

PREFABRICATED BUILDING FORMWORK COMPONENT FOR CAST-IN-PLACE

TECHNICAL FIELD

The present disclosure relates to the field of construction, and specifically to a prefabricated building formwork component for cast-in-place, and in particular to a formwork component applicable to columns or beams, a shear wall component, or a floor slab component.

BACKGROUND

Typically, reinforced concrete building structures, particularly frame beam-column structures, are provided with longitudinal rebars and transverse stirrups spaced along the longitudinal direction. The transverse stirrups, on the one hand, bear the structural shear forces, and on the other hand, provide confinement effect on the longitudinal rebars and the concrete, thereby improving the structural load-bearing capacity and seismic performance.

Conventional stirrups include, but are not limited to, the following forms: closed stirrups, as the simplest form, which are rectangular stirrups or composite stirrups formed by stacking up multiple rectangular stirrups, and are used to improve the shear resistance and seismic performance of building structures; annular stirrups, also a commonly used form, used for columns with circular cross-sections; spiral stirrups, stirrups in a spiral shape, typically used for circular or specially-shaped columns, which can provide good lateral confinement to the building structures; transverse hook stirrups, located in beams and columns, which can increase the shear strength and seismic performance of concrete beams and columns.

In building construction, formwork is the main material to shape the structure. Traditional construction technique comprises first erecting scaffolding, positioning and tying rebars, then using panels to assemble formwork for shaping structural beam or column, followed by pouring concrete, and removing the formwork after the concrete has hardened and been shaped. In traditional construction techniques, it is necessary to erect formwork on the construction site, connect the stirrups to the longitudinal rebars by tying or welding to form a rebar cage, then pour concrete, and remove the formwork after the building is formed. When there are large numbers of densely arranged rebars at joints of the building components, whether by tying or welding, on-site processing of the rebar cage not only results in low efficiency in rebar processing, but also causes repeated bending of rebars on construction site, failing to ensure rebars spacing and leading to reduced mechanical performance.

In the currently prevalent prefabricated construction, the process changes to prefabricating building components (such as floor slabs, beams, wall panels, stairs, balconies, etc.) in factories, then transporting them to the construction site, where they are assembled into a whole building on site by conventional connection methods (e.g., welding or sleeve grouting, etc.). On-site formwork is usually no longer required. However, if all these prefabricated components, especially the load-bearing columns or beams, are also prefabricated in factory, which are reinforced concrete components pre-cast with concrete, their overall weight and dimension are relatively large. Thus, this requires professional and expensive installation equipment on site, making installation extremely inconvenient and presenting significant safety hazards; as hoisting operations are almost all at height, risks during transportation, secondary handling, and hoisting are therefore considerable. For example, whether the pre-embedded lifting points of the hoisting operation are securely installed, whether the lifting claws and steel wire can bear the component weight, etc., are serious safety concerns in prefabricated construction. In addition, there are construction joints between all prefabricated components and cast-in-place concrete. Because the poor bonding between dry and wet concrete, in connection with the load disturbances from casting equipment and operators, problems such as cold joints, cracking, and leakage often occur at the construction joints, which is questionable to achieve desired strength, sealing, and stability.

Furthermore, in the prior art, stirrups for columns, beams, walls, and other structures are processed from rebars into the required shapes, and are either prefabricated by welding or other processes, or formed on site by tying to create interlaced rebar cages, which are then formed into building structures by on-site formwork and cast-in-place concrete, or by first pre-casting reinforced concrete building components and then assembling them on site into the overall building. On-site tied rebars are time-consuming and labor-intensive, which requires manual operation that cannot be standardized, and the connections formed by tying are very unstable. While the stirrup structures used in prefabricated construction are formed within precast reinforced concrete building components, they have large overall weight and dimension, requiring professional and expensive installation equipment on site, and making installation extremely inconvenient and hazardous.

For example, Chinese Patent Publication No. CN102535745A discloses a permanent formwork component for column construction, and specifically discloses a stirrup structure and a permanent formwork component for column construction, wherein the stirrup comprises an outer frame bar, within which one or more inner bars are arranged, where both ends of the inner bar are connected to the outer frame bar, forming a multi-leg mesh stirrup. This stirrup structure is pre-formed into multi-leg mesh stirrups, and then multiple layers of the multi-leg

mesh stirrups are pre-formed into a concrete form shell, wherein the outer frame of the multi-leg mesh stirrups is completely embedded in the form shell; both the outer frame bar and the inner bar are formed by an annular bar which is formed by bending a single rebar with its two ends welded together; and the contacting portions between rebars are welded, thus longitudinal rebars can be fixed within closed confining holes or closed rings formed by the rebars during construction. This patent disclosure discloses that the prefabricated rebar cage is embedded in a concrete form shell to form a prefabricated formwork, which can be mass-produced in factories, transported to the site for assembly, and then concrete is poured to form a composite structural component, allowing rapid construction without on-site formwork support. The formwork component can serve as construction formwork and does not need to be removed after construction.

The issues of lightweight and standardization of formwork can be addressed to some extent by this technology. However, it still requires concrete as the formwork to support the stirrup structure, meaning that both formwork and stirrups are needed to independently function as building components. The prefabrication process of the concrete form shell is time-consuming and labor-intensive, which is not conducive to large-scale and standardized production. Moreover, in this technology, the confinement effect on concrete, especially in the confined region, relies solely on the internal stirrups; the concrete form shell merely provides a supporting carrier for the pre-embedded rebars therein and does not substantially improve the confinement effect and confined region of the stirrup in form of rebar cages on the inner cast concrete. Whether for the prefabricated cast components used in prefabricated construction or the post-cast permanent formwork provided by the above-said patent, the confinement effect and confined region of the outer stirrups and concrete form shell on the concrete inside are also limited, and they cannot truly withstand the longitudinal pressure and lateral expansion stress of the inner cast concrete. When the building load-bearing capacity exceeds a certain limit, for example in high-rise buildings or during earthquakes, failure is likely to occur, and the strength of structures constructed in these ways poses great risks.

Chinese Patent Publication No. CN216196563U discloses a quick-installation permanent formwork assembly, comprising two prefabricated permanent formworks on both sides and multiple sets of quick connectors connected between the two prefabricated permanent formworks. The prefabricated permanent formworks are pre-cast from pouring concrete and internally provided with reinforcing steel mesh; the upper and lower end faces of the prefabricated permanent formworks are pre-embedded with connecting slots during casting; each set of quick connectors comprises a connecting rod and two inserts, with the inserts fixed at both ends of the connecting rod; the inserts are inserted into the connecting slots; when the

prefabricated permanent formworks are assembled in multiple layers, the lower half of the insert is inserted into the connecting slot on the upper end face of the lower prefabricated permanent formwork, and the upper half of the insert is inserted into the connecting slot on the lower end face of the upper prefabricated permanent formwork. The inner side of the prefabricated permanent formwork is provided with crossing reinforcing ribs, and the reinforcing ribs are distributed at positions facing each connecting slot. The reinforcing ribs greatly improve the structural strength of the prefabricated permanent formwork, enabling the prefabricated permanent formwork to withstand large pouring impact forces.

The formwork disclosed in this patent is also a reinforced concrete formwork structure pre-cast from concrete with a steel mesh provided therein, and it separately requires both formwork and stirrups, while the reinforcing ribs do not function as stirrups. Thus, the above technical problem of concrete confinement still exists. Moreover, this technology is explicitly only applicable to cast wall structures and is not suitable for beams or columns.

Chinese Patent Publication No. CN209509476U discloses a permanent steel formwork, peculiar in that multiple thin steel plates are used to enclose a casting cavity, and the shape of the casting cavity matches the shape of the component to be cast; the connections between steel plates are fixed by welding; as it is a steel formwork, spot welding can be used at the connections for lightly fixation. Specifically, this disclosure discloses that the permanent steel formwork of the vertical component comprises four steel plates, with multiple stiffening ribs on the formwork inner side of each steel plate, and each stiffening rib is provided with small round holes for inserting short rebars to ensure that the steel formwork does not fall off after the steel formwork is poured. The short rebars are sourced on-site, such as waste rebars end from the construction site; after the short rebars are installed on the steel plates, the formwork can be assembled; after assembly, supporting wooden beams are installed for external reinforcement of the formwork, and then supporting steel pipes are erected; after erection, concrete can be poured. The steel formwork integrates with the cast component, eliminating the removal step of conventional formwork in cast-in-place construction. Additionally, the formwork is pre-embedded into the concrete at multiple points via short rebars, ensuring firm connection between the formwork and the prefabricated component and increasing the strength and safety of the component.

Although this disclosure discloses steel plates as construction formwork for cast-in-place concrete without removal, the small round holes in the inner stiffening ribs are only for inserting short rebars to ensure that the steel formwork does not fall off after pouring, and do not provide additional assistance to the confinement of the most important inner cast concrete. Moreover, the steel plates merely serve as formwork and act independently from the internal rebars as

building components, i.e., separate formwork and separate stirrups are still required, and the confinement effect, particularly in the confined region, relies solely on the internal stirrups.

Furthermore, as part of the construction process, after the main building structure is completed by either on-site formwork construction or prefabricated component installation, surface treatments are still required, such as surface plastering and leveling, surface decoration, fireproofing, thermal insulation, waterproofing, etc. Chinese Patent Publication No. CN111576667A discloses a shear wall comprising: an inner leaf wall panel, including a first portion and a second portion arranged at a first angle; a middle wall panel, including a first portion and a second portion arranged at a second angle, the middle wall panel being connected to the inner leaf wall panel through a plurality of first tie components and forming a first cavity with the inner leaf wall panel, where the first cavity is provided with structural rebars for the wall; an outer leaf wall panel, including a first portion and a second portion arranged at a third angle, the outer leaf wall panel being connected to the middle wall panel through a plurality of second tie components and forming a second cavity with the middle wall panel, where the second cavity is provided with an insulation wall panel being connected to the second tie components. The inner leaf wall panel and the middle wall panel are tensile wall panels, made of materials including but not limited to cement-based composites, metals, and synthetic composite materials; the first tie components are made of materials with certain tensile strength, including but not limited to metals or synthetic composite materials; the second tie components may be made of materials with low thermal conductivity, such as stainless steel.

This patent technology asserted that the shear wall is a prefabricated component with a cavity structure, comprising two functional zones: a structural functional zone and an insulation functional zone, integrating external wall insulation and structural rebars of the shear wall. The shear wall is manufactured in a factory, demolded and cured after hardening, transported to the site for assembly, hoisted into place, and then concrete is poured into the cavity thereof to form the building wall. This technology can eliminate on-site formwork erection and removal work, insulation and waterproofing work, and even post-construction plastering work.

However, this technology is still a type of permanent formwork; it merely prefabricates the insulation layer together with the formwork. It still requires separate formwork and separate internal rebars. Although it discloses tie components between the inner leaf wall panels and middle wall panels, the formwork, its insulation layer, and the tie components do not play a substantial role in the confinement effect, particularly in the confined region, which still relies on the structural rebars provided in the first cavity instead.

For prefabricated floor slab components in prefabricated construction, composite floor slabs are currently widely used. They are formed by providing prefabricated upper and lower rebars on a cast-in-place base slab, and then pouring a composite layer of concrete on site to integrate the composite slab with the floor slab.

For example, Chinese Patent Publication No. CN220353196U discloses a prefabricated floor slab structure, comprising a floor slab body, with one side of the floor slab body having a first connecting portion protruding horizontally outward, and the other side having a second connecting portion protruding horizontally outward, and the first and second connecting portions being arranged in sequence along the thickness direction of the floor slab body. The bottom end of the first connecting portion is integrally cast with first strengthening rebars, the top end of the second connecting portion is provided with first grooves adapted to receive and engage with the diameter of the first strengthening rebars, the top end of the second connecting portion is integrally cast with second strengthening rebars, and the top end of the first connecting portion is provided with second grooves adapted to receive and engage with the diameter of the second strengthening rebars.

The assembly process disclosed in this patent technology is as follows: the floor slab body is placed on steel beams; when multiple floor slabs are spliced, the side of a floor slab body with the second connecting portion is placed on the steel beam at first, then the side of another floor slab body with the first connecting portion is placed on the same steel beam, with the first connecting portion positioned above the second connecting portion. The bottom end of the first strengthening rebar enters the first groove and the bottom end of the second strengthening rebar enters the second groove. Then, the splicing joint formed between the two floor slab bodies is cast; the arrangement of the first strengthening rebars, the second strengthening rebars, the first grooves, and the second grooves not only position the two floor slab bodies relative to each other but also makes the connection therebetween stronger. To enhance the strength of the floor slab body, third strengthening rebar is provided inside the floor slab body, where the third strengthening rebar is horizontally arranged and perpendicular to the first and second strengthening rebars.

The issues of firmness and standardization of composite floor slab splicing can be addressed to some extent by this technology. However, the floor slab body used in this disclosure is all concrete formwork and requires crossing upper and lower rebar cages and strengthening rebars perpendicular thereto to serve as a load-bearing support, meaning that both the concrete formwork and its upper and lower rebars are required to independently function as building components. The prefabrication process of the concrete floor slab is time-consuming and labor-intensive, which is not conducive to large-scale and standardized

production. Moreover, in this technology, the confinement effect on concrete, especially in the confined region, relies solely on the upper and lower rebars and the strengthening rebars; the concrete floor slab merely provides a supporting carrier for the building components and does not substantially improve the confinement effect and confined region of the rebar cage on the inner cast concrete. Whether in prefabricated cast components used in prefabricated construction or in the post-cast prefabricated floor slab provided by this disclosure, the confinement effect and confined region of the rebars and concrete prefabricated slab on the inner cast concrete are also limited, and they cannot truly withstand the longitudinal pressure and lateral expansion stress of the inner cast concrete. When the building load-bearing capacity exceeds a certain limit, for example in high-rise buildings or during earthquakes, failure is likely to occur, and the strength of structures constructed in these ways poses great risks.

Chinese Patent Application No. CN219491436U discloses a prefabricated floor slab, comprising a base layer formed by splicing multiple prefabricated concrete floor composite slabs and a cast-in-place layer poured on the base layer. The prefabricated concrete floor composite slab includes a rectangular base slab, a lower rebar mesh provided in the base slab, a plurality of load-bearing ribs arranged parallel and spaced apart on the base slab, and an upper rebar mesh provided on all the load-bearing ribs. The load-bearing ribs extend along the length direction of the base slab until their end faces are aligned with the corresponding side of the base slab, and all the load-bearing ribs divide the base slab into multiple pouring zones; the pouring zones of adjacent prefabricated concrete floor composite slabs are jointed to form butting zones where rebar cages are provided, and the cast-in-place layer is poured into the pouring zones and butting zones and is aligned with the upper surfaces of the load-bearing ribs. By providing upper and lower rebar meshes, the load-bearing ribs, and the rebar cages, the overall structural strength, fracture resistance, and load-bearing capacity of the prefabricated floor slab are greatly improved, making it less likely to breakage during construction and eliminating the need for temporary supports on site.

This technology still relates to composite floor slab splicing technology. The base slabs used herein are still concrete formworks and require crossing upper and lower rebar meshes and rebar cages cooperating therewith to serve as load-bearing supports, meaning that both the concrete formwork and the upper and lower rebar meshes and the rebar cages in the pouring zones are required to independently function as building components. The prefabrication process of the concrete floor slab is time-consuming and labor-intensive, and its rebar mesh structure is even more complex, which is not conducive to large-scale and standardized production. Moreover, in this technology, the confinement effect on concrete,

especially in the confined region, relies solely on the various rebars; the concrete floor slab merely provides a supporting carrier for the building components and does not substantially improve the confinement effect and confined region of the rebar cage on the inner cast concrete. Whether in prefabricated cast components used in prefabricated construction or in the post-cast prefabricated floor slab provided by this disclosure, the confinement effect and confined region of the rebars and concrete prefabricated slab on the inner cast concrete are also limited, and they cannot truly withstand the longitudinal pressure and lateral expansion stress of the inner cast concrete. When the building load-bearing capacity exceeds a certain limit, for example in high-rise buildings or during earthquakes, failure is likely to occur, and the strength of structures constructed in these ways poses great risks.

SUMMARY

To solve the above problems existing in the prior art, the present disclosure provides a prefabricated building component for cast-in-place, particularly a formwork component suitable for columns or beams, a shear wall component, or a floor slab component. The present disclosure provides the following solution:

It is a first aspect of the present disclosure to provide a prefabricated building formwork component for cast-in-place, particularly applicable to columns or beams, comprising a cylindrical form shell and stirrups fixed to the form shell, wherein upper and lower ends of the form shell are provided with mating portions adapted to mate with adjacent form shells; wherein the form shell is formed by enclosing steel plates, and the stirrups are jointly comprised of the steel plates and rod-shaped components fixedly connected to inner sides of the steel plates. A novel prefabricated building formwork for cast-in-place for the column or beam component is obtained by a basic technical solution provided by the present disclosure. The enclosing steel plates and the rod-shaped components therebetween are adapted to form a unitary structure, which performs the dual functions and effects of both construction formwork and structural stirrups in traditional construction processes. During building construction, there is no longer any need to erect additional formwork or tie stirrups on site, thereby saving production costs and reducing difficulties in processing and construction. More importantly, by using the enclosing steel plates and rod-shaped components provided therein to replace traditional formwork and stirrups, the novel prefabricated building formwork for cast-in-place for the column or beam component of the present disclosure can, to a certain extent, provide stronger confinement effect on the cast concrete and longitudinal rebars, and particularly can increase the confined region on the concrete, thereby improving the overall shear-bearing capacity and seismic performance of the building.

It is a second aspect of the present disclosure to provide a prefabricated building shear wall component for cast-in-place, comprising a first wall panel and a second wall panel arranged opposite to each other, wherein the first and second wall panels are connected by a plurality of tie components, forming a cavity therebetween; wherein both the first wall panel and the second wall panel are made of steel plates, and the tie components are steel rod-shaped components fixedly connected between inner sides of the first and second wall panels. A novel prefabricated building shear wall component for cast-in-place is obtained by the basic technical solution provided by the present disclosure. The steel plates of the first and second wall panels and the steel rod-shaped components therebetween are adapted to form a unitary structure, which performs the dual functions and effects of both construction formwork and structural rebar in traditional construction processes. During building construction, there is no longer any need to erect additional formwork or tie rebars on site, thereby saving production costs and reducing difficulties in processing and construction. More importantly, by using the wall panels with steel plates and the steel rod-shaped components therebetween to replace traditional formwork and rebars, the novel prefabricated building shear wall component for cast-in-place of the present disclosure can, to a certain extent, provide stronger confinement effect on the inner cast concrete, and particularly can increase the confined region on the concrete, thereby improving the overall shear-bearing capacity and seismic performance of the building.

It is a third aspect of the present disclosure to provide a prefabricated building floor slab component for cast-in-place, comprising floor slab bodies and a plurality of rod-shaped connecting portions protruding from an inner side of the floor slab body, wherein opposite floor slab bodies are connected by the connecting portions, and both ends of the floor slab component are provided with mating portions adapted to mate with adjacent floor slab component; the floor slab body is made of steel plates, and the connecting portions are provided with rebars being parallel to the floor slab body and forming a pouring cavity therebetween. A novel prefabricated floor slab component for cast-in-place is obtained by the basic technical solution provided by the present disclosure. The steel plates serving as the slab body and the load-bearing rebar mesh laterally formed at one side (inner side) of the slab body are adapted to form a unitary structure, which performs the dual functions and effects of both construction formwork and structural rebar in traditional construction processes. During building construction, there is no longer any need to erect additional formwork or tie rebars on site, especially eliminating the lower or low layer (or outer) rebar mesh, so that it is no longer necessary to have rebar meshes on both sides and to pour concrete on both sides to form a composite slab, thereby saving production costs and reducing difficulties in processing and construction. More importantly, by using the steel plates as slab body and the load-bearing

rebar mesh laterally formed at one side of the floor slab body to replace traditional formwork and rebars, the novel prefabricated building floor slab component for cast-in-place of the present disclosure can, to a certain extent, provide stronger confinement effect on the cast concrete, and particularly can increase the confined region on the concrete, thereby improving the overall shear-bearing capacity and seismic performance of the building.

Preferably, the form shell of the present disclosure is formed by fixed connection of a plurality of segments of steel plates that are longitudinally separated from each other along the enclosing center thereof; the first wall panel and/or the second wall panel of the present disclosure is formed by fixed connection of a plurality of segments of steel plates that are longitudinally separated from each other; and the floor slab bodies of the present disclosure are formed by fixed connection of a plurality of segments of steel plates that are separated from each other in the width direction thereof. In this further preferred technical solution, during factory prefabrication process, the plurality of separate segments of steel plates can be further processed to form an integral steel plate required in the final prefabricated component. This measure not only saves material but also facilitates product standardization, generalization, and large-scale assembly-line production.

Preferably, the fixed connection of the plurality of segments of steel plates in the present disclosure is formed by spot welding. In this further preferred technical solution, compared with direct connection of the multiple segments of steel plates integrally, the connection of the segments of steel plates by spot welding not only satisfies the integrity of the prefabricated building component but also further distributes the load-bearing on each segment better, avoiding the steel plates from participating in longitudinal load-bearing of the component, ensuring uniformity of the longitudinal flexural rigidity of the component, and also facilitating standardized and large-scale production on factory assembly lines.

Preferably, in the present disclosure, the outer side of the form shell and/or the first wall panel and/or the second wall panel and/or the floor slab body formed by the steel plates are further provided with a reinforcing layer being a magnesium phosphate-based material layer fixedly connected to the outer side. In this further preferred technical solution, by adding a reinforcing layer, particularly a reinforcing layer made of magnesium phosphate-based cementitious material, to the outer side of the steel plates of the building component of the present disclosure, the resistance of the steel plates against the lateral stress generated outward by the cast concrete can be enhanced due to the better bonding and supporting effect of the reinforcing layer to the steel plates, thereby further strengthening the confinement effect on the inner cast concrete, particularly reducing the area of the unconfined region. In addition to using a magnesium phosphate-based material layer as the reinforcing layer, other forms

such as rebar mesh with concrete may also be used as the reinforcing layer, as long as the confinement effect can be enhanced through better bonding with the steel plates.

Preferably, opposite outer sides of the form shell and/or the first wall panel and/or the second wall panel and/or the slab body formed by the steel plates of the present disclosure are respectively recessed inwardly to form grooves, while in the internal hollow region or cavity therebetween, protrusions corresponding to the grooves are formed, and both ends of the rod-shaped components or steel rod-shaped components or connecting portions respectively extend through the protrusions into the grooves, and both ends of the rod-shaped components or steel rod-shaped components or connecting portions are provided with connecting fasteners respectively, wherein the connecting fasteners is located in and fitted in the corresponding grooves; the connecting fasteners and the ends of the rod-shaped components or steel rod-shaped components or connecting portions are all located within the grooves and are disposed inward of the outer side surface of the form shell and/or the first wall panel and/or the second wall panel and/or the floor slab body. In this further preferred technical solution, the concave-convex structure is adapted to fit the rod-shaped components/connecting portions closely with the enclosing steel plates in a tight manner, acting as traditional stirrups with a confinement effect significantly superior to that of traditional stirrups, which can not only greatly increase the confined region on the internal concrete but also provide better confinement effect on the longitudinal rebars. Moreover, such design allows both ends of the rod-shaped components/connecting portions to be located within the internal space of the enclosing steel plates without protruding beyond the outer side of the steel plates, which not only avoids affecting the appearance of the outer surface of the building component but also avoids hindering other functional layers added to the outer side of the steel plates, while being also more ideal for production, packaging, and transportation during factory prefabrication.

Preferably, one end of the rod-shaped components or steel rod-shaped components or connecting portions of the present disclosure is provided with an upset anchor head, and an opposite end thereof is provided with an external thread adapted to be connected with a nut, wherein the upset anchor head and the nut respectively act as the connecting fasteners at two ends of the rod-shaped components or steel rod-shaped components or connecting portions. In this further preferred technical solution, the upset anchor head with an enlarged end on one side of the rod-shaped components/connecting portions is designed such that the rod-shaped components/connecting portions cooperate with the enclosing steel plates to act as traditional stirrups, with a confinement effect significantly superior to that of traditional stirrups. The enlarged upset anchor head can better resist the stress of the cast concrete on the steel plate side, not only greatly increasing the confined region on the internal concrete but also providing

better confinement effect on the longitudinal rebars. The use of a threaded connection at the other end of the rod-shaped components/connecting portions facilitates insertion of the rod-shaped components/connecting portions into the corresponding grooves on the steel plates. The rod-shaped components/connecting portions can be tightly fitted with the steel plates by merely screwing and fixing the nut on the threaded side without moving the enlarged upset anchor head at one end, which is more ideal for production, packaging, and transportation during factory prefabrication.

Preferably, both ends of the rod-shaped components or steel rod-shaped components or connecting portions of the present disclosure are provided with external threads adapted to be connected with nuts, respectively acting as the connecting fasteners at the both ends. In this further preferred technical solution, considering the difficulty of processing the upset anchor head, both ends are instead connected by threaded connections as a connecting fastener, thereby reducing processing difficulty, lowering processing costs, increasing product yield, and facilitating large-scale production.

Preferably, the connecting portions of the present disclosure are an L-shaped structure, with its bottom horizontal segment being directly fitted and fixedly connected to the inner side of the floor slab body as a connecting fastener, and its vertical segment being connected to the rebars. In this further preferred technical solution, further considering the difficulty and cost of processing the upset anchor head and the grooves, a direct fixation is used instead, thereby eliminating the need for grooves and connection and fixation on both inner and outer side, which can further reduce processing difficulty, lower processing costs, increase product yield, and facilitate large-scale production thereof.

Preferably, the upset anchor head of the present disclosure comprises an anchor head body having a diameter larger than that of the rod-shaped components or steel rod-shaped components or connecting portions, and protruding outwardly to form an annular fitting portion being capable of fitting with the grooves; or the anchor head body fitting with the grooves through a washer is provided on the rod-shaped components or steel rod-shaped components or connecting portions, the washer having a diameter larger than that of the anchor head body. In this further preferred technical solution, the rod-shaped components/connecting portions are designed with a fitting portion on the upset anchor head or an additional washer, such that the rigid confinement range of the anchor head is further enhanced, while enabling the rod-shaped components/connecting portions to fit more tightly with the enclosing steel plates to act as traditional stirrups, with a confinement effect significantly superior to that of traditional stirrups. The tight fit allows the rod-shaped components/connecting portions and the steel plates to better form an integral load-bearing unit, helping to better resist the stress of the cast

concrete, which not only greatly increases the confined region on the internal concrete but also provides better confinement effect on the longitudinal rebars.

Preferably, a side wall and a bottom of the grooves of the present disclosure form an angle of 30-60°; the diameter of the protrusions is 2–5 times the diameter of the rod-shaped components or steel rod-shaped components or connecting portions. In this further preferred technical solution, the grooves are designed to have wider outside and narrower inside, with the dimension larger than the diameter of the rod-shaped components/connecting portions, such that the rod-shaped components/connecting portions can pass smoothly from one side of the steel plate to the other side, and fit more tightly with the enclosing steel plates to act as traditional stirrups, with a hooping effect significantly superior to that of traditional stirrups, helping to better resist the stress of the cast concrete, which not only greatly increases the confined region on the internal concrete but also provides better confinement effect on the longitudinal rebars.

Preferably, the mating portions at one end of the component of the present disclosure can tightly fit with the corresponding mating portions of an adjacent component, so that the two components can be joined and their outer sides are aligned with each other. In this further preferred technical solution, by providing the mating portions, it is no longer necessary to prefabricate the components as a bulky complete component as in traditional prefabricated construction, while at the same time, it is convenient to assemble multiple formwork components on site into the required complete component. The mating portions can be processed into standard interfaces, greatly improving efficiency for factory mass production of standard parts, and reducing the skill requirements for installation workers, thus providing a good foundation for the application of intelligent construction technology.

Preferably, the mating portions of the present disclosure are in a form of slot connection or plug-in connection. In this further preferred technical solution, any suitable connection form known in the art may be used for joining multiple formwork components, with slot connection or plug-in connection being the most convenient for on-site operations and also relatively ideal for factory processing. However, as long as the function of connection and mating is achieved, other suitable connection forms may also be used.

Preferably, the rod-shaped components or steel rod-shaped components or connecting portions of the present disclosure are arranged in multiple layers along the longitudinal direction of the form shell and/or the first wall panel and/or the second wall panel and/or the floor slab body, with the rod-shaped components or steel rod-shaped components or connecting portions within the same layer being coplanar and parallel to each other, while the

rod-shaped components or steel rod-shaped components or connecting portions of adjacent layers being arranged to cross each other in a perpendicular direction or to cross each other in parallel directions at different positions. In this further preferred technical solution, the arrangement of multiple rod-shaped components/connecting portions, multiple layers of rod-shaped components/connecting portions, and different oriented rod-shaped components/connecting portions can provide confinement effect on the cast concrete at different positions and in different directions of the enclosing steel plates, helping to better resist the stress and structural shear forces of the cast concrete, which not only greatly increases the confinement range on the internal concrete but also provides better confinement effect on the longitudinal rebars. The spacing between layers or individual rod-shaped components/connecting portions can be set appropriately according to different building components, building parts, building types, etc., and those skilled in the art can optimize the selection based on specific construction requirements.

Preferably, the form shell of the present disclosure is made of seamless steel pipes or is formed by laterally bending and enclosing the steel plates. In this further preferred technical solution, bending steel plates to form the enclosing formwork of the present disclosure is generally used for columns and beams in concrete structures, on the one hand replacing the construction formwork in traditional construction processes, and on the other hand replacing the peripheral stirrups in concrete structures. During construction, it resists the lateral pressure generated during concrete pouring, and shares in structural load-bearing during use of the structure, primarily bearing structural shear forces. The prefabricated building formwork of the present disclosure is easily manufactured in factories by bending and welding steel plates into rectangular, T-shaped, cross-shaped, L-shaped, circular, etc., not only with low processing cost but also facilitating automated assembly-line production.

Preferably, the rebars of the present disclosure are a rebar mesh formed by a plurality of crossing rebars. In this further preferred technical solution, load-bearing rebars in form of a rebar mesh provide confinement effect on the cast concrete at different positions and in different directions of the steel plate slab bodies, helping to better resist the stress and structural shear forces of the cast concrete, and greatly increasing the confined region on the internal concrete. The number of connecting portions and crossing rebars and the spacing therebetween can be set appropriately according to different building parts, building types, etc., and those skilled in the art can optimize the selection based on specific construction requirements.

Beneficial Effect

In summary, compared with the prior art, the present disclosure has the following beneficial effects:

The novel prefabricated building component for cast-in-place of the present disclosure provides a proper cooperation between the steel plate structure and the rod-shaped components disposed therebetween, forming a combined force to simultaneously function as formwork and stirrups in the building structure. There is no longer any need to erect formwork or tie stirrups, thereby saving production costs and reducing difficulties in processing and construction. By using the steel plate structure and rod-shaped components provided therein to replace traditional construction formwork and stirrup structures, better confinement effect on the cast concrete, particularly by enlarging the confined region, can be achieved, thereby improving the overall shear resistance and load-bearing capacity of the building.

In the novel prefabricated building component for cast-in-place of the present disclosure, controlling the thickness of the steel plates may increase the spacing between the component and the internal longitudinal rebars and concrete; the cooperation between the multi-level internal confining components (such as rod-shaped components) and the steel plates (including the design of groove-protrusion and connecting fasteners such as upset anchor heads), not only increase the confined region on the internal concrete greatly, but also provides better confinement effect on the longitudinal rebars; the reinforcing layer on the outer side of the steel plates having better bonding effect on the steel plates may enhance the resistance of the steel plates against lateral stress from the internal concrete; the integral steel plate formed by welding the segments of the steel plates may significantly reduce the nonuniformity of longitudinal pressure at different positions subjected to the steel plates from the building structure. The above structural configurations of the novel prefabricated building component for cast-in-place of the present disclosure can better confine the cast concrete therein, particularly by enlarging the confined region.

The novel prefabricated building component for cast-in-place of the present disclosure provides a building structure formed by steel plates and the rod-shaped components disposed therebetween, which simultaneously functions as formwork and stirrups, wherein special connecting and fixing structures are used at the connection portions, facilitating the novel prefabricated building component for cast-in-place of the present disclosure to be pre-formed in advance. Neither the prefabrication process nor the on-site construction process requires tying or welding operations. The components can be directly mass-produced in factories according to standard specifications. This not only improves efficiency but also avoids inconsistent process during construction, shortening the construction period and reducing construction requirements.

The novel prefabricated building component for cast-in-place of the present disclosure, provides a building structure formed by the steel plate structure and the rod-shaped components disposed therebetween, which simultaneously functions as formwork and stirrups, eliminating the need for separate construction formwork (whether traditional wooden formwork erected on site or prefabricated concrete formwork). At the construction site, longitudinal rebars can be directly inserted into the novel prefabricated building component for cast-in-place of the present disclosure, and only need to be fixed at the ends to the steel plates and/or rod-shaped components by tying or welding (and may also be confined and fixed at the center by confining holes provided in the component). After the cast-in-place concrete has been formed, the prefabricated component for cast-in-place of the present disclosure does not need to be removed, at the same time, the prefabricated component may directly act as a part of the reinforced concrete building structure and bear stresses together with the internal rod-shaped component stirrups, thereby enlarging the confined region of the concrete.

The novel prefabricated building component for cast-in-place of the present disclosure may be prefabricated as standard components of minimum unit size, then being assembled from the mating portions at both ends of the component to form complete building components of the required dimension. Compared with finished building components in prefabricated construction, the prefabricated building components for cast-in-place of the present disclosure are lighter in self-weight, making transportation, hoisting, and installation more convenient. Moreover, as concrete is cast in place after installation, avoiding problems of insufficient strength, sealing, or stability at connection portions that exist in pre-cast integral prefabricated building components. At the same time, the components facilitate large-scale factory assembly-line production and convenient on-site installation, and may achieve integrated decoration and finishing, eliminating the need for plastering, puttying, or painting. The building components are miniaturized, lightweight, standardized, and integrated, facilitating the application of artificial intelligence technology, and achieving reduced construction costs, shortened construction periods, and improved quality.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the prefabricated formwork column component for cast-in-place according to Embodiment 1 of the present disclosure.

FIG. 2 is a cross-sectional view of FIG. 1.

FIG. 3 is a partially enlarged view of the upset anchor head at portion B of FIG. 2.

FIG. 4 is a schematic view of the mating portions and the reinforcing layer of the prefabricated formwork column component for cast-in-place according to Embodiment 1 of the present disclosure.

FIG. 5 is a schematic view of the prefabricated formwork U-shaped beam component for cast-in-place according to Embodiment 2 of the present disclosure.

FIG. 6 is a perspective view of the prefabricated shear wall component for cast-in-place according to Embodiment 3 of the present disclosure.

FIG. 7 is a cross-sectional view of FIG. 6.

FIG. 8 is a schematic view of the prefabricated floor slab component for cast-in-place according to Embodiment 4 of the present disclosure.

FIG. 9 is a partially enlarged view of the upset anchor head in the prefabricated floor slab component for cast-in-place according to Embodiment 4 of the present disclosure.

FIG. 10 is a comparative view of the longitudinal confined regions between the prefabricated formwork column component for cast-in-place according to Embodiment 1 of the present disclosure and a traditional formwork-stirrup concrete column.

FIG. 11 is a comparative view of the transverse confined regions between the precast formwork column component for cast-in-place according to Embodiment 1 of the present disclosure and a traditional formwork-stirrup concrete column structure.

FIG. 12 is a comparison of load-displacement curves of axially loaded compression components between a traditional reinforced concrete column and the prefabricated formwork column component for cast-in-place according to Embodiment 1 of the present disclosure, wherein the blue curve represents the traditional reinforced concrete column, and the red curve represents the data of the prefabricated formwork column component for cast-in-place of the present disclosure.

FIG. 13 is a comparison of hysteresis curves between a traditional reinforced concrete column and the prefabricated formwork column component for cast-in-place according to Embodiment 1 of the present disclosure from low-cycle reversed loading tests, wherein the blue curve represents the traditional reinforced concrete column, and the red curve represents the data of the prefabricated formwork column component for cast-in-place of the present disclosure.

FIG. 14 is a comparison of flexural beam test results (mid-span deflection vs. mid-span bending moment) between a traditional reinforced concrete beam and the prefabricated formwork beam component for cast-in-place according to Embodiment 2 of the present disclosure, wherein the blue curve represents the traditional reinforced concrete column, and the red curve represents the data of the prefabricated formwork column component for cast-in-place of the present disclosure.

FIG. 15 is a torque-rotation curve of the prefabricated formwork beam component for cast-in-place according to Embodiment 2 of the present disclosure.

Reference numerals:

1 – steel plate, wherein 101 – column form shell, 102 – beam form shell, 1031 – first wall panel, 1032 – second wall panel;

2 – rod-shaped component, wherein 201 – steel rod-shaped component, 202 – connecting portion;

3 – reinforcing layer;

4 – longitudinal rebar constraint structure;

5 – groove;

6 – protrusion;

7 – upset anchor head;

8 – anchor head body;

9 – nut;

10 – fitting portion;

11 – washer;

12 – plug-in portion;

13 – socket portion;

14 – weld seam;

DESCRIPTION OF EMBODIMENTS

The present disclosure is further described in detail below through specific embodiments. However, it should be noted that the following examples are merely for better illustrating the content of the present disclosure and do not mean that the content of the present disclosure is limited to the illustrated examples. Therefore, non-essential modifications and adjustments made to the embodiments by those skilled in the art based on the above disclosure still fall within the protection scope of the present disclosure as defined by the appended claims.

The term "building" as used in the present disclosure is a general term for construction and structure, referring to the artificial environment created by people, by utilizing available material and technical means, and by applying certain scientific laws, feng shui concepts, and aesthetic principles, so as to meet the needs of social life. The term "construction" has both broad and narrow interpretations. In a broad interpretation, it refers to all things artificially constructed, including both houses and structures; in a narrow interpretation, it refers to houses, excluding structures. A house refers to a spatial place with a foundation, walls, roof, doors, and windows, capable of sheltering from wind and rain, for people to live, work, study, entertain, store items, or conduct other activities. The "construction" used in the present disclosure has the narrow interpretation, and unless otherwise specified, " building " and "construction" are interchangeable terms with the same interpretation.

The term "building component" as used in the present disclosure refers to load-bearing components of a building, including foundations (components directly in contact with the ground), walls, columns, beams, floor slabs, roof trusses, etc. According to the composition of load-bearing components, buildings can be classified into the following types: 1) Brick-timber buildings: the main load-bearing components of such buildings are made of brick and timber, wherein walls and columns as vertical load-bearing components are built with bricks, and floor slabs, roof trusses, etc. as horizontal load-bearing components are made of timber. 2) Brick-concrete buildings: the vertical load-bearing components of such buildings are brick walls or brick columns, and the horizontal load-bearing components are reinforced concrete floor slabs, roof slabs, etc. 3) Reinforced concrete buildings: the load-bearing components of such buildings, such as beams, floor slabs, columns, walls, and roof trusses, are composed of two major materials—rebars and concrete, and its enclosure components such as walls and partitions are made of lightweight bricks or other masonry. Reinforced concrete buildings

include frame structures, frame-shear wall structures, shear wall structures, tube structures, frame-tube structures, and tube-in-tube structures. 4) Steel buildings: the main load-bearing components of such buildings are all made of steel, with high construction costs, and are not the main form of buildings at present. Unless otherwise specified, the buildings in the present disclosure refer to reinforced concrete buildings.

Among building components, walls and columns are both vertical load-bearing components that support the roof, floor slabs, etc., and transmit these loads and their own weight to the foundation. Walls include external walls located around the building, being enclosure components that function as wind protection, rain sheltering, thermal insulation, heat insulation, and sound insulation; and internal walls located inside the building, which mainly serve to partition internal spaces and also provide sound insulation and fire resistance functions to a certain extent. In terms of load-bearing conditions, walls are divided into load-bearing walls and non-load-bearing walls. Load-bearing walls refer to walls that directly bear loads transmitted from beams, floor slabs, roofs, etc.; non-load-bearing walls refer to walls that do not bear external loads. For a more precise classification, if external force acts on the upper and lower surfaces of the wall, i.e., longitudinal loading, it is called a "load-bearing wall"; if external force acts on the side surface on the thickness direction of the wall, i.e., transverse loading, it is called a "shear wall"; if external force acts on the side surface on the width direction of the wall, which is also a form of transverse loading, it is called a "retaining wall." Pure load-bearing walls, shear walls, or retaining walls are relatively rare; combinations of these wall types are more common. For example, the combination of load-bearing wall and shear wall is a relatively common form of wall, especially in the mid-to-high-rise buildings widely used at present, where both longitudinal and transverse loads are subjected to the walls. There is also a type of wall that bears no force in any of the three directions, so called an infill wall, or "partition," etc. The walls involved in the present disclosure include wall types that bear forces in one or multiple directions or combinations thereof, particularly shear walls, but do not exclude the use of the structure of the present disclosure for constructing other wall types or combinations thereof.

Columns are upright supporting components in buildings, which bear and transmit loads from beams and slabs.

Floor slabs are horizontal load-bearing components that separate the upper and lower spaces of a building, primarily functioning as bearing loads from people, furniture, etc., and transmitting these loads as well as their own weight to load-bearing walls, beams, columns, or foundation. The basic construction of a floor slab includes a surface layer, a structural layer, and a ceiling layer. In addition to bearing and transmitting vertical and horizontal loads, the

floor slab should also have certain capabilities for sound insulation, waterproofing, fire resistance, etc., and various horizontal service pipes and cables in the building are also installed within the floor slab. Depending on the materials used, floor slabs can be classified into timber floor slabs, brick-arch floor slabs, reinforced concrete floor slabs, and steel-deck bearing floor slabs, among others. Currently, reinforced concrete floor slabs are more widely used, including both prefabricated floor slabs and cast-in-place floor slabs. The most popular composite floor slabs are formed by prefabricating upper rebars supported on a cast-in-place base slab, with bottom rebars pre-embedded in the base slab, and then pouring a composite layer of concrete on site to integrate the composite slab with the floor slab.

Beams are transverse components spanning across spaces, mainly acting as horizontal load-bearing components in buildings, bearing loads transmitted from slabs above and then transmitting them to supporting columns or walls.

In addition to walls, columns, beams, and floor slabs that are essential for every floor, there are also some non-essential but common building components, such as balconies, roofs, elevators, staircases, etc. Unless otherwise specified, the building components of the present disclosure may be any of the above components required in a building.

According to construction methods, buildings can be classified into the following types: 1) cast-in-place and built-in-place buildings: the main load-bearing components of such buildings are all cast and built on the construction site; 2) prefabricated and assembled buildings: the main load-bearing components of such buildings are prefabricated components manufactured in factories and assembled on the construction site; 3) partially cast-in-place/built-in-place and partially prefabricated buildings: some components of such buildings (e.g., walls) are cast or built on site, while some components (e.g., floor slabs, staircases) are prefabricated components manufactured in factories. Different from the above classifications, the buildings of the present disclosure may be defined as "prefabricated for cast-in-place" buildings, i.e., the main load-bearing components are all prefabricated components manufactured in factories, but do not include cast concrete and internal longitudinal rebars, which are cast and installed by cast-in-place construction on site.

Currently, reinforced concrete buildings are the most common building structures. Reinforced concrete, often abbreviated as RC in engineering, refers to a composite material formed by adding rebar mesh, steel plates, or fibers to concrete, which acts together with the concrete to improve the mechanical properties of the concrete. Concrete (commonly abbreviated as C) is a general term for engineering composite materials formed by cementing aggregates with a cementitious material. The term "concrete" as commonly used in

construction engineering refers to cement concrete obtained by mixing cement as the cementitious material, sand and stone as aggregates, with water and other admixtures and additives in a certain proportion. In the present disclosure, the terms "concrete" and "C" have the same meaning and are interchangeable.

In reinforced concrete buildings, rebars (including longitudinal rebars and stirrups), formwork, and concrete are the main component. Longitudinal rebars are rebars arranged parallel to the longitudinal axis of the building component, acting as the main load-bearing and stress-bearing elements of the concrete in the longitudinal direction. Traditional stirrups are also a type of rebar, generally processed from plain round steel bars into the required shape by welding or other processes, and are arranged perpendicular to the longitudinal rebars to provide transverse shear resistance to the component.

Construction formwork is generally a temporary supporting structure, being designed and manufactured to shape reinforced concrete components into the specified position and geometric dimension, so as to maintain their correct position, and bear the self-weight of the formwork and external loads acting thereon. Classified by material properties, the formwork includes timber formwork, concrete formwork, steel formwork, aluminum formwork, etc.

The present disclosure differs from the prior art in that, it does not require two separate structures—formwork and stirrups—but instead uses a same structure to function simultaneously, both of which participate in the substantial confinement effect on the concrete.

The steel plate of the present disclosure has a thickness of 0.8–10 mm, more preferably 1–1.5 mm, and a longitudinal length of 40–1000 mm, more preferably 100–300 mm.

The term "enclosing" or "enclosing steel plate" as used in the present disclosure refers to a structure formed by a planar structure such as a steel plate bending inward along a certain axis, and surrounding and trending to close, for example by welding. The referred enclosing structure in the present disclosure may be a fully closed structure or a semi-closed structure with partial openings, with its cross-sectional shape being closed square, rectangular, circular, polygonal, or a semi-closed U-shape, cross-shape, L-shape, T-shape, etc.

Embodiment 1: Prefabricated Formwork Column Component for Cast-in-Place

A prefabricated column formwork component for cast-in-place, as shown in FIGS. 1-4, is formed by enclosing a 1.5 mm thick steel plate 1 into a closed rectangular column form shell 101. The column form shell 101 has a longitudinal length of 200 mm along its enclosing center, and opposite faces of the column form shell 101 are connected by rod-shaped components 2

in the form of screws vertically secured to the inner side surfaces of the enclosing column form shell 101. The column form shell 101 is formed by fixedly connecting a plurality of segments of steel plate 1 longitudinally separated along its enclosing center; FIG. 1 shows a welded connection of two segments of steel plate, with 14 referring to the weld seam. The rod-shaped components 2 are arranged in multiple layers, preferably in an even number of layers; the shown embodiment has four layers, with each layer of rod-shaped components 2 comprising ten coplanar rod-shaped components 2 arranged parallel to each other and spaced apart from each other, and the length directions of rod-shaped components 2 in adjacent layers being perpendicular to each other, alternating in longitudinal and transverse directions. A reinforcing layer 3 is covered and connected to the outer side of the column form shell 101. The column form shell 101 is provided with pouring holes (not shown) that allow concrete to be poured from the outside into the internal hollow region defined by the column form shell 101; the enclosing region also includes a structure for inserting and fixing longitudinal rebars (not shown).

The prefabricated column formwork component for cast-in-place of this embodiment is prefabricated in a factory. On the construction site, the required longitudinal rebars for the column formwork component are directly inserted into the internal hollow region of the column form shell 101, and the longitudinal rebars are fixed to the column form shell 101 and the rod-shaped components 2 by welding to form a rebar cage, followed by casting concrete into the hollow region to form a reinforced concrete structure.

In this embodiment, the column form shell 101 and the rod-shaped components 2 are fixed by a special connection. The outer side of the column form shell 101 is recessed inwardly at positions corresponding to the two ends of the rod-shaped components 2 to form grooves 5, and protrusions 6 corresponding to the grooves 5 are formed on the inner side of the column form shell 101. The grooves 5 are provided with through holes to allow two ends of the rod-shaped components 2 to pass freely through the grooves 5. Both ends of the rod-shaped components 2 are respectively connected with connecting fasteners which are located in the corresponding grooves 5 and fitted with the grooves 5 tightly.

In this embodiment, the connecting fasteners at the two ends of the rod-shaped components 2 are respectively an upset anchor head 7 and a nut 9. One end of the rod-shaped components 2 is provided with an upset anchor head 7 formed by integral upsetting, and the other end of the rod-shaped components 2 is machined with an external thread and connected with a nut 9. The upset anchor head 7 and the nut 9 respectively act as the connecting fasteners at the two ends of the rod-shaped components 2, so that a tight fit between the connecting fasteners at both ends and the grooves 5 can be achieved by

tightening the nut 9. Both ends may also be fixed and connected by threaded nuts.

As shown in FIG. 3, when the upset anchor head 7 is used, the upset anchor head 7 comprises an anchor head body 8 having a diameter larger than that of the rod-shaped components 2; the anchor head body 8 has a protruding annular fitting portion 10, and achieves tight fit with the groove 5 by the fitting portion 10. The internal shape of the groove 5 is conical or frustoconical, with the angle formed between the groove wall and the groove bottom being about 45° . In cases that the grooves 5 and the protrusion 6 are integrally formed by stamping, the shape of the protrusion 6 corresponding to the grooves 5 matches that of the grooves 5, and its inner diameter may be 2-3 times the diameter of the rod-shaped components 2 passing therethrough. When the fitting portion 10 is not integrally machined with the anchor head body 8, a washer 11 may be used instead of the fitting portion 10. In this way, during machining of the upset anchor head body 8, it is only necessary to ensure that the dimension of the upset anchor head 7 is larger than that of the corresponding rod-shaped components 2, and it is not necessary to machine a fitting portion 10 on the upset anchor head body 8; instead, a washer 11 of matching dimension is separately provided and sleeved over the rod-shaped components 2, and a tight fit with the grooves 5 is achieved through the washer 11. Preferably, as shown in FIG. 3, the connecting fasteners and the ends of the rod-shaped components 2 are all located inside the grooves 5 and do not extend beyond the outer side surface of the column form shell 101. Such design not only ensures a flat surface of the formwork, facilitating the subsequent provision of the reinforcing layer 3 and other functional or decorative layers on the outer side surface, but also allows the steel plates acting as formwork to be closer to the cast concrete in terms of load-bearing, helping to better confine the internal concrete.

When threaded nuts are used as the connecting fasteners, a washer 11 may also be added on the nut 9 to achieve a tight fit with the groove 5 through the threads, which will not be shown separately.

As shown in FIG. 4, the reinforcing layer 3 used in this embodiment is a magnesium phosphate-based polymer material layer. The use of such a material can better enhance the bonding force between this layer structure and the steel plate 1 of the formwork of the present disclosure, further helping to effectively confine the internal concrete. The reinforcing layer 3 covered and connected to the outer side of the column form shell 101 can effectively protect the outer side of the column formwork component, and after the reinforced concrete column is formed by cast-in-place, the reinforcing layer 3 can tightly fit with the column form shell 101, assisting the column form shell 101 in withstanding the lateral stress of the concrete and helping to better confine the internal concrete. Additional concrete layers, decorative layers,

thermal insulation layers, sound insulation layers, fireproof layers, wallpaper, etc. may also be additionally covered outside the reinforcing layer 3 as actually needed.

In the present disclosure, the reinforcing layer 3 may also be formed by any material known in the prior art that has good adhesion to steel plates, for example a rebar mesh layer and a concrete layer, with the rebar mesh layer being fixedly connected to the anchor head body 8 and/or the nut 9 by spot welding, where the rebar mesh layer is compressed and fixed by the anchor head body 8 and the nut 9.

The column formwork component of this embodiment is correspondingly provided with mating portions at both longitudinal ends (along the insertion direction of the longitudinal rebars). As shown in FIG. 4, in this embodiment, one longitudinal end of the column formwork component is provided with a plug-in portion 12 extending longitudinally outward, and the other longitudinal end of the column formwork component is provided with a socket portion 13, and its inner side of the side wall is shaped to correspondingly match the shape of the plug-in portion 12, such that the plug-in portion 12 of the column formwork component can tightly fit with the socket portion 13 of another column formwork component, making the outer side of the joined formwork components aligned with each other. Other mating structures known in the art, such as slot connections, may also be used, as long as multiple column formwork components can be tightly joined together and their outer surfaces are aligned with each other.

During on-site installation, the plug-in portion 12 of the column formwork component is inserted into a corresponding socket portion 13 of another column formwork component of the same type, and, if necessary, a third column formwork component may be further inserted into the latter, until the dimension meets the requirements of the column structure. After the required dimension is achieved, the column formwork components at the two ends of the jointed column structure without the mating portions can be used.

FIGS. 10 and 11 show schematic views of the confined regions of reinforced concrete columns obtained respectively by construction using the prefabricated column formwork component for cast-in-place of Embodiment 1 of the present disclosure and by using the traditional stirrup-formwork way. The unshaded areas within the regions represent the effectively confined regions, while the shaded areas represent the unconfined regions.

As can be seen from FIG. 10, in terms of longitudinal confinement effect, both the reinforced concrete column formed by traditional stirrups and formwork (the left figure) and the reinforced concrete column formed by the novel prefabricated column formwork component for cast-in-place of the present disclosure (the right figure) have unconfined

regions in the longitudinal intermediate zones between adjacent layers of screws, but the reinforced concrete column formed by the novel prefabricated column formwork component for cast-in-place of the present disclosure has a smaller unconfined regions in the corresponding regions.

As can be seen from FIG. 11, in terms of transverse confinement effect, both the reinforced concrete column formed by traditional stirrups and formwork (left figure) and the reinforced concrete column formed by the novel prefabricated column formwork component for cast-in-place of the present disclosure (right figure) have unconfined regions in the transverse intermediate zones and at the corner edge regions within the same layer, but the reinforced concrete column formed by the novel prefabricated column formwork component for cast-in-place of the present disclosure has smaller unconfined regions in the corresponding regions.

Embodiment 2: Prefabricated Formwork Beam Component for Cast-in-Place

A prefabricated U-shaped beam formwork component for cast-in-place, as shown in FIG. 5, is formed by enclosing a 1 mm thick steel plate 1 into a beam form shell 102 of U-shaped cross-section. The steel plate 1 forming the beam form shell 102 has a longitudinal length of 100 mm along its enclosing center, and the two opposite side surfaces of the steel plate 1 are fixedly connected by rod-shaped components 2 vertically secured to the inner side of the beam form shell 102. The rod-shaped components 2 are arranged in multiple layers, preferably in an even number of layers; the present embodiment has two layers, with each layer of rod-shaped components 2 comprising five coplanar rod-shaped components 2 arranged parallel to each other and spaced apart from each other, and the length directions of rod-shaped components 2 in adjacent layers being substantially the same, but the connection positions on the inner side surface of the beam form shell 102 may be staggered. A reinforcing layer 3 is covered and connected to the outer side of the beam form shell 102. The beam form shell 102 is provided with pouring holes (not shown) that allow concrete to be poured from the outside into the internal hollow region defined by the enclosing steel plate 1; the enclosing region also includes an undulating confinement structure 4 for inserting and fixing longitudinal rebars.

The beam formwork component of this embodiment is prefabricated in a factory. On the construction site, the required longitudinal rebars for the building beam component are directly inserted into the internal hollow region of the beam form shell 102, and the longitudinal rebars are fixed to the steel plate 1 and the rod-shaped components 2 by welding to form a rebar cage, followed by casting concrete into the hollow region to form a reinforced concrete

structure.

Similar to the column formwork component of Embodiment 1, the beam form shell 102 and the rod-shaped components 2 are fixed by a special connection. The outer side of the beam form shell 102 is recessed inwardly at positions corresponding to the two ends of the rod-shaped components 2 to form grooves 5, and the inner side of the beam form shell 102 is formed with protrusions 6 corresponding to the grooves 5. The grooves 5 are provided with through holes to allow two ends of the rod-shaped components 2 to pass freely through the grooves 5. Both ends of the rod-shaped components 2 are respectively connected with connecting fasteners which are located in the corresponding grooves 5 and fitted with the grooves 5 tightly.

Similar to the column formwork component of Embodiment 1, the connecting fasteners at the two ends of the rod-shaped components 2 are respectively an upset anchor head 7 and a nut 9. One end of the rod-shaped components 2 is provided with an upset anchor head 7 formed by integral upsetting, and the other end of the rod-shaped components 2 is machined with an external thread and connected with a nut 9. The upset anchor head 7 and the nut 9 respectively act as the connecting fasteners at the two ends of the rod-shaped components 2, so that a tight fit between the connecting fasteners at both ends and the grooves 5 can be achieved by tightening the nut 9. Both ends may also be fixed and connected by threaded nuts. When the upset anchor head 7 is used, the upset anchor head 7 comprises an anchor head body 8 having a diameter larger than that of the rod-shaped components 2; the anchor head body 8 has a protruding annular fitting portion 10, and achieves tight fit with the grooves 5 by the fitting portion 10. The internal shape of the groove 5 is conical or frustoconical, with the angle formed between the groove wall and the groove bottom being about 45° . In cases that the grooves 5 and the protrusion 6 are integrally formed by stamping, the shape of the protrusion 6 corresponding to the grooves 5 matches that of the grooves 5, and its inner diameter may be 2-3 times the diameter of the rod-shaped components 2 passing therethrough. A washer 11 may be used instead of the fitting portion 10. In this way, during machining of the upset anchor head body 8, it is only necessary to ensure that the dimension of the upset anchor head 7 is larger than that of the corresponding rod-shaped components 2, and it is not necessary to machine a fitting portion 10 on the upset anchor head body 8; instead, a washer 11 of matching dimension is separately provided and sleeved over the rod-shaped components 2, and a tight fit with the grooves 5 is achieved through the washer 11. Preferably, the connecting fasteners and both of the ends of the rod-shaped components 2 are all located inside the grooves 5 and do not extend beyond the outer side of the steel plate 1 acting as the beam form shell 102. Such design not only ensures a flat surface of the formwork, facilitating

the subsequent provision of the reinforcing layer 3 and other functional or decorative layers on the outer side, but also allows the steel plates acting as formwork to be closer to the cast concrete in terms of load-bearing, helping to better confine the internal concrete.

Similar to the column formwork component of Embodiment 1, when threaded nuts are used as the connecting fasteners, a washer 11 may likewise be added on the nut 9 to achieve a tight fit with the grooves 5 through the threads.

Similar to the column formwork component of Embodiment 1, the reinforcing layer 3 used in this embodiment is a magnesium phosphate-based polymer material layer. The use of such a material can better enhance the bonding force between this layer structure and the steel plate 1 of the beam formwork of the present disclosure, further helping to effectively confine the internal concrete. The reinforcing layer 3 covered and connected to the outer side of the beam form shell 102 can effectively protect the outer side of the beam formwork component, and after the reinforced concrete column is cast in place, the reinforcing layer 3 can tightly fit with the beam form shell 102, assisting the beam form shell 102 in withstanding the lateral stress of the concrete and helping to better confine the internal concrete. Additional concrete layers, decorative layers, thermal insulation layers, sound insulation layers, fireproof layers, wallpaper, etc. may also be covered outside the reinforcing layer 3 as actually needed.

Similar to the column formwork component of Embodiment 1, the reinforcing layer 3 may also be formed of a rebar mesh layer with concrete, wherein the rebar mesh layer is fixedly connected to the anchor head body 8 and/or the nut 9 by spot welding, where the rebar mesh layer is compressed and fixed by the anchor head body 8 and the nut 9.

Similar to the column formwork component of Embodiment 1, the beam formwork component of this embodiment is respectively provided with corresponding mating portions at both longitudinal ends (along the direction of insertion of the longitudinal rebars). One longitudinal end of the beam formwork component is provided with a plug-in portion 12 extending longitudinally outward, and the other longitudinal end of the beam formwork component is provided with a socket portion 13, and its inner side of the side wall is shaped to correspondingly match the shape of the plug-in portion 12, such that the plug-in portion 12 of the beam formwork component can tightly fit with the socket portion 13 of another column formwork component, making the outer side surface of the joined formwork components aligned with each other. Other mating structures known in the art, such as slot connections, may also be used, as long as multiple beam formwork components can be tightly joined together and their outer surfaces are aligned with each other.

During on-site installation, the plug-in portion 12 of the beam formwork component is inserted into a corresponding socket portion 13 of another beam formwork component of the same type, and, if necessary, a third column formwork component may be further inserted into the latter, until the dimension meets the requirements of the beam structure. After the required dimensions are achieved, the beam formwork components at the two ends of the assembled beam structure without the mating portions can be used.

Embodiment 3: Prefabricated Shear Wall Component for Cast-in-Place

In this embodiment, a steel plate 1 is used to form a first wall panel 1031 and a second wall panel 1032, and rod-shaped components 2 are used to form steel rod-shaped components 201, wherein the first wall panel 1031 and the second wall panel 1032 are connected by the steel rod-shaped components 201, with a pouring cavity formed therebetween. The specific solution is as follows:

A prefabricated shear wall component for cast-in-place, as shown in FIGS. 6 and 7, comprises a first wall panel 1031 and a second wall panel 1032 formed by steel plates having a thickness of 1.5 mm and a longitudinal length of 200 mm. Steel plates of the same dimension may be selected for the first wall panel 1031 and the second wall panel 1032, or steel plates of different dimension in the required range may be selected as needed. The opposite faces of the first wall panel 1031 and the second wall panel 1032 are connected by steel rod-shaped components 201 in a form of screws vertically secured to the inner sides thereof. The steel plates of the first wall panel 1031 and/or the second wall panel 1032 may be formed by fixedly connecting a plurality of segments of steel plates longitudinally separated. The steel rod-shaped components 201 are arranged in multiple layers, preferably in an even number of layers; the present embodiment has eight layers, with each layer of steel rod-shaped components 201 comprising five coplanar steel rod-shaped components 201 arranged parallel to each other and spaced apart from each other. Preferably, to the outer side of the first wall panel 1031 and the second wall panel 1032 are covered and connected with reinforcing layers 3, and different reinforcing layer materials, or the same reinforcing layer materials may be selected. The first wall panel 1031 and/or the second wall panel 1032 are provided with pouring holes (not shown) that allow concrete to be poured from the outside into the cavity between the two panels; the cavity also includes structures for inserting and fixing longitudinal rebars (not shown).

The prefabricated shear wall component for cast-in-place of this embodiment is prefabricated in a factory. On the construction site, the required longitudinal rebars for the shear wall component are directly inserted into the cavity between the first wall panel 1031

and the second wall panel 1032, and the longitudinal rebars are fixed to the steel plates of the first wall panel 1031 and/or the second wall panel 1032 and to the steel rod-shaped components 201 by welding to form a rebar cage, followed by casting concrete into the cavity to form a reinforced concrete structure.

In this embodiment, the steel plates of the first wall panel 1031 and/or the second wall panel 1032 are fixed to the steel rod-shaped components 201 by a special connection. The outer side of the steel plates of the first wall panel 1031 and/or the second wall panel 1032 is recessed inwardly at positions corresponding to the two ends of the steel rod-shaped components 201 to form grooves 5, and the inner side surfaces of the steel plates of the first wall panel 1031 and/or the second wall panel 1032 are formed with protrusions 6 corresponding to the grooves 5. The grooves 5 are provided with through holes to allow two ends of the steel rod-shaped components 201 to pass freely through the grooves 5. Both ends of the steel rod-shaped components 201 are respectively connected with connecting fasteners which are located in the corresponding grooves 5 and fitted with the grooves 5 tightly.

In this embodiment, as shown in FIG. 7, the connecting fasteners at the two ends of the steel rod-shaped components 201 are respectively an upset anchor head 7 and a nut 9. One end of the steel rod-shaped components 201 is provided with an upset anchor head 7 formed by integral upsetting, and the other end of the rod-shaped components 2 is machined with an external thread and connected with a nut 9. The upset anchor head 7 and the nut 9 respectively act as the connecting fasteners at the two ends of the steel rod-shaped components 201, so that a tight fit between the connecting fasteners at both ends and the grooves 5 can be achieved by tightening the nut 9. Both ends may also be fixed and connected by threaded nuts.

The shear wall component of this embodiment may also refer to the upset anchor head as designed for the column component of Embodiment 1 or the beam component of Embodiment 2. As shown in FIG. 3, when the upset anchor head 7 is used, the upset anchor head 7 comprises an anchor head body 8 having a diameter larger than that of the steel rod-shaped components 201; the anchor head body 8 has a protruding annular fitting portion 10, and achieves a tight fit with the grooves 5 by the fitting portion 10. The internal shape of the grooves 5 is conical or frustoconical, with the angle formed between the groove wall and the groove bottom being about 45°. In cases that the grooves 5 and the protrusions 6 are integrally formed by stamping, the shape of the protrusions 6 corresponding to the grooves 5 matches that of the grooves 5, and its inner diameter may be 2-3 times the diameter of the steel rod-shaped components 201 passing therethrough. When the fitting portion 10 is not integrally machined with the anchor head body 8, a washer 11 may be used instead of the fitting portion

10. In this way, during machining of the upset anchor head body 8, it is only necessary to ensure that the dimension of the upset anchor head 7 is larger than that of the corresponding steel rod-shaped components 201, and it is necessary not to machine a fitting portion 10 on the upset anchor head body 8; instead, a washer 11 of matching dimension is separately provided and sleeved over the steel rod-shaped components 201, and a tight fit with the grooves 5 is achieved through the washer 11.

Preferably, the connecting fasteners and the ends of the steel rod-shaped components 201 are all located inside the grooves 5 and do not extend beyond the outer side surface of the steel plates of the first wall panel 1031 and/or the second wall panel 1032. Such design not only ensures a flat surface of the steel plates, facilitating the subsequent provision of the reinforcing layer 3 and other functional or decorative layers on the outer side, but also allows the steel plates of the first wall panel 1031 and/or the second wall panel 1032 acting as formwork to be closer to the cast concrete in terms of load-bearing, helping to better confine the internal concrete.

When threaded nuts are used as the connecting fasteners, a washer 11 may also be added on the nut 9 to achieve a tight fit with the grooves 5 through the threads, which will not be shown separately.

The reinforcing layer materials on the outer side of the first wall panel 1031 and/or the second wall panel 1032 may be the same or may be different. As shown in FIG. 6, the reinforcing layer 3 on the outer side of the first wall panel 1031 used in this embodiment is a rebar mesh layer and a concrete layer, while the reinforcing layer 3 on the outer side of the second wall panel 1032 is a magnesium phosphate-based polymer material layer. The use of such materials can better enhance the bonding force between this layer structure and the steel plates of the shear wall component of the present disclosure, further helping to effectively confine the internal concrete. The reinforcing layer 3 covered and connected to the outer side of the first wall panel 1031 and/or the second wall panel 1032 can effectively protect the outer side of the shear wall component, and after the reinforced concrete wall is formed by cast-in-place, the reinforcing layer 3 can tightly fit with the steel plates, assisting the steel plates in withstanding the lateral stress of the concrete, thereby helping to better confine the internal concrete. Additional concrete layers, decorative layers, thermal insulation layers, sound insulation layers, fireproof layers, wallpaper, etc. may also be covered outside the reinforcing layer 3 as actually needed. In the present disclosure, the reinforcing layer 3 may also be formed by any material known in the prior art that has good adhesion to steel plates.

The shear wall component of this embodiment is respectively provided with

corresponding mating portions at both longitudinal ends (along the direction of insertion of the longitudinal rebars). One longitudinal end of the shear wall component is provided with a plug-in portion extending longitudinally outward, and the other longitudinal end of the shear wall component is provided with a socket portion, and its inner side of the side wall is shaped to correspondingly match the shape of the plug-in portion, such that the plug-in portion of the shear wall component can tightly fit with the socket portion of another shear wall component, making the outer side of the joined shear wall components aligned with each other. Other mating structures known in the art, such as slot connections, may also be used, as long as shear wall components can be tightly joined together and their outer surfaces are aligned with each other. These mating structures are well known to those skilled in the art, for example, the connecting slot structure disclosed in Chinese Patent Publication No. CN216196563U.

During on-site installation, the plug-in portion of the shear wall component is inserted into a corresponding socket portion of another shear wall component of the same type, and, if necessary, a third shear wall component may be further inserted into the latter, until the dimension meets the requirements of the building wall structure. After the required dimension is achieved, the shear wall components at the two ends of the assembled wall structure without the mating portions can be used.

In the present disclosure, utility and decoration accessories such as conduit tubes and junction boxes may also be provided between the first wall panel 1031 and the second wall panel 1032, all of which can be pre-installed and fixed in the wall with the steel rod-shaped components or steel plates acting as supports, thereby further improving construction efficiency. After concrete pouring, no subsequent utility and decoration accessory is required, facilitating application and promotion.

Embodiment 4: Prefabricated Floor Slab Component for Cast-in-Place

In this embodiment, a steel plate 1 is used to form a floor slab bodies 104, and rod-shaped components 2 is used to form connecting portions 202, by which the floor slab bodies 104 and rebars 15 are connected, with a pouring cavity formed therebetween. The specific solution is as follows:

A prefabricated floor slab component for cast-in-place, as shown in FIGS. 8 and 9, comprises a floor slab body 104 made of a 1.5 mm thick steel plate 1, having a longitudinal length of 200 mm. A plurality of rod-shaped connecting portions 202 protrudes from one side of the floor slab body 104 (defined as the inner side). One end of the connecting portions 202 is vertically fixed to the floor slab body 104, and the other end is provided with rebars 15, which

are parallel to the floor slab body 104 and form a pouring cavity therebetween. The floor slab component is provided with pouring holes (not shown) that allow concrete to be poured from the outside into the pouring cavity. The rebars 15 of the present disclosure are bi-directional rebars, comprising transverse load-bearing rebars and longitudinal load-bearing rebars arranged crisscross, facilitating force transmission and distribution and improving the load-bearing capacity of relatively larger-sized floor slabs.

The prefabricated floor slab component for cast-in-place of this embodiment is prefabricated in a factory. On the construction site, concrete is cast into the pouring cavity to form a reinforced concrete floor slab structure.

In this embodiment, the floor slab body 104 and the connecting portions 202 are fixed by a special connection. The outer side of the floor slab body 104 is recessed inwardly to form grooves 5, while the pouring cavity is formed with protrusions 6 corresponding to the grooves 5. One end of the connecting portions 202 passing through the grooves 5 from the outer side of the slab body 104 has an upset anchor head 7 formed by upsetting, with the upset anchor head 7 being located in the grooves 5 and fitting therewith as an outer-side connecting fastener. The connecting portions 202 are provided with an external thread at the junction between the connecting portions 202 and the inner side of the floor slab body 104, and a nut 9, acting as an inner-side connecting fastener, fits with the inner side on the inner side of the slab body 104.

As shown in FIG. 9, when the upset anchor head 7 is used, the upset anchor head 7 comprises an anchor head body 8 having a diameter larger than that of the connecting portions 202; the anchor head body 8 has a protruding annular fitting portion 10, and achieves a tight fit with the grooves 5 by the fitting portion 10. The internal shape of the grooves 5 is conical or frustoconical, with the angle formed between the groove wall and the groove bottom being about 45°. In cases that the grooves 5 and the protrusion 6 are integrally formed by stamping, the shape of the protrusion 6 corresponding to the grooves 5 matches that of the grooves 5, and its inner diameter may be 2-3 times the diameter of the connecting portions 202 passing therethrough. When the fitting portion 10 is not integrally machined with the anchor head body 8, a washer 11 may be used instead of the fitting portion 10. In this way, during machining of the upset anchor head body 8, it is only necessary to ensure that the dimension of the upset anchor head 7 is larger than that of the corresponding connecting portions 202, and it is necessary not to machine a fitting portion 10 on the upset anchor head body 8; instead, a washer 11 of matching dimension is separately provided and sleeved over the connecting portions 202, and a tight fit with the grooves 5 is achieved through the washer 11. Preferably, the end of the connecting portions 202 on the outer side of the floor slab body 104 is located

inside the grooves 5 and does not extend beyond the outer side surface of the floor slab body 104. Such design not only ensures a flat surface of the slab body 104, facilitating the subsequent provision of the reinforcing layer 3 and other functional or decorative layers on the outer side, but also allows the steel plates acting as formwork to be closer to the cast concrete in terms of load-bearing, helping to better confine the internal concrete.

Considering the difficulty of processing technology for the upset anchor head, threaded connection may be used as the connecting fasteners instead for both inner sides or outer side, thereby reducing processing difficulty, lowering processing costs, increasing product yield, and facilitating large-scale production.

The reinforcing layer 3 used in this embodiment is a magnesium phosphate-based polymer material layer. The use of such a material can better enhance the bonding force between this layer structure and the floor slab body 104 of the floor slab component of the present disclosure, further helping to effectively confine the internal concrete. The reinforcing layer 3 covered and connected to the outer side of the floor slab body 104 can effectively protect the outer side of the floor slab component, and after the reinforced concrete floor slab is cast in place, the reinforcing layer 3 can tightly fit with the floor slab body 104, assisting the floor slab body 104 in withstanding the lateral stress of the concrete and helping to better confine the internal concrete. Additional concrete layers, decorative layers, thermal insulation layers, sound insulation layers, fireproof layers, wallpaper, or other surface finishes or pre-embedded fittings for decoration and installation, such as cable trays, lamp mounting openings, or other pre-embedded parts, may also be provided as actually needed. In this way, no subsequent finishing or decoration is needed after the floor slab installation is completed, further improving the degree of prefabrication of the building.

In the present disclosure, the reinforcing layer 3 may also be formed of any material known in the prior art that has good adhesion to steel plates, for example a rebar mesh layer and a concrete layer, with the rebar mesh layer fixedly connected to the anchor head body 8 by spot welding, where the rebar mesh layer is compressed and fixed by the anchor head body 8.

The floor slab component of this embodiment is respectively provided with corresponding mating portions at both ends. One end is provided with a plug-in portion extending longitudinally outward, and the other end in longitudinal direction is provided with a socket portion, and its inner side of the side wall is shaped to correspondingly match the shape of the plug-in portion, such that the plug-in portion can tightly fit with the socket portion of another floor slab component, making the outer side of the joined floor slab components aligned with

each other. Other mating structures known in the art, such as slot connections, may also be used, as long as multiple floor slab component can be tightly joined together and their outer surfaces are aligned with each other.

During on-site installation, the plug-in portion of the floor slab component is inserted into a corresponding socket portion of another floor slab component of the same type, and, if necessary, a third floor slab component may be further inserted into the latter, until the dimensions meet the requirements of the floor slab structure. After the required dimensions are achieved, the floor slab components at the two ends of the assembled floor slab structure without the mating portions can be used.

Embodiment 5: Prefabricated Floor Slab Component for Cast-in-Place

The prefabricated floor slab component for cast-in-place differs from Embodiment 4 in that the connecting portions 202 is an L-shaped structure, with the bottom horizontal segment being directly fitted and fixedly connected to the inner side of the slab body 104 to act as a connecting fastener, and the vertical segment being connected to the rebars 15. That is, a direct fixing method is used, eliminating the need for grooves 5 and connection and fixation on both inner and outer side, which can further reduce processing difficulty, lower processing costs, increase product yield, and facilitate large-scale production.

Embodiment 6: Mechanical Tests on Column Components

A formwork component was first prepared according to the prefabricated column formwork component for cast-in-place of Embodiment 1, wherein the thickness of steel plate was 1.2 mm, the column height was 960 mm, and both the width and height of the column cross-section was 290 mm (with a 290 mm load-bearing cross-section width and height and a 30 mm non-load-bearing decorative layer thickness on the outer side). Then, longitudinal rebars was added at a longitudinal reinforcement ratio of 1.8%, and concrete was cast in place on site to obtain a test prefabricated formwork column component for cast-in-place. As a comparison, a traditional reinforced concrete column was prepared using removable formwork, with tied rebars and cast concrete, to obtain a control reinforced concrete column component after removing the formwork for test having the same dimension, with a height and width of the column cross-section both being 320 mm. The applicant commissioned Chongqing University to conduct relevant mechanical tests on the above prefabricated formwork column component for cast-in-place and the traditional reinforced concrete column component as a control, respectively, and obtained the following test data.

1. Axial Compression Test

The axial compression test is a test used to study the mechanical properties of vertical compression components such as columns under axial compression force. Under ideal conditions, the axial compression force passes through the axis of the component, and the component is subjected only to axial compression force without bending moments or shear forces. The basic principle is to apply a gradually increasing axial compression force and observe and record the deformation, strain, and failure modes of the component during compression.

The test loading was carried out using a 1000-ton long-column compression testing machine produced by Changchun Testing Machine Research Institute. Strain data were collected using electrical resistance strain gauges, and displacement was measured using electrical resistance displacement transducers with a measurement accuracy of 0.001 mm. Load, strain, and displacement data were collected using a DH5922D dynamic strain acquisition system produced by Donghua Testing Co., Ltd. The test kept components centered geometrically to ensure that the load center passed through the centroid of the component. Before the formal test, preloading method was used to eliminate the gap between the testing machine platens and the component. Subsequently, formal loading began. Before the load reached 70% of the calculated bearing capacity, a load-controlled stepwise loading method was used, with each step applying a load increment of 50 KN. Each step loading was performed and maintained for 5 minutes, and the next loading step was performed only after both strain and displacement had stabilized. After the load reached 70% of the calculated bearing capacity, a displacement-controlled loading method was used, with each displacement increment being 0.01 mm. The next loading was performed only after load, displacement, and strain data had all stabilized. When the load dropped to 85% of the ultimate load, the component was considered to be failed, and the test could be stopped. During the entire loading process, data such as displacement, strain, and load were monitored and recorded in real time.

The results are shown in Table 1 below. FIG. 12 shows a comparison of load-displacement curves of axially loaded compression components between the traditional reinforced concrete column and the prefabricated formwork column component for cast-in-place of the present disclosure.

Table 1 Axial compression test results of the traditional reinforced concrete column component and the prefabricated formwork column component for cast-in-place of the present disclosure

	Yield strength	Concrete cube	Ultimate bearing	Measured
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	of longitudinal rebar (MPa)	compressive strength (MPa)	capacity (code, kN)	ultimate bearing capacity (kN)
traditional reinforced concrete column component	456	45.1	4342.1	4390
prefabricated building formwork column component for cast-in-place	456	45.1	3599.3	4326

From the test results, it can be seen that after the traditional reinforced concrete column component reached its ultimate bearing capacity, the concrete on the column surface exhibited obvious spalling, the bearing capacity dropped rapidly, and the displacement increased sharply, showing a typical brittle failure. In contrast, for the prefabricated formwork column component for cast-in-place of the present disclosure, after reaching the ultimate bearing capacity, as the displacement increased, the bearing capacity of the component decreased slowly, and the component exhibited a very pronounced ductile failure. The tests show that using the same design method, the axial compression bearing capacity of the prefabricated formwork column component for cast-in-place is about 20% higher than that of the traditional reinforced concrete column component. Under axial compression, the prefabricated formwork column component for cast-in-place has better performance in both bearing capacity and ductility performance than the traditional reinforced concrete column component.

2. Column Low-Cycle Reverse Loading Test

The column low-cycle reverse loading test is mainly used to study the mechanical properties of columns under cyclic horizontal loads such as those induced by earthquakes. During an earthquake, the columns of a building are subjected to cyclic tension-compression and bending deformations, and this low-cycle reverse loading test can simulate the stressed state of columns under seismic action. Through the test, the hysteresis curves of the columns can be obtained, which reflect important mechanical performance indicators such as energy dissipation capacity, strength, and stiffness.

The horizontal loading was applied using a JSF-II high-precision static servo hydraulic console produced by Chengdu Servo Hydraulic Equipment Co., Ltd. The vertical loading was applied using a ZB4-500 electric oil pump produced by Liuzhou Ruike Machinery Co., Ltd., together with a QF-200T hydraulic jack produced by Dezhou Junda Hydraulic Apparatus Co.,

Ltd., applying the vertical loading in a single step. After the vertical loading was applied, a small-tonnage horizontal loading was used to verify the centering of the component. After confirming correct centering, horizontal displacement was applied in a displacement-controlled manner according to the predetermined loading protocol. The displacement loading protocol is shown in the figure below. During the test, a DH5922D dynamic strain acquisition system produced by Donghua Testing Co., Ltd. was used to monitor and record the vertical loading, horizontal loading, and horizontal displacement of the component in real time.

The relevant mechanical data of the prefabricated formwork column component for cast-in-place of the present disclosure and the existing traditional reinforced concrete column component used as a control were respectively measured in the low-cycle reverse loading tests, including the yield strength of longitudinal rebars, the concrete cube compressive strength, and the horizontal ultimate bearing capacity. The results are shown in Table 2 below. FIG. 13 shows a comparison of hysteresis curves between the traditional reinforced concrete column and the prefabricated formwork column component for cast-in-place of the present disclosure from low-cycle reverse loading tests.

Table 2 Low-cycle reverse loading test results of the traditional reinforced concrete column and the prefabricated formwork column component for cast-in-place of the present disclosure

	Yield strength of longitudinal rebar (MPa)	Concrete cube compressive strength (MPa)	design axial compression ratio (vertical loading)	Measured ultimate bearing capacity (KN)
traditional reinforced concrete column component	439	43.1	0.235(788KN)	403
prefabricated building formwork column component for cast-in-place	456	43.0	0.235(660KN)	421

From the above results, it can be seen that under the same axial compression, the ultimate horizontal force of the prefabricated formwork column component for cast-in-place of the present disclosure is greater than that of the traditional reinforced concrete column, indicating that the prefabricated formwork component for cast-in-place has stronger shear-bearing capacity. In terms of hysteresis curve shape, the hysteresis curves of the prefabricated

formwork column component for cast-in-place are fuller, with stronger energy dissipation capacity, indicating that under seismic action, the prefabricated formwork component for cast-in-place of the present disclosure exhibits better performance in energy dissipation and superior anti-seismic performance.

In summary, under seismic action, the prefabricated formwork column component for cast-in-place has better performance in both bearing capacity and energy dissipation capacity than the traditional reinforced concrete component.

Embodiment 7: Mechanical Tests on Beam Components

A formwork component was first prepared according to the prefabricated beam formwork component for cast-in-place of Embodiment 2, wherein the steel plate thickness was 1.2 mm, the beam width and height of the cross-section were 160×380 mm, three rebars HRB400 of 25 mm diameter were placed at the beam bottom, and two rebars HRB400 of 12 mm diameter were placed at the beam top. After the rebars were placed in the formwork, casting concrete in place on site to obtain the test prefabricated formwork beam component for cast-in-place. As a comparison, a traditional reinforced concrete beam was prepared by using removable formwork, with rebars tied and concrete cast, and the formwork was removed after casting, to obtain a reinforced concrete beam component as a control having the same dimensions, with beam cross-sectional dimensions of 200×400, two rebars HRB400 of 12 mm diameter at the beam top, three rebars HRB400 of 25 mm diameter at the beam bottom, and two-leg stirrups of 10 mm diameter at a spacing of 150 mm. The applicant commissioned Chongqing University to conduct relevant mechanical tests on the above prefabricated formwork beam component for cast-in-place and the control component, respectively, and obtained the following test data.

1. Beam Flexural Test

In building structures, beams are the primary flexural components. The beam flexural test aims to study the mechanical properties of beams under bending loads, including flexural bearing capacity, deformation characteristics, crack development patterns, and failure modes of the beam.

The test loading was carried out using a ZB4-500 electric oil pump produced by Liuzhou Ruike Machinery Co., Ltd., together with a QF-200T hydraulic jack produced by Dezhou Junda Hydraulic Apparatus Co., Ltd. The jack applied vertical load to a rigid beam, through which the load was then transmitted to the test component. Strain was measured using electrical resistance strain gauges, and displacement was measured using electrical resistance

displacement transducers. Strain data, displacement data, and load data were all dynamically collected in real time using a DH5922D dynamic strain acquisition system produced by Donghua Testing Co., Ltd.

The test procedure was as follows: the above test beam component was correctly installed on the testing machine supports, ensuring the beam axis was horizontal and the loading points were accurately positioned. Then preloading was performed to eliminate any horizontal clearance, ensuring the load to be passed through the center of the beam. After preloading, formal loading began. The test used a stepwise loading method. Before the load reached 70% of the estimated load, a load-controlled step loading method was used, with each step applying a load increment of 10 KN. Each step loading is performed and maintained for 5 minutes, and the next loading step was performed only after both strain and displacement had stabilized. After the load reached 70% of the estimated load, a displacement-controlled loading method was used, with each displacement step being 0.01 mm before reaching the ultimate load, and each displacement step being 0.05 mm after reaching the ultimate displacement. The test can be stopped until the load dropped to 85% of the ultimate load. Data such as load, displacement, and strain were recorded during the entire test.

The results are shown in Table 3 below. FIG. 14 shows a comparison of flexural beam test results between the traditional reinforced concrete beam and the prefabricated formwork beam component for cast-in-place of the present disclosure.

Table 3 Flexural test results of the traditional reinforced concrete beam and the prefabricated formwork beam component for cast-in-place

	Yield strength of longitudinal rebar (MPa)	Concrete cube compressive strength (MPa)	Ultimate bending moment (code, KN.m)	Measured ultimate bending moment
traditional reinforced concrete beam	445	29.1	197.42	102.96
prefabricated formwork beam for cast-in-place	456	35	199.84	273.40

From the test results, it can be seen that the deflection corresponding to the ultimate load of the prefabricated formwork beam component for cast-in-place is 22 mm, which is 1/140 of the span, while the deflection corresponding to the ultimate load of the traditional reinforced concrete beam is 16 mm, which is 1/180 of the span. After the prefabricated formwork beam component for cast-in-place reaches its ultimate bearing capacity, it can still maintain a certain

bearing capacity as the deflection continues to increase; when the mid-span deflection reaches 37 mm, i.e., 1/83 of the span, its bearing capacity remains at 89% of the ultimate bearing capacity. It can be seen that under bending moment, the ductility and bearing capacity of the prefabricated formwork beam component for cast-in-place are superior to those of the traditional reinforced concrete beam component.

2. Torsion Component Test

The cross-section and reinforcement arrangement of the torsion test components were the same as those of the flexural components. The loading for the torsion components was applied using a JSF-II high-precision static servo hydraulic control system produced by Chengdu Servo Hydraulic Equipment Co., Ltd. Strain was measured by using an electrical resistance strain gauge, and displacement was measured by using an electrical resistance displacement transducer. Strain data, displacement data, and load data were all dynamically collected in real time using a DH5922D dynamic strain acquisition system produced by Donghua Testing Co., Ltd. After the prefabricated formwork component for cast-in-place of the present disclosure in test was properly installed, a preloading was first performed to eliminate installation clearances, after which the load was reset and formal loading began. The loading was divided into two stages. Before reaching 70% of the estimated torque, load-controlled loading was used, with each step applying a torque increment of 1 KN·m. After each loading step, the load was maintained for 5 minutes, and a next loading step was performed only after displacement and strain data had stabilized. After reaching 70% of the estimated torque, displacement-controlled loading was used, with each step being a torsional displacement angle of 0.05°. When the torque is 85% of the ultimate torque, the component was considered to be failed, and the test could be stopped. Data such as load, displacement, and strain of the beam component were recorded throughout the test.

The test results are shown in Table 4 below. FIG. 15 shows the torque-rotation curve of the cast-in-place prefabricated formwork beam component of the present disclosure.

Table 4 Torsion test results of the prefabricated formwork beam component for cast-in-place of the present disclosure

	Yield strength of longitudinal rebar (MPa)	Concrete cube compressive strength (MPa)	Ultimate torque (code, KN.m)	Measured ultimate torque (KN.m)
prefabricated formwork beam	456	29.4	34.2	45.8

for cast-in-place				
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From the above results, it can be seen that the component reaches its elastic limit when the component rotation angle reaches 1.5° , with a corresponding torque of approximately 25 KN·m. When the component rotation angle reaches about 9° , the prefabricated formwork component for cast-in-place reaches its ultimate torque of 45.8 KN·m. According to the code, the calculated ultimate torsional bearing capacity of the component is 34.2 KN·m, and the ultimate bearing capacity measured from test is about 30% higher than the calculated value. As the component rotation angle continues to increase, the component can still maintain the ultimate torque with almost no reduction. Even when the loading actuator reaches its maximum stroke and the displacement transducers reach their maximum range, the bearing capacity of the component still shows no significant decrease. It can be seen that the ductility and bearing capacity of the prefabricated building formwork component for cast-in-place under torque are superior to those of traditional reinforced concrete torsion components.

In summary, the above loading test results demonstrate that the structures such as columns and beams formed by the prefabricated formwork component for cast-in-place of the present disclosure can better confine the cast concrete, particularly by enlarging the confined region, thereby improving the overall shear resistance and load-bearing capacity of the building, which is of great significance for seismic performance under earthquake conditions.

The above described are merely embodiments of the present disclosure. Well-known specific structures, characteristics, and other common general knowledge in the embodiments have not been described in detail herein. A person of ordinary skill in the art is deemed to know all common general knowledge in the technical field to which the disclosure pertains before the filing date, is capable of accessing all prior art in the field, and possesses the ability to apply conventional experimental means before that date. Such a person can, under the inspiration provided by the present disclosure, complete and implement the present solutions in combination with his or her own capabilities, and some typical well-known structures or well-known methods should not constitute an obstacle to implementation of the present disclosure by a person of ordinary skill in the art. It should be noted that for those skilled in the art, various modifications and improvements can be made without departing from the structure of the present disclosure, and these should also be regarded as falling within the protection scope of the present disclosure, and these will not affect the effect of implementation of the present disclosure or the practicality of the patent. The protection scope of the present disclosure shall be defined by the content of the appended claims, and the detailed embodiments and other records in the description may be used to interpret the content of the claims.

Claims:

1. A prefabricated building formwork component for cast-in-place applicable to columns or beams, comprising a cylindrical form shell and stirrups fixed to the form shell, wherein an upper end and a lower end of the form shell are provided with mating portions adapted to mate with adjacent form shells; wherein the form shell is formed by enclosing steel plates (1), and the stirrups are jointly comprised of the steel plates (1) and rod-shaped components (2) fixedly connected to inner sides of the steel plates (1).

2. A prefabricated building shear wall component for cast-in-place, comprising a first wall panel (1031) and a second wall panel (1032) arranged opposite to each other, wherein the first and second wall panels (1031, 1032) are connected by a plurality of tie components, forming a cavity between the first and second wall panels (1031, 1032); wherein both the first wall panel (1031) and the second wall panel (1032) are made of steel plates (1), and the tie components are steel rod-shaped components (201) fixedly connected between inner sides of the first and second wall panels (1031, 1032).

3. A prefabricated building floor slab component for cast-in-place, comprising floor slab bodies (104) and a plurality of rod-shaped connecting portions (202) protruding from an inner side of the floor slab bodies (104), wherein opposite slab floor bodies (104) are connected by the connecting portions (202), and both ends of the floor slab component are provided with mating portions adapted to mate with adjacent floor slab component; wherein the slab bodies (104) are made of steel plates (1), and the connecting portions (202) are provided with rebars (15) being parallel to the floor slab bodies (104) and forming a pouring cavity therebetween.

4. The prefabricated building formwork component of claim 1, wherein the form shell is formed by fixed connection between a plurality of segments of steel plates (1) that is longitudinally separated from each other along an enclosing center of the form shell.

5. The prefabricated building shear wall component of claim 2, wherein the first wall panel (1031) and/or the second wall panel (1032) is formed by fixed connection of a plurality of segments of steel plates (1) that are longitudinally separated from each other.

6. The prefabricated building floor slab component of claim 3, wherein the floor slab bodies (104) are formed by fixed connection of a plurality of segments of steel plates (1) that are separated from each other in the width direction of the floor slab bodies.

7. The prefabricated formwork component of claim 4 or the prefabricated building shear wall component of claim 5 or the prefabricated building floor slab component of claim 6,

wherein the fixed connection is formed by spot welding.

8. The prefabricated building formwork component of claim 1 or 4 or 7, or the prefabricated building shear wall component of claim 2 or 5 or 7, or the prefabricated building floor slab component of claim 3 or 6 or 7, wherein outer side of the form shell and/or the first wall panel (1031) and/or the second wall panel (1032) and/or the floor slab bodies (104) are further provided with a reinforcing layer being a magnesium phosphate-based material layer fixedly connected to the outer side of the form shell and/or the first wall panel (1031) and/or the second wall panel (1032) and/or the floor slab bodies (104).

9. The prefabricated building formwork component of claim 1 or 4 or 7, or the prefabricated building shear wall component of claim 2 or 5 or 7, or the prefabricated building floor slab component of claim 3 or 6 or 7, wherein opposite outer sides of the form shell and/or the first wall panel (1031) and/or the second wall panel (1032) and/or the floor slab body (104) are respectively recessed inwardly to form grooves (5); internal hollow region or cavity therebetween are provided with protrusions (6) corresponding to the grooves (5); both ends of the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202) respectively extend through the protrusions (6) into the grooves (5); both ends of the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202) are provided with connecting fasteners respectively, wherein the connecting fasteners is located in and fitted in the corresponding grooves (5); the connecting fasteners and the ends of the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202) are all located within the grooves (5) and are disposed inward of the outer side surface of the form shell and/or the first wall panel (1031) and/or the second wall panel (1032) and/or the slab bodies (104).

10. The prefabricated building formwork component or the prefabricated building shear wall component or the prefabricated building floor slab component of claim 9, wherein one end of the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202) is provided with an upset anchor head (7), and an opposite end thereof is provided with an external thread adapted to be connected with a nut (9), wherein the upset anchor head (7) and the nut (9) respectively act as the connecting fasteners at both ends of the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202).

11. The prefabricated building formwork component or the prefabricated building shear wall component or the prefabricated building floor slab component of claim 9, wherein both ends of the rod-shaped components (2) or steel rod-shaped components (201) or connecting

portions (202) are provided with external threads adapted to be connected with a nut (9), respectively acting as the connecting fasteners at the both ends of the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202).

12. The prefabricated building floor slab component of anyone of claims 9 to 11, wherein the connecting portions (202) are an L-shaped structure, with a bottom horizontal segment being directly fitted and fixedly connected to an inner side of the floor slab bodies as a connecting fastener, and a vertical segment being connected to the rebars (15).

13. The prefabricated building formwork component or the prefabricated building shear wall component or the prefabricated building floor slab component of claim 10, wherein the upset anchor head comprises an anchor head body (8) having a diameter larger than that of the rod-shaped component, and protruding outwardly to form an annular fitting portion (10) being capable of fitting with the grooves (5); or the anchor head body (8) fitting with the groove (5) through a washer (11) is provided on the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202), wherein the washer (11) has a diameter larger than that of the anchor head body (8).

14. The prefabricated building formwork component or the prefabricated building shear wall component or the prefabricated building floor slab component of claim 9, wherein a side wall and a bottom of the grooves (5) form an angle in a range of 30° to 60°; the diameter of the protrusions (6) is 2 to 5 times the diameter of the rod components (2) or steel rod-shaped components (201) or connecting portions (202).

15. The prefabricated building formwork component of claim 1 or the prefabricated building shear wall component of claim 2 or the prefabricated building floor slab component of claim 3, wherein the mating portions at one end of the component are tightly fitted with corresponding mating portions of adjacent components, so that two components are joined and their outer sides are aligned with each other.

16. The prefabricated formwork component or the prefabricated building shear wall component or the prefabricated building floor slab component of claim 15, wherein the mating portions are in a form of slot connection or plug-in connection.

17. The prefabricated building formwork component or the prefabricated building shear wall component or the prefabricated building floor slab component of anyone of claims 1 to 16, wherein the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202) are arranged in multiple layers along the longitudinal direction of the form shell and/or the first wall panel (1031) and/or the second wall panel (1032) and/or the floor slab

bodies (104), with the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202) within the same layer being coplanar and parallel to each other, and the rod-shaped components (2) or steel rod-shaped components (201) or connecting portions (202) of adjacent layers being arranged to cross each other in a perpendicular direction or to cross each other in parallel directions at different positions.

18. The prefabricated formwork component of anyone of claims 1, 4, and 7 to 17, wherein the form shell is made of seamless steel pipes or is formed by laterally bending and enclosing steel plates.

19. The prefabricated floor slab component of anyone of claims 3 or 6 to 18, wherein the rebars (15) are a rebar mesh formed by a plurality of crossing rebars.