shell analysis | karamba

2nd Exercise | Altering Mesh Elements

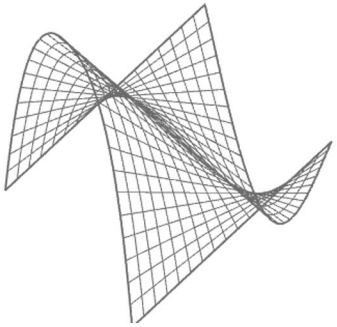
IaaC - Institute for Advanced Architecture of Catalonia | MAA01 - 2015 | Data Informed Structures | 2nd Exercise | Group 9 Students - Lubna Alayeli and Nina Jotanovic

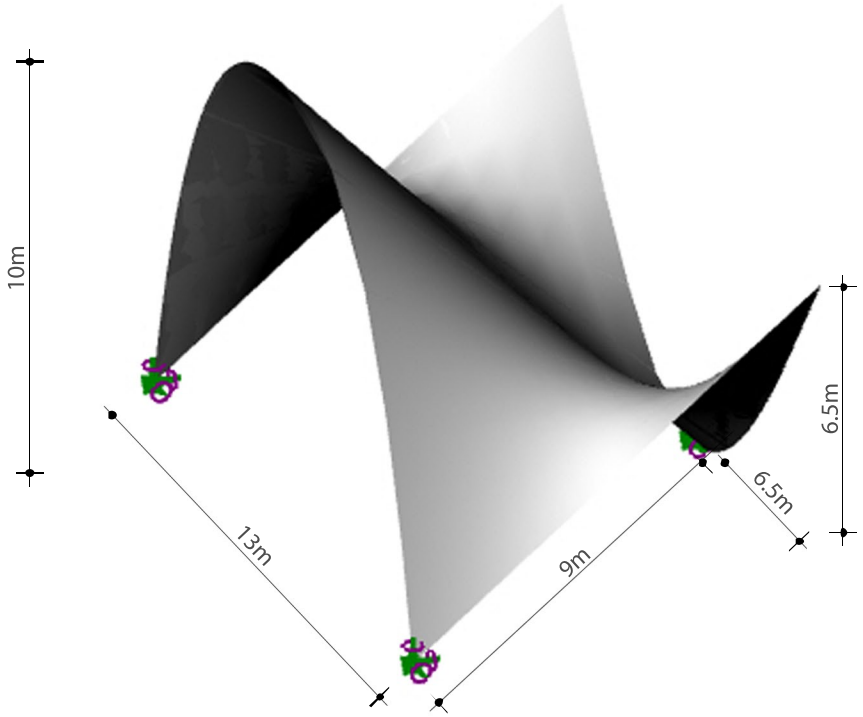
shell geometry |

1|

Double-curved, anticlastic shell.
Three support points on the ground level.
Vertical mesh load [-5 kN/m2].

Manipulating parameters |
A cross-section
B cross-section locally
C adding beams





2|

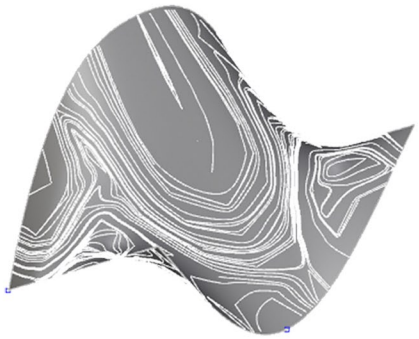
force flow

4|

principal stresses

3|

isolines



conclusion |

Forces are following the main curvatures on the shell.

Principal stresses are formed as curves that cross with change of curvature where there is larger stress.

Isolines are in the areas where shell changes the curvature [in the "valleys" of the shell], as well as at the supports.

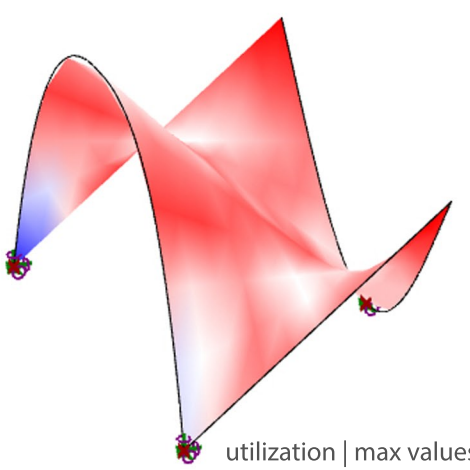
manipulating the cross - section | A

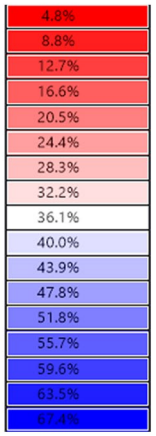
1|

cross - section 8cm

total mass | 33996.580758

displacement | 0.0359





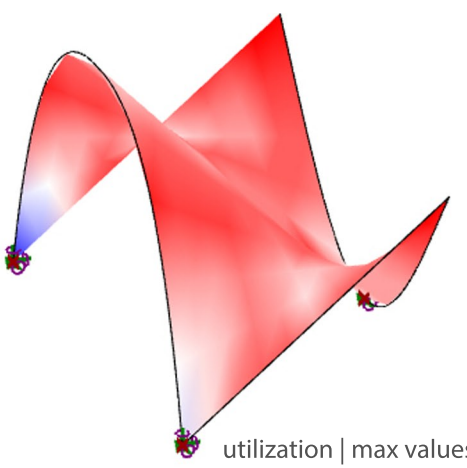
utilization | max values

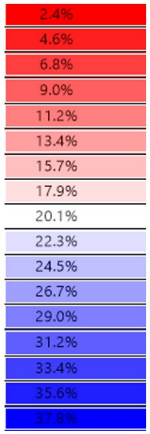
2|

cross - section 12cm

total mass | 50994.871137

displacement | 0.011735





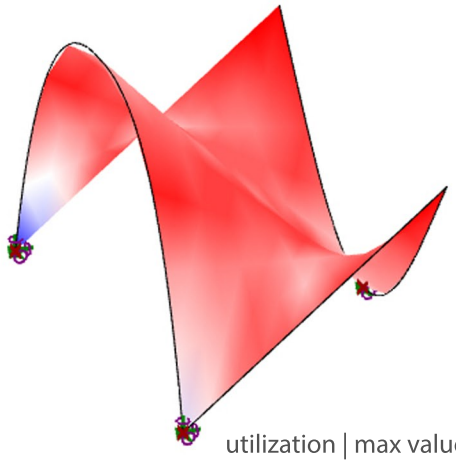
utilization | max values

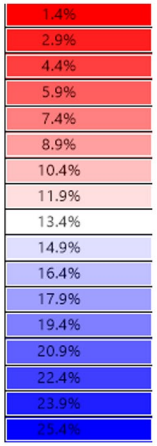
3|

cross - section 16cm

total mass | 67993.161516

displacement | 0.005352





utilization | max values

conclusion |

Along with increasing the cross section of the whole shell, the utilization values are becoming smaller. The whole shell is still working in the same way, meaning the same parts of the shell are responding to major parts of the loads. Total mass is increasing, and the displacement values are becoming less.

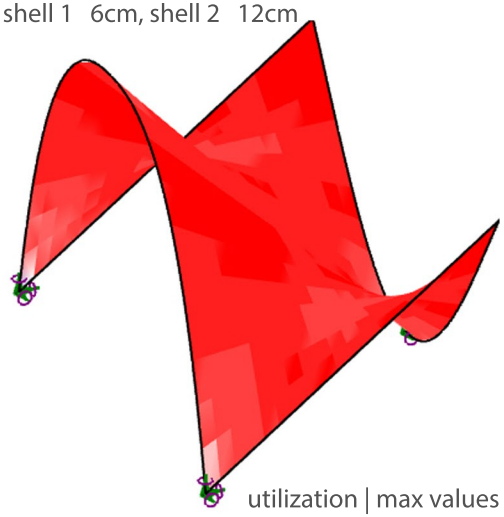
In next sequence cross-section is changing locally, only on parts of surface where utilization has the biggest values. ---> (next page)

displacement | trasholds
[lower 10%, upper 90%]

manipulating the cross - section locally | B

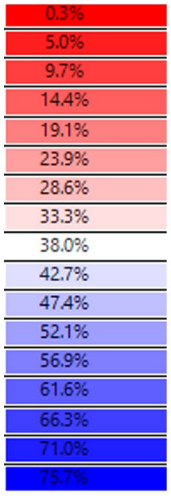
1| utilization

cross - section
shell 1 6cm, shell 2 12cm

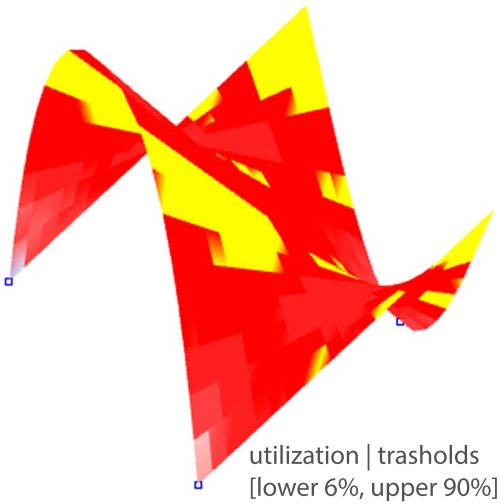


utilization | max values

total mass |
60532.177386

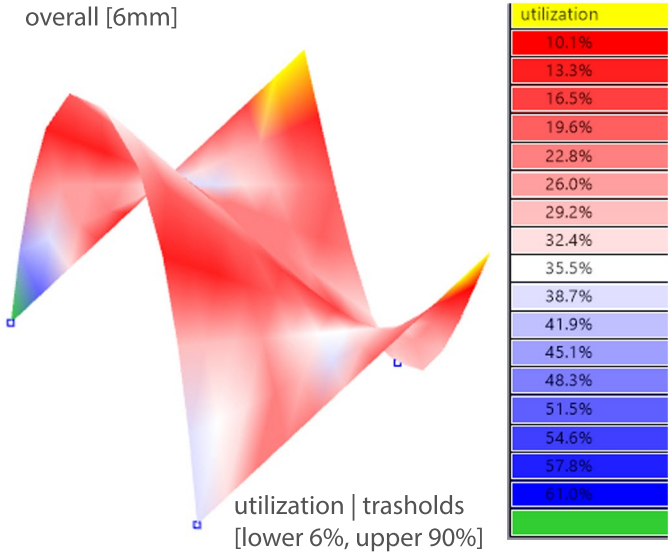


displacement |
0.015397

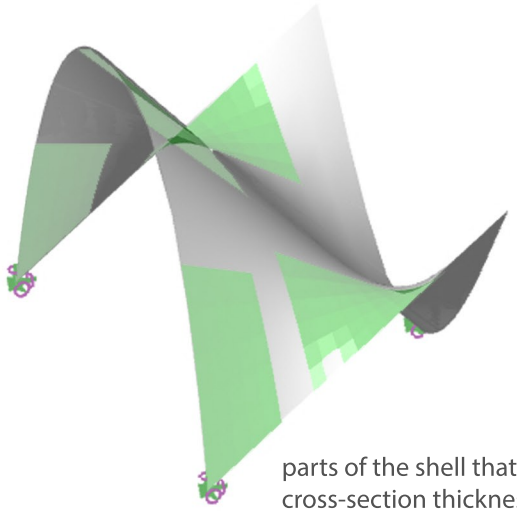


utilization | trasholds
[lower 6%, upper 90%]

shell with sam cross-section
overall [6mm]



utilization | trasholds
[lower 6%, upper 90%]



parts of the shell that have
cross-section thickness 12cm

conclusion |

Taking into account the areas of the shell with the biggest utilization values, cros-section of only those areas where thicken. As a result, forces inside the shell are more evenly distributed, instead of having two main support points bearing the major part of the loads inside the shell.

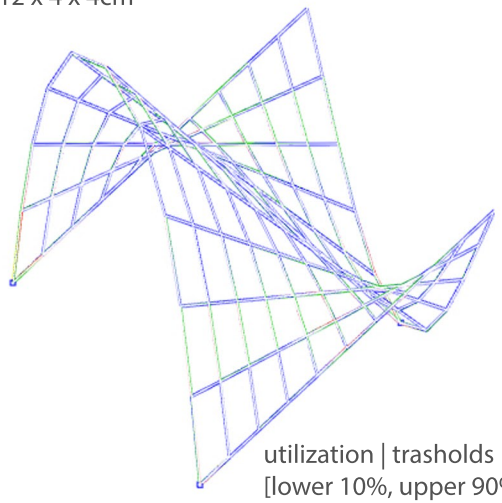
adding beams | C

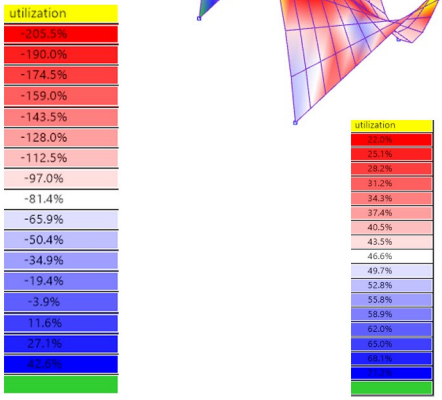
1| bending moments and utilization - full grid beams

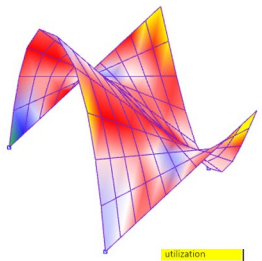
cross - section
12 x 4 x 4cm

total mass |
27012.14417

displacement |
0.014812







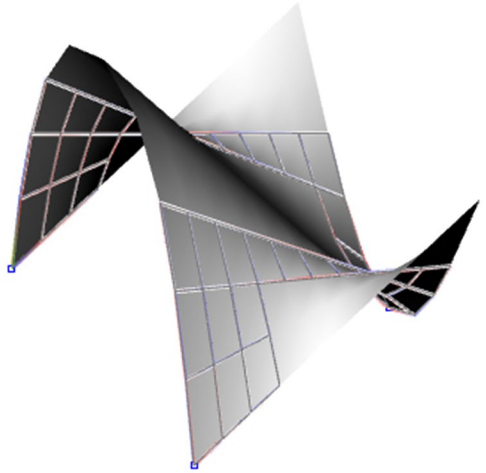
utilization | trasholds
[lower 10%, upper 90%]

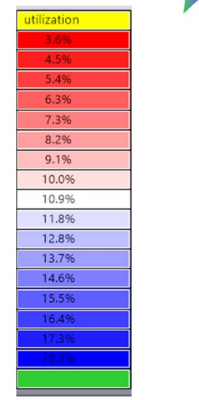
1| bending moments and utilization - part of grid as beams

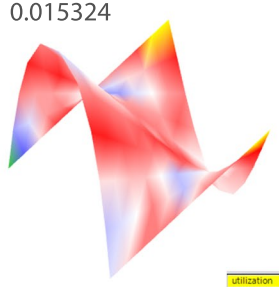
cross - section
12 x 4 x 4cm

total mass |
26089.86796

displacement |
0.015324





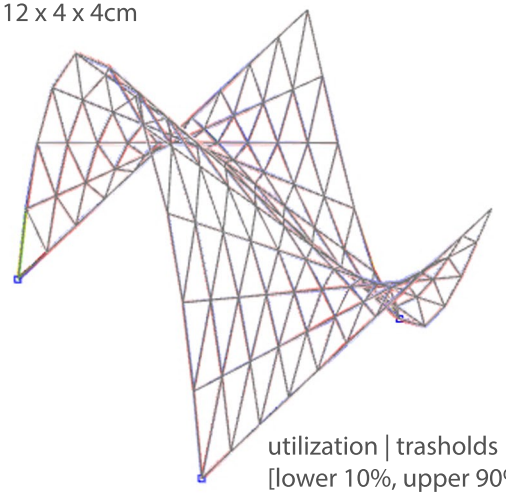


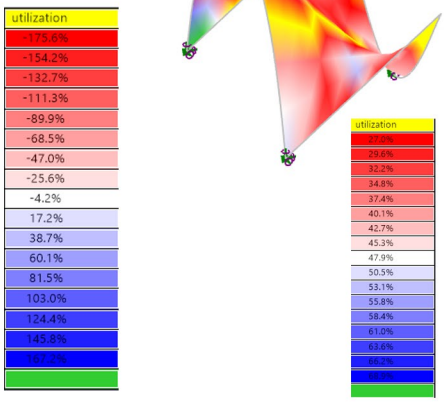
1| bending moments and utilization - full grid beams

cross - section
12 x 4 x 4cm

total mass |
27984.559109

displacement |
0.021479





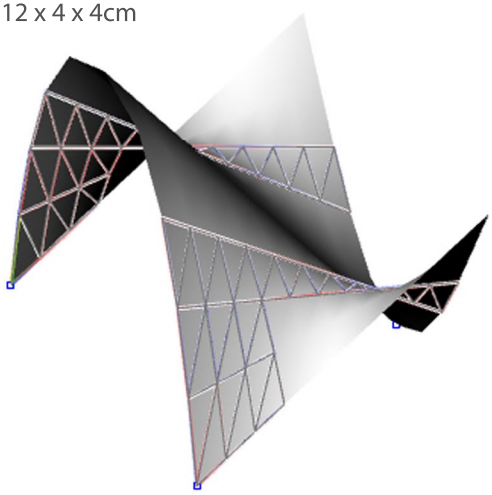
utilization | trasholds
[lower 10%, upper 90%]

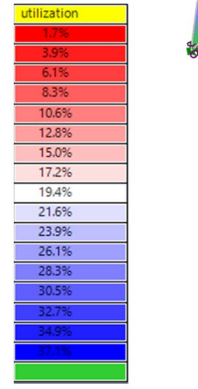
1| bending moments and utilization - part of grid as beams

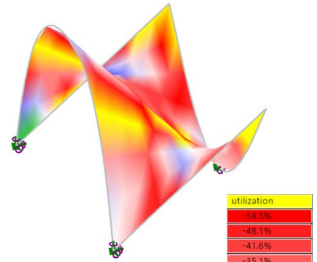
cross - section
12 x 4 x 4cm

total mass |
26395.553917

displacement |
0.022338



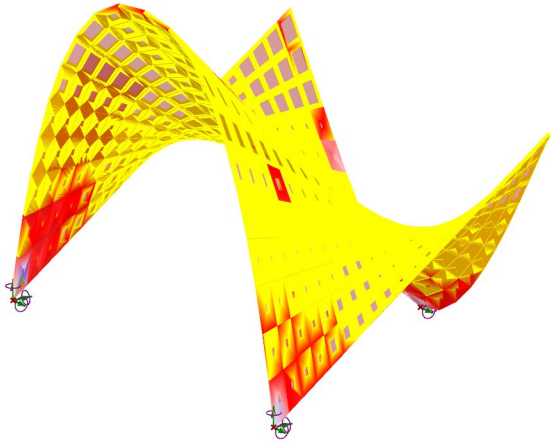




adding openings| D

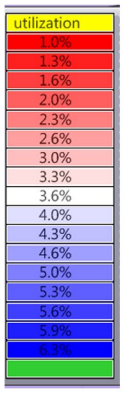
Openings biger in regions with less values of utilization and stresses.

cross - section
Shell A : 4cm
Shell B : 4cm
Shell C : 4cm

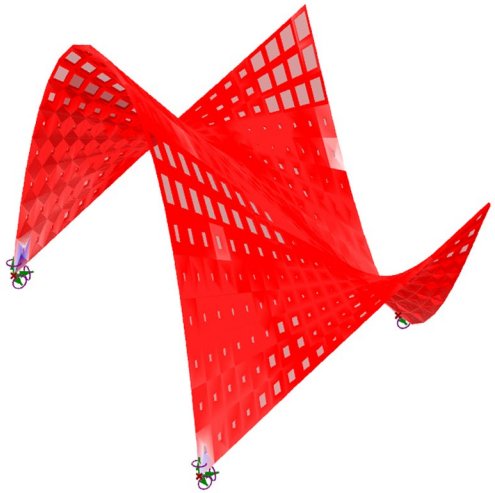


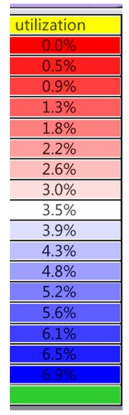
total mass |
133396.442165

displacement |
0.001255

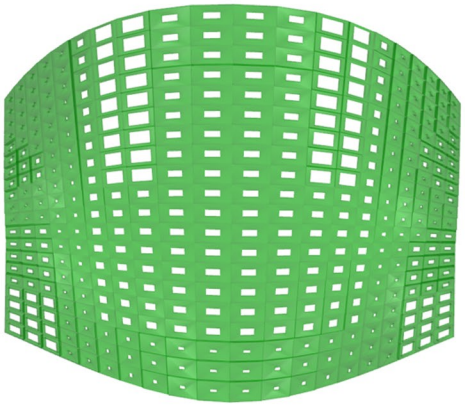


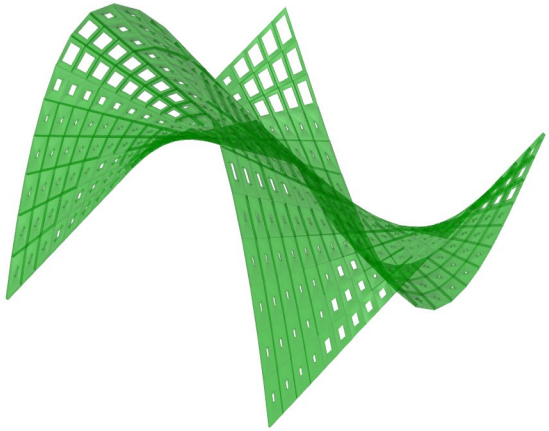
utilization | trasholds
[lower 10%, upper 90%]





utilization maximum
[lower 0%, upper 100%]





Conclusion|

Shells with openings will result first in less total mass. Yet these openings should be bigger in regions with less values of stresses and utilization. Openings are absent where material is working the hardest: at the support nodes and at the regions where curvature changes direction. If openings were the same in all the shell, then displacement would have been bigger.