ESPFEM2D 说明文件

1. Introduction

The Smoothed Particle Finite Element Method (SPFEM) has gained popularity as one of the effective numerical methods for modelling geotechnical problems involving large deformations. To advance the research and application of SPFEM in geotechnical engineering, we present ESPFEM2D, a two-dimensional SPFEM open-source solver developed using MATLAB. ESPFEM2D discretizes the problem domain into computable particle clouds and generates the finite element mesh using Delaunay triangulation and the alpha-shape technique to resolve mesh distortion issues. Additionally, it incorporates a node integration technique based on strain smoothing, effectively eliminating defects associated with the state variable mapping after remeshing. Furthermore, the solver adopts a simple yet robust approach to prevent instability arising from under-integration using only nodal values. The Drucker-Prager model is adopted to describe the soil's constitutive behavior as a demonstration.

2. MATLAB implementation of the open-source solver ESPFEM2D

The ESPFEM2D open-source solver is developed based on MATLAB. As the main program of ESPFEM2D, "SPFEM.m" controls and runs all functions under the open-source solver of ESPFEM2D. In ESPFEM2D, all these steps are implemented in the form of MATLAB functions except that the MATLAB script named "SPFEM.m" is used as the main program. All the MATLAB codes are summarized in Table 1.

Table 1 Summary of MATLAB codes

File name	Stage	Functionality
SPFEM.m	main program	the main program of ESPFEM2D
input data.m	pre-processing	Example input
ex bar gravity vibration.m	pre-processing	Example input
ex non cohesive soil stage1.m	pre-processing	Example input
ex non cohesive soil stage2.m	pre-processing	Example input
ex cohesive soil stage1.m	pre-processing	Example input
ex cohesive soil stage2.m	pre-processing	Example input
ex slope stage1.m	pre-processing	Example input
ex slope stage2.m	pre-processing	Example input
initializing.m	Computational step 1	Prepare for the calculation process of ESPFEM2D

File name	Stage	Functionality
mesh alpha shape.m	Computational step 1	Identify the computational domain boundary using the alpha-shape technique
mesh remesh.m	Computational step 2	Reconstruct the finite element mesh
mesh quality.m	Computational step 2	Get mesh quality
mesh get related element node.m	Computational step 3	Get related node and element information
element data prepare.m	Computational step 3	Get element information
node data prepare.m	Computational step 3	Get node information
mesh lap smoothing.m	Computational step 4	Calculate the smooth strain of the nodes
constitutive model.m	Computational step 5	Select constitutive model
mat model elas.m	Computational step 5	Elasticity constitutive models
mat model DP.m	Computational step 5	Drucker-Prager constitutive models

File name	Stage	Functionality
DP explicit.m	Computational step 5	Update nodal stresses through Drucker-Prager constitutive model integration
force int.m	Computational step 6	Calculate the nodal internal forces
update half velocity.m	Computational step 7	Prepare for the leapfrog time integration
force hourglass.m	Computational step 7	Hourglass control
time integration.m	Computational step 7	Time integration
contact wall.m	Computational step 7	Rigid boundary contact
output vtk.m	Post-processing	Output the calculation results
save monitor data.m	Post-processing	Output the calculation results of monitoring nodes