ELEMENT MIXED FLOW T6P3c commands

Synopsis

The ELEMENT MIXED_FLOW T6P3c command is used to describe all mixed, 6-node, quadratic triangular continuum elements that are to be used in a coupled flow-mechanical analysis.

Remarks

- The T6P3c is a mixed, isoparametric triangular element [2]. The element
  - Contains three (3) vertex nodes.
  - Contains three (3) mid-side nodes.
  - Has two (2) displacements degrees of freedom at each node, for a total of twelve (12) displacement degrees of freedom.
  - Employs a quadratic approximation for the displacement field.
  - Employs a linear, continuous approximation for the pressure (Figure 1).
  - Has a total of three (3) pressure degrees of freedom.

- The Q8P4c element should be used for coupled displacement-flow analyses of porous media. The element is based on a generalized Biot formulation.

Syntax

The following syntax is used to describe a typical T6P3c mixed-flow quadrilateral continuum element:

```
ELEment MIXed_Flow TYPe T6P3c
NODes #:#:# (MATerial #) (PERmeability #:.) (INItial #)
(CONstruction #) (EXCavation #) (THickness #:.)
(INCompressible_constituents)
(1_Additional #) (1_Increment #)
(2_Additional #) (2_Increment #)
(DONT_PRINT_Results)
(DONT_PRINT_STRAins) (DONT_PRINT_STREsses)
(PRINT_PRIN_STRAins) (PRINT_PRIN_STREsses)
(PRINT_VOLumetric_strain)
(PRINT_AVG_PREssure)
(PRINT_VELocity)
```
Explanatory Notes

- The numbering order of NODES associated with the T6P3c element is shown in Figure 1. For this element the numbers n1 to n6, numbered sequentially, apply.

![Node Numbering](image)

Figure 1: Node Numbering Associated with a Typical Mixed 6-Node Quadratic (T6P3c) Triangular Continuum Element

- The MATERIAL keyword is used to specify the number of the material idealization associated with the element. The default value for the MATERIAL number is one (1).

- The PERMEABILITY keyword is used to specify the number of the permeability (hydraulic conductivity) idealization associated with the element. In order to maximize flexibility, the PERMEABILITY number differs from the MATERIAL number. The default value for the PERMEABILITY number is one (1).

- The INITIAL keyword is used to specify the initial state number associated with the element. The default value for the INITIAL is zero (0).

- The incremental CONSTRUCTION and EXCAVATION numbers represent the time increment in which the material in this element(s) is added to or removed from the model. A CONSTRUCTION number equal to zero corresponds to a material in existence at the beginning of the analysis. Since this is the default condition, no input is required in such a case. The condition of no excavation is likewise the default. In the current version of APES the hydraulic boundary condition at the temporary top of a soil mass that is being constructed is zero flow; i.e., an impervious surface. The conditions on top of the final surface can, however, be specified through the use of the SPECIFICATIONS CONCENTRATED FLOW command.

- The THICKNESS keyword is used to specify the material thickness assumed for the element. Over a given element, the thickness is assumed to be constant. The default THICKNESS value is equal to one (1.0). For AXISYMMETRIC and PLANE STRAIN idealizations (see discussion of the ANALYSIS IDEALIZATION command), the THICKNESS must
be equal to 1.0. For such idealizations, specified values different from 1.0 are ignored and the proper value is used.

- If the \texttt{INCompressible} \texttt{constituents} keyword is used, both the solid skeleton and the pore fluid are assumed to be \textit{incompressible}. This supersedes any bulk modulus values specified in conjunction with the \texttt{MATERIAL FLUID} or \texttt{MATERIAL SOLID} commands. If an anisotropic poroelastic material idealization is used (refer to the description of the \texttt{MATERIAL POROELASTIC ANISOTROPIC} command), this implies an \textit{infinite} value for the “Biot modulus” $M$ (specified via the \texttt{M.MODULUS} keyword) for the element.

- The purpose of the \texttt{PRINT} commands is to eliminate unnecessary output generated by APES. More precisely, if the time history of strains and/or stresses is desired only for a select few elements, this option greatly speeds program output and facilitates inspection of results by the user. Information associated with the elements specified in this section will be printed for every solution (time) step. If \textit{generation} is performed using this \texttt{ELEMENT IRREDUCIBLE} command, then all the elements generated will be affected in a like manner by the above print control commands.

- Specification of the keyword \texttt{DONT PRINT Results} indicates that the analyst does not desire to see output of secondary dependent variables (i.e., strains and stresses) for this element.

- Specification of the \texttt{DONT PRINT STRAINS} keyword indicates that element strains are not to be printed. Under the default condition both strains are printed.

- Specification of the keyword \texttt{DONT PRINT STRESSES} indicates that stresses are not to be printed. Under the default condition stresses are printed.

- The \texttt{PRINT PRIN STRAINS} keyword indicates that principal strains are to be computed and printed for the element. Under the default condition these quantities are not computed and printed.

- The \texttt{PRINT PRIN STRESSES} keyword indicates that principal stresses are to be computed and printed for the element. Under the default condition these quantities are not computed and printed.

- The \texttt{PRINT VOLUMETRIC STRAIN} causes the volumetric strain to be computed and printed for the element. In addition, the ratio of the absolute value of the volumetric strain to the absolute value of the minimum non-zero normal strain in the element is printed. That is,

$$\frac{|\varepsilon_{\text{vol}}|}{\min(|\varepsilon_{11}|,|\varepsilon_{22}|,|\varepsilon_{33}|)} \quad \text{min}(\varepsilon_{11}, \varepsilon_{22}, \varepsilon_{33}) \neq 0$$

This ratio is instructive in the assessment of mixed and mixed/penalty elements used to simulate material response in the incompressible limit. Under the default condition the volumetric strain and the aforementioned ratio are not computed and printed.

- The keyword \texttt{PRINT_AVG_PRESSURE} causes the \textit{average} pressure to be computed and printed for the element. This value represents the average of the approximate pressures at the three pressure (vertex) nodes.

- The keyword \texttt{PRINT VELOCITY} causes the components of the Darcy velocity in the global $x_1$- and $x_2$-coordinate directions to be computed and printed at the element center.
Example of Command Usage
References
