

螺旋折りを利用した折りたたみ容器の性能評価

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折り紙構造



高剛性



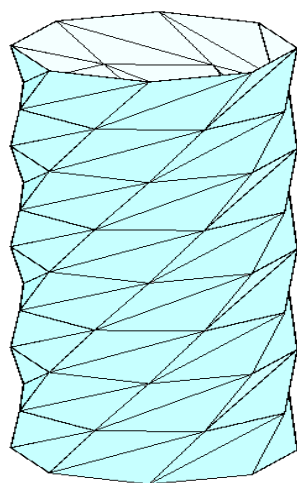
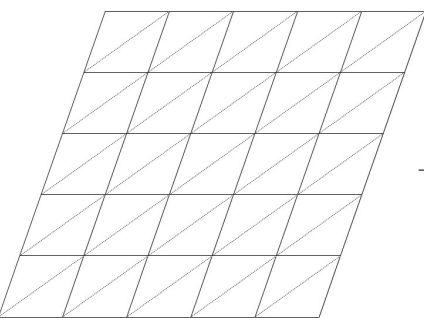
バネ性能

折りたたみ性能

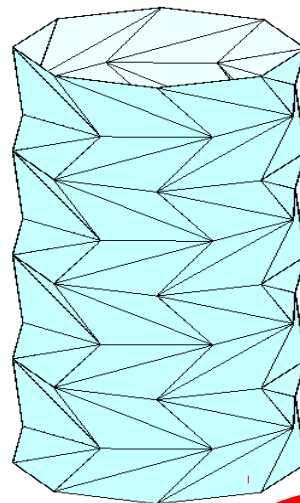
折りたたみ容器



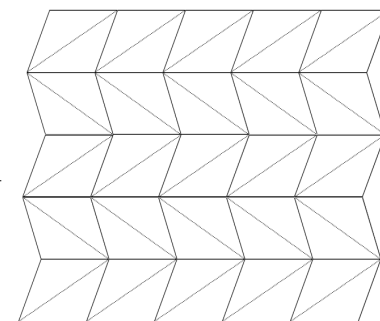
シロ産業:貯水タンク



回転螺旋折り円筒



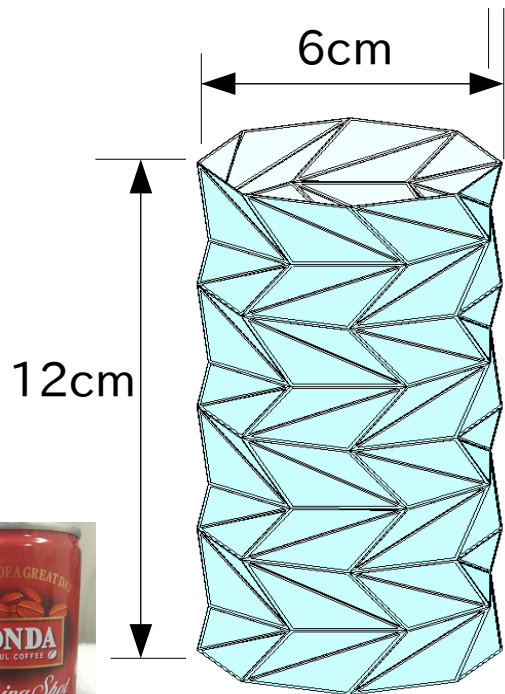
反転螺旋折り円筒



折り目パターンが
折りたたみ性能に影響するか

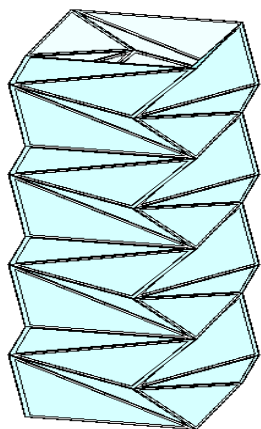
解析モデル

厚さ0.2mm

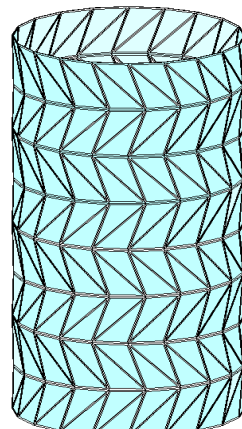


・周方向パターン数

4~20



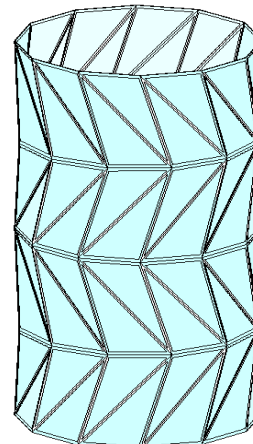
4



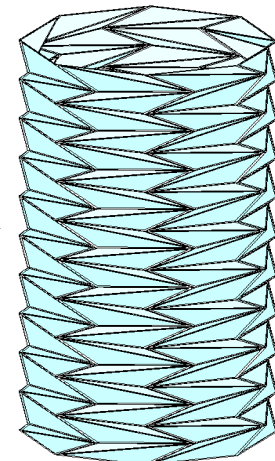
20

・高さ方向パターン

4~20



4



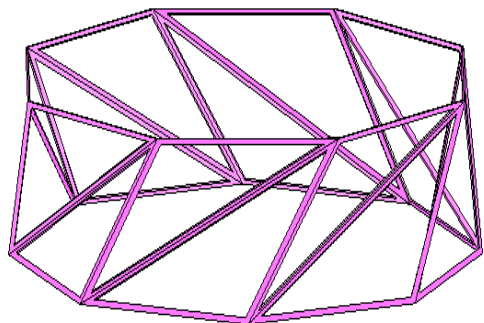
20

ヤング率=69GPa

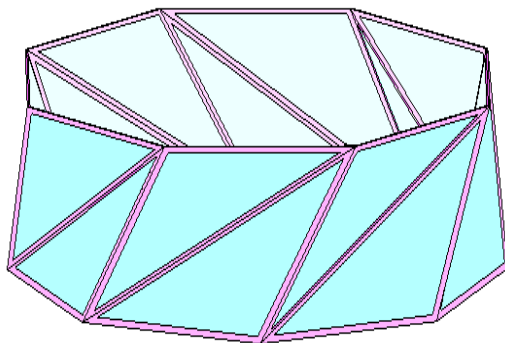
$\frac{1}{10000}$

ヤング率=6.9MPa

折り目部分に柔らかい部材(ゴム)を挟む



折り目(ゴム)部分



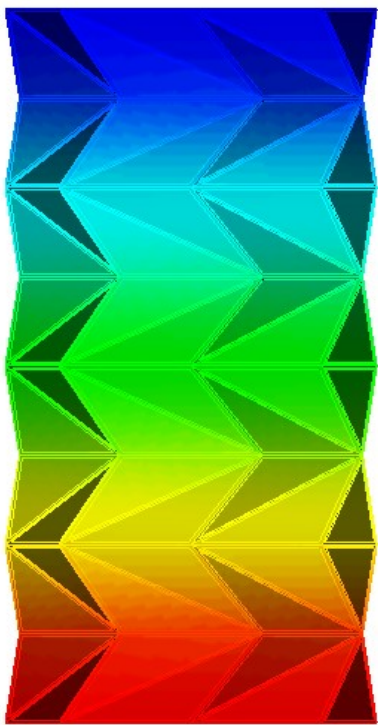
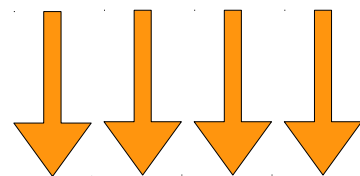
アルミ部分

解析方法

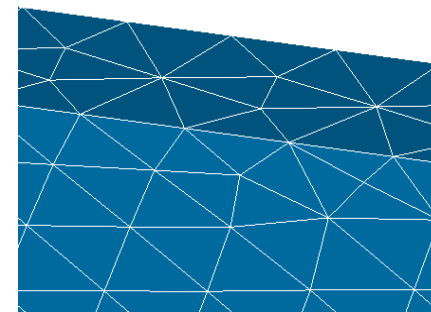
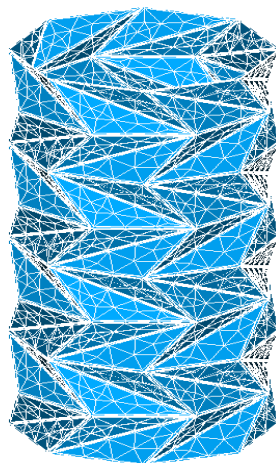
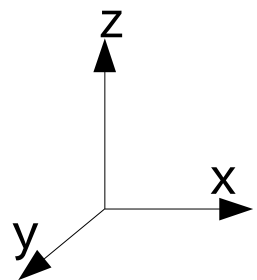
有限要素解析 Salome-meca

载荷・拘束条件

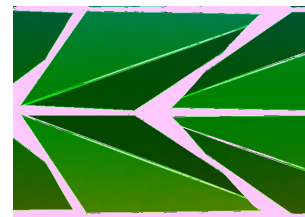
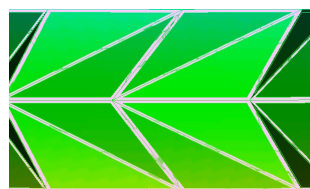
上端開口部
x,y方向拘束



下端開口部
全方向拘束



四面体で分割

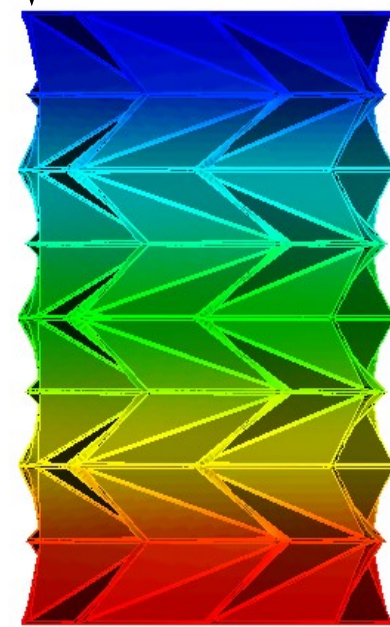


折り目が伸びる

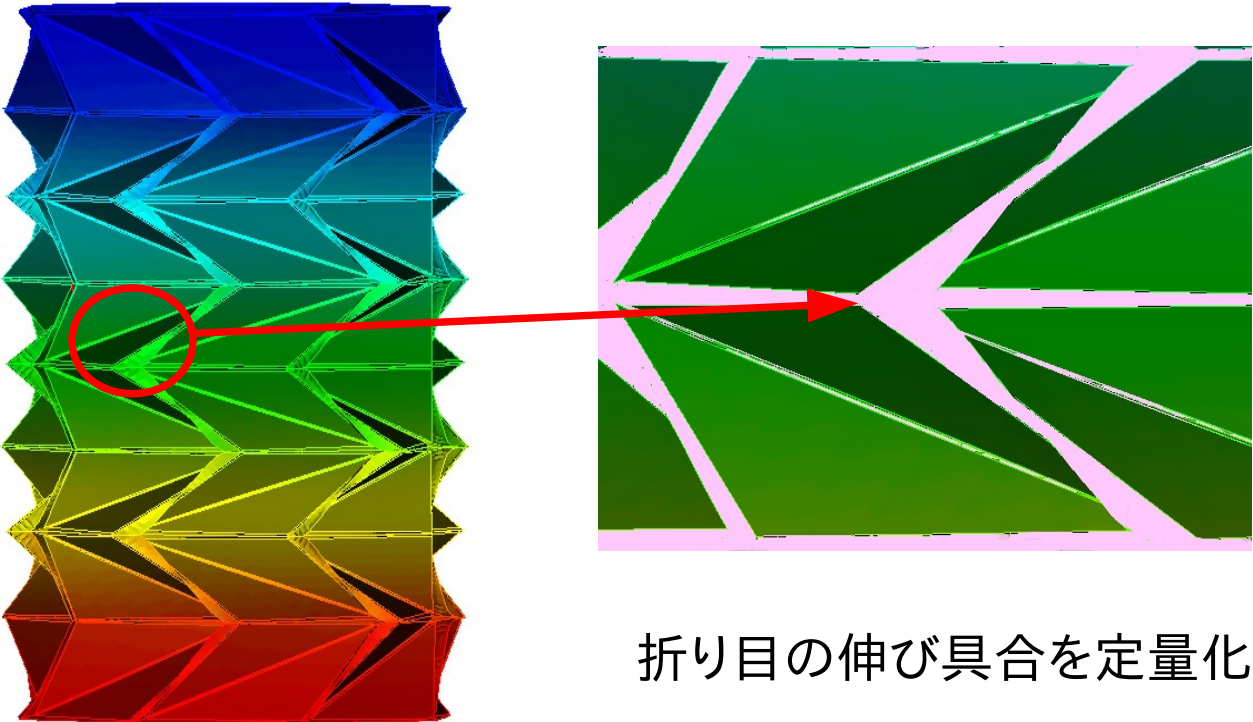


折りたたみにくさ

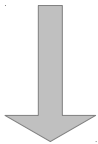
10%



折りたたみにくさの評価方法



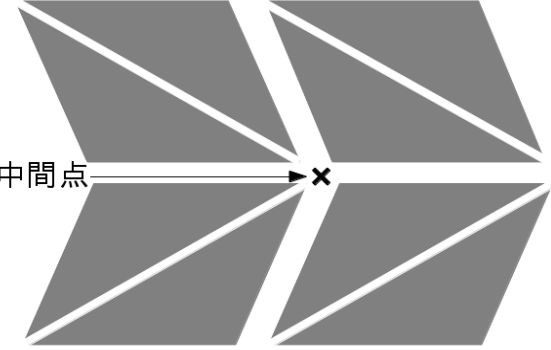
折り目の伸び具合を定量化



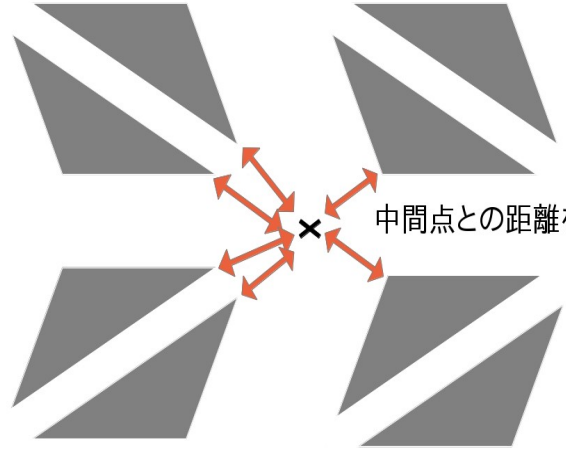
$$\text{伸び率} = \frac{\text{中間点の距離の全体平均[mm]}}{\text{半径[mm]}}$$

折りたたみにくさ

変形前



変形後



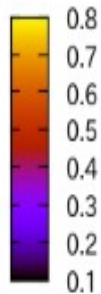
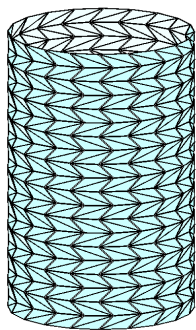
結果

アルミ
(69GPa)

折りたたみにくい

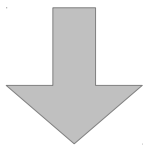
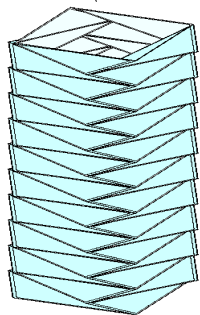
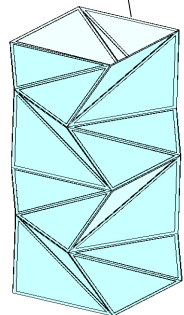
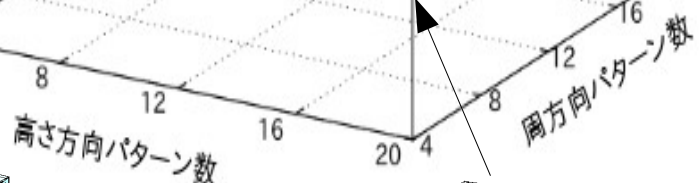
伸び率

0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1



折りたたみやすい

4

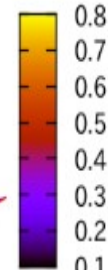
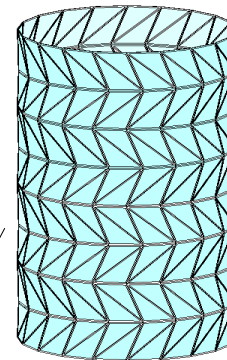


パターン数4の時に大きい値

アルミの10倍
(690GPa)

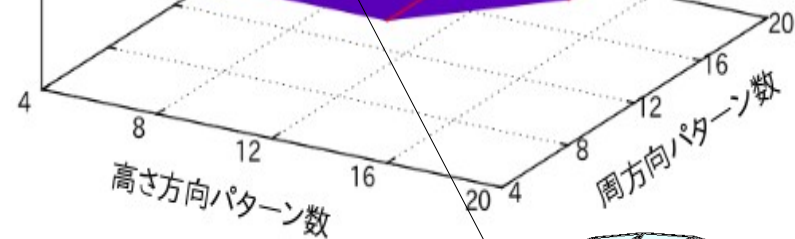
伸び率

小



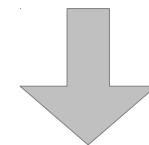
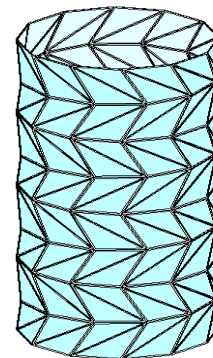
伸び率

0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1



伸び率

大

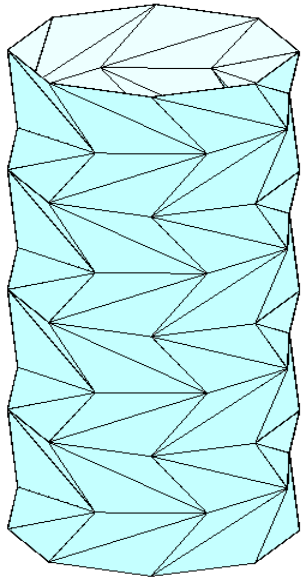


特定のパターン数の時に
伸び率が大きく変化

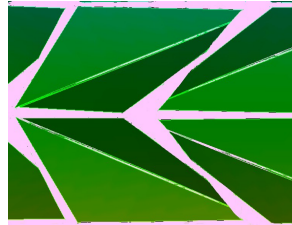
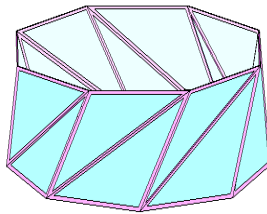
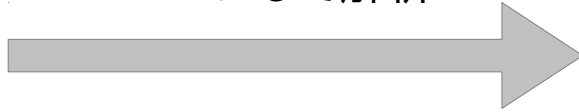
まとめ

折りたたみ性能

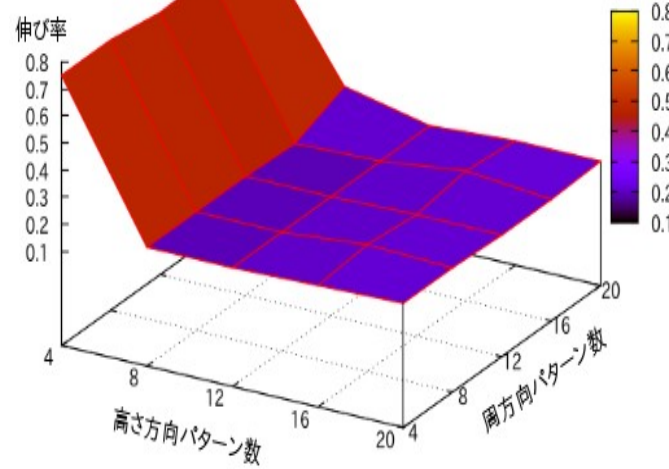
反転螺旋折り円筒



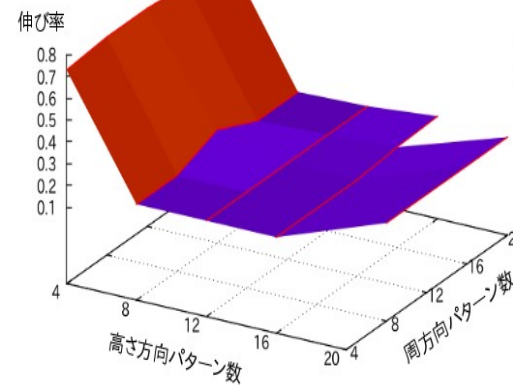
折り目を
ゴムにして解析



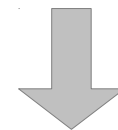
折りたたみやすい範囲が広い



材料を固くして解析

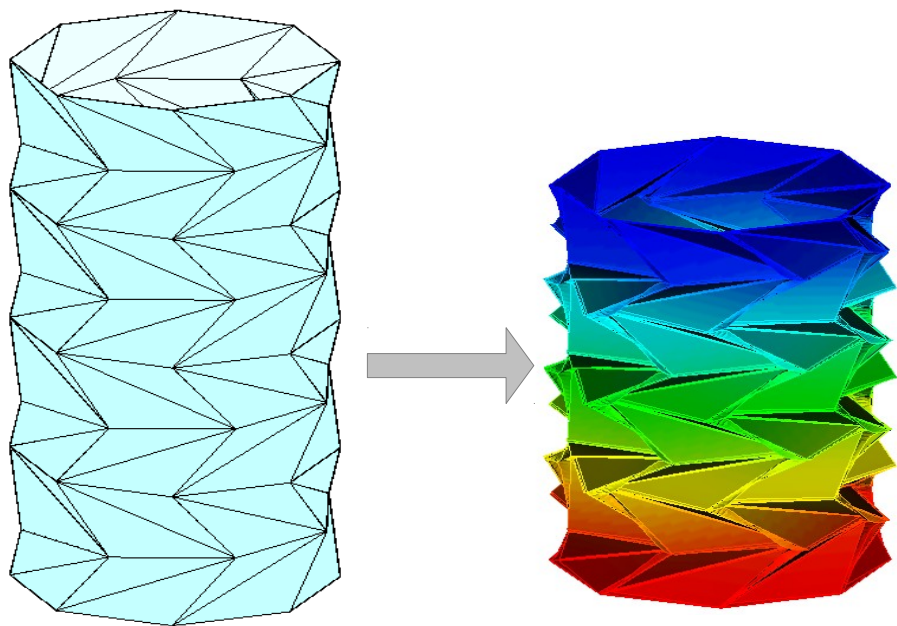


特定のパターンで
折りたたみやすさが変化



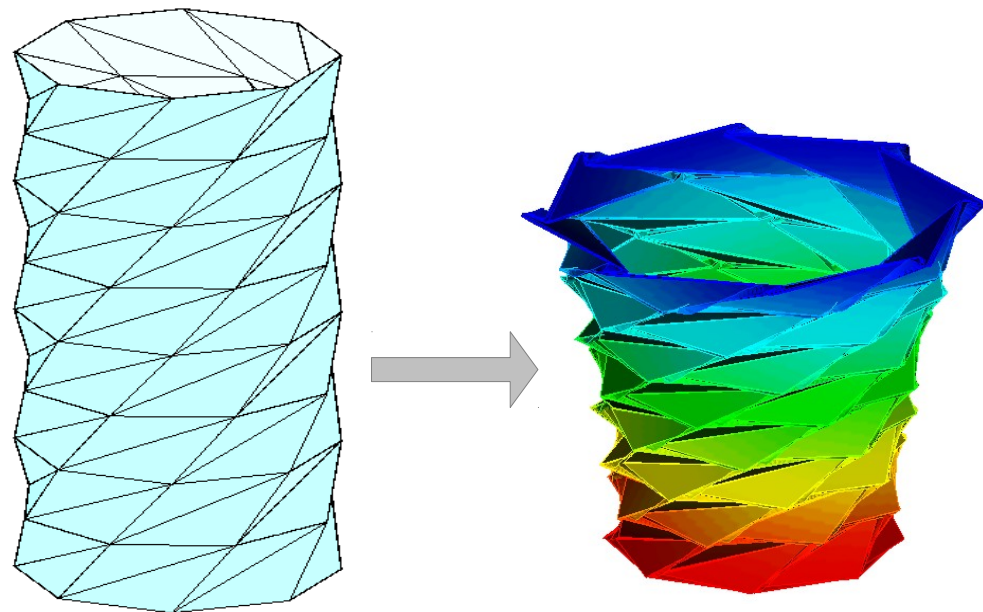
剛性やパターンに依存

反転螺旋折り

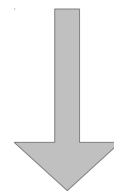


そのまままっすぐ折りたたむことができる

回転螺旋折り



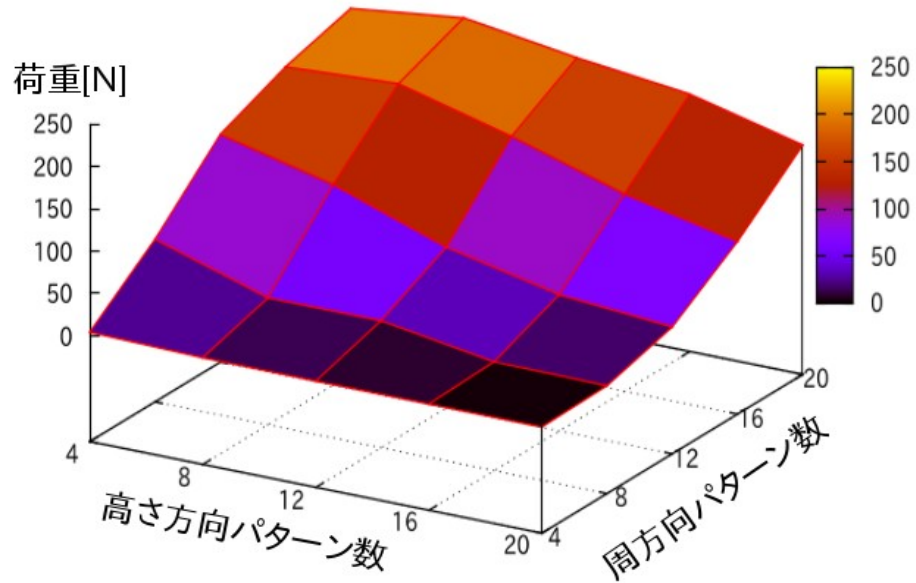
回転しながら折りたたまる



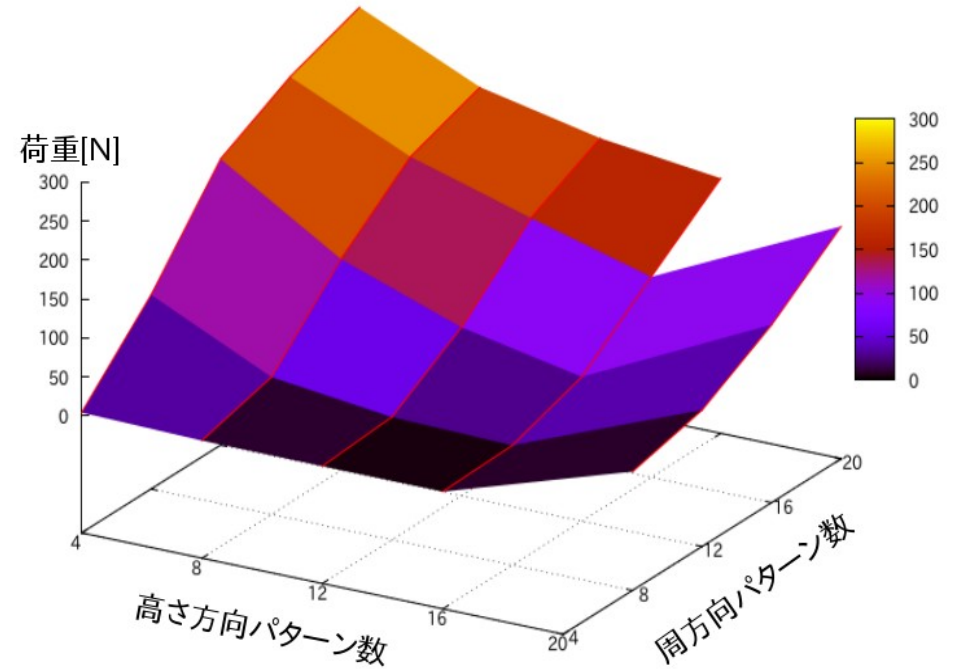
変形が上手くいかない

10%折りたたむのにかかった荷重

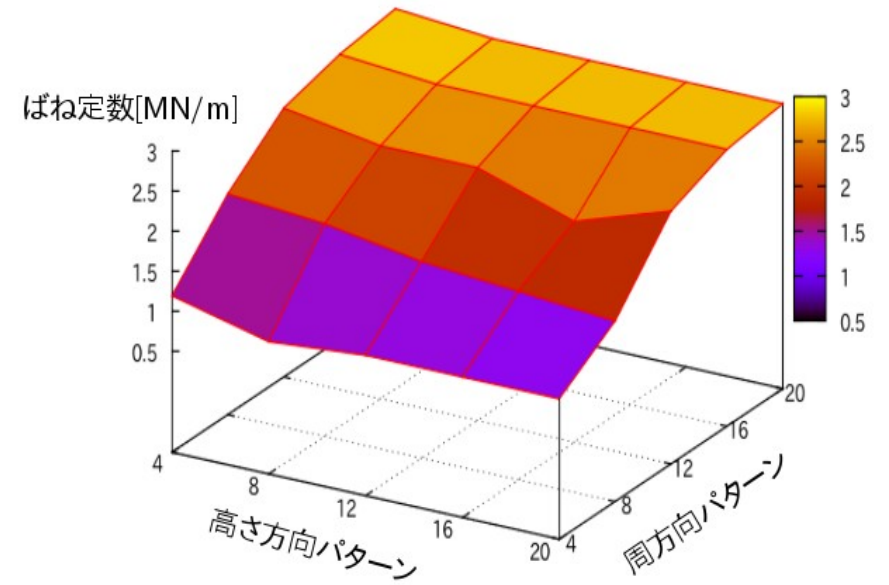
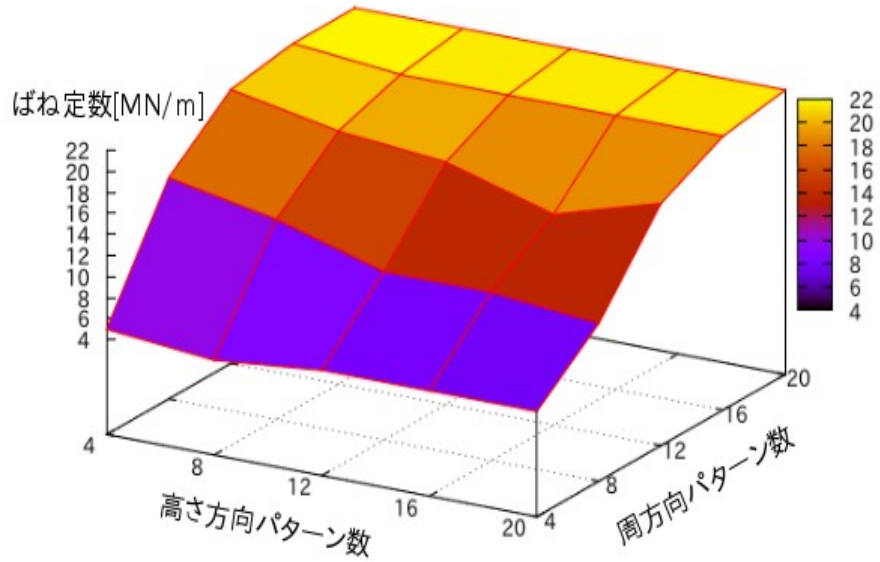
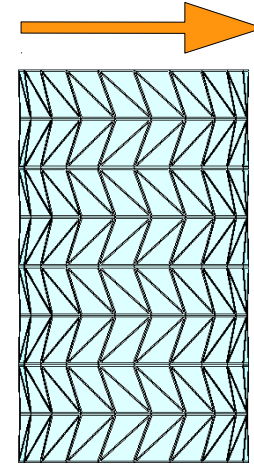
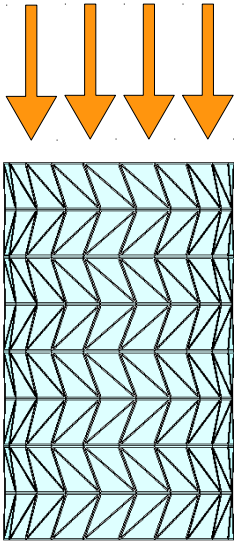
アルミ
(69GPa)



アルミの10倍
(690GPa)

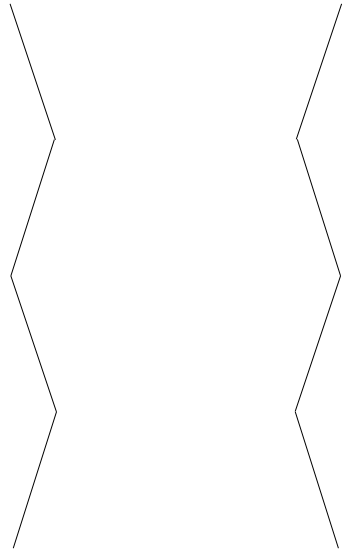
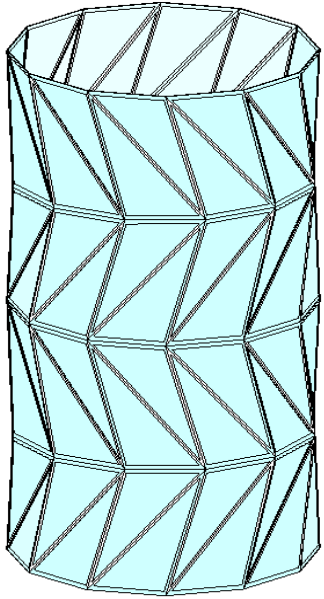


ばね定数

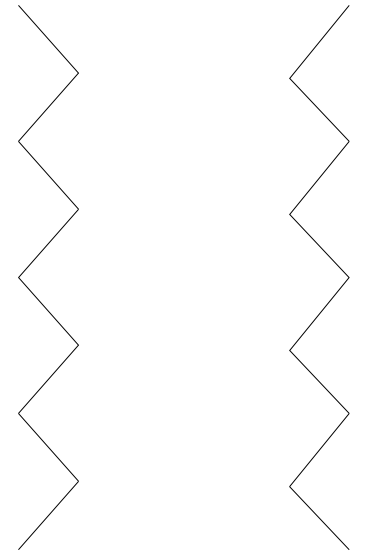
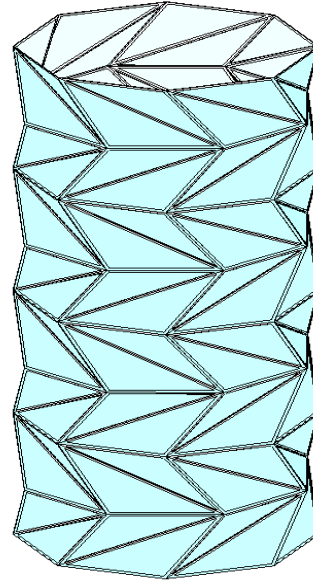


高さ方向パターン数4で 伸び率が大きくなる問題

高さ方向パターン数4



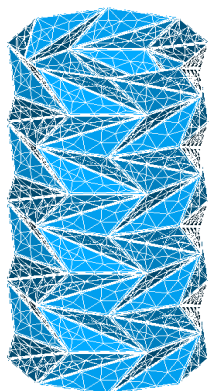
高さ方向パターン数8



初期状態での折りたたみが小さい

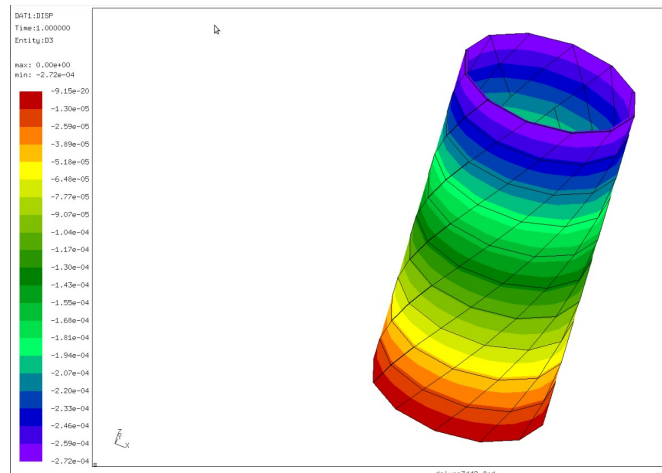
解析ツールの違い

昨年まで



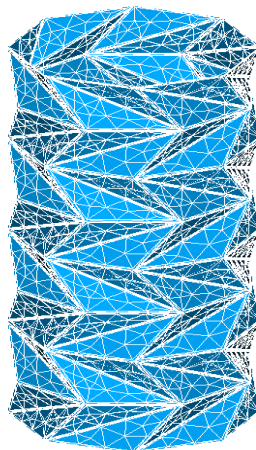
3Dモデリング
Salome-meca

← 別々のソフト →



有限要素解析・結果の表示
Calculix

今年から



3Dモデリング・有限要素解析・結果の表示
Salome-meca

1つのソフトでできる