Polyglot Sidequest

$$\frac{d}{dx}\left(\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\vec{w}\right)\right)\right)=\vec{f}$$

$$\vec{w}=\begin{bmatrix} w_x \\ w_y \\ w_z \end{bmatrix}=\begin{bmatrix} \alpha \\ \beta \\ \theta \end{bmatrix}$$

Step 2:

$N_1=(1-\epsilon-\eta-\phi)(2(1-\epsilon-\eta-\phi)-1)$

$N_2=\epsilon(2\epsilon-1)$

$N_3=\eta(2\eta-1)$

$N_4=\phi(2\phi-1)$

$N_5=4\epsilon\eta$

$N_6=4\eta\phi$

$N_7=4\epsilon\phi$

$N_8=4\epsilon(1-\epsilon-\eta-\phi)$

$N_9=4\eta(1-\epsilon-\eta-\phi)$

$N_{10}=4\phi(1-\epsilon-\eta-\phi)$

$$\alpha=[N_1\ N_2\ N_3\ \dots\ N_9\ N_{10}]\begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \vdots \\ \alpha_9 \\ \alpha_{10} \end{bmatrix} \qquad \beta\approx[N_1\ N_2\ N_3\ \dots\ N_9\ N_{10}]\begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \vdots \\ \beta_9 \\ \beta_{10} \end{bmatrix}$$

$$\alpha=\underline{\underline{N}}\,\underline{\underline{\alpha}} \qquad \beta\approx\underline{\underline{N}}\,\underline{\underline{\beta}}$$

$$\theta\approx[N_1\ N_2\ N_3\ \dots\ N_9\ N_{10}]\begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \vdots \\ \theta_9 \\ \theta_{10} \end{bmatrix}$$

$$\theta\approx\underline{\underline{N}}\,\underline{\underline{\theta}}$$

Cambio $\vec{w}$ a $\vec{H}$

$$\vec{H}=\begin{bmatrix} \alpha \\ \beta \\ \theta \end{bmatrix} \qquad \vec{H}\approx\begin{bmatrix} N & 0 & 0 \\ 0 & N & 0 \\ 0 & 0 & N \end{bmatrix}*\begin{bmatrix} \alpha \\ \beta \\ \theta \end{bmatrix}$$

$$\vec{H}\approx\underline{\underline{N}}^{*}\,\underline{\underline{w}}$$

$$\frac{d}{dx}\left(\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)\right)=f$$

Step 3:

$$R=\vec{f}-\frac{d}{dx}\left(\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)\right)$$

Step 4:

$$\int_v \underline{\underline{w}}^* R\,dv=0$$

$$\int_v \underline{\underline{w}}^*\left(\vec{f}-\frac{d}{dx}\left(\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)\right)\right)dv=0$$

$$\int_v \underline{\underline{w}}\frac{d}{dx}\left(\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)\right)dv=\int \underline{\underline{w}}^*\vec{f}$$

Step 5:

$$\int \underline{\underline{N}}^T\frac{d}{dx}\left(\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)\right)dv=\int \underline{\underline{N}}^T\vec{f}\,dv$$

Step 6:

$$U=\underline{\underline{N}}^T \qquad dv=\frac{d}{dx}\left(\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)\right)$$

$$du=\frac{d}{dx}\underline{\underline{N}}^T \qquad v=\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)$$

$$\underbrace{\underline{\underline{N}}^T\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)}_{N_1}-\int\frac{d}{dx}\underline{\underline{N}}^T\left(\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)\right)dv$$

$$U=\frac{d}{dx}\underline{\underline{N}}^T \qquad dv=\frac{d}{dx}\left(EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)\right)$$

$$du=\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}^T\right) \qquad v=EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)$$

$$N_1-\left(\frac{d}{dx}\underline{\underline{N}}^T * EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}^*\underline{\underline{w}}\right)\right)-\int_v\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}^T\right)EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)=\int N^T\vec{f}\,dv$$

$$\int\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}^T\right)EI\frac{d}{dx}\left(\frac{d}{dx}\underline{\underline{N}}\,\underline{\underline{w}}\right)dv=\int N^T\vec{f}\,dv$$

Sistema Local Final:

$$\mathbf{K}\mathbf{X} = \mathbf{b}$$

$$\mathbf{K}_{30x30} = EIJ \begin{bmatrix} \boldsymbol{\mu} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \boldsymbol{\mu} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \boldsymbol{\mu} \end{bmatrix}$$

$$J = \begin{vmatrix} x_2 - x_1 & x_3 - x_1 & x_4 - x_1 \\ y_2 - y_1 & y_3 - y_1 & y_4 - y_1 \\ z_2 - z_1 & z_3 - z_1 & z_4 - z_1 \end{vmatrix}$$

$$\boldsymbol{\mu}_{10x10} = \begin{bmatrix} A & E & 0 & 0 & -F & 0 & -F & G & F & F \\ E & B & 0 & 0 & -H & 0 & -H & I & H & H \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -F & -H & 0 & 0 & C & 0 & J & -K & -C & -J \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -F & -H & 0 & 0 & J & 0 & C & -K & -J & -C \\ G & I & 0 & 0 & -K & 0 & -K & D & K & K \\ F & H & 0 & 0 & -C & 0 & -J & K & C & J \\ F & H & 0 & 0 & -J & 0 & -C & K & J & C \end{bmatrix}$$

$$A = -\frac{1}{192c_2^2}(4c_1 - c_2)^4 - \frac{1}{24c_2}(4c_1 - c_2)^3 - \frac{1}{3840c_2^3}(4c_1 - c_2)^5 + \frac{1}{3840c_2^3}(4c_1 + 3c_2)^5$$

$$B = -\frac{1}{192c_2^2}(4c_1+c_2)^4 + \frac{1}{24c_2}(4c_1+c_2)^3 + \frac{1}{3840c_2^3}(4c_1+c_2)^5 - \frac{1}{3840c_2^3}(4c_1-3c_2)^5$$

$$C = \frac{4}{15}c_2^2$$

$$D = \frac{1}{192c_2^2}(4c_2-c_1)^4 - \frac{1}{3840c_2^3}(4c_2-c_1)^5 + \frac{1}{7680c_2^3}(4c_2+8c_1)^5 - \frac{7}{7680c_2^3}(4c_2-8c_1)^5 + \frac{1}{768c_2^3}(-8c_1)^5 - \frac{c_1}{96c_2^3}(4c_2-8c_1)^4 + \frac{2c_1-1}{192c_2^3}(-8c_1)^4$$

$$E = \frac{8}{3}c_1^2 + \frac{1}{30}c_2^2$$

$$F = \frac{2}{3}c_1c_2 - \frac{1}{30}c_2^2$$

$$G = -\frac{16}{3}c_1^2 - \frac{4}{3}c_1c_2 - \frac{2}{15}c_2^2$$

$$H = \frac{2}{3}c_1c_2 + \frac{1}{30}c_2^2$$

$$I = -\frac{16}{3}c_1^2 - \frac{2}{3}c_2^2$$

$$J = \frac{2}{15}c_2^2$$

$$K = -\frac{4}{3}c_1 c_2$$

$$c_1 = \frac{1}{(x_2 - x_1)^2}$$

$$c_2 = \frac{1}{x_2 - x_1}(4x_1 + 4x_2 - 8x_8)$$

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$$\mathbf{b}_{30x1} = \frac{J}{120}\begin{bmatrix} \boldsymbol{\tau} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \boldsymbol{\tau} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \boldsymbol{\tau} \end{bmatrix} \vec{f}$$

$$\boldsymbol{\tau}_{10x1} = \begin{bmatrix} 59 \\ -1 \\ -1 \\ -1 \\ 4 \\ 4 \\ 4 \\ 4 \\ 4 \\ 4 \end{bmatrix}$$