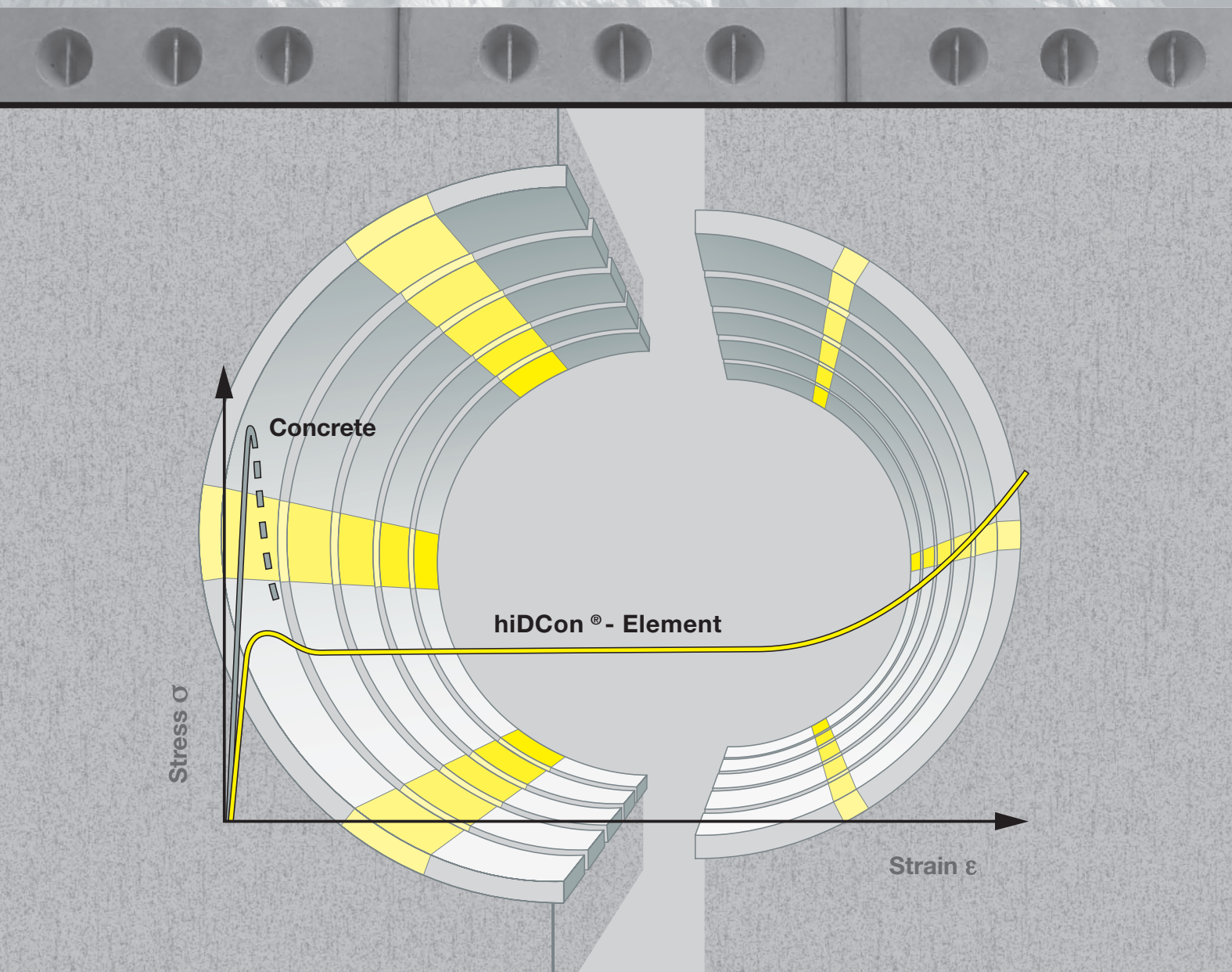
hiDCon® – Elements in Tunnelling

- Yielding sprayed concrete lining of high bearing capacity
- Modular Yielding Support in swelling rock



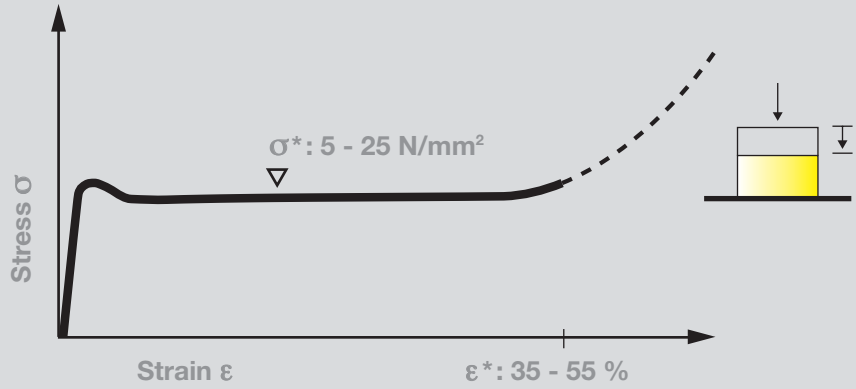
hiDCon® – High Deformable Concrete

▶ High ductility combined with high stress level

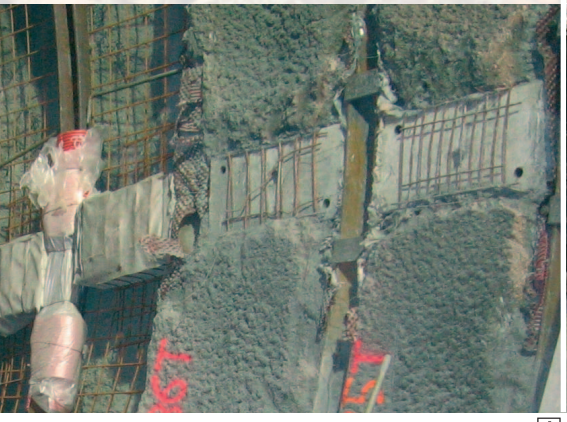
Material
High strength concrete matrix with porous aggregates

Reinforcement
Steel fibres, stirrups, rings and plates

Principle
Successive closure of the pores and prevention of lateral strain (ε*)

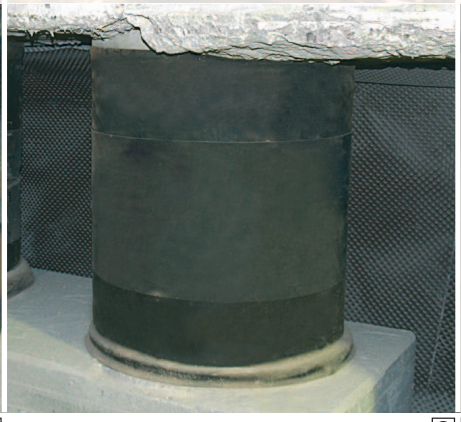


hiDCon beam elements for sprayed concrete lining



1

hiDCon foundation elements



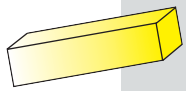
2

hiDCon anchor elements

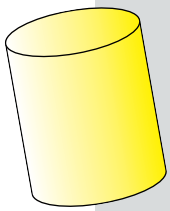
3

▶ Element types

Beams	Cylinder	Stamping cylinder
Sprayed concrete lining	Foundation elements	Anchor heads



1



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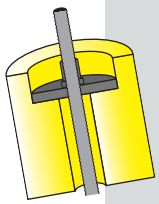
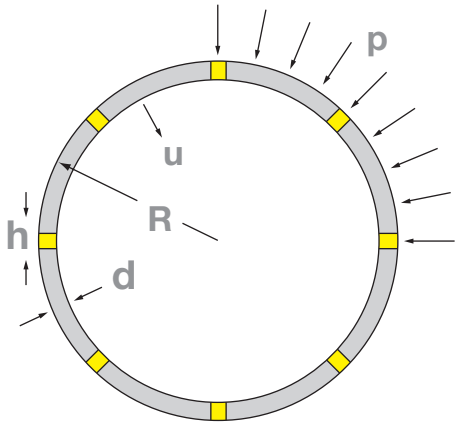


3



Yielding Sprayed Concrete Lining – Squeezing Rock



Lining resistance

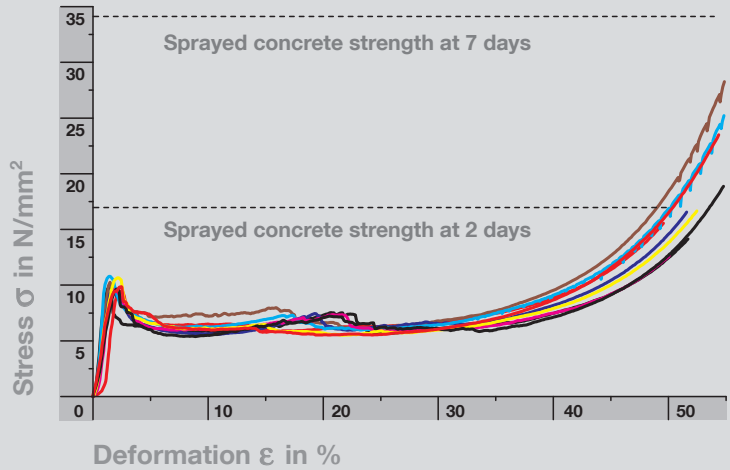
$$p \approx \sigma^* \cdot \frac{d}{R}$$

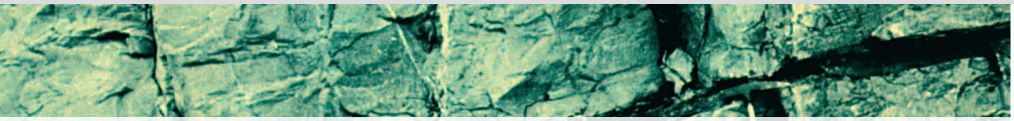
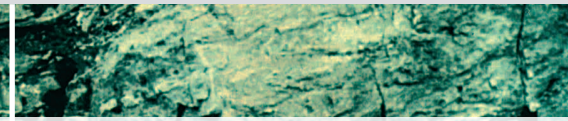
Maximum radial displacement

$$u \approx \frac{1}{4 \cdot \pi} n \cdot h$$

Assumptions:
circular profile / n: number of elements / ε^*: element deformation 50 %

Stress-strain diagram
Quality Control, Production

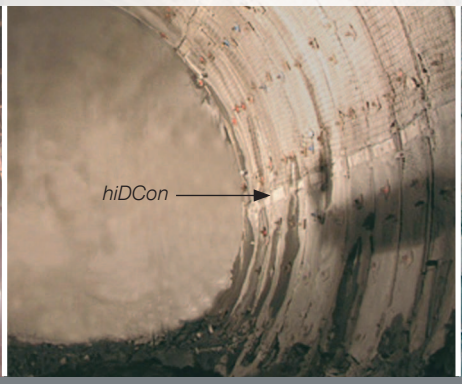


Yielding sprayed concrete lining with hiDCon elements and TH steel ribs

Prefabricated beam elements


hiDCon beam elements: Mitholz Carbonaceous Formation



▶ Lötschberg Base Tunnel

Mitholz Carbonaceous Formation / Element dimensions: 200 x 200 x 880 mm
8 Elements per cross section
$\sigma^* = 10$ N/mm² / $\varepsilon^* \approx 50$ %

Deformed element

St. Martin la Porte (Source: Razel, Bilfinger Berger, Pizarotti)

▶ Lyon-Turin-Ferroviaire Base Tunnel

Access tunnel St. Martin la Porte / Element dimensions: 200 x 400 x 750 mm
n = 9 elements per cross section
$\sigma^* = 7$ N/mm² / $\varepsilon^* \approx 50$ %



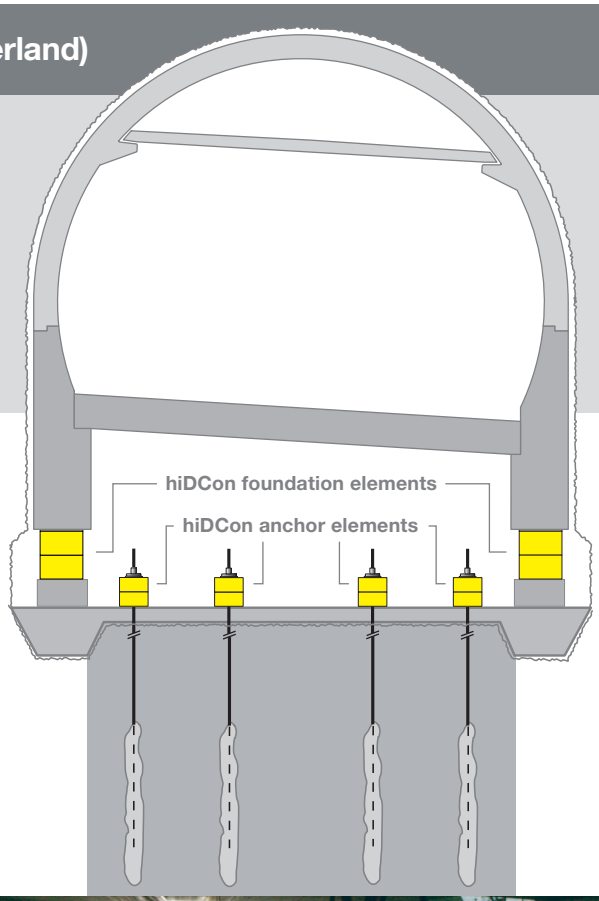
Modular Yielding Support – Heavily Swelling Rock

▶ Heave zone in Chienberg Road Tunnel (Switzerland)

Accessible yielding zone

Maintenance with no restriction on tunnel operations

Elements individually exchangeable




Heave zone Chienberg Road Tunnel, Switzerland (Source: Aegerter & Bosshardt AG)

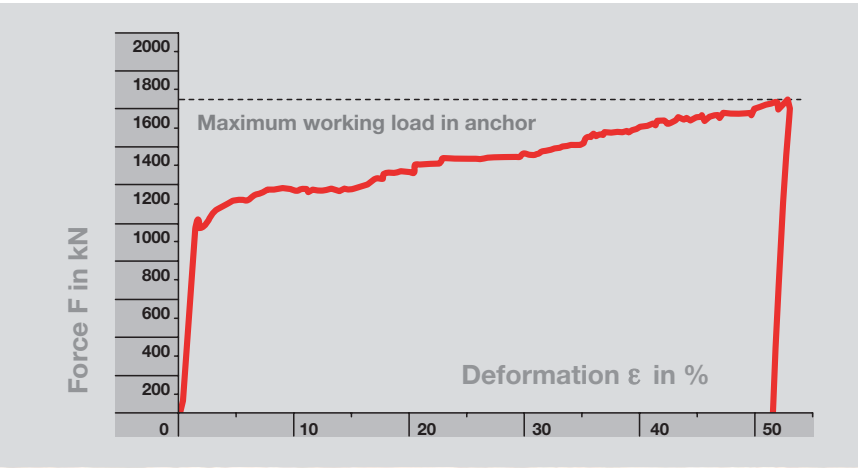
▶ Heave zone Chienberg Road Tunnel (Switzerland)

hiDCon foundation elements

TYPE *(depending on overburden)*	**TYPE 1**	**TYPE 2**	**TYPE 3**
Load under the longitudinal beams in MN/m	**3.0**	**4.0**	**5.0**
Load on each foundation element in MN	**4.5**	**6.0**	**7.5**
Yield stress σ^* for foundation elements in N/mm²	**7.1**		**11.8**
Deformation capacity ε^* in %	**40**	**35**	**30**

hiDCon foundation elements, Chienberg Road Tunnel: Height 100 cm / ø 90 cm

hiDCon anchor elements, Chienberg Road Tunnel: Height 60 cm / ø 60 cm / ø Plate 35 cm



Force-deformation diagram: Trial tests on anchor elements

hiDCon anchor elements

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hiDCon®

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