A RESEARCH ON EFFECTIVE FIRE/DISASTER PROTECTION OF UTILITY TUNNEL IN KOREA

Hung-joo Park*, Bong-sei Son*, Nam-yong Jee**

* Fire Safety Engineering Dept., Kyungwon College

** Architectural Engineering Dept., Hanyang University

Abstract

The pipes and cables buried below ground, which may have helped to improve city landscape, is becoming direct and indirect causes for various kinds of disaster in Korea. Every advantage from the use of utility tunnel can not be converted in a dollar since there is associated huge contribution to safe urban environment.

The Korean government has a certain role to play in helping promote utility tunnels for the past years. Most recently, many utility tunnels have been being checked to find out safety level, especially fire safety level, and main problems and shortcomings are checked out as a result of this survey.

Because the fire safety level of existing tunnel is low, possible approaches and solutions are presented according to the analysis of fire safety level. In order for these approaches to be effective, existing tunnel should be supplemented appropriately and extra equipment must be installed according to the solutions.

Hopefully, by performing both improvement of existing utility tunnel that provide a fire/disaster proof and introducing new types of tunnel which influence utility management and maintenance, the recent disaster rate in Korea can be diminished up to a desirable rate in a near future.

Introduction

To assure a safe, comfortable urban environment, as well as more efficient city management, the underground utility tunnel shall be constructed to provide common accommodations for water, gas, electricity, telephone and other types of pipes and cables which otherwise would be installed separately above and below ground. Also, this tunnel shall be accessed and passed with enough margins in order for people to maintain it (min. width, 1.8 m, and min. height 2.1 m).

As this tunnel enables to accommodate all these supply pipes, it can contribute to obviating repetitive street excavations, improving urban landscape, utilizing sub-street space effectively and enhancing urban safety. In urban improvements with lengthy development periods, the existence of the utility tunnel assures in advance that there will be sufficient apace for installing new facilities, enabling smooth installation, expansion and renewal of supply and processing facilities within the allotted time frames.

Need for systematic Introduction to utility tunnel for urban environment

Although a lot of endeavors have been placed to occupy the space for the utilities, it concludes that there is no extra space above and below ground. Many pipes and cables have been buried below ground through last two decades, but they would make city more ineffective, even dangerous because of introducing heavy accidents and traffic inconvenience under construction.

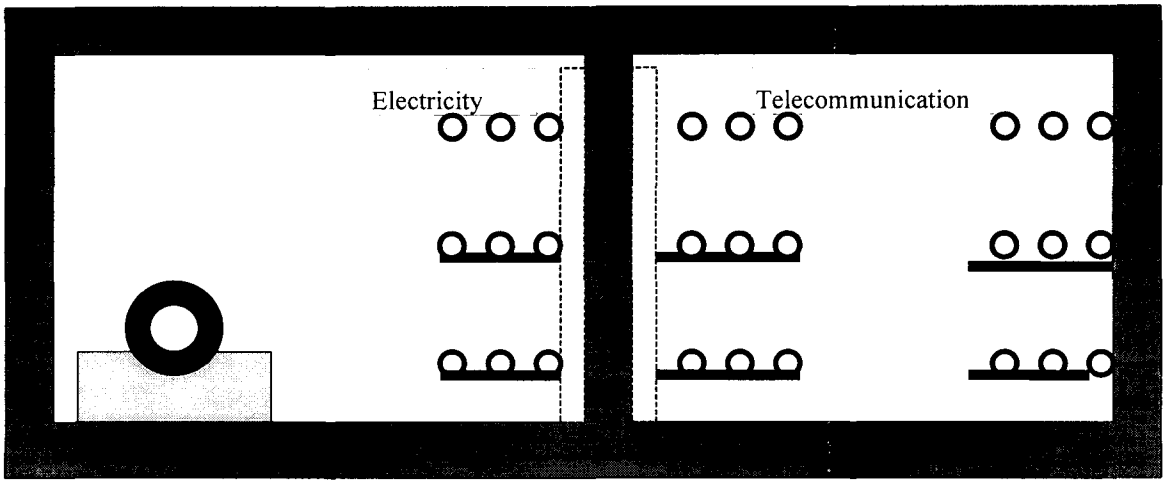

Figure 1: Cross-section of common utility tunnel in existing utility tunnels

In order to eliminate these problems ultimately, there is no way except converting utility pipes and cables to a large spaced tunnel below the road. Furthermore, the most important thing will be how well the utility tunnels will be organized in advance because of difficulties in accommodating various utilities into a space. The utilization of tunnels gives advantages and disadvantages as bellows.

- Advantages from obviation of pipes and cables above and below ground
  - ·Improvement of urban environmental condition
  - ·Elimination of traffic inconvenience under installation works
  - ·Prevention of disaster due to street excavation
  - ·Lengthening endurance life of road covers
- Advantages from effective utilization of sub-street space
  - ·Enabling sufficient space for expansion of city utilities in a feature
  - ·Enhanced management system through the integration of city utilities
- Disadvantages due to construction and maintenance work for utility tunnels
  - ·Need for early investment for construction of utility tunnels
  - ·Need for specialized managerial skill due to integrated utilities
  - ·Need for space fire/disaster proof for enclosed tunnel

All consideration should be placed to the plan and design stage in order to minimize the disadvantages in advance before the utility tunnels set up. If the disadvantages could be eliminated in advance, the ultimate solution for urban safety environment would be to convert existing underground pipes and cables to a utility tunnel. In Korea, a governmental organization has been trying to set up the location map for the buried pipes and cables for several years in order to prevent disaster resulted from misunderstanding the locations of dangerous utility pipes and cables.

Status of exiting underground utility tunnels in Korea

Since Korea introduced utility tunnels to Youido development, so many utility tunnels have been constructed in other area such as 29 locations in Seoul, 26 in Kyungki-province, 17 in Inchon, 15 in Taegu, 11 in Kwangju, 10 in Pusan, 4 in Daejun, 3 in Kyungnam, 2 in Kangwon, 2 in Kyungbuk, and 1 in Chungbuk. Most

of them are individual elelricity or telecommunication tunnels, and few tunnels accommodate 3 or 4 supply utilities.

Table 1: a status of existing utility tunnels in Korea

Location	Year of Comp.	Length of Route	Accommodated Utilities	Structure	Section
Youido, Seoul	1978.2	6.2km	●Water ●Electricity ●Telecommunication ●District heating	Cast-in-place R.Concrete Box (1 ~ 2 Continuous box culverts)	
Garak, Seoul	1983.4	7.4km	●Water ●Electricity ●Telecommunication	Cast-in-place R.Concrete Box (1 ~ 2 Continuous box culverts)	
Mockdong, Seoul	1987.12	11.8km	●Water ●Electricity ●Telecommunication ●District heating	Cast-in-place R.Concrete Box (1 ~ 4 Continuous box culverts)	
Gaepo, Seoul	1987.12	4.8km	●Water ●Electricity ●Telecommunication	Cast-in-place R.Concrete Box (1 ~ 2 Continuous box culverts)	
Pyungchon, Kyungkido	1995.12	14.3km	●Water ●Electricity ●Telecommunication	Cast-in-place R.Concrete Box (1 ~ 3 Continuous box culverts)	
Bundang Sungnam, Kyungkido	1995.12	14.7km	●Water ●Electricity ●Telecommunication	Cast-in-place R.Concrete Box (1 ~ 3 Continuous box culverts)	
Jungdong (continue) Puchon, Kyungkido	1995.6	6.8 km	●Water ●Electricity ●Telecommunication	Cast-in-place R.Concrete Box (1 ~ 3 Continuous box culverts)	
Ilsan Koyang Kyungkido	1996.7	11.3km	●Water ●Electricity ●Telecommunication	Cast-in-place R.Concrete Box (1 ~ 3 Continuous box culverts)	

Table 2: Main fire /disaster examples in utility tunnels in Korea

Locations	Time	Causes	Results & Damages
Dongdaemun, Seoul	94.3.10 16:10	●Cable ignition due to short circuit	■ Disconnection of telecommunica -tion line in long hours ■ Disconnection of bank computer lines ■ Evacuation of people in adjacent sub-commercial space
Namdaemun, Seoul	94.11.18 09:02	●Cable ignition due to short circuit	■ Damage in high performance cables ■ Traffic inconvenience in rush-hour
Pyungchon, Kyungkidd	94.12.19	●Cable ignition due to welding work	■ Damage in high performance cables ■ Damage of apartment wall
Olympic APT. Seoul	97.08.24	●Insulation cover ignition due to short circuit	■ Disconnection of water, electricity and telecommunication line in 3 days ■ Emergency evacuation of 4,000 families due to toxic gas through elevator shafts

Characteristics of the fire of utility tunnel

Generally, the fire of Geo. -spaces is different from building fire in terms of characteristics of frame and smoke transition. Furthermore, the fire of utility tunnel is not easy to be suppressed by fire fighters because of its enclosed space. Main characteristics of the fire of utility tunnel are as bellows:

- Characteristics due to bundled cables in tunnel
  - · Easy continuous flammability adjacent cables
  - · Emission of toxic gas due to fire of plastic materials
- Characteristics due to enclosed space of tunnel
  - · Mass production of CO Gas due to lack of O_2
  - · Difficulty in early detection of the ignited area due to low visibility
  - · Difficulty in fire fighting due to narrow space

Once a fire happens in the tunnel, it is impossible to suppress in early stage. There is no way to perfectly protect fire/disaster in the utility tunnel except for exchanging accommodated supply cables and insulation covers to non-combustible

materials.

Shortcomings of conventional development system for utility tunnel in Korea

Korea has been troubles in introducing and managing utility tunnels due to lack of safety provisions, and the importance of utility tunnel has been ignored during last 2 decades. The ultimate phase in the development of utility supply system as commodity is the use of its tunnel as a safe space. However, there are many shortcomings in conventional Korean development system in order for all cables and pipes to be accommodated to a tunnel.

(Development phase)
- No authority of municipal party for promoting utility tunnel in Development of new roads and towns due to no provisions
- Failure in introducing voluntary participation of suppliers due to high cost for Development of utility tunnels.

(Designing phase)
- No consideration of management & maintenance aspects in designing Structure, size, disaster equipment, etc.
- Lack of concept for co-construction with roads and city transportation Systems

(Managing & maintaining stage)
- Lack of fire/disaster protection experts in managing tunnels
- Inadequate allotment of maintenance fee to suppliers

Effective approaches to protect fire in existing utility tunnel

In order for existing utility tunnel to be safe in a future, some approaches should be appropriately developed which allow the tunnel administrators the opportunities to benchmark and enhance their safety level. The manner in which that approach's can evaluate their short-term fire/disaster proof will be by introducing the change in several systems as bellows.

■ Replacement their cables and pipe cover to non-combustible or frame retardant Materials

· Applying frame-retardant material to accommodated cables

· Replacing combustible pipe covers to non-combustible materials

■ Supplemental installation fire/disaster protecting systems (refer Figure 2)

· Installation fire compartment walls with fire door in min. distance of 500 m

· Installation of smoke screens and smoke extract fans in min. distance of 250 m

· Construction of perfect automatic detection system in whole length of tunnel

· Introduction to fire suppression system for entrance area and junction area

· Introduction to remote monitoring facility and wireless telecommunication

■ Improvement of existing management & maintenance system

·Establishment of specially organized administration for integrated management

· Reinforcement of mutual cooperation between maintenance organization and Utility suppliers

· Reposition of fire/disaster protection personnel to main control center

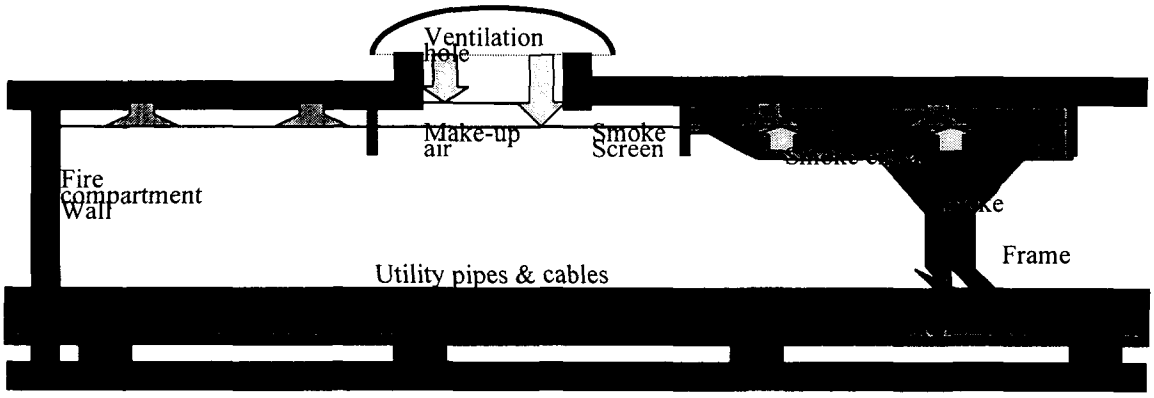

Figure 2: Example of supplemental installation fire/disaster protecting systems

Ultimate success factors

Evaluation of existing utility tunnels may strengthen their safety level, but in order for any municipal administrators to ultimately prevent disaster associated to underground utilities, the appropriate political measure should be developed which allows most of suppliers to participate voluntarily in promoting utility tunnel. In manner in which a policy evaluate the long-term solution will be attempts in several items list as bellows.

●Introduction to reasonable cost allocation for initial construction investment

·Cost sharing between municipal administration & utility suppliers

·Development of standardized regulations regarding reasonable sharing potion

●Introduction to designated roads for mandatory use of utility tunnel

· Municipal administration ruling on promoting utility tunnel

· Prohibition of buried cables and pipes below main road permanently

●Development of standard sections for utility tunnel fitting with Korea

· Development of a Korean style tunnel

· Development of easily manageable and maintainable structures

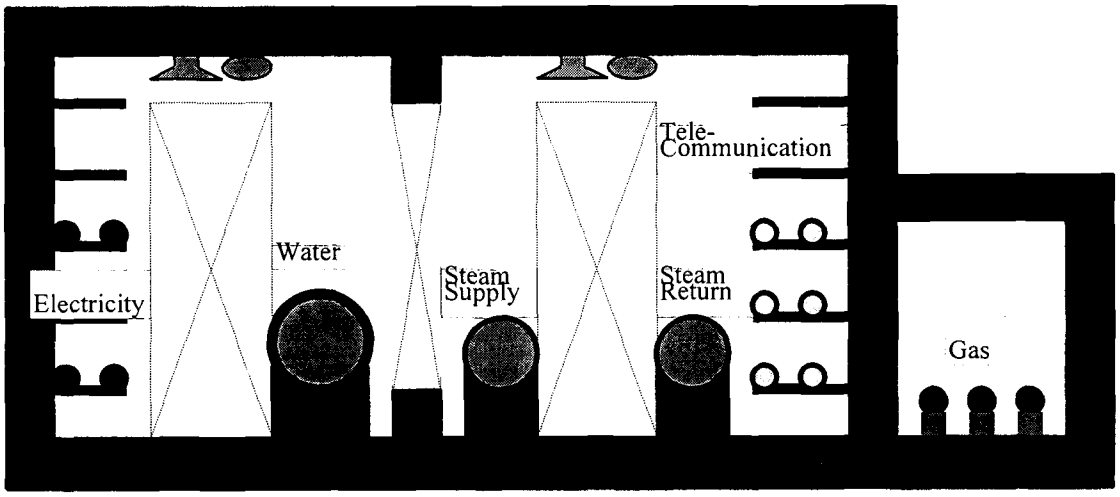

Figure 2: Example of standard section of utility tunnel module fitting w/ Korea

Conclusions

For last 2 decades, the volume of utility tunnels constructed in Korea are far less than 1/10 of volume in Japan. The difference in volume between 2 countries is derived from differences in governmental understanding the importance of utility tunnels. Therefore, Korean government should take efforts to increase the volume of utility tunnels in order to prevent disasters associated underground pipes and cables.

To achieve successful application of truly fire/disaster protected utility tunnels, they should be designed to work with managing and maintaining tasks, which will allow for effective measures into a truly controllable process. Therefore, existing

utility tunnels, which were already constructed in Korea, should be modified to a truly effective structure based on installation of fire compartment walls and smoke ventilation systems. Thus, these tunnels will be more effective to fire/disaster in terms of delaying flame spread and easy access of fire- fighters.

In conclusion, obviation of underground cables and pipes generated by utility tunnels with fire/disaster-proof ability will be a more significant contribution based on eliminated danger on excavation works in Korea. If this tunnel becomes recognized as a more fire/disaster proof, this proof will have significant impact on the development of various utility tunnels in Korea.

References

(Journal Articles)

1. Japan precast concrete utility tunnel association, Special Edition: Utility Tunnel, Journal of Civil Engineering volume 50, No.10, 1995

(Books)

2. Ronald Barham, Fire Engineering and Emergency Planning, Univ. of Central Lancashire, UK
3. Fire Fighting Research Association, Fire Fighting Strategy on Disasters of the Underground Space and Facility

(Brochures)

4. The City of Yokohama, Yokohama Mirato Mirai Utility tunnel, Road & Highway Bureau