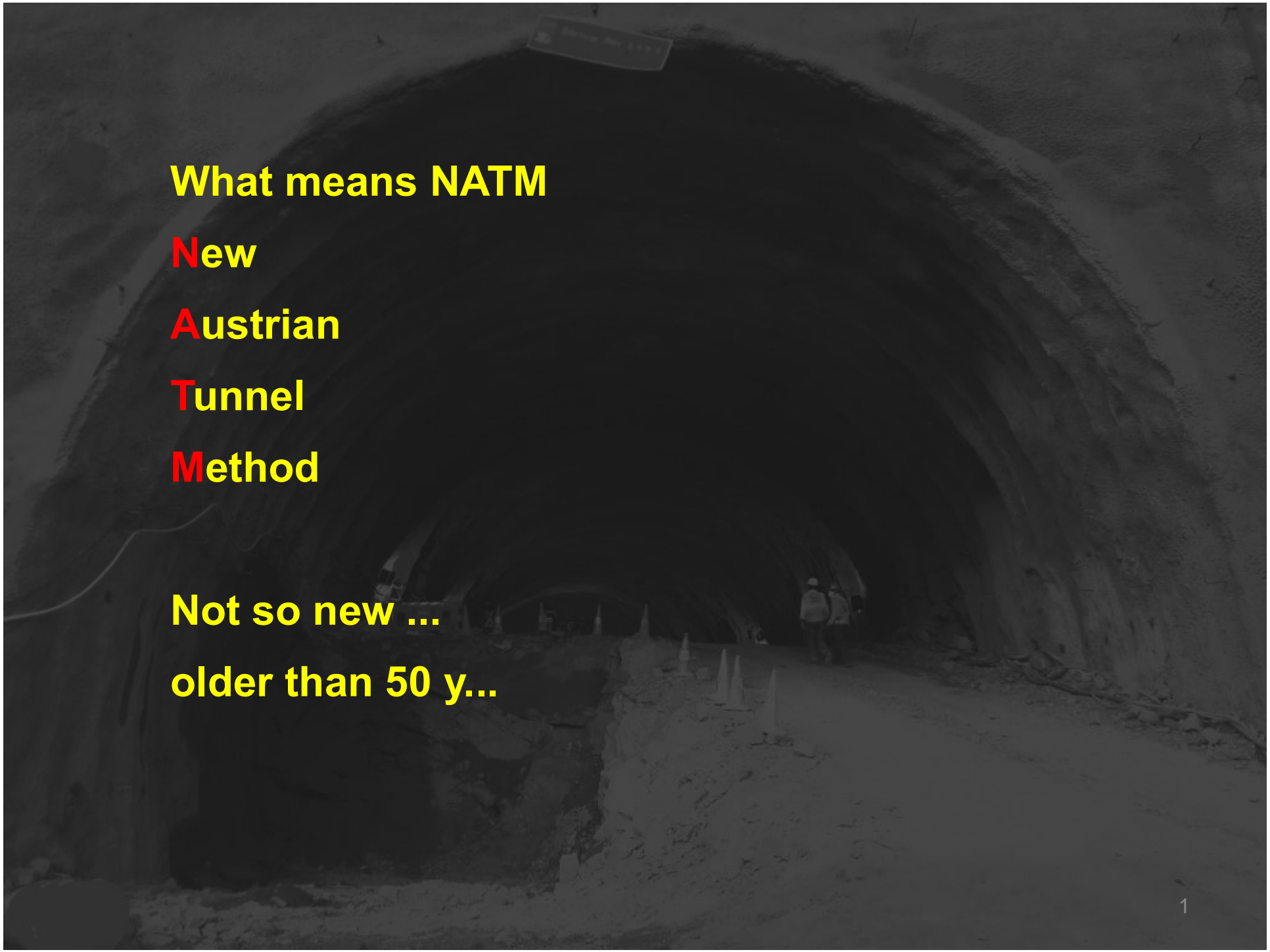
03 NATM



What means NATM

New

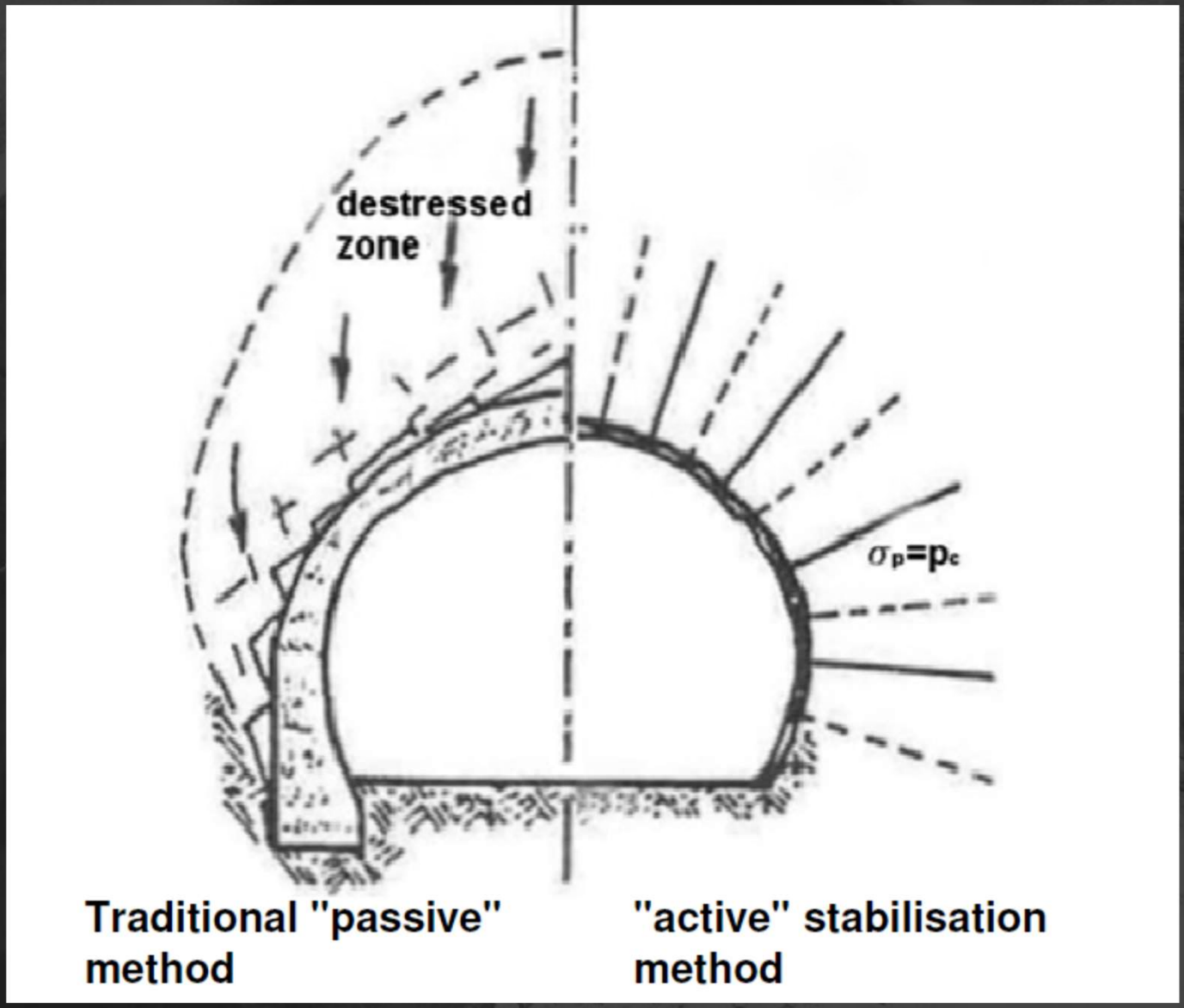
Austrian

Tunnel

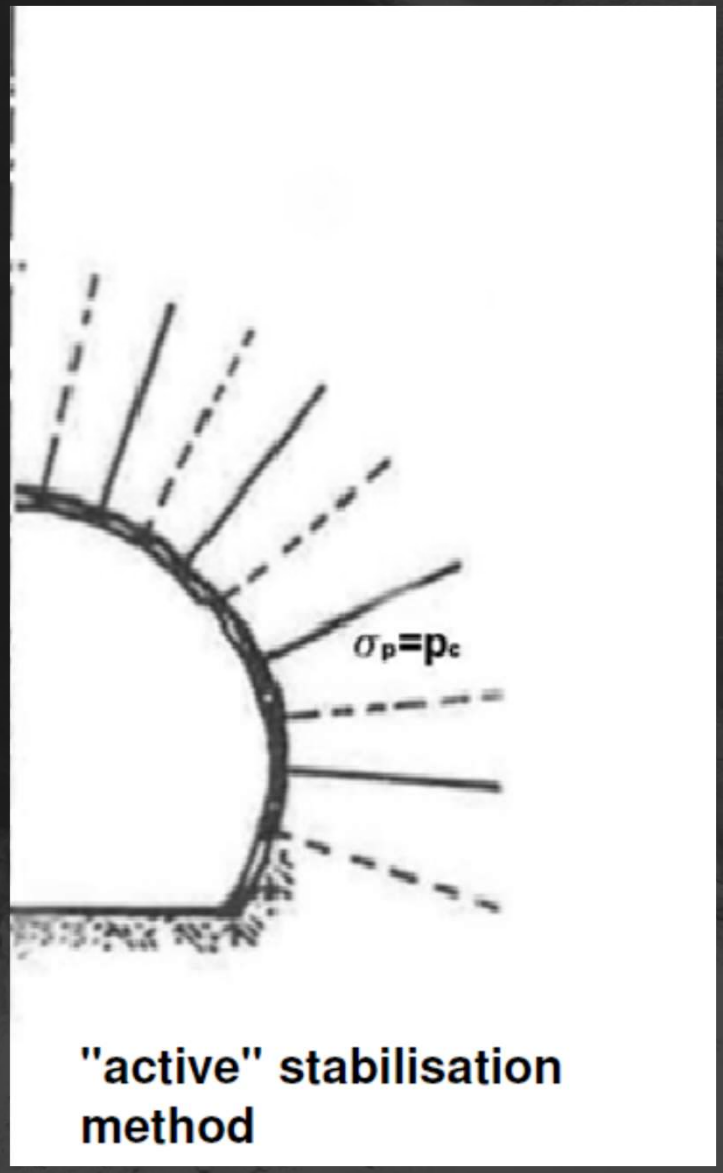
Method

Not so new ...

older than 50 y...

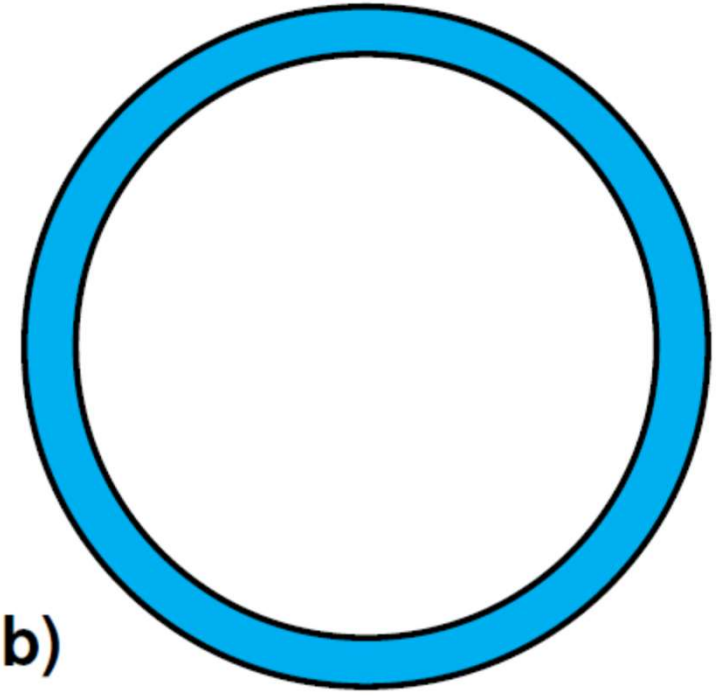

destressed
zone
$\sigma_p = p_c$
Traditional "passive"
method
"active" stabilisation
method

Main content of NATM is that a ring of rock around the excavated hole is requested to support some of the load coming from the overburden



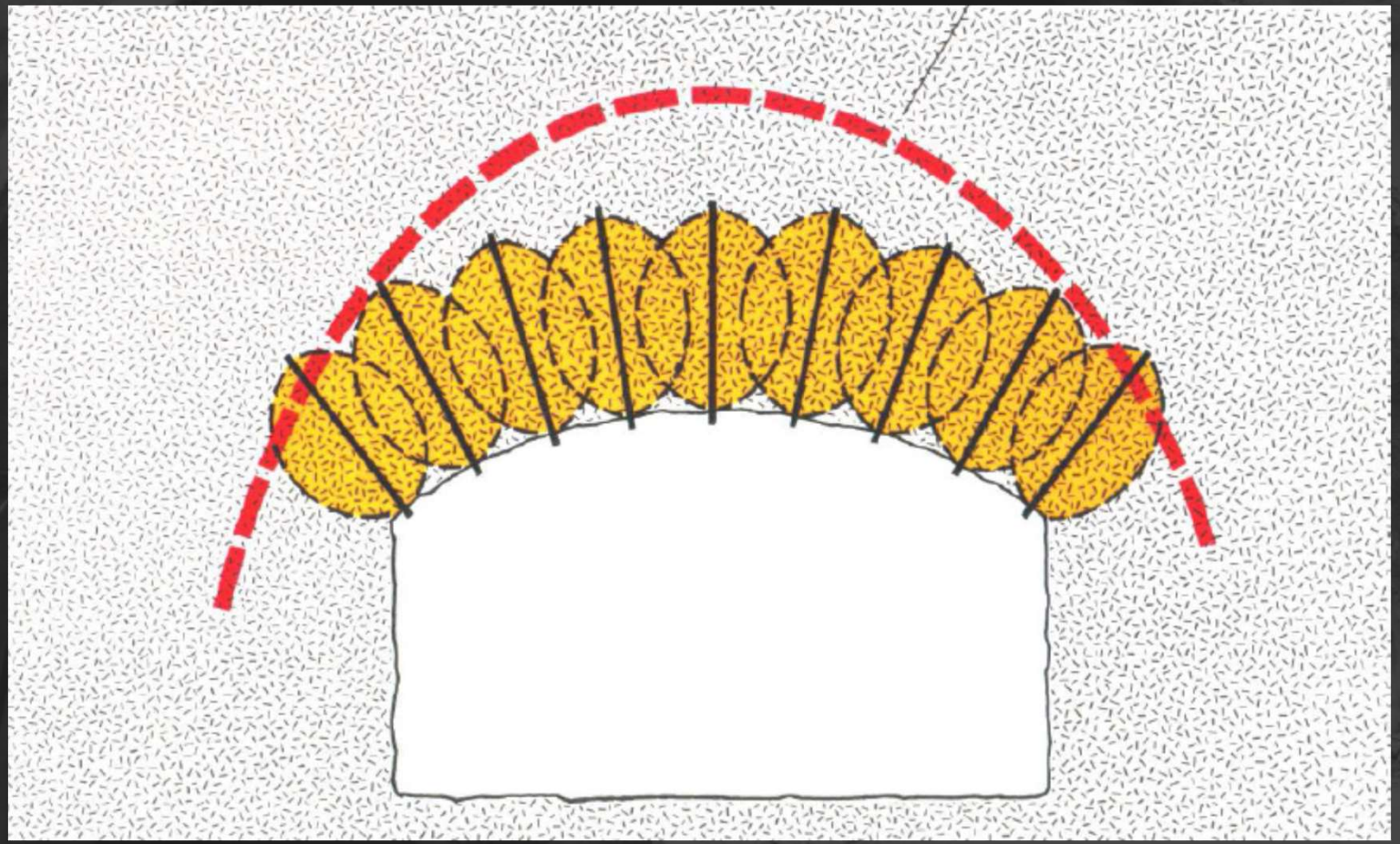
Criteri progettuali limite per realizzare i sostegni

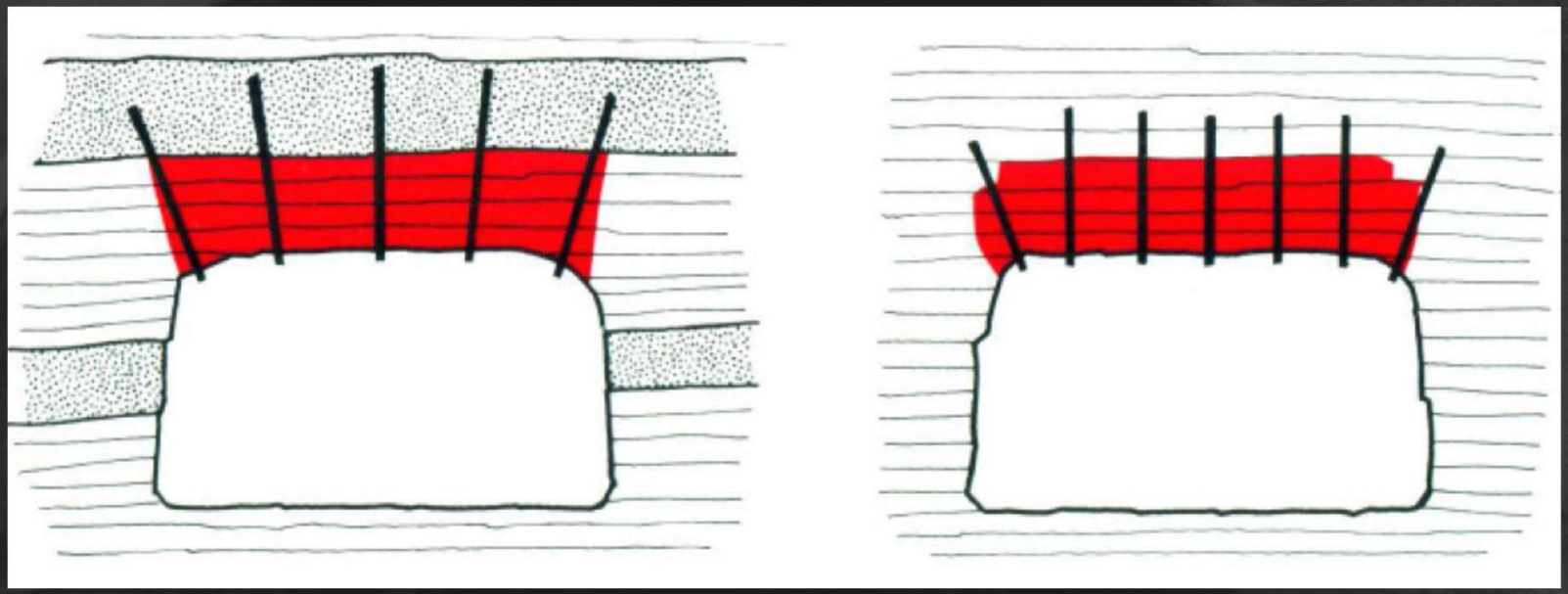
a)



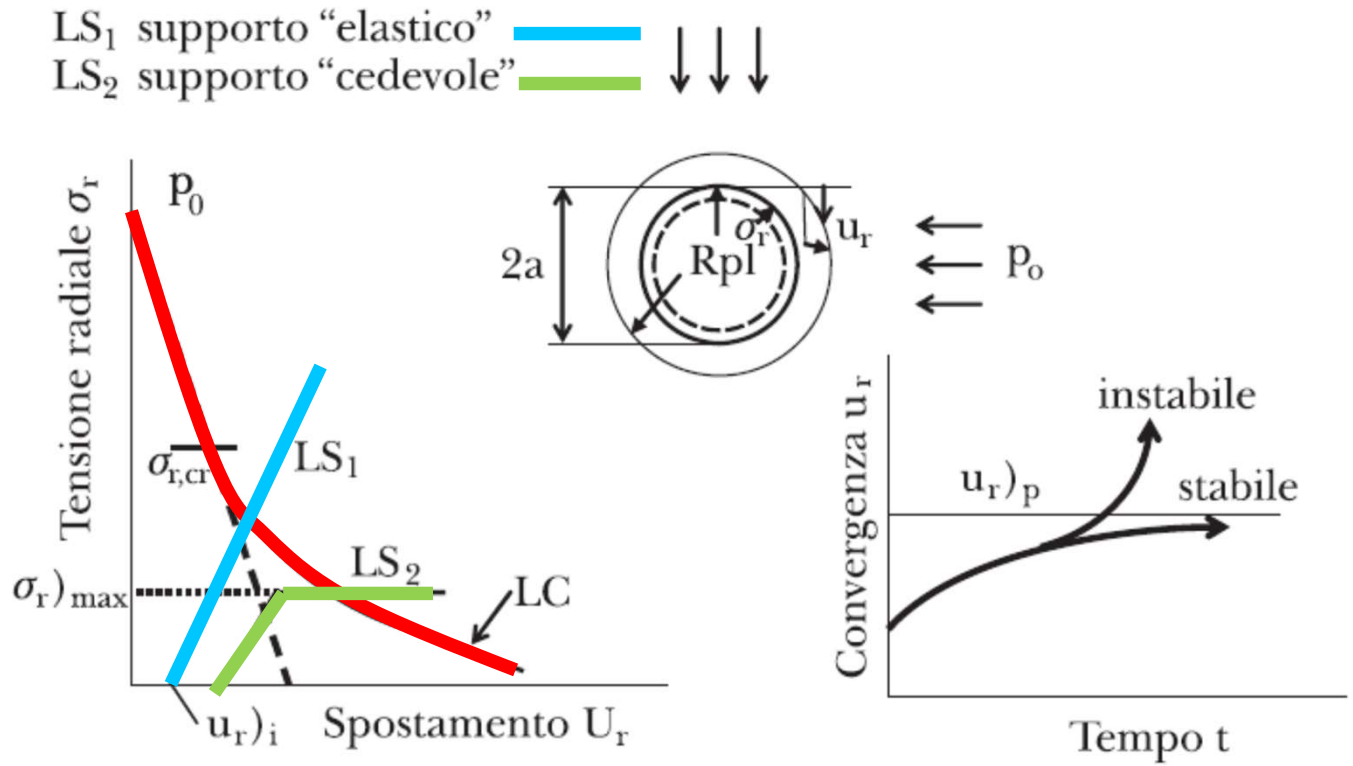
b)

sovrascavo





I bulloni aumentano la rigidita’ degli strati rocciosi


LS1 supporto "elastico"
LS2 supporto "cedevole"
Tensione radiale σr
p0
σr,cr
LS1
LS2
LC
σr) max
ur)i
Spostamento Ur
2a
Rpl
σr
ur
po
Convergenza ur
instabile
ur)p
stabile
Tempo t

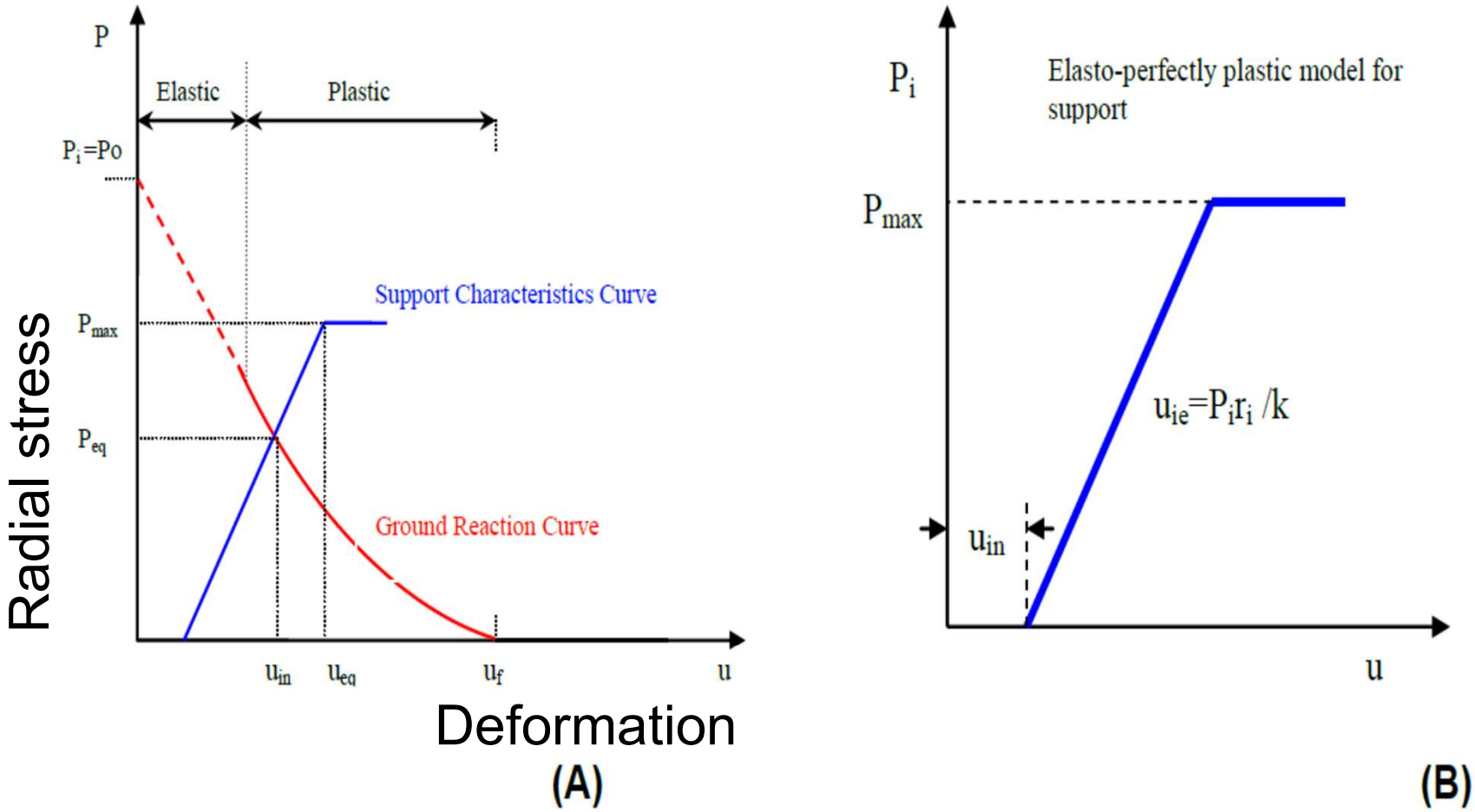
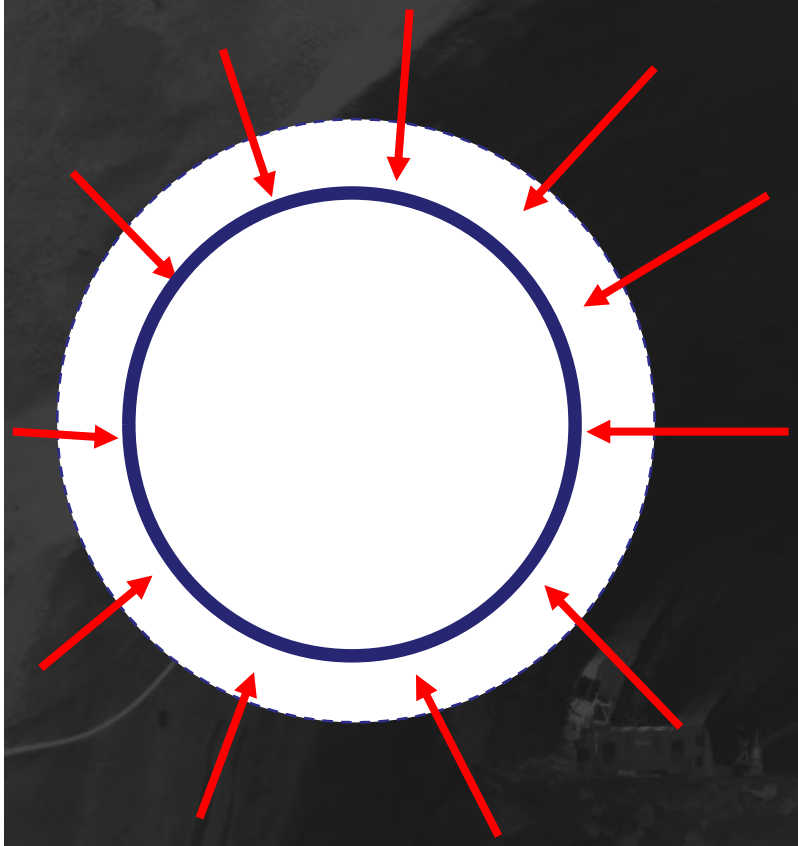
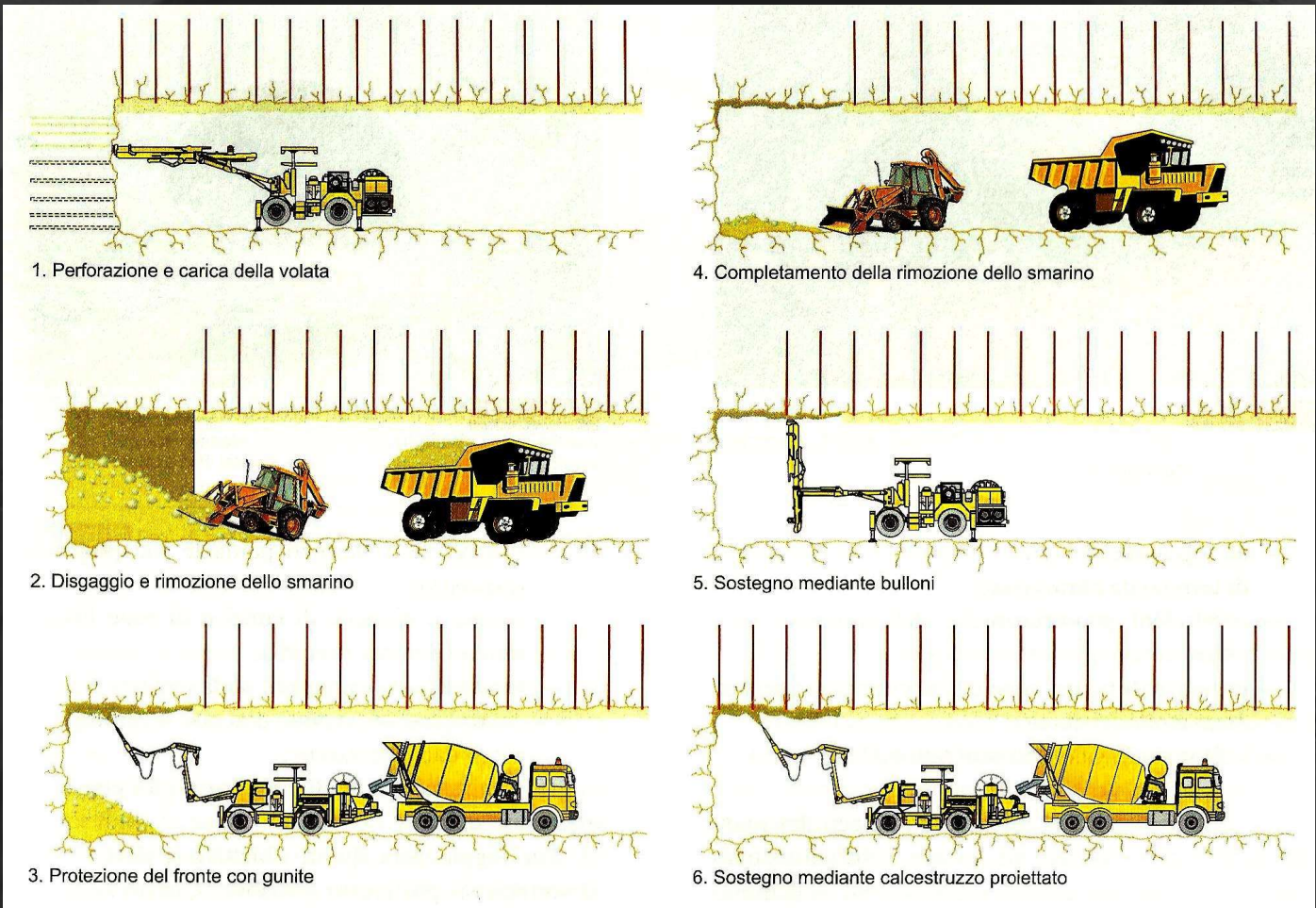


Figure 7-2: (A) The convergence-confinement method (B) Support characteristics curve (Hoek & Brown, 1980)



To allow that the rock take the load or part of the load a displacement of the tunnel periphery is requiered .

Primary support i.e. Shocrete rock bolts lattice girders have the only purpose to support the excavation phase (short term) and maintain the shape of the excavated profile .



1. Perforazione e carica della volata

2. Disgaggio e rimozione dello smarino

3. Protezione del fronte con gunite

4. Completamento della rimozione dello smarino

5. Sostegno mediante bulloni

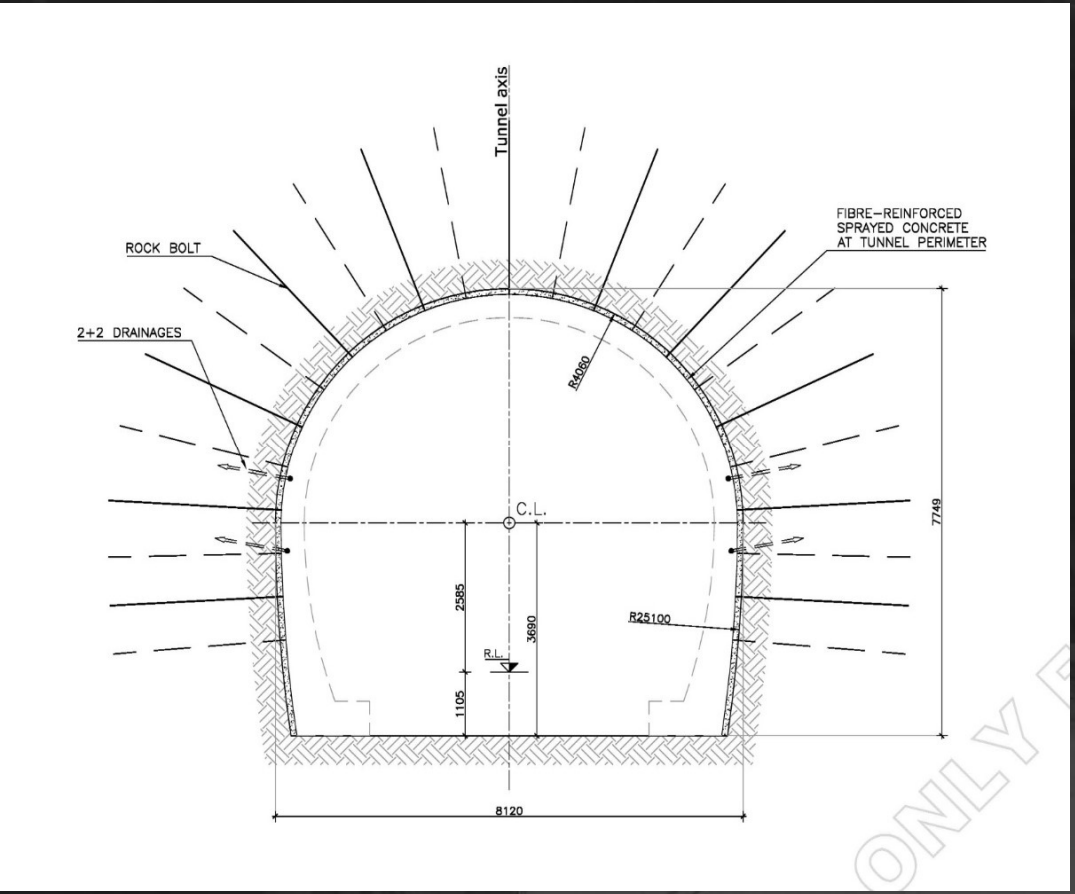
6. Sostegno mediante calcestruzzo proiettato

NATM construction method

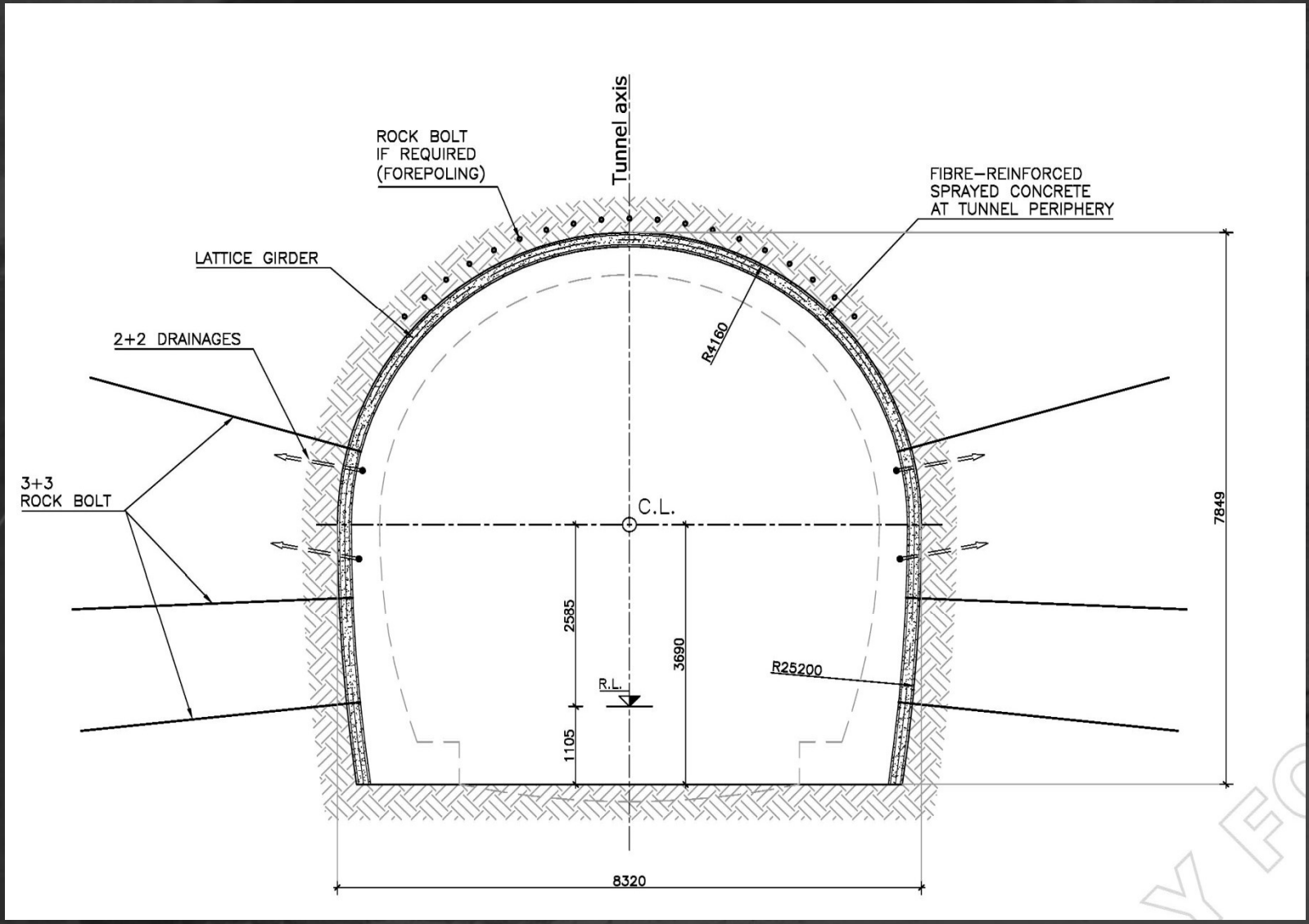
Blasting

Waterproofing and final lining

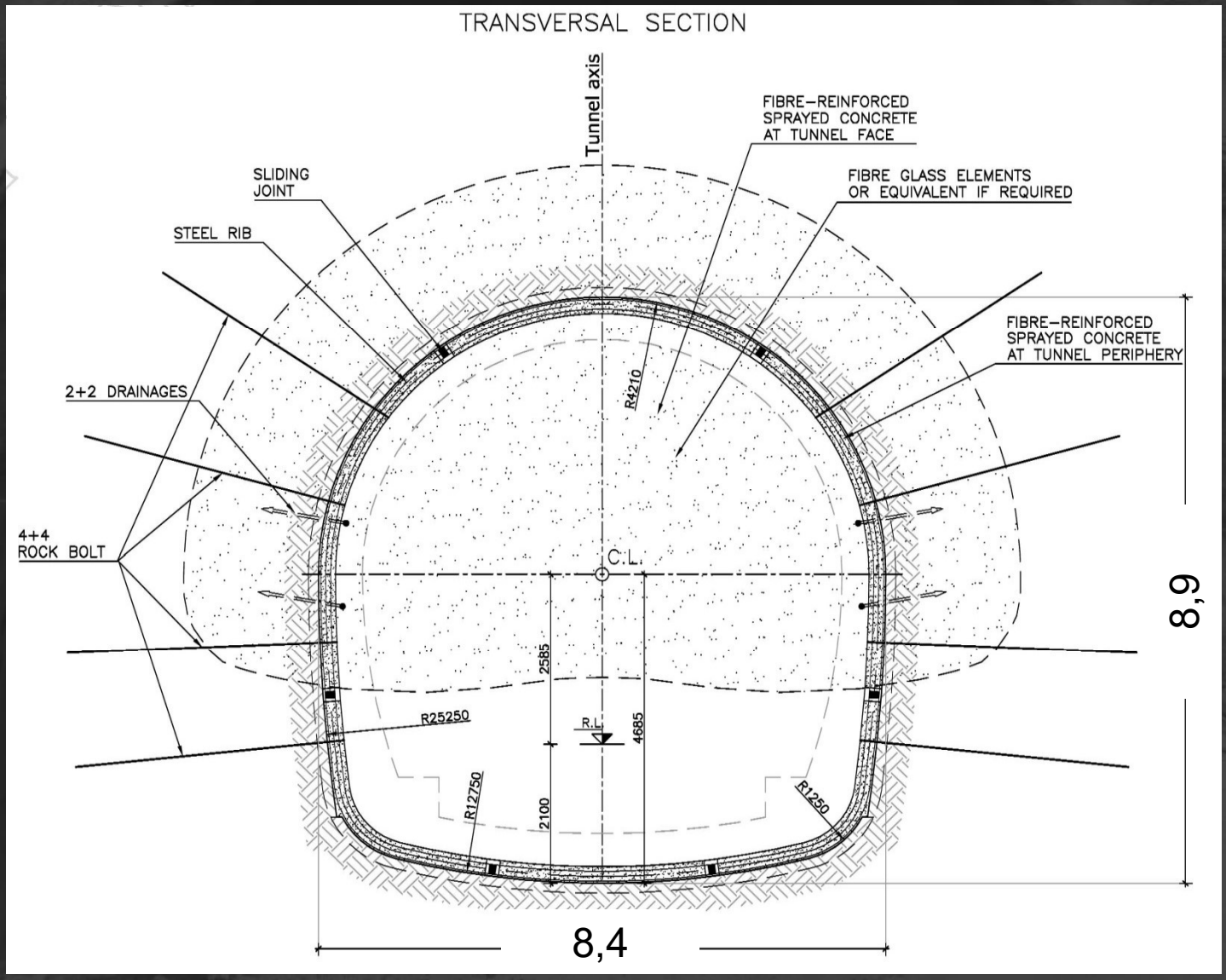
Support type



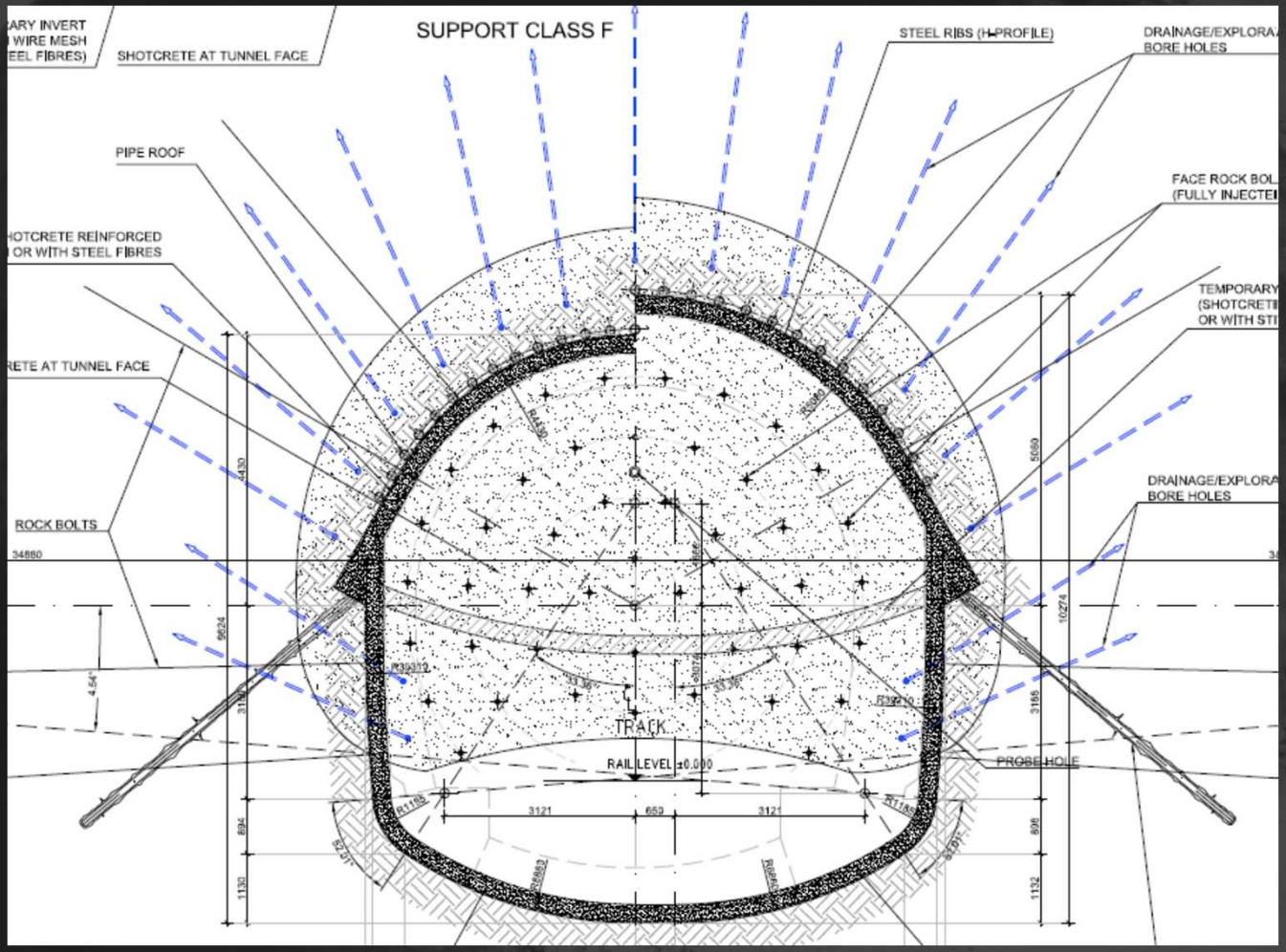
Support type



Support type



Support type



Pure NATM state that primary support is enough to support the tunnel load

Chenani Nashri concession agreement based on «pure» NATM

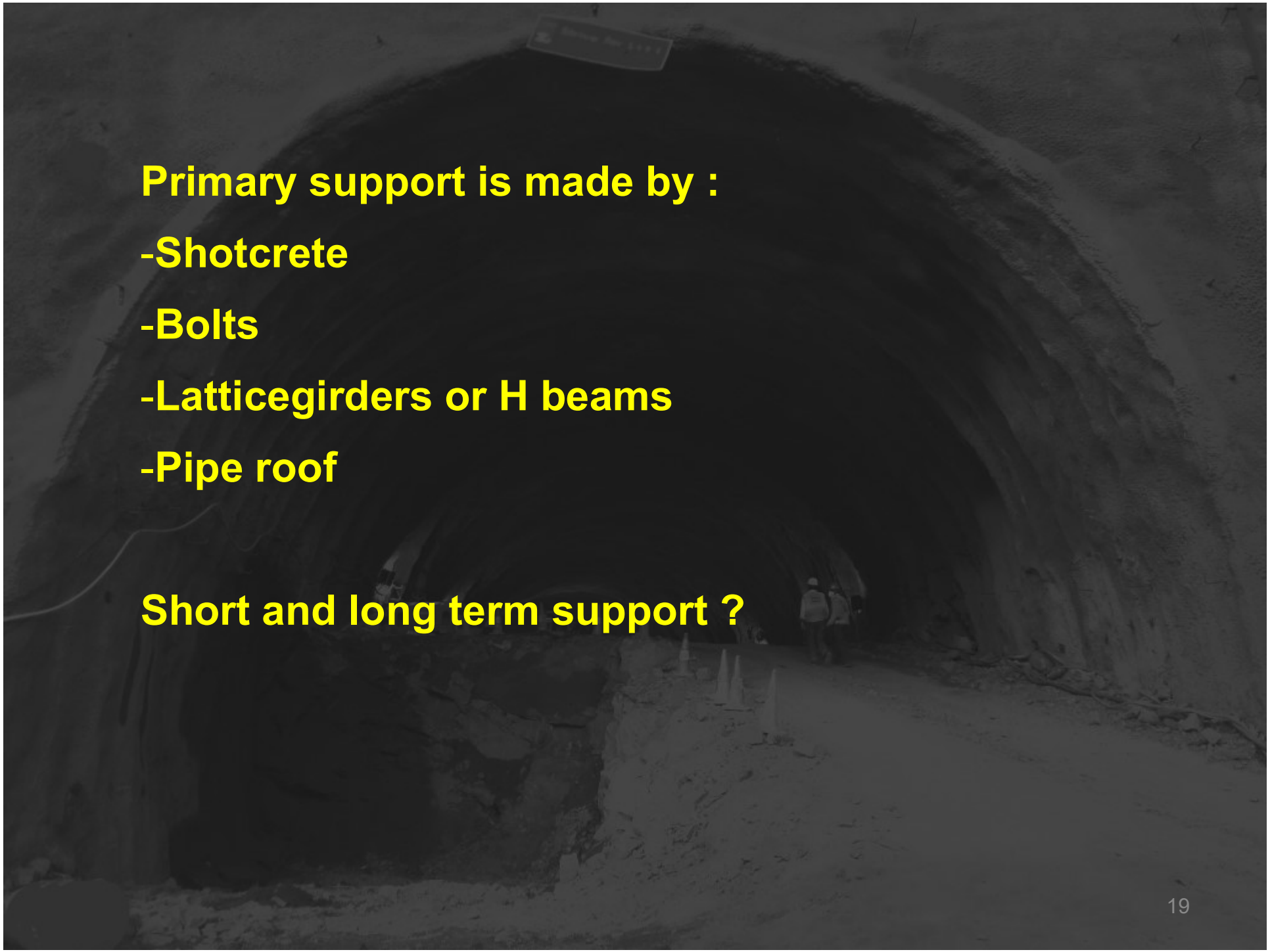
SECTION 7 - INNER LINING CONCRETE

7.1 GENERAL

This section contains specifications for the construction of the final tunnel lining, the foundation beams and the invert arch. These structures are predominantly un-reinforced, but they may also be reinforced locally, as approved by the ENGINEER.

7.1.1 Description

a. The final tunnel lining, a cast-in-situ concrete lining increases the safety factor of the tunnel lining system, provides a uniform interior surface and improves the water tightness of the tunnel lining. A smooth interior surface is required for air flow, aesthetic, lighting and maintenance reasons.



Primary support is made by :

-Shotcrete

-Bolts

-Latticegirders or H beams

-Pipe roof

Short and long term support ?

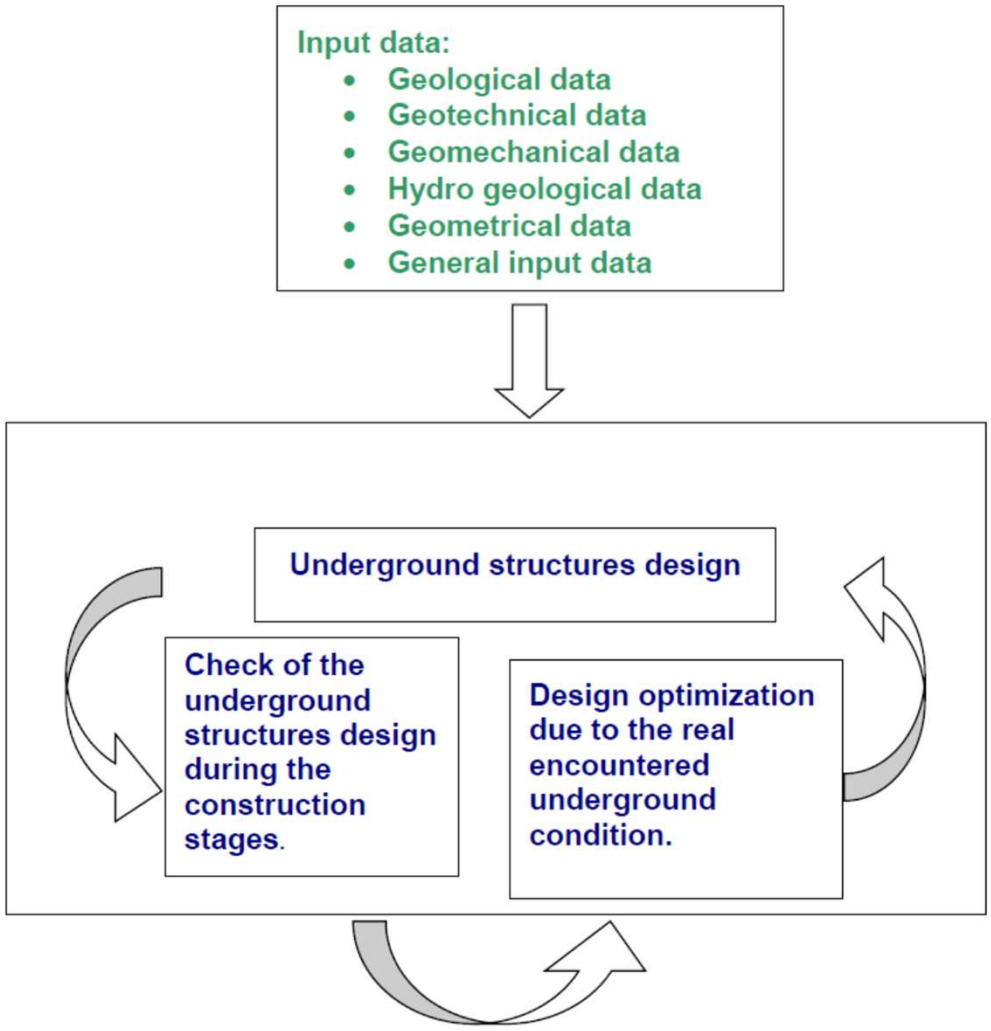


Figure 4.1 *- Observational method*

Load acting on the final lining

Empirical, **analytical** and **numerical** methods are used to estimate the ground load acting

elastic behaviour ("a/b" and "c" classes)

- **Empirical method**: the RMi system (Palmström 1996, 2000) or Q-Barton System (Grimstad & Barton, 1985).

elasto-plastic behaviour with relevant plastic zone around the tunnel (ex: deep tunnel, "d" classes):

- **Analytical method**: Convergence-Confinement Method (Carranza-Torres 2004)

- Qualification of the effect of the radial bolting according to the concept of "effective cohesion" (Grasso et al., 1989a,b).

Load acting on the final lining

•In case of **elastic behaviour**, the equations proposed by Unal (1983, 1992) is used to estimate the permanent support pressure (rock load):

$$p_V = \frac{100 - RMR}{100} \cdot \gamma \cdot B$$

$p_V = \frac{100 - RMR}{100} \cdot \gamma \cdot B$

where RMR is Rock Mass Rating and B is the horizontal span of the tunnel.

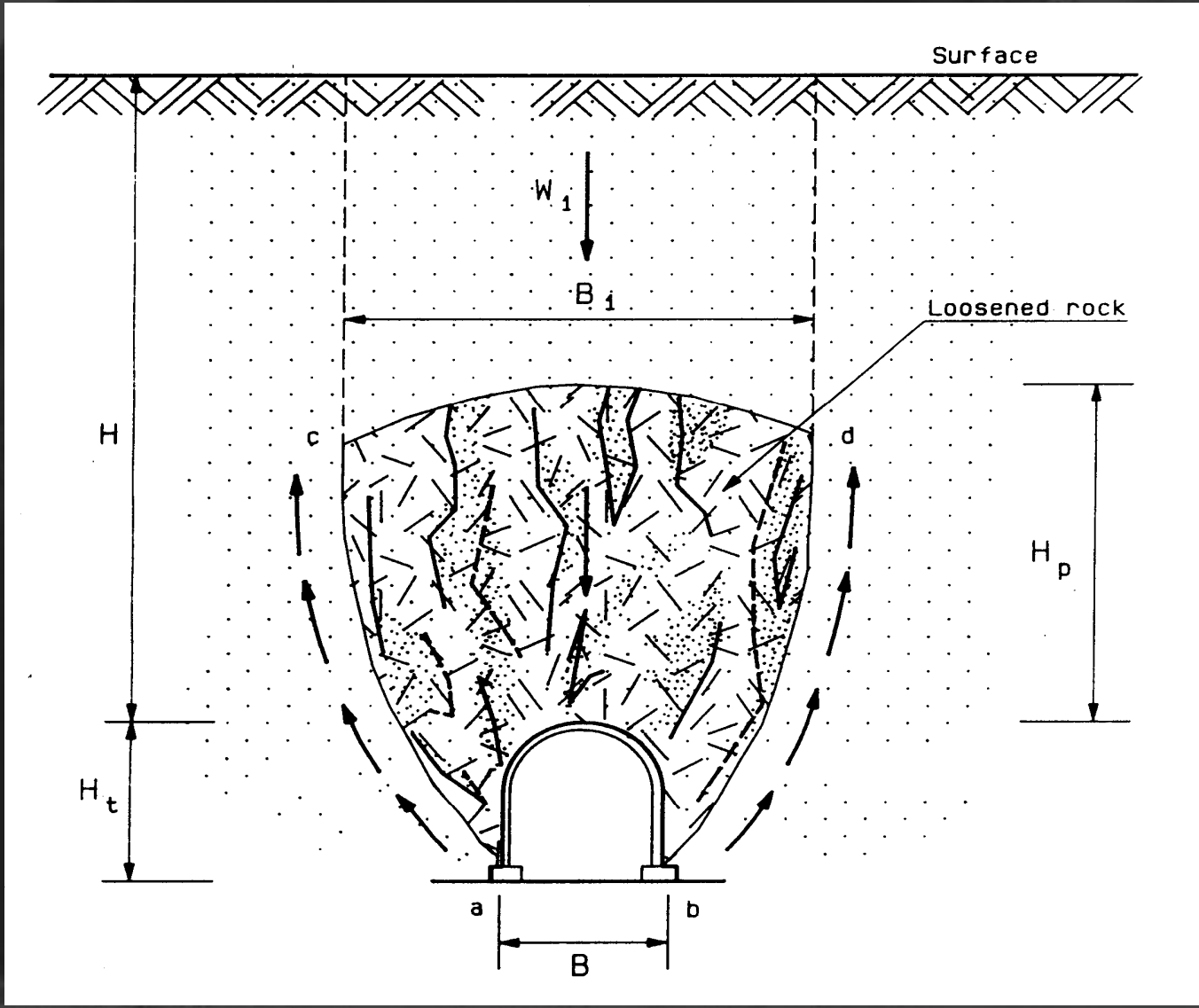
In the case of elasto-plastic behaviour:

•for deep tunnel: convergence-confinement method

•for shallow tunnel: Terzaghi's formulation

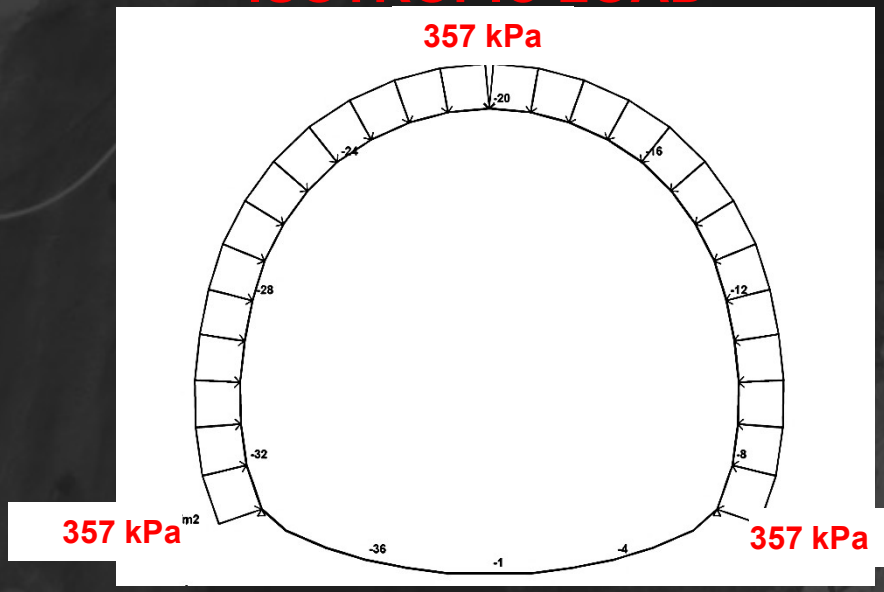
•FINAL LINING CAN BE POURED WHEN MONTLY DISPLACEMENT IS UNDER 2/4 MM (0,1 MM/DAY)

Load on shallow Tunnel Terzaghi 1946

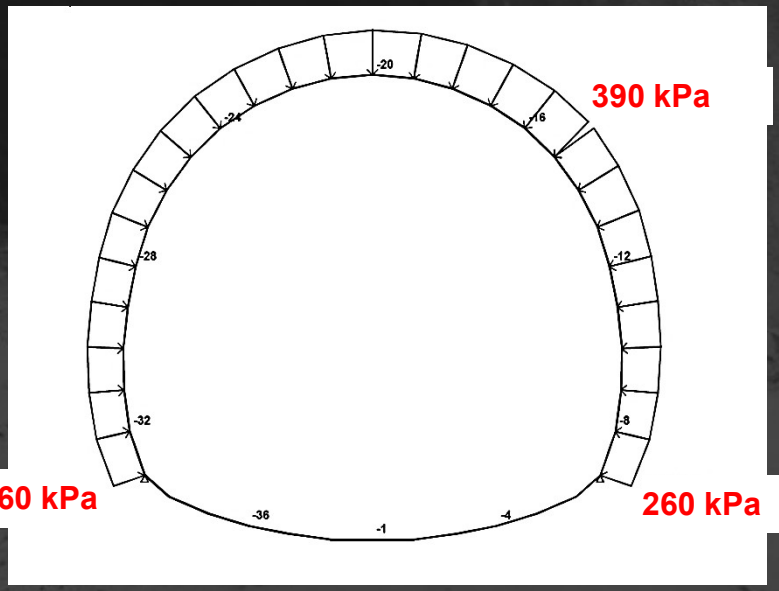


Load				
Load Condition	Type	$P_{(\theta = -135°)}$ (kPa)	K_0 (-)	$P_{(\theta = 45°)}$ (kPa)
Isotropic	$\gamma \cdot (R_{pl}-R_0)(*)$	357	1.0	357
Anisotropic	$\gamma \cdot (R_{pl}-R_0)(*)$	260	1.5	390

ISOTROPIC LOAD



ANISOTROPIC LOAD



Conclusion

Design and calculation of tunnel aren't defined by standard

Multi criteria approach is the most reliable solution

BUT NATM IS NOT THE ONLY WAY

….


E
E
BLOW
HORN
JK02P
9699
USE DIPPER
AT NIGHT
P9699


MOBILE PHONE
CAMERA AND
PHOTOGRAPHY
INSIDE TUNNEL
IS STRICTLY
PROHIBITED