International Journal of Internet, Broadcasting and Communication Vol.14 No.2 70-78 (2022)
http://dx.doi.org/10.7236/IJIBC.2022.14.2.70

IJIBC 22-2-11

Standardization and Method Selection for the Trenchless Repair Technology of Sewer using Cured-in-place Pipe

Taeeung Kim

Doctor, Chungcheongbuk-do Provincial Council, Korea
Kte0070@korea.kr

Abstract

The trenchless entire repair technology (TERT) have many different names depending on the companies, and they have the same or similar methods as well as materials. In addition, there was quiet difficulty in application of field working and even confuse to classify for new TERT, while application criteria of TERT is not listed systematically. This study proposed standardization and method for TERT affecting by pipe condition, working materials, working method, specification/quantity per unit according to field condition, strange affairs and others. Determination criteria of defective sewer pipe has proposed to effective method which modify a criteria between Ministry of Environment and Seoul Metropolitan City. A Cured-in-place pipe (CIPP) is suitable for TERT, and the design criteria for the entire broken pipe are proposed when the pipe itself deforms more than 10%. A check lists are specimen preparing, hardening site made by clamped mold, numbers, flexural and tensile property, water leak and desquamation test, and have to use material property of minimum CIPP value depend on ISO 11296-4, ISO 11297-4, KS M3550-7 and KS M3550-9.

Keywords: *Trenchless entire repair technology, Standardization, Cured-in-place pipe, Sewer pipe, ISO*

1. INTRODUCTION

It is difficult to change after the first burial is completed because the sewer pipe is buried underground. In addition, exacted design and maintenance are the most important because they correspond to industrial infrastructure that must be used for a long time. Since 1970, the maintenance of sewer pipe among the above pipeline has emerged, new technologies and methods have been working globally for the past half century to complete result as a concrete alternative by Kang [1] and Park [2].

The processes for trench or trenchless are used in the official repair and reinforcement method. So far, repair and reinforcement methods using trench are the main methods by Park et al. [3]. That was first introduced in Korea in 1990 early and has been contributed to the maintenance of pipelines for industrial infrastructures including oil, gas, water supply pipe and sewer pipe, especially sewer pipe. So, interest of the

Manuscript Received: March. 3, 2022 / Revised: March. 7, 2022 / Accepted: March. 11, 2022
Corresponding Author: kte0070@korea.kr
Tel: +82-43-220-5254, Fax: +82-43-220-5239
Doctor, Chungcheongbuk-do Provincial Council, Korea

trenchless entire repair technology (TERT) is increasing and intensive research is being carried out as well by Kim et al. [4]. The sewer pipe is affected to contaminate soil and groundwater due to bad joints, pipe breakage by John [5], and to occur bad odor, pipe corrosion due to sewer leakage by Bontus et al. [6], and to pollute water quality due to bad collection pipeline in sewer system by Go [7]. The sewer pipe is responsible for the maintenance of trench/trenchless on repair by David [8], Melisa [9], Mohammad [10].

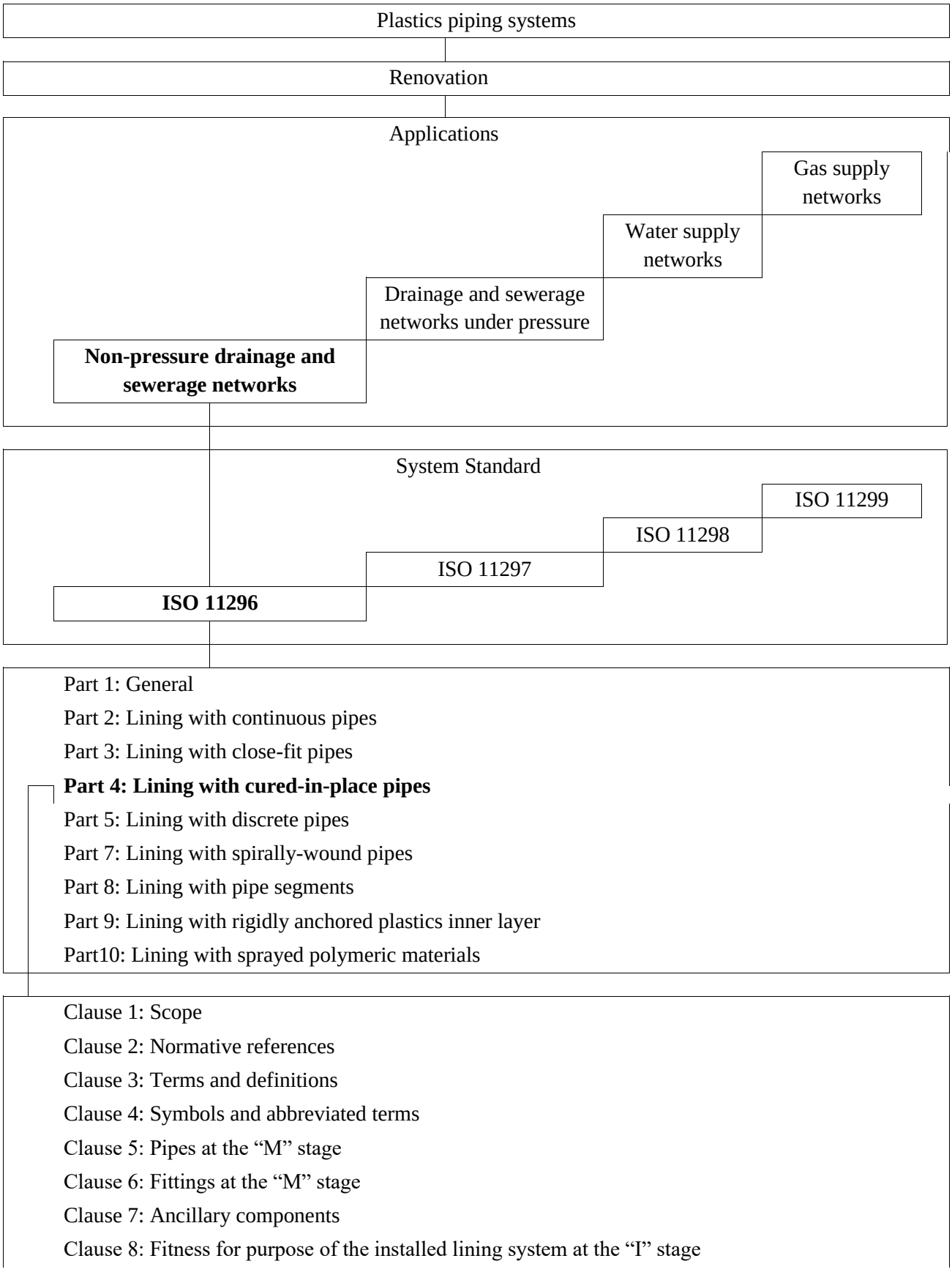
The non-TERT has increased various living inconveniences and social costs due to the deterioration of urban aesthetics, traffic congestion, disturbance of underground facilities, waste generation and re-construction by Park et al. [11], Lim [12], Choi [13]. On the other hand, the TERT is a method with many advantages in terms of stability, environment, work ability, and economy. In developed countries, the TERT is implemented in consideration of the problems of the trench process. In the case of the TERT, high-tech materials and many mechanical equipment are used different to general civil engineering technologies, so they require a high level of technology and experience. Therefore, it is required to establish more specific quality control standards for the application and construction of reasonable construction methods.

This study was conducted to identify the factors affecting the repair of sewer and to supplement the fault of the existing TERT to establish itself as an alternative to the repair and reinforcement method. In particular, by investigating and analyzing domestic and foreign of related literature, research results, and international standards, which are focus on cured-in-place pipe(CIPP) of the most widely applied TERT in Korea, it was proposed as basic data for quality management and presented quality management standards suitable for domestic conditions.

2. EXPERIMENT

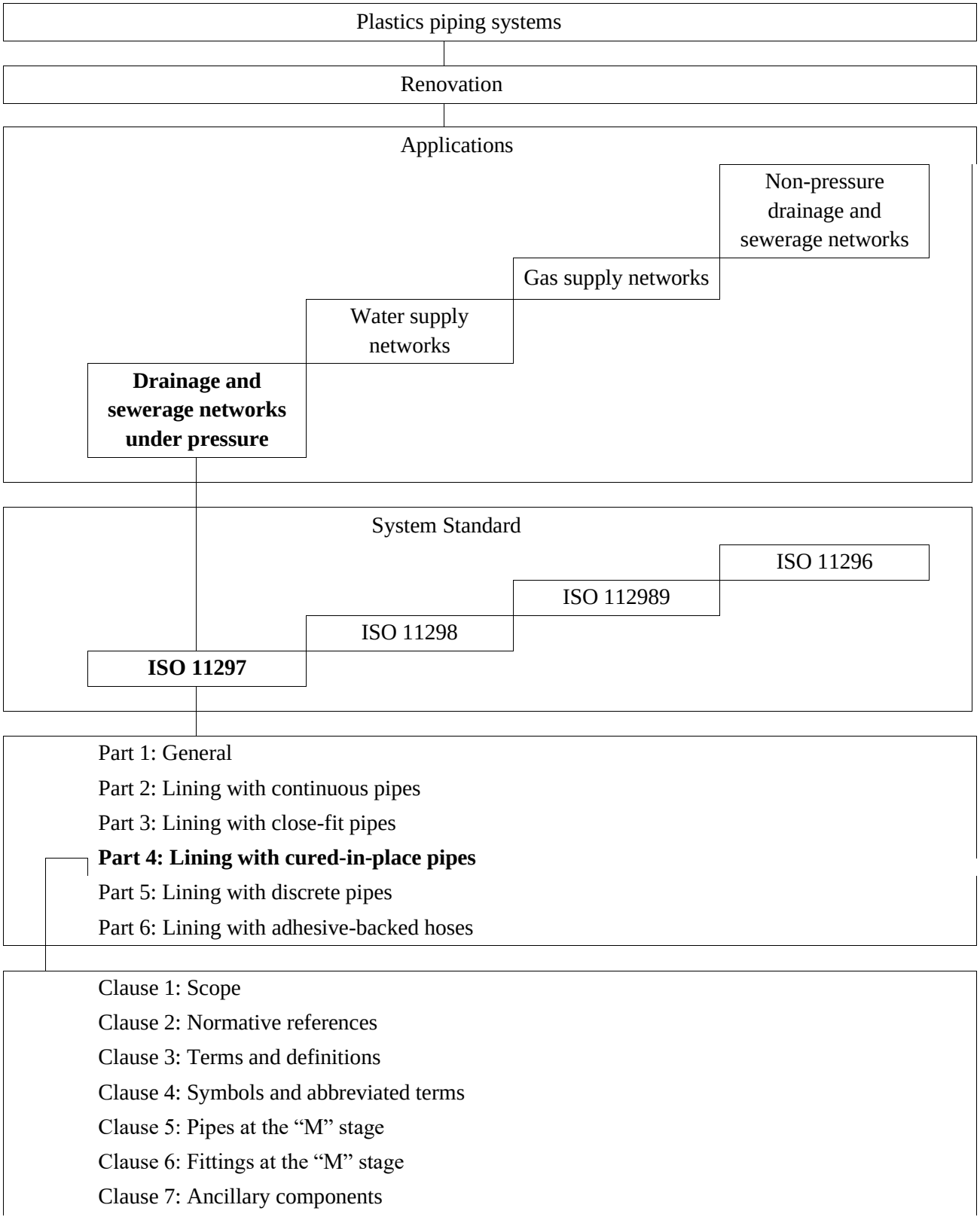
Based on international standards, the factors affecting sewerage repair were identified authorized institutions data mainly in advanced countries such as the United States, the United Kingdom, and Japan which existed on many cases of the TERT. Domestic and foreign literature, research results, and international standards on the TERT were investigated and analyzed to new technologies that were already introduced or promoted by domestic construction companies.

The advantages and disadvantages of the CIPP were compared and analyzed to the design standards of the Ministry of Environment and the Seoul Metropolitan Government as Figure 1 and Figure 2. Based on this, as a result of combining international standards and domestic design standards to the actual site, only the highest excellence was selected when applying the CIPP method to the site, and selected as standardization and method of the TERT.


Plastics piping systems
Renovation
Applications
Gas supply networks
Water supply networks
Drainage and sewerage networks under pressure
Non-pressure drainage and sewerage networks
System Standard
ISO 11299
ISO 11298
ISO 11297
ISO 11296
Part 1: General
Part 2: Lining with continuous pipes
Part 3: Lining with close-fit pipes
Part 4: Lining with cured-in-place pipes
Part 5: Lining with discrete pipes
Part 7: Lining with spirally-wound pipes
Part 8: Lining with pipe segments
Part 9: Lining with rigidly anchored plastics inner layer
Part10: Lining with sprayed polymeric materials
Clause 1: Scope
Clause 2: Normative references
Clause 3: Terms and definitions
Clause 4: Symbols and abbreviated terms
Clause 5: Pipes at the “M” stage
Clause 6: Fittings at the “M” stage
Clause 7: Ancillary components
Clause 8: Fitness for purpose of the installed lining system at the “I” stage

Clause 9: Installation practice

Figure 1. International standard of CIPP (ISO 11296-4:2018) [14]



Clause 8: Fitness for purpose of the installed lining system at the “I” stage

Clause 9: Installation practice

Figure 2. International standard of CIPP (ISO 11297-4:2018) [15]

3. RESULTS AND DISCUSSION

3.1 CRITERIA OF BAD SEWER PIPE

In determining a sewer maintenance, it is most important to systematically judge defective items and grades of sewage pipe as objective criteria after a preliminary investigation. Therefore, it was considered that the judgment standards implemented by the Seoul Metropolitan Government were quite suitable for the field situation as shown in Table 1. The bad standards were collected to the detailed items presented by the Ministry of Environment

Table 1. Criteria of bad sewer pipe suitable for domestic situation (proposal)

Items	Bad conditions	Grade		
		A	B	C
Connected pipe	Jut out	More than 2/3 of the main inner diameter	Less than 2/3 of the main inner diameter	Slight extrusion
	Joint	Breakage	Slight breakage	-
Main pipe	Joint	More than 1/3 of dislocating	Less than 1/3 of dislocating	Slight dislocating
	Influent	Occurrence	-	-
	Effluent	Occurrence	-	-
	Corrosion	Rebar extrusion	Construction surface extrusion or peel off	Slight corrosion
	Breakage and Crack	Structural hazard conditions such as sink etc.	Crack occurrence	Slight crack
	Curved line	More than 45° of deflection	Less than 45° of deflection	-
	Sink	More than 2/3 of sink	Less than 2/3 of sink	Slight sink
	Passing through another pipe	Passed through others	-	-
	Waste oil attachment	More than 1/2 of pipe diameter	1/2~1/4 of pipe diameter	Less than 1/4 of pipe diameter
	Mortar attachment	More than 1/2 of pipe diameter	1/2~1/4 of pipe diameter	Less than 1/4 of pipe diameter
	Sediment deposition	More than 1/2 of sedimentation	Less than 1/2 of sedimentation	Slight sedimentation
	Other obstacles	More than 1/2 of pipe diameter	1/2~1/4 of pipe diameter	Less than 1/4 of pipe diameter
	Flow ability lacking	More than 50 % of flow ability or habitual flooding area	Less than 50 % of flow ability or habitual flooding area	No shortage of flow ability

A: Bad sewer pipe bring to a large impact due to the cost of restoration and the surrounding environment by the destruction of sewer pipe

B: Bad sewer pipe bring to a small impact due to the cost of restoration and the surrounding environment by the destruction of sewer pipe, but it is batter to take precaution
C: Sewer pipe that has little or no impact on the surrounding environment by degree of defectiveness

3.2 APPLICATION STANDARD ON TERT

Based on the criteria of bad sewer pipe, it is select a pipe that needs repair and reinforcement, and the n it is suitable to select an entire repair process according to bad conditions of the existing old sewer pipe as Table2 and Table 3.

Table 2. Criteria of partial breakage pipes (proposal)

Items	Weight	Life
Case of non-deformation (Corrosion, flames etc.)	Water pressure	Semi-permanent
Case of flame and crack	CIPP shares resistance to load	Semi-permanent
Case of weak pipe reflection (less than 10%)	CIPP shares resistance to all load	Semi-permanent

Table 3. Criteria of hole breakage pipes (proposal)

Item	Weight	Life
Case of strong pipe reflection (more than 10%)	- A existing pipe don't resistance to load - CIPP shares resistance to all load	Semi-permanent

3.3 DESIGN OF CIPP

Two cases were considered separately according to the damage degree of the existing pipe which CIPP was applied. First, the existing pipe is partially damaged, and second, completely damaged because the pipe function cannot be performed at all. Since underground water flows to an equal distribution load on CIPP, water pressure is just considered.

3.4 SPECIFICATION AND MEASUREMENT OF CIPP

The necessary check items are manhole, pipeline corrosion, irregular pipe condition and intrusion water generation at construction on-site, which are classified into three grades as A, B, and C, respectively. During the on-site investigation, a plan apply to the whole after partial investigation and another plan apply to a full investigation after dredging should be reviewed, which is considered reasonable to be decided according to the on-site situation.

Table 4. Check list for construction on-site investigation (proposal)

Items	Grade		
	A	B	C
Manhole condition	Open well and no problem on entering	Open well and problem on entering	Open difficult and requires on entering
Pipeline corrosion condition	Less than 10 % on corrosion	10 % ~ 50 % on corrosion	More than 50 % on corrosion
Irregular pipe condition	Flection of the exist pipe is less than 10 ^{o}	Flection of the exist pipe is more than 10 ^{o} and less than two sections	Flection of the exist pipe is more than 10 ^{o} and more than two sections
Infiltration sewer generation	Nothing	Appearance of infiltration sewer	Overflow of infiltration sewer
Pipe bottom depth (b)	Less than 2.5 m	Less than 2.5 ~ 4 m	More than 4 m
sewer influent flow rate (sub-pipe number)	5 sites	5 ~ 10 sites	More than 10 sites

3.5 INSPECTION STANDARD AND ON-SITE SPECIFICATION OF CIPP

The inspection standard of CIPP shall include specimen preparation, and specimen hardening location, specimen count, short-term bending properties, short-term tensile properties, leak test, peel test of specimens made of clamped mold. In the case of specimen preparation, inspection standards are not applied in accordance with ASTM F1216 [16], KS M 3006 is applied separately in the case of short-term tensile properties. In the case of leakage tests, it is applied to decision of the supervisor in domestic, but needs of ordering body in foreign countries. In addition, it is proposed that the minimum value of CIPP requirement properties be implemented based on ISO 11296-4, ISO 11297-4, and KS M 3550-7, and KS M 3550-9 standards [17], [18], [19], [20], respectively.

3.6 STANDARDIZATION AND METHOD OF CIPP

Standardization shall be carried out at each stage of the process, including the introduction of the construction method and the pre-examination system, bidding restriction of construction company, giving priority to domestic production, qualifying by supervisor long-term tests and peel tests. Regarding trenchless process of the domestic sewage pipe, each quality control status and alternatives are presented by classifying companies according to functions from material production stage to post-construction test analysis.

4. CONCLUSION

Standardization and method for TERT proposed according to field condition, strange affairs and others were as followed.

1. Determination criteria of bad sewage pipe has proposed to effective method which modify a criteria between Ministry of Environment and Seoul Metropolitan City.

① It is practical to enhance the grade of connecting pipe joints from grades B and C to grades A and B for

repair and reinforcement and safety accidents.

② I/I and effluent were upgraded from grades B and C to grade A because it need to be repaired and reinforced based on the occurrence or not.

③ The curved line was lowered from 10° higher to 45° higher due to durability of the pipe material and technological development, but the grade is raised from grades B and C to grades A and B.

④ Waste oil, mortar and other obstacles were subdivided into more than half of the pipe diameter for grade A, 1/2 to 1/4 for grade B and less than one quarter for grade C, as there were no previous detailed evaluation criteria.

2. The CIPP is suitable for TERT, and the design criteria for the entire broken pipe are proposed when the pipe itself deforms more than 10%.

3. A check lists are specimen preparing, hardening site made by clamped mold, numbers, flexural and tensile property, water leak and desquamation test, and have to use material property of minimum CIPP value depend on ISO 11296-4, ISO 11297-4, KS M3550-7 and KS M3550-9.

4. The material requirements of CIPP should be a chemically resistant and tube intensity. A chemically resistant test should be exposed for a month depend on ASTM D 543, and tensile and elastic constant should be decreased about 20%.

5. It is proposed that policies should be implemented to operate pre-qualification system for each company's own specifications, and to grant priority construction rights for re-evaluation of technological development performance and technology development on standardization of process application and technology development.

6. Standardization of construction company need to restrict bid on securing manpower and possession of equipment, and to expand the amount of orders considered professionalism and smallness.

7. Standardization of material production company need continuous modification of criteria and guideline which are required to identify material properties and tubes such as felt, film, coating, to give priority to the domestic material producer.

8. Standardization of monitoring company are desirable for incubation of technical skills and operation of the qualification system using education and training by regular training practice including construction company and trench work.

9. Standardization of test certified company should be included qualification test which evaluate to CIPP's long-term character, and peel test as conditional test. The current system for sampling methods and test conditions should be divide into sampling point, sample size, and test conditions to ensure proper evaluation after construction work. There need to modify sample representation, flexural and tensile testing, and specimen temperature test.

References

[1] J.H. Kang, “Remediation Effect of Non-Excavation Repair Methods”, M.D. Thesis, *Chosun University*, Korea, December 2012.

[2] S.B. Park, “Development of Trenchless Replacement Technology based on Location and Leakage Detection of Water Pipeline”, Ph.D. Thesis, *University of Seoul*, Korea, February 2019.

[3] C. Adam, B. Peplinski, M. Michaelis, G. Kley and F.G. Simon, “Thermochemical treatment of sewage sludge ashes for phosphorus recovery”, *Waste Management, vol. 29*, pp. 1122-1128, March 2009. DOI: https://doi.org/10.1016/j.wasman.2008.09.011

[4] D. Huguenot, E. Mousset, E.D. van Hullebusch and M.A. Oturan, “Combination of surfactant enhanced soil washing

and electro-Fenton process for the treatment of soils contaminated by petroleum hydrocarbons", *Journal of Environmental Management, vol. 153*, pp. 40-47. April 2015.
DOI: https://doi.org/10.1016/j.jenvman.2015.01.037

[5] J.H. Park, S.R. Jeon and K.H. Lee, "Characterization of Repairing PVC profile for Trenchless Sewer Pipeline", *Journal of the Korea Academia-Industrial Cooperation Society, vol. 16, no. 7*, pp. 4977-4983, July 2015.
DOI: https://doi.org/10.5762/KAIS.2015.16.7.4977

[6] H.T. Kim, J.Y. Ryu, K.Y. Jung and D.U. Seo, "Comparative Study on the Subsurface Drainage Performance by the Type of Non-Excavation Subsurface Drainage Culvert", *The Korean Society of Agricultural Engineers*, *vol. 60*, pp. 73-81, September. 2018.
DOI: https://doi.org/10.5389/KASE.2018.60.6.073

[7] G. John, "New Approach to Design of Circular Liner Pipe to Resist External Hydrostatic Pressure Advances in Pipeline Engineering & Construction", *American Society of Civil Engineers, vol.2, no. 3*, pp. 52-62, September 2001.
DOI: https://doi.org/10.1016/j.tws.2014.09.001

[8] G. Bontus, M. Brandl, K. Oxner and J. Gumbel, "Trenchless Rehabilitation Options for Potable Water Systems-The Wave of the Future, Technological Development to Practical Application", *57th Annual Conference of the Western Canada Water and Wastewater Association*, March 2005.
DOI: https://doi.org/10.2478/v10267-012-0008-3

[9] C.Y. Go, "Evaluation of Propriety on Trenchless Pipeline Rehabilitation", M.D. Thesis, February 2012.

[10] H. David, "Risk Mitigation of Large Diameter Cured-In-Place-Pipe Rehabilitation Work Utilizing Fiber-Reinforced Composite Sandwich Technology, North American Society for Trenchless Technology", *2007 No-Dig Conference & Exhibition*, July 2007.

[9] A. Melisa, "Green Application in the Sanitary and Storm Sewer Rehabilitation Industry, North American Society for Trenchless Technology", *2008 No-Dig Conference & Exhibition*, July 2008.

[10] N. Mohammad, W. Roger and B. Rick, "Hydraulic Analysis of a Corrugated Metal Pipe (CMP) CIPP-Lined Culvert, North American Society for Trenchless Technology", *2008 No-Dig Conference & Exhibition*, July 2008.

[11] J.H. Park, J.H. Jeon, S.B. Park and K.S. Lee, "Development of Trenchless Replacement Method of the Local Water Supply System", *Korea Water and Wastewater Works Association, Vol.12*, December 2018.
DOI: https://doi.org/10.3389/frwa.2021.648622

[12] C.K. Lim, "Trenchless Sewer Repair Technology using Heat and Steam Pressure", M.D. Thesis, *Kyungpook National University*, Korea, February 2015.

[13] M.H. Choi, "A Study on the Domestic Introduction Situation and Construction on Field Applicability of the Unexcavation Repair Techniques in Water Supply Pipe", M.D. Thesis, *Incheon National University*, Korea, August 2014.

[14] ISO 11296-4, "Method of Test for the Determination of the Effects of Immersion in Liquid Chemicals", 2018.

[15] ISO 11297-4, "Method of Test for the Determination of the Effects of Immersion in Liquid Chemicals", 2018.

[16] ASTM D903-98, "Standard Test Method for Peel or Stripping Strength of Adhesive Bonds", 2017.

[17] ASTM D3839-14, "Standard Guide for Underground Installation of Fiberglass Glass-Fiber Reinforced Thermosetting-Resin Pipe", 2019.

[18] ASTM F1216-16, "Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube", 2019.

[19] ASTM F1743-17, "Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)", 2019.

[20] AWWA Manual M28, "M28 Rehabilitation of Water Mains, 3rd Ed.", *American Water Works Association*, Denver, 2014.