WATER SUPPLY, SEWERAGE, BUILDING CONSTRUCTION OF WATER RESOURCES PROTECTION

UDC 628.14

V. I. Shherbakov[1], H. C. Nguyen[2]

PROBLEMS OF WATER SUPPLY IN LARGE CITIES OF VIETNAM

Voronezh State University of Architecture and Civil Engineering
Russia, Voronezh, tel.: +7-980-345-99-00, e-mail: scher@vgasu.vrn.ru
[1]D. Sc. in Engineering, Prof. of Dept. of Hydraulics, Water Supply and Wastewater Disposal
Hochiminh City University of Natural Resources and Environment
Vietnam, Hochiminh, tel.: +7-952-950-58-53, e-mail: hcuongsgvn2003@gmail.com
[2]Lecturer

Statement of the problem. The issues of improving the water supply, pressure drop holding the elimination of individual installations and spare tanks in water systems of large cities in Vietnam are discussed. Combining deadlock sections of the network to form circles and circuits will improve the reliability of the network, pumping stations and water supply systems throughout the city.

Results. A water supply scheme with the accompanying transit flow lines of smaller diameter pipes, allowing one to provide the required amount of water supply and increase the pressure drop on the circle is proposed. A circle network hydraulic calculation using the program Bentley WaterGEMS V8i for the worst case of the system of water supply was designed. The plots the water supply network requires an increase in the diameter of pipes, which greatly reduces pressure drop losses and ensures a reliable supply of water to the consumer.

Conclusions. Laying of main pipelines accompanying with parallel lines connected to them of distribution networks provides better hydraulic conditions and reduces the pressure drop loss in the piping and shorten power consumption.

Keywords: water supply system, water networks, water pressure tanks, water quality, hydraulic calculation, graphics of water supply.

Introduction

In large cities of Vietnam the population and industry do not get sufficient water supply due to no pressure drop in water pipes especially in water supply peaks in areas away from water supply sources.

Water supply companies do not have expertise in developing water supply systems of the country's largest cities. In practice those results in the design and construction of local dead-end water mains with no consideration of population growth and increasing water use [1, 2]. This kind of the development of an urban system of water supply cannot meet peak demands for water and provide the pressure drop as well as normal flow distribution in the network [4, 6].

1. Current condition of water supply systems

Water supply mains of large cities of Vietnam were being developed in conjunction with a chaotic residential housing of individual areas with no consideration of possible growth. As a result, presently water supply networks are complex systems of transit water mains and lots of dead-end areas (Fig. 1).

Fig. 1. Water supply schemes of Thu Duc District of Ho Chi Minh

As shown in Fig. 1, the major transit and distribution water mains are joined to lots of dead-end areas to cater for one or more users. This number of dead-end areas gives rise to corrosion of steel and cast-iron pipes, biological contamination and increasing linear and local losses of pressure drop.

In old areas where pipes that have cracking, splitting and other damages significantly increase at maximum water pumping. Steel and cast-iron water mains have corrosion and organic deposits on interior pipe walls, which results in a dramatic reduction in their capacity and increasing resistance of water mains.

At the moment in Ho Chi Minh and Hanoi there is hardly any building with no elevated water tank of its own or any other reservoir for water supply due to insufficient water pressure drop and consumption in the supply network (Fig. 2).

The installation of individual extra tanks on building roofs and high lift stations that are supplied immediately by a water main system causes changes to a normal flow distribution and lower pressure drop in water mains that might eventually create a vacuum. If there are a few mains operating at the time of maximum water demand, contaminated ground water might enter a water supply network through cracks, splits and pipe joints [5].

Water from reservoirs and tanks comes in contact with the air and thus there is a reduction in the amount of chlorine in it, which gives rise to bacteria especially in the hot climate of Vietnam. The amount of contaminants in the water users get can be twice and more over the maximum allowable concentration (Table).

Fig 2. Water reservoirs on building roofs in Hanoi

A solution can be designing new areas of distribution systems to join them to existing mains and inner circle-shaped water distribution networks.

Table

Maximum allowable concentrations of major indicators of drinking water quality (Vietnam, 2009) [3]

Indicator	MAC regulations, not over
Hydrogen ion measurement, unit pH	6.0—8.5
Residual chlorine, mg/l	0.3—0.5
Iron (Fe, in total), mg/l	0.5
Ammonium nitrogen, mg/l	3
Total of coliform bacteria, the amount of bacteria in 100 ml	50
Thermal resistant bacteria in 100 ml	No
Chlorides (Cl^-), mg/l	300

2. Calculation and reconstruction of a water supply network

According to the regulations, accompanying water mains with the diameter of 300—600 mm must be designed in conjunction with transit mains with the pipe diameter of 1500—2000 mm [3]. As an example we have a water supply system of Thu Duc District of Ho Chi Minh typical of large cities of Vietnam. For this area main pipes should be laid, areas of the district network are circled, high lift water pumping stations must be eliminated (Fig. 3). These will improve the reliability and performance of the system, provide running water supply with sufficient pressure drop, will help avoid the use of individual storage tanks and reservoirs and keep the water quality high.

Based on the preliminary flow distribution, the diameters of accompanying water mains and new areas of the network joining dead-end areas into circles [7—9] were specified. The specified parameters will be made clear by joining newly-formed circles of the network of the district considering existing water pressure drops of pumping stations. A three-step graph of daily water supply by a pumping station of Thu Duc is presented in Fig. 4.

The graph suggests that the first group of pumps operates around the clock with the pressure drop of 25m, the second group of pumps operates from 1 p.m. to 5 p.m. with the pressure drop going up to 31m, the third group increases the pressure drop by 35m operating from 6 a.m. to 1 p.m.and from 5 p.m. to 9 p.m.

This operation regime of a pumping station is most consistent with the water consumption pattern.

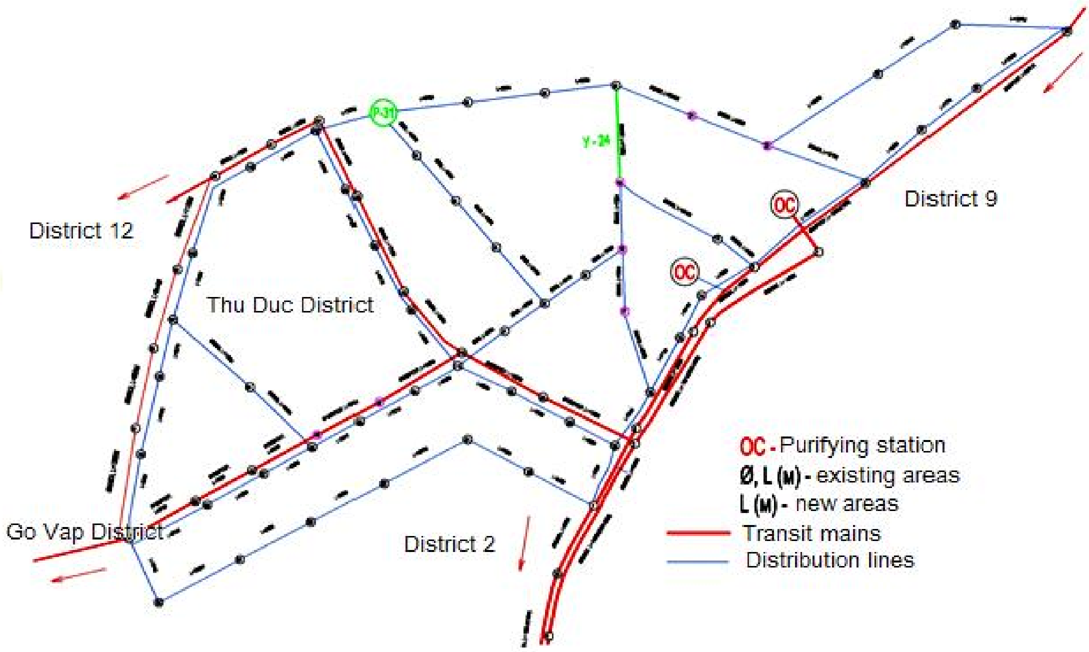

Fig. 3. Suggested calculation scheme for a water supply network of Thu Duc District

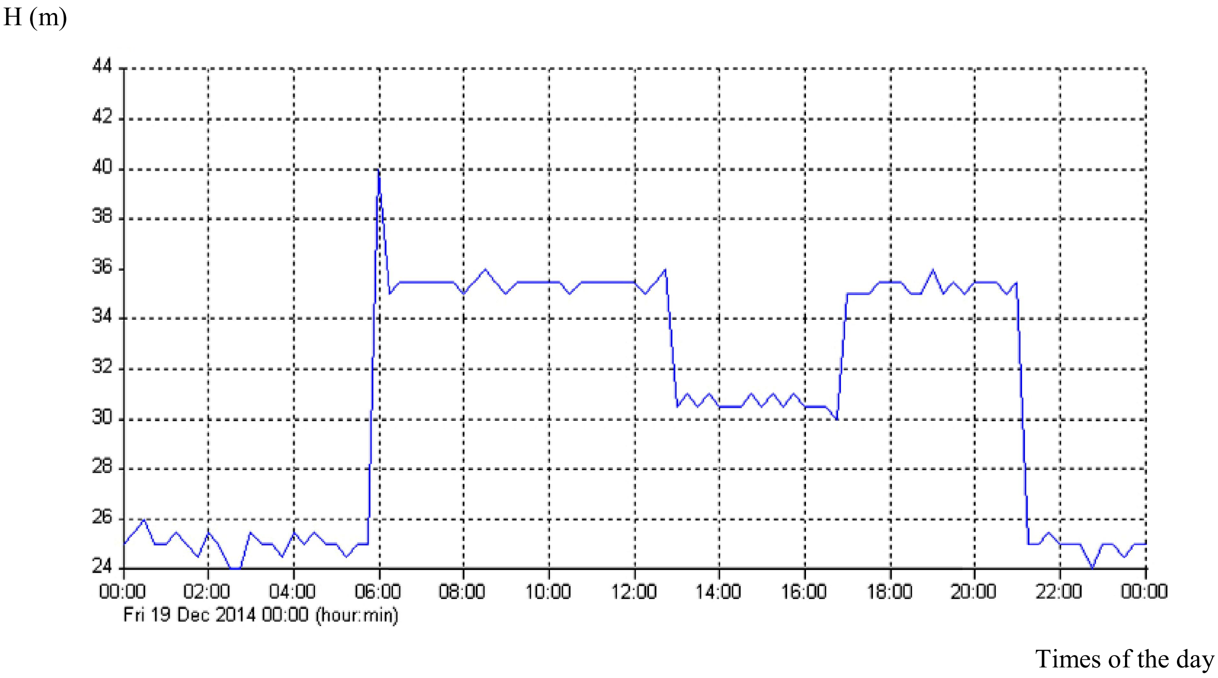

Fig. 4. Graph of water supply by a pumping station

The calculation of a circular water supply network using *Bentley WaterGEMS V8i* for all necessary non-emergency operation of the system. The coefficient of roughness for steel pipes and new pipes from nodular cast-iron pipes was identified using the Hazen-Williams equation [10—13]:

$$V = kCR^{0,63}I^{0,54},$$

where V is the fluid velocity; k is the proportionality coefficient depending on a system of physical values (k = 0.849 for the International System of Units (SI); k = 1.318 for the U.S. system of units); C is the coefficient of roughness; R is a hydraulic radius ; I is a hydraulic slope. The results of the flow distribution, geometric and hydraulic characteristics of the flows on the network areas at peak demands are in Fig. 5.

Area	Length (m)	Diameter (mm)	Material	Hazen-Williams S	Consumption (L/s)	Velocity (m/s)	Pressure drop losses (m)
У-3	1.486	2.000,0	Steel	140,0	3.545	1,13	0,60
У-4	1.631	2.000,0	Steel	140,0	3.545	1,13	0,66
У-5	2.428	2.000,0	Steel	140,0	1.596	0,51	0,22
У-6	1.297	2.000,0	Steel	140,0	1.596	0,51	0,12
У-8	500	2.000,0	Steel	140,0	904	0,29	0,02
У-10	500	2.000,0	Steel	140,0	2.254	0,72	0,09
У-11	1.283	2.000,0	Steel	140,0	2.254	0,72	0,22
У-12	1.020	2.000,0	Steel	140,0	2.254	0,72	0,18
У-13	885	2.000,0	Steel	140,0	1.995	0,64	0,12
У-14	1.655	2.000,0	Steel	140,0	1.995	0,64	0,23
У-15	441	2.000,0	Steel	140,0	1.995	0,64	0,06
У-18	541	300,0	Ductile Iron	130,0	83	1,17	2,44
У-19	711	250,0	Ductile Iron	130,0	72	1,47	6,10
У-20	968	350,0	Ductile Iron	130,0	112	1,17	3,63
У-21	709	300,0	Ductile Iron	130,0	85	1,20	3,34
У-22	769	250,0	Ductile Iron	130,0	43	0,87	2,48
У-23	1.119	300,0	Ductile Iron	130,0	126	1,79	11,11
У-24	1.106	300,0	Ductile Iron	130,0	120	1,70	9,93
У-25	935	150,0	Ductile Iron	130,0	19	1,08	8,23
У-26	935	100,0	Ductile Iron	130,0	12	1,48	23,67
У-29	777	350,0	Ductile Iron	130,0	76	0,79	1,43
У-33	1.590	300,0	Ductile Iron	130,0	44	0,62	2,24
У-34	2.876	600,0	Ductile Iron	130,0	383	1,36	7,60
У-35	1.596	600,0	Ductile Iron	130,0	535	1,89	7,84
У-36	822	250,0	Ductile Iron	130,0	54	1,09	4,03

Fig. 5. Hydraulic calculation of the suggested scheme of the network modernization

The hydraulic calculation showed that in areas A-19, A-23 – A-26, A-34 and A-35 the fluid velocities are over those economically reasonable of 0.7—1.2 m/sec, which leads to an increase in the pressure drop losses in pipes of up to 6-23 m. Therefore in these areas it is necessary to increase the pipe diameter by 1-2 gages to reduce the pressure drop losses and thereby increase the user consumption (Fig. 6).

Nodes	Marking (m)	Water use (L/s)	Water pressure drop (m)	Pressure (kPa)
T-12	2,00	1.995	47,96	449,8
P-13	6,00	31	37,92	312,4
P-14	5,00	10	44,80	389,5
P-15	5,00	10	42,35	365,6
P-16	4,00	28	36,26	315,7
P-17	5,00	28	32,63	270,4
P-18	5,00	33	29,29	237,7
P-19	5,00	49	26,81	213,5
P-20	6,00	47	16,88	106,5
P-21	5,00	31	8,65	35,7
P-22	5,00	59	32,31	267,3
P-24	5,50	13	37,00	308,3
P-25	6,00	13	35,57	289,4
P-27	6,00	29	29,94	234,3
P-28	5,50	43	30,08	240,5
P-29	6,00	28	12,84	67,0
P-30	5,50	31	11,75	61,2
P-31	5,00	38	17,60	123,3
P-32	5,00	18	21,12	157,8
P-33	4,50	33	29,67	246,4
P-34	4,50	26	26,09	211,3
P-35	4,50	23	22,23	173,5
P-36	4,50	22	20,03	152,0
P-37	4,00	9	31,76	271,7
P-38	3,00	21	38,55	347,9
P-39	3,00	22	36,39	326,8

Fig. 6. Calculation of the water use and pressure drop using the suggested scheme of the network modernization

Fig. 7 shows the graphs of changes in the water pressure drop and use per day at peak demands obtained using the hydraulic calculations in Thu Duc. The graphs of water supply by a water pumping station (see Fig. 4) and calculation pressure drop in the user network are not consistent and thus significant energy losses in pipes with ill-chosen diameters or deposits occurring in them and reducing their original diameter. The suggested scheme of a circular distribution network allows water supply with sufficient pressure drop without making use of individual high lift pumps or extra tanks.

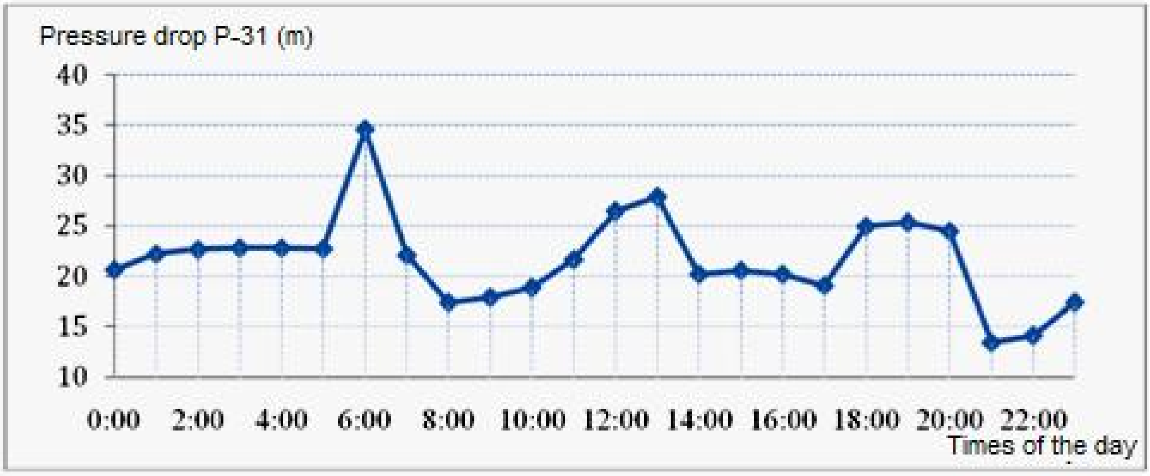

Fig. 7. Graph of pressure changes during the day for users

Conclusions

1. Circling of dead-end areas of water supply networks in order to improve their reliability helps to avoid the use of individual water pumping tanks, provide a normal hydraulic regime and a safe water supply of the city.

2. Distribution systems running parallel to mains of a smaller diameter provide better hydraulic conditions of flow distribution, reduces water drop losses in pipes and thus the energy consumption in water pumping stations.

3. The selected way of a hydraulic calculation of a water supply network using *Bentley WaterGEMS V8i* considering large diameters of mains up to 2000mm and more and dead-end areas of a distribution network with the diameter from 100 to 200 mm indicated a possibility of employing it in calculating water supply networks of large cities.

References

1. SAWACO-water company SAIGON (2012). Available at: http://www.thanhnien.com.vn/chinh-tri-xa-hoi/that-thoat-nuoc-tai-tphcm-moi-ngay-mat-3-ti-dong-489041.html. (accessed 13.07.2015)

2. Central Statistical Office Viet nam—2015. Available at: http://vi.wikipedia.org/wiki/Th_ành_phố_Hồ_Chí_Minh. (accessed 13.07.2015)

3. TCXDVN 33:2006. Cấp nước — Mạng lưới đường ống và công trình. Tiêu chuẩn thiết kế (Building regulations Vietnam 33:2006).

4. Shcherbakov V. I. *Gorodskoy vodoprovod* [City water supply]. Voronezh, 2000. 240 p.

5. Eletskikh V. L., Shcherbakov V. I. *Voda i lyudi* [Water and People]. Voronezh, OOO «Tvorcheskoe ob'edinenie "Al'bom"» Publ., 2004. 248 p.

6. Nguen Kh. K. Raschet i proektirovanie vodoprovodnykh setey na WaterCAD [Calculation and design of water supply systems in the WaterCAD]. *Nauchnyi vestnik Voronezhskogo GASU. Student i nauka*, 2008, no. 4, pp. 131—134.

7. Shcherbakov V. I., Panov M. Ya., Kvasov I. S. *Analiz, optimal'nyy sintez i renovatsiya gorodskikh sistem vodosnabzheniya i gazosnabzheniya* [The analysis, the optimal synthesis and renovation of urban water supply and gas supply]. Voronezh, 2001. 291 p.
8. Panov M. Ya., Levadnyy A. S., Shcherbakov V. I., Stogney V. G. *Modelirovanie, optimizatsiya i upravlenie sistemami podachi i raspredeleniya vody* [Modeling, optimization and control systems, water supply and distribution]. Voronezh, 2005. 489 p.
9. Panov M. Ya., Petrov Yu. F., Shcherbakov V. I. *Modeli upravleniya funktsionirovaniem sistem podachi i raspredeleniya vody* [Models of operation control systems, water supply and distribution]. Voronezh, 2012. 272 p.
10. Panov M. Ya., Shcherbakov V. I., Kvasov I. S. Modelirovanie vozmushchennogo sostoyaniya gidravlicheskikh sistem slozhnoy konfiguratsii na osnove printsipov energeticheskogo ekvivalentirovaniya [Modeling the disturbed condition of hydraulic systems of complex configuration based on the principles of energy equivalenting*]. Izv. AN RF. Energetika*, 2002, no. 6, pp. 130—137.
11. Panov M. Ya., Shcherbakov V. I., Kvasov I. S. Metodologiya faktornogo analiza vodoraspredeleniya i vodopotrebleniya [The methodology of factor analysis of water allocation and water use]. *Izv. vuzov. Stroitel'stvo*, 2001, no. 5, pp. 82—87.
12. Martynenko G. N. [i dr.] Optimal'nyy sintez gidravlicheskikh truboprovodnykh sistem v oblasti operativnogo upravleniya [The optimal synthesis of hydraulic piping systems in the field of operational management]. *Izv. vuzov. Stroitel'stvo*, 2004, no. 2, pp. 78—83.
13. Adichai Pornorommin. Chislennoe modelirovanie sistemy raspredeleniya vody v kvartale Thungmahamek, Bangkok, Tailand [Numerical modeling of the water distribution system in the quarter Thungmahamek, Bangkok, Thailand]. *Mezhdunarodnyy simpozium Azii. Simulyatory i modelirovanie 2007, Chiangmay, Tailand*, 2007, pp. 161—168.