III－100 Numerical analysis of unsaturated flow beneath a grass field

Abdel-Lah,Ahmed Khalaf , SAITAMA UNIVERSITY
Watanabe,Kunio , SAITAMA UNIVERSITY
Tazaki ,Nanaka , TAISEI CORPORATION

Introduction

Many man-made grass fields have been constructed in an urban and/or sub-urban area. These grass fields will be used as a park, a sports field, a horse racing course, and so on. The moisture condition in the shallow part of these ground must be well controlled because the moisture condition has much influences on the grass growth and the hardness of ground. The moisture condition is mainly controlled by the drainage system, the evapo-transpiration and the surface roughness. The present authors numerically analyzed the moisture movement in the shallow part of an idealized grass field with modeling the surface roughness and the transpiration. The surface roughness and the evapo -transpiration were measured in an actual grass field prior to the modeling.

1.Surface roughness and evapo-transpiration

The Tokyo Horse Racing Course was selected as an example of the actual grass field. This grass field has been well maintained and the moisture condition beneath the surface has been carefully checked because the moisture condition governs the hardness of the ground that effects the horse running. Figure 1 schematically shows the artificial soil structure in the shallow part. The shallow part is essentially composed of three types of soil, sandy clay,sand and sandy gravel . The height of the grass is about 3 - 5 cm and the roots are concentrating within a narrow zone developing beneath the surface. The thickness of this zone is about 8 cm. Figure 2 shows the surface roughness measured. The depressed part was originally formed by the horse hoofs and grasses in these parts are lacked. The edge parts of these depressions are covered with the grass leaves. Some small depressions are almost completely covered with leaves.

The evapo-transpiration was measured on August 25,1993 using a ventilation type evaporation-meter. Figure 3 shows the transient changes of the evapo-transpiration and the net-radiation. The evapo-transpiration temporarily changed mainly due to the radiation change. The transient change of the evapo-transpiration was approximated by a quadratic curve shown in Figure 4 for the numerical simulation of the moisture change.

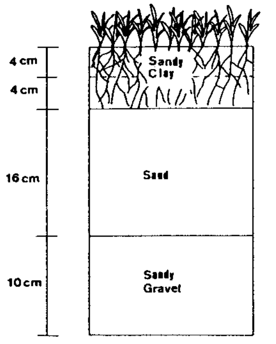

Fig. (1)

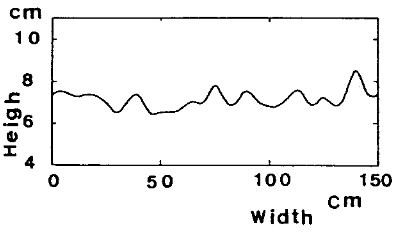

Fig. (2)

2. Numerical simulation of the moisture change

With taking the soil structure into the consideration, the shallow part of ground was modeled as shown by Figure 5 (a) and (b) that are a flat surface model and a rough surface model, respectively. A depression was assumed in the rough surface model. The effect of the surface roughness on the moisture movement can be investigated with comparing the calculated results obtained using these models. The distribution of the hydraulic conductivity was assumed as shown in these figures. A constant pressure head condition was given on the bottoms of these models. Pressure head of 0 was given on this bottom line. This condition implies that the bottom is identical to the water table. The no-flow condition was given on both side walls. Water was taken from many nodal points in the upper part of these calculated domain as sinks for modeling the water sucking by roots. The intensity of sink given on every nodal point must be approximated. The total amount of the water sucked from a vertical column of

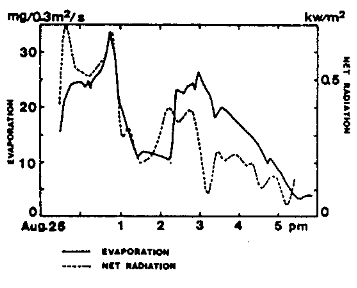

Fig. (3)

soil having a unit cross-section is identical to the evaporation rate measured. The intensity of the sucking of water may be a function of the density of roots because water is sucked by roots. With taking the vertical profile of the density distribution of roots, the intensity distribution of sink was approximated with the linear functions as shown in these figures. However, no sink was assumed under the depression in figure 5(b) because grasses are thought to be lacked in this part. As the initial condition, total head of 0 was given on every nodal point. The total evapo-transpiration (Ev) rate change was approximated with the quadratic curve in figure 4. The relation between the saturation, the suction and the relative permeability is indispensable for the calculation. Figure 6 shows the relation used in these calculations. These curves were selected with the assumption that the ground is mainly composed of sand.

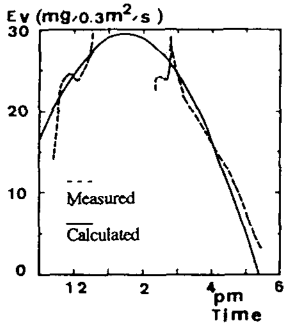

Fig. (4)

Figure 5 also shows the elements in these two models. The sizes of elements in the upper parts of this domain are small as compared with those in the other part. The element sizes under the depression are also small. The moisture movement is more precisely calculated in the parts of small element size.

Figure 7 (a),(b) shows two saturation distributions at 5:00 pm , respectively, calculated by using the flat surface model and rough surface model . It is clearly found that the surface roughness much influences the moisture movement in the shallow part of ground.

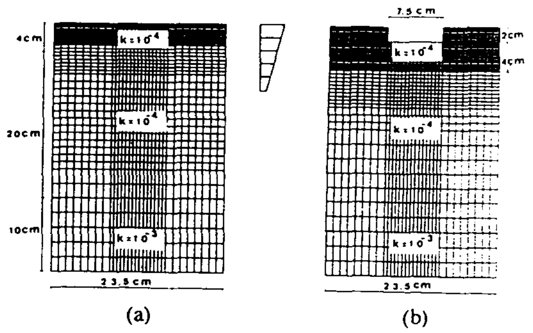

Fig. (5)

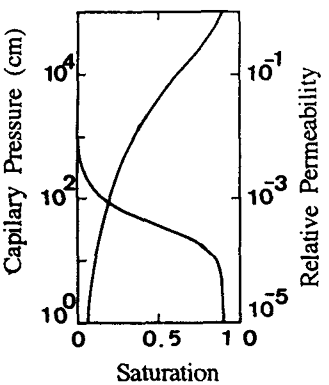

Fig. (6)

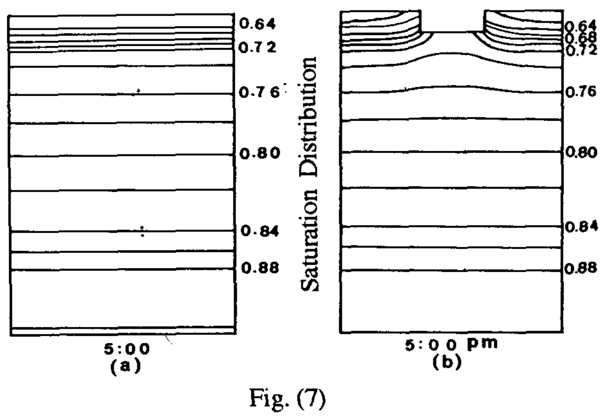

Fig. (7)

3. Conclusions and future problems

The moisture movement in the shallow part of underground is much influenced by the surface roughness and the distribution of the roots. It can be concluded that the detailed study on these featurs in the field are very important and indispensable to evaluate the moisture movement. Although the movement can be fairly well analyzed, there remain many problems unsolved. The largest problem is to precisely estimate the unsaturated properties of soil. It is necessary to know a new technique to measure the unsaturated properties of soil in the field. The relation between root system and the transpiration will be also investigated. These problems must be solved for evaluating the movement.

References

1)Watanabe ,K. & Tsutsui ,Y. (1994):"A new equipment used for measuring evaporation in a field ", Proc. 7 th Congress IAEG.