

【SPECIFICATION】

【Title of the Invention】

HIGHLY WATER-PRESSURE-RESISTANT WATER STOP GASKET FOR
USE IN TUNNEL CONSTRUCTED BY TBM

5 【Technical Field】

The present invention relates to a water stop gasket that is capable of preventing water from permeating a tunnel from the outside through a wall of the tunnel.

【Background Art】

10 Construction methods for a long-span tunnel are broadly classified into a blasting construction method and a mechanical construction method. A representative blasting construction method is an NATM (New Austrian Tunneling Method) construction method, and a
15 representative mechanical construction method is a TBM (Tunnel Boring Machine) construction method.

The TBM construction method is a construction method in which excavation is first performed using a TBM and subsequently a wall of the tunnel is formed by assembling
20 prefabricated concrete segments (hereinafter briefly referred to as "segments").

Because such a TBM construction method is adequate for tunnel construction in soft ground, which contains lots of moisture, it is primarily used for undersea tunnel
25 construction.

Further, because a TBM, which is expensive equipment, has recently and significantly been decreased in price and the TBM construction method does not require blasting work, which enables the construction noise level to be relatively low, the TMB construction method is also adequate for tunnel construction in downtown areas, and accordingly utilization thereof has recently been further increased.

FIG. 1 illustrates a wall 1 of the tunnel constructed through a TBM construction method, in which the wall 1 of the tunnel is formed by assembling prefabricated segments into a ring-shaped unit subsequent to excavation using a TBM. Because water may permeate the tunnel through a gap generated between one segment 10 and another adjacent segment 10, which constitute the wall 1 of the tunnel, water stop treatment is applied to the gaps among the segments 10.

FIG. 2 illustrates an example of the water stop treatment, which will now be explained in detail.

First, a groove 11 is formed in each side surface of the segment 10, and a water stop gasket is mounted in the groove. The water stop gasket is previously mounted in the groove 11 of the segment before the segments 10 are assembled together to form the wall 1 of the tunnel, and the segments 10 equipped with the water stop gaskets are

then assembled. When the segments 10 are assembled together to form the wall 1 of the tunnel, the water stop gasket mounted in one segment 10 and the water stop gasket mounted in another adjacent segment 10 come into contact with each other at sealing surfaces thereof, and are compressed to a certain degree.

It is preferable that, when the segments 10 are assembled together to form the wall 1 of the tunnel, the sealing surfaces of the water stop gaskets accurately contact each other without being offset with respect to each other, however, as shown in FIG. 2, in actual tunnel construction, the sealing surfaces of the water stop gaskets are frequently offset with respect to each other by a certain distance D .

Further, the segments are preferably mounted so as to maintain the distance between the segments 10 at a certain value that is predetermined in a design process, however, in actual construction, the segments are frequently mounted at a certain distance S therebetween, which is different from a design distance. That is, the actual distance between the segments 10 may become shorter or longer than a design distance.

Such an offset or distance error does not occur only when the segments 10 are mounted, but also occurs after the segments 10 are completely mounted. Large external

force may be applied to the wall 1 of the tunnel even after the construction is finished, which may cause the offset or distance error.

Such an offset D or distance error S in mounting of the segments 10 considerably affects the water stop performance of the water stop gasket, and the water stop gasket must be manufactured so as to be capable of demonstrating excellent water stop ability in spite of the error in mounting of the segments 10.

In order to satisfy this requirement, the material aspect and the shape aspect including, for example, the outer appearance and the shape and number of channels, have been highly taken into consideration in designing conventional water stop gaskets.

【Disclosure】

【Technical Problem】

The water in the areas where the construction of undersea tunnels is being currently considered is much deeper than that in the construction areas of the past, but the conventional water stop gasket does not have sufficient water stop ability to endure high water pressure in such a deep water environment. The water stop gasket, which was applied to a tunnel in a low water pressure environment, for example, the Eurotunnel in a water pressure environment of about 3 bar and the Japanese Aqua-Line in a water pressure

environment of about 6 bar, may not maintain the water stop performance until expiration of the period of use of the tunnel in a high water pressure environment of, for example, 10 bar or more.

5 That is, there is still a need for a highly water-pressure-resistant water stop gasket, which is capable of demonstrating excellent water stop performance even when used for an undersea tunnel constructed in a deep water environment.

10 **【Technical solution】**

 A water stop gasket of an embodiment is mounted in a segment groove formed in each of four side surfaces of at least some of a plurality of segments, which are mounted to form a wall of a tunnel excavated by a TBM or a shield machine, in order to prevent water from permeating between the segments, and is made of a contractible elastic material.

 The water stop gasket includes a plurality of legs and a plurality of channels.

20 Each of the legs may be seated on a bottom surface of the segment groove, and may be formed to expand in width toward a top thereof. That is, the leg may be formed such that the thickness in the left and right directions is gradually increased from the lower portion, which is

seated on the bottom surface of the segment groove, to the upper portion.

The plurality of legs may include a first outermost leg, a second outermost leg, and at least one intermediate leg. A width W between an outer lower edge of the first outermost leg and an outer lower edge of the second outermost leg may be larger than a width W_s of the bottom surface of the segment groove. When the water stop gasket is mounted in the segment groove, the first outermost leg and the second outermost leg are compressed and seated on the segment groove. A width between side surfaces of the segment groove may be increased from the bottom surface to the top thereof, and the water stop gasket may be easily mounted merely by pushing the water stop gasket vertically into the segment groove. The water stop gasket may be mounted in such a manner that the first outermost leg and the second outermost leg slide down along the side surfaces of the segment groove and the bottom surfaces of the legs are seated on the bottom surface of the segment groove. In this mounting process, the width between the first outermost leg and the second outermost leg is contracted by the side surfaces of the segment groove, and the legs are fitted into the segment groove.

The first outermost leg and the second outermost leg may be formed to spread away from each other such that the

bottom surfaces thereof are respectively inclined with respect to the horizontal plane in an outward direction. When the water stop gasket is mounted in the segment groove, the first outermost leg and the second outermost leg, which have spread away from each other, undergo rotational contractive deformation in a direction of approaching each other, and thus the bottom surfaces of the legs become parallel to the horizontal plane and are seated on the bottom surface of the segment groove.

The channels are formed to have respective empty inner spaces, and are arranged above the legs. At least some of the channels may be positioned directly above the respective legs (that is, above the center portions of the legs), and at least some of the channels may be positioned directly above the gasket grooves disposed between the legs. The water stop gasket may be designed such that webs formed between the gasket grooves and the channels positioned above the gasket grooves have the same minimum thickness. Further, the water stop gasket may be designed such that webs formed between the channels have the same minimum thickness. Such arrangement of the gasket grooves and the channels and uniform web thicknesses have advantages of facilitating uniform deformation of the water stop gasket and improving the sealing ability and durability thereof. Further, when the segment is mounted

to form a wall of the tunnel, the water stop gasket may be compressed and the segment groove may undergo compressive stress, and if the compressive stress is concentrated on a specific region, the segment groove may be damaged, but uniform deformation of the water stop gasket is effective in resolving the problem of stress concentration.

The water stop gasket may further include fixing support portions, which are formed in the outer surface of the first outermost leg and the outer surface of the second outermost leg.

Each of the fixing support portions may include two or more grooves, which are formed in each of the outer surfaces of the outermost legs and are arranged in the vertical direction, and at least one protrusion, which protrudes between the grooves and is formed to be decreased in thickness toward the tip portion thereof so as to flexibly and closely contact the side surface of the segment groove. Further, the protrusion of the fixing support portion may have a sawtooth shape having a tip portion, which is directed diagonally upwards. Such a sawtooth shape may further enhance the frictional force or the contact force with respect to the side surface of the segment groove.

Because it is practically impossible to achieve perfect close contact between the side surfaces of the

segment groove and the outer surfaces of the first and fourth legs of the water stop gasket over the whole length of the water stop gasket due to a processing error or the like, a gap may be generated between the side surfaces of the segment groove and the outer surface of the water stop gasket, but the protrusion of the fixing support portion may serve to prevent the generation of the gap through flexible deformation thereof. In addition, an adhesive may be used to secure the water stop gasket to the segment groove, and the adhesive may be introduced into the grooves of the fixing support portion, thereby further enhancing bonding force.

On the other hand, the water stop gasket may include a water-expanding water stop layer formed in a top surface (that is, a sealing surface) thereof, and a portion formed of an EPDM rubber material. Even when water permeates through a gap generated between the sealing surfaces of the adjacent water stop gaskets, the water-expansion water stop layer is expanded by the water and seals the gap, thereby preventing water permeation.

【Effects of the Invention】

A water stop gasket of an embodiment is capable of demonstrating excellent water stop performance in a high water pressure environment, thereby being used for an undersea tunnel in a deep water environment, and of

consistently maintaining the required water stop ability until expiration of the period of use of the tunnel.

【Brief Description of the Drawings】

FIG. 1 is a view illustrating a wall of a tunnel;

5 FIG. 2 is a sectional view taken along line A-A in FIG. 1;

FIG. 3 is a view illustrating a water stop gasket according to an embodiment;

10 FIG. 4 is a view illustrating the state in which the water stop gasket in FIG. 3 is mounted to a segment; and

FIG. 5 is a partially enlarged view illustrating the state in which an outermost leg is seated on a segment groove.

【Best Mode for Implementing the Invention】

15 Hereinafter, a water stop gasket 100 according to an embodiment will be described in detail with reference to FIGS. 3 to 5. In the following description, the up, down, left and right directions are defined with respect to the figures, and are used merely to further clarify the water
20 stop gasket 100.

First, the water stop gasket 100 of the embodiment has a substantially hexagonal cross-sectional shape.

The width in the left and right directions of the top surface is smaller than the width W in the left and right
25 directions of the base surface. Because the top surface has

a smaller width than the base surface, compressive force from the base surface is concentrated and applied to the top surface, and accordingly the top surface serves as a sealing surface 150, which functions to enhance sealing ability.

5 For convenience of explanation, the water stop gasket 100 of the embodiment may be divided into an upper portion, which includes the sealing surface 150, a middle portion, in which channels 111 to 113 and 121 to 124 are formed, and a lower portion, which includes grooves 141 to 143 and legs 10 131 to 134, which are seated on the bottom surface of a segment groove 11. In this embodiment, the channels 111 to 113 and 121 to 124 have an empty internal space.

 The sealing surface 150 is brought into compressive contact with the sealing surface 150 of another adjacent 15 water stop gasket 100. Such compressive contact between the sealing surfaces 150 of the water stop gaskets 100 prevents water from permeating between the segments 10.

 As the sealing surface 150 is compressed, the channels 111 to 113 and 121 to 124 in the middle portion are also 20 compressed and deformed. At this time, if the deformation of the middle portion is concentrated on a specific portion, it is difficult to obtain uniform sealing ability over the whole sealing surface 150. This embodiment is characterized in that the middle portion is evenly deformed due to the 25 channels 111 to 113 and 121 to 124 having a structure

illustrated in FIG. 3.

In detail, the channels 111 to 113 and 121 to 124 formed in the middle portion include first channels 111 to 113, which are arranged in a first horizontal axis *I*, and
5 second channels 121 to 124, which are arranged in a second horizontal axis *II*. Here, the first horizontal axis *I* and the second horizontal axis *II* are spaced apart from each other in a vertical direction.

The number of the first channels 111 to 113 is three,
10 and the intermediate first channel 112 has a smaller cross-sectional area than each of the left and right outer first channels 111 and 113. The intermediate first channel 112 has an inverted triangular shape, and each of the outer first channels 111 and 113 has such a shape that a vertex
15 portion of an inverted triangular shape, which is directed outward, is trimmed parallel to the outer surface of the gasket. Each of the first channels 111 to 113 is located at a position above the center portion of a corresponding one of the gasket grooves 141 to 143, which will be described
20 later.

The number of the second channels 121 to 124 is four, the two intermediate second channels 122 and 123 have the same shape as each other, and the left and right outer second channels 121 and 124 have the same shape as each
25 other. The second channels 121 to 124 have a substantially

water-droplet shape, and each of the two intermediate second channels 122 and 123 has a larger cross-sectional area than each of the left and right outer second channels 121 and 124. Each of the second channels 121 to 124 is positioned
5 directly above a corresponding one of the legs 131 to 134, which will be described later. Because each of the second channels 121 to 124 has such a shape that an upper portion thereof, which is located near the sealing surface 150, is narrow and a lower portion thereof is broad, the lower
10 portions of the second channels 121 to 124 are spread widely by the compressive load applied thereto from the sealing surface 150. That is, the compressive load applied from the sealing surface 150 disperses widely through the lower portions of the second channels 121 to 124.

15 The group of first channels 111 to 113 and the group of second channels 121 to 124 are not completely separated from each other but, instead, are arranged to partially overlap each other in the vertical direction. That is, the channels are arranged in such a manner that the second
20 channel 122 is disposed between the first channel 111 and the first channel 112, and the first channel 112 is disposed between the second channel 122 and the second channel 123. Through such an arrangement, some of the compressive load applied to the sealing surface 150 is transferred to the
25 lower portion of the gasket via the first channels 111 to

113, and the remainder of the compressive load is transferred to the lower portion of the gasket via the second channels 121 to 124.

FIG. 3 shows the structure in which the first channels 111 to 113 and the second channels 121 to 124 are arranged in a zigzag manner, and web thicknesses t_1 between adjacent channels 111 to 113 and 121 to 124 are the same. Since the web thicknesses t_1 between adjacent channels 111 to 113 and 121 to 124 are the same, compressive deformation is generated uniformly, and load transfer to the lower portion of the gasket also occurs uniformly.

On the other hand, the lower portion of the water stop gasket 100 includes a plurality of gasket grooves 141 to 143 and a plurality of legs 131 to 134.

The plurality of legs 131 to 134 include a first outermost leg 131, which is located at the outermost position on the left side, a second outermost leg 134, which is located at the outermost position on the right side, and two intermediate legs 132 and 133, which are located between the first outermost leg and the second outermost leg. These legs 131 to 134 are formed such that they are expanded in thickness from the bottom thereof to the top thereof.

The gasket grooves 141 to 143, which have an inverted U-shape, are disposed between the leg 132 and the leg 133. Each of the above-described first channels 111 to 113 is

located above the center portion of a corresponding one of the gasket grooves 141 to 143. Because each of the first channels 111 to 113 is formed such that the top thereof is broad and the bottom thereof is narrow, the compressive load is concentrated on the bottoms of the first channels 111 to 113 via the sealing surface 150, but is dispersed in the left and right directions by the inverted U-shaped gasket grooves 141 to 143.

The above-described shapes and arrangement of the first channels 111 to 113, the second channels 121 to 124, the legs 131 to 134 and the gasket grooves 141 to 143 have advantages such that the compressive load applied to the sealing surface 150 is uniformly dispersed and transferred to the legs 131 to 134, and the required number of the channels 111 to 113 and 121 to 124 is accommodated in the limited area of the middle portion of the gasket.

Further, as illustrated in the drawings, each of the gasket grooves 141 to 143 is disposed between two adjacent second channels 121/122, 122/123 and 123/124, and minimum web thicknesses t_2 between the gasket grooves 141 to 143 and the second channels 121 to 124 adjacent thereto are the same. This is advantageous for uniform deformation and load transfer.

As illustrated in FIG. 3, the web structure, which is formed above each of the gasket grooves 141 to 143, includes

an upper web structure 115, which has a V-shape, and a lower web structure 125, which has an inverted U-shape so as to be convexly curved upward. The load, which is concentrated on the V-shaped upper web structure 115, is dispersed by the inverted U-shaped lower web structure 125, and is transferred to each of the legs 131 to 134.

On the other hand, the first outermost leg 131 and the second outermost leg 134 are respectively biased outward, and accordingly, when mounted in the segment groove 11, the legs are pressurized inward as illustrated in FIG. 4. When the first outermost leg 131 and the second outermost leg 134 are mounted, they undergo rotational deformation δ in the inward direction, and thus come into closer contact with the side surfaces of the segment groove 11 due to the elastic restoring force after the mounting.

The bottom surfaces of the first outermost leg 131 and the second outermost leg 134 are respectively inclined in the outward direction at a predetermined angle α with respect to the horizontal plane, and accordingly undergo rotational deformation in the inward direction when mounted.

In addition, each of the first outermost leg 131 and the second outermost leg 134 has a fixing support portion 160 formed in the outer surface thereof.

The fixing support portion 160 includes a plurality of grooves 161 and a plurality of protrusions 162. Each of the

protrusions 162 has a sawtooth shape, that is, a substantially triangular shape, whose vertex is directed diagonally upwards.

Because the tip portion of each of the protrusions 162 is relatively thin, it may be flexibly deformed. Accordingly, the tip portions of the protrusions 162 of the fixing support portions 160 seal the gaps between the side surfaces of the segment groove 11 and the outer surfaces of the outermost legs 131 and 134, thereby further enhancing contact force therebetween.

Further, the grooves 161 of the fixing support portion 160 serve as spaces for retaining an adhesive therein so as to bond the water stop gasket 100 to the segment groove 11, thereby further enhancing bonding force.

Further, the sealing surface 150 of the water stop gasket 100 of this embodiment includes a water-expanding water stop layer 151. The sealing surface 150 is embodied as the water-expanding water stop layer 151, and the remaining portion of the gasket is formed of an EPDM rubber material. Because the sealing surface 150 includes the water-expanding water stop layer 151, even when water permeates through a gap generated between the sealing surfaces 150, the water-expansion water stop layer 151 expands and prevents water permeation.

Because the material of such a water-expanding water

stop layer 151 is well known in the art, a detailed explanation related to the material will be omitted.

The water stop gasket 100 may be formed in such a manner that the water-expanding water stop layer 151, which serves as the sealing surface 150, and the portion of an EPDM rubber material are integrally formed through an injection molding process.

【Industrial Applicability】

The present invention relates to a highly water-pressure-resistant water stop gasket for use in a tunnel constructed by a TBM.

The highly water-pressure-resistant water stop gasket for use in a tunnel constructed by a TBM of the present invention is capable of demonstrating excellent water stop performance in a high water pressure environment, thereby being used for an undersea tunnel in a deep water environment, and of consistently maintaining the required water stop ability until expiration of the period of use of the tunnel.

【CLAIMS】

【Claim 1】

A water stop gasket for use in a tunnel, configured to be mounted in a segment groove formed in each of four
5 side surfaces of at least some of a plurality of segments, the segments being mounted to form a wall of a tunnel excavated by a TBM or a shield machine, in order to prevent water from permeating between the segments, and made of a contractible elastic material, the water stop
10 gasket comprising:

a plurality of legs configured to be seated on a bottom surface of the segment groove, to expand in width toward a top thereof, and to include a first outermost leg, a second outermost leg, and at least one intermediate
15 leg formed between the first outermost leg and the second outermost leg, the legs being arranged such that a width W between an outer lower edge of the first outermost leg and an outer lower edge of the second outermost leg is larger than a width W_s of the bottom surface of the segment
20 groove;

a plurality of channels formed to have an empty inner space, respectively, and arranged above the legs such that at least some of the channels are positioned directly above the legs and at least some of the channels are
25 positioned above regions between the legs; and

fixing support portions, each including two or more grooves formed in each of an outer surface of the first outermost leg and an outer surface of the second outermost leg and arranged in a vertical direction, and at least one protrusion protruding between the grooves and formed to be decreased in thickness toward a tip portion thereof so as to flexibly and closely contact each of the side surfaces of the segment groove.

【Claim 2】

The water stop gasket for use in a tunnel according to claim 1, wherein the first outermost leg and the second outermost leg are formed to spread away from each other such that bottom surfaces thereof are respectively inclined with respect to a horizontal plane in an outward direction, and when the first outermost leg and the second outermost leg are mounted in the segment groove, the first outermost leg and the second outermost leg undergo contractive deformation in a direction of approaching each other such that the width W is decreased to the width W_s of the bottom surface of the segment groove.

【Claim 3】

The water stop gasket for use in a tunnel according to claim 1, wherein the protrusion of each of the fixing support portions has a sawtooth shape having a tip portion directed diagonally upwards.

【Claim 4】

The water stop gasket for use in a tunnel according to claim 1, wherein the channels include first channels arranged in a first horizontal axis *I*, and second channels arranged in a second horizontal axis *II*, located below the second horizontal axis *I*, and having a different shape from the first channels,

the water stop gasket further includes gasket grooves formed between the legs and convexly curved upwards,

the first channels, the second channels and the gasket grooves are arranged in a diamond shape such that one of the first channels and one of the gasket grooves face each other in the vertical direction and two of the second channels face each other, and

webs formed between the gasket grooves and the second channels have the same minimum thickness, and webs formed between the first channels and the second channels have the same minimum thickness.

【Claim 5】

The water stop gasket for use in a tunnel according to claim 4, wherein two intermediate channels of the second channels are formed to have a water-droplet shape, and at least one of the first channels is formed to have an inverted triangular shape between the water-droplet-shaped second channels.

【Claim 6】

The water stop gasket for use in a tunnel according to claim 1, wherein the water stop gasket includes a portion formed of an EPDM rubber material, and a water-expanding water stop layer formed in a top surface thereof and having a smaller width than the width W , the water-expanding water stop layer and the portion of the EPDM rubber material being integrally formed through injection molding.