Research on Planning and Design of Municipal Water Supply and Drainage Systems from the Perspective of Urban Renewal

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Abstract: In this paper, on account of the primitive tendency and functionality of water supply and drainage systems in spatial resources optimization and water resources recycling while preserving historical context, we systematically elaborate their core value. It digs down into the complexities, in specifics to fragmented data and old standards, spatial restrictions, and lack of co-ordination in policies. Targeted measures are proposed around building a digital pipe network platform, differentiated zonal renovation policy, technology integration and spatial composite utilization policy and full-cycle collaborative management mechanism. The science and method of water supply and drainage features in urban renewal supporting the optimization allocation of urban function, which will play a significant role to enhance urban quality.

1. Introduction

As two fundamental bearing infrastructures that ensure the normal operation of urban functions, municipal water supply and drainage systems accompany a number of regional economic development goals in the process of urban functional restructuring, spatial quality improvement and ecological environment enhancement. With the advent of a new era, urban renewal has begun to show more functional hybridization, diverse demands and complex constraints, so that water supply and drainage systems are required to be better at resilience, resource recycling and smart operation and maintenance. Due to the upsurge model by increment construction, return planning green space of old town renovation and historic preservation at industry transformation, traditional mode of planning and design increasingly difficult to adapt to some complex scenario. This paper calls for urgent re-exploration of conventional water supply and drainage planning and design concepts and methods systems-oriented, as well as technical pathways deeply integrated with urban renewal.

2. Core Significance of Planning and Design for Municipal Water Supply and Drainage Systems from the Urban Renewal Perspective

In the context of urban renewal, development planning and design technology of water supply and drainage systems are beyond the functional scope of traditional municipal engineering. They have gradually become important carriers to reshape urban spatial pattern, optimize resource allocation and protect cultural memory. The importance is in the fact that this turns what was simply upgrading the infrastructure into a systemic reconfiguration of the urban organism. The reintegration of underground space is driven by pipeline network renewal, which releases "land resources that are occupied inefficiently" for public service facilities.

Rainwater and wastewater are converted from urban burdens into usable water resources, transforming the traditional extensive model of simple emissions to a new system in which water circulates more scientifically to be used several times withthe city. At the same time, the renovation is carried out in respect of the historical fabric and cultural elements of the city, avoiding uniform "cookie-cutter" construction, buried its water supply and drainage facilities as a bridge connecting the city past and future. They function the functional requirements of urban activities in the present day reality and they also fulfill missions to preserve historical information of the city, through which comprehensive revitalization of urban space can be realized beyond physical renewal [1].

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3. Analysis of Difficulties in Planning and Design for Municipal Water Supply and Drainage Systems from the Urban Renewal Perspective

Renewal of urban system needs cooperation between stakeholders, and also the technical conditions are much complicated, which issues many restriction factors to renovate the water supply and drainage system. Key bottlenecks require in-depth analysis:

3.1 Fragmented Status Quo Data Hampers Planning Accuracy

Old downtown areas that have undergone decades of construction and partial renovations inevitably lead to complicated systems of underground pipelines. Many early pipelines consist of only diagrammatic representations in schematic views without true 3D spatial information. Subsequent expansions were implemented by different units, municipal and environmental departments in differing formats and no longer kept up-to-date. Many temporary connections or emergency reroutes are not recorded. The actual alignments, burial depths and diameters are often far different from drawings, especially in older homes and urban villages where there are many unsanctioned pipes of unidentified ownership and maintenance. Planning designers are not able to get accurate complete existing data and choose from only a fragmented piece of information, experience in deciphering the network layout. This results into disconnected designs with reality, many pipeline conflicts in construction stage causing unexpected delays, required forced design changes and reduced functionality of system [2].

3.2 Outdated Standards Struggle to Meet Renewal Needs

Water supply and drainage design standards were developed mainly during the rapid urbanization phase with a single-functional focus for respective land use, e.g., residential, industrial or commercial. Indeed urban renewal creates a lot of spaces that are mixed use and complex. Old factories may also be renovated to combine offices, commercial and cultural/creative functions, residential space. Water usage patterns shift from uniform industrial consumption to highly fluctuating composite demand, with peak flows concentrated around meal times far exceeding original design capacities. Traditional per capita water consumption indicators fail to reflect these complex patterns. Ground-floor conversions of old residences to restaurants generate large volumes of oily wastewater, overwhelming original domestic sewage pipes not designed for grease. High-tech firms in upgraded industrial parks demand extremely high water quality stability, yet existing municipal water supply pressure fluctuates and occasionally exceeds turbidity limits. These new situations fall outside the scope of current standards, leaving designers without reliable technical guidance.

3.3 New Technology Application Severely Constrained by Space

New concepts and technologies like Sponge City and Smart Water theoretically enhance system efficiency significantly but face severe spatial constraints in old urban areas. Bioswales require continuous green belts and specific depths, yet old residential compounds often lack sufficient spacing between buildings, with limited open space used for parking or drying laundry, leaving no room for green infrastructure. Permeable paving requires adequate underlying gravel and soil layers for infiltration, but old urban undergrounds are densely crisscrossed by water, sewer, gas, electricity, and telecom lines, leaving no infiltration space. Smart water meters, pressure sensors, and flow monitors need stable power and communication, yet old buildings have cramped, dark pipe wells lacking power outlets and network ports, making installation, operation, and maintenance difficult even if attempted. These objective limitations confine many advanced technologies to the conceptual stage [3].

3.4 Lack of Multi-disciplinary Coordination Mechanism is Prominent

Water supply and drainage system renovation must be synchronized with building upgrades, road reconstruction, and landscape enhancement. However, under the current design system, different disciplines belong to separate design institutes or departments, working independently according to their own codes with little information sharing or coordination. Building design fixes indoor plumbing points without considering outdoor network connection conditions. Road design sets road elevations and cross slopes without verifying the rationality of inlet locations. Landscape design creates micro-terrain without considering its impact on surface runoff direction. Electrical duct routes often clash with water/sewer pipes without coordination for sequencing or avoidance. This siloed approach results in numerous conflicts when drawings are consolidated.

4. Optimization Measures for Planning and Design of Municipal Water Supply and Drainage Systems from the Urban Renewal Perspective

Against the backdrop of urban renewal, innovative concepts and technical methods are needed to construct a scientific and efficient solution system for water supply and drainage planning and design.

4.1 Digital Infrastructure & Dynamic Planning Model Construction

The digital transformation of water supply and drainage systems in urban renewal must first address the unclear inventory of old pipelines. Organize a joint surveying team forming together with surveying units, geophysics / exploration companies and pipe network operators. For e.g. surface first and subsurface next, trunk lines first and branches second. Use ground-penetrating radar (GPR) for trial centre-lines and each side for every road surveyed in built-up areas. Verify anomalies with exploratory pits. Make comparisons with specific as-built drawings and repair records available to water authorities. For water-supply systems with old communities that do not have data, CCTV robotic inspection through manholes can record pipe material, deformation and siltation. Create a table with pipeline ID, start/end coordinates, depth, diameter, material, year of construction and owner. A GIS allows you to overlay these pipeline data on topographic maps, buildings, and roads. Seed hydraulic drainage model in SWMM with this data. Enter 10 years of rainfall and water consumption data for calibration Use simulation results to classify pipe sections and nodes susceptible to flooding. Develop renovation plans (e.g., pipe enlargement, adding pump stations, new storage facilities). Validate renovation effectiveness by feeding plan parameters back into the model [4].

4.2 Zonal Differentiation Strategy & Refined Design Plan Development

For narrow, winding alleys in historical/cultural blocks, use HDPE pipes with outer diameter <200mm. Employ horizontal directional drilling (HDD) from alley entrances to exits, avoiding trenching along the alley, using mud for wall stabilization. Pull new pipes through the drilled holes. In dense heritage-conservation building areas, install decentralized integrated wastewater treatment plants (capacity: 50-100t/d, footprint: 20-30m²), installable underground. Discharge treated water (reaching Class 1A standard) into nearby landscape water bodies. In general renewal areas combined with road widening, place concrete drainage pipes (DN800-DN1200) under vehicle lanes as mains. Place branch pipes (DN300-DN500) under sidewalks to collect road and building runoff. Install inlets every 30-50m with initial stormwater diversion chambers directing the first 15 minutes of runoff to the sewer and subsequent cleaner flow to the storm drain. In industrial transformation zones, configure water supply based on tenant types: Set up reverse osmosis water purification stations for electronics factories needing ultrapure water (<10μS/cm). Pre-treat high-concentration organic wastewater from pharmaceutical plants using anaerobic reactors before sending to the zone's advanced WWTP. Treat cleaning wastewater from food processing via grease traps and dissolved air flotation (DAF) for reuse in floor washing and irrigation.

4.3 Technology Integration Innovation & Spatial Sharing Mode Exploration

In land-scarce old urban areas, integrate stormwater storage functions into existing underground space retrofits. Select low-lying, flood-prone underground parking garages. Add flood barriers (60cm high) and automatic gates at entrances. Apply epoxy resin waterproof coating to garage floors. Install submersible sewage pumps and level sensors at the lowest points. Issue storm warnings in advance to move vehicles, temporarily converting the garage into a detention basin. Drain water via pumps within 48 hours post-storm to restore parking function. For new projects, require integrated design of green roofs and rainwater harvesting. Put drainage/storage boards on waterproof roof, Grow drought-tolerant species (e.g., Sedum lineare), Connect overflow outlets to downpipes. Channel harvested rainwater into subterranean modular PP tanks ($3m^3$ to $100m^2$ roof area configuration). Store water, which is passed through sand filters, are used in toilet flushing, car washing and irrigation [5]. At critical junctions, pump stations and outfalls, flow meters, water quality monitors and CCTV can be installed. Send real-time 4G/5G data through to the control center. Operators drinking and opening gates / pumps depend on monitoring data and video Implement automated control rules.

4.4 Collaborative Design Mechanism & Full-cycle Management Framework Establishment

Assess your Project Early by appointing an overall design contractor who consolidated the appeals of distinct disciplines – structure(architecture), water/drainage, roads + location in advance. An interface list that describes responsibilities (eg. Architecture: locations and consumption of water points; Structure, number, location & size of wall sleeves for pipes; Roads: Elevations/gradients). Hold bi-weekly coordination meetings. Use projection to overlay discipline drawings and identify clashes. Issue Fixing and Decision Recording — Whenever something is to be agreed upon or fixed, fix it right away. Wear unified layer naming conventions (such as W-RAIN for storm pipes, or W-SOIL sewer pipes) for easy construction identification. Choose low/no-maintenance equipment — Variable frequency drive (VFD) water supply units reduce the need for tank cleaning; Corrosion resistant FRP septic tanks leads to longer life spans; Self-cleaning filters minimize manual maintenance. Specify requirements on drawings. Prepare O&M manuals specifying routine inspection items, maintenance cycles, fault response procedures and spare parts lists. Offer of ≥40 hours hands-on training for O&M staff on the process post-handover [6].

5. Conclusion

Urban renewal is an opportunity to upgrade municipal water supply and drainage systems; it also poses unprecedented challenges. Four key challenges related to data, standards, space and coordination can be solved through the enabling of digital technology, guiding with differentiated strategies, breaking through with innovation and ensuring collaborative mechanisms. This provides the basis for rethinking water supply and drainage systems: Transitioning from broad-brush construction to targeted retrofitting, transition from single-function to multifunctional, and transitioning from end-of-pipe treatment to upstream management. Further efforts should be made to strengthen theoretical studies and practical exploration, continuously improving the technical system of water supply and drainage planning and design to better serve practice under urban renewal drive, so as to provide more reliable infrastructure support for high quality urban development and improvement of people's living standards.

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