Study On Construction Technology And Stacking Problem Of Laminated Plates

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Abstract: Construction industry has characteristics of high intensity of labor, complicated working environment and field work. The minuses far overweight that possible gain. Prefabricated construction can over come the shortcomings of traditional architecture and it can go through the hoops with its own predominance. The industrialization of buildings is at a stage of development. There are many problems in all aspects of production, hoisting and installation. Take an example of an assembly plant in Shandong as an example, we go through the study of the construction of the laminated plate, the problems of the stacked plate in the process of production and stacking are clarified.

1. Introduction

In China, prefabricated buildings have a long history. Even the prefabricated concrete structure has been used in our country for nearly half a century. Since the slogans on the industrialization of architecture were proposed by New China in the 1950s, due to the influence of various unfavorable factors in China, the assembly technology has been lagging behind. In recent years, China’s fabricated concrete technology has rapidly developed through the use of good foreign technologies and government support. Domestic scholars have a lot of research on many processes of laminates. However, there are few studies on the cracking of laminated plates due to the size of laminated plates. The author of this article introduced the production process of laminated boards and studied the cracking problems during the stacking process. The effect of the size of the laminate on its cracking was clarified and the construction process was perfected.

2. Project example

The project of Jinan Vanke is residential land along Jingshi Road, covers an area of 103870m\textsuperscript{2}, and the building area is 422744m\textsuperscript{2}. The residential building beams and pillars of No.1, No.2, No.9 and No.10 are cast-in-place, and the floor slabs are laminated. The board will be divided by the design institute on each floor and then the production of laminated boards will be carried out at the prefab plant. Finally, the laminated board is transported to the site for lifting and installation.

2.1. Construction process and problems

(1) In the production of laminated plates with a side die of 60 mm height, the thickness of the laminated plate is often more than 60 mm after being lifted and lifted, which does not meet the requirements for use.

(2) When the production plan is arranged according to the installation area, the types of laminates
produced each day are different. Workers need to be familiar with drawings repeatedly, which is not only error-prone but also reduces production speed. The actual production quantity usually does not meet the requirements of the plan.

(3) The size and fulcrum of the component have influences on the cracking moment of the component and the maximum bending moment in the plate. The designers lack the theoretical research in this field.

3. Production processes
When a worker casts concrete in a funnel, he cannot accurately determine the amount of concrete. The amount of concrete is often too much, resulting in plate thickness exceeding 60mm after production of the plate. As shown in Figure 1; The truss is connected by a stainless steel wire and a reinforced mesh. The distance H between the truss and the surface of the laminated board decreases with the increase in the thickness of the truss. After the laminate is installed, arrange the reinforcement and piping above it. Pipes sometimes need to pass between trusses and laminates. When H is smaller than the diameter D of the pipeline, the pipeline cannot be installed; On the other hand, as the thickness of the laminate increases, the thickness of the upper cast-in-place panel will decrease, and there may be a phenomenon of loosing. The laminated board profile is shown in Figure 2.

![Figure 1. Lamination of laminates](image1.png)

![Figure 2. Laminated board profile](image2.png)

Solution: The funnel used for pouring is a regular geometric figure. According to different heights, the volume of the funnel can be accurately calculated. With this characteristic of the funnel, technicians modify the funnel. The technician marks the inside of the funnel with a corresponding tick mark to indicate the volume of the funnel at this height. In addition, the technician counts each type of laminate and adds the volume of each panel to the production schedule. In the concrete pouring process, workers can accurately grasp the amount of concrete. Finally, professional training is conducted for workers to improve their technical skills and sense of responsibility, strengthen management, and reduce human error.

4. Improve production planning
In the design stage, when the designer decomposes the laminated plate according to the unit modulus through the construction drawings, there are many types of components, as shown in Figure 3. When the production plan is arranged according to the location of the area where each floor is installed, the type of laminated plates produced by workers on a daily basis is different. Technicians need to repeatedly guide the work of workers. Low worker proficiency leads to low productivity, and laminates cannot be produced as planned. On the other hand, the types and number of steel bars and
trusses are prone to errors, resulting in the quality of laminated plates not meeting the requirements and not being transported to the construction site for installation. Laminated panels are returned to the factory for re-prefabrication, which takes time and effort to increase costs.

Figure 3. Partial location prefabricated floor plan layout

Solution: The design department re-disassembled the components according to the drawings and optimized the size of the laminated board as much as possible. Compared with the original design scheme, the type of the laminated board was reduced. When each floor member is split, the model of each laminate is matched with its corresponding standard layer to achieve the standardization of the mold and the usage rate of the mold is improved.

When arranging production plans, three to five layers are used as a production cycle. The designer first divides the installation area of each layer, and then calculates the type and quantity of the laminated plates. When technicians arrange production plans according to the production cycle, the same type of laminates are completed one or two days and stacked in a specific site. According to the construction progress, the superimposed plates in each area are transported to the construction site in sequence for the installation of plates. After changing the production plan, because of the repeated production of the same type of board, the proficiency of the workers was improved, the production efficiency was significantly accelerated, and the quality of the boards was greatly improved due to the reduction of manual errors.

5. Research on cracking in stacking process
After the production of laminated plates was completed, the quality inspection personnel found some cracks along the width direction at the bottom of the plates, which affected the quality of the plates. To solve this problem, technicians performed theoretical calculation analysis and research on the effect of the size of the laminate on its cracking.

Theoretical calculation: According to the “Specifications for Design of Concrete Structures”, the bending moments of cracks in reinforced concrete flexural members are represented by equations (1) to (5):
In the formula: Take different laminate sizes for calculation. Take a 1200×3000 mm laminate as an example. The load standard value is 4.2 KN/m. The calculated maximum bending moment is 0.945 KN·m, and the bending moment diagram is shown in Fig. 4.

\[ M_{cr} = \gamma W_0 \]  
\[ \gamma = (0.7 + \frac{120}{h}) \gamma_m \]  
\[ W_0 = \frac{I_0}{\gamma_0} \]  
\[ x_0 = \frac{1}{2} bh^2 + (n-1)A_s x_0 \]  
\[ I_0 = \frac{h}{3} [x_0^3 + (h-x_0)^3] + (n-1)A_s (h_0 - x_0)^2 \]

Substituting the data of the laminate into the formula:
\[ \gamma = (0.7 + \frac{120}{400}) \times 1.15 = 1.15 \] (When h<400 mm, h takes 400 mm)
\[ a_s = 20 \text{ mm} \quad n = 14 \quad A_s = 201 \text{ mm}^2 \]
\[ x_0 = \frac{1}{2} \times 3000 \times 60^2 + 13 \times 201 \times 40 \]
\[ = 300 \times 60 + 13 \times 201 \]
\[ = 30.03 \text{ mm} \]
\[ I_0 = \frac{3000}{3} \times (30.03^3 + 29.97^3) + 13 \times 201 \times (40 - 30.03)^2 \]
\[ = 54060100.71 \text{ mm}^4 \]
\[ W_0 = 1802003.4 \text{ mm}^3 \]
\[ M_{cr} = 1.15 \times W_0 \times 1.43 = 2.963 \text{ KN} \cdot \text{m} \]

The adjusted cracking moment is: \[ M_{cr} = 2.694 \text{ KN} \cdot \text{m} \]

According to the above method, calculations are performed on plates of various sizes. The maximum bending moment values and cracking bending moment values corresponding to the various sizes of the plate are shown in Table 1.

| Numble | Board model | Plate bending moment | Mcr/KN·m |
|--------|-------------|----------------------|----------|
| 1      | 1200×3000   | 0.945                | 2.694    |
| 2      | 1200×4000   | 1.735                | 3.687    |
| 3      | 1200×5000   | 2.626                | 4.490    |
| 4      | 1200×7000   | 5.143                | 6.455    |
| 5      | 3000×3000   | 2.364                | 2.694    |
| 6      | 3000×4000   | 4.339                | 3.687    |
| 7      | 2000×4000   | 2.893                | 3.687    |
From the above formula and table, it can be seen that when the width of the plate does not exceed 300mm, the cracking moment of the laminated plate varies with its length, regardless of the width. Both the length and width of the plate affect the maximum bending moment between the plate support and the plate. When the board width is less than 3000mm, the aspect ratio of the board should not exceed 6:1. To prevent the production of cracks in the laminates, the cracking moments and the maximum bending moments of the components should be calculated during the design stage, and the aspect ratio of the components must be strictly controlled.

6. Conclusion
Through the construction practice in prefabricated factories, the funnels for pouring concrete were reconstructed in light of the problems in the production process, and the production plan for laminated plates was improved. For the problem of cracking of laminates, the authors studied the effect of the size of the laminate on its cracking, and found that the length-width ratio of the panel affects its cracking. The aspect ratio of the panel should not exceed 6:1. On the one hand, the improvement of funnels and production plans not only improves the productivity of workers but also improves the quality of laminates. On the other hand, the study of the dimensions of laminated plates has provided a theoretical basis for deepening the division of plates at the design stage.

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