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Issues and Implementation Methods for BIM in the Civil Infrastructure Domain

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1. Introduction

- In AEC, BIM has attracted much attention for several years.
- BIM is a new building design and construction process.
- In BIM, architects, structural engineers, facility engineers, construction engineers, owners, and other participants have access to a 3D building model and collaboratively proceed the design tasks much faster, considering more alternative design cases.
- BIM has already been adopted for actual design and construction of some building projects worldwide.
- On the other hand, BIM in the civil infrastructure domain has not been so adopted as in the building industry.
- Civil infrastructure domain: roads, bridges, tunnels, dams, river banks, harbors, etc.

Four questions raised and discussed

1. Why is the civil infrastructure domain slower in adopting BIM than building industry?
2. Is BIM necessary for the civil infrastructure domain or not? Are there any merits?
3. What would hinder the promotion and adoption of BIM in the civil infrastructure domain?
4. What is needed to promote and employ BIM in the civil infrastructure domain in terms of research and practice?

Asia Construction IT RT Meeting

- The 5th Asia Construction IT Round Table Meeting was held by Japan Construction Information Center (JACIC) and the Committee on Civil Engineering Informatics of Japan Society of Civil Engineers (JSCE) on August 6-7, 2009 in Tokyo (ACIT 2010).
- Thirteen experts in the field of IT in construction were invited from Asian countries and discussed various issues in the meeting.
- In the afternoon of the first day, a special session on Virtual Construction was organized, and we discussed the similar agenda of the previous slide.

2. Delay in Adoption of BIM in the Civil Infrastructure Domain

- Most structures in the civil infrastructure domain are designed and constructed by **public** organisations.
- The public sector tends to be cost-blind and has **low interest in improving efficiency**.
- Many people in the civil infrastructure domain believe that civil engineering structures are designed and constructed **without big problems** currently in terms of the business process.
- In this circumstance, they do not dare to take risks of failing by introducing new technologies such as BIM.

- Civil infrastructures are **less complex** and have less number of kinds of members than buildings.
- On the other hand, there are **many kinds** of civil infrastructures such as roads, bridges, tunnels, dams, river banks, harbours, etc.
- Furthermore, due to the nature of single part production and **non-standardized members**, it takes more time and efforts to create 3D CAD models of civil infrastructures than buildings.
- Created 3D models **cannot be recycled** at other projects.

- Owners of buildings are usually private companies while infrastructures are public.
- As for **private buildings**, architects, structural engineers, facility engineers, contractors can make up a team for design.
- The way the project is done by this way is called the **Design-Build** (DB) method.
- In principle, on the other hand, the process of **public work projects** is **Design-Bid-Build** (DBB), in which design is done by design consultants and then, general contractors tender bids and perform construction if they win.

- In the **DBB** method, design and construction are **separately contracted** and performed by different companies.
- A firm which has designed the project is not allowed to join the project for construction.
- Since **no official standards for representing 3D product data models of public infrastructures** exist, it is very difficult for owners to treat 3D model data.
- They say they cannot receive particular commercial CAD files from design consultants because the owners are public.
- On the other hand, in the DB method, which is popular in commercial building projects, participants do not have to worry about the standardization but they can use **de facto standard commercial CAD format**.

- Technically, it would take more time and effort to make 3D models of civil infrastructure domain.
- Furthermore, even if detailed design is done, the design usually must be changed according to the condition of nature. Especially, the geotechnical conditions cannot be fully surveyed before construction.
- In the design of civil infrastructure domain, exchanging design information would not be so often compared to building domain.

- In the commercial building design, cost of design is usually from 7 to 10% of construction cost, while it is only 3 to 4% in the public infrastructure domain, and thus, reduction of design cost and return on investment (ROI) by introducing BIM technology may be smaller in the civil infrastructure domain than in the building domain.
- The above idea may be wrong. It is known that BIM would increase the design cost but decrease the construction and maintenance costs.
- The problem is who will pay the increased design cost.
- Lack of IT knowledge among civil engineers.
- Lack of research and research funds about BIM in the infrastructure domain.

3. Necessity and Merit of BIM in the Civil Infrastructure Domain

- Most people would agree that BIM would be necessary and have merit in the civil infrastructure domain. But the degree depends on the person.
- Major merits:
 1. 3D models made in the design phase will be used for visual presentation, which will be effective in improving design and construction as well as negotiation and consensus building with citizens, other stakeholders, and activists.

2. 3D models are expected to improve the efficiency and safety of construction and quality with clash detection, 4D and 5D CAD capabilities.
3. With the design process improvement, the number and scale of design changes are expected to be decreased.
4. It is also expected to promote “computerised construction” by applying 3D model data to construction machine control, machine guidance, work progress control, and inspection, which can lead to reducing cost, shortening the construction period, and improving quality.

- Some experts say that BIM will be useful and effective for only complex structures and should not be used for simple civil structures.
- And others argue that frequency of design change during construction would not decrease in the civil infrastructure domain because of many uncertainty factors of underground.
- Some people say that therefore, BIM will be applicable to only large-scale and monumental projects.
- Intermediate perspective would be that it depends on benefit-cost ratio (B/C).

- New idea was that the public domain should consider shifting from the DBB method to the DB method so that BIM would be more applicable, the value of BIM would be maximized, and the knowledge of general contractors would be utilized in the design phase.

4. Obstacles for Adoption of BIM in the Civil Infrastructure Domain

- Since BIM will change the business model, flow, and method of public infrastructure design and construction, **conservativeness** of those who are engaged in the public construction domain will be a big obstacle for adoption of BIM.
- The characteristics that the owners are usually public will make it **difficult to change the project method from DBB to DB**.
- Thus, the **official standardized product model** is **needed** and the public owners will not adopt BIM until the standard becomes effective.
- Equality and fairness in bidding will be an obstacle for adopting new technologies such as BIM because weak companies which may not be able to utilize the new technology are considered patiently.

- Other obstacles include **slow development of BIM tools** for infrastructure domain, bad communication and different motivations between construction engineers and IT professionals, the **mindset that efficiency would come last** and the commercial sectors rely on the government unnecessarily.
- More obstacles include **lack of success stories** and insufficient education and training of BIM to engineers in the infrastructure domain, and lack of B/C ratio.

5. Requisite for Promotion of BIM in the Civil Infrastructure Domain

- In order to promote BIM in the infrastructure domain, relaxing the current relatively rigid contract methods and project systems are expected so that DB method can be more adopted instead of DBB method.
- At the same time, since it will take time for the public sectors to shift from DBB to DB method, relaxing the current rigid electronic data submission is expected.
- For example, the rule that electronic data must be conformance with the ISO standards is too strict.
- For better performance of construction projects, de facto standards or commercial CAD files may be added to design drawings by design consultants.

- Interoperable product models are necessary to share and exchange data.
- Many various tools which are interchangeable to the product model data are necessary as well.
- In addition, **new tools** such as an integrated system of Geographic Information System (**GIS**) and **CAD** would be important in the infrastructure domain from a standpoint of coordinate systems.

- In order to develop such product data models and tools, much **research and development would be necessary** at universities and research institutes as well as companies.
- Government should consider **raising funds** for those tasks.
- R&D and standardization should be done **collaborating** with international organizations, universities, research institutes, companies in foreign countries instead of doing alone.

- Fundamentally, **a new vision with a strong strategy** would be necessary to change the business model and process in the infrastructure domain, which is very conservative and which tends to resist change.
- The government should have a **policy** toward changes to improve the efficiency, quality, safety, etc. by adopting BIM, inventing new schemes such as giving incentives to those who challenge the changes.
- **Success stories** are necessary to promote changes.
- And **education of IT**, CAD, BIM, etc. to not only students but also practitioners and engineers is necessary. Government's support is important in these fields.

- As a new support business, a BIM information manager or a BIM information management company will be needed to promote and facilitate the new business process of BIM.
- BIM managers will collect various data and information related with the design and construction of the project, convert to some particular data format, distribute them to the related engineers and team members and support all participants to the project in terms of data and information they treat.
- This kind of work is currently done by the owner or public agencies. Just like design consultants were spun off from the owners some decades ago, BIM information managers will be born, raised up and spun off from the owners in the near future.

6. Conclusion

- First, the reason why the infrastructure domain is slower in adoption of BIM than building industry was identified as the following:
 - the cost-blind tendency and conservativeness of the public domain,
 - less complex structure than buildings,
 - difficulty in shifting from Design-Bid-Build (DBB) method to Design-Build (DB) method,
 - lack of official standards of product models in the infrastructure domain,
 - coordinate system problems,
 - less complex organization than building design industry,
 - smaller ratio of design cost in the total construction cost than buildings,
 - lack of IT familiarity and research of IT in civil engineering.

- The second issue was the necessity and merit of BIM.
 - Necessity of BIM would not be denied, but the level of necessity and merit depend.
 - BIM would improve the efficiency, safety, quality of design and construction of infrastructures.
 - However, the merit may be limited to complex and large scale structures.
 - Overall, it depends on B/C or ROI.
- The third issue was obstacles for adoption of BIM.
 - Potential obstacles include conservative mindset, rigid DBB contract method, lack of standard product data models, lack of communication between civil engineers and IT specialists, etc.

- The final issue was requisite for promotion of BIM.
 - In order to promote BIM in the civil infrastructure domain,
 - **shifting from DBB to DB method or**
 - **relaxing the need of rigid officially standardized product model**would be necessary.
 - However, **some standards** are apparently necessary and various interoperable tools are required.
 - **BIM information managers**, a new task, will be needed in the near future to promote BIM.
 - Finally, government's support including **strong vision**, strategy, education, research and development is necessary.

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