

Flexible Reservation: Reflections and Strategies for Construction-Oriented Renewal Design

--Taking the renewal of road and bridge laboratory of Southeast University as an example

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Abstract. In the bi-directional design-construction cycle in architectural renewal practice, various uncertainty problems often arise due to the neglect of construction in the design stage, the separation of construction from design in the construction stage and the complex site environment of the scheme practice. Based on the architectural renewal practice of the Road and Bridge Laboratory of Southeast University, this paper sorts out the uncertainty problems in the process of design-construction and carries out typical reflections, expounds the design method of “Flexible reservation” for construction. Three strategies are proposed: redundant reservation under construction uncertainty, space definition of multi-job coordination, and technology integration in atmosphere creation, to provide experience for design-construction facing various uncertainties in current architectural renewal practice.

Keywords: design-construction; construction uncertainty; architectural renewal.

1. Stock Development Era: Construction Clues for Building Renewal

Due to the rapid development of economy and the subdivision of professional jobs, design-construction were separated in most architectural practices in the past. However, as the building industry enters the era of stock development, on the one hand, architectural cultural awareness gradually returns to the reflection on the architecture ontology, architects start emphasizing the interrelation between design and site, the construction logic in design, the clarity and authenticity of structure, the clear handover between components and the reasonable presentation of material technology in architectural practice. At the same time, architectural theory rethinks design under constructing at different levels [1], studies the correlation between design and construction, and puts forward corresponding strategies, methods and systems, so as to better combine design and construction. On the other hand, architectural renewal has become an important practical direction and theoretical issue. In the practice of renewal, the spatial condition of the original building, relationships among structures, material presentation and process use are concrete and complex, as the prerequisite conditions and current environmental elements to be focused on in the design-build stage. Therefore, construction clues have become an important theme in the architectural renewal practice in the stock era, including materials, structures, technologies, technical conditions and process experiments on site.

2. Uncertainty in architectural renewal design: Design for construction

With the practice of architectural renewal entering the construction stage, it will gradually produce the issues that architects cannot accurately evaluate and control in the design stage, namely the uncertainty problem. Some scholars have discussed the uncertainty of architecture design from the perspective of space perception and design, specifically the uncertainty of design process and space presentation, including different perception factors of spatial order [2], the expression of multiple structural forms under mechanical logic [3]; Other scholars rethink the uncertainties in the

process of design-construction by studying related architecture practice, from the perspectives of design-construction under information theory [4], the spatial status of the original architecture and the expression of CAD drawings [5], unexpected situations in the construction process [6], technology practices and construction environment under special built background [7], the selection possibilities of materials, processes and technologies in construction-oriented design [8], and the integration of equipment system and structural system [9]. This paper also starts from the perspective of construction-oriented design, and further focuses on the uncertainty in design-construction process under the background of architectural renewal. At the same time, most of the above studies focus on the problems itself in engineering cases and the adjustments, while this paper focuses on the multi-temporal and multi-dimensional relationships between new and old structures, and the locally construction technology in the renewal design: these uncertain problems are inevitable, and cause a huge impact on the building operation process and building quality. Based on this, this paper takes the renovation project of Road and Bridge Laboratory of Southeast University as an example, to focus on and sort out the uncertainty problems in the architectural renewal project. While discussing the construction problem, it also integrates the construction-oriented design perspective, further reflects on the lack of structure and the presentation of materials, and summarizes the design strategy, in order to provide references for subsequent practical projects.

3. Flexibility in reservation: Uncertainties in architectural renewal design

In the construction-oriented architectural renewal design, various uncertainties mentioned above will gradually arise: as deterministic events in the design space, construction space and collaborative space, it also needs to be regarded as a part of the "unpredictability of the program", and the conflicts and contradictions between design and construction can be resolved by means of "Flexibility" and "Reservation". Also aiming at the "Flexibility in reservation" in renewal design, this paper does not discuss the flexibility and adaptability of function, scale or growth capacity between old and new Spaces, but extends the research scope to the bi-directional and continuous cycle of design-construction deeply from the perspective of construction, and reflects on the relationship between new and old buildings, the material presentation process in renewal design (fig.1). In this regard, "Flexibility" refers to the spatial elasticity at the structural scale and process level, while "Reservation" focuses on the construction reservation of the construction object, technology and process in the continuous design-build stage.

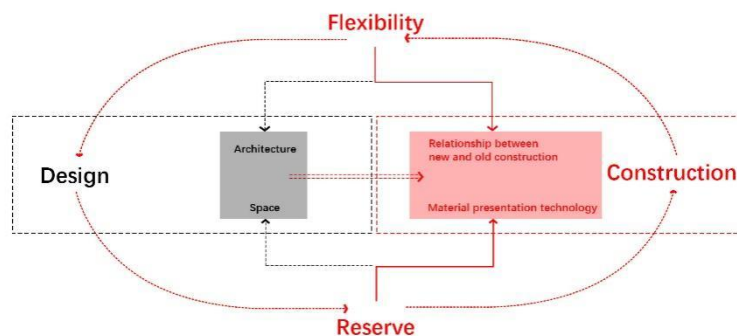


Fig. 1 The research technical road map of this paper

4. Flexibility deficiency and construction aphasia: Rethinking the renovation design of Road and bridge laboratory

4.1 Lack of structure: Integrity in the design of large space fire water systems

Before the material selection, purchase and installation of the fire control pipe network, the designer builds the fire control pipe network model in Sketch-Up, according to the CAD drawings and the site conditions. Obviously, designed by CAD drawings but separated from 3D model and site condition, the fire control pipe network ignores the perception of the old structure, spatial form and scale of the design area, and will destroys the spatial quality of the original design. At the same time, such simple block design leads to the overall complexity of the space, but also causes new problems in the installation of pipe network roots, to further affect the quality of the space as an uncertainty.

In the face of the above problems, the designer re-designed the overall fire pipe network system for construction. First of all, under the discussion with the plumbing engineer, the fire control pipe network in fourth floor and large space was integrated: two fire mains were arranged at the top of the space on both sides of the laboratory, and connected two spaces longitudinally through the opening of the roof truss; while the fire branch extends in the direction of the roof truss, enhancing the sense of order in the space and the dialogue between the old and new structures, avoiding the installation in the middle of the space and making the visual effect of the space close to the architect's original design (fig.2). Secondly, the method of installation was determined after on-site discussion with the structural engineer: the pipe network system was rooted by the old roof ribs, and the main pipe was lifted through the L-shaped branch pipe. Of course, the installation of the main pipe on both sides of the space can also minimize the length of the lifting rod, and better integrate the roof structure for installation (fig.3).



Fig. 2 Space effect of fire pipe network after installation



Fig. 3 The relations between fire mains and structure

The reflection on the uncertain problems of large-space fire pipe network system is as follows: In the construction of architecture renewal, faced with the certainty of fire code and fire pipe network construction, the uncertainty is brought about by the lag of design under the holistic perception of the current space and the lack of thinking about construction methods, also causing construction aphasia. Designers often need to take the initiative to model in Sketch-Up or Rhino from CAD drawings, examine the integrity of the new design and old site in the perception of the space: in the orderly large space, the fire pipe network system composed of multiple groups of pipelines is regarded as a complete design under the unified construction logic, rather than independent of each other; At the same time, the fire pipe network is attached to the existing construction site, the correlation between the old and new creations, the correlation of spatial relations, and the correlation of structures form a more complete perception of space. In this progressive holistic perception, architects routinely intervene in the thinking of structural relations and construction methods in advance, and clarify and deal with various uncertainties between the handover of multiple types of work, the expression of graphic drawings and working models, and the elaboration of design and construction.

4.2 Material construction: Continuity in process design of cast-in-place concrete in relation to old and new creations

As Eduard F. Sekler defines the connection between construction and materials: "... It can be done in many different materials and ways...Construction involves many problems such as selection of materials, process and technology." [10] For the design that defines the "shape" or "Texture", there will also be continuous deviations in the construction phase due to the diversity of materials, the uniqueness of the process, and the difference of the site construction environment. If architect does not control the continuous changes from the perspective of construction, then the final design of the architect will not be realized - and this can be regarded as a definite uncertainty.

In this project, technical experts keenly captured the uncertainty behind the expression of concrete materials before the project entered the construction phase. From the expression of materials, three kinds of materials were proposed: Cast-in-place wood-grained concrete, paint and concrete texture hanging board. And from the four perspectives of material selection, cost, shuttering design, and process design, we began to push the process of materials for construction. Different materials have unique construction technology and structural characteristics, that is, the presentation of materials has a certain degree of certainty and construction significance. The technical experts finally chose to use cast-in-place wood grain concrete: Compared with the hanging board, using cast-in-place wood grain concrete can reduce the number of cracks, avoid a series of problems such as the potential uneven and color difference of the later installation period of the hanging board, and can be closer to the material expression of the image of the architect in the design stage; Compared with paint, the material and structure are combined to clarify the meaning of concrete construction, and can also express the structural meaning of the image in the design stage (fig.4).

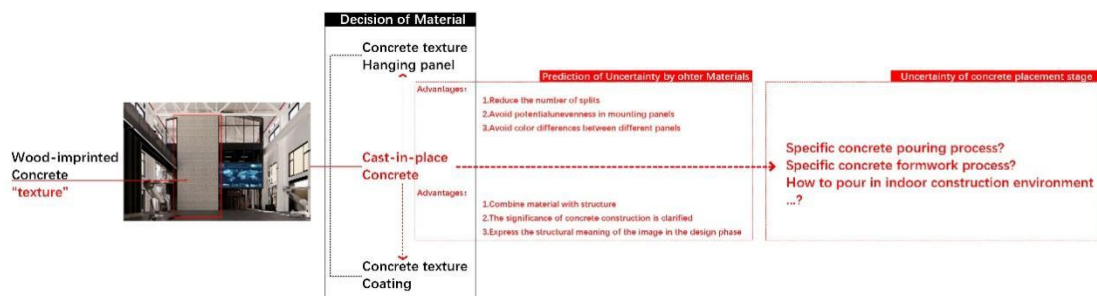


Fig. 4 Uncertainties in the process from “texture” to “material”

Faced to new uncertainties such as the concrete pouring process of cast-in-place wood-grained concrete and the indoor construction environment, the technical experts proposed a continuous process construction practice and divided the wood-grained concrete design-construction practice into three parts: 1. Wood-grained concrete structure, 2. Wood-grained concrete wall in outdoor courtyard and 3. The final interior wood-grained concrete core (fig.5). As the first and the most important experiment of the process, it determined the basic and core process details and design methods, by simulating the process of pouring in the work of drawings and models as a guide for the actual construction on the site. And in the final pouring process and results, verify the rationality of the process, compare the results of different wood texture process design methods, and the feasibility and optimal process of piece-wise pouring (fig.6). The wood-grained concrete of the outdoor courtyard is based on the pouring experiment of the previous structure, and the construction experience and the judgment of the uncertainty of the subsequent construction are accumulated in the transformation of the pouring scale. The certain design-construction process, design method of process details, the accumulated skills and experience of piece-wise pouring brought by continuous pouring practice, will be reproduced on the core cylinder.



Fig. 5 Three parts of the wood-grained concrete wall practice

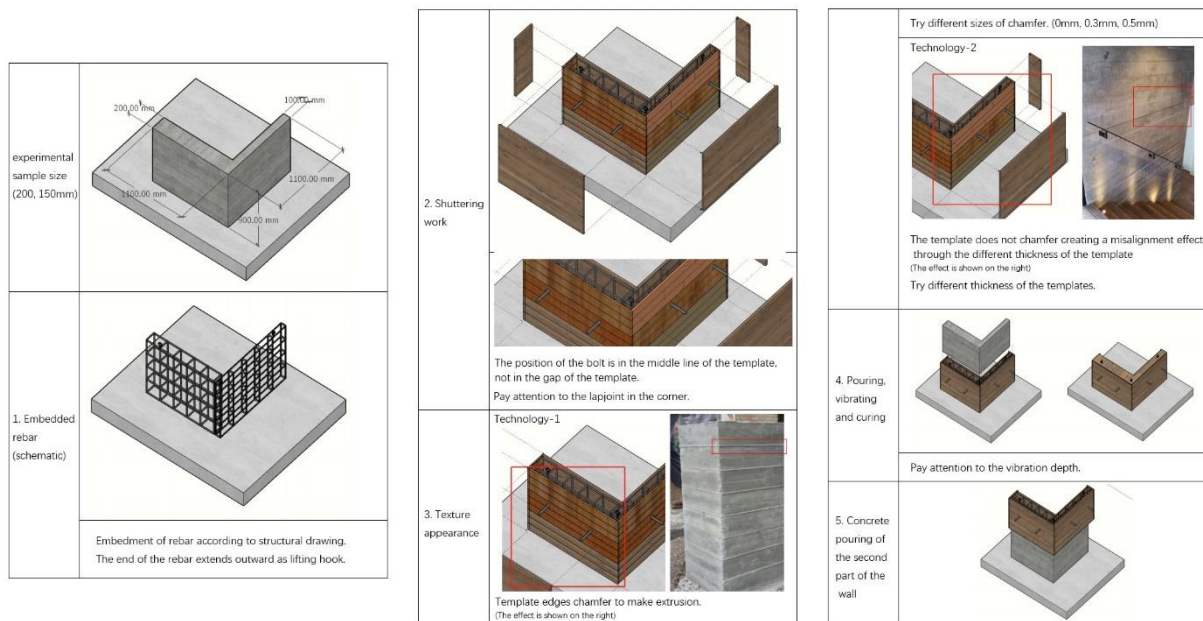


Fig. 6 The drawings instructing the wood-grained concrete construction experiment

In a word, different from the previous practice of using experience instead of experiment to evaluate the presentation of materials, through pre-planning and implementing a series of sufficient and mutually promoting process design, process experiment and process practice, it is more possible to concretely realize the architect's initial careful expression in the construction. The repeated thinking, deliberation and result verification of the materials, processes and techniques of multiple components during modeling and drawing or site construction, reflects the "continuity" of the wood-grain concrete pouring process. It is through this continuous construction-oriented practice that the whole design becomes more flexible.

5. Flexibility in reservation: strategies for the construction-oriented architectural renewal design

5.1 Material presentation: Continuity in process design of cast-in-place concrete in relation to old and new creations

With architects taking construction as the leading principle of later adjustments and expressions in design, the problems existing in constructions, structures, materials, processes, technologies and the complexity of design methods have gradually generated uncertainty. In this regard, architects need to take the initiative to consider the complexity of construction in advance, reserve the space

of different scale levels in the design, and consider the expression of design during construction, and gradually determine the complex problems in the construction process.

In the construction-oriented design, the "reserved" objects include the following types: 1) Capacity of the new equipment cavity: "cavity" is the expression of the form and volume of the equipment system after construction, and also implies the possibility of multi-level integration of the equipment system and the structure system during the design period. 2) Thickness of the material structure: the uncertainty of the material mainly lies in the diversity of material choices under the design expression and the corresponding unique process. Architects need to bring in this perspective of materials and techniques, and make reservations for the thickness of material structure in design phrase. 3) Gap between new and old constructions: In the design stage, architects need to judge whether the old structure can be changed, and comprehensively consider the relationship between every construction in the space, to reserve space for adjustments.

5.2 Strategy 2 Space definition of multi-job coordination

Planar drawings from a two-dimensional perspective, as the main carrier of information, are constantly circulating among various specialties within the design unit, between the design unit and the construction unit, and between the construction site and the design model. However, the expression of spatial information and construction information is often missing in the plane drawing, causing the uncertainty of design expression and construction. In view of this problem, compared with BIM workflows [11], the architectural renewal practice of non-BIM workflows needs to be based on "space" and establish the correlation between design ideas and on-site construction through repeated perception, review and expression. As the document criteria and working principles of multi-job coordination, "spatial data expression" and "spatial construction expression" run through the whole preliminary design and construction drawing design stage.

It can be considered that the spatial data representation is the reproduction of the original architectural space and the updated design space integrated in the working model and two-dimensional drawings. The meaning of "spatial" in "spatial construction expression" is more complex, which includes many aspects involved in drawings, models and construction site: 1) The expression of inside construction relationships; 2) The spatial relationships of important structures; 3) Clear construction details and diagram of simulated construction process; 4) Instant construction site. Although different types of work have differences and hierarchical divisions in the working time and content, the perception and expression of "spatial" is gradually unified in collaborative work, and the vision gradually focuses on construction naturally, to design the reservation of space from multi-job coordination. A comprehensive and accurate representation of the space is the premise of constructive reservation, and the space created in the reservation ensures the spatial data in subsequent stages to be accurately expressed.

5.3 Strategy 3 Technology integration in atmosphere creation

In architectural renewal practice, there are a large number of designs that are established in the unique space of the original building or expression of the technological atmosphere. The material presentation, structural relations, technological details and construction procedures in these designs break through the previous construction experience, and it is difficult to take the standard atlas as a reference, as well as to clarify the process and results through architectural diagrams. In this regard, it is necessary to integrate the experience and technologies of multi-job coordination or construction process in the perception of the constructing place, and carry out continuous and modular construction experiments.

6. Summary

As the practice of architectural renewal accelerates, more and more valuable historical buildings will be reintroduced, and designers will comb through design-build uncertainties in more detailed

and systematic ways. Complex space condition, continuous relationship between old and new space, and temporary material process practice are the characteristics of architectural renewal design. Only by reflecting on the common uncertainty problems and solutions in the design-construction process can we predict the constructional issues and make flexible reservation for the design in the later practice. The renovation project of Road and Bridge laboratory belongs to the Industrial laboratory architectural heritage renovation in the university, and its project positioning and design-construction process have certain particularity and certain typicality. Redundant reservation under construction uncertainty, space definition in multi-work coordination, and technology integration strategies in atmosphere creation can all reduce the influence of uncertainty. In the future, it is necessary to constantly discover and summarize the uncertainty problems and flexible reservation strategies in the updating practice, and promote the solution of the design-construction problems of such projects, so as to present the architect's design intention and better spatial quality.

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