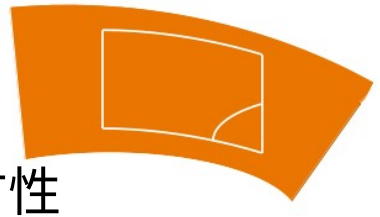
内部構造がせん断変形を与える異方性材料のモデル化

7021504　安藤伶緒

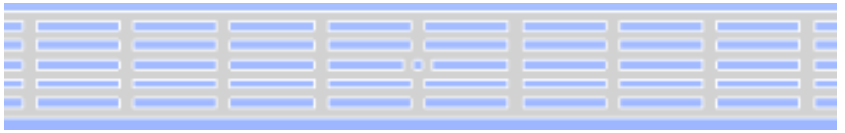
木材

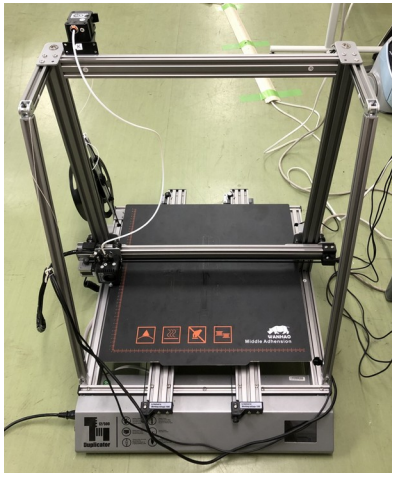


異方性

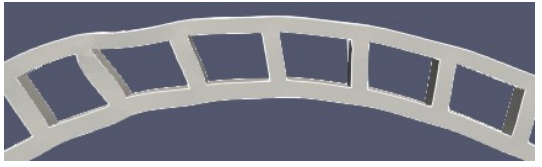
せん断変形大

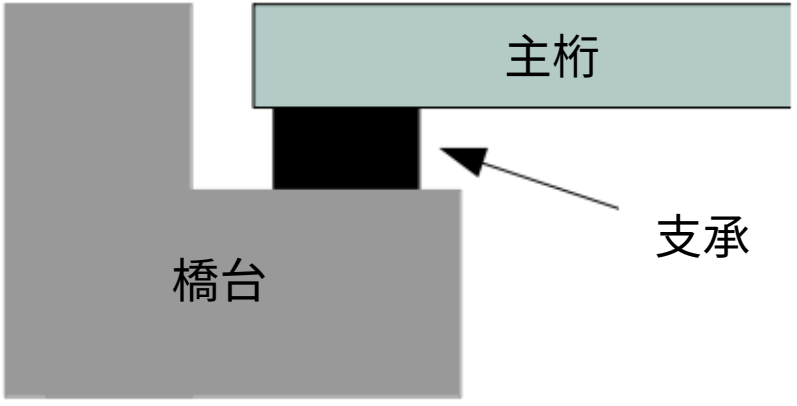
格子状



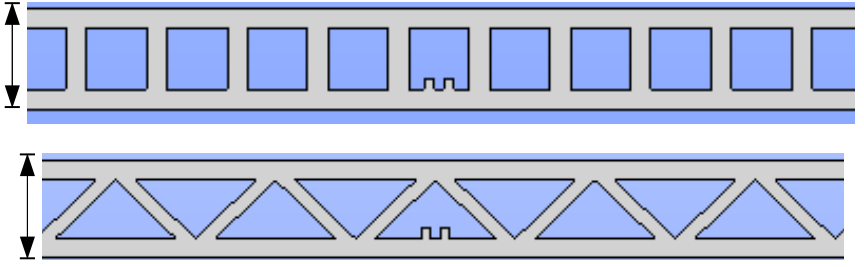


- 開発設計
- 製造

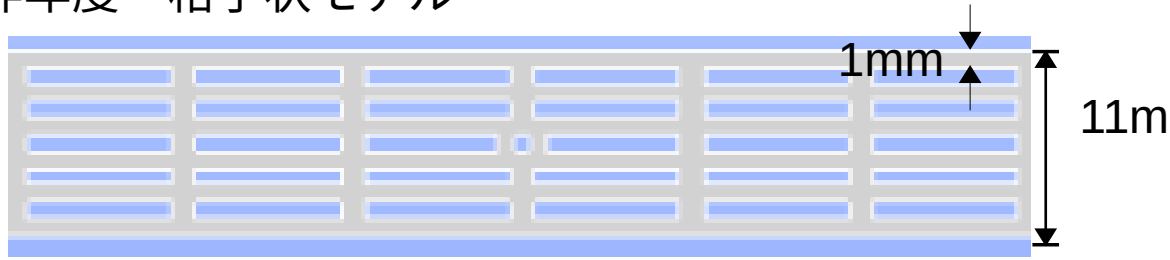




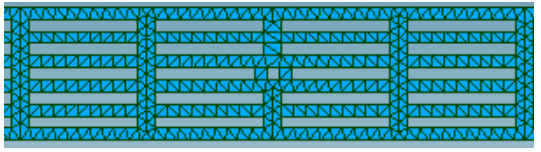
シンプルな構造でせん断変形を再現

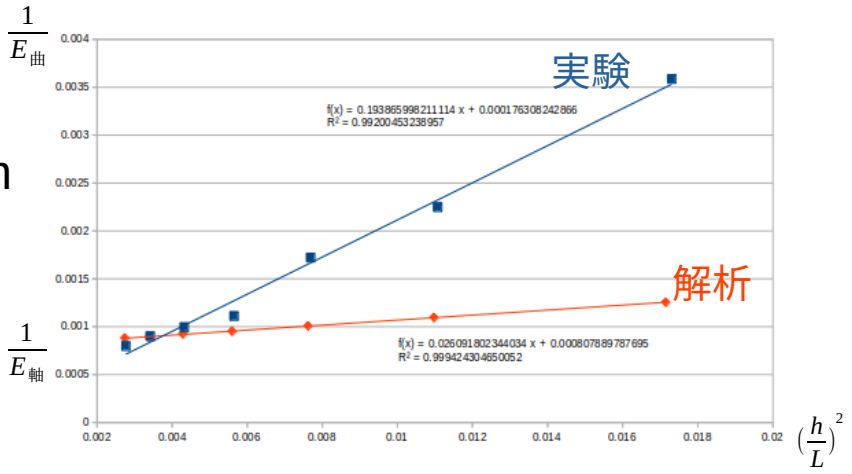


昨年度　格子状モデル

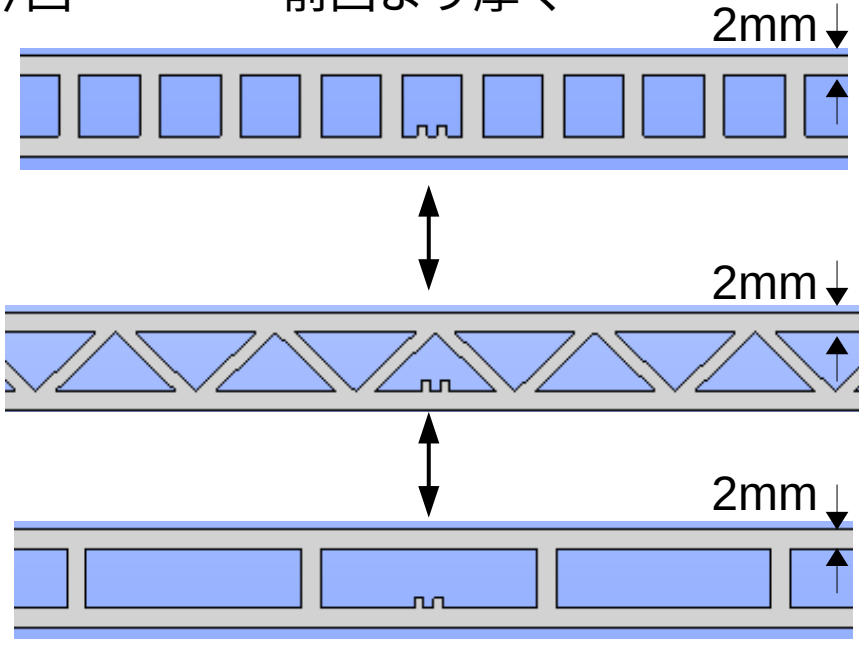


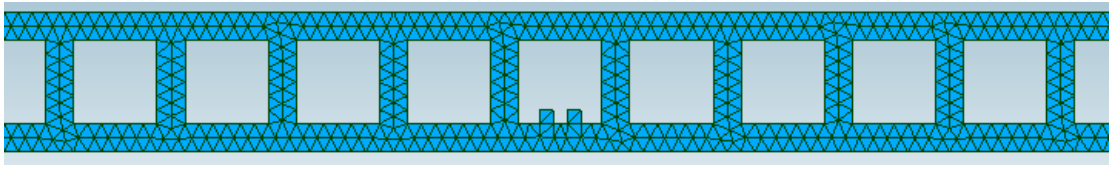
薄い ⟶ 誤差大





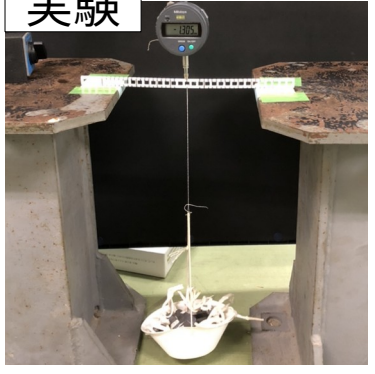
今回　　前回より厚く





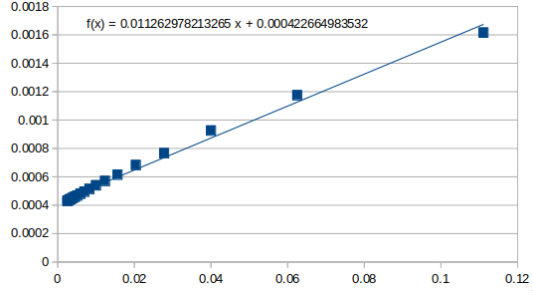
せん断弾性係数Gを算定

実験



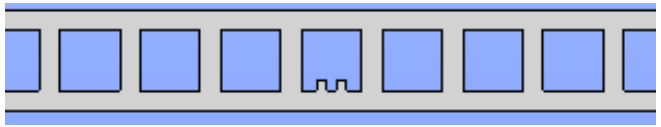
比較

解析

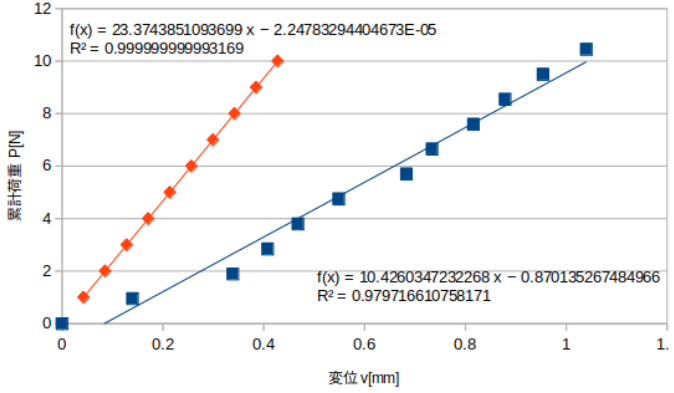


荷重と変位の関係

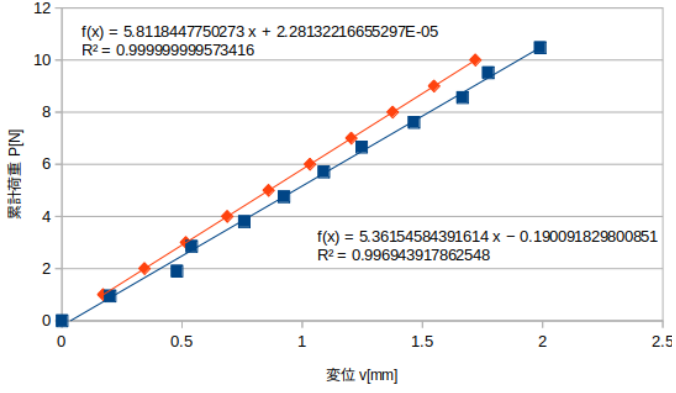
正方形梁



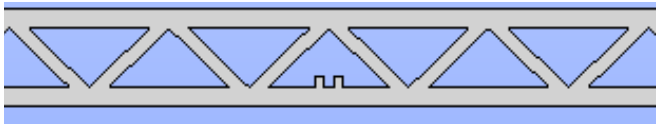
L=120mm



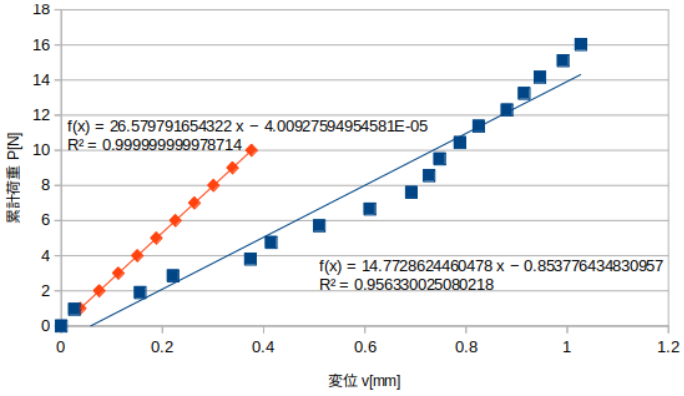
L=200mm



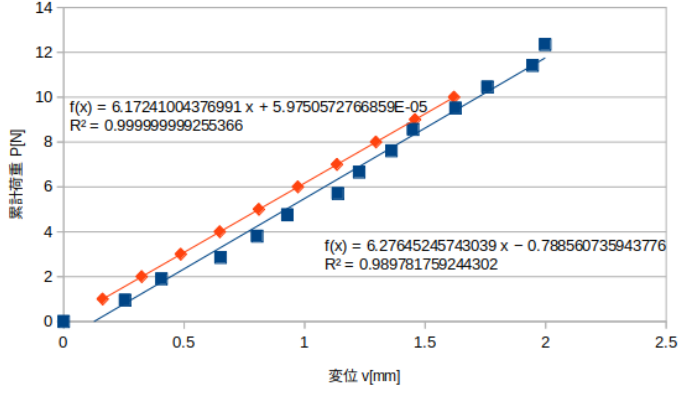
三角形梁



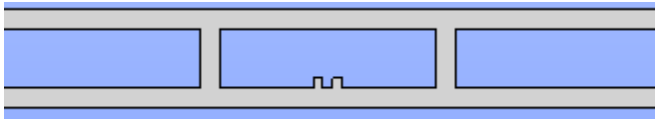
L=120mm



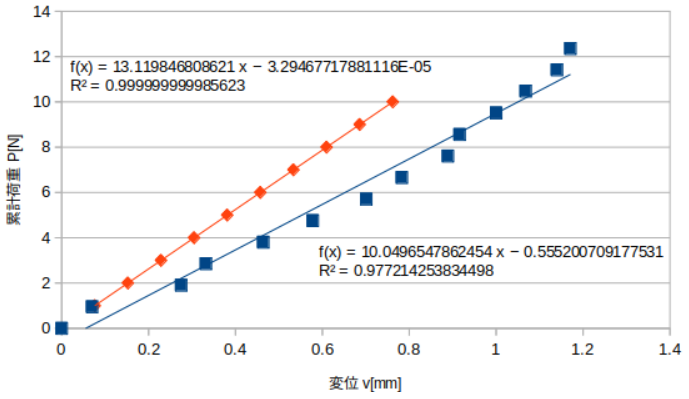
L=200mm



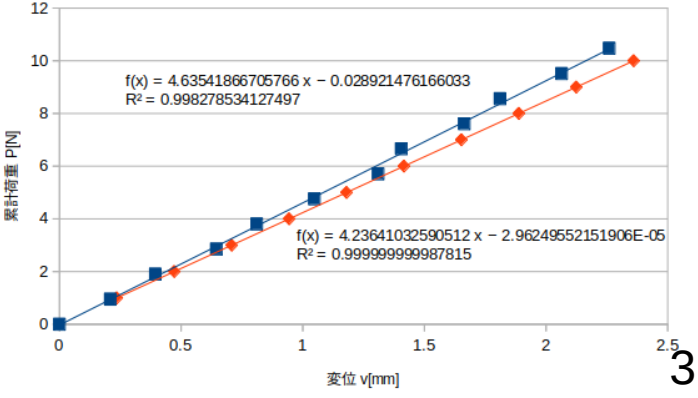
長方形梁



L=120mm

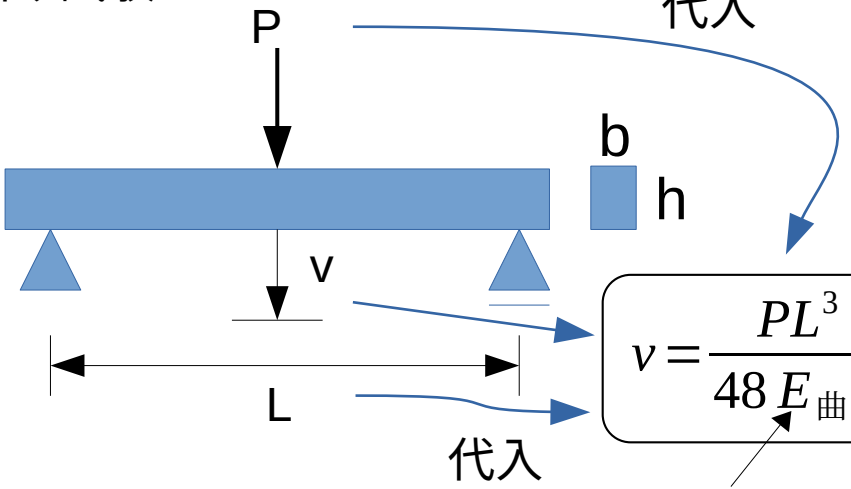


L=200mm



単純梁におけるGの算定

曲げ試験

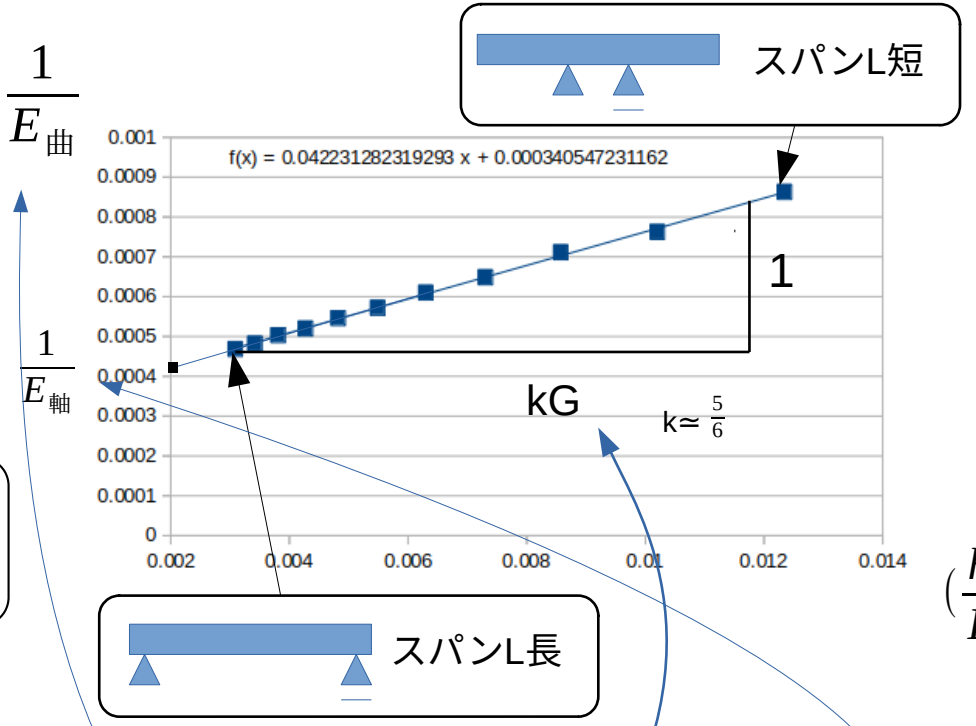


代入

$$v = \frac{PL^3}{48 E_{曲} I}$$

代入

せん断の影響含む



せん断変形を考慮すると，

ティモシェンコ梁のたわみ

$$v = \frac{PL^3}{48 E_{軸} I} + \frac{PL}{kGA} = \frac{PL^3}{48 E_{曲} I}$$

曲げたわみ　　せん断たわみ

変形

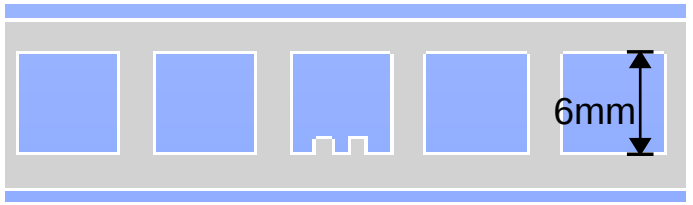
直線プロットの式

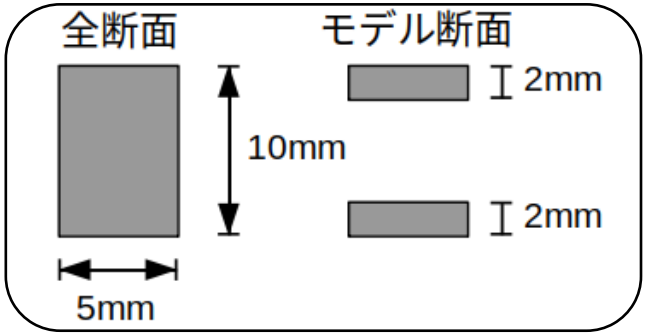
$$\frac{1}{E_{曲}} = \frac{1}{kG}\left(\frac{h}{L}\right)^2 + \frac{1}{E_{軸}}$$

傾き　　切片

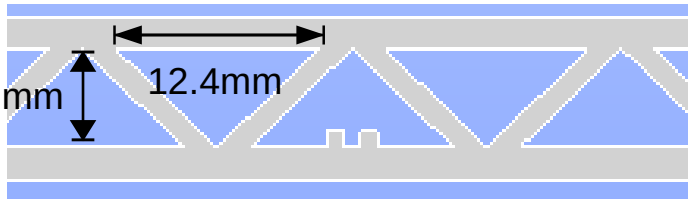
k:せん断補正係数

正方形梁 250mm,6924mm³

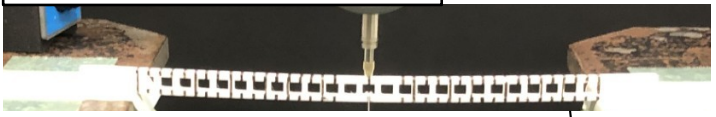




三角形梁 250mm,6924mm³



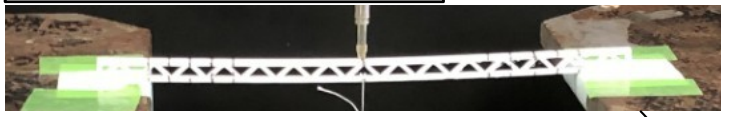
実物モデルでの実験



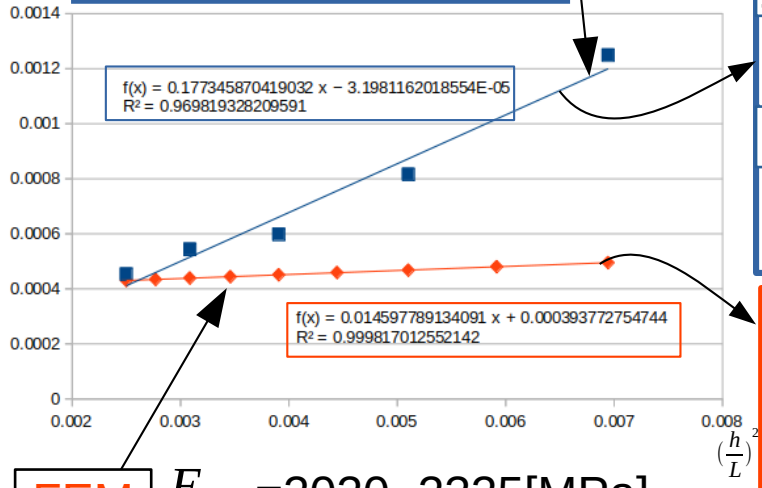
$E_{母材}=3135[MPa]$

$$E_{換算}=E_{母材}\times\frac{I_{モデル断面}}{I_{全断面}}=2458\ [\mathrm{MPa}]$$

実物モデルでの実験

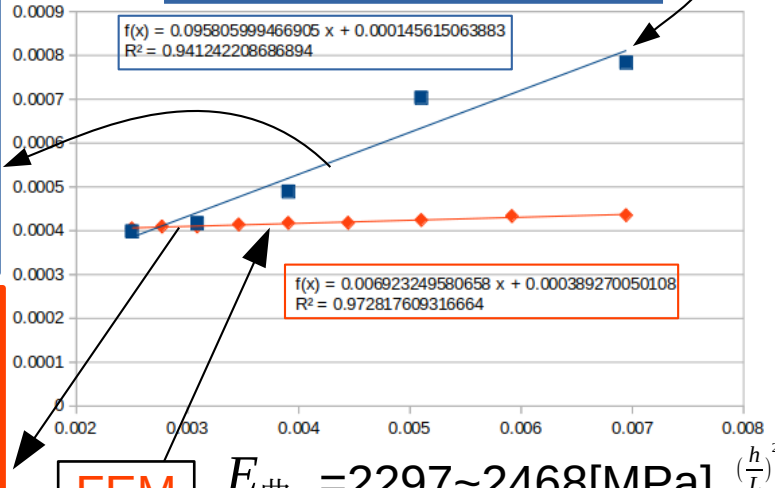


$E_{曲}$ =800.6~2205[MPa]



正方形	$G=6.61[MPa]$ $G=\frac{E}{372}$
三角形	$G=12.2[MPa]$ $G=\frac{E}{201}$
正方形	$G=80.3[MPa]$ $G=\frac{E}{30.6}$
三角形	$G=169[MPa]$ $G=\frac{E}{14.5}$

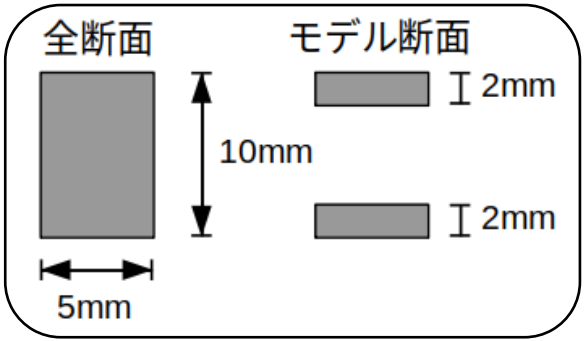
$E_{曲}$ =1276~2511[MPa]



FEM $E_{曲}$ =2020~2325[MPa]

FEM $E_{曲}$ =2297~2468[MPa]

長方形梁 266mm

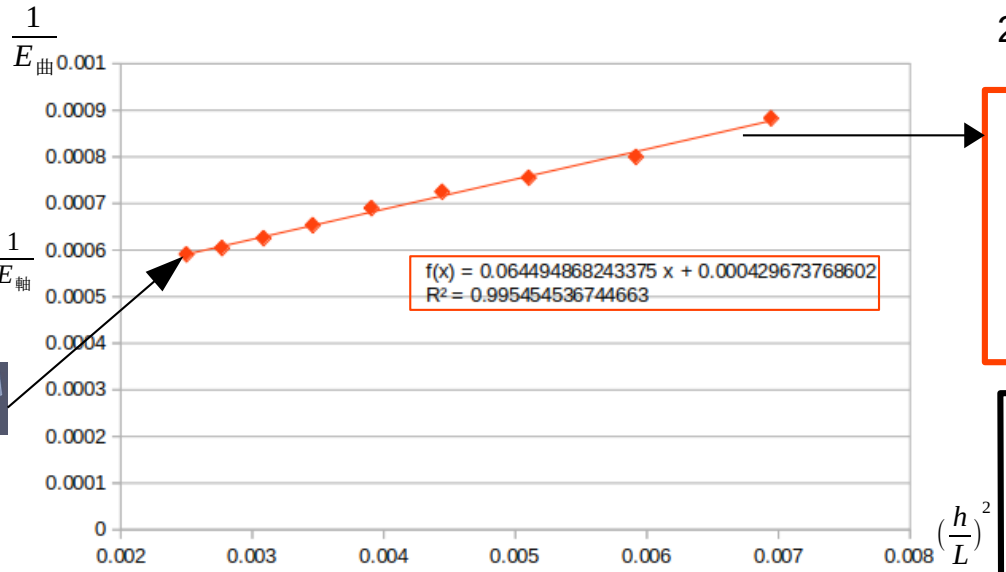


$E_{母材}=3135[MPa]$より

$$E_{換算}=2458 \text{ [MPa]}$$

FEM

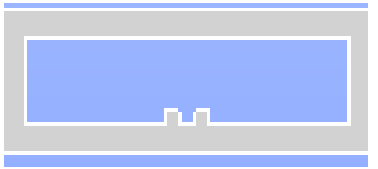
$$E_{曲} = 1133\sim1693[MPa]$$



$$G=18.2[MPa]$$

$$G=\frac{E}{135}$$

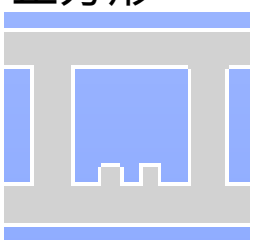
長方形



$$G=18.2[MPa]$$

$$G=\frac{E}{135}$$

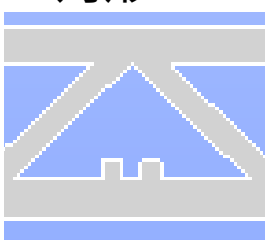
正方形



$$G=80.3[MPa]$$

$$G=\frac{E}{30.6}$$

三角形

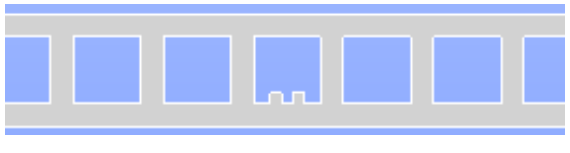


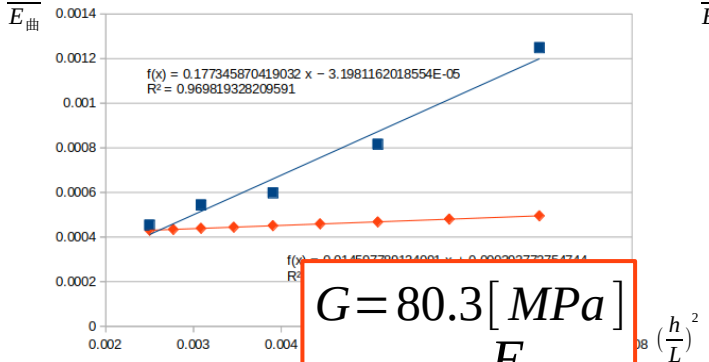
$$G=169[MPa]$$

$$G=\frac{E}{14.5}$$

まとめ

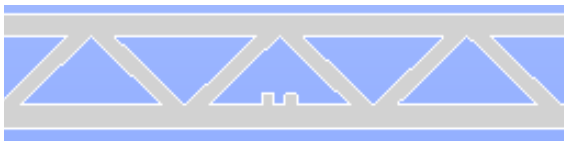
異方性を与える内部構造

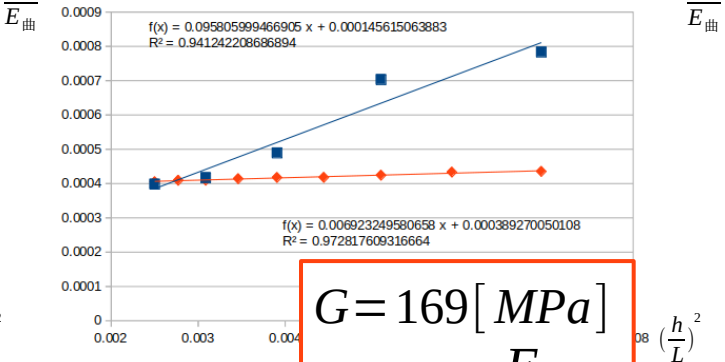




$$G=80.3[MPa]$$

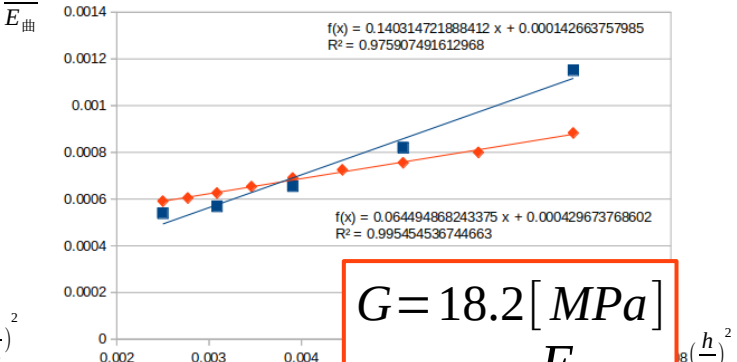
$$G=\frac{E}{30.6}$$





$$G=169[MPa]$$

$$G=\frac{E}{14.5}$$



$$G=18.2[MPa]$$

$$G=\frac{E}{135}$$

Gの算定・・・ $\frac{1}{E_{曲}}=\frac{1}{kG}\left(\frac{h}{L}\right)^2+\frac{1}{E_{軸}}$

内部構造の違いにより
異方性を制御できる

木材（異方性）

$$G=\frac{E}{15}$$

程度

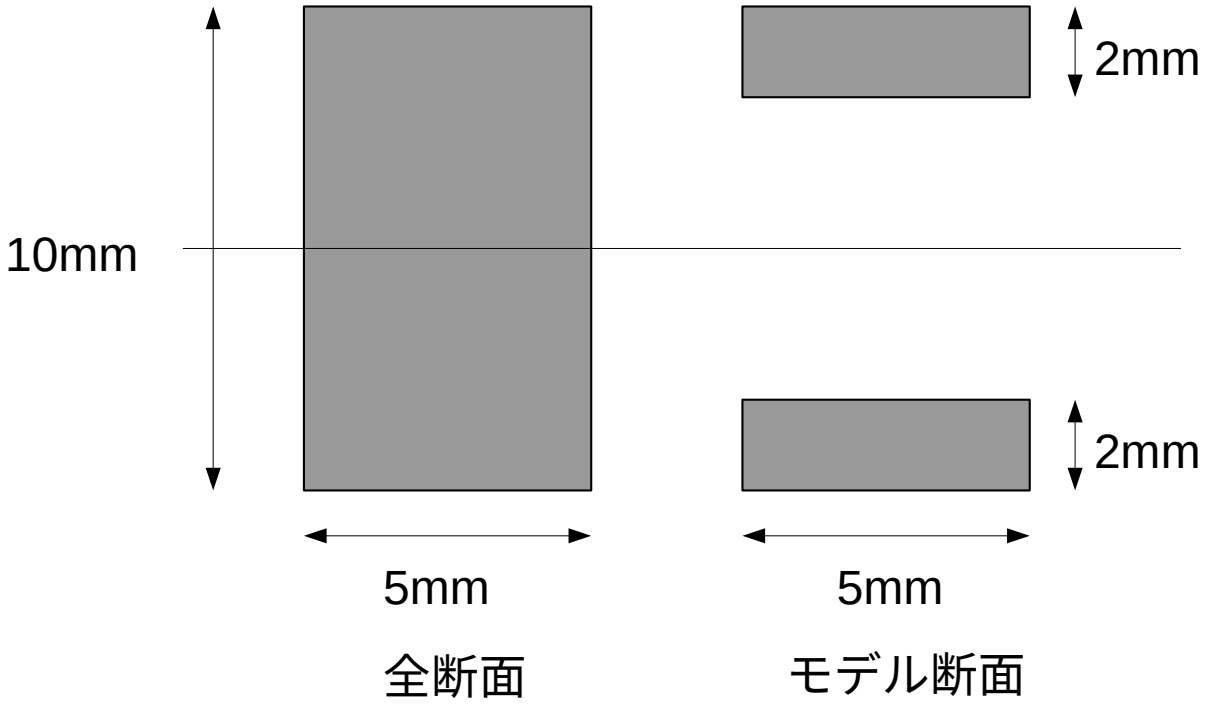
解析では適用可能
実験では困難

→

高い精度が必要
実験からGの算定は難しい

今後の課題
- 印刷精度の向上
- ねじり試験やねじり振動からGの算定

補足資料



$$I_{全断面} = 416.7\,mm^4$$

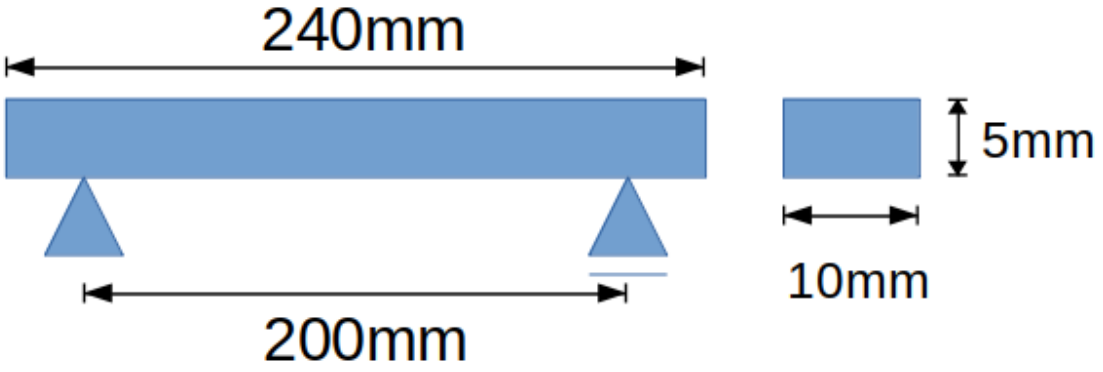
$$I_{モデル断面} = 326.7\,mm^4$$

$$\frac{I_{モデル断面}}{I_{全断面}} = 0.784$$

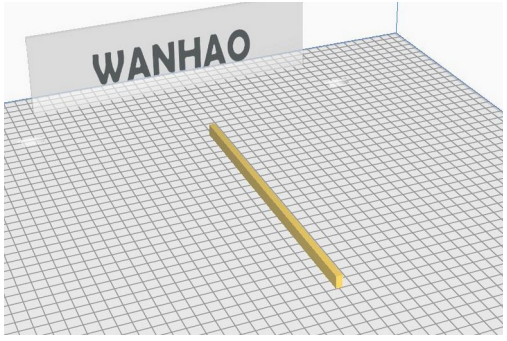
$$E_{換算} = E_{母材} \times \frac{I_{モデル断面}}{I_{全断面}} = 2457.84$$

[MPa]

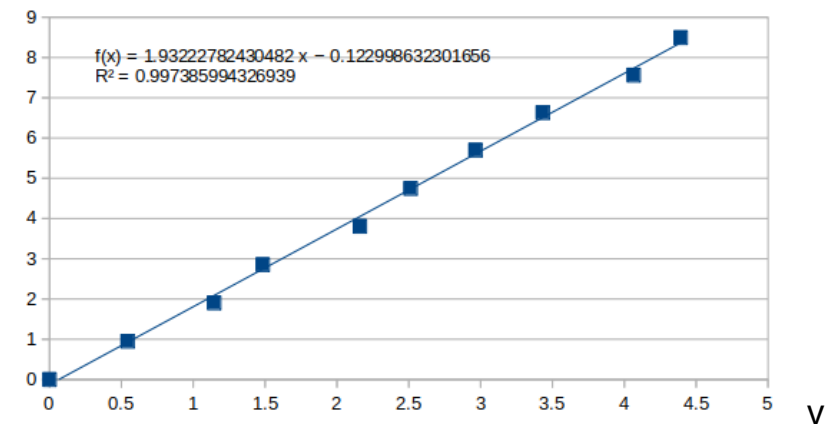
母材の曲げ試験



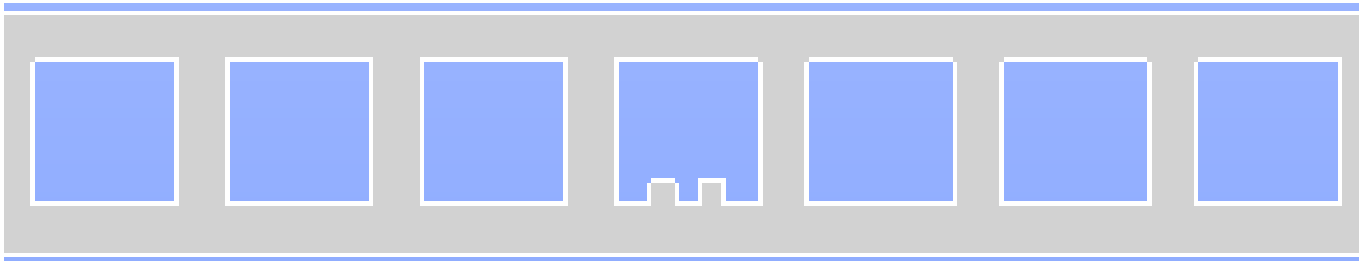
傾きから曲げヤング率を求める.



母材の曲げヤング率
E=3135[MPa]



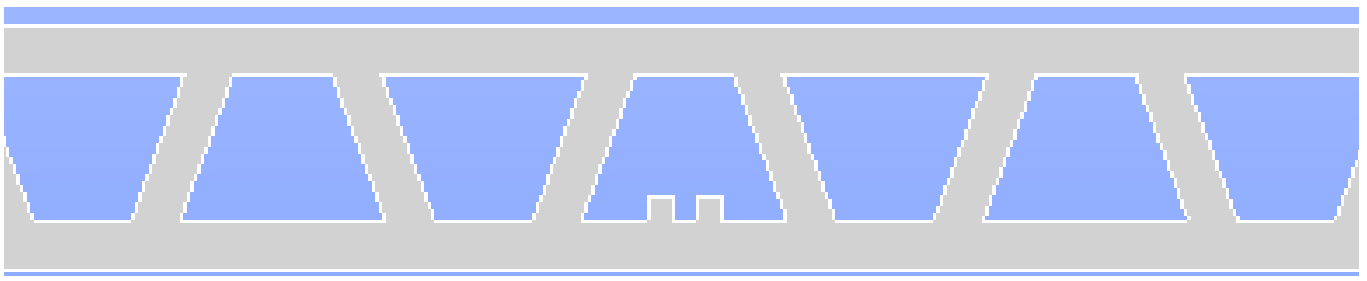
正方形



$G=80.25[MPa]$

$$G=\frac{E}{30.6}$$

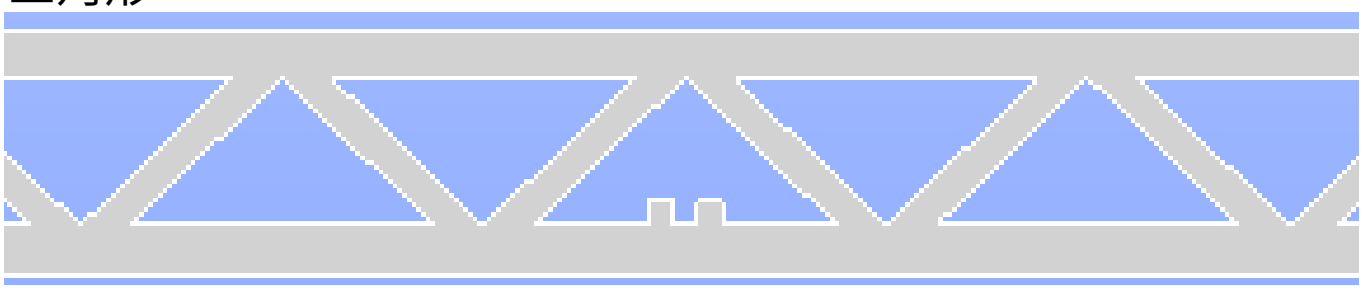
台形



$G=105.4[MPa]$

$$G=\frac{E}{23.3}$$

三角形



$G=169.2[MPa]$

$$G=\frac{E}{14.5}$$

G小

G大