NOMENCLATURE

\[ [A] = [B^T] \] - Pressure gradient nodal pressure relationship matrix for the element

\[ [A_i] \] - Main stiffness matrix corresponding to \( t_n \)

\[ [A_2] \] - Main stiffness matrix corresponding to \( t_{n-1} \)

\[ [B] = [B^T] \] - Strain displacement relationship matrix for the element

\[ [C] \] - Coupling matrix between solid and fluid for the element

\[ [C^n] \] - Elasticity matrix for the element

\( C_{ijkl} \) - Components of elasticity tensor

\[ [E] \] - Stiffness matrix of fluid for the element

\( e_v \) - Volumetric strain of the fluid

\( F_i \) - Components of the body force vector

\( F_0 \) - External nodal load vector before deformation (initial condition)

\( \{ F_n \} \) - External nodal load vector at \( t_n \)

\( \{ F_{n-1} \} \) - External nodal load vector at \( t_{n-1} \)

\( f \) - Porosity of the material

\[ [G] \] - Pore pressure shape function matrix for the element

\[ [H] \] - Dissipation matrix for the pore fluid in the element
- Shape functions for the isoparametric element
- Shape function derivatives with respect to r
- Shape function derivatives with respect to z
- Jacobian matrix
- Jacobian determinant
- Permeability coefficient
- Stiffness matrix for the solid phase
- Material property defining the compressibility of pore fluid
- NHR = Harmonic number
- Set of displacement shape functions
- Set of pore pressure shape functions
- The direction cosine of the outward normal
- External nodal fluid flow
- Prescribed flow of the fluid normal to the surface $s_2$
- Nodal flux vector
- Nodal flows prescribed at $t_n$
- Nodal flow prescribed at $t_{n-1}$
- Intensity of uniformly distributed load
- Relative velocity of the fluid
- Flux vector (function of space and time)
- The r co-ordinate in natural or local co-ordinates system of a point within the
element

\( S_1, S_2 \) - Surfaces of the domain

\( \{T_i\} \) - Prescribed boundary tractions on \( S_1 \)

\( \{T^r_i\} \) - Nodal tractions

\( t_{n-1} \) - Time at current time cycle

\( t_n \) - Time at next time cycle

\( \{u\} \) - Nodal displacement vector

\( \{u_0\} \) - Initial nodal displacement vector

\( \{u_t\} \) - Nodal displacement vector at \( t_n \)

\( \{u_{t-1}\} \) - Nodal displacement vector at \( t_{n-1} \)

\( \{u, (t)\} \) - The set of \( i^{th} \) components of the time dependent nodal point displacement for the entire system.

\( u_i^n(x, t) \) - The \( i^{th} \) component of the space and time dependent nodal displacement vector at \( (x, t) \) of the element

\( u_i \) - The components of the displacement vector for solid

\( U_i \) - The components of the displacement vector for fluid

\( w_i \) - Relative displacement of fluid with respect to solid

\( z(s, t) \) - The \( z \) co-ordinate in natural or local co-ordinate system, of a point with in the element

\( \star \) - Star operator indicating convolution integral
- Material property defining the compressibility of the solid particles

\( \alpha, \alpha_1, \alpha_2 \) - Amplitudes of incompatible modes for displacements in radial direction, corresponding to the shape functions \( h_5 \) and \( h_6 \) respectively

\( \beta_1, \beta_2 \) - Amplitudes of incompatible modes for displacements in axial (vertical) direction, corresponding to the shape functions \( h_5 \) and \( h_6 \) respectively

\( \gamma_1, \gamma_2 \) - Amplitudes of incompatible modes for displacements in circumferential direction, corresponding to the shape functions \( h_5 \) and \( h_6 \) respectively

\( \beta \) - A parameter, defining the variation of pore fluid pressure between \( t_{n-1} \) and \( t_n \)

\( \Pi \) - Pore fluid pressure

\( \{\Pi_0\} \) - Initial pore fluid pressure

\( \Pi^n(x, t) \) - The time and space dependent pore fluid pressure at \( (x , t) \) in the element

\( \{\Pi(t)\} \) - The set of time dependent nodal point pore fluid pressure

\( \{\Pi_{t_n}\} \) - Pore fluid pressure at \( t_n \)

\( \{\Pi_{t_{n-1}}\} \) - Pore fluid pressure at \( t_{n-1} \)

\( \sigma^n(x, t) \) - Stress tensor for solid phase

\( \{\sigma^n_0(x,t)\} \) - Initial stresses in the element before deformation

\( \sigma_{ij} \) - Components of the symmetric stress tensor for the porous solid

\( \sigma_r, \sigma_z, \sigma_\theta \) - Radial, axial and circumferential stresses respectively

\( \{\varepsilon\} \) - Strain vector

\( \varepsilon_{ij} \) - The components of the strain tensor
\( \varepsilon_r, \varepsilon_z, \varepsilon_\theta \) - Strains in radial, axial and circumferential directions respectively

\( \varepsilon^n(x,t) \) - The space and time dependent strain tensor

\( \tau_{ij} \) - The components of bulk stress tensor

\( \delta_{ik} \) - Kronecker delta

\( \rho \) - Total mass density of fluid solid mixture

\( \rho_f \) - Mass density of fluid

\( \mu, \lambda \) - Lame's constants

\( \eta \) - Kinematic viscosity of the fluid

\( \Delta t \) - Time step = \( t_n - t_{n-1} \)

\( \Delta t_0 \) - Very small time step \( \to 0 \) for initial condition

\( \Omega \) - Gurtin's functional

\( i_r, i_z, i_\theta \) - Pressure gradients in radial, axial and circumferential directions respectively

\( \gamma_{xz}, \gamma_{x\theta}, \gamma_{z\theta} \) - Shear strains in respective planes

Meaning of other notations / symbols used is explained at the place of their first occurrence.