EDSL Tas 9.3.0 Compliance with BS EN 13792:2012

1. Sunlit Factor Test

Three test cases were modelled. In each case the sunlit factor was measured on a vertical surface of height 2.8m and width 3.6m.

Test 1: South facing wall with infinite horizontal overhang of 1m depth.
Test 2: West facing wall with infinite vertical fin of 1m depth on south side.
Test 3: South facing wall with loggia; horizontal overhang of 1m depth, vertical fins of 1m depth on both sides.

All results were taken from day 196 and at latitude 52°N.

Results

To comply, results should be within 0.05.

	Target			Tas Results			Difference		
Time	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3	Test 1	Test 2	Test 3
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9.5	0.26	0.00	0.15	0.23	0.00	0.12	0.03	0.00	0.03
10.5	0.36	0.00	0.28	0.34	0.00	0.26	0.02	0.00	0.02
11.5	0.39	0.00	0.37	0.39	0.00	0.35	0.00	0.00	0.02
12.5	0.39	0.00	0.37	0.39	0.00	0.37	0.00	0.00	0.00
13.5	0.36	0.65	0.28	0.36	0.62	0.28	0.00	0.03	0.00
14.5	0.26	0.82	0.15	0.27	0.81	0.16	0.01	0.01	0.01
15.5	0.00	0.92	0.00	0.01	0.91	0.00	0.01	0.01	0.00
16.5	0.00	1.00	0.00	0.00	0.98	0.00	0.00	0.02	0.00
17.5	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
18.5	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
19.5	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
20.5	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
21.5	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
22.5	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
23.5	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00

Note: While the standard gave values of 1 for the last four hours for test case 2, the Tas results show zero as the sun is below the horizon.

2. Operative Temperature Test

Eighteen test cases were modelled. In each case one day, July 15th (day 196), was repeatedly simulated in a cycle until a steady result was reached. For each case the maximum, minimum and average operative temperatures for the day were compared to the target values from the standard.

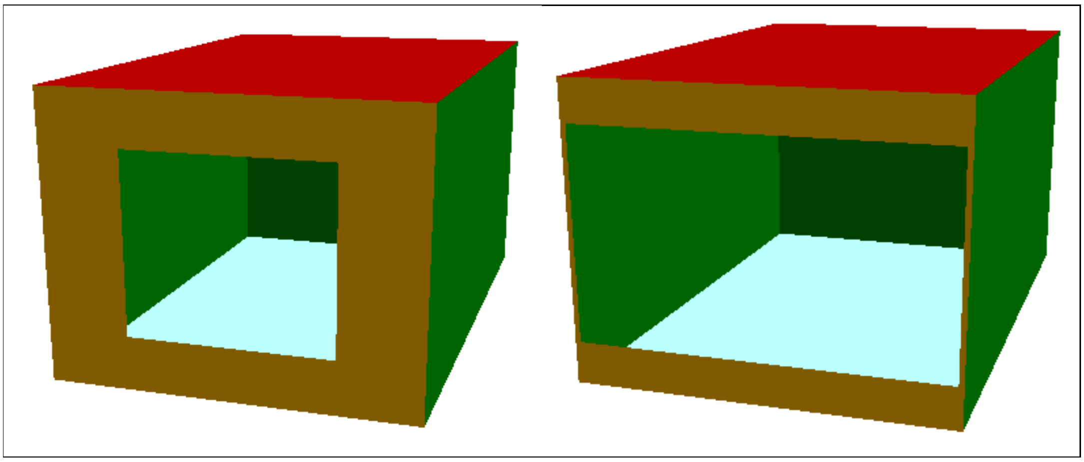
The operative temperature was calculated as the mean value of the room's dry bulb temperature and the mean radiant temperature of the room. Diffuse solar radiation flux was included in the calculation of the mean radiant temperature.

Input Data

Room Geometry

Two different geometries were used as a basis for the tests.

Geometry A: 3.5m^2 west-facing window. Latitude 40°N.
Geometry B: 7m^2 west-facing window. Latitude 52°N.



Left: Geometry A as seen in the Tas 3D modeller.
Right: Geometry B as seen in the Tas 3D modeller.

Element	Geometry A area (m^2)	Geometry B area (m^2)
External Wall	6.58	3.08
Glazing	3.50	7.00
Partition wall (left)	15.40	15.40
Partition wall (right)	15.40	15.40
Partition wall (back)	10.08	10.08
Floor	19.80	19.80
Ceiling	19.80	19.80

The volume of each geometry was 55.44m^3.

Construction Details

Opaque constructions were set up in accordance with table 4 of the standard. Details are given below in screenshots from Tas.

Type no. 1 (external wall)

Layer	M-Code	Width (mm)	Conductivity (W/m·°C)	Density (kg/m³)	Specific Heat (J/kg·°C)
Inner	Ext Wall Internal Plastering	15.0	0.7	1400.0	850.0
2	Ext Wall Masonry	175.0	0.79	1600.0	850.0
3	Ext Wall Insulation	60.0	0.04	30.0	850.0
4	Ext Wall Outer Layer	115.0	0.99	1800.0	850.0

Type no.2 (internal wall)

Layer	M-Code	Width (mm)	Conductivity (W/m·°C)	Density (kg/m³)	Specific Heat (J/kg·°C)
Inner	Int Wall Gypsum Plaster	12.0	0.21	900.0	850.0
2	Int Wall Mineral Wool	100.0	0.04	30.0	850.0
3	Int Wall Gypsum Plaster	12.0	0.21	900.0	850.0

Type no. 3 (ceiling / floor)

Layer	M-Code	Width (mm)	Conductivity (W/m·°C)	Density (kg/m³)	Specific Heat (J/kg·°C)
Inner	Type 3 Concrete	180.0	2.1	2400.0	850.0
2	Type 3 Insulation	40.0	0.04	50.0	850.0
3	Type 3 Concrete Floor	60.0	1.4	2000.0	850.0
4	Type 3 Covering	4.0	0.23	1500.0	1500.0

Note: order of layers is underside to topside.

Type no. 4 (ceiling / floor)

Layer	M-Code	Width (mm)	Conductivity (W/m·°C)	Density (kg/m³)	Specific Heat (J/kg·°C)
Inner	Type 4 Acoustic Board	20.0	0.06	400.0	840.0
2	Type 4 Mineral Wool	100.0	0.04	50.0	850.0
3	Type 4 Concrete	180.0	2.1	2400.0	850.0
4	Type 4 Insulation	40.0	0.04	50.0	850.0
5	Type 4 Concrete Floor	60.0	1.4	2000.0	850.0
6	Type 4 Covering	4.0	0.23	1500.0	1500.0

Note: order of layers is underside to topside.

Type no. 5 (roof)

Layer	M-Code	Width (mm)	Conductivity (W/m·°C)	Density (kg/m³)	Specific Heat (J/kg·°C)
Inner	Roof Concrete	200.0	2.1	2400.0	850.0
2	Roof Insulation	80.0	0.04	50.0	850.0
3	Roof External Layer	4.0	0.23	1500.0	1300.0

The glazing construction was set up in accordance with table 5 of the standard.

Component	Solar transmittance	Solar reflectance	Solar absorptance
Inner Pane	0.84	0.08	0.08
Outer Pane	0.84	0.08	0.08
Shade	0.2	0.5	0.3

The solar parameters were considered to be independent of the solar angle.

Three different arrangements of constructions were considered:

Test no.	External wall	Internal adiabatic wall	Adiabatic ceiling	Adiabatic floor	Roof
1	1	2	4	4	N/A
2	1	2	3	3	N/A
3	1	2	N/A	3	5

The same glazing was used in each case.

Internal Gains

All 18 test models have the same pattern of internal gains. The heat gains are 50% radiative and 50% convective.

11pm – 7am: No gains
7am – 11am: 1 W/m^2
11am – 3pm: 10 W/m^2
3pm – 6pm: 1 W/m^2
6pm – 10pm: 15 W/m^2
10pm – 11pm: 10 W/m^2

The view coefficient of these internal gains was set to zero.

Weather

The values for external dry bulb and solar gain on a horizontal surface were given in the standard as instantaneous values at each hour. These were converted to average values over the course of the hour. As specified in the standard, the dry bulb temperature and solar gain varies linearly from point to point, making it straightforward to calculate hourly values:

Weather data for Geometry A (latitude 40°N) on day 196

Hour	external air dry bulb temperature (°C)	Total solar radiation on a horizontal surface (W/m^2)	Diffuse solar radiation on a horizontal surface (W/m^2)
00:00 – 01:00	23.9	0	0
01:00 – 02:00	23.3	0	0
02:00 – 03:00	22.75	0	0
03:00 – 04:00	22.3	0	0
04:00 – 05:00	22.05	2	1.5
05:00 – 06:00	22.1	86	32.5
06:00 – 07:00	22.5	268.5	76.5
07:00 – 08:00	23.35	463	98
08:00 – 09:00	24.85	638	108.5
09:00 – 10:00	26.55	780.5	114.5
10:00 – 11:00	28.3	881	118
11:00 – 12:00	30.25	933	119.5
12:00 – 13:00	31.95	933	119.5
13:00 – 14:00	33.15	881	118

14:00 – 15:00	33.8	780.5	114.5
15:00 – 16:00	33.8	638	108.5
16:00 – 17:00	33.2	463	98
17:00 – 18:00	32.15	268.5	76.5
18:00 – 19:00	30.7	86	32.5
19:00 – 20:00	29.15	2	1.5
20:00 – 21:00	27.7	0	0
21:00 – 22:00	26.4	0	0
22:00 – 23:00	25.35	0	0
23:00 – 24:00	24.55	0	0

Weather data for Geometry B (latitude 52°N) on day 196

Hour	external air dry bulb temperature (°C)	Total solar radiation on a horizontal surface (W/m^2)	Diffuse solar radiation on a horizontal surface (W/m^2)
00:00 – 01:00	14.5	0	0
01:00 – 02:00	13.7	0	0
02:00 – 03:00	12.95	0	0
03:00 – 04:00	12.4	0	0
04:00 – 05:00	12.1	34.5	17
05:00 – 06:00	12.15	147	53.5
06:00 – 07:00	12.7	306.5	83
07:00 – 08:00	13.85	463.5	98.5
08:00 – 09:00	15.6	604	107
09:00 – 10:00	17.8	718.5	112
10:00 – 11:00	20.4	799.5	115
11:00 – 12:00	23.05	841.5	116.5
12:00 – 13:00	25.25	841.5	116.5
13:00 – 14:00	26.85	799.5	115
14:00 – 15:00	27.75	718.5	112
15:00 – 16:00	27.75	604	107
16:00 – 17:00	26.95	463.5	98.5
17:00 – 18:00	25.5	306.5	83
18:00 – 19:00	23.6	147	53.5
19:00 – 20:00	21.55	34.5	17
20:00 – 21:00	19.6	0	0
21:00 – 22:00	17.9	0	0
22:00 – 23:00	16.45	0	0
23:00 – 24:00	15.35	0	0

The values for the diffuse solar radiation are calculated from values given in the related standard, BS EN 13791, which uses the same weather data.

Ground Solar Reflectance

The ground solar reflectance for each geometry was set to give the correct solar gain on a west facing wall, as defined in section 6.2.5 of the standard.
For geometry A a ground solar reflectance of 0.4 was used. For geometry B a ground solar reflectance of 0.39 was used.

Ventilation

Three ventilation patterns were considered:
A: constant 1 ACH
B: 0.5 ACH from 6am – 6pm, 10 ACH at other times
C: constant 10 ACH

In each case air was brought in at the outside air temperature.

Other inputs

- **Heat transfer coefficients**
  - Section 4.2.2 of the standard specifies 13.5 W/(m^2K) for the external surface heat transfer coefficient (convective plus long wave).
    In the Tas model the external surface emissivities were set to zero and the wind speed was set to a constant 2.375 m/s, to give a total external heat transfer coefficient of 13.5 W/(m^2K) (4 + 4*windspeed).
  - Section 4.2.2 of the standard specifies 2.5 W/(m^2K) for the internal surface convective heat transfer coefficient and 5.5 W/(m^2K) for the internal long-wave radiative heat transfer coefficient.
    In the Tas model the convective heat transfer coefficient of all internal surfaces is set to 2.5 W/(m^2K). Tas calculates long wave radiation exchange based on emissivities, these values were set to get as close as possible to the required 5.5 W/(m^2K).
  - Section 6.2.3 of the standard specifies the following thermal resistances for the glazing:
    - 0.074 m^2K/W for the external surface of the blind – this is equivalent to the 13.5 W/(m^2K) heat transfer coefficient set on all external surfaces in the Tas model (see above).
    - 0.080 m^2K/W for the air gap between the blind and the outer pane – in the Tas model a convection coefficient of 12.5 W/(m^2K) was applied in the air gap with the surface emissivities set to zero.
    - 0.173 m^2K/W for the air gap between the outer and inner panes – in the Tas model a convection coefficient of 5.78 W/(m^2K) was applied in the air gap with the surface emissivities set to zero.
    - 0.125 m^2K/W for the internal surface of the inner pane – this is equivalent to the total 8 W/(m^2K) heat transfer coefficient set on all internal surfaces in the Tas model (see above).

- **Solar distribution**
  The distribution of the solar radiation on the internal surfaces of the room is time-independent. This was achieved by splitting the solar gain evenly over each of the internal opaque surfaces (weighted by surface area) on every hour.
- **Solar-to-air factor**
  10% of the solar heat entering the room through the window was added directly into the internal air.
- **Solar loss factor**
  No solar radiation which entered the room was reflected back outside.
- **External Surface Solar Absorptances**
  The external wall had an external solar absorptance of 0.6. The roof had an external solar absorptance of 0.9

Results

The test names are in three parts, indicating the geometry used, the construction set used, and the ventilation method used. For example, test B2a uses geometry B, construction set 2, and ventilation method A.

Below: Target temperatures, Tas results, and the differences between them. In each case this is shown for the maximum, average, and minimum operative temperatures. For class 1 compliance, the worst of the three difference values should be equal to or less than 1.0°C.

	Target Operative Temps			Results			Difference				
	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Worst	Compliance
A1a	38.8	35.9	33.6	38.79	36.27	34.23	0.01	0.37	0.63	0.63	Class 1
A1b	34.1	29.5	25.6	33.14	29.20	25.50	0.97	0.30	0.10	0.97	Class 1
A1c	33.6	29.1	25.4	33.13	28.96	25.45	0.47	0.14	0.05	0.47	Class 1
A2a	37.7	35.9	34.5	37.77	36.30	35.08	0.07	0.40	0.58	0.58	Class 1
A2b	32.3	29.5	26.6	31.50	29.18	26.48	0.80	0.32	0.12	0.80	Class 1
A2c	32.4	29.1	26.4	31.99	28.98	26.44	0.41	0.12	0.04	0.41	Class 1
A3a	40.6	38.6	37.0	41.00	39.32	37.94	0.39	0.72	0.94	0.94	Class 1
A3b	35.0	31.4	28.0	34.40	31.30	28.00	0.60	0.10	0.00	0.60	Class 1
A3c	33.6	30.2	27.4	33.23	30.13	27.48	0.37	0.07	0.08	0.37	Class 1
B1a	35.9	30.8	27.1	35.75	30.73	27.05	0.15	0.07	0.05	0.15	Class 1
B1b	30.0	22.3	16.5	29.87	22.28	16.53	0.13	0.02	0.03	0.13	Class 1
B1c	28.3	21.6	16.3	28.32	21.62	16.35	0.02	0.02	0.04	0.04	Class 1
B2a	33.9	30.8	28.6	33.56	30.76	28.69	0.34	0.04	0.08	0.34	Class 1
B2b	26.9	22.3	18.1	26.58	22.24	18.14	0.32	0.06	0.04	0.32	Class 1
B2c	26.5	21.6	17.8	26.36	21.64	17.91	0.14	0.04	0.11	0.14	Class 1
B3a	35.8	32.5	30.2	35.65	32.64	30.41	0.15	0.14	0.21	0.21	Class 1
B3b	29.3	24.0	19.2	29.04	23.99	19.36	0.27	0.01	0.16	0.27	Class 1
B3c	27.5	22.6	18.7	27.45	22.63	18.79	0.05	0.03	0.09	0.09	Class 1