Journal of Materials, Processing and Design (2023)
Clausius Scientific Press, Canada

DOI: 10.23977/jmpd.2023.070402
ISSN 2516-0923 Vol. 7 Num. 4

Construction Method and Application to Support In-Situ Curing Repair of Underground Pipeline

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Keywords: Water glass, cement base, pipeline repair

Abstract: This paper introduces the definition, classification and advantages of in-situ curing technology, and the construction technology and flow of in-situ curing technology of cement-water glass grouting.Through practical application cases, the important role of this technology in underground pipeline repair is demonstrated.The research direction and significance of cement based mortar materials used in the repair of low-temperature trenchless pipelines are also proposed.

1. Introduction

With the acceleration of urbanization, the number and scale of underground pipelines continue to increase, and the demand for pipeline repair also increases.Pipeline aging, aging phenomenon is serious, need to be repaired or replaced.With the development of construction technology, especially the development of minimally invasive repair technology, underground pipeline repair has become more simple, efficient and environmentally friendly.The government attaches great importance to the underground pipeline repair industry and has introduced a series of policies and regulations to promote the development of the underground pipeline repair industry.

With the improvement of environmental protection awareness, people pay more and more attention to the environmental pollution problem in the process of underground pipeline repair, and green and environmental protection restoration technology is welcomed.In summary, the background of underground pipeline restoration is the joint effect of many factors such as the acceleration of urbanization, pipeline aging, the development of construction technology, the support of policies and regulations, and the improvement of environmental protection awareness.These factors have promoted the development of the underground pipeline repair industry and provided a broad market and prospect for the research and application of repair technology.

In short, the purpose and significance of the research on in-situ curing of the pipeline is to provide more advanced, economical and environmentally friendly repair technology for the pipeline repair industry in China, improve the quality and efficiency of pipeline repair, and promote the development of repair technology.

2. Definition and classification of in-situ curing repair technology

In-situ curing repair technology refers to a technology that can be cured inside or outside the

pipeline without removing the pipeline.This technology is mainly through the injection of special curing materials, so that the defects of the pipeline can be repaired.According to the different repair materials and processes, conventional in-situ curing repair technology can be divided into the following categories.

2.1. Ceramic coating repair technology

The ceramic coating repair technology is to coat the inner wall of the pipeline with special ceramic materials and solidified it through a specific process to form a layer of ceramic coating with high hardness, wear resistance and corrosion resistance, so as to repair the pipeline [3].

2.2. Electromagnetic wave curing repair technology

Electromagnetic wave curing repair technology is to use electromagnetic wave energy to cure the repair material quickly, so as to realize the repair of the pipeline.This technology has the advantages of fast repair speed and small damage to the pipeline.Other repair technologies: In addition to the above common in-situ curing repair technologies, there are some other repair technologies, such as cement mortar repair, polymer cement repair, etc. [5].

2.3. Cement-based composite pipeline repair technology

This is a method commonly used in the repair of underground pipes, which is reinforced and repaired by injecting cement-based composite material into the inside of the pipe.Cement-based composite materials are usually composed of cement, sand, gravel and other raw materials, which can effectively improve the strength and sealing performance of pipelines, but conventional cement-based composite materials also have many defects, such as: large shrinkage rate, low compressive strength, poor corrosion resistance and other defects.In view of similar defects, we have conducted in-depth research on the water glass and cement grouting technology [6].

3. Overview of in-situ curing technology of cement-water glass double-liquid grouting:

3.1 Cement-water glass two-liquid grouting in situ curing technology

This is a method of repairing the pipe by mixing cement and water glass into the defective part of the pipe and curing the material through a chemical reaction.The technology has the advantages of simple operation, low cost and little damage to the pipeline.The procedure is as follows: Preparations: Check the pipe to determine the location and size of the defect.The cement and water glass according to a certain proportion of mixture, stir evenly, so that it fully dissolved.

3.1.1 Grouting

The mixed cement-water glass slurry is injected into the defect of the pipeline through the grouting equipment.The slurry will automatically penetrate into the cracks, pores and other defects of the pipeline and fill the voids.

3.1.2 Curing

Cement - The cement in the water glass grout reacts chemically with the water glass to form a silicate gel that solidifies the grout.During the curing process, the slurry will gradually lose its fluidity and be closely combined with the pipeline to improve the strength and sealing performance

of the pipeline.

3.1.3 Post-processing

After curing, the staff checked the pipeline to confirm the repair effect.If necessary, post-treatment such as sealing and anti-corrosion can be carried out to improve the service life of the pipeline.Cement-water glass two-liquid grouting in situ solidification technology is suitable for small and medium diameter pipeline repair, especially suitable for transporting domestic sewage, industrial wastewater, gas and other media pipelines.This technology can not only repair the pipeline, but also prevent further damage to the pipeline and improve the service life of the pipeline [2].

4. Construction technology and process

4.1 Preparations

Inspect pipes or foundations, determine the location and scope of repair or reinforcement, prepare water glass, cement, sand, water and other raw materials, and ensure that the quality meets the requirements.Build construction platform to ensure construction safety.

4.2 Matching Settings

According to the engineering requirements, design the mixing ratio of water glass and cement.In general, the proportion of water glass and cement is 1:3~1:5, and the specific proportion should be adjusted according to the actual situation.When mixing, first mix water glass and water in a certain proportion, stir evenly, then add cement and sand, continue to stir evenly, so that water glass and cement are fully mixed [1].

4.3 Fixed excavation

Mechanized trenchless pipeline in situ breaking and updating is a technology which can break and renew pipelines in situ without excavating pipelines.This technology uses specialized equipment to operate inside or outside the pipeline, through crushing, cleaning, extrusion and other methods, so that the pipeline defects are repaired or updated.The mechanized non-trenchable pipeline in-situ breaking and updating method has the advantages of simple construction, short cycle, low cost and small impact on the environment.According to the different construction methods and equipment, the in-situ breaking and updating construction method of mechanized trenchless pipelines can be divided into the following types.

4.3.1 Blasting method

Blasting method is the use of explosives and other blasting materials to break the pipeline, and then through the suction or conveying equipment to clean out the broken pipeline debris.This method is suitable for hard pipeline materials, such as concrete, cast iron, etc.Drilling and breaking method: Drilling and breaking method is to use a drill to drill inside or outside the pipeline, and then use a hammer drill, hammer drill and other tools to break the pipeline.This method is suitable for softer pipe materials, such as plastic, glass fiber reinforced plastic, etc. [4]

4.3.2 Extrusion break method

Extrusion breaking method is the use of special extrusion equipment, extrusion inside or outside

the pipeline, so that the pipeline has plastic deformation, thereby breaking.This method is suitable for various types of pipeline materials [3].

4.3.3 Laser breaking

Laser breaking method is the use of laser beam to heat the pipeline, so that the pipeline material melting, evaporation or expansion, thus broken.This method is suitable for high precision and high demand pipeline renewal projects.Other breaking methods: In addition to the above common mechanized trenchless pipeline in-situ breaking and updating method, there are some other breaking methods, such as electromagnetic breaking method, hydraulic breaking method, etc.In short, the mechanized non-trenchable pipeline in situ breaking and updating method is a method to repair and renew without excavating the pipeline, which has the advantages of simple construction, short cycle and low cost.According to different construction methods and equipment, the construction method can be divided into various types, providing technical support for different types of pipeline repair and renewal [1].

4.4 Pouring construction

Pour the mixed water glass and cement slurry into the pipe or inside the foundation, and pour to the design height.In the pouring process, it should be ensured that the slurry is fully filled with cracks, voids and other defects of the pipeline or foundation to ensure the repair effect.After the pouring is completed, the pouring part is maintained and kept moist to facilitate the solidification of the material.

4.5 Curing and curing

When water glass and cement are mixed, a chemical reaction occurs to form a silicate gel that solidifies the slurry.During the curing process, the slurry gradually loses its fluidity and is tightly bound to the pipe or foundation to improve its strength and sealing performance.

After we complete the maintenance, we check the pipe to confirm the repair or reinforcement effect. If necessary, we need to carry out post-treatment such as sealing, corrosion protection, etc., to improve the service life of the pipe or foundation.

5. Technical design points and quality control points

According to the requirements of the project, the mixing ratio of water glass and cement is reasonably selected to ensure the repair or reinforcement effect.

During the construction process, the pouring speed and pressure should be strictly controlled to avoid secondary damage to the pipeline or foundation.We can fully conserve the pouring part to ensure complete curing of the material.We can also choose the appropriate curing agent and accelerator according to the actual situation to improve the curing effect.

In short, the construction process and technical design of water glass and cement mixed pouring is an effective method for underground pipeline repair and foundation reinforcement.Through reasonable proportioning design, pouring construction and curing treatment, the performance of pipeline and foundation can be improved and its service life can be extended.

6. Application cases

On April 6, 2023, the Hengli Operation and Maintenance Group of the fifth branch company of the pipe network found that a large area of subsidence occurred around well chamber 23-1#, the

subsidence area was about 7.4m×9.5m, the deepest depth was about 20cm, and the subsidence position was about 3.3m away from well chamber 23-1#.There are serious safety risks, after the first time to report the town street, our company carried out an emergency shelter to ensure the safety of vehicles.

According to the inspection video, a total of 3 Wells were found to be leaking as shown in Figure 1 (all in well 23-1#), among which the most serious leak was located at the junction between well chamber and pipeline as shown in Figure 2 (Level 3) at 23-1#. The leakage caused soil and water loss around the inspection well, resulting in loose soil mass and large area of road cavity collapse.In view of the above defects, the corresponding repair measures should be taken to ensure that the current sewage pipe can restore its normal function.

6.1 Defect condition

Figure 1: Leakage at the interface of the riding well and the main pipe and leakage at the pipe top inside the well

Figure 2: Leakage of the bottom pipe inside the well

6.2 Construction Scheme

The upper and lower pipe diameter is blocked, grouting is carried out inside the horse shaft and outside the pipe, and grouting along the outer ring of the caisson shaft is carried out to strengthen the outside wall structure of the shaft.The cement-based material spraying method was used to repair the leakage in the inspection well.Excavation and grouting are used to repair the sunken pavement on site.

6.3 Plugging Measures

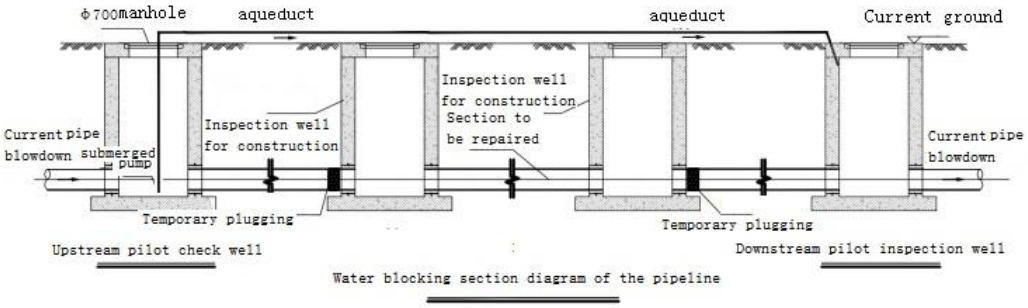

Figure 3: Water blocking section diagram of the pipeline

6.4 Main process

Well chamber No. 23-1 of Line H was repaired by soil grouting reinforcement and cement-based material spraying.Local settlement of road, pavement breaking, ground grouting solidified well chamber structure.Cement, water glass double liquid grouting, cement - water glass double liquid grouting process after the application of cement slurry adding water glass rapidly loses fluidity and becomes the characteristics of solidified body, quickly fill the gap in the stone layer, forming a relative waterproof layer, so as to achieve the purpose of anti-seepage and plugging.Compared with the non-plastic concrete cutoff wall, the process saves the trouging process and adopts the one-time perforating process from top to bottom, which makes the drilling and grouting work in parallel and saves the construction time.

6.5 Slurry preparation

Cement-water glass double-liquid grouting materials should be measured according to the proportion of slurry, and cement and other solid phase materials should be measured by mass (weight) weighing method, the allowable deviation should be ±5%;Water and additives can be measured by volume and the allowable deviation should be ±1%.

The cement slurry should be mixed evenly, the mixing time should not be less than 3min, and the density of cement slurry should be measured.

When the cement slurry is prepared centrally, it is advisable to prepare a cement slurry with a water-cement ratio of 0.5. The flow rate of the pipeline conveying the cement slurry is recommended to be 1.4m/s ~ 2.0m/s.Before grouting, the water-cement ratio of the centrally prepared cement slurry should be adjusted according to the design ratio of cement-water glass double-liquid grouting slurry.

Water glass should be diluted with water to 20 °Be ~ 35 °Be before use, and should ensure that the mixing is uniform.

Cement-water glass double liquid grouting grout should be filtered before use.The preparation time of the slurry to be used up should not exceed its initial setting time, and should not be greater than 2h.

The cement and water glass double-liquid grouting slurry should be kept between 5℃ and 40℃; When the cement-water glass double-liquid grouting slurry is prepared by mixing with hot water, the temperature of the mixing water shall not exceed 40℃.

6.6 Selection of construction tools

Cement - water glass double liquid grouting should be according to the grouting method and purpose, the selection of geological drilling rig and other hole forming equipment.The pulping equipment used for cement-water glass double liquid grouting should be determined according to the type of mixed slurry and the displacement of the grouting pump, and should meet the requirements of continuous and uniform mixing.Mixers are available for pulping equipment.

Cement-water glass double liquid grouting pump should be used and used, and should comply with the following provisions:

The technical performance of the grouting pump should not be adapted to the type and concentration of the grouting fluid, the rated working pressure of the grouting pump should be greater than 1.5 times the design maximum grouting pressure, and the discharge volume of the grouting pump should meet the requirements of the maximum injection rate and the adjustment of the double slurry ratio.The cement-water glass double-liquid grouting pipeline should make the slurry flow smooth, and should be able to withstand at least 2 times the design grouting pressure.Grouting pipe can use drill pipe, flower pipe, double pipe and other different forms and specifications of pipe.

Pressure gauges should be installed at the outlet of the grouting pump and the grouting hole, and the use pressure should be between 1/4 and 3/4 of the maximum nominal value of the pressure gauge.The pressure gauge should be equipped with a slurry isolation device between both paths.

The stop plug used for cement-water glass double liquid grouting should not be suitable for the grouting method, method, grouting pressure and geological conditions, should have good expansion and pressure resistance, and should be able to reliably close the grouting hole section under the maximum grouting pressure, and be easy to install and remove.The mixer for cement-water glass double liquid grouting can be set at the bottom of the hole or the hole opening.

6.7 Construction process

6.7.1 Organization of process flow

Security WeiDang - field screening - the road cutting break - measuring unreeling position -- -- -- -- -- -- -- drilling emplacement grouting project (drilling, grouting, waiting for curing - repairing pavement) diving - pipe plugging - guide drainage - tube repair - demolished block - water - surface recovery - to restore the traffic

6.7.2 Construction scheme of main process

The construction site should be levelled in advance, and the obstacles above and below ground must be clear.Then we punch holes as shown in Figure 3 and Figure 4.

Rig positioning: the main drill pipe of the rig is aligned with the hole position, and the body level and vertical shaft are measured with a level. The rig should be stable and firm.

Before drilling, the technical department of the project department issues a notice, and the supervision engineer agrees to start drilling.

Water injection test should be carried out before drilling to ensure the smooth flow of the pipeline. After drilling, water injection pressure should be gradually increased to reduce friction resistance and prevent the nozzle from being blocked.

In the process of drilling, the staff should pay attention to the formation changes at any time, and record the well depth, well collapse, slurry leakage and other conditions in detail.

Measuring hole depth: measuring the length of the drill pipe when drilling the final hole. As

shown in Figure 5.

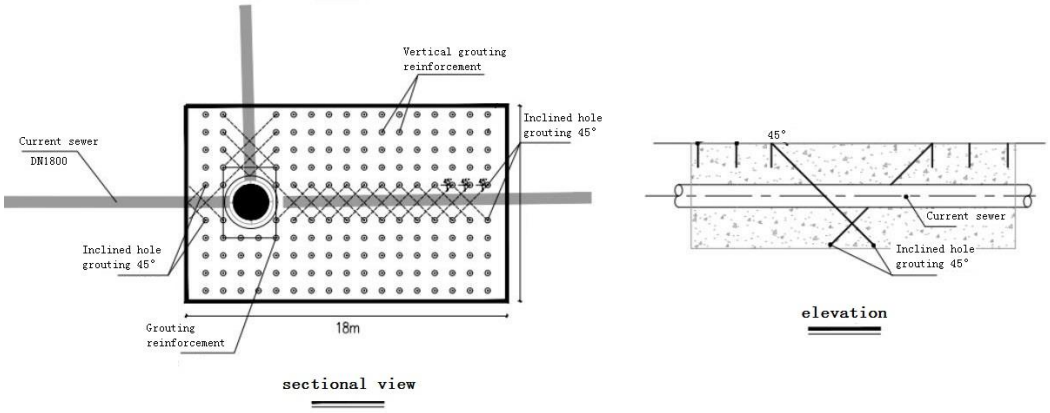

Figure 4: Schematic diagram of pavement repair by in-situ pipeline curing method

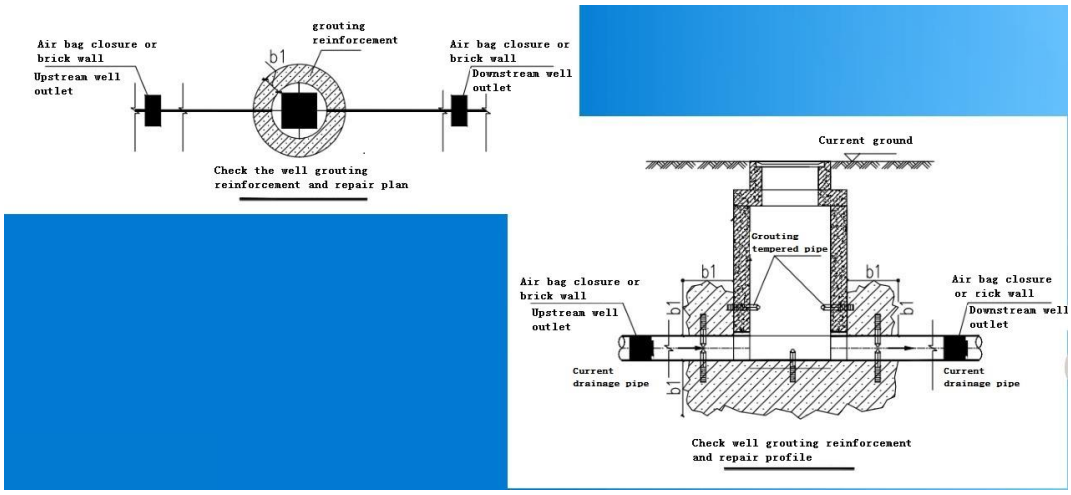

Figure 5: Schematic diagram of inspection well repair by pipeline in-situ curing method

6.8 Lower the spray tube

High pressure jet grouting can be carried out only after the drilling has passed the site acceptance. Check the following items before discharging the jet pipe.

① Measure the length of the jet tube, measure whether the center line of the nozzle is not consistent with the direction of the jet tube, and the jet tube should mark the scale.

② The staff should place the nozzle near the high-pressure pump, and pay attention to the distance between the slurry pipe and the non-high-pressure grouting pump should not be greater than 50m.

③ Before the spray pipe should be checked with high pressure water, each part of the seal ring is closed, qualified before spraying.

7. Conclusion

At present, the design of urban underground foundation is complicated, the urban traffic is very busy, and the underground space development is developing towards the depth.Under the conditions of increasing attention to urban environment and sustainable development, the traditional excavation method to build and repair and update underground pipelines has caused the phenomenon of urban road gut-breaking to occur frequently, seriously affecting urban traffic and

the life of surrounding residents.Trenchless pipeline repair technology can solve the problems of aging, corrosion, leakage, disconnection and deformation of urban pipelines, extend the service life of pipelines, and reduce the occurrence of secondary disasters.Cement mortar spray construction technology is widely used in cement pipe, steel pipe, cast iron pipe, asbestos cement pipe, clay pipe or inspection well lining trenchless construction.The cement mortar lining formed after spraying can not only repair the joints and minor leakage, but also prevent most leakage caused by the tube wall under normal working pressure.At present, the comprehensive index of ordinary mortar on the market can not meet the requirements of spraying construction of urban pipeline repair, or can meet the requirements of pipeline repair after spraying construction.The peak of underground engineering construction is usually the winter rainy period, and the ambient temperature is low in winter. Generally, cement-based materials should be constructed at an ambient temperature of 5 °C ~ 35 °C, and insulation measures should be taken below 5 °C.The adoption of thermal insulation measures put forward higher requirements for construction, and it is difficult to implement the underground works properly.Therefore, it is of great significance to develop a kind of low-temperature shotcrete mortar for the repair of trenchless pipeline.

References

[1] Zhang Zhiqiang, Wang Jin, Dong Hao. Progress in the repair technology of urban underground pipelines [J]. Journal of Southwest Jiaotong University, 2015, 50 (4): 57-65.

[2] Meng Qinghua, Li Zhuoliang, Zhao Yongbiao, etc. Overview of trenchless repair techniques of urban underground pipelines [J]. Journal of Shandong University of Science and Technology (Natural Science edition), 2015, 34 (4): 97-102.

[3] Tian Shumao, Ma Jing, Zhao Zhenhua. Research on the repair technology of underground pipes [J]. Journal of Liaoning Engineering and Technical University, 2016, 35 (2): 227-231.

[4] Wang Shengqiang, Hao Shujin, Zhao Wenbo, etc. Research on trenchless repair technology of urban underground pipelines [J]. Municipal facilities, 2016, 28 (2): 45-48.

[5] Li Zhuoliang, Meng Qinghua, Zhao Yongbiao, etc. Research on trenchless repair technology of underground pipeline [J]. Shandong Architecture, 2016, 36 (4): 177-181.

[6] Zhu Xinyu, Zhang Weidong, Zhao Yongbiao, etc. Research on the application of trenchless restoration technology of urban underground pipeline [J]. Engineering construction, 2017, 49 (2): 47-50.