hiDCon® – Elements in Tunnelling

- Yielding sprayed concrete lining of high bearing capacity
- Modular Yielding Support in swelling rock
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 ($\varepsilon^*$)

Element types

<table>
<thead>
<tr>
<th>Beams</th>
<th>Cylinder</th>
<th>Stamping cylinder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayed concrete lining</td>
<td>Foundation elements</td>
<td>Anchor heads</td>
</tr>
</tbody>
</table>

Stress $\sigma$: 5 - 25 N/mm$^2$

Strain $\varepsilon^*$: 35 - 55 %
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 / \( \varepsilon^* \): element deformation 50 %

Stress-strain diagram
Quality Control, Production

Sprayed concrete strength at 7 days
Sprayed concrete strength at 2 days

Deformation \( \varepsilon \) in %
**Lötschberg Base Tunnel**

Mitholz Carbonaceous Formation / Element dimensions: 200 x 200 x 880 mm
8 Elements per cross section

$\sigma^* = 10 \text{ N/mm}^2 / \varepsilon^* \approx 50 \%$

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**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

$\sigma^* = 7 \text{ N/mm}^2 / \varepsilon^* \approx 50 \%$

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**hiDCon® – Elements in Tunnelling**
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

hiDCon foundation elements

hiDCon anchor elements
**hiDCon foundation elements**

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

<table>
<thead>
<tr>
<th>TYPE (depending on overburden)</th>
<th>TYPE 1</th>
<th>TYPE 2</th>
<th>TYPE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load under the longitudinal beams in MN/m</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Load on each foundation element in MN</td>
<td>4.5</td>
<td>6.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Yield stress $\sigma^*$ for foundation elements in N/mm²</td>
<td>7.1</td>
<td>11.8</td>
<td></td>
</tr>
<tr>
<td>Deformation capacity $\varepsilon^*$ in %</td>
<td>40</td>
<td>35</td>
<td>30</td>
</tr>
</tbody>
</table>

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

Force-deformation diagram: Trial tests on anchor elements

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