Technical Key Points of Municipal Water Supply and Drainage Pipeline Construction

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Abstract: Municipal water supply and drainage pipelines are crucial infrastructure for urban operation and public health, responsible for collecting, storing, and safely discharging rainwater and sewage. Their patency directly impacts road lifespan, foundation stability, underground space safety, and residents' quality of life. With the acceleration of urban renewal and an increase in extreme rainfall events, risks such as leakage, misconnection, inadequate node capacity, and road collapse in old pipeline networks are becoming more frequent. Standardized construction, refined inspection and maintenance, and digital monitoring have become key measures to reduce urban flooding, control non-point source pollution, and enhance system resilience. Focusing on the goal of "building one line to drive a whole area," this paper outlines key points from a whole-life-cycle perspective, covering construction preparation, on-site implementation, quality inspection, completion acceptance, and operation and maintenance handover. It proposes operational technical paths such as surveying and verification, material quality control, trench excavation and support, pipeline installation and joint control, and forms a standardized, checklist-based, and closed-loop implementation plan combined with sensitive area diversion, rainwater-sewage diversion improvement, emergency drainage scheduling, and information-based ledgers, providing a reference for enhancing urban drainage safety and environmental quality.

1. Introduction

In recent years, the combination of extreme rainfall, repeated road excavations, and aging pipeline networks has led to frequent incidents of leakage, misconnection, flooding, and collapse, exposing weaknesses such as inadequate surveying, a disconnect between design and construction, lax material control, and perfunctory acceptance inspections. Especially in areas with high groundwater levels and busy traffic, any mistakes in trench stability, dewatering organization, joint sealing, and temporary drainage arrangements during construction can trigger a chain reaction of risks, increasing maintenance costs and social losses. Against this backdrop, systematically sorting out the key technical points of municipal water supply and drainage pipeline construction and clarifying control objectives and inspection standards at each stage hold both immediate urgency and long-term value. By integrating design review, material on-site inspection, trench support and installation procedures, closed-water testing, and backfilling and restoration, the overall quality of the project can be improved, traffic disruption time shortened, and environmental and resident interference minimized, providing reliable support for the safe and sustainable operation of the urban drainage system.

2. Significance of Municipal Water Supply and Drainage Pipeline Construction

2.1 Drainage pipelines are the foundation of urban development

Drainage pipelines are fundamental infrastructure for the normal operation of a city. They promptly drain rainwater during rainfall and safely transport sewage to treatment plants, preventing road surface ponding and underground leakage, and ensuring the stable use of buildings and roads. For this system to function effectively over the long term, construction must be carried out properly:

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the drawings should be carefully checked beforehand, on-site investigations conducted thoroughly, and qualified pipe materials selected; during excavation, the trench width and depth should be well controlled, with proper support and dewatering to prevent collapse and base disturbance; during installation, the elevation and slope should be strictly controlled, joints should be tightly sealed to prevent leakage, and inspection wells and ventilation devices should be installed at necessary locations; after completion, closed-water or airtight tests should be conducted, and only after passing these tests should backfilling be carried out in layers with proper compaction, followed by road surface restoration [1]. Each step is crucial for subsequent maintenance and residents' travel. Cutting corners or neglecting details can lead to unpleasant odors and ponding in mild cases and road subsidence and pipeline blockages in severe cases, resulting in high repair costs and wide-ranging impacts. Treating drainage pipelines as the "foundation" of the city for construction and maintenance is essential for supporting a safe travel environment and stable living order.

2.2 Drainage pipelines affect residents' immediate interests

Stable rainwater and sewage discharge channels are behind phenomena such as no ponding at the entrance of residential areas, no "water ponds" at intersections on rainy days, and no bad odors from kitchens and bathrooms. If pipeline construction is not up to standard, joint leakage can introduce sewage into the ground, breeding unpleasant odors and disease vectors; improper slope or insufficient turning radius can lead to sediment deposition and blockages, resulting in backflow and overflow; improper trench support or backfilling can also cause road subsidence and vehicle pitfalls, directly affecting travel safety. Conversely, strictly following the drawings during construction, verifying elevations and flow directions, using qualified materials, and conducting segmental closed-water tests before backfilling can significantly reduce the need for later emergency repairs, lower property and municipal maintenance costs, and minimize noise and traffic congestion caused by road occupancy for construction [2]. For residents, this means no water seepage in elevator shafts, no dampness in underground garages, no need to detour during the rainy season, and an odor-free community environment, increasing the value retention of houses and shops. Ensuring quality at every construction stage is not only a matter of project quality but also a direct measure to safeguard living comfort, public health, and travel safety.

3. Technical Key Points of Municipal Water Supply and Drainage Pipeline Construction

3.1 Construction Preparation Stage

3.1.1 Design Drawings

Construction preparation should first focus on reviewing design drawings. The consistency between general plans, longitudinal profiles, node details, and standard drawing sets should be verified, and pipe diameters, materials, joint types, slopes, and elevation control points should be clarified. Rainwater-sewage diversion, inlets, and discharge directions should be sorted out, and the crossing relationships and clearances with existing water supply, power, gas, communication, and other pipelines should be identified. Based on geological survey data, the stratum, groundwater level, bearing capacity, and unfavorable geological conditions should be reviewed, and design requirements for dewatering, support, and traffic diversion should be promptly proposed for areas with high groundwater levels, deep overburden, and narrow road sections. The positions of inspection wells, well bottom elevations, drops, and ventilation settings should be verified one by one, and the consistency between catchment areas and design flow rates with hydraulic calculations should be checked. For erosion-prone sections, pressure or semi-pressure flow sections, river crossings, and important road underpasses, measures such as material thickening, joint grade upgrading, and corrosion and anti-floating protection should be proposed [3]. A list of issues should be formed, and a drawing review meeting should be organized with the design, supervision, and construction units to clarify change procedures, on-site adaptation practices, and acceptance standards, providing an accurate basis for subsequent staking, procurement, and procedure arrangements.

3.1.2 Familiarization with Drawings

Familiarizing oneself with drawings is the first step in construction preparation, aiming to enable on-site personnel to clearly understand the route, elevations, slopes, and node construction methods. Technicians should compare the general plan with the longitudinal profile, mark the starting and ending points, turning points, inspection well positions, and pipe diameter changes, and verify the designed slope and well bottom elevation of each section to avoid errors during on-site staking. The directions of rainwater-sewage diversion, inlets, and final discharge should be clarified to prevent misconnection. Drawings should be reviewed together with geological survey data, with a focus on groundwater levels, soft soil layers, and old structures, and dewatering, support, and temporary diversion should be considered in advance. For road crossings, pipeline-dense areas, schools, hospitals, and other sensitive locations, construction time restrictions and finished product protection requirements should be recorded. Standard drawing set details such as joints, well chambers, bedding, and foundation construction methods should be matched one by one with specific project nodes to confirm material specifications, joint forms, and corrosion protection requirements. Questions should be compiled into a list, verified during on-site reconnaissance, and adjustment suggestions should be marked on the drawings if necessary and submitted for review and confirmation. Through this simple process of "understanding, remembering, and verifying," a solid foundation can be laid for subsequent staking, procurement, and procedure arrangements.

3.2 Inspection of Pipe Material Quality

First, verify the conformity certificates, factory inspection reports, and third-party inspection reports to confirm that pipe diameters, wall thicknesses, materials, and joint types are consistent with the drawings; randomly select samples to measure outer diameters, wall thicknesses, and ovality, and check whether markings are clear and batches are traceable. Visually inspect each pipe: the surface should be smooth without cracks, delamination, bubbles, or obvious scratches, and sockets and sealing grooves should not be chipped or deformed; rubber rings should be flexible without aging and match in size. For ductile iron pipes, pay attention to the integrity of the anti-corrosion coating and the thickness of the zinc-aluminum spray layer; for PVC, PE, and PP pipes, check the flatness of the fusion-welded ends and material uniformity; for steel pipes, verify the anti-corrosion grade and weld radiographic inspection records. If necessary, conduct drop impact, ring stiffness, or pressure sampling tests, and inspect joint accessories simultaneously. Stack pipes by specification, with timber pads off the ground, sockets staggered, and protected from sun and dirt to avoid deformation caused by sun exposure and heavy pressure. Reject unqualified or unidentified materials and form inspection ledgers and photo records to provide a basis for subsequent installation and acceptance.

3.3 Construction Stage

3.3.1 Trench Excavation and Support

Trench excavation and support should be carried out after staking and verification. First, determine the excavation width, slope, and segment length, avoiding existing pipelines and tree roots, and set up fencing and warnings. Use machinery as the main method with manual assistance, reducing bucket capacity and operating slowly near pipelines and buildings, and excavate in layers to 10–20 cm above the designed elevation before switching to manual leveling to avoid disturbing the original soil. For underground water or construction during the rainy season, arrange catch basins and drainage ditches in advance and use pumps for continuous dewatering to ensure a dry trench bottom without mud flipping. Control the slope according to soil properties or use support methods such as steel sheet piles, channel steel + wood planks, or steel supports, with support installed as excavation progresses; over-excavation and prolonged exposure are strictly prohibited; movable box culvert supports can be used in narrow road sections to ensure the safety of personnel entering the trench. If the trench bottom bearing capacity is insufficient, promptly replace it with sand and gravel or plain concrete cushions and conduct compaction sampling tests [4]. Set up walkways and access ladders, and install lighting and reflective markers at night. Re-measure the centerline and elevation daily, record displacement and settlement, and immediately reinforce and backfill if water seepage, trench edge collapse, or pipeline exposure are found, providing a stable working surface for subsequent foundation and pipeline installation.

3.3.2 Pipeline Installation

Pipeline installation should be carried out after the trench bottom has passed acceptance. First, lay the bedding and level it, and re-check the centerline and elevation before lowering the pipes. Lower the pipes in the direction of water flow from downstream to upstream, with sockets facing the incoming water side, and use cranes or tripods to slowly position them to prevent collisions. Before jointing, clean the sockets and rubber rings, evenly apply lubricant, and push them into place with the specified torque, checking the insertion depth mark; for welded or hot-melt connections, control the heating time and alignment, and ensure a flat appearance without cold welds or burns after forming. Re-measure the slope and elevation after installing each section, and adjust immediately if the deviation exceeds the limit; use short sections or elbows at turns and install flexible connections to avoid forced twisting. Construct inspection wells simultaneously with the pipelines, and build well bottom elevations, flow channels, and drops according to the drawings to ensure smoothness. For underground water, maintain continuous dewatering to keep the area dry, and it is strictly prohibited to install with water present. Before backfilling to a certain height above the pipe top, symmetrically compact the side fill with medium sand or graded sand and gravel to prevent displacement and suspension; for large-diameter pipes, install temporary fixation and anti-floating measures. Conduct closed-water or airtight tests after installation, and proceed with full-section backfilling and road surface restoration only after passing the tests, while organizing and archiving process data and measurement records simultaneously.

3.4 Completion Acceptance Stage

3.4.1 Closed-Water Test

The closed-water test is conducted after backfilling to a certain height above the pipe top and when conditions permit, aiming to inspect the leakage performance of the pipelines and inspection wells. First, set up temporary plugs in sections, check for cracks in the well walls, well seats, and joints before filling with water, control the test water head according to regulations, measure the upstream water level benchmark, slowly fill with water to the specified height, and soak for a certain period before starting the timer. Record the starting and ending water levels and test duration, and patrol the entire line and well chambers during the test to observe whether there is seepage, dripping, or dampness at joints, reductions, and through-walls; if leakage is found, immediately mark the location, drain the water, identify the cause, and repair it before retesting. Isolate external precipitation during the test to prevent rainwater from affecting readings; for road sections with high groundwater levels, take counter-pressure or temporary dewatering measures to prevent pipeline floating. Prepare record sheets for qualified sections, including section length, pipe diameter, material, water head, water seepage, test time, environmental conditions, and signatures of witnessing units. Issue a closed-water compliance certificate after completing all sections and summarizing the results, providing a basis for subsequent sphere passing, CCTV inspection, and completion acceptance. Collect and treat the test water and discharge according to environmental protection requirements, and prohibit indiscriminate discharge.

3.4.2 Trench Backfilling and Road Surface Restoration

Trench backfilling and road surface restoration can start after the closed-water or airtight test has passed and measurement re-verification has been completed, following a step-by-step, layered approach. First, carry out key backfilling around the pipe sides and near the pipe top, using medium sand or graded sand and gravel, filling symmetrically from both sides and lightly compacting to avoid uneven stress or displacement of the pipelines; switch to original soil or specified materials only after reaching 30–50 cm above the pipe top, and strictly prohibit the inclusion of organic matter, silt, and large stones. Control the backfill thickness at 20–30 cm per layer, compact layer by layer, and detect the compaction or resilient modulus, reworking if unqualified; for areas with underground water or soft soil, dewater or replace the soil first, lay geotextiles for separation, and set up temporary drainage ditches if necessary. Carefully compact around inspection wells and well cylinders to prevent the formation of a "well frame subsidence circle" in the future. When the pipeline trench crosses a road, first restore the base and sub-base, and pave the surface layer only after reaching the designed strength; for hot-mixed asphalt, spread and compact it in layers, cut the joints with the old road straight, and evenly distribute the tack coat; for cement concrete road surfaces, execute according to the slab division and curing time, and prohibit early opening to traffic [5]. Adjust the elevations of sidewalks, green spaces, rainwater inlets, curbs, and manhole covers along the line to ensure smoothness, no ponding, and no jumping. Organize measurement re-verification of road surface elevations and flatness after construction, take photos to record hidden parts, complete compaction, material, and test data, and handle segmental acceptance and handover to ensure safe and smooth roads and stable pipeline operation.

4. Conclusion

In conclusion, the construction and renovation of municipal water supply and drainage pipelines are not only an engineering and technical task but also a comprehensive reflection of urban safety, environmental quality, and governance capacity. This study proposes a systematic approach covering measurement re-verification, material control, trench excavation and support, pipeline installation, closed-water testing, layered backfilling, and road surface restoration, focusing on the three stages of construction preparation, implementation, and completion acceptance. It aims to reduce leakage and settlement risks and enhance system stability and maintainability through standardized processes, data-based records, and refined on-site management. Practice has shown that pre-project drawing reviews and risk lists, in-process quality witnessing and third-party inspections, and post-completion data archiving are key links for achieving "traceability, quantifiability, and handover." Facing the challenges of stock renewal and extreme weather, rainwater-sewage diversion improvement, storage and overflow control, sensitive section diversion, and temporary drainage guarantees should be considered simultaneously during project implementation to form a closed loop of engineering and operation and maintenance integration. In the future, BIM + GIS and Internet of Things monitoring should be combined to continuously optimize ledgers and operation and maintenance mechanisms, reduce impacts on traffic and livelihoods, and help create a safer, more resilient, and greener urban drainage system.

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