The determination of conditions for microbial growth in the Crawlspaces

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ABSTRACT

Temperature, relative humidity, pressure difference across the floor and microbial concentrations were investigated in the four buildings which had either concrete floor (1 piece) or wooden floors (3 pieces) and crawlspaces. The temperature followed the outdoor temperature in the crawlspaces having wooden floors. The relative humidity in all the crawl spaces was continuously for a month at least 75 %. The moisture and temperature conditions were favorable for microbial growth and several moisture indicating microbes were analyzed in crawlspaces and in indoor air. The crawl spaces were positively pressurized when compared to indoor spaces. Thus, the convective flow via the air leakages across the floor was possible and the microbes and their gaseous metabolites could be transported to the indoor air.

1. METHODS

1.1 Temperature and relative humidity
The temperature and relative humidity of air at crawlspaces was constantly measured during the measurements of the differential pressure. In addition, single measurements were conducted in several points of the crawlspaces in order to achieve the distribution of the temperature and the humidity. The temperature and relative humidity was measured using humidity transmitters, Vaisala RH/T HMP143 A and HMP 233 A models, which were calibrated at the outset. Measurement readings were recorded at 30-minute intervals using a data collection device. The seasonal measurements were started in February and were ended in August in 2006.

1.2 Pressure differences
The measurements were carried out using differential pressure transmitters, Setra 264 and 267 models, with a pressure measurement range of ±25 Pa, capable of measuring low pressure differences. Their respective errors are ≤1% and ≤0.4% of the full reading.

1.3 Microbes
Cultivable microbes in the crawlspaces and indoor air were determined from the air samples to evaluate the microbial contamination. Mesophilic fungi were cultivated on Rose Bengal malt agar (Hagem agar) and dichloran glycerol agar (DG18), and bacteria on tryptone yeast glucose agar (TYG) for 7 days at +25 ^{o}C. Microbes were identified using common mycological procedures.

2. RESULTS AND CONCLUSIONS

2.1 Temperature and relative humidity
The temperature followed the outdoor temperature in the crawlspaces having wooden floors and it varied from 5 (wintertime) to 15 ^{o}C (summer) in the concrete crawlspace. The relative humidity in all the crawl spaces was continuously for a month at least 75 % and continuously up to 95 % for two months in the tightest crawl space constructed from concrete.

2.2 Microbes
The air samples contained mostly outdoor air microbes: *Cladosporium, Penicillium*, basidiomycetes, yeasts and bacteria. The air samples included fungi favoring moisture environments (e.g. *Acremonium*, *Aureobasidium, Aspergillus (A.) versicolor, A. niger, A. penicillioides* and *Eurotium*). In addition, bacteria *Streptomyces* spp. was found in crawlspaces.
The moisture and temperature conditions favored the microbial growth in the crawlspaces where microbe concentrations and microbial diversity were multi fold in comparison with those detected in indoor air. In general, microbial concentrations and species were

different in different seasons in outdoor and indoor air and in crawlspaces. In summer, all the buildings had different kind of indicator microbes in indoor air compared to those in crawlspaces. In one of the buildings, same indicator microbes were found in indoor air as in crawlspace during winter, which suggests migration of microbes from crawlspace into indoor air. Microbial concentrations in crawlspaces were highest during winter time when also the probability of air leakages was greatest due to high temperature difference between crawlspace and indoor air.

2.3 Pressure differences

The averages of pressure difference across the floor was found to be positive in the range from 0.2 Pa to 4 Pa. This might provide the convective flow including e.g. microbes to enter indoor spaces via air leakages in the structures.

3. CONCLUSIONS

While mitigating the conditions in crawlspaces by depressurizing the crawlspaces by mechanical ventilation, the moisture increase from ground soil should be optimized. Preferable the mechanical warming and dehumidifying device should be installed to the crawlspaces and the soil surface should be insulated. In addition, the air leakages routes should be tightened.

According to the results obtained the most essential factors which should be notified when the crawl spaces are investigated and renovated are the air tightness of the floor, the pressure difference between the crawl space and indoor air, minimizing the humidity amount entering the crawl space especially from the ground, and effective ventilation of the crawl space.

REFERENCES

IICRC. (2003) Standard and reference guide for professional mold remediation. Institute of Inspection, Cleaning and Rastoration Certification, IICRC S520, Vancouver.