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AIR FLOW AND VENTILATION MEASURED IN GLAZED AREAS IN NARVIK

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SUMMARY

In the last decade in Norway it has been normal to build office or shop buildings with glazed spaces. Typical use is for entrance, glass corridors and glazed yards. The heat loss from infiltration cannot be calculated, but must be measured. A special problem is the air change from traffic of persons through a glazed area. In an entrance can the heat loss from door opening be high. For a glass corridor between 2 buildings will traffic give air exchange between the buildings and the glass corridor.

Use of traces gas with constant concentration can be used for air change measurements in glazed areas. This is done in a glass corridor, where the air change is found to be approx. 0.4 pr. hour. The influence from traffic can be seen on the results, but to give a expected extra heat loss from that is difficult.
Measurement of air change was also done in a staircase with ventilation. Ventilation in the room was expected to give problems, but the results in the glazed staircase showed that was no problem. The worst problem was good mixing of the tracer gass in the larger room.

Some of the problems from measurements of air change in glazed spaces are described in the paper. The tracer gas method can be used to evaluate the air tightness of the construction system for glass roofs and wall.

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INTRODUCTION

In the last decade in Norway it has been normal to build office or shop buildings with glazed spaces(1). The use of glass has given the architects new design possibilities. In Northern Norway it gives an area that is not influenced by snow, wind and rain. Typical use is for entrance, glass corridors and glazed yards.
These glazed areas do not have as good thermal insulation as the rest of the building. For heated areas can it give high energy consumption in the winter. An important factor is the thermal insulation and the air tightness of the construction. The heat loss from transmission can with good accuracy be calculated. The heat loss from infiltration cannot be calculated, but must be measured. A special problem is the air change from traffic of persons through a glazed area. In an entrance can the heat loss from door opening be high. For a glass corridor between 2 buildings will traffic give air exchange between the buildings and the glass corridor.
In the following is described measurements in some occupied buildings and the problems with the measurements are discussed.

BUILDINGS WITH GLAZED SPACES

The Narvik Institute of Technology and other institutions is located in an office building complex seen in figure 1. The institute has library and classrooms in the front building(SIVA 2) and offices in the back building (SIVA 5). There are 3 glass spaces at the building.

A glass entrance in 2 floors facing south – number 1 in figure 1. This is the head entrance to the building with much traffic. On the lower floor is a glass wall with a door to the interior of the building. This solution will prevent draft of cold air in the winter to the personal at the reception desk in the building. In the glass space is a staircase for the second floor. On the second floor is no division between the glass space and the

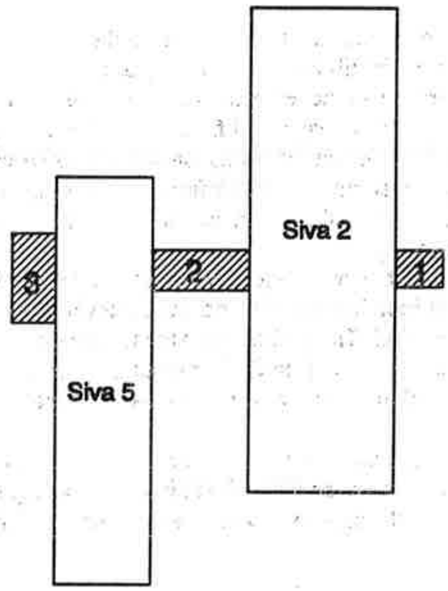


Figure 1. Buildings at Narvik Institute of Technology. The number 1 to 3 is glazed areas. Number 1 is the main entrance. Number 2 is a glass corridor. Number 3 is a glazed staircase.

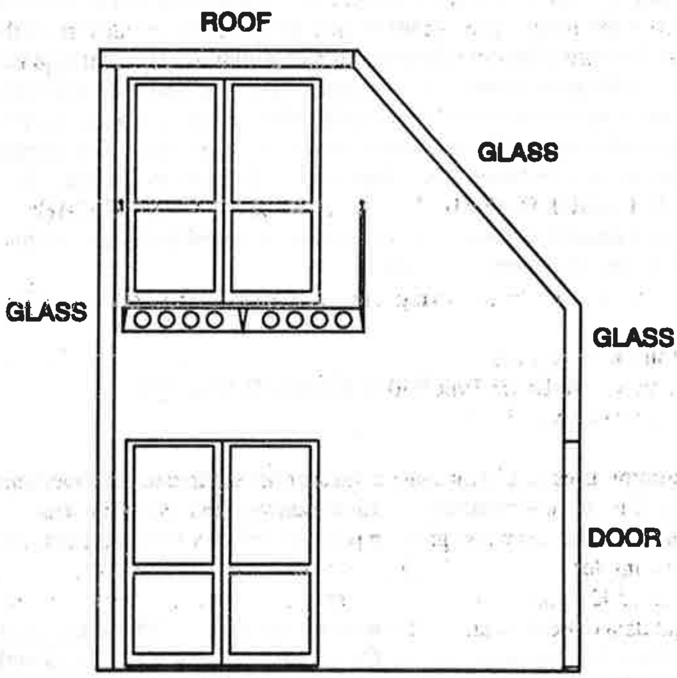


Figure 2. Vertical section of glass corridor (number 2 in figure 1) between the buildings.

building. There is free flow of air into the corridors on the second floor. And in most part of the year is the door from the library to the glazed space is open.
We have made measurements of the temperatures in the glass space, but find it impossible to measure the air change. It is difficult to define the volume we measure with the open connections to the interior of the building. This space is probably the most important for the energy consumption to air infiltration, as we have outer doors opening many times each day. Because of the uncertainty in the volume we have decided not to measure in this glass space.
A glass corridor 5 meter high between the 2 buildings – number 2 in figure 1. Figure 2 gives a section of the corridor. There can be traffic in 2 levels. At each end of the corridor is a door at each level. That is 2 doors to the front building and 2 to the back building. In the lower level is also an outer door – but it is not used so often. Most of the traffic is between the 2 buildings. In the corridor is also 3 openable windows, but they are not used.
In the corridor is no heating and ventilation, so the air change is caused by leakage in the constructions and traffic through the doors. To reduce the opening time of the doors is used doors with automatic closing (doorpumps). Measurement of air change was made in this corridor.

A glass space with a staircase from cellar to 3 floor and a ventilation room – number 3 in figure 1. There is a fire exit door to the outdoor but it is seldom open. On all floors is doors to the interior of the building. Only first and second floor is in use so the traffic is through the doors on these floors. Figure 3 gives a horizontal section of the room. There is staircase and an elevator and toilets at each floor.
During the day is ventilation from a duct to the glass room and exhaust from the toilets. In the night is the ventilation stopped. Measurements of air change in this glass space was made.

DESCRIPTION OF THE MEASUREMENT EQUIPMENT

The equipment consists of the following three elements (all from Brüel & Kjaer):

·Multi–gas Monitor Type 1302
·Multipoint Sampler and Doser Type 1303
·Application Software Type 7620

The 1302–monitor uses a photoacoustic measuring technique and can monitor up to 5 different gases and water–vapour. The 1303 sampler and doser provides for multipoint, multigas monitoring by drawing gas samples trough tubing from up to 6 locations and delivering the samples to the 1302. The software gives a full remote control over all the functions of the 1302–monitor and the 1303 sampler and doser to perform dosing, sampling, monitoring and data collection automatically.

Air is drawn from the sampling point via tubing to the 1303 Sampler and Doser and further to the analysis cell in the 1302 monitor. The cell is then hermetically sealed. Light from an infra red source passes through a mechanical chopper wheel that pulsates it and then through one of the optical filters in the filter carousel. The light transmitted by the optical filter is selectively absorbed by the gas being monitored. The temperature of the gas increases and decreases and this causes equivalent increase and decrease of the pressure of the gas in the closed cell. Two microphones mounted in the cell wall measure the pressure wave that is directly proportional to the concentration of the monitored gas present in the cell. By switching the filters, up to five gases can be measured. The measurement system is can compensate for the presence of water vapour in the air and for interference with other gases.

MEASUREMENT TECHNIQUE

The tracer gas used is sulphur hexafluoride SF6, a widely used gas for tracer gas measurements. The tracer gas is distributed to the room by a fan to get the mix that is provided for correct measurements. In large enclosures use of several fans can be necessary to get a uniform distribution of tracer gas in the enclosure. This gives more stable results, but on the other hand disturbance of the natural air movement can cause other airchange–rates than we usually have.

The constant concentration method is used in all referred measurements. A schematic description: The concentration of tracer gas is maintained at a constant level (for SF6 usually between 1 – 5 ppm). The air–change rate becomes then directly proportional to the tracer gas injection rate required to maintain the concentration on the chosen level. The 7620 Application Software uses a dosing algorithm for keeping the concentration of tracer gas at a constant level.

This method (2) offers two great advantages. It can be used to obtain an accurate long–term air–change rate in situations where the air–exchange rate varies. It also documents these variations in detail. E.g. the influence opening of windows and doors have on the air–change rate can be observed in detail. How detailed the information can be depends on the sampling rate and the volume of the enclosure.

MEASUREMENT IN THE GLASS CORRIDOR

Measurements has been done in two periods. In the first period was the gas dosing equipment placed on the lower floor and the concentration measuring point (c1) on the second floor. The mixing was done with two table fans. The mixing was checked by measuring the concentration at another point (c2). Measurements of the concentration is also done inside the two buildings on the second floor (c2 and c3). In measuring equipment was placed inside SIVA5 near c3. Table 1 gives an example of the results:

Time	Air-	SF_6	SF_6	SF_6	SF_6
	change	c1	c2	c3	c4
28/2/92 19:54	0.44	5.05	1.82	0.27	5.25
28/2/92 21:55	0.36	5.09	1.55	0.32	5.25
28/2/92 23:50	0.41	5.03	1.62	0.31	5.19
29/2/92 1:52	0.39	5.06	1.75	0.29	5.26
29/2/92 3:53	0.41	5.07	1.60	0.39	5.27
29/2/92 5:54	0.40	5.06	1.69	0.35	5.24
29/2/92 7:55	0.38	5.06	1.82	0.39	5.21
Average	0.40	5.06	1.69	0.32	5.24

Table 1. Two hour average–values of airchange and concentration in the glass–corridor (2 on figure 1). c1 is the constant concentration controlled by the equipment (5 ppm). c4 is the concentration at another point is the corridor to control the mixing. c2 is the concentration in SIVA 2. c3 is the concentration in SIVA 5.

The measurements was done during a weekend, where the doors was closed and there was no traffic. The outdoor temperature was around 0 C and the wind speed below 2m/s. The average air change was 0.4 times pr hour; most of this must be infiltration of outdoor air. The value showed that the glass/steel construction has a good air tightness. The 2 point in the corridor c2 and c4 gives stable values, so the mixing is good. The concentration in SIVA 5 is 0.3 ppm shows low leakage at the door. The higher value in SIVA 2 is not so easy to explain, but we expect the door did not close tight and an underpressure in the building will increase the traces gass concentration. The underpressure could be caused be the ventilation system.
Figure 4 gives the air change in the period. In the weekend it is 0.4 times pr hour. Monday march 2. there was little traffic in the corridor, as the students had an examination. The air change was a 0.45, so door openings had little effect. During the night the air change rose to 0.5. Tuesday march 3. was a more normal day with traffic in the corridor. The air change rose to 0.7 times pr hour. We expected that most of this increase in the air change is caused by the traffic between the buildings. This is confirmed from a rise in the concentration of traces gas in the buildings.

The second measurement series was done the next weekend. Then was the traces gass measurement only done in the corridor, not in the other buildings. The result is seen in figure 5. The air change is between 0.4 and 0.5.

The two measurement series gives the same air change 0.4 to 0.5 in periods with no traffic (weekends and nights). It is possible to use constant tracer gas concentration for measuring the air change in a glass corridor, if it is without ventilation system and with closed doors to other buildings. In periods with traffic can we measure air change, but the problem is to know if the result is normal for the building. It is important to know if the door close air tight, and the number of time the door is opened. Most important is cases, where the door is opened for longer periods. To get better information we must monitor the door openings and the air change. We expect to try that later in a diploma work for a student.

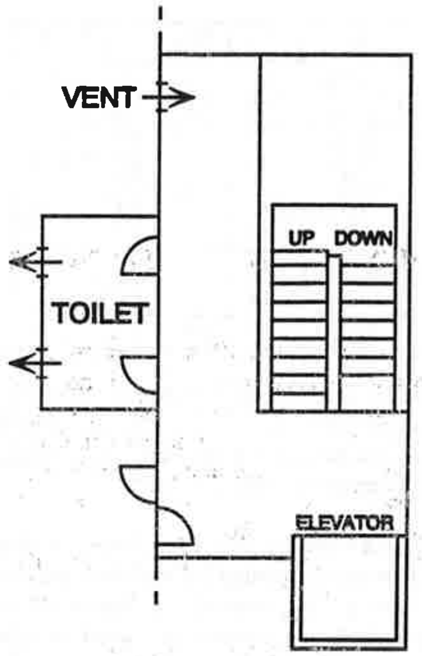


Figure 3. Horizontal section of the glazed staircase (number 3 on figure 1).

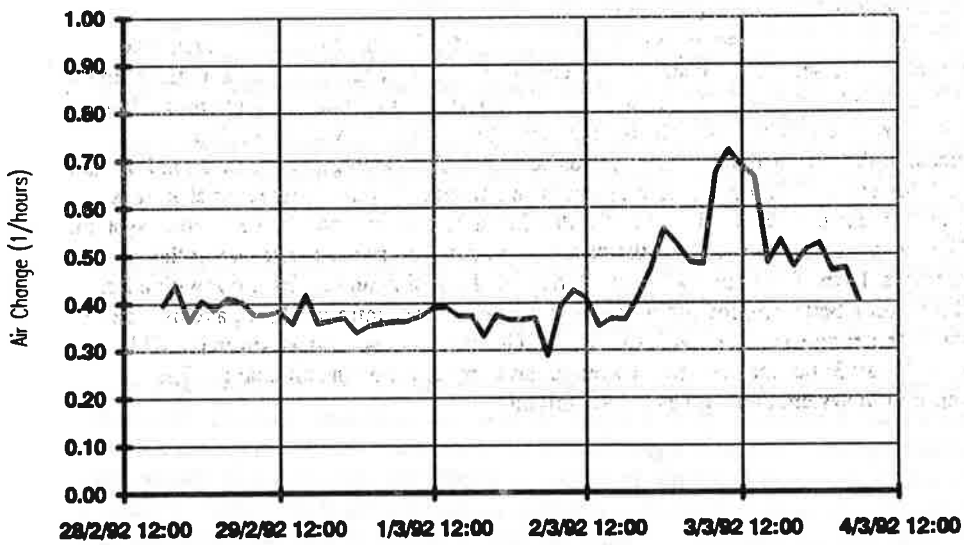


Figure 4. Measured air change in glass corridor. Two hour average values. The first part is for a weekend without traffic in the corridor.

MEASUREMENTS IN A GLAZED STAIRCASE

The glazed staircase gives access to all floors in SIVA5. A horizontal section is found in figure 3. Figure 6 is a vertical section of the staircase. There is doors between the staircase and the rooms in the building. These doors has automatic closing with doorpumps. Special problems is that the airvolume is not so well defined and we have ventilation in the room. The air volume in the elevator is not included. The ventilation system is necessary because of the toilets on each floor. Fresh air is blown into the staircase on the second floor and the exhaust is from the toilets.
The ventilation system gives 410 m3 air/h in the day. In the night is the ventilation stopped. The volume of the staircase is approx. 700 m3. The ventilation system can be expected to give an air chance of 0.6 timer pr. hour.
Figure 7 gives the results from the measurements. The constant tracer gass concentration is 2 ppm. The air change is around 1.3 in the day and 0.7 in the night. The difference is the ventilation of 410 m3/hour. In this case is it not possible to see the effect of traffic in the staircase – the normal variations in the results are too large. With one exception on March 6. at 11, when the tracer concentration goes down and the air change goes up. This is caused by opening the outer door.
On figure 7 is the measurements divided in periods. The measuring equipment was placed on the second floor and the concentration was measured on the same floor. In the first period (day 1) was the traces gas dosed into the ventilation air for the room. In the second period (night 1) was the dosing done at the first floor with a fan. The measurement show that the mixing was not good. The traces gas concentration fluctuate and this gives still more fluctuations in the air change. But the average air change is probably correct. On the third period (day 2) was the dosing into the ventilation system. The variations in air change in the day can be caused by traffic in and out of the staircase. In the fourth period (night 2) had we the dosing on the first floor with a fan. But to get a better mixing did we use 4 more fans in the staircase. That gave us a more stable tracer concentration and air change. The extra fans was also used in the fifth period (day 3) but that can not be seen to have any effect on the air change. The ventilation system alone gives a good mixing.

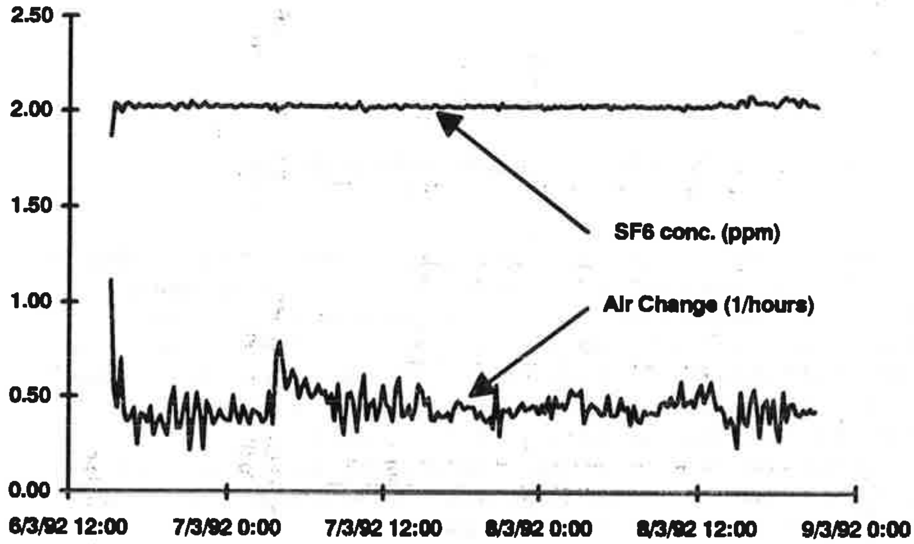


Figure 5. Measurements of air change in glass corridor. 15 minutes average values of SF6 concentration and air change. Second period(Weekend).

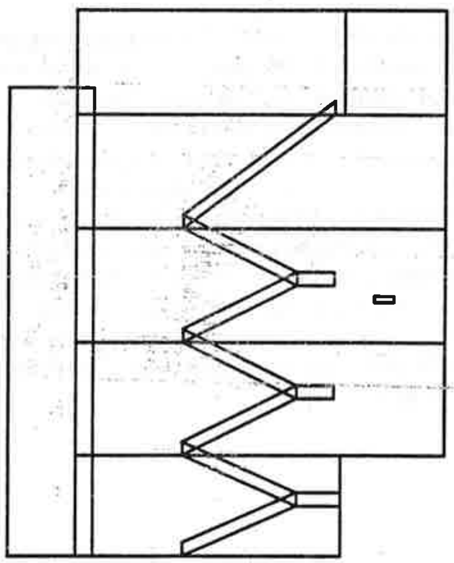
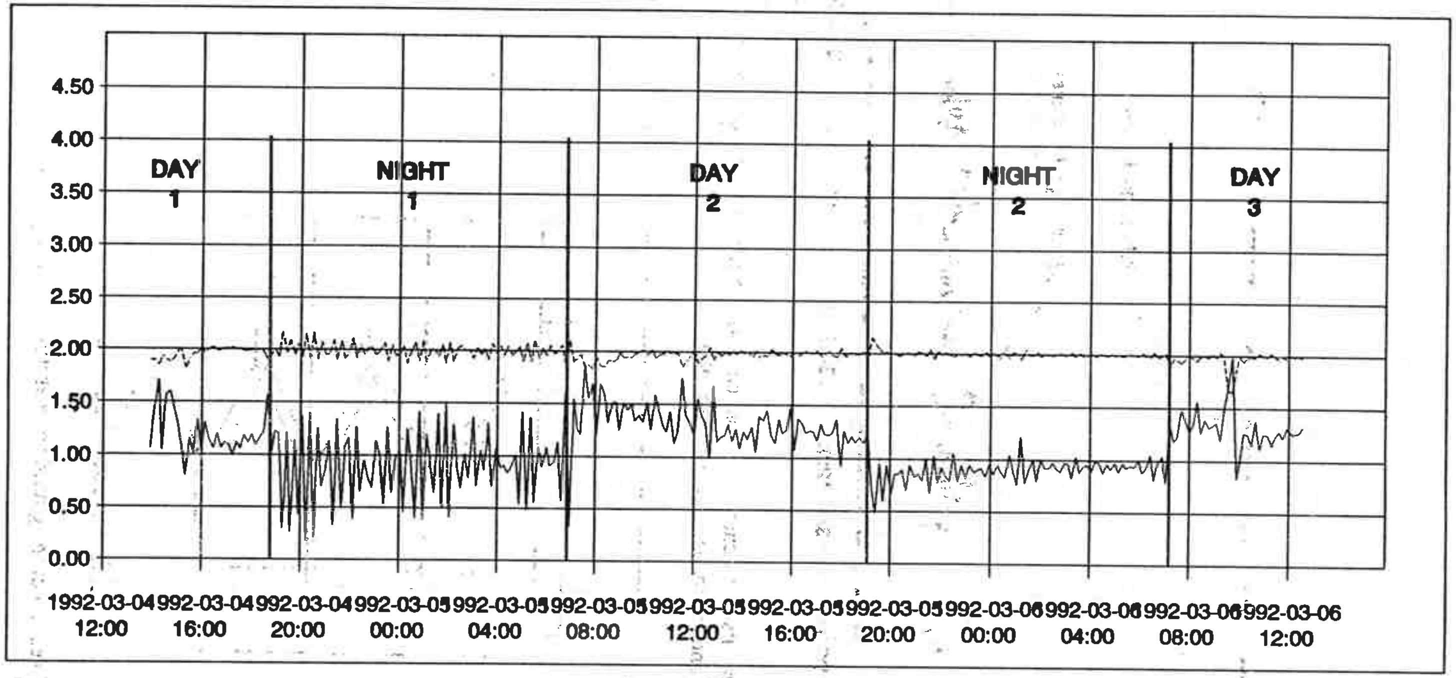


Figure 6. Vertical section of the glazed staircase(number 3 in figure 1).



C	Location:	Measurement	Line	Scale	Unit	Room Vol.
1	tr2.etg	Sulphur Hexaflouride	---	1E+00	ppm	700.00 m^3
1	tr2.etg	Air-change	——	1E+00	h-1	700.00 m^3

Figure 7. Measurements of air change and tracer gas concentration in glazed staircase.

CONCLUSIONS

Use of traces gas with constant concentration is easy to do in glazed areas, if the rooms is not integrated in the building. In most cases will there be walls with doors and windows to the interior of the building as in the cases with the glass corridor and the staircase. The problem is with integrated solutions as the glass entrance at SIVA2 in Narvik. To find the air change is difficult because we have to measure a large interior volume of the building. And after the measurement is it difficult to know the internal airflow in the building. We must measure air change in the whole building. Then it will be difficult to find the air change from outer door openings.
The measurement in the glass corridor shows, that it is easy to measure air change in a glazed room without ventilation. Ventilation in the room was expected to give problems, but the results in the glazed staircase showed that was no problem. The worst problem was mixing of the tracer gass in the larger room.
The results from the tracer gas measurement also can be used to evaluate the air tightness of the construction system for glass roofs and wall. The air tightness is normally tested in the laboratory but now a whole construction can be tested.
The constant concentration method can be used to find the influence from traffic through a glass space, but it will be a good idea also to measure the opening time and number of openings pr hour or day.

LITERATURE

1. C. Dreier et al. : Glass Roofs. Constructions. (in Norwegian) Handbook no 36, Norwegian Building Research Institute, Oslo 1985

2. AIVC Measurement Techniques Guide, Air Infiltration and Ventilation Center, UK, 1988