Research on the Key Points of Structural Design of General Purpose Mold for Layered Reiteration Plat

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Abstract: Based on the case of a prefabricated component factory, this paper adopts the universal design of a layered reiteration plat mold as the research object to improve the universality of layered reiteration plat molds and reduce the cost of reiteration plat molds without affecting the quality of the components or production efficiency. The traditional layered mold is not limited by the spacing of the ribs and can prevent the ribs from floating and leaking. It has been widely used in the production of reiteration plates, but the generality of the mold is still limited because the traditional layered mold is designed according to the size of the fixed components, and a set of molds cannot be used for the production of other reiteration plates without cutting or transformation. In this paper, a universal purpose mold for layered reiteration plates is studied. This mold can be combined into any plane shape and size by moving any one of the three sides of the mold and combining the two moduli, which completely realizes the universality of the mold. At the same time, in this paper, the design of the universal mold structure was optimized, eliminating the problem of nut pollution and the problem of edge angle loss during demolding. This optimization significantly enhanced the production efficiency and quality of reiteration plates and holds high potential for widespread adoption.

Keywords: Reiteration Plate; Layered Mold; Universal Design of Mold; Key Points of Design

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1 Introduction

As a common precast concrete component, [1] laminated slab molds for production can be divided into two categories: [2, 3] slot type and layered type. Usually, [4, 5] a slotted laminated plate mold is bent by a steel plate (see Figure 1). [6] To enhance the integration of the laminated plate with cast-in-place concrete, [7, 8] a chamfered design is applied to the upper section of the laminated plate. Additionally, [9-11] grooves are introduced at the ribs, and the mold is affixed to the table through welding, [12, 13] bolts, or magnetic boxes. [14] While the slotted die is lightweight, easy to process, and simple to disassemble, it presents challenges in maintaining the production quality of laminated plate components due to susceptibility to deformation and steel bar displacement. Moreover, the slotted mold exhibits limited versatility as it cannot accommodate changes in component dimensions or rib configurations without requiring mold reconstruction. Conversely, [15] the layered die finds extensive utility in laminated plate production. [16] It is not constrained by steel bar spacing, offers a degree of adaptability, [17] and

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effectively addresses issues related to steel bar displacement and slurry leakage.

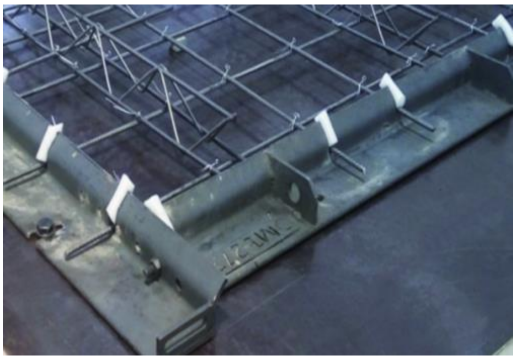

Figure 1 Physical diagram of a slotted laminated plate mold with a chamfer

2 Laminated Die

The layered die comprises four main components: the lower die, a middle layer of flexible material, the upper die, and connecting bolts (Figure 2). The lower mold layer can be affixed to the mold table through welding, bolted connections, or reinforced with magnetic boxes. A layer of flexible material is typically placed between the upper and lower mold layers. After steel bar perforation, the upper mold layer is secured to the lower mold layer using bolts, ensuring the appropriate compression of the middle layer of flexible material to prevent slurry leakage.

Figure 2 Physical diagram of the laminated die structure

In this study, the die perpendicular to the direction of the steel bars in the laminated plate truss is referred to as the side die, while the die parallel to the steel bar direction of the truss is termed the end die. The mold structure is generally configured as the end mold and the side mold (or the side mold and the end mold) [1] (Figure 3). Special adapters are added at the four corners of the mold and secured with bolts (Figure 4).

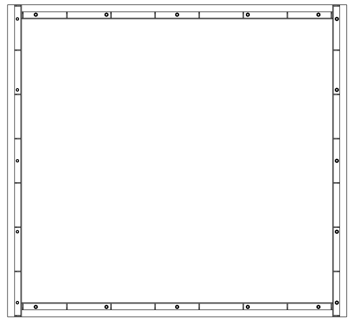

Figure 3 Structural diagram of the end die of the traditional die

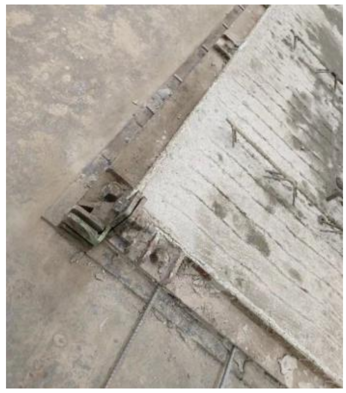

Figure 4 An actual image of four corners connection of traditional mold

The traditional layered die is designed based on the dimensions of the fixed member. Consequently, when there are alterations in the member's size, the length of the side die must be either cut or welded, resulting in a substantial transformation workload. This limitation hampers the overall versatility of the layered die.

3. A New Method for the Design of Layered Dies for General Purpose Laminated Plates

3.1 Modular Scheme

Through extensive research on the universality of the laminated plate die, this paper presents a novel die formation approach (Figure 5). This approach allows for the rapid achievement of universality in the double-layer laminated plate die without the need for cutting transformations. It departs from the traditional practice of encapsulating the end die within the side die (or vice versa) and eliminates the bolt connections at the four corners of the die. In the new method, each side die can move in the direction opposite to the adjacent side die, enabling effective adjustments to the die's dimensions. Consequently, when the dimensions of the laminated plate change, the mold size can be readily adapted by shifting any three sides of the mold [2]. This significantly enhances the mold's versatility. The resulting general lamination die (Figure 6) offers excellent size adjustment capabilities and ease of operation.

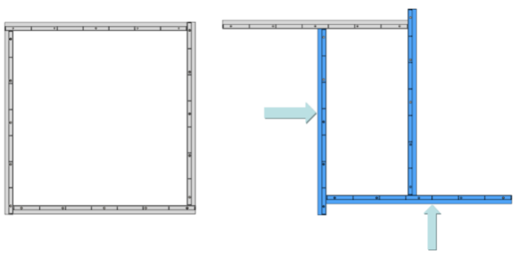

Figure 5 Operation principle diagram of the new modular scheme

Figure 6 Physical diagram of the lamination die for a general purpose laminated plate

This modular scheme is equally applicable to flat laminated plate members, including triangular, rhomboid, and pentagonal laminated plate members (Figure 7).

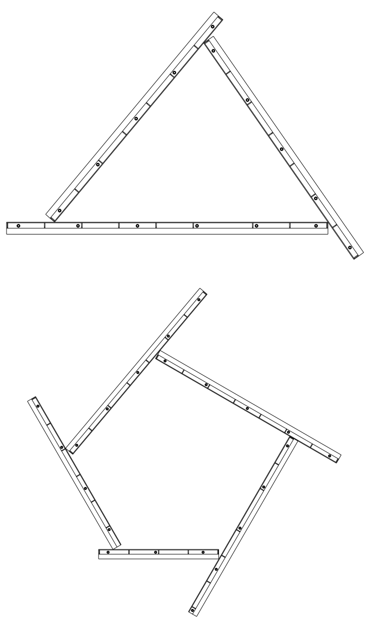

Figure 7 Schematic diagram of the mold combination of special-shaped laminated board members for a certain project

3.2 Modular Design

On the foundation of the new modular scheme, the examination of the modular design system [3] for the laminated plate mold can enhance the mold's adaptability. Using size data from an extensive collection of laminated plates [4], standardized side dies of 1 m, 1.5m, 2m, 2.5m, and 3m are chosen. Multi-sized laminated plate dies can then be constructed by freely combining these standardized side dies.

4 General Lamination mold Design Key Points

The basic principle of mold structure design is to meet the stiffness, strength and bearing capacity requirements of reasonable turnover times to meet the convenience of installation and disassembly, flexible assembly, and light weight. Combining the experience in component production and quality control, the following points are derived for designing the structure of the universal laminated plate mold.

4.1 Key Points of the Lower Mold Design

The lower mold thickness is chosen to ensure the protective layer thickness for steel bars. Considering the mid-layer flexible material applied to the lower mold for steel mesh positioning and easy replacement, the lower mold thickness should account for the remaining thickness of the compressed mid-layer material. This paper specifies a 15 mm protective layer thickness for steel bars with 8 mm nominal diameters for transverse and longitudinal ribs. Thus, the lower mold end die should be designed at 12 mm thickness, and the corresponding side die thickness should be set at 22 mm.

When using 12 mm and 22 mm steel plates directly, two issues arise: first, it is not possible to use a magnetic box for mold fixation, and second, the mold's weight becomes excessive. Therefore, the lower mold design incorporates two or more layers of steel plates welded into a stepped structure (Figure 8), with the lowest steel plate affixed with a magnetic box. The lower die can be assembled flexibly using standard plate thicknesses. For a lower end die thickness of 12 mm, it can be created by combining 6 mm + 6 mm or 8 mm + 4 mm plate thicknesses. For a lower side die thickness of 22 mm, it can be constructed using combinations such as 6 mm + 16 mm, 8 mm + 14 mm, or 6 mm + 8 mm + 8 mm.

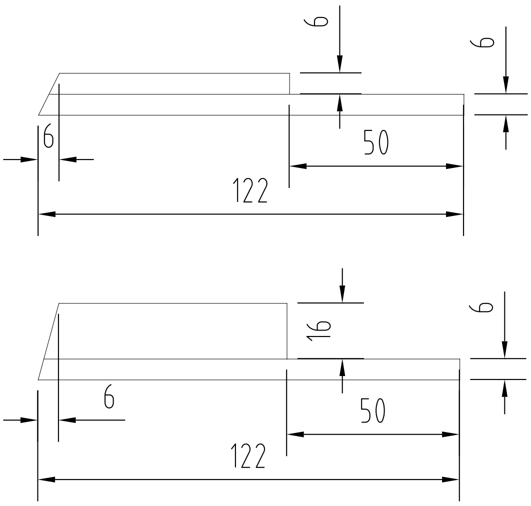

Figure 8 Schematic diagram of the lower molds of "6 mm+6 mm" and "6 mm+16 mm"

To improve production efficiency, the design of an appropriate demolding slope on the lower mold can realize direct demolding without disassembling the lower mold. Compared with the traditional demolding process, this demolding method not only prevents the demolding process of the magnetic magnet and the lower mold but also prevents the formation, positioning and installation of the lower mold. This approach greatly improved the efficiency of mold removal and mold assembly in the production of laminated plate members. Moreover, a reasonable demolding inclination can reduce appearance quality problems such as missing edges and falling angles during the demolding process.

4.2 Design Points of Mid-layer Flexible Materials

The middle-layer flexible materials should possess a balanced level of softness and hardness to fulfill the turnover requirements. In the case of steel bars with an 8 mm nominal diameter, a 10 mm thick sponge strip or rubber strip is frequently employed. It is essential to ensure that the cut opening of the flexible layer around the bolt remains relatively small to prevent pulp leakage at the bolt.

4.3 Main Points of the Upper Die Design

To simplify the assembly of the upper die and lower die, the upper die should feature an elongated waist hole (Figure 9). This design helps mitigate the impact of machining errors on die formation. Simultaneously, the waist hole's placement should ensure ample operational space to prevent any hindrance to the use of an electric wrench during the bolt-fastening process, thereby maintaining work efficiency.

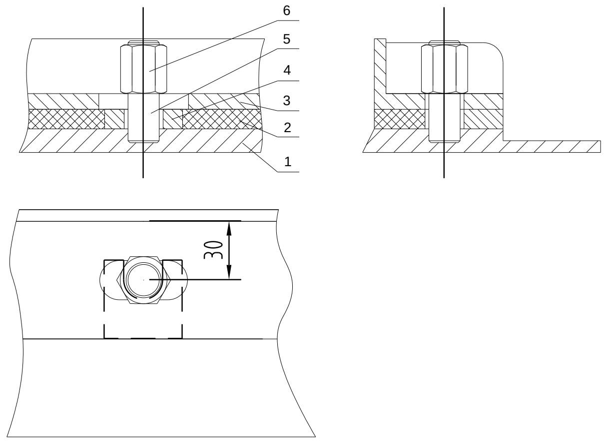

Figure 9 Assembly of the lamination die for a general purpose laminated plate

1 Lower die, 2 middle layer flexible material, 3 upper die, 4 limit block
1 Lower die, 2 middle layer flexible material, 3 upper die, 4 limit block
5 M16 lead rod, 6 M16 nut

4.4 Main Points of Bolt Design

To guarantee the connection quality between the upper and lower die and the slurry blocking effectiveness of the flexible material, it is essential to maintain a bolt spacing within the range of 300–400 mm (Figure 10). The maximum allowable spacing should not exceed 450 mm.

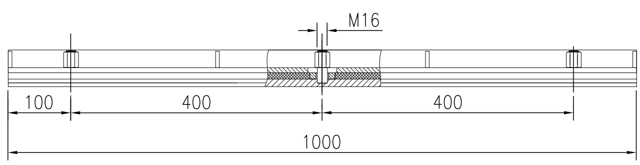

Figure 10 Bolt spacing design of the 1 m standardized side die

The nut of the traditional layered die is welded in the lower die, which can improve the bolt connection speed; however, there are problems such as dust or concrete falling into the nut inside the cleaning device, which results in bolts not being screwed into the predetermined position, resulting in quality problems such as an ultrathick protective layer on the laminated board, an excessive thickness of the laminated board [5], and an insufficient leakage height of the truss bar [6]. In this paper, the lead screw is welded into the lower die, and after the assembly of the upper die, the nut is securely fastened (Figure 9). This approach helps prevent a range of quality issues stemming from nut contamination at the root.

To prevent different nut tightening torques from causing uneven extrusion of flexible materials, which leads to inconsistent die heights in laminated plates, it is necessary to increase the limit structure to limit the extrusion degree of flexible materials. The limit block (Figure 9) is welded onto the lower die. When the nut is tightened until the upper die makes contact with the limit block, it signifies that the nut is securely fastened, and the overall height of the die becomes uniform.

5 Conclusion

According to the study of the general method of generating lamination dies in general lamination dies, the lamination die is completely universal in the true sense, and the cost of the die is greatly reduced. By investigating the essential aspects of designing a layered die for general laminated plates, we were able to optimize the die structure. This optimization addressed the challenges related to the real-world production of general laminated plate templates, resulting in enhanced production efficiency and assured component quality. The practical application of these improvements has yielded significant benefits, suggesting a promising potential for widespread adoption and application.

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