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Landslide Hazard Assessment on a site-specific scale: vertical road axis Nº75, Komotini-Nymfaia to Hellenic-Bulgarian border – *(SciNet NatHazPrev Project)*

Democritus University of Thrace (P1)

Department of Civil Engineering

Geotechnical Division

M. Psaroudakis, Th. Lazaridis, El. Petala, J. Gkiougkis, I. Markou, S. Skias and N. Klimis

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Activity 3.1:

Landslide Hazard Assessment (LHA) at a regional scale based on the adopted/ adapted methodology

Activity 3.4:

Slope stability analyses on natural and cut slopes in order to propose preventive measures.

Scales:

Regional (1:250,000 to 1:25,000)

Local (1:25,000 to 1:5,000)

Site – Specific (< 1:5,000)

As defined in SafeLand project (Corominas et al, 2013)

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Vertical Roadway Axis 75 (22.3km)

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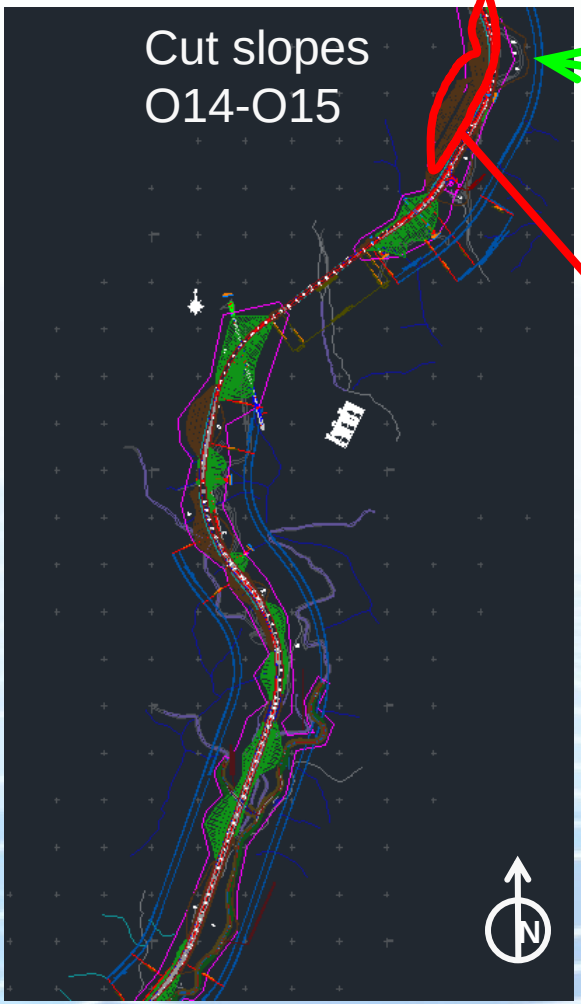

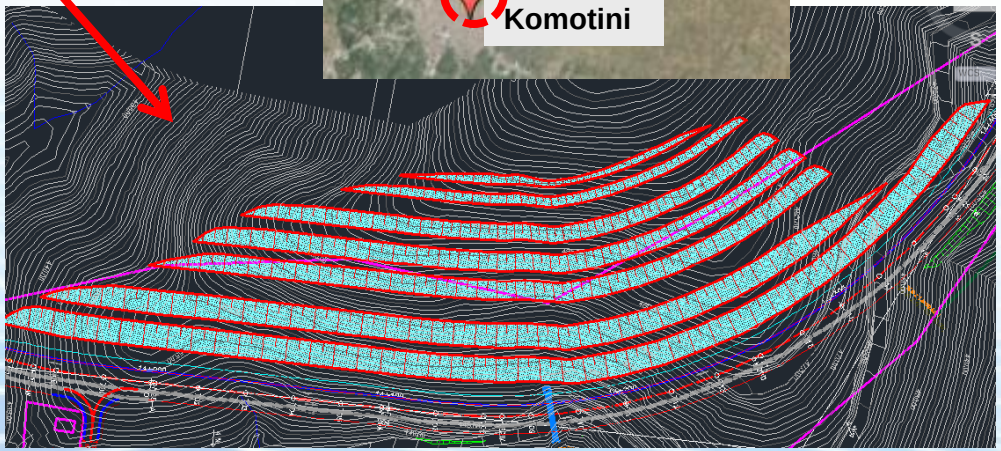

Cut slopes O14-O15 : km: 13+940 – 14+400

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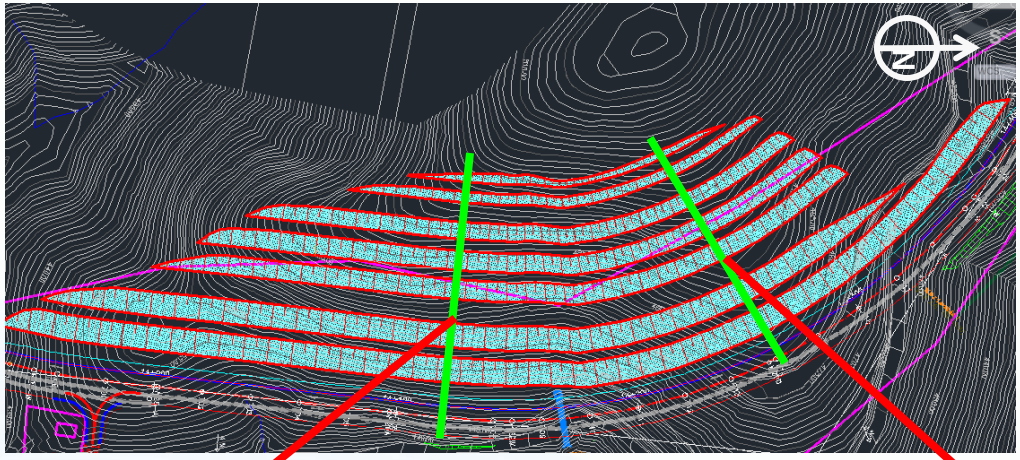
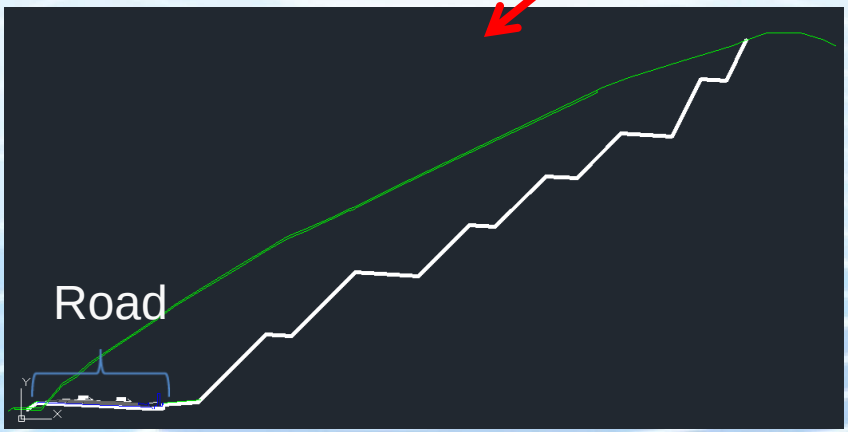
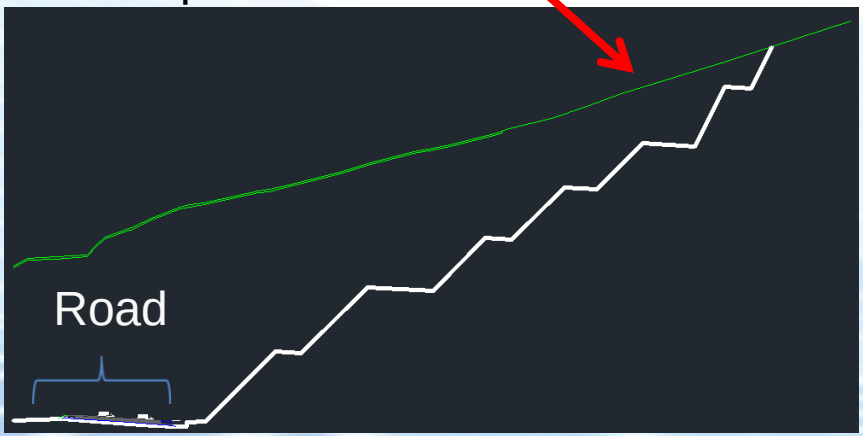


Cut Slope O14



Cut Slope O15



The slope stability analysis was carried out by using the specialized software **GSTABL7 with STEDwin**

This software has the ability of controlling automatically up to 5000 combinations of circular and polygonal plane surface of any shape, by using **limit equilibrium methods** such as Modified Bishop, Simplified Janbu etc.

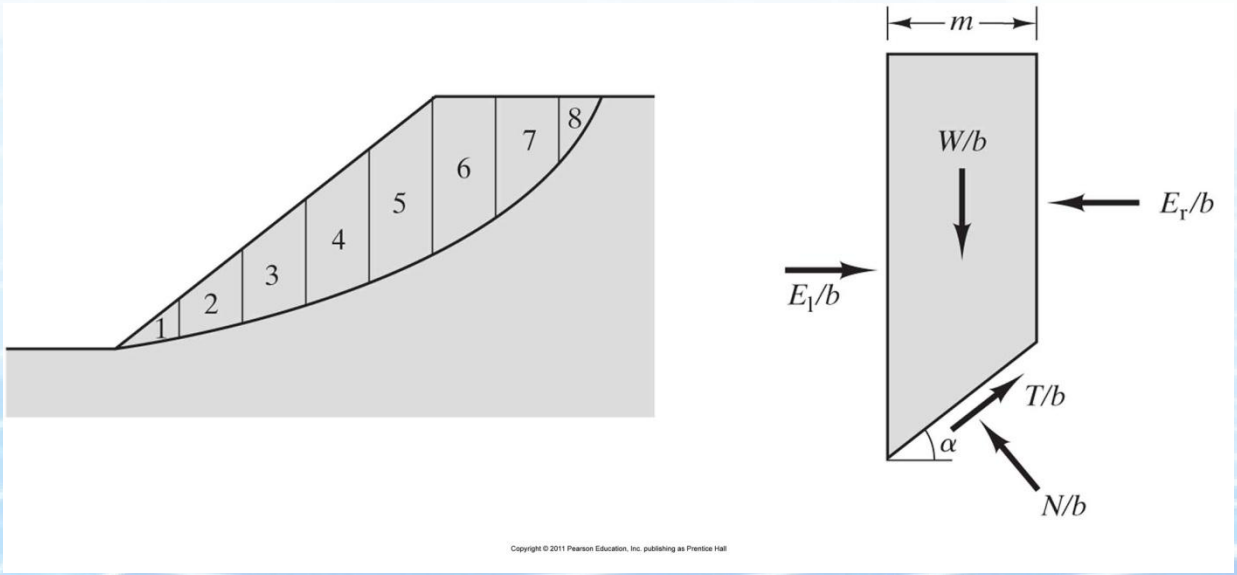
In this case

It was used the modified Bishop method which uses the method of slices to discretize the soil mass and determine the F_S (Factor of Safety).

Modified Bishop's Method:

- Assume some failure surface
- Discretize failure surface into smaller elements (slices)
- Calculate factor of safety for each slice (strength/stress) and overall factor of safety
- Find lowest F_S for different failure surfaces

$$FS = \frac{\sum \left\{ \frac{mc' + [(W/b) - um] \tan \phi'}{\psi} \right\}}{\sum [(W/b) \sin \alpha]}$$



$$\psi = \cos \alpha + \frac{\sin \alpha \tan \phi'}{FS}$$

Guidelines and Codes used:

The slope stability analysis was carried out [illegible]able geometrical cross section according to OMOE (H[illegible]ay Engineering) and EAK/2003 (Hellenic Seismic Co[illegible]

Those regulations are in accordance with the [illegible] of Transport Planning instructions (Federal Highwa[illegible] No. FHWA-SA-96-069R)

- Water Table
  or
- $r_u = \gamma_w / \gamma$ (ratio of the pore pressure over the total normal stress)

Required Factors of Safety:

A/A	Combination of Actions / Loads	F_S Required
1	**Static** (Permanent + Variable Actions / Loads)	**>1.40**
2	**Hydraulic** (Permanent + Variable Actions / Loads + Extreme hydraulic conditions corresponding to an event with a mean return period of 50 years)	**>1.30**
3	**Seismic** (Static conditions + earthquake, K_h=0.08g, K_v= ±0.04g) given that PGA=0.16g for the examined area	**>1.0**

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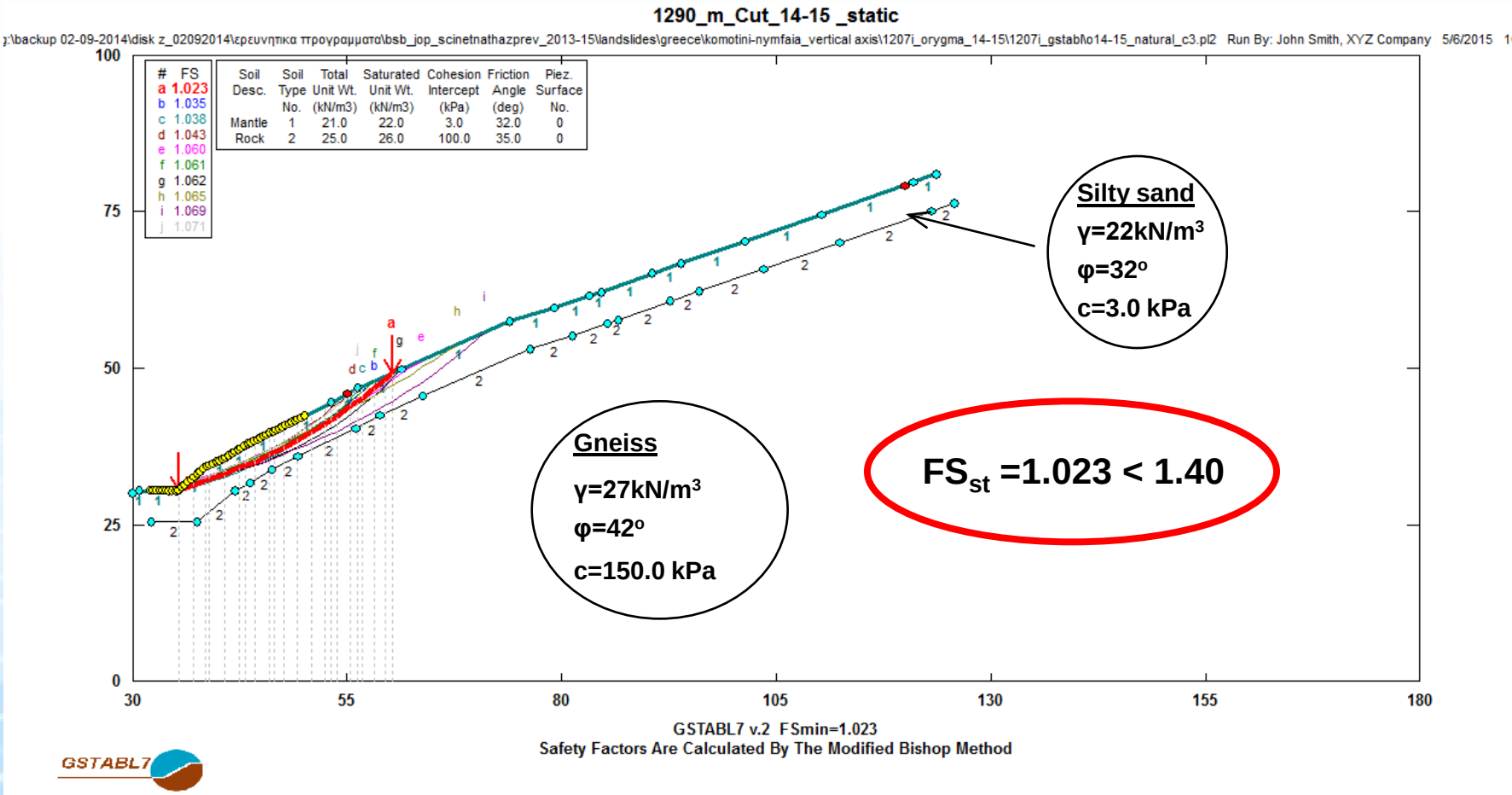
Natural Slope : Static Conditions



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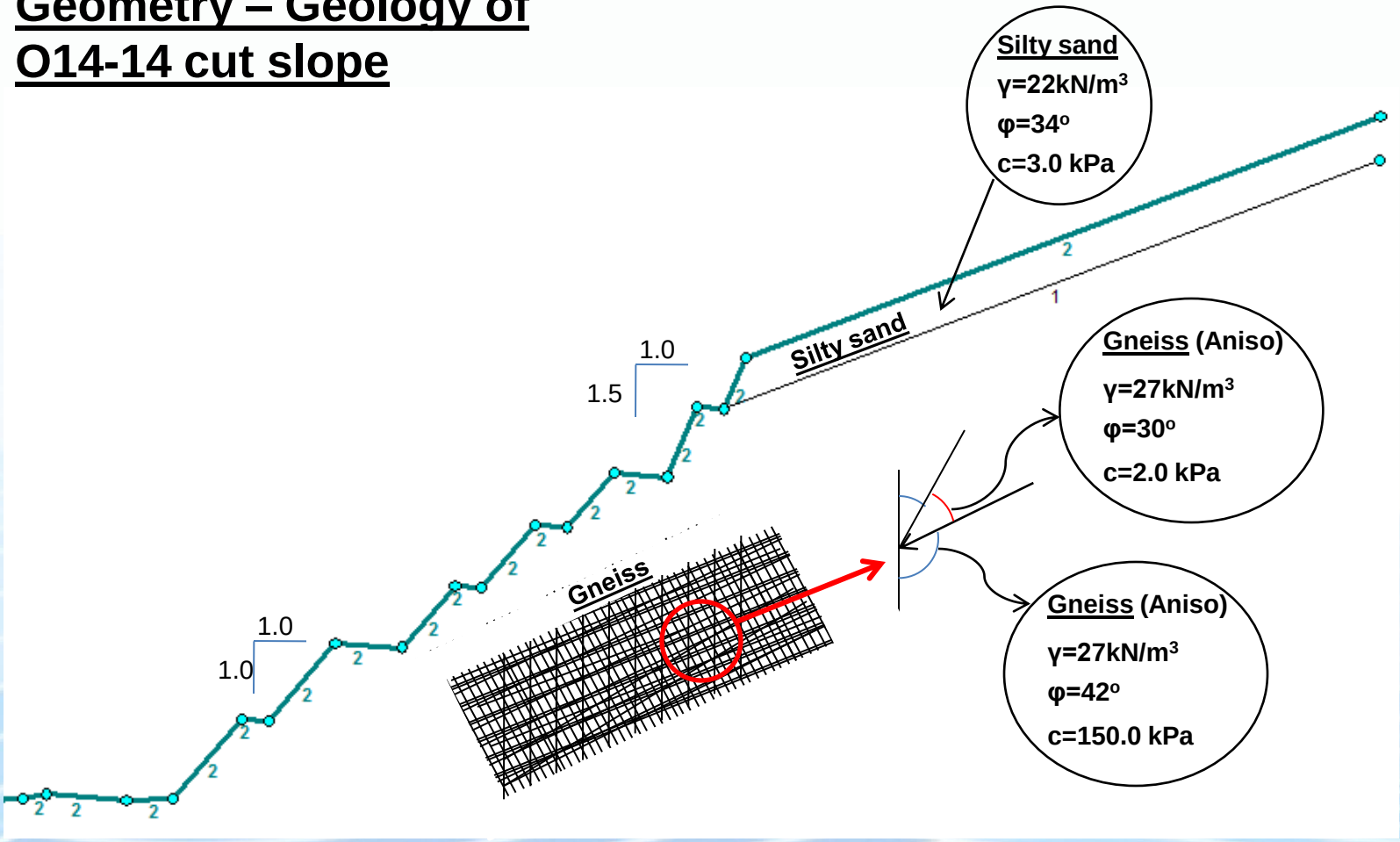
Geometry – Geology of O14-14 cut slope



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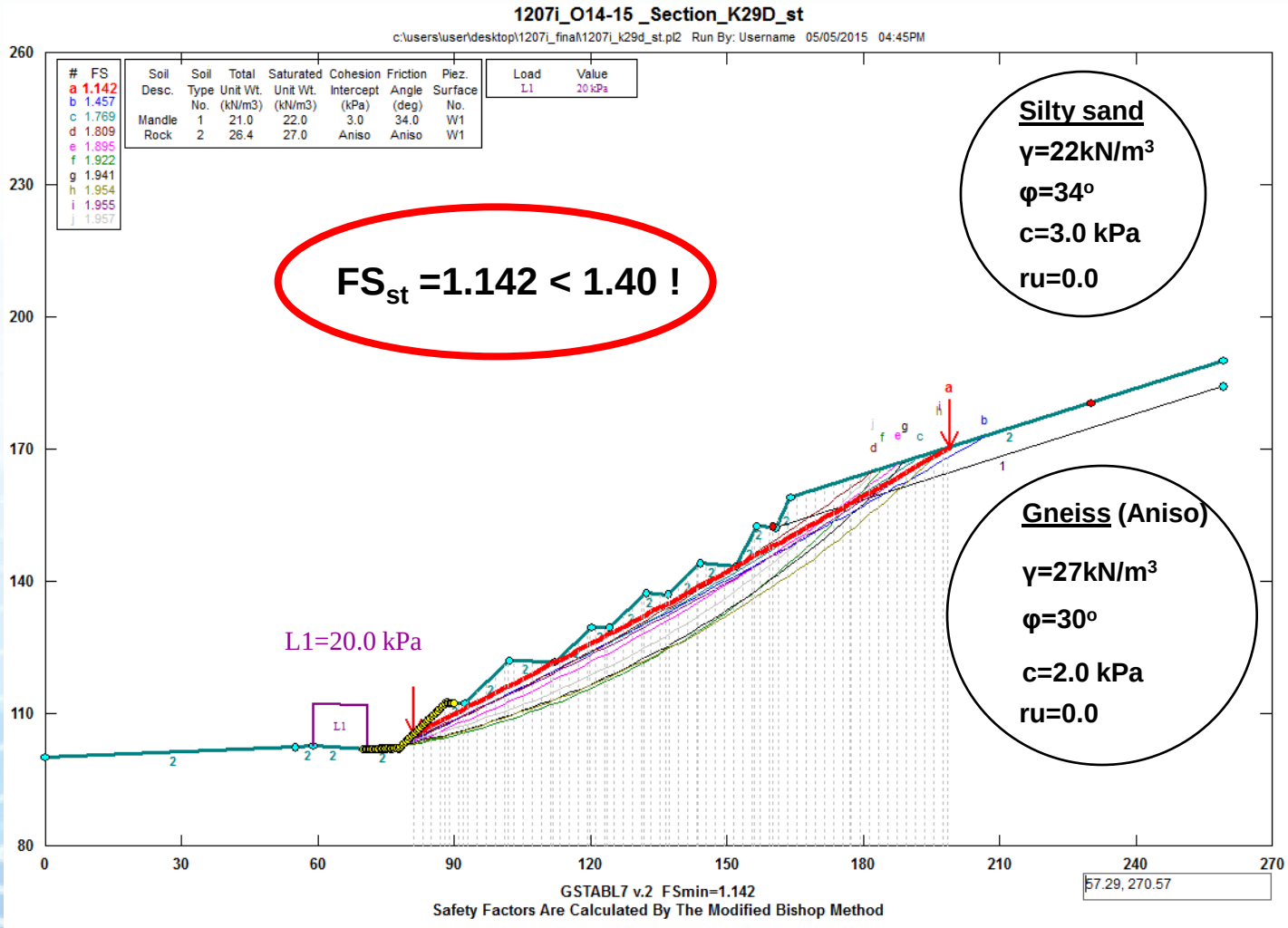
Conditions: Static without any countermeasure



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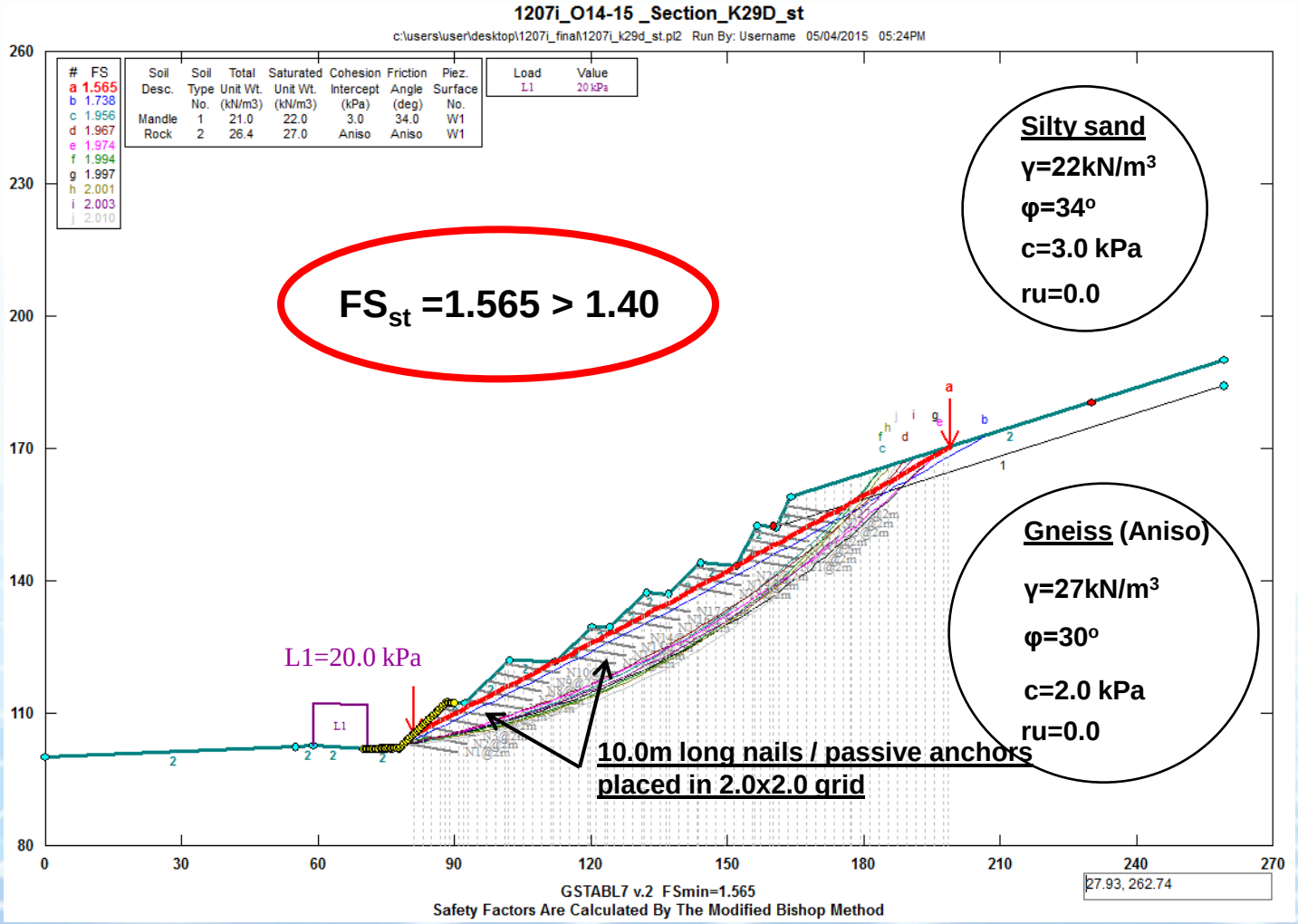
Conditions: Static with countermeasures (nails / passive anchors)



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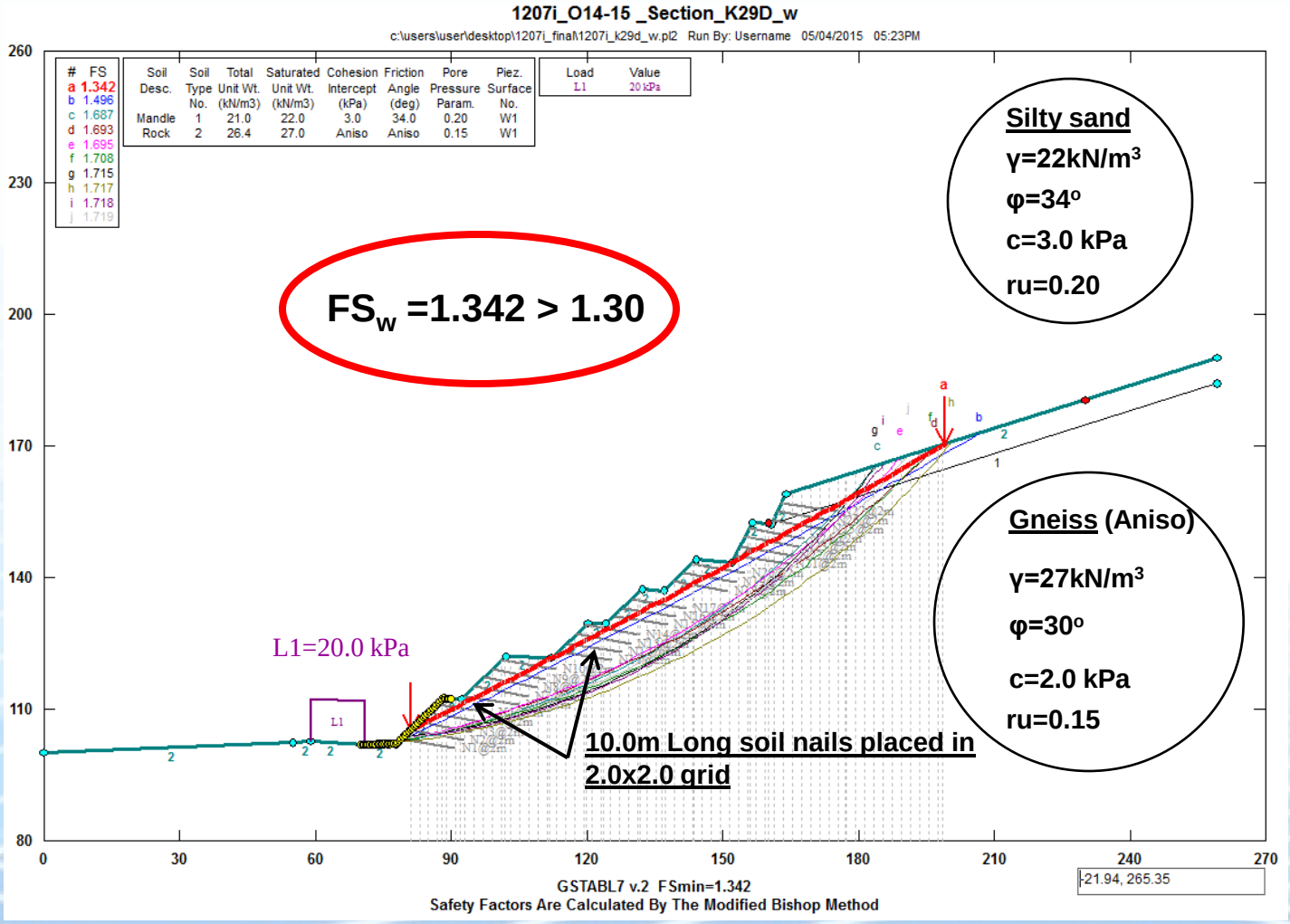
Black Sea CROSS BORDER COOPERATION

Conditions: Hydraulic with countermeasures (nails / passive anchors)



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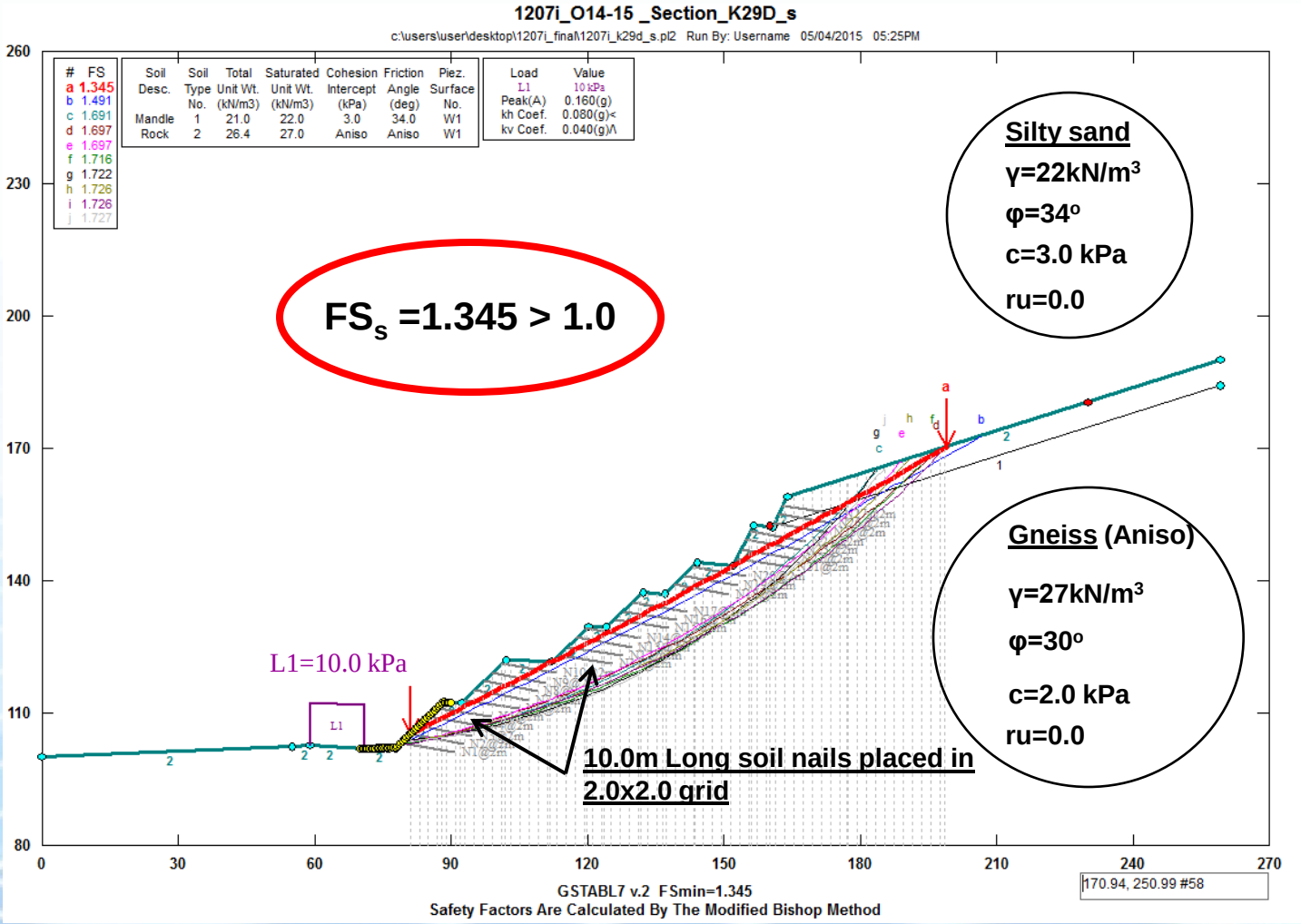
Black Sea CROSS BORDER COOPERATION

Conditions: Seismic with countermeasures (nails / passive anchors)



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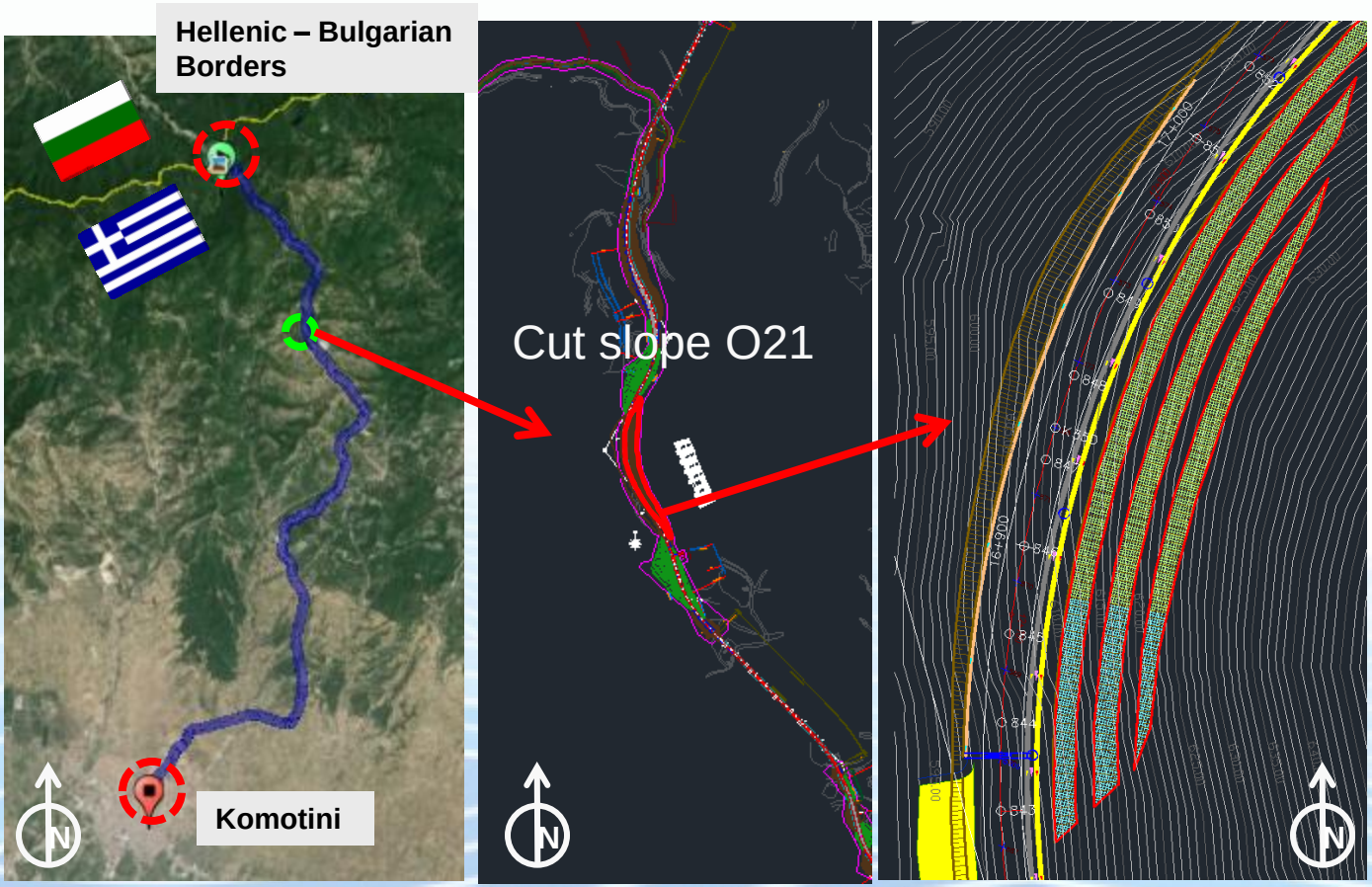
Cut Slope O21 : km: 16+640 – 17+080



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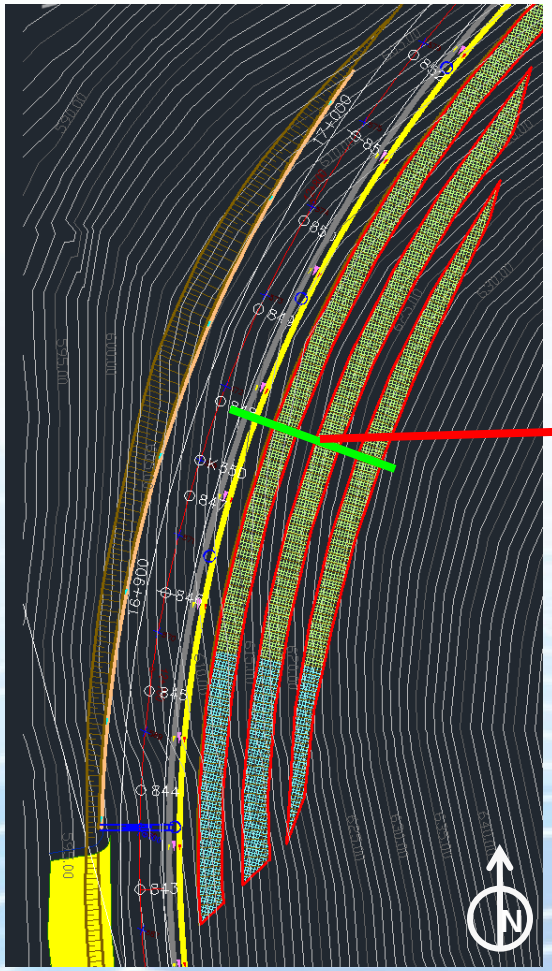
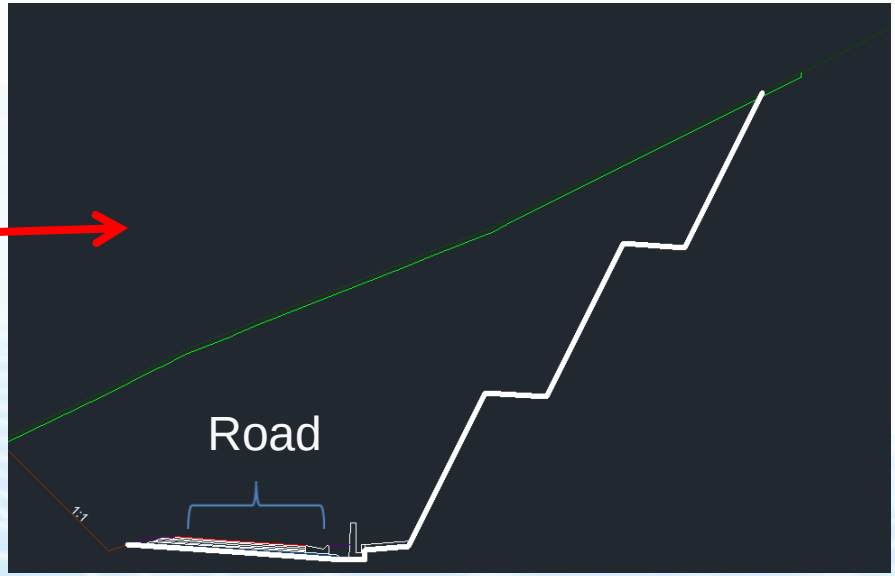


Cut Slope O21, Section: 848



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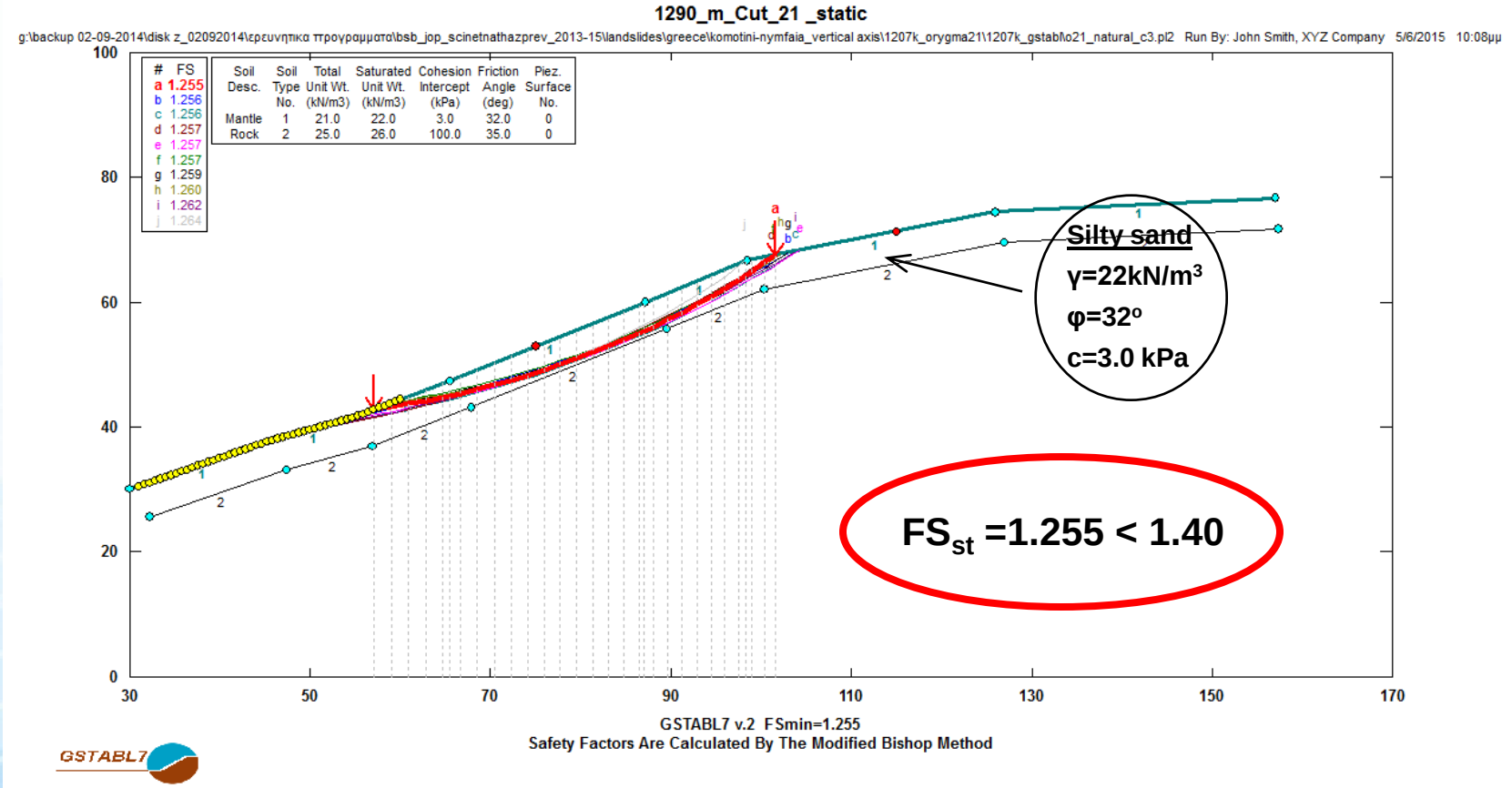
Natural Slope : Static Conditions



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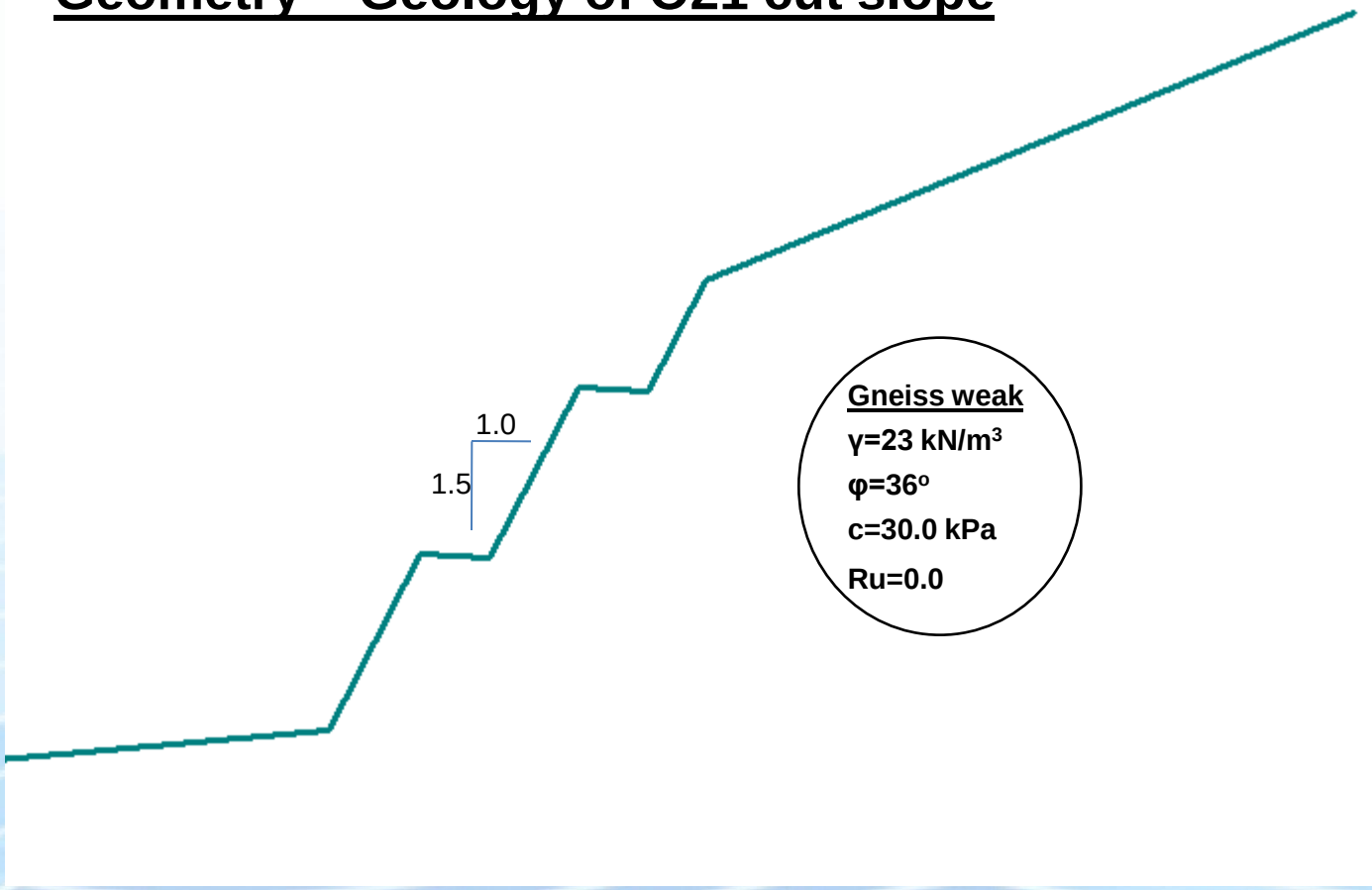
Geometry – Geology of O21 cut slope



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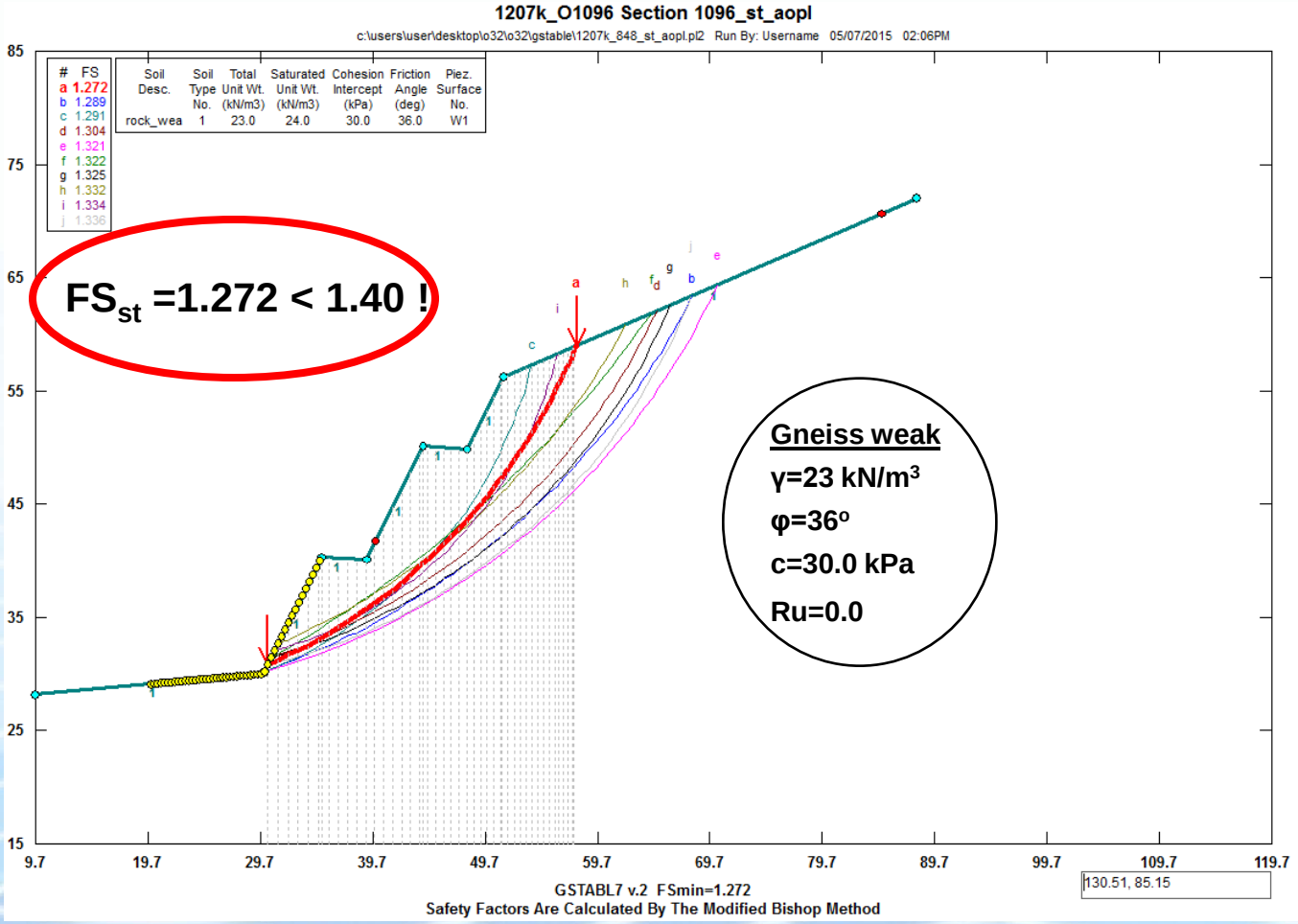
Conditions: Static without any countermeasure



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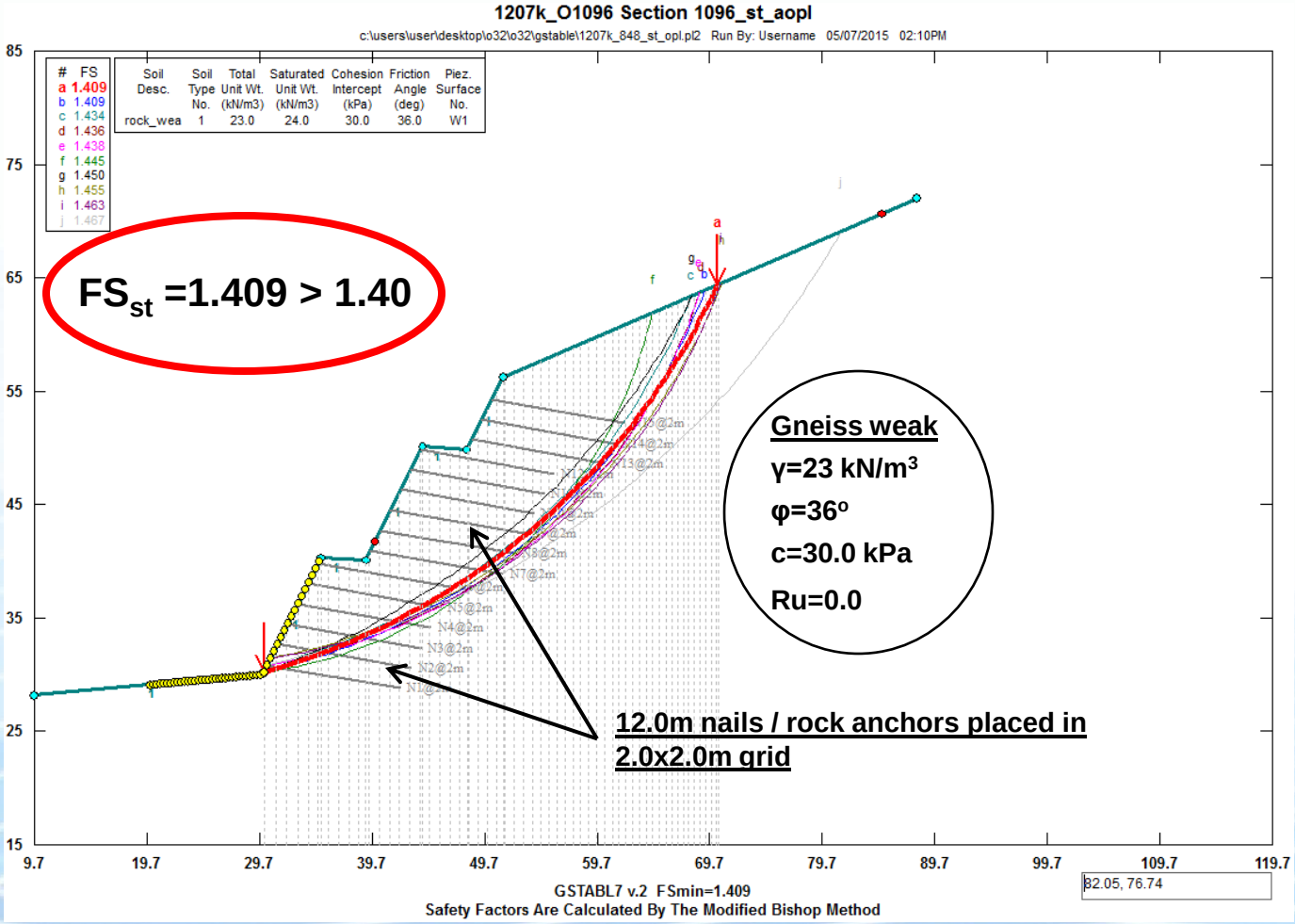
Black Sea CROSS BORDER COOPERATION

Conditions: Static with countermeasures (nails / passive anchors)



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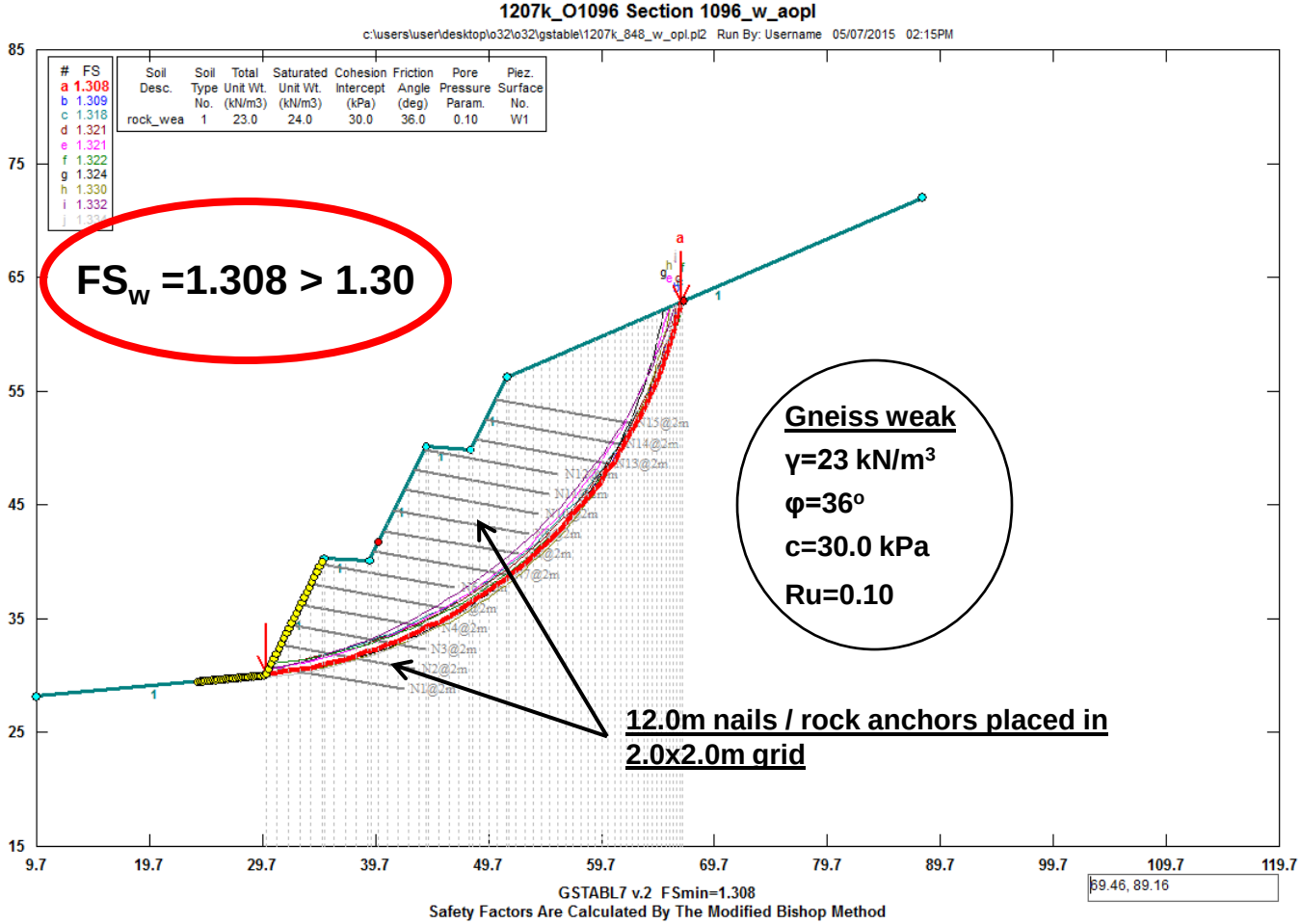
Conditions: Hydraulic with countermeasures (nails / passive anchors)



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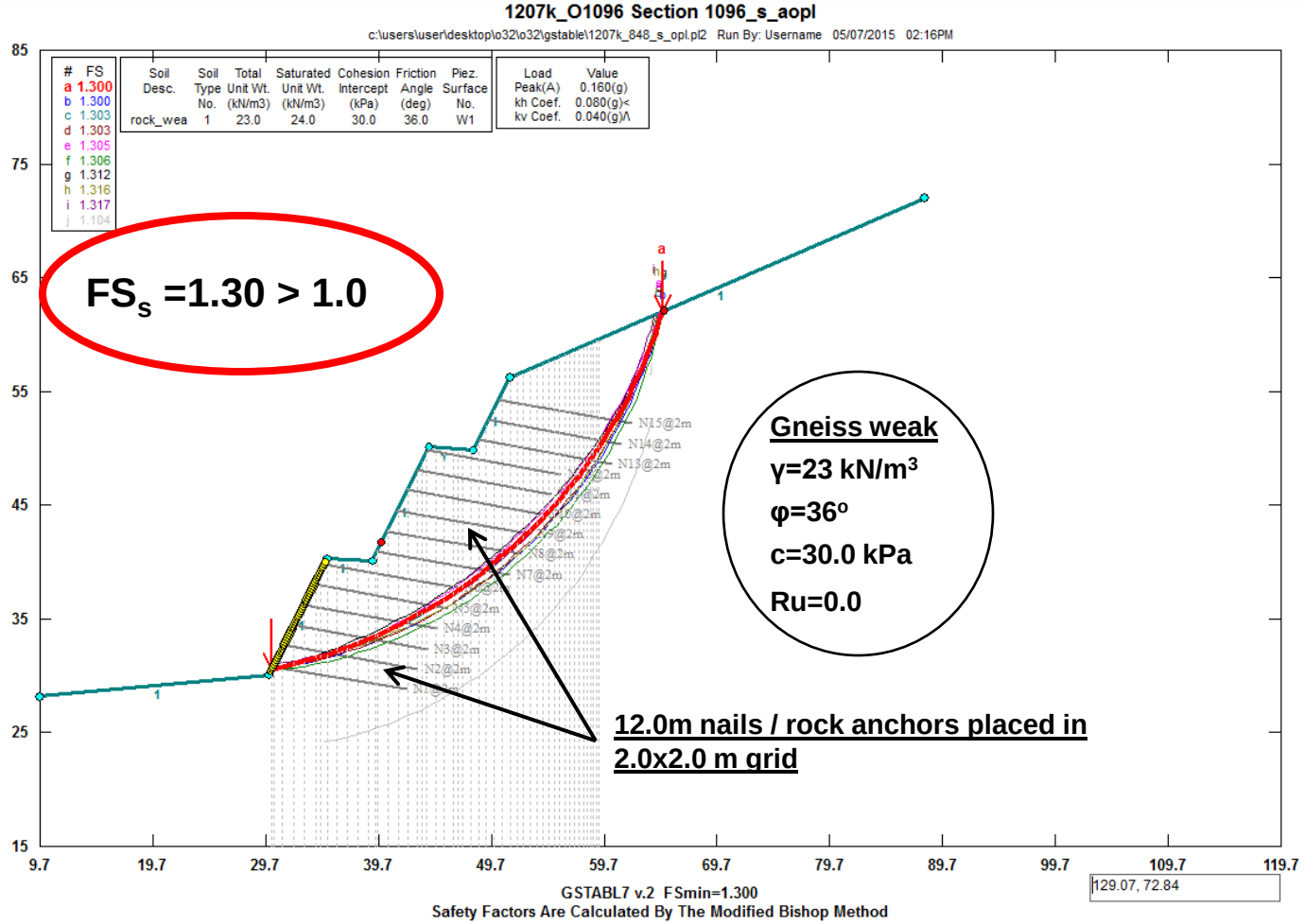
Black Sea CROSS BORDER COOPERATION

Conditions: Seismic with countermeasures (nails / passive anchors)



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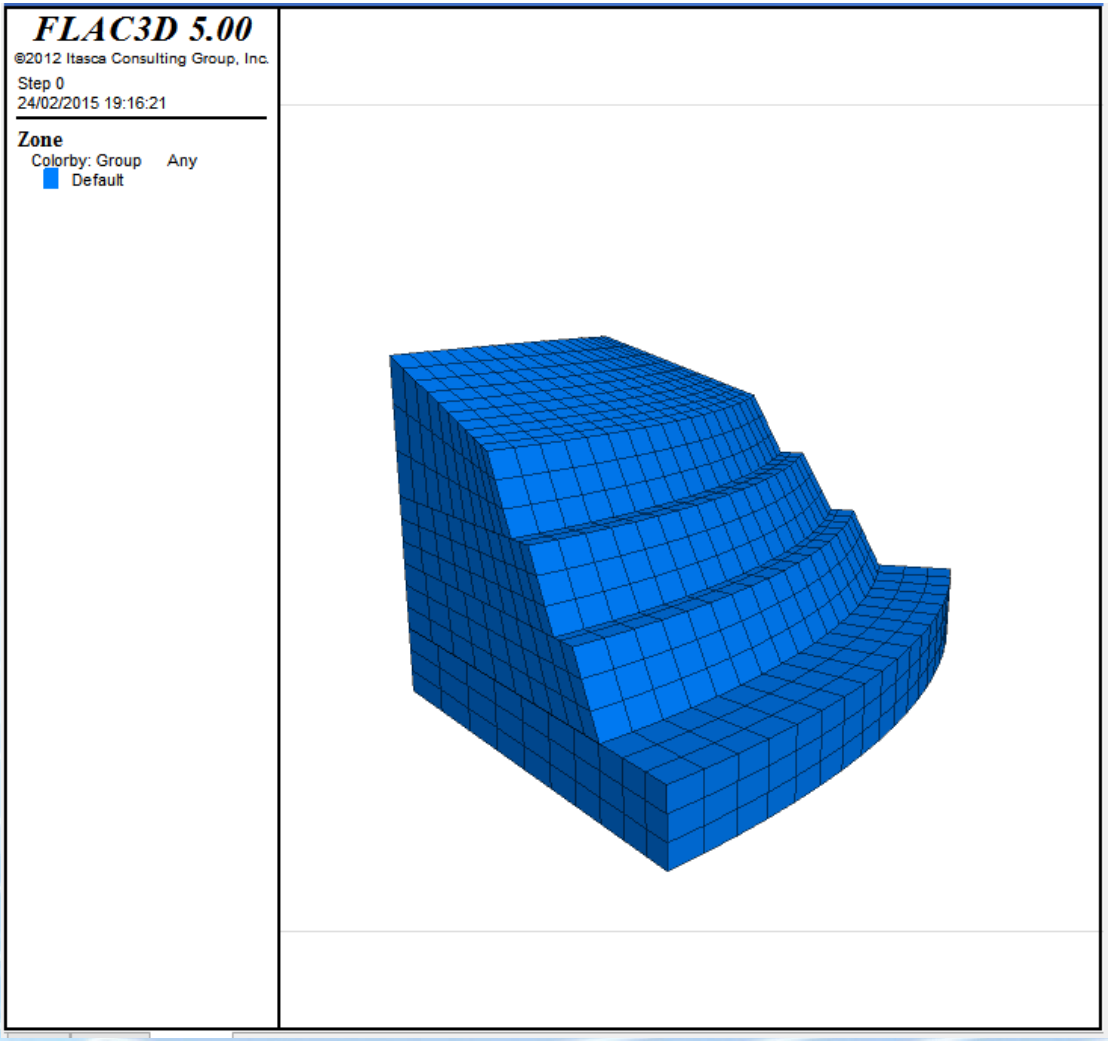

Parameters – Input data:

- Modulus of elasticity: 600 MPa
- Poisson ratio: 0.2
- Bulk modulus: 333 MPa
- Shear modulus: 250 MPa
- Friction angle: 36^{o}
- Cohesion: 30 kPa
- Tension limit: 30 kPa

3D Geometry
O21 cut slope

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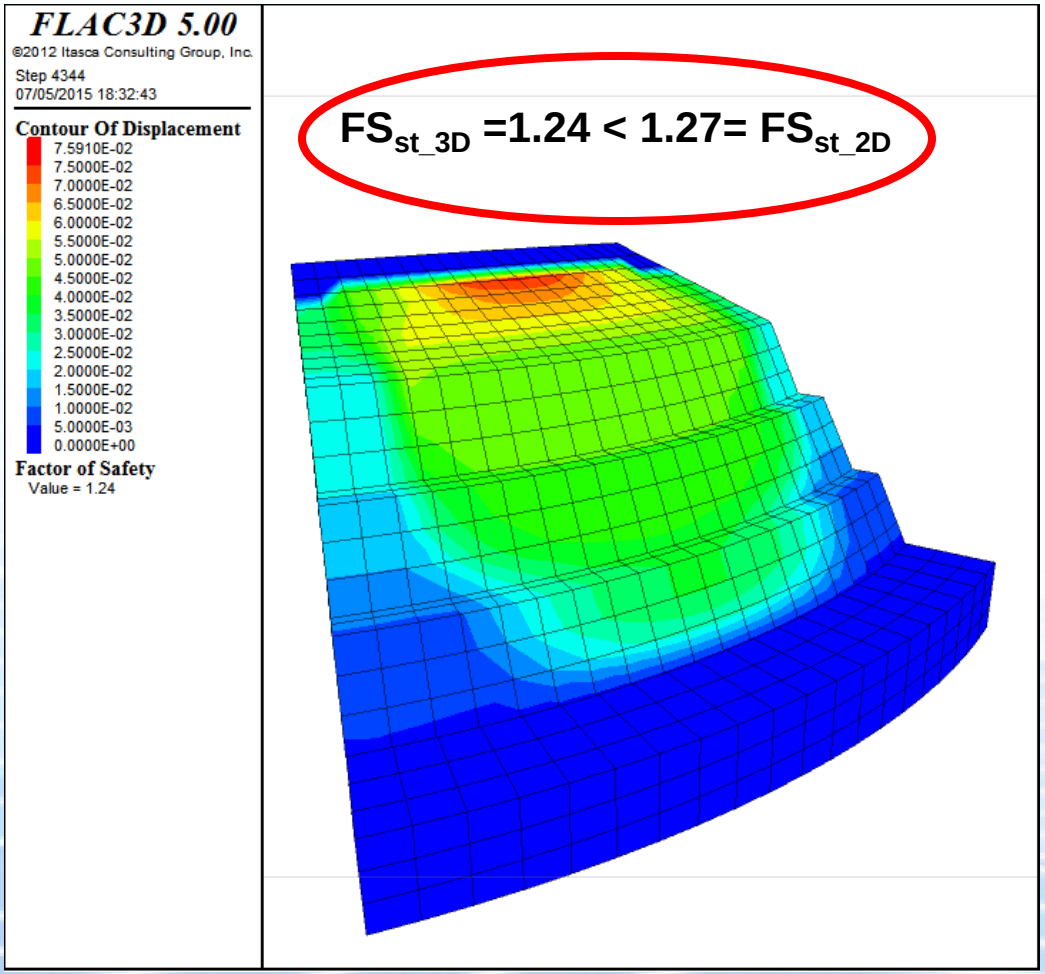
Conditions: Static – 3D Geometry convex cut slope



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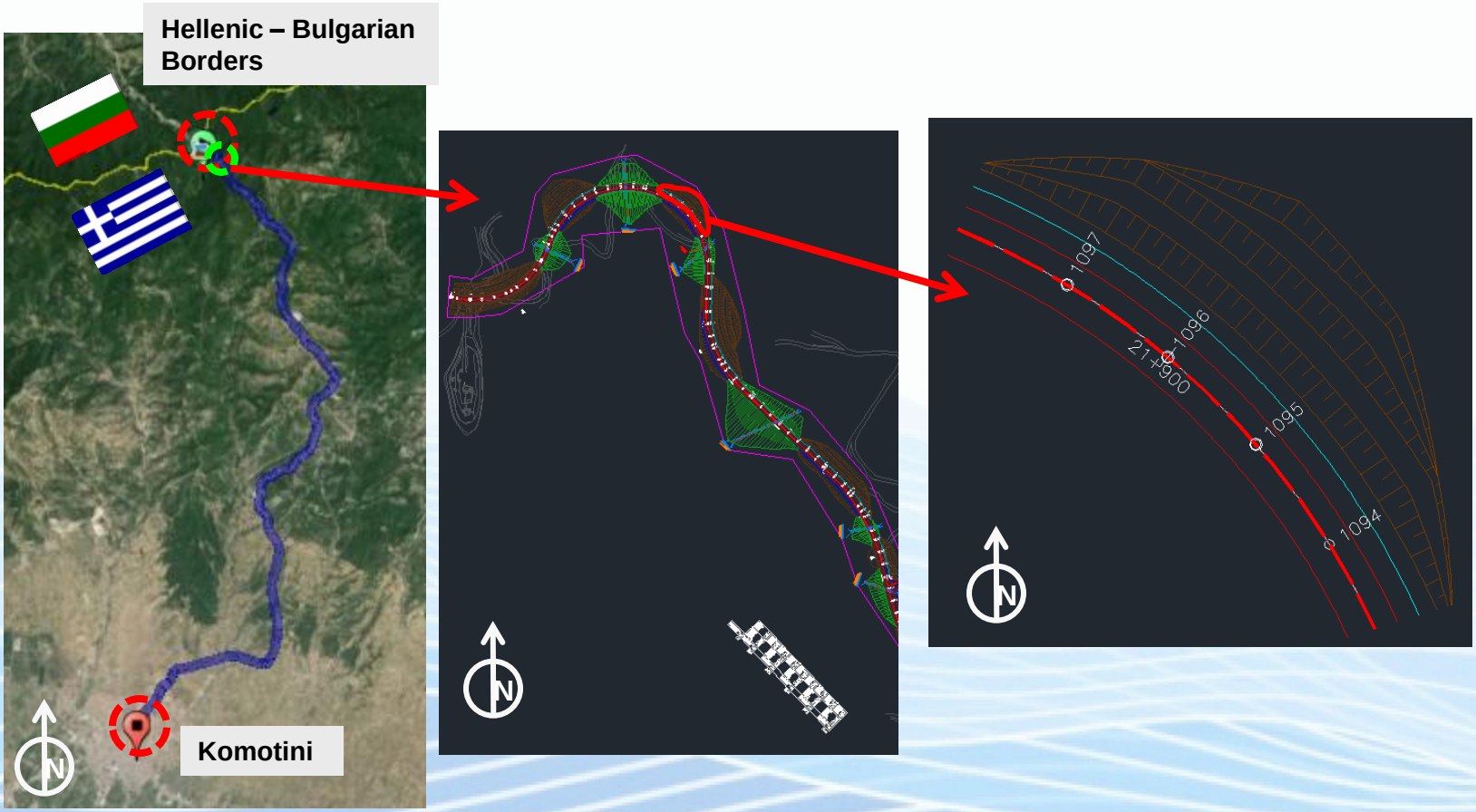
Cut Slope O32 : km: 21+300 – 21+460



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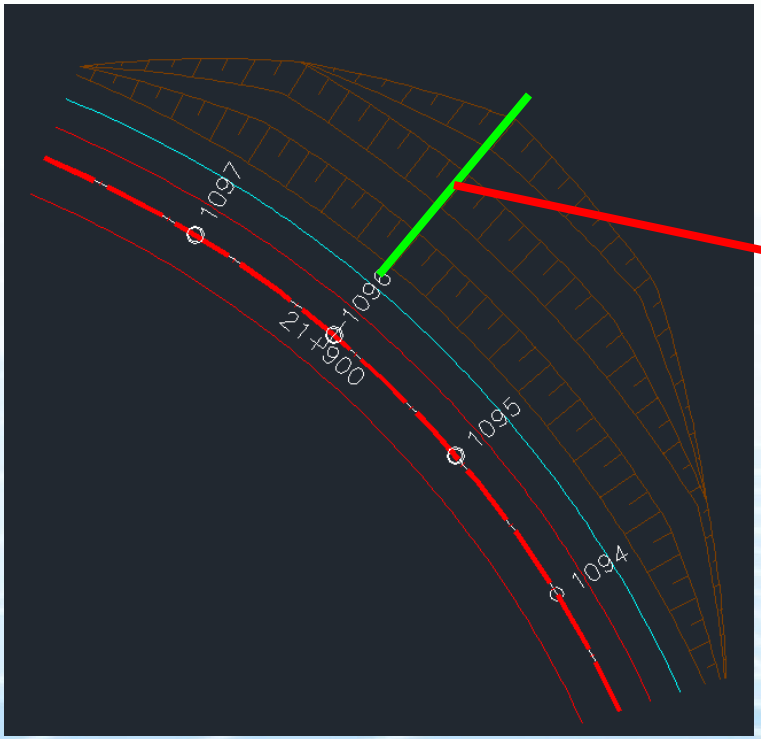
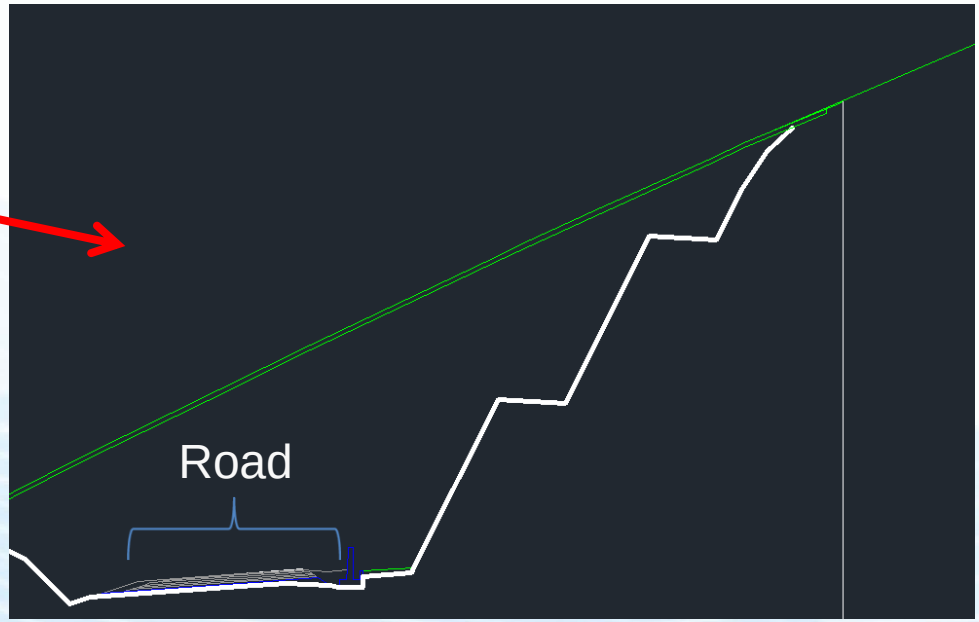
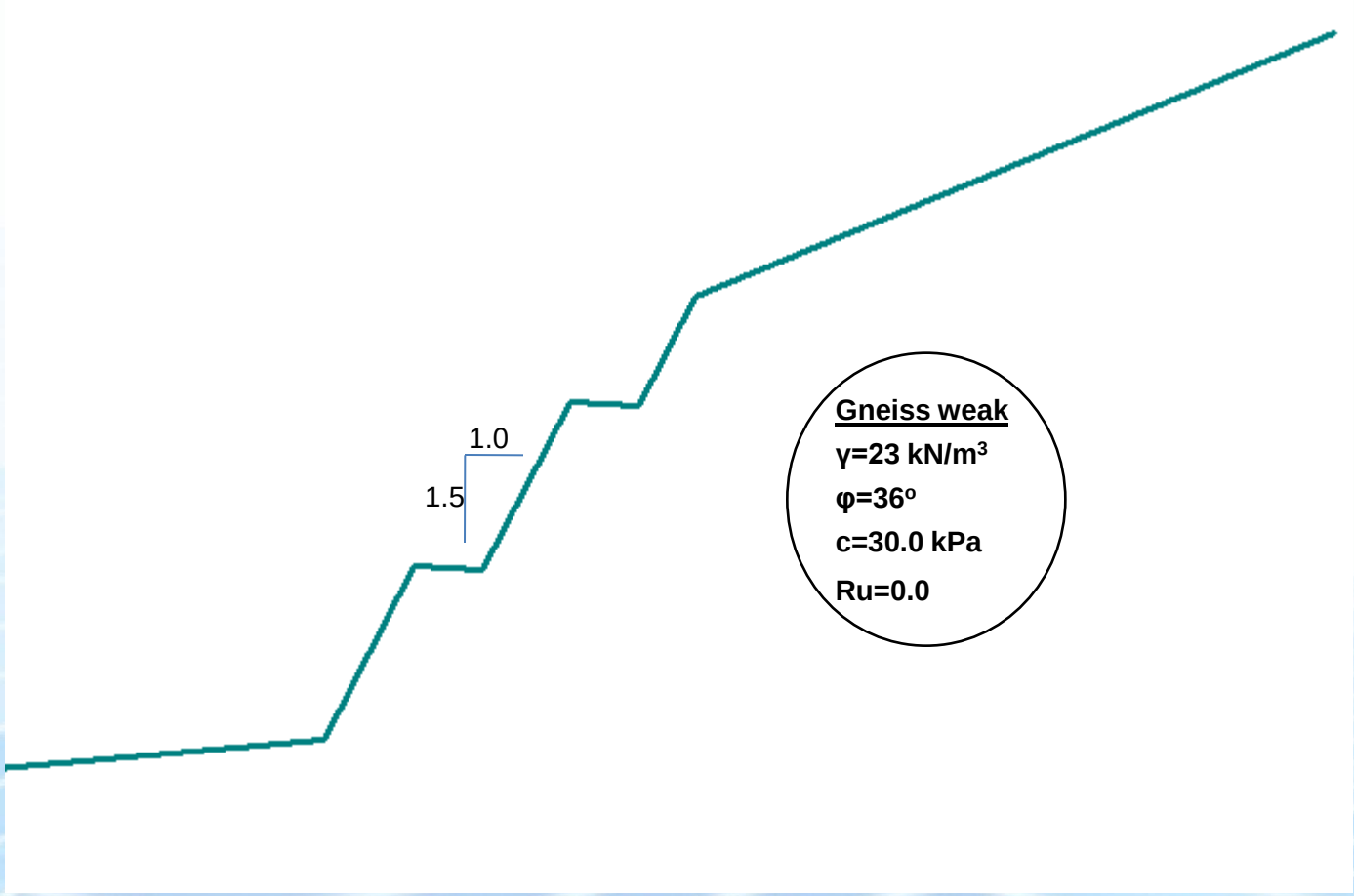


Cut Slope O32, Section: 1096



Geometry – Geology of Cut Slope O32



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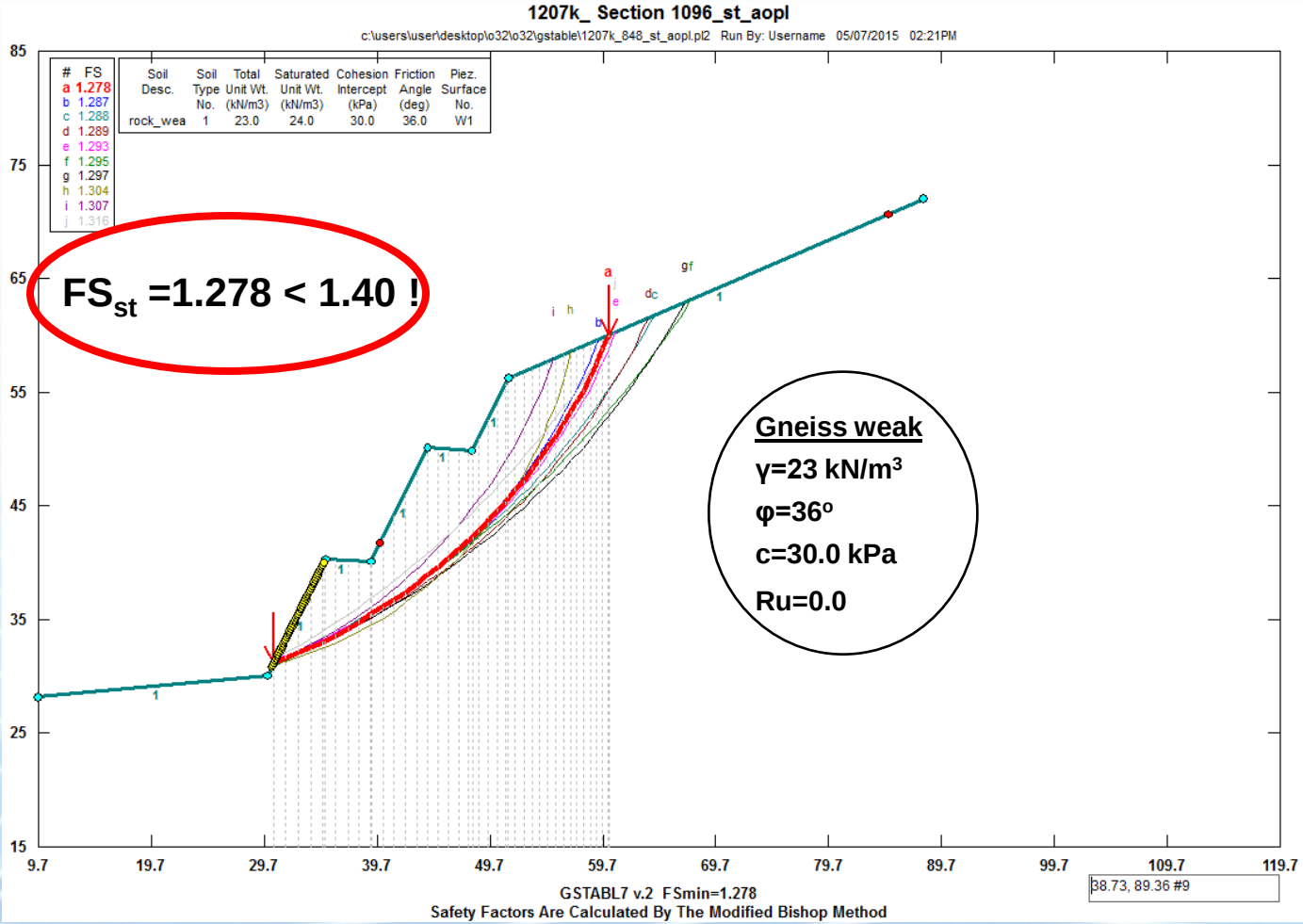
Conditions: Static without any countermeasure



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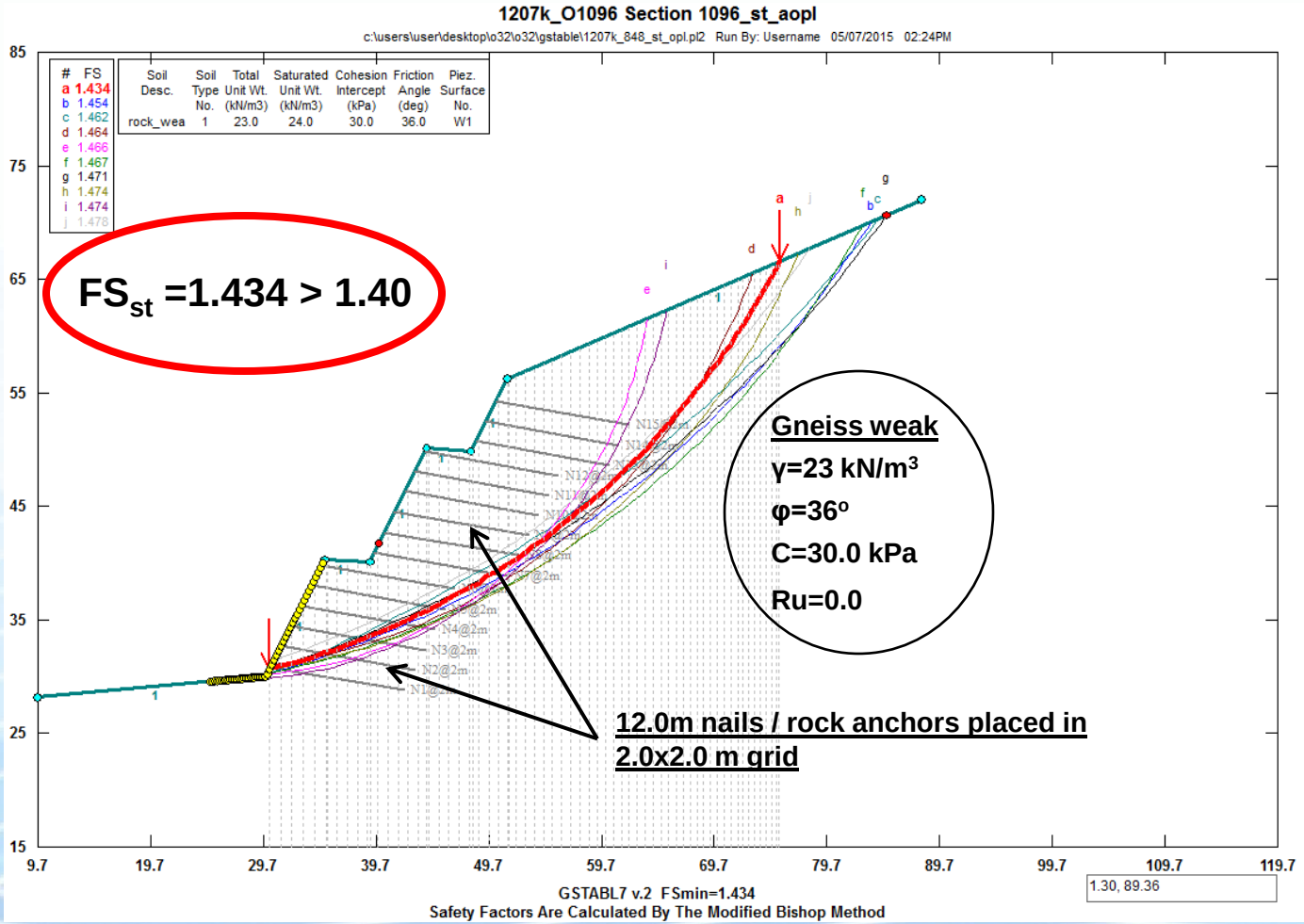
Conditions: Static with countermeasures (nails / passive anchors)



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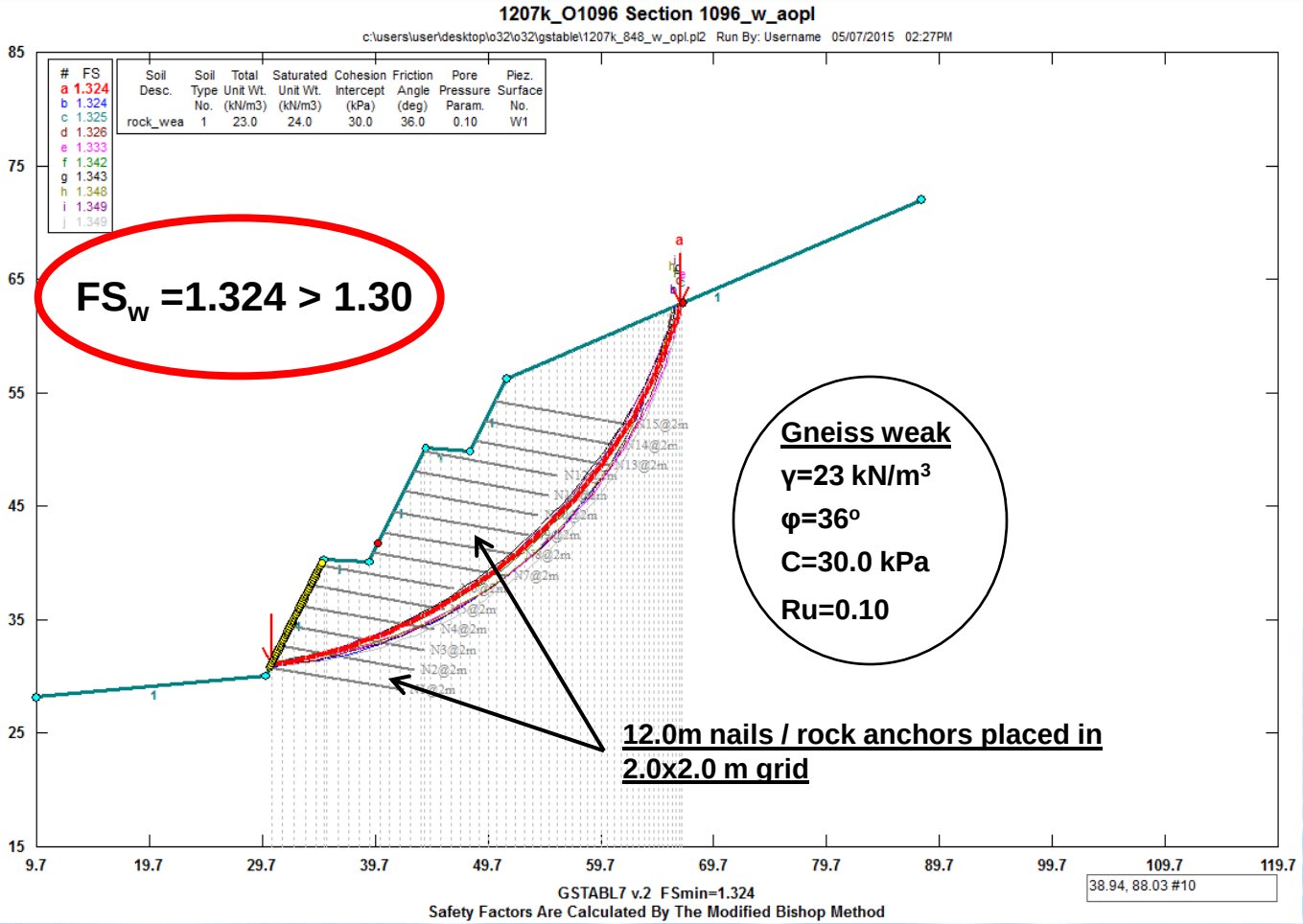
Conditions: Hydraulic with countermeasures (nails / passive anchors)



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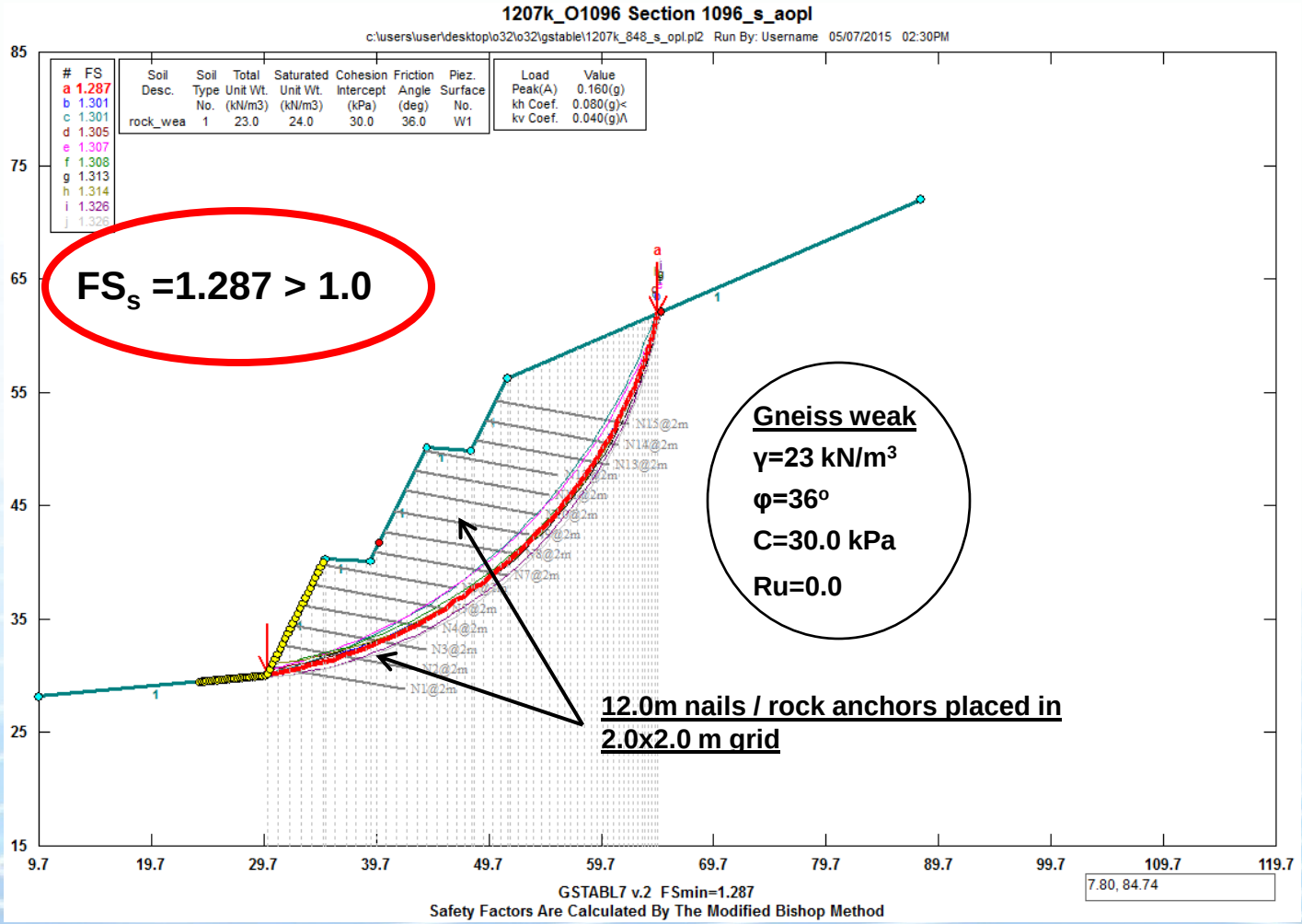
Conditions: Seismic with countermeasures (nails / passive anchors)



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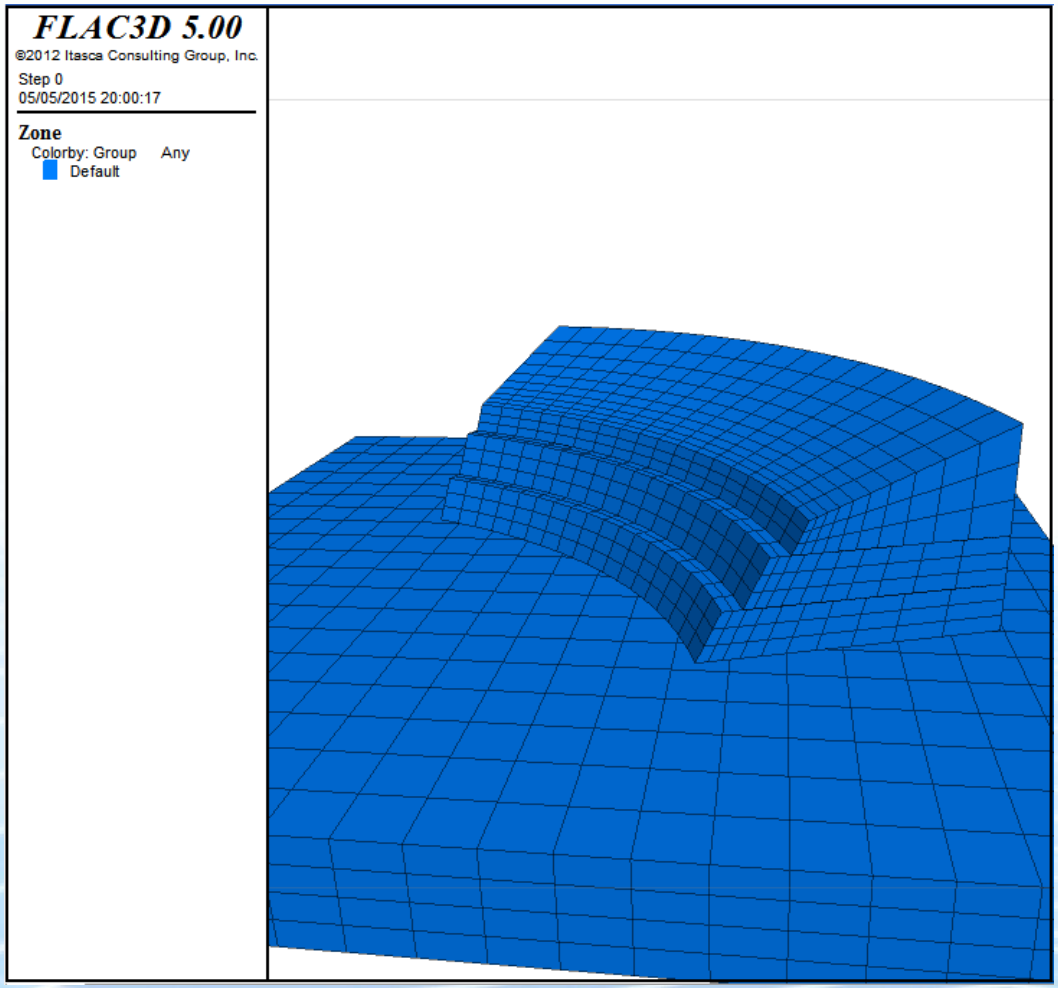

Parameters – Input data:

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- Poisson ratio: 0.2
- Bulk modulus: 333 MPa
- Shear modulus: 250 MPa
- Friction angle: 36^{o}
- Cohesion: 30 kPa
- Tension limit: 30 kPa

3D Geometry
O32 cut slope

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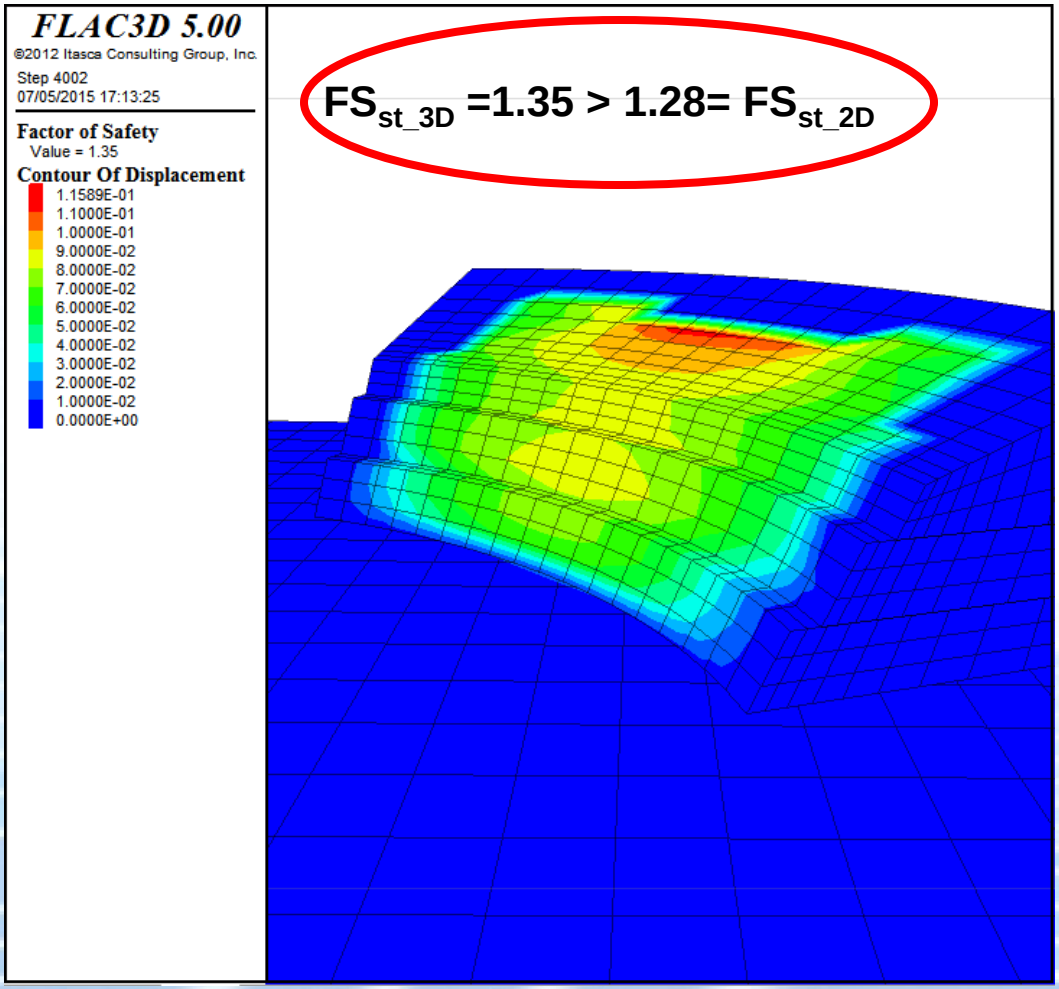
Conditions: Static – 3D Geometry concave cut slope



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Спасибі