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Input Parameters.

① node ID nodal co-ordinates

② ~~4~~. element ID Starting node, ending node section level volumnce, ~~material~~ section ID

~~3~~ ~~material define~~

③
- section ID.
- Rectangular width, depth
  circula r.
- nct
- steel layers steel area distance from middle.
- concrete material
- steel material.

④ · Boundary conditions.

node	dof
1	1 2 3
4	1 2 3

⑤ Structure level iteration • volumnce • convergence criteria
• max iteration.

⑥ Load controlling dof

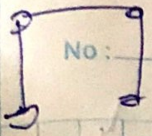
⑦ Displacement control Force ~~decide~~ control.

reference load vector.

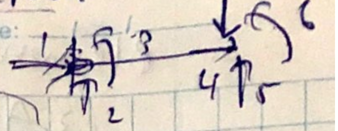
step size (+) (−)

number steps

⑧ external load,
dof
force step size, number of steps



* calculating initial structure stiffness



① structure level

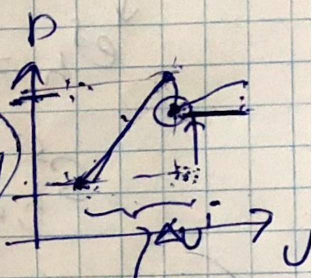
$$\begin{Bmatrix} F_1 \\ F_2 \\ F_3 \\ 0 \\ -1 \\ 0 \end{Bmatrix} = \begin{bmatrix} & & & \\ & & & \end{bmatrix} \begin{Bmatrix} 0 \\ 0 \\ 0 \\ u_4 \\ u_5 \\ u_6 \end{Bmatrix}$$

I structure stiffness → applying boundary

$$\begin{Bmatrix} u_4 \\ u_5 \\ u_6 \end{Bmatrix} = \left[\quad \right]^{-1}_{3\times3} \begin{Bmatrix} 0 \\ -1 \\ 0 \end{Bmatrix}$$

K^{i-1}

$\Delta P \begin{Bmatrix} 0 \\ -1 \\ 0 \end{Bmatrix}$



~~i = 1, $(\text{unbalan force})^{i-1}$~~

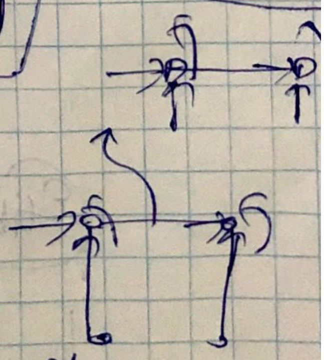
~~(unbalan force) = ΔP = $\begin{Bmatrix} 0 \\ -P \\ 0 \end{Bmatrix}$~~

$$\begin{Bmatrix} 0 \\ 0 \\ 0 \\ u_4 \\ u_5 \\ u_6 \end{Bmatrix}$$

* $(\text{resistin force})_i = K_i \Delta U^i \rightarrow \{\ \}_{6\times1}$

unbalance force i = unbalance force $i-1$ − resistin force

$$K_i^{-1}{}_{3\times3} \times \text{unbalan force} = \Delta V_{i+1}$$

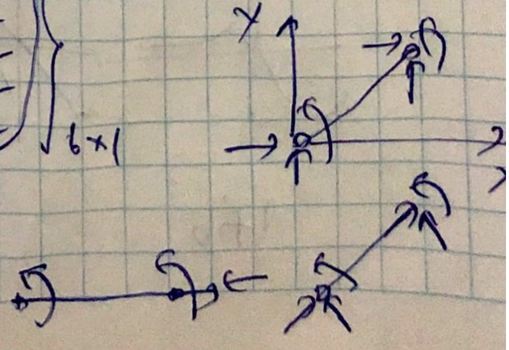


$$E = \frac{1}{2} \{\Delta V\}^T \{\text{unbal for}\}$$

② . converting to local co-ordinates

$$\Delta q^e_{local,i} = [\Gamma_{RCT}]\, \Delta q^e_{global,i} \left\{ \begin{matrix} - \\ - \\ - \end{matrix} \right\} \leftarrow \left\{ \begin{matrix} - \\ - \\ - \\ - \\ - \\ - \end{matrix} \right\}_{6\times1}$$

$$\Delta q^e = [\Gamma_{RBM}]\, \Delta q^e_{local,i}$$



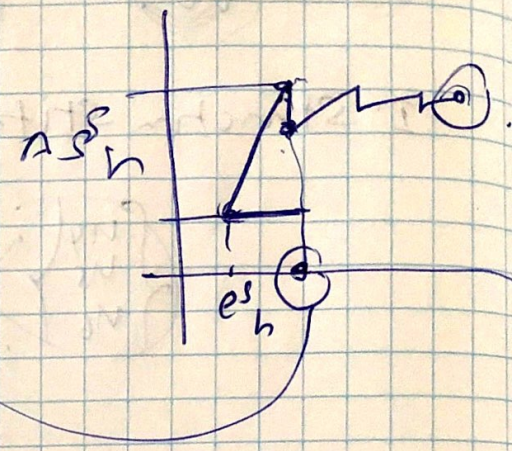
element force increment.

$$\{\Delta Q^e_{i-1}\} = [k^e_{i-1}]\{\Delta q^e_i\} - \{Q_{unb\,i-1}\}$$

shape function.

$$\Delta s^s_h = [N^h]\{\Delta q^e_i\}$$

section for incre



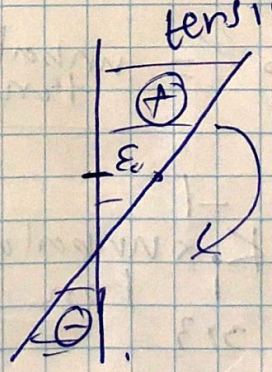
$$\{\Delta e^s_h\} = [k_{sec}]^{-1}\Delta s^s_h$$

$$e^s_h = e^s_h + \Delta e^s_h$$

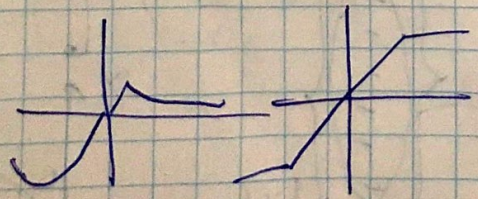
$$s^s_{h,unb\,z} = \Delta s^s_{h,unb\,z-1} - s^s_{h,resi}.$$

$$\Delta e^s_{h,z+1} = k_{sec\,z}\, s^s_{h,unb}$$

(3). $\begin{Bmatrix} \varepsilon_0 \\ k \end{Bmatrix}$



$$\varepsilon_{fib} = \varepsilon_0 - y k.$$



σ_{fib}

$$s^s_{h,res} = \begin{Bmatrix} \Sigma\, \sigma_{fib} A_{fib} \\ \Sigma - \sigma_{fib} A_{fib} y \end{Bmatrix}$$

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$$K_{sec} = \sum \begin{bmatrix} E_T A_{fib} & -E_T A_{fib} \\ -E_T A_{fib} & E_T A_{fib}^2 \end{bmatrix}.$$