For a tubbing made of concrete for lining a tunnel, such as a traffic tunnel, the tubbing can have a convexly curved outer surface and a concavely curved inner surface opposite the outer surface. The tubbing can be provided with a thermoplastic sealing layer on the outer surface of the concrete tubbing. The thermoplastic sealing layer can also be arranged on all sides of the outside surfaces facing the outer surface. The tubbing can, for example, have a recess that extends around the outer surface in a frame shape, and the sealing layer engages in the recess.
TUBBING HAVING A THERMOPLASTIC SEALING LAYER

RELATED APPLICATION

[0001] This application claims priority as a continuation application under 35 U.S.C. §120 to PCT/EP2012/067725, which was filed as an International Application on Sep. 11, 2012 designating the U.S., and which claims priority to European Application 11180966.1 filed in Europe on Sep. 12, 2011. The entire contents of these applications are hereby incorporated by reference in their entireties.

FIELD

[0002] The present disclosure relates to a concrete tubing for lining a tunnel, such as a traffic tunnel.

BACKGROUND INFORMATION

[0003] Although applicable to any desired area of construction, the present disclosure and problems that can solve will be explained in greater detail in the following with reference to a traffic tunnel.

[0004] In the field of mechanical tunnel construction using the shield drive technique, prefabricated steel-reinforced concrete parts have been used for the inner shell. These prefabricated concrete parts, called “tubnings” in technical jargon, are prefabricated in prefabrication plants, stored for a period of time until they reach the specified concrete strength, and then placed in the tunnel tubes for installation as needed. There, they are picked up by a tubing setting device, the so-called “erector,” and assembled into a tubing ring under the protection of the shield of the tunnel drilling machine. After the tunnel drilling machine has advanced while supporting itself with hydraulic jacks against the most recently installed tubnings, a new tubing ring is fitted in under protection of the shield. In this manner the machine works its way through the soil “tubbing ring by tubbing ring,” wherein the annular gap remaining between the tunnel lining (tubbing ring) and the soil is continuously filled with mortar, for example to prevent subsidence.

[0005] Not only standard traffic tunnels, but under specific geological conditions, also so-called supply or disposal tunnels for household, commercial or industrial buildings, which especially in the form of large-diameter collecting or distributing mains serve for central transport of wastewater or fresh water or as cable tunnels for accommodating high-voltage lines, are produced by the tubbing extension method using the above-described segmented construction technique. However, in all these areas of application, whether to maintain perfectly hygienic drinking water quality or to prevent functional breakdowns due to the penetration of soil moisture to the electric conductors, great demands are made on the impermeability and durability of the tubbing lining of the tunnel.

[0006] For this reason, up to now a separate, second working step in tunnel construction has been used for final sealing of the concavely curved outer surfaces of the tubnings, facing the exterior tunnel, and/or the production of an additional, second tubbing ring.

SUMMARY

[0007] A tubing for lining a tunnel is disclosed, comprising: a concrete tubing having a convexly curved outer surface and a concavely curved inner surface opposite the outer surface; and a thermoplastic sealing layer provided on the convexly curved outer surface of the concrete tubing, the thermoplastic sealing layer also being arranged on other outside surfaces of the concrete tubing adjacent the convexly curved outer surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In the following, the invention will be explained in greater detail based on the drawings, which illustrate aspects of exemplary embodiments, wherein:

[0009] FIG. 1 shows a lateral cross section through an exemplary tubing;

[0010] FIG. 2 shows an additional lateral cross section through an exemplary tubing;

[0011] FIG. 3 shows parts of an additional lateral cross section through an exemplary tubing with an injection opening;

[0012] FIG. 4 shows parts of a lateral cross section through two exemplary tubnings connected on the blind side; and

[0013] FIG. 5 shows parts of a lateral view of an exemplary tubing without a thermoplastic sealing layer.

[0014] Only elements essential for intuitive understanding of the exemplary embodiments illustrated are shown.

DETAILED DESCRIPTION

[0015] The present disclosure is directed to, for example, improving tubnings by increasing their impermeability to moisture located on the outside of the tubing ring and their durability, especially against corrosive groundwater.

[0016] A tubing is disclosed which is made of concrete for lining a tunnel, such as a traffic tunnel, wherein the tubing has a convexly curved outer surface and a concavely curved inner surface opposite the outer surface and wherein the tubing is provided with a thermoplastic sealing layer on its outer surface. Furthermore, the thermoplastic sealing layer is arranged on all of the outside surfaces that face the outer surface.

[0017] The tubing can have a segmented ring structure with a concavely curved inner surface, which in the installed state faces the interior of the tunnel, and an opposite, convexly curved outer surface, which in the installed state faces the surrounding soil. These two surfaces are attached on the sides over four additional surfaces, two longitudinal side surfaces, which in the installed state abut against the corresponding longitudinal side surfaces of the adjacent tubnings of the same tubing ring, and two front faces, which in the installed state abut against the corresponding face surfaces of the adjacent tubnings of an adjacent tubing ring.

[0018] The tubing has, for example, a recess that extends around the outer surface in a frame shape, and the sealing layer engages in the recess. This sealing layer can fill the recess at least partially, and especially completely.

[0019] This can be advantageous in that the contact surface is enlarged at the abutment points between two tubnings, and thus a greater sealing effect is achieved.

[0020] As a result of the tubnings in accordance with exemplary embodiments, no separate second work step is necessary for final sealing of the concavely curved outer surfaces of the tubnings facing the exterior of the tunnel. A possible second tubing ring also is not needed. Furthermore, tubnings with low wall thicknesses may be used and manufactured, since they are far superior to conventional tubnings in terms of impermeability to water and durability against corrosive groundwater. Both of these facts result in lower space require-
ments of the tunnel wall and thus to a gain in interior space and reduction of the required amount of construction material. In addition, tubbing disclosed herein can permit the use of alternative, less watertight and less corrosion-resistant concrete types. Furthermore, tubbing rings made from tubbings as disclosed herein can have excellent seepage resistance and impermeability.

[0021] FIG. 1 shows a lateral cross section through a tubbing in accordance with an exemplary embodiment disclosed herein.

[0022] The tubbing 1 is provided with a thermoplastic sealing layer 4 on its convexly curved outer surface 2. The thermoplastic sealing layer is further arranged on all sides of the outside surfaces facing the outer surface (longitudinal side surfaces 7 and front side surfaces 8); the two longitudinal side surfaces 7 are shown in FIG. 1. In this manner on one hand excellent adhesion of the thermoplastic sealing layer 4 to the tubbing and high seepage resistance are guaranteed. Furthermore, through enlargement of the contact surface of the thermoplastic sealing layers that touch one another, compared with for example a sealing layer which lacks an arrangement on all sides of the outside surface facing the outer surface, a greater sealing effect is achieved at abutment points between two tubbings.

[0023] The thermoplastic sealing layer 4 can be connected over its full surface to the outer surface 2, for example, cemented, leading to improvement in the seepage resistance.

[0024] To be optimally suited as a thermoplastic sealing layer 4, it should be as watertight as possible and should not break down or be mechanically damaged even under prolonged exposure to water or moisture. Especially suitable exemplary thermoplastic sealing layers are such materials as are already used in the prior art for waterproofing in surface and underground construction.

[0025] It can be advantageous if the thermoplastic sealing layer is made of a material with a softening point above 110° C., for example, between 140° C. and 170° C. The thermoplastic sealing layer should advantageously have at least a slight degree of elasticity in order, for example, to compensate for stresses caused by temperature-related differences in extension between the thermoplastic sealing layer and tubbing, without the thermoplastic sealing layer being damaged or tearing and the sealing function of this sealing layer being impaired.

[0026] The thermoplastic sealing layer can contain thermoplastic polyolefins and/or polyvinyl chloride (PVC).

[0027] The thermoplastic sealing layer can, for example, include material selected from the group comprising (e.g., consisting of) high-density polyethylene (HDPE), medium-density polyethylene (MDPE), low-density polyethylene (LDPE), polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), polyamide (PA), ethylene-vinyl acetate (EVA), chlorosulfonated polyethylene and thermoplastic polyolefins (TPO).

[0028] The thermoplastic sealing layer can, for example, comprise (e.g., consists of) 50% or more of weight, especially preferably more than 80% by weight of the aforementioned materials.

[0029] The thermoplastic sealing layer can, for example, have a layer thickness in the millimeter range, for example between 0.2 and 15 mm, preferably between 1 and 2 mm.

[0030] The thermoplastic sealing layer 4 on the side facing the convexly curved outer surface 2 can be surface treated. Surface treatments such as corona treatment, fluorination and flame treatment of the thermoplastic sealing layer can improve the adhesion of the thermoplastic sealing layer on the tubbing. In place of surface treatment, a nonwoven material can also be applied at the aforementioned location to improve the adhesive strength.

[0031] The thermoplastic sealing layer 4 can have a water-swellable profile 6, which is arranged on the side facing away from the outside surfaces (7, 8), as is apparent in FIG. 2, FIG. 3 and FIG. 4.

[0032] The water-swellable profile 6 contains water-swellable materials. The term “water-swellable materials” is defined in the present document as materials whose volume increases several fold upon contact with water, for example to 200-1000% of their original volume. In addition to the volume increase, certain water-swellable materials can also react chemically with water. Examples of such water-swellable materials include polyurethane-based, especially silane-modified polymers, which cure with moisture to form an elastic product. Additional examples of such swellable materials are bentonite-butyl rubbers or the acrylate-based polymers summarized under the name of “superabsorbents” (Superabsorbent Polymers, SAP), such as copolymers of acrylic acid and sodium acrylate, for example from BASF SE, Germany.

[0033] This can be advantageous in that at the abutment sites between two tubbings the contact area between the thermoplastic sealing layers that touch one another is enlarged and a greater sealing effect is achieved thereby.

[0034] It can be particularly advantageous if, for example, the water-swellable profile 6 contains additional materials that are described in the preceding as preferred for the thermoplastic sealing layer 4. This can be advantageous in that the water-swellable profile 6 can bond well with the thermoplastic sealing layer 4, for example by welding, cementing and/or vulcanization.

[0035] The arrangement of the water-swellable profile 6 shown by way of example in FIG. 2 is advantageous in that as a result thereof, the water-swellable profile 6 comes to lie at the abutment sites between two tubbings, as is apparent for example in FIG. 4. Contact with water, for example from the soil, causes swelling of the water-swellable profile 6, and thus leads to swelling pressure in the area of the abutment sites between two tubbings and consequently an increase in the sealing effect.

[0036] The tubbing advantageously can have a recess 5 extending around the outer surface 2 in a frame shape, and the sealing layer 4 engages with this recess, as is seen for example in FIG. 2. FIG. 5 shows a lateral view of the recess 5 of the tubbing extending around the outer surface 2 in a frame shape without the thermoplastic sealing layer.

[0037] The sealing layer can fill the recess at least partially, or especially completely.

[0038] The recess is arranged in the contact area of the outer surface 2 with the outside surfaces 7 and 8. This has the exemplary advantage, among others, that the tubbing is less liable to be damaged during manufacturing, transport or installation, since mechanical peak loads occur particularly at the side edges.

[0039] Furthermore, as a result a high precision of fit can be achieved at the abutment sites between two tubbings, which results in an increased sealing effect.
In addition, at the abutment sites between two tubbings, the contact area of the thermoplastic sealing layers that touch one another can be enlarged and consequently a higher sealing effect is achieved.

The tubing advantageously can have a sealing groove 9 that extends around the outside surfaces (7, 8), in which a sealing body 10 is arranged, as is apparent in FIG. 2. The sealing groove is formed in the tubing by molding and a sealing body is present therein, for example pressed in. The sealing body 10 is for example a hollow body. Particularly suitable materials for this sealing body are materials that are known as sealing materials for sealing rings and/or the materials described as swellable materials in the preceding. For example, this sealing body 10 comprises (e.g., consists of) ethylene-propylene-diene rubber (EPDM).

This can be advantageous in that in this way an additional barrier against penetrating water is erected at the abutment sites between two tubbings and thus a greater sealing effect is achieved.

The tubing can have a sealing coating 11 between the outer surface 2 and the thermoplastic sealing layer 4, as shown in FIG. 2 and FIG. 3. This sealing coating can be selected from the group comprising (e.g., consisting of) methacrylic acid, polyester resin, epoxy resin, polyurethane and polyurea. A particularly preferred sealing coating is epoxy resin.

Such a sealing coating 11 can be advantageous in that it protects the tubing from penetration of moisture. In addition, this strengthens the sealing effect of the tubing. Furthermore, during production of the tubing, extensive moisture loss during curing of the green body can be prevented. This sealing coating 11 is for example applied to the tubing by spraying or spreading on.

For the sealing body 10, all materials may be considered which are suitable for reducing or preventing the passage of liquids, especially water.

The sealing body can comprise (e.g., consists of) a thermoplastic or a thermoplastic elastomer. Thermoplastic elastomers can have an advantage that the sealing body thus produced has good elasticity in the face of horizontal and vertical displacements, especially displacements caused by mechanical stresses in the structure. Good elasticity of the sealing body prevents tearing or separation of the sealing body and thus failure of the seal.

Suitable thermoplastic elastomers are defined in this document as plastics which combine the mechanical properties of vulcanized elastomers with the workability of thermoplastics. For example, such thermoplastic elastomers are block copolymers with hard and soft segments or so-called polymer alloys with corresponding thermoplastic and elastomeric components.

Additional advantageous materials for sealing bodies are materials selected from the group comprising (e.g., consisting of) acrylate compounds, polyurethane polymers, silane-terminated polymers and polyolefins.

The tubing advantageously can have an adhesive layer 12 between the outer surface 2 and the thermoplastic sealing layer 4.

Possible adhesive layers 12 are all materials that are suitable for ensuring a strong bond of the thermoplastic sealing layer 4 on the tubing.

The adhesive layer can comprise (e.g., consists of) a structural adhesive, such as a reactive adhesive based on phenolic resin, epoxy resin, polyimide or polyurethane, a pressure-sensitive adhesive and/or a hot-melt adhesive. This ensures a good bond and good adhesion between the outer surface 2 and the thermoplastic sealing layer 4 and thus reduces the separation of the thermoplastic sealing layer and thus failure of the seal.

Structural adhesives, pressure-sensitive adhesives and hot-melt adhesives are generally known to the person skilled in the art and are described in CD Römpp Chemie Lexikon [Encyclopedia of Chemistry], Version 1.0, Georg Thieme Verlag, Stuttgart.

The adhesive layer 12 can be the sealing coating 11 (i.e., the sealing coating 11), which in addition to its waterproofing function, also produces a bond between the thermoplastic sealing layer 4 and the outer surface 2 of the tubing.

As shown in FIG. 3, the tubing can have injection openings 13. These penetrate the tubing from the convexly curved outer surface to the concavely curved inner surface; they also penetrate the thermoplastic sealing layer 4. These allow injection of injection material after the tubing rings are joined together, thus in the installed state, from the inside of the tubing rings into the area between the surrounding soil and the convexly curved outer surface. For example, after or during the withdrawal of the protective shield, the annular gap remaining between the tunnel construction (tubbing ring) and the surrounding soil is continuously filled with mortar. To further increase the water-tightness of the tubbing ring, additional injection material can be forced through the injection openings 13 into the area between the tubbing ring, (e.g., the thermoplastic sealing layers of the tubbings forming the tubing ring), and the mortar-filled annular gap. In this way the injection openings 13 and the intermediate area are closed fluid-tight.

It can be advantageous if the injection material, after introduction into the intermediate area, is hardened and expanded and/or is water-swellable in the hardened state.

The injection material can be advantageously selected from the list comprising (e.g., consisting of) polyurethane, epoxy resin, acrylics and mineral binders.

It can also be advantageous if the injection material contains water-swellable materials.

For example, the injection material includes products of the Sika® injection series, such as Sika® Injection-201 CE, Sika® Injection-201 RC, Sika® Injection-203, Sika® Injection-205, Sika® Injection-304, Sika® Injection-305, Sika® Injection-306, or the Sika® InjetoCem series, such as Sika® InjetoCem-190 or Sikadur®-52 Injection.

For application of the injection material, this can be injected, using a one- or two-component pump, through filling and injection tubing (injection packers) under pressure through the injection openings 13 into the intermediate area.

The tubing can be advantageously suitable for tunnel structures with a diameter of, for example, 0.5-50 m.

An additional aspect of the present disclosure relates to a structure, such as a tunnel, containing a tubing as disclosed herein.

It will therefore be appreciated by those skilled in the art that the present invention can be embodied in other specific forms without departing from the spirit or essential
characteristics thereof. The presently disclosed embodiments are therefore considered in all respects to be illustrative and not restricted. The scope of the invention is indicated by the appended claims rather than the foregoing description and all changes that come within the meaning and range and equivalence thereof are intended to be embraced therein.

LIST OF SYMBOLS

1 Tubbing
2 Convexly curved outer surface
3 Concavely curved inner surface
4 Thermoplastic sealing layer
5 Recess extending around the outer surface in a frame shape
6 Water-swellable profile
7 Longitudinal side surface
8 Front side surface
9 Sealing groove extending around the outside surfaces in a frame shape
10 Sealing body
11 Sealing coating
12 Adhesive layer
13 Injection opening

1. Tubbing for lining a tunnel, comprising:
a concrete tubbing having a convexly curved outer surface and a concavely curved inner surface opposite the outer surface; and a thermoplastic sealing layer provided on the convexly curved outer surface of the concrete tubbing, the thermoplastic sealing layer also being arranged on other outside surfaces of the concrete tubbing adjacent the convexly curved outer surface.

2. Tubbing according to claim 1, comprising:
a recess that extends around the convexly curved outer surface in a frame shape, the thermoplastic sealing layer engaging in the recess.

3. Tubbing according to claim 1, wherein the thermoplastic sealing layer comprises:
a water-swellable profile arranged on a side other than the outside surfaces.

4. Tubbing according to claim 1, comprising:
a sealing groove that extends around the outside surfaces, in which a sealing body is arranged.

5. Tubbing according to claim 1, wherein the thermoplastic sealing layer contains thermoplastic polyolefins and/or polyvinyl chloride (PVC).

6. Tubbing according to claim 1, wherein the thermoplastic sealing layer comprises:
material selected from the group consisting of: high-density polyethylene (HDPE), medium-density polyethylene (MDPE), low-density polyethylene (LDPE), ethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), polyamide (PA), ethylene-vinyl acetate (EVA), chlorosulfonated polyethylene and thermoplastic polyolefins (TPO).

7. Tubbing according to claim 1, comprising:
a sealing coating between the convexly curved outer surface and the thermoplastic sealing layer, wherein this sealing coating is selected from the group consisting of: methacrylate resin, polyester resin, epoxy resin, polyurethane and polyurea.

8. Tubbing according to claim 1, wherein the sealing coating is also arranged at least partially on the outside surfaces.

9. Tubbing according to claim 1, comprising:
an adhesive layer between the convexly curved outer surface and the thermoplastic sealing layer.

10. A tunnel structure containing a tubbing according to claim 1.

11. Tubbing according to claim 2, wherein the thermoplastic sealing layer comprises:
a water-swellable profile arranged on a side other than the outside surfaces.

12. Tubbing according to claim 11, comprising:
a sealing groove that extends around the outside surfaces, in which a sealing body is arranged.

13. Tubbing according to claim 12, wherein the thermoplastic sealing layer contains thermoplastic polyolefins and/or polyvinyl chloride (PVC).

14. Tubbing according to claim 13, wherein the thermoplastic sealing layer comprises:
material selected from the group consisting of: high-density polyethylene (HDPE), medium-density polyethylene (MDPE), low-density polyethylene (LDPE), polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), polyamide (PA), ethylene-vinyl acetate (EVA), chlorosulfonated polyethylene and thermoplastic polyolefins (TPO).

15. Tubbing according to claim 14, comprising:
a sealing coating between the convexly curved outer surface and the thermoplastic sealing layer, wherein this sealing coating is selected from the group consisting of: methacrylate resin, polyester resin, epoxy resin, polyurethane and polyurea.

16. Tubbing according to claim 15, wherein the sealing coating is also arranged at least partially on the outside surfaces.

17. Tubbing according to claim 16, comprising:
an adhesive layer between the convexly curved outer surface and the thermoplastic sealing layer.

18. A tunnel structure containing a tubbing according to claim 17.