PRACTICAL ATTEMPTS TO PREDICT INDOOR AIR QUALITY

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Many planners have a desire to be able to calculate the indoor climate. Such calculations, however, require a documentation og the material characteristics which is both technically and financially impossible to produce at present. A Danish full scale test has shown that it is technically possible based on common knowledge, common sense and creative thinking to obtain a satisfactory indoor climate, both in case of renovation and new buildings. An alternative way of planning and creativeness in new fields is a necessity to ensure a good indoor climate in buildings.

Mandates, a superior policy, planning and a progressive collaboration between indoor climate consultants and the architects may lead to new thinking on the drawing table. This process may result in development of new building materials and components and new working methods, and it may force contractors and workmen to think and work in a different way than customarily.

It is not technically possible to document adequately the indoor climate of a building under construction. It is recommended to provide the documentation before the building is put to use immediately after the completion of the work.

INTRODUCTION

Danish Technological Institute (DTI) has measured the indoor climate in buildings for many years. The objective has been to explain the cause of indoor inconveniences, and the experience is now used in a direct effort to predict the indoor climate and to prevent faults already known from other buildings. DTI has established a direct broad service to builders, consulting engineers, architects, manufacturers and suppliers.

This paper refers experience gained from two attempts to plan the indoor climate and the subsequent control of the predictions.

Case 1. In the autumn of 1987 the insurance company Baltica contacted DTI. Baltica planned to centralize all activities in new headquarters of 65,000 m² floor space. For the sake of the employees and the operation of the company Baltica wanted to have a headquarter with a good indoor climate. The company had bad experience from several previous building activities.

Case 2. In 1989 the Danish National museum started a reconstruction and extension of their buildings in Copenhagen and their store houses in Brede outside Copenhagen. For the sake of the staff and exhibits the building committee contacted DTI for expert assistance. The museum had had several unfortunate experience with the indoor climate, that is the staff had had inconveniences, and the exhibits had undergone undesirable alterations. DTI had assisted in clarification of these problems.

Case 1

An agreement was made about collaboration between Baltica's safety committee, the chosen architect firm (H. Dall & T. Lindhardtsen) and DTI.

WORKING HYPOTESIS

On the basis of common know-how it is possible to project and construct an office building with a good indoor climate without the well-known factors that cause the mentioned problems.

WORKING TASK AND LIMITATIONS

The policy and the mandates of the working group were adopted. Engineers should attend to the thermal climate and lighting. The working group should only attend to the indoor climate regarding emission of gases, dust and fibres from building materials, operation of the building, cleaning and maintenance.

PROCEDURE

An extremely positive and creative collaboration between the architect firm, DTI, and the building committee which was responsible and had the final decision, made it possible for the architects to design the building and to propose the constructions and choice of materials in a traditional way. Do not ever interfere in creative thinking. Then the choice was analysed and evaluated by DTI in relation to common know-how and well-known problems. It is necessary to stop the architects from thinking in grooves by defining qualified requirements to the material characteristics as concerns indoor climate - not only the usual and well-known requirements on appearance, life and low maintenance costs.

In a dialoque or rather a process, changes are discussed, but no final choices of alternative materials are made. Possibilities are possible requirements that are to be satisfied are presented. The process concludes in new solution proposals made by the architects. The architects shall be converted to think in alternative and untraditional ways. The result of the process depends on the attitude of the parties and their possibilities of relating to the problems. In this situation the collaboration must be considered being unsurpassed. Unexpected results were achieved.

INTENDED RESULTS IN PRACTICE

When selecting the building materials, the intire life of the whole building should be kept in mind, that is production phase, construction phase, use, cleaning, maintenance, renovation, rehabilitation and recycling, and also a possible deposit og the materials after demolition of the building. In all phases it is essential to consider the indoor climate, working conditions, and physical conditions. No single architect is able to assess all consequences of a given choice.

DIRECT POSSIBILITIES OF IMPROVEMENTS OF THE INDOOR CLIMATE

Use of pre-fabricated units during the construction. Reduction of the emission of dust, fibres, and smells, and open discussions of the emission problems will be welcomed by the workmen. The chemo-technical working processes should be moved from the site to protected factories. Glued and painted components should be finished at the factory. The use of surface treatments could be reduced if smooth surfaces were chosen. The emission could be accelerated by baking the products at the factory instead of baking on site. Intermediate stores equipped with forced ventilation could be established at the factory. Emission from surface treatment agents, glues and joint fillers used on site can be reduced by means of forced ventilation or baking of rooms or building. Rapidly emitting materials should be used. Dust- and fibre emitting work processes on site should be kept at a minimum. If necessary, the finishing processes should be made in a ventilated room adapted for the purpose. Products bases on fibre should not be exposed unless the stability and durability of the binding have been documented. In case of a long building period it is recommend to start using the building only when the whole work has been finished. During the actual case attempts were made to analyse and document this so-called "buffer-effect", and during the entire building period measurements of air-borne and deposited pollution were carried out.

ACTUAL MATERIALS, CONSTRUCTIONS AND SPECIAL LAY-OUTS

Carcase considts of concrete elements wich are faced on site. In view of the future flexibility of the offices the plans included movable partition walls. A completely new system based on a skeleton of stel laths covered with fibre-gypsum plates (clips-on-system) was developed. On the recommendation of DTI the cavities were filled with a newly developed mineral wool product which is manufactured pre-cut and wrapped in plast foil for the different partition wall systems.

It is not necessary to cut the mineral wool on site - that is done at the factory where precautionary measures to ensure a safe working environment can be made. The fibre-gypsum plates were painted at the factory, and it was planned to be baked out after manufacture. Then they were stored in a hyper-ventilated store room. For production-technical reasons the baking was not carried out. The surface treatment was smooth to avoid dust and facilitate cleaning. It also reduces the consumption of paint. The surfaces can be washed. Light colours were chosen because they reveal dirt. Doors can be placed in the partition walls without working on the walls in offices in use. Shelves etc. are placed on the partition walls in premade inserts - thus avoiding dust emission. When the partition walls need to be painted, they are taken to the factory and painted, baked and ventilated and then replaced in the offices.

A ceiling of mineral wool was designed and manufactured to the building. The requirements made to the producer were that all surfaces and edges should be sealed by means of a protective surface treatment. The product is documented to be free of emission before use. The ceiling plates are adjusted on site. All exposed edges are sealed immediately. Is was considered to cover the concrete surfaces with wall paper, but a surface treatment with acrylic-plastic paint was chosen, because the paint producer was able to reduce the content of solvents and preservatives in the paint.

The floors are filled with a cementbased product and covered with ordinary linoleum. The convector covering is designed for optimum air circulation. It can be demounted for cleaning or when it is necessary to install new communication cables etc. under the convector. The windows are traditional aluminium profiles with sealed double glazing. The doors were prepainted at the factory. The furniture was designed and produced in accordance with the requirements made for the building materials.

SUPERVISION OF WORKING PROCESSES AND AIR QUALITY

The supervision was carried out during a two-year building period. DTI inspected the site regularly. Temperature and air humidity were monitored in a prototype office constructed at an early stage. A subjective evaluation of the air quality was made. Expected emission of gases etc. was measured in relation to the theoretical values. The building activities close to the prototype office frustrated the expected reduction in the air pollution in relation to time. Measurements were made both in the prototype office and in the surrounding areas. Also dust and fibre content in air and on surfaces were measured, and the activities in the surroundings clearly influenced the results. The measurements of pollution were made during a simultaneous registration of the natural air change by means of tracer gas and decreasing concentration method. The air change measurements are decisive of a subsequent evaluation of the air pollution.

During recent years DTH has investigated the possibilities of assessing emission from building materials by means of a biological test method. Tests in the laboratory and on site give a somewhat doubtful result, and further development of the method is necessary. The method is based on the use of dishes with agar inoculated with bacteria (for instance bacillus cereus). A dish with bacteria is kept in contact with the surface of a material for a given period of time. The emission from the material affects the bacteria - during culture their growth is delayed in comparison with unexposed bacteria. Distinct dosage/response dependence has been demonstrated for formaldehyde. A combined effect from the action of more agents can be seen. At present the development work has been stopped because of lack of funds. The methods should be further developed by using other bacteria or genetic engineering.

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THE EVALUATION OF THE INDO

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Case 2

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PART RESULTS FROM THE MEASUREMENTS IN THE PROTOTYPE OFFICE

temp. 20 - 28°C RH: 30 - 55 %	just perform. mg/m^3	ready f. occup. mg/m^3
dust	0.34	0.03
formaldehyde	0.20	0.04
ammonia	0.70	< 0.07
white spirit	1.80	< 0.07
toluen	1.40	< 0.07
1,1,1-trichlorethan	< 0.05	< 0.07
MMMF	1000 - 1500 f/m^3	500 - 800 f/m^3

THE EVALUATION OF THE INDOOR CLIMATE BY THE USERS

Baltica is very satisfied with the indoor climate in the new headquarters. So far no complaints of the indoor climate have been made. A survey with questionnaires showed great satisfaction with the office environment among the users. DTI insisted that the users received a "user's information" specifying what should be done to preserve the good indoor climate as well as the restriction on use of the offices.

The cleaning has become visible, almost objective, and it is very easy because of the surface treatment. It is easy to see the dirt, and only ordinary detergents are used. The material producers have had input to development of new products and ideas of future requirements from architects and builders.

Case 2

The case of the Danish National Museum is similar to case 1. It was contemplated to use wall paper, but the content of acid in normal wall paper was disadvantageous tocertain exhibits. Special paper (Monarch Bankpost White) was examined but had to be rejected on account of the different character of the underlying layers. Bone glue and distemper are extensively used. In much frequented areas polyvinylacetate is added to the distemper. Freshly plastered walls are whitewashed in the traditional way. Ceilings are treated with a decoction of Iceland moss or distemepr. Less frequented wooden floors are treated with pipecaly and soap. Frequented areas are treated with oil. Windows are oilpainted at the factory, if possible. Walls in none-sensitive areas are surface treated with a newly developed acrylic-plastic paint. New building materials allowed are only tile, wood and gypsum plates. The store houses are cinstructed according to the system of Chinese boxes. Ventilation air is supplied to an inner zone, and the exhaust takes place in the marginal zone with unstable temperature and humidity. The air is conditioned.

A novelty was the introduction of a quality control system including control on receipt and of processes on site. The construction and renovation are now progressing, and the results of the attemts to improve the indoor climate have not yet been recorded.

CONCLUSION

The indoor climate can be secured in a satisfactory way in new buildings, or when renovationg existing buildings.

Among architects and engineers it is necessary to spread the knowledge of constraints on existing indoor climates, and to inform about the possibilities of finding remedies as well as preventive measures in order to avoid similar problems.

A thorough knowledge of manufacturing and processing building materials, and the building physique, which dictates emission from the materials and the release of dust and fibres, combined with common sense and creative thinking at the planning leves could lead to greatly improved indoor climates in our buildings.

Thorough consideration must be given to future operation and maintenance conditions in forder to preserve the planned indoor climate.

It is esential to change radically building practice and manufacturing processes in relation to the traditional approach. We are increasingly moving towards a building production which is based on manufactured components.

One should to a larger extent rely on individual assessments of indoor climates rather than costly measurings of the indoor climate in the buildings.

A promising biological testing method to assess the emission from building materials has been developed. The method is based on restraint on growth of bacteria after exposure of emission from the material. The method requires further developing. There is a lack of research results from corresponding tests from other institutions.

REFERENCES

None

DESIGN, CONSTRUCTION AN
OF A LOW-POLLUTIO

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A home was designed and built prin
tive family. Building materials were
and gaseous pollutants. Constructior
sulation materials as well as radon.
flux of fresh outside air and removal
qualitative effects on the health of
achieved.

INTRODUCTION

In recent years, it has become evide
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comes acute when ill health has alre
bated by indoor air pollutants.

In 1984, a house was designed and
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places were immediate and pronou
chemicals such as ammonia in hous
and pesticide sprays precipitated sev
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