Discussion on Aluminum Alloy Formwork Design Software Postprint

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Date: 2018-07-18T00:00:00+00:00

Abstract

This paper systematically reviews the aluminum alloy formwork design process and existing design software, and explores the development of user-friendly, efficient, and economical design software.

Full Text

Preamble

Discussion on Design Software of Aluminum Alloy Formwork

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Abstract

This paper examines the design process for aluminum alloy formwork and analyzes existing design software, discussing the development of user-friendly, efficient, and economical design software solutions.

Keywords: aluminum alloy formwork, design software, AutoCAD, BIM

1. Current State of Aluminum Alloy Formwork Design

Currently, two primary aluminum alloy formwork systems are used in the market: rod systems and plate systems. While their design processes are fundamentally similar, the key difference lies in installation methodology. Plate system plates pass through formwork joints, requiring strict joint alignment in wall formwork to ensure proper plate installation and structural safety of walls and columns. Rod system tie rods typically pass through the middle of formwork

panels. Although joint alignment is also required in principle, the demands are less stringent than for plate systems. Additionally, rod systems must be paired with walers to constitute a complete formwork design.

Aluminum alloy formwork design encompasses preliminary area estimation, detailed formwork drawing production, formwork matching design (including main structures, stairs, suspended formwork, and variation floors), statistical reporting, fabrication drawings, construction drawings, pre-assembly, numbering and packaging, and on-site assembly.

1.1 Formwork Quantity Estimation

During the bidding or quotation phase, detailed design has not yet begun. Accurate quantity estimation requires calculating the formwork area for each member, which involves substantial workload and risks of omission. Alternatively, rapid estimation based on experience depends on extensive practical engineering experience, affecting accuracy.

1.2 Design Detailing

Design detailing is a comprehensive task that tests the overall capability of aluminum formwork designers. Based on design institute blueprints, it must fully and accurately express both the blueprint requirements and client demands while facilitating formwork design, fabrication, and construction. For example, partition walls between doors/windows and beams should be modified to suspended beams; short wall piers adjacent to columns and shear walls should be cast together with columns and walls; door/window recesses, drip lines, slab openings, and architectural finishes must all be reflected in detailed drawings. This detailing work is the most critical and technically demanding aspect of aluminum formwork design, requiring repeated communication and revision with the design institute, client, and general contractor. Ideally, this work should be involved in the early design phase of the design institute. This portion of work is difficult to replace with software.

Funding: Applied Technology Research Project of China Academy of Building Research, "Research and Development of Intelligent Design Software for Aluminum Formwork Construction Based on BIM Technology" (Project No.: 201601200330730035).

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1.3 Formwork Layout

This task is extremely complex, involving massive quantities of formwork for a single project. Many designers still use AutoCAD for 2D layout design, drawing and labeling each formwork panel individually on plan drawings. Deter-

mining whether vertical formwork overlaps on plan drawings requires strong spatial imagination from designers, particularly for complex conditions such as door/window openings and member intersections where solid modeling is relatively complicated. This often leads to omitted formwork, overlapping panels, or chaotic numbering. The layout and drawing process is inefficient, verification is difficult, and many problems ultimately must be discovered and resolved during pre-assembly.

Many structural features such as drip lines, door/window recesses, and openings are typically handled by installing plastic strips or blocks on formwork, which also require design layout and graphical representation. These small accessory components vary in size, shape, installation position, and orientation, requiring designers to individually code and draw corresponding fabrication drawings, demonstrating the complexity of formwork matching work.

1.4 Aluminum Formwork Statistics

Based on layout design, compiling statistical reports of various formwork quantities is meticulous work prone to omissions. Currently, many designers create different blocks or plain text for various formwork specifications in AutoCAD, using AutoCAD's built-in data statistics functions to calculate quantities. After extraction, manual data merging, splitting, or sorting is still required. Without plugin or software assistance, errors easily occur.

1.5 Fabrication Drawings

Non-standard formwork requires fabrication drawings for factory production. The vast majority of these drawings are manually created in AutoCAD.

1.6 Construction Drawings

Installation construction drawings are primarily plan drawings. To avoid text overlap and ensure clarity, walls/columns, beams, and slabs are drawn separately. For clear expression, elevations and sections are sometimes required, all of which must be manually drawn in AutoCAD by designers, creating massive data volumes and error risks.

1.7 Pre-Assembly

The aforementioned aluminum formwork design work involves extremely cumbersome graphics and data processing. Despite designers' careful attention, errors and omissions are difficult to avoid with existing tools. Therefore, pre-assembly is required for inspection and discovery. Pre-assembly involves complete assembly at the factory according to actual project formwork. Through pre-assembly, design errors are corrected before numbering, packaging, and shipping to the construction site.

2. Basic Requirements for Aluminum Alloy Formwork Design Software

In aluminum alloy formwork design, designers are the primary actors, and even the best software serves only as an auxiliary tool. Therefore, software development should follow the design process and align with designers' thinking, rather than designing software first and then requiring designers to adapt to it, or so-called "guiding" designers.

2.1 User Habits

Software should minimize changes to designers' existing habits, offering flexible editing and simple operation while respecting designers' dominant role. Software should allow manual intervention and checking at any time, avoiding purely automatic modes.

2.2 Visualization

Three-dimensional solid display is required, showing either the entire structure or selected local areas and components in real-time, fast, and providing WYSIWYG visualization.

2.3 Data Management

Most current design platforms (such as AutoCAD and SOLIDWORKS) are primarily graphics platforms. AutoCAD, commonly used, is a 2D graphics platform, making it difficult to effectively perform data statistics, collision detection, grout leakage checking, and drawing generation. To achieve these functions in a graphics platform, software must establish its own database to describe structural members and formwork.

2.4.1 Modeling

To enable rapid formwork quantity estimation and matching, a structural 3D model is ideal. Software should provide structural modeling functions, integrating the design detailing process with modeling. When detailed drawings are completed, the model should be simultaneously finished.

2.4.2 Formwork Matching

Many aluminum formwork designers are not accustomed to building structural models first. Therefore, formwork matching should accommodate both scenarios with and without models. With a model, automation can be enhanced. However, since software cannot replace designers' continuously updated and optimized design thinking, semi-automatic matching with manual intervention must be considered, or manual single-panel layout mode. Without a model, many parameters cannot be directly obtained and require manual input by designers or software recognition from structural drawing annotations. Formwork

matching functions must also consider multi-user collaboration on one project, utilization of existing old formwork, formwork optimization, recesses and drip lines, with the most important consideration being convenient and fast editing and modification.

2.4.3 Statistics

Software should provide automatic statistical reporting functions for formwork and auxiliary material quantities, while also allowing manual report modification. Manually modified information should be preserved when reports are refreshed. For large structural areas, planar zoning and sub-regional statistics are also required.

2.4.4 Fabrication Drawings

Software should provide single-panel property editing functions, enabling customization of detailed parameters such as hole positions and slots, with automatic fabrication drawing generation and editing tools.

2.4.5 Construction Drawings

Including plan, elevation, and section drawings. Plan drawings are created during modeling and matching processes, supplemented with auxiliary drawing tools. Elevation and section drawings can be automatically generated for designer modification and refinement.

2.4.6 Virtual Assembly

Software requires 3D animation simulation of formwork assembly processes and virtual reality inspection of assembly conditions, providing collision detection and grout leakage checking functions.

3. Current State of Aluminum Alloy Formwork Design Software

Currently, most designers manually draw in AutoCAD, supplemented by some tool plugins. For complex parts such as stairs, general 3D software is used for design and drawing.

3.1 Tool Plugins

Represented by "Niu Mo Wang," most are AutoCAD plugins that primarily assist 2D formwork matching with relatively simple functions. These plugins provide considerable help for designers using AutoCAD, but require extensive input and offer limited efficiency improvement.

3.2 General 3D Software

Currently, SOLIDWORKS, SketchUp, and Revit are commonly used, primarily for complex spatial parts. The main advantage is 3D spatial formwork display, while disadvantages include difficult software mastery and complex, inefficient 3D operations.

3.3 Software Developed on BIM Platforms like Revit

In recent years, some organizations have developed aluminum formwork software on Revit. However, market adoption is minimal, partly due to development difficulty and low software maturity, and partly because operation methods differ significantly from AutoCAD, making learning and mastery challenging.

4. Aluminum Alloy Formwork Design Software Developed in This Study

Through in-depth investigation of the aluminum formwork design process and summarizing advantages and disadvantages of existing software, we determined the following basic scheme and conducted research and development according to the fundamental requirements for aluminum alloy formwork design software.

4.1 Platform

Since the vast majority of designers use AutoCAD, we selected AutoCAD as our base platform. Software editing and modification directly use AutoCAD commands, requiring no additional platform learning from users.

4.2 3D Visualization

AutoCAD' s 3D functions are inadequate and slow, making rotation difficult with large models. We developed a dedicated 3D display module with real-time linkage to AutoCAD 2D operations. The 3D display can show the entire structure or selected formwork portions, avoiding occlusion and solving location difficulties.

4.3 BIM Formwork Model

AutoCAD is essentially a graphics platform, not a BIM operation platform. Following IFC rules, we built an underlying BIM model database. AutoCAD platform command operations interact with the underlying BIM database, with the BIM model displayed in plan through AutoCAD and in 3D through our proprietary visualization module.

Currently, all software function modules except virtual assembly have been completed.

5. Conclusion

Through independent innovation, we have successfully built a BIM software system based on the AutoCAD graphics platform. By developing a 3D display module, we solved AutoCAD' s 3D visualization problems. On this foundation, we developed functional modules for structural modeling, formwork matching, statistical reporting, fabrication drawings, construction drawings, and mechanical verification, overcoming some shortcomings of existing software in the market.

Note: Figure translations are in progress. See original paper for figures.