Improvement of BIM-based building approval system

[Kim Karam and Yu Jungho]

Abstract—**Using Building Information Modeling (BIM)-based design technology for various building design processes has been global and widely adopted in building construction projects. Many projects, however, are still conducted thru traditional 2D-based work methodologies, and there are some concerns when making submissions for building approvals derived from BIM-based design information. For example, when an applicant manually inputs information into a specific application form, subjectivity can become an issue. Human mistakes can be made during the input data process when there is some miscommunication between participants related a project. To address this problem, this paper proposed an improved BIM-based building approval system with a BIM-based information collection approach. To that end, we surveyed several countries where the building permit process use a web-based system. Then based on the information input method we classified the required information into two types: BIM-external and BIM-internal. The proposed approach provides an approach that improve the efficiency and the accuracy of the building permit process, since a BIM-based building model can be applied directly.**

Keywords—**Building approval, BIM, Building permit, Information requirements, Submission system** *(key words)*

I. Introduction

Along with a global awareness about building information, there is a growing interest in building information modeling (BIM) in the architecture, engineering, and construction (AEC) industries. BIM technology is necessary for managing building information thru an integrated building model during the complete building life-cycle from the conceptual design phase to a dissolution phase. During the initial design phase, a designer planning a building within a conceptual shape and placement of the building use various BIM-based design software [1,2]. Then, in accordance with design processing, the building information is managed depending on each level of detail of the design phase into an integrated building information management system [3]. In this regard, some European countries, including Finland, Germany, Italy, Norway, and Sweden have pursued construction projects using BIM technology since the middle of the 21st century. Since 2006, any construction project in the U.S. that participates in a U.S. general services administration (GSA) project has a legal obligation to adopt BIM technology. In South Korea, from 2016, all new building construction projects will have to adopt BIM technology as a legal requirement using a standard guide related to BIM.

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In spite of the trend toward BIM-based construction projects, many projects are still done via traditional 2 dimension-based project work without BIM technology. In addition, although BIM may be adopted as a design process in the project, there are many parts still done thru traditional methodologies. To increase work productivity during the BIM-based design phase, it is necessary to have a data management methodology to manage building information with an integrated building model and where data values are created and managed using BIM technology.

In the current design phase, design documents to obtain building approval can be extracted from a BIM-based building model, however, in most cases the design documentation is manually created using 2D-based design drawing tools, such as AutoCAD. In this regard, although there is a BIM-based building model, it is just a reference model to illustrate the building model to an owner. There are some reasons for that, with one of the most critical reasons being limitations of 2D-based submittal systems that are often the only mechanisms available for a government building permit process. Since the building permit process has to be able to accept diversity in adopted software used to design a building, there are some potential problems when using a BIM-based building model for the building permit process.

The first issue arises due to specific file format requirements. Since various BIM-based design programs each have a specific file format to represent a building model [4], a governmental submission system for building approvals cannot be static in terms of accepting only a specific file format. If this is the case, then an applicant has to use a specific BIM-based program, even if they have never used the program. To that end, industry foundation classes (IFC) [5] have been developed by buildingSMART international in 1997 as an international standard file format to represent a building model. Last year, the latest version of IFC, IFC4, was adopted by most BIM-based design programs, such as Revit, ArchiCAD, Allplan, and Digitalproject. Although this standard exists, it still may be the case that when the applicant submits a IFC-based building model, the building model cannot be uploaded into the submittal system, or may be uploaded, but is then not used to obtain building approvals. In addition, traditional 2D-based application forms are often have specific information that must be manually input by an applicant. When an applicant manually inputs the information into the application form, subjectivity can become an issue. Human mistakes can be made during the input data process, especially if there is some miscommunication between a stakeholder and an applicant. This decreases efficiency and inserts delays in the building permit process.

To address these problems, this paper proposes an improved BIM-based building approval system with BIM-based information requirements collection. To that end, we surveyed the building permit process in several countries: the

USA, Hong Kong, Korea, and Singapore. Then based upon the information input method, we defined the required information necessary to obtain building approvals as two types: BIM-external and BIM-internal.

II. Current Approaches

A. United States of America

A building permit is required by almost every city or county in the USA in order to construct or alter a building or structure. In the USA, each state have a specific submittal system for their building permit process. These systems are quite similar in terms of the application forms, required design documents, and what an applicant has to input into the system. There is a website to apply for a building permit for any state in the country. Overall, most states require that all construction work on a building that requires a permit is also done by a licensed contractor. The first step is to obtain the proper application form from the each state in which the applicant wishes to pursue building project. The next step is fill out the specific application forms and submit them with design documents. In some areas, the city and county are one and the same entity. In general, the building and site plans will require the following: 1) structural drawings, 2) site plan, 3) floor plans, 4) electrical, plumbing and heat, ventilation, and air condition (HVAC) plans, and 5) landscaping. A building permit application approval process can be as quick as a month or as long as a year, depending on the project and the city or county's capacity. In addition, building permits usually have expiration dates and work must be started and completed within a given time frame before extensions are required.

There is an online permitting system in most cities and counties. In this regard, although they are little bit different from each other in terms of what has to be input or the applications forms, the general critical processes are very similar. Using online permitting, an applicant can submit documents related to required building permitting including their contract information. In New York city, there is an application filing and permit process using a web-based system[6] (see Figure 1).
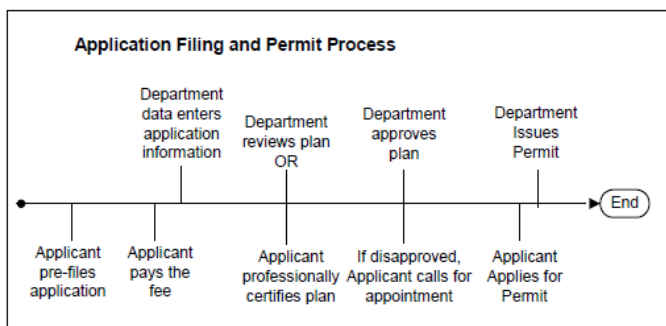
Figure 1. Application filing and permit process in New York city

B. Hong Kong

Pursuant to the powers under the building ordinance, the buildings department is responsible for the enforcement of the safety and health standards for the planning, design and construction of buildings and associated works on private land in Hong Kong [7]. When an applicant intends to carry out building works, they are required by law to appoint an authorized person, and where necessary a registered structural engineer and if building works at any stage involve geotechnical elements, a registered geotechnical engineer, to prepare and submit plans for approval by a building authority under the building ordinance. In addition, the applicant is also required to appoint a registered contractor to carry out the building work. In general, the design documents will require the following: 1) building plans, 2) general building plans, 3) spread footing plans, 4) hoarding plans, 5) site formation plans, 6) fire service installation plan, and 7) drainage plan. There is a web-based system to manage public application forms for building approvals provided by the government [8]. In this system, an applicant can obtain any application form related to the building permit process in Hong Kong.

Warehouse construction permits are under the administration of the Efficiency Unit, which receives all relevant building license applications for six government departments and two private utilities (i.e., telephone line and electricity supply) and coordinates joint inspections for two-storey warehouse projects. An online system was established in 2008, called the One Stop Centre (OSC) [9]. Using OSC, the building permit process can be simplified to the following steps: 1) obtain building plans approval, 2) apply and pay for technical audit of water supply connection works, 3) apply, pay and receive road excavation work permission from highways department, 4) notify and obtain approval from traffic police, and 5) obtain building consent from buildings department (see Figure 2)
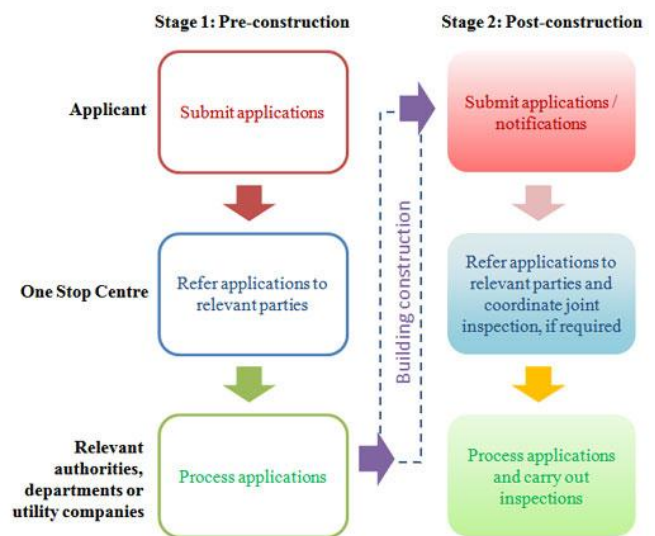
Figure 2. Conceptual process of One Stop Centre

C. Korea

An applicant who intends to pursue a building project in Korea has to obtain proof of ownership from the Property Register to show that the applicant has the right to construct a

building. The issuance date stated in the land registry should be three months prior to the date of submitting the application for a building permit. For the building permit process, an applicant must submit an application for a building permit to the county office of construction that includes the following: 1) the size of construction lot, 2) documentation showing the applicant's ownership or the right to use the construction lot, and 3) basic design drawings which must specify the approximate location of the water pipes, sewage, septic tank, electrical facilities, and telephone (Internet) lines. In addition, before construction work begins, the company informs the authority by including a copy of all relevant contracts between the relevant parties and the design drawings.

In 1998, the Korean government standardized an architectural information framework to increase the efficiency and accuracy of the traditional building permit process. There is a web-based architectural information system to submit an application called the Seumter system [10]. The Seumter system was implemented in 2008 for construction, register, residential service, and contractor management of a building project. In addition, there are plans to upgrade the Seumter system to facilitate BIM data and to apply 3D-based building model into a code checking process under the architectural law of Korea. The Seumter system can be a connection between an applicant and administration office providing architectural information management services (see Figure 3).
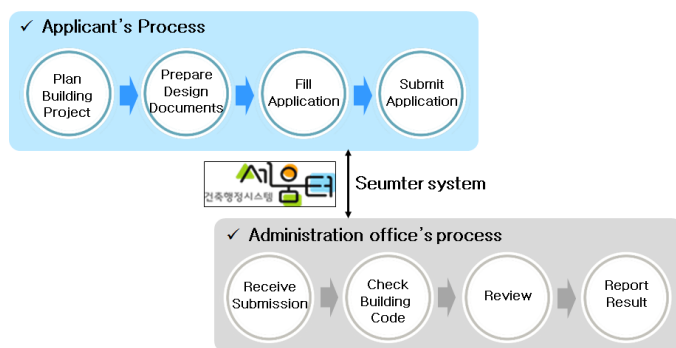

Figure 3. Conceptual process of Seumter system

D. *Singapore*

In Singapore, the application for permission from the Urban Redevelopment Authority (URA) can be done electronically by a Qualified Professional through the Electronic Development Applications. An applicant has to submit a form that includes the following: 1) proposal and sketch plans and 2) survey plans for sloping or undulating sites. To obtain structural plan approval and a building commencement permit, a Qualified Professionals will submit the structural plans through the Building and Construction Authority (BCA). The permit will not be issued without written or provisional permission from the URA and payment of any development charges, if applicable. Most applicants submit their application to URA and BCA for structural approval at the same time. In this regard, construction work must commence within 24 months from the approval date.

There is an integrated information system to re-engineer the business processes of the construction industry to achieve a quantum leap in turnaround time, productivity and quality named construction and real estate network (CORENET) by the Ministry of National Development and driven by the BCA [11]. The CORENET system has several sub-systems including the following: electronic buildable design appraisal system, electronic plan checking systems, and electronic submission system. The electronic buildable design appraisal system provides automated checking of building design against conformance to the building codes in Singapore. The electronic plan checking system (e-Plan Check) provides Qualified Persons with self-checking capabilities in their BIM-based design process prior to submission for approval. The electronic submission system (e-Submission) is a government to business (G2B) web-based portal for industry professionals to submit project related plans and documents to regulatory authorities for approval. Recently, administration of BCA established BIM-based design guidelines for the e-Submission system. In addition, regulatory agencies will then export received models to IFC for e-Plan Check system purposes [12].
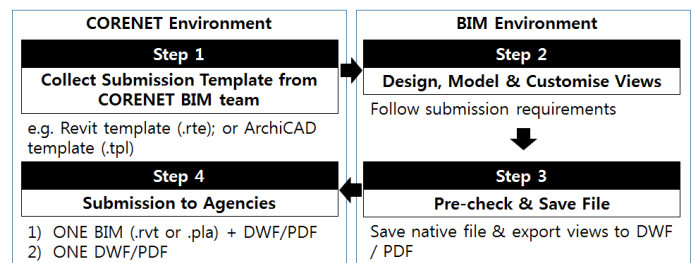

Figure 4. Conceptual process of CORENET system

III.   Proposed Approach

A. *Information Collection Improvement*

In general, a survey of current building permit processes in several countries in Section II, shows that the data requirements are similar depending on the regulatory requirements and the law of each country regarding building approvals. In this regard, the required information of submittal applications can be classified by two types: BIM-external and BIM-internal information requirements. BIM-external information consists of the information that has to be created and managed within collaborated design or a planning environment. In this regard, it doesn't matter whether or not BIM is adopted. These items include things such as ownership, licensing, and any health and safety information. When the applicant collects BIM-external information from the participants of a project, the applicant must to use a specific form to accurately complete an application for building approvals using a submission system. In comparison, there is some BIM-internal information necessary for the building permit process. These data can be entered using a BIM-based building model or design documents that are generated from a BIM-based building model including design concept, structure, and floor plans.

For the proposed information collection method, there is a standard manual or guideline of the building permit process. The standard manual contains the role and responsibilities of the required information, coordination work definition between related participants of a project, information delivery manual (IDM) [13], and model view definition (MVD) [14] of a BIM-based building model for the building permit process. Moreover, BIM-external information can be managed with an XLS file format that is user-friendly for related participants.

Figure 5. Improved information collection approach

B. *Process Improvement*

In terms of a process improvement, since it is necessary to reduce the cycle time of the building permit process, administrative work should be reduced in comparison to traditional approaches. One of the critical issues is accuracy and the legality of the submitted applications. Therefore, the applicant has to self-check the requirements of the respective government before submitting documents for building approvals. There are several code checking systems using specific rule sets, such as the Solibri Model Checker or e-Plan Check. In this regard, the applicant has to prepare an accurate rule-set to check their building model within a specific city or county legality. In addition, when a building model is exported via an IFC file format, an applicant can use any familiar BIM-based design program. This facilitates the quality of the design, since their work productivity is not hampered by a need to use unfamiliar software. Figure 6 shows the improved building permit process using BIM-based building approval requirement check and submission systems.

IV. Conclusion

Various government agencies have continually evolved their building permitting process in regards to architectural information to increase the efficiency and accuracy of the submitted work. In this regard, since the BIM-based design process has been increasingly adopted for building construction projects, the building permit process also need to be upgraded to facilitate BIM technology. Many current approaches for building permitting processes, however, are not yet fully integrated with BIM-based design information and tools. Thus, this paper proposed a BIM-based building approval system with BIM-based information requirements collection. To that end, we surveyed several building permit processes in various countries to review current approaches in order to develop an improved BIM-based building permit process. In addition, per the information management method, information requirements were classified by two types: as either BIM-external or BIM-internal.

Since this paper proposed a conceptual approach, it is also necessary to take the proposed approach and develop a practical implementation. In addition, it is necessary to consider that BIM-internal information is being often defined by the local regulatory agency and possibly specific to each environment. Consequently, these considerations need to be
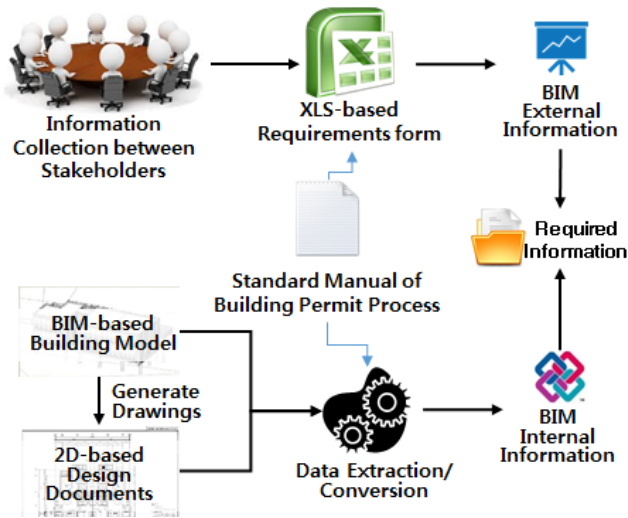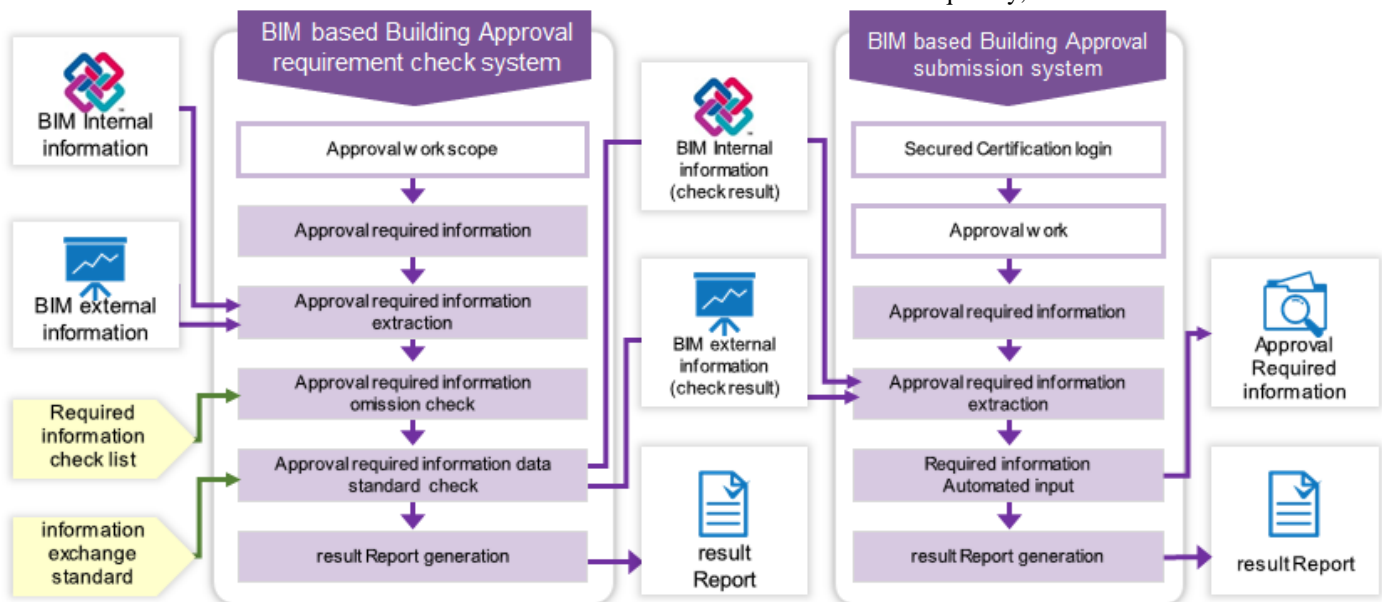

Figure 6. Improved building permit process using BIM-based building approval system

kept in mind in the development of a practical submission system and standard guidelines.

The proposed approach will further efficiency and accuracy in the building permit process, especially by directly utilizing BIM-based building model data. In addition, since an applicant is provide with a capacity to self-check compliance with building codes, the process for administrative review can be reduced. Finally, gathering required information that is managed by a BIM-based building approval system reduces the possibility for human error.

Acknowledgment

References

[1] Jin Q., Overend M., and Thompson P., "Towards Productivity Indicators for Performance-based Façade Design in Commercial Buildings", Journal of Building and Environment, Vol. 57, 2012, pp. 271-281.

[2] E. Hjelseth, "Exchange of Relevant Information in BIM Objects Defined by the Role- and Life-Cycle Information Model", Architectural Engineering and design management, Vol. 6, 2010, pp. 279-287

[3] American Institute of Architects, "Building Information Modeling Protocol Exhibit", AIA Document E202, 2008, pp. 1- 9

[4] Y. Rezui, A. Zarli and J. Hopfe, "Performance of different (BIM/IFC) exchange formats within private collaborative workspace for collaborative work", Journal of ITCon, Vol. 14, Special Issue BuildingInformation Modeling Applications, Challenges and Future Directions, 2009, pp. 736-752

[5] International Standard ISO, "Industry Foundation Classes for data sharing in the construction and facility management industries", ISO 16739, Publication stage 60-60 as of 21.03.2013.

[6] New York city Buildings, How to File and Application & Get a Permit, Available at: http://www.nyc.gov/html/dob/html/development/permits_howto.shtml (07. 07. 2014)

[7] Buildings Department, Public Services, New Building Works, Available at: http://www.bd.gov.hk/english/services/index_new1.html (07. 07. 2014)

[8] Buildings Department, Public Forms, Available at : http://www.bd.gov.hk/english/forms/index.html (07. 07. 2014)

[9] The Government of the Hong Kong Special Administrative Region, One Stop Centre for Warehouse Construction Permits, Avilable at: http://www.eu.gov.hk/english/osc/osc.html (07. 07. 2014)

[10] Korean Ministry of Land, Infrastructure and Transport, The Seumter, elecronic architectural information system, Available at: http://www.eais.go.kr/ (07. 07. 2014)

[11] Singapore Government, Building & Construction Authority, Construction and Real Estate Network, Availabe at: http://www.corenet.gov.sg/index.html (07. 07. 2014)

[12] Building and Construction Authority, "BIM e-Submission Guideline for Architectural Discipline version 3.5", Guideline, 2010

[13] J. Wix and J. Karlshøj, "Information Delivery Manual Guide to Components and Development Methods version 1.2", BuildingSMART, Publication, 2010, pp. 1-84.

[14] R. See, J. Karlshøj, D. Davis, "An Integrated Process for Delivering IFC Based Data Exchange", BuildingSMART, Publication, 2011, pp. 1-44.

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