

INFORMATION-SHARE BASED UPON IFC STANDARD IN ENGINEERING CONSTRUCTION

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ABSTRACT

The wide application of IFC standard by the AEC industry in the US and other countries has drawn much attention by the similar industry in China. Therefore, an initiative (also called national key project in scientific and technological research) entitled as “a key technology study on information in building industry” was established to handle the basic research effort of information exchange and sharing in engineering construction. In this project, we have conducted a further study on IFC standard, taking it equally adopted as a national standard. This is intended for future adoption as the foundation for its application of the building design standard in China. Moreover, we plan to develop up-to-date systems for architectural design and construction management based on this standard, for which the main goal is to solve any potential problems associated with information exchange and sharing in architectural design and construction management, to develop more effective architectural design and construction management systems, and to achieve data sharing of architectural construction model. In so doing, any CAD systems developed by different vendors can engage in information exchange using the IFC standardized framework, thus to make the information exchange and sharing between architectural design and project construction into a reality. Finally, our ultimate goal is to lay the groundwork for achieving information sharing for the complete lifecycle of a building. Further details about the national key project will be discussed in the full paper.

KEY WORDS

Construction project, IFC data standard, Information exchange and sharing, CAD systems

INTRODUCTION

Since the personal computer revolution in the 80's in 20th centuries and the Internet revolution and its universal application in the 90's, the computer network has make the information gathering, transferring and sharing which is contained in informationization meet technique requirement. The information technique is developing quickly and its application is becoming extensive in the last ten years, and its important meaning and profound influence to mankind is recognized throughout the world. In engineering construction realm, the computer application has already displayed its special potential and become the life line of the engineering technique development in new century.

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The engineering design industry takes the lead in using computer technique in construction realm, becoming an industry whose informationization work starts early, develops quickly and benefits high in our country. The application of CAD technique makes thorough revolution take place in engineering construction design. It has expanded the CAD application since later 80's in the realm of engineering design, and at the present time, CAD drawing rate in the entire industry has achieved more than 95%, which not only can thoroughly liberate engineering designers from traditional design calculation and drawing, putting more time and energy in the plan optimizing, improving and rechecking, but also can enhance design efficiency more than ten times or several ten times, greatly reducing the design cycle, improving the design quality and obtaining extremely remarkable economic efficiency.

The computer application in construction enterprise has raised the management efficiency, the technique level and the safe level of building construction available. Compared with in the realm of engineering design, the computer application in construction enterprise starts later in domestic, and its application level is not even and differs greatly. In the last few years, with the continuously raise of computer application technique level in engineering construction, the moment for construction enterprises applying and extending computer technique has already become mature. In the construction realm, computer application of single specialty develops quickly, such as in realms of construction item management, construction technique and engineering cost analysis etc., and especially, it also applies the computer information processing and automatic control technique in some specialized constructions, which not only lowers the cost and eases the work strength, but also overcomes some complex questions which solved difficultly in traditional construction way, and makes some highly difficult construction items completed. However, generally speaking, the application of computer management and computer technique in the whole process of construction is still behindhand currently. There are more than ten thousand construction business enterprises in our country, so the application foreground of construction software is extremely vast and the market potential is huge.

The whole-process and whole-orientation informationization construction has become the development mode that the construction enterprises pursue the compatibility with internationally accepted practices. In large-scaled construction enterprises and quicker developed enterprises in our country, and even in some medium-scaled or pint-scaled enterprises in flourishing regions, through the development of more than 20 years, the computer application has already experienced the start stage, popularization stage and network stage, and now is in the process of entering into integrated stage. In the realms of railway, electric power, highway etc., because of introducing into and expanding a batch of software which adopts the international standard and international general work pattern, it promotes the enterprise standardization as well as enterprise itself pursuing the compatibility with internationally accepted practices. This will play a stimulative role to the entire profession informationization development positively.

At the electronic government affairs aspect, the governmental affairs information network obtains strengthened. Since "95", the construction system has put effort to increase the governmental affairs information work's strength, and has established the governmental affairs information work net which covers the whole system and whole industry. The

establishment of construction industry information network plays a positive role in linking up construction market information and regulating market order. The ministry of construction has already set up 3 websites which cover operation management and public service, namely, the Chinese Engineering Information Net, the National House and Real Estate Information Net and the National Construction Information Net. Each local administrative department responsible for construction and scientific research institute and large or medium-sized enterprise, all establishes websites and enters the interconnection network to provide information service to society one after another. In order to strengthen the industry management, the ministry of construction successively organized the work of "the national engineering consultation design industry information system" and "the national construction market surveillance management information system", and achieved remarkable effect.

While fully using information technique, it also adopted various measures to safeguard reconnaissance design quality. It organized the related parties to develop "the construction drawing examination management system" and "the engineering quality surveillance management information system" as well as "engineering quality security accident bulletin system". The development and application of these systems powerfully promoted the standardization of quality control and the exaltation of management level.

THE EXISTING PROBLEMS IN CONSTRUCTION INFORMATIONIZATION

Thought engineering construction informationization work develops quickly and achieves encouraging result, and builds good foundation for further advancing engineering construction informationization work, compared with the international advanced level, it still exists quite big disparity, and this kind of disparity that is question not only exists in the technical aspect, but also exists in the management aspect, mainly manifested in the following aspects:

(1) The informationization consciousness is not strong, and the value is insufficient. Making it a rule to the traditional management mode, having no full understanding of information resource strategy, understanding less to the contents, functions and ways of informationization construction, valuing it insufficiently, all of these directly lead to the lack of deep plan and construction of informationization. Simultaneously, the devotion of informationization work is seriously insufficient, and the intellectual property protection work is bad, causing local software enterprises very difficult to contend with overseas big companies. The result is that, besides the CAD software domain, software of the system supported platform, the development kit and the database...etc., all regards foreign products as principle, and the overseas software enterprises surpasses the home in the aspects of scale and following software engineering standard. We lack the key technique with independent intellectual property, and have not established our foundation platform software which we own independent intellectual property.

(2) In information technique's application research, especially in essential technique's application research, the investment is insufficient, and as a result it lacks the mature solution. At the present time everybody has already realized that, the key of informationization lies in the establishment of advanced management mode firstly, and then is the system development. Yet, the advanced management pattern need take application research of information

technique in engineering construction as foundation. Compared with developed countries, the investment of research budget on this aspect in our country seems to be insignificant. This can be inferred from the present situation that the related research achievement is really few.

(3) The informationization standard urgently waits to be established. In developed countries, they have gradually established a more perfect standard system which can effectively guide, standardize, integrate the informationization process and can get twice the result with half the effort in the realms of item management, engineering design, engineering construction, real estate transaction management, municipal administration public and so on. However, we have just done the beginning work in this aspect, seriously lagging to the actual informationization course. Because of lacking data standard, the information that already obtained can not get fully applied, for example, architectural design enterprises have basically realized computer drawing in our country, but these numerous graphs and electronic documents can not or few can get use in afterward subsequent construction, supervision and property management work, and many foundation work will be repeated done in each construction management link.

The Singapore government is organizing to implement the engineering construction information standardization, its target is: The designing departments transfer their design proposal databases through Internet to the design supervision department and the governmental examining and approving department; After examination, the same database will be transferred to the construction departments and the material suppliers, and then they carry on the construction organization management design, the arrangement of material supply plan, the organization of manpower and construction equipments based upon it; While construction finished, the city management and the property management section will realize highly effective management based upon this database.

(4) The enterprise informationization management waits to be strengthened. Compared with foreign countries, there is great gap in applying information technique to enterprise management in construction industry. The information technique as well as the modern management technique supported by it has been applied to construction enterprises management in developed countries successfully, establishing modern enterprise system and enhancing enterprise's competitive ability. There are numerous successful cases in this aspect. However, there are few successful cases of information technique applied in this aspect in domestic, mainly limited to the single-itemed technique application. Some local software enterprises are concentrating on the enterprise management development work, with the concept of virtual enterprise, establishing automatic information circulation, comprehensively planning the resources, strengthening the integrated operation and fast response mechanism of enterprise, enhancing the competitive ability, the working efficiency and the quality of enterprise.

(5) The efficiency of information resources using is not high. An engineering project is a complicated and synthetically activity, and its participators always involve numerous specialties, and its life cycle may last as long as decades or even centuries, therefore, the engineering construction information exchange and sharing is one of the primary campaigns in engineering. The current construction software can just deal with the application of a certain stage or a certain specialized realm. There is neither a developer who can provide an application system which covers the entire life cycle of buildings, nor a project which is

finished by using only one kind of software product. In most cases, the work of information exchange and sharing is completed artificially, then, the human being turns to be the interface between different systems.

THE PROBLEMS THAT INFORMATION-SHARING IS FACING

THE PRESENT CONDITION OF INFORMATION USING

At present, with the establishment of electronic governmental affair systems which cover 31 provinces, 622 cities and thousands of government departments and more than ten thousand enterprises, it forms strong request of governmental affair information-share between the three distinctions of ministry, provinces and cities and between the same distinctions. With the further popularization and application of construction industry's unique city foundation space information technique and high resolution satellite remote sensing technique, it causes intense request of the city space information-share and remote sensing information-share. Currently, in order to do enterprise internal data management and information circulation, the enterprises with well done informationization work all have the interior coding system themselves. These enterprises all are some information "isolated islands", if they want to exchange data between different enterprises, these data can not be transferred directly.

In different stages of engineering construction such as the planning, the design, the budget, the construction, the supervision, the purchase, the logistics and the balance accounts etc., the same set of data is unable to be processed by computer, and only can be inputted to another system manually. Thus, it not only need to carry on massive repeated work, but also may come forth data mistake. The engineering design industry takes the lead in construction realm to apply the computer technique, becoming an industry whose informationization construction work starts early, develops quickly and benefits high in our country. The development and application of independent copyright specialized software also gets huge achievement, forming a batch of independent brands software products. Although some software development enterprises achieve the integration, information-share in the interior enterprise, the products by different developers are still basically independent and mutually not interlinked.

THE ENVIRONMENT CONDITION THAT INFORMATION-SHARING IS FACING

Since the personal computer revolutions in 80's in 20th century and the Internet revolution and its universal application in 90's, the computer network has make the realization of information collection, transmission and sharing contained by informationization meet technical requirement. Lack of the national uniform administrative laws of information-share and exchange, including the related laws and regulations, as well as the detailed rules, the work standard and the work flow and so on, it results in the information management system construction to some extent having no rules to follow, doing things in their own way and forming the information isolated islands.

At the present time, because of lacking the national uniform information system criterion and corresponding technique standard, various system development constructions are under separated and repeated condition. The system platforms and the database structures adopted

by each place and each section are various and are unable to achieve crossing area and crossing department information-share. There are three outstanding phenomenons in society now:

- (1) Various departments and enterprises have already accumulated a great deal of data and information resources through construction of years.
- (2) Each department feels that its own information is quite insufficient, and hopes to get hold some information and resources of other departments;
- (3) Some departments are not willing to put out their own information for various reasons, and regard holding information as one kind of privilege.

"The information isolated island" is regarded as one of the main barriers that must be eliminated from the start of informationization construction, however, with the informationization construction gradually going deep, and various software and systems being applied, and various "bridgehead" being established, the "information isolated island" phenomenon is more and more serious on the contrary. People knew that information is a kind of important resources very early, and now emphasizes that the information is an important strategic resource, so the originally problem "information isolated island" that should be solved through informationization gets further enhanced.

THE DEVELOPMENT STRATEGY OF INFORMATION-SHARING

Autodesk Corporation's BLM strategy

According to latest analysis by the world authoritative investigation organization "Greenway group", for reconnaissance, design and construction enterprises, the informationization construction model is the most important design tool, and is also the embodiment of an enterprise's designing capacity and competition ability. The informationization construction model actually is a database of building information, which contains abundant information related to building. The Revit of AutoDesk is developing forward to this direction. AutoDesk Revit 5.1 and AutoCAD 2004 contained by AutoCAD Revit Series have very strong supplementary with each other, and are able to use the existed AutoCAD platform to support various workflows simultaneity. For example: Use Revit to prepare the bidding document, and then design the item with AutoCAD or Revit; Utilize the Revit to accelerate decision-making in design stage, and then use AutoCAD to do the construction drawing; Use Revit to eliminate the design data mistake, and use AutoCAD to do the workflows simultaneously which need massive skilled specialists. Revit is the 3-D parameterized design system which AutoDesk Corporation purchased from Revit Technology Corporation. Its main function includes: project bidding; shop drawing design; Real-time output of all kinds of detailed lists such as the amount of engineering, architecture, structure component and so on; Inside inlayed large-scale database which supports many persons to carry on team design under the identical construction data model. Buzzsaw has two editions: Buzzsaw Professional is especially for the owners and developers; And Buzzsaw Standard suits for the architects and engineers. With the aid of Buzzsaw's computation advantage, it can simplify the management flow, reduce the management workload, enhance the management efficiency and management level, and can contribute to reducing time limit of a project as well. According to ENR Technology and Zweig White Corporation's investigation in March 2003, it reveals that Buzzsaw ranks first in the

multitudinously on-line coordinate work management systems which is for the architecture, the engineering and the building industry.

(1) The national Key Technologies Research and Development research

Qin-Shihuang unified China by adopting an important method, that was "unify book with the same language, unify vehicles with the same axle, unify people's action with the same ethic". Taking the history as warning, we may know that, if we want to completely achieve informationization in engineering construction, foundation work does not accommodate neglect. Doing foundation work of profession informationization, speaking from the essence, is paving the way for enterprise's informationization, thus to eliminate "isolated island" phenomenon of enterprise information. Information-share needs to unify the profession standard, to unify data coding system and to unify software standard interface.

The widespread application of IFC standard abroad attracts high attention of the related sections and academes in our country. From the "95" Key Technologies Research and Development plan, our country has studied and applied the IFC standard in scientific research items, and has continuously tracked its development, building good foundation for future deep research and application. Such as in the task "the digital community technique standard research and application demonstration based upon space information" in the item "the digital city space information management and service system and application demonstration " in the national 863 plan, it has done lots of deep research and discussion to the IFC standard, and completed the translation and local standardized work of IFC, and developed the data visit interface tool collection of IFC standard, applied and expanded the IFC standard in the realm of digital community construction and management. The national "15" Key Technologies Research and Development item "the construction industry informationization essential technique research" did some foundation research work in engineering construction information-share. In the task "architectural design and construction management system research based upon the international standard IFC" in the national "15" Key Technologies Research and Development plan "The architecture industry informationization essential technique research ", it did many further studies of the IFC standard, and took it as equal as our country standard, built foundation for the application of this standard in our country, and studied new generation of architectural design and construction management system based upon this standard, whose main goal was to solve the information-share problems in the process of architectural design and construction management, to develop more highly effective architectural design and construction management system, to achieve construction structural model data sharing: CAD software by different developers can realize information-share under the IFC standardized frame, each specialized CAD software by identical developer can realize information-share on the base of structural model data collection, and then realize construction structural design and construction information exchange and sharing, establishing the foundation for achieving information-share during the whole life cycle of building. The research work of this problem is being carried on currently.

THE ARCHITECTURE DESIGN AND CONSTRUCTION INFORMATION-SHARING BASED UPON IFC STANDARD

The reconnaissance design profession takes the lead in the construction realm to apply computer technique, and has become an industry whose informationization construction work starts early, develops quickly and benefits high in our country. At present, CAD drawing rate in large-scale reconnaissance design enterprises has achieved 100%, and the national average approximately is 87%, this can not only thoroughly liberate engineering designers from the traditional ways of design calculation and plotting, putting more time and energy in the project optimizing, improving and rechecking, but also can raise design efficiency ten times to several ten times, greatly reducing the design cycle, improving the design quality, as a result the economic efficiency is extremely remarkable. The development and application of independent copyright specialized software also obtains huge achievement, forming a batch of independent brands software products. But there is few application foundation research work carried on. On the one hand, the integrated technique application in the CAD has achieved certain effect, and some software development enterprises have finished the integration and information-share in the interior enterprise, on the other hand, products by different developers are basically independent and mutually not interlinked, and have not realized the standardization. Our construction enterprises, especially the large and middle scale design and construction enterprises, all own multitudinous construction professional application software, and in a engineering project, usually will use several kind of software, and it need transform data artificially, and its workload is extremely big, moreover it is very difficult to guarantee the accuracy, affecting the cooperation between engineering workers.

An engineering project is a complicated and synthesis activity, its participators involve multitudinous specialty, and its life cycle may last as long as decades or centuries, therefore, the engineering construction information exchange and sharing becomes one of the primary campaigns in an engineering project. The current construction software can only deal with the application of a certain stage or a certain specialized realm. There is neither a developer who can provide an application system that covers the entire life cycle of building, nor a project that finished by using only one kind of software product. In most cases, the information exchange and sharing is finished artificially, so the human being turns to be the interface between different systems, manually achieving (input once again) the information exchange, so the efficiency and quality of doing this can be imagined, And the result is that, it will take long to design and complete the engineering project, and the construction and management cost will be higher than needed. There is an England report (Latham Report) pointing out that about 30% cost of a construction item may lose in the broken process and communication of the project.

The solution of information exchange and sharing problem lies in standards. With the unified standard, different systems will have the common language while communicating, and the data will be on the move between different systems naturally. The IFC (Industry Foundation Classes) standard established by International Alliance for Interoperability IAI (International Alliance for Interoperability) is in fact the international construction data exchanging standard in engineering construction, and has already been accepted as the

international standard (the ISO standard). Taking the IFC standard as the foundation standard, can effectively solve the construction information exchanging and sharing problem that universally existed in our country at the present time.

As the arisen international standard in recent years, the IFC standard is a kind of object-oriented 3 dimensions construction product data standard. In few years, it has obtained extensive application in the realms of construction plan, architectural design, project construction, electronic government affairs...etc.. The Singapore government's electronic drawing examining system is the best example of the application of IFC standard in electronic government affairs. In Singapore, all design blue print must be submitted to the government reviewing by electronic way, and the government will take the compulsive requests in criterions as check-up qualifications, and then it will carry on the standard checking automatically by electronic way, and will be able to indicate the places and the reasons that breach the criterions. The Singapore government requests that all software's output data must match the IFC2x standard, and then the checking program only need to identify the data according with the IFC2x standard, and then can complete the task automatically without artificial intervention. Along with the technique advancement, the similar electronic governmental affairs items would be more and more, and the IFC standard will play more and more significant role.

The widespread application of IFC standard in the overseas attracts high attentions of the related departments and academe in our country. Since the national "95" Key Technologies Research and Development plan, our country has studied and applied the IFC standard in scientific research items, and has continuously tracking its development, building good foundation for the future deep research and application. For example, in the task "The digital community technique standard research application demonstration based upon space information" in the national 863 plan item "the digital city space information management and service system and application demonstration", it has done lots of in-depth research and discussion of IFC standard, completed the translation and local standardized work of IFC standard, and developed the IFC standard data visiting interface tool collection, applied and expanded the IFC standard in the digital community construction and management realms. In the task "architectural design and construction management system research based upon the international standard IFC" in the national "15" Key Technologies Research and Development plan "The architecture industry informationization essential technique research", it did many further studies of the IFC standard, took it as equal as our national standard, built foundation for the application of this standard in our country, and studied new generation of architectural design and construction management system based upon this standard, whose main goal was to solve the information-share problems in the process of architectural design and construction management, to develop more highly effective architecture design and construction management system, and to achieve construction structural model data sharing: CAD software by different developers can realize information-share under the IFC standardized frame, and each specialized CAD software by identical developer can realize information-share on the base of structural model data collection, and then realizes construction structural design and construction information exchange and sharing.

THE CONSTRUCTION ENGINEERING INFORMATION-SHARING IFC MODEL PLATFORM (CABRIFC)

This software has introduced the international construction profession standard—the IFC standard in domestic for the first time, taking the lead for the IFC standard's development and expansion in our country, and this software has actualized data exchange and sharing between construction software PKPM and the international construction industry standard IFC. PKPM design software (also called PKPMCAD) is a set of integrated CAD systems which gather the architecture design, the structure design, the equipment design (the water, the heating, the air conditioning, the electrics) as a whole. It holds absolute superiority in the domestic design profession, and has more than 9000 users, and its market share rate reaches more than 80%, it has become the most universal CAD system applied in domestic now. In the international market, the influence of PKPM also increases continuously, and it has occupied the primary market in the peripheral countries such as Vietnam, Singapore and so on. This software sets up information exchange and sharing between PKPM and the IFC standard, and this action has extremely vital significance in opening the international market and occupying one place in the international construction software profession for PKPM. At the same time, it also plays extremely positive role for the domestic construction profession software applying the IFC standard, moving towards standardization and cooperation.

This software is divided into two processes: IFC input and IFC output. In the IFC input process, it utilizes the C++ programming language and uses the IFC realization technique which was tied up before to create classes that exchange needed, and then to gain the model information in the IFC document through these classes, and then to obtain the middle data document, and finally to realize information transformation from IFC to SpasCAD by establishing the interface between the middle data document and the modeling software SpasCAD of PKPM series. In the IFC output process, with deep understanding of the EXPRESS language, it will output the PKPM data format according to the IFC standard, and then will obtain the IFC document. The entire software adopts advanced memory management technique and optimized algorithm, thus enhances the software capability, and the IFC information input and output speed all places the international leading level.

CONCLUSIONS

As the international standard of construction product data expression and exchange, the IFC standard supports the data exchange and sharing during the building's entire life cycle. At the landscape orientation, it supports data exchange between each applied system, and at the portrait, it solves the problem of data management during the building's entire life cycle. From the plan stage, the design stage, the construction stage to the property management stage in latter period, the document data of a building need ceaselessly accumulate and renew, also need unified standard. The application of IFC standard is a beneficial experiment, and it can solve the shortage of experience in engineering construction data management in our country, make the building data model as the real construction material information, evolve and develop with it synchronously, and be at any time provided for engineering and manager to search and analyze. The buildings are the important components of cities, and the construction product data standard research will certainly drive the digital city construction

development. The modern cities are completed through engineering construction, and their management and maintenance also cannot get away from the support of engineering construction. The construction data model should become the important components of digital city, and the construction product data standard research should be the support and consummation to the digital city theory.

To eliminate artificial "information isolated island", it must achieve norm and sanity of system and standard, and make clear the degree and quantity of information-share in the system, law and standard; Next, it should start from governors to eliminate original hierarchical system of information-share, to eliminate the information privilege idea of some sections, truly achieving information-share, and realizing coordination management. The purpose of informationization is to reduce the digital gap, to realize resources and information-share, to furthest achieve the benefit brought by information. Only after sharing, can information be repeatedly used, and then increase in value constantly; only reducing the digital gap then can it realize the balanced ,harmonious and continuable development.