KoZiBu

Comparison with EMPA Cell Test Results

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Abstract

This report presents simulation results obtained with KoZiBu software. These results are compared with preliminary experimental results published by Manz et al. within the framework of Task 34/annex 43 of the International Energy Agency (IEA).

KoZiBu is the new name of the CoDyBa software, formerly developed by Jean NOEL with the help of Professor Jean-Jacques ROUX [CET]. KoZiBu is a software used to determinate the heat flows in a building. It is specially oriented toward optimisation of energy performance in buildings.

A good agreement is found : results are presented, which show that in KoZiBu the modelling of a single room has reached a good degree of precision. The results simulated with the software are very closed to these obtained in experimental conditions in a case where the cell is perfectly known and described.

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Table of contents

List of tables and figures

I - Introduction

I - 1 - The EMPA Cell Test Facility

Manz et al. [EMPA], [MANZ] presents results obtained at EMPA where a series of experiments were performed in an outdoor test cell on the EMPA campus in Duebendorf, Switzerland. The objective of these experiments was to provide a high-quality data set for code developers and modellers to validate their solar gain models for windows with and without shading devices. The purpose of these experiments was to obtain results with shading devices in sunlight conditions, but the results presented at present don't take account of sun and are only preliminary results.

First a steady-state experiment was conducted to verify the overall thermal cell properties. Then a transient experiment without solar gains was performed in order to test the accuracy of the thermal cell modelling.

The results were compared with those given by the softwares DOE-2,1E, EnergyPlus, ESP-r and HELIOS.

I - 2 - The KoZiBu software

KoZiBu is the successor of software CoDyBa [CDB]. CoDyBa was a software, jointly developed by the CETHIL (INSA-Lyon Thermal Center [CET]) and a freelance engineer [JNL], without any state help. It is aimed for design offices, teaching and research organisms.

KoZiBu is a software used to determinate the heat flows in a building. It permits to estimate the instant heating or cooling powers needed to maintain a given set-point, or to calculate the interior temperatures when the heating or cooling system is insufficient. Humidity is treated in the same way.

The tool is aimed to conduct studies of heating and cooling strategy, air conditioning or ventilation options, insulating materials to be installed. The room occupancy is included. KoZiBu does not permit the study of the dynamic behaviour of a set of technological components : the main objective is to forecast the energy consumption and temperature evolution range.

KoZiBu runs on classical PC. The building is described accurately and the building description is given by the use of a graphical interface. KoZiBu is based on simply bricks assembled to form a complex building with its equipment. The assembly is conducted in a form to minimise data size and calculation time. The physical models of KoZiBu are those commonly admitted, but numerical algorithms are specific.

I - 3 - Some remarks on validation methodology

It's well known that a program may be validate by [BR][S140] :

- **Analytical verification** (the output from a program is compared to the result from a known analytical solution)
- **Comparative testing** (in which a program is compared to itself or to other program. This approach includes "sensitivity testing" and "intermodel comparisons")
- **Empirical validation** (in which calculated results from a program are compared to monitored data from a real experiment)

Analytical validations were already made during the development phases of the software KoZiBu, in order to trap basic errors in the implementation of the models.

Comparative testing were made, especially with the benchmark BESTEST, which is actually the best. For its authors, a program may be thought of as validated when it has passed successfully through the qualification series, that means when its result compare favourably with the reference program output for both the qualification cases. From this point of view, considering the results obtained by KoZiBu (or CoDyBa), one can consider that the software is on the level of the reference programs (BLAST, DOE2, ESP, SERIRES, SUNCODE, SERIRES, S3PAS, TASE, TRNSYS, DEROB).

Now empirical validation are undertaken to verify that the physical models used make it possible to represent correctly reality. The problem of thermal bridges is explicitly examined.

II - Description of test facility

II - 1 - Geometry and data

The description of the test facility (chapter II of this report) is taken out from the articles from Manz et al., ([EMPA], [MANZ]) with many direct texts "copy and paste".

II - 1 - 1 - Description of the geometry

The test facility is a cell designed for calorimetric measurements on facade elements (see figure 1). The five faces of the test cell are adjacent to a guarded zone (GZ). Each test cell and the guarded zone have its own climate control system that can provide heating or cooling to maintain space temperatures. A climate controlled exterior chamber can be mounted over an exterior panel. The wooden structure building surrounding the cell is insulated with a layer of 0,12 m glass wool.

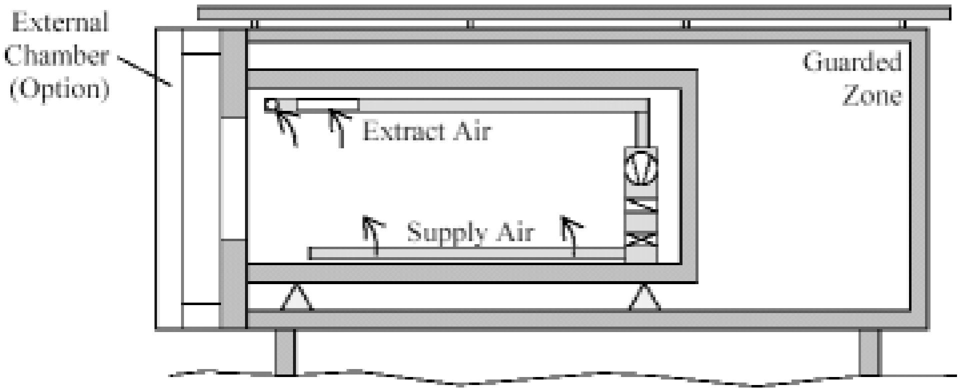

Figure 1 : Diagram of test room with an optional external chamber

The panel covered by the external chamber is facing the south. It is named "external surface" (ES).

The external chamber is denoted "EC" and the guarded zone "GZ". In KoZiBu calculations, these zones are regarded as air volumes of whose temperature is controlled.

II - 1 - 2 - Particularities of the geometry

II - 1 - 2 - 1 - Test cell ventilation

The goal of the test cell ventilation was to minimize the temperature stratification and to obtain a well-defined cell air temperature. Temperature stratification of cell air was smaller than 0,5 K in the experiments. Except for locations near the extract grills, air speeds in the whole cell were below 0,1 m/s.

Equipment for air recirculation in the guarded zone maintained a more uniform air temperature distribution. Recirculated air was supplied near the south wall of the cell by means of four large cylindrical fabric outlets that were mounted horizontally and vertically around the test cell. The air was extracted near the north cell wall to obtain a flow pattern close to a piston flow. Outer surface temperatures of the cell adjacent to the guarded zone were within a range of 2 K during experiments described in this paper.

To control the outside environment of all six faces of the test cell, an external chamber shown in Figure A was mounted at the cell’s south wall. The external chamber was covered with aluminium foil that reflects solar radiation, in order to minimize the impact of solar energy in the chamber.

Air temperature stratification in the exterior chamber was reduced by a fan. All outer surface temperatures of the south cell wall adjacent to the external chamber were within a band of 0,3 K during the experiments.

II - 1 - 2 - 2 - Thermal bridges (door, edges, etc.)

Manz et al. noted that a great part of the heat flow between cell and guarded zone occurs at thermal bridges ([EMPA] Table 7).

Then total thermal losses (including those at edges, door, sealing at external wall and intersections of pipes or flexes with the cell envelope) were computed using TRISCO software [TRSC]. This code enables 3D steady-state analysis of heat conduction processes.

The total thermal conductance of the whole cell envelope from cell air to the outer surface of the cell envelope, including all flows at thermal bridges, were calculated at temperatures of 0°C and 20°C as being 13,539 W/K and 14,721 W/K, respectively.

Thermal losses are evaluated by Manz et al. ([MANZ] Table 7) and the founded values are reported in Table A.

	Global thermal bridge conductance (W/K)
Guarded Zone (GZ)	4,526
External Chamber (EC)	0,04

Table A : Global thermal bridge conductances

II - 1 - 2 - 3 - Airtightness of the cell

All inner and outer cell surfaces were made of steel sheets, and the gaps between the sheets were sealed with silicone. Two-stage rubber sealings at the door and at the external wall made leak protection possible. The airtightness of the cell was measured using the blower door method. At an overpressure of 50 Pa in the test cell, air exchange was found to be 0,2 h^{-1}. The thermal effects of infiltration were therefore assumed to be negligible.

II - 1 - 2 - 4 - Cell internal thermal mass

The heat capacity of the technical equipment in the cell, which consisted of metallic ducts, grills, fans, a heat exchanger apparatus inside a metallic casing, an electrical cabinet etc. was estimated to be 200 ± 30 kJ/K.

However, the authors note that the impact of this thermal mass on the overall transient thermal behaviour of the cell was rather small.

II - 1 - 2 - 5 - Cell internal loads

Due to one constantly running recirculation fan inside the cell, there was an internal heat source of ~77 W during the entire experiment. After a preconditioning phase, an additional pseudo-random heat source of ~196 W was switched on and off in the cell. This source was located inside the recirculation / conditioning apparatus and can, therefore, be considered as a purely convective heat load. During the experiment the measured air temperature stratification was less than 0,5 K.

II - 2 - Experimental conditions

II - 2 - 1 - Description of the conditions of the steady-state experiment

In addition to the transient experiment, a steady-state experiment was performed in order to measure thermal conductances HGZ and HEW directly in the test facility. The external chamber (EC) was mounted over the external surface (ES) for conditioning of the sixth face of the cell. The air inside the test cell, the guarded zone and the external chamber were stirred in order to reduce temperature stratifications. Boundary condition parameters were kept as close as possible to constant values.

Parameters determined in the experiment were :

1. The heating power **PTC**
2. The space-averaged air temperature in the test cell **TTC**
3. The space-averaged outer surface temperature of cell in guarded zone **TGZ**
4. The space-averaged outer surface temperature of cell in external chamber **TEC**

Because there were two unknowns, HGZ and HEW, two equations, representing two different temperature boundary conditions, were needed. Indices A and B denote these two phases of the experiment. The solutions for HGZ and HEW were found analytically by solving this set of equations.

No ideal steady-state situation could be reached in this experiment. Higher fluctuations in boundary conditions occurred particularly on days with high solar irradiances and large differences between daily minimum and maximum outside air temperature. Hence, time intervals with an overcast sky and, therefore, less fluctuating boundary conditions were chosen for analysis. To eliminate small transient effects in the cell envelope, time averaged values were used.

The measured values are given in Table B ([MANZ] p. 16) :

	PTC (W)	**TGZ** (°C)	**TEC** (°C)	**TTC** (°C)
Phase A	282,26 $^{+/-\ 4}$	23,50 $^{+/-\ 0,5}$	23,24 $^{+/-\ 0,5}$	43,13 $^{+/-\ 0,5}$
Phase B	154,04 $^{+/-\ 3}$	23,33 $^{+/-\ 0,5}$	43,73 $^{+/-\ 0,5}$	36,45 $^{+/-\ 0,5}$

Table B : Measured temperatures in the cell for steady-state experiment

Based on this steady-state experiment and the procedure described above, numerical values and total uncertainties for the thermal conductances were calculated to be HGZ = 12,23 W/K ±0,53 W/K and HEW = 2,12 W/K ± 0,59 W/K. These values refer to the mean temperatures in the cell envelope of 36,6°C in the external wall, and, 31,6°C in the cell envelope adjacent to the guarded zone, occurring during this experiment.

II - 2 - 2 - Description of the conditions of the transient experiment

The goal of this transient experiment was to verify whether cell specifications provide an accurate characterization for modelling transient thermal behaviour of the cell. This transient experiment was configured in the same way as the steady-state experiment. Constant temperatures of approximately 23°C were maintained in the guarded zone and the external chamber. Fluctuations of less than ± 1 K occurred during this experiment.

Due to one constantly running recirculation fan inside the cell, there was an internal heat source of ~77 W during the entire experiment. After a preconditioning phase, the last 50 h of this phase, an additional pseudo-random heat source of ~196 W was switched on and off in the cell. This source was located inside the recirculation / conditioning apparatus and can, therefore, be considered as a purely convective heat load.

During the experiment the measured air temperature stratification was less than 0,5 K.

The time constant of the cell was determined by analyzing the temperature response of the cell to the first step increase of heating power and was found to be 17 h.

II - 3 - Simulation of transient experiment

Four building energy simulation codes were used to model the transient experiment. These codes included :

1. DOE-2,1E
2. EnergyPlus
3. ESP-r
4. HELIOS.

When the experiment was modelled, hourly averaged values of six outside cell envelope surface temperatures as boundary conditions and thermal power, including the pseudo-random heat source, were scheduled into the models. As in most building energy simulation codes thermophysical properties cannot be defined as a function of temperature, constant values were therefore employed.

II - 3 - 1 - HELIOS

HELIOS [HELIOS] was developed in the early 1980s and has been recently upgraded. In this code, the thermal bridges were simulated by adding an additional heat transfer surface with a fictitious area to the zone that had the same layer sequence as the walls and the ceiling. This element employed the same thermal conductance as computed for the thermal bridges. Because the thermal bridges were not located at one face, a mean outer surface temperature of all five faces was used. The thermal mass in the room was modelled as a 2 mm metal sheet using thermophysical properties of steel. HELIOS requires a constant value as input for the combined radiative and convective inside heat transfer coefficient. With regard to radiative heat transfer, view factors were calculated using the test cell geometry and assuming grey and diffuse inside cell surfaces. Because the surface temperatures in the cell were nearly the same at any given hour in this experiment, it could be shown that radiation is of very minor importance, and radiative heat transfer coefficient was therefore assumed to be zero.

II - 3 - 2 - EnergyPlus

The development of EnergyPlus began in 1996 by the US Department of Energy (DOE). Thermal bridges were simulated in this code by adding non-radiating surfaces to the back of the space with a constant outer cell surface temperature of 23,22°C, which was the time-averaged outer cell surface temperature during the transient experiment. Because EnergyPlus calculates the radiation heat transfer using view factors and assuming grey and diffuse surfaces, six additional surfaces that faced each other were added to the model. For the other surfaces, a detailed approach was used to compute the convective heat transfer coefficient as a function of temperature difference between surface and cell air. The thermal mass in the cell was modelled in a similar way as in HELIOS.

II - 3 - 3 - DOE-2,1E

The original version of DOE-2,1E [DOE2] was released in November 1993 by Lawrence Berkley Laboratories (LBL). To use the outer surface temperatures as boundary conditions, adjacent zones were created with a single zone air conditioner for each test cell surface. The zone temperature was scheduled as the outer cell surface temperature. The inside film resistance for these zones was specified as zero, thus making the adjacent zone temperature and the outer cell surface temperatures equal. For the inside of the test cell, numerical values of heat transfer coefficients were the same as in HELIOS. The thermal mass inside the cell was again modelled in a similar way as in HELIOS.

II - 3 - 4 - ESP-r

ESP-r [ESP] is an open source program, developed by the Energy Systems Research Unit at the University of Strathclyde with input from many other organizations. It has been developed over a 28-year period. Because ESPr requires a fully bounded zone, it was not possible to simulate the thermal bridges by simply 8 adding additional surfaces connecting the internal air temperature with the external environment to represent the thermal bridges. Different approaches for modelling edge effects were tried, but the one giving the best agreement with measured data was the use of a “fin” added to the back of the test cell with a total surface area equivalent to that used in the other simulation programs. This allowed the edge losses to be modelled without affecting the convective and radiative heat transfer from the 1-D heat transfer surfaces. Boundary temperatures were modelled by creating additional zones and imposing the measured temperatures. Several different convective regimes can be modelled by ESP-r, but the results presented here were based on the same convective coefficients as used in HELIOS. The thermal mass in the test cell was modelled as steel sheets in the room of appropriate dimensions.

II - 3 - 5 - Comments on the comparisons between software results

For HELIOS [HELIOS], discrepancies at the higher and lower temperatures were found that might mainly result from using a constant thermal conductivity (e.g. deviations tended to be smaller at the beginning and the end of the experiment, when a correct average envelope temperature of 26°C was used to calculate the thermophysical properties). Comparisons were made between the measured and predicted surface temperature for HELIOS. HELIOS under-predicted all cell surface temperatures. The wall surface temperatures were about 1 K lower at higher temperatures and 0,5 K lower at lower temperatures. Better agreement was seen at the ceiling where the temperature difference was about 0,3 K lower during the test. The largest discrepancies were seen when predicting the floor temperature; the error at high temperatures was nearly 3 K lower and at low temperatures was about 1 K lower.

For EnergyPlus, there were small discrepancies at the lower and higher temperatures. The deviations at lower temperatures may also be caused by using constant thermal conductivities for the PU and EPS foam. As in HELIOS, EnergyPlus under-predicted all the surface temperatures. The temperature differences for the walls were about 1 K at higher temperatures and 0,5 K at lower temperatures. The temperature differences for the floor during the experiment remained relatively constant at about 0,6 K. At the ceiling, the temperature differences for the high temperatures and low temperatures were about 0,7 K and 0,3 K, respectively. Large differences between surface temperatures for EnergyPlus and HELIOS were thought to be due to the selection (constant values were used in HELIOS and a temperature dependent algorithm was used in EnergyPlus) of convective heat transfer coefficients and the modelling of radiative heat transfer.

Similar discrepancies seen in the other simulations were also apparent in DOE-2,1E and ESP-r and are thought to come from assuming constant thermophysical and convective heat transfer coefficient properties. For ESP-r, the surface temperatures were lower than measured values, with slightly higher temperature differences compared to those predicted with EnergyPlus. The surface temperature was not an available output in this version of DOE-2; comparisons between measured and predicted surface temperatures therefore could not be made.

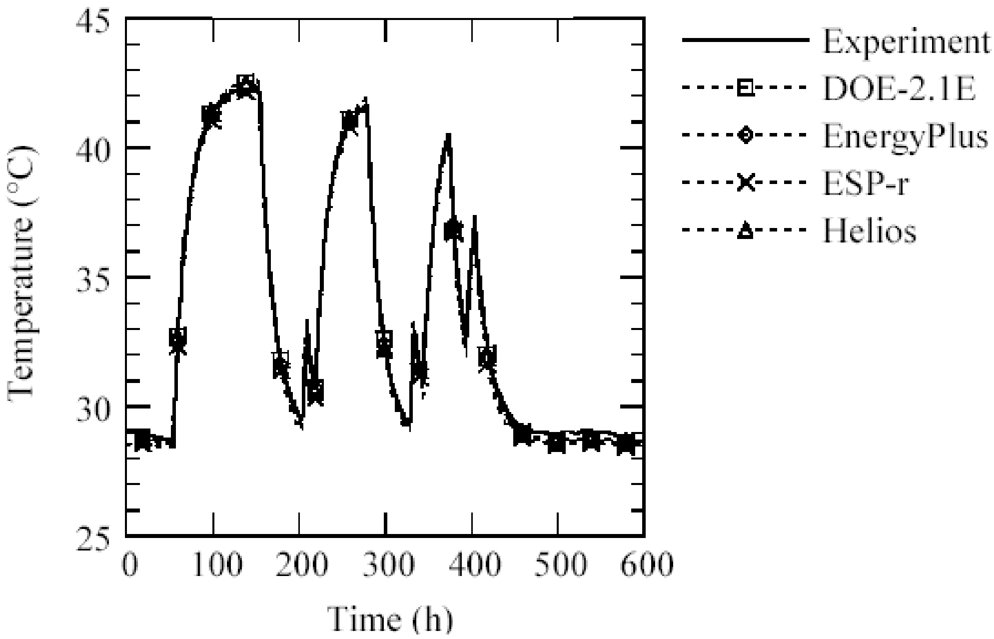

Figure 2 : Comparison between measured and simulated cell air temperatures

A comparison plot between values of mean cell air temperature computed by all four codes is shown in Figure 2.

III - Data used in KoZiBu calculations

III - 1 - Materials

Properties of used materials are detailed in Table C.

Materials	Conductivity (W/m.K)	Density (kg/m^3)	Specific heat (J/kg.°C)	Thickness (mm)
Air	0,026	1,2	1007	---
Thermal Bridge Material	2	1200	1200	---
Sheet_Steel_With_Surface_Structure	53,62	7837	460,8	2,5
EPS_Foam	0,03716	28	1460	130
Plywood	0,14333	850	1605	10
Heavy_PU_Foam	0,07	45	1800	20
Light_PU_Foam	0,023098	30	1800	139
Sheet_Steel	53,62	7837	460,8	0,7

Table C : Materials summary

Thickness is not a property of the material, but in the experiments materials are associated only to a layer type.

Except for the air and for the material of thermal bridge, data are given by the authors [EMPA], Tables 4b, 5b and 6b).

III - 2 - Volumes

III - 2 - 1 - Volumes description

The basic geometry of the test case building is a rectangular single zone with no interior partitions.

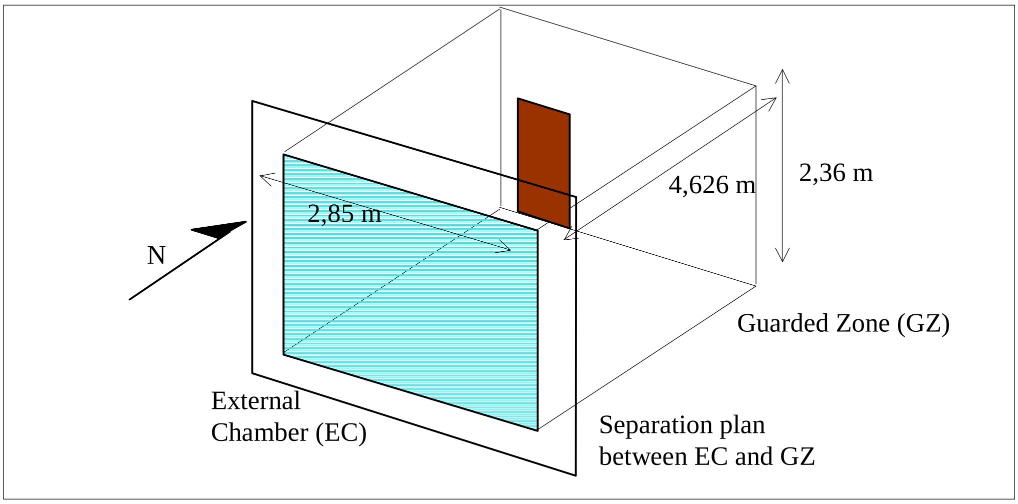

Figure 3 : Cell isometric view (not to scale)

The door is not directly comprised in the north wall. The door is taken into account by the mean of a part of the thermal bridges.

In KoZiBu, view factors are automatically calculated (in proportion to surfaces). The inside surfaces are supposed to be grey.

The guarded zone (GZ) is divided into 5 air zones, in order to be able to fix the "outside" surface temperature for each cell surface. These air zones are named GZ_Orientation if "Orientation" is related to a cell surface (for example "GZ_West").

III - 2 - 2 - Cell boundary conditions

For the steady-state case, the temperatures of the guarded zone (GZ) and of the external chamber (EC) are fixed to the values given by Manz et al. ([MANZ] p. 16). For the transient case, the time averaged values of the outside cell surface temperature are taken from the Excel file given with the "irradiance exercise" package [IEP] :

Volume	Volume Temperature (°C)		
	Steady-state case		Transient case
	A	B	
GZ_Ceiling	23,5	23,33	23,25
GZ_Floor			23,47
GZ_North			22,87
GZ_East			23,46
GZ_West			23,23
External Chamber	23,24	43,74	23,29

Table D : Air volume fixed temperatures for the different KoZiBu calculations

III - 2 - 3 - Cell internal mass

The thermal mass in the room was modelled as a 2 mm metal sheet using thermophysical properties of steel. This modelling is the same one as that employed at the EMPA with software HELIOS (cf. chapter II-3-1).

III - 2 - 4 - Cell internal load

KoZiBu cannot have scheduling with a time length higher than one week. Also, to give a solution to the problem, a file weather is created for which the temperature of external air $T_{\text{External Air}}$ is calculated according to the energy injected into the cell. Then, a flow of energy F is imposed between outside (from the described weather) and the cell in the following form :

$$F = k \, . \, T_{\text{External Air}}$$

This type of flow is only available in the "AirFlow" versions of KoZiBu.

III - 3 - Surfaces

III - 3 - 1 - Convective thermal exchange coefficients

The convective thermal exchange coefficients are detailed in table E :

Convective Surface Coefficients	α (-)	ε (-)	h (W/m².K)
Thermal Bridge Surface	0,01	0,01	1000
Inner Floor Surface	0,246 (1)	0,96 (1)	2,046 (3)
Inner Cell Surface	0,757 (1)	0,92 (1)	2,346 (3)
Guarded Zone Surface	0,76 (4)	0,93 (4)	1000
Outer/Inner South Surface	0,766	0,93 (1)	4,264 (3)
Internal Mass Surface	0,6 (2)	0,9 (2)	1

Table E : Detailed convective surface coefficients summary

(1) [MANZ] Table 6
(2) KoZiBu default values
(3) The convective thermal exchange coefficients are calculated from the wall thermal resistance given by Manz et al. ([EMPA], Table 7). The resistance refers to the heat flow between the cell air and the outdoor surface of the envelope). Calculations are detailed in the next lines.

Ceiling, north, east and west wall

$$R = 2.\frac{0{,}0007}{53{,}62} + \frac{0{,}139}{0{,}023098} + \frac{1}{h} = 6{,}0179 + \frac{1}{h} = \frac{41{,}745}{6{,}478}$$ then **h = 2,3462 W/m².K**

Floor

$$R = \frac{0{,}0007}{53{,}62} + \frac{0{,}139}{0{,}023098} + \frac{0{,}02}{0{,}07} + \frac{0{,}0025}{53{,}62} + \frac{1}{h} = 6{,}30361 + \frac{1}{h} = \frac{13{,}184}{1{,}941}$$ then **h = 2,046 W/m².K**

South wall

$$R = 2.\frac{0{,}01}{0{,}14133} + \frac{0{,}130}{0{,}03716} + \frac{1}{h} = 3{,}639903 + \frac{1}{h} = \frac{6{,}726}{1{,}736}$$ then **h = 4,264 W/m².K**

(4) These values don't play a role.

Since KoZiBu does not allow scheduling of surface coefficients, all coefficients are taken constant.

III - 3 - 2 - Surfaces description

The surfaces associated to the cell are named "Ceiling", "Floor", "North_Wall", "East_Wall", "West_Wall" and "South_Wall" (facing the External Chamber).

The next table summarises layer sequences, thicknesses and thermophysical properties of layers of the cell envelope (see EMPA, Tables 4b, 5b and 6b).

Name	Surface (m^2)	Surface coefficients	Thickness (mm)	Layers
Ceiling	13,18	Inner Cell Surface / GZ Surface	0,7	Sheet_Steel
			139	Light_PU_Foam
			0,7	Sheet_Steel
East_Wall	10,92	Inner Cell Surface / GZ Surface	0,7	Sheet_Steel
			139	Light_PU_Foam
			0,7	Sheet_Steel
West_Wall	10,92	Inner Cell Surface / GZ Surface	0,7	Sheet_Steel
			139	Light_PU_Foam
			0,7	Sheet_Steel
North_Wall	6,72	Inner Cell Surface / GZ Surface	0,7	Sheet_Steel
			139	Light_PU_Foam
			0,7	Sheet_Steel
South_Wall (external surface)	6,72	Outer/Inner South Surface / Outer/Inner South Surface	10	Plywood
			130	EPS_Foam
			10	Plywood
Floor	13,18	Inner Floor Surface / GZ Surface	2,5	Sheet_Steel_With_Surface_Structure
			20	Heavy_PU_Foam
			140	Light_PU_Foam
			0,7	Sheet_Steel
Thermal Bridge GZ	1	Thermal Bridge Surface / Thermal Bridge Surface	440	Thermal Bridge Material
Thermal Bridge EC	0,0088	Thermal Bridge Surface / Thermal Bridge Surface	440	Thermal Bridge Material
Internal Mass	27,7	Internal Mass Surface / Internal Mass Surface	2	Sheet_Steel

Table F : Detailed surfaces data

Layers are given from the outside to the inside of the cell.

The conductance of the two thermal bridges are equivalent to those given by Manz et al.. One must confess that the width was adjusted to fit the results, but this data was missing.

III - 3 - 3 - Thermal bridges

The thermal bridges were modelled either by two fictive walls (see "Thermal Bridge GZ" and "Thermal Bridge GZ" in previous paragraph) or by two resistances with the same conductances as those of the fictive walls.

Simulations were made with fictive walls if no more indication is given.

IV - Simulation results

The time step in an hour.

IV - 1 - Steady-state case

Comparisons between KoZuBu and experimental results are presented in Table G.

Steady-state Case	Data			Results	
				TTC (°C)	
	PTC(W)	TGZ (°C)	TEC (°C)	EMPA	KoZiBu
Phase A	282,26 $^{+/-\,4}$	23,50 $^{+/-\,0,5}$	23,24 $^{+/-\,0,5}$	43,13 $^{+/-\,0,5}$	43,0 $^{+/-\,0,7}$
Phase B	145,04 $^{+/-\,3}$	23,33 $^{+/-\,0,5}$	43,73 $^{+/-\,0,5}$	36,45 $^{+/-\,0,5}$	35,7 $^{+/-\,0,7}$

Table G : KoZiBu and experimental results in steady-state case

A good agreement can be observed.

Note that the mean KoZiBu results are obtained with the mean data values given in Table F. If one considers the uncertainties associated with the mean data values, one obtains the indicated uncertainties.

IV - 2 - Transient case

The figure 4 presents the results of KoZiBu compared with those obtained in the experiments for the transient case.

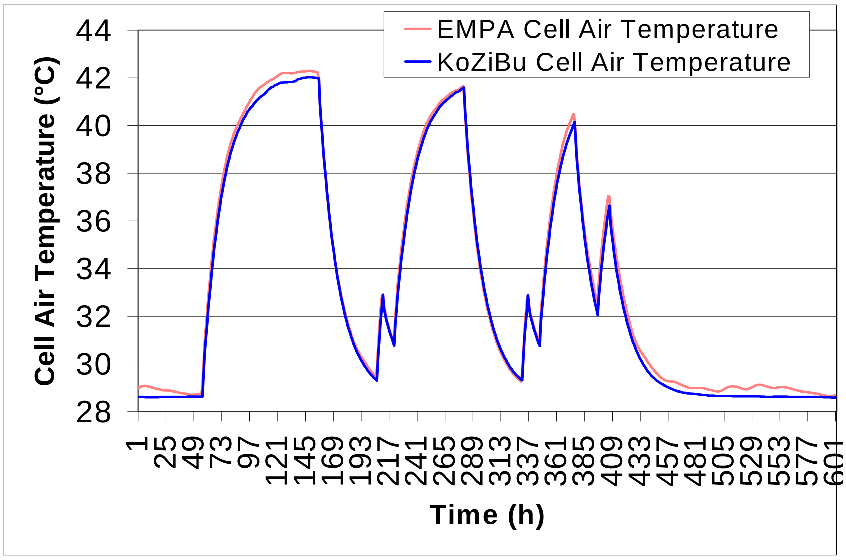

Figure 4 : KoZiBu and experimental results in transient case

In this case the thermal bridges are treated as fictive walls.

The figure 5 presents the results of KoZiBu compared with those obtained in the experiments for the transient case, but with thermal bridges treated as thermal resistances.

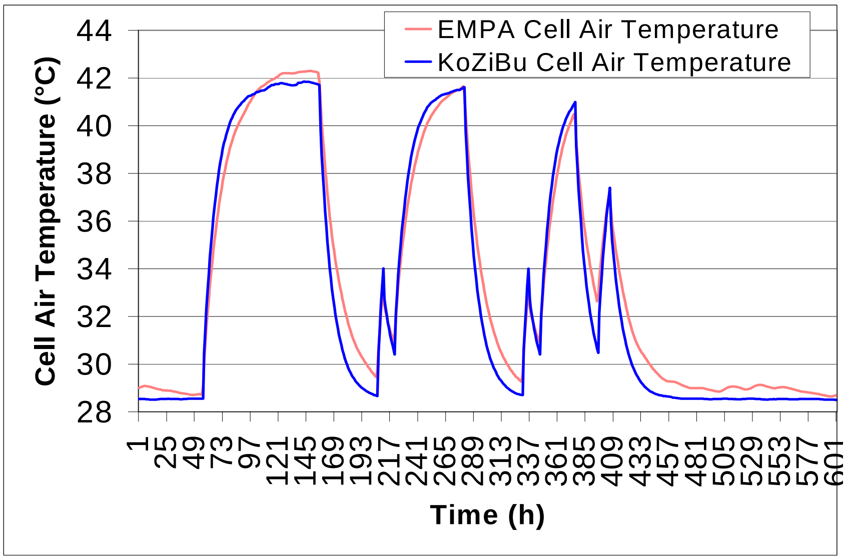

Figure 5 : KoZiBu and experimental results in transient case, the thermal bridges are massless

The results are worse.

V - Conclusions

The KoZiBu software (which corresponds to the CoDyBa Version 6,5) was used to simulate the transient evolution of the temperature in a cell where all boundary conditions were known.

The results obtained by KoZiBu are in very good agreement with those obtained from the experimentation.

For Manz et al., it seems certain that specifications given in their report adequately describe the transient thermal behaviour of the EMPA test cell. The data of the transient experiment is of high quality and can therefore be used by code developers and modellers for validation purposes. In their opinion these results are a good foundation to begin investigating solar gains with and without internal and/or external window shadings.

Indeed, the data presented make it possible to obtain concordant results quickly. It should be unfortunately regretted that the data concerning the mass of the thermal bridges are not objective, and that a certain tuning is necessary. In fact the thermal bridges play a great role in the thermal losses, and if a fictive wall is not present to represent an inertial thermal bridge, discrepancies may be observed in the comparison of the temperature evolution. Manz et al. admit that these exercises have confirmed that modelling has to be done very carefully and that the modeller can also be a major source of deviations even for very simple models such as that of a cuboid shape test cell, where detailed information about all the input parameters are available, because thermal bridges and/or convective heat transfer at surfaces can be modelled differently.

A future work will be conducted by Manz et al., and will concern glazing and shading devices with increasing degrees of complexity. Personally we await impatiently the publications of these results.

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