

# Foundation Calculation Report: «1750 OX Residences - 1750 N Oxford Ave. - Eau Claire, WI»

XC structural engineering

July 8, 2019

## Contents

<b>1</b>	<b>Introduction and scope</b>	<b>5</b>
<b>2</b>	<b>Building codes</b>	<b>5</b>
<b>3</b>	<b>Loading criteria</b>	<b>5</b>
3.1	Gravity loading . . . . .	5
3.2	Wind design criteria . . . . .	5
3.3	Snow loading . . . . .	6
<b>4</b>	<b>Seismic design criteria</b>	<b>7</b>
<b>5</b>	<b>Materials</b>	<b>7</b>
<b>6</b>	<b>Design and analysis software</b>	<b>8</b>
<b>7</b>	<b>Load combinations</b>	<b>8</b>
<b>8</b>	<b>Structural model</b>	<b>9</b>
<b>A</b>	<b>Appendices</b>	<b>13</b>
A	Loading criteria . . . . .	13
A.1	Dead loads . . . . .	13
A.2	Live loads . . . . .	14
A.3	Snow loads . . . . .	14
A.4	Wind loads . . . . .	15
A.5	Earthquake loads . . . . .	16
B	Calculation results. Internal forces on columns . . . . .	17
B.1	Ultimate limit states . . . . .	17
B.2	Serviceability limit states . . . . .	31

## List of Tables

<b>1</b>	<b>Gravity Loads</b> . . . . .	<b>6</b>
<b>2</b>	<b>Wind Design Criteria</b> . . . . .	<b>6</b>
<b>3</b>	<b>Snow Design Criteria</b> . . . . .	<b>7</b>
<b>4</b>	<b>Seismic Design Criteria</b> . . . . .	<b>7</b>
<b>5</b>	<b>Concrete properties</b> . . . . .	<b>7</b>

6	<b>Reinforcement properties</b>	8
7	<b>Combinations Ultimate Limit States</b>	8
8	<b>Combinations Serviceability Limit States</b>	9

## List of Figures

1	Load layout on first floor.	10
2	Elastic model, mesh.	11
3	Load case D: dead load (include slab selfweight) [units: kN,m].	11
4	Load case Lru: live load (uniform on rooms) [units: kN,m].	11
5	Load case Lrs: live load (staggered pattern on rooms) [units: kN,m].	11
6	Load case Lpu: live load (uniform on patios) [units: kN,m].	11
7	Load case S: snow [units: kN,m].	11
8	Load case Lps: live load (staggered pattern on patios) [units: kN,m].	12
9	Load case W_WE: wind West-East [units: kN,m].	12
10	Load case W_NS: wind North-South [units: kN,m].	12
11	ULS01: 1.4*D. Columns, internal axial force [kN]	17
12	ULS01: 1.4*D. Columns, bending moment about local axis y [m.kN]	17
13	ULS01: 1.4*D. Columns, bending moment about local axis z [m.kN]	18
14	ULS01: 1.4*D. Columns, internal shear force in local direction y [kN]	18
15	ULS01: 1.4*D. Columns, internal shear force in local direction z [kN]	18
16	ULS02_a: 1.2*D + 1.6*Lru + Lpu + 0.5*S. Columns, internal axial force [kN]	19
17	ULS02_a: 1.2*D + 1.6*Lru + Lpu + 0.5*S. Columns, bending moment about local axis y [m.kN]	19
18	ULS02_a: 1.2*D + 1.6*Lru + Lpu + 0.5*S. Columns, bending moment about local axis z [m.kN]	19
19	ULS02_a: 1.2*D + 1.6*Lru + Lpu + 0.5*S. Columns, internal shear force in local direction y [kN]	20
20	ULS02_a: 1.2*D + 1.6*Lru + Lpu + 0.5*S. Columns, internal shear force in local direction z [kN]	20
21	ULS02_b: 1.2*D + 1.6*Lrs + Lps + 0.5*S. Columns, internal axial force [kN]	20
22	ULS02_b: 1.2*D + 1.6*Lrs + Lps + 0.5*S. Columns, bending moment about local axis y [m.kN]	21
23	ULS02_b: 1.2*D + 1.6*Lrs + Lps + 0.5*S. Columns, bending moment about local axis z [m.kN]	21
24	ULS02_b: 1.2*D + 1.6*Lrs + Lps + 0.5*S. Columns, internal shear force in local direction y [kN]	21
25	ULS02_b: 1.2*D + 1.6*Lrs + Lps + 0.5*S. Columns, internal shear force in local direction z [kN]	22
26	ULS03_a: 1.2*D + 1.6*S + 0.5*Lru + Lpu. Columns, internal axial force [kN]	22
27	ULS03_a: 1.2*D + 1.6*S + 0.5*Lru + Lpu. Columns, bending moment about local axis y [m.kN]	22
28	ULS03_a: 1.2*D + 1.6*S + 0.5*Lru + Lpu. Columns, bending moment about local axis z [m.kN]	23
29	ULS03_a: 1.2*D + 1.6*S + 0.5*Lru + Lpu. Columns, internal shear force in local direction y [kN]	23
30	ULS03_a: 1.2*D + 1.6*S + 0.5*Lru + Lpu. Columns, internal shear force in local direction z [kN]	23
31	ULS03_b: 1.2*D + 1.6*S + 0.5*Lrs + Lps. Columns, internal axial force [kN]	24
32	ULS03_b: 1.2*D + 1.6*S + 0.5*Lrs + Lps. Columns, bending moment about local axis y [m.kN]	24

---

LIST OF FIGURES

33	ULS03_b: 1.2*D + 1.6*S + 0.5*Lrs + Lps. Columns, bending moment about local axis z [m.kN] . . . . .	24
34	ULS03_b: 1.2*D + 1.6*S + 0.5*Lrs + Lps. Columns, internal shear force in local direction y [kN] . . . . .	25
35	ULS03_b: 1.2*D + 1.6*S + 0.5*Lrs + Lps. Columns, internal shear force in local direction z [kN] . . . . .	25
36	ULS04_a: 1.2*D + 1.6*S + 0.5*W_WE. Columns, internal axial force [kN] . . . . .	25
37	ULS04_a: 1.2*D + 1.6*S + 0.5*W_WE. Columns, bending moment about local axis y [m.kN] . . . . .	26
38	ULS04_a: 1.2*D + 1.6*S + 0.5*W_WE. Columns, bending moment about local axis z [m.kN] . . . . .	26
39	ULS04_a: 1.2*D + 1.6*S + 0.5*W_WE. Columns, internal shear force in local direction y [kN] . . . . .	26
40	ULS04_a: 1.2*D + 1.6*S + 0.5*W_WE. Columns, internal shear force in local direction z [kN] . . . . .	27
41	ULS04_b: 1.2*D + 1.6*S + 0.5*W_NS. Columns, internal axial force [kN] . . . . .	27
42	ULS04_b: 1.2*D + 1.6*S + 0.5*W_NS. Columns, bending moment about local axis y [m.kN] . . . . .	27
43	ULS04_b: 1.2*D + 1.6*S + 0.5*W_NS. Columns, bending moment about local axis z [m.kN] . . . . .	28
44	ULS04_b: 1.2*D + 1.6*S + 0.5*W_NS. Columns, internal shear force in local direction y [kN] . . . . .	28
45	ULS04_b: 1.2*D + 1.6*S + 0.5*W_NS. Columns, internal shear force in local direction z [kN] . . . . .	28
46	ULS05_a: 1.2*D + W_WE + 0.5*Lru + Lpu. Columns, internal axial force [kN]	29
47	ULS05_a: 1.2*D + W_WE + 0.5*Lru + Lpu. Columns, bending moment about local axis y [m.kN] . . . . .	29
48	ULS05_a: 1.2*D + W_WE + 0.5*Lru + Lpu. Columns, bending moment about local axis z [m.kN] . . . . .	29
49	ULS05_a: 1.2*D + W_WE + 0.5*Lru + Lpu. Columns, internal shear force in local direction y [kN] . . . . .	30
50	ULS05_a: 1.2*D + W_WE + 0.5*Lru + Lpu. Columns, internal shear force in local direction z [kN] . . . . .	30
51	ULS05_b: 1.2*D + W_NS + 0.5*Lru + Lpu. Columns, internal axial force [kN]	31
52	ULS05_b: 1.2*D + W_NS + 0.5*Lru + Lpu. Columns, bending moment about local axis y [m.kN] . . . . .	31
53	ULS05_b: 1.2*D + W_NS + 0.5*Lru + Lpu. Columns, bending moment about local axis z [m.kN] . . . . .	32
54	ULS05_b: 1.2*D + W_NS + 0.5*Lru + Lpu. Columns, internal shear force in local direction y [kN] . . . . .	32
55	ULS05_b: 1.2*D + W_NS + 0.5*Lru + Lpu. Columns, internal shear force in local direction z [kN] . . . . .	32
56	ULS05_c: 1.2*D + W_WE + 0.5*Lrs + Lps. Columns, internal axial force [kN]	33
57	ULS05_c: 1.2*D + W_WE + 0.5*Lrs + Lps. Columns, bending moment about local axis y [m.kN] . . . . .	33
58	ULS05_c: 1.2*D + W_WE + 0.5*Lrs + Lps. Columns, bending moment about local axis z [m.kN] . . . . .	33
59	ULS05_c: 1.2*D + W_WE + 0.5*Lrs + Lps. Columns, internal shear force in local direction y [kN] . . . . .	34
60	ULS05_c: 1.2*D + W_WE + 0.5*Lrs + Lps. Columns, internal shear force in local direction z [kN] . . . . .	34
61	ULS05_d: 1.2*D + W_NS + 0.5*Lrs + Lps. Columns, internal axial force [kN]	34

62	ULS05_d: $1.2*D + W_{NS} + 0.5*Lrs + Lps$ . Columns, bending moment about local axis y [m.kN] . . . . .	35
63	ULS05_d: $1.2*D + W_{NS} + 0.5*Lrs + Lps$ . Columns, bending moment about local axis z [m.kN] . . . . .	35
64	ULS05_d: $1.2*D + W_{NS} + 0.5*Lrs + Lps$ . Columns, internal shear force in local direction y [kN] . . . . .	35
65	ULS05_d: $1.2*D + W_{NS} + 0.5*Lrs + Lps$ . Columns, internal shear force in local direction z [kN] . . . . .	36
66	ULS06_a: $1.2*D + 0.5*Lru + Lpu + 0.2*S$ . Columns, internal axial force [kN] . . . . .	36
67	ULS06_a: $1.2*D + 0.5*Lru + Lpu + 0.2*S$ . Columns, bending moment about local axis y [m.kN] . . . . .	36
68	ULS06_a: $1.2*D + 0.5*Lru + Lpu + 0.2*S$ . Columns, bending moment about local axis z [m.kN] . . . . .	37
69	ULS06_a: $1.2*D + 0.5*Lru + Lpu + 0.2*S$ . Columns, internal shear force in local direction y [kN] . . . . .	37
70	ULS06_a: $1.2*D + 0.5*Lru + Lpu + 0.2*S$ . Columns, internal shear force in local direction z [kN] . . . . .	37
71	ULS06_b: $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, internal axial force [kN] . . . . .	38
72	ULS06_b: $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, bending moment about local axis y [m.kN] . . . . .	38
73	ULS06_b: $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, bending moment about local axis z [m.kN] . . . . .	38
74	ULS06_b: $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, internal shear force in local direction y [kN] . . . . .	39
75	ULS06_b: $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, internal shear force in local direction z [kN] . . . . .	39
76	ULS07_a: $0.9*D + W_{WE}$ . Columns, internal axial force [kN] . . . . .	39
77	ULS07_a: $0.9*D + W_{WE}$ . Columns, bending moment about local axis y [m.kN] . . . . .	40
78	ULS07_a: $0.9*D + W_{WE}$ . Columns, bending moment about local axis z [m.kN] . . . . .	40
79	ULS07_a: $0.9*D + W_{WE}$ . Columns, internal shear force in local direction y [kN] . . . . .	40
80	ULS07_a: $0.9*D + W_{WE}$ . Columns, internal shear force in local direction z [kN] . . . . .	41
81	ULS07_b: $0.9*D + W_{NS}$ . Columns, internal axial force [kN] . . . . .	41
82	ULS07_b: $0.9*D + W_{NS}$ . Columns, bending moment about local axis y [m.kN] . . . . .	41
83	ULS07_b: $0.9*D + W_{NS}$ . Columns, bending moment about local axis z [m.kN] . . . . .	42
84	ULS07_b: $0.9*D + W_{NS}$ . Columns, internal shear force in local direction y [kN] . . . . .	42
85	ULS07_b: $0.9*D + W_{NS}$ . Columns, internal shear force in local direction z [kN] . . . . .	42
86	SLS01: $1.0*D$ . 1st floor beams, bending moment about local axis y [m.kN] . . . . .	43
87	SLS02_a: $1.0*D + 1.0*Lru + Lpu + 0.3*S$ . 1st floor beams, bending moment about local axis y [m.kN] . . . . .	43
88	SLS02_b: $1.0*D + 1.0*Lrs + Lps + 0.3*S$ . 1st floor beams, bending moment about local axis y [m.kN] . . . . .	43
89	SLS03_a: $1.0*D + 1.0*S + 0.3*Lru + 0.3*Lpu$ . 1st floor beams, bending moment about local axis y [m.kN] . . . . .	44
90	SLS03_b: $1.0*D + 1.0*S + 0.3*Lrs + 0.3*Lps$ . 1st floor beams, bending moment about local axis y [m.kN] . . . . .	44
91	SLS04_a: $1.0*D + W_{WE} + 1.0*Lru + Lpu$ . 1st floor beams, bending moment about local axis y [m.kN] . . . . .	44
92	SLS04_b: $1.0*D + W_{NS} + 1.0*Lru + Lpu$ . 1st floor beams, bending moment about local axis y [m.kN] . . . . .	45
93	SLS05_a: $1.0*D + W_{WE}$ . 1st floor beams, bending moment about local axis y [m.kN] . . . . .	45

94 SLS05_b: 1.0*D + W_NS. 1st floor beams, bending moment about local axis y [m.kN] . . . . .	45
---	----

## 1 Introduction and scope

This report describes the calculation procedure and data considered in order to design the foundation of a new apartment building in Eau Claire, Wisconsin.

The construction consists in a three-story apartment building with a first-floor footprint of about 19,500 square feet, a below-grade parking garage with a footprint of about 27,200 square feet, perimeter retaining walls, a slab-on-grade, and a conventional foundation system.

The first floor system is precast hollow core concrete plank on precast beams and columns. For the upper floors and roof, the system is wood-framed. Retaining walls and slab on grade are comprised of cast in place concrete, except for three reinforced CMU walls next to the garage aisles, that will be demolished during the second phase of construction.

The foundation uses conventional cast in place concrete footings to transfer axial compression and lateral loads to the ground.

## 2 Building codes

The following building and material codes were used for the design:

- Building code
  - International Building Code, 2018 Edition (IBC 2018) with reference to Minimum Design Loads for Buildings and Other Structures by the American Society of Civil Engineers, 2016 Edition (ASCE 7).
- Material codes
  - Reinforced Concrete: Building Code Requirements for Structural Concrete and Commentary by the American Concrete Institute, 2019 Edition (ACI 318).
  - Masonry: Building Code Requirements and Specification for Masonry Structures and Companion Commentaries, 2013 Edition (ACI 530/530).

## 3 Loading criteria

A summary of the project-specific loading criteria follows (see appendix A for a detailed list of load values).

### 3.1 Gravity loading

The gravity loads listed in Table 1 are in addition to the self weight of the structure. The minimum loading requirements were taken from ASCE 7 as well as the loading criteria supplied by the engineer of record. Loads are given in pounds per square foot (psf).

In addition to these uniform slab loads, a perimeter dead load of 12 psf was applied to the structure to account for the weight of the cladding system.

### 3.2 Wind design criteria

Wind loading is in accordance with the IBC and ASCE 7 requirements as shown in Table 2.

Table 1: Gravity Loads

Use	Live Loading	Superimposed Dead Loading
Parking Garage	40	3
Storage/HVAC	125	28
Stairways, exits	100	28
Level 1 residential	40	28
Level 1 corridors	100	28
Level 1 office, recreational	100	28
Level 1 courtyard (footprint)	150	150
Elevated levels residential	40	28
Elevated levels corridors	40	28
Cornices	60	-
Balconies	40	28
Roof	20	28

Table 2: Wind Design Criteria

Parameter	Value
Basic Wind Speed, 3-second gust (ultimate)	115 mph
Basic Wind Speed, 3-second gust (nominal)	90 mph
Exposure	B
Occupancy Category	II
Importance Factor ( $I_w$ )	1.0
Topographic Factor ( $K_{zt}$ )	1.0
Enclosure Classification	Enclosed
Mean Roof Height (h)	33'

### 3.3 Snow loading

Wind loading is in accordance with the ASCE 7 requirements as shown in Table 3.

Table 3: Snow Design Criteria

Parameter	Value
Ground snow load $p_g$	60 psf
Terrain category	B
Exposure factor $C_e$	1.0
Thermal factor $C_t$	1.0
Occupancy Category	II
Snow load importance factor $I_s$	1.0
Snow load flat roof	42 psf

## 4 Seismic design criteria

Seismic loads are in accordance with the IBC requirements as shown in Table 4.

Table 4: Seismic Design Criteria

Parameter	Value
Building Latitude/Longitude	44°49'01.8"N 91°30'34.8"W
Occupancy Category	II
Importance Factor $I_e$	1.0
Mapped Spectral Acceleration	$S_s = 0.045; S_1 = 0.038$
Site Class	B
Site Class Coefficients	$F_a = 1.0; F_v = 1.0$
Spectral Response Coefficients	$S_{DS} = 0.03; S_{D1} = 0.025$
Seismic Design Category	A

## 5 Materials

The material properties used for the design are summarized in Tables 5 and 6.

Table 5: Concrete properties

Member	Nominal $f'_c$
Footings	3.0 ksi
Basement Walls	4.0 ksi
Foundation frost walls	4.0 ksi
Stair landings and treads	4.0 ksi
Slab on grade	4.0 ksi

Table 6: Reinforcement properties

Standard	Nominal $f_y$
All ASTM A615 Grade 60	60 ksi

## 6 Design and analysis software

The computer software employed for the analysis of the structure is the Finite Element Program called **XC** (see program description at [http://xcengineering.xyz/html\\_files/software.html](http://xcengineering.xyz/html_files/software.html)).

## 7 Load combinations

The load combinations shown in Tables 7 and 8 follow the strength design load combinations listed in IBC, section 1605.

Table 7: Combinations Ultimate Limit States

Identifier	Load Combination
ULS01:	1.4*D
ULS02_a:	1.2*D + 1.6*Lru + Lpu + 0.5*S
ULS02_b:	1.2*D + 1.6*Lrs + Lps + 0.5*S
ULS03_a:	1.2*D + 1.6*S + 0.5*Lru + Lpu
ULS03_b:	1.2*D + 1.6*S + 0.5*Lrs + Lps
ULS04_b:	1.2*D + 1.6*S + 0.5*W_NS
ULS04_a:	1.2*D + 1.6*S + 0.5*W_WE
ULS05_a:	1.2*D + W_WE + 0.5*Lru + Lpu
ULS05_b:	1.2*D + W_NS + 0.5*Lru + Lpu
ULS05_c:	1.2*D + W_WE + 0.5*Lrs + Lps
ULS05_d:	1.2*D + W_NS + 0.5*Lrs + Lps
ULS06_a:	1.2*D + 0.5*Lru + Lpu + 0.2*S
ULS06_b:	1.2*D + 0.5*Lrs + Lps + 0.2*S
ULS07_a:	0.9*D + W_WE
ULS07_b:	0.9*D + W_NS

Where:

D = dead load

Lru = live load (uniform on rooms)

Lrs = live load (staggered pattern on rooms)

Lpu = live load (uniform on patios)

Lps = live load (staggered pattern on patios)

S = snow load

W\_WE = Wind West-East

W\_NS = Wind North-South

Table 8: Combinations Serviceability Limit States

Identifier	Load Combination
SLS01:	1.0*D
SLS02_a:	1.0*D + 1.0*Lru + Lpu + 0.3*S
SLS02_b:	1.0*D + 1.0*Lrs + Lps + 0.3*S
SLS03_a:	1.0*D + 1.0*S + 0.3*Lru + 0.3*Lpu
SLS03_b:	1.0*D + 1.0*S + 0.3*Lrs + 0.3*Lps
SLS04_a:	1.0*D + W_WE + 1.0*Lru + Lpu
SLS04_b:	1.0*D + W_NS + 1.0*Lru + Lpu
SLS04_c:	1.0*D + W_WE + 1.0*Lrs + Lps
SLS04_d:	1.0*D + W_NS + 1.0*Lrs + Lps
SLS05_a:	1.0*D + W_WE
SLS05_b:	1.0*D + W_NS

Where:

D = dead load

Lru = live load (uniform on rooms)

Lrs = live load (staggered pattern on rooms)

Lpu = live load (uniform on patios)

Lps = live load (staggered pattern on patios)

S = snow load

W\_WE = Wind West-East

W\_NS = Wind North-South

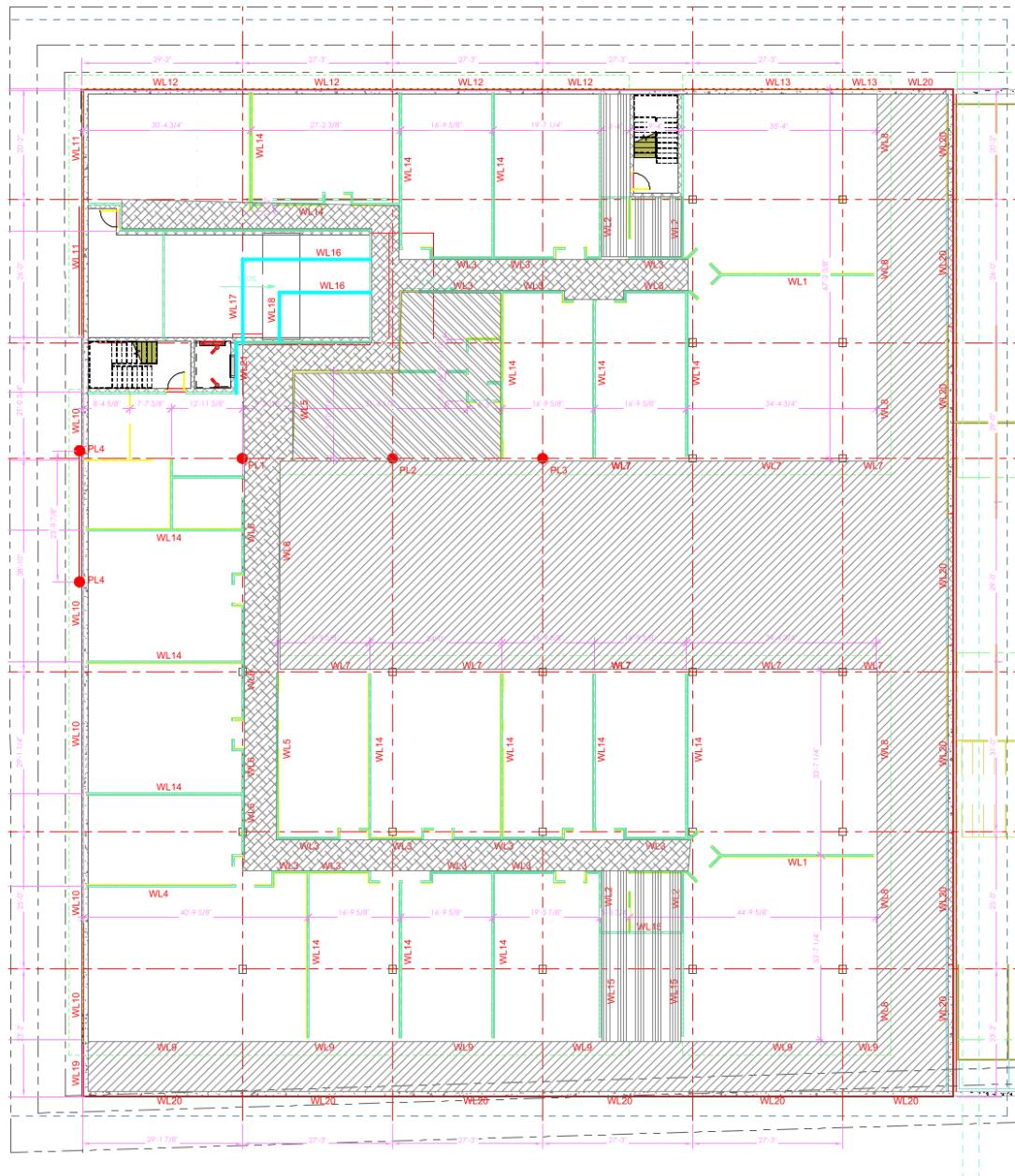
## 8 Structural model

A three-dimensional elastic computer model of the substructure is analyzed using XC. The model includes first floor frame and columns (see figure 2). The hollow core planks ar modelled using shell elements, while beams and columns are modelled using frame elements. Loads transmited by 2<sup>nd</sup>, 3<sup>rd</sup> floors and roof are applied to the 1<sup>st</sup>. Load layout is shown in figure 1. See in figures 3 to 10 load distribution for each load case.

Linear loads are expressed in kN/m and surface loads in kN/m<sup>2</sup>, where:

$$\begin{aligned} 1 \text{ kN/m} &= 68.52178 \text{ lb/ft} \\ 1 \text{ kN/m}^2 &= 20.885434 \text{ psf} \end{aligned}$$

## FOUNDATION CALCULATION REPORT



WALL LOAD SCHEDULE									
MARK	ELEV.	DEAD LOAD Ksi/ft	LIVE LOAD Ksi/ft	SNOW LOAD Ksi/ft	W-E WIND LOAD Ksi/ft	SOUTH/EAST W-E WIND LOAD Ksi/ft	N-S WIND LOAD Ksi/ft	W-E EARTH PRESSURE Ksi/ft	CHORD LOAD Ksi/ft
WL1	0'-0"	1.51	3.32	0.27	0.40	N/A	N/A	0.40	N/A
WL2	0'-0"	0.53	0.24	0.44	0.40	N/A	N/A	0.40	N/A
WL3	0'-0"	1.12	1.10	0.40	0.40	N/A	N/A	0.40	N/A
WL4	0'-0"	1.05	1.57	0.94	0.40	N/A	N/A	0.40	N/A
WL5	0'-0"	0.72	0.33	0.20	0.40	N/A	0.39	0.40	N/A
WL6	0'-0"	1.58	1.67	1.00	0.40	N/A	N/A	0.40	N/A
WL7	0'-0"	0.50	N/A	N/A	0.40	N/A	0.39	0.40	N/A
WL8	0'-0"	1.73	2.26	1.36	1.80	N/A	N/A	0.40	N/A
WL9	0'-0"	1.52	1.44	0.88	0.40	N/A	0.39	0.40	N/A
WL10	0'-0"	0.59	N/A	N/A	0.40	N/A	0.39	0.40	N/A
WL11	0'-0"	1.55	1.57	0.74	1.08	N/A	N/A	0.40	N/A
WL12	0'-0"	1.58	1.67	1.00	1.08	N/A	N/A	0.40	N/A
WL13	0'-0"	0.27	N/A	N/A	0.40	N/A	N/A	0.40	N/A
WL14	0'-0"	1.72	1.33	0.44	0.40	N/A	N/A	0.40	N/A
WL15	0'-0"	0.85	1.00	0.40	0.40	N/A	N/A	0.40	N/A
WL16	11'-2"	0.94	1.07	1.07	0.40	N/A	0.39	0.40	N/A
WL17	11'-2"	0.69	0.20	0.20	0.40	N/A	0.39	0.40	N/A
WL18	11'-2"	N/A	N/A	N/A	0.40	N/A	N/A	0.40	N/A
WL19	11'-2"	N/A	N/A	N/A	0.40	N/A	N/A	0.40	N/A
WL20	11'-2"	N/A	N/A	N/A	0.40	N/A	N/A	0.40	N/A

POINT LOAD SCHEDULE			
MARK	DEAD LOAD kN	LIVE LOAD kN	SNOW LOAD kN
PL1	15.24	25.01	15.01
PL2	30.47	50.02	30.02
PL3	15.24	25.01	15.01
PL4	17.64	17.40	10.30

SUPERIMPOSED UNIFORM LOAD SCHEDULE			
MARK	DEAD LOAD PSF	LIVE LOAD PSF	SNOW LOAD PSF
WALLS	150.00	150.00	42.00
CORRIDORS	20.00	100.00	N/A
STAIRS AND EXITS	20.00	100.00	N/A
STORE	20.00	100.00	N/A
PRIVATE ROOMS	20.00	40.00	N/A
MULTIFAMILY DWELLING	20.00	40.00	N/A

Figure 1: Load layout on first floor.

## 8. STRUCTURAL MODEL

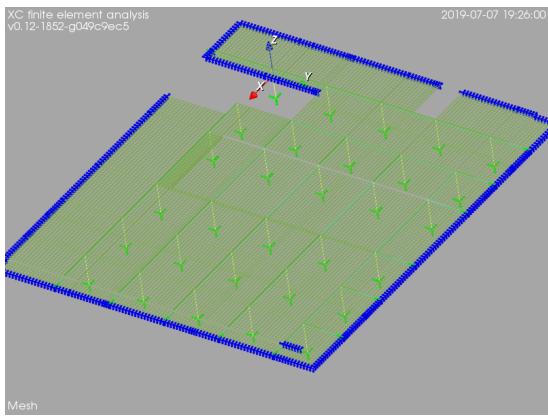


Figure 2: Elastic model, mesh.

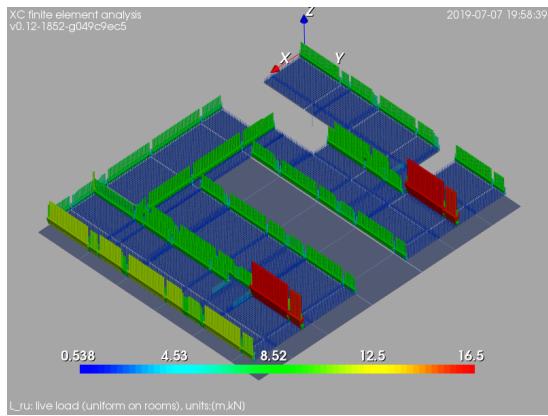


Figure 5: Load case Lrs: live load (staggered pattern on rooms) [units: kN,m].

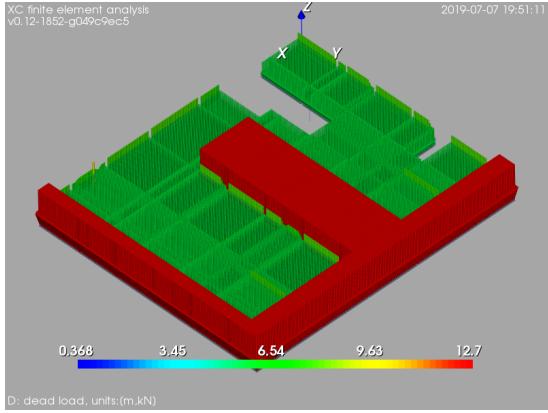


Figure 3: Load case D: dead load (include slab self-weight) [units: kN,m].

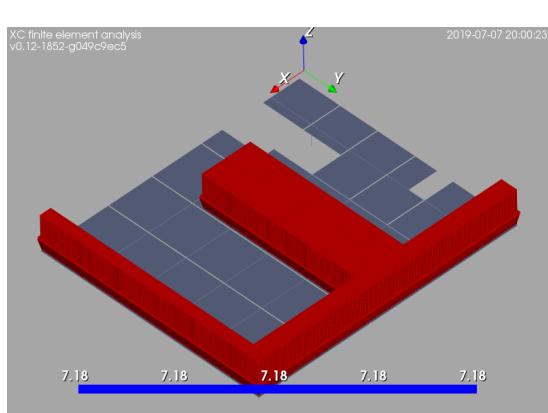


Figure 6: Load case Lpu: live load (uniform on patios) [units: kN,m].

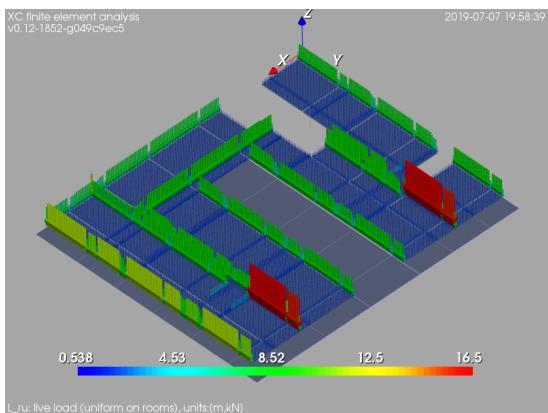


Figure 4: Load case Lru: live load (uniform on rooms) [units: kN,m].

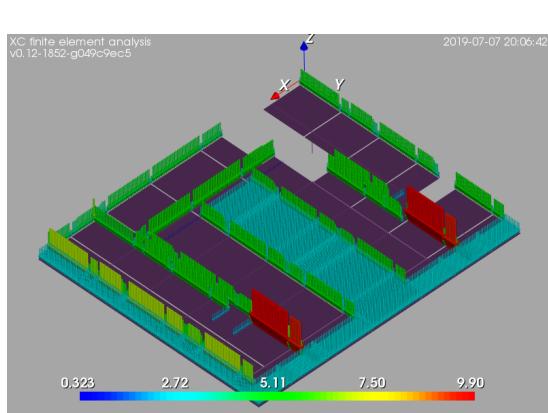


Figure 7: Load case S: snow [units: kN,m].

## FOUNDATION CALCULATION REPORT

---

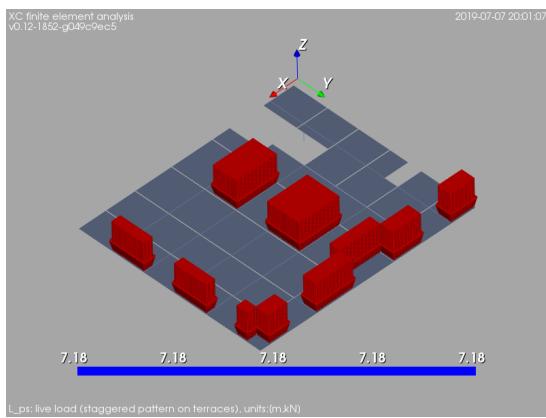


Figure 8: Load case L\_ps: live load (staggered pattern on patios) [units: kN,m].

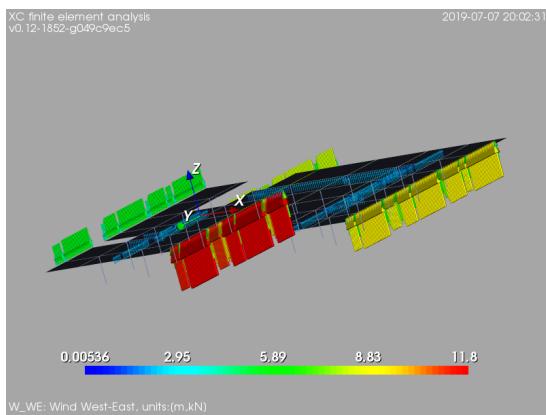


Figure 9: Load case W\_WE: wind West-East [units: kN,m].

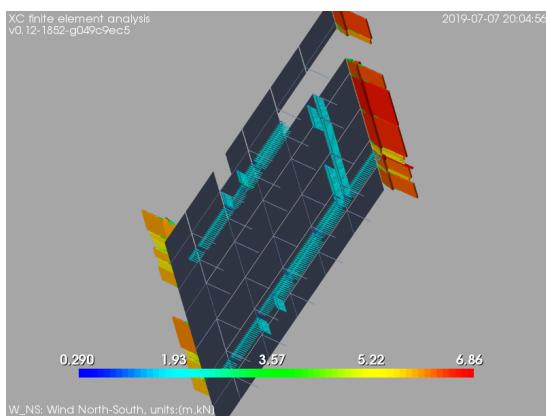


Figure 10: Load case W\_NS: wind North-South [units: kN,m].

# Appendices

## A Loading criteria

### A.1 Dead loads

#### Materials

Wood structural panel	$36.0 \text{ pcf} = 5655 \frac{\text{newton}}{\text{meter}^3}$
Concrete reinforced stone (including gravel)	$150.0 \text{ pcf} = 23563 \frac{\text{newton}}{\text{meter}^3}$
Steel	$489.0 \text{ pcf} = 76816 \frac{\text{newton}}{\text{meter}^3}$
Gypsum crete	$115.0 \text{ pcf} = 18065 \frac{\text{newton}}{\text{meter}^3}$
Gypsum, loose	$70.0 \text{ pcf} = 10996 \frac{\text{newton}}{\text{meter}^3}$
Earth (not submerged) sand and gravel (wet)	$120.0 \text{ pcf} = 18850 \frac{\text{newton}}{\text{meter}^3}$
Water	$62.4 \text{ pcf} = 9802 \frac{\text{newton}}{\text{meter}^3}$
Frame partitions	
Wood or steel studs, $\frac{1}{2}$ in gypsum board inside	8 psf = 383 pascal
Wood studs, 2x4 unplastered	4 psf = 192 pascal
Wood studs, 2x4 plastered one side	12 psf = 575 pascal
Wood studs, 2x4 plastered two sides	20 psf = 958 pascal
Movable steel partitions	4 psf = 192 pascal
Frame walls	
Exterior stud wall 2x4 @ 16in, $\frac{5}{8}$ gypsum insulated, $\frac{3}{8}$ in siding	11 psf = 526 pascal
Exterior stud wall 2x6 @ 16in, $\frac{5}{8}$ gypsum insulated, $\frac{3}{8}$ in siding	12 psf = 575 pascal
Exterior stud wall with brick veneer	48 psf = 2298 pascal
CMU wall 8in	60 psf = 9425 pascal
Window, glass, frame and sash	8 psf = 383 pascal
Cladding	
Fiber cement panels, large format $38.4\text{in} \times 102\text{in}$	3.2 psf = 153 pascal
Fiber cement panels, small scale $9.6\text{in} \times 102\text{in}$	3.2 psf = 153 pascal
Perforated metal panel at exterior HVAC location	
Floor truss	
Single chord @ 24in o.c. spacing	3.2 psf = 153 pascal
Double chord @ 24in o.c. spacing	4.25 psf = 203 pascal
Sheathing	
Roof sheathing	3.5 psf = 167 pascal
Floor sheathing	2.5 psf = 120 pascal
Ceilings	2.5 psf = 120 pascal
Deck composite sleepers (3in)	9.00 psf = 431 pascal

## A.2 Live loads

Occupancy or use	Uniform	Concentrated	Notes
Private rooms and corridors serving them in multifamily dwelling	40.0 psf = 1915 pascal	-	IBC-2018 Table 1607.1
Stairs and exits	100.0 psf = 4788 pascal	300 pound = 1334 newton	IBC-2018 Table 1607.1. Concentrated load on stair treads applied on an area of 2 inches by 2 inches
Balconies and decks	same as occupancy served	-	IBC-2018 Table 1607.1
Garages (passenger vehicles only)	40.0 psf = 1915 pascal	-	IBC-2018 Table 1607.1
Cornices	60.0 psf = 2873 pascal	-	IBC-2018 Table 1607.1
Elevator machine room and control room grating	-	300 pound = 1334 newton	IBC-2018 Table 1607.1. Concentrated load applied on an area of 2 inches by 2 inches
Flat roof (not occupiable) + maintenance	20.0 psf = 958 pascal	300 pound = 1334 newton	IBC-2018 Table 1607.1
Yards and terraces, pedestrians	100.0 psf = 4788 pascal	-	IBC-2018 Table 1607.1
Sidewalks, vehicular driveways and yards, subject to trucking	250.0 psf = 11970 pascal	8000 pound = 35586 newton	IBC-2018 Table 1607.1
Corridors first floor	100.0 psf = 4788 pascal	-	IBC-2018 Table 1607.1
Store first floor	100.0 psf = 4788 pascal	-	IBC-2018 Table 1607.1

## A.3 Snow loads

Ground snow load	$p_g = 60.0 \text{ psf} = 2873 \text{ pascal}$	ASCE 7. Figure 7.1
Exposure factor	$C_e = 1.0$	ASCE 7. Table 7-2. Terrain category B, roof partially exposed
Thermal factor	$C_t = 1.0$	ASCE 7. Table 7-3.
Snow load importance factor	$I_s = 1.0$	ASCE 7. Table 7-4. Structure risk category II
<b>Snow load flat roof</b>	$p_f = 0.7 \times C_e \times C_t \times I_s \times p_g = 0.7 \times 1.0 \times 1.0 \times 1.0 \times 60.0 = 42.0 \text{ psf} = 2873 \text{ pascal}$	ASCE 7. Sect. 7.3

#### A.4 Wind loads

Alternate all-heights method.

$$\text{Ultimate design wind speed} \quad V_{ult} = 115 \frac{\text{miles}}{\text{hour}} = 51 \frac{\text{meters}}{\text{second}}$$

$$\text{Velocity pressure exposure coefficient} \quad K_z = 0.72$$

$$\text{Topographic factor} \quad K_{zt} = 1.0$$

*IBC-2018, sect. 1609.6. Regularly shaped building, less than 75 feet in height, not sensitive to dynamic effects, not channeling effects or buffeting, simple diaphragm building*

*IBC-2018, figure 1609.3(1). Risk category II building*

*ASCE 7, table 27.3.1. Exposure B, height above ground level  $z \approx 33$  feet*

*ASCE 7, sect. 26.8*

**Net pressure coefficients**  $C_{net}$ . Main windforce-resisting frames and systems

Description	$C_{net} + \text{Internal pressure}$	$C_{net} - \text{Internal pressure}$
Windward wall	0.43	0.73
Leeward wall	-0.51	-0.21
Sidewall	-0.66	-0.35
Parapet windward wall		1.28
Parapet leeward wall		-0.85
Flat roof	-1.09	-0.79

*IBC-2018, Table 1609.6.2, enclosed*

**Design wind pressures**  $P_{net}$ . Main windforce-resisting frames and systems

$$P_{net} = 0.00256 \times V^2 \times K_z \times C_{net} \times K_{zt}$$

Description	$P_{net} + \text{Internal pressure}$	$P_{net} - \text{Internal pressure}$
Windward wall	10.5 psf = 501 pascal	17.8 psf = 852 pascal
Leeward wall	-12.4 psf = -595 pascal	-5.1 psf = -245 pascal
Sidewall	-16.1 psf = -770 pascal	-8.5 psf = -409 pascal
Parapet windward wall		31.2 psf = 1494 pascal
Parapet leeward wall		-20.7 psf = -992 pascal
Flat roof	-26.6 psf = -1272 pascal	-19.3 psf = -992 pascal

*IBC-2018, sect. 1609.6.3*

### A.5 Earthquake loads

Parameter	0.2-second spectral response acceleration	$S_s = 0.045$	IBC-2018, figure 1613.3.1(1). Site class B
Parameter	1-second spectral response acceleration	$S_1 = 0.038$	IBC-2018, figure 1613.3.1(2). Site class B
Seismic design category		$S_1 \leq 0.04$ and $S_s \leq 0.15 \rightarrow$ SDS A	IBC-2018, sect. 1613.3.1
Site coefficients		$F_a = 1.0, F_v = 1.0$	IBC-2018, tables 1613.3.3(1) and 1613.3.3(2). Site class B
Maximum considered earthquake spectral response acceleration for short periods		$S_{MS} = F_a \cdot S_s = 0.045$	IBC-2018, sect. 163.3.3
Design spectral response acceleration parameters		$S_{M1} = F_a \cdot S_1 = 0.038$ $S_{DS} = \frac{2}{3}S_{MS} = 0.03$ $S_{D1} = \frac{2}{3}S_{M1} = 0.025$	IBC-2018, sect. 163.3.4 IBC-2018, sect. 163.3.4

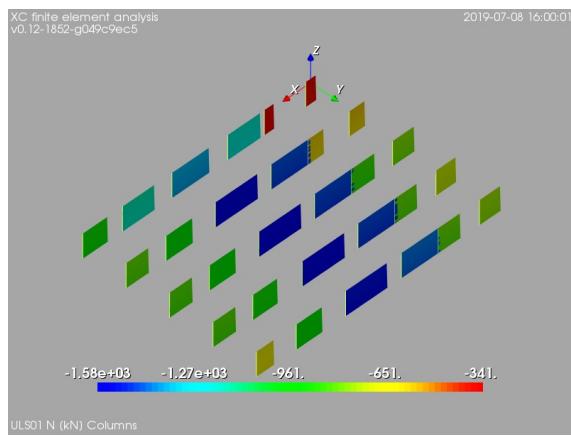


Figure 11: ULS01: 1.4\*D. Columns, internal axial force [kN]

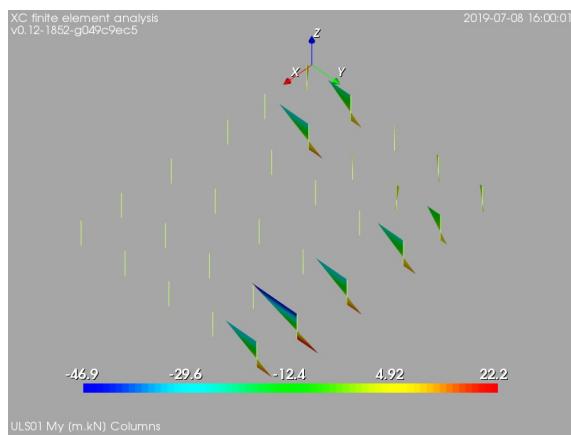


Figure 12: ULS01: 1.4\*D. Columns, bending moment about local axis y [m.kN]

## B Calculation results. Internal forces on columns

### B.1 Ultimate limit states

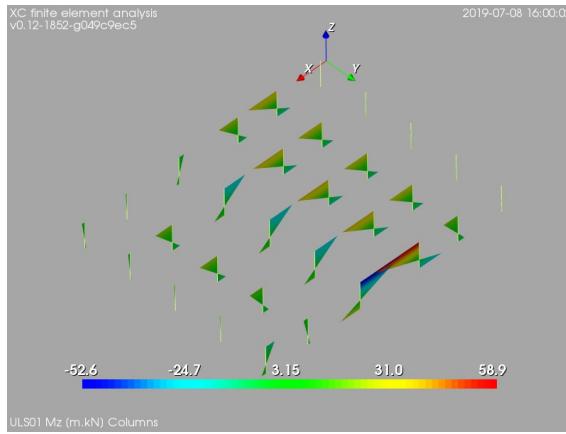


Figure 13: ULS01: 1.4\*D. Columns, bending moment about local axis z [m.kN]

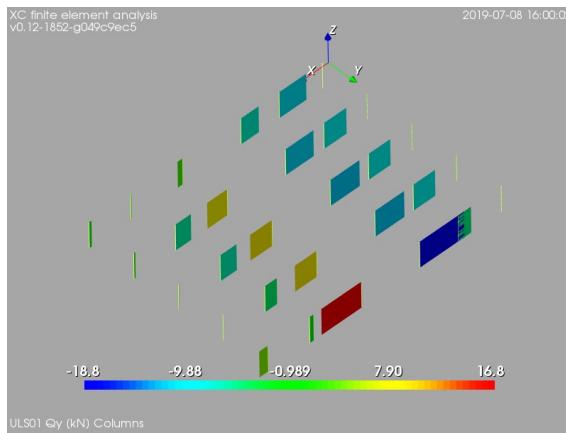


Figure 14: ULS01: 1.4\*D. Columns, internal shear force in local direction y [kN]

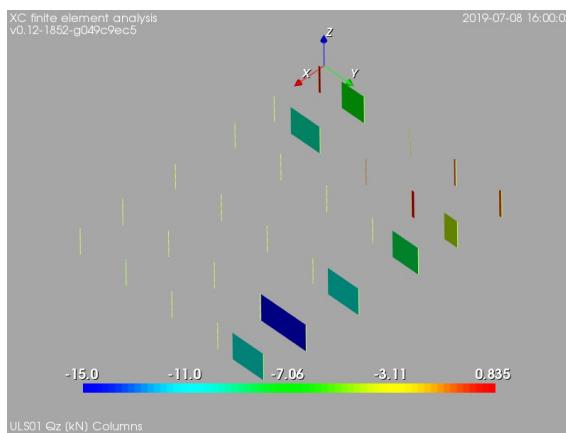


Figure 15: ULS01: 1.4\*D. Columns, internal shear force in local direction z [kN]

## 8. STRUCTURAL MODEL

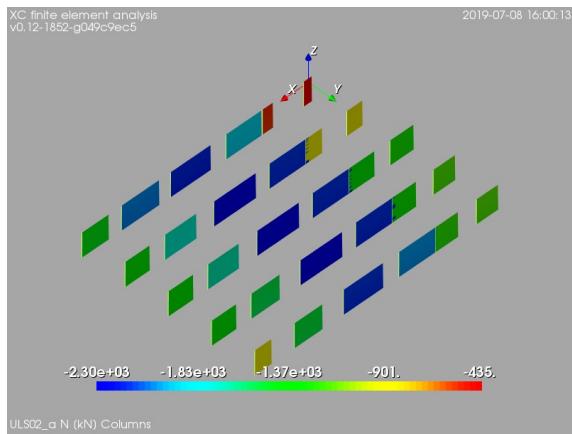


Figure 16: ULS02\_a:  $1.2*D + 1.6*Lru + Lpu + 0.5*S$ . Columns, internal axial force [kN]

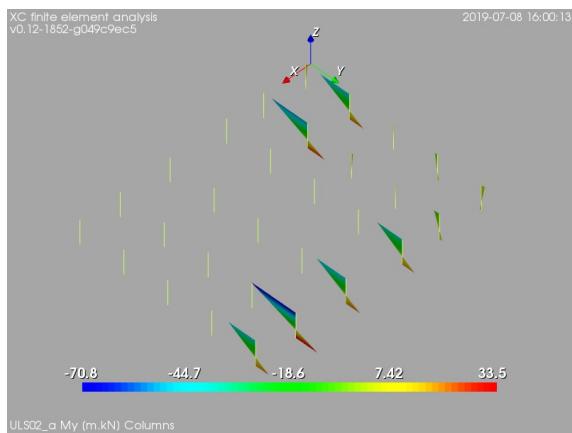


Figure 17: ULS02\_a:  $1.2*D + 1.6*Lru + Lpu + 0.5*S$ . Columns, bending moment about local axis y [m.kN]

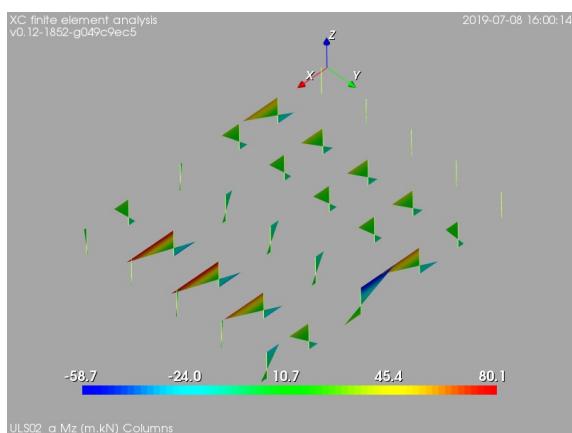


Figure 18: ULS02\_a:  $1.2*D + 1.6*Lru + Lpu + 0.5*S$ . Columns, bending moment about local axis z [m.kN]

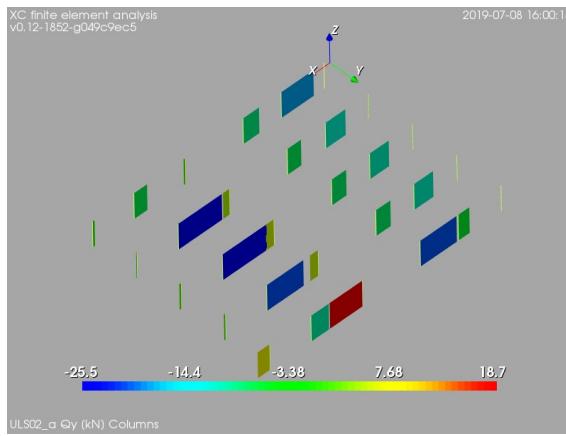


Figure 19: ULS02\_a:  $1.2*D + 1.6*Lru + Lpu + 0.5*S$ . Columns, internal shear force in local direction y [kN]

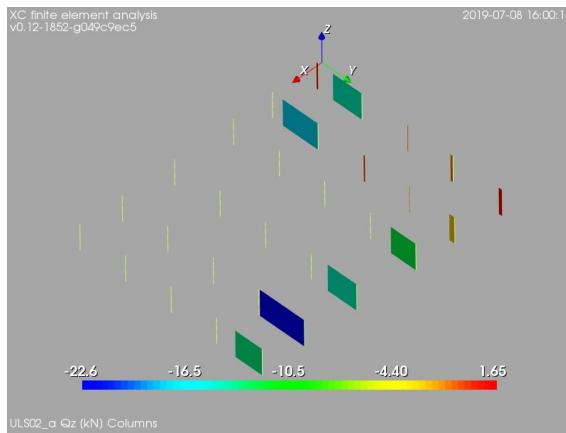


Figure 20: ULS02\_a:  $1.2*D + 1.6*Lru + Lpu + 0.5*S$ . Columns, internal shear force in local direction z [kN]

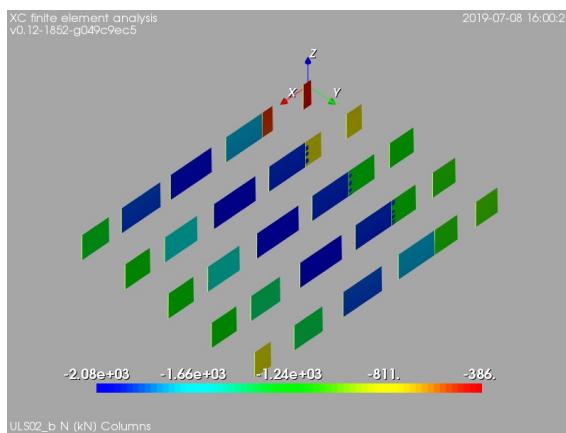


Figure 21: ULS02\_b:  $1.2*D + 1.6*Lrs + Lps + 0.5*S$ . Columns, internal axial force [kN]

## 8. STRUCTURAL MODEL

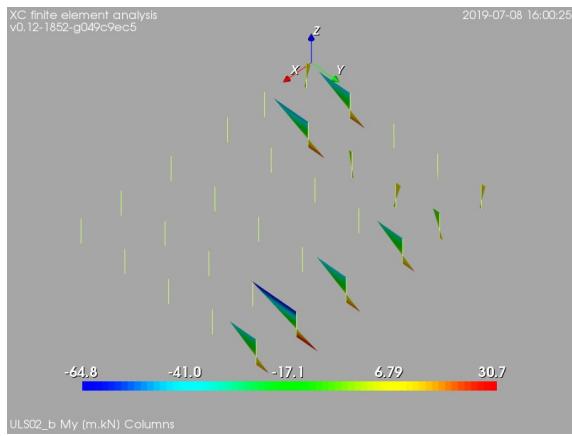


Figure 22: ULS02\_b:  $1.2*D + 1.6*Lrs + Lps + 0.5*S$ . Columns, bending moment about local axis y [m.kN]

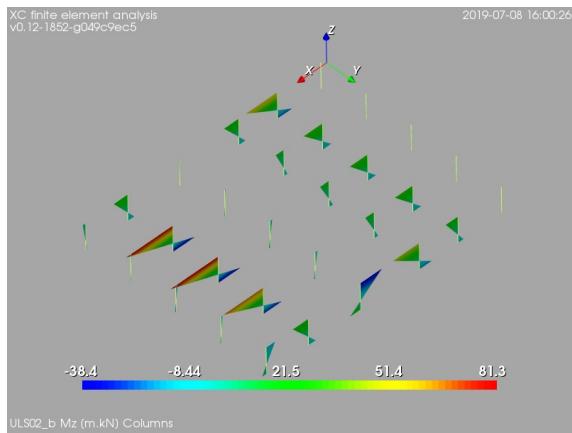


Figure 23: ULS02\_b:  $1.2*D + 1.6*Lrs + Lps + 0.5*S$ . Columns, bending moment about local axis z [m.kN]

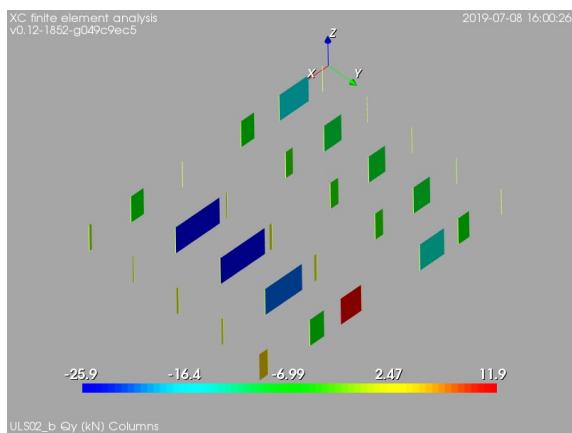


Figure 24: ULS02\_b:  $1.2*D + 1.6*Lrs + Lps + 0.5*S$ . Columns, internal shear force in local direction y [kN]

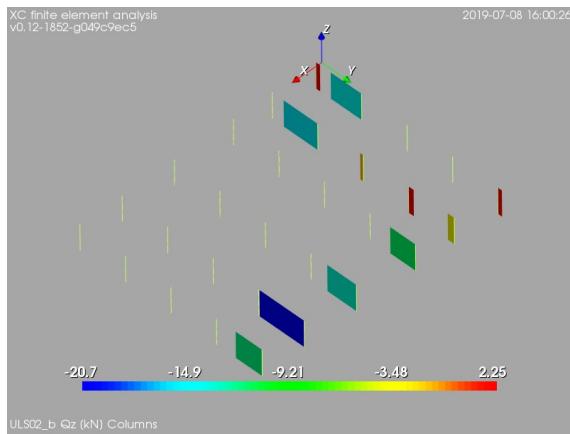


Figure 25: ULS02\_b:  $1.2*D + 1.6*Lrs + Lps + 0.5*S$ . Columns, internal shear force in local direction z [kN]

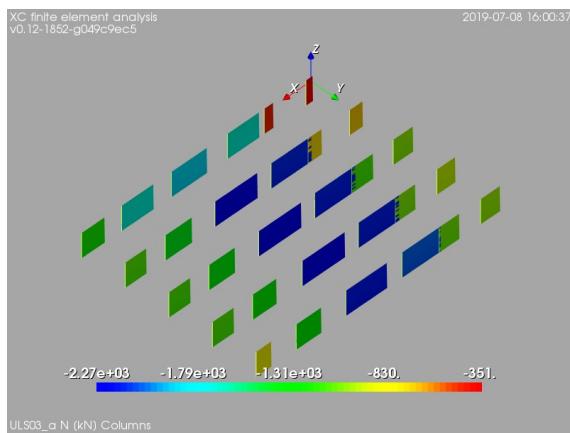


Figure 26: ULS03\_a:  $1.2*D + 1.6*S + 0.5*Lru + Lpu$ . Columns, internal axial force [kN]

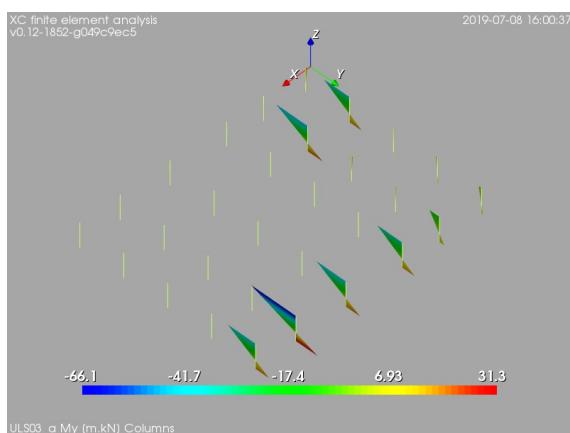


Figure 27: ULS03\_a:  $1.2*D + 1.6*S + 0.5*Lru + Lpu$ . Columns, bending moment about local axis y [m.kN]

## 8. STRUCTURAL MODEL

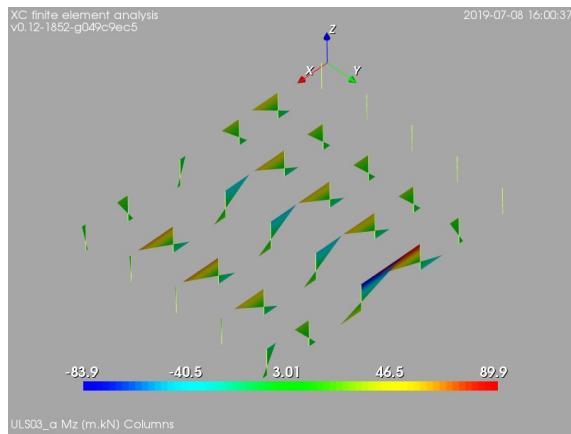


Figure 28: ULS03\_a:  $1.2*D + 1.6*S + 0.5*Lru + Lpu$ . Columns, bending moment about local axis z [m.kN]

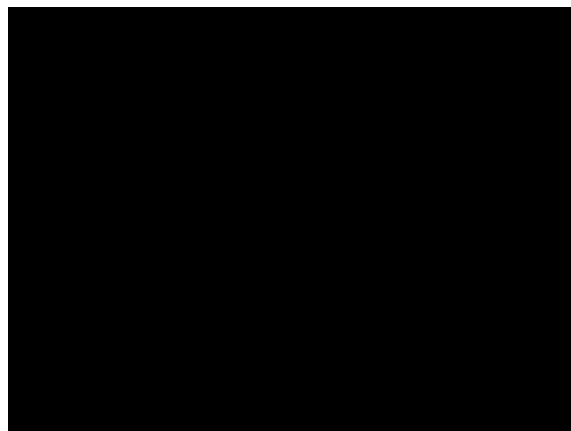


Figure 29: ULS03\_a:  $1.2*D + 1.6*S + 0.5*Lru + Lpu$ . Columns, internal shear force in local direction y [kN]

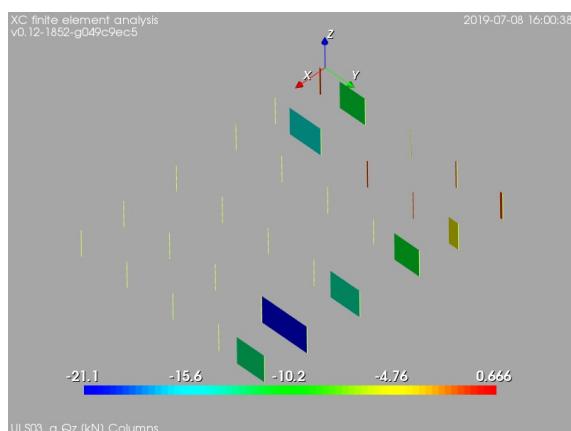


Figure 30: ULS03\_a:  $1.2*D + 1.6*S + 0.5*Lru + Lpu$ . Columns, internal shear force in local direction z [kN]

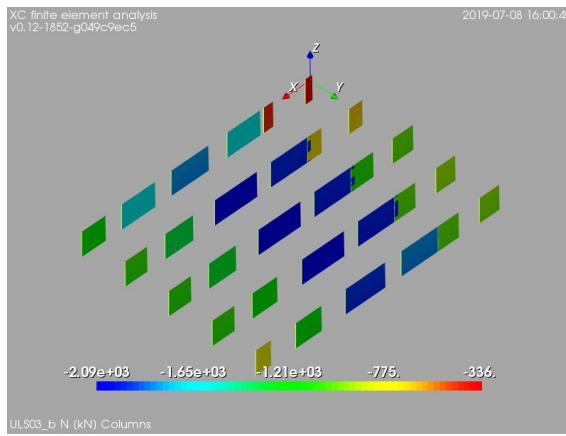


Figure 31: ULS03\_b:  $1.2*D + 1.6*S + 0.5*Lrs + Lps$ . Columns, internal axial force [kN]

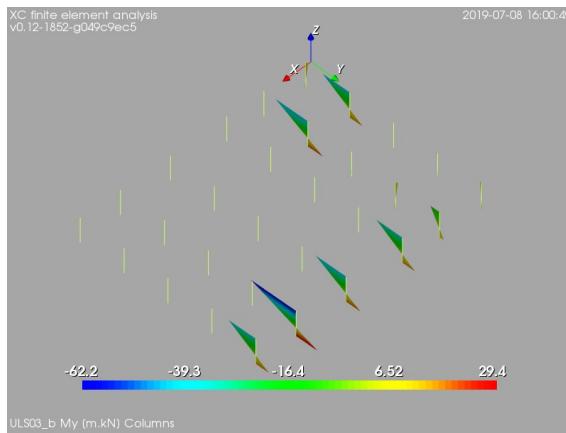


Figure 32: ULS03\_b:  $1.2*D + 1.6*S + 0.5*Lrs + Lps$ . Columns, bending moment about local axis y [m.kN]

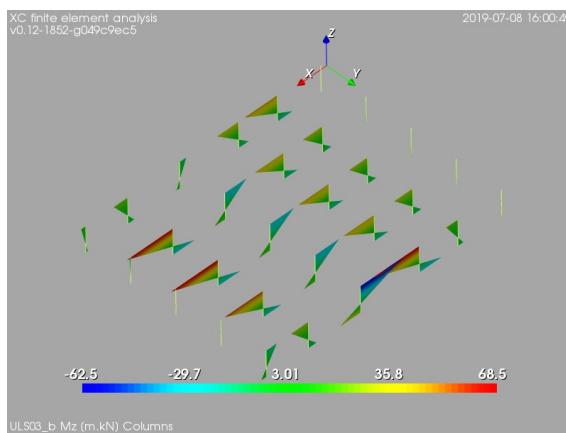


Figure 33: ULS03\_b:  $1.2*D + 1.6*S + 0.5*Lrs + Lps$ . Columns, bending moment about local axis z [m.kN]

## 8. STRUCTURAL MODEL

---

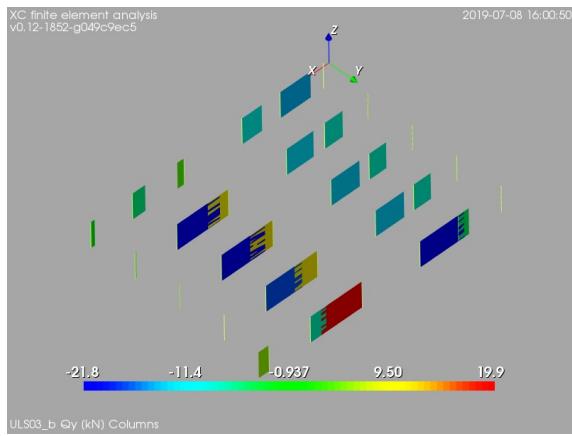


Figure 34: ULS03\_b:  $1.2*D + 1.6*S + 0.5*Lrs + Lps$ . Columns, internal shear force in local direction y [kN]

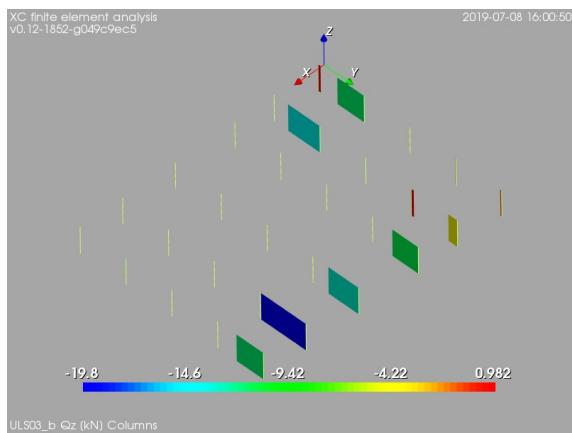


Figure 35: ULS03\_b:  $1.2*D + 1.6*S + 0.5*Lrs + Lps$ . Columns, internal shear force in local direction z [kN]

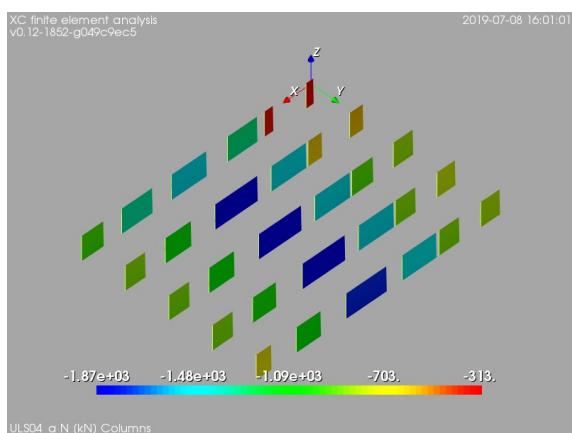


Figure 36: ULS04\_a:  $1.2*D + 1.6*S + 0.5*W\_WE$ . Columns, internal axial force [kN]

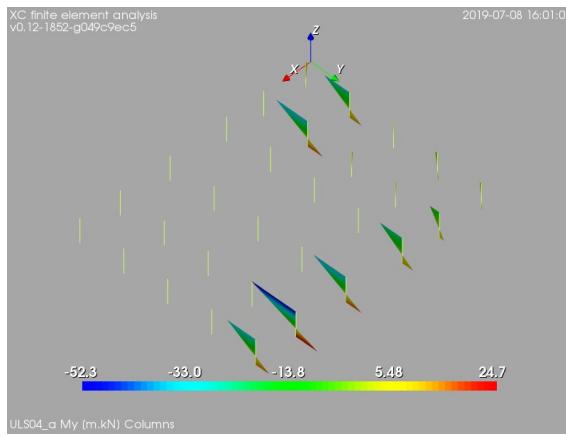


Figure 37: ULS04\_a:  $1.2*D + 1.6*S + 0.5*W\_WE$ . Columns, bending moment about local axis  $y$  [ $\text{m.kN}$ ]

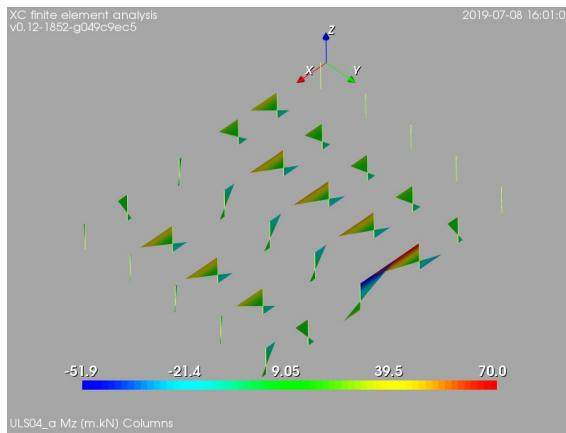


Figure 38: ULS04\_a:  $1.2*D + 1.6*S + 0.5*W\_WE$ . Columns, bending moment about local axis  $z$  [ $\text{m.kN}$ ]

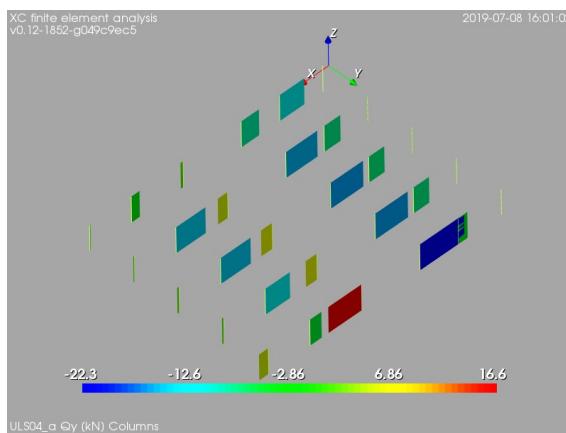


Figure 39: ULS04\_a:  $1.2*D + 1.6*S + 0.5*W\_WE$ . Columns, internal shear force in local direction  $y$  [ $\text{kN}$ ]

## 8. STRUCTURAL MODEL

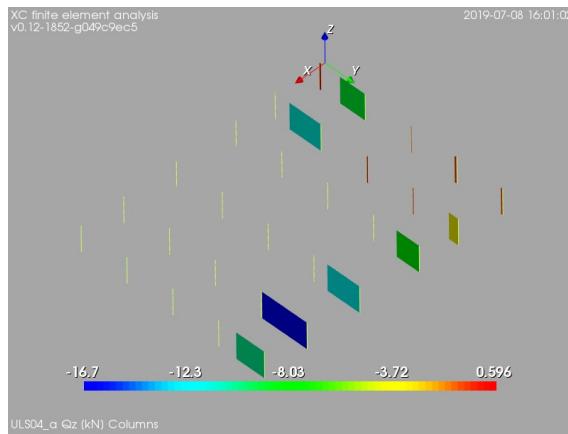


Figure 40: ULS04\_a:  $1.2*D + 1.6*S + 0.5*W\_WE$ . Columns, internal shear force in local direction z [kN]

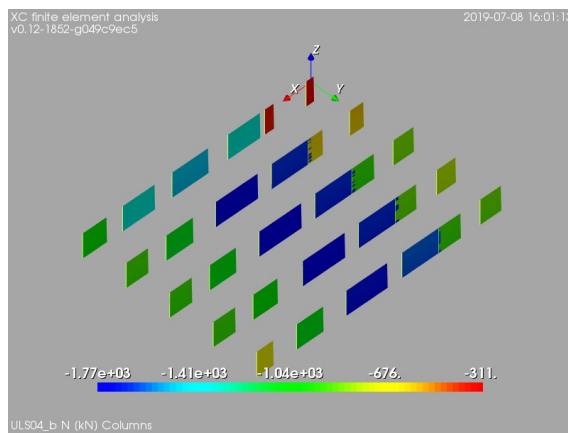


Figure 41: ULS04\_b:  $1.2*D + 1.6*S + 0.5*W\_NS$ . Columns, internal axial force [kN]

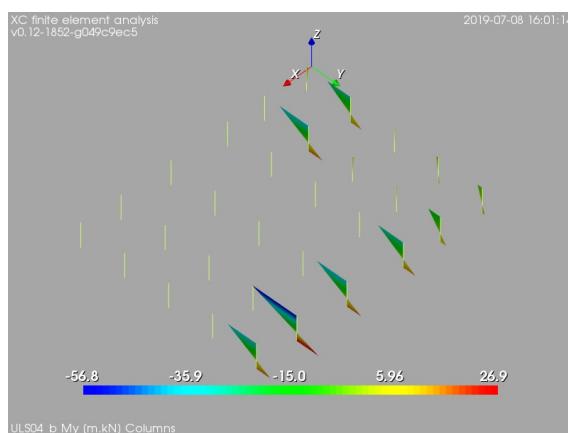


Figure 42: ULS04\_b:  $1.2*D + 1.6*S + 0.5*W\_NS$ . Columns, bending moment about local axis y [m.kN]

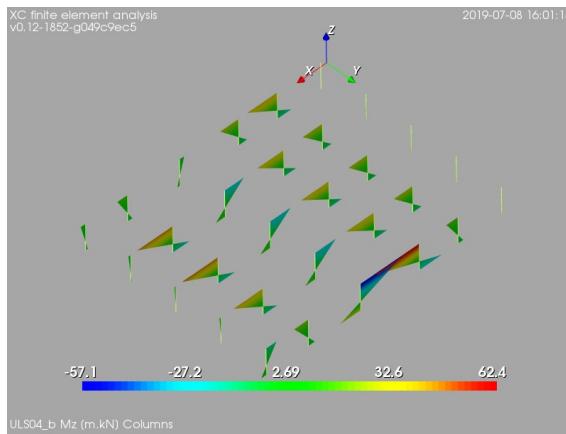


Figure 43: ULS04\_b:  $1.2*D + 1.6*S + 0.5*W_{NS}$ . Columns, bending moment about local axis z [m.kN]

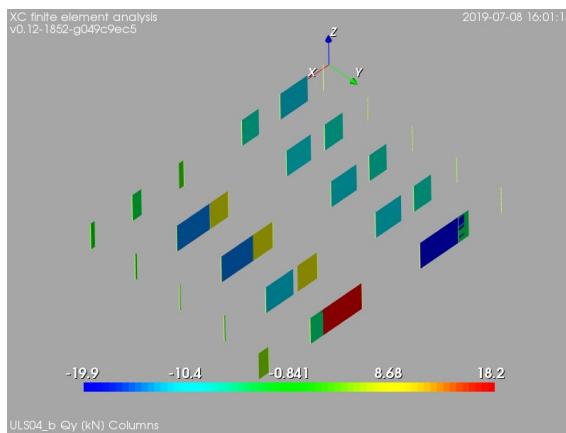


Figure 44: ULS04\_b:  $1.2*D + 1.6*S + 0.5*W_{NS}$ . Columns, internal shear force in local direction y [kN]

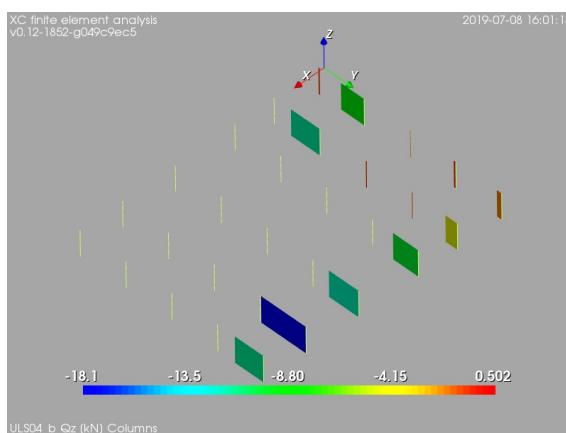


Figure 45: ULS04\_b:  $1.2*D + 1.6*S + 0.5*W_{NS}$ . Columns, internal shear force in local direction z [kN]

## 8. STRUCTURAL MODEL

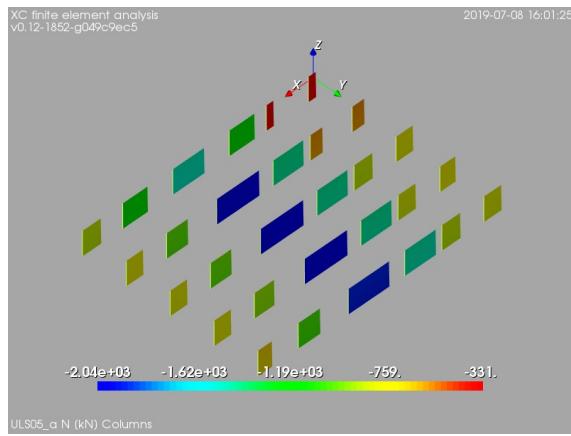


Figure 46: ULS05\_a: 1.2\*D + W\_WE + 0.5\*Lru + Lpu. Columns, internal axial force [kN]

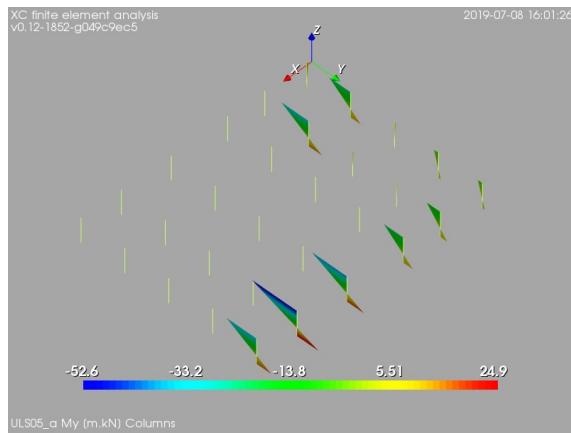


Figure 47: ULS05\_a: 1.2\*D + W\_WE + 0.5\*Lru + Lpu. Columns, bending moment about local axis y [m.kN]

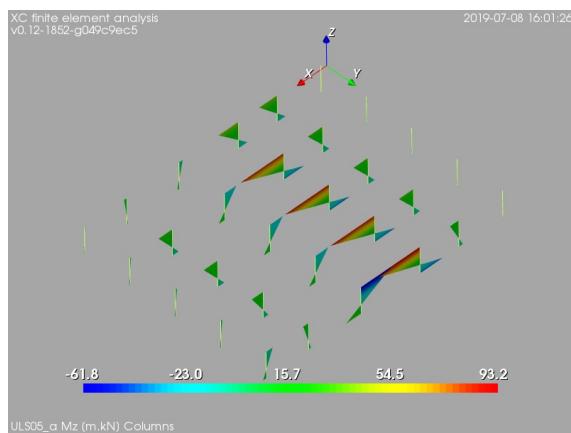


Figure 48: ULS05\_a: 1.2\*D + W\_WE + 0.5\*Lru + Lpu. Columns, bending moment about local axis z [m.kN]

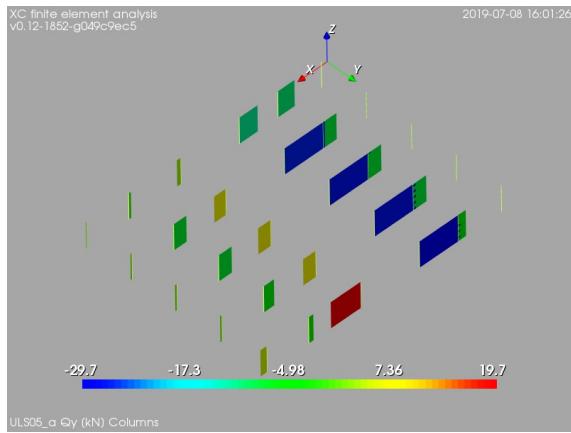


Figure 49: ULS05\_a:  $1.2*D + W\_WE + 0.5*Lru + Lpu$ . Columns, internal shear force in local direction y [kN]

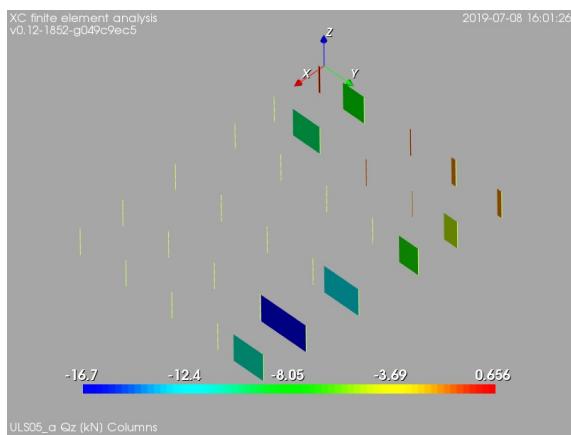


Figure 50: ULS05\_a:  $1.2*D + W\_WE + 0.5*Lru + Lpu$ . Columns, internal shear force in local direction z [kN]

## 8. STRUCTURAL MODEL

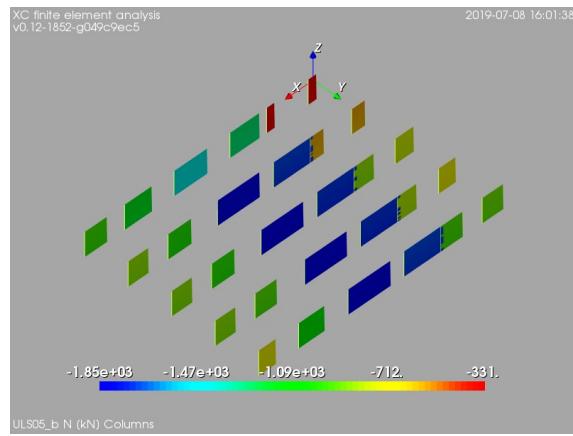


Figure 51: ULS05\_b:  $1.2*D + W_{NS} + 0.5*L_{ru} + L_{pu}$ . Columns, internal axial force [kN]

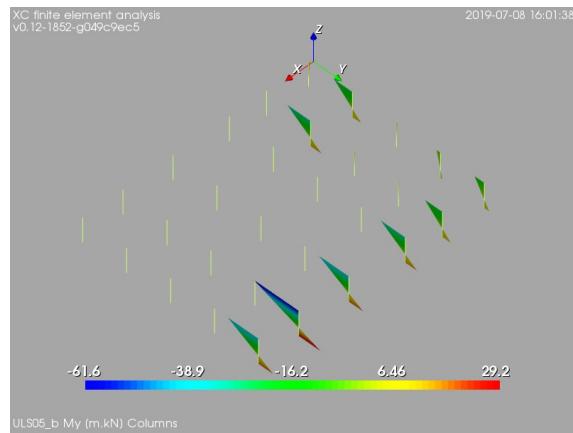


Figure 52: ULS05\_b:  $1.2*D + W_{NS} + 0.5*L_{ru} + L_{pu}$ . Columns, bending moment about local axis y [m.kN]

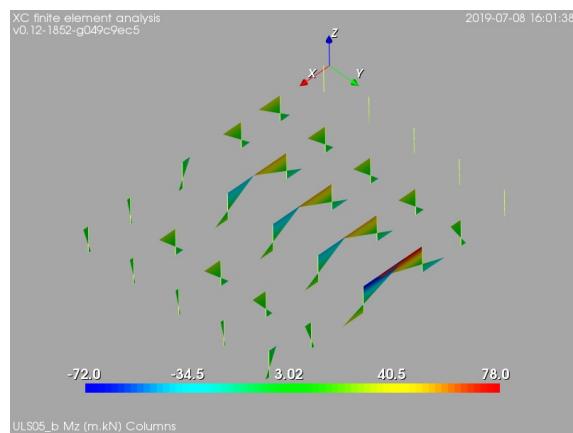


Figure 53: ULS05\_b:  $1.2*D + W_{NS} + 0.5*L_{ru} + L_{pu}$ . Columns, bending moment about local axis z [m.kN]

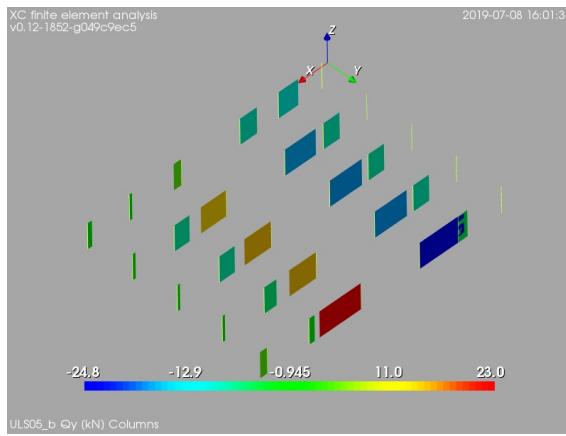


Figure 54: ULS05\_b:  $1.2*D + W\_NS + 0.5*Lru + Lpu$ . Columns, internal shear force in local direction y [kN]

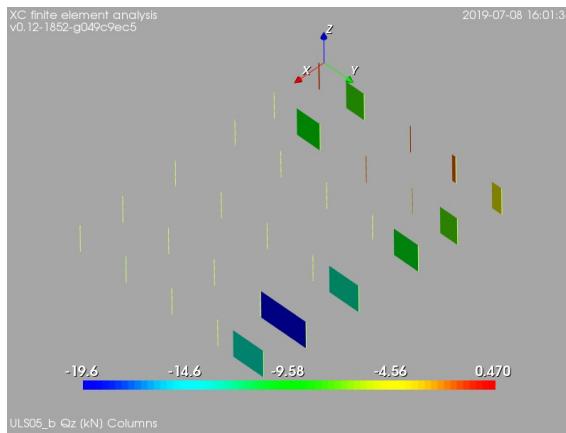


Figure 55: ULS05\_b:  $1.2*D + W\_NS + 0.5*Lru + Lpu$ . Columns, internal shear force in local direction z [kN]

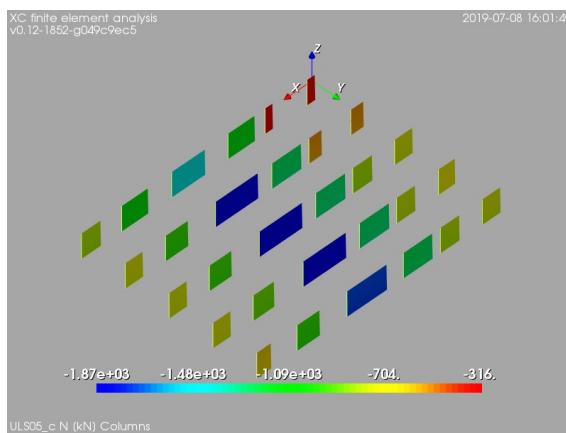


Figure 56: ULS05\_c:  $1.2*D + W\_WE + 0.5*Lrs + Lps$ . Columns, internal axial force [kN]

## 8. STRUCTURAL MODEL

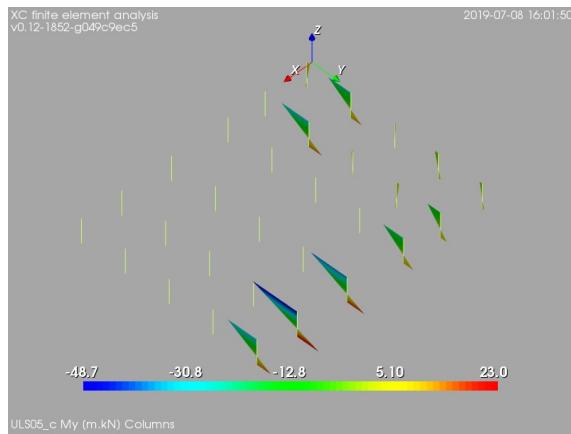


Figure 57: ULS05\_c:  $1.2*D + W\_WE + 0.5*Lrs + Lps$ . Columns, bending moment about local axis y [m.kN]

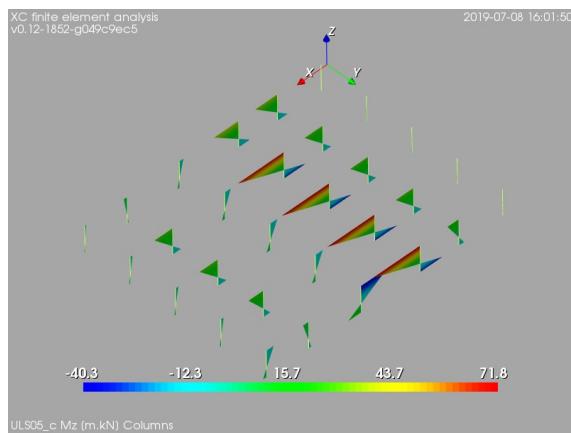


Figure 58: ULS05\_c:  $1.2*D + W\_WE + 0.5*Lrs + Lps$ . Columns, bending moment about local axis z [m.kN]

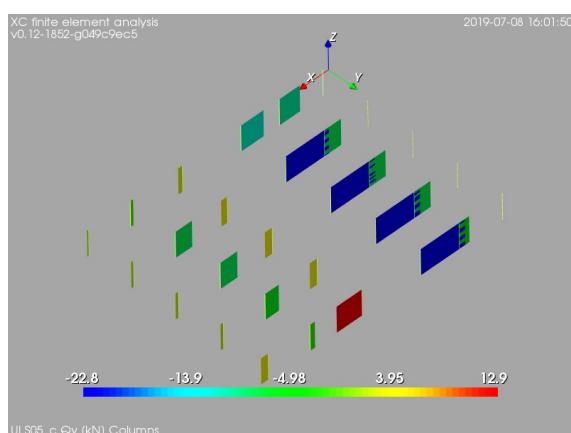


Figure 59: ULS05\_c:  $1.2*D + W\_WE + 0.5*Lrs + Lps$ . Columns, internal shear force in local direction y [kN]

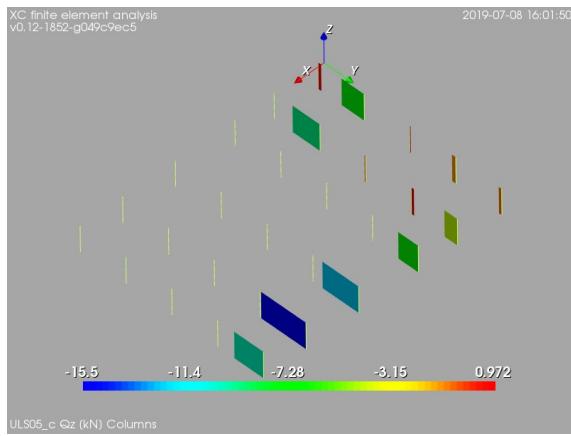


Figure 60: ULS05\_c: 1.2\*D + W\_WE + 0.5\*Lrs + Lps. Columns, internal shear force in local direction z [kN]

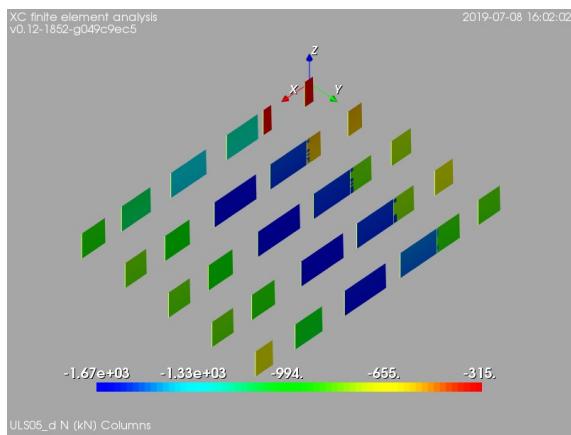


Figure 61: ULS05\_d: 1.2\*D + W\_NS + 0.5\*Lrs + Lps. Columns, internal axial force [kN]

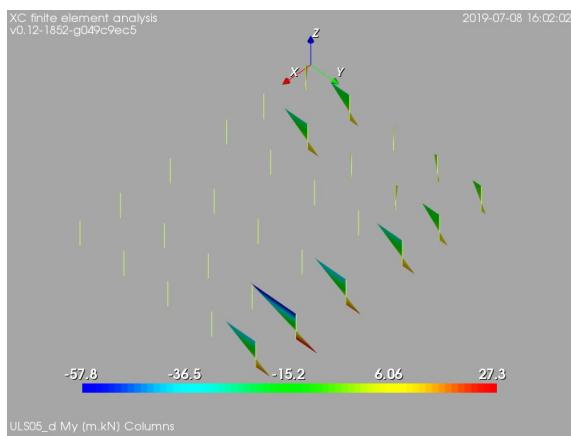


Figure 62: ULS05\_d: 1.2\*D + W\_NS + 0.5\*Lrs + Lps. Columns, bending moment about local axis y [m.kN]

## 8. STRUCTURAL MODEL

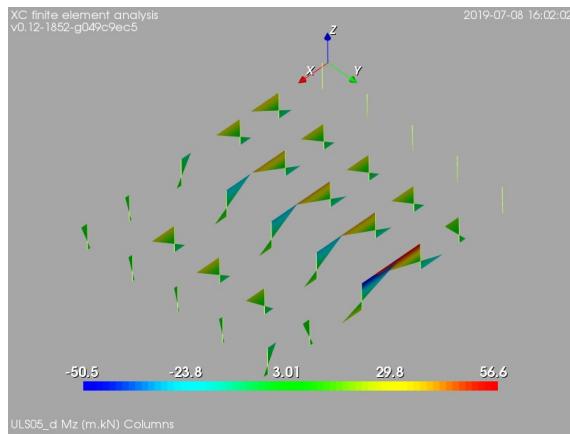


Figure 63: ULS05\_d: 1.2\*D + W\_Ns + 0.5\*Lrs + Lps. Columns, bending moment about local axis z [m.kN]

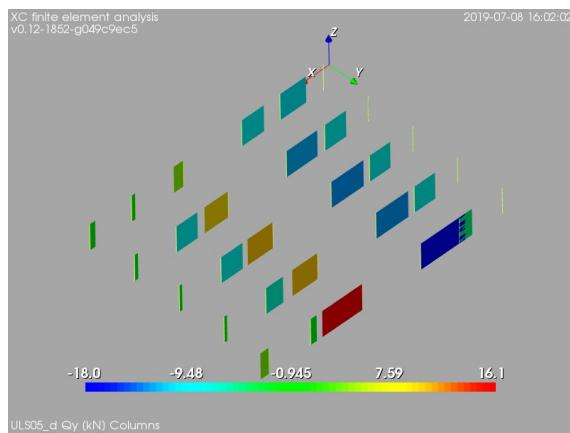


Figure 64: ULS05\_d: 1.2\*D + W\_Ns + 0.5\*Lrs + Lps. Columns, internal shear force in local direction y [kN]

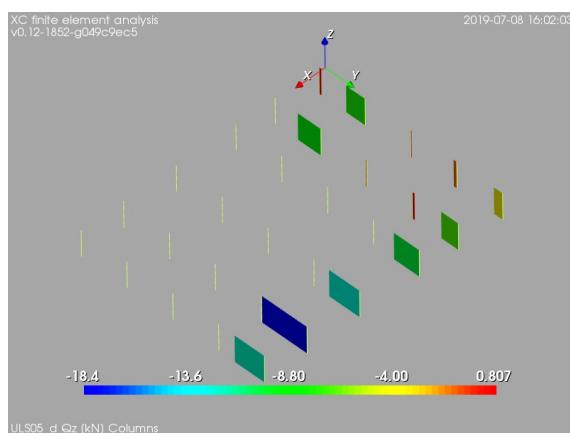


Figure 65: ULS05\_d: 1.2\*D + W\_Ns + 0.5\*Lrs + Lps. Columns, internal shear force in local direction z [kN]

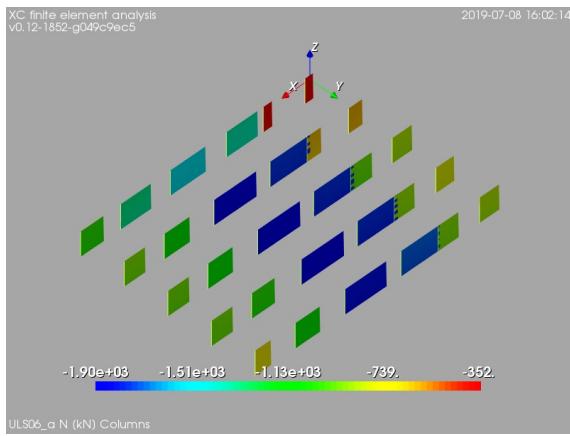


Figure 66: ULS06\_a:  $1.2*D + 0.5*Lru + Lpu + 0.2*S$ . Columns, internal axial force [kN]

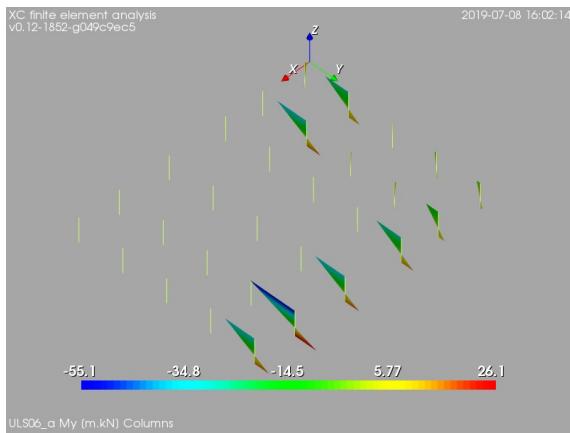


Figure 67: ULS06\_a:  $1.2*D + 0.5*Lru + Lpu + 0.2*S$ . Columns, bending moment about local axis y [m.kN]

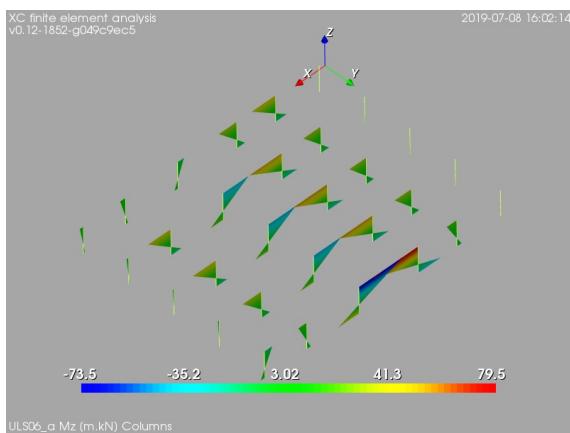


Figure 68: ULS06\_a:  $1.2*D + 0.5*Lru + Lpu + 0.2*S$ . Columns, bending moment about local axis z [m.kN]

## 8. STRUCTURAL MODEL

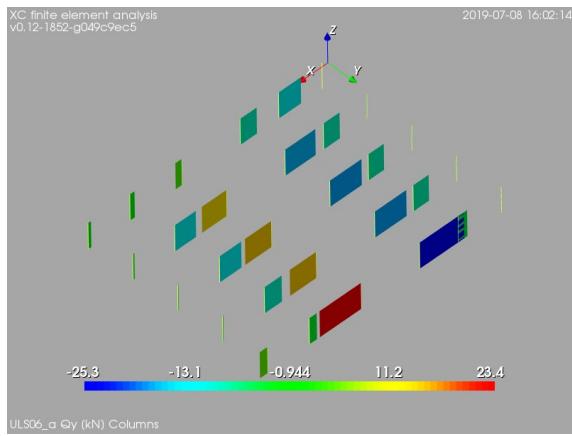


Figure 69: ULS06\_a:  $1.2*D + 0.5*L_{ru} + L_{pu} + 0.2*S$ . Columns, internal shear force in local direction y [kN]

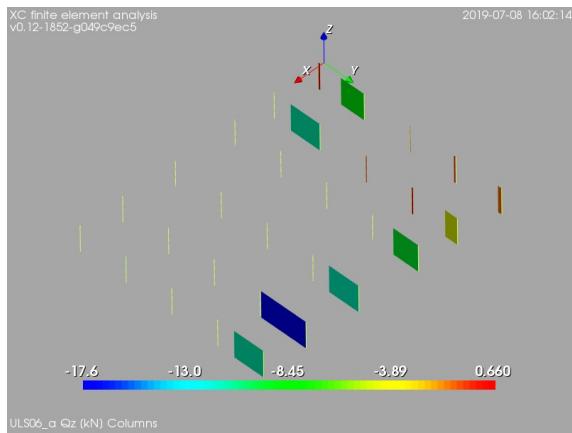


Figure 70: ULS06\_a:  $1.2*D + 0.5*L_{ru} + L_{pu} + 0.2*S$ . Columns, internal shear force in local direction z [kN]

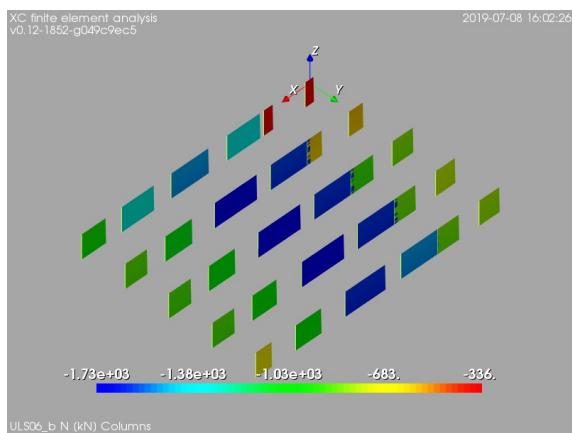


Figure 71: ULS06\_b:  $1.2*D + 0.5*L_{rs} + L_{ps} + 0.2*S$ . Columns, internal axial force [kN]

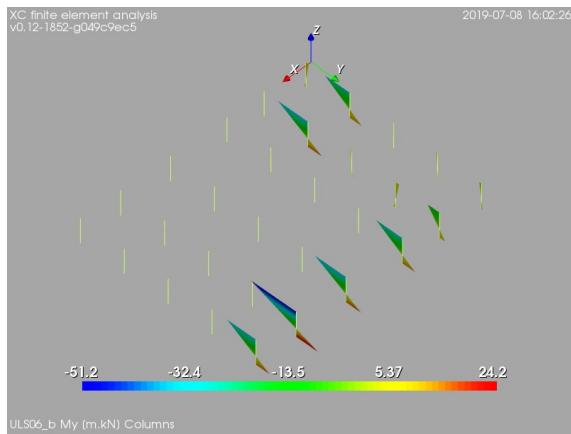


Figure 72: ULS06\_b:  $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, bending moment about local axis y [m.kN]

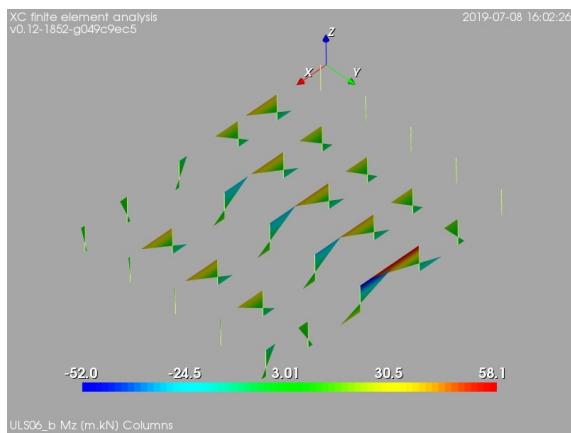


Figure 73: ULS06\_b:  $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, bending moment about local axis z [m.kN]

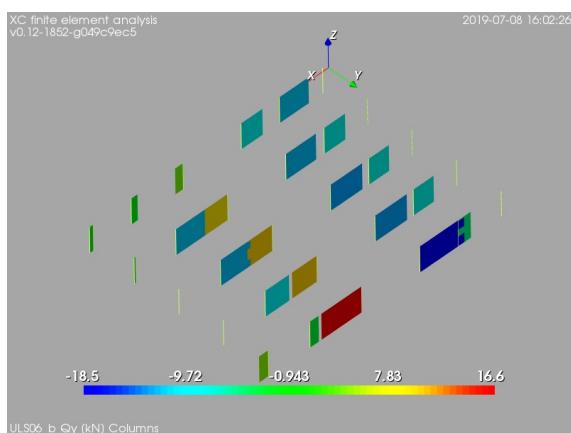


Figure 74: ULS06\_b:  $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, internal shear force in local direction y [kN]

## 8. STRUCTURAL MODEL

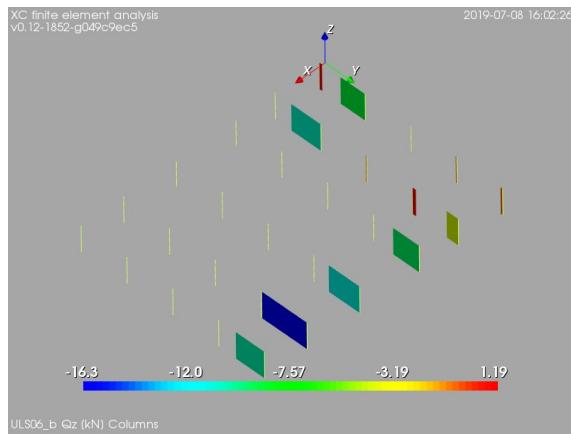


Figure 75: ULS06\_b:  $1.2*D + 0.5*Lrs + Lps + 0.2*S$ . Columns, internal shear force in local direction z [kN]

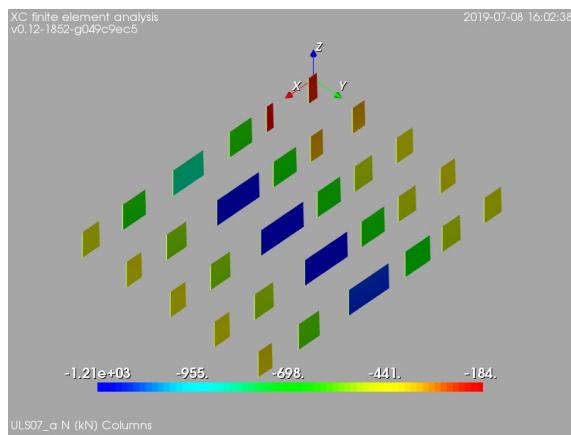


Figure 76: ULS07\_a:  $0.9*D + W\_WE$ . Columns, internal axial force [kN]

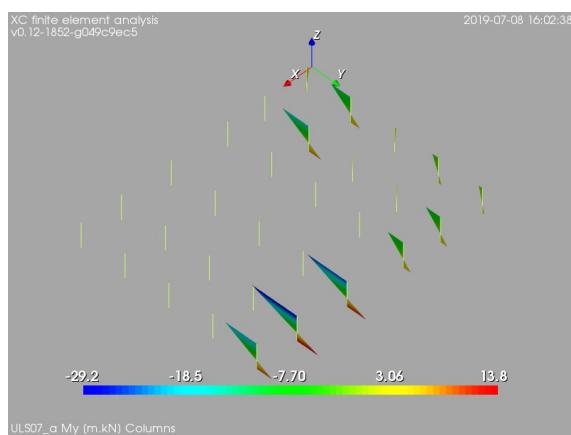


Figure 77: ULS07\_a:  $0.9*D + W\_WE$ . Columns, bending moment about local axis y [m.kN]

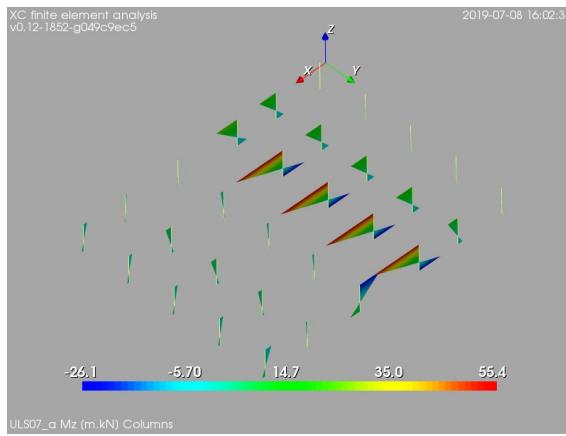


Figure 78: ULS07\_a: 0.9\*D + W\_WE. Columns, bending moment about local axis z [m.kN]

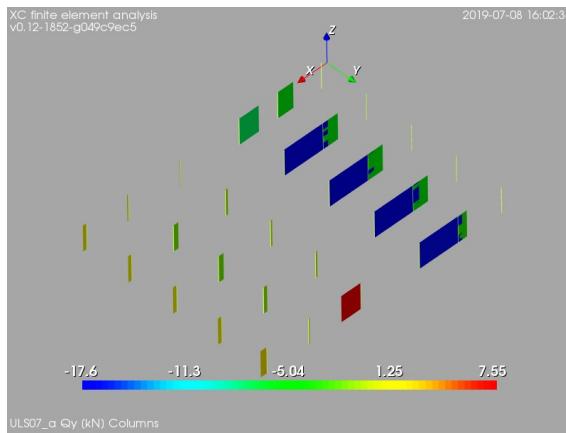


Figure 79: ULS07\_a: 0.9\*D + W\_WE. Columns, internal shear force in local direction y [kN]

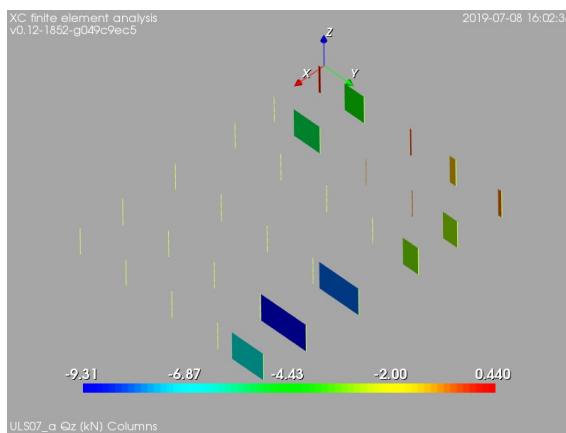


Figure 80: ULS07\_a: 0.9\*D + W\_WE. Columns, internal shear force in local direction z [kN]

## 8. STRUCTURAL MODEL

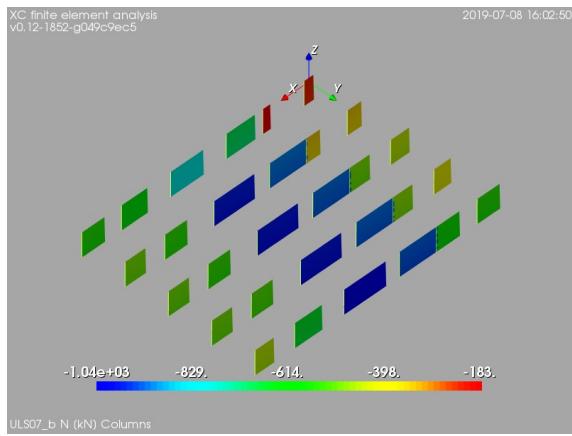


Figure 81: ULS07\_b: 0.9\*D + W\_NS. Columns, internal axial force [kN]

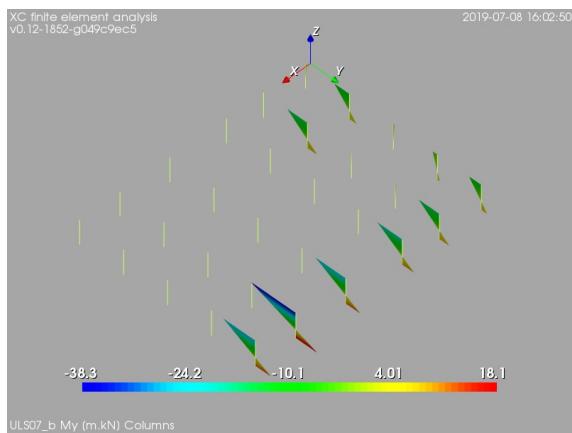


Figure 82: ULS07\_b: 0.9\*D + W\_NS. Columns, bending moment about local axis y [m.kN]

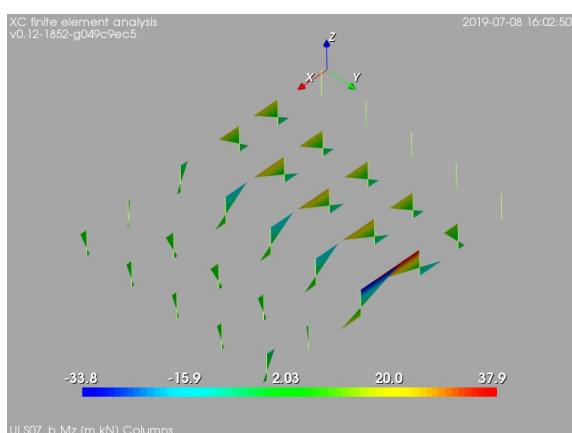


Figure 83: ULS07\_b: 0.9\*D + W\_NS. Columns, bending moment about local axis z [m.kN]

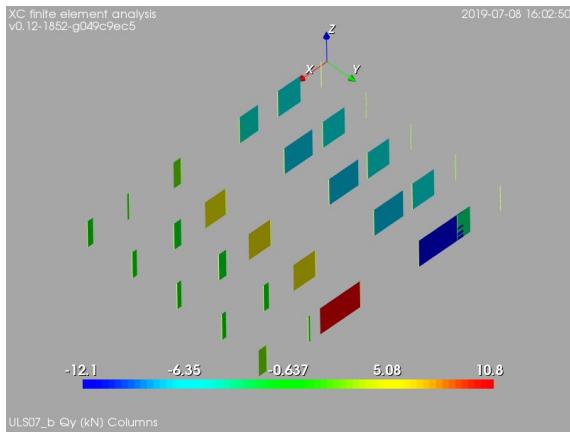


Figure 84: ULS07\_b: 0.9\*D + W\_NS. Columns, internal shear force in local direction y [kN]

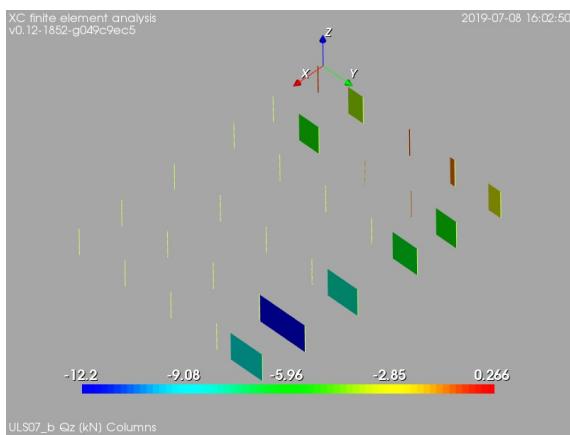


Figure 85: ULS07\_b: 0.9\*D + W\_NS. Columns, internal shear force in local direction z [kN]

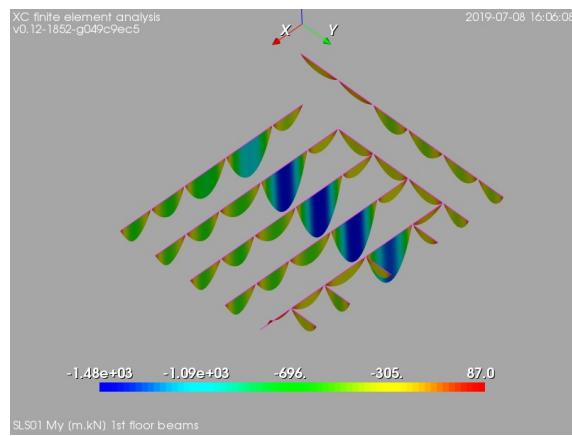


Figure 86: SLS01: 1.0\*D. 1st floor beams, bending moment about local axis y [m.kN]

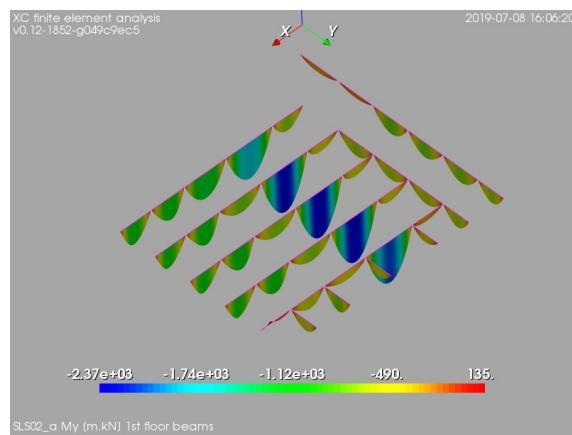


Figure 87: SLS02\_a: 1.0\*D + 1.0\*Lru + Lpu + 0.3\*S. 1st floor beams, bending moment about local axis y [m.kN]

## B.2 Serviceability limit states

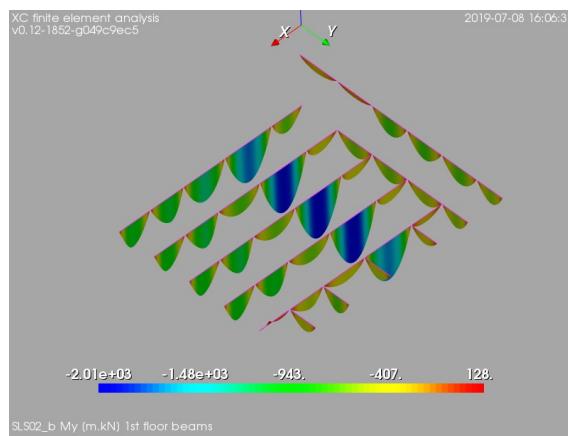


Figure 88: SLS02\_b:  $1.0*D + 1.0*Lrs + Lps + 0.3*S$ . 1st floor beams, bending moment about local axis y [m.kN]

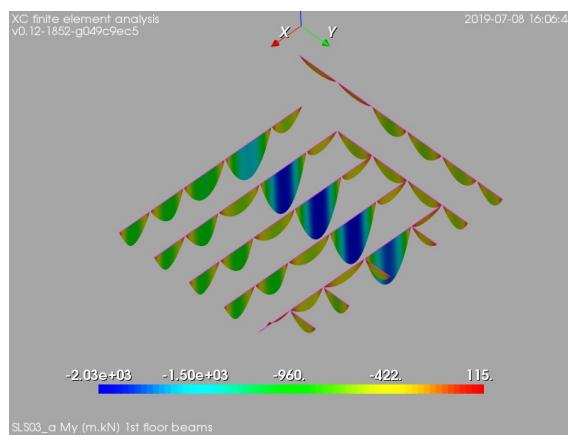


Figure 89: SLS03\_a:  $1.0*D + 1.0*S + 0.3*Lru + 0.3*Lpu$ . 1st floor beams, bending moment about local axis y [m.kN]

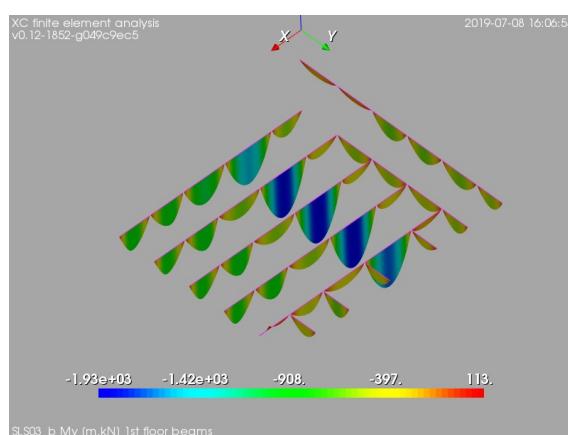


Figure 90: SLS03\_b:  $1.0*D + 1.0*S + 0.3*Lrs + 0.3*Lps$ . 1st floor beams, bending moment about local axis y [m.kN]

## 8. STRUCTURAL MODEL

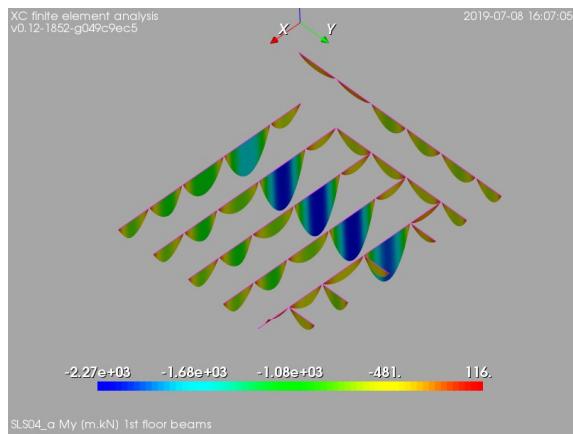


Figure 91: SLS04\_a:  $1.0*D + W\_WE + 1.0*Lru + Lpu$ . 1st floor beams, bending moment about local axis y [m.kN]

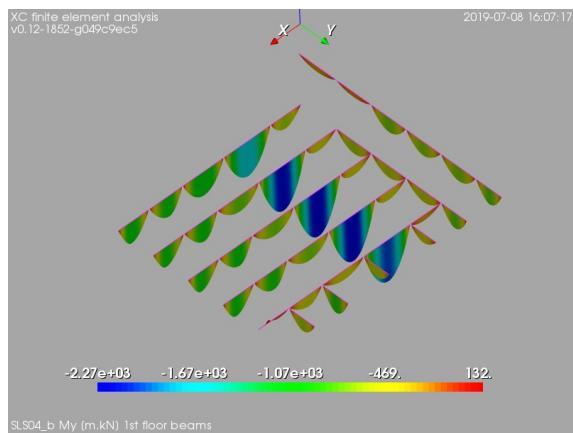


Figure 92: SLS04\_b:  $1.0*D + W\_NS + 1.0*Lru + Lpu$ . 1st floor beams, bending moment about local axis y [m.kN]

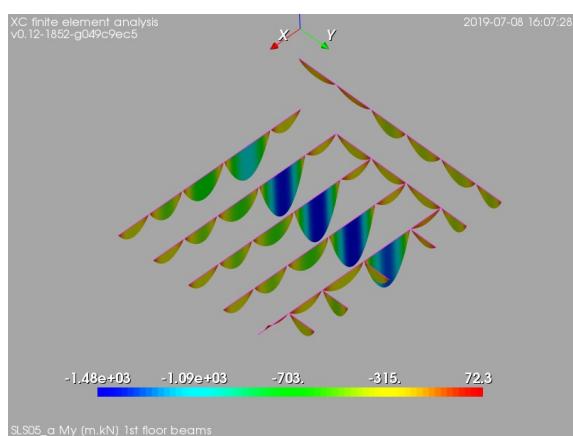


Figure 93: SLS05\_a:  $1.0*D + W\_WE$ . 1st floor beams, bending moment about local axis y [m.kN]

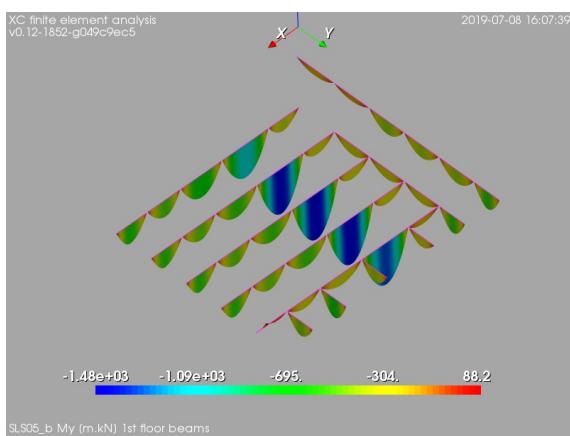


Figure 94: SLS05\_b: 1.0\*D + W\_NS. 1st floor beams, bending moment about local axis y [m.kN]