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Prevention of Cold Air Flow Penetration into Industrial Buildings – A Design Guide

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Introduction

The penetration of cold outdoor air into industrial buildings is a severe problem in countries having a cold, arctic or subarctic climate. The cold air, penetrating into the building mainly through the open doorways, causes discomfort to the workers, disturbs the functioning of the ventilation system and increases the energy and maintenance costs of the building. What even worse, the industrial process could be disturbed and even stopped, which could lead to high production and financial losses. To prevent all such adverse effects in advance, the preventive measures should be integrated into the planning and building process.

The goal of the activity described here, was to develop for the ventilation designer a tool, which he could use to support the analysis, design and decision making related to the cold air aspect. In the first stage a quantitative verification of the adverse effects of the cold air penetration was made (1, 2). In the second stage an analysis and classification of the drawbacks was carried out. Further, a systematic approach (a design guide) (3) to tackle the problem was developed and finally a computational supportive tool was finalised.

Connections to the Design Process

The design of an industrial ventilation system is a complicated task and has to be done on the conditions of the industrial process. One possible approach is presented in (4). The cold air problem should be taken into account from a very early design stage. The direction of the building, the placement of the largest openings/doorways and the horizontal and vertical division into internal zones have a strong effect on the later need for prevention and the possibilities to put any prevention measures into practise. Usually the ventilation designer can not influence these solutions. He just has to do after-care using ventilation, air curtains and other related measures.

Harm Index

For the ventilation engineer (and the architect) to be able in the early planning stage to assess the risk possibly caused by cold air penetration, a harm index (HI) was developed. The index is calculated based on adverse factors, which are given a score each and finally subtracted all to give the harm index. If e.g. the building is going to be placed on the coast, the environmental adverse factor gains a high value, because on the coast the wind is stronger than elsewhere. If there are large doorways, the construction related adverse factor has a high value and so on. In total, there are six factors containing twenty-two sub-factors, having scores from 1 to 10. The HI was calculated for ten different existing industrial buildings giving values between 23 and 41. Based on this, a classification shown in Table1 was created.

Table 1. Harm index classes for assessment of cold air penetration risk.

Harm index	Classification	Typical features
HI > 40	The building is very sensitive to cold air and requires strong measures to prevent cold air penetration	High building, several large doorways, continuos use of doors, workplaces close to doors, temperature sensitive process.
30 < HI ≤ 40	The building is sensitive to cold air penetration and requires special attention of prevention measures	High building or large doorways, frequent use of doors, workplaces close to doors.
25 < HI ≤ 30	The building is not especially sensitive to cold air penetration and requires not special measures.	Doors not in frequent use, some workplaces close to doors.
HI ≤ 25	The building is not sensitive to cold air and requires no measures.	No large doors and/or minor use of doors.

Design Procedure

The computation of the HI number is the first stage in the design procedure for cold air prevention. In the design guide (3) there is a flowchart for each of the four HI classes shown in table 1. The flowcharts guide the user to check and assess all relevant features related to the doors, the tightness and insulation of the building envelop affecting moisture condensation and the indoor thermal conditions as well as the possible unbalance of the ventilation. The flowchart also proposes sufficient prevention methods for each case. If an air curtain is chosen, some supporting data and procedures for the proper dimensioning of the curtain device are given.

Tools

The assessment of the neutral level height in the building is one important step included in the flowcharts. The neutral level gives an indication of the criticality of the cold air penetration risk and is also one of the main factors in the air curtain dimensioning. The design guide contains a rough procedure for neutral level height assessment using a table. However, a more sophisticated computation tool for this purpose was also developed. The model is based on the adjustment of the air flow mass balance of the building and is implemented as an Excel worksheet. The input data contains indoor temperature, weather parameters, building pressure coefficients and wind sheltering, dimensions and placement of doorways as well as other leakage openings in the building envelop and finally the possible airflow due to ventilation unbalance. As output is given, except the neutral level, also flow rates through the doorway (inwards and outwards) and other openings, and the indoor-outdoor pressure difference at the floor level.

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