

État Rankine - Modèle

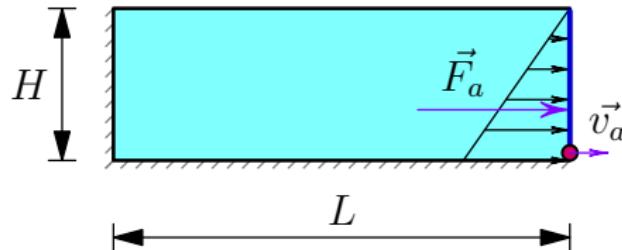


Figure 1 – Pression active :le mur s'éloigne du sol

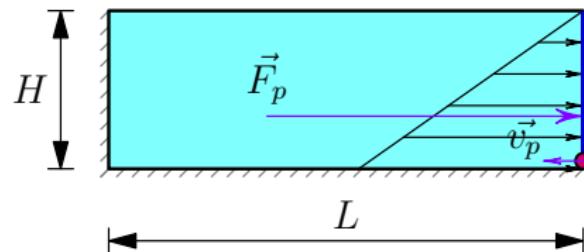


Figure 2 – Pression passive :le mur se rapproche du sol

Observer la pression sur le mur en bleu

Paramètres principaux

Symbol	Paramètre	Valeur
L	Longueur	3 m
H	Hauteur	1 m
ρ	Densité	2700 kg/m ³
E	Module de Young	1×10^9 Pa
ν	Coefficient de Poisson	0.2
φ	Angle de frottement interne	25°
ψ	Angle de dilatance	≈ 0°
v	Vélocité de déplacement	0.005 m/s
c	Cohésion	0 & 100 Pa
N	Nombre de point matériel	1200
μ	Coefficient de frottement entre le mur et les PMs	0

Table 1 – Paramètres du Modèle (loi Mohr-Coulomb)

État Rankine - Stabiliser

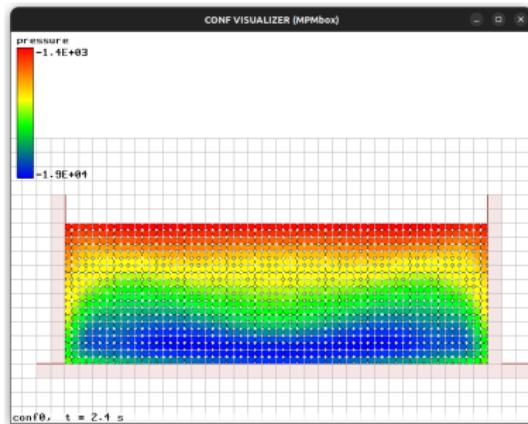


Figure 3 – Pression en bas

$$P_{\text{théorique}} = 2.65e4 \text{ (Pa)}$$

→ L'écart est 0.65 kPa

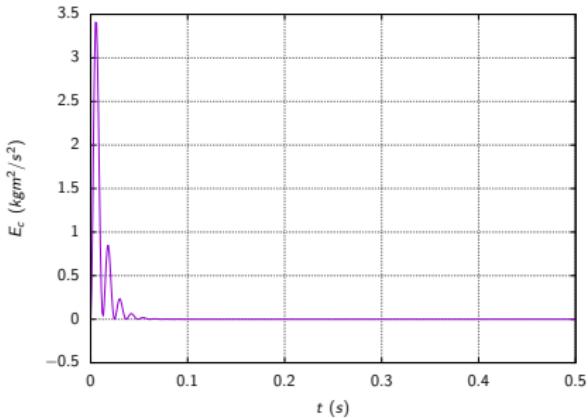


Figure 4 – Énergie cinétique

$$P_{\text{simulation}} = 2e4 \text{ (Pa)}$$

État Rankine - Théorie

Coefficient K : la relation entre la contrainte verticale et horizontal :

- Poussée active : $K_a = \frac{1 - \sin(\varphi)}{1 + \sin(\varphi)} = 0.406$

- Poussée passive : $K_p = 1/K_a = 2.464$

- État au repos [Jaky, 1944] :

$$K_0 = (1 - \sin(\varphi)) \frac{1 + 2/3 \sin(\varphi)}{1 + \sin(\varphi)} \approx 1 - \sin(\varphi) = 0.577$$

La somme de pression $F(kN)$ appliquée sur le mur :

Sans cohésif :

$$F_a = \frac{1}{2} \gamma H^2 K_a = 5.376861$$

$$F_a = \frac{1}{2} \gamma H^2 K_p = 32.619458$$

$$F_0 = \frac{1}{2} \gamma H^2 K_0 = 7.647$$

Cohésif :

$$F_a = \frac{1}{2} \gamma H^2 K_a - 2cH\sqrt{K_a} = 5.249425$$

$$F_p = \frac{1}{2} \gamma H^2 K_p + 2cH\sqrt{K_p} = 32.93334$$

$$F_0 = \frac{1}{2} \gamma H^2 K_0 + 2cH\sqrt{K_0} = 7.495$$

État Rankine reposé

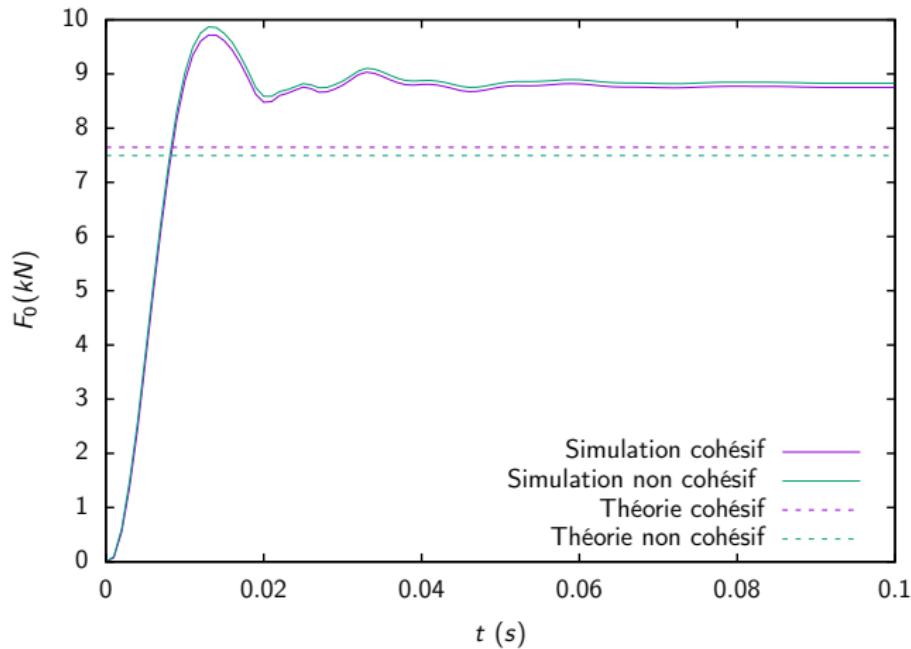


Figure 5 – Pression sur le mur en bleu

→ L'écart est 1 kPa (13%)

État Rankine - film de mur bougé

Figure 6 – Pression active

Figure 7 – Pression passive

État Rankine - Pression Active

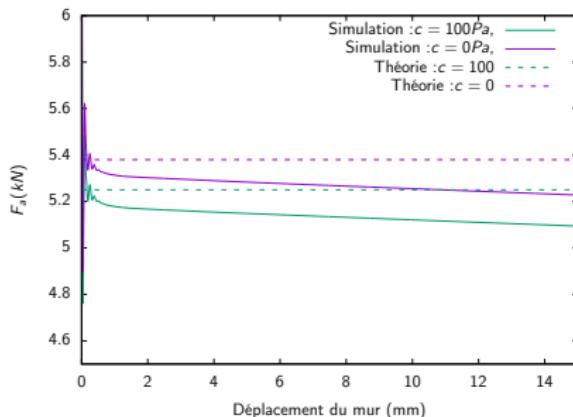


Figure 8 – Pression active
 $v = 0.005 = \text{const}$

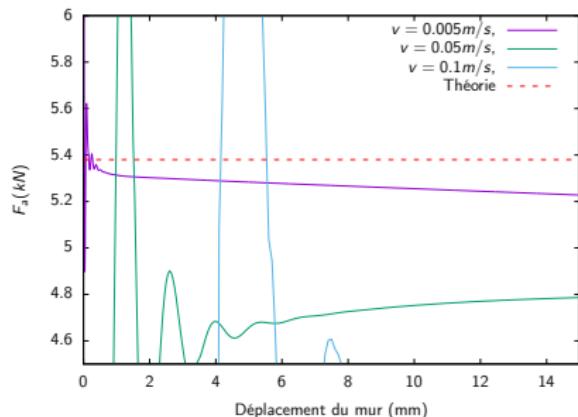


Figure 9 – Pression active $c = 0 = \text{const}$
 Effet cinétique ? Résistance rigide du matériau ?

→ L'écart est 0.2 kN (3%)

État Rankine - Pression Passive

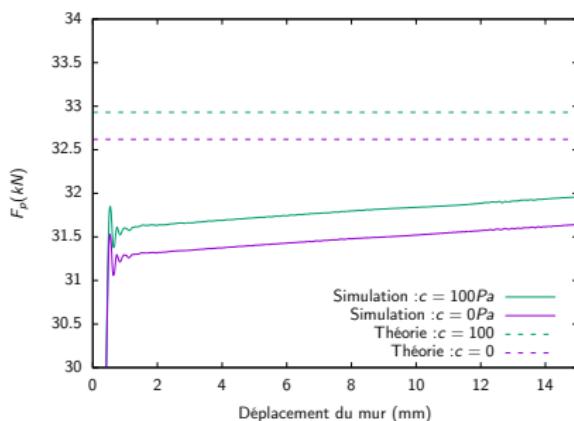


Figure 10 – Pression passive
 $v = -0.005 = \text{const}$

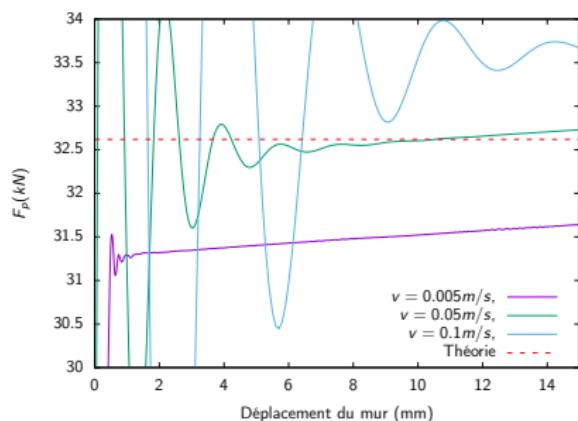


Figure 11 – Pression passive
 $c = 0 = \text{const}$

Effet cinétique ?

→ L'écart est 1 kN (3%)

Stabilisation - Théorie élastique

$$\sigma_{yy} = \rho g H = 2700 \cdot 9.81 \cdot 1 = 26487 \text{ Pa} \quad (1)$$

$$F_{yy} = \sigma_{yy} \cdot L = 26487 \cdot 3 = 79461 \text{ Pa} \quad (2)$$

$$\sigma_{xx} = K_0 \sigma_{yy} = K_0 \gamma y \quad (3)$$

$$F_{xx} = \int_0^H K_0 \gamma y \, dy = \frac{1}{2} \frac{\nu}{1-\nu} \gamma z^2 = \frac{1}{2} \cdot \frac{0.2}{1-0.2} \cdot 2700 \cdot 9.81 \cdot 1^2 = 3.3 \text{ kN} \quad (4)$$

$$I = \frac{\nu}{H_0} \sqrt{\frac{m}{P}} = \frac{0.005}{3} \sqrt{\frac{0.05^2 \cdot 2700}{2700 \cdot 9.81 \cdot 1}} = 5 \cdot 10^{-4} \quad (5)$$

$$t_c = \frac{\pi}{20} \sqrt{\frac{m}{k_n}} = \frac{\pi}{20} \sqrt{\frac{0.05^2 \cdot 2700}{1e9}} = 10^{-5}(s) \quad (6)$$

Stabilisation - Théorie élastique vs Rankine

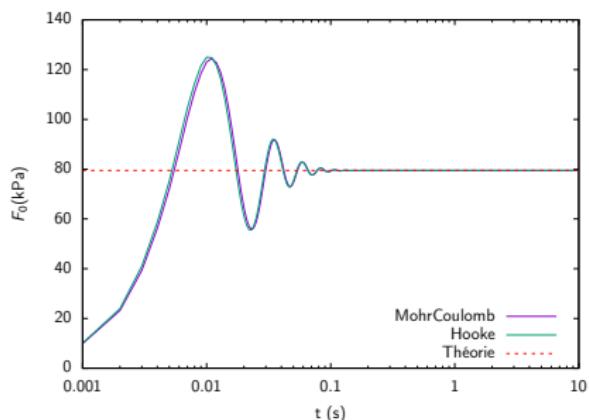


Figure 12 – La force au fond au repos

à 1s le modèle est bien stabilisé. La force au fond de deux loi est presque exactement la même.

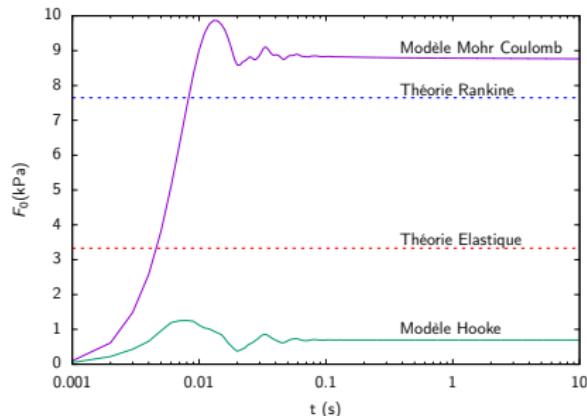


Figure 13 – La force au mur au repos

Un écart de différence entre les 2 théories

Stabilisation - Modèle Mohr-Coulomb

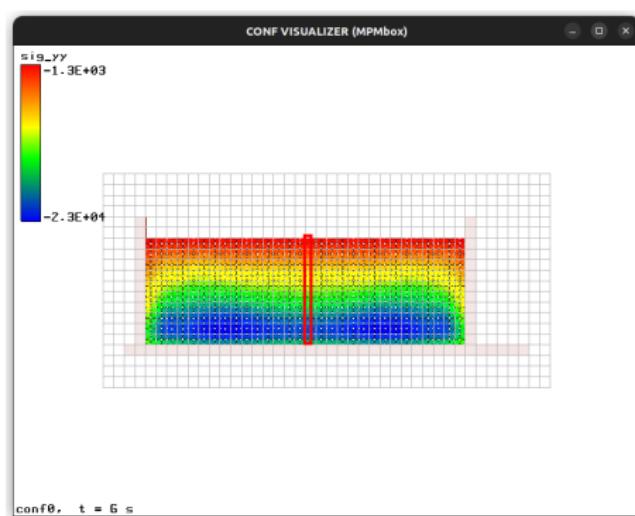


Figure 14 – σ_{yy} quand
 $\nu = 0.2, \varphi = 25^\circ, c = 0$

σ dans la couche de MP horizontale
au fond présente l'effet de bord

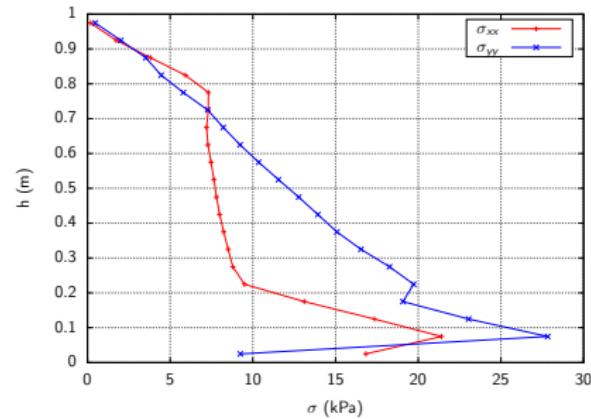


Figure 15 – La contrainte de bande au milieu de cas $\nu = 0.2, \varphi = 25^\circ, c = 0$

Le coefficient K_0 varie fortement

Stabilisation - Modèle Mohr-Coulomb

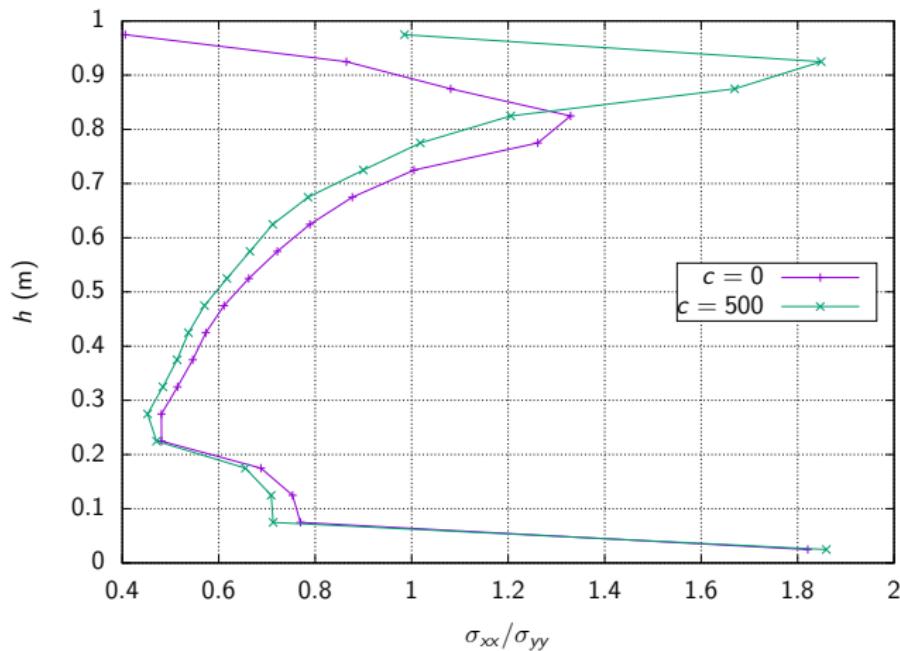


Figure 16 – Taux $K_0 = \sigma_{xx}/\sigma_{yy}$ quand $\nu = 0.2, \varphi = 25^\circ$ au chaque points vertical de la bande au milieu

Stabilisation - Modèle Mohr-Coulomb

Le Coefficient K_0 quand on fixe $\varphi = 25^\circ$, $\psi = 0^\circ$, $c = 0$ et varie ν :

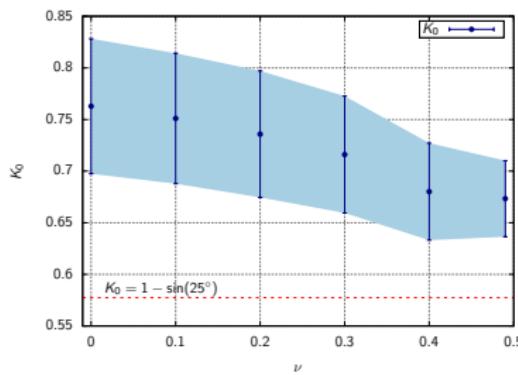


Figure 17 – Ratio de moyen

$$K_0 = \frac{\overline{\sigma_{xx}}}{\overline{\sigma_{yy}}}$$

$$\text{Std}(K_0) \approx K_0 \sqrt{\left(\frac{\text{Std}(\sigma_{xx})}{\overline{\sigma_{xx}}} \right)^2 + \left(\frac{\text{Std}(\sigma_{yy})}{\overline{\sigma_{yy}}} \right)^2}$$

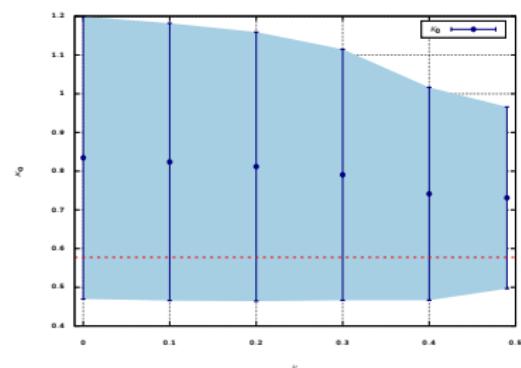


Figure 18 – Moyen de ratio

$$K_0 = \frac{1}{N} \sum_{i=1}^N \frac{\sigma_{xx,i}}{\sigma_{yy,i}}$$

$$\text{Std}(K_0) = \sqrt{\frac{1}{N-1} \sum_{i=1}^N \left(\frac{\sigma_{xx,i}}{\sigma_{yy,i}} - K_0 \right)^2}$$

Stabilisation - Modèle Mohr-Coulomb

Le Coefficient K_0 quand on fixe $\varphi = 25^\circ$, $\nu = 0.2$, $c = 0$ et varie ψ :

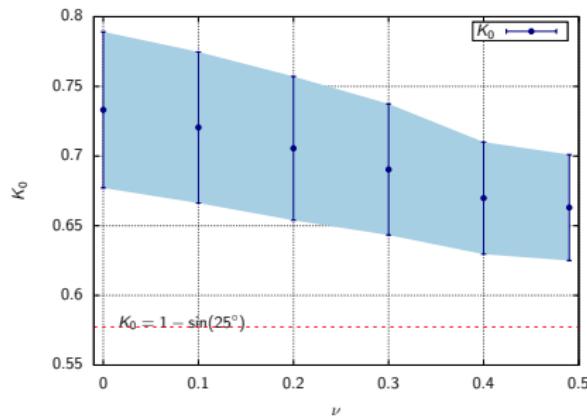


Figure 19 – Ratio de moyen

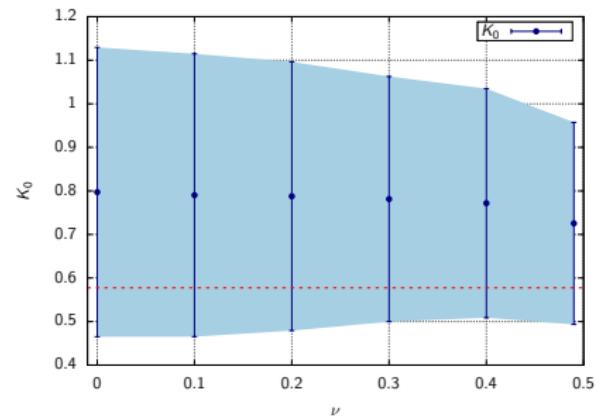


Figure 20 – Moyen de ratio

La différence est négligeable.

Stabilisation - Modèle Élastique

Le Coefficient K_0 quand on fixe $\nu = 0.2$, $\psi = 0^\circ$, $c = 0$ et varie φ :

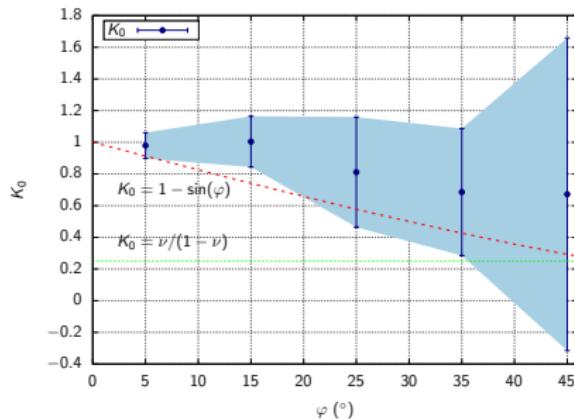


Figure 21 – Ratio de moyen

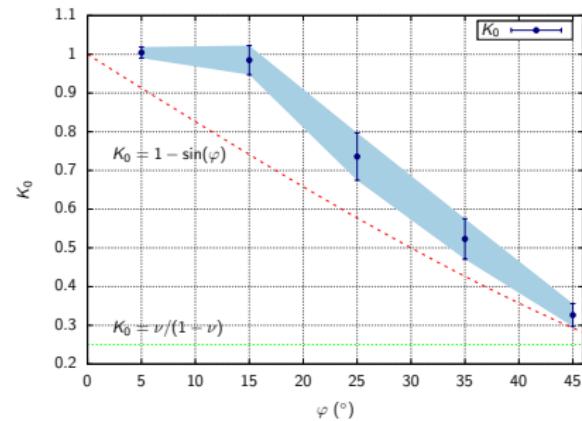


Figure 22 – Moyen de ratio

Stabilisation - Modèle Élastique

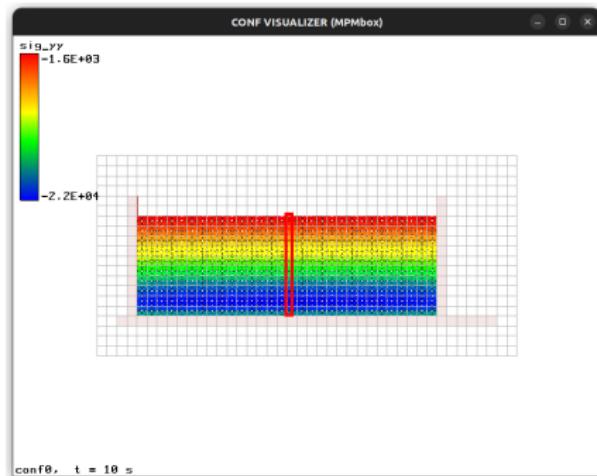


Figure 23 – σ_{yy} ($\nu = 0.2, E = 1\text{e}9 \text{ Pa}$)

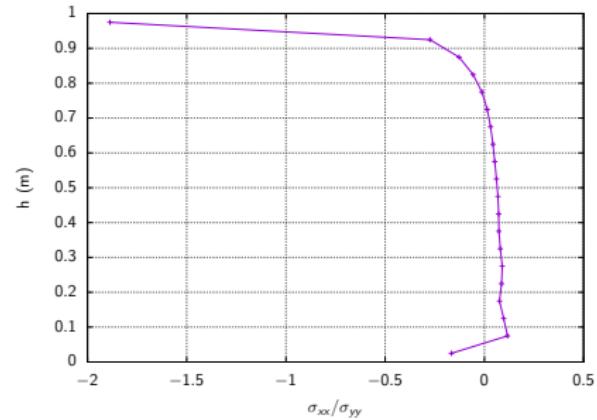


Figure 24 – La contrainte de bande au milieu de cas $\nu = 0.2, E = 1\text{e}9 \text{ Pa}$

Stabilisation - Modèle Élastique

$$PIC = 99\%$$

Le Coefficient K_0 quand on fixe $E = 1e9 Pa$, $PIC = 0.9$ et varie ν :

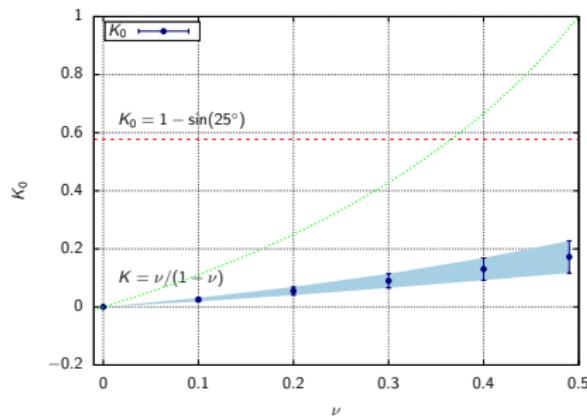


Figure 25 – Ratio de moyen

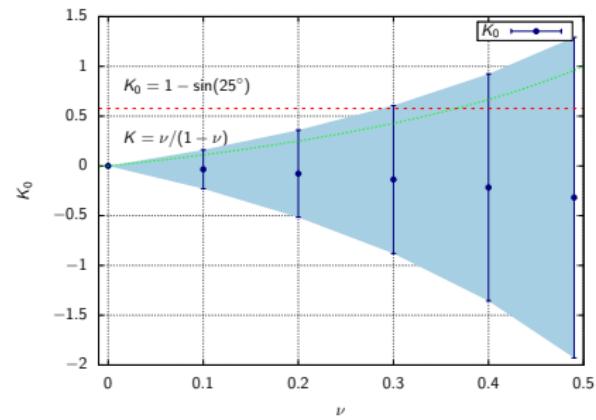


Figure 26 – Moyen de ratio

Stabilisation - Modèle Élastique

L'influence de PIC/FLIP : $E = 1e9 \text{ Pa}$, $\nu = 0.4$

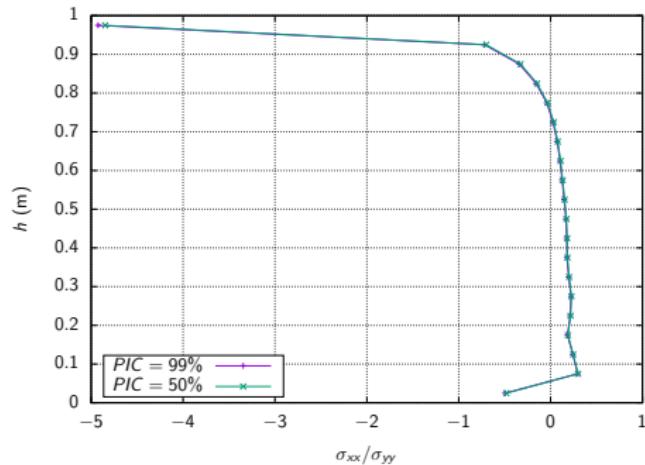


Figure 27 – Taux de σ_{xx}/σ_{yy}

Le PIC n'influence pas significativement le résultat final.