

## SMART MANUFACTURING: OPTIMIZATION TECHNIQUES FOR LAMINATED PLYWOOD PREFABRICATION

**Wang Chen**

Department of Architectural Engineering, Binzhou Polytechnic, Binzhou, China

### **Abstract:**

*: To align with national policies aimed at fostering sustainable and healthy growth in the construction industry, Shandong Province introduced the "Shandong Prefabricated Construction Development Plan (2018-2025)." This plan underscores the importance of propelling the sustainable and healthy advancement of prefabricated buildings. Furthermore, to facilitate the widespread adoption of prefabricated construction methods and foster the modernization of the construction industry, the Binzhou Housing and Urban-Rural Development Bureau, in collaboration with other relevant authorities, issued "Opinions on Further Promoting the Development of Prefabricated Buildings." These opinions lay out essential guidelines, including development tasks, approval processes, supervision mechanisms, policy incentives, and employment security measures, all aimed at accelerating the growth of prefabricated buildings. Prefabricated construction stands as a pivotal catalyst for transforming the old and new energies within the construction industry. It offers an eco-friendly, low-energy building approach and has garnered the attention of governmental bodies at all administrative levels. This research endeavors to explore and enhance the production processes and equipment involved in prefabricated component manufacturing. This, in turn, represents a critical step in advancing the development of prefabricated buildings and facilitating the transformation and upgradation of the construction industry.*

**Keywords:** Prefabricated buildings, Sustainable development, Construction industry, Production process optimization, Policy implementation

### **1. Introduction**

In order to implement the requirements of various policies such as the "Opinions of the General Office of the State Council on Promoting the Sustainable and Healthy Development of the Construction Industry", Shandong Province formulated the "Shandong Prefabricated Construction Development Plan (2018-2025)" to promote the sustainable and healthy development of prefabricated buildings. In order to further promote the development of prefabricated buildings throughout the city and promote the transformation and upgrading of the construction industry, the Binzhou Housing and Urban-Rural Development Bureau, etc. jointly issued "Opinions on Further Promoting the Development of Prefabricated Buildings", clarifying the city's prefabricated construction development tasks, approval and supervision, implementation of preferential policies, job security, etc., to accelerate the development of prefabricated buildings.

Prefabricated buildings serve as a starting point for the conversion of old and new kinetic energy in the construction industry, and are a green, low-energy construction model. Its development has received attention from departments at all levels. Research and optimization of the production process and equipment of prefabricated components is a necessary measure to promote the development of prefabricated buildings and promote the transformation and upgrading of the construction industry.

## **2. Problems in the production of prefabricated components**

### ***2.1 There are many process links in the production process that cannot meet the requirements of energy saving and emission reduction***

At present, the production of prefabricated components is mainly customized according to the different requirements of different projects. Due to the diversification of component sizes and various types of components, different projects cannot use the same mold. After a project is completed, the molds will be stacked in the warehouse, making component management more difficult, resulting in increased production costs.

On the other hand, the individual characteristics of components also lead to molds being scrapped after the end of an engineering project. Production enterprises can only choose to stack them in warehouses or sell waste products, resulting in great waste.

Researching and optimizing the production process and equipment of prefabricated components can improve the utilization rate and turnover rate of molds, and reduce waste of concrete materials<sup>[1]</sup>. It is sufficient to promote the development of energy saving and emission reduction technology while reducing the operating costs of enterprises, which has a certain effect on improving the economic efficiency of enterprises.

### ***2.2 There are still some problems with the working environment for workers in the production of assembled components***

In the production process of prefabricated components, there are unsafe construction processes and behaviors such as production workers working overloaded; hoisting molds and components lack technical standards; and smashing components with a heavy hammer when unmolding<sup>[2]</sup>. Therefore, researching and optimizing the production process and equipment of prefabricated components can provide a safer working environment for workers in the production of prefabricated components.

### ***2.3 Compared with the construction stage, the production stage pays more attention to the research of the construction stage***

The construction stage is a visible production process, so there is a lot of research on the construction stage of prefabricated buildings. Since research at the production stage is research across disciplines such as civil engineering and electrical machinery, the process is complicated, and the requirements for researchers are relatively high, so most of the research is biased towards a single professional construction stage.

### ***2.4 There is a lack of systematic safety operating procedures in the production process of fabricated components***

There is a lot of cross-work in the production of prefabricated building components; lifting and hoisting machinery such as gantries is required to hoist formwork, etc.<sup>[3]</sup>; rebar trusses require manual handling, etc. More scientific safety operating procedures need to be formulated for each process.

## **3. Suggestions for optimizing and improving the production process of prefabricated laminated plywood**

### ***3.1 Optimize the mold design and demoulding process, reduce the deformation of the component mold and improve the utilization rate***

In the production process of assembled components, the gap of the mold is relatively large. Concrete is poured into some of the gaps without being filled, which causes the concrete to leak out. Leaking concrete will also bond the mold to the component, affecting mold removal. In order to be able to disassemble the mold, the production personnel will hang the component together with the mold, and then hit the mold with a heavy hammer to make it fall to the ground to demould the component. However, this demoulding method accelerates the deformation of the mold. Defects in the equipment and the roughness of the stripping process make this vicious cycle reduce the use effect and turnover rate of the mold, increase the labor intensity and workload of workers, cause noise pollution, and raise production costs.

### ***3.2 Optimize the concrete pouring process, improve the degree of equipment automation, and improve pouring efficiency and effectiveness***

In the production process of precast concrete components, it is often discovered that there are various defects in the appearance of concrete components after unmolding. Basically, they can be determined through visual inspection, that is, the apparent defects of concrete. Apparent defects in concrete generally refer to problems such as dense bubbles on the surface, sand spots, sand leakage, etc. The vast majority of them are more or less present in various components. Once these defects exceed the limit value, they will affect not only the appearance, but also the durability of the concrete precast components. The main reasons for the apparent defects of concrete are the problems of the construction technology in the construction process, and the problems of the use of the production formwork. However, the gravel material, mixing ratio, unloading method, formwork, etc. used in the construction process of the component factory cannot be changed in general, so improvements can only be made in terms of affecting the apparent quality of the components, reducing the viscosity of concrete, promoting the emission of bubbles, and improving the mold removal effect.

### **3.3 Revise safety operating procedures for high-risk parts**

The production of prefabricated building components is carried out indoors, but its technological process is similar to that of the construction site. For example, there is a lot of cross-work; lifting and hoisting machinery such as gantry is required to hoist formwork, etc.; rebar trusses require manual handling, etc. More cross-work and more lifting work means that there are more safety monitoring points at the production site. Workers carry a lot of weight when carrying, and the damage to the worker's body is greater. In order to improve process safety and ensure the safety and health of production personnel, it is necessary to formulate more scientific safety operating procedures.

## **4. Suggestions for optimizing the production process of prefabricated laminated plywood**

### **4.1 Mold table cleaning**

A sealing device for mold gaps has been designed and laminated plywood is produced. Mold cleaning does not require lifting, gravity hammering, etc., to eliminate adhering to the coagulation map, etc., but only a very small amount of concrete leaks. Mold cleaning mainly cleans concrete on all sides of the mold, and mold table cleaning mainly removes large pieces of abrasion and stickiness; requires light tapping, removal, and grinding of the mold to achieve no dust by hand, and no foreign matter. The mold table is bright and clean, and the visual inspection is bright, no foreign objects, no dust, and no protrusions.

### **4.2 Scribing**

The second step of the prefabricated laminated plate production process is marking the table, as shown in Table 1.

*Table 1: Scribing*

Process steps numbering	Job content and method	Tooling tools Accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Ruler draw point	Chalk	Box ruler	Consistent with drawing size
2	Two dot line	Ink bucket	Box ruler	Be consistent with the drawing size, and ensure the perpendicularity and straightness

### **4.3 Coating accessories, mold assembly**

The third step of the prefabricated laminated plate production process is to brush the auxiliary materials to prevent concrete adhesion on the assembly platform and assemble the laminated plate mold, as shown in Table 2.

*Table 2: Coating accessories, mold assembly*

Process steps numbering	Job content and method	Tooling tools Accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Side mold brush oil	brush, oil	none	Apply the accessories evenly in the matching area to ensure full coverage of the inner surface of the edge mold
2	Side release mold	none	Rectangular ruler	Side mold and line alignment, edge mold interface alignment
3	Magnetic box	none	none	Be sure to press both ends of the side mold to ensure the level below the magnetic box
4	Fuel injection	injector, oil	none	Ensure full coverage within the side mold range

#### 4.4 Inspection mold assembly

The fourth step of the prefabricated laminated plate production process requires the inspection of the mold assembly to prevent the subsequent work from being affected, as shown in Table 3.

Table 3: Inspection mold assembly

Step number	Job content and method	Tooling accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Inspection (mold assembly)	none	Rectangular ruler	The deviation is within the allowable range

#### 4.5 Lashing rebar trusses

The fifth step of the production process of prefabricated laminated board is binding steel truss, which includes installing plastic bracket, binding steel bar, placing truss, binding truss, placing boom, binding boom, marking wiring box, rechecking edge die card slot filling foam, and transporting, etc., as shown in Table 4.

Table 4: Lashing rebar trusses

Process steps numbering	Job content and method	Tooling accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Install the plastic bracket	none	none	Make sure the rebar snaps into the bracket card slot
2	Lashing steel bars	hooks	none	Make sure the steel bars are tied tightly

3	Put the truss, tie the truss	hooks	Box ruler	Make sure the position is consistent with the drawing and the binding is secure
4	Set the boom, tie the boom, mark it	hooks	Box ruler	Make sure the position is consistent with the drawing and the binding is secure
5	Discharge the cable box, re-check	hooks	Box ruler	Make sure the position is consistent with the drawing and the binding is secure
6	Side mold card slot filled with foam	none		Make sure each card slot is tightly filled
7	ferry	none	none	Pay attention to the front and rear mold table scheduling to prevent collisions

**4.6 Arrangement and embedded reservation and hydropower pipeline installation and inspection (concealed project acceptance)**

Steel bar connection sleeve, embedded parts, reserved holes, water and electricity pipelines, etc. belong to concealed works. Installation and inspection of these embedded reservations and water and electricity pipelines should be carried out before concealment, as shown in Table 5.

*Table 5: Arrangement and embedded reservation and hydropower pipeline installation and inspection*

Process steps numbering	Job content and method	Tooling accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Rebar connecting sleeve	none	steel tape measure	Place it according to the center line and verticality requirements; Ensure that the specifications and models are correct
2	Embedded parts	none	steel tape measure	Placed according to vertical or horizontal installation requirements;
				The quantity specifications are correct; Exposure inspection.

3	Reserved holes	none	steel tape measure	Accurate position, size and quantity
4	Water and electricity pipelines, etc.	none	steel tape measure	Arrange according to the "Wiring Operation Map"

#### **4.7 Feeding, distribution and vibration**<sup>[4]</sup>

After the installation and inspection of the embedded reservation and water and electricity pipelines, the concrete shall be transported, poured and vibrated by relevant machinery, as shown in Table 6.

*Table 6: Feeding, distribution and vibration*

Process steps numbering	Job content and method	Tooling accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Descending stage	none	none	Ensure that the mold table is in place and the vibrator is tight
2	cloth	remote control	none	The cloth is full and leak-free
3	pave	Chops	none	Ensure that the concrete of each side mold is full and flat
4	vibrate	none	none	Ensure that the concrete of each side mold is full and flat
5	Masumodai	none	none	Ensure that the mold platform is back in place

#### **4.8 Pre-brushed demagnetized box**

The eighth step of the prefabricated laminated plate production process is the pre-drawn magnetic box removal, and its requirements are shown in Table 7.

*Table 7: Pre-brushed demagnetized box*

Process steps numbering	Job content and method	Tooling tools Accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Put the label	none	none	Arrange according to the requirements of the drawings and attach to the surface
2	Demagnetize the box	crowbar	none	Avoid side die deformation or material leakage



3	Artificial bristles	Four-tooth rake	none	Horizontal laminated plywood requires this process
---	---------------------	-----------------	------	--

#### **4.9 Palletizing**

The ninth step of the prefabricated laminated plate production process is palletizing, and its requirements are shown in Table 8.

*Table 8: Palletizing*

Process steps numbering	Job content and method	Tooling tools Accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Into the warehouse	none	none	Record mold warehouse, laminated plywood number
2	out of warehouse	none	none	Record mold warehouse, laminated plywood number

#### **4.10 Mold removal and lifting**

In the process of mold removal and hoisting, the strength of the laminated plate should be checked first, and then the lifting, mold removal, lifting, loading and ferrying, etc. The specific requirements are shown in Table 9.

*Table 9: Mold removal and lifting*

Process steps numbering	Job content and method	Tooling tools Accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Check the strength of laminated plate	none	none	Record the laminated plywood numbers
2	Lifted	Hook chain	none	Hold the hook smoothly at the four lifting points to balance the lifting
3	Mold removal	Hammers, iron bars	none	Remove the side mold vertically to prevent product damage
4	Lift and load	Hooks, trailers	none	Balanced lifting and smooth placement on the trailer
5	ferry	none	none	Pay attention to the front and rear mold table scheduling to prevent collisions

#### **4.11 Cleaning**

The last step is cleaning: storing the side die, cleaning the side die and cleaning the die table, as shown in Table 10.

*Table 10: Cleaning*

Process steps numbering	Job content and method	Tooling tools Accessories	Measurement tools	Key Quality Control Points & Safety Tips
1	Side mold for storage and storage	none		Classify side molds of different sizes
2	Clean the side mold	shovel		No concrete residue on the surface of the side mold
3	Clean and clean the mold table	Shovel, broom, spade		No residue on the mold table surface

## 5. Conclusion

The popularization of prefabricated structures is suitable for the development of energy-saving and green buildings, but there are still many problems in the production process of components. By optimizing the production process of prefabricated laminated slab, not only the pouring efficiency and effect of concrete can be improved, but also the safety of the process can be improved to ensure the safety and health of production personnel.

## Acknowledgements

Research on Production process and equipment optimization of prefabricated building components (2020yjkt22).  
Study on quality control and improvement measures of laminated plate production (2022SHFZ016).

## References

- SHEN Zhen-duo. Prefabricated column hoisting construction [J]. Jiangxi Building Materials, 2020 (1): 102-103.*
- Huang Linqing, Liang Yu, Yang Xiaogao. Application of BIM and RFID technology in the hoisting process of prefabricated components [J]. Building Safety, 2020, 35 (2): 42-45.*
- Wang Yu, Zhou Qiang, Zhu Mintao. Application Research of Standardized Component Library Based on BIM Technology [J]. Construction Techniques. 2018 (S1): 72-75.*
- Cai Zhengsen, He Zhe, Hou Ziyi. Cement-concrete distribution technology for tunnel sliding mold construction [J]. Construction Technology and Application, 2018, 35 (4): 77-81.*