

Modern methods of tunnels waterproofing and types of waterproof materials

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DOI: <https://doi.org/10.52340/building.2024.70.21>

Abstract The work describes, considers and systematizes new engineering and technical solutions of tunnels dewatering and waterproofing measures.

Measures of the second direction (tunnel waterproofing) foresees provision of water impermeability of the tunnel support itself or rock massif surrounding the mine working that is achieved using the following methods:

- Tunnel support waterproofing through application of different insulating materials on its internal or external surface;
- Tunnel support water impermeability provision through support erection from waterproofing materials;
- Tamping of mountain massif and space behind the support.

Due to diversity of geological and hydrogeological features of mountain massifs the conditions of their intercrossing tunnels' service-maintenance and operation are different and, in some cases, differ considerably from each other.

Keywords Tunnel; Waterproofing; Materials.

Introduction

In order to secure normal operation conditions for transport tunnels it is necessary to solve many difficult problems, and one of the most important among them is a tunnel protection from underground waters, which endanger safe traffic.

Ground waters is the main problem for tunnel constructors and in general for people involved in the underground structures' construction. Underground waters substantially complicate the processes of tunnel driving and reinforcing during construction of the underground structures, and their leakage in most cases leads to insoluble problems in the underground

structures being in operation. Based on this fact, tunnel designing and construction with consideration to the measures for avoidance the underground waters impact on the structure is a high-priority task in order to provide normal operation of tunnels for securing safety traffic.

Main part

The norms and standards determining selection of methods for underground structures' water protection under specific engineering and geological conditions still have not been developed.

Different technologies of tunnels waterproofing provide different levels of moisture protection. Motorway or railway tunnels, pedestrian crossings and subways (undergrounds) must have maximal level of waterproofing according to standards, which make appearance of wet spots, condensate or moisture drops inadmissible.

At the appearance of signs of waterproofing defect, the repair works are conducted immediately.

In the hydraulic engineering tunnels and communal facilities appearance of wet spots, condensate or drops of moisture is admissible depending on the tunnel purpose and waterproofing class.

For each type of facilities, the relevant technologies are used, depending on constant dynamic and static load, availability of transport or pedestrian traffic, depreciation properties of materials, ground features and presence of ground waters.

Waterproofing technologies:

- *membrane waterproofing*. Modern methods of membrane use provide application of quality waterproofing without considerable thickening of concrete constructions. Roll membrane materials are the most sought-after

materials used for quality tunnel waterproofing.

- *waterproofing by means of profiled membrane.* There are used profiled roll PVC (polyvinylchloride) materials of high strength.

- insulation using roll membrane is taken as a basis, when operating in deep tunnels with high requirements to dryness.

- vacuum membrane technologies. There is used a trademark waterproofing package containing polymer fillers and composed of several membrane layers. It is used for waterproofing of transport tunnels operating under high loading.

- waterproofing by means of welded, bitumen, roll materials. This is one of the most effective methods for elimination of washout and leakage at relatively small depth (up to 10 meters).

- except for welded roll materials, it is possible to use closed waterproofing membranes in tunnels.

- Application of sprayed materials, "liquid rubber" and polymers in combination with membrane technology.

- spraying of special composition to inner and outer sides of structures, which increases waterproofing properties, plugs up seams (joints) and structural junction points.

- the given method provides maximal insulation of surfaces and makes it possible to avoid material damage (breakdown) and increased porosity of concrete structures due to effect of ground waters and ground. Spraying is performed by special devices under high pressure.

The easiest and most labor-consuming method is pumping of sand-cement mortar into the structure in order to eliminate contact with soil and ground waters. Modern concrete additives secure sufficient plasticity and flow ability of a mass.

The mixture grouts into holes and thereby provides waterproofing. Installation of steel shields or roll waterproofing layer is added to this method. Application of this technology is reasonable when conducting the works at great depth or if the danger of ground waters breakthrough exists.

If there is a hazard of soil sliding, it is necessary to strengthen waterproofing with steel or cast-iron structures, waterproofing with extra-strong concrete and installation of additional concrete structures. There are formed high-strength concrete structures with consolidating blocks.

It is possible to use different complexes; water drainages are installed, and holes are plugged with concrete pads and shields. In combination with modern materials and membranes it makes possible provision of reliable packet waterproofing with minimum resources consumption.

Shield methods of waterproofing are used for tunnels with a depth up to 10 meters and more.

Tunnel waterproofing repair

Experts conduct studies and determine the capability of repair works related to waterproofing of tunnels, seams and cracks, and insulation of ground waters and aggressive grounds. Concrete structure studies are carried out according to standards.

State-of-the-art methodologies of waterproofing if timely addressed make it possible to enhance structural strength and extend the tunnels' operational life.

Tunnels must be obligatorily inspected every year, with conducting of studies related to availability of cracks, microcracks, material wear, waterproofing defect, and repair works must be carried-out timely.

High-quality waterproofing may improve tunnel performance properties and extend its operational life up to 10 years.

Basic techniques for waterproofing repair are as follows:

1. Spraying and welding on of bitumen and polymer materials according to standards.
2. Installation of new waterproofing using profiled roll membranes.
3. Injection method;
4. Penetrant method;
5. Pumping of cement and cement-polymeric, polymeric mortars.

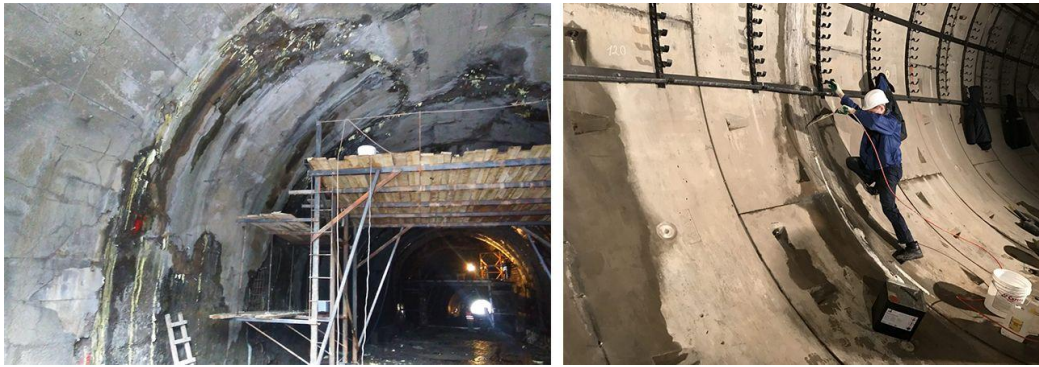


Fig.1.Injection technologies with the use of concrete and polymeric materials

At appearance of insignificant cracks, it is possible to apply injection technologies, when polymeric waterproofing materials are directly grouted into structure by means of properly disposed boreholes.

As a result, polymeric membranes are formed inside the structure, which fill cavities, microcracks, and structural gaps. These operations require special equipment and specific polymeric, epoxydic, acrylate and polyurethane compositions.

- in some cases, injection technologies and application of inner membranes with polymeric fillers makes it possible to insulate numerous minor cracks and attain complete waterproofing of the structure;

- when cracks extend, polymers fill the volume and thereby provide reliable waterproofing under complex conditions – in case of shaking and increased depreciation loads on tunnels;

- special polymeric mixtures are activated in touch with water only;

- in case of leakage and water appearance hazard, the pumped injection polymers form protective film membranes, which are absolutely impermeable (waterproof) for moisture;

- application of modern materials and engineering technologies makes it possible to reach high quality of waterproofing within a shortest time possible.

Penetrating repair waterproof mixtures

Penetrating waterproofing method is based on the use of special finely dispersed reagents, which penetrate into material pores and minute cracks and thereby form waterproof layer on contact with water and as a consequence promote concrete quality enhancement – increase frost resistance, strength, resistance to depreciation load, and attain more plasticity to material.



Fig.2.Tunnel waterproofing with polymeric membrane

Spraying of insulating materials or membrane waterproof package are used in case of a great number of communication connections and availability of increased depreciation loads.

Modern synthetic coatings during reconstruction and construction of tunnel facilities

Based on the critical review and analysis of synthetic waterproofing materials there has been considered reasonable to study main characteristics of the following coatings:

- epoxy resins;
- Isoplast;
- Monoflex.

Among still less explored characteristics of the mentioned coatings are: water impermeability, adhesion degree, deformability, hardening terms, frost resistance.

Waterproof tests have been carried out using the special device, in which water pressure on the coating was created by means of compressed air.

Samples, which withstood 5 atm pressure, have been tested to frost resistance, for this purpose specimens have been placed in water for one day at +15°C temperature, and afterwards have been hold for 24 hours in the refrigeration chamber, where -25°C temperature was kept. If surface destruction didn't observe after 25 cycles of freezing and melting, it is considered that a surface withstood the tests. Afterwards the samples have been retested to water impermeability, at that water pressure was getting increased up to 15 atm.

The degree of surveyed material bonding with concrete is established through small size concrete tiles adhesion. Load has been applied on bonding surface and the load value has been recorded at the press.

The results of water impermeability, frost resistance and concrete bonding degree tests have showed that coatings prepared on the basis of epoxy resins, polyurethane varnish and Monoflex are distinguished by

the best performance among the coatings. Study of deformability and hardening terms, as well as full-scale test has been conducted for coating based on epoxy resin, which had the best waterproofing performance.

Use of Monoflex for tunnel waterproofing

Waterproofing guniting mortar "Monoflex" is a mixture of non-contracting portlandcement or expanding portlandcement "Monoflex" with construction sand taken in 1:1 proportion, to which water is added.

Tunnel section, where waterproofing works are in progress, must be provided with forced ventilation, water- and 30-volt electric supply.

Use of Isoplast for tunnel waterproofing

Waterproofing material "Isoplast P" is a bitumen-polymeric fusible roll material.

"Isoplast P" is prepared on the polyester base with double-sided application of a binder. This binder consists of bitumen, polymeric additive and filler.

This material can be used under any climate conditions.

Conclusion

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