S3: Validation examples of the triangular element of DDFS^{3D} associated with "DDFS^{3D}: a set of open-source codes leveraging hybrid 3D displacement discontinuity method and fictitious stress method to simulate fractures"

Louis Ngai Yuen Wong[1, 2], Xin Cui [1, 2, *]

[1] *Department of Earth Sciences, the University of Hong Kong, Pokfulam, Hong Kong, China*

[2] *Shenzhen Institute of Research and Innovation, the University of Hong Kong, Shenzhen, China*

Abstract

The constant quadrilateral element of DDFS^{3D} has been validated by three numerical examples presented in section 3 of the master paper. Here we use the constant triangular element to perform the same verification examples, and the results thereof are either compared with the analytical solution or with that obtained from using quadrilateral elements. The input and output files of these examples are included in the respective DDM, FSM and DD-FS folders under the triangular element category.

S3-1. Penny shape crack

In this verification example, we use 731 triangular DDM elements to discretize the penny shape crack. The contour of the crack aperture and the comparison between DDM evaluation and the analytical solution (Eq. (25) in the master paper) are displayed in Fig. S3-1.

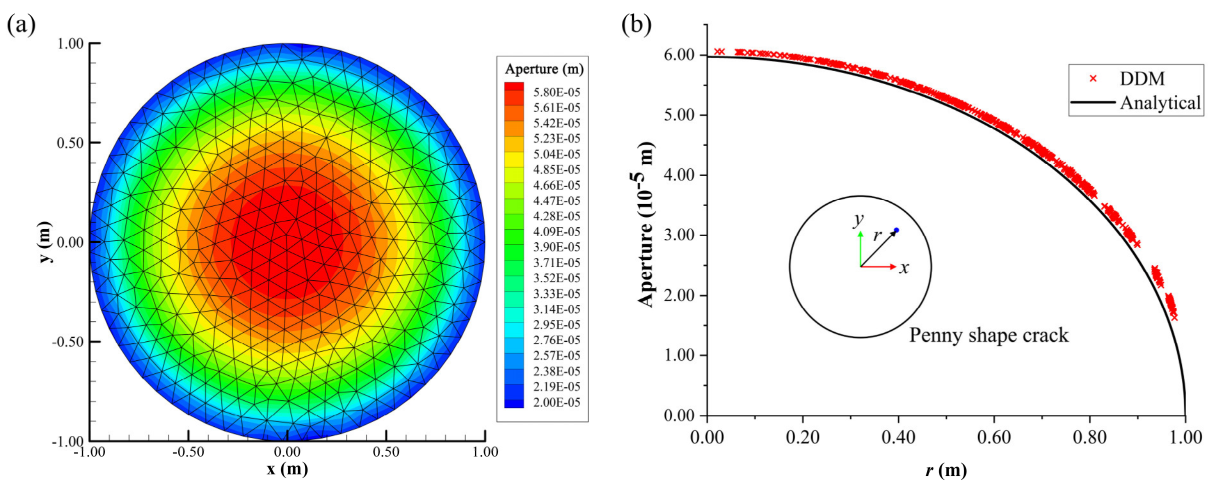

Fig. S3-1 Penny shape crack subject to inner pressure simulated by constant triangular elements: (a) mesh with the aperture contour as background, and (b) aperture evaluated by triangular elements as compared with the analytical solution.

S3-2. Intact Brazilian disc

We use 3504 triangular FSM elements to discretize the intact Brazilian disc. The mesh of triangular elements is shown in Fig. S3-2(a), while the evaluations of σ_{xx} by both triangular and quadrilateral elements are compared in Fig. S3-2(b). The σ_{xx} results of using triangular elements and quadrilateral elements well agree with each other.

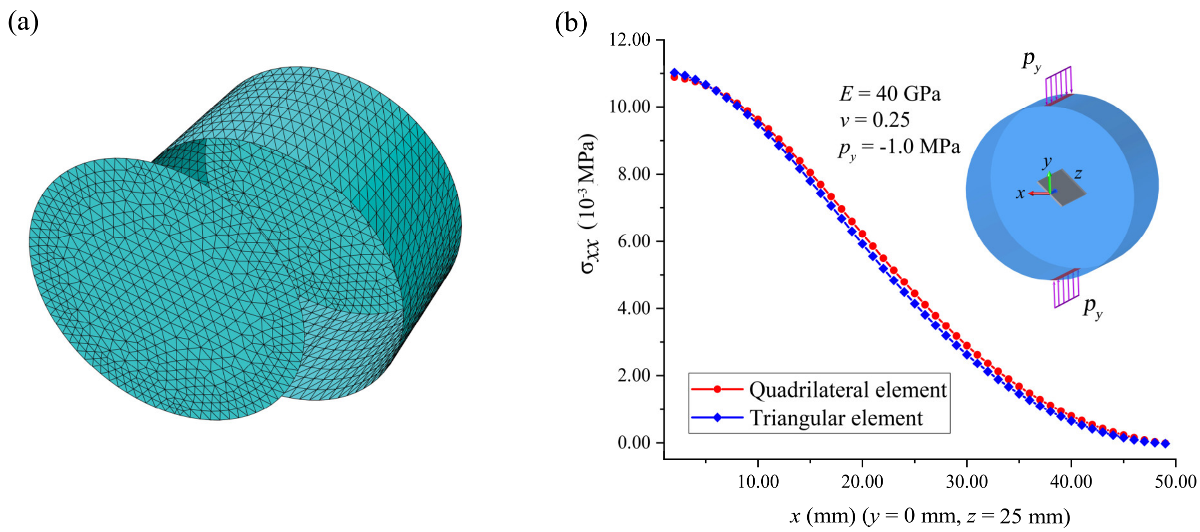

Fig. S3-2 Intact Brazilian disc simulated by DDFS^{3D}. a) Mesh of triangular elements and b) σ_{xx} evaluated by both triangular and quadrilateral elements.

S3-3. Flawed Brazilian disc

We use 3504 triangular FSM elements and 72 triangular DDM joint elements to discretize the Brazilian disc and pre-existing flaw, respectively (Fig. S3-3). The stress and displacement evaluated by both triangular and quadrilateral elements are compared in Fig. S3-4. Notable differences of σ_{xx} take place at the top tip and central part of the flawed Brazilian disc due to the significant stress concentration therein. Since the triangular element mesh is finer than the quadrilateral element mesh, the result of the former tends to be more accurate. In contrast, the displacements evaluated by both triangular and quadrilateral elements agree with each other fairly well.

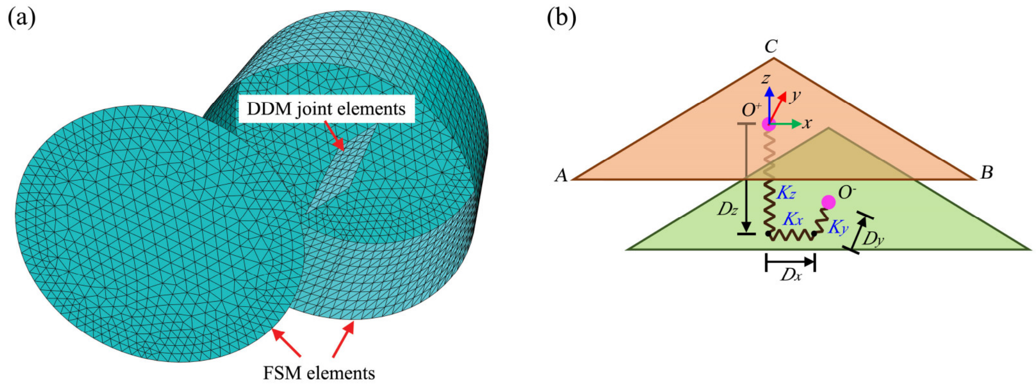

Fig. S3-3 (a) Mesh of the flawed Brazilian disc using triangular FSM elements and DDM joint elements, and (b) schematic of the triangular DDM joint element.

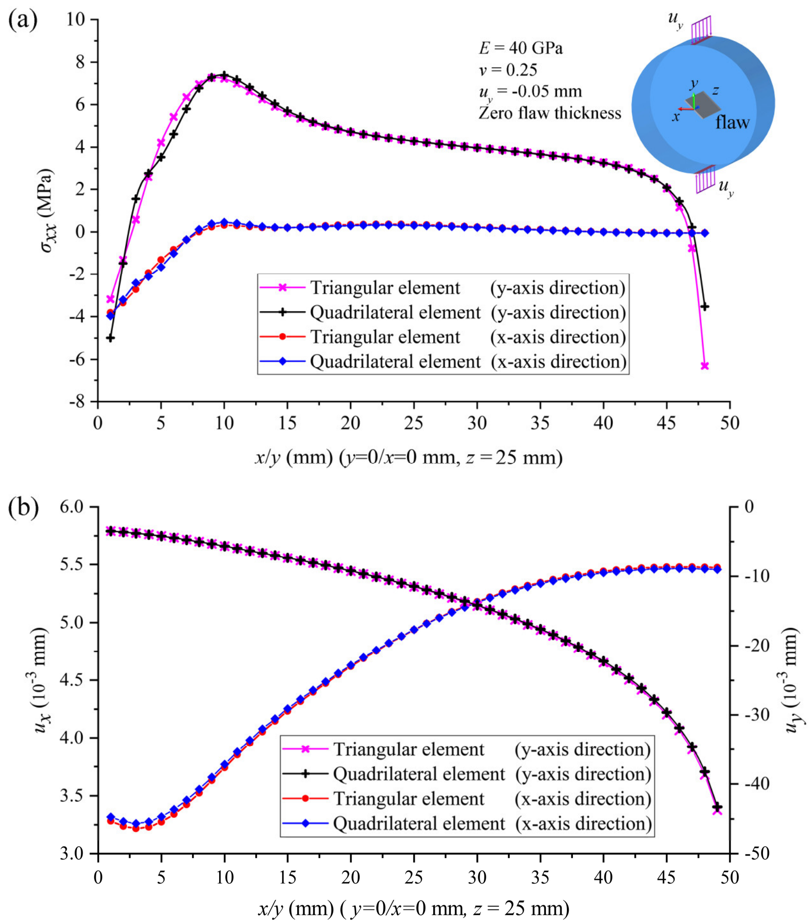

Fig. S3-4 Flawed Brazilian disc simulated by DDFS^{3D}. (a) The stress σ_{xx} along two rays, one emanating from (0, 0, 25) and extending in the *x*-axis direction while the other emanating from the same point but extending in the *y*-axis direction, are compared by using both triangular and quadrilateral elements. (b) The displacements u_x/u_y along the *x*-axis/*y*-axis direction ray in (a) are also compared by using triangular and quadrilateral elements.