The impact of intense rainfall on a storm sewage system of the east part of Trnava city

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Abstract. In large urbanized areas is used rainwater drainage and that has a negative impact on the functionality of the sewerage system during heavy rainfall. Pipes and objects on the sewer network are being overloaded. This causes quick floods. In our research, we are focused on the assessment of part of the sewerage of Trnava city. The collectors C and D belonging to the eastern part of the city. In our assessing we use boundary rain from ombrografic station of Trnava City.

1. Introduction

Urban drainage is one of the basic structural elements ensuring the standard of urban society, comfort, and health protection of the population. Urban drainage must have also a function of environmental protection. Newer grow up urbanization is causing an increase in production wastewater and stormwater which consequently leads to endangering the functionality of sewerage networks [1, 2, 3]. These facts require a complex solution of wastewater and stormwater management in a systematic way. Most municipalities have now built sewer systems, which at the time of their application was with desired capacities. Over time, the historical development of the urban areas itself, as well as the approach to solving the urban drainage, there is a need for reconstruction, restoration, completion or optimization of the system's function. In heavily urbanized areas, it is necessary to separate and purify water in the first run-off. The primary goal in this optimization is water retention with the possibility of infiltration into the ground. The water quality in the recipient is directly affected by the optimal operation of the sewer system [4, 5, 6].

2. Methods

The town of Trnava is located in the western part of Slovakia. The regional town of Trnava is between the Váh River and the Low Carpathians Mountains in the Danube Lowlands. It is part of the geomorphological complex of the Podunajská pahorkatina. The main recipient in the town is Trnávka river. The town of Trnava has built a rainwater sewage system with mechanical-biological wastewater treatment plant with anaerobic sludge stabilization. Completion of the sewage network was gradually being currently discharged sewage and rainwater from the entire urban area. Sewerage network, especially in the old city are hydraulically undersized, but also capacitively overloaded which is not in accordance with the current requirements for reliable operation of the sewer [7, 8, 9].

The hydro-technical calculations of the Trnava sewer network were carried out in the SeWaCAD program system. The SeWaCAD software system is a software tool for designing and assessing sewer networks. The program assesses dimensions or rainwater collecting systems or Wastewater collecting systems for draining rainwater, sewage, and industrial wastewater and pump stations.
Figure 1. Situation of sewerage network in program SeWaCAD.

As output provides the user with hydro-technical calculations, graphical outputs: longitudinal profiles and arbitrary types of drawing drawings. Ground sewer network is the main sewage collectors. The main drainage collector is intended for the supply of wastewater from the city of Trnava from the connection of collector C and D to the WWTP Trnava Zeleneč.

On the sewer network is built 20 combined sewerage overflows from which relief is water discharged into the recipient Trnávka. The CSO chambers are designed according to the dilution step and load the recipient in a ratio of 1: 4. D collector collects water from the eastern part of the city of Trnava (Figure 1).

We divide the rain by the height of the falling water column and the duration of the two groups, normal (normal) and extreme (abnormal). Short-lasting rain or extreme rainfall are (floods) or long-term (regional). Short and intense rains are critical dimensioning of sewer profiles, rainwater tank design and assessment of the impact of rainwater on the major recipient. Significant is also longer-lasting rain, occurring with short breaks. Information about the total rainfall, the duration of rainfall, intensity and time course in (weather station) are used rain gauge that writes time-escalation rain heights or intenzitografs that write time course intensity. An important factor for the mathematical simulation of rainfall surface runoff is the total period of years following years of rainfall in a given location. For the design of sewers for extremely heavy rain, a sufficiently long series of rain records must be available but must not be less than ten years [10].

3. Results and discussion

In calculating the assessment of part of collector B, we used the drainage coefficients corresponding to the surface area of the site. The terrain consists of built-up areas (roofs), transport and similar areas, non-built-up areas, cemeteries, playgrounds, and green areas. The slope of the terrain is mostly flat, inclined to 1 \%. In assessing the sewer network we used drainage coefficients that correspond to the surface area of the site. In the area considered, the terrain consists of built-up areas, pavements, and similar paved areas, playgrounds and green tracks. In the calculations we divided the area into four groups according to the density of the built-up area and we chose the coefficient $\psi$ accordingly (Table 1).
Table 1. Runoff coefficients $\psi$.

| Name                  | Coefficient $\psi$ |
|-----------------------|--------------------|
| Open spaces           | 0.2                |
| Slightly built-up areas | 0.35              |
| Medium built-up areas  | 0.6                |
| Densely built-up areas | 0.8                |

The precipitation frequency $P$ 5.0 corresponds to rain occurring 5 times a year. In the rain with this periodicity, 33 sections are overloaded, and 150 sections are satisfactory. Out of the total length of the assessed sewerage network of 24.7 km, 4.952 km are overloaded and 19.774 are without problems (Figure 2).

![Figure 2. Sewerage network overload at periodicity P 5.0.](image_url)

The precipitation period $P$ 0.5 corresponds to rain occurring once every 2 years. In the rain with this periodicity, 83 sections are overloaded and 100 sections are satisfactory. Out of the total length of the assessed sewerage network of 24.7 km, 11.134 km are overloaded and 13.59 are without problems. (Figure 3).
Figure 3. Sewerage network overload at periodicity P 0.5.

The precipitation period P 0.2 corresponds to the rain occurring once every 5 years. In the rain with this periodicity, 90 sections are overloaded and 93 sections are satisfactory. Out of the total length of the assessed sewage network of 24.7 km, 11.358 km are overloaded and 13.366 km are without problems (Figure 4).

Figure 4. Sewerage network overload at periodicity P 0.2.

4. Conclusion

In the research work, we considered the sewer network of Trnava - East. The main collector B was judged, judged by two model rains. The rain was analyzed with a periodicity of 0.5 and 0.1. From the analysis of the results, the overload is evident up to 500%. For the periodicity of 0.1 and 0.5, all sections except three were overloaded. Subsequently, a complex analysis of the results of surface drain simulation and subsequent simulation of flow in the sewer network reveals an enormous overload of the
sewerage network. As a consequence of the subsequent pickup of the individual collectors even during the usual rainfall event (Table 2).

| Length | 100 - 150% (m) | 150 - 250% (m) | 250 - 500% (m) | >500% (m) | 0 - 100% (m) |
|--------|----------------|----------------|----------------|----------|-------------|
| P = 5  | 3967.07        | 960.96         | 22.36          | 0        | 19774.03    |
| P = 1  | 2767.95        | 3889.93        | 3444.13        | 220.16   | 14402.25    |
| P = 0.5| 1456.81        | 3601.63        | 5354.65        | 721.23   | 13590.1     |
| P = 0.2| 630.03         | 2801.51        | 6281.38        | 1645.39  | 13366.11    |

The results indicate the need for the recovery and extension of the sewer network, or the design of the sewer network objects, which allow the control of extreme flows in the network. (Table 2). From the analysis of the results it is clear that the sewage system does not fulfill its purpose even in normal rain.

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