Water Supply Systems in Multi-Apartment Buildings and their Design Characteristics

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Abstract. The research considers ongoing changes in the current system of legal regulation in the field of water supply and wastewater disposal of multi-apartment buildings (MABs). The authors present results of operational and design standards of water consumption analysis. It is shown that the existing regulatory and technical documents need adjustment in terms of determining the maximum possible consumption of cold and hot water for MABs residential units. The paper also puts forward an algorithm of hydraulic calculation of MABs domestic water supply systems according to the methodology developed in the Academy of Construction and Architecture in Samara State Technical University (ACA SamSTU).

1. Introduction
Determining maximum water flow rate, which value of determines the capacity of the MABs water supply system, is the primary task of hydraulic calculation. Incorrect selection of the source data can lead either to the situation when consumers living in MABs lack access to municipal resources (cold and hot water), or to water overconsumption.

Currently, in accordance with the norms of the Federal law "Town-Planning Code of the Russian Federation" (TCR RF) [1-5], it is established that the water supply system of MABs should be designed on the basis of design standards, and its operation should be carried out in accordance with operational standards.

A significant discrepancy in the values of the actual water consumption during MABs operation and their design values requires an analysis of this discrepancy, which confirms the relevance of this scientific work.

2. Materials and methods
The analysis of operational and design standards of water consumption revealed a certain functional and target insufficiency and systemic lack of clarity in the specification of the TCR RF requirements...
The current situation has determined the main task of this scientific research which is to analyze the calculation results of the capacity of MABs household and drinking water supply systems calculated according to the methodology given in SP (Code Specification) 30.13330.2016 [6], as well as according to the calculation method developed at the Academy of Construction and Architecture of the Samara State Technical University (the method of ACA SamSTU) by I. Yu. Mikhailova under the guidance of Doctor of Technical Sciences, Professor A.K. Strelkov [8].

The main methodological difference between the method of ACA SamSTU and SP 30.13330.2016 methodology lies in different approach when selecting the source data for the calculation. Thus, the selection of pipe diameters and equipment sizes the method of ACA SamSTU is based on the values of peak utility resource costs determined by the standards of its consumption. It means that when determining the estimated costs values and choosing pipe diameters, this method takes into account not only the economic and hygienic need for water, but also some social factors. Figure 1 presents a block diagram of the methodology for determining the calculated (limit) costs of cold and hot water in centralized systems of household and drinking water supply at the entrance to the residential premises of MABs (see Fig. 1).

![Block Diagram for Calculating Cold and Hot Water Consumption](image)

**Figure 1.** Block diagram for determining the calculated (maximum) consumption of cold and hot water at the entrance to the residential units.
3. Research and discussion

In the calculations of concentrated water consumption, the researchers considered a 16-storey MAB, located in the 2nd construction and climate zone. The number of people living in it was 864 people. The number of water-intake devices equaled 1152 pcs. for cold water and 864 pcs. for hot water. Consumption standards were taken as $5.92 \text{ m}^3\text{month}^{-1}\text{person}^{-1}$ cold water, $3.24 \text{ m}^3\text{month}^{-1}\text{person}^{-1}$ hot water. In order to correctly compare calculation results obtained by both methods, the authors considered the same values of average water consumption for one equivalent water-intake device per second and per hour, and the same maximum water consumption rates per hour and per day when determining the probability of the equivalent water-intake device per second and per hour.

Calculation results are given in Tables 1 and 2.

Table 1. Cold water consumption calculated by various methods.

| No | Characteristic | Estimated value |
|----|----------------|-----------------|
| 1  | Hour rate of consumption, $q_{cht,ut} \frac{l}{h}$ | 7.1 |
| 2  | Water consumption, instrument-aided calculation $q_{ct} \frac{l}{day}$ | 0.2 |
| 3  | Water consumption, instrument-aided calculation, $q_{cht} \frac{l}{hr}$ | 200 |
| 4  | Daily water consumption rate, $Q_{ct} \frac{l}{hr}$ | 165 |
| 5  | Probability, $P_c$ | 0.0074 |
| 6  | $N/P_c$ | 8.52 |
| 7  | $\alpha_c$ | 3.683 |
| 8  | Probability, $P_{cht}$ | 0.0266 |
| 9  | $N/P_{cht}$ | 30.6 |
| 10 | $\alpha_{cht}$ | 9.608 |
| 11 | Consumption per hour, $q_{cht} \frac{m^3}{hr}$ | 9.608 |
| 12 | Daily consumption in a multi-apartment building (MAB), $Q_{cht} \frac{m^3}{day}$ | 236.7 | 142.6 |
| 13 | Average consumption per hour, $q_{cht} \frac{m^3}{hr}$ | 5.94 |
| 14 | Momentary discharge, $q_{cht} \frac{l}{sec}$ | 4.384 | 3.683 |

Analysis of the calculation results shows that the values of the maximum water consumption momentary discharge calculated according to the SP 30.13330.2016 method are 1.19 times less for cold water and 1.57 times less for hot water than the values of the consumption calculated according to the ASA SamSTU method. The authors believe this discrepancy results from the different technologies of rationing design and operational standards.

A significant discrepancy in the momentary discharge values, which are used to select the values of pipe diameters and standard sizes of equipment, clearly indicates the need to adjust the regulatory and technical documents in terms of determining the maximum costs of cold and hot water for MABs residential units. Therefore, the design of the methodology for hydraulic calculation of internal
systems of MABs household and drinking water supply should be carried out with account of the following new requirements for these systems:

- MABs water supply systems should provide the possibility of transporting the municipal resource (water) at any time when there is a need for it.
- The estimated (marginal) water consumption in water supply systems for MABs residential units should be determined with account of the normative values for the consumption of municipal resources.

### Table 2. Hot water consumption calculated by various methods.

| No | Characteristic                                      | Estimated value |
|----|-----------------------------------------------------|-----------------|
|    |                                                     | Method of ACA   | SP (Code |
|    |                                                     | SamSTU       | Specification) |
|    |                                                     | 30.13330.2016 | methodology |
| 1  | Hour rate of consumption, $q_{hr,u}$, $l_{hr}$      | 8.5            |               |
| 2  | Water consumption, instrument-aided calculation, $q_{hr}$, $l_{sec}$ | 0.2            |               |
| 3  | Water consumption, instrument-aided calculation, $q_{hr}$, $l_{sec}$ | 200           |               |
| 4  | Daily water consumption rate, $Q_u$, $l_{hr}$      | 85             |               |
| 5  | Probability, $P$                                   | 0.0118         |               |
| 6  | $N\cdot P^h$                                       | 10.2           |               |
| 7  | $\alpha^h$                                         | 4.185          |               |
| 8  | Probability, $P_{hr}$                              | 0.042          |               |
| 9  | $N\cdot P_{hr}$                                    | 36.3           |               |
| 10 | $\alpha_{hr}$                                      | 11.02          |               |
| 11 | Consumption per hour, $q_{hr}$, $m^3_{hr}$          | 11.02          |               |
| 12 | Daily consumption in a multi-apartment building (MAB), $Q_{hr}$, $m^3_{day}$ | 156.4         | 73.4          |
| 13 | Average consumption per hour, $q_{hr}$, $m^3_{hr}$ | 3.1            |               |
| 14 | Momentary discharge, $q_{hr}$, $l_{sec}$            | 6.516          | 4.160         |

As a result of this research, the authors worked out a Standard of the Self-Regulatory Organization "Volga Regional Association of Architects and Designers" (SRO "PRAAP") named "Determination of the estimated costs of cold and hot water in the internal systems of household and drinking water supply of apartment buildings" as a supplement to SP 30.13330.2016. The approval of the Standard is scheduled for May 2021.

### 4. Conclusions

The research yielded the following conclusions:

- The analysis of the requirements for MABs internal systems of household and drinking water supply made it possible to put forward new methodological aspects of their hydraulic calculation which meet the exiting housing legislation requirements.
- The research demonstrates that it is long past time to update the existing method of hydraulic
calculation by adding a section on calculating water supply systems transporting water to MABs residential units.

- The method of ACA SamSTU suggests making hydraulic calculation of MABs household and drinking water supply systems with account of the social factors of water consumption in residential units.

5. References

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