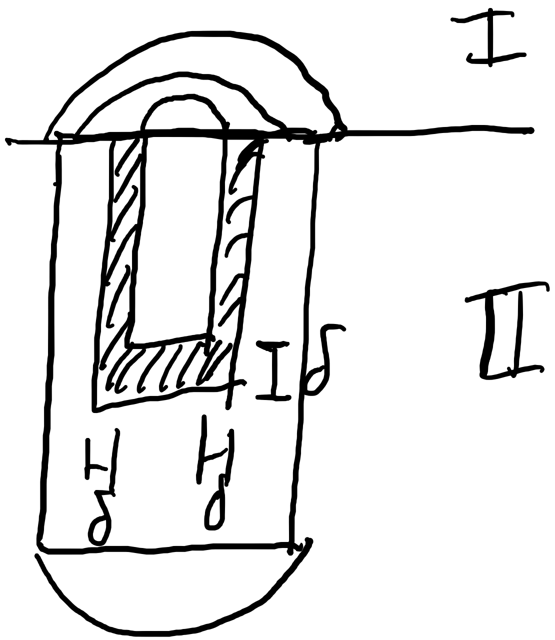
$0.5\,\text{GPa} \le E \le 1\,\text{GPa}$

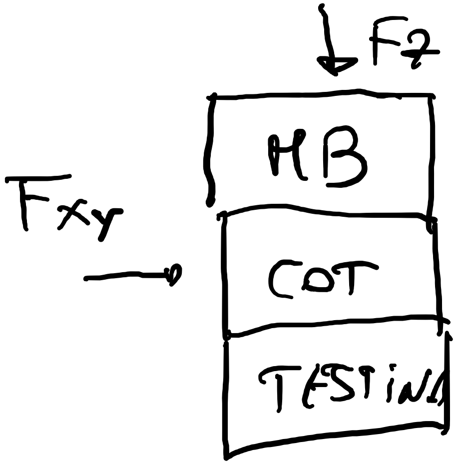
δ_{cem} = costante in tutte le direzioni



Metodo omog. parziale

blocco I

$E_{oss.sano} = 0.5\ \text{GPa}$



$$\begin{cases} \dfrac{1}{E_z} = \dfrac{f_{MB}}{E_{MB}} + \dfrac{f_{COT}}{E_{COT}} + \dfrac{f_{TEST}}{E_{TEST}} \\ E_{xy} = f_{MB} E_{MB} + f_{COT} E_{COT} + f_{TEST} \cdot E_{TEST} \\ f_{MB} + f_{COT} + f_{TEST} = 1 \end{cases}$$

$$f_{TEST} = \frac{V_{TEST}}{V_{TOTEP1}} = \frac{\frac{2}{3}\pi r^3_{test}}{\frac{2}{3}\pi r^3_{ep1}} = \left(\frac{r_{test}}{r_{ep1}}\right)^3$$

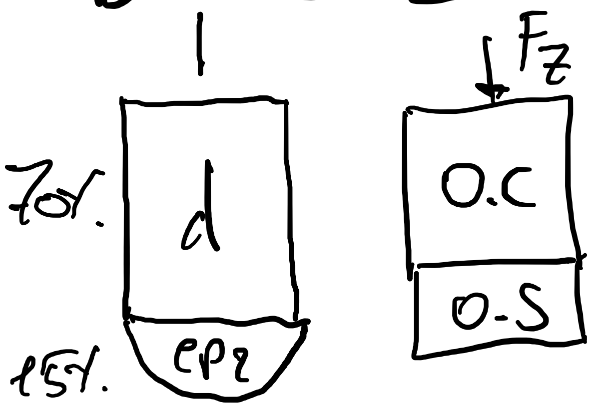
$$f_{COT} = \frac{V_{COT}}{V_{TOTEP1}} = \frac{\frac{2}{3}\pi r^3_{est\,cot} - \frac{2}{3}\pi r^3_{int\,cot}}{\frac{2}{3}\pi r^3_{ep1}} = \frac{r^3_{est\,cost} - r^3_{incot}}{r^3_{ep1}} =$$

$$= \frac{r^3_{est\,cot} - r^3_{test}}{r^3_{ep1}}$$

$$f_{MB} = \frac{V_{MB}}{V_{TOTEP1}} = \frac{\frac{2}{3}\pi r^3_{est\,MB} - \frac{2}{3}\pi r^3_{in\,MB}}{\frac{2}{3}\pi r^3_{ep1}} = \frac{r^3_{MBest} - r^3_{MBint}}{r^3_{ep1}}$$

$$= \frac{r^3_{QC} - r^3_{est\,cot}}{r^3_{ep1}}.$$

blocco II



$$\frac{1}{E_z} = \frac{f_{oc}}{E_{oc}^{z}} + \frac{f_{os}}{E_{os}}$$

$$E_{xy} = f_{oc} \cdot E_{oc}^{xy} + f_{os} E_{os}$$

$$f_{oc} + f_{os} = 1$$

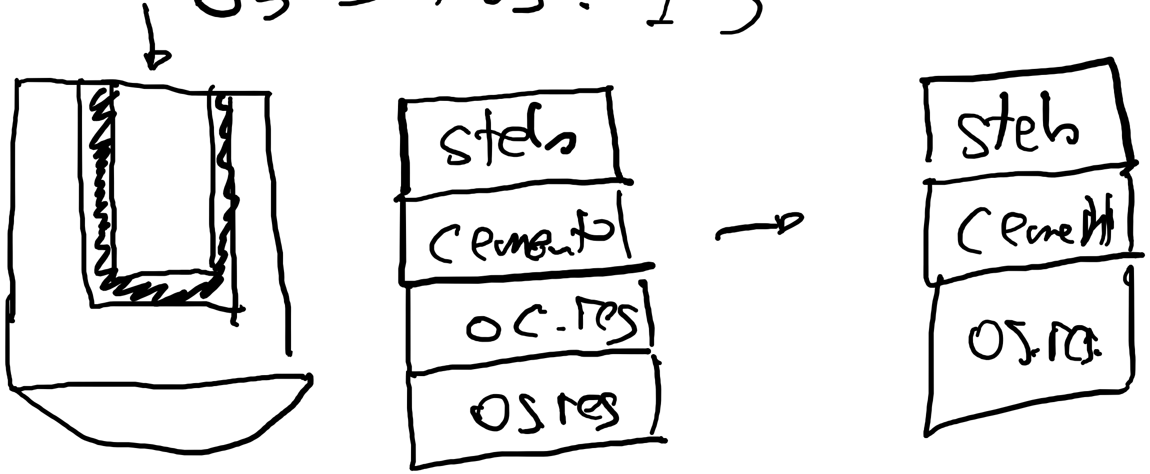
$$100 : 85 = x_c : 70$$

$$100 : 85 = x_{os} : 15$$

$$E_{zres} = E_z (1-p)^{\alpha} A^{\beta} \dot{\varepsilon} \delta^{\gamma}$$

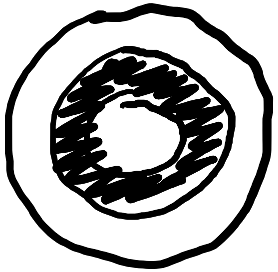
$$E_{zres} = E_z (1-p)^{\alpha}$$

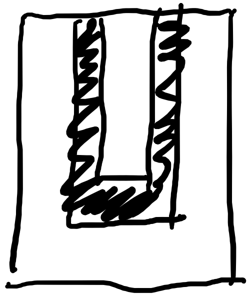
$$p = f_{st} + f_{cem}$$



$$
\begin{cases}
\dfrac{1}{E_z} = \dfrac{f_{ST}}{E_{ST}} + \dfrac{f_{cem}}{E_{cem}} + \dfrac{f_{osres}}{E_{osres}^{z}} \\
E_{xy} = f_{ST} E_{ST} + f_{cem} \cdot E_{cem} + f_{os.res} E_{osres}^{xy} \\
f_{ST} + f_{cem} + f_{os.res} = 1
\end{cases}
$$

$$
f_{ST} = \frac{V_{ST}}{V_{tot.ossres}} = \frac{\pi r_{st}^2 h_{st}}{\pi r^2_{fem} h_{fem} + \frac{2}{3}\pi r^3_{epi}} = A
$$





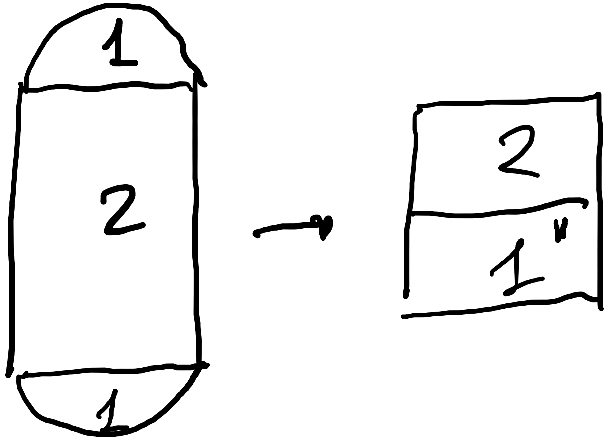
$$
f_{cem} = \frac{\left[\pi (r_{st} + \delta_{cem})^2 (h_{st} + \delta_{cem})\right] - \left[\pi r_{st}^2 h_{st}\right]}{\pi r^2_{fem} h_{fem} + \frac{2}{3}\pi r^3_{epi}}
$$

$$
f_{osres} = \frac{\left[\left(\pi r^2_{fem} \cdot h_{fem}\right) - \pi (r_{st} + \delta_{cem})^2 (h_{st} + h_{cem})\right] + \frac{2}{3}\pi r^3_{epi}}{A}
$$

1) non si è grado tutta l'ep.1 o tutta ep1 + parte diafisi

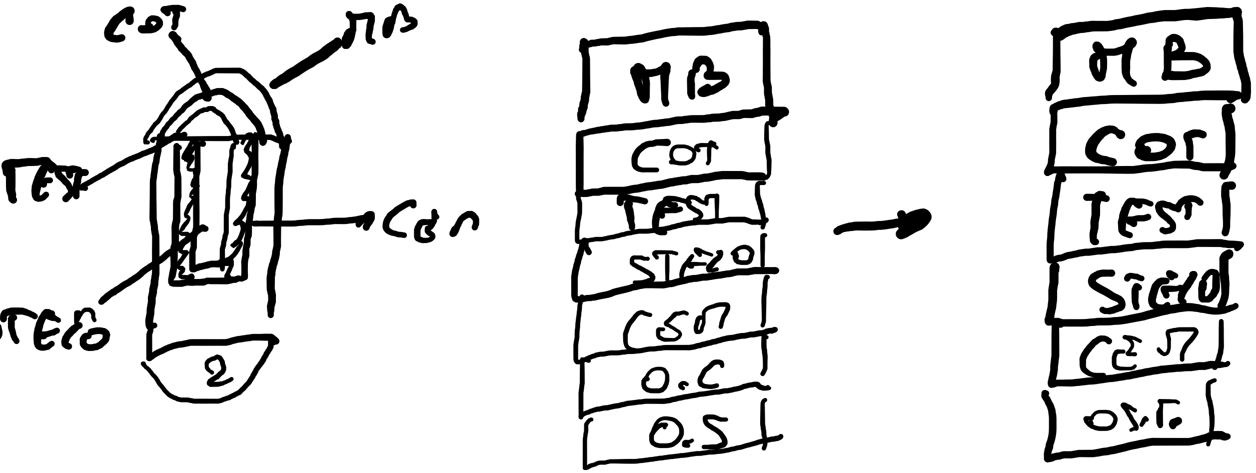
2) perdita ortotropia.

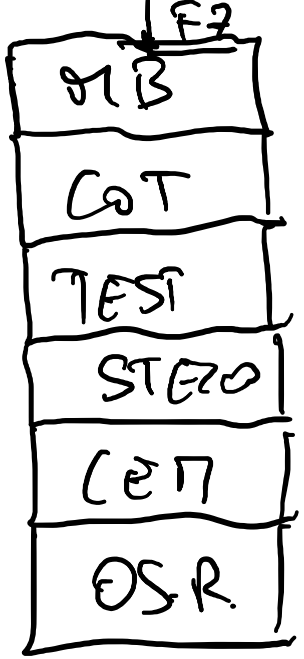
Omogenizzazione totale



$$\frac{1}{E_z} = \frac{f_1'}{E_{os}} + \frac{f_2}{E_{oc}^{z}}$$

$$E_{xy} = f_1' E_{os} + f_2 E_{oc}^{xy}$$





$$\frac{1}{E_z} = \frac{\rho_{MB}}{E_{MB}} + \frac{\rho_{COT}}{E_{COT}} + \frac{\rho_{TEST}}{E_{TEST}} + \frac{\rho_{STERO}}{E_{STERO}} + \frac{\rho_{CEM}}{E_{CEM}} + \frac{\rho_{OSR}}{E^{z}_{O.R}}$$

$$E_{xy} = \rho_{MB} E_{MB} + \rho_{COT} E_{COT} + \rho_{TEST} E_{TEST} + \rho_{ST} \cdot E_{ST} + \rho_{CEM} \cdot E_{CEM} + \rho_{OSRES} \cdot E^{xy}_{O.R}$$

$$\rho_{MB} + \rho_{COT} + \rho_{TEST} + \rho_{ST} + \rho_{CEM} + \rho_{OSRES} = 1$$

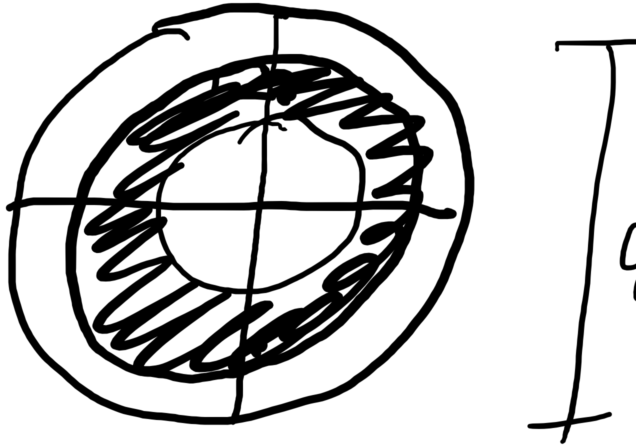
Iso 1 = $\sigma_{xy} = \sigma_z$

$$\frac{R_z}{2\pi R^2_{MB_{int}}} = \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{MB_{int}}}{h_{MB}}}$$

Iso 2

$$\frac{R_z}{2\pi R^2_{TEST}} = \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{TEST}}{h_{TEST}}}$$

I_{SO3} $\frac{R_z}{\pi R_{st}^2} = \frac{R_{xy}}{2\pi R_{st} h_{st}}$



I_{SO4} $\frac{R_z}{\pi (R_{st}+\delta_{cem})^2} = \frac{R_{xy}}{2\pi (R_{st}+\delta_{cem})(h_{st}+\delta_{cem})}$

$\approx$

2πBcst = 2.ca

δ_{COT} = 10.2 mm.

$\frac{R_z}{\pi (R_{st}+\delta_{cem})^2} = \frac{R_{xy}}{2\pi (R_{st}+\delta_{cem}) h_{st}}$

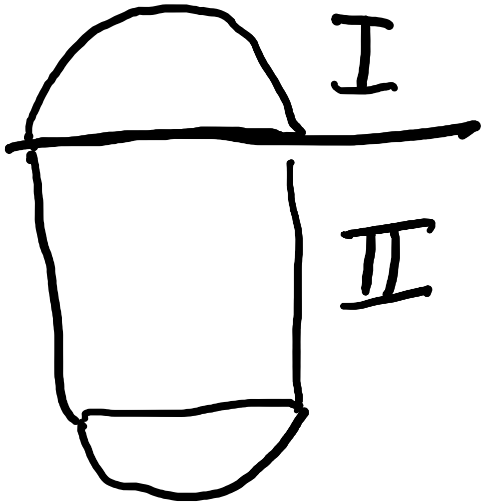
1 mm < δ_{cem} < 2 mm

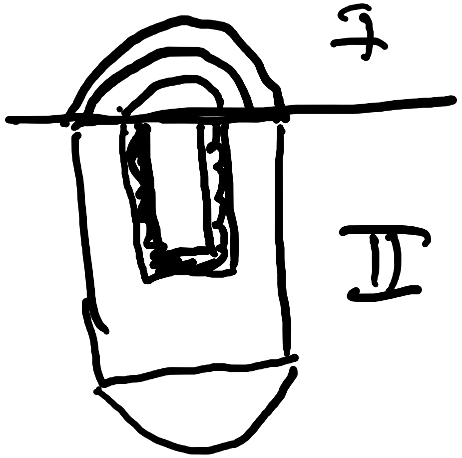
$\delta_{cem} \simeq 1.1$ mm.

1) Perdita ortotropia

2) perdita di isostress tra c.a e n.B.

Pontuale parziale

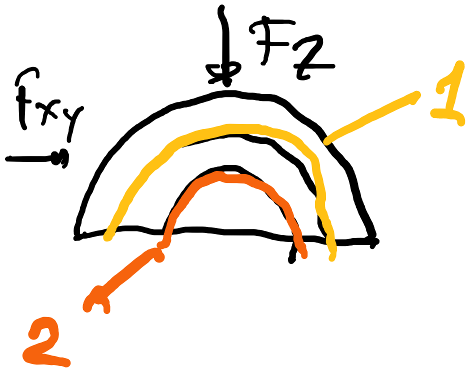




$$\varepsilon_{oss\,sano} = \varepsilon_{oss + protesi}$$

$$\varepsilon^{xy}_{os.sano} = \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3 ep_1}{h\,ep_1}} \cdot \frac{1}{\varepsilon_{oss.sp.}}$$

$$\varepsilon^{z}_{os.sano} = \frac{R_z}{2\pi R^2 ep_1} \cdot \frac{1}{\varepsilon_{os.spo}}$$



$$\varepsilon_{xy} = \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{MB}}{h_{MB}}} \cdot \frac{1}{E_{MB}} + \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{COT}}{h_{COT}}} \cdot \frac{1}{E_{COT}} + \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{TEST}}{h_{TEST}}} \cdot \frac{1}{E_{TEST}}$$

$$\varepsilon_{Z} = \frac{R_Z}{2\pi R^2_{MB}} \cdot \frac{1}{E_{MB}} + \frac{R_Z}{2\pi R^2_{COT}} \cdot \frac{1}{E_{COT}} + \frac{R_Z}{2\pi R^2_{TEST}} \cdot \frac{1}{E_{TEST}}$$

$I_{So\,1}$

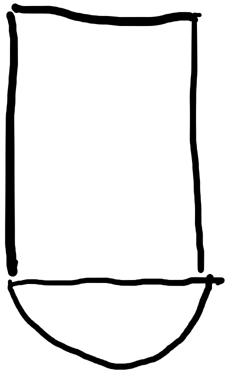
$$\frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{COT}}{h_{COT}}} = \frac{R_Z}{\pi R^2_{COT}}$$

$$R_{MBest} = R_{a.c.}$$

$$\delta_{COT} = 10.2 \text{ mm.}$$

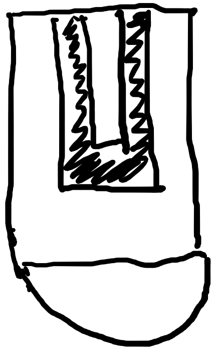
$I_{So\,2}$

$$\frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{TEST}}{h_{TES}}} = \frac{R_Z}{\pi R^2_{TEST}}$$

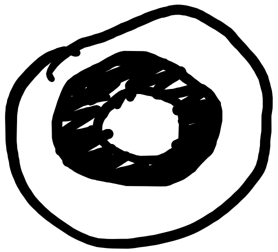


$$\varepsilon_z = \frac{R_z}{\pi R^2_{fem}} \cdot \frac{1}{E^z_{oc.}} + \frac{R_z}{\pi R^2_{epz}} \cdot \frac{1}{E_{os}}$$

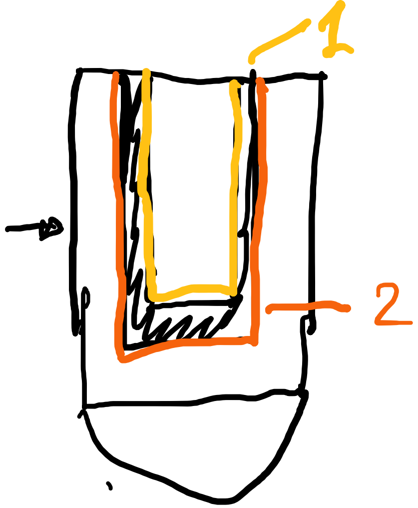
$$\varepsilon_{xy} = \frac{R_{xy}}{2\pi R_{fem} h_{fem}} \cdot \frac{1}{E^{xy}_{oc}} + \frac{R_{xy}}{\frac{\frac{2}{3}\pi R^3_{epz}}{h_{ep1}}} \cdot \frac{1}{E_{os}}$$



$$\varepsilon_z = \frac{R_z}{\pi R^2_{st}} \cdot \frac{1}{E_{ST}} + \frac{R_z}{\pi (R_{st} + \delta_{cem})^2 - \pi R^2_{st}} \cdot \frac{1}{E_{cem}} +$$



$$+ \frac{R_z}{\pi R^2_{fem} - \pi (R_{st} + \delta_{cem})^2} \cdot \frac{1}{E^z_{ostes}} + \frac{R_z}{\pi R^2_{epi}} \cdot \frac{1}{E_{ossp.}}$$



$$\varepsilon_{xy} = \frac{R_{xy}}{2\pi R_{fem} \cdot h_{fem}} \cdot \frac{1}{E^{xy}_{o.c\,res}} + \frac{R_{xy}}{2\pi (R_{st}+\delta_{cem})(h_{st}+\delta_{cem})} \cdot \frac{1}{E_{cem}}$$

$$+ \frac{R_{xy}}{2\pi R_{st} h_{st}} \cdot \frac{1}{E_{st}} + \frac{R_{xy}}{\frac{2}{3}\pi \frac{R_{ep_2}}{h_{ep_2}}} \cdot \frac{1}{E_{os.res}}$$

JS_{o1} $$\frac{R_z}{\pi R^2_{st}} = \frac{R_{xy}}{2\pi R_{st} h_{st}}$$

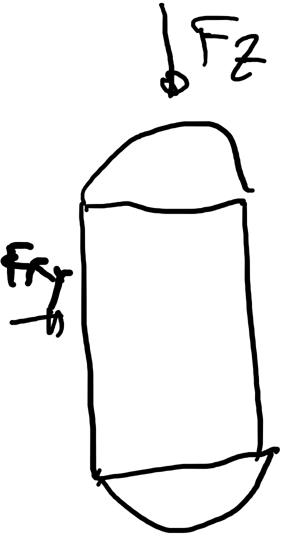
JS_{o2} $$\frac{R_z}{\pi (R_{st}+\delta_{cem})^2} = \frac{R_{xy}}{2\pi (R_{st}+\delta_{cem})(h_{st}+\delta_{cem})}$$

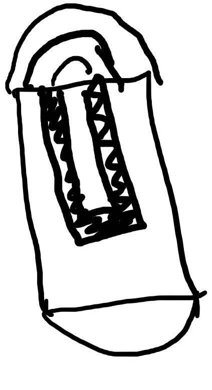
1) perdita di ortotropia.

2) a) o non è stato valutato bene

b) α non valutato correttamente

Metodo puntuale totale





$$\varepsilon_z = \frac{R_z}{2\pi R^2_{ep1}} \cdot \frac{1}{E_{pr1}} + \frac{R_z}{\pi R^2_{fem}} \cdot \frac{1}{E^z_{oc}} + \frac{R_z}{\pi R^2_{ep2}} \frac{1}{E_{pr2}}$$

$$\varepsilon_{xy} = \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{ep1}}{h_{ep1}}} \cdot \frac{1}{E_{pr1}} + \frac{R_{xy}}{2\pi R_{fem} h_{fem}} \cdot \frac{1}{E^{xy}_{oc}} + \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{ep2}}{h_{ep2}}} \cdot \frac{1}{E_{pr2}}$$

$$\varepsilon_Z = \frac{R_z}{2\pi R^2_{MB}} \cdot \frac{1}{E_{MB}} + \frac{R_z}{2\pi R^2_{COT}} \cdot \frac{1}{E_{COT}} + \frac{R_z}{2\pi R^2_{TES}} \cdot \frac{1}{E_{TEST}} + \frac{R_z}{\pi R^2_{St}} \cdot \frac{1}{E_{ST}}$$

$$+ \frac{R_z}{\pi (R_{St} + \delta_{cem})^2 - \pi R^2_{St}} \cdot \frac{1}{E_{CEM}} + \frac{R_z}{\pi R^2_{fem} - \pi (R_{St} + \delta_{cem})^2} \cdot \frac{1}{E_{OC.res}^{z}} +$$

$$+ \frac{R_z}{\pi R^2_{ep2}} \cdot \frac{1}{E_{osres}}$$

$$\varepsilon_{xy} = \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{MB}}{h_{MB}}} \cdot \frac{1}{E_{MB}} + \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{COT}}{h_{COT}}} \cdot \frac{1}{E_{COT}} + \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{TEST}}{h_{TEST}}} \cdot \frac{1}{E_{TEST}} + \frac{R_{xy}}{2\pi R_{fem} h_{fem}} \cdot \frac{1}{E^{xy}_{osres}}$$

$$+ \frac{R_{xy}}{2\pi (R_{St} + \delta_{cem}) \cdot (h_{St} + \delta_{cem})} \cdot \frac{1}{E_{CEM}} + \frac{R_{xy}}{2\pi R_{St} h_{St}} \cdot \frac{1}{E_{ST}} + \frac{R_{xy}}{\frac{2}{3}\pi \frac{R^3_{ep2}}{h_{ep2}}} \cdot \frac{1}{E_{osres}}$$

2πBest

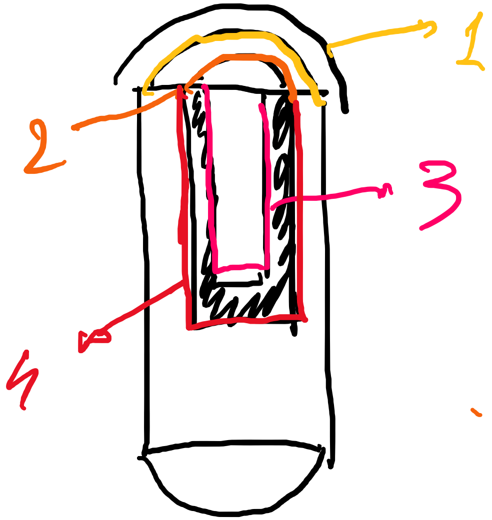
2πBint = 2cotest

ℓcotint = ℓtest

ℓst

hst

δcem



$$Iso1 \quad \frac{Rz}{2\pi R^2_{cot}} = \frac{Rxy}{\frac{2}{3}\pi \frac{R^3_{cot}}{n_{cot}}}$$

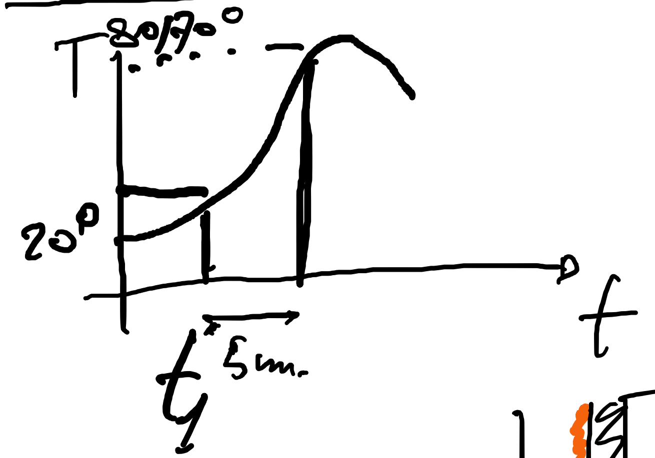
$$Iso2 \quad \frac{Rz}{2\pi R^2_{TES}} = \frac{Rxy}{\frac{2}{3}\pi \frac{R^3_{TEST}}{n_{TES}}}$$

$$Iso3 \quad \frac{Rz}{\pi R^2_{st}} = \frac{Rxy}{2\pi R_{st} h_{st}}$$

$$Iso4 \quad \frac{Rz}{\pi (R_{st} + \delta_{cem})^2} = \frac{Rxy}{2\pi (R_{st} + \delta_{cem})(h_{st} + \delta_{cem})}$$

1) Perdite di ortotropia

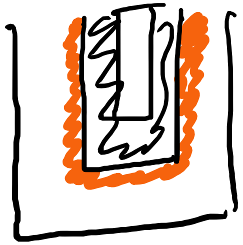
2) più gradi di libertà
- θ non è fisso
- α non è fisso
- σ bonding e σ torsione non sono trascurabili.

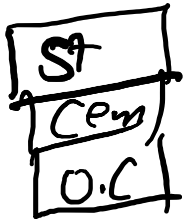


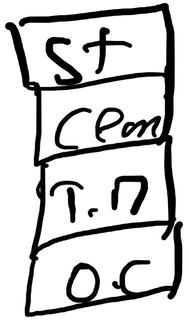
$\delta_{cem} = 1$ mm

$\delta_{cem}^{real} = 1.04$ mm.

ritiro volumetrico = 4 %.







$$\frac{\partial T}{\partial t} = D \frac{\partial^2 T}{\partial x^2} \qquad D = \frac{\text{conducibilità termica}}{\text{densità} \cdot \text{calore specifico}}$$

$$D = \frac{K}{\rho c_p} \qquad [K] = \left[\frac{W}{m \cdot {}^\circ K}\right] \qquad [\rho] = \left[\frac{Kg}{m^3}\right]$$

$$[c_p] = \left[\frac{J}{Kg \cdot {}^\circ K}\right]$$

$$[D] = \frac{W}{\cancel{m} \cdot \cancel{{}^\circ K}} \cdot \frac{m^{\cancel{3}\,2}}{\cancel{Kg}} \cdot \frac{\cancel{Kg}\ \cancel{{}^\circ K}}{J} = \left[\frac{\cancel{J}}{s} \cdot \frac{m^2}{\cancel{J}}\right] = \frac{m^2}{s}$$

$$\frac{\partial T}{\partial t} = D\frac{\partial^2 T}{\partial x^2}$$

$$T(t, x)$$

$$\begin{cases} \dfrac{\partial T}{\partial t} = A = \text{cost} \\ D\dfrac{\partial^2 T}{\partial x^2} = A = \text{cost} \end{cases}$$

$$\partial T = A\,\partial t$$

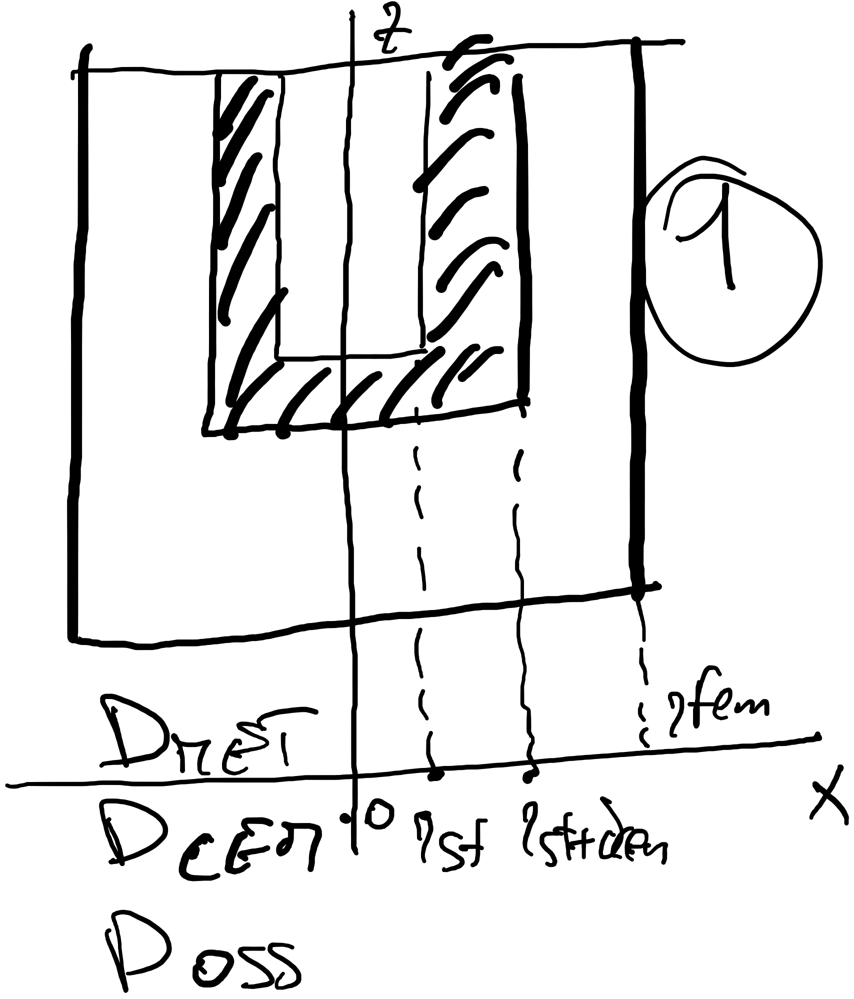
$$\int_{T(x,0)}^{T(x,t^*)} \partial T = A\int_0^{t^*} t$$

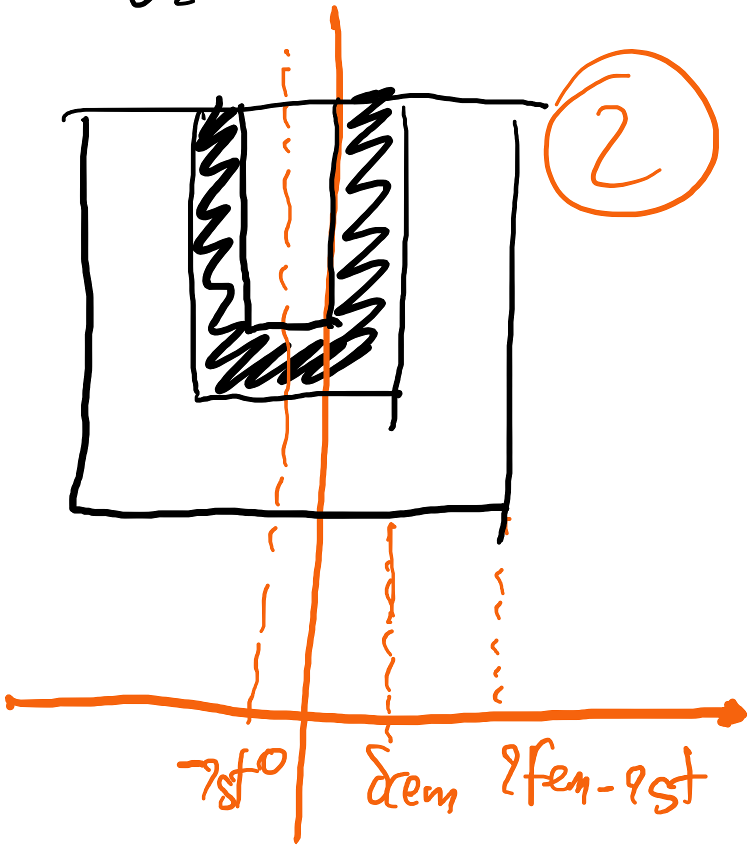
$$T(x,t^*) - T(x,0) = A t^*$$

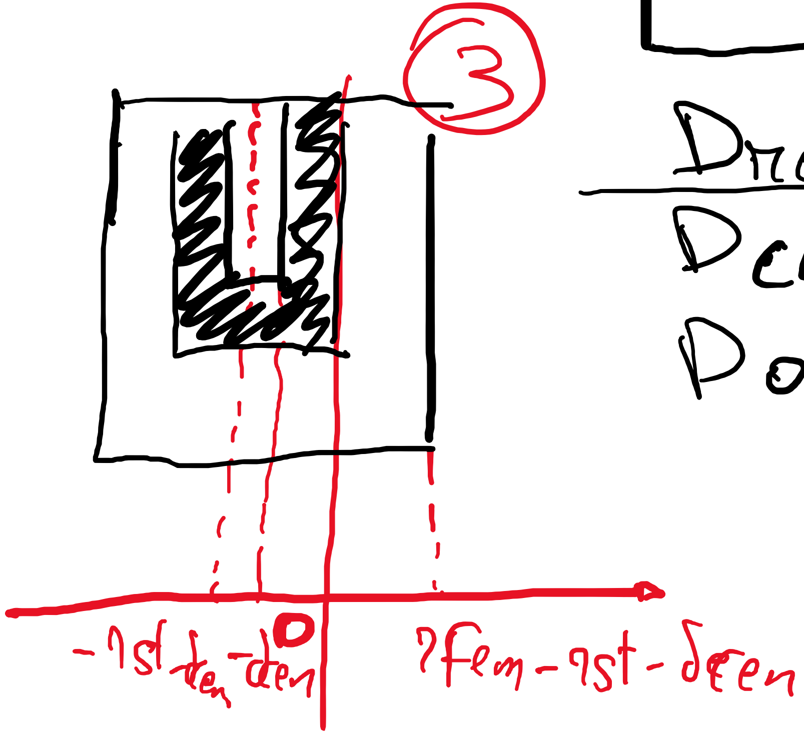
$$A = \frac{T(x,t^*) - T(x,0)}{t^*}$$

$$D\frac{\partial^2 T}{\partial x^2} = A$$

$$\frac{\partial^2 T}{\partial x^2} = \frac{A}{D}$$







$$\frac{\partial^2 T}{\partial x^2} = \frac{A}{D} = B$$

$$\int\int_{T(0,t)}^{T(x,t)} \partial^2 T = \int\int_{0}^{x} B \, \partial x^2$$

$$\int T(x,t) - T(0,t) \, \delta T = B(x + \Gamma)$$

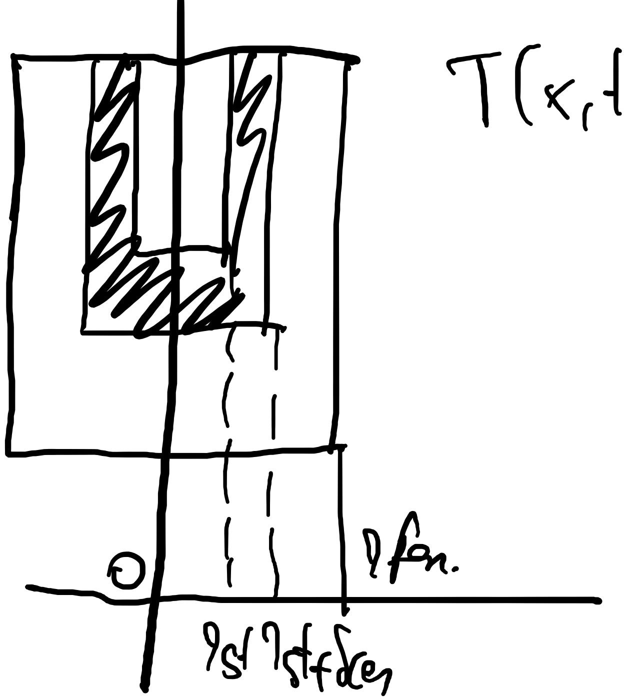
$$\frac{T^2(x,t)}{2} - \frac{T^2(0,t)}{2} = B\left(\frac{x^2}{2} + \Gamma x + \varepsilon\right) = \frac{A}{D}\left(\frac{x^2}{2} + \Gamma x + \varepsilon\right)$$

$$\frac{T^2(x,t)}{2} - \frac{T^2(0,t)}{2} = \frac{T(x,t^*) - T(x,0)}{t^* \quad D}\left(\frac{x^2}{2} + \Gamma x + \varepsilon\right)$$

$$t = t^*$$

$$\frac{T^2(x,t^*)}{2} - \frac{T^2(0,t^*)}{2} = \frac{T(x,t^*) - T(x,0)}{t^* \quad D}\left(\frac{x^2}{2} + \Gamma x + \varepsilon\right)$$

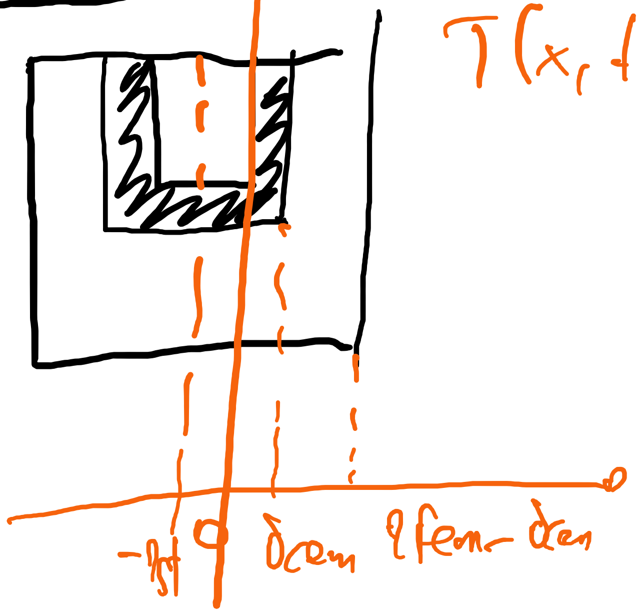
$$T(x,t^*) < \frac{1}{2}$$



$T(x,t)$

$$T(0,0) = 20°C$$
$$T(l_{st},0) = 70/80°C$$
$$T(\infty,0) = 37°C$$
$$T(l_{st},\infty) = 37°C$$

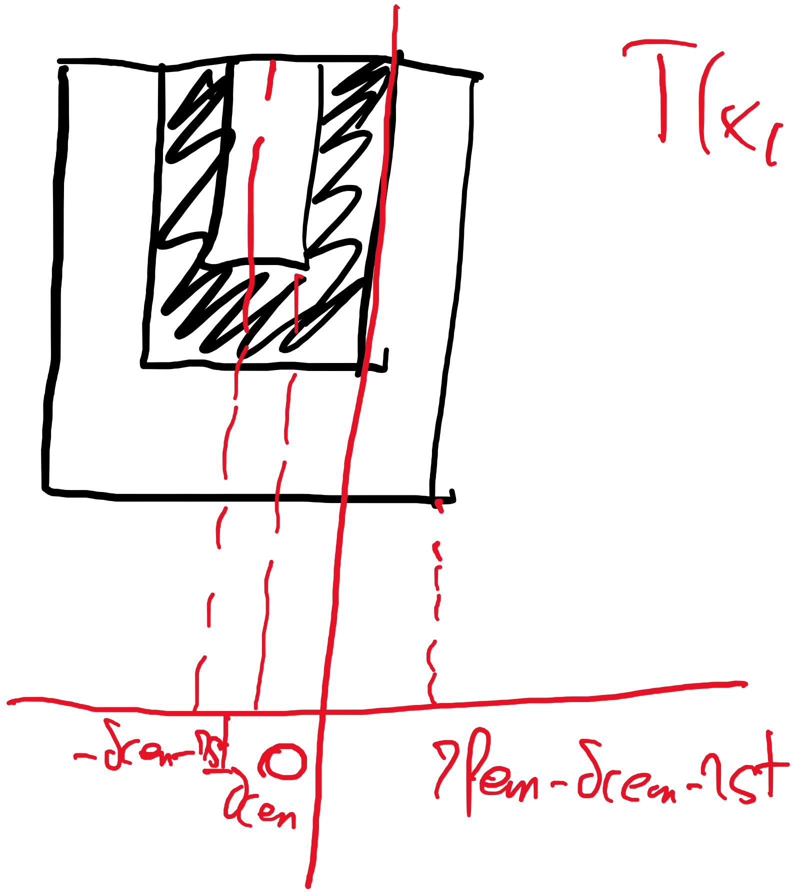
D_{stelo}



$T(x,t)$

$$T(0,0) = 70/80°C$$
$$T(\delta_{cem},0) = 37°C$$
$$T(\infty,0) = 37°C$$
$$T(\delta_{cem},\infty) = 37°C$$

D_{cem}



$T(x,t)$

$$T(0,0) = 37°C$$

$$T(-\delta_{cem}, 0) = 70°/80° C$$

$$T(2f_{em}-\delta_{cem}-2s_t, 0) = 37°C$$

$$T(2f_{em}-\delta_{cem}-2s_t, 8) = 37°C$$

D_{osso}