PhiPsi Keywords Manual

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This manual simply describes the usage of each keyword used in PhiPsi.

1 Basic control keywords

*Work_Dirctory: File location of the input files of PhiPsi, i.e., the work directory

*Filename: Filename of the input files of PhiPsi (all input files have the same filename)

*Key_Unit_System: Unit system

= 1, international system of units (default)

= 2, mm-ton-s

*Key_Dimension: The dimension of the problem

= 2, two-dimension (Plane stress or plane strain)

= 3, three-dimension

*Key_Type_2D: Plane stress or plane strain

= 1, plane stress

= 2, plane strain (default)

*Key_Analysis_Type: Analysis type

= 1, quasi-static (default)

= 2, implicit dynamic

= 3, hydraulic fracturing simulation

= 7, nonlinear problem (such as plastic deformation problem)

= 15, field problem (such as heat transfer problem)

*Key_SIFs_Method: Method to calculate the stress intensity factors (SIFs)

= 1, displacement interpolation method (default)

= 2, the interaction integral method

*Key_Contact: Consider contact between crack surfaces or not

= 0, no (default)

= 1, yes

* fric_mu_Cont: Friction coefficient of crack surfaces (default to 0.3)

*kn_Cont_Penalty: Normal penalty stiffness of crack surfaces (default to 1.0e13)

*kt_Cont_Penalty: Tangential penalty stiffness of crack surfaces (default to 1.0e13)

*Conve_Tol_Penalty: Convergence tolerance for the contact iteration (default to 1.0e-5)

*Num_Substeps: Number of steps need to be performed

*CFCP: Criterion of crack propagation

= 1, maximum tensile circumferential stress criterion (default)

= 2, maximum principal tensile stress criterion

*Key_Force_Control: The method to control the value of the applied force for each step

= 1, the force is applied all at once (default)

= 2, the applied force increases linearly in each step

= 3, not available yet

= 4, special scheme for cohesive crack

= 5, make sure that only one crack grows in each step

*Key_Initiation: Initiation of cracks

= 0, no new crack generated (default)

= 1, new cracks are allowed to be generated

*Key_Propagation: Propagation of cracks

= 0, cracks are not allowed to propagate

= 1, cracks are allowed to propagate (default)

*Factor_Propagation: Factor of propagation length of cracks, i.e., Δl = *Factor_Propagation $\times$ average size of enriched elements

*Key_Gravity: Gravity

= 0, no gravity (default)

= 1, apply gravity to the whole model

*g_X_Y_Z: Values of gravitational acceleration in x, y and z directions

1- gravitational acceleration in x direction

2- gravitational acceleration in y direction

3- gravitational acceleration in z directions

*Key_Random: Random generation

= 0, randomly generates, but the generated results remain unchanged

= 1, randomly generates and the generated results are different (default)

2 Linear solvers

*Key_SLOE: Select the solver of linear system

= 1, the direct solver (finding the inverse matrix)

= 2, Gaussian elimination

= 3, Pardiso (not available yet)

= 4, ITPACK

= 5, LAPACK (default)

= 6, MUMPS

= 7, UMFPACK

3 Define initial cracks, voids (holes) and inclusions

*num_Crack: Number of initial cracks

*num_Hole: Number of initial holes

*num_Circ_Incl: Number of circular inclusions

*num_Poly_Incl: Number of polygonal inclusions

*CRACK_1 - *CRACK_100: Define the coordinates of each initial cracks (line segments) for 2D problem (input format: x_of_P1, y_of_P1, x_of_P2, y_of_P2, x_of_P3, y_of_P3 ...)

*Crack3D_Coor_1 - *Crack3D_Coor_100: Define the coordinates of each initial cracks (plane in 3D composed of four points) for 3D problem (input format: x1, y1, z1, x2, y2, z2, x3, y3, z3, x4, y4, z4)

*Hole_Coor_1 - *Hole_Coor_100: Define the coordinates of initial holes (input format: x, y, r)

*Circ_Inclu_Coor_1 - * Circ_Inclu_Coor_100: Define the coordinates of initial circular inclusions (input format: x, y, r)

*Key_Random_NaCr: Randomly generate initial cracks or not

= 0, do not generate (default)

= 1, generates

*num_Rand_Na_Crack: Number of cracks need to be randomly generated

*NaCr_Orientation: Average direction (in degrees) of the cracks need to be randomly generated

*NaCr_Ori_Delta: Fluctuation range (+ or -) of the average direction (in degrees)

*NaCr_Length: Average length of the cracks need to be randomly generated

*NaCr_Len_Delta: Fluctuation range (+ or -) of the average length

*Key_Rand_Circ_Incl: Randomly generate circular inclusions or not

= 0, do not generate (default)

= 1, generates

*num_Rand_Circ_Incl: Number of circular inclusions need to be randomly generated

*Rand_Circ_Incl_R: The average radius of the circular inclusions need to be randomly generated

*Rand_Circ_Inc_R_Delta: Fluctuation range (+ or -) of the average radius

*Key_Rand_Poly_Incl: Randomly generate initial regular polygonal inclusions or not

= 0, do not generate (default)

= 1, generates

*num_Rand_Poly_Incl: Number of regular polygonal inclusions need to be randomly generated

*num_Vert_Poly_Incl: Number of edges of regular polygonal inclusions

Rand_Poly_Incl_R: Average radius of circumcircle of regular polygonal inclusions

Rand_Poly_Inc_R_Delta: Fluctuation range (+ or -) of the average radius of circumcircle of regular polygonal inclusions

4 Definition of material parameters

Material_Type_1 - Material_Type_10：material type definition for each material：

1-*isotropic material*

2-*plastic material* (*Von Mises yield criterion*)

Material_Para_1 - Material_Para_10: 15 parameters need to be defined for each material:

1-elasticity modulus, E

2-Poisson's ratio, v

3-density, ρ

4-thickness, t

5-tensile strength, σ_t

6-fracture toughness, K_{Ic}

7-compressive strength, σ_c

8-coefficient of thermal expansion

9-specific heat coefficient, c

10-conductivity coefficient, K_{xx}

11-conductivity coefficient, K_{yy}

12-15-blank

5 Keywords related to hydraulic fracturing simulation

Num_Frac: Number of steps of the hydraulic fracturing simulation

Key_Symm_HF: Symmetric model

= 0, no (full model)

= 1, yes

Cracks_HF_State: Initial states of each crack (contains fluid or not)

= 0, free crack without fluid

= 1, hydraulic fluid-driven crack

*Inject_Crack_Num: For full model (*Key_Symm_HF=0), define the crack which contains the injection point of fluid (For symmetric model, the injection point is just the*

mouth of the edge crack which is also crack number 1)

**Inj_Point_Loc*: For full model, define the coordinates of the injection point (input format: x, y)*

**Inject_Q_Time*: Define the time instants of the data curve of injection rate of fracturing fluid (20 time instants at most)*

**Inject_Q_Val*: Define the values of injection rate of the data curve of injection rate of fracturing fluid (20 at most)*

**Inject_c_Time*: Define the time instants of the data curve of volumetric concentration of injected proppant (20 time instants at most)*

**Inject_c_Val*: Define the values of concentration of the data curve of volumetric concentration of injected proppant (20 at most)*

**Key_Visco_Type*: Static viscosity or dynamic viscosity

= 1, static viscosity

= 2, dynamic viscosity

**Viscosity*: The viscosity of fracturing fluid*

**Viscosity_Par_m*: Parameter m of dynamic viscosity (define when *Key_Visco_Type =2)*

**Key_Proppant*: Consider proppant or not

= 0, no (default)

= 1, yes

**Key_Propp_Trans*: Consider the transport of proppant or not

= 0, no (default)

= 1, yes

**Key_Leakoff*: Consider the leak off of the fracturing fluid or not

= 0, no (default)

= 1, yes

**Coeff_Leak*: Leak coefficient of the Carter model (define when *Key_Leakoff =1)*

6 Keywords related to nonlinear analysis

** NL_ITRA：Maximum number of Newton-Raphson iteration （default：30）*

** NL_ATOL：Maximum Norm-2 value of the residual of Newton-Raphson iteration （default：1.0e8）*

** NL_NTOL：Maximum number of bisection of force for Newton-Raphson iteration （default：6）*

** NL_TOL：Convergence tolerance for Newton-Raphson iteration （default：1.0e-6）*

**NL_TIMS_1-*NL_TIMS_10：Load step control, 5 parameters are needed for each load step:：*

1-starting time for the current load step

2-ending time for the current load step

3-time increment for the current load step

4-starting force factor for the current load step

5-ending force factor for the current load step

7 Keywords related to cohesive crack

**Coh_Constitutive_type: Constitutive model of the cohesive crack:*

*= 1, bilinear model, first rise and then fall (Define both * Coh_Width_Critical1 and *Coh_Width_Critical2)*

*= 2, linear model (Define *Coh_Width_Critical2)*

*= 3, constant model (Define *Coh_Width_Critical2)*

** Coh_Width_Critical1: Normal width of crack at which the crack surface has the ultimate normal traction (needs to be defined only when *Coh_Constitutive_type =1)*

** Coh_Width_Critical2: Normal width of crack at which the crack surface has no normal traction*

** Coh_f_Ultimate: The ultimate normal traction*

** Coh_Tangential_Key: Consider tangential traction or not*

= 0, no (default)

*= 1, yes (Define *Coh_Width_Critical1_T, *Coh_Width_Critical2_T, *Coh_f_Ultimate_T)*

** Coh_Width_Critical1_T: Tangential width of crack at which the crack surface has the ultimate tangential traction (needs to be defined only when *Coh_Constitutive_type =1 and * Coh_Tangential_Key =1)*

** Coh_Width_Critical2_T: Tangential width of crack at which the crack surface has no tangential traction*

** Coh_f_Ultimate_T: The ultimate tangential traction*

8 Keywords related to implicit dynamic analysis

**IDy_Num_Iteras: Number of steps of the implicit dynamic analysis*

**IDy_Num_force_Itr: Number of steps with force applied (In other words, the applied force will be removed if the current step number is larger than *IDy_Num_force_Itr)*

**Delt_Time_NewMark: Time increment of the Newmark time integration algorithm (default to 1.0e-6)*

**Key_EQ: Earthquake analysis*

= 0, no (default)

= 1, yes

*num_EQ_Ac_nodes: Number of the nodes with earthquake acceleration applied

*EQ_Ac_nodes: List of nodes with earthquake acceleration applied

*EQ_Ac_Time_Gap: Time interval of the earthquake acceleration data (define when *Key_EQ=1)

9 Coupling of degrees of freedom

*num_CP_x_nodes: The total amount of nodes need to be coupled in x direction

*CP_x_nodes: The nodes number of all the nodes need to be coupled in x direction

*num_CP_y_nodes: The total amount of nodes need to be coupled in y direction

*CP_y_nodes: The nodes number of all the nodes need to be coupled in y direction

*num_CP_z_nodes: The total amount of nodes need to be coupled in z direction

*CP_z_nodes: The nodes number of all the nodes need to be coupled in z direction

10 Control of the program

*Key_Clear_All: Clear all the results files in the current work directory before starting

= 0, disable

= 1, enable (default)

*Key_Close_Window: Close the console window when calculation is finished

= 0, wait user to close (default)

= 1, auto close

*Key_Data_Format: Save data in ASCII format or in binary format

= 1, ASCII format (default)

= 2, binary format

*Key_Num_Process: Set the number of threads of CPU (if taken as 99, then all threads are available, default to 1)