

Title of Invention: METHOD FOR ALTERNATELY CONSTRUCTING UNDERGROUND VERTICAL MEMBERS USING TOP-DOWN CONSTRUCTION METHOD

TECHNICAL FIELD

[1] The present invention is provided to shorten a period of underground frame construction in top-down construction method, and more specifically, provides a construction method for alternately constructing underground vertical members downward to lower levels and then constructing remaining vertical members during the same time period after mat and foundation construction, thus making it possible to shorten a construction period of the vertical members and an overall construction period.

BACKGROUND

[2] The top-down construction method is a construction method for shortening the construction period by constructing frames on the above-ground levels while forming the frames downward to the underground levels.

[3] The general order of the top-down construction method for the underground level includes installing an earth retaining wall and pillars, excavating each level, and then constructing the last lowest foundation or mat while constructing a slab downward to have a depth of 4th to 7th underground levels.

[4] Among the underground vertical members, the piles

(pillar posts) are constructed at an initial stage of construction, a core part of one underground level is constructed for the frame construction of the above-ground level(superstructure), and the remaining vertical members are constructed in order (from a lower level to an upper level) after placing the foundation or the mat.

[5] At this time, although the frame construction of the above-ground level is constructed during the same time period with the underground level, the number of levels that go up before the foundation and mat construction, and the number of levels that go up until the completion of the construction of the underground vertical members are structurally limited. For example, construction constraint conditions are given in which construction of the slab only up to the 8th level is allowed until the foundation and the mat are placed, construction of the slab only up to the 15th level is allowed until construction of the underground vertical members is completed, and construction of the roof level is allowed without restrictions after construction of the underground vertical members is completed.

[6] Therefore, if the frame construction period of the underground level increases, the above-ground level frame has to be constructed only up to the 8th or 15th level, and then the construction stops and waits. Conversely, if the frame construction of the underground level is accelerated, the frame construction of the above-ground level will also be accelerated, so that the overall construction period is

greatly affected by the underground level work.

[7] In particular, for the construction of the above-ground level frame, it takes 6 to 7 days for one level to construct one reference level, so that more than four levels are constructed in one month, but for the construction of the underground level frame, it takes 1.5 or 2 months for one level, so that a construction speed of the underground level is relatively slow.

[8] The problems in the conventional top-down construction method are as follows.

[9] The conventional construction order of the underground construction includes constructing the earth retaining wall, the post, excavation of each level down, slab construction of each level, foundation or mat construction of the lowest level, and the construction of the underground vertical members upward in a sequence.

[10] Here, the underground vertical member has a feature that it proceeds in a sequence (construction from the lower level to the upper level) after the foundation or the mat is placed. The construction period of the underground vertical members takes 20 to 25 days for one level, so that it takes 4 to 5 months for the six underground levels.

[11] The underground vertical members are constructed in a sequence (down-top) after the foundation or the mat is placed. Since the above-ground level can continue to go up after the underground vertical members are completed, the underground vertical member is a critical path that determines the

construction period.

[12] On the other hand, the construction speed of the construction of the above-ground level frame is fast, with a cycle of 6 to 7 days for one level, while the number of levels that can go up to the time point of placing of the underground level mat (for example, the 8th above-ground level) and the number of levels that can go up to the completion time point (15th above-ground level) of the underground vertical member is limited. Therefore, construction stops and construction waiting occurs at an inflection point of the 8th and 15th above-ground levels.

[13] During the construction period of the underground vertical members, it is necessary to achieve a condition that the construction of each level has to be carried out continuously and smoothly without temporal flexibility. If even one level is delayed, the above-ground level construction will be delayed by that much. Therefore, the existing construction method, in which the underground vertical members have to be continuously and smoothly constructed in a short period of time, has a very high risk of delay.

[14] The top-down construction method has an advantage of shortening the construction period by constructing the above-ground level while constructing the underground level. However, according to the structural constraint that the above-ground level cannot go up to more than a certain number of levels depending on the construction speed of the

underground level, the construction period is greatly affected by the construction of the underground level frame.

[15] Related applications are as follows.

[16] Application No./Date 1020110024619 (March 18, 2011), Applicant Hanbit Structure Engineering Co., Ltd., Registration No./Date 1012420170000 (March 5, 2013), Title of Invention Simultaneous construction method of ground and underground structure using ground core pre-construction and latticed lintel beam in core.

[17] Construction method

[18] Application No. 1995-0003110, Application Date February 18, 1995, Method of simultaneously constructing frameworks for floors and underground levels of a building.

[19] Application No. 10-2003-0037296, Application Date June 10, 2003, Simultaneous construction method of building having mixed structure of reinforced concrete construction and steel framed reinforced concrete structure.

[20] Application No. 10-2011-0087835, Application Date August 31, 2011, Registration No. 10-1101182, Registration Date December 26, 2011, Top-down method of underground structure.

[21] Application No. 10-2013-0004918, Application Date January 16, 2013, Registration No. 10-1426511, Registration Date July 29, 2014, Temporary skeleton system used in constructing an underground structure of a building and a top-down underground construction method using a temporary skeleton system.

SUMMARY OF INVENTION

Technical Problem

[22] The present invention was created to solve the problems of the prior art as described above, and an object thereof is to shorten the construction period of the underground vertical members using a top-down construction method so that the above-ground level frame construction can be continuously carried out. Accordingly, the overall construction period is shortened.

Solution to Problem

[23] In order to achieve the above object and solve the problems of the prior art, a method for alternately constructing underground vertical members according to the present invention includes alternately constructing underground vertical members downward, and thereafter, constructing the remaining vertical members during the same time period by being distributed between the previously constructed vertical members.

Advantageous Effects

[24] According to the present invention, the following effects can be expected.

[25] The construction period is shortened by pre-constructing a number of underground vertical members on the overall process table and excluding them from the main process line (critical path) that determines the construction period.

[26] By alternately constructing underground vertical members, a buckling length of the pillar is shortened, allowing more above-ground levels to be constructed, thereby shortening the overall construction period.

[27] If the vertical members are alternately constructed, the remaining portions which are constructed upward can be constructed during the same time period, thereby shortening the overall construction period.

[28] Since the underground vertical members can be constructed early after the construction of the corresponding level slab, there is less room for construction delay and thereby the overall construction period is not delayed.

[29] The construction period can be further shortened by constructing only the reinforcing bar assembly first and placing concrete during the same time period.

[30] In the prior art, after placing of the mat, the 6th underground level vertical member is constructed, and then the 5th underground level, the 4th underground level, the third underground level, and the second underground level are constructed in a sequence. Accordingly, in the prior art, it took a total of 125 days to construct 5 levels in a sequence in a case of 25 days per level. However, according to the present invention it takes only 25 days by constructing the 6th underground level, the 4th underground level, and the second underground level during the same time period which are the even-numbered levels after the mat is constructed because the odd-numbered levels have already been completed

before the mat is placed. As a result, in the prior art, it took 125 days after the mat is placed, but according to the present invention, it takes 25 days, so that as a result, about 100 days are shortened.

[31] According to the present invention, it exhibits an effect of shortening the construction period of about 3 months (about 8% of the total construction period) for 36 months compared to 39 months in an office building with 6 underground levels and 39 above-ground levels.

[32] The reduction of the overall construction period in the office and officetel buildings, and the like reduces construction costs such as construction management costs and on-site expenses from the construction company side, and has a high economic effect that early sales, rental income, additional sales (25% of annual sales), and the like from the building owner's side.

BRIEF DESCRIPTION OF THE DRAWINGS

[33] FIG. 1 is an overall flow chart of a method for alternately constructing underground vertical members according to the present invention.

[34] Figs 2 and 3 are examples of process tables of an office building of the 39th level in a method for alternately constructing underground vertical members according to the present invention.

[35] FIG. 4 is an enlarged process table of an underground vertical member process of FIG. 2 according to the present

invention.

[36] FIG. 5 is an example of a process table of the latest start point of construction of the underground vertical members which are alternately constructed according to the present invention.

[37] FIG. 6 is a comparison process table of the earliest start point and the latest start point of construction of the underground vertical members which are alternately constructed according to the present invention.

[38] FIG. 7 is an overall flow chart of a method for constructing underground vertical members of a conventional construction method.

[39] Figs 8 and 9 are examples of process tables of an office building of the 39th level to which the conventional construction method is applied.

[40] FIG. 10 is an enlarged process table of the underground vertical member process of the conventional construction method of FIG. 8.

[41] FIG. 11 is a comparison process table in which the conventional construction method is compared with the process of the underground vertical members alternately constructed according to the present invention.

[42] Figs 12 and 13 are comparison tables of a schedule difference in which the overall process table (FIGS. 8 and 9) of the conventional construction method is compared with the overall process table (FIGS. 2 and 3) of the underground vertical members alternately constructed according to the

present invention.

[43] FIG. 14 is a process comparison graph in which the overall process table of the conventional construction method (FIGS. 8 and 9) is compared with the overall process table of the underground vertical members alternately constructed according to the present invention (FIGS. 2 and 3) in an S-Curve form.

BEST MODE FOR INVENTION

[44] Hereinafter, a method for alternately constructing underground vertical members using a top-down construction method according to the present invention will be described in detail.

[45] FIG. 1 is an overall flow chart of the method for alternately constructing underground vertical members using a top-down construction method according to an embodiment of the present invention. A target project to be executed is an SRC office building with 6 underground levels and 39 above-ground levels.

[46] Referring to FIG. 1, in the method for constructing the underground vertical members according to the present embodiment, in an earth retaining wall construction step S10, the earth retaining wall is constructed in the underground level based on an outer wall of the underground level of the building, and a slurry wall, a CIP, an H-pile, an earth plate, and the like are constructed.

[47] In an underground post construction step S20, pillars of

the building are constructed from the above ground to the foundation and the mat to support a slab of the underground level in the top-down construction method, and a PRD and a RCD are constructed.

[48] In the first level construction slab step S30, the first level slab is completed by excavating the first underground level and placing a steel beam, a deck plate, and concrete using the pillars constructed in the step S20.

[49] In the first underground level slab construction step S40, the second underground level is excavated and the first underground level slab is completed as in the first above-ground level.

[50] In the first underground level vertical member (core parts and pillars) construction step S50, the first underground level core parts are completed from the first underground level slab constructed in the step S40, and a core part frame can be constructed upward to the above-ground level.

[51] In the above-ground frame (primary) construction step S60, the core parts and the pillars of the above-ground level are completed from the core parts and the pillars of the first underground level constructed in the step S50. For example, if the frame can be constructed up to the 8th above-ground level before the mat construction under a structural condition of a PRD file, in the construction step of the frame (primary) of the above-ground level, the frame is constructed up to the 8th above-ground level.

[52] In the second underground level slab construction step S70, the second underground level slab is constructed after excavating the third underground level downward following the step S40.

[53] In the third underground level slab construction step S80, the third underground level slab is constructed after excavating the 4th underground level downward following the step S70.

[54] In the third underground level vertical member construction step S90 according to the features of the present invention, the third underground level core part is completed from the third underground level slab constructed in the step S80. After constructing the first underground level core part in the step S50, if the construction of the second underground level core part is omitted and the third underground level core part is alternately constructed, the construction can be done in a sequence, thereby making construction easy.

[55] In the prior art, the third underground level core part is constructed in a sequence from the 6th underground level after the mat has been placed, but according to the present invention, the third underground level vertical member is first alternately constructed after the first underground level core part is constructed, and thereby the construction period is shortened.

[56] In the 4th underground level construction slab step S100, the 4th underground level slab is constructed after

excavating the 5th underground level downward following the step S80.

[57] In the 5th underground level slab construction step S110, the 5th underground level slab is constructed after excavating the 6th underground level downward following the step S100.

[58] In the 5th underground construction vertical member step S120 according to the features of the present invention, the 5th underground level core part is completed from the 5th underground level slab is constructed in the step S110. After constructing the third underground level core part in the step S90, if the construction of the 4th underground level core part is omitted and the 5th underground level core part is alternately constructed, the construction can be done in a sequence.

[59] In the prior art, the 5th underground level core part is constructed in a sequence from the 6th underground level after the mat has been placed, but according to the present invention, the 5th underground level vertical member is first alternately constructed after the third underground level core part is constructed, and thereby the construction period is shortened.

[60] The third underground vertical member construction step S90 and the 5th underground vertical member construction step S120 are the method for alternately pre-constructing in a sequence before placing of the mat according to the features of the present invention, and thereby the construction period

is shortened.

[61] After that, in the foundation or mat construction step S130, the foundation and the mat are constructed after the final excavation downward following the step S110. When the mat is constructed, now the construction is turned again and the underground level vertical member and the above-ground level frame are constructed during the same time period. For example, the above-ground level frame can go up to the 8th above-ground level before the mat construction, the construction up to the 15th level can be performed until the construction of the underground level vertical members are completed, and the construction up to the roof level, which is the top level, is carried out after the underground level vertical members are completed.

[62] When the foundation and the mat are completed (S140), the underground levels vertical members (core parts and pillars) are constructed.

[63] Of the underground level vertical members, the first underground level vertical member (S50), the third underground level vertical member (S90), and the 5th underground level vertical member (S120) were alternately pre-constructed according to the present invention, so the remaining vertical members are in the 6th underground level, the 4th underground level, and the second underground level. In the present invention, for the construction of the remaining vertical members (6th underground level, 4th underground level, and second underground level), since the

core part has already been constructed above and below the corresponding level, it has an advantage and a feature that the construction can be carried out at a time (S150, S160, and S170).

[64] In the prior art, after the 6th underground level core part is constructed, the 5th underground level core part is constructed, and then the 4th underground level core part, the third underground level core part, and the second underground level core part has to be constructed in order. However, according to the present invention, since the remaining vertical members (6th underground level, 4th underground level, and second underground level) can be constructed during the same time period, only one level construction period is required.

[65] Accordingly, before the mat is placed, the core parts of two levels of the third underground level and the 5th underground level are first constructed, the mat is placed, and then the remaining vertical members (6th underground level, 4th underground level, and second underground level) are constructed during the same time period, so that an effect that the pre-construction of a total of 4 levels is carried out is provided. Therefore, in the prior art, in a case where it takes 25 days for the construction of the vertical member of one level, it takes 125 days, but according to the present invention, it takes 25 days, and thereby the total construction period of 100 days is reduced.

[66] As described above, when the construction of the

underground level vertical member is completed (S170), construction of the above-ground level frame (secondary) (S180) can be started. For example, the above-ground level frame (primary) can be constructed up to the 15th above-ground level until the underground level vertical members are completed, and after the underground level vertical members are completed, the above-ground level frames (secondary) (S180) from the 16th above-ground level to the top above-ground level (roof) can be constructed without restrictions.

[67] Figs 2 to 3 are an overall process tables of the method for alternately constructing underground vertical members using a top-down construction method in accordance with an embodiment of the present invention.

[68] Referring to FIG. 2, the present embodiment is carried out in an office building with 6 underground levels and 39 above-ground levels, and has an SRC structure, and using top-down construction method. The construction start date is January 1, 2019.

[69] Referring to the process table, H-pile/CIP is constructed in the earth retaining wall construction stage (work No. 6 in the first column on the left of the process table), and the work period is 80 days.

[70] PRD of work No. 7 is provided to construct a number of pillar posts in the underground level, and the construction period is 70 days.

[71] Excavation of the first underground level and first level slab of work No. 8 are SRC construction in which the

first level floor steel beams are constructed on posts, and the deck plate and concrete are placed when the PRD construction of work No. 7 is completed, and the construction period is 50 days.

[72] Excavation of the second underground level and construction of the first underground level slab (work No. 9, hereinafter, indicated by only the number) are construction in which the second underground level is excavated downward when the first level slab (No. 8) is completed, and then the first underground level slab (No. 9) is constructed, and the construction period is 50 days.

[73] When the first underground level slab (No. 9) is completed, the first underground level core part and the pillar (No. 22) are constructed so that the construction can proceed to the above-ground level. As a result, the underground level downward construction and the above-ground level upward construction are simultaneously carried out, and this is generally referred to as top-down construction.

[74] When the first underground level core part (No. 22) is completed, it is possible to continuously construct from the second above-ground level slab (No. 25) to the 8th above-ground level slab (No. 31). At this time, a load on the above-ground level up to the 8th above-ground level is received by the PRD.

[75] Since the 9th above-ground slab (No. 32) can proceed only when the mat concrete (No. 15) is constructed, the construction is stopped for about 4 months after the

construction of the 8th above-ground level (No. 31) is completed. According to a structural calculation, since the PRD can only support the load up to the 8th above-ground level (No. 31), the construction of the 9th above-ground level (No. 32) can be started after the mat is placed.

[76] Alternatively, the construction of the above-ground levels from the second above-ground level can be started about 3 months late, and the waiting period of the construction between the 8th and 9th above-ground levels can be minimized to continuously construct or proceed slowly up to the 8th above-ground level.

[77] When the first underground level slab (No. 9) is completed, the second underground level slab (No. 10) is constructed after the third underground level is excavated downward, and the construction period is 50 days.

[78] When the second underground level slab (No. 10) is completed, the third underground level slab (No. 11) is constructed after the 4th underground level is excavated, and the construction period is 50 days.

[79] When the third underground level slab (No. 11) is completed, the third underground level core part (No. 20) is first constructed according to the features of the present invention. In the existing construction method, the third underground level core part (No. 20) is constructed upward from the 6th underground level after the mat (No. 15) is completed. Therefore, according to the present invention, the three underground level core part (No. 20) is constructed

first compared to the existing construction method, and thereby the construction period is shortened.

[80] After constructing the first underground level core part (No. 22), the second underground level core part (No. 21) is skipped and the third underground level core part (No. 20) is alternately constructed. The reason is that it is difficult to construct a connection part if the second underground level core part (No. 21), which is immediately below the first underground level, is constructed in the top-down construction method after the construction of the first underground level core part (No. 22). Therefore, if the third underground level core part (No. 20) is alternately constructed after the first underground level core part (No. 22) is constructed, since the second underground level, which is the upper level of the third underground level, is empty, the third underground level can be constructed in a sequence, so that the construction is easy.

[81] When the first underground level core part (No. 22) and the third underground level core part (No. 20) are alternately completed, the second underground level core part (No. 21) disposed between them can be constructed by sandwiching therebetween.

[82] When the third underground level slab (No. 11) is completed, the construction continues downward, and the 4th underground level slab (No. 12) is constructed after the 5th underground level is excavated, and the construction period is 50 days.

[83] When the 4th underground level slab (No. 12) is completed, the 5th underground level slab (No. 13) is constructed after the 6th underground level is excavated, and the construction period is 50 days.

[84] At this time, when the 5th underground level slab (No. 13) is completed, the 5th underground level core part (No. 18) is first constructed according to the features of the present invention. In the existing construction method, the 5th underground level core part (No. 18) is constructed upward in order from the 6th underground level after the mat 15 is completed. Therefore, according to the present invention, the 5th underground level core part (No. 18) has the feature of being constructed first compared to the existing construction method, and thereby the overall construction period is shortened.

[85] After the third underground level core part (No. 20) is constructed, the 4th underground level core part (No. 19) is skipped and the 5th underground level core part (No. 18) is alternately constructed. The reason is that the construction of the connection part is difficult to construct the 4th underground level core part (No. 19), which is immediately below the third underground level, using the top-down construction method after the third underground level core part (No. 20) is constructed. This is the same as the case of the third underground level core part (No. 20).

[86] After the 6th underground level is excavated, the mat excavation (No. 14) is carried out, and then the foundation

and the mat (No. 15) are constructed.

[87] When the mat (No. 15) is completed, the mat 15 supports the load that has been supported by the PRD, so that the above-ground level can go up to the 9th level (No. 32) or more.

[88] On the other hand, the reason for limiting that the above-ground level can only go up to the 15th level until the completion of the underground vertical member after the construction of the mat (No. 15) is the buckling of the underground level PRD, and the PRD pillars from the 6th underground level to the second underground level are exposed for about 5 levels. However, according to the present invention, since the odd-numbered levels have already been alternately constructed, the PRD pillar is exposed for the height of only one level, so that there is little buckling restriction. Therefore, depending on the above-ground level construction method, a new effect of capable of constructing higher above-ground levels is exhibited.

[89] After completion of the mat (No. 15), the number of the remaining frames in the underground levels now is three, that is, the 6th underground level core part (No. 17), the 4th underground level core part (No. 19), and the second underground level core part (No. 21). Since the third underground level core part (No. 20) and the 5th underground level core part (No. 18) have been alternately completed in advance, the core parts of the remaining three levels may be constructed by sandwiching therebetween.

[90] According to the features of the present invention, since the odd-numbered level core parts have already been constructed, the remaining three levels can be worked simultaneously, at the same period, or in sequence.

[91] On the other hand, in the construction of the second underground level core part (No. 21) and the 4th underground level core part (No. 19), reinforcing bars are pre-constructed, and the concrete is placed during the same time period after the mat 15 is placed to further increase productivity.

[92] Therefore, in the prior art, three levels (about 75 days) were required because three levels had to be constructed in a sequence, but according to the features of the present invention, since it is possible to construct three levels at the same period, the construction period (25 days) of only one level is required, so that the effect of shortening two levels is provided because it takes for only one level (25 days).

[93] According to the present invention, the construction period of two levels is shortened by simultaneously constructing the underground level vertical members and pre-constructing the third underground level core part (No. 20) and the 5th underground level core part (No. 18) before the mat construction, and the core parts (Nos. 17, 19, and 21) of the remaining three levels are constructed at once after the mat (No. 15) is excavated to shorten the construction period of two levels, thereby having the effect of shortening the

construction period of a total of four levels. Since the underground level core part is the main construction line (critical path), the total construction period is shortened.

[94] Referring to FIG. 3, the final work, that is the finishing work, is displayed along with the frame construction from the 5th above-ground level to the 39th above-ground level. According to the structural calculation of the top-down construction, a process table is created in which the 9th above-ground level slab (No. 32) can be started after the mat is placed, and the 16th above-ground level slab (No. 39) is started after all of the underground vertical members are completed. From the 16th level to the 39th level of the top level, the construction of the frames is carried out in a cycle of 6 days, and the general finishing construction was applied for one year. The finishing construction includes interior decoration construction, elevator construction, dismantling of temporary construction such as external curtain wall and tower crane, roof construction, landscaping construction, and the like after the roof frame is completed.

[95] Therefore, the total construction period of the office building with the 39 levels takes 1,106 days (about 36 months) as illustrated in the work No. 1 in FIG. 2 when applying the method for alternately constructing underground vertical members using a top-down construction method according to the present invention. The total construction period is shortened by about 3 months compared to the

existing construction method.

[96] FIG. 4 is an enlarged process table of the underground vertical member process of FIG. 2.

[97] Referring to FIG. 4, the construction of the odd-numbered underground level vertical members (the first underground level core part (No. 22), the third underground level core part (No. 20), and the 5th underground level core part (No. 18)) among the underground level vertical members are started after the corresponding level slabs are completed. The construction of the remaining even-numbered vertical members (the 6th underground level core part (No. 17), the 4th underground level core part (No. 19), the second underground level core part (No. 21)) of 3 levels are carried out at the same period in parallel after the mat 15 is placed.

[98] The remaining even-numbered level vertical members (Nos. 17, 19, and 21) have features that can be constructed during the same time period by sandwiching therebetween since the odd-numbered levels have already been alternately constructed.

[99] FIG. 5 is an example of the process table of the latest start point of the underground vertical members that are alternately pre-constructed according to the present invention.

[100] The latest start point refers to the work schedule that can be constructed the latest without affecting the subsequent process. As late as possible start (finish) time means a schedule that can be constructed the latest without affecting the subsequent process.

[101] Referring to FIG. 5, the first underground level core part (No. 22) is constructed after completion of the first underground level slab for the above-ground level construction (No. 25~). Next, the three underground level core part (No. 20) can be constructed the latest before the even-numbered underground vertical members (Nos. 17, 19, and 21) are constructed.

[102] FIG. 6 is a comparison process table of the earliest start point and the latest start point of the underground vertical members which are alternately constructed according to the present invention. FIG. 6 is provided for explaining the contents of the construction which is carried out at which date or time point in the process table because the construction order of the vertical members is determined.

[103] Referring to FIG. 6, work Nos. 16 to 21 indicate an early process (FIG. 4), and work Nos. 23 to 28 indicate a late process (FIG. 5). The third underground level core part can be compared through the early work No. 20 and the late work No. 27. In other words, referring to the start column in No. 20, the construction of the third underground level can be started quickly on January 1, 2020, and can be started on May 15, 2020 in No. 27. Of course, the construction thereof can be started at any time between January 1 and May 15, 2020.

[104] As described above, the idea and embodiments of the method for alternately constructing underground vertical members according to the present invention from FIG. 1 to FIG. 6 have been described.

[105] The following describes the construction concept and embodiment of the underground vertical member of the conventional construction method using the top-down construction method in FIGS. 7 to 10.

[106] FIG. 7 is an overall flow chart of the underground vertical member construction method of the conventional construction method using the top-down construction method.

[107] Referring to FIG. 7, after the earth retaining wall (T10) is constructed on the outside of the building, the PRD or RCD posts (T20) are constructed underground in order to form frames using the top-down construction method. After that, the underground slabs are constructed downward while excavating the underground levels (T30 to T100). After excavating the 6th underground level (T100), the foundation and the mat (T110) are completed.

[108] Thereafter, the underground vertical members (T130 to T170) are constructed upward in a sequence from the 6th underground level (T130).

[109] On the other hand, for the above-ground level, after the completion of the first underground level core part (T50), the above-ground frame (primary) (T60) is constructed. For example, the construction up to the 8th above-ground level slab is carried out until the mat is placed. After placing of the mat, the above-ground level frames (secondary) (T180) from the 9th to 15th above-ground levels are constructed. When the underground vertical members (T130 to T170) are completed, it can be constructed without restrictions from

the 16th above-ground level.

[110] In the conventional top-down construction method, after construction is carried out downward from the ground to the lowest level, that is, the mat is used as a turning point and U-turned to construct the underground vertical members upward in a sequence.

[111] Therefore, the order of the underground levels is long, and the underground construction period is long.

[112] Figs 8 and 9 are overall process tables of the top-down construction method to which the conventional construction method is applied.

[113] Referring to FIG. 8, the building is an office building with 6 underground levels and 39 above-ground levels, and has an SRC structure, and using the existing reverse construction method of a top-down construction method. The construction start date is January 1, 2019. The configuration of FIG. 8 is similar to that of FIG. 2. The reason for explaining the process table by applying the existing construction method is to examine a difference in the construction sequence and the total construction period with the construction method according to the present invention.

[114] Referring to the process table, the earth retaining wall construction step (work No. 6 in the first column on the left of the process table) is H-pile/CIP work and the construction period is 80 days.

[115] The PRD of work No. 7 is provided to construct a number of pillar posts in the underground levels, and the

construction period is 70 days.

[116] Excavation of the first underground level and the first level slab construction of Work No. 8 are SRC work that installs the first level steel beams on the posts and places the deck plate and concrete when PRD work of work No. 7 is completed, and the construction period is 50 days.

[117] In the construction of excavation of the second underground level and the first underground level slab (work No. 9, hereinafter, indicated only by the number), when the first level slab (No. 8) is completed, the second underground level is excavated downward, and then the first underground level slab is constructed, and the construction period is 50 days.

[118] When the first underground level slab (No. 9) is completed, the core part and the pillar (No. 22) of the first underground level are constructed so that the construction can proceed to the above-ground levels. Therefore, the underground level downward construction and the above-ground level upward construction are simultaneously carried out, and this is generally referred to as a top-down construction.

[119] When the first underground level core part (No. 22) is completed, it can work continuously from the second above-ground level slab (No. 25) to the 8th above-ground level slab (No. 31). At this time, the load on the above-ground levels up to the 8th level is supported by the PRD.

[120] Since the 9 level slab (No. 32) can be constructed only when the mat concrete (No. 15) has to be placed, the

construction is stopped for about 4 months after the 8th above-ground level (No. 31) is completed. Since the PRD can only support the load up to the 8th above-ground level (No. 31), it is possible to undertake the 9th above-ground level (No. 32) after the mat is placed.

[121] When the first underground level slab (No. 9) is completed, the second underground level slab (No. 10) is constructed after the third underground level is excavated downward, and the construction period is 50 days.

[122] When the second underground level slab (No. 10) is completed, the third underground level slab (No. 11) is constructed after the 4th underground level is excavated, and the construction period is 50 days.

[123] When the third underground level slab (No. 11) is completed, the construction continues downward, and the 4th underground level slab (No. 12) is constructed after the 5th underground level is excavated, and the construction period is 50 days.

[124] When the 4th underground level slab (No. 12) is completed, the 5th underground level slab (No. 13) is constructed after the 6th underground level is excavated, and the construction period is 50 days.

[125] After the 6th underground level is excavated, the foundation or mat (No. 15) is constructed after the mat (No. 14) is excavated. When the mat (No. 15) is completed, since the mat (No. 15) supports the load which has been supported by the PRD, so that the above-ground level can go up to the

9th level (No. 32) or more.

[126] When the mat (No. 15) is completed, the underground vertical members (Nos. 17 to 21) are continuously and directly constructed from the 6th underground level core part (No. 17) to the second underground level core part (No. 21), and it takes 25 to 30 days per level. During this construction period, the above-ground level can be constructed from the 9th level (No. 32) to the 15th level (No. 38).

[127] Referring to FIG. 9, the 10th to 39th above-ground levels and finishing construction are indicated. The process table is created in which the construction of the 16th above-ground level slab (No. 39) is started when all the underground vertical members are completed. From the 16th level to the top level, the construction of the frames is carried out in a cycle of 6 days without any restrictions on the underground levels, and the general finishing construction is applied for one year.

[128] Therefore, if the method for alternately constructing underground vertical members according to the present invention is applied, the total construction period of the office building with the 39 levels takes 1,194 days (about 39 months) as illustrated in work No. 1 of FIG. 8.

[129] The total construction period of 39 months is longer by 3 months than the total construction period of 36 months according to the present invention. The reason is that it takes a lot of time to construct the underground vertical

walls in a sequence from the 6th underground level to the second underground level.

[130] FIG. 10 is an enlarged process table of the underground vertical member process of the conventional construction method of FIG. 8. It illustrates that the underground vertical members are constructed in a sequence from work No. 17 to work No. 21 after the construction of the mat (No. 15), and the construction period is 130 days, that is, it takes about 4.3 months.

[131] FIG. 11 is a comparison process table in which the process of the underground vertical members alternately constructed according to the present invention is compared with the conventional construction method.

[132] Referring to FIG. 11, work No. 1 to work No 19 are the process tables of the conventional construction method, work No. 20 to work No 38 are the process tables according to the present invention, and work No. 39 is a difference in construction period between the conventional construction method and the construction method of the present invention.

[133] First, in the conventional construction method, from work No. 12 to work No 16, the five underground level core parts (No. 10) are constructed in a sequence after construction of the mat (No. 10), and it takes 130 days.

[134] On the other hand, according to the present invention, from work No. 31 to work No 35, only 30 days are required after construction of the mat 29, and thereby it indicates that the construction period is shortened by 100 days in the

present invention (No. 39).

[135] The reason is that the third underground level core part (No. 34) and the 5th underground level core part (No. 32) are previously constructed, and the remaining three level core parts (Nos. 31, 33, and 35) can be constructed by inserting each other simultaneously or at the same time point (at the same period) after the construction of the mat 29. After odd-numbered level core parts are constructed, the remaining even-numbered level core parts are constructed at once. As a result, the conventional construction method requires construction of 5 times. However, in the present invention, the effect of shortening 100 days of 4 levels with construction of only one time is exhibited

[136] Figs 12 and 13 are comparison tables of a schedule difference in which the overall process tables (FIGS. 8 and 9) of the conventional construction method are compared with the overall process tables (FIGS. 2 and 3) of the underground vertical members alternately constructed according to the present invention.

[137] Referring to FIG. 12, the total construction period difference (work No. 1) in the two construction methods is 88 days of about 3 months, that is, it takes about 39 months in the conventional construction method and 36 months in the construction method of the present invention, and it can be seen that about 8% of the total construction period is shortened.

[138] The underground excavation, the top-down slab, and mat

construction (Nos. 6 to 15) are the same in the construction period in both construction methods.

[139] The difference therebetween occurs from the underground vertical members, and according to the present invention, the underground vertical members (core parts) are alternately constructed downward, and the construction of the remaining core parts is carried out at the same time.

[140] The last column (I) is a value obtained by subtracting the completion date for each level (column E) of the existing construction method from the completion date for each level (column H) according to the present invention.

[141] From the 16th above-ground level (No. 39), the difference of 88 days is fixed and continues until construction is completed.

[142] FIG. 13 illustrates that the schedule difference (completion date difference column (I)) of 88 days continues from the 16th above-ground level (No. 39) until the completion of the construction.

[143] FIG. 14 is a process comparison graph in which the overall process tables (FIGS. 8 and 9) of the conventional construction method are compared with the overall process tables (FIGS. 2 and 3) of the underground vertical members alternately constructed according to the present invention by indicating in an S-Curve form from FIGS. 12 and 13 which are arranged in tables.

[144] Referring to FIG. 14, a blue line indicates the existing construction method, and a red line indicates the

construction method of the present invention.

[145] Construction is started on January 1, 1999, and the 6th underground level mat is placed on June 8, 2020 (lowest point in the graph).

[146] Thereafter, the red line according to the present invention indicates that two levels are already alternately constructed, and three levels are constructed during the same time period in one month to complete the underground vertical members, and then lead to the 16th level.

[147] On the other hand, the blue line according to the conventional construction method indicates that it takes about 4.3 months to construct the underground vertical member for each level after the mat construction, and then leads to the 16th level. From the 16th level and above, the two construction methods are the same.

[148] As described above, the differences between the existing construction method and the construction method of the present invention are compared through the process tables and the graph.

[149] The following is a description of a case where some work is performed differently in embodiments of the present invention.

[150] In construction of a case where the final excavation is the 5th underground level, the underground core parts are first constructed downwards on the first and third underground levels, and after the mat is completed, the 5th underground level is constructed, and then the 4th and second

underground levels may be constructed during the same time period. Therefore, after the mat construction, the remaining core parts are constructed twice.

[151] In construction of a case where the final excavation is the 4th underground level, the underground core parts are first constructed downward on the first and third underground levels, and after the mat is completed, the 4th and second underground level core parts can be constructed during the same time period. It is the same concept as the construction of the 6 underground levels.

[152] Since the level height of the lowest underground level is not high, the lowest two levels (for example, the 5th and 6th underground levels) may be simultaneously excavated, the mat be completed, and then the 5th underground level slab be constructed. In this case, after simultaneously constructing the 6th underground level core part and the 5th underground level slab, the 5th underground level core part is constructed. Therefore, after the mat construction, the remaining core parts are constructed twice.

[153] As described above, in a case of simultaneously excavating two levels with odd numbered levels or the lowest two levels, it occurs in some construction that the remaining core parts are constructed twice in a sequence after the mat is completed. Therefore, according to one embodiment of the present invention, after alternately completing the core parts, there are many cases where the remaining core parts are completed at once, and in some construction, a case of

constructing the remaining parts twice is derived.

[154] The process table of the above embodiment is an example in which the date calculation is accurate because it is prepared by a program specializing in process table preparation. The Kant chart, which is a red bar chart in the process table, represents a major operation that determines the total construction period as a critical path of the major progress line. The blue bar chart represents an operation with float in the number of temporal flexible dates. Therefore, in order to shorten the construction period, the red line, which is the main construction line, has to be shortened. A connection line (relationship) including arrows connecting the bar charts in the process table indicates the preceding and subsequent relationship between works.

[155] As described above, according to the features of the present invention, based on the idea of alternately completing the core parts in order to shorten the construction period of the underground core parts, which determines the overall construction period, it can be seen that there may be some derivative core part construction in a sequence depending on the features of the site. However, unlike the sequential core part construction method which is the existing construction method, engineers in the construction industry clearly know that the core part construction method partially modified based on the idea of shortening the overall construction period through the alternate core part construction method according to the

present invention is included the gist of the present invention.

Modes for Carrying Out the Invention

[156] This is the sequence of the method for alternately constructing vertical members using a top-down construction method in a case of 8 underground levels according to an embodiment of the present invention.

[157] The construction sequence is as follows.

[158] Earth retaining wall

[159] Underground pillars (PRD, RDC, and ACT pillar)

[160] Excavation of the first and second underground levels

[161] Placing of the reinforced concrete of the steel deck in the first underground level (placing of slab)

[162] Excavation of the third underground level

[163] Placing of the second underground level slab, and placing of the first underground level core wall pillar

[164] Excavation of the 4th underground level

[165] Placing of the third underground level slab

[166] Excavation of the 5th underground level

[167] Placing of the 4th underground level slab, and placing of the third underground level core wall pillar

[168] Excavation of the 6th underground level

[169] Placing of the 5th underground level slab

[170] Excavation of the 7th underground level

[171] Placing of the 6th underground level slab, and placing of the 5th underground level core wall pillar

[172] Excavation of the 8th underground level and excavation

of the mat

[173] Placing of the 7th underground level slab, placing of the core wall pillar of the 7th underground level

[174] Placing of the 8th underground level mat

[175] Placing of the remaining levels of 8th underground level, 6th underground level, and 4th underground level, and the core wall pillar of 4th underground level (simultaneous construction of 4 levels)

[176] Alternatively, after primary construction of 2 levels of the 8th underground level and added one level, secondary construction of the core wall pillars of 2 levels (construction of 2 levels twice)

[177] Alternatively, after primary construction of 2 levels of the 8th underground level and added one level, secondary and tertiary construction of the core wall pillars of the remaining 2 levels one by one (construction of total 3 times of 2 levels once, and 1 level twice)

[178] Alternatively, after construction of the core wall pillar of the 8th underground level, construction of the remaining 3 levels one by one (construction of total 4 times for 4 levels)

[179] After placing of the mat, the remaining levels are 4 levels, and the 4 levels are placed by dividing into 1 time, 2 time, 3 time, and 4 time.

[180]

[181] The followings are the sequence of the method for alternately constructing vertical members using a top-down

construction method in a case of 7 underground levels according to an embodiment of the present invention.

[182] Earth retaining wall

[183] Underground pillars (PRD, RDC, and ACT pillar)

[184] Excavation of the first and second underground levels

[185] Placing of the reinforced concrete of the steel deck in the first underground level (placing of slab)

[186] Excavation of the third underground level

[187] Placing of the second underground level slab, and placing of the first underground level core wall pillar

[188] Excavation of the 4th underground level

[189] Placing of the third underground level slab

[190] Excavation of the 5th underground level

[191] Placing of the 4th underground level slab, and placing of the third underground level core wall pillar

[192] Excavation of the 6th underground level

[193] Placing of the 5th underground level slab

[194] Excavation of the 7th underground level and excavation of the mat

[195] Placing of the 6th underground level slab, placing of the 5th underground level core wall pillar

[196] Placing of the 7th underground level mat

[197] In the remaining levels of the 7th underground level, the 6th underground level, the 4th underground level, and the second underground level

[198] After primary construction of 2 levels of the 7 underground level and added one level, secondary construction

of the core wall pillars of the remaining 2 levels

[199] Alternatively, secondary construction of the 7th underground level and 2 levels among the remaining 3 levels, and construction of the remaining 1 level (construction by dividing total 3 times)

[200] Alternatively, construction of total 4 times one level by one level

[201]

[202] The followings are the sequence of the method for alternately constructing vertical members using a top-down construction method in a case of 6 underground levels according to an embodiment of the present invention.

[203] Earth retaining wall

[204] Underground pillars (PRD, RDC, and ACT pillar)

[205] Excavation of the first and second underground levels

[206] Placing of the reinforced concrete of the steel deck in the first underground level (placing of slab)

[207] Excavation of the third underground level

[208] Placing of the second underground level slab, and placing of the first underground level core wall pillar

[209] Excavation of the 4th underground level

[210] Placing of the third underground level slab

[211] Excavation of the 5th underground level

[212] Placing of the 4th underground level slab, and placing of the third underground level core wall pillar

[213] Excavation of the 6th underground level and mat

[214] Placing of the 5th underground level slab and placing of

the mat

[215] Placing of the 6th underground level mat and placing of the 5th underground level core wall pillar

[216] In the remaining levels of the 6th underground level, the 4th underground level, and the second underground level

[217] Simultaneous construction of the remaining 3 levels (total 1 time)

[218] Alternatively, after construction of the 6th underground level, simultaneous construction of the 4th underground level and the second underground level (total 2 times)

[219] Alternatively, after simultaneous construction of the 6th underground level and the 4th underground level, construction of the second underground level (total 2 times)

[220] Construction of 3 levels one level by one level for total 3 times (construction by dividing into 3 times).

[221]

[222] The followings are the sequence of the method for alternately constructing vertical members using a top-down construction method in a case of 5 underground levels according to an embodiment of the present invention.

[223] Earth retaining wall

[224] Underground pillars (PRD, RDC, and ACT pillar)

[225] Excavation of the first and second underground levels

[226] Placing of the reinforced concrete of the steel deck in the first underground level (placing of slab)

[227] Excavation of the third underground level

[228] Placing of the second underground level slab, and

placing of the first underground level core wall pillar

[229] Excavation of the 4th underground level

[230] Placing of the third underground level slab

[231] Excavation of the 5th underground level, and excavation of the mat

[232] Placing of the 4th underground level slab, and placing of the third underground level core wall pillar

[233] Placing of the 5th underground level mat

[234] In the remaining levels of the 5th underground level, the 4th underground level, and the second underground level

[235] After construction of the 5th underground level, simultaneous construction of the 4th underground level and the second underground level (total 2 times)

[236] Alternatively, after simultaneous construction of the 5th underground level and the second underground level, construction of the 4th underground level (total 2 times)

[237] Construction remaining 3 levels one level by one level (total 3 times).

[238]

[239] The followings are the sequence of the method for alternately constructing vertical members using a top-down construction method in a case of 4 underground levels according to an embodiment of the present invention.

[240] Earth retaining wall

[241] Underground pillars (PRD, RDC, and ACT pillar)

[242] Excavation of the first and second underground levels

[243] Placing of the reinforced concrete of the steel deck in

the first underground level (placing of slab)

[244] Excavation of the third underground level

[245] Placing of the second underground level slab, and placing of the first underground level core wall pillar

[246] Excavation of the 4th underground level and excavation of the mat

[247] Placing of the third underground level slab and placing of the 3th underground level core wall pillar

[248] Placing of the 4th underground level mat

[249] In the remaining levels of the 4th underground level and the second underground level

[250] Simultaneous construction of the remaining 2 levels (total 1 time)

[251] Construction of 2 levels one level by one level (total 2 times).

Industrial Applicability

[252] Currently, most of the top-down construction is carried out in downtown construction. With respect to the alternately constructing method according to the present invention, first, a structural design office designs the method, a contractor manufactures the steel frame and the formwork, and then the construction is carried out. Therefore, the present invention can be directly applied industrially.

CLAIMS

1. A construction period shortening method through a method for alternately constructing underground vertical members in construction of underground vertical members of a building in which an above-ground frame is constructed upward in parallel with construction of an underground structure downward, comprising:

a first step of excavating and constructing an underground level slab downward;

a second step of alternately pre-constructing an underground vertical member; and

a third step of constructing remaining underground vertical members alternately, during the same time period, or in 2 times after the construction of the second step,

wherein the construction is alternately carried out.

2. The construction period shortening method through a method for alternately constructing underground vertical members according to claim 1,

wherein when the underground level is a 6th underground level,

first underground level, 3rd underground level, and 5th underground level core parts are alternately pre-constructed while constructing the underground slab downward, and then 6th underground level, 4th underground level, and 2nd underground level core parts are constructed during the same time period.

3. The construction period shortening method through a method for alternately constructing underground vertical members according to claim 1,

wherein when the underground level is a 5th underground level,

first underground level and 3rd underground level core parts are alternately pre-constructed while constructing the underground slab downward, and then the 5th underground level core part is constructed, the 4th underground level core part is constructed, and the second underground level core part is constructed during a construction period of the 5th underground level and the 4th underground level.

4. The construction period shortening method through a method for alternately constructing underground vertical members according to claim 1,

wherein when the underground level is a 4th underground level,

first underground level and 3rd underground level core parts are alternately pre-constructed while constructing the underground slab downward, and then the 4th underground level and second underground level core parts are constructed during the same time period.

5. The construction period shortening method through a method for alternately constructing underground vertical

members according to claim 1,

wherein when 2 levels of the lowest level of the underground levels and an upper level thereof are simultaneously excavated,

the core parts are alternately pre-constructed while constructing the underground slab downward, the mat or the foundation is constructed, the lowest level core part and an upper level slab thereof are constructed, and then the remaining core parts are constructed during the same time period.

6. The construction period shortening method through a method for alternately constructing underground vertical members according to any one of claims 1 to 5,

wherein the core parts, which are alternately pre-constructed, and the remaining core parts, which are constructed thereafter during the same time period, are constructed by dividing into preceding and subsequent based on the mat excavation work.

7. The construction period shortening method through a method for alternately constructing underground vertical members according to any one of claims 1 to 5,

wherein a construction schedule of each of the core parts, which are alternately pre-constructed, is in a range between an earliest possible start date (early start date) which starts after the completion of the corresponding level

slab and the latest completion date (late finish date) which is completed before a time point when the remaining core parts are constructed subsequent.

8. The construction period shortening method through a method for alternately constructing underground vertical members according to any one of claims 1 to 5,

wherein the underground vertical member includes a core part or a pillar connected to an above-ground level.

9. The construction period shortening method through a method for alternately constructing underground vertical members according to claim 1,

wherein in the alternately constructed underground vertical members, the core part or the pillar of the odd-numbered (or even-numbered) underground level is pre-constructed while constructing the underground slab downward, the mat or the foundation is constructed, and then the core part or the vertical member of the pillar of the even-numbered (or odd-numbered) level, which is the remaining level, is constructed at once or twice depending on site conditions.

10. The construction period shortening method through a method for alternately constructing underground vertical members according to claim 1,

wherein the construction of the remaining core parts

subsequent and at once further includes a method for placing concrete, which is a subsequent process, at the same period after installing a reinforcing bar of the remaining underground core part as early as possible.

11. A construction period shortening method through a method for alternately constructing underground vertical members, comprising:

(a) a step of constructing a temporary earth retaining wall in a ground by a conventional method;

(b) a step of vertically installing an above-ground level core part and pillar, from above ground, which is constructed upward in parallel with construction of a underground structure downward when the underground structure and the above-ground structure are constructed;

(c) a step of excavating the first above-ground level, constructing a floor part thereof, excavating the first underground level, and then constructing a floor part thereof;

(d) a step of excavating each of the remaining underground levels in order in a downward direction and constructing the floor part, and simultaneously constructing core parts of one underground level or a plurality of underground levels first to support the above-ground level core part which is preferentially constructed upward;

(e) a step of preferentially constructing the above-ground level core part in an upward direction on an upper

part of the underground level core part which is constructed first, and installing the underground level frame in the downward direction in parallel therewith;

(f) a step of alternately installing the core parts after the core part of one underground level is installed first in the step of installing the underground level frame in the downward direction;

(g) a step of forming the foundation after the underground level frame is completed to the foundation, and installing the core parts of the remaining levels to be alternately constructed downward in the upward direction from the lowest level to the underground level core part which is constructed first, during the same time period or sequentially; and

(h) a step of constructing the construction completion through the remaining frame construction of the above-ground level and the final construction that is finishing work,

wherein the underground core parts are constructed first or during the same time period within a certain possible range to exclude them from a main process line critical path to shorten an overall construction period.

12. The construction period shortening method through a method for alternately constructing underground vertical members according to claim 11,

wherein the step of alternately installing the core parts includes constructing the odd-numbered level core part,

the remaining level core parts include the even-numbered level core parts, the odd-numbered level and even-numbered level core parts are converted based on the mat construction, and the lowest level core part and the upper level core part thereof are sequentially constructed depending on site features.