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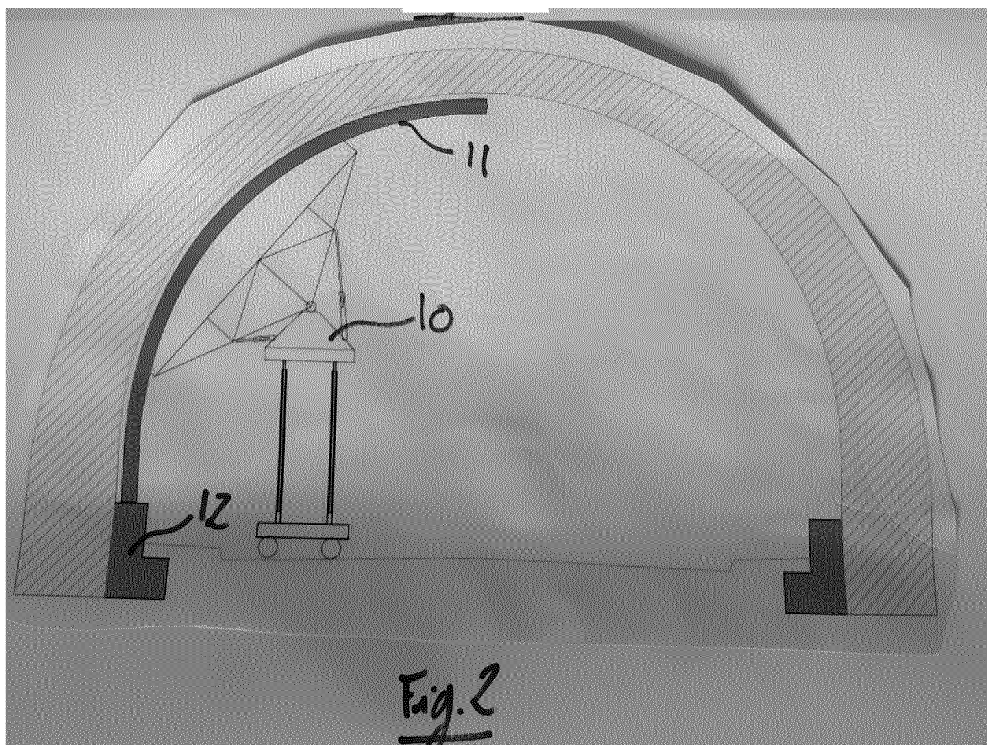
(54) **METHOD FOR INSTALLING TUNNEL SEGMENTS INSIDE AN EXISTING TUNNEL**

(57) Method for installing tunnel segments inside an existing tunnel presenting a longitudinal axis comprising the steps of:

- providing a precast concrete half-arch to-be-positioned segment,
- securing said segment on a positioning device,
- positioning said segment so as to lean against two pre-

viously positioned half-arch concrete segments in a staggered arrangement, wherein the positioning comprises rotating and translating according to the longitudinal axis of the tunnel said to-be-positioned segment, and

- unsecuring said to-be-positioned segment from the positioning device, wherein the positioning device is located under the segments



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Description

Technical Field

[0001] The invention pertains to the field of civil engineering and more specifically to the installation of tunnel segments inside existing tunnels excavated using traditional methods.

Background Art

[0002] The maintenance of tunnels is a highly sensitive issue because it often leads to the closure of the tunnel. Such closure causes lengthy detours to the users in need to join the other side. In case of railway, it can even completely stop trains to make the junction.

[0003] Therefore maintenance methods allowing only partial closure of the tunnels are desirable. Typically, the tunnel is closed at night so that the maintenance can be performed, and reopened during daytime.

[0004] However, depending on the task to be performed it is not always possible. Typically, when water infiltration needs to be taken care of, or when the tunnel starts to shrink, typically when the tunnel has been excavated in soft ground, the maintenance consists of building another structural support inside the tunnel. Different solutions are known. For example placing a steel support combined with reinforced shotcrete ; this solution is labor intensive and risky in terms of safety. It also requires the use of a heavy shield (in steel or concrete) to protect the traffic during the time of operation and until the concrete has set.

[0005] One can also cast in situ a new support in reinforced concrete thanks to a heavy movable form which is a significant constrain against opening of the traffic in the day time.

[0006] Another known method for building such structural support includes building a curved pre-slab consisting of a thin curved precast concrete layer with steel spikes configured to retain another layer of concrete to be cast onsite. However, such pre-slabs are not stable by themselves and need to be supported by props until the final slab has been set up and stabilized.

[0007] These props cannot be removed during the day and therefore prevent the intermittent reopening of the tunnel during the maintenance.

Technical Problem

[0008] There is thus a need for an alternative method for installing tunnel segments inside an existing tunnel which does not prevent its reopening, i.e which can be interrupted during several hours without hindering the lumen of the tunnel.

Summary of the invention

[0009] The invention provides a solution consisting in

setting up pre-cast concrete segments in a staggered arrangement so that each concrete segment can lean on others. The installation takes place thanks to a positioning device which can operate from the lumen of the tunnel, preventing the need for cranes which are not always usable due to encumbrance issues.

Disclosure of invention

[0010] An object of the present invention is therefore a method for installing tunnel segments inside an existing tunnel presenting a longitudinal axis comprising the steps of:

- providing a precast concrete half-arch to-be-positioned segment,
- securing said segment on a positioning device,
- positioning said segment so as to lean against a previously positioned half-arch concrete segment in a staggered arrangement, wherein the positioning comprises rotating and translating according to the longitudinal axis of the tunnel said to-be-positioned segment, and
- unsecuring said to-be-positioned segment from the positioning device, wherein the positioning device is located under the segments.

[0011] The longitudinal axis of the tunnel is an axis which follows the shorter path from one extremity of the tunnel to the other. It can be a curved axis as the tunnel can include turns and does not need to be linear.

[0012] The precast concrete half-arch comprises dry concrete and can preferably be used without any further treatment. It can have any size although its weight typically ranges from 10 to 20 tons. Its half-arch shape can be polygonal or curved: in the meaning of the present invention, an arch does not necessarily present a C shape and encompasses any shape which can effectively form a bridge over the traffic lanes of the tunnel. Similarly, "half" is to be understood broadly and the two halves of an arch do not need to be identical. For instance, in the meaning of the present invention, the letters I and J could be considered two halves of the letter U.

[0013] Preferably however, the arch presents a C shape as the external walls of a tunnel often present that shape so as to minimize the constraints in the tunnel support due to ground convergence..

[0014] The precast concrete half-arch to-be-positioned segment can be provided by a forklift or the like, either inside or outside the tunnel, and is secured on the positioning device to allow its accurate installation.

[0015] The positioning device then brings the precast concrete half-arch to-be-positioned segment on its installation site. In case the segment has been provided and secured outside of the tunnel, the positioning device and its secured segment are thus brought inside the tunnel.

[0016] The positioning device then installs the segment by rotating it so as to align it with previously posi-

tioned segments, and by translating it so that it leans on the other segments in a staggered arrangement.

[0017] The segment can then be unsecured from the positioning device. When the unsecuring occurs, the positioning device is located under the arch: the positioning device is not located between the walls of the original tunnels and the segments, which could only be possible in case a lot of space is available.

[0018] Obviously, the installation of the first segment cannot be done this way since no other segments are available for it to lean on. The first segment can be installed by any known means as it is not critical since it is only done once. Typically it can be installed using props.

[0019] Similarly, in order to carry the segments at the bottom, any foundation can be used without departing from the scope of the present invention.

[0020] Preferably, there is a first foundation on one side of the tunnel and another foundation on the other side of the tunnel which are not mechanically connected, and when the positioning device proceeds to the rotation of the segment, it is brought in contact with the proper foundation on which it can lean or cooperate by any male-female design. The foundation is preferably configured so that the segment can then be translated by the positioning device without departing from its contact.

[0021] Two-parts foundation are easier to install in case of maintenance and are less likely to necessitate an interruption of traffic as they do not interact with the middle of the tunnel where the traffic lanes are located.

[0022] Once a segment is installed, every step can be repeated until all segments are installed or the method can be interrupted. Indeed, the installed segments are stable and no props are needed: the lumen of the tunnel and the traffic lanes can be cleared by removing the positioning device. Later on, the method can be resumed easily.

[0023] The method according to the present invention preferably further comprises filling a gap between the tunnel and the precast concrete half-arch segments with a waterproof material, preferably selected from a resin, concrete or a geopolymer mixture such as geopolymer porous concrete used for pavements in urban areas.

[0024] The method according to the present invention preferably further comprises filling a gap between the tunnel and the precast concrete half-arch segments with a draining material. Such draining material can be used either alternatively or in conjunction with previously mentioned waterproof material.

[0025] The filling mechanically stabilizes the structure, however it to be noted that the segments are stable even without any filling and, as such, that the traffic can be opened even if no filling has been provided between the segments and the walls of the existing tunnel.

[0026] The use of a waterproof and/or of a draining material depends on the chosen solution to evacuate the water. It is usually necessary to provide a way to drain the water which can infiltrate from the walls of the tunnel. Such drain can be done by a draining material, pipes, or

any known means without departing from the invention. However, using a draining material as a filling is a convenient way to drain it as a filling material is suitable anyway. Waterproof materials prevent the water from reaching the segments and can be used either all along the tunnel, preferably in conjunction with other draining solutions, or only on some carefully chosen location so as to direct the water on identified path in order to ease its drain.

[0027] The to-be-positioned segment can also advantageously be coated with a draining geocomposite layer which takes care of all the draining and/or complement previously mentioned options. Such coating can advantageously be applied when the segment is manufactured, effectively simplifying the steps onsite.

[0028] Preferably, the draining material is selected from a gravel-cement mix, a gravel-resin mix, a geopolymer mixture such as geopolymer porous concrete used for pavements in urban areas or a draining geosynthetic composite..

[0029] Preferably, the precast concrete half-arch to-be-positioned segment presents a waterproof external face. As a matter of fact, the concrete of the segment is likely to present cracks in which water could accumulate, threatening the stability of the structure. It is therefore preferable to provide a waterproof external face. The external face of the segment is the face which faces the wall of the existing tunnel and which does not face the lumen of the tunnel and the traffic lanes.

[0030] Said external face can comprise a waterproof coating, preferably a waterproof coating selected from an applied resin or applied bitumen. Such coating can be applied before bringing the segment onsite by any convenient means.

[0031] The external face would also be provided with a polymeric or bituminous waterproof membrane either alternatively or in conjunction with the waterproof coating.

[0032] The precast concrete half-arch to-be-positioned segment is preferably secured on the positioning device by fastening means, more preferably by fastening means selected from screws, bolts, magnets, or suction cups. The fastening means need to be dimensioned according to the weight of the segments so as to allow an accurate and stable handling of the segments. The fastening means are advantageously easily implemented and unimplemented so as to improve the efficiency of the installation and to avoid security issues caused by complex mechanics and corresponding training and maintenance.

[0033] The method according to the present invention can further comprise bolting together the precast concrete half arch segments. The bolting can be done between two segments which are facing each other, i.e. located on opposite sides of the tunnel, and/or between two segments located side-by-side on the same side of the tunnel. Although the segments are configured so that they are stable when they only lean on each other, providing an additional bolting can be interesting in stressful

area, e.g. when there is a seismic issue.

[0034] Although bolting is the preferred way to consolidate the segments together in that case, any other mean can be used including use of polymer material or elastic joints configured to absorb deformation between the segments, for example using tendons and/or turnbuckles.

[0035] The precast concrete half-arch to-be-positioned segment preferably comprises a quenching joint configured to swell when exposed to water, and wherein said quenching joint is configured to be positioned between two segments.

[0036] Indeed, such joint can provide easy water sealing. Advantageously, the joint of the to-be-positioned segment is configured to contact another joint of a previously positioned segment. The contact does not need to be completely tight as the joints will swell when exposed to water, effectively providing water sealing when it will be needed.

[0037] The method according to the present invention preferably comprises removing the positioning device from the tunnel, interrupting the method for several hours, setting up back the positioning device and repeating the steps of the present invention.

[0038] In order to easily remove and position the positioning device, the positioning device is preferably wheeled and comprises outrigger stabilizing legs so as to stabilize the device when operating.

[0039] The positioning device is preferably self-propelled and/or configured to be towed. Self-propulsion allows a greater versatility whereas towing can address some encumbrance issues and/or allow adapting the propulsion to the access conditions such as important slopes or uneven grounds.

Brief Description of Drawings

[0040] Other features, details and advantages will be shown in the following detailed description and on the figures, on which:

Fig. 1

[Fig. 1] is a cross-sectional view of a tunnel in which a positioning device is carrying a segment according to an embodiment of the invention ;

Fig. 2

[Fig. 2] shows the tunnel of Figure 1 after the positioning device has rotated the segment;

Fig. 3

[Fig. 3] is a tridimensional view showing the positioning of a segment according to an embodiment of the invention ;

Fig. 4

[Fig. 4] is the tridimensional view of Figure 3 at a later stage of the positioning of the segment according to an embodiment of the invention ;

Description of Embodiments

[0041] Figures 1 to 4 and the following detailed description contain, essentially, some exact elements. They can be used to enhance understanding the invention and, also, to define the invention if necessary.

[0042] It is now referred to the maintenance of an existing tunnel which is mainly due to water infiltration through the existing concrete structure.

[0043] Concrete tunnel segments are precast. The concrete includes additives which reduce its permeability. The precast segments have a half-hemicylinder shape. Two symmetrical types of segments are cast which will be referred as left and right segments. Every segment presents two extremities which can be referred as basis 110 and crown 112. Three pins are provided, two on the basis and one on the crown.

[0044] The external surface of the segments is coated with a waterproof coating made of a bi-composite material based on a hydraulic ligand and an elastomeric material. The coating is applied on the whole surface but micro-cracks can be filled with an extra amount of the coating or, alternatively, with a different coating.

[0045] A gasket 15 is positioned on both sides of the segments.

[0046] The first few segments are positioned in the tunnel with props and traditional methods so as to obtain a stable beginning of the structure. The segments are positioned in a staggered arrangement as shown on Figures 3 and 4: left and right segments do not face each other perfectly but are staggered so that the crown of a left segment faces two right segments and vice versa.

[0047] Once the beginning of the structure is stable, next segments are positioned sequentially.

[0048] A segment 11 to-be-positioned is brought on-site, in the vicinity of the already positioned segments forming the stable structure in construction, by a positioning device 10 on which it is secured with screws and bolts. The positioning device is a self-propelled wheeled device. When moving, the segment it carries is on a balanced position as shown on Figure 1. When the positioning device 10 is under the structure, outrigger stabilizing legs (not represented on the figures) are deployed so as to avoid any stability issue when handling the segment 11.

[0049] The segment 11 is then rotated so that the pins on its basis are positioned on the foundations 12 and so that it is parallel to previously positioned segments 13 and 16 as shown on figure 2 and 3.

[0050] The segment is then translated along the axis of the tunnel so that it leans on previously positioned segment 14 as shown on figure 4.

[0051] The gaskets 15 on the side of the segment to-be-positioned 11 and the previous segment on the same side 13 are put in contact together.

[0052] The segment 11 is then unsecured from the positioning device 10 and next segment can be installed.

[0053] As the segments are staggered, the installation

of each piece pushed in the final position by the positioning device 10 avoids the use of provisional supports.

[0054] The waterproofing is made directly on the external surface of the precast segments thanks to the coating applied before their installation. The sealing of the vertical joint is made through the gaskets 15 and the sealing of the crown is made after the installation through the injection of a resin from the inner side.

[0055] The gap between the existing tunnel and the new structure is filled with draining geopolymer material to guarantee the convey of the drained water on the sides of the arch.

[0056] It is understood that the described embodiments are not restrictive and that it is possible to make improvements to the invention without leaving the framework thereof.

[0057] Unless otherwise specified, the word "or" is equivalent to "and/or". Similarly, the word 'one' is equivalent to 'at least one' unless the contrary is specified. Unless otherwise specified, all percentages are weight percentages.**

Claims

1. Method for installing tunnel segments inside an existing tunnel presenting a longitudinal axis comprising the steps of:
 - providing a precast concrete half-arch to-be-positioned segment,
 - securing said segment on a positioning device,
 - positioning said segment so as to lean against a previously positioned half-arch concrete segment in a staggered arrangement, wherein the positioning comprises rotating and translating according to the longitudinal axis of the tunnel said to-be-positioned segment, and
 - unsecuring said to-be-positioned segment from the positioning device, wherein the positioning device is located under the segments.
2. Method for installing tunnel segments inside an existing tunnel according to claim 1, further comprising filling a gap between the tunnel and the precast concrete half-arch segments with a waterproof material, preferably selected from a resin, concrete or a geopolymer mixture.
3. Method for installing tunnel segments inside an existing tunnel according to any one of the preceding claims, further comprising filling a gap between the tunnel and the precast concrete half-arch segments with a draining material.
4. Method for installing tunnel segments inside an existing tunnel according to the preceding claim wherein the draining material is selected from a gravel-cement mix, a gravel-resin mix, a geopolymer mixture or a draining geosynthetic composite.
5. Method for installing tunnel segments inside an existing tunnel according to claim 1, wherein the precast concrete half-arch to-be-positioned segment presents a waterproof external face.
6. Method for installing tunnel segments inside an existing tunnel according to the preceding claim, wherein said external face comprises a waterproof coating, preferably a waterproof coating selected from an applied resin or applied bitumen.
7. Method for installing tunnel segments inside an existing tunnel according to claim 6, wherein said external face comprises a waterproof membrane, preferably a polymeric or bituminous membrane.
8. Method for installing tunnel segments inside an existing tunnel according to anyone of the preceding claims, wherein the precast concrete half-arch to-be-positioned segment is secured on the positioning device by fastening means, preferably by fastening means selected from screws, bolts, magnets, or suction cups.
9. Method for installing tunnel segments inside an existing tunnel according to anyone of the preceding claims, further comprising bolting together the precast concrete half arch segments.
10. Method for installing tunnel segments inside an existing tunnel according to anyone of the preceding claims, wherein the precast concrete half-arch to-be-positioned segment comprises a quenching joint configured to swell when exposed to water, and wherein said quenching joint is configured to be positioned between two segments.
11. Method for installing tunnel segments inside an existing tunnel according to any of the preceding claims further comprising removing the positioning device from the tunnel, interrupting the method for several hours, setting up back the positioning device and repeating the steps of claim 1.
12. Method for installing tunnel segments inside an existing tunnel according to any of the preceding claims wherein the positioning device is wheeled and comprises outrigger stabilizing legs.
13. Method for installing tunnel segments inside an existing tunnel according to the preceding claim wherein the positioning device is self-propelled.
14. Method for installing tunnel segments inside an existing tunnel according to any one of the preceding

claims, wherein the to-be-positioned segment is coated with a draining geocomposite layer..

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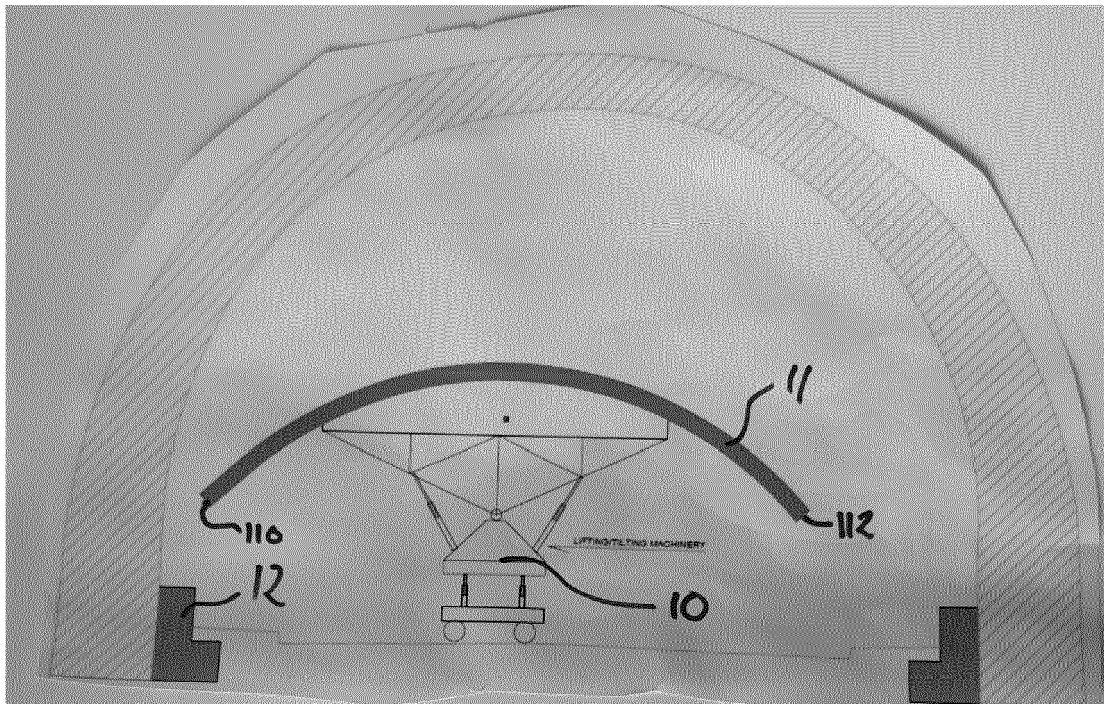


Fig. 1

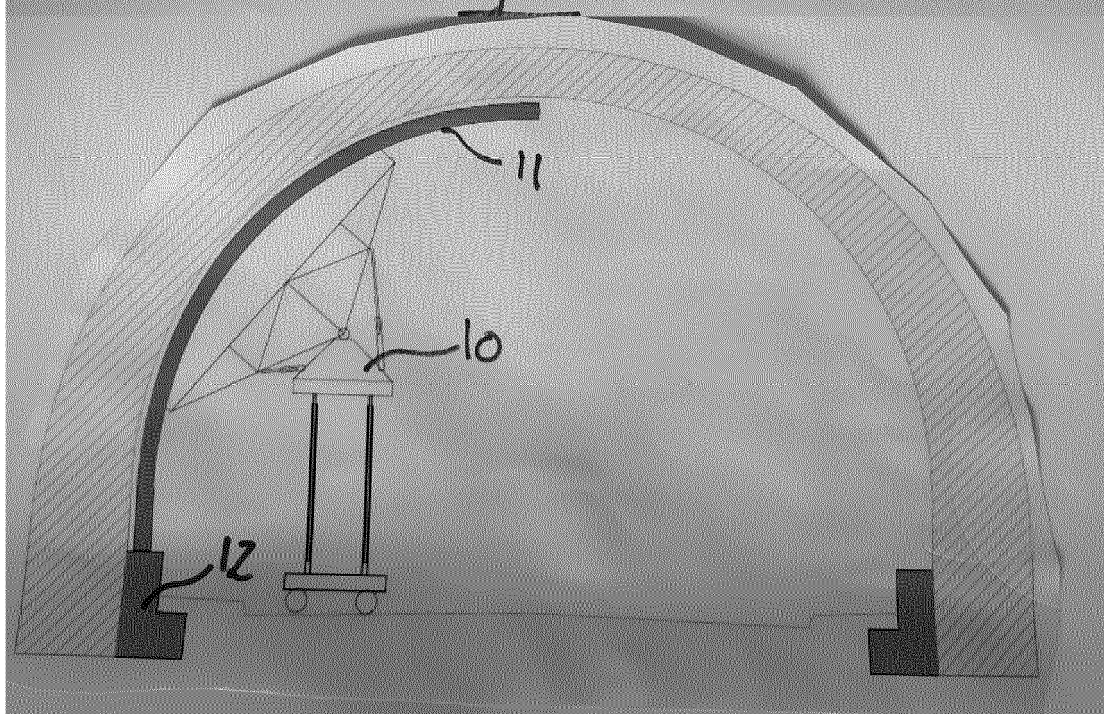
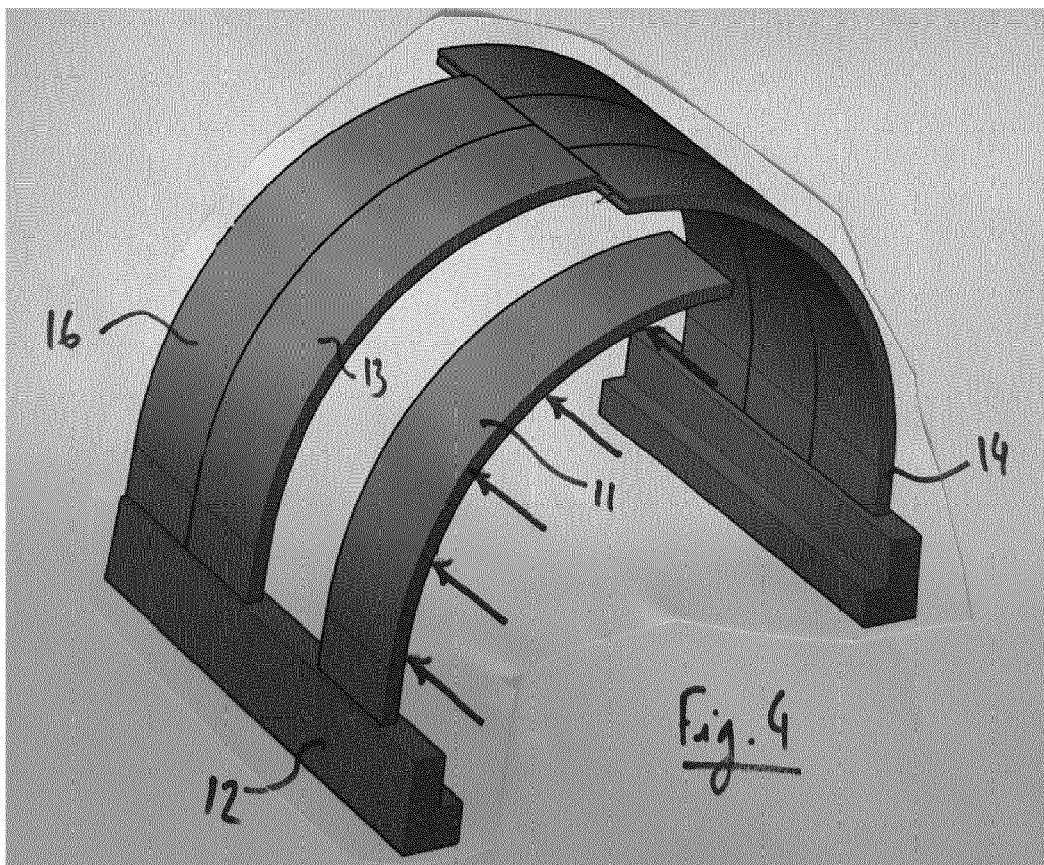
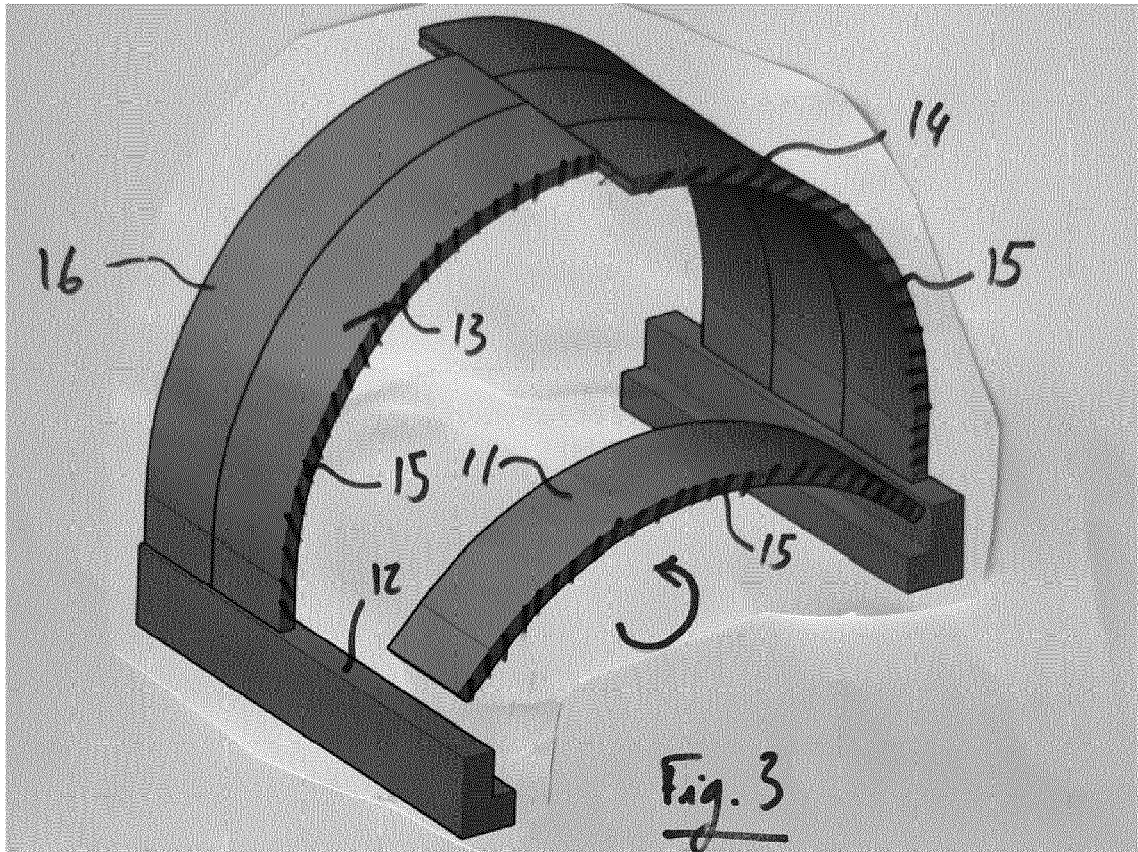


Fig. 2





EUROPEAN SEARCH REPORT

Application Number
EP 20 30 5885

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Place of search The Hague		Date of completion of the search 10 November 2020	Examiner Hustedt, Bernhard
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