Original Research Article

Optimization strategies for indoor comfort in water supply systems

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Abstract: This research mainly explores the impact of water supply systems on indoor comfort and human health, and proposes optimization strategies to improve the performance and effectiveness of water supply systems. Through the analysis of factors such as water quality, pipe selection, layout, and end-point water supply facilities in the water supply network, a series of optimized designs were proposed, including the installation of pre filters, central water purifiers, and softeners. The material and layout of the water supply pipeline were also optimized. Research has shown that scientific and rational optimization of water supply systems can significantly improve indoor water comfort, ensure human health, extend equipment lifespan, reduce maintenance costs, achieve efficient and reliable water supply systems, and provide a better quality of life experience.

Keywords: Water supply system; Indoor comfort; Water quality optimization; Wipeline design

1. Introduction

In modern architectural environments, the water supply system is a crucial component for ensuring indoor comfort and human health. This study investigates the impact of various elements within the water supply network on indoor environmental comfort and human health, including water quality, the selection of materials for water transport pipelines, layout, and end-user supply facilities. It also proposes optimization designs aimed at enhancing the performance and effectiveness of the water supply system. The goal is to ensure the system operates efficiently and reliably, thereby providing a higher quality living experience and better health protection for individuals in their daily lives.

2. The Impact of Water Supply Systems on Quality of Life

2.1. Human Demand for Residential Water Quality

2.1.1. The Impact of Water Quality on Human Health

Microorganisms and chemical pollutants in drinking water can cause health problems. Minerals in water can accumulate in pipes, water heaters, and other household appliances, forming scale and shortening equipment lifespan. Given the current trends in water treatment technology, market direction, and people's lifestyles and drinking habits, low mineral drinking water is becoming increasingly popular.[1].

2.1.2. Standards and Demands for Water Quality in Different Uses

In daily life, the proportion of water used for bathing, flushing toilets, and personal hygiene is the highest. The average water consumption for bathing is 43L/(person · day); The flushing volume of the toilet is 30L/(person · day)[2]; The hot water for cleaning, laundry, and other household chores is 1.6 L/(person · day)[3]. In terms of age, water consumption per capita decreases by an average of 5 L/(person·day) as people age from youth to old age[4].

According to the research data analyzed by Xie Tian et al., 66.1% of households use purified water for drinking, 25.5% for cooking, 7.4% for cleaning vegetables, and 1.0% for other purposes. Therefore, 91.6% of households use water for drinking and cooking, indicating that they prefer specific water sources such as bottled water or water from purifiers[5].

2.2. Current Situation of Building Water Supply System

Excessive or insufficient water pressure can hinder the normal water intake of high-rise residents. The aging and corrosion of water supply pipelines can lead to rust entering the water supply system, affecting water quality, increasing the risk of waterborne diseases, and may also cause corrosion and blockage of pipeline walls.

If there is a problem with the main water supply pipeline, the lack of water treatment facilities and redundant design in the water supply system may lead to water supply interruption. Lack of monitoring equipment makes it difficult to detect and solve problems in a timely manner.

The current situation and problems of residential water supply systems are diverse and complex. To address these issues, it is particularly important to improve the quality, design, and management of the water supply system.

3. Optimization Strategies for Water Supply Systems

3.1. Design Principles for Residential Water Supply Systems

Ensure water quality safety and prevent pollutants from entering the water supply system. Use high-quality pipelines and equipment to extend the service life of the water supply system. Design backup pipelines and water sources for the water supply system. Ensure that each water supply point has sufficient water pressure. In hot water systems, insulation measures and efficient water heaters are used to reduce heat and energy consumption. Design pipeline layout and equipment locations that facilitate daily inspection and maintenance. Adopting water-saving appliances and equipment to reduce water resource waste.

3.2. Design Strategies for Residential Water Supply Systems

3.2.1. Pipeline Design

Select the appropriate pipe diameter based on water demand and pressure conditions. Use partitioned water supply and balancing valves to ensure balanced water flow and pressure at each water supply point. Install pressure regulating valves and pressure reducing valves to prevent pipeline damage caused by excessive pressure. Simplify pipeline layout, reduce bends and fittings to minimize water flow resistance and pressure loss. In cold regions, pipelines should be insulated to prevent freezing and cracking in winter.

3.2.2. Equipment and Material Selection

Pre filters are mainly used for initial filtration of incoming water, which can effectively improve the quality of domestic water and protect subsequent water treatment equipment and pipeline systems.

Central water purifier is a centralized water treatment equipment. It deeply removes impurities and pollutants from water through multi-stage filtration, thereby improving water quality and ensuring safe drinking water.

The water softener uses ion exchange technology to remove calcium and magnesium ions from water. This effectively prevents the formation of scale, protects pipelines and household appliances, improves the efficiency of heat exchange equipment, and achieves energy conservation.

4. Enhancing Comfort in Residential Water Supply Design

4.1. Project Overview

The remodeled floor plan is illustrated in Figure 3-1. The primary water points in this layout are the living room pipeline system, bathroom toilet, shower, bathroom cabinet, washing machine, and kitchen sink. From the floor plan, it can be observed that the kitchen water points are located at a considerable distance from the bathroom water points, potentially creating significant resistance and resulting in lower water pressure in the kitchen. The original water supply system lacked water purification equipment, failing to meet the homeowner's demand for higher water quality.

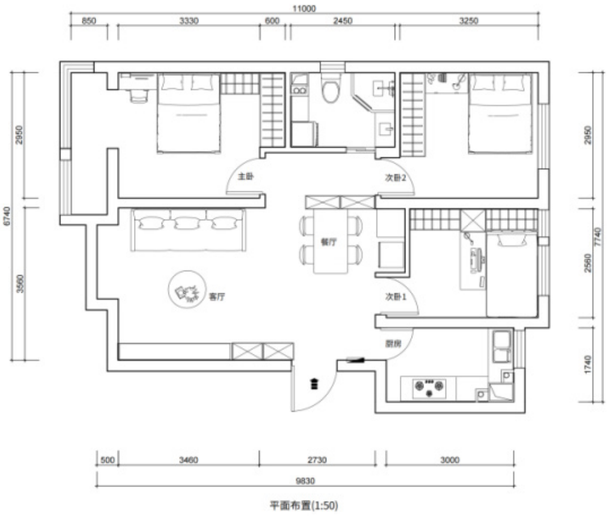

Figure 1. Layout plan.

According to the research of scholars such as Zhong Yutao on the diameter and installation method of residential water supply systems, the standard water consumption per capita is uniformly set at 220L/(person • d), and the peak demand coefficient is 2.5. The water consumption per household is calculated based on one kitchen and one bathroom. The quantity, rated flow rate, and equivalent value of sanitary appliances are detailed in Table 3-1[8].

Table 1. Information of WWTPs in China from 2013 to 2017.

Water fixtures	"Number of sanitary fixtures"	"Rated flow rate (L/s)"	"Equivalent"
Washing machine	1	0.20（0.14）	1.00（0.70）
Wash basin	1	0.15（0.10）	0.75（0.50）
closestool	1	0.10	0.50
Shower	1	0.15（0.10）	0.75（0.50）

4.2. Pipeline Layout

In residential projects, the overall layout of water supply pipelines is shown in Figure 3-2. In order to solve the problems of indoor net space height, the pipeline installation method of residential buildings adopts pre embedded design. Reducing pipeline length is a fundamental principle for optimizing the layout of water supply and drainage systems, which can lower the cost of building materials. In addition, shorter pipelines typically help reduce friction losses, improve system hydraulic efficiency, and save energy.

Figure 2. Construction drawing of water supply pipeline.

A pre filter was installed after the main water source in the kitchen. A water purifier is installed below the sink to reduce the risk of water pollution.Each water supply point is equipped with a separate water purification pipeline, making the control and maintenance of the water purification system more flexible and reducing the impact of malfunctions on the water supply.

When designing pipelines, reduce the areas where water flow may stagnate to avoid wall scaling and poor water quality. Using appropriate pipe diameter and flow rate can ensure smooth water flow and reduce sediment accumulation. As shown in Figure 3-3.

Figure 3. Kitchen waterway construction.

The water purifier under the sink is divided into two pipes: one leads to the living room water dispenser, and the other leads to the kitchen water softener. The water softener converts the purified water in the sink into soft water, which is then transported to the bathroom's sanitary equipment. The bathroom is equipped with 4 cold water outlets and 2 hot water outlets for toilets, showers, washing machines, and sinks, as shown in Figure 3-4.

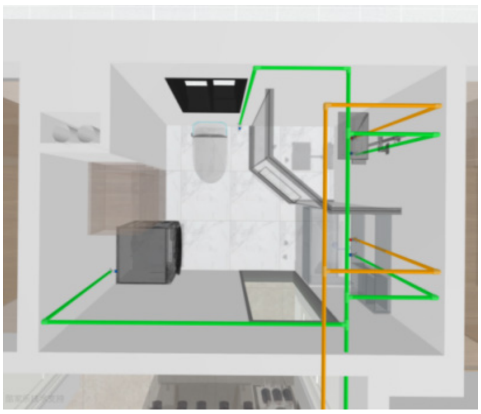

Figure 4. Toilet waterway construction.

4.3. Pipe Material Selection

For residential buildings with kitchens and bathrooms, considering the flow rate inside the pipes, the design flow rate of the residential inlet pipe is 0.460L/s per second, the design flow rate of the cold water pipe is 0.42L/s, and the design flow rate of the hot water pipe is 0.27L/s per second. The head losses per unit length of the pipeline are 0.497kPa/m, 0.420kPa/m, and 0.398kPa/m, respectively [7].

This project mainly uses newly built PP-R pipes. PP-R pipes have high overall strength and good heat resistance. Show better adaptability under the same temperature and pressure conditions. The raw materials of PP-R pipes are relatively clean and comply with national food hygiene standards. In addition, PP-R pipes are easy to install and ensure safe connections between adjacent fittings[8].

5. Conclusion

The optimization of modern residential water supply systems should focus on the following aspects: introducing advanced water treatment technologies, optimizing pipeline materials and layout, and implementing intelligent management and monitoring systems. These measures can comprehensively improve the performance and service level of the water supply system, provide residents with safe, stable, and high-quality water, and effectively save water resources, promoting the sustainable development of the city.

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