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BIM Utilization for Design Improvement of Infrastructure Project in Japan

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Abstract

In Japan, MLIT had been taking the leadership in the CALS/EC project which was just partially successful. We have to learn from "the experiences of CALS/EC" to get the fruit from BIM introduction to infrastructure projects. BIM technology is the powerful tool to realize the virtual construction and information sharing among each project phase. If public sectors in Japan would not notice the similarity of issues of CALS/EC and BIM, Japanese construction industry may experience the same kind of frustration as one they had while executing CALS/EC projects. In this study, by comparing CALS/EC and BIM, the authors confirmed that the most critical issue is related to the contract of the construction projects and some new types of contracts are investigated from the viewpoint of utilizing BIM in the lifecycle of construction projects.

Keywords: Building information modelling, data sharing, contract, CALS/EC

1. Background

Serious schedule delay is caused by unpredictable condition change in construction process. As the result of the delay, contractors might face serious risk of productivity reduction. Owner side also may have to take steps to meet critical situation. Frontloading is effective to decrease such risk caused by design change, and can improve the productivity of the project.

The Japanese labor productivity had largely decreased whereas the productivity of manufacturing industry rose. BIM (Building Information Modeling) is going to be mandatory to the public construction in the U. K. in 2016. There are significant merits such as improvement of the labor productivity, the securing of market in foreign countries.

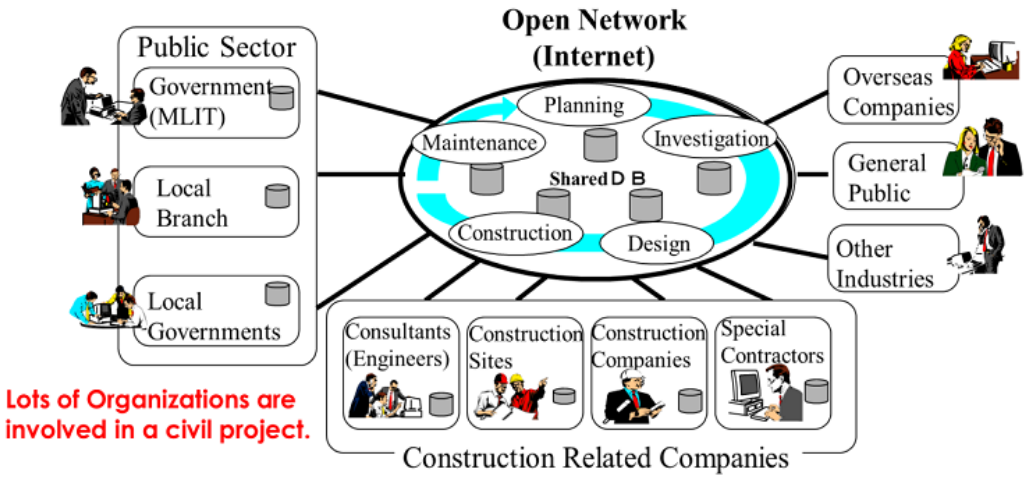

Fig.1: Image of CALS/EC (Curtsey of JACIC)

Virtual construction in design process must be the powerful method to predict what would happen in the construction process. Although virtual construction can be accomplished by using Building Information Modelling technology, information and knowledge on construction phase or fabrication phase should be available in design stage to do that. In Japan, MLIT had been taking the leadership in the CALS/EC project which was just partially successful. We have to learn from "the experiences of CALS/EC" to get the fruit from BIM introduction to infrastructure projects.

The term of CALS/EC is defined as "Continuous Acquisition, Lifecycle Support and lectronic Commerce" and used as the word expressing a series of activities to innovate construction projects by using the technologies of networking, electronic data and data sharing in Japan and Korea. **Fig.1** illustrates the image of CALS/EC set at the beginning of the project. A series of database is used for sharing information among public sectors, construction related companies and other organization or persons such as overseas companies, general public and other institutions. The number of organizations and persons involved in any civil project is not a few. Also, during the life cycle of facilities, the information can be utilized and recycled as well. From planning to maintenance, all the information produced during a project can be accumulated and used for various purposes.

In the case of projects based on design-bid-build contract, data sharing or information sharing was prohibited based on the contract between the designer and the contractor or the fabricator. This research summarizes four types of CALS/EC utilization. Also this research summarizes the results of the CAL/EC project in Japan. Although an idea of information sharing was precedent, nobody did not sufficiently grasp the merit of knowledge sharing for each organization.

BIM technology is the powerful tool to realize the virtual construction and information sharing among each project phase. Design change in construction phase or insufficient design of existing structure decrease drastically the efficiency of operation and maintenance. This research compares the issues of three types of contract from the viewpoint of BIM utilization. In the case of design-bid-build contract, since data sharing should be restricted based on the contract, consultants or engineers for designing are to become more capable of utilizing information relevant to construction or fabrication. One method to realize this for consultants is to hire more engineers who have rich experiences on construction or fabrication, which means that the mobility of personnel is to be promoted in construction industry. Since most of civil engineering projects are executed on this type of contract, overcome of this issue is crucial.

2. CALS/EC Projects Based on Design-Bid-Build Contract

In the case of projects based on design-bid-build contract, data sharing or information sharing is prohibited based on the contract between the designer and the contractor or the fabricator. **Table 1** summarizes four types of CALS/EC utilization in that case. First two are information sharing between design phase and construction/fabrication phase. The first type shows the case if the designer does not have sufficient information or knowledge on construction/fabrication, it would not be essential for the designer to try to produce construction or fabrication related information. He may have better to concentrate more on the quality of basic design concept. However, if he concentrates to the kind of task, reduction of his business opportunity would occur. Such a situation is not acceptable for the designer.

Table 1: Merits and Issues of CALS/EC Utilization based on design-bid-build contract.

Type	Merits	Issues
Design-to-Construction	Consultant can concentrate to the task essentially needed in the subsequent phase.	Consultant cannot accept reduction of business opportunity.
Design-to-Construction Frontloading	Unpredictable condition change after commencement of the work can be decreased.	Contract does not allow information sharing in design process.
Construction or fabrication Phase	Productivity improvement with cooperative activities among owner, contractor and engineer	Project-by-project utilization of software for information sharing
Maintenance Phase	Cost reduction and adequate decision making with information acquisition	Information required for long-term maintenance was not identified.

Second one is so-called frontloading.

If the designer succeeds to get enough information for the sake of construction or fabrication at

design stage and put that information into delivered documents, the contractor do not encounter unpredictable condition change after commencement of the work. However, the contract does not allow share information in design process with any contractor. Also, for designers, it is serious issue to be capable of acquiring construction related information during designing if he does not have much experience to construct on sites. Third type shows the case of information sharing among the engineer, the contractor and the owner sides during construction. Various kinds of software to assist that sort of activity were developed and used in various projects, and unfortunately project-by-project utilization of specific software caused another problem. For example, engineers of the owner side were forced to use several different systems for simultaneously handling different projects. The last type shows the case of maintenance phase. Since civil facility has to be operated for some decades, cost reduction and adequate decision making by using information acquired from design to construction processes. Main issue is in this case identification of information needed for long-term maintenance.

3. Failure and Success of CALS/EC Projects

Table 2 summarizes the results of the CAL/EC project in Japan. An idea of information sharing is precedent, and nobody did not sufficiently grasp the merit of knowledge sharing for each organization. Electronic bidding succeeded and transparency and equality of bidding chance was enhanced dramatically as a result. Knowledge transfer from design phase to construction/fabrication phase was supposed to be done by using 2D CAD standardization. Though the compatibility of the standard format for 2D drawing was insufficient, the use of the format was forced.

Table 2: Has CALS/EC succeeded?

Activity	Success?	Cause of Failure
Electronic Bidding	Success	Transparency and Equality of Bidding Chance
Knowledge sharing between Design and Construction phases	Partial Success	2D CAD Standardization is insufficient.
Data sharing during Construction Execution	Partial Success	Compatibility of software is insufficient.
Electronic Delivery	Partial Success	Additional delivery of paper documents was required together with E-documents.
Usage of Delivered Data	Partial Success	Acquired data is stored in each closed system
Data Acquisition for Maintenance	Partial Success	Required Information has not been identified adequately.

As mentioned above, information sharing during construction execution among related

organizations or persons did not succeed. Other activities of electronic delivery, usage of delivered data and data acquisition for maintenance did only partially succeed.

4. Overcome of the Issues on Data Sharing

BIM technology is power to realize the virtual construction and information sharing among phases. **Fig.2** illustrates virtual construction by using BIM technology. The 3D model is combined with scheduling data and cost data and then some virtual components such as construction machines and labors are installed to simulate all the construction process virtually.

In the case of projects based on design-bid-build contract, data sharing or information sharing is prohibited based on the contract stated above. **Table 3** summarizes the four types of BIM utilization in this case. First one is information sharing construction/fabrication. In this case, contractors could do anything based on their own decision for productivity improvement. Issue related to technology is not critical.

Fig.2: Virtual construction by using BIM technology (Curtsey of Taesung S&I)

Table 3: BIM utilization based on design-bid-build contract

Type	Merits	Issues
Construction Phase	Productivity improvement by contractor Contractors could do anything based on their own decision.	-
Design-to-Construction Phase	Virtual construction during design phase for productivity improvement.	How to contract?
Maintenance Phase	Cost Reduction during Maintenance	Information needed for long-term maintenance should be identified.

Table 4: Merits and issues of data sharing between design and construction/fabrication

Organization	Merits	Issues to overcome
Owner	Improvement of Productivity	Contract Improvement
Contractor	Risk Reduction caused by Design Change	Knowledge Sharing with Consultant
Consultant	Higher Dependency on Design Quality	Improvement of Design Ability

If the designer has sufficient information or knowledge on construction/fabrication, it would not be essential for the designer to try to produce construction or fabrication related information. Second one is so-called frontloading. As mentioned above related to CALS/EC, the contractor do not encounter unpredictable condition change. In the case of maintenance phase, cost reduction for maintenance can be reached with BIM together with essential information acquired, since duration of maintenance is about 50years to 100years for infrastructures.

Table 4 summarizes merits and issues to be overcome in the case of utilization of BIM from the design phase based on design-bit-build contract. For the merits for all participants, owner side has responsibility to overcome contract-related issues. For example, Integrated Project Delivery (IPD) has used in the case of the World Trade Center re-development project. Also, it is essential for designers to be capable of being familiar to construction or fabrication related information or knowledge.

4. Contract Types used for BIM application

Man of each phase is different in the execution form in Japan. It's the current state that it takes funds for upkeeping much because I lack consistency from a design. I propose contract confirmation and aim at utilization of more effective BIM to improve those by BIM. **Table 5** shows four types of contracts applied for international construction projects based on FIDIC contract articles. The higher the position of the contract type in the table is, the more easily the contract type is applied for BIM utilization. The lower the position is, the less easily the type is applied. For example, in the case of BOT, all phases including construction and design are carried out by the contractor, which means that it is so easy to share information and data. On the contrary, in the case of re-measurement contract (design-bid-build contract) , information and data should be shared among designer, contractor and owner, which means that there are some serious issues to overcome. On the other hand, design-bid-contract is the best choice to assure the confirmation of the transparency of the project. These days, other types of contract such as CM/GC contract and ECI contract have been proposed for the sake of utilization of information on construction in the phase of design. **Table 6** to **Table 8** shows the merits and issues for each one of BOT, CM/GC and ECI for BIM utilization.

Table 5: Contract types applied for international construction projects.

Contract	The FIDIC provision name	Applied construction project
Build, Operate and Transfer Contract	Condition of Contract for Design, Build.	➢PFI and PPP ➢Development right project.
Engineering, Procurement and Construction／ Turnkey Contract	Conditions of Contract for EPC／ Turn-key project	➢Large construction projects ➢Lamp Sam contract.
Design Build Contract	Conditions of Contract for Plant and Design build for Electrical & Mechanical Plant & for Building & Engineering Works Designed by the Contractor	➢Plant construction originally. ➢Large civil construction, city railroads and freeways ➢Lamp Sam contract
Re-measurement Contract	Conditions of Contract for Construction for Building and Engineering Works designed by the Employer	➢ The basic form of the construction project contract ➢ Design-Bid-Build ➢ Unit price contracting system

Table 6: Merits and issues of Build-Operate-and-Transfer for BIM utilization

	Owner	Consultant	Contractor
Merits	It is possible to manage each project without any financial burden.	With own inventive idea, they can run the public accommodation with the charge income.	
General issues	It takes time for selection of the project manager.	Collective strength of a construction company is needed.	
Issues to introduce BIM	No critical issue. Private sector can manage all the phases including design and construction and operation, which means all the information sharing can be done just in the private sector.		

Table 7: Merits and issues of CM/GC contract for BIM utilization

	Owner	Consultant	Contractor
Merits	It is easy to reflect opinions on construction planning and design. The budget can be grasped early.	Possible to acquire knowledge on construction or fabrication in the design stage	Possible to provide technical assistance decrease the difficulty on the stage of construction
General issues	The number of times of the contract may not be one time. Participation of the owner is important.	Breakaway from the positioning called the design for cost estimation is required.	High level of estimation ability is required.
Issues to introduce BIM	No critical issue. Information sharing among owner, designer and contractor from design phase can be smoothly accomplished.		

Table 8: Merits and issues of ECI contract for BIM utilization

	Owner	Consultant	Contractor
Merits	Possible to use constructor's know-how from early stage Reduction of construction period Reduction of design change Reduction of tender cost	Possible to use constructor's know-how from early stage Reduction of design change	Reduction of construction period (Construction can be prepared at the planning stage.)
General issues	It is hard to reflect opinions on construction planning and design.	Easiness of construction may be over emphasized.	Cost reduction may be required in the stage of the selection of the contractor.
Issues to introduce BIM	No critical issue. Information sharing among owner, designer and contractor from design phase can be smoothly accomplished.		

4. Conclusion

In the case of design-bid-build contract, since data sharing should be restricted based on the contract, consultants or engineers for designing are to become more capable of utilizing information relevant to construction of fabrication. The mobility of personnel is to be promoted in construction industry. Public sectors have to be more positive overcome contract related issues

with their own leadership. If public sectors in Japan would not notice the similarity of issues of CALS/EC and BIM, Japanese construction industry may experience the same kind of frustration as one they had while executing CALS/EC projects. Frontloading by using BIM technology efficiently can be achieved based on design-build contract, or relatively new contract types of CM/GC or ECI.

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