TYPIFIED DEVICES FOR MEASURING FLOW RATE AND REGIME MONITORING OF WASTEWATER

Roumen Marinov

Department of Water Management and Use, National Institute of Meteorology and Hydrology – Bulgarian Academy of Sciences, 66 Tsarigradsko Shose Blvd., Sofia 1784, Bulgaria

Abstract

Continual measurement on flow rate and wastewater regime in sewage systems is a new activity resulting from the synchronization of legislation on environmental protection of Bulgaria with the European requirements. The existing sewer systems are mostly of the mixed type – for domestic-industrial and rainwater runoff. The water of the first type is of ecological interest and is orders of magnitude less in quantity than rainwater.

A large-scale research program for monitoring of wastewater regime and quantity is aimed at overcoming the above issues. The developed hydrometric equipment corresponds to almost all conditions and status of sewer systems in Bulgaria. A range of typified hydrometric devices is worked out for pipe diameters from Ф160 to Ф300 mm. They are suitable for measurement of non-stationary water flows and create minimal backwatering level in the pipes and minimal prerequisites for retention of suspended matter, ensuring high accuracy for minimal values of water quantity.

The adopted principle of typifying has the advantages of easy installation, accurate "wet zero" adjustment and an option for laboratory calibration allowing the expansion of the operation range and offering the possibility to create geometrically similar models. Experimental models are in successful operation on a number of sites in Bulgaria.

Key words: *hydraulic research, water meter devices, wastewater monitoring, typified structures*

Continual measurement on flow rate and regime of wastewater in sewage systems is a new activity that has become necessary after synchronizing the legislation on environmental protection of Bulgaria with the European requirements.

The performance of such measurements in the country encounters significant technical difficulties due to the following reasons:

1. The existing sewer systems in the settlements are outdated and their technical condition is often unsatisfactory. Figure 1 shows examples from our studies for their status at different sites – settlement and departmental sewage collectors for wastewater disposal.
2. As early as at the phase of their design, as well as during their construction, no conditions or prospects had been ensured for conducting hydrometric works. The additional provision of such conditions is related to the necessity of reconstruction of the existing infrastructure.
3. The built sewer systems are mostly of the mixed type – for domestic-industrial and rain water. The first type of water, which is orders of magnitude less in quantity compared to water formed by intensive precipitation, represents an ecological interest. This hampers seriously the accurate measurement of the domestic-industrial component, which is in fact the purpose of this measurement.
4. Wastewater generated in the settlements is characterized by clearly expressed hour, daily and weekly non-stationarity, which restricts the possibility to apply the simplest means of measurement by a "calibrated profile".
5. No executive technical documentation is available for the old sewer systems and the existing drawings do not often correspond to the changes that have taken place during construction or after

it. For this reason new geodetic and other linear measurements are necessary, which are strongly hampered due to the facilities deeply lying under the earth's surface.



Fig. 1 Poor technical condition of the old sewage facilities

The aim of the work team during the eight-year period of the large-scale research program for theoretical substantiation and design of the measuring devices for continuous automatic monitoring of the regime and amount of wastewater was to overcome the above difficulties. At present it may be considered that hydrometric facilities have been already developed for incorporation in existing sewage collectors that meet almost all requirements and conditions of sewer systems in Bulgaria [1,2,3].

So far the method for incorporation in the practical cases was based on individual design, manufacturing and installation at the sites. The calibration was realized theoretically on the base of the existing hydraulic relationships, established as an average of a large number of experiments.

The collected extensive experience in this activity proves that in a number of cases, mainly in newly built or envisaged in future sewer sections, new modern building materials are used, mostly standard PVC pipes. There is a possibility for these cases to offer finished products in a wide range of the used standardized diameters. This refers to the most widespread sites in the country – mouth collectors in water intakes of industrial enterprises and sewers of industrial sites.

A range of finished hydrometric equipment has been developed on the base of this idea for pipe diameters from 160 mm to 300 mm. The whole experience from the projects implemented so far is used in this innovative activity applying the principle of unifying the solutions for the diverse geometrical, constructional and technological conditions of the sites.

The suitability of the equipment construction for measurement of non-stationary flows is considered as the basic requirement for measuring these unsteady flows. It is known that this condition is met by all types of measuring weirs and measuring beds.

The measuring weirs create additional backwatering level in the pipes, which has to be in accordance with their flow capacity for the maximum amount of the generated wastewater. In addition, they ensure an insurmountable barrier for suspended mechanical matter, typical for the greater part of wastewater.

In this context, forward-inclined weirs with a sharp edge are used in the construction design, the slope and height of the spillway panel being subjected to theoretical and experimental optimization.

The second requirement for the structure of the measuring devices is to create conditions for high measurement accuracy even for the minimal values of water quantity, which are more important for environment than the drainage of high rainwater. This problem is solved by applying forward-inclined

combined weirs with a sharp edge, so that the low flow rates pass through a triangular weir, a modified Thomson type, and the high flow rates pass over the horizontal edge of the spillway, situated on both sides of the triangular orifice.

The transducer for measuring the pressure head of the weir in the individual facilities is installed separately, at an appropriate place in the arrangement of the measuring point, and then an adjustment is made between its "zero" and the elevation of the spillway edge. This operation is accomplished by means of a laser level in the confined space of manholes and is a very difficult activity to perform. To avoid this inconvenience, the typified facilities are designed in such a manner that the weir panel and the sensitive element of the transducer are mounted in a single monolithic body with precisely coordinated "zero" elevations (Fig. 2).



Fig. 2 Monolithic structure of the typified hydrometric facilities

Standard T-shaped deviation fittings of PVC are used for the facility body, which allow easy connection to the sewer pipes. The large sizes of the individual measuring devices do not provide the possibility of experimental calibration under laboratory conditions. Therefore, as already mentioned, they are calibrated using theoretical relationships with reference literature data for the water quantity coefficient. Furthermore, the use of these relationships is admissible only within the range of the pressure head, for which the weir operation is not subjected to the impact of the vault effect of the upper arch of the sewer pipe.

This disadvantage has been also avoided with the typified elements since their calibration can be performed in an experimental manner under laboratory conditions due to their significantly smaller dimensions. Moreover, their model investigation becomes also possible and the results obtained from the model can be transferred to considerably larger pipe diameters applying the methodology of hydraulic modeling.

At this stage the models of the typified sizes Φ160 mm, Φ200 mm and Φ250 mm have been developed. Photos of their laboratory calibration within the entire range of their flow capacity are shown in Figs. 3, 4 and 5.

The results of the laboratory calibration are compared with the theoretically obtained relationships by means of the coefficients given in reference literature.

The calibration dependences obtained for the typified size Φ 160 mm are shown in Fig. 6.

The regulated zone of using the theoretical dependence is indicated in the plotted graph.

The following inferences can be made on the base of the results obtained:



Fig. 3 Laboratory calibration of typified size Φ 160 mm

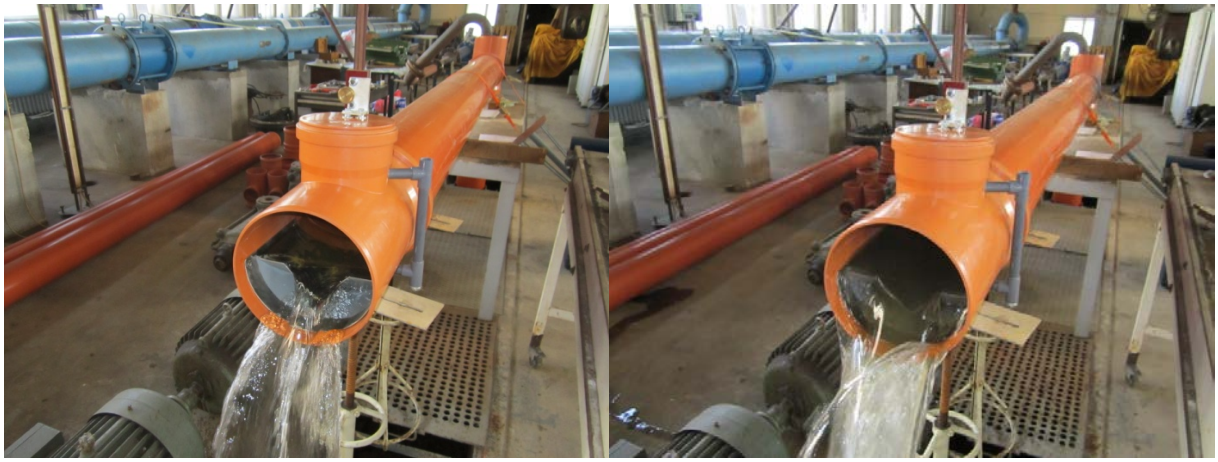


Fig. 4 Laboratory calibration of typified size Φ 200 mm



Fig. 5 Laboratory calibration of typified size Φ 250 mm

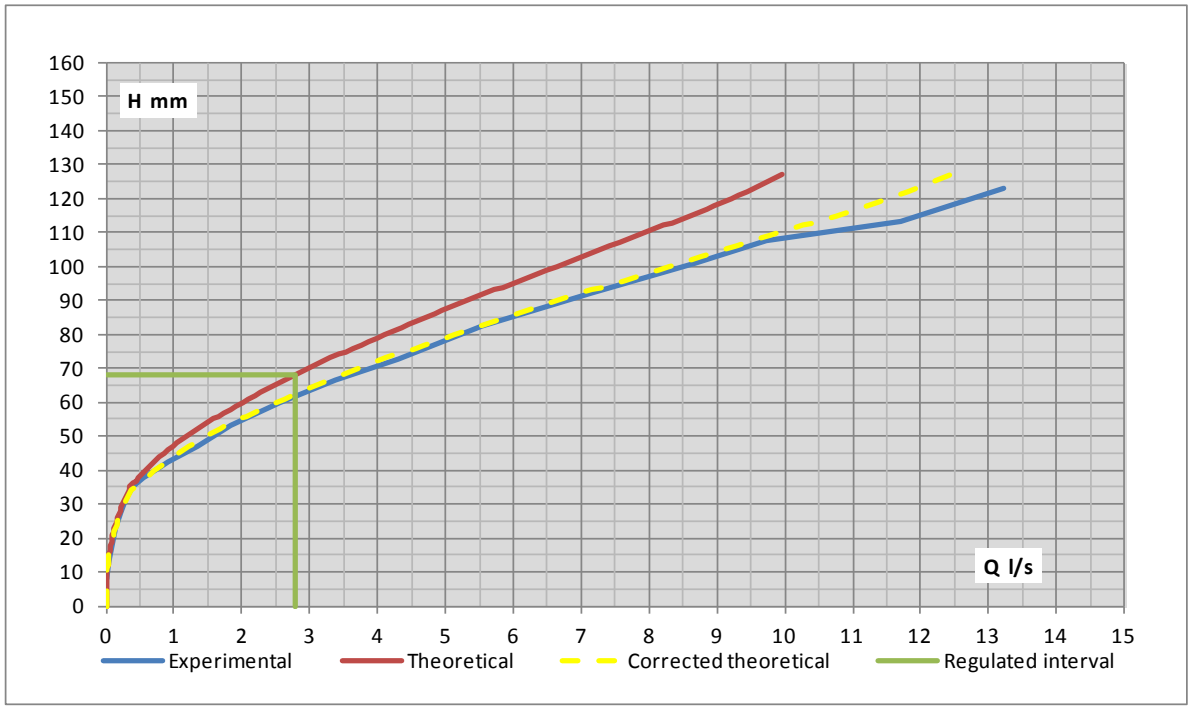


Fig. 6 Calibration dependences for typified size Φ 160 mm

- The actual flow capacity of the element is higher by about 10 % of the theoretically determined dependence. The theoretical curve, corrected with 10 %, is also shown in the plot. It coincides very well the experimental dependence.
- The preliminary regulated interval of the theoretical dependence validity is up to pressure heads of the weir 68 mm or up to 2.78 l/s. The experimental verification shows that it may be significantly extended, it upper limit reaching pressure heads of the weir up to 108 mm, respectively water quantity up to 9.8 l/s.
- The impact of the vault effect of the pipe on the weir operation starts above these new limits, which is clearly shown in the graph.
- Very similar results have been also obtained for the laboratory calibration of the typified size Φ200 mm (Fig. 7):
- The actual flow capacity of the element is by 10 % higher from the theoretically determined one.
- The vault effect of the pipe becomes noticeable for pressure head of the weir exceeding 127 mm, while during the theoretical calibration it is fixed for safety at 85 mm.
- There is a certain difference in the experimental calibration of typified size Φ250 mm (Fig. 8):
- The actual flow capacity of the facility in the triangular part of the weir here coincides entirely with the theoretical calibration dependence and it is higher by 14 % for the horizontal part of the spillway edge.
- The vault effect of the pipe is less pronounced and becomes noticeable for pressure heads exceeding 140 mm. The restriction for using the theoretical curve is set for pressure heads over 93 mm.

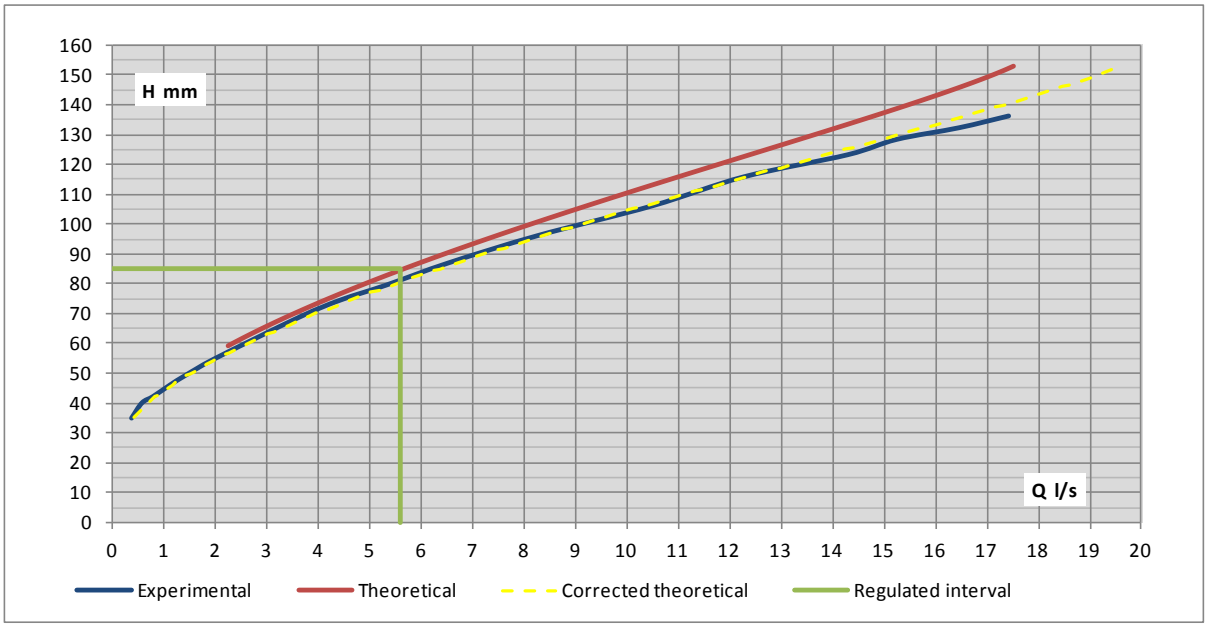


Fig. 7 Calibration dependences for typified size Φ 200 mm

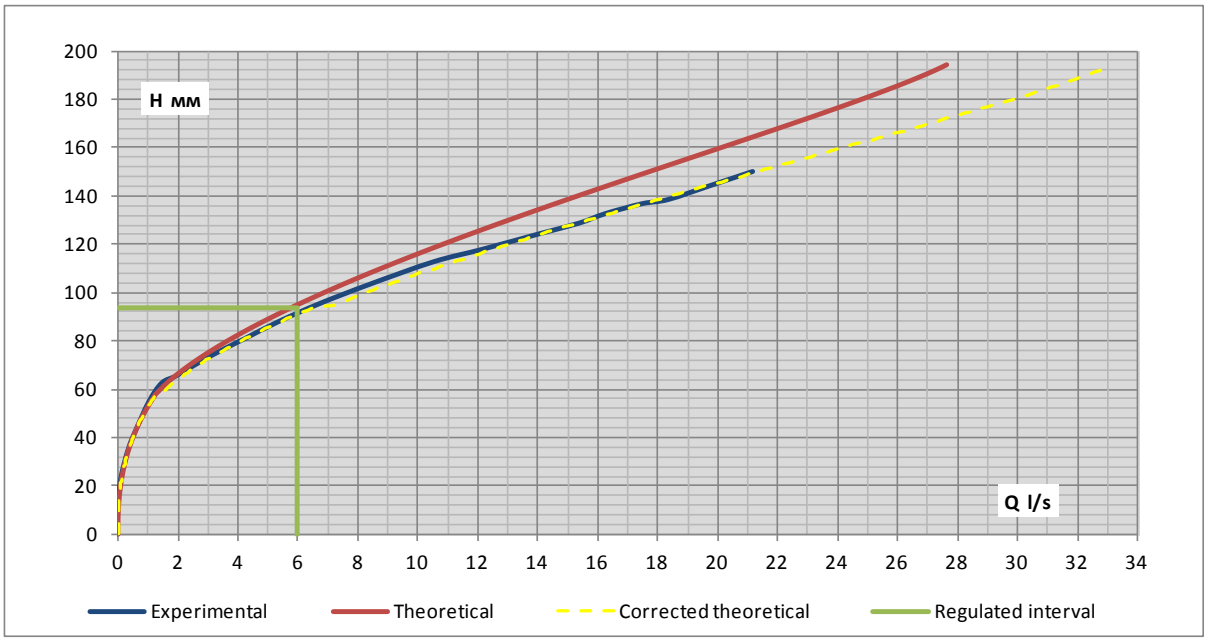


Fig. 8 Calibration dependences for typified size Φ 250 mm

The following conclusions may be drawn from the work on the typified devices for wastewater and the conducted laboratory investigations with them:

1. The adopted typifying principle undoubtedly offers possibilities beyond comparison for an easier way of mounting the measuring devices and precise “zero” adjustment of the gauge.
2. The possibility for laboratory calibration of the device increases the accuracy of measurement and extends the scope of using it throughout the entire range of pressure heads till the transition to a pressure head regime of the pipe.

3. The vault effect of the pipe, which restricts the validity of the theoretical calibration, does not exert any effect on the laboratory calibration since it is recorded automatically from the test results.
4. The typified constructions of the device make it possible to apply hydraulic modeling, which will allow reliable calibration of geometrically similar models with significantly larger dimensions using tests with smaller models. The development of this option is an object of the next cycle of research.
5. The typified measuring devices have been designed for joint operation with a hydrostatic transformer of the weir pressure head and a specialized electronic controller for continuous recording of results, data storage and transfer.

Specimens of the experimental series have been already implemented on a number of sites in Bulgaria with flawless operation. Examples of their application for wastewater measurement are the industrial sites of the following enterprises:

The Marshall 91 EOOD Plant for soft drinks, Bagrentsi village, Kyustendil district – collector diameter of 160 mm. The device installation is performed in an existing manhole at the end of the industrial site of the plant (Fig. 9). The panel with the recording electronic equipment is installed on a concrete-fixed steel stand in the immediate proximity to the manhole (Fig. 10).



Fig. 9 Water meter device for wastewater of the Marshall 91 plant



Fig. 10 Panel with electronic recording equipment

Kondov Ecoproducts OOD Dairy, Staro Selo, Troyan municipality – collector diameter of 200 mm. Because of the built channel of corrugated plastic pipe, a part of this pipe has been used as housing for the device (Fig. 11).

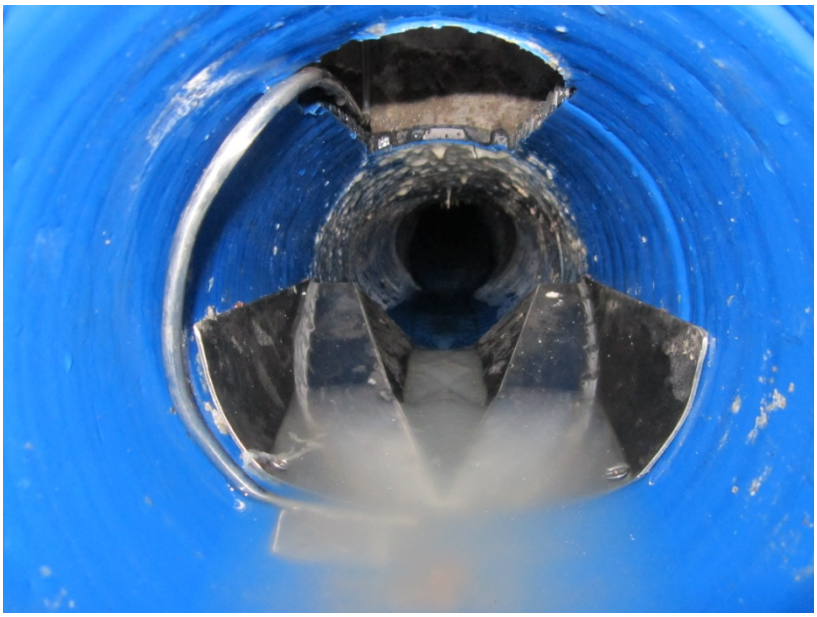


Fig. 11 Water meter device for wastewater of Kondov Ecoproducts OOD dairy

REFERENCES

1. Monev, E., R. Marinov, V. Dimitrov, Water meter devices for wastewater in sewer systems, Third Workshop with International Participation “Water Meter Economy”, BAWS, Sofia, 2008.
2. Monev, E., R. Marinov, V. Dimitrov, A. Angelov, Implementation of water metering equipment for sewer systems in Bulgaria, Third Workshop with International Participation “Water Meter Economy”, BAWS, Sofia, 2008.
3. Monev E., R. Marinov, Monitoring on wastewater discharges in settlements in Bulgaria, BALWOIS Conference, Ohrid, 2008.