THE AIR FLOWS AND MICROBIAL CONTAMINATION TO INDOOR AIR FROM SANDWICH FACADE – CASE STUDY

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ABSTRACT

The subject building of this case study had high counts of actinobacteria in insulation layer of sandwich facade and in indoor air of specific flats. The aim was to resolve the air draft routes that might have conveyed microbes from external wall indoors, and find and prevent a cause to high microbial contamination in a specific flat. The study included pressure difference measurements, airflow measurements, microbial air samples, structural investigations and follow up measurements. The main contamination routes were located to the bushings in the exterior wall and after reparations the indoor air actinobacteria counts were clearly decreased.

KEYWORDS: microbial contamination, concrete, actinomycetes, structure, air tightness, wall

INTRODUCTION

Role of external wall as a biocontamination source is not axiomatic. To have an effect on indoor air quality, the contamination source outside the internal structure must be connected to the indoor air.

A significant actinobacterial growth was discovered inside the insulation layer of sandwich facade panels of the studied building. Building facade was made of concrete sandwich panels witch are common in high-rise buildings in Finland. Microbial quality of indoor air was studied from several grouped flats attached to studied panels. Indoor air samples and insulation samples showed corresponding, and therefore it seemed to be very probable that the indoor air contamination originated from the insulation.

The aim of this case study was to resolve the air draft routes that might have conveyed microbes from external wall indoors, and find and prevent a cause to high microbial contamination in a specific flat. The study included pressure difference measurements, airflow measurements, microbial air samples, structural investigations and follow up measurements.

METHODS

Background

A sandwich-type precast concrete building (building year 1973) was studied. The building had exhaust ventilation system without any supply air vent holes. Relatively high under-pressure indoors was very probable.

Mineral wool samples were taken from external wall insulation and cultured. Mesophilic fungi were analysed on MEA and bacteria on TYG agar [1]. Apartments next to studied panels were examined visually and with surface moisture probe to avoid moisture and mould problems other than external wall. Air samples were taken with Andersen sampler (Andersen 10-800, Graseby Andersen ltd.) on MEA and TYG.

Flat number 9 (kitchen) was chosen to be a subject of closer examination because it has the highest contamination. Formerly, the outermost kitchen cupboard had been used as cooler (pantry), and there were ventilation ducts through the exterior wall (Figure 1). Used steel ducts have been sealed from inside of the duct, as the cupboard was not used anymore as a cooler.

Air flow studies

The air flows were studied by measuring air velocity rates near wall surfaces and exterior panel joints during normal pressure difference conditions and during artificially under-pressurised period.

Foot ledges and covering lists around window opening were removed in the test room (*kitchen*) and the covering boar between outermost cupboard and exterior wall was removed. The air-drafts in normal pressure conditions was measured (Figure 1).

Two chambers with PE-plastic and timber frame were build. Chamber *Pantry* covered the area around lover ventilation duct between outermost dresser and exterior wall. It was loose plastic hood and it's purpose was to examine air-drafts around air duct hole. Chamber *Tent* covered rest of the exterior wall as shown in Figure 1. It was made air tight and its purpose was to examine air-drafts from normal joints of sandwich panel during under-pressurising.

The pressure differences compared to the outside air pressure were studied from room, chamber *Tent* and insulation layer of exterior wall in different states of experiment by using measuring pipes (8 mm) between different locations and pressure difference meter (accuracy 1 Pa).

The chamber *Tent* was under-pressurised (52 Pa under the normal condition) by vacuum cleaner with HEPA-class filters to avoid contamination of kitchen air.

Measuring of air transmitted microbes

The air transmitted microbial contamination through the bushings of steel ducts of former cooler cupboard was measured after 3 hour in normal pressure difference (Column *Pantry* in figures 3 and 4).
The initial microbial levels in chamber *Tent* were measured with 3 air samples (First set of columns *Tent 1-3* in figures 3 and 4) before artificial under-pressurising and accumulated microbial contamination from inside the exterior wall was measured after 4 hours under-pressurising again with 3 air samples (Second set of columns *Tent 1-3* in figures 3 and 4).

Thickening repairs and follow up measurements

After first under-pressurising the joints in exterior wall inside of chamber *Tent* were sealed with elastic sealing compound and the under-pressurising and air-draft measurements were

redone. No significant air flows were detected after the sealing reparations.

Afterwards the rest of flat 9 was repaired with same method. At the next summer the sealed joints of exterior facade were repaired from whole building. Several follow up measurements with air samples were done (Results are shown in table 2.)

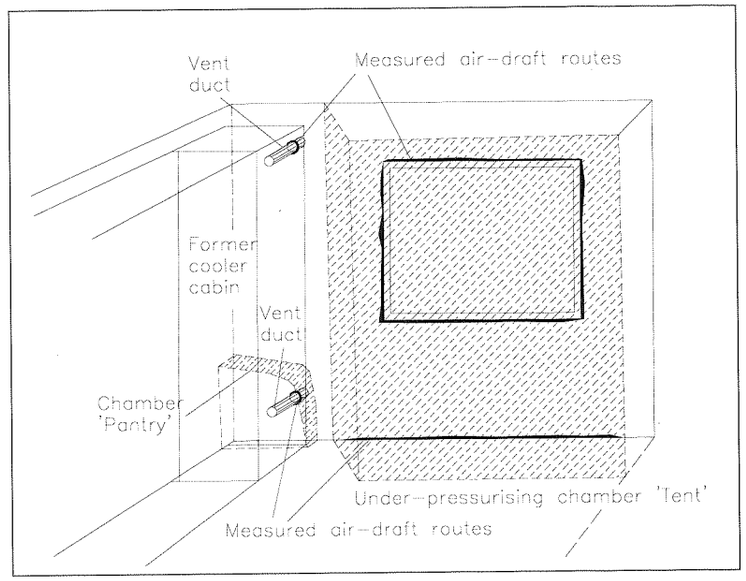

Figure 1. Test chambers and detected air-draft routes

RESULTS

Air flows and pressure differences

The pressure difference measurements are shown in table 1. The normal pressure difference between indoor and outdoors seemed to be –15 Pa. But wind was very mild in that day and in windy days the difference can be much higher.

Table 1. Pressure difference measurements

	Pressure differences compared to the outdoor air pressure		
	Indoor	Insulation layer	Chamber *Tent*
Initial state before chamber conctruction	-15 Pa	-10 Pa	not measured
After 15 min under-pressurising	-16 Pa	-42 Pa	-68 Pa
after 4 hour under-pressurising	-17 Pa	-31 Pa	-69 Pa
15 minutes after ending under pressurising	-15 Pa	-9 Pa	-15 Pa

Artifical under-pressurising

The pressure difference between insulation layer and outdoors was about two thirds of total pressure difference over exterior wall. So the sealed joints of outer concrete slab were tighter than joints in inner concrete slab. Also during the under-pressurising the under-pressure in insulation layer was more than half of pressure difference through whole wall.
The air velocity around bushings of steel ducts was as high as 5 m/s, bur were not able to determine the volume of air flows inside chamber *Pantry*.
The exhaust air volume from under-pressurised chamber *Tent* was 20 m^3/h and measured air velocities near joints varied from 0.15 to 0.5 m/s.

Air transmitted microbes

Concentrations of both actinobacteria and *Penicillium-Aspergillus* -group were highest in the former cooler cabin (*Pantry)* and explained well the high counts of the flat 9. Actinobacterial counts were similar to *kitchen* in the *Tent* -chamber before the artificial under-pressurising, but fungal counts much lower. During the under-pressurising, the actinobacterial counts in *Tent* -chamber did not change, but the fungal species changed similar to outdoor source: the main genera were basidiomycetes and *Cladosporium* and other outdoor moulds.
The main source of actinobacterial and *Aspergillus-Penicillium* -group spores of indoor air was found to be connected to inaccurate structural details in the bushings of the exterior wall. Furthermore, there were obvious air flows in elastic joints around window frames, and in bottom- and side-edges of interior slab of sandwich panel. *The microbial flora that came through them was mostly outdoor orientated.*

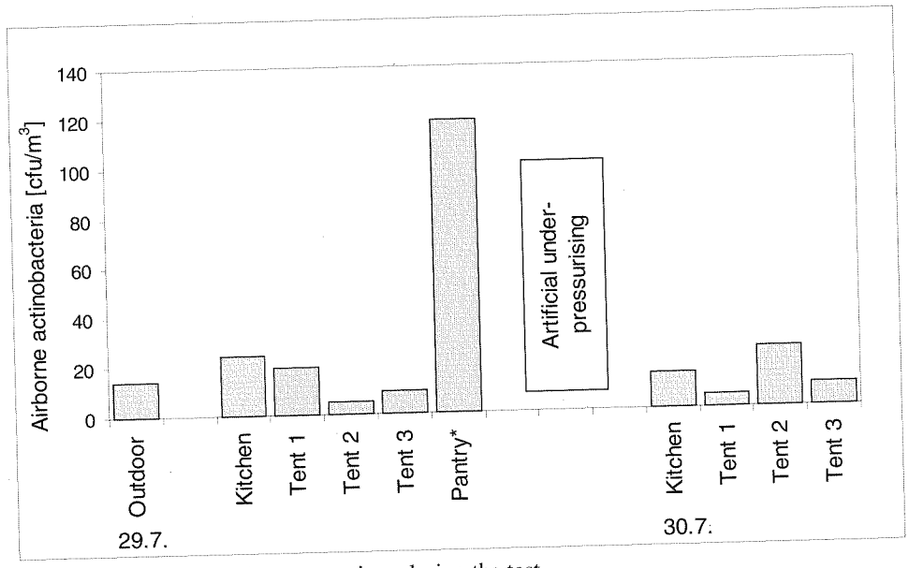

Figure 2. Actinobacterial concentrations during the test

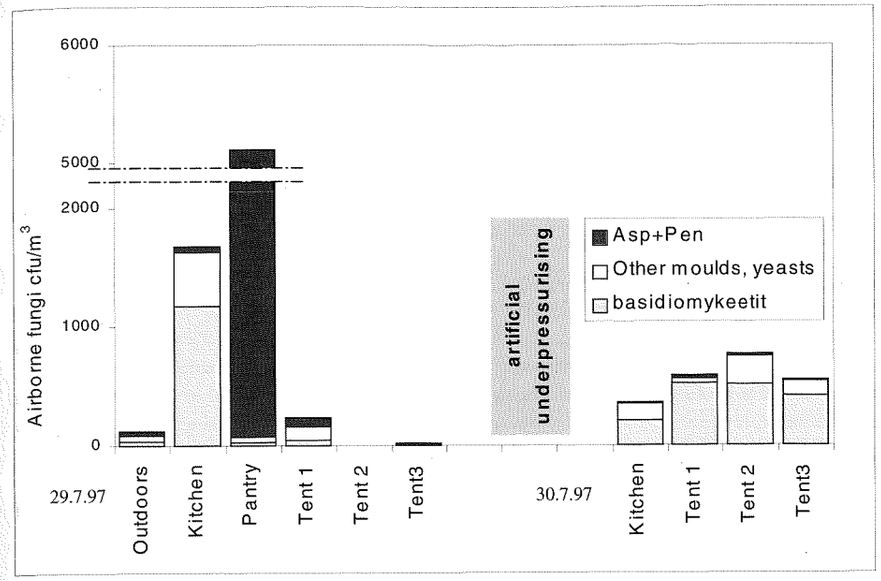

Figure 3. Fungal concentrations during the test

Effect of thickening repairs

The actinobacterial counts before and after reparations are shown in table 2. The arrangement of studied flats are shown in figure 4.

Table 2. Actinobacterial counts

Samples		Flat 4	3	2	9	10	12	Out door
Insulation samples cfu/g (maximum of the attached panel)		11300	7400	0	12300	7600	0	
Air samples cfu/m^3								
130597	Sampling 1	25	4	4	420	25	0	0
270597	Sampling 2	-	-	-	215	-	-	9
	Repairs of internal concrete slab elastic joints in flat 9							
111197	Follow-up A1	10	0	0	24	24	21	2
090198	Follow-up A2	0	0	0	29	38	17	0
	Repairs of external concrete slab elastic joints in summer '98, whole building							
170199	Follow-up B1	21	0	0	14	7	5	0
080299	Follow-up B2	5	0	0	7	0	0	-
100399	Follow-up B3	0	0	10	7	5	0	-

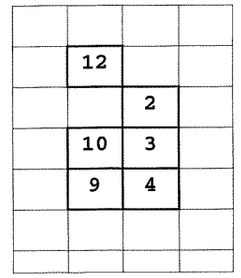

Figure 4. Arrangement of the studied flats

Before any remedial measures, very high actinobacterial counts were found in flat 9 and increased in flats above (10) and adjacent (4). With *Penicillium* and *Aspergillus* counts, a slight increase in counts of the flat 9 was found (not shown here) before reparations.

There was remarkable drop in actinobacterial counts of flat 9 after thickening repairs.

DISCUSSION

Although this was only a case study, there are some points to mention.

First of all, in this case the main sources of actinobacteria was clearly the loose bushings of steel ducts of former cooler cupboards.

Secondly, although there were significant air flow through normal joints of windows and cracks in concrete grout joints, the air transported microbes were oriented to the outdoors and not to insulation layer.

The thickening repairs of inner concrete panel did decrease the actinobacterial counts inside, but we cannot separate the effects of reparations of loose bushings and cracks in normal joints.

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REFERENCES

1. Pessi, A-M , Helkiö, K, Suonketo, J et al. 1999 Microbial growth inside exterior walls of concrete buildings as a possible risk factor for indoor air quality. Indoor Air'99 1-899.

2. The Finnish Pollen Bulletin, Vol.22 (23) pp.6