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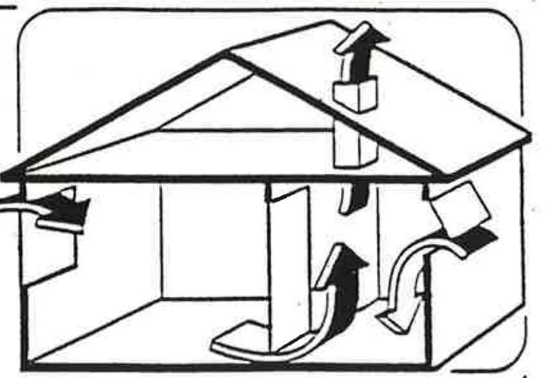

Weather and aeraulic data set for validation

The LESO Building

Part. 2
Building description and Measurement report

(March 1990)

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ABSTRACT

The document presents the LESO Building and its principal parameters as dimensions, air leakage distribution, pressure coefficients and air renewal. This data base is provided to help for one step in the validation of air infiltration simulation codes.

The reference gives associated papers which are necessary for the use of the data set.

INTRODUCTION

This document constitutes the core of the LESO data-set for validation of multi-zone air infiltration models. It describes the building and the test site and report the aeraulic measurements made between 1987 and 1990, according the reporting format described in the AVC tech. note 6.

This document, with the principal papers quoted in references [5, 6, 7, 8, 9,], may allow the use of the data-set. But the authors want to emphasize that, since there is much diffuse information which cannot be included in such a document, a correct use of the data-set and a comprehensive analysis of the results obtained by its use requires a close discussion with the authors.

The floppy disk containing numerical data set is not automatically annexed to this document but is available from the authors. Moreover, it is planned to include the LESO data set in the AIVC data base.

The document is divided in four items :

1. General information
2. Test site description
3. Building desription
4. Operation and numerical data set.

1. GENERAL INFORMATION

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1.8 ***Title of the project*** ERL - Task B 3.2

"Programmes de calcul détaillés et simplifiés des échanges d'air dans le bâtiment : Validation à l'aide de mesures expérimentales" [1, 2, 3].

1.9 ***Principal objectives***

Constitution of a data-set for purpose of validation.

1.10 ***References***

1. 1. Status Seminar "Forschungsprogramm : Energierelevante Luftströmungen in Gebäuden", *Winterthur, Switzerland, 1987 (French and German).*

2. 2. Status Seminar "Forschungsprogramm : Energierelevante Luftströmungen in Gebäuden", *Lausanne, Switzerland, 1988 (French and German).*

3. 3. Status Seminar "Forschungs programm : Energierelevante Luftströmungen in Gebäuden", *Zurich, Switzerland, 1989 (French and German).*

4. J.-L. Scartezzini, J.-M. Fürbringer, C.-A. Roulet
"Data needs for purpose of air infiltration computer code validation"
8th AIVC Conference proceedings, Ueberlingen, RFA, 1987.

5. J.-M. Fürbringer, C. Roecker, C.-A. Roulet
"The use of a guarded zone pressurization technique to measure air flow permeabilities of a multi-zone building"
9th AIVC Conference proceedings, Gent, Belgium, 1988.

6. J.-M. Fürbringer, R. Compagnon, C.-A. Roulet, A. Gadilhe
"Wind and pressure requirements of the validation of a multi-zone air infiltration program"
10th AIVC Conference proceedings, Espoo, Finland, 1989.

7. J.-M. Fürbringer, C.-A. Roulet
"Study of the errors occurring in measurement of leakage distribution in buildings by multifan pressurisation"
Submitted to "Building and Environment", Feb. 1990.

8. J.-M. Fürbringer, R. Compagnon
"Weather and aeraulic data-set for validation : the LESO building"
Part I : "Content of the data-set" - *LESO Internal report (1989).*

9. A. Faist et al. - Projet NEFF 110 "Rapport de Synthèse"
LESO report, Lausanne, Switzerland, 1985.

10. Institut Suisse de Météorologie "Valeurs journalières des précipitations enregistrées aux stations météorologiques et pluviométriques suisses"
ISM, Zurich (4ème trimestre 1988).

2. TEST SITE DESCRIPTION

2.1 Geographic information

1.1.1 Location

The LESO building is a laboratory building of the Ecole Polytechnique Fédérale, which is in Ecublens near Lausanne, a suburban area, at 500 [m] of the lake shore.

Longitude :	(E)	6.58
Latitude :	(N)	46.53

2.1.2 Height above the sea level

The front door is at ≈ 400 m above the sea level.

2.1.3 Terrain

Suburban area. The building is surrounded by slightly higher buildings (see Annex 3).

2.1.4 Orientation

The building has its main axis East-West, the main façade, mostly glazed, is south oriented.

2.1.5 Location of meteorological station

The building has its own meteorological station. Temperatures, reference pressure, air moisture, solar radiation are measured on the roof of the building.

The wind speed and direction are measured at 18.2 [m] from ground level, on a mast 5.5 [m] over the roof. Figure 2.2 presents the location of the probes on the building.

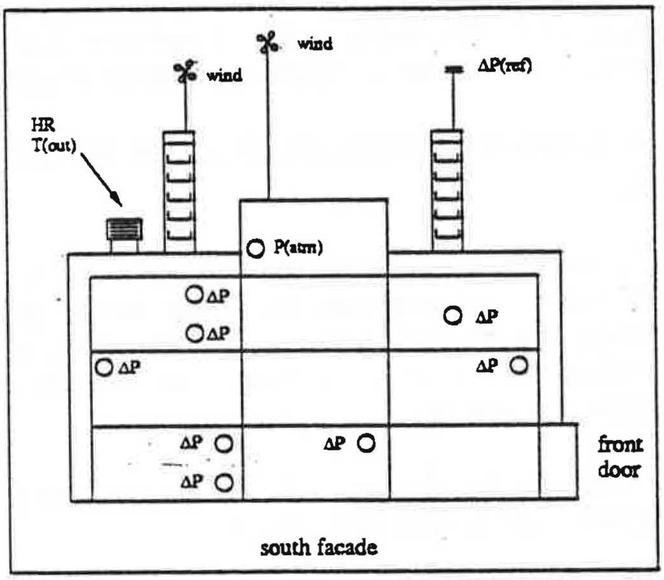


Figure 2.2 : South façade of the LESO Building with meteorological parameters probes position.

2.2 Climatic information

2.2.1 *Distribution of wind speed versus direction*

Two kinds of distributions are presented to evaluate the wind speed versus direction distribution from quarterly wind speed and direction measurements :

- The wind occurrence percentage in a given sector which indicates the orientation distribution without intensity information.

- The average wind integral (relative or not) in a given sector which indicates the distribution of the wind intensity.

The statistics and the graphics are extracted from 1989 all year measurements and from the two tracer gas measurement periods included in the data-set.

Figure 2.3 presents the distribution of the wind direction in 1989 in 36 sectors of 10° (south = 0°, West = 90°, North = 180°). The dominant winds come from North and South. This corresponds to the main winds in the area (north and south-west), the effect being enhanced by the surrounding buildings.

The average wind speed, calculated for every month in 1989 is presented in figure 2.4. The mean value is between 2 and 3 [m/s]. These winds are however feeble when compared to coastal areas or flat countries.

To have a statistical signification, this data should concern a longer time (≈ 10 years).

Figure 2.5 presents the relative wind integral for a 10 days period in December 1987 which corresponds with the tracer gas measurements. During this period the average wind speed has been west (m/s) with a dominant direction. The relative occurrences distribution presented in figure 2.6 confirms this results.

The same statistics for the year 1988 measurement period (figures 2.7 and 2.8) have given a dominant north wind.

Table 2.1 presents daily averages of wind speed, external temperature and moisture, insolation for the periods which correspond with the tracer gas measurement campaigns.

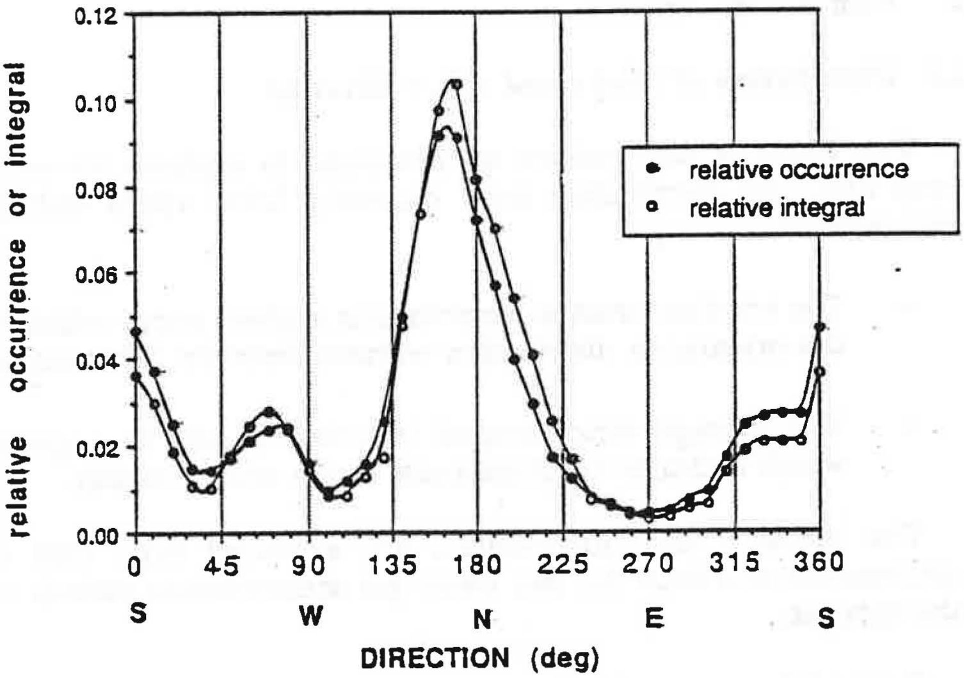


Figure 2.3 : Wind relative distribution (occurrences and integral) in 1989 from quartely wind measurement on the LESO-building.

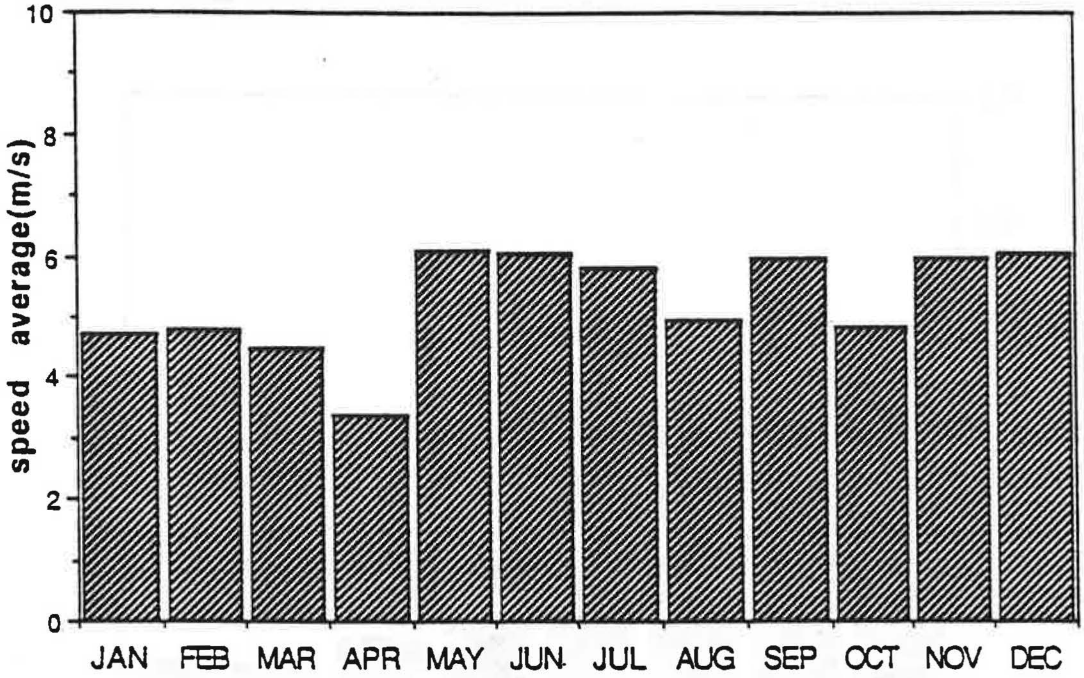


Figure 2.4 : Monthly average wind speed in 1989 from quartely wind measurement on the LESO-building.

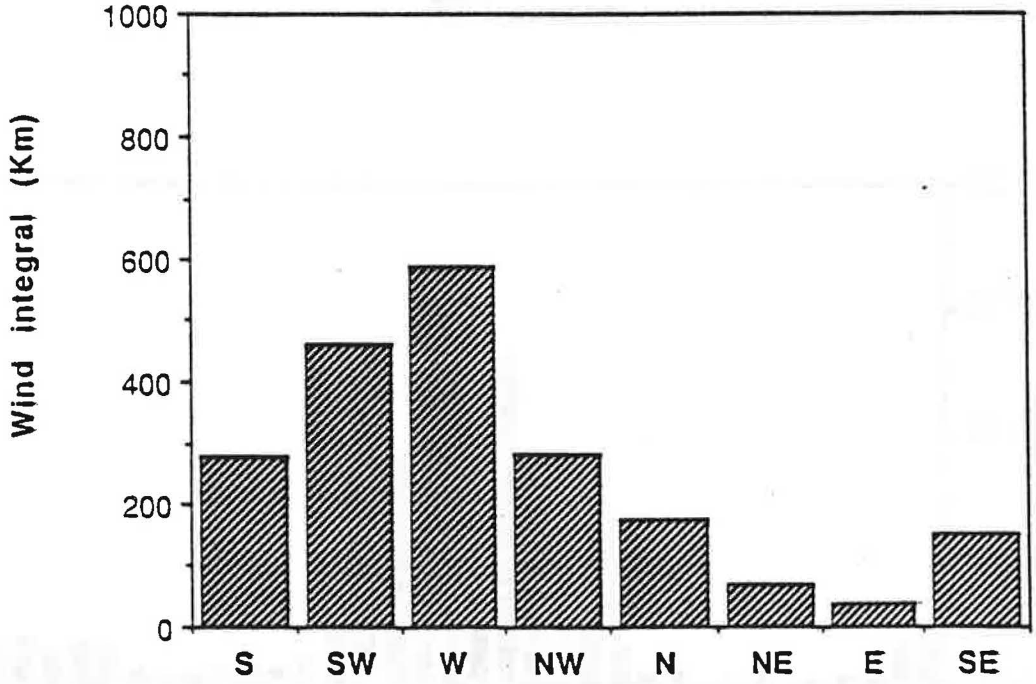


Figure 2.5 : Wind integral distribution for the 10 days measurement period in 1987.

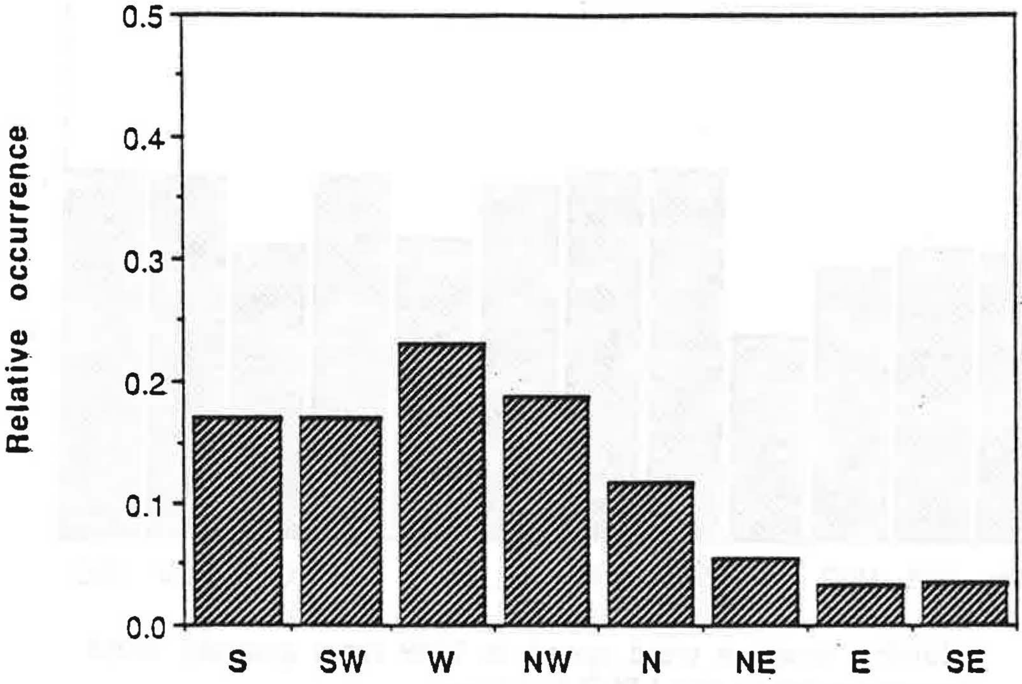


Figure 2.6 : Relative wind occurrence distribution for the 10 days measurement period in 1987.

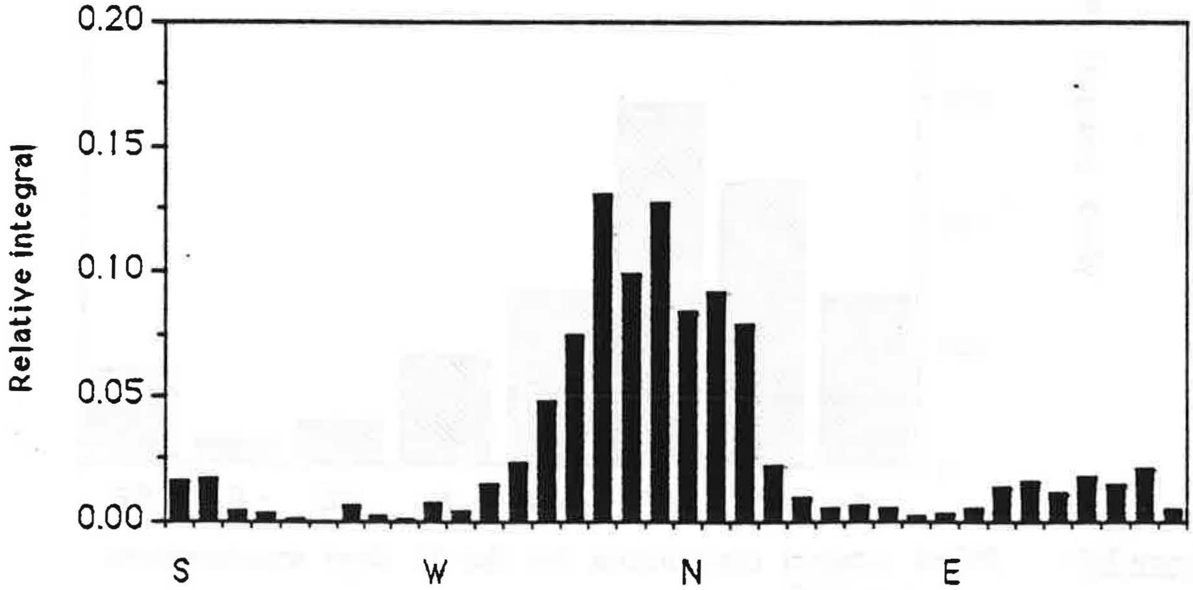


Figure 2.7 : Wind integral relative distribution for the measurement period B in 1988.

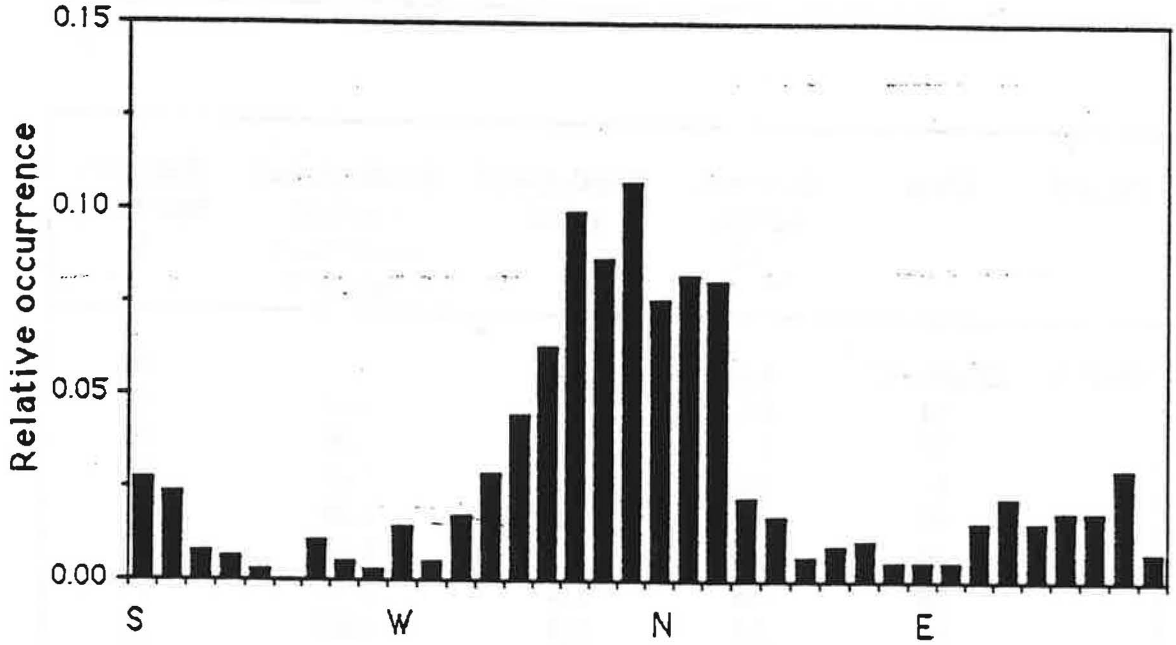


Figure 2.8 : Relative wind occurrence distribution for the measurement period B in 1988.

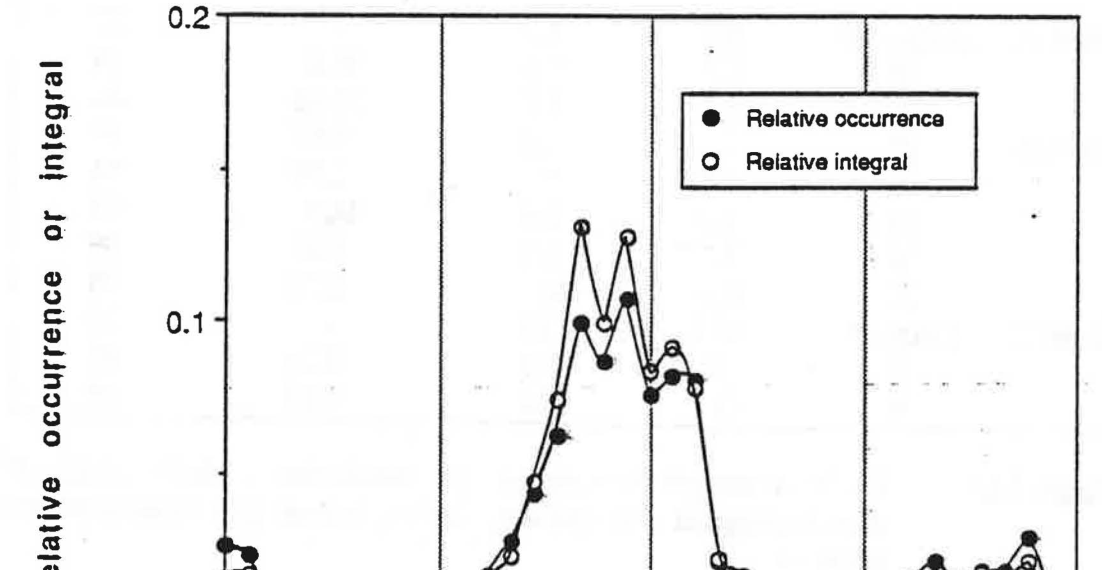


Figure 2.9 : Relative wind occurrence and integral comparison for the measurement period B in 1988.

Period	Date	External temp. [°C]	Wind speed [m/s]	South global vertical insolation [MJ/m²]	Relative humidity %
1987 A	23 déc. 87	4.2	1.8	-	81
	24	3.1	1.6	1.03	85
	25	4	1.3	.99	91
	26	5.4	1.6	1.24	88
	27	4.5	1.4	1.36	91
	28	3.8	1.4	1.40	93
	29	2.8	1.3	1.10	92
	30	2.8	1.3	4.85	91
	31	3.7	1.0	2.23	89
	1 jan. 88	6.1	1.5	1.10	88
	2	8.1	3.5	6.09	79
	3	7.6	4.3	5.48	77
	4	4.8	5.1	0.46	87
1988 A	24 déc. 88	8.2	2.3	-	77
	25	7.7	1.3	36.8	84
	26	4.5	1.8	50.45	86
1988 B	27	5	.8	2.97	89
	28	4.4	2	1.79	84
	29	1.5	2.9	44.9	92
	30	2.7	1.1	5.31	89
	31	0.8	2	2.75	93
1988 C	2 jan. 89	-0.2	3.9	-	84
	3	0	2.3	2.26	81
	4	-1.1	3.0	2.25	86

Table 2.1 : Daily averages (excepted for insolation : daily sum) of meteorological parameters during tracer gas measurement periods.

2.2.2 *Wind speed versus temperature*

This information can be obtained from the full data-set, but is not shown here.

2.2.3 *Solar radiation*

Table 2.2 gives the list of the insolation measurements included in the data-set, since table 2.1 has exibited the daily averaged insolation during the tracer gas measurement periods.

Parameter		Channel	Unit
Global	Horizontal	can 102 SM	W/m^2
Diffuse	Horizontal	can 124 SM	W/m^2
Global	South	can 106 SM	W/m^2

Table 2.2 : Insolation parameters included in the data-set.

Figures 2.10 - 2.12 present three years of monthly averaged insolation and outside air temperature.

2.2.4 *Cloudiness*

No information available.

2.2.5 *Precipitation, humidity*

No information on precipitation is contained in the set.

The Swiss meteorology institute gives for the region of Lausanne in 1988, 1249 [mm] of precipitation since the annual average between 1901 and 1960 is 1064 [mm] of water [10].

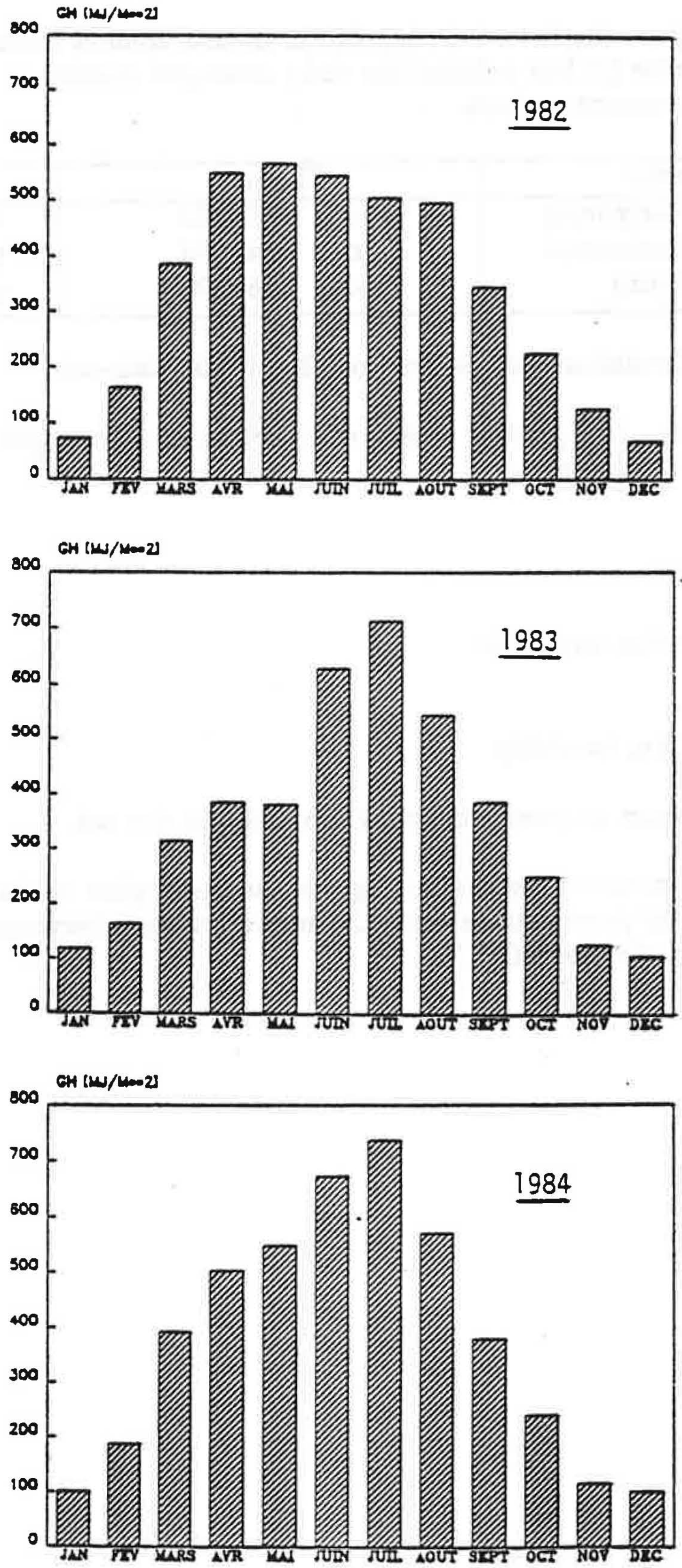


Figure 2.10 : Global horizontal insolation measured in the LESO.

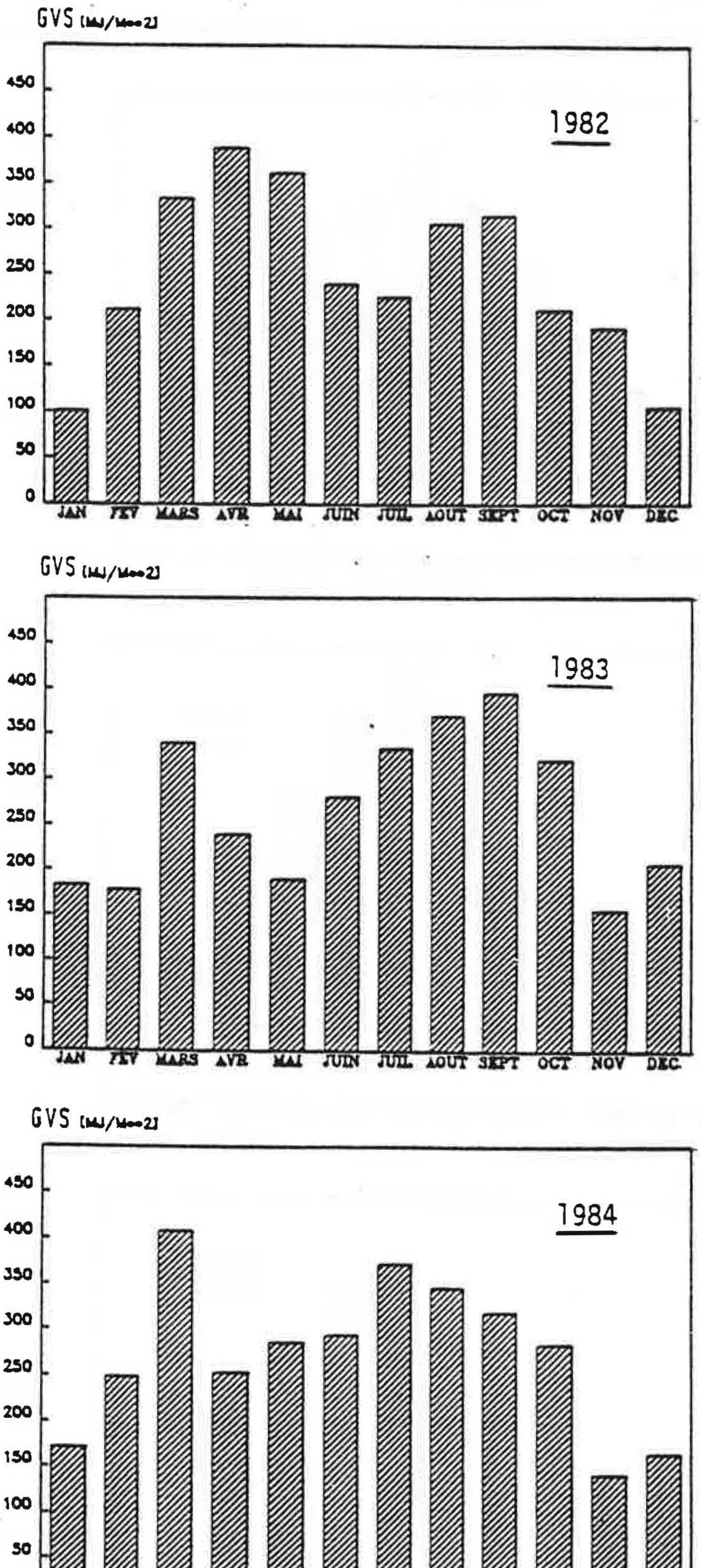


Figure 2.11 : Global vertical insolation measured in the LESO.

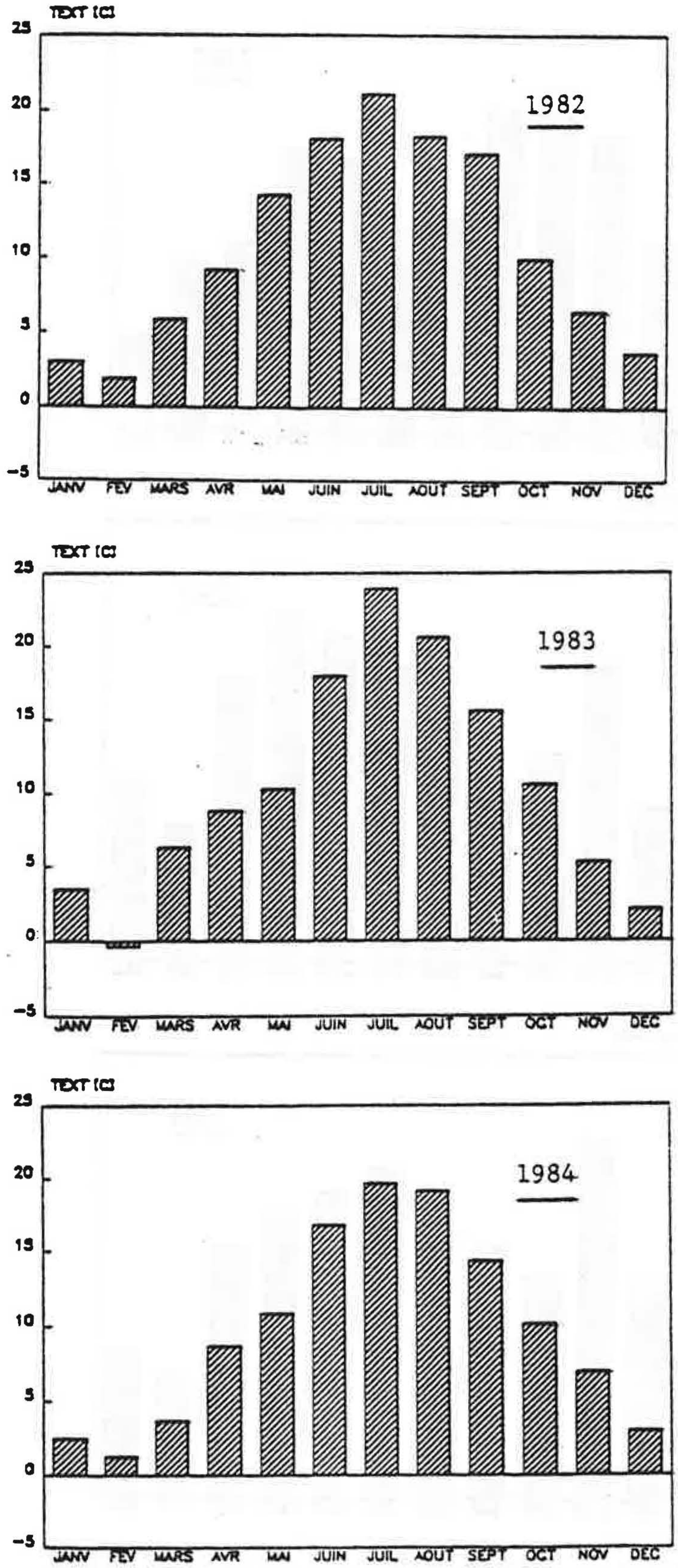


Figure 2.12 : Monthly averaged outside air temperature.

3. BUILDING DESCRIPTION

3.1 Building name LESO (Laboratoire d'Energie Solaire)

3.2 Building type Administrative, office building

3.3 History

The LESO-building was built in 1983 to serve as laboratory and work office to the LESO-PB (Laboratory of solar energy and building physics) [9].

After few years of study on the thermal problems attached to the passiv solar systems, the laboratory has now expanded in domain to energy in buildings and a group is specialised on air infiltration research.

3.4 Construction

The building is constituted of nine south oriented cells with different façades and 10 [cm] insulation between the cells themselves.

The thermal insulation is very high : 20 [cm] between inside and outside. The structure is in concrete. The partition walls are non finished concrete blocs.

Figures 3.1 - 3.4 present the thermal conductances.

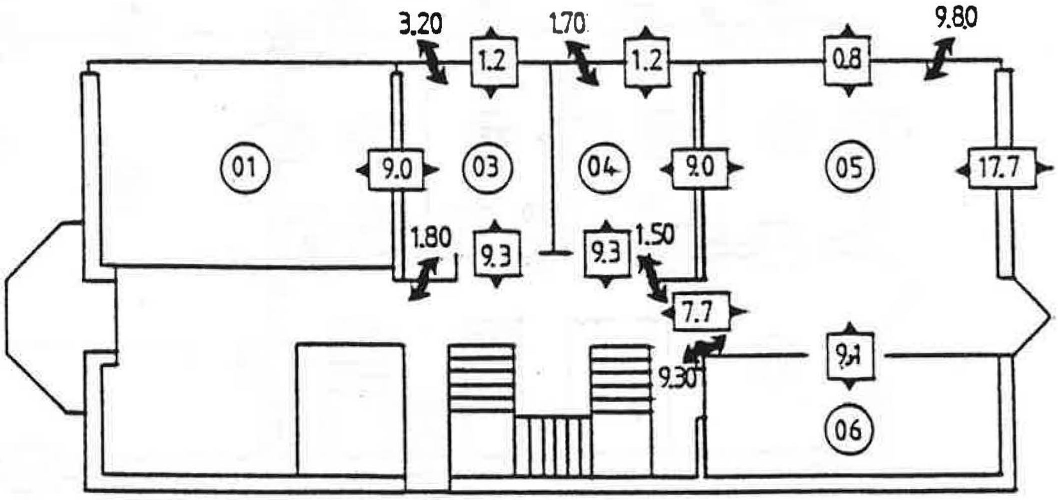


Figure 3.1 : Thermal conductances in [W/K] between rooms and also with outside. First floor.

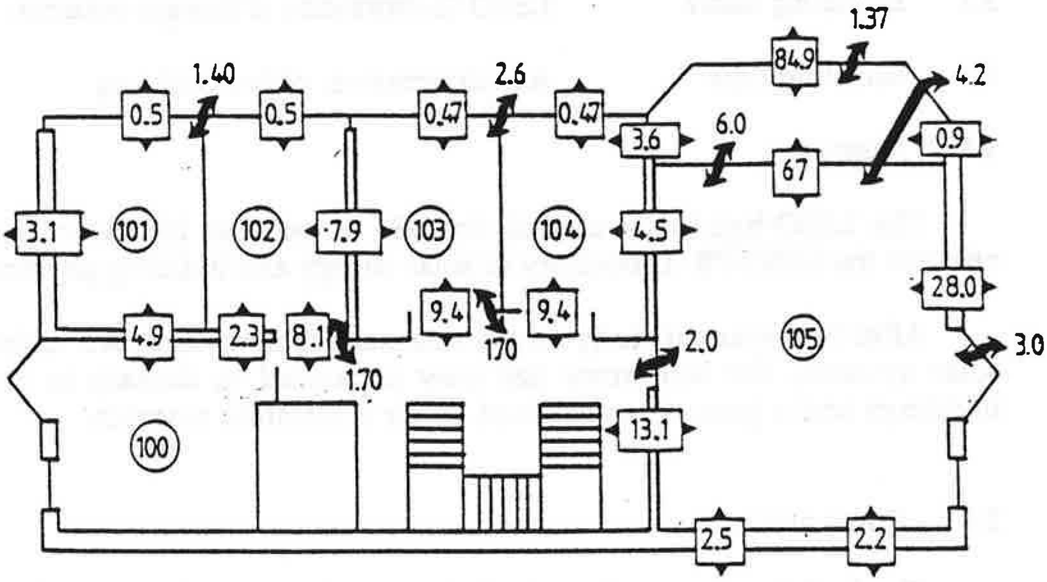


Figure 3.2 : Thermal conductances in [W/K] between rooms and also with outside. Second floor.

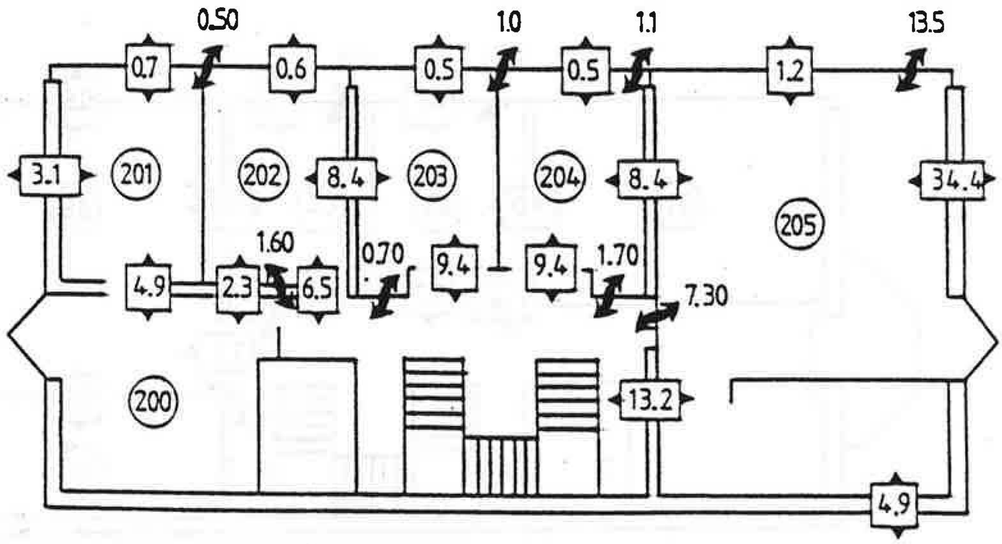


Figure 3.3 : Thermal conductances in [W/K] between rooms and also with outside. Third floor.

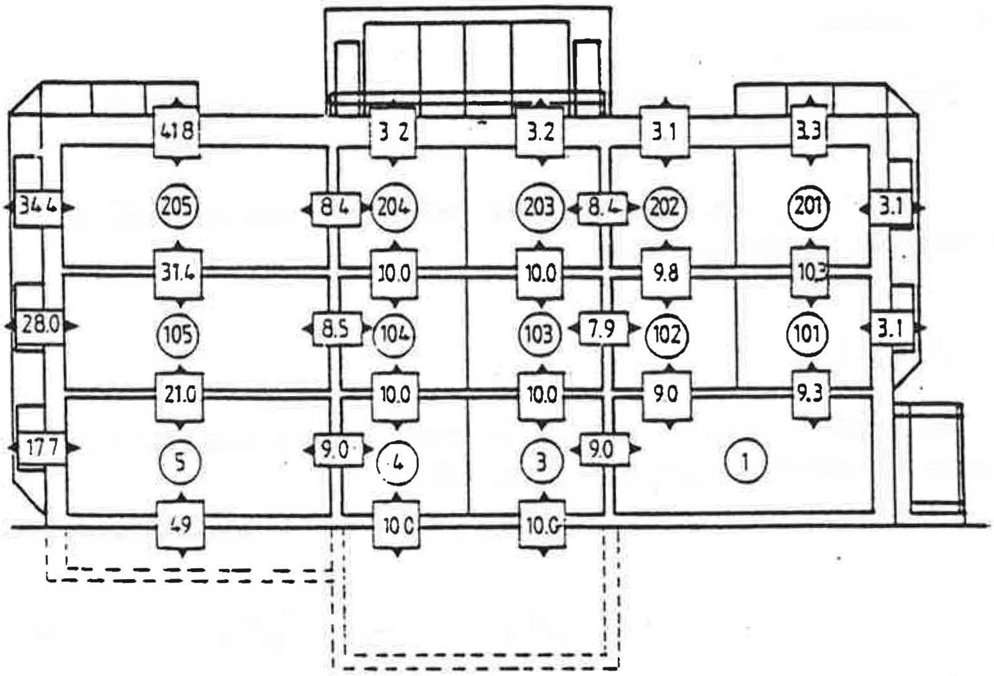


Figure 3.4 : Thermal conductances in [W/K] between rooms and also with outside (South elevation). Circles contain room number.

3.5 Dimension

3.5.1 Plan

see annex 3

3.5.2 Elevation

see figure 3.12

3.5.3 Global parameters

Total volume :		2 165	[m³]
Floor area :		785	[m²]
Window area :	South	118.3	[m²]
	East	5.5	[m²]
	North	2.1	[m²]
	West	2.7	[m²]
K :		.55	[W/m²K]
Total external area :		833	[m²]
Ground area :		346.5	[m²]

3.5.4 *Windows*

There are various types of windows. A comprehensive description is given in reference [9].

In 1988 the greenhouse has been removed (room 005, 105) and now a conventional façade replaces it.

3.5.5 *Front door*

The front door is an air lock in metal framed glas, built untight for purpose of natural ventilation (see fig. 3.5).

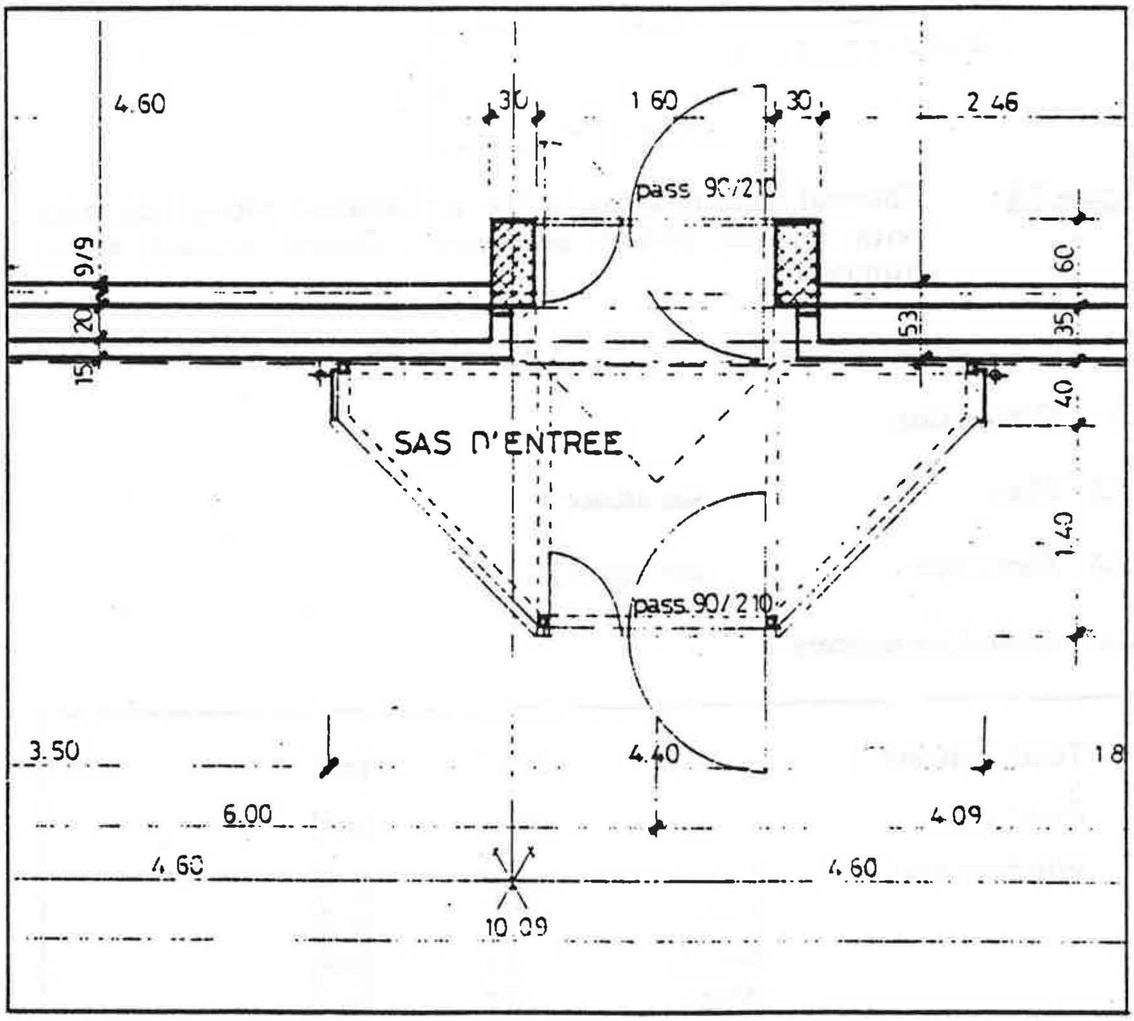


Figure 3.5 : The front door plan.

3.5.6 *Rooms*

Figure 3.6 presents the plan of the rooms.

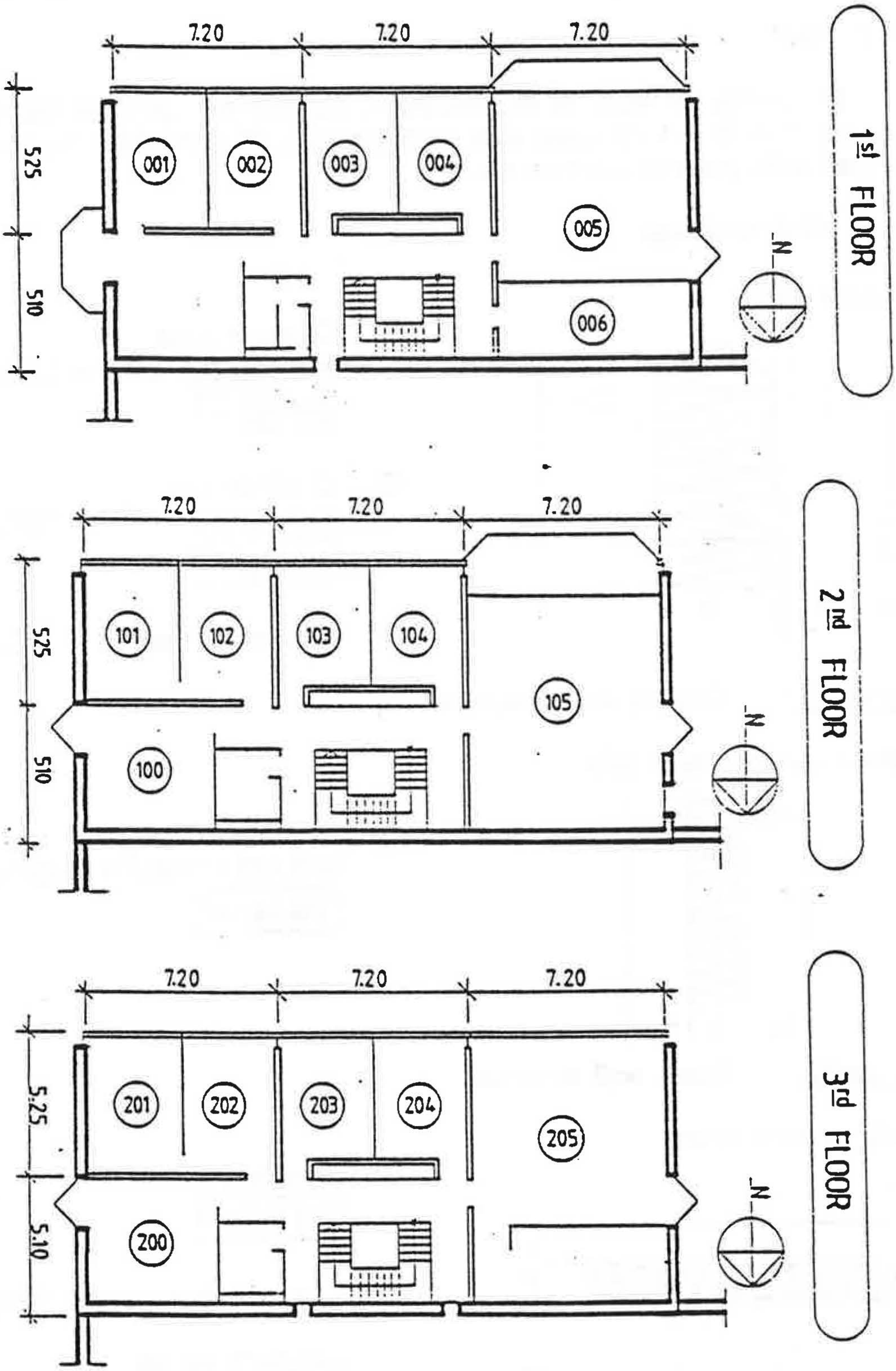


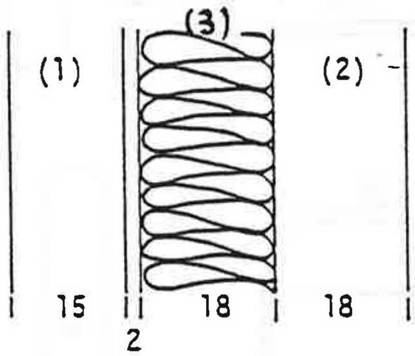
Figure 3.6 : Plan of the rooms in the LESO building.

3.5.7 Roof

The roof is flat with the excrescence of the stair case and two chimneys (see fig. 2.2). It is a concrete dam with external, 20 [cm] thick insulation, covered with grave or concrete slabs.

3.5.8 Wall thickness

Outside walls



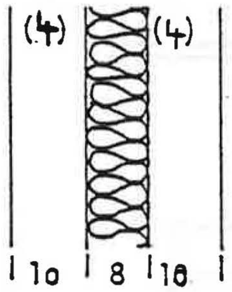
(1) Concrete blocs
$39.5 \times 19 \times 15$ cm³ = 20.130 kg
268 kg/m²

(2) Concrete blocs
$39.5 \times 19 \times 18$ cm³ = 22.333 kg
298 kg/m²

(3) Glass wool $\lambda = 0.04$ W/mK

Figure 3.7 : Outside wall structure.

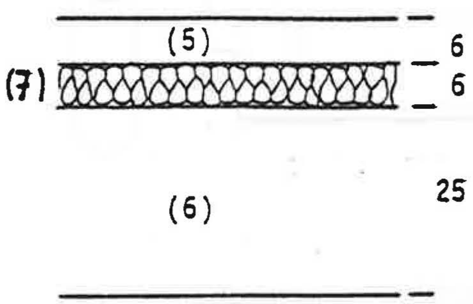
Lateral walls between cells



(4) Concrete blocs
$49.5 \times 19 \times 10$ cm³ = 12.357 kg
132 kg/m²

Figure 3.8 : Inside wall structure.

Deck between floors



(5) Covering (estimated)
132 kg/m²

(6) Sample ϕ 16 cm h = 32 cm

weight 15.641 kg

2431 kg/m³ 608 kg/m²

(7) Glass wool $\lambda = 0.036$ W/mK

Figure 3.9 : Floor structure.

3.6 Air leakage information

The air leakage information consists on the values of the air conductances of the major elements of the building. The vertical air conductances have been neglected.

The measurement have been performed using the guarded zone technique. The technique is presented in [5] and discussion on the error is made in [7]. The authors want to emphasize on the necessity to consider this item as seriously as required since errors in leakage parameters could reach 100% in very common situations.

Figure 3.10 presents the aeraulic net of the LESO, the nodes corresponding to the rooms and the "resistances" to the air leakage.

Figure 3.11 presents the measurement results for C in [$m^3/h\ Pa^n$] and for n since tables 3.1 - 4 give the list of the leakage like they are modelled for G.C. Comis code (C in [$kg/s\ Pa^n$]). This data concerns the building how it was in 1987.

The transformations made in the current of 1988 needed to perform additional measurement which will be included in the data as soon as possible (Summer 1990).

Some elements have not been separatly measured and have been estimated from global measurements as it is the case for the south and west façades of rooms 005, 105 and 205. Their own measurement would need a very complex experiment.

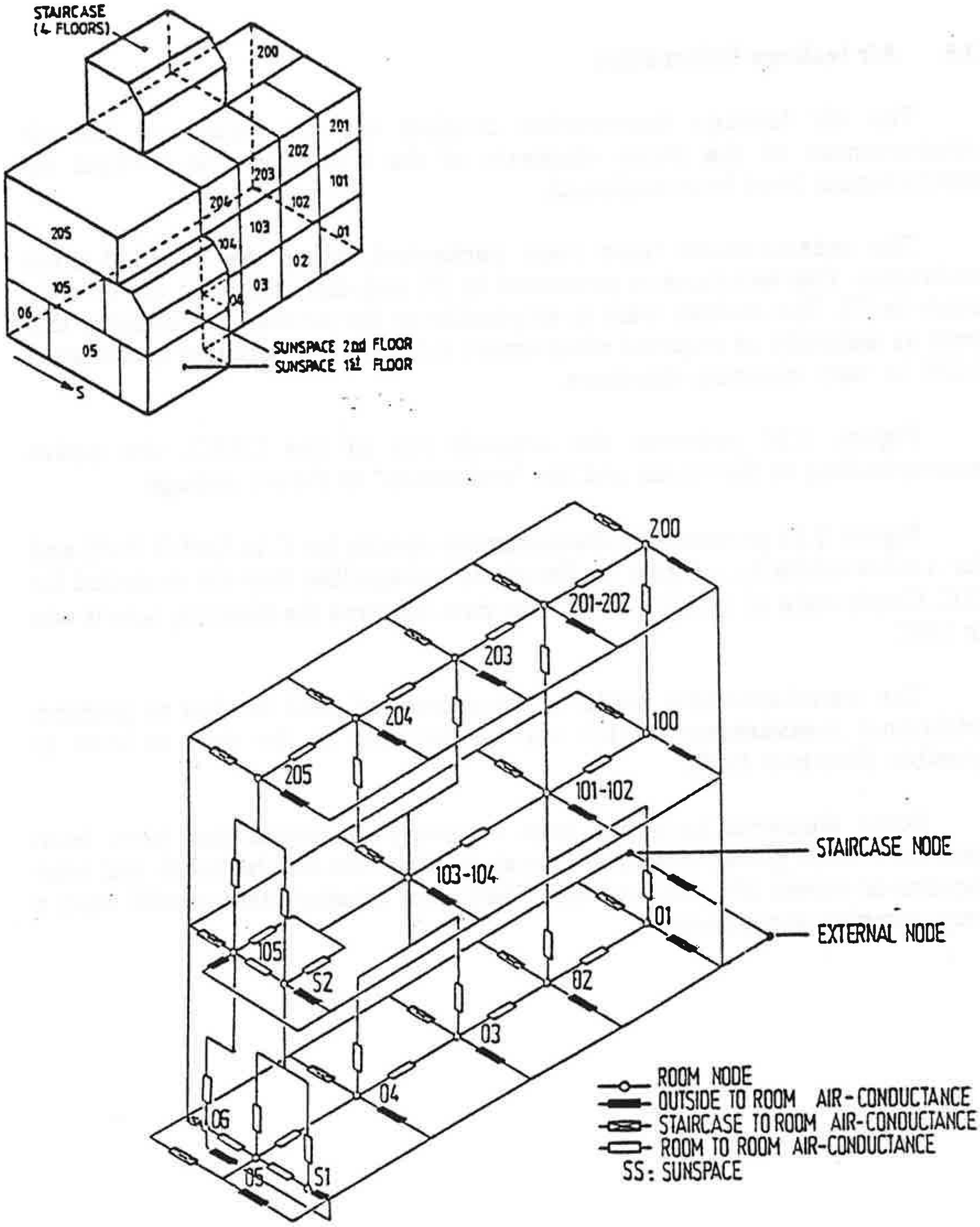
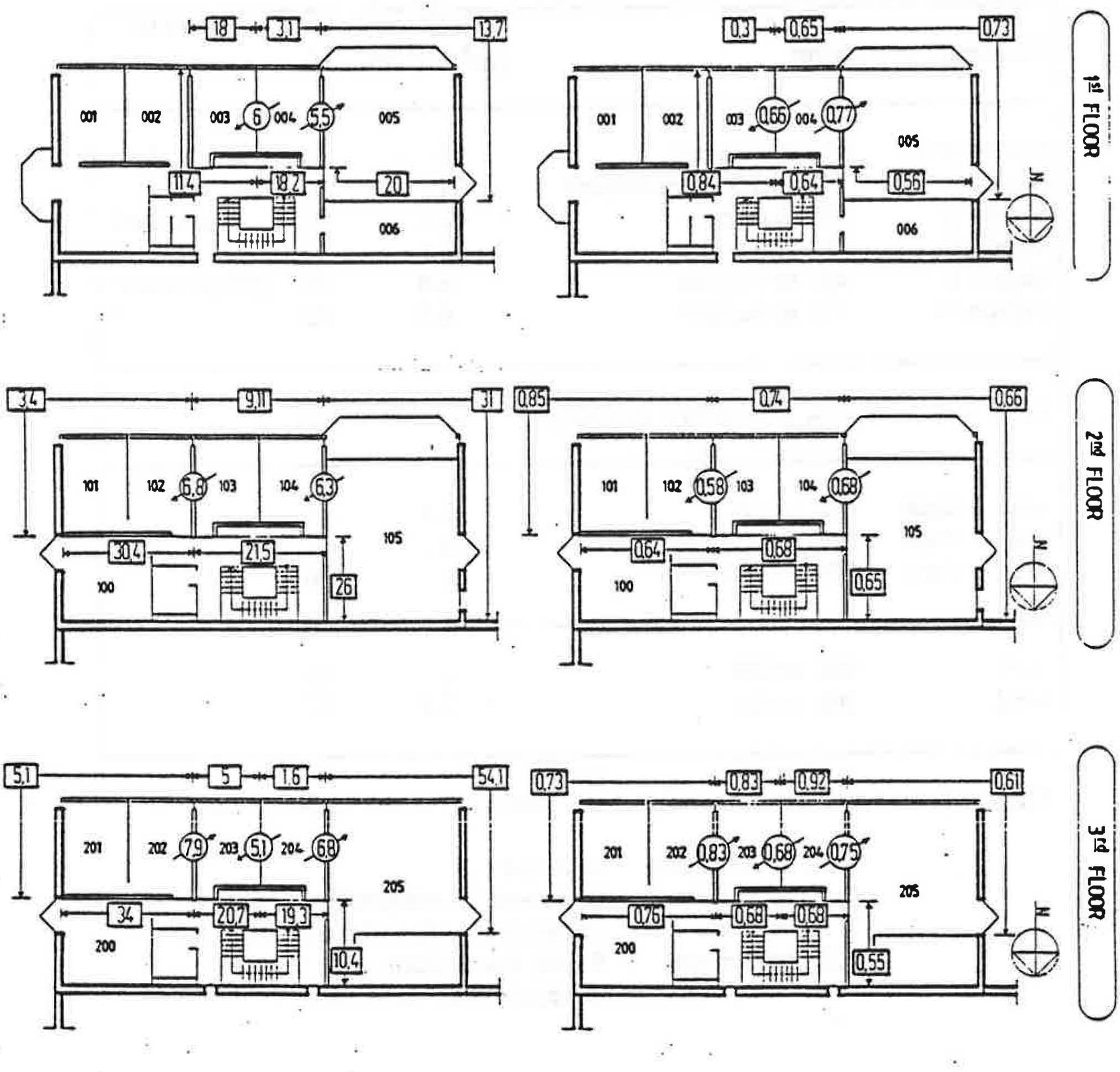


Figure 3.10 : Perspective of the LESO-Building (top) and corresponding conductances net (bottom).



a) b)

Figure 3.11 : a) C-values of the LESO-Building C [m^3/h Pa^n]
b) Exponents n [-].

☐ values for exfiltration from a room to outside or staircase.

⌀ values for exfiltration from a room to another room with the sense of measurement.

Element	from	C [m³/h Paⁿ]	n [-]	comments
front door	STC to outside	96	.60	
façade S	(001 and 002) to outside	21	.60	
façade S	003 to outside	3.1	.65	estimated
façade S	004 to outside	3.1	.65	
façade S	005 to outside	6.8	.73	greenhouse*
façade W	005 to outside	6.8	.73	*
door N	STC to adjacent building	20	.60	*
wall + door	003 to STC	11.4	.84	
wall + door	004 to STC	18.2	.64	
wall + door	005 to STC	20	.56	
wall	004 to 003	6	.66	
wall	005 to 004	5.5	.77	

Table 3.1 : Air-conductances of the first floor of the LESO in 1987

STC means staircase
* means that result is arbitrarily parted between different elements
S,E,N,W mean South, East, North and West orientation of an element.

Element	from	C [$m^3/h\ Pa^n$]	n [-]	comments
façade E	100 to outside	15	.6	*
façade S	(101 and 102) to outside	4	.85	
façade S	(103 and 104) to outside	9.2	.74	
façade S	105 to outside	2.4	.66	*greenhouse
façade W	105 to outside	7.2	.66	*
window N	STC to outside	15	.6	*
wall + door	101 and 102 to STC	30.4	.64	
wall + door	103 and 104 to STC	21.5	.68	
wall + door	105 to STC	26	.65	
wall	103 to 101	6.8	.58	
wall	105 to 103	6.3	.68	

Figure 3.2 : Air-conductances of the second floor of the LESO in 1987

STC means staircase
* means that result is arbitrarily parted between different elements
S,E,N,W mean South, East, North and West orientation of an element.

Element	from	C [m³/h Paⁿ]	n [-]	comments
window E	200 to outside	15	.6	*
façade S	(201 and 202) to outside	5.1	.73	
façade S	203 to outside	1.6	.83	winter posit.
façade S	204 to outside	5	.92	summer pos.
façade S	205 to outside	9	.61	*
Façade W	205 to outside	7.2	.61	*
window N	STC to outside	30	.6	*
skylight	200 to outside	38.4	.61	vertical,*
skylight	205 to outside	38.4	.61	vertical,*
wall + door	201 and 202 to STC	34	.76	
wall + door	203 to STC	20.7	.68	
wall + door	204 to STC	19.3	.68	
wall + door	205 to STC	10.4	.55	
wall	203 to 202	7.9	.83	
wall	204 to 203	5.1	.68	
wall	205 to 204	6.8	.75	

Table 3.3 : Air-conductances of the third floor of the LESO in 1987.
STC means staircase
* means that result is arbitrarily parted between different elements
S,E,N,W mean South, East, North and West orientation of an element.

Element	from	C [m³/h Paⁿ]	n [-]	comments
window W	STC to outside	5	.6	*
window S	STC to outside	5	.6	*
window + door E	STC to outside	10	.6	*

Table 3.4 : Air-conductance of the roof level of the LESO in 1987.
STC means staircase
* means that result is arbitrarily parted between different elements
S,E,N,W mean South, East, North and West orientation of an element.

3.7 Pressure coefficients

Average pressure coefficients Cp have been measured by D. Dickeroff from LBL in the wind tunnel of the departement of Architecture in Berkeley University.

The measurement was made at a flow speed of 5 (m/s) on a 1:100 scale model.

The reference point for pressure and speed is settled at the top of the west chimney (fig. 2.2).

The wind profile simulated in the wind tunnel has an $\alpha = 0.152 \pm 0.09$ according to the law

$$V = \left(\frac{h}{h_{ref}}\right)^{\alpha} \qquad 3.1$$

The measurement have been physically averaged through a tank of 100 (litres).

Figure 3.12 shows the elevations of the building with the probe positions and tables 3.5 - 8 present the pressures coefficients Cp for different angles of wind incidences.

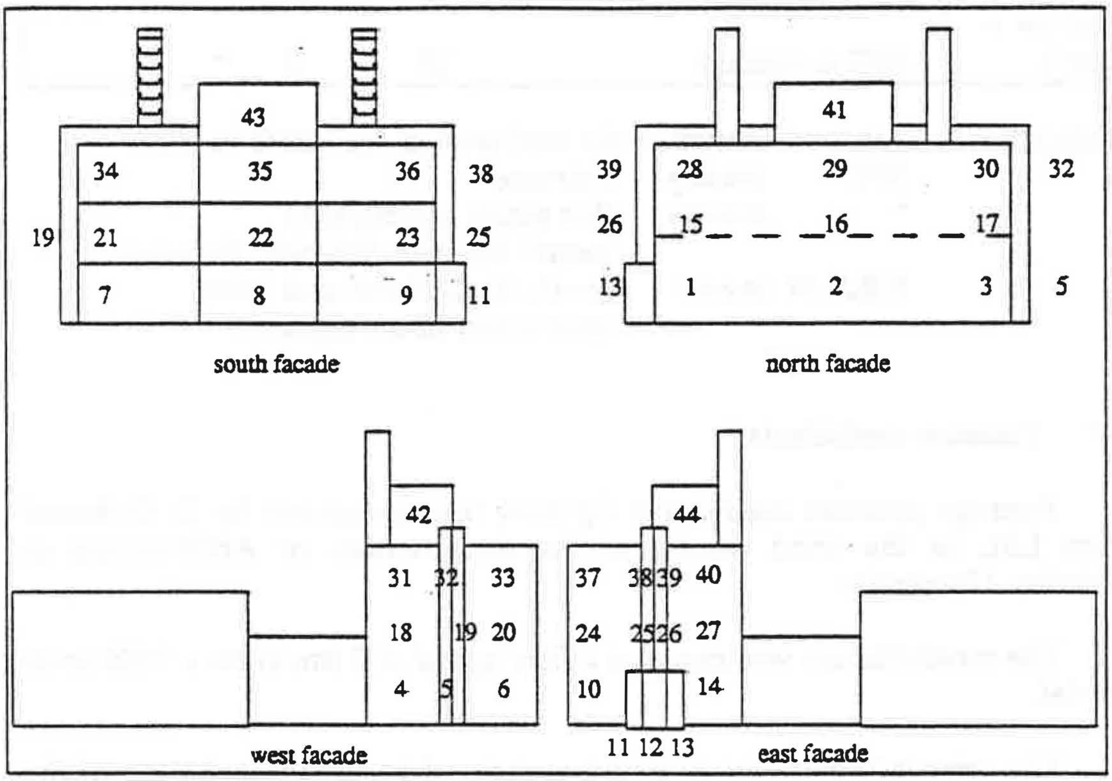


Figure 3.12 : Elevations of the LESO-Building with the pressure tube positions (number).

Pressure Coefficients from the LESO Model								
	North Wall Measurement Positions							
Angle	15	16	17	28	29	30	41	average
0	0.13	0.26	0.14	0.01	0.02	0.09	0.29	0.13
15	0.32	0.32	0.05	0.31	0.07	-.14	0.30	0.18
30	0.25	0.28	0.07	0.37	0.16	-.17	0.31	0.18
45	0.11	0.16	0.07	0.21	0.16	-.02	0.13	0.12
60	0.00	0.04	0.06	0.07	0.04	0.03	-.07	0.02
75	-.23	-.04	0.04	-.14	-.05	0.01	-.16	-.08
90	-.44	-.15	-.04	-.40	-.15	-.06	-.25	-.21
105	-.40	-.16	-.07	-.40	-.21	-.09	-.31	-.24
120	-.12	-.07	-.04	-.21	-.15	-.06	-.29	-.13
135	-.08	-.04	-.04	-.31	-.20	-.09	-.25	-.14
150	-.05	-.07	-.11	-.26	-.19	-.12	-.22	-.15
165	-.18	-.13	-.13	-.28	-.22	-.14	-.24	-.19
180	-.16	-.13	-.14	-.19	-.17	-.18	-.17	-.16
195	-.15	-.15	-.20	-.16	-.23	-.28	-.24	-.20
210	-.06	-.05	-.08	-.09	-.18	-.25	-.20	-.13
225	-.01	-.01	-.09	-.04	-.13	-.21	-.14	-.09
240	0.15	0.11	0.10	0.14	0.05	-.01	-.02	0.07
255	0.05	0.03	0.09	0.02	-.07	-.05	-.11	-.00
270	-.04	-.02	0.11	-.05	-.06	0.03	-.18	-.03
285	-.01	0.03	0.14	-.03	0.01	0.14	-.04	0.03
300	-.01	0.01	0.01	-.03	0.01	0.09	0.04	0.02
315	0.08	0.09	-.04	-.04	0.06	0.10	0.18	0.06
330	0.08	0.16	-.05	-.16	0.06	0.09	0.30	0.07
345	0.04	0.26	0.04	-.20	0.02	0.14	0.35	0.09
360	0.13	0.25	0.11	0.00	0.01	0.05	0.37	0.13

Table 3.5 : North façade mean pressure coefficients Cp for different wind incidences, 0° corresponding to North and 90° corresponding to East wind incidence. The probe position are shown in figure 3.12.

Pressure Coefficients from the LESO Model															
	East Wall Measurement Positions														
Angle	10	11	12	13	14	24	25	26	27	37	38	39	40	44	average
0	-.12	-.19	-.13	0.08	0.07	-.11	-.26	0.05	0.00	-.16	-.27	0.06	-.02	-.19	-.08
15	-.18	-.30	-.22	0.22	0.31	-.22	-.33	0.35	0.31	-.21	-.40	0.46	0.27	-.03	0.00
30	-.17	-.24	-.23	0.33	0.44	-.12	-.25	0.44	0.42	0.01	-.34	0.53	0.42	0.01	0.09
45	0.01	-.06	-.06	0.41	0.49	0.16	-.08	0.52	0.51	0.34	-.14	0.62	0.56	0.07	0.24
60	0.21	0.14	0.19	0.48	0.54	0.39	0.16	0.63	0.62	0.52	0.13	0.69	0.67	0.22	0.40
75	0.39	0.36	0.39	0.55	0.57	0.55	0.48	0.69	0.65	0.60	0.43	0.71	0.68	0.40	0.53
90	0.55	0.50	0.53	0.61	0.62	0.62	0.67	0.72	0.68	0.71	0.68	0.75	0.65	0.21	0.61
105	0.52	0.50	0.54	0.54	0.57	0.58	0.68	0.65	0.60	0.70	0.70	0.68	0.63	0.33	0.59
120	0.14	0.13	0.17	0.19	0.25	0.14	0.19	0.20	0.19	0.22	0.21	0.19	0.21	0.25	0.19
135	0.06	0.07	0.02	0.04	0.05	0.01	0.12	-.05	-.00	0.10	0.17	-.10	0.02	0.22	0.05
150	-.23	-.22	-.16	-.09	-.06	-.28	-.17	-.18	-.14	-.30	-.16	-.25	-.19	0.01	-.17
165	-.19	-.06	-.13	-.07	-.08	-.25	-.04	-.29	-.17	-.18	-.10	-.34	-.28	-.03	-.16
180	-.26	-.20	-.19	-.13	-.12	-.28	-.19	-.23	-.20	-.27	-.23	-.26	-.24	-.16	-.21
195	-.34	-.27	-.23	-.19	-.18	-.35	-.29	-.22	-.21	-.35	-.33	-.22	-.22	-.25	-.26
210	-.47	-.23	-.24	-.16	-.13	-.49	-.37	-.20	-.20	-.40	-.37	-.20	-.22	-.22	-.28
225	-.32	-.01	-.18	-.08	-.08	-.34	-.15	-.13	-.09	-.25	-.18	-.11	-.09	-.15	-.15
240	-.01	0.22	-.05	0.08	0.08	-.18	0.11	0.02	0.02	-.10	-.01	.01	0.00	-.06	0.01
255	-.02	0.08	-.02	0.01	0.02	-.06	0.06	0.02	0.02	-.05	0.00	0.02	0.03	-.05	0.00
270	-.14	-.12	-.10	-.09	-.08	-.14	-.13	-.11	-.12	-.13	-.14	-.11	-.10	-.16	-.12
285	-.14	-.13	-.10	-.08	-.07	-.15	-.14	-.11	-.11	-.16	-.16	-.13	-.12	-.21	-.13
300	-.16	-.14	-.12	-.11	-.10	-.16	-.14	-.13	-.11	-.18	-.15	-.14	-.13	-.28	-.15
315	-.11	-.10	-.10	-.07	-.07	-.11	-.10	-.09	-.10	-.12	-.12	-.11	-.11	-.28	-.11
330	-.10	-.12	-.17	-.17	-.16	-.14	-.13	-.19	-.21	-.14	-.13	-.19	-.18	-.27	-.16
345	-.13	-.15	-.13	-.12	-.09	-.14	-.19	-.13	-.23	-.15	-.19	-.17	-.20	-.31	-.17
360	-.14	-.18	-.14	0.06	0.07	-.13	-.29	0.01	-.04	-.19	-.29	0.03	-.06	-.22	-.11

Table 3.6 : East façade mean pressure coefficients Cp for different wind incidences, 0° corresponding to North and 90° corresponding to East wind incidence. The probe position are shown in figure 3.12.

Pressure Coefficients from the LESO Model											
	South Wall Measurement Positions										
Angle	7	8	9	21	22	23	34	35	36	43	average
0	-.10	-.11	-.11	-.09	-.10	-.11	-.10	-.11	-.12	-.25	-.12
15	-.09	-.10	-.10	-.09	-.08	-.10	-.10	-.09	-.09	-.26	-.11
30	-.12	-.10	-.10	-.12	-.10	-.10	-.11	-.11	-.11	-.27	-.12
45	-.14	-.12	-.11	-.16	-.12	-.13	-.14	-.13	-.12	-.30	-.15
60	-.18	-.22	-.18	-.21	-.25	-.18	-.19	-.23	-.22	-.34	-.22
75	-.13	-.29	-.21	-.21	-.30	-.24	-.25	-.29	-.22	-.35	-.25
90	0.01	-.13	-.34	-.01	-.17	-.41	-.05	-.19	-.35	-.22	-.19
105	0.14	0.11	-.06	0.11	0.10	-.18	0.09	0.09	-.07	0.03	0.04
120	0.27	0.18	0.14	0.23	0.20	0.07	0.17	0.19	0.17	0.14	0.18
135	0.36	0.32	0.25	0.39	0.38	0.30	0.35	0.36	0.32	0.19	0.32
150	0.74	0.65	0.40	0.84	0.76	0.53	0.69	0.61	0.50	0.06	0.58
165	0.43	0.55	0.46	0.50	0.62	0.55	0.56	0.63	0.67	0.36	0.53
180	0.49	0.53	0.36	0.58	0.59	0.43	0.60	0.60	0.53	0.15	0.48
195	0.48	0.51	0.38	0.53	0.57	0.48	0.59	0.59	0.53	0.17	0.48
210	0.48	0.65	0.75	0.62	0.82	0.88	0.61	0.62	0.75	-.03	0.61
225	0.24	0.37	0.54	0.34	0.44	0.49	0.28	0.28	0.32	-.01	0.33
240	0.26	0.30	0.60	0.23	0.35	0.42	0.28	0.27	0.33	0.28	0.33
255	0.03	0.06	0.17	0.02	0.07	0.11	0.03	0.04	0.06	-.00	0.06
270	-.14	-.01	0.01	-.19	-.05	-.02	-.21	-.11	-.07	-.24	-.10
285	-.38	0.06	0.03	-.42	-.18	-.05	-.34	-.22	-.14	-.41	-.20
300	-.40	0.00	-.01	-.47	-.18	-.04	-.36	-.25	-.14	-.35	-.22
315	-.34	-.18	-.15	-.33	-.21	-.14	-.31	-.22	-.15	-.32	-.24
330	-.09	-.10	-.10	-.09	-.08	-.10	-.09	-.07	-.10	-.20	-.10
345	-.11	-.12	-.13	-.10	-.11	-.13	-.10	-.10	-.12	-.26	-.13
360	-.12	-.12	-.12	-.10	-.11	-.13	-.11	-.11	-.13	-.26	-.13

Table 3.7 : South façade mean pressure coefficients Cp for different wind incidences, 0° corresponding to North and 90° corresponding to East wind incidence. The probe position are shown in figure 3.12.

Pressure Coefficients from the LESO Model											
	West Wall Measurement Positions										
Angle	4	5	6	18	19	20	31	32	33	42	average
0	0.12	0.22	-.26	0.13	-.23	-.26	0.07	0.16	-.28	-.10	-.04
15	-.05	0.09	-.20	-.26	-.23	-.21	-.25	-.24	-.19	-.27	-.18
30	0.01	0.12	-.03	-.33	-.26	-.18	-.37	-.33	-.18	-.29	-.18
45	0.12	0.19	0.10	-.25	-.22	-.09	-.36	-.34	-.12	-.26	-.12
60	0.08	0.09	0.04	-.07	-.06	-.04	-.12	-.16	-.05	-.20	-.05
75	-.02	-.07	0.02	-.03	-.00	-.09	-.04	-.07	-.14	-.19	-.06
90	-.04	-.12	-.07	-.09	-.07	-.13	-.08	-.11	-.14	-.15	-.10
105	-.06	-.11	-.17	-.10	-.16	-.17	-.11	-.15	-.18	-.21	-.14
120	-.08	-.10	-.13	-.10	-.02	-.20	-.07	-.11	-.19	-.19	-.12
135	-.11	-.14	-.22	-.12	-.07	-.28	-.11	-.12	-.25	-.23	-.16
150	-.26	-.26	-.51	-.25	-.25	-.55	-.22	-.24	-.51	-.25	-.33
165	-.19	-.22	-.30	-.20	-.19	-.36	-.20	-.22	-.35	-.26	-.25
180	-.26	-.30	-.25	-.17	-.03	-.32	-.29	-.33	-.30	-.13	-.24
195	-.18	-.29	-.23	-.29	-.06	-.29	-.33	-.39	-.23	-.05	-.23
210	-.05	-.09	-.22	-.11	-.22	-.32	-.13	-.24	-.34	-.01	-.17
225	-.03	-.09	-.11	-.09	-.06	-.16	-.07	-.19	-.10	0.12	-.08
240	0.23	0.33	0.19	0.19	0.21	0.18	0.22	0.11	0.22	0.28	0.21
255	0.27	0.33	0.08	0.18	-.01	0.02	0.25	0.23	0.13	0.30	0.18
270	0.36	0.33	0.14	0.27	-.09	-.02	0.51	0.49	0.31	0.53	0.28
285	0.43	0.44	0.19	0.43	-.08	0.08	0.62	0.66	0.42	0.70	0.39
300	0.41	0.45	0.09	0.44	-.07	0.14	0.52	0.56	0.43	0.42	0.34
315	0.33	0.45	-.18	0.35	-.24	-.04	0.34	0.40	0.14	0.08	0.16
330	0.23	0.38	-.28	0.27	-.30	-.31	0.30	0.40	-.22	0.01	0.05
345	0.18	0.33	-.30	0.26	-.26	-.31	0.28	0.40	-.32	-.05	0.02
360	0.09	0.23	-.25	0.02	-.24	-.26	0.05	0.19	-.27	-.12	-.06

Table 3.8 : West façade mean pressure coefficients Cp for different wind incidences, 0° corresponding to North and 90° corresponding to East wind incidence. The probe position are shown in figure 3.12.

4. OPERATION AND NUMERICAL DATA SET

4.1 Tracer gas campaigns

During the tracer gas measurement periods the building is not inhabited. The ventilation is off, the windows are closed and the inside doors are opened or closed depending on the experimental plans presented in figures 4.1 - 2 and table 4.1. The heating system is controlled at 19 [°C] with a PID controller in each room.

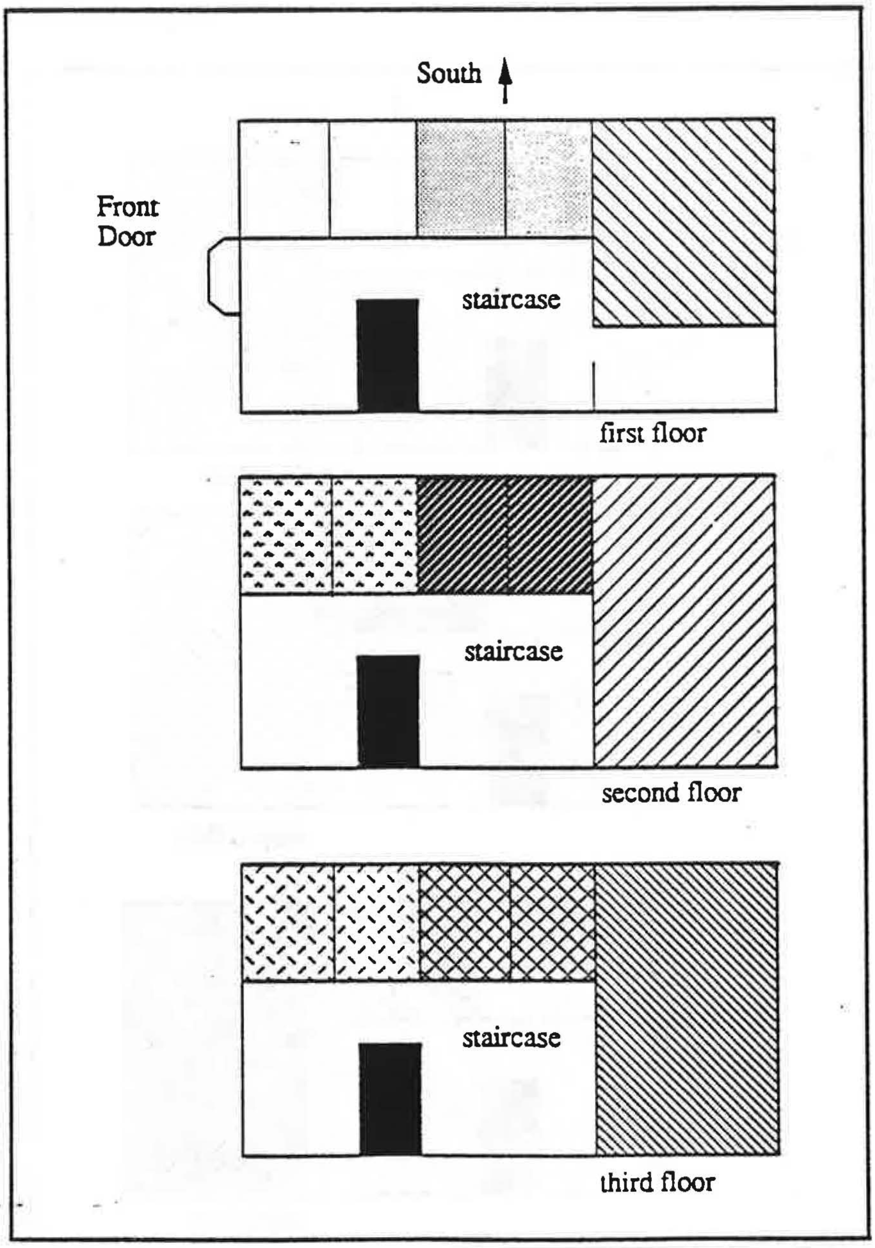


Figure 4.1 : Experimental plan for tracer gas measurement in December 87. The dashed surfaces represent the measured rooms.

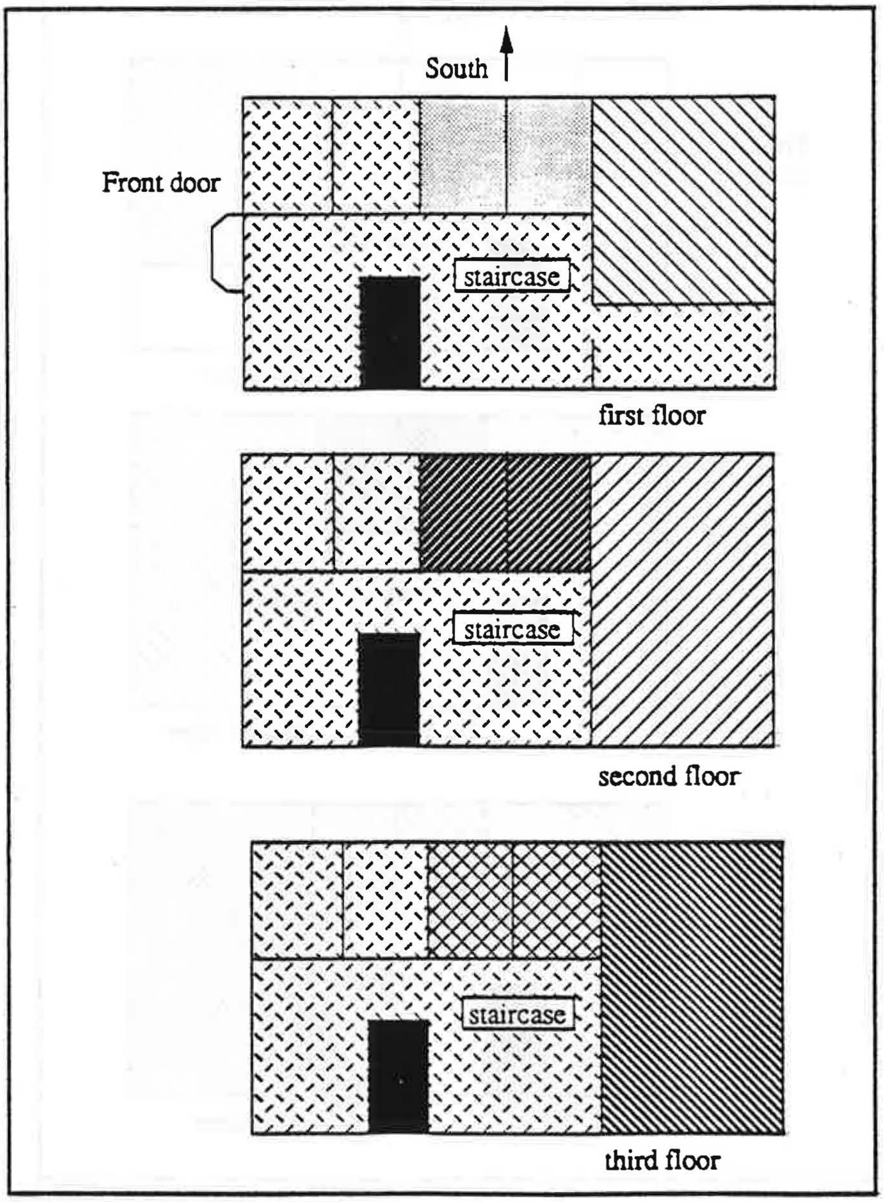


Figure 4.2 : Experimental plan for tracer gas measurement in December 88. The dashed surfaces represent the measured rooms. In 1988 N_2O has been also injected in the staircase.

Room	to	floor	Door 1987	position 1988
001	hall	1	open	open
002	hall	1	open	open
003	hall	1	closed	closed
004	hall	1	closed	closed
005	hall	1	closed	closed
006	hall	1	open	open
100	hall	2	open	open
101	102	2	open	open
102	hall	2	closed	open
103	hall	2	closed	closed
103	104	2	open	closed
104	hall	2	closed	closed
105	hall	2	closed	closed
200	hall	3	open	open
201	202	3	open	open
202	hall	3	closed	open
203	hall	3	closed	closed
204	hall	3	closed	closed
205	hall	3	closed	closed

Table 4.1 : Position of the doors during the tracer gas measurement campains.

4.2 Available numerical data files.

4.2.1 Nomenclature

All data files concerning tracer gas measurements of air renewals and corresponding weather data are identified as follows :

LESO*aa*A*xxx*.*yyy*

with the meaning :

LESO measurements performed in purpose of validation of air infiltration codes

aa year of measurement (beginning)

A identification of the series of measurements. A serie being a continue following of measurements with a constant time step (1988 data has three periods A.B.C.)

xxx identification of the content (see later)

yyy format identification. The available files are written in our own data format, called GRES (Annex 1) identified by yyy = DAT.

4.2.2 *Different files*

The 1987-measurement files include measurement data collected between day 357 at 19h.15 (December 23rd, 1987) until day 369 at 14h.30 (January 4th, 1988).

The 1988 measurement files include three periods :

A, from day 358 at 21h.20 (December 24th 1987) to day 360 at 15h.40)
B, from day 360 at 18h.20 to day 365 at 24h.)
C, from day 367 at 19h. to day 369 at 14h. (January 4th 1989)

Measurements have been performed quarterly but the data files are available with a time step of 15 minutes or 30 minutes (version "30").

- Files LESOaaAVNR.DAT contain the weather data and building data (the comprehensive list is given in Annex 2)
  - Meteorological data
  - Room temperatures
  - Indoor-outdoor temperatures
  - Electrical consumption.
- Files LESOaaAREN.DAT contain the air flows Q_{Ai} incoming in each measured room (unity : $[m^3/s]$) and also the confidence intervals (cf. Annex 2).
- Files LESOaaANJI.DAT contain the η_{ji} coefficients of equation 4.1 describing the air flows between the room i and the staircase and also the adjacent rooms j

$$Q_{Ai} = Q_{oi} + \sum_{j=1}^{N} \eta_{ji} Q_{ji} \qquad 4.1$$

Q_{Ai} : measured air flow in room i
Q_{oi} : resultant air flow between the room and outdoor
Q_{ji} : resultant air flow between the rooms i and j

- Files LESOaaATEM.DAT give the mean temperature (high = 1.4 [m]) and the gradient between 0.5 [m] and 2.3 [m] for each room (unity [°C]).

4.2.3 Channel codification

The LESO-PB performing meteorological measurements since a few years, has developed his own standard codification to spot the different kinds of measurements in the records.

This codification is constituted by two letters (X, Y). The first (X) gives information on the ***physical quantity***. The second (Y) precises the ***type of record*** : the data logger scans the channels at short time intervals (***measuring intervals***) and records the data at longer intervals (***recording interval***). It has then the possibility to record on the tape for every recording interval either the ***instantaneous value*** or the ***integrated value*** which is the sum of the measurements performed during the recording intervals or the ***average value*** which is the integrated value divided by the measurements number. Table 4.2 gives the code for X and Y :

X :	P	→	Temperature (Pt100)
	E	→	Power (or Energy if integrated)
	K	→	Pressure
	S	→	Solar radiation
	G	→	Opening angle (window, doors)
	D	→	Wind direction
	W	→	Wind speed
	V	→	Wind projection (sin, cos)
	H	→	Humidity
	F	→	Flow
Y :	N	→	Instantaneous value
	M	→	Averaged value during the recording interval
	I	→	Integrated (sum) value during the recording interval
	S	→	Root mean square during the recording interval

Table 4.2 : Channel codification in the LESO data set.

4.2.4 *Channel list*

Annex 2 gives the list of the channels included in files described in paragraph 4.2.2 for 1987-data. 1988-data have some additional channels as a second static pressure probe (CSTB-probe) on channel 152 KM or the two ortogonal projections of the wind vector :

$$V_1 = |\vec{V}| \cos(\theta) \qquad 4.2$$

$$V_2 = |\vec{V}| \sin(\theta) \qquad 4.3$$

on channels 1 VM and 2 VM.

4.2.5 *Defects on channels*

The following channels have some defects in the file LESOaaAVNR.DAT :

C 451 KM, a differential pressure channel is defectuous from time 367/22:45 to 368/1:45 in 1987-data.

C 350 KM, a differential pressure channel is defectuous from time 363/4:45 to 364/12:00 in 1987-data.

C 21 PN is defectuous in all the data.

CONCLUSIONS

This document, together with the cited references, constitutes the first quoted draft of the description of the LESO validation data set.

It contains the description of numerous data measured on the LESO Building. Some of these data are needed as input for multizone air infiltration simulation codes, like the building site description, the air leakage network and the pressure coefficients. Other data are provided, such as air flow rates and differential pressures, which can be compared with the results of the codes.

The confidence interval of most of the measurements are also given in order to evaluate the result of this comparison, that is to decide if the fit is good or bad.

A part of this set was used once before its publication in a validation exercise, and has proved to be useable. This does not mean however that it can be used for any code in any case. Therefore, the following important points are remembered here :

1) The potential user should take liaison with the authors, first to obtain the data set on a magnetic tape or disc and secondly to get the data which are unintentionally forgotten in this paper.

2) The users are kindly requested to send their comments to the authors, in order to enhance the quality and the usability of this set.

As the aim of this workshop is to finalize the structure of the Centre's database and explain data sources and needs, we give here some personal comments.

Infiltration codes steatily evoluate, taking into account more phenomenon as moisture and temperature gradients, air compressibility and turbulence effects. Nevertheless we would like to be simultaneously able to validate new codes with a data set. It is surely not an easy position; but before analysing some of its consequences we want to justify it.

The rapid evolution of the simulation codes is now mainly driven by the possibilities of the computers. Since there is very small experimental feedback, any new computer system allows to add new features to the codes without any information on either the necessity nor the accuracy of such new features. Moreover, it is not possible that way to ensure a good homogeneity in the accuracy of the various results of a given code. That code may have performant and accurate subroutines for some phenomena but be completely wrong for others.

We propose that the confrontation with measurements shall indicate the main directions to improve the codes. The measurements are certainly not perfect; they are contaminated with errors, as shown in reference [7], but measurements are the link with the reality and show the technical limits. Therefore, it does not appear necessary to calculate influences which cannot be measured.

Let us come back to the consequences of such a position. There is a need for an improvable data base. How to provide it ?

On one hand it is not possible to add a later measurement in a time dependant data set. On another hand, experiences have shown that it is unrealistic to measure every possible physical quantity without knowing how these measurements will be used. It is well known that such type of data usually ends in the rubbish bin.

Our proposal is to keep some instrumented buildings ready for measurement, improving that way steadily the quality of the measurements.

So the data base could evaluate together with the codes, being an element of constant dialogue and not, as today a difficult examination whose result is seldom clear.

That proposal looks expensive but may not really be as expensive as the use of not completely validated codes. Nevertheless, it is surely less expensive that new comprehensive measurements and a new data base for each code.

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