From Manufacture to Construction—Studies on Concurrent Operation of Chinese Construction Process

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ABSTRACT

Based on serial mode of Chinese traditional construction process, with the help of concurrent engineering in the field of manufacturing, the article proposes three translation strategies. They are developing integrated building information model, forming interdisciplinary teams which can divide building structure and establishing building data management system respectively. As a result, they will enable the inefficient operation of building system to be innovated.1

INTRODUCTION

According to market demand, using of subjective knowledge and skills, with hand or objective material tool, and adopting effective technological process and necessary energy, manufacturing is the whole process in which human beings transform raw materials into material products and put them on the market for the end[1]. Following the emergence and development of human society, manufacturing industry has experienced many steps, such as original manufacturing, handicraft workshops, machinery production, mechanized production and assembly line production and automated production line. The trend has been formed, which are multi-disciplinary, multi-technology crossing, system optimizing and integration in contemporary society. Also, manufacturing industry has formed the trend of cross and fusion of computer, information, automation, manufacturing, management and other technologies. The integration of organization, technology and management has been emphasized. Compared to manufacturing industry, construction industry has undergone less change. The problems of “design with construction” system operation procedure still exist. Due to product with small scale, involving less relevant conditions and no relations with a particular site, the integrated system of

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“design with manufacturing” is relatively easier to establish than “design with construction”. Compared with Manufacturing, construction is closely associated with place, space, style, behavior and culture and so on. Because of the industrialization process not yet completed, lacking of appropriate technology and personnel, organizational model of design agency still follows the traditional way, the phenomenon of separation between design and construction is more obvious in contemporary architectural operation process in China.

CASE BACKGROUND

Contemporary architectural operation process of china basically follows the serial mode, in which there are a lot of steps, such as investigation and analysis before designing, scheme design, expanded preliminary design, construction drawing design, construction on the specific site. Once a stage is completed, the next stage can be implemented. When the stage of scheme creation starts, designers complete the process from concept sketches to scheme creation, which is an experience of hammering out the drawing of plan, elevation, section and shapes. After completing this stage, construction drawing design team begin the stage of expanded preliminary design and construction drawing design. And then construction team completed constructing on the specific site, the project will be undertaken acceptance at last.

In this mode, each work stage separates from each other. Scheme design, construction drawing design and constructing only start to do, based on the demand and optimization of its own stage, and lack systemic communication and information exchange between each other. Designer rarely consider various factors from design to construction, such as operation, maintenance, repair, scrap throughout the entire life cycle. Architects who are in the stage of scheme design pay more attention to the drawings of plan, elevation, section and shapes, but pay less attention to innovative design of building details. When construction design stage is coming, designers do not almost communication with scheme creator and revise the structure, space, and shape of scheme sometimes, for consisting with the standards which are regarded as a reference. Finally it leads to the change of the creation. During construction stage, builders seldom communicate with scheme creators and construction drawing designers. The technicians who come from the supervision company guide them to conduct on-site coordination. So it is the lack of collaboration and co-ordination in the whole process, which will eventually lead to a drop in quality of construction.

OPERATION STRATEGY

Based on the current situation above, it is inevitable to translate advanced mode of manufacturing industry for settling the lagging development of construction
industry. For serial development issues, based on computer integrated manufacturing systems, including integrated manufacturing and collaborative design, concurrent engineering is integrated operation mode of information, communication and management, which is easier to solve the drawbacks of contemporary architectural operation process. Concurrent engineering proposed firstly by DARPA of the US Institute for defense analyses is systematic work mode, which designs products and related processes (including manufacturing and support processes) in an integrated and concurrent way. In this mode, designers need to consider a variety of factors of the entire life cycle (from conceptualization to scrap) including quality, cost, schedule, customer needs and so on at the beginning of design. So this mode will maximize the efficiency and success rate of product development [2].

1. Developing Integrated Building Information Model

“Models” which are in physical form mainly provide geometry information in traditional architectural design process, for scheme scrutiny or professional discussion of various fields. So, it should firstly join engineering characteristic non-geometric information description (such as material information division of component, connections information, precision tolerances, manufacturing information, surface roughness, project cost information etc.) on the basis of geometric model, which describe geometric and non-geometric information in the unified model by establishing information repository through computer programs. Secondly, it should put building information model into three-dimensional digital model including information of the entire life cycle, which could form integrated building information model to provide relevant data resources for different users and applications (Figure1).

![Figure 1. Evolution from geometric model to integrated building information.](image)

On this basis, it is the integrated building information model as the core of different processes which ensure the consistency of sharing information of various stages from conception, design, construction, evaluation, and maintenance to perish. on the platform of integrated building information model, interdisciplinary teams
from different fields achieve their goals of collaboration, which form a circulation of integrated building information model in different application areas such as CAD/CAE/CAPP/CAM etc. (Computer Aided Design/Computer Aided Engineering/Computer Aided Process Planning/Computer Aided Manufacturing) and technology integration of design, construction, craft production and so on.

Besides, because different application areas, including CAD, CAE, CAPP, CAM, participating in the development of projects, so construction industry should establish a hardware system of global networked workstation of computer and mainframe equipment. According to the division of building structure, workstations in different application areas based on integrated building information model develop different building blocks respectively. They need to give more digital definitions and make virtual construction experiments by computer. The problems that we have found in virtual construction experiments will be solved timely by other application workstations. Digital manufacturers of terminal could make integrated building information model come true by using 3D printing technology and CNC (Computer numerical control) tools on the specific site, which will realize the integration of “design with construction”.

2. Building Interdisciplinary Teams Which Can Divide Building Structure

Concurrent Operation mode dominated by projects, breaking the traditional departments or professional groups, divide building blocks in accordance with structural module, such as modules of enclosure, structure, energy use, equipment technology, space organization etc., then form the integrated building team (IBT). The division based on integrated building information model make different modules in dynamic relationship, which also make the IBT modules working in co-ordination way receive feedback and resolve problems timely (Figure 2).

Whichever level and location is located in the community, IBT team faced with different module types is a fractal Structure, each internal organization of which is in exactly the same way[3]. IBT technicians, who are composed of members from various functional departments constitute a complete system required by project development. The upper IBT members who head and coordinate the lower IPT are drawn from the lower leaders and other staff. They also make preliminary and overall design and define relationships of components involved in the underlying IBT. IBT systems for specific projects break the traditional serial operation process.
3. Establishing Building Data Management System

It makes application systems of digital design, craft and manufacturing grow with the development and application of digital technology. However, these applications which are self-contained generate a great deal of correlation data. But these data lack effective information sharing and utilization, which will form the “information island” because of different file format and management ways. Besides, IBT members from various departments of the project development exchange information frequently, which involved a wide range of information such as text, voice, data, graphics, images, tables and text etc.

Building Data Management system (BDM) is a technology for managing all project-related information (including building codes, building blocks information, electronic documents, model file, access permissions, etc.) and processes (including drawings for approval and granting, engineering changes, etc.), which could define, organize data and make consistent data and documents throughout the entire life cycle of building (from conceptual design, analysis, detailed design, craft process design, manufacture, to the building extinction) efficiently in accordance with

Figure 2. Organizational mode of construction IBT.
certain management [4]. In addition to its own functions, the BDM is an integrated platform or framework in which different applications (CAD/CAE/CAPP/CAM etc.) can also be integrated. It could create a collaborative development environment in which owners, designers, manufacturers, construction technicians could participate in the development of projects together and provide data and process management of the entire life cycle [5] (Figure 3).

**CONCLUSION**

It is imminent to innovate traditional construction process by adopting concurrent engineering operation mode, for what advanced manufacture industry has provided successful paradigm (Figure 4). It is useful to translate and apply selectly advanced mode for construction systems after compared with similarities and differences between manufacturing and construction systems. It is true that application of digital technology has not yet been popular in the construction industry, computer hardware system needs to be improved and appropriate training of technicians also needs to develop further. But I believe that operation of construction process to get more efficient, by which we will construct high degree of completion and high quality buildings in the near future.
REFERENCES