Ecuación a resolver en 4 dimensiones

$$-\nabla(\nabla K T) = Q$$

$$\nabla = \begin{bmatrix} \frac{\delta}{\delta x} \\ \frac{\delta}{\delta y} \\ \frac{\delta}{\delta z} \\ \frac{\delta}{\delta p} \end{bmatrix}$$

Operador nabla

$\frac{\delta}{\delta p}$ → Cuarta dimensión

paso 1 Localización

$N_1 = 1 - \epsilon - \eta - \phi - \Omega$

$N_2 = \epsilon$

$N_3 = \eta$

$N_4 = \phi$

$N_5 = \Omega$

partición de la unidad

$$1 - \cancel{\epsilon} - \cancel{\eta} - \cancel{\phi} - \cancel{\Omega} + \cancel{\epsilon} + \cancel{\eta} + \cancel{\phi} + \cancel{\Omega} = 1$$

$1 = 1$ Cumple la condición

Mantenimiento de la Frontera

$N_1(0,0,0,0) = 1$
$N_1(1,0,0,0) = 0$
$N_1(0,1,0,0) = 0$
$N_1(0,0,1,0) = 0$
$N_1(0,0,0,1) = 0$

$N_3(0,0,0,0) = 0$
$N_3(1,0,0,0) = 0$
$N_3(0,1,0,0) = 1$
$N_3(0,0,1,0) = 0$
$N_3(0,0,0,1) = 0$

$N(0,0,0,0) = 0$
$N(1,0,0,0) = 0$
$N(0,1,0,0) = 0$
$N(0,0,1,0) = 0$
$N(0,0,0,1) = 1$

$N_2(0,0,0,0) = 0$
$N_2(1,0,0,0) = 1$
$N_2(0,1,0,0) = 0$
$N_2(0,0,1,0) = 0$
$N_2(0,0,0,1) = 0$

$N_4(0,0,0,0) = 0$
$N_4(1,0,0,0) = 0$
$N_4(0,1,0,0) = 0$
$N_4(0,0,1,0) = 1$
$N_4(0,0,0,1) = 0$

$$N_1(0,0,0,0)t_2 + N_2(0,0,0,0)t_2 + N_3(0,0,0,0)t_3 + N_4(0,0,0,0)t_4 + N_5(0,0,0,0)t_5$$

$$= T_1$$

$$N_1(1,0,0,0)t_2 + N_2(1,0,0,0)t_2 + N_3(1,0,0,0)t_3 + N_4(1,0,0,0)t_4 + N_5(1,0,0,0)t_5$$

$$= t_2$$

$$N_1(0,1,0,0)t_2 + N_2(0,1,0,0)t_2 + N_3(0,1,0,0)t_3 + N_4(0,1,0,0)t_4 + N_5(0,1,0,0)t_5$$

$$= t_3$$

$$N_1(0,0,1,0)t_2 + N_2(0,0,1,0)t_2 + N_3(0,0,1,0)t_3 + N_4(0,0,1,0)t_4 + N_5(0,0,1,0)t_5$$

$$= T_4$$

$N_1(0,0,0,1)t_2 + N_2(0,0,0,1)\,t_2 + N_3(0,0,0,1)t_3 + N_4(0,0,0,1)t_4 + N_5(0,0,0,1)t_5$

$= t_5$

Paso 2 Interpolación

$$\underline{\underline{T}} \approx N_1 t_1 + N_2 t_2 + N_3 t_3 + N_4 t_4 + N_5 t_5$$

$$\begin{bmatrix} N_1 & N_2 & N_3 & N_4 & N_5 \end{bmatrix} \begin{bmatrix} T_1 \\ t_2 \\ t_3 \\ t_4 \\ t_5 \end{bmatrix} = \underline{\underline{N}}\,\underline{\underline{T}}$$

$\underline{\underline{T}} \approx \underline{\underline{N}}\,\underline{\underline{T}}$ * En notación matricial

Paso 3 Aproximación del modelo

$$-\nabla\left(\nabla k \underline{\underline{T}}\right) = Q \quad \text{(Modelo original)}$$

$$-\nabla(k \nabla \underline{\underline{N}})\underline{\underline{t}} \approx Q \quad \text{(modelo aproximado)}$$

Definición del residual

$$R = Q + \nabla(k \nabla \underline{\underline{N}})\underline{\underline{t}}$$

Paso 4 Método de los residuos ponderados

$$\int W R \, dHV = 0$$

HV = Hiper Volumen

$$\int_{HV} \underline{\underline{W}} \left(Q + \nabla (k \nabla \underline{\underline{N}}) \underline{\underline{T}} \right) dHV = 0$$

Paso 5 Método de Galerkin

$$\underline{\underline{W}} = \underline{\underline{N}}^{t}$$

$$\int_{HV} \underline{\underline{N}}^{t} \left(Q + \nabla (k \nabla \underline{\underline{N}}) \underline{\underline{T}} \right) dHV$$

$$-\int_{HV} \underline{\underline{N}}^{t} \left(\nabla (k \nabla \underline{\underline{N}}) \right) \underline{\underline{T}} \, dHV = \int_{HV} \underline{\underline{N}}^{t} Q \, dHV$$

Resolución de las integrales

Integral izquierda

$$-\int_{HV} N^{t} \nabla(K \nabla N) \underline{\underline{T}} \, dHV = \left(\int_{HV} N^{t} \nabla(K \nabla N) \, dHV \right) \underline{\underline{T}}$$

T afuera para mayor comodidad

método de integración por partes

$U = N^{t}$ $\quad V = K \nabla N$

$dU = \nabla N^{t}$ $\quad dV = \nabla(K \nabla N)$

$$\underline{N^{t} K \nabla N} + \underbrace{\int_{HV} \nabla N^{t} K \nabla N \, dV}$$

• término a ignorar ya que se utilizará en condición de frontera

$$\nabla N = \begin{bmatrix} \frac{\delta}{\delta x} \\ \frac{\delta}{\delta y} \\ \frac{\delta}{\delta z} \\ \frac{\delta}{\delta p} \end{bmatrix} \begin{bmatrix} 1-\epsilon-\eta-\phi-\Omega & \epsilon & \eta & \phi & \Omega \end{bmatrix}$$

$$\begin{bmatrix} \frac{\delta}{\delta x} \\ \frac{\delta}{\delta y} \\ \frac{\delta}{\delta z} \\ \frac{\delta}{\delta p} \end{bmatrix} = J^{-1} \begin{bmatrix} \frac{\delta}{\delta \epsilon} \\ \frac{\delta}{\delta \eta} \\ \frac{\delta}{\delta \phi} \\ \frac{\delta}{\delta \Omega} \end{bmatrix}$$

$$\nabla N = J^{-1} \begin{bmatrix} \frac{\delta}{\delta \epsilon} \\ \frac{\delta}{\delta \eta} \\ \frac{\delta}{\delta \phi} \\ \frac{\delta}{\delta \Omega} \end{bmatrix} \begin{bmatrix} -\epsilon-\eta-\phi-\Omega & \epsilon & \eta & \phi & \Omega \end{bmatrix}$$

$$\cancel{\nabla N = J^{-1}} \begin{bmatrix} -1 & 1 & 0 & 0 & 0 \\ - & 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 \\ -1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\nabla N = \frac{1}{J} \underline{\underline{A}}\, \underline{\underline{B}}$$

$$\boxed{\text{Jacobiano inverso} \quad J^{-1} = \frac{1}{J} A}$$

$$\nabla N^T = \frac{1}{J} B^T A^T$$

* Ignorando término de Dirichlet

$$\int_{HV} \nabla N^T K \nabla N \, dHV = \frac{1}{J} \underline{\underline{B}}^T \underline{\underline{A}}^T K \frac{1}{J} \underline{\underline{A}}\,\underline{\underline{B}} \int_{HV} dHV = \boxed{\frac{(HV)}{J^2} B^T A^T A B}$$

Resolución integral izquierda

$$\int_{HV} dHV = HV$$

Integral de la derecha

$$\int_{HV} Q N^T \, dHV \rightarrow Q \iiiint N^T \, dx\,dy\,dz\,dp$$

$$dx\,dy\,dz\,dp = J \, d\epsilon \, d\eta \, d\phi \, d\Omega$$

$$= Q J \iiiint N^T \, d\epsilon \, d\eta \, d\phi \, d\Omega$$

$$= QJ \iiiint \begin{bmatrix} 1-\epsilon-\eta-\phi-\Omega \\ \epsilon \\ \eta \\ \phi \\ \Omega \end{bmatrix} d\epsilon \, d\eta \, d\phi \, d\Omega$$

Comenzaremos con

$$\int_{HV} \eta \, dHV$$ (Dejaremos las constantes afuera por comodidad)

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \int_0^{1-\Omega-\eta-\phi} \eta \; d\sigma \, d\eta \, d\phi \, d\Omega$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \eta \int_0^{1-\Omega-\eta-\phi} d\sigma \, d\eta \, d\phi \, d\Omega$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \eta \; (1-\Omega-\eta-\phi) \, d\eta \, d\phi \, d\Omega$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} (\eta - \eta\Omega - \eta^2 - \eta\phi) \, d\eta \, d\phi \, d\Omega$$

Resolución de integuales separadas

- $$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \eta \, d\eta \, d\phi \, d\Omega = \int_0^1 \int_0^{1-\Omega} \frac{(1-\Omega-\phi)^2}{2} \, d\phi \, d\Omega$$

- $$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \eta\Omega \, d\eta \, d\phi \, d\Omega = \int_0^1 \int_0^{1-\Omega} \Omega \, \frac{(1-\Omega-\phi)^2}{2} \, d\phi \, d\Omega$$

- $$\int_0^1\int_0^{1-\Omega}\int_0^{1-\Omega-\phi}\eta^2\,d\eta\,d\phi\,d\Omega=\int_0^1\int_0^{1-\Omega}\frac{(1-\Omega-\phi)^3}{3}\,d\phi\,d\Omega$$

- $$\int_0^1\int_0^{1-\Omega}\int_0^{1-\Omega-\phi}\eta\,\phi\,d\eta\,d\phi\,d\Omega=\int_0^1\int_0^{1-\Omega}\phi\,\frac{(1-\Omega-\phi)^2}{2}\,d\phi\,d\Omega$$

Uniendo respuestas de cada integral

$$\left(\int_0^1\int_0^{1-\Omega}\frac{(1-\Omega-\phi)^2}{2}\,d\phi\,d\Omega-\int_0^1\int_0^{1-\Omega}\Omega\,\frac{(1-\Omega-\phi)^2}{2}\,d\phi\,d\Omega\right.$$

$$\left.-\int_0^1\int_0^{1-\Omega}\frac{(1-\Omega-\phi)^3}{3}\,d\phi\,d\Omega-\int_0^1\int_0^{1-\Omega}\phi\,\frac{(1-\Omega-\phi)^2}{2}\,d\phi\,d\Omega\right)$$

Resolución de cada integral doble anterior

$$\int_0^1\int_0^{1-\Omega}\frac{(1-\Omega-\phi)^2}{2}\,d\phi\,d\Omega=\frac{1}{2}\int_0^1\int_0^{1-\Omega}(1-\Omega-\phi)^2\,d\phi\,d\Omega$$

$$\frac{1}{2}\underline{\int_0^1\int_0^{1-\Omega}(1-\Omega-\phi)^2\,d\phi\,d\Omega}=\frac{1}{2}\left(\frac{1}{12}\right)=\frac{1}{24}$$

Detalle más adelante

$$\int_0^1\int_0^{1-\Omega} \Omega\,\frac{(1-\Omega-\phi)^2}{2}\,d\phi\,d\Omega$$

$$= \frac{1}{2}\underline{\int_0^1 \Omega\int_0^{1-\Omega}(1-\Omega-\phi)^2\,d\phi\,d\Omega} = \frac{1}{2}\left(\frac{1}{60}\right) = \frac{1}{120}$$

Detalle más adelante

$$\int_0^1\int_0^{1-\Omega} \frac{(1-\Omega-\phi)^3}{3}\,d\phi\,d\Omega = \frac{1}{3}\underline{\int_0^1\int_0^{1-\Omega}(1-\Omega-\phi)^3\,d\phi\,d\Omega}$$

Detalle más adelante

$$= \frac{1}{3}\left(\frac{1}{20}\right) = \frac{1}{60}$$

$$\int_0^1\int_0^{1-\Omega} \phi\,\frac{(1-\Omega-\phi)^2}{2}\,d\phi\,d\Omega = \frac{1}{2}\underline{\int_0^1\int_0^{1-\Omega}\phi\,(1-\Omega-\phi)^2\,d\phi\,d\Omega}$$

Detalle más adelante

$$= \frac{1}{2}\left(\frac{1}{60}\right) = \frac{1}{120}$$

*Detalles de integrales dobles en la siguiente página

Uniendo todos los resultados

$$= \frac{1}{24} - \frac{1}{120} - \frac{1}{60} - \frac{1}{120} = \frac{1}{120}$$

Detalles de las integrales

- $$\int_0^1 \int_0^{1-\Omega} (1-\Omega-\phi)^2 \, d\phi \, d\Omega$$

$$\left\{ \begin{array}{l} \text{Sea } u = 1-\Omega-\phi \\ \int u^2 \to \left.\dfrac{u^3}{3}\right|_0^{1-\Omega} = \dfrac{(1-\Omega)^3}{3} - 0 \end{array} \right.$$

$$\frac{1}{3}\int_0^1 (1-\Omega)^3 \, d\Omega$$

$$\left\{ \begin{array}{l} \text{Sea } u = 1-\Omega \\ \int_0 u^3 du = \left.\dfrac{u^4}{4}\right|_0^1 = \dfrac{1}{4} - 0 \end{array} \right.$$

$$\frac{1}{3}\left(\frac{1}{4}\right) = \boxed{\frac{1}{12}}$$

- $$\int_0^1 \Omega \underbrace{\int_0^{1-\Omega} (1-\Omega-\phi)^2 \, d\phi}_{\text{ya conocida por la de arriba}} \, d\Omega \longrightarrow \frac{(1-\Omega)^3}{3}$$

$$\int_0^1 \Omega\left(\frac{-\Omega^3 + 3\Omega^2 - 3\Omega + 1}{3}\right) d\Omega$$

$$\frac{1}{3}\left(\int_0^1 (-\Omega^4 + 3\Omega^3 - 3\Omega^2 + \Omega) \, d\Omega\right)$$

$$\frac{1}{3}\left(-\frac{1}{5} + \frac{3}{4} - \frac{3}{3} + \frac{1}{2}\right) = \boxed{\frac{1}{60}}$$

- $$\int_0^1\int_0^{1-\Omega} (1-\Omega-\phi)^3 \, d\phi \, d\Omega$$

$$\left\{ \begin{array}{l} \text{Sea } u = 1-\Omega-\phi \\ \int_0^{1-\Omega} u^3 du = \frac{u^4}{4}\Big|_0^{1-\Omega} = \frac{(1-\Omega)^4}{4} - 0 \end{array} \right.$$

$$\int_0^1 \frac{(1-\Omega)^4}{4} d\Omega = \frac{1}{4}\int_0^1 (1-\Omega)^4 \, d\Omega$$

$$\left\{ \begin{array}{l} \text{Sea } u = 1-\Omega \\ \int_0^1 u^4 du = \frac{u^5}{5}\Big|_0^1 = \frac{1}{5} - 0 \end{array} \right.$$

$$= \frac{1}{4}\left(\frac{1}{5}\right) = \boxed{\frac{1}{20}}$$

- $$\int_0^1\int_0^{1-\Omega} \phi \quad (1-\Omega-\phi)^2 \, d\phi \, d\Omega$$

$$\int_0^1 \phi \int_0^{1-\phi} (1-\Omega-\phi)^2 \, d\Omega \, d\phi$$

Sea $u = 1-\Omega-\phi)$

$$\int_0^{1-\phi} u^2 du = \frac{u^3}{3}\Big|_0^{1-\phi} = \frac{(1-\phi)^3}{3} - 0$$

$$\frac{1}{3}\int_0^1 \phi(1-\phi)^3 d\phi$$

sea $u = (1-\phi)$

$du = -1 \, d\phi$

$$\int_0^1 -u^3 \cdot (u-1) \, du$$

$$\int_0^1 -u^4 + u^3 \, du = -\frac{u^5}{5} + \frac{u^4}{4}\Big|_0^1 = -\frac{1}{5} + \frac{1}{4} + 0$$

$$\frac{1}{3}\left(-\frac{1}{5} + \frac{1}{4}\right)$$

$$\boxed{= \frac{1}{60}}$$

Fin de detalles de las integrales

$$\int_0^1\int_0^{1-A}\int_0^{1-A-B}\int_0^{1-A-B-C} D \, dC \, dD \, dB \, dA = \frac{1}{120}$$

podemos reorganizar el orden de los límites para que las integrales sean equivalentes

$$\int_0^1\int_0^{1-\Omega}\int_0^{1-\Omega-\phi}\int_0^{1-\Omega-\eta-\phi} \eta \, d\epsilon \, d\eta \, d\phi \, d\Omega = \frac{1}{120}$$

$$\int_0^1\int_0^{1-\Omega}\int_0^{1-\Omega-\phi}\int_0^{1-\Omega-\epsilon-\phi} \epsilon \, d\eta \, d\epsilon \, d\phi \, d\Omega = \frac{1}{120}$$

$$\int_0^1\int_0^{1-\epsilon}\int_0^{1-\epsilon-\phi}\int_0^{1-\epsilon-\phi-\Omega} \Omega \, d\eta \, d\Omega \, d\phi \, d\epsilon = \frac{1}{120}$$

$$\int_0^1\int_0^{1-\epsilon}\int_0^{1-\epsilon-\Omega}\int_0^{1-\epsilon-\Omega-\phi} \phi \, d\eta \, d\phi \, d\Omega \, d\epsilon = \frac{1}{120}$$

$$\int_0^1\int_0^{1-\Omega}\int_0^{1-\Omega-\phi}\int_0^{1-\Omega-\eta-\phi} \underbrace{1-\epsilon-\eta-\phi-\Omega}_{\text{ya los conocemos}} \, d\epsilon \, d\eta \, d\phi \, d\Omega$$

$$\int_0^1\int_0^{1-\Omega}\int_0^{1-\Omega-\phi}\int_0^{1-\Omega-\eta-\phi} 1 \, d\epsilon \, d\eta \, d\phi \, d\Omega - \frac{1}{120} - \frac{1}{120} - \frac{1}{120} - \frac{1}{120}$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \int_0^{1-\Omega-\eta-\phi} 1 \, d\sigma \, d\eta \, d\phi \, d\Omega$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} (1-\Omega-\eta-\phi) \, d\eta \, d\phi \, d\Omega$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} d\eta \, d\phi \, d\Omega = \int_0^1 \int_0^{1-\Omega} (1-\Omega-\phi) \, d\phi \, d\Omega$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \Omega \, d\eta \, d\phi \, d\Omega = \int_0^1 \int_0^{1-\Omega} \Omega (1-\Omega-\phi) \, d\phi \, d\Omega$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \eta \, d\eta \, d\phi \, d\Omega = \int_0^1 \int_0^{1-\Omega} \frac{(1-\Omega-\phi)^2}{2} \, d\phi \, d\Omega$$

$$\int_0^1 \int_0^{1-\Omega} \int_0^{1-\Omega-\phi} \phi \, d\eta \, d\phi \, d\Omega = \int_0^1 \int_0^{1-\Omega} \phi (1-\Omega-\phi) \, d\phi \, d\Omega$$

$$\int_0^1\int_0^{1-\eta} (1-\eta-\phi)\,d\phi\,d\eta - \int_0^1\int_0^{1-\eta} \eta(1-\eta-\phi)\,d\phi\,d\eta$$

$$-\int_0^1\int_0^{1-\eta} \frac{(1-\eta-\phi)^2}{2}\,d\phi\,d\eta - \int_0^1\int_0^{1-\eta} \phi\,(1-\eta-\phi)\,d\phi\,d\eta$$

$$\int_0^1\int_0^{1-\eta} (1-\eta-\phi)\,d\phi\,d\eta = \frac{1}{6}$$

Detalles de las integrales en la siguiente página

$$\int_0^1\int_0^{1-\eta} \eta(1-\eta-\phi)\,d\phi\,d\eta = \frac{1}{24}$$

$$\int_0^1\int_0^{1-\eta} \phi\,(1-\eta-\phi)\,d\phi\,d\eta = \frac{1}{24}$$

$$\int_0^1\int_0^{1-\eta} \frac{(1-\eta-\phi)^2}{2}\,d\phi\,d\eta = \frac{1}{2}\left(\frac{1}{12}\right) = \frac{1}{24}$$

Uniendo las partes

$$\frac{1}{6} - \frac{1}{24} - \frac{1}{24} - \frac{1}{24} = \frac{1}{24}$$

Detalles de las integrales anteriores

- $$\int_0^1\int_0^{1-\Omega} (1-\Omega-\phi)\, d\phi\, d\Omega$$

$$\left\{ \begin{array}{l} \text{Sea } u=(1-\phi-\Omega) \\ \int u = \dfrac{u^2}{2}\Big|_0^{1-\Omega} = \dfrac{(1-\Omega)^2}{2} - 0 \end{array} \right.$$

$$\int_0^1 \frac{(1-\Omega)^2}{2}$$

$$\frac{1}{2}\int_0^1 (1-\Omega)^2$$

$$\left\{ \begin{array}{l} \text{Sea } u = 1-\Omega \\ \int u^2 du = \dfrac{u^3}{3} = \dfrac{u^3}{3}\Big|_0^1 = \dfrac{1}{3} - 0 \end{array} \right.$$

$$\frac{1}{2}\left(\frac{1}{3}\right) = \boxed{\frac{1}{6}}$$

- $$\int_0^1\int_0^{1-\Omega} \Omega(1-\Omega-\phi)\, d\phi\, d\Omega = \int_0^1 \Omega \int_0^{1-\Omega} (1-\Omega-\phi)\, d\phi\, d\Omega$$

$$\int_0^1 \Omega\frac{(1-\Omega)^2}{2}\, d\Omega = \frac{1}{2}\int_0^1 \Omega(1-\Omega)^2\, d\Omega$$

$$= \frac{1}{2}\left(-\frac{1}{4} + \frac{1}{3}\right)$$

$$= \boxed{\frac{1}{24}}$$

sea $u = (1-\Omega)$

$du = -1\, d\Omega$

$$\int_0^1 -u^2\cdot(u-1)\, du$$

$$\int_0^1 -u^3 + u^2 = \frac{u^4}{4} + \frac{u^3}{3}\Big|_0^1$$

Detalles de las integrales anteriores

- $$\int_0^1\int_0^{1-\Omega} \phi\,(1-\Omega-\phi)\,d\phi\,d\Omega = \int_0^1 \phi \int_0^{1-\phi} (1-\Omega-\phi)\,d\Omega\,d\phi$$

(equivalente a la integral anterior)

$$= \boxed{\frac{1}{24}}$$

- $$\int_0^1\int_0^{1-\Omega} \frac{(1-\Omega-\phi)^2}{2}\,d\phi\,d\Omega = \frac{1}{2}\int_0^1\int_0^{1-\Omega} (1-\Omega-\phi)^2\,d\phi\,d\Omega$$

$$U=(1-\Omega-\phi)$$

$$\int U^2 = \left.\frac{U^3}{3}\right|_0^{1-\Omega} = \frac{(1-\Omega)^3}{3}$$

$$\frac{1}{2}\int_0^1 \frac{(1-\Omega)^3}{3}\,d\Omega = \left(\frac{1}{6}\right)\left(\int_0^1 (1-\Omega)^3\,d\Omega\right)$$

$$U = 1-\Omega$$
$$\int U^3 = \left.\frac{U^4}{4}\right|_0^1$$

$$\frac{1}{6}\left(\frac{1}{4}\right) = \boxed{\frac{1}{24}}$$

Fin de detalles de las integrales

continuación

$$\frac{1}{24} - \frac{1}{120} - \frac{1}{120} - \frac{1}{120} - \frac{1}{120} = \frac{1}{120}$$

$$\int_{HV} \underline{\underline{N}}^{t} Q \, dHV = Q \begin{bmatrix} 1/120 \\ 1/120 \\ 1/120 \\ 1/120 \end{bmatrix} = \frac{Q\,J}{120} \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

Unificando los resultados de ambas integrales

$$\frac{(HV)}{J^2} B^t A^t A B \underline{\underline{T}} = \frac{QJ}{120} \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

$$KT = b$$