Application of Laminated Plate Construction Technology in Prefabricated Building Structure

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Abstract

With the development of China's construction field, prefabricated building structure has gradually become a very common building structure in the current construction engineering by virtue of its many advantages in the actual construction field. Combined with the engineering practice, this paper summarizes the hoisting technology of precast composite slab and precast staircase in prefabricated building structure. This paper focuses on the optimization design of laminated plate support under the conditions of wood formwork and aluminum formwork system and the key and difficult points in the construction process, and puts forward a set of practical and feasible construction methods for prefabricated components. This paper focuses on the analysis of the design concept, materials, structural form, manufacturing technology, hoisting and installation, and construction technology of M-type light steel concrete composite slab. This paper discusses and summarizes the advantages and disadvantages of M-type light steel reinforced concrete composite slab at present, and analyzes its development and application prospects. At the same time, in order to determine the reasonable type of laminated plate, the material budget analysis of assembled laminated plates with different structural forms is carried out. The conclusions are as follows: PK prestressed concrete composite slab has great advantages in the whole material budget cost, which is suitable for all kinds of span buildings. One way steel truss slab and YH prestressed concrete composite slab are suitable for small span buildings.

Keywords*: Prefabricated building, composite slab, one-way steel truss slab, YH prestressed concrete composite slab.*

I. Introduction

With the rapid development of China's economy, the level of new urbanization construction is getting higher and higher [1]. The urbanization housing construction will maintain a high level for a long time, and the requirements of residents for building energy conservation and environmental protection and living environment are also increasing. However, there is a traditional building mode with high energy consumption, high pollution, extensive and low efficiency in China's construction industry [2-3]. It is still a labor-intensive industry, which is far from the development of new urbanization, industrialization and informatization. The promotion of prefabricated building is an important measure to realize the industrialization of building and residential building, improve the quality of housing and ensure the sustainable development of the construction industry.

Building industrialization can improve the speed of engineering construction, establish a new structural system, reorganize the construction industry in the way of industrialization, which has the characteristics of energy saving, environmental protection, safety and high speed [4]. Prefabricated building refers to the main components of the building, such as wallboard, floor, beam slab, stairs, etc., which are prefabricated in the factory, transported to the construction site after maintenance, and connected to form an integral building product by means of post pouring concrete or sleeve grouting. In the construction of prefabricated building, the amount of wet work is less, the construction links are reduced, the labor force is saved, the efficiency of engineering construction is improved, the dust emission is controlled, and the pollution is reduced [5-6]. At present, China's construction industrialization is in the stage of rapid development, and has gradually become the development trend of the construction industry. The national policy has begun to tilt the direction of the prefabricated construction industry, and the proportion of

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prefabricated buildings in the new construction field is gradually increasing.

In the building structure, the floor is the main load-bearing component, and the stress of the floor system directly affects the overall stability of the building structure [7]. According to the different production process, floor components are divided into cast-in-place and precast. Compared with the full precast floor, the thickness of the precast floor is thinner, and it is less difficult to manufacture and hoist. When pouring concrete, the joint between the precast floor and the laminated concrete are poured together to form a high integrity floor. The laminated slab has the dual characteristics of cast-in-place slab and full precast slab. The development of laminated slab in the field of prefabricated building is conducive to the overall promotion of the floor system.

II. Introduction of prefabricated concrete composite floor

2.1 Typical mechanical characteristics of composite floor

There are two kinds of stress characteristics of composite floor, which are divided into "one-stage stressed composite floor" and "two-stage stressed composite floor". They are also called composite floor with temporary support in construction stage and composite floor without temporary support in construction stage. The biggest difference between the two stress characteristics is whether the precast floor is treated as a stress structure when pouring the composite layer concrete [8-10]. After pouring the concrete on site, the composite floor is stressed as a whole. At this time, there is no difference between the two stress characteristics. The composite floor should meet the external load conditions in the construction stage as a template and after pouring concrete to form the integral floor of the building structure.

One stage stressed composite floor means that the strength of precast floor can not meet the load generated when pouring concrete, so it needs additional support for precast floor to bear part of the load generated when pouring concrete. When the post pouring concrete reaches the design strength, the precast floor and post pouring concrete layer form an integral composite floor, and then the support can be withdrawn. At this time, the overall stress of the composite slab is completed at one time, and the composite slab with this stress characteristic is called one-stage stress composite slab. The two-stage stressed composite floor has two-stage stress characteristics. Before the construction of concrete, the precast floor needs to be directly used as the stress structure to bear the construction load without additional support. When the composite concrete reaches the design strength, the composite floor is stressed as a whole. The composite floor with this stress characteristic is called two-stage stressed composite floor.

2.2 Advantages and disadvantages of composite floor

1)Advantages of laminated floor

Compared with the cast-in-place floor and factory prefabricated floor, the prefabricated composite floor has obvious advantages:

(1) High strength steel bars and high strength concrete are mostly used for precast floor materials, which can improve the strength of precast floor and save the amount of steel and concrete at the same time. During construction, it can be used as formwork to reduce the amount of formwork, speed up the construction progress and improve the economic benefits.

(2) The laminated plate is prefabricated in the factory, and the prefabricated bottom plate template has reusability, high mechanization and high accuracy. The reinforcement of composite slab is designed and processed in accordance with the specification atlas. The arrangement of reinforcement is better controlled than that of on-site construction, and the spacing of reinforcement is more uniform. The thickness of protective layer of prefabricated bottom slab can meet the design requirements, and the surface of bottom slab is flat, which is convenient for on-site construction.

(3) The composite slab structure needs formwork support in the case of large span and too thick precast floor, and

generally, the composite slab does not need formwork support in construction, especially in the case of difficult formwork support in high-rise buildings.

(4) Prefabricated bottom plates are prefabricated in the factory and then transported to the construction site for concrete pouring, which does not take up the construction period on site and avoids the use of steel binding and formwork. Reduce the amount of concrete poured on site, reduce the wet workload, improve the construction safety and shorten the construction period. Reduce construction dust and improve environmental quality of construction site.

(5) Post-cast concrete and precast floor form a composite plate as a whole, and the composite structure participates in the stress as a whole, which has high rigidity. After receiving the external load, the deformation of the composite plate is small, which effectively improves the shear and bending resistance of the composite structure. Compared with the fully prefabricated floor, the connection between the composite floor and wallboard, beam and column is better in integrity, which is conducive to earthquake resistance. The anti-crack treatment effect between slab joints is good, the overall anti-crack ability is increased, cracks are not easy to occur, and the waterproof performance of the floor slab is improved.

2)Disadvantages of composite floor

At present, there are still many shortcomings and immature places in the laminated floor, and the various forms of laminated floor in the market also have their own manufacturing and design defects.

(1) There are great requirements for the professionalism of workers, the factory prefabricated laminated plate needs professional workers to operate, and each step of operation must meet the requirements; after the production, the hoisting of laminated plate needs special lifting tools and professional construction workers to operate. In general, the precast floor needs to be maintained in the precast workshop, which costs relatively high; different laminated slabs have different precast floor structures, so the acceptance of precast floor needs special machines for testing, and the technology and machines need to be constantly updated to cultivate workers' professional knowledge.

(2) When the precast floor has concrete ribs or multi ribbed structure, the hydropower pipeline can only be arranged according to the concrete ribs and multi ribbed lines, which is easy to cause the waste of pipeline. In the process of concrete pouring in the composite layer, it is necessary to carry out sufficient vibration. The rib holes should be filled with concrete to make the composite plate completely dense and improve the bonding force and integrity.

(3) The shear performance of composite slab is determined by the bonding force of precast bottom plate and cast-in-place concrete layer, so the shear design of composite surface is very important. The construction unit has high technical requirements when pouring the composite layer concrete, so as to ensure that the composite slab can achieve the designed shear strength.

III. Study on the Structure of M-type Light Steel Concrete Composite Slab

3.1 Survey

M-type light steel concrete composite plate is a new type of composite plate, which is upgraded and improved by understanding the existing composite plate structure and manufacturing process, such as the four typical composite plates detailed in the previous chapter and research reference materials, combined with the company's patented products on their structural basis and characteristics.

M-type light steel concrete composite slab is a new type of composite slab, which is connected by M-type light steel and metal mesh with fasteners. After arranging the bottom plate distribution reinforcement and insulation board, pouring concrete to prefabricate the bottom plate. After the construction site installation is completed, pouring composite layer concrete to form a new type of composite slab. M-type light steel concrete composite

slab is composed of M-type light steel, metal mesh, insulation board, self tapping screw, embedded parts and structural reinforcement. The M-type light steel concrete composite plate with wall thickness of 0.8 mm, 1.00 mm and 1.2 mm is selected as the section steel plate. The spacing between the sections is generally 300 mm or 400 mm. The M-type light steel is connected with the metal mesh by self tapping screws, and the insulation plate is filled between the M-type light steel and the distributed reinforcement at the bottom of the plate.

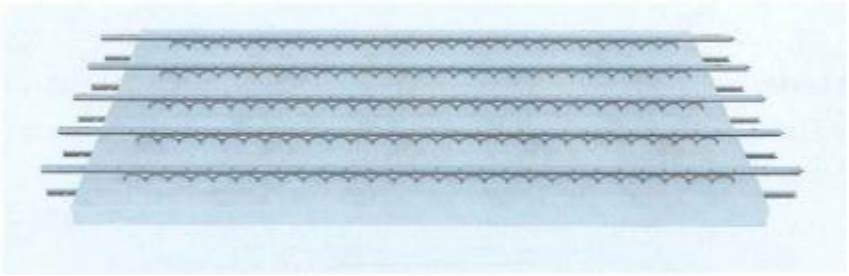

Fig 1: Schematic diagram of M-type light steel concrete composite slab precast bottom plate (works of the company)

3.2 Material

M-type light steel, sheet metal mesh and connectors shall be made of Q235 and Q345 steel which meet the current national standards and meet the design requirements. When some special projects have special requirements for the materials used, other grades of steel can also be selected for design and processing according to the basis. Before the installation of the composite slab, the performance of materials such as bearing stiffeners, rigid supports and temporary supports shall be checked and accepted, which shall conform to the corresponding national standards. The external dimensions and mechanical properties of ordinary bolts shall comply with the current national standards. Self-drilling screws and self-drilling screws shall comply with the current national standards. Generally, concrete with C30 and C40 strength is selected for precast floor and composite layer. Ordinary rebar of grade HPB300, grade HR.B335, grade HRB400 and grade HRBF400 should be adopted for distributed rebar of composite slab.

3.3 Test results of wood properties

The material property test of m-section light steel is one-way tensile test. The specimens are made of the same batch of m-section light steel as the laminated plate. The steel grade is Q235, the width is 140cm, the length is 600mm, and the wall thickness is 1.0mm. The material property test of M-type light steel is carried out in the laboratory of China Academy of building materials science, and the test data are accurate. The test results of M-type light steel are shown in the figure.

Fig 2: Material property test report of M-type light steel

It can be seen from the inspection report that the tensile strength of M-shaped light steel with a thickness of 1.2mm reaches 469 MPa, and the mechanical properties of finished Q235 steel plate number are 374MPa, which meets the industry standards. The measured yield strength is 328MPa, which is greater than the nominal yield strength of 235MPa. The ratio of measured tensile strength to measured yield strength is greater than 1.2, and the elongation of section steel is greater than 20%, which meets the requirements of Code for Seismic Design of Buildings GB/T50011-2010.

The design grade of concrete poured by M-type light steel concrete composite slab is C40. The cube concrete test block with 150 mm side length is made in the laboratory, and the curing age is 28 days under standard conditions. According to the current national standard GB/T 50081-2002, the compressive strength of concrete is measured. The compressive strength test results are shown in Table 1.

Table 1 Concrete compression test results

Design strength grade	Specimen size (mm)	Specimen number	Experimental value (N / mm^2)	Error (%)
C40	150×150×150	SK1	28	4.4
		SK2	28.5	6.3
		SK3	27.9	4.1
		Average value	28.1	4.8

It can be seen from table 1 that the actual measured values of tensile strength of test blocks made of concrete poured by composite slabs are higher than the design standard values of compressive strength of standard test pieces.

3.4 Characteristics of M-type light steel reinforced concrete composite slab

1) Advantages of M-type light steel concrete composite slab

(1) Independent research and development of main components. Compared with other components used in laminated plate, the main components of M-type light steel laminated plate structure, such as M-type light steel and metal mesh, are the products of the company. There are a large number of practical engineering cases, which

are safe and reliable. They have in-depth research on various material properties of components, and retain the first-hand data.

(2) Embedding of insulation board. In the existing laminated plate structure, few thermal insulation boards are embedded in the precast floor. During the manufacturing process of the composite board, the insulation board is directly made into the composite board, which has the same service life as the composite component, and does not fall off in advance. It meets the needs of the integration of structure and insulation, and conforms to the concept of prefabricated building development. For the northern area with high thermal insulation requirements, the laminated board system has a great market prospect.

(3) The manufacturing process is simple. Compared with the prestressed concrete composite slab, the composite slab system uses ordinary reinforcement, which saves the process of tensioning prestressed reinforcement. Compared with the fabrication process of the precast bottom plate of the reinforced frame, the fabrication of the double M-type light steel members is simple, and only two sections with the same specifications need to be bound by stirrups. During the pouring of precast floor, the metal mesh and insulation board can be used as the formwork at the bottom of the slab, which reduces part of the formwork time.

(4) The integrity of connection nodes is high. Both the composite slab and the distributed reinforcement have reserved lengths to facilitate the connection of nodes. The mechanical characteristics of section steel are higher than those of steel bars of the same specification. When the laminated plate section steel is connected with wallboard and beam, the section steel is directly built into wallboard and beam, and the longitudinal reinforcement and transverse reinforcement are overlapped and anchored according to the current national standard, which increases the structural safety of joints.

(5) The bottom plate has good crack resistance. On the construction site, after the precast floor is hoisted and placed, the reserved transverse reinforcement is bound at the flat-fell seam to form a steel mesh, and the metal mesh is cut to the same width as the flat-fell seam, and nailed into the steel skeleton. The flat-fell seam is of integral structure. After pouring concrete, the composite slab has good integrity and better crack resistance, and can transmit shear force and bending moment. Compared with the general treatment of flat-fell joints of laminated plates, it has great advantages.

2) M-type light steel reinforced concrete composite slab

(1) In the current research, the stability of the double M-type light steel formed by binding is not high, which is easy to cause the weak connection point, and will have a certain impact on the stress. In the follow-up structural research, we should increase the treatment here, adopt a more reliable connection mode or design a special light steel for floor slab.

(2) The embedded insulation board improves the thermal insulation performance of M-type light steel concrete composite board, but the insulation board is a light material, so it needs anti floating treatment to avoid the floating of insulation board during concrete pouring, which makes the precast board thicker and increases the difficulty of hoisting and transportation.

(3) The problem of cold bridge has not been solved effectively. The thermal insulation board is arranged between the steel bar and the section steel. There is no thermal insulation board in the internal gap of double-m light steel. It is easy to form the problem of cold bridge and reduce the thermal insulation effect of the whole composite board.

V. Conclusion

With the acceleration of the process of building industrialization, prefabricated building has been paid more and more attention. More and more national and local policies begin to favor prefabricated building. The study of composite structure is conducive to the development and improvement of prefabricated buildings. We should increase the experimental research on M-type light steel concrete composite slab, draw the standard reference atlas, develop the supporting equipment, improve the M-type light steel concrete composite structure system,

vigorously promote the composite slab system, and provide contribution for the development of composite structure.

The cost calculation of prefabricated laminated plate involves many aspects, because of my limited level and less information about the cost of laminated plate. This paper only calculates the material of the laminated plate, hoping that in the future, the laminated plate can be selected by reference to the actual project, and the cost of production, transportation and installation can be added to calculate the cost of the whole process of construction, so as to improve the cost of the laminated plate and provide a more reliable basis for the reasonable selection of the laminated plate in the construction project.

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