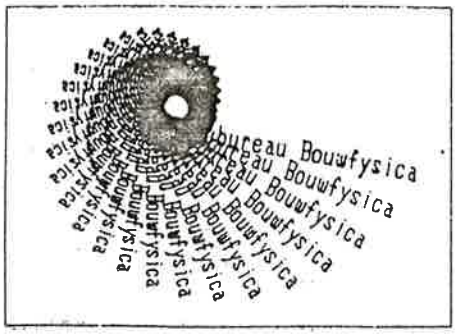

Contribution to the IEA workshop
"Condensation and energy problems: a search for an international strategy"
Leuven, 23-25 september 1985

DRAFT PROPOSAL:

RESEARCH PROJECT "MOISTURE DISTRIBUTION IN BUILDINGS"

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0. Summary

This paper describes the results of a pre-investigation, which is carried out by the tradegroup FAGO of the Technological University of Eindhoven (Holland) in cooperation with the Constructional Physics Division of the Government Buildings Department.
This investigation concerns a stock-taking in order to cataloque the remaining problem-area's with regard to moisture problems. From this, the tradegroup FAGO and the Constructional Physics Division formulated the next research-plan:

A detailed calculation of the dynamic behaviour of the indoor-air humidity with the same degree of accuracy as that for heat transfer processes is not available.
In the present-day air-flow simulation models for buildings, moisture transfer and diffusion in and between rooms are not taken into account.
Aim of the research project is the development of an integral hygro-thermal model in which the above mentioned aspects are incorparated.
After validating the model by means of comparising calculation results and measurements, a simplified version applicable to micro-computers will be developed.
Use of such a model might improve insight in the present-day moisture problems in our buildings as well as improve diagnoses.
The extensive model will be used to determine new values for characteristic conditions for in- and outdoor climate in different situations.
Besides, the extensive model will be available for use in specific research projects.

2.2 Social demand in Holland

From the preceding described stock-taking becomes evident there is a rather high demand in society for useful aids for judging moisture problems in the constructional practise.
The present-day tendacy is the causes for moisture-problems are due to mismanagement (by tenants or user's behaviour) of improved air tightness. Insight concerning the hygric indoor-climate is wanted nevertheless and therefore the influence of several factors on the moisture-regime cannot be determined. This also means that no solution can be given concerning liability in juridical problems.
From the correspondence appears that the umbrella organizations for Building-societies in Holland, the NCIV (Instituut voor Volkshuisvesting) and the NWR (Nationale Woningraad) are frequently confrontated with these problems.

Both organizations support the formulated investigation lay-out, with the emphasis on the importance of development of practical useable aids.
The NCIV-activities are focused on the drawing up of an inventory and on combining all the present-day knowledge as well as practical experiences with as objective to achieve a practical guide for evaluating moisture problems.
However, scientific research is considered necessary, with air-flow in buildings as important aspect.
The NWR remarks that a rather high demand exists for information concerning effects of several measures for fighting moisture problems. In relation to this the importance is underlined of simple calculation-models to analyse hygro-thermal processes in houses.
Especialy the influence of the crawl space must be expressed in the future models.
The NWR does not carry out technical-scientific research concerning moisture issue by itself. Their activities are limited to classing experiences of moisture problems in houses.

Due to the still increasing energyprices, energy-saving remains necessary. A possible causal connection with moisture problems is however often an argument that exercises a restraining influence.
On the application of measures concerning energy-saving, the dutch Gasunie NV remarks that a high need for study of this exists and that this should be an important aspect in scientific research with regard to moisture issue.

Research for achieving an improved insight in the complete moisture regime of buildings resulting in simple useful aids and guide-lines for fighting moisture problems is an urgent case, considered the size of the moisture issue in Holland.
This appears so due to a stock-taking made by Bouwcentrum Rotterdam containing moisture complaints in rented houses. An average of twenty percent of these rented houses are seriously damaged, caused by moisture.

1. Preface

Damage in buildings as a result of moisture problems and the often occurance of mould is a current problem of considerable size in Holland as well as abroad.
The number of moisture problems has not increased, although the impression exists that they have become more and more serious.
Besides that, moisture problems often go together with complaints concerning health, especially those concerning the respiratory organs.
As a results of this, the tradegroup FAGO ("Physical Aspects of the Building Environment") of the Technological University of Eindhoven in cooperation with the Constructional Physics Division of the Department of Government Buildings have started a pre-investigation in january of this year. They have 2 objectives:

a: a description of the complete investigation-field with regard to moisture problems, with an outline of the present-day knowledge and a cataloque of the remaining problem-area's.
From this, the tradegroup FAGO and the Constructional Physics Division formulate their investigationplan.

b: the formulation of a frame, in which the moisture-investigation of the remaining problem-area's might be coordinated, nationally as well as possibly internationally.
As a result of this we persue that the investigation, which is formulated on the basis of a pre-study, is carried out in close cooperation with other research-institutes.

In the following parts, the results of the pre-investigation so far are described.

2. Pre-investigation of the tradegroup FAGO and the Constructional Physics Department

2.1 Procedure

On behalf of the in the preface described pre-investigation, a start was made with a rough literature-study and several official bodies in Holland as well as abroad were contacted. In the appendix you will find the contents of the letter in question.
The joint activities of the tradegroup FAGO and the Constructional Physics Division are explained in this letter, as well as a general description of the problem-area. This description has not the illusion of being complete, but has as objective to achieve an overall picture of the present-day investigations and those yet to come as also an overall picture of the still remaining and of importance considered investigation area's.
The mailing-list is also added in the appendix.
The list includes several members of the international CIB-W40 commitee ("Heat and moisture transfer").
At the same time, there is an exchange of ideas with sevaral persons who are concerned in the moisture research. A survey of these personal contacts, most of all occur in Holland, can also be found in the appendix.

The pre-investigation described above is still progressing and will most likely be completed by the end of 1985. In the following technical moisture investigation, the several contacts will be further worked out.

2.3 Conclusion

From the stock-taking and literature-study, which are to be carried out by the Constructional Physics Department in cooperation with the trade-group FAGO, can as yet the following conclusions be drawn:

a. It appears that the scientific research in Holland with regard to the moisture transfer in buildings and building constructions has almost come to an end. The small amount of research that at this moment is being carried out, has an inventorial character, focused on classing moisture complaints and concerning practical experiments. The tradegroup FAGO in cooperation with the Constructional Physics Division want to re-stimulate the scientific research in Holland with regard to the moisture issue.

b. In the past were investigations with regard to the moisture issue one-sidedly focused on the hygro-thermal behaviour of building materials and building constructions. The attention was namely drawn to the possible harmful consequences of interstitial condensation as well as the way its occurence could be prevented.
The best known calculation method still is Glaser's. An improved mathematic description of the combined heat- and moisture transfer in cappilary-porous bodies is given by D.A. de Vries (Vri58), O. Krischer (Kri63) and, A.V. Luikov (Lui73) Connected to this, K. Kießl (Kie83) has developed a uni-dimensional calculation model with an improved definition of the material properties, so that the several transfer-mechanisms can be decribed.
From the correspondence is concluded that comparable activities take place with several institutes abroad.
- At the moment, the "Hochschule für Architektur und Bauwesen" in Weimar (DDR) is working on an improved uni-dimensional description of the heat- and moisture transfer in building constructions.
- In imitation of Kießl's work, a more-dimensional model is being developed by the studygroup Bouwfysica of the Catholic University of Leuven (Belgium). Besides this, the "Bundesanstalt für Materialprüfung" (BAM) in Berlin will at short notice start with the development of a numerical calculationprocedure for more-dimensional moisture transfer in construction elements.

In general, they state that further model development is interesting from scientific point of view, but its social relevance is exaggerated (L.E. Nevander). Solutions to the topical moisture problems will not be obtained (H. Künzel, J. Gronau).
K. Gertis doubts the necessity for extension to more dimensions, since in contrast to heat-technical calculations a uni-dimensional desription of the moisture transfer (Kießl) appears to fullfil the conditions practically well.
In several experiments, a more-dimensional moisture gradient has not determined, which differs clearly from the usual occuring disturbance as a result of impurity of the material. Besides, a more dimensional description will remain problematical, because the material qualities are difficult to determine (G. Hauser, J. Gronau).

In genaral can be stated that, since the character of the present-day moisture problems, scientific research should not be focused on interstitial condensation, but study with regard to surface condensation should have priority.

c. The development of uniform calculation methods to improve determination of materialproperties is stated as an important research area (J.P. Cornish, K. Gertis, C. Langlais, J. Gronau). At the moment, Isover Saint-Gobain (France), in cooperation with researchers from Toulouse, and the University of Strathclyde by order of the Building Research Establishment (UK) are both carrying out activities concerning this.
Due to an improved description and determination of the material characteristics, the applicabilaty of calculation models will increase.
One should pursue to normalize the calculation methods, if possible with countries abroad.

d. Causes mentioned for present-day moisture problems in houses are: inexpert application of thermal insulation and decreased ventilation-rate in combination with lowered airtemperature.
Research focused on determination of causes is not found necessary. However there is a need for complete description of the indoor-climate, in which the coherence of these factors is expressed and so that the dynamic behaviour of the indoor-humidity can be studied. (K. Gertis, J. Gronau).
In two papers, the 1 st by T. Kusuda (Kus83) and the 2 nd by G.N. Wallon (Wal84) the conclusion is drawn that research with regard to indoor-humidity calculations is limited to one-chamber models.
Recently Cauberg-Huygen Maastricht (Holland) has carried out a study concerning this (Ada84).
At the moment, G.Hauser of the "Gesamthochschule Kassel" (BRD) is developing a mathematical program, in which the indoor humidity can be calculated under sumplified limiting conditions.
It is not certain wether the model is a more-chamber model or not; this cannot be determined from the correspondence.

Specific points for attention in the development of such models are:
- determination of heat-and moisture transfer coëfficients, namly in corners (G. Hauser).
- calculation of the air-infiltration-rate (G. Hauser)
- moisture transfer by streaming air (H. Hens, L. Nevander, K. Gertis)

Although several air-flow models are available (developed from energetic point of view), there still is no simultaneous description of interroom air- and moisturetransfer known.
Seeing that most likely in the near future the demands concerning airpermeability of the building-envelope are becoming stricter, so will also increase the need for possibilities to predict the moisture and contaminant distribution throughout a building.
A first step in developing calculation technics as described above is to improve the description of air flow in as well as between rooms.
Research concerning all this is being carried out by the National Bureau of Standards, Center for Building Technology in Washington. Recent research results were published by G.N. Walton (Wal84). They state there that it might be possible to carry out simultaneous a study concerning moisture transfer due to air-flow.

e. Fighting present day moisture problems will have to be done for a great deal by instructing the tenants or occupants (handing them a guide of some kind). The emphasis should be put on the development of occupant-aids.

3. Research project: "Moisture distribution in buildings a model for computer simulation"

3.1 Defining the problem

Temperature of indoor-air and wallsurfaces, both varying in time, can be calculated rather accurate by means of present-day computer-simulation models, which are developed to calculate the dynamic energy balance in buildings.
The basis of these models is formed by a detailed description of heat transfer equations for radiation, convection and conduction.
A detailed indoor-humidity calculation is not available with the same degree of sophistication.
Predicting the humidity of the indoor-air however, is very important.
This is demonstrated by the following propositions.

a. The occurrence of condensation on the innersurface of building structures should be minimized. Condensation is often a major cause of material deterioration.
Besides this, knowledge of variation in indoor-air humidity is desired to study the internal moisture regime of building structures (particularly with regard to interstitial condensation).

b. The durability of building materials, wall finishing and furniture is also influenced by air humidity.
High relative humidity may cause mould growth in boundary layers; a low humidity level may cause cracking and flaking.

c. Levels of some indoor contaminants are influenced by the humidity level, e.g. formaldehyde.

d. Thermal comfort of occupancy is influenced by extremely high or low relative humidity.

e. Low relative humidity may cause problems with static electricity.

At the moment indoor-air-humidity is often determined based on stationary mass-balances or quasi-stationary room-models in which absorption and desorption processes of moisture by wall surfaces, furniture etc. are ignored.
Besides, interroom moisture-transfer is not or not correctly taken into account.
The present calculation-models, which deal with air-flow in buildings are developed from the energetic point of view; in these convection-models the physical laws, applicable to moisture transfer, are not taken into account.
For lacking of insight in the interaction of heat- and moistureprocesses and the influence of damp-diffusion in relation to the presence of local damp-sources, giving an accurate prediction of the dynamic behaviour of the indoor-air humidity is not posible.
As a consequence some moisture-problems might be wrongly diagnosed.

3.2 Aim of the project

- The development of a hygro-thermal building-model to improve better insight in the moisture-regime and with which the local variation of indoor-air humidity in different rooms can be predicted rather accuratly.
  The indoor-air humidity is one of the boundary conditions needed in calculations of heat- and moisture-transfer in constructions or at wallsurfaces, calculations that can be made rather accurately with the existing calculation methods as long as the boundary conditions used are as accurately to.

- Investigation of the influence, of different parameters suchas: damp-production, damp-absorption and desorption, ventilation and infiltration on the humidity of indoor-air.

- Obtaining clearness in the role of the crawl-space in the moisture-regime of the entire building.

- Obtaining insight in the potential relation between energy-conservation and moisture-problems.
  Obtimizing the energy-use of a building without obtaining moisture problems.

- Contribute to the development of simple methods to diagnose moisture problems, taking into account the dynamic character of the indoor climate.

3.3 Plan of work

Stage 1: Model-strategy

Based on a literature-study and contacts with (foreign) institutes dealing with research on moisture problems, a model-strategy will be developed.
Literature-sources and (foreign) contacts will be selected from the stock-taking which is described before. Besides, existing packages for systemsimulation will be investigated.
Model calculations might improve insight into the behaviour of the hygro-thermal indoor-climate.
The boundary-conditions are set by building-characteristics (such as air-permeability of the building-envelope), as well as occupants-behaviour, damp-production, moisture-acumulation and damp-removal (exhaust-air etc.).
For validation of the calculation-model practical experiments will have to be done. Therefore, synchronous, a measurement-strategy will be developed.

Stage 2: Mathematical model

In the second stage, a mathematical model will be developed that gives an integral description of the dynamic heat- and moisture-balance of buildings.
An existing thermal calculation model, based on the finite element principles, will be used as a starting point.

Next, in coörperation with Technisch Physische Dienst TNO-TH, Delft (Holland), a measurement-procedure to study interroom air- and moisture-transport will be developed.
Measurements will be executed in buildings of the Dutch Government Buildings Department. Besides, existing experimental results concerning the moisture balance of crail-spaces, (available at Technisch Physische Dienst) will also be used.
Comparison of experimental data on indoor-humidity with model calculations might indicate the accuracy of prediction of indoor-air humidity.

Stage 3: Use of the model

With the aid of the developed calculation-model the influence of the different parameters in the moisture-balance will be investigated. Due to social demand, the influence of damp crawl spaces on indoor humidity and the presumed relation between energy-saving and moisture problems, will be studied.

To increase the usefulness of the model an attempt will be made to develop a simplified version, applicable to micro-computers.
The extensive calculation-model will remain applicable as a tool in specific research projects in which an accurate prediction indoor-air humidity is desired (for instance predicting formaldehydeemission from building materials).

Finally, new values for characteristic in- and outdoor climate conditions in different situations will be determined. This will be done by calculations with the extensive model and data obtained from practical experiment several research-institutes will based on.
An improved definition carried out by of the boundary conditions, taking into account dynamical effects, gives a more reliable basis for determining the hygro-thermal behaviour of building constructions.
In this way the practical itility of existing calculation methods can be increased.

Appendix

Includes:

- Letter of the Constructional Physics Department dated 11th of april 1985
- Mailing-list
- Survey of personal contacts

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Zie verzendlijst

Uw kenmerk	Uw brief van	Ons kenmerk	Toestel	Datum
		13 51939	542	11 APR. 1985

Onderwerp

Dear Sir,

Damage to buildings as a result of moisture problems and in some cases therefore causing mould formation, appears frequently these last few years. In spite of a great ammount of research in this matter, a clear insight into the causes of moisture problems is still lacking. Universal and useful aids or calculation techniques for preventing and fighting against this particular damage are not yet available.
It appears that, due to stock-taking in the Netherlands as well as abroad, several bodies and companies are already occupied with research concerning problems caused by damp. These researches are all seperaretly adressed to certain aspects and are being carried out without any mutual coherence.
An investigation will be started at short notice by the department FAGO (Physical Aspects of the Building Environment) of the Technological University of Eindhoven in cooperation with the Constructional Physics Division of the Directorate of Government Buildings (Ministry of Housing, Physical Planning and Environment) with as ultimate objective: the contribution to the prevention of moisture problems by means of useful aids for construction.

The starting-point as well as definite formulation of the research-plan itself is still up for discussion. As many experts from as many different bodies and companies as possible will be involved in the planning of the investigation, intending to achieve an overall picture of the available knowledge and of all other investigations. Our investigation will only deal with the remaining problem area`s.

12

Ons kenmerk
IB. 51939

Datum
11 APR. 1985

Vervolgblad nr

The Contructional Physics Division of the Directorate of Government Buildings has in consultation with prof. ir. J. Vorenkamp of the Technological University of Eindhoven formulated the folowing description of the research area:

a. via several different departments and companies which are confronted with moisture problems inside buildings, an overall picture containing the complaints and a classification of the most likely causes, will be attempted to be made up.

b. the present-day calculation technique, which in regard to humidity systems in walls frequently used, is based on a uni-dimensional stationary transfer-equation (Glaser) and is in fact only intended for walls in freezingchambers.
Improvement has taken place due to studies made by de Vries, van der Kooi, Hens and recently Kiessl. Although these studies describe the simultaneous occurance and mutual influence of the dynamic heat and moisture-transfer in constructions, they restrict themselves to a uni-dimensional view. Due to contacts with prof. ir. H. Hens of the Catholic University of Leuven (Belgium), studygroup "Bouwfysica", we are convinced that for an improved insight in the present-day moisture problems a two- or possibly three-dimensional mathematical model is required.

c. The properties of materials as well as anisotropy should be described more detailed (especially concerning various forms of moisture-transfer) and researched more properly. Methods of measurements should be written down unequivocally.

d. The marginal conditions mentioned in the mathematical model must be examined seperately. The total system of heat en and moisture in the building has changed as a result of both, the increased insolation and improved draft exclusion as well as a possible result of an alteration in occupant's behaviour. Special attention could be paid to the air current in buildings from the moisture-transfer's point of view.

e. The ultimate research results must lead to an unequivocal and uniform calculation- and evaluation techniques concerning the essential non-stationary moisture-balance of constructions. These methods must at all times be simple and practical and could also be used as means of aid for planning.

Ons kenmerk
13. 51939

Datum 11 APR. 1985

Vervolgblad nr

The range of research described above is still up for discussion and does not intend to give a complete summary of the total problem area. It is well known that several problem aspects are already being investigated.
In case you will or are already dealing with certain activities in this area, we would be most grateful to learn that from you. It is also possible that in your opinion several, not yet mentioned, problem aspects should have special attention.
The seperate aspects, which are of importance to the Ministry of Housing, Physical Planning and Environment and the Technological University of Eindhoven, will eventually be formulated out of the range of research described above.
It is niether ruled out that other bodies will participate in the total survey.
We are looking forward to your reply concerning the above and hope te hear from you soon. (if possible before the first of june)

Yours faithfully

ir. O.C.G. Adan ir. A.C. van der Linden

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