Mat_Foundation_Analysis

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1 Mat Foundation Analysis and Design using SAP2000

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1.1 Assumptions for the Model

- Allowable Bearing Capacity = $200kPa$
- Allowable deflection of soil = $10mm$
- Spring stiffness coefficient = $200kPa$ / $10mm$ = $200000kN/m^3$
- Thickness of foundation = $1.50m$
- Keep in mind that the results of SAP2000 from the table if extracted via Resultant forces are in kN/m or $kN.m/m$. SAP2000 divided by a **tributary width of 1m**. The result must then be multiplied by the **tributary area** of the resultant force or moment.
- The Earthquake was neglected on the analysis due the fact that column load combination are governed by Dead plus Live. The governing shearwall combination includes EQX and EQY. But the analysis is focused on the positive and negative steel reinforcements per column on top of the mat.
- The stresses were extracted from SAP2000 via tables and plotted here for better visualization.

The verification of modeling of the mat foundation was modeled initially with a isolated footing and compared it with its RCD counter part. The results summary are as follows:

- the Ultimate bearing capacity (Pu/Ag) distributed along the isolated footing of the SAP2000 model were exactly the same as the RCD's Ultimate bearing capacity. The difference in the bearing capacity is that the SAP2000 model's spring reaction (idealized from the soil pressure reaction) are more distributed in a circular manner than the RCD's approach which is distributed evenly.
- The Moment and punching shear of the SAP2000 model are nearly identical compared to the RCD's approach. The computation of the moment is at the critical section (at the face of the column for moment and column dimension C + d (depth of footing) distance from the center of the column for critical punching area for shear)

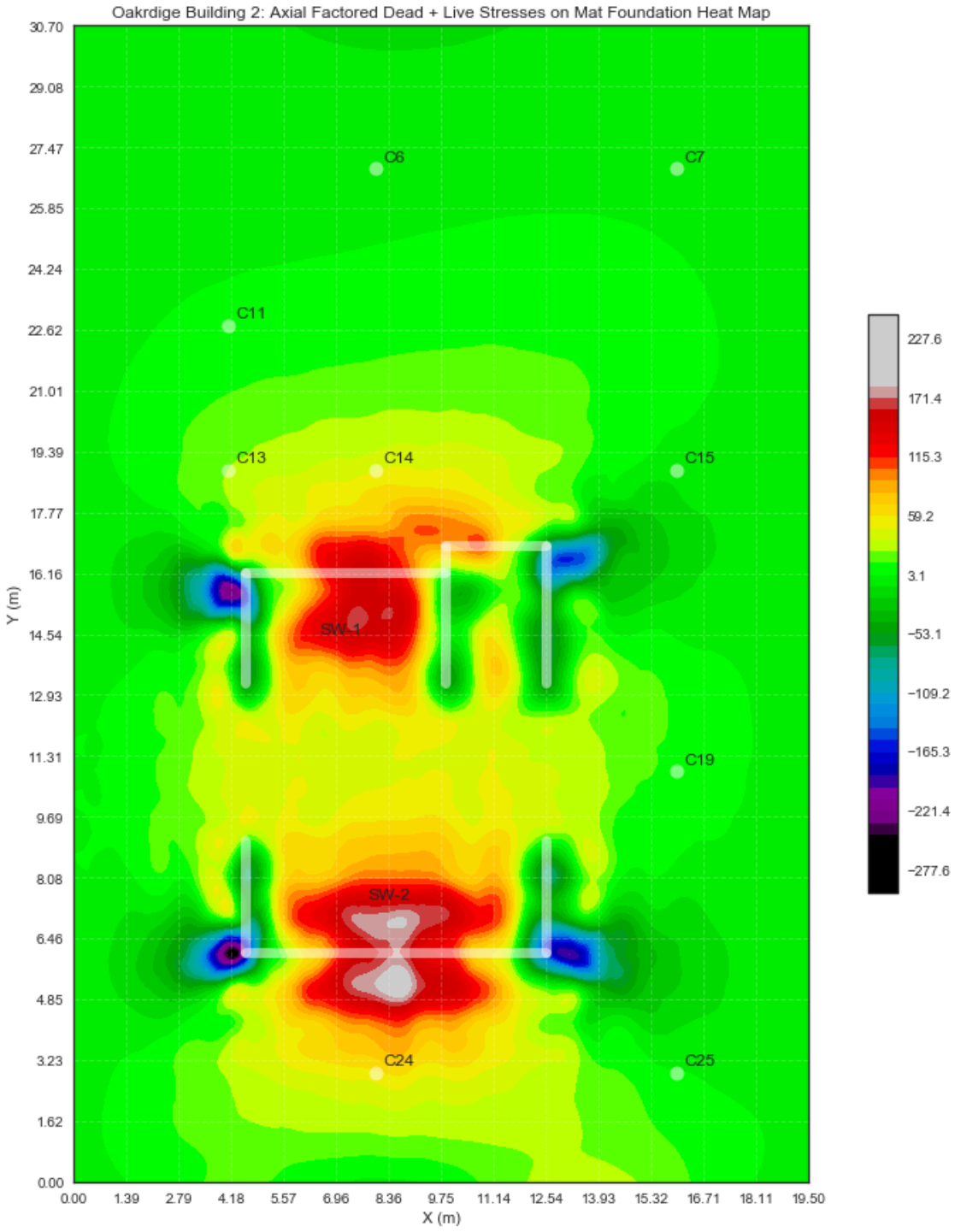
2 Exploration of the Data

2.1 Summary Statistics of the Mat Foundation Ultimate Bearing Capacity

Out[3]:

	Joint	GlobalX (mm)	GlobalY (mm)	Dead_(kN)	EQX_(kN)
count	888.000000	888.000000	888.000000	888.000000	888.000000
mean	463.959459	9551.041667	15132.162162	144.930963	35.655324
std	257.418111	5909.219702	8938.546894	46.321112	35.734753
min	1.000000	0.000000	0.000000	8.828000	-29.239000
25%	242.750000	4475.000000	7843.330000	121.683000	6.940750
50%	464.500000	9425.000000	14773.330000	155.777500	31.280000
75%	686.250000	14490.625000	22750.000000	177.992750	61.144000
max	908.000000	19500.000000	30700.000000	216.582000	135.156000

2.2 Plotting the Heat map of the Ultimate Beariing Capacity of Mat Foundation Based of Dead + Live



2.3 Summary Statistics of the Mat Foundation Shell Forces

Out[6]:

	Joint	GlobalX (mm)	GlobalY (mm)	F11	F22
count	888.000000	888.000000	888.000000	888.000000	888.000000
mean	463.959459	9551.041667	15132.162162	23.028826	-9.630043
std	257.418111	5909.219702	8938.546894	59.642665	71.201937
min	1.000000	0.000000	0.000000	-331.550000	-610.381667
25%	242.750000	4475.000000	7843.330000	-1.010000	-4.736875
50%	464.500000	9425.000000	14773.330000	5.628750	0.581250
75%	686.250000	14490.625000	22750.000000	37.054375	12.420000
max	908.000000	19500.000000	30700.000000	305.281667	84.335000

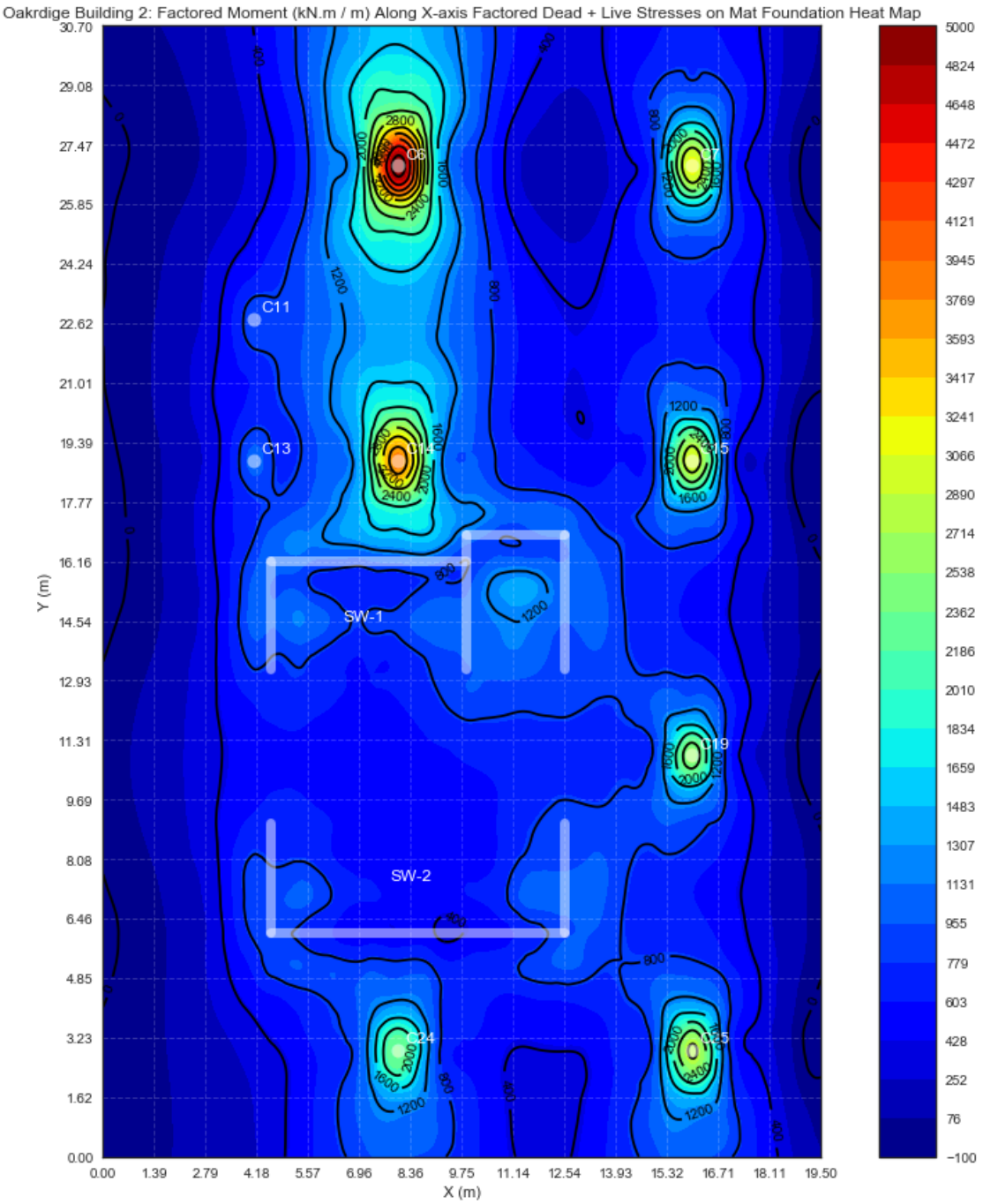
	F12	FMax	FMin	FAngle	FVM
count	888.000000	888.000000	888.000000	888.000000	888.000000
mean	0.846994	43.554174	-30.155535	0.323122	72.071122
std	31.384247	55.449521	88.068414	42.668738	113.279964
min	-157.791667	-33.100000	-839.435000	-89.402000	0.010560
25%	-5.561250	7.500625	-21.881875	-27.880562	11.867500
50%	0.210000	24.952500	-6.831250	0.536850	32.021250
75%	6.774375	56.845625	-1.806875	28.881375	75.271875
max	158.472500	310.683333	45.007500	88.856250	889.335000

	M11	M22	M12	MMax	MMin
count	888.000000	888.000000	888.000000	888.000000	888.000000
mean	628.123909	252.299246	2.110660	739.293697	141.129456
std	538.808755	502.471305	158.074327	539.163111	442.631580
min	-81.734350	-628.994300	-591.538675	-28.802850	-629.168975
25%	226.233469	-52.960000	-78.107894	389.348038	-101.041681
50%	565.267787	188.591850	-7.379187	648.303488	65.744512
75%	873.664975	464.040735	88.606700	970.014762	318.922388
max	4982.597425	4151.461700	541.670875	5015.867975	4118.191100

	MAngle	V13	V23	VMax	VAngle
count	888.000000	888.000000	888.000000	888.000000	888.000000
mean	-3.471924	-8.397617	-6.917992	422.129671	-1.421440
std	37.261246	363.124529	357.849489	481.578875	95.332948
min	-89.499000	-2327.440000	-2369.987500	5.740000	-175.304500
25%	-21.153500	-155.916250	-145.062500	170.406875	-85.078500
50%	-1.442375	-26.580000	0.235000	286.978750	-0.512125
75%	14.985750	155.240625	139.566250	473.906250	73.495437
max	89.356000	2189.277500	2075.260000	4393.025000	178.232000

2.4 Plotting the Contour Map of Axial Factored Dead + Live load of Mat Foundation

2.5 Design of Steel along X-Direction



Maximum Bottom bar reinforcement for C6 and C14:

```
p: 0.003130069464583729
pmin:  0.0034
```

```
4/3*p:  0.0042
usep:  0.0034
Moment:  11259.00, no of bars: 38 using  28 mm rebar 1 layers
spacing:  135 mm
```

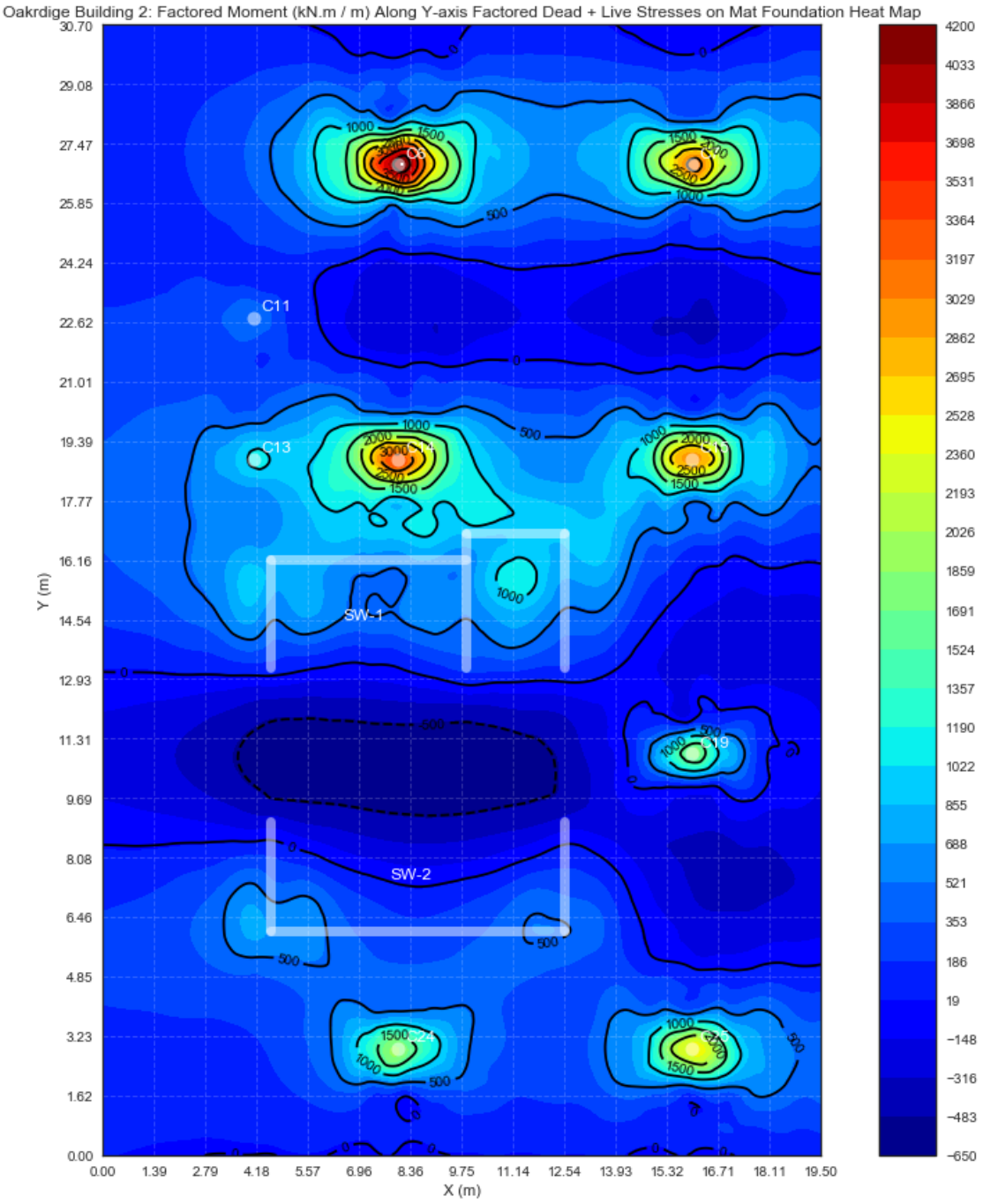
Maximum Bottom bar reinforcement for C24, C25, C19, C15 and C7:

```
p: 0.0017380376821601482
pmin:  0.0034
4/3*p:  0.0023
usep:  0.0023
Moment:  6755.40, no of bars: 28 using  28 mm rebar 1 layers
spacing:  158 mm
```

Maximum Bottom bar reinforcement for C11 and C13:

```
p: 0.0007386522711734751
pmin:  0.0034
4/3*p:  0.0010
usep:  0.0020
Moment:  1801.44, no of bars: 15 using  28 mm rebar 1 layers
spacing:  99 mm
```

2.6 Design of Steel along Y-Direction



Maximum Bottom bar reinforcement for C6 and C14

```
p: 0.0018017250286220137
pmin:  0.0034
4/3*p:  0.0024
```

```
usep:  0.0024
Moment:  7484.40, no of bars: 31 using  28 mm rebar 1 layers
spacing:  168 mm
```

Maximum Bottom bar reinforcement for C19, C24, and C25

```
p: 0.003919320516904343
pmin:  0.0034
4/3*p:  0.0052
usep:  0.0039
Moment:  16038.00, no of bars: 50 using  28 mm rebar 1 layers
spacing:  148 mm
```

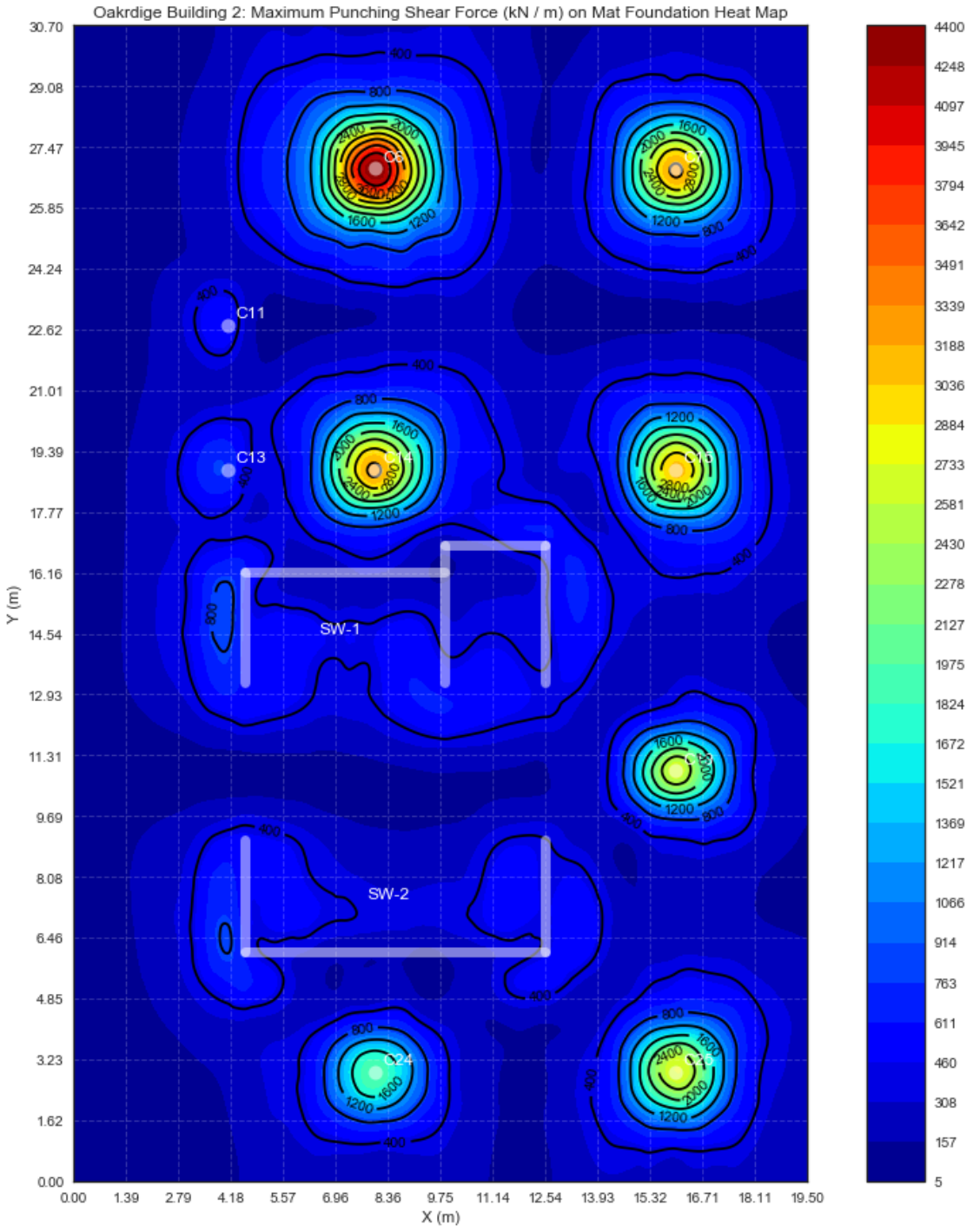
Maximum Bottom bar reinforcement for C7 and C15

```
p: 0.004730638398353554
pmin:  0.0034
4/3*p:  0.0063
usep:  0.0047
Moment:  19245.60, no of bars: 61 using  28 mm rebar 1 layers
spacing:  137 mm
```

Maximum Top bar reinforcement for Mat Foundation both ways

```
p: 0.000920885805596799
pmin:  0.0034
4/3*p:  0.0012
usep:  0.0020
Moment:  3849.12, no of bars: 26 using  28 mm rebar 1 layers
spacing:  174 mm
```

2.7 Check for Punching Shear



3 Analyzing Mat Foundation due to Earthquake along X-Direction