Concessionaria per la progettazione, realizzazione e gestione del collegamento stabile tra la Sicilia e il Continente Organismo di Diritto Pubblico
(Legge n° 1158 del 17 dicembre 1971, modificata dal D.Lgs. n°114 del 24 aprile 2003)

PONTE SULLO STRETTO DI MESSINA

PROGETTO DEFINITIVO

EUROLINK S.C.p.A.

IMPREGILO S.p.A. (MANDATARIA)
SOCIETÀ ITALIANA PER CONDOTTE D'ACQUA S.p.A. (MANDANTE)
COOPERATIVA MURATORI E CEMENTISTI - C.M.C. DI RAVENNA SOC. COOP. A.R.L. (MANDANTE)
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IL PROGETTISTA	IL CONTRAENTE GENERALE	STRETTO DI MESSINA	STRETTO DI MESSINA
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Unità Funzionale	OPERA DI ATTRAVERSAMENTO	PS0004_F0
Tipo di sistema	SOVRASTRUTTURE	
Raggruppamento di opere/attività	ELEMENTI DA CARATTERE GENERALE	
Opera - tratto d'opera - parte d'opera	Generale	
Titolo del documento	Modello Semi-Locale IBDAS, torri	

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REV	DATA	DESCRIZIONE	REDATTO	VERIFICATO	APPROVATO
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INDICE

Elenco delle Appendici

1 Introduzione

1.1 Scopo

Scopo della presente relazione è quello di presentare e descrivere il modello semi locale preparato per le torri durante il Progetto Definitivo.

1.2 Struttura della relazione

La presente relazione si compone dei seguenti capitoli:

- Il Cap. 1 comprende l'introduzione ed elenca i riferimenti incluse le specifiche e le norme di progetto
- Il Cap. 2 descrive il modello IBDAS Globale
- Il Cap. 3 descrive la rigidità degli Elementi ed i pesi aggiunti al modello di analisi
- Il Cap. 4 indica i risultati selezionati

1.3 Riferimenti

Lo stesso modello semi-locale fa parte del modello di analisi globale.

La presente relazione fornirà esclusivamente le informazioni supplementari necessarie per il modello semi-locale. Per informazioni dettagliate sul modello di analisi globale fare riferimento alla relazione preparata per la relazione di analisi IBDAS Globale, “CG1000-P-RG-D-P-SV-00-00-00-00-00-01”, del 28 ottobre 2010.

1.3.1 Specifiche di Progetto

[1] CG1000-P-RG-D-P-GE-00-00-00-00-00-02 “Manuale applicativo riferito ai fondamenti progettuali”, 11 Ottobre 2010.

2 Descrizione del modello Semi-Locale delle Torri

Il presente capitolo descrive il modello FEM globale usato per l'analisi Semi Locale delle torri.

Il modello semi-locale è incluso nel modello di analisi globale nel senso che per la maggior parte del ponte viene usato il modello globale (travi), mentre per alcune parti selezionate viene usata una modellazione più dettagliata con elementi shell e diaframmi. Ciò garantirà delle condizioni a margine corrette per il modello dettagliato.

Il termine “semi locale” al posto del termine “locale” viene usato per richiamare l'attenzione sul fatto che alcuni dettagli potrebbero non essere modellati con precisione. Qui di seguito verrà chiarito il livello di dettaglio del modello shell semi locale.

2.1 Geometria.

Il modello semi locale viene posizionato attorno al 2° traverse ed alle sezioni adiacenti delle gambe delle torri.

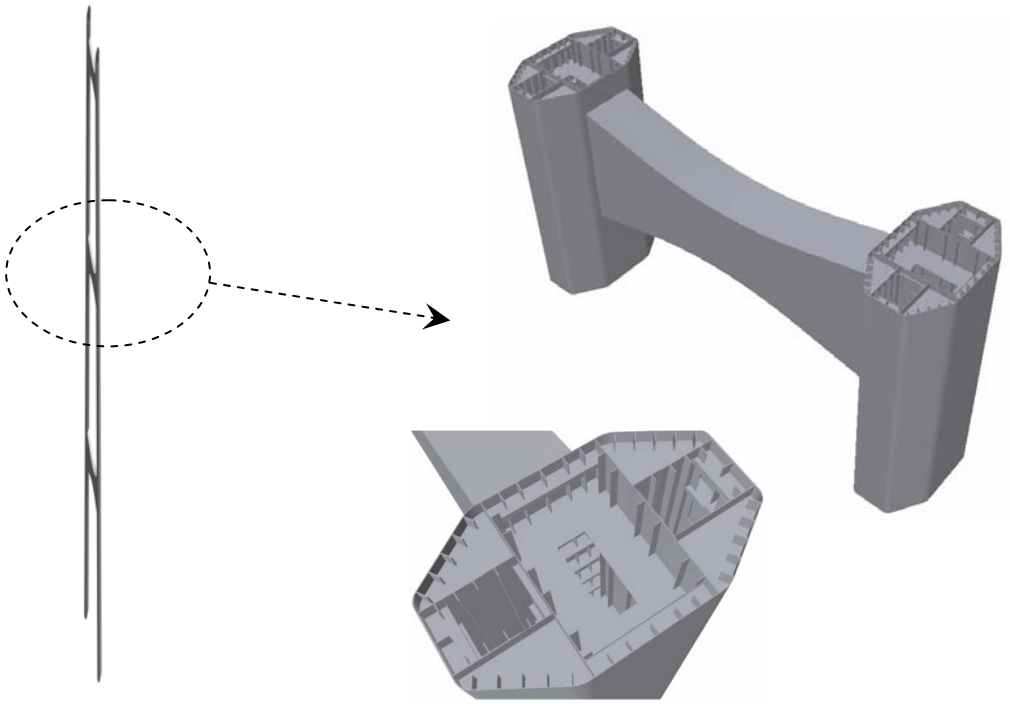


Figura 2.1: Ponte sullo Stretto di Messina, modello della geometria del modello semi locale delle torri.

Le gambe delle torri sono modellate in modo geometricamente corretto con tutti gli acciai longitudinali. I diaframmi ed i telai trasversali nelle gambe delle torri vengono modellati con una geometria piuttosto corretta come mostrato sui disegni di progetto ad eccezione dei cut-out circolari nelle quattro piastre angolari.

I traversi vengono modellati correttamente per la carpenteria longitudinale, ma con gli irrigidimenti situati in maniera leggermente diversa come risulta dai disegni di progetto. I diaframmi nel traverso vengono modellati con una piastra in acciaio piena di spessore costante, tenendo conto del peso globalmente distribuito.

2.2 Sistemi di coordinate

2.2.1 Sistema globale delle coordinate

Il sistema globale delle coordinale usato per indicare ad esempio spostamenti e reazioni è un sistema sinistrorso così definito:

- l'asse **S** (1^ asse) si estende lungo la linea di mezzeria del ponte, positiva verso la Calabria, s=0 si trova al centro della campata principale.
- l'asse **Y** (2^ asse) è ortogonale rispetto all'asse **S** e all'asse **Z** formando un sistema di coordinate sinistrorso. L'asse Y si estende quindi in orizzontale trasversalmente alla linea di mezzeria del ponte.
- l'asse **Z** (3^ asse) è verticale e si estende positiva verso l'alto, zero ad un'elevazione 0,00 secondo i disegni di progetto.

Il sistema globale delle coordinate è indicato in Figura 2.2.

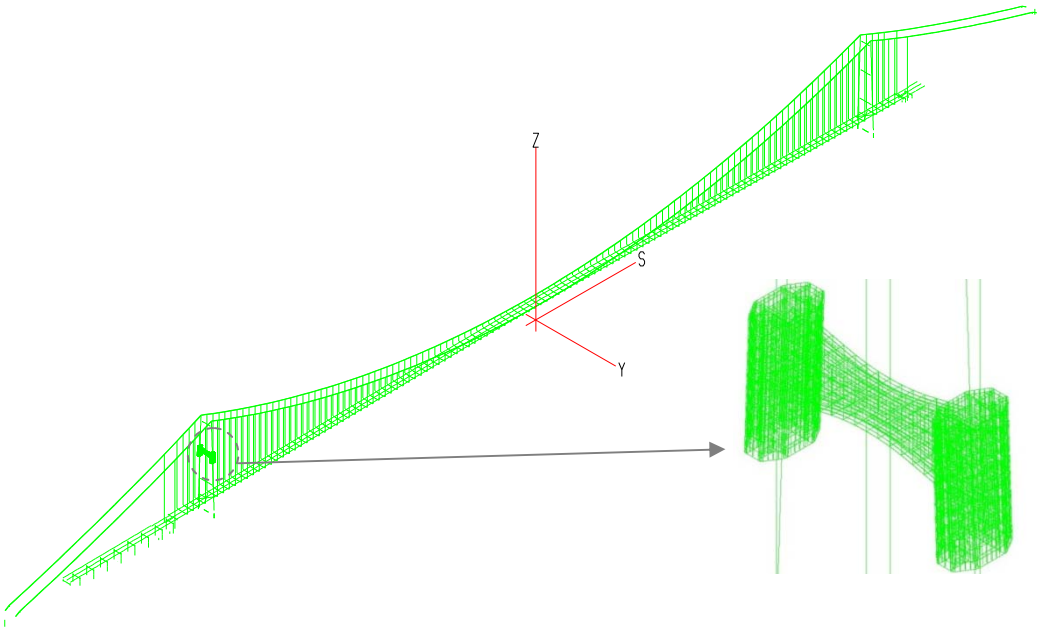


Figura 2.2: Sistema di coordinate sinistrorso globale usato nel modello IBDAS. Il diagramma mostra inoltre l'intero modello FEM nonché il modello semi locale selezionato per la Torre Sicilia.

2.2.2 Sistemi delle coordinate degli elementi

I diagrammi che seguono mostrano i sistemi di coordinate solo per gli elementi shell del modello semi locale. I sistemi delle coordinate sono tutti sistemi sinistrorsi. Tali sistemi vengono usati per indicare le azioni degli elementi quali le sollecitazioni generalizzate (forze delle sezioni).

Tutti gli elementi hanno sempre l'asse s lungo l'elemento positiva verso l'alto per le gambe delle torri e positiva verso l'asse y globale. L'asse y degli elementi shell è trasversale rispetto all'asse s sul piano dell'elemento e l'asse z è ortogonale rispetto all'elemento.

I sistemi delle coordinate sono illustrati nella figura seguente

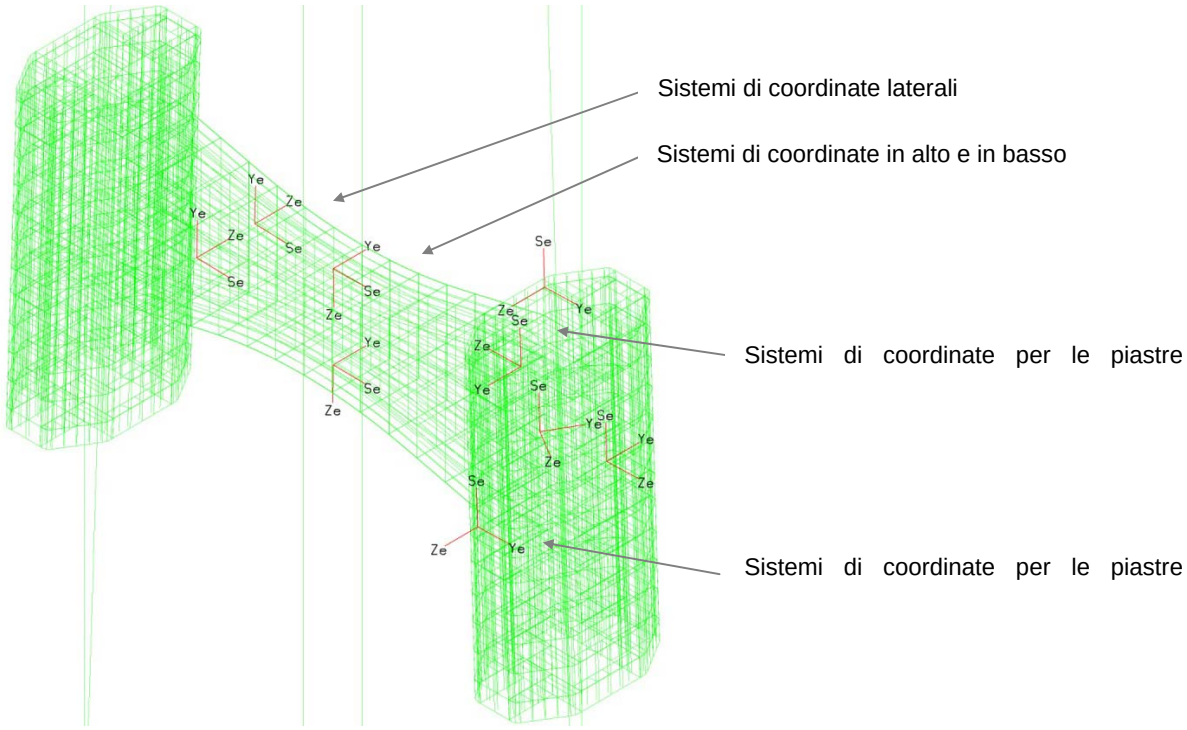


Figura 2.3: Sistemi di coordinate degli elementi (sinistrorsi) nelle gambe e nei traversi delle torri.

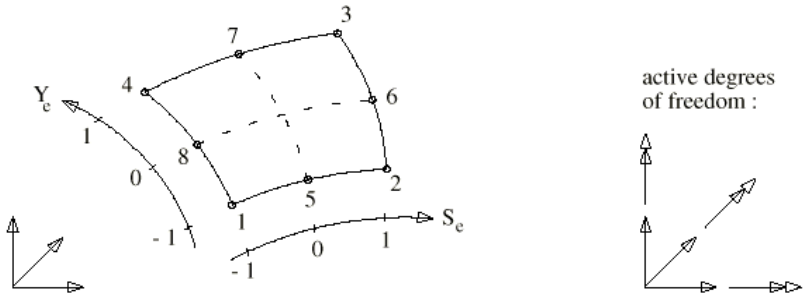
2.3 Elementi

Gli elementi IBDAS usati nel modello globale sono tutti elementi 3D isoparametrici di travi o controventi. Gli elementi shell vengono usati nel modello semi locale.

Generalmente, tutti gli elementi in acciaio strutturali vengono modellati usando elementi di trave parabolici a tre nodi (IBDAS BEAM18) con 6 gradi di libertà in ciascun nodo, dove si tiene conto delle deformazioni di taglio.

I cavi dei pendini ed i cavi principali vengono modellati con elementi di controvento a due nodi (IBDAS TRUSS6) con 3 gradi di libertà in ciascun nodo.

Gli elementi shell incorporati nel modello semi locale usano elementi shell a 8 nodi (IBDAS SHELL48) con 8 gradi di libertà in ciascun nodo, dove si tiene conto delle deformazioni di taglio fuori piano.



gradi di libertà attivi

2.4 Condizioni di supporto

Le condizioni di supporto del ponte sono uguali a quelle descritte per il modello di analisi globale.

3 Rigidità, Masse e Pesi

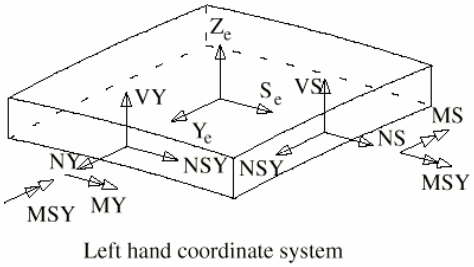
3.1 Masse e Pesi

La diversa gestione dei pesi tra il modello globale ed il modello semi locale consiste nel fatto che i diaframmi vengono modellati nel modello semi locale senza quindi aggiunta del peso per i diaframmi in corrispondenza della parte modellata con elementi shell.

3.2 Segni convenzionali

I segni delle forze usati nell'IBDAS sono indicati più sotto .

I segni delle risultanti delle sollecitazioni in un elemento infinitesimale attorno ad un punto gaussiano di un elemento shell sono indicati nella figura seguente . Il modello di analisi e quindi i risultati si basano sul sistema di coordinate sinistrorso. E' tuttavia da notare che esso si applica in generale e che un momento positivo attorno ad un'asse trasversale genera compressione sul lato superiore del guscio.



Sistema di coordinate sinistrorso

Figura 3 Risultati nel punto di sollecitazione per l'elemento shell spaziale. Viene mostrato un elemento infinitesimale attorno ad un punto di sollecitazione.

4 Risultati ottenuti dal modello semi locale

I risultati dettagliati ottenuti dal modello semi locale verranno, ove possibile, presentati nelle varie relazioni di progetto. La presente relazione contiene solo risultati selezionati e spiega ciò che è stato analizzato.

Onde evitare effetti terminali vicino alla transizione tra le sezioni di beam e le sezioni di shell, i risultati sono validi solo ad una certa distanza dalla transizione, vale a dire a distanza di un diaframma.

Vengono così ottenuti diagrammi di profilo e diagrammi dei valori di sollecitazione.

Il numero dei casi di carico tracciati è molto limitato in modo da limitare il numero di diagrammi forniti ai gruppi di progettazione.

Sono stati scelti i seguenti casi di carico:

- Caso 1 (Carico permanente totale) - condizione di riferimento del ponte
- Caso 6902 (involucro ULS)
- Caso 6931 (involucro SILS)

4.1 Diagrammi di profilo

I risultati di questo tipo ricavati dal modello semi locale e riportati al gruppo di progettazione vengono forniti sotto forma di diagrammi che indicano:

* diagrammi di profilo delle sollecitazioni sss, syy e ssy (sia massime che minime)

* diagrammi di profilo delle sollecitazioni Von Mises (sia massime che minime)

In genere, i tipi di diagrammi sopra citati vengono generati per 7 diverse posizioni:

1) Diaframma superiore nel traverso 2
2) Diaframma inferiore nel traverso 2
3) Parete H/G/H (lato campata laterale)
4) Parete A (lato campata laterale)
5) Parete B (lato campata laterale)
6) Parete C (lato campata laterale)
7) Parete D (lato campata laterale)

L'Appendice A contiene i risultati del Caso 1 (Condizione di riferimento) e del Caso 6931 (involucro SILS).

Un diagramma di profilo delle sollecitazioni normali massime nel Caso 1 (carico permanente totale) è illustrato nella figura sotto riportata. Il diagramma viene riportato come esempio delle informazioni che è possibile ottenere usando il modello semi locale.

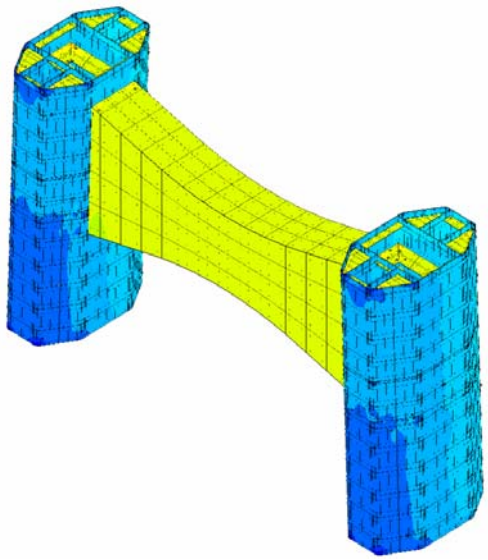


Figura 4.1: Diagramma di profilo – sollecitazioni normali max. (sss) nel Caso 1 (carico permanente totale)

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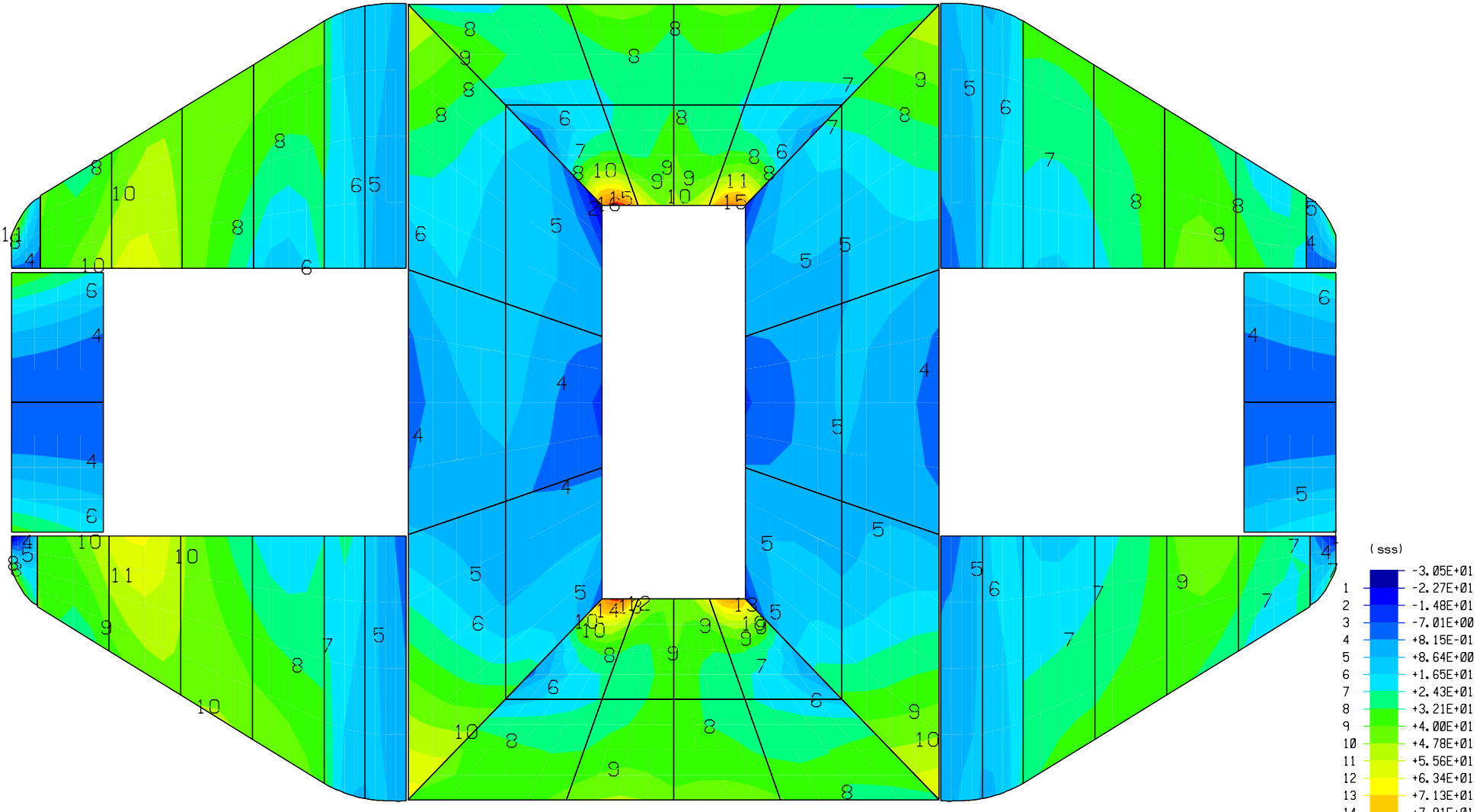

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Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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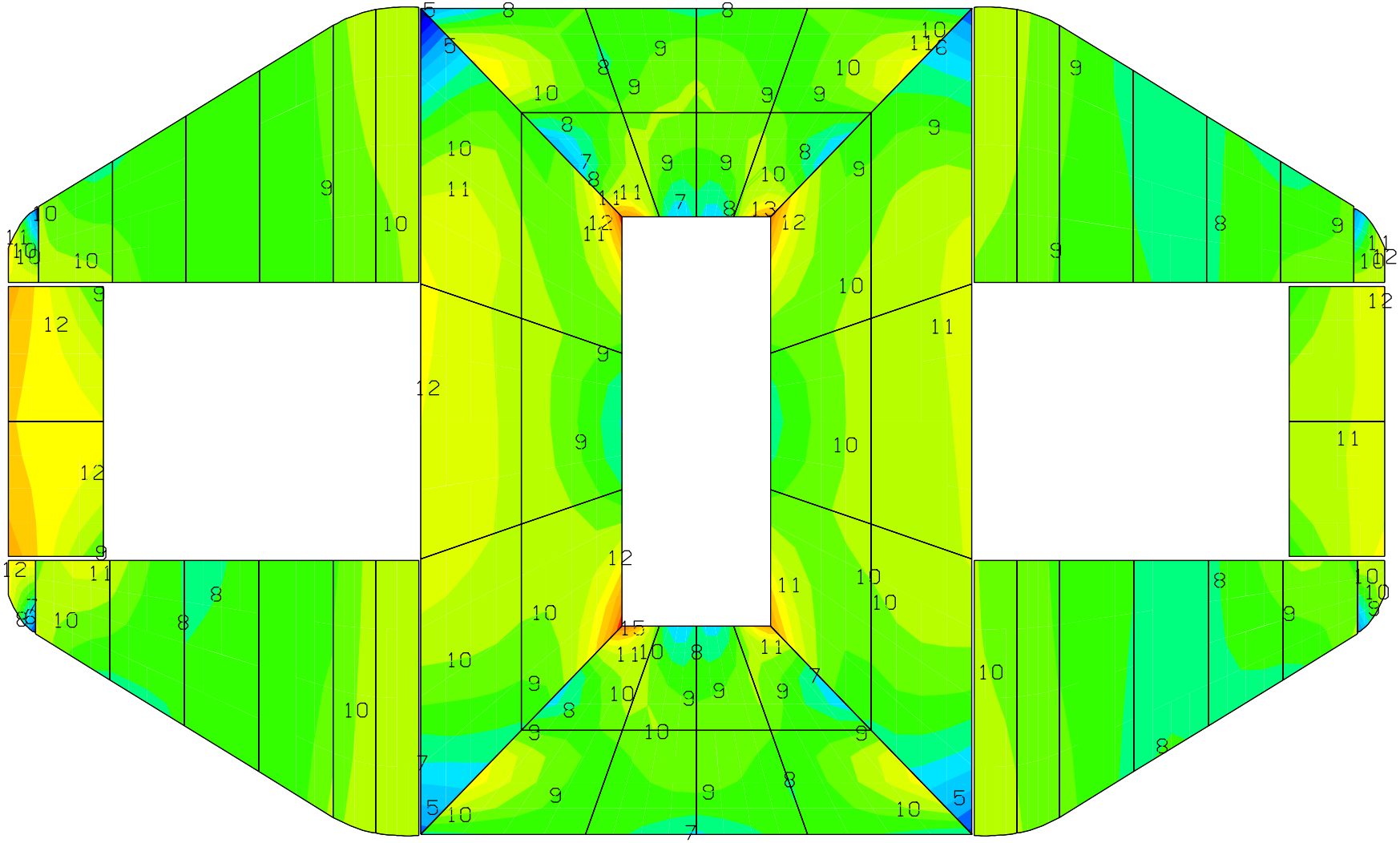

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Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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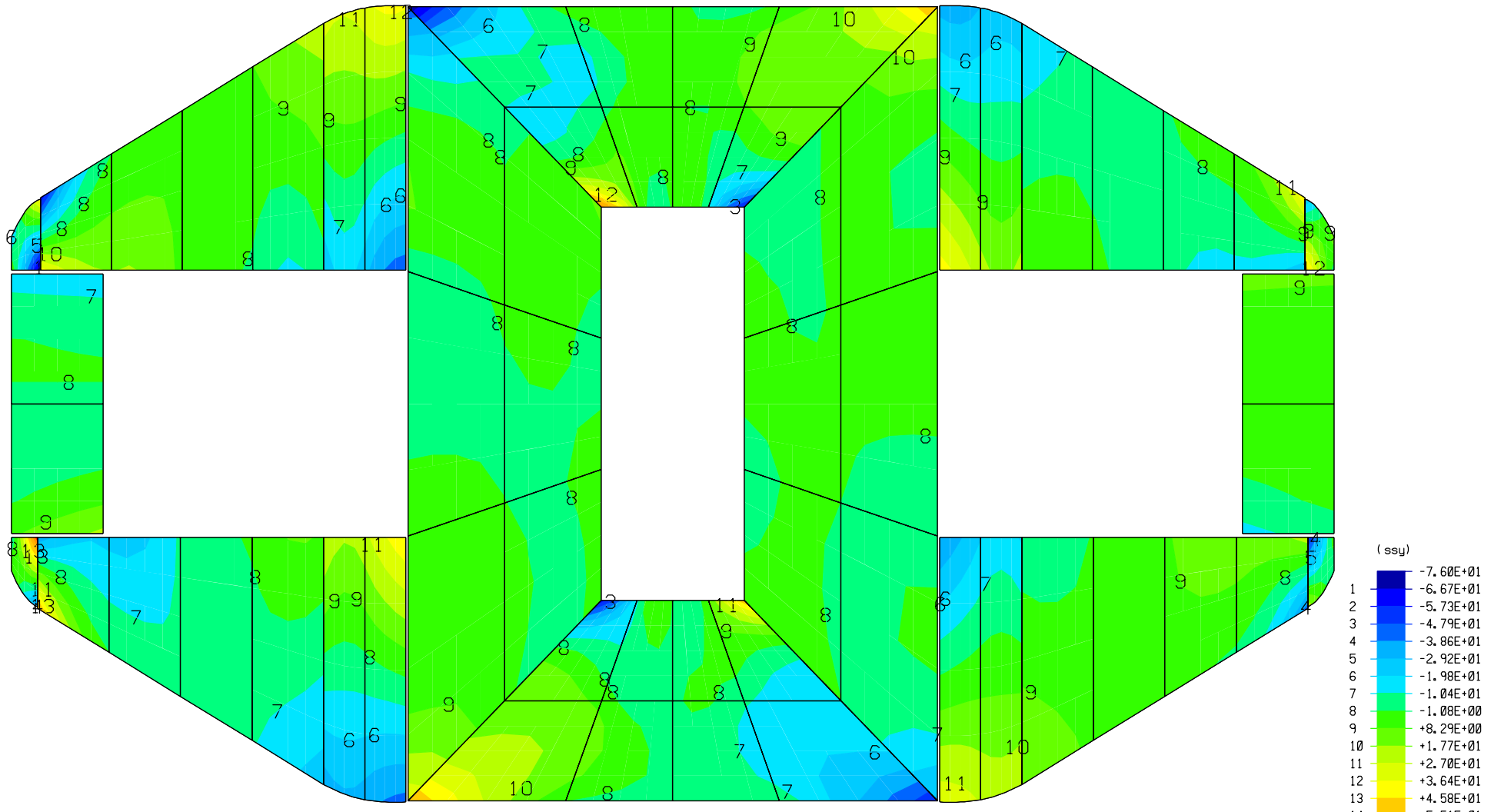

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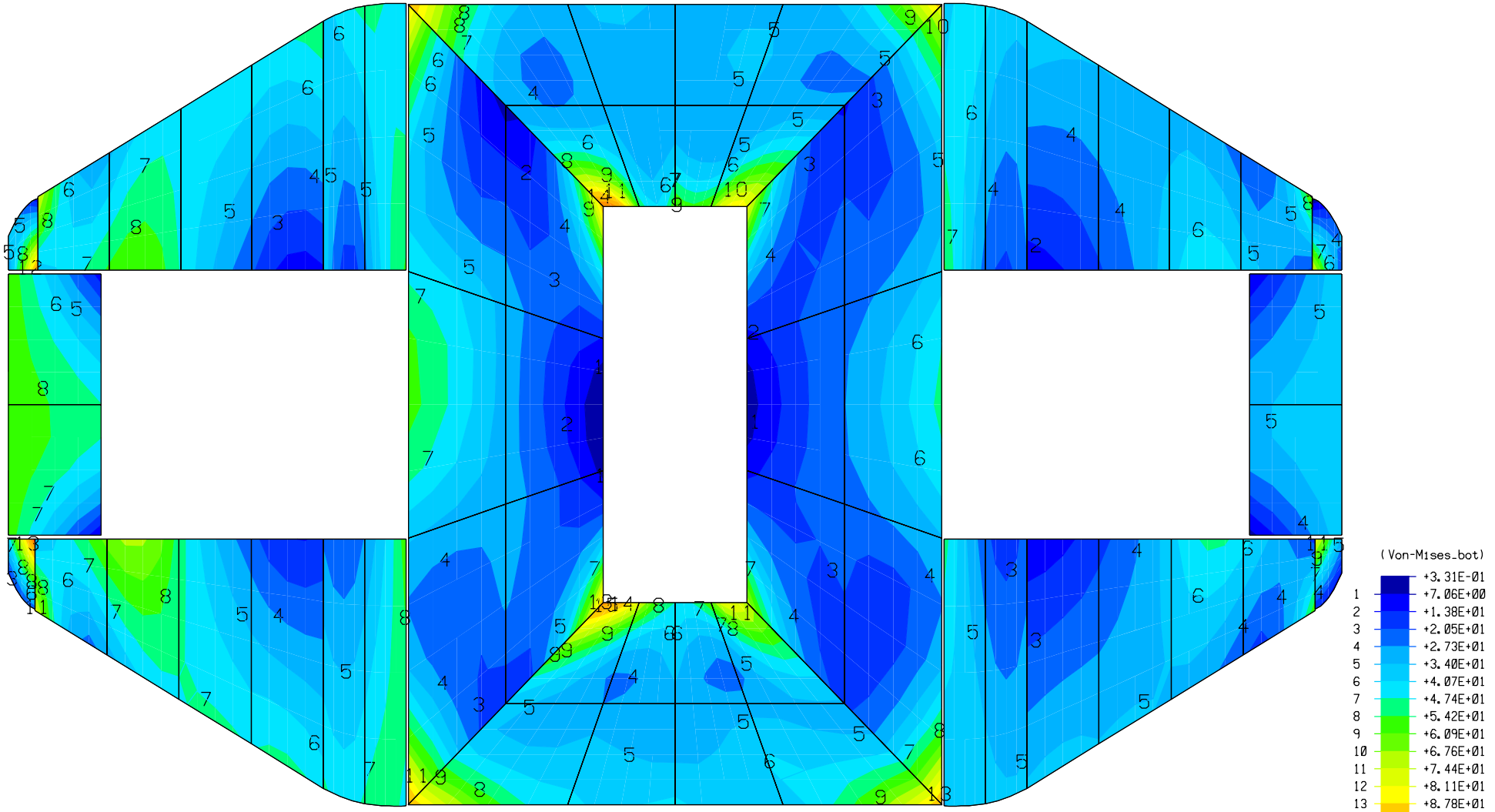

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Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) Von-Mises_bot [MPa] (max) (elastic)

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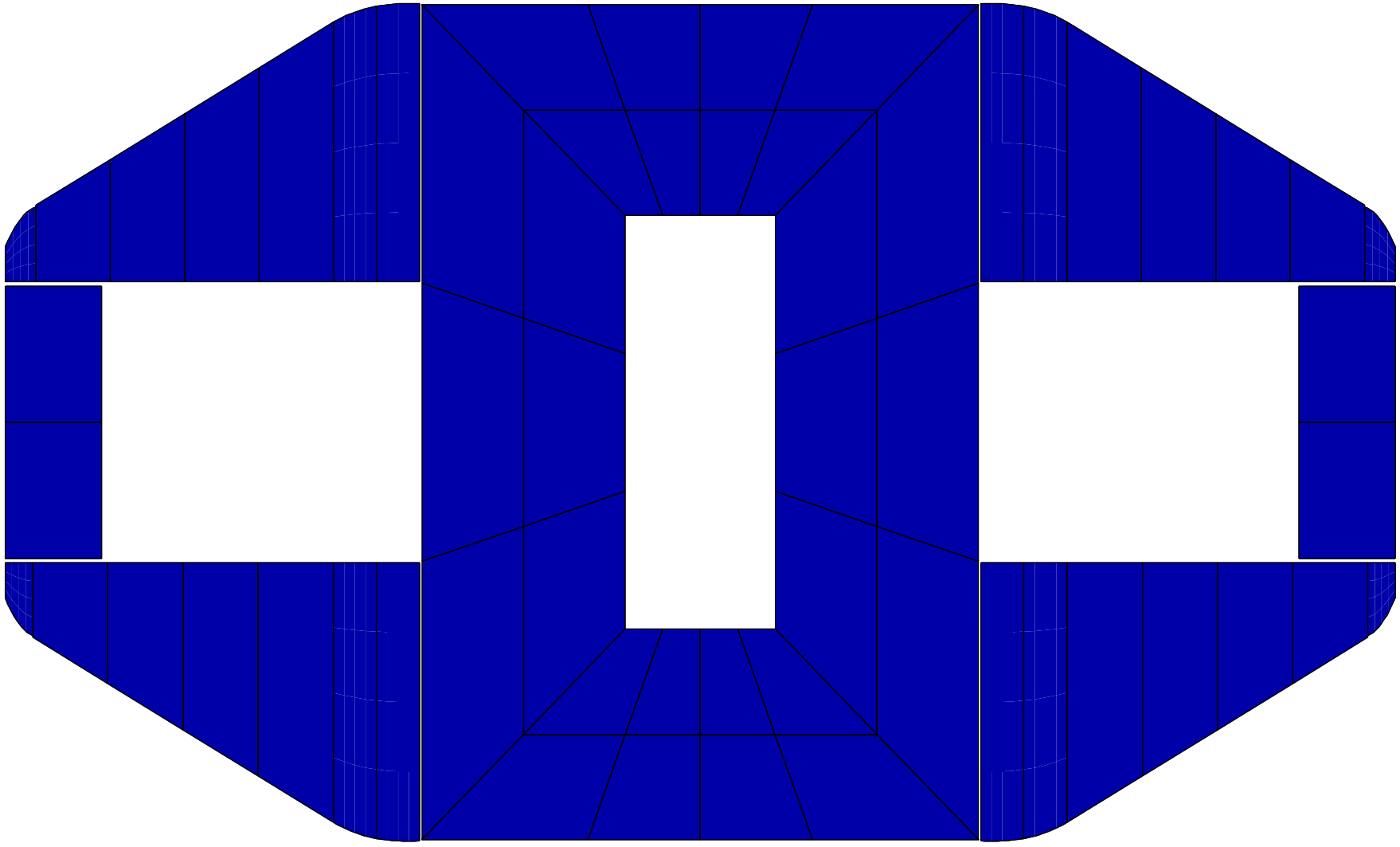

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Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) T [mm]

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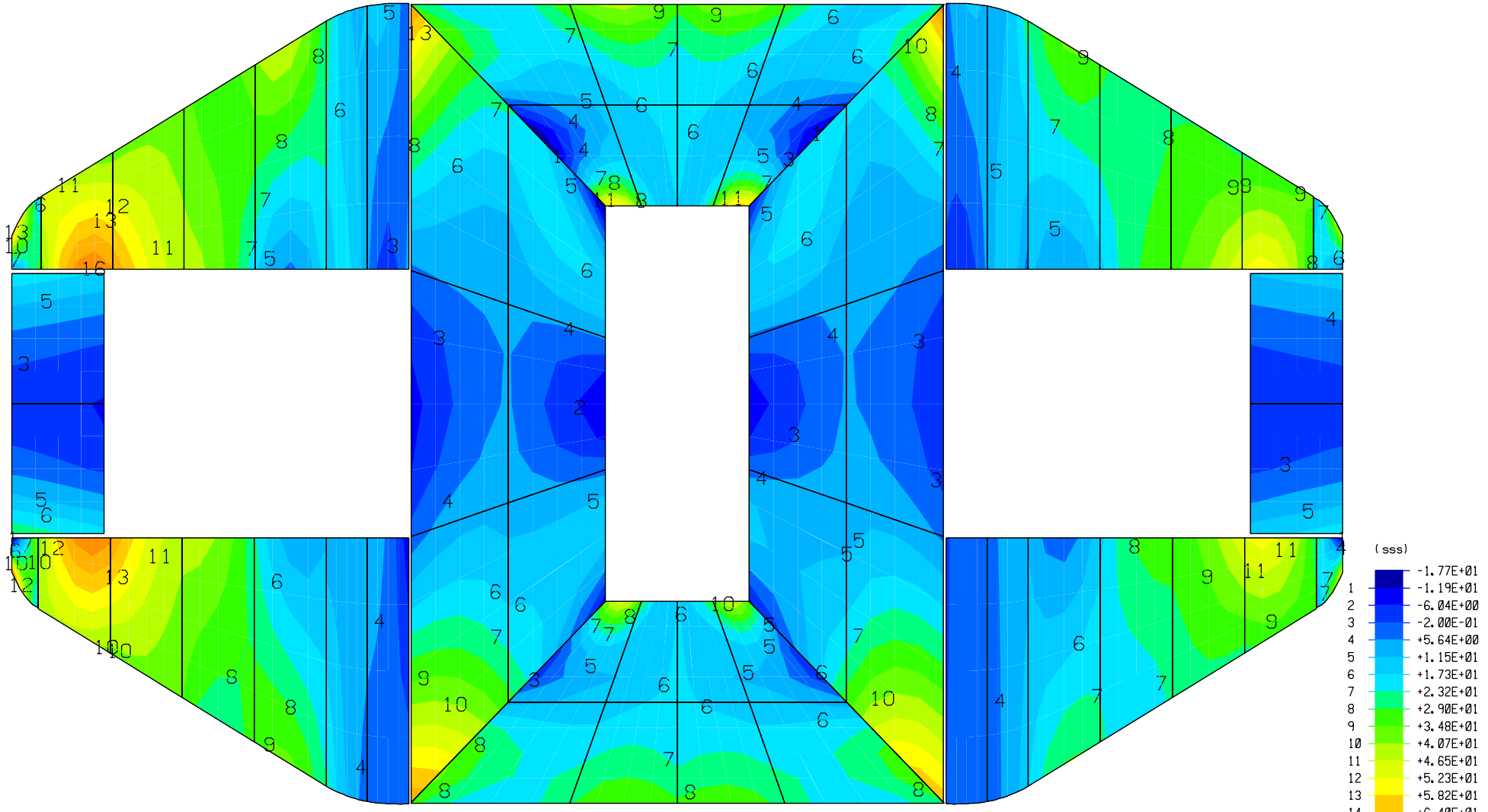

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Lower Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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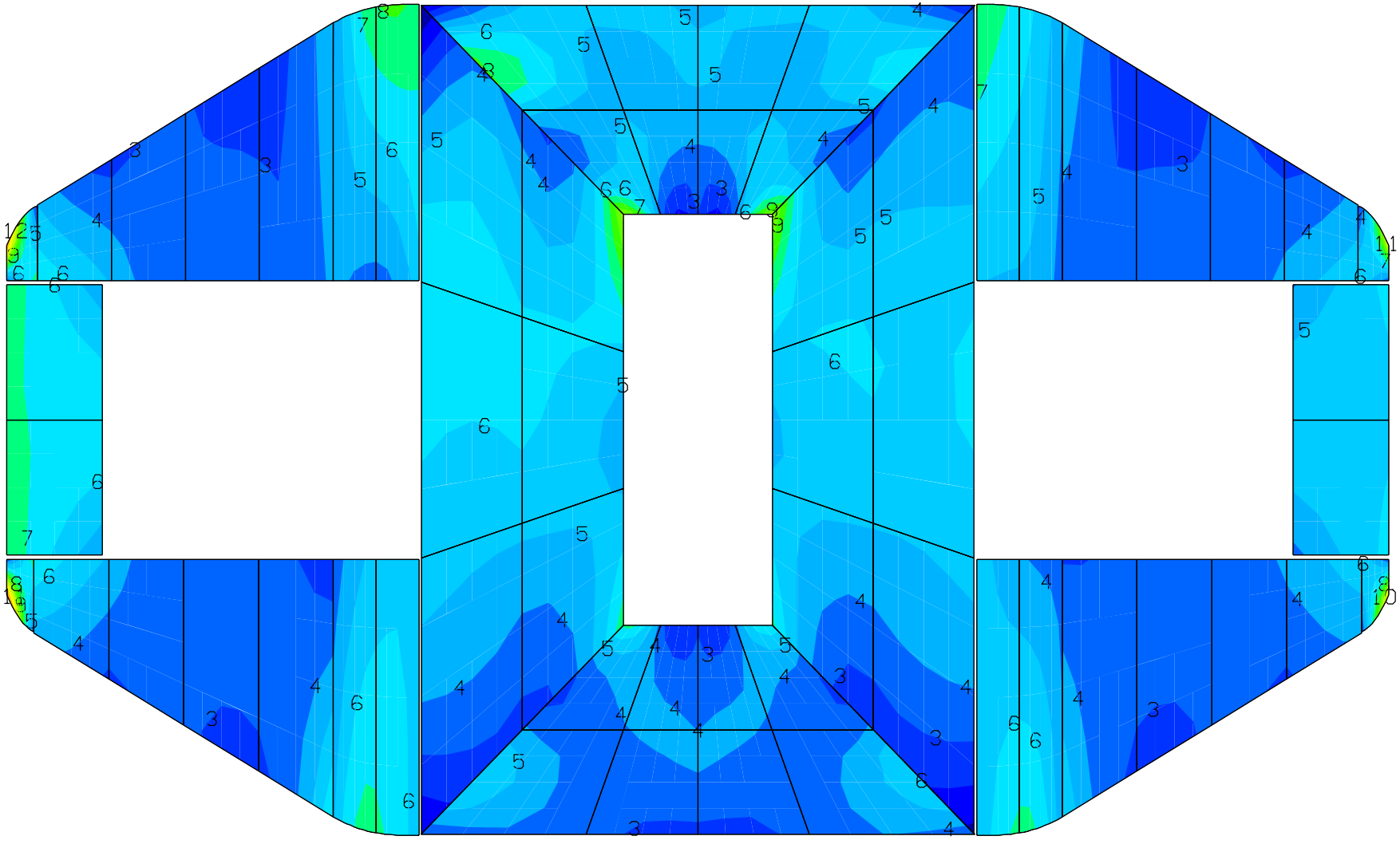

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Lower Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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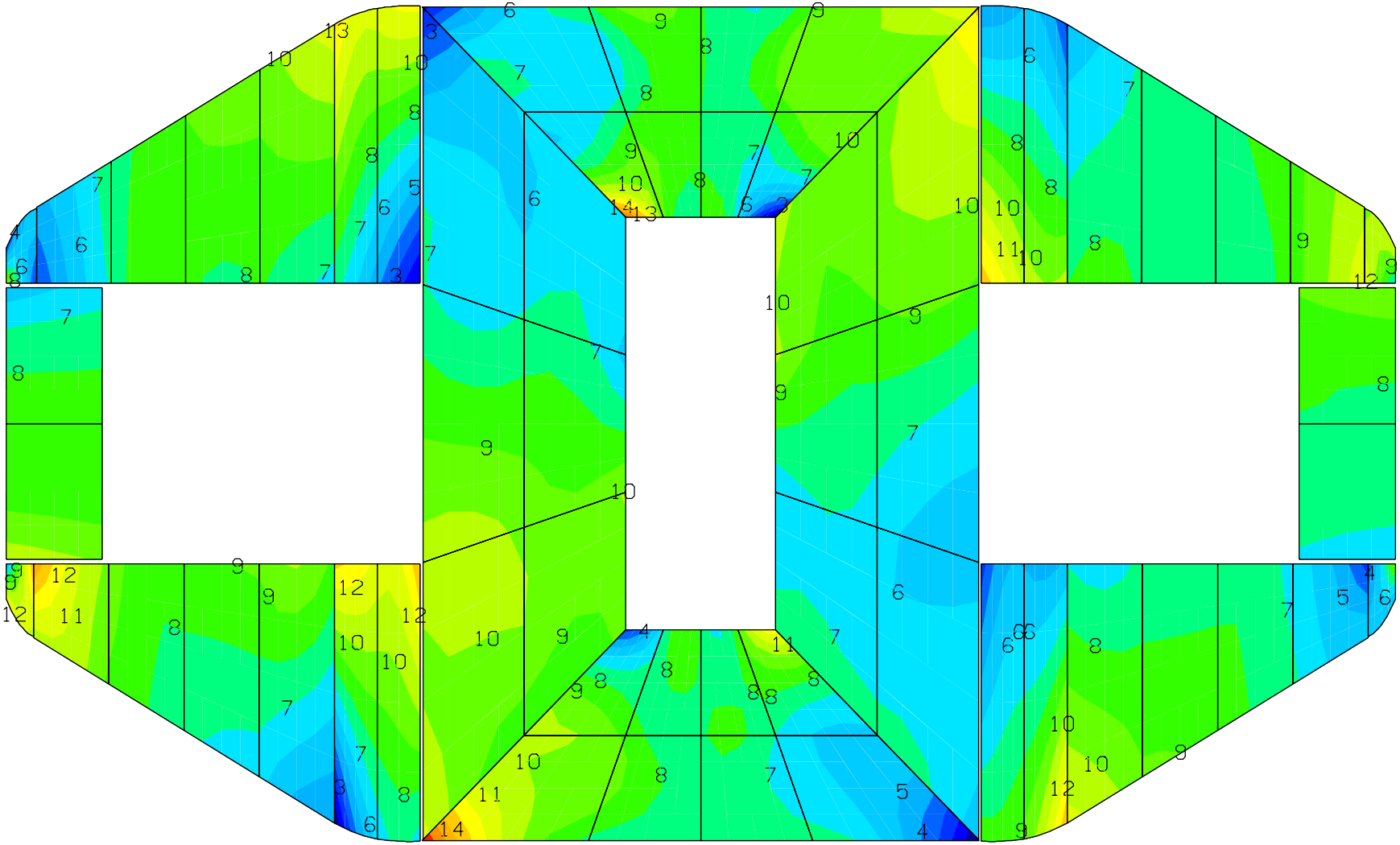

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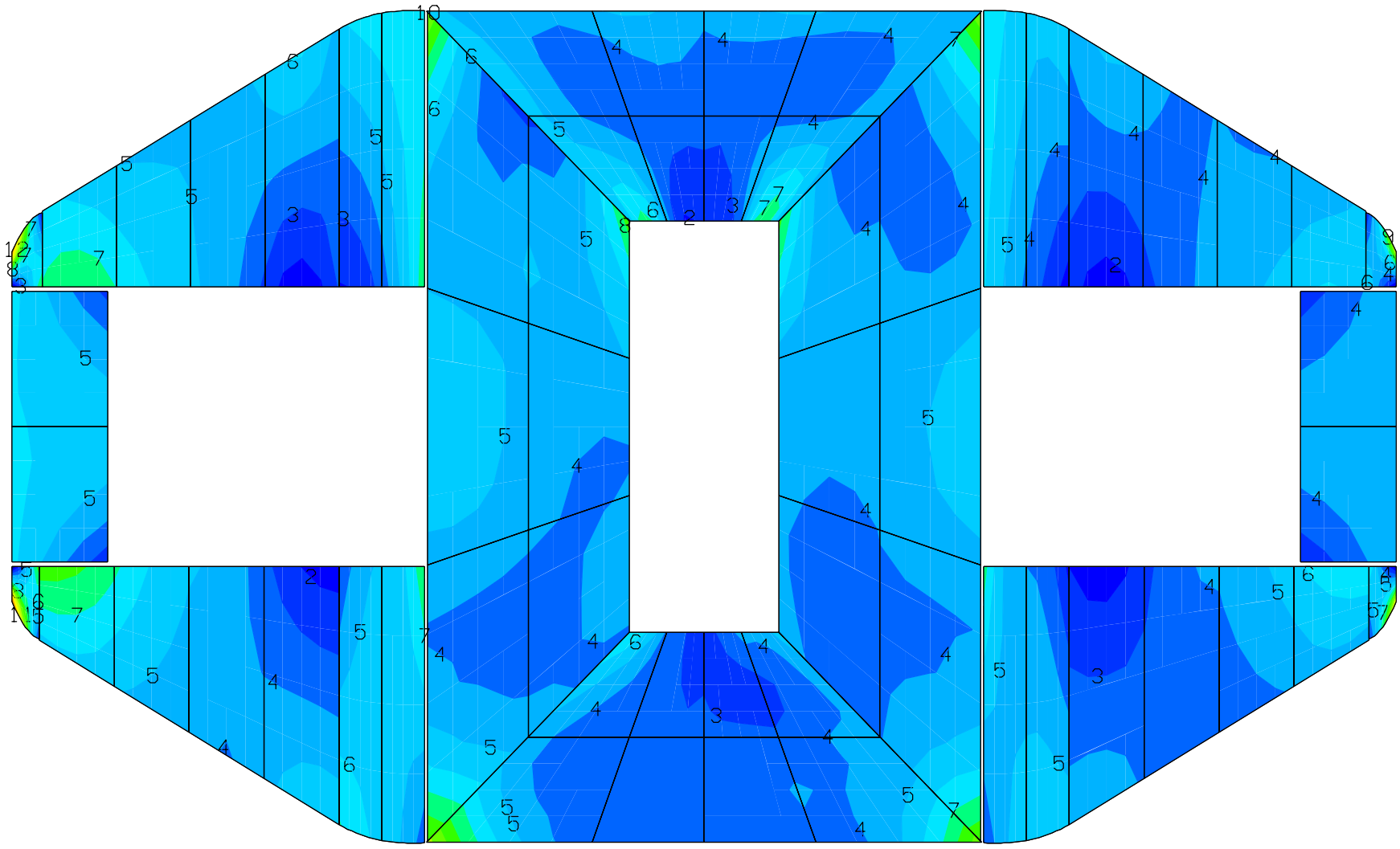

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Lower Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) Von-Mises_bot [MPa] (max) (elastic)

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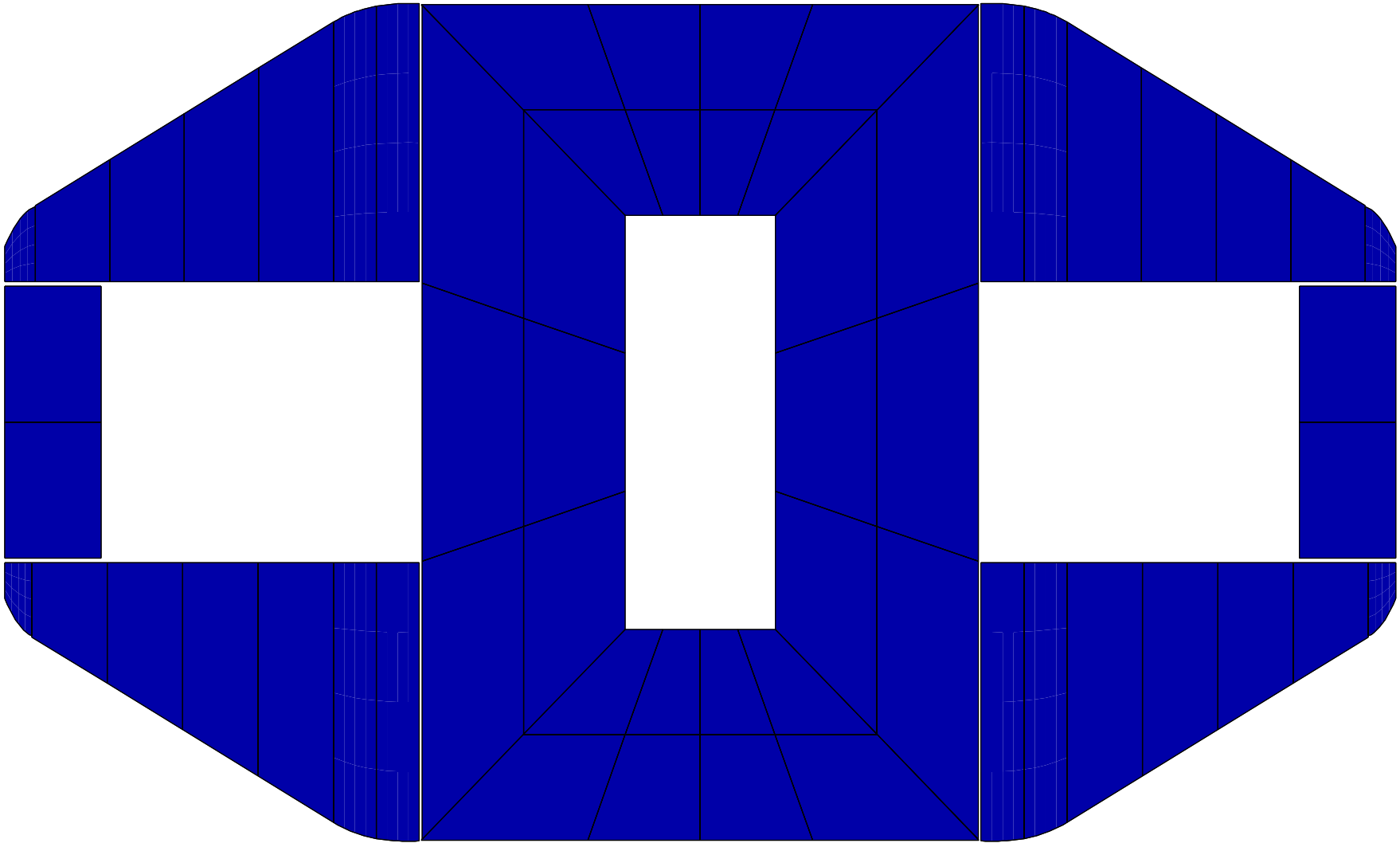

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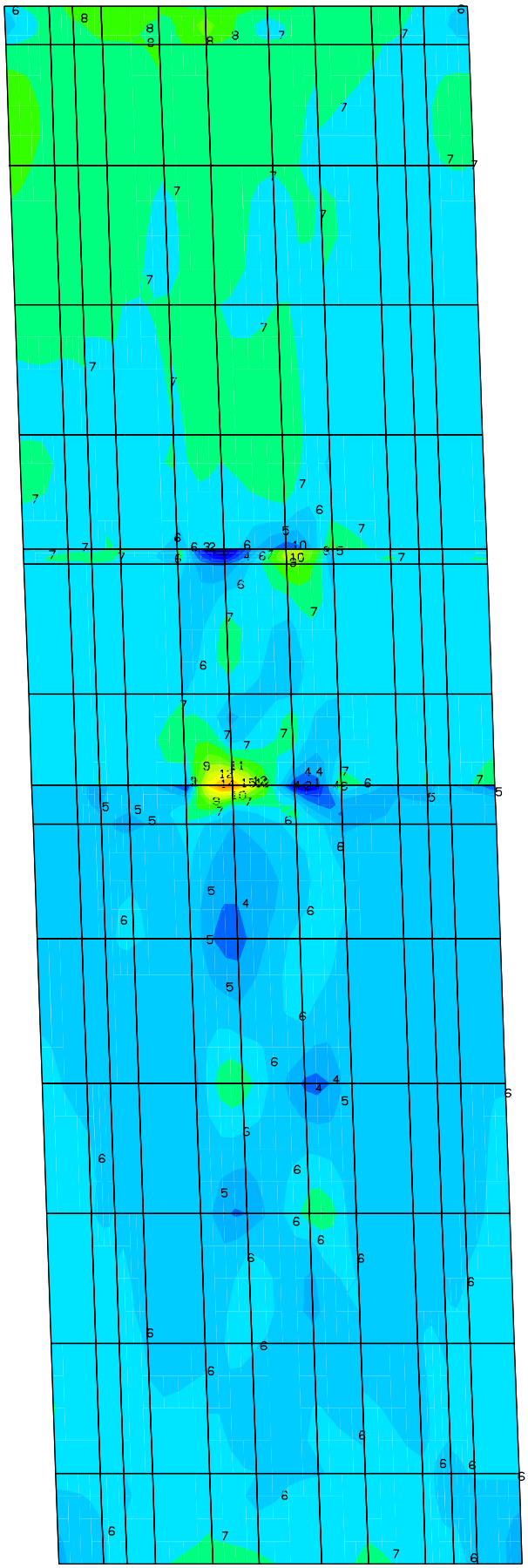
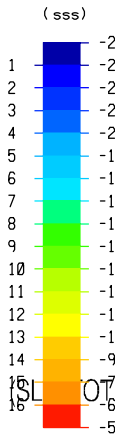
Lower Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) T [mm]





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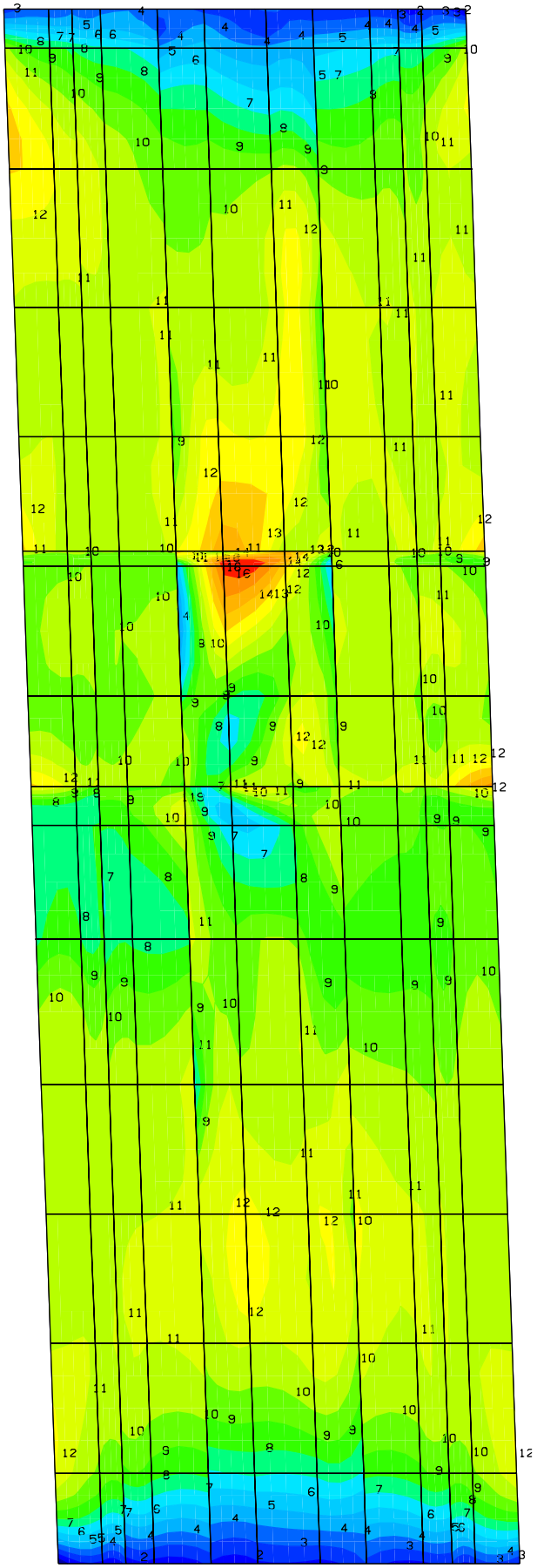

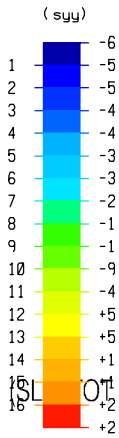

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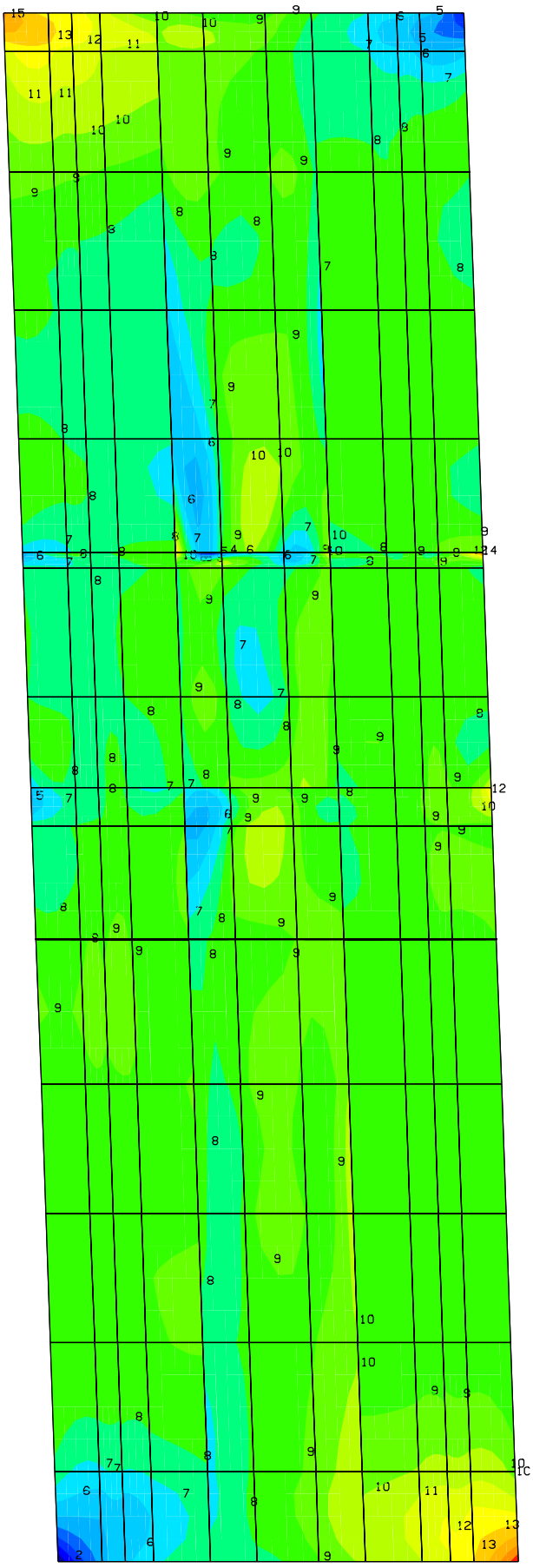

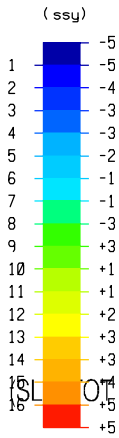

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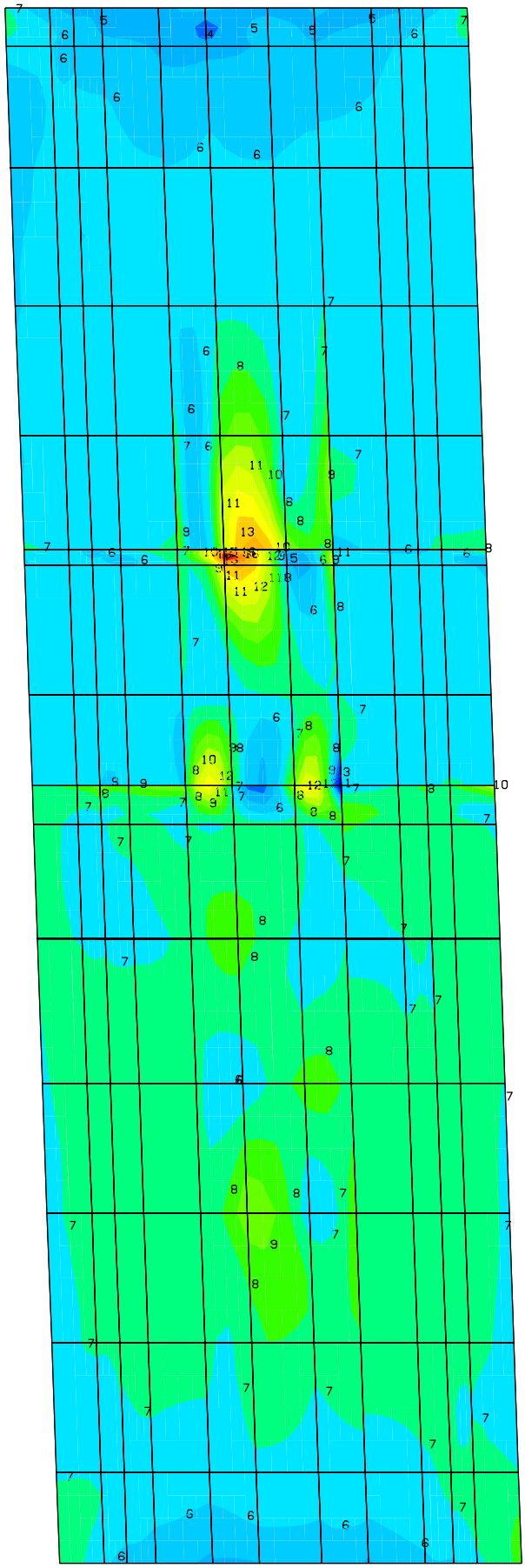
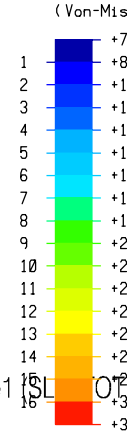
Wall H/G/H (sidespan side) (left view) ssy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)





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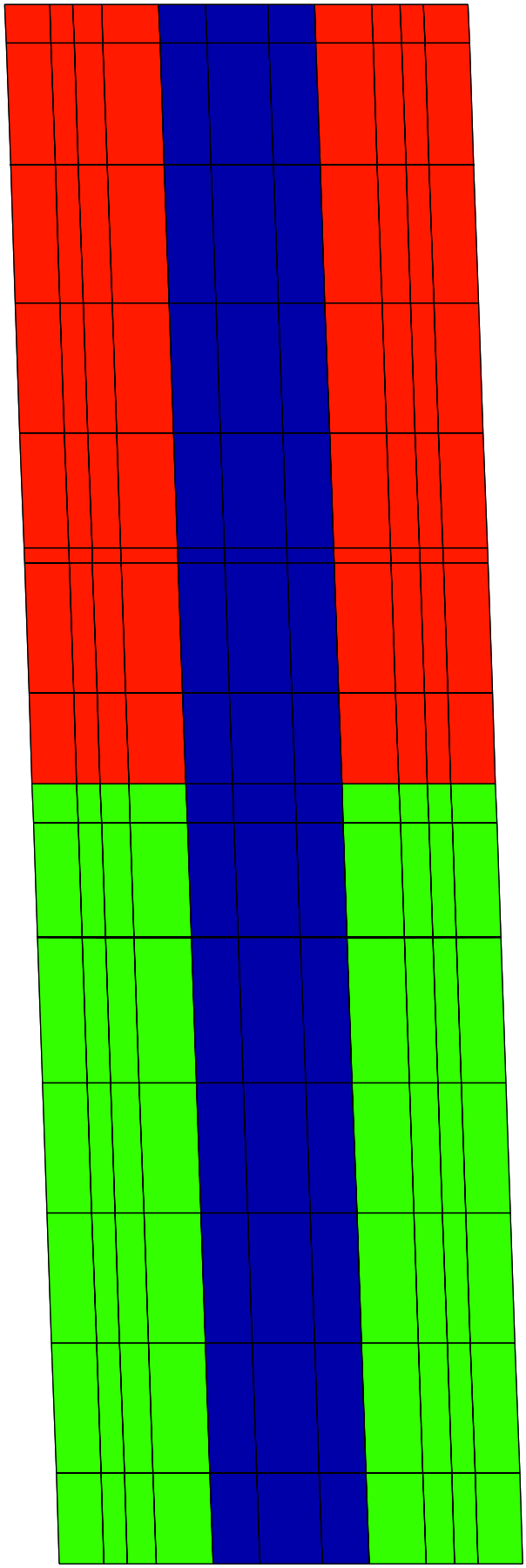
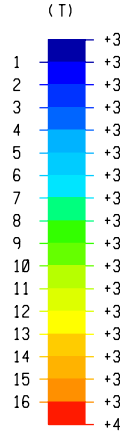
Wall H/G/H (sidespan side) (left view) Von-Mises_bot [MPa] (max) (elastic)





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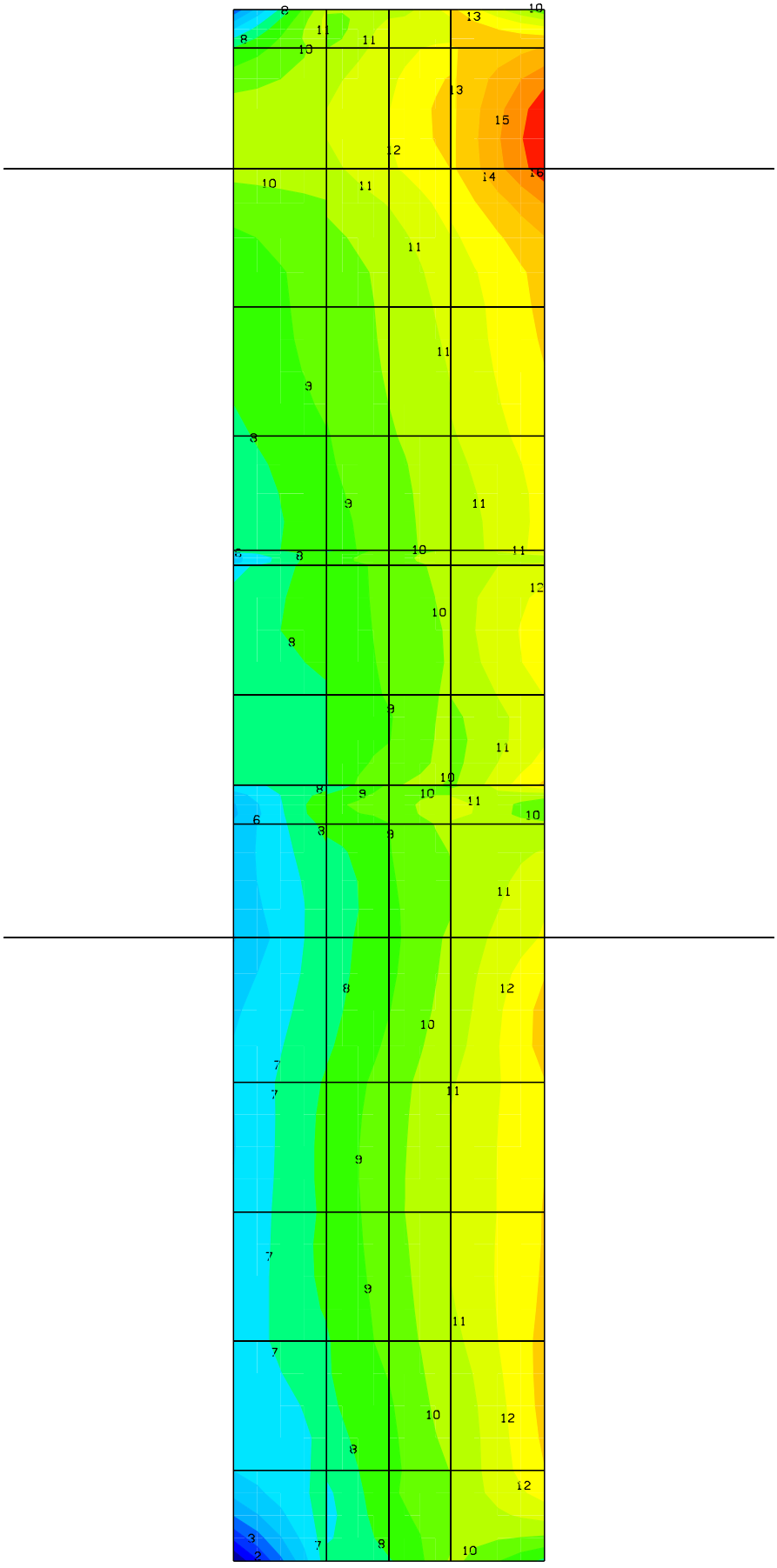
Wall H/G/H (sidespan side) (left view) T [mm]



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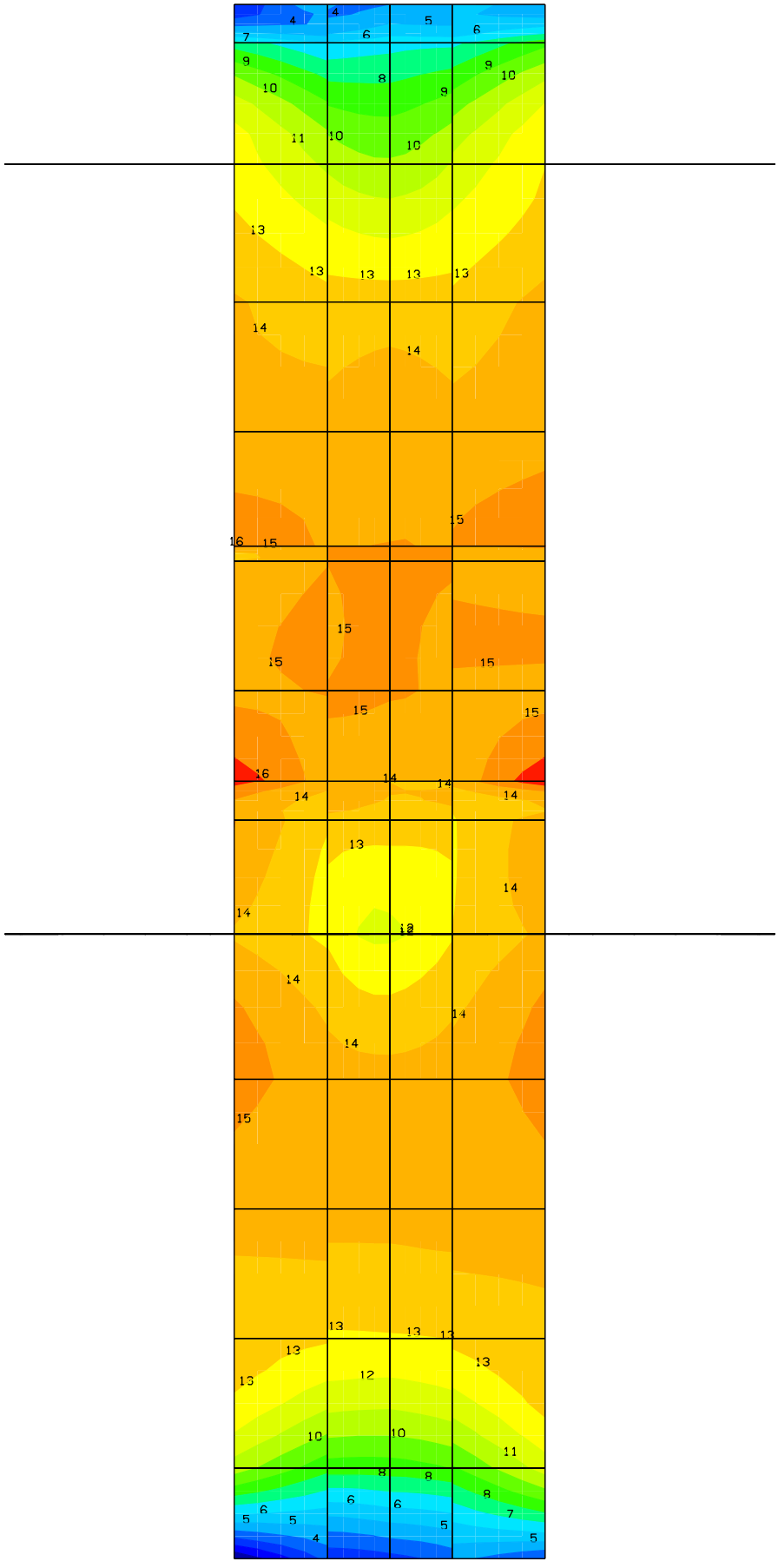
Wall D (cross beam side) (front view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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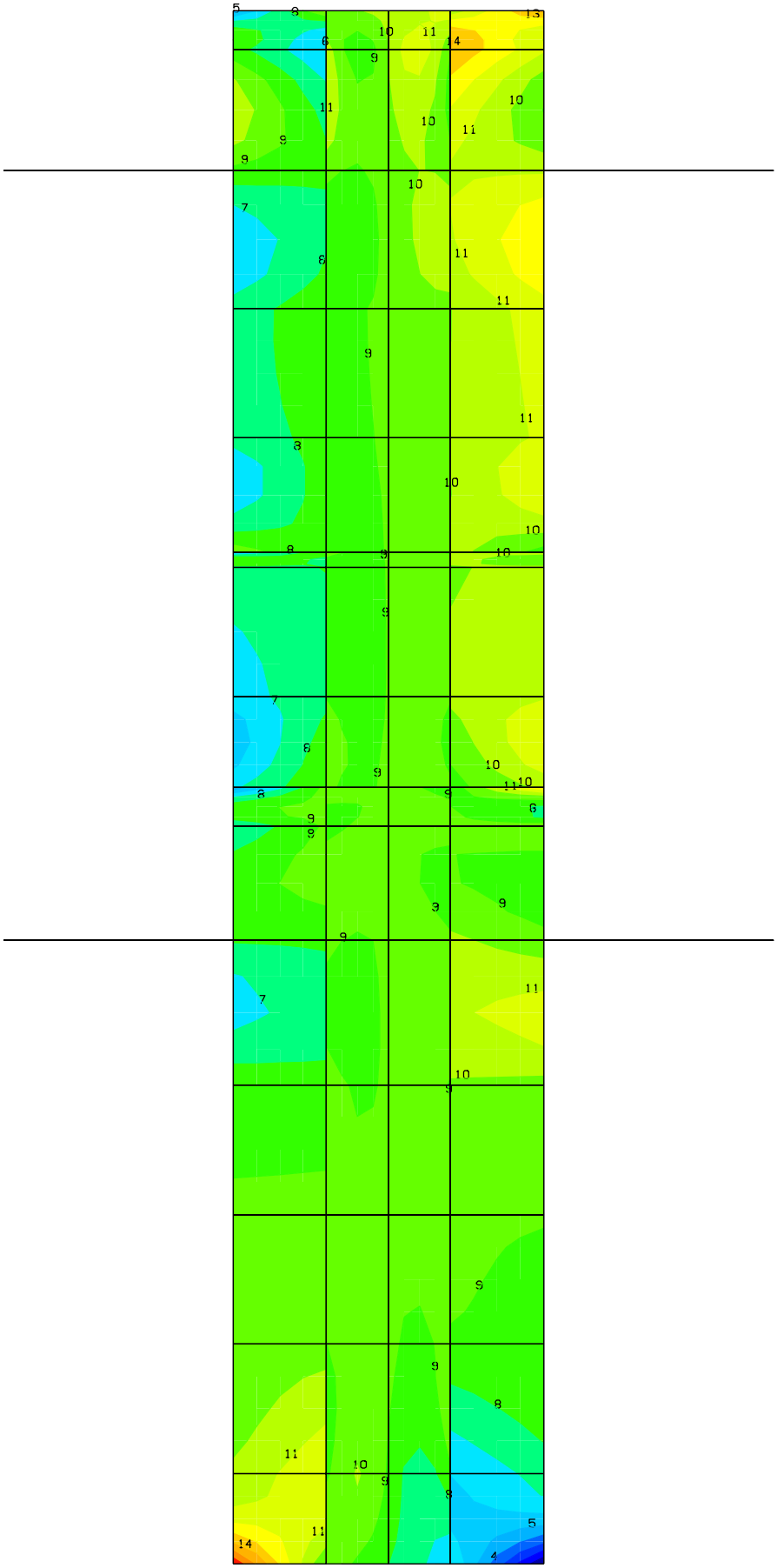
Wall D (cross beam side) (front view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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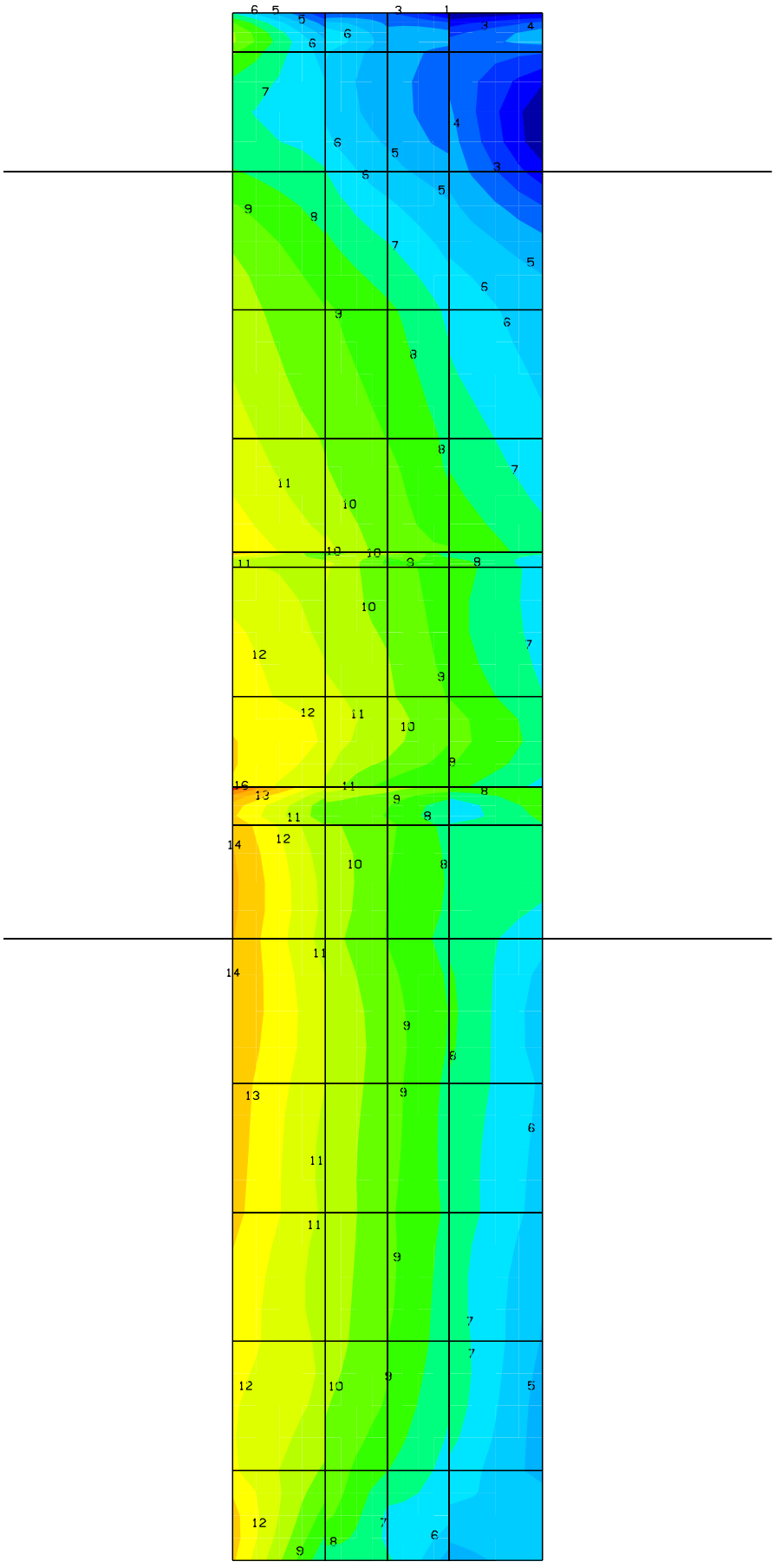
Wall D (cross beam side) (front view) ssy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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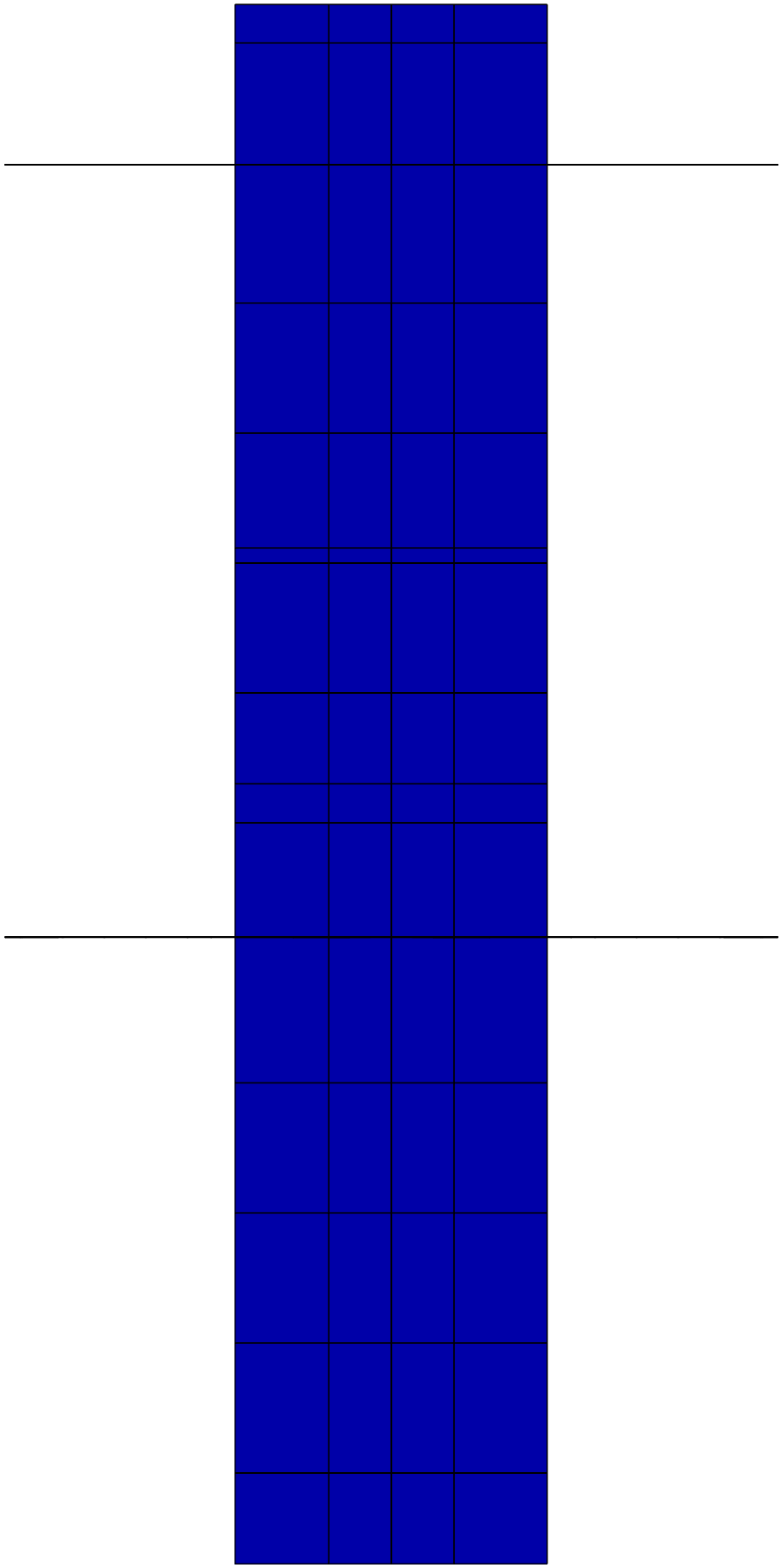
Wall D (cross beam side) (front view) Von-Mises_bot [MPa] (max) (elastic)



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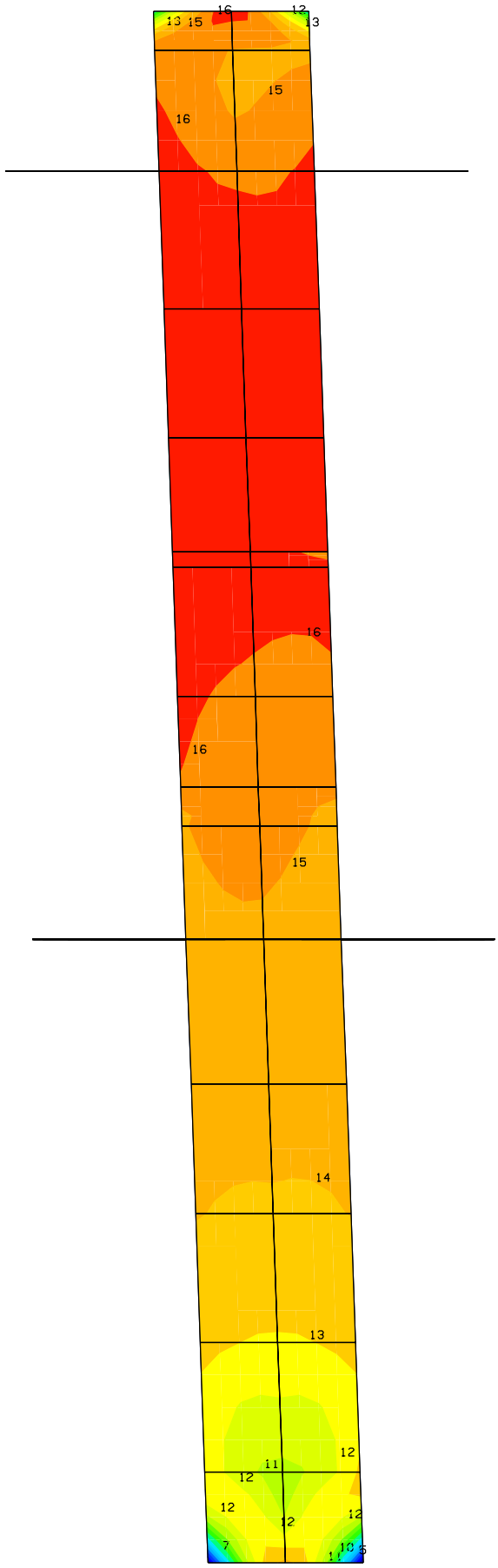
Wall D (cross beam side) (front view) T [mm]



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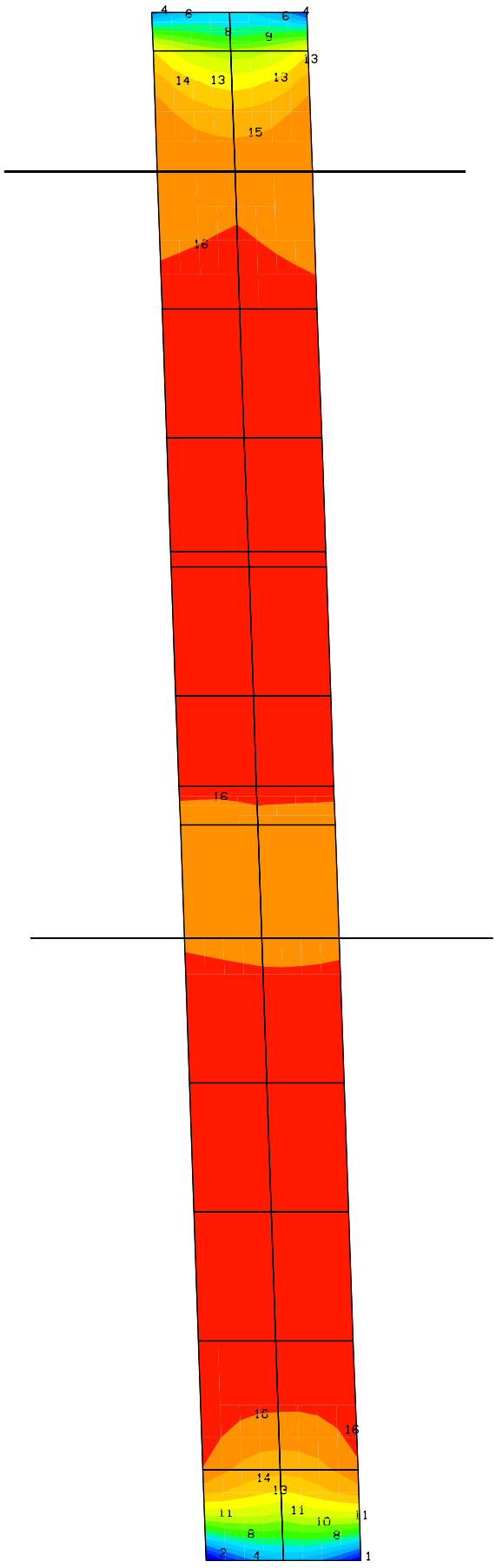
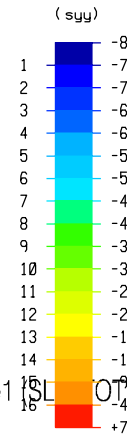
Wall A (Sidespan side) (left view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)





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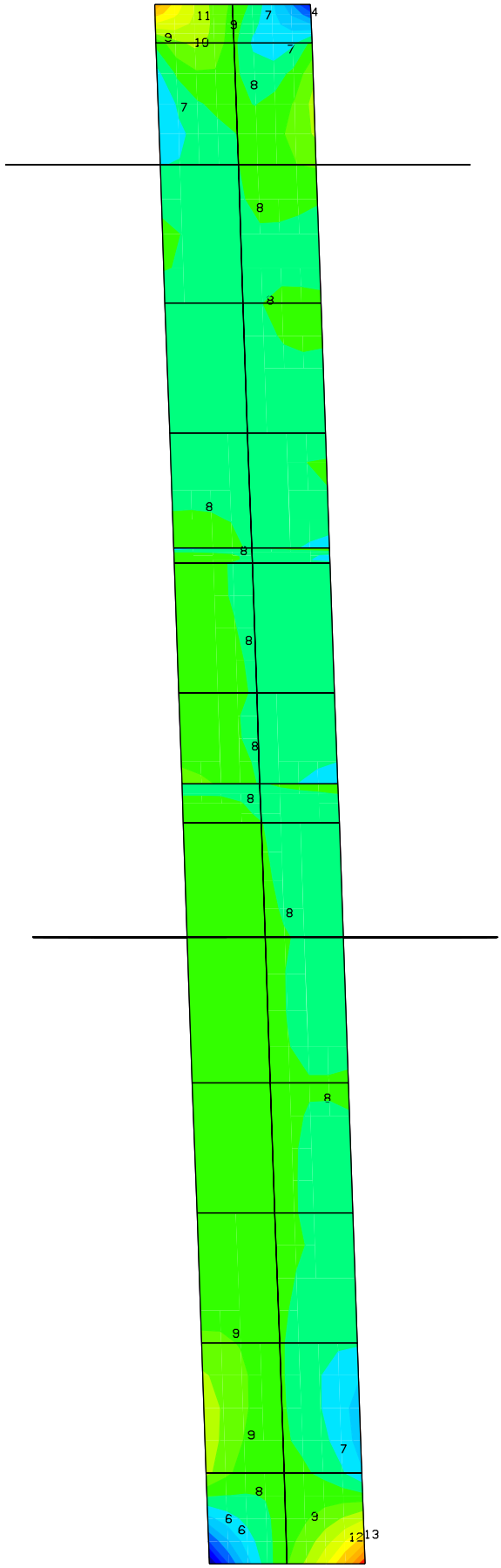
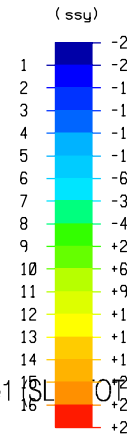
Wall A (Sidespan side) (left view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)





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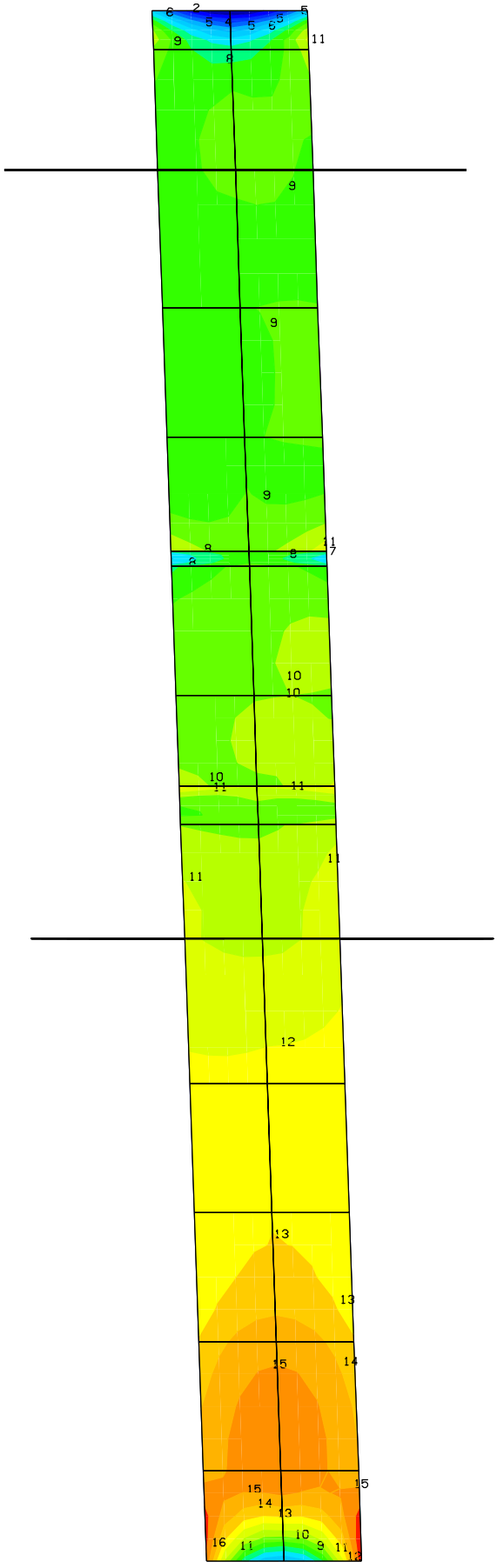
Wall A (Sidespan side) (left view) ssy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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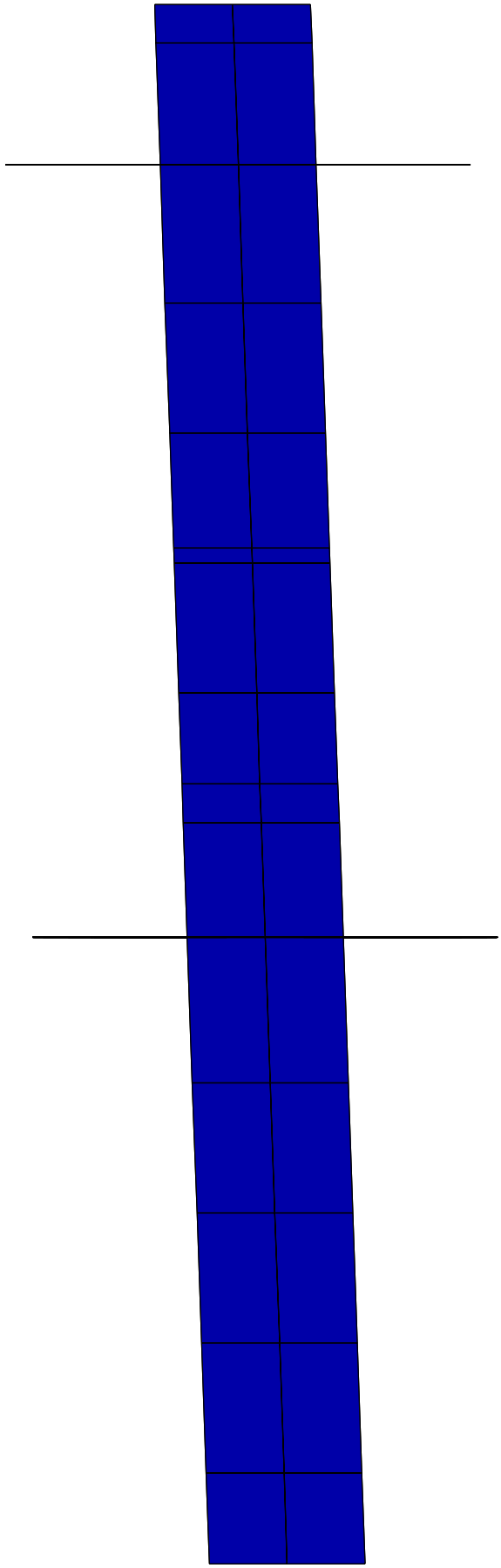
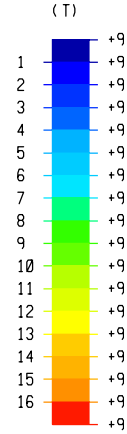
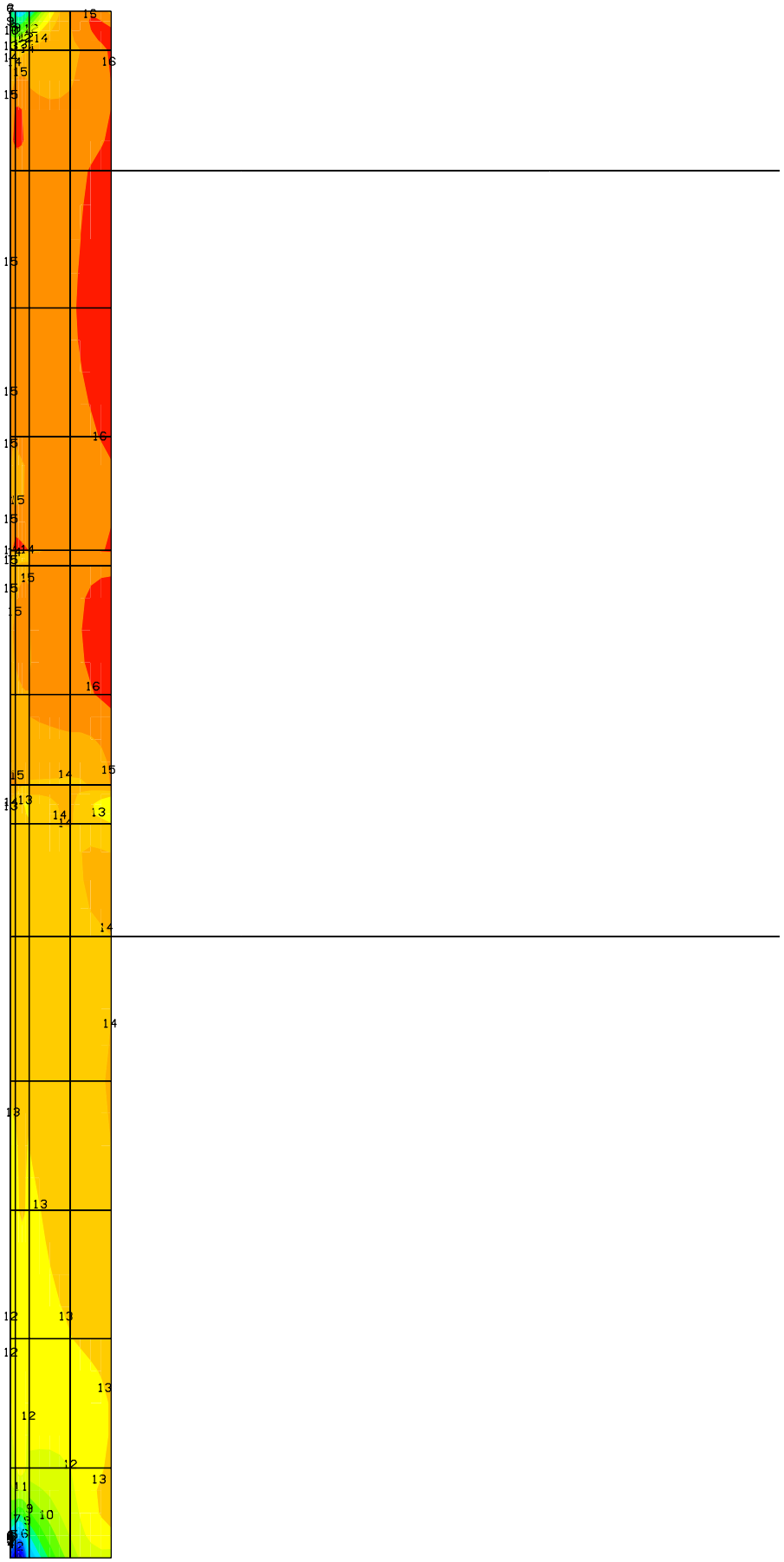
Wall A (Sidespan side) (left view) Von-Mises_bot [MPa] (max) (elastic)

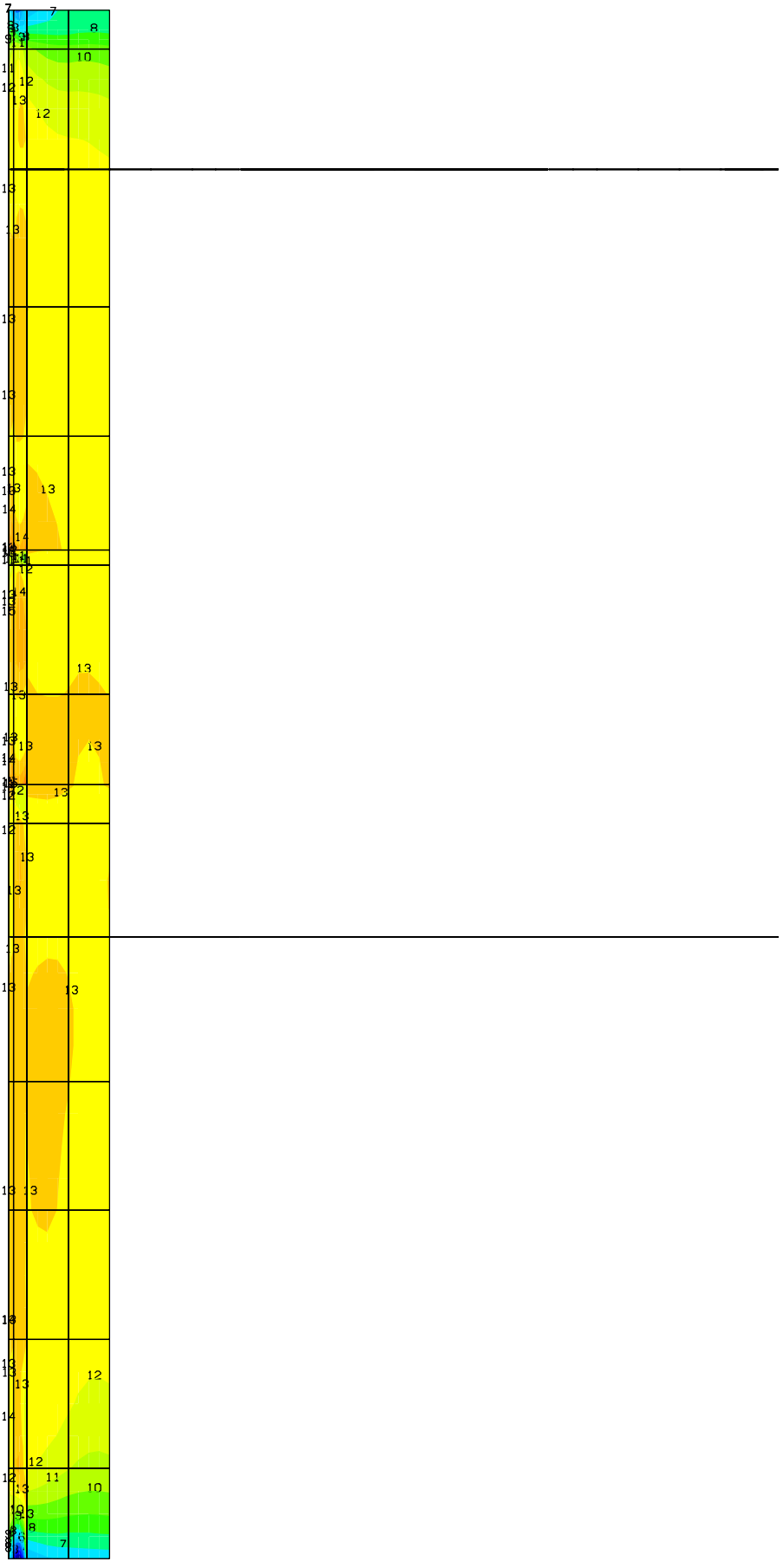




seranl19<'c:\ibdasjobs\72889\towershell\messina-v3'320<'g6c1'4<global (phase1100 at time=100.0days)
Wall A (Sidespan side) (left view) T [mm]



seranl19<'c:\ibdasjobs\72889\towershell\messina-v3'320<'g6c1'4<global (phase1100 at time=100.0days) case1 [SL OT
Wall B (Sidespan side towards Cross beam) (front view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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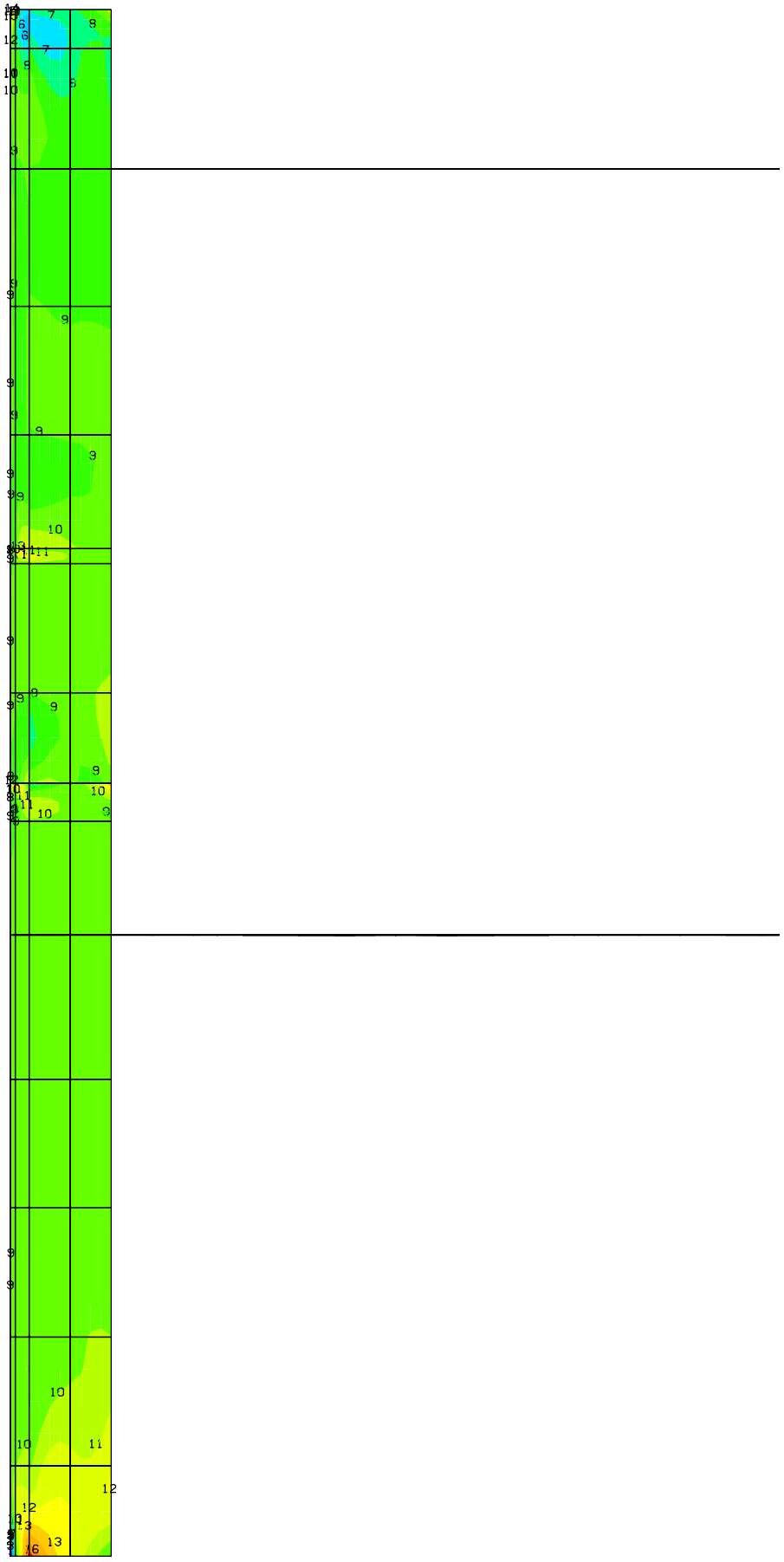
Wall B (Sidespan side towards Cross beam) (front view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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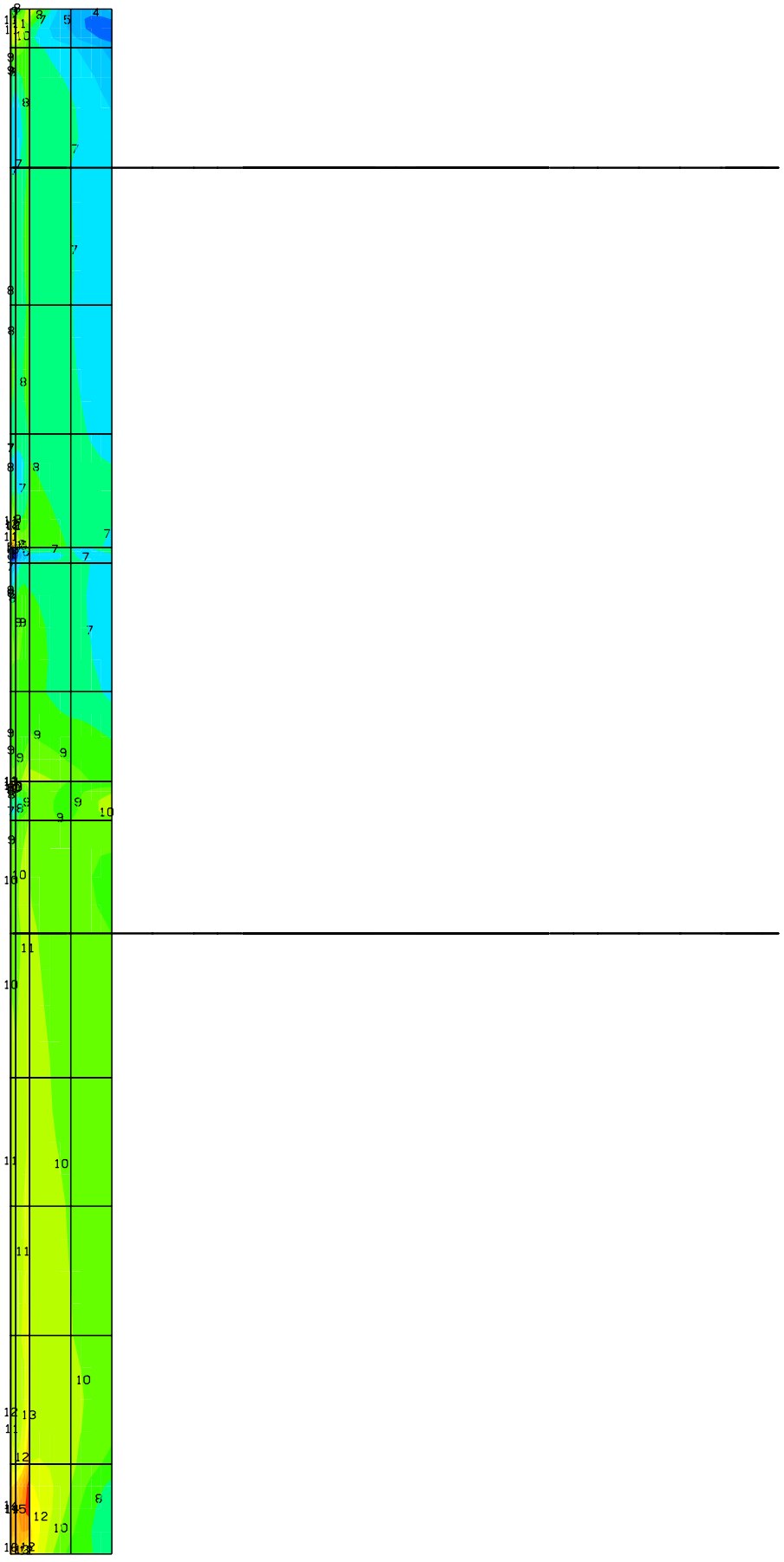
Wall B (Sidespan side towards Cross beam) (front view) ssy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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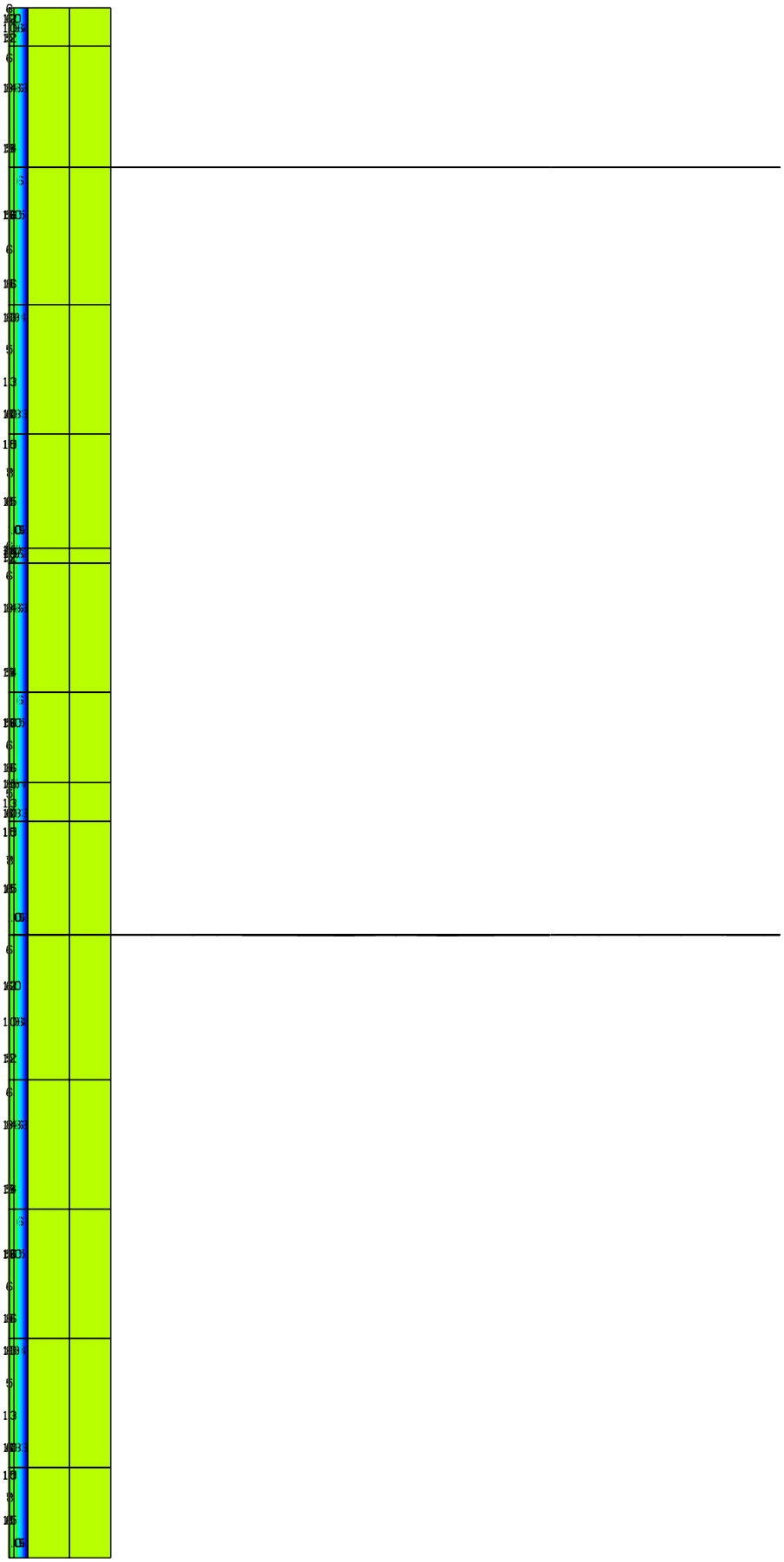
Wall B (Sidespan side towards Cross beam) (front view) Von-Mises_bot [MPa] (max) (elastic)



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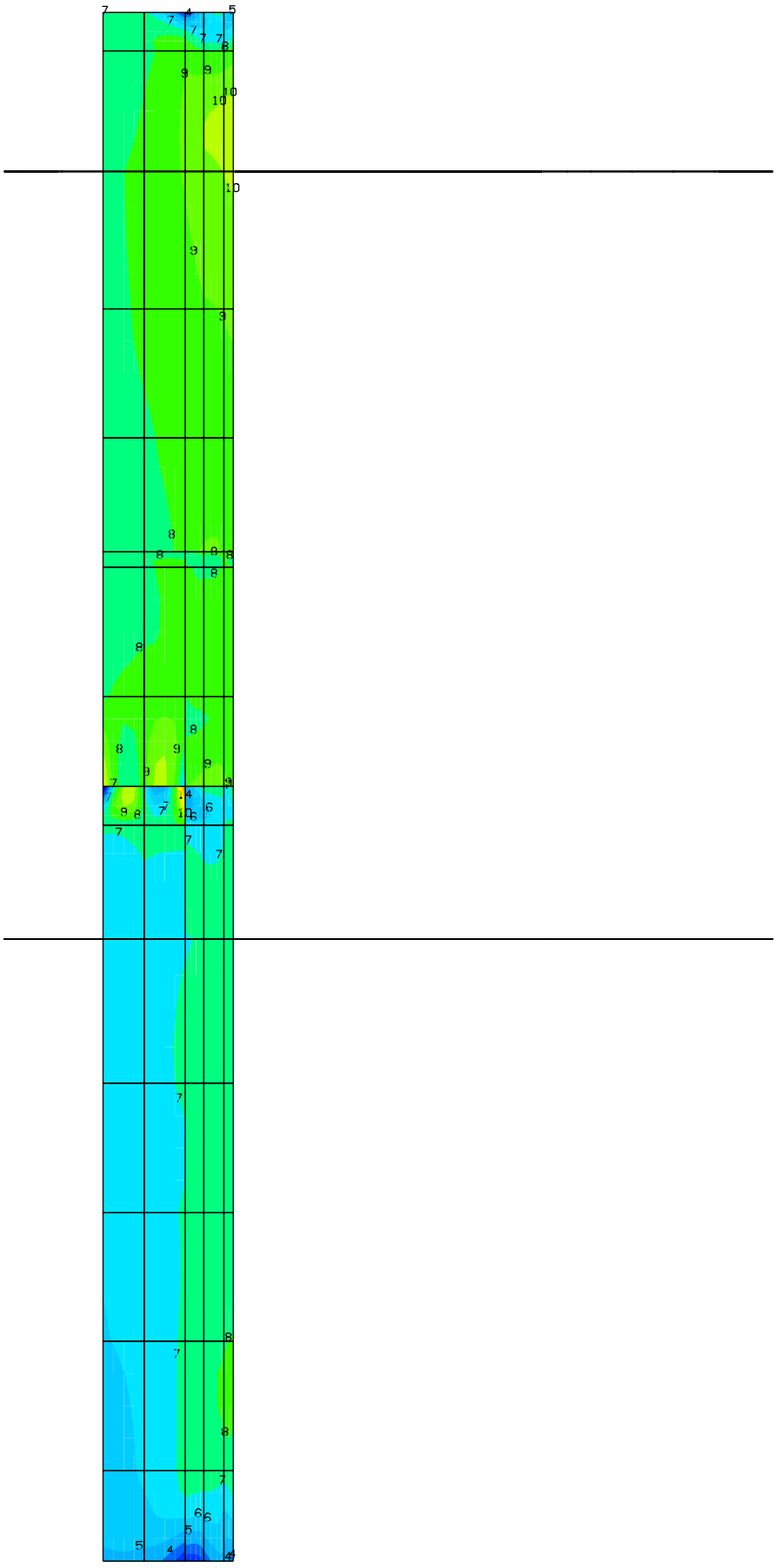
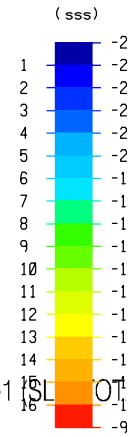
Wall B (Sidespan side towards Cross beam) (front view) T [mm]





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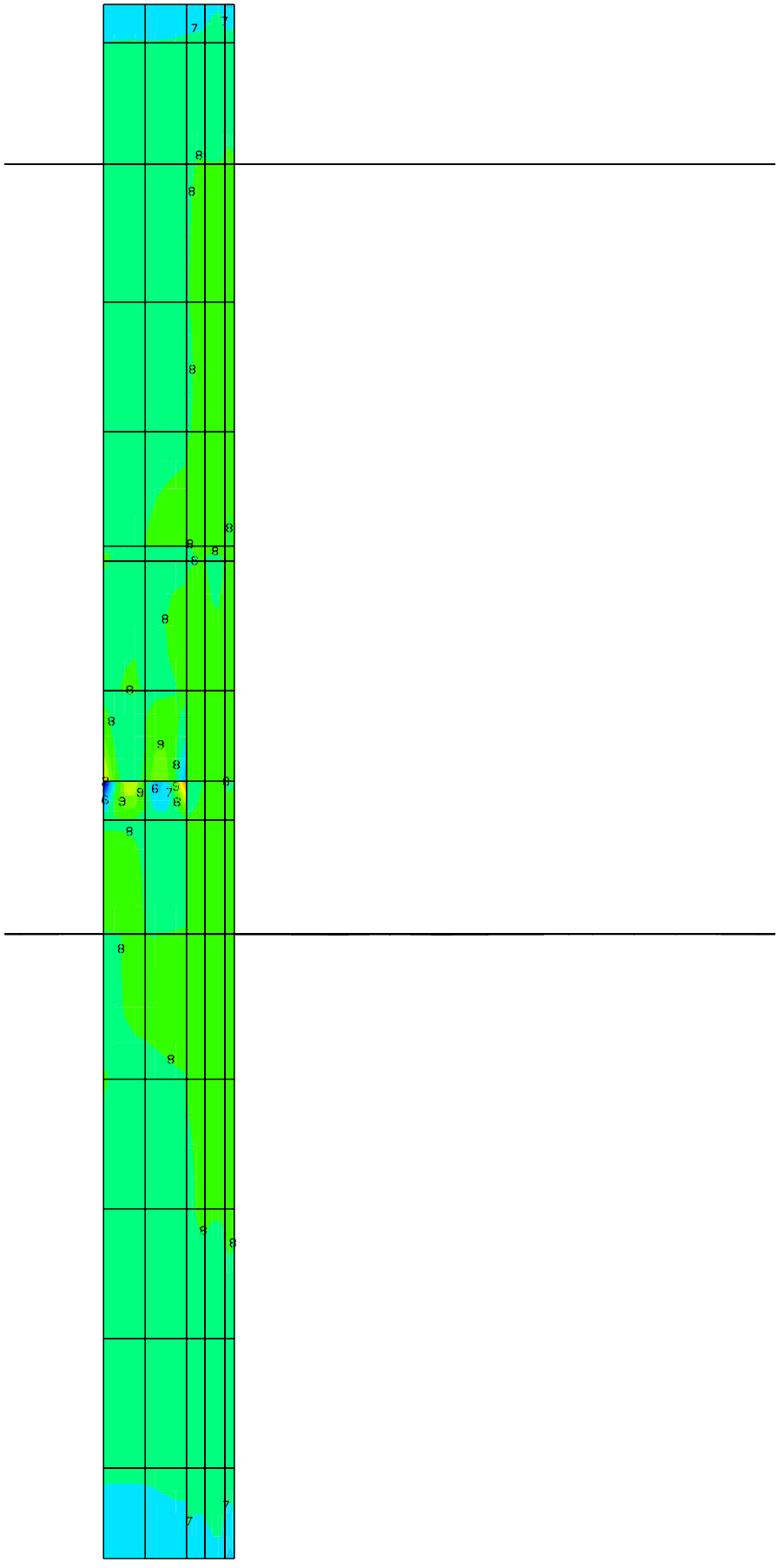
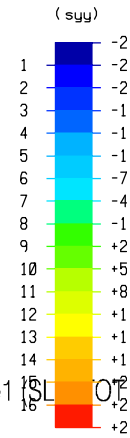
Wall C (Sidespan side towards Cross beam) (front view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)





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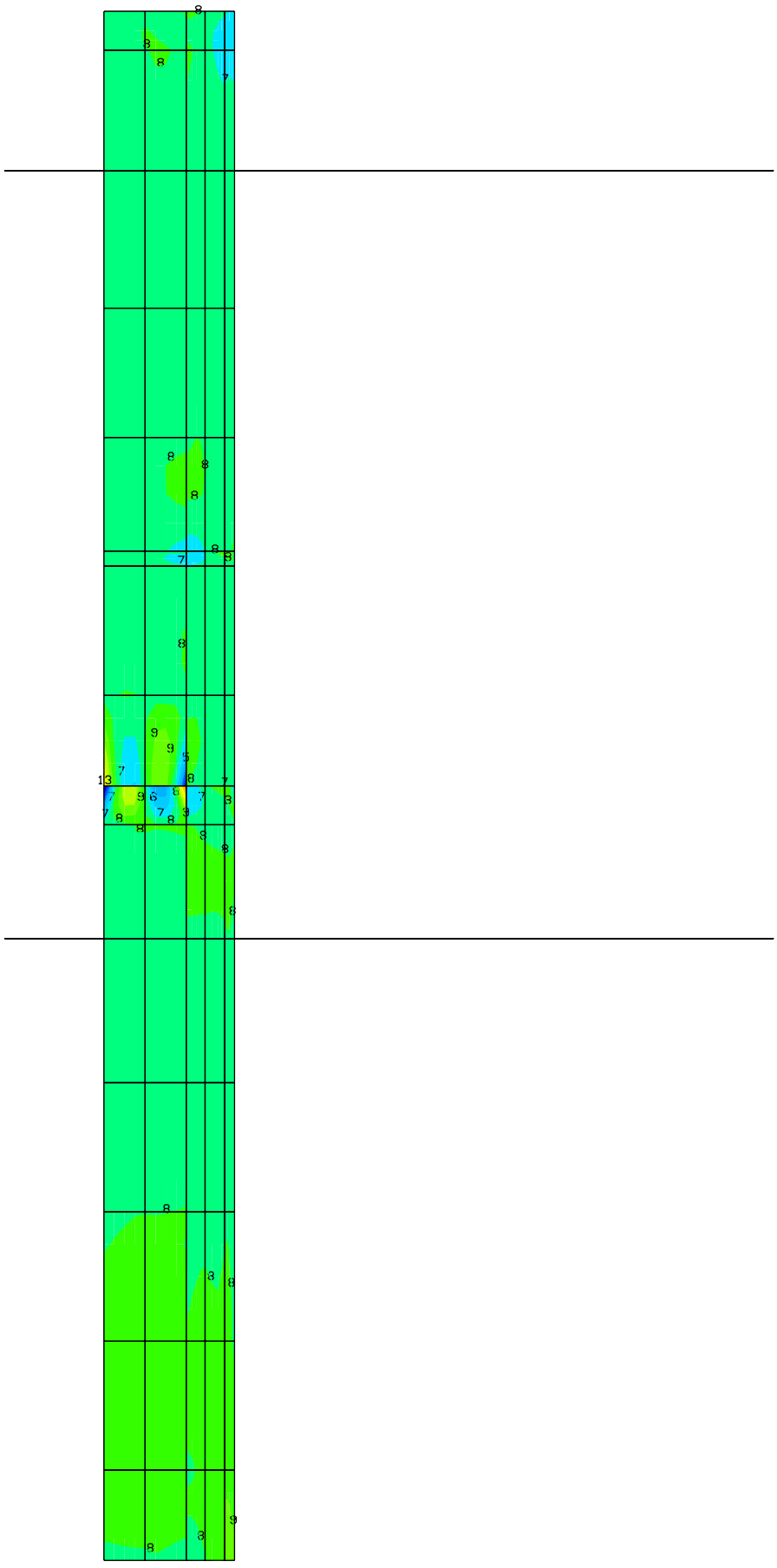
Wall C (Sidespan side towards Cross beam) (front view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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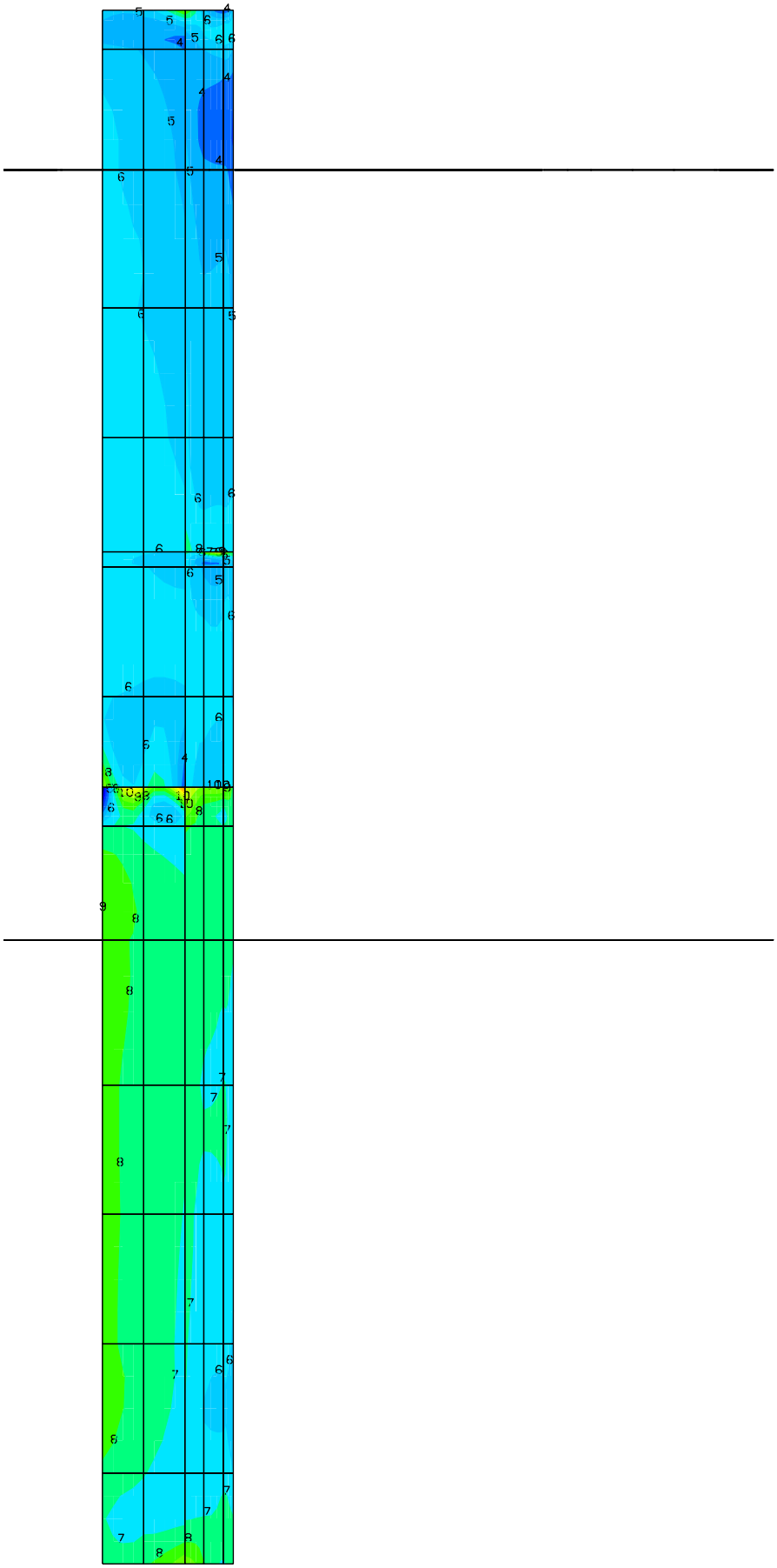
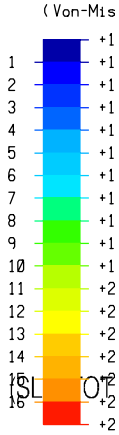
Wall C (Sidespan side towards Cross beam) (front view) ssy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)





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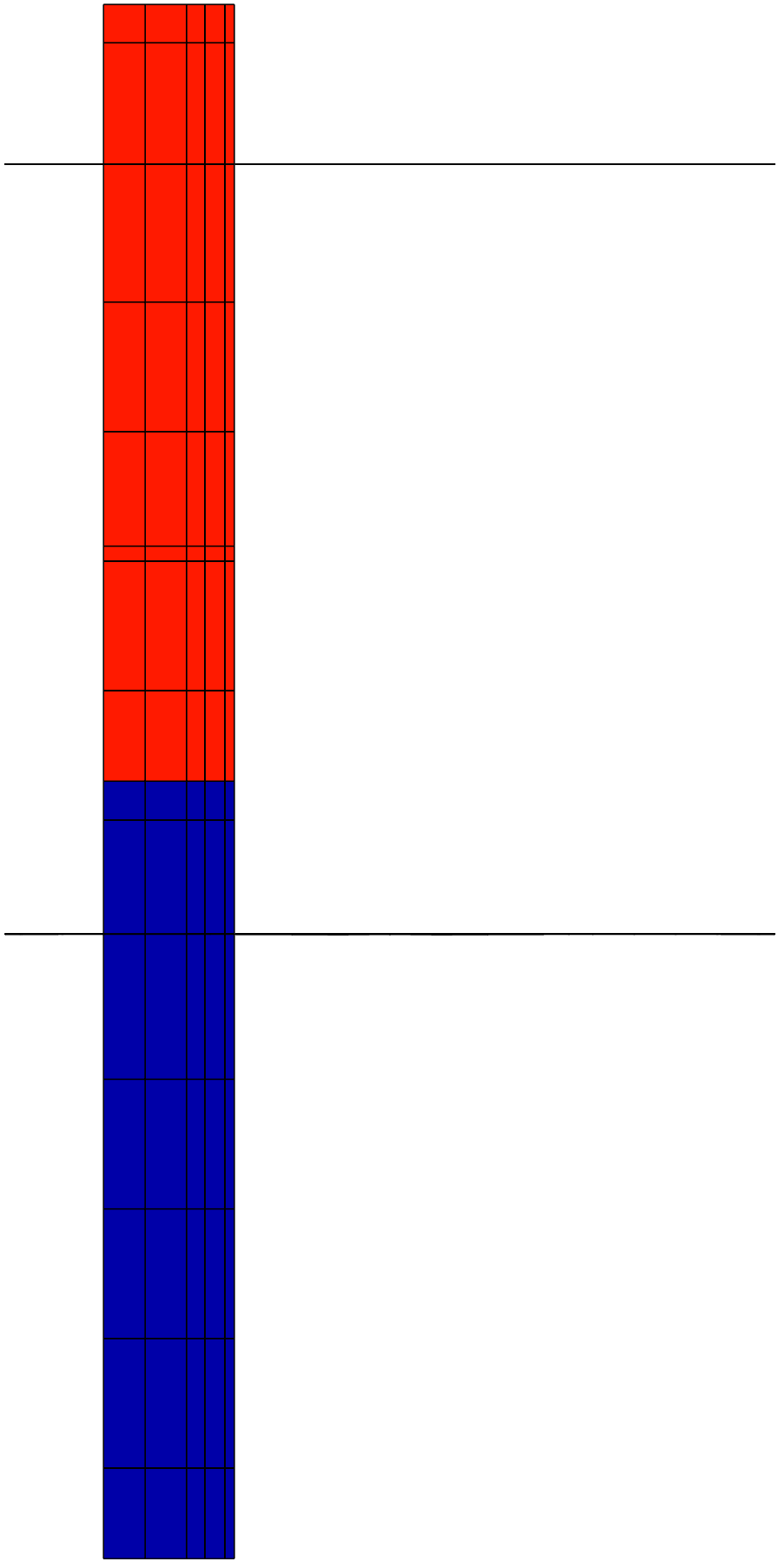
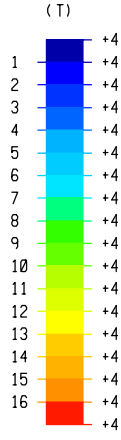
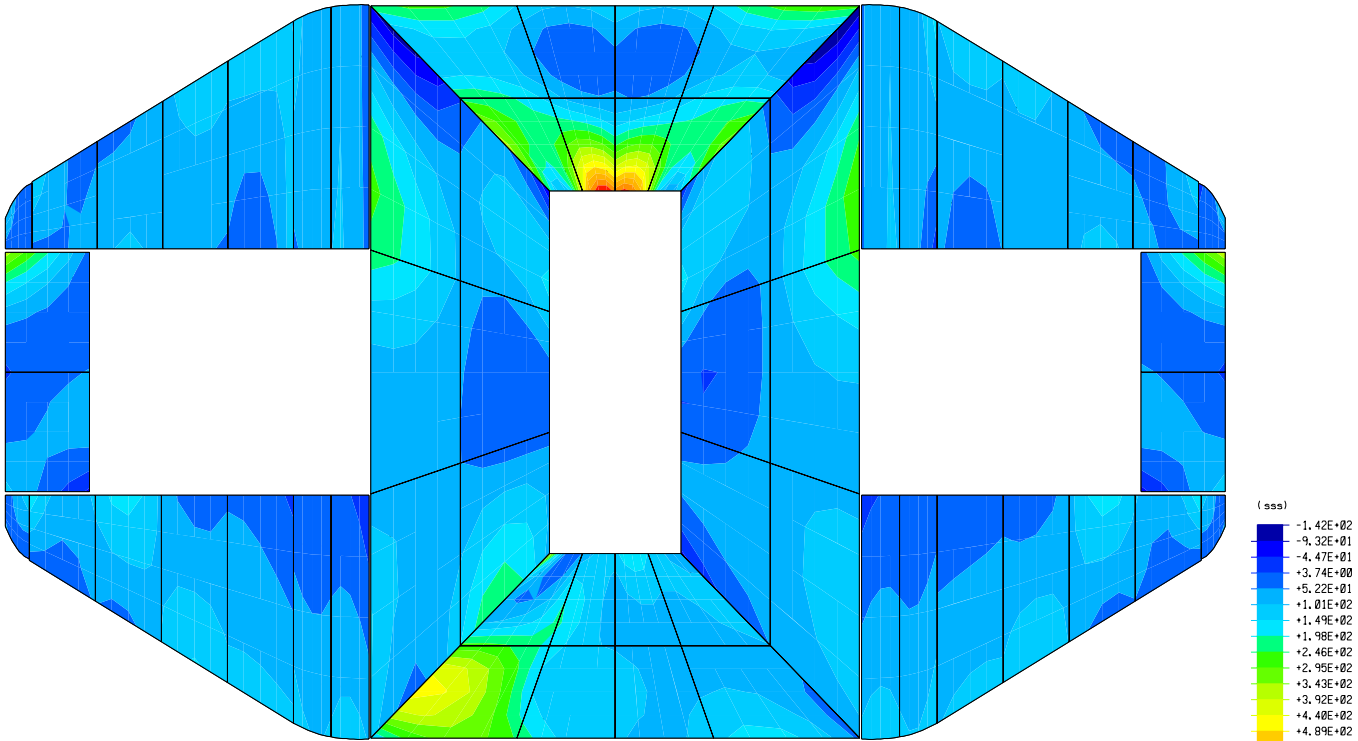
Wall C (Sidespan side towards Cross beam) (front view) Von-Mises_bot [MPa] (max) (elastic)





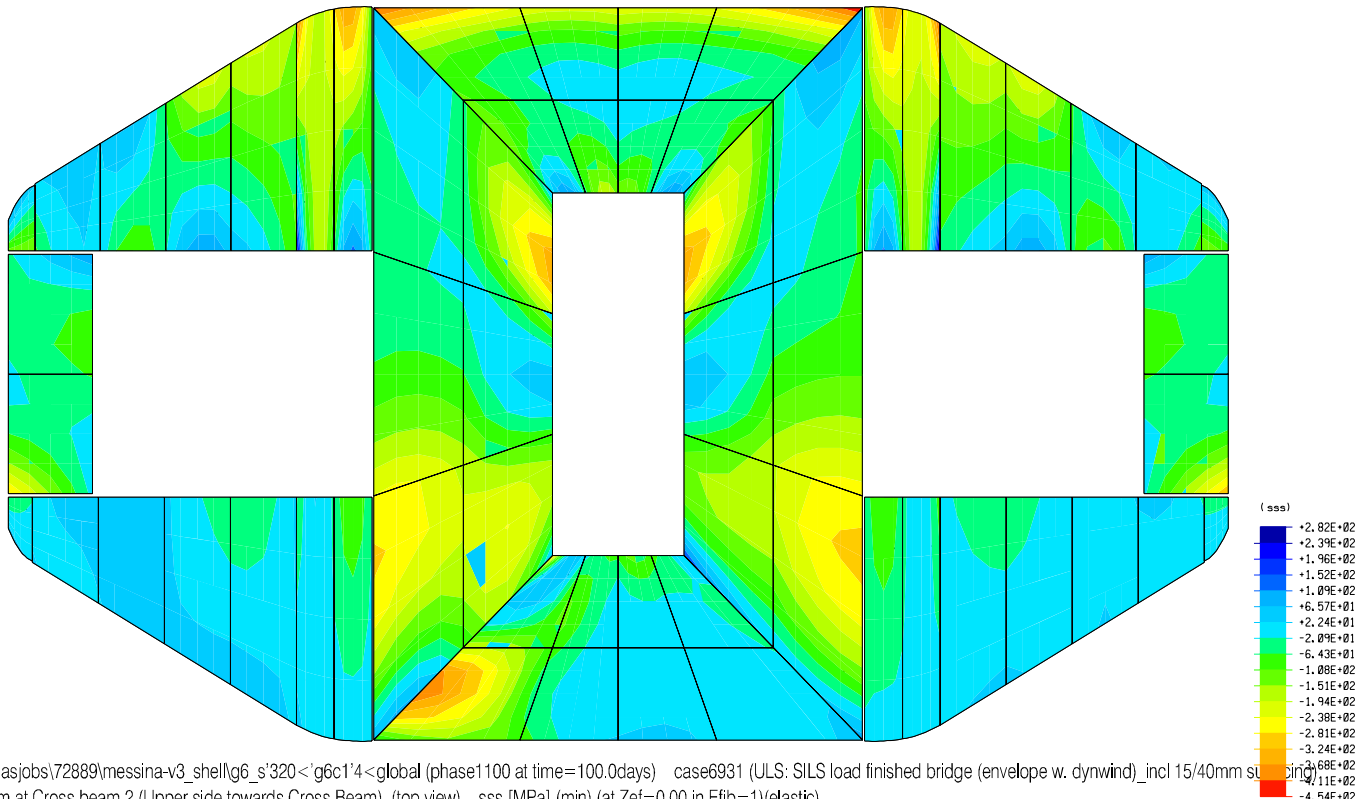
seranl19<'c:\ibdasjobs\72889\towershell\messina-v3'320<'g6c1'4<global (phase1100 at time=100.0days)
Wall C (Sidespan side towards Cross beam) (front view) T [mm]

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72889-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



seranl19<'c:\ibdasjobs\72889\messina-v3_shell\g6_s'320<'g6c1'4<global (phase1100 at time=100.0days) case6931 (ULS: SILS load finished bridge (envelope w. dynwind)_incl 15/40mm su[illegible]cing)
Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72889-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



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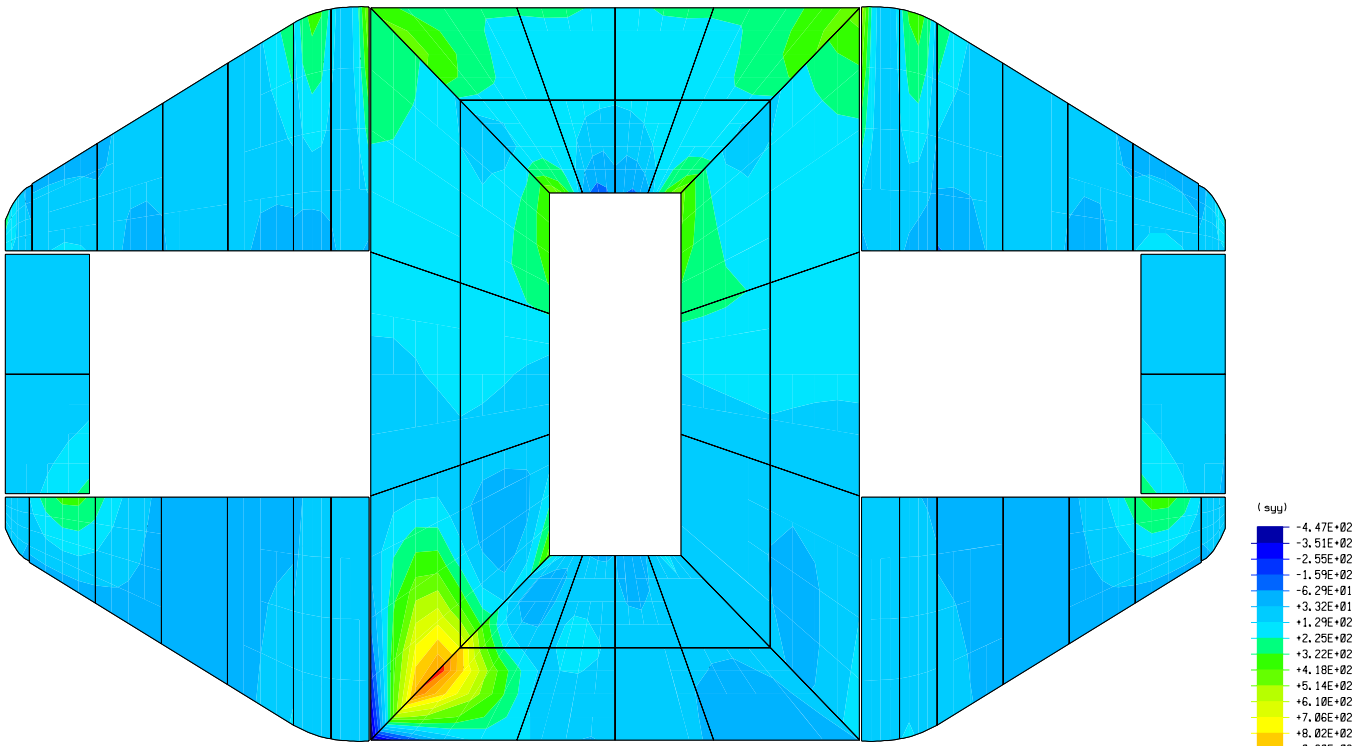
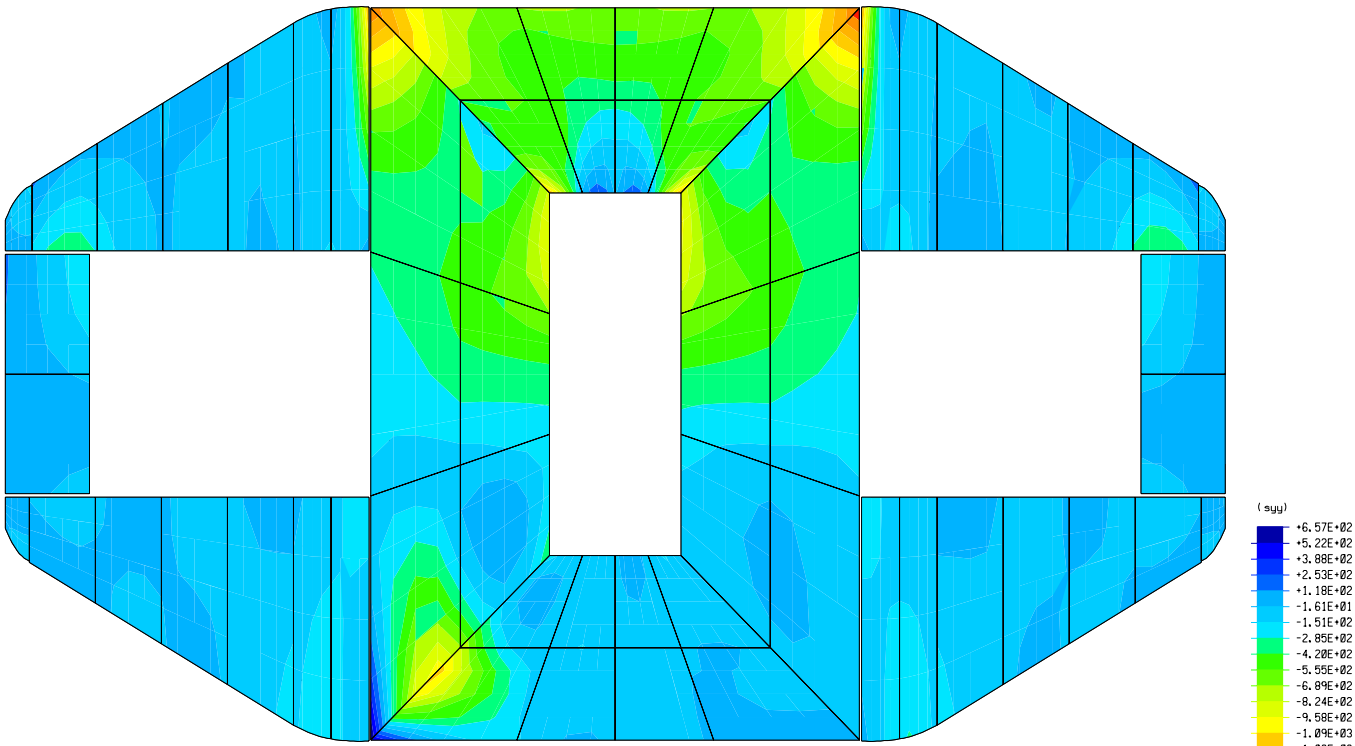
Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) sss [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72889-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



seranl19<'c:\ibdasjobs\72889\messina-v3_shell\g6_s'320<'g6c1'4<global (phase1100 at time=100.0days) case6931 (ULS: SILS load finished bridge (envelope w. dynwind)_incl 15/40mm su[illegible]cing)
Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72889-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



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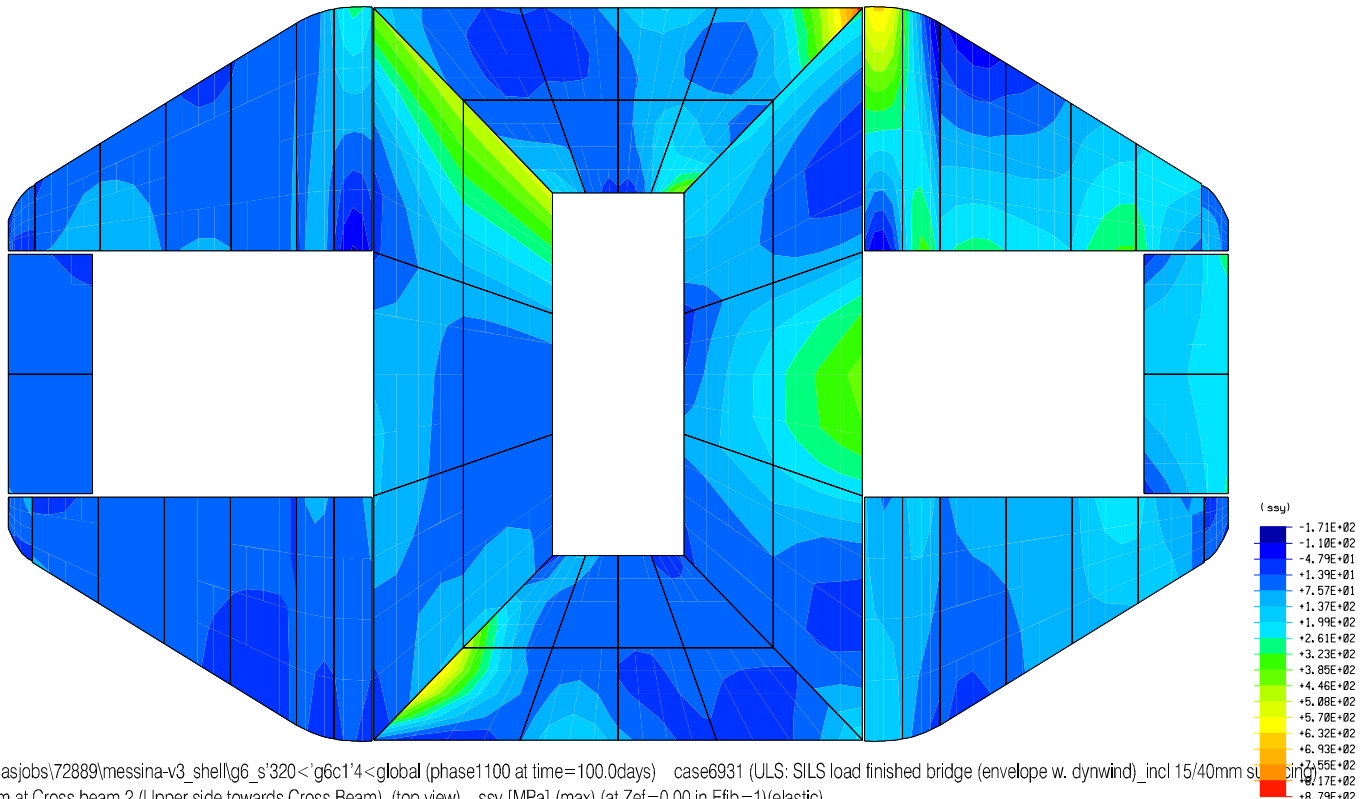
Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) syy [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72889-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



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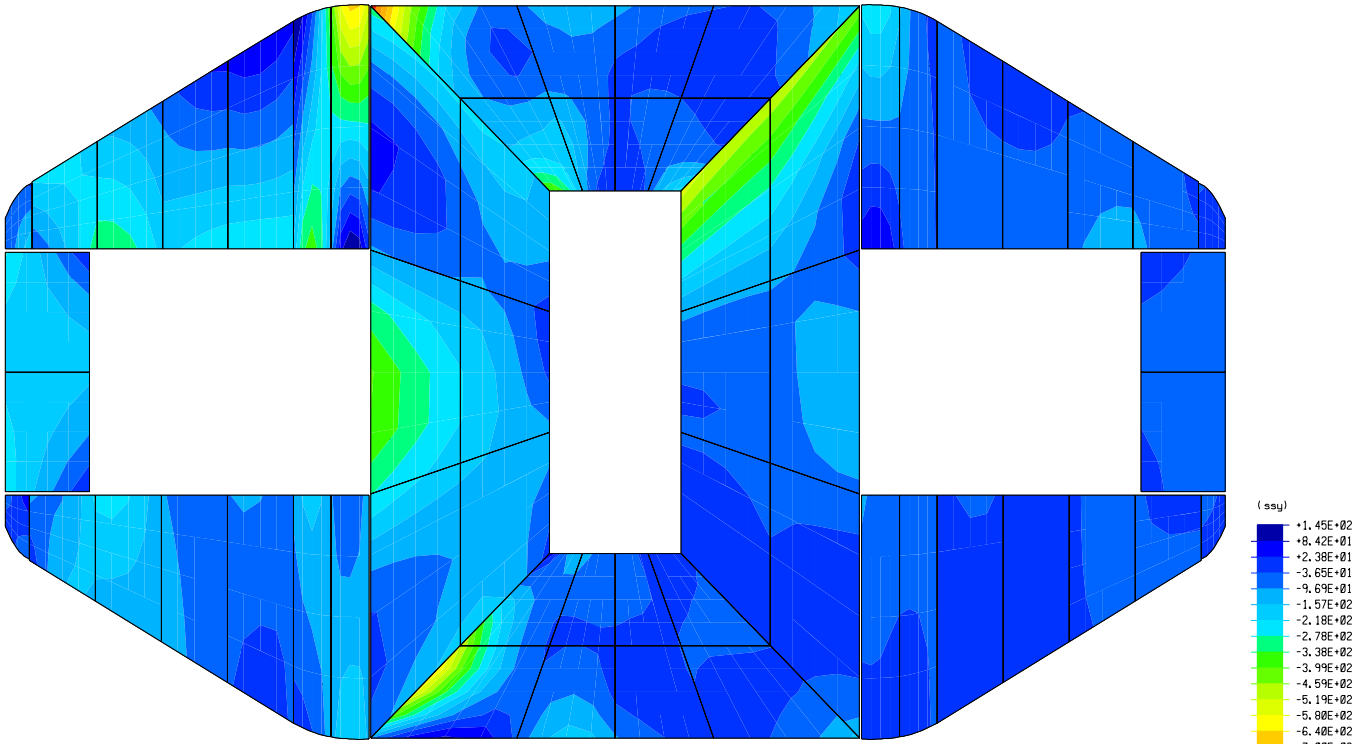
Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) ssy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72889-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



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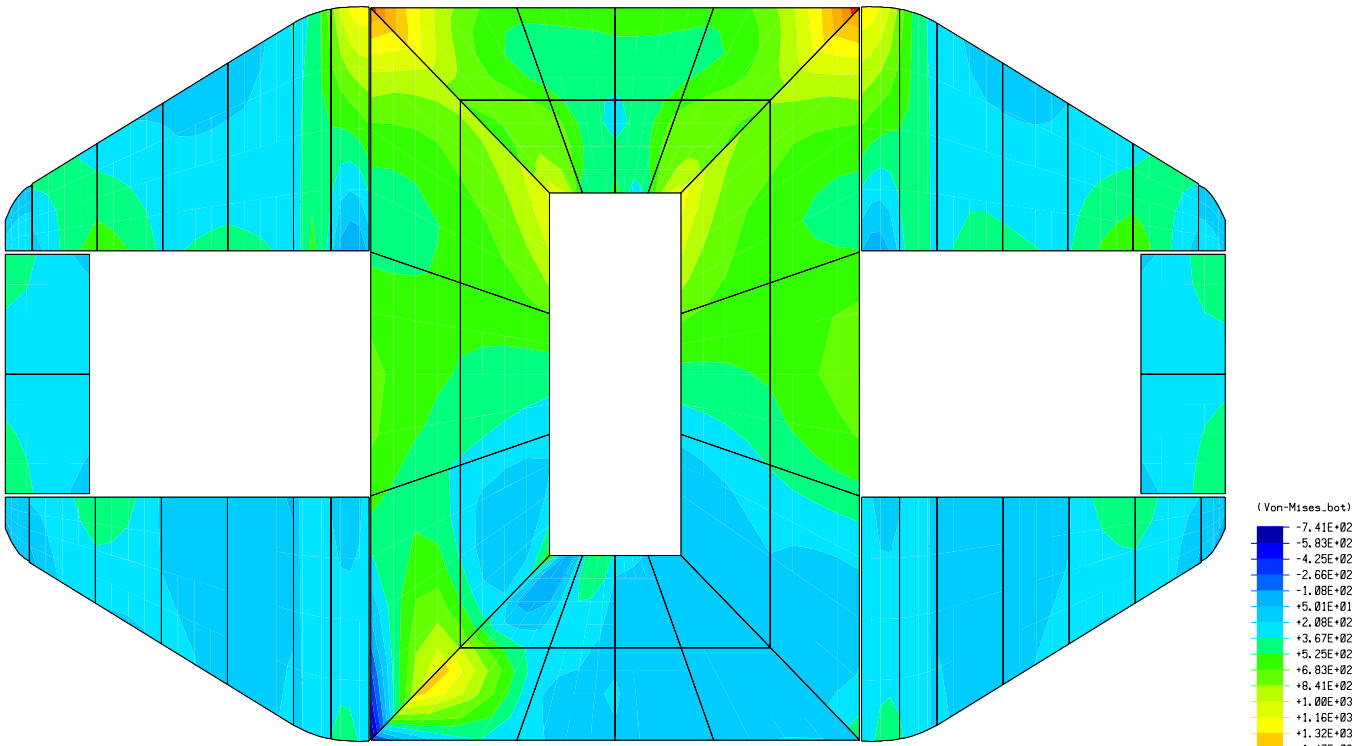
Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) ssy [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72889-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



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Upper Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) Von-Mises_bot [MPa] (max) (elastic)

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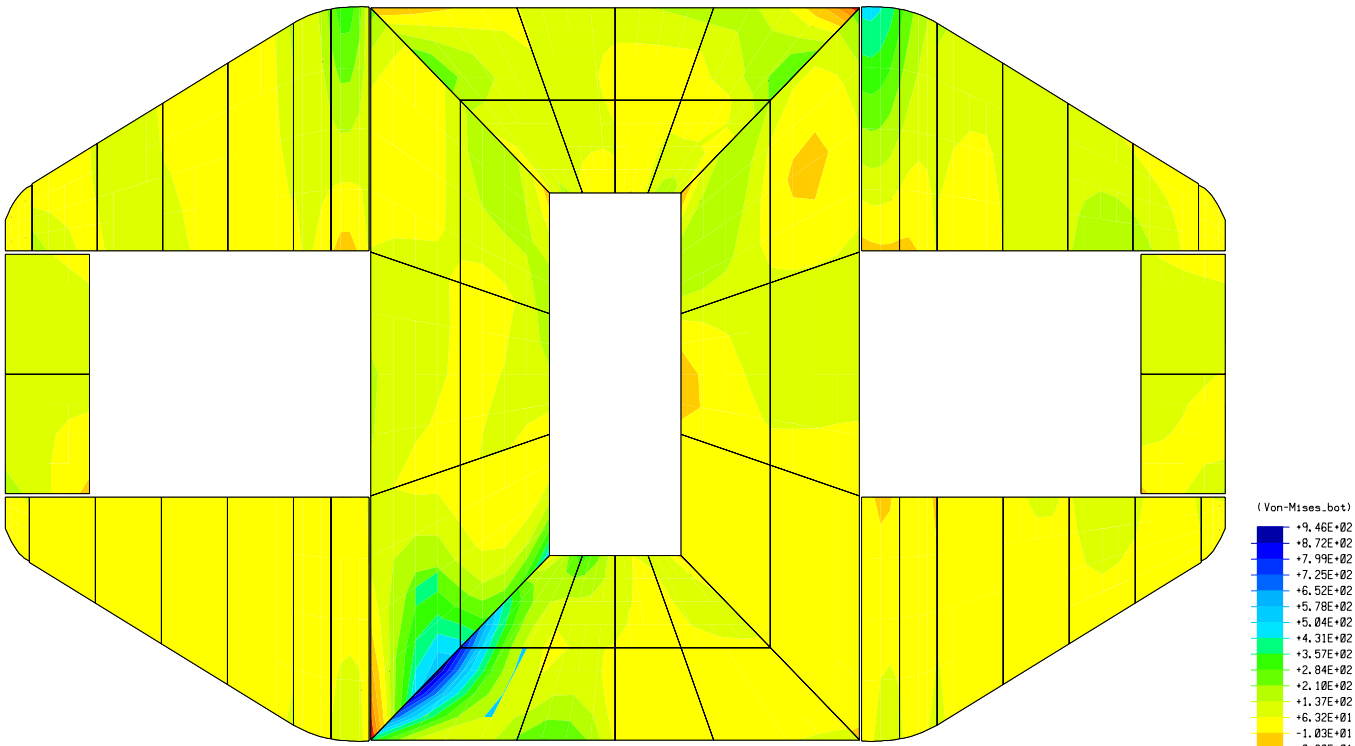

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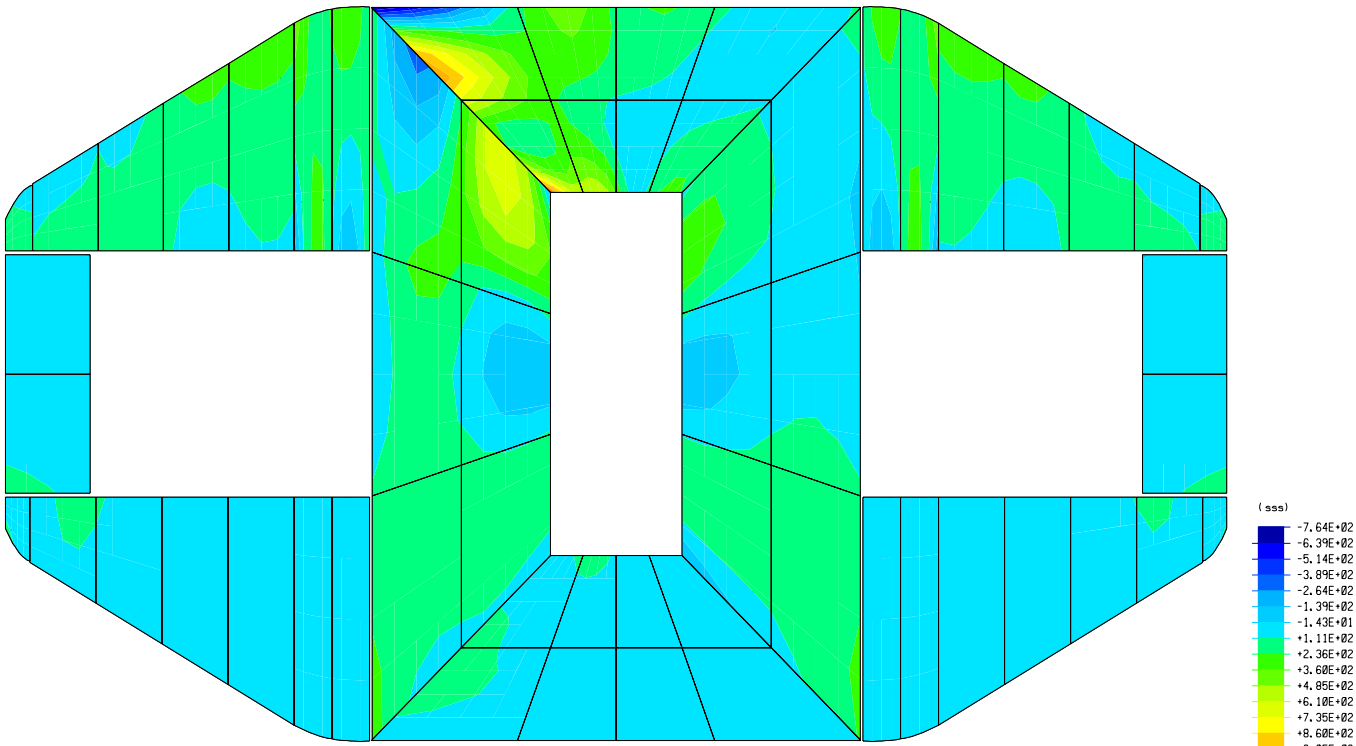

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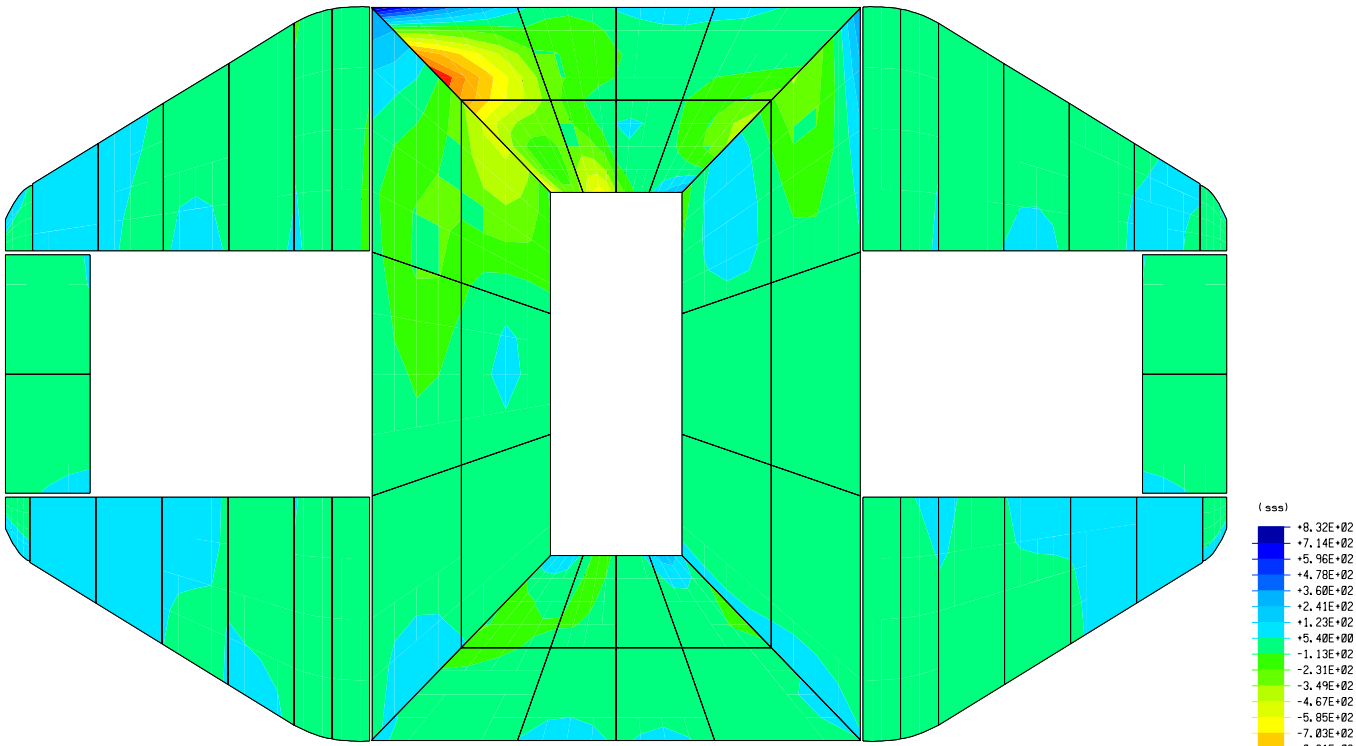
Lower Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72889-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



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Lower Diaphragm at Cross beam 2 (Upper side towards Cross Beam) (top view) sss [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

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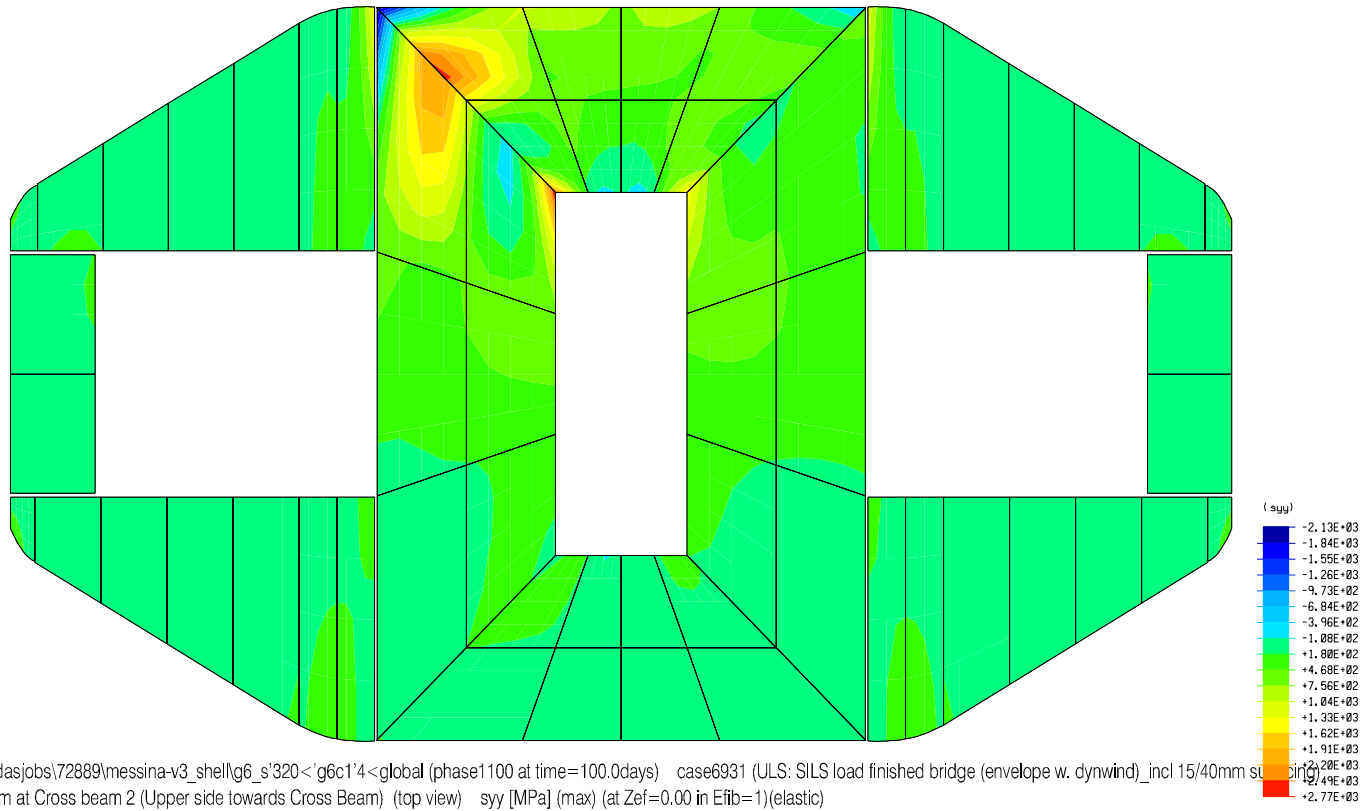

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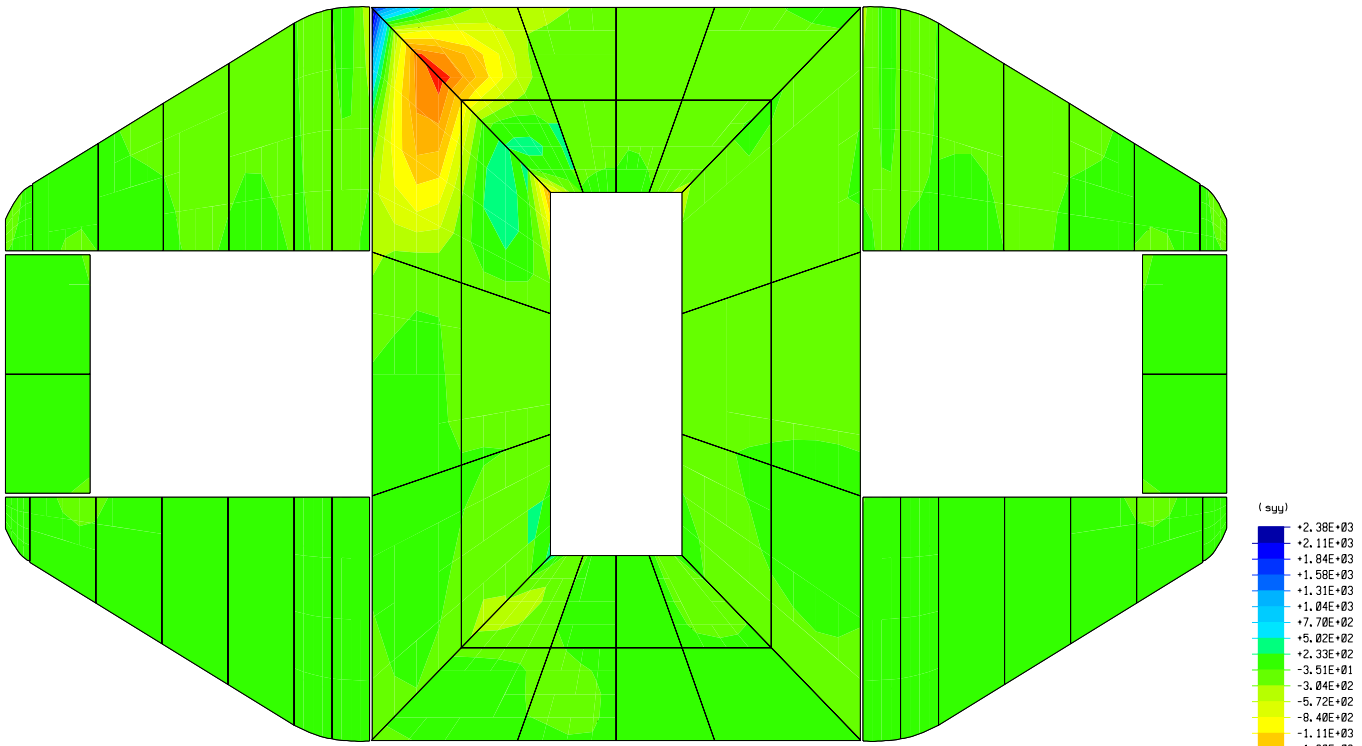

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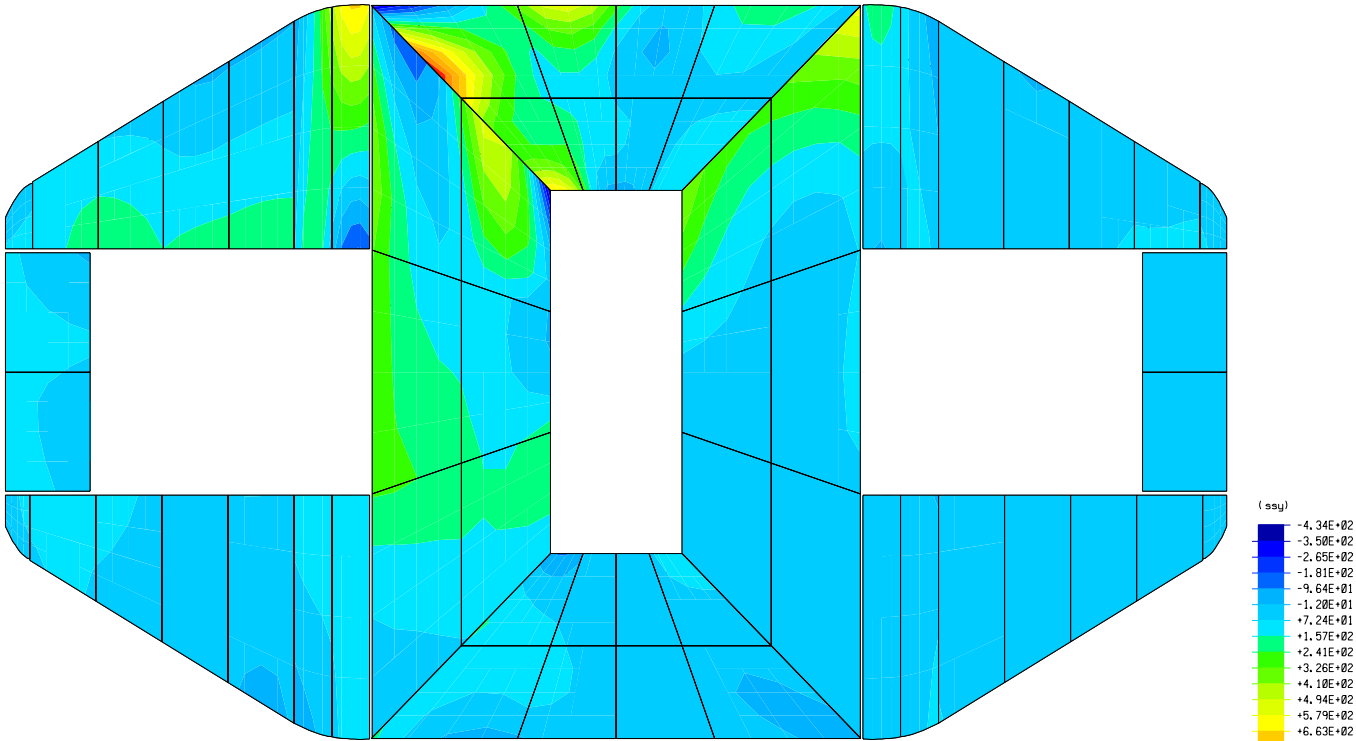

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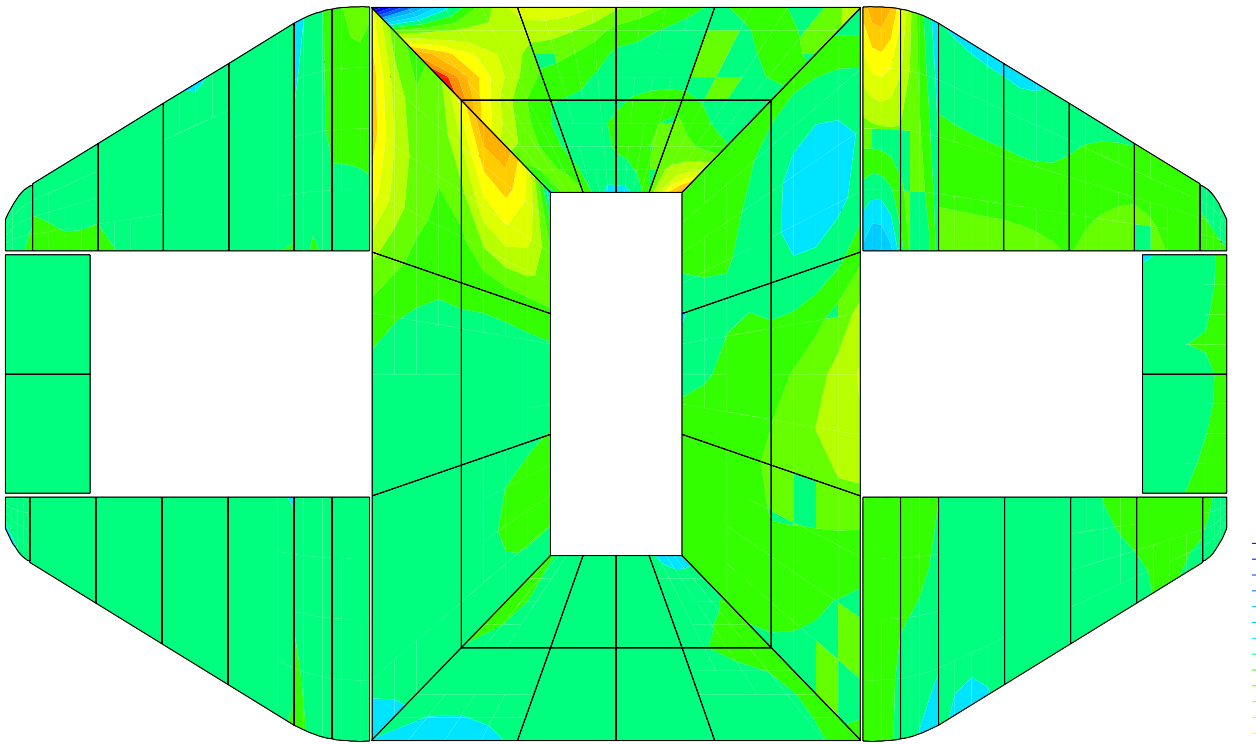

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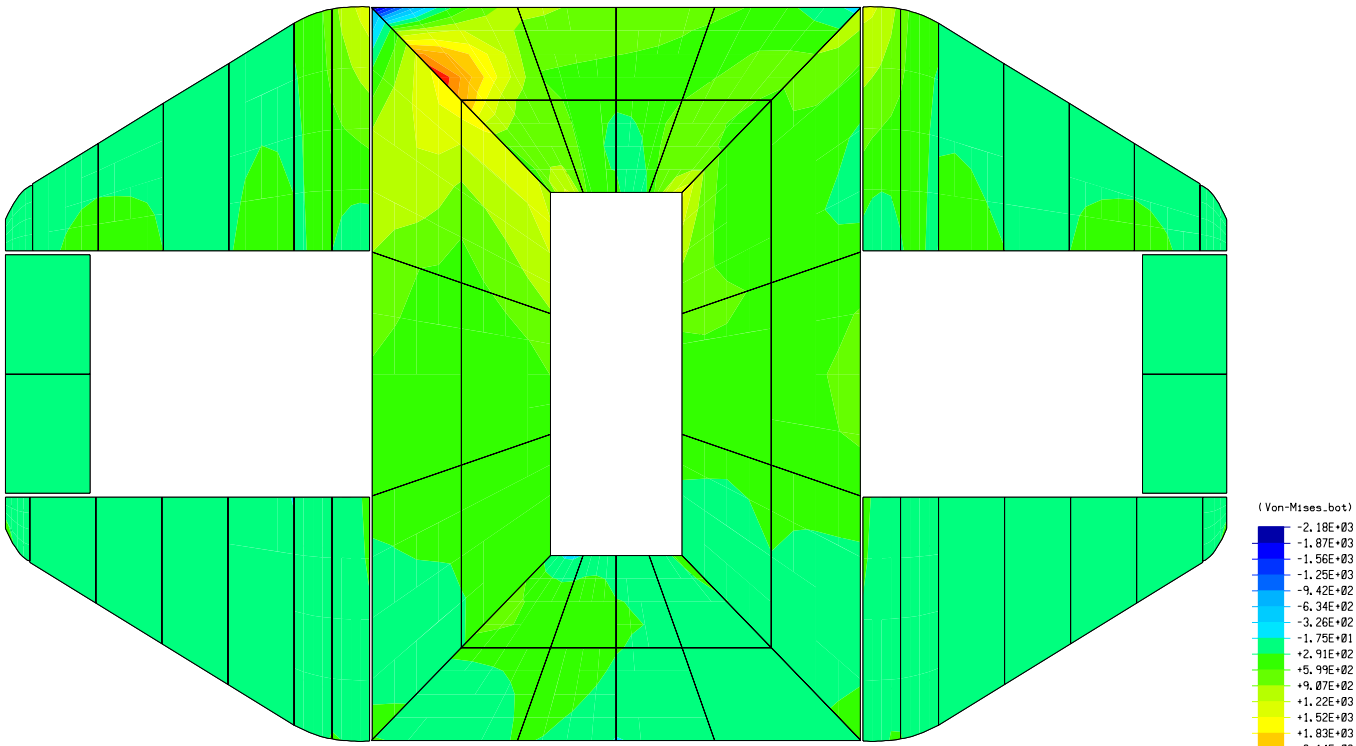

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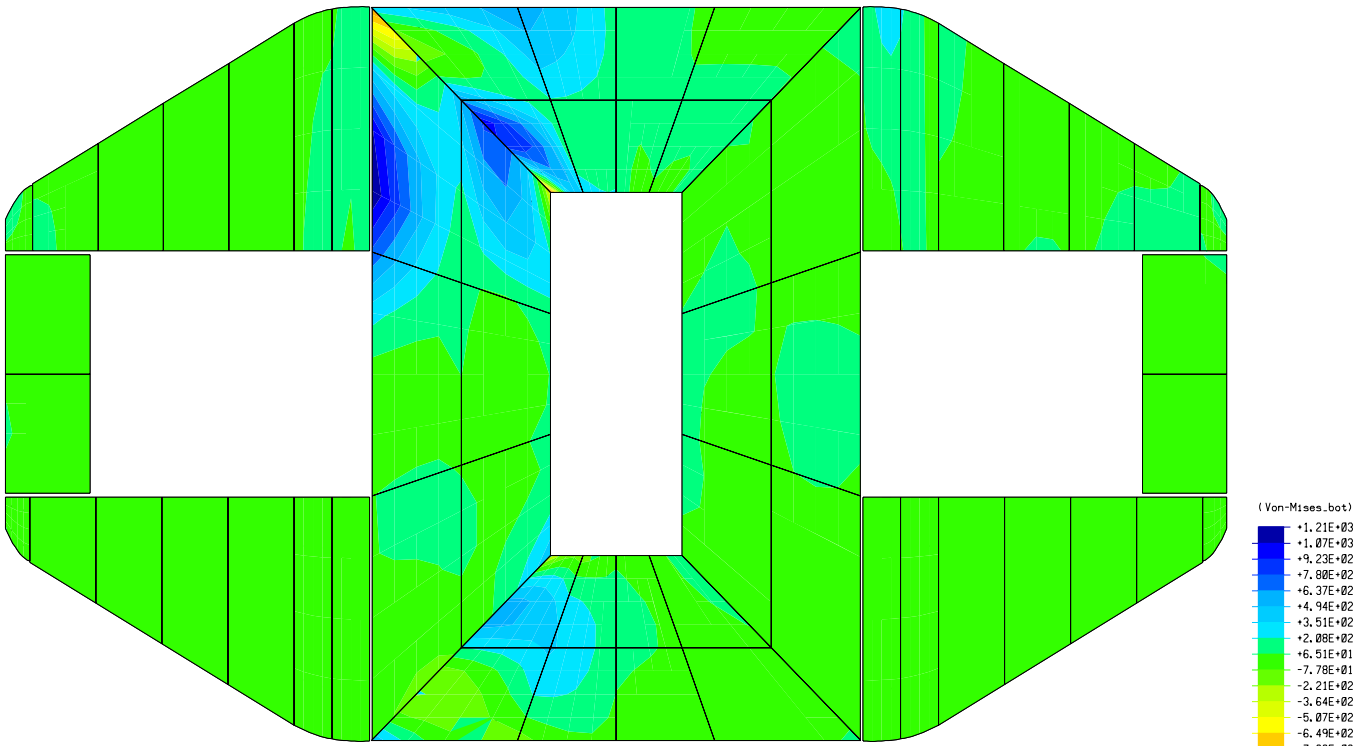

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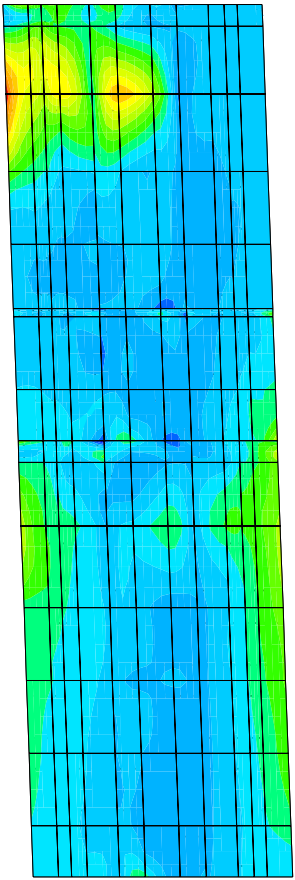

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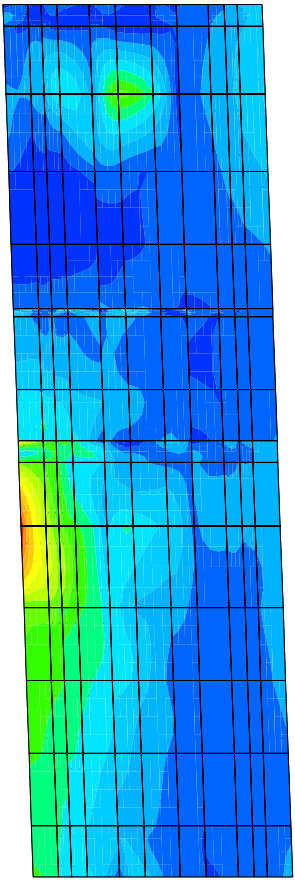
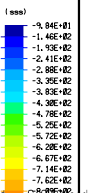
Wall H/G/H (sidespan side) (left view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72689-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:





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Wall H/G/H (sidespan side) (left view) sss [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

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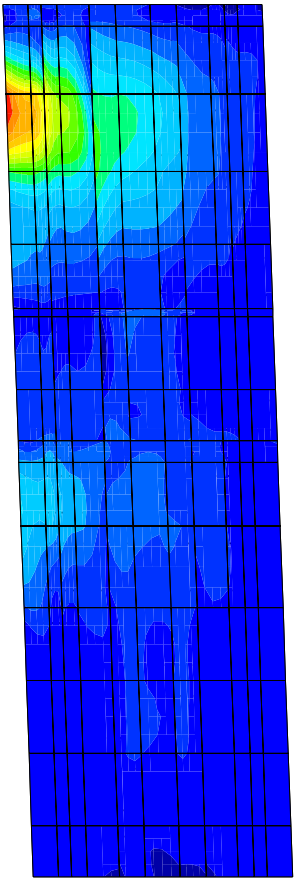

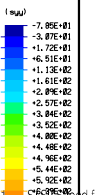

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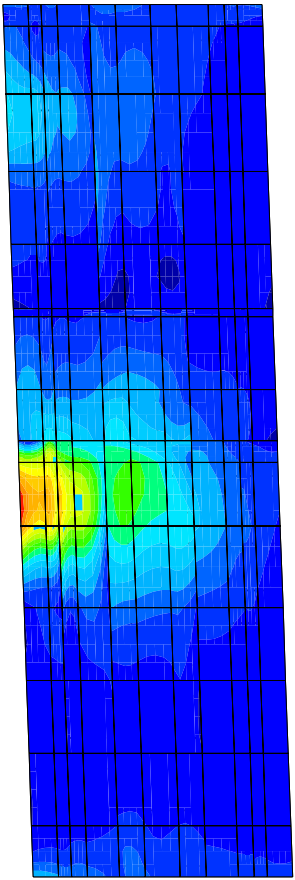
Wall H/G/H (sidespan side) (left view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)



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Wall H/G/H (sidespan side) (left view) syy [MPa] (min) (at Zet=0.00 in Efib=1)(elastic)

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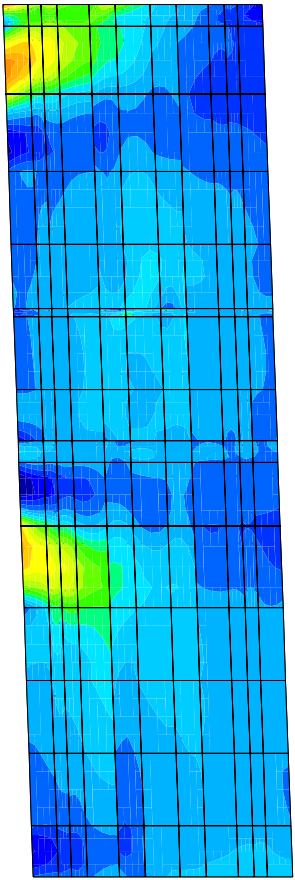

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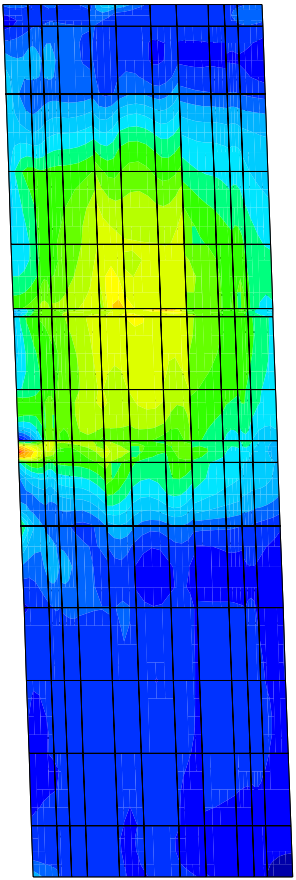

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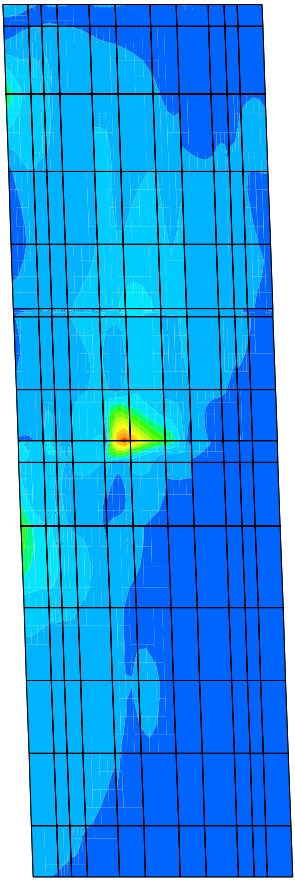

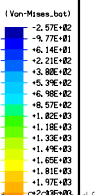

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Wall H/G/H (sidespan side) (left view) Von-Mises_bot [MPa] (max) (elastic)

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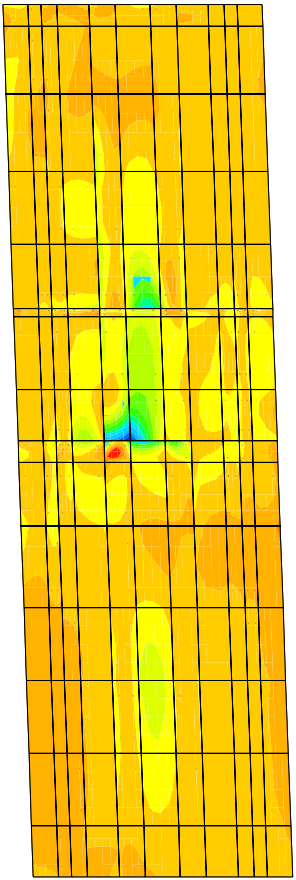

(Von-Mises_bot)
+1.07E+03
+9.97E+02
+9.28E+02
+8.60E+02
+7.91E+02
+7.22E+02
+6.53E+02
+5.84E+02
+5.15E+02
+4.46E+02
+3.78E+02
+3.09E+02
+2.40E+02
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+1.02E+02
+3.32E+01
-3.56E+01
-1.05E+02

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Wall H/G/H (sidespan side) (left view) Von-Mises_bot [MPa] (min) (elastic)

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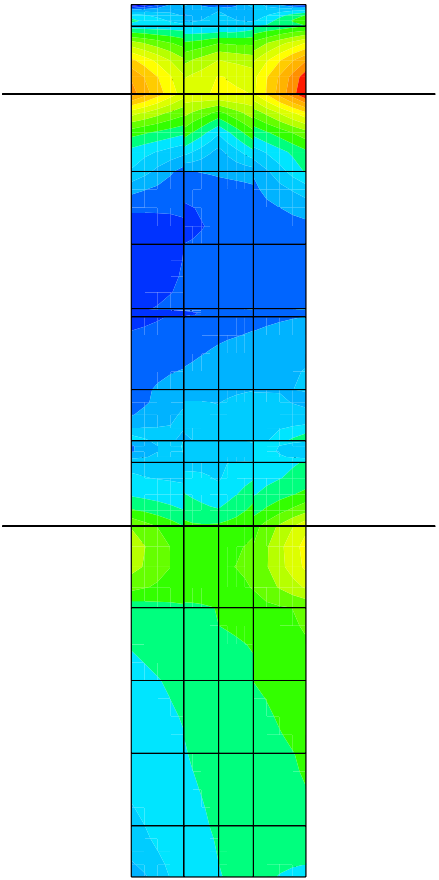

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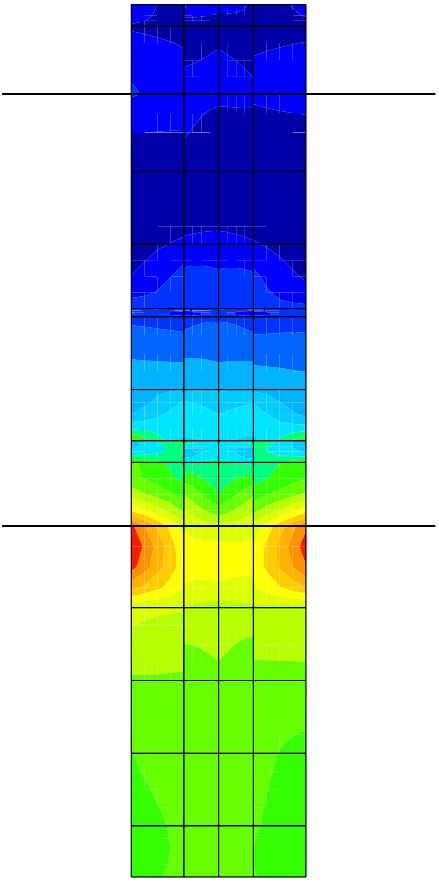
Wall D (cross beam side) (front view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

COWI Author: scc Date: 04-oct-10 16:46	Job no: 72689-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:



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Wall D (cross beam side) (front view) sss [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

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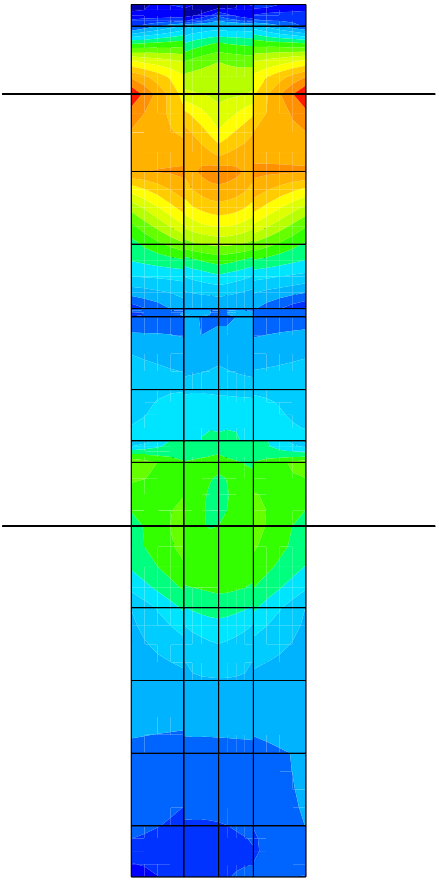

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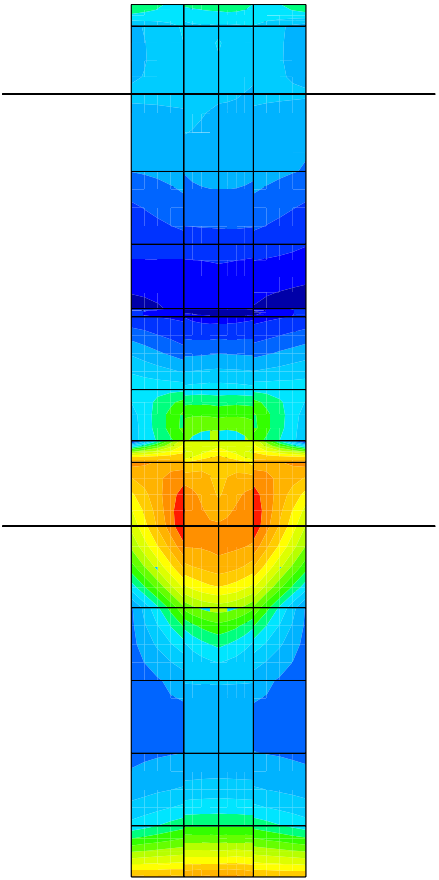

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Wall D (cross beam side) (front view) syy [MPa] (min) (at Zef=0.00 in Efb=1)(elastic)

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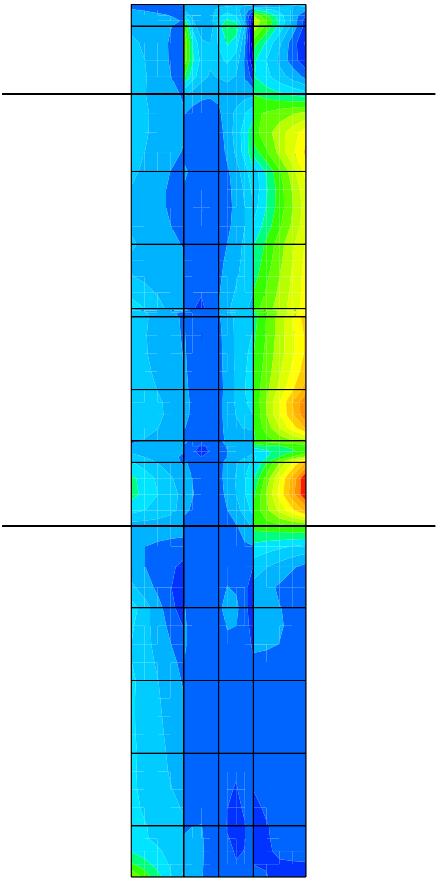

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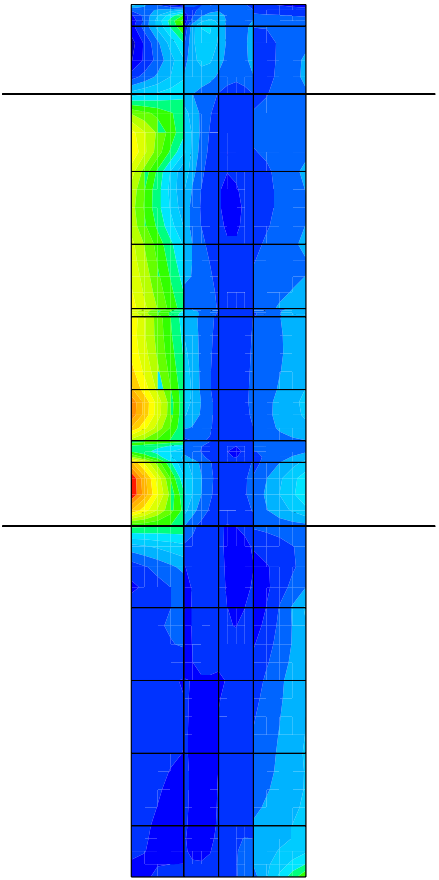

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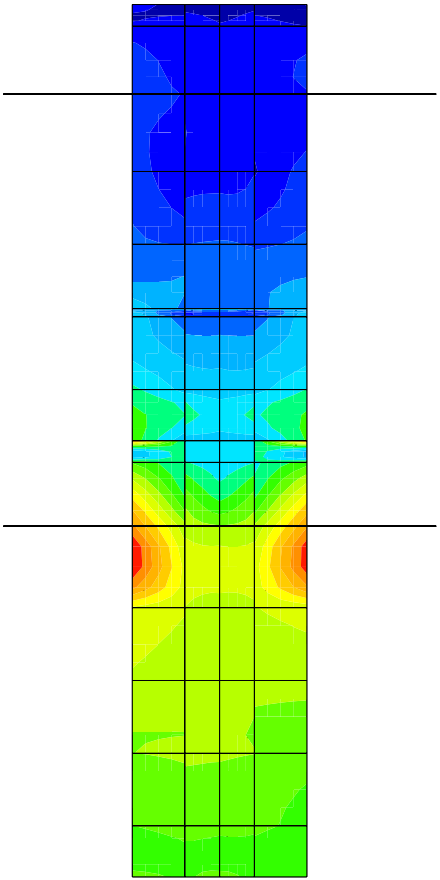

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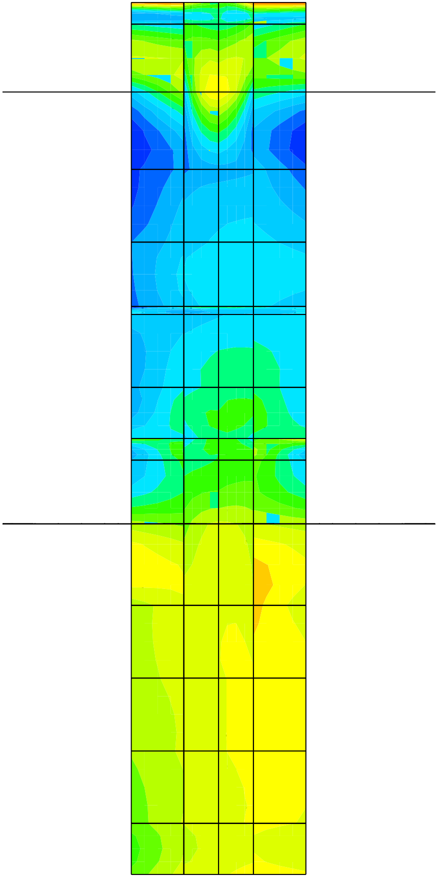

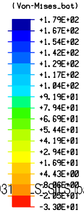

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Wall D (cross beam side) (front view) Von-Mises_bot [MPa] (min) (elastic)

IBDAS V1.10-2 pc26016 c:\ibdasjobs\72889\messina-v3_shell\shelloutput_tower

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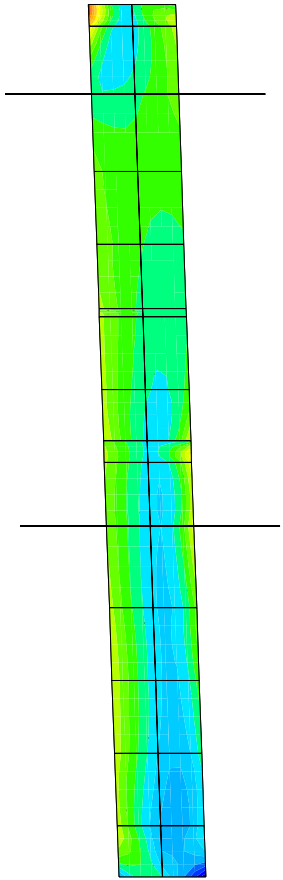

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Wall A (Sidespan side) (left view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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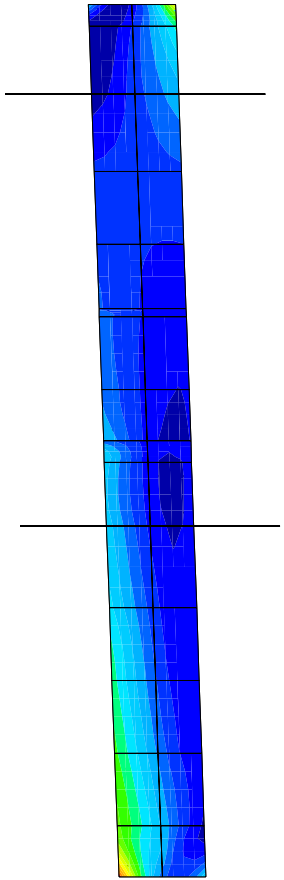

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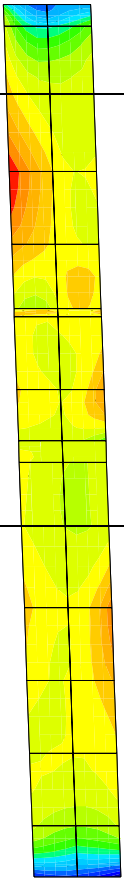

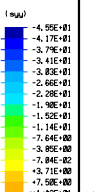

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Wall A (Sidespan side) (left view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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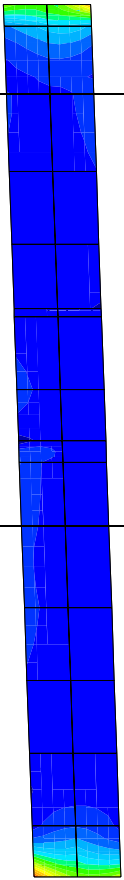

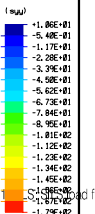

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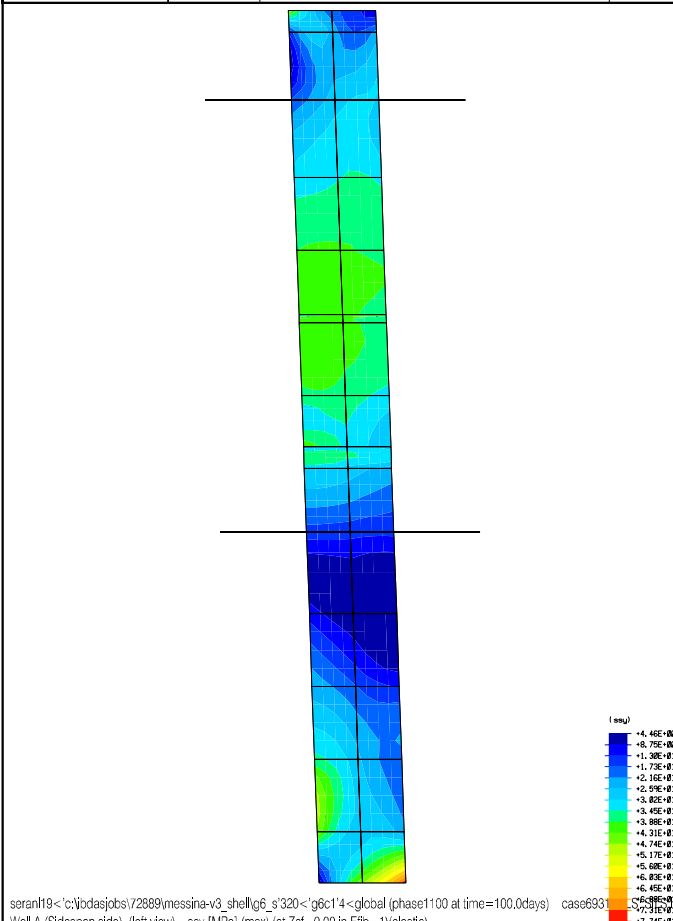

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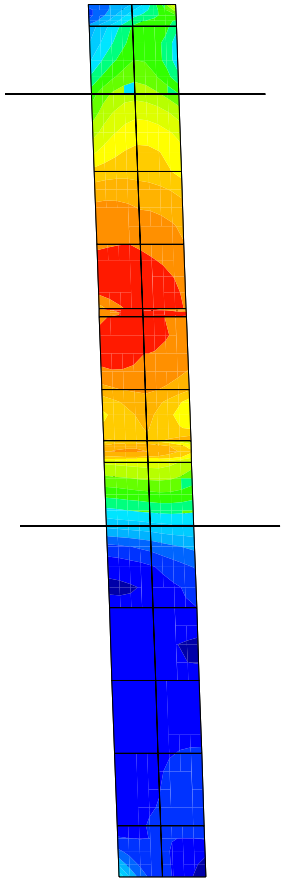

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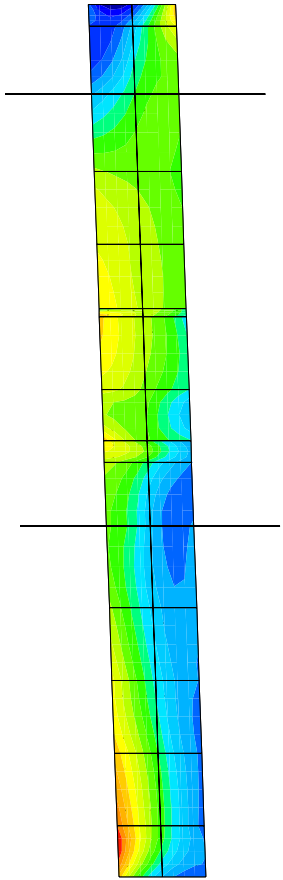

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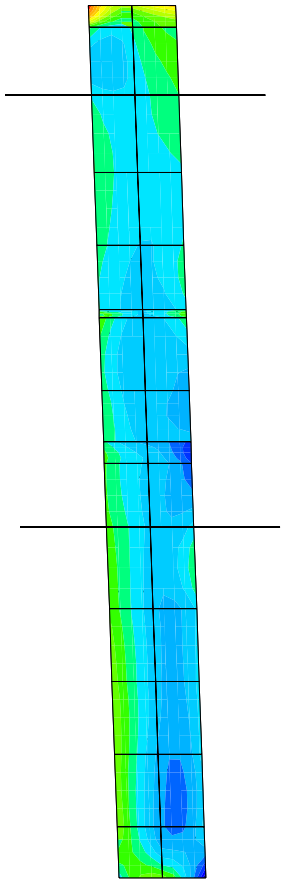

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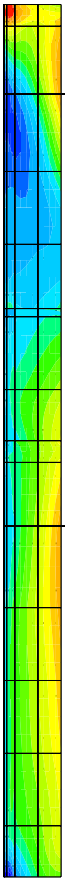

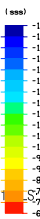

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Wall B (Sidespan side towards Cross beam) (front view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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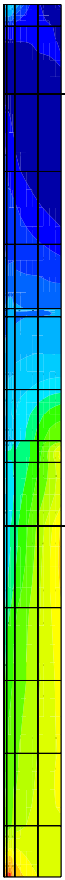

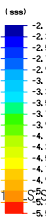

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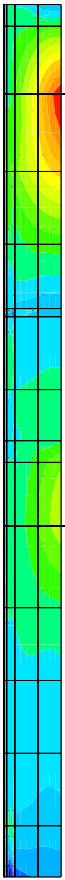

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Wall B (Sidespan side towards Cross beam) (front view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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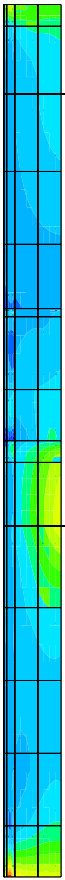

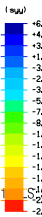

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Wall B (Sidespan side towards Cross beam) (front view) syy [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

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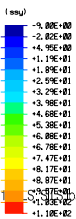

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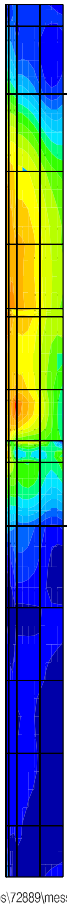

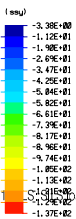

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Wall B (Sidespan side towards Cross beam) (front view) ssy [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

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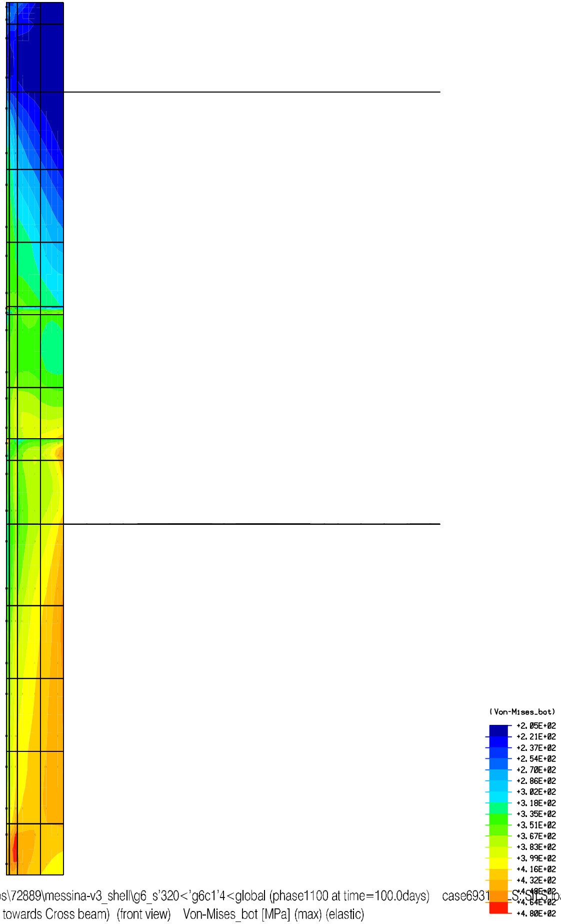

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Wall B (Sidespan side towards Cross beam) (front view) Von-Mises_bot [MPa] (max) (elastic)

IBDAS V1.10-2 pc26016 c:\ibdasjobs\72889\messina-v3_shell\shelloutput_tower

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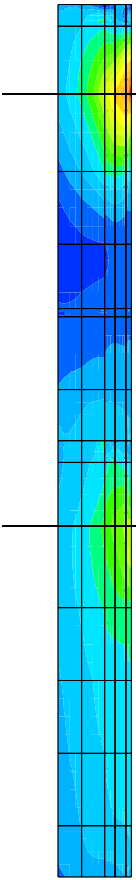

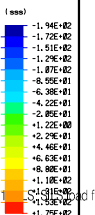

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Wall C (Sidespan side towards Cross beam) (front view) sss [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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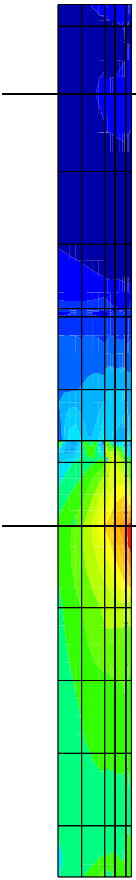

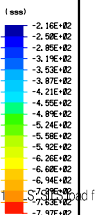

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Wall C (Sidespan side towards Cross beam) (front view) sss [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

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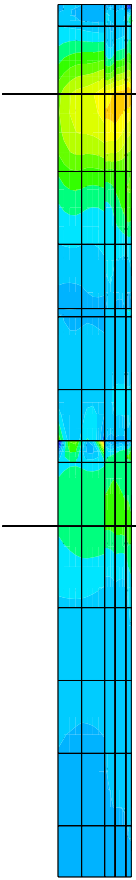

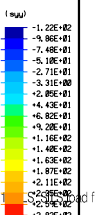

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Wall C (Sidespan side towards Cross beam) (front view) syy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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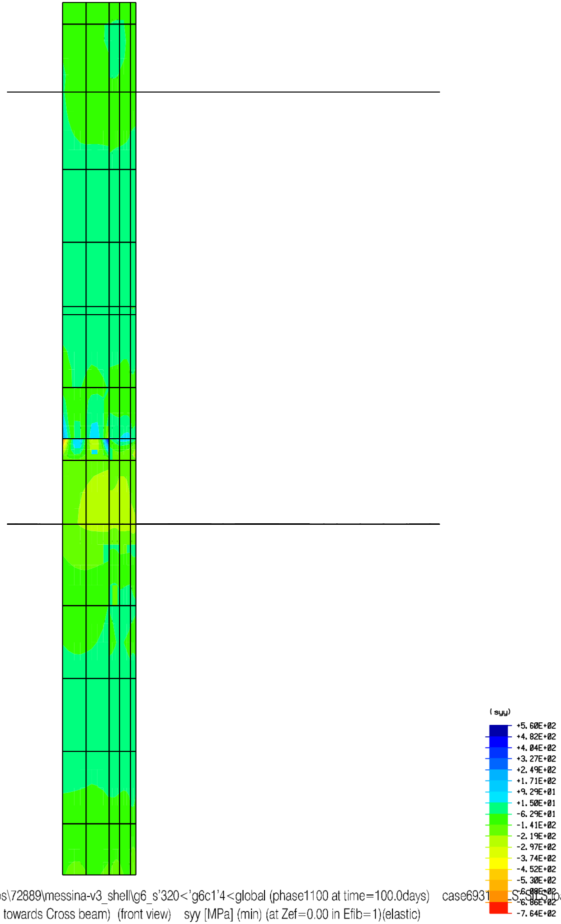

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Wall C (Sidespan side towards Cross beam) (front view) syy [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

IBDAS V1.10-2 pc26016 c:\ibdasjobs\72889\messina-v3_shell\shelloutput_tower

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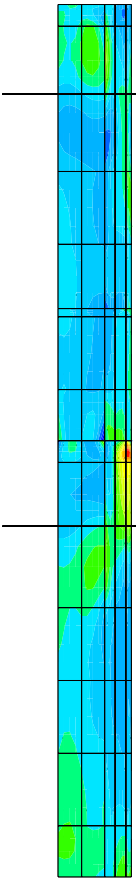

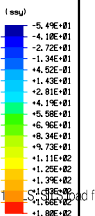

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Wall C (Sidespan side towards Cross beam) (front view) ssy [MPa] (max) (at Zef=0.00 in Efib=1)(elastic)

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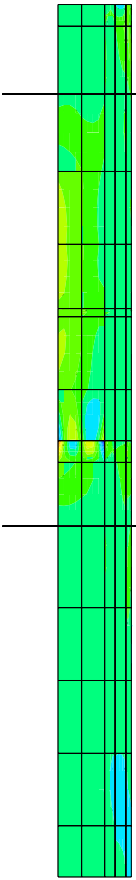

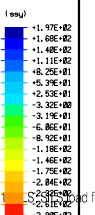

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Wall C (Sidespan side towards Cross beam) (front view) ssy [MPa] (min) (at Zef=0.00 in Efib=1)(elastic)

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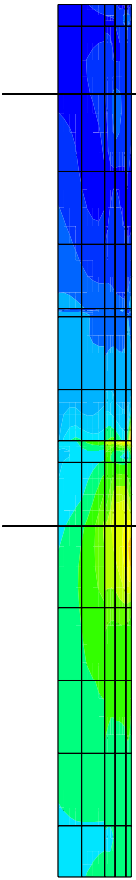

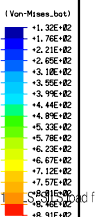

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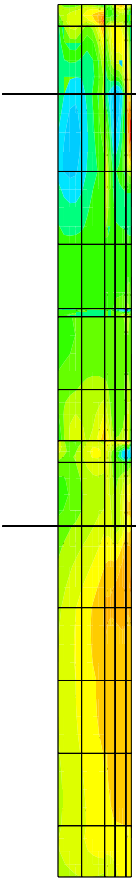
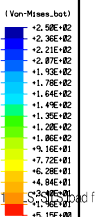
Wall C (Sidespan side towards Cross beam) (front view) Von-Mises_bot [MPa] (max) (elastic)

COWI Author: scc Date: 05-oct-10 08:47	Job no: 72689-a	Bridge across Strait of Messina Progetto Definitivo. Model ver. 3.3a	Page:





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Wall C (Sidespan side towards Cross beam) (front view) Von-Mises_bot [MPa] (min) (elastic)