

[Document Name] Description

[Title of Invention] CONSTRUCTION METHOD OF UNDERGROUND STRUCTURE

[Technical Field]

The present invention relates to a construction method of an underground structure capable of construction without interfering with an upper traffic in excavation and construction of an underground structure having a large width in a ground under a railway, a road and the like in a traverse direction.

[Background Art]

In excavation of an underground structure having a large width in a ground under a railway, a road or the like in a traverse direction, a protecting work for supporting the upper traffic is necessary, and it includes provision of a pipe roof in which steel pipes and the like are arranged horizontally.

However, if the pipe roof is formed as a separate construction in advance, and an underground structure is constructed as a box body (box culvert) and propelled under the pipe roof, earth covering becomes thicker for a portion of presence of this pipe roof. Moreover, a protecting work for pipe roof construction becomes a construction separate from a main construction of laying the underground structure in the ground, which increases construction cost and period.

Moreover, excavation of a working face portion is performed for propelling the underground structure and then, it is advanced. Thus, a process for excavating the working face portion is needed, and not only that a construction cost is increased for that portion but also a construction period is prolonged for that portion.

Moreover, an excavating work of the working face involves a risk of collapse of the working face portion, and a work for ground improvement such as stabilization processing for stabilizing the working face portion has been needed.

In order to solve such nonconformities, the inventors have filed an application and obtained a patent right of a

construction method of an underground structure in which, when a concrete box body is to be propelled after a box-shaped roof is pressed in as indicated in the following Patent Literatures, earth and sand of the working face portion are pushed out together with the roof along with propulsion of the box body, and thus, a work for excavating the working face portion is not separately needed, whereby cost reduction and shortening of a construction period can be realized, and since an excavating work of the working face portion which involves a risk is saved, safety can be improved and moreover, by distributing reaction force resistance for propelling the box body, a large-scale facility is not required.

[Patent Literature 1] Japanese Patent No. 3887383

[Patent Literature 2] Japanese Patent No. 4134089

[Patent Literature 3] Japanese Patent No. 4317843

This construction method was named an SFT method and is carried in the following Non-Patent Literature 1.

The SFT construction method is an abbreviation of "Simple and Face-Less Method of construction of Tunnel".

[Non-Patent Literature 1] Homepage of Uemura Engineering Co., Ltd. and Underpass Engineering Association on the Internet websites

In the SFT construction method, an earth-retaining steel sheet pile 2 is cast beside an upper traffic (not shown) such as a railway as a first process as illustrated in Fig. 25, a starting shaft 3 and an arriving shaft 4 are constructed, a propelling machine 5 is installed in the starting shaft 3, and a box-shaped roof 6 which is a cylindrical body for roof is pressed in by that toward the arriving shaft 4. A friction cut plate 7 is placed on an upper surface of the box-shaped roof 6 and it is pushed out together with the box-shaped roof 6.

The box-shaped roof 6 is a box-shaped cylindrical body having a rectangular section as illustrated in Figs. 29 and 30, hook-shaped or flat plate-shaped joints 6a and 6b are formed on a side surface continuously in a longitudinal direction, and the friction cut plate 7 made of a flat plate is mounted on the

upper surface. A flange for bolt joining is formed on front and rear ends of the box-shaped roofs 6 so that they can be buried with a required length by being sequentially connected in a length direction, and moreover, they are arranged in parallel through the joints 6a and 6b continuously in vertical and horizontal directions.

Though the propelling machine 5 is not shown in detail, it is for excavating the box-shaped roof 6 by pushing it out by a base-pushing jack using an earth-and-sand discharge pipe as a pushing-out body, and excavation of a distal end face of the box-shaped roof 6 is performed by providing an excavating mechanism such as an auger screw in addition to a case by providing a manual excavation cutting edge.

Regarding the box-shaped roofs 6, they are arrayed/installed having a square shape so as to correspond to an outer shape of a concrete box body 9 to be propelled, and an earth retaining member 19 is disposed in the working face portion surrounded by the array of the box-shaped roofs 6.

Reference numeral 17 in the figure denotes a waling material and is fixed by a tie rod material 18 connecting the earth-retaining steel sheet pile 2 on the starting shaft 3 side and the earth-retaining steel sheet pile 2 on the arriving shaft 4 side. Reference numeral 20 denotes a starting base.

Subsequently, as illustrated in Fig. 26 of a second process, the concrete box body 9 is installed at the starting shaft 3, and the base-pushing jack 10 and a strut 16 are disposed as a propelling facility between it and a reaction wall 8 on a rear of the concrete box body 9.

Then, the friction cut plate 7 is fixed to the starting shaft 3 side by a retaining member 14. The box-shaped roof 6 and the concrete box body 9 as well as peripheral earth and sand are subjected to trimming by this friction cut plate 7.

Subsequently, a distal end of the concrete box body 9 is joined or made to abut to a rear end of the boxes-shaped roof 6 having been pushed out in advance, and the concrete box body 9 is pushed out forward by extending the base-pushing jack 10

as a third process as illustrated in Fig. 27.

At the same time as pushing-out of the concrete box body 9, the box-shaped roof 6 is also pushed out and moreover, without excavating the working face portion, an earth retaining member 19 (a part of the earth-retaining steel sheet pile 2 is used) disposed in a portion surrounded by the box-shaped roofs 6 is pushed out at the same time as the box-shaped roof 6 is pushed out so that earth and sand α on a front thereof are also pushed out at the same time. In this case, since the box-shaped roof 6 and the concrete box body 9 as well as the peripheral earth and sand have been trimmed by the friction cut plate 7 as described above, the box-shaped roof 6 and the concrete box body 9 are propelled smoothly.

When the box-shaped roof 6 and the earth and sand pushed out at the same time while being surrounded by the box-shaped roofs 6 have reached the arriving shaft 4 as above as a fourth process as illustrated in Fig. 28, the box-shaped roof 6 is removed by the arriving shaft 4, and the earth and sand are excavated and removed.

Then, the distal end of the concrete box body 9 is further propelled so as to reach the arriving shaft 4, whereby propulsion of the whole length of the concrete box body 9 is completed.

[Summary of the Invention]

[Problem to be Solved by the Invention]

In the aforementioned conventional SFT construction method, under a water-retaining ground condition, that is, a ground condition having so-called underground water, construction needs to be performed after applying ground improvement such as chemical grouting or the like as a measure against water.

An object of the present invention is to provide a construction method of an underground structure capable of construction without using an expensive supplementary construction method even in the water-retaining ground.

[Means for Solving the Problem]

In order to achieve the aforementioned object, the present invention described in claim 1 is characterized in that, in a construction method of an underground structure in which friction cut plates are overlapped on outer side surfaces and box-shaped roofs are assembled and disposed into a rectangular array of a lower stage, a side part, and an upper stage so as to correspond to an outer shape of a concrete box body to be propelled by being pressed into the ground together with the friction cut plates, and after the box-shaped roof is pressed into the ground, the box body is disposed by matching a distal end portion of the box body with an end portion of the box-shaped roof, and earth and sand inside the rectangular array of the box-shaped roofs are pushed out with propulsion or towing of the box body together with the rectangular array of the box-shaped roofs while leaving the friction cut plate, a water stop structure is formed by overlapping side ends of the friction cut plates.

According to the present invention, since the friction cut plates arranged laterally are overlapped and form the water stop structure, underground water to intrude is stopped by this friction cut plate and does not flow into the concrete box body.

The present invention described in claim 2 is characterized in that a water stop member is interposed between the friction cut plates whose side ends are overlapped.

According to the present invention described in claim 2, a reliable water stop structure can be obtained by interposing the water stop member.

The present invention described in claim 3 is characterized in that, at an arriving shaft for pushing out the earth and sand together with the rectangular array of box-shaped roofs, an earth-retaining jack is provided, and pushing-out is performed by contracting the earth-retaining jack while the earth and sand to be pushed out by this earth-retaining jack are retained.

According to the present invention described in claim 3, since the earth and sand inside to be pushed out together with

the rectangular array of the box-shaped roofs are also soft by retaining water, they can be safely pushed out by contracting the earth-retaining jack and performing pushing-out while the earth and sand to be pushed out are retained by the earth-retaining jack.

[Advantageous Effect of the Invention]

The construction method of an underground structure of the present invention is capable of construction without using an expensive supplementary construction method even in the water-retaining ground as described above.

[Brief Description of the Drawings]

[Fig. 1] Fig. 1 is an explanatory view illustrating arrangement of a box-shaped roof of a construction method of an underground structure of the present invention.

[Fig. 2] Fig. 2 is a front view illustrating a concrete box body of the construction method of an underground structure of the present invention.

[Fig. 3] Fig. 3 is a longitudinal sectional side view of a first process illustrating a first embodiment of the construction method of an underground structure of the present invention.

[Fig. 4] Fig. 4 is a longitudinal sectional side view of a second process illustrating the first embodiment of the construction method of an underground structure of the present invention.

[Fig. 5] Fig. 5 is a longitudinal sectional side view of a third process illustrating the first embodiment of the construction method of an underground structure of the present invention.

[Fig. 6] Fig. 6 is a longitudinal sectional side view of a fourth process illustrating the first embodiment of the construction method of an underground structure of the present invention.

[Fig. 7] Fig. 7 is a longitudinal sectional side view of a fifth process illustrating the first embodiment of the construction method of an underground structure of the present

invention.

[Fig. 8] Fig. 8 is a longitudinal sectional side view of a sixth process illustrating the first embodiment of the construction method of an underground structure of the present invention.

[Fig. 9] Fig. 9 is a longitudinal sectional side view of a first process illustrating a second embodiment of the construction method of an underground structure of the present invention.

[Fig. 10] Fig. 10 is a longitudinal sectional side view of a first process of a first method of divided removal of the box-shaped roof illustrating the second embodiment of the construction method of an underground structure of the present invention.

[Fig. 11] Fig. 11 is a longitudinal sectional side view of a second process of the first method of divided removal of the box-shaped roof illustrating the second embodiment of the construction method of an underground structure of the present invention.

[Fig. 12] Fig. 12 is a longitudinal sectional side view of a second process of a second method of divided removal of the box-shaped roof illustrating the second embodiment of the construction method of an underground structure of the present invention.

[Fig. 13] Fig. 13 is a longitudinal sectional side view of a third process of the second method of divided removal of the box-shaped roof illustrating the second embodiment of the construction method of an underground structure of the present invention.

[Fig. 14] Fig. 14 is a longitudinal sectional side view of a first process of a third method of divided removal of the box-shaped roof illustrating the second embodiment of the construction method of an underground structure of the present invention.

[Fig. 15] Fig. 15 is a longitudinal sectional side view of a complete form illustrating the second embodiment of the

construction method of an underground structure of the present invention.

[Fig. 16] Fig. 16 is a side view of the first process of use of an arriving-side earth-retaining jack.

[Fig. 17] Fig. 17 is a side view of the second process of use of an arriving-side earth-retaining jack.

[Fig. 18] Fig. 18 is a side view of the third process of use of an arriving-side earth-retaining jack.

[Fig. 19] Fig. 19 is an image view of connection between the box-shaped roof and a concrete box body.

[Fig. 20] Fig. 20 is an end surface view of the box-shaped roof and a friction cut plate.

[Fig. 21] Fig. 21 is an explanatory view of overlapping of the friction cut plates.

[Fig. 22] Fig. 22 is an explanatory view of interposition of a water stop member.

[Fig. 23] Fig. 23 is an explanatory view of interposition of the water stop member.

[Fig. 24] Fig. 24 is an end surface view of the water stop member.

[Fig. 25] Fig. 25 is a longitudinal sectional side view illustrating a first process of a conventional construction method of an underground structure.

[Fig. 26] Fig. 26 is a longitudinal sectional side view illustrating a second process of the conventional construction method of an underground structure.

[Fig. 27] Fig. 27 is a longitudinal sectional side view illustrating a third process of the conventional construction method of an underground structure.

[Fig. 28] Fig. 28 is a longitudinal sectional side view illustrating the third process of the conventional construction method of an underground structure.

[Fig. 29] Fig. 29 is a front view of an example of the box-shaped roof.

[Fig. 30] Fig. 30 is a front view of another example of the box-shaped roof.

[Embodiments for Carrying Out the Invention]

Embodiments of the present invention will be described below in detail by referring to the attached drawings. Figs. 3 to 8 are longitudinal sectional side views of each process illustrating a first embodiment of a construction method of an underground structure of the present invention, and the same reference numerals are given to the same constituent elements as those in Figs. 25 to 28 illustrating the conventional example.

This embodiment is for a case where an underground structure is to be constructed in a water-resistant ground β .

In the present invention, too, as in the conventional SFT construction method, as a first process as illustrated in Fig. 1, a temporary earth-retaining pile made of an earth-retaining steel sheet pile 2 of a sheet pile or the like is cast beside upper traffic (not shown) such as a railway, a starting shaft 3 and an arriving shaft 4 are constructed, a starting base 20 by debris and base concrete cast is formed at the starting shaft 3 as illustrated in Fig. 2, a propelling machine (not shown, see Fig. 25) is installed, and a box-shaped roof 6 which is a cylindrical body for roof is pressed in by this toward the arriving shaft 4.

An arriving base 21 by debris and base concrete cast is also formed at the arriving shaft 4.

The box-shaped roof 6 is a box-shaped cylindrical body having a rectangular section as illustrated in Figs. 29 and 30 similarly to the conventional example, and a flange for bolt joining is formed on front and rear ends (not shown) so that a required length can be buried by sequentially connecting it in a length direction.

The box-shaped roof 6 used in the present invention is formed by continuing hook-shaped or flat plate-shaped joints 6a and 6b in a longitudinal direction on the side surface and the friction cut plate 7 is placed on the upper surface.

The friction cut plate 7 is a band-plate steel sheet but an end portion is welded and integrated to an end portion of

the box-shaped roof 6 while it is simply placed other than that, and when the box-shaped roofs 6 are sequentially connected in the length direction, the friction cut plates 7 are assumed to be also continued by connecting to each other by welding or the like.

In the present invention, as illustrated in Figs. 20 and 21, the friction cut plate 7 has a large width so as to extend to right and left from a width of the box-shaped roof 6, and side ends are overlapped so as to have a water stop structure.

In overlapping as above, one of side ends of the friction cut plate 7 is bent in the length direction so as to form it as a floated-shaped flange 7a, and one of side ends 7b of the adjacent friction cut plate 7 enters below it.

By constituting as above, the friction cut plates 7 arranged laterally are aligned without changing their levels but firmly overlapped without going diagonal.

Moreover, as illustrated in Figs. 22 to 24, the friction cut plates 7 overlapped at the side ends may have a water stop member 22 interposed between the overlapped portions.

Various materials can be employed for the water stop member 22, but those by molded synthetic rubber are suitable. The one illustrated in Fig. 24 has projections and recesses as a mountain-shaped stripe pattern given on a sheet-shaped body.

As illustrated in Fig. 22, the water stop member 22 is bonded to a rear side of the floated-shaped flange 7a and is crushed so as to stop water when the friction cut plates 7 are overlapped on the side ends.

As illustrated in Figs. 1 and 3, the box-shaped roof 6 in which the friction cut plates 7 are overlapped is pressed from the starting shaft 3 into the arriving shaft 4, and the box-shaped roofs 6 are assembled and disposed into a rectangular array of a lower stage, a side part, and an upper stage so as to correspond to an outer shape of the concrete box body 9 to be propelled.

As illustrated in Fig. 4, a distal end of the concrete box body 9 to be installed on the starting base 20 at the starting

shaft 3 is matched with an end of the box-shaped roof 6 arrayed in the earth, and the base-pushing jack 10 is installed in front of the reaction wall 8 of the starting shaft 3 and this is made to abut to a rear end of the concrete box body 9 through a rough square 23.

A rough square 24 by an H-shaped steel material as a box body connecting work is attached to a front end of the concrete box body 9.

The friction cut plate 7 releases connection with the box-shaped roof 6 on the end portion (releases welding fixation) and is fixed to the earth-retaining steel sheet pile 2.

The distal end of the concrete box body 9 is joined to or is made to abut to the rear end of the box-shaped roof 6 as illustrated in Fig. 4, and the concrete box body 9 is pushed out by the base-pushing jack 10 together with the box-shaped roof 6. Reference numeral 16 in the figure denotes a strut used in pushing-out.

The concrete box body 9 can be also towed other than the case of propulsion. The towing is performed such that a front reaction wall of the box body is provided, a fixing device or a towing jack is attached to a rear part of the box body, the other end of a towing cable having one end attached to this fixing device or the towing jack is fixed to the towing jack or the fixing device fixed to the reaction wall, and towing is performed by the towing jack. Propulsion or towing of the concrete box body 9 may be performed by using either one of them or both of propulsion and towing.

As described above, the concrete box body 9 is to be propelled or towed, and the box-shaped roof 6 is also pushed out at the same time as propulsion and towing of the concrete box body 9 and moreover, without preforming excavation of the working face portion, the box-shaped roof 6 is pushed out as it is when there is no earth and sand between the box-shaped roofs 6 or when there are earth and sand, the box-shaped roof 6 is pushed out together with the earth and sand by the arriving shaft 4.

The earth-retaining member 19 is disposed in the working face portion surrounded by the box-shaped roofs 6 and is pushed out together with the box-shaped roofs 6 while retaining the earth and sand by that, and as this earth-retaining member 19, an inside steel sheet pile surrounded by the box-shaped roofs 6 can be used by opening the temporary earth-retaining pile 2 to both sides.

Moreover, regarding the friction cut plate 7 stacked on the box-shaped roof 6, by stopping and leaving the end portion in the vicinity of a pit mouth when the box-shaped roof 6 is to be pushed out at the same time as propulsion or towing of the concrete box body 9, the box-shaped roof 6 or the concrete box body 9 and a rock mass can be trimmed.

Moreover, the friction cut plates 7 arranged laterally are overlapped so as to form the water stop structure as a cylindrical body and thus, the underground water to intrude is stopped by this friction cut plate 7 and does not flow into the concrete box body 9. As a result, back-filling and pouring is not necessary for the concrete box body 9.

When the box-shaped roofs 6 have reached the arriving shaft 4, as described above, the box-shaped roofs 6 are sequentially removed altogether by the arriving shaft 4.

Fig. 8 is a stage where pressing-in of the concrete box body 9 is completed, and all the concrete box bodies 9 are installed.

The earth and sand are also pushed out to the arriving shaft 4 together with the box-shaped roofs 6, and this is also removed with removal of the box-shaped roofs 6.

Figs. 9 to 15 illustrate a second embodiment of the present invention in which a construction length of the underground structure is long and an interval between the starting shaft 3 and the arriving shaft 4 is large. The box-shaped roof 6 also becomes long.

In such a case, as illustrated in Figs. 11 to 15, when the box-shaped roof 6 has reached the arriving shaft 4, the box-shaped roofs 6 are divided and removed by the arriving shaft

4.

When the box-shaped roofs 6 are divided and removed as above, as illustrated in Figs. 16 to 18, an earth-retaining jack 25 is provided at the arriving shaft 4 for pushing out the earth and sand together with the rectangular array of the box-shaped roofs 6.

Then, the earth-retaining member 19 is pushed by this earth-retaining jack 25, and pushing-out is performed by contracting the earth-retaining jack 25 while the earth and sand to be pushed out are retained.

The pushed-out earth and sand are removed after the earth-retaining member 19 is excluded.

[Description of Symbols]

2	earth-retaining steel sheet pile
3	starting shaft
4	arriving shaft
5	propelling machine
6	box-shaped roof
6a, 6b	joint
7	friction cut plate
7a	flange
7b	side end
8	reaction wall
9	concrete box body
10	base-pushing jack
14	retaining member
16	strut
17	waling material
18	tie rod material
19	earth-retaining member
20	starting base
21	arriving base
22	water stop member
23	rough square
24	rough square
25	earth-retaining jack

[Document Name] Claims

[Claim 1]

A construction method of an underground structure characterized in that;

friction cut plates are overlapped on outer side surfaces and box-shaped roofs are assembled and disposed into a rectangular array of a lower stage, a side part, and an upper stage so as to correspond to an outer shape of a concrete box body to be propelled by being pressed into the ground together with the friction cut plates, and after the box-shaped roof is pressed into the ground, the box body is disposed by matching a distal end portion of the box body with an end portion of the box-shaped roof, and earth and sand inside the rectangular array of the box-shaped roofs is pushed out with propulsion or towing of the box body together with the rectangular array of the box-shaped roofs while leaving the friction cut plate, a water stop structure is formed by overlapping side ends of the friction cut plates.

[Claim 2]

The construction method of an underground structure according to claim 1, wherein

a water stop member is interposed between the friction cut plates whose side ends are overlapped.

[Claim 3]

The construction method of an underground structure according to claim 1 or 2, wherein

at an arriving shaft for pushing out the earth and sand together with the rectangular array of box-shaped roofs, an earth-retaining jack is provided, and pushing-out is performed by contracting the earth-retaining jack while the earth and sand to be pushed out by this earth-retaining jack are retained.