ADVANCED LIFELINE SYSTEMS IN KOREA

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ABSTRACT

Lifeline systems such as conveying and transportation line, water and sewage line, high speed information and communication line, and energy and power supply line of mega cities are the typical civil infrastructures which are the mainstream of industry. Lifeline system is essential for economic activities and quality improvement of living standard of citizens. The safety and security of this lifeline system is a real lifeline of the mega cities as well as a nation. This paper introduces the advanced lifeline systems for the construction of safe lifeline systems for mega cities and proposes a technical road map for research and development projects.

1. INTRODUCTION

Civil infrastructures of mega cities, which consist of line type networks such as conveying and transportation network, water and sewage network, information and communication network, and electric power network, are called lifeline system. The lifeline system is a basis of social activities in a mega city and improves the quality of living standard of citizens. The lifeline system is basically a network type system for the transfer of the material resources such as human beings, products, water and sewage, information, and energy, and electric power and covers mega cities of a nation as an essential infrastructure of a nation.

For the case of South Korea, about 400km subways are in service in 6 mega cities like Seoul, Busan, Daegu, Incheon, Kwangju and Daejon and more subways are now under construction. Other lifeline systems like highway, high speed railroad, metropolitan water line and underground water line, high speed information and communication line, urban gas and electric power network are growing nationwidely. If the huge projects like Korea-Russia Energy Supply Project, Korea-Japan Deepwater Tunnel Project and North Korea Energy Supply Project are materialized, a different technical and social problems than current problems in the lifeline may occur specially on the safety and the security of lifeline system. From the experience of recent accident of last year blackout of major cities in north-east region of the North America and fire at subway station in Daegu city in South Korea, the safety and security of the lifeline system in mega cities is surely one of very important social issues.

2. PROBLEM OF PRESENT LIFELINE SYSTEM

2.1 Characteristics of lifeline disaster

One of typical characteristics of disasters in lifeline system is a close tie of a local function failure to global or overall malfunctioning of total lifeline system, for example, a partial local failure in a lifeline system may paralyze an entire city. It is also very difficult to cope with human-made accidents or natural disasters, because the lifeline systems in mega cities are mostly constructed in underground. From a fire disaster at subway in Daegu city in South Korea, it is known that the limitations to cope with the lifeline disasters in a lifeline system are very critical and the disaster themselves are closely related to not only system hardware problems but also human errors of users or operators of the system. In fact, there always exists a possibility of serious human errors. In addition to direct human casualties and property damages soon after the disasters, additional damages like inconvenience of citizens and social confusion are remaining even long after the disasters. Based on understanding of the aforementioned characteristics of the lifeline disaster, a concept for new lifeline system is under development in Korea for various types of lifelines as shown in Table 1.

Table 1: Current status of underground lifelines in Korea

System	Total Length (km)	Necessary budget (Won/year) 1200won=1US$	Related Ministries in Government and Corporation
Gas / Oil pipe line	3,501	2,143 hundred million (1.78 hundred million US$)	The Ministry of Commerce, Industry and Energy, Korea Gas Corporation, Oil Pipe Line Corporation (DOPCO)
Electric power line	17,892	7,330 hundred million (6.11 hundred million US$)	The Ministry of Commerce, Industry and Energy, Korea Electric Power Corporation (KEPCO)
Communi-cation line	126,178	1,500 hundred million (1.25 hundred million US$)	The Ministry of Information and Communication, Korea Telecom
Water supply line	3,087	4,153 hundred million (3.46 hundred million US$)	The Ministry of Environment, Korea Water Resource Corporation
Sewage line	68,194	8,078 hundred million (6.73 hundred million US$)	The Ministry of Environment, Local Urban Government, Korea Land Corporation
City subway line	569		The Ministry of Construction and Transformation, Local Urban Government, Subway Corporation

Table 2: Major lifeline disasters in cities of Korea

Date	Accident	Direct damages	Secondary damage
2003. 2.	Fire disaster of subway in Daegu city	About 200 persons died. 142 persons injured	The suspension of subway operation Raise of social conflict
2003. 1.	Bursting of water supply pipe in Yeomchang-Dong, Seoul		Interruption of water supply for 20 hours to twenty six thousands house
2001. 1.	Bursting of water supply pipe in southern part of Banpo bridge, Seoul	A spillage of 15,000 tons piped water	Interruption of water supply
2000. 2.	Fire of underground cable tunnel in Youido, Seoul		Paralysis of a network as finance-computer network for 24hours
1999. 8.	Breakage of water supply pipe in Abgujeong-Dong , Seoul		Interruption of water supply to 100 million persons for 24 hours
1998. 8.	Collapse of construction site in the No.2 subway, Busan	Paralysis of surrounding seven roads due to collapse	Block the surrounding road and expense of recovery
1997. 4.	Explosion of city gas line in Kongdok-Dong, Seoul	6 persons injured 7 billion won damage	Interruption of city gas supply
1996. 5.	Explosion of city gas line in Chunchean city	5 persons injured 130 million won damage	Interruption of city gas supply
1995. 4.	Gas explosion of construction site in the subway, Daegu	101 persons died 202 persons injured	Interruption of city gas supply Raise of huge social confusion
1994. 12.	Explosion of gas-supply site in Ahyun-Dong, Seoul	12 persons died 170 persons injured	Interruption of city gas supply Raise of huge social confusion

2.2 Major lifeline disasters in Korea

The disasters in the lifelines cover from simple failures due to busting or explosion or fire in water supply line or underground cable tunnel to huge fire or explosion in subways or city gas line and secondary property damages is getting large due to the complexity of the disasters occurred in cities(Kim, 2003). For example, the fire at underground cable tunnel at Youido, which is a major financing town of city Seoul, did not cause any

human casualties but total interruption of heating and power supply in the town as well as paralysis of communication network for stock market there due to damage in communication line was occurred. It shows seriously that those kinds of secondary damage at a local lifeline in mega cities may cause city-wide damage but also a nation-wide financial disasters. Even the disasters in the Table 2 is only based on well known accidents reported in the news media, a number of minor accidents related to the lifeline system in the cities like bursting of water supply or gas line during excavation of underground are continuously occurring, but are not even reported to citizens sometimes. Even safety manuals or maintenance manuals for the lifelines after each accident were published, an accurate information for construction or maintenance for some of existing lifelines in cities are not existed sometimes and systematic maintenance or construction with serious understanding of the lifeline disasters have not been properly conducted either.

3. CURRENT TECHNOLOGY FOR LIFELINE SYSTEM

3.1 Unites States of America

Since the USA is one of typical advanced nations on lifeline technology, the USA is selected to introduce current technology on the lifeline system. Based on nationwide understanding on the importance of the lifelines in mega cities, the USA has been conducting researches to acquire the technology on global planning and stability of lifeline and the multiple scenarios for lifeline disasters. Systematic approach on lifeline technology has been established by a committee on construction and maintenance of lifeline in the American Society of Civil Engineers (ASCE) since year 1950. Researches on efficient mitigation for possible huge damages in the lifeline due to natural disasters have been carried out since 1970. In the 1990's, major concerns on the lifeline technology has shifted to performance improvement of lifeline through efficient maintenance. For example, such researches on structural and functional characteristics of water and power supply lines due to cracks and corrosions were conducted. The researches on the lifelines were successfully concentrated by the so-called American Lifeline Alliance (ALA), which is a joint cooperation established with help of the ASCE and the Federal Emergency Management Agency (FEMA), in 1997(Taylor and VanMarcke, 2002). Any other agencies and corporations on power supply, gas supply, water supply and sewage, transportation, communication etc. do huge investment for the preparation of mitigation standard specifications against multiple disasters in the lifeline based on common upper level specifications on planning, design, construction, repair or replacement and maintenance prepared by the ALA(Beaver, 2003).

3.2 South Korea

Compared to the size of lifeline system in South Korea, investment for research and development(R&D) to the lifeline system in Korea is very small. Partial and separated research and development are being conducted independently by related ministries or corporations in Korea(Table 1) and integrated researches considering life cycle cost or unified specification are very few. Since the R&D's were conducted separately or individually, the researches on both integrated development plan and joint measures for disaster mitigation are also few. Researches on numerical techniques for the design of lifeline systems have been conducted since 1970, but outcomes of the researches are limited to partial developments of related techniques, which do not predict expected damages, possessed performance and financial impacts as well as exact causes of the disasters in lifelines. It was from middle of 1990's that the importance and the necessity of R&D for secure and safe lifeline system in Korea were understood and made researchers in the academies conduct basic researches on the verification of lifeline disasters acquiring safety of lifeline and life cycle cost of the lifeline system in Korea. However, recent major lifeline disasters in Korea as shown in Table 2 made possible for extensive researches on integrated analysis, design and construction, and maintenance and disaster mitigation for the lifeline system for next generation. Recently completed National Technology Road Map (NTRM) considers the technology on the lifeline system as an essential technology in advanced infrastructure construction technologies, which will be explained in details at next Chapter(MST, 2002). The critical research subjects on lifeline system and their technology comparison between USA and Korea is shown in Fig. 1.

4. LIFELINE SYSTEM FOR NEXT GENERATION

4.1 Necessity of a new lifeline system

For integrated research on the lifeline system as shown in the example of advanced researches on the lifeline system in the USA, it is necessary to combine all the technologies of almost all related engineering fields on the lifeline system. The research should focus on not only safety of lifeline system but also economical and social secondary effects of lifeline disasters for convenient living standards of citizens. Although continuous efforts to prevent the lifeline disasters have been made independently by each authority for the lifeline system in Korea, accidents in the lifeline systems are continuously increasing. Therefore, a new concept for the lifeline system, which combines all the information on the lifeline systems by each authority and integrates related information, is obvious. In order to meet the need for variety and complexity of the lifeline system in mega cities, a united construction of rational maintenance and mitigation systems on the lifeline system by all the authorities should by carefully made. The integration is more necessary in the stage of the research and development projects on the lifeline system for next generation.

4.2 Content of technology on lifeline system

In order to construct the lifeline system for next generation of mega cities, the R&D project on the lifeline system should be one of core R&D projects in the field of civil engineering so that it requires appropriate amount of investment from a nation or local governments of the cities. The safe lifeline system of mega cities based on the aforementioned new concept requires a unified technology on total life cycle including planning, design, construction, maintenance, and disaster mitigation of lifeline. The content of related researches for the technologies on the lifeline system should cover conventional researches in the civil engineering as well as those in the information-communication engineering field like real-time monitoring and GIS, introduction of advanced measuring technology, environmental technology, and advanced design and construction, introduction of advance materials and risk handling technology. Successful construction of the new lifeline system as outcome of the researches should be set as the objective of the R&D project on the lifeline system. Fig. 2 shows the details of technologies for the lifeline system for next generation in mega cities proposed in the national technology road map (MCT, 2002) on lifeline system in Korea.

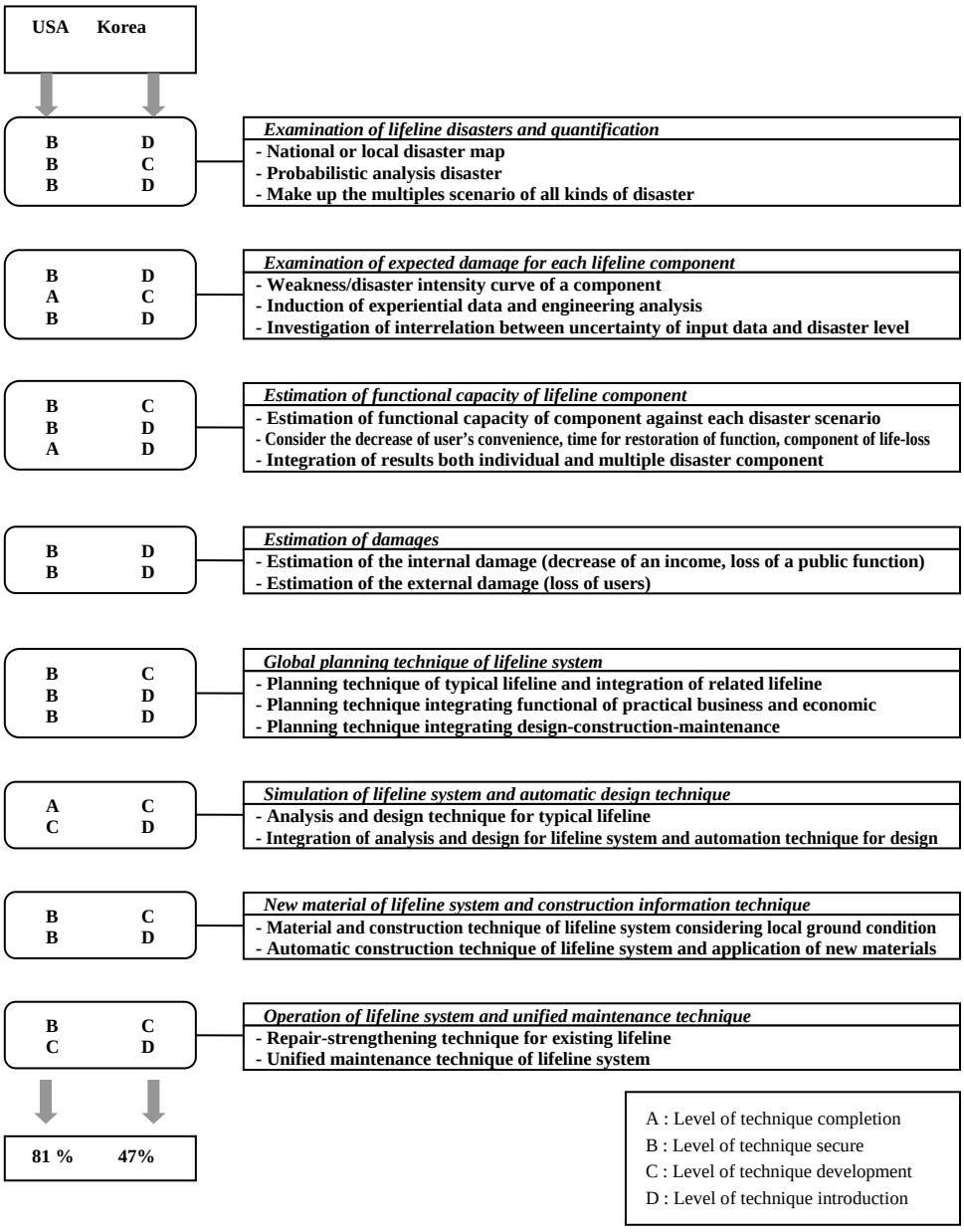

Figure 1: Comparison of lifeline technology

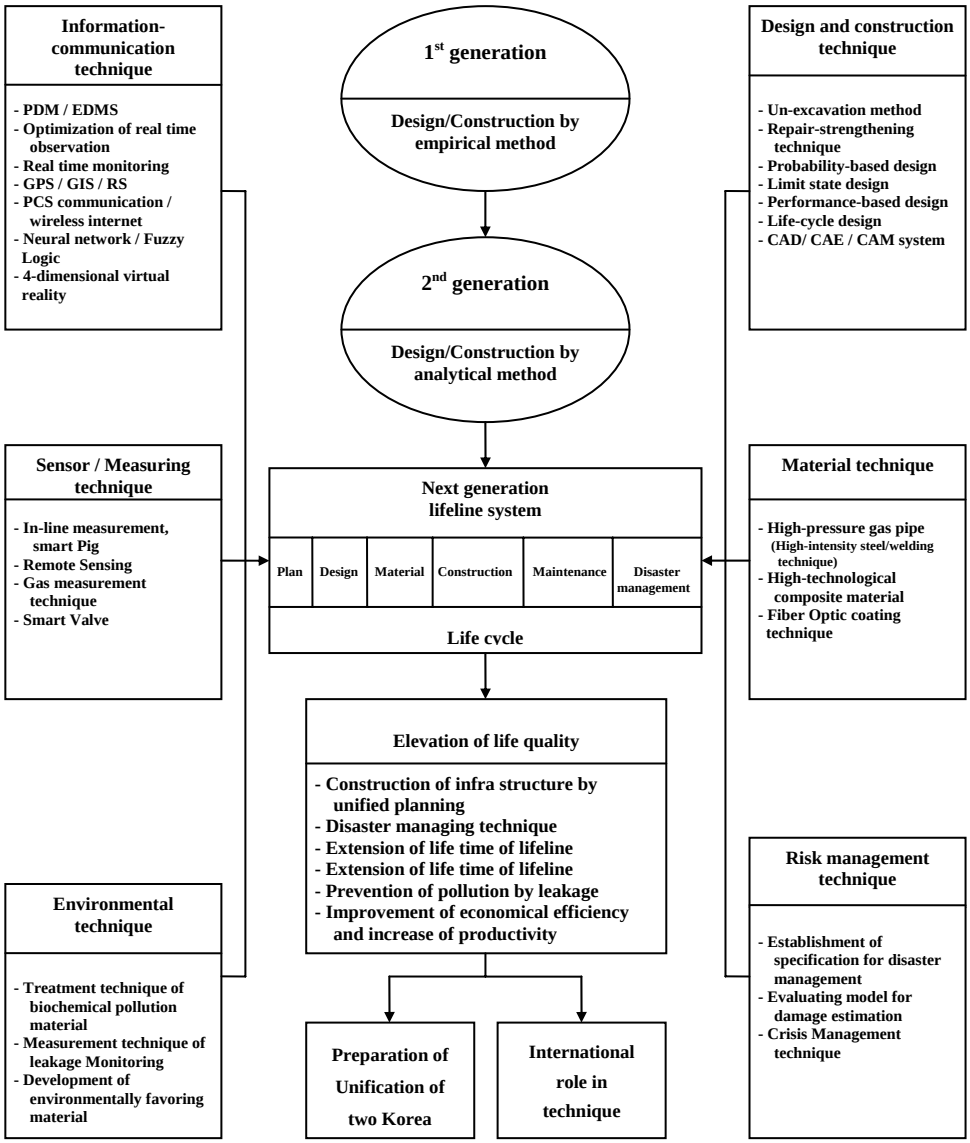

Figure 2: Road map of related research on lifeline (MST, 2002)

5. CONCLUDING REMARK

There exist many subjects to solve for the construction of safe lifeline system in mega cities. As an attempt to solve the subjects, a technology road map on lifeline system for next generation was proposed. A main concept of the road map is the integration of individual or independent developments on the lifeline system and the combination of all the related technologies from all other engineering fields including civil engineering field even in initiation stage of the research. The integration and the combination of all the technologies of other countries in the world will be useful for the successful construction of the lifeline system. We are proposing to form an Asian research consortium on the lifeline system in mega cites as the first step.

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