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A STUDY ON THE USE OF CONSTRUCTION STANDARD INFORMATION IN THE PLANNING STAGE OF THE NATIONAL ROAD CONSTRUCTIO

Abstract:

The safety and quality of national road facilities must be guaranteed in the project implementation process. So the proper use of the construction standards in the project management planning process is a key success factor of a construction project. This study suggested a way for promote the use of the construction standards. For this purpose, this study was conducted to propose an information structure for construction standards based on WBS and CBS information structures used in the Standard for Digital Quantity Calculation of South Korea and the code numbering system of Korea Construction Standard. And the proposed structure was defined as XML schema so that the project participants could easily exchange or reuse the information and contents of the construction standards.

Keywords:

Project management planning, National road Construction, Construction standards, WBS, CBS, XML schema

JEL Classification: L74, O21, D80

1. Introduction

National road construction projects require the investment of a significant amount of funds during their early stage, and the invested funds are difficult to recover. Therefore, a major success factor of construction projects is how well the task list has been planned in the project management planning (PMP) process to build a national road before the project is started. Several project management methods (PMMs) use the work breakdown structure (WBS) as a classification standard for managing costs, processes, resources, and risks to successfully carry out the project with a limited budget and resources. WBS is a classification standard that forms the foundation for project scoping, planning, and controlling. With the rising importance of the time-work based schedules and cost management around WBS, an increasing number of PMMs are using the earned value management system (EVMS).

Furthermore, several studies have been released on planning and controlling methods based on WBS, including the cost breakdown structure (CBS), the organizational breakdown structure (OBS), and time-work based scheduling. Once national road facilities are completed, they are used for over several decades. Thus, if faulty structures are built, they can not only cause socioeconomic damages, but also threaten the life of their users. Therefore, the safety and quality of national road facilities must be guaranteed in the project implementation process.

To guarantee a certain level of safety and quality, the Korean government and public ordering agencies have prepared the Korea construction standards (KCS) that designers, engineers, constructors and project managers are required to follow. Even though the use of KCS is important in the national road construction project process, most PMMs have not presented any concrete planning method for using it or any information structure based on the WBS for the use of KCS in the PMP process. This study was conducted to propose an information structure for KCS based on WBS so as to promote the use of KCS in the PMP process. For this purpose, the WBS and CBS information structures used in the Standard for Digital Quantity Calculation (SDQCE or QDB), the code numbering system (CNS) of KCS, and preceding studies related to WBS and KCS were investigated. From the investigation results, a KCS information structure based on WBS was proposed for the use of KCS.

The information and contents of KCS prepared according to the proposed information structure were defined as XML schemas so that the project participants could easily exchange or reuse them in the construction project management information system (CPMIS), EVMS, spreadsheets, etc. In this process, XML schema naming rules were defined to provide consistent systems for naming elements, attributes, and entities included in the XML schema.

This study was a meaningful attempt to use WBS for the utilization of the information and contents of KCS in the PMP process. Furthermore, the KCS information structure proposed in this study could be used to establish PMPs in other construction projects, including ports, rivers, railways, etc.

2. Related case studies

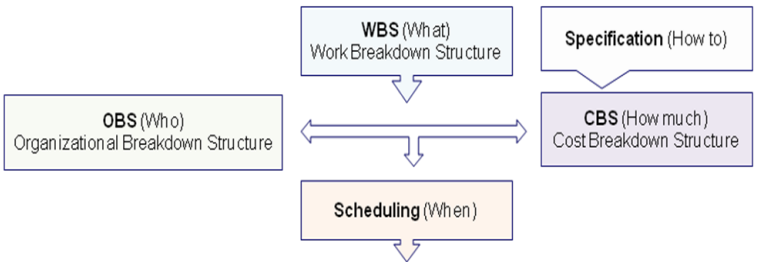
2.1. Work Breakdown Structure

The U.S. Navy first used the term “WBS” in the 1950s while developing the project evaluation & review techniques (PERT) system as part of a missile development program. At present, WBS is being used in most PMMs such as PMBOK, PRICENS2, and EVMS. WBS is interpreted in many different ways depending on the perspective, but it is generally referred to as a classification standard for a task list for project participants to enable them to successfully carry out a project.

To select and classify tasks, the project scope is defined and task elements with similar characteristics are grouped. Furthermore, different task elements are classified, and the project scope and task information are expressed hierarchically from the top level to the bottom level. The lowest levels of WBS are classified as work packages or activities. A work package is a task management unit for which a group of the time-work based schedules and construction costs is assigned, planned, and controlled. One work package can include multiple activities. Activities consist of multiple tasks, which are the minimum units assigned to one task element.

Several PMMs and papers use WBS as a classification standard for planning and controlling CBS, OBS, time-work based schedules, etc. in the PMP process. Figure 1 shows a framework for breakdown structuring in the PMP process (Alberto 2011).

Figure 1: General framework for the construction management planning process



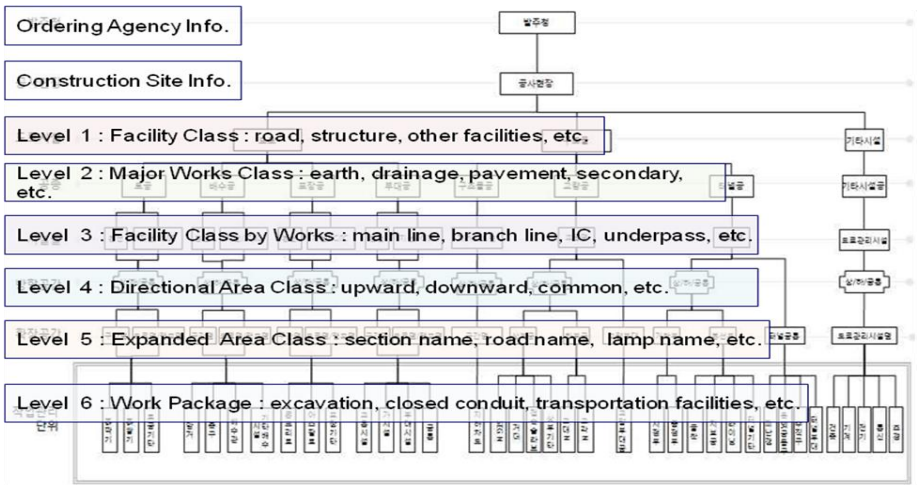
In South Korea, most ordering agencies and constructors participating in national road construction projects use their proprietary CPMIS or EVMS. Such CPMIS and EVM have the functionality to plan the time-work based schedules and construction costs based on WBS. For example, the Regional Construction Management Administration has a functionality for exchanging the time-work based schedules and construction cost information around WBS between the ordering national road agency and the participants in a national road construction project.

They prepared QDB to facilitate the exchange of the time-work based schedules and construction cost information needed for a national road construction. QDB is a standardized information system with a standard file format based on XML schema for the exchange and reuse of quantity calculation breakdown information between the ordering agency and the contractors (Han et al., 2014).

QDB contains not only the details of the construction cost calculation breakdown, but also the schedule-cost information such as the project information, completed amount, and schedule

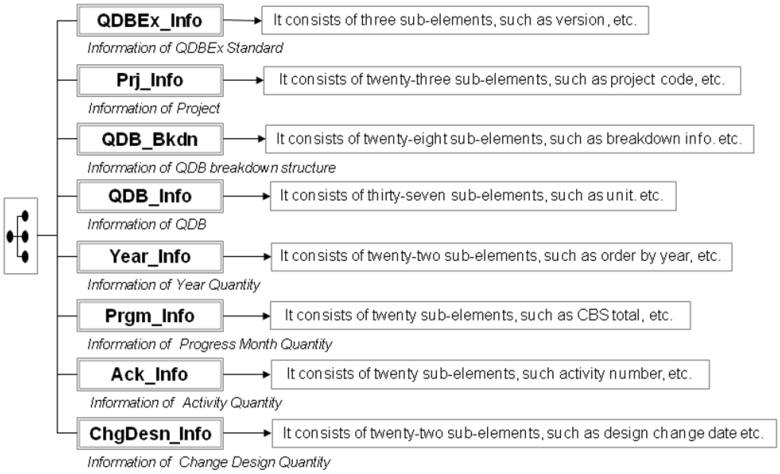
management information. For the classification standard of the schedule-cost information to build a national road, a six-level WBS was used, as shown in Figure 2.

Figure 2: Example of hierarchical classification system of WBS



The ordering agency assigned the schedule-cost in a work package as the minimum management unit of WBS from the management perspective. On the other hand, the contractors planned and controlled the details of the time-work based schedules and construction cost in the activity unit, which is the minimum unit of WBS from the work perspective, considering the conditions of the project and the construction site. Figure 3 shows the information structure of the highest level defined in QDB, which illustrates the logical structure to develop as an XML schema. The information structures contain multiple lower-level elements and attributes.

Figure 3: Logical structure of QDB



2.2. Korea Construction Standards

KCS refers to the design and construction standards that must be followed by construction project participants for the improvement of the technical and environmental aspects of the construction work. KCS largely consists of design standards (DS), construction specifications (CS), and low-level technique specifications. DS and CS related to national road construction

refer to 7 or more types of standards, and the low-level technique specifications include over 105 techniques such as construction regulations, guidelines, and handbooks, etc.

The Korea Construction Standards Center (KCSC) is now focusing on the development, management, verification, and evaluation of DS and CS. It developed a CNS of KCS to manage the history of the establishment and revisions of KCS in order to ensure interconnectivity and compatibility of DS with CS (Park et al., 2013). This CNS of KCS consisted of DS and CS division, a code system that combined a code related to a classification system with the established/revised year, as shown in Table 1. A CBS for low-level technique specifications has not been developed yet.

Table 1: Classification system for the CNS of KCS

Level	Category	Digits	Division
1	Standards	3	DS or CS
2	Large categories	2	Divided into common, facility, and project
3	Medium-categories	2	Characteristics of the code are given.
4	Small categories	2	Detailed work type classification of the medium level
5	Subcategories	2	Only corresponds to CS; Subdivisions of the small categories
6	Year established or revised	4	'YYYY' type

2.3. KCS metadata

In accordance with Article 18 (*Establishment of a Construction Technology Information System*) of the Construction Technology Promotion Act, the Korea Institute of Civil Engineering and Building Technology (KICT) has collected and built a database of construction technology data that includes KCS and services the related information through the construction technology information system (Ahn et al., 2014). Metadata based on the Dublin Core were used to facilitate the systematic management of KCS and the search for the desired information. Metadata refers to sets of data elements that have united the meanings and properties of data with the structural information among the data.

The DC metadata have 15 basic elements that represent information resources. The KCS metadata consist of 14 DC elements: 'Title', 'Creator', 'Subject', 'Description', 'Publisher', 'Contributor', 'Date', 'Type', 'Format', 'Identifier', 'Source', 'Language', 'Relation', and 'Rights,' with the exclusion of 'Coverage', and 6 proprietary elements that include 'Project Organization', 'Metadata', 'KC Subject', 'Record Unit', 'Collection', and 'Open'. KICT defined the information structure of the KCS Metadata according to the syntax rules that define the XML Data Type Definition (DTD).

2.4. Preceding studies

The ordering agency manages the information required for construction project management from the management perspective. On the other hand, the contractors manage more specific data such as costs, organizations, processes, risks and resources from the work perspective, and establish a more detailed PMP than that at the ordering agency's management level. Due to this environment, no PMM has been established yet at the national level in South Korea. Therefore, Ahn et al. (2005), Park et al. (2007), and Ryu et al. (2011) published research results to introduce PMBOK and PRINCE2 in PMP. Park et al. (2009) and Kim et al. (2012)

presented methods of using CPIMS or EVMS for schedule-cost management based on WBS. Lee et al. (2014) published a paper on the CNS of KCS, whereas other papers mainly focused on the standardization of KCS and system improvement measures.

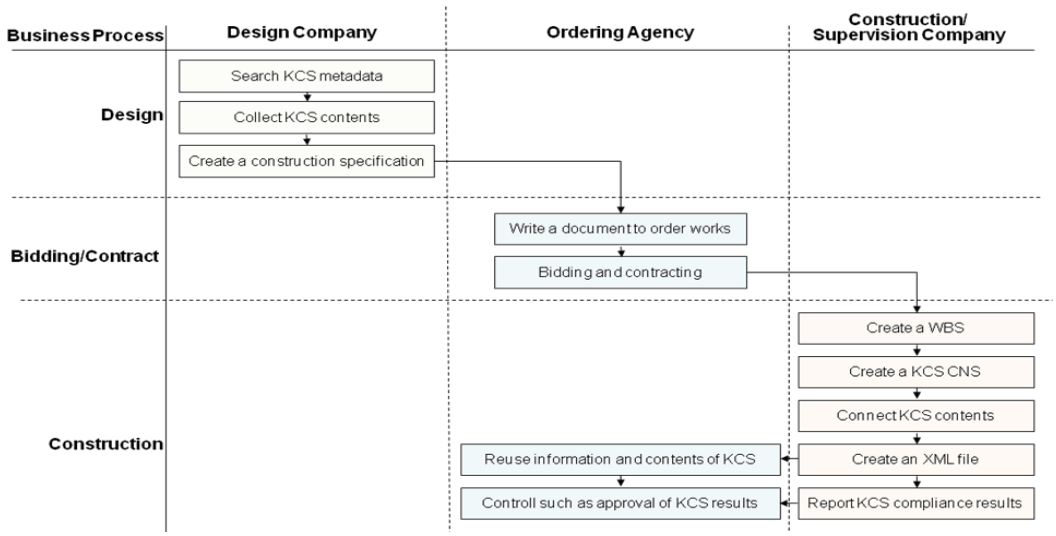
Peterson et al. (2010) and Sharma (2009) presented planning and controlling methods for project activities in PMP using 3D CAD, BIM, and Primavera, and expressed PMP information in the XML format. Lee et al. (2010) reported on the process of combining the project process and WBS using the XML Process Definition Language (XPDL). There have been studies that used XML to express PMP information as shown in these papers. However, no study could be found on the use of WBS to utilize construction standards or on the expression of PMP information in XML schema.

3. Development of the KCS information stucture based on WBS

3.1. Redesign of the PMP process

Several PMMs presented processes and methods of planning and controlling the work scope, costs, and schedule based on WBS in the PMP process. However, No process and method of using construction standards based on WBS have been presented yet. In this study, a process for referencing or exchanging related KCS information and contents according to the classification standard of WBS in the PMP process was designed as shown in Figure 4.

Figure 4: Example of process for the use of KCS



In Figure 4, the design company collects the KCS information and contents that correspond to the WBS that needs to be performed in the project, using the KCS metadata provided by the construction technology information system, and then prepares the construction specifications.

The ordering agency prepares a work order based on the prepared construction specifications, and selects the construction company and the supervising company through a bidding process. The contractors prepare a WBS appropriate for the project and the construction site. It collects and processes the KCS information and contents that include the

technical details and project management requirements that must be followed to carry out the work packages of the WBS by referring to the metadata and CNS of KCS.

The processed information and contents of KCS are created as XML instance files according to the XML schema. Next, the contractors create a database with the KCS information and contents of the XML instance files in the proprietary CPMIS or EVMS of the ordering agency or contractors, with no additional conversion process.

Furthermore, the contractors perform tasks that correspond to the work packages, and reports the KCS compliance results to the ordering agency and the supervising company. Then the ordering agency and the supervising company issues instructions on the approval, rejection, change, etc. of the reported KCS compliance results.

3.2. Definition of the logical structure

3.2.1 Naming rules of the information structure

In this study, the KCS information and contents were prepared according to a standardized information structure, and the KCS information structure was developed in XML schema to facilitate the exchange and reuse of the KCS information and contents prepared in CPMIS, EVMS, spreadsheets, etc. For this purpose, the naming rules were defined as follows to give names to the elements and attributes in KCS in a consistent manner.

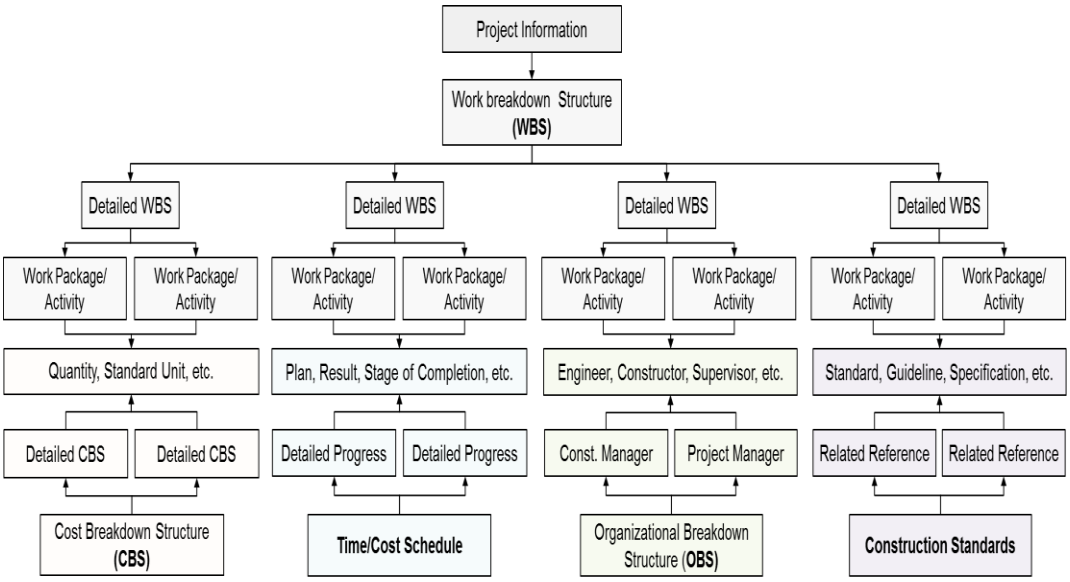
First, the names in construction glossaries should, in principle, be used for the elements and attributes of the information structure. Second, the elements and attributes should, in principle, be given full names, except when abbreviations can clearly deliver the meaning. Third, the names of the elements and attributes must be singular and written in the present tense. Fourth, ‘info’ must be added to the end of the name of representative elements to differentiate main elements from sub-elements. Fifth, an underline (“_”) must be added between words when two or more words are used in order to distinguish the words. Sixth, the first letter in the names of elements must be in the upper case, and the other letters, in the lower case. All the letters in the names of attributes and entities must be in the lower case.

Next, the logical structure of the KCS information was defined and developed in XML schema according to the XML syntax rules.

3.2.2 Definition of a logical structure of the WBS information

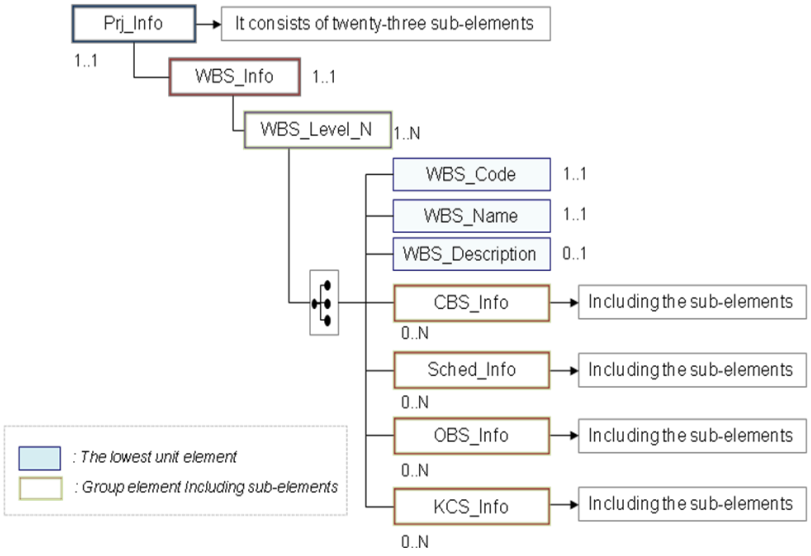
For QDB, the CBS and scheduling were planned and controlled using the classification standard of WBS. In this study, the WBS information structure in Figure 2, which has six levels, was used for compatibility with QDB. However, whereas QDB defined WBS information and project information at the same level, the project information is placed one level higher than the WBS information so that the WBS can be the center of the classification system that consists of KCS, CBS, OBS, and time-cost scheduling as shown in Figure 5.

Figure 5: Example of the framework of the PMP classification system



Next, tasks that must be performed in line with the conditions of the construction project and the construction site were assigned according to the classification standard of WBS. Figure 6 shows the logical structure of the WBS information.

Figure 6: A logical structure of the WBS information

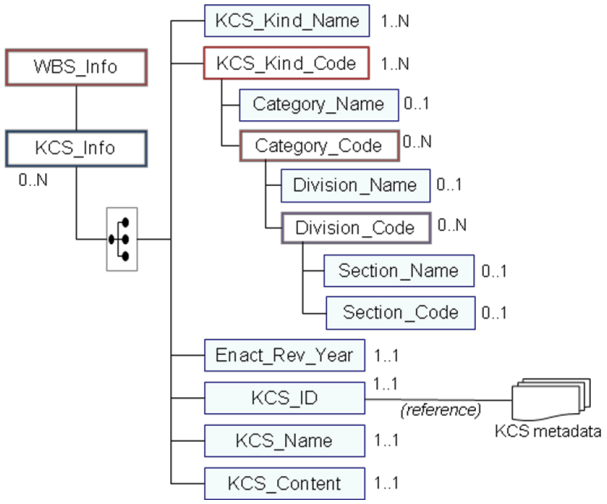


In Figure 6, the 'WBS_Level_N' element is used to specify the level number (N). This element has sub-elements that indicate the classification code (WBS_Code), the code name (WBS_Name) that corresponds to the specified level number (N), and a description of the classification code (WBS_Description). The 'WBS_Description' element is used selectively (0,1). The other elements are used as zero or more selectively.

3.2.3 Definition of a logical structure of the KCS information

The contents of KCS can be changed by reinforcing the construction standards and developing new techniques and engineering methods. The connection between the KCS metadata and NCS was considered so that the latest KCS can be referenced at all times. Furthermore, the information structure was prepared to allow the extraction, combination, reading, and reuse of the KCS information and contents that must be followed by the project performance team and the project management team in work package units of the WBS. Especially to ensure connectivity with the NCS of KCS, the structural information of KCS was hierarchically defined in the Category-Division-Section sequence, as defined in the NCS of KCS. Furthermore, the ID and name of KCS were defined for connection with the KCS metadata.

Figure 7: Logical structure of the KCS information



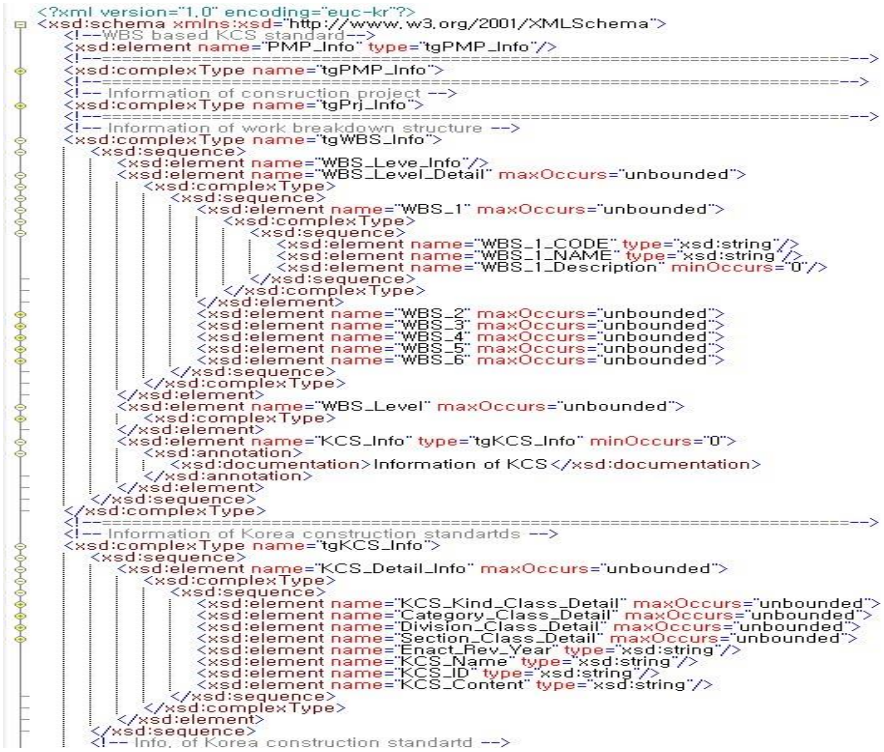
In Figure 7, the 'KCS_Info' element is a major element that defines the information and contents of KCS as a group that must be complied with for the performance of the work packages of the WBS. The 'KCS_Kind_Code' element specifies the classification code that corresponds to the DS or CS. The 'Category_Code' element corresponds to large categories in Table 1 and can contain 0 or more 'Division_Code' elements (0,N). The 'Division_Code' element in turn corresponds to medium categories and can contain 0 or more 'Section_Code' elements (0,N).

The 'KCS_ID' element is used to have relationship with KCS metadata that contain the KSC contents.

3.3. Development of XML schema

The XML schema is an information structure that defines the logical structure of information with elements, attributes, data types, etc. according to the XML syntax rules defined by the W3C standardization organization. In this study, the logical structures of WBS and KCS were developed in XML schema according to the XML syntax rules, as shown in Figure 8.

Figure 8: Sample XML schema



```
<?xml version="1.0" encoding="euc-kr"?>
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <!--WBS based KCS standard-->
  <xsd:element name="PMP_Info" type="tgPMP_Info"/>
  <!--=========================================================================-->
  <xsd:complexType name="tgPMP_Info">
  <!--=========================================================================-->
  <!-- Information of consruction project -->
  <xsd:complexType name="tgPrj_Info">
  <!--=========================================================================-->
  <!-- Information of work breakdown structure -->
  <xsd:complexType name="tgWBS_Info">
    <xsd:sequence>
      <xsd:element name="WBS_Leve_Info"/>
      <xsd:element name="WBS_Level_Detail" maxOccurs="unbounded">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="WBS_1" maxOccurs="unbounded">
              <xsd:complexType>
                <xsd:sequence>
                  <xsd:element name="WBS_1_CODE" type="xsd:string"/>
                  <xsd:element name="WBS_1_NAME" type="xsd:string"/>
                  <xsd:element name="WBS_1_Description" minOccurs="0"/>
                </xsd:sequence>
              </xsd:complexType>
            </xsd:element>
            <xsd:element name="WBS_2" maxOccurs="unbounded">
            <xsd:element name="WBS_3" maxOccurs="unbounded">
            <xsd:element name="WBS_4" maxOccurs="unbounded">
            <xsd:element name="WBS_5" maxOccurs="unbounded">
            <xsd:element name="WBS_6" maxOccurs="unbounded">
          </xsd:sequence>
        </xsd:complexType>
      </xsd:element>
      <xsd:element name="WBS_Level" maxOccurs="unbounded">
        <xsd:complexType>
      </xsd:element>
      <xsd:element name="KCS_Info" type="tgKCS_Info" minOccurs="0">
        <xsd:annotation>
          <xsd:documentation>Information of KCS</xsd:documentation>
        </xsd:annotation>
      </xsd:element>
    </xsd:sequence>
  </xsd:complexType>
  <!--=========================================================================-->
  <!-- Information of Korea construction standartds -->
  <xsd:complexType name="tgKCS_Info">
    <xsd:sequence>
      <xsd:element name="KCS_Detail_Info" maxOccurs="unbounded">
        <xsd:complexType>
          <xsd:sequence>
            <xsd:element name="KCS_Kind_Class_Detail" maxOccurs="unbounded">
            <xsd:element name="Category_Class_Detail" maxOccurs="unbounded">
            <xsd:element name="Division_Class_Detail" maxOccurs="unbounded">
            <xsd:element name="Section_Class_Detail" maxOccurs="unbounded">
            <xsd:element name="Enact_Rev_Year" type="xsd:string"/>
            <xsd:element name="KCS_Name" type="xsd:string"/>
            <xsd:element name="KCS_ID" type="xsd:string"/>
            <xsd:element name="KCS_Content" type="xsd:string"/>
          </xsd:sequence>
        </xsd:complexType>
      </xsd:element>
    </xsd:sequence>
    <!-- Info. of Korea construction standartd -->
```

The XML schema can define the correlations between elements and attributes, such as the fields and basic data types used in a relational DBMS. Therefore, such attributes as the data type, required or not, and the repetition count were defined together with the elements so that the information and contents of KCS that correspond to the WBS could be extracted from the XML instance files prepared in accordance with the XML schema and then directly stored in the database of CPMIS and EVMS. Furthermore, the information and contents of KCS prepared in accordance with the XML schema can be reused in spreadsheets such as MS Excel.

Figure 9: Sample KCS information in MS Excel

A	B	C	D	E	F	G	H
WBS_Info							
	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**	
WBS_Code	F11000	13	F11120	S31100	S1618001	E11440	
WBS_Name	road	drainage	main line	common	section 1(Sta.13+884.	closed conduit	
KCS_Info							
KCS_Kind	**Category**	**Division**	**Scetion**	**Enact**	**KCS_Name**	**KCS_ID**	**KCS_Content**
KCS	11	40	5	2014	Reinforced concrete	CS140304	Reinforced concrete (RC) is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of
					Culvert repair method	CS1401230	3.2 inner section decision 1. The limits of road construction should be over

Figure 9 shows the five elements that represent the NCS of KCS that corresponds to the classification standard of WBS and the 'KCS_Name' and 'KCS_ID' elements for finding the KCS metadata. Furthermore, the contents of KCS were represented by referring to the NCS of KCS and the KCS metadata.

4. Conclusion

Unlike projects in other industries, national road construction projects require the investment of a significant amount of funds during their early stage. Furthermore, the safety of road facilities is very important during the performance of the project and after its completion. Therefore, planning and control for the proper use of the construction standards in the PMP process is a key success factor of a construction project. Several PMMs and preceding studies have presented methods of using WBS as a schedule-cost classification standard in the PMP process, but they have not specifically dealt with methods of using the construction standards.

In this study, a KCS information structure based on WBS was proposed to improve the use of KCS considering the connectivity between the QDB of South Korea and the NCS of KCS. The findings of this study could be applied to the PMP process for constructing ports, railways, etc.

One drawback of this study is that there was no mapping table for the accurate interconnection of the classification standard of WBS and the NCS of KCS. Another drawback is the selection of the NCS of KCS based on subjective judgment. As a result, the selected NCS of KCS may be unrelated to the WBS. To address this problem, additional research is required to develop a mapping table for interconnecting the WBS and the NCS of KCS based on objective criteria.

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