

Design considerations for infiltration trenches applied to small villages

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INTRODUCTION

Population growth, changes in people's habits and urbanisation are some of the causes of the overloading of sewerage drainage systems, both combined or separate. At the same time, the transportation of water by drainage systems causes important changes in the natural hydrological cycle (Matos, 2000). Drainage systems of small villages, usually combined systems, do not have the capacity to receive the volume of water coming from new urban areas. Source control is a very interesting solution for a sustainable urban stormwater drainage system.

At Évora University a research area has been developed for the study of infiltration trenches applied at small villages in the Alentejo Region. Two infiltration trenches of 3 m length, 0.6 m width and 1.0 m depth were built in an area that provides the most representative group of soils in the Alentejo. Two numerical models were developed to simulate hydraulic functioning of the infiltration trench: COAP/InfilTrex Model applying Richard's equation to represent the drainage in the trench and in the soil, and the Simplified Model also applying the Richard's equation to represent drainage in the trench and the Green-Ampt equation in the soil.

Using numerical models, economic design criteria for infiltration trenches will be assessed in order to increase the efficiency of the trench, i.e. the relation between the infiltrated flow and the inflow of the trench.

This paper presents one example of a nomogram developed, using the Simplified Model and applied to infiltration trench design. The nomogram, based on Green-Ampt model, must be used with care because of its specificity to the soils studied in this research.

NUMERICAL MODELS

COAP/InfilTrex Model

In this model, drainage through the trench is represented by the Richard's equation, in its one-dimensional form, considering that the longitudinal length of the trench is much

greater than its transverse dimensions:

$$\frac{\partial h}{\partial t} - \frac{K}{2n} \frac{\partial^2 h^2}{\partial y^2} - \frac{K_i}{n} \frac{\partial h}{\partial y} = -\frac{Q_{inf}}{nb} + \frac{Q_{abast}}{nb} \quad (1)$$

It is assumed that the drainage through the material filling the trench takes place in a saturated environment and that the saturated hydraulic conductivity and the effective porosity of the filling material remain constant in time.

The equation for the one-dimensional drainage, Equation (1), is solved numerically through the application of the Finite Differences Method with an explicit scheme, calculating water height in different sections along the trench and at different moments. Initial conditions are water heights at selected sections. Boundary conditions assume that hydraulic heads at boundary sections are equal to hydraulic head at neighbouring sections.

Having obtained the water height variation at the trenches, the volume of infiltrated water is then calculated. The movement of water in the soil is represented by the Richard's Equation in its bi-dimensional form:

$$C(h) \frac{\partial h}{\partial t} = \text{div}(K \text{grad}(h - Z)) \quad (2)$$

in which:

$$C(h) = \frac{\partial \theta}{\partial h} \quad (3)$$

It is assumed that effective porosity and saturated hydraulic conductivity are constant in time.

The numerical solution of Equation (2), applied to a cross-section perpendicular to the longitudinal direction of the trench, is achieved through the application of the Finite Differences Method with an implicit scheme (Tabuada, 1989), by calculating the effective pressure and the water content at the different points of the calculation grid.

The application domain of the equation corresponds to the surrounding soil at the cross section of the trench, as shown