CONVEGNO

"SISMA ED ELEMENTI NON STRUTTURALI

Approcci, Stati Limite e Verifiche Prestazionali"

Bologna – 24 ottobre 2014

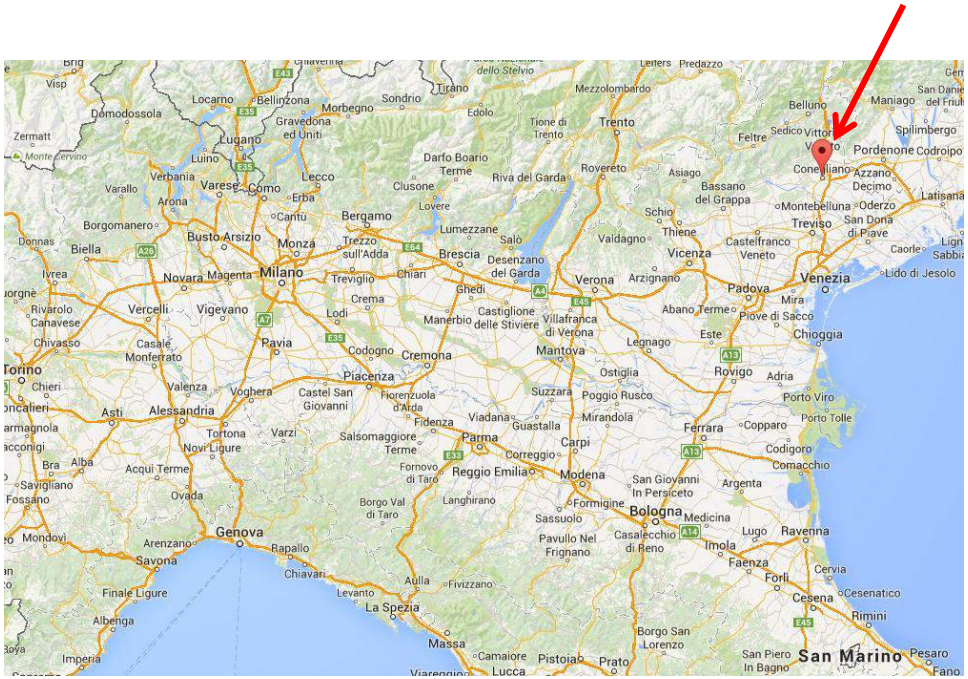
CASI DI INTERVENTO

Bologna, 22-25 ottobre

Ingegneria Sismica Italiana

ICOeng S.R.L. - Conegliano

Domenico Positello ingegnere



esempi:

+ copertura/tettoia a sbalzo

+ copertura di collegamento: effetti della modifica della configurazione di carico

+ copertura/tettoia a sbalzo: sviluppo di un nodo

+ altri esempi

esempio #1

+ struttura a sbalzo con sviluppo in pianta 70 m x 10 m circa

+ materiale: acciaio

+ colonne incastrate a terra (nelle due direzioni)

+ supporto dato dalla struttura in calcestruzzo armato di un viadotto/sopraelevata

+ luogo: Qatar

Normative:

ASCE7-02 - Minimum Design Loads for Buildings and Other Structures

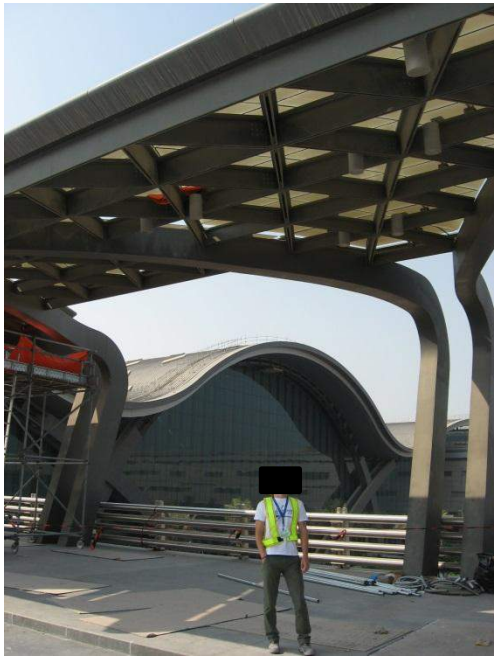
AISC(13th) - 2005 - Manual of steel construction, LRFD

ANSI/AISC 350-05 - Specifications for Structural Steel Buildings

ACI 318/AC308 - Building Code Requirements for Structural Concrete

esempio #1

+ localizzazione



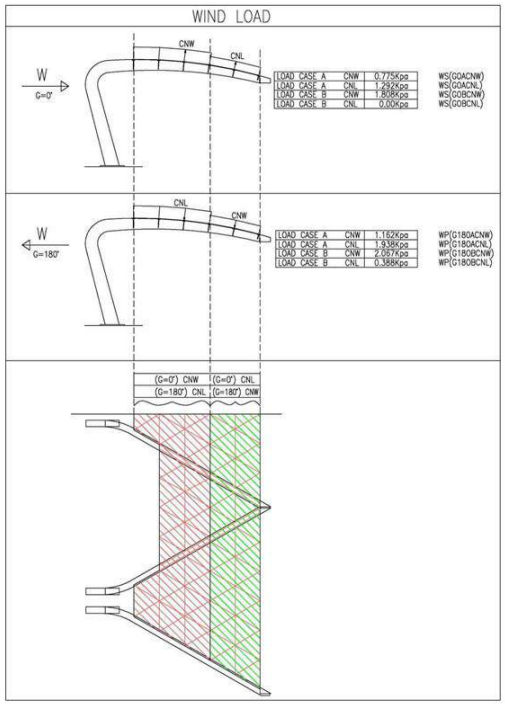
esempio #1

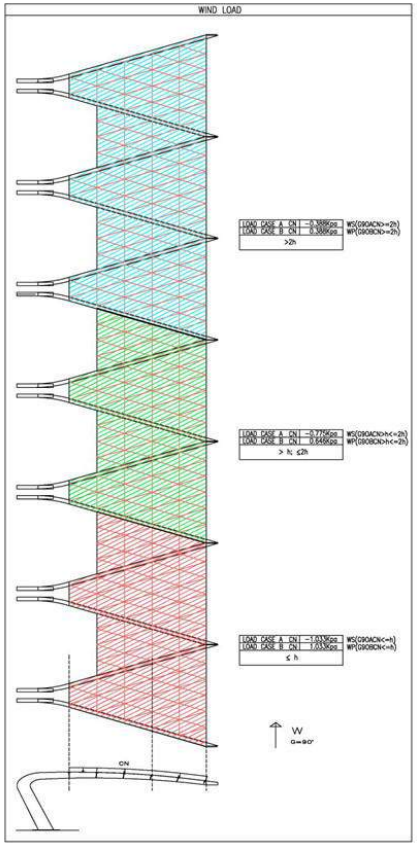
Analisi:

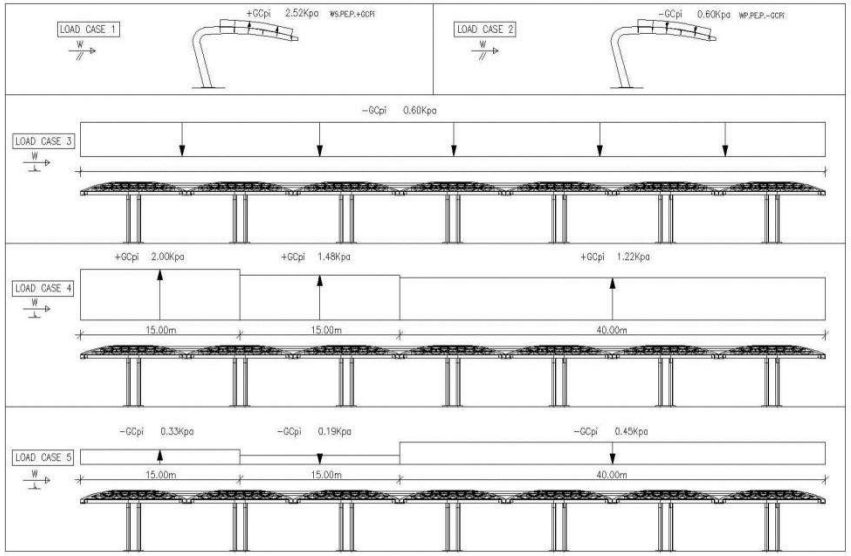
+ vento

+ sisma

+ (…)







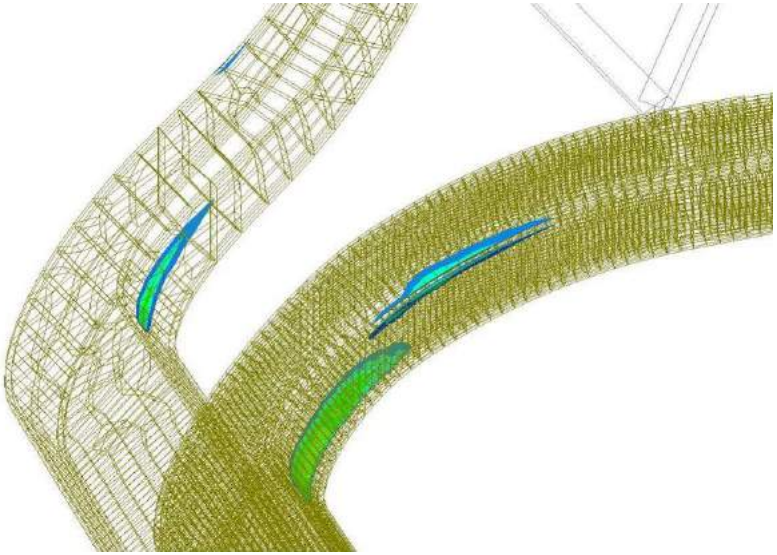
esempio #1

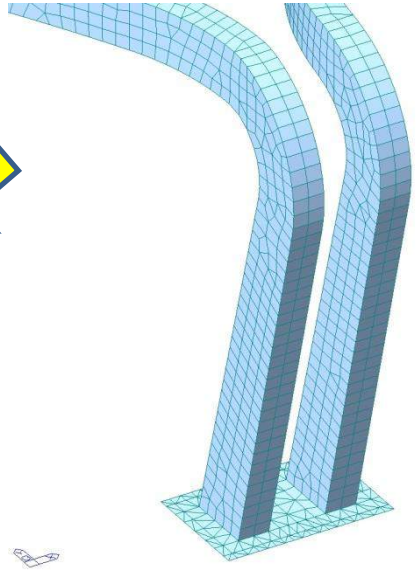
analisi con diversi «livelli di dettaglio» per:

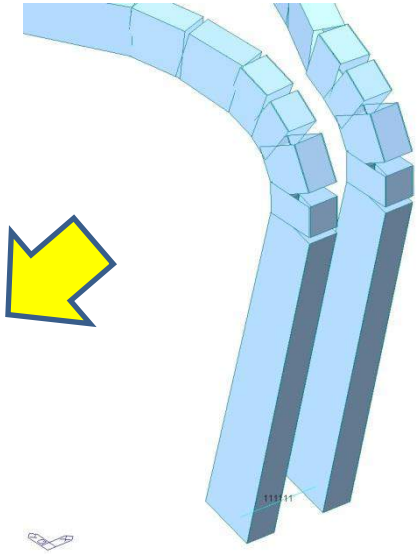
+ verifica deformabilità/deformata finale

+ instabilità globale e locale

+ verifica a fatica



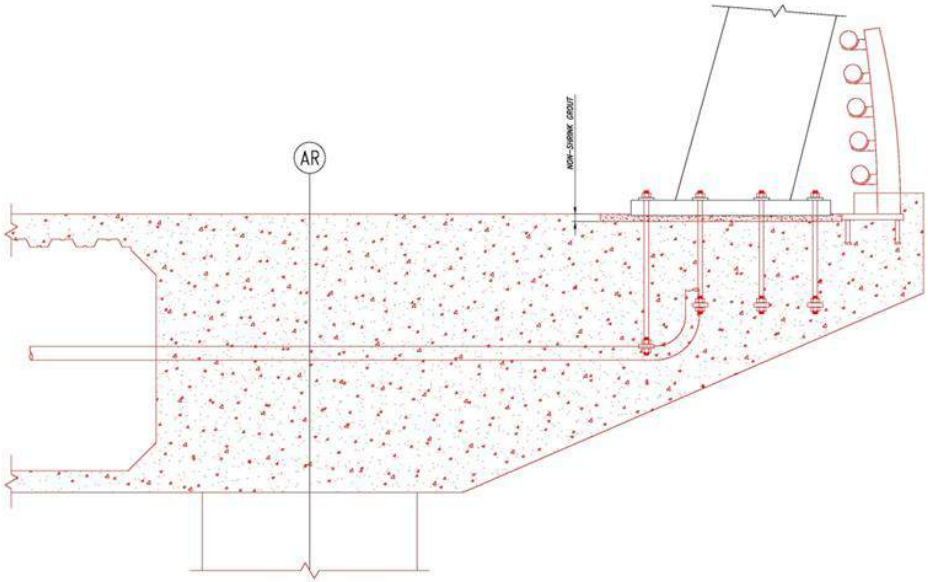


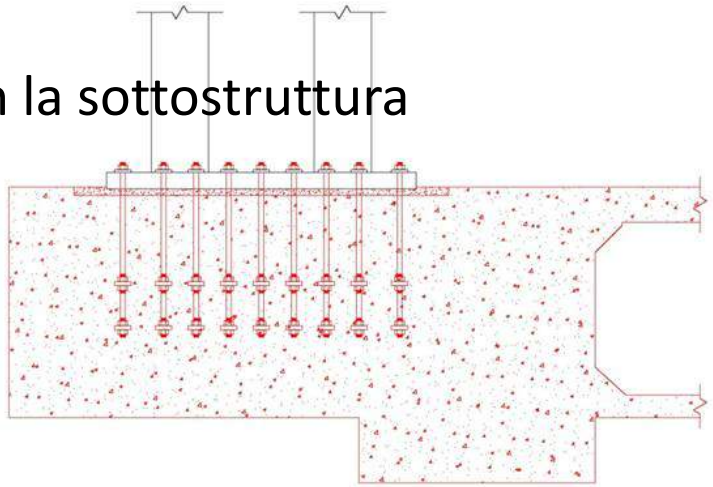


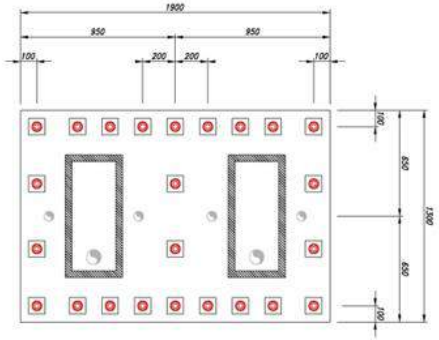
esempio #1

criticità:

+ nodo a terra (incastro) - interazione con la sottostruttura







esempio #1

criticità:

+ nodo a terra (incastro)

+ momento 2200 kN*m

… retrofit in cantiere

esempio #2

+ successione di portali con sviluppo in pianta a L

+ materiale: acciaio

+ colonne incernierate a terra (nelle due direzioni)

+ supporto dato dalla struttura in calcestruzzo armato di un edificio multipiano

+ luogo: Ryiadh

Normative:

ASCE7-05 Minimum Design Loads for Buildings and Other Structures

SAUDI BUILDING CODE 301 - Loads & Forces Requirements

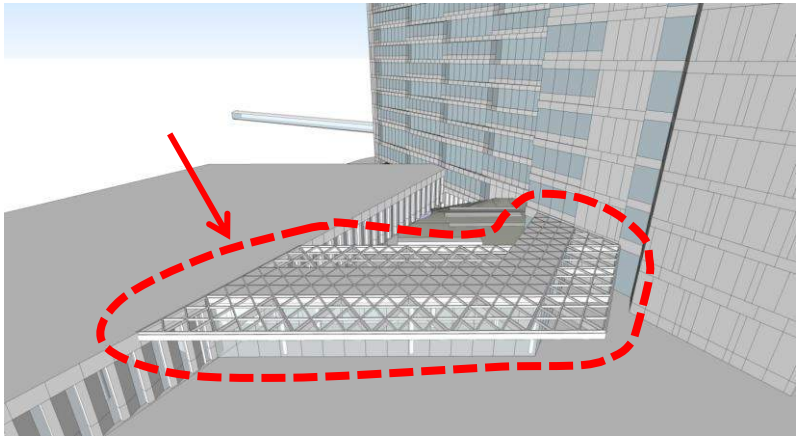
AISC(13th) - 2005 - Manual of steel construction, LRFD

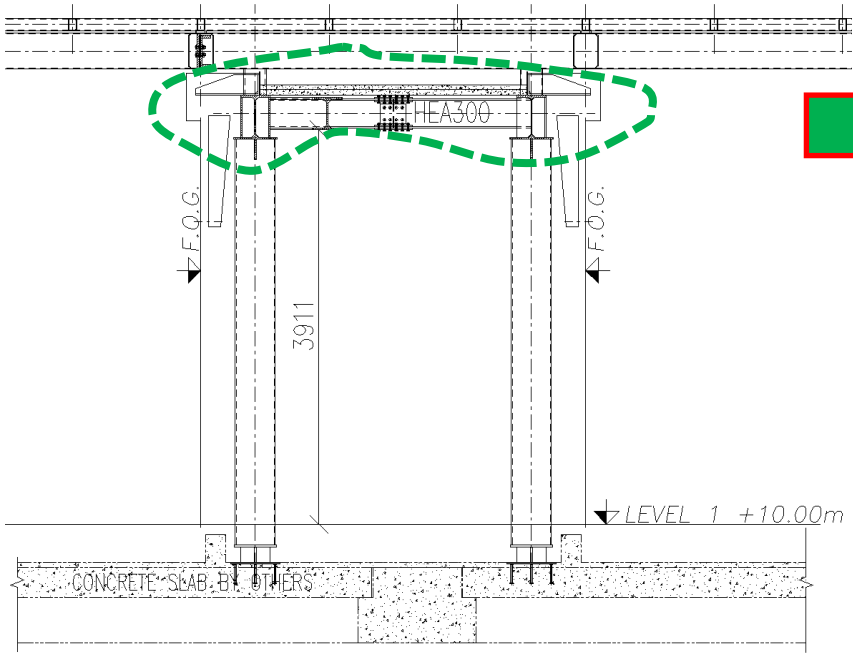
ANSI/AISC 350-05 - Specifications for Structural Steel Buildings

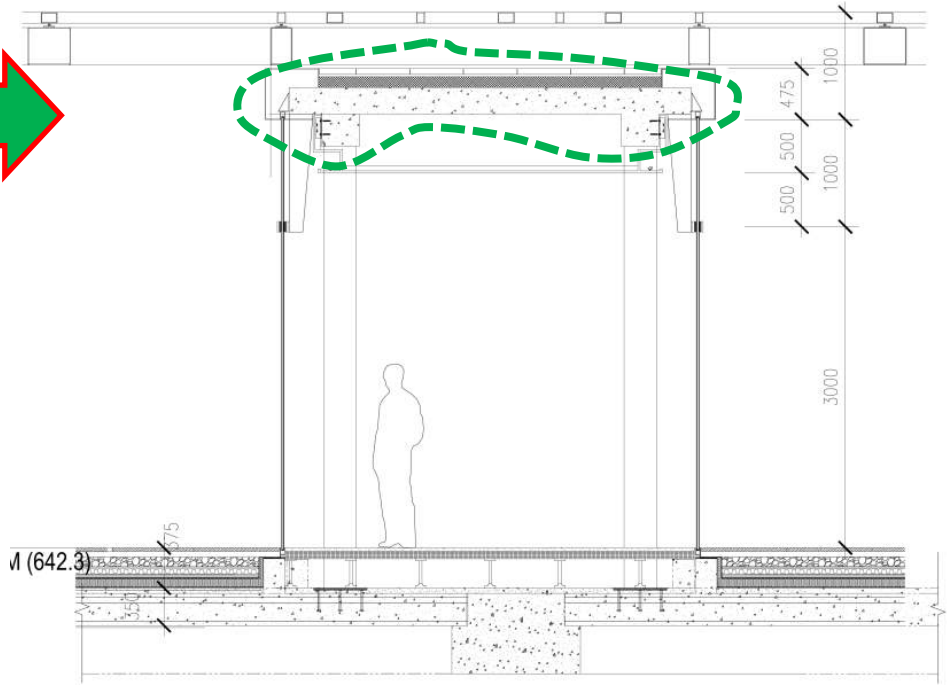
ACI 318M-05 - Building Code Requirements for Structural Concrete

esempio #2

+ modifica della configurazione di carico: copertura in reticolo d'acciaio trasformata in soletta di calcestruzzo armato







esempio #2

analisi:

+ vento

+ sisma

+ (...)

Seismic load is calculated in accordance with SBC 301 chapter 9 and chapter 10.

Site Class: B

Mapped Spectral Response Accel. at Short Periods: Ss = 0.8%g (Figure 9.4.1(f))

Mapped Spectral Response Accel. at 1 sec. Period: S1 = 0.2%g (Figure 9.4.1(n))

Site Coefficient at Short Periods: Fa = 1.0 (Table 9.4.3a)

Site Coefficient at 1s Period: Fv = 1.0 (Table 9.4.3b)

SMS = Fa * Ss = 0.008 (Eq. 9.4.3-1)

SM1 = Fv * S1 = 0.002 (Eq. 9.4.3-2)

Design Spectral Response Acc. at Short Periods: SDS = (2/3) * SMS = 0.0053 (Eq. 9.4.4-1)

Design Spectral Response Acc. at 1 s Period: SD1 = (2/3) * SM1 = 0.0013 (Eq. 9.4.4-2)

Occupancy Category: II

Importance Factor I = 1.00 (Table 9.5)

Seismic Design Category from SDS: A (Table 9.6a)

Seismic Design Category from SD1: A (Table 9.6b)

Seismic Design Category from both SDS and SD1: A

Structural steel systems not specifically detailed for seismic resistance (Table 10.2)

Response modification coefficient: R = 2.5

Deflection amplification factor: Cd = 3

The seismic behaviour of the structure and the story drift were investigated by a Modal Response Spectrum Analisys as per SBC 301 Section 10.10: the following response spectrums are used for the analisys:

T0 = 0.2 * SD1/SDS = 0.05 sec

TS = SD1/SDS = 0.25 sec

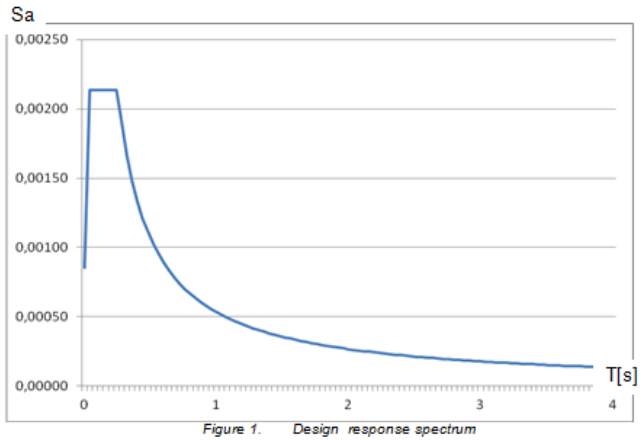


Figure 1. Design response spectrum

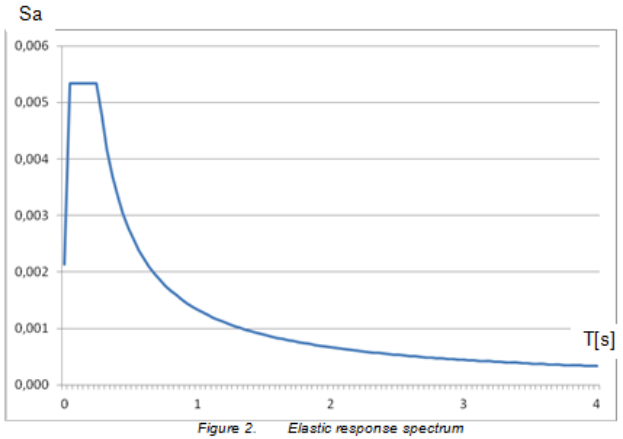


Figure 2. Elastic response spectrum

The design seismic forces are applied separately in each of the two orthogonal directions considering the 100% of the forces for one direction plus 30% of the forces for the perpendicular direction.

Please note that the elastic response spectrum is used to find the story drifts.

esempio #2

effetti della modifica:

+ copertura da «piano flessibile» diventa «piano rigido»

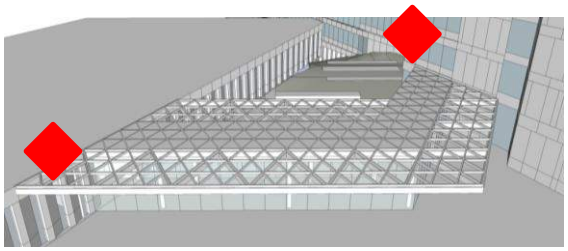
+ reazioni a terra (taglio) variate in aumento

+ diminuzione dello scarico verticale (uplift)

verifiche:

+ controllo sugli spostamenti relativi tra galleria ed edificio esistente (giunto sismico)

+ controllo sugli spostamenti relativi tra porzioni della stessa struttura (pareti verticali)



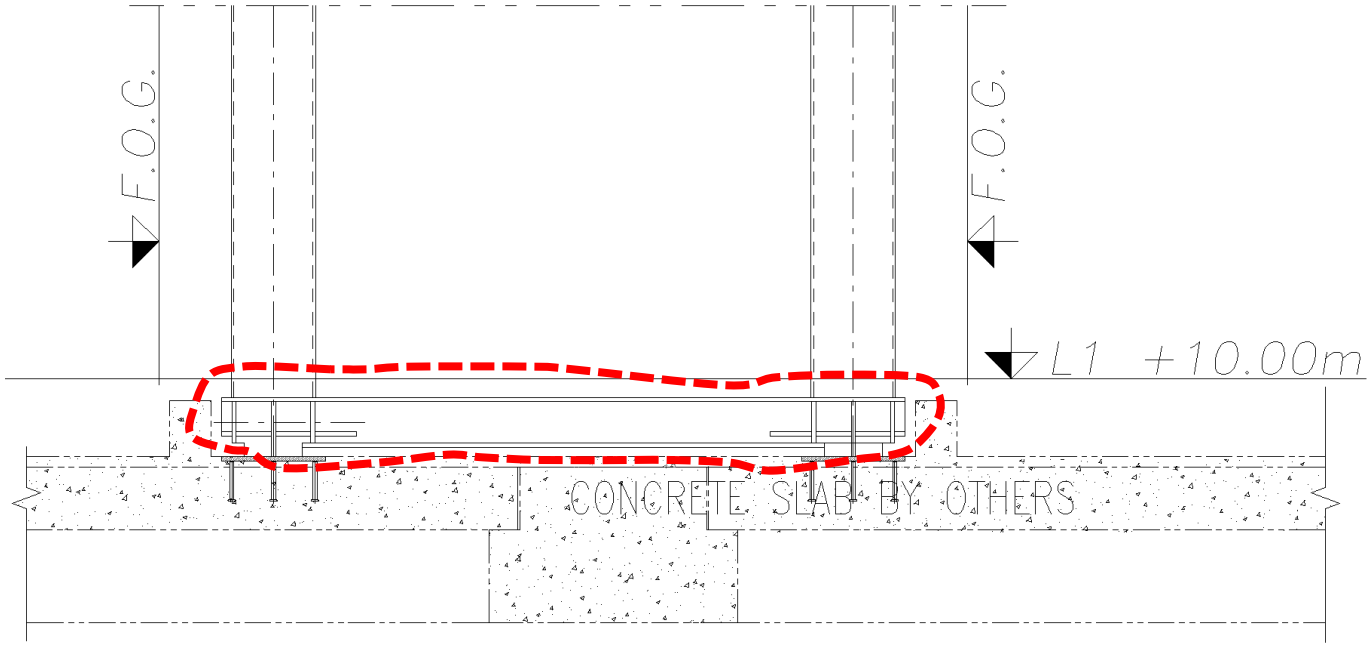
esecuzione:

+ irrigidimento telaio trasversale con profilo di banchina a terra…

esempio #2

criticità: spostamenti

+ per limitare il drift interpiano è stato cambiato lo schema statico trasversale del portale creando un «incastro» a terra e modificando quindi i vincoli a terra delle colonne in acciaio



esempio #3

+ copertura su colonne esili: sviluppo in pianta 50m x 11m circa

+ materiale: acciaio

+ colonne incastrate a terra (x-dir e y-dir) e incernierate in sommità

+ supporto: struttura in calcestruzzo armato di un ed. multipiano

+ luogo: Ryiadh

Normative:

ASCE7-05 Minimum Design Loads for Buildings and Other Structures

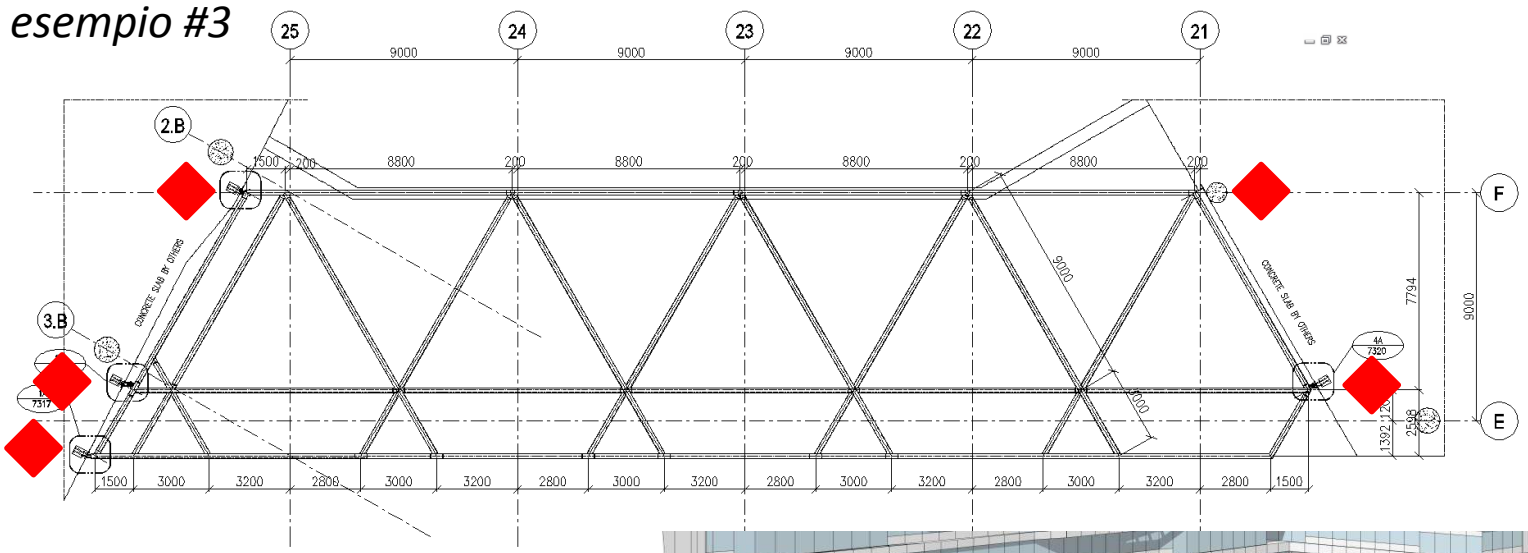
SAUDI BUILDING CODE 301 - Loads & Forces Requirements

AISC(13th) - 2005 - Manual of steel construction, LRFD

ANSI/AISC 350-05 - Specifications for Structural Steel Buildings

ACI 318M-05 - Building Code Requirements for Structural Concrete

esempio #3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CONCRETE SLAB BY OTHERS
CONCRETE SLAB BY OTHERS
9000
5000
7794
9000
1392
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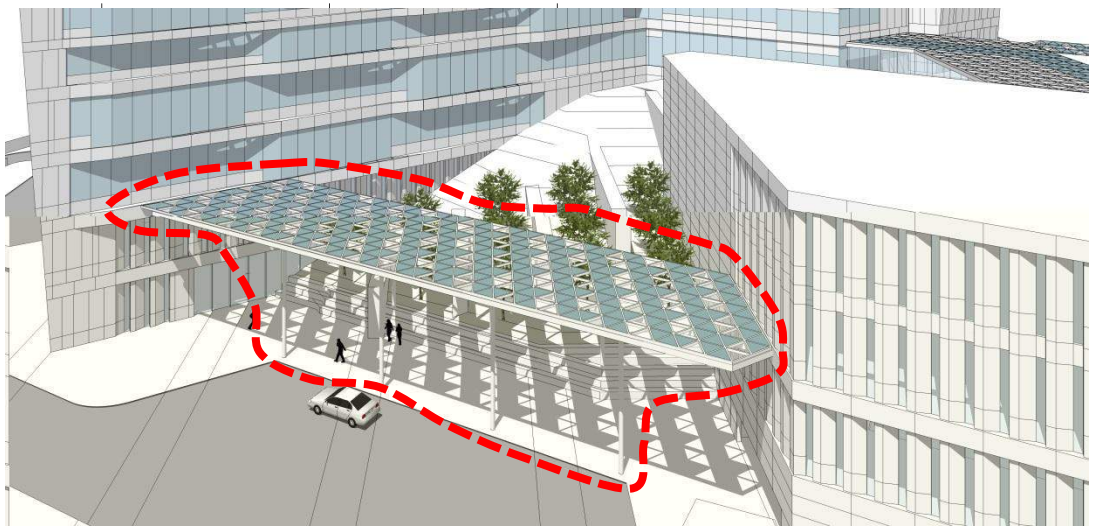
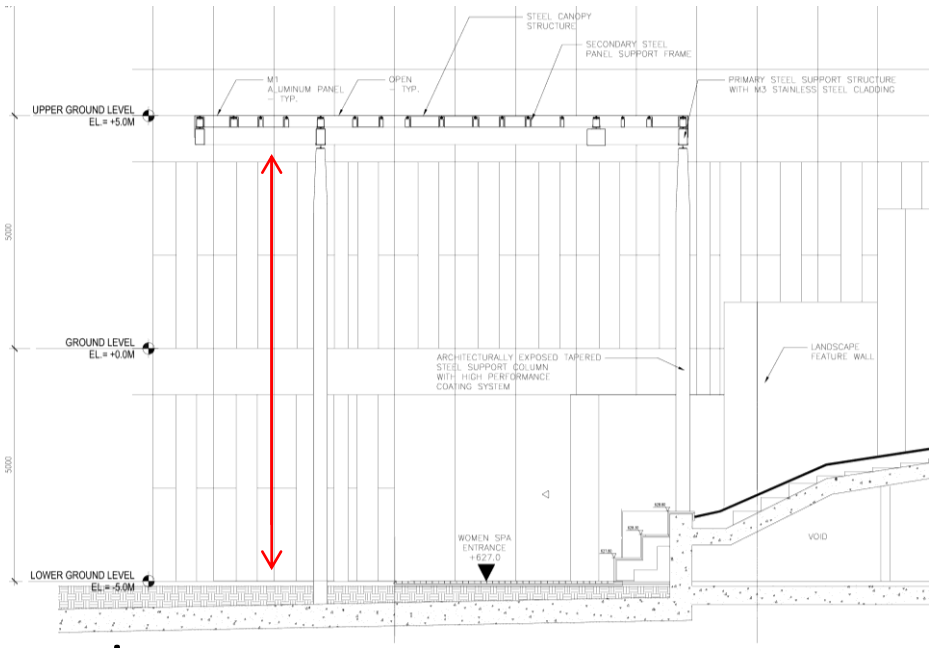


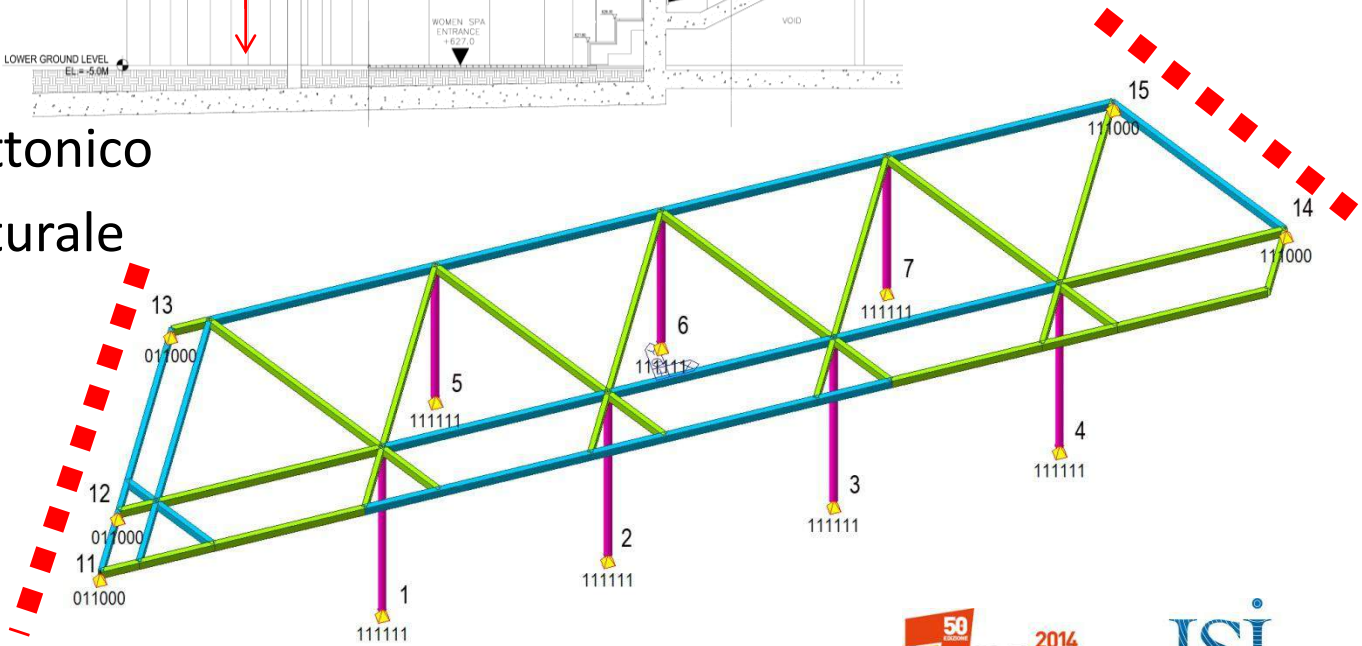
esempio #3



scopo:

+ risultato architettonico

+ … efficacia strutturale



esempio #3

criticità:

+ colonne snelle incernierate in sommità: … pendolo inverso

+ interazione con struttura principale in calcestruzzo armato: spostamenti eccessivi in condizioni sismiche

+ connessioni ai nodi

esempio #3

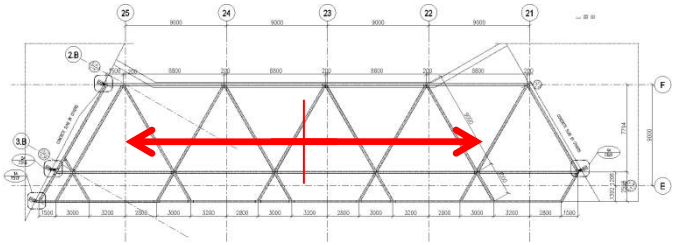
analisi:

+ vento

+ sisma

+ (…)

esempio #3



considerati:

+ spostamenti della struttura secondaria acciaio

+ spostamenti della struttura principale c.a.

esecuzione:

+ spostamenti bloccati alle estremità

solo in una direzione

ottengo:

+/- 105 mm (slot range 210 mm)

4.3.4 Drift check and building separation design

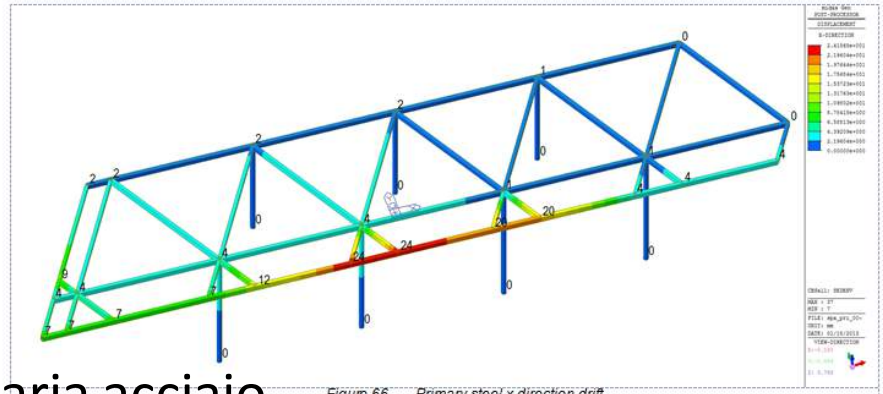


Figure 66. Primary steel x direction drift

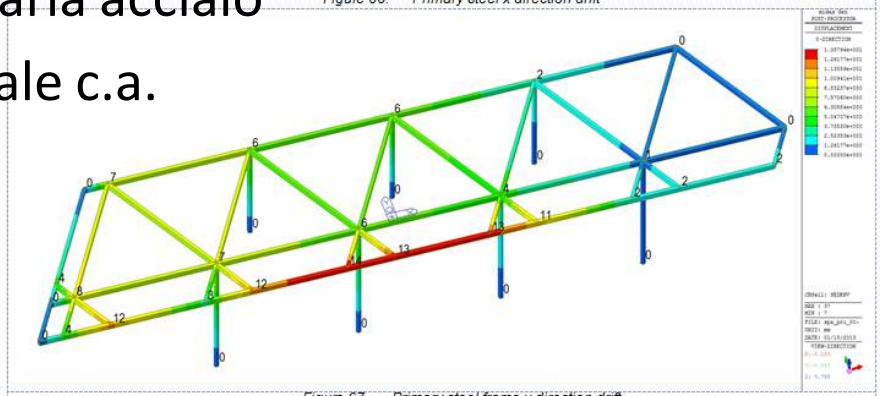


Figure 67. Primary steel frame y direction drift

The above drift results are obtained using elastic response spectrum and as per SBC 301 10.9.7.1 must be multiplied by the quantity Cd/I = 2.5.

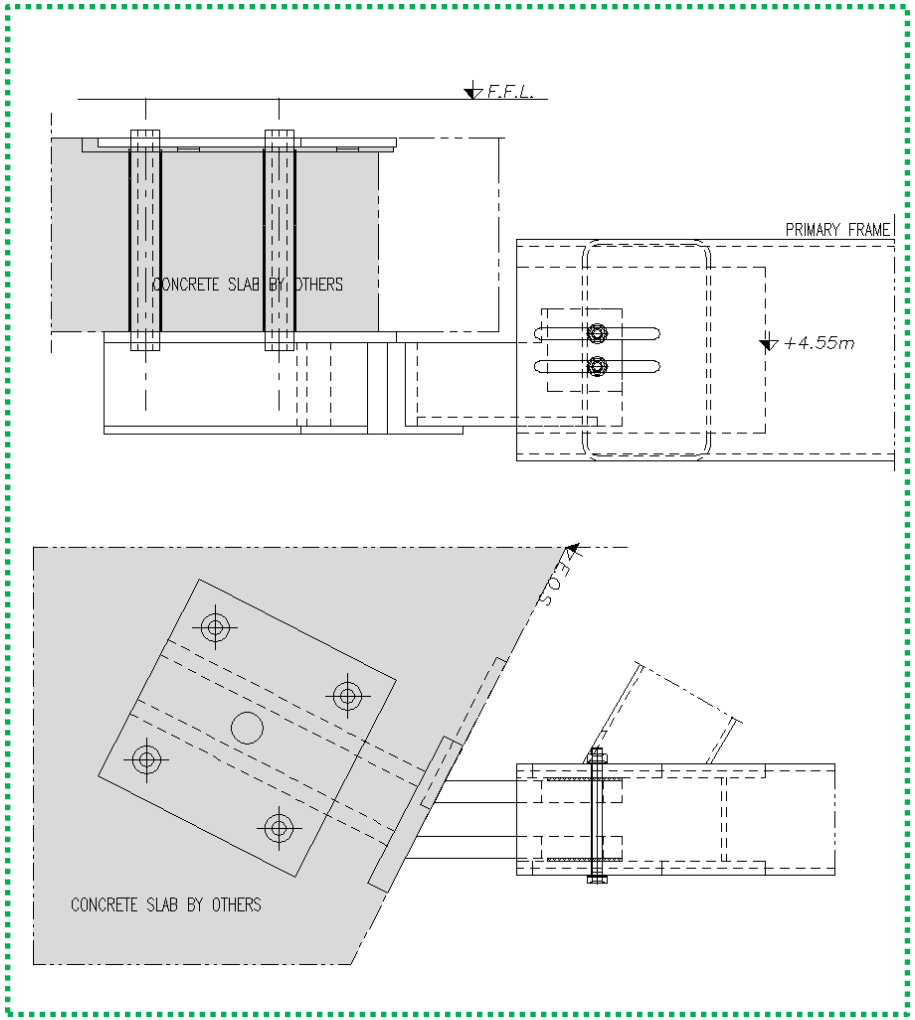
$\Delta xy = (Cd/I) * sqrt(\Delta x^2 + \Delta y^2) = 2.5 * sqrt(9^2 + 4^2) = 25$ mm – design drift

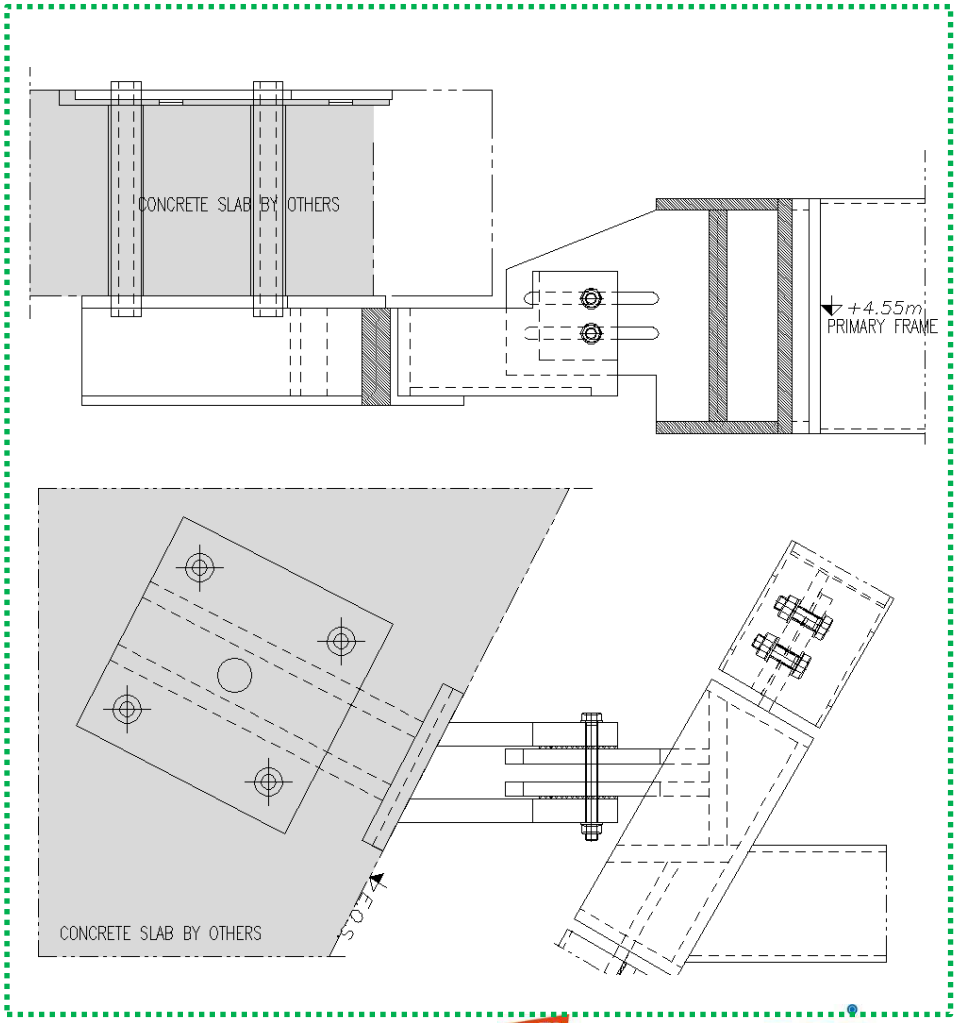
$\Delta x < 0.015$ hsx = 0.015 * 7900 = 118.5 mm (allowable story drift Table 10.12) **checked**

We consider as horizontal maximum design building movement (interstory drift) at any floor H/400 (please see the Enclosure Performance Requirements specs section 01830-4).

esempio #3

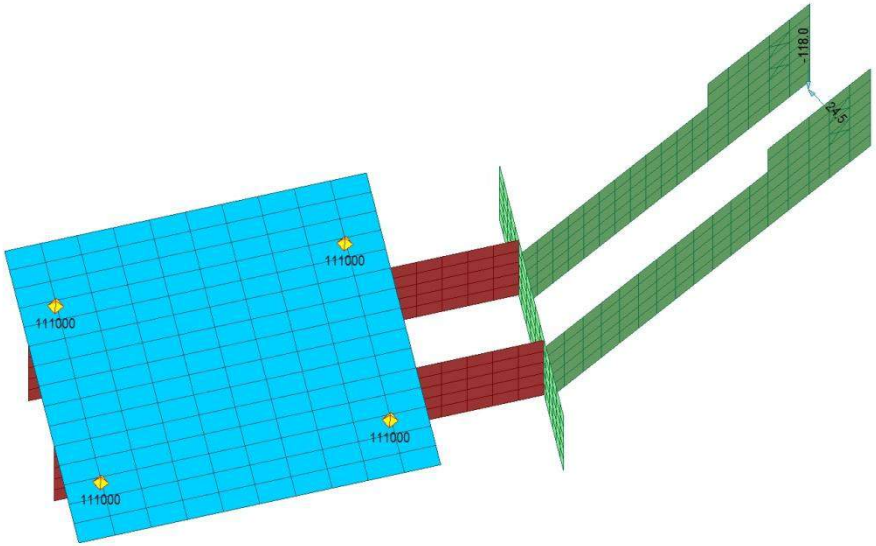
tipologico nodi:

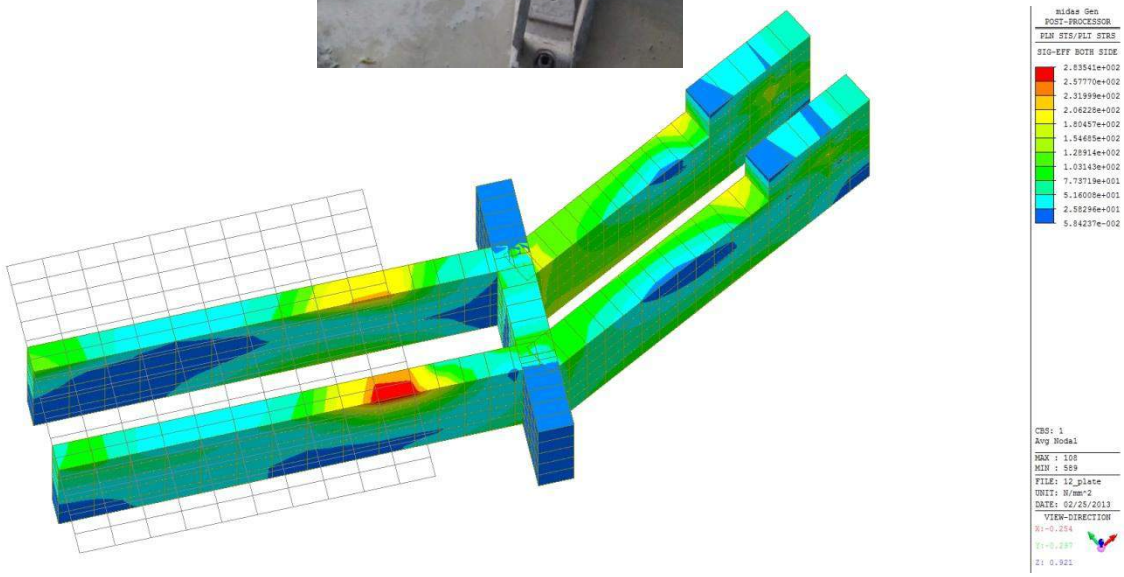




esempio #3

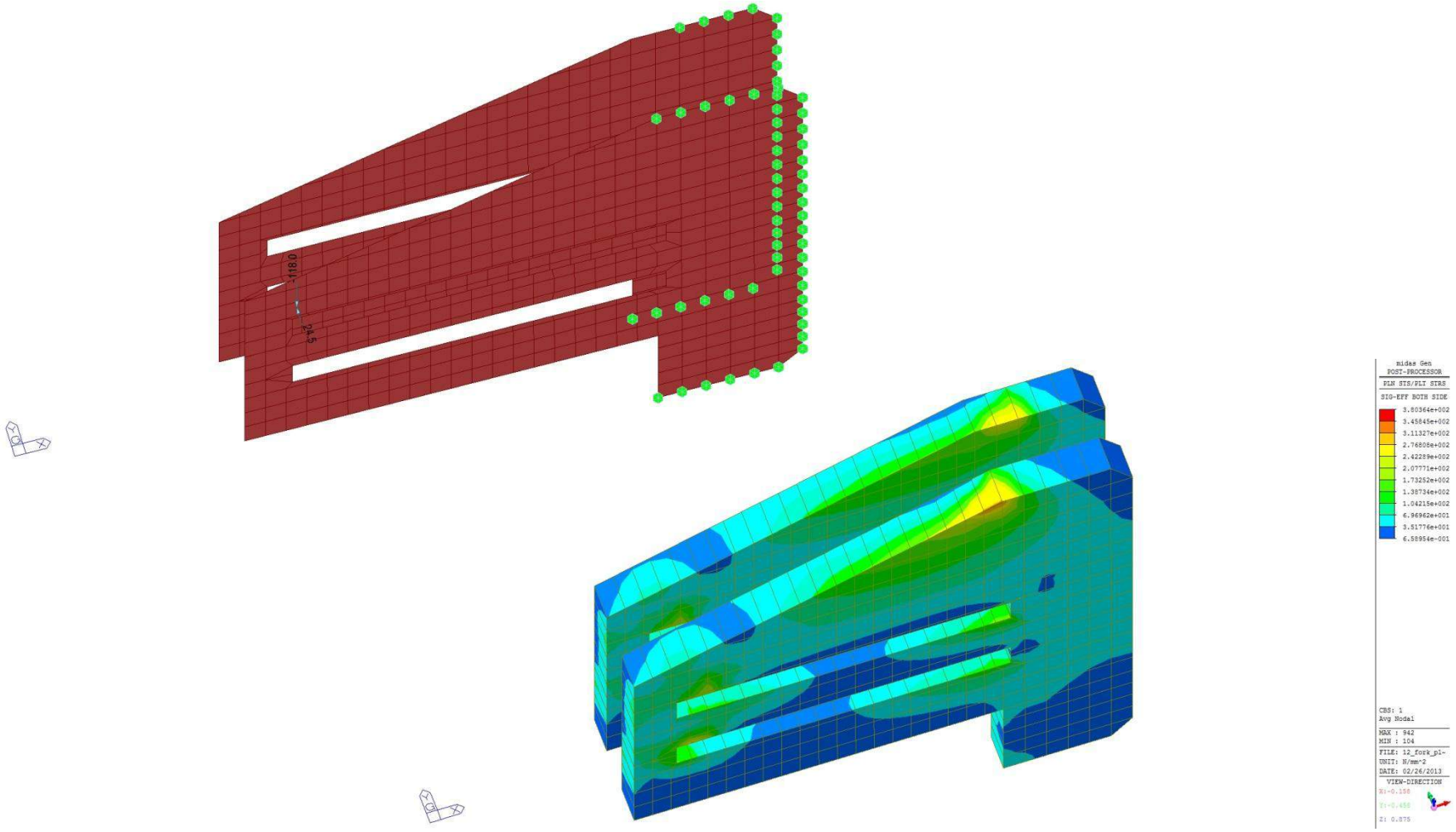
dettaglio di studio di un nodo: bracket





esempio #3

dettaglio di studio di un nodo: terminali profilo



esempio #4

+ copertura su colonne esili

+ materiale: acciaio

+ colonne incastrate a terra (x-dir e y-dir) e incernierate in sommità

+ supporto: struttura in calcestruzzo armato

+ luogo: Baku

Normative:

ASCE7-05 Minimum Design Loads for Buildings and Other Structures

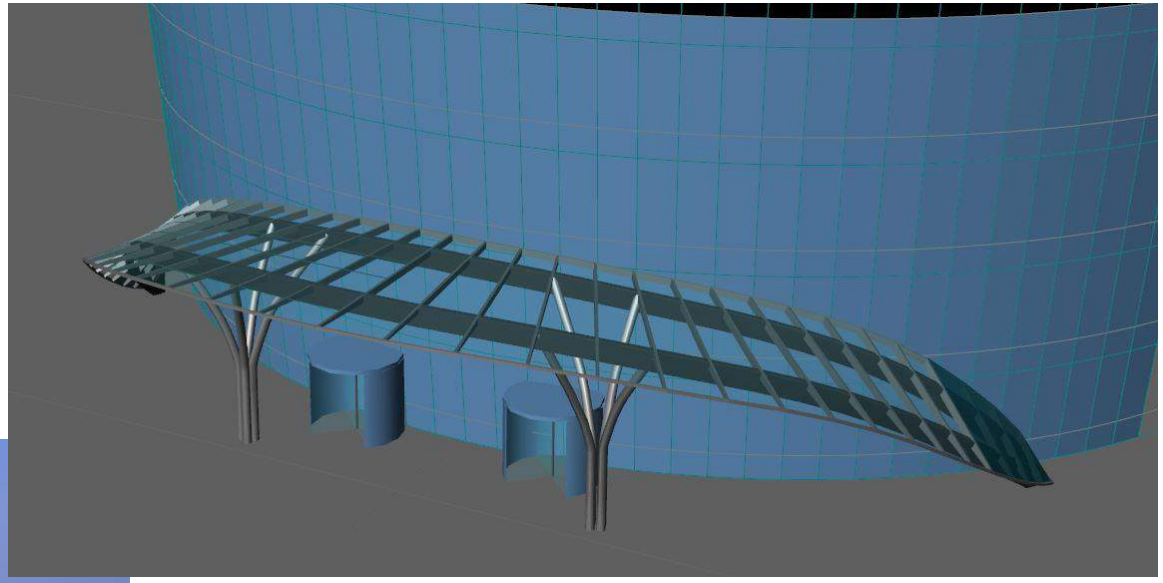
SNiP 2.01.07-85 Building Codes and Standards - Loads and effects

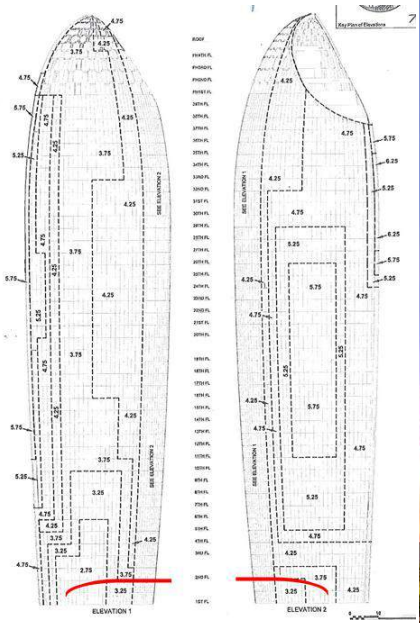
AISC(13th) - 2005 - Manual of steel construction, LRFD

ANSI/AISC 350-05 - Specifications for Structural Steel Buildings

ACI 318M-05 - Building Code Requirements for Structural Concrete

esempio #4





esempio #4

analisi:

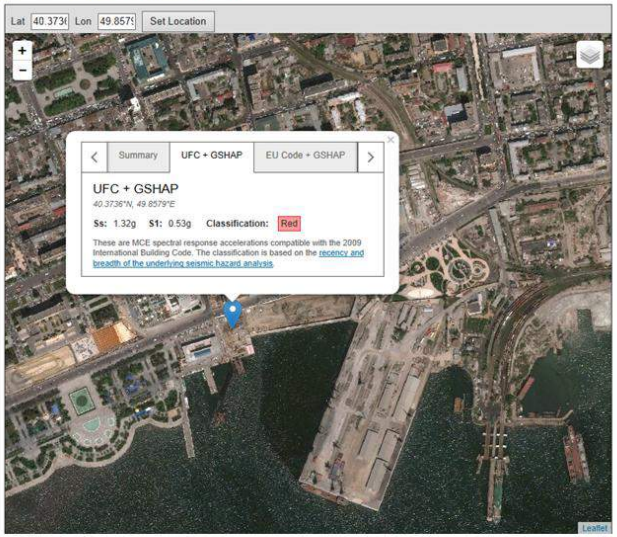
+ vento

+ e sisma

Seismic load is applied in accordance with ASCE/SEI 7-05.

Site Class: D (soil properties not known - Section 11.4.2)

Site seismic design parameters S1 and Ss were derived from USGS Worldwide Seismic Design Tool (http://geohazards.usgs.gov/designmaps/ww/):



Spectral Response Accel. at Short Periods: Ss = 1.32g

Spectral Response Accel. at 1 sec. Period: S1 = 0.53g

Site Coefficient at Short Periods: Fa = 1.0 (Table 11.4-1)

Site Coefficient at 1s Period: Fv = 1.5 (Table 11.4-2)

SMS = Fa * Ss = 1.32g (Eq. 11.4-1)

SM1 = Fv * S1 = 0.795g (Eq. 11.4-2)

Design Spectral Response Acc. at Short Periods: SDS = (2/3) * SMS = 0.88g (Eq. 11.4-3)

Design Spectral Response Acc. at 1 s Period: SD1 = (2/3) * SM1 = 0.53g (Eq. 11.4-4)

Occupancy Category: II

Importance Factor I = 1.00 (Table 11.5-1)

Seismic Design Category from SDS: D (Table 11.6-1)

Seismic Design Category from SD1: D (Table 11.6-2)

Seismic Design Category from both SDS and SD1: D

Ordinary steel moment frames (Table 12.2-1)

Response modification coefficient: R = 3.5

Deflection amplification factor: Cd = 3

EIGENVALUE ANALYSIS

Mode No	Frequency (radisec)	Frequency (cyclesec)	Period (sec)	Tolerance
1	7.8838	1.2514	0.7991	0.0000e+000
2	11.3828	1.8084	0.5530	0.0000e+000
3	17.0422	2.6978	0.3661	0.0000e+000
4	29.9000	4.7600	0.2101	0.0000e+000
5	38.3603	6.1052	0.1638	0.0000e+000
6	54.0071	8.5956	0.1163	3.0750e-096
7	54.3999	8.6580	0.1155	1.0330e-087
8	57.6526	9.1757	0.1090	1.6852e-094
9	72.9857	11.6160	0.0861	1.1787e-080
10	78.9266	12.5616	0.0796	6.2625e-074
11	79.5404	12.6593	0.0790	1.5761e-071
12	82.2515	13.0907	0.0764	3.8573e-072

MODAL PARTICIPATION MASSES PRINTOUT

Mode No	TRAN-X MASS(%)	TRAN-X SUM(%)	TRAN-Y MASS(%)	TRAN-Y SUM(%)	TRAN-Z MASS(%)	TRAN-Z SUM(%)	ROTN-X MASS(%)	ROTN-X SUM(%)	ROTN-Y MASS(%)	ROTN-Y SUM(%)	ROTN-Z MASS(%)	ROTN-Z SUM(%)
1	34.9775	34.9775	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	8.2368	8.2368	48.1098	48.1098
2	0.0000	34.9775	81.8641	81.8641	0.0000	0.0000	31.6220	31.6220	0.0000	8.2368	0.0000	48.1098
3	52.8213	87.7988	0.0000	81.8641	0.0000	0.0000	0.0000	31.6220	13.0440	21.2807	33.3340	81.4438
4	0.0000	87.7988	5.2561	87.1202	0.0000	0.0000	13.1468	44.7687	0.0000	21.2807	0.0000	81.4438
5	0.2187	88.0156	0.0000	87.1202	0.0000	0.0000	0.0000	44.7687	4.2436	25.5243	4.8464	86.8903
6	0.0000	88.0156	0.1777	87.2979	0.0000	0.0000	0.5906	45.3594	0.0000	25.5243	0.0000	86.8903
7	0.0016	88.0172	0.0000	87.2979	0.0000	0.0000	0.0000	45.3594	0.0000	25.5243	0.0010	86.8913
8	0.0000	88.0172	1.0297	88.3276	0.0000	0.0000	3.2771	48.6365	0.0000	25.5243	0.0000	86.8913
9	0.2036	88.2207	0.0000	88.3276	0.0000	0.0000	0.0000	48.6365	2.1664	27.6908	3.0178	90.9091
10	0.0000	88.2207	0.2538	88.5814	0.0000	0.0000	0.4303	49.0668	0.0000	27.6908	0.0000	90.9091
11	3.2235	91.4442	0.0000	88.5814	0.0000	0.0000	0.0000	49.0668	2.9884	30.6792	0.1484	90.1575
12	0.0000	91.4442	2.3965	90.9779	0.0000	0.0000	4.0644	53.1312	0.0000	30.6792	0.0000	90.1575

Mode No	TRAN-X MASS	TRAN-X SUM	TRAN-Y MASS	TRAN-Y SUM	TRAN-Z MASS	TRAN-Z SUM	ROTN-X MASS	ROTN-X SUM	ROTN-Y MASS	ROTN-Y SUM	ROTN-Z MASS	ROTN-Z SUM
1	6.8001	6.8001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	12.5788	12.5788	889.8247	889.8247
2	0.0000	6.8001	15.9155	15.9155	0.0000	0.0000	48.2916	48.2916	0.0000	12.5788	0.0000	889.8247
3	10.2892	17.0892	0.0000	15.9155	0.0000	0.0000	0.0000	48.2916	19.9262	32.4990	582.8794	1472.5042
4	0.0000	17.0892	1.0219	16.9373	0.0000	0.0000	20.0772	68.3688	0.0000	32.4990	0.0000	1472.5042
5	0.0421	17.1114	0.0000	16.9373	0.0000	0.0000	0.0000	68.3688	6.4806	38.9796	84.0075	1556.5117
6	0.0000	17.1114	0.0345	16.9718	0.0000	0.0000	0.9020	69.2708	0.0000	38.9796	0.0000	1556.5117
7	0.0003	17.1117	0.0000	16.9718	0.0000	0.0000	0.0000	69.2708	0.0000	38.9796	0.0189	1556.5306
8	0.0000	17.1117	0.2042	17.1760	0.0000	0.0000	5.0047	74.2755	0.0000	38.9796	0.0000	1556.5306
9	0.0396	17.1513	0.0000	17.1760	0.0000	0.0000	0.0000	74.2755	3.3065	42.2861	70.8330	1627.3635
10	0.0000	17.1513	0.0493	17.2214	0.0000	0.0000	0.6571	74.9326	0.0000	42.2861	0.0000	1627.3635
11	0.6267	17.7779	0.0000	17.2214	0.0000	0.0000	0.0000	74.9326	4.5636	46.8519	2.6835	1630.0470
12	0.0000	17.7779	0.4059	17.6273	0.0000	0.0000	6.2070	81.1395	0.0000	46.8519	0.0000	1630.0470

The seismic behaviour of the structure was investigated by a Modal Response Spectrum Analisys as per Section 12.9: the following design response spectrum is used for the analisys (Section 11.4.5):

T0 = 0.2 * SD1/SDS = 0.12 sec

TS = SD1/SDS = 0.60 sec

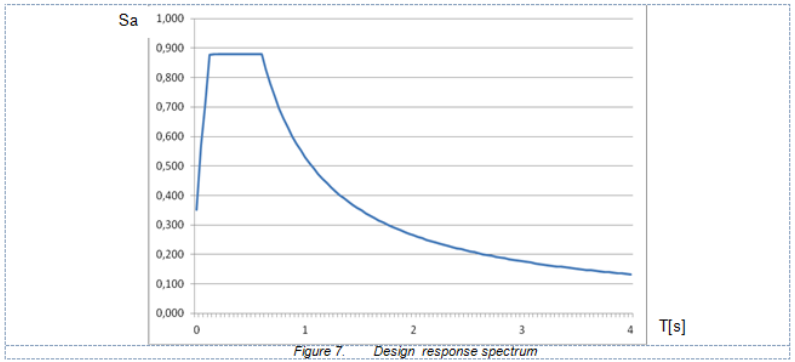
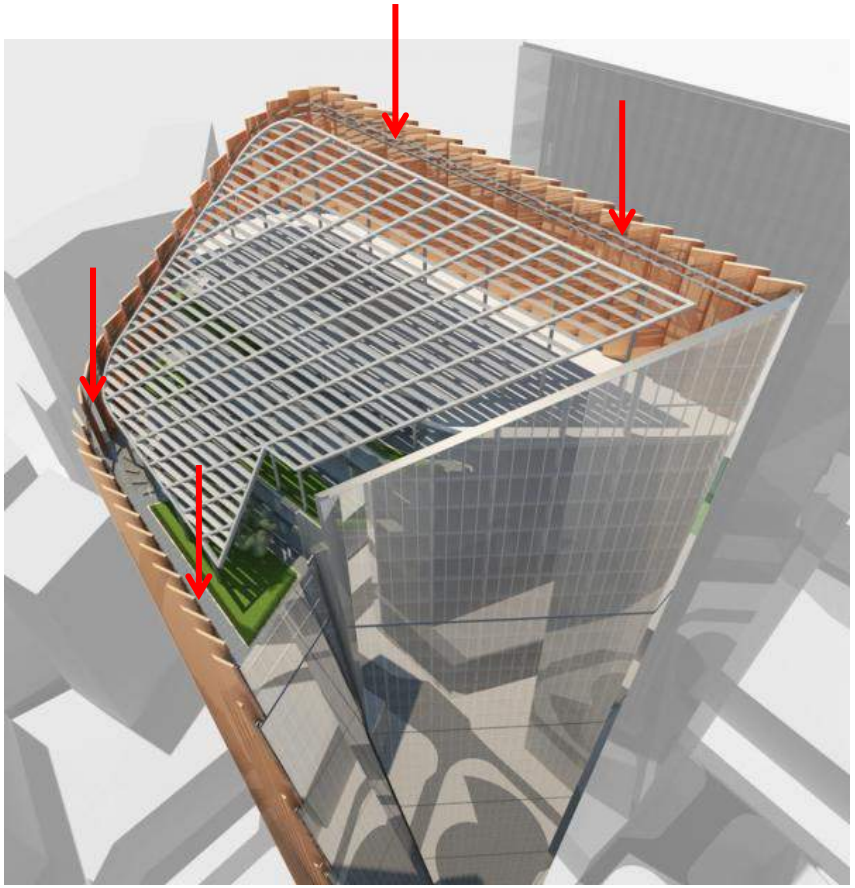


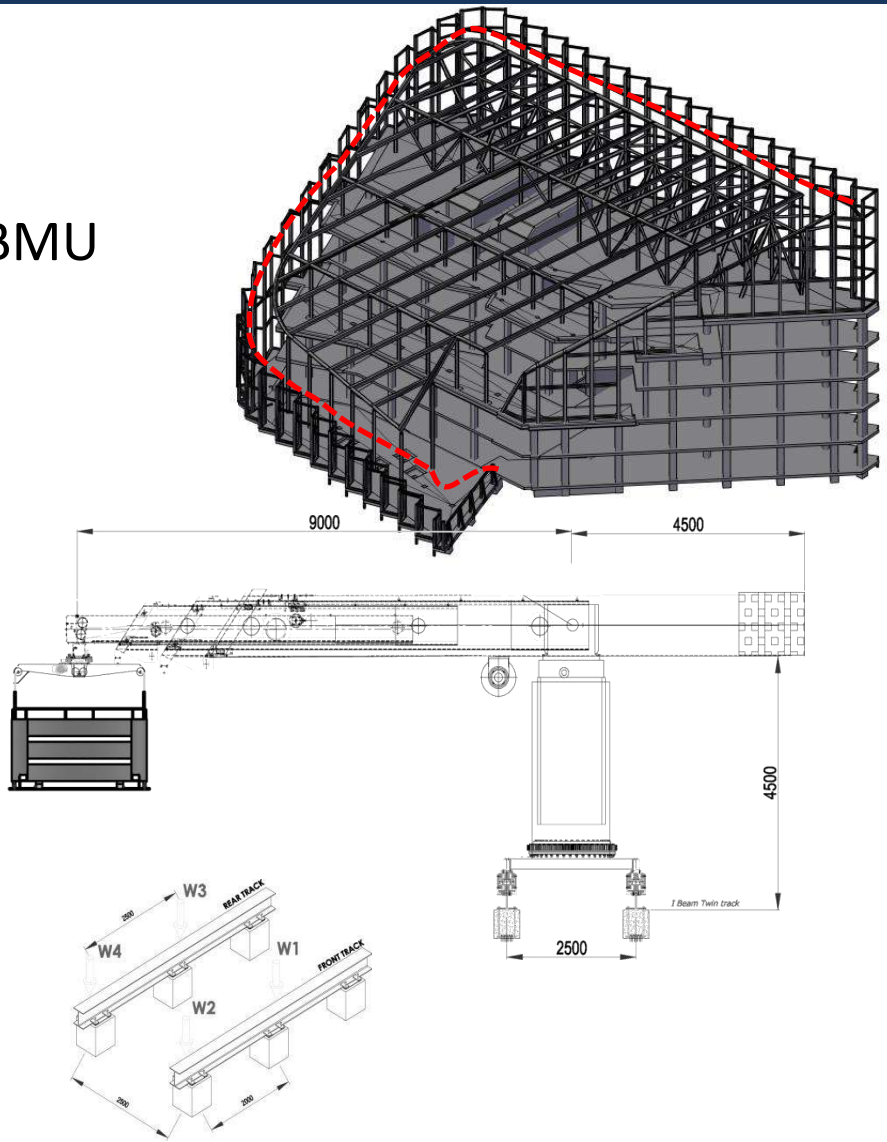
Figure 7. Design response spectrum

The design seismic forces are applied separately in each of the two orthogonal directions considering the 100% of the forces for one direction plus 30% of the forces for the perpendicular direction.

esempio #5

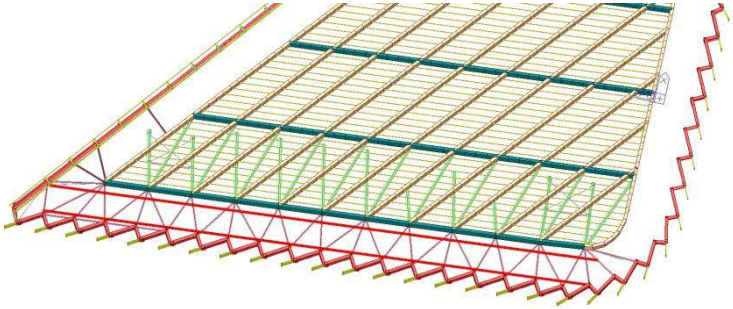
altri esempi di strutture secondarie: BMU

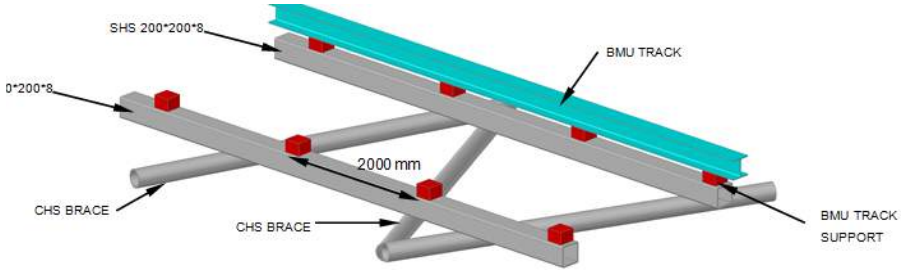




esempio #5

stralci di report…





esempio #6

altri esempi di strutture secondarie (?!?): silos

+ vicinanza ad elementi simili

+ vicinanza ad edifici residenziali

+ vicinanza a via pubblica

esempio #6

silos: dettagli costruttivi dei piedi di appoggio…

+ spostamenti per variazione configurazione di carico