円筒折り紙構造のパターンと挙動

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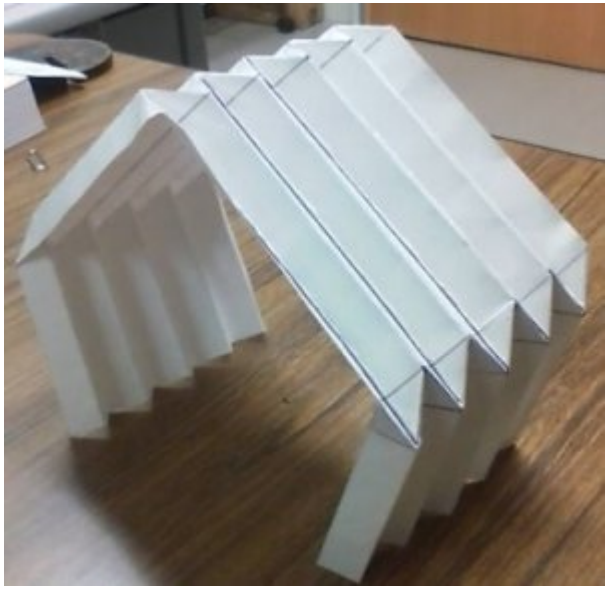
折り紙構造とは…

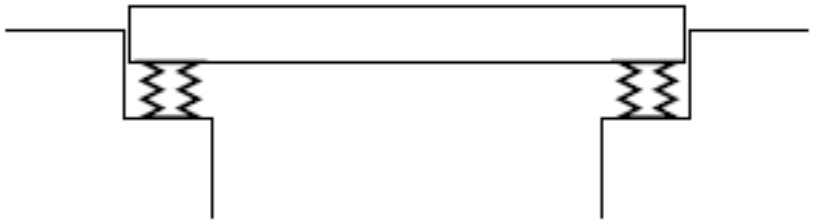
- コンパクト
- 薄くて丈夫

- 宇宙構造物
- 医療
- 自動車 など

} ・研究
・実用

・畳める屋根?





・ゴム支承の代わり?

- ばね性能
- 座屈荷重
- 強度

２つの円筒折り紙構造を解析

オープンソースのFEM解析ツールCalculiXを使用

1.ダイヤカット円筒

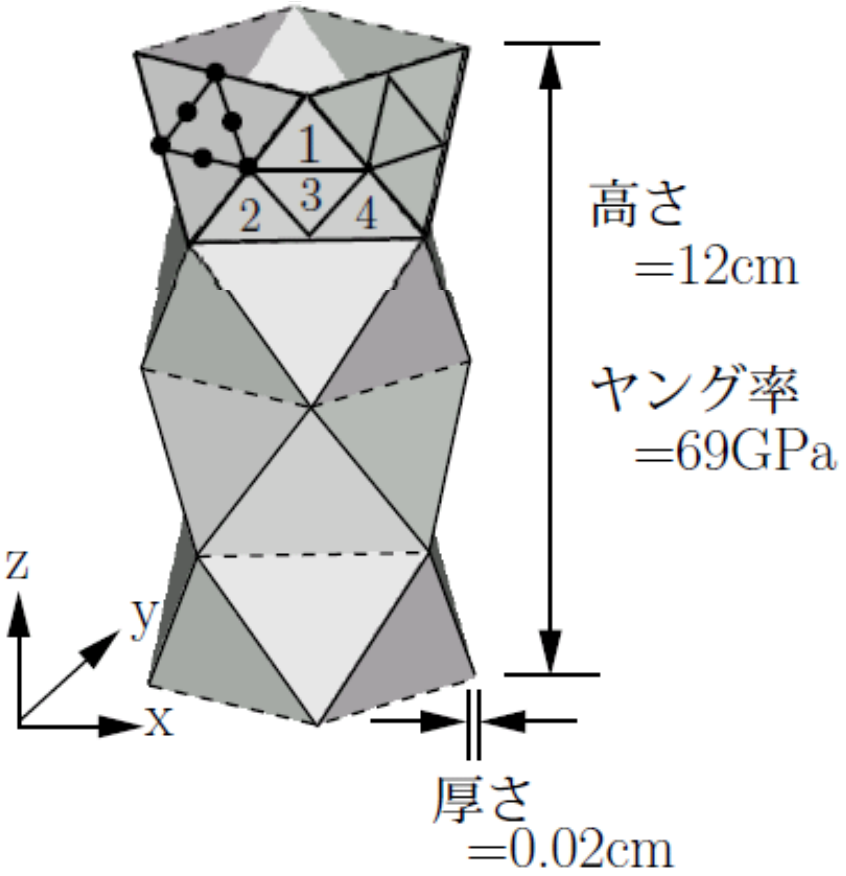
・薄型、高強度化を期待
・アルミ缶飲料の軽量

2.折り畳み円筒

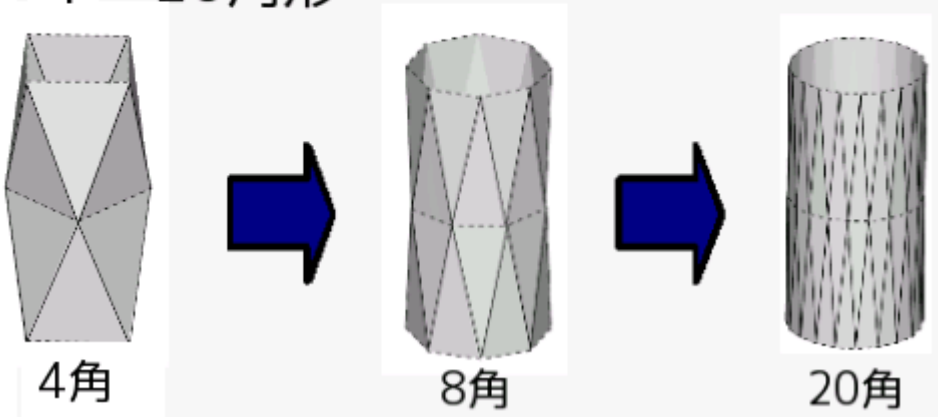
・ばね性能を期待

ダイヤカット円筒の解析

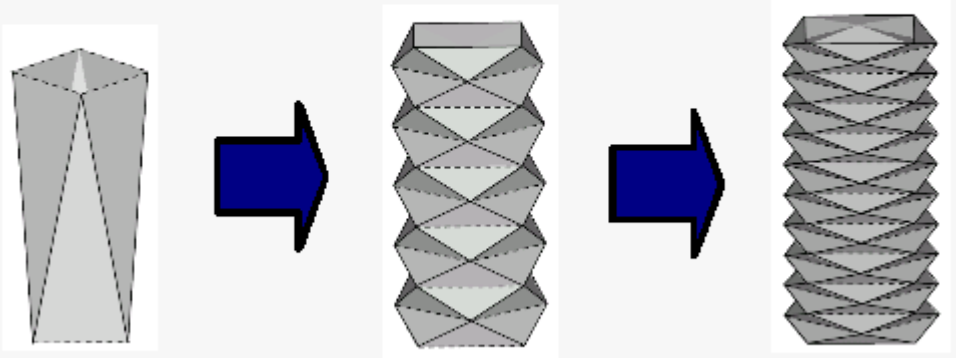
外接円の半径
=3cm



・周方向のパターン数
4～20角形



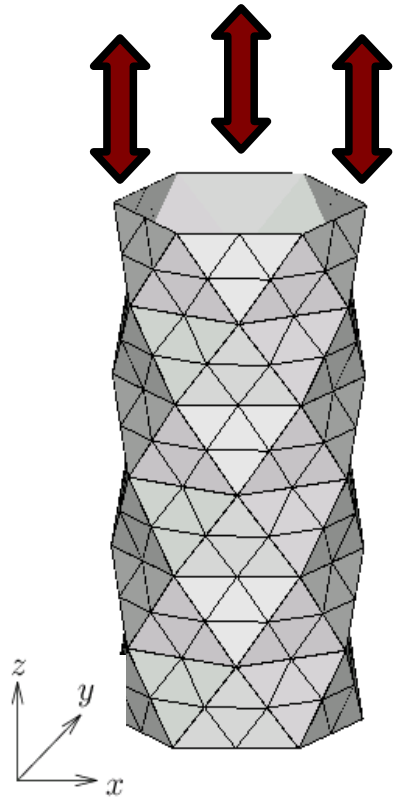
・高さ方向のパターン数
1～20段



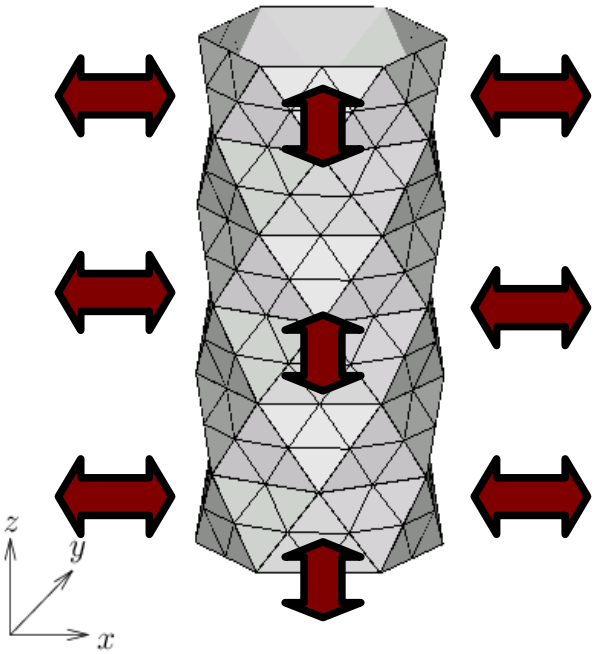
解析手法

載荷条件

上端の各節点に
圧縮、引張力を載荷



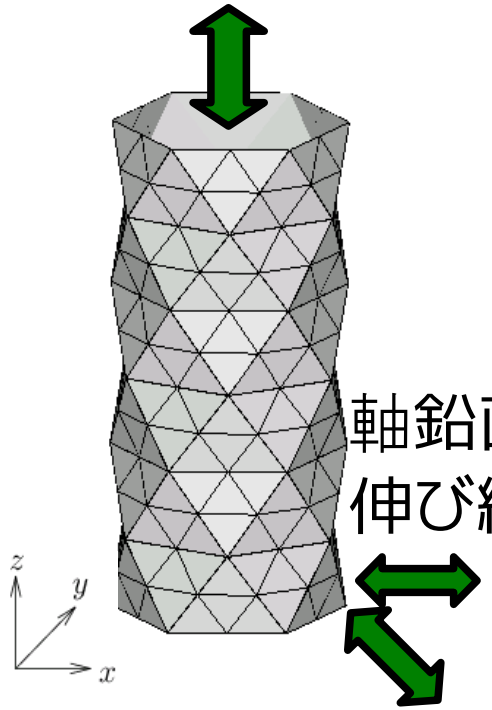
各節点から
中心方向に圧縮、
引張力を載荷



境界条件

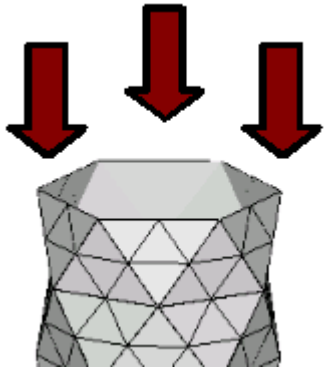
軸方向伸び縮み可能

軸鉛直方向
伸び縮み可能

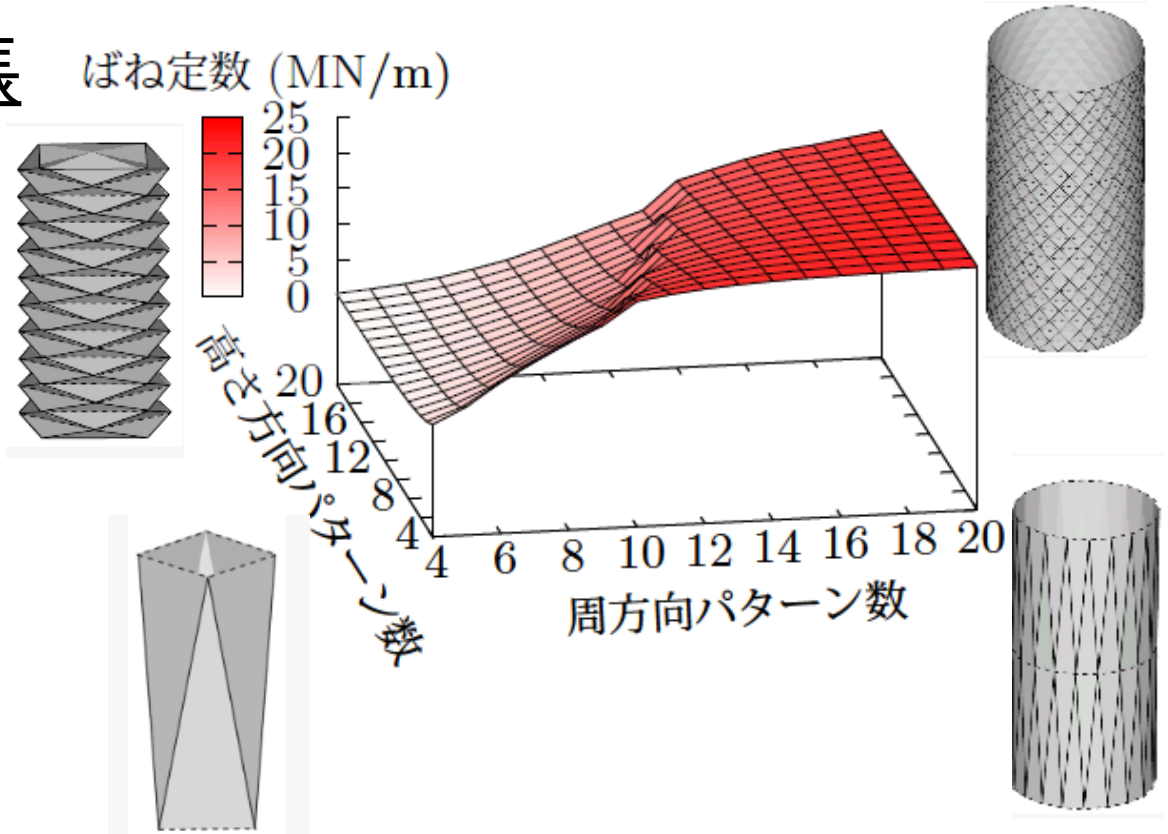


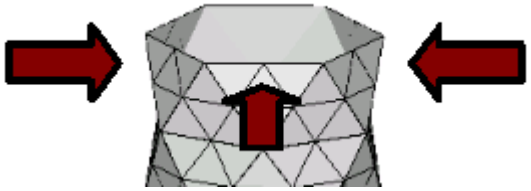
ばね定数

圧縮=引張

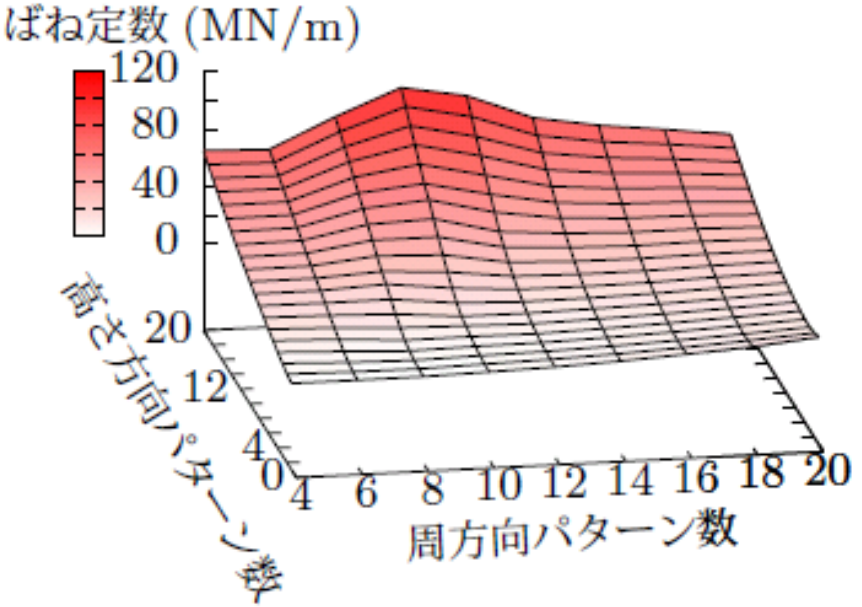


周方向=影響



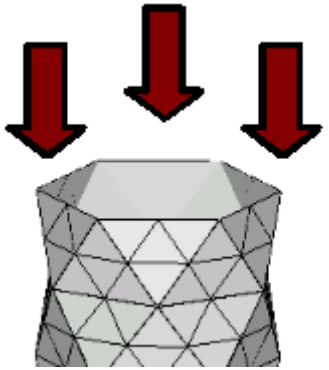


高さ方向=影響



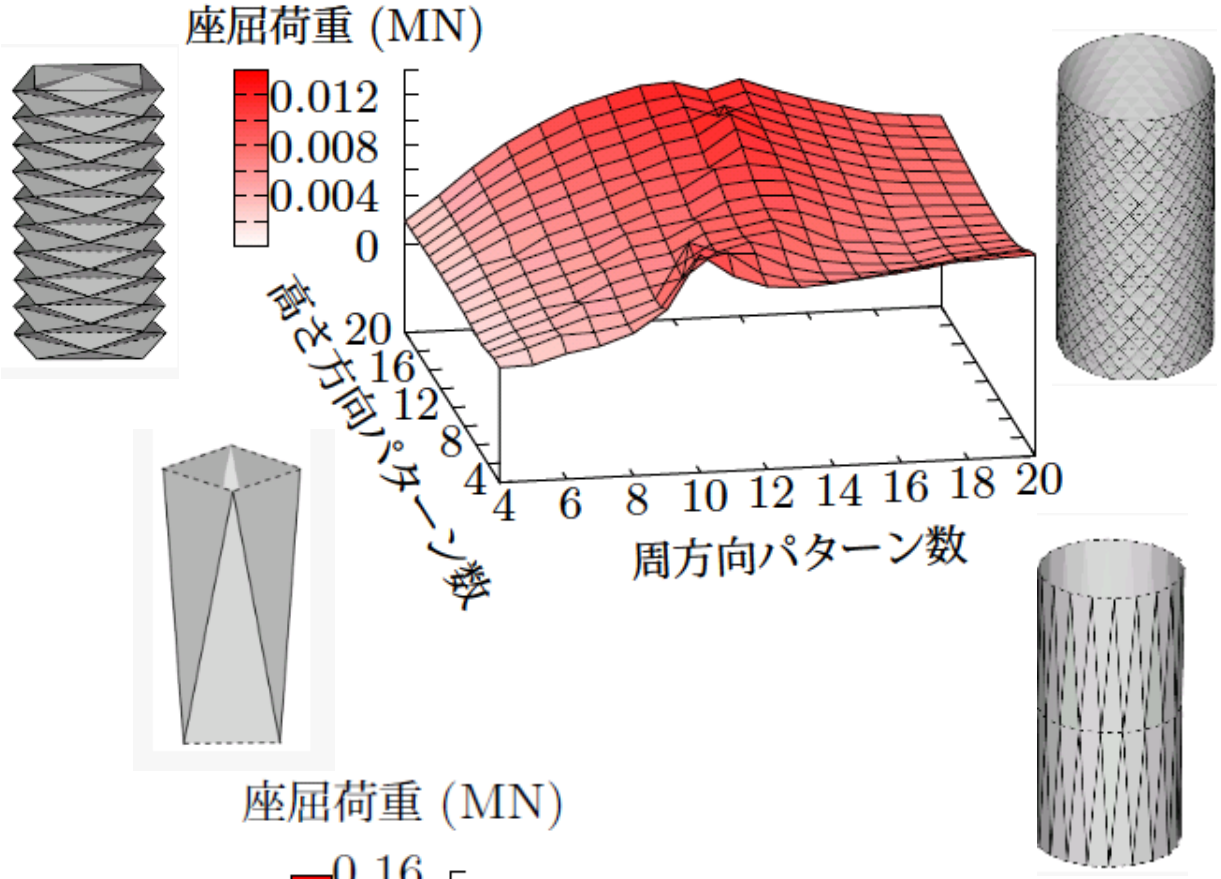
$$\text{ばね定数} = \frac{\text{荷重}}{\text{変位}}\ (\text{MN/m})$$

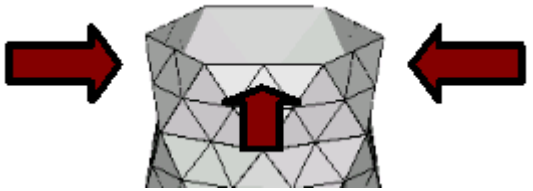
座屈荷重(圧縮)



周方向 → 大

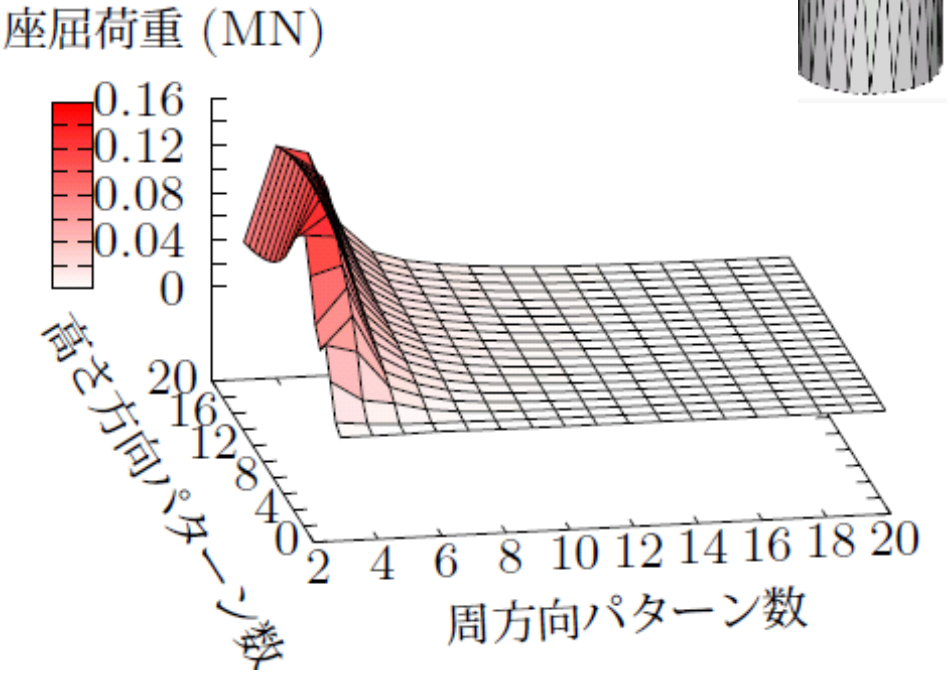
座屈荷重 → 大



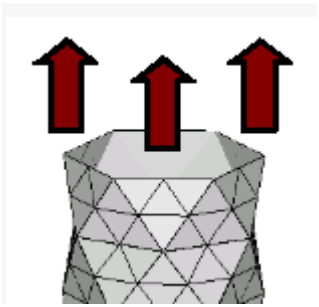


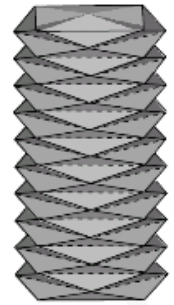
周方向 → 大

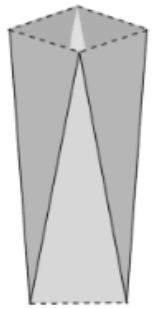
座屈荷重 → 小

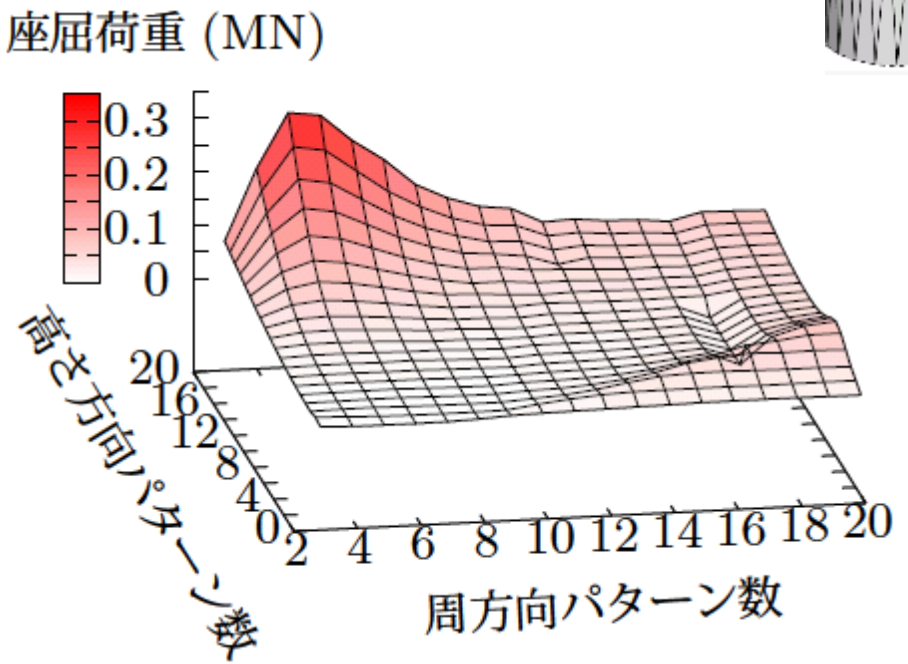


座屈荷重（引張）





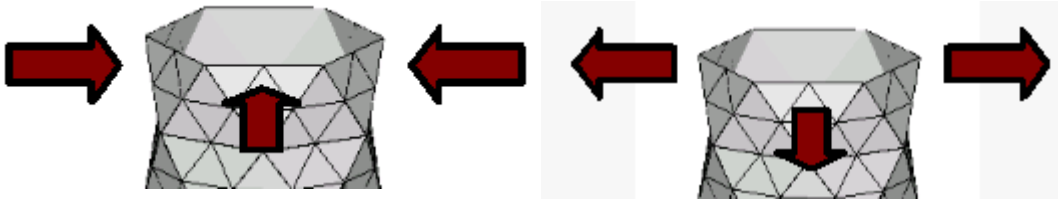


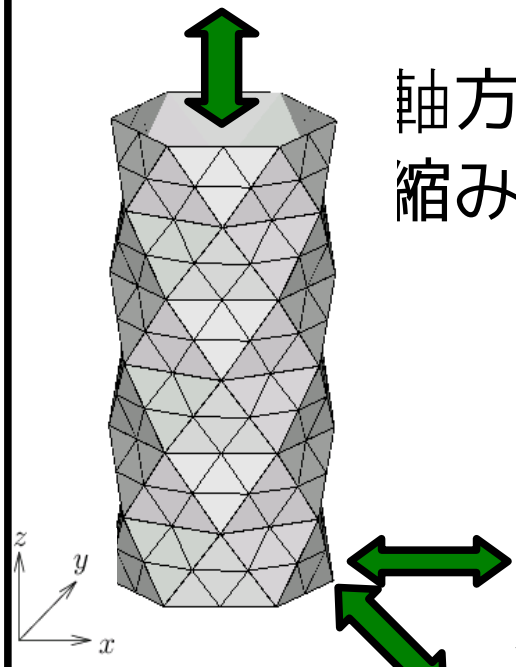


圧縮と似ている

境界条件をかえる

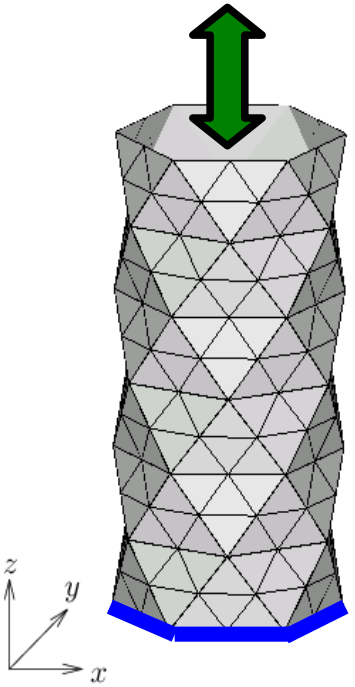
中心方向圧縮載荷、引張載荷において





軸方向伸び縮み可能

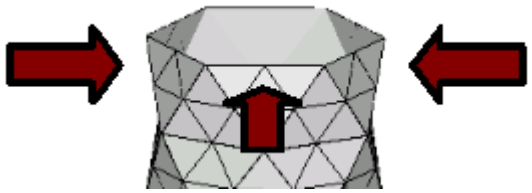
軸鉛直方向伸び縮み可能



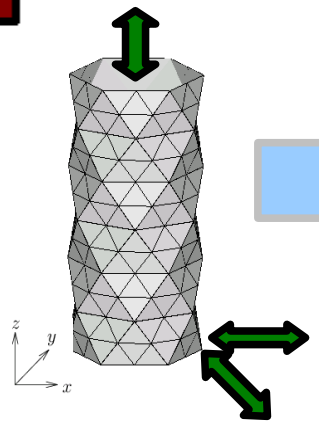
軸方向伸び縮み可能

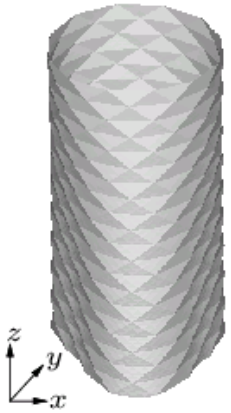
全節点拘束

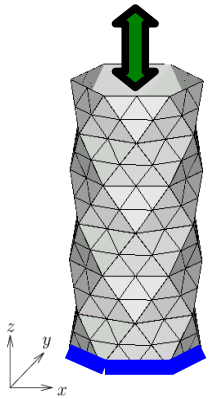
中心方向圧縮載荷

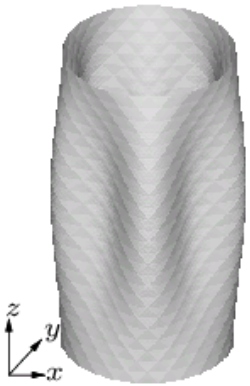


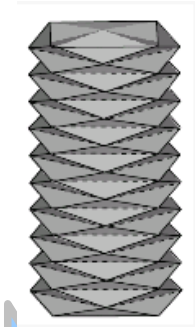
座屈モード

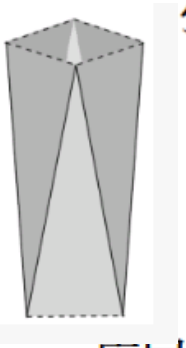


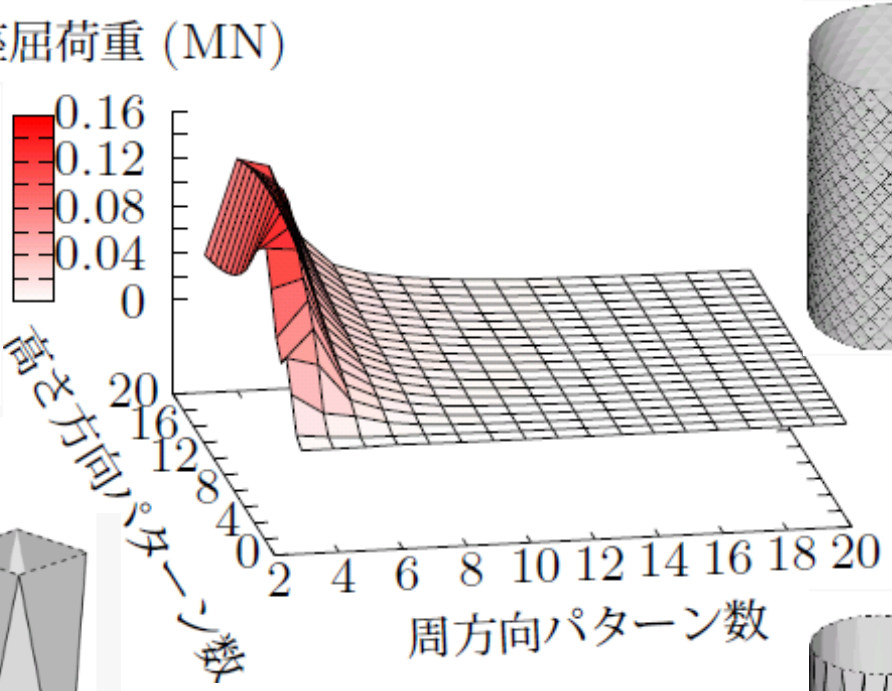


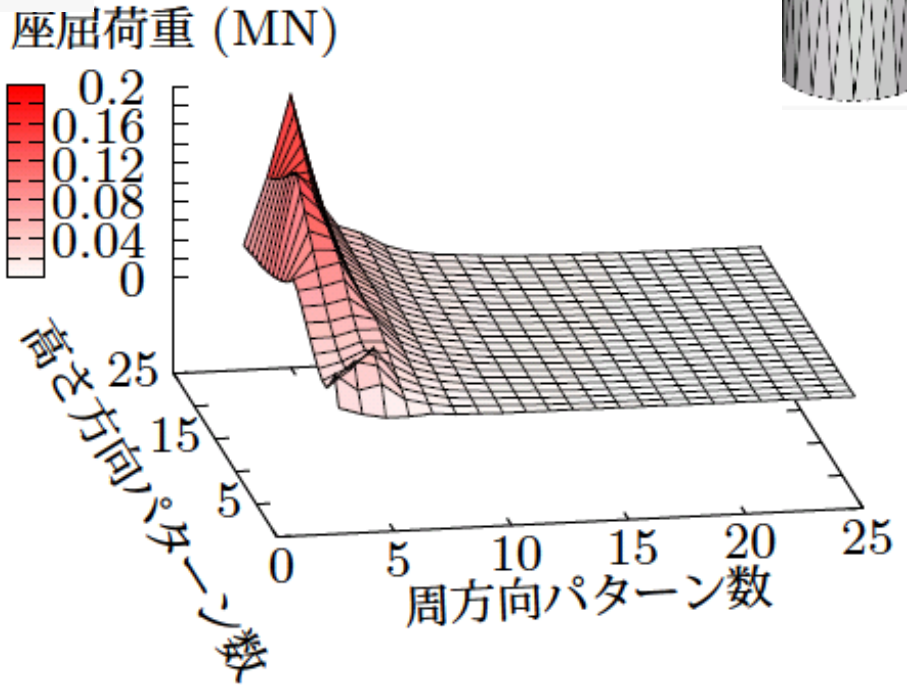




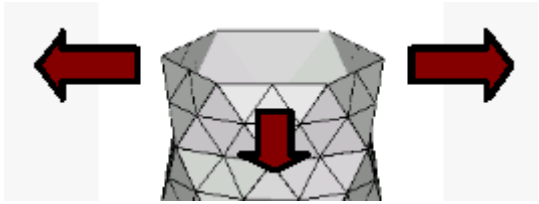








中心方向引張載荷



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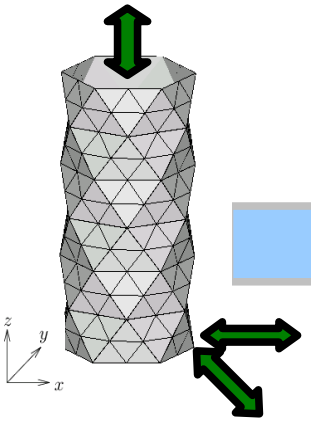
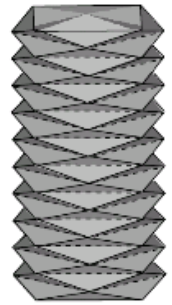
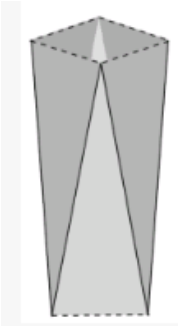
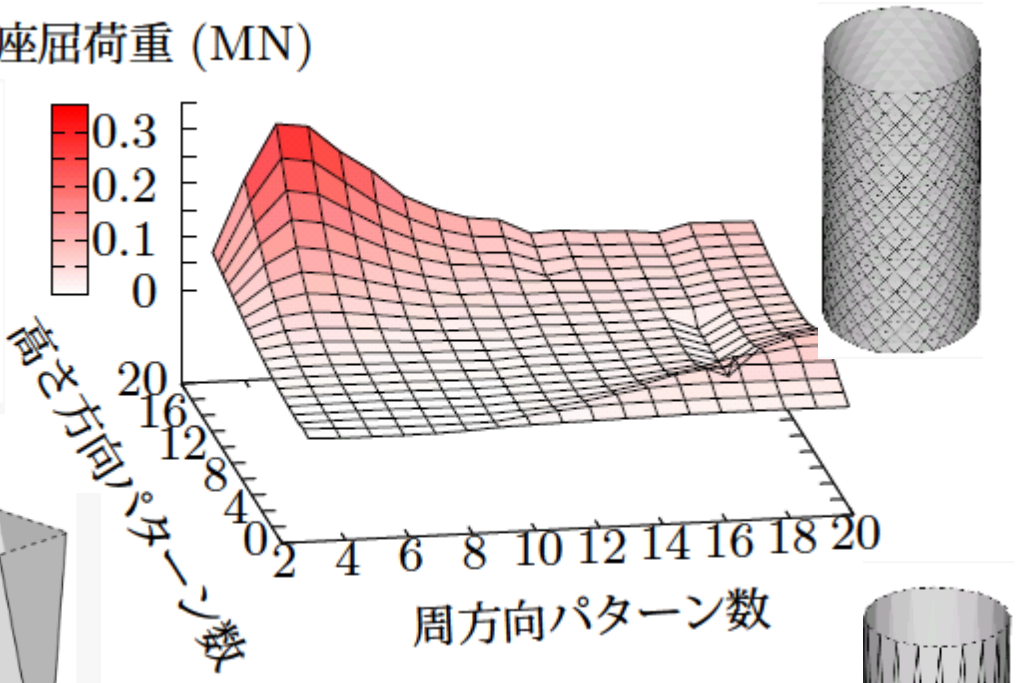
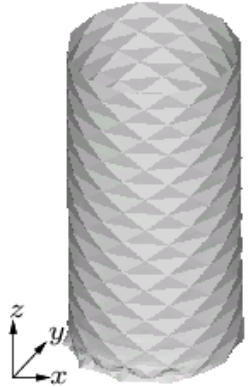
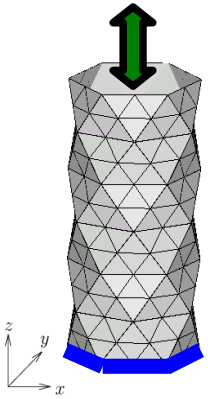


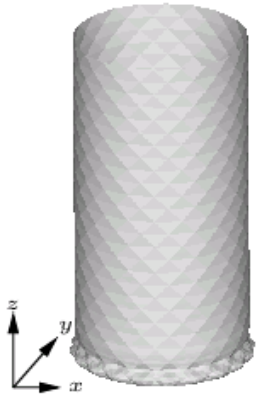


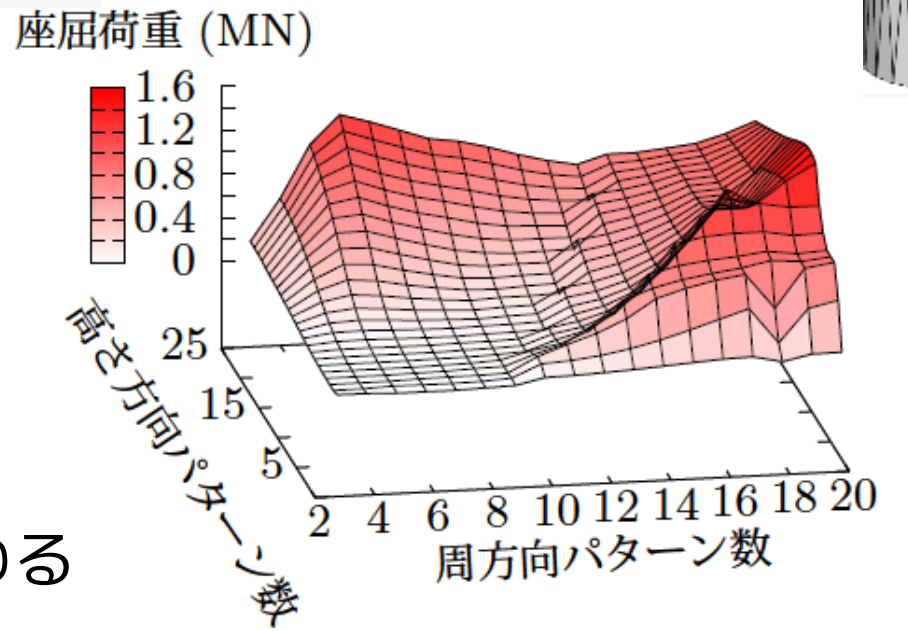












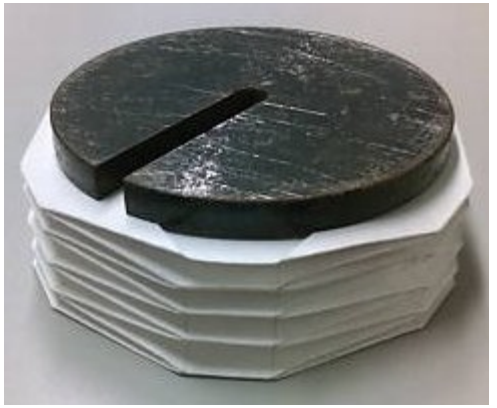
境界条件 → 座屈しやすさ変わる

折り畳み円筒の解析

折り畳み円筒

力を加える

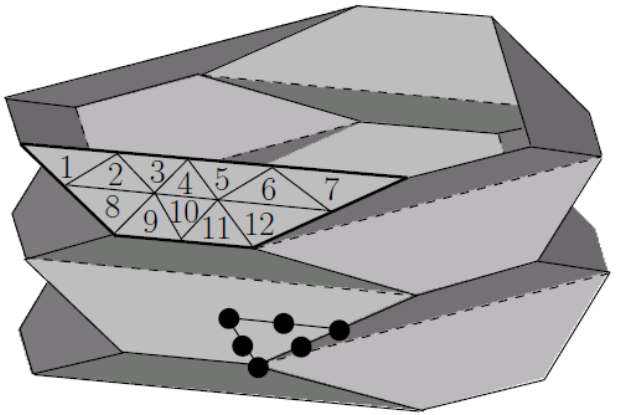
つぶれる!!

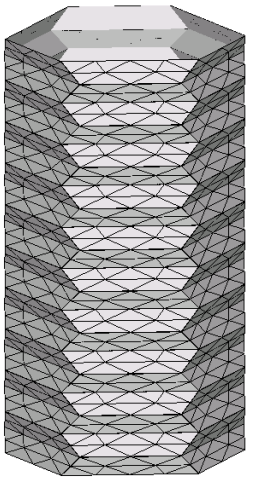


台形の角度を変えると…

解析方法

ダイヤカット円筒
と同じ断面形状

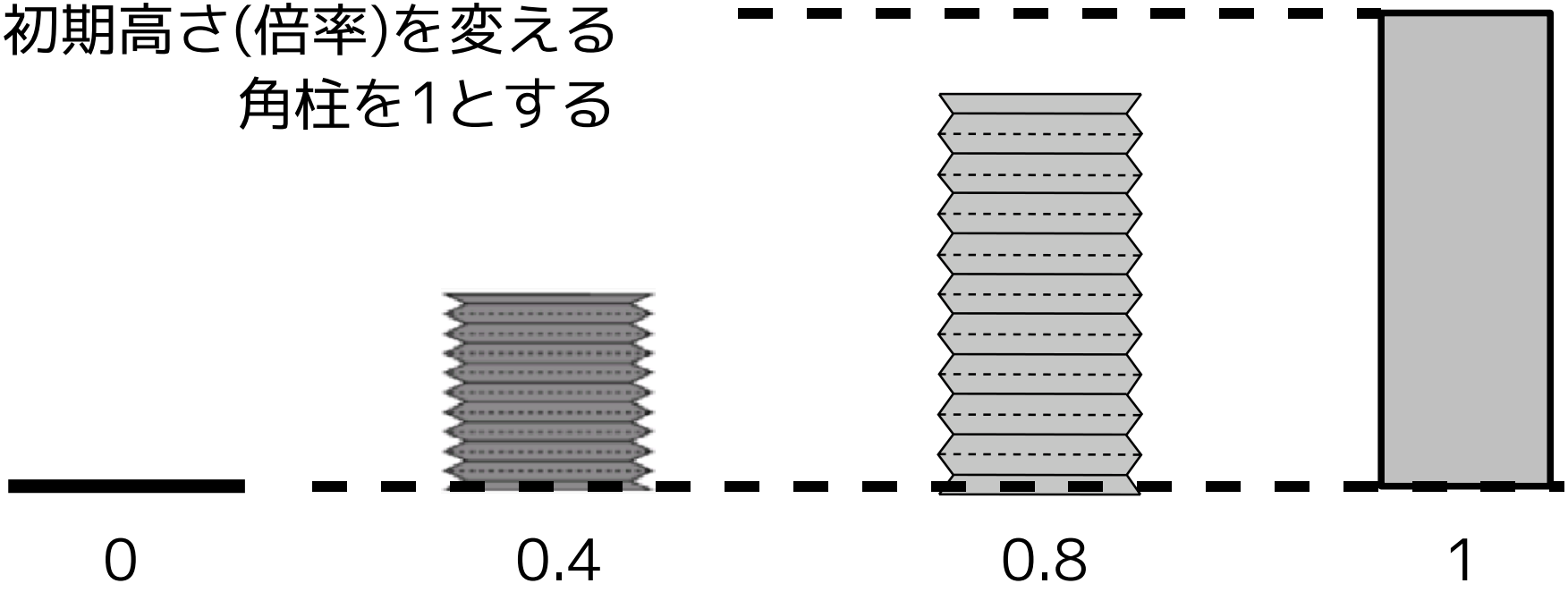




高さ方向パターン数
を20段に固定

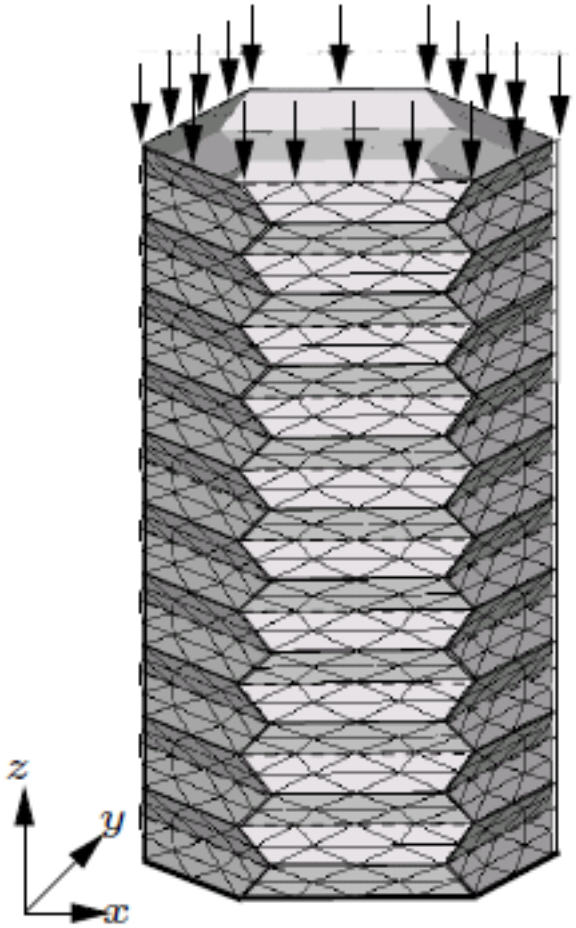
・周方向のパターン数を4～10角形と
増やしていく

・初期高さ(倍率)を変える
角柱を1とする



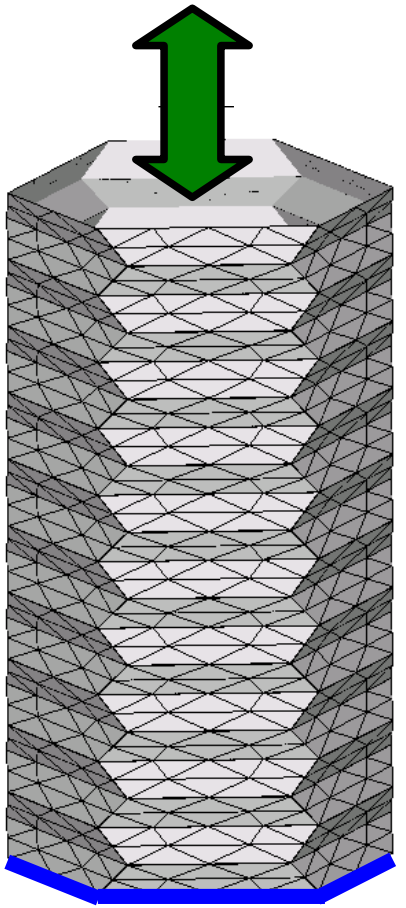
載荷・拘束

載荷方法



各節点に、
圧縮力
引張力

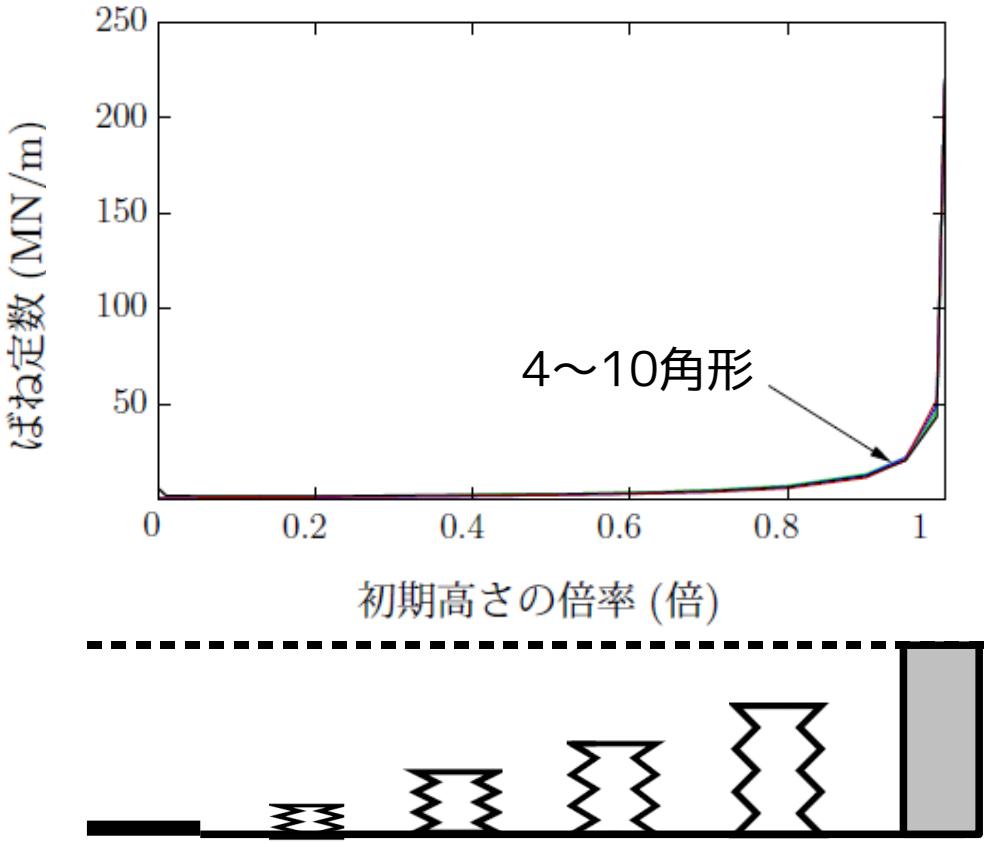
境界条件

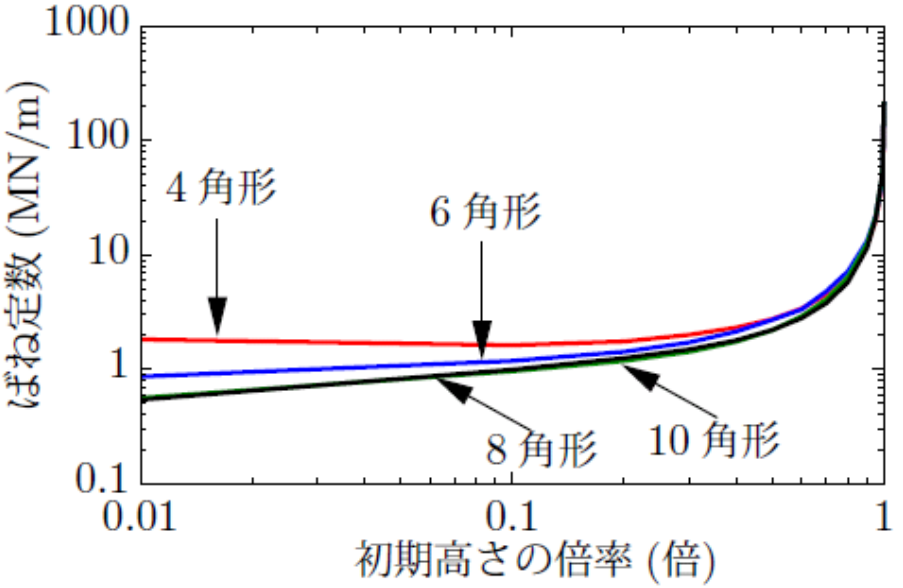


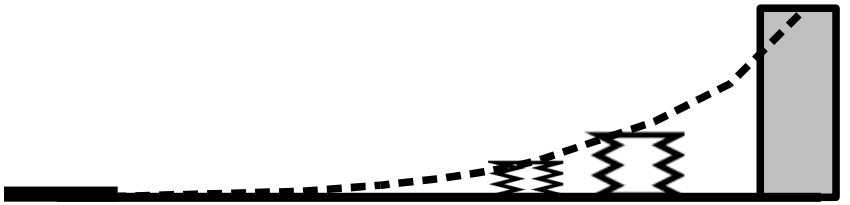
軸方向
伸び縮み可能

全節点拘束

ばね定数



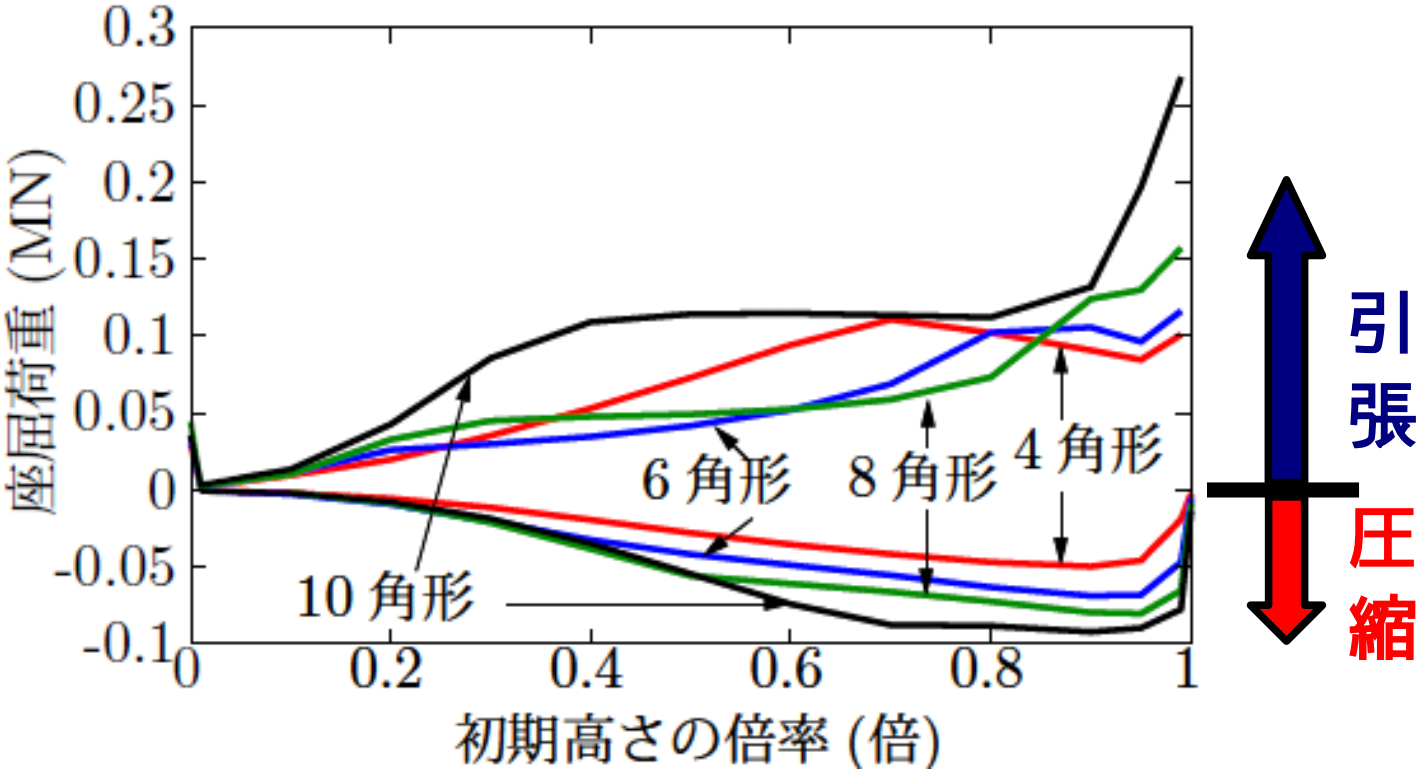


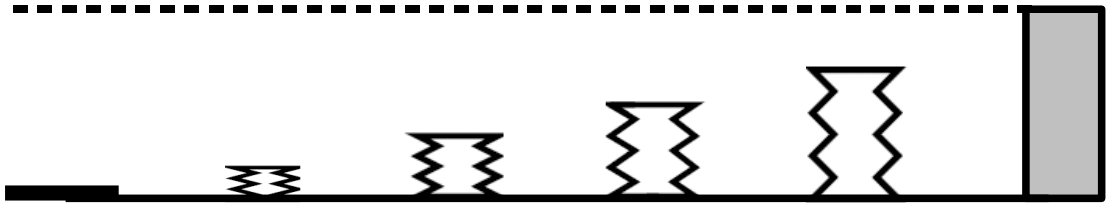


・初期高さ
・周方向パターン数

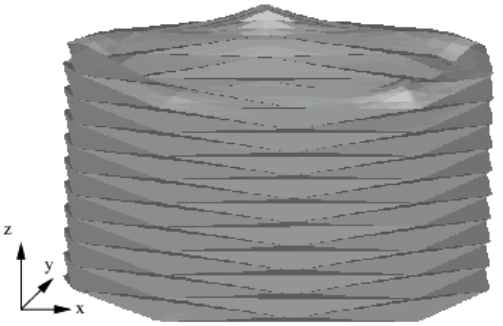
多くなれば → ばね定数 大

座屈荷重を求める

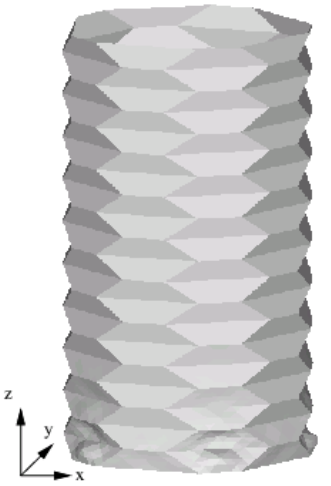




座屈モード

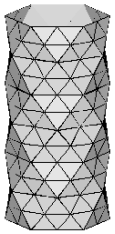


初期高さ　0.3



初期高さ　0.9

まとめ



・ダイヤカット型折り畳み円筒

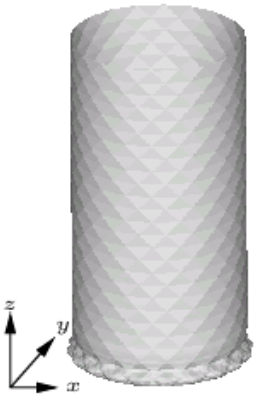
ばね剛性…パターン数と単調な相関

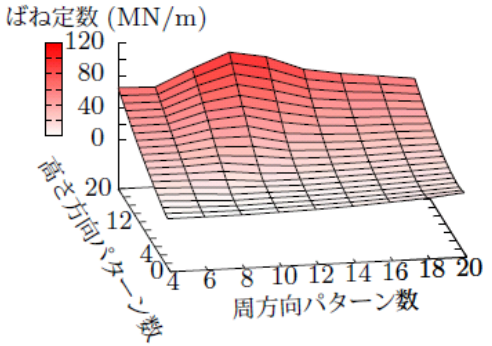
座屈荷重…パターン数

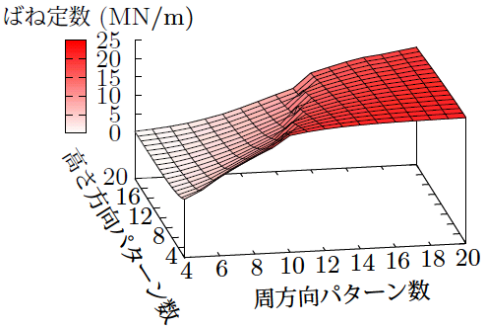
荷重方向

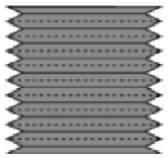
境界条件

} 依存



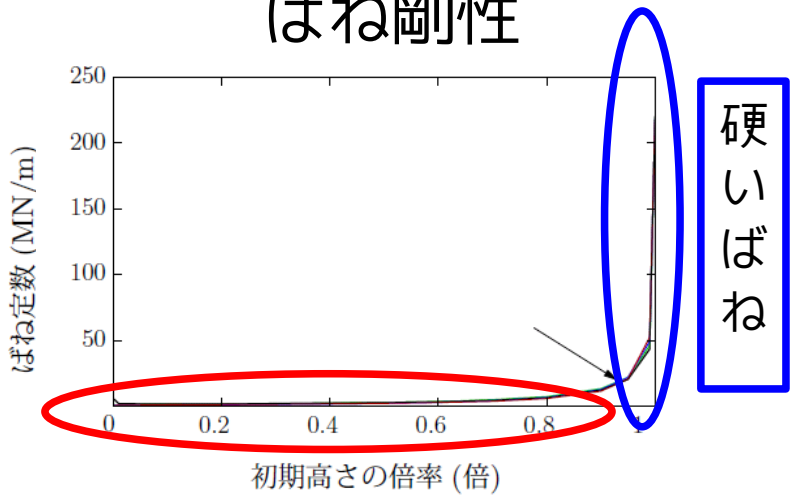






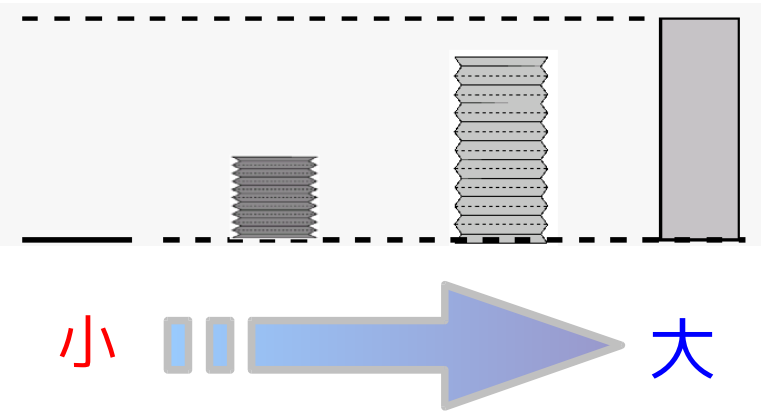
・折り畳み円筒

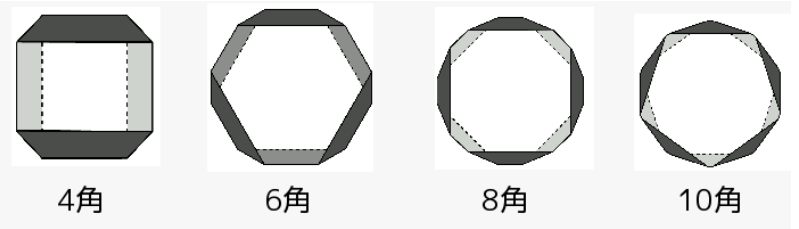
ばね剛性

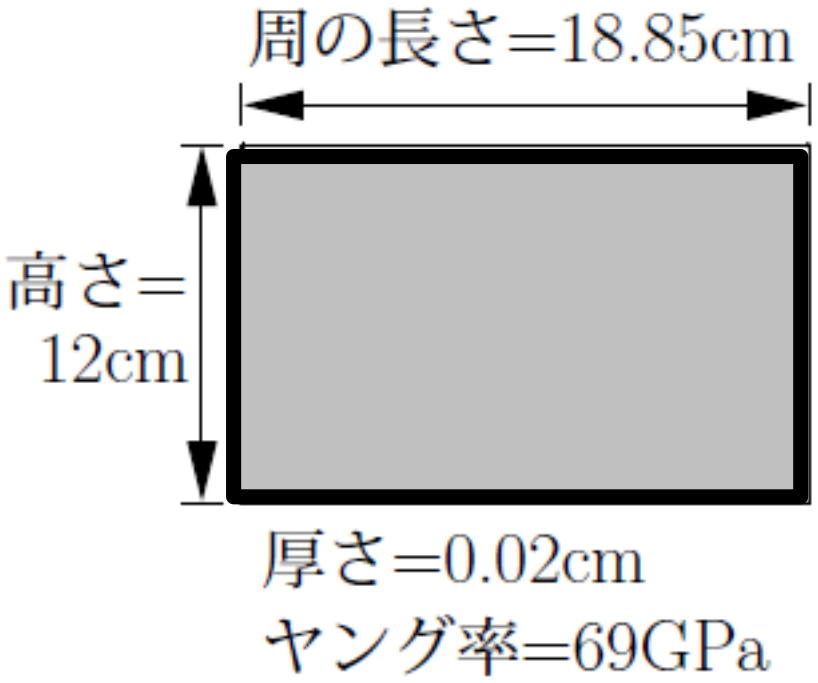


柔らかいばね

座屈荷重






周の長さ=18.85cm
高さ=
12cm
厚さ=0.02cm
ヤング率=69GPa