

BEAM STRING STRUCTURE OF FOUNDATION PIT, AND ASSEMBLING METHOD

TECHNICAL FIELD

The present invention relates to the technical field of construction engineering, and particularly relates to a beam string structure of a foundation pit and an assembling method.

BACKGROUND

To ensure the safety of underground structure construction and surroundings around foundation pits, it is necessary to adopt supporting, reinforcement, and protection measures for the side walls of and the surroundings around the foundation pit. Whether for deep foundation pit engineering in high-rise buildings or subway construction, most excavations are carried out in urban areas, and there are usually various structures such as main traffic roads, existing buildings, or pipelines around the foundation pit. Hence, to ensure the safety of the surroundings around the foundation pit, as well as to save construction time and reduce costs, the beam string structure system has been widely used.

Due to differences in the boundary shapes, site conditions, and excavation depths of each foundation pit, various specifications of beam string structures are required for matching application. In the prior art, components of various specifications of beam string structures have poor universality in the beam string structure system. This will lead to excessive component inventory, low turnover rate, and decreased economic benefits.

SUMMARY

The objective of the present invention is to overcome the above-mentioned defect existing in the prior art and to provide a beam string structure of a foundation pit and an assembling method. A plurality of universal-length standard steel tie rods are adopted in the middle of the lower chord of the beam string structure, with one end of each standard steel tie rod being a single lug and the other end being a double lug. A single-lug pre-embedded steel tie rod and a double-lug pre-embedded steel tie rod are adopted at both sides of the lower chord of the beam string structure,

respectively. The steel tie rods are continuously connected by single lugs and double lugs. The pre-embedded steel tie rods may be directly converted from standard steel tie rods. By configuring the number of intermediate standard steel tie rods, beam string structures of two or more spans may be formed. In this way, various spans of lower chords of a beam string structure may be formed by only using one specification (length) of steel tie rod. Two ends of the steel tie rod body are provided with a right-hand thread and a left-hand thread. When the embedded steel tie rod is removed and reused, the other end may be directly unscrewed by applying force to the single lug or double lug. The strut is prefabricated. Several specifications of components can meet the requirements of different specifications of the beam string structure, with strong component interchangeability, high universality, few specification types, convenient for use and management. Various specifications of beam string structures can be assembled only using a few of standard parts, which greatly improves the applicability of the beam string structure and the utilization rate of standard parts, thereby resulting in a higher turnover rate and better economic efficiency. The single category of components makes yard management and on-site construction and installation more convenient and simpler.

The objective of the present invention can be achieved by the following technical solutions:

A beam string structure of a foundation pit is provided, comprising: a horizontal support assembly and a vertical support assembly.

The horizontal support assembly includes: an upper-chord concrete beam, a prefabricated strut, and a lower-chord steel tie rod; and the vertical support assembly includes: a support unit, a stand column, and a corbel.

The lower-chord steel tie rod includes: a single-lug pre-embedded steel tie rod, a plurality of standard fixed-length steel tie rods, and a double-lug pre-embedded steel tie rod that are connected in sequence; one end of the single-lug pre-embedded steel tie rod is connected to the upper-chord concrete beam, and the other end of the single-lug pre-embedded steel tie rod is connected to the standard fixed-length steel tie rods; one end of the double-lug pre-embedded steel tie rod is connected to the upper-chord concrete beam, and the other end of the double-lug pre-embedded steel tie rod is connected to the standard fixed-length steel tie rods; and two of the standard fixed-length steel tie rods are connected via a tie-rod joint unit on the prefabricated strut.

The support unit includes a standard large support and a standard small support. One end of the standard small support is connected to the upper-chord concrete beam, and the other end of the standard small support is disposed on the standard large support. One end of the standard large support is disposed on the corbel, and the other end of the standard large support is connected to the upper-chord concrete beam, or both ends of the standard large support are disposed on the corbel. The corbel is welded or bolted to the stand column; and the prefabricated strut is disposed on the standard small support.

Further, the prefabricated strut includes: a tie-rod joint unit, a standard section, a prestress application section, and a secondary grouting adjustment section that are connected in sequence. The standard fixed-length steel tie rod includes: a first rod body a double-lug joint, a single-lug joint, and a lock nut; the double-lug joint and the single-lug joint are both connected to the first rod body via the lock nut. Both ends of the first rod body are provided with a right-hand threaded section and a left-hand threaded section, and both the right-hand threaded section and the left-hand threaded section have a consistent thread length, thus facilitating disassembly, assembly, and conversion of a joint. The single-lug pre-embedded steel tie rod includes: a second rod body, an anchorage head, and a single-lug joint. The anchorage head and the single-lug joint are disposed at both ends of the second rod body. The double-lug pre-embedded steel tie rod includes: a third rod body, a double-lug joint, and an anchorage head. The double-lug joint and the anchorage head are disposed at both ends of the third rod body, and the anchorage head is anchored either inside or outside the upper chord concrete.

Further, the prefabricated strut includes: a tie-rod joint unit, a standard section, a prestress application section, and a secondary grouting adjustment section that are connected in sequence. The standard fixed-length steel tie rod is connected to the tie-rod joint unit by a pin shaft. Both the single-lug joint and the double-lug joint are in threaded connection with the first rod body, the second rod body, and the third rod body. A lock nut is configured to ensure firm connection. The lengths of the single-lug pre-embedded steel tie rod, the standard fixed-length steel tie rod, and the double-lug pre-embedded steel tie rod may be freely adjusted to accommodate construction tolerances. Assuming the adjustment length of a single end is $\pm L$, when it is adjusted to $+L$, the length of the lock nut ensures that the threads are not exposed. Such a configuration protects the

threads from being damaged caused by exposure and prevents impurities from entering. Moreover, the non-exposed threads may serve as a basis for on-site installation adjustment, thus preventing the joint from being excessively unscrewed and ensuring load-bearing safety.

Further, the prefabricated strut includes: a tie-rod joint unit, a standard section, a prestress application section, and a secondary grouting adjustment section that are connected in sequence. One end of the tie-rod joint unit is bolted with the standard section, and the other end of the standard section is bolted with one end of the prestress application section. The bolt holes for connecting the tie-rod joint unit, the standard section, and the prestress application section are consistent, thereby allowing for standardized allocation, installation, and convenient length adjustment. The prestress application section is abutted against the secondary grouting adjustment section, and the secondary grouting adjustment section serves to adjust on-site installation tolerances and leveling during the construction phase.

Further, the prefabricated strut includes: a tie-rod joint unit, a standard section, a prestress application section, a secondary grouting adjustment section, and a concrete corbel adjustment section. The concrete corbel adjustment section is disposed on the upper-chord concrete beam and is cast integrally with the upper-chord concrete beam. The concrete corbel adjustment section is cast integrally with the upper-chord concrete beam, which serves to adjust the design length of the strut during the design phase, and may be configured as required.

Further, the prefabricated strut includes: a tie-rod joint unit, a standard section, a prestress application section, and a secondary grouting adjustment section that are connected in sequence. The tie-rod joint unit is a single-tie rod joint or a double-tie rod joint. The tie-rod joint unit includes: a first rectangular steel tube, a lug plate, a first stiffening plate, and a first end plate that are disposed on the first rectangular steel tube. The standard section includes: a second rectangular steel tube, a second end plate and a second stiffening plate that are disposed on the second rectangular steel tube.

Further, the prefabricated strut includes: a tie-rod joint unit, a standard section, a prestress application section, and a secondary grouting adjustment section that are connected in sequence. The prestress application section includes: a jack joint, an L-shaped support, a cushion block, a jack, a connecting member, a connecting plate, a movable head, and a steel wedge block. One end

of the jack joint is bolted with the standard section, and the other end of the jack joint is bolted with the cushion block via the movable head. A side edge of the jack joint is connected to the L-shaped support; the L-shaped support includes a channel steel and a third stiffening plate. The L-shaped support is erected on the upper-chord concrete beam; the jack is disposed in a groove of the jack joint. When two jacks are provided, the jacks are connected to the jack joint by upper and lower bolts; when a single jack is provided, the jack is connected to the jack joint by the connecting member. A piston rod in front of the jack is connected to the cushion block by the connecting plate, a bottom portion of the connecting member is bolted with the jack joint. A slotted hole is disposed in a top portion of the jack joint, and the top portion of the jack joint is connected to a side face of the jack. An angled joint oil pipe is adopted for oil delivery of the jack; the use of the angled joint oil pipe may make full use of limited space.

Further, both ends of the standard large support are a first end plate end and a first notched end. The first notched end is connected to an embedded part on the upper-chord concrete beam, and the standard large support may be extended through the first end plate end. Both ends of the standard small support are a second end plate end and a second notched end, and the second notched end is connected to the upper-chord concrete beam via the embedded part.

Further, the standard large support and the standard small support are both H-shaped steel. The prefabricated strut and the standard small support are connected by a #-shaped stirrup. The standard large support and the standard small support are connected by a clamp or a bolt; and the standard large support is connected to the corbel by welding or bolting.

The present invention further provides an assembling method of a beam string structure of a foundation pit. The prefabricated strut includes: a tie-rod joint unit, a standard section, a prestress application section, and a secondary grouting adjustment section that are connected in sequence.

The method includes the following steps:

assembling the vertical support assembly: welding the corbel to the stand column, connecting one end of the standard small support to the upper-chord concrete beam, disposing the other end of the standard small support on the standard large support, disposing one end of the standard large support on the corbel, connecting the other end of the standard large support to the upper-chord concrete beam, or disposing both ends of the standard large support on the corbel;

assembling the horizontal support assembly: connecting the tie-rod joint unit, the standard section, and the prestress application section in sequence to form the prefabricated strut, and connecting the prefabricated strut to the standard small support; connecting the single-lug pre-embedded steel tie rod, the plurality of standard fixed-length steel tie rods, and the double-lug pre-embedded steel tie rod in sequence to form the lower-chord steel tie rod; connecting one end of the single-lug pre-embedded steel tie rod to the upper-chord concrete beam, and connecting the other end of the single-lug pre-embedded steel tie rod to the standard fixed-length steel tie rod; connecting one end of the double-lug pre-embedded steel tie rod to the upper-chord concrete beam, and connecting the other end of the double-lug pre-embedded steel tie rod to the standard fixed-length steel tie rod; and connecting two standard fixed-length steel tie rods by the tie-rod joint unit; and

assembly transformation: transforming the standard fixed-length steel tie rod into a single-lug pre-embedded steel tie rod or a double-lug pre-embedded steel tie rod by removing the double-lug joint or the single-lug joint from the standard fixed-length steel tie rod and adding the anchorage head, and disposing the single-lug pre-embedded steel tie rod and the double-lug pre-embedded steel tie rod at both ends, respectively; configuring a plurality of standard fixed-length steel tie rods to form various spans of lower chords of the beam string structure available; where each of the steel tie rods may be configured in a single layer, a double layer, or more; and splicing the standard large support into one or more sections as needed.

Compared with the prior art, the present invention has the following advantages:

(1) The design of the universal fixed-length steel tie rod enables the assembly of different specifications of lower chords of the beam string structure using a single standard steel tie rod.

(2) Two ends of the steel tie rod body are provided with a right-hand thread and a left-hand thread, and when the embedded steel tie rod is removed and recycled, the other end can be directly unscrewed by applying force to the single lug or double lug.

(3) The strut is prefabricated, and several specifications of components can meet the requirements of different specifications of beam string structures, with strong component universality.

(4) The support is designed for universality, with a few types of specification, making it

convenient for use and management.

(5) Beam string structures of various specifications can be assembled only using a few standard parts, which greatly improves the applicability of beam string structures and the utilization rate of standard parts, resulting in a higher turnover rate and greater economic efficiency. The single category of components makes storage yard management, on-site construction and installation more convenient and simpler.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a beam string structure of a foundation pit;

FIG. 2 illustrates schematic diagrams showing different specifications of horizontal support assemblies;

FIG. 3 illustrates schematic diagrams showing different specifications of vertical support assemblies;

FIG. 4 illustrates schematic diagrams showing different specifications of beam string structure of a foundation pit;

FIG. 5 is a schematic diagram showing an A-A diagram of the beam string structure of a foundation pit;

FIG. 6 is a schematic diagram showing a connection mode of a lower-chord steel tie rod;

FIG. 7 is a schematic diagram showing a standard fixed-length steel tie rod;

FIG. 8 is a schematic diagram showing a double-lug pre-embedded steel tie rod;

FIG. 9 is a schematic diagram showing a single-lug pre-embedded steel tie rod;

FIG. 10 is a schematic diagram showing a standard large support;

FIG. 11 is a schematic diagram showing a standard small support;

FIG. 12 is a schematic diagram showing connection between a support unit and an embedded part;

FIG. 13 is a schematic diagram of a standard section;

FIG. 14 is a schematic diagram of a tie-rod joint unit;

FIG. 15 is a schematic diagram of a prestress application section;

FIG. 16 is a schematic diagram of an L-shaped support;

FIG. 17 is a schematic diagram of a prefabricated strut;

FIG. 18 is a schematic diagram showing connection between the prefabricated strut and a single-layer standard fixed-length steel tie rod;

FIG. 19 is a schematic diagram showing connection between the prefabricated strut and a double-layer standard fixed-length steel tie rod;

FIG. 20 is a schematic diagram of a connecting plate; and

FIG. 21 is a schematic diagram of a connecting member.

Reference numerals: 1-upper-chord concrete beam; 2-prefabricated strut; 3-lower-chord steel tie rod; 4-standard large support; 5-stand column; 6-corbel; 7-standard small support; 8-standard fixed-length steel tie rod; 9-single-lug pre-embedded steel tie rod; 10-double-lug pre-embedded steel tie rod; 11-prestress application section; 12-standard section; 13-secondary grouting adjustment section; 14-concrete corbel adjustment section; 15-first rod body; 16-double-lug joint; 17-single-lug joint; 18-lock nut; 19-tie-rod joint unit; 20-lug plate; 21-first stiffening plate; 22-first end plate; 23-first rectangular steel tube; 24-second rectangular steel tube; 25-second end plate; 26-second stiffening plate; 27-jack joint; 28-L-shaped support; 29-cushion block; 30-jack; 31-connecting member; 32-connecting plate; 33-movable head; 34-steel wedge block; 35-channel steel; 36-third stiffening plate; 37-double-tie rod joint; 38-single-tie rod joint; 39-right-hand threaded section; 40-left-hand threaded section; 41-anchorage head; 42-first end plate end; 43-first notched end; 44-second end plate end; 45-second notched end; 46-embedded part; 47-angled joint oil pipe; 48-pin shaft.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present invention will be described in detail below with reference to the drawings and detailed embodiments. In this technical solution, any features such as component models, material names, connection structures, control methods, and algorithms that are not explicitly stated shall be deemed as common technical features disclosed in the prior art.

Embodiment 1

This embodiment provides a beam string structure of a foundation pit. As shown in FIGS. 1, 2, 3, 4, and 5, the structure includes: a horizontal support assembly and a vertical support assembly.

The horizontal support assembly is configured to support a foundation pit enclosure structure, and the vertical support assembly is configured to support the weight of the horizontal support assembly.

The horizontal support assembly includes: an upper-chord concrete beam 1, a prefabricated strut 2, and a lower-chord steel tie rod 3; the vertical support assembly includes: a support unit, stand column 5, and a corbel 6.

The prefabricated strut 2 includes: a tie-rod joint unit 19, a standard section 12, a prestress application section 11, and a secondary grouting adjustment section 13 that are connected in sequence.

As shown in FIGS. 6, 7, 8, and 9, the lower-chord steel tie rod 3 includes: a single-lug pre-embedded steel tie rod 9, a plurality of standard fixed-length steel tie rods 8, and a double-lug pre-embedded steel tie rod 10 that are connected in sequence. One end of the single-lug pre-embedded steel tie rod 9 is connected to the upper-chord concrete beam 1, and the other end of the single-lug pre-embedded steel tie rod 9 is connected to the standard fixed-length steel tie rod 8. One end of the double-lug pre-embedded steel tie rod 10 is connected to the upper-chord concrete beam 1, and the other end of the double-lug pre-embedded steel tie rod 10 is connected to the standard fixed-length steel tie rod 8. Two standard fixed-length steel tie rods 8 are connected via the tie-rod joint unit 19.

As shown in FIG. 10 and FIG. 11, the support unit includes a standard large support 4 and a standard small support 7. One end of the standard small support 7 is connected to the upper-chord concrete beam 1, and the other end of the standard small support 7 is disposed on the standard large support 4. One end of the standard large support 4 is disposed on the corbel 6, and the other end of the standard large support 4 is connected to the upper-chord concrete beam 1, or both ends of the standard large support 4 are disposed on the corbel 6. The corbel 6 is welded or bolted to the stand column 5. The prefabricated strut 2 is disposed on the standard small support 7.

In a detailed embodiment, the standard fixed-length steel tie rod 8 includes: a first rod body 15, a double-lug joint 16, a single-lug joint 17, and a lock nut 18. Both the double-lug joint 16 and the single-lug joint 17 are connected to the first rod body 15 via the lock nut 18. Both ends of the first rod body 15 are provided with a right-hand threaded section 39 and a left-hand threaded

section 40. The right-hand threaded section 39 and the left-hand threaded section 40 have a consistent thread length, facilitating disassembly, assembly, and conversion of the joints. The single-lug pre-embedded steel tie rod 9 includes: a second rod body, an anchorage head 41, and a single-lug joint 17. The anchorage head 41 and the single-lug joint 17 are disposed at both ends of the second rod body. The double-lug pre-embedded steel tie rod 10 includes: a third rod body, a double-lug joint 16, and an anchorage head 41. The double-lug joint 16 and the anchorage head 41 are disposed at both ends of the third rod body. The anchorage head 41 is anchored inside or outside the upper chord concrete.

In a specific embodiment, the standard fixed-length steel tie rod 8 is connected to the tie-rod joint unit 19 via a pin shaft. Both the single-lug joint 17 and the double-lug joint 16 are connected to the first rod body 15, the second rod body, and the third rod body via threads. A lock nut 18 is configured to ensure firm connection. The lengths of the single-lug pre-embedded steel tie rod 9, the standard fixed-length steel tie rod 8, and the double-lug pre-embedded steel tie rod 10 may be freely adjusted to accommodate construction tolerances. Assuming the adjustment length of a single end is $\pm L$, when it is adjusted to $+L$, the length of the lock nut 18 ensures that the threads are not exposed. On one hand, such a configuration protects the threads from being damaged caused by exposure and prevents impurities from entering; on the other hand, the concealed threads serve as a basis for on-site installation adjustment, thus preventing excessive unscrewing of the joints and ensuring load-carrying safety.

As shown in FIG. 17, in a specific embodiment, one end of the tie-rod joint unit 19 is bolted with the standard section 12. The length of the standard section 12 is configured according to the specifications of the beam string structure. The other end of the standard section 12 is bolted to one end of the prestress application section 11. The bolt holes for connecting the tie-rod joint unit 19, the standard section 12, and the prestress application section 11 are consistent, thereby allowing for standardized allocation, installation, and convenient length adjustment. The prestress application section 11 is abutted against the secondary grouting adjustment section 13, and the secondary grouting adjustment section 13 serves to adjust on-site installation tolerances and leveling during the construction phase.

In a specific embodiment, the prefabricated strut 2 further includes: a concrete corbel

adjustment section 14. The concrete corbel adjustment section 14 is disposed on the upper-chord concrete beam 1; the concrete corbel adjustment section 14 is cast together with the upper-chord concrete beam 1. The concrete corbel adjustment section 14 is cast together with the upper-chord concrete beam 1 and serves to adjust the design length of the strut during the design phase, capable of being set as required.

As shown in FIG. 5 and FIG. 14, in a specific embodiment, the tie-rod joint unit 19 is a single-tie rod joint 38 or a double-tie rod joint 37. The tie-rod joint unit 19 includes: a first rectangular steel tube 23 and a lug plate 20, a first stiffening plate 21, and a first end plate 22 that are disposed on the first rectangular steel tube 23. As shown in FIG. 13, the standard section 12 includes: a second rectangular steel tube 24, and a second end plate 25 and a second stiffening plate 26 that are disposed on the second rectangular steel tube 24.

As shown in FIG. 15, 20, and 21, the connecting plate 32 is a rectangular plate provided with a hole at each of its four corners, and three holes are evenly distributed at its center. The connecting member 31 includes four interconnected plates. The bottom plate of the connecting member 31 is provided with two threaded holes, and the top plate of the connecting member 31 is provided with two waist-type holes. In a specific embodiment, the prestress application section 11 includes: a jack joint 27, an L-shaped support 28, a cushion block 29, a jack 30, a connecting member 31, a connecting plate 32, a movable head 33, and a steel wedge block 34. One end of the jack joint 27 is bolted to the standard section 12, and the other end of the jack joint 27 is bolted to the cushion block 29 via the movable head 33. The side edge of the jack joint 27 is connected to the L-shaped support 28. As shown in FIG. 16, the L-shaped support 28 includes a channel steel 35 and a third stiffening plate 36, and is erected on the upper-chord concrete beam 1. The height of the L-shaped support 28 may be adjusted to match the height of the upper-chord concrete beam 1 by the position of the upper and lower bolts. The jack 30 is disposed in the groove of the jack joint 27 and may be configured as a single jack 30 or two jacks 30 depending on the required prestress. When two jacks 30 are provided, the jacks 30 are connected to the jack joint 27 via upper and lower bolts. The front, rear, and side faces of the jack 30 are all provided with internally-threaded connection holes. When a single jack 30 is placed, the single jack 30 is connected to the jack joint 27 via the connecting member 31. The piston rod in front of the jack 30 is connected to the cushion block 29

via the connecting plate 32. All connecting plates 32 are provided with countersunk holes, and when bolts are disposed in the countersunk holes, bolt nuts may be concealed. The bottom of the connecting member 31 is bolted with the jack joint 27. The top of the jack joint 27 is provided with a slotted hole and is connected to the side of the jack 30. An angled joint oil pipe 47 is adopted for oil delivery of the jack 30. The use of the angled joint oil pipe 47 may make full use of limited space.

As shown in FIG. 10, 11, and 12, in a specific embodiment, both ends of the standard large support 4 are a first end plate end 42 and a first notched end 43. The first notched end 43 is connected to an embedded part 46 on the upper-chord concrete beam 1. The standard large support 4 may be extended via the first end plate end 42. Both ends of the standard small support 7 are a second end plate end 44 and a second notched end 45. The second notched end 45 is connected to the upper-chord concrete beam 1 via the embedded part 46.

In a specific embodiment, both the standard large support 4 and the standard small support 7 are H-shaped steel. The prefabricated strut 2 and the standard small support 7 are connected by a #-shaped stirrup. The standard large support 4 and the standard small support 7 are connected by a clamp or a bolt; and the standard large support 4 is connected to the corbel 6 by welding or bolting.

This embodiment further provides an assembling method of a beam string structure of a foundation pit, including the following steps:

assembling the vertical support assembly: The corbel 6 is welded to the stand column 5. One end of the standard small support 7 is connected to the upper-chord concrete beam 1, and the other end of the standard small support 7 is disposed on the standard large support 4. One end of the standard large support 4 is disposed on the corbel 6, and the other end of the standard large support 4 is connected to the upper-chord concrete beam 1, or both ends of the standard large support 4 are disposed on the corbel 6.

Assembling the horizontal support assembly: The tie-rod joint unit 19, the standard section 12, and the prestress application section 11 are connected in sequence to form the prefabricated strut 2. The prefabricated strut 2 is connected to the standard small support 7; the single-lug pre-embedded steel tie rod 9, the plurality of standard fixed-length steel tie rods 8, and the double-lug

pre-embedded steel tie rod 10 are connected in sequence to form the lower-chord steel tie rod 3. One end of the single-lug pre-embedded steel tie rod 9 is connected to the upper-chord concrete beam 1, and the other end of the single-lug pre-embedded steel tie rod 9 is connected to the standard fixed-length steel tie rod 8. One end of the double-lug pre-embedded steel tie rod 10 is connected to the upper-chord concrete beam 1, and the other end of the double-lug pre-embedded steel tie rod 10 is connected to the standard fixed-length steel tie rod 8. Two standard fixed-length steel tie rods 8 are connected via the tie-rod joint unit 19.

Assembly conversion: The standard fixed-length steel tie rod 8 is transformed into the single-lug pre-embedded steel tie rod 9 or double-lug pre-embedded steel tie rod 10 by removing the double-lug joint 16 or the single-lug joint 17 from the standard fixed-length steel tie rod 8 and adding the anchorage head 41. The single-lug pre-embedded steel tie rod 9 and double-lug pre-embedded steel tie rod 10 are disposed at both ends, respectively. A plurality of standard fixed-length steel tie rods 8 may be configured to form various spans of lower chords of the beam string structure. The steel tie rod may be configured in a single layer, a double layer, or more; and the standard large support 4 may be spliced into one or multiple sections as required.

Components not described in detail in this embodiment are existing components available for purchase through public channels.

The above description of the embodiments is provided to facilitate understanding and use of the invention by those of ordinary skill in the art. Obviously, those skilled in the art can easily make various modifications to these embodiments and apply the general principles described herein to other embodiments without creative efforts. Therefore, the present invention is not limited to the above embodiments, and improvements and modifications made by those skilled in the art according to the present invention without departing from the scope of the present invention shall all be within the scope of protection of the present invention.

WHAT IS CLAIMED IS:

1. A beam string structure of a foundation pit, comprising: a horizontal support assembly and a vertical support assembly;

wherein the horizontal support assembly comprises: an upper-chord concrete beam (1), a prefabricated strut (2), and a lower-chord steel tie rod (3); and the vertical support assembly comprises: a support unit, a stand column (5), and a corbel (6);

the lower-chord steel tie rod (3) comprises: a single-lug pre-embedded steel tie rod (9), a plurality of standard fixed-length steel tie rods (8), and a double-lug pre-embedded steel tie rod (10) that are connected in sequence; one end of the single-lug pre-embedded steel tie rod (9) is connected to the upper-chord concrete beam (1), and the other end of the single-lug pre-embedded steel tie rod (9) is connected to the standard fixed-length steel tie rods (8); one end of the double-lug pre-embedded steel tie rod (10) is connected to the upper-chord concrete beam (1), and the other end of the double-lug pre-embedded steel tie rod (10) is connected to the standard fixed-length steel tie rods (8); and two of the standard fixed-length steel tie rods (8) are connected via a tie-rod joint unit (19) on the prefabricated strut (2);

the support unit comprises a standard large support (4) and a standard small support (7); one end of the standard small support (7) is connected to the upper-chord concrete beam (1), and the other end of the standard small support (7) is disposed on the standard large support (4); one end of the standard large support (4) is disposed on the corbel (6), and the other end of the standard large support (4) is connected to the upper-chord concrete beam (1), or both ends of the standard large support (4) are disposed on the corbel (6); the corbel (6) is welded or bolted to the stand column (5), and the prefabricated strut (2) is disposed on the standard small support (7);

the prefabricated strut (2) comprises: the tie-rod joint unit (19), a standard section (12), a prestress application section (11), and a secondary grouting adjustment section (13) that are connected in sequence; the standard fixed-length steel tie rod (8) comprises: a first rod body (15), a double-lug joint (16), a single-lug joint (17), and a lock nut (18); the double-lug joint (16) and the single-lug joint (17) are both connected to the first rod body (15) via the lock nut (18), both ends of the first rod body (15) are provided with a right-hand threaded section (39) and a left-hand threaded section (40), and both the right-hand threaded section (39) and the left-hand threaded section (40) have a consistent thread length, thus facilitating disassembly, assembly, and conversion of a joint; the single-lug pre-embedded steel tie rod (9) comprises: a second rod body, an anchorage head (41), and a single-lug joint (17); the anchorage head (41) and the single-lug joint (17) are disposed at both ends of the second rod body; the double-lug pre-embedded steel tie

rod (10) comprises: a third rod body, a double-lug joint (16), and an anchorage head (41); the double-lug joint (16) and the anchorage head (41) are disposed at both ends of the third rod body, and the anchorage head (41) is anchored either inside or outside the upper chord concrete;

the prestress application section (11) comprises: a jack joint (27), an L-shaped support (28), a cushion block (29), a jack (30), a connecting member (31), a connecting plate (32), a movable head (33), and a steel wedge block (34); one end of the jack joint (27) is bolted with the standard section (12), and the other end of the jack joint (27) is bolted with the cushion block (29) via the movable head (33); a side edge of the jack joint (27) is connected to the L-shaped support (28); the L-shaped support (28) comprises a channel steel (35) and a third stiffening plate (36), and the L-shaped support (28) is erected on the upper-chord concrete beam (1); the jack (30) is disposed in a groove of the jack joint (27); when two jacks (30) are provided, the jacks (30) are connected to the jack joint (27) by upper and lower bolts; when a single jack (30) is provided, the jack (30) is connected to the jack joint (27) by the connecting member (31); a piston rod in front of the jack (30) is connected to the cushion block (29) by the connecting plate (32), a bottom portion of the connecting member (31) is bolted with the jack joint (27), and a slotted hole is disposed in a top portion of the jack joint (27), the top portion of the jack joint (27) is connected to a side face of the jack (30); and an angled joint oil pipe (47) is adopted for oil delivery of the jack (30).

2. The beam string structure of a foundation pit according to claim 1, wherein the standard fixed-length steel tie rod (8) is connected to the tie-rod joint unit (19) by a pin shaft; the single-lug joint (17) and the double-lug joint (16) are both in threaded connection with the first rod body (15), the second rod body, and the third rod body.

3. The beam string structure of a foundation pit according to claim 1, wherein the tie-rod joint unit (19) is bolted with one end of the standard section (12), and the other end of the standard section (12) is bolted with one end of the prestress application section (11).

4. The beam string structure of a foundation pit according to claim 1, wherein the prefabricated strut (2) further comprises a concrete corbel adjustment section (14) disposed on the upper-chord concrete beam (1), and the concrete corbel adjustment section (14) is cast together with the upper-chord concrete beam (1).

5. The beam string structure of a foundation pit according to claim 1, wherein the tie-rod joint unit (19) is a single-tie rod joint (38) or a double-tie rod joint (37), and the tie-rod joint unit (19) comprises: a first rectangular steel tube (23), and a lug plate (20), a first stiffening plate (21), and a first end plate (22) that are disposed on the first rectangular steel tube (23); the standard section (12) comprises: a second rectangular steel tube (24), and a second end plate (25) and a second stiffening plate (26) that are disposed on the second rectangular steel tube (24).

6. The beam string structure of a foundation pit according to claim 1, wherein both ends of the standard large support (4) are a first end plate end (42) and a first notched end (43), the first notched end (43) is connected to an embedded part (46) on the upper-chord concrete beam (1), and the standard large support (4) is capable of being extended through the first end plate end (42); both ends of the standard small support (7) are a second end plate end (44) and a second notched end (45), and the second notched end (45) is connected to the upper-chord concrete beam (1) via the embedded part (46).

7. The beam string structure of a foundation pit according to claim 1, wherein the standard large support (4) and the standard small support (7) are both H-shaped steel; the prefabricated strut (2) and the standard small support (7) are connected by a #-shaped stirrup; the standard large support (4) and the standard small support (7) are connected by a clamp or a bolt; and the standard large support (4) is welded or bolted to the corbel (6).

8. An assembling method of the beam string structure of a foundation pit according to any one of claims 1 to 7, comprising the following steps:

assembling the vertical support assembly: welding the corbel (6) to the stand column (5), connecting one end of the standard small support (7) to the upper-chord concrete beam (1), disposing the other end of the standard small support (7) on the standard large support (4), disposing one end of the standard large support (4) on the corbel (6), connecting the other end of the standard large support (4) to the upper-chord concrete beam (1), or disposing both ends of the standard large support (4) on the corbel (6).

assembling the horizontal support assembly: connecting the tie-rod joint unit (19), the standard section (12), and the prestress application section (11) in sequence to form the prefabricated strut (2), and connecting the prefabricated strut (2) to the standard small support (7); connecting the single-lug pre-embedded steel tie rod (9), the plurality of standard fixed-length steel tie rods (8), and the double-lug pre-embedded steel tie rod (10) in sequence to form the lower-chord steel tie rod (3); connecting one end of the single-lug pre-embedded steel tie rod (9) to the upper-chord concrete beam (1), and connecting the other end of the single-lug pre-embedded steel tie rod (9) to the standard fixed-length steel tie rod (8); connecting one end of the double-lug pre-embedded steel tie rod (10) to the upper-chord concrete beam (1), and connecting the other end of the double-lug pre-embedded steel tie rod (10) to the standard fixed-length steel tie rod (8); and connecting two standard fixed-length steel tie rods (8) by the tie-rod joint unit (19); and

assembly transformation: transforming the standard fixed-length steel tie rod (8) into a single-lug pre-embedded steel tie rod (9) or a double-lug pre-embedded steel tie rod (10) by removing the double-lug joint (16) or the single-lug joint (17) from the standard fixed-length steel tie rod (8)

and adding the anchorage head (41), and disposing the single-lug pre-embedded steel tie rod (9) and the double-lug pre-embedded steel tie rod (10) at both ends, respectively; configuring a plurality of standard fixed-length steel tie rods (8) to form various spans of lower chords of a beam string structure; wherein each of the steel tie rods is capable of being configured in a single layer, a double layer, or more; and splicing the standard large support (4) into one or more sections as needed.