

[Description on the Invention]**[Name of the Invention]**

WIRE-SAW EXCAVATION APPARATUS AND TUNNEL EXCAVATION METHOD USING THE SAME

[Technical Area]

[0001] This Invention relates to a wire-saw excavation apparatus which can change the cutting lines according to the cutting section and the tunnel excavation method using it, which can improve excavation speed and collect the types of stone available to use.

[Background Technology of the Invention]

[0003] In case of the location where the rock is buried in construction of the tunnel by drilling the ground, excavate the tunnel using the blasting method or TBM (Tunnel Boring Machine).

[0004] In the blasting method, cut the rock along the cutting baseline and install the perforations for blasting. Then, charge the explosive, perform blasting and excavate the rock within the range. In case of the blasting method, it takes a lot of works and time to blast the rock in stability and the desired shape. In addition, explosions of explosives often excavate rocks to the unforeseen extent and cause problems due to pollution such as noise and dust scattering generated from blasting.

[0005] TBM is a rotary excavator which rotates the cutter head equipped with lots of disc cutters, breaks and dig rocks. Excavation using TBM has advantages of faster construction speed than the blasting method, improved safety and low pollution problem. However, TBM is the very expensive equipment and has problems of more difficulty in small/ medium sized tunnel excavation works and reuse of stone not available in that the rocks collected through exaction is crushed at the size of gravel.

[0006] For solving this problem, the technology of cutting and excavating rocks using a wire-saw is posted on the Patent Registration No. 10-1649328 (Precedent Literature 1).

[0007] In order to excavate the tunnel using a wire-saw, the target surface to be excavated should be plotted and the entry hole shall be drilled around the circumference of the section. After then, insert the arm installed with a wire-saw to 2 adjoining entry holes from the entry holes, operate a wire-saw excavation apparatus and cut 1 segment of the section.

[0008] For example, if the section area is a rectangle, cut 4 sides of a rectangle at 4 times with the wire-saw proposed at Antecedent Literature 1 and cut the end of the inside cut lastly. In order to construct a tunnel, there could be lots of section areas, the working hours for arm installation cut, removal would be inevitably increased geometrically.

[0009] On the other hand, Japanese Patent Publication No. 07-269266 (Antecedent Literature 2) also posts the excavation apparatus using a wire-saw.

[0010] When excavating a tunnel using a wire-saw, the target surface is not always constant and so it is sometimes necessary to change the cutting section.

[0011] However, the wire-saw excavation apparatus proposed in Antecedent Literature 2 has 4 support arms fixed to each other as a fixed member and so change of the entry arm location or number depending on the cutting section is limited. In the case of using the wire-saw excavation apparatus proposed in Antecedent Literature 2, the work efficiency decreases, such as drilling an entry hole even where it is unnecessary.

[0012] Therefore, there is a need for a new method available in the field.

[Contents of the Invention]

[Tasks to be solved]

[0014] The Invention is to solve the above problems and provides for the TN excavation method using wiresaw excavation apparatus that can excavate the target surface at the minimum time.

[0015] On the other hand, other objects not specified in the Invention will be further considered within the scope that can be easily inferred from the following detailed descriptions and effects.

[Means of solving the tasks]

[0017] The wire-saw excavation apparatus according to an embodiment of the Invention for achieving the above objective is installed at the several entry holes drilled according to the cutting section of the target surface of the rock and to excavate the above target surface using the wire-saw include the entry arm with at least 1 pulley is installed with the wire-saw wired at the end of the insertion direction, the insertion unit where the trapping sill is formed between the above entry arms with the less sectional area than the above entry arm with the end at the opposite direction to the insertion direction of the above entry arm, support frame with the matrix structure corresponding to the above cutting section by crossing of the first frame at the direction 1 and the second frame placed at the direction 2, the entry hole where the above entry unit is inserted to prevent the above entry arm from being pushed at the direction opposite to the insertion by the above trapping sill, wire-saw which is wired at the caterpillar along the above entry arm and the driving roller which operates the above wire-saw in circulation, move the opposite direction to the above target surface and causes the above wire-saw to cut the rock.

[0018] The wire-saw excavation apparatus according to an embodiment of the Invention for achieving the above objective is installed at the several entry holes drilled according to the cutting section of the target surface of the rock and to excavate the above target surface using the wire-saw include the entry arm with at least 1 pulley is installed with the wire-saw wired at the end of the insertion direction, the insertion unit where the trapping sill is formed between the above entry arms with the less sectional area than the above entry arm with the end at the opposite direction to the insertion direction of the above entry arm, support frame with the matrix structure corresponding to the above cutting section by crossing of the first frame at the direction 1 and the second frame placed at the direction 2, the entry hole where the above entry unit is inserted to prevent the above entry arm from being pushed at the direction opposite to the insertion by the above trapping sill, wire-saw which is wired at the caterpillar along the above entry arm and the driving roller which operates the above wire-saw in circulation, move the opposite direction to the above target surface and causes the above wire-saw to cut the rock and is characterized by the number of entry arms installed at the support frame above available to change depending on the cutting section.

[0019] Tunnel excavation method using a wire-saw excavation apparatus according to another embodiment of this Invention for achieving the above object includes (a) the drilling step where the plural entry holes are drilled along the cutting section on the target surface of the rock to drill, (b) the insertion step of inserting into insertion holes the above entry arms where the insertion unit where the wire-saw is wired to match with the cutting line in the above cutting section and has the cross sectional area less than the above entry arm at

the insertion opposite direction of the above entry arms, (c) the frame installation step of preparing the support frame which has the matrix structure corresponding to the above cutting section by crossing the first frame placed at the direction 1 and the second frame placed at the direction 2 and the insertion holes are formed to insert the above entry unit and installing the support frame to insert the above entry unit into the above entry hole and (d) the step of operating the driving roller where a part of the above wire-saw is wound and cutting the rock at the location for the wire-saw to cut.

[Effects of the Invention]

[0021] This Invention may improve the work efficiency significantly as the wire-saw excavation apparatus according to an embodiment of this invention can simultaneously perform cutting operations on a plurality of the plotted surface using the support frame with the matrix structure. In particular, the wire-saw excavation apparatus according to an embodiment of this Invention can efficiently cut various types of cutting sections by installing a plurality of pulleys on the support frame and one support arm.

[0022] Accordingly, the tunnel excavation method using a wire-saw excavation apparatus according to an embodiment of this Invention is efficient because it can excavate the tunnel with a minimum number of times.

[0023] On the other hand, even if the effects are not explicitly mentioned herein, the effects described in the following statement expected by the technical features of this Invention and its potential effects would be treated as described in the statement of this Invention..

[Brief Description on Drawings]

[0025] Figure 1 is a shape of the pulley mounted in the horizontal, vertical and diagonal directions to the entry arm and its end. Figure 2 is the schematic perspective view of the entry arm and wire-saw of the wiresaw excavation apparatus where the wire-saw is wired to cut the cutting section at once using the entry arm with the several pulleys but omitted the driving roller and the support frame for clarification of the descriptions. Figure 3 is the schematic perspective view of the excavation apparatus according to the embodiment of horizontal cutting. Figure 4 is a schematic cross-sectional view according to an embodiment. Figure 5 is a schematic plan view according to an embodiment of this Invention. Figure 6 is a schematic flow chart of a tunnel excavation method using a wire-saw excavation apparatus according to an embodiment of this

Invention. Figure 7 shows an example of the cutting line shape that can cut the cutting section of the target surface to be excavated with one wire at once. Figures 8, 9, and 10 are reference diagrams for explaining an excavation method using a cutting section that can be drilled efficiently by drilling an entry hole only in the edge of the cutting section. Figures 11 and 12 schematically show cutting sections of another type. Figure 13 is a layout view of the entry arm pulley seen from the entry hole, and α , β and γ pulley are mounted to the entry arms in the horizontal, vertical and diagonal directions, respectively.

※ Please be informed the attached drawings are examples as reference for understanding the technical idea of this Invention, which does not limit the scope of this Invention.

[Specific contents to execute this Invention]

[0026] In describing this Invention, when it is determined that the matters related to the disclosed functions but evident to the engineers in this field may be unnecessarily obscure the points of this Invention, the detailed descriptions were omitted.

[0027] Figure 3 is the schematic perspective view of the wire-saw excavation apparatus according to one embodiment of this Invention, Figure 4 is the schematic cross-sectional view of a wire-saw excavation apparatus according to one embodiment of this Invention and Figure 5 is the schematic plan view of a wiresaw drilling excavation according to one embodiment of the Invention.

[0028] With reference to Figures 3~5, each configuration of the wire-saw excavation apparatus according to one embodiment of this Invention would be described.

[0029] The wire-saw excavation apparatus according to an embodiment of this Invention is installed in the plurality of entry holes (5) drilled according to the cutting section of the target surface (1) and excavate the target surface (1) using the wire-saw. For this, the wire-saw excavation apparatus includes the entry arm (10), support frame (20) and driving roller (30). On the other hand, the cutting section may be composed of horizontal line, vertical line or diagonal line.

[0030] Before installing the wire-saw excavation apparatus of this Invention, drill a plurality of entry holes (5) on the target surface (1) according to the cutting section. The cutting section refers to a set of sections composed of cutting lines to be cut in order to excavate rocks. That is, by cutting the rock to a

predetermined depth according to the cutting line of the cutting section and cutting the end of the rock located at the predetermined depth, it is possible to take out the cut stone according to the cutting section using the equipment. By repeating this work, the tunnel can be excavated and the stone available to use may be obtained at the same time.

[0031] An entry hole (5) is formed at the point where one cutting line and the other cutting line of the cutting section meet. The entry hole (5) may be drilled using a jumbo drill but not limited to it. The entry arm (10) where the wire-saw is wired is inserted into the entry hole (5). Entry arm (10) is formed long in one direction to be inserted into the entry hole (5), the cross section may be rectangular or circular but is not limited thereto. That is, the cross section of the entry arm (10) may be polygonal.

[0032] When driving in circulation and pulling the wire-saw which is wired as in Figure 5 to the target surface, the rock is cut along the cutting line. In particular, the wire-saw excavation apparatus of this Invention has the advantage that the cutting operation can be performed simultaneously for a plurality of cutting sections.

[0033] At the end of the entry arm (10), the pulley (12) to which the wire-saw is inserted and helps the circulation driving is installed. The pulley (12) may be installed to extend from the end of the entry arm (10) as shown in the drawings but is not limited thereto. For example, the pulley (12) may be installed inside the end of the entry arm (10) or on one side of the end.

[0034] Figure 1 shows another embodiment of the entry arm (10). Referring to Figure 1, a plurality of fixing wedges (16) operated by the lever (15) may be installed at the entry arm (10). After the entry arm (10) is inserted into the entry hole (5), it is possible to fix the entry arm (10) to the entry hole (5) since the fixing wedge (16) is enfolded to the wall of the entry hole (5) by operating the lever (15). It is also possible for a plurality of pulleys (12a, 12c and 12d) to be placed in one entry arm (10). Thereafter, each pulley (12a, 12b and 12c) has a cover (13a, 13b, 13c). As such, placement of the plurality of pulleys (12a, 12b and 12c) in one entry arm (10) is to perform the cutting operation for a plurality of cutting sections at once using the wiresaw excavation apparatus of this Invention as described above.

[0035] In addition, the target surface (1) of the rock to be excavated varies in each place where excavation is performed and the cutting section also varies each time. If the cutting section is different, the number of entry holes (5) changes. The wire-saw excavation apparatus of this Invention can actively respond to such environmental changes. That is, the use of the wire-saw excavation apparatus of this Invention has the advantage that the number of entry arms installed in the support frame can be changed depending on the

cutting section.

[0036] Like this, the wire-saw excavation apparatus of this Invention uses the support frame (20) to use the plurality of entry arms (10) at once or to respond to different environment. In soft rock, the time required for installation of entry holes may be reduced by reducing the number of entry holes. On the contrary, in the hard rock, the time required for cutting may be reduced by increasing the number of entry holes. In addition, it is possible to adjust the shape of the stone produced during the excavation of the tunnel, which can significantly increase the availability of the stone to be produced.

[0037] The support frame (20) consists of the first frame (21) placed at the direction 1 and the second frame placed at the direction 2 (22). For example, as shown in Figure 3, the first frame (21) may refer to a frame placed in the horizontal direction and the second frame (22) may refer to the frame placed in the vertical direction.

[0038] The support frame (20) may have a matrix structure in which the first frame (21) and the second frame (22) cross each other and correspond to the cutting section.

[0039] At the support frame (20), the insertion hole (23) corresponding to the entry hole (5) of the cutting section. Insertion hole (23) may be installed in the first frame (21) or the second frame (22) but not limited thereto. For example, the insertion hole (23) may be formed by combining a separate insertion member to the first frame (21) or the second frame (22).

[0040] The support frame (20) is formed with an expansion hole (24). At the expansion hole (24), a conversion roller (25) for adjusting the direction so that the wire-saw (W) does not damage the support frame (20) or more than 1 support fixture (26) which is protruded outward to fix the support frame (20) to the wall may be installed.

[0041] The wire-saw (W) is wired into the caterpillar along the entry arm. The wire-saw (W) is circulated by the driving roller (30). As the driving roller (30) rotates, the wire-saw (W) is circulated to cut the rock according to the cutting line. Furthermore, the driving roller (30) is gradually moved in the opposite direction to the insertion, the tension of the wire-saw (W) is maintained depending on movement of the driving roller (30) to cure the rock continuously.

[0042] On the other hand, as shown in Figures 4~5, the entry arm (10) placed on the outside of the entire cutting section of the entry arm (10) may be installed so as to open to the outside of the cutting section. When the rock of the target surface (1) is excavated using the wire-saw excavation apparatus of this Invention,

the excavation operation must be continued by reinstalling the wire-saw cutting apparatus for the newly exposed target surface. At this time, if the entry arm (10) placed outside of the entire cutting section of the entry arm (10) is not placed to be estranged outward of the cutting section, the newly exposed target surface may have a smaller area than the existing target surface (1). However, as shown in Figures 2~4, if the entry arm 10 placed on the outside of the entire cutting section of the entry arm (10) is installed to be estranged to the outside of the cutting section, the space for reinstalling the wire-saw excavation apparatus be provided. This can significantly increase the efficiency of the excavation work.

[0043] Hereinafter, the excavation method of the tunnel using a wire-saw excavation apparatus according to an embodiment of this Invention will be described.

[0044] Figure 6 is a schematic flow chart of a tunnel excavation method (M100) using a wire-saw excavation apparatus according to another embodiment of this Invention.

[0045] Referring to Figure 6, the tunnel excavation method (M100) using the wire-saw excavation apparatus according to another embodiment of this Invention includes the drilling step (S10) where the plural entry holes are drilled along the cutting section on the target surface of the rock to drill, the insertion step (S20) of inserting into insertion holes the above entry arms where the insertion unit where the wire-saw is wired to match with the cutting line in the above cutting section and has the cross sectional area less than the above entry arm at the insertion opposite direction of the above entry arms, the support frame installation step (S30) of preparing the support frame which has the matrix structure corresponding to the above cutting section by crossing the first frame placed at the direction 1 and the second frame placed at the direction 2 and the insertion holes are formed to insert the above entry unit and installing the support frame to insert the above entry unit into the above entry hole and the step (S40) of operating the driving roller where a part of the above wire-saw is winded and cutting the rock at the location for the wire-saw to cut.

[0046] First, the drilling step (S10) is performed. The drilling step (S10) is to set the cutting section on the target surface of the rock to be excavated, and to drill the entry hole using the jumbo drill at the point where the cutting lines constituting the cutting section cross over.

[0047] Next, an insertion step S20 of inserting the wire-saw wired entry arm into the plurality of entry holes to correspond to the cutting line to be cut is performed. In this case, when the entry arm is provided with a fixing wedge, the entry arm may be fixed to the entry hole by operating a lever.

[0048] The support frame installation step (S30) installs the support frame which has the matrix structure corresponding to the cutting section by crossing the first frame placed at the direction 1 and the second frame placed at the direction 2 and to which the insertion holes are formed to insert the entry unit. On the other hand, before performing the support frame installation step (S30), the auxiliary support frame installation step of installing the auxiliary support frame which has the matrix structure corresponding to the cutting section by crossing the first frame placed at the direction 1 and the second frame placed at the direction 2 and to which the auxiliary support hole is formed to insert the above entry arm.

[0049] The insertion step (S20) and the support frame installation step (S30) may be changed in order. For example, the entering arm may be inserted to the entry hole by installing the support frame to match the insertion hole with the insertion unit after inserting in the insertion arm into the insertion hole or arranging the insertion unit of the entry arm to the entry hole of the support frame and moving both the support frame and the entry arm at the same time.

[0050] Like this, when the entry arm is inserted into the entry hole, the wire-saws that are wired with caterpillar are placed in a 'C' shape by adjacent entry arms and the rock between them. In other words, the rock is located at the center of the 'C' shape.

[0051] Next, a step (S40) of operating the driving roller where a part of the above wire-saw is winded and cutting the rock at the location for the wire-saw to cut is performed. The driving roller moves to the direction opposite to the target surface gradually while it rotates. Accordingly, the wire-saw wired in "C" shape initially is gradually unfolded and cuts the rock.

[0052] On the other hand, as shown in Figure 7, it is also possible to cut all rocks at once according to the cutting section.

[0053] The several entry holes with cutting lines are called as "Coupling entry holes" and the entry holes with odd number of the above cutting lines are called as "Base entry holes". When there are "0" or 2 base entry holes at the cutting section, all rocks may be cut along the cutting section.

[0054] For example, if the wire-saw is wired from Point S in Figure 7 and wired from Point S point to Point F along the arrow, wiring for all cutting lines (L) is possible. At this time, some entry holes pass through the wire-saw at several times and, for this purpose, the entry arm may have a plurality of pulleys installed at the end.

[0055] Figure 2 is a schematic perspective view of the wire-saw excavation apparatus in configuration of wiresaw to enable to cut the cutting segments at once using the entry arm with several pulley but excluded the clear descriptions on the driving roller and the support frame.

[0056] First, perform the drilling step (S10). Several entry holes (51b~51d, 52a~52d, 53a~53d, 54b~54d) are drilled at the target surface (1).

[0057] Then, perform the inserting step (S20) of inserting several entry arms (10) into the several entry holes (51b~51d, 52a~52d, 53a~53d, 54b~54d).

[0058] In the inserting step (S20), the wire-saw (W1,W2,W3) should be wired to the entry arm (10) and the driving roller before inserting the entry arm to the entry holes (51b~51d, 52a~52d, 53a~53d, 54b~54d). All wiresaws may be wired to the same drive roller, but this Invention is not limited thereto. That is, it is also possible for the wire-saw excavation apparatus to have a plurality of driving rollers to drive independently each other, and some of the plurality of wire-saws may be wired to different drive rollers.

[0059] On the other hand, the number of pulleys (12) installed in the entry arm (10) may vary depending on the number of wire-saws inserted into the entry holes. For example, in the case of the entry arm (10) inserted into the entry holes 51b and 54b, the first wire-saw (W1), the second wire-saw (W2) and third wiresaw (W3) are all wired and so 3 pulleys (12) are installed. Since only 2 wire-saws are wired to the remaining entry holes, 2 pulleys (12) are installed.

[0060] If the plurality of pulleys (12) are not installed in the entry arm (10), there is a possibility of damage including break of the wire-saw due to friction of crossed part of the wire-saw during excavation. However, the wire-saw excavation apparatus of this Invention drives each of the plurality of wire-saws by varying the number of pulleys 12 installed in the entry arm (10) depending on the number of wire-saws inserted into the entry hole, it is possible to prevent the intersecting parts of wire-saws from being broken due to friction during the excavation process. That is, the wire-saw excavation apparatus of this Invention has an advantage that the cutting lines of the cutting section can be cut at only single excavation by varying the number of pulleys (12) installed in the entry arm (10).

[0061] Like this, after inserting the wire-saw wired entry arm into the entry hole as described above, the rock may be cut (S40) by installing the support frame (S30) and operating the driving roller.

[0062] On the other hand, in the wire-saw excavation method, the process of drilling the entry holes according to the cutting section also takes a lot of time. In addition, the target surface does not always have same rock

quality and the different working environment is faced in each work. Therefore, as shown in Figures 8, 9 and 10 as necessary, the entry hole can be drilled only in the edge of the cutting section, so that the drilling can be carried out more efficiently. As such, when the entry holes are drilled only on the edge of the cutting section, the type and position of the entry arms of the wire-saw excavation apparatus and wiring of the wiresaw may be configured only as in the edge of the cutting section shown in Figure 8.

[0063] On the other hand, in this case, a time interval (for example, 10 minutes) should be provided to prevent friction of the wire-saws inner parts of the cutting sections intersecting with each other during the excavation process. Specifically, it is as follows.

[0064] First, as shown in Figure 8, cut (C) the first cutting line (L1) corresponding to the first wire. Then, as shown in Figure 9 after taking a time interval, cut (C) the second cutting line (L-2) corresponding to the second wire. The time interval is not conditional to the complete cutting along the first cutting line (L1) but granting the room so that the Swire-saw which performs the post cutting after inserted to a certain depth is not in friction with the wire-saw which performs the precedent cutting. For example, start cutting along the second cutting line (L2) 10 minutes after starting cutting along the first cutting line (L1,). Lastly, as shown in Figure 10, cut (C) along the third cutting line (L3) with a time interval with cutting of the second cutting line (L2). But, sometimes, it is possible for (L1) and (L2) to cut at the same time.

[0065] According to the process shown in Figure 8, 9 and 10, perform the cutting operations on several cutting section at the same time but it is possible to reduce working hours by reducing the unnecessary drilling works for entry holes and prevent the damage due to friction of wire-saw crossing each other by time interval of wire-saw driving. In addition, even by the method shown in Figures 8, 9, and 10, there is an advantage of cutting all the cutting lines of the cutting section once by installing a wire-saw excavation apparatus.

[0066] Another advantage of using the wire-saw excavation apparatus of this Invention is that it can easily respond to various types of cutting sections. It will also be possible to make a rhombus cutting section (Figure. 11). Furthermore, the wire-saw excavation apparatus of this Invention can also correspond to the arch type of cutting section as shown in Figure 12.

[0067] Thus, the shape consisting of a frame on the outside of the support frame may be a polygon more than rectangle. In addition, some of the curbed support frames may be used for example. For example, if the cutting section has an arch type of upper part, the upper part of the arch upper shape may be formed simpler by applying a curved frame (e.g., semicircle) there. Furthermore, it is also theoretically possible to make the form which consists of the outside frame of a support frame in circular or elliptical.

[0068] Since the wires rotate in the respective directions to the pulley placed in the form of Figure 13, it has characteristics of cutting the rock at the same time without reciprocal interference.

[0069] Finally, this Invention has the advantage of actively responding to various working environments using a wire-saw excavation apparatus.

[0070] As described above, it is possible to make excavation of the target surface by using the wire-saw excavation apparatus according to an embodiment of this Invention. Further, it is possible to obtain stone in forms available to use in the process of excavating a tunnel.

[0071] The protection scope of this Invention is not limited to the expressions and entries explicitly described above. In addition, it is again noted that the protection scope of this Invention may not be limited due to obvious changes or substitutions in the technical field to which this Invention belongs.