Modeler Report
IEA Task34/Annex43 Double façade test cases

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Building Energy Simulation Software and Version(s):

The software tool of TRNSYS-TUD is a research code that was developed at the Institute of Thermodynamics and Building Systems Engineering of Technical University of Dresden (TUD) based on the frame of the former TRNSYS version 14.2. Modifications and developments at the original source code were necessary to stabilize calculation processes, to improve both user-friendliness as well as handling of the software and to extend fields of software application. In this context some new features have been added especially to the building model, as detailed long-wave radiation exchange, under-floor heating and thermally activated building systems, detailed solar distribution, internal windows, simple day lighting, etc. Also the ability to run with very little simulation time steps (seconds) was implemented. The realization of some of these features has been initialized by the IEA Task34/Annex43 software validation tests. The air flow model of TRNSYS-TUD originally based on COMIS but was also upgraded with some new features as for instance air flow model through large openings.

Building Model

The building model was built by dividing both Zone 1 (double skin façade) and Zone 2 (Cube) into 4 sub-zones each. Each of the sub-zones is represented by a single air temperature node. Sub-zones are stacked upon each other and are separated by fictitious walls. Due to this configuration temperature stratification could be modeled. The air temperature inside DSF reported in the output file is calculated based on the air temperatures of each of the stacked zones which have been weighted according to the specific air volumes of four sub-zones using the following equation:

$$\vartheta_{\mathrm{air,DSF}} = \frac{0.94\mathrm{m}^3 \times \vartheta_{\mathrm{air,DSF,1}} + 4.66\mathrm{m}^3 \times \vartheta_{\mathrm{air,DSF,2}} + 4.66\mathrm{m}^3 \times \vartheta_{\mathrm{air,DSF,3}} + 0.94\mathrm{m}^3 \times \vartheta_{\mathrm{air,DSF,4}}}{0.94\mathrm{m}^3 + 4.66\mathrm{m}^3 + 4.66\mathrm{m}^3 + 0.94\mathrm{m}^3}$$

The fictitious walls between stacked sub-zones are dimensionless, without any mass, and fully transparent. They also allow vertical air flow. The vertical airflow is calculated by the program depending on temperature and pressure conditions at the nodes of the airflow network assuming a large opening. A c_D-value of 0.5 was used for the simulations.

Figure 1 shows a grid of the building model.

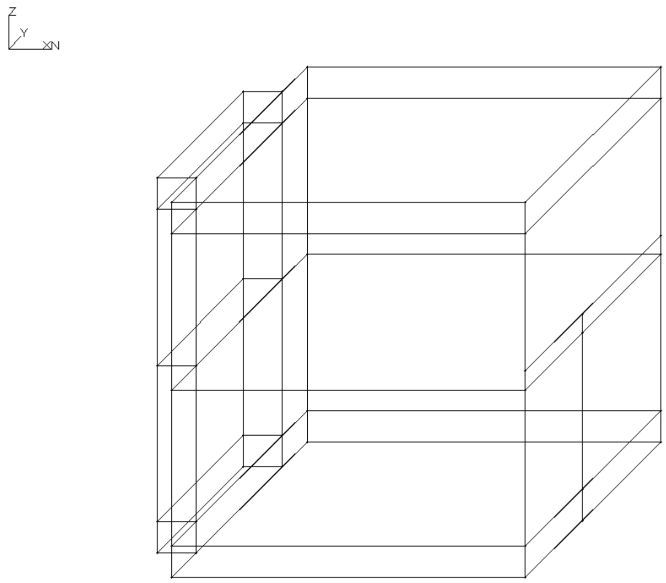

Figure 1: Building grid model

Optical and thermal properties of the glass (external and internal windows) have been calculated using WINDOWS 5.2a [1] and OPTICS 5.1[2]. IGDB identifiers were given in the specification. Figure 2 shows optical glazing properties as used for simulation in dependency on solar incident angle. This angle again depends on the sun's position at the sky and varies with time.

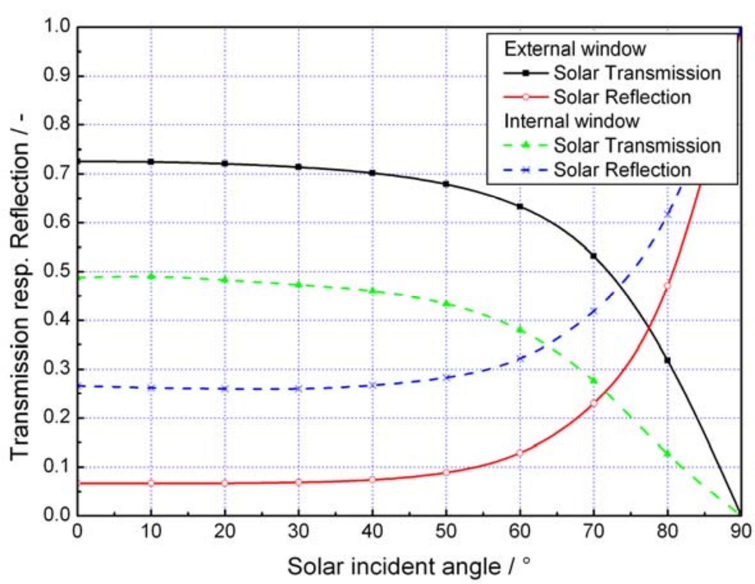

Figure 2: Optical glazing properties

Distribution of solar radiation within the zones is calculated in two steps:

1. At first direct solar radiation is distributed according to an algorithm that accounts for geometric relations between the sun's position and different locations of surfaces. Reflected parts of direct solar radiation were treated as diffuse.
2. Afterwards all diffuse radiation is distributed by an area weighted method.

Solar reflectance properties of surfaces have been calculated based on given spectral data. The normalized relative spectral distribution of solar radiation defined in prEN410 [3] and ISO9050 [4] was used to calculate a uniform reflectance value for all surfaces. Figure 3 shows spectral distribution defined in the relevant standards.

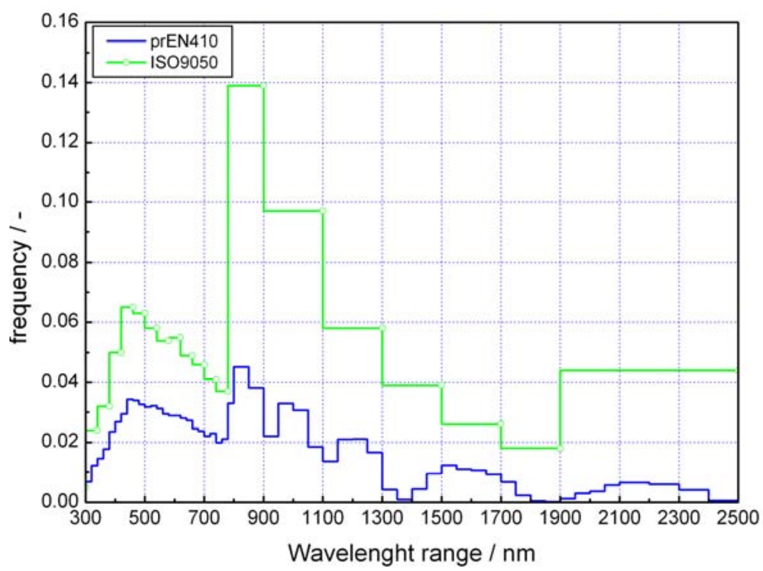

Figure 3: Frequency of solar radiation spectrum

The solar properties used in empirical simulations are as follows:

	Zone 1 (DSF)	Zone 2 (Cubus)
Solar Reflectance	78%	76 %
Solar Absorptance	22 %	24 %

Convective film coefficients have been fixed. Different values were chosen to model the impact of air flow on heat transfer.

External walls: 4.4 W/m²K (inside) 25 W/m²K (outside)

Roof / external window: 3 W/m²K (inside) 25 W/m²K (outside)

Floor:	3 W/m²K
Internal walls / internal window:	4.4 W/m²K (both sides)

Radiative heat transfer depends on view factors, emission properties and surface temperatures.

Test Case 100_2

All openings were closed. This test case was easily to simulate. The simulation time step was 0.1 hr = 6 min.

Test Cases 200_3 and 200_4

Free area of the openings had to be 0.6m² for both external and internal windows. The air flow model of TRNSYS TUD calculates area A of the openings in dependency on the angle α windows are opened as follows:

$$A = B \times H \times f(\alpha)$$

Here the function $f(\alpha)$ again depends on window construction. For these software validation exercises a function as depicted in Figure 4 was used. This function was found from a literature review.

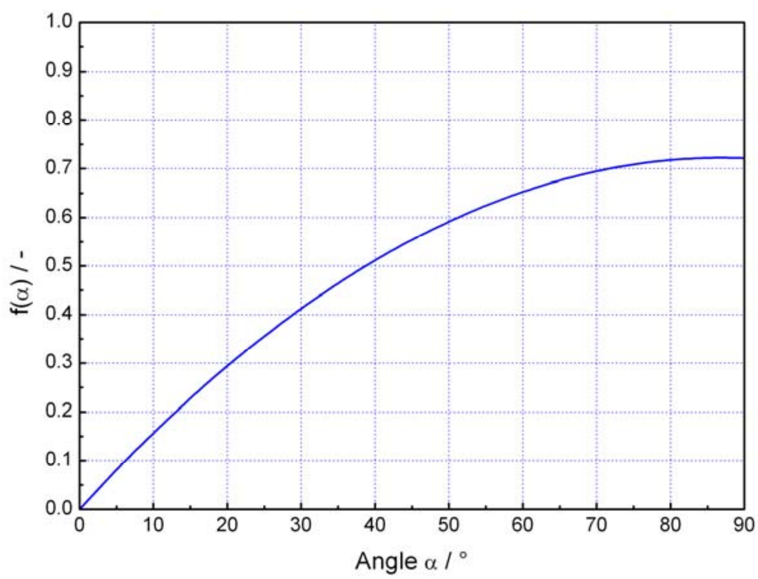

Figure 4: Correction of free area of openings

Using the curve above both external and internal openings have been assumed to be opened with an angle of about 26° to realize a free area as requested.

The simulation time step was 0.1 hr = 6 min.

Test Case 200_e

The simulation time step was 0.1667 hr = 10 min. A 24 hr period for preconditioning was defined. Detailed boundary conditions as provided for the ground and the adjacent zones have been used for simulation but no surface spectral data could be taken into account. Different from the wind profile described in the empirical test case specification a wind profile power law was used. Figure 5 shows a comparison between measure wind profile values and the power law approximation. The wind profile exponent was set to 0.34.

Due to the specified free area of openings windows were assumed to be opened at an angle of 16° (bottom opening) and 13.3° (top openings), respectively.

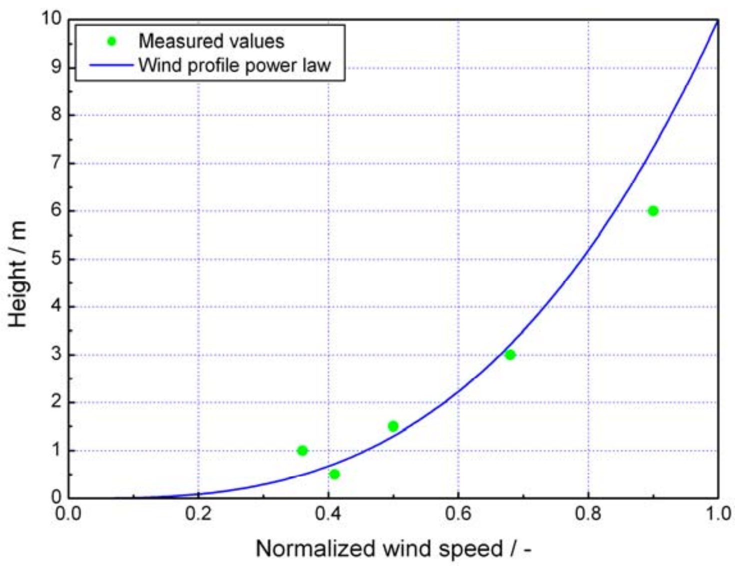

Figure 5: Comparison between measured values and wind profile power law

Test Case 400_3

Openings were assumed to be opened with an angle of 45°. Independent from this the air flow through the building was nearly fixed by defining a constant fan air flow.

The simulation time step was 0.1 hr = 6 min.

References

[1] WINDOWS 5.2a, 2005, Lawrence Berkeley National Laboratory (LBNL)

[2] OPTICS 5.1, 2003, Lawrence Berkeley National Laboratory (LBNL)

[3] prEN410: Glass in building - Determination of luminous and solar characteristics of glazing; German version EN 410:1998

[4] ISO9050: Glass in building - Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors