Development a Modification Factor for Lugeon's Water Pressure Test

Kamal Ganjalipour

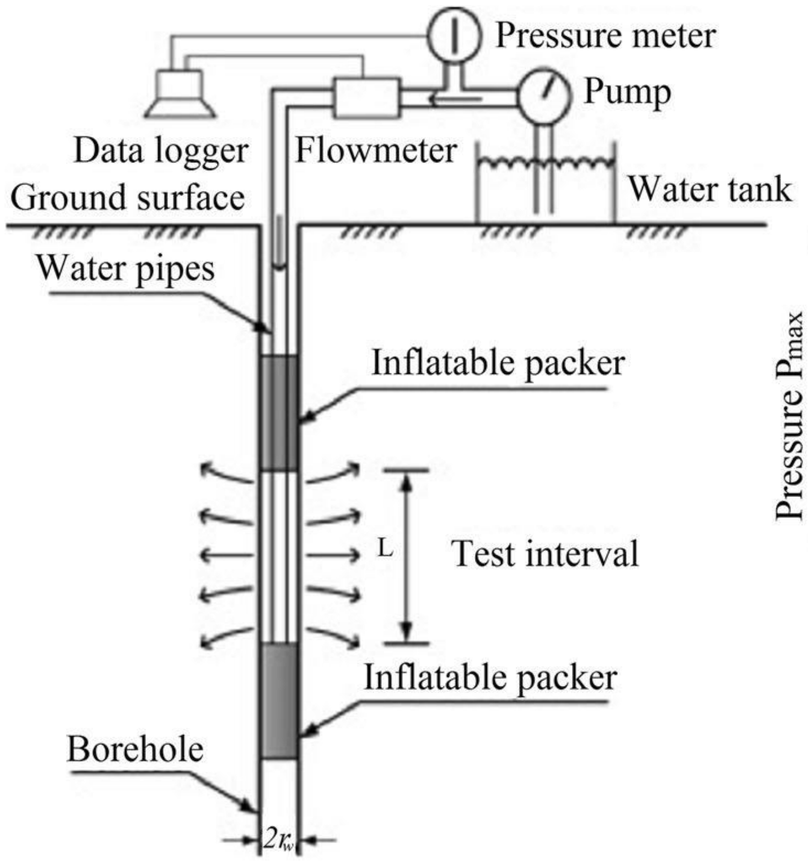
e-mail: k.ganjalipour@gmail.com

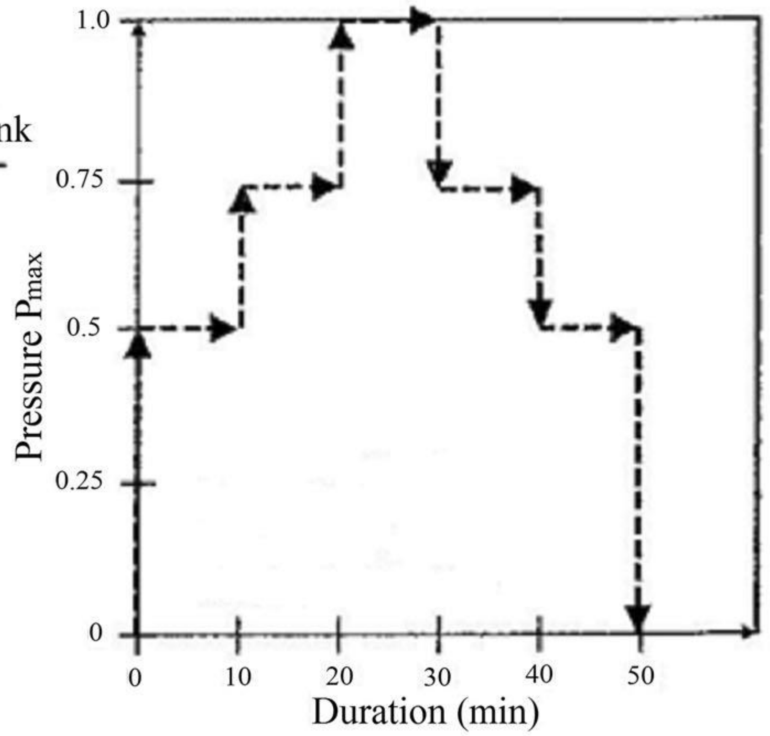
REFRENCE: https://doi.org/10.1007/s10706-020-01566-1

Abstract

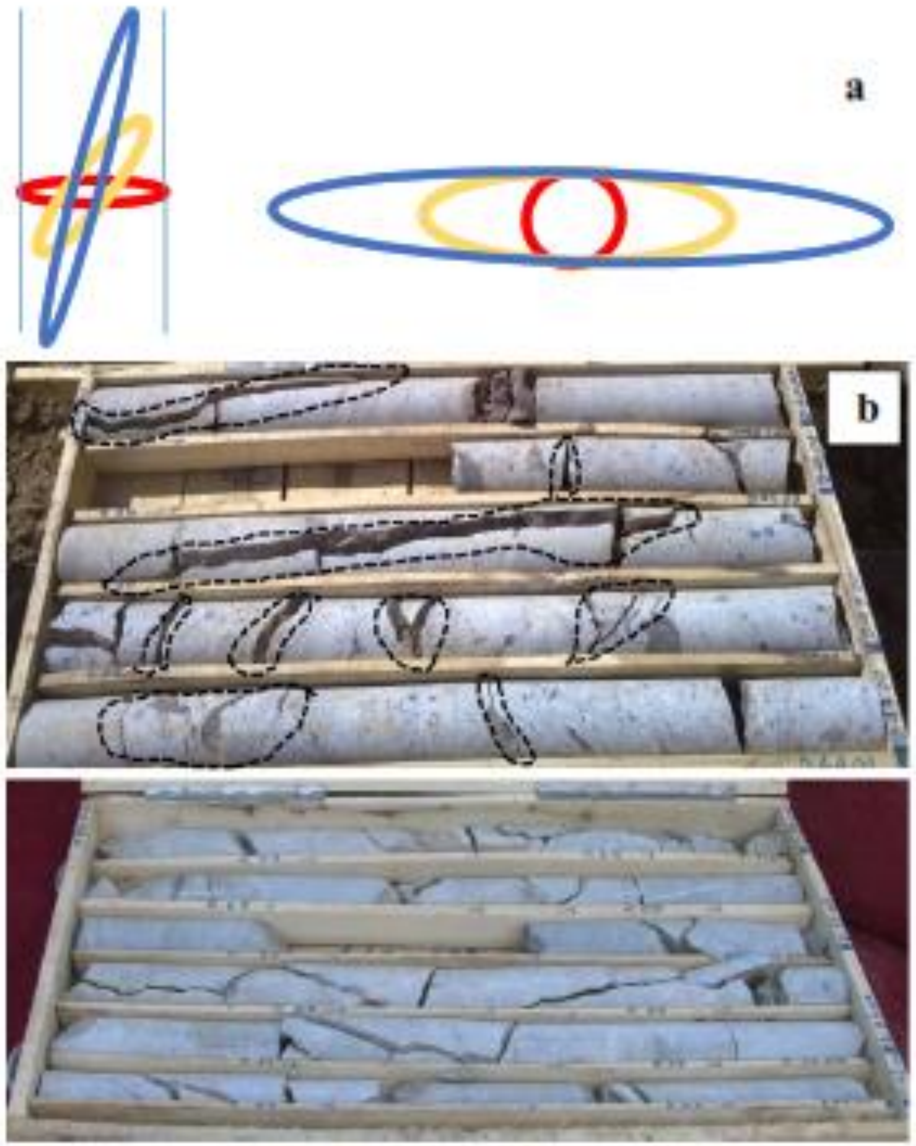
- Since 1933, this test has been used with the least possible modification.
- Some researchers have been trying to interpret the results of this test, including Ewert (1997) and Foyo et al. (2005).
- The authors believe the changes in contact length of the discontinuities in borehole walls lead to a change in Lugeon test results
- The authors developed a correction factors to eliminate the effect of changes of drilling angle of the borehole based on the results of Lugeon test

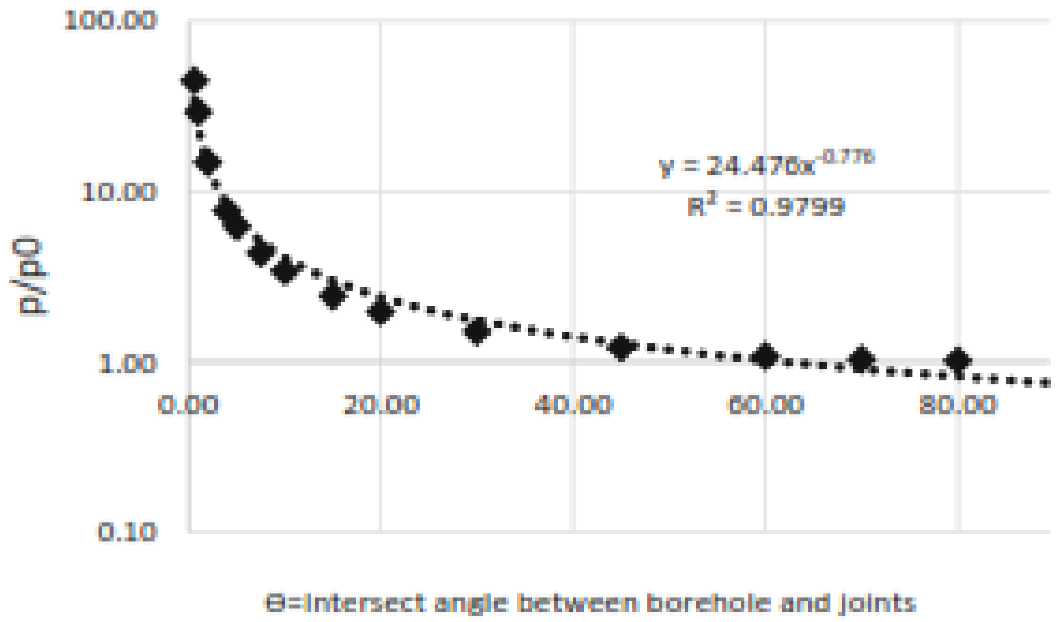
Definition of Lugeon Test





$$N = \frac{10Q}{P_e} \quad (1)$$

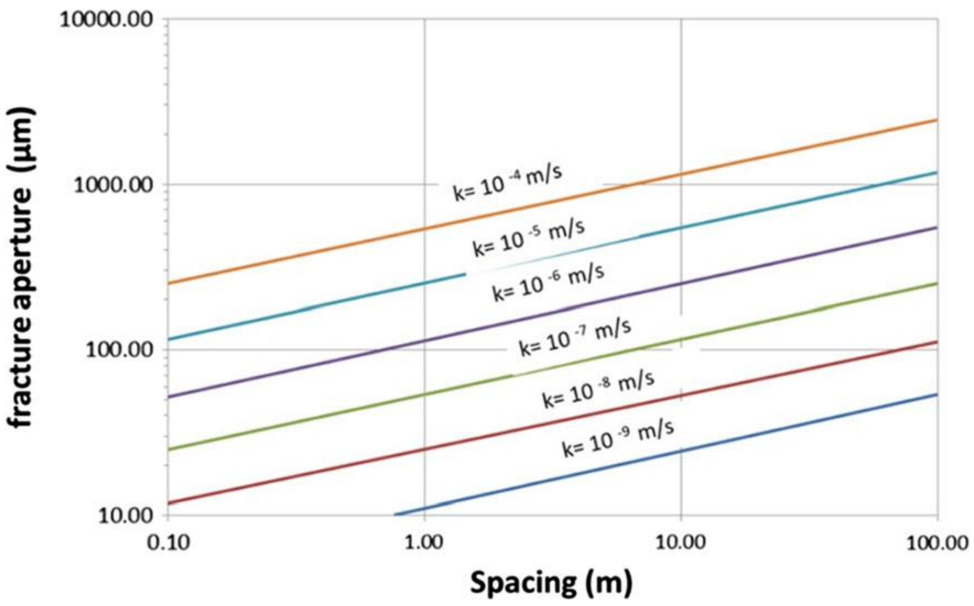




Changes of the ratio of p/p0 against the angle between the borehole and discontinuities

Modeling Below the Groundwater Level

- Inside joints and
- The space around the joints or the environment without joints



$$k = \frac{e^2}{12f},$$

$$f = \left[1 + c_1\left(\frac{r_a}{2e}\right)^{c2}\right],$$

$$e = \frac{E^2}{\mathrm{JRC}^{2.5}},$$

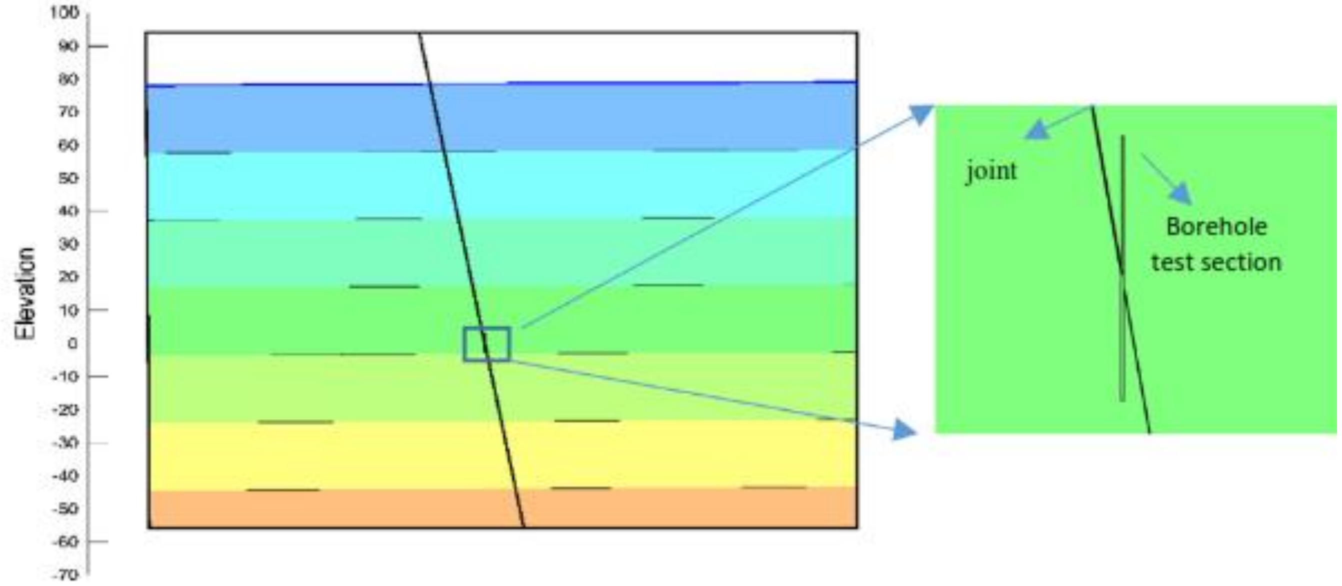
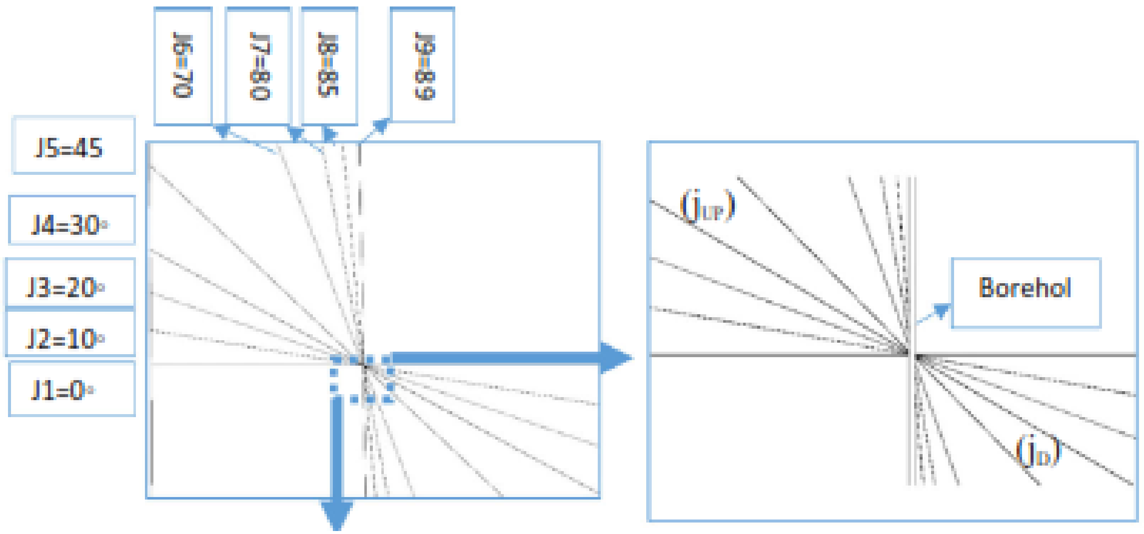
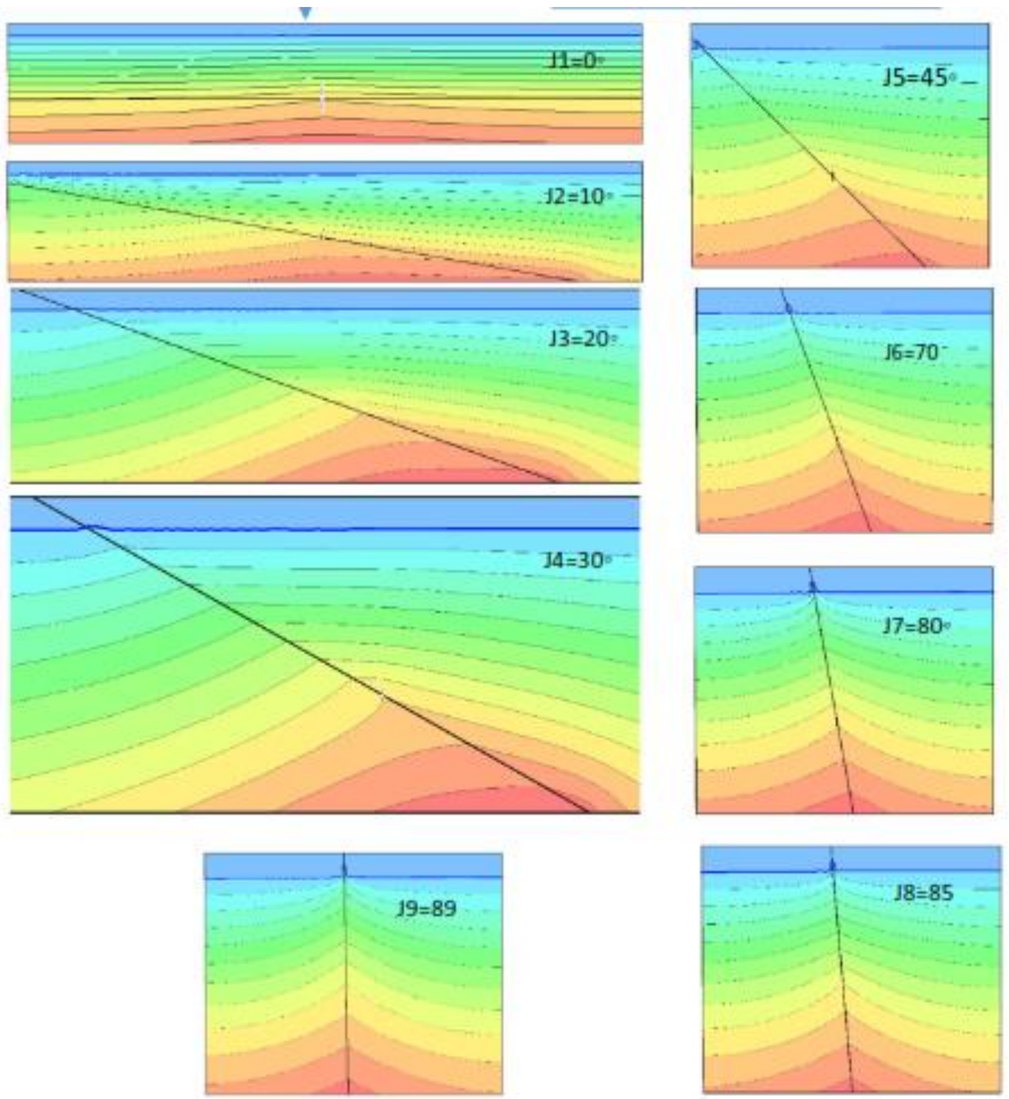


Fig. 5 Steady state analysis of the model





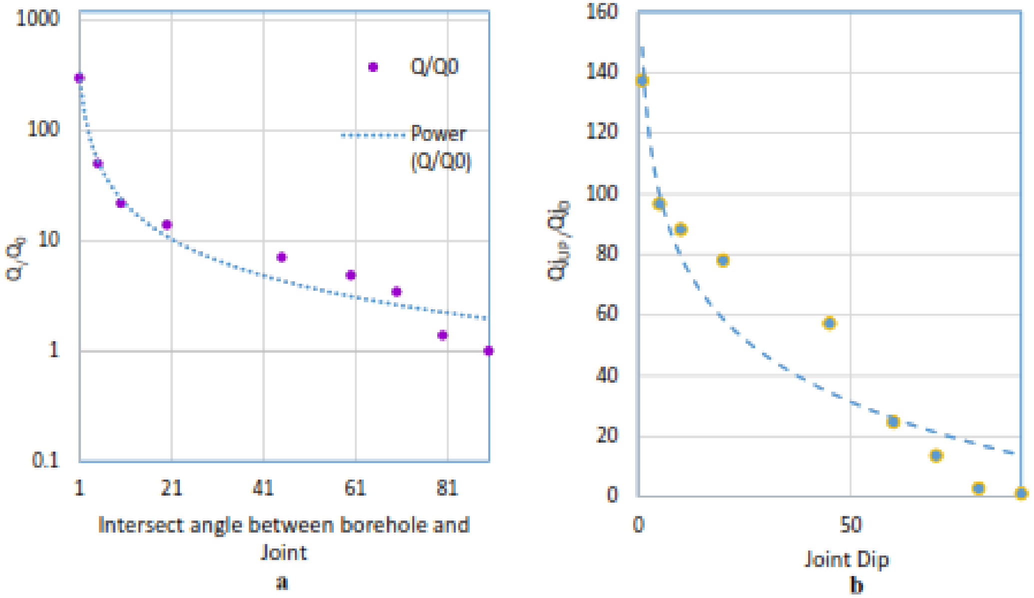


Fig. 7 **a** The ratio of the penetration of water into the jUP to jD; **b** the Q/Q0 ratio versus the angle between the vertical boreholes and the joint, Q0 is inlet flow into the joint, which is perpendicular to the axis of the borehole that, hereinafter, is called the reference joint, also Q is the inlet flow into the joint with any angle (the test section is modeled below the groundwater level)

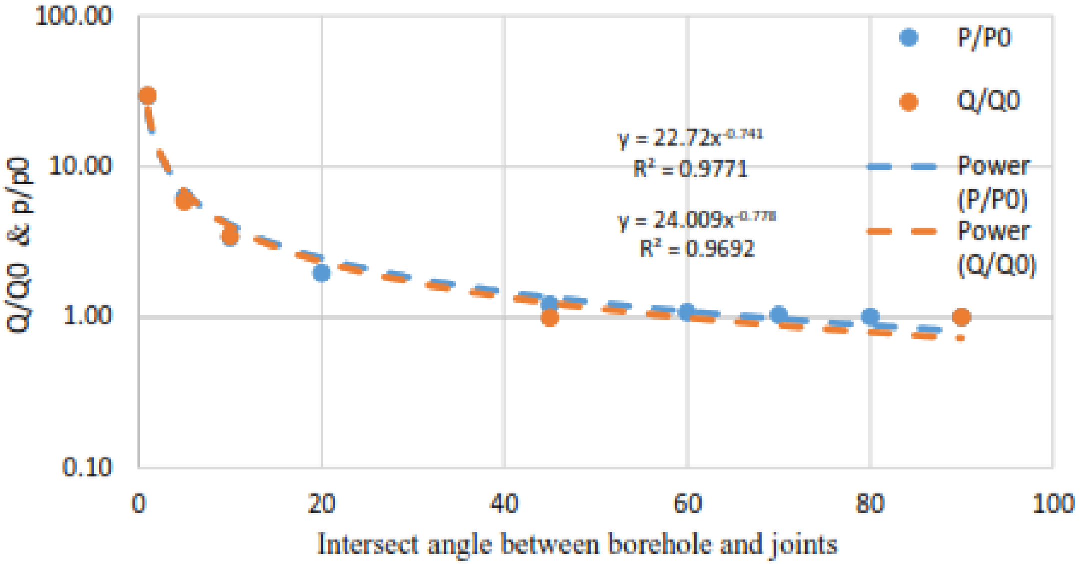
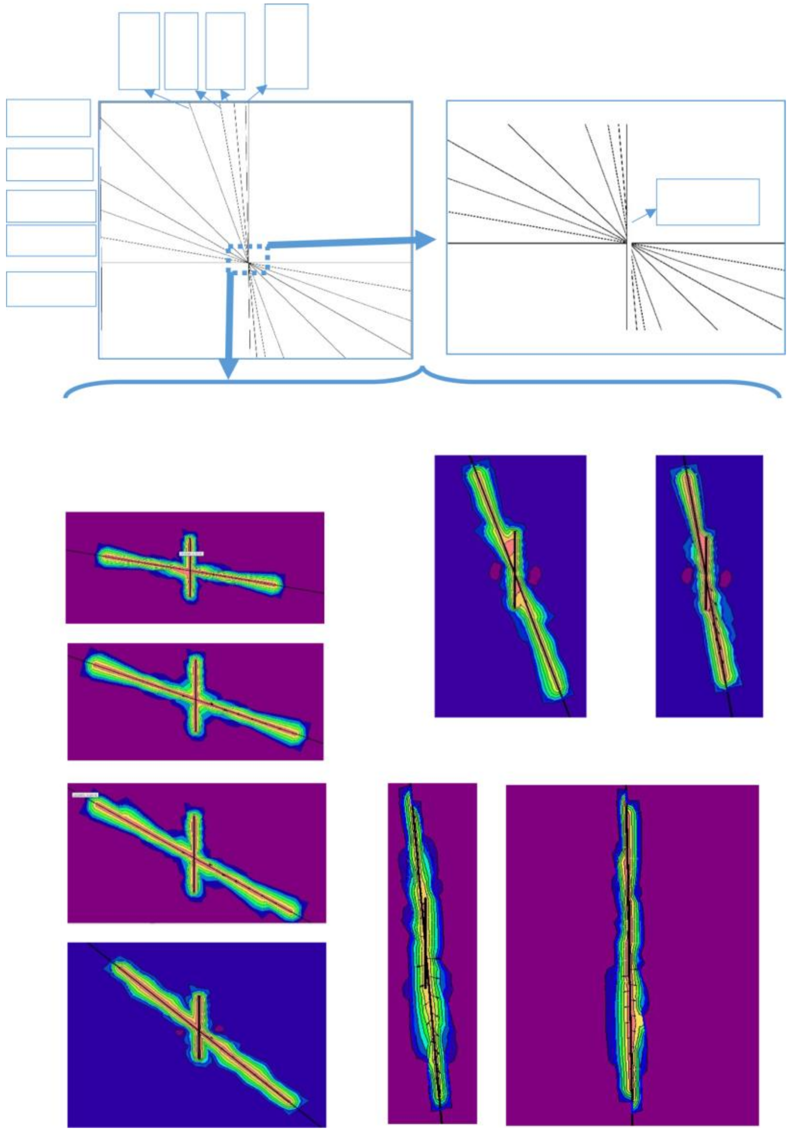
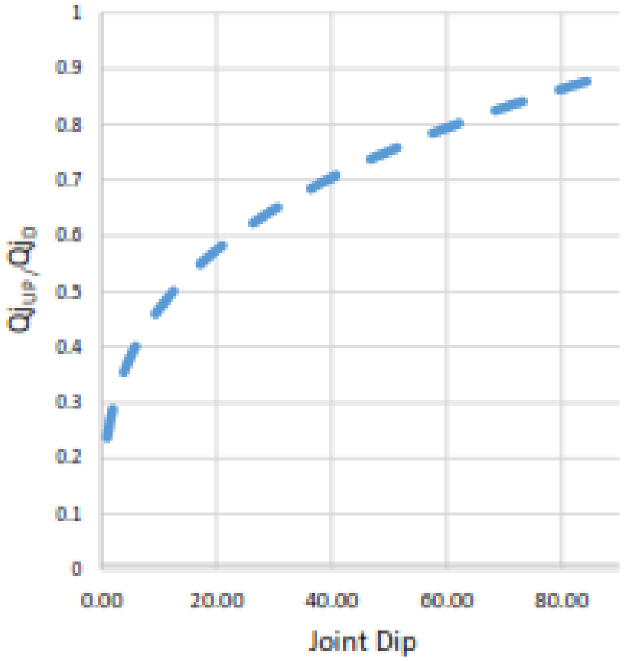


Fig. 8 The ratio Q/Q_0 and P/P_0, versus the angle between joint and the vertical borehole (j_D)

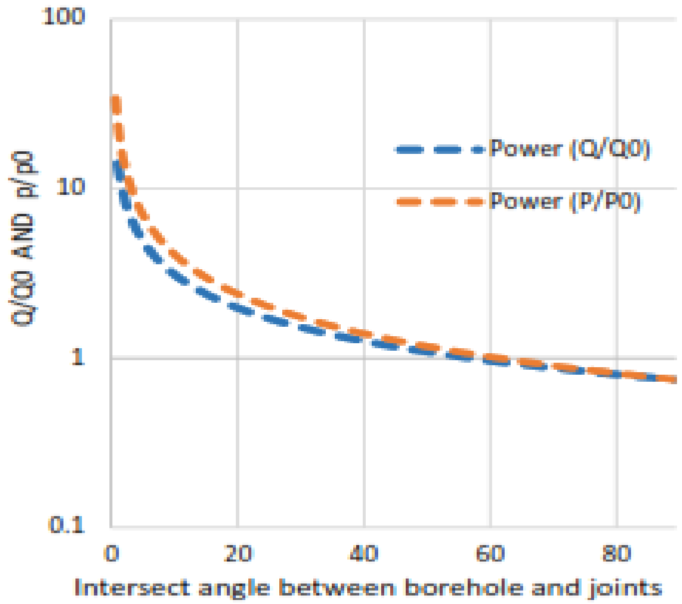
$$\frac{Q}{Q_0} \cong \frac{P}{P_0}$$

Modeling Above the Groundwater Level





a

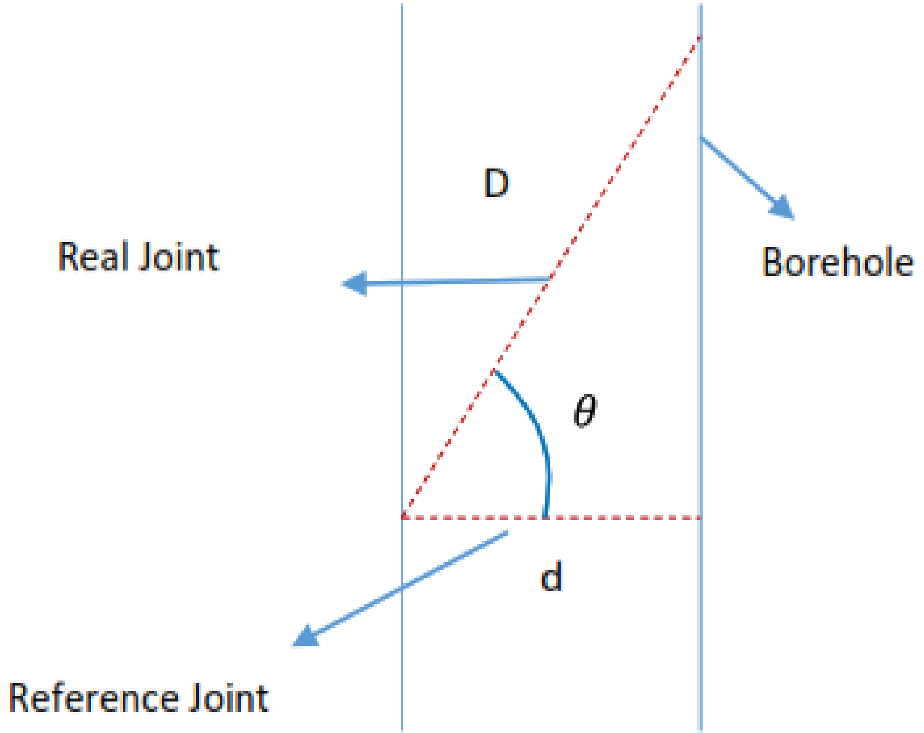


b

Discussion

$$\frac{Q}{Q_0} \cong \frac{P}{P_0} = f \qquad \dot{q} = f q_0 \qquad N = \frac{10 f q_0}{Pe}$$

$$N = f \frac{10 q_0}{Pe} \qquad N = f N_0 \qquad N_0 = \frac{N}{f}$$



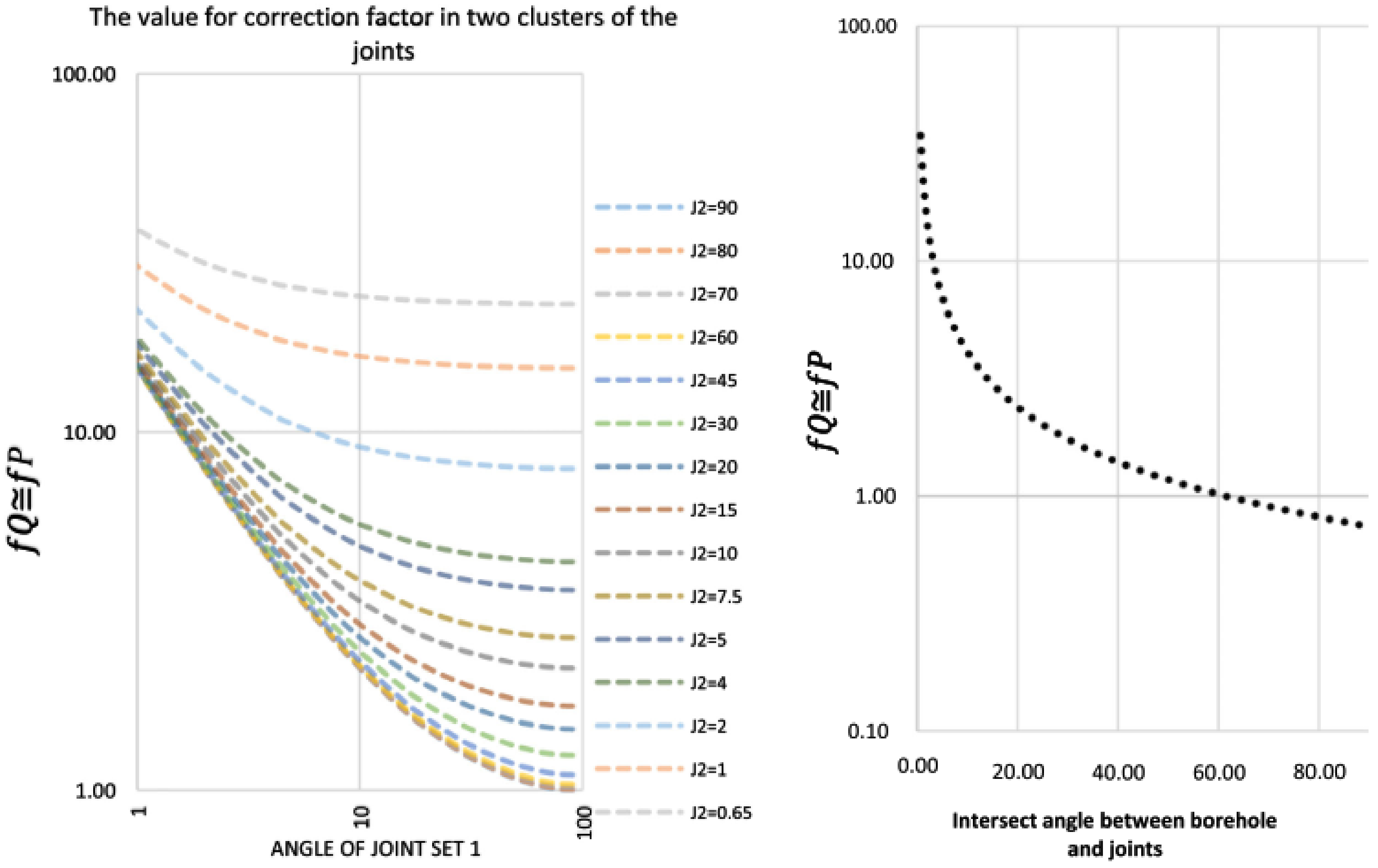


Fig. 12 The graph of the correction factors; **a** for the conditions of existence of one joint; **b** for conditions of existence of two joint

$$\text{Reference joint} = \text{perimeter of circle} \quad P_0 = \pi d \tag{10}$$

$$\text{Existence joint} = \text{perimeter of an ellipse} \quad P = \pi\left(\frac{D+d}{2}\right) \tag{11}$$

$$f_p = \frac{P}{P_0} = \frac{\pi\left(\frac{D+d}{2}\right)}{\pi d}$$

$$f_p = \frac{\pi\left(\frac{\frac{d}{\cos\theta}+d}{2}\right)}{\pi d} = \frac{d\left(\frac{1+\cos\theta}{2\cos\theta}\right)}{d} = \left(\frac{1+\cos\theta}{2\cos\theta}\right)$$

If $\quad 0 \leq \boldsymbol{\theta} < \frac{\boldsymbol{\pi}}{2}$

$$f_p = \left(\frac{1+\cos\theta}{2\cos\theta}\right)$$

and if $\boldsymbol{\theta} = \frac{\boldsymbol{\pi}}{2}$

$$f_p = \frac{2(d+l)}{\pi d}$$

$$f_p = \frac{\left(\frac{1+\cos\theta_1}{2\cos\theta_1}\right) + \left(\frac{1+\cos\theta_2}{2\cos\theta_2}\right) + \cdots + \left(\frac{1+\cos\theta_n}{2\cos\theta_n}\right)}{n} + \frac{2m(d+l)}{\pi d} \tag{16}$$

It can be summarized as:

$$f_p = \frac{\sum_{i=1}^{i=n}\left(\frac{1+\cos\theta_i}{2\cos\theta_i}\right)}{n} + \frac{2m(d+l)}{\pi d} \tag{17}$$

$$Q_{TOTAL} = Q_1 + \cdots + Q_n$$

$$w = \frac{Q_J}{Q_{TOTAL}}$$

$$Q = \left(\frac{a^3}{12\mu}\right)\left(\frac{\Delta h}{l}\right) \tag{20}$$

$$Q_{TOTAL} = \sum_{i=1}^{i=n}\left(\frac{a_i^3}{12\mu}\right)\left(\frac{\Delta h_i}{l_i}\right) \tag{21}$$

$$i = \frac{\Delta p}{l} \tag{22}$$

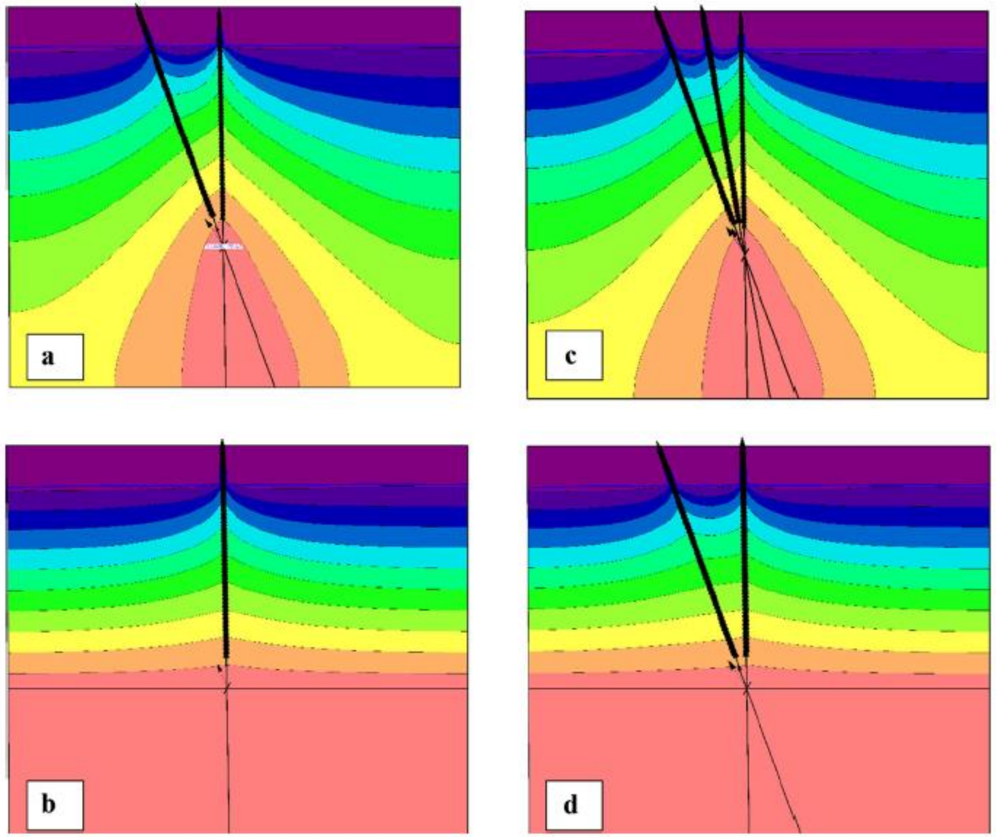
and for inclined joints, we can say:

$$i = \frac{\Delta p}{\frac{l}{\cos\propto}} = i\cos\propto \tag{23}$$

$\propto$ is the angle between the joint with the vertical joint or the vertical axis. By placing of Eqs. 20, 21 and 23 in Eq. 19 we can obtain the impact factor of each joint.

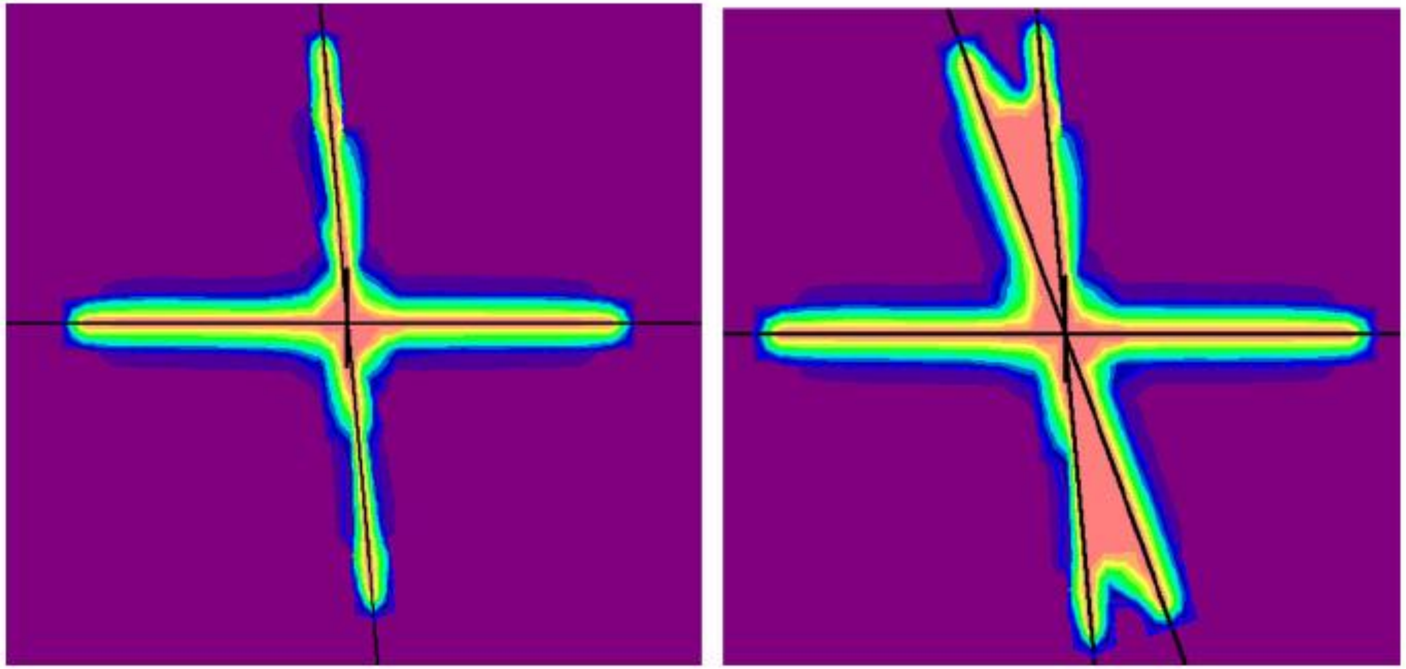
$$w = \frac{\left(\frac{a^3 i\cos\propto}{12\mu}\right)}{\left(\frac{a_{eq}^3 i\cos\propto_{eq}}{12\mu}\right)} = \frac{a^3\cos\propto}{a_{eq}^3\cos\propto_{eq}} \tag{24}$$

$$f_p = \frac{\sum_{i=1}^{i=n}\left(w_i\frac{1+\cos\theta_i}{2\cos\theta_i}\right)}{n} + \sum_{j=1}^{j=m}\left(w_j\frac{2(d+l)}{\pi d}\right)$$



$$w = \frac{\left(\frac{a^3 i}{12\mu}\right)}{\left(\frac{a_{eq}^3 i}{12\mu}\right)} = \frac{a^3}{a_{eq}^3} \tag{27}$$

$$a_{eq} = \sqrt[3]{\sum_{i=1}^{n} a_i^3} \tag{28}$$



با تشکر