1 Plan

1.1 Today

- Fix thermal bending moment loading
- Code to compose responses from thermal loads (easy peasy)
- Validate temperature against Axis

1.2 Mon - Wed

- Mesh refinement & material property verification (straightforward work)
  - >= 1 discrepancy in material properties to fix
  - mesh refinement around load
  - reduce amount of nodes in unecessary places

1.3 Thurs - 31st

- Run *some* classification experiments on Lisa cluster
  - Python code on Lisa is straightforward to execute
  - setting up OpenSees on Lisa seemed awkward
    * will try again some evening, not crucial
    * found a "singularity container" for OpenSees

2 Comment

Load/Response	Status
Displacement	Validated
Strain	Good regression line
	Mean and min converging (figure below)
	Max: will try more nodes & mesh refinement
Temperature	Try validation today
Pier displacement	

Hopefully the work Mon-Wed will bring things into better agreement.

3 Thermal Bending Moment

The explanation was really good, it makes a lot of sense to me after I went over it again. I still have some questions though.

- I guess this implementation makes the assumption that strain (bending moment component) due to a difference in temperatre is distributed linearly along the height of the element?
- Sanity check, the moments in Newton meters are appled in loading positions Rx, Rz?
- Do you have any inclination to how the nodes should be fixed, in all the previous simulations the axes of rotation have been free, but perhaps not in this case?
- The "back of the envelope" calculation of strain to verify the axial loading makes sense because the change in length/width/height from the axial loading is the same response collected from simulation. However I dont' expect the same calculation to work for rotation. Is there something similar?
- Can you confirm the magnitude and direction of moments added in the diagram below?

```
     N
 |-------|
W|       |E
 |       |
 |-------|
     S
```

```
For moment calculated along S face: + Rz
For moment calculated along N face: - Rz
For moment calculated along W face: + Rx
For moment calculated along E face: - Rx
```

3.1 Implementation

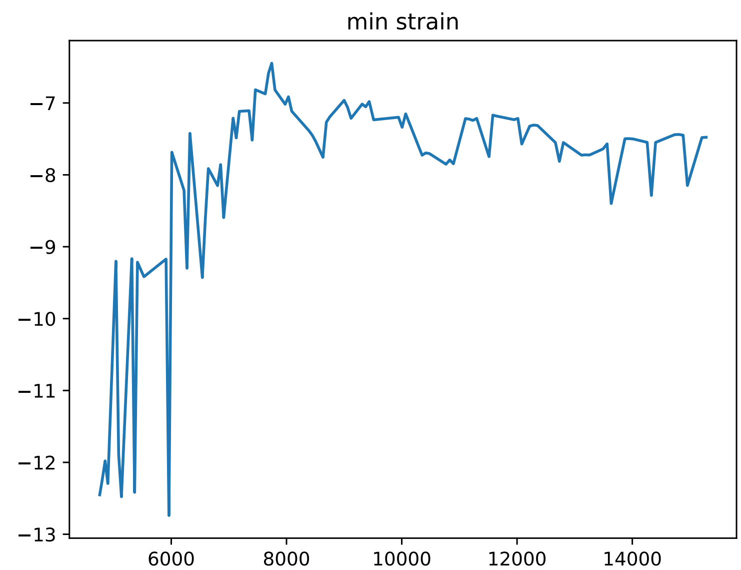
- Added `unit_moment_thermal_load = 1` to `Config`
- Run simulation with the unit load, applying code below

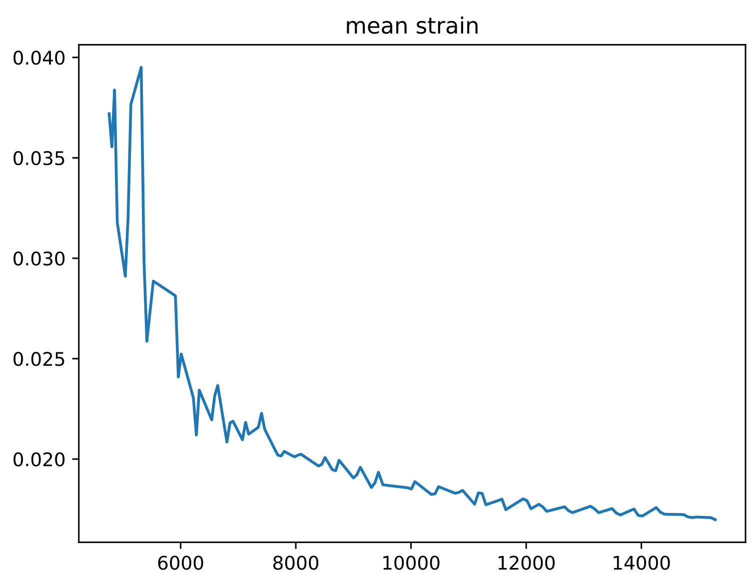
```
x_moment_per_node = ...
z_moment_per_node = ...
for shell in deck:
    strain_top = CTE * moment_unit_load
    stress_top = strain_top * E
    for node0, node1 in shell: # Each pair of nodes per face.
        n = node0.distance_to(node1)
        # Integrate stress over the area. Or if the stress is considered a plane
        # of the wedge, then multiply by height of the wedge (thickness / 2),
        # the width (n), and half because the wedge is half a cuboid.
        force_top =  stress_top * (thickness / 2) * n * (1 / 2)
        # Force * 2/3rds the height.
        moment_top = force_top * (2 / 3) * thickness / 2
        for node in [node0, node1]:
            node_moment = moment_top / 2
            # Depending on face direction +- moment to x/z_moment_per_node.
```

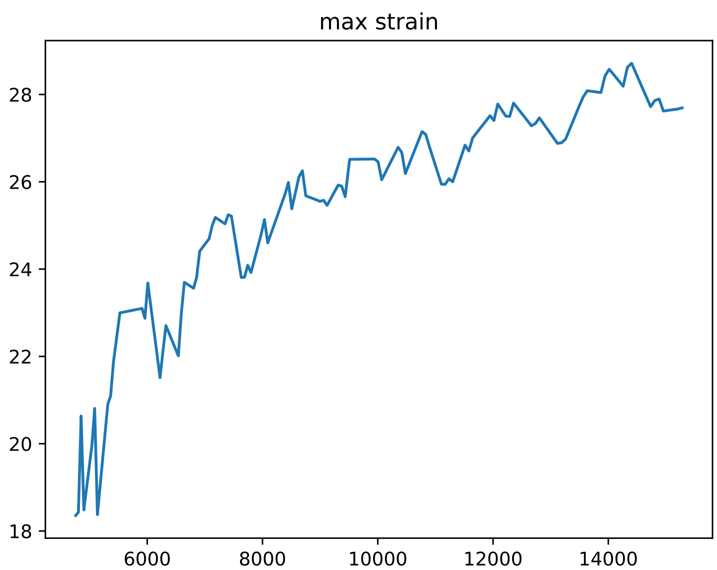
```
cte = 1.2e-05
delta_temp = 1
strain_top = 1.2e-05
youngs = 38400000000
stress = 460800.0
node distance = 0.3666
section thickness = 0.74
force top n = 31251.91
moment n = 7708.80
nodal moment n = 3854.4
```

4 Strain Convergence

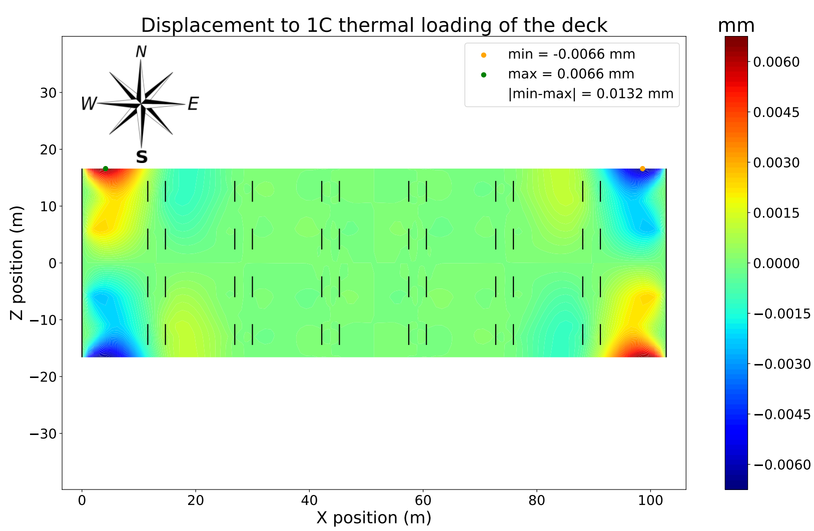
Quick and dirty convergence plots.

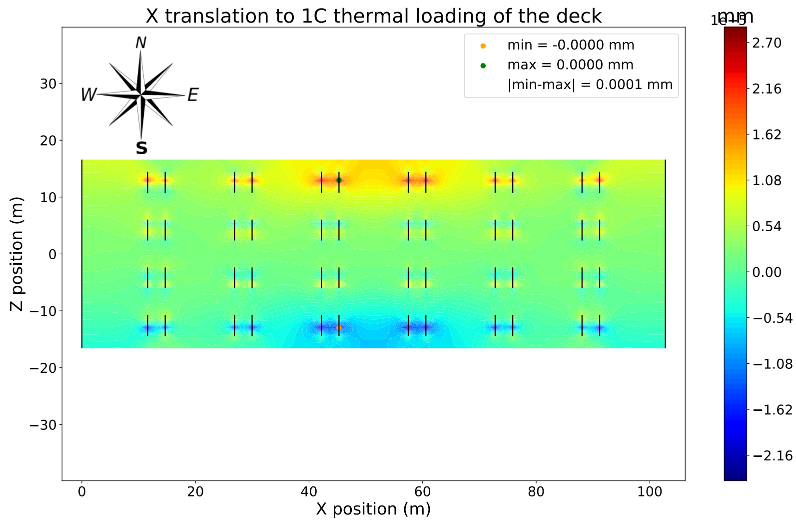

min strain
−7
−8
−9
−10
−11
−12
−13
6000
8000
10000
12000
14000

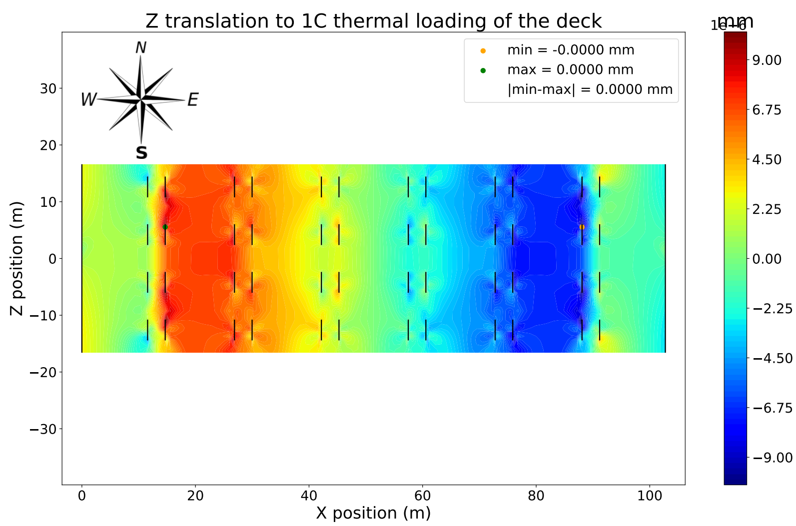

mean strain
0.040
0.035
0.030
0.025
0.020
6000
8000
10000
12000
14000



5 Thermal Moment Results




X translation to 1C thermal loading of the deck
min = -0.0000 mm
max = 0.0000 mm
|min-max| = 0.0001 mm
N
W
E
S
Z position (m)
X position (m)
1e−5
mm
2.70
2.16
1.62
1.08
0.54
0.00
−0.54
−1.08
−1.62
−2.16


Z translation to 1C thermal loading of the deck
min = -0.0000 mm
max = 0.0000 mm
|min-max| = 0.0000 mm
N
W
E
S
Z position (m)
X position (m)
1e−6
mm
9.00
6.75
4.50
2.25
0.00
−2.25
−4.50
−6.75
−9.00