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Modelling unsaturated flow patterns in green roof substrates

Anna Palla, Ilaria Gnecco, and Luca G. Lanza
University of Genova, DICAT (Dept. of Construction, Environmental and Territorial Engineering, Genoa, Italy)
(anna.palla@dicat.unige.it)

The aim of this research is to examine the unsaturated flow within the green roof substrates realized with high conductivity and coarse grained porous media. In order to base our research on experimental evidences, a monitoring program was carried out at University of Genova (Italy).

The green roof experimental site was obtained by retrofitting an existing single-layer vegetated roof built in the sixties into a modern technological system fully equipped with sensors for on-site meteorological, hygrometric and flow rate measurements. The drainage and growing substrates are volcanic material mined, blended and graded by Europomice Srl (Grosseto, Italy). These graded porous media are employed in green roof systems for their low bulk density, high porosity and high hydraulic conductivity. The site is equipped with a meteorological station (for rain data, air temperature and humidity, solar radiation and air pressure), four TDR probes for continuous water content monitoring along a vertical profile and a suitable hydraulic device for continuous outflow monitoring.

The SWMS - 2D model that solves the Richards' equation for two-dimensional saturated -unsaturated water flow was used to simulate the hydrologic response of the experimental green roof. The model was calibrated and validated using rain events recorded at the experimental site in a one-year monitoring campaign. The calibration and validation events are selected in order to include events representative of the four seasonal conditions characterized by different antecedent dry weather periods and consequently different initial soil water content distributions. The calibration and validation strategy involved comparing predicted and measured outflow hydrographs.

The mechanistic model, here employed to describe the variably saturated flow within the thin stratigraphy of a green roof, is based on a single porosity approach and is demonstrated to suitably describe both the outflow hydrograph and the water content observed at various depths along a vertical profile. The investigated approach properly reproduces the infiltration process and is therefore suited for coupling with a soil-vegetation-atmosphere-transfer module to simulate (describe) the whole water cycle at the green roof scale.