EGU2020-14810, updated on 08 Dec 2022
https://doi.org/10.5194/egusphere-egu2020-14810
EGU General Assembly 2020

The applicability of analytical elasto-plastic solutions and issues of the formation of shear bands zones

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Key Words: numerical modelling, elasto-plastic analytical solutions, shear bands, geomechanics.

The correct analysis of wellbore stability in unconventional reservoirs receives much interest from the industry as shale rock and tar sands demonstrate perceptible plastic behavior which influences the estimation of rock failure. To tackle this problem the 3D finite element code has been developed for computing the stress-strain state in the elastoplastic medium near a borehole. The accuracy of the results, obtained due to the application of the finite element technique, can be affected by various numerical effects. Since the theory of plasticity assumes infinitesimal load increments, errors associated with finite increments are almost inevitable. The accuracy of the numerical solution can be verified by comparing the numerical results with the analytical solutions. Elasto-plastic analytical solutions [1], [2] stand out among others because they are the only ones among many others, mentioned in the cited monographs, that consider analytical solutions under conditions of non-hydrostatic loading.

In this study, the numerical and analytical solutions were verified and relative errors were calculated for different loading paths. It turned out, for example, that Galin's analytical solution works well not only in the field of its applicability, but also outside of it, despite different errors. This work discusses questions related to the influence of the increment of the applied load on the structure of a stationary elasto-plastic solution, including in the case of the formation of zones of localized plastic deformation. The issue of the appearance of shear bands zones is also considered: these bands develop directly around the hole under certain boundary conditions or gradually grow out of the zones of elliptical plastic deformation.

The first, third and fifth authors acknowledge support of research by Geosteering technologies company within the scope of Geonaft project sponsored by Skolkovo foundation, Russia.

The second and fourth authors acknowledge support of research by Government of Russian

Federation under grant 2019-220-07-9139.

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