Investigation of hydrometeorological basis of storm sewer calculation for Astana city

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ABSTRACT

Precision of precipitation intensity is important for storm sewers design. Therefore, this work is devoted to the development of available automatic rain gauges for the territory of Kazakhstan.

Keywords: storm sewer; rainfall measurement

Meteorological stations operated by Republican State Enterprise Kazhydromet (RSE KazHydroMet) are involved in the measurement of precipitation in Kazakhstan. Each station sends the measurement results to the Meteorological Center, which analyses the received data. As a rule, the distance between the meteorological stations is 60–100 km. In regions where the weather changes dramatically, for example, in the mountains or closer to the north, the density of stations increases, and the distance between them is reduced to 15 km.

Transmission of observations around the world occurs simultaneously and in strictly fixed hours: eight times a day, every three hours, on Greenwich Mean Time.

Fig. 1. Desktop in the room of Meteostation building.

The big amount of precipitation falls in the form of rain: the removal of these precipitations is the task of storm sewer.

Amount determination of liquid precipitation is performed using special instruments are called rain gauges. The amount of liquid precipitation is determined by the thickness of the water layer (in millimeters).

Currently, most weather stations in Kazakhstan use simple rain gauges, one of which is shown in Figure 2. Unfortunately, simple rain gauges do not record the precipitation process, but record only the total precipitation over a certain period of time.

Fig. 2. Simple rain gauge.

For a more accurate prediction and the establishment of estimated rainfall close to the actual, it is necessary to have accurate data on the duration and the amount of precipitation.

The main parameter for a rational calculation of storm sewers is the intensity of the rainfall itself, defined as the quotient of the precipitations in mm divided by the time during which this precipitation occurred:

$$i = \frac{h}{t} \tag{1}$$

where i – intensity of precipitation on the layer;

h – is the height of the precipitation layer in mm;

t - duration of precipitation in min.

Such data can only be obtained from automated rain gauges.

As a result of a comparative analysis of known types of rain gauges, it was concluded that a high accuracy and speed while maintaining ease of manufacture can be obtained with some improvement in the tipping bucket rain gauge used in foreign practice.

The principle underlying the tipping bucket rain gauge is ensures accuracy of rainfall measuring. The bucket is divided into two parts and mounted on a tungsten axle and pivots. When one part fills, the bucket tips to discharge the water to the ground and also activates a pair of switches. The other part of the bucket then fills and the cycle is repeated for as long as rain is falling. The typical tipping bucket rain gauge is shown in Figure 3.

There are round base element and the triangle bucket in the Figure. Base diameter is 143.5 mm, base height is 32.21 mm. Bucket length is 96.44 mm and height is 29 mm.

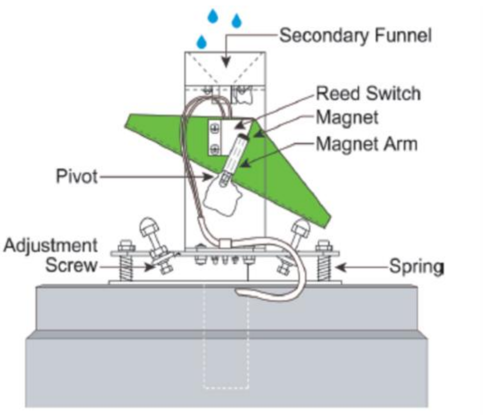

Fig. 3. The typical bucket rain gauge.

Further, taking into account the rains in Kazakhstan, we will calculate the dimensions of the rain gauge receiving bucket and will select the sensor of the tipping moments. Let us dwell on the choice of the size of the receiving funnel area S, cm^2. Denote the rain intensity R, mm/h, the volume of each of the cuvette buckets V, cm^3, the filling time of the cuvette chamber (time constant) - τ, s. As already noted, it should be within a few seconds for heavy rain and a few dozen for weak. Will recalculate the intensity of R, mm/h, to r, cm/s:

$$r = \frac{R}{36000} \tag{2}$$

At the same time, the volume of water poured into the cuvette bucket by the funnel in one second is equal to r S, and during the time τ is equal to r S τ, or

$$V = \frac{RS\,\tau}{36000} \tag{3}$$

As a result, the rain intensity R, mm / h, necessary for one tipping of the cuvette during time τ is

$$R = \frac{36000\,V}{S\tau} \tag{4}$$

If we substitute the above values of typical rain intensity into this formula, it turns out that it is convenient to choose a value slightly greater than 1,000 cm^2 as the optimal area of the receiving funnel of the rain gauge. For example, you can choose a square funnel with sides of 35 × 35 cm, which was implemented in this design.

Reed switch was selected as a tipping frequency sensor. The rain intensity data recording system will be built on the basis of a microcontroller. To simplify the implementation, a ready-made board was used, together with the registration and storage module. The module for recording and storing data contains a real-time clock chip.

In conclusion, we would like to note that this device is at the development stages. After some time, the device will be tested, calibrated, patented and installed in the territory of Astana city.

REFERENCES

Shneerov, A.I. (1953). Storm sewer. Moscow, 30-33.

Mink, J.W.A. (1974). Sensitive tipping-bucket rain gauge. Rev. Scientific Instruments. 45, N 10, 1268–1270.

Hasan, M. (1985). Rain Measurements for MM-Wave Propagation: A Review. 11, N 2, 179–200.

Levadnyi, Yu.V., Malyshenko, Yu.I., Chistova, T.E. (2016). Development of a rain gauge with enhanced accuracy and high rapidity with numerical indication of rain rate time dependency. Radio Physics and Electronics. T 7(21), №4, 56-59.

Loenko, N., Sakhanova, A., Beisembayeva, A. (2017). Where there is a forecast for weather: the Kazhydromet manual. Press service of RSE Kazhydromet.