Classification of objects and their properties defined in Korea Building Act to translate into KBimCode and their application

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Abstract –

This paper aims to classify and structure explicit objects and properties which can be utilized in KBimCode and develop a database of the Korean building Act. In order to conduct automated building code compliance checking, it is essential to translate permit requirements in Korean Building Act into a series of explicit and logic-based form for computers. As a basis of the first step in translation of Korean building permit requirements for the automated building code compliance, previous research shows how to analyze regulation sentences written in natural language.[1] Based on this, 1200 target objects and their related properties were extracted. The objects were captured in noun phrases of regulation sentences and classified into a series of types according to their information. Through the process of removing the similar and ambiguous meaning of objects and properties, they were transformed into an explicit form. Then they were categorized into two types of generic building object and building regulation-specific objects. In particular, the latter that condition regulations require to check have are based on dynamically instantiable objects from the implementation perspective. The same process of object extraction and classification was conducted for identification of target object properties. As an application of the objects and properties database, the web-based database is suggested for the user-friendly interface to easily find and manage objects and properties and measure the stats and frequency of usage of them.

Keywords –

Building Information Modeling (BIM), automate building checking, Korean Building Act, Building Regulation-specific object, Classification, Database, Web-based application.

1 Introduction

Recently, interest and application of building information modelling (BIM) have increased in the architecture, engineering, construction and facility management (AEC-FM) industry. In Korea, it is obligatory to apply BIM to buildings with a construction cost of over 50 million dollars and supports the active introduction of BIM through the development of the BIM environment at the national level.

The application of BIM has enabled the creation and utilization of building models with rich information handled throughout AEC-FM industry in the computer environment. This has helped to automate design assessment which had been conducted by a hand-based method on 2D-based drawings. This paper focuses on the Translating design assessment contents described in natural language into computer-executable form as the first stage of the automate design assessment system

Building regulation codes, which are the main content of the design assessment contents, are different in the language and expression in each country, and regional development is essential. Some of the sentences in Korean Building Act have complex relationships among them. And they contain many words which have a double meaning and similar words referring to the same meaning. So it is difficult to translate sentences into explicit and logical forms for execution on the computer.

As a preliminary research to support the rule-making based on the building permit regulations, the studies aim to analyze and organize the objects and related properties of building described in Korean Building Act. Simultaneously, the characteristics and classification system of objects and properties on the building regulation sentence can be utilized as one of elements to translate information of the sentences into an explicit form so that it can be applied to automation design assessment based on BIM.

This paper deals with analysis of building regulation-

specific objects in Korea Building Act and the scope of this study is as follows:

1. Analysis of the Korean Building Act focusing on Noun phrases
2. Classifying and structuring of objects and properties
3. Development of objects and properties data-base and its application as a dictionary

2 Background

2.1 Building requirement checking projects

As an approach to BIM application, building design assessment gradually has accepted automatized and related projects have been carried out at the level of government in the several countries. For example, CORENET led by Singapore is the representative project accomplished to automate building design assessment based on the IFC model structure. GSA (General Services Administration) project focused on the evaluation of a circulation system automatically drew over the courthouse building model [2]. As the prerequisite step of assessment, building regulations written in natural language have to be translated into the computer-executable code.

Conventionally, the rule translating process has been performed by both rule interpretation and hard-coding process at the same time. The code generated in this way has limitation such as specific software dependant, the difficulty of reuse the existing resource in defining a new rule, therefore rule-maker have to create new ruleset with the repetitive and redundant process.

To solve the problem, an approach has been proposed that code definition using data modeling languages focused on the IFC, the international standards. The DesignCheck (2006) is the Australia building code checking system utilizing EDM (Express Data Manage) to share the object-oriented database. Because the rule-checking attributes such as entities or rules are defined in EXPRESS language, this approach has been evaluated as developer focused method. Both methods pursue the code generation method mainly focused on the developer and have the limitation that accessibility is low for the domain workers who have little programming knowledge.

The Korean government has been led the KBim project to establish the framework for the automatic building permit system. As the part of the project, KBimLogic is devised to translate building regulation sentences written in natural language into the computer-executable format, KBimCode. The detail is discussed in the next chapter.

2.2 Logic rule-based mechanism : KBimLogic

The KBimLogic is based on the logic rule-based mechanism to translate building permit related regulations from Korea Building Act into the computer-executable ruleset file. As the first step, regulation sentences are decomposed and examined to deduce building objects, methods and sentence relationship. By the components in the database, KBimCode is generated with language syntax and managed by KBimCode editor and composer. Generated KBimCodes are also collected as KBimCode DB and reused for the other KBimCodes' relational contents and can be exported as ruleset file. The ruleset is composed of the standardized and intermediate language that both human and computer readable. Also the ruleset can be utilized in various rule checking software at the phase of rule review with BIM model.

The logic rule-based mechanism is composed of three parts 1) classifying objects and properties extracted from the regulation sentences 2) stereotyping verb phrases from sentences 3) decomposing sentences as atomic sentences. The scope of this paper is focused on the extracting and classifying building objects and their properties from the noun phrases in the sentences.

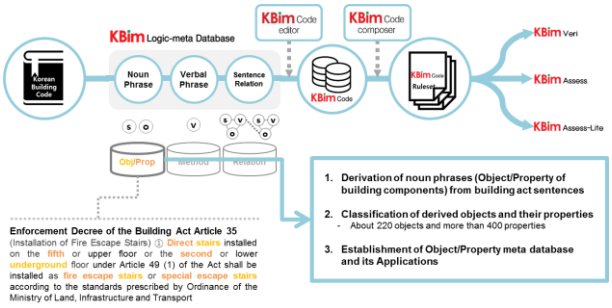

Figure 1. Object and property database and example among the overall KBim project

'Figure 1' shows the overall flow of project and the scope of this research. By analyzing sentences from Korean Building Act, noun phrase, verbal phrase, and sentence relation are deduced and accumulated as a database for reuse to generate KBimCode. For example, EDBA (Enforcement Decree of the Building Act) article 35 is examined to derive the building components such as stairs or underground and their properties such as type and number of the floor. Similarly, predicates that are common and high frequency from verbal phrases are also collected and classified in the database to be used as methods for defining the exact action of the object.

The directly related sentence component for the rule-making process is a method for querying building object and checking whether the property requirement is satisfied. As the parameter of the method, objects and

properties have to be precisely defined to imply the exact definition described in the regulation. Therefore, this research proceeds the study by following five steps.

1. Extract the target object from the noun phrase
2. Include specific object defined in the regulation
3. Extract the property for check object based on the BIM modeling
4. Categorizing objects and properties considering different expression of same meaning, or different meaning of the same expression
5. Concretizing the object and property database by developing web-based dictionary

3 Object Extraction from Noun Phrases of Building Permit Requirements

3.1 Korea building permit requirements analysis

The requirements for the building permit are regulated by various type of documents such as building acts or fire evacuation-related regulations. Since an article includes several clauses and paragraphs, it is hard to understand the exact contents at one view. Also, each article has complicated sentence relationship with other articles or paragraphs such as upper-lower relationship or reference and commission to another level of regulations. Fundamentally, the upper level of regulations assign the outline or general features of requirements and refer relation of lower level of regulation sentences. In contrast, lower level of regulations basically designates detail requirements and method for checking regulations. According to the type of regulations, description manner and contents structure differ by type. Therefore, building permit related requirements are especially hard to be translated into computer-executable form.

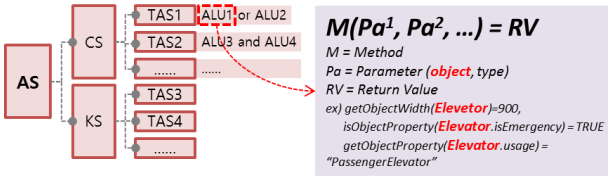

Figure 2. Level of dividing single sentence into multiple units of atomic sentence

To figure out complicate meaning included, the article has to be identified at the level of the atomic sentence (AS) which composed of S (subject) + O (object) + V (verb) and has a Boolean result. Then the sentence is again fragmentized as translated atomic sentence (TAS). Finally, TAS is divided as arithmetic logic unit (ALU) composed of unsplinterable S, O, and V. By fragmentizing sentences into the least unit, target object of regulation can be easily identified. To translate natural language sentences into the logical structure of semantic attributes, every logical unit has to be connected according to the logical relationship described in regulation to restructure the meaning of original article.

By the logic rule-based mechanism, natural language sentences are composed of minimum semantic components without redundant meaning. Translated logic structure of the sentences is collected as sentence database to compose KBimCode much easily than before.

3.2 Object name extraction from the Korea building regulations and its database

As the pre-process to structure the database for object and property, subject and object in every type of noun phrase were extracted and collected as name database. The database includes the wide range of expression of same meaning or related objects or properties. 'Figure 3' shows the web-based object name database and the interface for searching. The (a) in the image is typing "wall" in the name box to query wall or related objects or properties. The (b) is the part of queried result including wall, different type of wall and related objects that extracted from every noun phrases in the building permit related regulations.

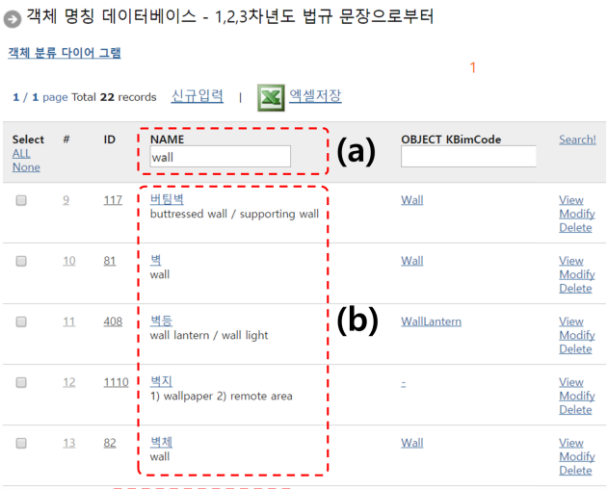

Figure 3. Searching "Wall" on the name database

'Table 1' shows the part of queried result when search 'Wall' as the name in the searching tool of web-based database like 'Figure 3'. In Korean, the id 81 and 82 expressions are different but have the same meaning that exact 'Wall'. Name database is useful for solving this issue that how to figure out some expressions having similar meaning and merge them.

Table 1. Example of the various usage of "Wall"

ID	Korean Name	English Name
117	버팀벽	Buttressed wall / Supporting wall
81	벽	Wall
408	벽등	Wall lantern / Wall light
1110	벽지	1. Wallpaper 2. Wall light
82	벽체	Wall

4 Classification and Definition of Objects and Properties on the Building Permit Requirements

In order to establish the basis of various applications of BIM, standardizing process of building object information that occurs in the entire construction industry is being done.

IFC [12] and Omniclass [13], which are international standards, are information systems for building objects that can be directly linked to BIM. But these international standardization systems do not deal with specific information handled in the Korean AEC-FM industry. In Korea, the research on systematization of building information was conducted for the purpose of, which is led by the Korea Institute of Construction Technology [14.] However, the Korean construction and building information systems are not intended to reflect the specific data in the building codes because they are aimed to standardize general objects that are handled throughout the Korean industry. For the permit related rule checking process, it is necessary to establish information system not only for general building objects but also the specific building objects of Korean Building Act, properties and their relationships. Next two sections introduce the approach for explicitly identifying the objects and properties required in the regulations. As a result, 220 objects and 583 properties are defined as the explicit form for KBimcode.

4.1 Definition of objects

Based on the object names extracted from the 1977 sentences of the target Building Act, the classification of them and count are the same as Table 2'.

Table 2 Classification and example of objects

Level1	Level2	Level3	Count
Target object	Space objects	Space	122
		Floor	12
		Area	17
	Building objects	Building	322
		Building element	110
		MEP	386
		HVAC	37
	Materials		20
	External building objects	Site	9
	District / Region		67
Non-Target object	External building objects	External Structure / Road/ River	37
	Subject and Institutions		36
	Etc.		14
	Gross		1200

The objects could be classified by building objects, space objects, materials, the external building objects, subjects, institutions, and District / Region, etc. These are classified into the rule-checking target objects and non-target objects according to the whether they can be automatically assessed.

The target objects include the building objects, space objects, the material, and the building site among the external building objects, and it occupies 93% of the whole extracted objects. (Figure 4.) On the other hand, the non-target objects include subject, institutions and external structure, road, river among the external building objects

The target objects include BIM-enabled objects and non-BIM objects related to the building permit process. The former refers to the objects that can be directly defined by IFC objects, and the latter refers to the external objects derived from BIM data such as indoor circulation graph, work space, energy zone, scaffold, etc.

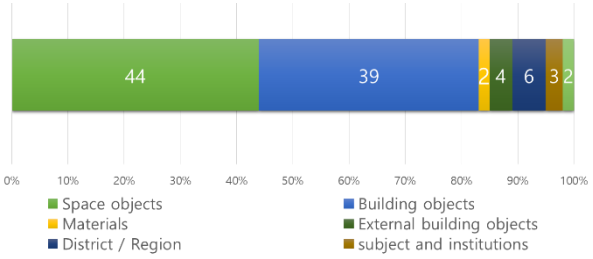

Figure 4. Target object types

The target objects are categorized into two types of

generic building object and building regulation-specific objects. The generic building objects can be defined as a static objects such as building, slab, door and wall. On the other hand, a building regulation-specific objects whose condition regulations require to be checked is based on dynamically instantiable objects from the implementation perspective. The building regulation-specific objects include three categories that they are defined by (1) set of building objects (object group), (2) a certain generic object with specific properties and (3) partial space object.

'Table 3' show example elements of building regulation-specific objects and their related generic object and category.

Table 3. Category of building regulation-specific objects and the examples

Object Name	Generic Object	Category
Passage	Space	1
Main Structural Part	Column, Floor, Beam, Roof, Stair	1
Parking Lot	Space	2
Living Room	Space	2
Elevator Shaft	Zone	2
Specific Fire-Fighting Building	Building	2
Open Floor Structure	Slab	2
Floor Slab	Slab	2
Balcony	Slab	2
Ceiling	Covering	2
Ceiling Covering	Covering	2
Parking Unit	Space	3
Parking Area	Space	3
…	…	…

4.2 Definition of object properties

Properties are depend on specific object and cannot be detached from the object. In order to identify target properties, the same process as object extraction and classification was conducted. The systematization of the properties in the target regulations was carried out by referring to the properties classification system of the BIM application guide (2010) of ministry of land infrastructure and transport republic of Korea. As a result, 583 properties were extracted from the target sentences. In addition, 217 properties were identified through the process removing redundant meaning.

Table 4. Examples of object properties type s

Type	Element	Count
Basic Property	Building data Region/district Floor location Usage Material Building structure …	39
Geometry property	Geometry …	29
Object-specific property	opening Electric Pressure Count …	125
Relational property		6
Calculation property	Allocation Count Slope between objects Sealing / Exposure / Openness Walking distance …	14
Complex property		3
Reference property		1
Gross		217

'Table 4' and 'figure 5' summarize the results of classifying the detailed items of each type into the basic property, geometry property, object-specific property relational property, calculation property, complex property and reference property from the 217 properties.

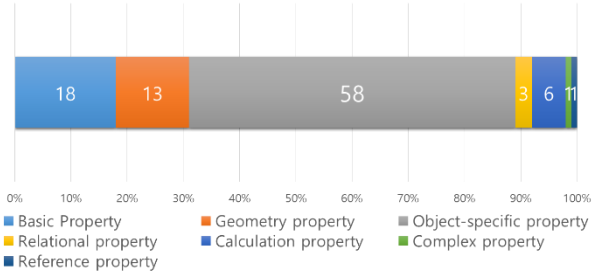

Figure 5. Object properties types

5 Web-based Database As Application of Object and Property Database

To manage structured object and property, this research utilizes the web-based database for a continuous and real-time update of the elements. Through the database, new object and property can be added and the existing data can be modified with authorized account. The database also includes the indexes about object and property such as ID, object, object KBimCode, property, property KBimCode, return value of corresponding object and property and role as the object dictionary. Through using database, statistical data about frequency of using object and property can be calculated. Also, not only for the checking Building Act, but also can be used in various field of building design assessment phase.

5.1 User interface of the database

The object KBimCode, object property KBimCode, ID, data type and description are managed by the web-based database. One of the databases about object name is already explained in section 3.2. This section describes the finalized database of the object and property that reflecting systematized and structured data structure of the database.

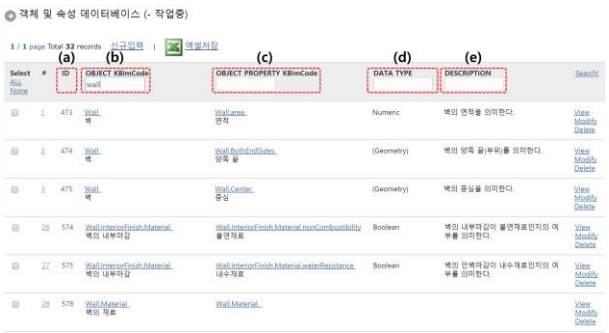

Figure 6. Searching interface

'Figure 6' shows the result of searching "Wall" as section 3.2 describing the Object name database and result about searching the same object. The database structure depends on the classification of OBJECT KBimCode (b). Each object and property has its own ID number (a). Different with Object name database, object and property database provides real KBimCode of the object (b) including general object and specifically defined object by regulation. Also, the property that used with the object is also described in (c) OBJECT PROPERTY KBimCode. The (d) part explains the data type of the property. Object property connected with method node has specific type of return value. By the (e), the description of the object and property, the user easily find the definition of the object and property.

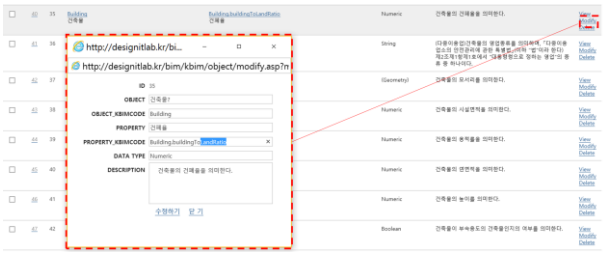

Figure 7. Editing interface for add and modifying

The database also offers the interface for editing of the existing information about object and property. (Figure 7) Through the authorized account, the user can access to the editing system. If the definition of the object described in regulation is changed or a new object is needed for additional KBimCode, new object or property can be added to the database through the new object input interface.

5.2 Usability of database component

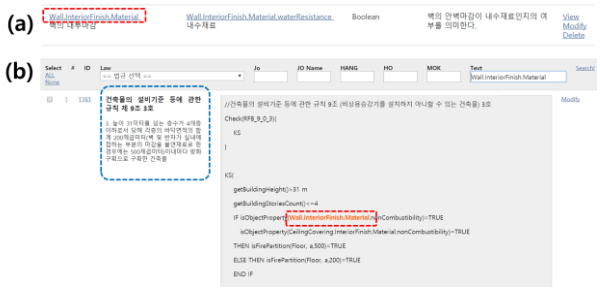

Figure 8. Example of using searching interface

The database is not only for checking definition and description of object and property. Using KBimCode DB, user can easily find the usage example of object and property in KBimCode. KBimCode example provides the method for utilization of composing other codes with the object and property. Compared with original text of regulation, user also can find which original word is coincidence with code.

'Figure 8' shows the example of using searching interface for querying object and property by connecting KBimCode DB. Among the written KBimCode, the user can find the code of object and property easily by marking up the target part. If user clicks property of the object, the same result about clicked property is queried. In this way, database includes the related regulation and KBimCode using same object and property or reference regulation used for defining the definition and scope for object and property. For example, "Wall.InteriorFinish.-Material" property is used in regulations for facilities, evacuation and fireproof structure, and sprinkler facilities standard.

6 Conclusion

This paper introduced classification of objects and properties information from the sentences related to building permitting from Korean Building Act, as a part of rule translation process for the automat building code compliance checking.

In order to conduct automated code compliance checking, it is essential to translate natural language-based requirements in building regulation into computer-executable form. Because the sentences of Korea Building Act have similar but different expression and ambiguous meaning at the same time, logic rule-based mechanism for the explicit form is necessary.

Logic rule-based mechanism and its database development ultimately aims to support translating process of Korean regulation information into a code (KBimCode). Objects and properties can be translated into the code which has a specific grammar structure by combination of other elements of logic-based systemization (methods and sentence relationship).

As one part of the logic rule-based mechanism, the objects and properties were extracted from the noun phrases of related sentences and managed in the object-name database. Based on this, the target objects and related properties which are needed and possible to assess were classified and organized. Then, through a removing process of similar and ambiguous objects and properties, they were transformed into explicit form and can be managed in a web-based database.

Dictionary function of the web-based database can give some benefits to concerned expert who do not much have programing knowledge. It help them to change and manage the objects and properties in general web interface. And the sentence and code in which each item is used can be found. It also can help to grasp the frequency of items or related contents. In addition, these benefits can be helpful for future studies of mapping between the result of this study and objects and properties of IFC model, which are data standards for BIM.

Based on this mechanism, the database of objects and their properties on Korean Building Act can be extended to other target requirements or more general descriptions (e.g. design guideline, RFP, etc.).

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