2D and 3D Simulation of Tunnel using NATM

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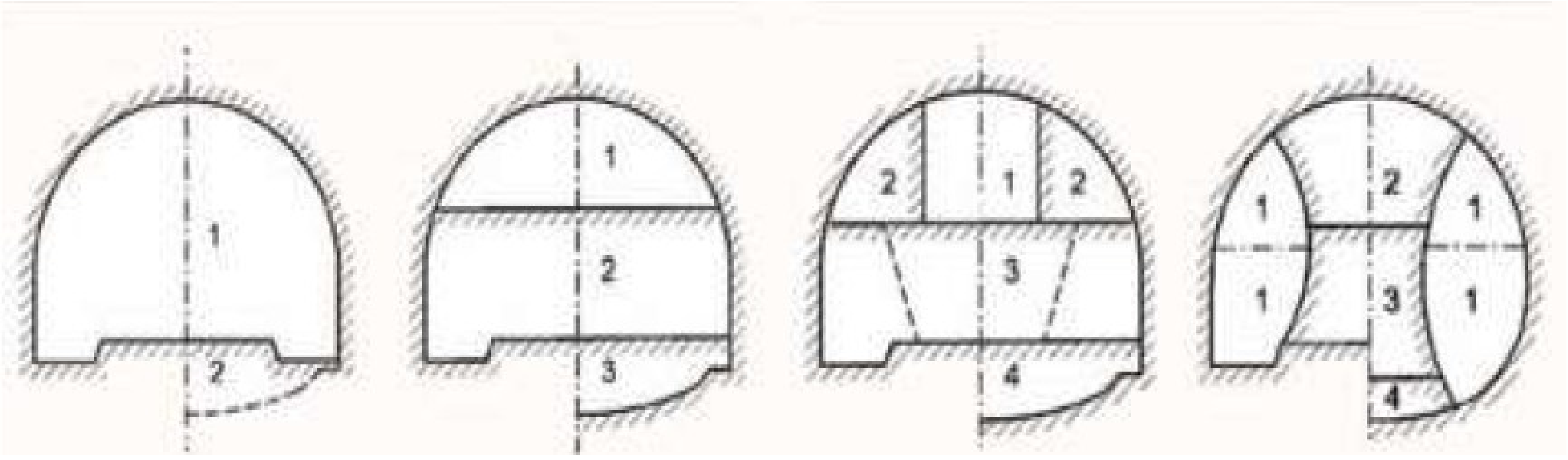
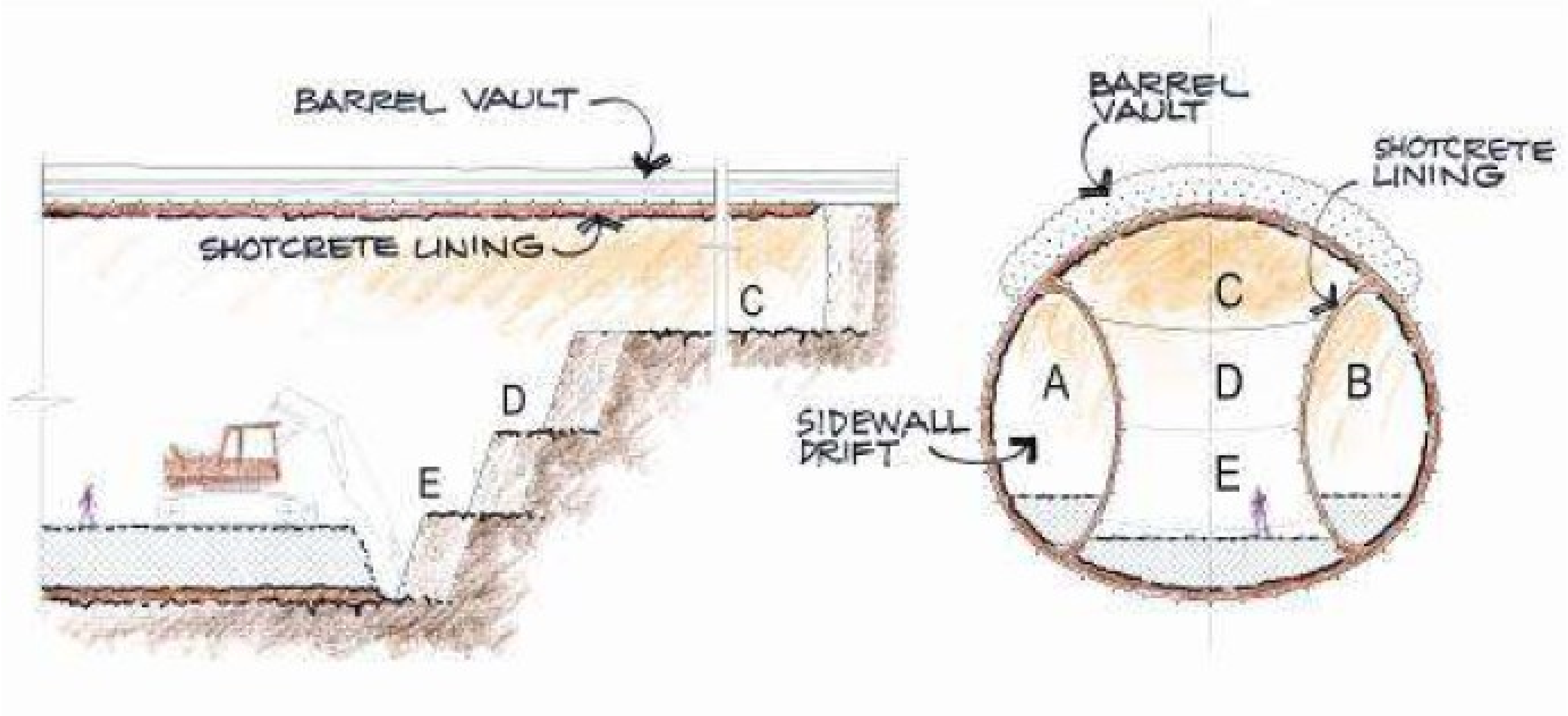
INTRODUCTION

NATM (New Austrian Tunneling Method)

- Also known as Sequential Excavation method



Full Face | Partial excavation heading/benching invert | Partial excavation (caverns) | Partial excavation (with side drifts)



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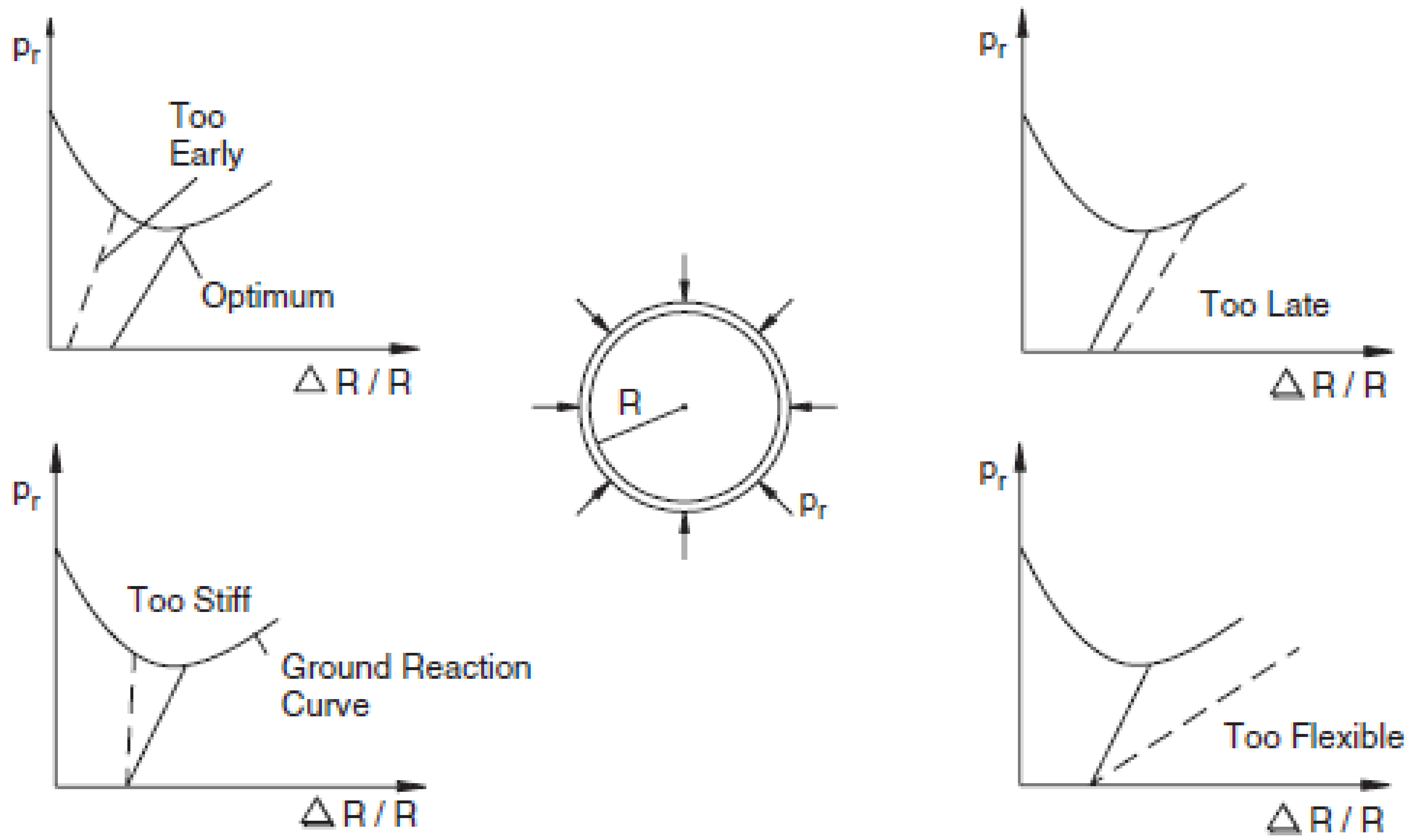
Philosophy of NATM

- NATM is based on the philosophy of "Build as you go" approach with the following caution.

"Not too stiff ,
Nor too flexible
Not too early,
Nor too late."



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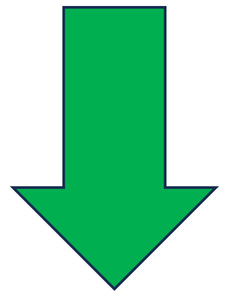
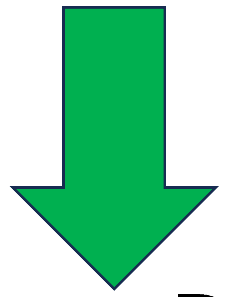
Rockmass Support Interaction

- Rockmass support system has two components
  - Tunnel as a structure excavated in rock/rockmass
  - Support system

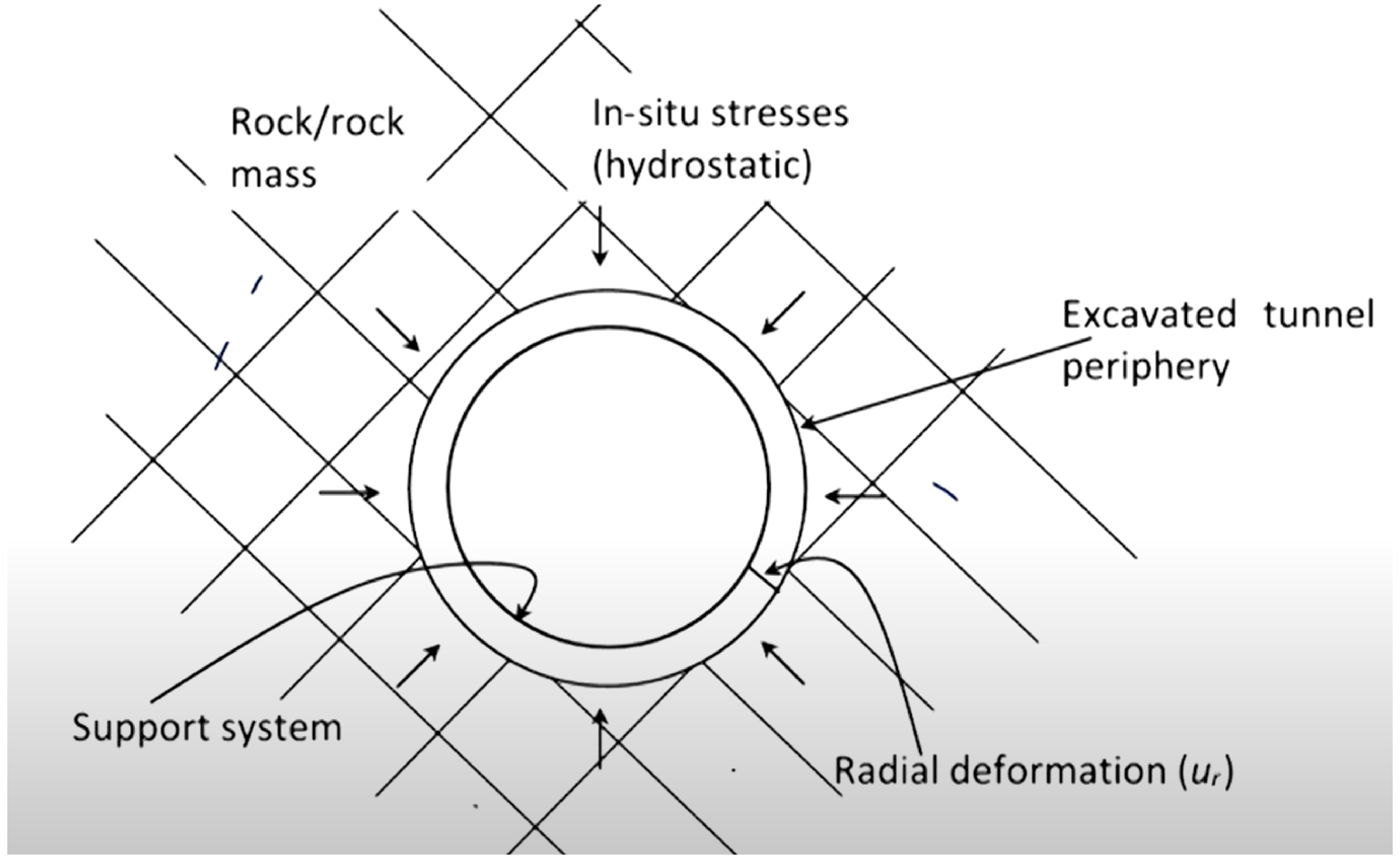
Interdependent behavior



Mechanical responses



Pressure vs Deformation



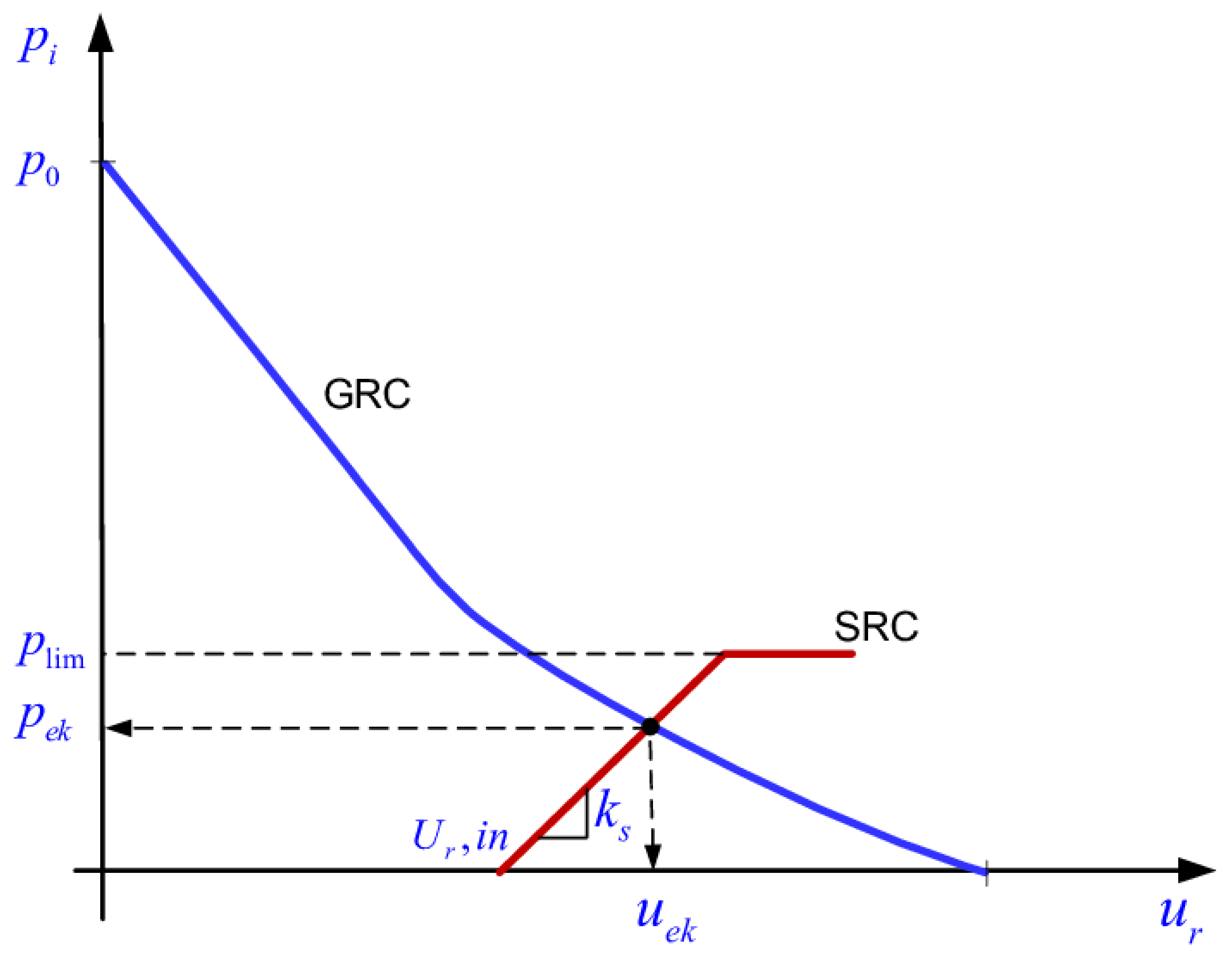
Rockmass Support Interaction

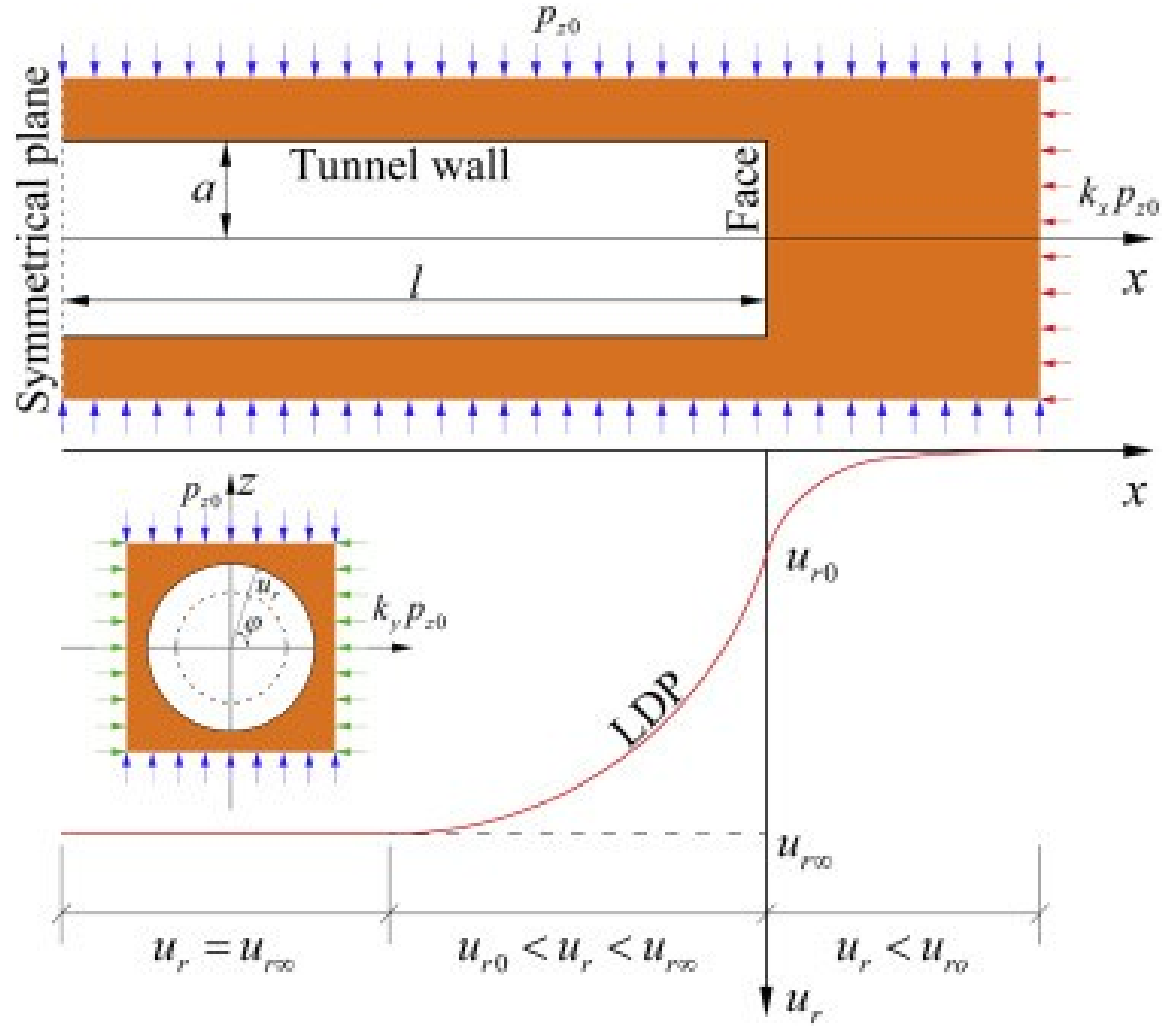
GRC, SRC & LDP

- Ground reaction curve (GRC) describes the relationship between diminishing internal pressure and deformation.

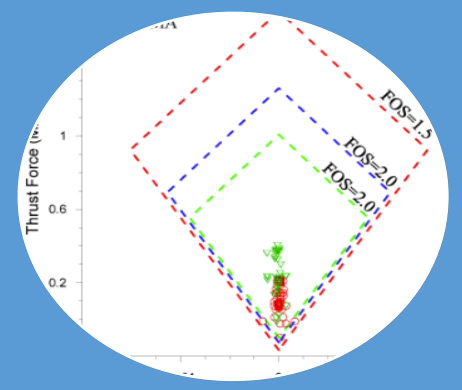
- Support reaction curve (SRC) is defined as the relationship between increasing pressure on the support

- Longitudinal deformation profile (LDP) relates the tunnel wall deformations to the location along tunnel axis, behind and ahead of the tunnel face



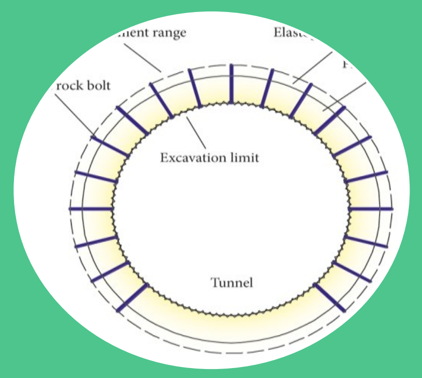


Tunnel Design Methodologies



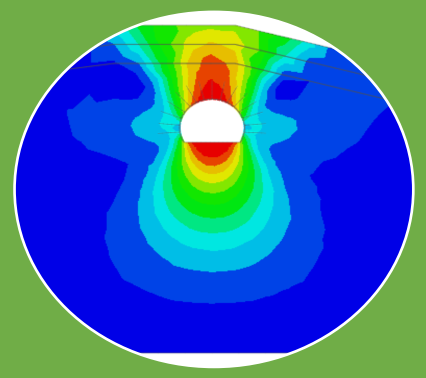
Empirical

- Based on Q system
- Based on RMR system



Analytical

- Based on the published literature



Numerical

- 2D FEM model
- 3D FEM model

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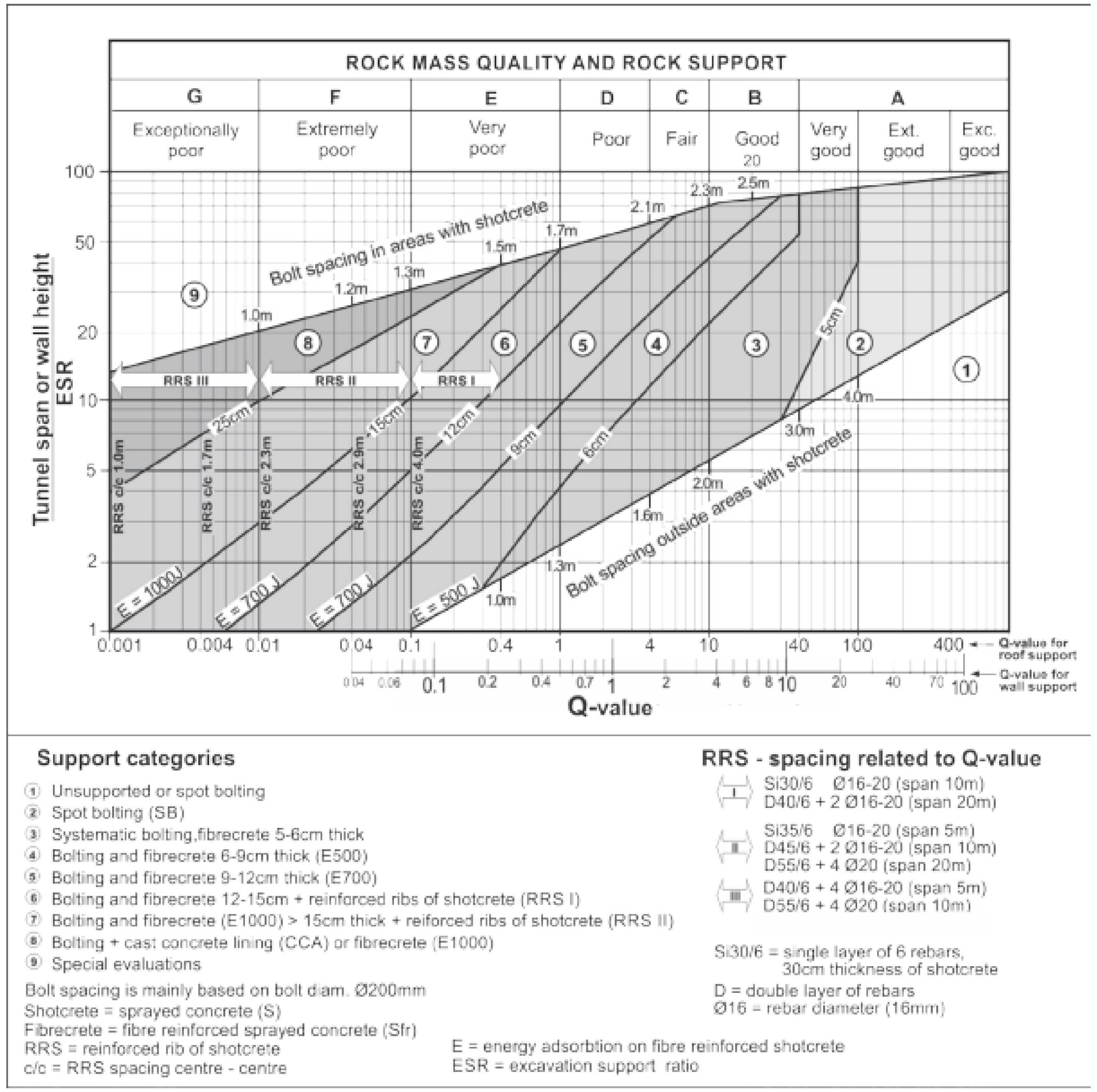
Empirical Method

Q System

- Q system was developed at NGI between 1971 and 1974 (Barton et al. 1974)
- One of the most popular methods used by the industry



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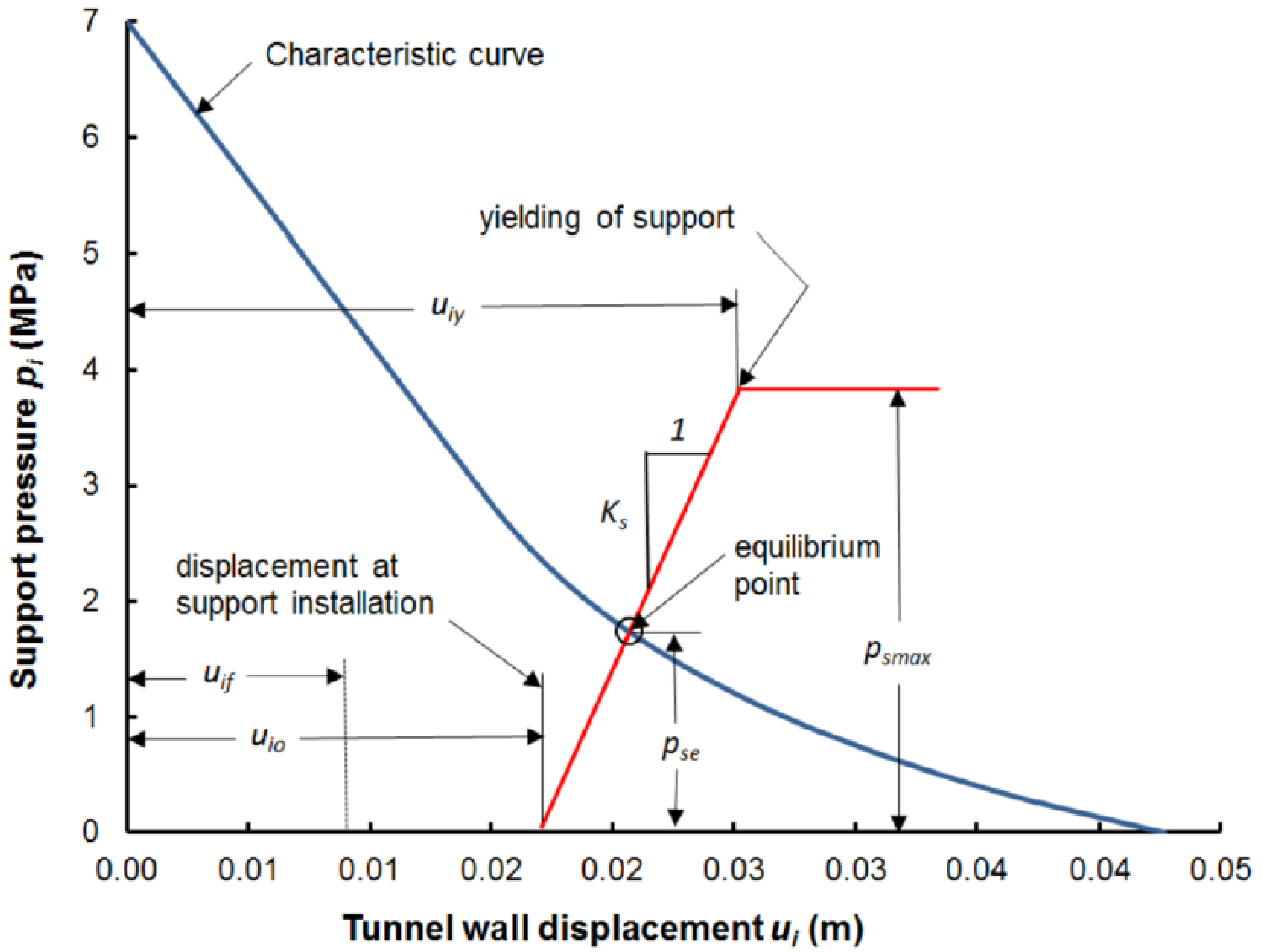
Analytical Method

Convergence Confinement Method

The first AFTES recommendations on the Convergence confinement methods were issued in 1984.



Analytical Method

CONVERGENCE-CONFINEMENT METHOD

SOMMAIRE

1 - INTRODUCTION

Designing tunnel support was for many years considered too complex for strict engineering analysis and remained an empirical art repeating techniques that had proven satisfactory under similar geological conditions in the past. This similarity approach was based on qualitative factors that were neither well-defined nor interpreted in any consistent way.

The analytical methods which are a basic tool for construction engineers were found to be unsuitable for tunnel support design. This left the way open for dogmatic claims about the universal suitability of certain methods and techniques, claims failing to stand up to quantitative analysis.

The difficulty of designing tunnel support

Additionally, time-dependent response dictated by the rheological properties of the ground may also have to be considered.

The convergence-confinement method is a simplified method of analysing this interaction between the ground and the support. In its basic form using extreme axisymmetry assumptions, it becomes a two- or one-dimensional problem, providing a simple understanding of the ground/support interaction processes occurring near the working face.

These Recommendations describe the general principles of the convergence-confinement method, including the rules for selecting the confinement loss value, which is the keystone of the method. They also describe the field of application of the method and its relationship to other existing methods.

Contrary to what is mistakenly assumed in

- Methods for determining the loads acting on the support, regardless of support type and deformation.
- Support design methods which consider loads exerted by the ground as input data but allow for support stiffness and deformation and the reactions of the surrounding ground.
- More recent methods taking full account of the ground/support interaction.

These methods, which are the subject of earlier AFTES Recommendations [1], are briefly reviewed in the following.

1.1 - Empirical methods based on geotechnical classification systems

Various rock classification systems have been proposed. The most widely used are

Numerical Method

2D Tunnel Design using GTS NX

Assumption taken in 2D modelling

- The geometry of the tunnel is the same along a significant tunnel length so as to permit the three-dimensional problem to be modelled in two dimensions as a plane strain analysis.

- The rock mass surrounding the tunnel is homogenous, isotropic in all directions.

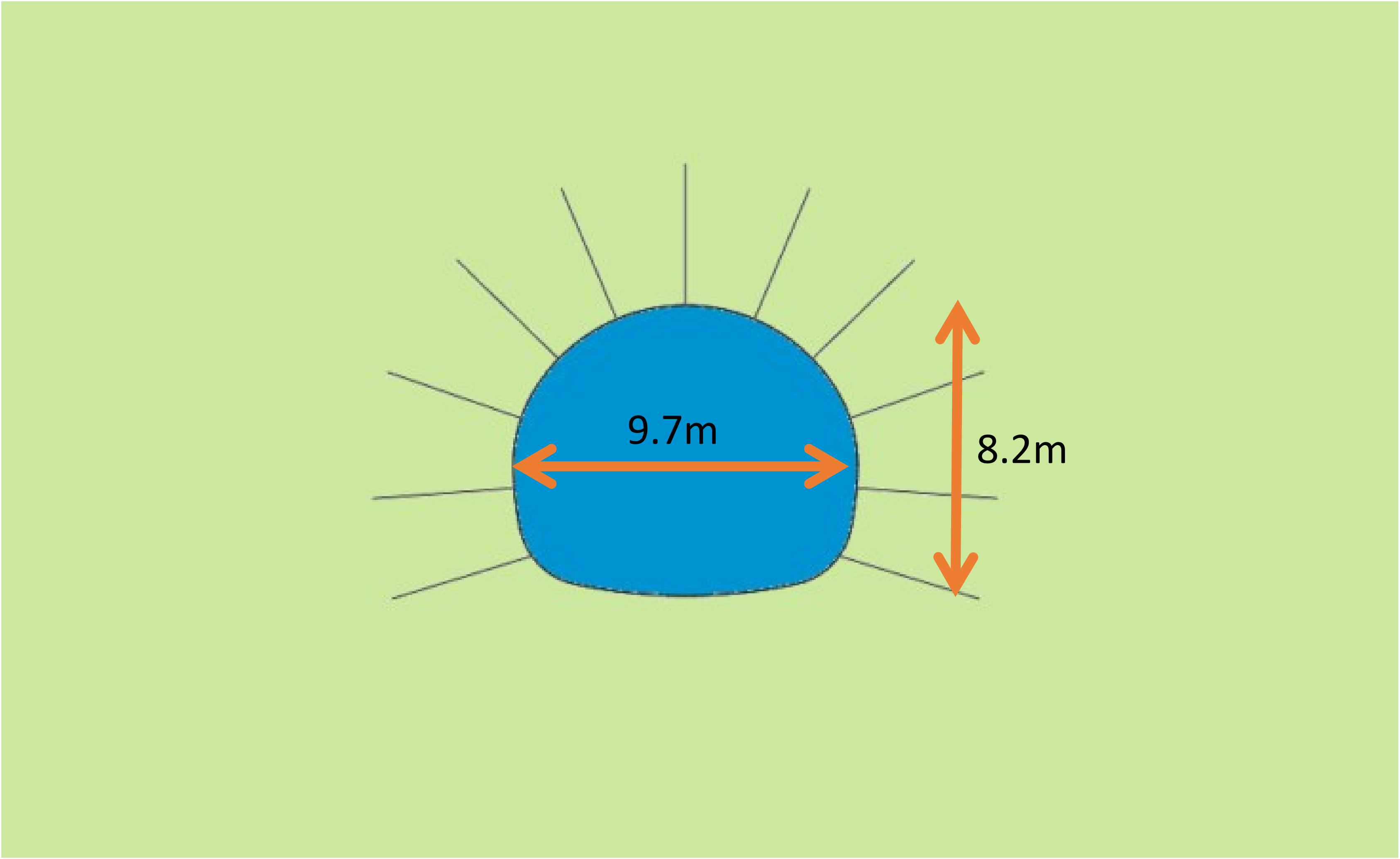
- Structural elements: the primary tunnel lining is modelled as elastic beam elements in 2D plane strain.

Numerical Method

2D Tunnel Design using GTS NX

Problem Statement

- A modified horseshoe shape tunnel of opening width 9.7m
- Cover of the tunnel is 100m from tunnel axis
- GSI (Geological strength Index) = 40
- Mi of Rock = 7
- Erm(Deformation Modulus of Rock) = 800MPa
- UCS (Uniaxial Compressive Strength) = 35MPa
- Disturbance Factor = 0



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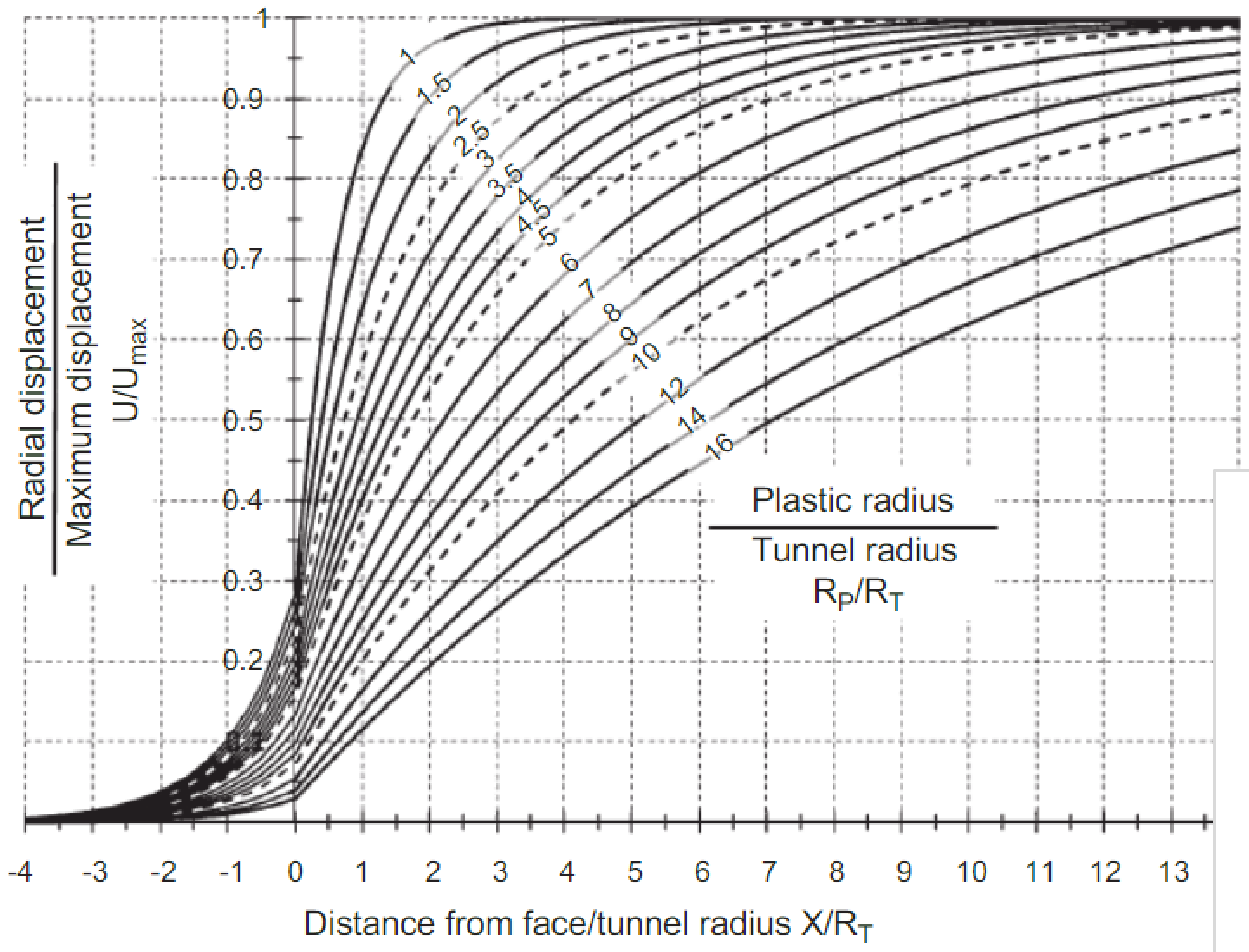
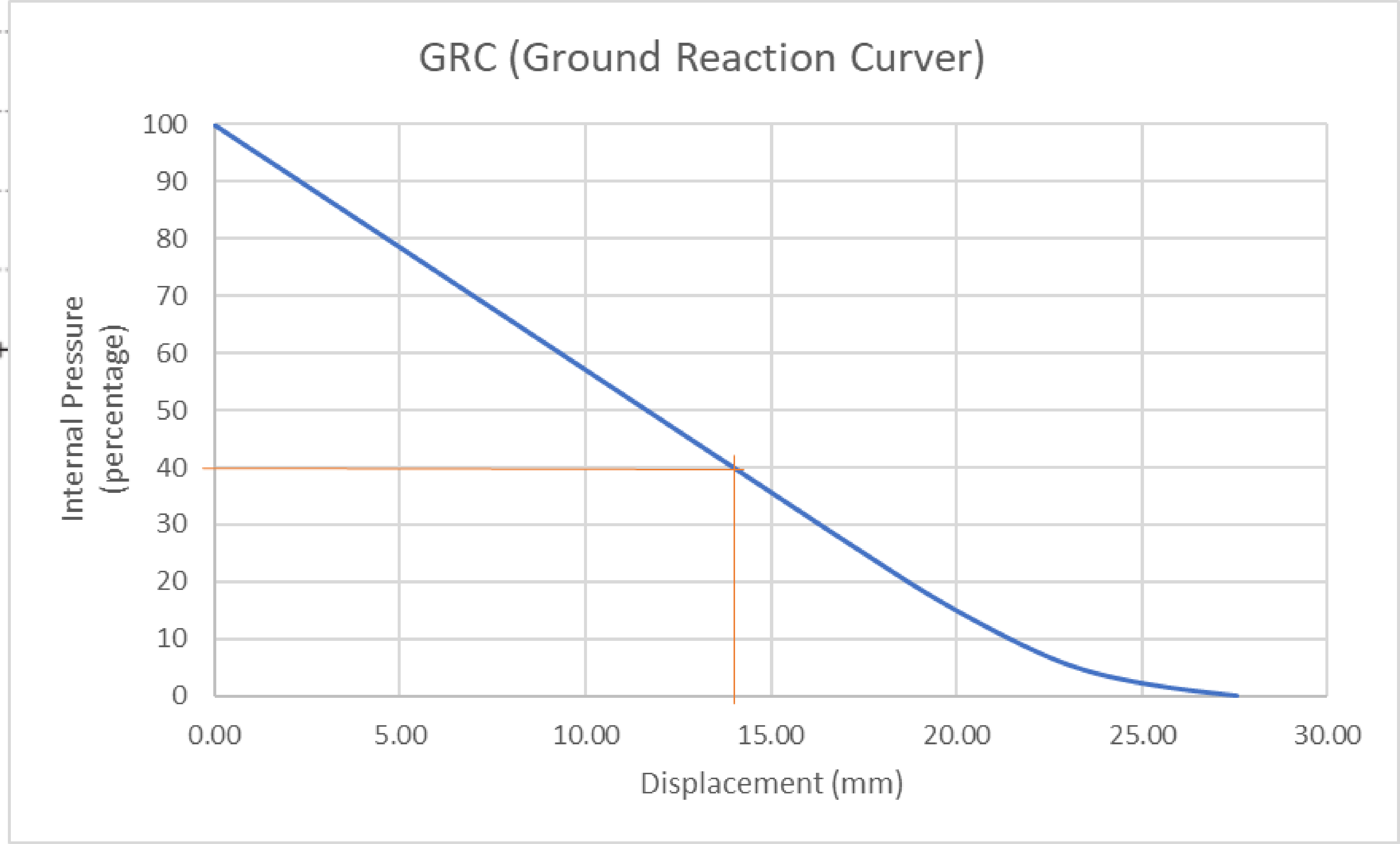
Numerical Method

2D Tunnel Design using GTS NX

Relaxation Calculation



Plot using Vlachopoulos and Diederichs equations



Ground Reaction Curve

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Numerical Method

3D Tunnel Design using GTS NX

Advantage of 3D over 2D

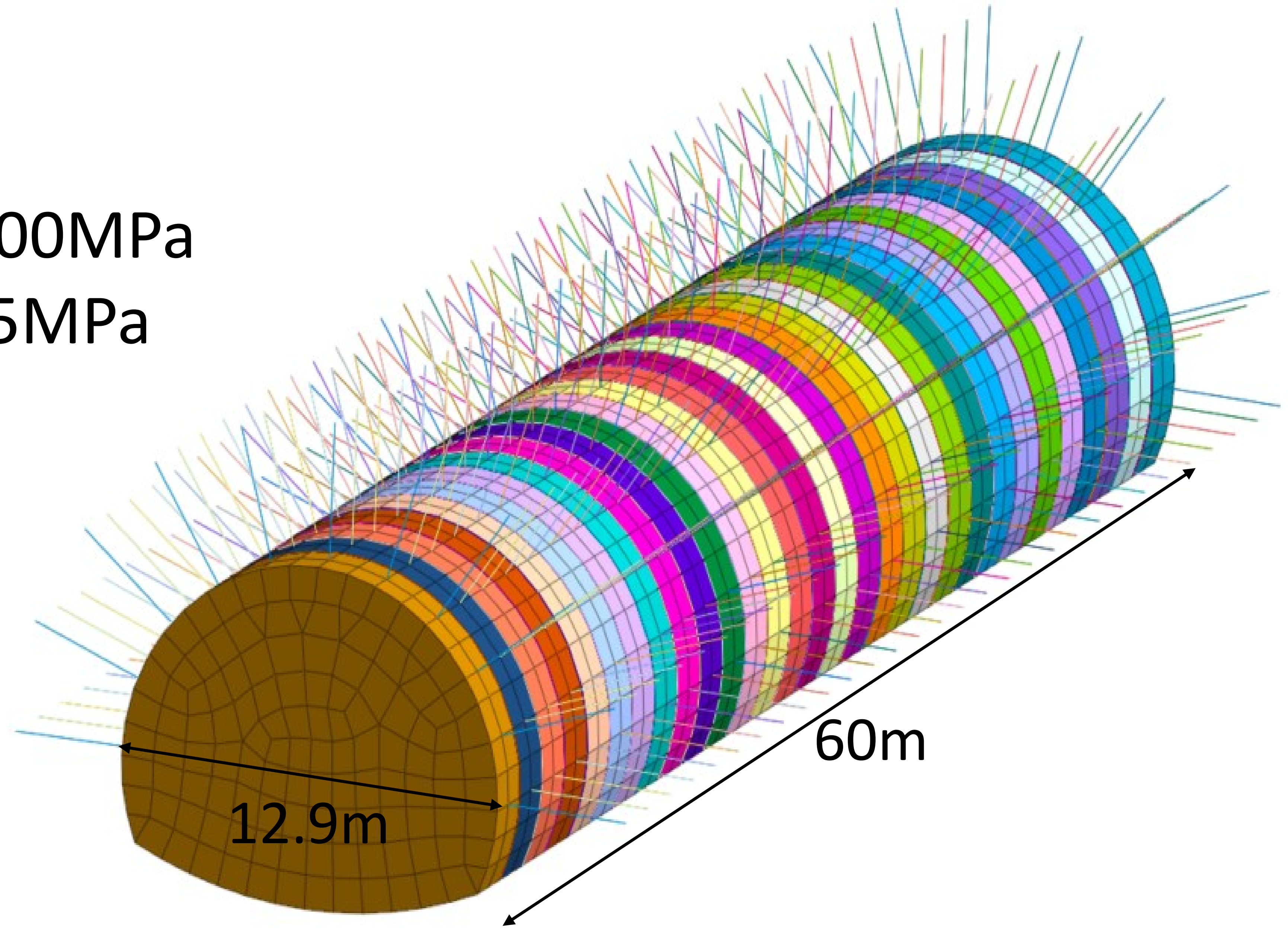
2D modeling	3D modeling
In case of 2D model, geometry of the tunnel is same along a significant tunnel length so as to permit the three-dimensional problem to be modeled in two dimensions as a plane strain analysis.	Not required in 3D model
Curvature effect of the tunnel should neglect	Curvature modeling is possible in 3D model
Two-dimensional modelling methods would not provide any information on the behavior of tunnel with **excavation sequence simulation**.	Excavation sequence simulation is possible in 3D model
Calculation of the relaxation value using empirical equations.	In 3D tunnel modeling relaxation calculation is not required
Intermediate stage results are difficult to achieve	Easily get intermediate stage result

Numerical Method

3D Tunnel Design using GTS NX

Problem Statement

- A modified horseshoe shape tunnel of opening width 12.9m with shotcrete lining and rock bolts.
- Cover of the tunnel is 100m
- GSI (Geological strength Index) = 50
- Mi of Rock = 7
- Erm(Deformation Modulus of Rock) = 2000MPa
- UCS (Uniaxial Compressive Strength) = 45MPa
- Disturbance Factor = 0



THANK YOU