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(54) **METHOD FOR CONNECTING PRECAST SEGMENTS TENDON DUCTS AND RESULTING STRUCTURE**

(57) A method for establishing an air-tight connection between post-tensioning tendon ducts (20) of two consecutive precast segments (10) of a structure, each segment (10) being cast with a recess (40) opening out on a jointing face (14;15) of the segment leaving an access to ends of the ducts (20), the method comprising:
c) Connecting pairs of respective duct ends (20) of the

two consecutive segments (10) together, and
d) pouring a sealing material into the recesses (40) of the two consecutive segments around the duct ends (20) while preventing the material to enter the internal space of the ducts, thus forming an air-tight connection at the junction of ducts.

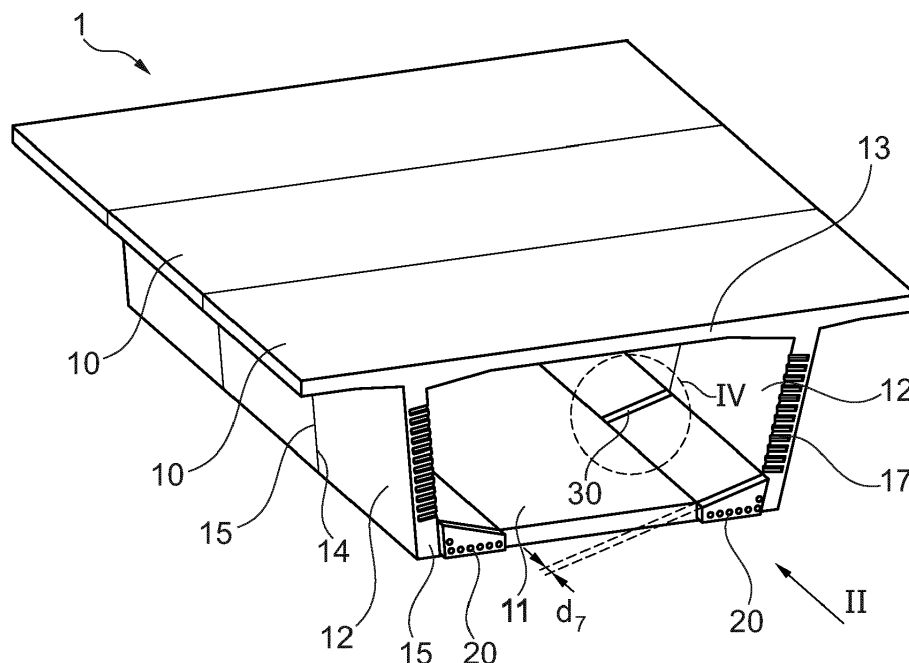


Fig. 1

Description

[0001] The present invention relates to the assembly of precast construction segments (PCS) for building pre-stressed structures such as post-tensioned concrete segmental structures.

[0002] It applies in particular, but not exclusively, to decks of cantilevered bridges built using precast concrete box segments. These structures are frequently subjected to post-tensioning using tendons (also called "strands") threaded inside corresponding ducts embedded in the concrete of several successive segments.

[0003] These segments are preferably made in accordance with a match cast method to ensure a very closely fitting joint.

[0004] The connection of ducts at the joint of two adjacent segments is exposed to a risk of infiltrations of various corroding substances such as deicing solutions and achieving a good seal at the joint if required.

[0005] Furthermore, grout is often injected into the ducts to create a mechanical bound between the tendons and the concrete of the segments and help protect the tendons from corrosion. This grout must not escape from the ducts during injection.

[0006] The joint between two consecutive segments can be made according to a so-called "dry joint" process where the segments are placed side by side without any interface product or according to a so-called "glued joint" process where an adhesive such as epoxy paste is introduced between the segments. In the latter case, the sealing at the junction of ducts also needs to prevent the adhesive from penetrating into the ducts and hinder the further introduction of the tendons.

[0007] In general, pneumatic tests are carried out to check the quality of the sealing before installing the tendons and injecting the grout. If leaks are detected in some ducts, the injection of grout is rendered more difficult and some extra work is needed to guarantee the tendons will be preserved from corrosion.

[0008] One test defined by Appendix A1 of the Technical Report No 72 Durable Post-Tensioned Concrete Structures from the Concrete Society requires in the case of PCS construction that the duct assembly after concreting should resist an air pressure of 0,1 bar and maintain this with no more than 10% loss of pressure for 5 minutes.

[0009] Various solutions relying on the use of specific couplers have been proposed in the past to provide air tightness and grout tightness at the joints.

[0010] Some existing duct couplers are formed of many components and are expensive and complex to use.

[0011] Some other couplers are believed not to provide the required sealing and would have difficulties in passing the air tightness test defined above.

[0012] Furthermore, the use of some couplers is limited to the situation where the ducts are nominally perpendicular to the joint, which is not always the case as in some

instances the tendons are inclined in the concrete webs.

[0013] FR-A-2 596 439 discloses a device to insert between sections of pre-stressing ducts, comprising a cylindrical sleeve engaged between the openings of two adjacent sections to ensure the continuity of the ducts, and an elastic seal surrounding the cylindrical sleeve to ensure sealing and compensate for the positioning variations and dimensional deviations of the adjacent segments which are assembled against each other.

[0014] WO 99/043910 discloses a device to engage in the ducts to connect the adjacent sections in a sealed manner.

[0015] These devices are believed to perform quite well in many situations but there remains a need for further improving the coupling of ducts at the joints to obtain a duct continuity that could pass with repeatability the air-tightness test mentioned above even when the tendons are inclined in the webs.

SUMMARY OF THE INVENTION

[0016] An object of the present invention is thus to propose a simple and efficient solution to the problem of achieving a duct continuity that would pass the air tightness test mentioned above with repeatability and even in situations when the tendons are inclined in the webs.

[0017] A further objet of the invention is to provide a solution that is reliable and easy to implement.

[0018] The invention achieves this goal thanks to a method for establishing an air-tight connection between post-tensioning tendon ducts of two consecutive precast segments of a structure, each segment being cast with a recess (also called a "box-out") opening out on a jointing face of the segment leaving an access to duct ends, the method comprising:

- a) Connecting pairs of respective duct ends of the two consecutive segments together, and
- b) pouring a sealing material into the recesses of the two consecutive segments around the duct ends while preventing the material to enter the internal space of the ducts, thus forming an air-tight connection at the junction of ducts.

[0019] By "air tight connection" it is meant a connection that passes a pneumatic test usually performed for testing the quality of the connection for this type of structure and preferably a connection that passes the 0,1bar test referred to above.

[0020] The sealing material is preferably a High Performance Concrete (HPC) and most preferably an Ultra High Performance Fibre Reinforced Concrete (UHP-FRC).

[0021] The use of UHPFRC provides an air-tight, long term durable "coupling" between the ducts which will not crack nor allow ingress of any contaminant due to its complete lack of porosity and extreme durability.

[0022] The method provides a simple way to obtain the

air tightness connection at a similar or lower cost compared to the use of known couplers.

[0023] The invention allows obtaining an air tightness connection even for tendons that are significantly deviated at the joints.

[0024] It is accepted that a very small thickness of UHPFRC is equivalent in durability terms to many times that thickness in normal concrete. Its pore structure is non-continuous so therefore it is not vulnerable to the environment.

[0025] Experiments have shown that a connection made in accordance with the invention is able to repeatedly pass the air-tightness test mentioned above.

[0026] The connection of the duct ends of a pair at step a) does not need to provide air-tightness as it suffices it prevents ingress of the UHPFRC into the ducts during filling of the recesses with that material.

[0027] One easy way to make this connection is to use a thermo-retractable sleeve that is pre-fixed on one of the duct ends of a pair of ducts. The length of such sleeve ranges for example from 70 mm to 130 mm. The sleeve is slid over and sealed onto the pair of ducts before UHPFRC is poured. This sleeve is a non-structural element that aims to prevent ingress of the UHPFRC into the ducts when UHPFRC is poured into the recesses. The sliding and sealing of the sleeve may take place or not after the tendons are threaded into the ducts.

[0028] Other possibilities exist to make a connection between the ducts that would prevent ingress of UHPFRC into the ducts such as the use of an inflatable tube or an inflatable ball, introduced into the ducts and inflated before UHPFRC is poured so as to seal the inner part of the joint between ducts.

[0029] It is also possible to use a coupler such as a rigid or flexible sleeve engaged on the ducts for the purpose of preventing ingress of UHPFRC.

[0030] If the distance between the two duct ends of a pair is small, an adhesive tape wound around the duct ends may also be used.

[0031] Preferably, the segments are deprived of reinforcement bars protruding out into the recesses, as the use of UHPFRC negates the need to reinforce the infill concrete connection.

[0032] The absence of reinforcement bars protruding into the recess makes the casting of the recesses relatively straightforward and the access to the ends of the ducts is unfettered. A reusable insert may be used for such casting.

[0033] Step b) may take place concurrently with tendon threading.

[0034] HPC concrete is a concrete with a compressive strength equal or exceeding 70 MPa.

[0035] UHPFRC concrete is a concrete with a compressive strength usually exceeding 150 MPa, and of at least 120 MPa.

[0036] The UHPFRC comprises fibres that ensure tensile strength with a ductile behavior.

[0037] The UHPFRC has a relatively high content of

binder, which leads to the absence of capillary porosity.

[0038] Compared to conventional concrete mix, the UHPFRC has a dense matrix. The water/binder ratio (w/b) of UHPFRC typically lies between 0,16 and 0,2.

[0039] In some exemplary embodiments, the recesses are provided in a lower slab and/or an upper slab of the segments and open out into the top surface of the lower slab and/or upper slab. These recesses may be adjacent the lateral walls (also called "webs") of the segments.

[0040] Preferably, the segments are made using match casting technique. The segments may be box segments, for example one-cell box segments.

[0041] The method may comprise testing the air-tightness of the connection of the ducts.

[0042] A further aspect of the invention is a method for casting a segment, comprising:

a) Positioning in a mould :

- ducts for the passage of tensioning tendons,
- inserts for making recesses into which the ends of the ducts extend,
- reinforcing bars,

b) pouring concrete in the mould.

[0043] The reinforcing bars may be curtailed so as not to extend within the recesses.

[0044] A further aspect of the invention is a method for building a segmental structure comprising assembling precast segments, preferably segments with match cast joints, in the continuity of each other, each segment comprising post-tensioning tendon ducts, the method comprising implementing the method as defined above for connecting the ducts.

[0045] A further aspect of the invention is a segmental structure, in particular a structure made in accordance with the method as defined above, preferably a bridge deck, comprising at least two precast segments incorporating ducts in which tensioning tendons are threaded, the ducts being connected together at the joint of the segments by at least one block of a sealing material, preferably Ultra High Performance Fibre Reinforced Concrete (UHPFRC), extending around duct ends of the two adjacent segments, this block extending into adjacent recesses of the segments each opening out on a jointing face of the segments.

[0046] The joint between the two consecutive segments preferably comprise two such blocks. These blocks preferably each extend inwardly of the adjacent lateral wall (or web) of the segments, in the bottom slab. The blocks preferably open out on top of the bottom slab, in the corner thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0047]

FIG. 1 is a partial perspective view of a segmental structure made in accordance with the present invention;

FIG. 2 is a front view along arrow II of figure 1;

FIG. 3 shows detail III of figure 2;

FIG. 4 represents a joint between two consecutive segments with a bundle of tendon ducts shown in transparency;

FIG. 5 is a partial longitudinal section view of a joint taken where the ducts connect;

FIG. 6 shows a jointing face of a precast segment before assembly with a next segment; and

FIGS. 7A to 7C illustrate the formation of a connection between a pair of ducts.

DETAILED DESCRIPTION

[0048] The invention is described below with reference to FIGS. 1-7C in its application to a segmental structure 1 such as a bridge deck made of several precast segments 10 with match-cast coupling surfaces.

[0049] Each segment 10 is in this example a one-cell box concrete segment comprising a bottom slab 11, two symmetrically inclined lateral walls (or webs) 12 and a top slab 13 extending in cantilever fashion beyond the walls (or webs) 12 to define a width of the bridge deck.

[0050] In the longitudinal direction, each segment 10 is delimited by a rear face 14 and a front face 15. The rear face 14 is intended to come into contact against the front face 15 of the previous segment installed on the structure during construction. Likewise, the front face 15 of each segment 10 is intended to receive the rear face 14 of the next segment 10.

[0051] The jointing faces 14, 15 of the adjacent segments 10 are provided with a number of interlocking reliefs 17 ensuring a good shear resistance of the joint and helping relative positioning of the segments as well when they are brought together. In the example shown in FIG. 1, these reliefs 17 are located on the end faces of the lateral walls (or webs) 12 of the segments 10.

[0052] The interlocking reliefs 17 may comprise raised keys each in the shape of a rectangular prism with tapered sides to provide mechanical interlock for accurate location and shear resistance.

[0053] Preferably the segments 10 are match cast, which means that when casting a segment, the jointing face is match cast against its previously cast mating segment so that this segment can act as a former or as part of the mould for this new segment.

[0054] Each segment 10 comprises a number of longitudinal tendon ducts 20, intended to receive post tensioning tendons. These tendons are anchored at their ends by means of any appropriate anchoring devices (not shown).

[0055] It is important to ensure an air-tight connection of each pair of corresponding ducts 20 at the joint of two consecutive segments 10.

[0056] According to the invention, the ducts 20 are con-

nected through blocks 30 of a sealing material that prevents ingress of corrosive substances and provides mechanical resistance. Preferably, this sealing material is UHPFRC.

[0057] The blocks 30 extend at the joint of two consecutive segments 10 on the bottom slab 11 near the lateral walls (or webs) 12.

[0058] Each segment 10 is cast with a recess 40 opening out in the jointing face of the segment 10 and in the top face of the bottom slab 11, as shown in FIG. 6.

[0059] To make the recess 40, an insert (not shown) with appropriate shape is placed in the mould used to cast the segment 10. This insert is preferably reusable.

[0060] Preferably, the bottom slab 11 comprises reinforcing bars (not shown) but these bars are curtailed not to extend into the recess 40. This facilitates the casting thereof.

[0061] When the segments 10 are assembled in the continuity of each other to make the structure, as shown in FIG. 7A, their jointing faces 14, 15 being in contact, the recesses 40 of the two adjacent segments 10 form together a space 47 into which pairs of corresponding duct ends 20 protrude.

[0062] The rear face 43 of each recess 40 may taper inwardly going upward as shown in FIG. 7A. This helps retain the block 30 in the bottom slab 11, as the two rear faces 43 converge upward. The outer side face 44 of the recess 40 may extend in the continuity and alignment of the inner face of the adjacent wall (or web) 12, as shown in FIG. 3.

[0063] One thermo-retractable sleeve 21 may be prefixed (for example threaded or installed otherwise) on one duct end of each pair, as shown, and slid over the other duct end as shown in FIG. 7B. Then the sleeve 21 is sealed on the ducts 20. This connection prevents ingress of UHPFRC into the ducts 20.

[0064] UHPFRC is then poured into the space 47 to fill in the recesses 40 and make the block 30 extending around the duct ends 20, as shown in FIG. 7C.

[0065] UHPFRC is expected to reach a strength of far more than 50 MPa in less than 24 hours and exhibit a stiffness at least equal to that of equivalent strength normal concrete so the stressing operation is not impacted. Preferably, the filling in of the recesses 40 takes place concurrently with tendon threading inside the ducts.

[0066] Each block 30 connects the incorporated ducts 20 in an air-tight fashion and enables the connection to pass the 0,1 bar pneumatic test defined above. Furthermore, each block 30 provides the required mechanical resistance at the junction.

[0067] Each block 30 may have a depth d_7 (measured along the longitudinal axis of the structure) ranging between 150 and 350 mm, for example of about 250 mm.

[0068] In the example shown, the thickness d_1 of UHPFRC extending below the ducts 20 may range from 40 to 60 mm, being for example of about 50 mm.

[0069] The thickness d_2 of the bottom slab 11 below each recess 40 may range from 25 to 35 mm, being for

example of about 30 mm.

[0070] The thickness d_3 of UHPFRC above the ducts 20 where the blocks 30 are thinner, i.e. at their inner side, may range from 75 to 85 mm, being for example of about 80 mm.

[0071] The width d_4 of the blocks 30 may range from 750 to 1250 mm, being for example of about 1050 mm.

[0072] The blocks 30 may have a bottom face 41 that is inclined downwards toward the jointing face. The upper edge of the face 41 may be spaced from the ducts 20 by a distance d_6 as shown in FIG.5 that ranges from 15 to 25 mm, being for example of about 20 mm. The thickness d_5 of UHPFRC at the lower edge of face 41 below the ducts 20 is higher and may range from 50 to 60 mm, being for example of about 55 mm. The volume of infill UHPFRC may be about 0.2 m³ per joint and may be prepared easily on site.

[0073] The invention is not limited to the illustrated embodiment.

[0074] For example, the invention applies to other segmental structures, for example to two-cell box segments 10.

[0075] Furthermore, the tendon ducts may be provided elsewhere on the segments, for example in the top slab and/or in the lateral walls (or webs).

[0076] The number of pairs of ducts 20 connected by each block 30 may vary.

Claims

1. A method for establishing an air-tight connection between post-tensioning tendon ducts (20) of two consecutive precast segments (10) of a structure, each segment (10) being cast with a recess (40) opening out on a jointing face (14;15) of the segment leaving an access to ends of the ducts (20), the method comprising:

a) Connecting pairs of respective duct ends (20) of the two consecutive segments (10) together, and

b) pouring a sealing material into the recesses (40) of the two consecutive segments around the duct ends (20) while preventing the material to enter the internal space of the ducts, thus forming an air-tight connection at the junction of ducts.

2. The method according to claim 1, wherein the sealing material is Ultra High Performance Fibre Reinforced Concrete (UHPFRC).

3. The method of any one of claims 1 and 2, the segments (10) being deprived of reinforcement bars protruding out into the recesses (40).

4. The method according to any one of claims 1 to 3,

wherein a thermo-retractable sleeve (21) is pre-fixed, notably threaded or installed otherwise, on one of the duct ends (20) of a pair of ducts, a length of the sleeve (21) preferably ranging from 70 mm to 130 mm, and then the sleeve (21) is slid over and sealed onto the pair of ducts (20).

5. The method according to any one of claims 1 to 3, wherein an inflatable tube or an inflatable ball, is introduced into the ducts and inflated before the sealing material is poured so as to seal the inner part of the joint between ducts.

6. The method of any one of claims 1 to 5, wherein step b) takes place concurrently with tendon threading.

7. The method according to any one of claims 1 to 6, wherein the recesses (40) are provided in a lower or upper slab (11) of the segments (10) and open out into the top surface of the said lower or upper slab (11).

8. The method of claim 7, wherein the recesses (40) are adjacent the lateral walls (12) of the segments (10).

9. The method according to any one of claims 1 to 8, wherein the segments (10) are made using match casting.

10. The method according to any one of claims 1 to 9, wherein the segments (10) are box segments.

11. The method according to any one of claims 1 to 10, comprising testing the air-tightness of the connection of the ducts.

12. A method for casting a segment (10), comprising :

c) Positioning in a mould :

- ducts (20) for the passage of tensioning tendons,
- inserts for making recesses (40) into which the ends of the ducts extend,
- reinforcing bars,

d) pouring concrete in the mould.

13. The method according to claim 12, wherein the reinforcing bars are curtailed so as not to extend within the recesses (40).

14. A method for building a segmental structure (1) comprising assembling precast segments (10), preferably segments with match cast joints, in the continuity of each other, each segment (10) comprising post-tensioning tendon ducts (20), the method comprising

implementing the method of any one of claims 1 to 11 for connecting the ducts (20).

15. A segmental structure (1), in particular a structure made in accordance with claim 14, preferably a bridge deck, comprising at least two precast segments (10) incorporating ducts (20) in which tensioning tendons are threaded, the ducts (20) being connected together at the joint of the segments (10) by at least one block (30) of Ultra High Performance Fibre Reinforced Concrete (UHPFRC) extending around duct ends (20) of the two adjacent segments, this block extending into adjacent recesses (40) of the segments opening out on a jointing face (14; 15) of the segments.

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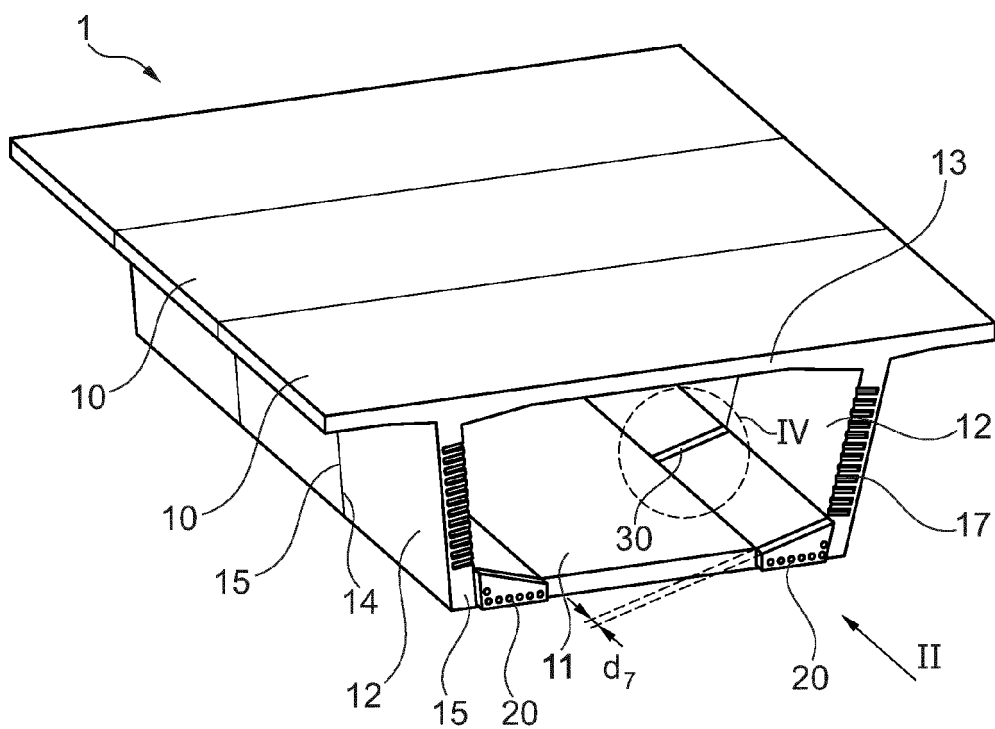


Fig. 1

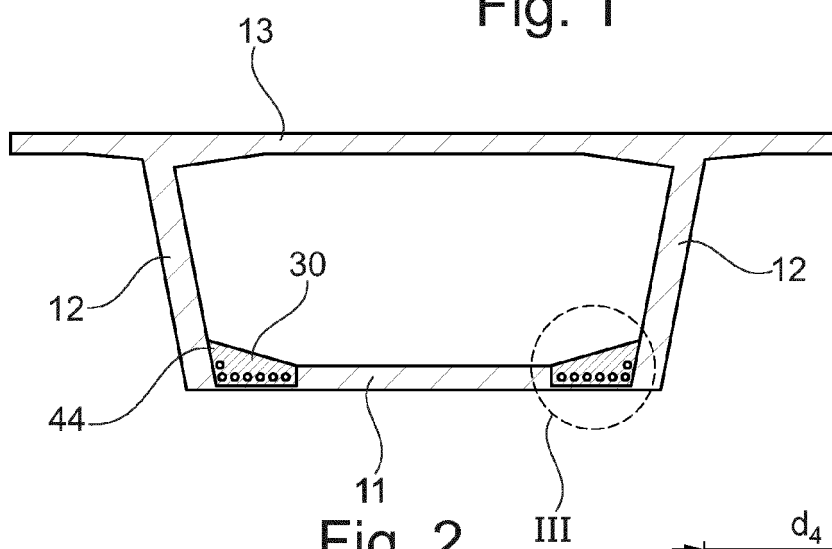


Fig. 2

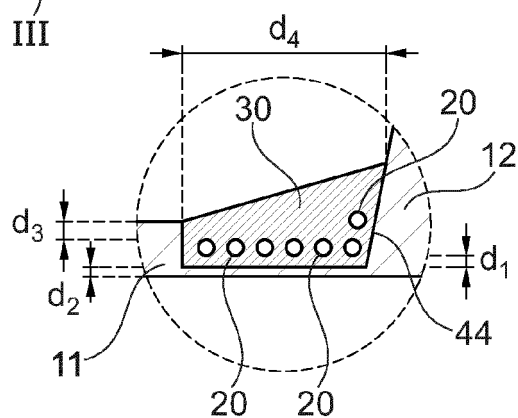


Fig. 3

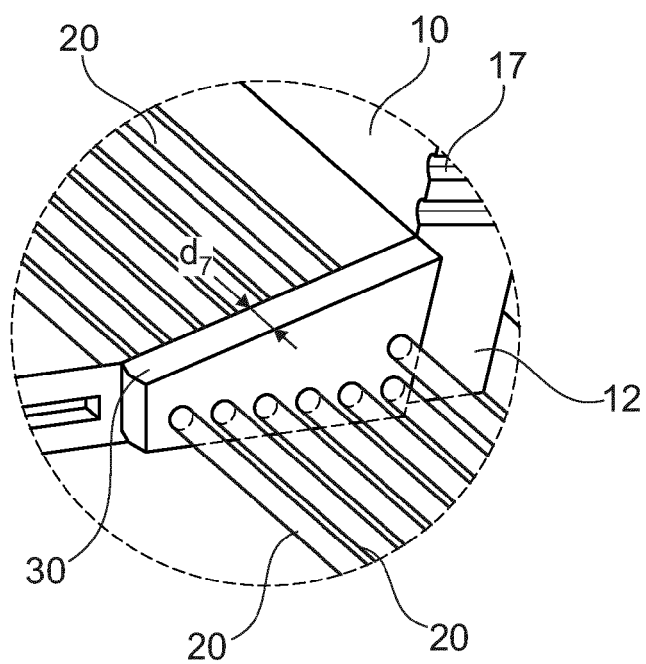


Fig. 4

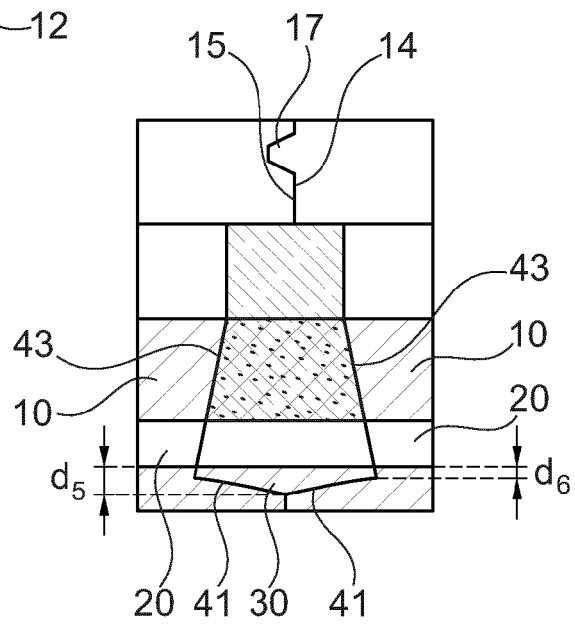


Fig. 5

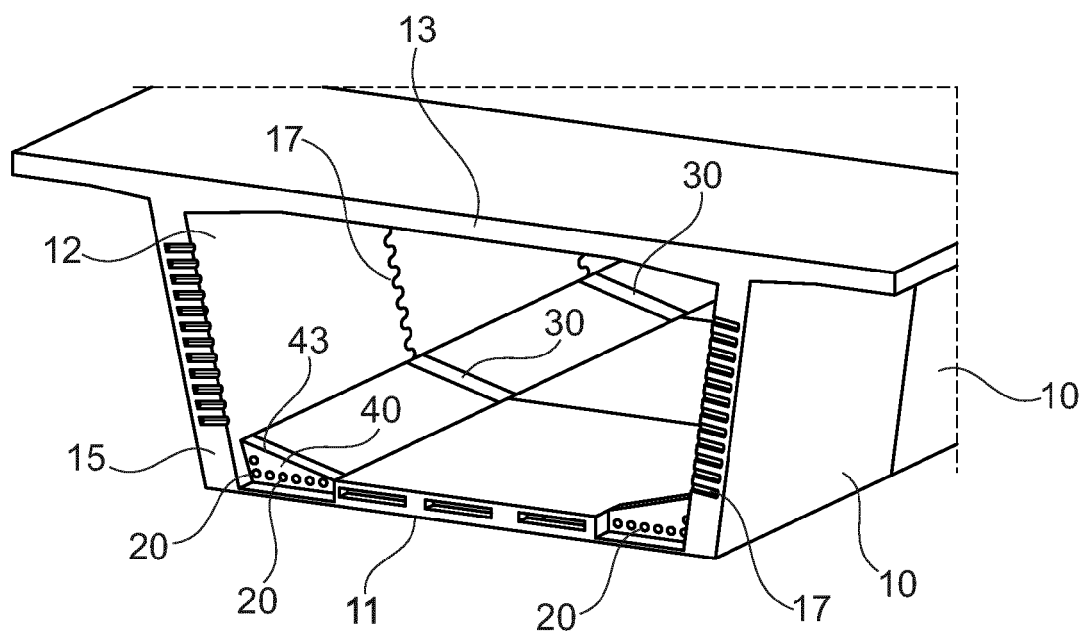
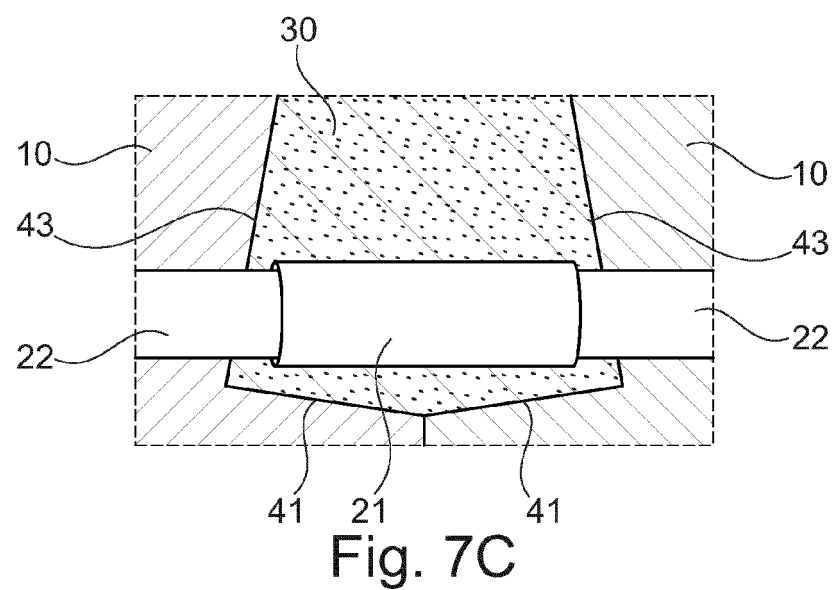
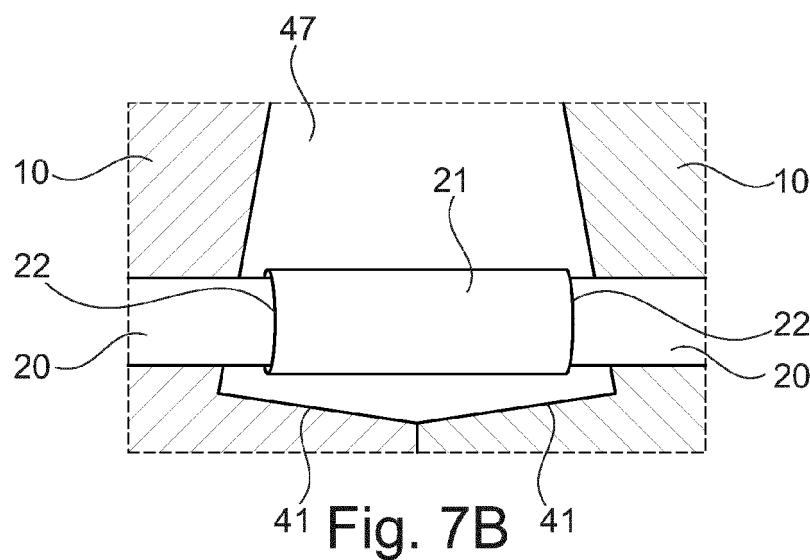
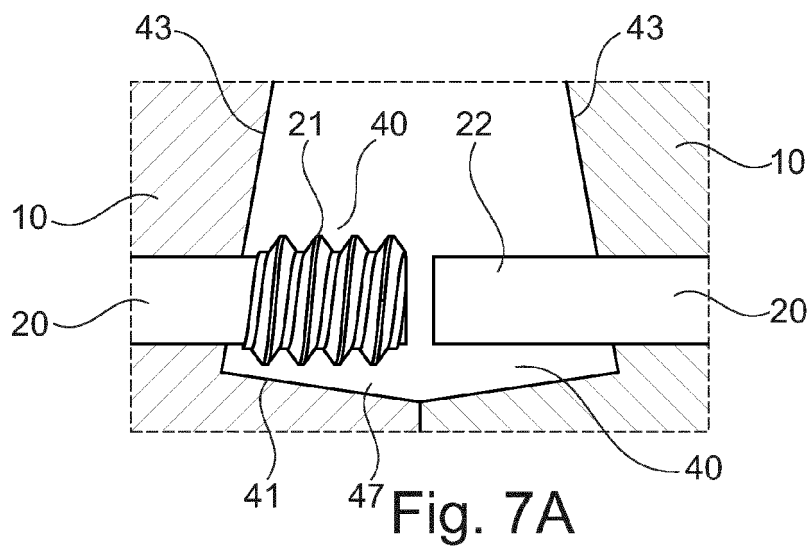


Fig. 6





EUROPEAN SEARCH REPORT

Application Number
EP 18 30 5330

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2010/088985 A1 (MELLIER ERIK [FR] ET AL) 15 April 2010 (2010-04-15) * paragraph [0026] * -----	1-3,6-15	INV. E04C5/10 E01D19/16
X	DE 12 48 269 B (HOCHTIEF AG HOCH TIEFBAUTEN) 24 August 1967 (1967-08-24) * figures *	1-3,6-15	
Y	-----	4	
Y	JP 2017 078268 A (KAJIMA CORP) 27 April 2017 (2017-04-27) * figures 1-2 *	4	
X	JP H07 127304 A (HATSUMI SANGYO KK; NOUYOUCI KENSETSU KYOGYO KUMI) 16 May 1995 (1995-05-16) * figures 4-5 *	1-3,6-15	
X	EP 0 348 870 A1 (ZAPF WERNER) 3 January 1990 (1990-01-03) * figures *	1-3,6-15	
X	DE 15 59 491 B1 (CHRISTMANN WALTER DIPL ING [DE]) 4 June 1970 (1970-06-04) * figures * -----	1-3,6-15	TECHNICAL FIELDS SEARCHED (IPC) E04C E01D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 September 2018	Examiner Demeester, Jan
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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 30 5330

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2010088985 A1	15-04-2010	FR 2970724 A1	27-07-2012
		JP 2010090693 A	22-04-2010
		US 2010088985 A1	15-04-2010
DE 1248269 B	24-08-1967	NONE	
JP 2017078268 A	27-04-2017	NONE	
JP H07127304 A	16-05-1995	JP 2580476 B2	12-02-1997
		JP H07127304 A	16-05-1995
EP 0348870 A1	03-01-1990	AT 105899 T	15-06-1994
		DE 3824107 A1	15-03-1990
		EP 0348870 A1	03-01-1990
DE 1559491 B1	04-06-1970	AT 264092 B	12-08-1968
		CH 449910 A	15-01-1968
		DE 1559491 B1	04-06-1970

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- FR 2596439 A [0013]
- WO 99043910 A [0014]