Brief Article

The Author

July 11, 2018

Algorithm 1 Calculate deformation input to constitutive model and update material state to Q^n

procedure TIME STEPPING METHOD

Solve for the max flux over the time step and attain the end of step fluid mass m^n and end of step pressure p^n,

- $m^{n+1} = m^n + k^n \rho^n \left(\nabla p^n\right) \Delta t$

Update the velocity to the mid-step

- $\mathbf{v}^{n+\frac{1}{2}} = \mathbf{v}^n + \mathbf{a}^n \frac{\Delta t}{2}$

Update the displacement to the end of the step

- $\mathbf{x}^{n+1} = \mathbf{x}^n + \mathbf{v}^{n+\frac{1}{2}} \Delta t$

Calculate deformation input to constitutive model and update material state to Q^{n+1}

Solve for the acceleration $t^{n+1}\left(a_i^{n+1}\right)$. Note that this includes the fluid pressure p^{n+1} applied as a boundary condition

Update the velocity to the end of step

- $\mathbf{v}^{n+1} = \mathbf{v}^{n+\frac{1}{2}} + \mathbf{a}^{n+1} \frac{\Delta t}{2}$

end procedure

Algorithm 2 Calculate deformation input to constitutive model and update material state to Q^n

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1: procedure CALCULATE DEFORMATION INPUT TO CONSTITUTIVE MODEL AND UPDATE MATERIAL STATE TO Q^n
2:     for Each Element do
3:         Gather nodal nodal degrees of freedom for total/inc displacement
4:         for Each quadrature point do
5:             Calculate gradient for total/inc displacement (mult-mult operations)
6:             Calculate gradient for the force (local operations with 3 × 3 matrices)
7:             Incremental kinematic step
8:             Constitutive update step
9:             Accumulate quadrature sum
10:        end for
11:        Scatter nodal degrees of freedom to force vector
12:    end for
13: end procedure
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