

[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 constructing an existing crossing structure 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 a railway and the like, in construction methods of structures crossing under the ground, a temporary track construction method or a track temporary receiving construction method by excavating construction method (construction girder) has been a mainstream at first. However, with an increase in the number of trains, employment of the excavating construction method with many in-track works has become difficult. Thus, a non-excavating construction method was developed as a construction method by which crossing structures can be constructed under the track in a state where operations of trains are ensured. This is called a jacking method and as illustrated in Fig. 26, a precast concrete box body 1 (box culvert) as an underground structure made of reinforced concrete with a large width is jacked.

This jacking is performed by mounting a cutting edge 2 by a hood made of steel at a distal end of the precast concrete box body 1 (box culvert) and by performing excavation inside the cutting edge 2 so as to provide a gap in front and also by jacking this concrete box body 1 with a base-pushing jack 4 installed at a starting shaft 3.

In the figure, reference numeral 9 denotes an arriving vertical shaft, and the starting vertical shaft 3 and the arriving vertical shaft 9 are constructed by sandwiching the crossing spot below an upper traffic 8 such as a track and by retaining it with an earth-retaining member 13.

In the figure, reference numeral 5 denotes a reaction wall to be provided at the arriving vertical shaft 3, reference numeral 6 denotes a strut, and reference numeral 7 denotes a base concrete. The concrete box body 1 is formed by connecting and extending rectangular unit box bodies 1a each having a width of 1 to 2 m into a vertical row.

As described above, by jacking the concrete box body 1 under the upper traffic 8 such as a track and when the cutting edge 2 comes out of the arriving vertical shaft 9, this is removed, and the buried concrete box body 1 is used as a tunnel or any other underground structures.

In order to excavate the precast concrete box body (box culvert) 1 having a large width in the ground below the railway, a road or the like in a traverse direction, a protecting work for supporting the upper traffic is required, and such protecting works conventionally include a pipe-roof construction method in which pipe roofs with steel pipes and the like juxtaposed horizontally are provided.

The pipe roof construction method is a method of inserting the pipe roof 16 (steel pipe) under the track in advance as a protecting work for the track, and after the track is temporarily received for each steel pipe by a timbering work, earth and sand under the pipe roof 16 is excavated, and the concrete box body 1 is constructed.

The pipe roofs 16 are, as illustrated in Fig. 27, continuously arrayed and constructed so as to surround an upper side and sides of the concrete box body 1 which forms a rectangular section as a gate-shaped frame, and the concrete box body 1 is excavated in the frame formed by the pipe roofs 16 with a gap of several tens cm.

[Summary of Invention]

[Problems to be Solved by Invention]

The jacking construction method illustrated in Fig. 26 as above is to jack the concrete box body 1 with the bas-pushing jack 4 installed at the starting vertical shaft 3, and friction resistance against the concrete box body 1 received from an

inside of the earth increases as a cast length of the concrete box body 1 becomes longer, which requires a stronger jacking force for that portion and increases a size of the base-pushing jack.

Moreover, in the pipe-roof construction method, a body structure is excavated inside the roofs or walls in which the pipes (steep pipes) are horizontally cast having an arch shape or a columnar shape, and a top end position of the concrete box body 1 becomes low for that portion in addition to an earth covered portion and a diameter portion of the pipe (steel pipe), which makes jacking in a deep position.

Moreover, since the pipe forming the pipe roof 16 cannot be removed, there are problems that a construction cost rises and the like.

An object of the present invention is to solve nonconformity of the aforementioned prior-art example and to provide a construction method of installing an underground structure in which, as a protecting work in a case of performing a jacking construction method of the concrete box body, since earth covering of the structure can be made shallow, an access road gradient becomes gentle, and an underpass which is safe and easy to use can be installed, since an access road section can be reduced, it can be applied easily even in an existing city area, since an excavation depth of the entire work is shallow, a construction cost of the entire underpass is lowered, the structure can be made in a bright state where management is easy, since a box-shaped rigid-frame structure can be installed, the protecting work can be applied even in a case where a traverse length is long, and since the box-shaped roof as the protecting work can be re-used, it is economical.

[Means for Solving the Problems]

In order to achieve the aforementioned object, the present invention described in claim 1 has a gist that, as a protecting work when a concrete box body to be installed as an underground structure is to be jacked, a box-shaped roof in which box-shaped cylindrical steel pipes each having a

rectangular section are arrayed so as to match an outer edge of the concrete box body scheduled to be installed, this box-shaped roof is pushed in and penetrated between a starting vertical shaft and an arriving vertical shaft which is an entire length of a traverse section in advance, the concrete box body in which a cutting edge which is a cutting-face excavating work space made of steel is installed at a rear end thereof is installed, the box-shaped roof is pushed out while the cutting face is excavated in the cutting edge and the concrete box body is jacked, and the box-shaped roof and the concrete box body are replaced and installed.

According to the present invention described in claim 1, the box-shaped roof which is the protecting work is a steel pipe having a rectangular section, and since it can be arrayed so as to match the outer edge of the concrete box body scheduled to be installed, earth covering of the structure can be made shallow.

Then, since the earth covering (α , β) of the structure can be made shallow, the access road gradient becomes gentle, and an underpass which is safe and easy to use can be installed. Fig. 28 illustrates comparison between the present invention and the prior-art example.

Moreover, since the road section for access can be reduced, it can be applied easily even in the existing city area, and since the excavation depth of the entire work becomes shallow, a construction cost of the entire underpass is lowered.

Furthermore, a state in which a traverse spot is left unstable for a long time is not continued as in the excavating construction method in which a large groove in the ground is made while earth-retaining is performed, and a concrete structure is formed by using a mold in it or as in a cast-in-place concrete construction method by a temporary receiving of timbering in which the timbering is assembled and an inside thereof is excavated so as to form a concrete structure, but the structure concrete box body can be manufactured in a bright state where management is easy, safety is extremely high.

By using the box-shaped roof, a box-shaped rigid-frame structure can be installed, and it can be applied also to a case where a traverse length is large.

Since the box-shaped roof can be re-used, it is economical as compared with the pipe roof.

The present invention described in claim 2 has a gist that, the box-shaped roof is pushed in and penetrated between the starting vertical shaft and the arriving vertical shaft by placing a friction cut plate made of a band-shaped flat plate on an outer side surface, this friction cut plate is fixed at an end portion to the starting vertical shaft side and is left at pushing-out of the box-shaped roof, the concrete box body is excavated inside the friction cut plate, and the friction cut plate forms a friction cut with a rock mass when the concrete box body is jacked.

According to the present invention described in claim 2, since the box-shaped roof is a box-shaped cylindrical body having a rectangular section, the friction cut plate which is a steel plate for the friction cut can be placed on an upper surface of, (for example) the outer side surface of this box-shaped roof, and by leaving the friction cut plate in the ground at installation of the box body, connection with the rock mass is cut off, and disturbance of an upper ground can be prevented.

Moreover, by means of an effect of pushing-out of the box-shaped roof and the friction cut plate, an installation position of the box body can be made shallow.

The present invention described in claim 3 has a gist that, in the box-shaped roof, the unit cylindrical body is press-fitted one by one, a joint flange for bolt joint is formed at an end portion, and a required length is buried by extending the joint flanges in a length direction one by one by fastening the joint flanges to each other with a bolt and a nut.

According to the present invention in claim 3, in the box-shaped roof, the predetermined length can be ensured by fastening the unit cylindrical body with the bolt and nut, and

by fastening these joint flanges to each other with the bolt and nut, strength against deflection or the like can be ensured even if a predetermined length is ensured.

Furthermore, in the case of removal of the box-shaped roof, too, they can be separated one by one by releasing the fastening with the bolt and the nut, can be easily recovered without cutting, and moreover, since they can be reused, it is economical.

The present invention described in claim 4 has a gist that the fastening with the bolt and the nut is made at a portion where an end-portion corner angle of the unit cylindrical body is made a box-out by opening it outward.

According to the present invention described in claim 4, in addition to an action of claim 3, since the bolt and the nut performing the fastening are contained in the box-out, they do not extend or interfere with jacking or the like and moreover, fastening or releasing work can be performed from an outside of the box-shaped roof.

The present invention described in claim 5 has a gist that, in the box-shaped roof, hook-shaped or flat-plate shaped joints are formed on a side surface continuously in a longitudinal direction.

According to the present invention described in claim 5, since the box-shaped roofs to be juxtaposed laterally are connected through the joints formed on the side surface, they can be sequentially jacked by using the box-shaped roof to be buried at first as a reference guide, and intervention of earth and sand can be also prevented by the joints.

The present invention described in claim 7 has a gist that the box-shaped roof is arranged in a flat-plate shape so as to correspond to an upper floor plate of the concrete box body to be jacked, the concrete box body in which the cutting edge which is the cutting-face excavating work space made of steel is installed at a rear end thereof is installed, and the box-shaped roof is pushed out while the cutting face is being excavated in the cutting edge, and the concrete box body is jacked.

According to the present invention described in claim 7, as a jacking method of the concrete box body to be installed as an underground structure, the concrete box body in which the cutting edge which is the cutting-face excavating work space is installed is mounted, and the box-shaped roof is pushed out while the cutting face is being excavated in the cutting edge, and the concrete box body is jacked, and the box-shaped roof can be pushed out by the concrete box body with a jacking force (a jacking jack or a traction jack) for performing jacking of the concrete box body.

The present invention described in claim 8 has a gist that a small jack is arranged on the box-shaped roof rear end between that and the concrete box body, and jacking of the box-shaped roof with the small jack using the concrete box body as a reaction force and jacking of the concrete box body are performed alternately.

According to the present invention described in claim 8, the small jack is extended and the box-shaped roof is sequentially jacked one by one using the concrete box body as a reaction force, and once advancement of the box-shaped roof is completed, the small jack is contracted and then, the concrete box body 1 is excavated and thus, a large jacking facility is not needed, and it is suitable for a case where a traverse extension of construction is long, a case where the entire width of the box body is large and the like.

The present invention described in claim 9 has a gist that the box-shaped roof is arranged having a square shape so as to correspond to an outer shape of the concrete box body to be jacked, an earth-retaining member is disposed in the cutting face portion surrounded by the box-shaped roof, and earth and sand of the portion surrounded by the box-shaped roof are pushed out at the same time without excavating the cutting face portion when the box-shaped roof is pushed out.

According to the present invention described in claim 9, after the box-shaped roof is press-fitted, when the concrete box body is to be jacked, the earth and sand of the cutting face

portion are pushed out together with the box-shaped roof with the jacking of the box body and thus, a work of excavating the cutting face portion is not separately required, and cost reduction and a work period reduction can be realized, and moreover, safety can be improved by saving the excavating work of the cutting face portion involving a risk, and moreover, by distributing reaction force resistance for jacking the box body, a large facility is no longer required.

[Advantageous Effect of the Invention]

As described above, the construction method of an underground structure of the present invention as the protecting work in the case of performing the jacking construction method of the concrete box body, since earth covering of the structure can be made shallow, the access road gradient becomes gentle, the underpass which is safe and easy to use can be installed, since the access road section can be reduced, it can be applied even in the existing city area easily, since the excavation depth of the entire work is shallow, the construction cost of the entire underpass is lowered, the structure can be made in a bright state where management is easy, since a box-shaped rigid-frame structure can be installed with the protecting work, the protecting work can be applied even in the case where the traverse length is long, and the box-shaped roof as the protecting work can be re-used, which is economical.

[Brief Description of the Drawings]

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

[Fig. 3] Fig. 3 is a perspective view illustrating a connecting method of box-shaped roofs.

[Fig. 4] Fig. 4 is a perspective view illustrating a removal situation of the box-shaped roof.

[Fig. 5] Fig. 5 is a side view of a connection portion of the box-shaped roofs.

[Fig. 6] Fig. 6 is a front view illustrating arrangement of the box-shaped roof and a friction cut plate.

[Fig. 7] Fig. 7 is a perspective view illustrating a fixed example of the friction cut plate.

[Fig. 8] Fig. 8 is a perspective view illustrating another fixed example of the friction cut plate.

[Fig. 9] Fig. 9 is a side view illustrating jacking of the box-shaped roof.

[Fig. 10] Fig. 10 is an explanatory diagram illustrating a pattern of joints of the box-shaped roof.

[Fig. 11] Fig. 11 is a side view of a first process of a first embodiment of the construction method of the underground structure of the present invention.

[Fig. 12] Fig. 12 is a side view of a second process of the first embodiment of the construction method of the underground structure of the present invention.

[Fig. 13] Fig. 13 is a side view of a third process of the first embodiment of the construction method of the underground structure of the present invention.

[Fig. 14] Fig. 14 is a side view of a fourth process of the first embodiment of the construction method of the underground structure of the present invention.

[Fig. 15] Fig. 15 is a side view when the first embodiment of the construction method of the underground structure of the present invention is completed.

[Fig. 16] Fig. 16 is a side view of a second embodiment of the construction method of the underground structure of the present invention.

[Fig. 17] Fig. 17 is a side view of a third embodiment of the construction method of the underground structure of the present invention.

[Fig. 18] Fig. 18 is a side view of a fourth embodiment of the construction method of the underground structure of the present invention.

[Fig. 19] Fig. 19 is a side view of a fifth embodiment of the construction method of the underground structure of the present invention.

[Fig. 20] Fig. 20 is a side view before jacking of the box-shaped roof of the sixth embodiment of the construction method of the underground structure of the present invention.

[Fig. 21] Fig. 21 is an enlarged side view before jacking of the box-shaped roof of the sixth embodiment of the construction method of the underground structure of the present invention.

[Fig. 22] Fig. 22 is a side view after jacking of the box-shaped roof of the sixth embodiment of the construction method of the underground structure of the present invention.

[Fig. 23] Fig. 23 is an enlarged side view after jacking of the box-shaped roof of the sixth embodiment of the construction method of the underground structure of the present invention.

[Fig. 24] Fig. 24 is a side view of a preceding step of a seventh embodiment of the construction method of the underground structure of the present invention.

[Fig. 25] Fig. 25 is a side view of a post step of the seventh embodiment of the construction method of the underground structure of the present invention.

[Fig. 26] Fig. 26 is a side view illustrating a jacking construction method as a prior-art example.

[Fig. 27] Fig. 27 is a front view illustrating a pipe-roof protecting work in the jacking construction method as the prior-art example.

[Fig. 28] Fig. 28 is an explanatory view illustrating comparison between the present invention and the prior-art example.

[Description of Embodiments]

Embodiments of the present invention will be described below in detail by referring to the attached drawings.

The present invention uses a box-shaped roof 17 which is a steel pipe of a box-shaped cylindrical body having a

rectangular section as a protecting work.

The box-shaped roof 17 protects a track or the like instead of a pipe roof, and this is a construction method of installing a structure body under the track, while this box-shaped roof 17 is pushed out, and the protecting work of the underground structure to be excavated in the ground is not performed as a separate construction work but is performed at the same time as excavation of the underground structure and thus, a construction work can be performed safely, reliably, and inexpensively and construction can be made with shallow earth covering.

The box-shaped roof 17 is formed to a predetermined length by connecting unit cylindrical bodies 17a, and this unit cylindrical body 17a is a box-shaped cylindrical body having a substantially regular square section of 800 x 800 (mm), and a required length can be buried by sequentially connecting those each having a length of 3 to 6 m in a length direction and are juxtaposed in a lateral direction through a joint.

The unit cylindrical body 17a of the box-shaped roof 17 has a connection flange 17c formed at a corner angle portion of an end portion as illustrated in Figs. 3, 5, and 6, and the connection flanges 17c are fastened to each other with a bolt and nut 19 or the end-portion corner angle of the unit cylindrical body 17a is made a box-out 20 opened outward so that the fastening with the bolt and nut 19 is performed at this portion of this box-out 20.

When the box-out 20 is to be provided as above, fastening or releasing of the bolt and nut 19 can be performed from an outside of the box-shaped roof. Fig. 4 illustrates a state of removal of the box-shaped roof.

On the box-shaped roof 17, a friction cut plate 21 made of a band-shaped steel plate having a plate thickness of 9 to 12 mm is placed on an outer side surface such as an upper surface, and a length of this friction cut plate 21 is substantially the same as that of the unit cylindrical body 17a and is extended by connection through welding when the unit cylindrical body 17a

is connected.

Joints 17b are continuously formed in a longitudinal direction on the side surface of the unit cylindrical body 17a of the box-shaped roof 17, but the joint 17b is a joint having a hook shape or a flat plate shape, and its pattern is illustrated in Fig. 10.

How to arrange the box-shaped roofs 17 includes a gate type in which an upper floor plate and a side wall plate are combined conforming to a shape of the concrete box body 1 as illustrated in Fig. 1 and a shape of a combination of the upper floor plate, the side wall plate, and a bottom floor plate as illustrated in Fig. 2, that is, rectangular arrangement which is a sectional shape of the concrete box body 1 and there is a case of a straight line type, though not shown, besides them.

As a first embodiment, as illustrated in Fig. 11, the earth-retaining member 13 such as a steel sheet pile beside upper traffic such as a railway is cast, the starting vertical shaft 3 and the arriving vertical shaft 9 are constructed, and as illustrated in Fig. 9, the base-pushing jack 4 is installed as a jacking machine in the starting vertical shaft 3 and the box-shaped roof 17 is press-fitted by this toward the arriving vertical shaft 9 for each unit cylindrical body 17a.

The box-shaped roof 17 has a cutting-edge pipe 18 mounted at a distal end thereof, and the cutting face is excavated by manually or by a machine such as an auger and jacked. In the figure, reference numeral 14 denotes a soil discharge pipe for discharging the excavated earth and sand.

Moreover, on the upper surface of the box-shaped roof 17, the friction cut plate 21 is mounted and is disposed in the ground by being pushed out together with the box-shaped roof 17, and the friction cut plate 21 is fixed to the starting vertical shaft 3 side by a fixing member 26. Figs. 7 and 8 illustrate a fixed example of the friction cut plate 21.

The friction cut plate 21 is welded to a distal end of the box-shaped roof 17 such as the cutting-edge pipe 18, for example, only at a distal end thereof, while the other portions

are left unfixed and only placed and pushed out together with the box-shaped roof 17.

The box-shaped roof 17 is to press-fit the unit cylindrical body 17a one by one, and the required length from the starting vertical shaft 3 to the arriving vertical shaft 9 is buried by adding one by one in the length direction, and further, a second, a third, ... are sequentially buried and juxtaposed with respect to the first piece buried as above.

Then, as illustrated in Fig. 13, the concrete box body 1 as the underground structure is set in the starting vertical shaft 3, the base-pushing jack 4 is provided between a reaction force wall 5 and the concrete box body 1, and the cutting edge 2 is provided at the distal end of the concrete box body 1.

Earth and sand in the cutting edge 2 and in front of the cutting face are excavated. The box-shaped roof 17 serves as the protecting work.

Since a gap is created for a portion of excavation and soil discharge, the base-pushing jack 4 is extended so as to jack the concrete box body 1, the box-shaped roof 17 is jacked while the friction cut plate 21 is left through the concrete box body 1 at the same time.

The concrete box body 1 advances inside the friction cut plate 21, and the friction cut plate 21 forms a friction cut with the rock mass in jacking of the concrete box body 1.

In the figure, reference numeral 6 denotes a strut interposed between the base-pushing jack 4 and the reaction force wall 5.

As described above, advancement of the box-shaped roof 17 and the advancement of the concrete box body 1 are performed at the same time, and when one piece of the unit cylindrical body 17a of the box-shaped roof 17 fully extends to the arriving vertical shaft 9, the fastening between the connection flanges 17c with the bolt and nut 19 is released and the connection flanges 17c are divided in the length direction and sequentially removed.

Then, when the distal end of the concrete box body 1

reaches the arriving vertical shaft 9, the cutting edge 2 and the like are removed, back-filling grouting is performed as appropriate and construction is completed.

The concrete box body 1 may be connected by suspending the pre-cast unit box body 1a sequentially in the starting vertical shaft 3 or may be increased to the required length by casting the concrete in the starting vertical shaft 3.

Fig. 16 illustrates a second embodiment, in which the concrete box body 1 is divided into a plurality, and an intermediate jack 15 is interposed between the concrete box bodies 1.

The plurality of concrete box bodies 1 are advanced alternatively by the base-pushing jack 4 and the intermediate jack 15, and when the previous concrete box body 1 is to be pushed out, for example, the intermediate jack 15 is extended by using the subsequent concrete box body 1 supported by the base-pushing jack 4 as a reaction force.

The pushing-out of the subsequent concrete box body 1 is performed by releasing the extended intermediate jack 15 and by extending the base-pushing jack 4. The advancement of the box-shaped roof 17 and the advancement of the concrete box body 1 are performed at the same time similarly to the first embodiment.

Fig. 17 illustrates a third embodiment, and the concrete box body 1 is pulled in from the arriving side by using a traction member by a center-hole type traction jack 10 and a PC steel wire 12.

A reaction force body 32 including a bearing wall 31 is provided on the arriving side, and one end of the PC steel wire 12 is penetrated through this reaction force body 32 and the bearing wall 31 and fixed by a fixing tool 11.

At a rear end of the concrete box body 1, a jack bearing beam 30 is installed, the traction jack 10 is provided here, and the concrete box body 1 is pushed out by pulling the PC steel wire 12 by this traction jack 10.

Fig. 18 illustrates a fourth embodiment, and use of the

base-pushing jack 4 in the first embodiment and use of the traction member by the center-hole type traction jack 10 and the PC steel wire 12 in the third embodiment are both used.

Fig. 19 illustrates a fifth embodiment, and the concrete box body is divided into a plurality of concrete box bodies 1₁ and 1₂, and the intermediate jack 15 which is a jacking jack is arranged between the plurality of concrete box bodies 1.

Even when the concrete box body is formed of three or more divided box bodies, the box bodies are sequentially advanced by the intermediate jack 15 from the preceding box body, and the last concrete box body is advanced by the traction jack 10.

Moreover, though not shown, this divided traction method can be a mutual traction method, and precast concrete box bodies 1 (box culvert) in which the cutting edge by a steel hood is mounted at a distal end are installed on both sides of a traverse spot below the upper traffic such as a track with traction directions mutually faced with each other.

On one of the concrete box bodies 1, the traction jack 10 is mounted on a rear part thereof, while on the other concrete box body 1, the fixing tool 11 is mounted on a rear part thereof, the PC steel wire 12 used as a traction member of the traverse spot is passed therethrough, and an end of this PC steel wire 12 is fixed to the traction jack 10 and the fixing tool 11.

The traction jack 10 is a center-hole jack and is made of a fixing block illustrated in the fixing tool 11 and a wedge-shaped split-pin type wedge entering into a hole of this fixing block. The wedge enters into the hole of the fixing block while one of twisted wires of the PC steel wire 12 penetrated, and the PC steel wire is fixed to the fixing tool 11 by a wedge effect.

When the PC steel wire is to be fixed to the traction jack 10, the fixing tool 11 is mounted and fixed to the PC steel wire penetrated through and exiting from the traction jack 10.

By using the traction jack 10 as described above, the concrete box bodies 1 constructed on the both sides of the traverse spot are mutually towed one by one using the other side

as a reaction force resistance body.

When each of the concrete box bodies 1 is to be towed, excavation is performed from the inside of the cutting edge so as to create a box-out in the front earth and sand, and the concrete box body 1 is advanced for that portion. The concrete box body 1 which becomes the reaction force resistance body is the box body before such excavation is performed. The excavation is performed using an excavating machine or is performed manually.

In this embodiment, an endless self advancing method can be also employed.

The intermediate jacks 15 are arranged between the plurality of precast concrete box bodies $1_1, 1_2, 1_3, \dots 1_n$, and juxtaposed in a row in a vertical direction, and the cutting edge 2 is mounted on the concrete box body 1_1 in the foremost row.

The traction jack 10 is mounted on a rear part of the last concrete box body 1_n , while the fixing tool 11 is mounted on a front part of the first concrete box body 1_1 , and the traction jack 10 and the fixing tool 11 are connected by the PC steel wire 12. The PC steel wire 12 is disposed by being passed through the juxtaposed concrete box bodies $1_1, 1_2, 1_3, \dots 1_n$.

A principle of the endless self advancing method resembles movement of a measuring worm. First, a tail part is fixed (reaction force), and a head part is advanced. Then, the head part is fixed (reaction force), and movement is made as if the tail part is withdrawn. Advancement is made by repeating this.

First, the portion of the cutting edge 2 is excavated from the inside, a stroke of the intermediate jack 15 set between the first concrete box body 1_1 and the concrete box body 1_2 in the rear thereof is extended and advanced by a certain amount, and when all the concrete box bodies $1_1, 1_2, 1_3, \dots 1_n$ have been advanced by the certain amount, then, the same operation is repeated from the first.

In that case, in order to advance the first box body 1_1 ,

the fixing tool 11 and the traction jack 10 are left idle, and the intermediate jack 15 between the first concrete box body 1_1 and the second concrete box body 1_2 is operated by using self weights of the concrete box bodies $1_2, 1_3, \dots 1_n$ in the rear and friction resistance by an earth pressure as a reaction force.

Subsequently, the advancement of the second box body 1_2 is performed by fixing the fixing tool 11 and the traction jack 10 to the PC steel wire 12, by operating the traction jack 10 so as to tense the PC steel wire 12, and by using the intermediate jack 15 between the second concrete box body 1_2 and the third concrete box body 1_3 by using the first concrete box body 1_1 and the third concrete box body 1_3 as the reaction force.

The box bodies after the third concrete box body are also advanced as described above, and since the jacking of the concrete box bodies close to the last lacks the self weights of the subsequent concrete box bodies, the jack reaction force is transmitted to the concrete box bodies in front by the PC steel wire 12 so as to compensate for the shortage.

Regarding the jacking of the last concrete box body 1_n , it is advanced by pulling it forward by operating the traction jack 10 and by tensing the PC steel wire 12. At a point of time when the advancement of the last concrete box body 1_n has been completed, one session of the jacking is completed.

In the aforementioned embodiments, the case where the advancement of the box-shaped roof 17 and the advancement of the concrete box body 1 are performed at the same time is described, but further as a sixth embodiment, a small jack 22 may be interposed between the concrete box body 1 and the box-shaped roof 17 as illustrated in Figs. 20 to 22.

In the box-shaped roof 17, a jack accommodating pipe 24 storing the small jack 22 is disposed on an installation side of the concrete box body 1.

The box-shaped roof 17 is sequentially jacked one by one by extending the small jack 22 and leaving the friction cut plate 21 by using the concrete box body 1 as a reaction force, and once all the box-shaped roofs 17 have been advanced, the small

jack 22 is contracted, and then, the concrete box body 1 is excavated by the base-pushing jack 4 or the traction jack 10 and the PC steel wire 12.

As described above, the box-shaped roof 17 extending to the arriving vertical shaft 9 is sequentially removed, while the advancement of the box-shaped roof 17 and the jacking or traction of the concrete box body 1 are alternately repeated. Then, when the distal end of the concrete box body 1 reaches the arriving vertical shaft 9, the cutting edge 2 or the like is removed, and back-filling grout is performed as appropriate, and the construction is completed.

Fig. 24 illustrates a seventh embodiment, in which the box-shaped roofs 17 are arranged in a square shape so as to correspond to the outer shape of the concrete box body 1 to be jacked as illustrated in Fig. 2, and an earth-retaining member 23 is disposed in the cutting face portion surrounded by the box-shaped roofs 7. For this earth-retaining member 23, a part of the earth-retaining member 13 on the starting side and the arriving shaft side, that is, the portion surrounded by the box-shaped roofs 17 in the square shape is subjected to mirror-cutting and used as an earth-retaining steel sheet pile.

The earth-retaining members 23 on the starting side and the arriving shaft side are fixed by the fixing tool 27.

A starting base 29 is formed on the starting side, the concrete box body 1 is installed and then, the distal end of the concrete box body 1 is joined to or brought into contact with the rear end of the previously pushed-out box-shaped roof 17.

The concrete box body 1 is to jack or to tow, and the box-shaped roof 17 is also pushed out at the same time as the jacking or traction of the concrete box body 1, and moreover, excavating of the cutting face portion is not performed, and the earth and sand of the portion surrounded by the box-shaped roofs 17 is also pushed out at the same time as pushing-out of the box-shaped roofs 17.

When the box-shaped roof 17 and the earth and sand pushed

out at the same time by being surrounded by the box-shaped roof 17 arrive at the arriving side as illustrated in Fig. 25 as described above, the box-shaped roof 17 is removed on the arriving side and the earth and sand are excavated and discharged at the same time.

Though not shown, in the jacking and traction of the concrete box body 1, the jacking is performed by a thrust force of the base-pushing jack by disposing the base-pushing jack and the strut as a jacking facility between the rear part of the box body and the reaction force wall on the rear of the box body, and the traction is performed by traction of the traction jack by providing the reaction force wall in front of the box body, by mounting the fixing device or the traction jack on the rear part of the box body, and fixing the other end of a traction cable having one end attached to this fixing device or the traction jack to the traction jack or the fixing device fixed to the reaction force wall. The jacking and the traction of the concrete box body 1 may be performed by using either one of or both of the jacking and the traction.

Moreover, if the friction cut plate 21 is overlapped with the upper surface or the side surface of the box-shaped roof 17, the end portion of the friction cut plate 21 is retained in the vicinity of the pit mouth when the box-shaped roof 17 is pushed out at the same time as the jacking or traction of the concrete box body 1, and the box-shaped roof 17 and the concrete box body 1 can be separated from the peripheral earth and sand by leaving it.

[Reference Signs List]

- 1 concrete box body
- 1a unit box body
- 2 cutting edge
- 3 starting vertical shaft
- 4 base-pushing jack
- 5 reaction force wall
- 6 strut
- 7 base concrete

- 8 upper traffic
- 9 arriving vertical shaft
- 10 traction jack
- 11 fixing tool
- 12 PC steel wire
- 13 earth-retaining member
- 14 soil-discharge pipe
- 15 intermediate jack
- 16 pipe roof
- 17 box-shaped roof
- 17a unit cylindrical body
- 17b joint
- 17c connection flange
- 18 cutting-edge pipe
- 19 bolt and nut
- 20 box-out
- 21 friction cut plate
- 22 small jack
- 23 earth-retaining member
- 24 jack accommodating pipe
- 26 fixing member
- 29 starting base
- 30 jack receiving beam
- 31 bearing wall
- 32 reaction force body

[Document Name] Claims

[Claim 1]

An installing method of an underground structure comprising, as a protecting work when a concrete box body to be installed as an underground structure is to be jacked, a box-shaped roof in which box-shaped cylindrical steel pipes each having a rectangular section are arrayed so as to match an outer edge of the concrete box body scheduled to be installed,

in the box-shaped roof, a unit cylindrical body is press-fitted one by one, a joint flange for bolt joint is formed at an end portion, and a required length is buried by extending the joint flanges in a length direction one by one by fastening the joint flanges with a bolt and a nut,

the fastening with the bolt and the nut is made at a portion where an end-portion corner angle of the unit cylindrical body is made a box-out by opening the same outward,

in the box-shaped roof, hook-shaped or flat-plate shaped joints are formed on a side surface continuously in a longitudinal direction,

this box-shaped roof is pushed in and penetrated between a starting vertical shaft and an arriving vertical shaft which is an entire length of a traverse section in advance, the concrete box body is installed at a rear end thereof, the box-shaped roof is pushed out and the concrete box body is jacked, and the box-shaped roof and the concrete box body are replaced and installed.

[Claim 2]

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

the box-shaped roof is pushed in and penetrated between the starting vertical shaft and the arriving vertical shaft by placing a friction cut plate made of a band-shaped steel plate on an outer side surface, this friction cut plate is fixed at an end portion to the starting vertical shaft side and left as it is at pushing-out of the box-shaped roof, the concrete box body is excavated inside the friction cut plate, and the friction cut plate forms a friction cut with a rock mass when the concrete box body is jacked.

[Claim 3]

The installing method of an underground structure according to any one of claims 1 to 2, wherein

in the box-shaped roof, a jack accommodating pipe accommodating a small jack is disposed on a concrete box body installation side.

[Claim 4]

The installing method of an underground structure according to any one of claims 1 to 3, wherein

the box-shaped roof is arranged in a flat-plate shape so as to correspond to an upper floor plate of the concrete box body to be jacked, a cutting edge which is a cutting-face excavating work space made of steel is installed at a distal end of the concrete box body installed on the rear thereof, and the box-shaped roof is pushed out while the cutting face is being excavated in the cutting edge, and the concrete box body is jacked.

[Claim 5]

The installing method of an underground structure according to claim 4, wherein

a small jack is arranged between the box-shaped roof rear end and the concrete box body, and jacking of the box-shaped roof with the small jack using the concrete box body as a reaction force and jacking of the concrete box body are performed alternately.

[Claim 6]

The installing method of an underground structure according to any one of claims 1 to 3, wherein

the box-shaped roof is arranged having a square shape so as to correspond to an outer shape of the concrete box body to be jacked, an earth-retaining member is disposed in the cutting face portion surrounded by the box-shaped roof, and earth and sand of the portion surrounded by the box-shaped roof are pushed out at the same time without excavating the cutting face portion when the box-shaped roof is pushed out.