OVERALL ASSESSMENT OF A SLOPE STABILITY IN THE MINING OPERATIONS - PERIMETER URICANI

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Abstract: In a slope stability assessment was done stability analysis, which aims to confirm existing slides, to specify how they are stabilized, the shear strength parameters confirm and quantify the effect of excavation and supporting stability the entire slope.
Keywords: stability, analysis, calculations of stability. slope geometry.

1. Analysis of slope stability

This analysis is designed to confirm existing slides, to specify how they are stabilized, the shear strength parameters confirm and quantify the effect of excavation and supporting the stability of the whole mountain. The calculations were made by means of limit equilibrium hypothesis flat.

The profile were carried out 4 geological drilling which accredits the idea that information is something more complete than in other profiles. In addition, continuity and thickness of colluvial are indisputable in this profile and depth of the excavation leads to one of the worst situations columns on request. For this reason in this profile have been performed, and the simulations.

2. Confirmation slip of a slope existing primary

Existence platform to share cvasiorizontale 610.00 m at the base completely devoid of outcrops accredited deluviu an old idea of colluvial landslide on bedrock absolute phenomenon plausible existing geological and hydrogeological conditions at the site. Depending on the current morphology was assumed plausible configuration of a hypothetical existing slope, quite close to the current configuration with amendments especially in the significant platform to share 610.00 m, fig.1.

Stability calculations were made Janbu adopting the model considered most appropriate for such forms of sliding surface, using the packet GEOSLOPE.Ver SLOPEW module. International GeoSlope 4.0 product, Calgary, Alberta, Canada.

In a first step to reverse an analysis of the slope stability hypothetical existing defined above, which was adopted a range of cohesion values based on the recommended study of c = 50 kPa GEOTEC up to c = 0, for three distinct values of internal friction angle: φ = 220, 250 and 280, provided that the natural slope angle of observation, the material from the site may be even more frictional. As regards cohesion values, 50 kPa seems a great value for this type of material, even as peak value, the more residual one.

For accurate calibration and elimination of harmful superficial calculation of landslides caused by the adoption of an internal friction angle lower than the angle of repose naturally took into account the state of unsaturated above the curve of depression by a variation of cohesion with a suction angle φ^b = 220. This value can incorporate the effect of vegetation superficial.

For the proposed configuration of the depression curve were calculated and infiltration forces acting adversely on the deluviu volume. In table 1 are shown the values of infiltration forces acting on each of the four proposed areas calculated assuming a porosity of 40%.

Potential slip surfaces were selected after an assessment based on overall stability circular cylindrical surfaces failure, after which they identified the main trends of instability. The following were the most likely optimized four sliding surfaces as the surfaces defined by some form of diluvium bedrock interface and connected to the foot of the slope, the bed Jiu. Such cinematic possible under a high level in the aquifer and possible erosion of the riverbed slope foot, perfect possible conditions to be met over time.

Table 1. *Calculation of infiltration forces (kN/ml) for existing slope*

	Sliding surfaces			
	Surface 1	Surface 2	Surface 3	Surface 4
The resultant forces infiltration	670	690	430	450

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The results of stability calculations are summarized in Table 2 and graphs in Figure 2, relatively narrow beach of values of stability factor of around Fs = 1 confirming a poor stability of the entire slope. Alura curves demonstrate the high sensitivity of the model to variations in cohesion and extremely low internal friction angle variations, which is explained in great length sliding surfaces compared with depth.

A careful analysis of the values resulting from the calculation also highlights that the values of shear strength parameters do not allow slipping triggering even in the most pessimistic primary application scenarios. The areas 1 and 4 proved to be the most unstable, so the most likely to trigger the primary sliding, while the surface 3 appears to be the most stable. Instability surface type 4 foot erosion caused possibly can primary landslides induced by retrogression to the crest of the slope. Another scenario suggested overall stability analysis of circular cylindrical surfaces could be that of independent sliding surfaces onset of type 4 and type 1 output surfaces in slope at an elevation above the tunnel somewhere without being affected even material of the tunnel. This hypothesis is partially confirmed by finite element analysis, but is dependent on local bedrock elevation of the site is not advisable to be taken into calculations.

The bottom of the slope stability analysis is that existing in absolutely plausible assumptions request, ie a high hydrostatic level superimposed a moderate earthquake (K_S = 0.10), the primary sliding slope confirmed, with the relocation of the material in a more stable geometry with any subsequent reactivation triggered either by raising the aquifer or erosions foot. Acceptance of the primary slipping and tripping of the reactivated maintenance is inconsistent with the values of cohesion optimistic 50 kPa becoming a residual cohesion with values closer to 0.

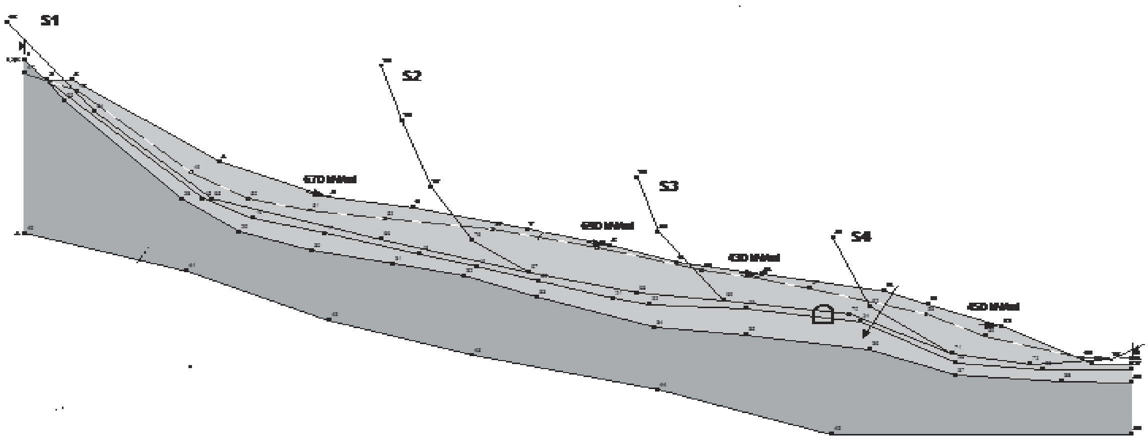

Figure 1. *Simplified calculation model for the representation of the 4 existing slope sliding surfaces*

Table 2. *Back-analysis to specify the parameters of peak and residual shear strength*

Sliding surface	φ = 22^0					φ = 25^0					φ = 28^0				
	Cohesion c (kPa)					Cohesion c (kPa)					Cohesion c (kPa)				
	50	**40**	**30**	**20**	**0**	**50**	**40**	**30**	**20**	**0**	**50**	**40**	**30**	**20**	**0**
S1	1.19	1.06	0.93	0.81	0.55	1.27	1.15	1.02	0.89	0.64	1.36	1.23	1.11	0.98	0.73
S2	1.27	1.12	0.98	0.84	0.56	1.35	1.21	1.07	0.93	0.64	1.44	1.30	1.16	1.02	0.73
S3	1.39	1.23	1.06	0.90	0.58	1.48	1.31	1.15	0.99	0.68	1.57	1.41	1.25	1.09	0.77
S4	1.27	1.12	0.96	0.81	0.50	1.35	1.19	1.04	0.88	0.58	1.42	1.27	1.11	0.96	0.66

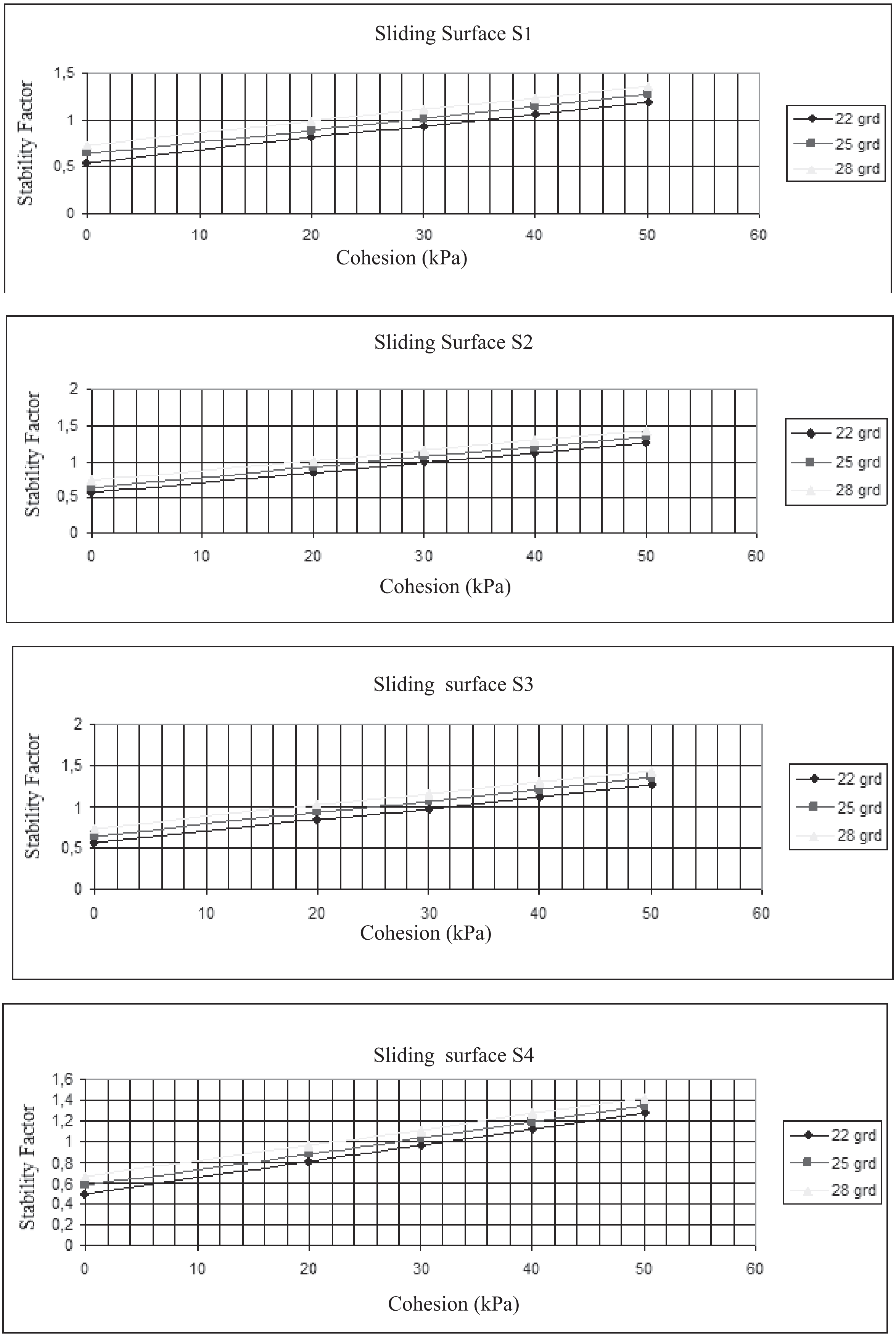

Figure 2. *Influence of shear strength parameters on the stability of existing slope to select the most plausible values that can confirm slipping primary*

3. The existing slope stability and determination of residual shear strength parameters

The next step aims behaviour slope stability analysis to calibration parameters existing residuals of resistance shear to be involved in supporting the calculation solution.

The model adopted is the one in Figure 1, the groundwater is drained and seepage forces are calculated for new configuration of the depression curve in table 3.

Analysis of overall stability on surfaces of circular-cylindrical surfaces after release highlights also sliding surfaces predisposition to type 4 and type 1 output surface of the slope. Examination map with isolines stability factors shown in figure 3 confirm this statement.

In the calculations for the 4-releasing surface was analyzed as some two hypotheses, one corresponding to a high hydrostatic level almost similar to that in which investigations were made - End of Season umed- and the other in which this situation was superimposed a moderate earthquake (K_S = 0.10). The range of values of cohesion declined to values lower than 20 kPa for friction angle values $\varphi = 22^0$ and $\varphi = 25^0$. Values stability factors obtained are summarized in tables 4 and 5.

Table 3. *Calculation of seepage forces (kN /m) and components for the axes existing slope*

<table>
<tr><td rowspan="3"></td><td colspan="8">Sliding surfaces</td></tr>
<tr><td colspan="2">Surface 1</td><td colspan="2">Surface 2</td><td colspan="2">Surface 3</td><td colspan="2">Surface 4</td></tr>
<tr><td>Concentrated forces</td><td>Forces distributed nodes</td><td>Concentrated forces</td><td>Forces distributed nodes</td><td>Concentrated forces</td><td>Forces distributed nodes</td><td>Concentrated forces</td><td>Forces distributed nodes</td></tr>
<tr><td>The resultant forces infiltration</td><td>50</td><td>16.66</td><td>690</td><td>230</td><td>220</td><td>73.33</td><td>90</td><td>30</td></tr>
<tr><td>Horizontal components</td><td>48</td><td>16</td><td>669</td><td>223</td><td>214</td><td>71</td><td>88</td><td>29.3</td></tr>
<tr><td>Vertical components</td><td>-10</td><td>-3.33</td><td>-167</td><td>-58</td><td>-49</td><td>-16.3</td><td>-15</td><td>-5</td></tr>
</table>

Table 4. *Slip the assumption static stability, NH high residual parameters of shear strength. Factors existing slope stability*

<table>
<tr><td rowspan="3">Sliding surface</td><td colspan="2">$\varphi = 22^0$</td><td>$\varphi = 25^0$</td></tr>
<tr><td colspan="2">Cohesion c (kPa)</td><td>Cohesion c (kPa)</td></tr>
<tr><td>20</td><td>0</td><td>0</td></tr>
<tr><td>S1</td><td>1.36</td><td>1.05</td><td>1.19</td></tr>
<tr><td>S2</td><td>1.36</td><td>0.99</td><td>1.14</td></tr>
<tr><td>S3</td><td>1.67</td><td>1.23</td><td>1.41</td></tr>
<tr><td>S4</td><td>1.59</td><td>1.16</td><td>1.30</td></tr>
</table>

Table 5. *Stability slip assuming pseudo-static, NH high shear strength parameters of residual. Factors existing slope stability*

<table>
<tr><td rowspan="3">Sliding surface</td><td colspan="2">$\varphi = 22^0$</td><td>$\varphi = 25^0$</td></tr>
<tr><td colspan="2">Cohesion c (kPa)</td><td>Cohesion c (kPa)</td></tr>
<tr><td>20</td><td>0</td><td>0</td></tr>
<tr><td>S1</td><td>1.00</td><td>0.77</td><td>0.87</td></tr>
<tr><td>S2</td><td>1.00</td><td>0.73</td><td>0.83</td></tr>
<tr><td>S3</td><td>1.22</td><td>0.89</td><td>1.03</td></tr>
<tr><td>S4</td><td>1.22</td><td>0.88</td><td>0.98</td></tr>
</table>

Comparing values in Tables 3 and 5. factors for slope stability with pre-existing geometry, in the present one, in situations similar request, highlights the stability surplus acquired for each of the areas likely sliding on the slope and resettlement conditions improve drainage, drainage accompanied by a significant reduction in infiltration forces.

The new geometry of the drainage slope and new conditions reveal an more obvious predisposition sliding surfaces of type 1 and 2 and less on the type 3 and 4. This accredits the idea that any slip could reactivation affect the entire slope to the ridge, regardless of whether the movement would primer ridge because lifting aquifer or foot slope eroded basement excavation or improperly supported.

The comparison of the stability factor values with those in Table 4. Table 5. highlights the significant weakening of the stability as a result of seismic action as she modeled pseudo sense, as an additional horizontal force unfavorable. It is known that in our country's conditions, landslides are triggered by seismic action immediately, but are favored by it, in that slippage occurs usually at a certain time after the earthquake, if other conditions remain unfavorable .

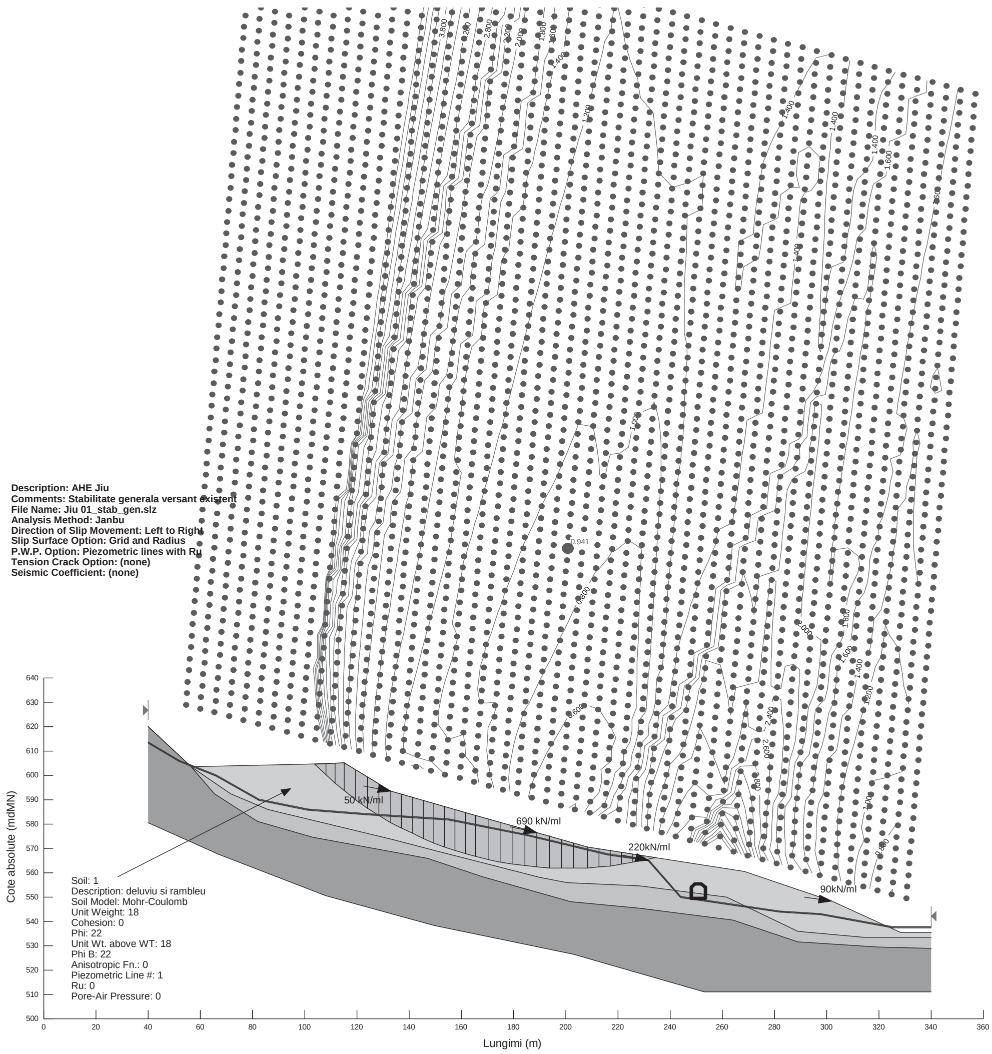

Figure 3. *Analysis of overall stability and isolines map for slope stability factors existing representation seepage forces resultants*

4. Evaluation thrust on supporting the excavated slope assumption, calculated on the basis of limit equilibrium

In the next step of the slope excavation stability was examined under the conditions that the last strip is supported by the various forces concentrated. The amount of force necessary to maintain balance, stability factor, (Fs> 1) the entire slope - on all 4 types of surfaces alunecare- will be numerically equal to the resultant thrust on supporting active. In figure 4 is presented the calculation described.

Beach shear strength parameters was further narrowed. For internal friction angle $\varphi = 22^0$ value was adopted, although it seems that the actual value is slightly higher, but taking into account the influence of low friction, this value was maintained.

For Cohesion were adopted two values: c = 0 and c = 20 kPa.

To maintain the balance of forces required were chosen values between P = 600, 800 and 1000 kN / ml slope. To thrust of 600 kN / ml was achieved and a pseudo account.

Table 6. *Slip assuming static stability, NH high residual parameters of shear strength. Factors excavated slope stability*

Sliding surface	$\varphi = 22^0$					
	Cohesion c=0 (kPa)				Cohesion c=20 (kPa)	
	P=0 kN/ml	P=600 kN/ml	P=800 kN/ml	P=1000 kN/ml	P=600 kN/ml	P=600 kN/ml Pseudostatic
S1	0.98	1.02	1.04	1.05	1.31	0.97
S2	0.89	0.95	0.97	1.00	1.29	0.96
S3	1.06	1.21	1.27	1.33	1.61	1.20
S4	0.82	1.06	1.18	1.29	1.43	1.16

Limit equilibrium calculation values are presented in Table 6, as stability factors make at different levels of support deployed forces. It is observed that the stability factor values beach is not too wide, their variation is not much influenced by the strength of support. A slight variation of cohesion even significantly alter the stability factor values. We note also that the forces in support values so obtained are comparable to the interaction forces between strips model adopted by Janbu.

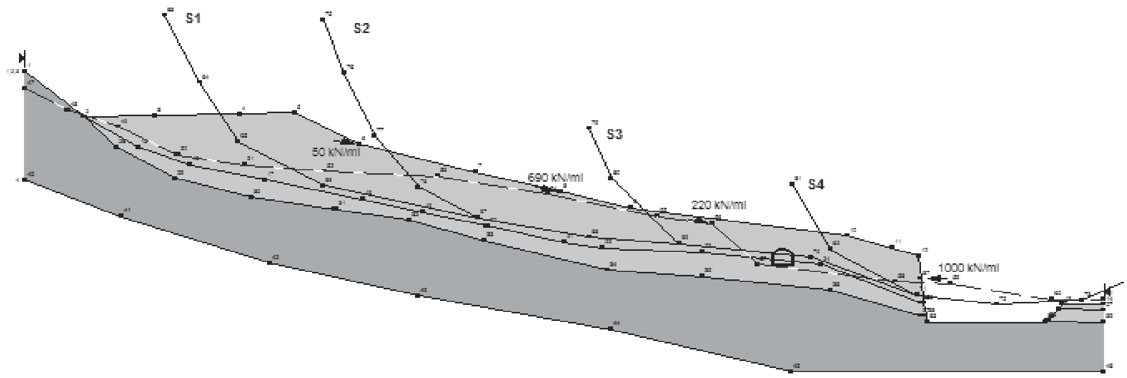

Figure 4. *Simplified calculation model for the representation of the four excavated slope surfaces sliding foot slope excavation and seepage forces resultants*

5. Conclusions

It was assumed plauyibilă configuration of a hypothetical existing slope.

An analysis was made of the stability reversed.

Since that calculation was reached conculiza primary sliding slope confirm with the relocation of the material in a more stable geometry and possible subsequent reactivation triggered either by raising the aquifer either eroy of picor.

Stability factor is numerically equal to the resultant thrust on supporting active.

References

1. Moldovan. A.C.
Studies and cerctări the possibility of building a plant often unstable slope in the underground coal mining in the Jiu Valley - Uricani perimeter,
PhD Thesis, 2015