Concrete Linings for Tunnel built by underground Construction

Recommendations by DAUB, December 2000

Owing to the length of this article, the German text was published in Tunnel 3/2001. In this issue follows the English version.

1 Preliminary Remarks

These recommendations relate to the compilation of demands applicable to permanent concrete linings for tunnels with regard to their characteristics for use, their composition, the execution of construction and quality assurance. Regulations that are already available in Germany such as Guideline 853 [1], the ZTV-Tunnel [2, 3] and the corresponding Austrian guidelines [28] as well as findings obtained in conjunction with concrete linings are summarised and presented in relation to one another. In this way, recommendations for producing qualitatively high-grade tunnel linings will be provided, which assure serviceability over a life span of around 100 years with low maintenance costs. Static calculations are not included.

2 Function and Design of the Tunnel Lining

The final tunnel lining has to sustain a large number of influences. The main ones are:

Stemming from the ground:

- ground pressures of all kinds (dead load, relaxation pressures, creeping pressures, swelling pressures, etc.)
- landslips, earth subsidence
- earthquakes
- water pressures
- chemical actions resulting from aggressive water or aggressive subsoil components.

Resulting from construction activities:

- construction activities such as dead weight in fresh state, intermediate construction activities with part lining of the cross-section
- removal of the hydration heat, shrinking
- annular gap grouting, roof grouting
- transport activities for ready-made parts (segments, ready-made pipes)
- jacking forces, back-up loads.

Through utilisation:

- influences of temperature on the air or from sewage or the likes
- chemical attacks from gases, sewage, thawing salt and the likes
- traffic influences
- transportation of rubble or stones in the case of water pressure tunnels
- fire in the case of transport tunnels.

The permanent tunnel lining has to be dimensioned both in static and constructional terms to cope with these influences.

The lining's sealing effect can be attained either by ensuring that impermeable concrete is used or by attaching a membrane to the outside of the shell. Watertight concrete structures generally require greater expenditure on the concrete production often involving reworking (crack grouting). However, they possess the advantage that faults are normally easier to localise and seal. External membranes ensure that the concrete shell is protected against water and in turn, possible chemical influences but they are hard to redevelop.

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GERMAN COMMITTEE FOR
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The "Concrete inner Shells" working group of the German Committee for Underground Construction compiled the recommendations. The group consisted of:
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The requirements posed on the sealing systems are dealt with in detail in the Ril 853 [1] for railway tunnels and in [2] and [3] for road tunnels.

The design and production of the final concrete lining come about through the interplay of tunnel cross-section, geological and hydrological conditions, driving length and length of tunnel.

The following forms of executing permanent tunnel linings will now be examined:

- shell concrete
- shotcrete
- reinforced concrete segments
- reinforce concrete pipes.

3 Tunnel Lining made of Shell Concrete

3.1 General

Tunnel linings made of shell concrete are usually produced using a formwork car. At the point when the permanent tunnel lining is installed, the drive has already been completed or the concreting work takes place far behind the actual face: The temporary support has been installed and ground deformations have long since ceased. The inside contour of the final lining can be chosen as required. It can be adapted to the subsequent use and the static requirements. Normally, the inner shell is created in 8 to 12 m blocks, which are separated from one another by expansion joints. Usually, the individual blocks are split up into two or even more concreting sections in the event