GRAPHICAL INTERFACE DESIGNED FOR SECONDARY STRESS LOAD EVALUATION

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Abstract
The paper presents theoretical aspects regarding secondary stress load in the rocks around vertical wells and modern methods for evaluate them. A GUI interface is designed for calculate the stress load according Terzaghi model.
***Keywords*:** secondary stress load, graphical interface, Terzaghi model

1. Introduction

The stability of the drilling work is affected by the loads which manifest in the rock massive. The largest share of the load which affects stability belongs to:

- the initial stress load;
- tension concentration;
- water quantities from the rock massive.

The resistance properties of the rock mass and the value of the secondary stress load developed after the opening of the terrestrial crust through drilling are evaluated by a number of factors such as:

- depth or diameter of wells;
- drilling methods used;
- unsupported drill hole duration.

The secondary stress load represents the weakening of the rock mass, of the weight of the rocks, of the tectonic forces of the rock reexpansion and of the swelling amount, as a result of the physical and chemical interaction between water and rock.

The factors that affect the secondary tension state around vertical drill holes are:

- spatial or geometric factors of the drilling works;
- deformation factors of rocks around terrestrial crust drilling apertures
- the nature and specific characteristics of the natural field of tension of the rock massive;
- particularities of the effects upon the rocks surrounding the drilling works

The spatial factors are as follows: the profile of the well, the cross-sectional size ratio between the diameter and length of the well, and the interaction of neighboring wells.

Deformation factors are related to geological-tectonic phenomena, to the physical and mechanical characteristics of rocks, to elastic and plastic characteristics, as well as to the rheological properties or flow of rocks.

The characteristics of the natural tension field take into account the nature of the primary tension state due to the gravitational, tectonic or hereditary field and well depth.

The rocks surrounding the drilling works change properties over time due to the well-rock interaction; hence a physical and chemical alteration occurs.

Regardless, the influence of all the factors listed abovecannot be taken into consideration for the quantitative assessment of the secondary tension state in the rocks surrounding vertical wells.

In this way the problem has been simplified, which has led to the development of calculation models of the tensions that can appear.

One of these models is that of Terzaghi.

2. The Terzaghi Model

According to Terzaghi, the actual horizontal and lateral tensions are as follows:

$$\sigma_{hef} = \sigma_h - p_p = \frac{\mu}{1-\mu}\left(\sigma_v - p_p\right) \qquad (1)$$

where σ_h represents lateral tension;
p_p – the pressure in the rock pores or layer pressure;
μ – Poisson's coefficient;
σ_v – vertical tension due to the weight of the rocks.

$$\sigma_h = \frac{\mu}{1-\mu}\left(\sigma_v - p_p\right) + p_p \qquad (2)$$

Vertical tension is

$$\sigma_v = \Gamma_{lit} \cdot H \qquad (3)$$

Pore pressure is

$$p_p = \Gamma_p \cdot H \qquad (4)$$

where Γ_{lit} and Γ_p represent the litostatic gradient and the gradient of the pores, and σ_{h1} and σ_{h2} represent lateral tensions according to the Ox and Oy axes.

For vertical cracks (Figure 1) $\sigma_v > \sigma_{h1} > \sigma_{h2}$

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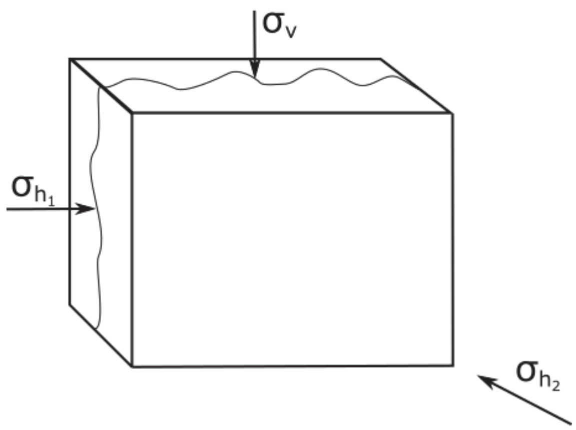

Fig.1 **Vertical cracks**

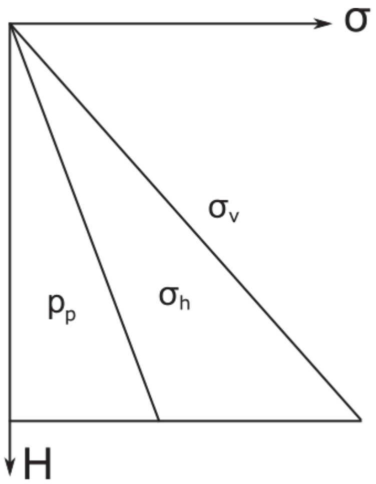

Fig. 2 **Tension variation depending on depth well**

For horizontal cracks (Figure 3):

$$\sigma_{h1} > \sigma_{h2} > \sigma_v$$

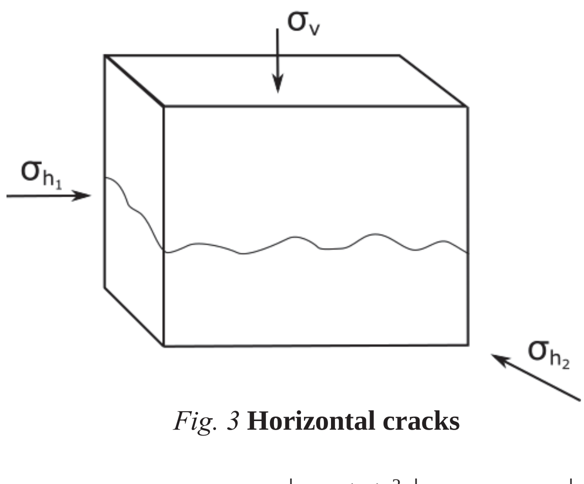

Fig. 3 **Horizontal cracks**

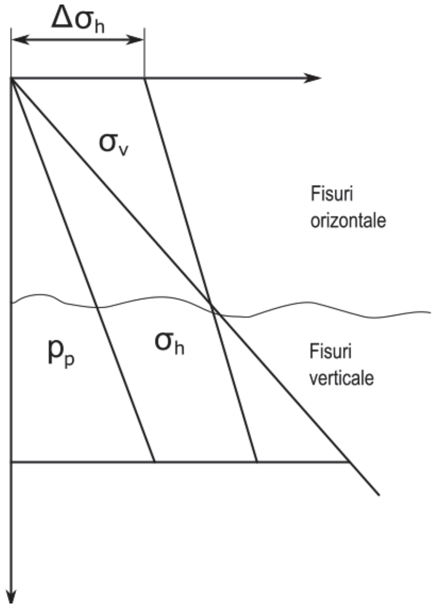

Fig.4 **Tension in a massive rock with horizontal and vertical cracks**

Radial and tangential tensions in cylindrical coordinates (*r, Θ*) as shown in figure 5, which determine the secondary tension states around a vertical well full of drilling fluid with D_s diameter are:

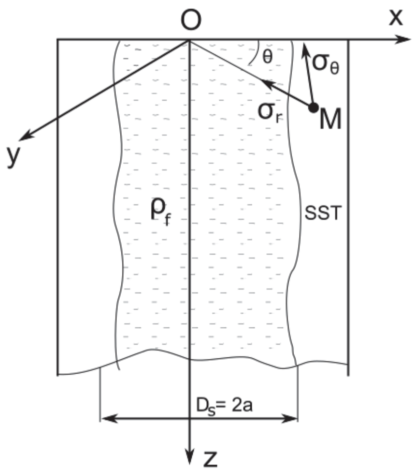

Fig. 5 **Secondary stress load around a vertical well**

$$\sigma_r = \frac{\sigma_{h1}+\sigma_{h2}}{2}\left[1-\left(\frac{a}{r}\right)^2\right]+\frac{\sigma_{h1}-\sigma_{h2}}{2}\left[1+3\left(\frac{a}{r}\right)^4-4\left(\frac{a}{r}\right)^2\right]\times\cos 2\theta+\left(\frac{a}{r}\right)^2 p_f \tag{5}$$

$$\sigma_\theta = \frac{\sigma_{h1}+\sigma_{h2}}{2}\left[1+\left(\frac{a}{r}\right)^2\right]+\frac{\sigma_{h1}-\sigma_{h2}}{2}\left[1+3\left(\frac{a}{r}\right)^4\right]\times\cos 2\theta-\left(\frac{a}{r}\right)^2 p_f \tag{6}$$

where p_f – hydrostatic pressure of the drilling fluid

At the well wall for $r=a$:

$$\sigma_r = p_f \tag{7}$$

$$\sigma_\theta = \sigma_{h1} + \sigma_{h2} - 2(\sigma_{h1} - \sigma_{h2})\cos 2\theta - p_f \tag{8}$$

Maximum tangential tension is determined for

$$\theta = \frac{\pi}{2};\ \cos 2\frac{\pi}{2} = -1$$

$$\sigma_{\theta\max} = 3\sigma_{h1} - \sigma_{h2} - p_f \tag{9}$$

Minimum tangential tension is determined for:

$\theta = 0$

$\cos 0 = 1$

$$\sigma_{\theta mim} = 3\sigma_{h2} - \sigma_{h1} - p_f \tag{10}$$

If $\sigma_{h1} = \sigma_{h2} = \sigma_h$

$$\sigma_\theta = 2\sigma_h - p_f \tag{11}$$

Radial and tangential effective tension are:

$$\sigma_{ref} = \sigma_r - p_p \tag{12}$$

$$\sigma_{\theta ef} = \sigma_\theta - p_p \tag{13}$$

For $\theta = \frac{\pi}{4};\ \cos 2\frac{\pi}{4} = \cos\frac{\pi}{2} = 0$

Results:

$$\sigma_r = \frac{\sigma_{h1} + \sigma_{h2}}{2}\left[1 - \left(\frac{a}{r}\right)^2\right] + \left(\frac{a}{r}\right)^2 p_f \tag{14}$$

$$\sigma_\theta = \frac{\sigma_{h1} + \sigma_{h2}}{2}\left[1 + \left(\frac{a}{r}\right)^2\right] - \left(\frac{a}{r}\right)^2 p_f \tag{15}$$

Graphical interface is built in Matlab GUI. There are used predefined objects available in Matlab, such as:

- 4 objects type Edit Text
- 24 objects type Static text
- 1 object type Push Button

Once made the GUI generates two files Terzaghi.fig and Terzaghi.m (fig. 6). The second file is the one where are defined the object's properties.

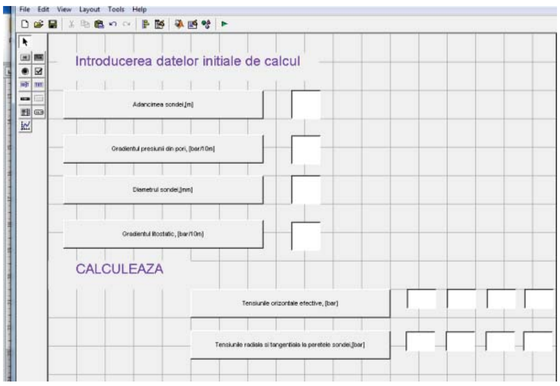

Fig. 6 **Graphical interface created**

After the button CALCULEAZA is pushed, the GUI returns the results according to the presented algorithm as is shown in figure 7.

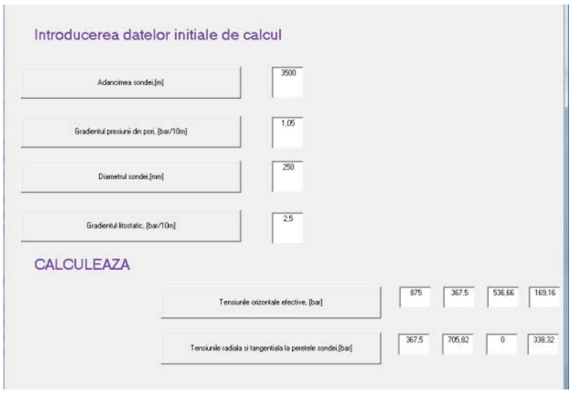

Fig. 7 **The results obtained by running the program**

3. Conclusions

With the completion of drilling operations, the tension state of the massif gets altered by the emergence of tension concentrations that threaten the stability of the drill holes, as a consequence of the created pressure environment.

Modifications of the pressure state (figure 8) depend on the physical and mechanical properties of the rocks, on the tension states, on the spatial position of the drill hole direction, on drill hole size, time, and depth. Tensions increase as depth increases.

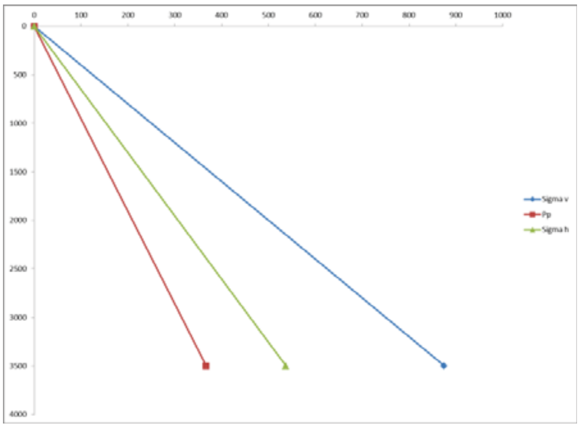

Fig. 8 **The variation of horizontal, vertical tension and pore pressure according to depth well**

In order to achieve stable, durable, and economical drilling it is necessary to know the phenomena underlying the drilling operations and how to best face the technical and economic problems which are frequently encountered in the field of well drilling.

For the purpose of determining the secondary tension state around certain vertical wells have been elaborated more methods that have diversified the solving of the problem via the use of calculation models.

The Terzaghi model has been used for homogeneous, elastic, and isotropic rocks, and a series of scenarios have been carried out in order to determine the respective tensions in a variety of situations.

The Terzaghi model is based on the elastic theory of thick-walled tubes and has led to the determining of the secondary tension state around the vertical drill hole. According to this theory, the drill hole consists of a thick-walled tube of elastic, homogeneous and isotropic rock, and is subjected to a hydrostatic request.

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