Technical article

DEMAND-BASED VENTILATION IS LOGICAL IN SCHOOLS

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The quality of the indoor climate in schools has been found to be poor in a number of surveys. Poor indoor air causes an increase in symptoms and illness, and it shortens attention span. The commonest indoor climate problem is inadequate ventilation. To achieve a good indoor climate, an adequate airflow should be used and the airflow should be demand-based to optimize the energy economy.

Problems related to indoor climate have been raised in a number of studies. In Finland, the University of Technology and Oulu Polytechnic have found numerous problems in schools' indoor climate. Similar results have been obtained in Sweden, Norway, the USA and elsewhere. In Minnesota, USA, the following indoor climate problems were found: (1) inadequate outdoor airflow 48%, (2) damage caused by damp and water leaks 26%, and (3) ventilation balancing and poor regulation 19%.

According to a study of Norwegian schools, a poor indoor climate causes respiratory infections. Bad cleaning, high concentrations of dust, high humidity rates and temperature aggravate symptoms and reduce the pupils' attention span.

The way to reduce the above problems is to increase ventilation in classrooms. On the other hand, from the energy economy viewpoint, it is worthwhile adjusting the ventilation on a demand basis.

Demand-based ventilation is a way to regulate spaces in various capacity situations. There is an ever-growing need for this, for one reason because teaching in upper secondary schools is becoming increasingly course-based. Similarly, in lower stages of comprehensive schools, work is being done in various team rooms in addition to traditional classes, so that the number of pupils in the classroom varies considerably.

A logical point of departure would be to regulate the ventilation in the space according to the activity taking place in it and to configure an adequate fresh airflow to ensure good conditions in all capacity situations.

Ventilation according to activity

In offices, the workgroup method that has spread rapidly is also being applied in schools from the comprehensive school lower stage level upwards. Teacher-centred teaching is given in classrooms and teamwork is done at workgroup stations, which may be in corridors.

Some schools hold no breaks between lessons at all. Instead there is just a five-minute pause for changing classrooms. This method reduces the overall length of the school day. From the ventilation viewpoint, this means that there is no time for window ventilation, even on the theoretical level.

In upper secondary schools, the non-class system has come to stay. The concept of a non-class upper secondary school is that the pupils decide their courses for themselves from the options provided by the school. In other upper secondary schools, efforts are being made to comply with the old upper limit of 36 pupils per class, while others have the limit at 35, 38 or 40 pupils. The usual minimum for starting a new group is 8 – 15 pupils.

In a survey by the leading Finnish daily newspaper Helsingin Sanomat, nine of the almost one hundred upper secondary schools had groups of over 40 pupils. The usual average size of groups in upper secondary schools is 20 – 30 pupils. All upper secondary schools also had small groups with 3 – 10 pupils.

An entirely separate category is represented by the other activities taking place in schools, such as evening clubs and adult education. One can envision private financing entering schools, whereupon more efficiency in the use of premises will be required.

The schools of the future may be sports halls and course centres, with activities around the clock and throughout the year.

On the practical level, large variations in demand will require a ventilation system which enables demand-based control. Airflow control should be possible within very wide parameters, such as from 5 to 43 people, so that differences in the size of the group can be managed energy-economically. In a standard class of 36 people, the possibility must be allowed of increasing airflow by 20% so that larger teaching groups can also be catered for. Increasing the dimensioning of central units does not necessarily have the desired effect; the same airflow is distributed in different ways to accommodate different space capacity situations.

To achieve good condition, the ventilation system should provide (1) the right amount, (2) at the right time, and (3) in the right place. This is not possible with an inflexible system. Future systems should regulate ventilation to meet human needs – not, as now, ventilate square metres of space.

A targeted airflow

In schools, the dimensioned figure for airflow usually used is 6 l/s per pupil. People are often unaware of what this airflow is adequate for: in a steady state, the CO_2 concentration is approximately 1200 ppm, when the CO_2 output per student is 18 l/s and the outdoor air CO_2 concentration is 400 ppm.

In a steady state, the air volume of the classroom is not figured in, nor is the possible effect of window ventilation. If there are 20% more pupils in the class than is assumed in the dimensioning, the CO_2 concentration will increase to 1400 ppm.

In the classification system for indoor climate, which is still at the comments stage, the targeted figure for the best class (S1) is 700 ppm. The targeted figure for indoor climate class S2 is 900 ppm and S3 is 1200 ppm. The present practice results in an airflow of 6 l/s per person, which meets the requirements for class S3. This assumes that the size of the group in the classroom is in line with the dimensioning.

By contrast, one can consider what the airflow should be to attain the desired CO_2 concentration. In a state of equilibrium 900 ppm required 10 l/s per person and 700 ppm 16 l/s per person. Reducing the CO_2 concentration from 900 ppm to 700 ppm will increase the airflow 60%.

Using higher airflows in classrooms is also a live subject internationally. In the draft CEN standards, ventilation is divided into three classes by quality (A, B and C). The draft standard gives the following figures for school ventilation:

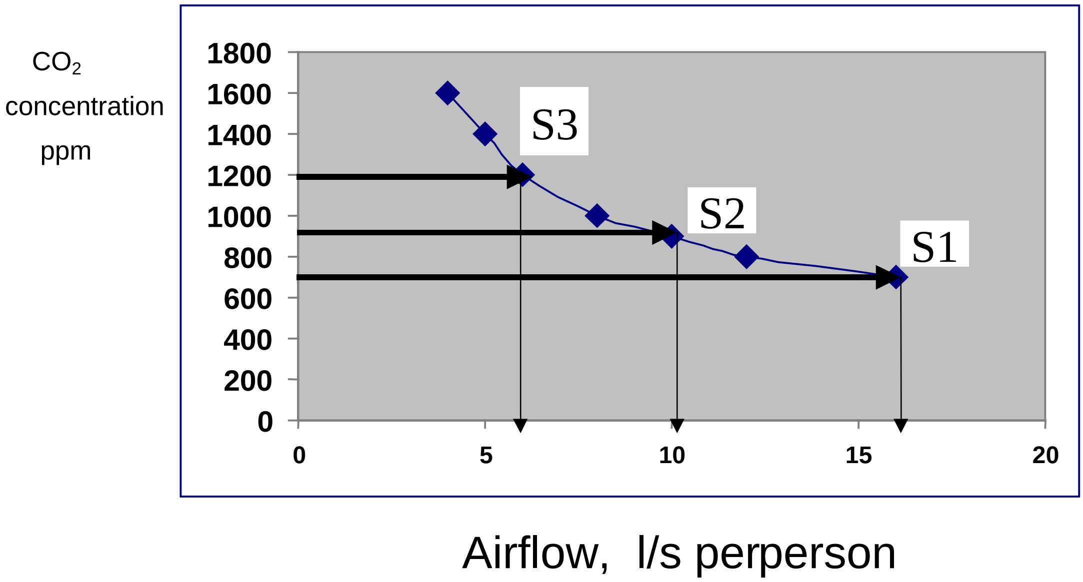
- Level A: 6 l/s per m^2 (12 l/s per person)
- Level B. 4.2 l/s per m^2 (8.4 l/s per person)
- Level C: 2.4 l/s per m^2 (4.8 l/s per person)

Generally, the activities taking place in the spaces should be considered in the dimensioning of airflows and the need for flexibility should be figured in. In the early planning stage, the targeted level should be decided (e.g., S2). The room equipment is dimensioned to this targeted level, taking into account the real size of groups being taught.

A good starting point for dimensioning might be an airflow of 10 l/s per person, which will permit system flexibility and ensure good conditions (level S2).

The efficiency demand of room spaces does not necessarily affect the dimensioning of the central units, such as a ventilation unit. The capacity of the central unit is just distributed in a different way to the places where the pupils are at any given time.

Figure



CO_2 concentration in different airflows, when the starting point is a steady state. Airflows corresponding to the proposed indoor climate classifications (l/s per person) are S1 (700 ppm) 16 l/s per person, S2 (900 ppm) 10 l/s per person and S3 (1200 ppm) 6 l/s per person.