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POSTER P7

AIRTIGHTNESS OF MASONRY WALLS

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SYNOPSIS

This paper presents results of air leakage measurements on brick walls and concrete block walls, used as outer or inner leaf of a cavity wall. The results are obtained using a pressure box on a series of test walls.

The variable parameters that are examined :

- workmanship
- pointing of the joints
- plastering of the inner leaf

Out of the results can be concluded that, in general, only a plastered wall can guarantee a sufficient airtightness.

More information about this research can be found in [ref. 5], [ref. 6].

LIST OF SYMBOLS

q	(m3/m2s)	air flow
Δp	(Pa)	pressure difference
a,b		coefficients in the function $q = a \cdot \Delta p^b$
ρ	(kg/m3)	density
A	(m2)	area

INTRODUCTION

Requirements must be formulated concerning the airtightness of masonry walls, since, next to complaints concerning comfort and an important increase of heating costs, a lack of airtightness can also cause rain penetration. In case of driving rain, windgusts can actually 'pump' a considerable amount of rainwater through the wall.

To evaluate the airtightness, measured values found in literature are however often not useful :

- the reliability is insufficient (the measurement equipment is not mentioned, few measurements,...) ;
- the airtightness is considered as constant, while in reality there is, according to the material, a more or lesser dependence on the pressure difference ;
- joints are not taken into account (e.g. the airtightness of a masonry wall is not equal to the airtightness of the brick itself) ;
- too high pressure differences are considered, while for use in applications in infiltration research and building physics, especially the lower pressure differences (0 - 20 Pa) are important ;
- workmanship, local practice and material properties can differ between regions.

Consequently, measurements are in many cases recommended to get reliable values for the airtightness of a building element. The measured values must however be regarded as an indication, since in many practical situations, the workmanship, the presence of joints, the assembling tolerances,... have a major influence on the airtightness.

Proposals for a good practice from the point of view of airtightness should eliminate, as far as possible, these uncontrollable factors (e.g. plastering is safer then a 'good' pointing up of a wall).

1. AIR LEAKAGE MEASUREMENTS ON MASONRY WALLS

1.1. Measurement set up (fig. 1)

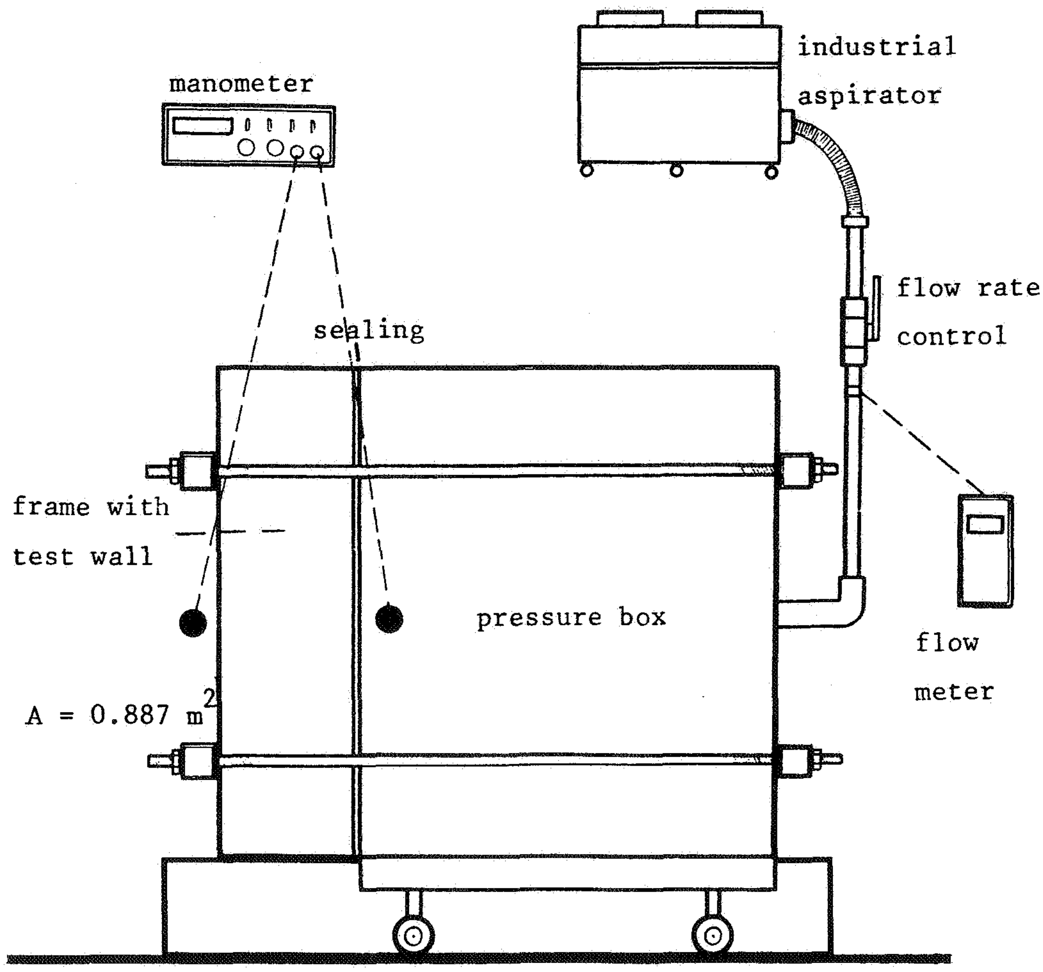

fig. 1, measurement set up

flowmeter : rotameter 1416 U10 (0-40 m/s),
Wilh. Lambrecht GmbH

manometer : micromanometer FC12 (0-20 Pa, 0-200 Pa),
Furness Controls Ltd.

The airflow through the test wall is measured at several pressure differences (at least 15) from 0 to 200 Pa, with accent on the low pressure differences (0 - 20 Pa).

1.2. The test walls

Following walls have been measured :

outer leaf

- brickwork
- brickwork
- concrete blocks

the variable parameters that are examined :

- workmanship
- pointing of the joints

inner leaf

- lightweight brickwork
- hollow concrete blocks
- cellular concrete blocks
- sandlime bricks

the variable parameters that are examined :

- pointing of the joints
- plastering of the inner leaf
  (1 cm gypsum plastering on the inside)

1.3. Processing of the measurements

An exponential curve is fitted through the measurements (.pi, qi) using a least squares technique :

$$q = a \cdot \Delta p^b$$

q = air flow through the test wall (m3/m2s)
Δp = pressure difference (Pa)
a,b = calculated coefficients,
$0.5 < b < 1$,
$b = 0.5$: fully turbulent flow
$b = 1$: laminar flow

1.4. Example of a measurement

Test wall : inner leaf, hollow concrete blocks
(39 x 19 x 14 cm), ρ = 954 kg/m3

measurement	pressure difference (Pa)	air flow (m3/m2s)
1	2.0	4.90 E-4
2	3.2	7.69 E-4
3	5.2	1.10 E-3
4	8.8	1.82 E-3
5	16.4	2.98 E-3
6	24.8	4.12 E-3
7	33.4	5.17 E-3
8	43.6	6.33 E-3
9	54.7	7.17 E-3
10	65.0	8.33 E-3
11	79.0	9.68 E-3
12	95.4	1.12 E-2
13	114.1	1.25 E-2
14	134.3	1.44 E-2
15	150.0	1.58 E-2
16	182.0	1.84 E-2
17	198.1	1.96 E-2

q = 3.09 E-4 . Δp^0.79 m3/m2s

r^2 = 0.9994

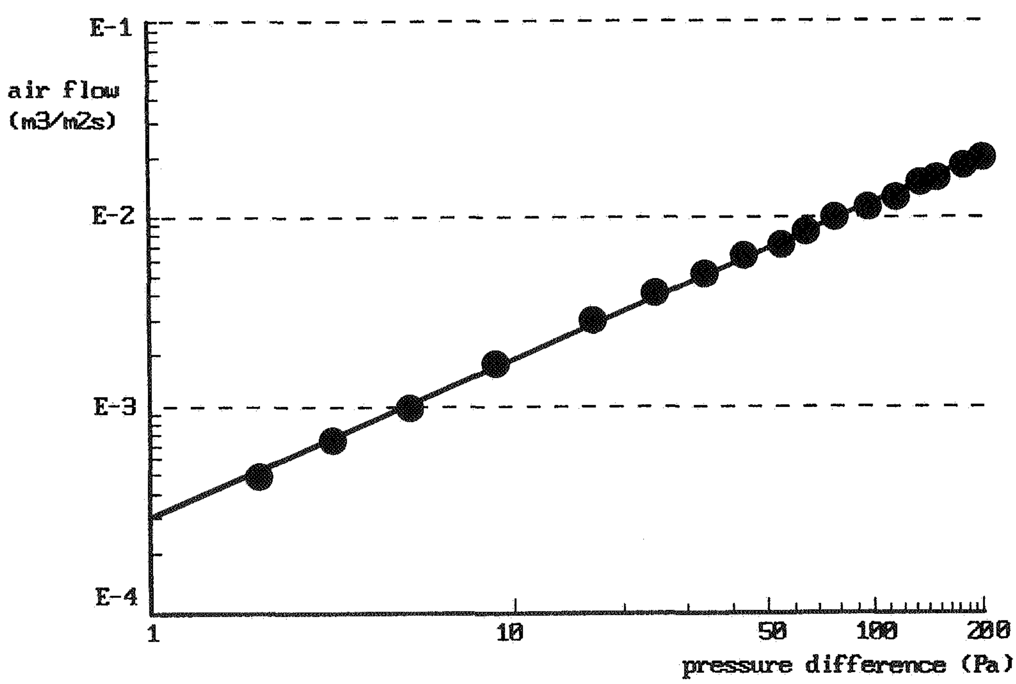

fig. 2, air flow as function of the pressure difference

1.5. Overview of the results

The air flow is given as :

$$q = a \cdot \Delta p^b$$

q = air flow through the wall (m3/m2s)
Δp = pressure difference (Pa)
a,b = tabled coefficients

dimensions : length x height x thickness (cm)

1.5.1. Outer leaf, brickwork

dimensions : 19 x 9 x 4.5 cm

	a	b
no pointing, bad workmanship	2.7 E-4	0.69
no pointing, good workmanship	8.4 E-5	0.75
pointing of the joints	2.9 E-5	0.80
	3.0 E-5	0.79

1.5.2. Outer leaf, brickwork

dimensions : 19 x 9 x 6.5 cm

	a	b
no pointing, bad workmanship	6.0 E-4	0.68
no pointing, good workmanship	1.3 E-4	0.71
pointing of the joints	3.0 E-5	0.81
	2.9 E-5	0.82

1.5.3. Outer leaf, concrete blocks

dimensions : 19 x 9 x 9 cm

	a	b
pointing of the joints ρ = 1955 kg/m3	1.2 E-4	0.88
pointing of the joints ρ = 1927 kg/m3	1.6 E-4	0.86
pointing of the joints ρ = 1881 kg/m3	2.3 E-4	0.82

1.5.4. Inner leaf, lightweight brickwork

dimensions : 29 x 14 x 14 cm

	a	b
no pointing	2.2 E-3 3.5 E-3	0.59 0.57
pointing of the joints	2.4 E-5 1.7 E-5 1.4 E-5	0.72 0.81 0.82
one side plastering	3.1 E-7 2.3 E-7	0.96 0.97

1.5.5. Inner leaf, hollow concrete blocks

dimensions : 39 x 19 x 14 cm

	a	b
no pointing		
ρ = 987 kg/m3	3.3 E-3	0.58
ρ = 954 kg/m3	4.2 E-3	0.56
ρ = 910 kg/m3	5.0 E-3	0.55
pointing of the joints		
ρ = 987 kg/m3	1.6 E-4	0.91
ρ = 954 kg/m3	3.1 E-4	0.79
ρ = 910 kg/m3	5.0 E-4	0.70
one side plastering		
ρ = 987 kg/m3	2.9 E-7	0.96
ρ = 954 kg/m3	2.2 E-7	0.95
ρ = 910 kg/m3	2.6 E-7	0.97

1.5.6. Inner leaf, cellular concrete (glued)

dimensions : 60 x 24 x 14 cm

	a	b
no pointing	1.9 E-3	0.61
	1.2 E-3	0.62
pointing of the joints	8.0 E-5	0.64
	8.5 E-5	0.63
one side plastering	3.4 E-7	0.97

1.5.4. Inner leaf, sandlime bricks

dimensions : 29 x 14 x 14 cm

	a	b
no pointing	2.7 E-3	0.61
	3.5 E-3	0.57
pointing of the joints	1.9 E-5	0.75
	1.5 E-5	0.80
one side plastering	2.5 E-7	0.95

2. CONCLUSIONS

2.1. The walls can be divided in two groups :

- walls built up using airtight blocks (brickwork, sandlime bricks) ;
- walls built up using airopen blocks (concrete blocks, cellular concrete blocks) ;

In the first case, leaks have a major influence (e.g. not completely filled joints in unplastered brickwork). Pointing of the joints leads to an important increase of the airtightness of the wall ; the airtightness is mainly determined by the shrinkage cracks between brick and mortar. Plastering of the inner leaf is nevertheless recommended to obtain a satisfactory airtightness.

In case of airopen blocks, pointing of the joints has a minor influence on the airtightness. The obtained airtightness is always insufficient. Plastering is therefore a necessity when using these blocks as inner leaf. Attention must be paid to avoid air leaks when wall sockets or switches are fixed in the wall.

2.2. Recommendations

Out of these measurements can be concluded that plastering of the inner leaf of a cavity wall is always recommended to obtain a sufficient airtightness of the construction.
The plastering of the inner leaf can eventually be replaced by a cement rendering on the cavity side of the inner leaf (fig. 3), (fig. 4).

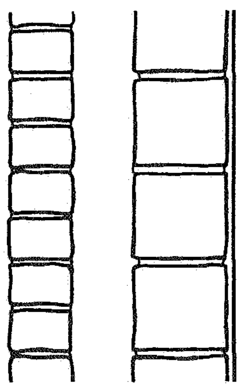

fig. 3, plastering

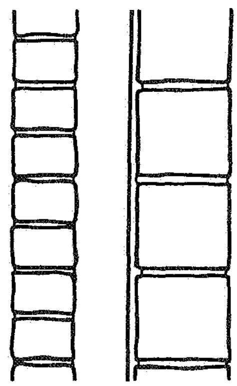

fig. 4, cement rendering

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