

Advanced Products and New Installation Techniques designed to Improve Tunnel Lining

P. Riegl. AGRU Kunststofftechnik GmbH, Austria. r@agru.at

ABSTRACT

The improvement and increase of the infrastructure in Europe required the realization of very ambitious construction projects for streets and railway tunnels during the past years. A lot of tunnels are apart of these European transversals because of the geologic and topographic conditions. The technically high-grade sealing of the tunnel means a very important feature with regard to the service life of the structure and the operating safety, especially in the railway traffic sector. The corresponding standards and guidelines have also been improved accordingly, in order to standardize the sealing itself, but also the complete tunnel with regard to the state-of-the-art. Polymer geomembranes have been proven as high-grade and long lasting sealing element. New material combinations as well as special products designed for the individual installation technologies in tunnels result in an improvement of the sealing quality, but reduce also the installation costs of such projects. Tunnel liners made of modern polyolefin materials provide a safe, cost-effective and long lasting solution of the sealing problem in tunnels based on the guaranteed service life of more than 100 years.

1. BASICS OF TUNNEL CONSTRUCTION

The following constructions of tunnels are defined in general:

1.1 Open construction

An open concrete pipe is manufactured and covered with a prefabricated concrete element after the sealing. Finally these surfaces are recultivated and grassed. This method is mainly used for smooth and geologically plain areas.

1.2 Mining

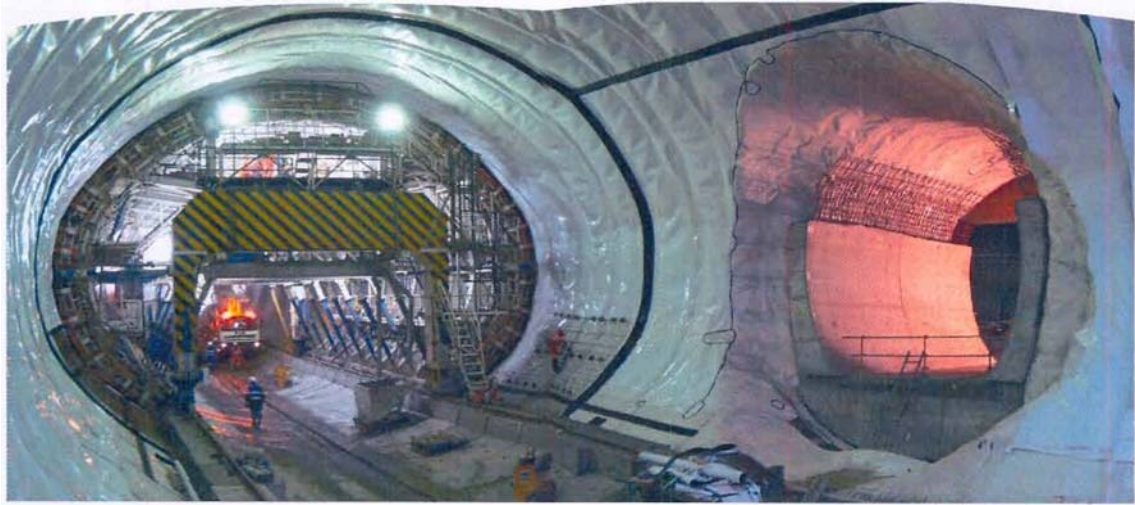
Mining is the classic tunnel construction method, where TBM's (tunnel boring machines) or blasting are used to penetrate the mountain and then the inside lining is done. Depending on the topography and geologic conditions different lining methods are available:

Segment lining: Precasted concrete segments are inserted and the liner is installed afterwards (with or without bonding).

Cast-in-situ method: Spray concrete is used to cover the rough surface, which is combined with the geomembrane and liner then. Finally the concrete segment is inserted through a formwork carriage by means of the cast-in-place concrete. Both, the umbrella sealing (only drainage of upstream water) and the pressure water sealing (fully surrounding sealing) can be set.

The polymer liner is used as standard sealing for all above described methods. Liners out of PVC were originally popular, but it has been detected that plasticizers are rinsed out because of the continuous backwater which changed the chemical mixtures and finally the quality of the liner. This was the reason, why polyolefin liners (e.g. PEVLD) established accordingly during the past years. The flexible liners offer a similar flexibility as PVC and provide also excellent long term characteristics.

Figure 1



2. Standards and guidelines for tunnel liners

National, regional and also product specific requirements were set in the past, but now regulations are valid, which standardize the tunnel liners:

- EAG-EDT; Recommendations for tunnel sealing systems (DGGT)
- Additional technical contract conditions (ZTV-ING)
- Guideline 853 "Engineering, construction and maintenance of railway tunnels"

These guidelines mainly consider that the service life of tunnel constructions can be estimated with more than > 100 years in general. The corresponding construction standards also define the installation technology, the protection of the sealing system and further technical details.

3. Service life of tunnel sealings

As already mentioned above, the problem of the change of PVC materials after long application with backwater is still obvious. The new regulations include now a fastmotion-test (based on the requirement from the "Bundesanstalt für Materialforschung und -Prüfung"), in order to be able to estimate the service life of tunnel liners. The so-called autoclave test considers the combined loads of oxidation, temperature and permeation. Based on the performance of tests with increased temperature and mathematic modes (e.g. Arrhenius equation) the service life of such materials can be projected with high probability. A currently running research project of the Federal Highway Research Institute (BAST) should enable a screening on the actually used geomembranes. This procedure has already been standardized as index test in the EN 13438.

Figure 2



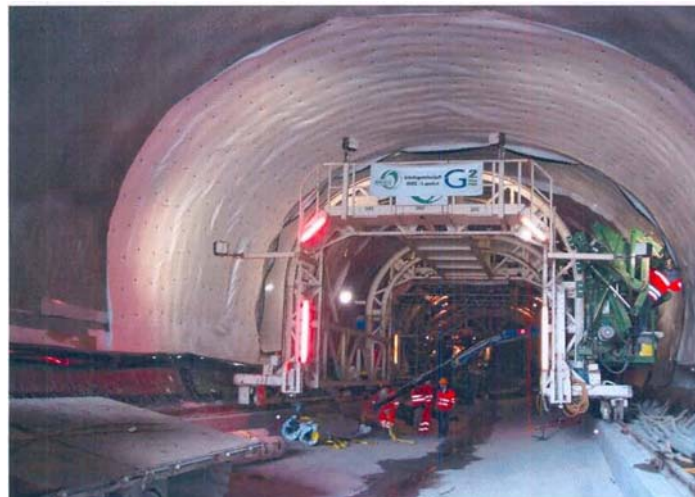
4. Tunnel sealing technologies

In addition to optimize the material quality with the focus on long service life, new developments appeared, especially with regard to the installation technology. Easy installation and cost reduction, but also quality assurance are main topics for the processability. In any case the tunnel liner is prefabricated with a geotextile, which serves as contact surface for the prepared tunnel inside surface.

Based on experiences in practice the following innovative solutions are presented:

- Bonding of liners with geotextile fabric backing on segment surfaces
- New bonding technology in mining tunnels with "Velcro" fastener
- Thermal connection of liners with geotextile on a special installation frame

Figure 3



One of the main advantages of this innovative technology is the production of liners with larger widths (currently up to 4 m) with fabric backed geotextile. On the one hand the installation efforts are reduced and on the other hand the operating safety and tightness is increased due to lower welding joints. Experiences on this project have shown that a reduction of the installation costs up to 30 % is realistic under the condition of corresponding preparation and adaptation of the construction process. A decisive factor for the effectiveness of the tunnel liner is also the same material performance of all connection components and accessories (e.g. waterstop profiles) and a high quality of the installation works on site. Quality assurance systems as usual e.g. for waste disposals should absolutely be considered for the tunnel construction.

Figure 4

