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

Discussion on Design Software for Aluminum Alloy Formwork

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Abstract

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

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

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1. Current Status of Aluminum Alloy Formwork Design

Currently, two primary aluminum alloy formwork systems are used in the market: rod systems and strip systems. While their design processes are fundamentally similar, the key difference lies in installation methodology. Strip systems require strips to pass between formwork joints, necessitating precise alignment of wall formwork to ensure proper strip installation. In contrast, rods for rod systems typically pass through the middle of formwork panels. Although alignment is still required in principle, the tolerance is less stringent than for strip systems. Additionally, rod systems must be complemented with backing ribs to constitute a complete formwork design.

The aluminum alloy formwork design process encompasses preliminary estimation of formwork area, production of detailed formwork drawings, formwork layout design (including main structures, staircases, suspended formwork, and transition floors), statistical reporting, fabrication drawings, construction drawings, pre-assembly, numbering and packaging, and on-site assembly.

1.1 Template Quantity Estimation

During the bidding or quotation phase, detailed design has not yet begun. Accurate quantification requires calculating the formwork area for each structural member, which is labor-intensive and prone to omissions. Alternatively, rapid estimation based on experience can be used, though accuracy depends heavily on extensive practical engineering experience.

1.2 Design Detailing

Design detailing represents a comprehensive test of a formwork designer’ s capabilities. Based on the design institute’ s blueprints, this process must fully and accurately express both the design intent and client requirements while facilitating the design, fabrication, and construction of aluminum alloy formwork. For example, partition walls between doors/windows and beams may be modified to suspended beams, short wall piers adjacent to columns and shear walls may be cast integrally with them, and details such as door/window recesses, drip lines, floor openings, and architectural finishes must all be reflected in the detailed drawings. This detailing work is the most critical and technically demanding aspect of aluminum alloy formwork design, requiring repeated communication and revision with the design institute, client, and general contractor. Ideally, this involvement should begin during the initial design phase at the design institute. This portion of work is difficult to replace with software automation.

1.3 Template Layout

This task is extremely complex, involving massive quantities of formwork panels for a single project. Many designers still rely on AutoCAD for 2D layout design, manually drawing and labeling each panel on plan drawings. Determining whether vertical formwork panels overlap on plan drawings requires strong spatial imagination from designers, particularly at complex locations such as door/window openings and member intersections where solid modeling is relatively complicated. This approach often leads to missing panels, overlapping panels, or confused numbering. The layout and drawing process is inefficient, verification is difficult, and many issues ultimately must be discovered and resolved during pre-assembly.

Many construction details such as drip lines and door/window recesses, as well as openings, are typically handled by installing plastic strips or blocks on the formwork. These also require design layout and graphical representation. Due to variations in size, shape, installation position, and orientation, designers must individually differentiate, code, and produce corresponding fabrication drawings for these small accessory components, further demonstrating the complexity of the layout task.

1.4 Statistics of Aluminum Alloy Formwork

Based on the 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, utilizing AutoCAD' s built-in data statistics functions to quantify formwork usage. The extracted data still requires manual merging, splitting, or sorting. Without plugin or software assistance, errors are easily introduced.

1.5 Template Processing Drawings

Non-standard formwork panels require fabrication drawings for factory production. The vast majority of these drawings are manually produced in AutoCAD.

1.6 Construction Drawings

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

1.7 Pre-assembly

The aforementioned formwork design work involves extremely tedious graphical 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 of the actual engineering formwork at the factory to identify design errors before numbering, packaging, and shipping to the construction site.

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2. Basic Requirements for Aluminum Alloy Formwork Design Software

In aluminum alloy formwork design, the designer is the principal actor, and even the best software serves only as an auxiliary tool. Therefore, software development should follow the design workflow and align with designers' thought processes, 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 and workflows, offering flexible editing and simple operation while respecting designers' dominant role. The software should allow manual intervention and verification at any time, avoiding purely automatic modes.

2.2 Visualization

Three-dimensional spatial solid display is required, capable of both overall and selective regional or member display with real-time, rapid updates for true "what you see is what you get" functionality.

2.3 Data Management

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

2.4.1 Modeling For rapid formwork quantity estimation and layout, a structural 3D model is ideal. The software should provide structural modeling functionality, integrating the design detailing process with modeling so that when detailing is complete, the model is simultaneously finished.

2.4.2 Formwork Matching Many aluminum alloy formwork designers are not accustomed to building structural models first. Therefore, formwork matching should accommodate both scenarios with and without a model. With a model, automation can be enhanced, but since software cannot replace designers' continuously evolving and optimizing design thinking, semi-automated matching with manual intervention must be supported, as well as manual single-panel placement. Without a model, many parameters cannot be directly obtained and must be entered by designers or recognized and extracted from structural drawing annotations by the software.

Formwork matching functionality must also consider multi-user collaboration on a single project, utilization of existing old formwork, formwork optimization, recesses and drip lines, among other factors. Most importantly, it must enable convenient and rapid editing and modification.

2.4.3 Statistics The software must provide automatic statistical reporting of formwork and auxiliary material quantities, while also allowing manual modification of reports. 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 Processing Drawings The software must provide single-panel attribute editing functionality, enabling customization of detailed parameters such as hole positions and slots, and automatically generating processing drawings with editing and modification tools.

2.4.5 Construction Drawings Including plan drawings, elevations, and sections. Plan drawings are created during modeling and layout but require auxiliary drawing tools. Elevations and sections should be automatically generatable for designers to modify and refine.

2.4.6 Virtual Assembly The software requires 3D animation simulation of the formwork assembly process and virtual reality inspection of formwork assembly conditions. It must provide clash detection and grout leakage checking functions.

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3. Current Status of Aluminum Alloy Formwork Design Software

Currently, most designers manually draft in AutoCAD, supplemented by some tool plugins. For complex components such as staircases, general-purpose 3D software is used for design and drafting.

3.1 Tool Plugins

Represented by "Niu Mo Wang,"most are AutoCAD plugins that primarily assist with 2D formwork layout. While these provide considerable help for AutoCAD users, they require extensive input and offer limited efficiency improvements.

3.2 3D General-Purpose Software

Currently, SOLIDWORKS, SketchUp, and Revit are commonly used, mainly for complex spatial components. Their primary advantage is 3D visualization of spatial formwork, but they are difficult to learn and master, with complex 3D operations and low efficiency.

3.3 Software Developed on BIM Platforms

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 their operation methods differ significantly from AutoCAD, making them difficult to learn and master.

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4. Aluminum Alloy Formwork Design Software Developed in This Study

Through in-depth investigation of the aluminum formwork design workflow and summarization of existing software advantages and disadvantages, we have established and developed the following basic solution 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. The software' s editing and modification directly uses AutoCAD commands, eliminating the need for users to learn other platforms.

4.2 3D Visualization

AutoCAD' s 3D functionality is inadequate and slow, making rotation difficult with large models. We developed a dedicated 3D visualization module that operates in real-time synchronization with AutoCAD 2D operations. The 3D display can show the entire model or selected portions of formwork, avoiding occlusion and resolving search difficulties.

4.3 BIM Template Model

AutoCAD is essentially a graphic platform, not a BIM operations platform. Following IFC standards, we constructed an underlying BIM model database. AutoCAD platform commands 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 functional modules except virtual assembly simulation have been completed.

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5. Summary

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

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