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Influence of soil water content on thermal performance of green roofs

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DECLARATION

I declare that this research report is my own unaided work. It is being submitted in partial fulfilment of the Degree of Master of Science in Engineering to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

……

(Signature)

…….. day of ……..., ……

(day) *(month)* *(year)*

ABSTRACT

Covering bare roofs with growing medium creates a bionetwork that has ecological benefits. This study investigates the effect of soil water content (SWC) on the thermal performance of green roofs. The objective is to determine whether green roofs are effective under various climatic conditions. Simulation of a direct application extensive green roof was done on the roof of the Hillman building at the University of the Witwatersrand in Johannesburg, South Africa. Measurements of SWC (measured as volumetric water content - VWC) and temperature were taken from December 2011 to January 2012. Laboratory soil bulk density tests were done once every two weeks. In order to observe the effect of SWC on thermal performance, average temperature (T_{ave}) and amplitude (A) in temperature variation were plotted as a function of VWC. These parameters increased slightly with SWC in either vegetation or soil. SWC levels were higher in vegetation compared to soil. Heat capacity (C_v) and thermal conductivity (K_q) were also plotted as a function of VWC so as to see the effect on thermal properties. The relationship between C_v and VWC was linear. High SWC increased C_v, hence a reduction in both T_{ave} and A was shown with increasing SWC. The trend for (K_q) was not clear due to inconsistences in the method used to approximate thermal diffusivity (D_q). Research on other methods for computing D_q is recommended. K_q appeared constant with increasing SWC. On the other hand, with evapotranspiration, as SWC increased, there is a tendency for VWC Vegetation to initially decrease. This trend may point out evapotranspiration as the dominant factor compared to the thermal properties. The study needs to be repeated in winter so that a comparison is done between summer and winter. Data should also be collected over a longer period of time.

In loving memory of my mother, Rezen, who passed on when I was only two weeks and five days old. May her soul rest in peace.

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LIST OF SYMBOLS

Density of water	ρ_w
Heat capacity based on volume	C_v
Mass water content	θ_m
Mean specific heat capacity of solid components	C_{pav}
Pi	π
Specific heat of soil and water mixture	C_p
Specific heat of water	C_{pw}
Soil Bulk density	ρ_b
Thermal Diffusivity	D_q
Thermal conductivity	K_q
Volumetric water content	θ_v

LIST OF ACRONYMS

SWC	Soil Water Content
UHI effect	Urban Heat Island effect
VWC	Volumetric Water Content