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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **Tunnel with exterior tube and reinforced interior tube**

(57) The tunnel of ductile double tube is a tunnel to be built in weak soil (1), constituted by two concentric tubes, acting together: an exterior tube (3) formed by precast segments (10), which are mounted by a tunnel boring machine, and an interior tube (4), which is cast inside the exterior tube (3).

The interior tube (4) is provided with longitudinal reinforcements (7) and transversal reinforcements (8), both confined by confining reinforcements (9).

The tunnel is provided with supports, regularly spaced, constituted by groups of piles (6) horizontally flexible, which are anchored upon in concrete blocks (5), evolving de exterior tube (3), and in the stiff soil below (2).

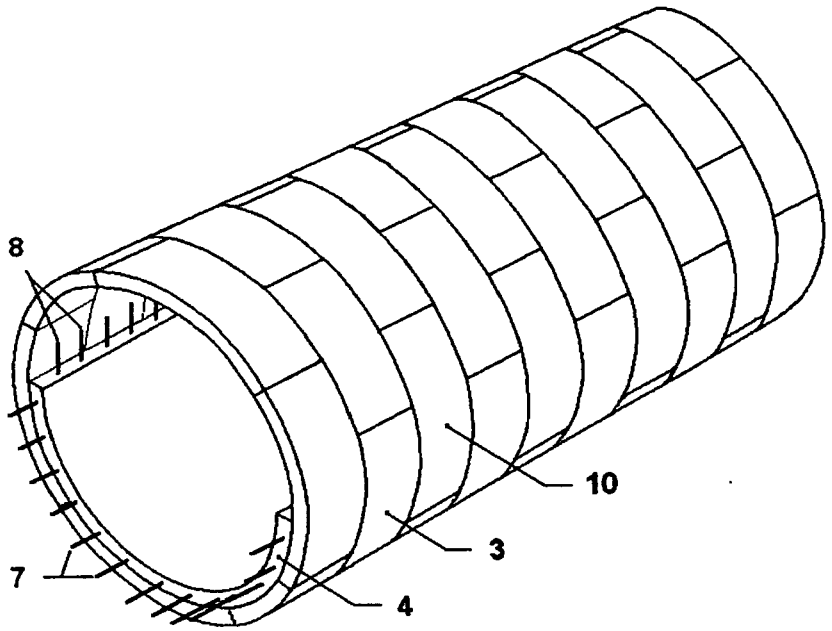

Figure 1

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Description

The former technique

[0001] The technique of execution of tunnels with tunnel boring machines is increasingly used, by technical, economical and environmental reasons.

[0002] With this technique, the machine excavates the soil with its disc cutter head and places precast segments around the excavated surface, forming the circular wall of the tunnel.

[0003] This solution of tunnel building is appropriate for stiff soil, because the tunnels obtained in this way have their stability assured by the strength of the surrounding soil, thus, they do not need to have significant strength in both the transversal direction and the direction of the tunnel axis.

[0004] In the case of weak soil, the execution of tunnels with a tunnel boring machine is unreliable, because, in the tunnel thus formed, the connections between precast segments are very weak; hence, the strength and the ductility of the tunnel are low, so it has the risk of sinking, or collapsing, particularly during earthquakes.

[0005] Document JP 2005-248656 discloses an underground structure, constituted by three arch portions: an outer and an inner arch made of square cylinders, and an intermediate portion made with natural ground between the two arches.

[0006] Document JP7042181 also discloses an underwater tunnel constituted by three tubes, an inner and an outer tube and a third tube formed by filling of the space between.

[0007] Document JP 2-128098 discloses a method of shield lining of a tunnel, in which precast concrete blocks are fixed to the concrete tunnel behind, through reinforcing bars, projected from those blocks.

[0008] Document JP7048851 discloses an underwater tunnel fixed to the bottom ground by mooring members, which is provided with sensors that activate propellers to react against the tidal current, in order to stabilise the tunnel.

[0009] Document US4338045 discloses a device of anchoring a pipeline to the seabed made up of metallic saddle clamps secured on both extremities to piles embedded on the ground.

Technical domain of the invention

[0010] The present invention constitutes an innovative solution for the construction of tunnels of the roadway and the railway types, executed with tunnel boring machines, when the referred tunnels are executed in weak soil (e.g., mud), in seismic areas, allowing for the tunnel to be provided with the necessary strength and ductility.

Description of the figures

[0011] The present invention is illustrated in figures 1, 2, 3 and 4. Figure 1 shows a perspective of the tunnel. Figure 2 shows half cross-section of the tunnel and the reinforcements. Figure 3 shows a detail of the tunnel and the anchor bolts. Figure 4 shows a cross-section of the tunnel and a support.

Detailed description of the invention

[0012] The tunnel is constituted by two concentric tubes in concrete; an exterior tube (3), which is built by a tunnel boring machine in the weak soil (1), and an interior tube (4), which is executed later on, inside the exterior tube (3).

[0013] The tunnel boring machine excavates the weak soil (1) and places precast segments (10) around the tunnel surface, which are linked together, forming the exterior tube (3) of the tunnel, which is circular.

[0014] Inside the exterior tube (3) a concentric interior tube (4) is cast, using the exterior one (3) as exterior formwork and with the help of a supplementary interior formwork.

[0015] Anchor bolts (11) are applied, distributed on the interior surface of the exterior tube (3), to improve the connection between the two tubes. Epoxy resin or similar product can also be applied on the interior surface of the exterior tube (3), to improve the referred connection.

[0016] Longitudinal reinforcements (7) and transversal reinforcements (8) are laid inside the thickness of the interior tube (4), both confined by confining reinforcements (9), in order to provide the tunnel with the necessary strength and ductility, to resist the earthquakes.

[0017] Supports, regularly spaced along the axis of the tunnel, constituted by groups of reinforced concrete piles (6), horizontally flexible, are provided, in order to resist vertical loads while allowing for horizontal movements of the tunnel during earthquakes.

[0018] The piles (6) are connected to the tunnel through concrete blocks (5), evolving the exterior tube (3). The piles are executed by vertically drilling through the weak soil (1) and the concrete blocks (5), being anchored in those blocks (5) and in the stiff soil (2) below.

Claims

1. Tunnel **characterized by** being constituted by two concentric tubes in concrete, acting together; an exterior tube (3) formed by precast segments (10) mounted by a tunnel boring machine, and an interior tube (4), which is cast inside the exterior tube (3) and is provided with longitudinal reinforcements (7) and transversal reinforcements (8), both confined by confining reinforcements (9).

2. Tunnel according to claim 1, **characterised by** being provided with anchor bolts (11), applied on the interior surface of the exterior tube (3), in order to improve the connection between the two tubes (3)

(4).

3. Tunnel according to claim 1, **characterised by** being provided with supports, regularly spaced, constituted by groups of piles (6) horizontally flexible, which are anchored upon in concrete blocks (5), evolving de exterior tube (3), and in the stiff soil (2) below.

Amended claims in accordance with Rule 137(2) EPC.

1. Tunnel **characterized by** being constituted by two concentric tubes in concrete: an exterior tube (1) formed by precast vault segments (3) mounted by a tunnel boring machine, and an interior tube (2), which is cast against the exterior tube (1) and is provided with two layers of longitudinal reinforcements (4) and transversal reinforcements (5), in steel bars of high ductility, confined by confining reinforcements (6).

2. Tunnel according to claim 1, **characterized by** the confining reinforcements (6) to be made from reinforcing bars, bent in multiple stirrups, linking the two layers of reinforcements (4) (5).

3. Tunnel according to claim 1, **characterised by** being provided with anchor bolts (7), applied on the interior surface of the precast vault segments (3), to improve the connection between the two tubes (1) (2).

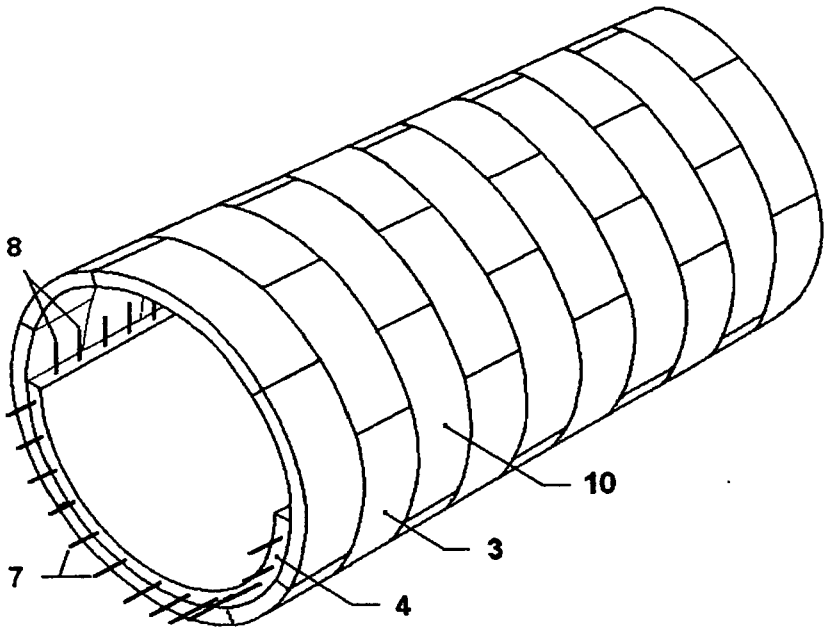

Figure 1

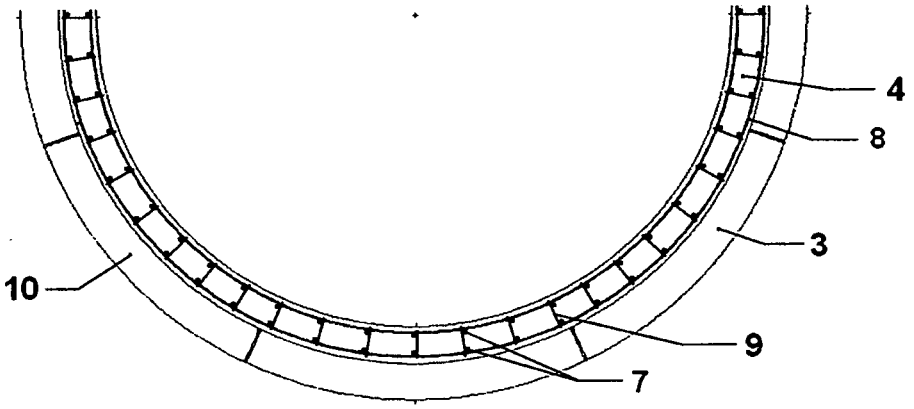

Figure 2

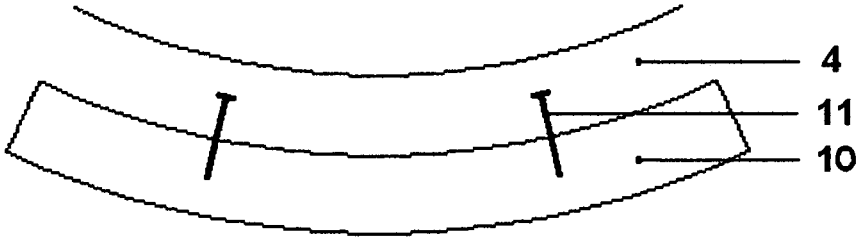

Figure 3

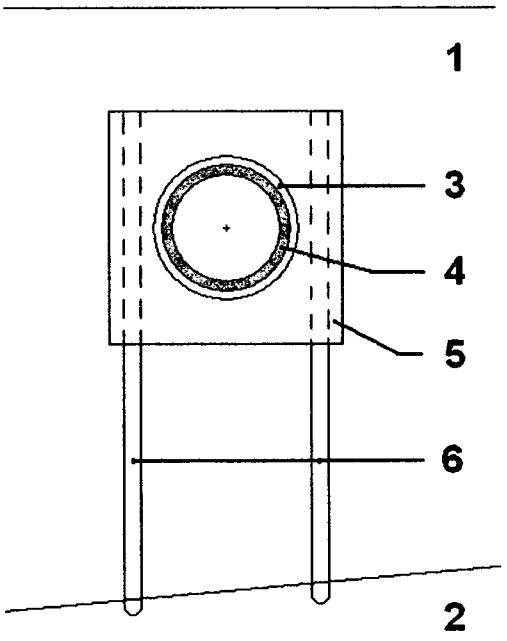

Figure 4

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EUROPEAN SEARCH REPORT

Application Number
EP 11 00 1722

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 Y	JP 2009 203623 A (TOKYU KENSETSU KK) 10 September 2009 (2009-09-10) * abstract *	1 2	INV. E21D11/08 ADD. E21D11/10
Y	JP 7 011897 A (ISHIKAWAJIMA KENZAI KOGYO KK) 13 January 1995 (1995-01-13) * abstract *	2	
A	US 2003/116210 A1 (ISHIKAWA MASATOSHI [JP] ET AL) 26 June 2003 (2003-06-26) * abstract *	1	
A	JP 9 303092 A (KONOIKE CONST) 25 November 1997 (1997-11-25) * abstract *	1	

TECHNICAL FIELDS SEARCHED (IPC)

E21D

1 ~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
The Hague	7 July 2011	Garrido Garcia, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1, 2

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 11 00 1722

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1, 2

   Double tube tunnel

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2. claim: 3

   Support of a tunnel with the help of piles and concrete blocks

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 00 1722

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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07-07-2011

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2005248656 A **[0005]**
- JP 7042181 B **[0006]**
- JP 2128098 A **[0007]**
- JP 7048851 B **[0008]**
- US 4338045 A **[0009]**