Numerical Simulation Analysis of Temperature Field of Airport Concrete Pavement

Jun-hong LUO, Rui ZENG and Hong-wei LIU

Department of Airfield Engineering and Support, Air Force Logistics College, Xuzhou 221000

Abstract. In this paper, through the analysis of the structure of airport concrete pavement surface, thermal properties, thermal properties, air parameters, solar radiation, atmosphere long wave radiation, obvious heat exchange and latent heat exchange of background and other factors, this paper build one dimension ground temperature field model. Then, we find finite element method solution of the model by ANSYS, get the temperature contours of the airport road surface, so as to provide theoretical support for the airport equipment of infrared stealth design, camouflage to guide the practice of airport equipment, camouflage effectiveness evaluation.

Preface

The airport way surface is to provide an airplane take-off, land slippery run and carry on flight before prepare with support to maintain of the place is the corpus part of airport. Currently local big part at use of airport way surface is cement concrete rigid way surface, the surface strength high, whole good, the degree just was big, could bear a bigger airplane machined round to carry a lotus, but because the cement concrete has hot the capacity is small and absorb heat to heat a quick hot thing characteristics, be subjected to function of the factors, such as atmosphere temperature and the sun heat radiation, etc., make the cement concrete way surface of temperature the other background variety is obvious, become the red outside of airport typical model revelation symptom.

To certain earth's surface, its surface composing is certain. As long as knowing earth's surface temperature, can compute the red outside of an earth's surface radiation circumstance. The earth's surface temperature is the result of the Earth, the sun and atmosphere interaction. Influencing the factor of natural earth's surface temperature is a lot of, such as short-wave absorption rate, long wave blast-off rate, the sun Fu shine on degree, atmosphere temperature, air degree of humidity, wind velocity and surroundings environment etc., but return a knot bottom, of earth's surface and environment always the existence radiation, convection and heat conduct three basically change hot process. Pass to analyze these hot processes, can get a variety regulation of earth's surface temperature, get the red outside of an earth's surface radiation regulation further.

Airport Way Surface Temperature Field Model

Airport Way Surface Temperature Field Model Boundary Condition

Airport way surface temperature field model boundary condition the influence of the perpendicular gradient upon the way surface temperature field of the way surface temperature is the biggest, while the hot conduction of level direction can look like to neglect not to account, therefore, the on the side boundary condition is commendable to change the hot coefficient into 0 of cut off a hot boundary condition.

(1) Last boundary condition: Then earth's surface energy hot equilibrium equation

The red and outside Fu degree of earth's surface is decided by its surface temperature and surface to shoot a rate, but it surface temperature from it the hot equilibrium equation decide. Earth's surface and the hot commutation item of environment mainly include the earth's surface absorption sun short-wave radiation. The earth's surface absorbs atmosphere long wave radiation, namely atmosphere the red outside radiate. The earth's surface oneself heat radiates; Earth's surface and environment show hot commutation, mainly consider that the convection of earth's surface and

surroundings air changes hot. Earth's surface because the humidity is lost but the causable latent heat exchange and mainly consider the evaporation of earth's surface humidity, congealed and lose a luck and decline factors like water, etc. Earth's surface hot flux, earth's surface energy hot equilibrium equation[1]:

$$Q_{sun} + Q_{skyr} + M_g + H + EL + G = 0 \qquad (1)$$

In the formula:

The Q_{sun} is the sun short-wave that the earth's surface absorbs to radiate; The Q_{skyr} is the atmosphere long wave that the earth's surface absorbs to radiate;

M_g is the Fu of the earth's surface degree; The H is that the of earth's surface and environment show hot commutation; The EL is an earth's surface because the humidity is lost but the causable latent heat exchange; The G gets for the earth's surface of hot flux.

(2) Underneath boundary condition: According to theory analytical with actually measure result enunciation, at underground deep is one meter place, lying quality temperature day and night to change can neglect not to account, consequently underneath boundary conditional control equation BE:

$$\left.\begin{array}{l} T\big|_{z=z_0} = T_0 \\ \dfrac{\partial T}{\partial z}\bigg|_{z=z_0} = 0 \end{array}\right\} \qquad (2)$$

The T_0 is the earth's surface depth z_0 temperature, take the value as the average air temperature of the region or so, higher in summer, low in winter. During the textual calculation, the z_0 takes one meter, the T_0 takes to be worth to 290 K.

$$\rho c_p \frac{\partial T}{\partial \tau} = \frac{\partial}{\partial x}\left(\lambda \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(\lambda \frac{\partial T}{\partial y}\right) + \frac{\partial}{\partial y}\left(\lambda \frac{\partial T}{\partial y}\right) \qquad (3)$$

（3）hot conduction of level direction：

In the type: The T is an object in a sudden Tai temperature; The τ carries on for the process of time; The λ transmits heat coefficient for material and makes a constant processing; The ρ is the density of material, make a constant processing; The c_p certainly presses specific heat to permit for material and makes a constant processing.

The Atmosphere Long Wave Radiates

For the clear sky, from Brown especially formula, atmosphere long wave radiation BE[3]:

$$Q_{sky} = (a + b\sqrt{e})\varepsilon\sigma T_a^4 \qquad (4)$$

In the type, the ε is the blast-off rate, an of earth's surface, a and b is experience parameter, and the e is a steam pressure (KPa) in the air,

$$e = rh \times 0.61078 \times \exp(17.269 \frac{T_a - 273.15}{T_a - 35.19}) \qquad (5)$$

The rh is relative humidity, the T_a is the sky background absolute zero, the σ f is the Si Te Fan-Bo Er Man constant, $\sigma = 5.67 \times 10^{-8} W/(m^2 \cdot K^4)$.

For the cloudy sky, atmosphere long wave radiation BE:

$$Q_{sky} = (1 + nc^2)(0.61 + 0.05\sqrt{e})\sigma T_a^4 \qquad (6)$$

The c is a bank of clouds overlay degree; The n is experience parameter, low, Gao bank of clouds distinguish to 0.2 with 0.04.

The Earth's Surface Oneself Heat Radiates

According to the aroma-Boer of Si Di Man laws, earth's surface because of the hot radiation aroused by the temperature of oneself with it surface of four powers of temperature become direct proportion, description as follows:

$$M_g = \varepsilon \sigma T_g{}^4 \tag{7}$$

The ε in type is the blast-off of earth's surface to lead; The T_g is the temperature of earth's surface, K.

The Earth's Surface Shows Heat and Latent Heat Flux

(1)Show hot calories commutation[4] BE:

$$H = \rho_a C_p C_D u_a (T_a - T_g) \tag{8}$$

In the type: ρ_a Air density, 1.29 kg/m3; C_p The air certainly presses specific heat, $1.0 \times 10^3 J / kg \cdot K$; T_a The atmosphere temperature that makes reference to high place, K; T_g the temperature of earth's surface K; C_D Drag coefficient, $C_D = 0.002 + 0.006 \times z / 5000$; z Elevation height; u_a Wind velocity (the normal wind velocity adds gust wind influence).

(2)The latent heat calories exchanges for[4]:

$$EL = \rho_a L C_D u_a (q_a - q_g) \tag{9}$$

In the last type, L the vaporization latent heat of water, $L = (597.3 - 0.555t) \times 4200 J / kg$, the t is an air temperature; q_a Making reference to the ratio of high place is wet; q_g the saturation of earth's surface compares wet.

q_a and q_g is from next say two types respectively to:

$$q_a = q_{sat}(T_a) \times rh \tag{10}$$

$$q_{sat}(T_a) = 0.622 \times \frac{e(T_a)}{p_0 - 0.378 \times e(T_a)} \tag{11}$$

$$q_g = 0.622 \times \frac{e(T_g)}{p_0 - 0.378 \times e(T_g)} \tag{12}$$

$$e \, (T_a) = rh \times 0.61078 \times \exp(17.269 \frac{T_a - 273.15}{T_a - 35.19}) \tag{13}$$

In the type: $q_{sat}(T_a)$ the saturation compares wet; rh Relative humidity.

Airport Way Surface Temperature the Field Solve

Build up the earth's surface of earth's surface to cut noodles model in ANSYS, demarcation mesh, constitution material the attribute and boundary condition and beginning starts a condition, time d=276, the atmosphere clarity P takes 0.80, the bank of clouds overlies degree 30%, bank of clouds

high experience parameter n=0.04, the density ρ of cement concrete=2500, specific heat, C_p=837 $J/(kg \cdot K)$, transmit heat coefficient λ=1.28, reflectivity α=0.25, compare a radiation rate ε=0.92. The density ρ of soil=1800 kg/m^3, specific heat C_p=1580 $J/(kg \cdot K)$, transmit heat coefficient λ =0.596, reflectivity α=0.32, compare a radiation rate ε=0.82. The crushed stones layer parameter takes the average value of the cement concrete parameter and soil layer parameter; The tallest air temperature is 25 ℃, lowest the air temperature is 13 ℃, add to carry heat to flow to carry a lotus to carry on solving, temperature cloud diagram such as figure 1 show, can keep the view ground temperature variety that visits way noodles surface in an airport for a day circumstance from temperature cloud diagram.
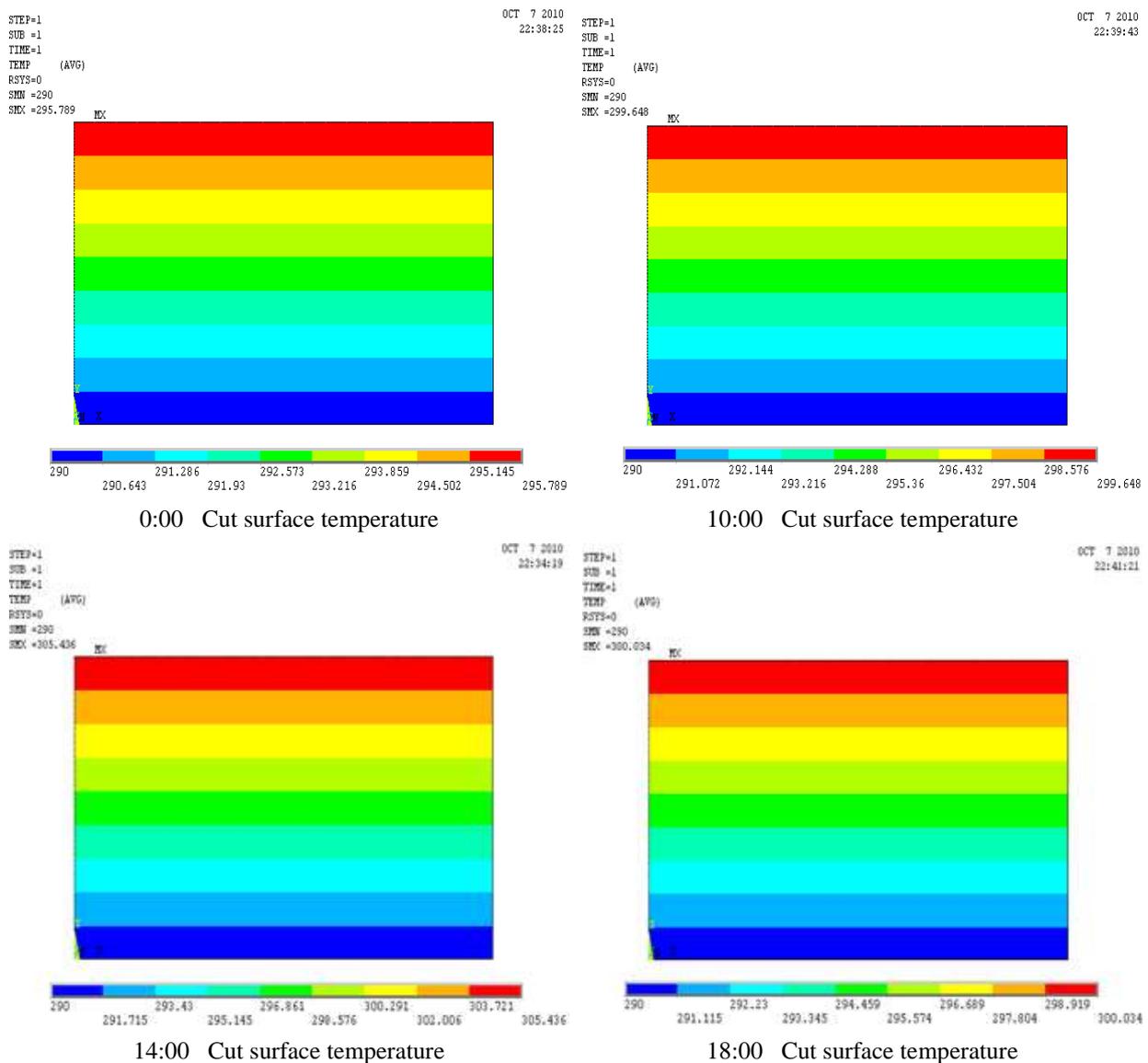

0:00   Cut surface temperature

10:00   Cut surface temperature

14:00   Cut surface temperature

18:00   Cut surface temperature

Figure 1. The airport way the surface temperature field distributes.

Conclusions

For acquire the airport guarantee material background of red outside radiation characteristic, this text passes to analyze airport concrete a way the type of the noodles earth's surface, the structure, hot thing and air parameter, the sun radiation and atmosphere long wave radiation, earth's surface and environment of show heat and latent heat to exchange etc. factor, build up an one dimensional background way noodles temperature field model, make use of ANSYS as to its carry on a limited

dollar to solve, get temperature cloud diagram, can have already aimed at the ground to develop outside concealed body design, then guide the camouflage fulfillment of the material of airport guarantee, evaluate camouflage effect, raise the battlefield of the material of airport guarantee existence ability.

Reference

[1] Xinai Bai. The radiation changes the calculation of hot Cape coefficient [J]. Red and outside technique, 2008, 29:(8)30~33.

[2] Huang Liang. The red outside radiation characteristic of the ground background the calculation and red outdoor scene elephant is born[D]:[Master degree thesis]. Nanking: Nanking tech university, 2009.

[3] Wren, G.P., et al., Analysis Of Bore Surface Temperature in Electrothermal-Chemical Guns[R]: Final report, AD-A242198,1991.

[4] Yimin Xuan, Yuge Han, Lanbo Cai. Ground target and the red and outside characteristic of background[M]. Peking: Defence industry publisher, 2004.124~127.