Research on BIM Model Identification System for Substation Project Management

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Abstract. In the current construction of the Internet of Things, informational data has become an important technical content. Among them, information classification and coding are the basis of informational data construction. In the BIM (Building Information Modeling, 3-dimension information model) project management, the identification system code is used as the encoding carrier by the BIM model. Through the coding, the corresponding physical model objects can be found, which makes the information database more clear and complete, and helps to apply the life cycle database. At present, the application of BIM technology to substation engineering management is a relatively new field. The corresponding BIM identification system coding research work is not enough, and the traditional KKS identification system shows great defects in the current professional technical rules and application of the project management platform using BIM technology. This paper aims to improve the BMS technology project management by substation BIM technology project based on the existing KKS identification system framework, through unifying coding format, enhancing coding level identification, creating substation building code identification and prominent electrical main professional identification. To form a three-dimensional model identification system and apply it to substation BIM technology project management and carry out practice in actual engineering projects. To realize the accurate delivery and standardization of BIM model information data by the life cycle information management platform.

1. Preface

In the report of the 2019 two sessions, the State Grid Corporation proposed to build and operate the “ubiquitous power Internet of Things” and become a key task in comparison with the strong and intelligent grid. The construction and application of informational data plays a vital role in the construction and operation of the Internet of Things, and information classification and coding are the basis of informational data construction.

BIM (Building Information Modeling) technology uses 3D model as the information carrier of engineering project, which can organize the project information in a three-dimensional and intuitive way, which is beneficial to the more convenient use of information and further transfer to the operation and maintenance stage [1]. To form a database that can be used throughout the life cycle. Although there are still many problems in specific applications, its advantages in data management and application inevitably make it become the development trend of project construction management [2-3].
When using BIM technology for project management, it is necessary to organize and construct 3D model data according to the professional technical rules of the mapped physical objects and use digital technology to simulate the running rules of physical entities [4-5]. The initial identification system of the 3D design model is generated by the design software itself during modeling, but it does not conform to the rules of the project, and it is more difficult to be recognized by engineers and application software compilers. To truly realize the application of BIM information data in project management, it is necessary to establish a set of identification system that meets professional technical rules and is easy for engineering personnel to identify as a communication medium between data and personnel. The identification system that conforms to the objective laws of professional technology and project management is the premise to realize the full-life circulation and application of engineering project data [6].

At present, in the field of professional engineering such as construction and rail transit, the research on the 3D model identification system [7-13] for BIM project management has been carried out, and some achievements have been made. In the construction industry, the national standard GB/T51269-2017 "Building Information Model Classification and Coding Standards" was published [14].

In the information classification and coding work of the power industry, since the mid-20th century, the advanced industrial countries in Europe and the United States have successively formed CCC, EDF, EIIS, ERDS, KKS and other identification systems, and are widely used in power engineering projects. However, these marking systems were formed earlier, unable to fully adapt to computer technology and digital three-dimensional design technology, severely limiting their application level. The ubiquitous construction of the power Internet of Things [15-20] has reached an unprecedented level of application accuracy requirements for digital three-dimensional models. When these identification systems are applied in the project management platform based on BIM technology, there are obvious defects. At present, the research on the digital three-dimensional model identification system of the power industry has been seriously lagging behind.

This paper is based on a practical substation project. In the construction management practice of applying BIM technology, the paper analyzes the inadequacies of KKS code. On the basis of the KKS framework, the civil engineering part code is extended, the coding and text format is unified, the information expression content is simplified, and the convenient use scheme is designed to form the coding system of the digital three-dimensional model identification system of the substation. Through practical application, it proves to be applicable to the construction management of substation projects based on BIM technology.

2. Overview of the advantages and disadvantages of the existing KKS identification system
Currently, the KKS code [21] is the most widely used and mature identification system in the worldwide power industry project. Since the introduction of the identification system in the construction of power engineering projects in the 1990s, China has gradually determined the framework structure based on KKS code coding through practice and comparison. In 2010, the national standard GB/T 50549 "Code for Power Plant Engineering Identification System" [22] was released. In 2014, the national standard GB/T 51061 "Code Specification for Power System Engineering Identification System" was issued.

2.1 Advantages of the KKS Identification System
KKS code is complete in content, convenient in expansion, flexible in use, rigorous in structure, unique in identification, and incorporates the technical rules of the main process of power projects and is widely accepted in the practical application of power project construction.

2.2 Defects in the application of KKS identification system to BIM project management
When applying BIM technology for project management, the GB/T 51061 national standard KKS code system showed the following defects:
(1) The KKS code has a shallow coding depth for the construction of non-process systems, and only expresses the depth to the location of the room. The structural components of the building are not refined, but the management of the building is an important part of the project construction, so it cannot meet the construction management requirements.

(2) The composition expression is three-line: process-related identification, installation point identification, and location identification. The three types of identification representations partially overlap, and the three-line format also makes the three-dimensional model implementation of attribute input more cumbersome, and the management software recognizes that the read logic is difficult to create.

(3) The hierarchical distribution pattern of some process-related identifiers is not suitable for computer software reading.

(4) The number of process-related identification codes inherent in the original KKS needs to be increased in the coding of specific scenes such as buildings.

(5) The position identification in the KKS code is mainly used to identify the position of the device. In the context of using the three-dimensional model, its original main use is weakened.

(6) There is an intermediate omitting code, which does not satisfy the requirement of software reading for format curing.

(7) The complexity of the identification code makes it necessary for the participants to spend a lot of time and energy to write and learn to use.

2.3 Conditions that the BIM project management identification system should meet:
Based on the above analysis, the conditions that should be met by the identification system applied to BIM background project management are proposed:

   (1) Meet the main technical rules of the project
   (2) Meet the project construction management rules
   (3) Adapt to the requirements of computer application read and write logic
   (4) Meet the computer read and write format requirements
   (5) It has a method of using the computer computing power.

The KKS code satisfies the conditions (1) and (2), and it also has the advantage of popularization. Therefore, it is adapted based on the KKS code to form a substation BIM model identification system that satisfies the conditions (3)(4)(5).

3. Creation of substation BIM model identification system based on KKS code
The specific adaptation of the KKS code is mainly reflected in the specification format, streamlining the content, improving the level of recognition, and expanding the coding content of the civil part.

3.1 Specification encoding format
Starting from the requirements identified by the platform software, the structure of the building code and the electrical system code is kept consistent, using 0-level code (1 bit, G) + 1 level code (6 bits, F0F1F2F3FN1FN2) + 2 level code (6 bits, A1A2AN1AN2AN3A3) + 3 level code (4 bits, B1B2BN1BN2) + continuation code (no bit limit, C1C2C3...) structure. When the continuation code is not included, it is specifically:

RNAANNAANNANNAANNN
R – for letters or Arabic numerals
N – represents Arabic numerals
A – representative letter

In order to adapt to the characteristics of the software to read data, and reduce the workload of the encoding input, it is stipulated that the intermediate segment of the encoding is not allowed to be omitted, but the remaining encoding after the last significant encoding is allowed to be omitted.

The code does not allow any symbols other than English letters and Arabic numerals (including spaces), and the English letters I and O are forbidden letters.
The format of the continuation code is a loop of one English letter + one Arabic number, which can be used to define the required number of digits according to the actual situation of the project.

The format without the continuation code basically follows the national standard KKS code process installation identification format, which facilitates the interoperability of the two coding formats.

3.2 Reduced identification type
In order to facilitate the software platform to read, reduce the modeling input workload, and meet the BIM construction management, the three-line coding format of the KKS code is changed to one-line. The location identifier is primarily used to identify the location of the device. In the mode of project management using 3D models, the recognition of the location of people has deviated from the coding. Therefore, in the digital three-dimensional model identification system, the position identification line is cancelled, and at the same time, the definition of the construction structure is deepened by the reference position identification code, and the same coding code format is used to form the construction structure identification coding system.

The installation point identification code is mainly applied to the internal equipment of the secondary system panel. In the project construction management, the screen cabinet is considered as the whole installation. In the BIM model identification system, the installation point identification code is canceled, and the relevant panel is generally identified by the process identification.

3.3 Improve the level of recognition
When dividing the identification level, the identification of the main professional should be guaranteed first. The most important content in the substation is the power distribution equipment of each voltage level. In the national standard KKS system, the conventional substation except the transformer is distinguished by the Arabic alphabet, and the rest is classified as the public system with the value “Y”. It is necessary to go to the 4th bit code (system code F2) to distinguish the management belonging unit of the component, which seriously reduces the recognition and calculation efficiency of the platform software.

Based on the above problem, in the new identification system, the 0-level code G in the first bit of the whole code is redefined so that it can identify the voltage level of the power distribution device and adapt to the logic characteristics recognized by the computer software.

The coding value of the 0-level code G in the substation project is: Arabic numerals represent the main transformer unit numbers; A~N are the power distribution devices of each voltage class; the letters from P and later are the remaining professional codes.

| Table 1. Level 0 Code Set Value Tables |
|---------------------------------------|
| G | Scope                                |
|---|--------------------------------------|
| 1~9 | #1~#9 main transformer unit          |
| A~N | Power distribution units of various voltage levels: 1000kV power distribution unit ~<1kV power distribution unit |
| P  | Control and protection, communication, etc |
| Q  | General map, building               |
| S  | Hydraulic                            |
| T  | HVAC                                 |

3.4 Expanding the building identification system code
The original national standard KKS code system has a shallow depth of building code, only to the room level, and cannot meet the requirements of construction management. The digital three-dimensional model identification system uses the same code as the process identification code format and combines the characteristics of the construction process to create a new building code system.
In view of the difference between the structural characteristics of the building and the process system, when designing the identification system of the building, the coding system based on the grid is used, the main component is attached to the grid. The next-level component is attached to the coding system structure of the higher-level component. The main points are as follows:

1. Depth of definition of each level of code
   - Level 0 code (unit code): defined to professional
   - Level 1 code (system code): defines the specific floor/height of a specific building
   - Level 2 code (device code): defined to the main structural unit such as beam, plate, column, wall, pile foundation, etc.
   - Level 3 code (part code): defined to the secondary level, door, window and other secondary unit

2. The coding principle of the first level code
   - The level 1 code refers to the relevant position code of the national standard system.

3. Important component level 2 code encoding method
   - According to the principle of grid positioning, the column and pile foundation are defined by coordinate point coding.
   - Walls, main beams, etc. are attached to the column, and the code defines the type of component and the orientation relative to the attached column.
   - Floors, roofs, etc. are attached to the floor and are coded in order.

4. The coding principle of the 3rd level code
   - Secondary beams, doors, windows, etc. are attached to the main beam, wall, etc., and the code defines the type of parts and the orientation and order of the corresponding parts.

3.5 Highlighting the identification of the electrical system
The electrical system identification of the national standard KKS identification system is relatively complete. On the basis of the digital three-dimensional model identification system, combined with the characteristics of BIM project management, the following changes were made to the electrical system coding:

1. Depth of definition of each level of code
   - Level 0 code (unit code): Defines the voltage level to the power distribution unit.
   - Level 1 code (system code): Defined to a specific interval unit, phase, and unit.
   - Level 2 code (device code): Defined to a specific single device installation unit, including individual equipment and a single installation unit inside the unit.
   - Level 3 code (part code): According to the management accuracy requirements, the definition can be locally deepened to the equipment installation parts.

2. Strengthen and clarify the identification function of F3 code in system code
   - The recognition of the original F3 code is defined as a distinguishing system. It is now clearly defined as a system and a complete set of units. The new F3 code definition includes AIS interval, GIS, HGIS, switchgear, capacitors, reactors, etc., taking into account the type of interval, and also considers the complete set of equipment as an integral unit in construction management.

3. Cancel the definition of station power system in the special sense
   - Combined with the characteristics of BIM management, according to the electrical position of the actual station power system in the main wiring. The high-voltage part of the station above 1kV is included in the power distribution device, and the power consumption part of the station below 1kV is included in the category of the zero-level code "N".

4. Enhance the identifiability of the main wiring
   - Electrical primary wiring is an important basis for electrical professionals to identify installation content. In the three-dimensional model identification system, the reinforced components are compared with the identifiability of the electrical primary wiring to suit the characteristics of BIM management. The main measures are: according to the level of primary wiring, the definition depth of each level of code, the connection conductor embodied in the primary primary wiring are included in the unified coding system.
4. Practical application of substation BIM model identification system

4.1 Practical application

The 3D model identification system code with uniform format, complete information, clear hierarchy and software identification rules is applied to all the components to be managed in the BIM model of the substation, and implemented in the BIM construction management platform.

First of all, the "Engineering Convention and Coding Index" was compiled. The main body is the coding dictionary. The coding principle of the specific project identification system is proposed and explained, which is easy for users to use.

Then, according to the "Engineering Convention and Coding Index", the direct guidance document for engineering identification coding work - "Engineering Identification Code List", lists the specific coding of each component. The code is associated with the management component as a property input in the 3D model. Examples are as follows:

Table 2. A HVAC Louver Code in the Coding List

| Level0 | Level1 |
|--------|--------|
| G      | F0     | F1     | F2     | F3     | FN1FN2 |
| Q      | 1      | U      | F      | A      | 96     |

Level2

| A1     | A2     | AN1    | AN2    | AN3    | A3     |
|--------|--------|--------|--------|--------|--------|
| H      | C      | 0      | 3      | 0      | E      |

Level3

| B1     | B2     | BN1    | BN2    |
|--------|--------|--------|--------|
| B      | B      | 0      | 1      |

Value description:
Q (G, professional total score, construction and general plan)
1 (F0, building number, number 1 in this project)
U (F1, professional subdivision, building)
F (F2, building category, indoor station building)
A (F3, building variety subdivision, substation building)
96 (FN, floor height, this example - 3.0~3.99 meters underground floor)
H (A1, component category, concrete wall of this example)
C (A2, C axis) 0 (AN1, corresponding position to the letter axis, 0 - on the axis)
3 (AN2, the clock position of the intersection with the axis, 3-3 o'clock)
0 (AN3, corresponding position to the digital axis, 0-on the axis)
E (A3, digital axis, 5 axes)
BB (B1B2, small parts, HVAC)
0 (BN1, material, this example takes place)
1 (BN2, the first from the intersection of the axis, the first one in this example).
The part is coded as Q1UFA96SD030EBB01, which uniquely identifies the first HVAC louver on the concrete wall of the D-axis (3 o'clock, ie the D-axis) attached to the intersection of the D-axis and the 5-axis in the basement of -3.0~3.99 m.

Finally, after the model is completed, the platform operator in the management platform, according to the "engineering code identification list", the code is compiled into a Chinese name that can be directly recognized by personnel. In this way, the operator does not need to look up the "Engineering Convention and Coding Index" and "Engineering Identification Code List" to select and manage parts or component groups by Chinese name in the platform.

4.2 Practical application benefits

Through the project management practice summary of the substation, the benefit of the 3D model identification system of substation project management based on BIM technology is significant, mainly reflected in the following aspects:

(1) Improve the friendliness of human-machine interface and improve work efficiency

Operating a three-dimensional model from a computer two-dimensional display has the problem of overlapping spatial components. Therefore, it is quite difficult to directly select components, especially component groups, from a three-dimensional model, which has plagued the application of three-dimensional technology. In the BIM project management platform, the system identification code is adopted, which can realize text indexing, avoiding the operation of directly selecting from the 3D model, greatly optimizing the selection mode of the 3D model, and improving the work efficiency.

(2) Deepen the manageable precision of BIM projects
The system identification code is adopted in the BIM project management platform. As long as the components are coded according to the rules, they can be included in the management scope without being limited by the overall model size and complexity of the project. In the substation project, the subdivision management of the steel bar lashing and wall construction process sequence (masonry, decoration, etc.) was partially tried, and it was proved that this management depth can be achieved.

Fig. 3 Filter 3D model parts with drop-down menus

Fig. 4 Filter 3D model parts by keywords

(3) Release human resources

In the traditional identification system application, all personnel involved in the project must be familiar with the identification system code of their professional part, and the identification system code itself is a large and complex system. In addition to the staff's energy, it also raises the threshold for people to participate in the project, which brings great pressure on human resources. After the system identification code is compiled by the BIM project management platform, most of the project personnel can no longer contact the identification system, reducing the workload and training time, reducing the threshold for personnel to participate in the project, and alleviating the pressure on human resources.

5. Conclusions and prospects

With the continuous deepening of the application of BIM technology in the field of power engineering project construction, it is essential to establish a unified coding system to promote information exchange in the power industry. In the whole process engineering consulting management of the substation project in Wuxi, Jiangsu, based on KKS identification system, a three-dimensional model identification system for substation project management based on BIM technology was developed. The identification system format is in line with the national standard KKS code, inheriting and retaining its advantages, and is more suitable for the characteristics of computer and digital three-dimensional technology.
Based on the substation BIM model identification system coding, throughout the design, construction, operation and maintenance life cycle of the project, not only can the substation project phase and the different participating units be organically combined, but also strengthen the effective control and management of the cost, quality and progress of the project. The digital identification system code provides a standardized means for engineering information data collection and integration and provides guarantee for the use of accurate and valuable information for substation projects and contributes to the ubiquitous construction of the Internet of Things.

The research on the digital three-dimensional model identification system of electric power is still in its infancy, and it is necessary to expand the research scope to substations, lines, power stations, etc. of various voltage levels. At the same time, it is necessary to increase the research of application methods, strengthen the application of automation technology, and further free the engineering personnel from the mechanical operation labor.

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