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Rainwater Infiltration in Urban Areas

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Preface

Urban drainage has become one of the most important components of civic amenities. Ensuring long-term functioning of sewerage networks and wastewater treatment plants is, however, connected with constantly rising costs, and today, it is clear that the modern method of urban drainage cannot for financial reasons be universally resolved. The existing methods of urban drainage continually imperil the status of watercourses as well as water sources. Urban hydrology was created in order to improve methods of managing the runoff of precipitation in towns and should protect them from flooding while also protecting public health or the environment. The essence of a future solution consists in finding an acceptable compromise of an alternative solution for draining rainwater from a territory. The content of this work is a study focused on resolving the percolation of water from surface runoff and the confrontation between a field test, laboratory analysis and numerical analysis. By confronting and subsequently proposing conditions for percolation, documents will be created for making urban drainage better and more efficient. The reason for the origin of the subject work follows from the insufficient information on infiltration systems in Slovak technical standards and likewise the lack of support for the percolation of water from surface runoff. This work points out the approaches, principles and fundamentals of a proposal for percolation. The aim of the work is the distribution of scientific knowledge in the field of research and solutions for the percolation of water from surface runoff, with emphasis placed on the retention capacity of the selected territory and the intensity of precipitation.

This book presents a comprehensive study of the percolation of water from surface runoff with an emphasis on the retention capacity and intensity of precipitation. The content of this work is a study focused on resolving the percolation of water from surface runoff and the confrontation between a field test, laboratory analysis and numerical analysis. By confronting and subsequently proposing conditions for percolation, documents will be created for making urban drainage better and more efficient. The aim of the work is the distribution of scientific knowledge in the field of research and solutions for the percolation of water from surface runoff, with emphasis placed on the retention capacity of the selected territory, determination of filtration coefficient and the intensity of precipitation.

Keywords Precipitation • Surface runoff • Percolation of precipitation
Runoff coefficient • Urban drainage

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Gabriela Hudáková is graduated with master's degree and Ph.D. degree in the field of Environmental Engineering at the Institute of Environmental Engineering, Faculty of Civil Engineering at the Technical University of Košice, Slovakia. Her scientific work as well as her thesis was devoted to rainwater management and design of infiltration facilities. She was participating in project implementation regarding the rainwater management in urban areas, and she published the results of her research in scientific proceedings of national and international conferences.

Agnieszka Stec currently works at the Department of Infrastructure and Water Management, Rzeszów University of Technology, Poland. She does research in Environmental Engineering focusing on rainwater management, rainwater utilization and drainage systems in urban areas. Her most recent publication is "The impact of land use and urbanization on drainage system." She is participating in research as well as professional projects.

Chapter 1
Rainwater Management in Urban Areas

Abstract At present, a new trend is arising in regard to approaches which try to renew the developmental treatment of runoff and the quality of water, with growing interest and acknowledgement of the fact that renewing the natural water balance contributes to a healthier environment and improves living conditions in urban landscapes. In the past, rainwater was considered only as an inconvenience; today, it is considered with increased interest as a resource. Yet, despite progress many uncertainties exist in urban hydrology. Additional research is required into the time–spatial dynamic of urban precipitation, particularly in order to improve the short-term prediction of the amount of precipitation. All problems and challenges are covered by the uncertainty of climate changes, which adds the obligation to ensure that systems of rainwater management are adaptable and resistant to changes. Urban hydrology plays an important role in the resolution of these problems.

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All problems and challenges are covered by the uncertainty of climate changes, which adds the obligation to ensure that systems of rainwater management are adaptable and resistant to changes. Urban hydrology plays an important role in the resolution of these problems.

The science of urban hydrology has evolved with the aim of improving urban water management for public health and hygiene, for flood protection, as well as for the protection of the environment and the life cycle of cities. Management of urban drainage requires several disciplines: engineering, environmental science, public health and sociology. Urban hydrology is not even close to being simple and requires the development of new technologies that point out the technical problems in towns and which

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correspond to the needs of urban communities. The ability to measure and model hydrological parameters and processes depends on the ability to measure and predict precipitation on a high level in relation to time and spatial accuracy. This requirement is even more necessary in the case of towns. This has led to many innovations in the measurement of precipitation, such as the use of digital rain gauges and the development of precipitation models for application in simulations of precipitation–drainage processes in towns.

In recent decades, a wide scale of approaches has been developed for alleviating hydrological influences as well as impacts on the quality of water as a consequence of urbanization. However, a significant debate still remains over the best approaches, suggesting that the drainage of precipitation and storm water in towns remains a complex and complicated area. A new trend has arisen in regard to more integrated approaches which deal with changes in the regimen of flows and at the same time the quality of water and which attempt to consider rainwater as a source or resource and not only as a problem that has to be eliminated. The development of integrated models for prediction and assessment of the effectiveness of alternative approaches toward drainage of rainwater in cities, considered as part of a broader urban water cycle, has only recently become a major point of interest.

The work tackles an issue from urban hydrology and from the field of handling rainwater. It clarifies the progress achieved in recent years in the field of urban drainage and current trends and deficiencies which represent obstacles for a fully integrated approach to the resolution of urban drainage, so that the needs of both cities and the environment are met. The work is focused on the study of rainwater percolation in selected territories. The achieved results support the development of urban hydrology and resolution of the drainage of rainwater from urbanized territories.

Topicality of the Subject

Management of precipitation water is an important activity not only in agriculture and water management, but also in the construction field. The percolation of precipitation water is a current and important issue, especially in the present in association with climatic change, when it is necessary to slow the runoff of water from land, support the percolation of water into soil and increase the retention capability of the ground. The importance of the presence of water in soil and rock underlines the fact that all the processes in them are closely linked with water, and this is, together with air, nutrients and heat, a primary condition of soil fertility.

An engineer comes across groundwater with a variety of intentions: to utilize it or to protect against it. Therefore, to determine its presence and to conduct quantitative and qualitative analyses is of great importance. The cooperation of hydrologists with geologists, chemists and pedagogues and often with biologists and bacteriologists is, however, necessary. In places where the movement of groundwater takes place under very complex conditions, the laws governing such movements are very complex. The resolution of problems in the conditions of Slovakia requires deeper study of groundwater movement.

Purpose and Aims of the Work

The purpose of the work is the proposal of conditions for percolation, which are derived from an analysis of precipitation, a geological survey in the selected localities, and from existing known equations for calculating the percolation of precipitation from surface runoff, for the needs of urban drainage.

The work is processed in the sense of Slovak legislation, specifically Act No. 364/2004 Coll. on Waters, in the wording of Act No. 394/2009 Coll., Government Regulation No. 269/2010 Coll. by which the requirements for achieving a good state of water are provisioned, and Regulation of the Slovak Ministry of the Environment No. 397/2003 Coll., by which details on measuring the amount of water supplied to public water mains and amounts of released waters are provisioned, on the method of calculating the amount of released wastewaters and waters from surface runoff and on directive numbers of water usage, and existing foreign standards, such as DWA—A 138—Design, construction and operation of percolation facilities for precipitation water, or Czech standard ČSN 75 9010—Percolation facilities for precipitation waters, are included.

The aim of the work is the distribution of scientific knowledge in the field of research and resolving the percolation of water from surface runoff with an emphasis on the retention capacity of the selected territory and intensity of precipitation. The fulfillment of the aim of the work requires resolving tasks through the following subjects:

- setting the proposed values of the amount of precipitation water from the monitored data;
- description of the range and methods of carrying out a geological survey for the percolation of precipitation water;
- resolution and research of the mutual relation of rainfall intensity and percolation of water from surface runoff with the task of determining the percolation period;
- evaluation of alternative solutions for the percolation of rainwater, proposal of an optimal resolution for the given conditions;
- setting the conditions for the percolation of precipitation water;
- interpretation of the scientific contribution of the work and its use in practice.

Methods Used and Process of the Solution

The methods used come from practical experience as well as from knowledge obtained from the available literature and consultation with professionals dealing with the given issue in practice. Figure 1.1 shows an outline of methodology of the research process.

As follows from the diagram, four methods of research are proposed. A field test uses the real measuring of precipitation with parallel percolation. With laboratory analysis, a grading curve is determined and subsequently the filtration coefficient, and numerical analysis deals with the modeling of percolation. Empirical relations and dimensional analysis belong to numerical analysis. A detailed description of

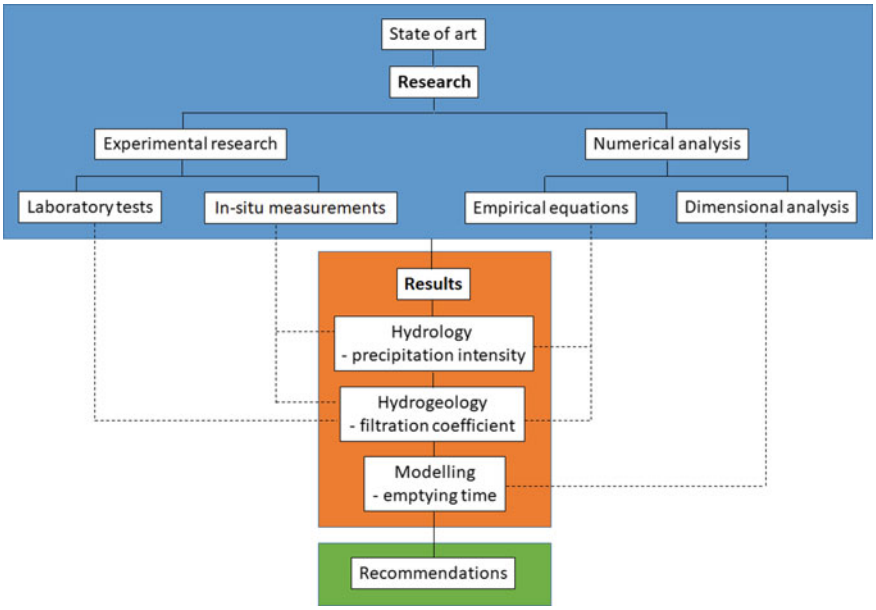

Fig. 1.1 Diagram of the methodological approach of resolving the work

these methods of research is given in Chap. 2. The result of the research is a proposal of conditions for percolation.

Importance of the Work

This work should provide information and resolve the issue of urban drainage. The research problem becomes the subject of a solution, the results of which are documents usable for designers with the proposal of percolation facilities. The importance of this work consists particularly in the proposal of conditions for percolation in the conditions of the Slovak Republic, which supplements the mentioned importance of the work. The conclusions of the work will form the foundations for additional research in the area of urban drainage, since the need for the percolation of precipitation water continues to show a rising tendency.

Synopsis of the Work

The work is composed of four chapters. The introduction contains a brief background summary for the study and outlines the research problem, purpose and aims of the study. In this Chapter, an overview of knowledge from hydrology, an overview of knowledge on the percolation of precipitation from surface runoff in the context of urban drainage and likewise an overview of basic activities from hydropediology and hydrogeology are presented. The Chap. 2 describes a specific study on model territory I—Košice—and model territory II—Prešov—and also their instrumental