Web-Based Construction Project Specification System

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Abstract: Due to discrepancies and multiple ownerships of construction specifications in Korea, writing a project specification is very challenging. This paper presents a framework and architecture of a Web-based construction specification system (aka SPEC WRITER). Its database includes 15 standard specifications, 13 specialty specifications, national design guidelines, technical standards, standard drawings, over 45,000 construction materials, and more than 600 lists of manufacturers. This system is linked to national construction laws, regulations, and decrees through the internet. A functional framework and system architecture is proposed and construction information breakdown structure is used to reorganize the specifications and construction materials because of different numbering systems and formats. SPEC WRITER enables specification writers to write or edit a project specification in accordance with the national guideline and allows them to find all the related sections using a few keywords. Specification writers can also review, edit, and generate complex specifications with minimum efforts by using premade templates. This paper also presents a method to update and validate the SPEC WRITER through the internet.

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Introduction

Information technology has been widely adopted and implemented in Korean construction industry based on the construction continuous acquisitions and logistics support (CALS) plan (MOCT 1998, 1999). In 2001, digitization of project documents in public construction projects became mandatory in Korea and the Korean Ministry of Construction and Transportation (MOCT) publicized guidelines for releasing information on public construction projects (MOCT 2001). As a result, contractors are required to submit project documents to their respective project owners electronically.

Project owners and contractors are responsible for compiling and providing project documents electronically through the internet. Ranges of computerized programs for estimating, scheduling, drafting, drawing, contract management, and project management have been implemented in the construction industry in Korea. However, implementations have focused more on functional program development rather than integrated management systems including specification systems.

Currently, 15 standard specifications and 13 specialty specifications published by 12 academic associations and four public corporations are being used in the Korean construction industry. Additional design guidelines, technical manuals, and standard drawings published by MOCT have been widely used in engineering and construction projects. However, each specification has its own format and often discrepancies among the specifications are found because government standards vary widely from project to project.

Moreover, four large public corporations and government funded organizations, which are subsidiary to the MOCT, Korea Highway Corporation, Korea Housing Corporation, Korea Water Resource Corporation, and Korea Land Corporation, have been enforced to use their own specifications for their projects. Thus architects and engineers had difficulty in preparing project specifications which comply with both standard specifications and corporations' specific specifications for public projects.

Various professional associations and public corporations had owned standard specifications and specialty specifications. They had kept the specification in print format and had made no effort to fix the inconsistencies among different specifications. In 2002, The Korean supreme court decided to transfer the ownership of the standard specifications to the public. Since then, providing and digitizing the construction specifications through the internet became possible. However, architect and engineers still face challenges complying with all specifications related to a project due to a lack of effort to correct discrepancies by the specification owners.

Problem Statement

Writing and digitalizing project specifications are a growing concern because of inconsistency in their contents and formats as well as rapid changes in today's construction environment introduce conflicting guidelines from different disciplines (Rasdorf

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and Lakmazaheri 1990; de la Garza and Oralkan 1995; Kim et al. 2002; Kululanga and Price 2005; Boukamp and Akinci 2007). Specification discrepancies in Korea are particularly critical, however, an effort to revise and unify the specifications is slow (Kim et al. 2002).

Project specifications, guidelines, and manuals are often inconsistent in their context because of different technical guidelines imposed by multiple project disciplines. It causes confusion among engineers, contractors, and project professionals of different disciplines. Besides, the information on construction materials and manufacturers must closely correspond with the specifications, various guidelines, and manuals. However, there is no universally adopted approach to manage the standard specifications consistently. For that reason, engineers waste time and effort on checking specifications, guidelines, and manuals for their appropriateness and applicability to the project.

In the past, few programs were developed to assist specification editors. Most of them were running on personal computers and were not integrated with information related to construction materials. As a result, crosschecking of materials and their associated specifications was difficult and inefficient. It was difficult to replace any part of specifications and update material and manufacturer information unless an on-line distribution channel would be considered.

There have been a few attempts to develop programs that can assist specification writers for construction projects. In 1978, SPECTEXT, a database-based specification editing program, was created to assist specification writers with prewritten specifications (Construction Sciences Research Foundation, Inc. 2003a,b). A systematic approach to define the structure of specifications was studied by ASCE and an independent construction specifications institute (Kululanga and Price 2005; Lam et al. 2007). However, these systems do not have additional information other than specifications. Therefore, specification writers still need to access other information to look for standard drawings, design guidelines, and construction laws and regulations. To support inspection and quality control tasks, an automated construction specifications processing model was studied (Boukamp and Akinci 2007). Their research showed the arrangement of specification and links to its final product. Semantic schemas were used to model processes, exchange constraints, and manipulate information between computerized systems (Mutis et al. 2005). However, without an on-line tool, real-time update of such information is very difficult.

Due to the fact that within each project there are participating engineers from various disciplines, specification writers are required to consult with other disciplines prior to completing a project specification. Often, it is common to reuse previous project specifications from similar projects to avoid using conflicting information by various parties. With multiple individuals participating in the compilation of project specifications, this practice often leads to inconsistencies at best and outright conflicting provisions at worst, leading to project delays, cost overruns, and litigation. Therefore, there is a need to offer a comprehensive tool for specification writers to review similar sections and chapters of specifications.

This paper presents a model to develop a Web-based specification system, SPEC WRITER, for project design, procurement, and construction phase. A framework to integrate essential database for writing specifications are described in detail. Also, a module for systematic maintenance is proposed for SPEC WRITER. The system will help specification writers compare sections easily regardless of discrepancies and increase the reusability of existing project specifications. Framework and architecture of the system as well as construction information breakdown structure (CIBS) for specifications and construction materials are adopted in accordance with the computer-aided logistics support/contractor integrated technical information service standards in construction in Korea. By applying the proposed approach, specification publishers can have a unified access to specification databases. The system focuses on an effort to minimize inconsistency and to increase reusability of project specifications.

Framework and Architecture of SPEC WRITER

A CD-ROM-based specification writer was developed by the writer prior to this research. To remove limitations of previous application, information breakdown structure was adopted to rearrange related documents, specifications, and guidelines in a standard format. This section describes the database, the framework, and the system configuration of SPEC WRITER.

Previous Work on SPEC WRITER

Kim et al. (2002) developed a Windows-based specification program as part of the Korean construction CALS plan. The objective of this implementation was to digitize existing specifications and develop a computer program for specification writers. It was focused on defining relationships of the specifications so it could search for specific sections or combine sections together. The program contains all standard specifications, guidelines, and a collection of material and manufacturer information. It enables specification writers to find construction materials that match with the specifications or guidelines.

The program was coded using Visual Basic and Microsoft Access as database engines. MediaView, Microsoft's development system for customized on-line documentation, was used as an embedded control program to manage text and multimedia contents. Visual Basic was the key programming language, and Microsoft Word was linked to edit project specifications, which were required to be in rich text format. Updating the database was a significant concern of the application because no institution was in charge of collecting and customizing specifications. This system also served as a tool for specification owners and writers to revise the specification.

Standard Specifications and Materials

Throughout the project life cycle, construction projects in public sectors are executed in accordance with various construction laws and regulations. The laws and regulations identify the legality of construction projects for planning initiative, public hearings, budget establishment, approval of bids and awards, procurement, execution of construction, facility operation, and maintenance. Therefore, it is essential to review all specifications, guidelines, laws, and regulations to avoid any potential problems. Discrepancies between the scope of projects and the agreements may require additional information to clarify the scope.

Fifteen standard specifications published by 12 institutions are being used in the construction industry in Korea, as shown in Table 1. There are 13 specialty specifications in the construction industry which can be grouped into five categories: civil, architecture, mechanical installation, electrical construction, and information and telecommunications. These five groups were chosen because it represents major construction trades. Academic asso-

Table 1. List of Standard Specifications and Publishers (Kim et al. 2002)

Standard specifications (year)	Publishers/owners
Bridge construction (1999)	Korea Road and Transportation Association (www.krta.co.kr)
Building construction (1999)	Architectural Institute of Korea (www.aik.or.kr)
Civil construction (1996)	Korean Society of Civil Engineers (www.ksce.or.kr)
Concrete construction (1999)	Korea Concrete Institute (kci.or.kr)
Electrical construction (1998)	Korean Institute of Illuminating and Electrical Installation Engineers (www.kiiee.or.kr)
Highway construction (1996)	Korea Road and Transportation Association (www.krta.co.kr)
Landscape architecture construction (1996)	Korea Institute of Landscape Architecture (www.kila.or.kr)
Marina construction (1996)	Korea Port and Harbour Association (www.koreaports.or.kr)
Mechanical installation (1996)	Society of Air-Conditioning and Refrigerating Engineers of Korea (www.sarek.or.kr)
Plant construction (1999)	Korea Institute of Construction Technology (www.kict.re.kr)
Railroad construction (1999)	Korean National Railroad (www.korail.go.kr)
Subway construction (1997)	Korean Society of Civil Engineers (www.ksce.or.kr)
Tunnel construction (1999)	Korean Tunnelling Association (www.tunnel.or.kr)
Water supply construction (1997)	Ministry of Environment (www.me.go.kr)
Waterway construction (1999)	Korea Water Resources Association (www.kwra.or.kr)

ciations and public institutions generally own a specialty specification to describe project requirements. It is difficult to synchronize contents of the specifications because some of the standard specifications serve as specialty specifications.

Contents and Databases

Table 2 shows the database contents of SPEC WRITER. It contains standard design guidelines and drawings published by MOCT and additional 103 design manuals and guidelines. In addition, design review comments frequently made by the Central Design Review Committee (CDRC) are included since all public projects must be reviewed by the CDRC. Request for information (RFI) from contractors to the government are also included since many interpretation of project documents may cause legal conflicts in public projects. MOCT has repeatedly collected and published suggestions and recommendations from the committees as an addendum to the design guidelines.

Learning such comments and RFIs prior to design review is crucial to reduce any avoidable modifications or potential interruptions during design phase. The database is designed for specification writers and design engineers to avoid common design mistakes or errors. To provide design and construction engineers single access point to various sources required by the government, all applicable designs and construction documents including specifications, manuals, guidelines, laws and regulations, and contract documents must be included.

Thirty sets of standard drawings and requests for information data submitted to MOCT are included. In addition, construction materials and their manufacturers are classified and linked to those documents. As shown in Table 2, 14 additional specialty specifications have been published in addition to 15 standard specifications, as shown in Table 1. Design manuals such as 16 standard guidelines and specialty guidelines including environmental design guideline, standard drawings, and bid and contract guidelines are also included.

All contracts, both general conditions and special conditions, used in Korea are digitized. More than 45,000 construction materials were included in the SPEC WRITER databases as well as information from some of the manufacturers in the construction industry. Except laws and regulations, the entire data have been digitalized and stored in the SPEC WRITER databases. Laws and regulations are linked to national databases due to frequent

Table 2. Contents of SPEC WRITER

Items (number of items)	Description (number of items)
Specifications (30)	• Standards specifications (15)
	• Specialty specifications (13)
	• Highway and waterway guide specifications (1)
	• Specification editor's guide (1)
Design manuals (103)	• Design guidelines and standard drawings(16)
	• Design document preparation guidelines (2)
	• Environmental quality guidelines (32)
	• Bid and contract guidelines, ordinances and regulations, working rules (30)
	• Subordinate technical guidelines (23)
Laws and regulations (31)	• Construction laws, enforcement ordinances, and enforcement regulations (31)
Contracts (40)	• Financial established regulations (30)
	• Notice, bulletins, announcements (3)
	• Notes, notifications, circulars, instructions (7)
Material and manufacturers (over 45,000)	• Construction material (over 45,000)
	• Manufacturers (over 600)

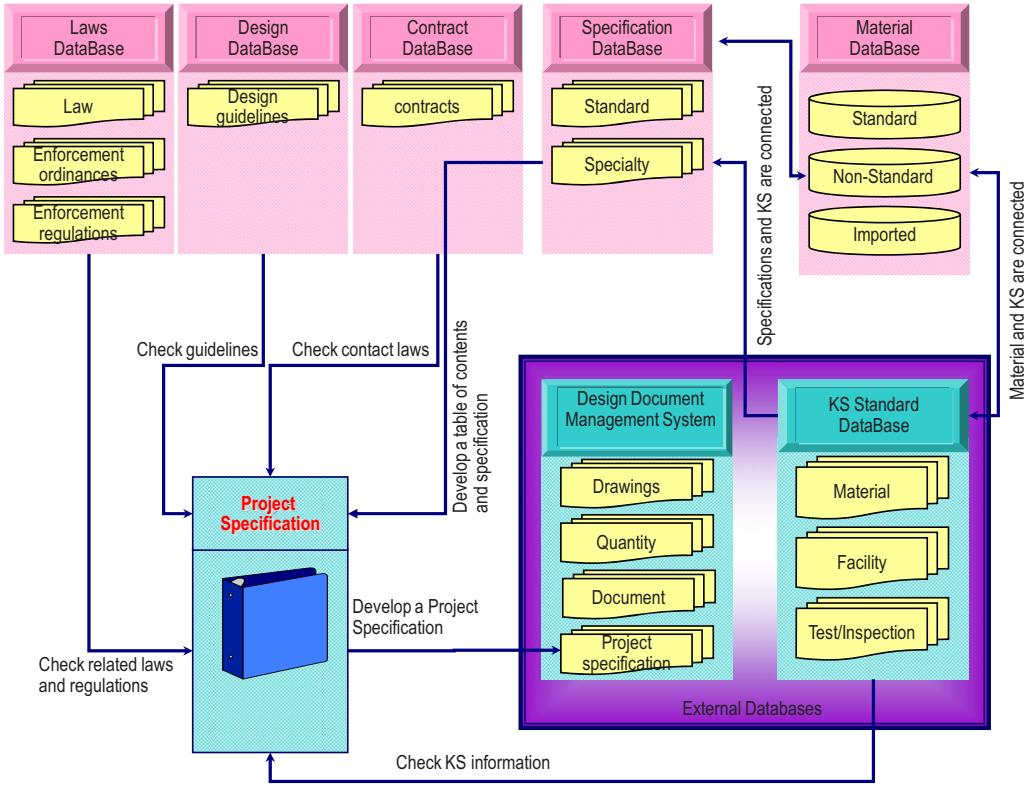


Fig. 1. Databases of SPEC WRITER

change in nature. Thus real-time update is achievable without any additional effort. With a complete set of 31 construction laws and regulations and 40 contract laws, specification writers or design engineers are able to review any legal disagreements during design and construction phases.

When detailed design is completed, specification writing and estimating follows. Using specification and construction law databases, design engineers can confirm and verify chapters and sections from related specifications and compose a specification for a specific project. More than 45,000 construction materials and over 600 manufacturer information are digitized. They are linked to appropriate material sections of the specifications. Materials are then classified into three: Korean standard (KS) certified, non-KS, or imported products. Materials that are produced and comply with KS are classified as KS certified materials. Materials that are produced and complied with KS but have not been certified are classified as non-KS. Imported materials are the materials that are complied with KS but produced in foreign countries.

The standard specifications are digitized and categorized according to the new framework, as shown in Fig. 1. Related materials and associated KS are linked to each section of the specifications so that specification writers can check the availability of materials that are presented by design engineers. The link helps specification writers find sections, guidelines, and materials using a few keywords. It also displays relationships among them. The link also provides manufacturers with an access to update desired materials. However, some of the specialty specifications are not digitized because some public organizations have the exclusive rights even though they are government funded public corporations.

SPEC WRITER is capable of communicating with two external systems: design management system (DMS) and national standard database system (NSDS). Both systems contain drawings, quantity take off, design documents, project specifications, and KS standard database including material, facility, and test/inspection guidelines. This connection was developed because DMS contains design drawings along with lists of construction materials and NSDS offers national quality standards in a database format. This link enables SPEC WRITER to offer cross-reference functions, therefore project specifications are consistent and reusable.

Functional Framework and System Architecture

Innovator, a structured system design life cycle developed by Samsung Data Systems was used to design and develop SPEC WRITER. Eleven Web development modules were used to produce design document. This methodology was selected because it provides the developers with quality assurance model, structured methodology maps, samples of deliverables, CASE tools, configuration tools, and project management tasks.

The proposed framework for standard specifications is shown in Table 2. To reduce inconsistency among the specifications, chapters and sections of the standard specifications were reorganized using the CIBS proposed by the Korean Institute of Construction Technology (KICT), a research arm of MOCT. Fig. 2 shows the integration of specification, national standards, construction materials, applicable laws, and regulations according to CIBS. Mandatory database, specifications, and national standards are linked first, then other databases, such as laws/regulations and contract templates are linked later.

CIBS consists of different levels: facility level, space or area level, element level, work level, and resource level. Facility level is to describe a final deliverable, i.e., residential home or commercial building. Space or area level is to describe children nodes

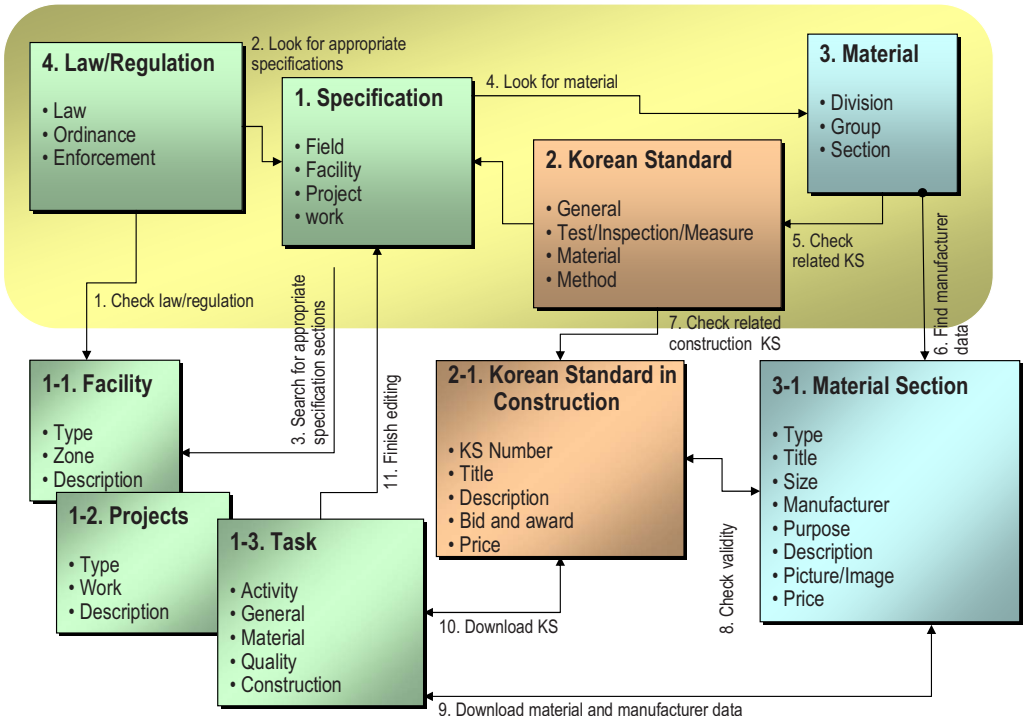


Fig. 2. Process diagram of SPEC WRITER

of facility level and consists of major components of the building, i.e., site work, superstructure, interior, or exterior. Element level is to show what parts the facility has such as slab, roof, or wall. Work level is to show required trades to complete facility elements such as concrete or finishes. Resources including equipment, laborers, or materials are described in the resource level. The collected documents were then reorganized in accordance with CIBS for SPEC WRITER.

In Fig. 2, the specification database plays a key role for the entire databases. Other databases such as KS, materials, law, and regulations are linked to the standard specification. The other databases have been rearranged according to the standard specifications. Relationships between the standards and others are defined. Key data fields of each database are listed in Fig. 2. Children databases, for example, 1-1 facility database, 1-2 projects database, and 1-3 task database, belong to their parent database, 1 specification. The child databases do not contain partial data to support their parent databases. An arrow with a number shows the sequence of operation to find appropriate clauses from specifications, guidelines, and drawings.

A guide specification is a template provided for specification writers. The purpose of the guide specification is to provide users with exemplary tables of contents of related chapters and sections. It is useful for less experienced specification writers who are working on an unfamiliar project. It also can be used to review all related specifications or update existing project specifications to keep consistency among project specifications. Specification writers can later choose suitable chapters or sections for editing.

An entity relationship diagram is presented to show relationships among the entities in the database of SPEC WRITER. Specifications and KS are linked because the specifications describe the quality requirements of construction materials. KS and available materials are coupled so that owners can find quality materials during bidding or award phases. Selected construction materials are then grouped and linked based on the project specifications. This project specification is then structured according to a project plan so that each section of a project specification is connected to engineering or construction activities.

A system configuration for internet service of SPEC WRITER is shown in Fig. 3. KICT offers SPEC WRITER through the internet. This configuration allows MOCT and KICT to manage the SPEC WRITER server through the internet. One server is a Web server to service SPEC WRITER and another server is to update the SPEC WRITER database. The SPEC WRITER can be integrated with existing management systems since the system architecture is reachable via the internet. The public corporations in construction provide this service by linking their Web sites to the SPEC WRITER server (Ryoo 2002).

Application and Maintenance of SPEC WRITER

This section describes how SPEC WRITER can be used during design and construction phases. Use of SPEC WRITER, their purposes, and related databases are shown in Figs. 4 and 5. A few screen images are included to explain how SPEC WRITER works. The feedback model is then presented to assist individuals who want to update data. Processes for updating and validating new data are also explained.

Application in Design and Construction Phases

SPEC WRITER is intended to serve from the planning phase of a project. This is possible because SPEC WRITER offers a virtual work space. Specification writers can store working files and share previous specifications with other specification writers in this virtual space. This function increases the reusability of project specifications. The project specifications can be reused, revised, or reproduced once it is created. By using SPEC

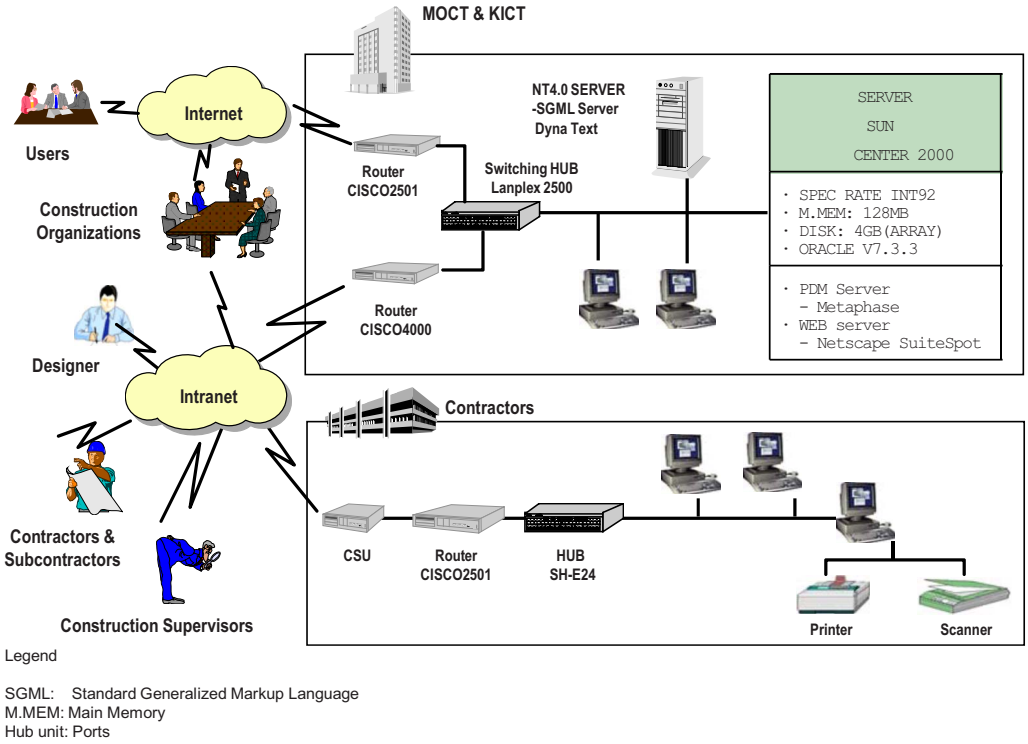


Fig. 3. System configuration of SPEC WRITER

WRITER, engineers can estimate possible legal and technical limitations that might affect the project. In the design phase, information on the applicable laws, regulations, and design guidelines assist engineers to evolve from basic drawings to detailed drawings. Figs. 4 and 5 show the business processes and related databases used during design and construction phases. The material database can be used for inspection during the procurement phase, construction phase, and operation phase of projects.

Two types of services of SPEC WRITER—closed service and open service—are described in Table 3. The member service is a closed service and is only available to registered users. They do have access to the databases without any limitation. Nonmembers

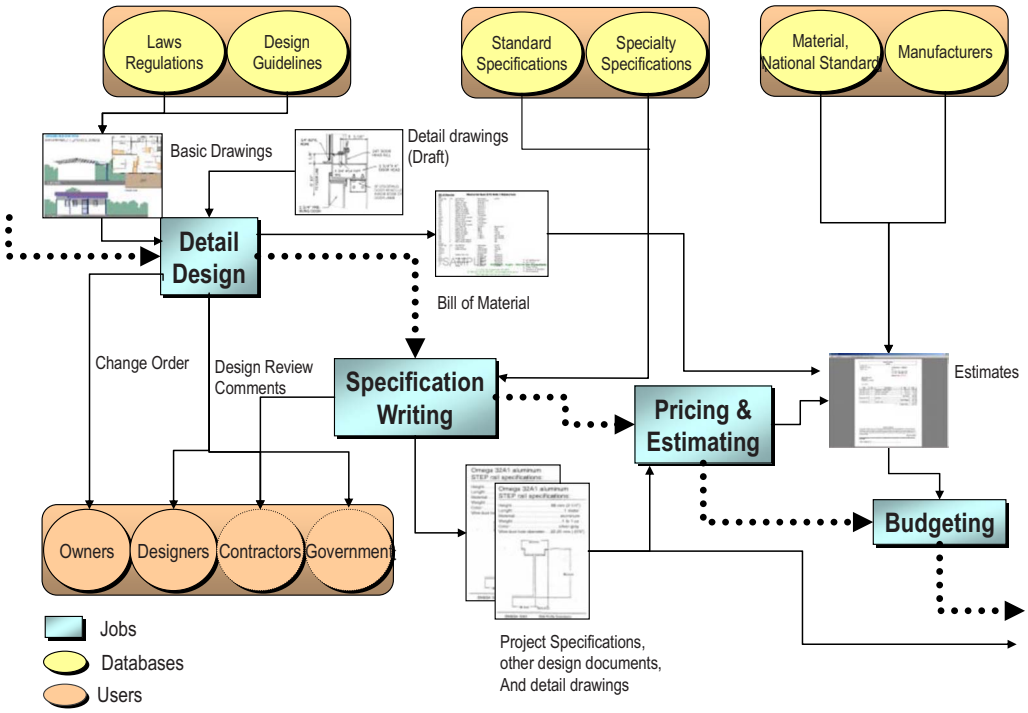


Fig. 4. Use of SPEC WRITER in the design phase

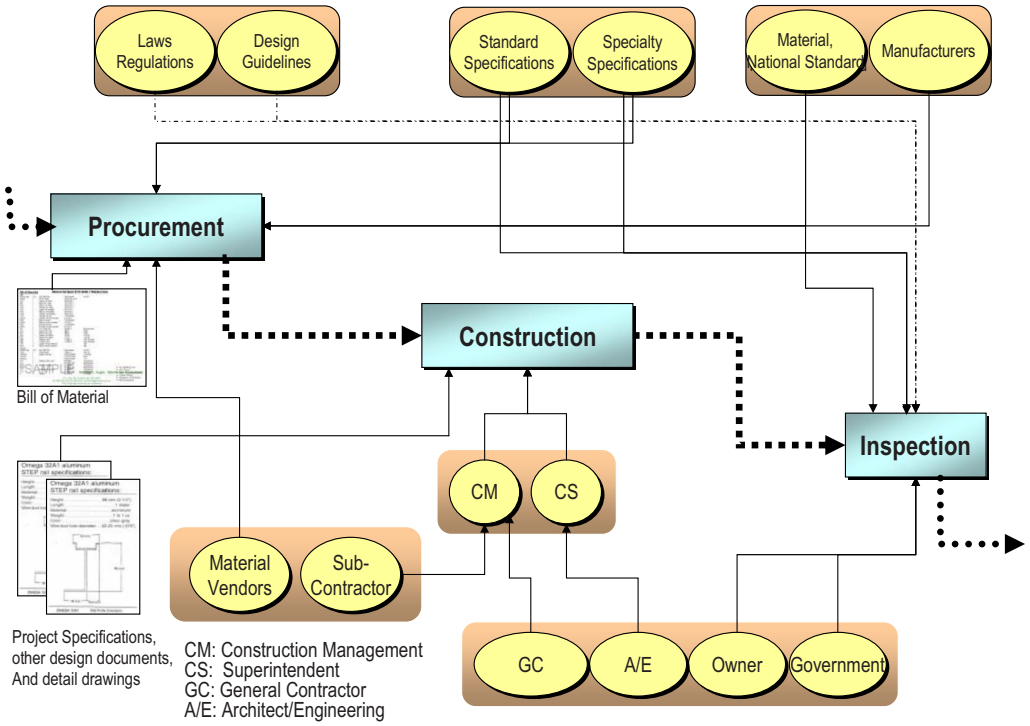


Fig. 5. Use of SPEC WRITER in construction phase

can only access the databases of specifications, design guidelines, and laws and regulations since these are public information. There is no need to update the data by users. Two virtual spaces are considered. One is for specification writers to edit project specifications and the other is to share project specifications with others. This space was intended to serve as an authorization tool to monitor users.

Use of SPEC WRITER

Fig. 6 illustrates the examples of SPEC WRITER. It shows how SPEC WRITER is designed and what steps specification writers should follow. A specification writer can search and display up-to-date construction documents by following this process. Search option will give specification writers a chance to search the entire database using a keyword or keywords. Specification writers can then choose a specification as the backbone of the project specification. The users can use multiple keywords to reduce the number of findings or narrow down to a specific section. Chinese characters can also be used as keywords. In fact, it is recommended to use Chinese characters to eliminate irrelevant results from search. Any word processor can then be used to edit a project specification draft.

At the beginning, a specification writer selects an area of the project such as residential or heavy construction. The writer can use keywords to search applicable sections from all standards and specialty specifications. Findings will be displayed in the right display pane, as shown in Fig. 6(a). The writer can search specific construction materials described in the sections in the specifications or explore suitable materials for the job in the sections, as shown in Figs. 6(b and c). All manufacturers in the databases will be displayed and once a material or a manufacturer is selected then the manufacturer's information will be searched, as shown in Fig. 6(b). Selected sections will be reorganized and the table of contents will become a main menu to compile selected sections, as shown in Fig. 6(e). The writer can edit, rewrite, or modify the sections in accordance with the characteristics of the project, as shown in Fig. 6(f).

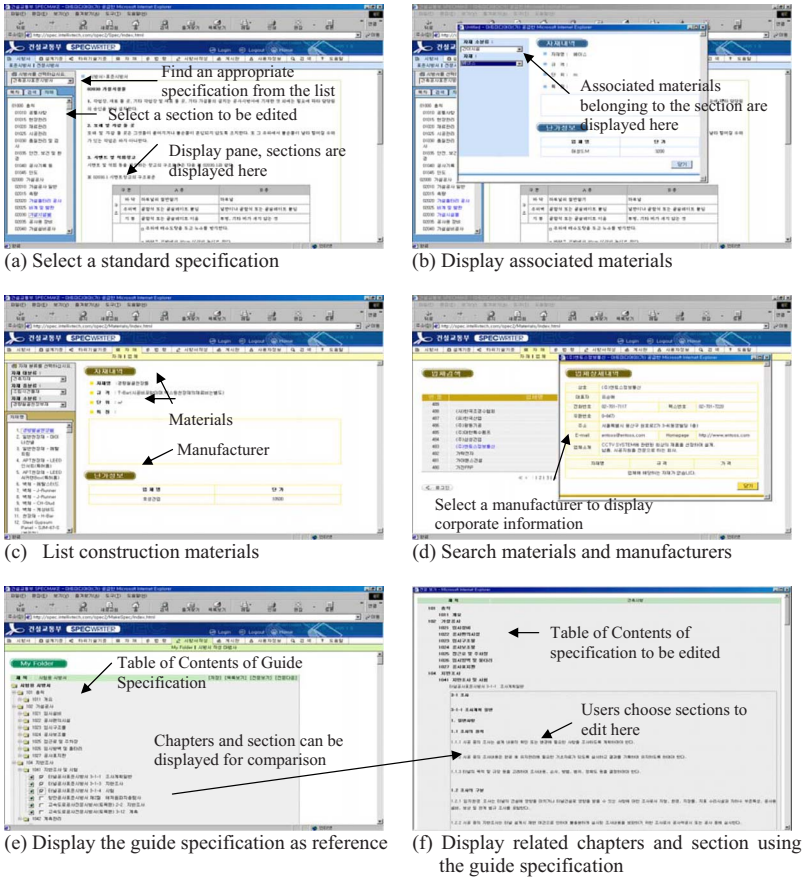
Table 3. Types of Services

Open services	Closed services (members only)
Specifications	Materials
Design manuals	Manufacturers
Laws and regulations	Specification editor
	Bulletin board

Updating System Database

It is crucial to keep the database up to date since most construction projects have multiple year contracts. A feedback process is proposed to update the database efficiently. It collects changes in any format and converts into a right format before sending out to SPEC WRITER main databases. As shown in Fig. 7, manufacturers, the specification owners, or construction managers can access the system to report any changes, mistakes, inconsistency, or discrepancies. For example, manufacturers can submit new material information to the server. Once a change is submitted, the system administrator is responsible for verifying and validating the submitted data. Once the validation of the submitted data are completed, the main databases will be updated automatically. This is required because many changes can be made during a project period. In particular, any changes in specifications, laws, and regulations must be kept as evidences to avoid possible legal disputes. It is also helpful for specification owners to keep track of changes in their specifications.

SPEC WRITER uses two groups of databases: the internal database group and the external database group. The internal da-



(a) Select a standard specification

(b) Display associated materials

(c) List construction materials

(d) Search materials and manufacturers

(e) Display the guide specification as reference

(f) Display related chapters and section using the guide specification

Fig. 6. Screenshots of SPEC WRITER

tabase group is databases containing specifications, design guidelines, material, and lists of manufacturers. The external database group includes laws, regulations, and national standards. This is considered because some databases must be updated frequently and the real-time service capability of the system is critical. The internal database group is broken into two parts: service databases and repository databases. The service databases are active databases of SPEC WRITER. The repository databases are to pile up temporary information before transferring to the service databases.

The management of the internal databases and the external databases must be handled differently to offer on-line and real-time service over the internet, as shown in Fig. 8. The administrator of the SPEC WRITER should monitor any updates and revisions in the internal databases by manufacturers. The service of updates or revised databases will not be published until permission from the administrator is granted. The administrator must confirm the validity of updates and revisions in the internal databases.

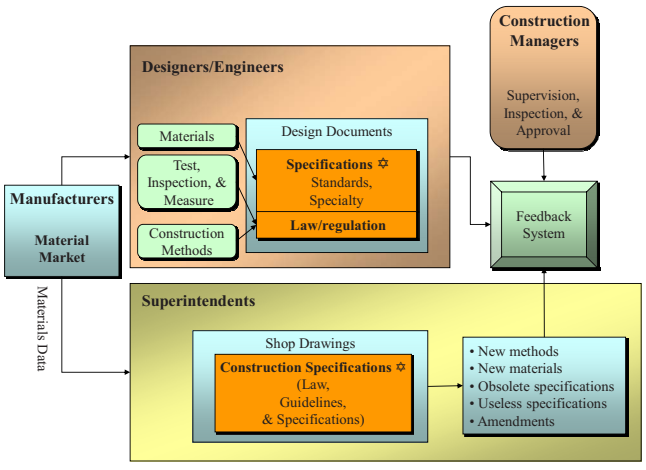


Fig. 7. Feedback from users to update databases

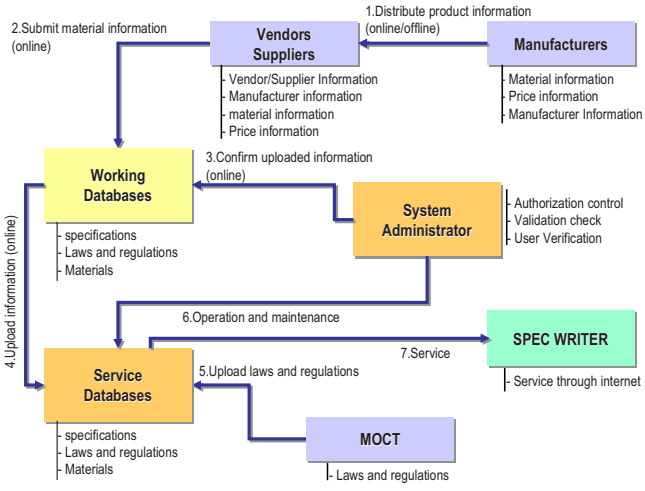


Fig. 8. Roles and responsibility of updating database

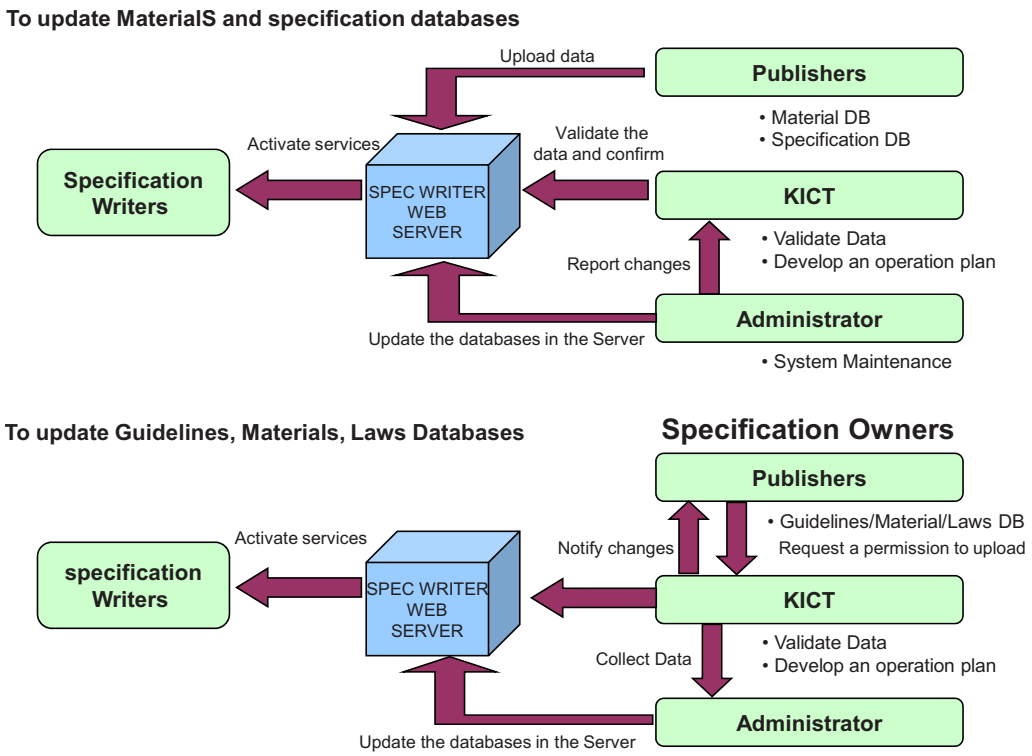


Fig. 9. Authorization and validation processes of database

Because of the financial instability of most material manufacturers, many of them go out of business every year. Allowing manufacturers to access the databases via the internet is critical because collecting manufacturer's data are hard. Fig. 9 shows a proposed authorization and validation processes that can be applied to the specification owners and manufacturers.

The operation and maintenance participants of the system falls into three groups: information service providers, intellectual property holders, and users. Since its high profitability and intellectual property are concerned, KICT and system managers act as an information service provider group. Thirteen specification owners become intellectual property holders and the construction industry becomes a user group. As updated specifications are available, publisher group or information service provider group can revise the databases using the manager tool. This is provided because the types of specification contents are text, images, tables, figures, or charts.

Implementation and Observation

Regardless of its functional flawlessness, there are issues to be resolved. One of the limitations of this system is that the specification owners claim the intellectual property even though the specifications are public knowledge. Therefore, it is the government's responsibility to persuade the specification owners to make the information public. Also, additional digitization of newly revised sections of the specifications is slow in progress. For example, during the financial crisis in the late 1990s, about 70% of the manufacturers have disappeared in Korea (Kim et al. 2002) and it was difficult to update manufacturers' data in the construction industry. MOCT and KICT strongly encourage manufacturers to load or update their product data via the internet. Regardless of its limitations, unlike existing CD-ROM-based specification systems, the ability to access and update SPEC WRITER maximizes the benefits from instant updates and real-time access to its databases.

Conclusions and Suggestions

This paper presents a framework and architecture of an integrated Web-based specification system. Its system takes an advantage of commonly available Web-based information handling and systems development technologies. The paper discusses how construction information can be linked and reorganized using CIBS. With this approach, synchronizing construction specifications with construction materials and KS can be achieved.

A significant contribution of this research is to present a framework of a Web-based specification writing system which is required to access many databases in different platforms. This framework, originally developed for the Korean construction industry, is to provide specification writers to securely access remote databases without significant effort. With this approach, benefits from synchronizing construction specifications with associated material and national quality standards can be realized. This kind of framework is especially beneficial when an integrated information system is required to collect data directly from various data sources.

Potential beneficiaries include specification owners, designers, engineers, construction superintendents, and construction managers. This internet-based system will give them a freedom of access to various resources on design, engineering, and construction specifications. This also provides real-time up-to-date specifications through the internet. The proposed model is particularly effective if multiple organizations are involved in sharing their

data through the internet. The model can also link specifications written in different language for international projects.

The majority of specification systems currently used in the North America provide information mainly on construction specifications, and material information is not included or linked. The future research will focus on a similar system for the North American construction market similar to SPEC WRITER.

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