



UNWEDGE ANALYSIS

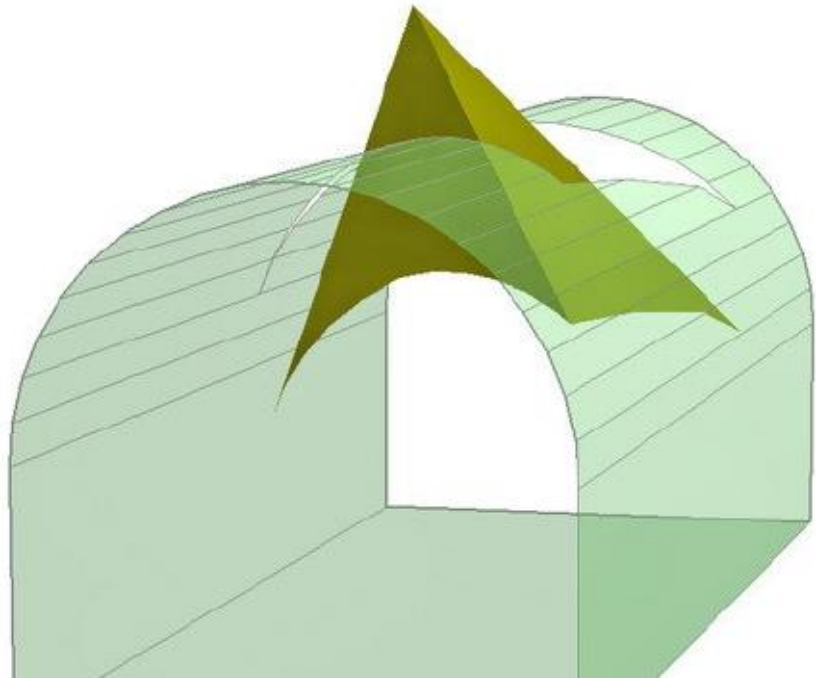
STRUCTURALLY CONTROLLED
INSTABILITY IN TUNNELS

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UNWEDGE Software

UNWEDGE is very important tool to determine the 3D stability of wedges in the underground tunnels, cavern and big openings.

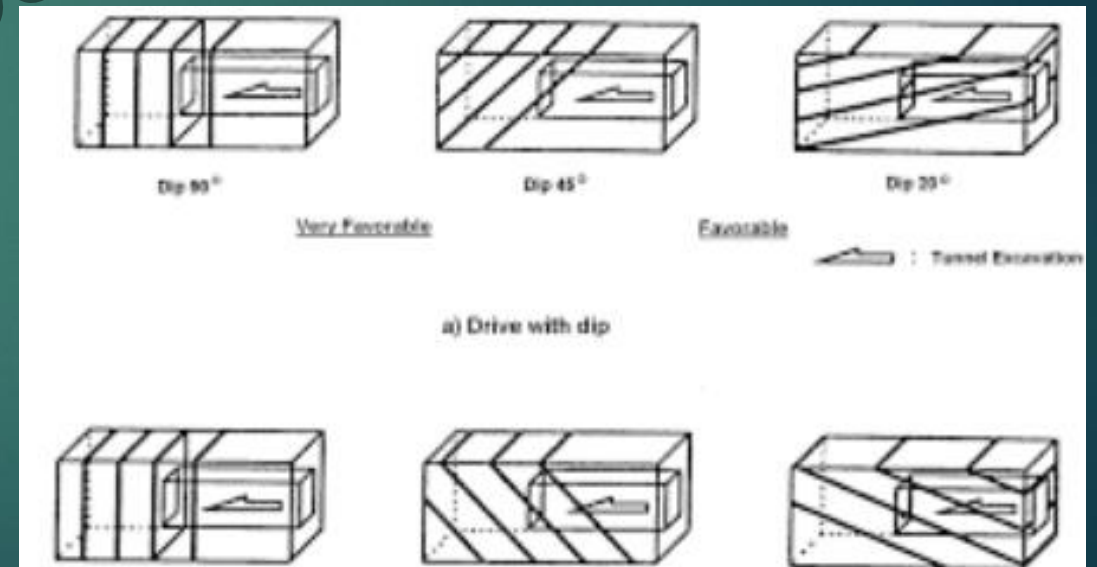
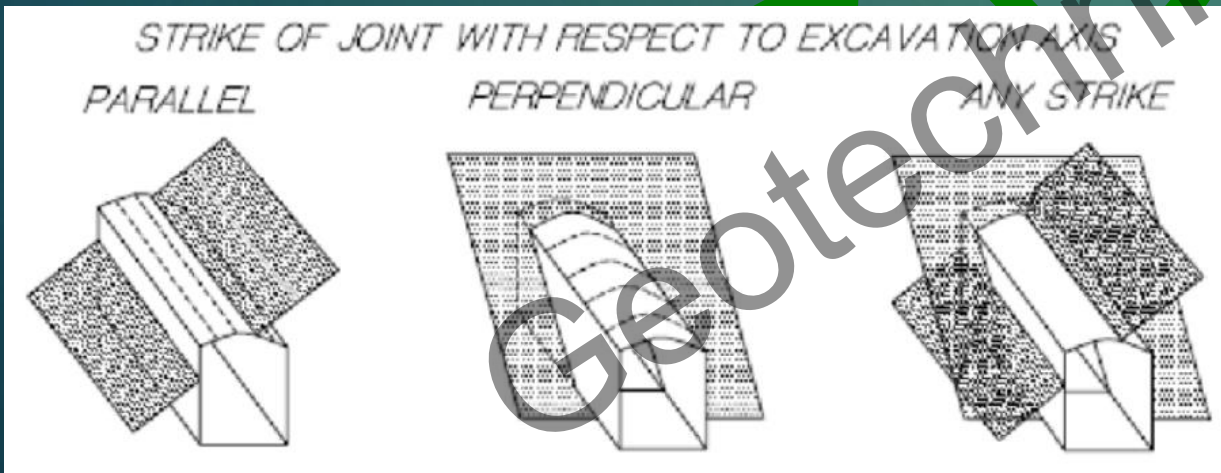
- Wedges are governed by discontinuity/joint sets
- Usually, wedges are formed in good and hard rocks.
- And where stress induced failures does not occur.

UNWEDGE Software

- The wedges are subjected to **gravitational loading** only, due to the wedge weight.
- The size and volume of wedge depends upon the persistence of discontinuities making the wedge.

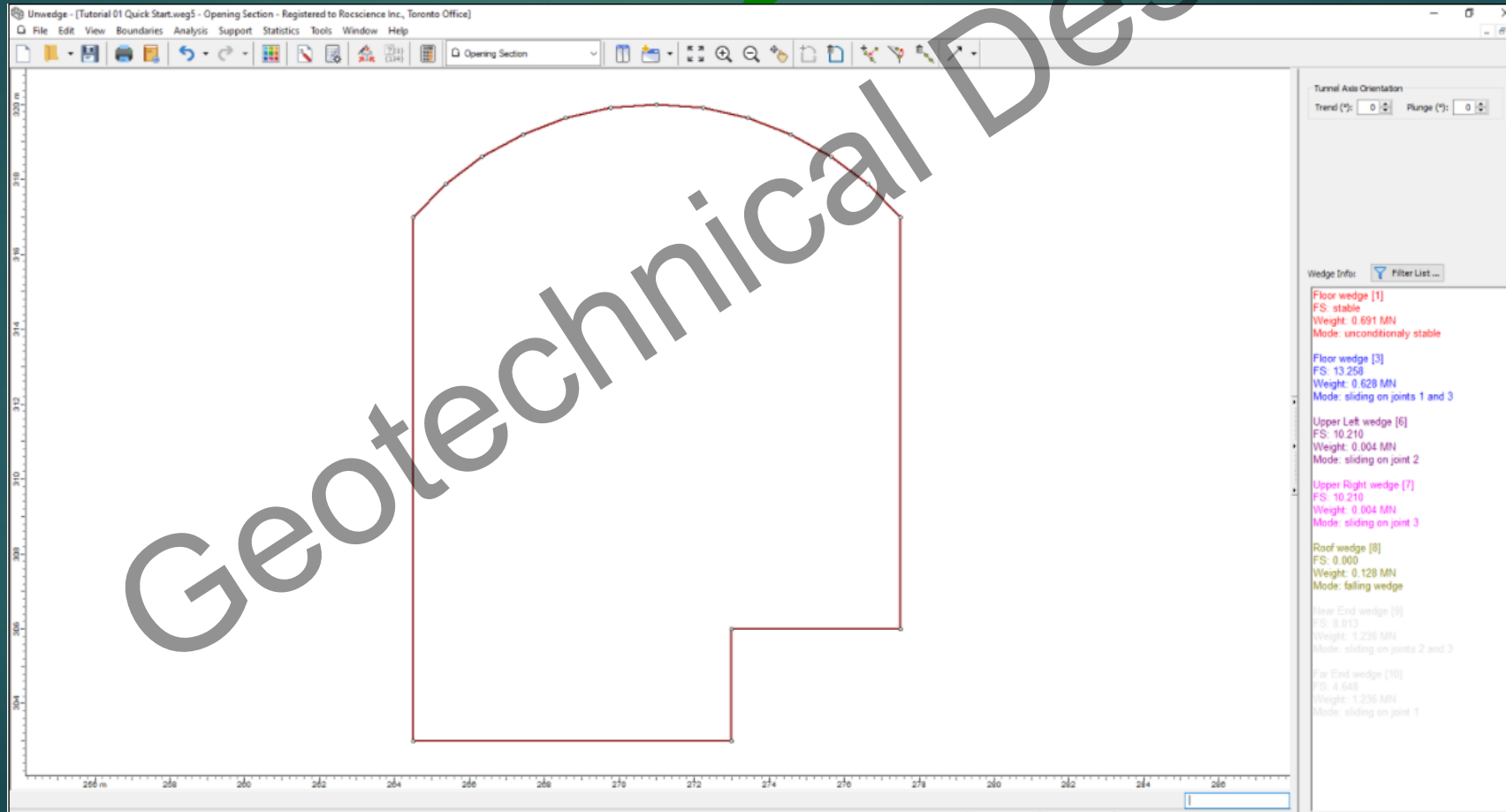
Tunnel Direction & Joint Orientations

- Wedges in the tunnels will be formed or not depends upon the direction of axis of tunnel and joint set orientations with respect to tunnel axis direction.



Tunnel Geometry Adopted

- We need to provide coordinates in the software for the geometry of the tunnel we want to analysis.



Inputs Required – Tunnel Direction

- Input parameters required to get the factor of safety of wedges formed inside the tunnel.

➤ Inputs are as follows:

1. Tunnel Trend = 45° (from north)
2. Tunnel Plunge = 0°

Here I have considered FOS = 1, just to keep wedge in equilibrium condition. If FOS of any wedge < 1 , Support system needs to provide.

Input Data

General Joint Orientations Joint Properties

Tunnel Axis Orientation

Trend (°): 45 Plunge (°): 0

Seismic Force

Direction: Sliding

Seismic Coefficient: 0

Tunnel Length

Length (m): 50

Design Factor of Safety

Design Factor of Safety: 1

Unit Weight

Rock (MN/m3): 0.027

Water (MN/m3): 0.00981

Minimum Wedge Size

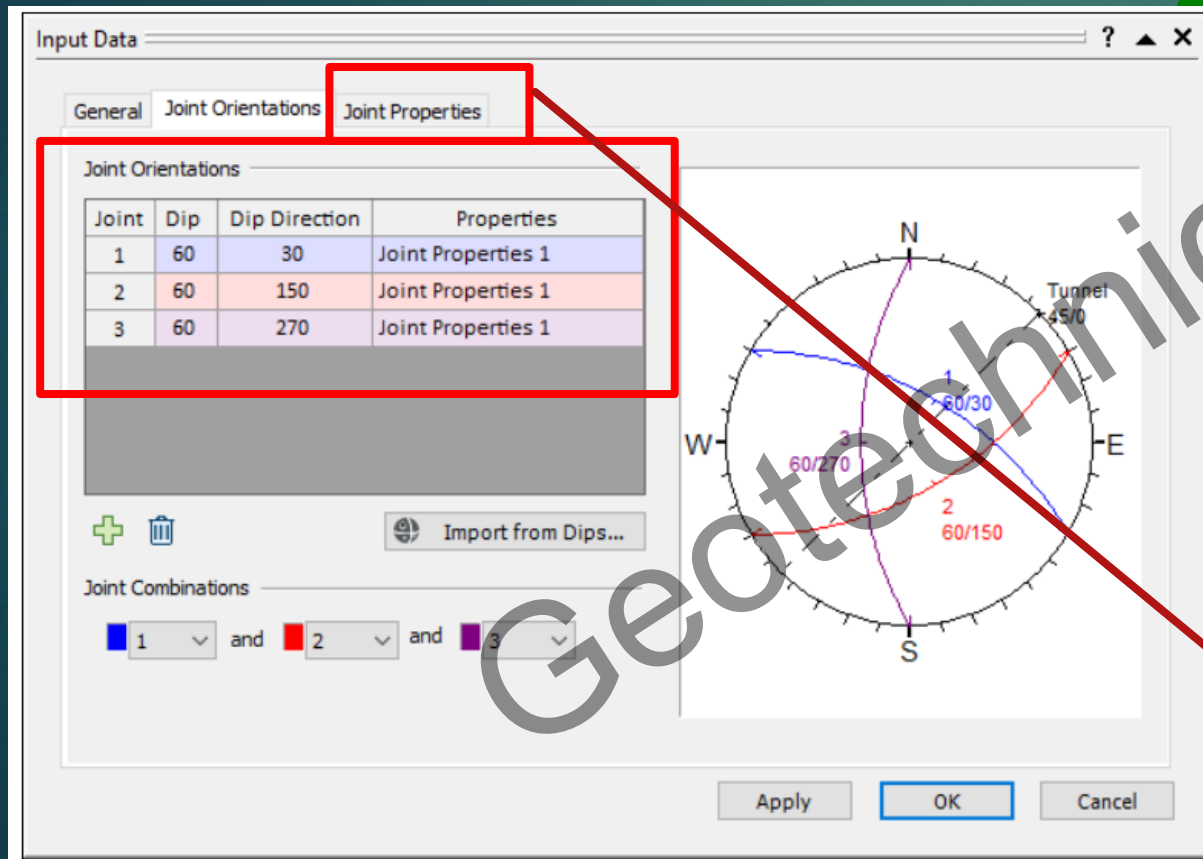
Weight (MN): 0.001

Min. Apex Angle (°): 0

Apply OK Cancel

Tunnel Properties - Joint Orientations

- Input parameters required to get the factor of safety of wedges formed inside the tunnel.



Joint Orientations – We need to put Dip and Dip Direction for each joint .

Joint 1 = 60/30

Joint 2 = 60/150

Joint 3 = 60/270.

Here we will see that all joint have same joint properties. To give joints different joint properties we need to
Go to Joint Properties.

Tunnel Properties - Joint Orientations

- Input parameters required to get the factor of safety of wedges formed inside the tunnel.

The screenshot shows the 'Input Data' dialog box with the 'Joint Properties' tab selected. The 'Name' field is set to 'rough joint'. The 'Shear Strength' section is configured with the 'Mohr-Coulomb' model, a friction angle (Phi) of 35 degrees, and a cohesion of 0.01 MPa. The 'Water Pressure' is set to 'Constant' at 0 MPa. The 'Joint Structure' is set to 'Infinite' continuity and 0 degrees waviness. The 'OK' button is highlighted.

Parameter	Value
Name	rough joint
Model	Mohr-Coulomb
Phi (°)	35
Cohesion (MPa)	0.01
Tensile Strength (MPa)	0
Water Pressure	Constant
Pressure (MPa)	0
Joint Structure	Infinite
Waviness (°)	0

Joint Properties

Here we are providing the joint properties of **ROUGH JOINT**.

Tunnel Properties - Joint Orientations

- Input parameters required to get the factor of safety of wedges formed inside the tunnel.

Input Data

General Joint Orientations Joint Properties

rough joint
smooth joint

Name: smooth joint

Shear Strength

Model: Mohr-Coulomb $\tau = c' + \sigma'_n \tan \phi'$

Phi (°): 20 Tensile Strength (MPa): 0

Cohesion (MPa): 0

Water Pressure

Constant

Pressure (MPa): 0

Joint Structure

Continuity: Infinite

Waviness (°): 0
= [average angle] - [minimum angle]

Apply OK Cancel

Joint Properties

Here we are providing the joint properties of **SMOOTH JOINT**.

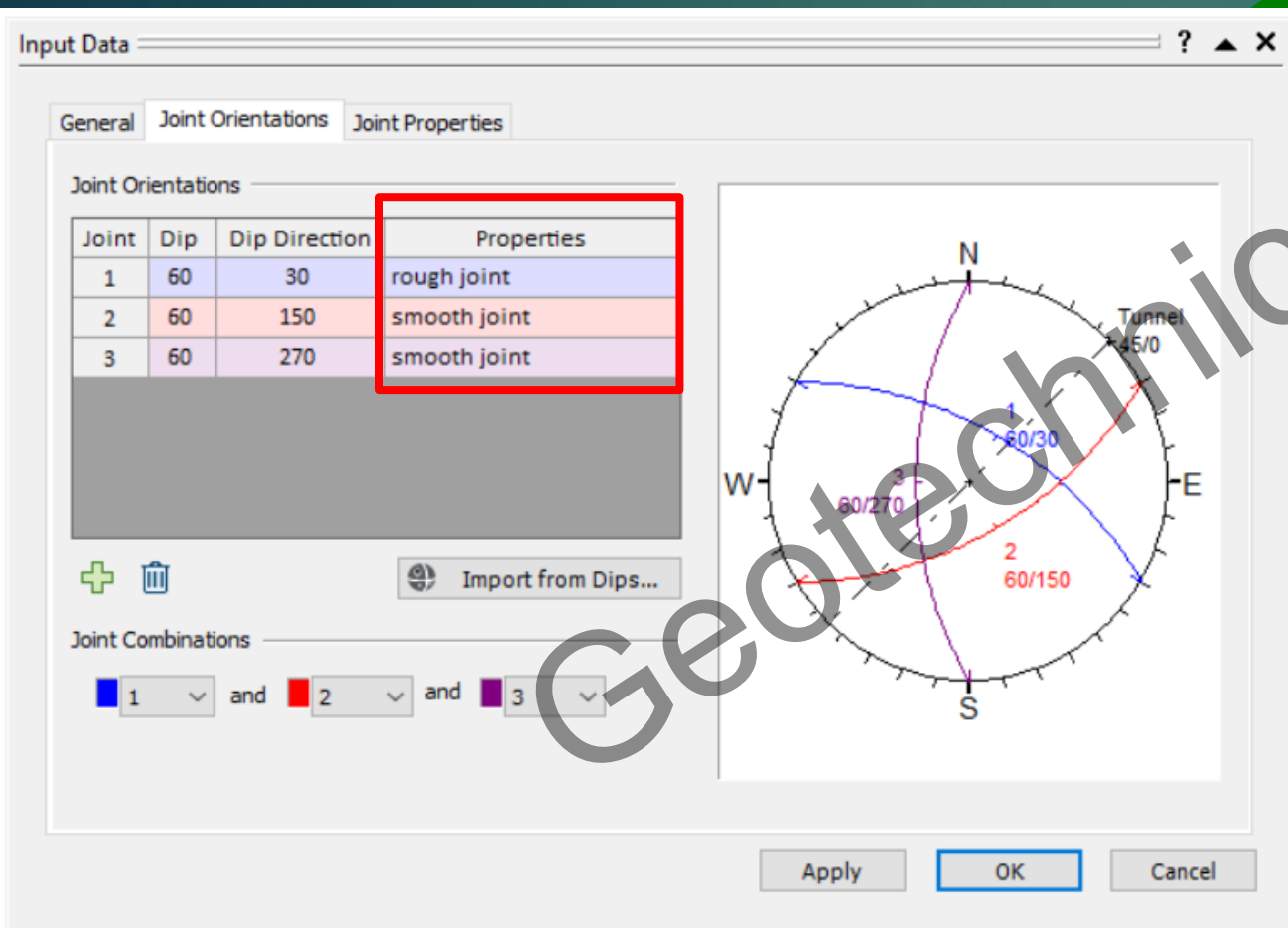
So here we have two joint properties

1. Rough Joint
2. Smooth Joint

Accordingly, we will provide the joint properties to the joints encountered in the geology of tunnel.

Tunnel Properties - Joint Orientations

- Input parameters required to get the factor of safety of wedges formed inside the tunnel.



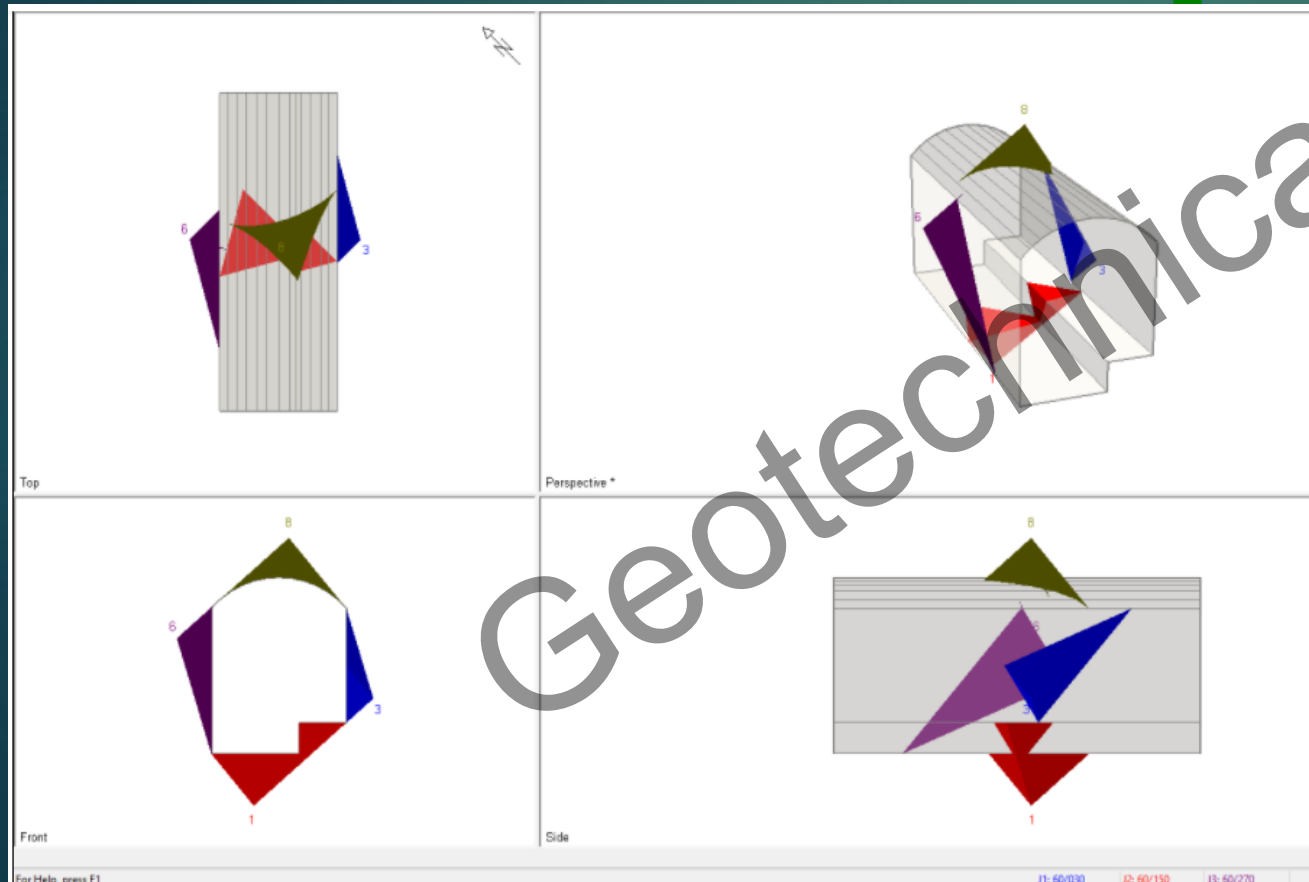
Joint Properties

- **Joint 1** has properties of rough joint.
- **Joint 2 and 3** have properties of smooth joint.

The joint properties have a great effect on FOS of Wedge failures.

Analysis Results

- It is Deterministic Analysis where we know the values of input parameters. These three joints forming wedges on roof, walls and base of Tunnel.



FOS of Wedges

Wedge Info:	
Floor wedge [1]	
FS: stable	
Weight: 2.404 MN	
Mode: unconditionally stable	
Lower Right wedge [3]	
FS: 1.059	
Weight: 0.998 MN	
Mode: sliding on joints 1 and 3	
Lower Left wedge [6]	
FS: 0.210	
Weight: 2.103 MN	
Mode: sliding on joint 2	
Roof wedge [8]	
FS: 0.000	
Weight: 1.057 MN	
Mode: failing wedge	
Base End wedge [9]	
FS: 0.000	

Analysis Results – Factor of Safety

➤ Factor of Safety.

FOS of Wedges



Wedge Info:	Filter List...
Floor wedge [1]	
FS: stable	
Weight: 2.404 MN	
Mode: unconditionally stable	
Lower Right wedge [3]	
FS: 1.069	
Weight: 0.998 MN	
Mode: sliding on joints 1 and 3	
Lower Left wedge [6]	
FS: 0.210	
Weight: 2.103 MN	
Mode: sliding on joint 2	
Roof wedge [8]	
FS: 0.000	
Weight: 1.067 MN	
Mode: failing wedge	
Base End wedge [9]	
FS: 0.777	

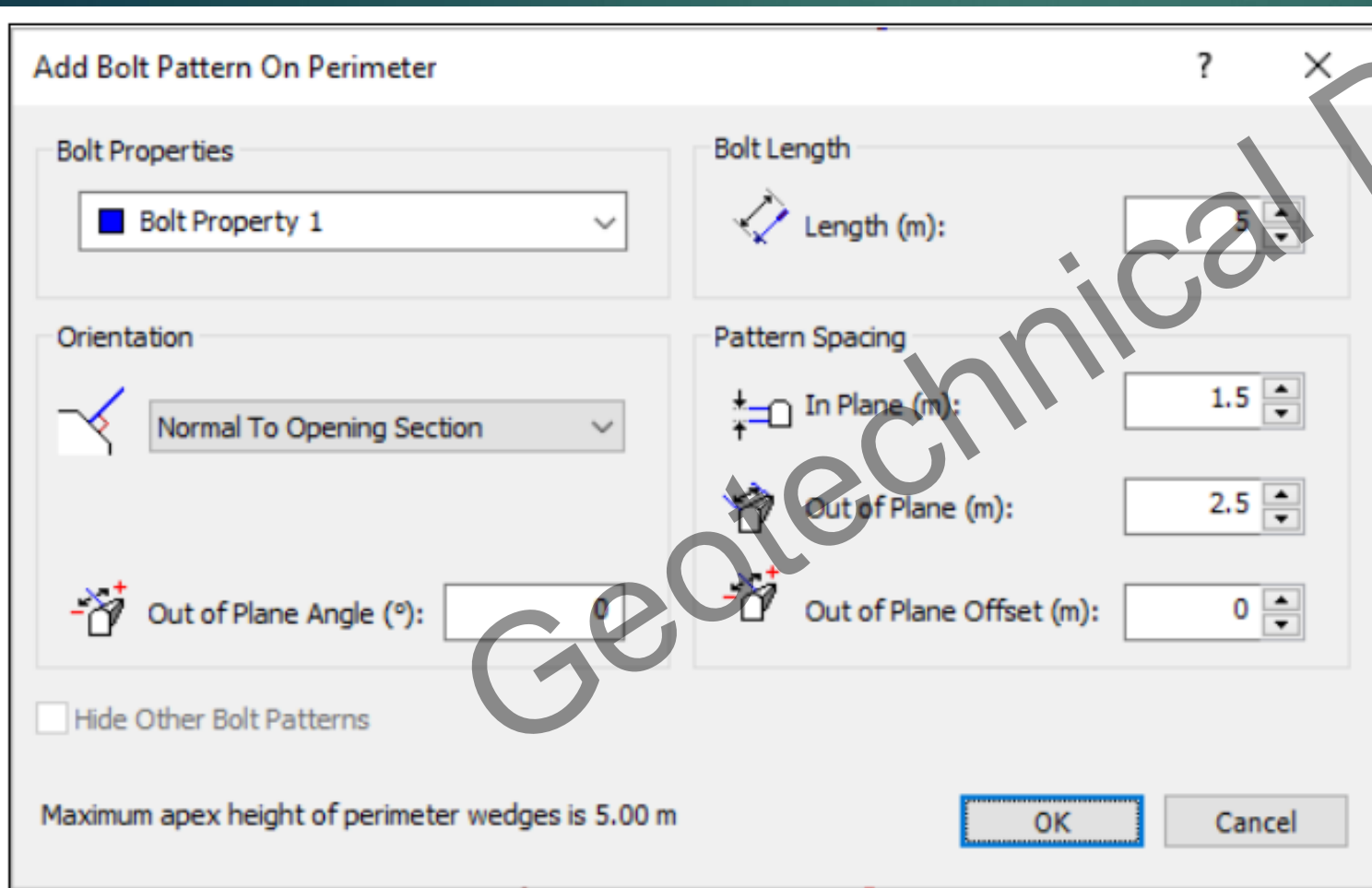
Factor of Safety

Here for **wedge 6 and 8** the factor of safety is less than 1.

This shows that wedge 6 and wedge 8 will fail and they can stabilize only by providing support system.

Support Measures

- The below image show how we can provide the support system.
- Shotcrete of 100mm



Add Bolt Pattern On Perimeter

Bolt Properties
Bolt Property 1

Bolt Length
Length (m): 5

Orientation
Normal To Opening Section

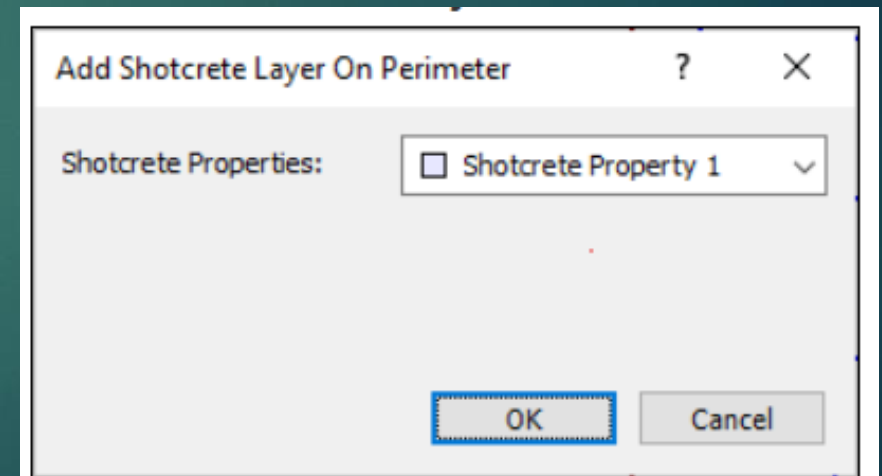
Pattern Spacing
In Plane (m): 1.5
Out of Plane (m): 2.5
Out of Plane Offset (m): 0

Out of Plane Angle (°): 0

Hide Other Bolt Patterns

Maximum apex height of perimeter wedges is 5.00 m

OK Cancel



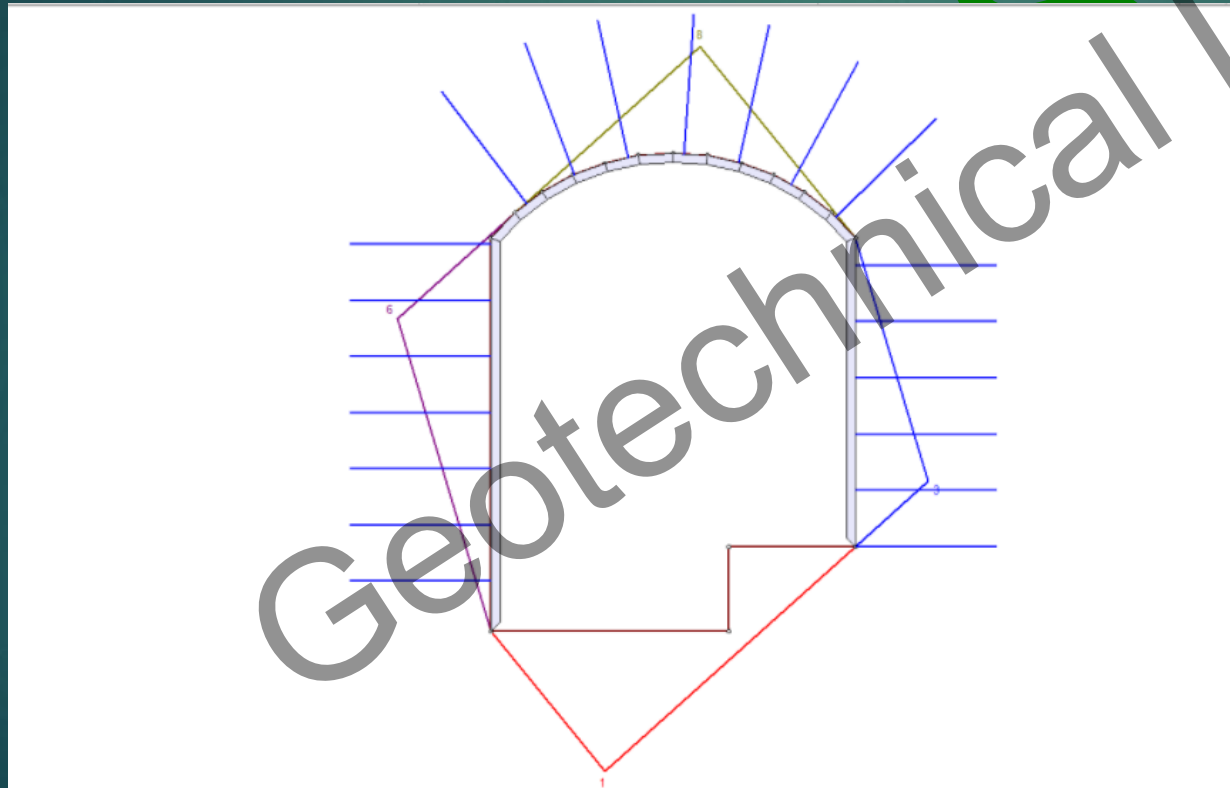
Add Shotcrete Layer On Perimeter

Shotcrete Properties: Shotcrete Property 1

OK Cancel

Support Measures

- This is how we provide the supports in opening.
- See the FOS of Wedges. It has improved drastically and are stable.



Floor wedge [1]
FS: stable
Weight: 2.404 MN
Apex Height: 5.00 m
Lower Right wedge [3]
FS: 7.695
Weight: 0.998 MN
Apex Height: 2.59 m
Lower Left wedge [6]
FS: 2.379
Weight: 2.103 MN
Apex Height: 3.32 m
Roof wedge [8]
FS: 3.482
Weight: 1.057 MN
Apex Height: 3.85 m

**THANK YOU
FOR
YOUR PRECIOUS TIME**

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