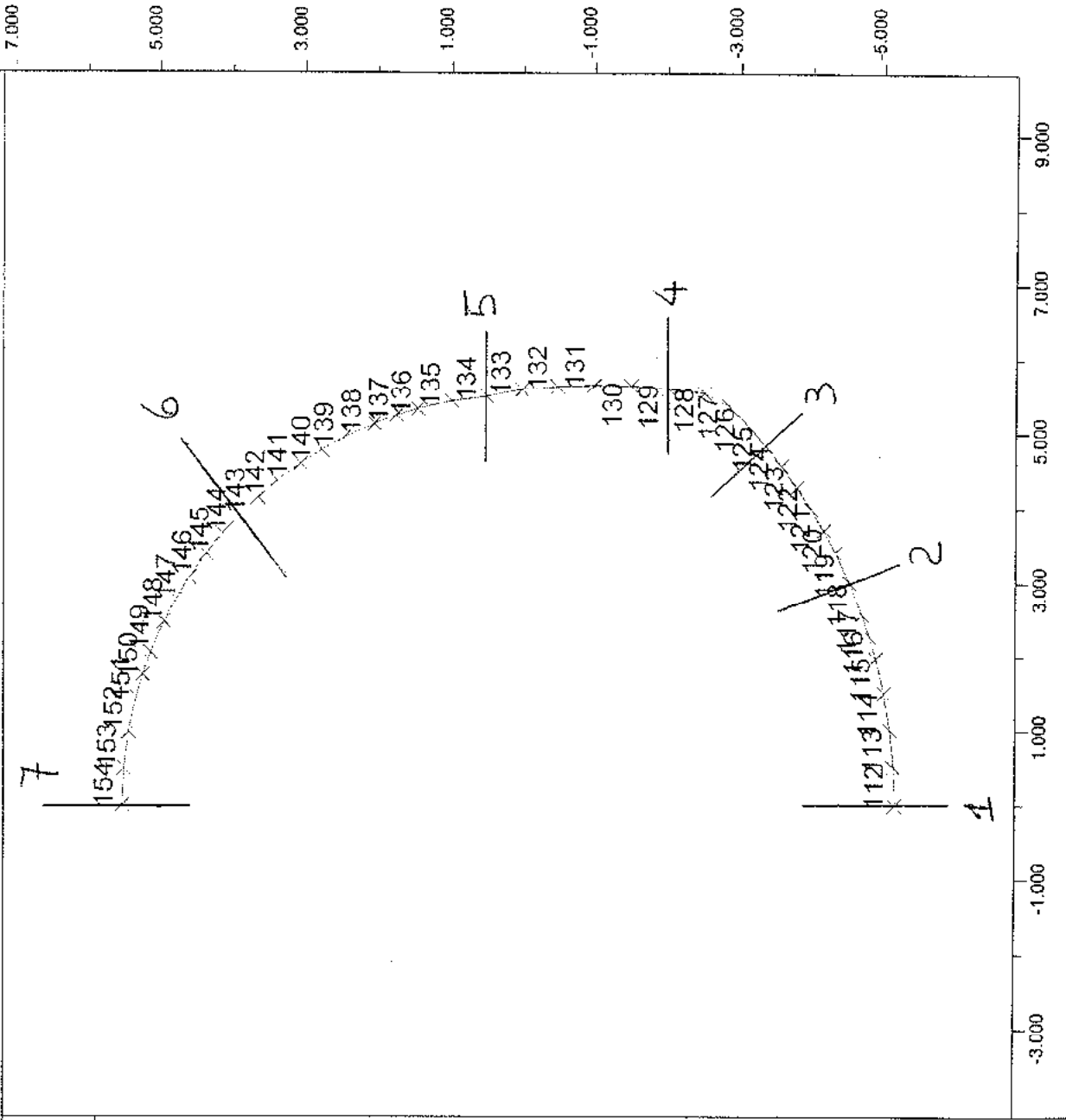
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:51
step 35019
-4.181E+00 <x< 9.830E+00
-6.824E+00 <y< 7.187E+00

Beam Plot
Structural Element Numbers

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



Sezione tipo B4/1 - Ap gruppo 2
Verifica del rivestimento definitivo

TIME 5 - Getto Murette e A.R., maturazione SB

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	112	1.00	1415	-472.9	-0.33	5.7
SEZIONE INTERMEDIA A.R.	118	1.00	1334	-394.8	-0.30	4.4
ATTACCO A.R. - MURETTA	124	1.00	1214	-254.9	-0.21	2.8

TIME 6 - Getto calotta

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	112	1.00	2068	-392.1	-0.19	4.4
SEZIONE INTERMEDIA A.R.	118	1.00	2012	-345.1	-0.17	4.1
ATTACCO A.R. - MURETTA	124	1.00	1951	-366.5	-0.19	4.2
ATTACCO CAL. - MURETTA	129	0.80	567	-38.0	-0.07	1.1
PIANO DEI CENTRI	133	0.80	539	123.1	0.23	2.1
RENI	143	0.80	521	-12.4	-0.02	0.8
CHIAVE CALOTTA	154	0.80	515	-6.1	-0.01	0.7

TIME 7 - Decadimento ammasso e prinvestimento

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	112	1.00	2469	-352.3	-0.14	4.6
SEZIONE INTERMEDIA A.R.	118	1.00	2453	-344.5	0.14	4.6
ATTACCO A.R. - MURETTA	124	1.00	2505	-550.9	-0.22	6.0
ATTACCO CAL. - MURETTA	129	0.80	2276	-291.5	-0.13	5.6
PIANO DEI CENTRI	133	0.80	2767	411.4	0.15	7.3
RENI	143	0.80	3009	-18.2	-0.01	3.9
CHIAVE CALOTTA	154	0.80	3248	-13.3	0.00	4.2

Sezione tipo B4/1 - Ap gruppo 2

Output Analisi alle Differenze Finite FLAC

TIME	Riduzione forze di scavo [%]	Spostamento y in chiave calotta [cm]		Spostamento x sul piano dei centri [cm]		Spostamento y in chiave A.R. [cm]		Tensioni prev. [MPa]		Tensioni Riv. def. [MPa]
		Nodo I=1=68	Nodo I=12=57	Nodo I=12=57	Nodo I=1=47	$\sigma_{SB,max}$	$\sigma_{s,max}$	$\sigma_{cis,max}$		
TIME 1 - Geostatico	0.0	-	-	-	-	-	-	-	-	-
TIME 2 - Taratura e scavo	94.0	22.5	22.2	20.6	-	-	-	-	-	-
TIME 3 - Posa centina e pre-spritz	94.8	22.7	22.5	21.0	-	-	-	-	-	-
TIME 4 - Installazione bulloni e completamento spritz	96.8	22.8	22.9	21.7	4.20	63.05	-	-	-	-
TIME 5 - Getto Murette e A.R., maturazione SB	99.0	22.9	23.2	22.6	10.97	164.57	-	-	-	5.7
TIME 6 - Getto calotta	100.0	22.9	23.2	22.7	-	-	-	-	-	4.4
TIME 7 - Decadimento ammasso e preinvestimento	100.0	22.9	23.3	22.7	-	-	-	-	-	7.3

Materiali	Tipo	Tensioni ammissibili [MPa]
Spritz-beton	fcm	19.20
Centina	Fe	210
Calcestruzzo	Rck	7.50

Tensioni positive nel cls : compressione

Tensioni positive nell'acciaio : trazione

Spostamenti x positivi verso destra, spostamenti y positivi verso l'alto

JOB TITLE : Cunicolo Castagnola (Ap gruppo 2) - SEZ. TIPO B4/1

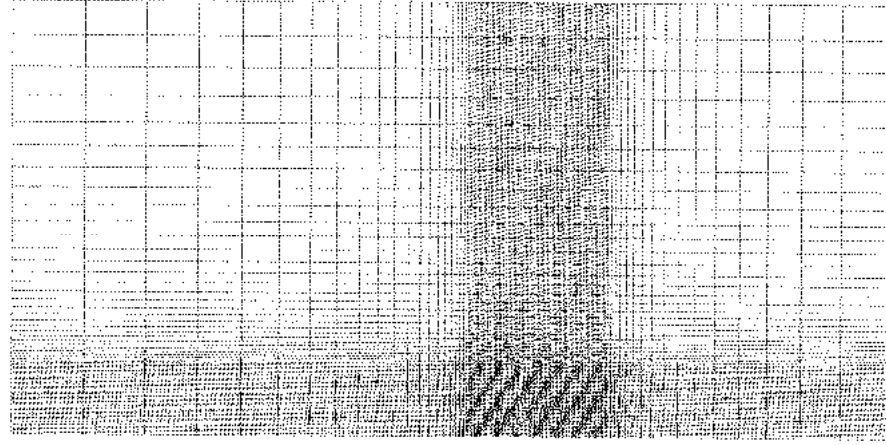
(*10^2)

FLAC (Version 4.00)

LEGEND

20-Feb-04 9:23
step 9395
-1.067E+02 <x< 2.267E+02
-1.417E+02 <y< 1.917E+02

MESH DI CALCOLO



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JOB TITLE : Cunicolo Castagnola (Ap gruppo 2) - SEZ. TIPO B4/1

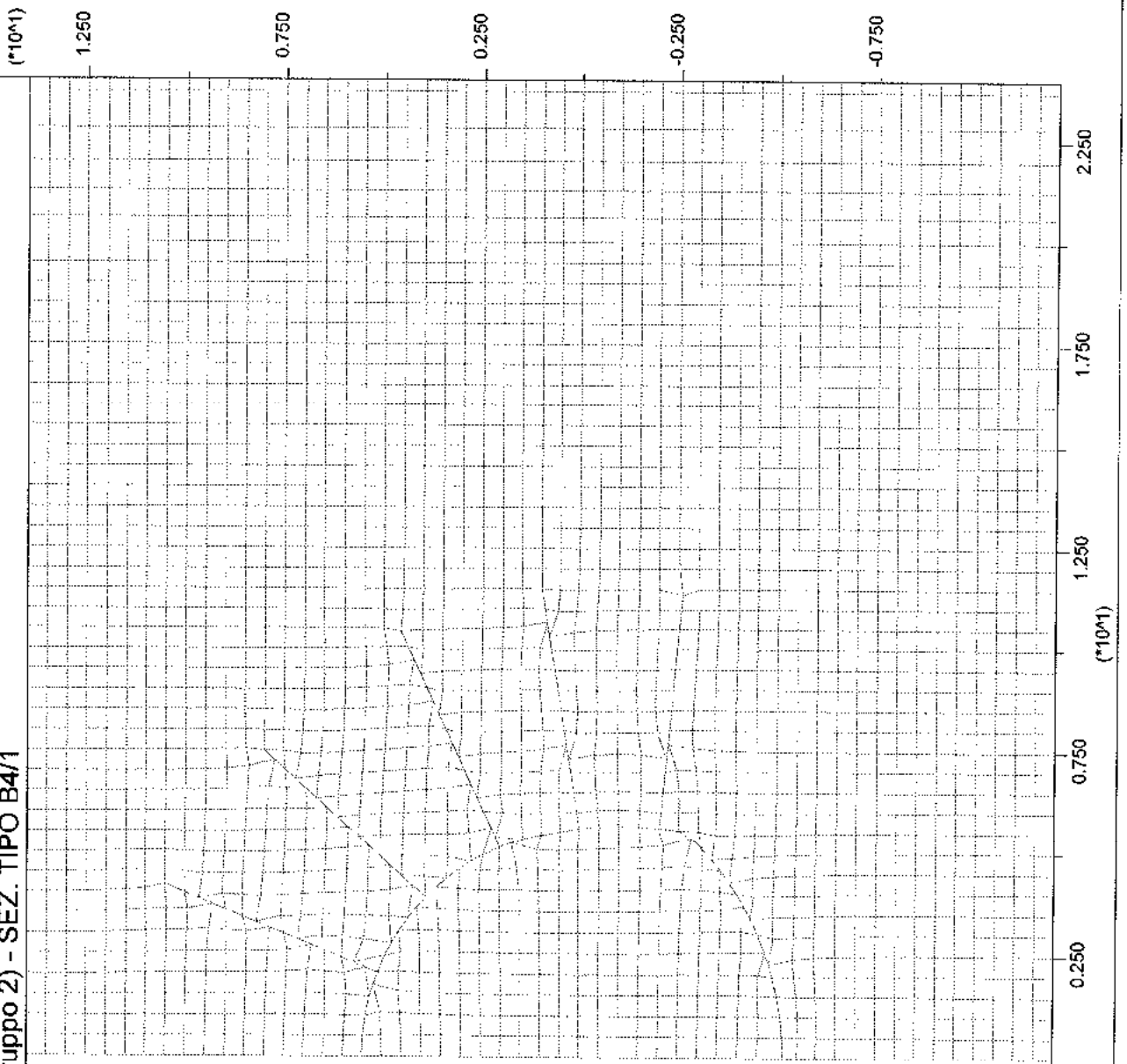
FLAC (Version 4.00)

LEGEND

20-Feb-04 9:23
step 9395
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

MESH DI CALCOLO

0 5E 0



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 1"

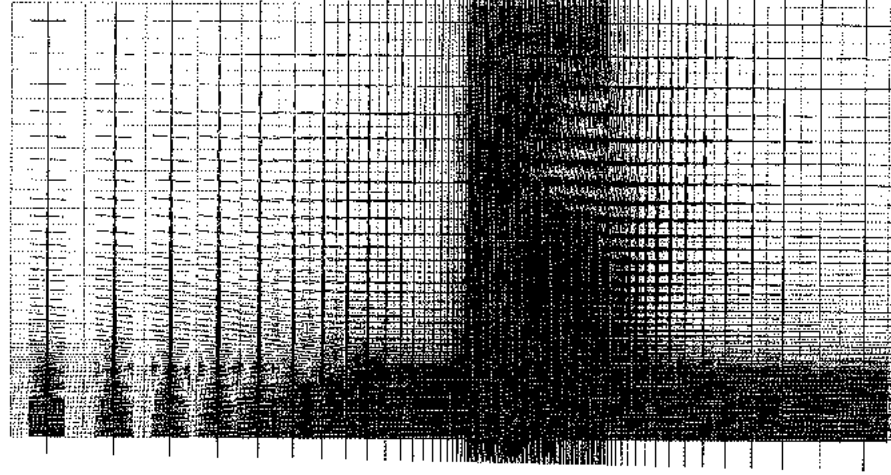
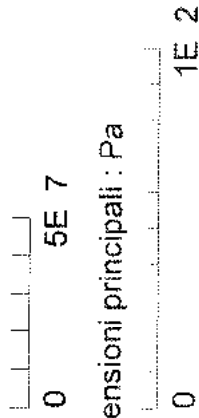
FLAC (Version 4.00)

LEGEND

20-Feb-04 9:23
step 9395
-1.067E+02 <x< 2.267E+02
-1.417E+02 <y< 1.917E+02

Principal stresses

Max. Value = -9.617E+06
Min. Value = -1.583E+07



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 1"

FLAC (Version 4.00)

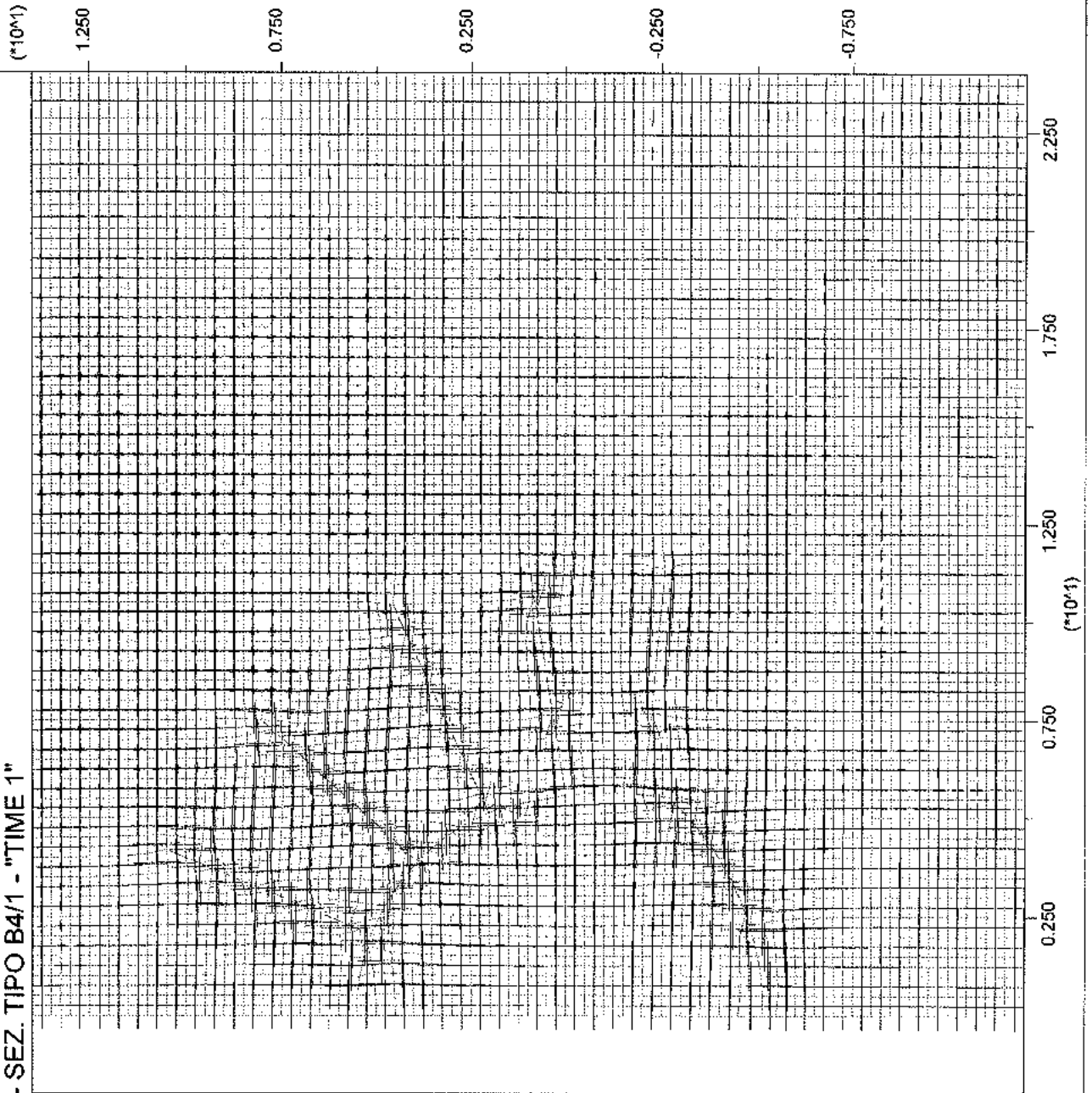
LEGEND

20-Feb-04 9:23
step 9395
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses
Max. Value = -1.290E+07
Min. Value = -1.369E+07



Tensioni principali : Pa



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 2"

FLAC (Version 4.00)

LEGEND

20-Feb-04 9:27
step 21231
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

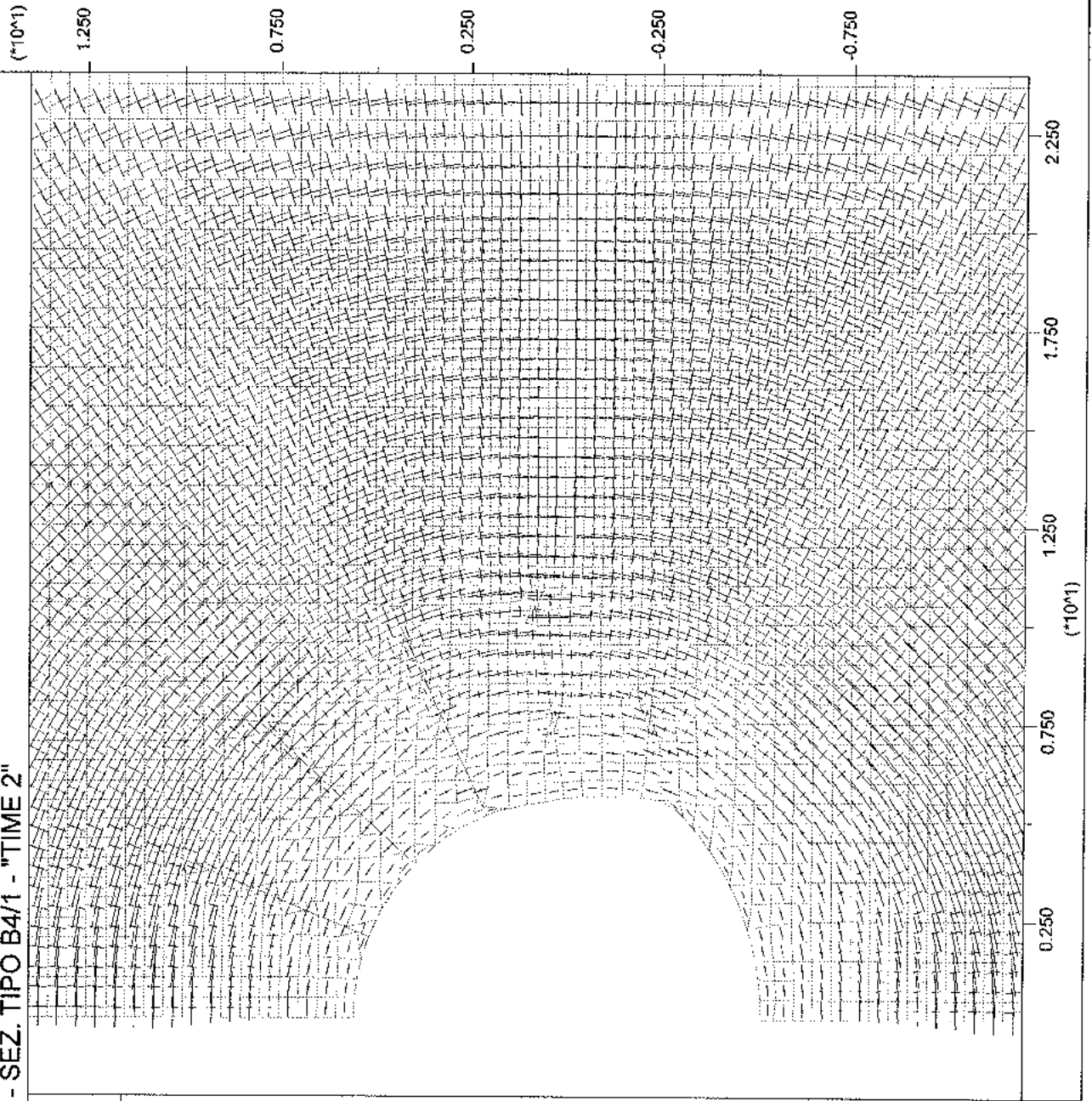
Principal stresses

Max. Value = -4.552E+05
Min. Value = -2.168E+07

0 1E 8

Tensioni principali : Pa

0 5E 0



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Minneapolis, Minnesota USA

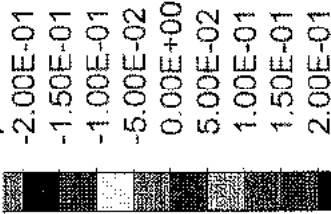
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 2"

FLAC (Version 4.00)

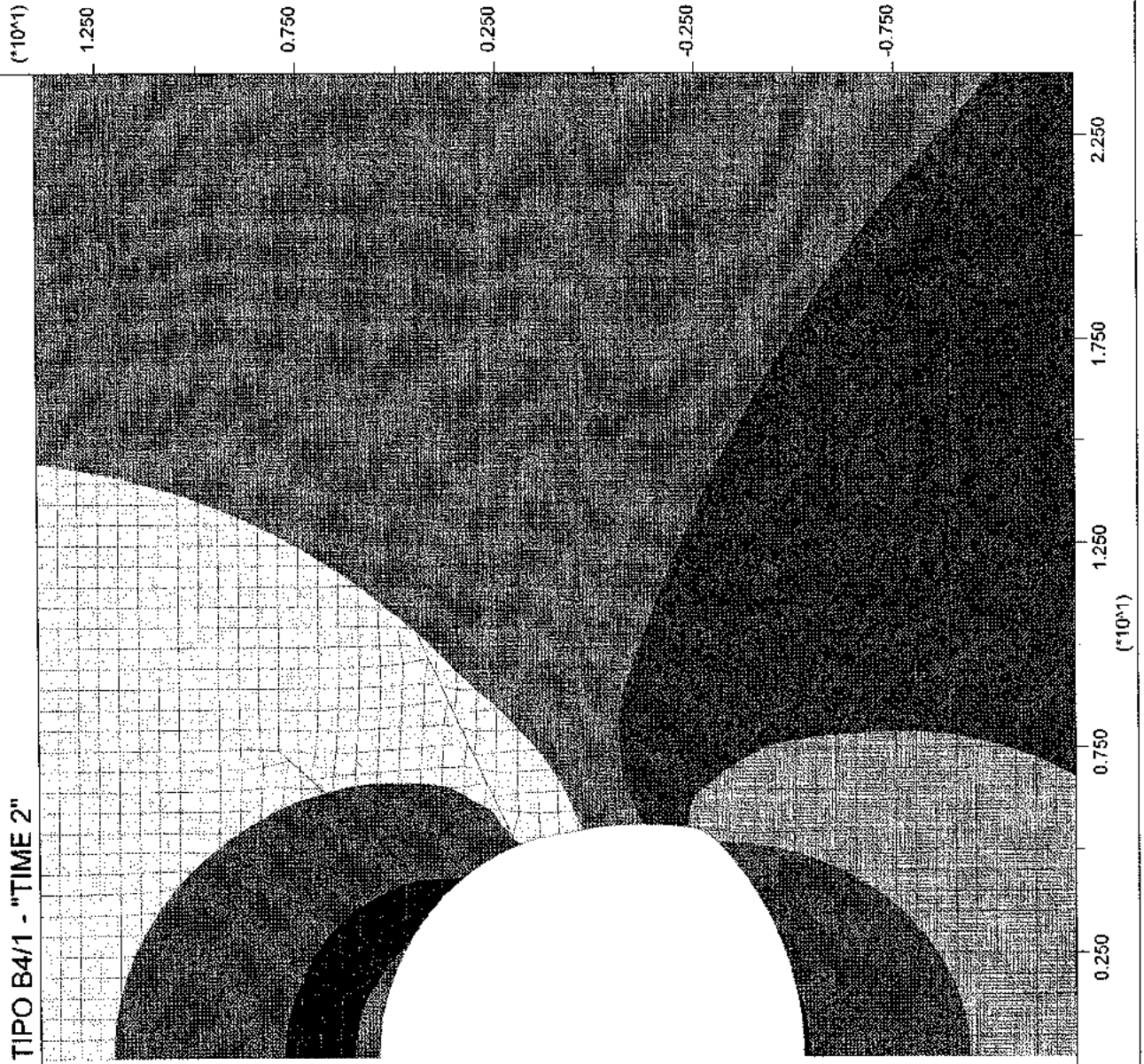
LEGEND

20-Feb-04 9:27
step 21231
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 5.00E-02
Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 2"

FLAC (Version 4.00)

LEGEND

20-Feb-04 9:27

step 21231

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-2.00E-01

-1.75E-01

-1.50E-01

-1.25E-01

-1.00E-01

-7.50E-02

-5.00E-02

-2.50E-02

0.00E+00

Contour interval= 2.50E-02

Spostamenti orizzontali



(*10^1)

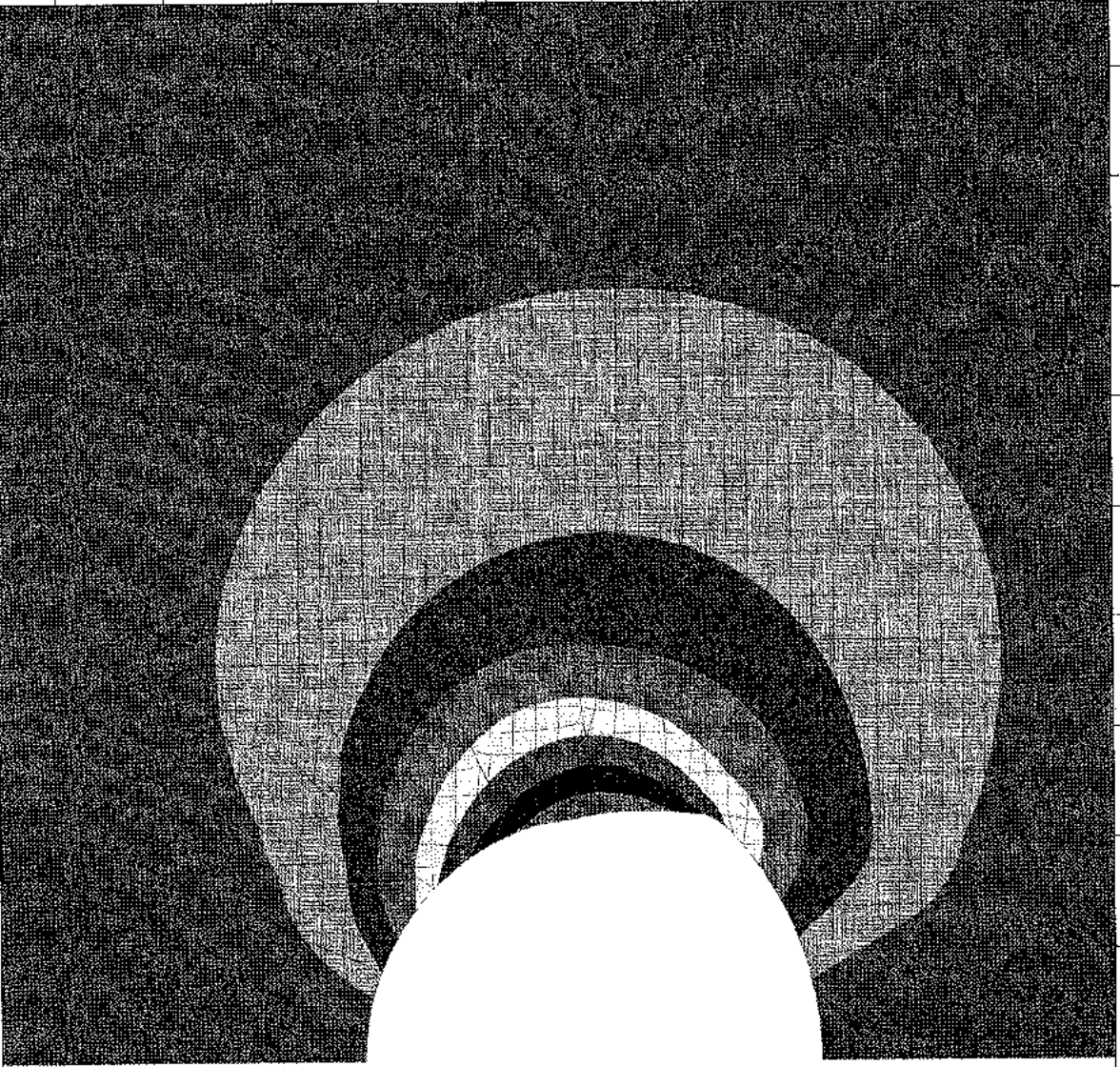
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

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Minneapolis, Minnesota USA

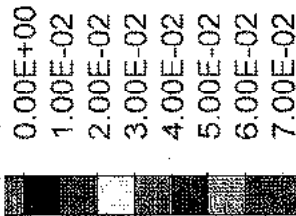
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 2"

FLAC (Version 4.00)

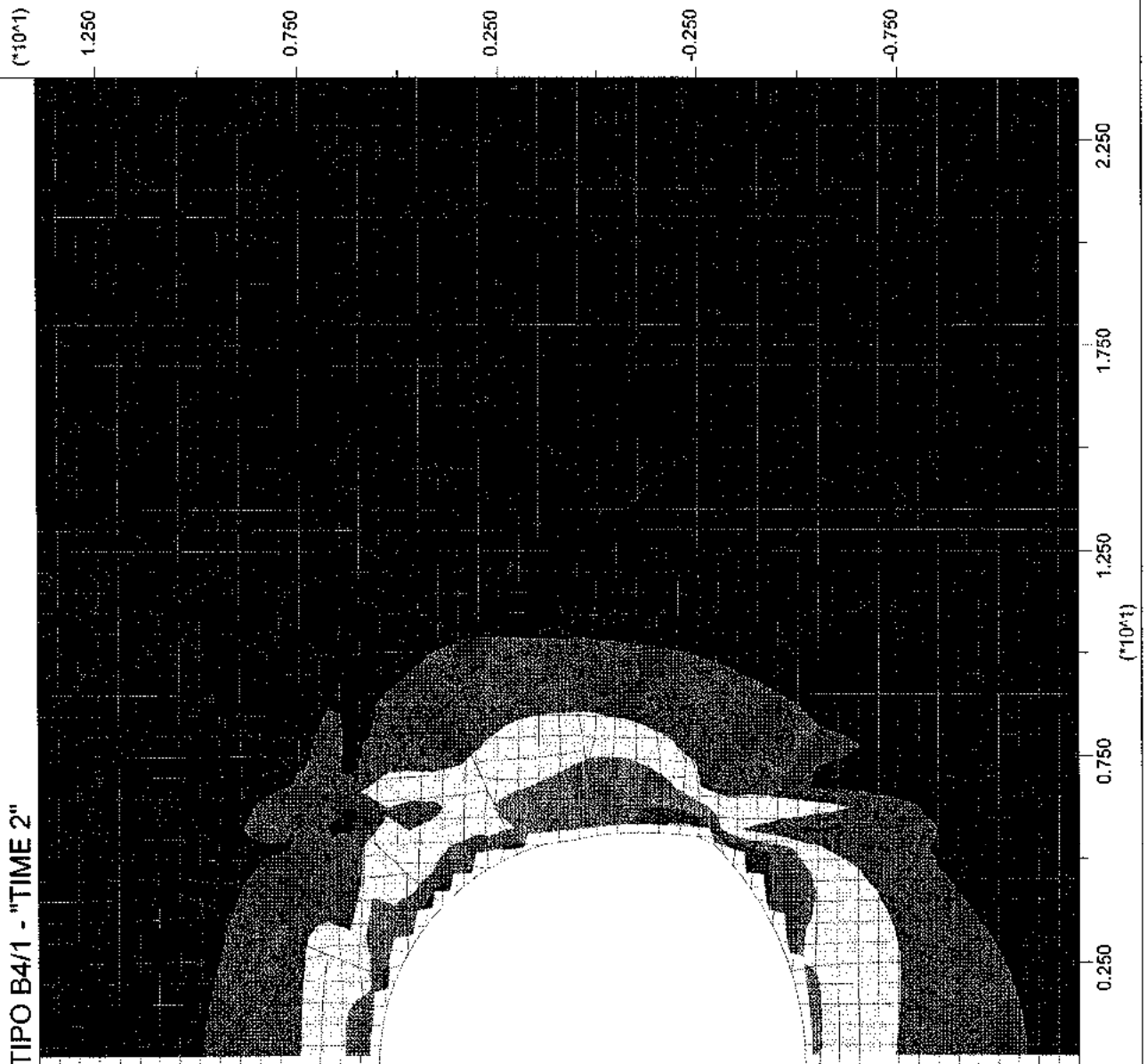
LEGEND

20-Feb-04 9:27
step 21231
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 3"

FLAC (Version 4.00)

LEGEND

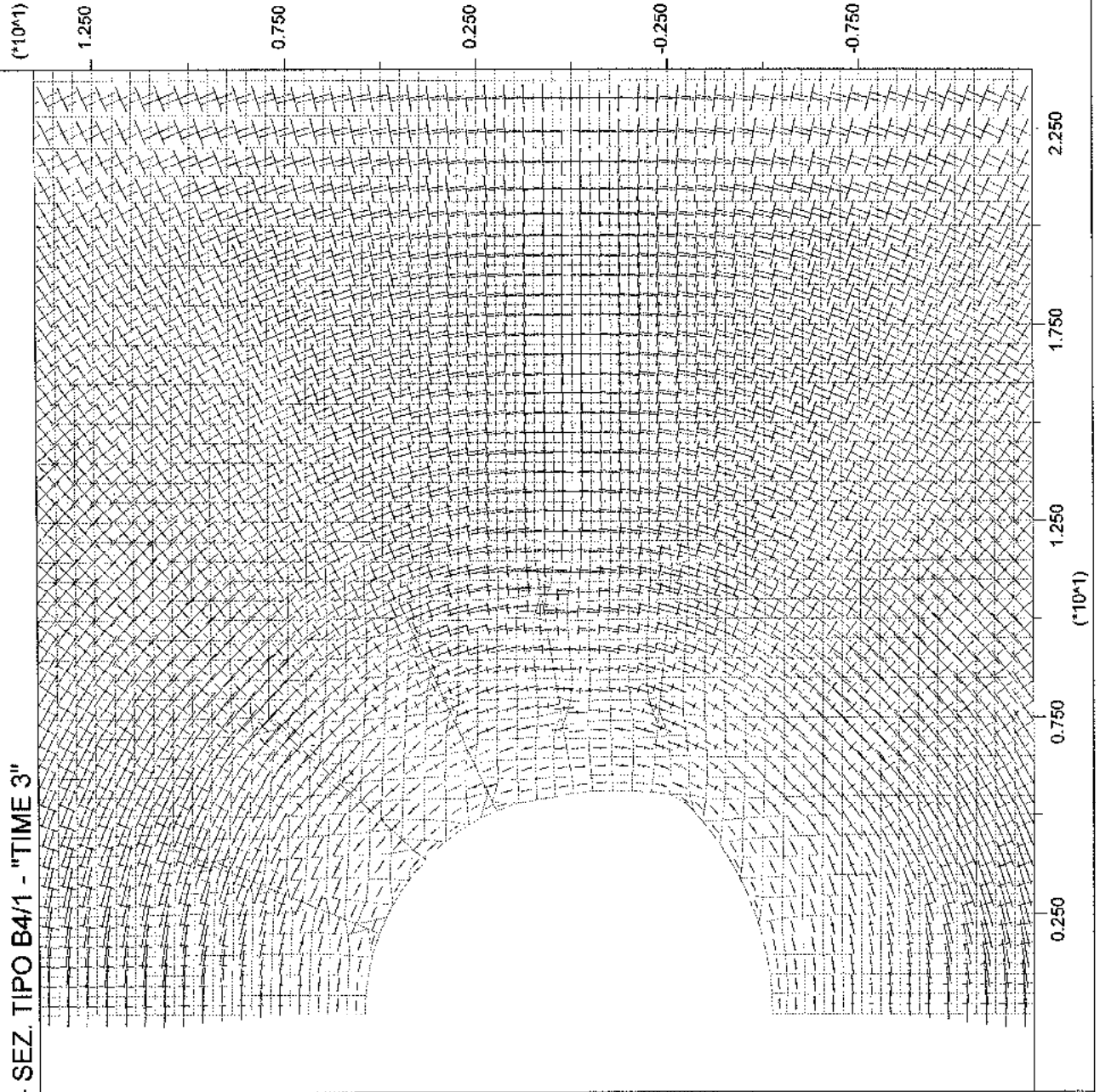
20-Feb-04 10:04
step 22303
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -4.039E+05
Min. Value = -2.167E+07



Tensioni principali : Pa



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 3"

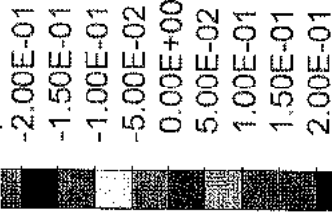
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:04
step 22303

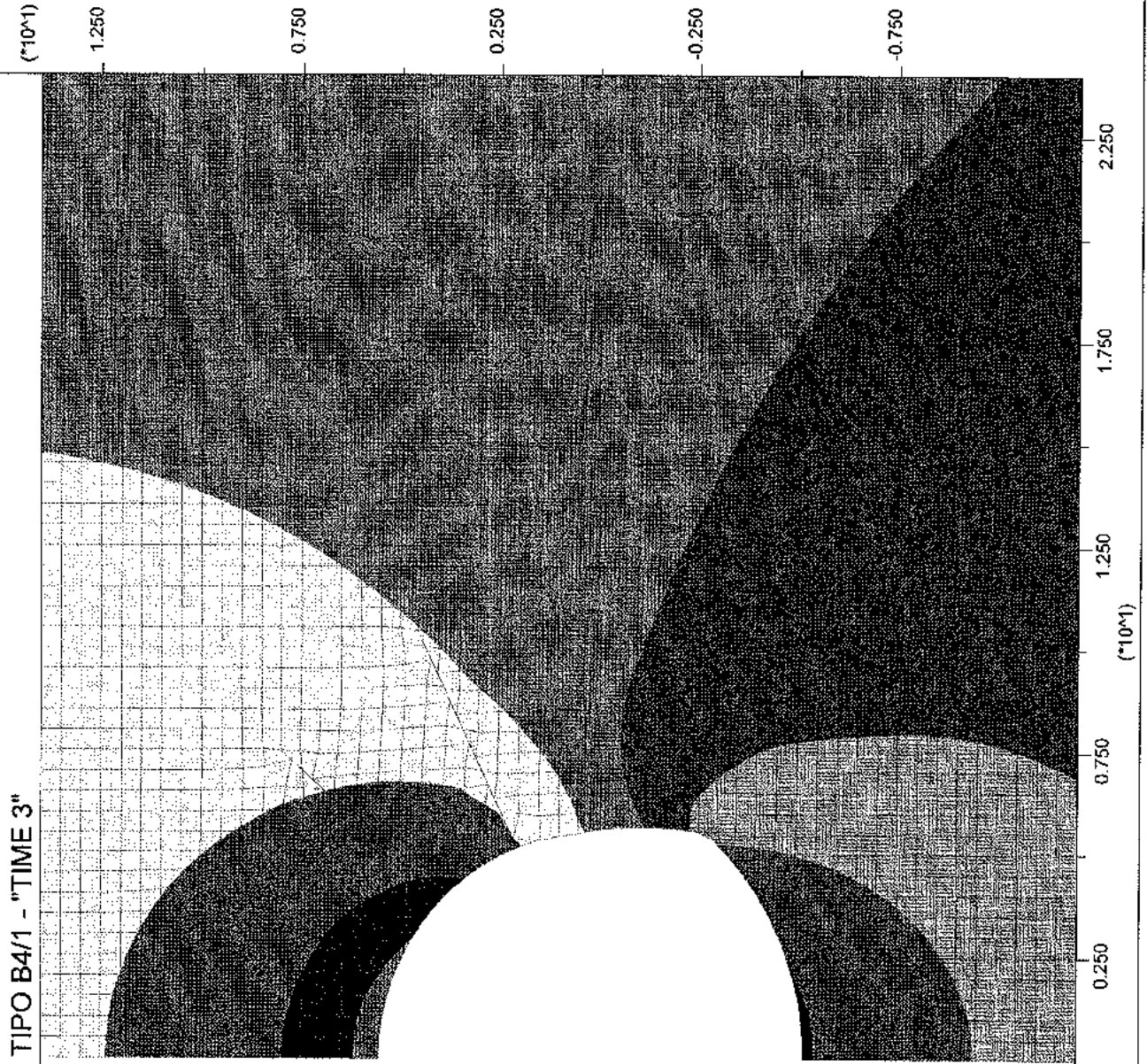
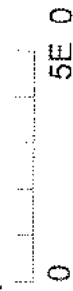
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 5.00E-02

Spostamenti verticali



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 3"

FLAC (Version 4.00)

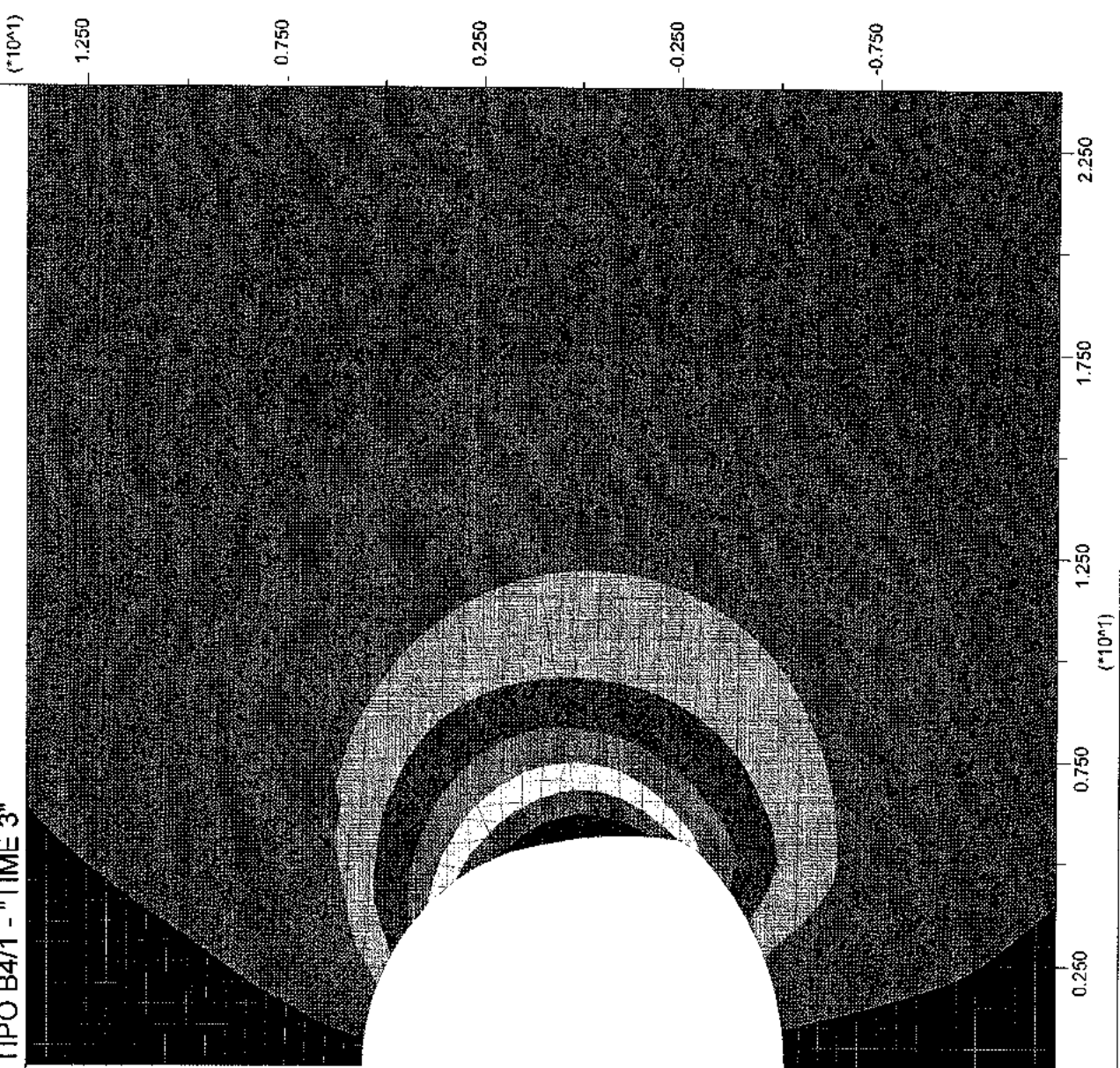
LEGEND

20-Feb-04 10:04
step 22303
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

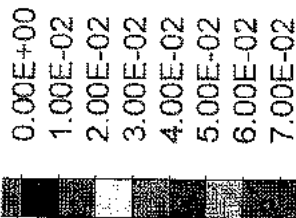
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 3"

FLAC (Version 4.00)

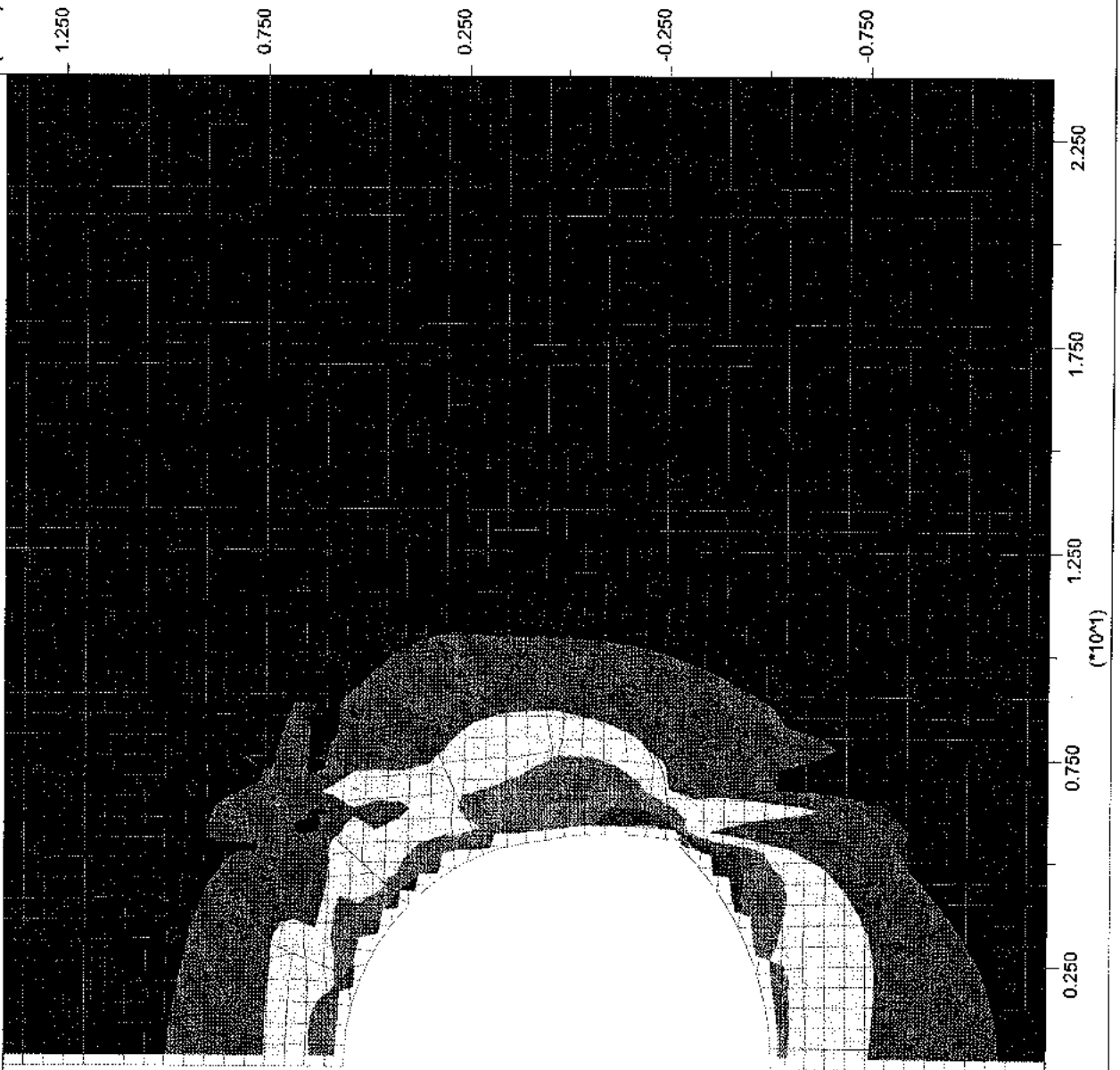
LEGEND

20-Feb-04 10:04
step 22303
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 3"

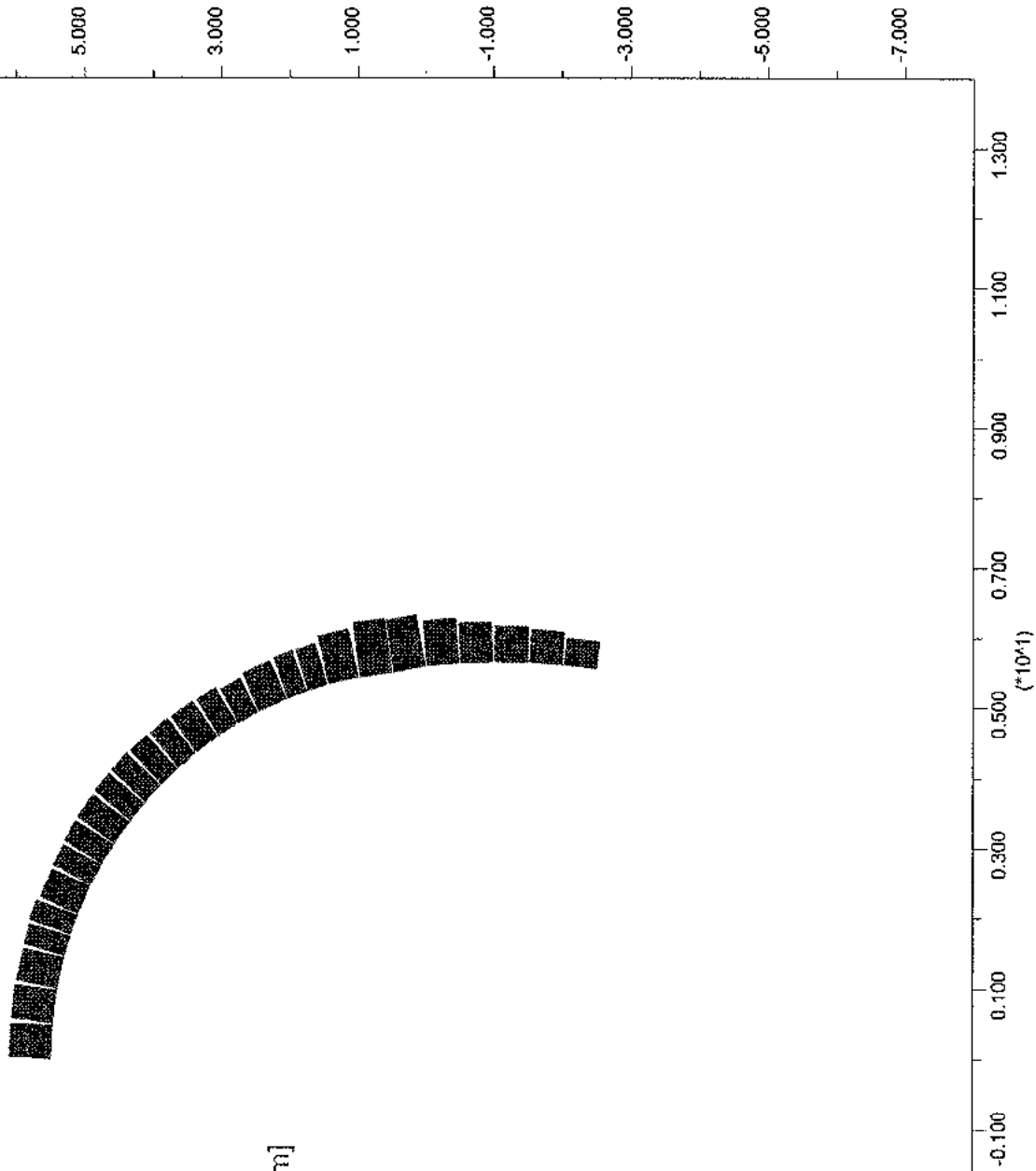
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:04
step 22303
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. (primo strato) Sforzo normale [N/m]

■ Axial Force on
Structure Max. Value
1 (Beam) 3.534E+05



Itasca Consulting Group, Inc.
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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 3"

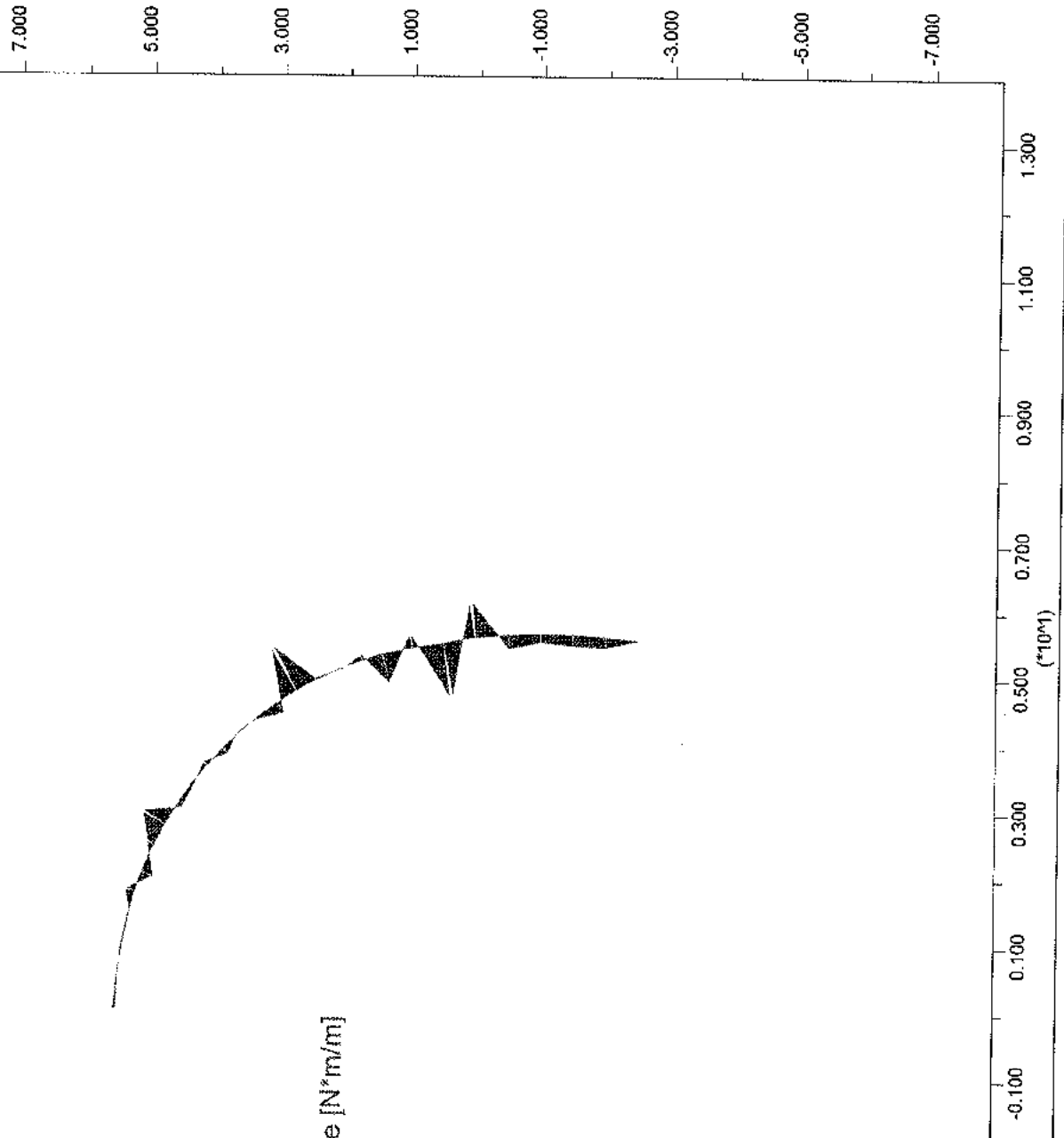
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:04
step 22303
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Priniv. (primo strato) Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -2.658E+02



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

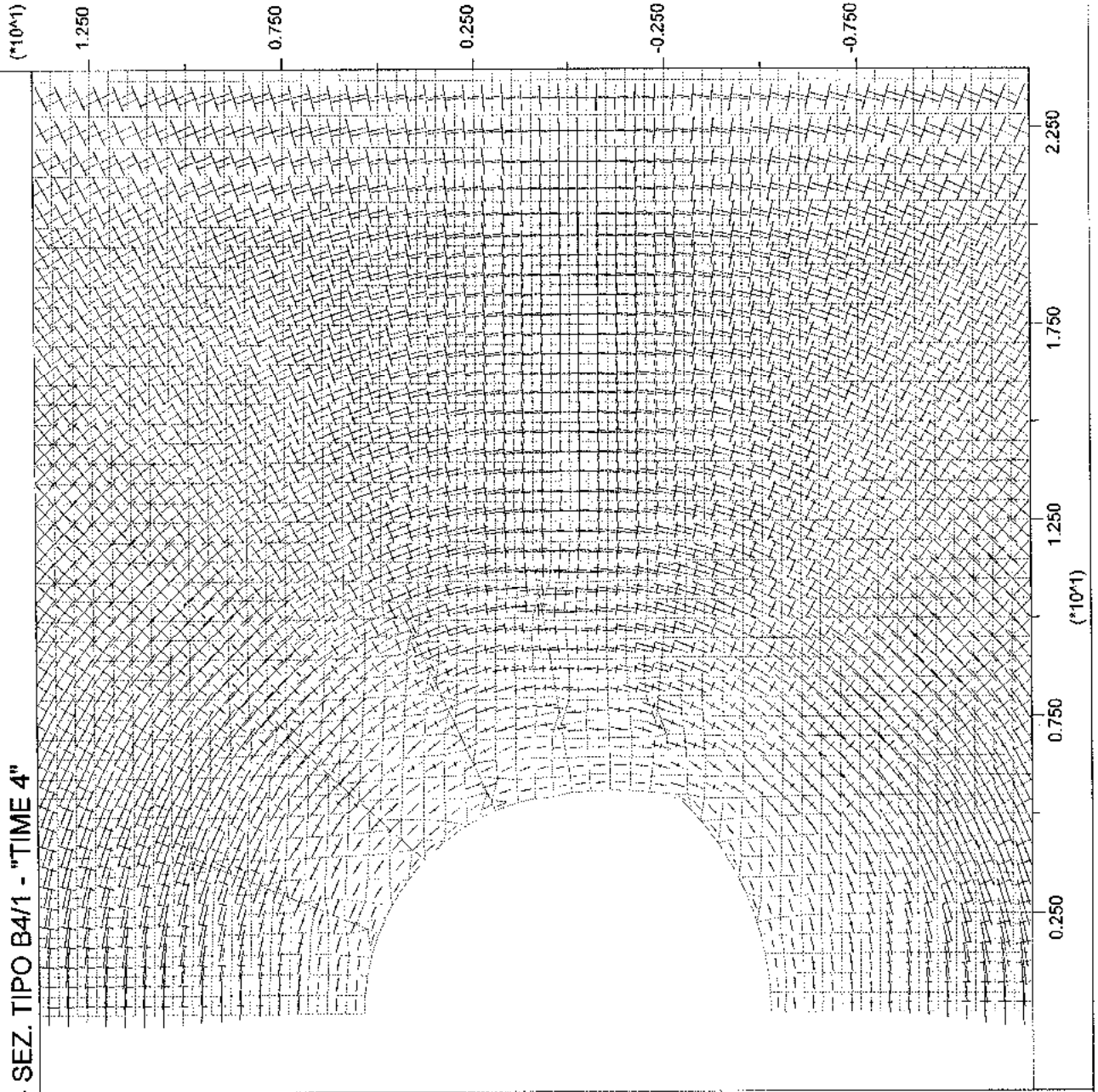
20-Feb-04 10:05
step 26752
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -3.159E+05
Min. Value = -2.165E+07



Tensioni principali : Pa



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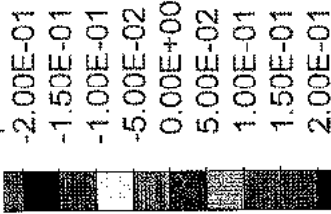
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

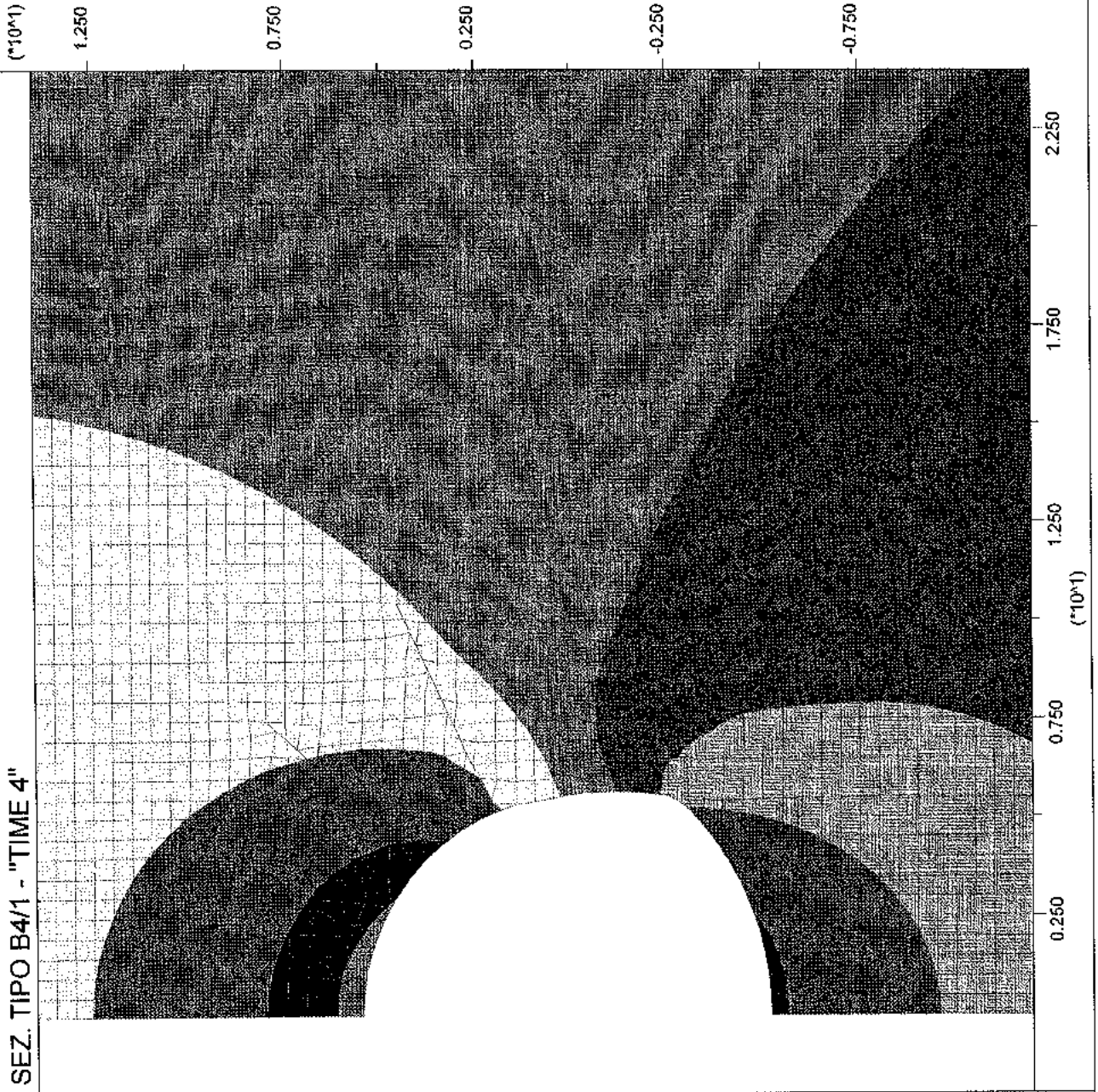
20-Feb-04 10:05
step 26752
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 5.00E-02

Spostamenti verticali



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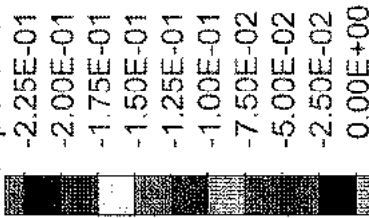
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 4"

FLAC (Version 4.00)

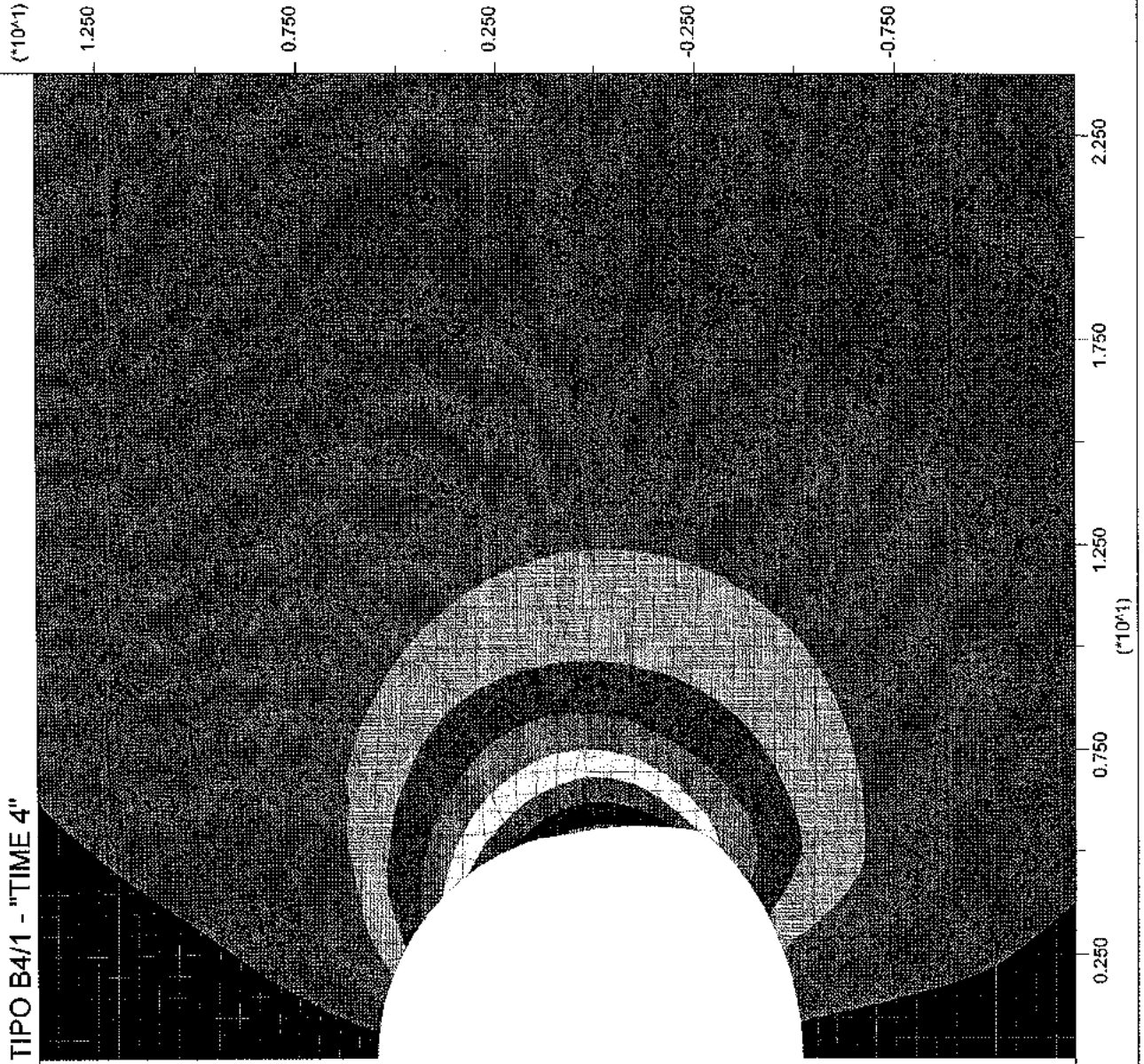
LEGEND

20-Feb-04 10:05
step 26752
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 4"

FLAC (Version 4.00)

LEGEND

20-Feb-04 10:05

step 26752

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

1.00E-02

2.00E-02

3.00E-02

4.00E-02

5.00E-02

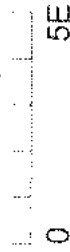
6.00E-02

7.00E-02

8.00E-02

Contour interval= 1.00E-02

Deformazioni plastiche per taglio



(*10⁻¹)

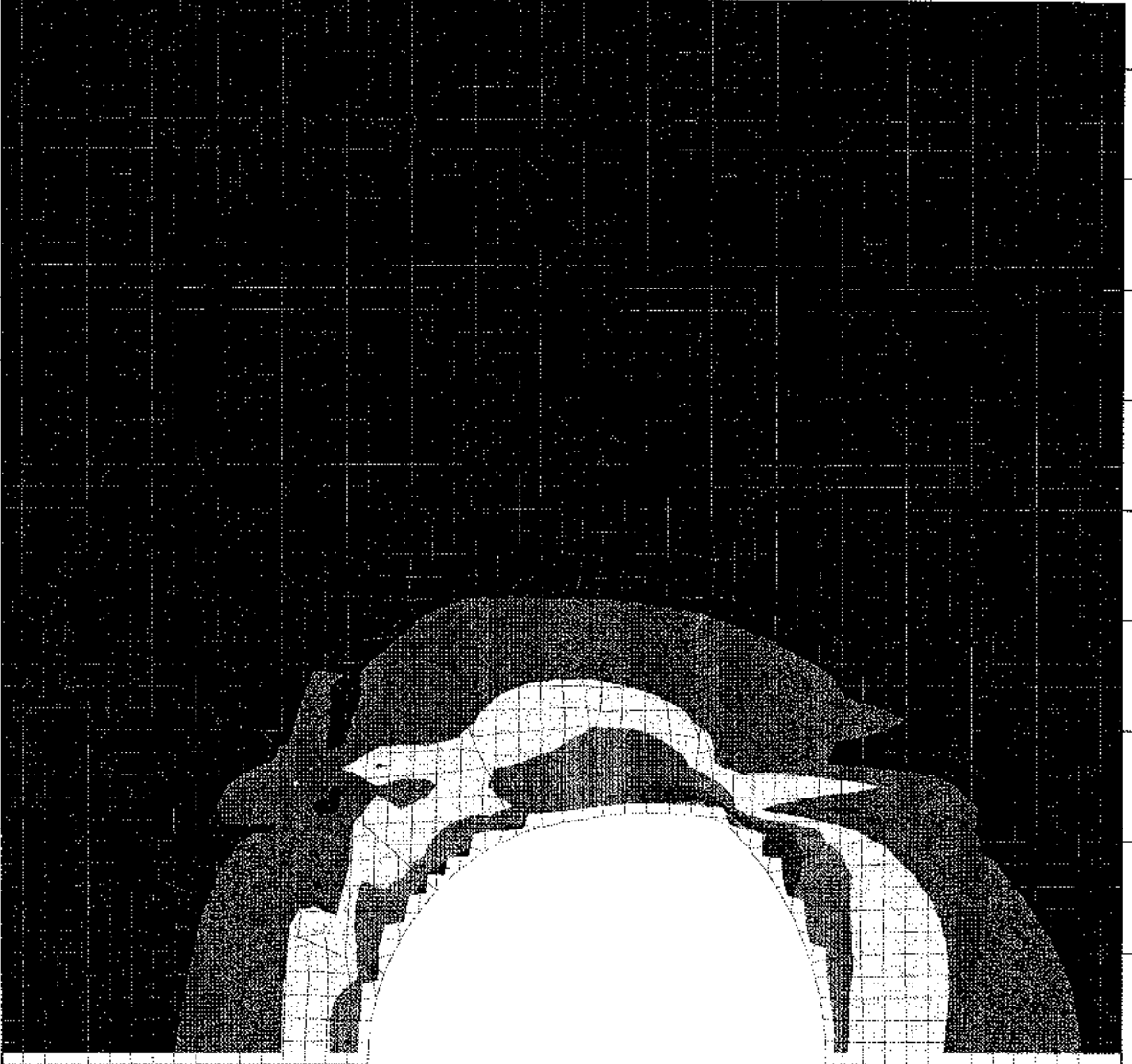
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

(*10⁻¹)

0.750

0.250

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 4"

FLAC (Version 4.00)

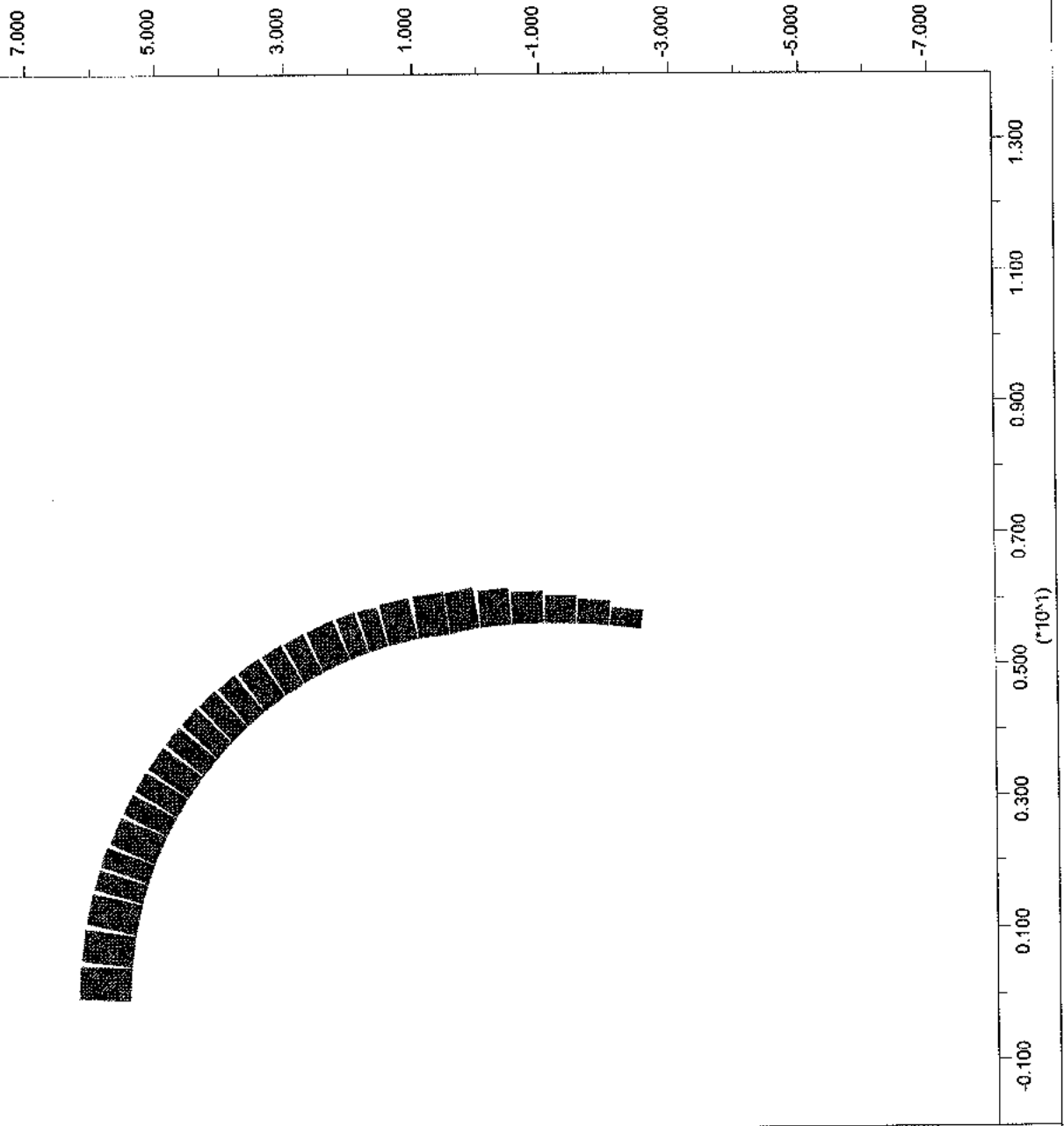
LEGEND

20-Feb-04 10:05
step 26752
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
1 (Beam) 1.215E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 4"

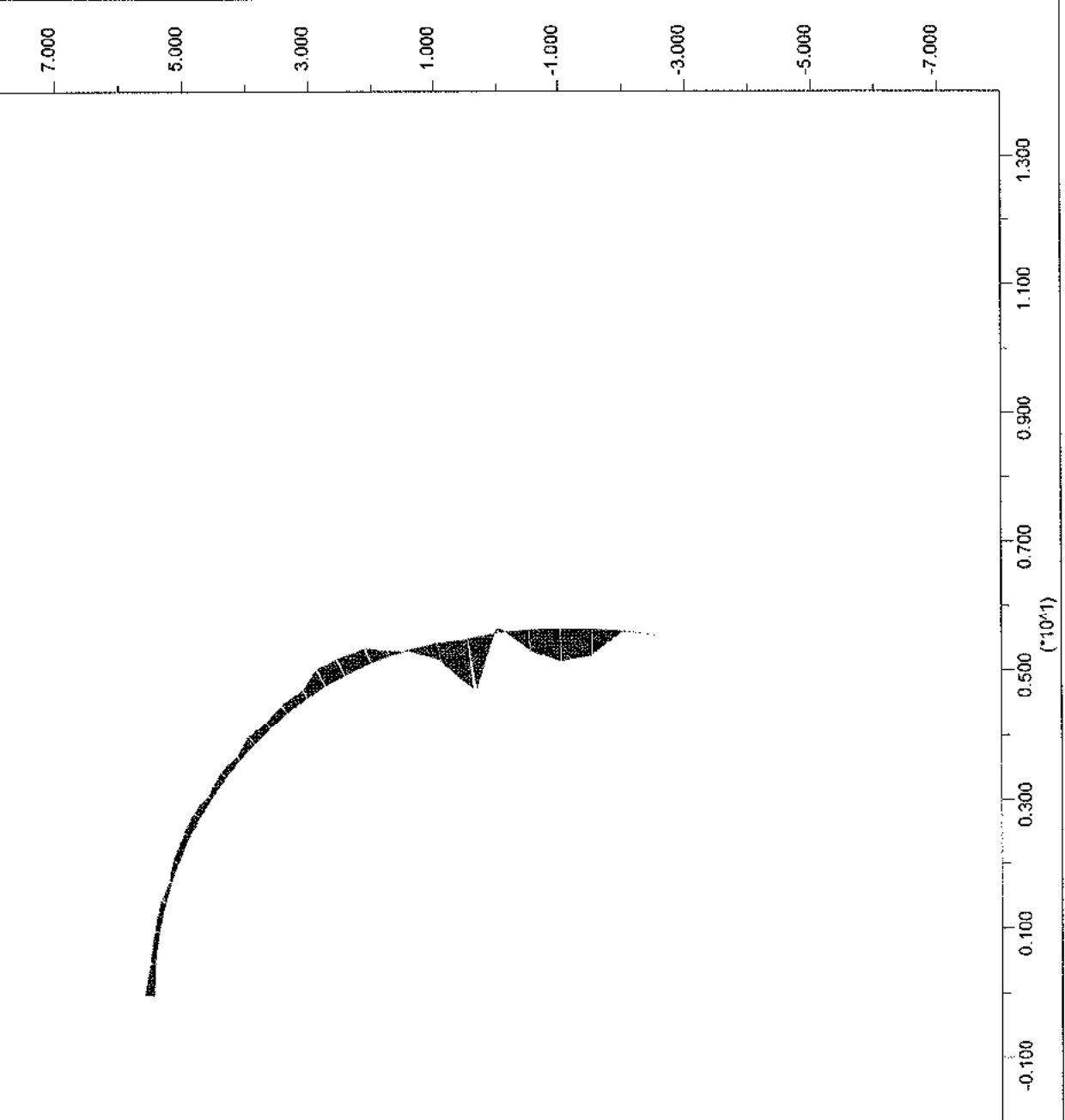
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:05
step 26752
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -1.797E+04



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 4"

(*10⁻¹)

FLAC (Version 4.00)

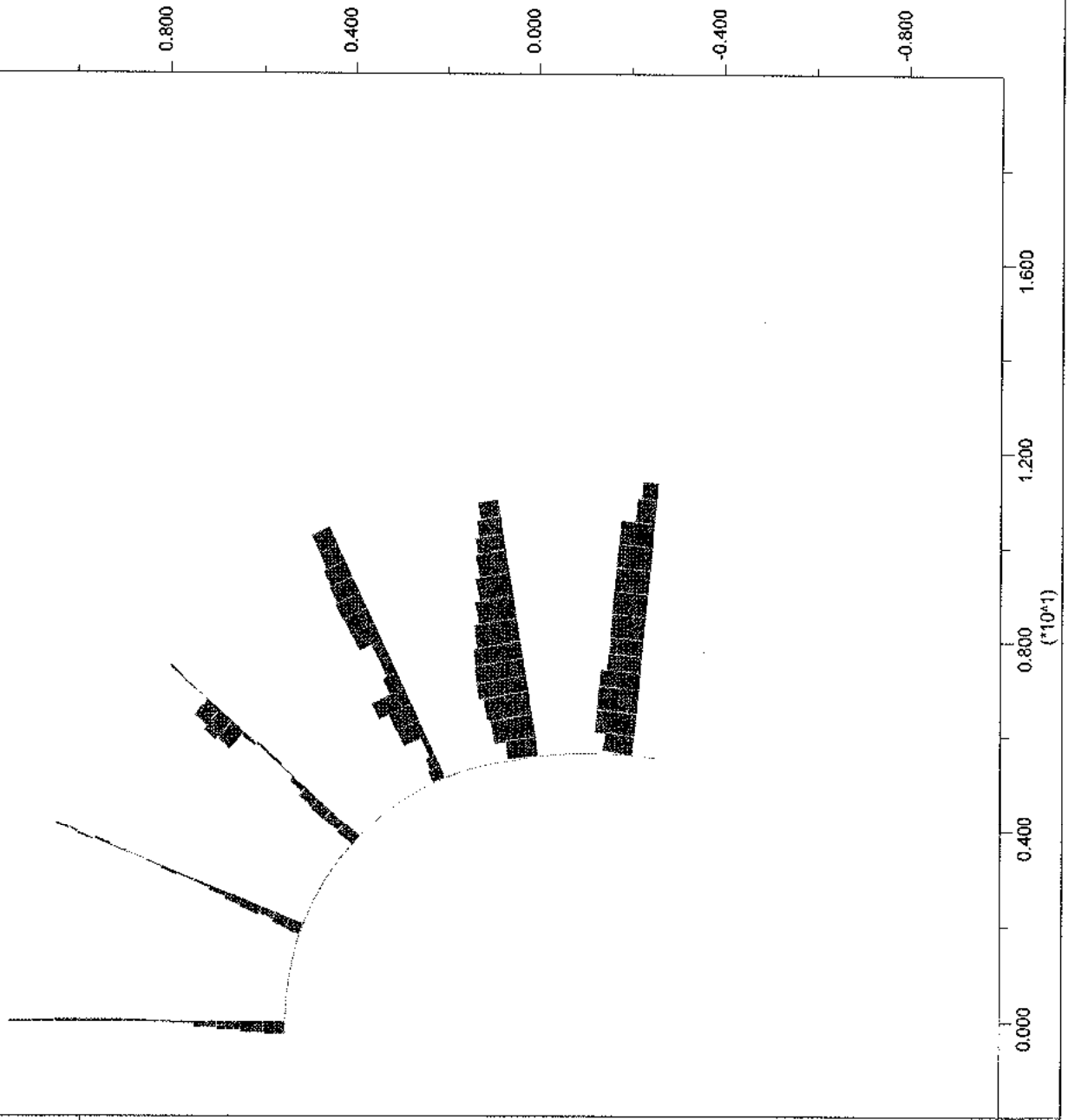
LEGEND

20-Feb-04 10:05
 step 26752
 -2.000E+00 <x< 2.000E+01
 -1.000E+01 <y< 1.200E+01

Beam plot
 Cable Plot
 Ax. F-Y Rat on
 Structure Max. Value
 # 2 (Cable) 4.551E-02
 # 3 (Cable) 4.157E-02
 # 4 (Cable) 8.993E-02
 # 5 (Cable) 1.310E-01
 # 6 (Cable) 1.856E-01
 # 7 (Cable) 1.450E-01
 Bulloni - Sforzo assiale [N]

Axial Force on
 Structure Max. Value
 # 2 (Cable) -1.201E+04
 # 3 (Cable) -1.097E+04
 # 4 (Cable) -2.374E+04
 # 5 (Cable) -3.458E+04
 # 6 (Cable) -4.899E+04
 # 7 (Cable) -3.829E+04

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 Minneapolis, Minnesota USA



JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

FLAC (Version 4.00)

LEGEND

20-Feb-04 10:33

step 32397

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

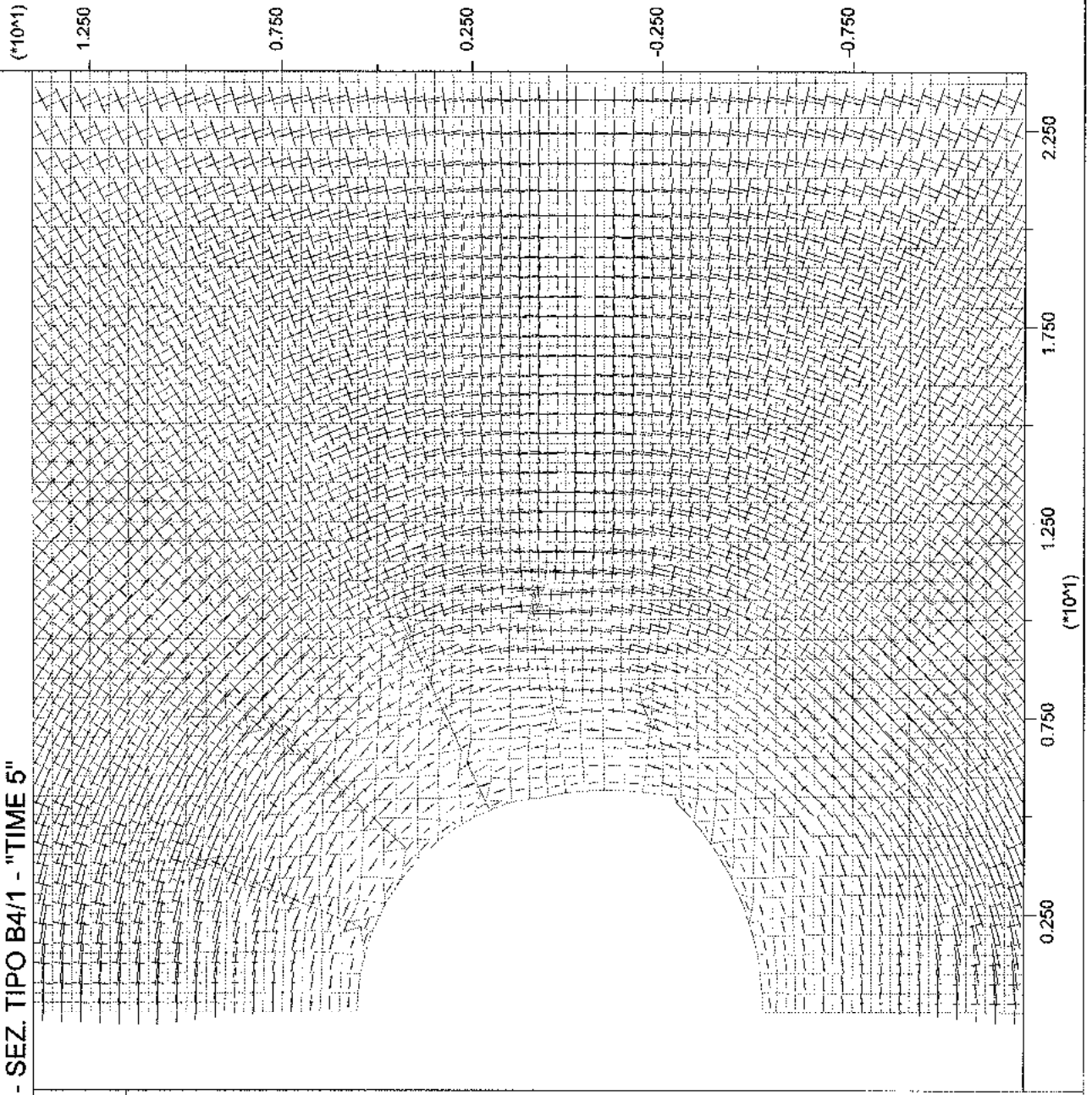
Principal stresses

Max. Value = -1.637E+04

Min. Value = -2.167E+07



Tensioni principali : Pa



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

FLAC (Version 4.00)

LEGEND

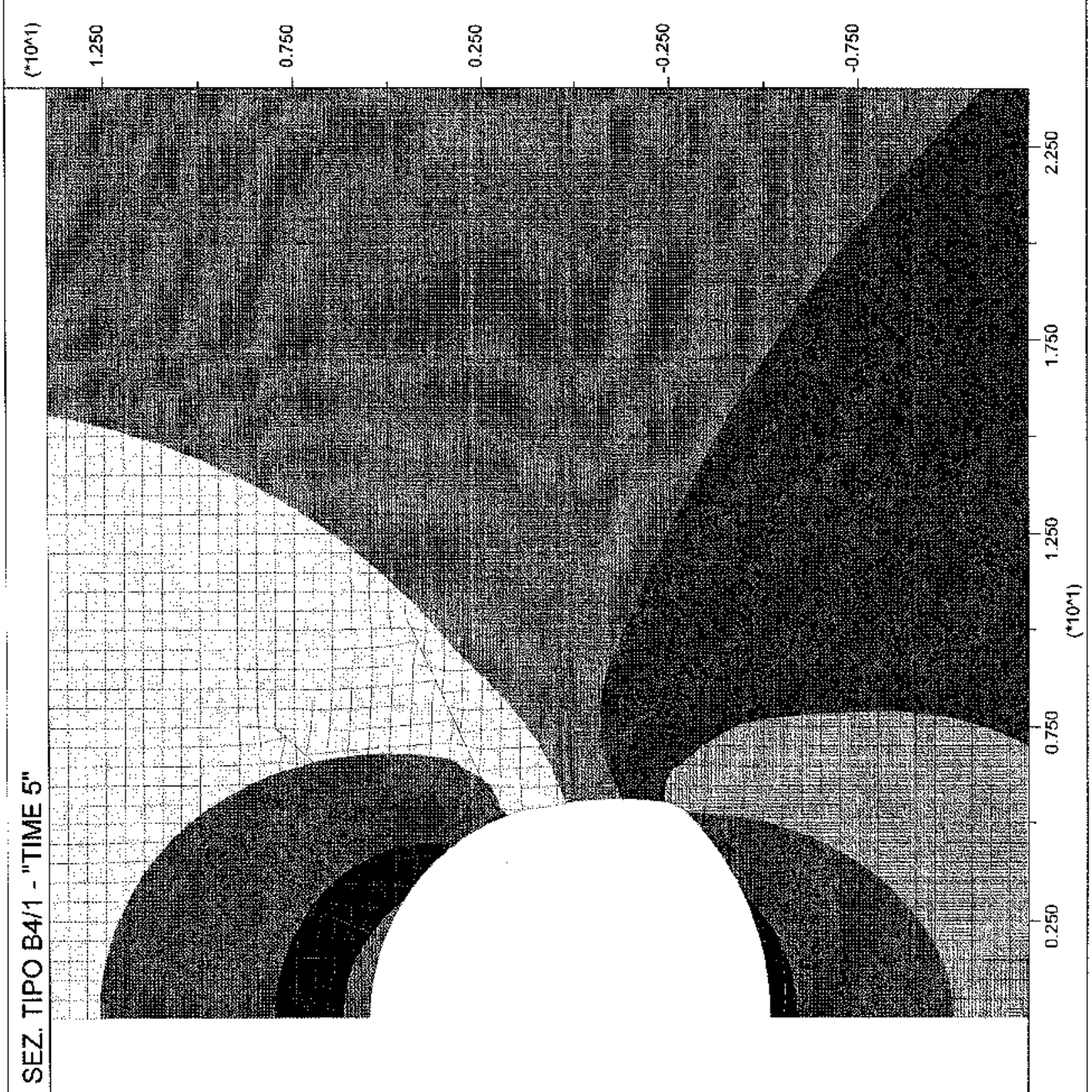
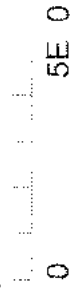
20-Feb-04 10:33
step 32397
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours

- 2.00E-01
- 1.50E-01
- 1.00E-01
- 5.00E-02
- 0.00E+00
- 5.00E-02
- 1.00E-01
- 1.50E-01
- 2.00E-01

Contour interval= 5.00E-02

Spostamenti verticali



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

FLAC (Version 4.00)

LEGEND

20-Feb-04 10:33

step 32397

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-2.25E-01

-2.00E-01

-1.75E-01

-1.50E-01

-1.25E-01

-1.00E-01

-7.50E-02

-5.00E-02

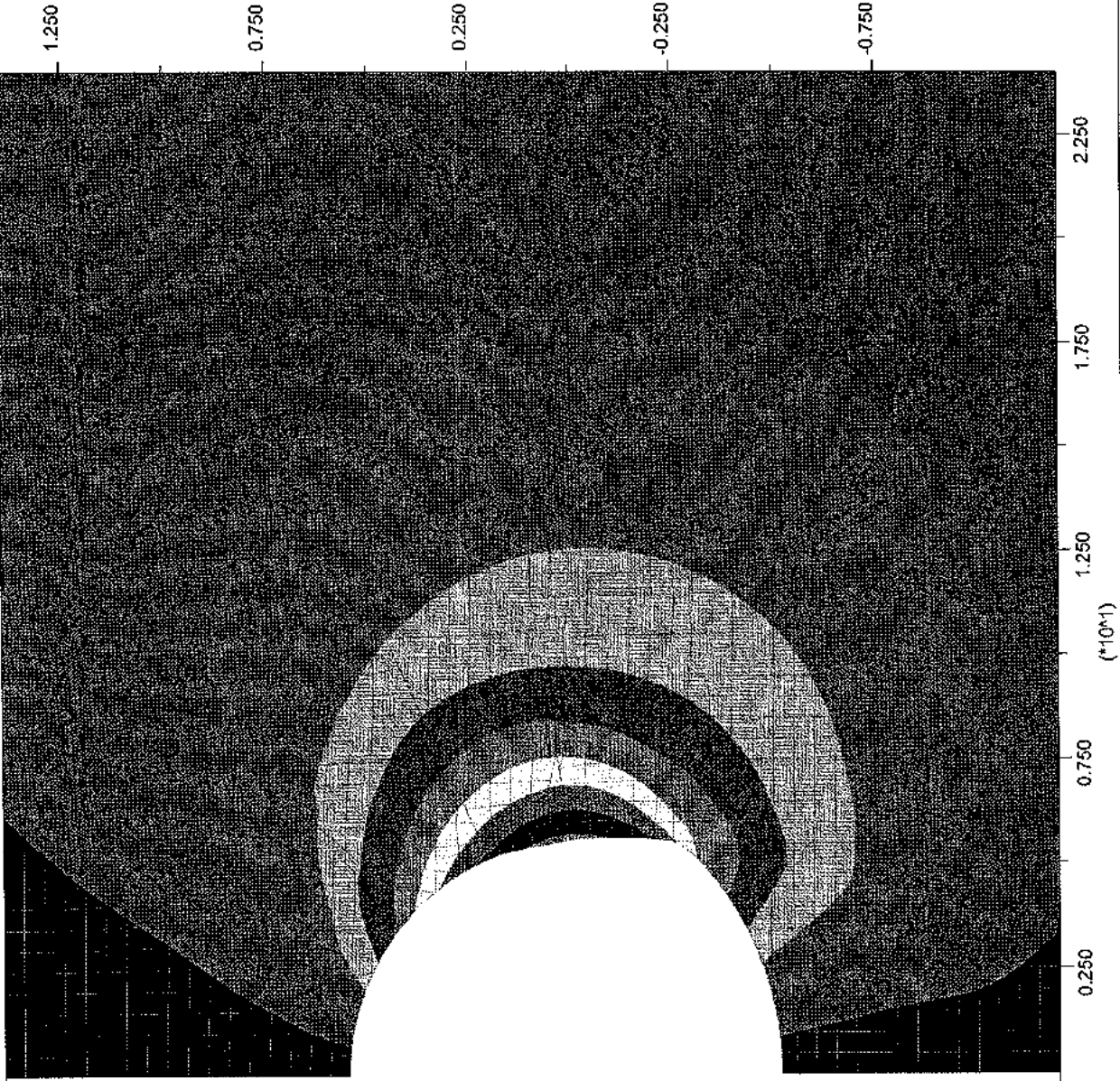
-2.50E-02

0.00E+00

Contour interval= 2.50E-02

Spostamenti orizzontali

0 5E 0



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnoia - SEZ. TIPO B4/1 - "TIME 5"

FLAC (Version 4.00)

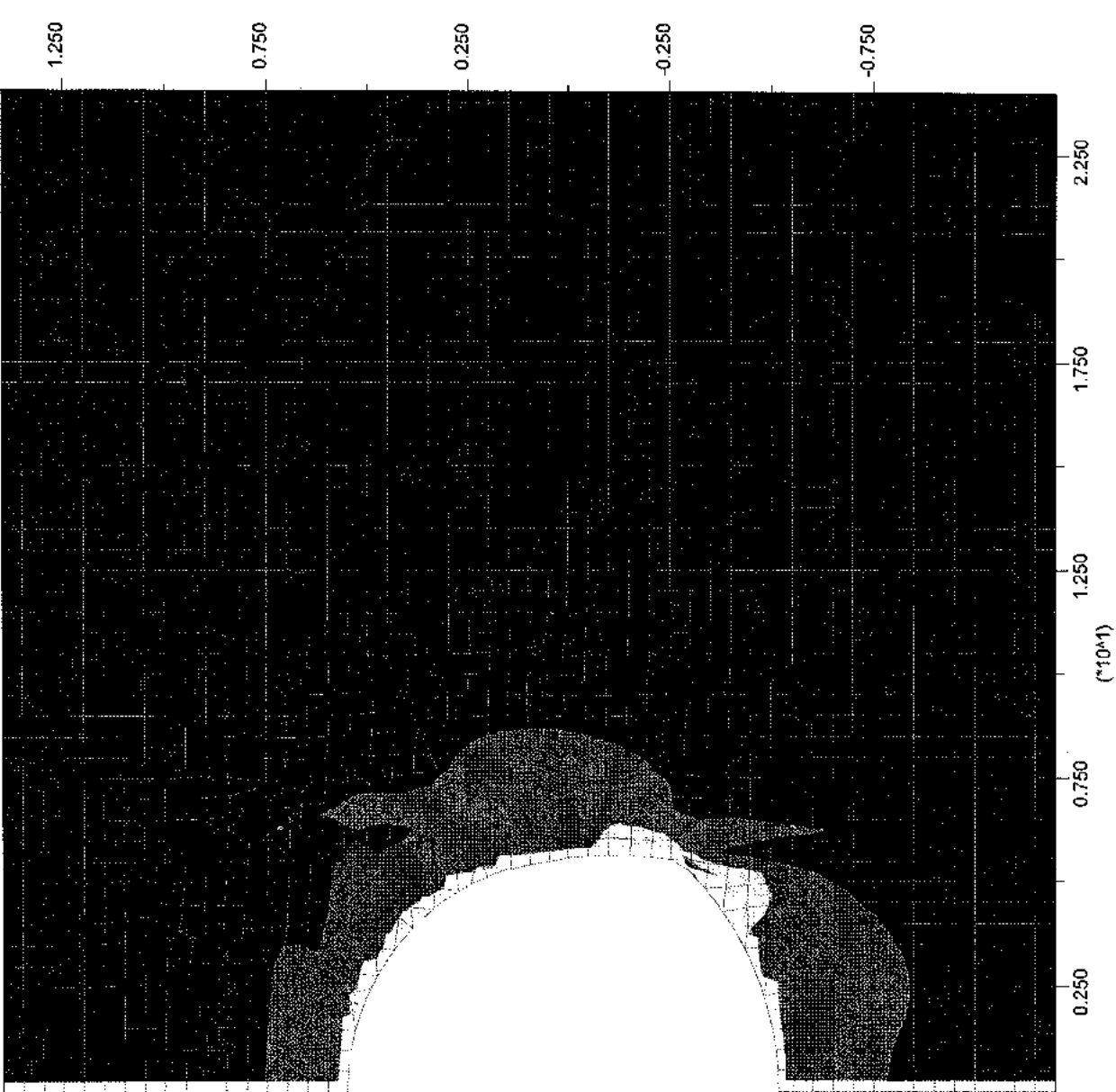
LEGEND

20-Feb-04 10:33
step 32397
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 2.00E-02
Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

FLAC (Version 4.00)

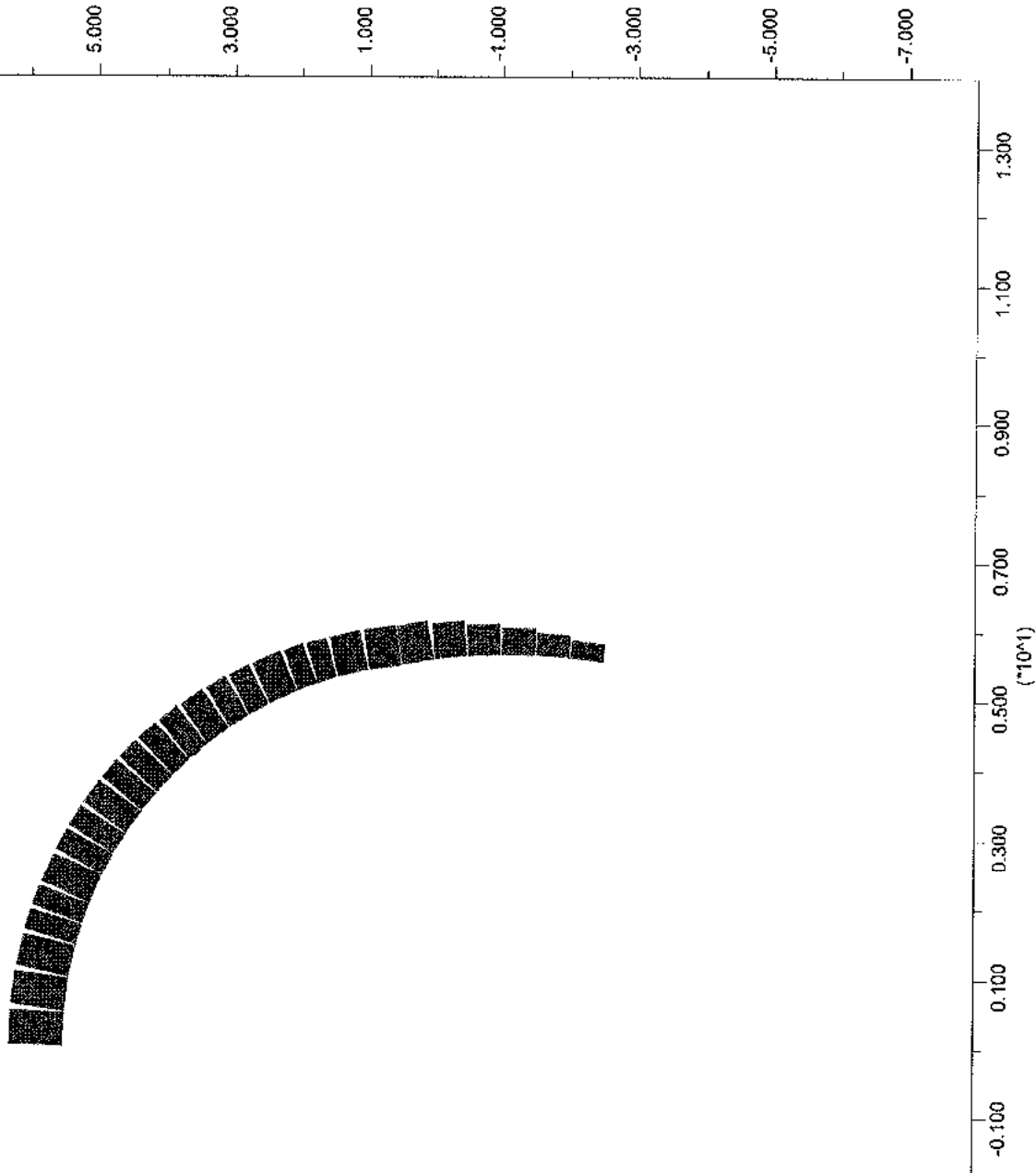
LEGEND

20-Feb-04 10:33
step 32397
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
1 (Beam) 2.382E+06



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

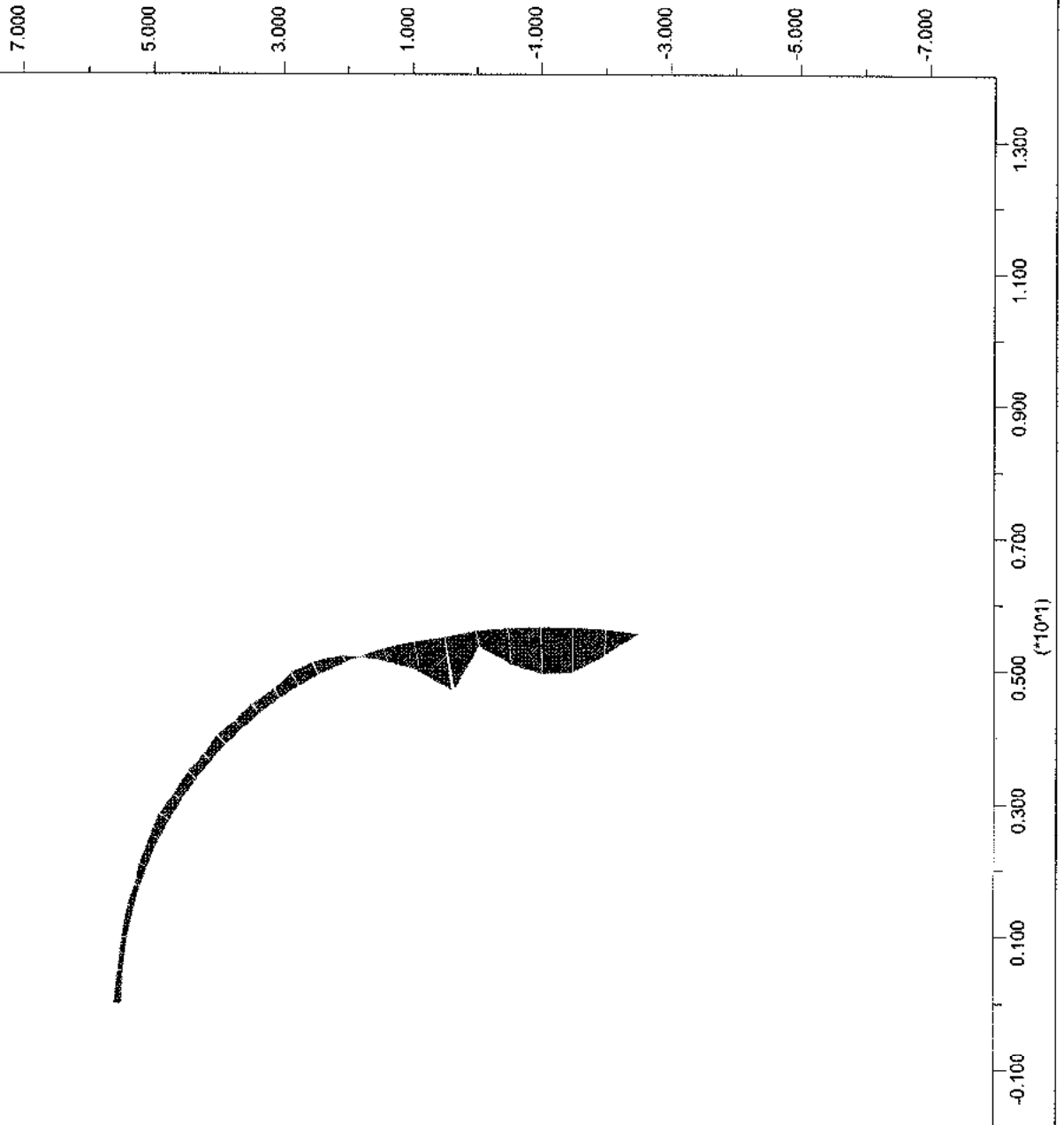
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:33
step 32397
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -6.368E+04



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

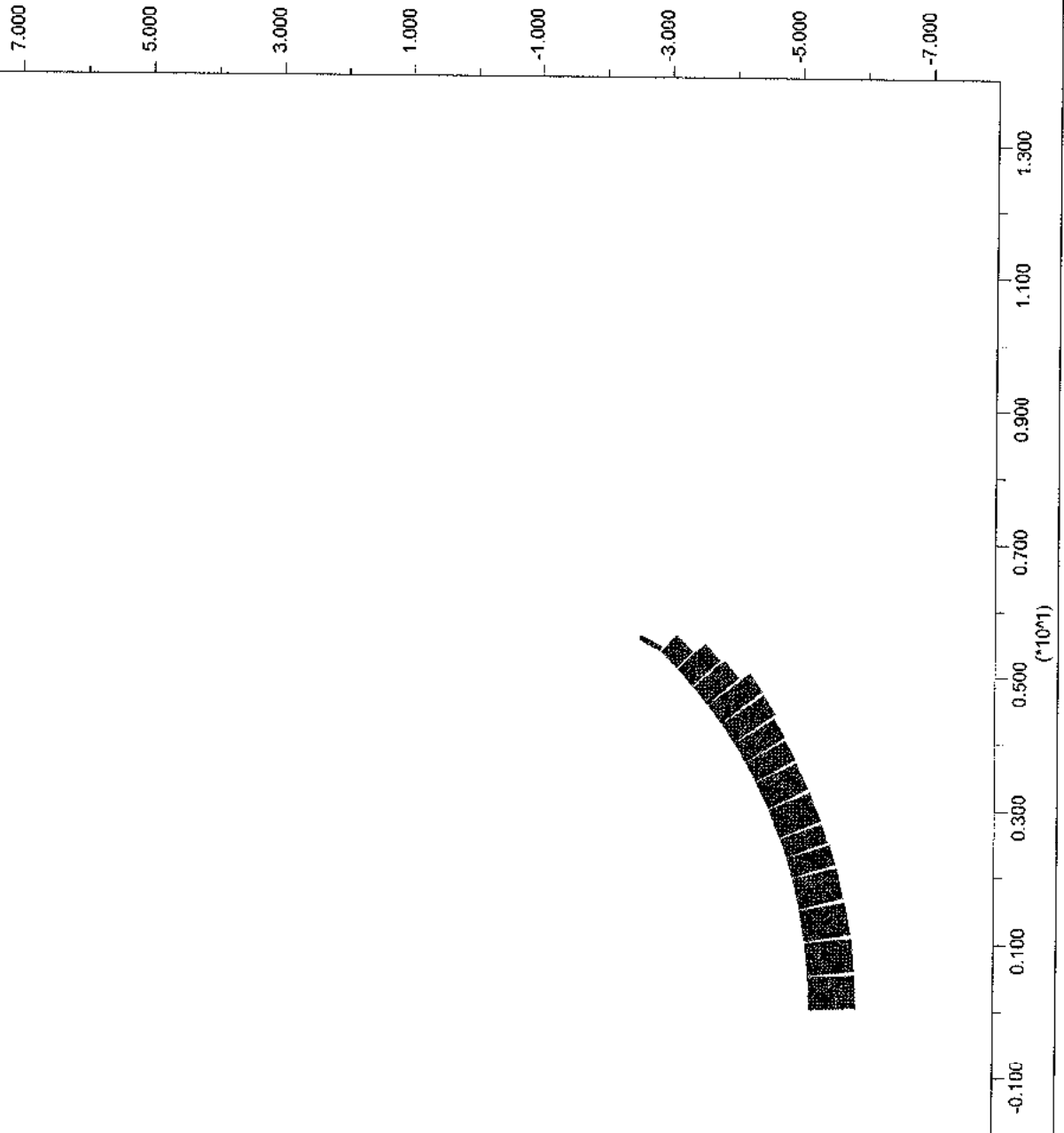
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:33
step 32397
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
8 (Beam) 1.555E+06

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA




JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

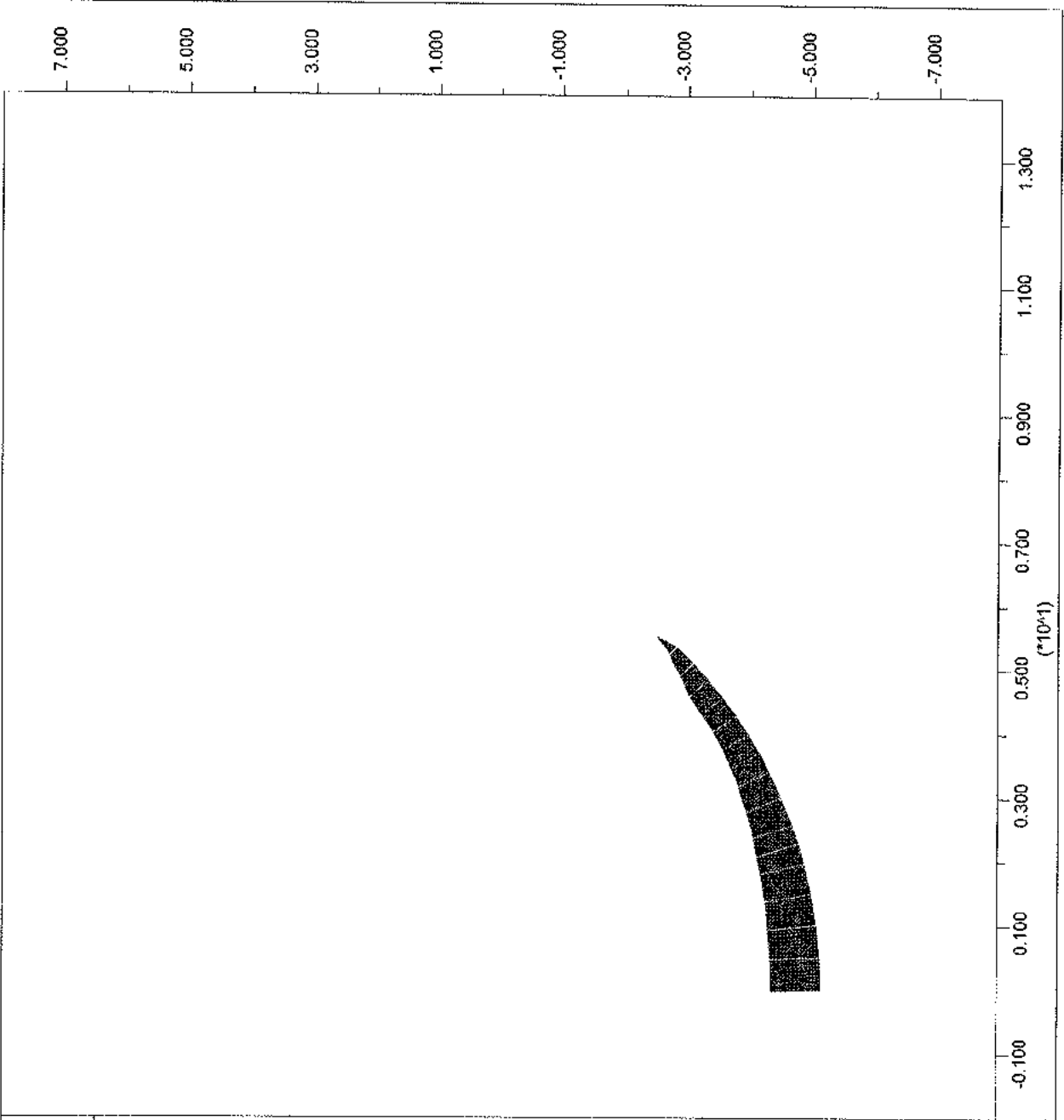
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:33
step 32397
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Momento flettente [N*m/m]

 Moment on
Structure Max. Value
8 (Beam) -4.729E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

FLAC (Version 4.00)

LEGEND

20-Feb-04 10:33
 step 32397
 -2.000E+00 <x< 2.000E+01
 -1.000E+01 <y< 1.200E+01

Beam plot
 Cable Plot
 Ax. F-Y Rat on

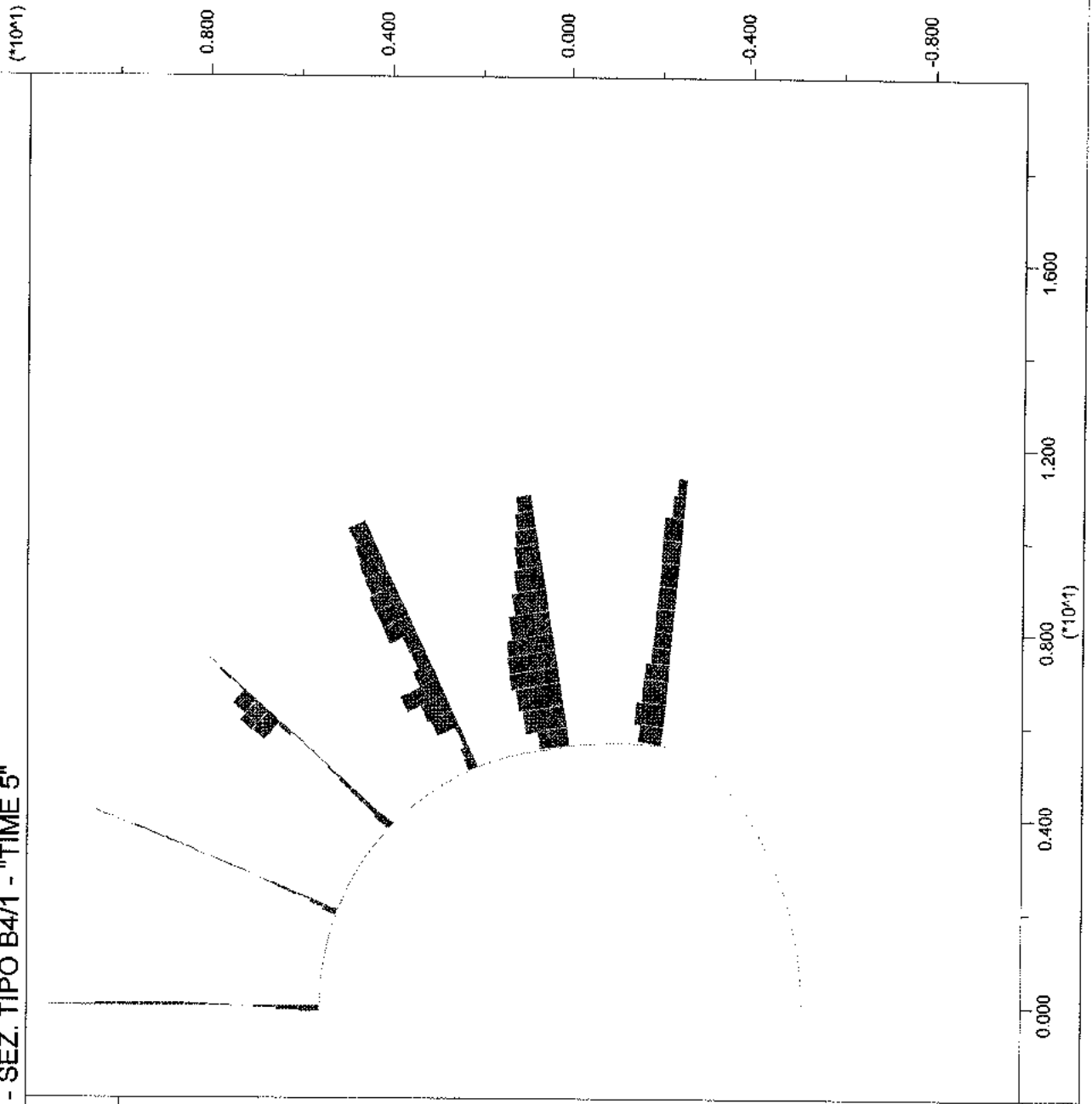
Structure	Max. Value
# 2 (Cable)	5.203E-02
# 3 (Cable)	5.915E-02
# 4 (Cable)	2.382E-01
# 5 (Cable)	3.861E-01
# 6 (Cable)	4.687E-01
# 7 (Cable)	2.752E-01

Bulloni - Sforzo assiale [N]

Axial Force on

Structure	Max. Value
# 2 (Cable)	-1.374E+04
# 3 (Cable)	-1.562E+04
# 4 (Cable)	-6.288E+04
# 5 (Cable)	-1.019E+05
# 6 (Cable)	-1.237E+05
# 7 (Cable)	-7.264E+04

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 Minneapolis, Minnesota USA



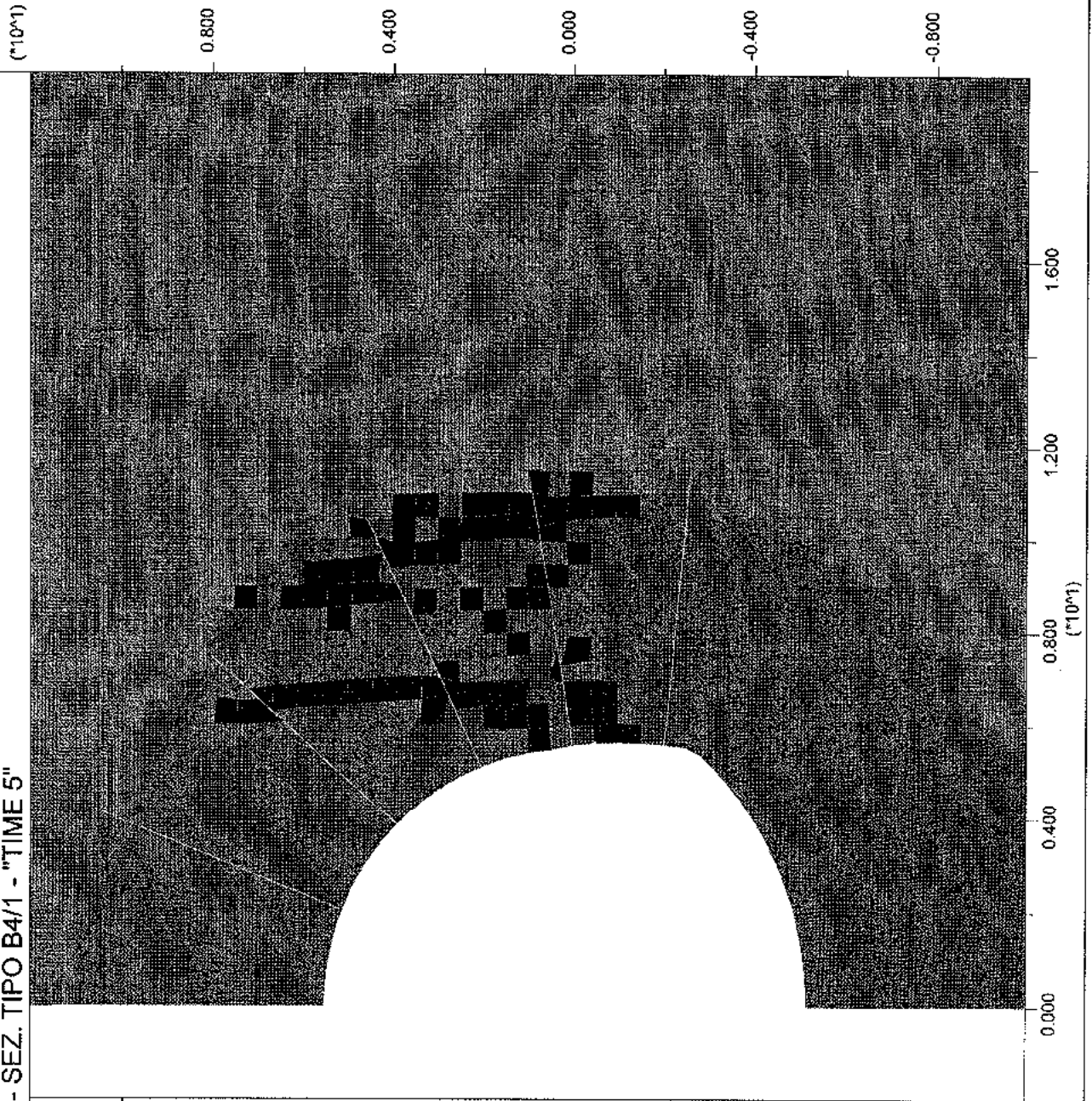
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 5"

FLAC (Version 4.00)

LEGEND

20-Feb-04 10:33
step 32397
-2.000E+00 <x< 2.000E+01
-1.000E+01 <y< 1.200E+01

state
Elastic
At Yield in Shear or Vol.
Elastic, Yield in Past
Grid plot



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 6"

FLAC (Version 4.00)

LEGEND

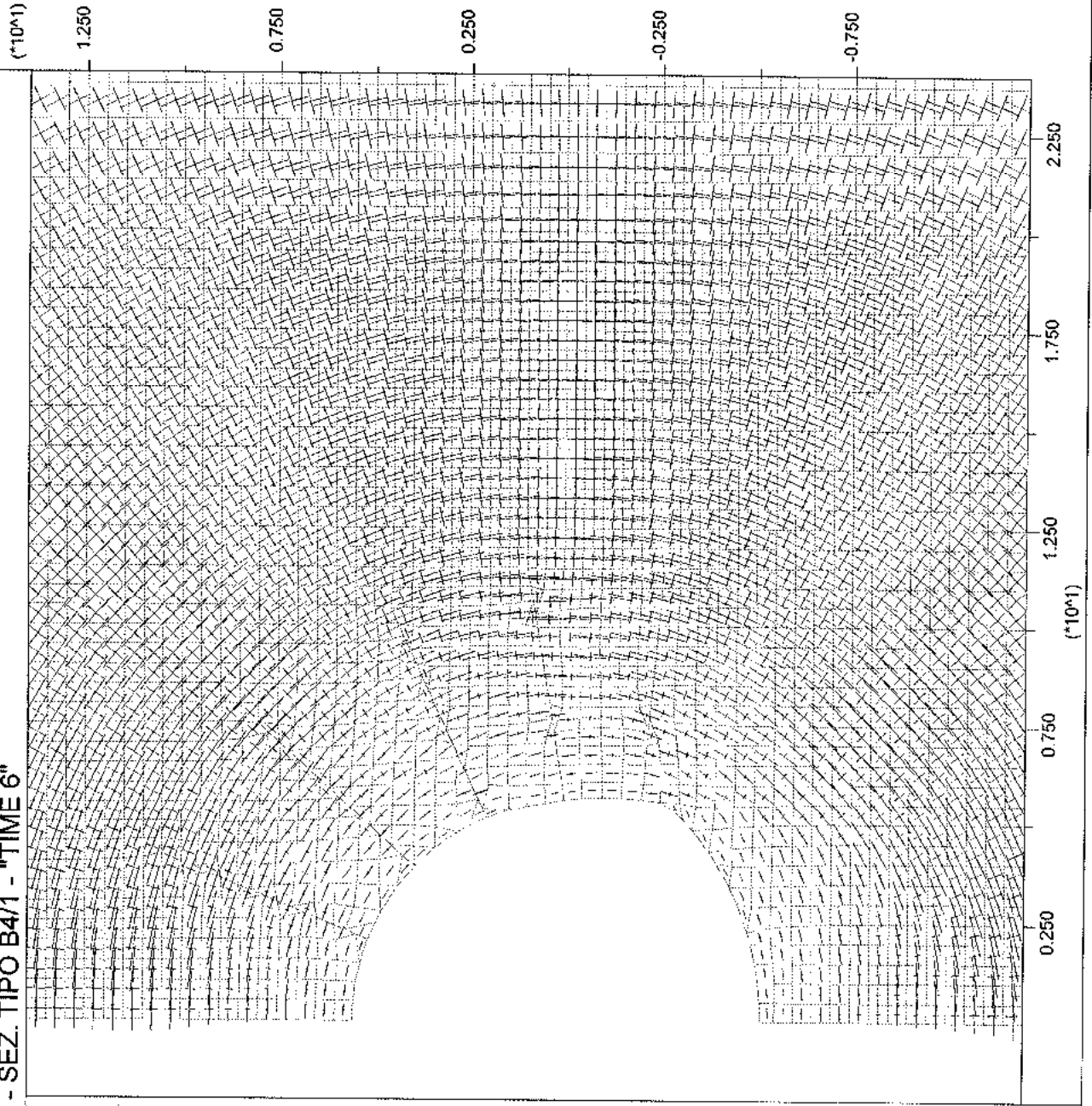
20-Feb-04 10:35
step 33413
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -4.352E+04
Min. Value = -2.167E+07



Tensioni principali : Pa



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

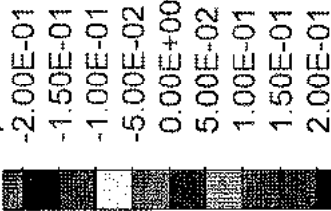
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 6"

FLAC (Version 4.00)

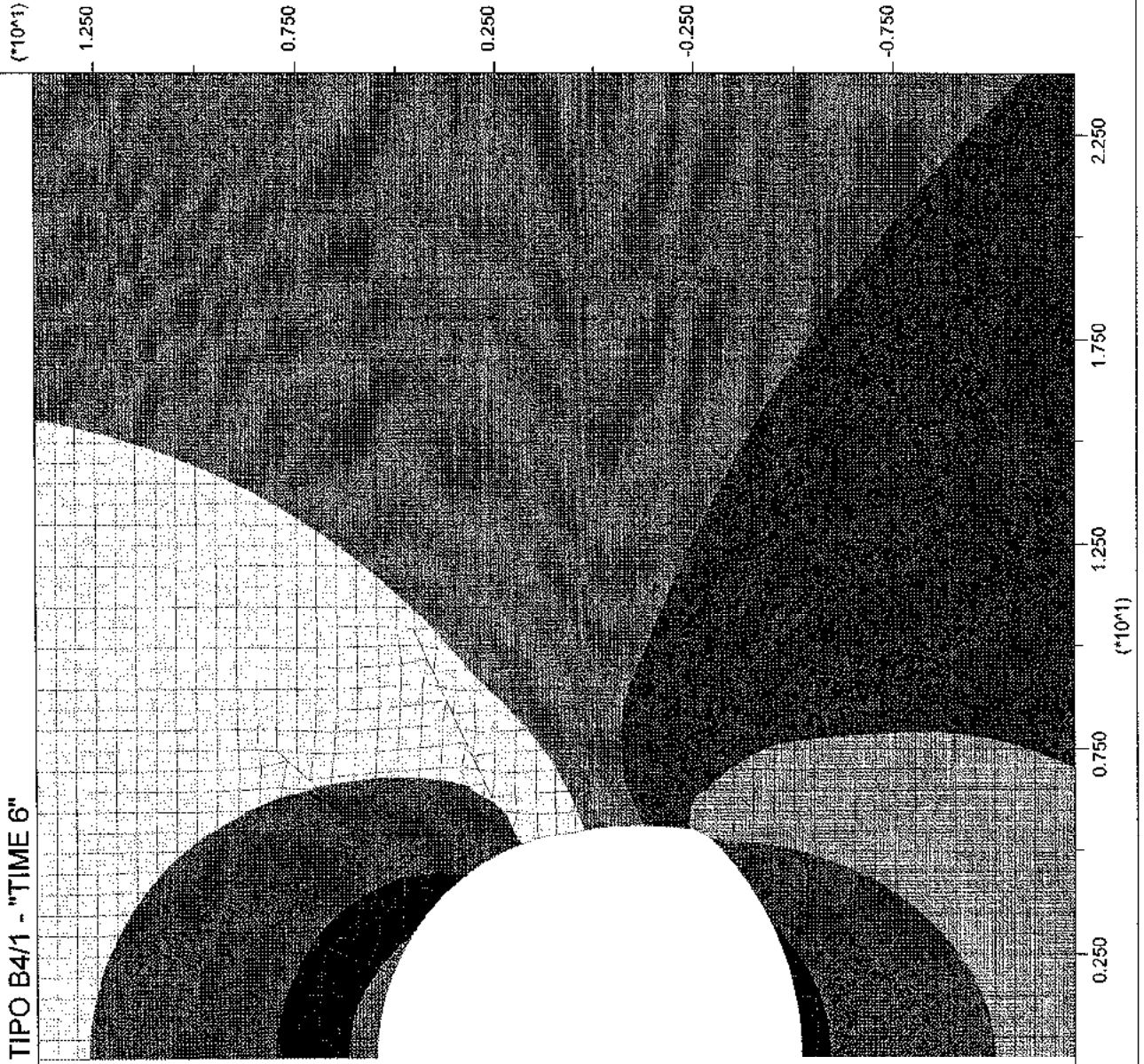
LEGEND

20-Feb-04 10:35
step 33413
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 5.00E-02
Spostamenti verticali



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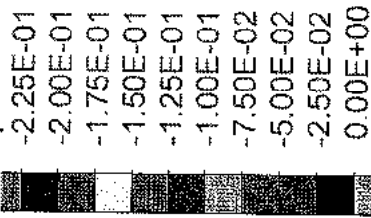
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 6"

FLAC (Version 4.00)

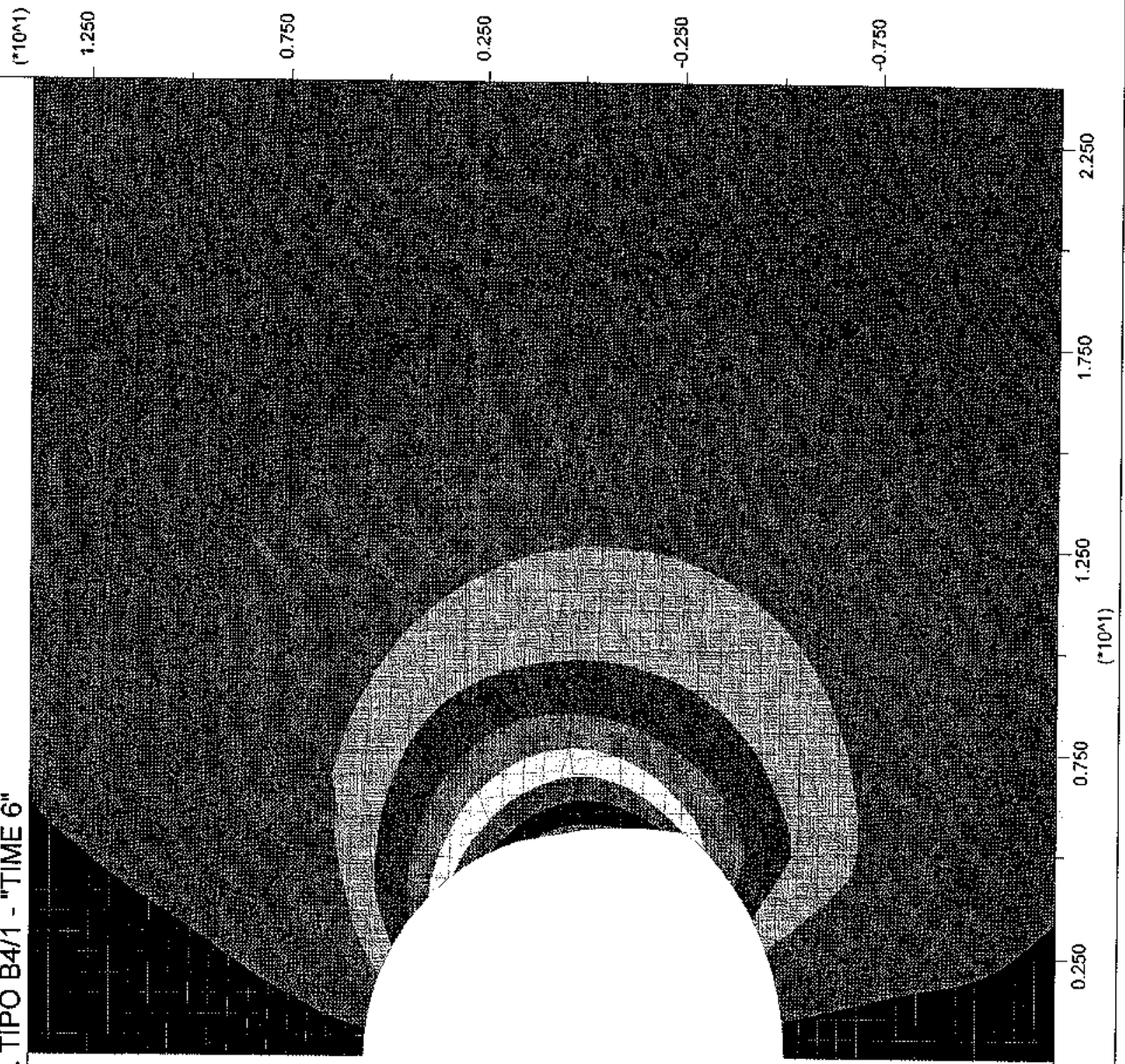
LEGEND

20-Feb-04 10:35
step 33413
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02
Spostamenti orizzontali



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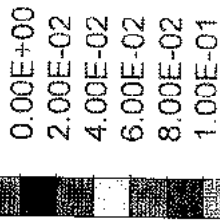
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 6"

FLAC (Version 4.00)

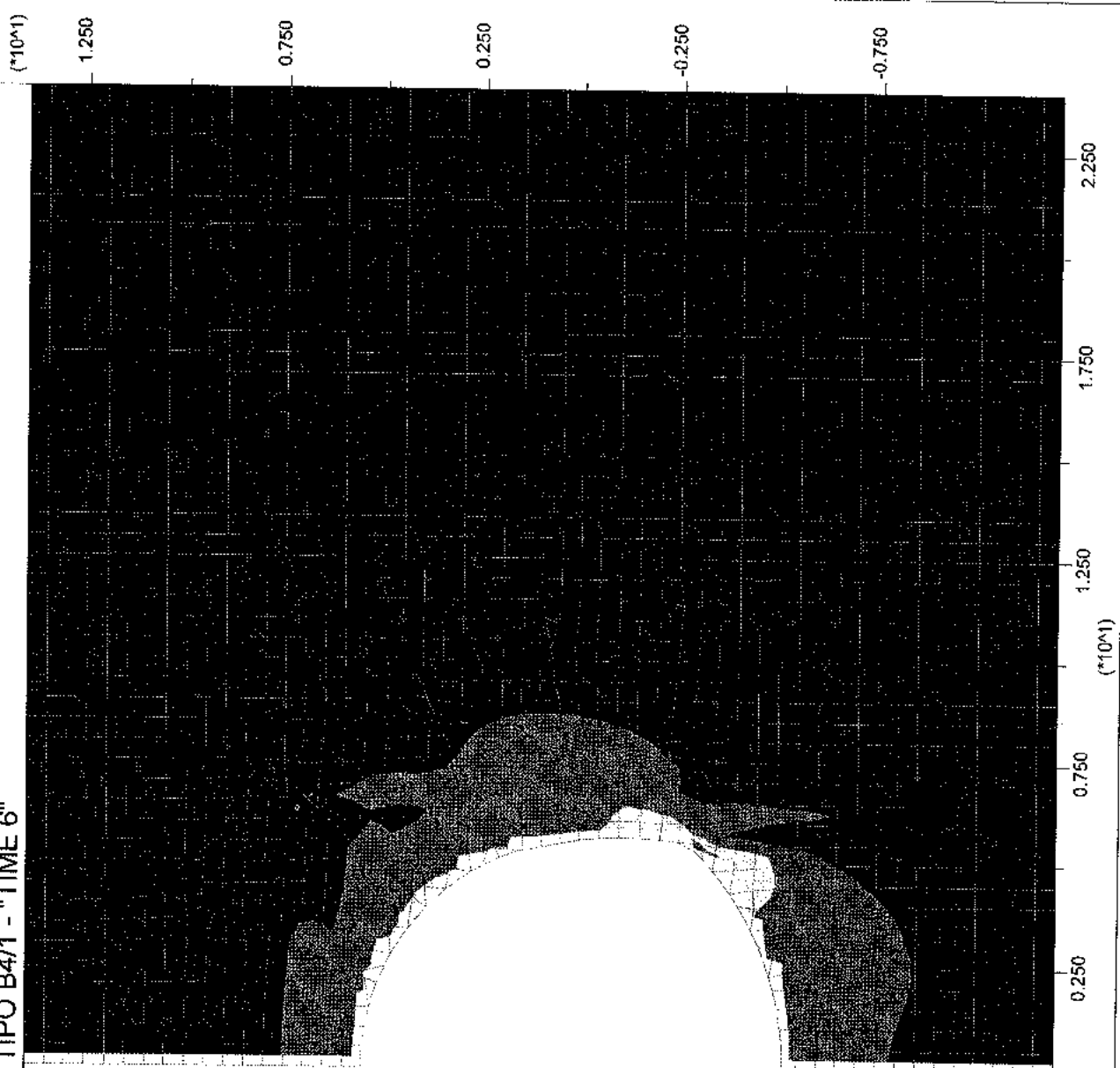
LEGEND

20-Feb-04 10:35
step 33413
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 2.00E-02
Deformazioni plastiche per taglio



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 6"

FLAC (Version 4.00)

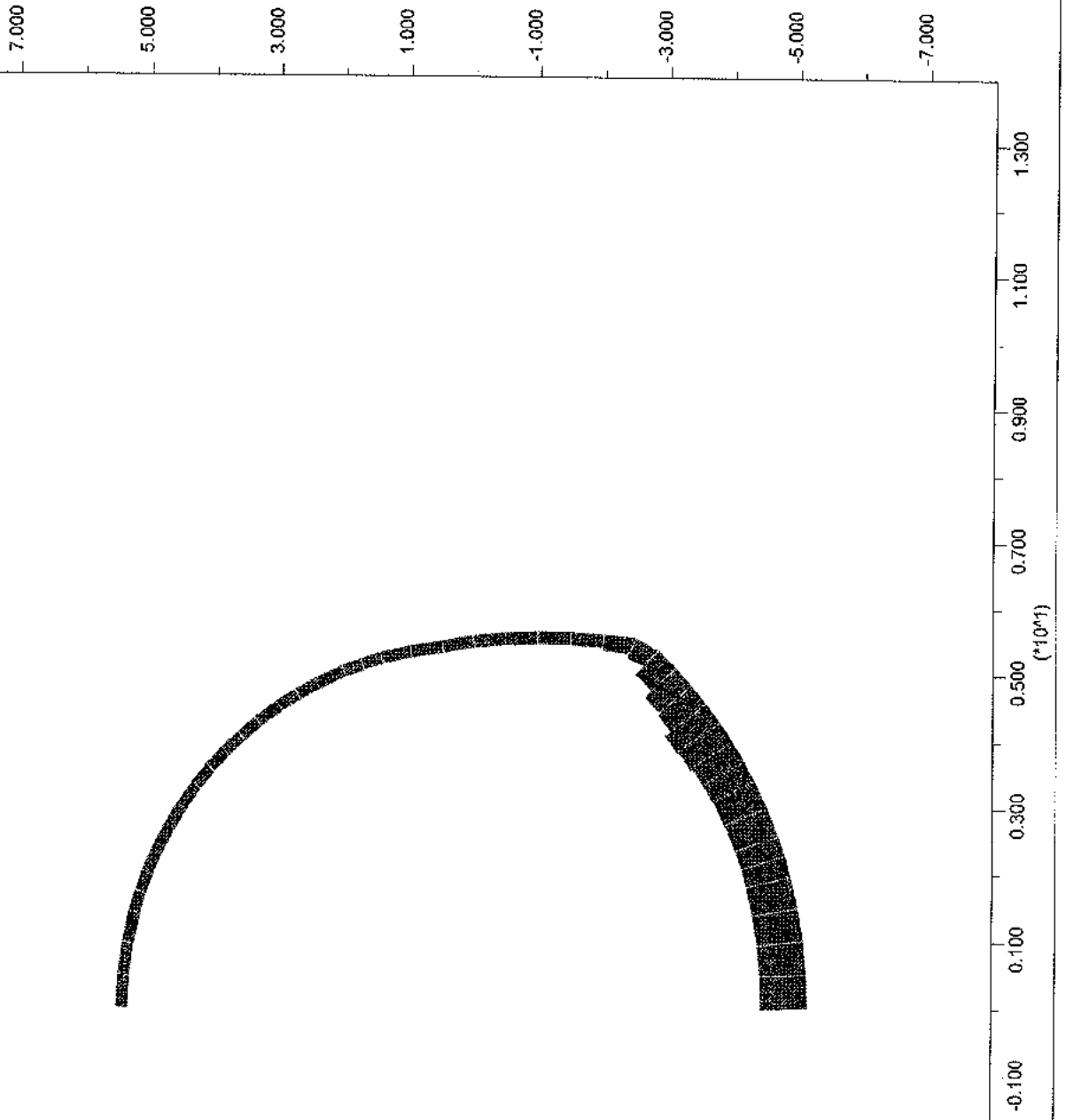
LEGEND

20-Feb-04 10:35
step 33413
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-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
8 (Beam) 2.282E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 6"

FLAC (Version 4.00)

LEGEND

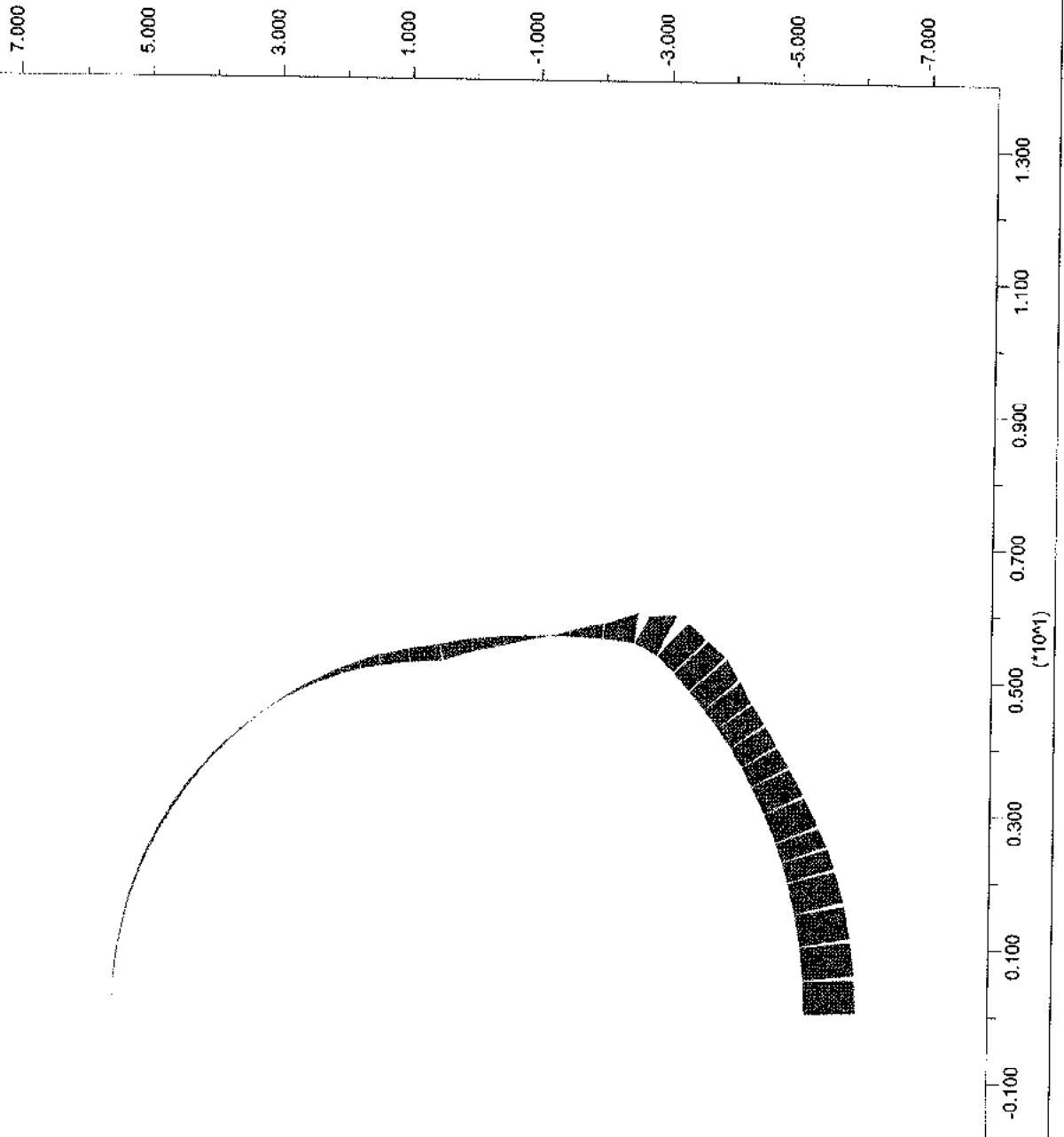
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step 33413
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-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

■ Moment on

Structure Max. Value

8 (Beam) -3.921E+05



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 7"

FLAC (Version 4.00)

LEGEND

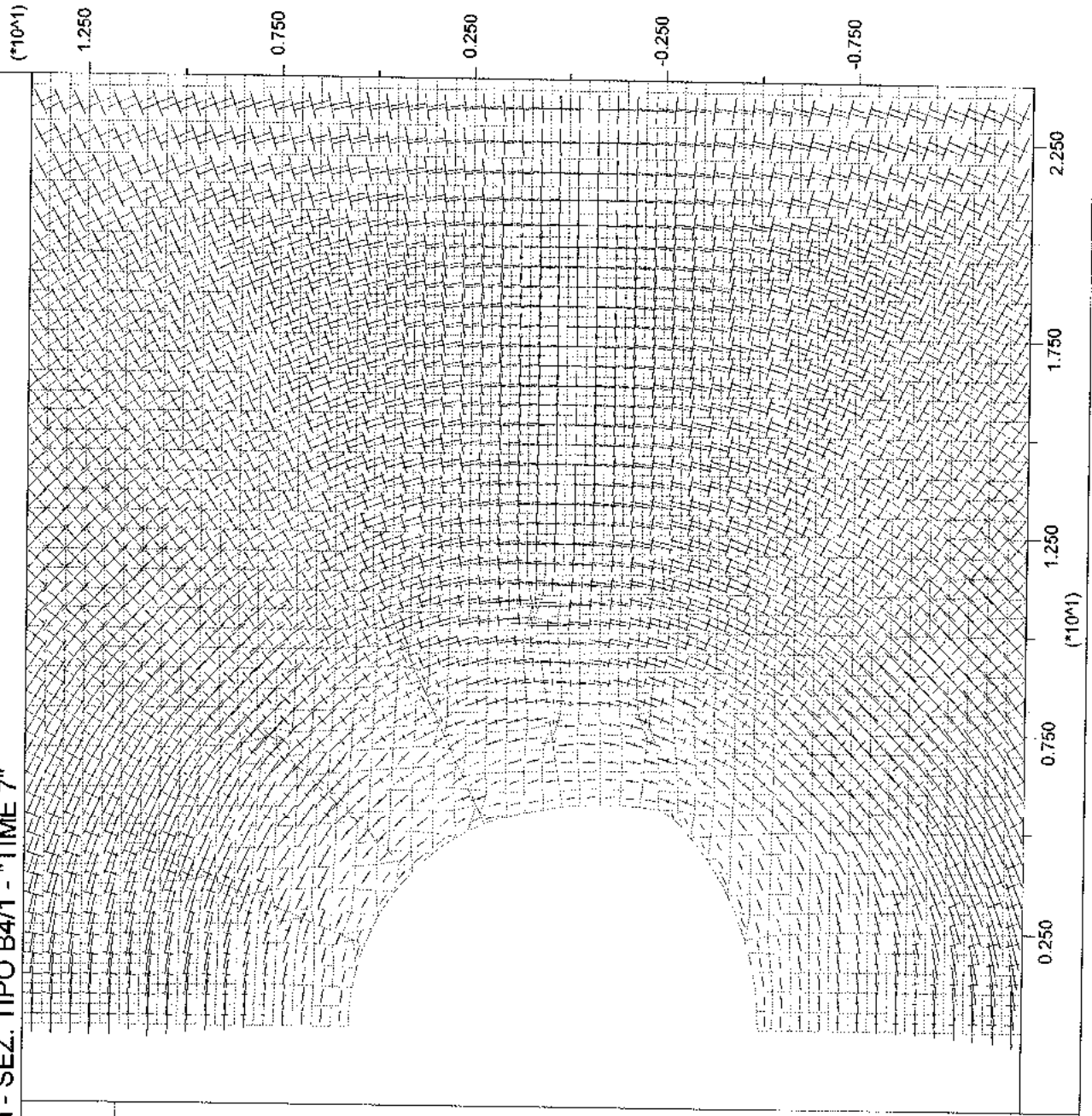
20-Feb-04 10:51
step 35019
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -2.025E+05
Min. Value = -2.167E+07



Tensioni principali : Pa



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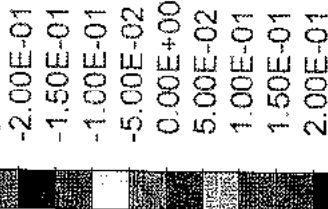
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FLAC (Version 4.00)

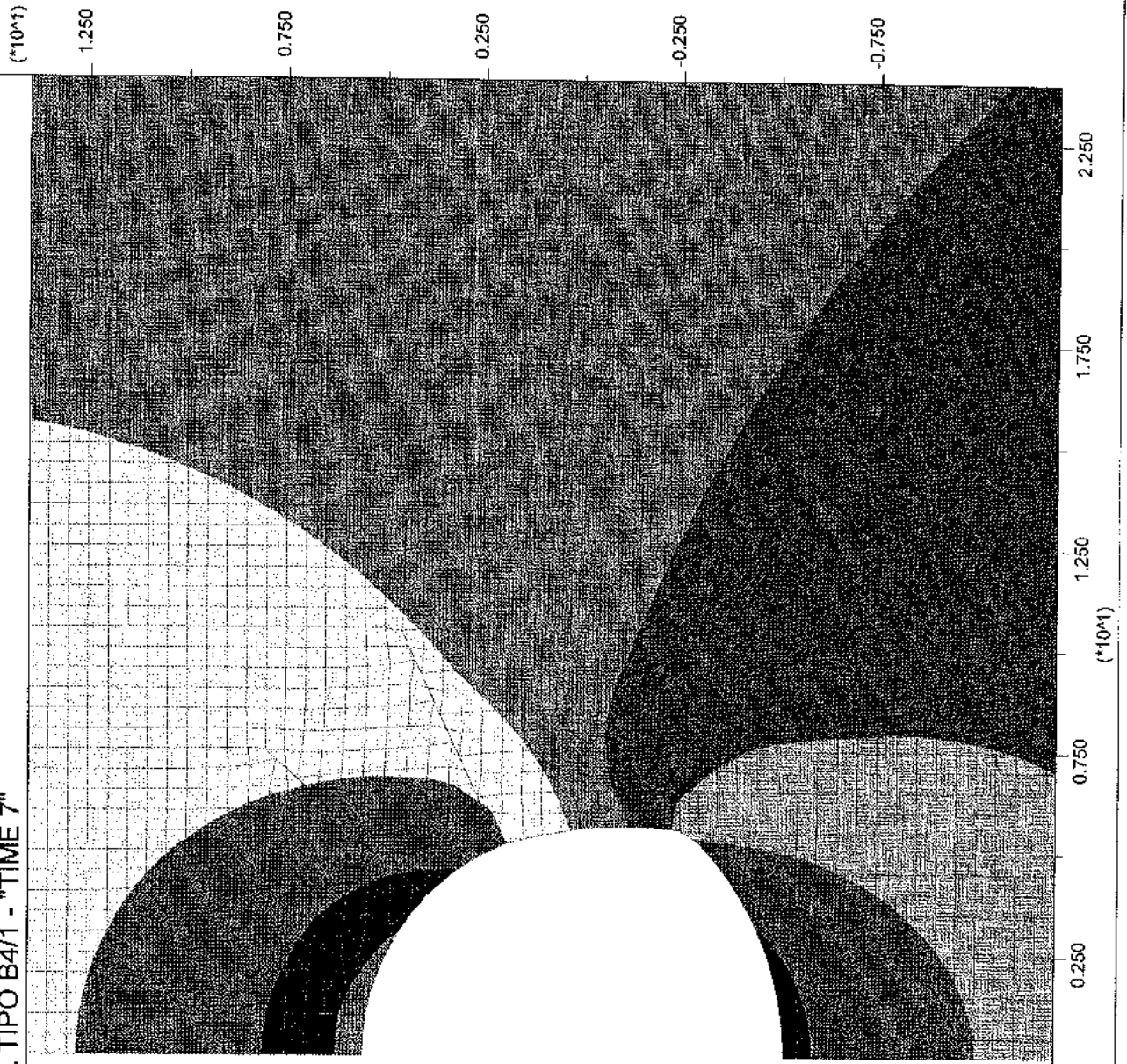
LEGEND

20-Feb-04 10:51
step 35019
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 5.00E-02
Spostamenti verticali



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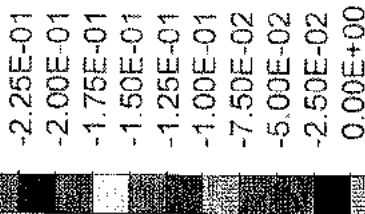
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FLAC (Version 4.00)

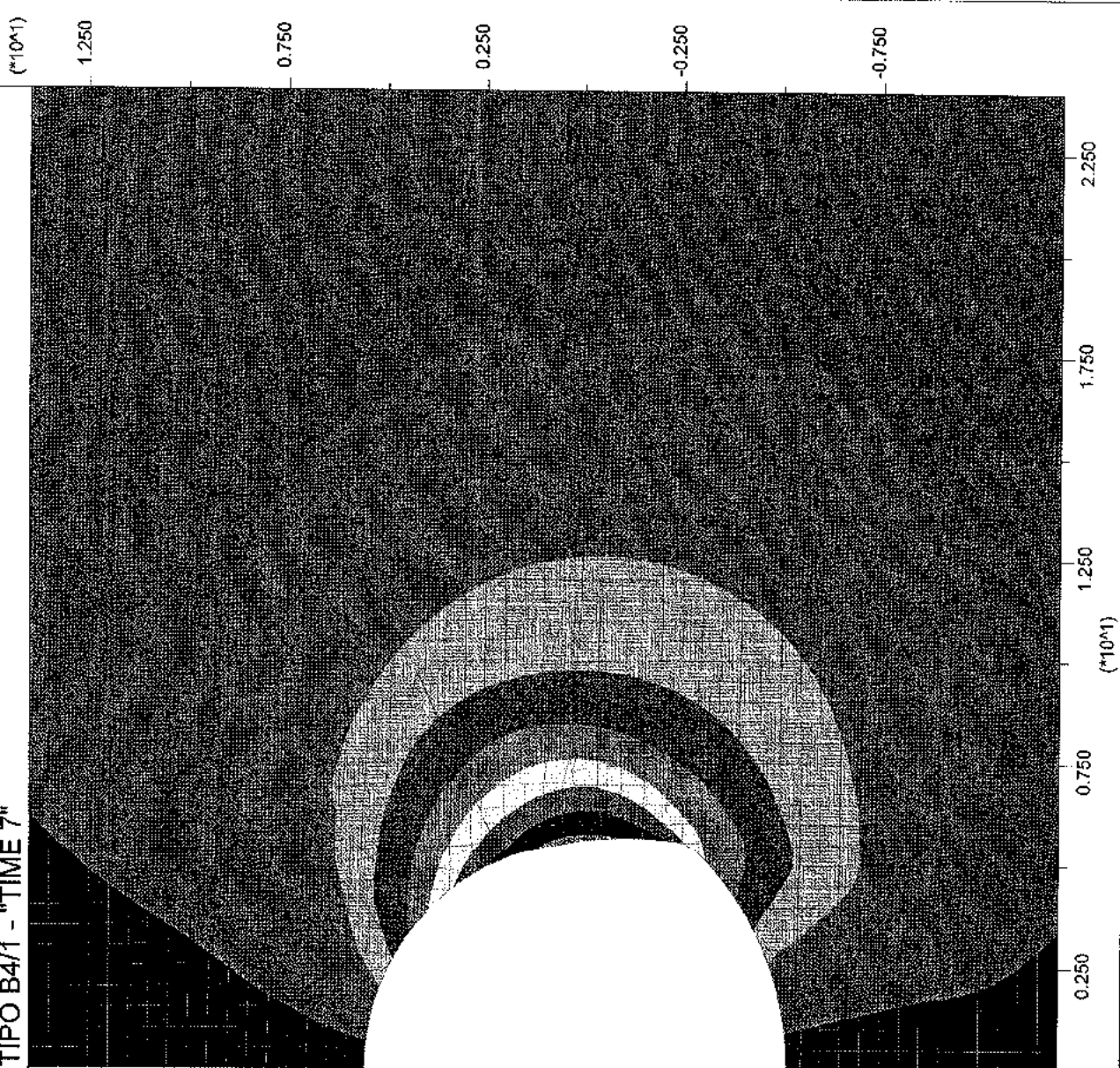
LEGEND

20-Feb-04 10:51
step 35019
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02
Spostamenti orizzontali



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 7"

FLAC (Version 4.00)

LEGEND

20-Feb-04 10:51

step 35019

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

2.00E-02

4.00E-02

6.00E-02

8.00E-02

1.00E-01



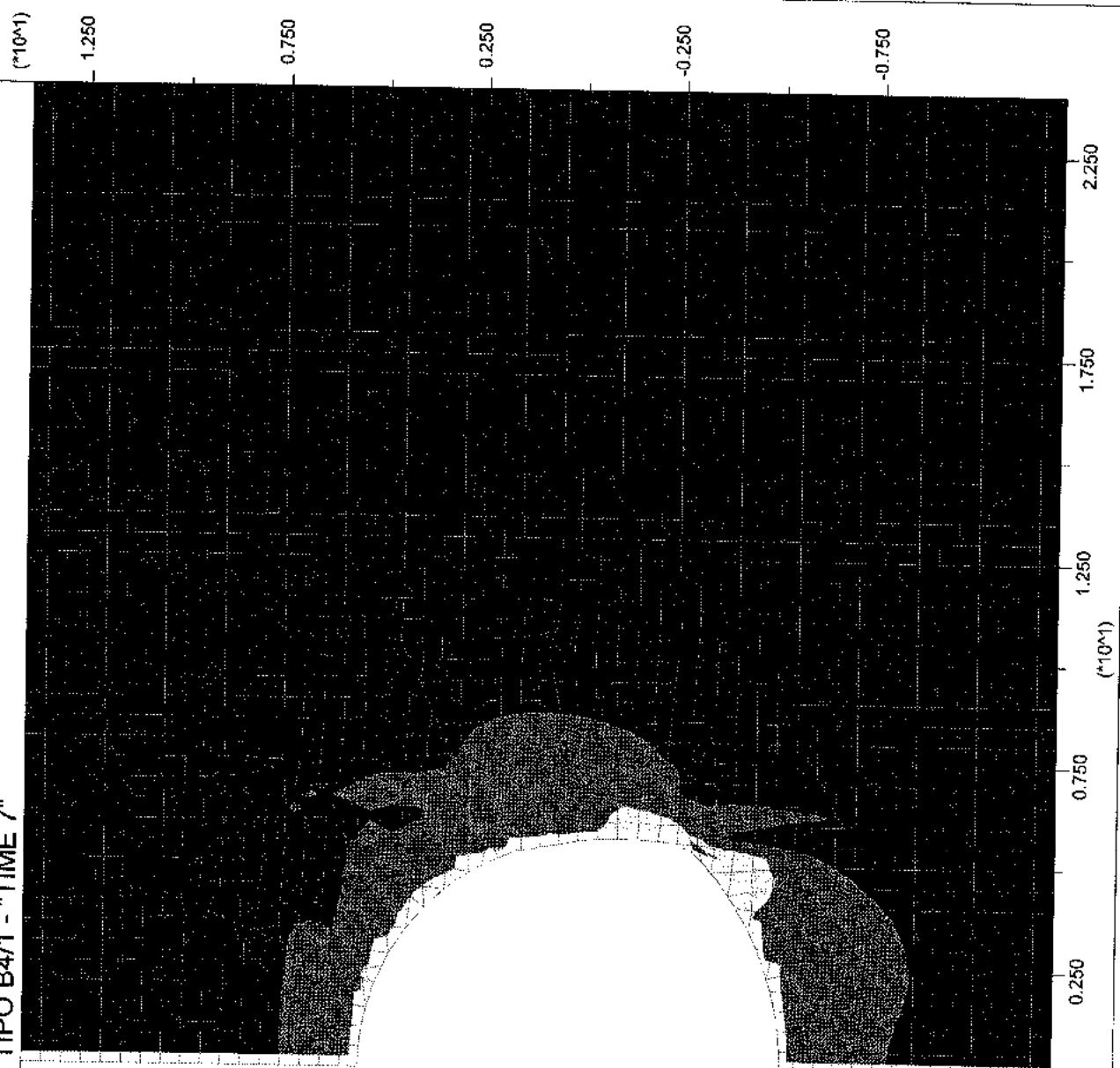
Contour interval= 2.00E-02

Deformazioni plastiche per taglio



0

5E 0



(*10^1)

1.250

0.750

0.250

-0.250

-0.750

2.250

1.750

1.250

0.750

0.250

(*10^1)

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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 7"

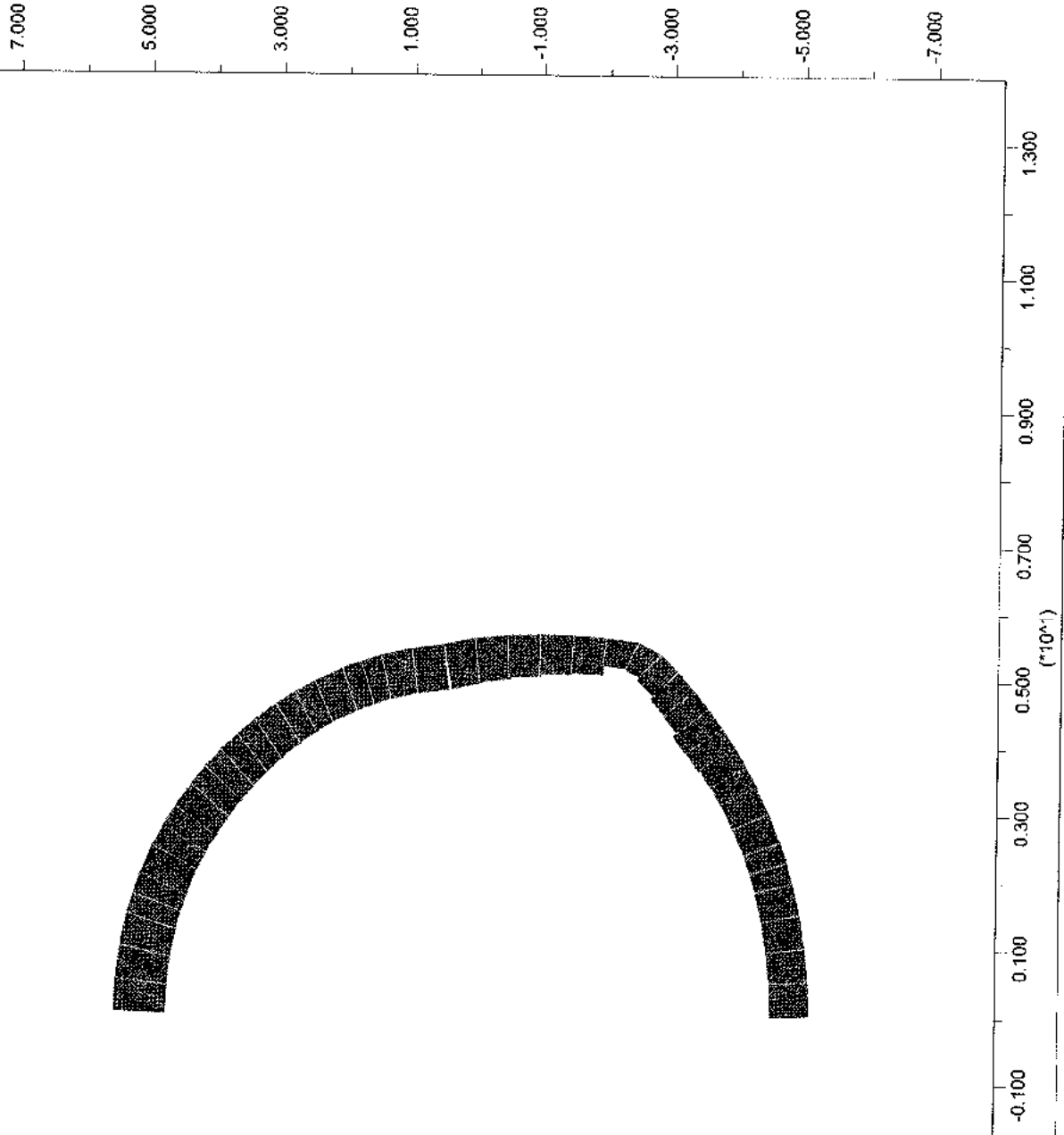
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:51
step 35019
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on
Structure Max. Value
1 (Beam) 3.248E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/1 - "TIME 7"

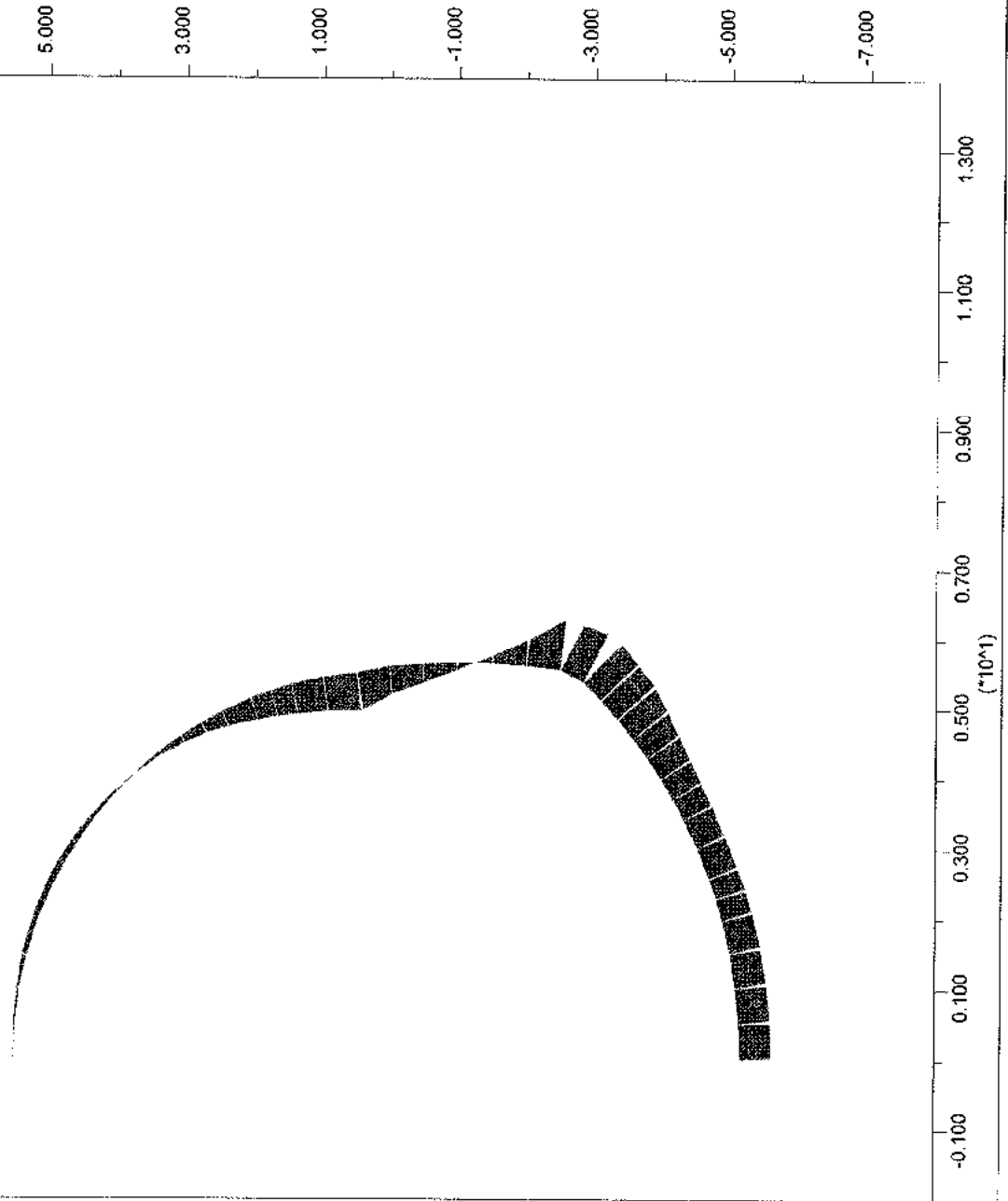
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:51
step 35019
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-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -6.058E+05



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Calcolo FLAC – Sezione tipo B4/2

ANALISI FLAC

Sezione tipo B4/2 - Ap gruppo 2

Input Analisi alle Differenze Finite FLAC

Geometria	
Copertura (m)	600,00
Altezza falda statica (m)	0,00
Coefficiente efficacia di innescio	0,20
Altezza falda dinamica (m)	0,00
Raggio scavo (m)	5,50

Materiali	
Spitz-beton	$E_{s,1}$ (MPa) 14000 $E_{s,2}$ (MPa) 28500 $f_{c,k}$ (cm ²) 2,25E+03
Centine	Tipologia IPN240 A (cm ²) 46,1 J_{x2} (cm ⁴) 4239,0
Revestimenti	$R_{s,1}$ (MPa) 30 $E_{s,max}$ (MPa) Armato D
A.R.	1,00 31220 5,0
Celofan	3,0 0,90 31220 9,0

Parametri geometrici	1° strato		2° strato	
	Picco	Residuo	Picco	Residuo
Valori di picco e residuo	2,7	2,7		
Peso di volume (KN/m ³)	32	30		
Angolo attrito (°)	1,00	0,9		
Coesione (MPa)	1,65	1,65		
Modulo elastico (GPa)	0,30	0,30		
Modulo di Poisson	1,38	1,38		
Modulo di deformazione volumetrica (Bulk modulus) (GPa)	0,63	0,63		
Modulo elastico tangenziale (Shear modulus) (GPa)				
Modello costitutivo	Strain-Softening			

Fasi di calcolo (TIME)	x (m)	x/R	RPanet	RDEM	Epre (MPa)	$E_{s,1}$ (MPa)
TIME 1 - Geostatico	-∞	-∞	0,000	0,000		
TIME 2 - Taratura e scavo	0,00	0,000	0,260	0,970		
TIME 3 - Posca centine e pre-spitz	1,00	0,179	0,570	0,974	14000	
TIME 4 - Installazione bulloni e completamento spitz	6,00	1,071	0,861	0,980	14000	
TIME 5 - Getto Murette e A.R. maturazione SB	20,00	3,571	0,974	0,980	34000	31220
TIME 6 - Getto calotta	40,00	7,143	0,982	1,000		31220
TIME 7 - Decadimento ammasso e preinvestimento	-∞	-∞	1,000	1,000		

Relazione per il calcolo di RPanet, RDEM:

$$R = u_0 + (r \cdot \omega - u_0) \cdot \left[\frac{1 - \frac{x}{R_p}}{1 - 0,84 \cdot R_p} \right]$$

- R = Convergenza radiale ad una distanza di x metri dal fronte espressa come % di u_0
- u_0 = Convergenza radiale in corrispondenza del fronte espressa come % di u_0
- ω = Convergenza radiale ad una distanza infinita dal fronte
- R_p = Raggio Panet
- R = Raggio della galleria
- x = distanza fra il fronte e la sezione di calcolo

TIMES DI CALCOLO	
TIME 1 - Geostatico	Viene applicato il peso proprio del terreno, ricostruendo in termini di tensioni costache la situazione preesistente in scavo della galleria
TIME 2 - Taratura e scavo	Viene simulato l'arrivo dal fronte di scavo tenendo in conto il contributo dei consolidamenti
TIME 3 - Posca centine e pre-spitz	Viene simulata la posa in opera delle centine e dello strato di 5 cm di spitz-beton
TIME 4 - Installazione bulloni e completamento spitz	Viene simulata la posa in opera dei bulloni ed il completamento dello spitz-beton
TIME 5 - Getto Murette e A.R. maturazione SB	Viene simulato il getto delle murette e dell'arco rovescio, la maturazione dello spitz e l'avanzamento dello scavo.
TIME 6 - Getto calotta	Si simula il getto del rivestimento distribuito a calotta
TIME 7 - Decadimento ammasso e preinvestimento	Si applica un deaullimento delle caratteristiche meccaniche del preinvestimento e dell'ammasso

LEGENDA SIMBOLI

- $f_{c,k}$ = resistenza media cilindrica a compressione dello spitz-beton
- s = spessore dello spitz-beton
- $E_{s,1}$ = modulo elastico inferiore dello spitz-beton
- $E_{s,2}$ = modulo elastico superiore dello spitz-beton
- $f_{c,t}$ = resistenza di inerzia dello spitz-beton
- n = numero di centine per gruppo
- p = passo centine
- A_s = area del profilo della singola centina
- h = altezza del profilo centina
- J_{x2} = momento di inerzia del profilo della singola centina
- $R_{s,1}$ = resistenza caratteristica cubica a compressione del c/c
- S = spessore del rivestimento definitivo
- $E_{s,max}$ = modulo elastico del c/c riarmato
- D = Distanza di getto fra investimenti definitivi e fronte (moltiplo del diametro della galleria)
- E_{pre} = modulo elastico del preinvestimento

JOB TITLE : Sezioni di verifica - Prerivestimento

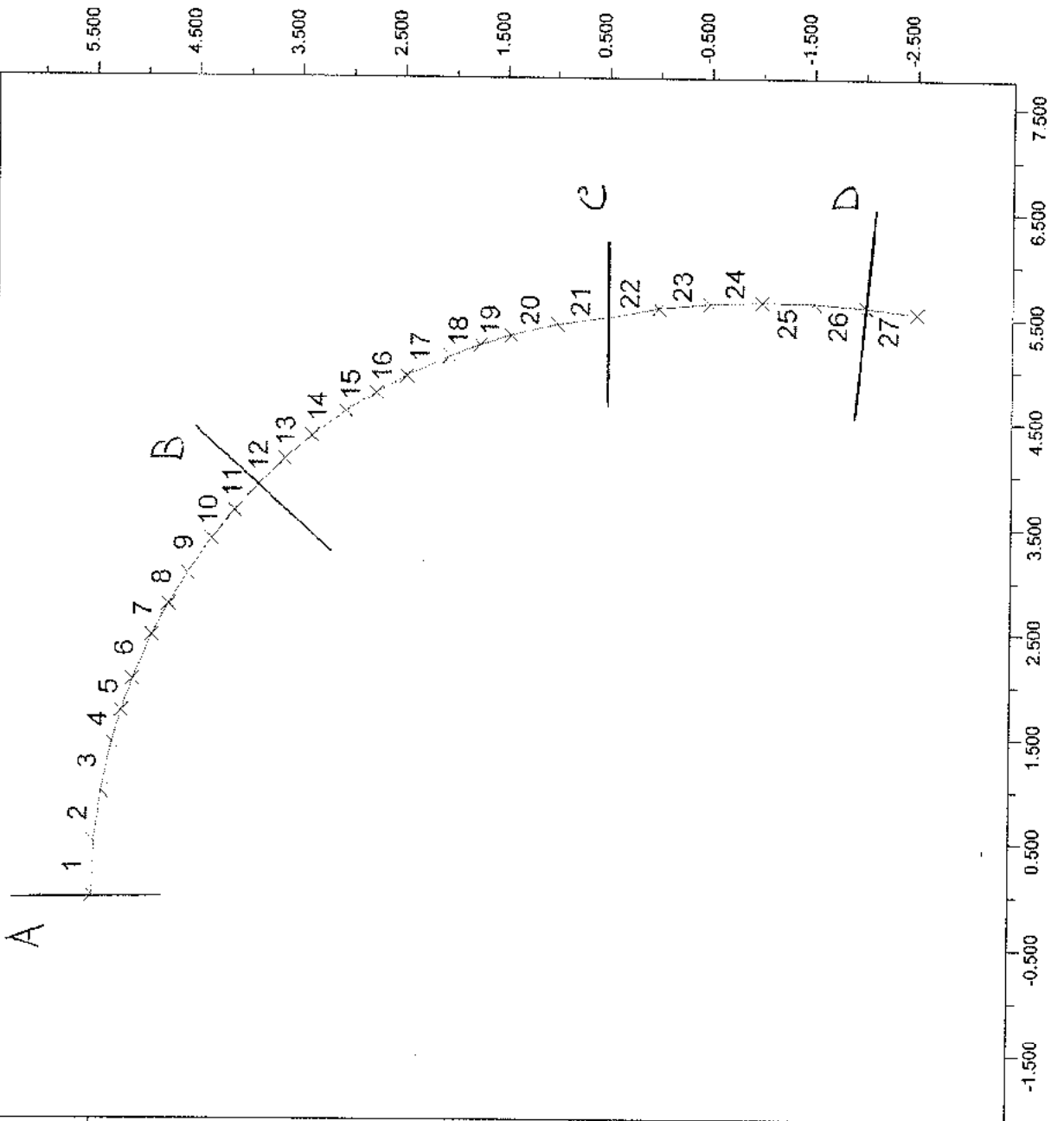
FLAC (Version 4.00)

LEGEND

19-Feb-04 9:42
step 20395
-2.121E+00 <x< 7.770E+00
-3.438E+00 <y< 6.454E+00

Beam Plot
Structural Element Numbers

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



Sezione tipo B4/2 - Ap gruppo 2

Verifica del prerivestimento

CARATTERISTICHE GEOMETRICHE E MECCANICHE

MATERIALI	Tipo	σ_{max} (MPa)	H (cm)	Passo (m)	n^*	A (cm ²)	I (cm ⁴)
Spritz-beton	Fcm 25	19.20	30	-	-	3000.0	2250.0
Centine	IPN240	210	24.00	1.00	2.00	46.1	4239.0
Sezione omogeneizzata						4290.8	129064.4

Coefficiente omogeneizzazione m 15
 Baricentro centina d (cm) 12.00 dall'estradosso
 Baricentro sezione omogeneiz. Yg (cm) 14.10 dall'estradosso
 e'lim,e = I'/(A*Yg) (cm) 2.13 dimensione nocciolo d'inerzia estradosso
 e'fim,i = I'/(A*(H-Yg)) (cm) 1.89 dimensione nocciolo d'inerzia intradosso

e = M/N eccentricità

Fomule impiegate

$$\sigma_{sb,i} = N/A^* + (M(H-Yg))/I^* \quad \sigma_{sb,e} = N/A^* - (MYg)/I^*$$

$$\sigma_{s,j} = m(N/A^* + M(d+H_s/2-Yg)/I^*)$$

$$\sigma_{s,e} = m(N/A^* - M(d-H_s/2-Yg)/I^*)$$

Tensioni positive se di compressione

Sezione	Elemento	Altezza (m)	N (KN/m)	M (KN*m/m)	e (m)	$\sigma_{sb,i}$ (Mpa)	$\sigma_{sb,e}$ (Mpa)	$\sigma_{s,j}$ (Mpa)	$\sigma_{s,e}$ (Mpa)
CHIAVE CALOTTA	1	0.30	1447	3.9	0.00	3.65	2.95	55.07	44.20
RENI	11	0.30	1363	4.3	0.00	3.71	2.71	52.60	40.60
P.C.	22	0.30	1155	-21.9	-0.02	-0.01	5.08	15.17	76.26
PIEDE	27	0.30	538	-6.0	-0.01	0.51	1.91	11.90	28.64

CHIAVE CALOTTA	1	0.30	2875	10.5	0.00	7.99	5.55	112.59	83.30
RENI	11	0.30	2099	19.6	0.01	8.71	4.15	116.91	62.24
P.C.	22	0.30	2101	-80.7	-0.04	-5.05	13.71	-19.43	205.67
PIEDE	27	0.30	893	-39.6	-0.04	-2.80	6.41	-14.36	96.10

TIME 4

TIME 5

JOB TITLE : Riv. definitivo - Sezioni di verifica

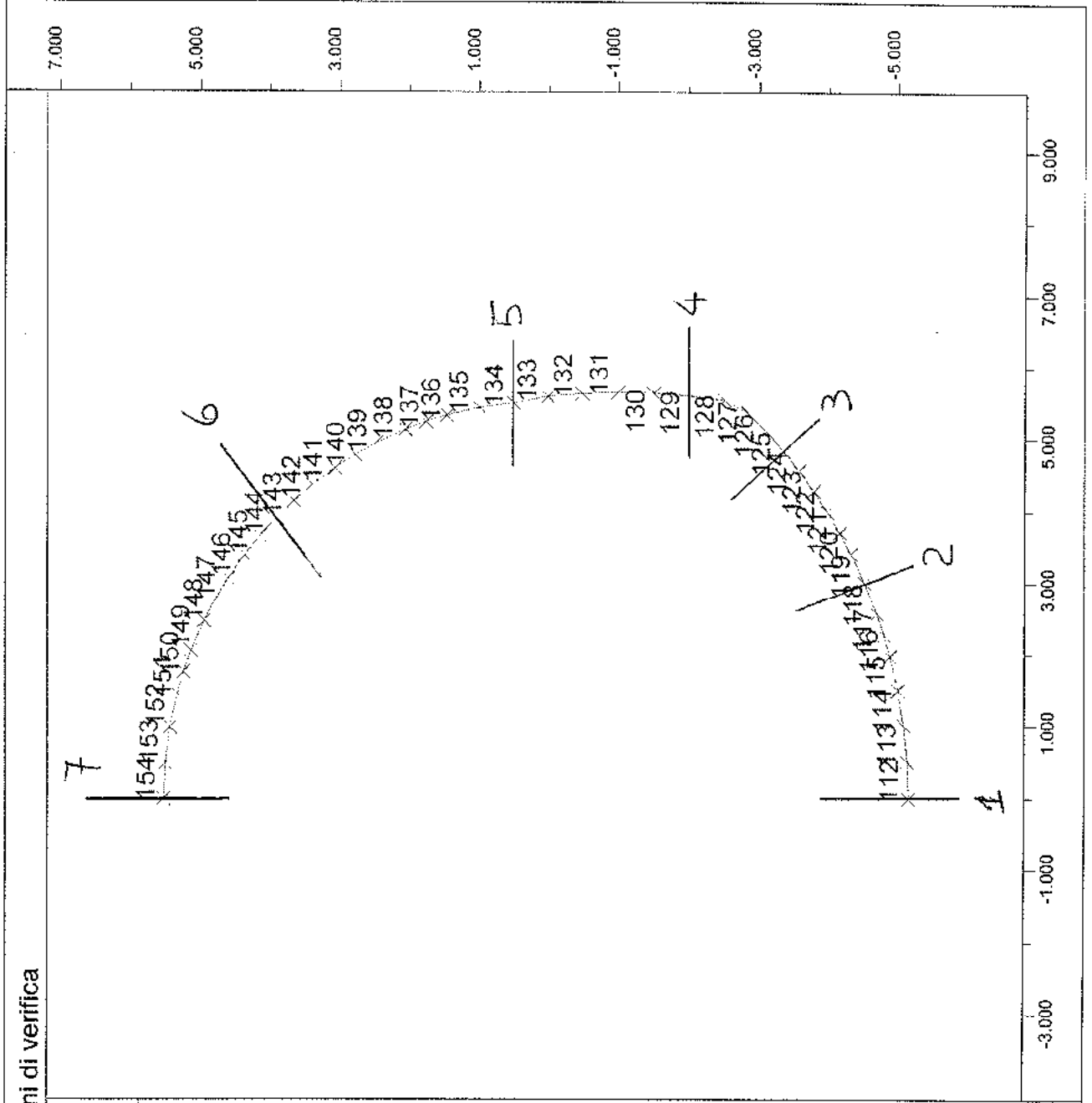
FLAC (Version 4.00)

LEGEND

20-Feb-04 10:51
step 35019
-4.181E+00 <x< 9.830E+00
-6.824E+00 <y< 7.187E+00

Beam Plot
Structural Element Numbers

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



Sezione tipo B4/2 - Ap gruppo 2
Verifica del rivestimento definitivo

TIME 5 - Getto Murette e A.R., maturazione SB

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	112	1.00	1933	-631.1	-0.33	7.4
SEZIONE INTERMEDIA A.R.	118	1.00	1644	-520.8	-0.32	6.0
ATTACCO A.R. - MURETTA	124	1.00	1517	-352.7	-0.23	3.8

TIME 6 - Getto calotta

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	112	1.00	2555	-541.1	-0.21	5.9
SEZIONE INTERMEDIA A.R.	118	1.00	2489	-462.6	-0.19	5.3
ATTACCO A.R. - MURETTA	124	1.00	2403	-477.4	-0.20	5.3
ATTACCO CAL. - MURETTA	129	0.90	676	-139.3	-0.21	1.9
PIANO DEI CENTRI	133	0.90	648	150.0	0.23	2.0
RENI	143	0.90	627	-168.5	-0.27	2.3
CHIAVE CALOTTA	154	0.90	621	-7.7	-0.01	0.7

TIME 7 - Decadimento ammasso e prinvestimento

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)
CHIAVE A.R.	112	1.00	2973	-502.3	-0.17	6.0
SEZIONE INTERMEDIA A.R.	118	1.00	2940	-458.7	-0.16	5.7
ATTACCO A.R. - MURETTA	124	1.00	2971	-686.1	-0.23	7.3
ATTACCO CAL. - MURETTA	129	0.90	2596	-322.1	-0.12	5.3
PIANO DEI CENTRI	133	0.90	3266	488.3	0.15	7.3
RENI	143	0.90	3548	-12.8	0.00	4.0
CHIAVE CALOTTA	154	0.90	3737	-14.2	0.00	4.3

Sezione tipo B4/2 - Ap gruppo 2

Output Analisi alle Differenze Finite FLAC

TIME	Riduzione forze di scavo [%]	Spostamento y in chiave calotta		Spostamento x sul piano dei centri		Spostamento y in chiave A.R.		Tensioni prev.		Tensioni Riv. def.
		[cm]	Nodo I=1 J=68	[cm]	Nodo I=12 J=57	[cm]	Nodo I=1 J=47	$\sigma_{SB,max}$ [MPa]	$\sigma_{S,max}$ [MPa]	$\sigma_{cis,max}$ [MPa]
TIME 1 - Geostatico	0.0	-	-	-	-	-	-	-	-	-
TIME 2 - Taratura e scavo	94.5	25.1	-	24.7	-	23.0	-	-	-	-
TIME 3 - Posa centina e pre-spritz	96.0	25.3	-	25.1	-	23.5	-	-	-	-
TIME 4 - Installazione bulloni e completamento spritz	98.0	25.5	-	25.4	-	24.4	5.08	76.26	-	-
TIME 5 - Getto Murette e A.R., maturazione SB	99.0	25.6	-	25.9	-	25.5	13.71	205.67	7.4	7.4
TIME 6 - Getto calotta	100.0	25.6	-	25.9	-	25.6	-	-	5.9	5.9
TIME 7 - Decadimento ammasso e pririvestimento	100.0	25.5	-	26.0	-	25.6	-	-	7.3	7.3

Materiale	Tipo	Tensioni ammissibili [MPa]	
Spritz-beton	fcm	25	19.20
Centina	Fe	430	210
Calcestruzzo	Rck	30	7.50

Tensioni positive nel cis : compressione

Tensioni positive nell'acciaio : trazione

Spostamenti x positivi verso destra, spostamenti y positivi verso l'alto

JOB TITLE : Cunicolo Castagnola (Ap gruppo 2) - SEZ. TIPO B4/2

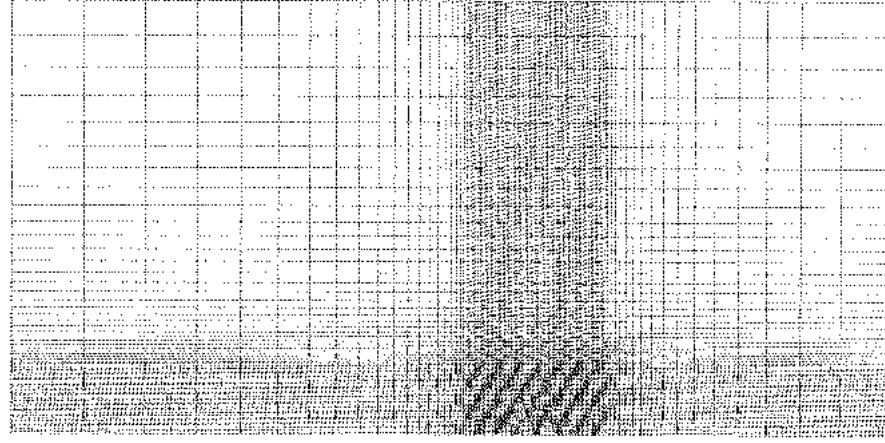
FLAC (Version 4.00)

LEGEND

19-Feb-04 14:52
step 9523
-1.067E+02 <x< 2.267E+02
-1.417E+02 <y< 1.917E+02

MESH DI CALCOLO

0
1E 2



(*10^2)

1.500

1.000

0.500

0.000

-0.500

-1.000

-0.750

-0.250

0.250

0.750

1.250

1.750

(*10^2)

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JOB TITLE : Cunicolo Castagnola (Ap gruppo 2) - SEZ. TIPO B4/2

FLAC (Version 4.00)

LEGEND

19-Feb-04 14:52

step 9523

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

MESH DI CALCOLO

0

5E 0

(*10^1)

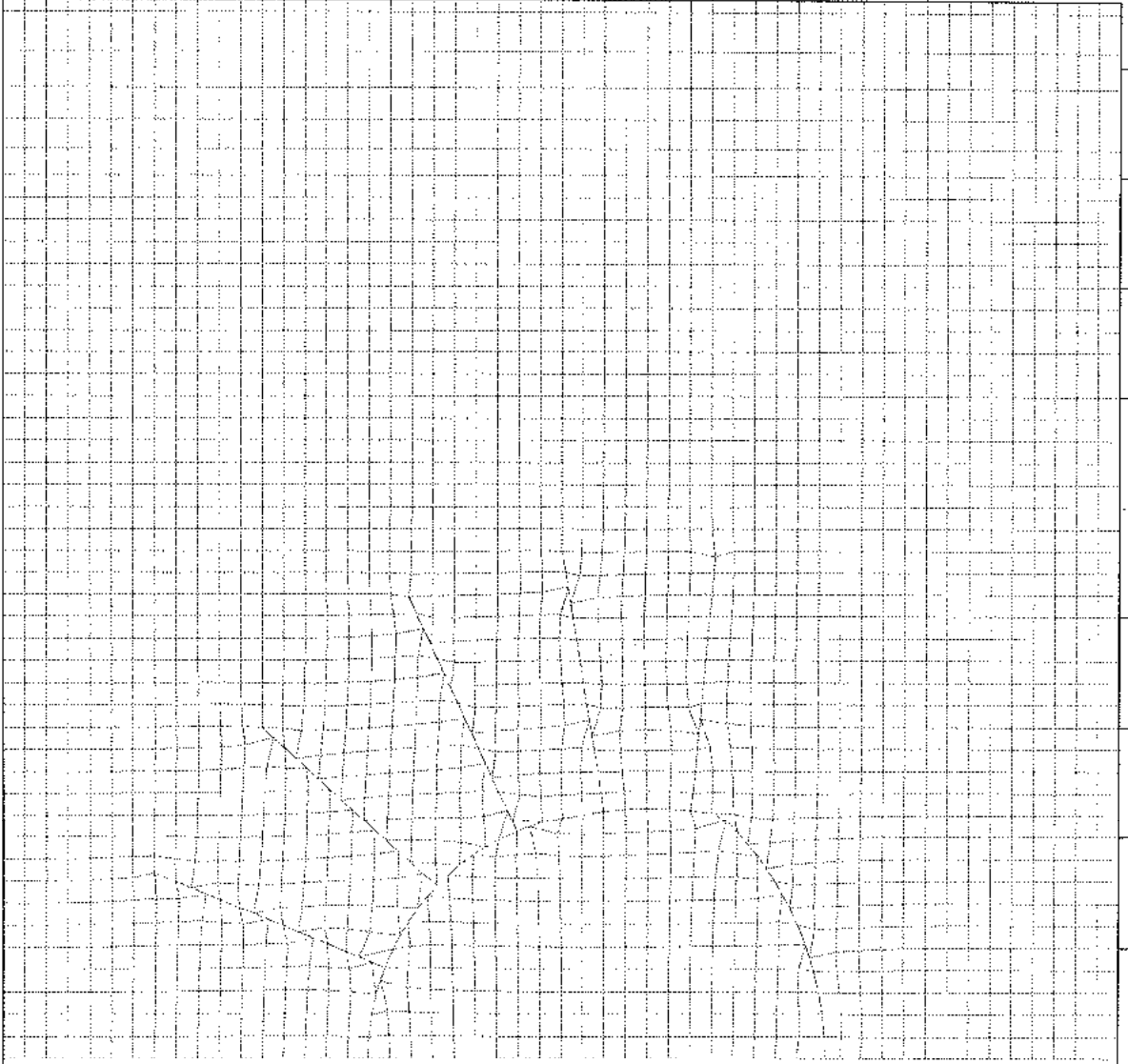
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 1"

FLAC (Version 4.00)

LEGEND

19-Feb-04 14:52

step 9523

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Principal stresses

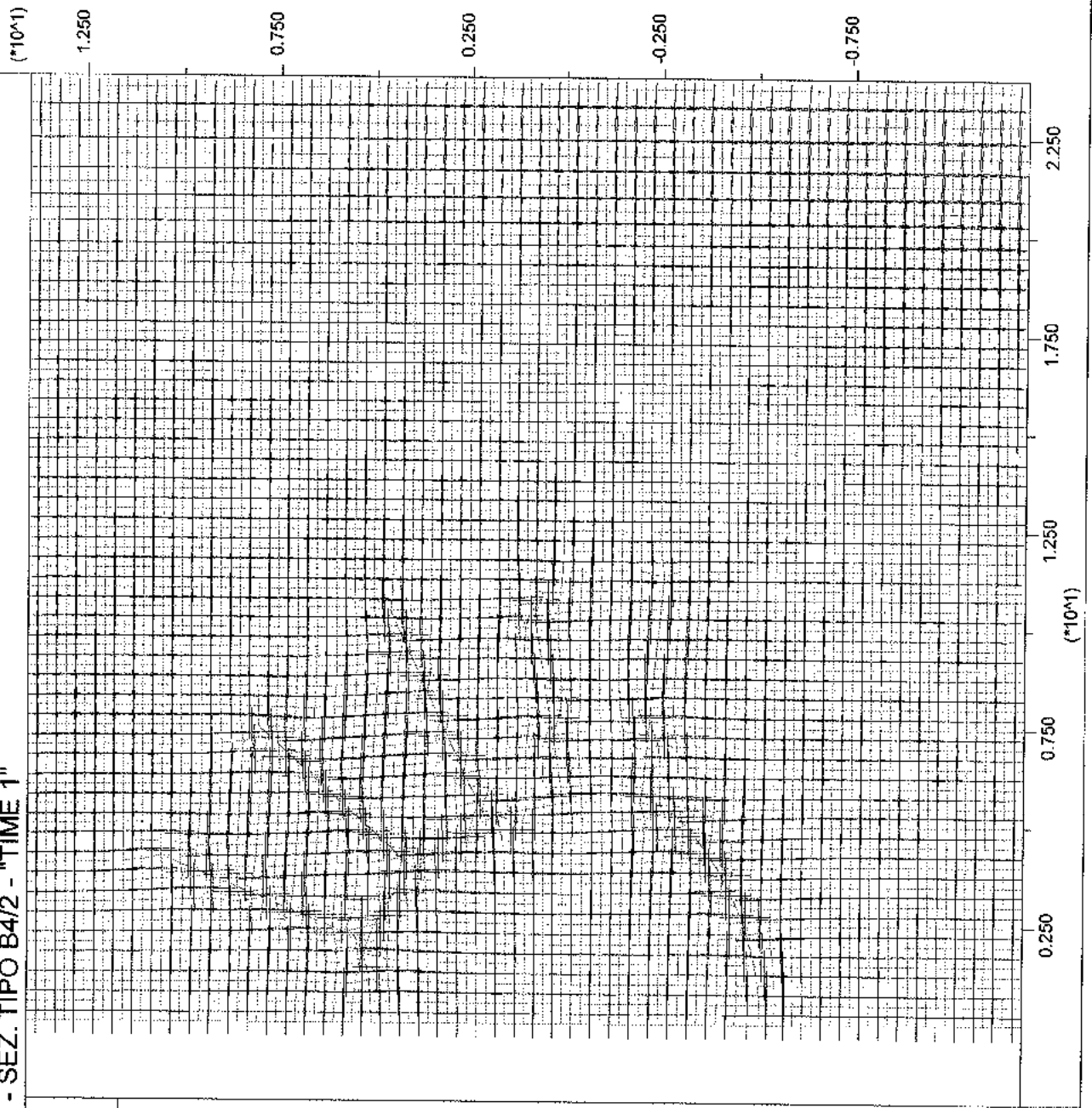
Max. Value = -1.559E+07

Min. Value = -1.640E+07

0 1E 8

Tensioni principali : Pa

0 5E 0



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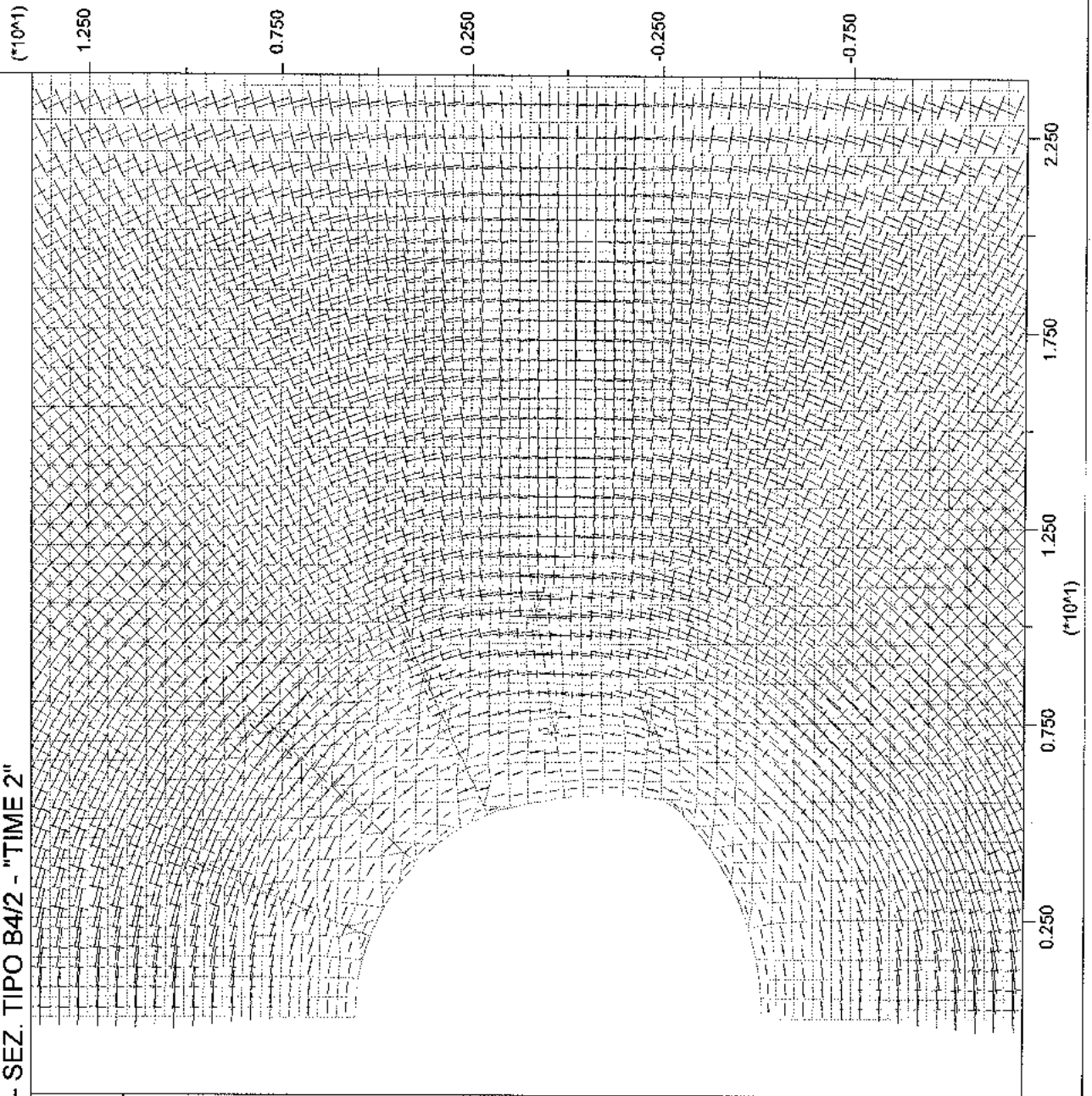
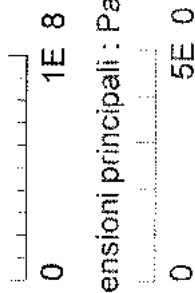
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 2"

FLAC (Version 4.00)

LEGEND

19-Feb-04 15:55
step 20909
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses
Max. Value = -5.330E+05
Min. Value = -2.665E+07



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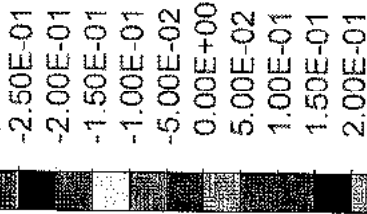
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 2"

FLAC (Version 4.00)

LEGEND

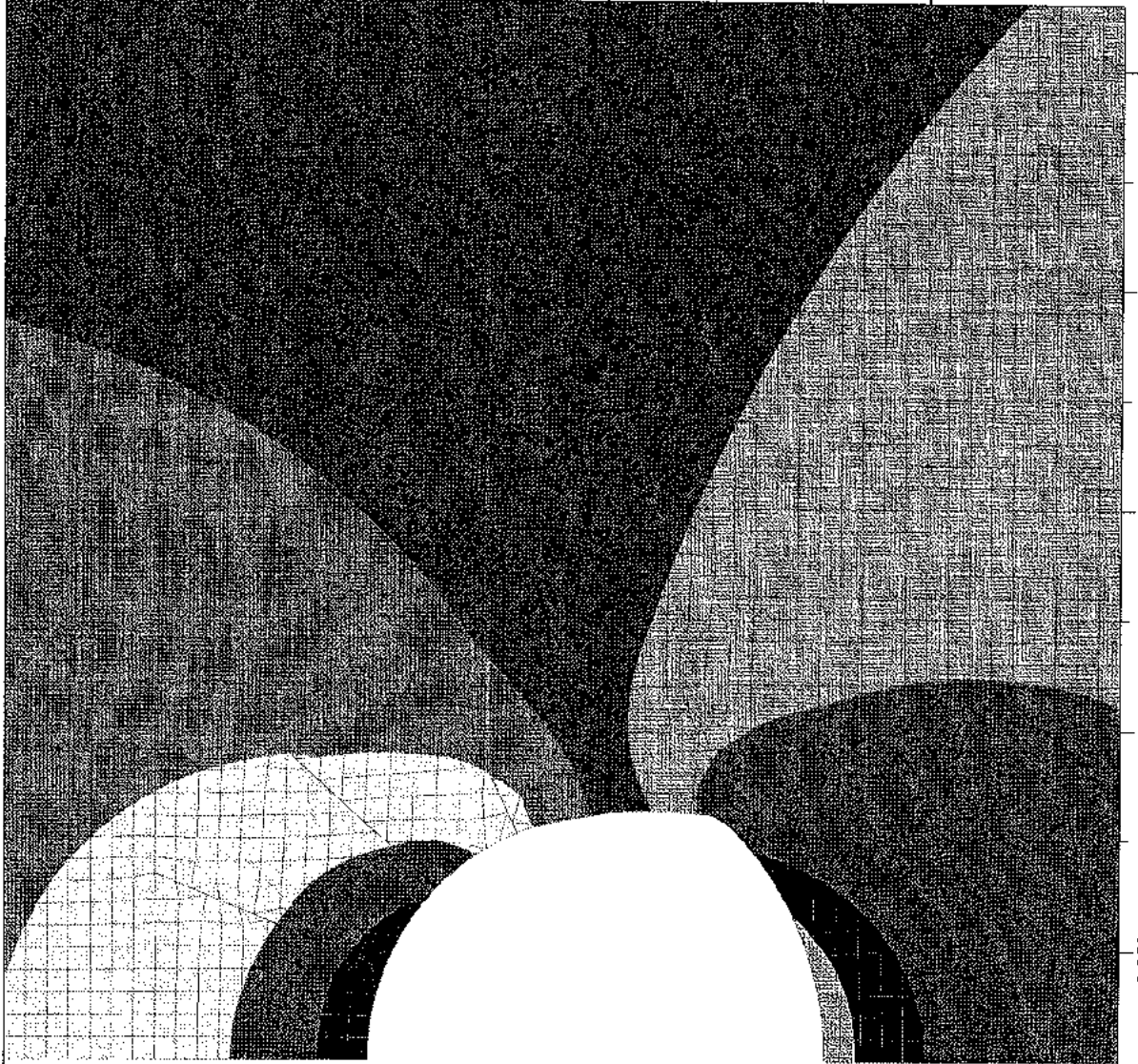
19-Feb-04 15:55
step 20909
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 5.00E-02

Spostamenti verticali



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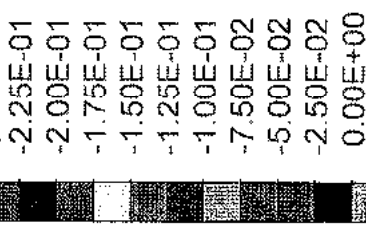
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 2"

FLAC (Version 4.00)

LEGEND

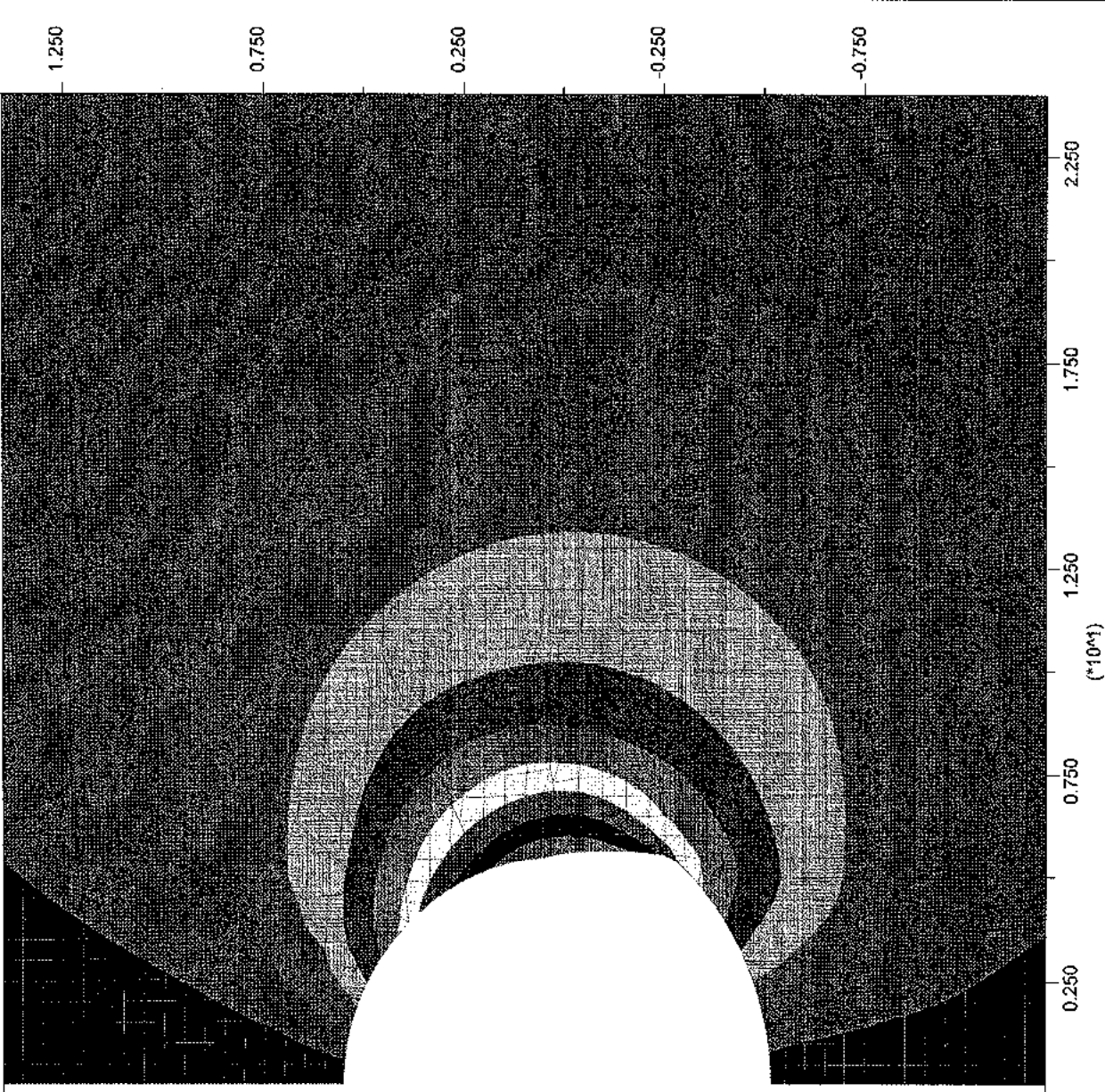
19-Feb-04 15:55
step 20909
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02

Spostamenti orizzontali



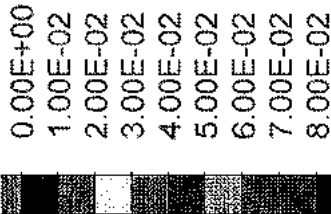
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 2"

FLAC (Version 4.00)

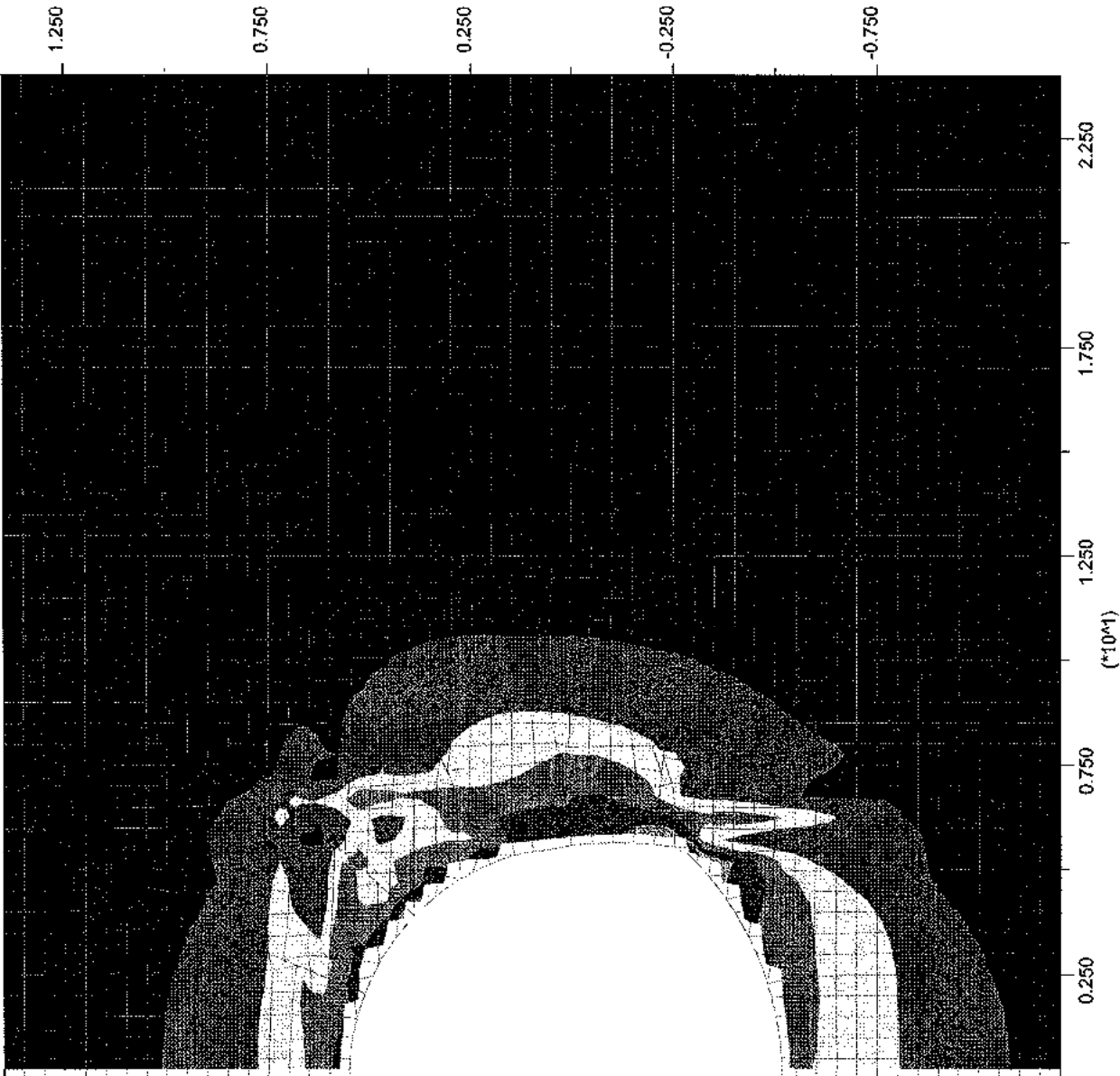
LEGEND

19-Feb-04 15:55
step 20909
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



(*10^1)

1.250

0.750

0.250

-0.250

-0.750

2.250

1.750

1.250

0.750

0.250

(*10^1)

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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

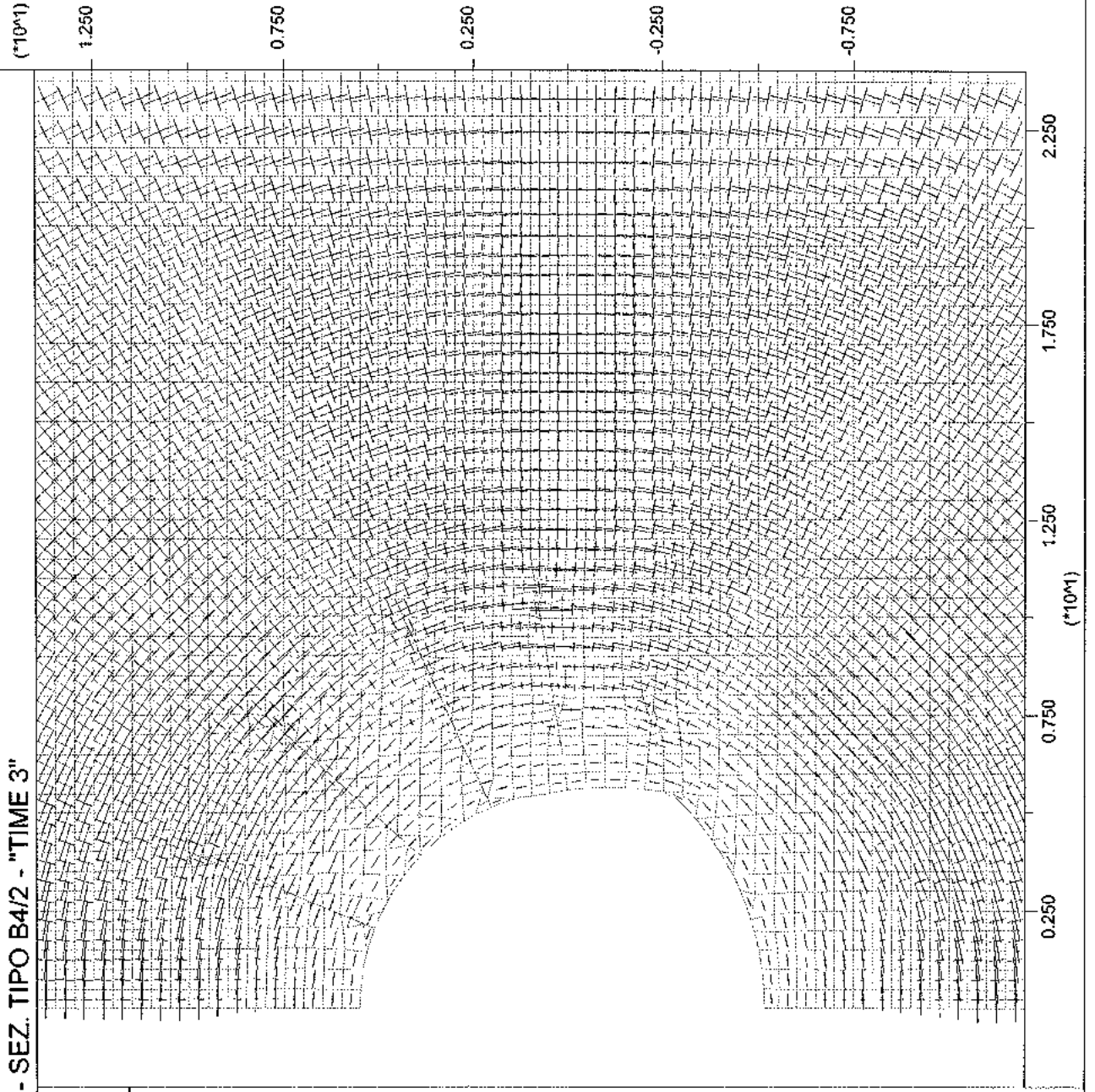
19-Feb-04 15:56
step 22210
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -4.881E+05
Min. Value = -2.666E+07



Tensioni principali : Pa



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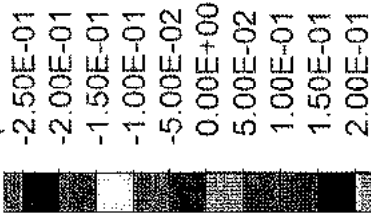
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

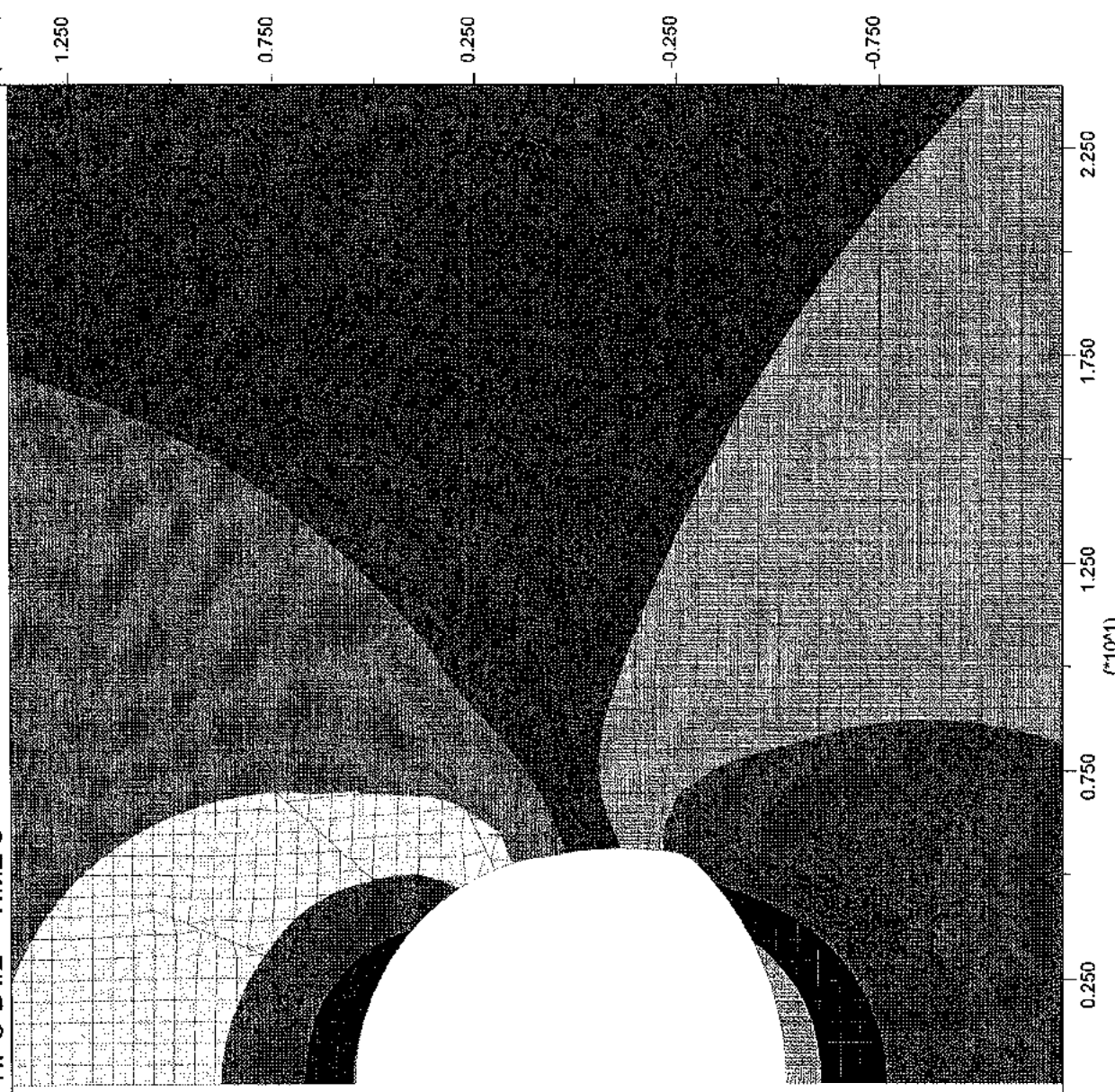
19-Feb-04 15:56
step 22210
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 5.00E-02

Spostamenti verticali



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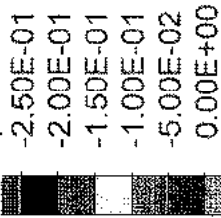
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

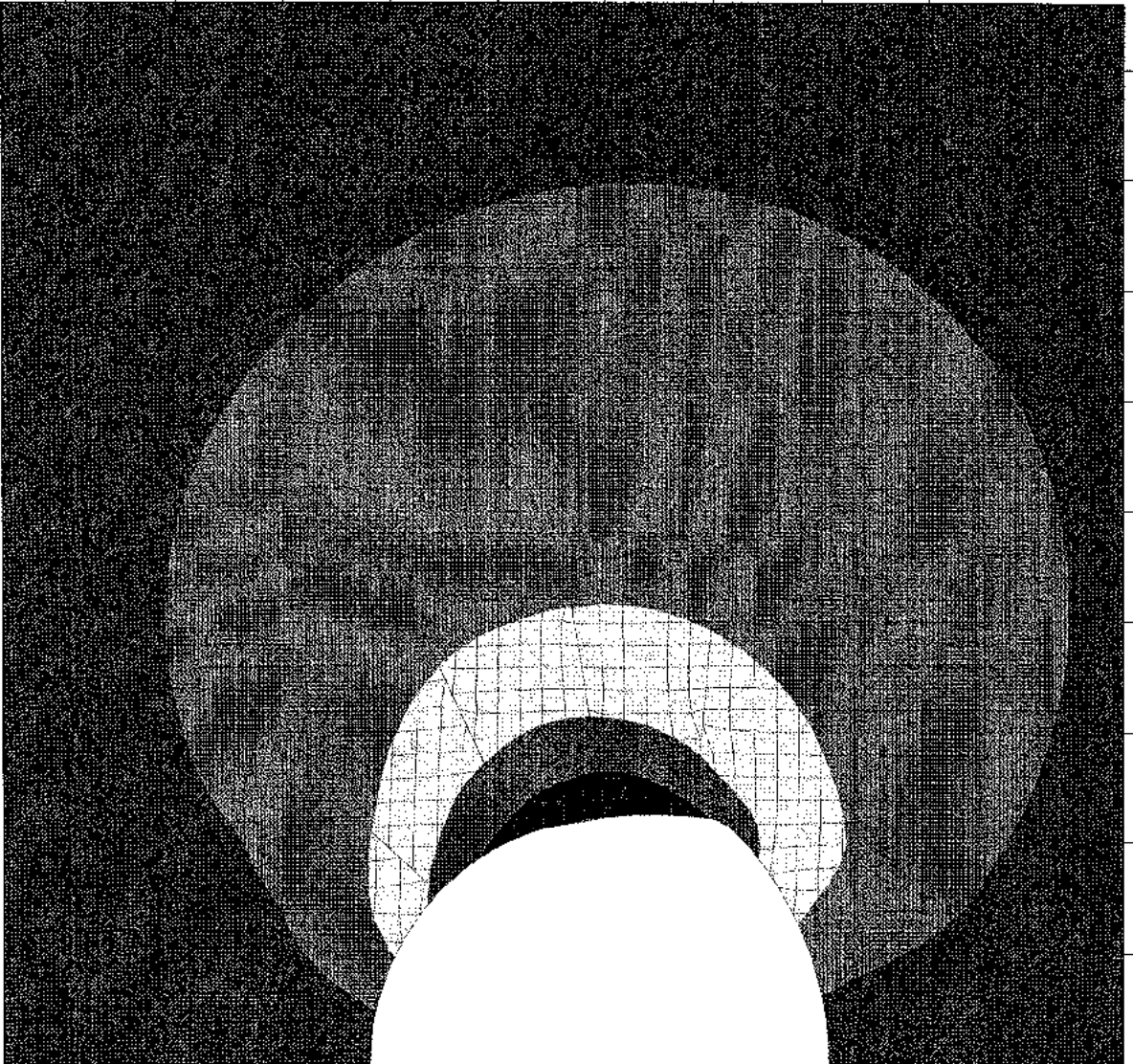
19-Feb-04 15:56
step 22210
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02

Spostamenti orizzontali



(*10^m)

1.250

0.750

0.250

-0.250

-0.750

2.250

1.750

1.250

0.750

0.250

(*10^m)

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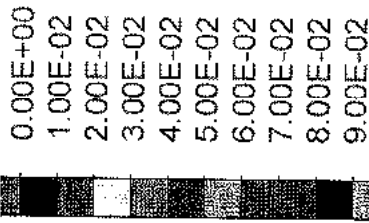
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 3"

FLAC (Version 4.00)

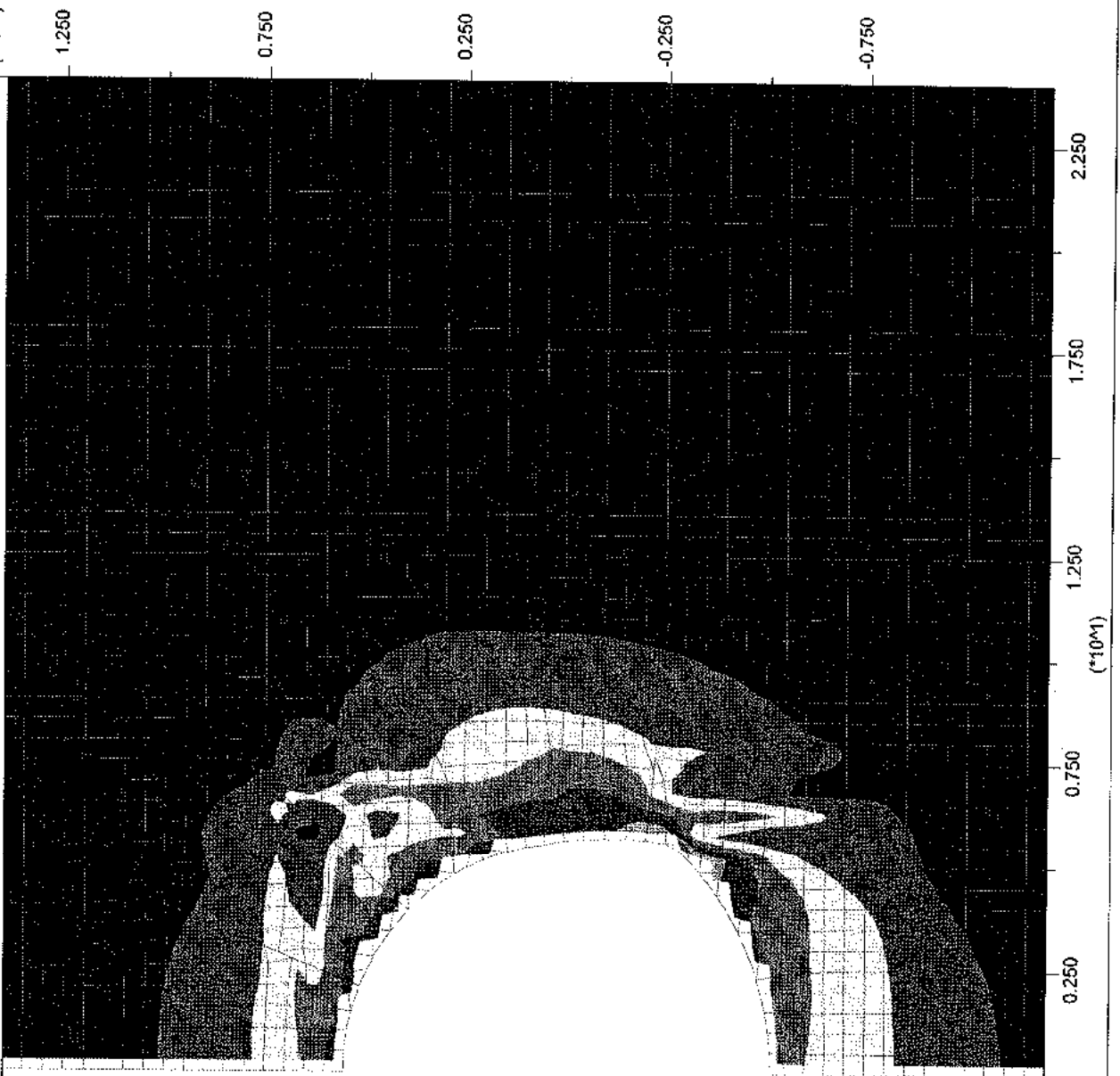
LEGEND

19-Feb-04 15:56
step 22210
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 3"

FLAC (Version 4.00)

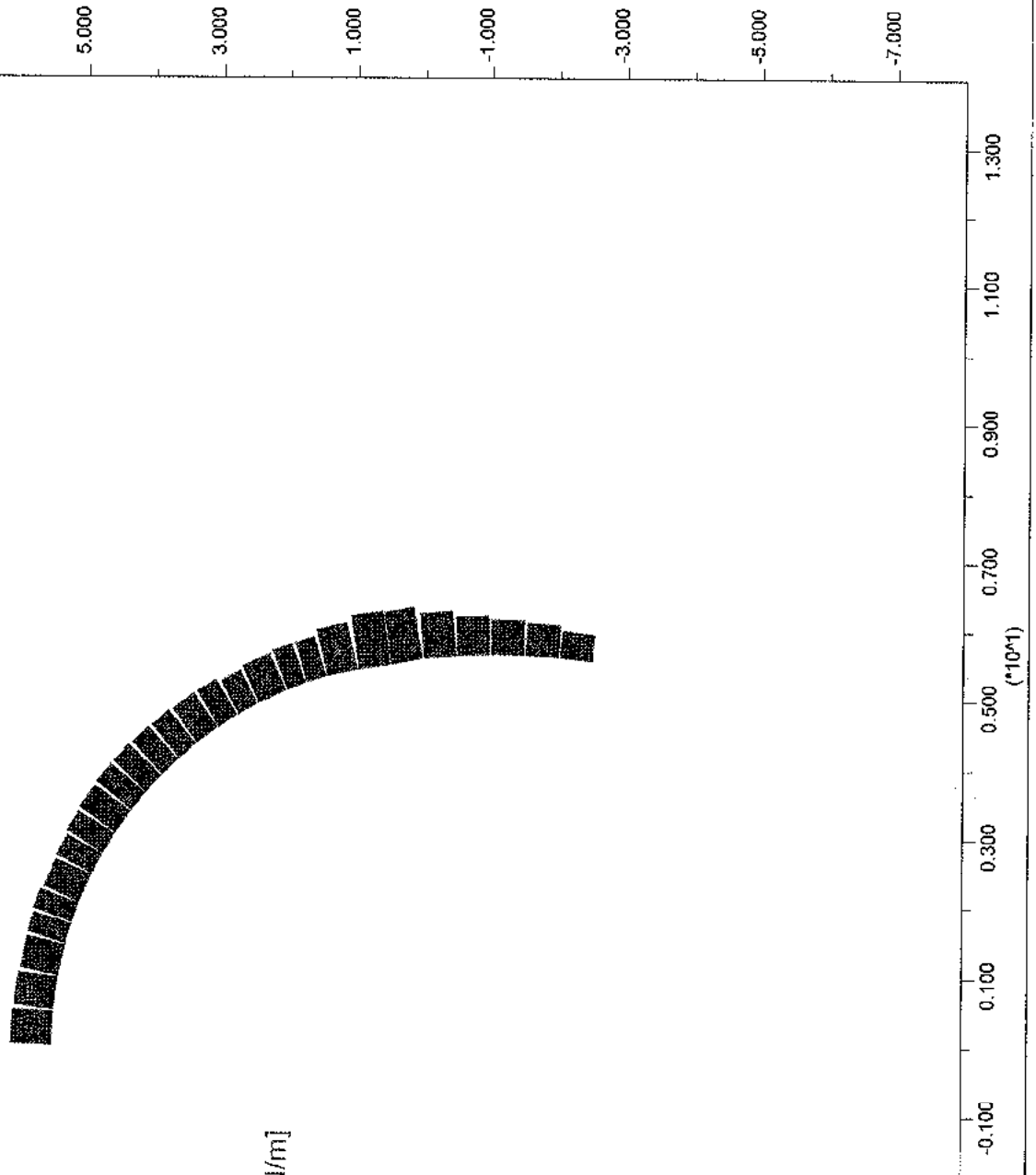
LEGEND

19-Feb-04 15:56
step 22210
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. (primo strato) Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
1 (Beam) 4.335E+05



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 3"

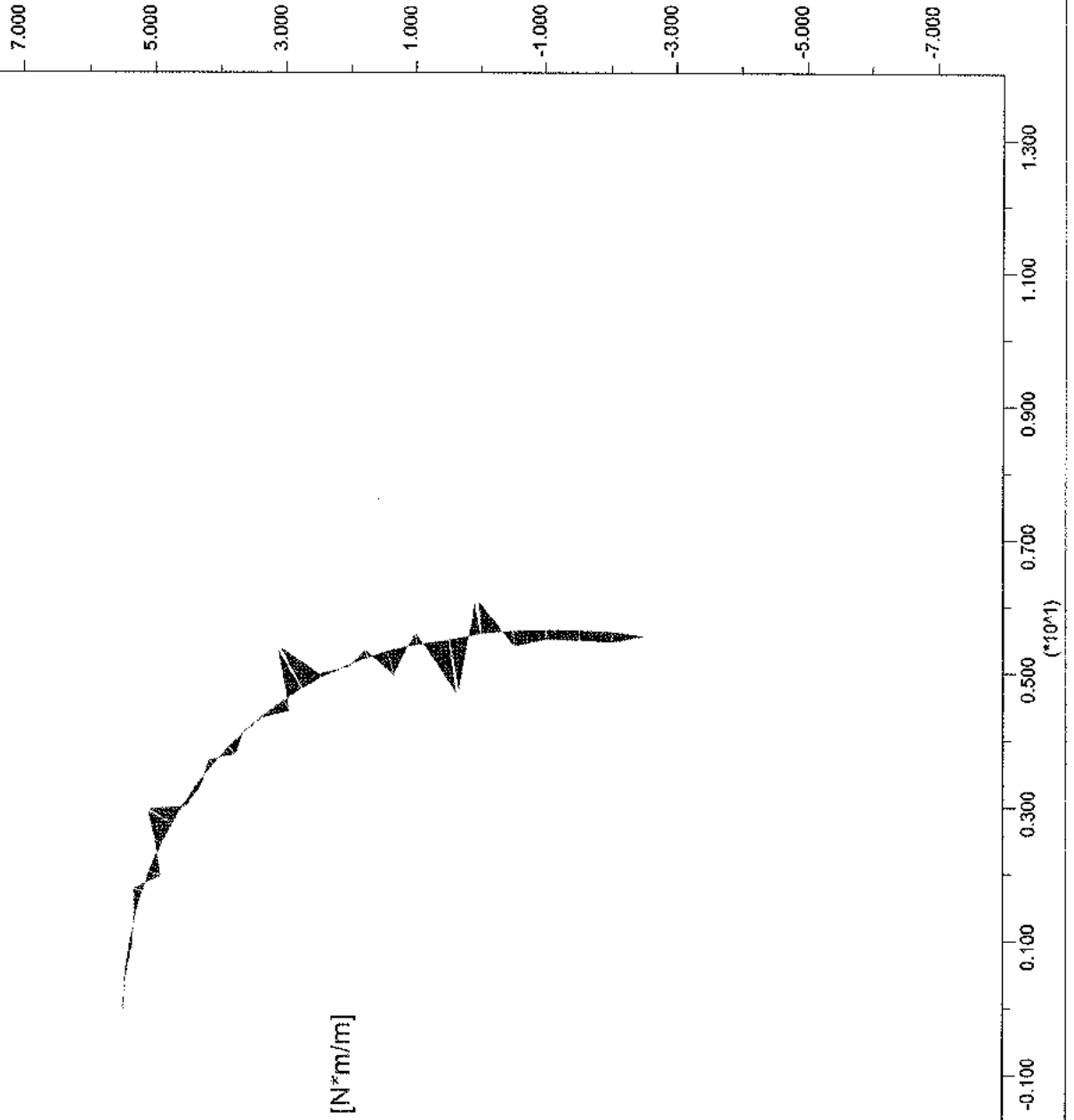
FLAC (Version 4.00)

LEGEND

19-Feb-04 15:56
step 22210
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Priv. (primo strato) Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -3.312E+02



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 4"

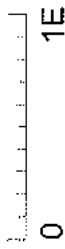
FLAC (Version 4.00)

LEGEND

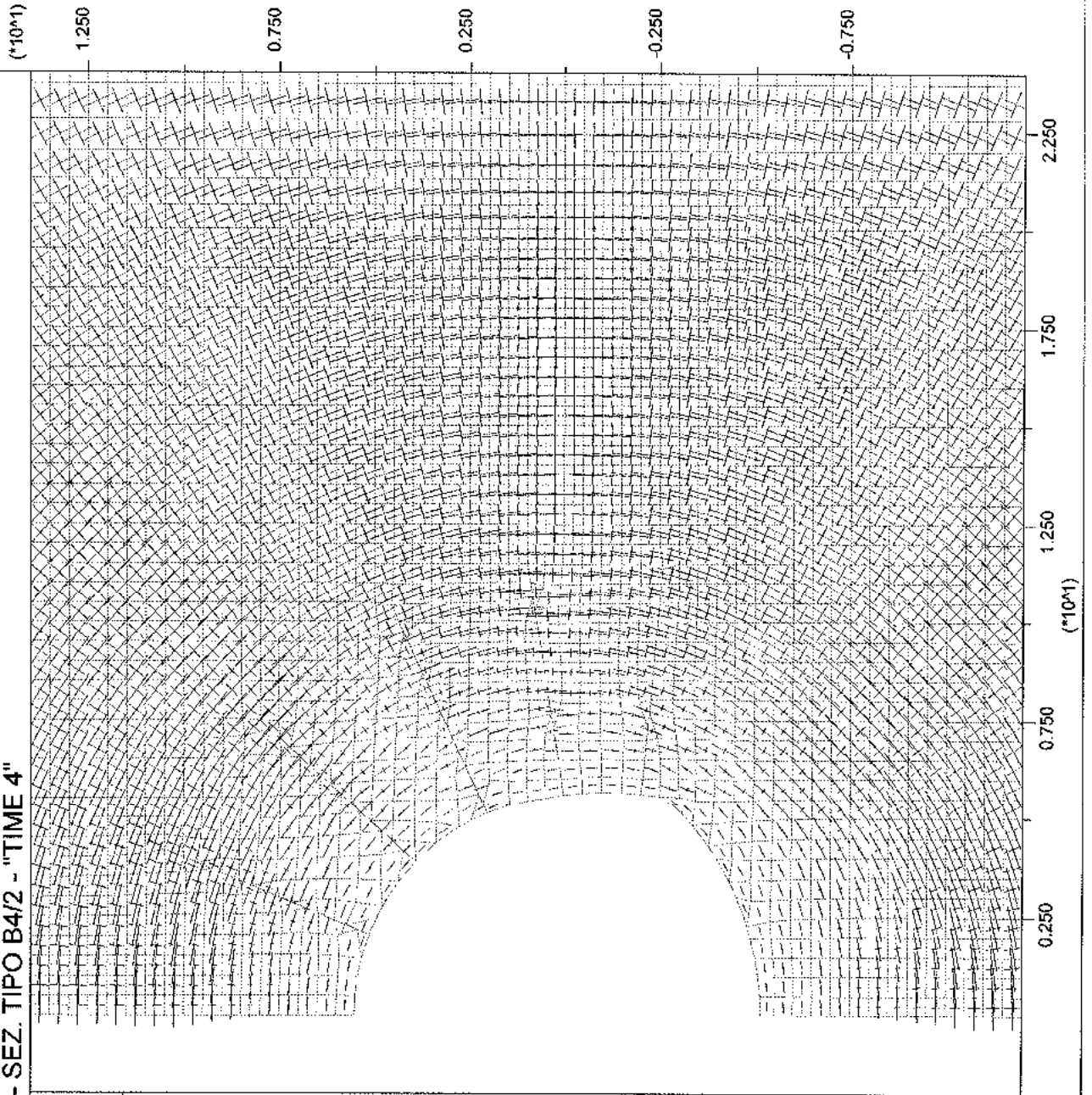
19-Feb-04 15:57
step 27191
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -3.806E+05
Min. Value = -2.665E+07



Tensioni principali : Pa



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 15:57

step 27191

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Y-displacement contours

-2.50E-01

-2.00E-01

-1.50E-01

-1.00E-01

-5.00E-02

0.00E+00

5.00E-02

1.00E-01

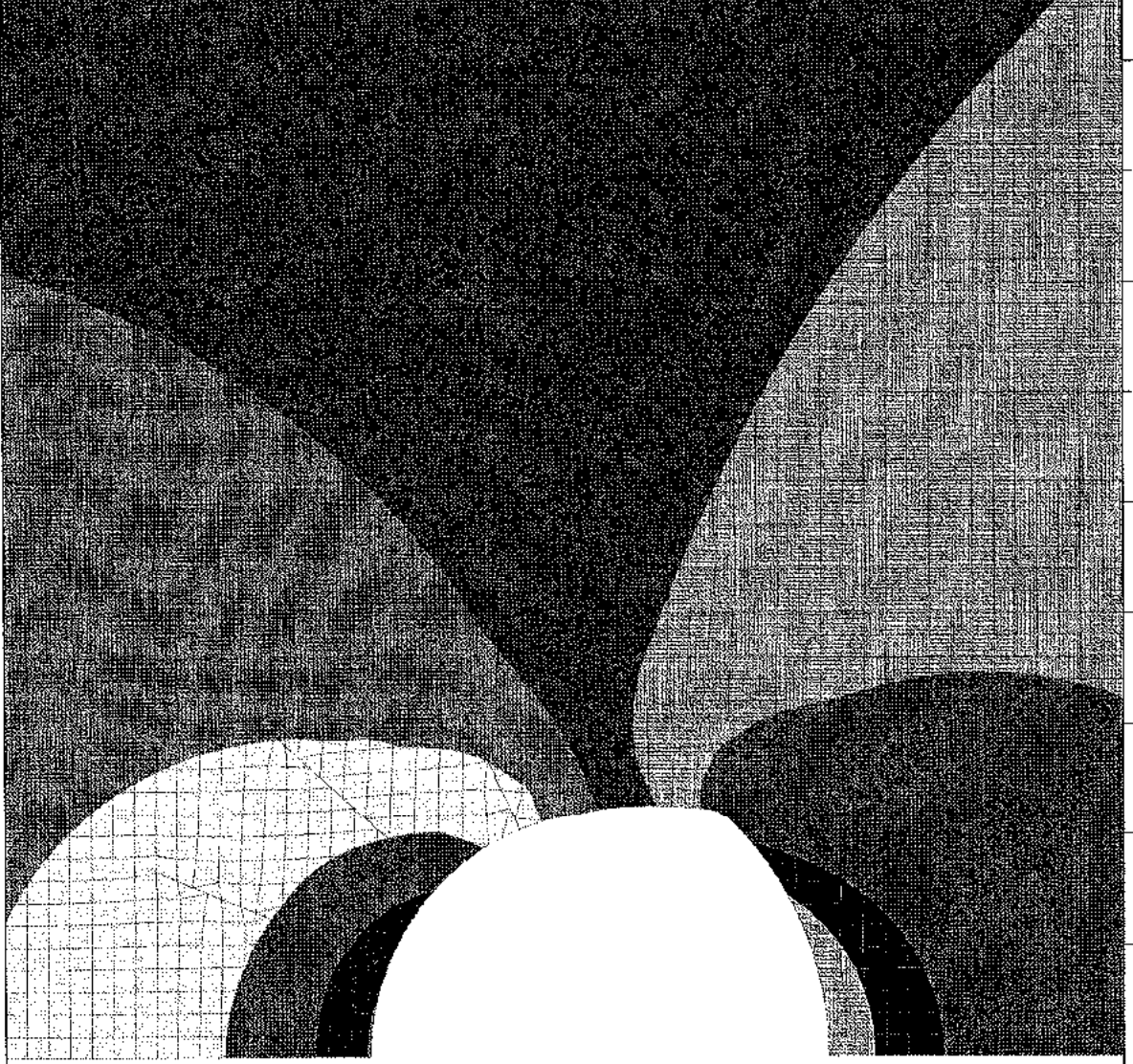
1.50E-01

2.00E-01

Contour interval= 5.00E-02

Spostamenti verticali

0 5E 0



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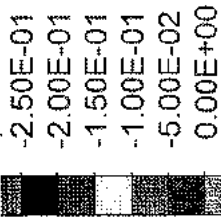
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 4"

FLAC (Version 4.00)

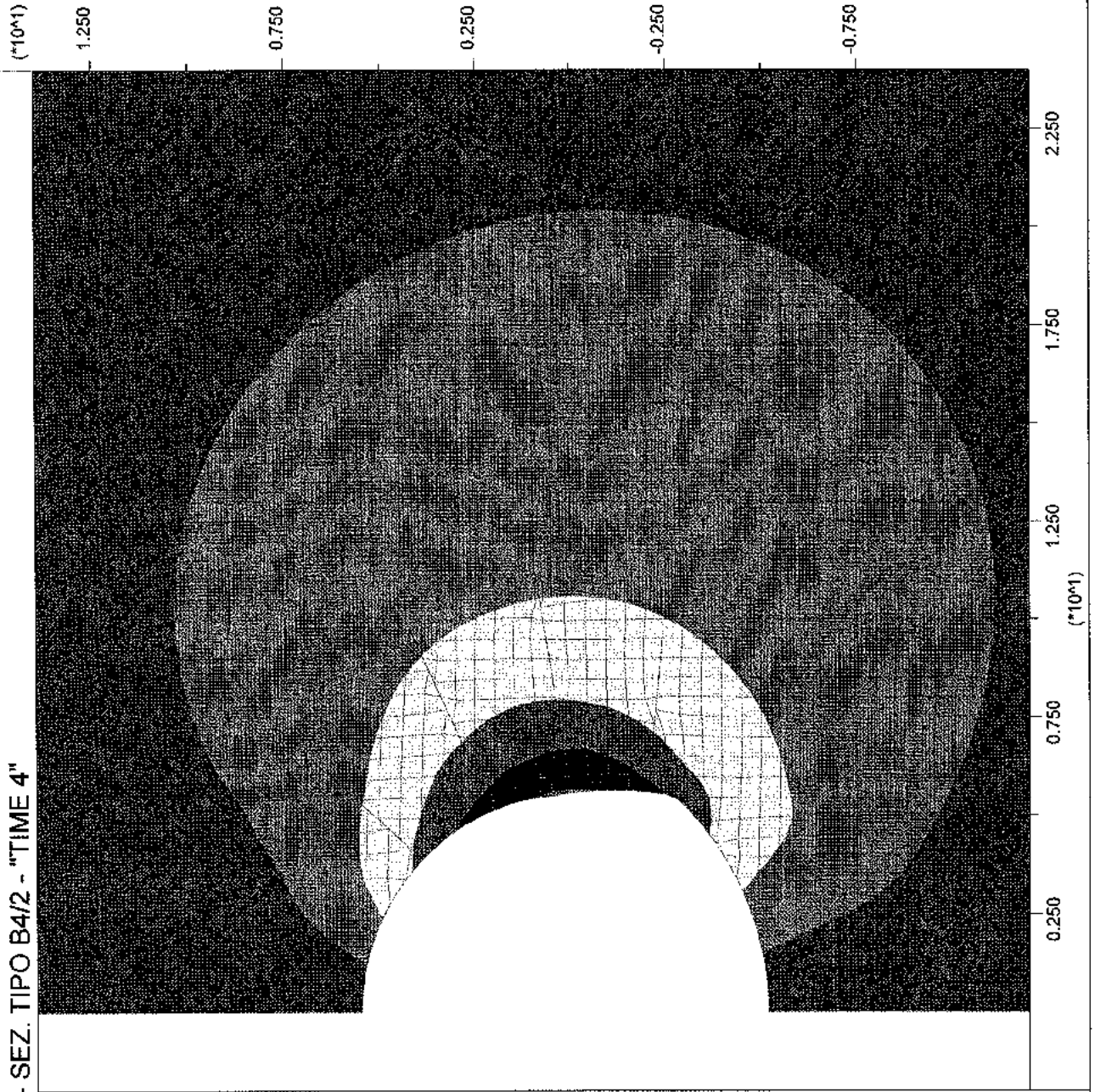
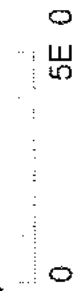
LEGEND

19-Feb-04 15:57
step 27191
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02
Spostamenti orizzontali



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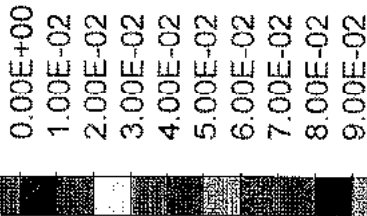
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 4"

FLAC (Version 4.00)

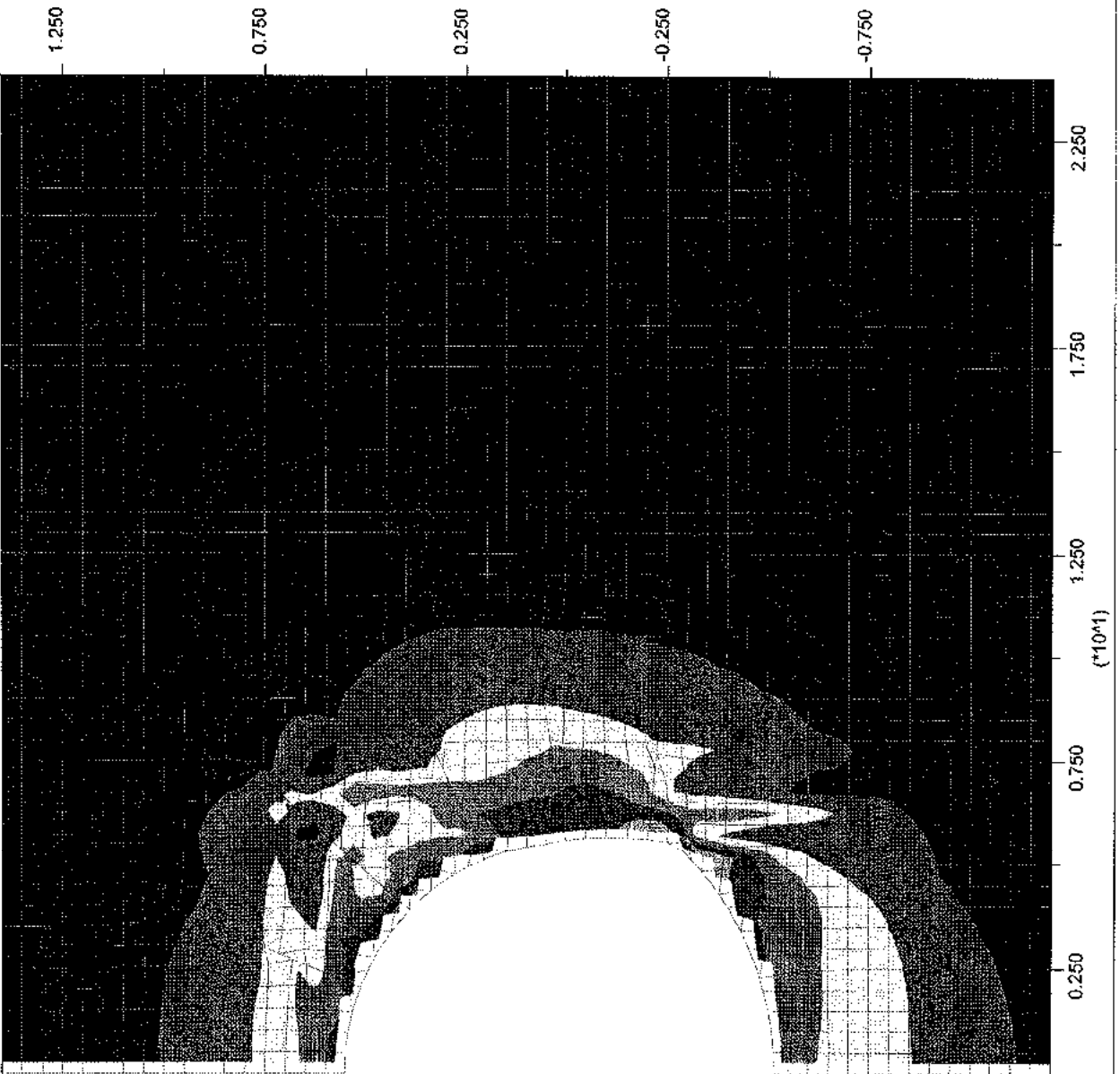
LEGEND

19-Feb-04 15:57
step 27191
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



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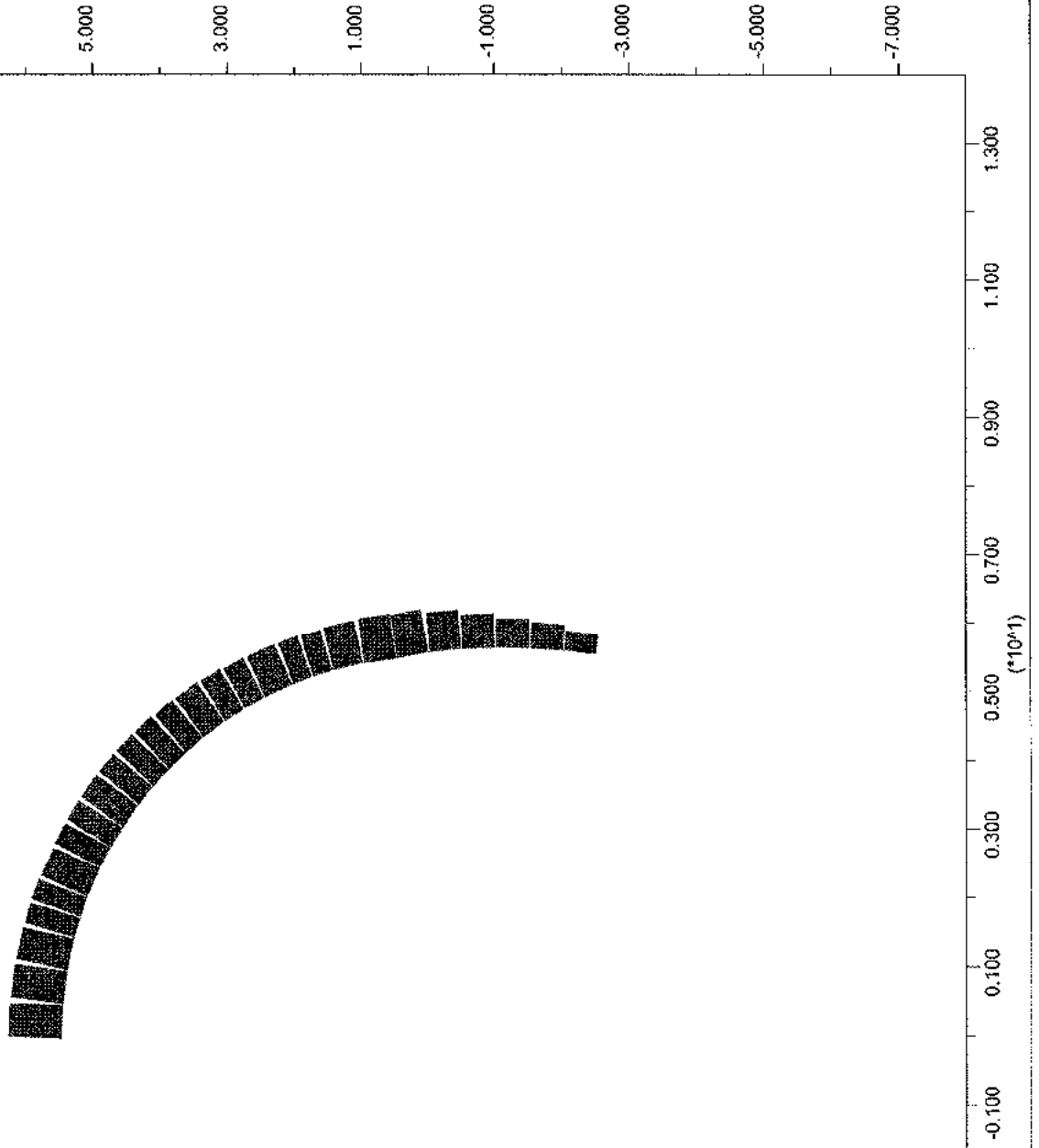
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 15:57
step 27191
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 1.447E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 4"

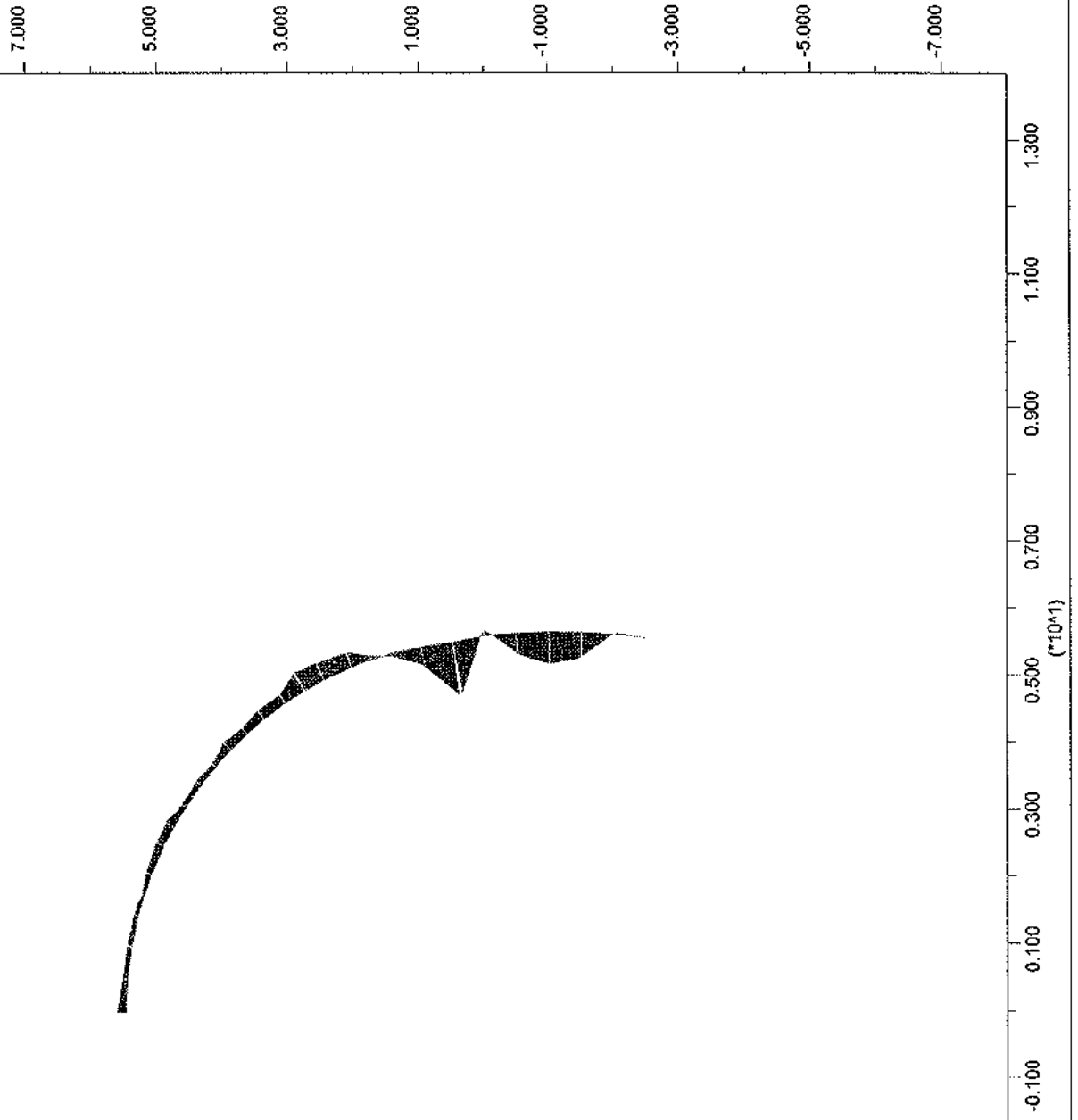
FLAC (Version 4.00)

LEGEND

19-Feb-04 15:57
step 27191
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -2.186E+04



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

19-Feb-04 15:57
 step 27191
 -2.000E+00 <x< 1.400E+01
 -8.000E+00 <y< 8.000E+00

Beam plot
 Cable Plot
 Ax. F-Y Rat on

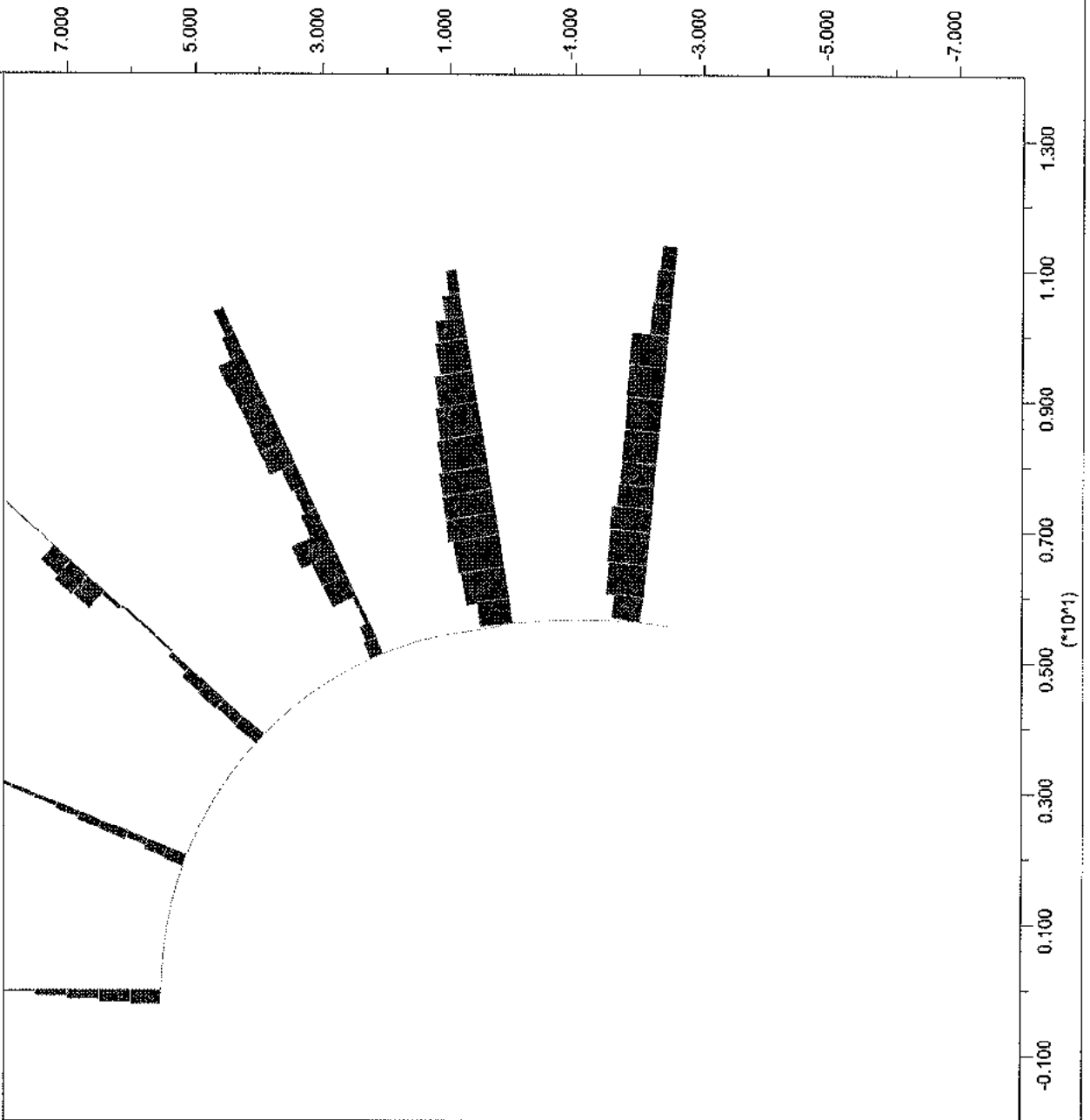
Structure	Max. Value
# 2 (Cable)	6.024E-02
# 3 (Cable)	5.241E-02
# 4 (Cable)	1.056E-01
# 5 (Cable)	1.670E-01
# 6 (Cable)	2.235E-01
# 7 (Cable)	1.775E-01

Bulloni - Sforzo assiate [N]

Axial Force on

Structure	Max. Value
# 2 (Cable)	-1.590E+04
# 3 (Cable)	-1.384E+04
# 4 (Cable)	-2.788E+04
# 5 (Cable)	-4.410E+04
# 6 (Cable)	-5.902E+04
# 7 (Cable)	-4.686E+04

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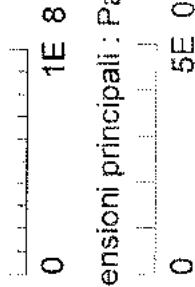
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

FLAC (Version 4.00)

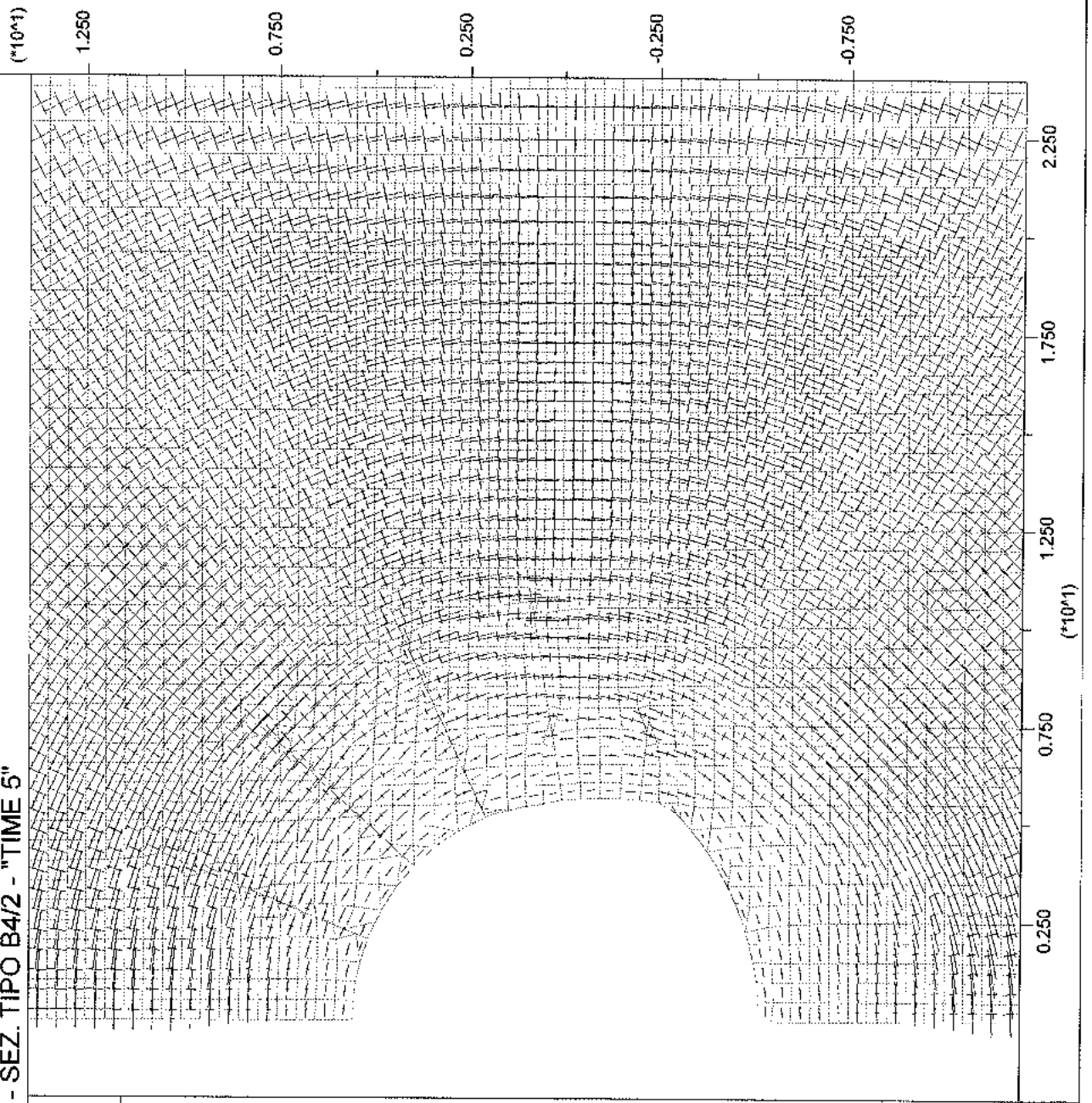
LEGEND

19-Feb-04 16:09
step 32801
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses
Max. Value = -1.670E+04
Min. Value = -2.671E+07



Tensioni principali : Pa



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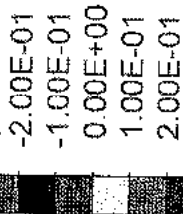
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

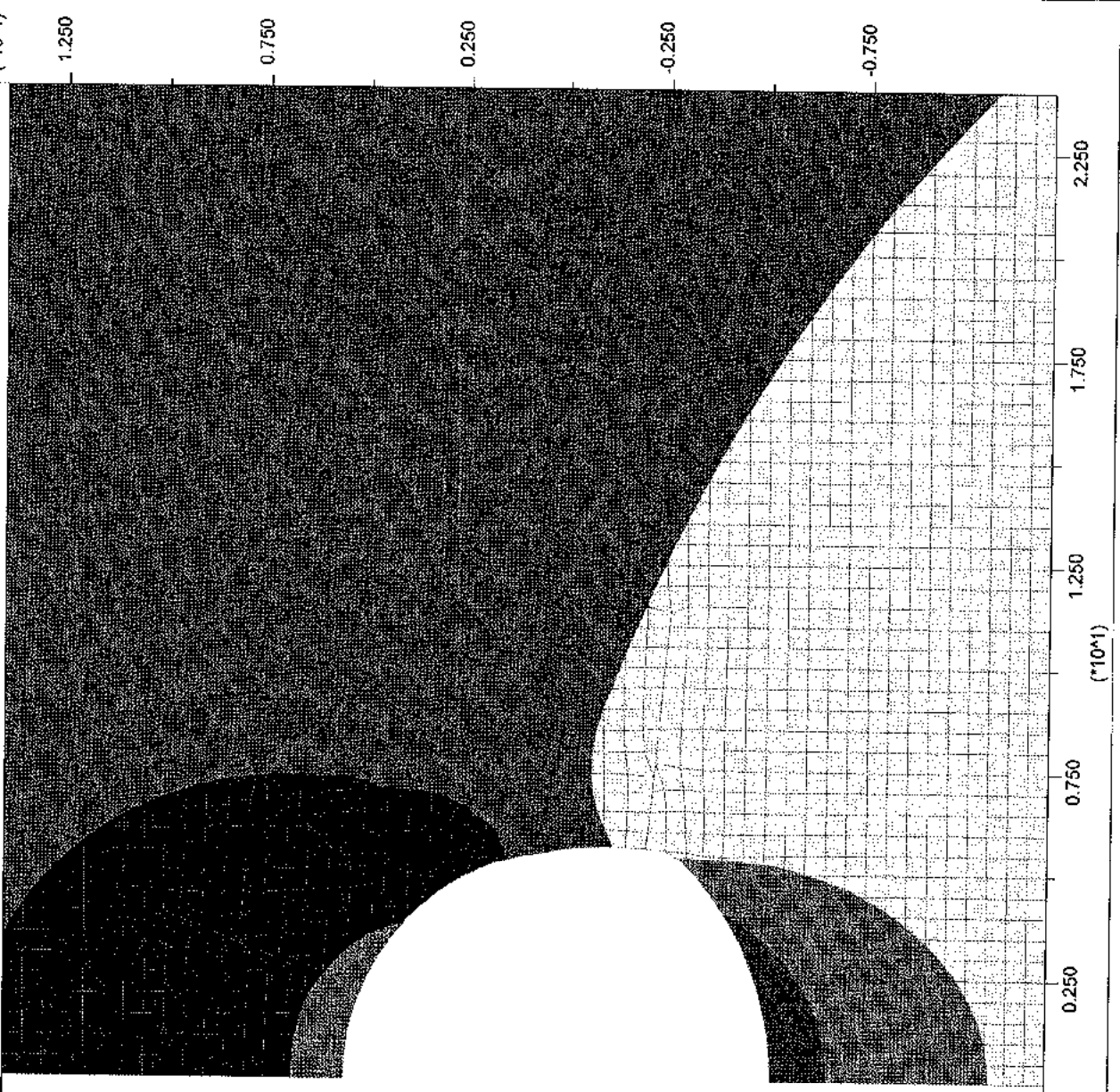
19-Feb-04 16:09
step 32801
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



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Minneapolis, Minnesota USA

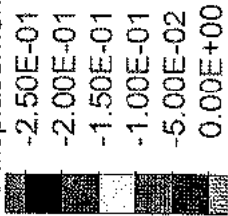
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

FLAC (Version 4.00)

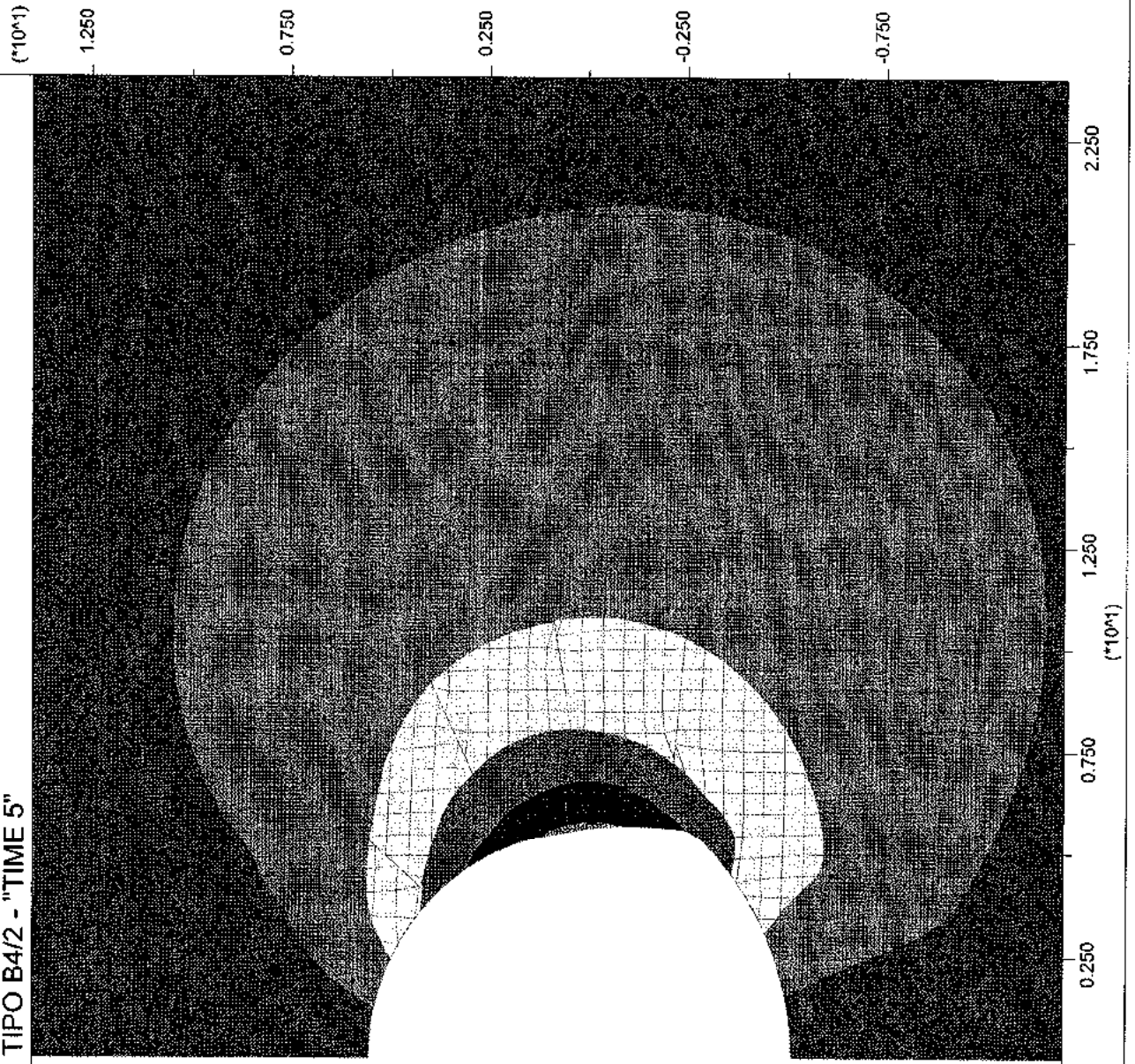
LEGEND

19-Feb-04 16:09
step 32801
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02
Spostamenti orizzontali



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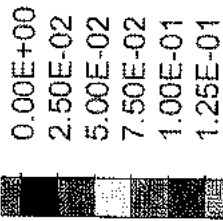
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

FLAC (Version 4.00)

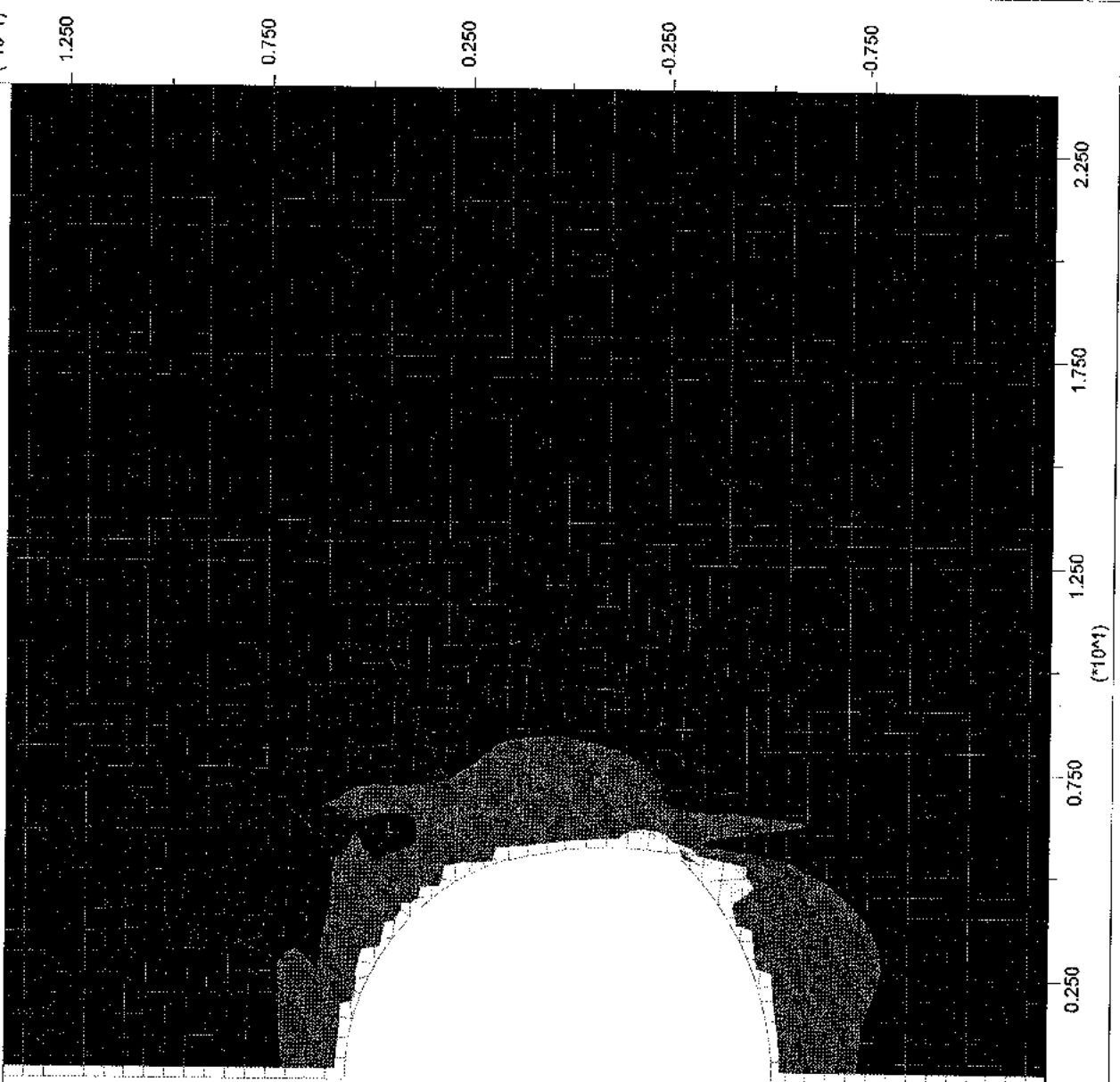
LEGEND

19-Feb-04 16:09
step 32801
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 2.50E-02
Deformazioni plastiche per taglio



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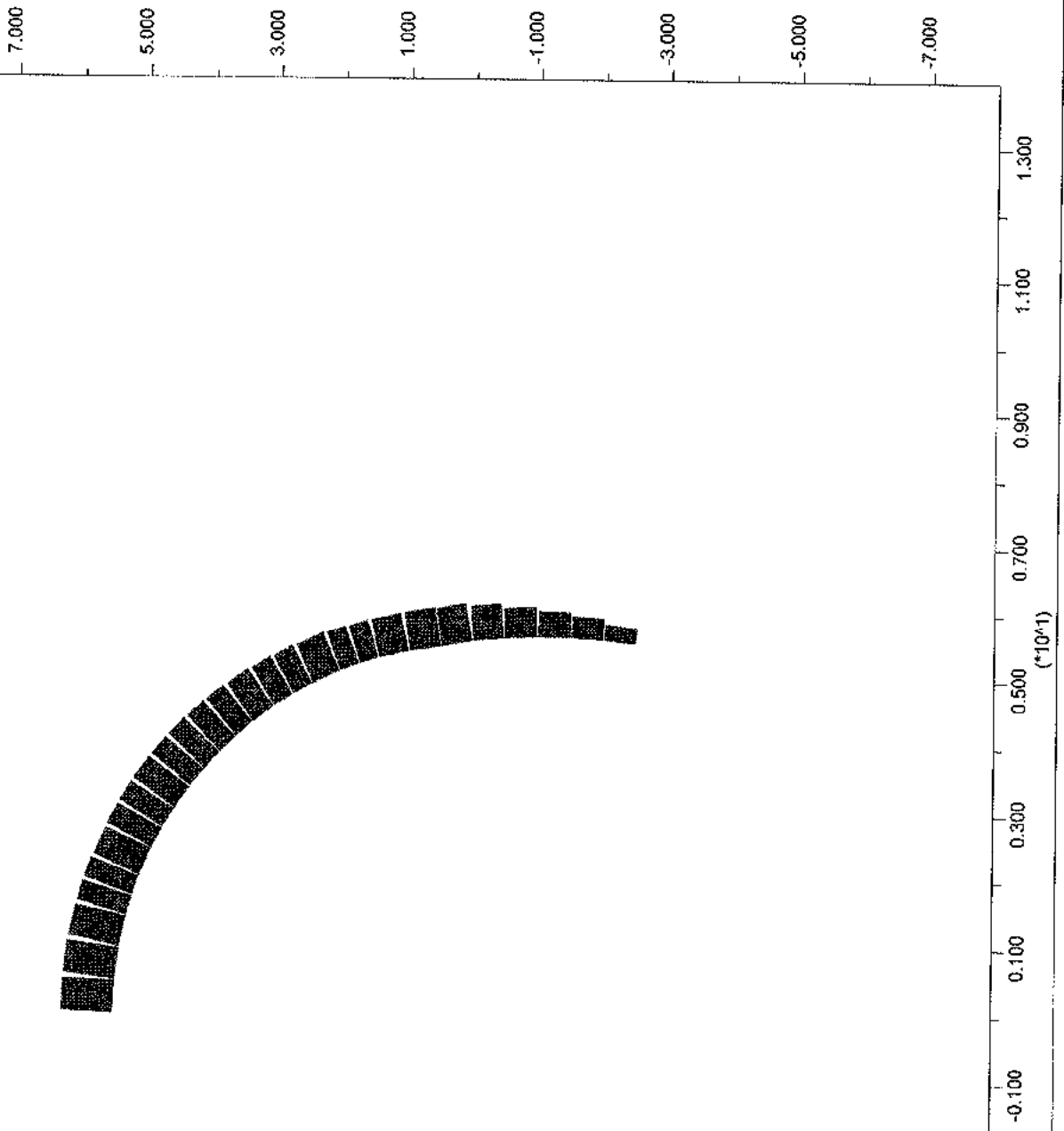
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

19-Feb-04 16:09
step 32801
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 2.875E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

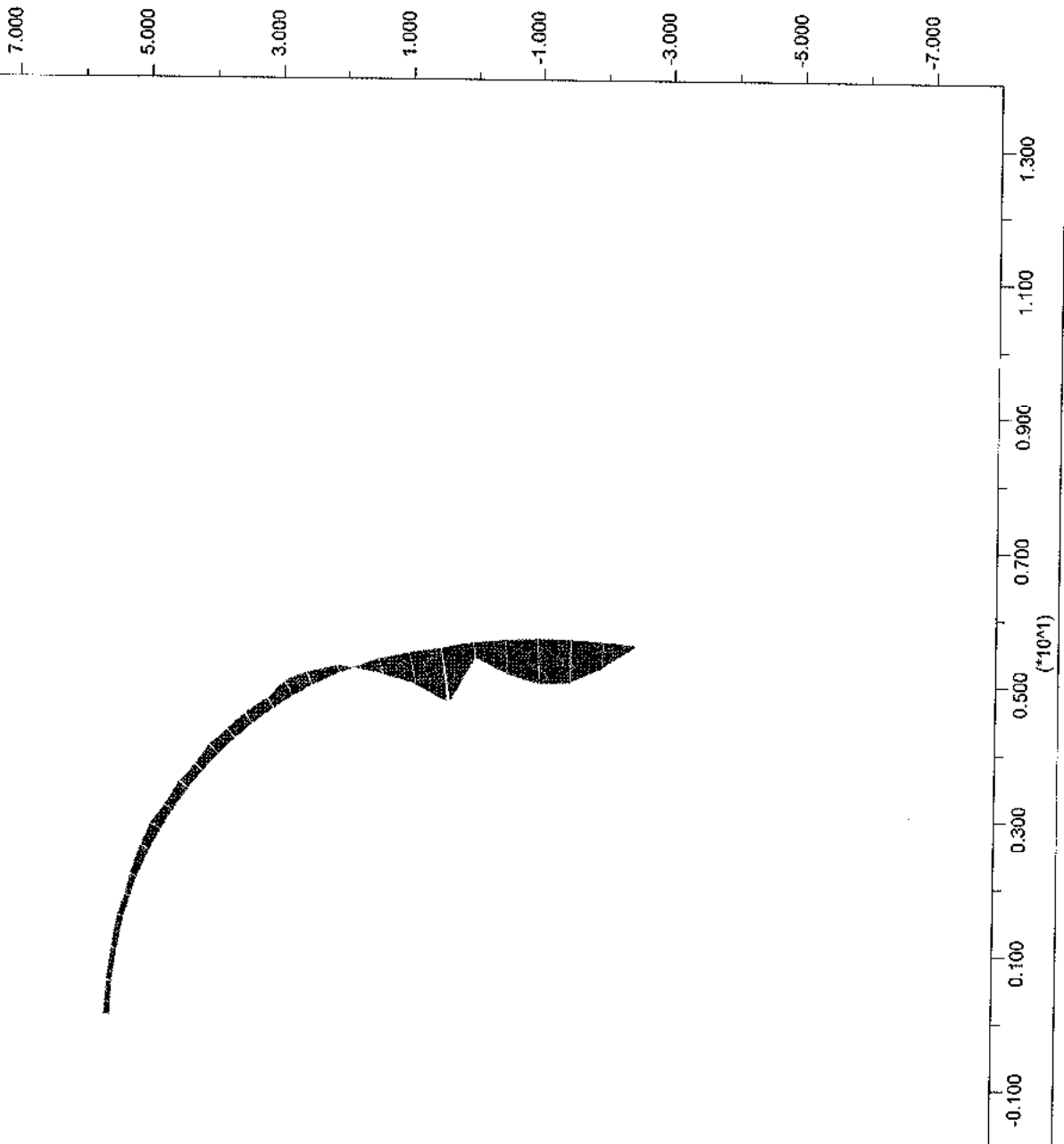
FLAC (Version 4.00)

LEGEND

19-Feb-04 16:09
step 32801
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -8.072E+04



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

FLAC (Version 4.00)

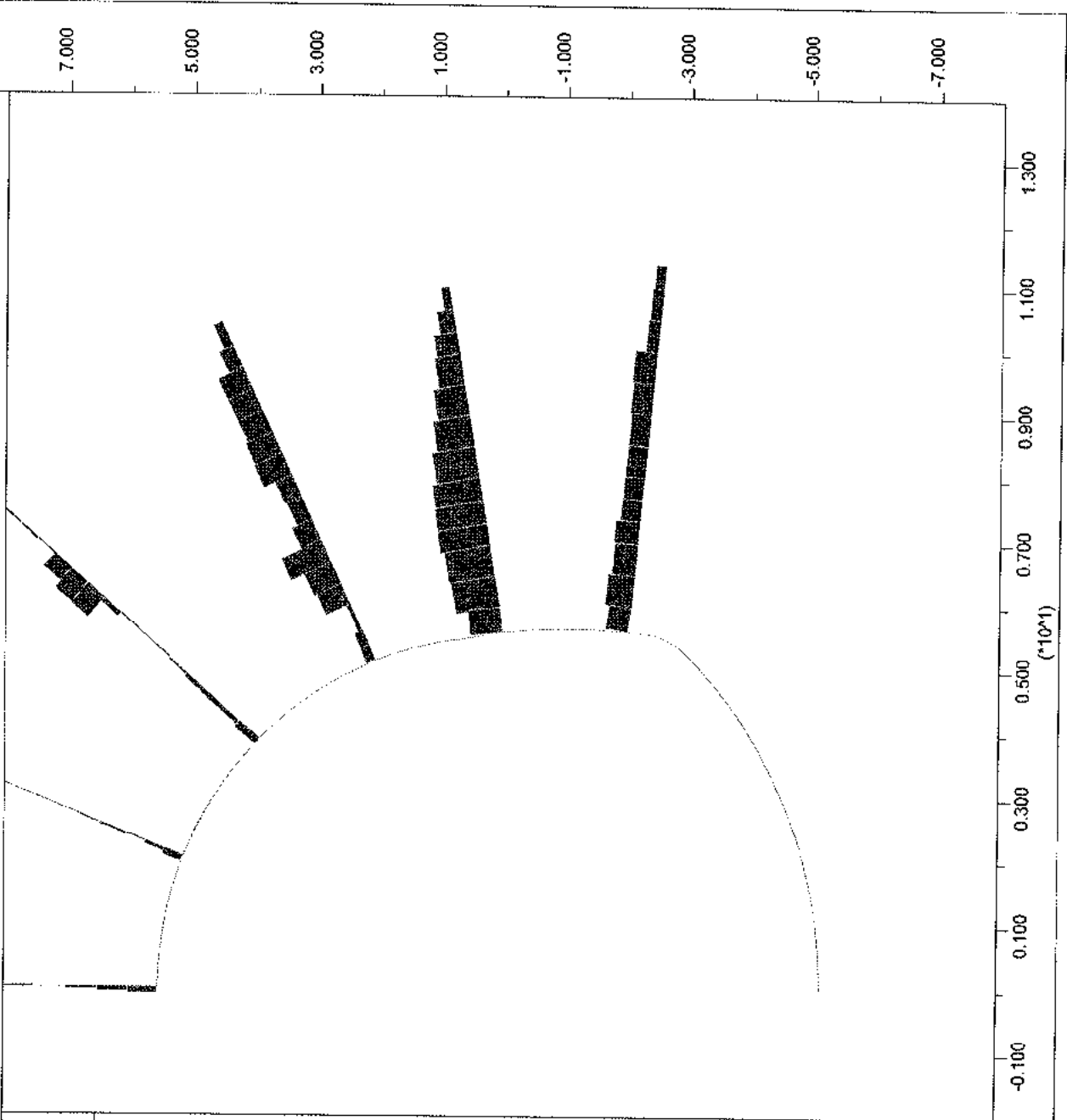
LEGEND

19-Feb-04 16:09
 step 32801
 -2.000E+00 <x< 1.400E+01
 -8.000E+00 <y< 8.000E+00

Beam plot
 Cable Plot
 ■ Ax. F-Y Rat on
 Structure Max. Value
 # 2 (Cable) 6.614E-02
 # 3 (Cable) 7.181E-02
 # 4 (Cable) 2.916E-01
 # 5 (Cable) 5.044E-01
 # 6 (Cable) 5.722E-01
 # 7 (Cable) 3.038E-01
 Bulloni - Sforzo assiale [N]

■ Axial Force on
 Structure Max. Value
 # 2 (Cable) -1.746E+04
 # 3 (Cable) -1.896E+04
 # 4 (Cable) -7.697E+04
 # 5 (Cable) -1.332E+05
 # 6 (Cable) -1.511E+05
 # 7 (Cable) -8.019E+04

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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

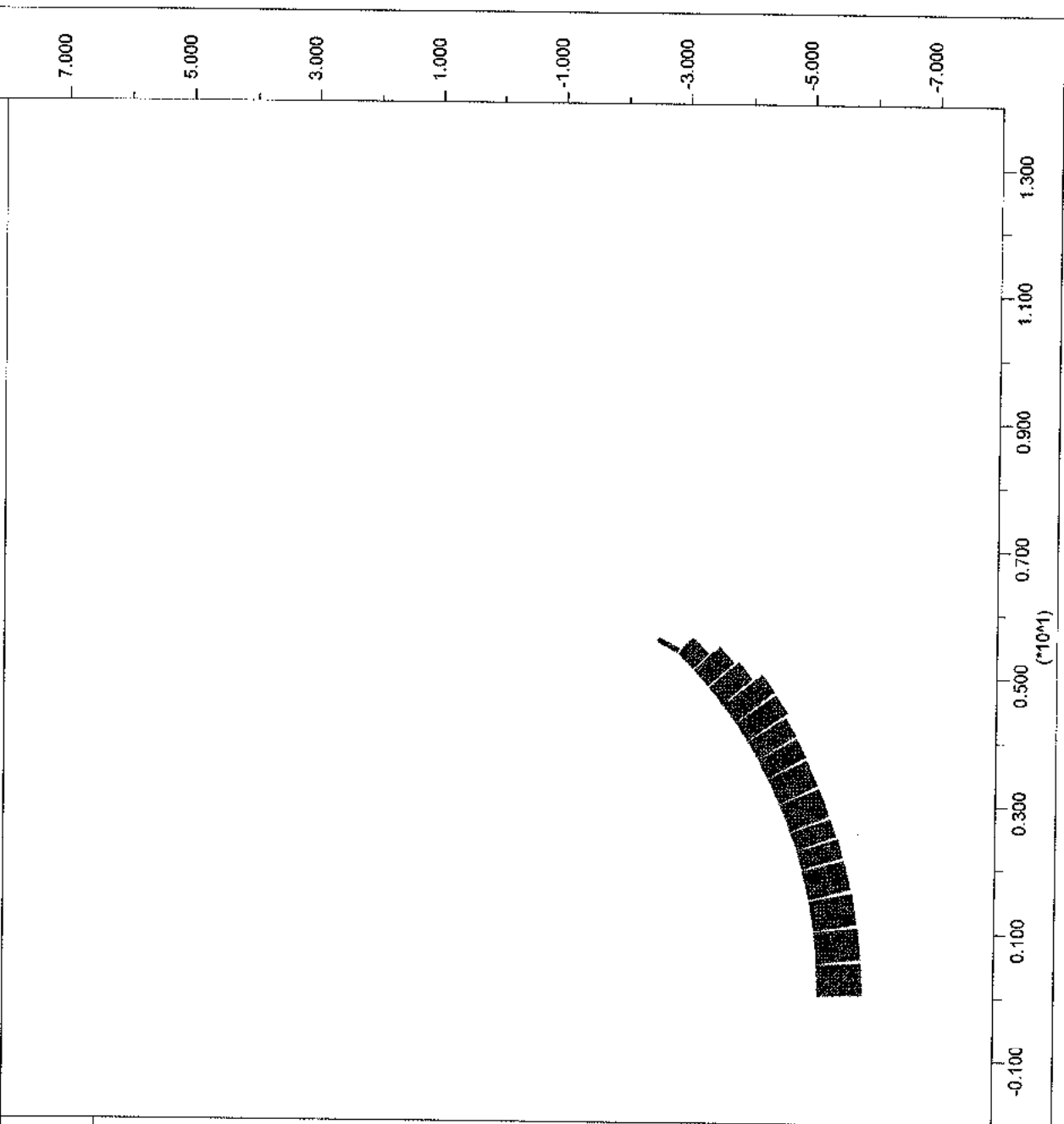
FLAC (Version 4.00)

LEGEND

19-Feb-04 16:09
step 32801
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
8 (Beam) 1.935E+06

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Minneapolis, Minnesota USA



JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 5"

FLAC (Version 4.00)

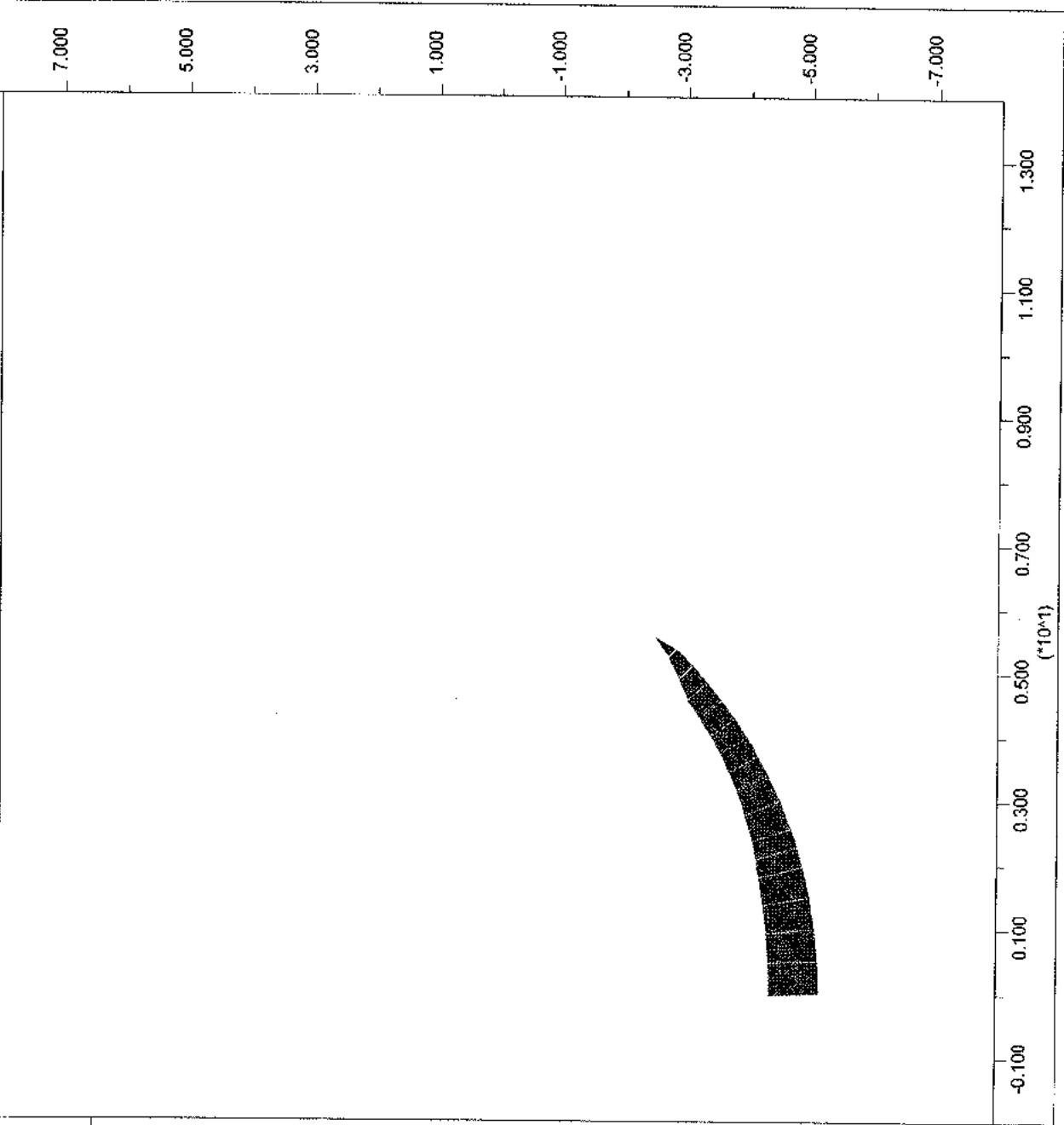
LEGEND

19-Feb-04 16:09
step 32801
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Momento flettente [N*m/m]

■ Moment on

Structure Max. Value
8 (Beam) -6.311E+05



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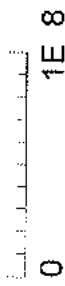
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 6"

FLAC (Version 4.00)

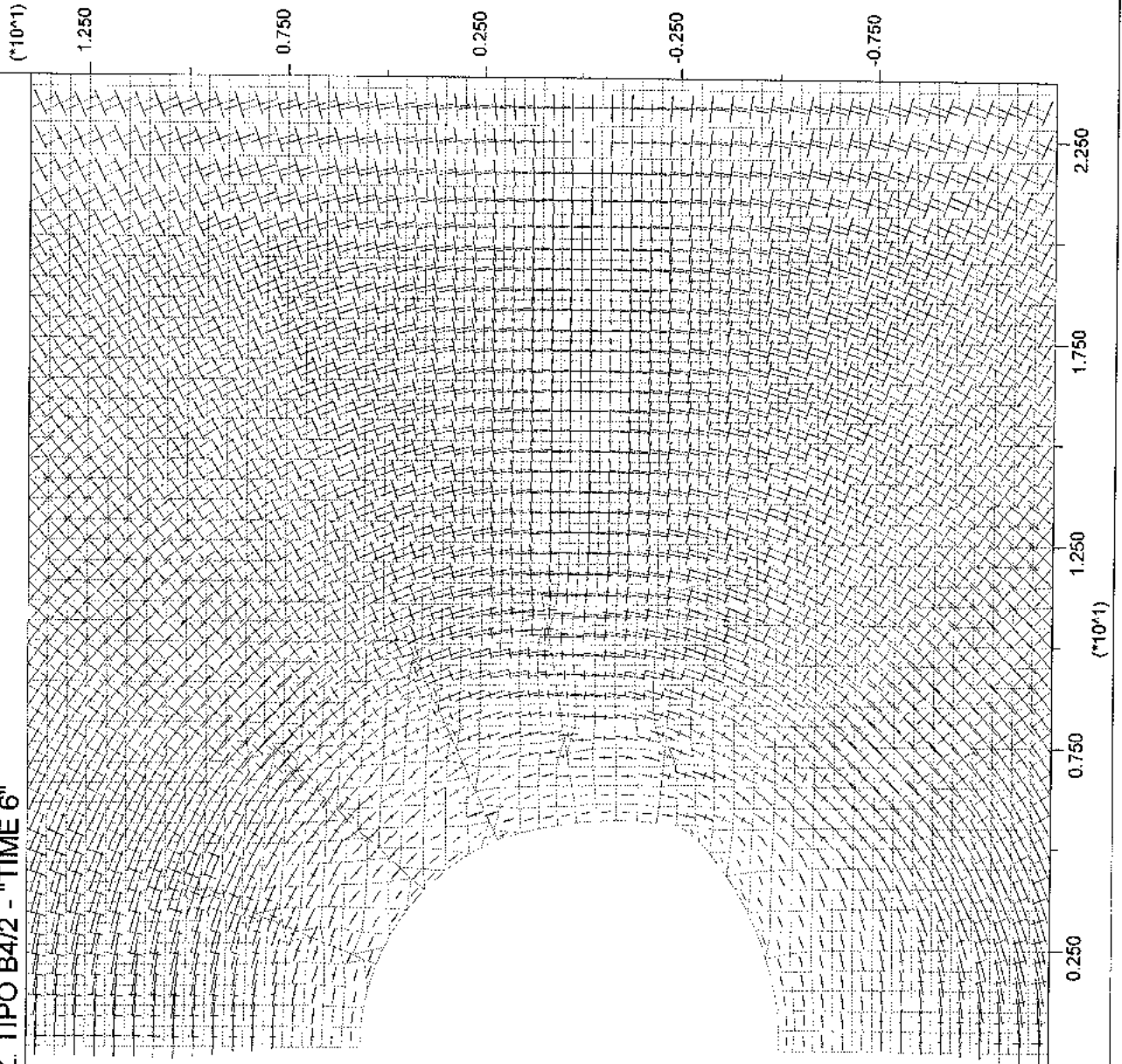
LEGEND

19-Feb-04 16:22
step 33821
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses
Max. Value = -4.764E+04
Min. Value = -2.672E+07



Tensioni principali : Pa



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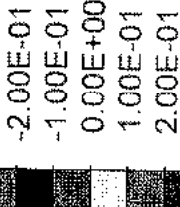
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 6"

FLAC (Version 4.00)

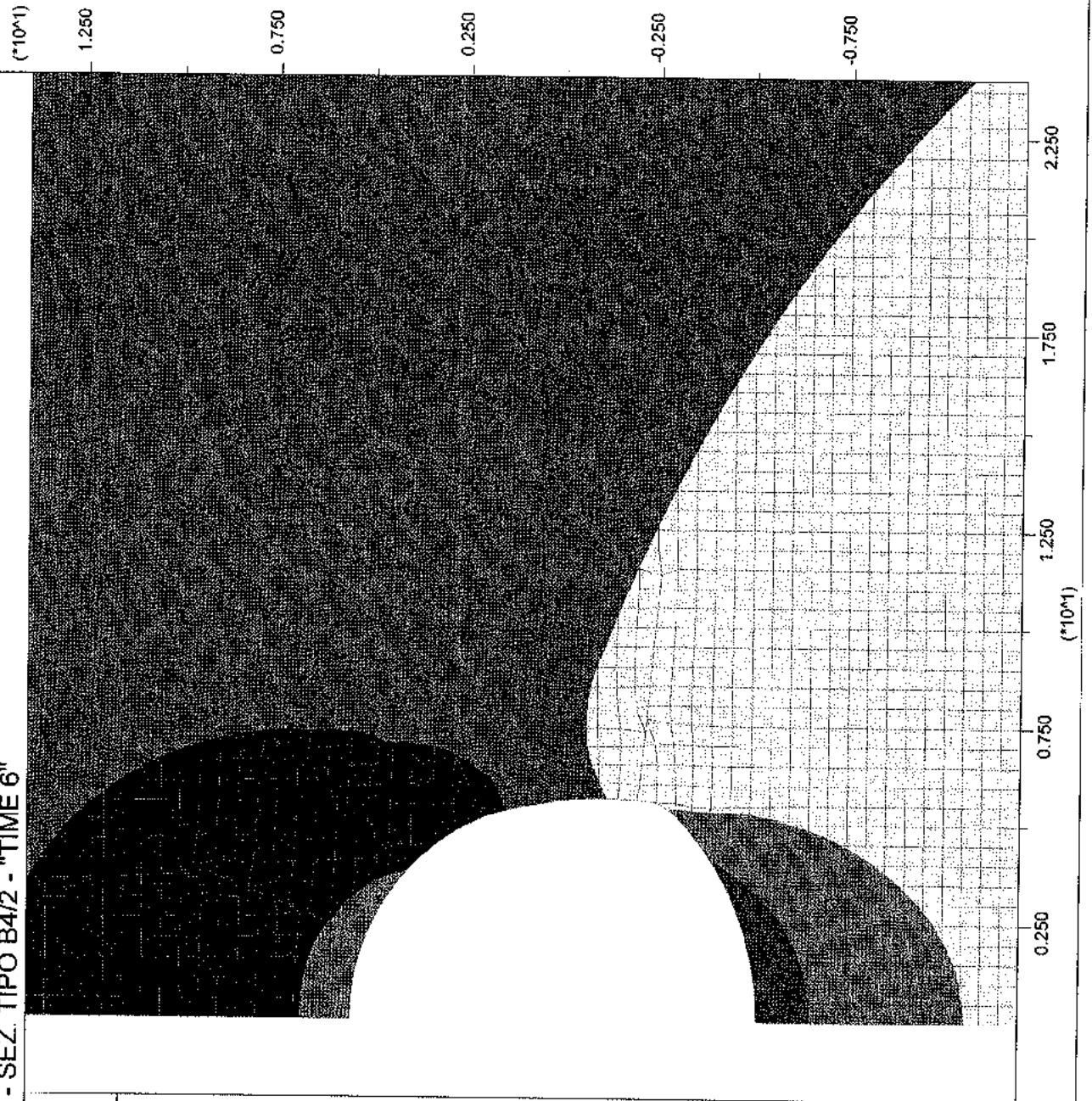
LEGEND

19-Feb-04 16:22
step 33821
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01
Spostamenti verticali



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 6"

FLAC (Version 4.00)

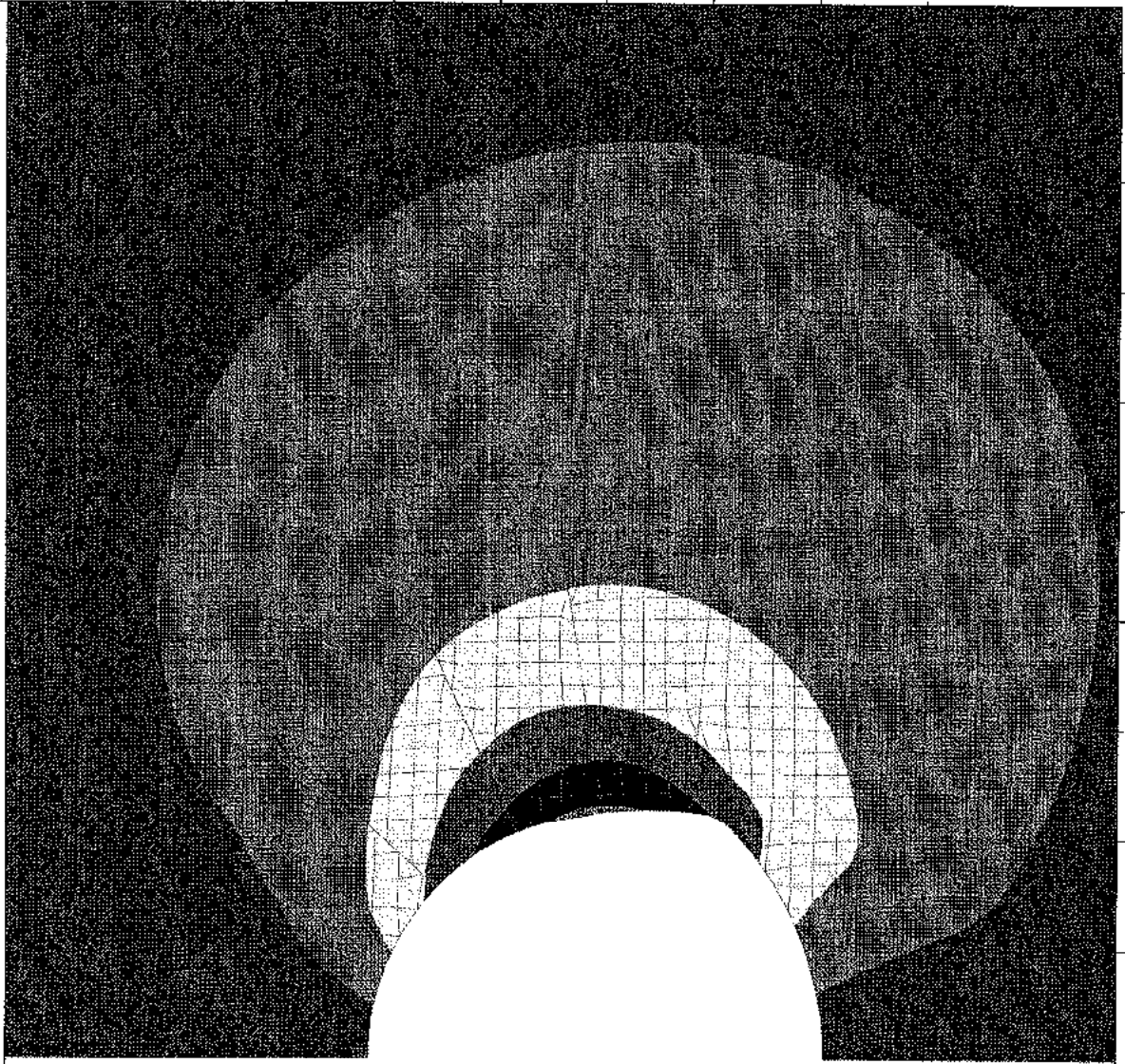
LEGEND

19-Feb-04 16:22
step 33821
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02
Spostamenti orizzontali



(*10^1)

1.250

0.750

0.250

-0.250

-0.750

2.250

1.750

1.250

0.750

0.250

(*10^1)

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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 6"

FLAC (Version 4.00)

LEGEND

19-Feb-04 16:22

step 33821

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

2.50E-02

5.00E-02

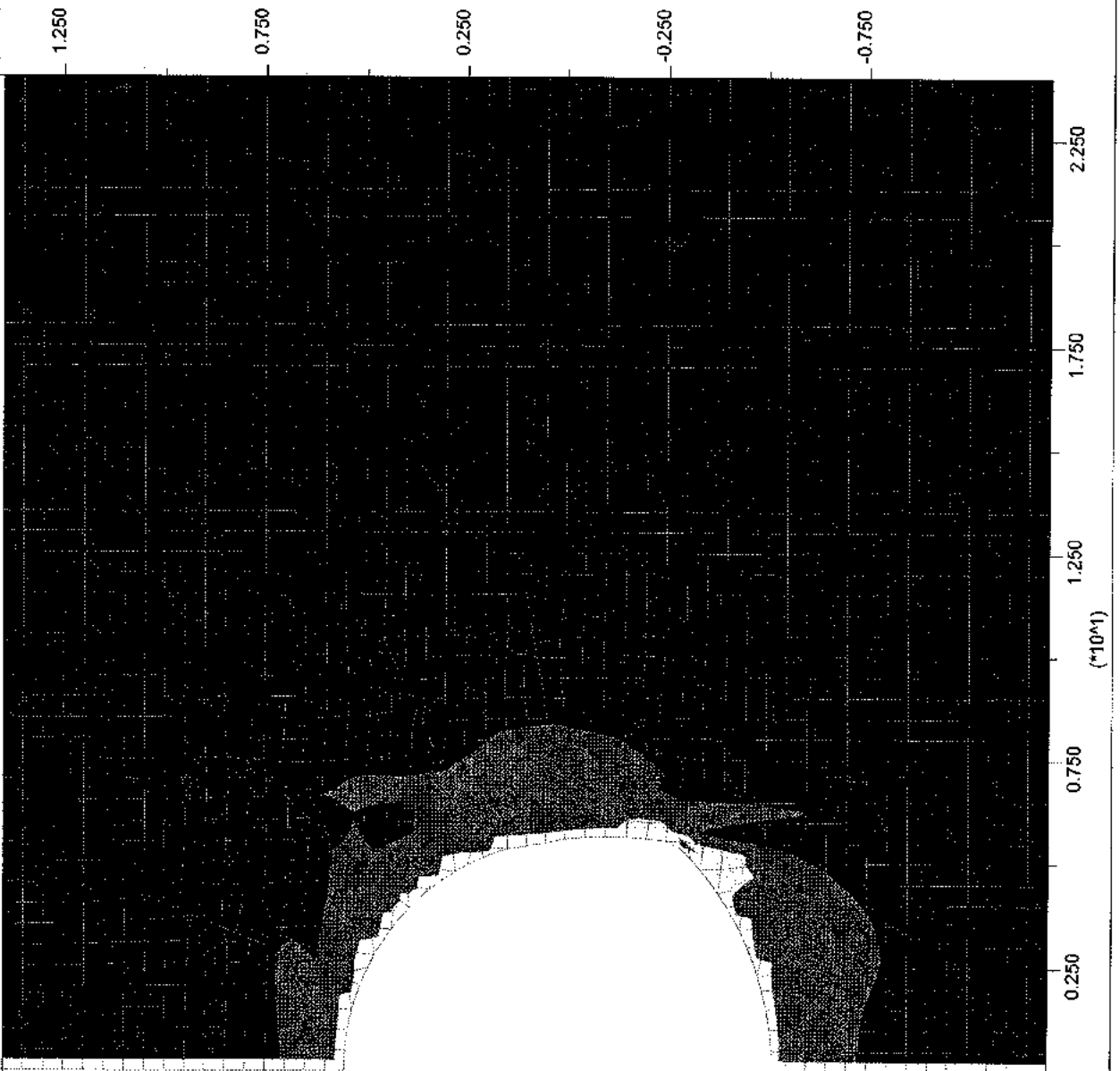
7.50E-02

1.00E-01

1.25E-01

Contour interval= 2.50E-02

Deformazioni plastiche per taglio



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 6"

FLAC (Version 4.00)

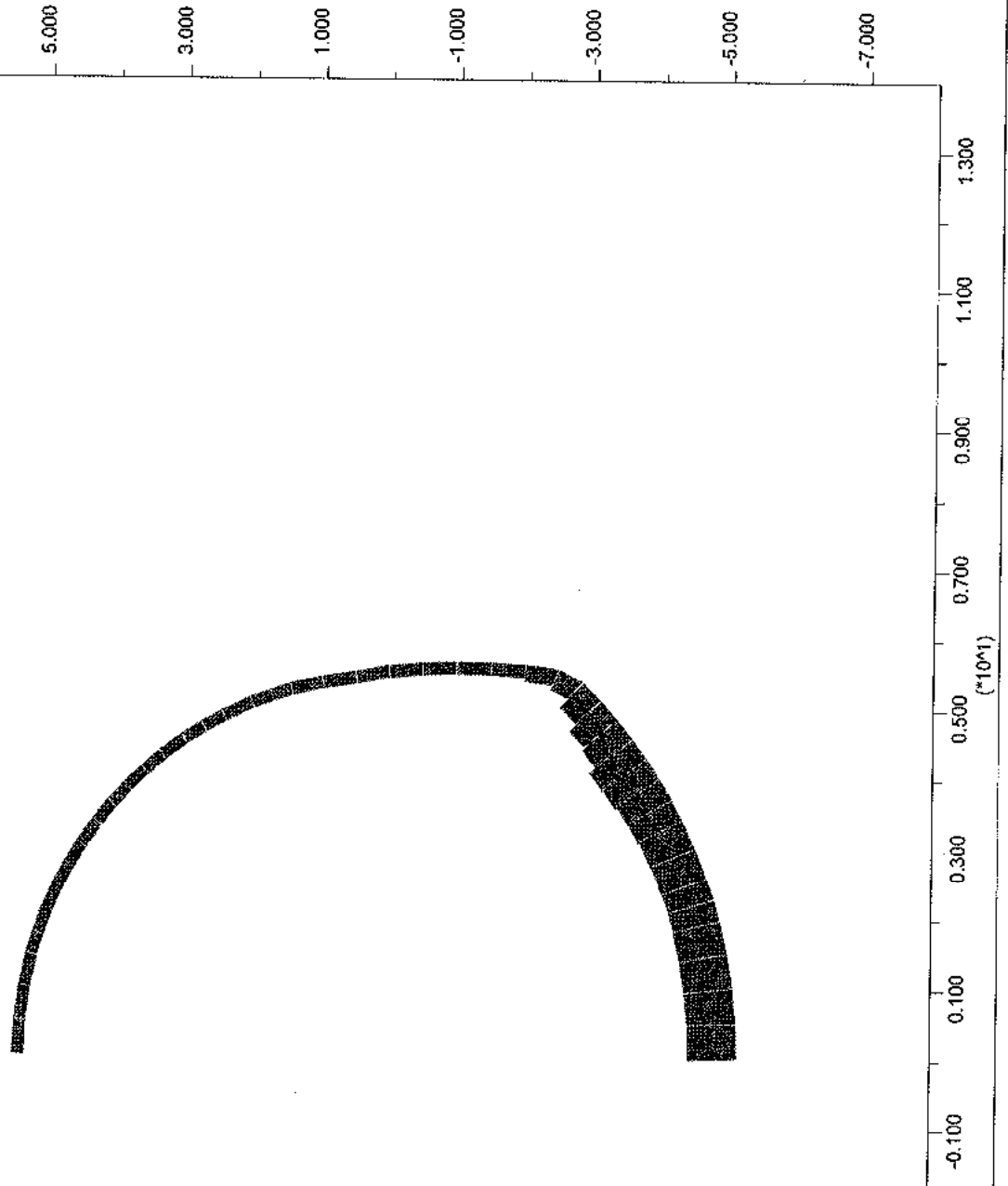
LEGEND

19-Feb-04 16:22
step 33821
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
8 (Beam) 2.810E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 6"

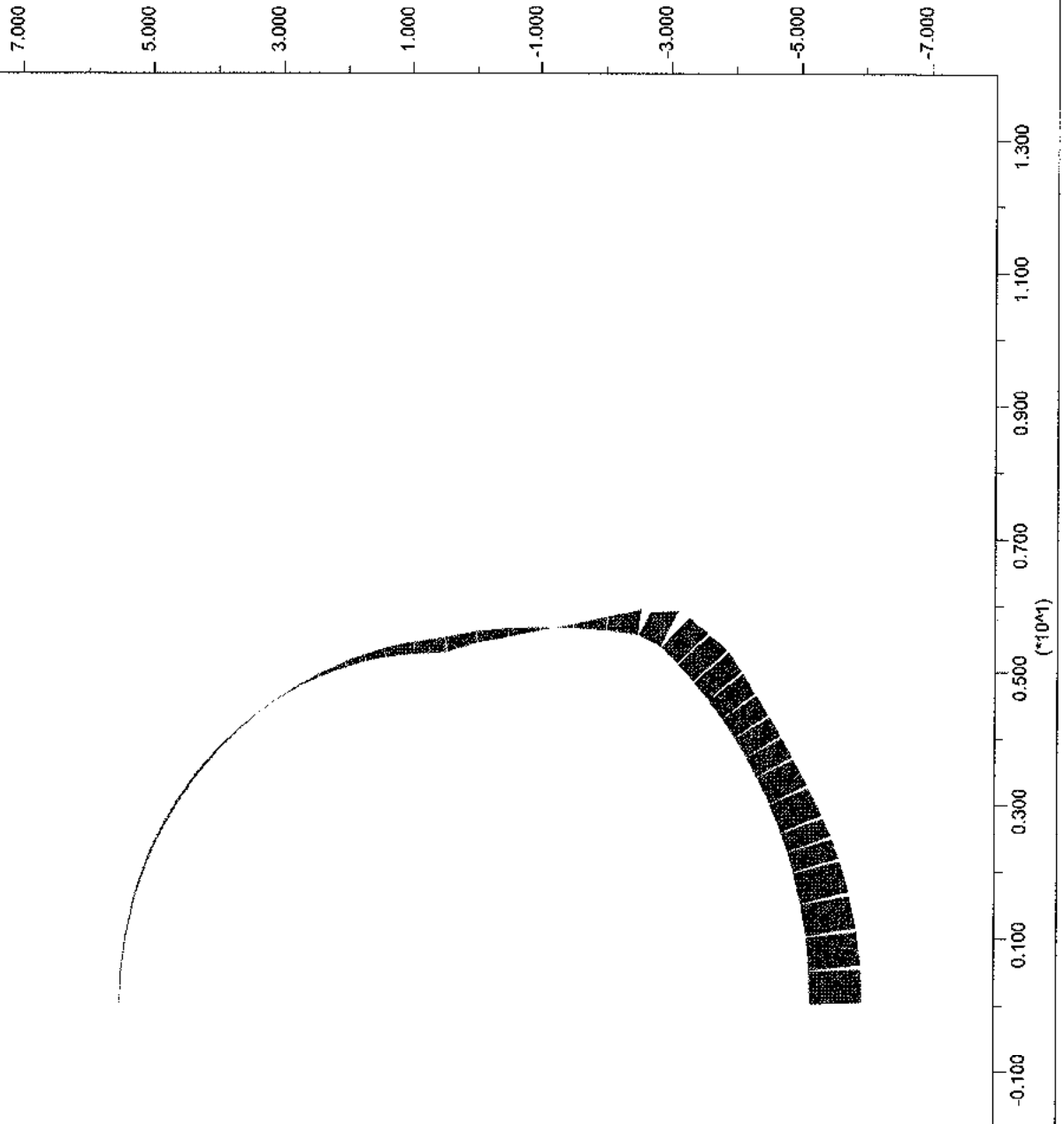
FLAC (Version 4.00)

LEGEND

19-Feb-04 16:22
step 33821
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
8 (Beam) -5.411E+05






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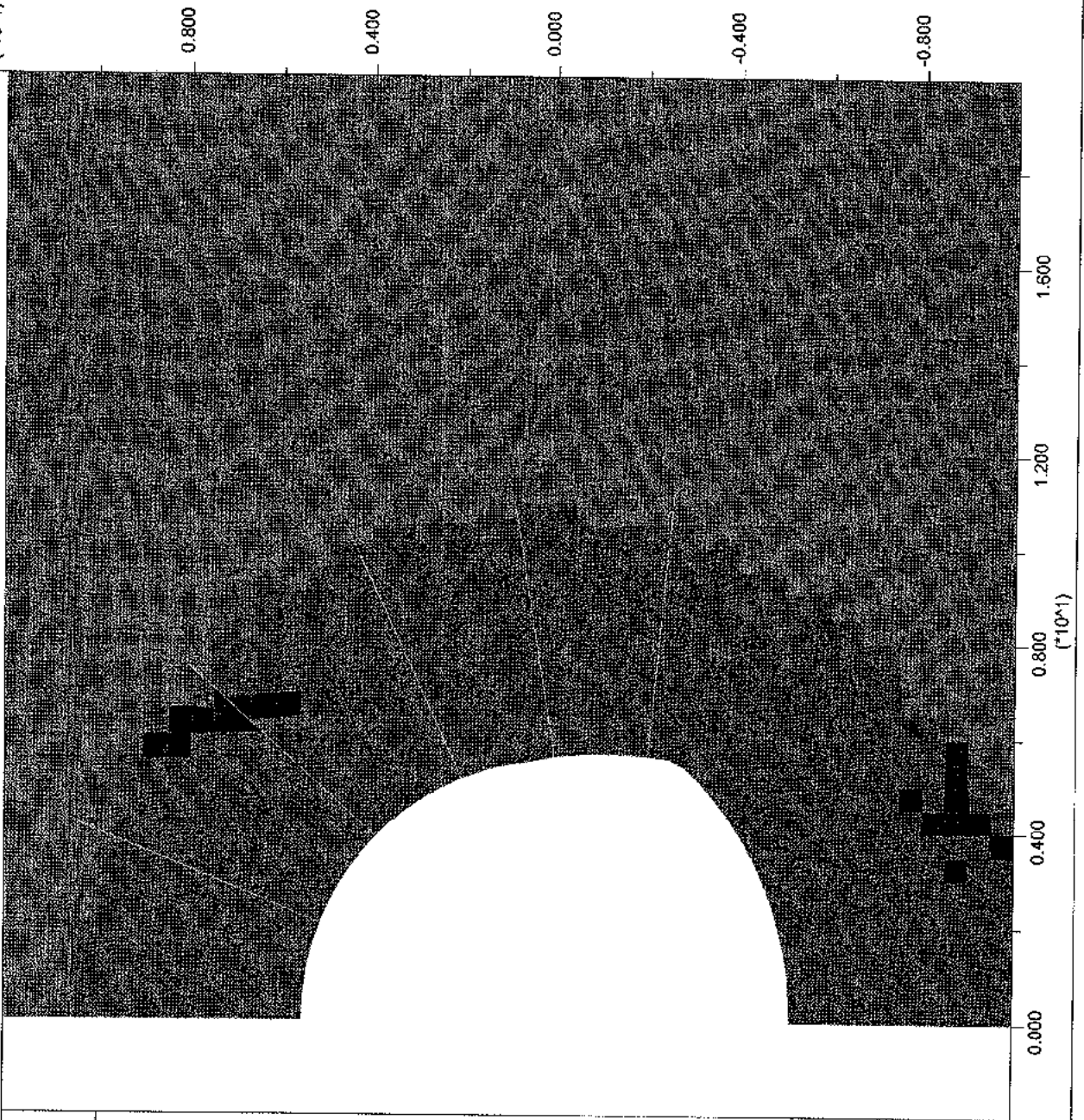
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 6"

FLAC (Version 4.00)

LEGEND

19-Feb-04 16:22
step 33821
-2.000E+00 <x< 2.000E+01
-1.000E+01 <y< 1.200E+01

- state
-  Elastic
 -  At Yield in Shear or Vol.
 -  Elastic, Yield in Past
- Grid plot



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 7"

FLAC (Version 4.00)

LEGEND

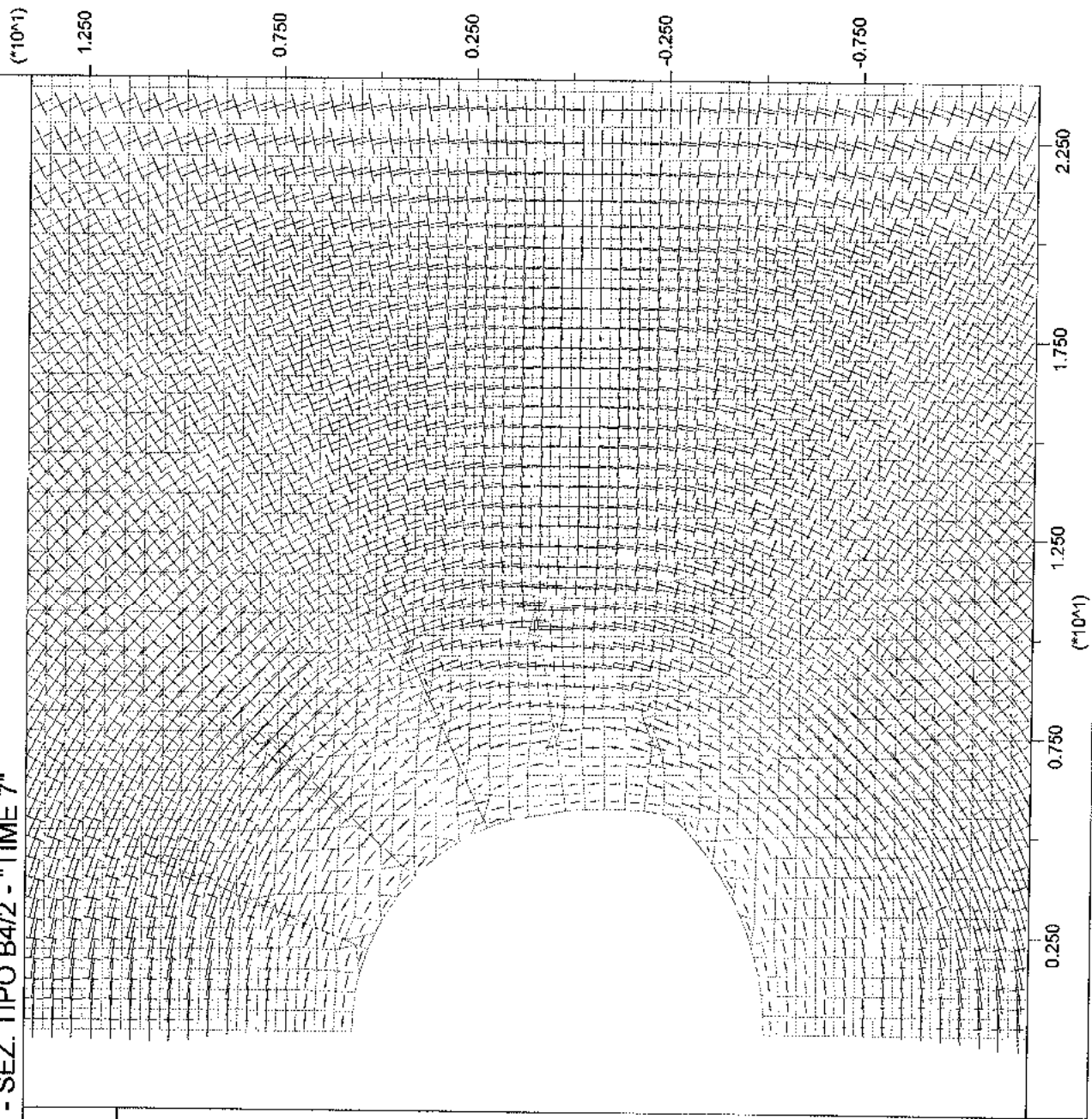
19-Feb-04 16:44
step 35506
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -1.944E+05
Min. Value = -2.679E+07



Tensioni principali : Pa



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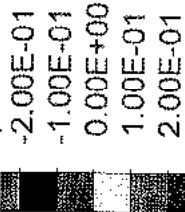
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 7"

FLAC (Version 4.00)

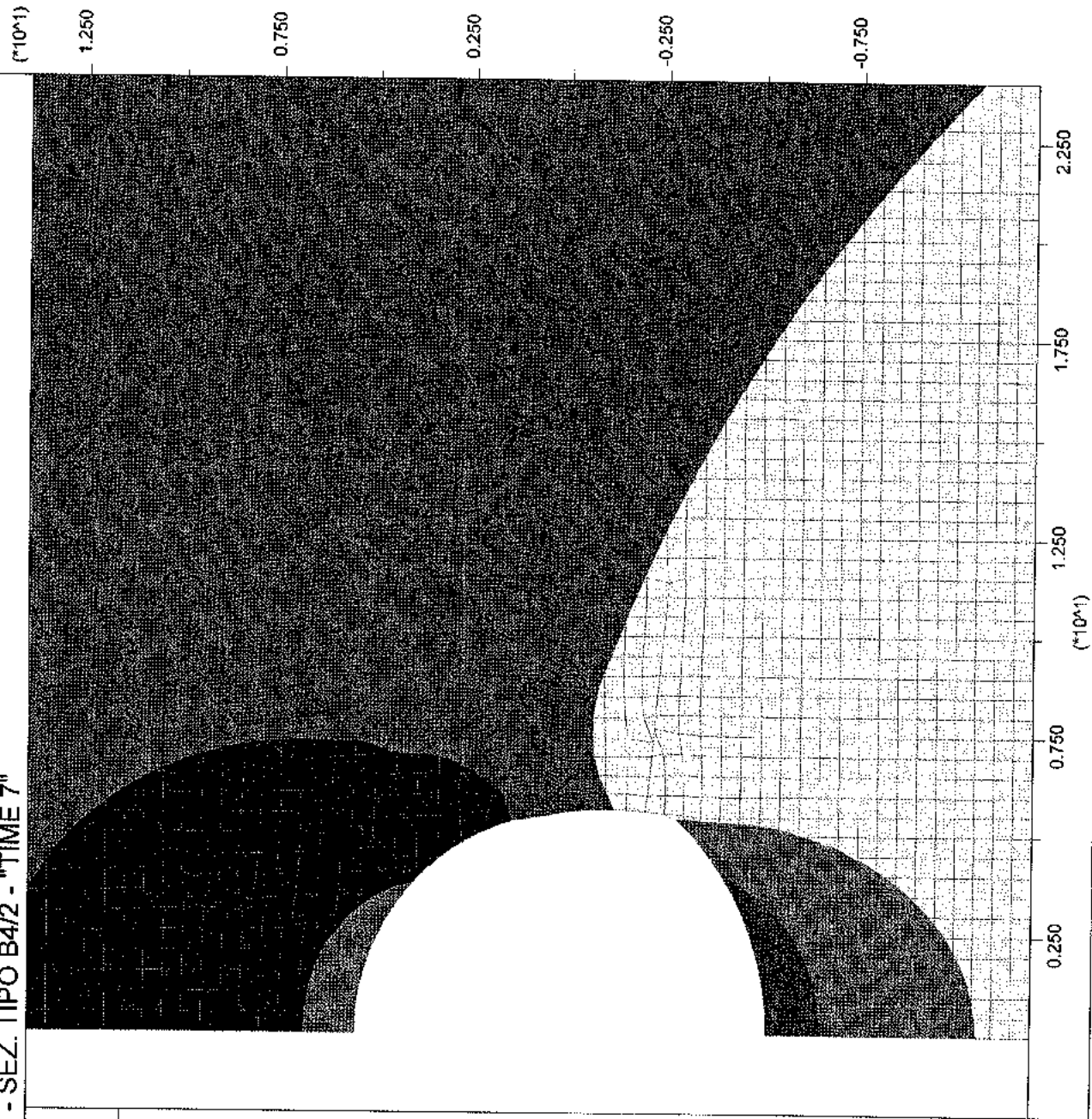
LEGEND

19-Feb-04 16:44
step 35506
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01
Spostamenti verticali



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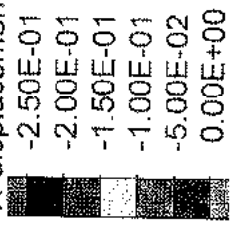
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 7"

FLAC (Version 4.00)

LEGEND

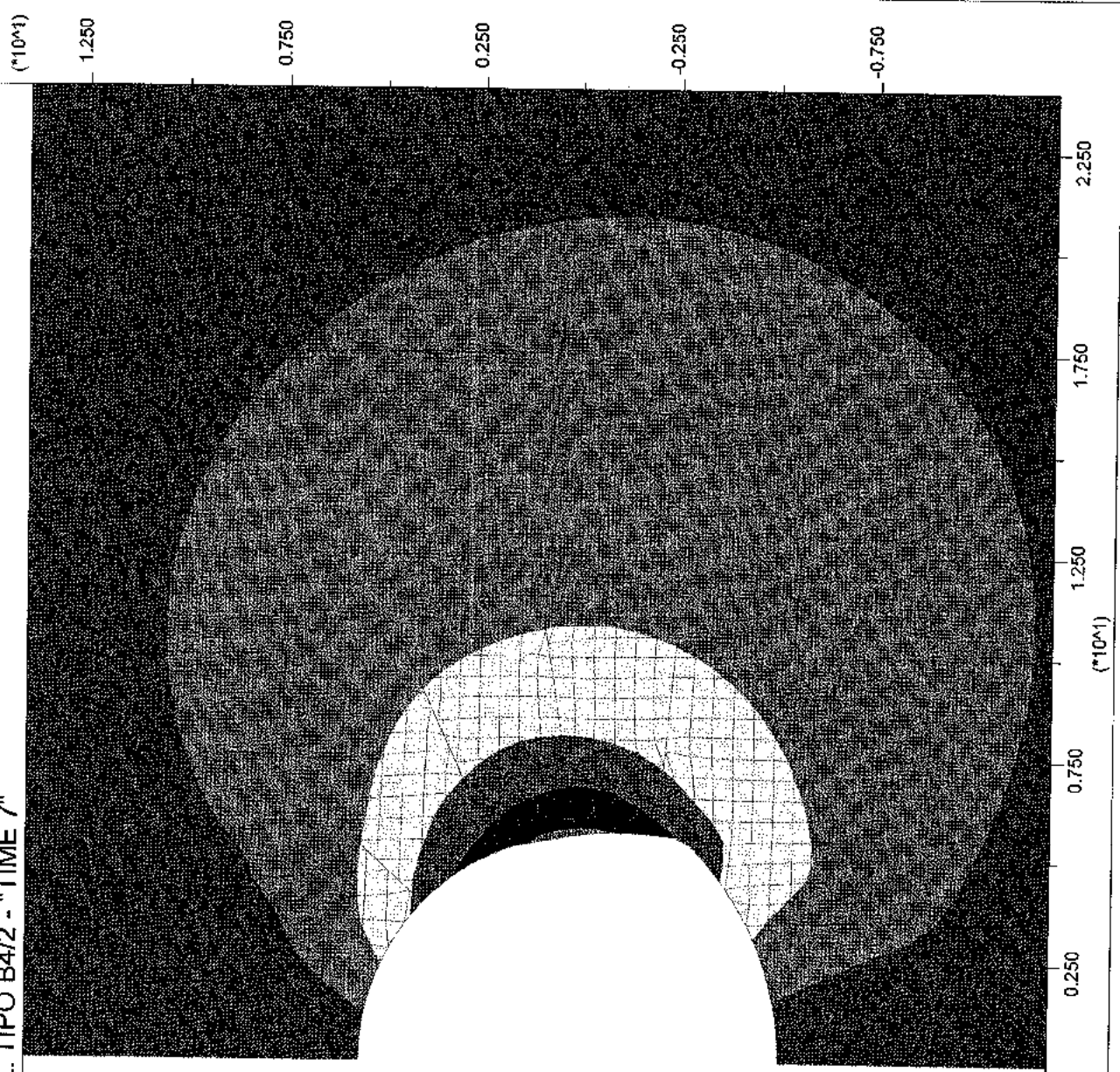
19-Feb-04 16:44
step 35506
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02

Spostamenti orizzontali



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 7"

FLAC (Version 4.00)

LEGEND

19-Feb-04 16:44

step 35506

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

2.00E-02

4.00E-02

6.00E-02

8.00E-02

1.00E-01

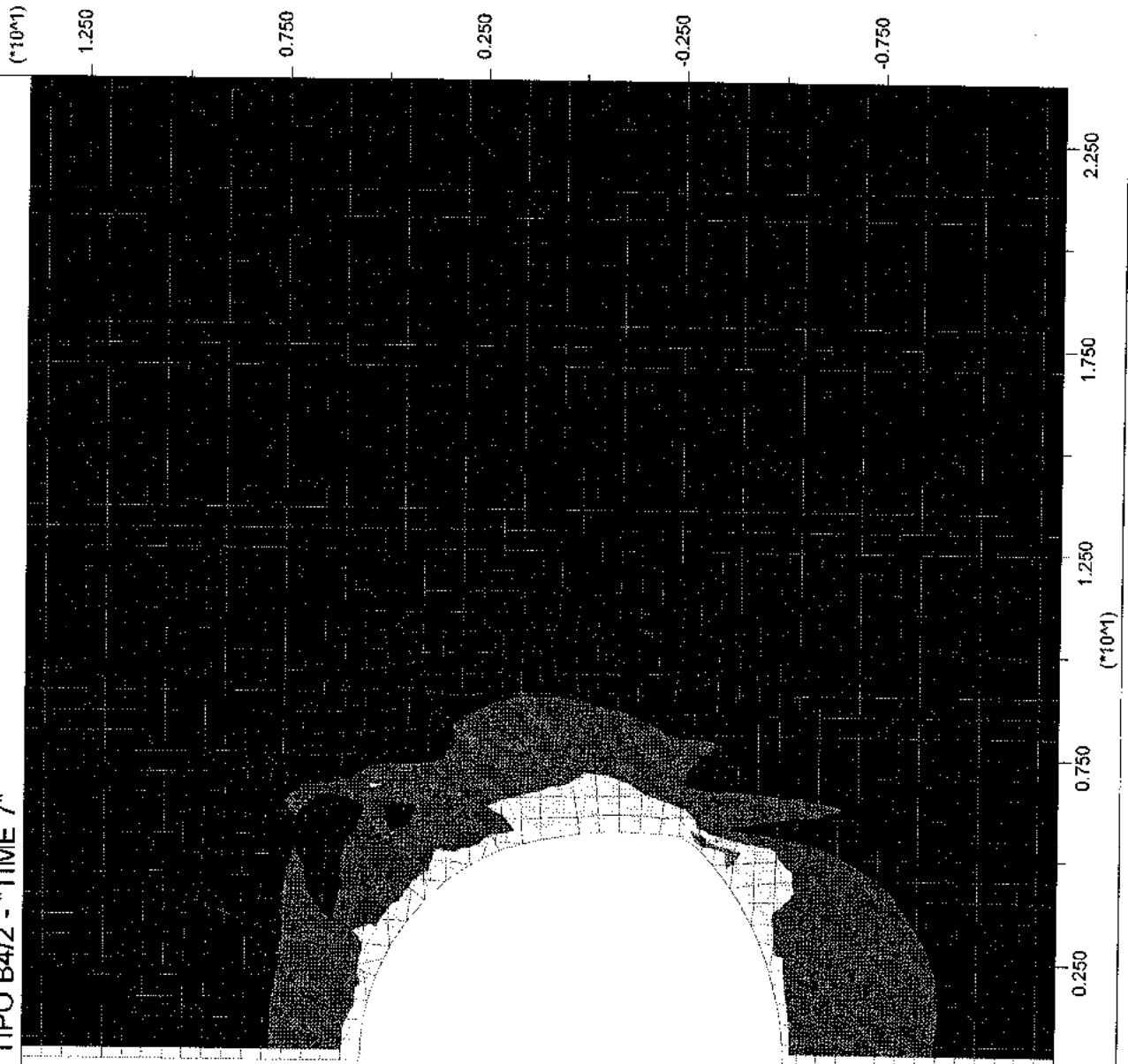
1.20E-01

Contour interval= 2.00E-02

Deformazioni plastiche per taglio

0

5E 0



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 7"

FLAC (Version 4.00)

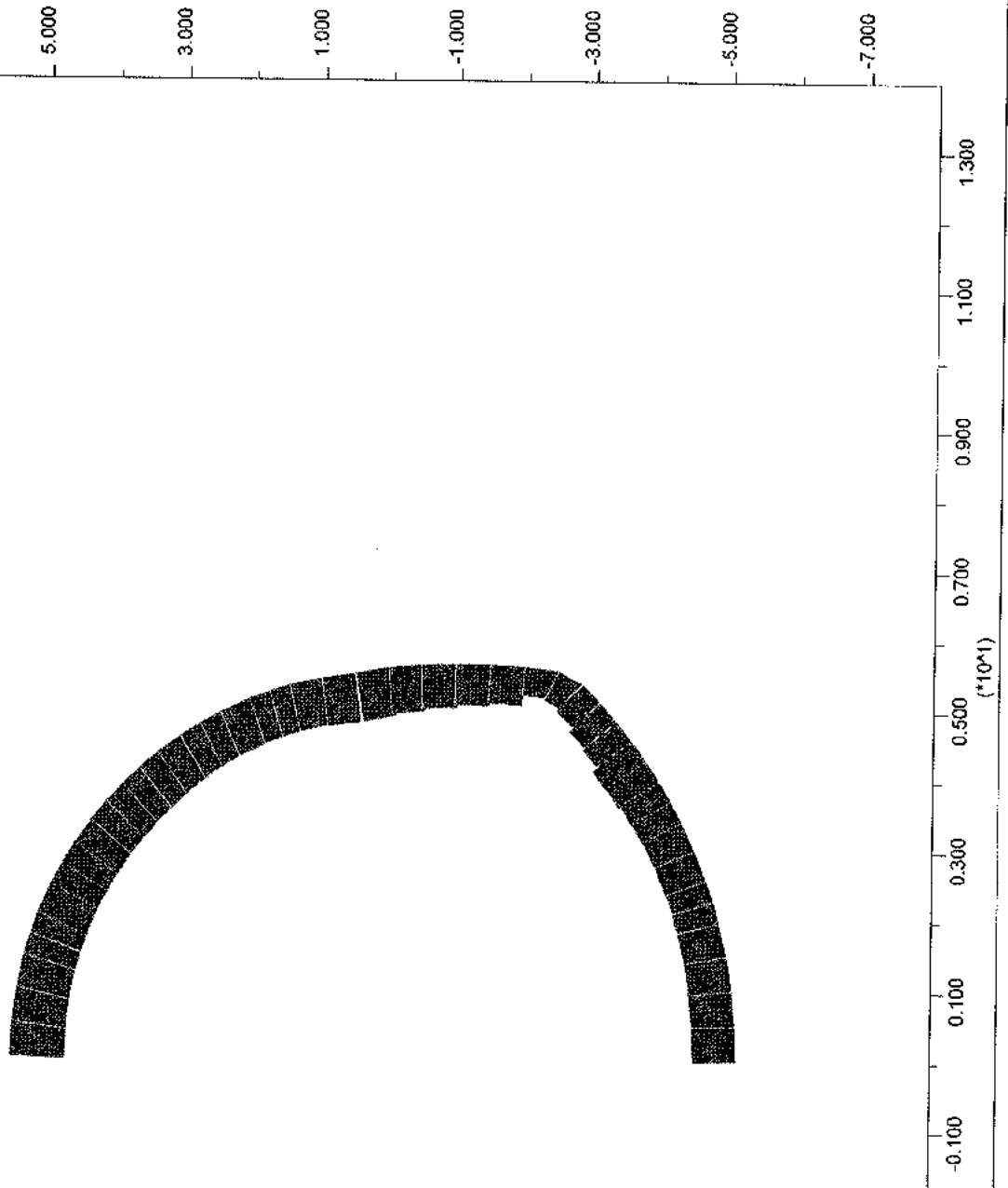
LEGEND

19-Feb-04 16:44
step 35506
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
1 (Beam) 3.737E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO B4/2 - "TIME 7"

FLAC (Version 4.00)

LEGEND

19-Feb-04 16:44

step 35506

-2.000E+00 <x< 1.400E+01

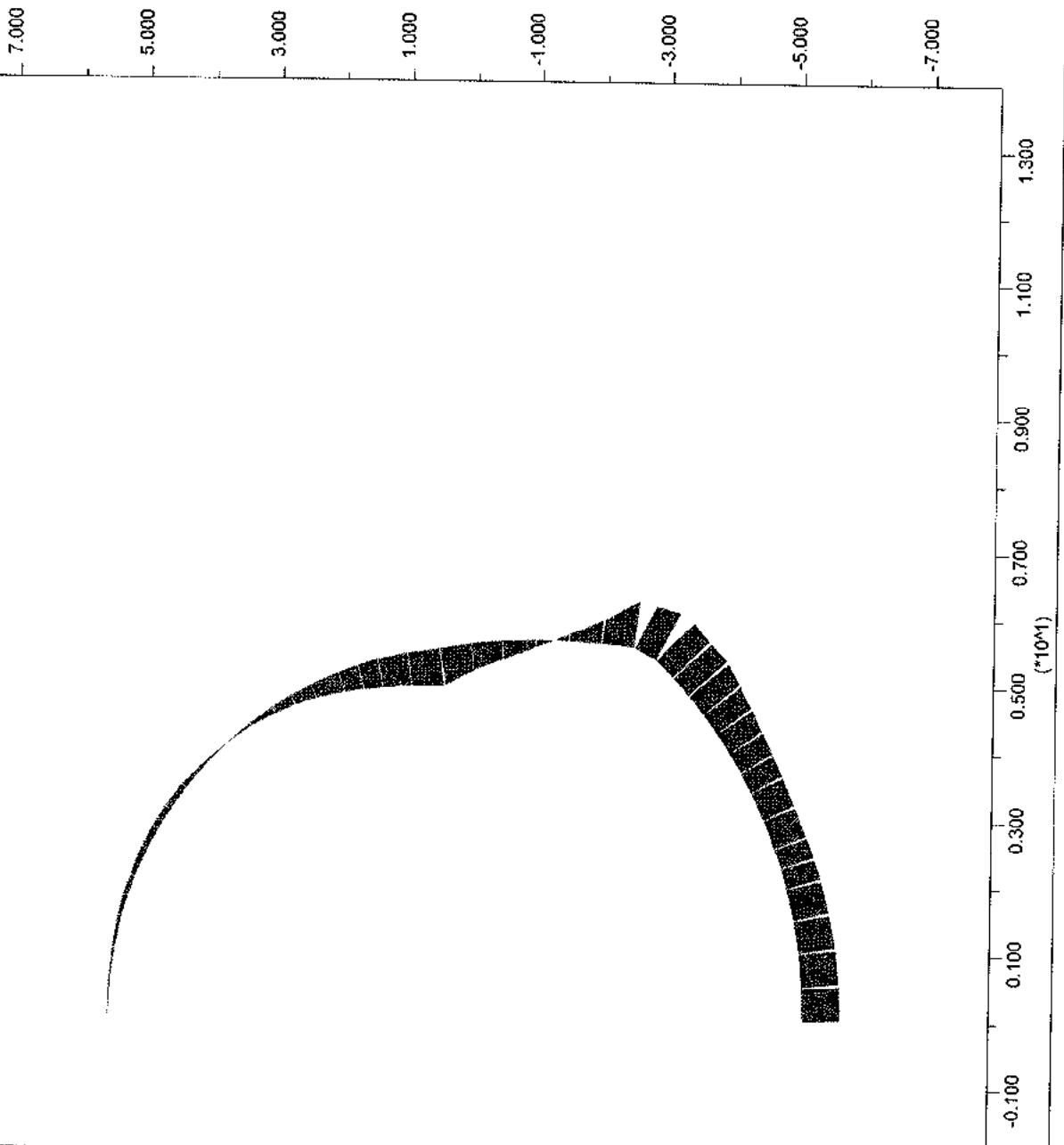
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

■ Moment on

Structure Max. Value

1 (Beam) -7.077E+05



Itasca Consulting Group, Inc.
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Calcolo FLAC – Sezione tipo C2

ANALISI FLAC

Sezione tipo C2 - Ap gruppo 3

Input Analisi alle Differenze Finite FLAC

Geometria	
Copertura (m)	800.00
Altezza falda statica (m)	0.00
Coefficiente di sicurezza di progetto	0.20
Altezza falda dinamica (m)	0.00
Raggio scavo (m)	5.80

Materiali	
Spritz-beton	f_{cm} (MPa) 30, s (m) 0.50, E_{as} (MPa) 4800, E_{sp} (MPa) 13000, I_{as} (cm ⁴) 2.25E+03
Centine	Tipi n, p (m) 1.00, A_s (cm ²) 1.06E+02, J_{ox} (cm ⁴) 11259.0
Rivestimenti	R_{st} (MPa) 30, S (m) 1.00, E_{mod} (MPa) 31220, ρ (t/m ³) 3.0
A.R.	30, 0.90, 31220, 42020 cm intr, 9.0
Calotta	30, 0.90, 31220, 42020 cm intr, 9.0

LEGENDA SIMBOLI

- f_{cm} - resistenza media di calcolo a compressione dello spritz-beton
- s - spessore dello spritz-beton
- E_{sp} - moduli elastici inerziali dello spritz-beton
- E_{as} - modulo elastico finale dello spritz-beton
- I_{as} - momento di inerzia dello spritz-beton
- n - numero di centine per gruppo
- p - passo centine
- A_s - area del profilo della singola centina
- J_{ox} - altezza del profilo centina
- ρ - momento di inerzia del profilo della singola centine
- R_{st} - resistenza caratteristica cubica a compressione dei dis
- S - spessore del rivestimento definitivo
- E_{mod} - modulo elastico del c/c maturato
- D - Distanza di getto tra rivestimenti definitivi e finale (multiplo del diametro della galleria)
- E_{pre} - modulo elastico del pre-rivestimento

Parametri geomeccanici	1° strato		2° strato		Fascia consolidata	
	Picco	Residuo	Picco	Residuo	Picco	Residuo
Valori di picco e residuo	27	27				
Peso di volume (kN/m ³)	29	27			32	
Angolo attrito (°)	0.70	0.65			1.40	
Coesione (MPa)	1.20	1.20			2.40	
Modulo elastico (GPa)	0.30	0.30			0.30	
Modulo di Poisson	1.00	1.00				
Modulo di deformazione volumetrica (Bulk modulus)(GPa)	0.48	0.48				
Modulo elastico tangenziale (Shear modulus)(GPa)						
Modello costitutivo	Strain-Softening					

Fasi di calcolo (TIME)	x (m)	x/R	R/Pinet	R/DEM	Epre (MPa)	Esp (MPa)
TIME 1 - Geostatico	-18.00	-0.00	0.000	0.000		
TIME 2 - Creazione coronella terreno trattato	0.00	0.000	0.280	0.948		
TIME 3 - Taratura e scavo	1.00	0.178	0.510	0.954	10000	
TIME 4 - Posi centine e SB	4.00	0.714	0.790	0.959	20000	
TIME 5 - Maturazione SB	8.00	1.428	0.901	0.962	37500	
TIME 6 - Maturazione SB finale	16.00	2.857	0.963	0.974	18000	
TIME 7 - Getto Muricella e A.R. non maturati	24.00	4.286	0.981	0.977	37500	31220
TIME 8 - Maturazione muricella e A.R.			1.000	1.000	37500	31220
TIME 9 - Getto calotta			1.000	1.000	37500	31220
TIME 10 - Decadimento ammesso e pre-rivestimento			1.000	1.000	37500	31220

Relazione per il calcolo di R/Pinet, R/DEM:

$$R = u_0 + (x \cdot \omega - r \cdot 0) \cdot \left[1 - \frac{1}{1 + 0.34 \cdot \frac{x}{R_p}} \right]$$

R' = Convergenza radiale ad una distanza di x metri dal fronte espressa come % di u_0
 u_0 = Convergenza radiale in corrispondenza del fronte espressa come % di u_0
 ω = Convergenza radiale ad una distanza infinita dal fronte
 R_p = Raggio plastico
 R = Raggio della galleria
 x = distanza fra il fronte e la sezione di calcolo

TIMES DI CALCOLO

TIME	Descrizione	Stato
TIME 1 - Geostatico	Viene applicato il peso proprio del terreno, ricostruendo in termini di tensioni litostatiche la situazione preesistente lo scavo della galleria.	
TIME 2 - Creazione coronella terreno trattato	Si simula l'arrivo del consolidamento al contorno delle future sagome di scavo	
TIME 3 - Taratura e scavo	Viene simulato l'arrivo del fronte di scavo, tenendo conto del contributo offerto dai consolidamenti al fronte	
TIME 4 - Posi centine e SB	Viene simulata la posa in opera delle centine e dello spritz-beton.	
TIME 5 - Maturazione SB	Viene simulata la maturazione parziale dello spritz-beton e l'arricchimento dello scavo.	
TIME 6 - Maturazione SB finale	Viene simulata la completa maturazione dello spritz-beton e l'avanzamento dello scavo.	
TIME 7 - Getto Muricella e A.R. non maturati	Viene simulato il getto della muricella e dell'arco rovescio non maturati e l'avanzamento dello scavo.	
TIME 8 - Maturazione muricella e A.R.	Si simula la completa maturazione della muricella e dell'arco rovescio e l'avanzamento dello scavo.	
TIME 9 - Getto calotta	Si simula il getto del rivestimento definitivo di calotta.	
TIME 10 - Decadimento ammesso e pre-rivestimento	Si applica un decadimento della caratteristiche meccaniche del pre-rivestimento e nell'ammesso	

JOB TITLE : Elementi strutturali del prriverimento - Sezioni di verifica

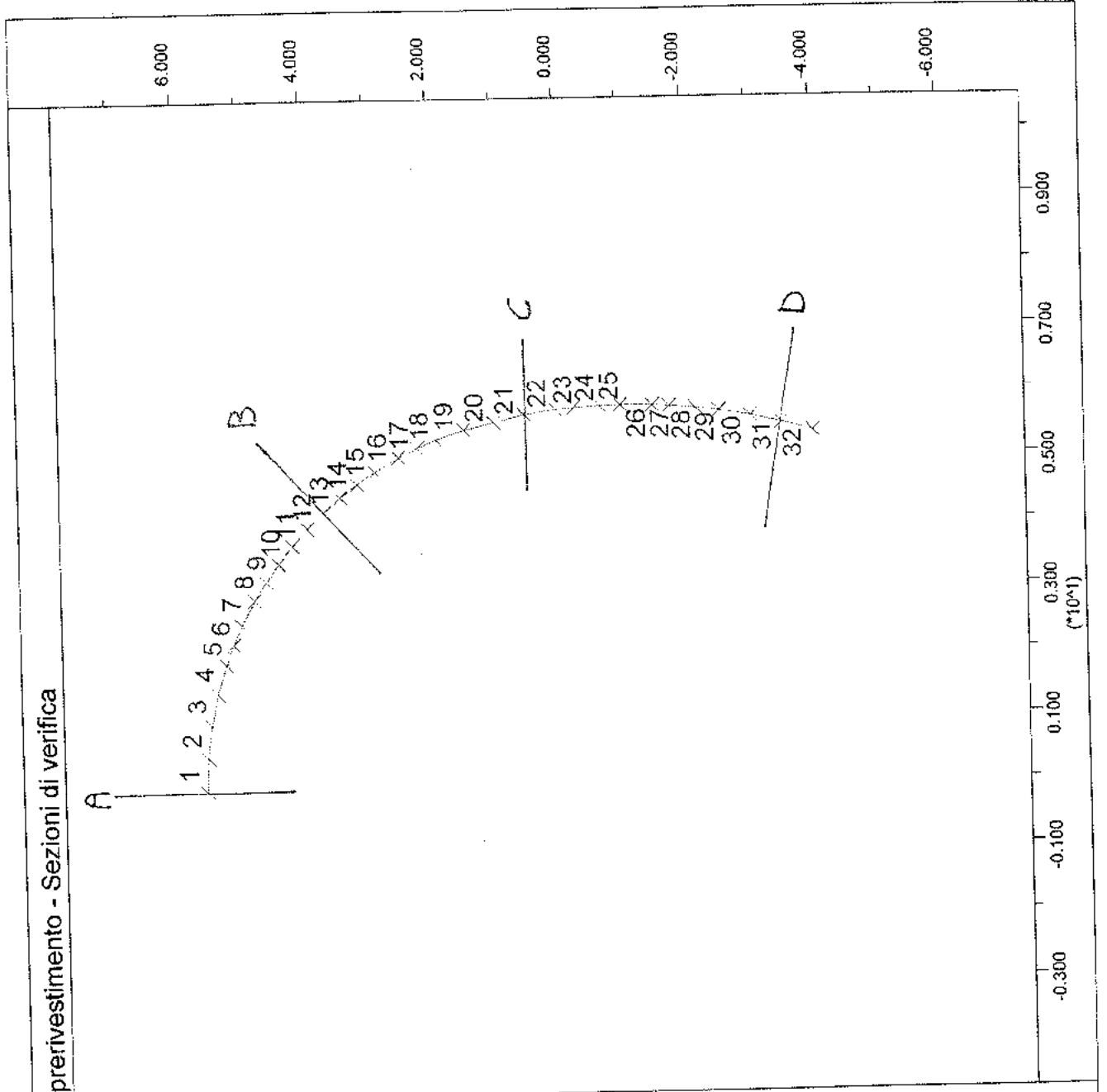
FLAC (Version 4.00)

LEGEND

5-Feb-04 18:32
step 22377
-4.714E+00 <x< 1.049E+01
-7.351E+00 <y< 7.854E+00

Beam Plot
Structural Element Numbers

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



Sezione tipo C2 - Ap gruppo 3

Verifica del prerivestimento

CARATTERISTICHE GEOMETRICHE E MECCANICHE

MATERIALI	Tipo	σ_{max} (MPa)	H (cm)	Passo (m)	n°	A (cm²)	I (cm⁴)
Spritz-beton	Fcm 30	23.00	30	-	-	3000.0	2250.0
Centine	HEB240	210	24	1	1	106.0	11259.0
Sezione omogeneizzata						4484.0	168811.8

Coefficiente omogeneizzazione m	15	
Baricentro centina d (cm)	12.00	dall'estradosso
Baricentro sezione omogeneiz. Yg (cm)	14.01	dall'estradosso
e'lim,e = I'/(A*Yg) (cm)	2.69	dimensione nocciolo d'inerzia estradosso
e'lim,i = I'/(A*(H-Yg)) (cm)	2.35	dimensione nocciolo d'inerzia intradosso

e = M/N

eccentricità

Formule impiegate

Tensioni positive se di compressione

$$\sigma_{sb,i} = N/A^* + (M(H-Yg))/I^* \quad \sigma_{sb,e} = N/A^* - (MYg)/I^*$$

$$\sigma_{s,i} = m(N/A^* + M(d+H_s/2-Yg)/I^*)$$

$$\sigma_{s,e} = m(N/A^* - M(d-H_s/2-Yg)/I^*)$$

Sezione	Elemento	Altezza (m)	N (KN/m)	M (KN*m/m)	e (m)	$\sigma_{sb,i}$ (Mpa)	$\sigma_{sb,e}$ (Mpa)	$\sigma_{s,i}$ (Mpa)	$\sigma_{s,e}$ (Mpa)	
CHIAVE CALOTTA	1	0.30	1031	2.1	0.00	2.50	2.13	36.35	31.88	TIME 4
RENI	13	0.30	921	6.6	0.01	2.68	1.51	36.67	22.60	
P.C.	21	0.30	834	-11.9	-0.01	0.73	2.85	17.33	42.71	
PIEDE	31	0.30	226	4.00	0.02	0.88	0.17	11.11	2.58	
CHIAVE CALOTTA	1	0.30	1943	3.9	0.00	4.70	4.01	68.46	60.14	TIME 5
RENI	13	0.30	1773	14.6	0.01	5.34	2.74	72.27	41.14	
P.C.	21	0.30	1565	-24.4	-0.02	1.18	5.51	30.69	82.72	
PIEDE	31	0.30	656	12.5	0.02	2.65	0.43	33.04	6.39	
CHIAVE CALOTTA	1	0.30	2556	6.8	0.00	6.34	5.14	91.54	77.04	TIME 6
RENI	13	0.30	2305	19.6	0.01	7.00	3.51	94.51	52.71	
P.C.	21	0.30	1984	-30.6	-0.02	1.53	6.98	39.20	104.45	
PIEDE	31	0.30	805	19.1	0.02	3.60	0.21	43.89	3.16	
GETTO DELL'ARCO ROVESCIO - Le verifiche del piede centina saranno omesse										
CHIAVE CALOTTA	1	0.30	3441	4.6	0.00	8.11	7.29	119.19	109.38	TIME 7
RENI	13	0.30	3318	13.2	0.00	8.65	6.30	122.72	94.57	
P.C.	21	0.30	3209	-68.8	-0.02	0.64	12.87	46.26	192.98	
CHIAVE CALOTTA	1	0.30	3614	4.9	0.00	8.52	7.65	125.25	114.80	TIME 8
RENI	13	0.30	3499	30.3	0.01	10.67	5.29	143.95	79.34	
P.C.	21	0.30	3429	-75.2	-0.02	0.52	13.89	47.94	208.30	

JOB TITLE : Elementi strutturali del rivestimento definitivo - Sezioni di verifica

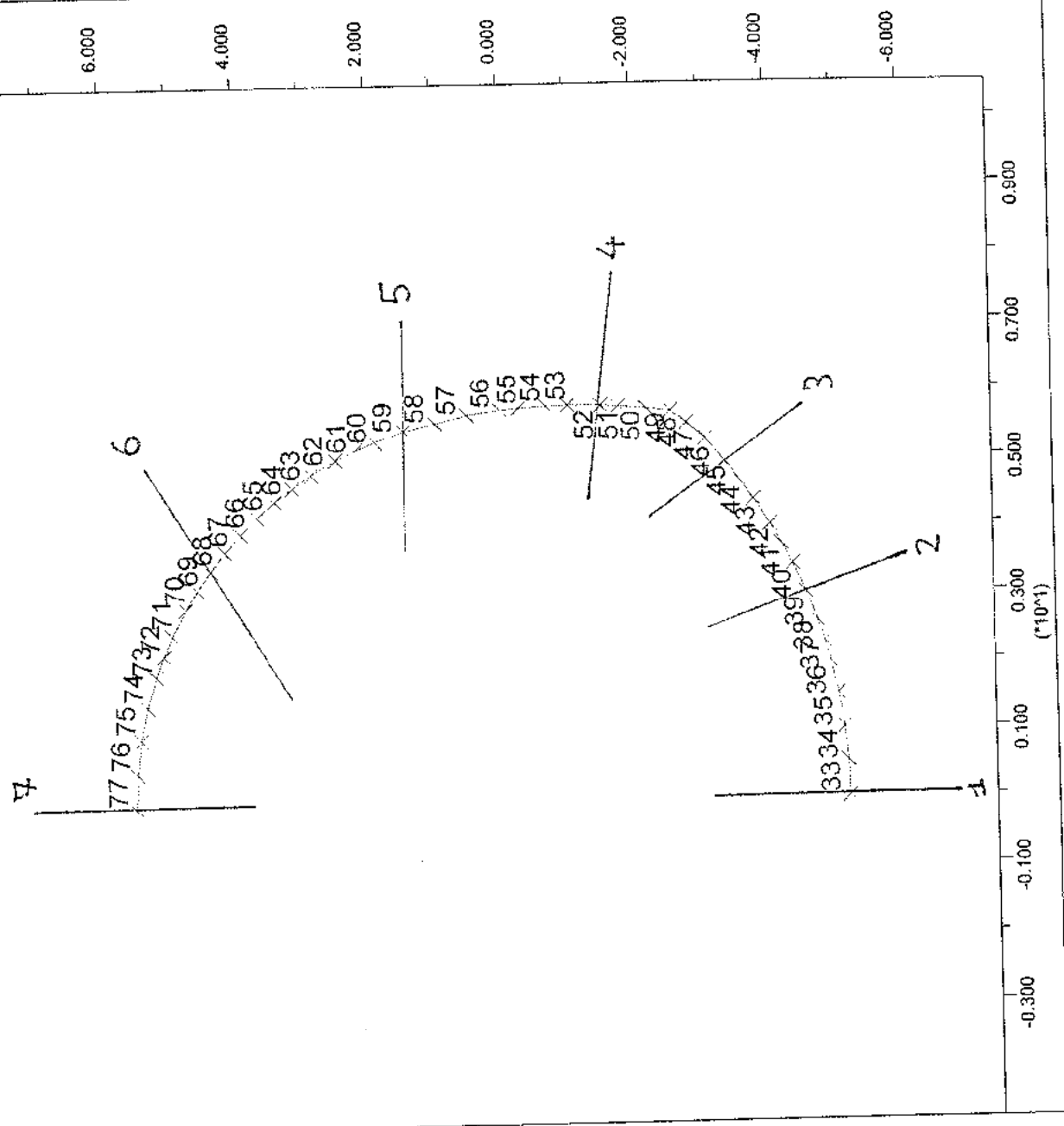
FLAC (Version 4.00)

LEGEND

6-Feb-04 11:27
step 29109
-4.714E+00 <x< 1.049E+01
-7.351E+00 <y< 7.854E+00

Beam Plot
Structural Element Numbers

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



Sezione tipo C2 - Ap gruppo 3
Verifica del rivestimento definitivo

TIME 7 - Getto Murette e A.R. non maturati

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)	σ_s (MPa)
CHIAVE A.R.	33	1.00	1331	120.6	0.09	1.9	-28.5
SEZIONE INTERMEDIA A.R.	39	1.00	1339	68.5	0.05	1.7	-25.5
ATTACCO A.R. - MURETTA	45	1.00	878	-101.7	-0.12	1.4	-21.0

TIME 8 - Maturazione murette e A.R.

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)	σ_s (MPa)
CHIAVE A.R.	33	1.00	1579	139.7	0.09	2.3	-34.5
SEZIONE INTERMEDIA A.R.	39	1.00	1582	91.2	0.06	2.0	-30.0
ATTACCO A.R. - MURETTA	45	1.00	1065	-115.6	-0.11	1.6	-24.0

TIME 9 - Getto calotta

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)	σ_s (MPa)
CHIAVE A.R.	33	1.00	3815	490.0	0.13	6.3	-94.5
SEZIONE INTERMEDIA A.R.	39	1.00	3861	274.3	0.07	5.2	-78.0
ATTACCO A.R. - MURETTA	45	1.00	2984	-454.4	-0.15	5.3	-79.5
ATTACCO CAL. - MURETTA	52	0.90	1644	-207.5	-0.13	3.1	-46.5
PIANO DEI CENTRI	58	0.90	1516	270.1	0.18	3.7	2.1
RENI	68	0.90	1463	-36.2	-0.02	1.7	-25.5
CHIAVE CALOTTA	77	0.90	1483	-6.3	0.00	1.7	-25.5

TIME 10 - Decadimento ammasso e priverimento

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σ_c (MPa)	σ_s (MPa)
CHIAVE A.R.	33	1.00	4815	421.1	0.09	6.9	-103.5
SEZIONE INTERMEDIA A.R.	39	1.00	5122	169.6	0.03	5.8	-87.0
ATTACCO A.R. - MURETTA	45	1.00	4239	-445.9	-0.11	6.5	-97.5
ATTACCO CAL. - MURETTA	52	0.90	4006	174.6	0.04	5.9	-88.5
PIANO DEI CENTRI	58	0.90	4165	607.5	0.15	9.2	-138.0
RENI	68	0.90	4249	-142.1	-0.03	5.3	-79.5
CHIAVE CALOTTA	77	0.90	4175	-19.4	0.00	4.7	-70.5

Sezione tipo C2 - Ap gruppo 3

Output Analisi alle Differenze Finite FLAC

TIME	Riduzione forze di scavo [%]	Spostamento y in chiave calotta [cm]		Spostamento x sul piano dei centri [cm]		Spostamento y in chiave A.R. [cm]		Tensioni prefiv. [MPa]		Tensioni riv. definitivo [MPa]	
		Nodo i=1 j=6B	Nodo i=1 j=6B	Nodo i=12 j=57	Nodo i=12 j=57	Nodo i=1 j=47	Nodo i=1 j=47	$\sigma_{SB,max}$	$\sigma_{s,max}$	$\sigma_{cis,max}$	$\sigma_{s,max}$
TIME 1 - Geostatico	0.0	-	-	-	-	-	-	-	-	-	-
TIME 2 - Creazione coronella terreno trattato	0.0	-	-	-	-	-	-	-	-	-	-
TIME 3 - Taratura e scavo	94.8	-23.6	25.2	28.5	28.5	-	-	-	-	-	-
TIME 4 - Posa centina e SB	95.4	-23.7	25.6	28.6	28.6	2.85	42.71	2.85	42.71	-	-
TIME 5 - Maturazione SB	95.9	-23.8	25.9	30.5	30.5	5.51	82.72	5.51	82.72	-	-
TIME 6 - Maturazione SB finale	96.2	-23.8	26.1	31.0	31.0	7.00	104.45	7.00	104.45	-	-
TIME 7 - Getto Murette e A.R. non maturati	97.4	-24.0	26.2	31.0	31.0	12.87	192.98	12.87	192.98	1.9	-28.5
TIME 8 - Maturazione murette e A.R.	97.7	-24.0	26.2	31.1	31.1	13.89	208.30	13.89	208.30	2.3	-34.5
TIME 9 - Getto calotta	100.0	-24.0	26.2	31.2	31.2	-	-	-	-	6.3	-94.5
TIME 10 - Decadimento ammasso e pririvestimento	100.0	-24.1	26.3	31.2	31.2	-	-	-	-	9.2	-138.0

Materiale	Tipo	Tensioni ammissibili [MPa]
Spritz-beton	fc	23.00
Centina	Fe	210
Ferri d'armatura	FeB	255
Calcestruzzo	Rck	9.75

Tensioni positive nel cis : compressione
 Tensioni positive nell'acciaio : trazione
 Spostamenti x positivi verso destra, spostamenti y positivi verso l'alto

JOB TITLE : Cunicolo Castagnola (Ap gruppo 3) - SEZ. TIPO C2

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:05

step 9305

-1.067E+02 <x< 2.267E+02

-1.417E+02 <y< 1.917E+02

MESH DI CALCOLO

0

1E 2

(*10²)

1.500

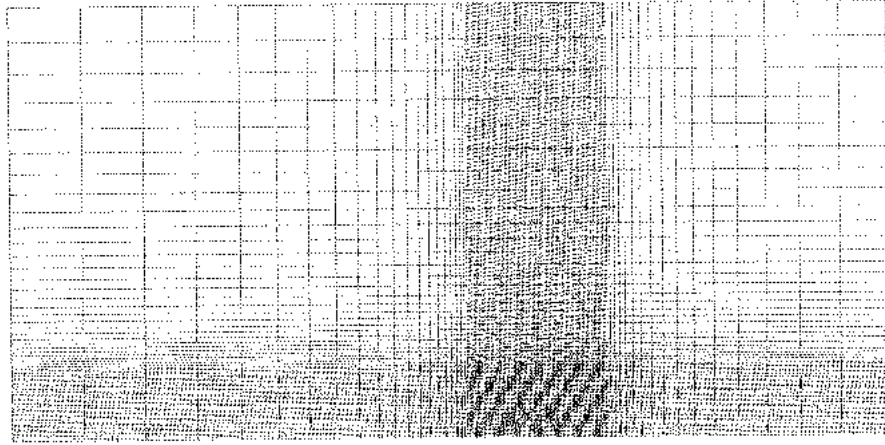
1.000

0.500

0.000

-0.500

-1.000



1.750

1.250

0.750

0.250

-0.250

-0.750

(*10²)

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola (Ap gruppo 3) - SEZ. TIPO C2

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:05

step 9305

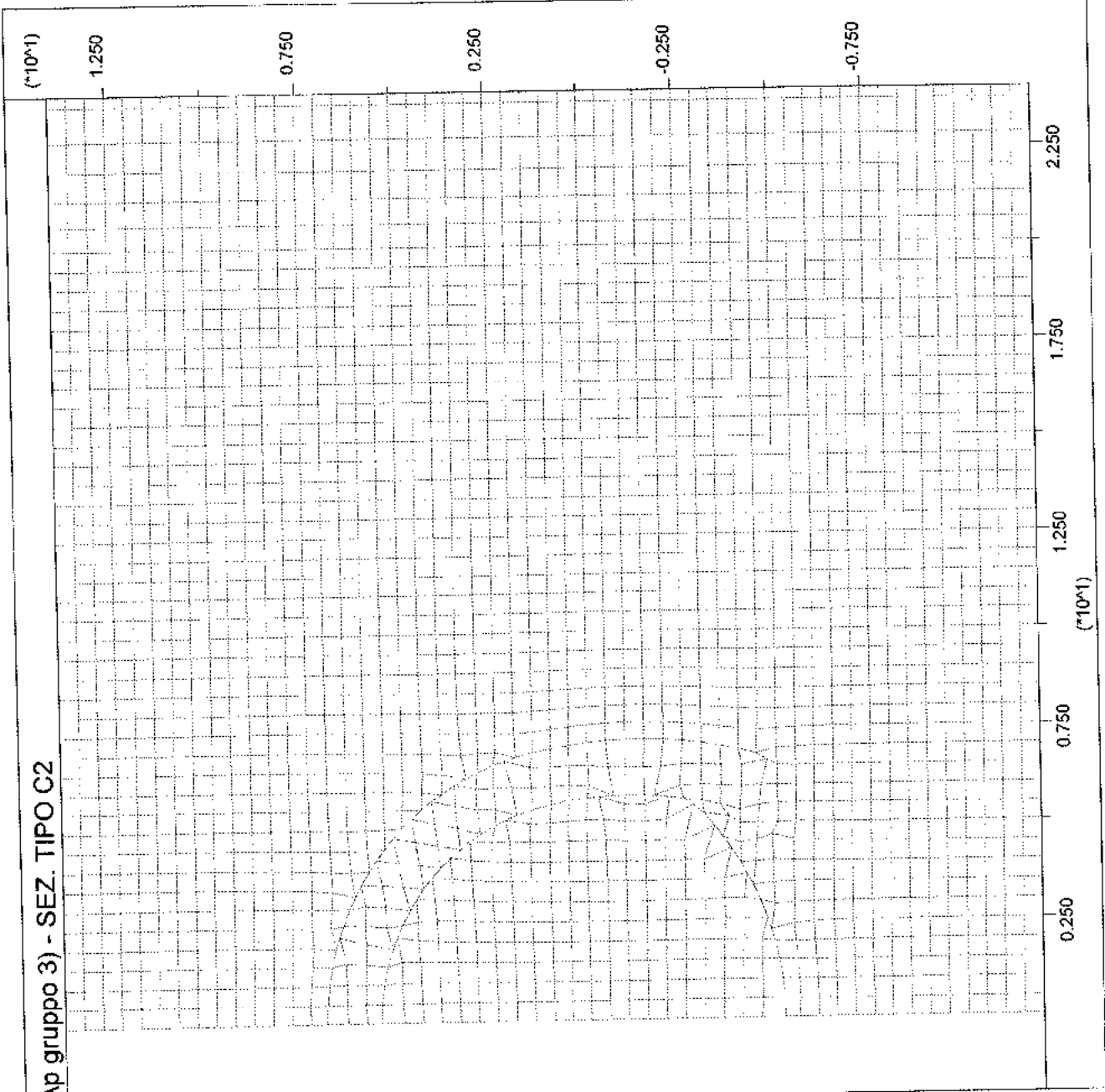
-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

MESH DI CALCOLO

0

5E 0



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 1"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:05

step 9305

-1.067E+02 <x< 2.267E+02

-1.417E+02 <y< 1.917E+02

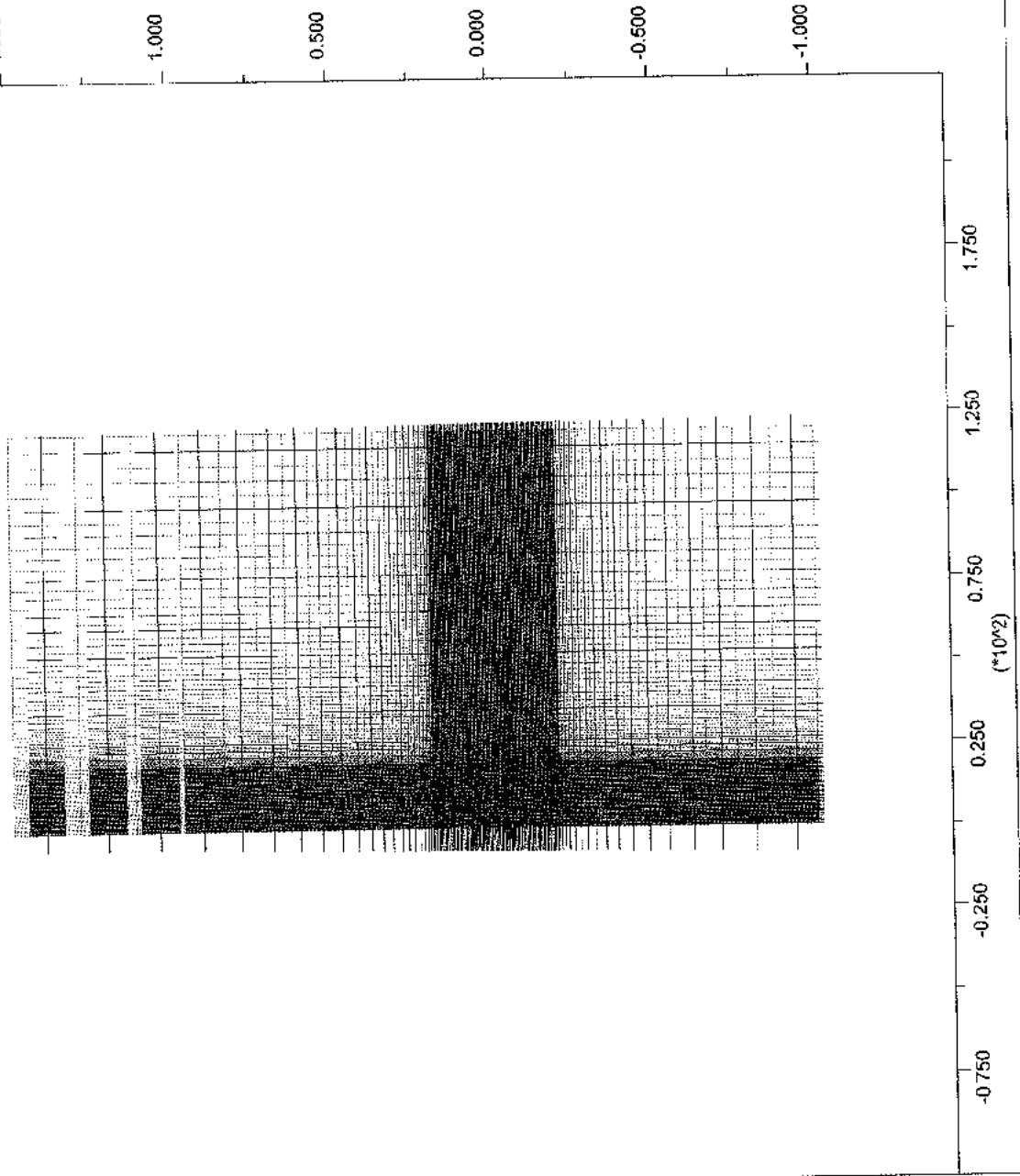
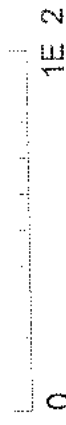
Principal stresses

Max. Value = -1.242E+07

Min. Value = -1.854E+07



Tensioni principali : Pa



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 1"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:05

step 9305

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -1.574E+07

Min. Value = -1.640E+07

0 5E 0 1E 8

Tensioni principali : Pa

0 5E 0

(*10⁴)

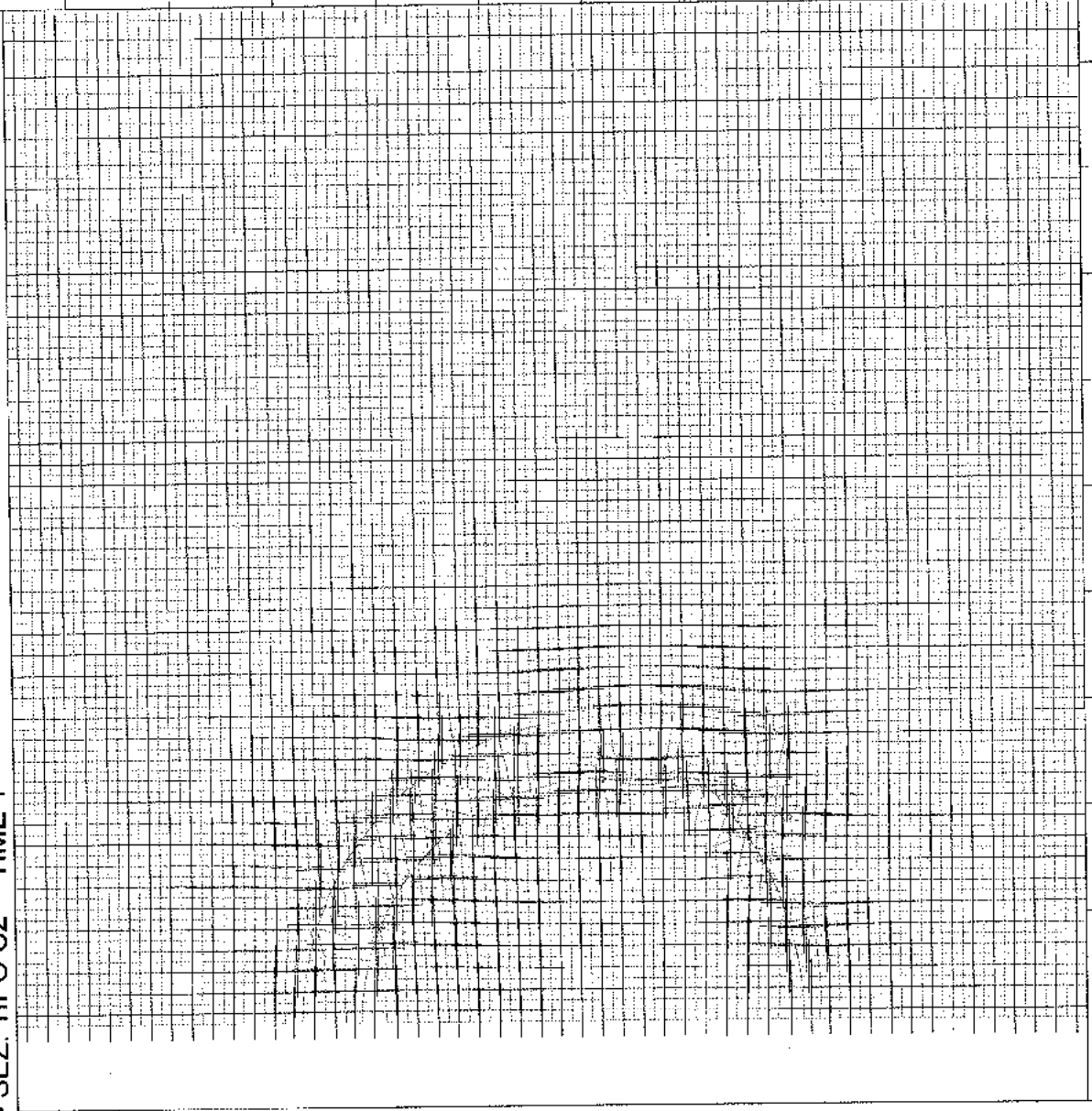
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10⁴)

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 2"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:06

step 12705

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Coronella di terreno consolidato



'Ap gruppo 3'

'Terreno trattato'

(*10^1)

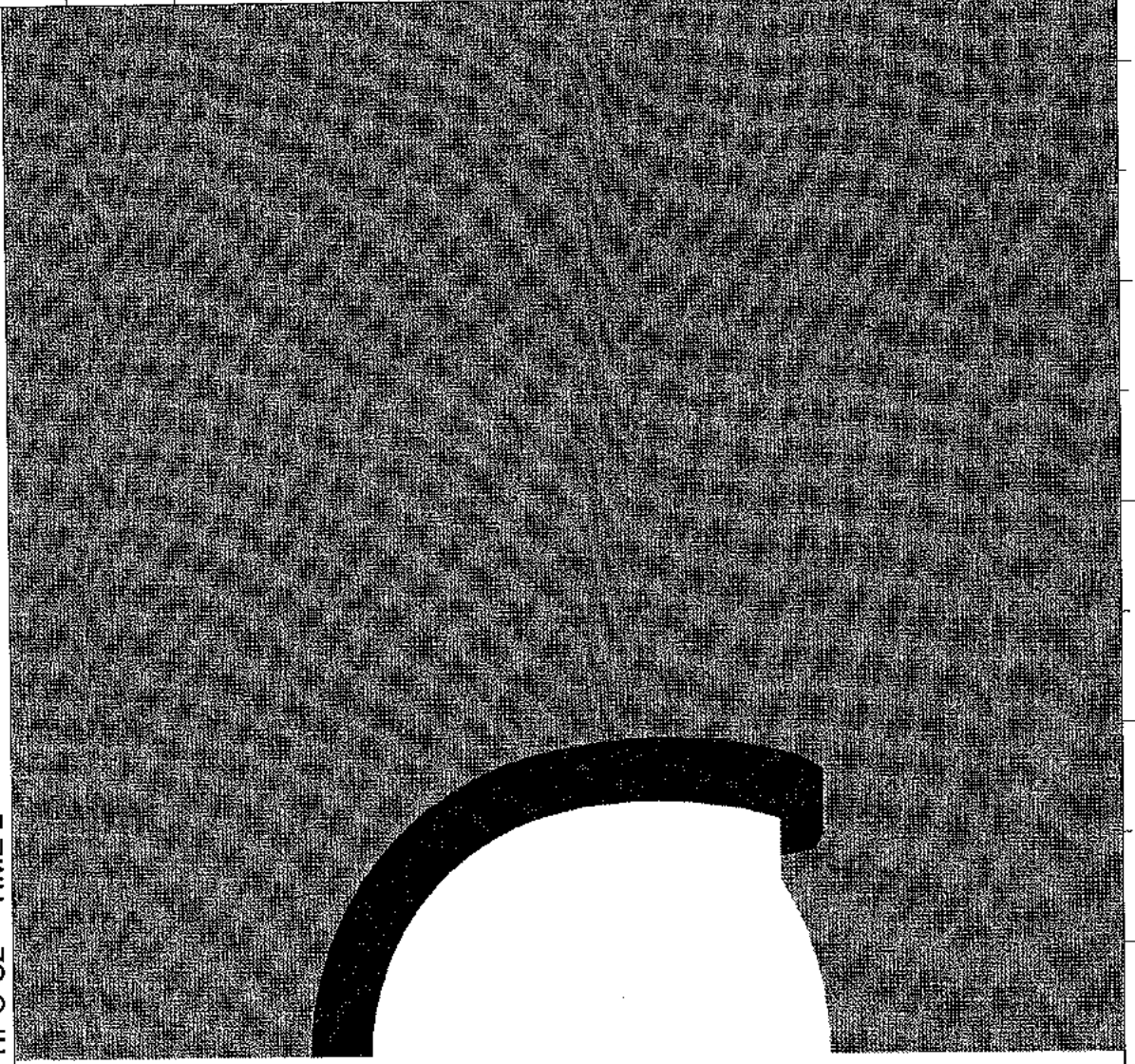
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

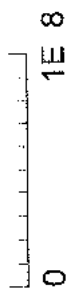
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 3"

FLAC (Version 4.00)

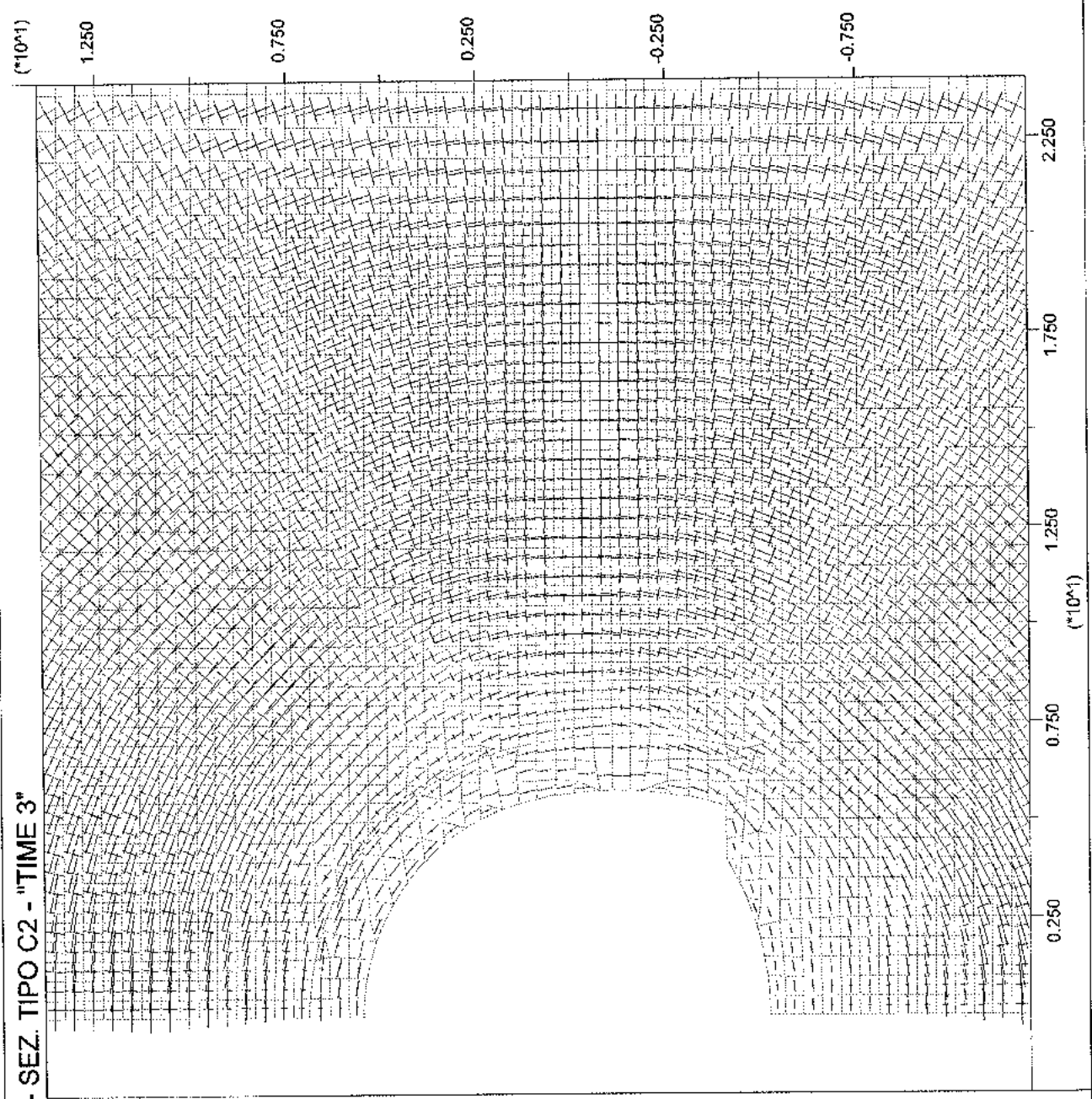
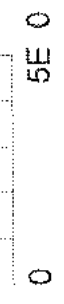
LEGEND

9-Feb-04 12:08
step 19389
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses
Max. Value = -3.214E+05
Min. Value = -2.577E+07



Tensioni principali : Pa



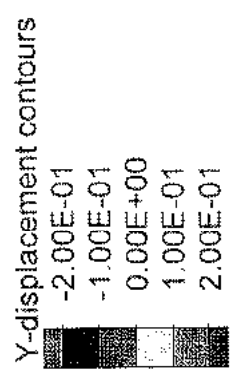
Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 3"

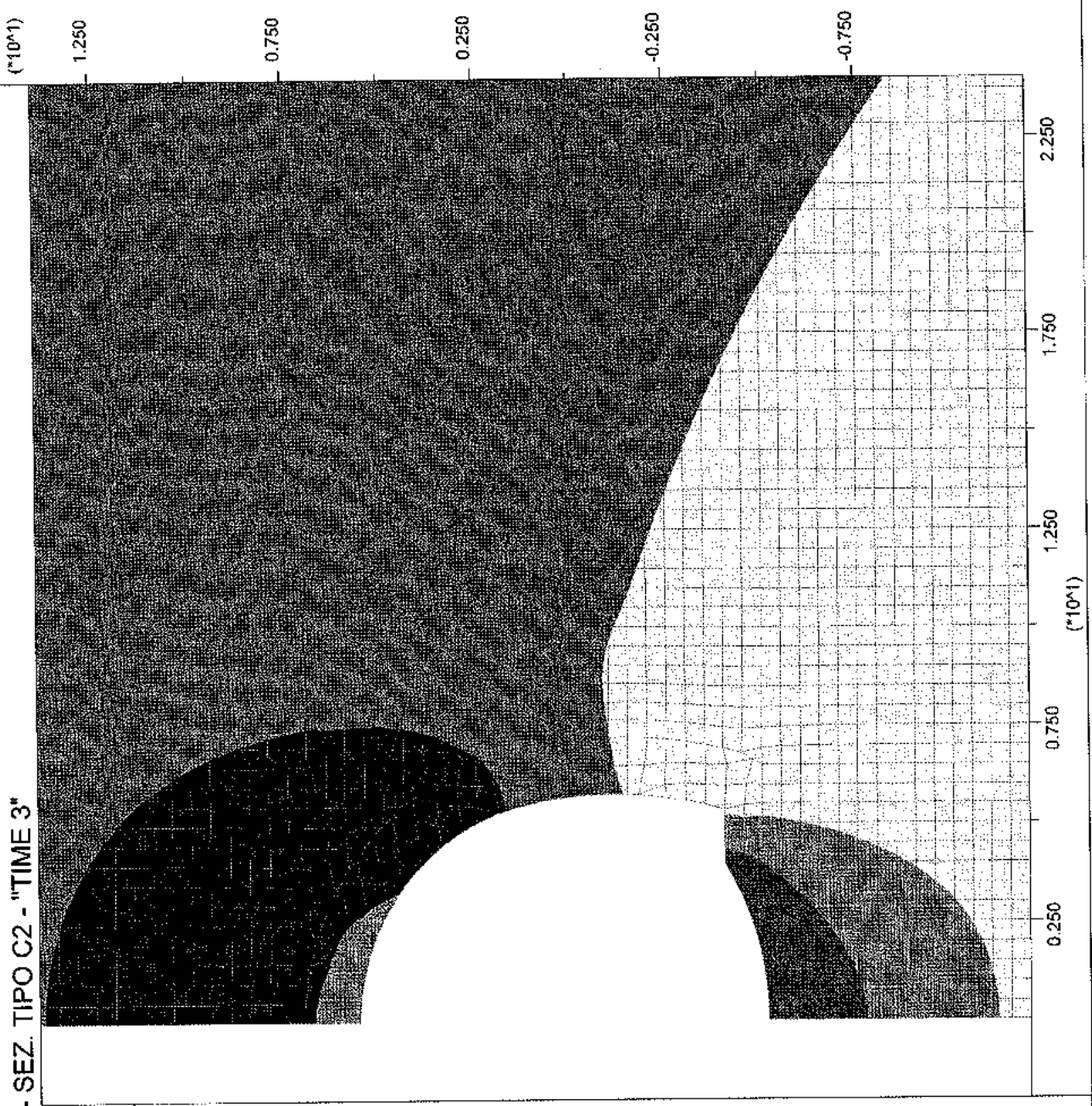
FLAC (Version 4.00)

LEGEND

9-Feb-04 12:08
step 19389
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01



Contour interval= 1.00E-01
Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:08

step 19389

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-2.50E-01

-2.00E-01

-1.50E-01

-1.00E-01

-5.00E-02

0.00E+00

Contour interval= 5.00E-02

Spostamenti orizzontali



(*10^1)

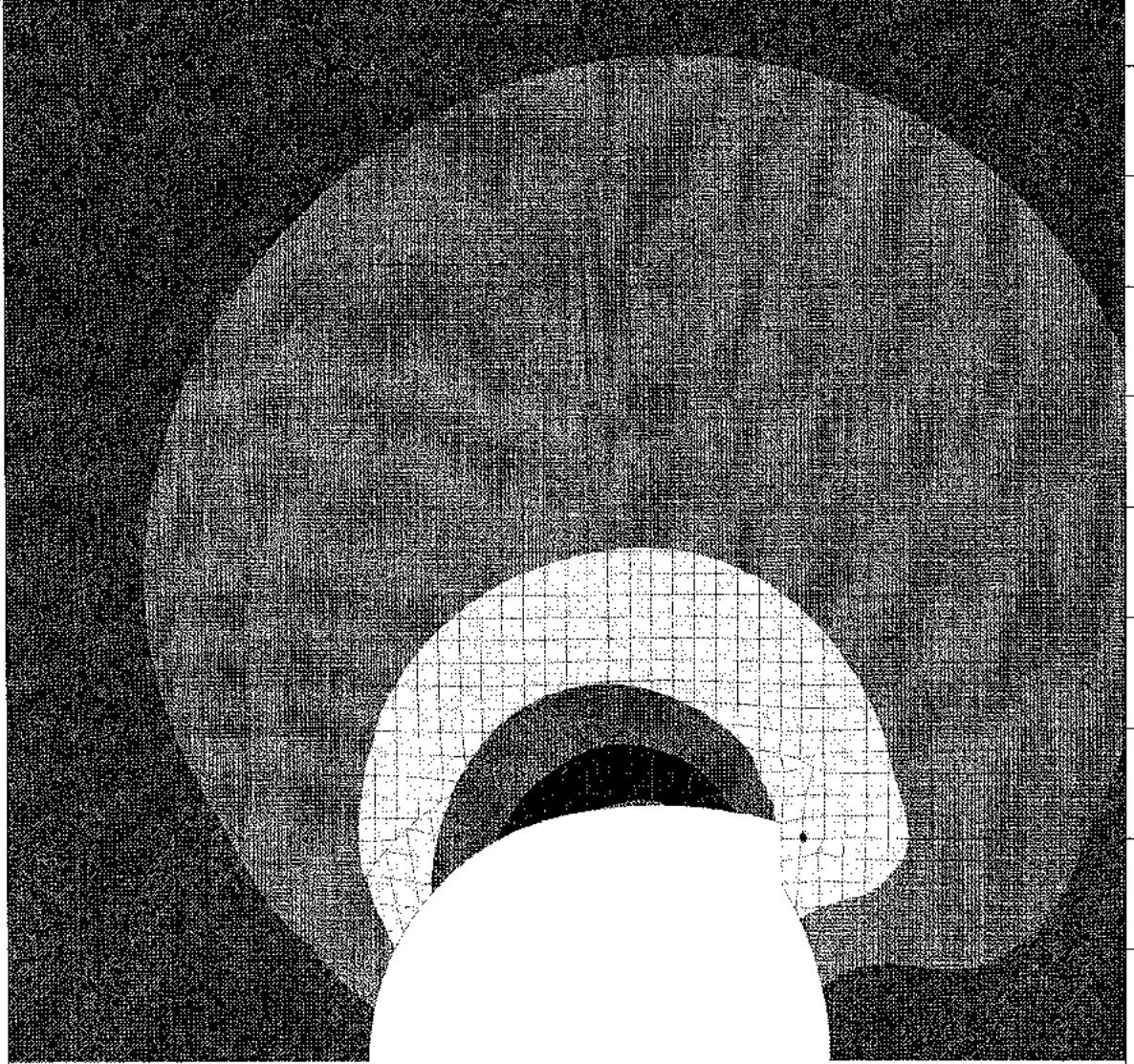
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 3"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:08

step 19389

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

1.00E-02

2.00E-02

3.00E-02

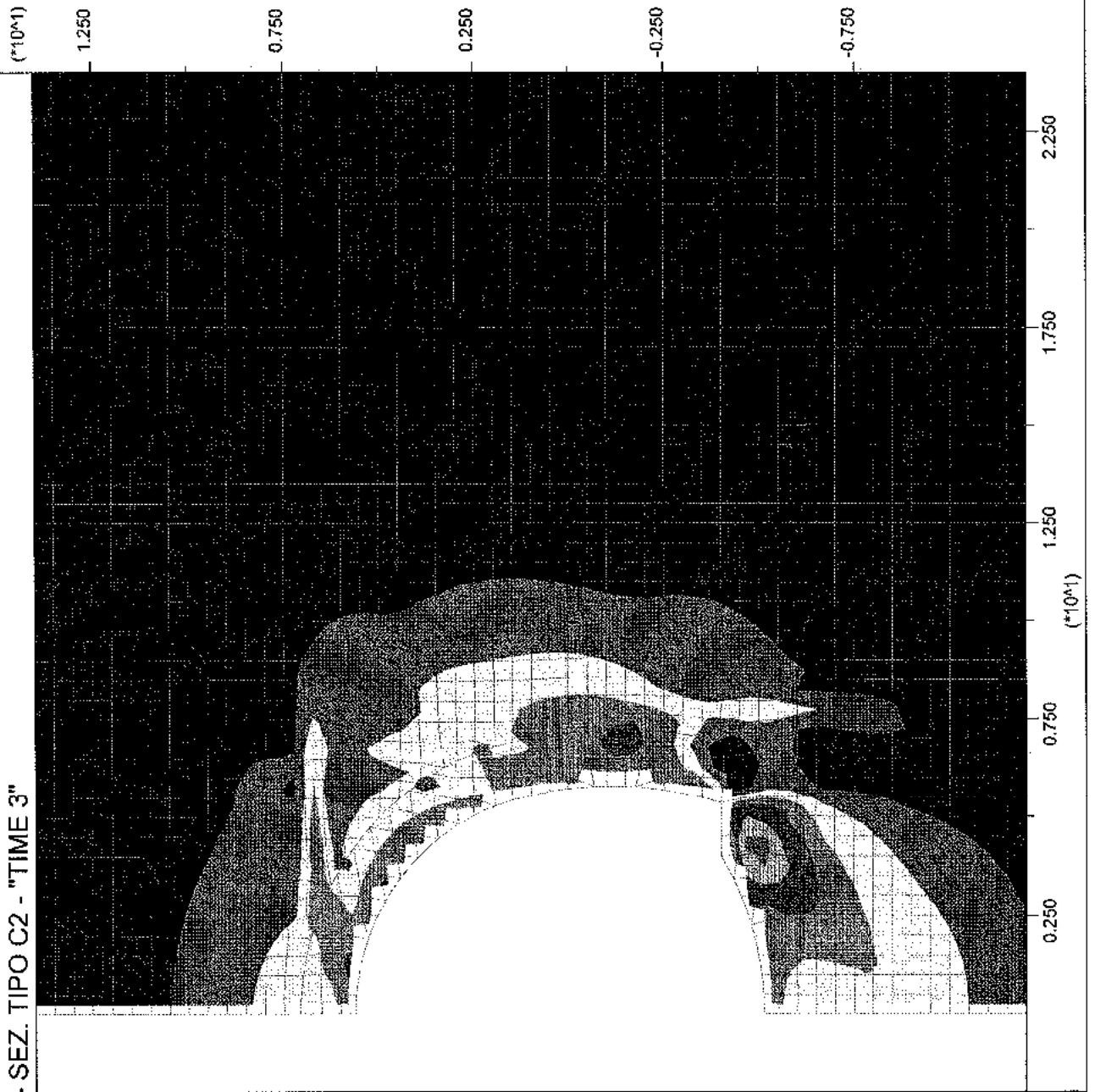
4.00E-02

5.00E-02

6.00E-02

Contour interval= 1.00E-02

Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:35
step 20793
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

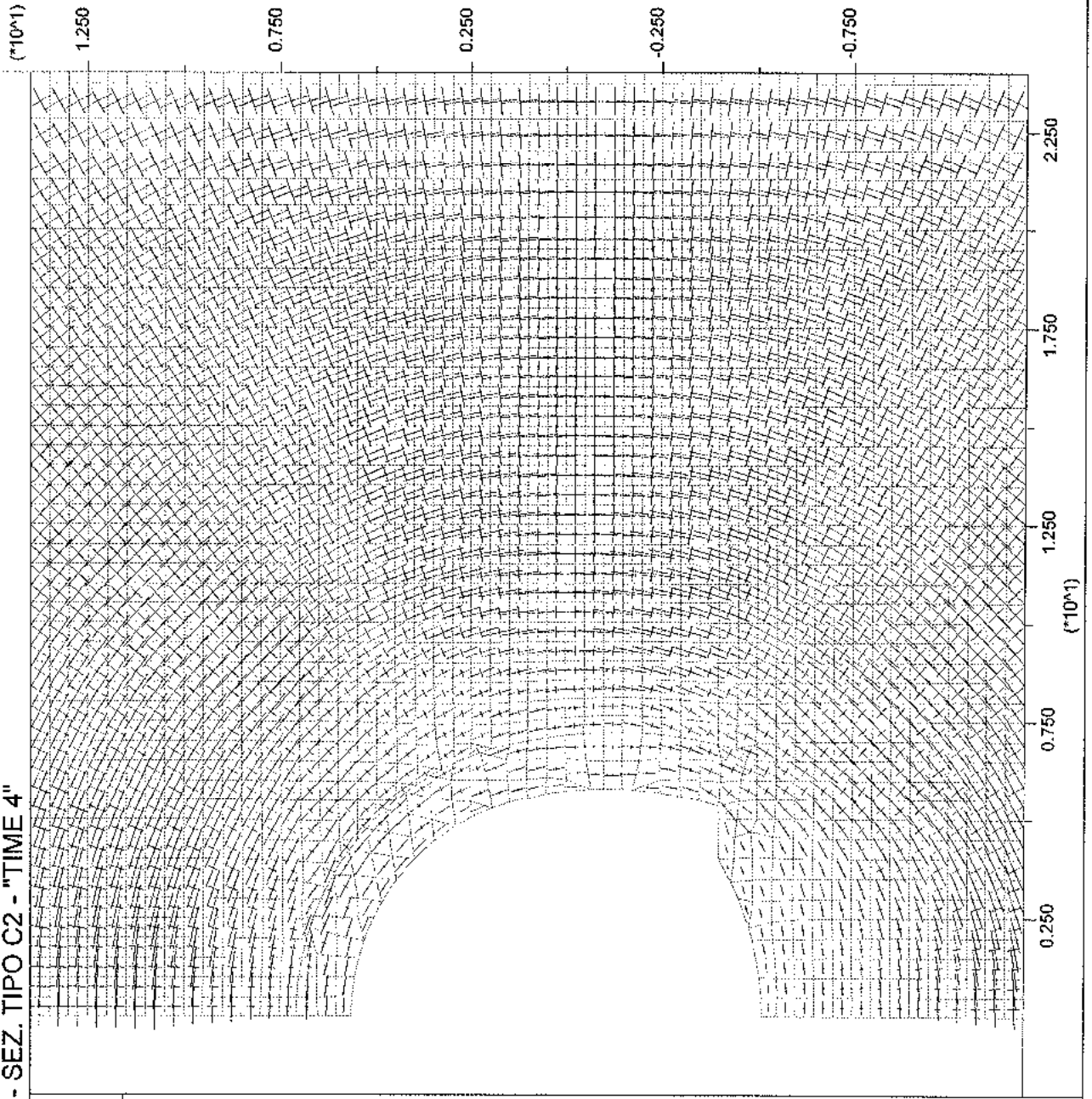
Principal stresses

Max. Value = -2.066E+05
Min. Value = -2.564E+07

0 1E 8

Tensioni principali : Pa

0 5E 0



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 4"

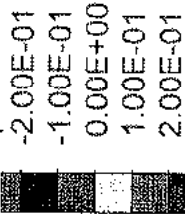
FLAC (Version 4.00)

LEGEND

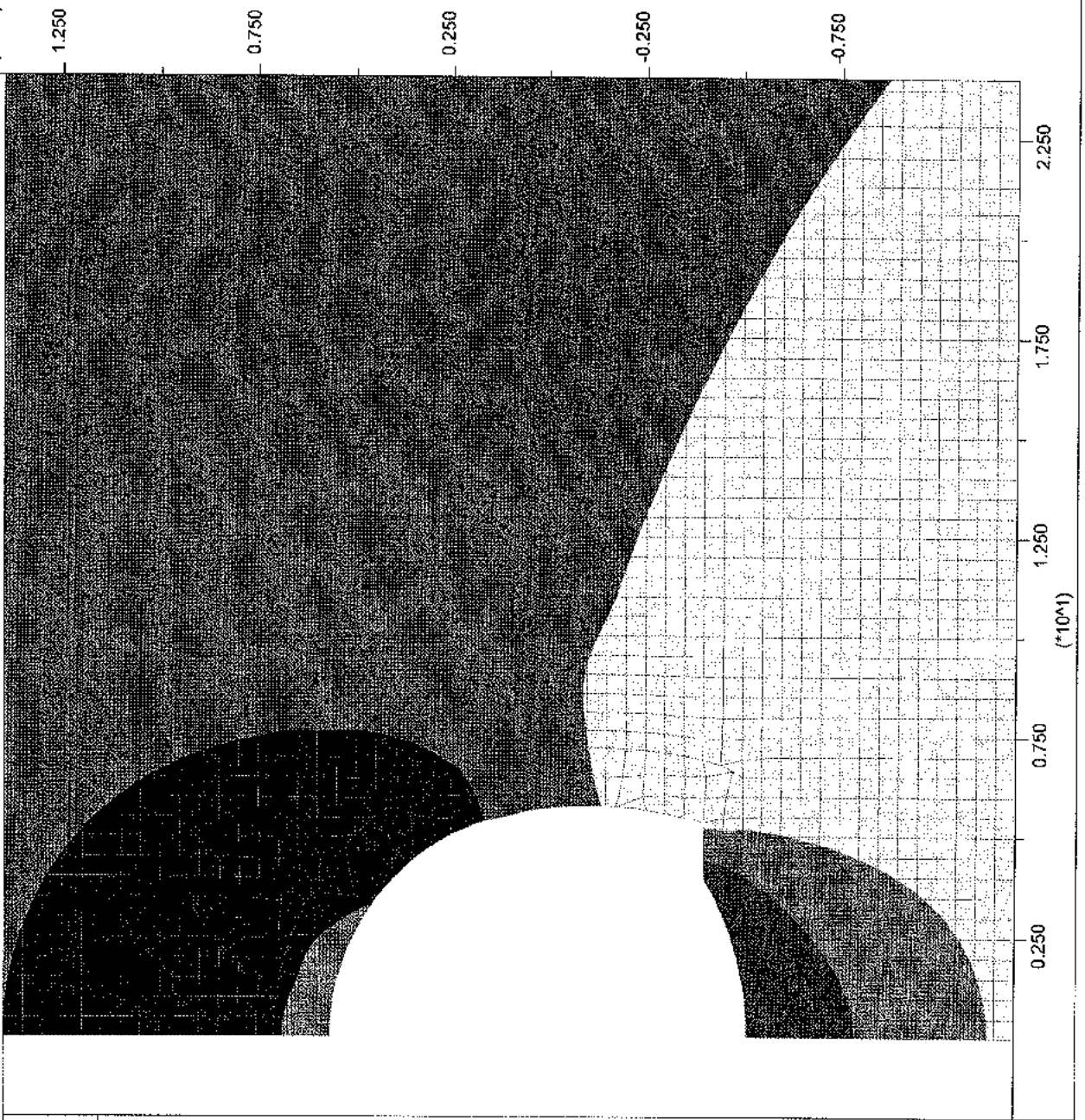
9-Feb-04 12:35
step 20793

-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01
Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:35

step 20793

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-2.50E-01

-2.00E-01

-1.50E-01

-1.00E-01

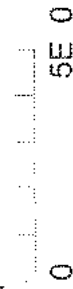
-5.00E-02

0.00E+00



Contour interval= 5.00E-02

Spostamenti orizzontali



(*10^1)

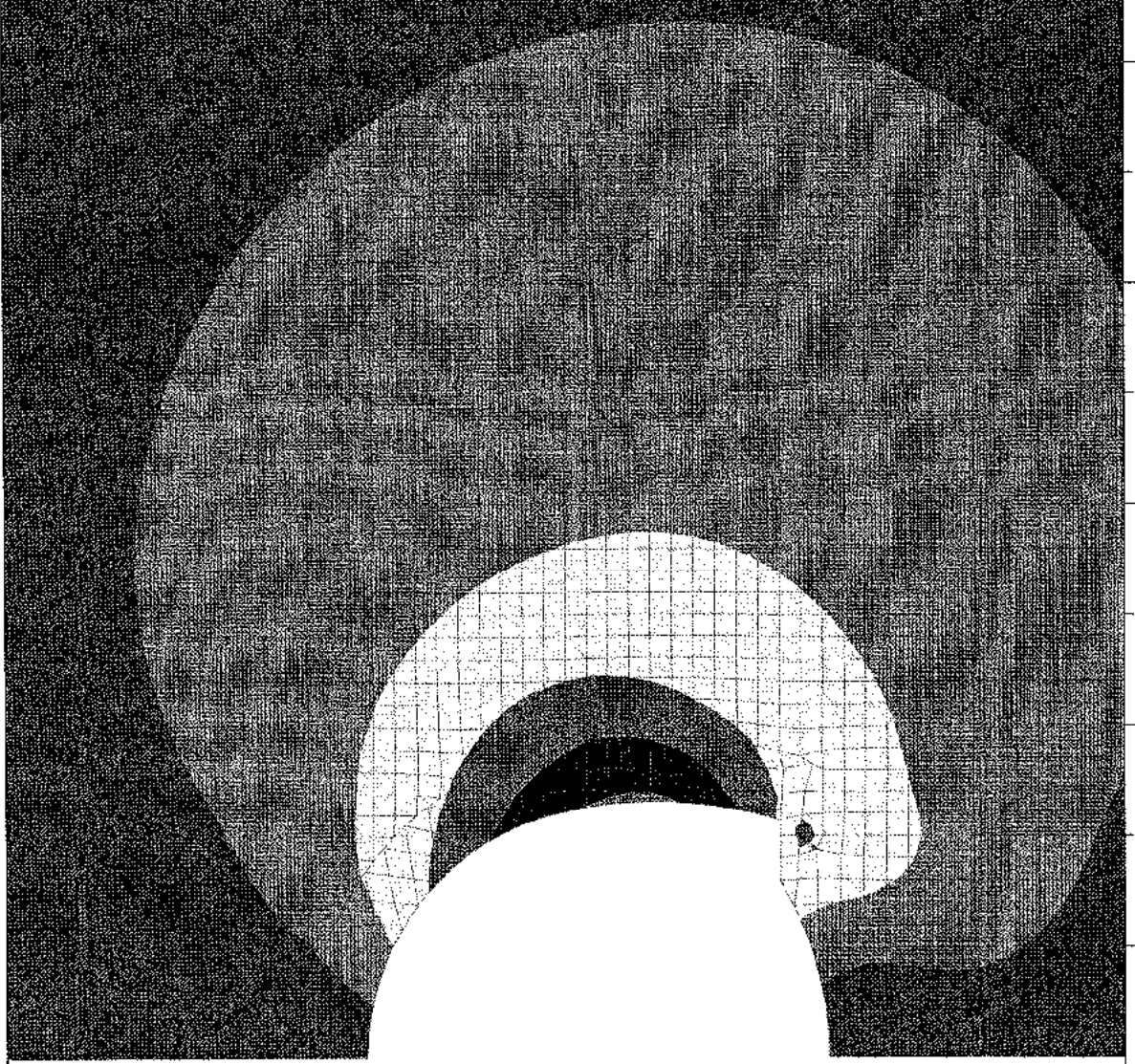
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:35

step 20793

-2.00E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

1.00E-02

2.00E-02

3.00E-02

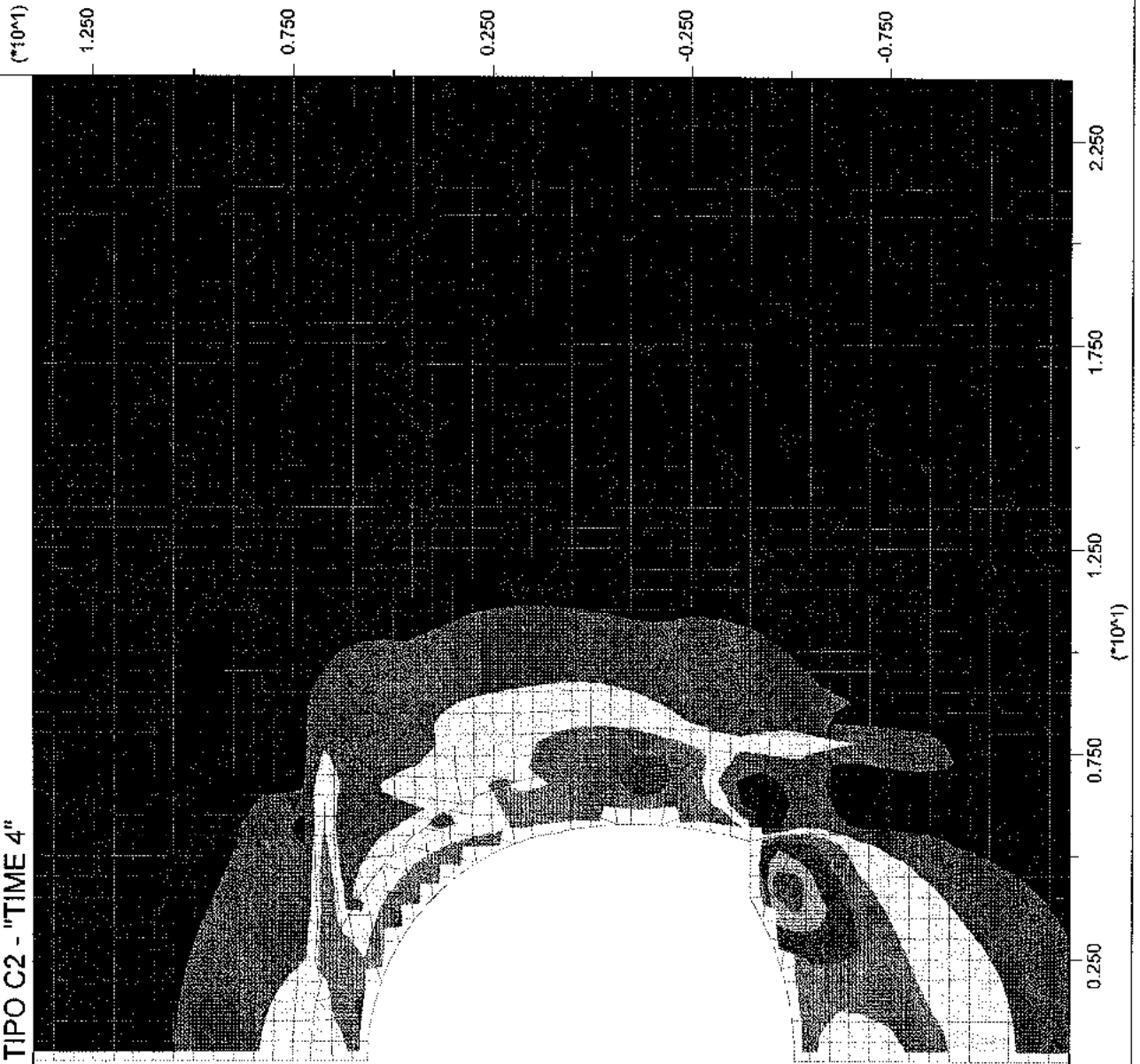
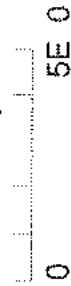
4.00E-02

5.00E-02

6.00E-02

Contour interval= 1.00E-02

Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:35

step 20793

-2.000E+00 <x< 1.400E+01

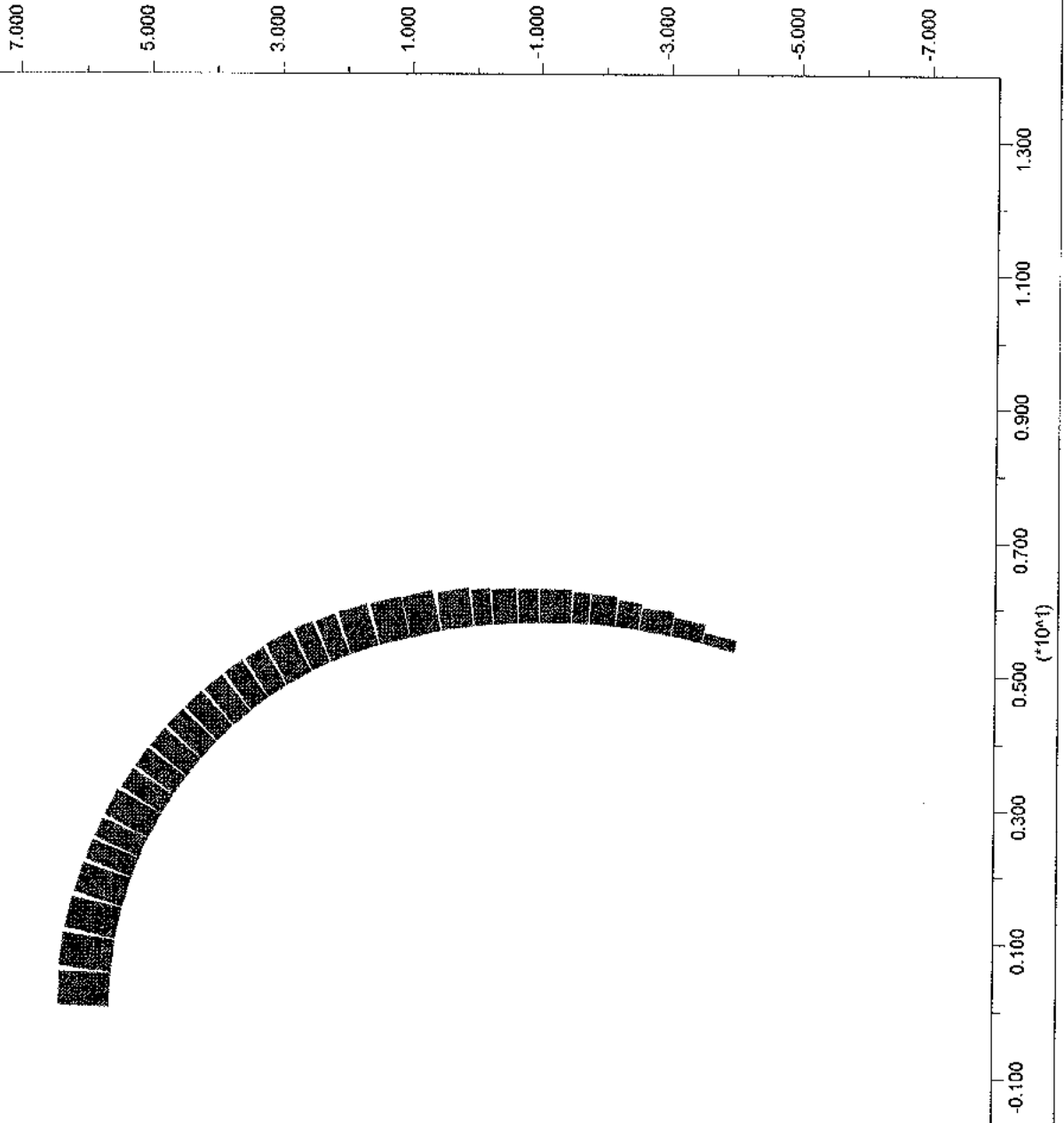
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value

1 (Beam) 1.052E+06



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 4"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:35

step 20793

-2.000E+00 <x< 1.400E+01

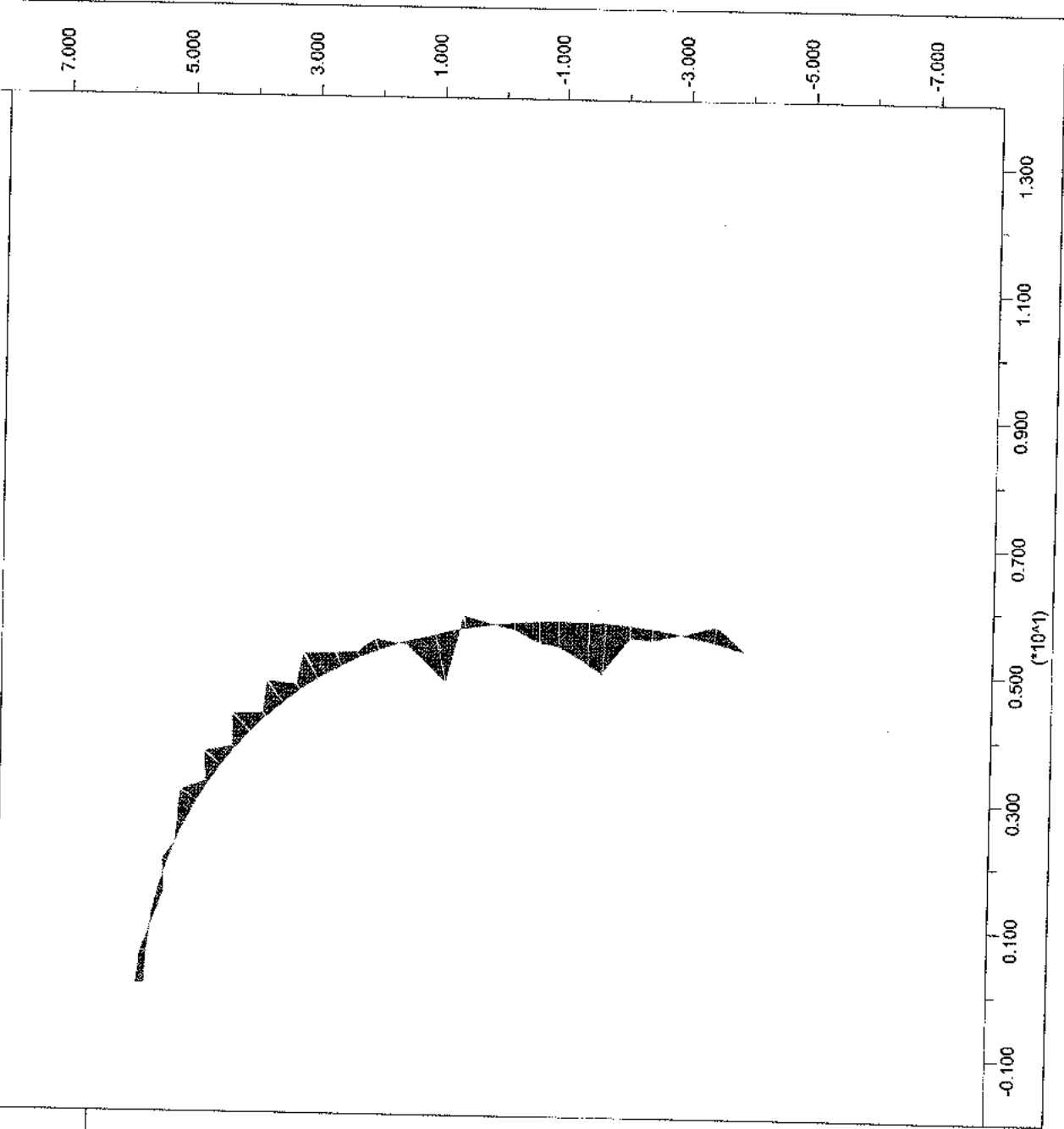
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on

Structure Max. Value

1 (Beam) -1.243E+04



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

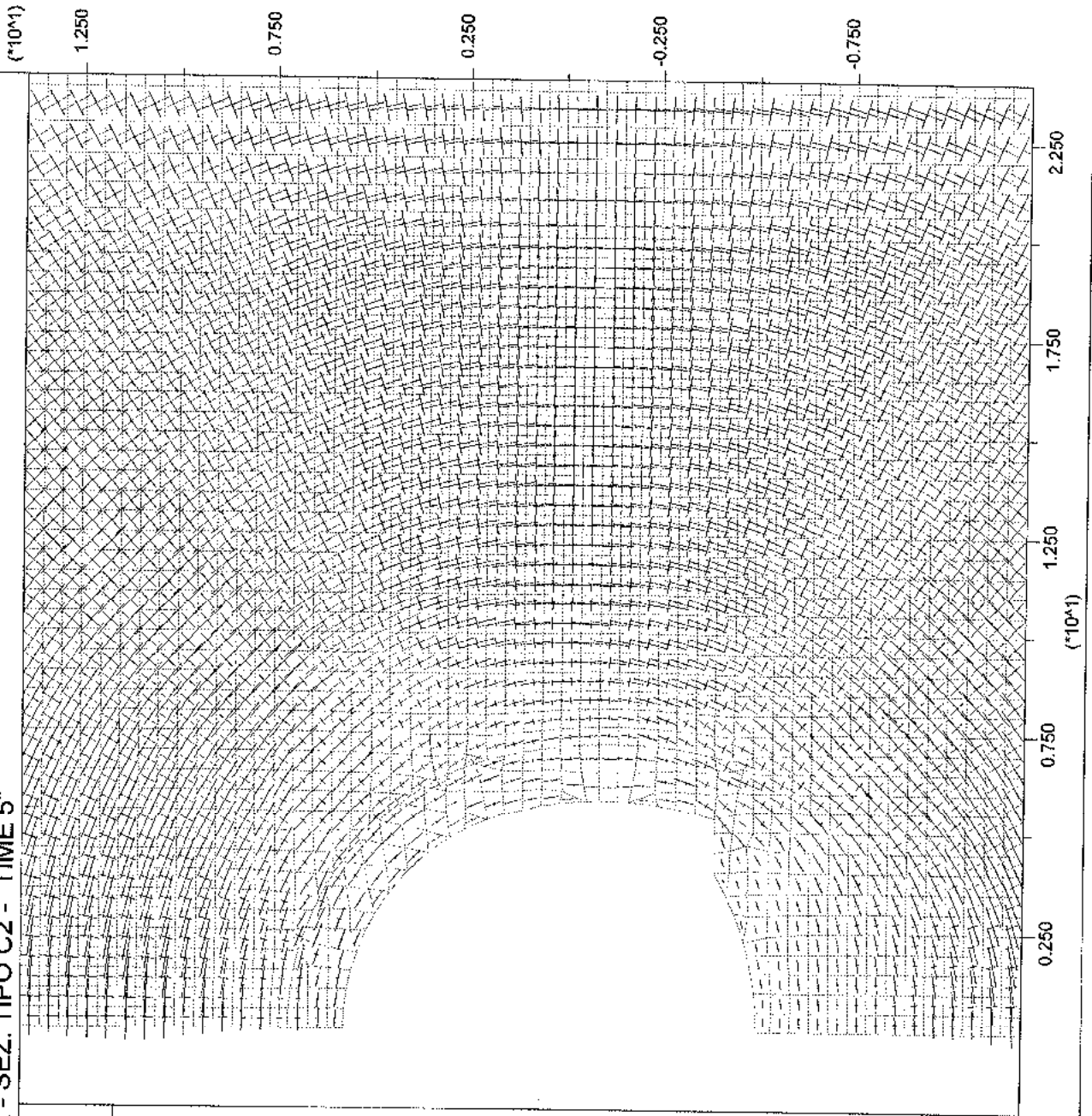
9-Feb-04 12:35
step 21755
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -1.067E+05
Min. Value = -2.573E+07



Tensioni principali : Pa



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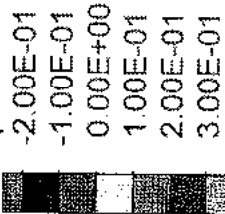
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

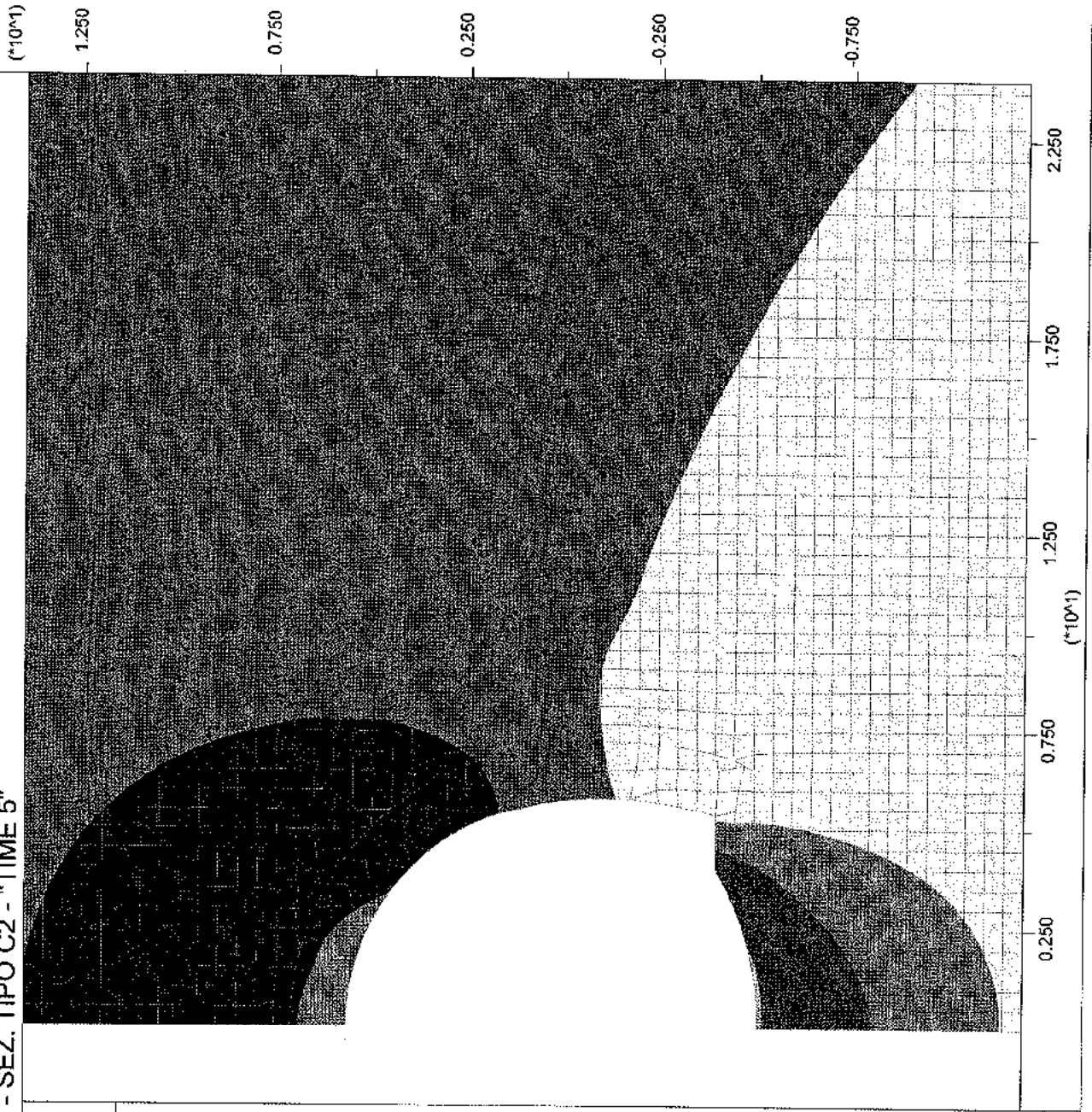
9-Feb-04 12:35
step 21755
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 5"

FLAC (Version 4.00)

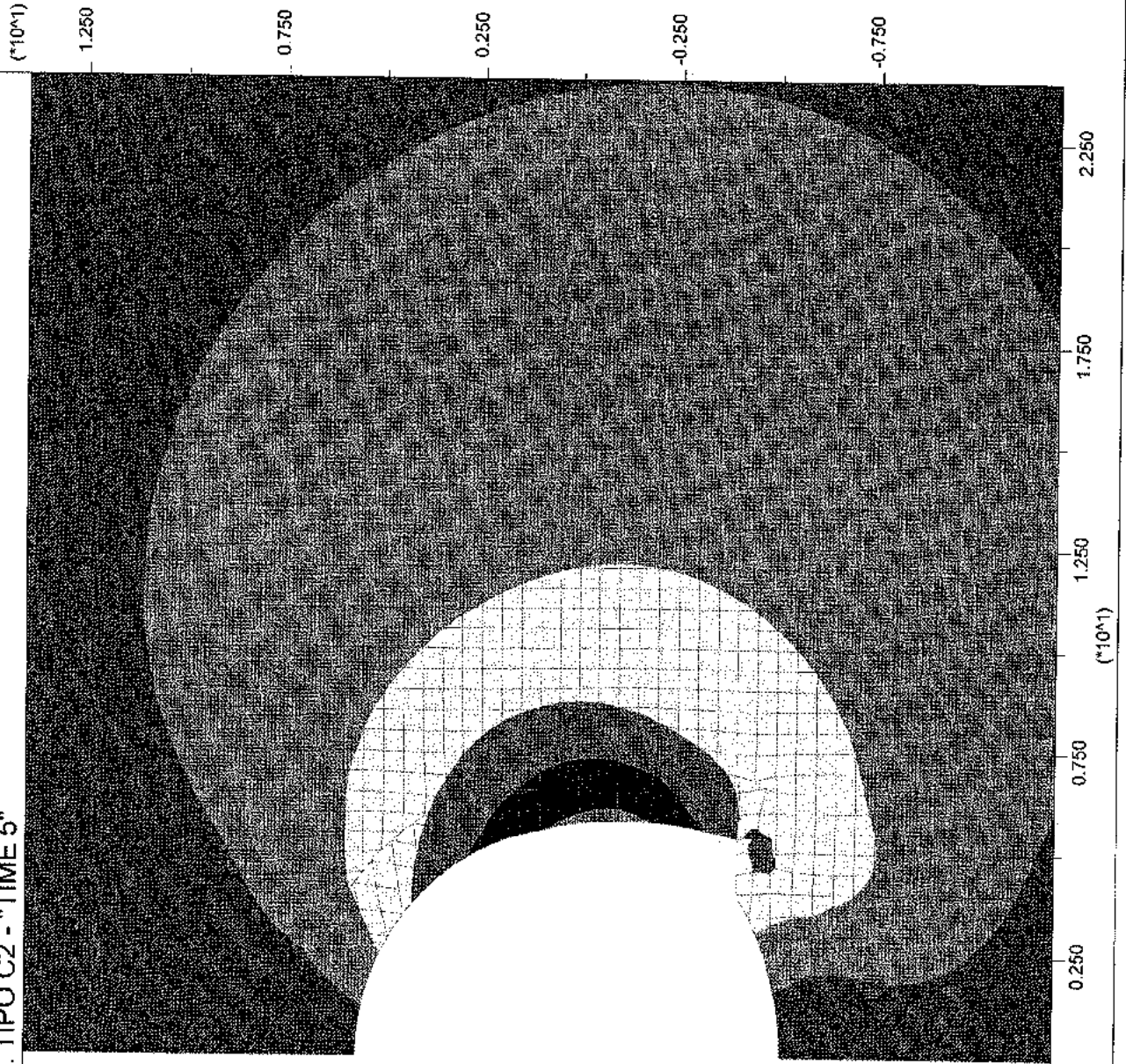
LEGEND

9-Feb-04 12:35
step 21755
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 5"

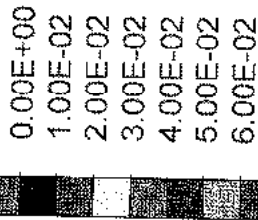
FLAC (Version 4.00)

LEGEND

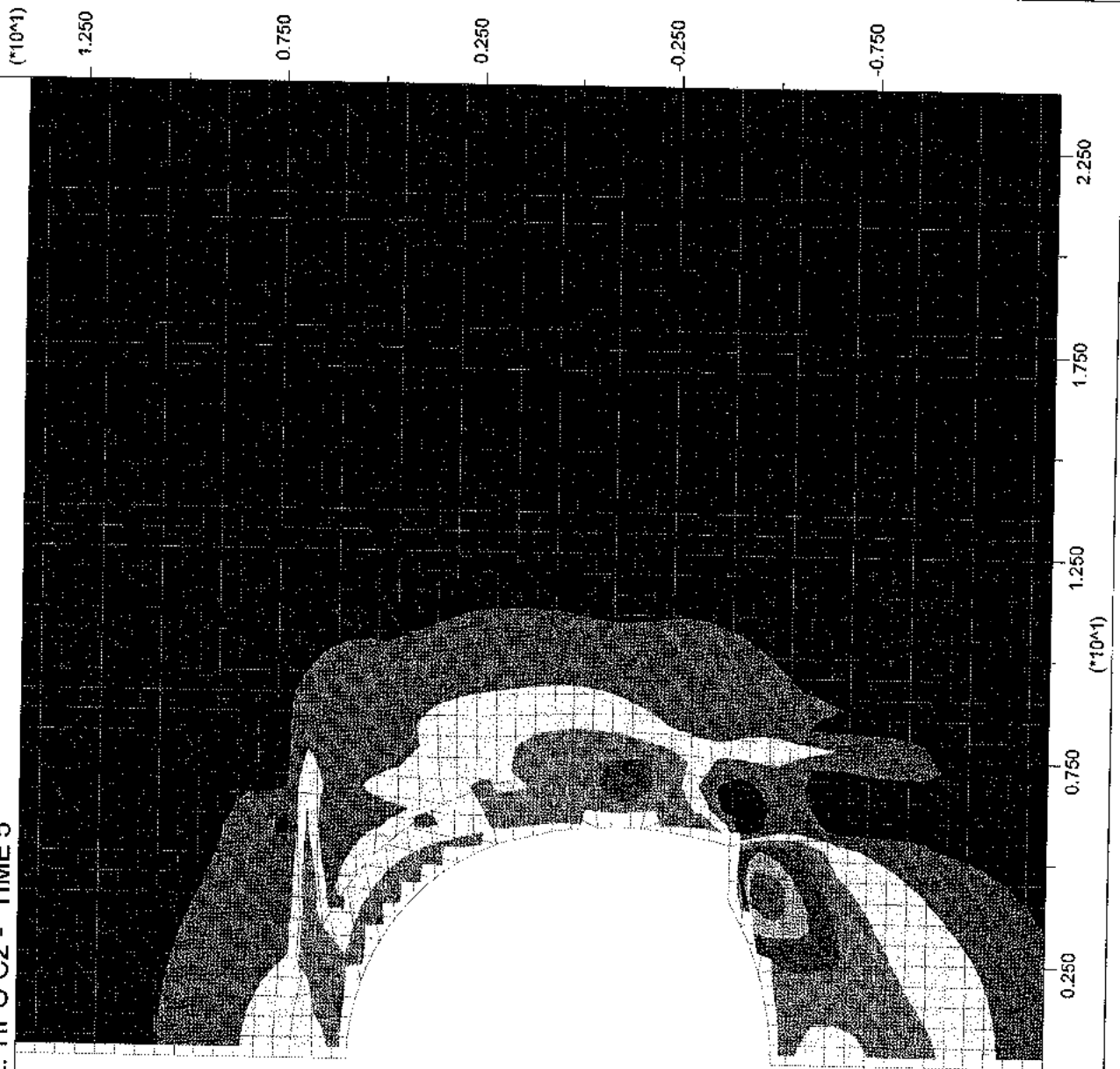
9-Feb-04 12:35
step 21755

-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



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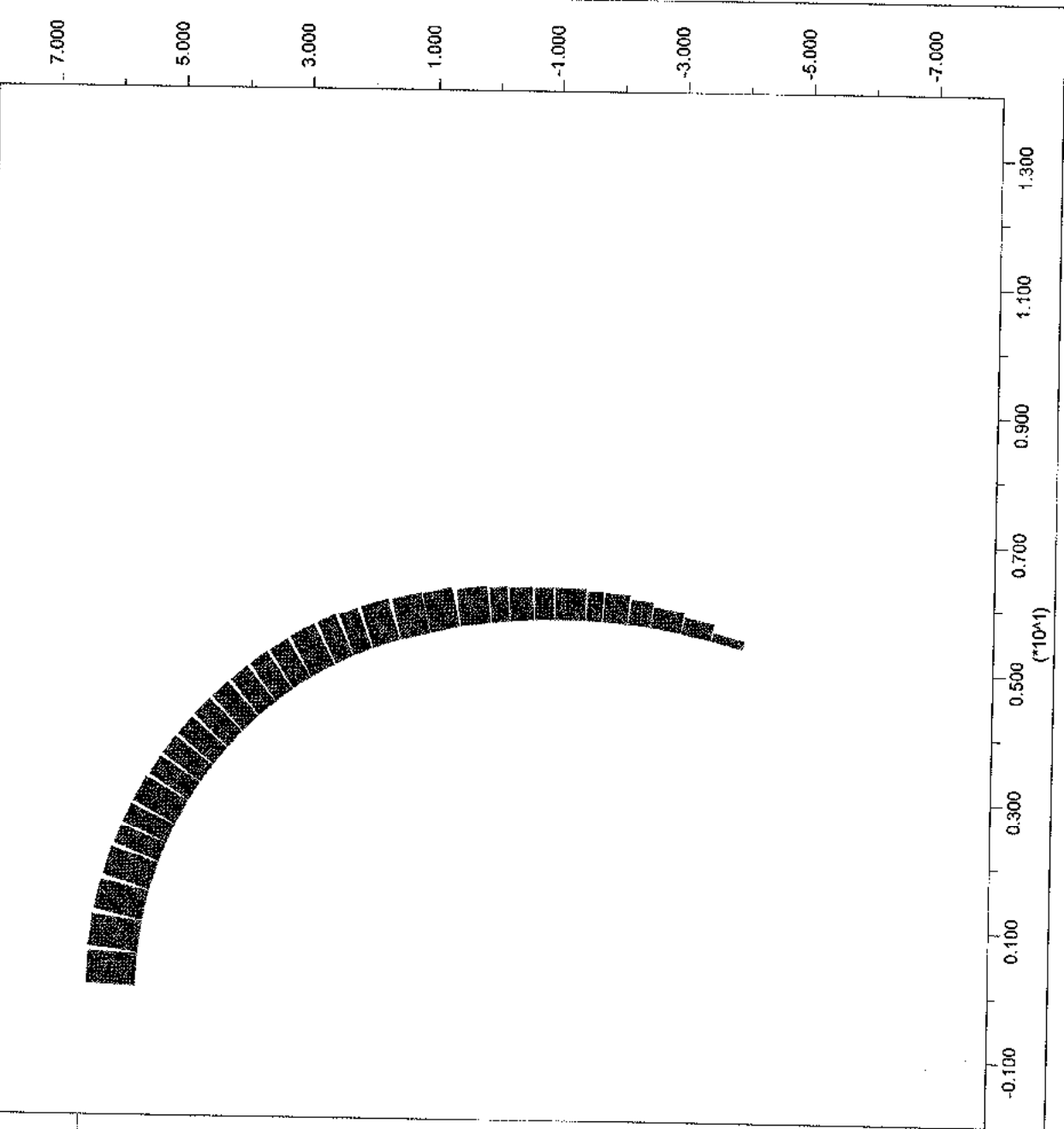
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 5"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:35
step 21755
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Pririv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 1.967E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 5"

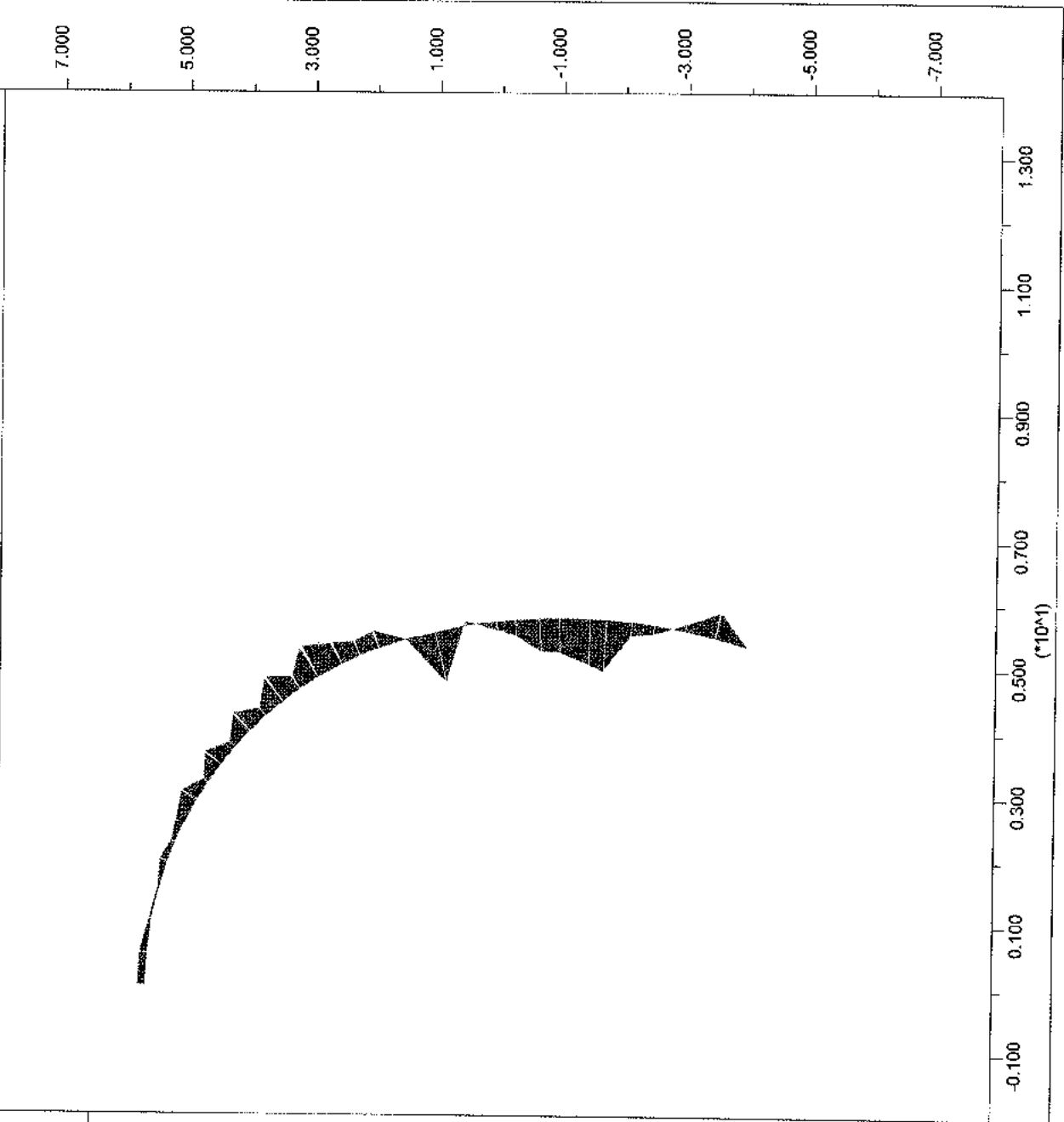
FLAC (Version 4.00)

LEGEND

9-Feb-04 12:35
step 21755
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -2.472E+04



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 6"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36

step 22893

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

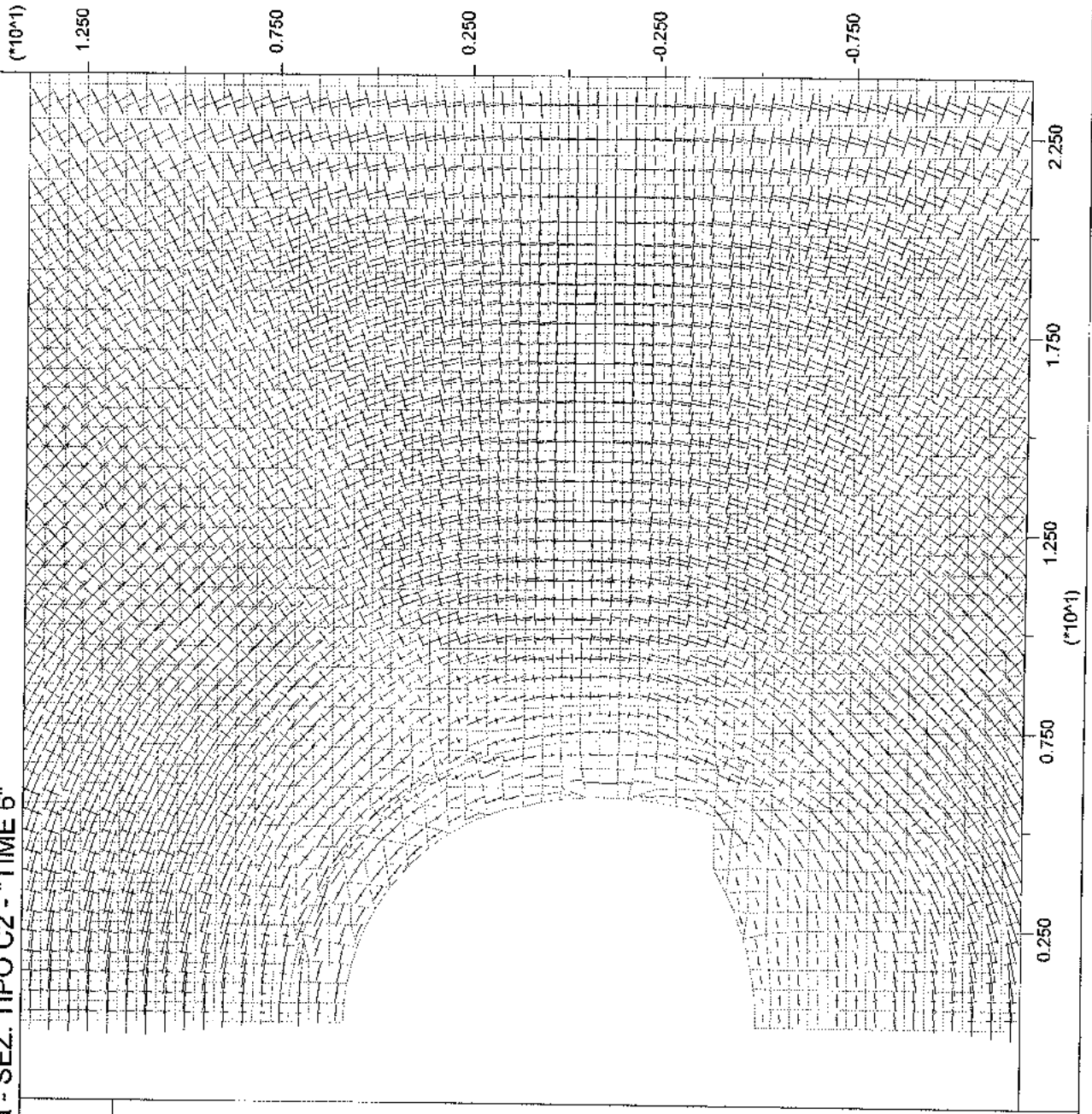
Principal stresses

Max. Value = -4.388E+04

Min. Value = -2.561E+07



Tensioni principali : Pa



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 6"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36

step 22893

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Y-displacement contours

-2.00E-01

-1.00E-01

0.00E+00

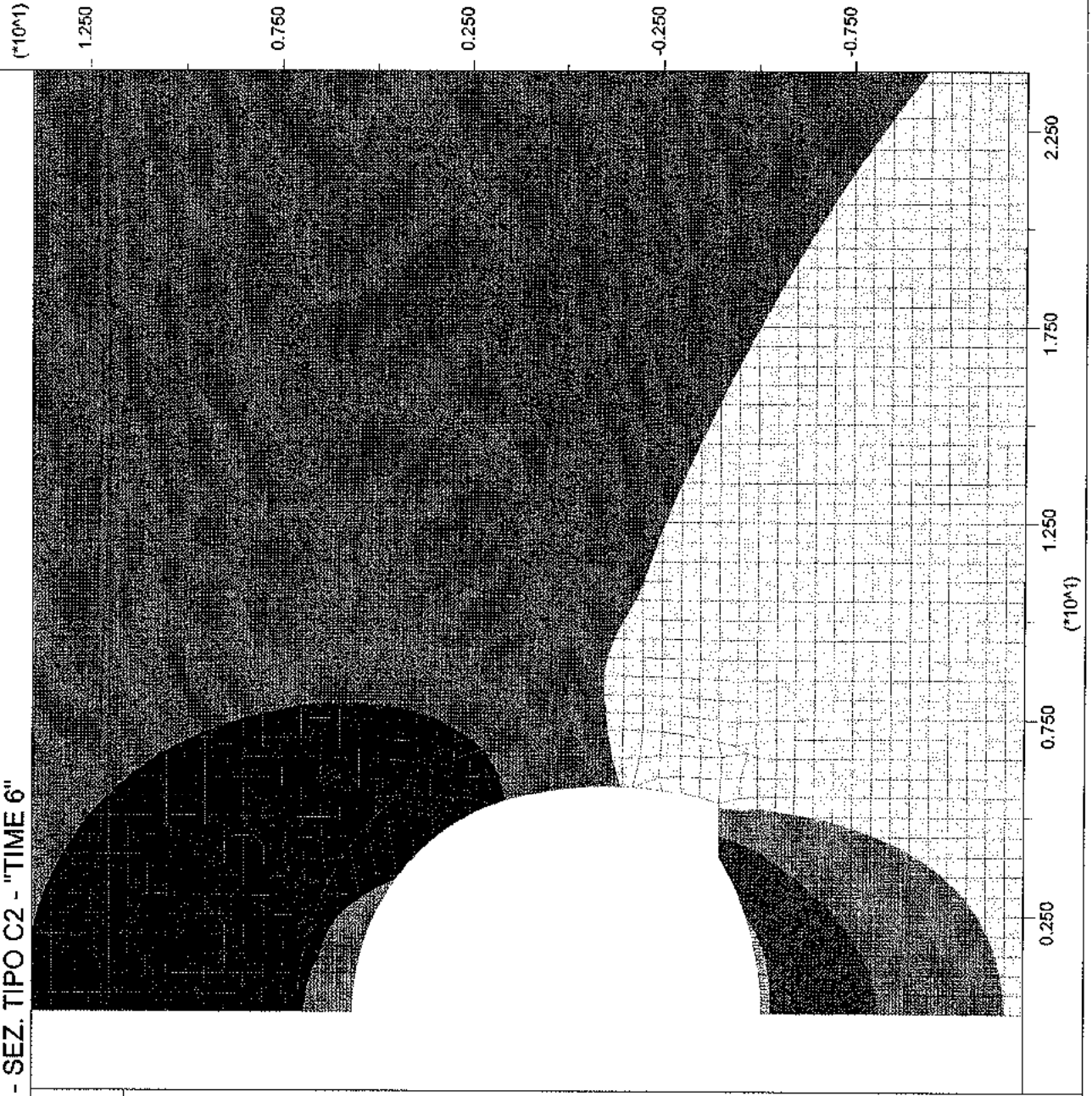
1.00E-01

2.00E-01

3.00E-01

Contour interval= 1.00E-01

Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 6"

FLAC (Version 4.00)

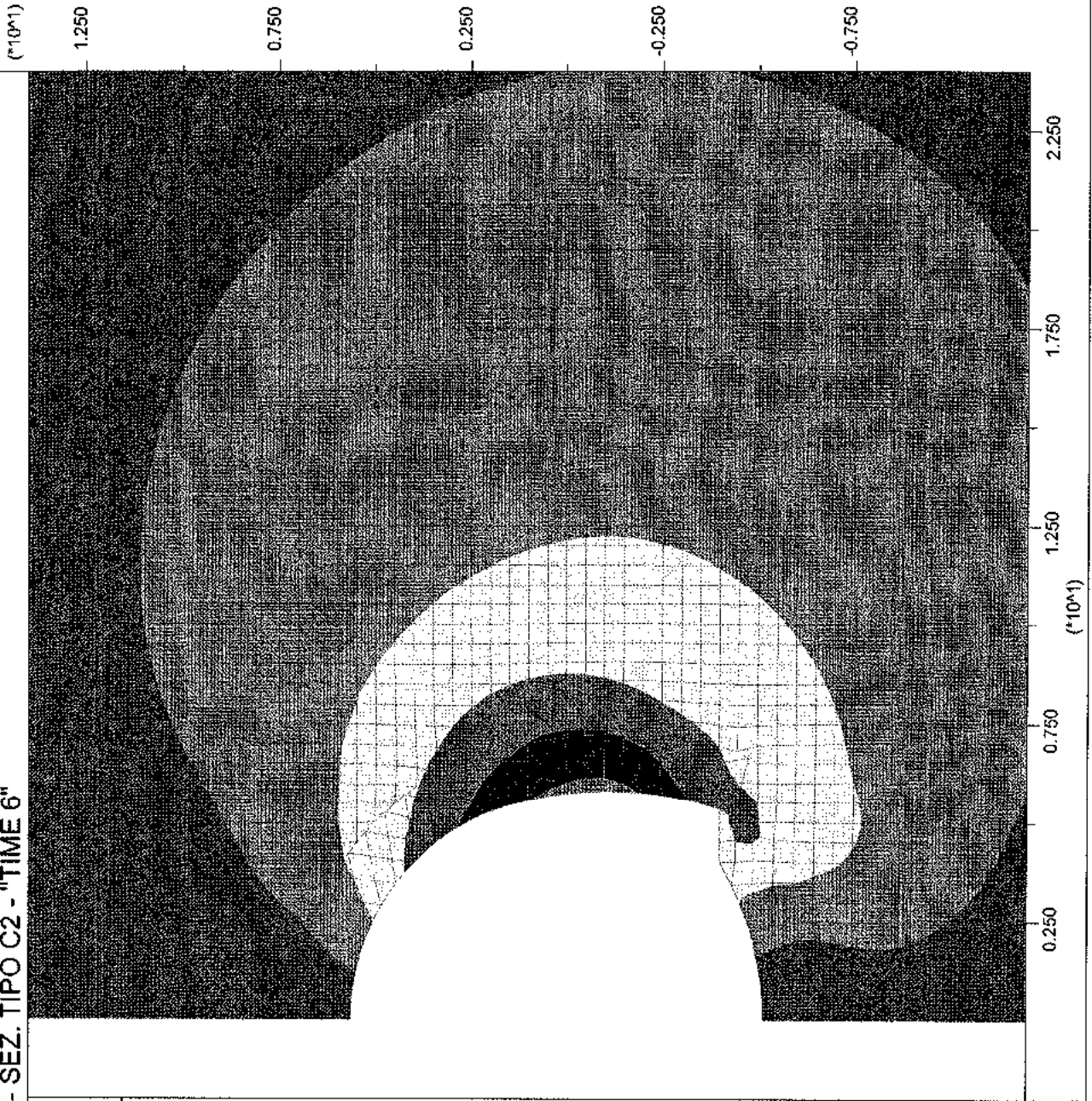
LEGEND

9-Feb-04 12:36
step 22893
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 6"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36

step 22893

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

1.00E-02

2.00E-02

3.00E-02

4.00E-02

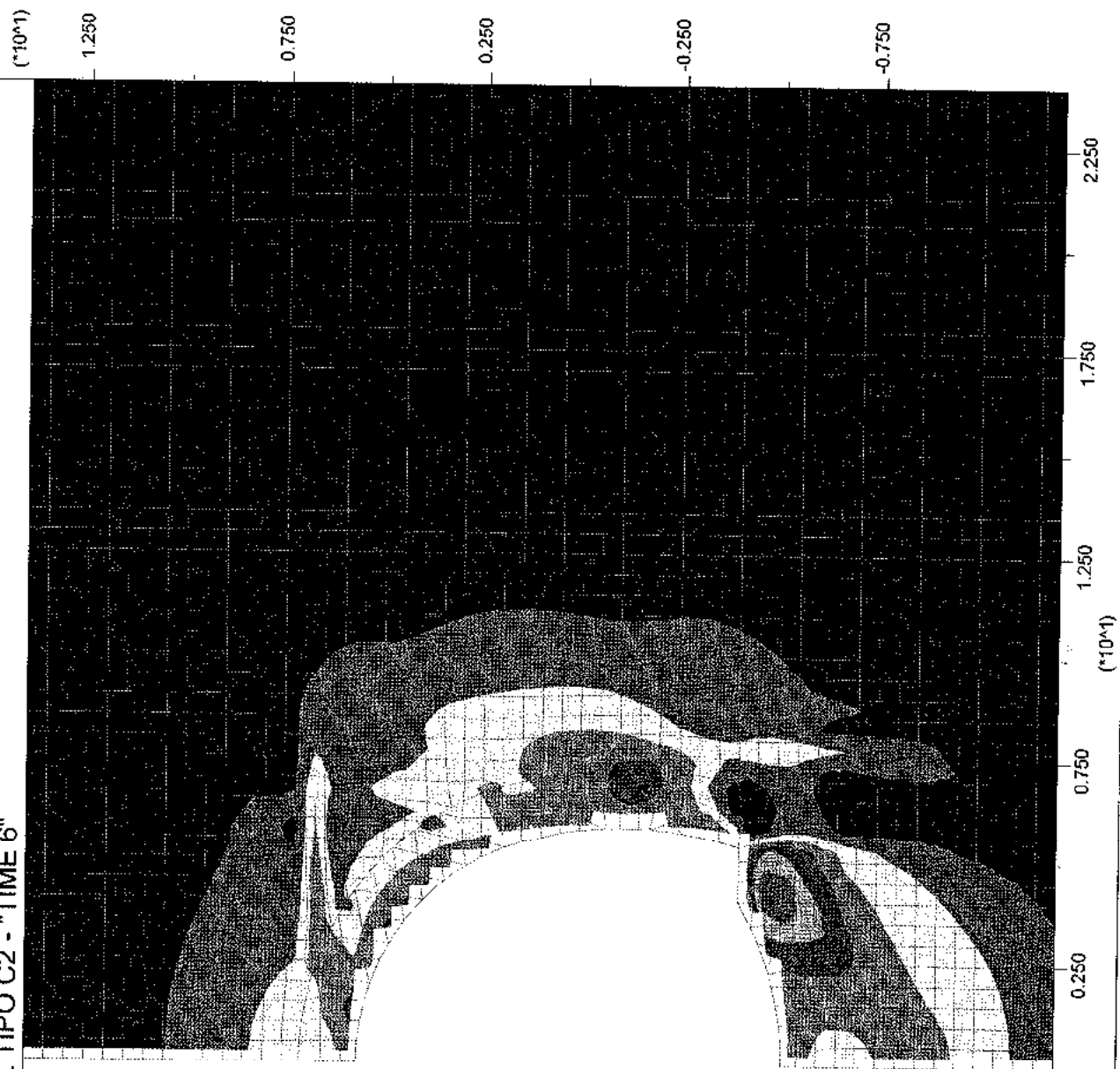
5.00E-02

6.00E-02

7.00E-02



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



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Minneapolis, Minnesota USA

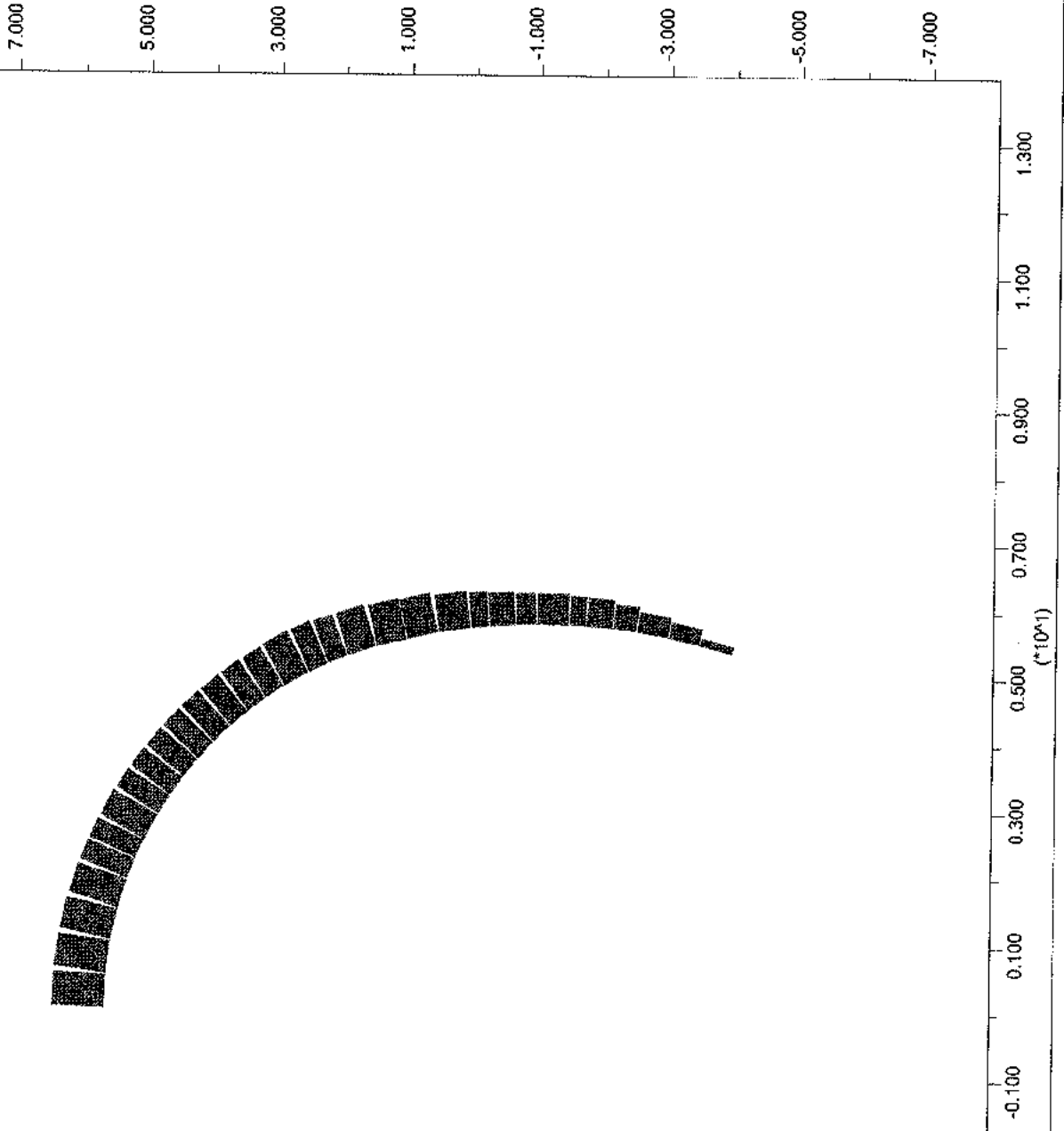
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 6"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36
step 22893
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Priv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 2.579E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 6"

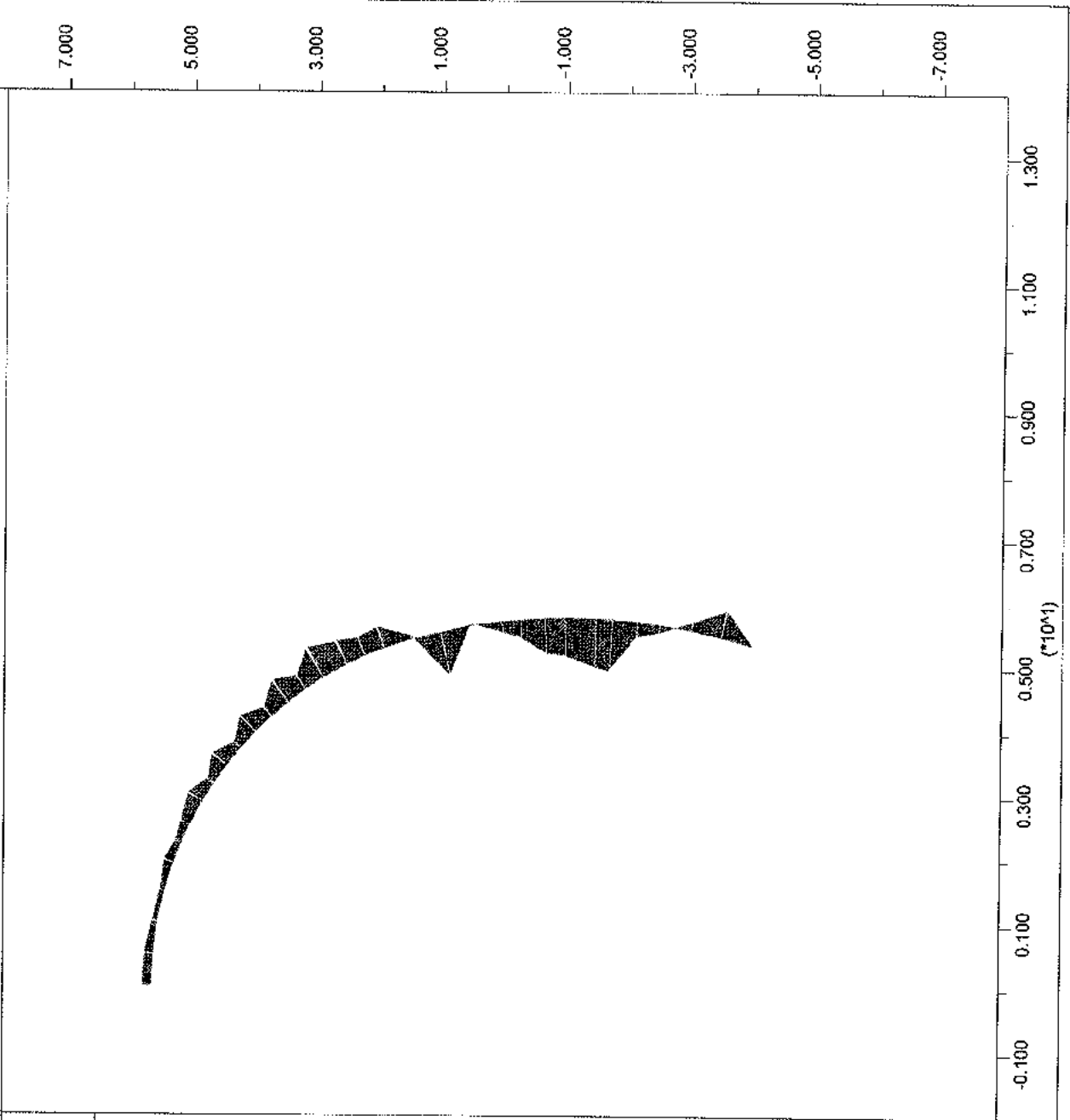
FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36
step 22893
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -3.644E+04



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 7"

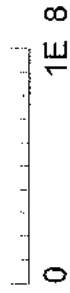
FLAC (Version 4.00)

LEGEND

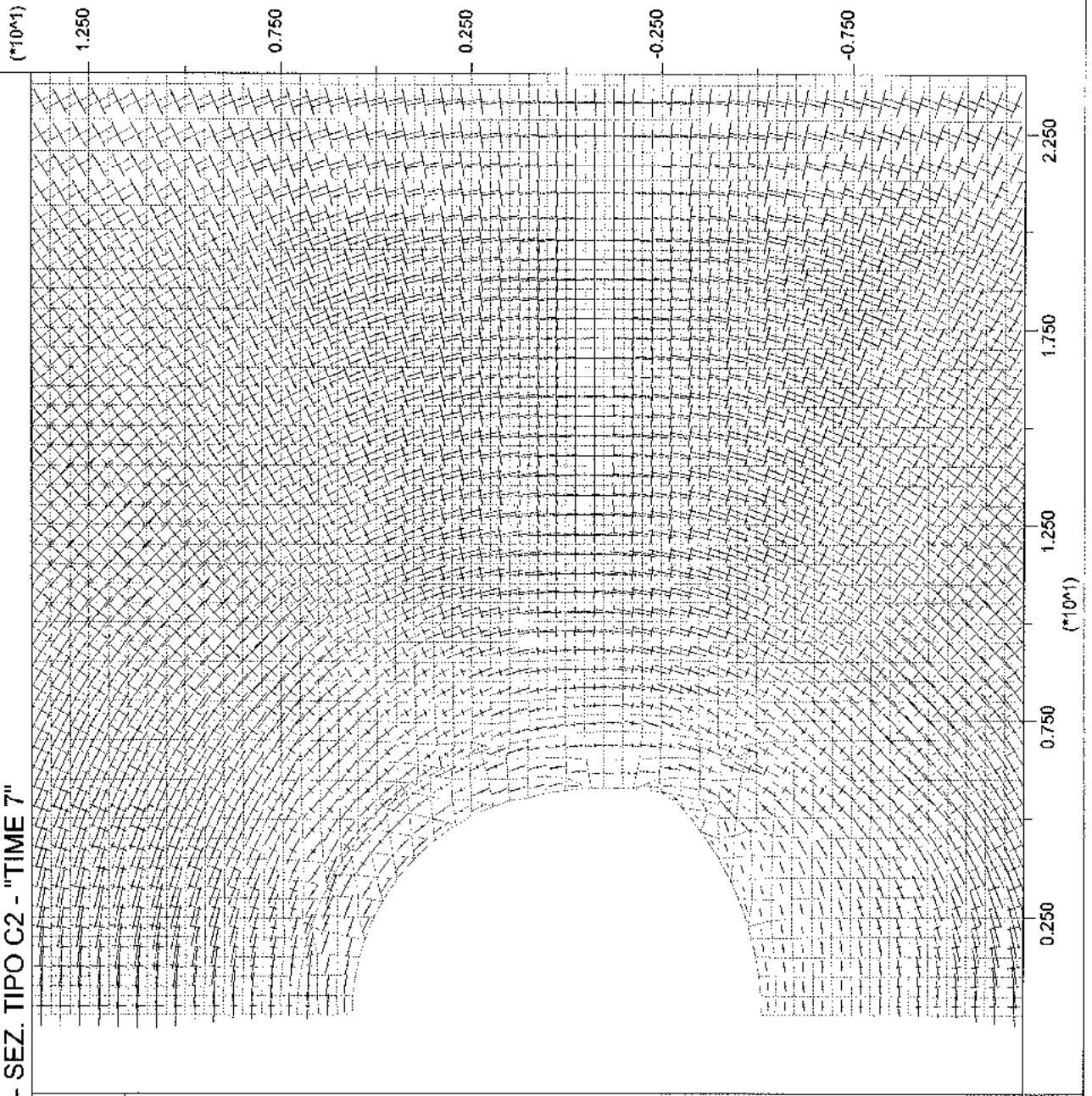
9-Feb-04 12:36
step 25102
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = 1.488E+06
Min. Value = -2.559E+07



Tensioni principali : Pa



JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 7"

FLAC (Version 4.00)

LEGEND

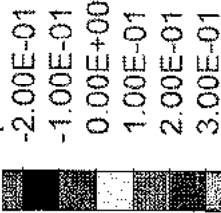
9-Feb-04 12:36

step 25102

-2.000E+00 <x< 2.400E+01

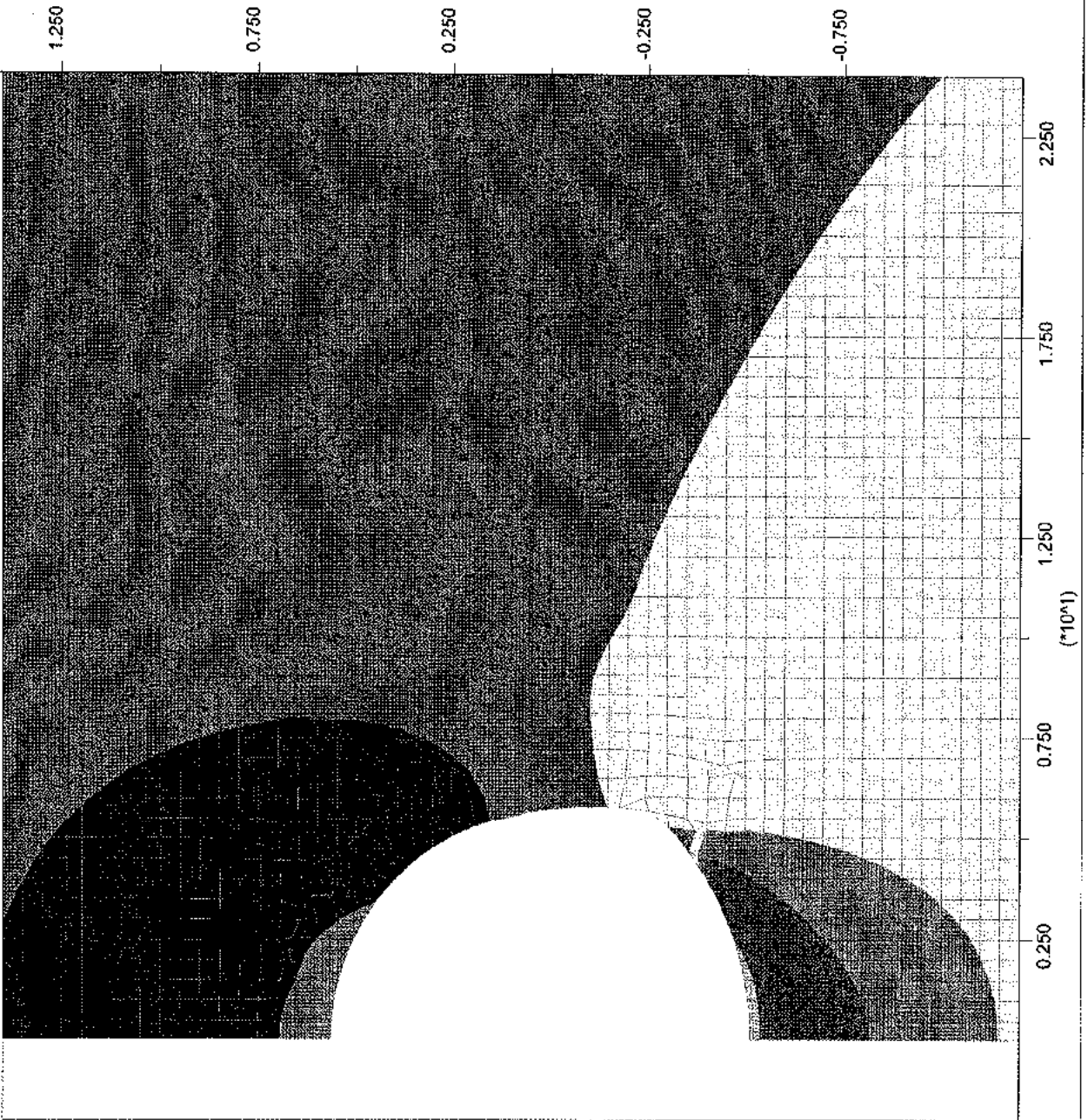
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 7"

FLAC (Version 4.00)

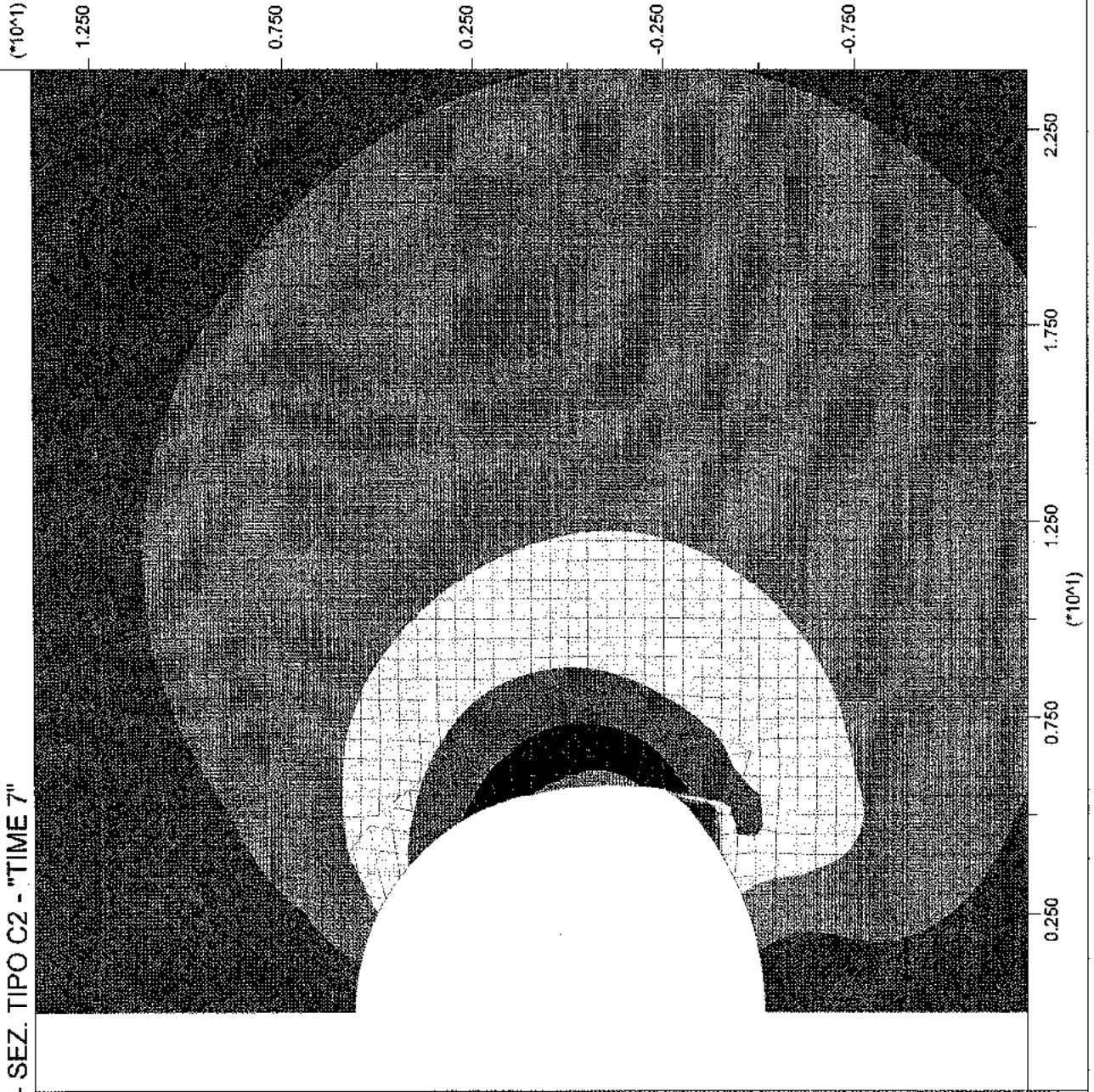
LEGEND

9-Feb-04 12:36
step 25102
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 7"

FLAC (Version 4.00)

LEGEND

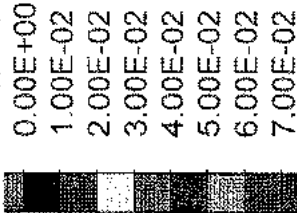
9-Feb-04 12:36

step 25102

-2.000E+00 <x< 2.400E+01

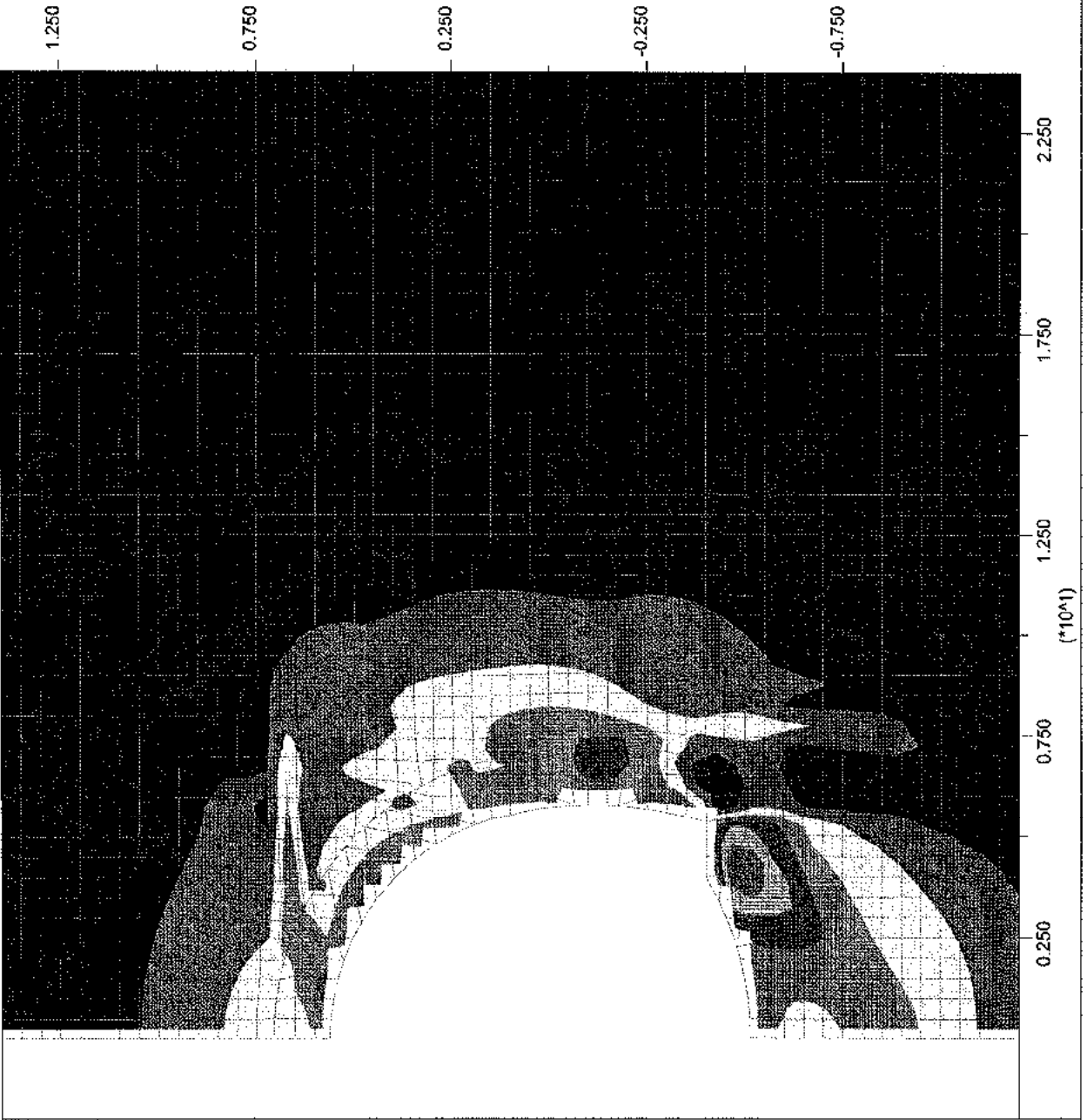
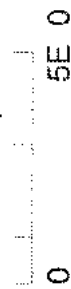
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02

Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

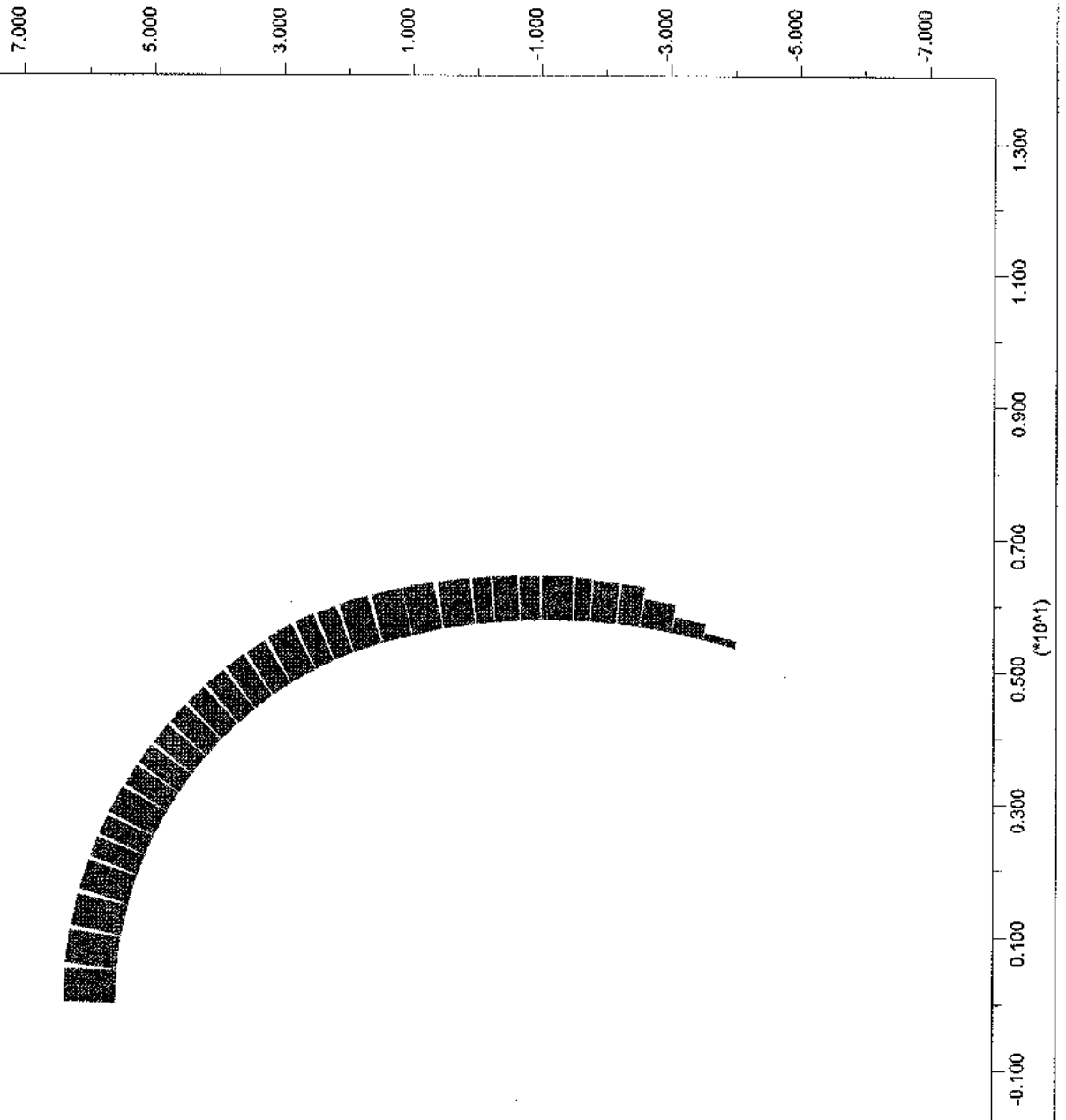
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 7"

FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36
step 25102
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 3.467E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA


JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 7"

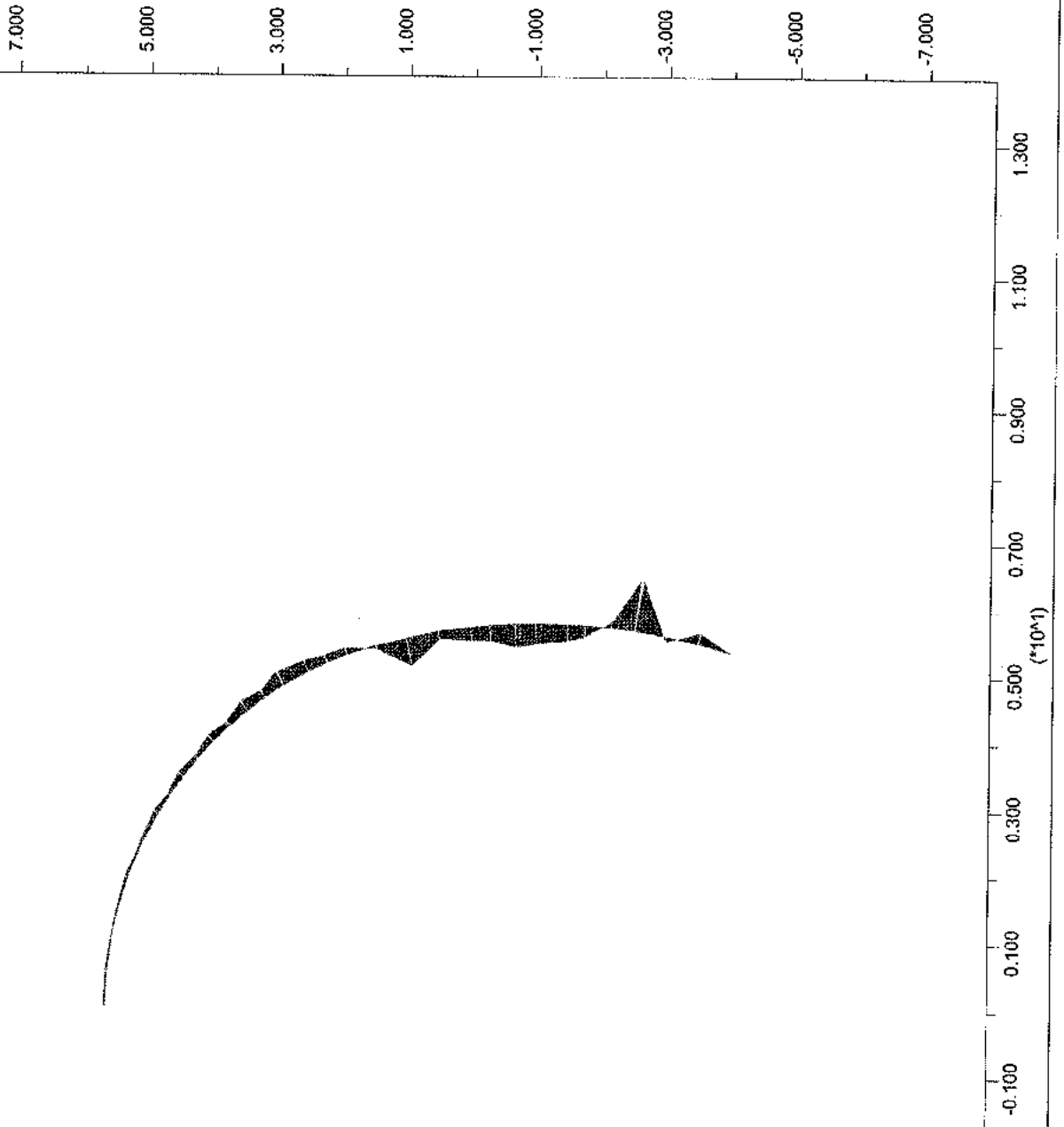
FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36
step 25102
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

 Moment on
Structure Max. Value
1 (Beam) 1.309E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 7"

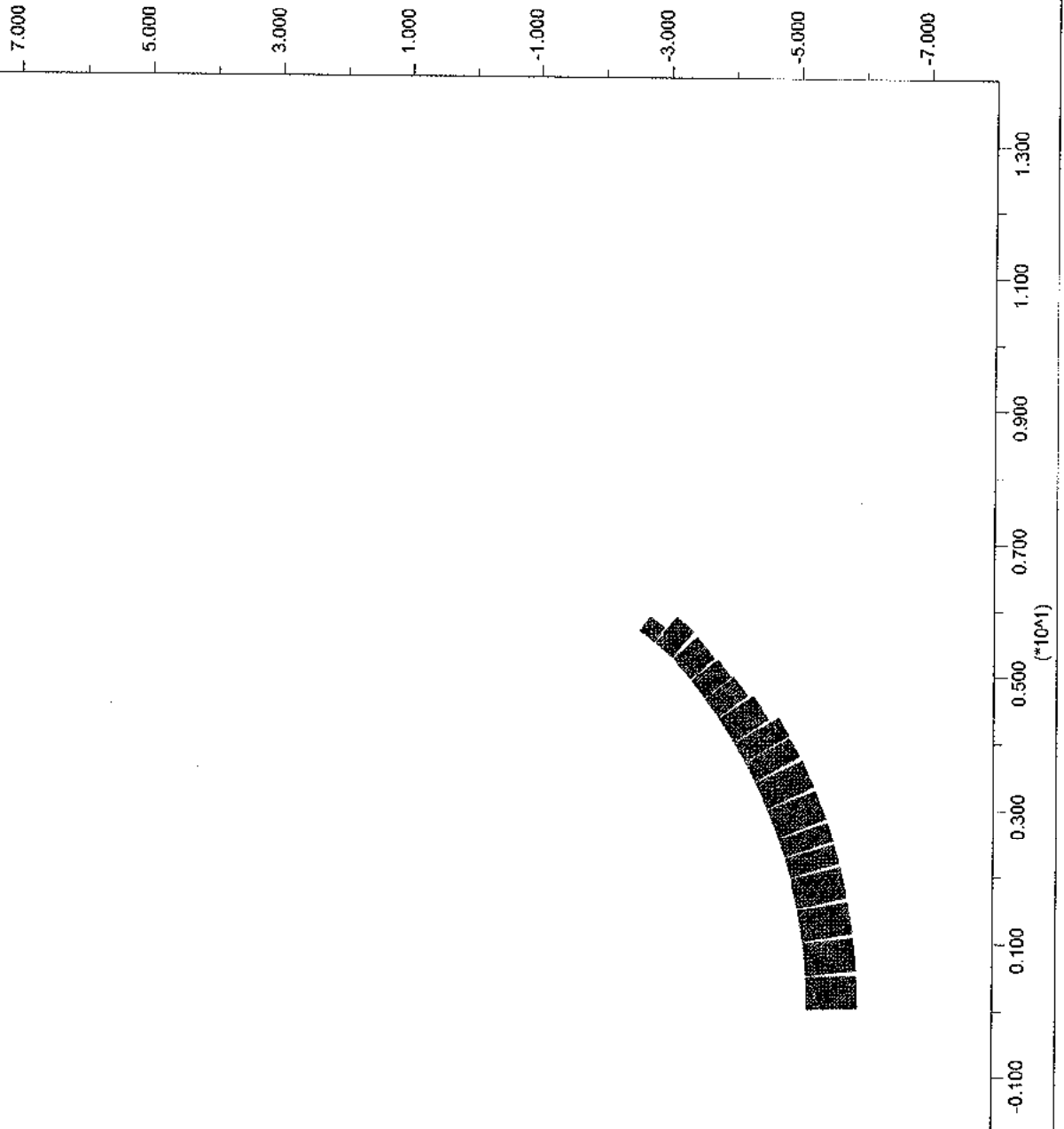
FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36
step 25102
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
2 (Beam) 1.345E+06

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 7"

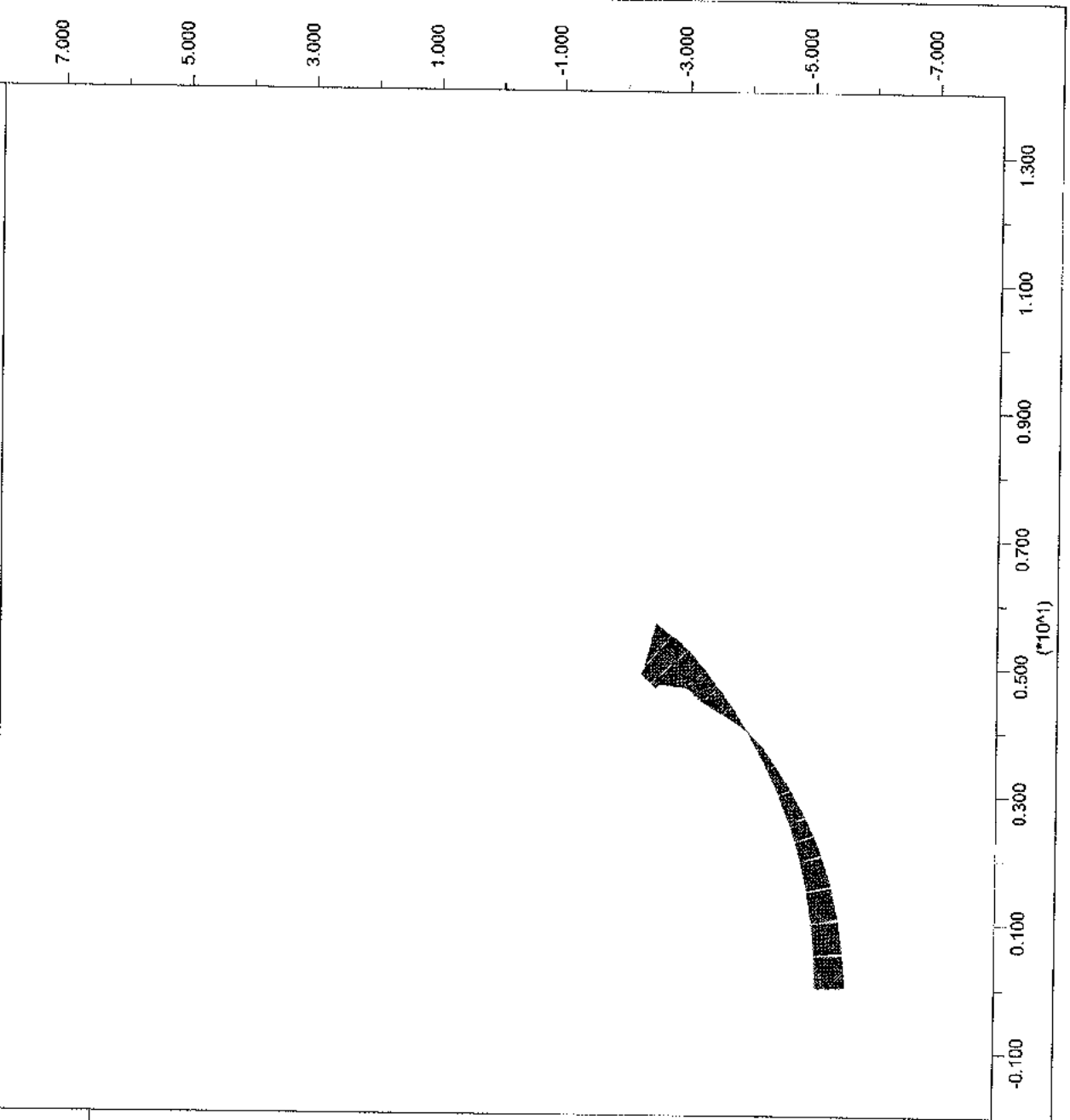
FLAC (Version 4.00)

LEGEND

9-Feb-04 12:36
step 25102
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
2 (Beam) -1.977E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 8"

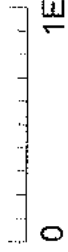
FLAC (Version 4.00)

LEGEND

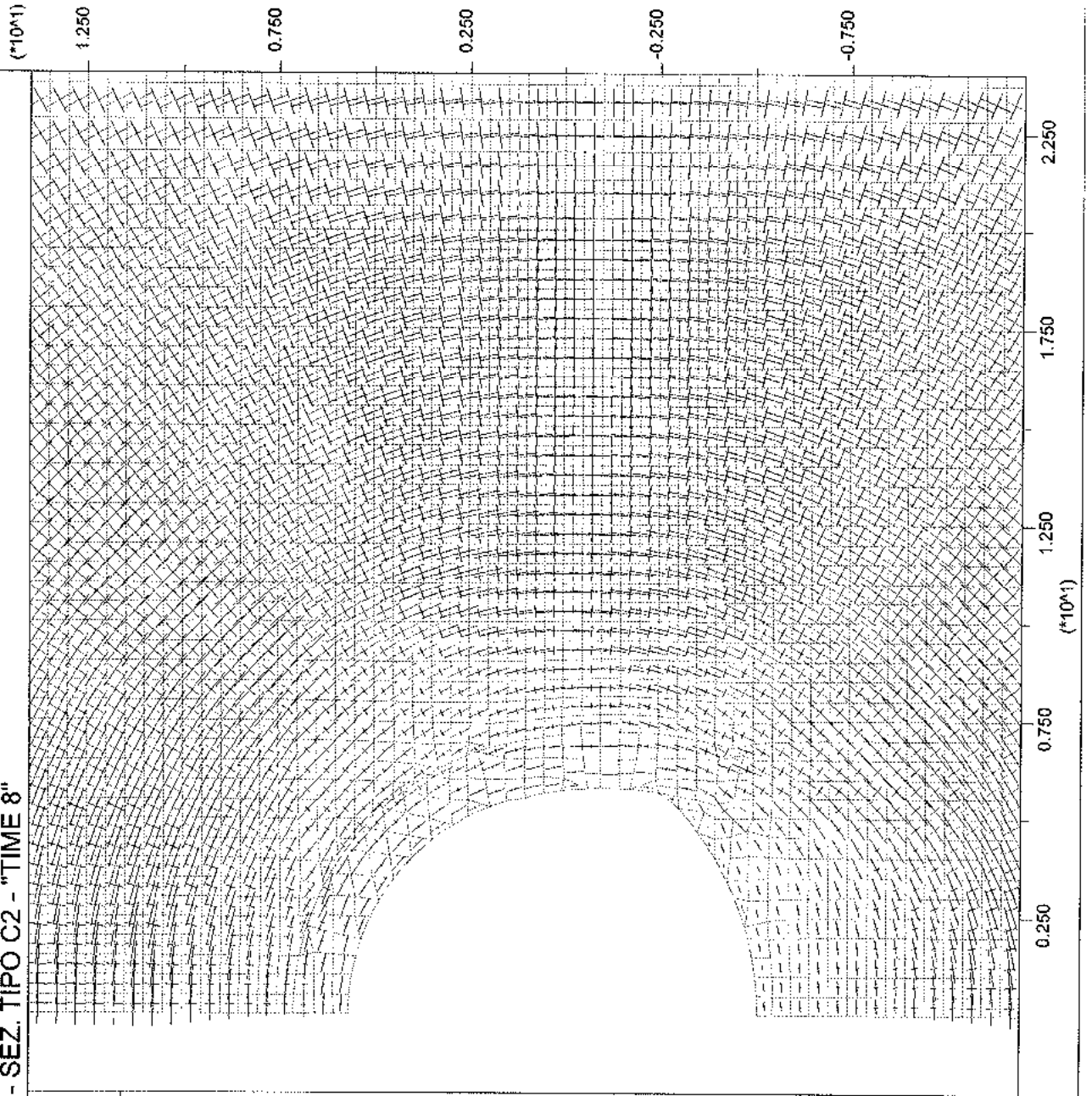
9-Feb-04 15:47
step 26411
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = 1.741E+06
Min. Value = -2.559E+07



Tensioni principali : Pa



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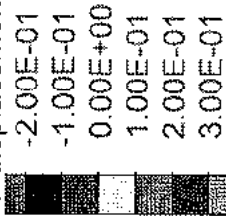
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 8"

FLAC (Version 4.00)

LEGEND

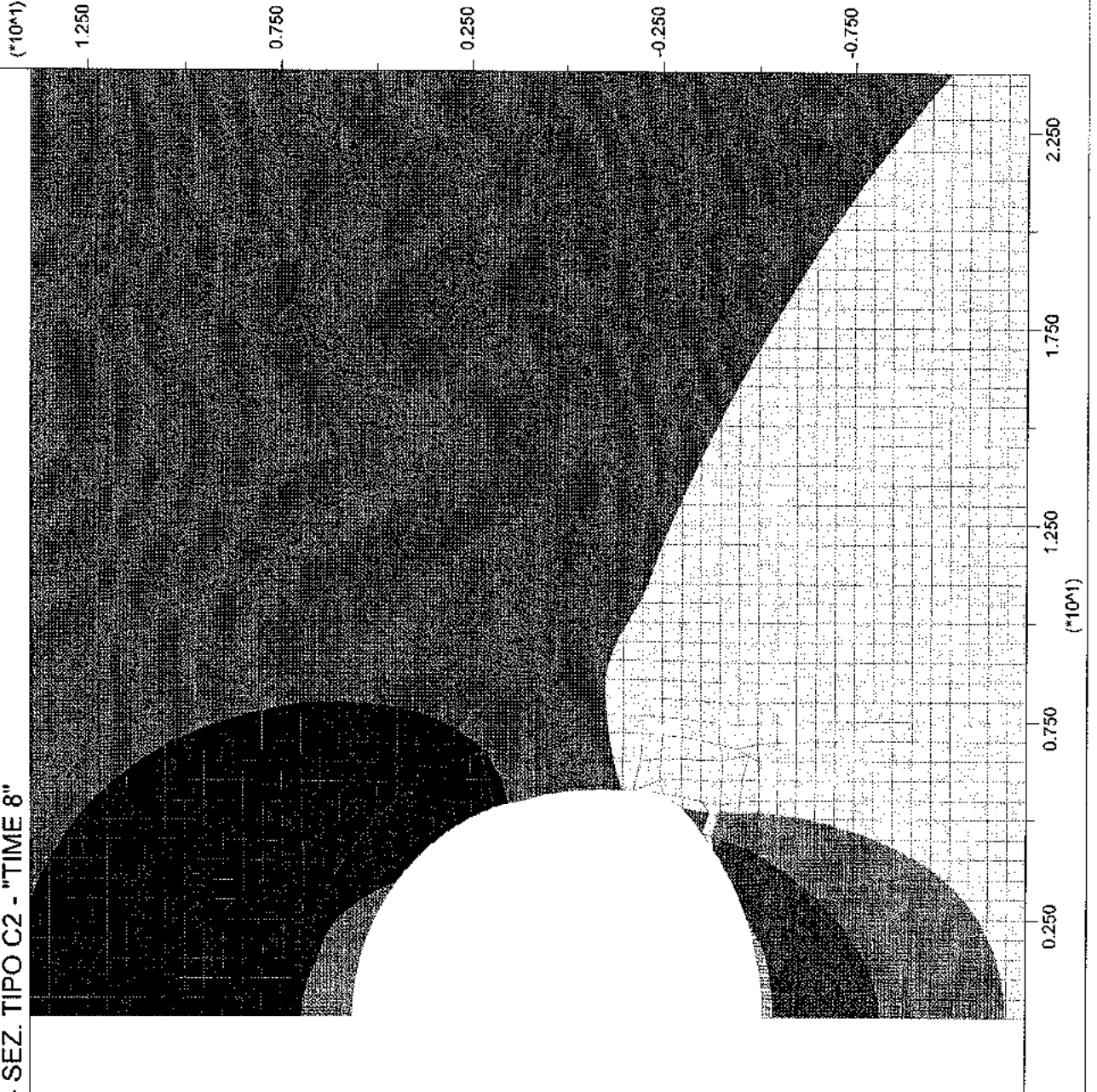
9-Feb-04 15:47
step 26411
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

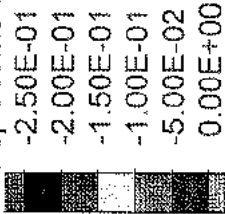
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 8"

FLAC (Version 4.00)

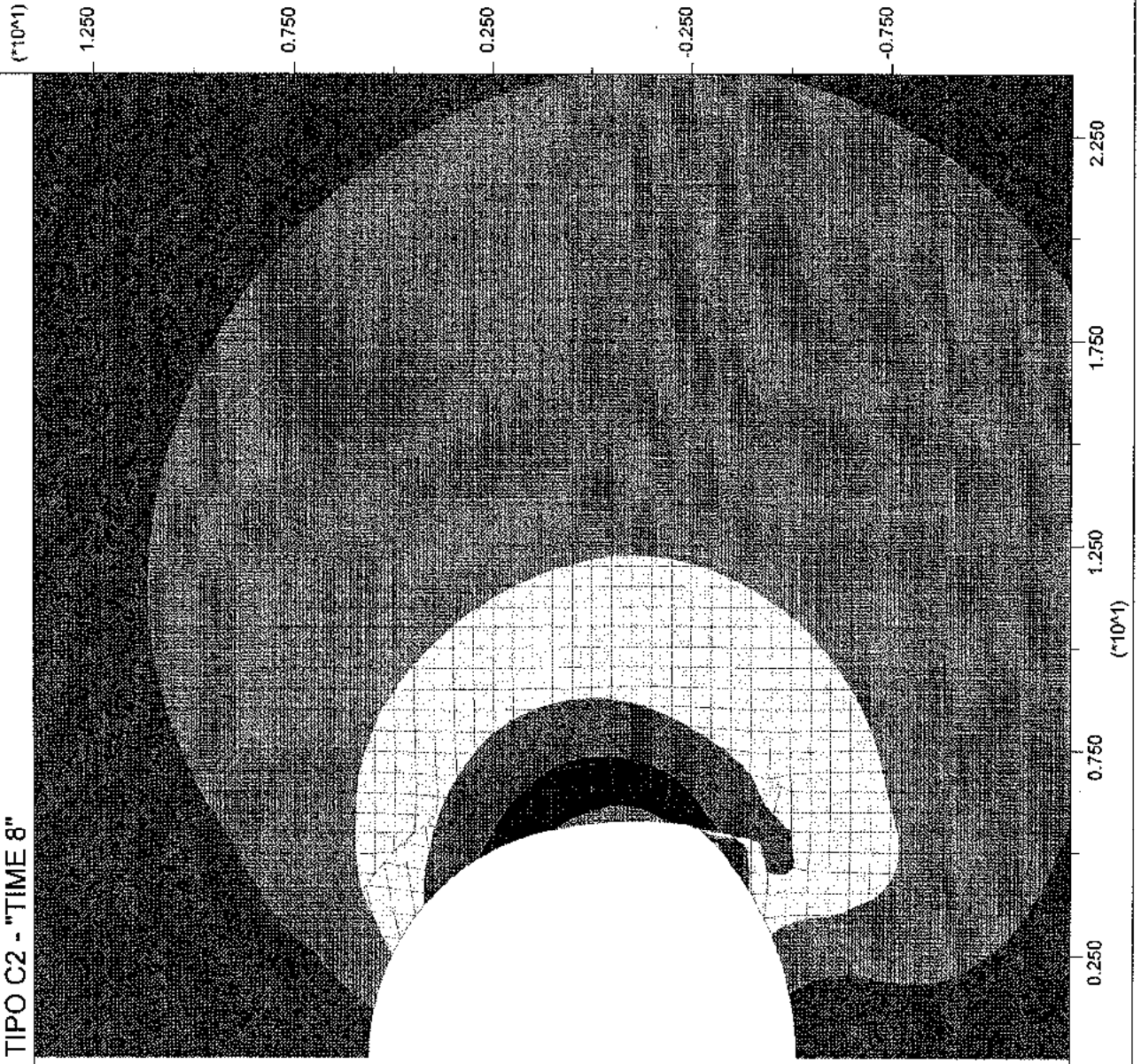
LEGEND

9-Feb-04 15:47
step 26411
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 8"

FLAC (Version 4.00)

LEGEND

9-Feb-04 15:47

step 26411

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

1.00E-02

2.00E-02

3.00E-02

4.00E-02

5.00E-02

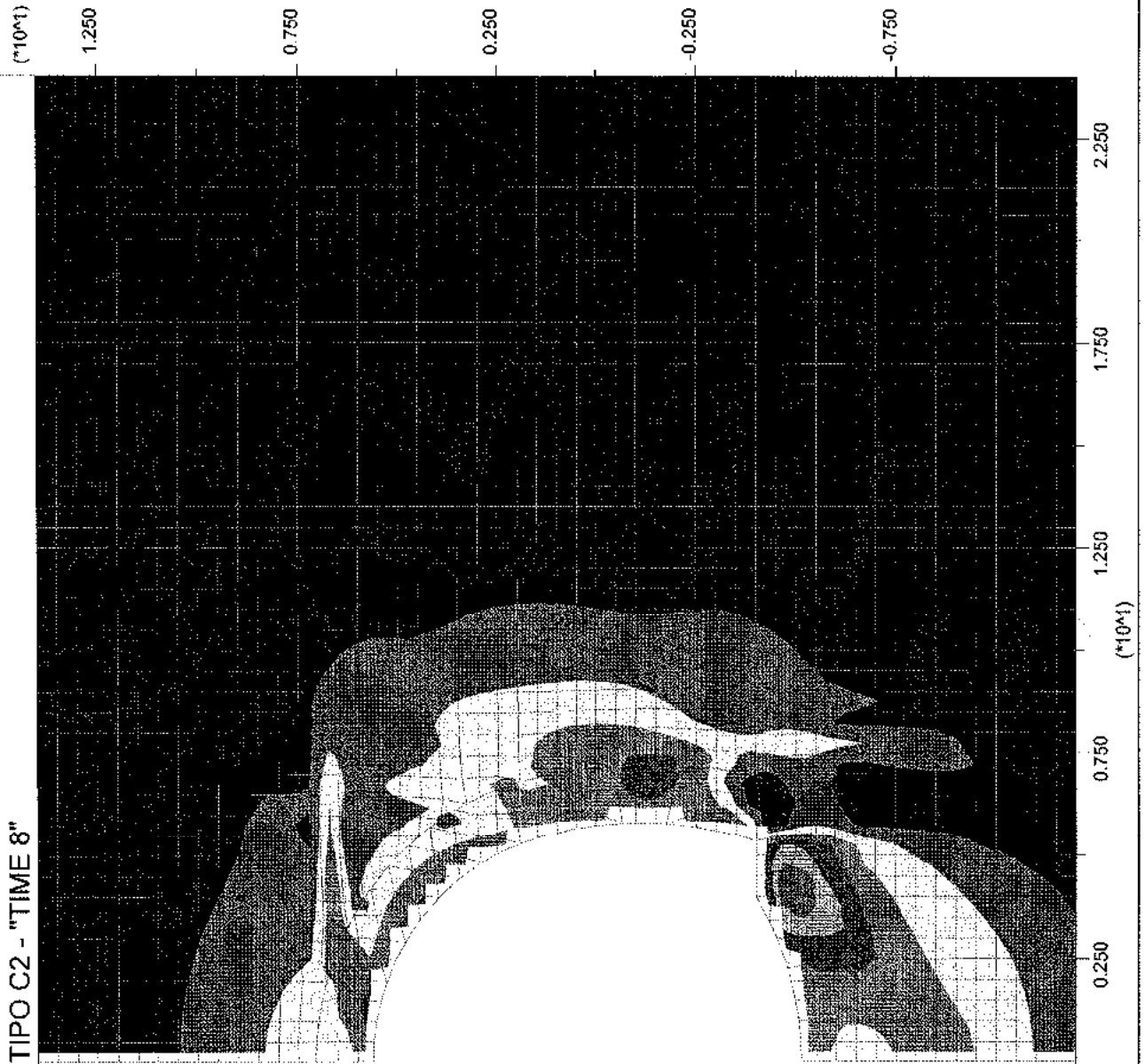
6.00E-02

7.00E-02

Contour interval= 1.00E-02

Deformazioni plastiche per taglio

0 5E 0



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Minneapolis, Minnesota USA

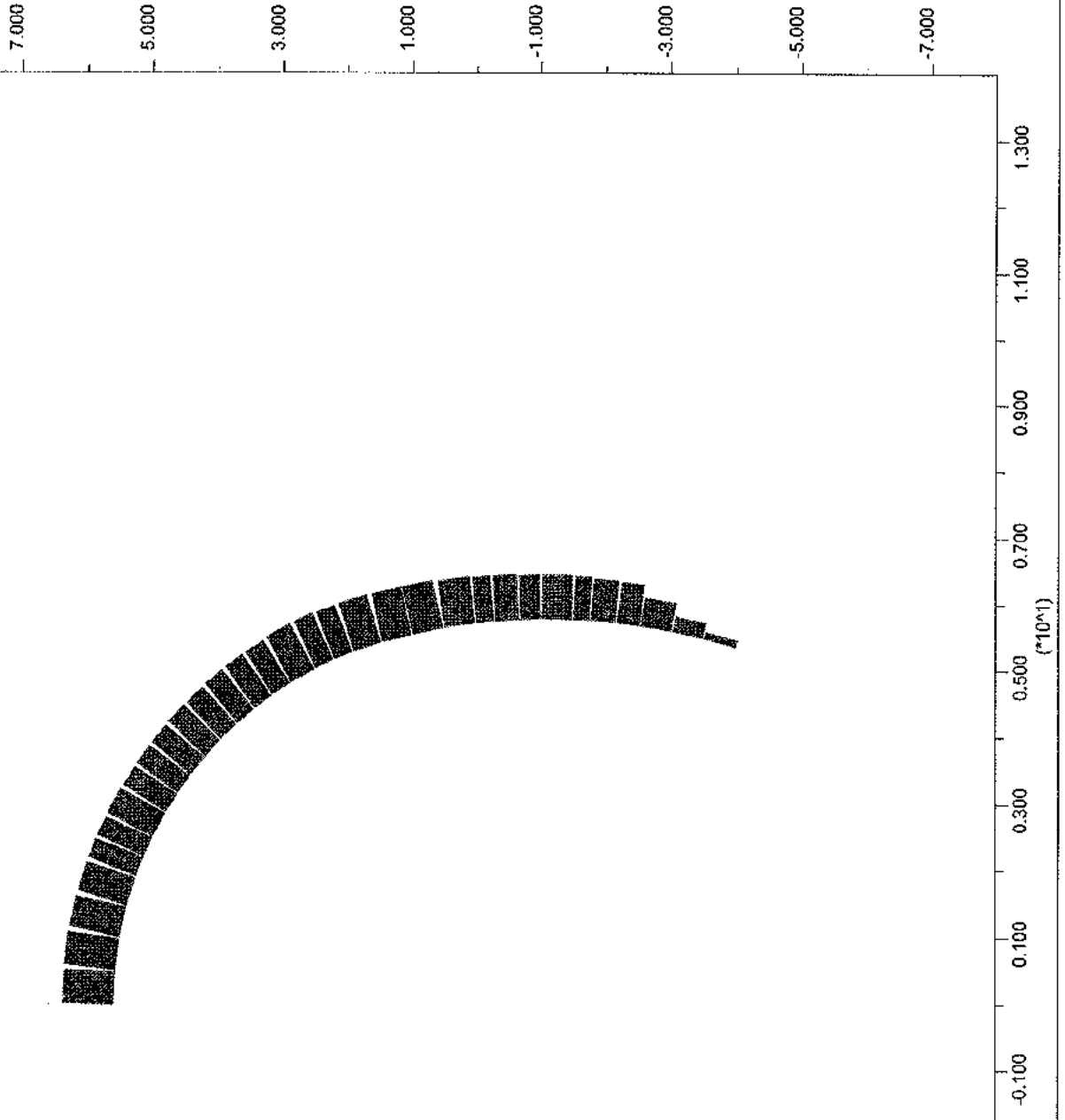
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 8"

FLAC (Version 4.00)

LEGEND

9-Feb-04 15:47
step 26411
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 3.639E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA


JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 8"

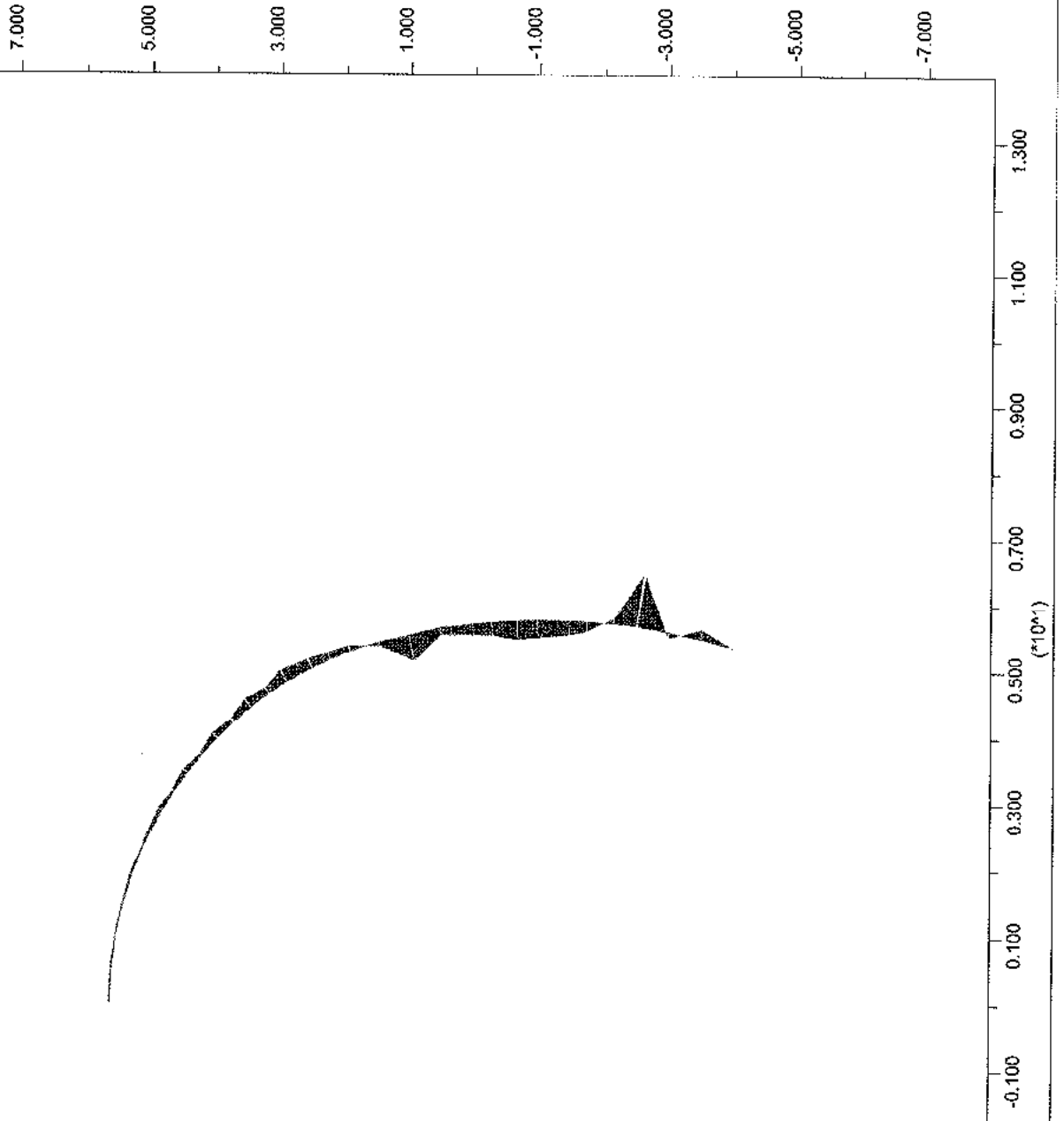
FLAC (Version 4.00)

LEGEND

9-Feb-04 15:47
step 26411
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

 Moment on
Structure Max. Value
1 (Beam) 1.512E+05



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Minneapolis, Minnesota USA

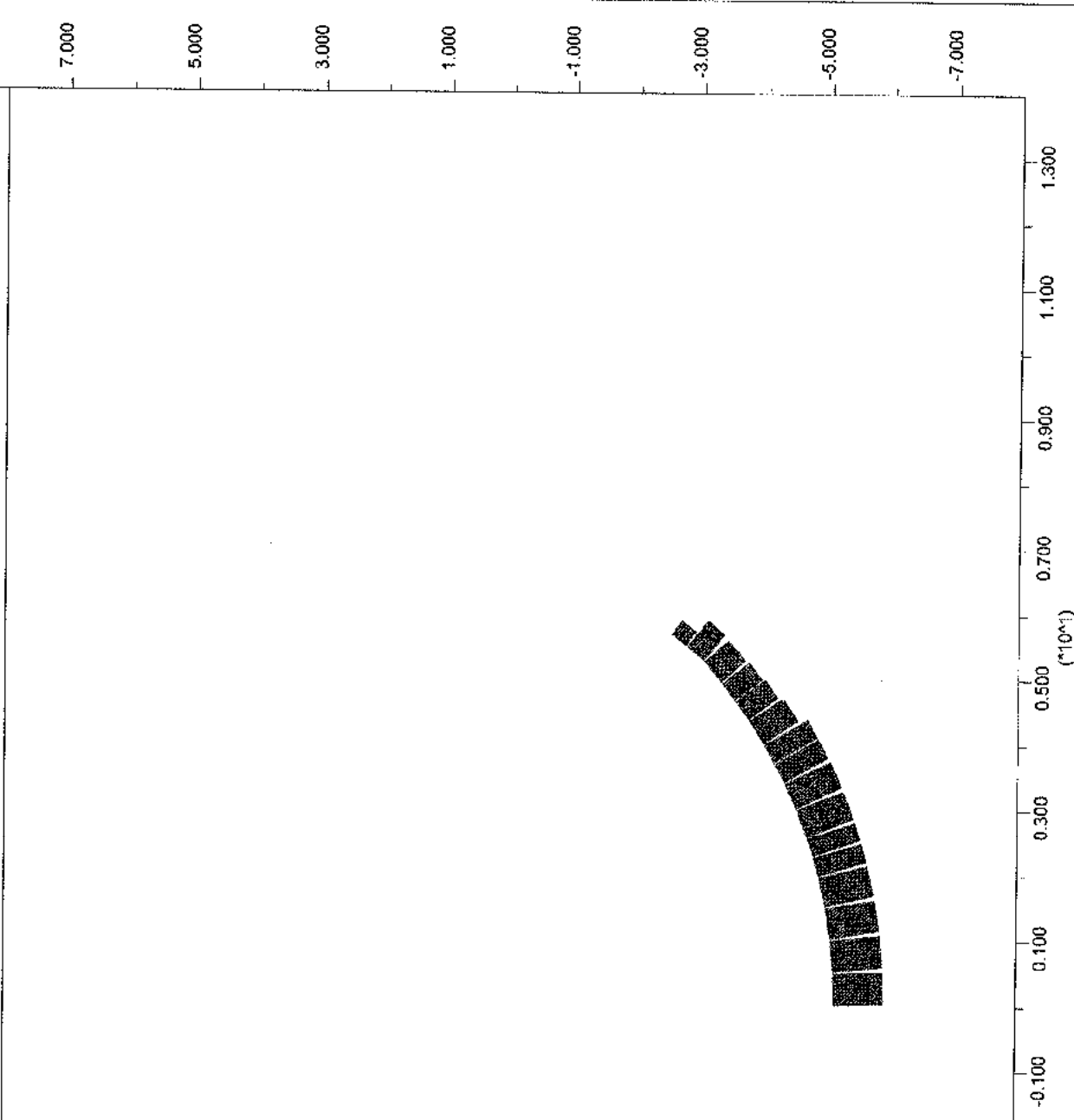
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 8"

FLAC (Version 4.00)

LEGEND

9-Feb-04 15:47
step 26411
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
2 (Beam) 1.588E+06



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Minneapolis, Minnesota USA

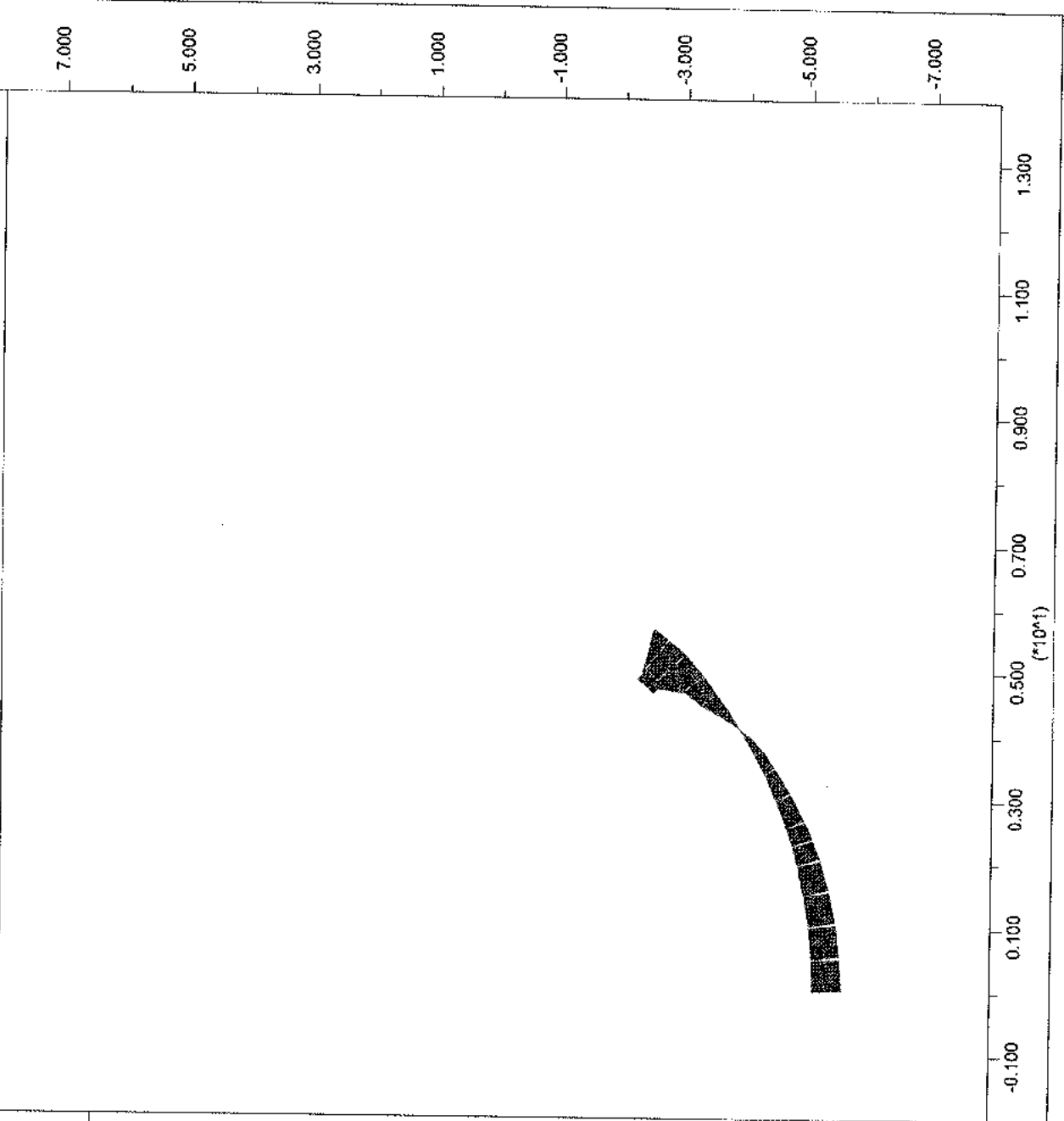
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 8"

FLAC (Version 4.00)

LEGEND

9-Feb-04 15:47
step 26411
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Momento flettente [N*m/m]
■ Moment on
Structure Max. Value
2 (Beam) -2.283E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 9"

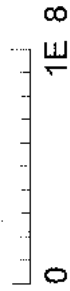
FLAC (Version 4.00)

LEGEND

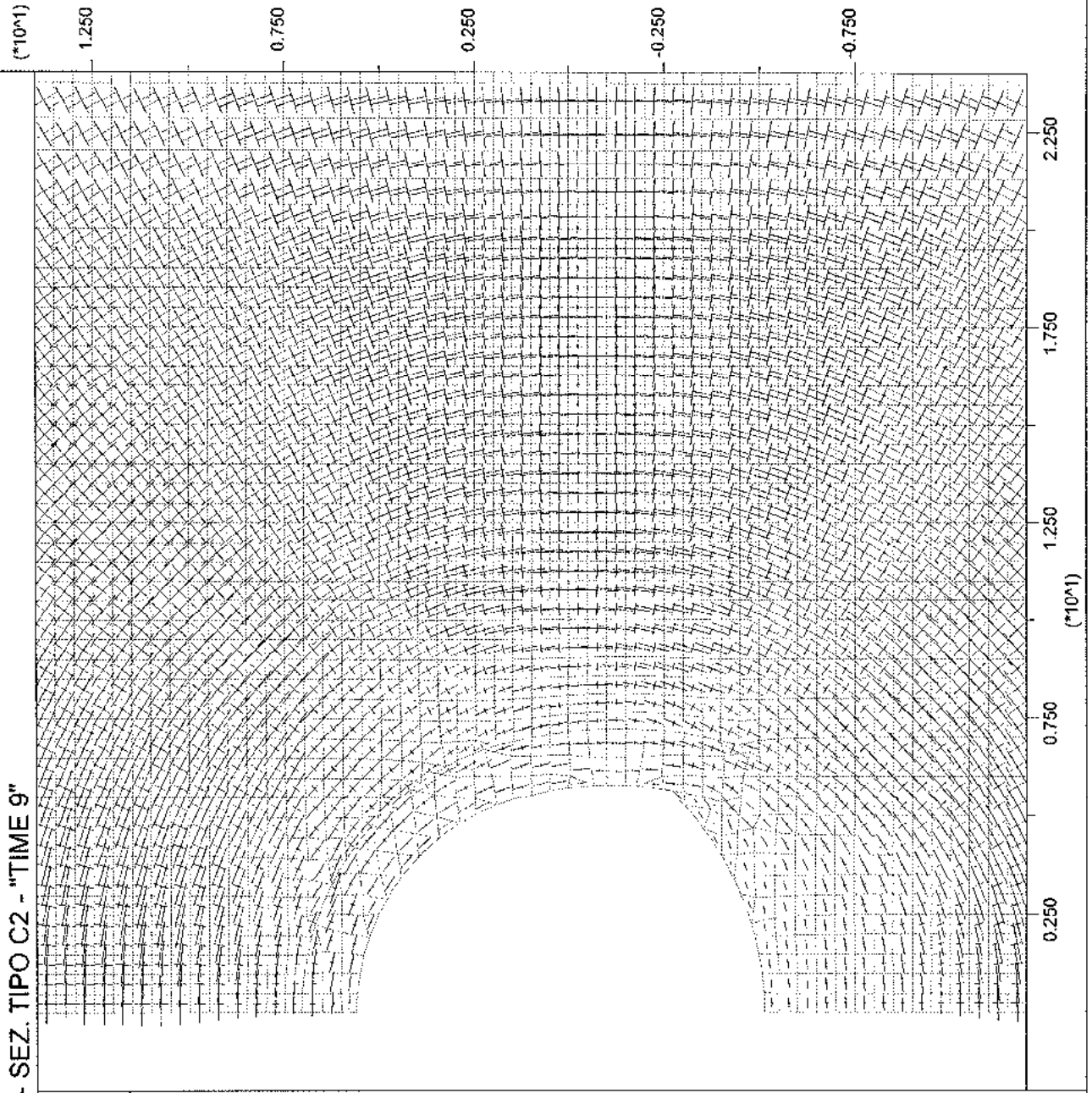
9-Feb-04 15:50
step 28464
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = 1.749E+06
Min. Value = -2.559E+07



Tensioni principali : Pa



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

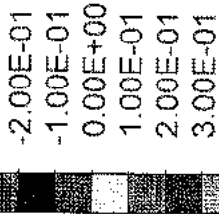
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 9"

FLAC (Version 4.00)

LEGEND

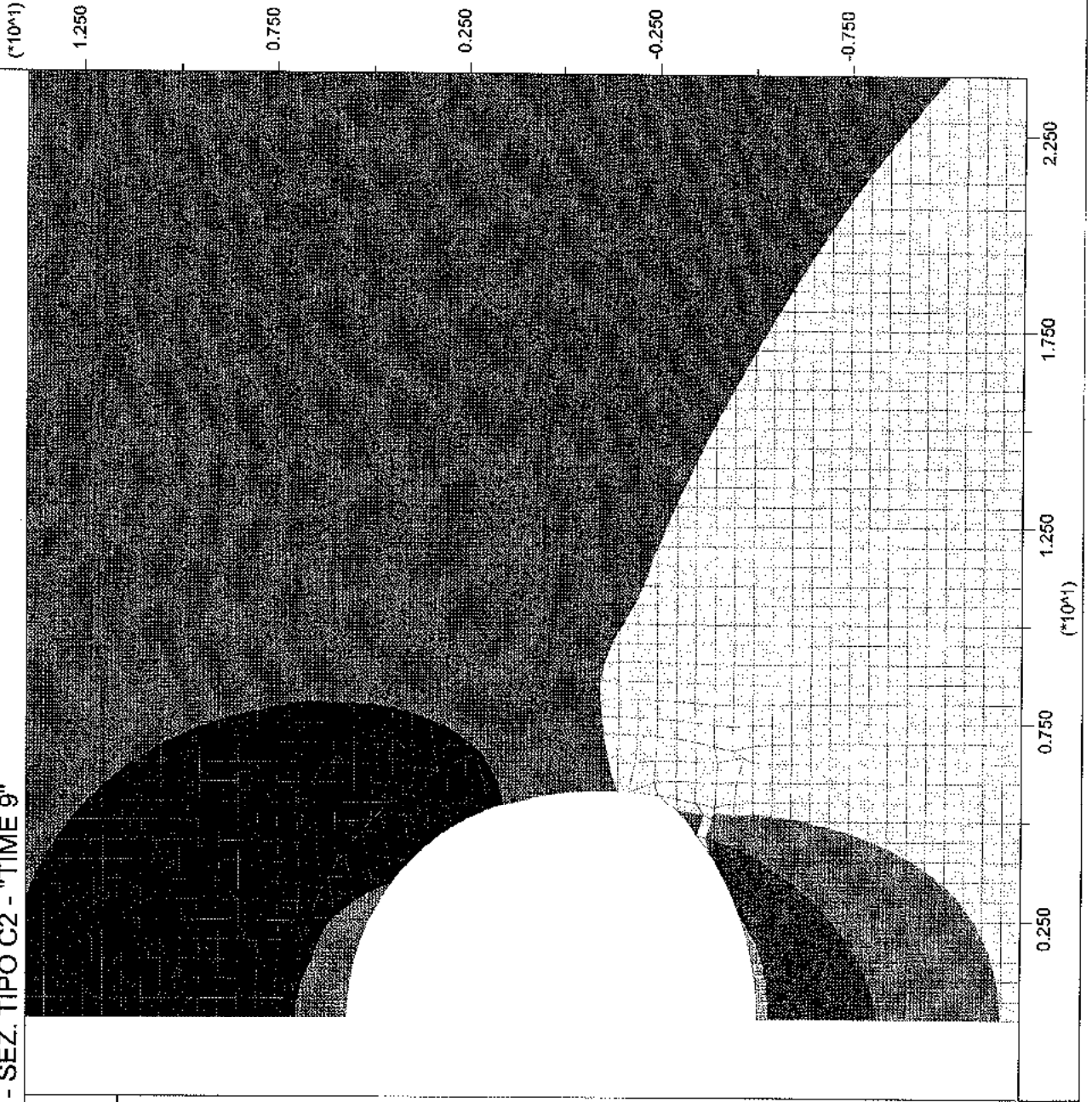
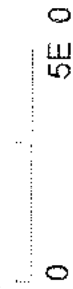
9-Feb-04 15:50
step 28464
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 9"

FLAC (Version 4.00)

LEGEND

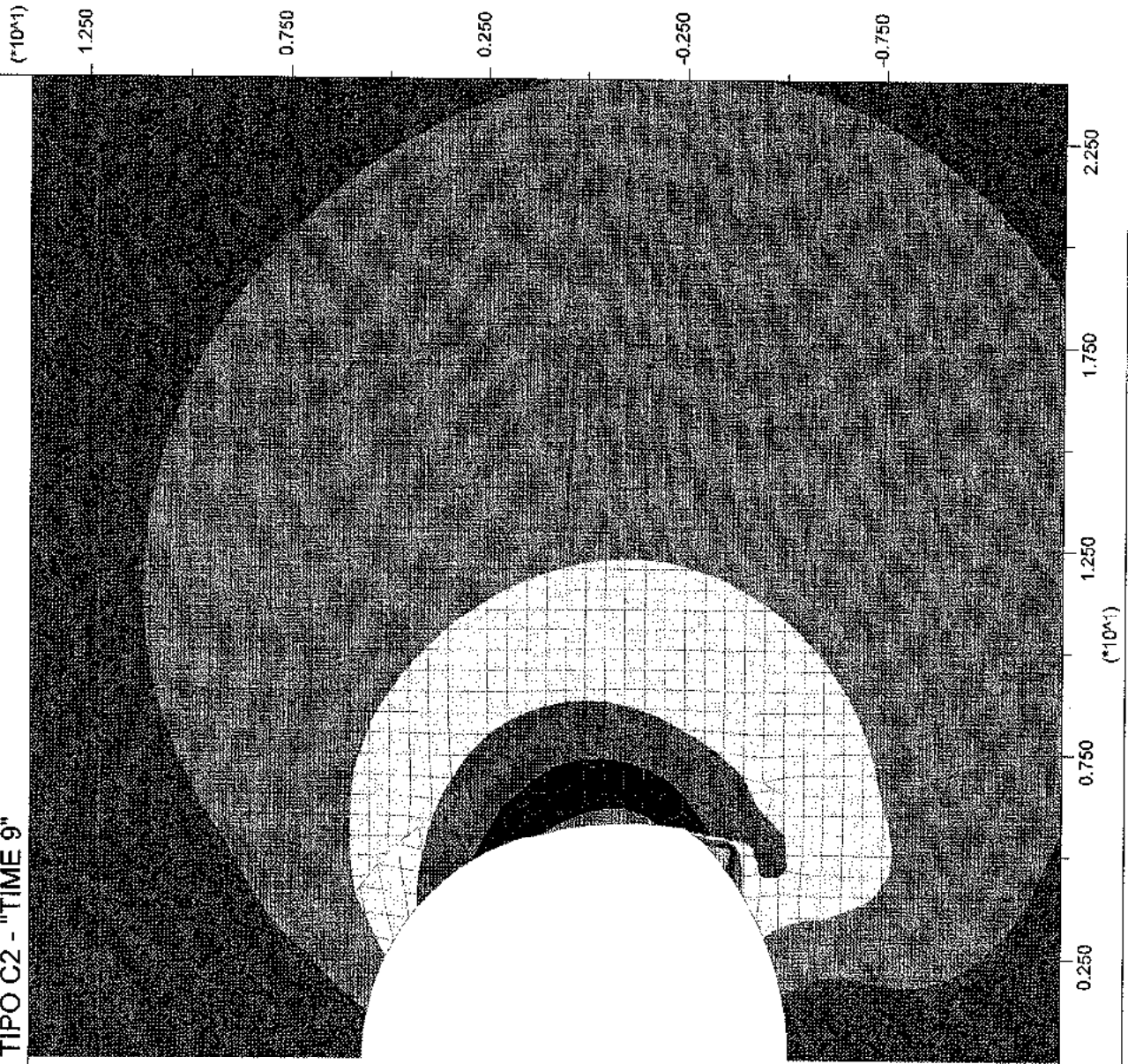
9-Feb-04 15:50
step 28464
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02

Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

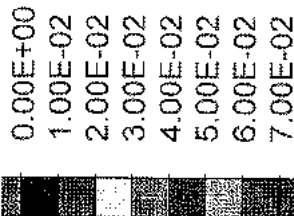
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 9"

FLAC (Version 4.00)

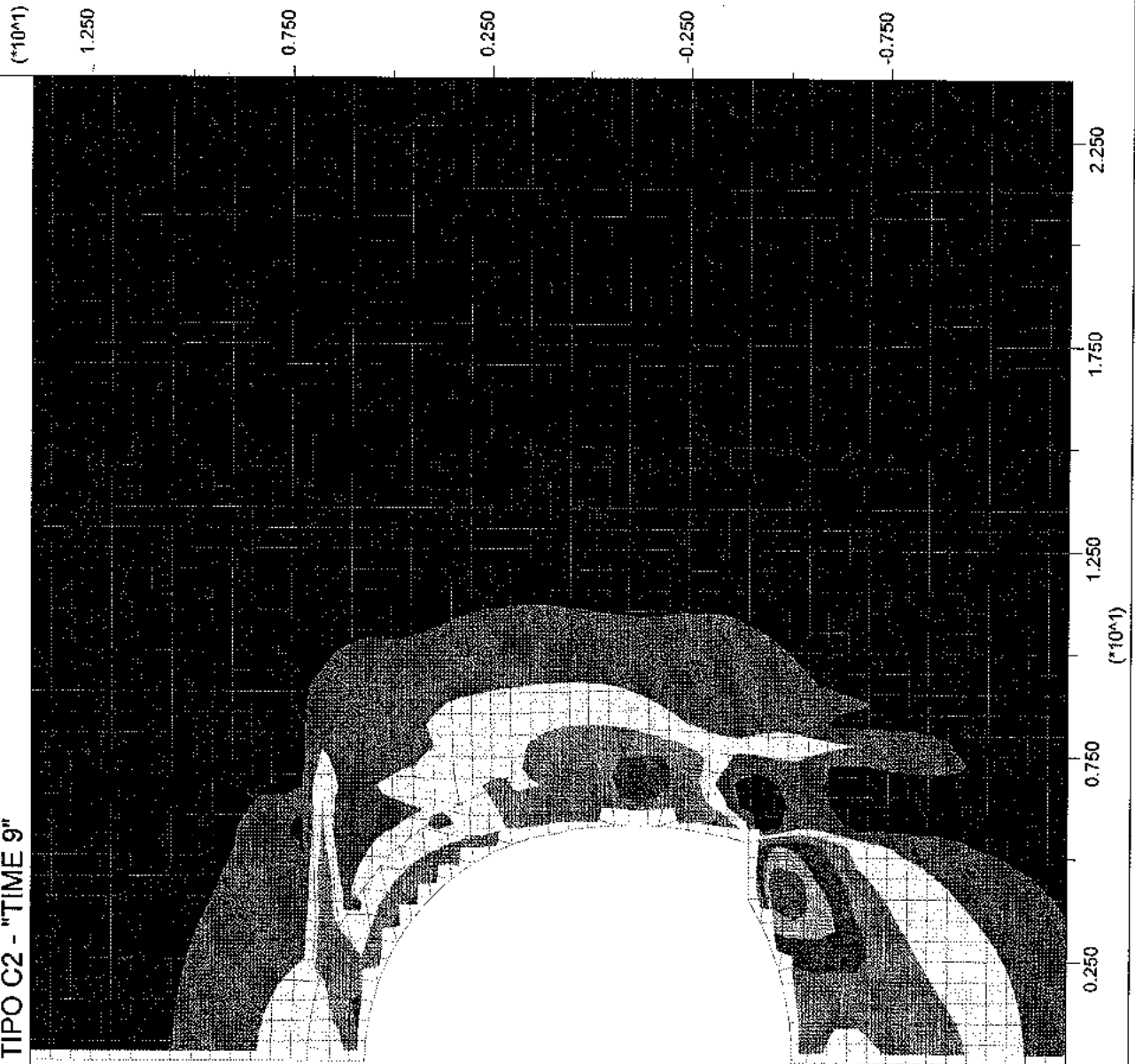
LEGEND

9-Feb-04 15:50
step 28464
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 9"

FLAC (Version 4.00)

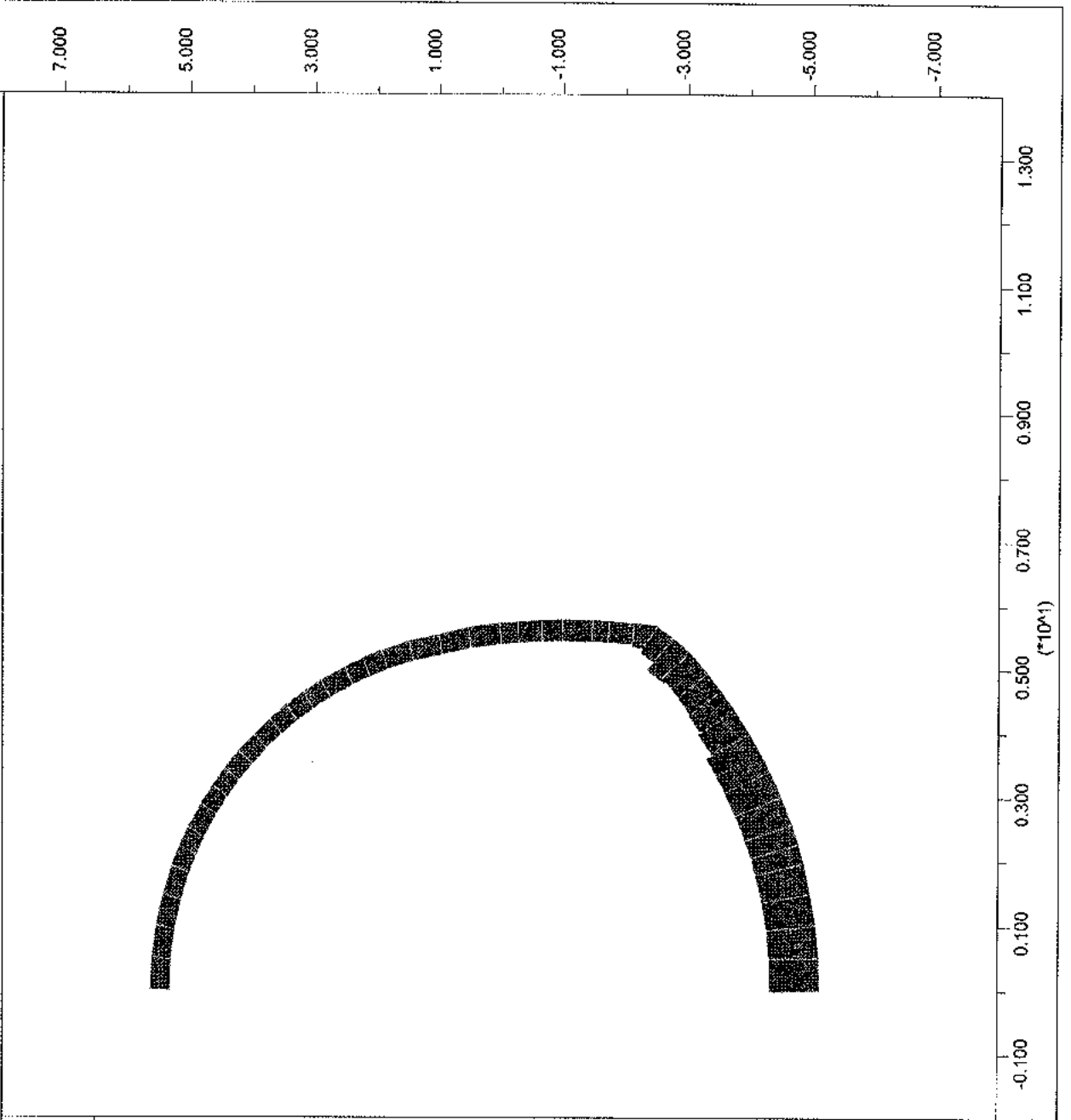
LEGEND

9-Feb-04 15:50
step 28464
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
2 (Beam) 3.878E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA


JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 9"

FLAC (Version 4.00)

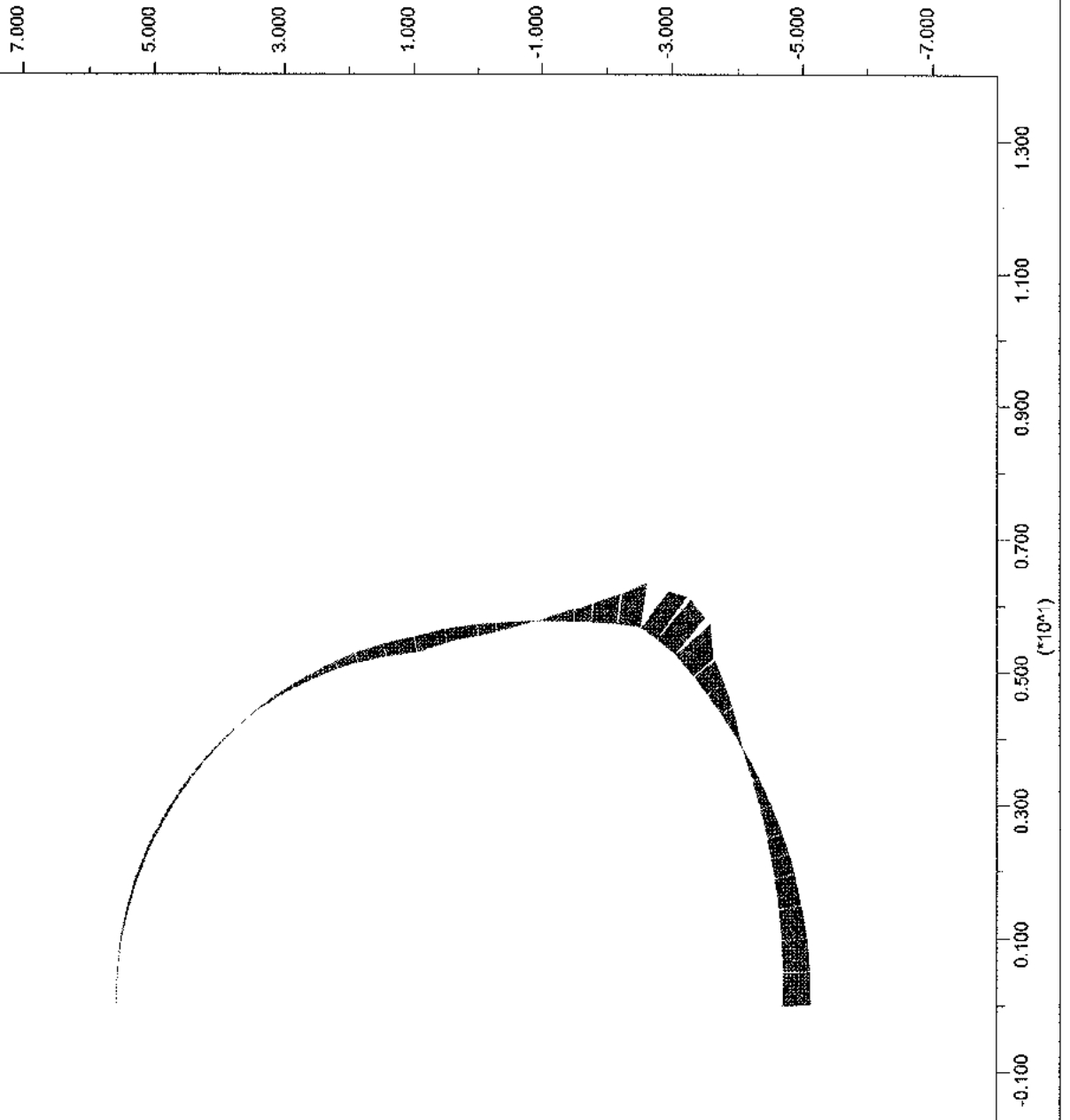
LEGEND

9-Feb-04 15:50
step 28464
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

 Moment on

Structure Max. Value
2 (Beam) -8.970E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 10"

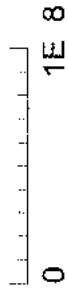
FLAC (Version 4.00)

LEGEND

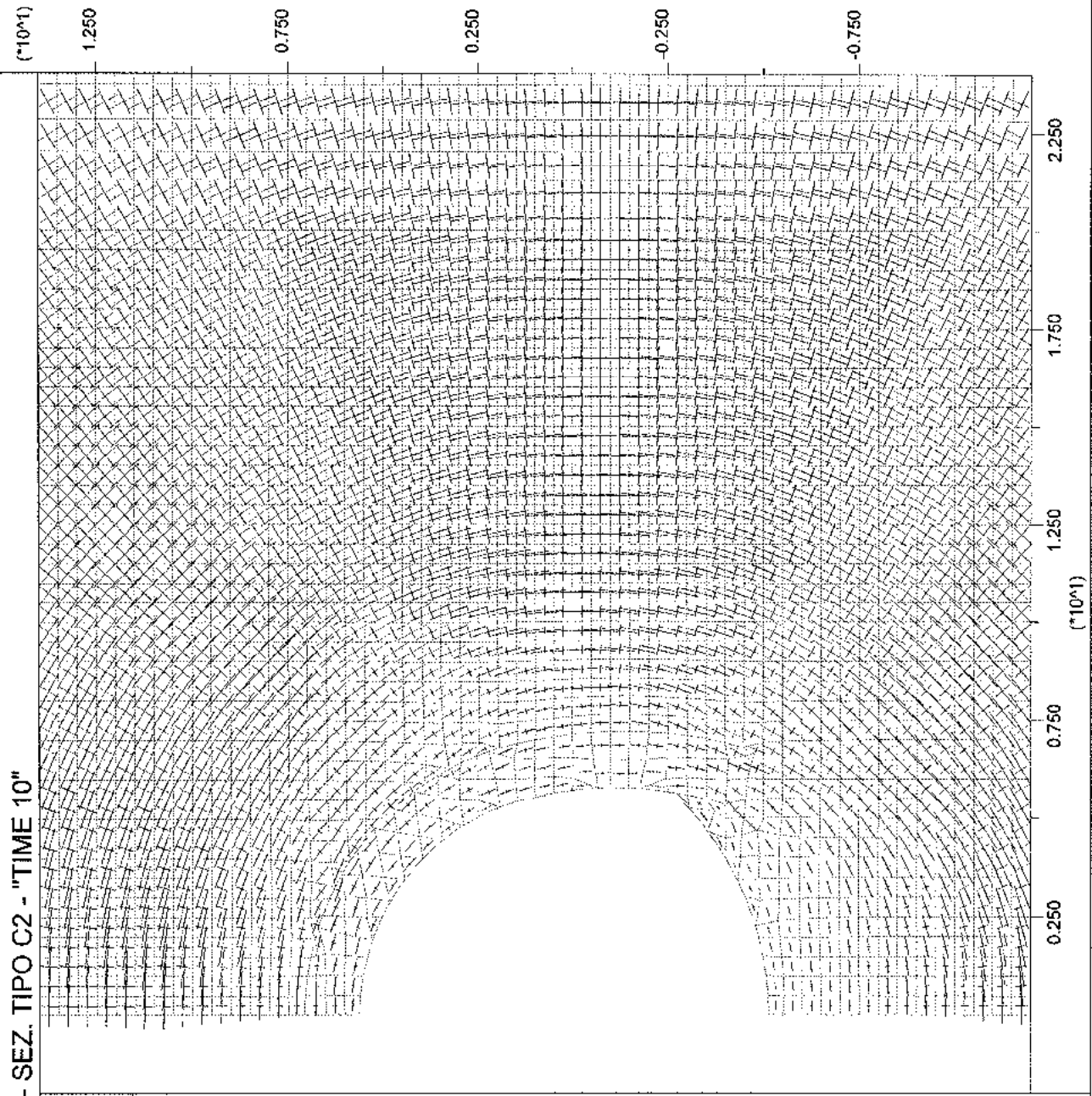
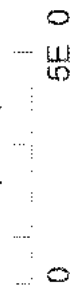
9-Feb-04 17:10
step 30226
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = 7.668E+05
Min. Value = -2.557E+07



Tensioni principali : Pa



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Minneapolis, Minnesota USA

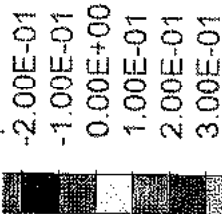
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 10"

FLAC (Version 4.00)

LEGEND

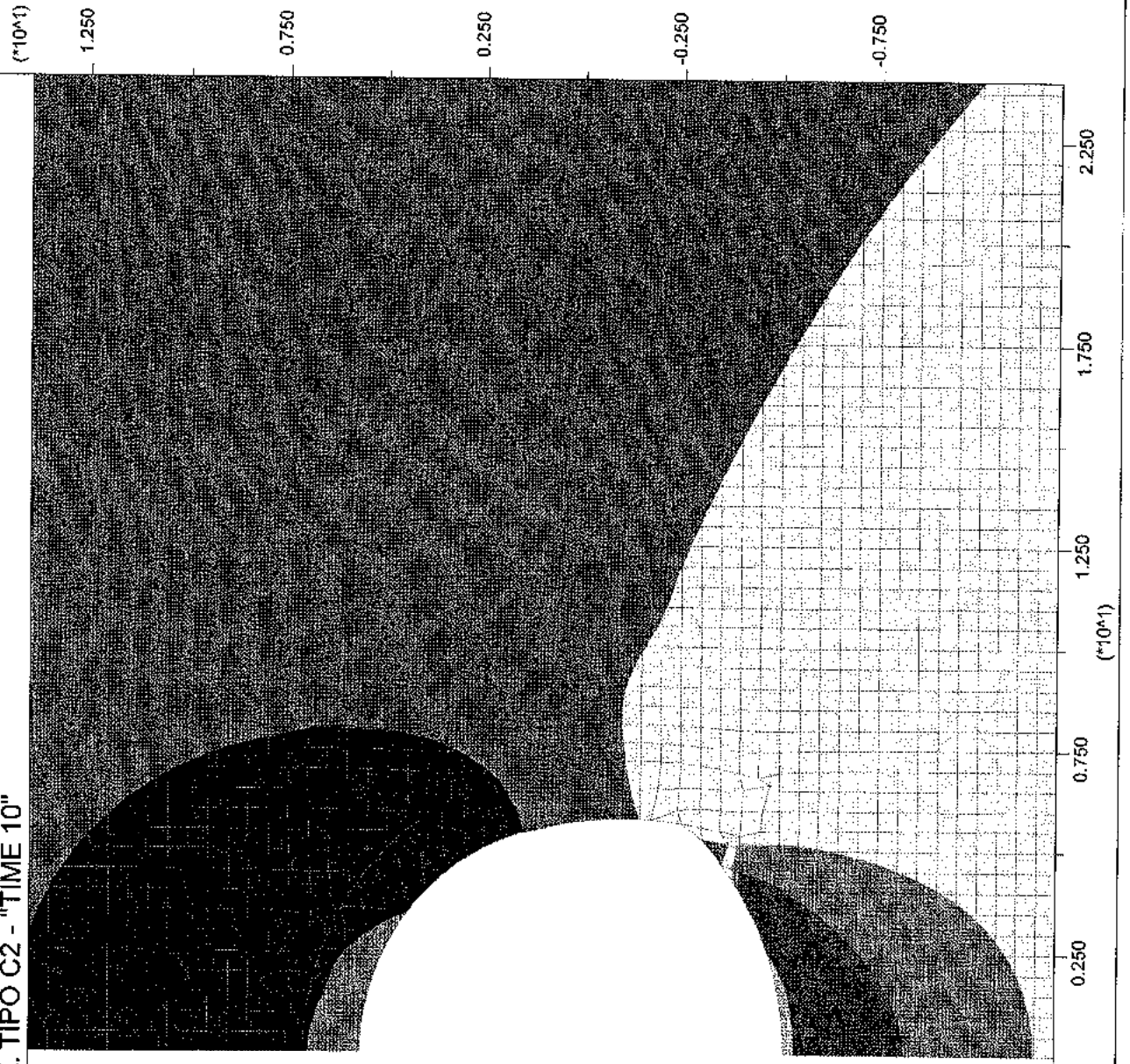
9-Feb-04 17:10
step 30226
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 10"

FLAC (Version 4.00)

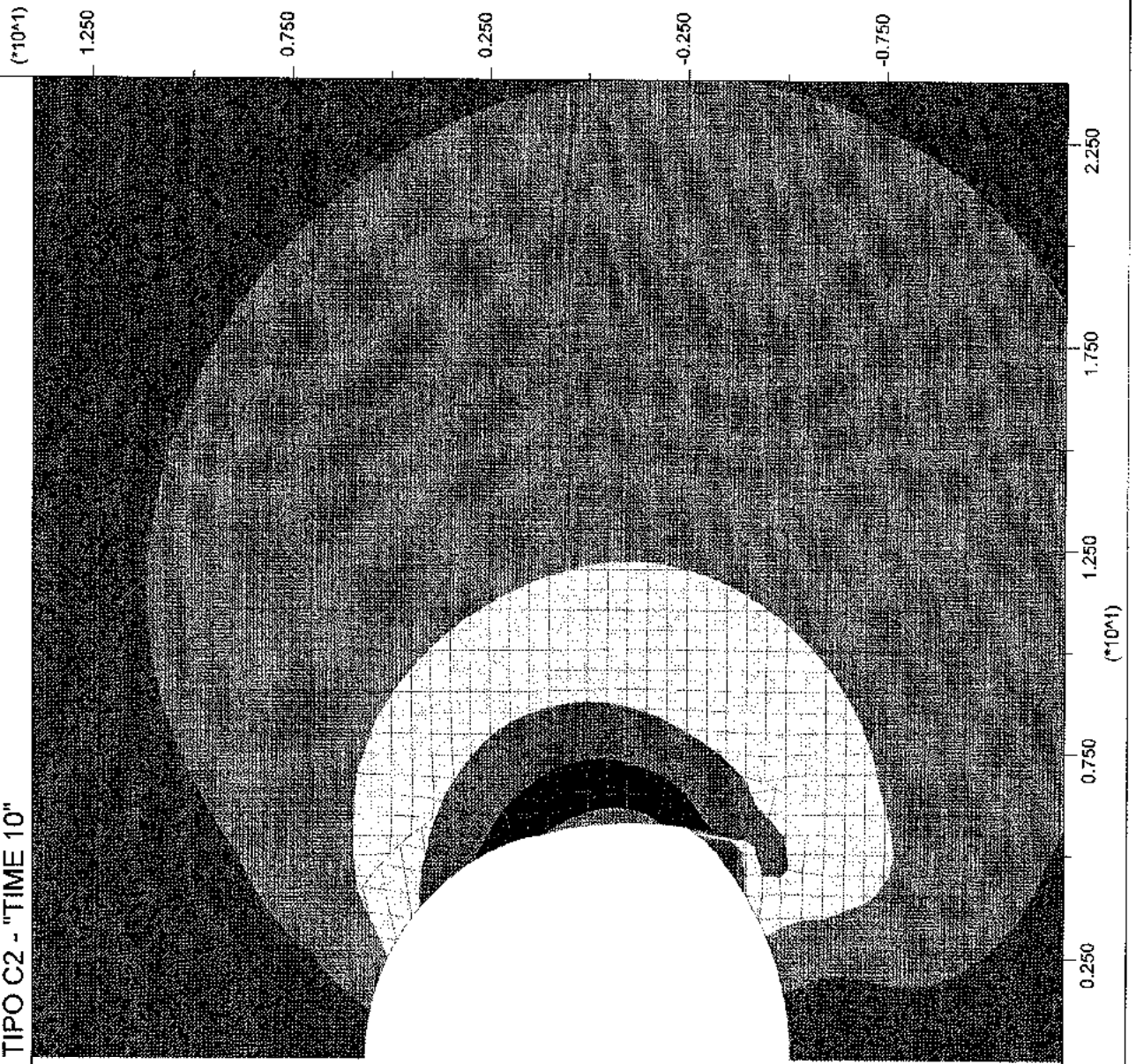
LEGEND

9-Feb-04 17:10
step 30226
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 5.00E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

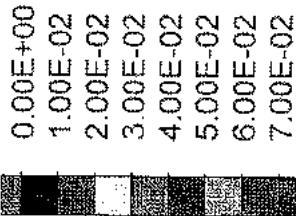
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 10"

FLAC (Version 4.00)

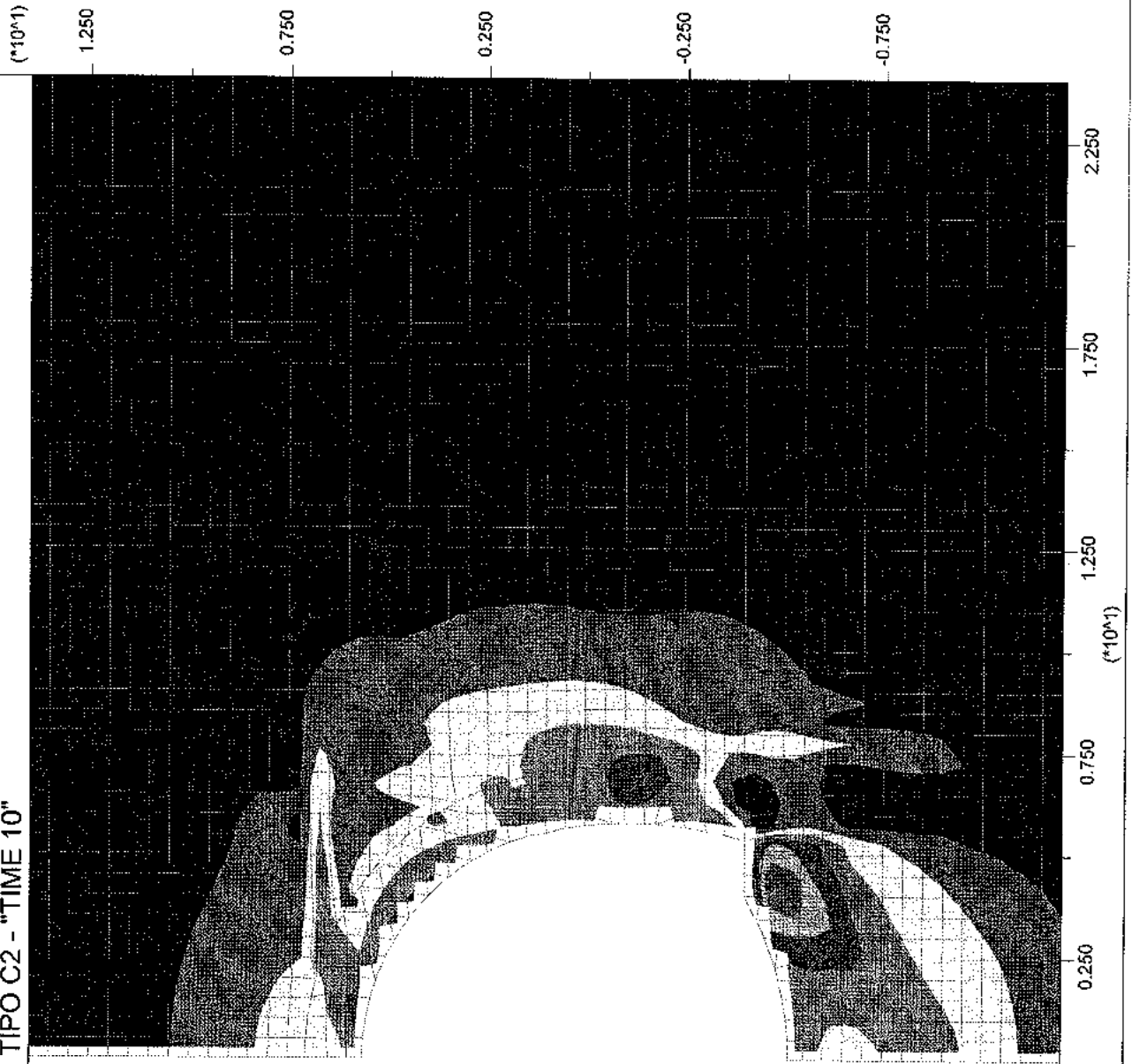
LEGEND

9-Feb-04 17:10
step 30226
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 10"

FLAC (Version 4.00)

LEGEND

9-Feb-04 17:10

step 30226

-2.000E+00 <x< 1.400E+01

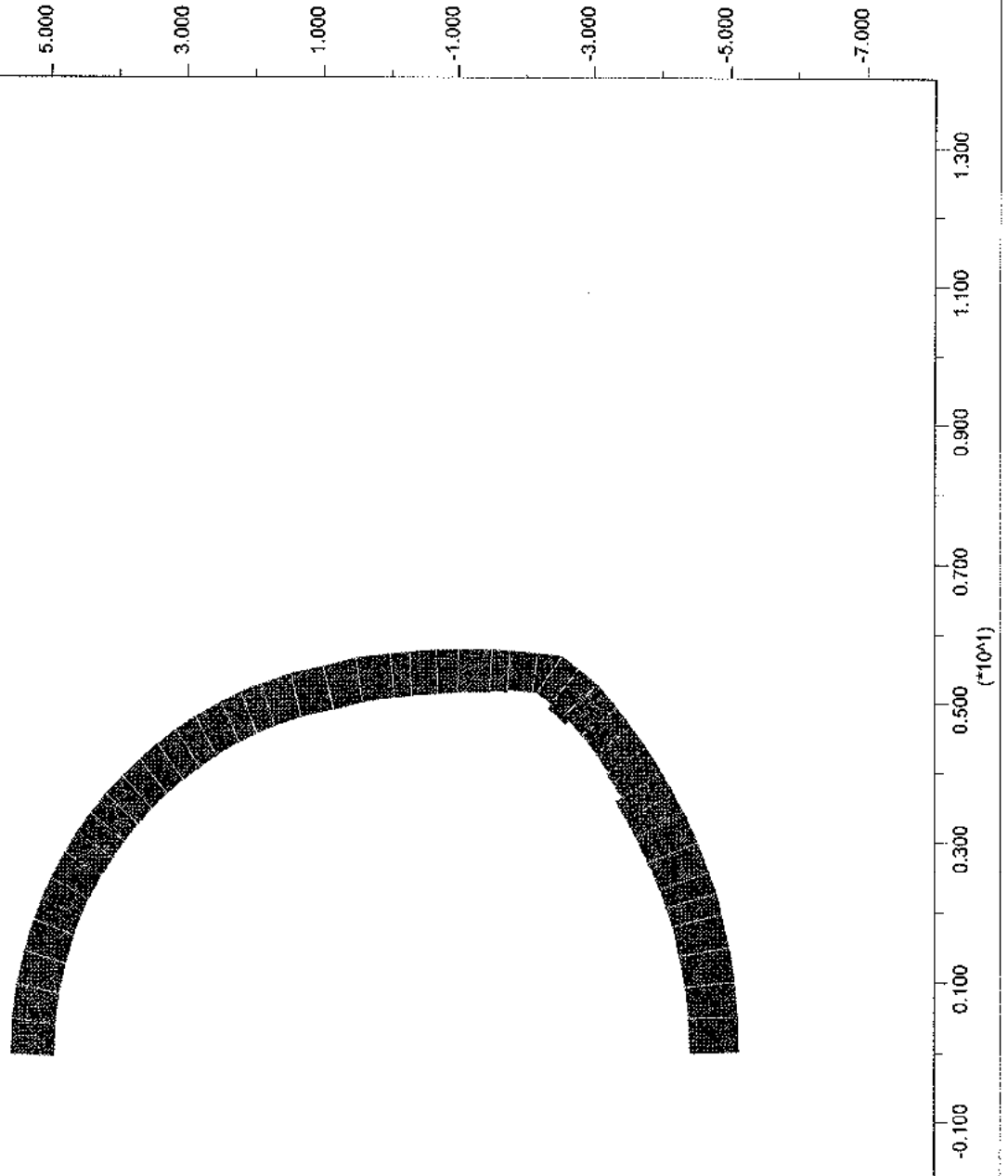
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value

2 (Beam) 5.244E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C2 - "TIME 10"

FLAC (Version 4.00)

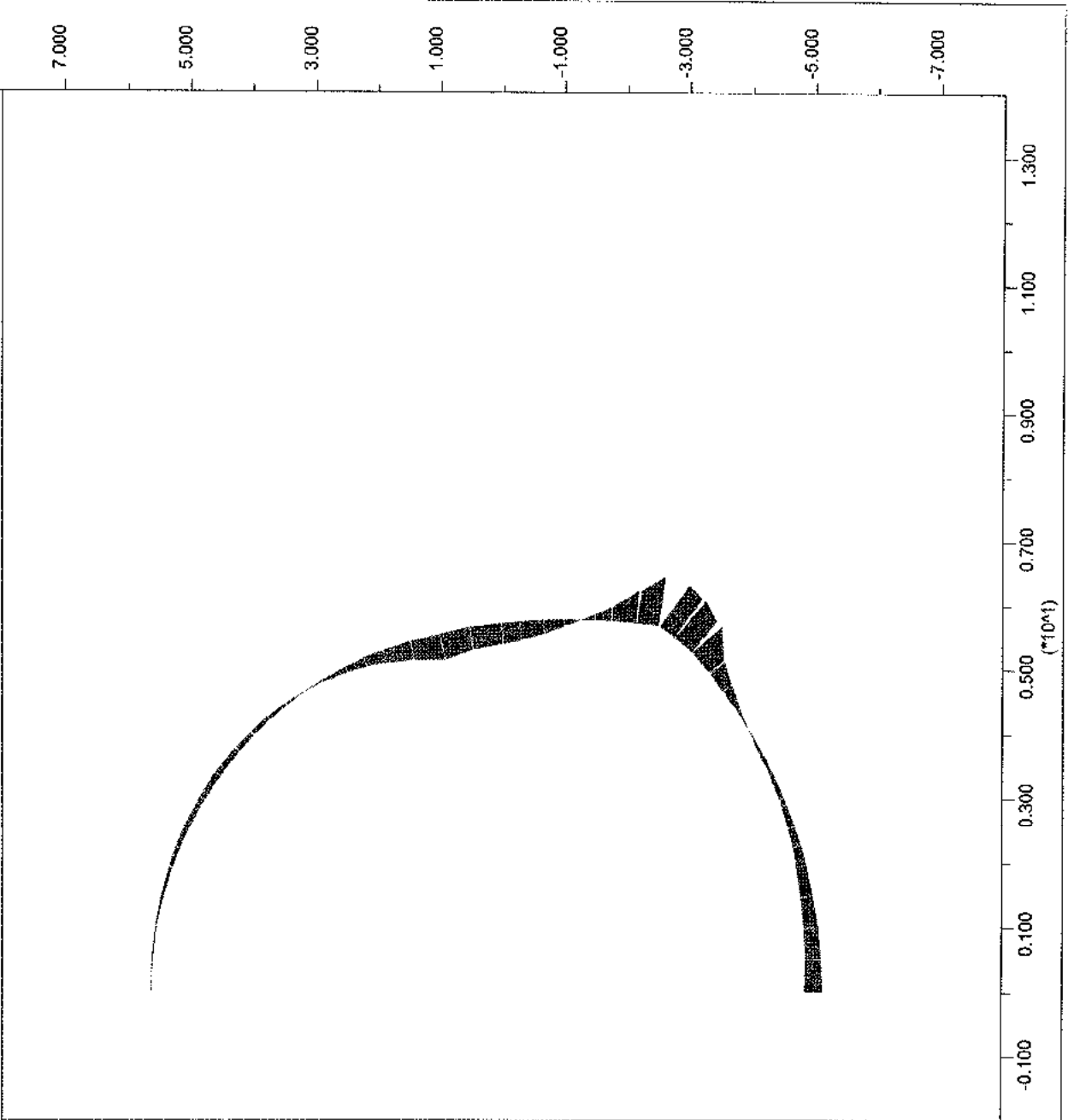
LEGEND

9-Feb-04 17:10
step 30226
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

■ Moment on

Structure Max. Value
2 (Beam) -1.199E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

Calcolo FLAC – Sezione tipo C4

Sezione tipo C4 - Ap gruppo 3

Input Analisi alle Differenze Finite FLAC

Geometria	
Copertura (m)	800.00
Altezza falda statica (m)	0.00
Coefficiente efficienza drenaggio	0.20
Altezza falda dinamica (m)	0.00
Raggio scavo (m)	5.60

Materiali				
Spritz-beton	E_{sb} (MPa)	E_{sb} (MPa)	E_{sb} (MPa)	I_{sb} (cm ⁴)
	30	3000	13000	31200
Cartrine	tipo	p (m)	h (m)	J _{sc} (cm ⁴)
	HEB240	1.00	1.06E+02	11258.0
Resistimenti	R _c (MPa)	E _{max} (MPa)	Affinità	0
A.R.	30	31220		30
Cartrine	30	31220		9.0

LEGENDA SIMBOLI

- E_{sb} - resistenza media cilindrica a compressione dello spritz-beton
- I_{sb} - momento d'inerzia cilindrica a compressione dello spritz-beton
- E_{sc} - resistenza media cilindrica a compressione delle cartrine
- I_{sc} - momento d'inerzia cilindrica a compressione delle cartrine
- E_{max} - modulo elastico finale dello spritz-beton
- E_{sb} - modulo elastico iniziale dello spritz-beton
- I_{sb} - momento d'inerzia cilindrica dello spritz-beton
- n - numero di cartrine per gruppo
- p - passo cartrine
- h - altezza del profilo della singola cartrina
- J_{sc} - momento di inerzia del profilo della singola cartrina
- R_c - resistenza caratteristica cubica a compressione del c/c
- S - spessore del rivestimento definitivo
- E_{mat} - modulo elastico del c/c maturo
- D - distanza di getto fra rivestimenti definitivi e fonte (moltiplicato del diametro della galleria)
- E_{mat} - modulo elastico del prerivestimento

Parametri geomeccanici	1° strato		2° strato		Faccia consolidata	
	Picco	Residuo	Picco	Residuo	Picco	Residuo
Valori di picco e residuo	27	27	27	27		
Peso di volume (KN/m ³)	25	27	25	27		
Angolo attrito (°)	0.70	0.65	0.70	0.65		
Coesione (MPa)	1.20	1.20	1.20	1.20		
Modulo elastico (GPa)	0.30	0.30	0.30	0.30		
Modulo di Poisson	1.00	1.00	1.00	1.00		
Modulo di deformazione volumetrica (Bulk modulus) (GPa)	1.00	1.00	1.00	1.00		
Modulo elastico tangenziale (Shear modulus) (GPa)	0.46	0.46	0.46	0.46		
Materiale costitutivo	Strain-Softening					

Fasi di calcolo (TIME)	x (m)	x/R	R/Panel	RDEM	Epre (MPa)	E _{sb} (MPa)
TIME 1 - Geostatico	-∞	-∞	0.000	0.000		
TIME 2 - Creazione cono della falda statica	-24.00	-4.286	0.000	0.000		
TIME 3 - Taratura e scavo	0.00	0.000	0.280	0.843		
TIME 4 - Fosa centrale e SB	1.00	0.179	0.510	0.954	10000	
TIME 5 - Maturazione SB	4.00	0.714	0.790	0.969	20000	
TIME 6 - Maturazione SB finale	8.00	1.428	0.901	0.974	37500	
TIME 7 - Getto Muretta e A.R. non maturati	16.00	2.857	0.953	0.974	16000	
TIME 8 - Maturazione murette e A.R.	24.00	4.286	0.981	0.977	37500	
TIME 9 - Getto calotta	42.00	7.500	1.000	1.000	31220	
TIME 10 - Decadimento ammasso e prerivestimento	42.00	7.500	1.000	1.000	31220	

Relazione per il calcolo di R/Panel, RDEM

$$R' = \frac{1}{1 + \frac{x}{0.84 \cdot R_p}} \left[1 - \frac{x}{R_p} \right]$$

- R' = Convergenza iniziale ad una distanza di x metri dal fronte espressa come % di u_0
- u_0 = Convergenza iniziale in corrispondenza del fronte espressa come % di u_c
- u_c = Convergenza radiale ad una distanza infinita dal fronte
- R_p = Raggio plastico
- R = Raggio della galleria
- x = distanza tra il fronte e la stazione di calcolo

TIMES DI CALCOLO

TIME 1 - Geostatico	Monte applicato il peso proprio del terreno, ricorrendo in termini di tensioni lineastiche la situazione preesistente lo scavo della galleria.
TIME 2 - Creazione cono della falda statica	Si simula l'arrivo dei consolidamenti al contorno della falda statica di scavo.
TIME 3 - Taratura e scavo	Viene simulato l'arrivo del fronte di scavo, tenendo conto del contributo offerto dai consolidamenti al fronte.
TIME 4 - Fosa centrale e SB	Viene simulata la posa in opera della centrale e dello spritz-beton.
TIME 5 - Maturazione SB	Viene simulata la maturazione parziale dello spritz-beton e l'avanzamento dello scavo.
TIME 6 - Maturazione SB finale	Viene simulata la completa maturazione dello spritz-beton e l'avanzamento dello scavo.
TIME 7 - Getto Murette e A.R. non maturati	Viene simulato il getto delle murette e dell'arco rovescio non maturati e l'avanzamento dello scavo.
TIME 8 - Maturazione murette e A.R.	Si simula la completa maturazione delle murette e dell'arco rovescio e l'avanzamento dello scavo.
TIME 9 - Getto calotta	Si simula il getto del rivestimento definitivo in calotta.
TIME 10 - Decadimento ammasso e prerivestimento	Si applica un decadimento della caratteristiche meccaniche del prerivestimento e dell'ammasso.

JOB TITLE : Elementi strutturali del priverimento - Sezioni di verifica

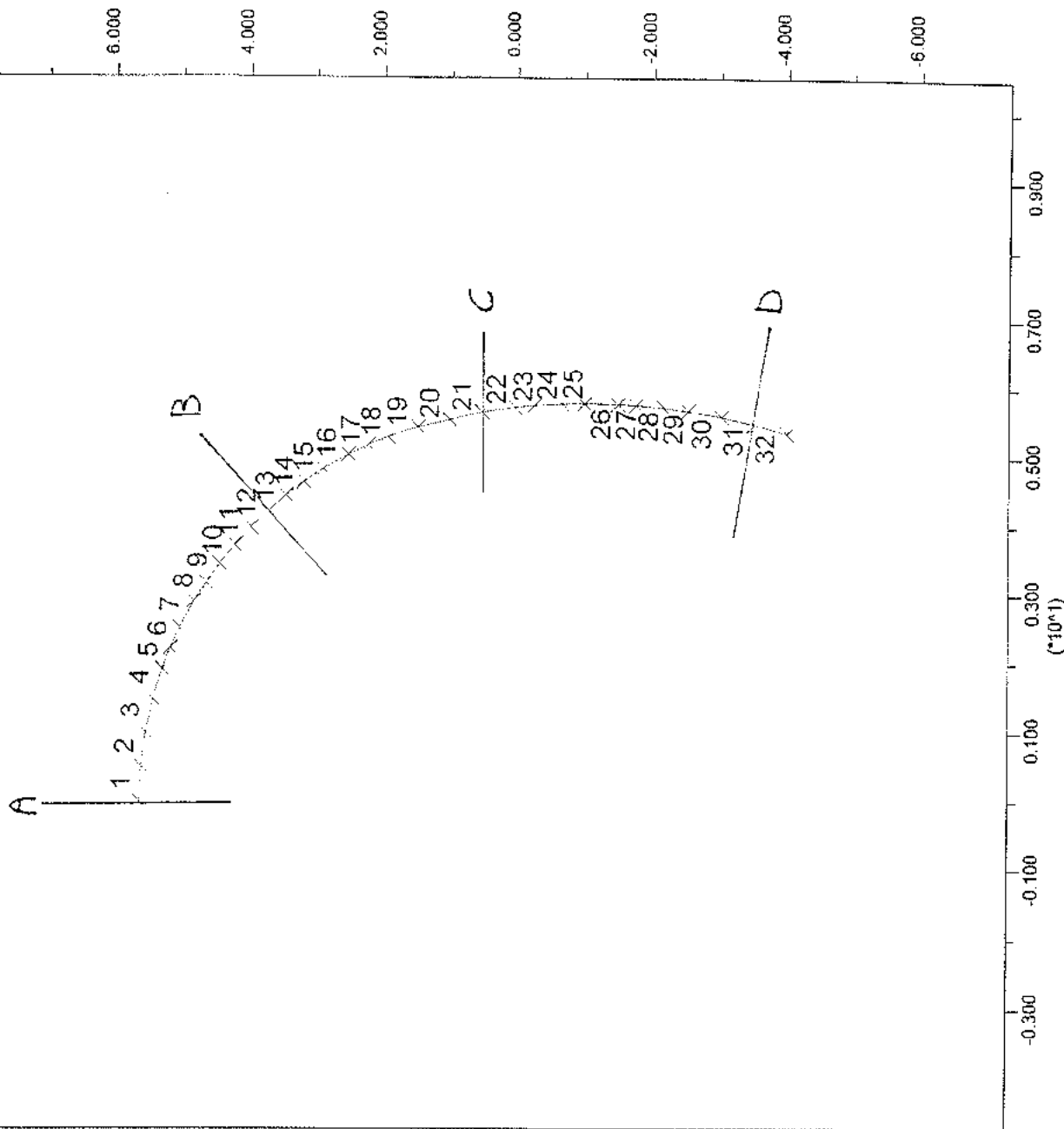
FLAC (Version 4.00)

LEGEND

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step 22377
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Beam Plot
Structural Element Numbers

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



Sezione tipo C4 - Ap gruppo 3

Verifica del prinvestimento

CARATTERISTICHE GEOMETRICHE E MECCANICHE

MATERIALI	Tipo	σ_{max} (MPa)	H (cm)	Passo (m)	n^o	A (cm ²)	I (cm ⁴)
Spritz-beton	Fcm 30	23.00	30	-	-	3000.0	2250.0
Centine	HEB240	210	24	1	1	106.0	11259.0
Sezione omogeneizzata						4484.0	168811.8

Coefficiente omogeneizzazione m	15	
Baricentro centina d (cm)	12.00	dall'estradosso
Baricentro sezione omogeneiz. Yg (cm)	14.01	dall'estradosso
$e^*lim,e = I^*/(A*Yg)$ (cm)	2.69	dimensione nocciolo d'inerzia estradosso
$e^*lim,i = I^*/(A*(H-Yg))$ (cm)	2.35	dimensione nocciolo d'inerzia intradosso

$e = M/N$ eccentricità

Formule impiegate

$$\sigma_{sb,i} = N/A^* + (M(H-Yg))/I^* \quad \sigma_{sb,e} = N/A^* - (MYg)/I^*$$

$$\sigma_{s,e} = m(N/A^* + M(d+H_s/2-Yg)/I^*)$$

$$\sigma_{s,i} = m(N/A^* - M(d-H_s/2-Yg)/I^*)$$

Tensioni positive se di compressione

Sezione	Elemento	Altezza (m)	N (KN/m)	M (KN*m/m)	e (m)	$\sigma_{sb,i}$ (Mpa)	$\sigma_{sb,e}$ (Mpa)	$\sigma_{s,i}$ (Mpa)	$\sigma_{s,e}$ (Mpa)	
CHIAVE CALOTTA	1	0.30	971	0.2	0.00	2.18	2.15	32.66	32.23	TIME 4
RENI	13	0.30	923	5.5	0.01	2.58	1.60	35.76	24.03	
P.C.	21	0.30	818	-10.4	-0.01	0.83	2.68	18.06	40.24	
PIEDE	31	0.30	447	3.30	0.01	1.31	0.72	17.88	10.85	
CHIAVE CALOTTA	1	0.30	1942	1.3	0.00	4.45	4.22	66.12	63.35	TIME 5
RENI	13	0.30	1832	12.5	0.01	5.27	3.05	72.38	45.73	
P.C.	21	0.30	1605	-21.5	-0.01	1.54	5.36	34.60	80.46	
PIEDE	31	0.30	808	9.8	0.01	2.73	0.99	35.73	14.83	
CHIAVE CALOTTA	1	0.30	2816	4.0	0.00	6.21	5.50	91.06	82.53	TIME 6
RENI	13	0.30	2413	16.9	0.01	6.98	3.98	95.73	59.69	
P.C.	21	0.30	2064	-26.7	-0.01	2.07	6.82	45.34	102.28	
PIEDE	31	0.30	992	13.9	0.01	3.53	1.06	45.53	15.88	
GETTO DELL'ARCO ROVESCIO - Le verifiche del piede centina saranno omesse										
CHIAVE CALOTTA	1	0.30	3460	3.0	0.00	8.05	7.51	119.08	112.68	TIME 7
RENI	13	0.30	3404	25.5	0.01	10.01	5.48	136.51	82.13	
P.C.	21	0.30	3300	-62.7	-0.02	1.42	12.56	54.72	188.43	
CHIAVE CALOTTA	1	0.30	3647	3.0	0.00	8.42	7.88	124.66	118.27	TIME 8
RENI	13	0.30	3571	25.7	0.01	10.40	5.83	142.28	87.47	
P.C.	21	0.30	3491	-67.9	-0.02	1.35	13.42	56.49	201.29	

JOB TITLE : Elementi strutturali del rivestimento definitivo - Sezioni di verifica

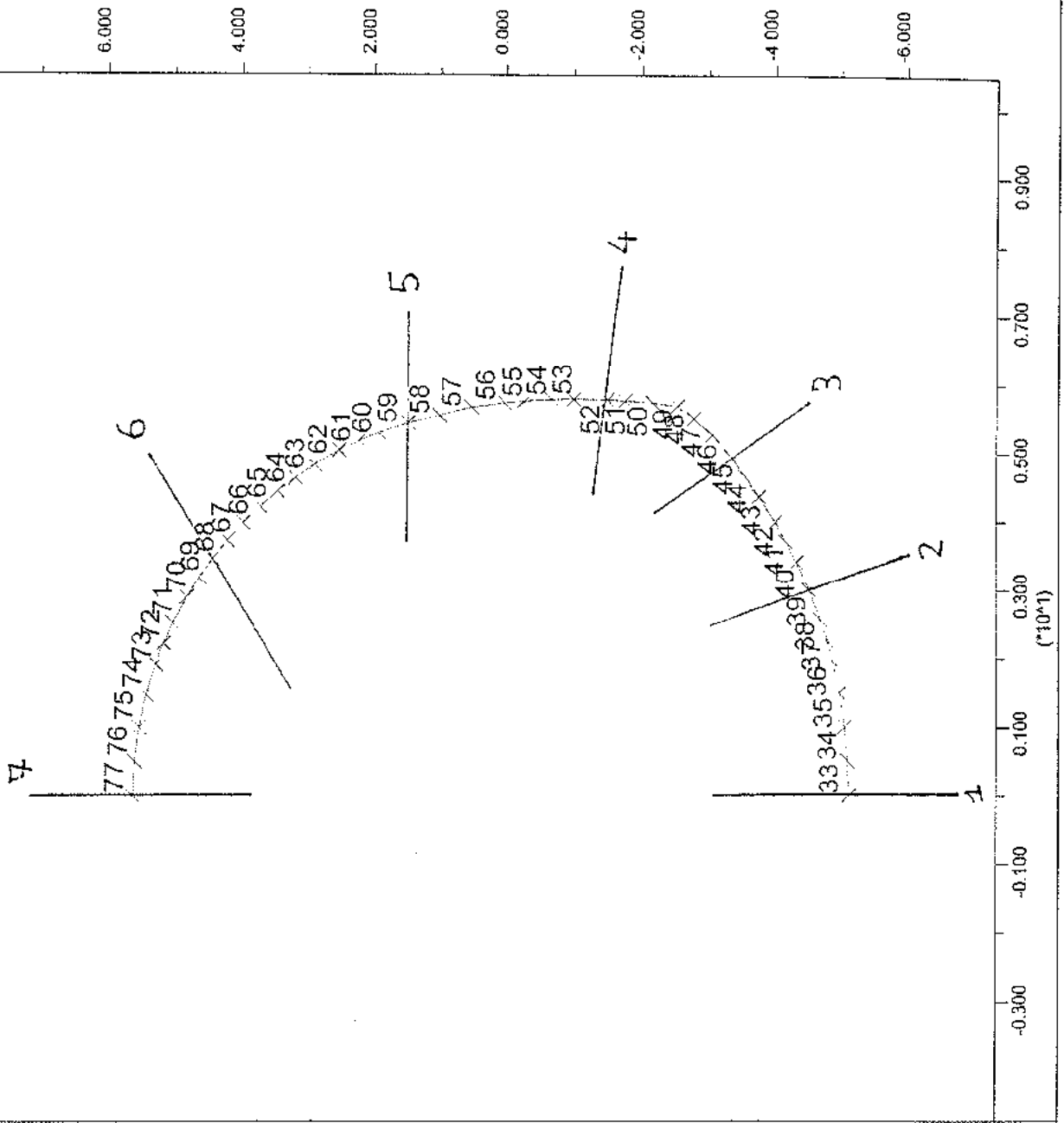
FLAC (Version 4.00)

LEGEND

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Beam Plot
Structural Element Numbers

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



Sezione tipo C4 - Ap gruppo 3
Verifica del rivestimento definitivo

TIME 7 - Getto Murette e A.R. non maturati

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σc (MPa)
CHIAVE A.R.	33	1.00	1319	124.7	0.09	2.1
SEZIONE INTERMEDIA A.R.	39	1.00	1335	66.6	0.05	1.7
ATTACCO A.R. - MURETTA	45	1.00	871	-104.0	-0.12	1.5

TIME 8 - Maturazione murette e A.R.

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σc (MPa)
CHIAVE A.R.	33	1.00	1533	140.2	0.09	2.4
SEZIONE INTERMEDIA A.R.	39	1.00	1554	87.6	0.06	2.1
ATTACCO A.R. - MURETTA	45	1.00	1042	-116.6	-0.11	1.7

TIME 9 - Getto calotta

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σc (MPa)
CHIAVE A.R.	33	1.00	3753	500.6	0.13	6.8
SEZIONE INTERMEDIA A.R.	39	1.00	3810	265.6	0.07	5.4
ATTACCO A.R. - MURETTA	45	1.00	2936	-462.3	-0.16	5.7
ATTACCO CAL. - MURETTA	52	0.90	1610	-200.2	-0.12	3.3
PIANO DEI CENTRI	58	0.90	1511	273.1	0.18	3.7
RENI	66	0.90	1445	-38.3	-0.03	1.9
CHIAVE CALOTTA	77	0.90	1452	-7.7	-0.01	1.7

TIME 10 - Decadimento ammasso e prinvestimento

Sezione	Elemento	Altezza (m)	N (kN/m)	M (kNm/m)	e (m)	σc (MPa)
CHIAVE A.R.	33	1.00	3981	545.0	0.14	7.3
SEZIONE INTERMEDIA A.R.	39	1.00	4099	263.8	0.06	5.7
ATTACCO A.R. - MURETTA	45	1.00	3334	-574.6	-0.17	6.8
ATTACCO CAL. - MURETTA	52	0.90	2211	-193.3	-0.09	3.9
PIANO DEI CENTRI	58	0.90	2299	506.9	0.22	6.7
RENI	68	0.90	2314	-103.8	-0.04	3.3
CHIAVE CALOTTA	77	0.90	2218	-35.6	-0.02	2.7

Sezione tipo C4 - Ap gruppo 3

Output Analisi alle Differenze Finite FLAC

TIME	Riduzione forze di scavo [%]	Spostamento y in chiave calotta [cm]	Spostamento x sul piano dei centri [cm]	Spostamento y in chiave A.R. [cm]	Tensioni pririv.		Tensioni Riv. Def.
					$\sigma_{SB,max}$ [MPa]	$\sigma_{s,max}$ [MPa]	
TIME 1 - Geostatico	0.0	Nodo i=1 j=68	Nodo i=12 j=57	Nodo i=1 j=47	-	-	-
TIME 2 - Creazione coronella terreno trattato	0.0	-	-	-	-	-	-
TIME 3 - Taratura e scavo	94.8	-23.1	23.4	28.1	-	-	-
TIME 4 - Posa centina e SB	95.4	-23.3	23.7	29.1	2.68	40.24	-
TIME 5 - Maturazione SB	95.9	-23.3	24.1	30.0	5.36	80.45	-
TIME 6 - Maturazione SB finale	96.2	-23.3	24.2	30.6	6.98	102.28	-
TIME 7 - Getto Murette e A.R. non maturati	97.4	-23.5	24.3	30.6	12.56	188.43	2.1
TIME 8 - Maturazione murette e A.R.	97.7	-23.5	24.4	30.6	13.42	201.29	2.4
TIME 9 - Getto calotta	100.0	-23.5	24.4	30.8	-	-	6.8
TIME 10 - Decadimento ammasso e pririvestimento	100.0	-23.5	24.4	30.8	-	-	7.3

Materiale	Tipo	Tensioni ammissibili [MPa]
Spritz-beton	fcm	23.00
Centina	Fe	210
Calcestruzzo	Rck	7.50

Tensioni positive nel cls : compressione
 Spostamenti x positivi verso destra, spostamenti y positivi verso l'alto

JOB TITLE : Cunicolo Castagnola (Ap gruppo 3) - SEZ. TIPO C4

(*10^2)

FLAC (Version 4.00)

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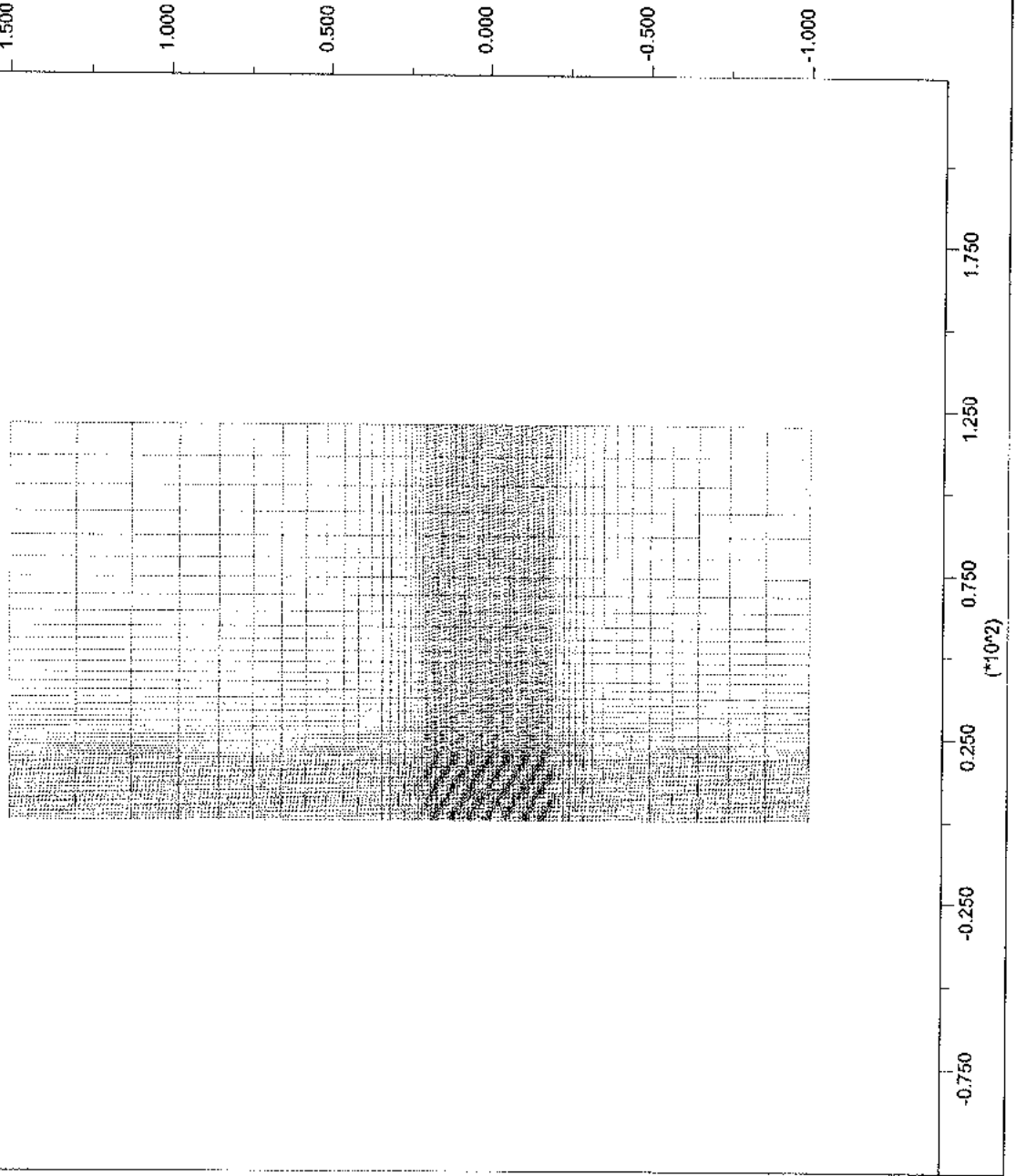
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step 9664

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-1.417E+02 <y< 1.917E+02

MESH DI CALCOLO



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JOB TITLE : Cunicolo Castagnola (Ap gruppo 3) - SEZ. TIPO C4

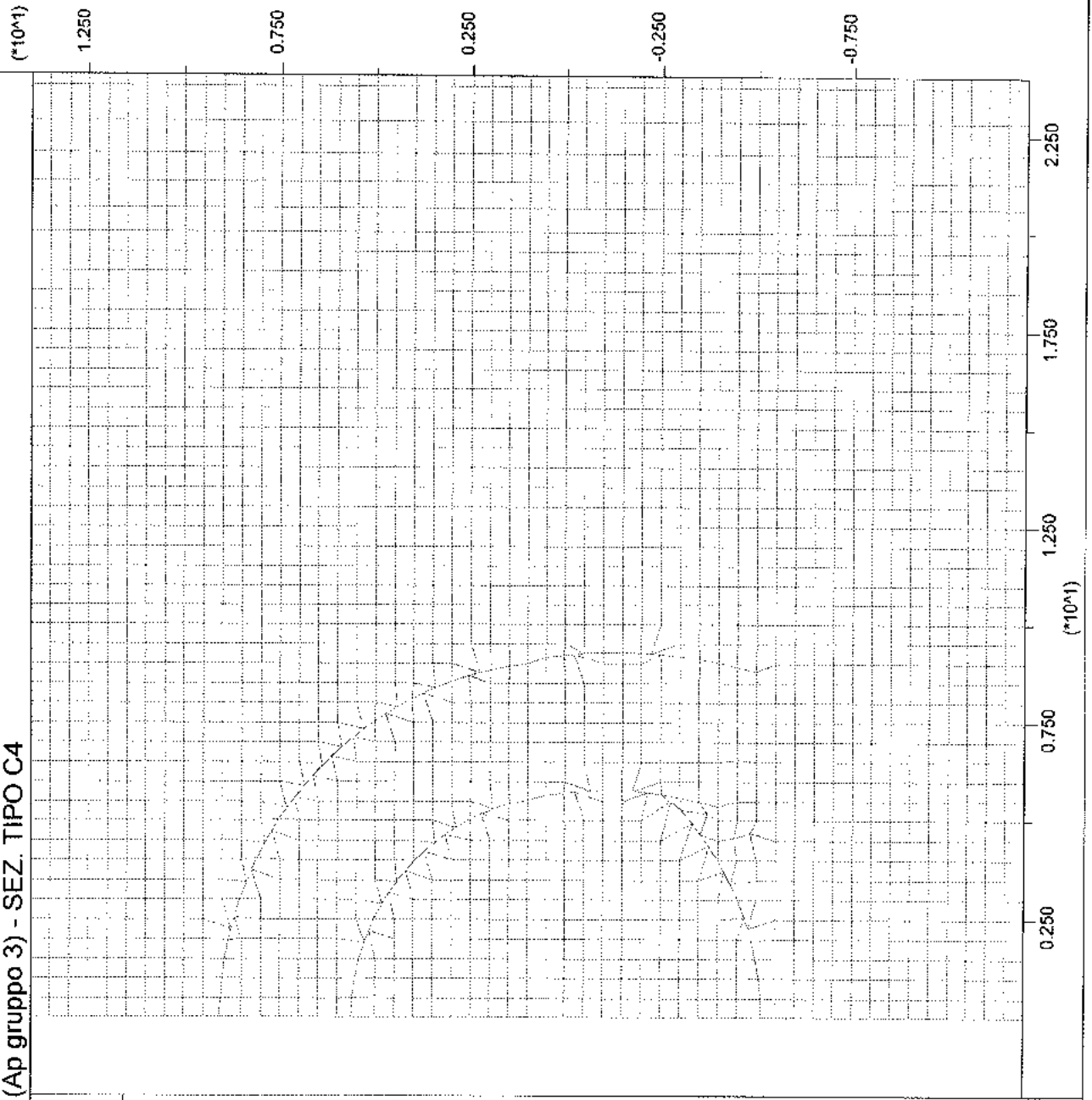
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LEGEND

16-Feb-04 11:11
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MESH DI CALCOLO

0 5E 0



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 1"

FLAC (Version 4.00)

LEGEND

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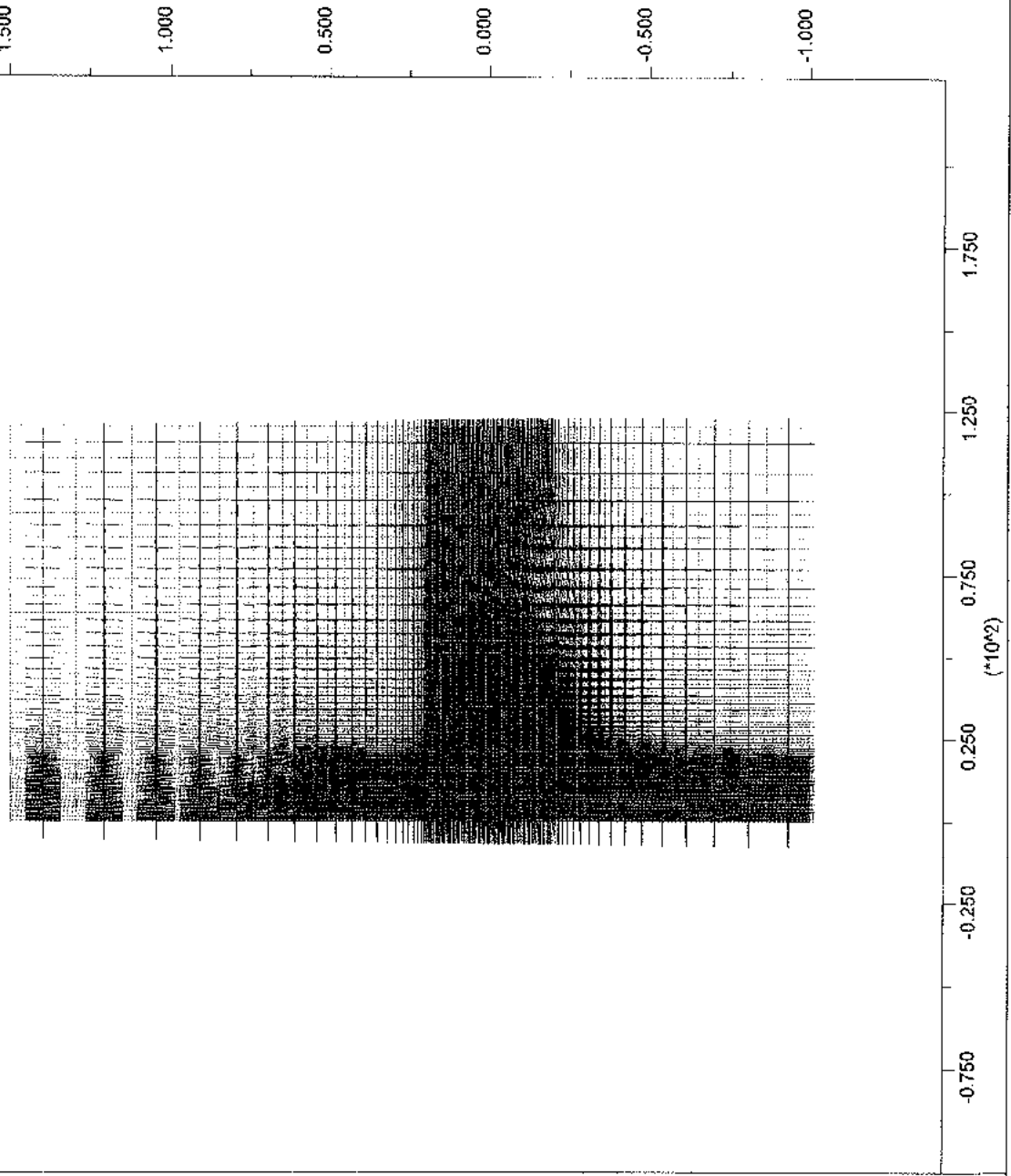
Principal stresses

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Min. Value = -1.853E+07

0 1E 8

Tensioni principali : Pa

0 1E 2



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 1"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:11

step 9664

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-1.200E+01 <y< 1.400E+01

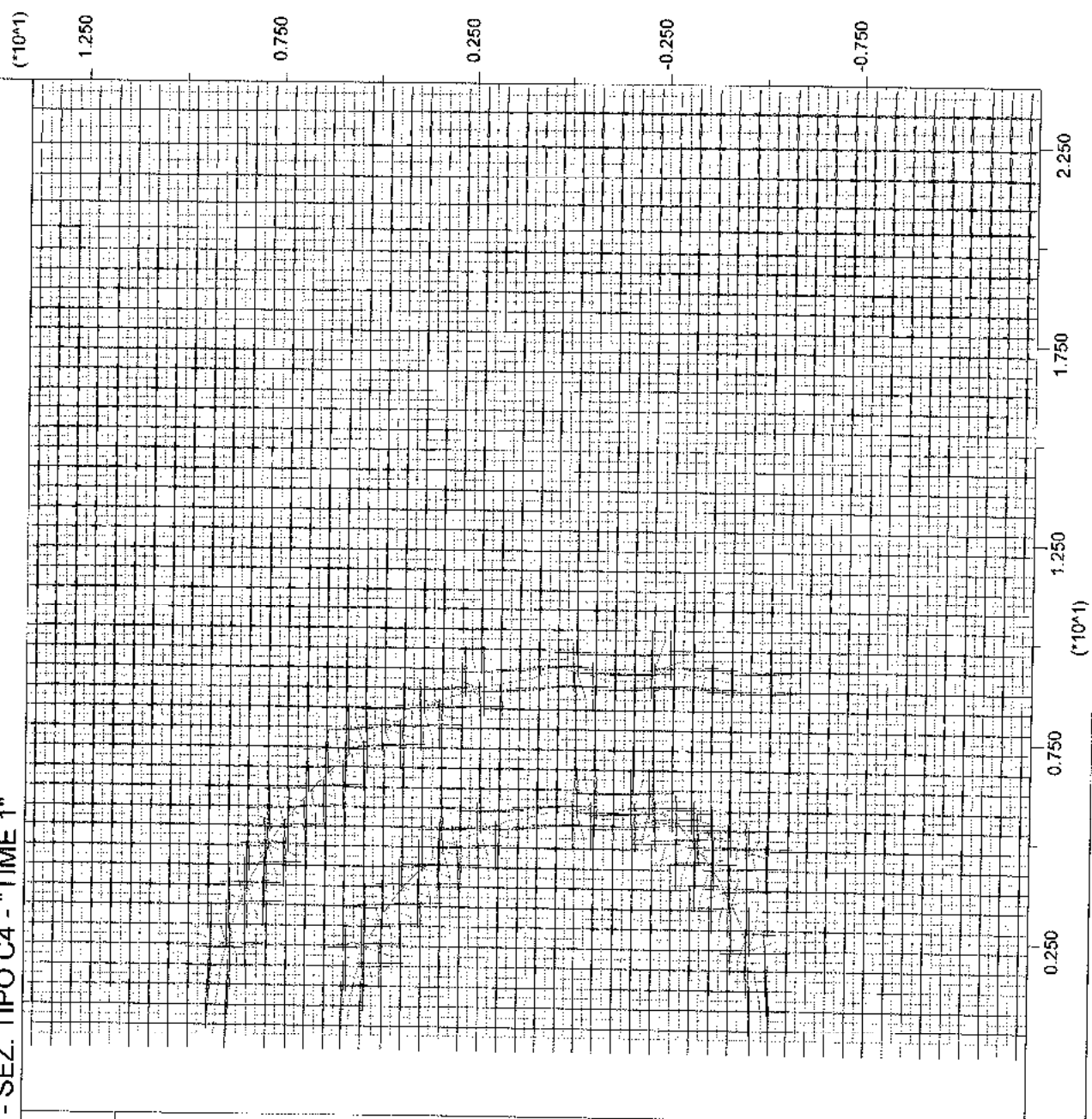
Principal stresses

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Tensioni principali : Pa



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 2"

FLAC (Version 4.00)

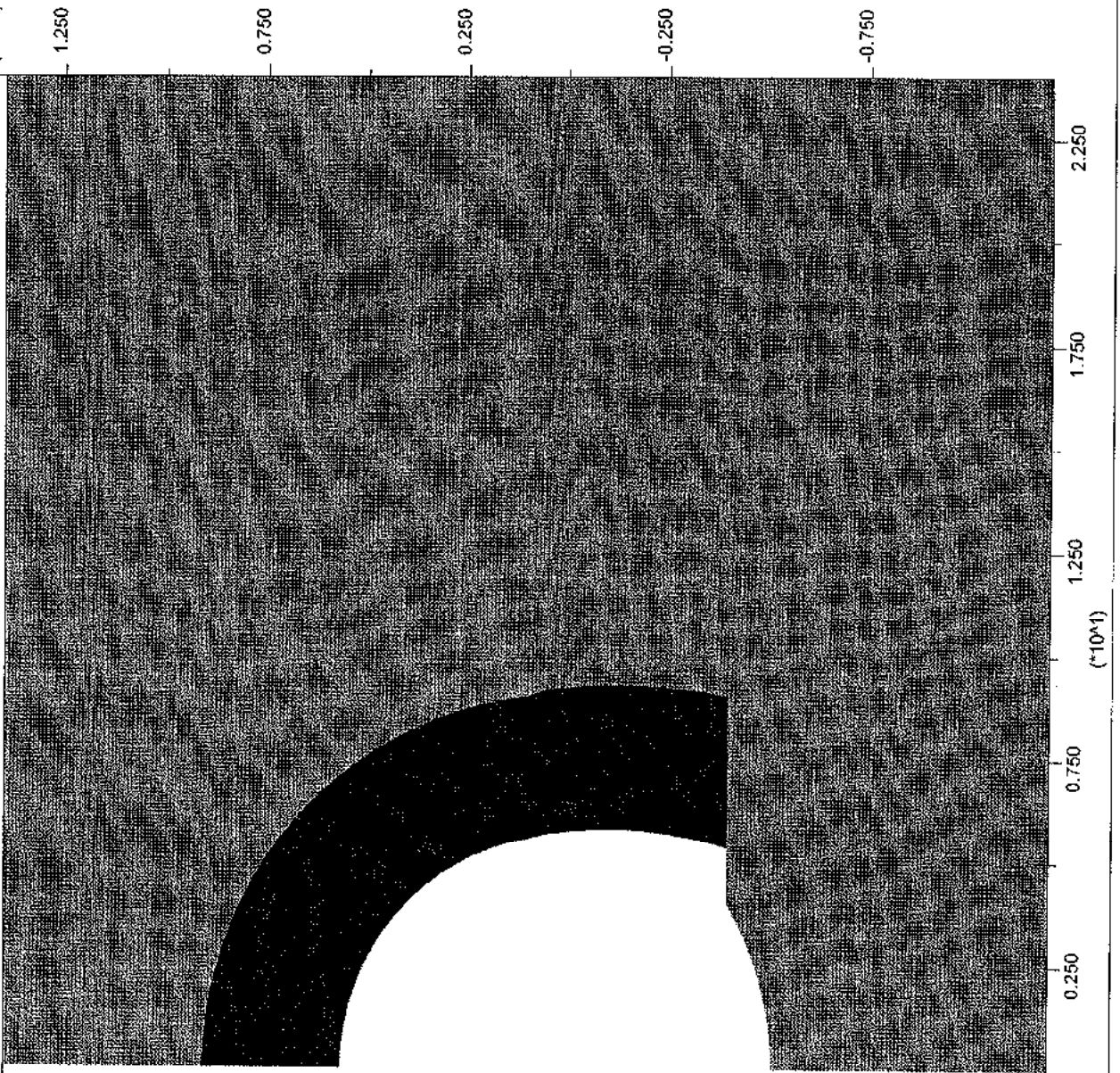
LEGEND

16-Feb-04 11:19
step 13113
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-1.200E+01 <y< 1.400E+01

Coronella di terreno consolidato

■ 'Ap gruppo 3'

■ 'Terreno trattato'



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 3"

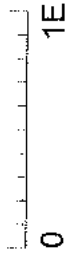
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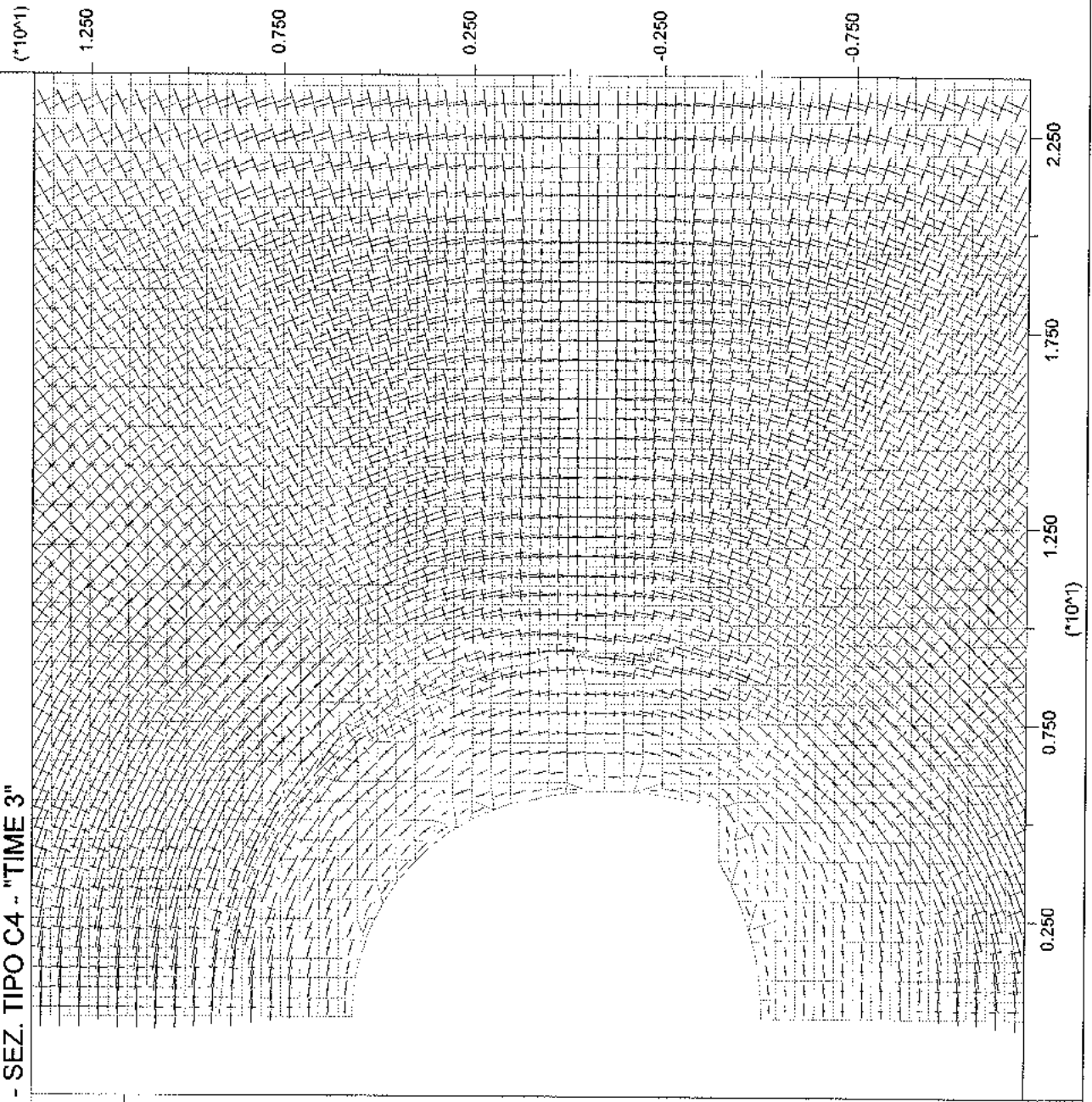
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Principal stresses

Max. Value = -3.767E+05
Min. Value = -2.538E+07



Tensioni principali : Pa



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 3"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21

step 21576

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-2.25E-01

-2.00E-01

-1.75E-01

-1.50E-01

-1.25E-01

-1.00E-01

-7.50E-02

-5.00E-02

-2.50E-02

0.00E+00

Contour interval= 2.50E-02

Spostamenti orizzontali

0 5E 0

(*10^1)

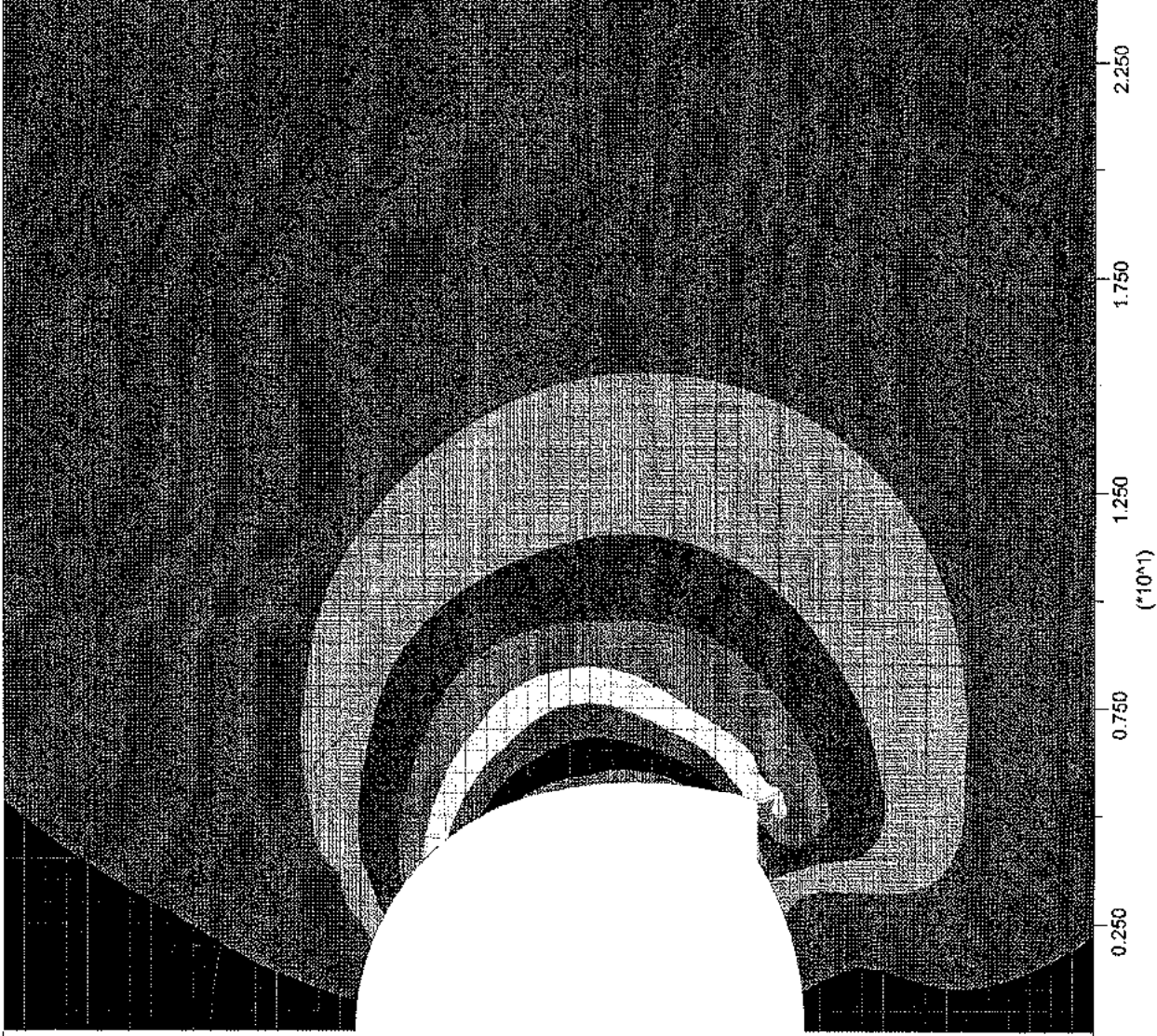
1.250

0.750

0.250

-0.250

-0.750



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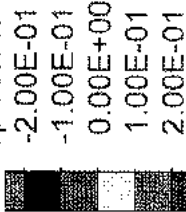
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 3"

FLAC (Version 4.00)

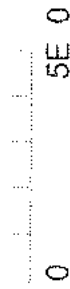
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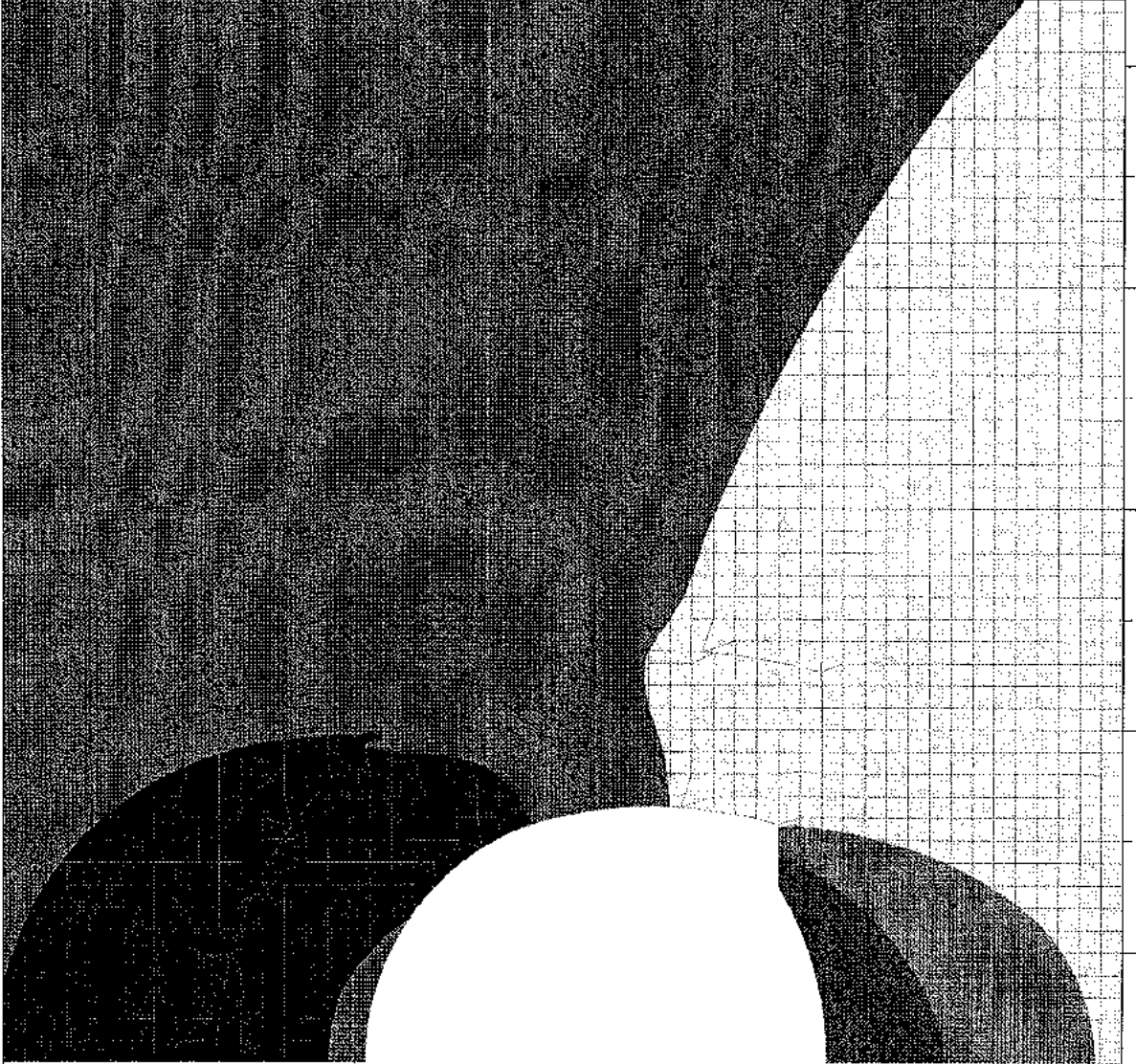
Y-displacement contours



Contour interval= 1.00E-01
Spostamenti verticali



(*10^1)



2.250

1.750

1.250

0.750

0.250

(*10^1)

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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 3"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21

step 21576

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

1.00E-02

2.00E-02

3.00E-02

4.00E-02

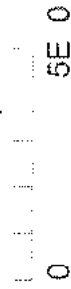
5.00E-02

6.00E-02

7.00E-02

Contour interval= 1.00E-02

Deformazioni plastiche per taglio



(*10^1)

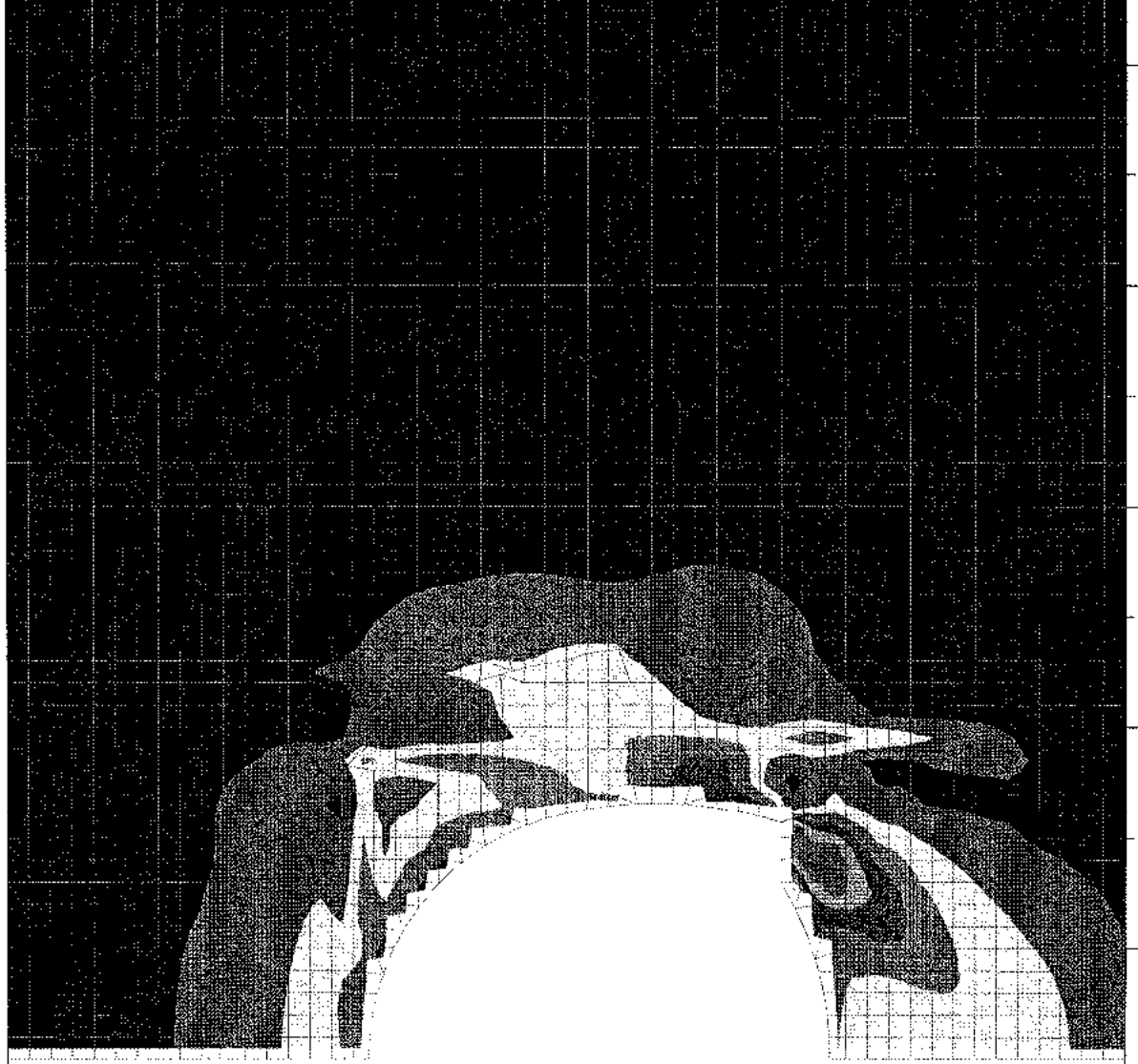
1.250

0.750

0.250

-0.250

-0.750



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 4"

FLAC (Version 4.00)

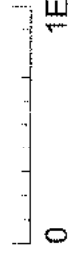
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Principal stresses

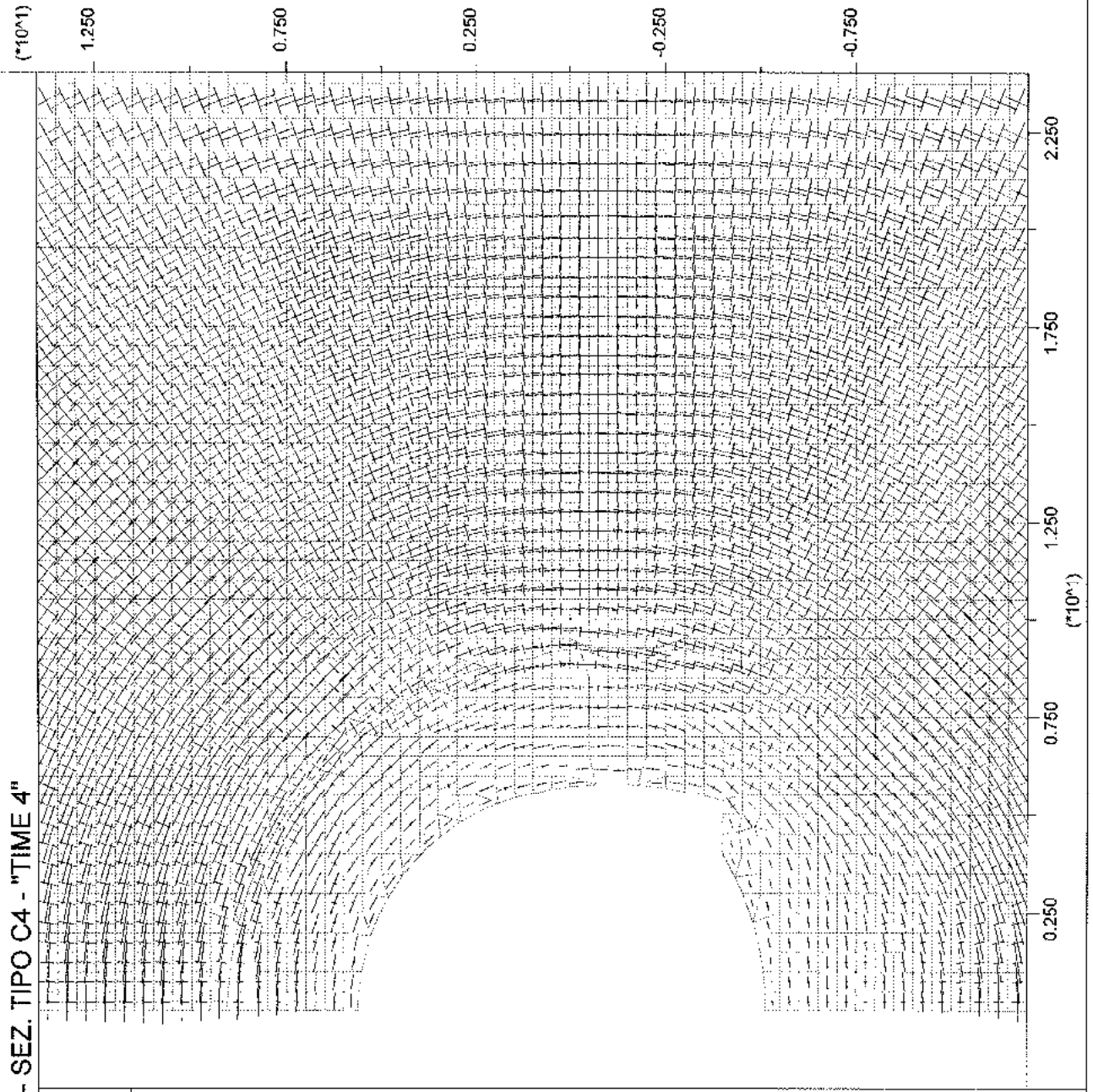
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Tensioni principali : Pa

0 5E 0



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

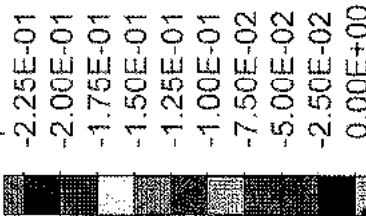
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 4"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21
step 22596
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02

Spostamenti orizzontali



(*10^1)

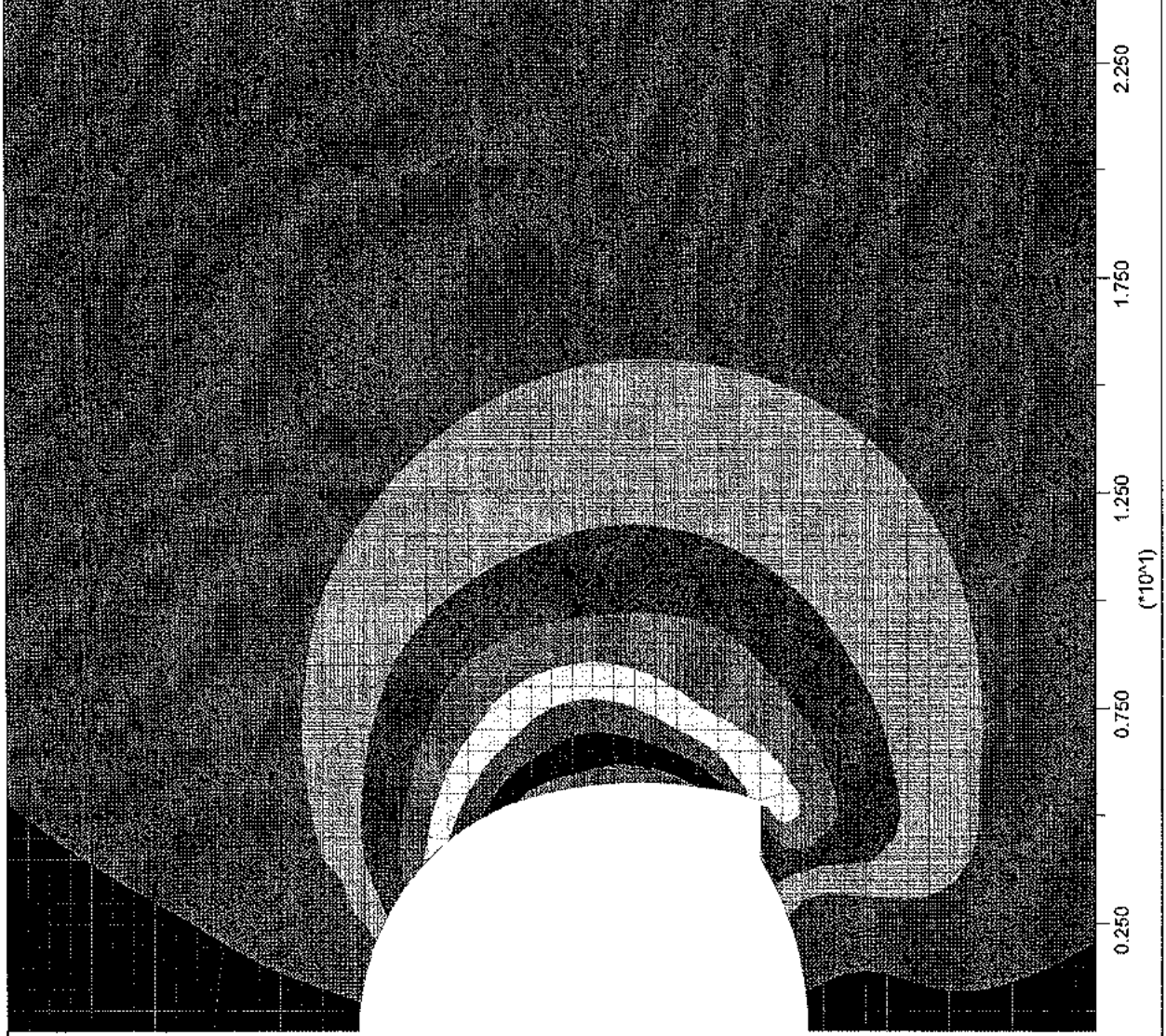
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

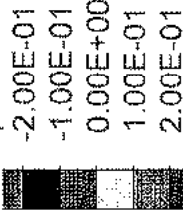
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 4"

FLAC (Version 4.00)

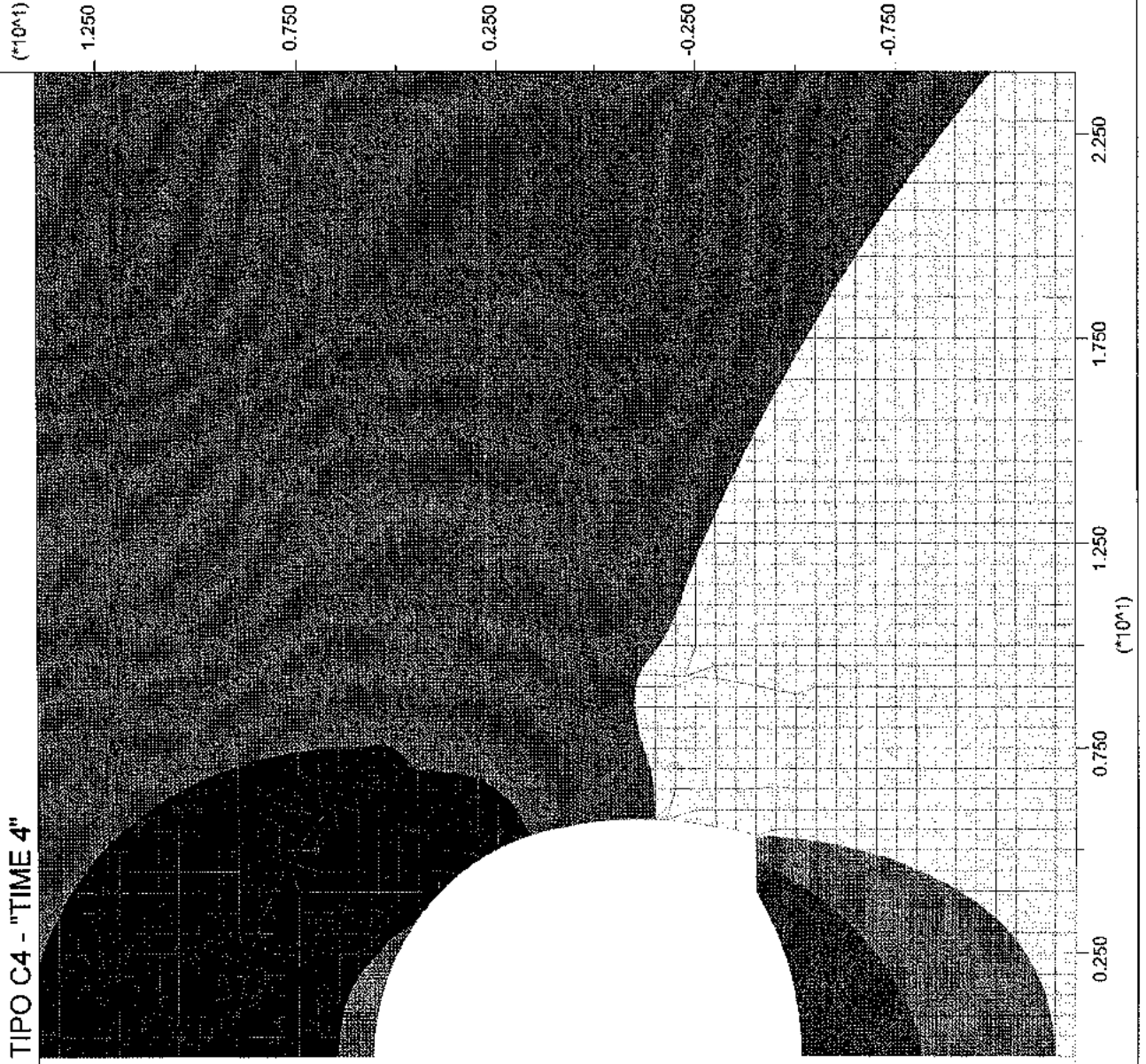
LEGEND

16-Feb-04 11:21
step 22596
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01
Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 4"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21

step 22596

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

Max. shear strain increment

0.00E+00

1.00E-02

2.00E-02

3.00E-02

4.00E-02

5.00E-02

6.00E-02

7.00E-02

Contour interval= 1.00E-02

Deformazioni plastiche per taglio



(*10^1)

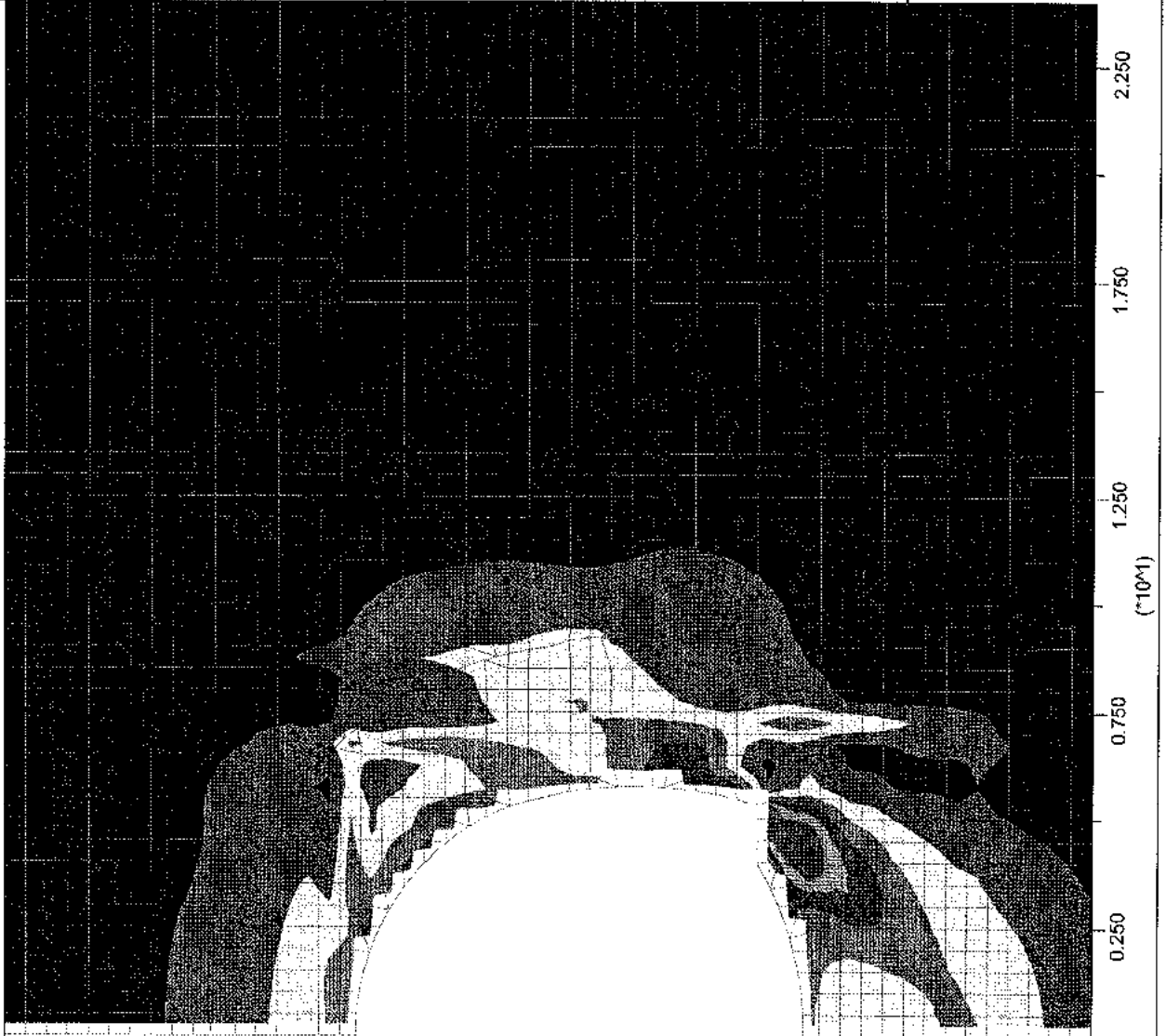
1.250

0.750

0.250

-0.250

-0.750



Itasca Consulting Group, Inc.
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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 4"

FLAC (Version 4.00)

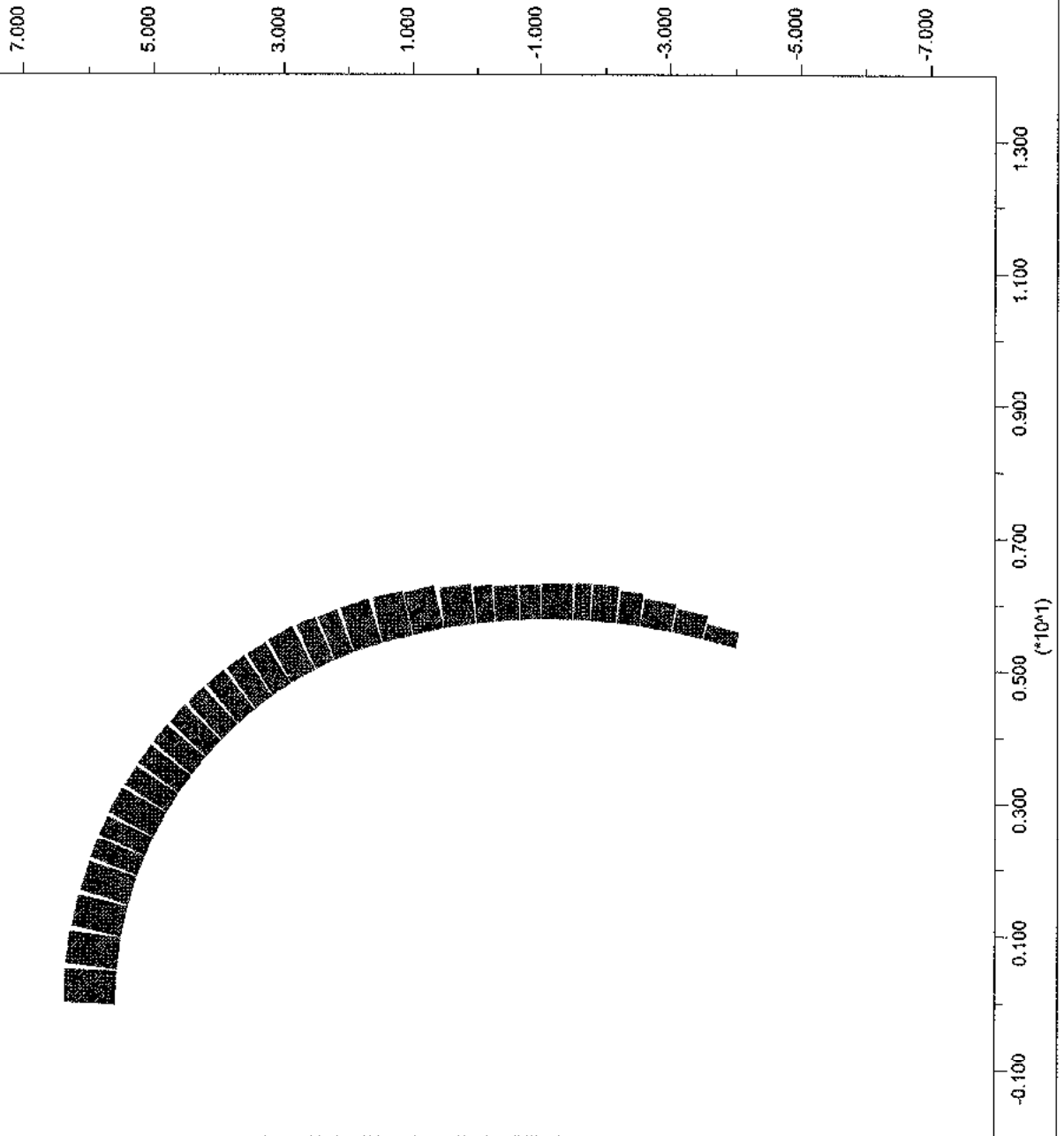
LEGEND

16-Feb-04 11:21
step 22596
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
1 (Beam) 9.714E+05



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
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 4"

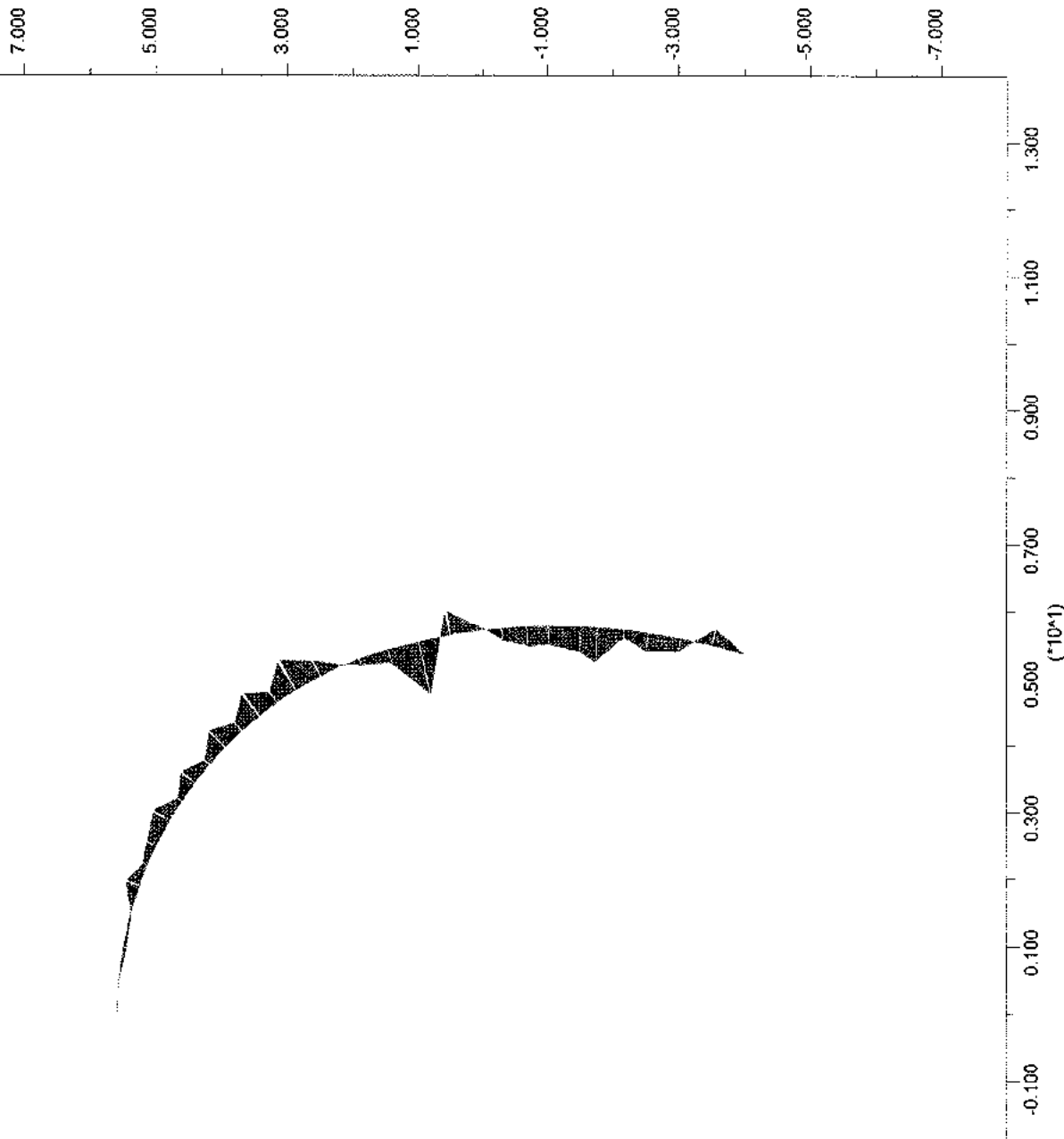
FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21
step 22596
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

 **Moment** on
Structure Max. Value
1 (Beam) -1.038E+04



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 5"

FLAC (Version 4.00)

LEGEND

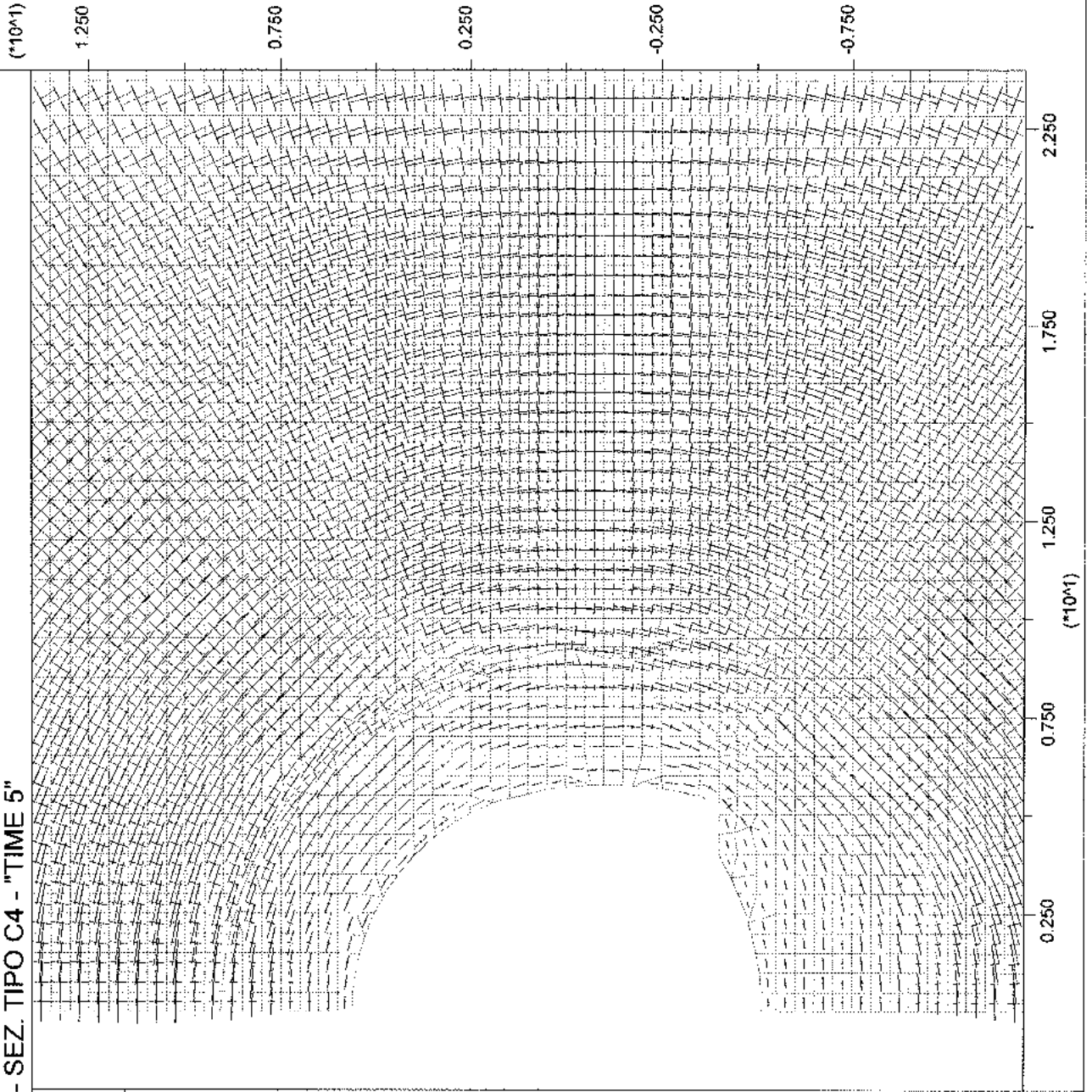
16-Feb-04 11:21
step 23453
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = -2.199E+05
Min. Value = -2.529E+07



Tensioni principali : Pa



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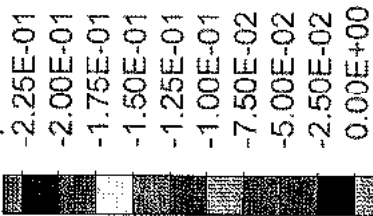
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 5"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21
step 23453
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02

Spostamenti orizzontali



(*10^1)

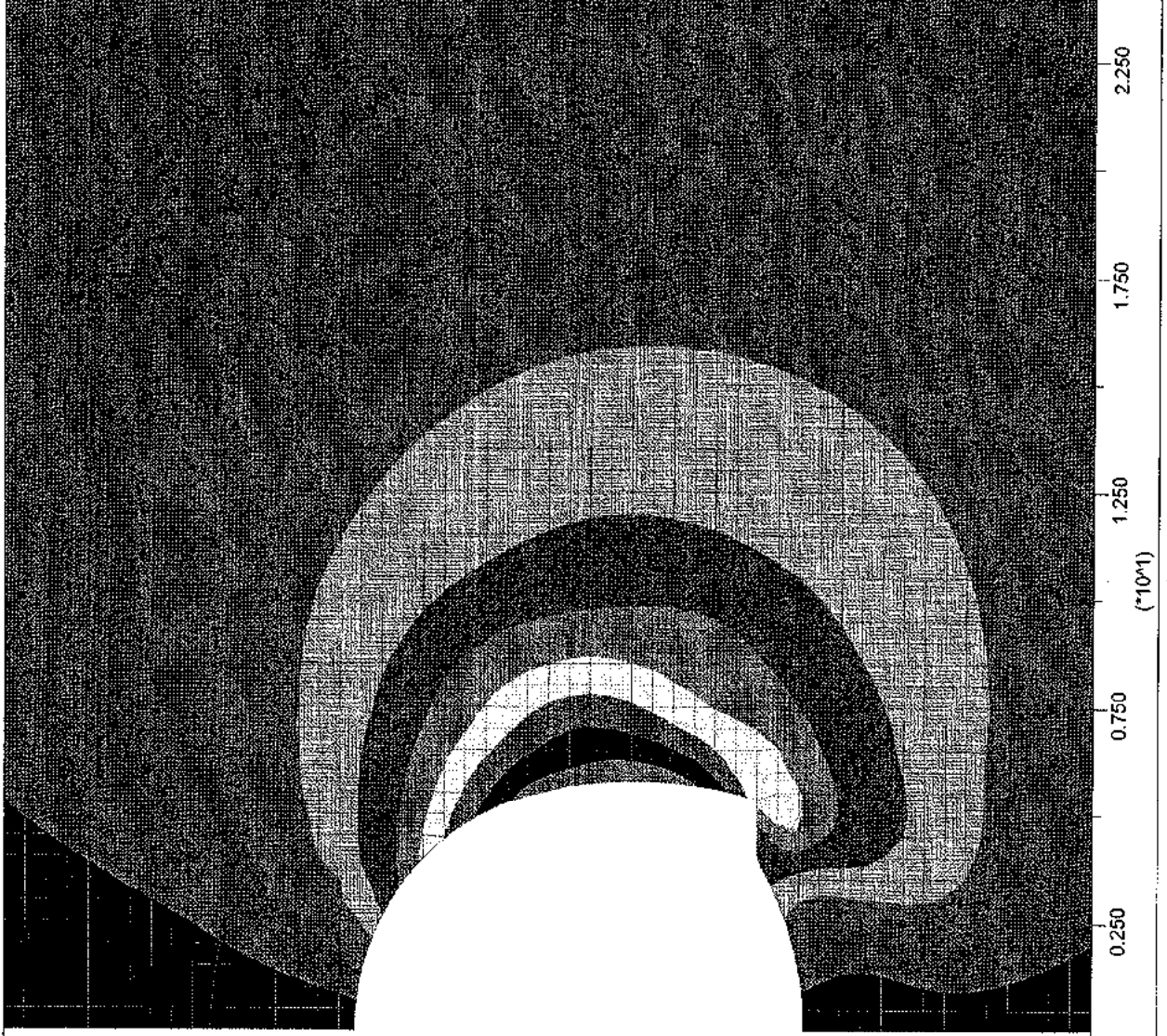
1.250

0.750

0.250

-0.250

-0.750



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

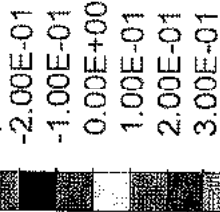
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 5"

FLAC (Version 4.00)

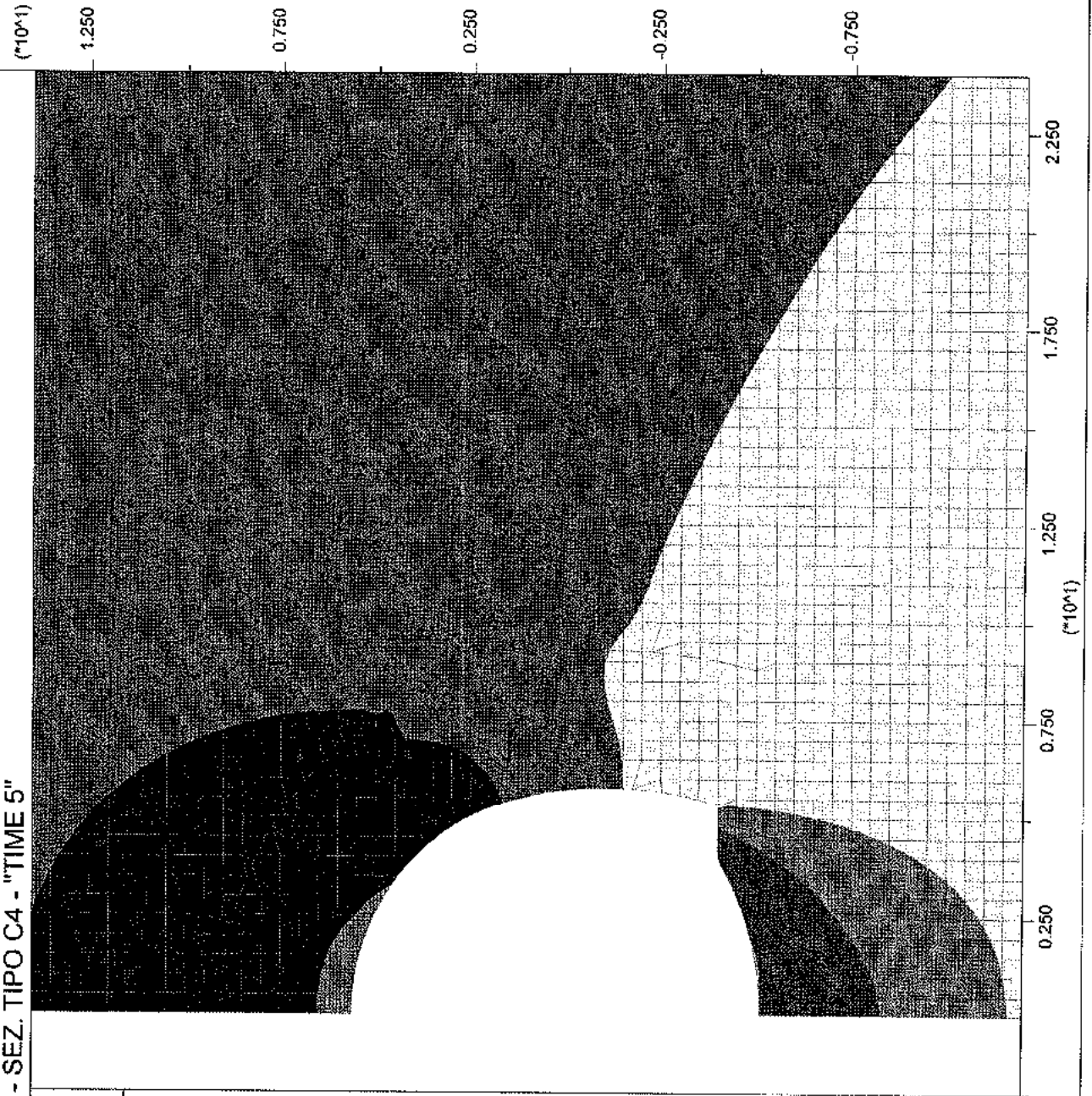
LEGEND

16-Feb-04 11:21
step 23453
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01
Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 5"

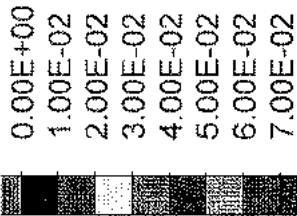
FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21
step 23453

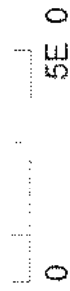
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02

Deformazioni plastiche per taglio



(*10⁴)

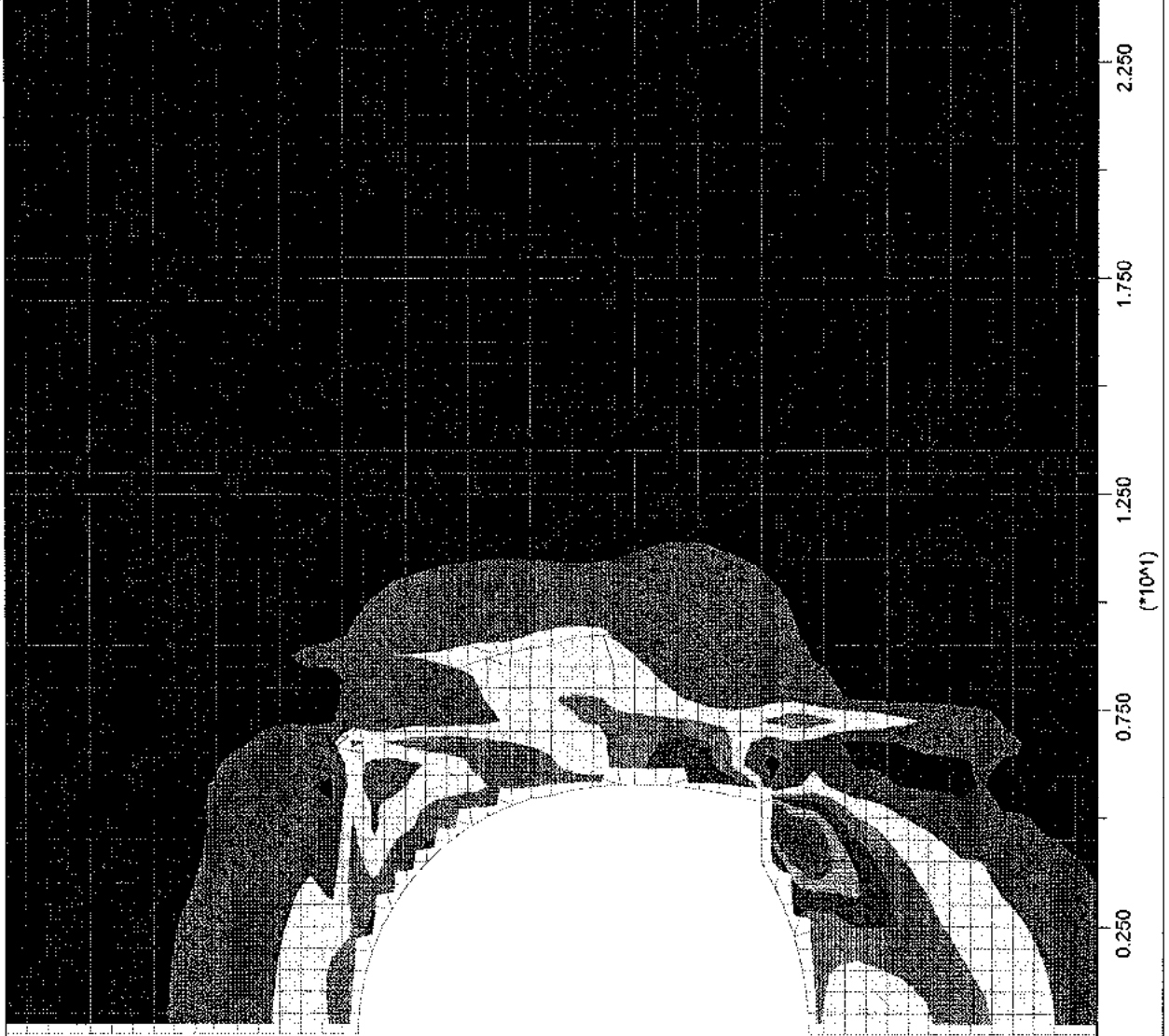
1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10⁴)

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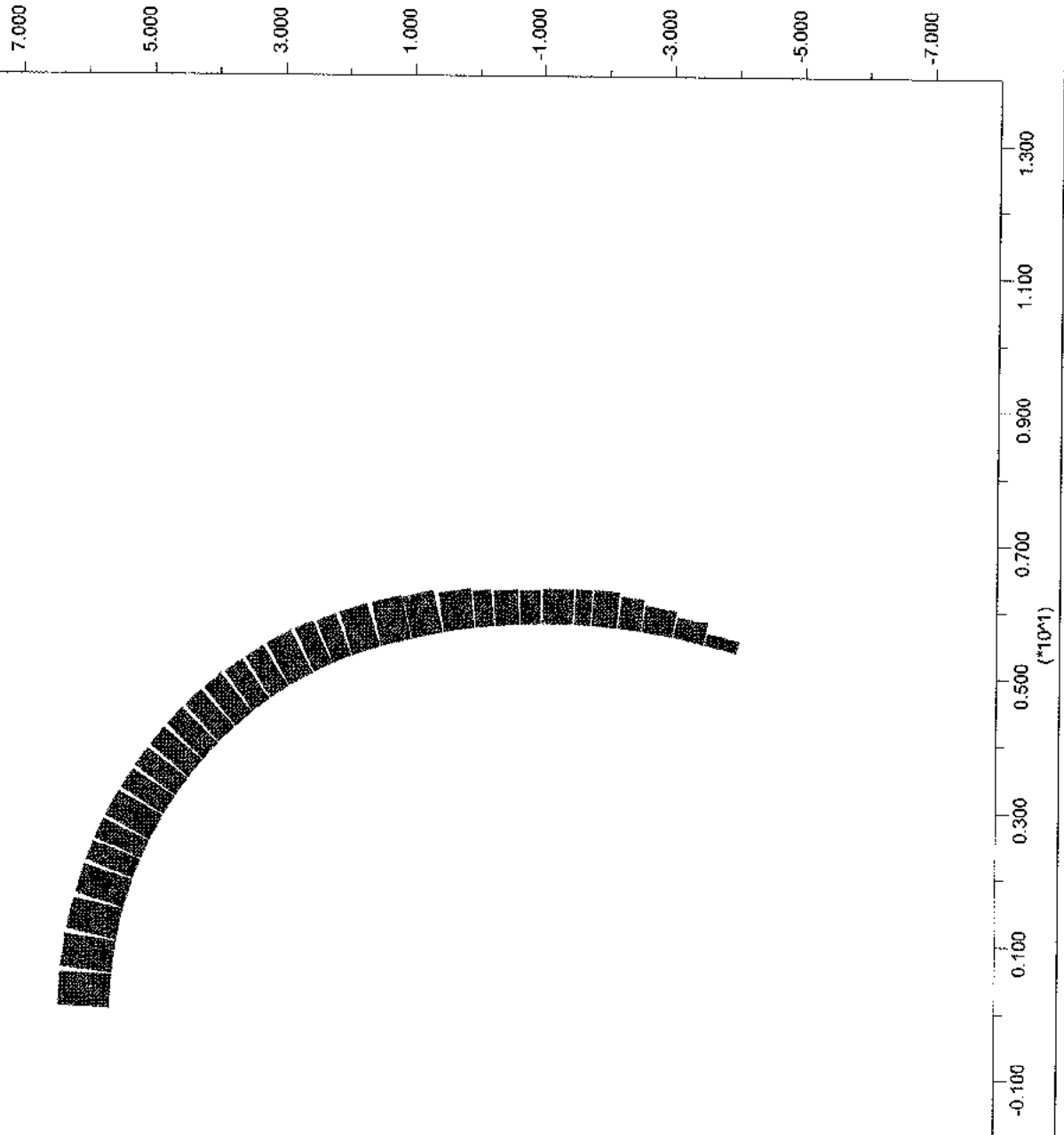
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 5"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21
step 23453
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preiv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 1.942E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 5"

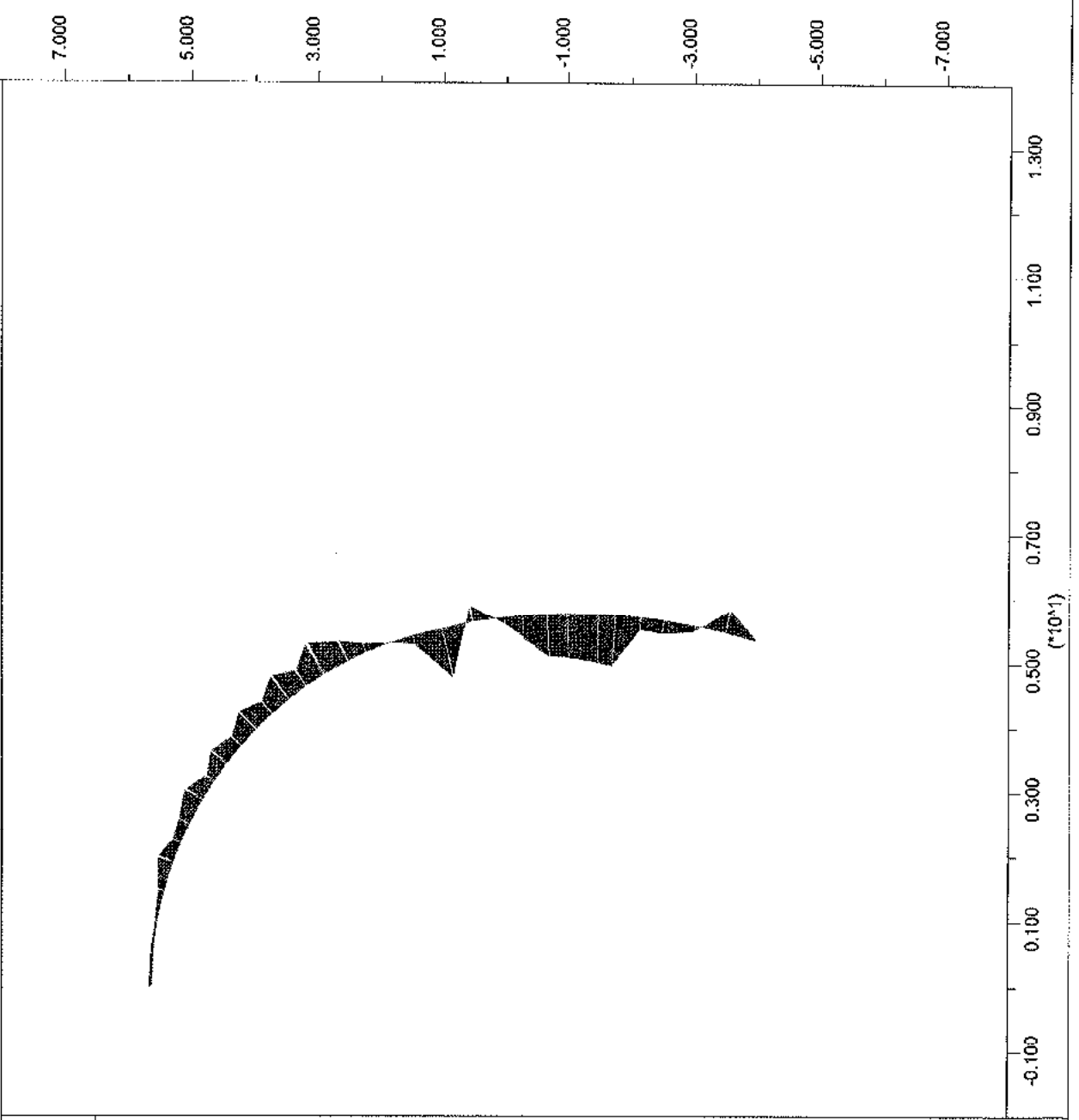
FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21
step 23453
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -2.209E+04



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 6"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21
step 24307
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

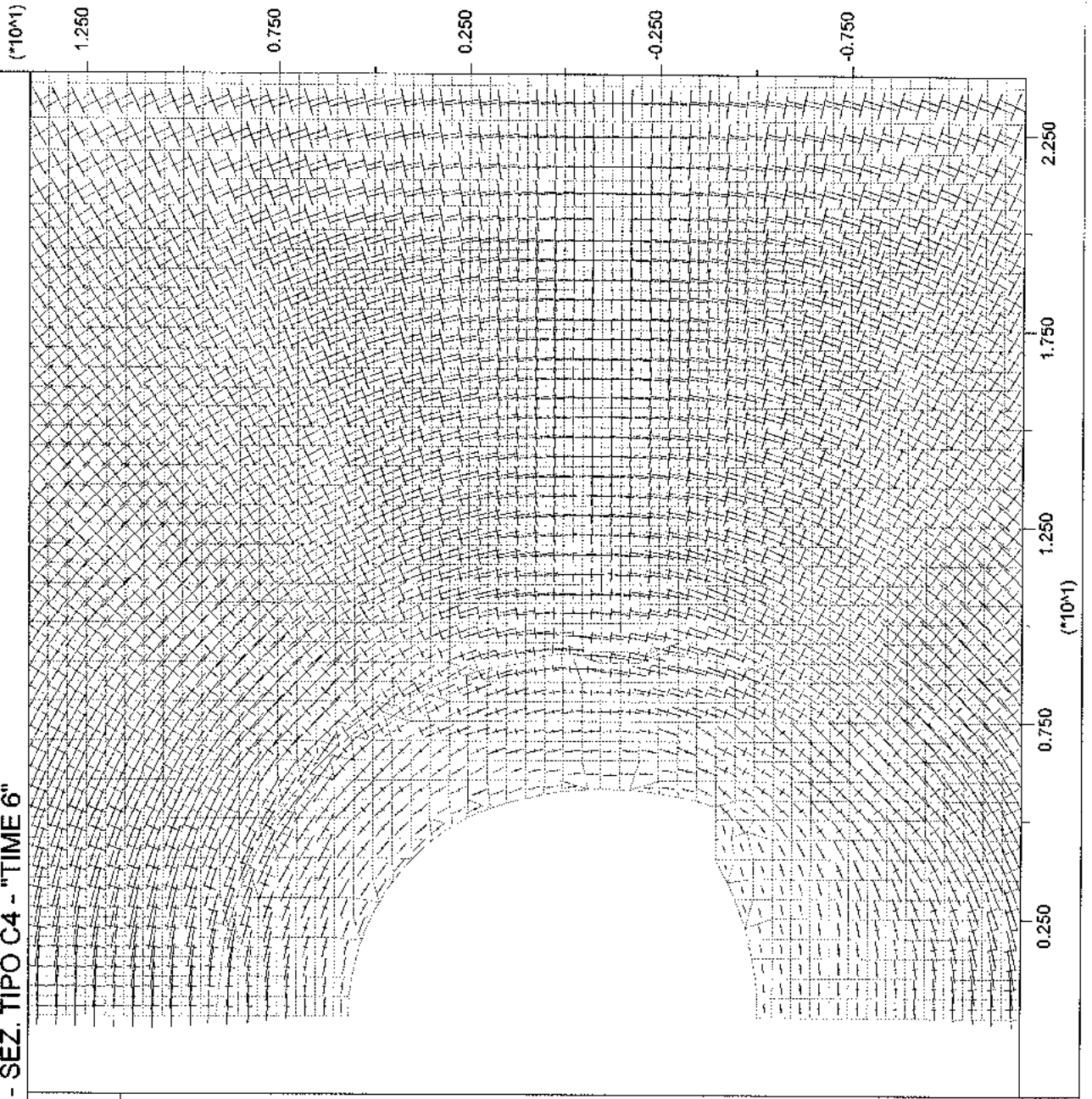
Principal stresses

Max. Value = -1.776E+05
Min. Value = -2.532E+07

0 1E 8

Tensioni principali : Pa

0 5E 0



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Minneapolis, Minnesota USA

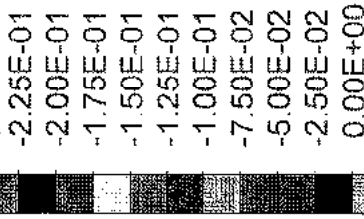
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 6"

FLAC (Version 4.00)

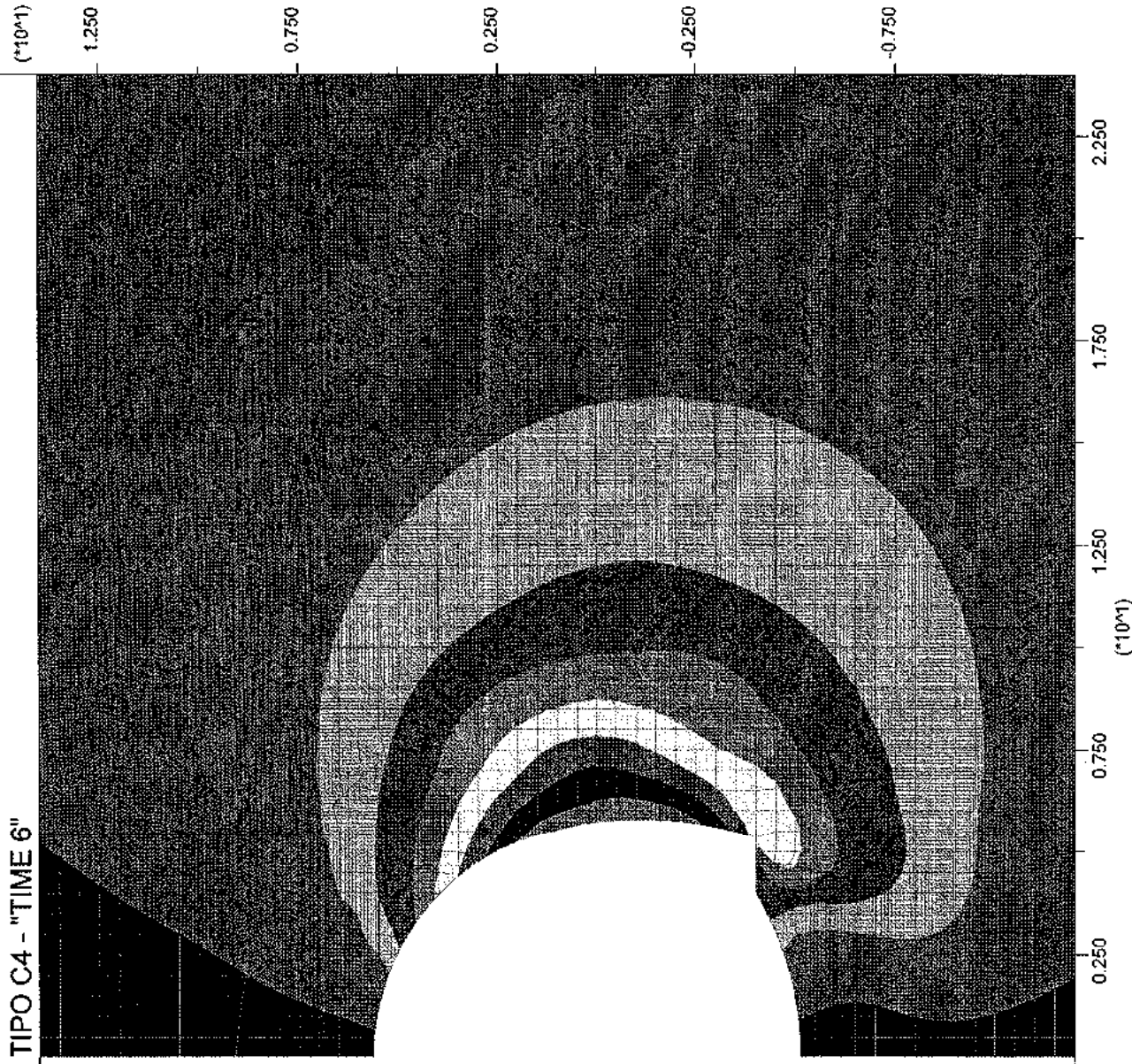
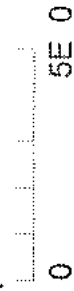
LEGEND

16-Feb-04 11:21
step 24307
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02
Spostamenti orizzontali



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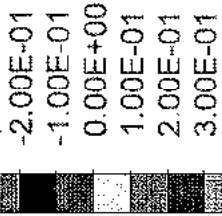
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 6"

FLAC (Version 4.00)

LEGEND

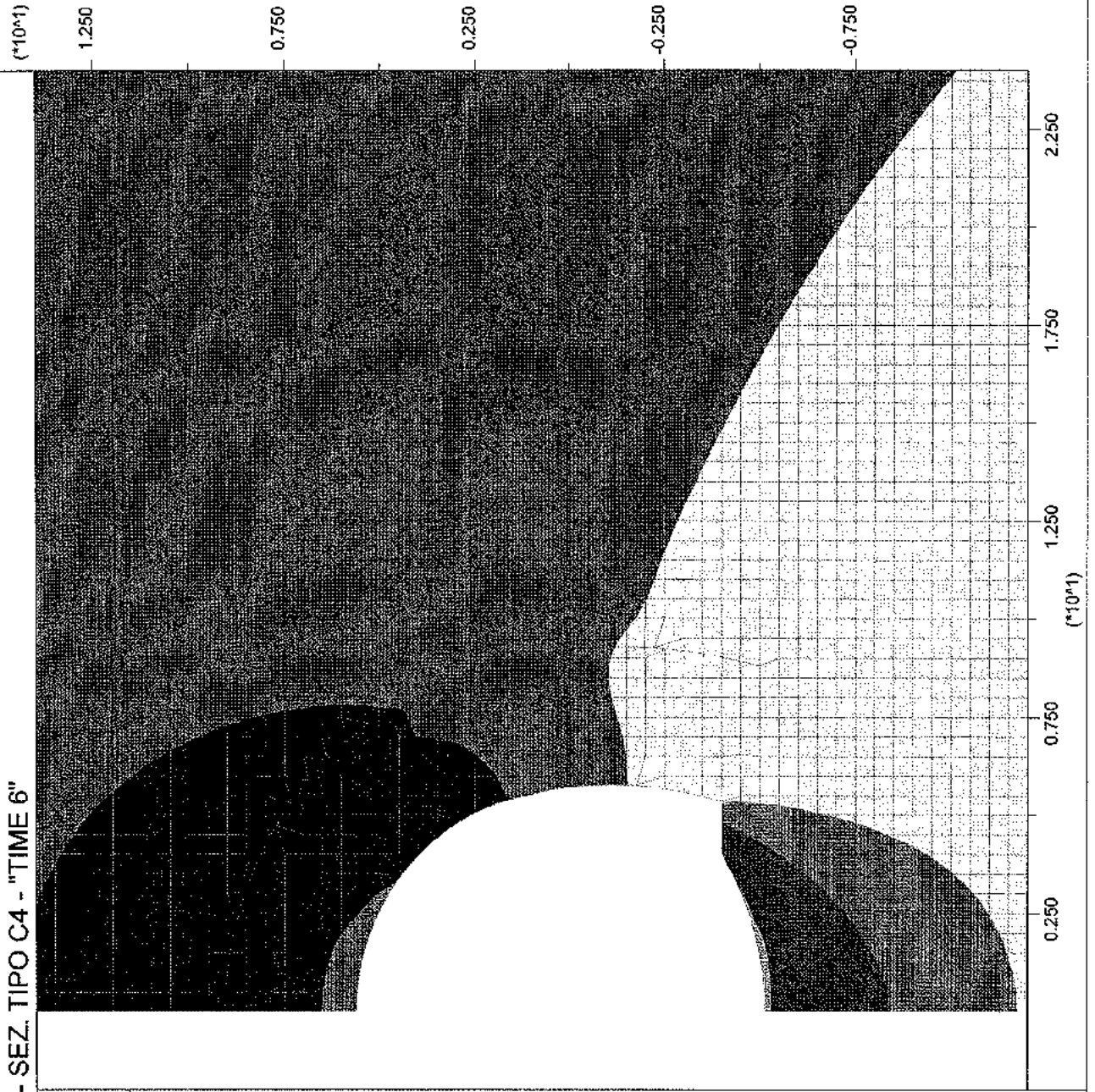
16-Feb-04 11:21
step 24307
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



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Minneapolis, Minnesota USA

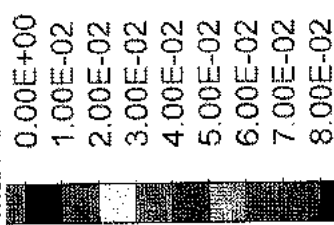
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 6"

FLAC (Version 4.00)

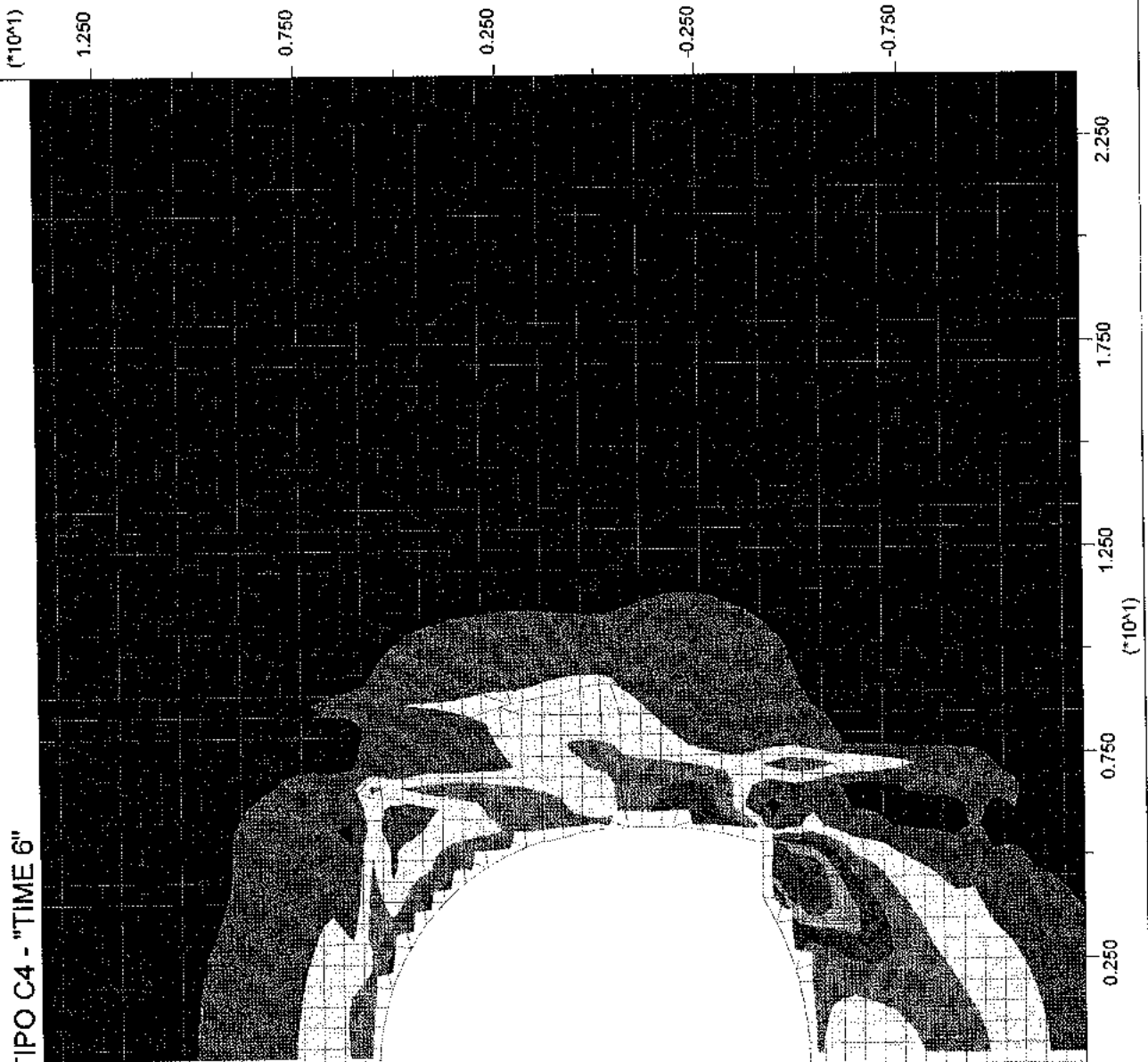
LEGEND

16-Feb-04 11:21
step 24307
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 6"

FLAC (Version 4.00)

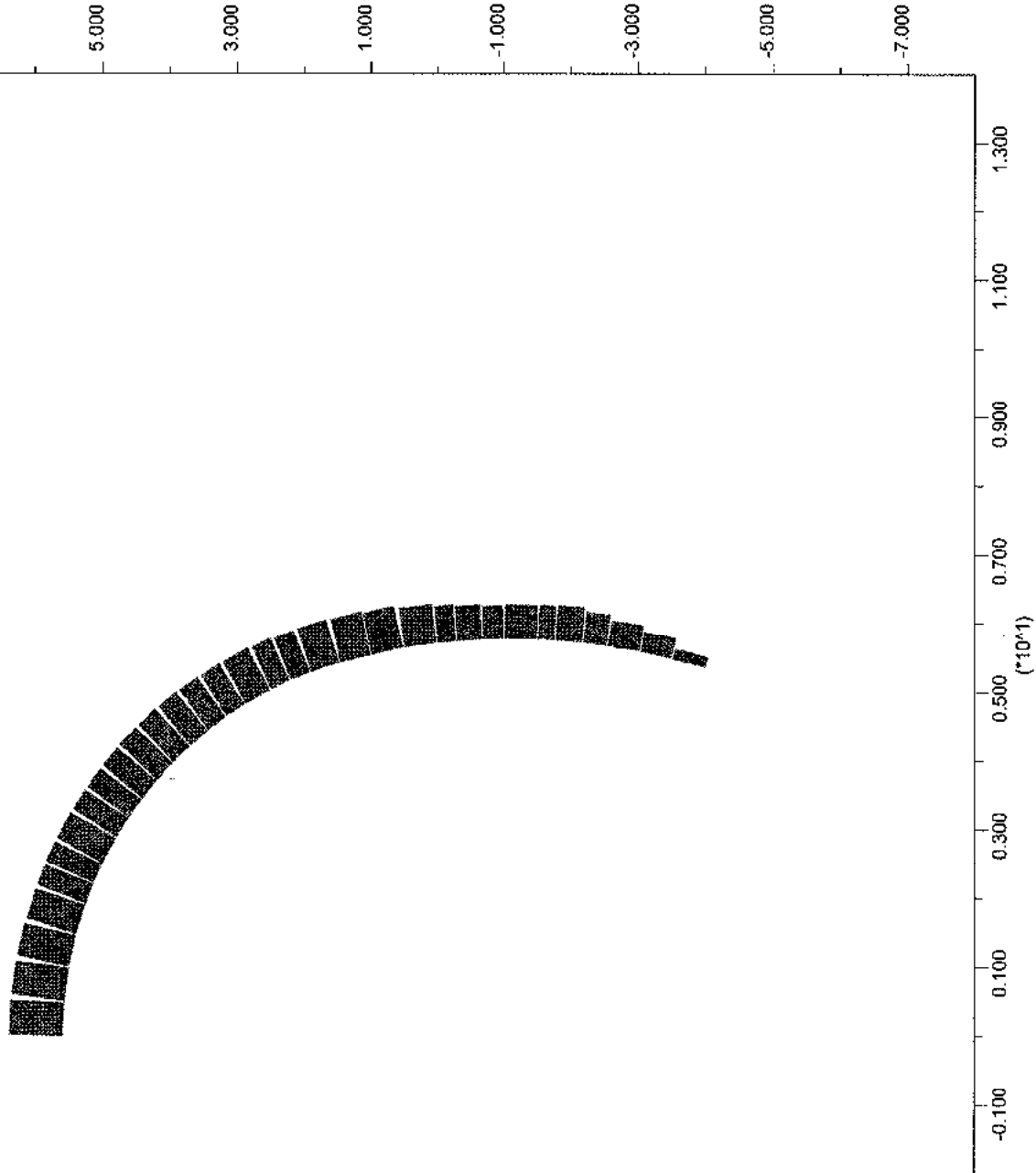
LEGEND

16-Feb-04 11:21
step 24307
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
1 (Beam) 2.616E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 6"

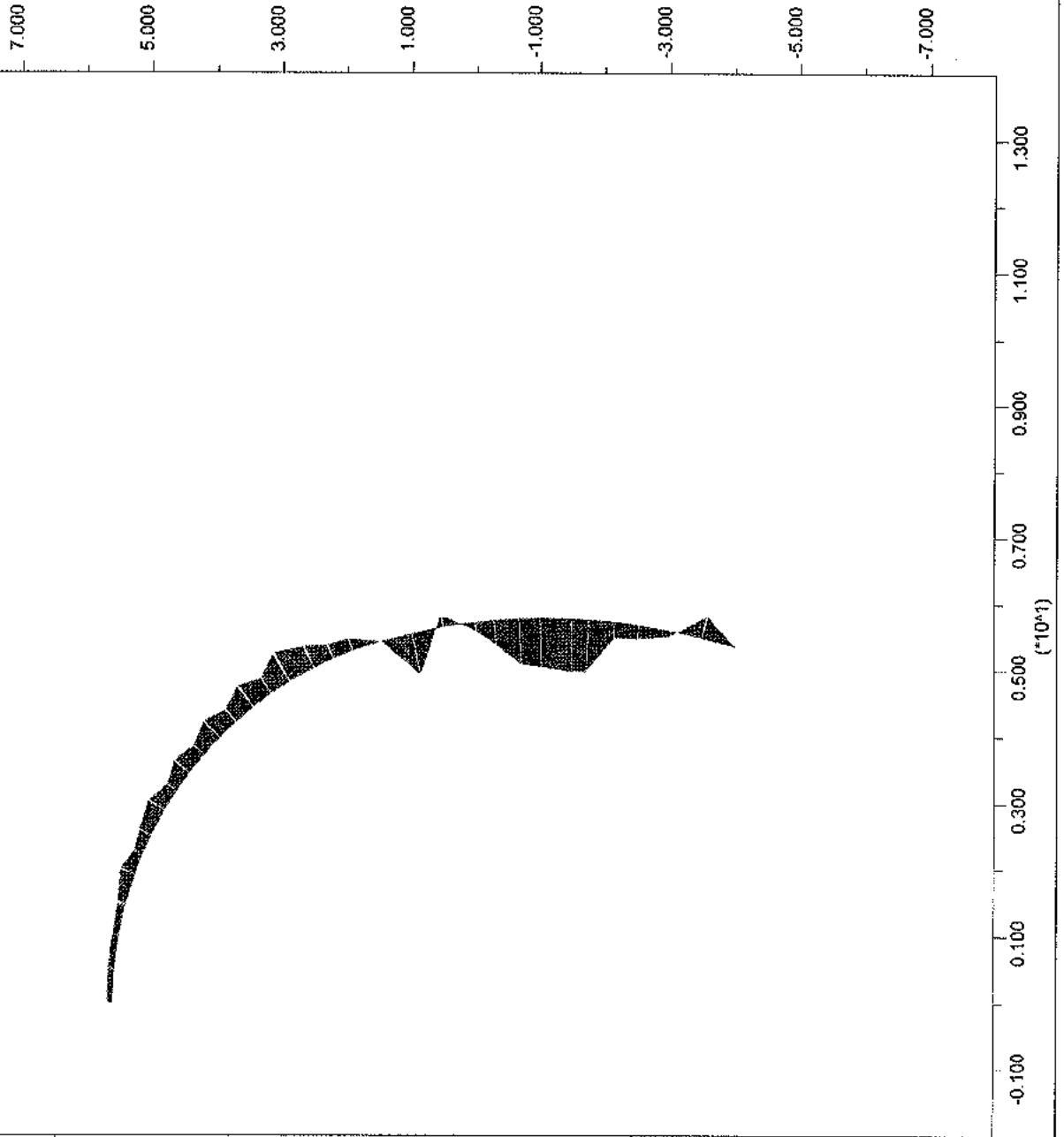
FLAC (Version 4.00)

LEGEND

16-Feb-04 11:21
step 24307
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Preriv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) -3.399E+04



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 7"

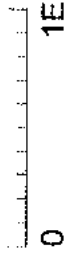
FLAC (Version 4.00)

LEGEND

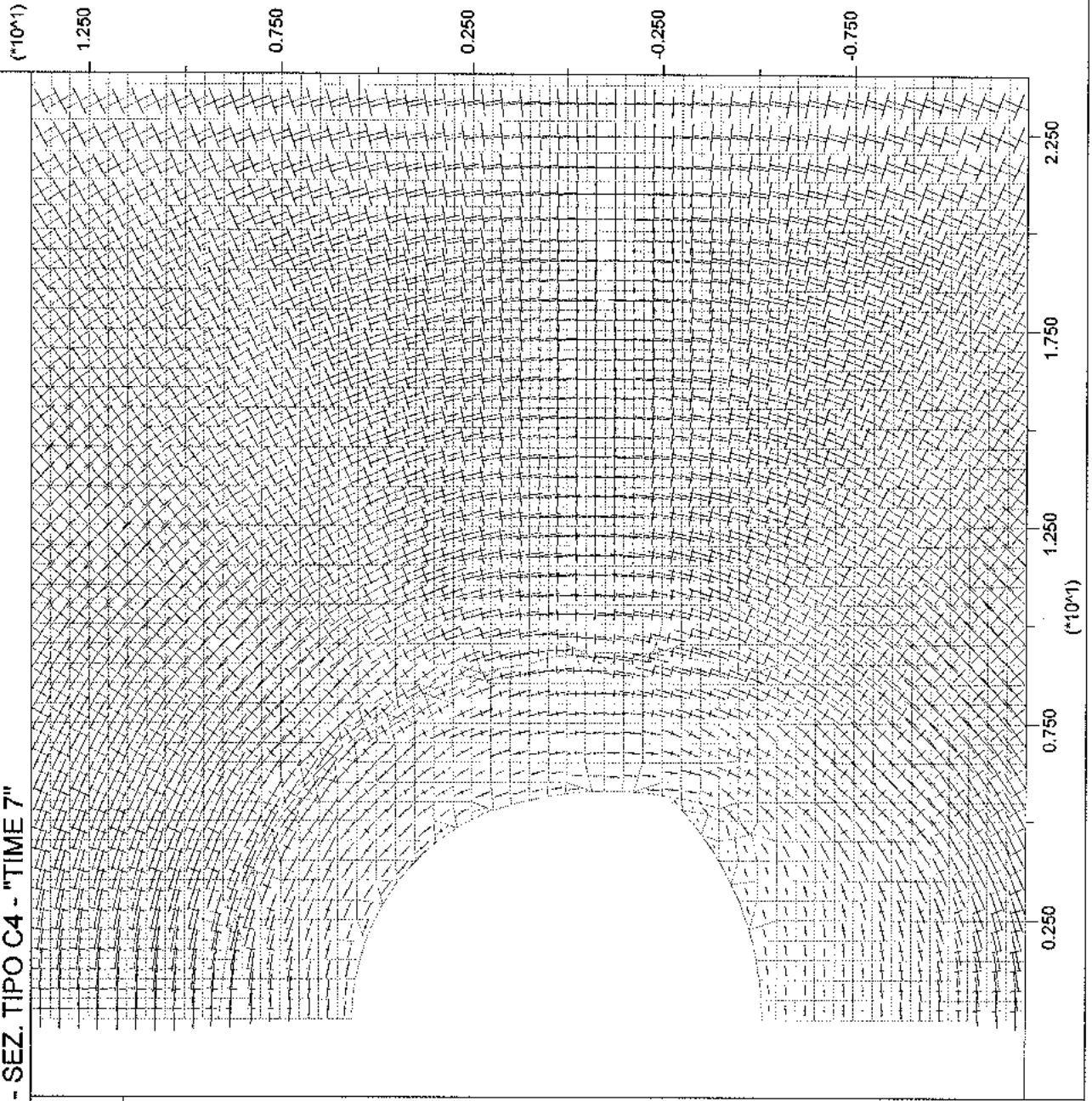
16-Feb-04 11:22
step 26831
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = 1.577E+06
Min. Value = -2.536E+07



Tensioni principali : Pa



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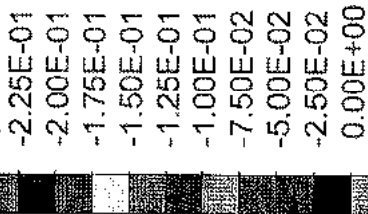
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 7"

FLAC (Version 4.00)

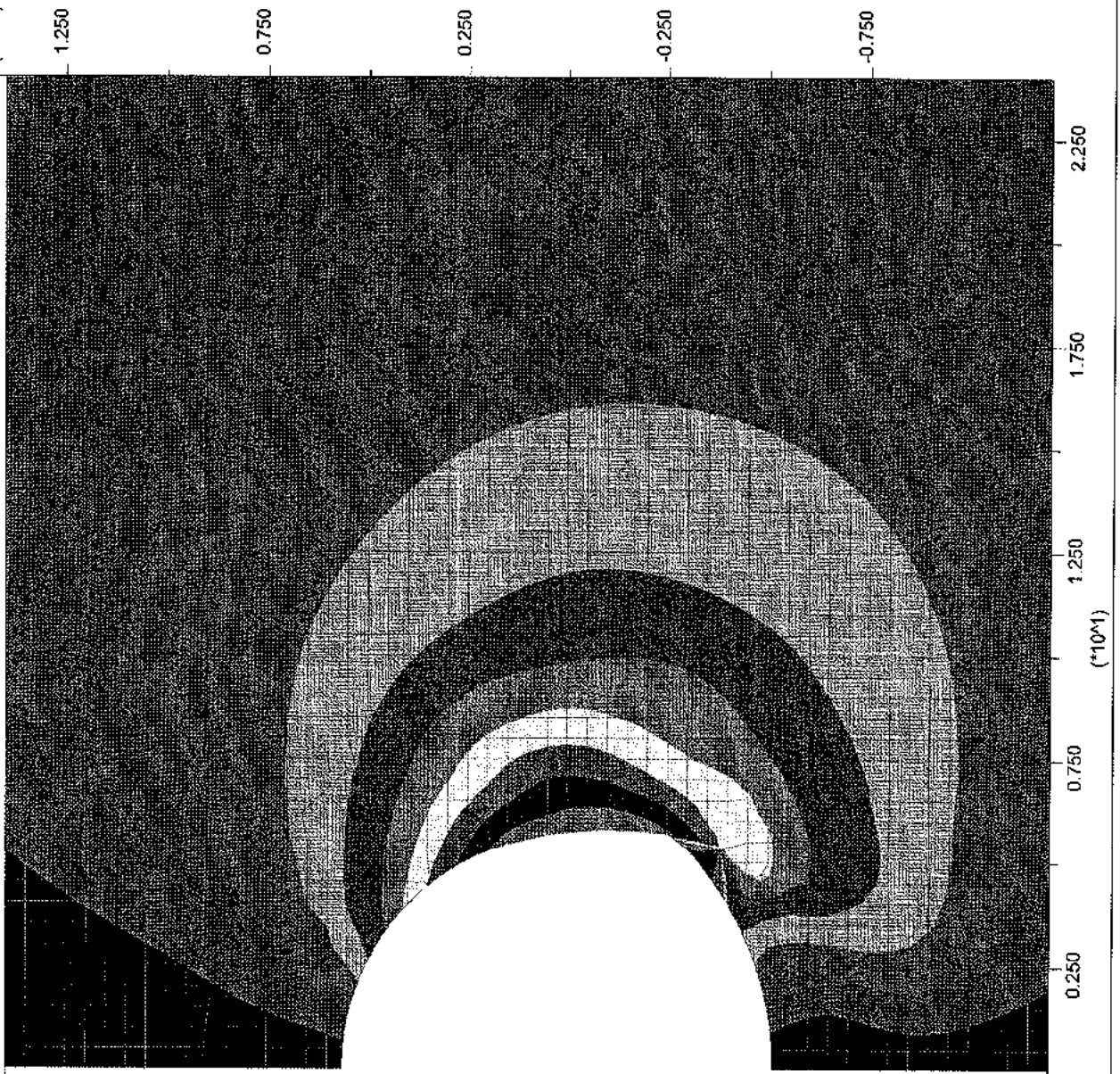
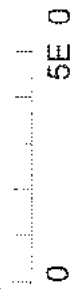
LEGEND

16-Feb-04 11:22
step 26831
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02
Spostamenti orizzontali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 7"

FLAC (Version 4.00)

LEGEND

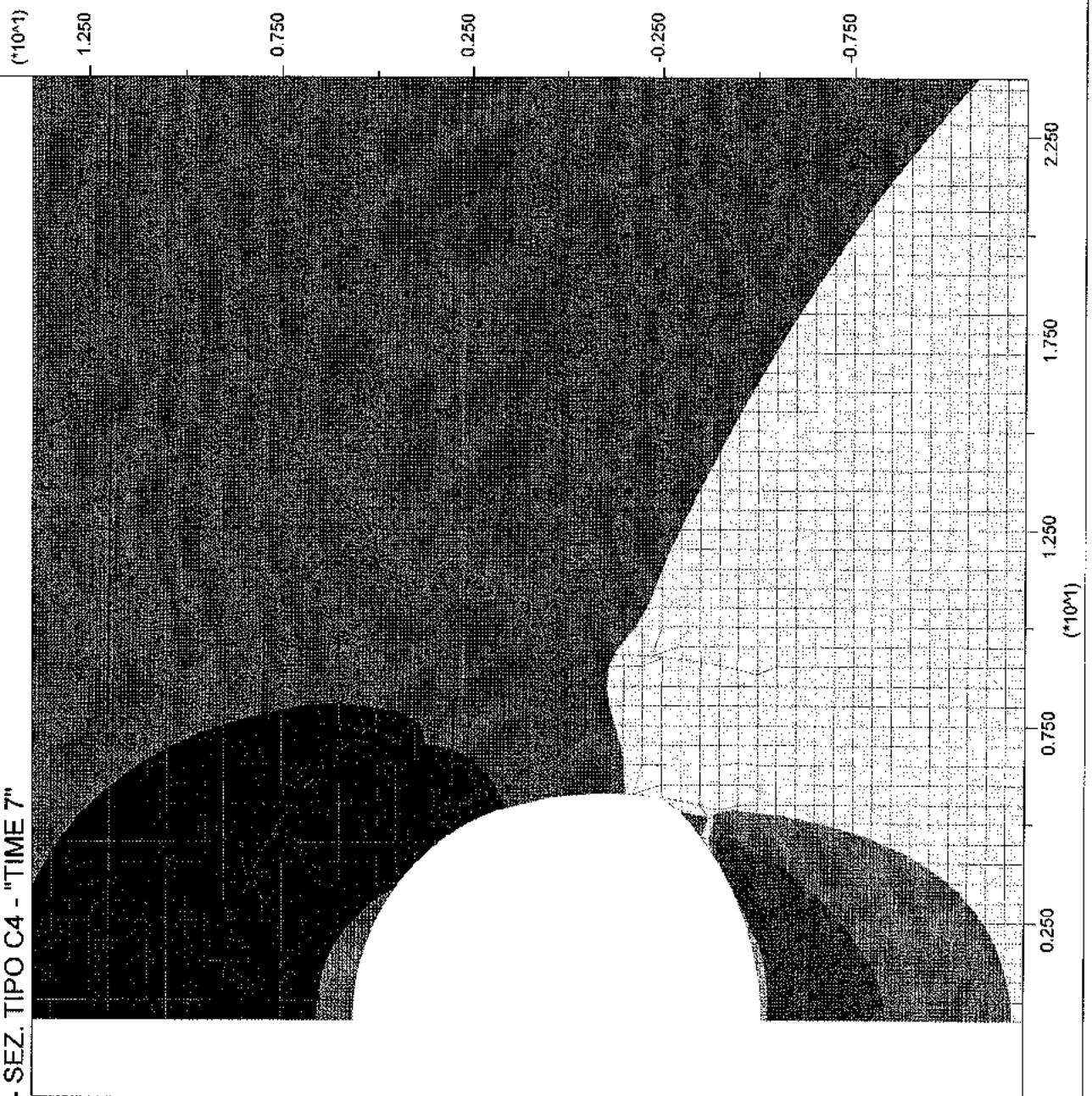
16-Feb-04 11:22
step 26831
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

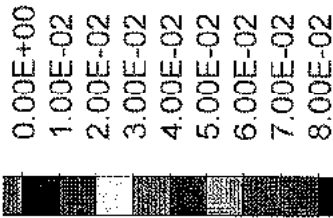
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 7"

FLAC (Version 4.00)

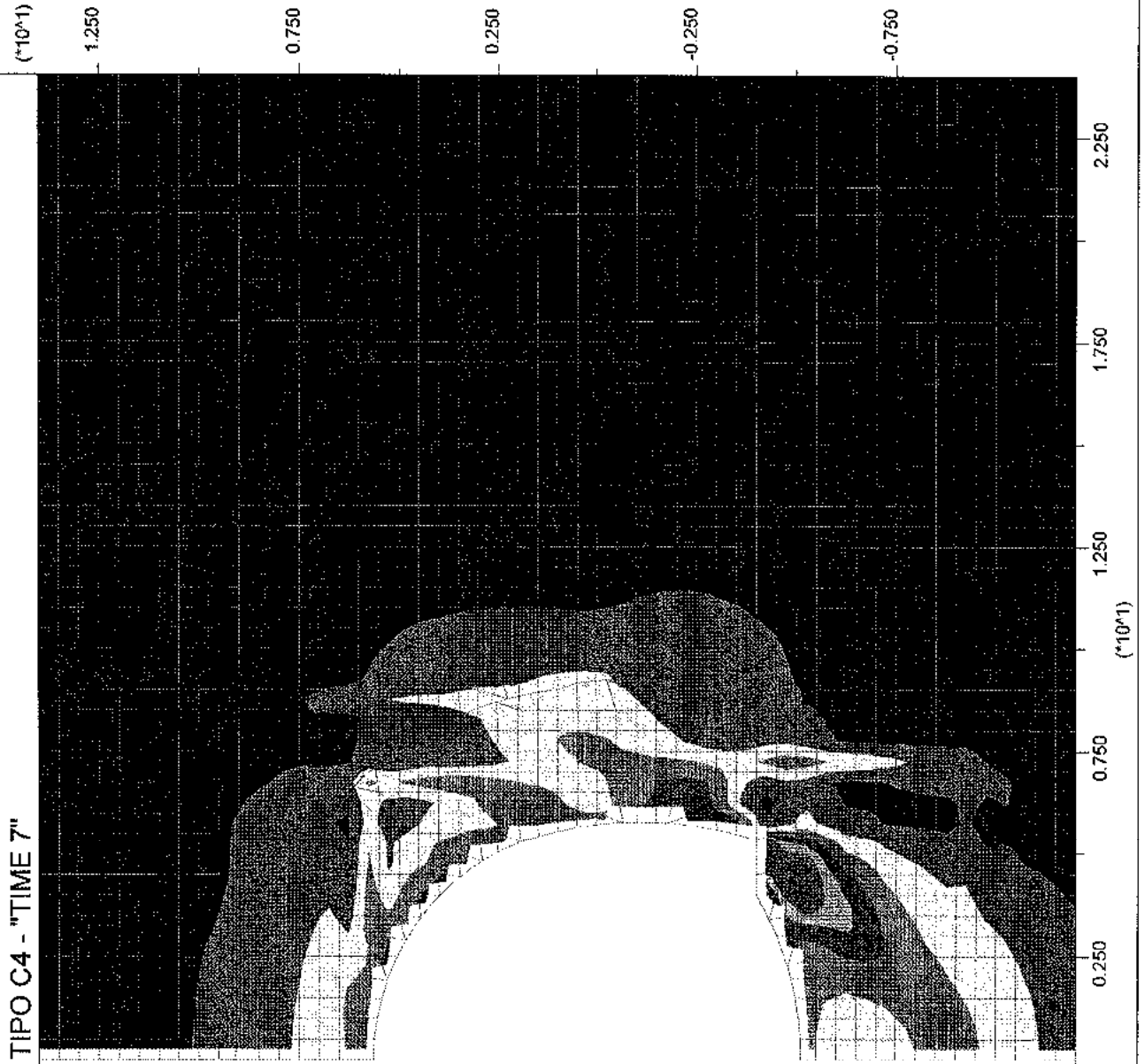
LEGEND

16-Feb-04 11:22
step 26831
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



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Minneapolis, Minnesota USA

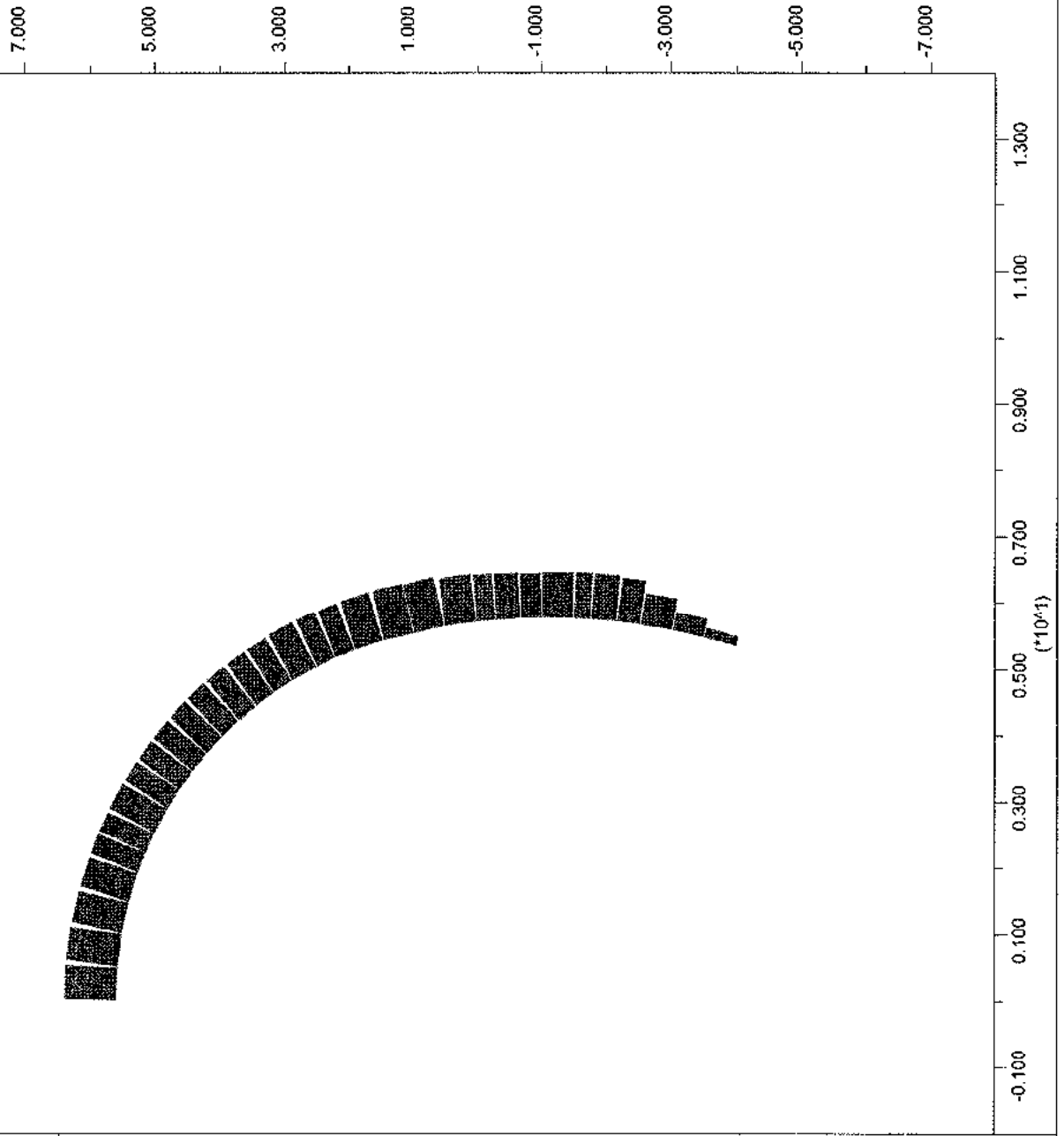
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 7"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:22
step 26831
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Pririv. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
1 (Beam) 3.480E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA


JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 7"

FLAC (Version 4.00)

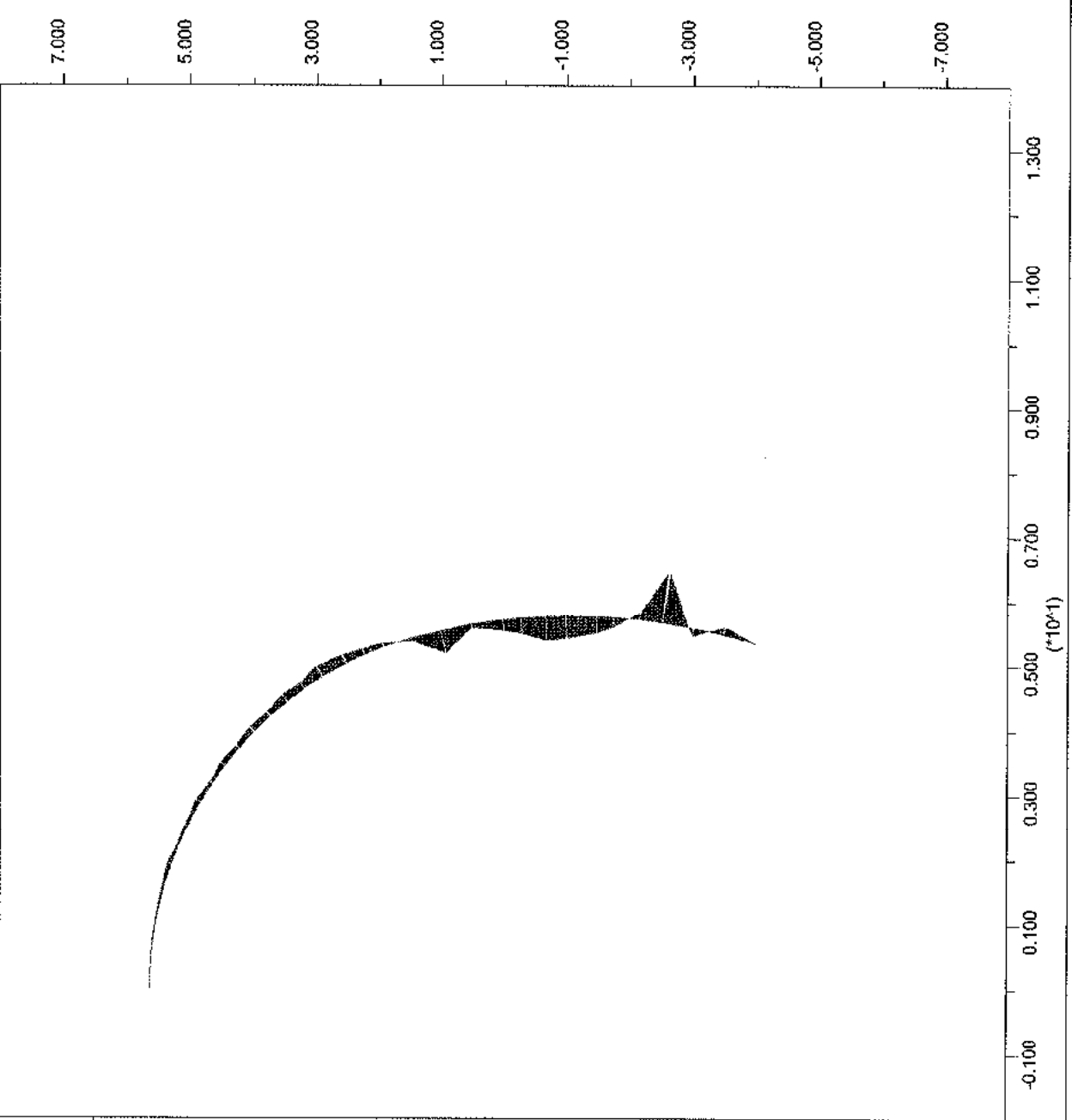
LEGEND

16-Feb-04 11:22
step 26831
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Priniv. Momento flettente [N*m/m]

 **Moment** on

Structure Max. Value
1 (Beam) 1.435E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 7"

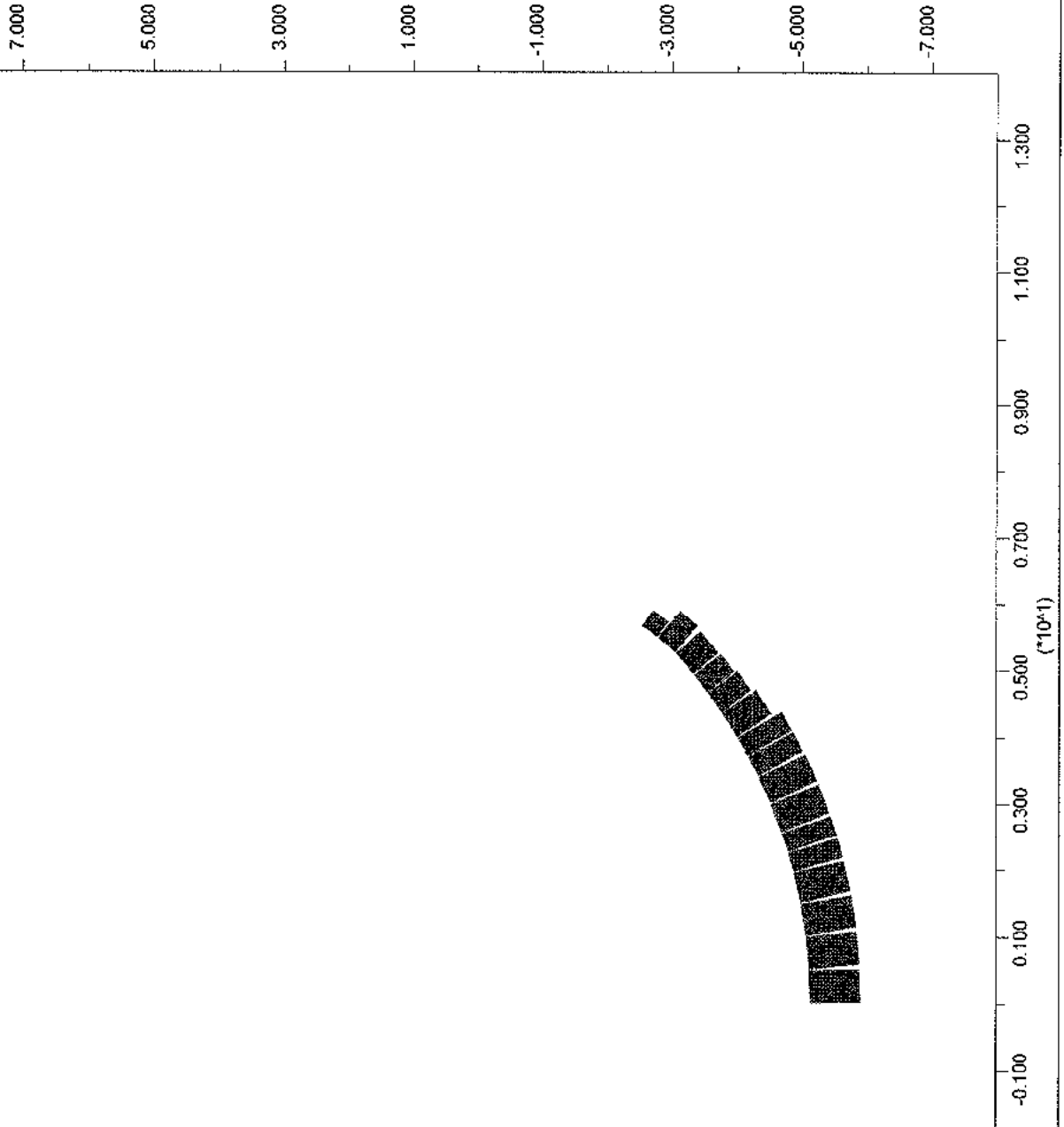
FLAC (Version 4.00)

LEGEND

16-Feb-04 11:22
step 26831
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
2 (Beam) 1.336E+06

Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA



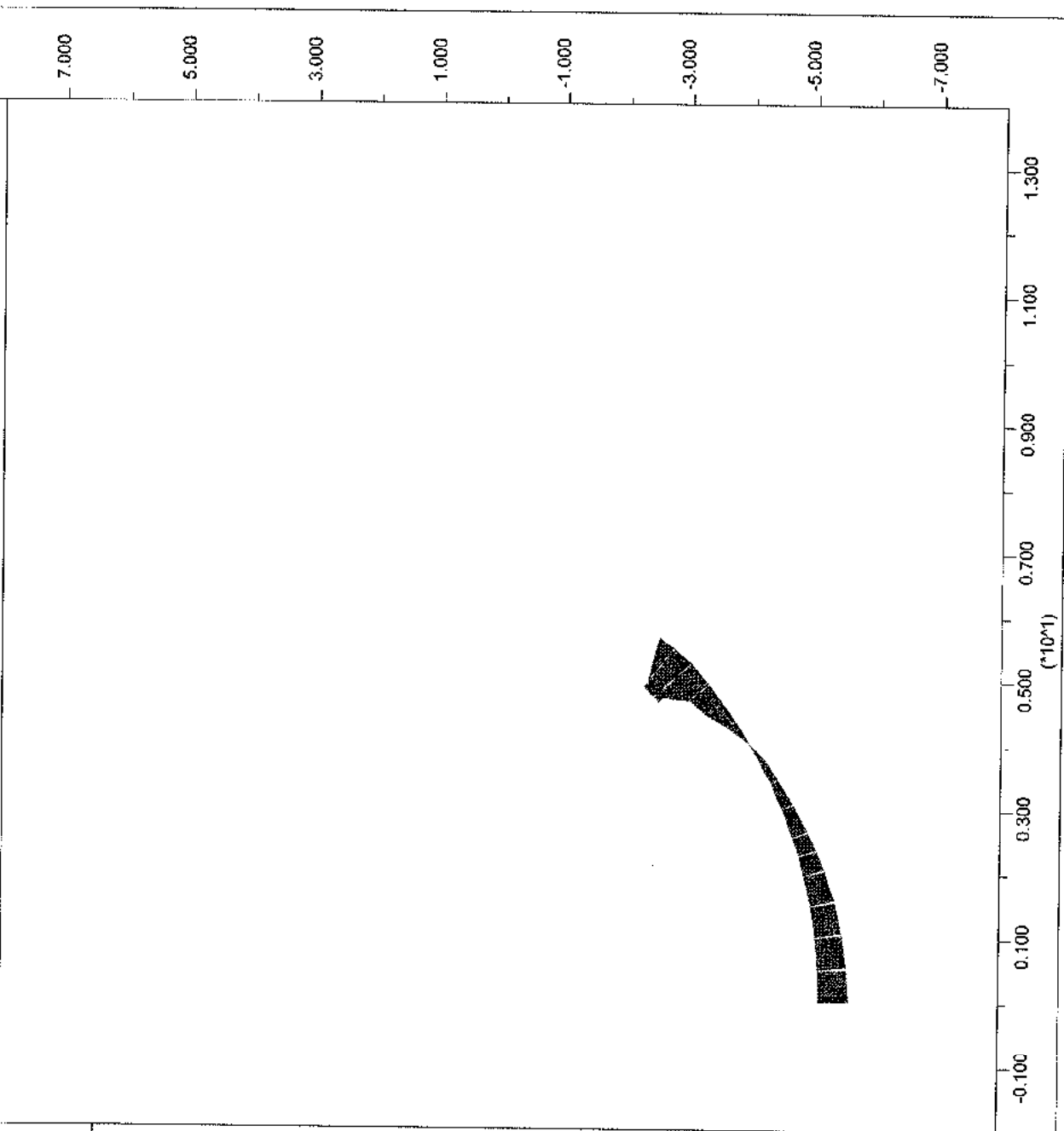
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 7"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:22
step 26831
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Momento flettente [N*m/m]
■ Moment on
Structure Max. Value
2 (Beam) -2.065E+05



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 8"

FLAC (Version 4.00)

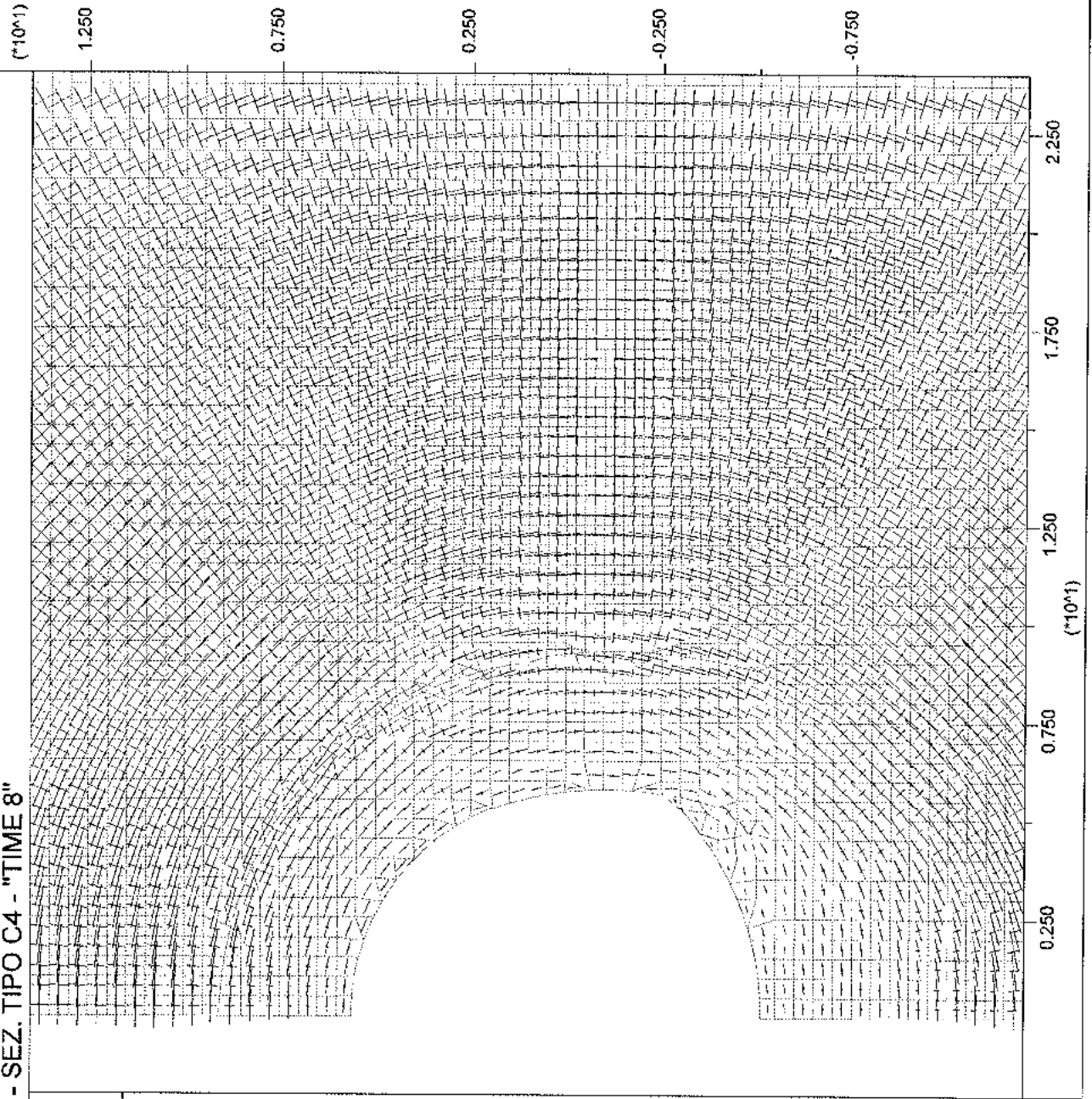
LEGEND

16-Feb-04 11:22
step 27591
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses
Max. Value = 1.807E+06
Min. Value = -2.536E+07



Tensioni principali : Pa



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Minneapolis, Minnesota USA

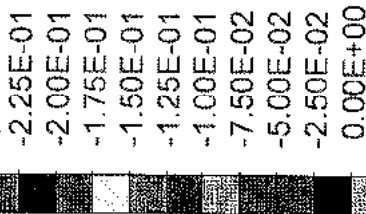
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 8"

FLAC (Version 4.00)

LEGEND

16-Feb-04 11:22
step 27591
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02
Spostamenti orizzontali



(*10^1)

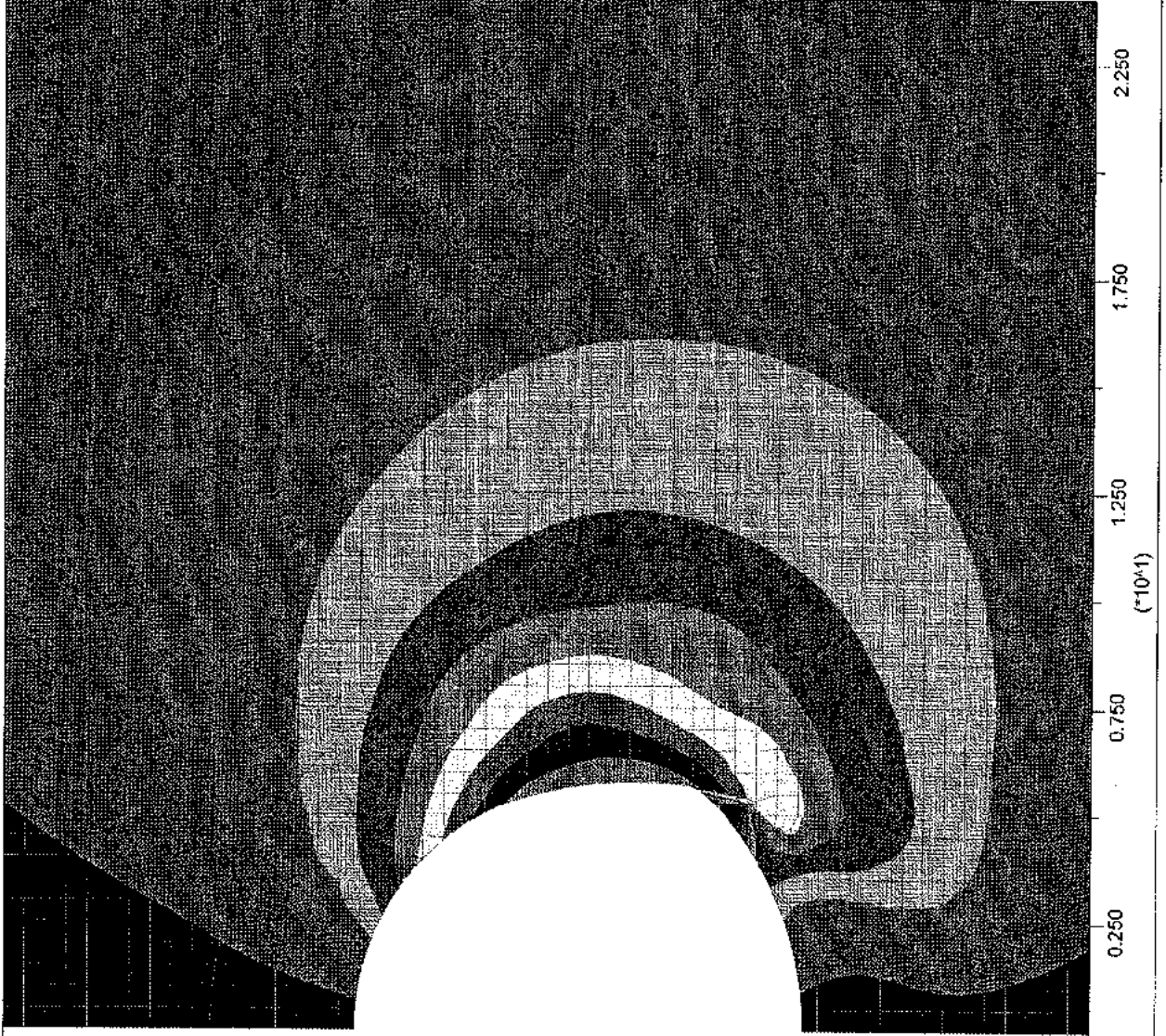
1.250

0.750

0.250

-0.250

-0.750



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 8"

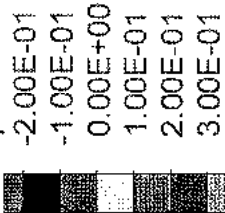
(*10^1)

FLAC (Version 4.00)

LEGEND

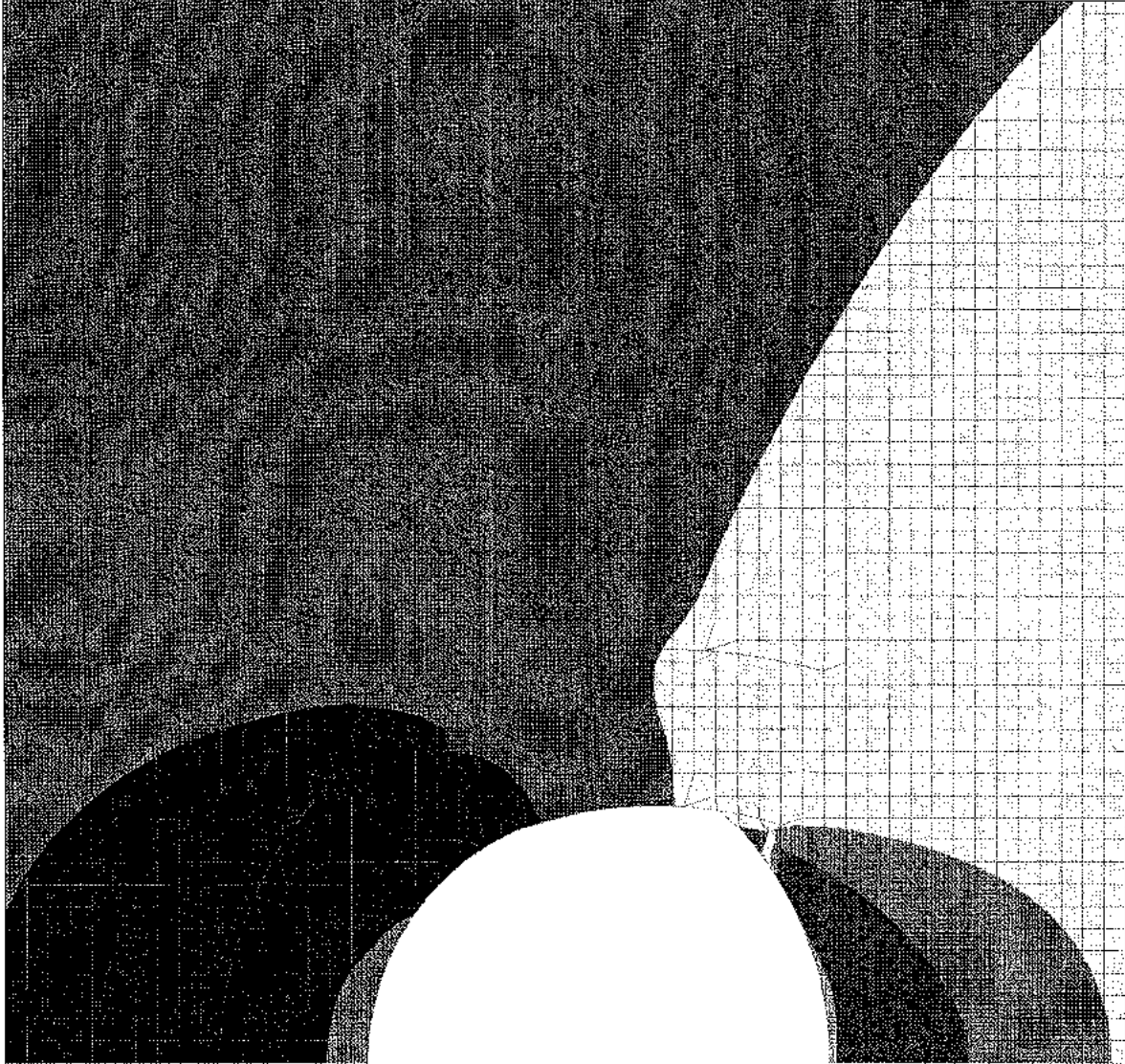
16-Feb-04 11:22
step 27591
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

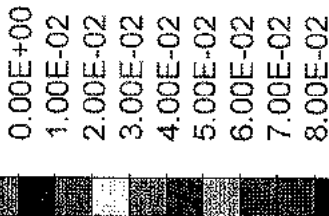
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 8"

FLAC (Version 4.00)

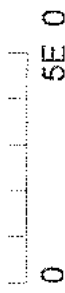
LEGEND

16-Feb-04 11:22
step 27591
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



(*10^1)

1.250

0.750

0.250

-0.250

-0.750



2.250

1.750

1.250

0.750

0.250

(*10^1)

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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 8"

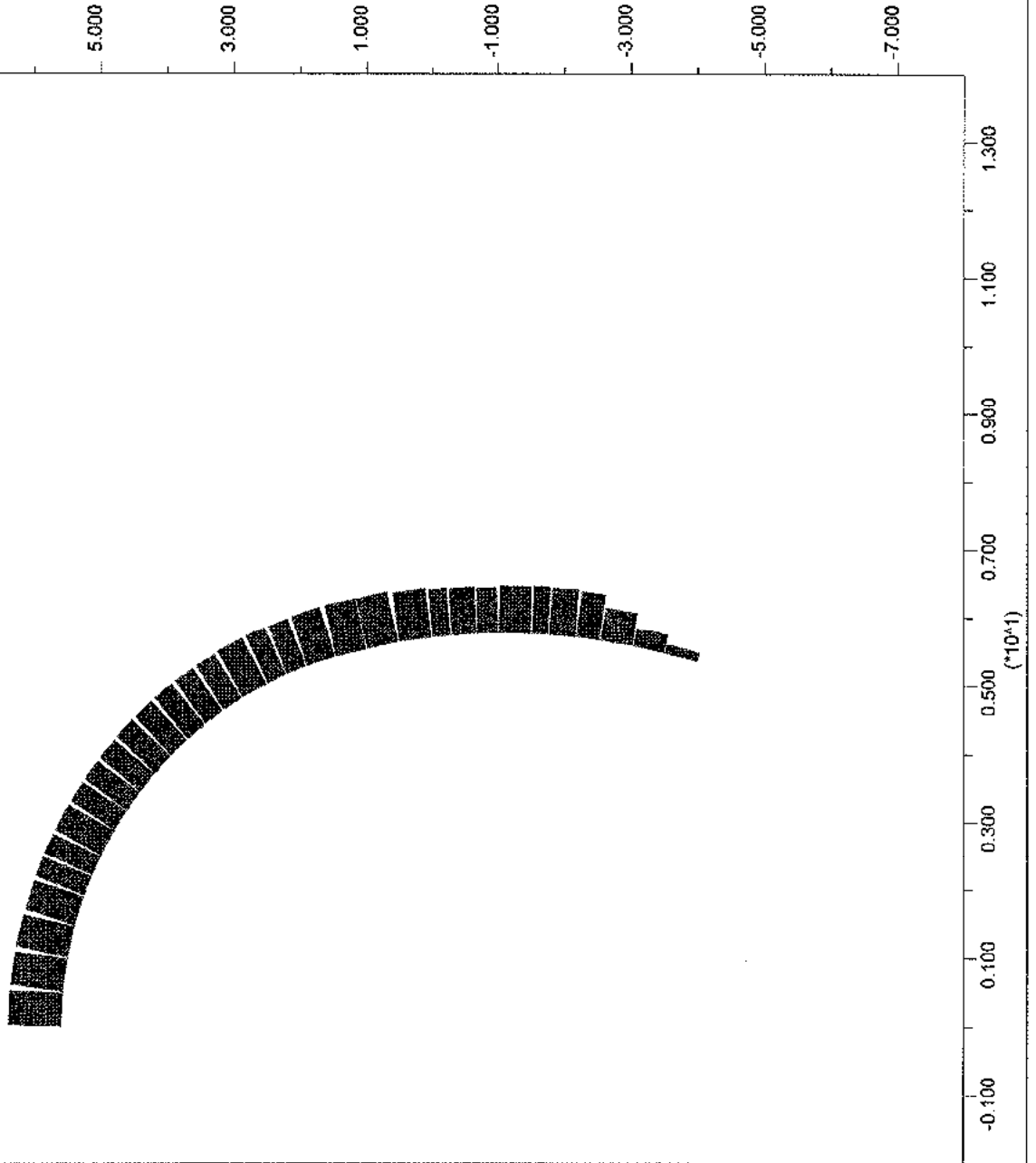
FLAC (Version 4.00)

LEGEND

16-Feb-04 11:22
step 27591
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Priv. Sforzo normale [N/m]

■ Axial Force on
Structure Max. Value
1 (Beam) 3.647E+06



Itasca Consulting Group, Inc.
Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 8"

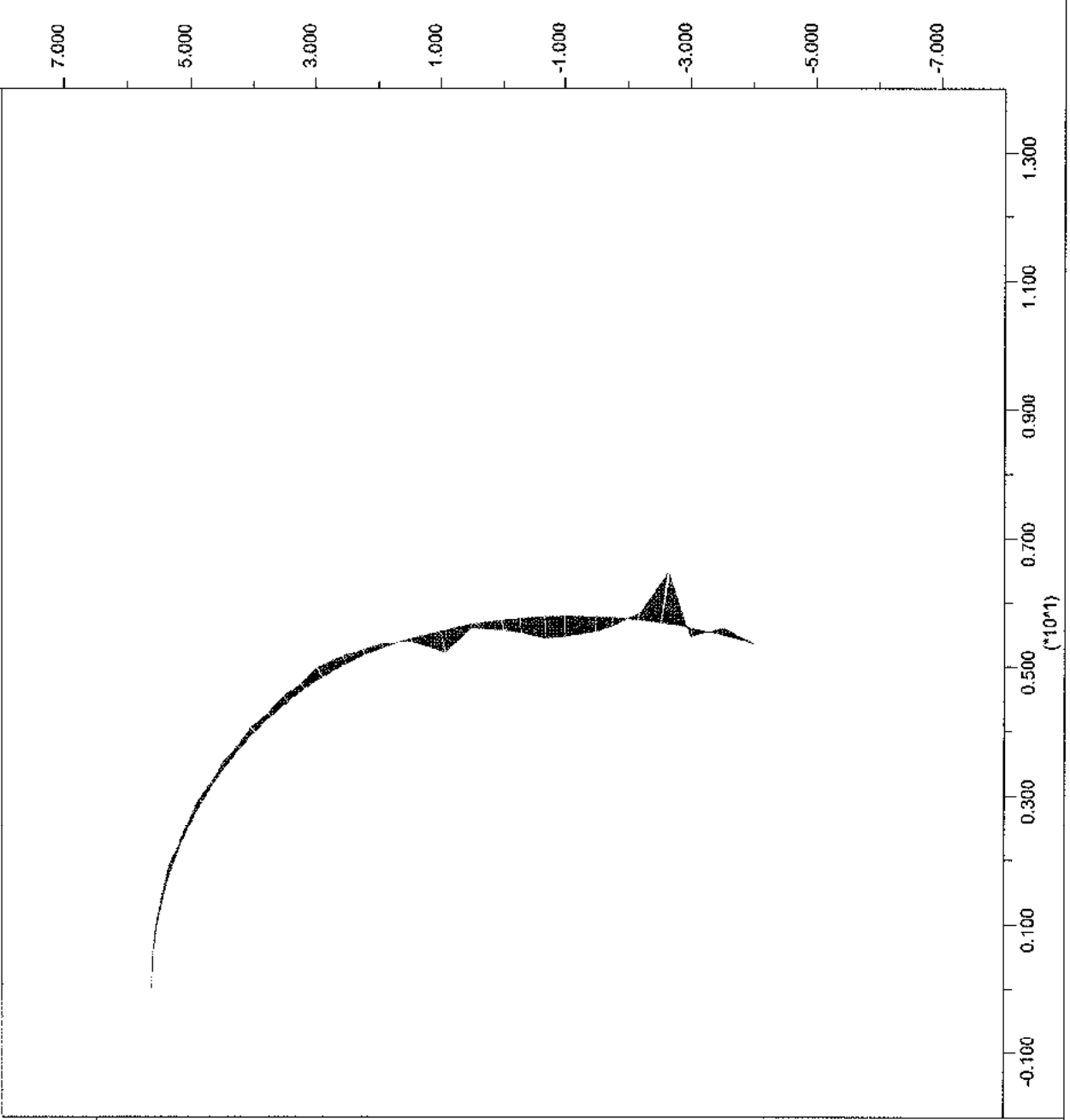
FLAC (Version 4.00)

LEGEND

16-Feb-04 11:22
step 27591
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Priv. Momento flettente [N*m/m]

■ Moment on
Structure Max. Value
1 (Beam) 1.628E+05



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 8"

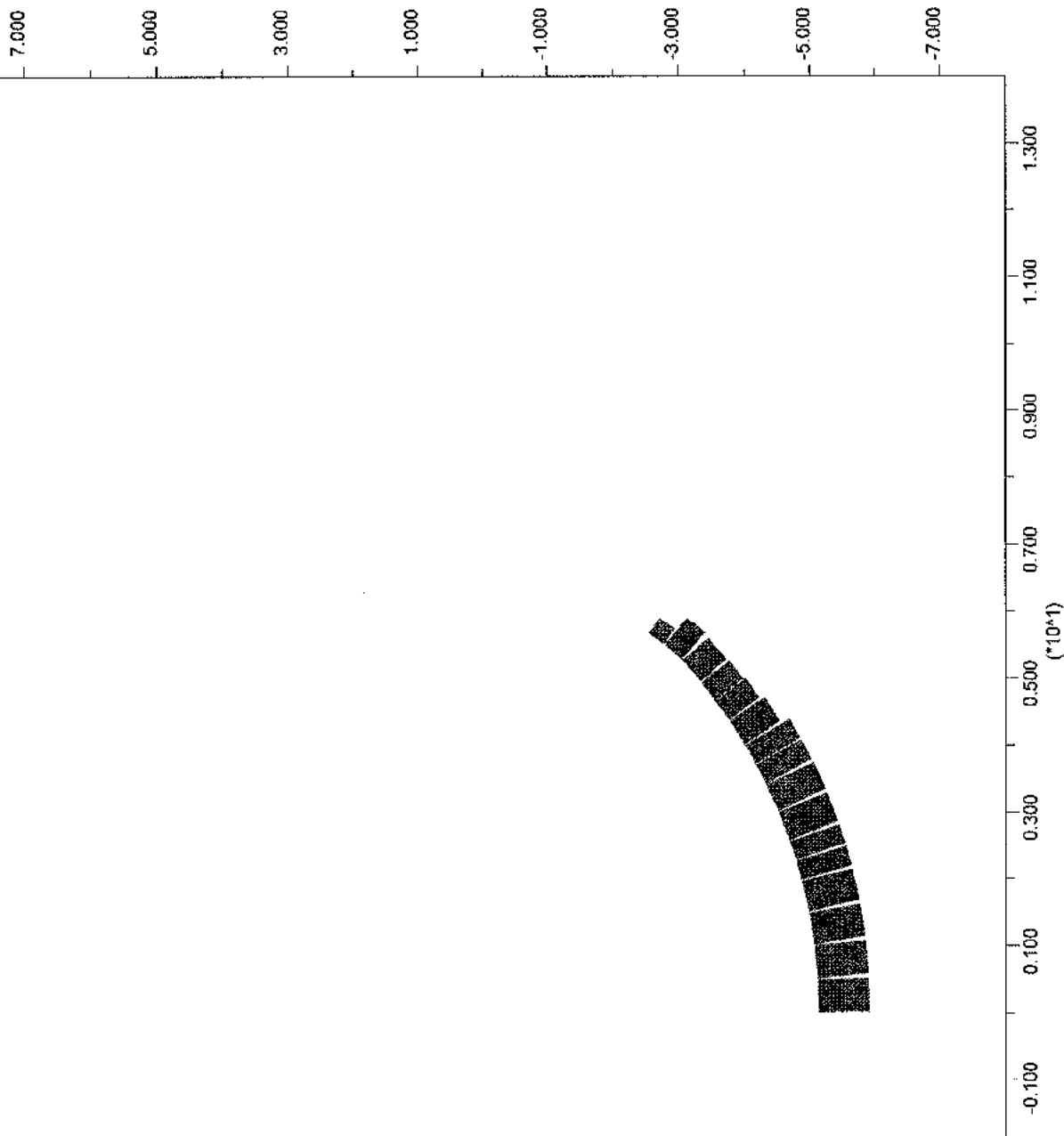
FLAC (Version 4.00)

LEGEND

16-Feb-04 11:22
step 27591
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Sforzo normale [N/m]
■ Axial Force on
Structure Max. Value
2 (Beam) 1.555E+06

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Minneapolis, Minnesota USA




JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 8"

FLAC (Version 4.00)

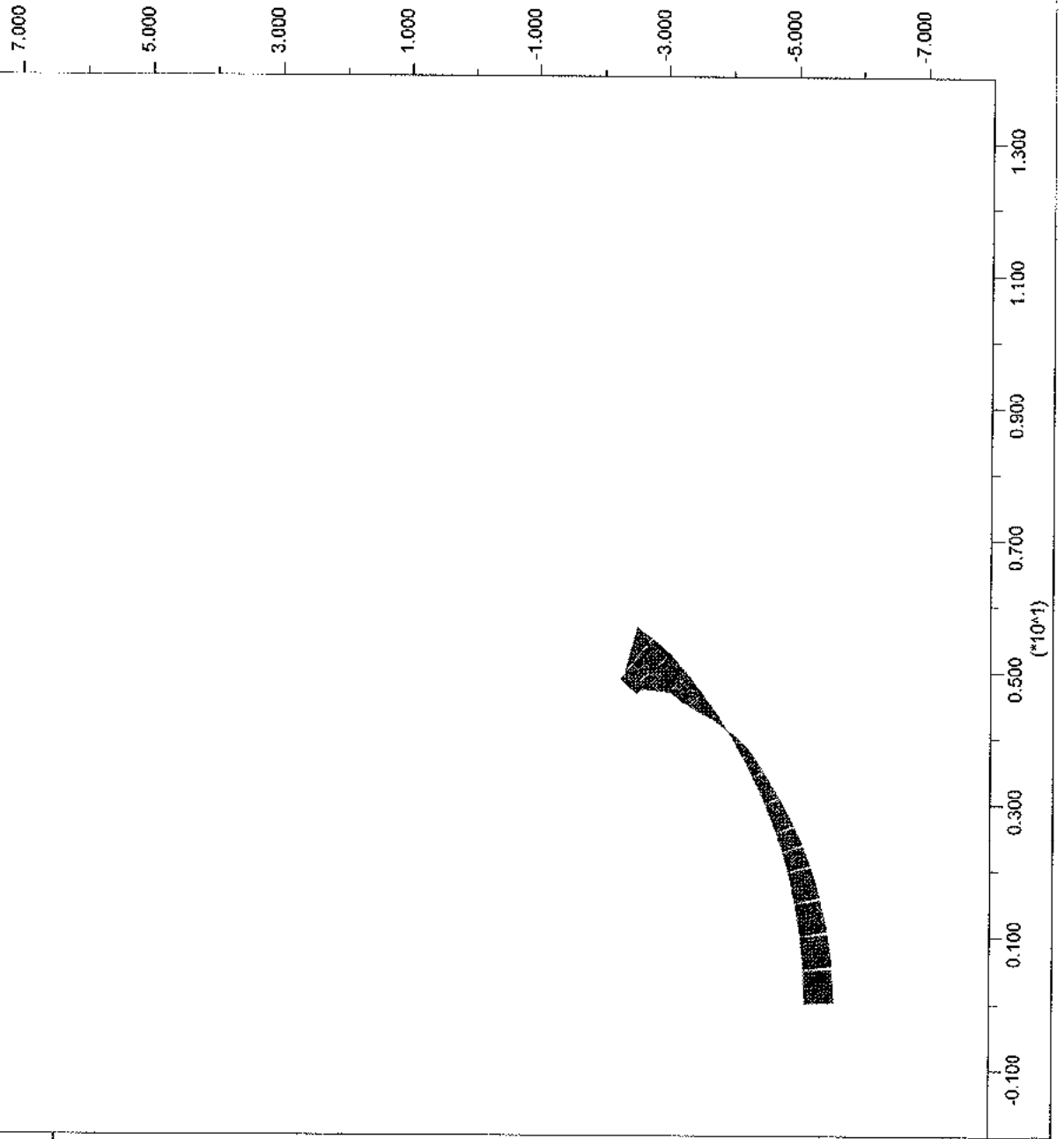
LEGEND

16-Feb-04 11:22
step 27591
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

A.R. Momento flettente [N*m/m]

 **Moment** on
Structure Max. Value
2 (Beam) -2.354E+05

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Minneapolis, Minnesota USA



JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 9"

FLAC (Version 4.00)

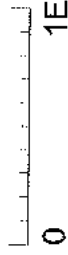
LEGEND

16-Feb-04 11:23
step 29396
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

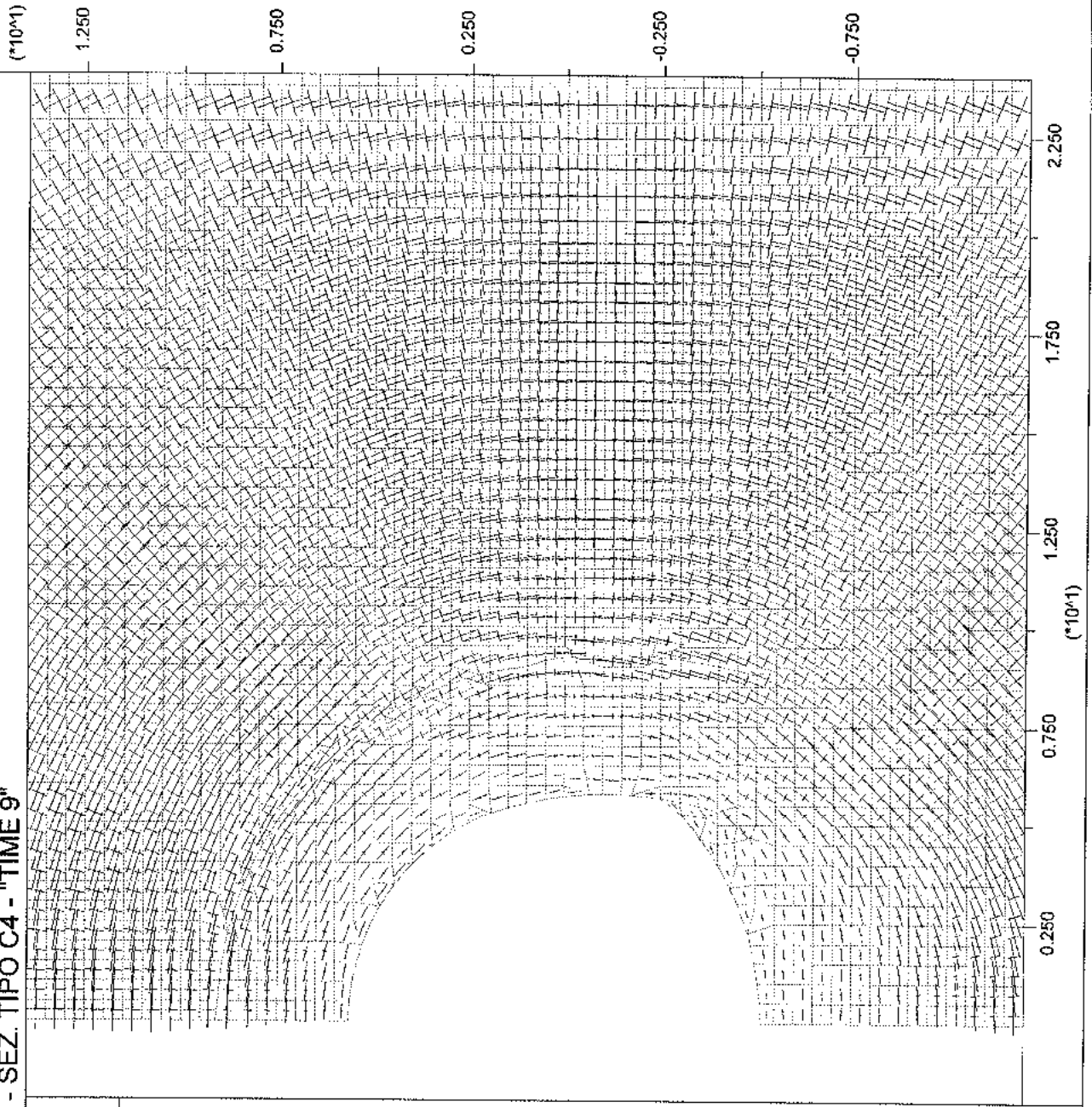
Principal stresses

Max. Value = 1.836E+06

Min. Value = -2.538E+07



Tensioni principali : Pa



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 9"

FLAC (Version 4.00)

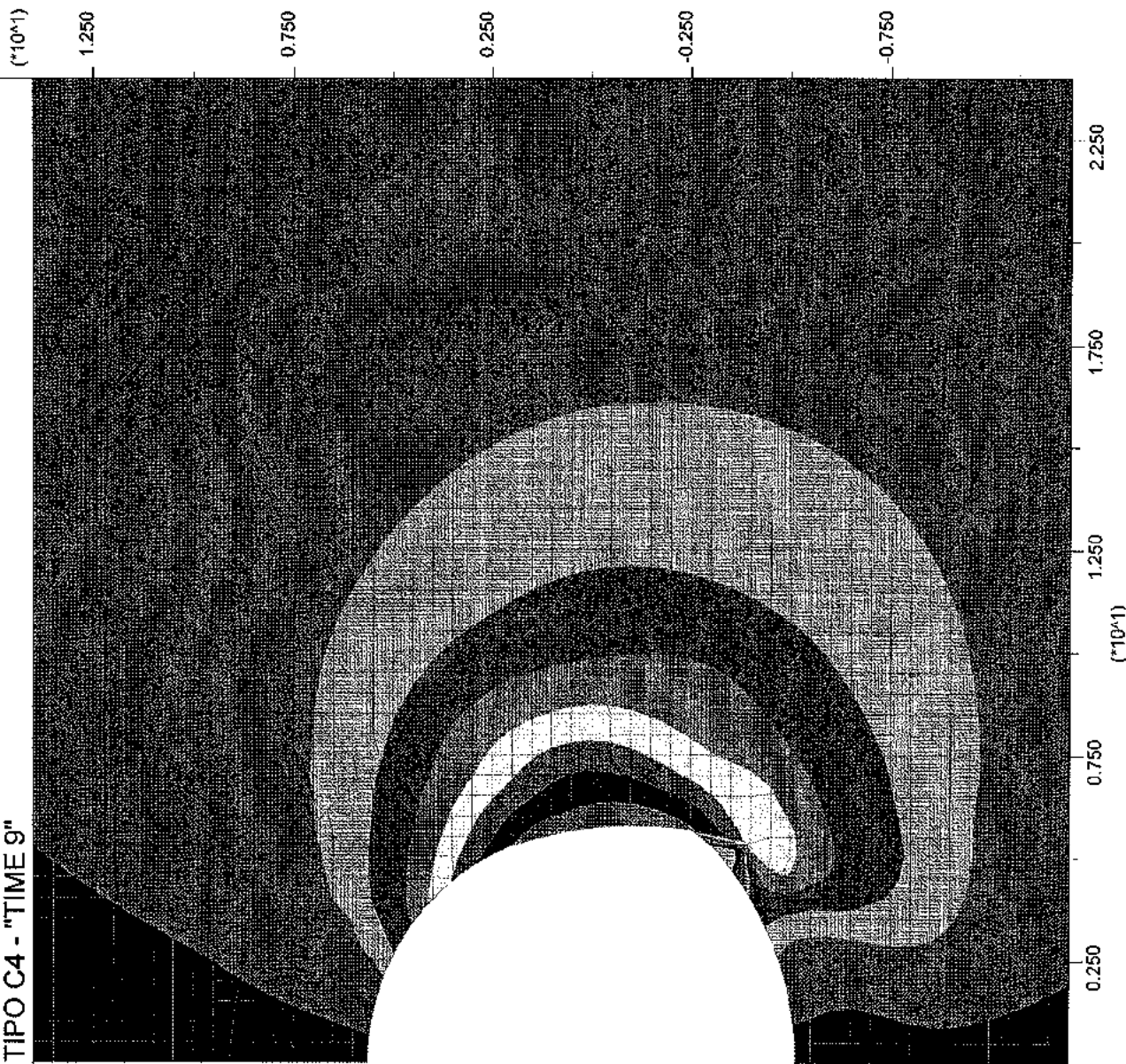
LEGEND

16-Feb-04 11:23
step 29396
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

X-displacement contours



Contour interval= 2.50E-02
Spostamenti orizzontali



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 9"

FLAC (Version 4.00)

LEGEND

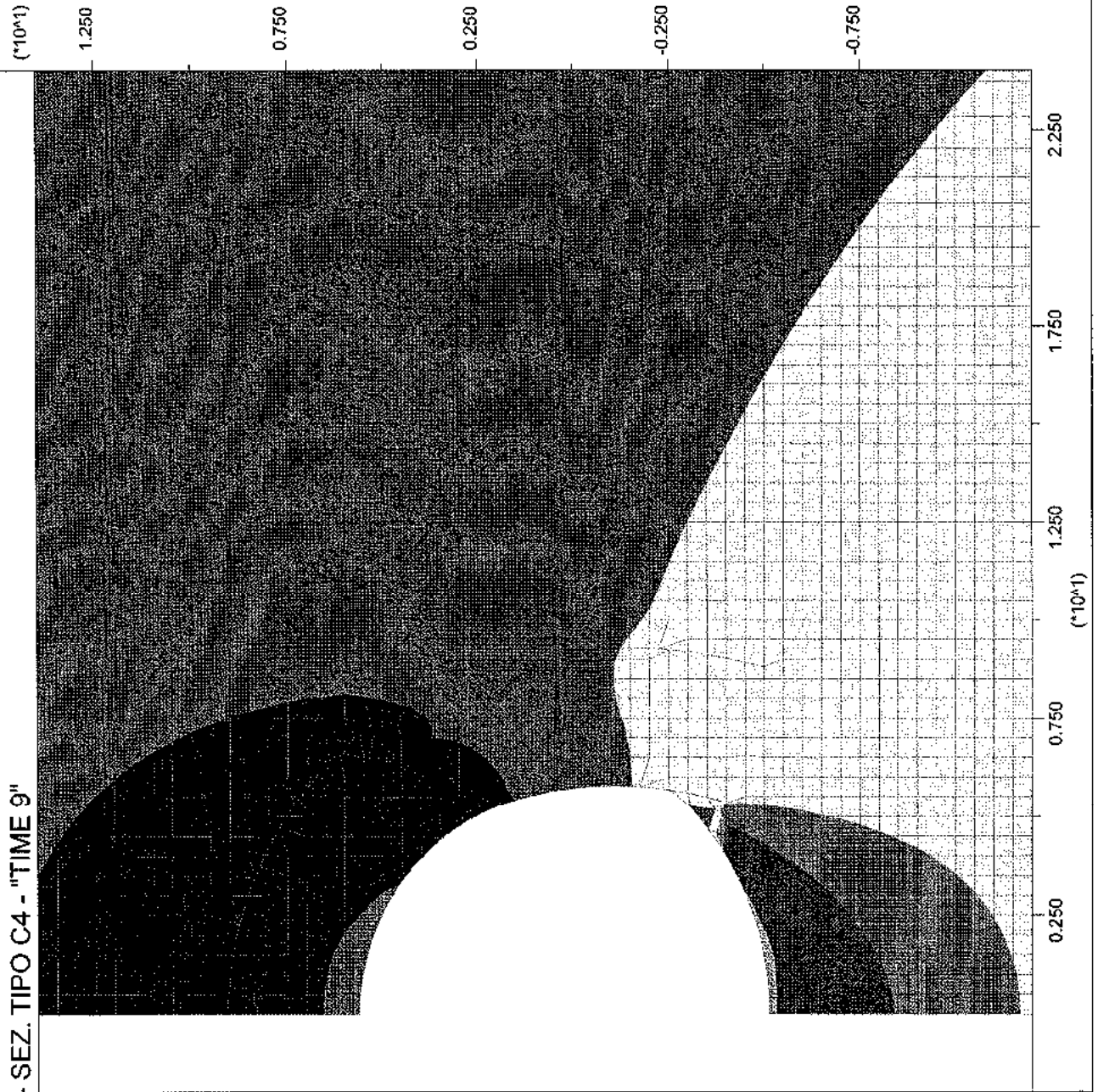
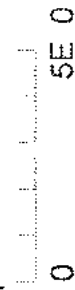
16-Feb-04 11:23
step 29396
-2.000E+00 <X< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



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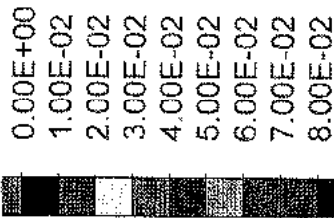
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 9"

FLAC (Version 4.00)

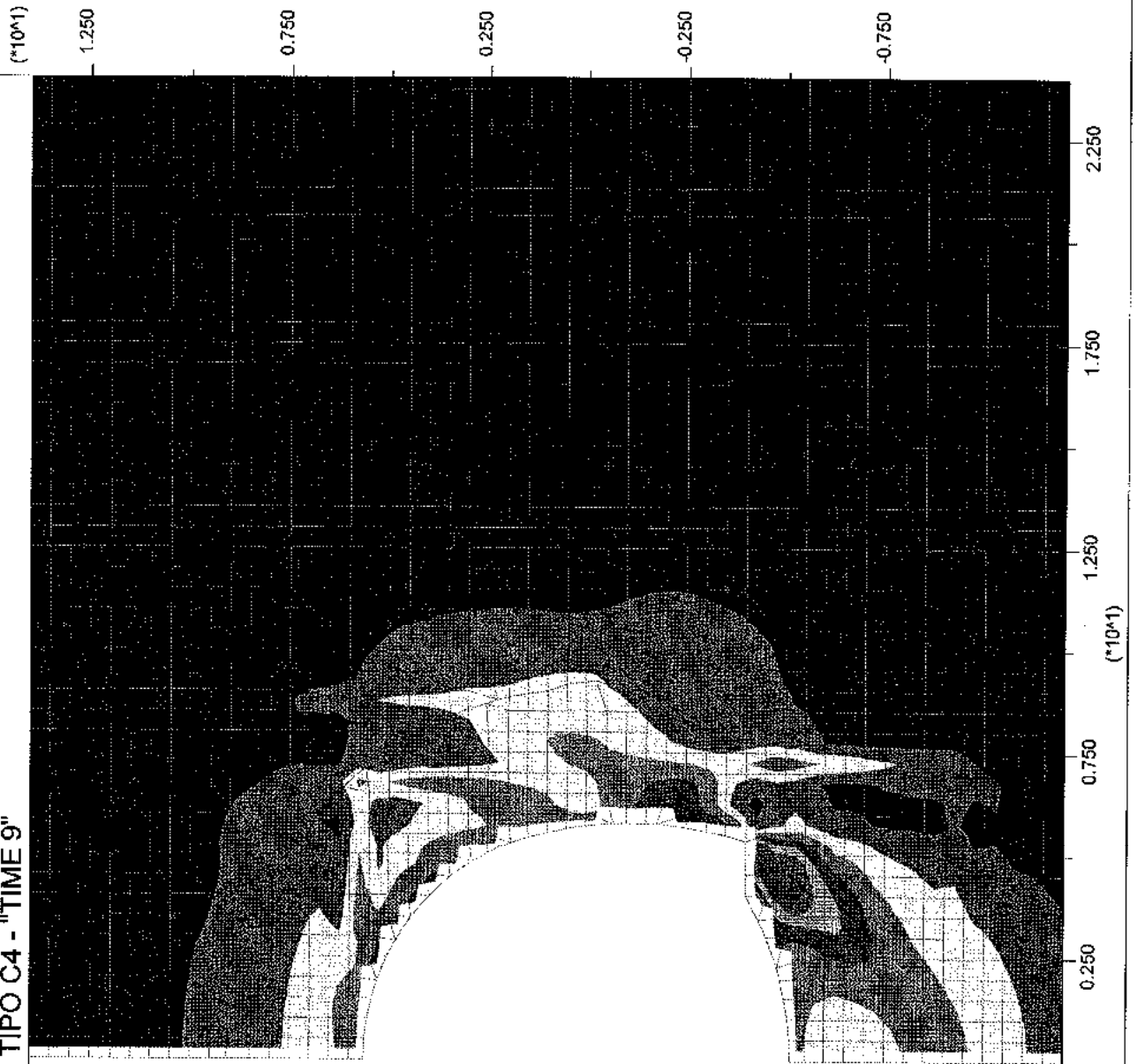
LEGEND

16-Feb-04 11:23
step 29396
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 9"

FLAC (Version 4.00)

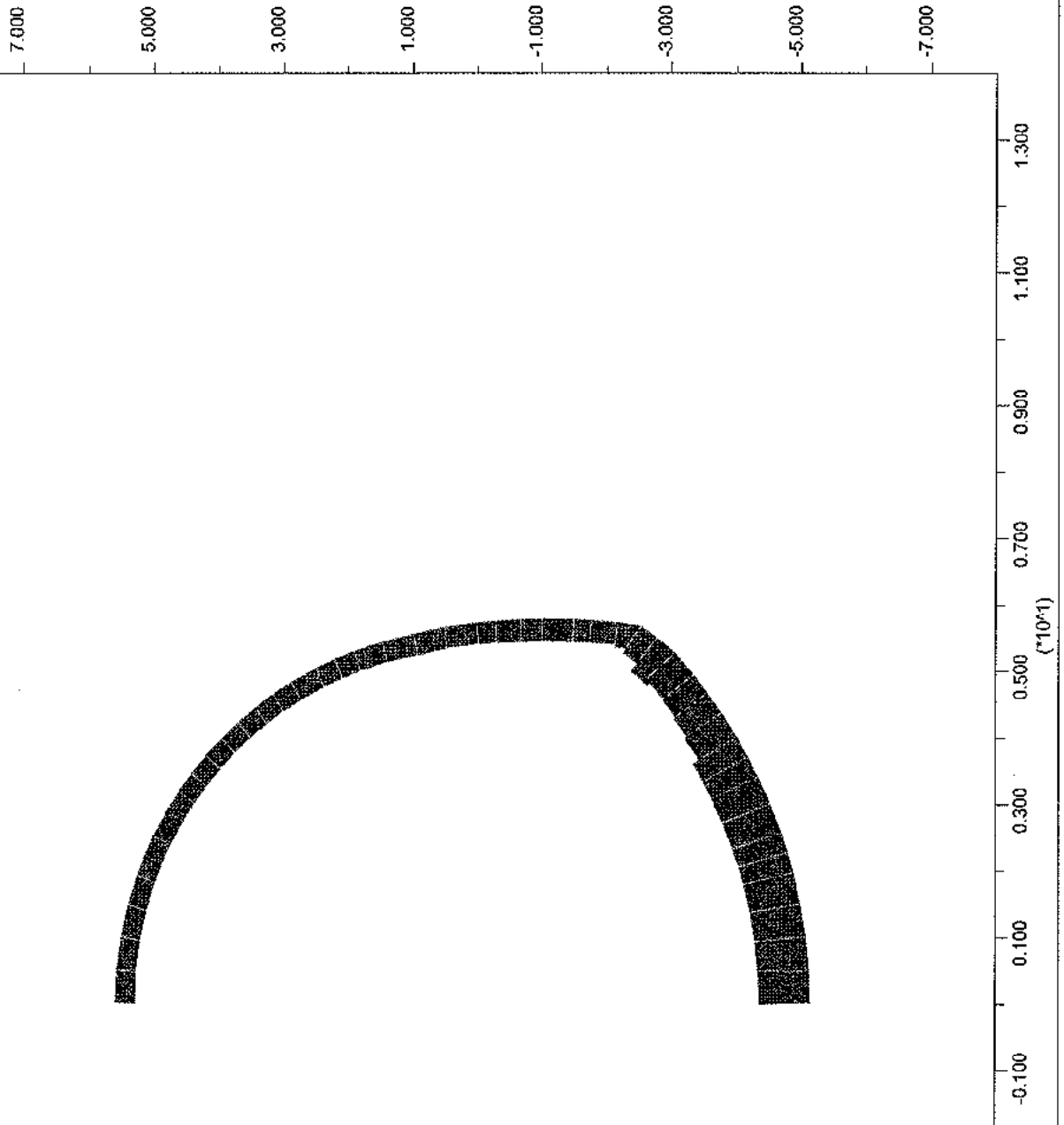
LEGEND

16-Feb-04 11:23
step 29396
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
2 (Beam) 3.814E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 9"

FLAC (Version 4.00)

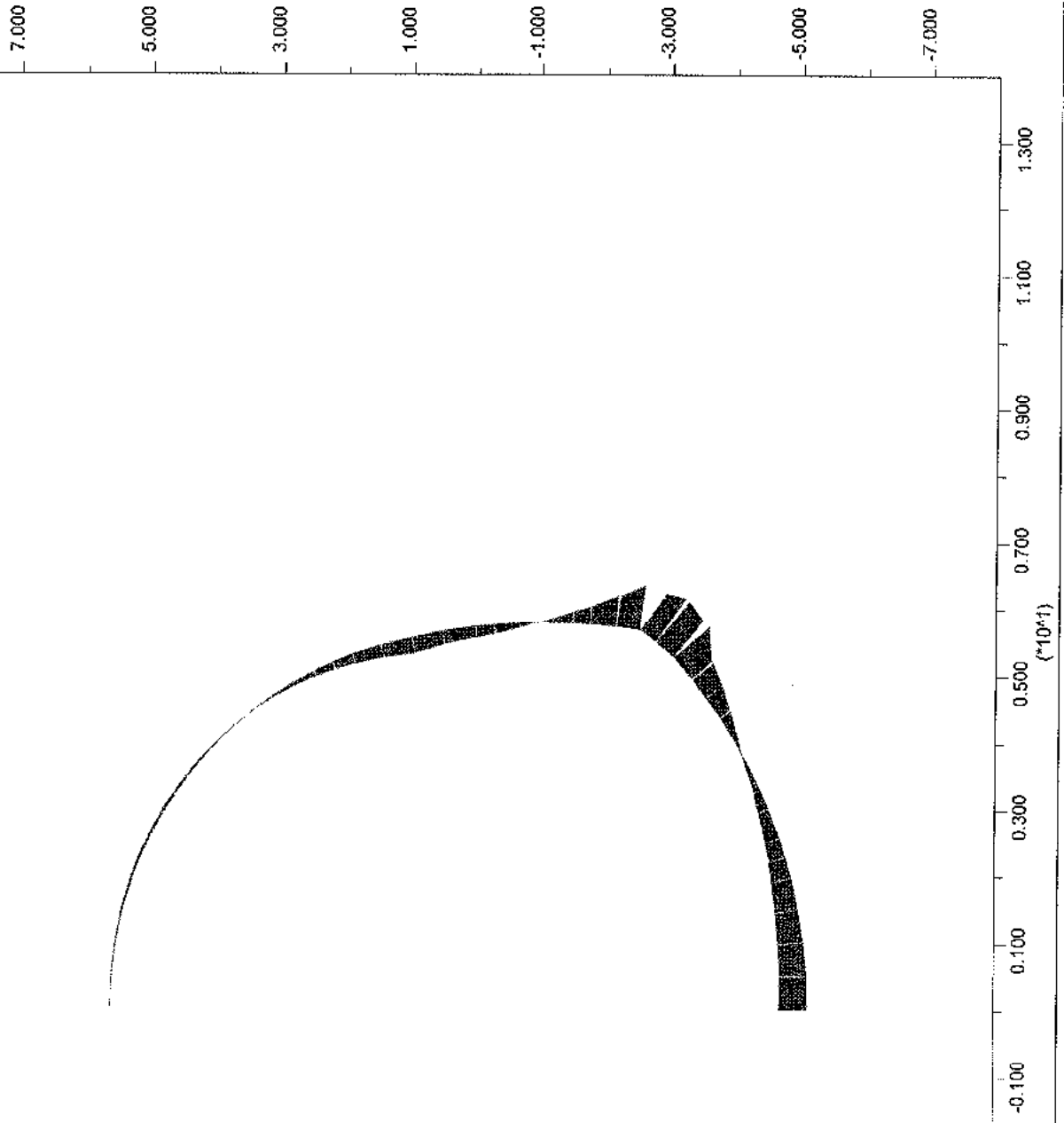
LEGEND

16-Feb-04 11:23
step 29396
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

 Moment on

Structure Max. Value
2 (Beam) -9.109E+05



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 10"

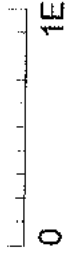
FLAC (Version 4.00)

LEGEND

16-Feb-04 12:26
step 31109
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Principal stresses

Max. Value = 1.755E+06
Min. Value = -2.539E+07

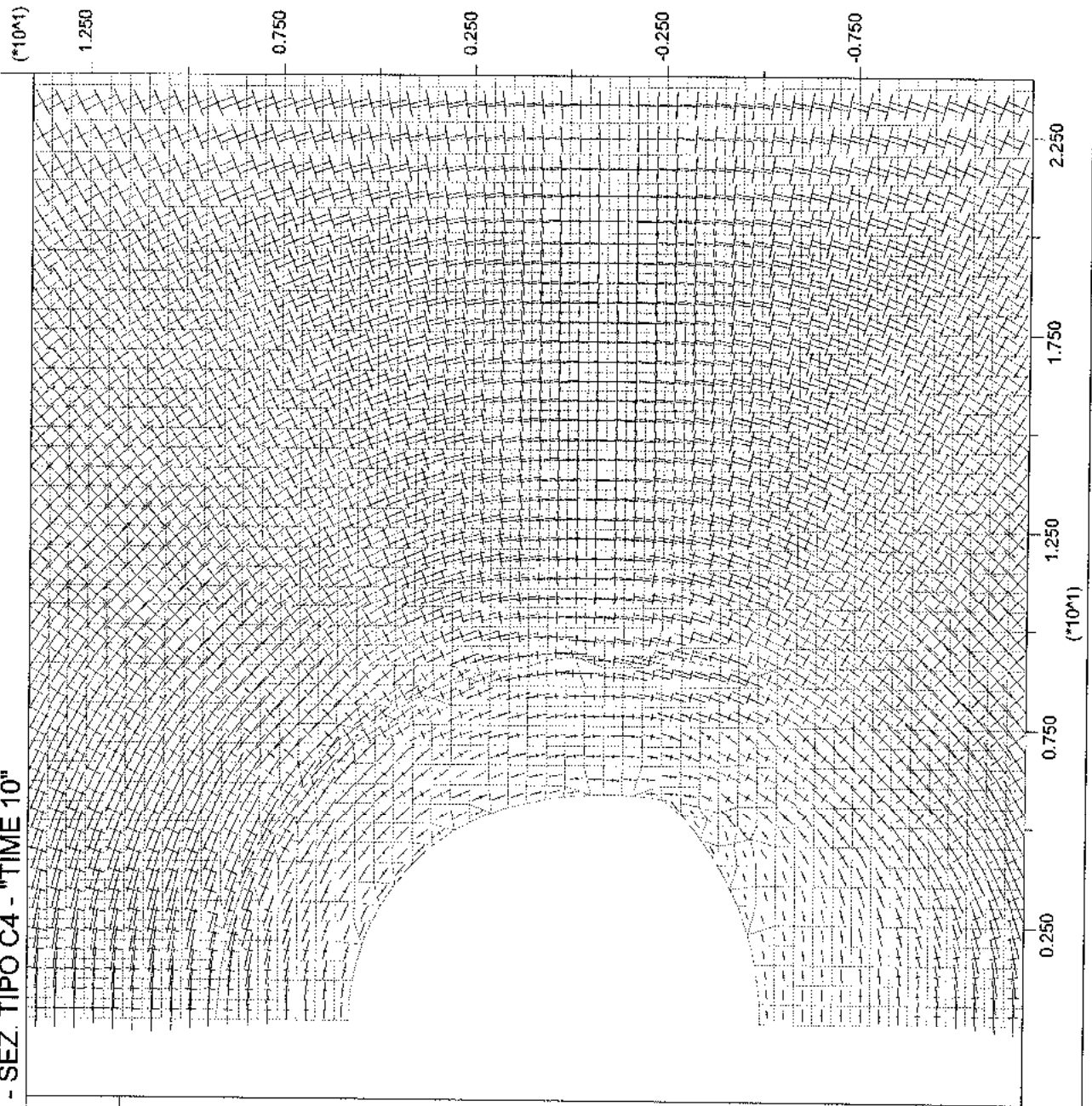


0 1E 8

Tensioni principali : Pa



0 5E 0



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 10"

FLAC (Version 4.00)

LEGEND

16-Feb-04 12:26

step 31109

-2.000E+00 <x< 2.400E+01

-1.200E+01 <y< 1.400E+01

X-displacement contours

-2.25E-01

-2.00E-01

-1.75E-01

-1.50E-01

-1.25E-01

-1.00E-01

-7.50E-02

-5.00E-02

-2.50E-02

0.00E+00

Contour interval= 2.50E-02

Spostamenti orizzontali



0

5E 0

(*10^1)

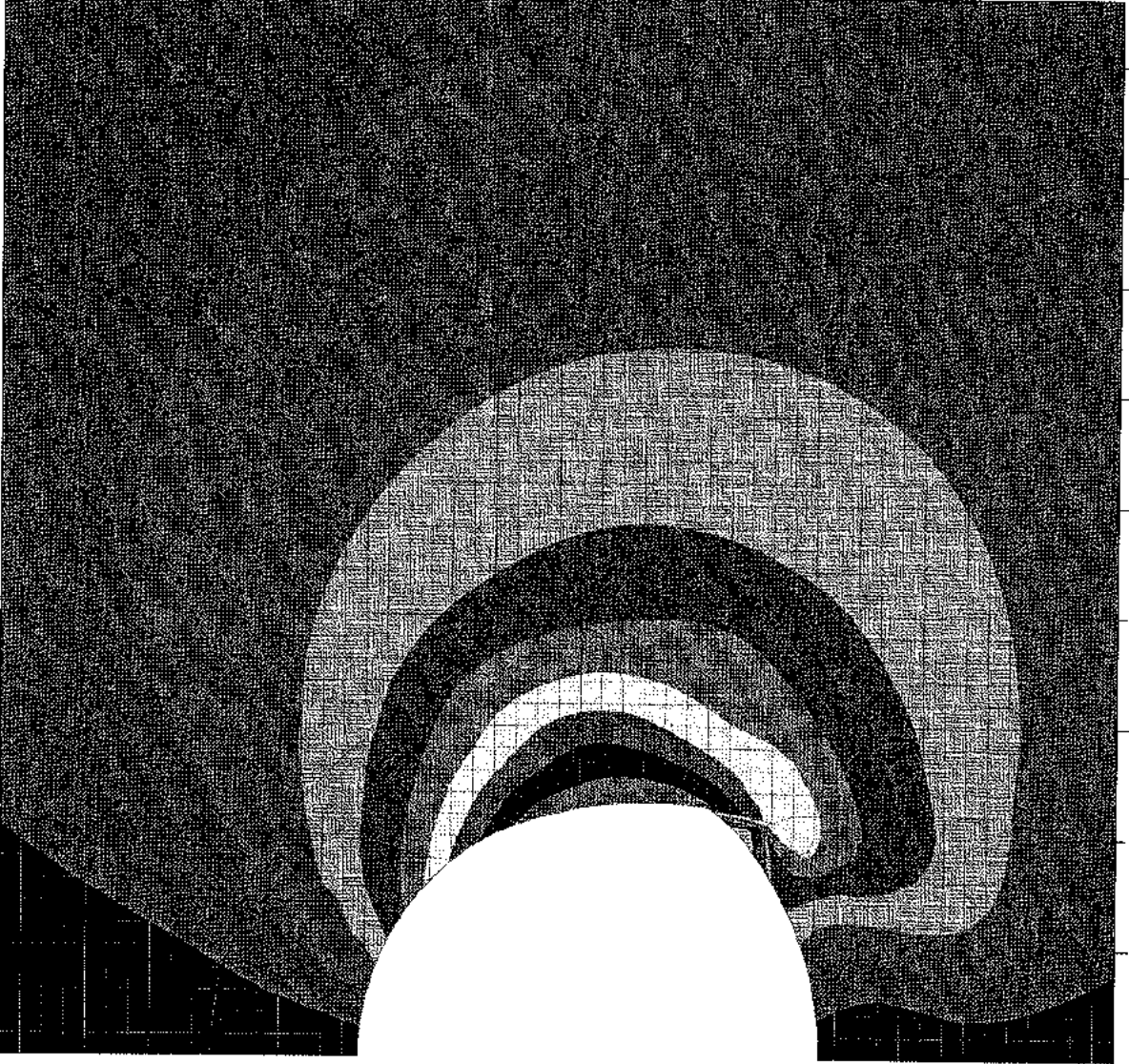
1.250

0.750

0.250

-0.250

-0.750



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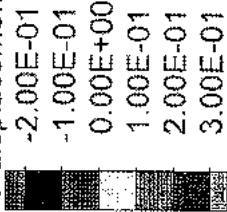
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 10"

FLAC (Version 4.00)

LEGEND

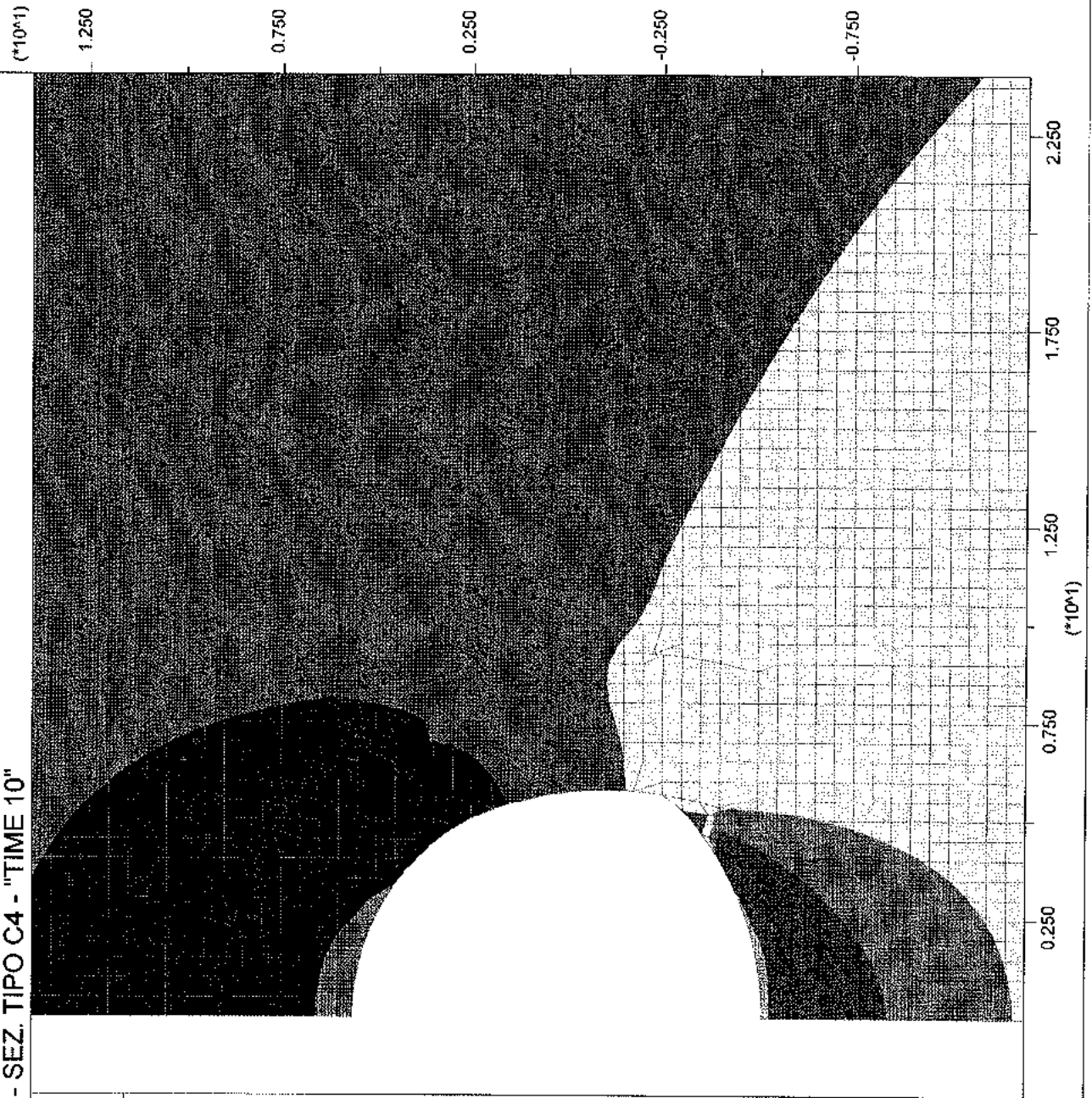
16-Feb-04 12:26
step 31109
-2.000E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Y-displacement contours



Contour interval= 1.00E-01

Spostamenti verticali



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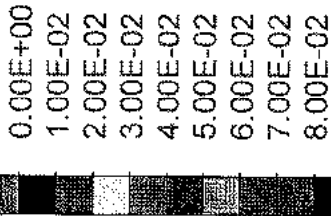
JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 10"

FLAC (Version 4.00)

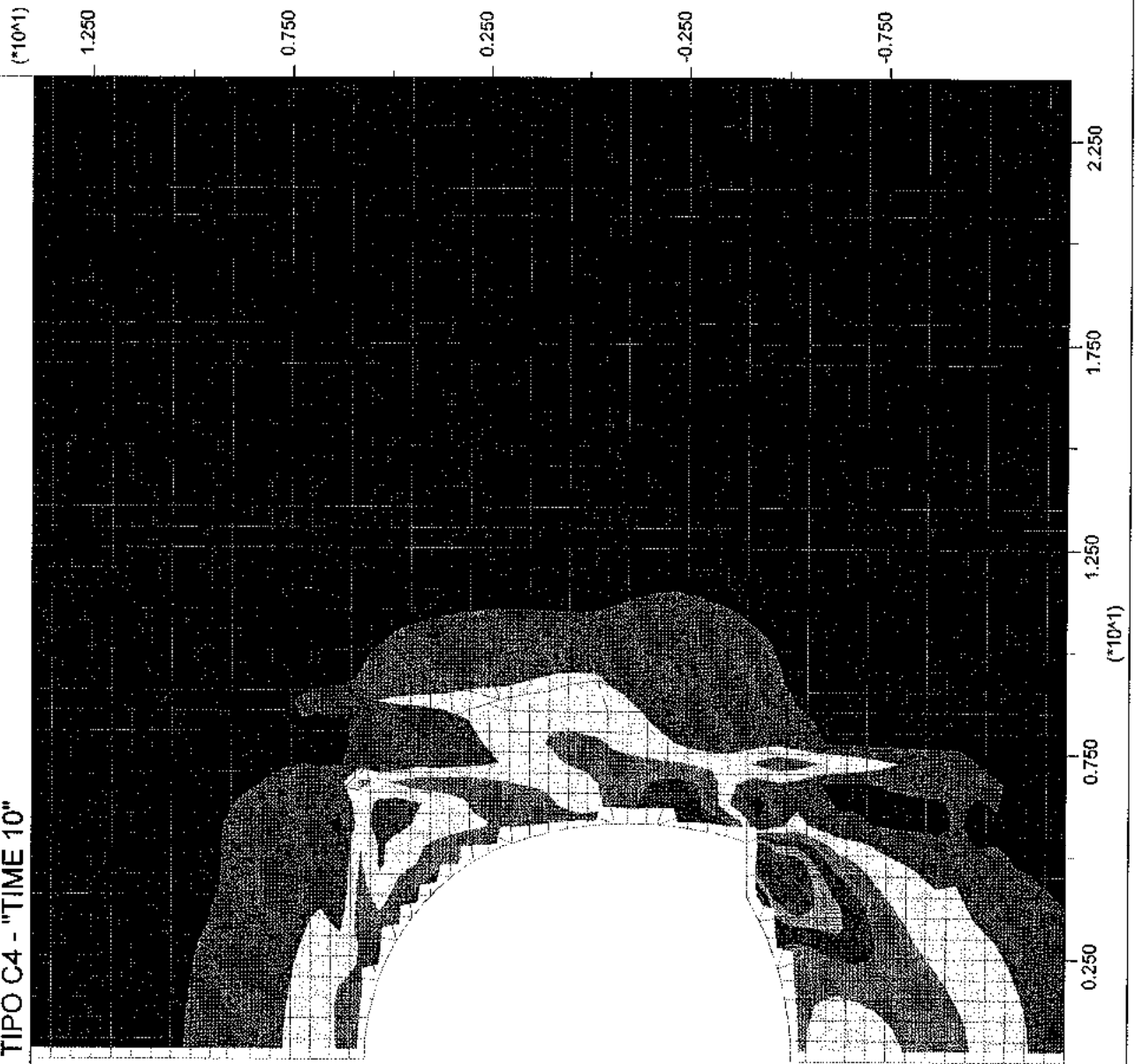
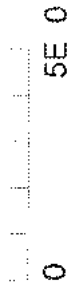
LEGEND

16-Feb-04 12:26
step 31109
-2.00E+00 <x< 2.400E+01
-1.200E+01 <y< 1.400E+01

Max. shear strain increment



Contour interval= 1.00E-02
Deformazioni plastiche per taglio



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Minneapolis, Minnesota USA

JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 10"

FLAC (Version 4.00)

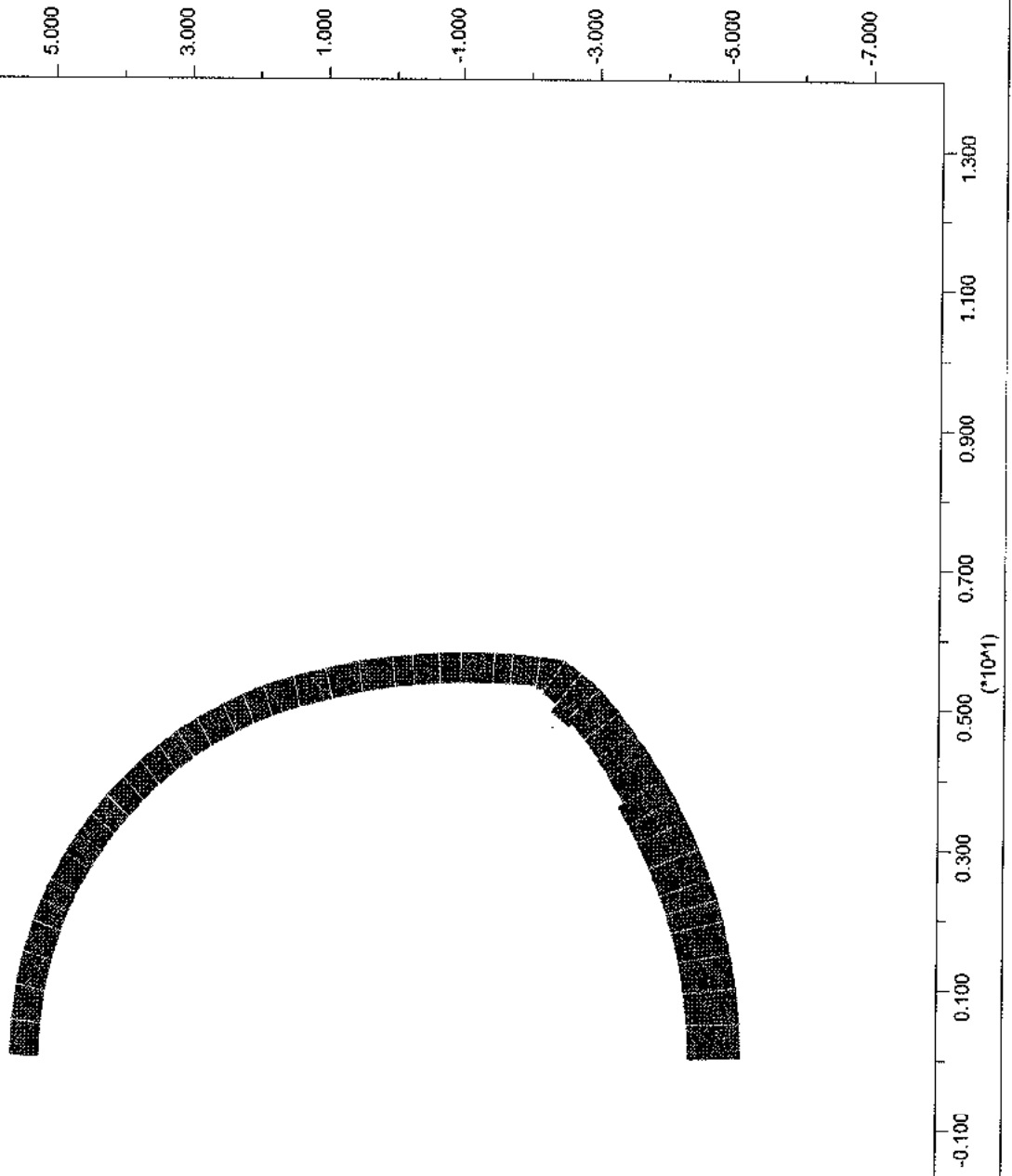
LEGEND

16-Feb-04 12:26
step 31109
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Sforzo normale [N/m]

■ Axial Force on

Structure Max. Value
2 (Beam) 4.126E+06



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JOB TITLE : Cunicolo Castagnola - SEZ. TIPO C4 - "TIME 10"

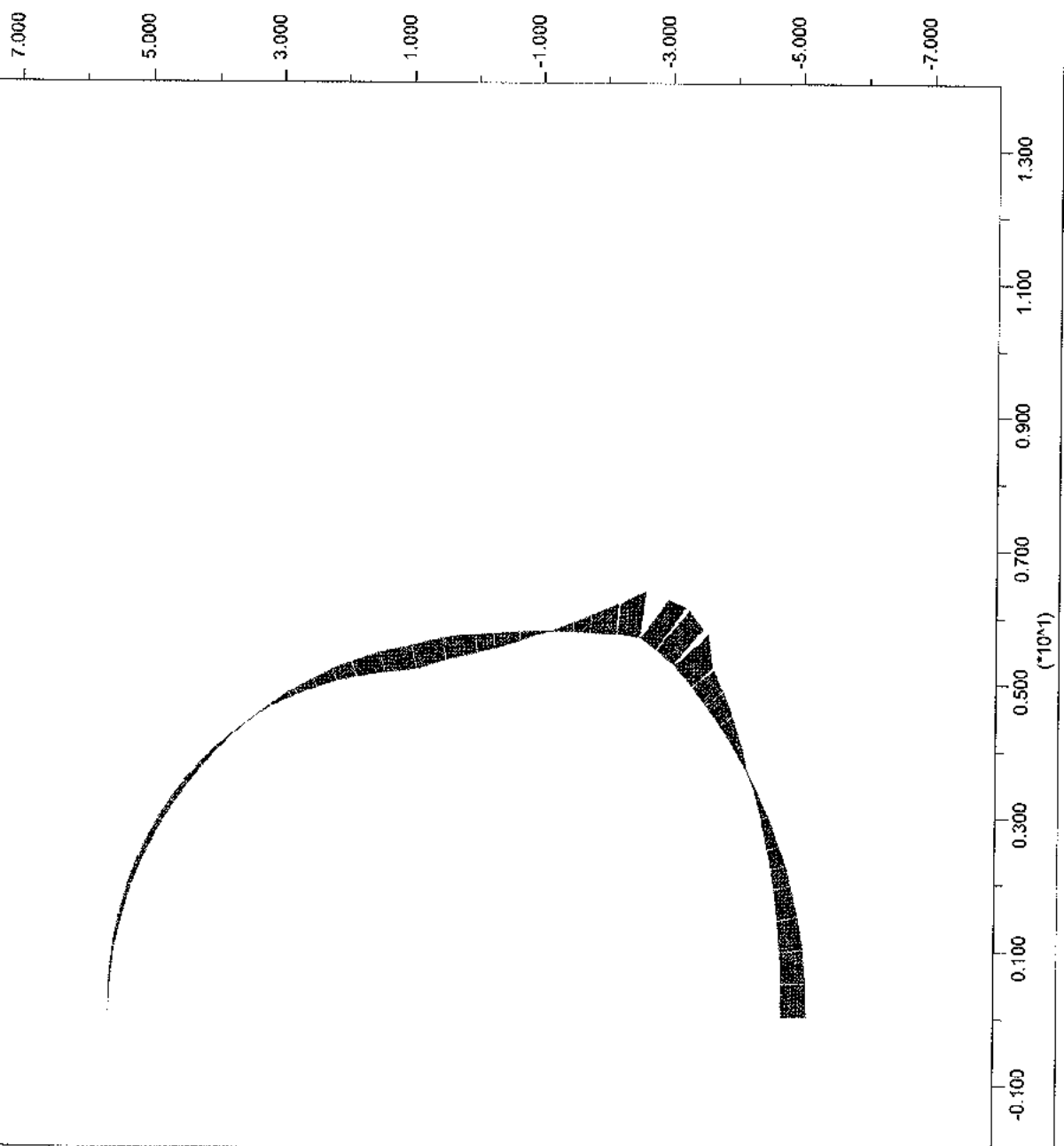
FLAC (Version 4.00)

LEGEND

16-Feb-04 12:26
step 31109
-2.000E+00 <x< 1.400E+01
-8.000E+00 <y< 8.000E+00

Riv. def. - Momento flettente [N*m/m]

 Moment on
Structure Max. Value
2 (Beam) -1.090E+06



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