



(11) **EP 4 772 703 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
08.07.2026 Bulletin 2026/28

(21) Application number: **24930419.7**

(22) Date of filing: **21.10.2024**

(51) International Patent Classification (IPC):
E04B 2/74 ^(2006.01) **E04B 2/82** ^(2006.01)
B28B 7/22 ^(2006.01) **B28B 23/02** ^(2006.01)
B28B 19/00 ^(2006.01) **B28B 1/14** ^(2006.01)
B28B 11/24 ^(2006.01)

(86) International application number:
PCT/CN2024/125973

(87) International publication number:
WO 2025/194761 (25.09.2025 Gazette 2025/39)

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **19.03.2024 CN 202410312462**

(71) Applicant: **BEIJING URBAN CONSTRUCTION
DESIGN AND DEVELOPMENT
GROUP CO., LTD.
Beijing 100037 (CN)**

(72) Inventors:
• **YANG, Xiuren
Beijing 100037 (CN)**
• **PENG, Zhiyong
Beijing 100037 (CN)**

- **HUANG, Meiqun
Beijing 100037 (CN)**
- **LIN, Fang
Beijing 100037 (CN)**
- **QI, Hong
Beijing 100037 (CN)**
- **MAO, Yun
Beijing 100037 (CN)**
- **LIU, Chunmei
Beijing 100037 (CN)**
- **LI, Peiqing
Beijing 100037 (CN)**

(74) Representative: **Franke, Dirk
Franke & Partner
Patent- und Rechtsanwälte
Widenmayerstraße 25
80538 München (DE)**

(54) **ULTRA-LIGHT FABRICATED WALLBOARD BASED ON MULTILAYER COMPOSITE
STRENGTHENING METHOD AND PREPARATION METHOD THEREFOR**

(57) An ultra-light fabricated wallboard based on a multilayer composite strengthening method and a preparation method therefor. The wallboard comprises a frame, a wall core, and surface layers, wherein the frame comprises a right side frame, a left side frame, and a bottom frame having a groove, and a light three-dimensional fiber mesh is attached to the inner side of the frame; the surface layers are located on the front surface layer and the rear surface layer of the front and rear surfaces of a wall body, and a tightly pressed corner strengthening layer is formed at the lower part of the wall body; the whole light three-dimensional fiber mesh is attached to the inner sides of the front surface layer and the rear surface layer; the surface layers and the

frame define an inner space for accommodating the wall core; the wall core is formed by filling an enclosure structure with a foam concrete core material to which ultra-light particles are fully mixed; and solidification maintenance is conducted to finally form the wallboard. In this way, according to the present invention, the wallboard has a light weight, the bearing performance is improved, sound insulation and noise reduction, water-proof and moisture-proof, fire-resistant and corrosion-resistant, and facing functions are achieved, the board body has a light weight and high strength, rapid assembly can be achieved, and the wallboard is wide and convenient to apply.

EP 4 772 703 A1

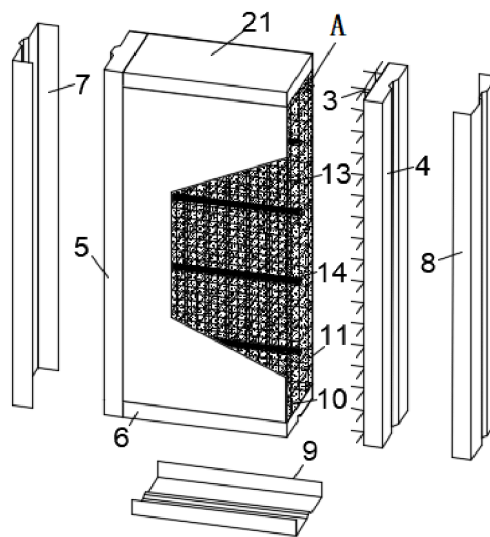


Fig. 1

DescriptionTECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to the field of construction engineering, especially relates to an ultra-light prefabricated wall panel based on a multi-layer composite strengthening method and a preparation method, which is suitable for the construction of prefabricated walls of buildings in a variety of professional fields with requirements of sound insulation and noise reduction, waterproof and moisture-proof, fire resistance, air pressure and corrosion resistance, as well as requirements of light weight, high strength, and rapid assembly of the panel.

BACKGROUND OF THE INVENTION

[0002] Building walls are an important part of various construction projects. Traditional ground buildings mostly use block masonry to construct walls. With the development of building structures and building material technologies, various ground building technologies and structural forms dominated by concrete structures have continued to evolve, and the construction methods of building walls have also changed accordingly. In addition to traditional masonry walls, various cast-in-place and prefabricated load-bearing walls mainly made of concrete structures, non-load-bearing partition walls prefabricated in factories using lightweight building materials and then transported to the site for installation, and partition walls constructed on-site using light steel keels and panel materials are all applied. Among them, the application of prefabricated walls has shown outstanding advantages over traditional masonry construction methods in terms of project quality, construction efficiency, and the number of workers used.

[0003] In the urban rail transit station, a certain number of station equipment and management function rooms need to be set up, and the area of equipment and management rooms of each station is about 3000 to 3500m², these rooms are generally single-storey layout, and the total wall area is about 11000 to 15000m². Up to now, most of the walls of the station's internal equipment and management rooms are constructed using the traditional manual masonry mode.

[0004] Due to the constraints of the construction period and large scale of wall masonry, it is required a large number of construction workers in the internal building of the station, and the traditional masonry process of the wall is complicated, and the labor intensity of workers per unit time is high, resulting in low actual construction quality and efficiency of the wall.

[0005] On the other hand, due to the constraints of the construction period, the internal station building construction process usually needs to be carried out simultaneously with the installation of some station building equipment, resulting in intensive multi-professional cross-operation on site, difficult construction management, and further reduced construction efficiency. In addition, the internal space of the subway station is closed, the construction environment is poor, the noise is loud, and there is a lot of construction dust, in addition to the poor labor and operating environment, the equipment installed in advance is also seriously affected by dust, and the failure rate increases.

[0006] In order to solve the above problems, in the construction of the internal station building of the subway station, the ground prefabricated wall technology has been introduced. Traditional representative prefabricated wall panels include ALC wall panels, foam ceramic wall panels, space panels, etc., which can meet the construction needs of internal station buildings in subway stations to varying degrees, but outstanding problems also appear in the implementation process to as following:

(1) Due to the use of relatively simple lightweight materials, the strength of the wall panel is relatively weakened, especially the wall panel of a single lightweight material is prone to local bumping and falling in the wall panel joint area during the splicing process, which affects the assembly accuracy and quality of the wall panel;

(2) Due to the poor wall panel splicing effect, the joints cannot be connected with high precision, so a series of post-processing must be carried out on the wall panel joints after the wall panel splicing is completed (such as applying adhesive between the joints; or apply cast-in-place tape to improve the connection performance between joints; or after the wall panel splicing is completed, the whole wall is treated with integrated surface decoration such as pasting, netting or hanging netting to prevent the wall from cracking). Even if the above measures are taken, the reciprocating wind pressure and micro-vibration of the train caused by the back and forth of the subway station in the confined environment of the subway station can easily lead to different degrees of cracking of the wall panel and its joints, resulting in unsatisfactory actual construction effect;

(3) In order to improve the strength and assembly accuracy of the wall panel, ribs are set on the wall and steel frames are set on the edge of the wall panel, which improves the strength of the wall panel, but it will still lead to the deformation and corrosion of the frame during the assembly process, and the weight of the plate increases, increasing the difficulty of construction;

(4) In addition, after the completion of wall assembly, multiple finishing processes will occupy a lot of manpower and construction period resources, and the dust pollution generated will still adversely affect the construction environment and high-precision equipment.

[0007] To sum up, the prefabricated wall panels used in the internal buildings of the subway station mainly have problems such as a single wall panel structure, and the overall strength of the panel is not high; the seam accuracy is difficult to control, and the assembly effect is not good; and secondary construction, resulting in low construction efficiency, low quality, construction dust pollution affecting the construction environment and normal use of equipment. To this end, in view of the above defects, the designer of the present invention designs an ultra-light prefabricated wall panel with a multi-layer composite strengthening method and preparation method thereof through dedicated research and design, in combination with the experience and achievements of many years of engaging in related industries, so as to overcome the above defects.

SUMMARY OF AN EMBODIMENT OF THE INVENTION

[0008] An object of the present invention is to provide an ultra-light prefabricated wall panel and preparation method thereof with multi-layer composite reinforcement method, which can effectively overcome defects of the prior art, not only meet requirements of the lightweight of the wall panel, realize the multi-layer reinforced protection of the wall, but also have the advantages of thermal insulation, sound insulation and noise reduction, waterproof and moisture-proof, fire and corrosion resistance and finish integration.

[0009] In order to achieve the above object, the present invention discloses an ultra-light prefabricated wall panel based on a multi-layer composite reinforcement method, comprising three parts: a frame, a wall core and a surface layer, wherein the frame is set in surrounding position, and comprises a left frame with a convex tongue, a right frame with a concave groove, as well as a bottom frame with a groove; the right frame, the left frame and the bottom frame are made of active powder concrete to form an outer frame load-bearing structure of composite wall plate, wherein the inner side of the frame is attached to a lightweight three-dimensional fiber mesh, the surface layer comprises a front surface layer and a back surface layer located in the front and back surfaces of the wall core, and a stacked corner reinforcement layer is formed in the lower part of the wall core, and a whole piece of the lightweight three-dimensional fiber mesh is attached to inside of the front surface layer and the back surface layer; the surface layer and the frame enclose to form an internal space that accommodates the wall core; the wall core comprises a lightweight three-dimensional mesh structure, which is reinforced with a lightweight three-dimensional fiber mesh and filled with foam concrete core, the lightweight three-dimensional fiber mesh structure is pressed into the space formed by enclosed structure, and the foam concrete core material that has been fully mixed with ultra-light particles is filled into the enclosed structure, and the wall panel is formed finally after solidification and maintenance.

[0010] The ultra-light particles have microwave hot melt performance, after microwave hot melt treatment, the ultra-light particles melt into a liquid state, the liquid material formed by ultra-light particles by hot melt treatment is coated on the pore wall of the internal pore cavity occupied by the ultra-light particles, and finally forms the ultra-light particle hot-melt reinforced bubble wall film inside the wall panel after the liquid material solidifies again.

[0011] Wherein the foam concrete core material follows the following formula (1):

$$\begin{cases} \frac{V-V_1-V_2}{V} \leq \delta_0 = \frac{V_2}{V} \\ \frac{V_1}{V_2} = \beta \end{cases} \quad (1)$$

V: total volume of wall core filling;

V_1 : filling volume of ultra-light particles;

V_2 : volume of original foam concrete before foaming;

δ_0 : original foaming rate of the foam concrete;

β : volume occupancy ratio of ultra-light particles.

[0012] There is also disclosed a preparation method for ultra-light prefabricated wall panels based on the multi-layer composite reinforcement method, which is characterized by the following steps:

Step 1: laying flat a bottom frame template, a left frame template and a right frame template;

Step 2: injecting activated powder concrete into the bottom frame template, the left frame template and the right frame template respectively to form an unsolidified bottom frame, left frame and right frame;

Step 3: pressing multi-layer narrow strip lightweight three-dimensional fiber mesh into the unsolidified bottom frame, left frame and right frame respectively, to form solidification through maintenance;

Step 4: placing the bottom frame implanted with narrow strip lightweight three-dimensional fiber mesh into a surface layer preparation device;

Step 5: on front surface layer template, back surface layer template of the surface layer preparation device, and surface of the bottom frame, continuously spraying front surface layer and back surface layer, which are maintained in unsolidified state;

Step 6: pressing the multi-layer wide lightweight three-dimensional fiber mesh into the unsolidified front surface layer and the back surface layer respectively;

Step 7: under a set control time, that is, when the front surface layer and the back surface layer are gradually entering solid state from liquid state but are not completely solidified, the front surface layer template and the back surface layer template in the surface layer preparation device are rotated by 90 degrees around a connecting axis from the horizontal state to the vertical state, forming a corner reinforcement area at the bottom of the front and back surface layers of the wall panel;

Step 8: after the front surface layer and the back surface layer are completely solidified, molding the left frame, right frame and bottom frame with the front surface layer and the back surface layer;

Step 9: injecting foam concrete containing ultra-light particles into the space formed by the molding;

Step 10: after reaching age of wall core, performing demolding and maintenance, to gradually form a wall panel without microwave hot melt treatment;

Step 11: sending the wall panel into a microwave device to hot melt the ultra-light particles in the wall panel, which are softened by heat into liquid state and adhered to internal pore cavity wall formed by occupation of ultra-light particles, and the panel being heated with plate flapping repeatedly, by the microwave hot melt according to the strength requirements, then the ultra-light particle melt softened by heat is fully coated on the internal pore cavity wall, so that a layer of ultra-light particle hot melt reinforced pore cavity film is formed on the inner pore cavity wall, and finally an ultra-light prefabricated wall panel based on the multi-layer strengthening method is formed.

[0013] In Step 8, the multi-layer wide lightweight three-dimensional mesh and the multi-layer narrow strip lightweight three-dimensional mesh are connected.

[0014] The wall is further reinforced, and a multi-layer additional wide and lightweight three-dimensional mesh is added to the space formed by the molding.

[0015] In step 10, active powder concrete is used to pour top frame.

[0016] From the above content, it can be seen that the ultra-light prefabricated wall panel of the multi-layer composite reinforcement method of the present invention and the preparation method thereof have the following effects:

1. By using ultra-light particles as the light aggregate of the main concrete of the wall panel, using microwave hot melt technology to hot melt the ultra-light particles in the formed wall panel body, and through the flipping of the plate, the ultra-light particles are hot melted to form a reinforcing film that is fully attached to the concrete pore wall, which improves the structural strength of the wall. Microwave hot melt ultra-light particles form the inner wall reinforcement film of the inner pore wall of the wall.

2. It can be customized according to the building requirements of the underground station: the height can be set arbitrarily from the assembled ground to the top surface or less than the top surface. The width can be determined by modulation according to the transportation, lifting, weight, and installation difficulty. The frame of wall panel is made of active powder concrete to form the outer frame bearing structure of the wall panel. The wall adopts lightweight three-dimensional mesh (reinforced structure). The interior of the wall is filled with foam concrete mixed with ultra-light particles. The ultra-light particles have microwave hot melt properties.

[0017] The details of the present invention can be obtained through the following description and accompanying

drawings.

DESCRIPTION OF THE FIGURES

[0018]

Fig.1 shows a schematic diagram of the ultra-light prefabricated wall panel based on the multi-layer composite reinforcement method of the present invention.

Fig.2A shows an enlarged view of part A in Fig.1.

Fig.2B shows an enlarged view of part B in Fig.2A.

Fig.3 shows the relationship diagram between the ultra-light particle volume occupancy ratio and the foam wall thickness in the present invention.

Fig.4 shows a schematic diagram of the corner reinforcement treatment in the present invention.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

[0019] Referring to Figs. 1 to 4, which shows the ultra-light prefabricated wall panel of the multi-layer composite strengthening method of the present invention and the preparation method thereof.

[0020] A shown in FIG. 1, the ultra-light prefabricated wall panel structure based on multi-layer composite strengthening method of the present invention comprises a frame, a wall core and a surface layer. The frame is set in a circumferential position, comprises a right frame 4 with a concave groove, a left frame 5 with a convex tongue and a bottom frame 6 with a groove. An optional top frame 21 can be set as needed. The right frame 4, the left frame 5 and the bottom frame 6 are made by activated powder concrete 23 (RPC concrete) to form a load-bearing structure of the outer frame of the composite wall panel, wherein the inner side of the frame (the side against the wall core) can also be attached to a lightweight three-dimensional fiber mesh. Specifically, the sides against the wall core of the right frame 4, the left frame 5 and bottom frame 6 can be implanted with the lightweight three-dimensional fiber mesh when the right frame 4, left frame 5 and bottom frame 6 are poured.

[0021] The surface layer is located in the front surface layer 10 and the back surface layer 11 of the front and back surfaces of the wall core. A stacked corner reinforcement layer 17 is formed in the lower part of the wall, the front surface layer 10 and the back surface layer 11 may be made of the same foam concrete material as the wall core (modified inorganic materials with high adhesion or other reinforcing materials with high adhesion may also be used), the front surface layer 10 and the back surface layer 11 inside (on the side of the wall core) are attached to the whole surface of the lightweight three-dimensional fiber mesh, and the front surface layer 10 and the back surface layer 11 are poured and implanted with a lightweight three-dimensional fiber mesh to form a load-bearing structure of the composite plate surface.

[0022] The surface layer and the frame enclose to form an internal space that accommodates the wall core, and the wall core comprises a lightweight three-dimensional mesh structure 13, which is reinforced with a lightweight three-dimensional fiber mesh and filled with foam concrete core material 2 (the lightweight three-dimensional fiber mesh structure 13 is placed in the space formed by the enclosed structure, and the foam concrete core material 2 which has been fully mixed with ultra-light particles 1 is filled into the enclosed structure), and the solidification and maintenance finally forms a wall panel.

[0023] As shown in Figs. 2A and 2B, ultra-light particles 1 have microwave hot melt properties. After microwave hot melt treatment, ultra-light particles 1 melt into a liquid state, the liquid material formed by ultra-light particles by hot melt treatment is coated on the pore wall of the internal pore cavity 20 originally occupied by ultra-light particle 1, and after the liquid material solidifies again, it finally forms an ultra-light particle hot-melt reinforced bubble wall film 19 inside the wall, as shown in Figs. 2A and 2B, a layer of ultra-light particle hot-melt reinforced bubble wall film 19 is attached to the wall of the internal pore 20 of the foam concrete 2, thus it forms a part of the internal load-bearing structure of the composite wall panel.

[0024] The ultra-light prefabricated wall panel structure based on the multi-layer composite strengthening method of the present invention adopts four types of strengthening methods of wall core strengthening, wall connection surface strengthening, surface layer strengthening and wall corner strengthening.

[0025] The wall core reinforcement method includes:

(1) Lightweight three-dimensional fiber mesh is implanted in the wall core, which plays a role in reinforcement and strengthening the wall as a whole. The structural form of lightweight three-dimensional fiber mesh can be single-piece, double-layer or integral three-dimensional mesh structure running through the wall core; materials of lightweight three-dimensional fiber mesh can be glass fiber, basalt fiber mesh, steel wire fiber mesh, etc., and the structural form and material of lightweight three-dimensional fiber mesh can be designed according to the target strength of the wall panel.

(2) In the process of preparing foam concrete of core material for wall core, under the condition that the quality of the

filled foam concrete remains unchanged (which also means that the volume of concrete before foaming remains unchanged), in order to make the foam concrete form a relatively thick foam wall, it is proposed a technology (process) which uses a method of filling occupation material to improve the foam concrete bubble wall thickness: that is, while the pre-filling amount (and volume) of concrete before foaming remains unchanged, a certain amount of ultra-light particles are mixed according to the wall plate strength requirements for space-occupying filling. Under the condition that the total filling volume remains unchanged, the concrete mixed with ultra-light particles is foamed. This will compress the foam volume that can be produced by concrete while the total volume of filling and the total amount (and volume) of concrete before foaming remain unchanged, so as to increase the average thickness of the foamed foam wall, and improve the structural strength of the wall core while keeping the wall lightweight. In order to improve the thickness of foam concrete foam wall, the following formula (1) needs to be met:

$$\begin{cases} \frac{V-V_1-V_2}{V} \leq \delta_0 = \frac{V_2}{V} \\ \frac{V_1}{V_2} = \beta \end{cases} \quad (1)$$

V: total core filling volume (known);

V_1 : filling volume of ultra-light particles;

V_2 : volume of the original foam concrete before foaming (known);

δ_0 : original foaming rate of foam concrete;

β : volume occupancy ratio of ultra-light particles (related to the thickness t of the foam wall: under the unit volume, the foam wall thickness t produced by a certain label foam concrete is directly proportional to the volume occupancy ratio of ultra-light particles (that is, the bubble wall thickness t increases with the increase of the occupancy ratio), in principle, the thickest extreme value t_{extre} of the foam wall should be taken. However, considering that the cost of ultra-light particle materials is higher than that of concrete materials, it is advisable to choose a more cost-effective scheme under the premise of meeting the strength requirements of the wall panel, so on the basis of comprehensive consideration of the wall panel strength demand and economic indicators, the thickness of the foam is chosen as t_{opt} , corresponding optimal occupancy ratio of ultra-light particles is β_{opt} . The schematic diagram of the relationship between the occupancy ratio of ultra-light particles and the thickness of the foamed foam wall is shown in Fig. 3.

[0026] Due to the slightly different relationship between the occupancy ratio of ultra-light particles and corresponding thickness of the foam wall under different labels of foam concrete, the specific curve distribution needs to be determined by specific material tests, and combined with the design strength requirements and cost analysis of wall panels, the optimal occupancy ratio of specific ultra-light particles is comprehensively determined as β_{opt} , and the amount of mixed ultra-light particles is finally determined as V_1 .

[0027] (3) Concrete as the wall core filling material is mixed with ultra-light particles. The ultra-light particle material has hot-meltable properties. After the wall panel is formed, the ultra-light particles are changed from solid to liquid (only from solid state to liquid state, and other physical and chemical properties do not change). Through the posture adjustment of the wall panel, so that the liquid ultra-light particle material is coated on the pore wall formed by the original ultra-light particle solid, and then solidifies again to form the inner wall pore cavity reinforcement film, so that the structural strength of the wall is improved from the perspective of mesoscopic pores while keeping the lightweight of the wall unchanged.

[0028] The wall connection surface reinforcement methods include:

The frame made of activated powder concrete (RPC) can form a high-precision and high-strength frame on the wall connection surface, realize the accurate and straight frame connection surface, and facilitate the high-precision dry docking of the wall panel connection surface during wall panel splicing. At the same time, when the wall panels are prestressed and tensioned, the tensile load can be effectively distributed and transferred. It avoids the problems of easy bumping and cracking of the wall edge and indirect glue treatment of the wall panel joints during the assembly process of traditional lightweight wall panels. In addition, the lightweight three-dimensional fiber mesh implanted inside the frame can maintain the integrity of the connection between the frame and the wall, avoiding the problem of separation between the frame and the wall that is easy to occur in traditional framed wall panels.

[0029] The surface layer strengthening method involves spraying the surface layer material on the template and pressing it into a three-dimensional fiber mesh to form a reinforced surface layer, so that the wall panel has better surface strength and crack resistance under the environment of rail wind pressure and train micro-vibration.

[0030] The wall corner strengthening method includes the accumulation of spraying slurry in the bottom area of the mold through the mold posture adjustment at the same time, forming a wall corner accumulation area with thickness and volume much greater than the thickness of the sprayed surface layer, and realizing the corner strengthening of the wall panel.

[0031] Wherein, as shown in Figs. 1 to 4, the preparation method of the multi-layer reinforced ultra-light composite wall panel of the present invention comprises the following specific steps:

Step 1: laying flat bottom frame template 9, left frame template 7 and right frame template 8;

Step 2: injecting activated powder concrete 23 into the bottom frame template 9, the left frame template 7 and the right frame template 8 respectively to form an unsolidified bottom frame 6, the left frame 5 and the right frame 4;

Step 3: pressing multi-layer narrow strip lightweight three-dimensional fiber mesh 3 into the unsolidified bottom frame 6, left frame 5 and right frame 4 respectively, to form solidified bottom frame 6, the left frame 5 and the right frame 4 through maintenance;

Step 4: placing the bottom frame 6 implanted with narrow strip lightweight three-dimensional fiber mesh 3 into a surface layer preparation device 22;

Step 5: on front surface layer template 15, back surface layer template 16 of the surface layer preparation device, and surface of the bottom frame 6, continuously spraying front surface layer 10 and back surface layer 11, which are maintained in unsolidified state;

Step 6: pressing the multi-layer wide lightweight three-dimensional fiber mesh 12 into the unsolidified front surface layer 10 and the back surface layer 11 respectively;

Step 7: under a set control time, that is, when the front surface layer 10 and the back surface layer 11 are gradually entering solid state from liquid state but are not completely solidified, the front surface layer template 15 and the back surface layer template 16 in the surface layer preparation device 22 are rotated by 90 degrees around a connecting axis 18 from the horizontal state to the vertical state as shown in Fig. 4; because the front surface layer 10 and the back surface layer 11 are not completely solidified during the rotation process, the grouting of the spraying material of the front surface layer 10 and the back surface layer 11 is accumulated at the corner to form the corner reinforcement area 17 at the bottom of the front and back surface layers of the wall plate;

Step 8: before the front surface layer 10 and the back surface layer 11 are not solidified, the left frame 5, the right frame 4 and the bottom frame 6 are molded together with the front surface layer 10 and the back surface layer 11, and the multi-layer wide lightweight three-dimensional fiber mesh 12 and the multi-layer narrow strip lightweight three-dimensional fiber mesh 3 can be connected (hot welding, physical binding or hooking and other appropriate methods can be used to connect), wherein, it is preferable that the wall core can be further reinforced, and a multi-layer wall core lightweight three-dimensional fiber mesh 13 can be added to the space formed by the molding after the front surface layer 10 and the back surface layer 11 are completely solidified;

Step 9: As shown in Fig. 2A, foam concrete 2 containing ultra-light particles 1 (which has microwave hot melt properties (i.e., particles can be converted into liquid state under microwave heating, but the physical properties remain unchanged)) is injected into the space formed by closing the mold;

Step 10: after the wall core reaches its age, demolding and maintenance, gradually forming a wall panel that has not been microwave hot melt treatment, and the top frame can also be poured with active powder concrete in this step;

Step 11: sending the wall panel into a microwave device to hot melt the ultra-light particles 1 in the wall panel, which are softened by heat into liquid state and adhered to internal pore cavity wall 20 formed by occupation of ultra-light particles, and the panel being heated with plate flapping repeatedly, by the microwave hot melt according to the strength requirements, then the ultra-light particles 1 melt softened by heat is fully coated on the internal pore cavity wall 20, so that a layer of ultra-light particle hot melt reinforced pore cavity film 19 is formed on the inner pore cavity wall 20, and finally an ultra-light prefabricated wall panel based on the multi-layer strengthening method is formed;

[0032] Therefore, the core filling layer of the composite panel of the present invention adopts ultra-light particles as the light aggregate of the main concrete of the wall panel, and the ultra-light particles in the formed wall panel body are hot-melted by microwave hot melt technology, and through the flipping of the plate, the ultra-light particles are hot-melted to form a reinforcing film that is fully attached to the concrete pore wall, and the structural strength of the wall is enhanced, and the multiple strengthening measures of the present invention include the structural frame reinforcement of the active powder concrete as the wall frame, and the reinforcement of the wall as a whole with a multi-layer lightweight three-

dimensional mesh, The corner of the wall formed by mechanical extrusion and accumulation is strengthened, and the inner wall of the wall is strengthened by microwave hot melt ultra-light particles to form the inner pore wall reinforcement film of the wall.

[0033] The plate of the present invention can be customized according to the requirements of the underground station building: the height can be arbitrarily set from the assembled ground to the top surface or less than the top surface. The width can be determined by modulation according to the transportation, lifting, weight, and installation difficulty. The wall frame is made of active powder concrete to form the outer frame bearing structure of the wall panel. The wall adopts lightweight three-dimensional mesh (reinforced structure); The interior of the wall is filled with foam concrete mixed with ultra-light particles; Ultra-light particles have microwave hot melt properties. The overall principle of the wall panel construction process is to first establish the connection between the narrow strip of lightweight three-dimensional mesh (reinforced structure) and the active powder concrete frame layer; At the same time, the connection between the whole lightweight three-dimensional mesh (reinforced structure) and the surface layer is established, and the corner part of the surface layer is strengthened when the surface layer is molded, then the surface layer and the border are assembled, and the narrow strip is connected with the intersection of the whole lightweight three-dimensional mesh (reinforced structure). The external structure of the wall is formed. Then the foam concrete mixed with ultra-light particles is injected into it and poured to form a composite wall. The lightweight of the wall panel relies on the solution as following: the wall is made of lightweight three-dimensional mesh (reinforced structure), and the wall is filled with foam concrete mixed with ultra-light particles; lightweight three-dimensional mesh (reinforced structure) and ultra-light particles belong to material weight reduction, while foam concrete belongs to porous structure weight reduction.

[0034] It is clear that the above descriptions and records are only examples and not intended to limit the public content, application, or use of the invention. While already described in embodiments and embodiments are described in the drawings, the present invention is not limited to specific examples by examples of drawings and specific examples described in embodiments as the best pattern currently considered to be the best mode for the implementation of the teachings of the invention, and the scope of the invention will include any embodiments falling into the preceding specification and the attached claims.

Claims

1. An ultra-light prefabricated wall panel based on a multi-layer composite reinforcement method, comprising a frame, a wall core and a surface layer, wherein the frame is set in surrounding position, and comprises a right frame with a concave groove, a left frame with a convex tongue, and a bottom frame with a groove,

the right frame, the left frame and the bottom frame are made of active powder concrete to form an outer frame load-bearing structure of composite wall plate, wherein inner side of the frame is attached to a lightweight three-dimensional fiber mesh,

the surface layer comprises a front surface layer and a back surface layer located in the front and back surfaces of the wall panel, and a stacked corner reinforcement layer is formed in the lower part of the wall panel,

a whole piece of the lightweight three-dimensional fiber mesh is attached to inner side of the front surface layer and the back surface layer,

the surface layer and the frame enclose to form an internal space that accommodates the wall core,

the wall core comprises a lightweight three-dimensional mesh structure, which is reinforced with a lightweight three-dimensional fiber mesh and filled with foam concrete core,

the lightweight three-dimensional fiber mesh structure is pressed into space formed by enclosed structure, and the foam concrete core material that has been fully mixed with ultra-light particles is filled into the enclosed structure, and the wall panel is formed finally after solidification and maintenance, wherein the ultra-light particles have microwave hot melt performance, after microwave hot melt treatment, the ultra-light particles melt into liquid state, liquid material formed by ultra-light particles by hot melt treatment is coated on the pore wall of the internal pore cavity originally occupied by the ultra-light particles, and finally forms ultra-light particle hot-melt reinforced bubble wall film inside the wall panel after the liquid material solidifies again.

2. The ultra-light prefabricated wall panel based on a multi-layer composite reinforcement method as in Claim 1, wherein the foam concrete core material follows the following formula (1):

$$\begin{cases} \frac{V-V_1-V_2}{V} \leq \delta_0 = \frac{V_2}{V} \\ \frac{V_1}{V_2} = \beta \end{cases} \quad (1)$$

V: total volume of wall core filling;
 V_1 : filling volume of ultra-light particles;
 V_2 : volume of original foam concrete before foaming;
 δ_0 : original foaming rate of the foam concrete;
 β : volume occupancy ratio of ultra-light particles.

3. A preparation method for ultra-light prefabricated wall panels based on the multi-layer composite reinforcement method, which is **characterized by** the following steps:

Step 1: laying flat a bottom frame template, a left frame template and a right frame template;
 Step 2: injecting activated powder concrete into the bottom frame template, the left frame template and the right frame template respectively to form an unsolidified bottom frame, left frame and right frame;
 Step 3: pressing multi-layer narrow strip lightweight three-dimensional fiber mesh into the unsolidified bottom frame, left frame and right frame respectively, to form solidification through maintenance;
 Step 4: placing the bottom frame implanted with narrow strip lightweight three-dimensional fiber mesh into a surface layer preparation device;
 Step 5: on front surface layer template, back surface layer template of the surface layer preparation device, and surface of the bottom frame, continuously spraying front surface layer and back surface layer, which are maintained in unsolidified state;
 Step 6: pressing a multi-layer wide lightweight three-dimensional fiber mesh into the unsolidified front surface layer and the back surface layer respectively;
 Step 7: under a set control time, that is, when the front surface layer and the back surface layer are gradually entering solid state from liquid state but are not completely solidified, the front surface layer template and the back surface layer template in the surface layer preparation device are rotated by 90 degrees around a connecting axis from the horizontal state to the vertical state, forming a corner reinforcement area at the bottom of the front and back surface layers of the wall panel;
 Step 8: after the front surface layer and the back surface layer are completely solidified, molding the left frame, the right frame and the bottom frame with the front surface layer and the back surface layer;
 Step 9: injecting foam concrete containing ultra-light particles into the space formed by the molding;
 Step 10: after reaching age of wall core, performing demolding and maintenance, to gradually form a wall panel without microwave hot melt treatment;
 Step 11: sending the wall panel into a microwave device to hot melt the ultra-light particles in the wall panel, which are softened by heat into liquid state and adhered to an internal pore cavity wall formed by occupation of ultra-light particles, and the panel being heated with plate flapping repeatedly, by the microwave hot melt according to the strength requirements, then the ultra-light particle melt softened by heat is fully coated on the internal pore cavity wall, so that a layer of ultra-light particle hot melt reinforced pore cavity film is formed on the inner pore cavity wall, and finally an ultra-light prefabricated wall panel based on the multi-layer strengthening method is formed.

4. The preparation method for ultra-light prefabricated wall panels based on the multi-layer composite reinforcement method as in Claim 3, wherein in Step 8, the multi-layer wide lightweight three-dimensional mesh and the multi-layer narrow strip lightweight three-dimensional mesh are connected.
5. The preparation method for ultra-light prefabricated wall panels based on the multi-layer composite reinforcement method as in Claim 4, wherein the wall is further reinforced, and a multi-layer additional wide and lightweight three-dimensional mesh is added to the space formed by the molding.
6. The preparation method for ultra-light prefabricated wall panels based on the multi-layer composite reinforcement method as in Claim 3, wherein in Step 10, active powder concrete is used to pour a top frame.

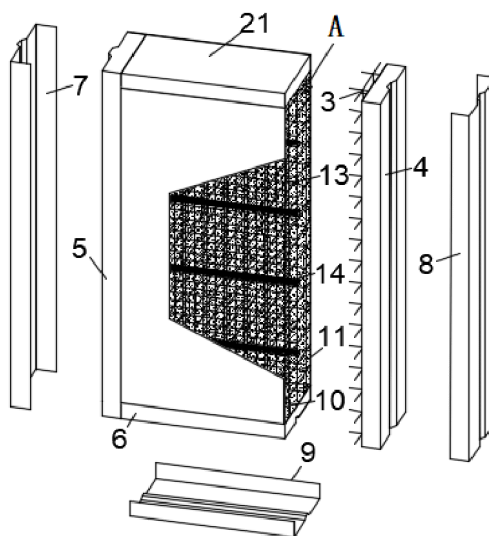


Fig. 1

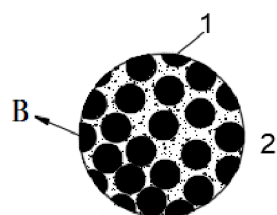


Fig. 2A

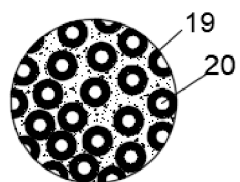


Fig. 2B

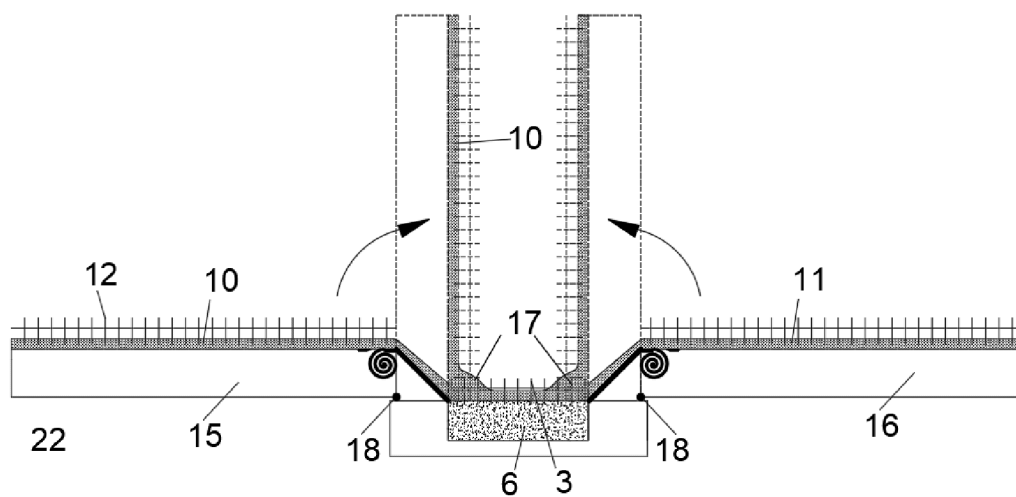


Fig. 3

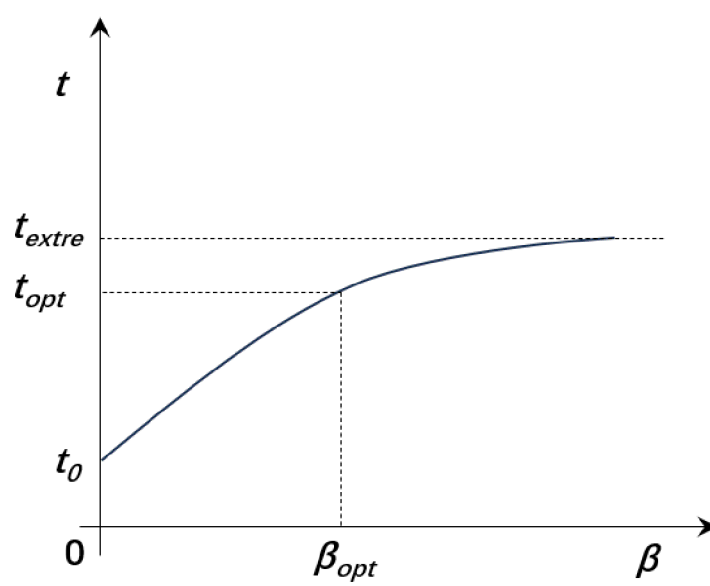


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/125973

A. CLASSIFICATION OF SUBJECT MATTER

E04B 2/74(2006.01)i; E04B 2/82(2006.01)i; B28B 7/22(2006.01)i; B28B 23/02(2006.01)i; B28B 19/00(2006.01)i; B28B 1/14(2006.01)i; B28B 11/24(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: E04B, B28B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNXT, CNABS, CNKI, VEN, ENTXT: 超轻, 泡沫, 颗粒, 装配, 模, 框, 脚, 角, 面层, 浇筑, 混凝土, 微波, light, foam, concrete, particle, assembly, mold, mould, reinforce, angle, base, cast, face, surface, layer, frame, microwave

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 118327193 A (BEIJING URBAN CONSTRUCTION DESIGN & DEVELOPMENT GROUP CO., LTD.) 12 July 2024 (2024-07-12) claims 1-7, description, paragraphs 12-81, and figures 1-4	1-6
A	CN 115492305 A (CENTRAL SOUTH UNIVERSITY) 20 December 2022 (2022-12-20) description, paragraphs 4-70, and figures 1-11	1-6
A	CN 210117923 U (GUO XUEMING et al.) 28 February 2020 (2020-02-28) description, paragraphs 4-23, and figures 1-3	1-6
A	CN 117103434 A (ZHUZHOU FENGSHOU TEMPLATE CO., LTD.) 24 November 2023 (2023-11-24) entire document	1-6
A	JP H0820936 A (MAEDA CORP.) 23 January 1996 (1996-01-23) entire document	1-6

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 13 January 2025	Date of mailing of the international search report 15 January 2025
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088	Authorized officer Telephone No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2024/125973

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN	118327193	A	12 July 2024	None	
CN	115492305	A	20 December 2022	None	
CN	210117923	U	28 February 2020	None	
CN	117103434	A	24 November 2023	None	
JP	H0820936	A	23 January 1996	None	