

Article

Suggestion for a Framework for a Sustainable Infrastructure Asset Management Manual in Korea

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Academic Editor: Marc A. Rosen

Received: 6 June 2015 / Accepted: 2 November 2015 / Published: 11 November 2015

Abstract: This study proposes a framework for an infrastructure asset management manual containing infrastructure asset management processes and operation techniques, which can be adjusted by different ordering authorities to develop their own manuals. The following conclusions were drawn in this study. First, the justification for implementation of asset management was examined through analysis of changes and status of asset management in domestic infrastructure, and the current status and insufficiencies in the asset management manuals of the government and ordering authorities were inspected. Second, the current status and systems of infrastructure asset management manuals in developed foreign nations such as Australia, the United Kingdom and the United States were examined, to analyze and compare the characteristics of asset management manuals among different nations. The directivity for composition of an infrastructure asset management manual in Korea was deduced for reference. Third, based on the directivity for composition of a domestic and foreign infrastructure asset management manual, a framework for an infrastructure asset management manual that can be utilized by the ordering authorities was proposed for (1) a general infrastructure asset management manual connected to global asset management manuals; (2) a manual that considers the asset management experience of the ordering authorities; (3) a systematic manual that takes user convenience into account; and (4) a circulatory process, which links infrastructure policy and strategy in the decision-making stage.

Keywords: infrastructure; asset management; manual; framework; process

1. Introduction

1.1. Background and Purpose of Study

Infrastructure assets, such as roads, rivers, dams, harbors, airports, waterworks and railroads, are important national assets directly related to economic growth and quality of life of citizens; they are also important indicators of national competitiveness. As an enormous amount of infrastructure was constructed (asset value of about 272 trillion and 115.4 billion Korean won [1]) in the 1970–80s, the budget for new Social Overhead Capital (SOC) is gradually being reduced. Existing infrastructures are showing deterioration from aging and require an increased budget for maintenance. Furthermore, due to the creative economy and the drastic increase in the budget for national welfare [2], ambitiously promoted by the (to fulfill the pledge of the Park Geun-hye government, it is necessary to supply 135 trillion won for the next five years (major details of pledge: 80.3% on national welfare, 33.6% on economic revival, 16.8% on preparation of grounds for peaceful unification and 6.7% on cultural prosperity). The government decided to reduce expenditure on SOC by 12 trillion won for five years to prepare for this investment.) Park Geun-hye government, financial pressure and budget competition to secure an appropriate maintenance budget for infrastructure are expected to increase. Management of domestic infrastructure has been focused on simple history management and passive follow-up maintenance activities after construction, primarily centered on structural safety inspections. There is lack of optimal managerial and economic approaches, such as minimization of total asset cost, from a life-cycle perspective. In addition, as the National Accounting Standards, which are based on an accrual basis of accounting, oblige public institutions to annually report national asset assessment results to the National Assembly, greater emphasis will be placed on asset management for infrastructure.

Despite the efforts of ordering authorities to document tax savings and provide transparent and predictable maintenance costs, there is no guideline for operational procedures and techniques for asset management. In other words, there is an increasing need for asset management techniques that accommodate an emphasis on responsibility and performance of budget execution, efficient management of infrastructure, and distribution of financial resources and performance analysis. Ordering authorities do not have the manuals needed for infrastructure asset management.

In developed foreign countries like the United States and those in Europe, budget pressure from rapid increases in maintenance costs has come to the fore as a social issue because costs associated with the deterioration of infrastructure constructed after World War II [3] of the overall construction budget. They are actively implementing asset management techniques that simultaneously reduce the tax burden of citizens, maximize the functions of infrastructure, and minimize cost by integrating management and economic techniques into engineering. These developed nations have varying general asset management manuals to provide standard processes and operation techniques for use by authorities. Korea lacks the processes and guidelines for infrastructure asset management and has a pressing need for the development of a general manual, which can be utilized by authorities to cope with the national demand for efficient management performance, increased deterioration of infrastructure and financial pressure. Therefore, with the increasing demand for measurement of management performance and investment in infrastructure and sustainability, the purpose of this study is to propose a framework for an infrastructure asset management manual so that ordering authorities can adjust the framework to create their own manuals.

1.2. Subjects and Methods of Study

The scope of this study is limited to roads, railroads, harbors, dams, airports and other infrastructure assets (including waterworks), defined as (In Korea, this is defined under Article 14 (Infrastructure) of the National Accounting Standards.) infrastructure in the Rules on the National Accounting Standards. The subjects of this study were selected as the authorities that manage infrastructure.

Relevant materials and institutions were surveyed through research papers and publications. Since the purpose of this study was to propose a framework for an infrastructure asset management manual to be utilized by ordering authorities, relevant authorities were visited and interviewed to reflect their opinions on the current status of asset management and directivity for development. Major institutions interviewed in Korea included government institutions (Ministry of Land, Infrastructure and Transport, Ministry of Strategy and Finance), ordering authorities (Korea Expressway Corporation, Korea Water Resources Corporation, Korea Railroad Corporation and Korea Infrastructure Safety Corporation) and research institutes (Korea Institute of Construction Technology).

The structure of the manuals developed or operated by the International Infrastructure Management Manual (IIMM) of Australia, PAS-55 of the UK and the Federal Highway Administration (FHWA) of the United States were used as references for the development of an asset management manual in this study. Interviews with and materials from the domestic and foreign institutions that manage infrastructure were reflected in the development of the framework for the infrastructure asset management manual presented in this study.

2. Asset Management Status of Domestic Infrastructure

2.1. Environmental Change and Current Status of Infrastructure Asset Management

This section analyzes infrastructure maintenance and asset management systems, along with environmental change and the current status of asset management in domestic infrastructures such as obliged infrastructure asset assessment, aging of infrastructure, market expansion of existing infrastructure, national financial pressure and increased rationale required for budget securement. It also describes the insufficiencies of infrastructure asset management in Korea and justification for development of an asset management manual.

(1) Obligation to measure performance against investment through assessment of infrastructure asset value.

To provide reliable information on the national financial status, financial execution results and financial operation performance, and to reinforce the competitiveness of the public sector and soundness of government financing, major developed nations have switched to an accrual basis accounting method, which conforms to the global accounting standard called the International Financial Reporting Standards (IFRS).

Ever since the introduction of accrual accounting by New Zealand (1993) [4], major members of OECD and IMF have converted their existing cash basis accounting into accrual basis accounting. Korea also converted its government accounting to accrual basis accounting (2009) [5] to focus on responsible budget execution and a performance-oriented responsible administration system. Accordingly, the Ministry of Strategy and Finance first conducted price evaluation on infrastructure assets in 2011 and

obliged reporting of infrastructure value to the National Assembly. According to the criteria provided by the accounting guidelines on infrastructure asset revaluation, the overall value of existing infrastructure was evaluated to be about 272 trillion and 115.4 billion Korean won. Such obligatory infrastructure evaluation requires more accurate and responsible spending with regards to taxes paid to the government by citizens as consumers of infrastructure. This becomes the grounds for measurement of performance against investment, and the importance of asset management techniques that handle such performance measurement is expected to have increased [6,7].

(2) Deterioration of infrastructure and market expansion of existing infrastructure.

The majority of infrastructure in Korea was constructed as part of the industrialization and economic revival in the 1970–90s, and played a pivotal role in the national economy. However, quantitative increases and deterioration of such infrastructure are seriously impacting the limited national finances and maintenance budgets. According to the number of use years of type 1 and type 2 infrastructure in Korea shown in Table 1, type 1 and type 2 structures, which mainly include infrastructure such as bridges and tunnels, were increased by a factor of 5.2 from 11,444 in 1995, the year of the “Special Act on Safety Control for Infrastructure”, (Due to a series of accidents involving large-scale infrastructure such as the collapse of Seongsudaegyo Bridge (1994), safety inspections and maintenance were systematized in 1995 with the Special Act on Safety Control for Infrastructures, which placed these obligations and responsibilities on infrastructure administrators. This law requires infrastructure of a certain size to be divided into type 1 and 2 infrastructure for safety inspection.) to 60,106 in 2012. Of type 1 and type 2 infrastructure, infrastructure constructed 21 or more years ago includes dams (73.8%), harbors (29.2%), waterworks and sewage (28.3%), rivers (27.4%), bridges (15.7%), retaining walls (15.2%), tunnels (12.5%) and cut slopes (1.0%). Deterioration of infrastructure related to water resources, such as dams, harbors, waterworks and sewage, and rivers, is of particular concern. In particular, rivers have a higher percentage of the infrastructure constructed five years ago than other infrastructure after completion of the four rivers project on the scale of 22 trillion Korean won.

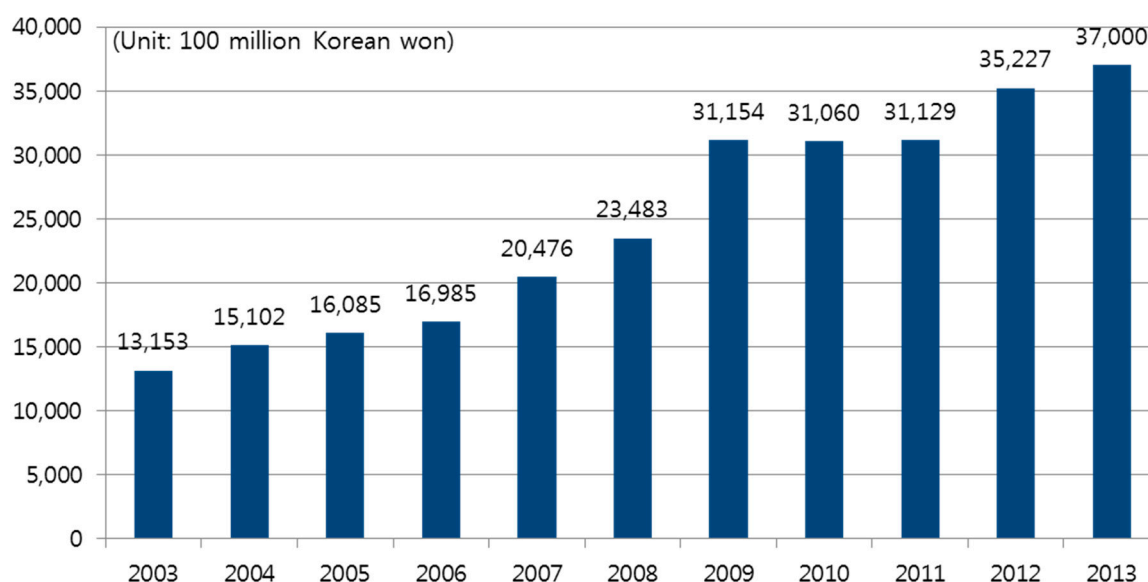
Since the asset management market is extremely limited in Korea, the facilities maintenance market was analyzed. The facilities maintenance market increased by 8% to 3.7 trillion Korean won in 2013, compared to 2012, when it was 3.5 trillion Korean won as shown in Figure 1. This represented a 2.8-fold increase compared to the 1.3153 trillion Korean won market of 2003, suggesting that the facilities maintenance market has grown by about 25% every year for 10 years (2003–2013) [8].

Despite environment-caused changes in infrastructure and considering that the size of domestic construction market is 130 trillion Korean won [9], the size of the facilities maintenance market (3.7 trillion Korean won) is only 2.8% of the total construction market. Based on the fact that maintenance markets in developed foreign nations take up about 40%–60% of the overall construction market, the potential and market for infrastructure asset management should be analyzed for expansion in Korea. Accordingly, the development of processes and guidelines for infrastructure asset management is expected to gain importance.

Table 1. The number of use years of type 1 and type 2 infrastructure in Korea. (Unit: each, %).

Item	5 Years or Less	6~10 Years	11~15 Years	16~20 Years	21~25 Years	26~30 Years	31 Years or More	Total
Bridges	2291	2042	2016	1219	543	343	516	8970
	25.5%	22.8%	22.5%	13.6%	6.1%	3.8%	5.8%	100.0%
Tunnels	803	553	502	289	74	124	108	2453
	32.7%	22.5%	20.5%	11.8%	3.0%	5.1%	4.4%	100.0%
Harbors	71	49	53	62	31	17	49	332
	21.4%	14.8%	16.0%	18.7%	9.3%	5.1%	14.8%	100.0%
Dams	18	38	52	29	32	53	300	522
	3.4%	7.3%	10.0%	5.6%	6.1%	10.2%	57.5%	100.0%
Buildings	9609	11,463	12,021	8143	1124	468	432	43,260
	22.2%	26.5%	27.8%	18.8%	2.6%	1.1%	1.0%	100.0%
Rivers	945	89	98	129	125	86	264	1736
	54.4%	5.1%	5.6%	7.4%	7.2%	5.0%	15.2%	100.0%
Waterworks and sewage	238	284	297	177	130	125	137	1388
	17.1%	20.5%	21.4%	12.8%	9.4%	9.0%	9.9%	100.0%
Retaining walls	424	212	142	99	35	15	108	1035
	41.0%	20.5%	13.7%	9.6%	3.4%	1.4%	10.4%	100.0%
Cut slopes	82	179	105	29	2	2	0	399
	20.6%	44.9%	26.3%	7.3%	0.5%	0.5%	0.0%	100.0%
Total	14,481	14,909	15,286	10,176	2096	1233	1914	60,095
	24.1%	24.8%	25.4%	16.9%	3.5%	2.1%	3.2%	100.0%

Source: Data on Facility Management System, Korea Infrastructure Safety Corporation, 2014.

**Figure 1.** Increasing trend in the facilities maintenance market of Korea [8].

(3) Increasing financial pressure of the nation and rationale for budget securement.

With recent increases in the financial budget competition in Korea, greater emphasis is being placed on rationale for securing an appropriate infrastructure maintenance budget. Financial pressure and budget competition for an appropriate maintenance budget for infrastructure will be further increased by the efforts to secure a growing budget for national welfare and the creative economy ambitiously promoted by the Park Geun-Hye government.

Looking at the SOC maintenance expenses and budget distribution of the Ministry of Land, Infrastructure and Transport, expenses have increased from 1.2436 trillion Korean won in 2011 to 1.5250 trillion Korean won in 2012, and 1.6986 trillion Korean won in 2013, but the limited budget results in insufficient support for the demands of various affiliated organizations [10]. In the case of the Korea Expressway Corporation (2012), while the repair and reinforcement funding demanded by regional headquarters was 288.5 billion Korean won, the allocated budget was 128.2 billion Korean won, approximately 45% of demand. Budget expenditures were divided as follows: 16% for new construction of road facilities, 74% for reinforcement (bridge deck improvement, seismic reinforcement, expansion joint, *etc.*) and 10% for other administrative expenses. A preventive maintenance budget was not included. This budget shortfall is the result of the ordering authorities' failure to provide sufficient rationale for a maintenance budget for the corresponding infrastructure [11]. Accordingly, ordering authorities in Korea are conducting research on asset management to improve budget rationale, but this research is only in the preliminary stages of level of service, and there is no standardized asset management process or manual for efficient management and embodiment of infrastructure.

2.2. Domestic Infrastructure Maintenance and Asset Management System

(1) Facilities maintenance system.

Facilities maintenance work in Korea is performed by organizations affiliated with the central government, according to the characteristics of each facility, and the maintenance system is further divided into metropolitan cities, provinces and local governments. Based on the "Special Act on Safety Control for Infrastructures" (Special Act on SCI), the representative maintenance laws of Korea, such maintenance work requires safety inspections and diagnoses to be conducted within a certain period for infrastructure assets of a certain size. Targets of the Special Act on SCI are divided into type 1 and type 2 infrastructures, according to size. However, the safety inspections of such infrastructure are mainly about structural safety, and do not consider asset management techniques, which integrate managerial and economic techniques with engineering to maximize function and minimize cost [6].

(2) Infrastructure asset management promotion status of the government and ordering authorities

Representative Korean government institutions promoting infrastructure asset management include the Ministry of Strategy and Finance and the Ministry of Land, Infrastructure and Transport. The Ministry of Strategy and Finance has made official its interest in the implementation of accrual basis accounting to accommodate for IFRS, and it has begun to reinforce the basis for legal grounds and systems by amending the National Accounting Act and National Finance Act in 2008. Particularly for infrastructure, various guidelines, such as the Accounting Guideline for Asset Revaluation and the

Accounting Guideline for Infrastructure, were prepared with the intention that the Ministry of Strategy and Finance will apply the National Accounting Standards to accrual basis accounting [5]. The national settlement report, prepared according to accrual basis accounting, examined the asset values of major infrastructure through price revaluation. Nonetheless, these guidelines are only provided for asset revaluation of infrastructure and do not include asset management methodology, processes and relevant guidelines.

The Ministry of Land, Infrastructure and Transport, which supervises major infrastructure assets such as roads, railroads and public buildings, conducted infrastructure asset evaluation with the Ministry of Strategy and Finance. The Ministry of Land, Infrastructure and Transport merely executes some functions of asset management on the level of listing and price evaluation of infrastructure assets. It does not have guidelines on the procedures and processes involved in asset management to cope with national demand for efficient management of infrastructure against investment, increasing deterioration and financial pressure.

After visiting and interviewing major ordering authorities such as the Korea Expressway Corporation, shown in Table 2, Korea Water Resources Corporation and Korea Railroad Corporation to examine existing infrastructure asset management manuals, it was determined that none of these organizations had independent asset management procedures. Korea Water Resources Corporation has an “asset management manual”, according to the asset management regulations, but this manual focuses on tax accounting of fixed assets and real estate properties; it does not define asset management to a satisfactory level of service demand for dams and waterworks management for minimum cost and maximum effect. There is a great need to supplement core details of asset management such as LOS (Level of Service) and risk management [12].

Table 2. Current asset management manual of the Korea Water Resources Corporation.

Chapter	Composition	Major Details
Chapter 1	Grounds for establishment of corporation	Type of corporation
		Classification of assets
Chapter 2	Asset overview and system	Inventory assets
		Fixed assets
		Off-balance fixed assets
		Off-balance inventory assets
		Fixed asset constant
Chapter 3	Asset management work	Inventory level of spare materials
		Supply plan establishment system
		Acquisition of fixed assets
		Management and depreciation of fixed assets
		Depreciation of fixed assets
Chapter 4	Real estate management	Disuse and disposition of fixed assets
		Concept and type of real estate management
		Real estate management work
		Acquisition of real estate
		Real estate study

Table 2. Cont.

Chapter	Composition	Major Details
Chapter 5	Taxes related to assets	Review of value added tax upon purchase and sale of delivery vehicles
		Value added tax upon selling of company house
		Acquisition of generation plant building and facility upon completion of dam construction
		Matters on acquisition/registration taxes according to national investment in kind
		Payment of ship and pontoon acquisition tax
Chapter 6	Accounting related to assets	Problem of local tax on approval of booster station building
		Accounting on acquisition, disuse and disposition of fixed assets
		Accounting on landscape trees
		Accounting method on insurance gain
		Land resale accounting know-how
		Accounting on additional tax after payment of ship acquisition and registration taxes
		Accounting on advertisement display boards
Chapter 7	Asset-related system	Arrangement of tangible and intangible assets according to implementation of financial accounting standards
		Questions related to accounting on fixed assets
		Financial Accounting Standards Provision 3 Intangible Assets
		Financial Accounting Standards Provision 5 Tangible Assets
Chapter 8	Methods of using asset management and material management systems	Method of using asset management systems
		Method of using spare material management systems

Source: Financial Management Office, Korea Water Resources Corporation, 2006.

3. Current Status and System of Infrastructure Asset Management Manuals in Developed Foreign Nations

This chapter analyzes the composition and system of infrastructure asset management manuals in Australia, the UK and the United States to choose significant aspects of the manuals from each nation for use as the basis of the framework for infrastructure asset management in Korea.

3.1. Australia

In 1986, in the midst of a serious economic crisis in government finance caused by a sharp increase in energy prices and interest rates due to the global economic crisis, the Australian government led strong reformation to introduce a new concept of public facility maintenance called asset management. Along with this concept, most infrastructure, such as roads, was completed in the 1980s. The maintenance

expense caused by deterioration of infrastructure constructed at this time was inflicting serious impact on national finance. National asset management councils were organized, starting with roads, and the first edition of the Asset Management Manual was published in 1996. Australia prepared the International Infrastructure Management Manual (IIMM) in 2000 [13], with continued revisions published in 2002, 2006 and 2011. Figure 2 shows the Asset Management Maturity Index of the IIMM. Working Groups of the United States, South Africa and the UK with participation of New Zealand and Australia [14].

This manual places emphasis on general use so that it can be applied by anyone related to asset management including asset managers, asset planners, operators, maintainers and developers. A Maturity Index was used to assign different levels of difficulty to different activities ranging from minimum to advanced, from organizations first starting to use asset management to organizations with a great deal of experience in asset management.

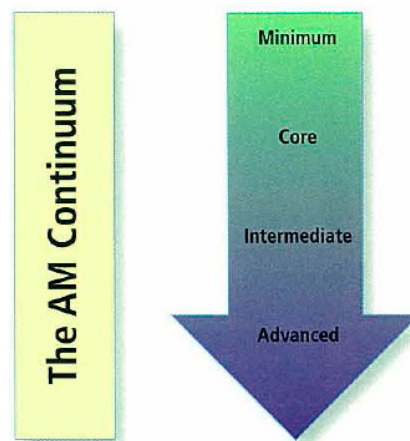


Figure 2. Asset Management Maturity Index of the International Infrastructure Management Manual.

The IIMM consists of five sections as shown in Figure 3: Section 1 is an Introduction to Infrastructure Asset Management; Section 2 is covers Understanding and Defining Requirements; Section 3 discusses Developing Asset Management Lifecycle Strategies; Section 4 is about Asset Management Enablers. Lastly, Section 5 addresses Country-specific Issues. In addition, Sections 2 and 3 have a cyclic structure to allow feedback from asset management strategies in decision-making [15].

Specifically, Section 1 introduces the benefits of AM, definition of AM, AM process and method of using the manual. Section 2 introduces AM policy/strategy, the level of service, forecasting of future demand, assessment of asset condition and risk management. Section 3 introduces decision-making techniques, operational strategies and plans, maintenance strategies and plans, capital investment strategies and plans, and financial and funding strategies. Section 4 introduces AM teams, AM plans, information systems and tools, service delivery methods, quality management and continuous improvement. Section 5 introduces an infrastructure overview, AM laws and AM institutions in Australia, New Zealand, the United Kingdom and the United States.

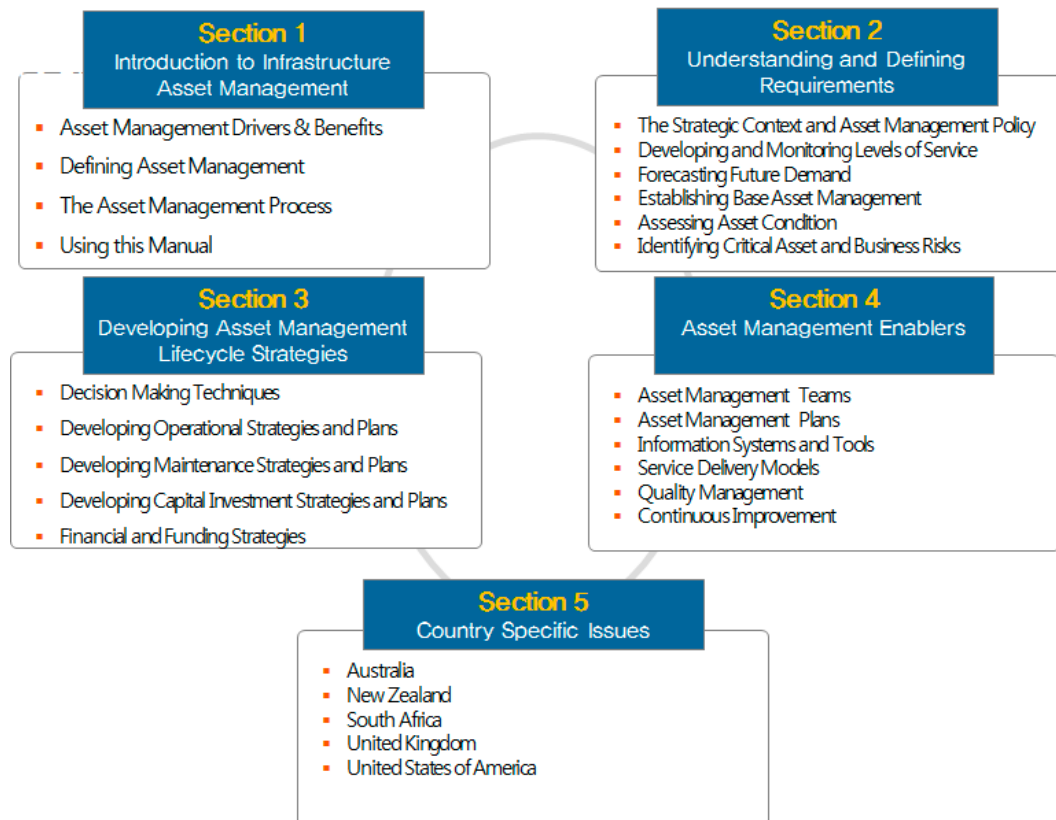


Figure 3. Composition of the IIMM.

3.2. The United Kingdom

PAS-55 is an asset management specification prepared by the Institute of Asset Management (IAM) in cooperation with the British Standards Institution (BSI) for utilization in public projects. The IAM is a representative asset management institute in the UK that promotes projects such as development of asset management techniques, development of asset management licenses and hosting of asset management conferences to expand understanding and knowledge regarding infrastructure asset management. Along with the BSI, the IAM is trying [16] to dominate the asset management hegemony in the global market through International Organization for Standardization (ISO) certification on ISO 55000, ISO 55001 and ISO 55002, for spread of international and general asset management techniques and applications.

Since a large group of infrastructure assets in the UK is providing services for longer than their design life, PAS-55 stresses the importance of lifecycle. PAS-55 was developed for general use, regardless of organizational size and nationality, by organizations that wish to establish sustainable asset management and optimal infrastructure asset management throughout a long-term lifecycle [17]. The PAS-55 consists of 28 detailed items under the categories of Plan-Do-Check-Act, shown in Figure 4. In addition, PAS-55 is used as a tool to measure the degree of performance on each of the 28 individual elements as shown in Figure 5.

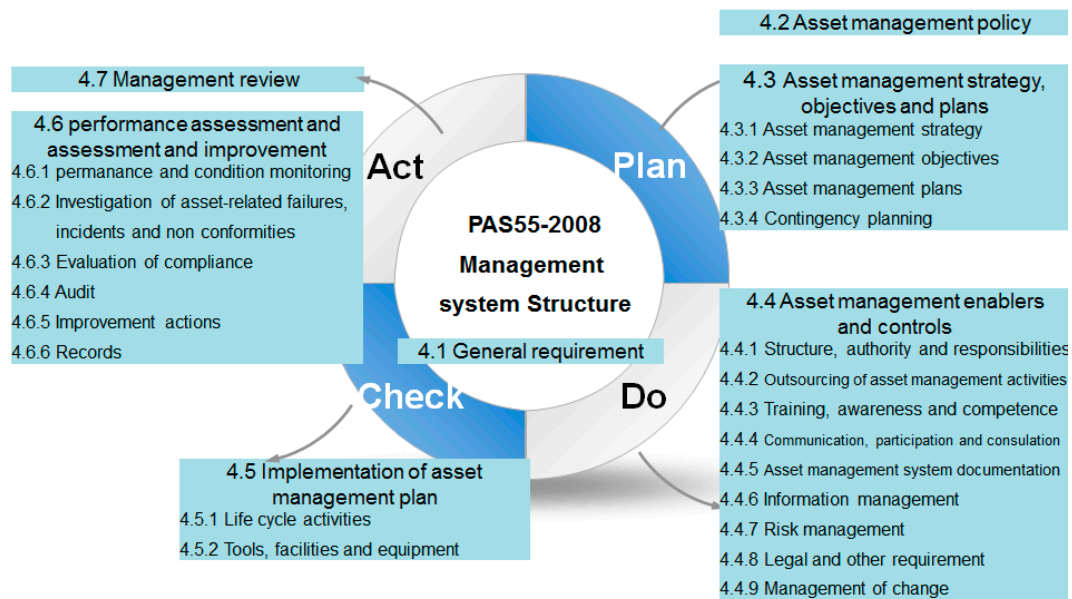


Figure 4. Structure of PAS-55.

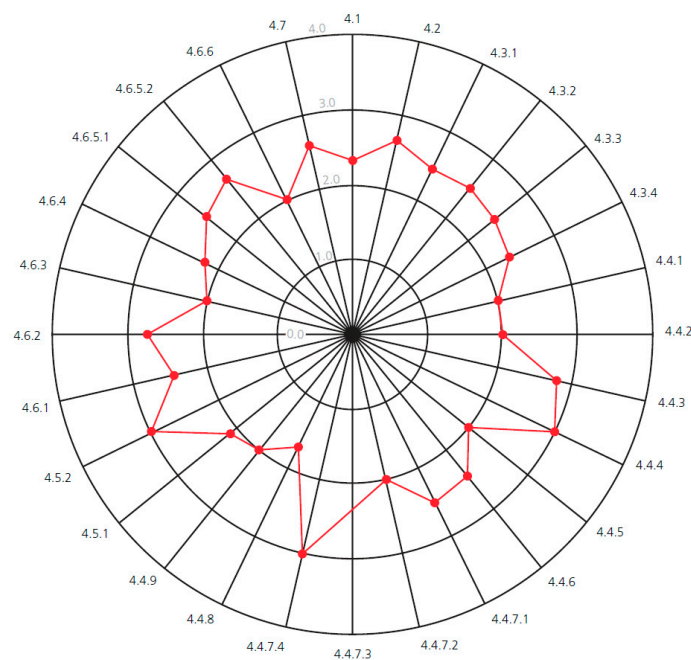


Figure 5. Asset management performance measurement of PAS-55.

3.3. The United States

After World War II, the United States concentrated its investment on construction of highways and large-scale infrastructure in the 1960s through the early 1980s. As it is fully equipped with enormous infrastructure like roads, substantial cost was associated with new construction and maintenance of facilities. The building paradigm shifted from construction to maintenance, repair and management.

State/local governments of the United States spend over 10% of their annual budget (140–150 billion USD) [18] on the maintenance of SOC facilities. As this had significant impacts on the budget execution of state/local governments, a more accurate and systematic approach was necessary. Also, systematic

budget execution procedures and techniques needed to be addressed because citizens, as consumers of infrastructure, demanded more accurate and responsible use of their tax dollars. Accordingly, the United States obligated state and local governments to report values and operation expenses for all SOC facilities (roads, bridges, waterworks and sewage, power supply facilities, public schools, parks, *etc.*) according to the accounting standards of GASB34 (1999, Government Accounting Standards Board). This clause prepared the grounds for ordering authorities and government institutions to implement infrastructure asset management by demanding evaluation of the value of infrastructure, asset condition (every three years), and expected maintenance expenses and development of a budget plan [19]. Meanwhile, according to the data provided by the American Society of Civil Engineers (ASCE), 11 of 15 infrastructures (Airport facilities, bridges, dams, waterworks, energy, hazards, waterways, parks, railroads, roads, schools, waste, public transportation and wastewater) received a D (poor) grade for safety problems. For the next five years, maintenance expenses were estimated to be 2.2 trillion USD [20], placing greater emphasis on the importance of asset management.

For effective management of public infrastructure, the United States utilizes asset management techniques based on managerial and economic techniques used in the private sector to entirely entrust infrastructure asset management to the federal government and organizations under the federal government such as the DOT (Department of Transportation), EPA (Environmental Protection Agency), and 85,000 local governments [15]. While the concept of asset management has been implemented in infrastructure, a general asset management manual, which can be used by ordering authorities, was needed. As a representative example, the Federal Highway Administration (FHWA) set up an asset management office in 1999 and published the Asset Management Primer in December of the same year as shown in Figure 6 [21].

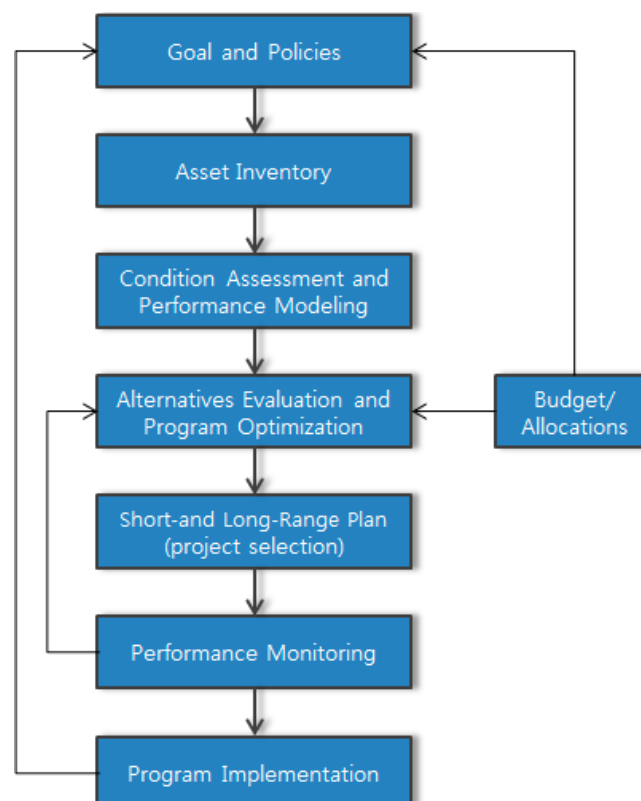


Figure 6. Asset management elements and flow of the US FHWA.

This Asset Management Primer (AMP) is an asset management manual of the FHWA for roads, and it consists of 6 chapters: Chapter 1, Goal and Policies; Chapter 2, Asset Inventory; Chapter 3, Condition Assessment and Performance Monitoring; Chapter 4, Alternative Evaluation and Program Optimization; Chapter 5, Short- and Long-range Plans; and Chapter 6, Program Implementation and Performance Monitoring. Details are described in Table 3. AMP does not differ greatly from other manuals in terms of content, but it prioritizes long-term scenarios more than other manuals, and is characterized by the utilization of reports summarizing each procedure submitted to Congress as the rationale for performance against budget input and budget planning. Long- and short-term plans can be used to develop scenarios based on budget level, to predict infrastructure maintenance programs based on these scenarios, and to logically secure the budget by providing a long-term budget plan and outcomes regarding the input budget.

Table 3. Asset Management Details of the US Asset Management Primer.

Item	Major Details
Goal and Policies	Setting forth Level of Service requirements for infrastructures
	Setting forth management objectives with consideration of safety, sustainability and economic feasibility
Asset Inventory	Selection of assets subject to management
	Input regarding infrastructure location, type, size, traffic volume, construction expense and maintenance history
Condition Assessment and Performance Modeling	Analysis on the history of inspection, diagnosis, maintenance and reinforcement
	Evaluation of conditions and residual lifetime of existing infrastructures
	Evaluation of asset value of existing infrastructures
Alternatives Evaluation and Program Optimization	Computation of budget necessary for accomplishing the target Level of Service
	Composition of applicable scenarios for budget level
	Determination of optimal scenarios through asset evaluation and value evaluation for each scenario
Short- and Long-Range Planning (Project Selection)	Establishment of maintenance program implementation planning based on scenario
	Determination of program priority and selection of infrastructure subject to maintenance
	Establishment of short-term and long-term program implementation plans
Program Implementation and Performance Monitoring	Implementation of a program for achievement of management objectives
	Continued feedback management through monitoring of implementation results

Note: Asset Management Primer, 1999.

Data accumulated in each procedure of the AMP are submitted in a report called “Conditions & Performance (This report has been prepared by the DOT (U.S. Department of Transportation) since 1984 on the conditions, performance and future investment demands of highways, bridges and public transit in all parts of the United States for submission to the Congress. This report aids decision-making on alternative future investment scenarios for highways, bridges and public transit through objective evaluation on physical conditions, operational performance and financing mechanisms based on future/present conditions.)” (reported biennially to the United States Congress) and used to analyze performance of infrastructure against budget input and securement of budget. This report also provides supporting data for legislation at all levels of the government, various policy development programs,

and evaluation and development of budget options [22]. Asset Management Details of the US AMP are shown in Table 3.

3.4. Analysis of Characteristics

The IIMM of Australia, PAS-55 of the UK and AMP of the US FHWA were examined above.

This section summarizes the characteristics of the asset management manuals of each nation to suggest the directivity for the asset management manual of Korea.

Unlike other nations where asset management is led by the private sector, the United States regulated infrastructure asset management through a government-initiated law (GASB34). State and local governments and ordering authorities needed a systematic approach and process for asset management. Accordingly, the United States FHWA and AASHTO developed a manual called the Asset Management Primer, only concentrating on the transport sector. The Asset Management Primer is characterized an emphasis on long-term scenarios compared to the manuals of Australia and the UK. Long- and short-term planning can be used to develop scenarios well-suited for the budget level, to apply and predict the performance of an infrastructure maintenance program based on these scenarios, and to logically secure a budget by providing a long-term budget plan and performance regarding the input budget.

Also, data accumulated by the Asset Management Primer are submitted as a report called Conditions & Performance, and are used as a tool to measure the performance of institutions. They are utilized as data to support legislation, various policy development programs, and evaluation and development of budget options.

Characteristics of asset management manuals published in Australia, the UK and the United States can be summarized in Table 4.

Table 4. Comparison of characteristics of current infrastructure asset management manuals in Australia, the UK and the United States.

Classification	IIMM (Australia)	PAS-55 (UK)	AMP (US)	Note
Composition of manual	5 Sections	7 Chapters	8 Chapters	
Government initiation	×	△	○	
Generality	○	○	△	The US focuses on the transit sector
Consideration of specific areas	×	×	△	
Consideration of specific users	×	×	△	
Consideration of maturity of each stage	○	×	×	IIMM considers maturity of stage
Cyclic structure	○	○	○	Structure in which asset management strategy/policy affects decision-making and offers feedback
Connection with ISO	×	○	×	

Note: Yes (○); Partially (△); No (×).

Characteristics of the IIMM, PAS-55 and AMP were summarized to deduce the following framework.

The framework was developed to include the general infrastructure asset management manual, suggestion of a manual that considers the maturity of ordering authorities on asset management, composition of a comprehensive manual that contains an overview, practice, examples and references for infrastructure asset management, and cyclic process composition, which allows for consistent and systematic processes and infrastructure asset management policies, strategies and LOS. The basic framework explained above was used to discuss the specific direction in Section 4.

4. Suggestion of a Framework for an Infrastructure Asset Management Manual in Korea

This chapter refers to the basic framework and characteristics of the infrastructure asset management manuals of Australia, the UK and the United States to suggest a framework for an infrastructure asset management manual in Korea based on the following four perspectives. This framework reflects the specific requirements and opinions (Opinions on the directivity for social infrastructure asset management manual were collected (17 March 2014~4 April 2014) through individual interviews with infrastructure asset management experts at ordering authorities (Korea Expressway Corporation, Korea Water Resources Corporation, Korea Railroad Corporation, Korea Infrastructure Safety Corporation) and Korea Institute of Construction Technology. Major opinions include provision of a general infrastructure asset management manual and process, provision of asset management manual based on the maturity of institutional asset management, *etc.*) gathered from ordering authorities and infrastructure asset management experts in Korea (early stage of asset management, lack of institutional and technical bases, *etc.*).

4.1. General Infrastructure Asset Management Manual Connected to Global Asset Management Manuals

As mentioned in Section 1, the development of a national general asset management manual that can be adjusted for different ordering authorities according to their characteristics is needed. A standard manual needs to be suggested so that each ordering authority can adjust it according to its characteristics. This manual needs to include the characteristics of and expertise regarding all domestic infrastructure, as well as infrastructure asset management processes presented by the IIMM of Australia, PAS-55 of the UK and AMP of the United States, so that it is connected to global asset management manuals to prepare for foreign advancement. In other words, it is necessary to not only develop a manual for domestic ordering authorities, but to provide a standard manual that considers mutual advancement of domestic and foreign infrastructure asset management companies. Therefore, as shown in Figure 7, the table of contents and process of developing an infrastructure asset management manual should be composed by referencing widely used international asset management manuals like the IIMM of Australia, PAS-55 of the UK and AMP of the United States, and adjusting or combining the contents of these manuals to correspond with the infrastructure asset management situation in Korea.

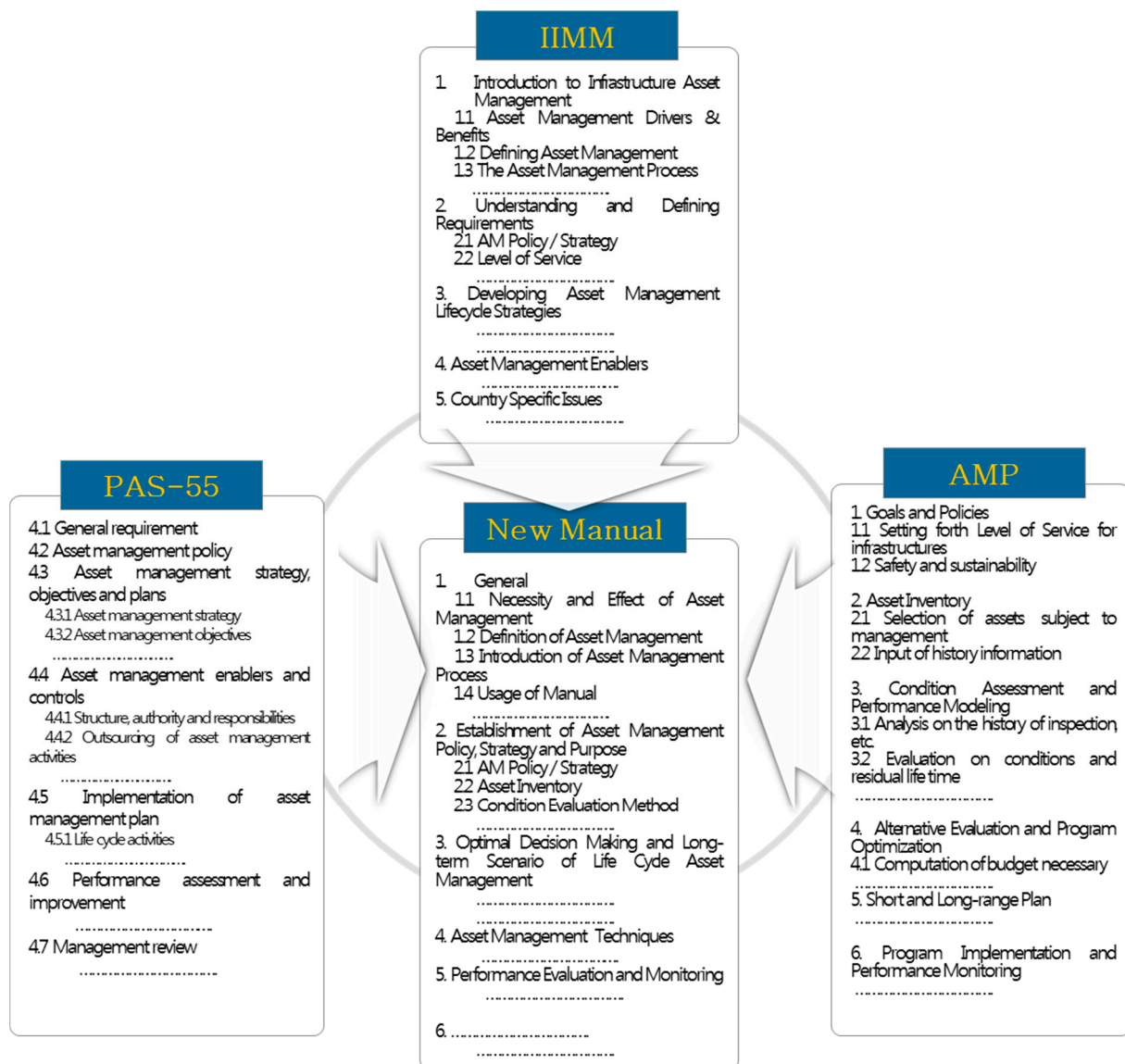


Figure 7. Basic concept of the general infrastructure asset management manual.

4.2. Manual with Consideration of Asset Management Experience of Ordering Authority

Looking into the IIMM of Australia, details are provided according to infrastructure asset management experience of the ordering authorities, by providing options in four stages including Minimum, Core, Intermediate and Advanced [15].

Taking into account the insufficient infrastructure asset management technology, institutional base and experience in Korea, the manual must consider the asset management capabilities of the ordering authorities. In other words, the manual requires a step-wise composition that consists of (1) simple, (2) standard and (3) detailed forms, so that ordering authorities can use an asset management process according to their level of asset management and capacity.

Accordingly, this paper divides the infrastructure asset management manual into simple, standard and detailed types as shown in Table 5. The “simple type” uses existing maintenance data in performing basic asset management as shown in Figure 8. This allows the ordering authorities responsible for management of infrastructure to easily apply the manual to asset management, considering the

insufficient institutional and technical grounds for infrastructure asset management in Korea. The “standard type” focuses on the essential basics and core details of asset management handled by foreign asset management manuals such as the IIMM of Australia and PAS-55 of the UK. The “detailed type” is suggested for ordering authorities with high levels of experience and capabilities of asset management to enable high-level asset management.

Table 5. Types of infrastructure asset management manuals.

Type	Experience Level	Criteria	Recommended Application Period
Simple type (A)	Beginner	Focuses on the basics of infrastructure asset management	1–4 years
		Maximal utilization of existing maintenance data for conversion from infrastructure maintenance to asset management	
Standard type (B)	Intermediate	Focuses on the essential basics of foreign asset management manuals	5–10 years
Detailed type (C)	Advanced	In-depth steps for more advanced asset management	10 years or longer

Note: The recommended application period can differ according to the asset management capability of the ordering authorities.

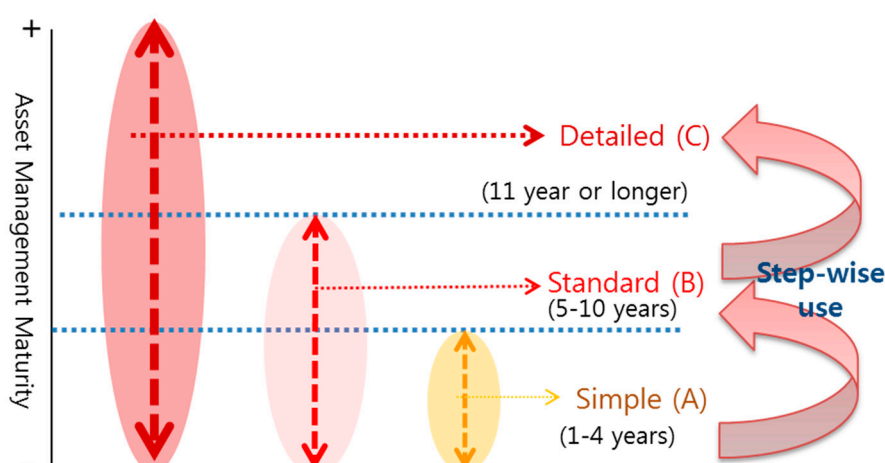


Figure 8. Basic concept of the manual considering the asset management experience of ordering authorities.

The asset management manual proposed in this study was suggested, as shown in Table 6, in reference to the IIMM of Australia and PAS-55 of the UK, the asset management experience of ordering authorities, and the opinions of ordering authorities and asset management experts.

Table 6. Composition of sustainable infrastructure asset management (SIAM) (draft).

IIMM (Australia)	PAS-55 (UK)	AMP (United States)	New Draft (Sustainable Infrastructure Asset Manual, SIAM)	Simple Type (A)	Standard Type (B)	Detailed Type (C)	Note
1. Introduction to Infrastructure Asset Management	4.1. General requirement	1. Goal and Policies	1. General				Introduction and use of asset management
1.1. AM Drivers & Benefits	4.2. Asset management policy	• Setting forth the Level of Service for infrastructure	1.1 Necessity and Effect of AM	○	○	○	
1.2. Defining AM	4.3. Asset management strategy, objectives and plans	• Setting forth management objectives with consideration of safety, sustainability and economic feasibility	1.2 Definition of AM	○	○	○	
1.3. The AM Process	4.3.1. AM strategy		1.3 Introduction of the AM Process	○	○	○	
1.4. Using this Manual	4.3.2. AM objectives		1.4 Usage of Manual	○	○	○	
2. Understanding and Defining requirements	4.3.3. AM plans		2. Establishment of Asset Management Policy, Strategy and Purpose				How to establish AM policy, strategy and purpose
2.1. The Strategic Context and AM Policy	4.3.4. Contingency planning	2. Asset Inventory	2.1 AM Policy/Strategy	○	○	○	
2.2. Level of Service	4.4. Asset management enablers and controls	• Selection of assets subject to management	2.2 Asset Inventory	○	○	○	
2.3. Forecasting Future Demands	4.4.1. Structure, authority and responsibilities	• Input on infrastructure location, type, size, traffic volume, construction expense and maintenance history	2.3 Condition Evaluation Method	○	○	○	
2.4. Assessing Asset Condition	4.4.2. Outsourcing of AM activities		2.4 Prediction of Future Demand	×	○	○	
2.5. Risk Management	4.4.3. Training, awareness and competence		2.5 Level of Service	○	○	○	
3. Developing Asset Management Lifecycle Strategies	4.4.4. Communication, articulation and consultation	3. Condition Assessment and Performance Modeling	2.6. Continuous Plan	×	×	○	
3.1. Decision-making Techniques	4.4.5. AM system documentation	• Analysis on the history of inspection, diagnosis, maintenance and reinforcement	3. Optimal Decision-making and Long-term Scenario of Lifecycle Asset Management				Optimal analysis/ establishment and long-term scenario
3.2. Developing Operational Strategies and Plans	4.4.6. Information management		3.1 Decision-making Techniques (BCA, MCA)	○	○	○	
	4.4.7. Risk management		3.2 Operational Strategies and Plans	×	×	○	
			3.3 Maintenance Strategies and Plans	×	×	○	
			3.4 Capital Investment Strategies and Plans	×	×	○	

Table 6. Cont.

IIMM (Australia)	PAS-55 (UK)	AMP (United States)	New Draft (Sustainable Infrastructure Asset Manual, SIAM)	Simple Type (A)	Standard Type (B)	Detailed Type (C)	Note
			3.5 Selection of Target Infrastructures and Determination of Priorities	○	○	○	
			3.6 Computation of a Budget for Achieving the Target Level of Service	○	○	○	
	4.4.8. Legal and other requirements	• Evaluation on conditions and residual lifetime of existing infrastructures	3.7. Financing and Funding Strategies	○	○	○	
3.3. Developing Maintenance Strategies and Plans	4.4.9. Management of change		3.8 Applicable Scenarios for the Budget Level	×	○	○	
3.4. Developing Capital Investment Strategies and Plans	4.5. Implementation of the asset management plan	• Evaluation on asset value of existing infrastructures	3.9 Determination of the Optimal Scenario through Asset and Value Evaluation for Each Scenario	×	○	○	
3.5. Financial and Funding Strategies	4.5.1. Lifecycle activities	4. Alternatives Evaluation and Program Optimization	3.10 Establishment of a Maintenance Program Implementation Plan based on the Scenario	×	×	○	
4. Asset Management Enablers	4.5.2. Tools, facilities and equipment	• Computation of the budget necessary for accomplishing the target Level of Service					
4.1. AM Teams	4.6. Performance assessment and improvement	• Composition of applicable scenarios for budget level	4. Asset Management Techniques				Separate elements that allow for AM
4.2. AM Plans	4.6.1. Performance and condition monitoring	• Determination of the optimal scenario through asset evaluation and value evaluation for each scenario	4.1 AM Organization (Structure/Authority and Responsibility, Training, Communication/Participation)	△	○	○	Possible only with function
4.3. Information Systems and Tools	4.6.2. Investigation of asset-related failures, incidents and non-conformities		4.2 Information Systems and Tools	△	○	○	Possible with Excel
4.4. Service Delivery Models		5. Short and Long-range Plan	4.3 Risk Management (Law, Demand management, etc.)	○	○	○	
4.5. Quality Management	4.6.3. Evaluation of compliance	• Establishment of a maintenance program implementation plan based on the scenario	4.4 Service Procurement Method	×	○	○	
4.6. Continuous Improvement	4.6.4. Audit		4.5 Quality Management	×	×	○	
5. Country-specific Issues	4.6.5. Improvement actions		5. Performance Evaluation and Monitoring				Performance evaluation and monitoring
5.1. Australia	4.6.6. Records		5.1 Performance and Condition Monitoring	○	○	○	
5.2. New Zealand	4.7. Management review		5.2 Investigation of Asset-related Failures, Incidents, etc.	×	×	○	
5.3. United Kingdom							
5.4. United States of America							

Table 6. Cont.

IIMM (Australia)	PAS-55 (UK)	AMP (United States)	New Draft (Sustainable Infrastructure Asset Manual, SIAM)	Simple Type (A)	Standard Type (B)	Detailed Type (C)	Note
			5.3 Audit and Records	×	○	○	
			5.4 Continuous Feedback with Monitoring	○	○	○	
			6. Foreign Examples	○	○	○	AM examples of different nations
		<ul style="list-style-type: none"> Determination of program priority and selection of infrastructures subject to maintenance Establishment of long-term and long-term program implementation plan 	6.1 Australia				
			6.2 New Zealand				
			6.3 United Kingdom				
			6.4 United States of America				
			6.5 Korea				
			7. Asset Management Forms and Templates	○	○	○	Forms needed for AM
			7.1 Establishment of AM Policy, Strategy and Purpose				
			7.2 Establishment of Lifecycle AM Strategy and Long-term Scenarios				
			7.3 AM Techniques				
			7.4 Performance Assessment and Monitoring				
		<ul style="list-style-type: none"> Continued feedback management through the monitoring of implementation results 	7.5 Other				
			8. References	○	○	○	References needed for AM
			8.1 IIMM				
			8.2 PAS-55				
			8.3 FHWA Manual				
			8.4 Others				

Notes: 1. Applied (○); Partially applied (△); Not applied (×); 2. Types A, B and C can be adjusted according to the conditions of each ordering authority.

This Sustainable Infrastructure Asset Manual (SIAM) comprised Chapter 1, General Information; Chapter 2, Establishment of an Asset Management Policy, Strategy and Purpose; Chapter 3, Optimal Decision-making and Long-term Scenarios of Lifecycle Asset Management; Chapter 4, Asset Management Techniques; Chapter 5, Performance Evaluation and Monitoring; Chapter 6 Foreign Examples; Chapter 7, Asset Management Forms and Templates; Chapter 8, References.

SIAM was further divided into (1) simple (A); (2) standard (B) and (3) detailed types (C) according to level of asset management. SIAM allows ordering authorities to adjust and combine different details of types A, B and C to create a new type best suited to their own characteristics.

4.3. Systematic Manual with Consideration of User Convenience

One of the major demands of supervisors of ordering authorities, found through interviews, was to develop a manual that considers user convenience. Accordingly, it is necessary to suggest a systematic manual that can integrate overview, practice, examples and references of infrastructure asset management in this study [23,24]. SIAM was prepared as a systematic and step-wise manual that offers convenience for infrastructure asset management supervisors such as asset managers, asset planners, operators, maintainers and developers. The manual has an integrated composition with a series of informational sections, including an overview of asset management, practical techniques, examples, forms, and references. This method is also used by PAS-55 of the UK. Section 4.2 (Manual with Consideration on Asset Management Maturity of Ordering Authority) above was systematized to form detailed items as a Plan, Do, Check and Act series [17]. Thus, this manual categorizes different chapters into A (Overview) → B (Practice) → C (Examples and Support) ↔ D (References) as shown in Figure 9, so that detailed items of each chapter fall into a specific system, in a step-wise order. The manual can be used to understand general requirements (A) of asset management, such as necessity, effect, process and method of using the manual, reviewing economic feasibility and applicability, with a scenario based on optimal decision-making and budget level (B), and making use of various foreign examples and forms (C) and references (D).

Therefore, this manual has four volumes including Volume 1, General Information; Volume 2, Particulars; Volume 3, Examples and Forms; Volume 4, References. Volume 1 (General Information) handles general matters introducing the necessity and effect of asset management and the method of using the manual. Volume 2 (Particulars) handles practical techniques of asset management such as asset management policies, strategies, optimal decision-making and asset management techniques with Chapters 2–4. Volume 3 (Examples and Forms) provides examples of asset management in developed foreign nations like Australia and New Zealand, as well as the forms and templates needed for asset management. Volume 4 (References) consists of references for asset management manuals such as the IIMM of Australia and PAS-55 of the UK.

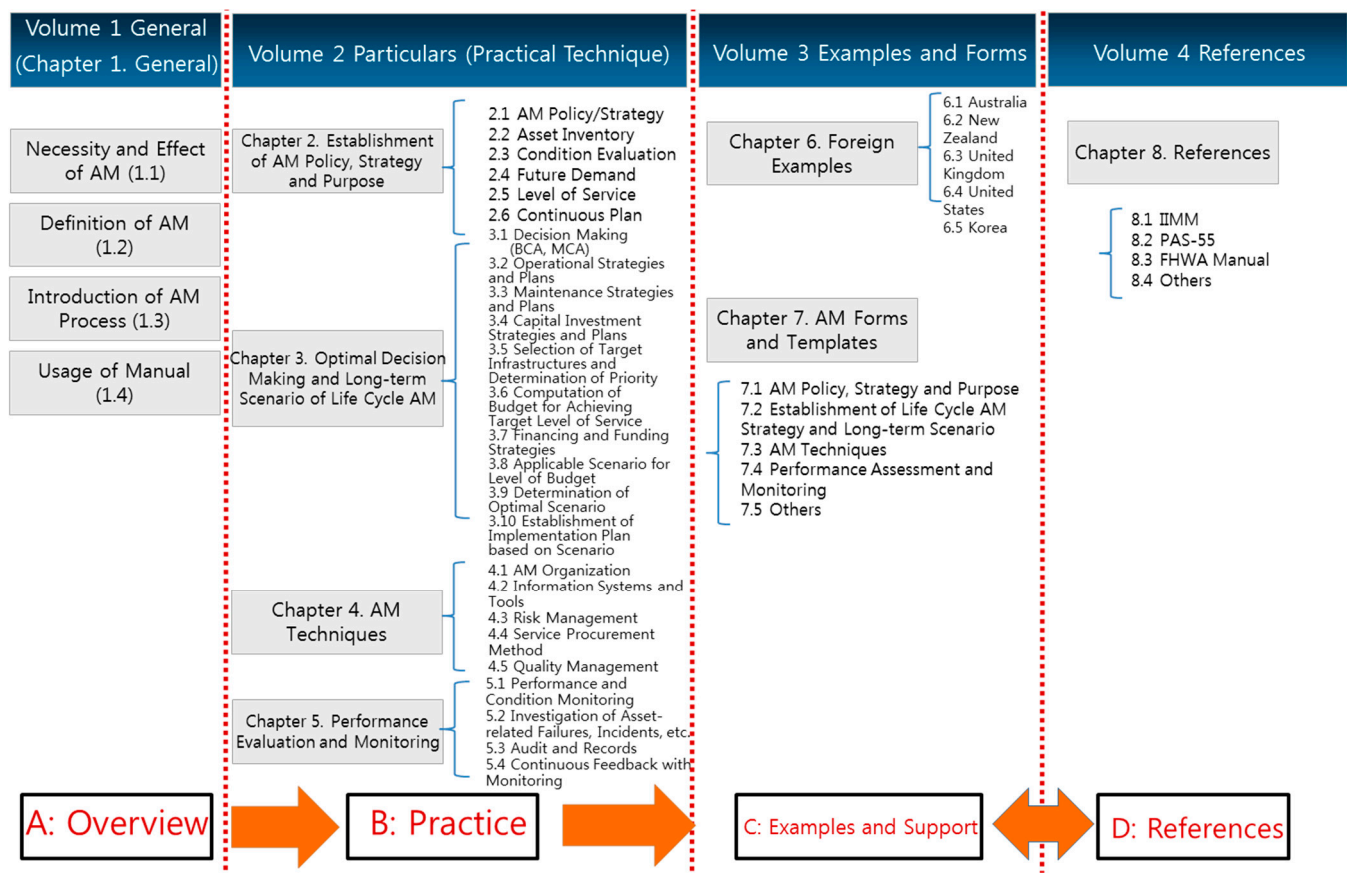


Figure 9. Composition of a systematic manual (draft) that considers user convenience.

4.4. Cyclic Process in Which Infrastructure Policy Is Connected to the Decision-Making Step

Recently, in the maintenance of existing infrastructure, there was a lack of facility management policies and strategies for organizations. This was due to post-management maintenance, as well as the difficulty in measuring performance against input during the lifecycle of infrastructure, and making consistent decisions because of such insufficiency in policies and strategies [25,26].

Accordingly, this manual proposes a cyclic process that can consistently and systematically reflect and provide feedback on asset management policies, strategies and level of service of the organizations for lifecycle decision-making and long-term scenarios.

Based on the details of the cyclic process proposed in this manual, as shown in Figure 10, the process is carried out in the order of “Chapter 2, Establishment of Asset Management Policy, Strategy and Purpose”: AM Policy/Strategy (2.1), Asset Inventory (2.2), Condition Evaluation Method (2.3), Prediction of Future Demand (2.4), Level of Service (2.5) and Continuous Plan (2.6). Predictable decision-making is made possible through “Chapter 3, Optimal Decision-making and Long-term Scenarios for Lifecycle Asset Management” with Decision-making Techniques (3.1) such as Benefit-Cost Analysis (BCA) and Multi-Criteria Analysis (MCA), Operational Strategies and Plans (3.2) and Establishment of a Maintenance Program Plan based on a Scenario (3.10). AM Organization (4.1), Information Systems and Tools (4.2), Risk Management (4.3), Service Procurement Method (4.4) and Quality Management (4.5) of “Chapter 4, Asset Management Techniques” are used as the means to more efficiently support the asset management process. “Chapter 5, Performance Evaluation and Monitoring”

monitors performance against plans, failures and various records from Chapters 2–4 to reflect upon asset management processes such as asset management policy, strategy and purpose. In other words, the process of this manual operates in the order of Chapter 2, Chapter 3 and Chapter 5. Chapter 4 supports this process.

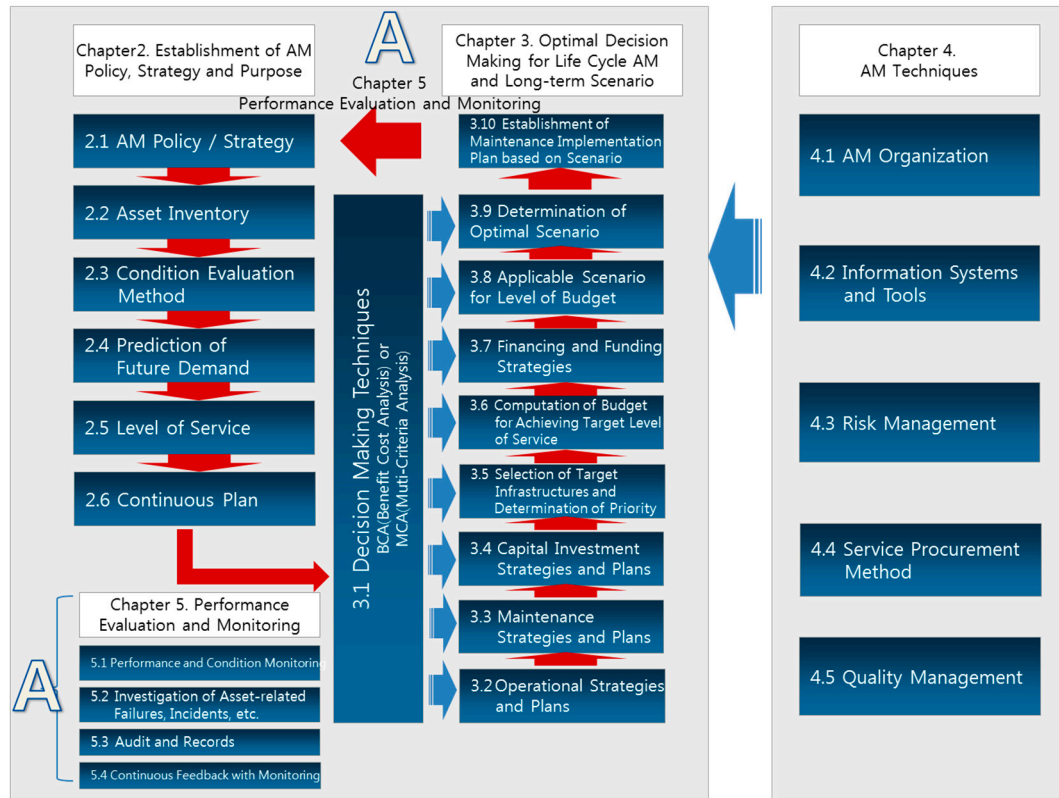


Figure 10. Composition of the infrastructure asset management manual process. (Note: The red arrow notes a major asset management process and Chapter 4 “Asset Management Techniques” refers to the system that supports this process.)

5. Conclusions

The government has recently required annual assessment and reporting of infrastructure assets to the National Assembly to measure asset management performance of public institutions and improve the transparency of government accounting. Greater emphasis has thus been placed on infrastructure asset management with preparation of a clause on responsible management performance of the ordering authorities. While ordering authorities are investing in infrastructure asset management, such as tax savings for citizens and computation of transparent and predictable maintenance expenses, there are currently no guidelines for asset management procedures and techniques. Developed nations have developed general asset management manuals with standardized processes and operation techniques for utilization by different authorities, according to their individual characteristics. Korea lacks processes and guidelines for infrastructure asset management and a general manual is needed so that ordering authorities can cope with the national demand for efficient management performance, increased deterioration of infrastructure and financial pressures.

Accordingly, in this study, a framework was suggested for the composition and utilization of a standard infrastructure asset management manual containing asset management processes and operation techniques allowing authorities to adjust it to meet their own needs. The following conclusions were reached in this study. First, justification for the implementation of asset management was examined through analysis of changes and status of asset management in domestic infrastructure, and the current status of and insufficiencies in government and ordering authority asset management manuals were inspected. Second, the current status and systems of infrastructure asset management manuals from developed foreign nations including Australia, the UK and the United States were analyzed and compared. The directivity for composition of an infrastructure asset management manual in Korea was deduced for reference. Third, based on the composition of domestic and overseas infrastructure asset management manuals, a framework for an infrastructure asset management manual that can be utilized by ordering authorities was proposed as (1) a general infrastructure asset management manual connected to global asset management manuals; (2) a manual that considers the experience of the ordering authorities in asset management; (3) a systematic manual that takes user convenience into account; and (4) a circulatory process, which links infrastructure policy and strategy with the decision-making stage.

Lastly, this study is focused on the analysis of existing manuals by comparing their structure to establish a framework. Further studies are needed to suggest a manual focused on contents. Also, the framework for the infrastructure asset management manual proposed in this study is a standard manual that can be used by various ordering authorities for asset management, but a demonstration project may also be necessary to resolve problems in operation. Further studies are needed to prepare an institutional device for efficient use of an infrastructure asset management manual and corresponding asset management techniques.

Acknowledgments

This research was supported by a grant (14CTAP-C078774) from the infrastructure and transportation technology promotion research program funded by the Ministry of Land, Infrastructure and Transport of the Korean government.

Author Contributions

Sanghoon Park and Sang-Ho Lee contributed to conception of the idea, analyzing the data and writing the article; Jong Myung Kim made a substantial contribution to the interpretation of the results. All authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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