International Journal of Database Theory and Application
Vol.9, No.9 (2016), pp.11-24
http://dx.doi.org/10.14257/ijdta.2016.9.9.02

Study on Standardization and Construction of Inventory Database for Asset Management in Water Supply System

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Abstract

To standardize and construct an inventory database for a water supply system, an inheritance tree is constituted from Level 1 to 5 for specification of a classification structure for the water supply system. Level 1 is specified based on systems while Level 2 to 5 are specified to classify water supply systems by considering a structure's role, function and type for each system. Also, the property information for asset management of each structure is systematcially investigated and written on a form to enable standardization of an inventory database. The property information is divided into asset classification information, asset location spatial information, asset specification information and asset management-related information, and the definitions, types, units and descriptions of the examined data are systematcially organized

Keywords*: Asset management, Inventory database construction, Standardization, Water supply system, Inheritance tree*

1. Introduction

A water supply system, which is recognized as being a critical and necessary form of infrastructure and lifeline for our everyday lives, is a facility aiming to supply water to those who demand it in a safe, stable manner. Due to aging and deterioration, however, issues such as reduction in functionality, leakage and consumer complaints as well as reduction in stability and increase in socio-economic costs, one of which is maintenance cost, have recently been generated regarding such facilities, and, subsequently, a need for a corresponding asset management technique is being raised.

Thus, this research aims to introduce an asset management system in water supply network facilities for their operation and systematic, efficient maintenance. Through this research, the means to construct a water supply system inventory database are proposed as a base step to achieve establishment of an asset management structure and asset management system.

1.1. Need for Construction Inventory Database of Water Supply System

An inventory of a water supply system refers to detailed asset object list information of each facility and base information of each asset object that constitute an overall water supply system, and a group of such informational data can be called an inventory database for a water supply system. In other words, construction of an inventory database for a water supply system can be defined as a process in which redundancy retained by the detailed asset object list and base information that together form a water supply system is

ISSN: 2005-4270 IJDTA

eliminated, and information is unified, structured and stored to seek efficiency in data processing and utilization including, for example, data search.

Through utilization of an inventory database for a water supply system, asset management techniques such as LCC (Life Cycle Cost) analysis conducted on water supply networks can be introduced.

1.2. Construction Process of Inventory Database of Water Supply System

For construction of an inventory database for a water supply system, an overall understanding of related structures through a review and analysis of the water supply system and all relevant data must be achieved in advance. Also, if understanding and organization of data items related to facilities, which are fundamentally required for introduction of an asset management technique in a water supply system, are accomplished, it is then possible to form inventory inheritance tree, a detailed classification for construction of a water supply system inventory database, and a framework related to construction of an inventory database, which can be utilized in asset management of a water supply system. Through these, a standardized inventory database composition form may be written for development of software for writing of a water supply system inventory database in a structured, stable and systematic manner. In other words, through this research, not only methodologies including ways to approach construction of an inventory database for a water supply system will be proposed but also necessary forms for constitution of a facility inheritance tree and database standardization, which aim to achieve construction of a water supply system's inventory database, are to be specified.

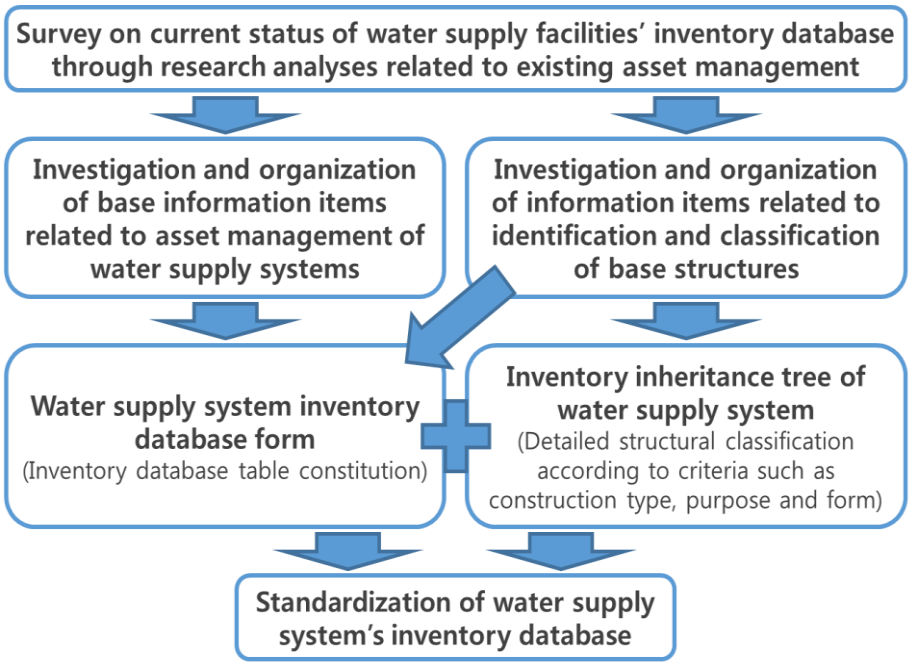

Figure 1. Construction Process of Inventory Database of Water Supply System

2. Constitution of Inventory Inheritance Tree of Water Supply System

2.1. Classification of Water Supply Network Facilities

As the first step for construction of an inventory database of a water supply system and development of software, the inventory inheritance tree of the supply system is established. For an overall analysis on the status of water supply systems, standard literature such as construction books and drawings, network drawings, other design documents and water supply system criteria (Ministry of Environment, 2010) related to water supply systems are utilized. Water supply system facilities including water conveyance facilities, transportation facilities, drainage facilities and water supply facilities are specified as Level 1, and structures corresponding to each type are categorized and summarized as in Table 1.

Table 1. Facility Classification of Water Supply System Criteria

Level 1	Level 2	Level 3
Water conveyance facility	Drainage pipe, aqueduct, water balancing reservoir	Building, structure, machine equipment, control measurement facility
Transportation facility	Water pipe, pump station, balancing reservoir	
Drainage facility	Cess pipe, distributing reservoir, water tower and elevated tank	
Water supply facility	Water pipe, reservoir	

Level 2 summarizes notable structures for each type and Level 3 specifies a classification system that considers characteristics of each structure type including buildings, structures, machine equipment and control measurement facilities. Based on these, detailed structures that constitute a water supply system were investigated and, subsequently, a classification system was created. Table 2 shows detailed structures for each type specified in Level 1.

Table 2. Organization of Detailed Structures that Constitute a Water Supply System

Level 1	Detailed structures
Water conveyance facility	Pipes (wrapped steel pipes, cast iron pipes, ductile cast iron pipes, PVC pipes, PE pipes, hume pipe, *etc.*), valves, pumps, drainage system, duct protection system, pressure control tanks, flowmeter, junction wells, cut-off walls, water pipe bridges, special pipe protection, valve room structures, manholes/service openings, aqueduct, water drainage tunnels, aqueduct bridges, regulating gates, screens, water level controlling valves, overflow equipment, reservoir pumps, reservoir valves, water reservoir structure
Transportation facility	Pipes (wrapped steel pipes, cast iron pipes, ductile cast iron pipes, PVC pipes, PE pipes, hume pipe, *etc.*), valves, drainage system, duct protection system, device for prevention of electrical corrosion/corrosion pipes, flowmeter, water-pressure gauges, water quality measuring apparatus, special pipe protection, manholes/service openings, valve room structures, water pipe bridges, water supply pumps, water supply pump room, overflow pipes, water reservoir structure
Drainage	Pipes (wrapped steel pipes, cast iron pipes, ductile cast iron pipes,

facility	PVC pipes, PE pipes, *etc.*), valves, drainage system, device for prevention of electrical corrosion/corrosion pipes, non-shut-off system, flowmeter, water-pressure gauges, water quality measuring apparatus, special pipe protection, manholes/service openings, valve room structure, water pipe bridges, common ducts, additional chlorine disinfection facility, overflow weir, water sampling facilities, water gauges, ventilation device, distributing reservoir structure, water tower structure, elevated tank structure
Water supply facility	Pipe (wrapped steel pipes, cast iron pipes, ductile cast iron pipes, PVC pipes, PE pipes, zinc-coated steel pipes, hume pipes, STS pipes, PB pipes, Metapole pipes, *etc.*), valves, pumps, water-saving supply fittings, water meter, water-pressure gauges, special pipe protection, manholes/service openings, valve room structures, pipe type, underground reservoir, elevated water tank, pressurized water supply tank, small-sized tank, drainage system, water gauges, underground reservoir room, elevated water tank room

2.2. Specification of Asset Classification Levels for Water Supply Systems

For a systematic and efficient management of detailed structures in a water supply system, there is a need to build facility classification system and classify the water supply network facilities in detail according to the classification criteria considering utility. To classify the objects that belong to each of the detailed water supply system structures proposed in Table 3, items such as construction type, facility purpose, function and type were selected to categorize and constitute systematic levels on these structures.

The number of levels for water supply system classification is 5 in total, and the descriptions for each of these levels are as follows.

Table 3. Definition and Description of Asset Classification Levels for Water Supply Systems

Classification Level	Name of Classification Level	Description of Classification Level (Standard)
Level 1	System	A group of facilities that fall into the category of water supply systems, which can be divided into water conveyance facilities, transportation facilities, drainage facilities and water supply facilities according to facility systems
Level 2	Facility Classification	Facilities of a comprehensive concept that constitute each facility system, categorized in Level 1, are further classified based on their purpose and type.
Level 3	Construction Type	Facilities categorized in Level 2 are further classified based on their construction types (characteristics)
Level 4	Classification	Facility assets corresponding to different facility areas based on construction type classification in Level 3 are further classified in detail according to their purpose, function and type
Level 5	Sub-Classification	Breakdown of Level 4 classification

2.3. Composition of Inventory Tree for Water Supply System

Based on the five levels specified for a water supply system, an inventory tree was created for the system network facilities within. In case of pipes, which occupy the highest percentage in a water supply system network, they were classified based on pipe type in Level 4 (Classification) and pipe diameter in Level 5 (Sub-classification). This is because these are information that can easily be checked in existing data such as pipe network drawings during an on-site investigation conducted for asset management of a water supply system, and also because pipes have distinct characteristics and purposes of usage based on type and diameter, which makes them suitable criteria for classification. Structures other than pipes were classified up to Levels 4 or 5 according to their purposes of usage and functions. Table 4 below is an example of creating an inventory tree on transportation facilities, a type of system network facilities.

Table 4. Part of the Inventory Tree Composition for Water Supply Systems (Transportation Facility)

Level 1	Level 2	Level 3	Level 4	Level 5
System	Facility Classification	Construction Type	Classification	Sub-classification
Transportation facility	Water pipe	Structures	Wrapped steel pipes	600mm ~ 1,200mm
			Cast iron pipes	
			Ductile cast iron pipes	
			PVC pipes	
			PE pipes	
			Hume pipes	
		Control measurement facilities	Valves	Emergency shut-off valves, air valves, reducing valves, safety valves, hydrants
		Structures	Drainage system	Drainage pipes
		Structures	Duct protection system	Anti-water hammering system
		Machine equipment	Device for prevention of electrical corrosion/corrosion pipes	
		Control measurement facilities	Flowmeter	
		Control measurement facilities	Water-pressure gauges	
		Control measurement facilities	Water quality measuring apparatus	
		Structures	Special pipe protection	
		Structures	Manholes/service openings	
		Structures	Valve room structure	
		Structures	Water pipe bridges	Water pipe bridge

				structure
				Added bridge pipes
	Pump station	Machine equipment	Water supply pump	
		Buildings	Water supply pump room	
	Reservoir	Structures	Overflow pipes	
		Structures	Drainage system	Cess pipes
		Buildings	Reservoir structure	

3. Writing a Form for Standardization of Inventory Database of Water Supply System

Through the results of an inventory tree construction for a water supply system, facility asset objects were classified in detail, and a form was prepared for standardization of a water supply system inventory database on such objects. The form, which was created on Microsoft Excel, organized property information related to facility assets and proposed definitions, description, property information data type, categorization and input type for each of the property information items in the list.

The property information related to water supply system assets can be largely divided into ① asset classification information ② asset location spatial information ③ asset specification information and ④ asset management-related information. A legend for the item list is shown below and, in the legend, the constituting items of the property item list as well as definitions of the terminology are provided in brief.

Classification of target input property information in legend The input property information is divided into 4 types (asset classification information, asset location spatial information, asset specification information and asset management-related information).

Definition and description of items constituting item list The constituting items entered in for each asset in an item list include data name, data type, unit, data classification and input type. Data name can be written in Korean or English independently or in combination, and data types include text (character-type information, expressed in characters either in Korean or English), string (string information, listed one-dimensionally by combining characters and numbers), number (numeric information, expressed in numbers, associated with unit (or non-dimensional) information), date (date information, expressed in the form, YYYYMMDD). Units are only entered when applicable and, in this item list, MKS and CGS unit systems were proposed by default. The entire data is classified by acquired information (existing data acquired) and created information (data newly created through specifications, different from existing data), and data input types can be categorized into required (standard items) and selected (additional of user-defined) items.

Based on the four classification criteria for property information, an item list for asset management of water supply system facilities is proposed as below in Tables 5 to 8.

Table 5. Asset Classification Information Item List

Data Name		Data Type	Unit	Definition and Description of Detailed Property Information	Data Categorization and Input Type			
					Acquired Information		Created Information	
Classification	Detailed Property Information				Required	Selected	Required	Selected
Asset Classification Information	System	Text	-	Choose one among water conveyance facility, transportation facility, drainage facility and water supply facility, all of which are water supply system types (Level 1 classification)	O			
	Facility Classification	Text	-	Classification of facilities that constitute corresponding water supply system types (Level 2 classification)			O	
	Construction Type	Text	-	Choose one of the major areas that constitute a target facility: construction, civil engineering, electricity, piping, machinery, devices, measurement and others (Level 3 classification)			O	
	Classification	Text	-	Types of major facilities included in corresponding construction types (Level 4 classification)			O	
	Sub-Classification	Text	-	Classification of detailed facilities corresponding to each of the major facility types (Level 5 classification)			O	
	Asset Name	Text	-	A general term for a target facility, possible to use in combination with an arbitrarily provided name			O	
	Classification Code (Control No.)	String	-	A string code (characters or numbers) arbitrarily assigned to a target facility for its efficient classification/ management			O	
	Existing	Strin	-	Existing code for facility		O		

	Facility Control Code	g		management, a string code (characters or numbers) assigned to each facility (Ex: serial number, tag number)				

Table 6. Asset Location Spatial Information Item List

Data Name		Data Type	Unit	Definition and Description of Detailed Property Information	Data Categorization and Input Type			
					Acquired Information		Created Information	
Classification	Detailed Property Information				Required	Selected	Required	Selected
Asset Location Spatial Information	Installation Location	Text/String	-	Refers to information expressing the location where an asset is currently installed or buried underground, refers to location information like local addresses such as street names, geographic information system (GIS), or spatial information for inside of buildings	O			
	Map Number (Topographic Map Number)	String	-	Distinct serial number of a topographic map expressing the topography of where a target facility is installed or buried underground	O			
	Facility Level	No.	m	The sea level value of a facility (or burial depth for facilities buried underground)		O		

Table 7. Asset Specification Information Item List

Data Name		Data Type	Unit	Definition and Description of Detailed Property Information	Data Categorization and Input Type			
					Acquired Information		Created Information	
Classification	Detailed Property Information				Required	Selected	Required	Selected
Asset Specification Information	Description of Specification	Text	-	Refers to the specification information expressing the characteristics of an asset, possible to input manufacturing and	O			

				design information including name of manufacturer, product name, model name or material, type, method, size (bore diameter, length, *etc.*), performance and function for pre-existing assets				
	Purpose of Facility	Text	-	Specifies detailed purposes of an asset facility		O		

Table 8. Asset Management-related Information Item List

Data Name		Data Type	Unit	Definition and Description of Detailed Property Information	Data Categorization and Input Type			
					Acquired Information		Created Information	
Classification	Detailed Property Information				Required	Selected	Required	Selected
Asset Management-related Information	Main body responsible for design	Text	-	Main body responsible for design of an asset		O		
	Main body responsible for construction	Text	-	Main body responsible for construction of an asset		O		
	Main body responsible for management	Text	-	Specifies the name of an organization or person responsible for management of a facility	O			
	Date manufactured	Date	-	Date on which the manufacturer produced and released an asset, for existing assets		O		
	Date acquired	Date	-	Date on which an asset was acquired by the main body responsible for operation (not a date on which an asset was installed or operated)		O		
	Date installed (date buried undergro	Date	-	Date on which an acquired asset was installed for operation (construction, burying underground,	O			

	und or construction)			installation, *etc.*)				
	Usage expiration period	Number	Year/Month/Day	The usage period of an asset from its manufactured or acquired date to present				O
	Book cost	Number	₩	Cost spent on purchase of an asset, also called 'historical cost', usually includes the cost of asset purchase and additional cost spent on acquisition	O			
	Current value	Text/Number	₩	A number that expresses the current value of an asset in an economic way			O	
	Legal amortization period	Number	Year	- Years used = remaining life + durable years (= estimated years)	O			
	Re-investment price	Number	₩	(Estimated) cost spent for restoration of an asset's performance and functions			O	
	Warranty period	Number	Year/Month/Day	The period during which the main body responsible for manufacturing, sales and construction of an asset assures of its quality		O		
	Warranty-related explanation	Text	-	Description on detailed conditions related to warranty and quality assurance		O		
	History of malfunctions	Text	-	History of accidents or malfunctions generated such as physical damage, reduced performance or functional suspension of an asset			O	
	History of repairs	Text	-	History of malfunctions of an asset and their causes, countermeasures taken, and restoration of the asset's performance and functions			O	
	Criteria for renewal (existing assets)	Text	-	Criteria for performance degradation limits of an asset for judgment of a need for a renewal; existing criteria for	O			

				renewal of the asset in possession prior to a renewal				
	Criteria for renewal (after renewal)	Text	-	Criteria for performance degradation limits of an asset for judgment of a need for a renewal; newly specified criteria for renewal of an asset after a renewal			O	

4. Conclusion

For systematic asset management in a water supply system, a process for construction of an inventory database for each facility is required and, through this research, a form was prepared for constitution of a water supply system inheritance tree and standardization of an inventory database.

For inheritance trees, different levels, from 1 to 5, were formed to specify a classification system by considering characteristics and purposes of water supply systems. Level 1 was specified according to various types that constitute a water supply system such as water conveyance, transportation, drainage and supply. Level 2 classifies comprehensive equipment and facilities that constitute each of the aforementioned types based on their purpose and type, and Level 3 is specified based on construction types of each facility, including buildings, structures, mechanical equipment and control measurement facilities. Lastly, Levels 4 to 5 classify those facilities in detail, which have been categorized as independent objects and thus require asset management, based on various criteria such as purpose, characteristics, form and function.

In addition, a form was prepared in such a way that the property information (historical information) for asset management of each facility was systematically investigated and entered in to enable standardization of an inventory database. The property information is divided into asset classification information, asset location spatial information, asset specification information and asset management-related information, and also definitions, description, property information data type, categorization and input type for each of the property information items in the list were proposed.

Through this research, it can be concluded that securing of property information through field surveys as well as subsequent asset management by facility is possible based on forms prepared for construction of an inventory database for water supply systems. Moreover, it is expected that field staffs can use such forms to development of an inventory database construction program with which they can check basic information of structures and enter survey items more easily.

Acknowledgments

This study was supported by a grant from the national research, the development of an asset management solution for waterworks facilities.

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