

RECESS STRUCTURE FOR REINFORCING CONNECTION BETWEEN RAILWAY SLEEPER AND TRACK BED, AND CONSTRUCTION METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims priority of Chinese Patent Application No. 201811550015.X, filed on December 18, 2018, the contents of which are herein incorporated by reference in their entirety.

TECHNICAL FIELD

[0002] The present invention belongs to the related technical field of ballastless tracks, relates to a technology for connecting a plurality of concrete blocks by means of concrete-filled steel tubes, and more specifically to a recess structure for reinforcing connection between a sleeper and a track bed, and a construction method thereof.

BACKGROUND

[0003] In the railway ballastless track system, a prefabricated sleeper is provided. The sleeper is installed in the track bed or integrated with the track bed by means of concrete pouring, for installing clips, so as to further fix rails above the sleeper. There is a requirement that a good connection between the sleeper and the track bed is needed to be maintained.

[0004] Chinese patent document CN 105463948B discloses a sleeper for a ballastless track, which comprises concrete-filled steel tube (concrete-filled steel tube sleeper). The concrete-filled steel tubes serve as connecting pieces of the sleeper. Compared with the conventional steel truss connection of combined type, the integrity of the concrete-filled

steel tube sleeper for a ballastless track is better, which may effectively alleviate the deformation of the concrete sleeper during storage and transportation. Furthermore, since the concrete-filled steel tubes and concrete blocks of the sleeper are molded in one piece, that is, the concrete-filled steel tubes are formed during a pouring process of the sleeper concrete blocks, and since the concrete-filled steel tubes are designed to be formed by a plurality of hollow steel tubes, the geometry maintaining ability of the sleeper is effectively improved, the steel consumption is reduced, and the constructability is improved. It is possible to directly construct the above sleeper on site and meet the requirements of resistance to bending and twisting of the sleeper.

[0005] However, further research indicates that the above sleeper still has several problems.

[0006] The concrete-filled steel tubes are formed after filling the steel tubes with the concrete, the surface of which is a relatively smooth steel surface. After the concrete-filled steel tubes are directly buried in the materials, such as concrete, recycled rubber, resin materials, etc., the bond stress between the concrete-filled steel tubes and the material is limited. Taking two steel tubes with an outer diameter of 40 mm inserted into a sleeper concrete block with a depth of 200 mm as an example, the bond stress between the steel tubes and the concrete is 2.5 t. Therefore, the connection between the concrete-filled steel tubes and the sleeper needs to be strengthened.

[0007] During the prefabricated double-block concrete-filled steel tube sleepers are transported to the construction site, there are difficulties in bundling, hoisting and stacking.

[0008] It needs to be improved that after the prefabricated concrete sleepers are transported to the construction site of the track line, during the on-site pouring process of the track bed, the connection between the buried portion of the sleeper and the post-poured track bed concrete is not strong enough; there is a durability problem between new concrete and old concrete; cracks and other hazards may be produced.

SUMMARY

[0009] In view of at least one of the above defects or improvement requirements in the related art, the embodiments of the present invention provide a connection reinforcing structure of recess type between a sleeper block and a track bed, and a construction method thereof. A connection reinforcing structure of recess type is provided at sidewalls of the sleeper, which is a recess having an arc, circular-arc, polygon or irregular cross-section for example. In particular, the position of the recess and the connection member of the sleeper are specially designed, such that the connection between the sleeper and the track bed is stronger.

[0010] In order to achieve the above objective, according to one aspect of the embodiments of the present invention, a connection reinforcing structure of recess type between a sleeper block and a track bed is provided. The connection reinforcing structure is configured to reinforce a connection between a prefabricated sleeper unit and the track bed in a ballastless track. The prefabricated sleeper unit includes two or more sleeper blocks and connection members for connecting the sleeper blocks to one another in a transverse direction of the track. The sleeper block is formed by means of concrete pouring. The connection member is configured to be arranged in a mold for manufacturing the sleeper block and integrated with the sleeper block by means of concrete pouring during a pouring process of the sleeper block. A reinforcing member is provided on one or more sidewalls of the sleeper block in a longitudinal direction of the track. The reinforcing member is a recess recessed inward from the sidewall of the sleeper block, such that during a pouring process of the track bed, the recess and a certain height of the sleeper block are buried in concrete of the track bed and integrated with the track bed by means of concrete pouring, and the concrete is directly filled into the recess to reinforce the connection between the sleeper block and the track bed.

[0011] In one embodiment, the reinforcing member of recess type is eccentrically arranged in a direction which is deviated downward from an overall center of a longitudinal vertical cross-section of the track.

[0012] In one embodiment, the connection member is a plurality of concrete-filled steel tubes, the concrete-filled steel tubes are configured as follows: hollow steel tubes are arranged in a mold for manufacturing two sleeper blocks adjacent to each other; and then,

by means of concrete pouring during the pouring process of the sleeper block, the hollow steel tubes are integrated with the sleeper blocks and filled with the concrete at the same time. During the pouring process of the track bed, the concrete-filled steel tubes and the sleeper blocks are buried in the track bed, whereby the sleeper blocks, the concrete-filled steel tubes and the track bed are integrated together by means of concrete pouring.

[0013] In one embodiment, the recess extends along the transverse direction of the track, and extends throughout a transverse sidewall.

[0014] In one embodiment, the same transverse sidewall comprises a plurality of through recesses which are arrayed in parallel with one another along a vertical direction.

[0015] In one embodiment, the recess extends along the transverse direction of the track. The same transverse sidewall comprises a plurality of recesses which are arranged with an interval in a longitudinal direction of the sleeper block.

[0016] In one embodiment, the same transverse sidewall comprises a plurality of sets of the recesses arranged with an interval. The sets are arranged in parallel with one another along the vertical direction. For the plurality of sets of the recesses arranged with an interval and in parallel with one another along the vertical direction, the interval between the recesses in each set being gradually reduced in a direction from bottom to top.

[0017] In one embodiment, in a cross-section of the sleeper block, a size of a cross-section of each of the recesses arranged in the vertical direction is sequentially increased, from top to bottom.

[0018] Alternatively, when the recess extends from a transverse middle portion of the track in a direction towards a transverse outside, a center height of a cross-section of the recess in a cross-section of the sleeper block is gradually increased.

[0019] Alternatively, when the recess extends from a transverse middle portion of the track in a direction towards a transverse outside, a depth of the recess in a cross-section of the sleeper block is gradually reduced.

- [0020] Alternatively, when the recess extends from a transverse middle portion of the track in a manner of enlarging-diminishing-enlarging, a depth of the recess in a cross-section of the sleeper block is repeatedly fluctuated in a manner of enlarging-diminishing-enlarging, such that a bottom surface of the recess is corrugated.
- [0021] In one embodiment, projection of the recess on a horizontal plane has a horizontal length component, and projection of the recess on a longitudinal vertical cross-section of the track has a vertical height component.
- [0022] In one embodiment, the recess structure further includes a recess which extends on the sidewall of the sleeper block along a vertical direction.
- [0023] In one embodiment, a lower end of the recess penetrates through a bottom surface of the sleeper block.
- [0024] In one embodiment, in a cross-section of the sleeper block, a depth of the recess, which extends along the vertical direction, is gradually increased in a direction from top to bottom
- [0025] Alternatively, in a cross-section of the sleeper block, a depth of the recess, which extends along the vertical direction, is repeatedly fluctuated from top to bottom in a manner of enlarging-diminishing-enlarging, such that a bottom surface of the recess is corrugated.
- [0026] Alternatively, projection of the recess on a cross-section of the track has a vertical height component, and projection of the recess on a horizontal plane has a horizontal length component transverse to the track.
- [0027] Alternatively, a plurality of recesses, which extend along the vertical direction, are arranged with an interval in the transverse direction of the track, and lengths of the plurality of recesses which extend along the vertical direction are sequentially reduced in a direction towards a transverse outside from a transverse middle portion of the track.
- [0028] Alternatively, a plurality of recesses, which extend along the vertical direction, are sequentially arranged with an interval in the transverse direction of the track, and

lengths of the plurality of recesses which extend along the vertical direction are repeatedly fluctuated in a manner of enlarging-diminishing-enlarging..

[0029] In one embodiment, a depth at which a depth at which the sleeper block is buried in the track bed is 150 mm; a center axis of the lowermost recess is 30-50 mm from a bottom surface of the sleeper block, and a diameter of the recess is 20-50 mm.

[0030] In order to achieve the above objective, according to another aspect of the embodiments of the present invention, a connection reinforcing structure of recess type between the sleeper block and the track bed is provided. The connection reinforcing structure being configured to reinforce a connection between a prefabricated sleeper unit and the track bed in a ballastless track. The prefabricated sleeper unit includes two or more sleeper blocks and a connection member for connecting the sleeper blocks to one another in a transverse direction of the track. The sleeper block is formed by means of concrete pouring. The connection member is integrated with the sleeper block by means of concrete pouring. A reinforcing member is provided at one or more sidewalls in a longitudinal direction of the track. The reinforcing member is a recess recessed inward from the sidewalls of the sleeper, such that during a pouring process of the track bed, the recess and a certain height of the sleeper block are buried in concrete of the track bed and integrated with the track bed by means of concrete pouring, and the concrete directly filled into the recess to reinforce the connection between the sleeper block and the track bed.

[0031] In a yet further aspect of the embodiments of the present invention, construction method for the connection reinforcing structure of recess type between the sleeper block and the track bed described above is further provided. The construction method includes the following steps.

[0032] In step S1, a plurality of hollow steel tubes of a predetermined dimension for subsequent production of concrete-filled steel tubes are produced.

[0033] In step S2, two molds of a predetermined dimension are produced, and a protrusion of a predetermined dimension are detachably installed on an inner side of the mold at a height of 30-50 mm from a mold bottom, to form a recess at a sidewall of the

sleeper block after pouring concrete; and two ends of each of the plurality of hollow steel tubes are inserted into the two molds.

[0034] In step S3, the concrete is poured, so that the hollow steel tubes are filled with the concrete to form the concrete-filled steel tubes, periphery of the protrusions is filled with the concrete, and the concrete is pressed to be compacted.

[0035] In step S4, maintenance of the sleeper is performed together with the molds.

[0036] In step S5, the protrusion is removed, the protrusion is disconnected from the sides of the mold, the protrusion and the molded sleeper are demolded, and the protrusion and the molded sleeper are separated, so as to obtain a prefabricated sleeper unit having recesses.

[0037] In step S6, the prefabricated sleeper unit is transported to construction site of the track, the concrete of the track bed is poured, the recess is directly filled with the concrete, and the sleeper block 1 and the concrete-filled steel tubes are configured to meet a designed buried depth, such that the sleeper block 1, the concrete-filled steel tubes and the track bed are integrated together by means of concrete pouring.

[0038] The above preferred technical features may be combined with each other as long as not causing conflicts with each other.

[0039] In general, the above technical solutions conceived by the embodiments of the present invention have the following beneficial effects compared with the related art.

[0040] 1. In the connection reinforcing structure of recess type between a sleeper and a track bed of the embodiments of the present invention, a reinforcing member of recess type is provided at any sidewalls around the sleeper block and/or bottom surface of the sleeper block. In some examples, the reinforcing member may be a recess with an curved, circular-arc, polygon or irregular cross-section. During the on-site pouring process of the track bed, the prefabricated sleeper block is buried in the concrete of the track bed, and the recesses are directly filled with the concrete of the track bed (there is no other structures between the recesses and the track bed). Therefore, the recesses and the sleeper block are integrated with the track bed by means of the concrete pouring to provide a

locking effect, so that the sleeper block and the post-poured material are tightly connected with each other. When subjected to a longitudinal and transversal force as well as pull forces in vertical direction, the sleeper block and the post-poured material are connected with each other, so that the sleeper is firmly fixed in the track bed. In this way, the sleeper block is difficult to loose, and the decrease of the cracks between the sleeper block and the track bed is further facilitated.

[0041] 2. In the connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention, the specific position of the reinforcing member of recess type in the sleeper block are specially designed. Further research found that, old concrete surface and new concrete surface consolidated between ordinary sleeper block and the track bed are both flat surfaces. During the operation of the train, a complex relative force in a longitudinal, transversal directions and in vertical direction is generated between the sleeper block and the track bed, so that after several years, cracks and other hazards may appear on the surface of the track bed and around the sleeper block. The related art only focus on the reinforcement and maintenance operations at the upper junction of the sleepers, but ignores the internal hazards. In the embodiments of the present invention, through theoretical analysis and practical tests, the recesses are in particular eccentrically arranged below the middle portion of the sleeper block, and especially, eccentrically arranged below the middle of the buried depth of the sleeper block. For example, the height of the prefabricated sleeper block is generally 160-180 mm; the buried depth of the sleeper block in the track bed is generally 150 mm; the center axis of the lowermost recess is 30-50 mm from the bottom surface of the sleeper block; and the diameter of the recess is 20-50 mm. In above position, the connection between the recess and the track bed is more firm, thereby providing a better locking effect. These findings and measures have not been reported in the related art yet. After the prolonged operation of the train, it may effectively reduce the hazards at the internal connection between the sleeper block and the track bed.

[0042] 3. The connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention has a wide application prospect. A Chinese CRTS I type double-block ballastless track, a CRTS II type double-block ballastless track, a Germany Rheda2000 type track, a Zublin type track and a slab

track, as well as CRTS I type, CRTS II type and CRTS III type ballastless tracks, all may adopt the connection reinforcing structure of recess type of the embodiments of the present invention. In particular, in the double-block ballastless track of the concrete-filled steel tube sleeper type, the reinforcing member of recess type can realize the connection between each two of the sleeper block, the concrete-filled steel tube and the track bed, such that the sleeper block, the concrete-filled steel tube and the track bed are formed as an integrated structure.

[0043] 4. In the connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention, based on the variations of the recesses extending in the substantially horizontal direction and the variations of the relative relationships between a plurality of recesses, a number of different combinations can be provided, such as through-type, parallel-type and spaced-type configurations. Different areas are reinforced respectively, and the interval between the recesses can be adjusted to gather the recesses from both sides of the lower portion to the middle portion and the upper portion, thereby balancing the force subjected by each area. Furthermore, the recess structure has different strength levels, so that the adjustment of the connection strength of the recess structure is realized, a comprehensive strengthening effect of multi-level gradients is obtained, strength requirements in different regions are met, and a balance between weight reduction and cost is reached. Moreover, a plurality of sets of the recesses, which are arranged in parallel with one another in the vertical direction, are still arranged in accordance with the above-mentioned principle of depth and eccentricity. That is, the overall center of the plurality of sets of the recesses is eccentrically arranged below the middle portion of the sleeper block, especially below the middle of the buried depth of the sleeper block.

[0044] 5. In the connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention, based on the above-mentioned principle of depth and eccentricity, in order to ensure the recesses of greater depth among the recesses extending in the substantially horizontal direction to play a major role, or to obtain resistance forces in multiple directions on the sidewall surface, several recess configuration solutions are provided, which may be taken alone or in any of their technically possible combinations. The recesses subjected to forces with multiple

components in multiple directions are partially or entirely provided to be of curved configuration, such as corrugated configuration, zigzag configuration, threaded configuration, etc. As such, the contact length between the recess and the concrete is increased for the sleeper block of unit size, and the fastening force is increased, thereby improving the degree of connection between the sleeper block and the concrete of the track bed.

[0045] 6. In the connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention, due to the recesses extending in the substantially vertical direction, the force acting on the sleeper block and the track bed in the horizontal direction is optimized. The recesses extending in the substantially horizontal direction and the recesses extending in the substantially vertical direction may be used singly or in combination. When used in combination, these recesses may or may not be intersected with each other. Moreover, based on the above-mentioned principle of depth and eccentricity, in order to ensure the lower portion of the recesses extending in the substantially vertical direction to play a major role, or to obtain resistance forces in multiple directions on the sidewall surface, several recess configuration solutions are provided, which may be taken alone or in any of their technically possible combinations. The recesses subjected to forces with multiple components in multiple directions are partially or entirely provided to be of curved configuration, such as corrugated configuration, zigzag configuration, threaded configuration, etc. As such, the contact length between the recess and the concrete is increased for the sleeper block of unit size, and the fastening force is increased, thereby improving the degree of connection between the sleeper block and the concrete of the track bed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0046] FIG. 1 is a schematic diagram of a double-block sleeper, in which the connection reinforcing structure of recess type between a sleeper block and a track bed is shown.

[0047] FIG. 2 is a schematic side sectional view of the connection reinforcing structure of recess type between a sleeper block and a track bed of embodiments of the present invention.

[0048] FIG. 3 is a schematic diagram of a plurality of sets of parallel recesses extending in a substantially horizontal direction in the connection reinforcing structure of recess type between a sleeper block and a track bed of embodiments of the present invention.

[0049] FIG. 4 is a schematic side sectional view of a plurality of sets of parallel recesses extending in a substantially horizontal direction in the connection reinforcing structure of recess type between a sleeper block and a track bed of embodiments of the present invention.

[0050] FIG. 5 is a schematic diagram of spaced recesses extending in a substantially horizontal direction in the connection reinforcing structure of recess type between a sleeper block and a track bed of embodiments of the present invention.

[0051] FIG. 6 is a first schematic diagram of a plurality of sets of spaced recesses extending in a substantially horizontal direction in the connection reinforcing structure of recess type between a sleeper block and a track bed of embodiments of the present invention, with the sets being arranged in parallel with one another in a vertical direction.

[0052] FIG. 7 is a second schematic diagram of a plurality of sets of spaced recesses extending in a substantially horizontal direction in the connection reinforcing structure of recess type between a sleeper block and a track bed of embodiments of the present invention, with the sets being arranged in parallel with one another in a vertical direction.

[0053] FIG. 8 is a schematic side sectional view of a plurality of sets of recesses extending in a substantially vertical direction in the connection reinforcing structure of recess type between a sleeper block and a track bed of embodiments of the present invention.

[0054] In the above accompanying drawings, the unit of the size indicia is millimeter (mm).

DETAILED DESCRIPTION

[0055] In order to explain more clearly the purpose, technical solutions and advantages of the embodiments of the present invention, the embodiments of the present invention will be further illustrated in detail in combination with accompanying drawings and embodiments hereinafter. It should be understood that the specific implementations described here are used only to explain the embodiments of the present invention, rather than limit them. Furthermore, the technical features involved in the various implementations of the embodiments of the present invention described below may be combined with each other as long as not causing conflicts with each other. The embodiments of the present invention will be further described in detail in combination with specific implementations.

[0056] The embodiments of the present invention provide a connection reinforcing structure of recess type, for reinforcing a connection between a prefabricated sleeper unit and a post-poured track bed in a ballastless track. The prefabricated sleeper unit includes two or more sleeper blocks 1 and connection members which connect the above sleeper blocks 1 to one another in a transverse direction of the track. The sleeper block 1 is formed by means of concrete pouring. The connection member is configured to be arranged in a mold for manufacturing the sleeper block 1 and integrated with the sleeper block 1 by means of concrete pouring during a pouring process of the sleeper block 1. A connection reinforcing member is provided between the sleeper block 1 and the track bed. Here, the post-poured track bed is a track bed 10.

[0057] As shown in FIGS. 1 to 8, a reinforcing member 3 is provided on one or more sidewalls of the sleeper block 1 in a transversal direction of the sleeper block 1, i.e. in a longitudinal direction of the track. The reinforcing member 3 is a recess recessed inward from the sidewalls of the sleeper block 1 (as shown in FIG. 1), such that, during a pouring process of the track bed 10, the recess and a certain height of the sleeper block 1 are buried in the concrete of the track bed 10, and are integrated with the track bed 10 by means of concrete pouring. The concrete is directly filled into the recess so as to reinforce the connection between the sleeper block 1 and the track bed 10. In the connection

reinforcing structure of recess type between a sleeper and a track bed of the embodiments of the present invention, a reinforcing member of recess type is provided at any sidewalls around the sleeper block and/or bottom surface of the sleeper block. In some examples, the reinforcing member may be a recess with an curved, circular-arc, polygon or irregular cross-section. During the on-site pouring process of the track bed, the prefabricated sleeper block is buried in the concrete of the track bed, and the recesses are directly filled with the concrete of the track bed (there is no other structures between the recesses and the track bed). Therefore, the recesses and the sleeper block are integrated with the track bed by means of the concrete pouring to provide a locking effect, so that the sleeper block and the post-poured material are tightly connected with each other. When subjected to a longitudinal and transversal force as well as pull forces in vertical direction, the sleeper block and the post-poured material are connected with each other, so that the sleeper is firmly fixed in the track bed. In this way, the sleeper block is difficult to loose, and the decrease of the cracks between the sleeper block and the track bed is further facilitated.

[0058] In one embodiment, as shown in FIG. 2, the reinforcing member 3 of recess type is eccentrically arranged on the sleeper block 1 at a position which is deviated downward from an overall center of a cross-section of sleeper block (i.e. a longitudinal vertical cross-section of the track), i.e. from a center of the sleeper block 1. In the connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention, the specific position of the reinforcing member of recess type in the sleeper block are specially designed. Further research found that, old concrete surface and new concrete surface consolidated between ordinary sleeper block and the track bed are both flat surfaces. During the operation of the train, a complex relative force in a longitudinal, transversal directions and in vertical direction is generated between the sleeper block and the track bed, so that after several years, cracks and other hazards may appear on the surface of the track bed and around the sleeper block. The related art only focus on the reinforcement and maintenance operations at the upper junction of the sleepers, but ignores the internal hazards. In the embodiments of the present invention, through theoretical analysis and practical tests, the recesses are in particular eccentrically arranged below the middle portion of the sleeper block, and especially, eccentrically arranged below the middle of the buried depth of the sleeper

block. For example, the height of the prefabricated sleeper block is generally 160-180 mm; the buried depth of the sleeper block in the track bed is generally 150 mm; the center axis of the lowermost recess is 30-50 mm from the bottom surface of the sleeper block; and the diameter of the recess is 20-50 mm. In above position, the connection between the recess and the track bed is more firm, thereby providing a better locking effect. These findings and measures have not been reported in the related art yet. After the prolonged operation of the train, it may effectively reduce the hazards at the internal connection between the sleeper block and the track bed.

[0059] In one embodiment, the connection members are a plurality of concrete-filled steel tubes 2 (as shown in FIG. 1, and the connection members are omitted in FIG. 2), which are configured as follows: hollow steel tubes are arranged in a mold for manufacturing two sleeper blocks 1 adjacent to each other; and, by means of concrete pouring during the pouring process of the sleeper block 1, the hollow steel tubes are integrated with the sleeper blocks 1 and filled with the concrete at the same time. During the pouring process of the track bed 10, the concrete-filled steel tubes and the sleeper blocks are buried in the track bed, so that the sleeper blocks 1, the concrete-filled steel tubes 2 and the track bed 10 are integrated in one piece by means of concrete pouring. In one embodiment, a connection reinforcing structure is provided between the concrete-filled steel tube 2 and the sleeper block 1. Of course, the reinforcing member of recess type should be arranged to dodge the position where the concrete-filled steel tubes 2 is located. The connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention has a wide application prospect. A Chinese CRTS I type double-block ballastless track, a CRTS II type double-block ballastless track, a Germany Rheda2000 type track, a Zublin type track and a slab track, as well as CRTS I type, CRTS II type and CRTS III type ballastless tracks, all may adopt the connection reinforcing structure of recess type of the embodiments of the present invention. In particular, in the double-block ballastless track of the concrete-filled steel tube sleeper type, the reinforcing member of recess type can realize the connection between each two of the sleeper block, the concrete-filled steel tube and the track bed, such that the sleeper block, the concrete-filled steel tube and the track bed are formed as a integrated structure.

[0060] In one embodiment, as shown in FIG. 1, the recess extends along the longitudinal direction of the sleeper block, i.e. along the transverse direction of the track, and extends throughout a transverse sidewall. In one embodiment, as shown in FIGS. 3 to 4, one same transverse sidewall includes a plurality of through recesses which are arrayed in parallel with one another along a vertical direction. Here, the transverse sidewalls refer to the sidewalls located on two sides of the sleeper block that are opposite to one another in the longitudinal direction of the track, i.e., the sidewalls on the left and right sides as shown in FIG. 4.

[0061] In one embodiment, as shown in FIG. 5, the recess extends along the longitudinal direction of the sleeper block, i.e. along the transverse direction of the track. A same transverse sidewall includes a plurality of recesses which are arranged in a longitudinal direction of the sleeper block 1 with an interval. In one embodiment, as shown in FIGS. 6-7, the same transverse sidewall includes a plurality of sets of the recesses arranged with an interval. The sets are arranged in parallel with one another along the vertical direction. For the plurality of sets of the recesses arranged with an interval and in parallel with one another along the vertical direction, the interval between the recesses in each set is gradually reduced from bottom to top. Here, the transverse sidewalls refer to the sidewalls located on two sides of the sleeper block that are opposite to one another in the longitudinal direction of the track, i.e., the sidewalls on the left and right sides as shown in FIG. 4.

[0062] In the connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention, based on the variations of the recesses extending in the substantially horizontal direction and the variations of the relative relationships between a plurality of recesses, a number of different combinations can be provided, such as through-type, parallel-type and spaced-type configurations. Different areas are reinforced respectively, and the interval between the recesses can be adjusted to gather the recesses from both sides of the lower portion to the middle portion and the upper portion, thereby balancing the force subjected by each area. Furthermore, the recess structure has different strength levels, so that the adjustment of the connection strength of the recess structure is realized, a comprehensive strengthening effect of multi-level gradients is obtained, strength requirements in different regions are met, and a

balance between weight reduction and cost is reached. Moreover, a plurality of sets of the recesses, which are arranged in parallel with one another in the vertical direction, are still arranged in accordance with the above-mentioned principle of depth and eccentricity. That is, the overall center of the plurality of sets of the recesses is eccentrically arranged below the middle portion of the sleeper block, especially below the middle of the buried depth of the sleeper block.

[0063] In one embodiment, in a cross-section of the sleeper block 1, from top to bottom, sizes of a cross-section of each of the recesses arranged in the vertical direction is sequentially increased. Alternatively, when the recess extends from a transverse middle portion of the track in a direction towards a transverse outside, a center height of a cross-section of the recess in a cross-section of the sleeper block 1 is gradually elevated. Alternatively, when the recess extends from a transverse middle portion of the track in a direction towards a transverse outside, a depth of the recess in a cross-section of the sleeper block 1 is gradually reduced. Alternatively, when the recess extends from a transverse middle portion of the track in a direction towards a transverse outside, a depth of the recess in a cross-section of the sleeper block 1 is repeatedly fluctuated in a manner of enlarging-diminishing-enlarging, such that a bottom surface of the recess is corrugated. In one embodiment, projection of the recess on a horizontal plane has a horizontal length component, and projection of the recess on a longitudinal vertical cross-section of the track has a vertical height component. In the connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention, based on the above-mentioned principle of depth and eccentricity, in order to ensure the recesses of greater depth among the recesses extending in the substantially horizontal direction to play a major role, or to obtain resistance forces in multiple directions on the sidewall surface, several recess configuration solutions are provided, which may be taken alone or in any of their technically possible combinations. The recesses subjected to forces with multiple components in multiple directions are partially or entirely provided to be of curved configuration, such as corrugated configuration, zigzag configuration, threaded configuration, etc. As such, the contact length between the recess and the concrete is increased for the sleeper block of unit size, and the fastening force is increased, thereby improving the degree of connection between the sleeper block and the concrete of

the track bed.

[0064] In one embodiment, as shown in FIG. 8, the present application also includes a recess which extends on the sidewall of the sleeper block along a vertical direction. In one embodiment, a lower end of the recess penetrates through a bottom surface of the sleeper block.

[0065] In one embodiment, for the recess which extends along the vertical direction, a depth of the recess in a cross-section of the sleeper block 1 gradually increases from top to bottom. Alternatively, in a cross-section of the sleeper block 1, a depth of the recess, which extends along the vertical direction, is repeatedly fluctuated in a manner of enlarging-diminishing-enlarging from top to bottom, such that a bottom surface of the recess is corrugated. Alternatively, projection of the recess on a cross-section of the track has a vertical height component, and projection of the recess on a horizontal plane has a horizontal length component transverse to the track. Alternatively, a plurality of recesses, which extend along the vertical direction, are arranged with an interval in the transverse direction of the track, and lengths (vertical heights) of the plurality of recesses which extend along the vertical direction are sequentially reduced in a direction towards a transverse outside from a transverse middle portion of the track. Alternatively, a plurality of recesses, which extend along the vertical direction, are sequentially arranged with an interval in the transverse direction of the track, and lengths of the plurality of recesses which extend along the vertical direction are repeatedly fluctuated in a manner of enlarging-diminishing-enlarging.. In the connection reinforcing structure of recess type between a sleeper block and a track bed of the embodiments of the present invention, due to the recesses extending in the substantially vertical direction, the force acting on the sleeper block and the track bed in the horizontal direction is optimized. The recesses extending in the substantially horizontal direction and the recesses extending in the substantially vertical direction may be used singly or in combination. When used in combination, these recesses may or may not be intersected with each other. Moreover, based on the above-mentioned principle of depth and eccentricity, in order to ensure the lower portion of the recesses extending in the substantially vertical direction to play a major role, or to obtain resistance forces in multiple directions on the sidewall surface, several recess configuration solutions are provided, which may be taken alone or in any

of their technically possible combinations. The recesses subjected to forces with multiple components in multiple directions are partially or entirely provided to be of curved configuration, such as corrugated configuration, zigzag configuration, threaded configuration, etc. As such, the contact length between the recess and the concrete is increased for the sleeper block of unit size, and the fastening force is increased, thereby improving the degree of connection between the sleeper block and the concrete of the track bed.

[0066] The embodiments of the present invention further provides a construction method for the connection reinforcing structure of recess type between the sleeper block and the track bed as described above. The construction method includes the following steps.

[0067] In step S1, a plurality of hollow steel tubes of a predetermined dimension for subsequent production of concrete-filled steel tubes 2 are produced, for example two hollow steel tubes with a length of 2000 mm and an outer diameter of 40 mm are produced.

[0068] In step S2, two molds of a predetermined dimension are produced, for example two molds with a length of 650 mm, a width of 300 mm and a height of 150 mm, and a protrusion of a predetermined dimension are detachably installed on an inner side of the mold at a height of 30-50 mm from a mold bottom, to form a recess at a sidewall of the sleeper block after pouring concrete, for example an arc recess correspondingly formed by a half-cylinder with a length of 600 mm and a radius of 20 mm; and two ends of each of the plurality of hollow steel tubes are inserted into the two molds.

[0069] In step S3, the concrete is poured, so that the hollow steel tubes are filled with the concrete to form the concrete-filled steel tubes 2, periphery of the protrusions is filled with the concrete, and the concrete is pressed to be compacted.

[0070] In step S4, maintenance of the sleeper is performed together with the molds.

[0071] In step S5, the protrusion is removed, the protrusion is disconnected from the sides of the mold, the protrusion and the molded sleeper are demolded, and the protrusion and the molded sleeper are separated, so as to obtain a prefabricated sleeper unit having

recesses.

[0072] In step S6, the prefabricated sleeper unit is transported to construction site of the track, the concrete of the track bed 10 is poured, the recess is directly filled with the concrete, and the sleeper block 1 and the concrete-filled steel tubes 2 are configured to meet a designed buried depth, such that the sleeper block 1, the concrete-filled steel tubes 2 and the track bed 10 are integrated together by means of concrete pouring.

[0073] Those skilled in the art can easily appreciate that, what are described above are merely preferred embodiments of the embodiments of the present invention, and are not to limit the embodiments of the present invention. And any modification, equivalent and improvement within the spirit and principles of the embodiments of the present invention shall be covered in the protective scope of the embodiments of the present invention.

CLAIMS

1. A connection reinforcing structure of recess type between a sleeper block and a track bed, the connection reinforcing structure being configured to reinforce a connection between a prefabricated sleeper unit and the track bed in a ballastless track, the prefabricated sleeper unit comprising two or more sleeper blocks and a connection member for connecting the sleeper blocks to one another in a transverse direction of the track, the sleeper block being formed by means of concrete pouring, the connection member being configured to be arranged in a mold for manufacturing the sleeper block and integrated with the sleeper block by means of concrete pouring during a pouring process of the sleeper block, a reinforcing member being provided on one or more sidewalls of the sleeper block in a longitudinal direction of the track, the reinforcing member being a recess recessed inward from the sidewall of the sleeper block; during a pouring process of the track bed, the recess and a certain height of the sleeper block are buried in concrete of the track bed and integrated with the track bed by means of concrete pouring, and the concrete being directly filled into the recess to reinforce the connection between the sleeper block and the track bed.

2. The connection reinforcing structure of recess type between the sleeper block and the track bed of claim 1, wherein the reinforcing member of recess type is eccentrically arranged in a direction which is deviated downward from an overall center of a longitudinal vertical cross-section of the track.

3. The connection reinforcing structure of recess type between the sleeper block and the track bed of claim 1, wherein the connection member is a plurality of concrete-filled steel tubes, the concrete-filled steel tubes being configured as follows: hollow steel tubes are arranged in a mold for manufacturing two sleeper blocks adjacent to each other; and then, by means of concrete pouring during the pouring process of the sleeper block, the hollow steel tubes are

integrated with the sleeper blocks and filled with the concrete at the same time; during the pouring process of the track bed, the concrete-filled steel tubes and the sleeper blocks are buried in the track bed, whereby the sleeper blocks, the concrete-filled steel tubes and the track bed are integrated together by means of concrete pouring.

4. The connection reinforcing structure of recess type between the sleeper block and the track bed of claim 3, wherein the recess extends along the transverse direction of the track, and extends throughout a transverse sidewall.

5. The connection reinforcing structure of recess type between the sleeper block and the track bed of claim 4, wherein the same transverse sidewall comprises a plurality of through recesses which are arrayed in parallel with one another along a vertical direction.

6. The connection reinforcing structure of recess type between the sleeper block and the track bed of claim 3, wherein the recess extends along the transverse direction of the track, a same transverse sidewall comprising a plurality of recesses which are arranged with an interval in a longitudinal direction of the sleeper block.

7. The connection reinforcing structure of recess type between the sleeper block and the track bed of claim 6, wherein the same transverse sidewall comprises a plurality of sets of the recesses arranged with an interval, the sets being arranged in parallel with one another along the vertical direction, and for the plurality of sets of the recesses arranged with an interval and in parallel with one another along the vertical direction, the interval between the recesses in each set being gradually reduced in a direction from bottom to top.

8. The connection reinforcing structure of recess type between the sleeper block and the track

bed of any one of claims 4 to 7, wherein in a cross-section of the sleeper block, a size of a cross-section of each of the recesses arranged in the vertical direction is sequentially increased, in a direction from top to bottom;

or when the recess extends from a transverse middle portion of the track in a direction towards a transverse outside, a center height of a cross-section of the recess in a cross-section of the sleeper block is gradually increased;

or when the recess extends from a transverse middle portion of the track in a direction towards a transverse outside, a depth of the recess in a cross-section of the sleeper block is gradually reduced;

or when the recess extends from a transverse middle portion of the track in a manner of enlarging-diminishing-enlarging, a depth of the recess in a cross-section of the sleeper block is repeatedly fluctuated in a manner of enlarging-diminishing-enlarging, such that a bottom surface of the recess is corrugated.

9. The connection reinforcing structure of recess type between the sleeper block and the track bed of any one of claims 4 to 7, wherein projection of the recess on a horizontal plane has a horizontal length component, and projection of the recess on a longitudinal vertical cross-section of the track has a vertical height component.

10. The connection reinforcing structure of recess type between the sleeper block and the track bed of any one of claims 4 to 7, further comprising a recess which extends on the sidewall of the sleeper block along a vertical direction.

11. The connection reinforcing structure of recess type between the sleeper block and the track bed of claim 10, wherein a lower end of the recess penetrates through a bottom surface of the sleeper block.

12. The connection reinforcing structure of recess type between the sleeper block and the track bed of claim 10, wherein in a cross-section of the sleeper block, a depth of the recess, which extends along the vertical direction, is gradually increased in a direction from top to bottom;

or, in a cross-section of the sleeper block, a depth of the recess, which extends along the vertical direction, is repeatedly fluctuated from top to bottom in a manner of enlarging-diminishing-enlarging, such that a bottom surface of the recess is corrugated;

or, projection of the recess on a cross-section of the track has a vertical height component, and projection of the recess on a horizontal plane has a horizontal length component transverse to the track;

or, a plurality of recesses, which extend along the vertical direction, are arranged with an interval in the transverse direction of the track, and lengths of the plurality of recesses which extend along the vertical direction are sequentially reduced in a direction towards a transverse outside from a transverse middle portion of the track;

or a plurality of recesses, which extend along the vertical direction, are sequentially arranged with an interval in the transverse direction of the track, and lengths of the plurality of recesses which extend along the vertical direction are repeatedly fluctuated in a manner of enlarging-diminishing-enlarging.

13. The connection reinforcing structure of recess type between the sleeper block and the track bed of any one of claims 4 to 7, wherein a depth at which the sleeper block is buried in the track bed is 150 mm; a center axis of the lowermost recess is 30-50 mm from a bottom surface of the sleeper block, and a diameter of the recess is 20-50 mm.

14. A connection reinforcing structure of recess type between the sleeper block and the track bed, the connection reinforcing structure being configured to reinforce a connection between a

prefabricated sleeper unit and the track bed in a ballastless track, the prefabricated sleeper unit comprising two or more sleeper blocks and a connection member for connecting the sleeper blocks to one another in a transverse direction of the track, the sleeper block being formed by means of concrete pouring, the connection member being integrated with the sleeper block by means of concrete pouring, a reinforcing member being provided on one or more sidewalls of the sleeper block in a longitudinal direction of the track, the reinforcing member being a recess recessed inward from the sidewall of the sleeper block; during a pouring process of the track bed, the recess and a certain height of the sleeper block are buried in concrete of the track bed and integrated with the track bed by means of concrete pouring, and the concrete being directly filled into the recess to reinforce the connection between the sleeper block and the track bed.

15. A construction method for the connection reinforcing structure of recess type between the sleeper block and the track bed of any one of claims 3 to 14, comprising the following steps:

S1: producing a plurality of hollow steel tubes of a predetermined dimension for subsequent production of concrete-filled steel tubes;

S2: producing two molds of a predetermined dimension, and detachably installing a protrusion of a predetermined dimension on an inner side of the mold at a height of 30-50 mm from a mold bottom, the protrusion being configured to form a recess at a sidewall of the sleeper block after pouring concrete; and inserting two ends of each of the plurality of hollow steel tubes into the two molds;

S3: pouring the concrete to fill the concrete into the hollow steel tubes to form the concrete-filled steel tubes, filling periphery of the protrusions with the concrete, and pressing the concrete to compact the concrete;

S4: performing maintenance of the sleeper together with the molds;

S5: removing the protrusion, disconnecting the protrusion from the sides of the molds, demolding the protrusion and the molded sleeper, separating the protrusion and the molded sleeper, to obtain a prefabricated sleeper unit having the recess;

S6: transporting the prefabricated sleeper unit to construction site of the track, pouring the concrete of the track bed, directly filling the recess with the concrete, and ensure the sleepers and the concrete-filled steel tubes to meet a designed buried depth, such that the sleepers, the concrete-filled steel tubes and the track bed are integrated together by means of concrete pouring.