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Comparative Test Case Specification

Test Cases DSF200_3 and DSF200_4 : IEA ECBCS Annex43/SHC Task 34 : Validation of Building Energy Simulation Tools

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IEA ECBCS Annex43/SHC Task 34
Validation of Building Energy Simulation Tools

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1. General information

This document includes a definition of the comparative test cases DSF200_3 and DSF200_4, which were previously described in the Comparative Test Case Specification for the test cases DSF100_3 and DSF_3 [**Ref. 1**].

The comparative test cases DSF200_3 and DSF200_4 were chosen during the breakout sessions at the Annex meeting in Iowa, Des-Moines. The test cases DSF200 consider natural driving forces and the variable external environment.

Case DSF200. Openings are open to the outside. DSF function is to remove surplus solar heat gains by means of natural cooling. Temperature conditions and air flow conditions in the DSF are to be examined together with the magnitude of natural driving forces (Figure 1).

The same modelling rules and geometrical assumptions are to be applied for modelling, as the ones described in the comparative test case specification for the test cases DSF100_3 and DSF400_3 [**Ref. 1**]. Specific information on modelling test cases DSF200_3 and DSF200_4 is given in the following chapters.

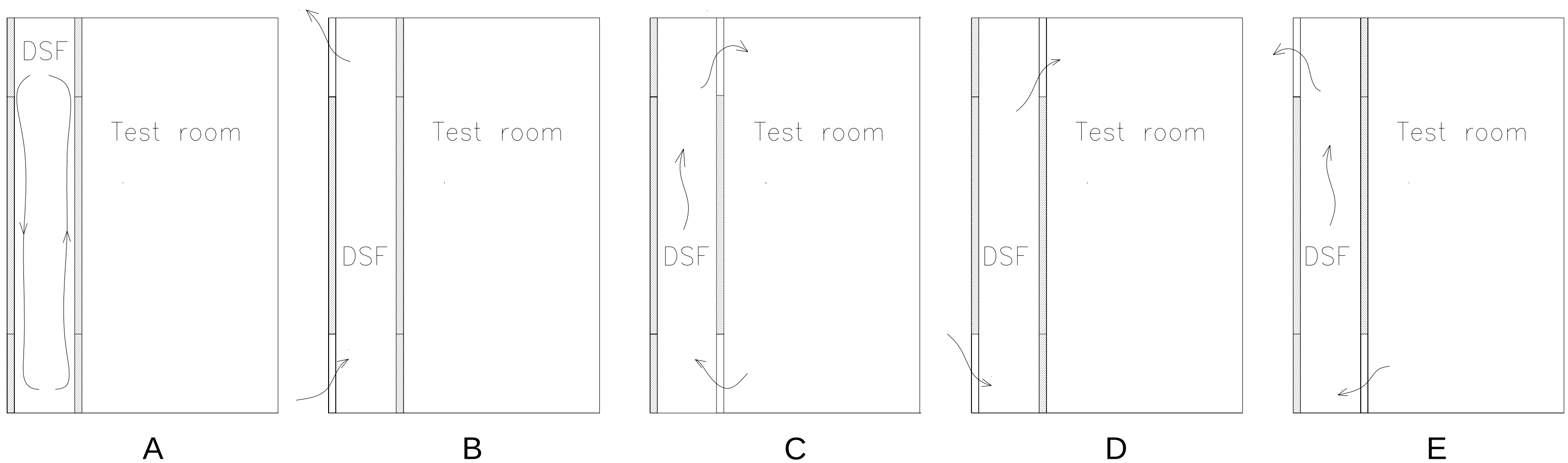


Figure 1. Test Cases. (A)-Case DSF100, (B)-Case DSF200, (C)-Case DSF300, (D)-Case DSF400, (E)-Case DSF500.

Case DSF100 - all openings are closed
Case DSF200 - openings are open to the outside
Case DSF300 - openings are open to the inside
Case DSF400 - bottom opening is open to the outside and the top opening is open to the inside (preheating mode)
Case DSF500 - top opening is open to the outside and the bottom opening is open to the inside (chimney/exhaust mode)

General test case	Test Case	Solar shading		Driving force				Boundary conditions			Openings area		Empirical
		Yes	No	Buoyancy	Wind	Mechanical	Combined	Internal=const External=const	Internal=const External=floating	Internal=floating External=floating	No control	Control	
DSF 100	DSF100_1		X					X					
	DSF100_2		X						X				(E)*
	DSF100_3	X							X				E
DSF 200	DSF200_1		X	X				X			X		
	DSF200_2	X		X				X			X		
	DSF200_3		**X**	**X**					**X**		**X**		**(E)***
	DSF200_4		**X**				**X**		**X**		**X**		**E**
	DSF200_5	X					X		X		X		E
DSF 300		undefined											
DSF 400	DSF400_1		X			X		X			X		
	DSF400_2	X				X		X			X		
	DSF400_3		X			X			X		X		(E)*
	DSF400_4	X				X			X		X		E
	DSF400_5	X					X		X			X	E
DSF 500	DSF500_1		X			X			X		X		
	DSF500_2	X				X			X		X		E
	DSF500_3	X					X			X	X		E
	DSF500_4	X					X			X		X	E

* - it is uncertain whether this test case will include empirical validations or not.

Table 1. Summary table of modeling cases. The comparative test cases to be modelled are highlighted.

2. Test case DSF200

2.1. Objectives and methods

The main objective of this test case is to test the building simulation software on its general ability to model the transmission of solar heat gains through the two layers of fenestration combined with airflow motion through the DSF cavity. The transmission of solar heat gains has been already investigated in the DSF100_2 test case [**Ref. 1**], the influence of the naturally driven air flow through the cavity is included in the present test case. This time, the air movement exists only between the cavity and external, and the air temperatures in the cavity are mainly influenced by external environmental temperatures and solar radiation. The internal conditions remain constant, as in the previous DSF100_2 case [**Ref. 1**]. The Cooling/Heating system should is introduced to the model to keep internal temperature in the zone 2 constant to 20 degrees.

2.2. Additional definitions

2.2.1 Driving force

In the test case DSF200_3 thermal buoyancy is only the driving force, while in the test case DSF200_4 thermal buoyancy is combined with the wind influence. In both of the test cases driving forces have variable character.

2.2.2 Weather data

The weather data files are prepared for the same season of the year, as the test case DSF100_2 and DSF400_3 [Ref. 1], thus for the spring season, including both days with high direct and high diffuse solar irradiation. The weather data files are named in correspondence to the name of the test cases:

wDSF200_3.xls – the weather data file for the test case DSF200_3
wDSF200_4.xls – the weather data file for the test case DSF200_4

In weather data file *wDSF200_3.xls* the wind velocity is set to zero to ensure the buoyancy driven flow.

2.2.3 Area of the openings

Operable windows in the double skin façade are open to the outside, can be seen on Figure 2. Size of the openings is 0.2 m^2 for each section that corresponds to 0.6 m^2 of total opening area at the top of DSF and 0.6 m^2 at the bottom.

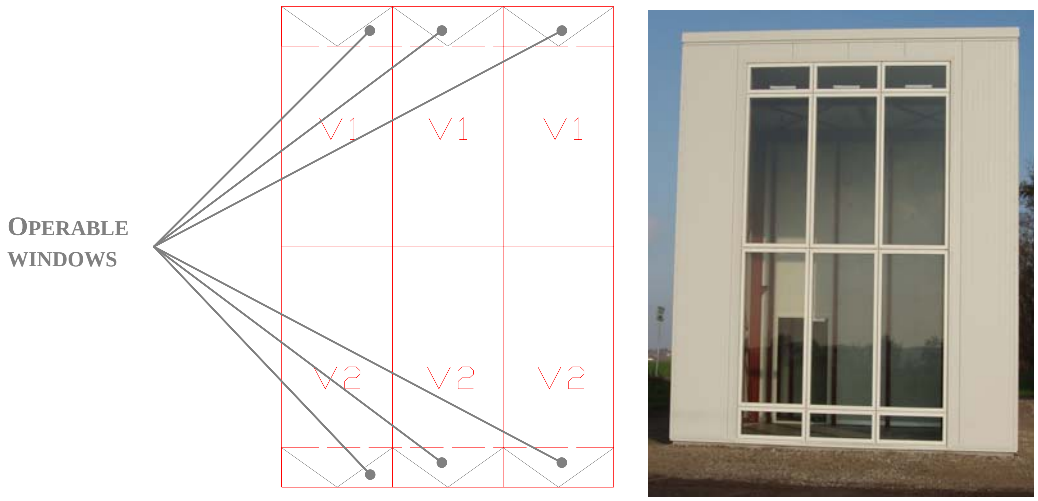


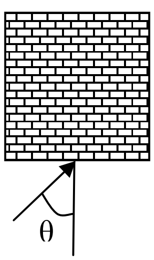
Figure 2. External window sections (left), photo of the DSF from the outside (right).

2.2.4 Discharge coefficient

Each opening is defined with the discharge coefficient of 0.65

2.2.5 Wind pressure coefficients

For the empirical test cases the wind pressure coefficients will be obtained by experiments, while for the comparative test cases the wind pressure coefficients are assumed according to **Ref. 2**.



θ – wind angle

Location	*Wind angle*							
	0°	*45°*	*90°*	*135°*	*180°*	*225°*	*270°*	*315°*
Top openings	0.58	0.22	-0.71	-0.5	-0.36	-0.5	-0.66	0.22
Bottom openings	0.61	0.33	-0.55	-0.5	-0.35	-0.5	-0.61	0.33

Table 2. Wind pressure coefficients [Ref. 2.**].**

2.3. Inputs fore the Case DSF200_3 and 200_4

№	*Attributes*	*Specification*
1	Internal zone dimensions	As specified above /**Ref. 1**, section Geometry/
2	Windows' dimensions	As specified above /**Ref. 1**,section Geometry/
3	Operable window sections at the top and bottom (Open/Closed)	The external top and bottom operable windows are open. The area of one open section is 0.2 m^2 – it is the maximal value for the every small operable section, which can be seen in Figure 2.
4	Open windows properties	The discharge coefficient for all openings is set to be 0.65.
5	Construction materials	As specified /**Ref. 1**, section Physical properties of constructions/
6	Material properties	As specified /**Ref. 1**, section Physical properties of constructions/
7	Window	As specified /**Ref. 1**, section Physical properties of constructions/
8	Interior surface heat transfer coefficients	This is not prescribed, as it depends on the techniques used by software tool /**Ref. 1**, section Surface coefficients/. The values (techniques) used for simulations have to be reported
9	Exterior surface heat transfer coefficients	This is not prescribed, as it depends on the techniques used by software tool /**Ref. 1**, section Surface coefficients/. The values (techniques) used for simulations have to be reported
10	Surface finish properties	All the surfaces are to be modeled white with the specified reflection and absorbance properties. The roughness of the surface and emissivity of the glass are also prescribed
11	Weather data	The weather data file is wDSF200_3.xls for the test case DSF200_3 and the weather data file is DSF200_4 for the test case DSF200_4 The weather data files for the test cases differ one from another
12	Ground temperature	The 10 ^{o}C value is specified above and to be kept the same for whole period of simulation.
13	Total solar heat transmittance (g-value)	Calculated by the technique which is included into the program code or by the user decision /**Ref. 1**, section Physical properties of constructions/
14	Transmission of solar radiation	It is not prescribed. The approach of calculation depends on the software package. In the modeller report please notify the approach used for calculations.
15	Distribution of transmitted solar radiation	Whether the software being tested allows the solar incidence to be distributed geometrically correct to surfaces (detailed analyses of the path of direct solar radiation through a building, thus calculating shadowing by constructions, etc.), apply this function. When this is not possible, use the most accurate, physically correct option, able to handle solar radiation heat transmission. This has to be documented in the report /**Ref. 1**, Other parameters and specifications /
16	Longwave radiation with exterior and interior	If the software being tested allows the calculation of the longwave radiation exchange with the exterior, use this function, else note it in the report /**Ref. 1**,Other parameters and specifications /
17	Additional definition for the Wall 3	The user shall build up the model with the Wall 3, partly having adiabatic features and partly – facing external environment, as

№	Attributes	Specification
		explained above /**Ref. 1**,Other parameters and specifications /
18	Internal gains	There are no internal gains considered for this test case
	Systems. Zone 1	
19	Shading	No shading devise defined for this test case
20	Driving force	The driving force in the DSF is thermal buoyancy in the test case DSF200_3 and thermal buoyancy combined with the wind forces in the test case DSF200_4(this is determined by the weather conditions)
21	Zone air temperature	The zone air temperature is not controlled.
22	Other systems	No other systems included into Zone 1.
	Systems. Zone 2	
23	Shading	No shading devise defined for this test case
24	Zone air temperature	The air temperature in zone 2 is regarded to be uniform, with a fixed value of 20^{o}C. In order to keep this temperature constant a control of cooling/heating system has to be included, as explained further down.
25	Efficiency of cooling/heating system	100 %
26	Heating/Cooling system	The Zone 2 is provided with a mechanical heating/cooling system to provide constant zone air temperature. The energy has to be provided to the zone air only by means of convection. The controlling sensor has to be located in same zone. The schedule of the systems has to be *always,* during the simulation.
28	Control of the openings	Small operable sections facing the external environment at the bottom and internal environment at the top are fully open. No control.

Table 3. Specification for the test case DSF200_3 and DSF200_4.

2.4. Output parameters for the test case DSF400_3 and DSF400_4

The output parameters for these cases are almost the same as for the case DSF100_2 and DSF400_3 [**Ref. 1**].

N	*Output*	*Unit*	*Description*
1	Direct solar irradiation on the window surface	W/m^2	Mean hourly value
2	Diffuse solar irradiation on the window surface	W/m^2	Mean hourly value
3	Total solar irradiation on the window surface	W/m^2	Mean hourly value
4	Total solar radiation received on the external window glass surface	kW	Mean hourly value
5	Solar radiation transmitted from the outside into zone 1	kW	Mean hourly value
6	Solar radiation transmitted from zone 1 into zone2 (first order of solar transmission)	kW	Mean hourly value
7	Energy used for cooling/heating in the zone 2	kW	Mean hourly value (with the '+'sign for heating and '-'sign for cooling)
8	Hour averaged surface temperature of external window surface facing external	^oC	Mean hourly value
9	Hour averaged surface temperature of external window surface facing zone1	^oC	Mean hourly value
10	Hour averaged surface temperature of internal window surface facing zone1,	^oC	Mean hourly value
11	Hour averaged surface temperature of internal window surface facing zone2	^oC	Mean hourly value
12	Hour averaged floor surface temperature in the zone 1	^oC	Mean hourly value
13	Hour averaged ceiling surface temperature in the zone 1	^oC	Mean hourly value
14	Hour averaged floor surface temperature in the zone 2	^oC	Mean hourly value
15	Hour averaged ceiling surface temperature in the zone 2	^oC	Mean hourly value
16	Hour averaged air temperature in the zone 1	^oC	Mean hourly value
17	Air flow rate in the zone 1	m^3/h	Mean hourly value

Table 4. Required output parameters for the test case DSF400_3 and DSF400_4.

Depending on the software tool used for modelling and its accuracy the minimum required outputs defined in the above table. Besides that a modeler is asked to report on additional outputs, if this is possible:

- Solar radiation absorbed in the opaque surfaces in zone 1 and zone 2 (mean hourly values)
- Convective/ radiative heat fluxes at the glass surfaces (mean hourly values)
- Vertical temperature distribution of the DSF-air, when provide this data, then please provide data for vertical temperature distribution of all window glass surfaces
- Anyone using CFD, please provide vector plots together with the data sheets

Modelers are asked to report on how the transmitted solar radiation is calculated and distributed to the surfaces.

3. List of references

Ref. 1. Kalyanova O., Heiselberg P. (2005). Comparative Test Case Specification – Test Cases DSF100_2 and DSF400_3: Report for IEA ECBCS Annex 43/SHC Task 34 Validation of Building Energy Simulation Tools / Aalborg : Instituttet for Bygningsteknik, Aalborg Universitet.

Ref. 2. Straw M.P. (2000). Computation and Measurement of Wind Induced Ventilation: PhD thesis/ Nottingham UniversityStraw M.P. (2000). Computation and Measurement of Wind Induced Ventilation: PhD thesis/ Nottingham University

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