Building apartment information, calculating conditions and parameter settings

(1) Plain layout of the flat

The plain layout of a typical 3-occupant residential apartment with three occupants for simulation is shown below. The layout of the residential apartment is identified from multi-level residential buildings in Chongqing, China.



Figure 1 plain layout of the 3-occupant apartment

Room number:

R1 - Main bedroom; R2 – Toilet; R3 - Secondary bedroom; R4 - Storage & Kitchen

R5 - Sitting Room

Window sizes (m2):

 R1: 3.9200; R2: 2.1420; R3: 2.5200; R4: 3.2340; R5: 4.3120

R1 – south window: 2.60 m x 1.5 m;

R2 – east window: 1.43 m x 1.5 m;

R3 – east window: 1.68 m x 1.5 m;

R4 – north window: 2.16m x 1.5 m;

R5 – south window: 2.88m x 1.5 m;

Window height from the floor: 0.8 m

(2) Calculation conditions: considering three types of external wall compositions for different thermal mass scenarios

The same recommended U-value of 0.83 W/(m2K) is chosen for all the three external wall compositions. Thermal properties of the building materials are referred to the reference [GB50176-2016, Code for thermal design of civil building, China Architecture & Building Press, 2016].

Scenario 1: Heavy weight wall (from external to internal wall)

 38.7 mm EPS insulation +15mm Cement mortar +240 mm Reinforced Concrete+15mm Plasterboard

* Densities: EPS insulation 19 kg/m3; Cement mortar 1800 kg/m3; Reinforced Concrete 2500 kg/m3; Plasterboard 1100 kg/m3
* Thermal conductivities: EPS insulation 0.046 W/mk; Cement mortar 0.93 W/mK; Reinforced Concrete 1.70 W/mK; Plasterboard 0.41 W/mK
* Specific capacities: EPS insulation 2500 J/kgK; Cement mortar 840 J/kgK; Reinforced Concrete 920 J/kgK; Plasterboard 840 J/kgK
* U= 1/(0.13+(0.0387/0.046+0.015/0.93+0.240/1.7 +0.015/0.41)+0.04)=0.83 W/m2K

Scenario 2: Medium weight wall (from external to internal wall)

 15 mm Cement mortar + 196.5 mm ACB (Aerated Concrete Block)+15 mm plasterboard

* Densities: Cement mortar 1800 kg/m3; ACB 680 kg/m3; Plasterboard 1100 kg/m3
* Thermal conductivities: Cement mortar 0.93 W/mK; ACB 0.20 W/mK; Plasterboard 0.41 W/mK
* Specific capacities: Cement mortar 840 J/kgK; ACB 1050 J/kgK; Plasterboard 840J/kgK
* U= 1/(0.13+(0.015/0.93+0.1965/0.20+0.015/0.41)+0.04)=0.83 W/m2K

Scenario 3: Light weight wall (from external to internal wall)

 10 mm stainless steel plate+ 47.55 mm EPS insulation +10 mm stainless steel plate

 Thickness

* Densities: stainless steel 7850 kg/m3; EPS insulation 19 kg/m3
* Thermal conductivities: stainless steel 15 W/mK; EPS insulation 0.046 W/mk
* Specific capacities: stainless steel 500 J/kgK; EPS insulation 2500 J/kgK
* U= 1/(0.13+(0.010/15+0.04755/0.046+0.010/15)+0.04)=0.83 W/m2K

(3) Aim of calculations:

To compare the differences of building heating & cooling loads of the typical apartment throughout the year under TMY weather data (Changsha/Chongqing/Shanghai).

Note: Part space Heating& Cooling for Room 1, Room 3 and Room 5 and no heating or cooling for Toilet (Room 2) and Storage & Kitchen (Room 4).

(4) Input parameters setting

 a. Basic information

Location: Chongqing/ Changsha/Shanghai, China

Weather data: Chongqing\_shapingba/ Changsha / Shanghai TMY meteorological conditions

The flat is assumed to be in the middle of a multi-story residential building and thus ceiling and roof are assumed to be cyclic boundary conditions. All the four outer facades of the flat are presumed as external walls.

b. Building envelope except external walls

Composition of the internal walls:

* 15 mm plasterboard + 120 mm CLAY BRICK +15 mm plasterboard

Composition of the ceiling (from inside to outside):

* 20 mm plasterboard + 150 mm CEMENT+20 mm cement mortar

Composition of the floor (from inside to outside):

* 20 mm cement mortar + 150 mm CEMENT +20 mm plasterboard

Number of window glass layers: 2; Single glazing thickness: 3mm;

THERMAL CONDUCTIVITIES, W/(M K)

CLAY BRICK 0.81;CEMENT MORTAR 0.93; PLASTERBOARD 0.41;FLAT PLATE GLASS 0.76;EPS(EXPANDED POLYSTYRENE) 0.046; CEMENT 1.54

DENSITY,kg/m3:

CLAY BRICK 1800; CEMENT MORTAR 1800; PLASTERBOARD 1100;FLAT PLATE GLASS 2500;EPS 19; CEMENT 2400

SPECIFIC HEAT AT CONSTANT PRESSURE, J/(kg K)/:

CLAY BRICK 880; CEMENT MORTAR 840; PLASTERBOARD 840; FLAT PLATE GLASS 840; EPS 2500; CEMENT 840

Cp\_air=1005 J/(kg K);

c. Parameters

Emittance of internal wall surfaces: 0.94 (for calculating radiative heat transfer coefficients amongst internal wall surfaces)

Emittance of glass surface: 0.84

Absorptance of external and internal surfaces of walls: 0.7 (Default value as chosen in EnergyPlus)

d. Heat transfer coefficients

Convective heat transfer coefficient on the vertical surfaces of internal walls: 3.5 W/(m2 K)

Convective heat transfer coefficient on the ceiling inner surface: 1.0 W/(m2 K)

Convective heat transfer coefficient on the floor inner surface: 4.0 W/(m2 K)

Radiative heat transfer coefficient of external wall surfaces: estimation according to sky background radiation temperature formula;

Radiative heat transfer coefficient of internal wall surfaces: estimation according to the classic fourth-order correlation

Longwave radiation heat transfer coefficients of internal walls: estimation according to a fixed indoor temperature 20 Celsius Degree

Window comprehensive heat transfer coefficient 2.8 W/(m2 K)

e. Air infiltration

Air Change Rate per hour: 1.0 h-1 for all five rooms;

f. Heating & Cooling period (stipulated in the Design Standard 2010) and calculating thermal comfort benchmark

Heating period: 1 December – 28 February (90 days), room target temperature 18 C (Heating below 18 C while required), relative humidity less than 65% (for calculating latent load).

Cooling period: 15 June – 31 August (77 days), room target temperature 26 C (Cooling above 26 C while required), relative humidity less than 65% (for calculating latent load).

Part space Heating& Cooling for Room 1, Room 3 and Room 5.

No heating or cooling for Toilet (Room 2) and Storage & Kitchen (Room 4).

g. Internal heat gains:

Occupant behaviour profile for Part time Heating&Cooling:

 R1 – Main bedroom, OCCUPIED TIME SLOTS OF 2 OCCUPANTS:

* MONDAY TO SUNDAY: 0:00-6:00 am & 20:00-24:00 pm

 R3 – Secondary bedroom, OCCUPIED TIME SLOTS OF 1 OCCUPANT:

* MONDAY TO SUNDAY: 0:00-6:00 am & 20:00-24:00 pm

 R5 –Sitting room, STAYING TIME SLOTS OF 3 OCCUPANTS:

* MONDAY TO FRIDAY: 6:00-8:00 am & 18:00-20:00 pm
* SATURDAY TO SUNDAY: 6:00 am-20:00 pm

As to Room 2 (Toilet) & Room 4 (Storage &Kitchen), no fixed occupied time is considered.

 Occupant sensible heat dissipation: 70 W/person

 Occupant latent heat dissipation: 60 W/person

 Occupant humidity dissipation (moisture gain which will be transformed to latent heat): 50 g/(h. person)

Timeframe of lighting and equipment in Rooms R1, R3, R5:

Lighting density: 4.3 W;

* Lighting for bedrooms: Monday to Sunday 6:00 – 8:00 am; 20:00–22:00 pm
* Lighting for sitting room: Monday to Friday 6:00 – 8:00 am; 18:00–20:00 pm;

 Saturday to Sunday 6:00 am– 20:00 pm

Time slots of Equipment on are the same as lighting, with a heat emission rate of 6 W.

Convective fraction of the internal heat gains from occupants, lighting and equipment are 0.5, 0.8, 0.48, respectively, as the default values chosen in EnergyPlus.