AIR PERMEABILITY OF DWELLING UNITS

D. Béguin, J. Chandellier
Centre Scientifique et Technique du Bâtiment
(Scientific and Technical Building Center)
Paris, France

1. INTRODUCTION

Observations and measurements performed on existing building have made it possible to demonstrate that in the ventilation of premises, the proportion of "parasite" air infiltration is of the same order of magnitude, sometimes even larger, than the proportion of air change, specific to ventilation systems.

"Parasite" air infiltration is due to seal defects in the building envelope.

The air change specific to a dwelling unit is provided by ventilation equipment installed to satisfy the occupancy needs of the premises.

Furthermore, the CSTB has initiated a reflection, intended to determine, for all building construction techniques and in particular for dwelling units, the basis which will make it possible :

- to reduce the air permeability of dwelling units in order to improve occupant comfort and to minimise energy expenses,
- in certain cases, to define different air permability levels,
- to define the technical arrangements associated with these levels.

2. ANALYSIS METHOD

In order to be as thorough as possible, the study of parasite air infiltrations has been set up based upon the following principle :

An observer, placed at the center of the room, studies the causes of air infiltrations by tracing the routing of the air from the inside of the room to outside of the building.

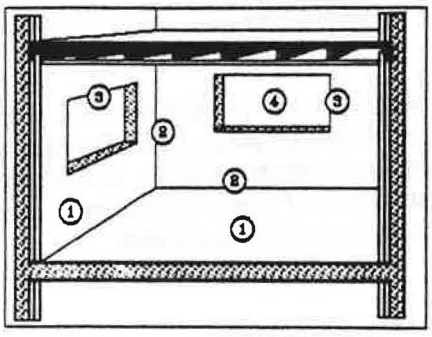


Figure 1 : Location of the various categories

The observer can be real ; this is the case of the occupant or expert who directly observes the effects of infiltration and can only adopt a curative approach.
But the observer may be virtual ; this is the case of the company or of the main contractor who wishes to know what technical solutions would prevent infiltration problems, thus adopting a preventive approach.
The method adopted aims to respond to these two interrogation modes.

So air infiltration can be broken down into four categories according to their locations, i.e. undifferentiated part of walls, connections between undifferentiated parts, junctions between undifferentiated parts in walls and inclusions located within these walls and finally, actually within the inclusions (see figure 1).
All the possible cases of infiltration are the identified for each category. The parameters taken into account may be the nature of the walls, the type of structure ... but do not bring in a particular building technique.
For each case identified in a category, we build up a so called "findings" file which describes the problems and the causes of infiltration. At this stage, the various building technologies are integrated into the analysis.
The problems described in the "findings" file are handled in the "solution" files which may be common to several "findings" files.

So we end up with two sets of files :
- "findings" files : description of the problem and its various aspects,
- "solution" files : solution of the ways and means for solving air infiltration problems.

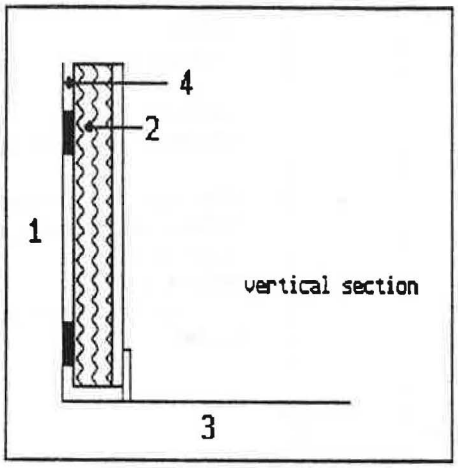
The purpose of the study is to :
- Analyze, in the most thorough possible orderly and detailed manner, air infiltration in building structures (category files).
- Propose technical measures which can be adopted and specified, supported by quantitative performed both in the laboratory and in existing dwelling units.

3. EXAMPLES

"Findings" file C2-11 corresponds to a building technique which is quite usual in France, i.e. that of walls receiving heat insulation installed on the inside. In the file we indicate the various techniques for building this type of wall and in particular, the technique which employs plaster panel/insulation material heat insulation complexes, bonded using an adhesive mortar on a masonry of small elements with a thin, non ventilated, interposed air space. Im fact, we state that although this air layer is expected to be non ventilated, substantial air infiltration may appear, in particular at the foot of the lining which, until present, was only sealed by the baseboard, a fairly ineffective solution.

"Findings" file C3-21 is relative to the junction between a façade component (window) and a backing wall or a thin lining wall, type plaster panel/insulation material heat insulation complex. According to the results of the measurements, it is at this connection where a major part of the parasite infiltrations encountered in French dwelling units is found. The work on this particular point leads to configurations which are often complex.

CATEGORY 2 : Connection aroud the outside of the wall	
Connection at the floor thin walls/heavy floor	C2-11

DIAGRAM	DESCRIPTION
	1 : masonry shuttered concrete heavy or light precast panel framing wall light semi-curtain façade light panel façade 2 : panel partition on framing complex bonded or fastened fixed sandwich 3 : solid slab underslab joists-filler elements 4 : air layer ventilated or not

Air infiltration at the baseboard is the results of pressurising the air layer. According to the wall design, there are two cases :

A : <u>The air layer is normally ventilated</u> :

* Framing wall or wall with aerated air space — record S3
* Masonry wall, type III — record S3
* Dynamic insulation wall — record S3

The air seal can only be set up at the connection

B : <u>The air layer is normally non ventilated</u> :

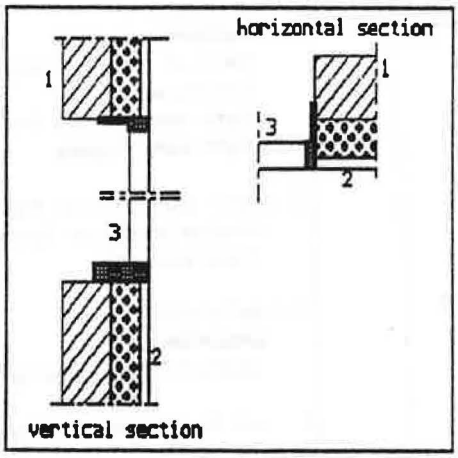
Accidental penetration of air into the air layer may be due to a fault :

* In the outside wall seal : On this subject, see the category C1 record based upon the technique adopted for the outside wall :
  - Masonry wall : Masonry of small elements — record C1-3
  - Masonry wall : Shuttered concrete — record C1-4
  - Light façades — record C1-5
  - Façades of heavy panels — record C1-6

* Connections on the periphery of the outside wall : See the other category C2 records

* At the junction between inclusions and the outside wall : See the category C3 records
  - Case of envelope components — record C3-11
  - Case of other inclusions — record C3-12

CATEGORY 3 : Wall/inclusion connections	
Connection between thin vertical wall and back wall/envelope component	C3-21

DIAGRAM	DESCRIPTION
	1 : masonry shuttered concrete panel framing wall 2 : panel on framing bonded or fastened complex 3 : fixed part of a component : window, door window, fixed opening sash outside door housing of rolling shutter, closet

The wall is composed of several separate layers with variable thickness air layers whose ventilation is difficult to control. Air infiltration in the connection plane of the fixed part of a component at the vertical envelope of the building may come either from the outside, or from one of the variable tickness air layers, existing between two layers of different materials.

In the DTU* it is specified that the caulking must be done in order that the joint between the window and the shellwork provides, over its whole perimeter, airtightness and watertightness given the exposure conditions and the predictable differential movement between window and shellwork.

The air penetration risk depends upon :

- The nature of the materials : fixed part of component, envelope wall lining element.
- Type of incorporation technique employed.
  For the problem which concern us, the building of this type of connection work is complicated by the multilayer composition of the room envelope walls.
- And the position of the building, i.e. exposure and heigt of the façade.

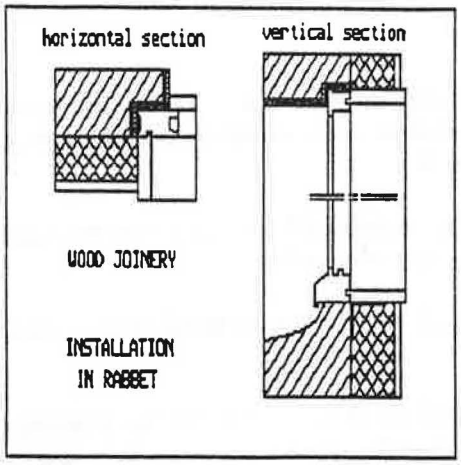
Rules relative to executing caulking are reviewed in : record S31

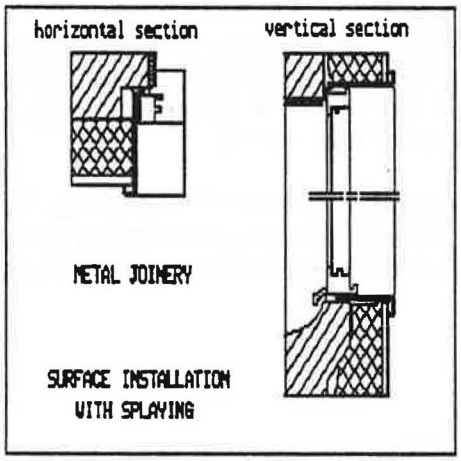
Special aspects of the problem for handing the connection of a component included in a wall containing a lining are covered by the : record S33

* DTU : Documents Techniques Unifiés (Unified Codes of Practice)

	S33

DIAGRAM	COMMENTS





Within such a design pattern, the air tightness problem is posed in two ways ; on the one hand, we need to make sure of the airtightness on the joint plane between the included component and the envelope shellwork of the room, a problem already covered in record S32, and on the second hand, to prevent both risk of infiltration through an air layer or space in the multilayer wall. The origin of such air circulation in spaces inside the wall is often related to a seal fault in the wall's outside coats or coverings.

The recommendations for executing this caulking are included in record S31. The choice of the caulking system depends upon the type of installation of the component and the nature of the materials present.

The types of installation most frequently encountered are installation in rabbet, surface mounting with splaying on as-cast masonry or on finished bay, surface mounting on the inside in as-cast masonry or on finished bay. In all these approaches, the loads specific to and applied upon the component inserted must be transmitted to the supporting shellwork. The adjacent illustration shows that this installation method requires the use of window ledge and dummy jamb lining in order to complete the installation in the wall layers not located within the plane of the inclusion.

The air coming from the air layer can be sealed :

- either by trying to build a caulking, framing the opening of the bay, in the plane separating the two layers of material. This solution is not always practical if one of the materials is excessively permeable, or if the air layer is too thick. It can also make it difficult to install a system.
- or by doing two caulkings, between the ledge, dummy jamb liner and fixed sash of the component, as well as between the ledge, dummy jamb liner and the lining structure.

Finally, "solution" record S33, associated with the abovementioned "findings" record, mainly explains the various solutions to be applied in the various installation cases based upon the type of material and installation utilised. A wiser design, particularly with regard to the position of the window with relation to the shellwork can make it possible to considerably reduce the risk of seal defect.

4. CONCLUSION

All the results of this study constitute a collection of solutions based upon which the designer can establish an overall approach to working with relation to the building envelope, making it possible to prevent risk of air infiltration into dwelling units.

All the records will be able to be published in "educational" form and they will contribute to a better dissemination of knowledge of building structure behaviour.

The study undertaken with relation to air permeability problems in dwelling units will be exploited in various ways :

- Each of the building participants will be able to pick up the elements which are necessary to them and in this way disseminate specific recommendations in an appropriate form.

- In a second phase, the various professions will be arbitrating among the various solutions proposed and will be making choices to better guarantee satisfactory overall permeability for the dwelling unit.
  The analysis method adopted demonstrates that reduction in air volumes resulting from parasite infiltrations does not entail adopting all the proposed solutions, it rather entails careful selection of solutions which might make it possible to obtain an optimal efficiency both in terms of technology and in terms of cost.

The work is now at the final analysis stage. The solutions which we have proposed, from now on, need to be completed, improved and validated by mainly "in situ" measurements on experimental worksites along with qualitative observations concerning feasibility mainly generated from laboratory configurations.