8 THERMAL LOADS

8.1 Scope of Applications

Thermal load is defined as the temperature that causes the effect on buildings, such as outdoor air temperature, solar radiation, underground temperature, indoor air temperature and the heat source equipment inside the building. The change of the temperature in the structural and non-structural member causes thermal stress and is defined as the effect of thermal load.

8.1.1 Change of temperature

The initial temperature is defined as the temperature which causes no thermal effect on a building. The temperature difference ΔT has two parts, mean cross-section temperature ΔT_d and the temperature gradient in the cross-section $\Delta T_g / t$.

8.1.2 Consideration of thermal load

Thermal loads should be considered for the following building types: building constructed in an area where there is a considerable change in outdoor air temperature, building with large length, building with large space inside, building with direct influence of solar radiation like a building with glass roof, building or structure with heat source such as a chimney, silo containing warm material, heat storage tank, refrigerated warehouse and electric power plant. When the building is divided into smaller parts with expansion joints to reduce the movement in each part, or the temperature change in the structural member is reduced by thermal insulation, thermal load may not be considered.

8.2 Thermal Load

The basic thermal load is the 100-year-return period of the change in outdoor air temperature, solar radiation, underground temperature or equivalent value.

The basic thermal load of outdoor air temperature is based on the 100-year-return period value of the annual highest and lowest temperature. The temperature in a member should be calculated using the outdoor air temperature and/or solar radiation, in consideration of the type of the structure, reinforced concrete structure or steel structure, solar radiation absorption factor, thermal inertia, heat transfer coefficient, and the annual and daily variations of temperature and solar radiation.

It is recommended that the temperature in the member be calculated using time-history analysis considering the change of outdoor air temperature and solar radiation. It is also possible to calculate the temperature in member with steady state of highest or lowest temperature, ignoring the daily change, but the result of the calculation may be too conservative when the member has large thermal inertia, like a reinforced concrete member.

8.2.1 Outdoor air temperature

(1) 100-year-reccurence value of highest and lowest outdoor air temperature

The 100-year-reccurence value of highest and lowest outdoor air temperature was calculated using fitting of extreme value distribution on 41-year data from 1961 to 2001 obtained from Meteorological Office.

(2) Time history data of outdoor air temperature and solar radiation

The time history data based on the 100-year-reccurence value is not ready. Instead, some of the published data for air-conditioning are shown.

8.2.2 Solar radiation

The effect of solar radiation on a building should be considered using Sol-Air Temperature T_{SAT} (8.2.3).

$$T_{SAT} = T_0 + \frac{a}{\alpha_0} J \tag{8.2.3}$$

where

T : Outdoor air temperature

J : Solar radiation

a : solar absorptivity

α_0 : total heat transfer coefficient of outer surface

8.2.3 Underground temperature

The underground temperature should be considered to determine the thermal effects on basement structures and foundations. Daily changes of temperature come down to only 0.5 meter below grade. Where it is deeper than 10 meters from the ground surface, it is considered that the temperature does not change and is equal to the annual mean air temperature.

8.2.4 Indoor temperature

The indoor temperature should be determined by evaluating the scheduled air-conditioning environment. It is also important to consider the indoor temperature for the condition when the building's air-conditioning does not function as expected. It is ideal that the indoor temperature when it is not air-conditioned be calculated considering the thermal insulating properties of the building, but it is also possible to consider the temperature of the structural members of the building to be the same as the outdoor air temperature.

8.2.5 Other temperatures

Some data from the actual measurement of various building structures are introduced.