Design Of Pluggable Solar Greenhouse

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Abstract. Original design of a plug-in assembly type solar greenhouse, good insulation effect, plug and pull, can change the height and length of the wall according to production needs. This new type of solar greenhouse adopts plug-in heat preservation wall. This kind of wall adopts standardized module, which can be industrialized mass production. It has the advantages of low cost, convenient disassembly, assembly and transportation, and protection of land and environment.

1. Introduction
Most of the traditional solar greenhouse walls are made of soil, clay brick and solid wall, with a thickness of 50 - 300cm, covering a large area. Once the land planning changes or illegal construction needs to be demolished, it will cause a lot of construction waste, serious land pollution and other problems, such as in the past two years, the demolition of greenhouse houses nationwide, resulting in a large number of arable land fertility reduction, pollution or even waste [1]. For this reason, many scholars have carried out research on the assembled solar greenhouse and its wall [2-4]. Wang Shaojie and others developed the assembled heterogeneous composite wall with soil sandwich [5]. The wall uses the light energy-saving insulation board as the outer insulation layer of the wall chamber, and the soil and ordinary reinforced concrete board as the heat storage layer. At the same time, the inner and outer wall panels are connected through the reinforcement materials or columns, so as to improve the structural stability and disaster resistance ability. Zhou Changji introduced a kind of assembled solar greenhouse with polyester cotton quilt as thermal insulation material to cover the roof and wall behind the greenhouse, which is firmly connected and has good sealing performance. There is basically no cooling phenomenon in the greenhouse in the form of cold air infiltration [6].

The original design of this project is a new type of assembled wall of solar greenhouse, which can be plug and pull, and can change the height and length of the wall according to the production needs. The standardized module of plug-in insulation wall can be industrialized mass production, low cost, convenient disassembly, assembly and transportation, and protect the land and environment.

2. Structure & Composition

2.1. Structure and composition of solar greenhouse
The solar greenhouse includes north wall, east wall, west wall, plug-in door, shed membrane pole and shed membrane, as shown in Figure 1.
The north wall, the east wall and the west wall all adopt plug-in insulation wall, which has a wall structure composed of two kinds of splicing wall modules, and the top modules used to install connecting rods are spliced with each other. Among them, the specific structure of two types of wall modules is as follows:

As an auxiliary module, the wall module of configuration 1 is a rectangular integrated structure with plug-in terminal on the top and plug-in slot on the bottom. The wall module of configuration 2 is the main module, which is an integrated structure formed by two wall modules of configuration 1, which are symmetrical on the left and right and connected on the side. Then, there are two plug-in slots on the bottom and two plug-in terminals on the top of the wall module of configuration 2. The top module has two structures, one is the rectangular structure with one slot on the bottom and two slots on the bottom; and the side has the connection slot to install the connecting rod. Through the above two types of wall modules, the main module and auxiliary module are spliced and assembled alternately to form the plug-in insulation wall in this project, and the top module is installed at the top layer to realize the installation of connecting rod.

2.2. Structure and composition of unit module

The wall module and the top module have five layers of structure, which are poured and formed. In the five layer structure, the middle layer is the skeleton layer, and the hot-dip galvanized steel plate is used to play a supporting role. Both sides of the skeleton layer are fireproof and thermal insulation layers, and rigid polyurethane foam is poured through the polyurethane raw materials. The outer side of the fire insulation layer is respectively coated with solar energy selective absorption coating and heat insulation coating. Among them, the solar energy selective absorption coating is used as the outer wall of the east wall, the west wall and the north wall. The coating is composed of pigment and binder. The absorption of pigment to sunlight and the absorption of substrate to infrared constitute the spectral selectivity of the solar energy selective absorption coating. The pigment materials are lead sulfide, silicon germanide and other semiconductor materials with an absorption rate of more than 0.90. The radiation rate is below 0.3; the binder has good adhesion, high long wave transmittance and stability at high temperature; the binder adopts alkenyl material, which has good infrared transparency, while the silicone has good temperature resistance and absorbs the radiation energy of the sun to the maximum extent. Thermal insulation coating is used as the inner wall of the east wall, west wall and North wall. Its main component is ceramic particles, with low thermal conductivity, good thermal insulation and moisture absorption performance, which can remove the excess water vapor produced in the planting of crops in the solar greenhouse and prevent the infection of crop germs. Therefore, the wall module and the top module have the advantages of flame retardant, heat insulation, stability and heat preservation.
3. Connection & Installation

3.1. Connection and installation of north wall
The connection and installation of the north wall are shown in Figure 2. The wall structure of the north wall ladder is n-layer, in which the first layer has two wall modules of m-block configuration, which makes the two wall modules of adjacent configuration fit between the sides. The second layer consists of M-1 wall module of configuration 2 and 2 wall modules of configuration 1. In the second layer, two plug-in slots on the bottom of each wall module of configuration 2 correspond to the adjacent plug-in terminals on the top of the two adjacent wall modules of the first layer. The bottom slots of two wall modules of configuration 1 correspond to the remaining plug-in terminals on the top of the two wall modules of configuration 2 in the first layer. The head fits the plug. The fourth floor and the third floor, the fifth floor and the fourth floor are respectively connected in the same way as the second floor and the first floor, the third floor and the second floor, and so on, forming the wall structure of plug-in north wall. If n is an even number of layers, the top module with two slots structure at the bottom of M block shall be inserted in the same way as the third layer to form the top connection surface of north wall ladder. If n is an odd number, the top-level module with two slot structures on the bottom of M-1 block and the top-level module with one slot structure on the bottom of M-1 block shall be plugged in the same way as the second floor; the ground sockets of each wall module at the bottom of north wall shall be used to plug in corresponding to the convex designed on the installation plane. The height of the north wall ladder can be adjusted according to the needs.

![Fig.2 Figure of the connection and installation of the north wall](image)

3.2. Connection and installation of east wall
The installation and connection of the east wall are shown in Figure 3. The east wall and the north wall ladder have the same number of layers of wall structure, which are n layers. In the first layer, p-block configuration 2 wall module is used to make the adjacent configuration 2 wall module side to side fit. In the second layer, M-1 wall module of configuration 2 and 1 wall module of configuration 1 are used; in the second layer, two plug-in slots on the bottom of each wall module of configuration 2 correspond to the adjacent plug-in terminals on the top of the two wall modules of adjacent configuration 2 on the first layer respectively; one slot on the bottom of the wall module of configuration 1 corresponds to the remaining plug-in terminals on the top of the wall module of configuration 2 at the back end of the first layer respectively Combined plugging. The third layer adopts M-1 block configuration 2 wall module, in which, M-1 block configuration 2 wall module respectively corresponds to the adjacent plug-in terminals on the top of the two adjacent configuration 2 wall modules on the second layer; the remaining slot on the bottom of the two configuration 2 wall modules corresponds to the remaining plug-in terminals on the top of the configuration 2 wall module on the second layer and the configuration 1 wall module on the back of the second layer The plug-in joint on the top of the block is matched with plug-in. The fourth layer and the third layer, the fifth layer and the fourth layer are respectively connected in the same way as the second layer and the first layer, the third layer and the
second layer, and so on to form the plug-in east wall. If \( n \) is an even number, the top-level module with two slot structures and one top-level module with one slot structure shall be inserted in the same way as the third layer; if \( n \) is an odd number, the top-level module with two slot structures and two top-level modules with one slot structure shall be inserted in the same way as the fourth layer; and finally, the whole East wall is formed. The bottom socket of each wall module at the bottom of the east wall is used to connect with the convex designed on the installation plane.

3.3. Connection and installation of west wall

The installation and connection of the west wall are shown in Figure 4. There is a gap on the west wall, which is used to set the plug-in door for the staff to enter and exit; the plug-in door has a plug-in door frame; the width of the wall module is \( l \) and the height is \( h \); then the width of the door frame is \( KL \), \( k = \{1, 2, 3\} \); the height of the door frame is \( RH \) and \( R \) is odd. The door frame is designed with a jack at the bottom and a plug-in connector at the top. The plug-in mode of the west wall is as follows:

The number of floors of west wall and North wall ladder is the same as that of \( N \) floors; the jack on the bottom of the door frame is connected with the convex designed on the installation plane; then the west wall is composed of three parts, namely the wall on the left side of the door frame, the wall on the right side of the door frame and the wall above the door frame. Among them, the wall on the left side of the door frame has \( r \)-layer, which can be inserted according to the wall structure of the east wall, so that the top surface of the rectangular part of the top wall module of the wall structure on the left side of the door frame has the same height as the top surface of the door frame; therefore, the top layer of the wall on the left side of the door frame has a configuration 1 wall module, which is replaced by the top side module with a groove below. The wall on the right side of the door frame also has an \( r \)-layer, which can be inserted according to the wall structure of the north wall, so that the top surface of the rectangular part in the top wall module of the wall structure on the right side of the door frame is the same height as the top surface of the door frame. The top plug of the door frame is designed to be \( 2K \), arranged along the left and right directions of the door frame, and the distance between the two plug-in axes at the left and right ends and the left and right sides of the door frame is equal to the distance between the plug-in axes on the wall module of configuration 1 and the side; and the distance between the adjacent plug-in axes is equal to the distance between the two plug-in axes on the wall module of configuration 2. And ensure that the street axis inserted on the top surface of the door frame is coplanar with the plug axis of the top wall module on the left side of the door frame, and the plug axis of the top wall module on the right side of the door frame is coplanar. At this time, the wall on the left side of the door frame, the wall on the right side of the door frame and the top surface of the door frame can be regarded as the first floor of the east wall. After continuing to plug the N-R floor, the west wall will finally be formed.

![Fig.3 Figure of the installation and connection of the east wall](image-url)
3.4. Connection and installation of other parts

The gap between the east wall and the north wall of the solar greenhouse and between the west wall and the north wall is covered by color steel plate. The color steel plate has the characteristics of heat preservation and good support, and it is foldable and easy to assemble. At the same time, the east wall is opposite to the connection groove on the top layer module of the west wall, and the connection groove on the top layer module of the north wall is facing the solar greenhouse.

The connecting rod includes a transverse connecting rod and a longitudinal connecting rod. The two ends of the transverse connecting rod are respectively inserted into the connecting groove on the East-West symmetrical top-level module in the east wall and the west wall; one end of the longitudinal connecting rod is inserted into the connecting groove on the top-level module in the north wall, and the other end is bent and inserted into the installation plane, so as to form the horizontal supporting structure of the greenhouse film, and the greenhouse film is laid on the supporting structure, finally forming the greenhouse.

The final shape of the east wall and the west wall designed in this project is ladder type, which is convenient for the staff to climb on the top of the solar greenhouse to carry out the operation of heat preservation quilt collection and release, shed film laying, inspection and replacement. The connecting rod can be of sectional structure, and each section is connected by screw. At the same time, the connecting groove on the top module is designed as internal thread groove, and the end of a connecting rod connected with the top module is designed as external thread, which can be connected and fixed with the internal thread groove on the top module by matching the thread, so as to facilitate assembly and disassembly.

4. Conclusion

The solar greenhouse designed in this project has good heat preservation effect, can plug and pull, and can change the height and length of the wall according to the production needs. The plug-in insulation wall has the advantages of low cost, convenient disassembly, assembly and transportation, and also can protect the land and environment.

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