Investigation of the effect of jog deviations on Riedel fractures by three-dimensional elasto-plastic analysis

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The Riedel fracturing process is strongly affected by the presence of jogs. For example, Fig. 1 describes left strike-slip fault with discontinuity of fault zone. The jog on the far side will be expanded with an accumulation of fault displacement and it causes depression of the ground surface as shown in Fig. 2(a), whereas the jog on the front side will be compressed and it causes bulge of the ground surface in Fig. 2(b). These transtensional/transpressional deformation fields called pull-apart/push-up are under the pure shear on which the tension/compression is superposed due to the presence of jogs. Authors have conducted three-dimensional elasto-plastic finite deformation analysis considering jogs of pull-apart and push-up as boundary conditions to numerically obtain the Riedel fracturing process. The abstract especially reports numerical investigations on the effects of the jog deviation on the angle of Riedel shears with principal stress rotation.

Simulations are implemented with the dynamic/static soil-water coupled elasto-plastic finite deformation analysis code ***GEOASIA***. Although the analysis code can accommodate two-phase analysis, only the one-phase analysis is carried out in the abstract. Finite element mesh with consideration of bending fault zone is shown in Fig. 3. Material parameters for SYS Cam-clay model are conformed to the preceding study[2)]. We prepared three models whose length is equal/doubled/tripled to the model in the *y*-direction (α=1, 2, 3). The analysis is conducted parametrically changing the jog deviation *d*=5, 10, 15mm. Figure 4 indicates shear strain distributions at the end of the simulations. The right diagonal Riedel shear band are obtained as a result of shear strain localization.

As for the results of *d*=15mm, the duplexing fracture patterns are obtained on the push-up side (α=1) whilst the P-shears are obtained on the pull-apart side (α=2, 3). However these fracturing patterns could no longer be detected in the cases of *d*=10, 5 mm. Especially in the case of *d*=5mm, only the independent single shears appear on the surface. The result suggests the significance of the installation of jogs to simulate these secondary fractures.

Focusing on the angle of Riedel shears on the tripled scale model α=3, there’s no difference in terms of fracture angles between the push-up and the pull-apart sides. However, the increase of a jog deviation makes Riedel shear angle lower/higher against the strike-slip running direction on the push-up/pull-apart side. It can actually be understood by the change of the principal stress direction. Figure 5 indicates the direction of maximum principal stress on the Riedel fractures above the regions A and B shown in Fig. 3 at the end of calculations, where the clockwise angle against running direction is positive. Because the direction of maximum principal stress in a pure sheared zone (straight fault zones without jogs) should be 45° in general, the angle deviation from 45° can be regarded as a result of jog installation. The figure indicates that the angle of the maximum principal stress become larger/smaller than 45° on the push-up/pull-apart side under transpressional/transtensional stress distribution. However, these transpressional/transtensional stress distribution gradually turn into pure shear with the decrease of a jog deviation. Therefore, the small difference of fracture angle between the push-up and the pull-apart sides with small jog deviation can be understood as a consequence of the increased percentage of pure shear in transpression/transtension.

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3) Toyoda et al. (2018): Simulation of Riedel shear bands considering strong non-linearity of ground and geometrical barrier on strike-slip fault, JpGU2018, SCG66-05.

Keywords: strike-slip fault, Riedel shear, jog, elasto-plasticity, numerical analysis, fracture

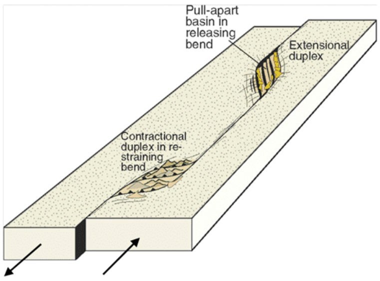

Fig. 1 Jog on strike-slip fault[1)]

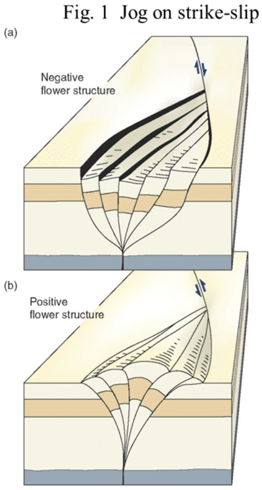

Fig. 2 Flower structures[1)]

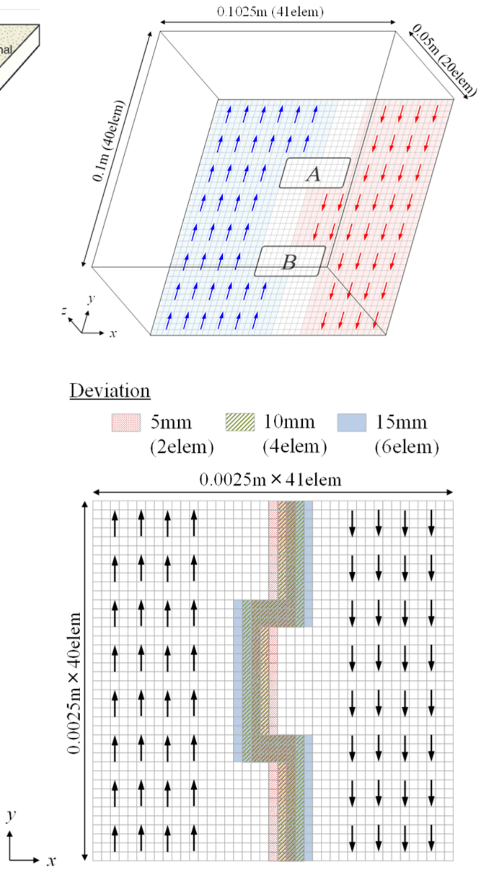

Fig. 3 Finite element mesh and boundary conditions

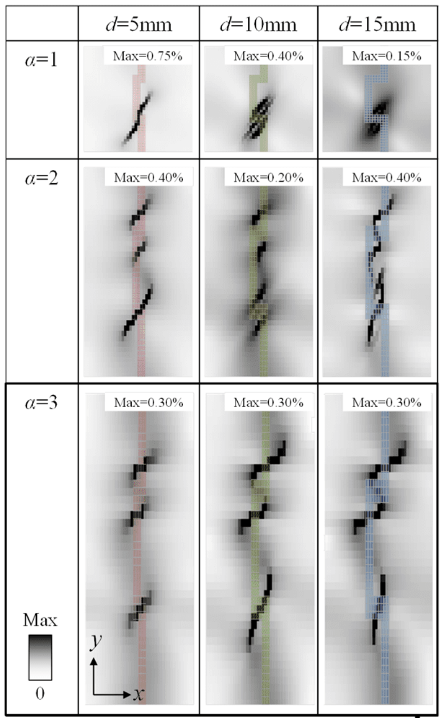

Fig. 4 Shear strain distributions at the surface

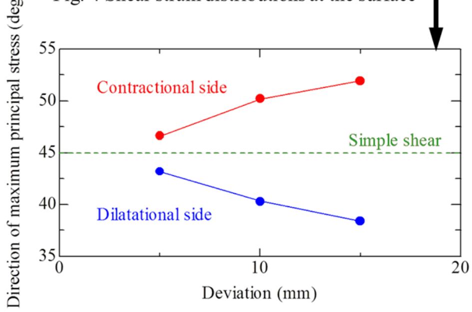

Fig. 5 rotation of the direction of principle stress