Department of Civil, Geo and Environmental Engineering
Chair of Concrete and Masonry Structures

About the load bearing behaviour of unreinforced tunnel inner linings

Name	**Dipl.-Ing. Tobias Nevrly**
E-Mail	**tobias.nevrly@tum.de**
Supervisor	**Univ.-Prof. Dr.-Ing. Dipl.-Wirtsch.-Ing. Oliver Fischer** **Professor, Chair of Concrete and Masonry Structures**
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Tunnels excavated by conventional methods are usually fitted with double-shell tunnel linings. After the excavation and the decay of the rock deformation the inner lining is constructed. This permanent inner lining is separated from the temporary support. Inner linings of traffic tunnels in Germany are usually designed as reinforced concrete constructions. Non-reinforced inner linings are carried out only occasionally. However in Austria and Switzerland the non-reinforced construction is the standard method.

The design of unreinforced inner linings in Germany is limited to projects with favourable geological conditions. This is the case when the resulting rock pressure is moderate and the load effect on the vault of the inner lining is distributed evenly. The advantages of unreinforced constructions are the savings due to the not applied reinforcement and the economy of time as this method simplifies and speeds up the construction process. Construction and design of unreinforced inner linings are not yet regulated by German standards or guidelines.

The analysis of tunnel linings is usually performed on two-dimensional models. Finite element models and in simple cases elastically bedded beam models are suitable for this purpose. For structural design of unreinforced inner linings in particular the design models should be further detailed in order to cover both the specific structural behaviour of unreinforced concrete and the requirements of relevant standards and regulations for concrete in general.

The structural behaviour of tunnel linings depends mainly on the flexural stiffness. Taking the non-linear material behaviour of concrete into account calculative reduction of the rigidity and thus a

decreasing flexural loading of the lining is achieved. The current standards for concrete and reinforced concrete structures explicitly allow for the consideration of nonlinear methods for structural calculations. Though tension stiffening effects have to be considered with appropriate models. Therefore with regard to unreinforced constructions the post crack behaviour is of particular interest.

The aim of this work is to establish a global approach for the structural design of unreinforced inner linings in ULS and SLS on the basis of non-linear calculation methods. In the process special focus is on a consistent safety concept so that it will be applicable for conventional calculation models for tunnel structures.

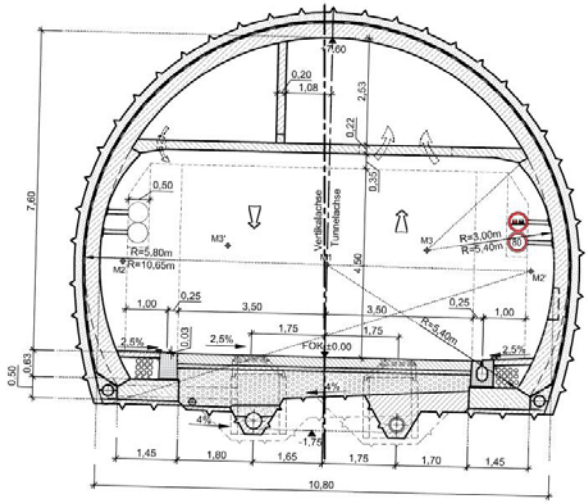

Fig. 1: Typical cross section of a street tunnel with unreinforced inner lining.

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