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Memorandum on Building Physics

De la physique du bâtiment

Memorandum über Bauphysik

elaborated by IABSE Working Commission "Building Physics"

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SUMMARY

The construction activities all over the world are and will be influenced by the requirements of building physics. An IABSE working commission "Building Physics" has been set up which has elaborated this memorandum.

RÉSUMÉ

Les activités de la construction, dans le monde entier, sont et seront influencées par les exigences de la physique du bâtiment. Une commission de travail, créée au sein de l'AIPC, a élaboré ce rapport.

ZUSAMMENFASSUNG

Das Baugeschehen wird derzeit und künftig in aller Welt von bauphysikalischen Erfordernissen geprägt. Innerhalb der IVBH ist deshalb eine Arbeitskommission "Bauphysik" gegründet worden, die das vorliegende Memorandum ausgearbeitet hat.

1. INTRODUCTION

Building science and building technology have rapidly developed in the last decade. Problems or even damage due to condensation, high costs of energy for heating and cooling or poor sound insulation have arisen due to neglect of a proper appreciation of building physics.

The highly developed state of the art which has been reached in some areas of building science has clearly not been reached in those properties of building which are influenced by the rules of building physics. It is even more remarkable especially as the state of the art of building physics has developed at the same time. Building physics has not been introduced into building practice (design and execution) adequately. Any neglect of the principles of building physics has financial implications both for the private client as well as at national level. Subjects such as thermal insulation, sound insulation and fire protection all influence the value of buildings to a great extent and the first of these plays a very significant role in reducing energy consumption (for example in middle and northern Europe energy consumption for space heating is about 30 to 50 % of the total energy demand). Building physics is the foundation for the energy conservation measures in buildings and community systems, prevention of building damage and evaluation of durability of materials and building elements. The traditional way of considering the different building trade disciplines separately must cease. This memorandum's intent is to motivate a better integration of building physics into education and construction practice.

2. DISCIPLINES OF BUILDING PHYSICS

Building physics includes the phenomena of heat (energy), moisture and humidity, air, acoustics, fire and daylight which may occur in the interior of rooms, in building and structural components and in the environment (physics in urban environment):

Heat:	-Calculation, planning and execution of necessary heat protection measures in buildings.
	-Possibilities of energy conservation and application of "alternative energies".
Moisture and humidity:	-Problems of weatherproofing and humidity protection against all forms of moisture from outside, inside, below and within the building envelope.
Air:	-Problems of air infiltration and air transport in the building envelope with respect to energy loss and indoor climate.
	-Problems of achieving high natural ventilation rates in warm-humid countries.
Acoustics:	-Planning and execution of noise and vibration control from outside, between and within the buildings.
	-Problems of room acoustics.
Fire:	-Transposition of existing laws and regulations for the protection of life, health and property into planning and construction.

Daylight: -Planning of natural illumination, insolation and natural colours in buildings.

Urban environment physics: -Problems of environmental changes due to buildings and constructions.

This list shows that all professions within the building trade have to deal with building physics problems and therefore need knowledge of the subject. This will help ensure:

-Durable structures free from defects, satisfying the demands of comfort and health.

-The use of potential energy saving measures including consideration of "alternative" energy sources and environmental protection.

-Economic use of new products and methods of construction without risks of defects and minimized running costs, even when the energy price climbs up further.

-Utilization of the results of research in practice.

3. EDUCATION

Until now building physics has not been recognized with the necessary degree of importance at universities in general and in building science and architecture especially. This may result from the fact that building physics is situated at the border between physics and building; it is the use of physical rules in building. Consequently, it has not been found important enough for physics and also not for building and architecture. Irrespective of this, the subject of building physics has developed and its importance has grown so that it may be seen to be a discipline in its own right.

A real improvement in the necessary use of building physics in building practice can only be reached if this discipline is taught adequately both to undergraduate students in architecture and civil engineering and to their post-graduate counterparts who are practising architects or engineers. Undergraduate education in building physics is particularly important, post-graduate education in building physics is also important due to the continual change in building systems and building materials and also the change in requirements (e.g. higher thermal insulation since the energy crisis), which use physical solutions. Building physics must be integrated into the education of students of architecture and civil engineering at technical universities and similar institutions, and post-graduate courses in building physics should be offered by these institutions *). Furthermore, building physics should also be taught to students in physics who should be aware that physical problems exist in buildings and that physical rules may be used to obtain their solutions.

The problems related to building physics are so numerous and difficult in modern building that it is often necessary to consult an expert. It would therefore appear necessary to introduce the possibility for students to specialize in building physics with more detailed education in this field and perhaps with a spe-

*) The contents of a post-graduate course in architectural science at the University of Sydney may be mentioned as an already existing example, which contains several courses on topics of building physics. Most architectural departments at Japanese universities offer courses in building physics and also at Chinese universities.

cial diploma (or post-graduate diploma) after satisfactory completion of the course. The diploma also appears necessary to protect the title of 'expert in building physics' which would then only be used by holders of the diploma.

The aim of the education of architects and civil engineers in building physics should be to enable them to use the rules of building physics in planning and design in general and recognize those special problems which are difficult or important. The question whether a teacher for building physics is included within the department for architecture or for civil engineering (or even for physics) either separately or to serve the different disciplines is of minor importance and can only be solved in relation to the existing university structure which varies from country to country and from university to university. It is, however, important that the different problems of building physics are taught by one lecturer in one discipline, otherwise the students may not recognize the interaction between the various fields (e.g. if thermal insulation and water vapour transmission are dealt with in one lecture and sound insulation in another, the student may not hear both lectures or may fail to recognize that water vapour problems exist in sound insulation layers).

The topics which should be taught are listed below:

Education in building physics for architects and civil engineers should include:

<u>Outdoor and indoor climate</u>

Indoor temperature
humidity
air velocity
air quality
comfort criteria
radiation and light diffusion
visually physiological fundamentals
daylight and lighting
advantages and disadvantages of daylight lighting

Outdoor temperature
solar radiation
sol-air-temperature
long-wave radiation
wind and wind pressure
rain and snow
humidity and moisture, precipitation

<u>Thermal insulation and energy conservation design</u>

With respect to:
- comfort of the inhabitants
- the construction
- energy consumption (economic aspects)

Principles of steady-state heat transfer

Two- and three-dimensional heat transfer (thermal bridges)

Heat balances

Energy conservation

Non-steady state thermal insulation performance (heat storage capacity of the structure and the fabric of the building)

Thermal characteristics of materials and building elements

Additional insulation

Solar energy use by design (active solar energy, passive solar energy)

Thermal load of building components

Thermal insulation in different climates

National requirements for thermal insulation and their fulfillment

Moisture

Moisture content in air and in materials, moisture sorption

Principles of moisture transfer, vapour flow, water flow, moisture convection, theory and calculations

Moisture characteristics of materials and building elements

Moisture balances in building elements, condensation

Critical moisture content, criteria for moisture damage

Structural measures in accordance with moisture transmission

Sealing of structures against ground water and moisture

Effects of driving rain, ground water

Principles for moisture design

Air flow and ventilation

Principles of air flow in buildings

Air flow characteristics of materials and building elements

Air flow in building elements

Air flow in buildings, natural ventilation

Aerodynamics around buildings

Stack effects

Mechanical ventilation, heat recovery, etc.

Effects of air flow on thermal insulation

Minimum required air change rate (with respect to different climates and especially hot humid climates)

Ventilation of buildings by wind catchers (above roofs)

Acoustics and sound insulation

Principles of sound and sound propagation

Physiological acoustics

Outdoor sound propagation (environmental noise)

Sound propagation in rooms (room acoustics)

Airborne sound insulation

Impact sound insulation

Noise control for sanitary installations

Environmental noise control

National requirements for sound insulation and their fulfillment

Fire

Fire protection, principles, necessity and aims

Design and structures with respect to fire protection

Behaviour of building materials and building components in fires

Restoration of fire-damaged buildings

National requirements for structural fire protection and how they are achieved

Daylight

Sun and sky

Radiation and light diffusion

Visually physiological fundamentals

Daylight and lighting

Advantages and disadvantages of daylight lighting

Building physics in town planning

The role of building physics in town planning

Fundamentals of meteorology

Aerodynamics around buildings

Heat and moisture balance of built-up areas and areas not covered by buildings

Air pollution (emission of central heating plants, chimneys, etc.)

Noise control

4. BUILDING PHYSICS AND ITS APPLICATION

Building physics is of prime importance for all building related professions. The professions engaged, from initial planning to final construction, are:

The client:

Determines the room-layout and usage-program and the approximate cost limits.

The architect:

Designs, plans, chooses materials, decides upon consulting experts, oversees construction and settles the accounts.

The structural engineer:

Designs the building for static, dynamic, thermal and hygric stresses.

The quantity surveyor:

(Utilized at present primarily in the UK and Australia. In other countries these duties belong to the architect.) Measures the work and approves the account for payment by the client. Engages architects, structural engineers etc. on small contracts.

The management contractor:

On behalf of major contractors integrates designs into building practice. Appoints all contractors. Provides management and quality assurance teams.

The mechanical (or building) services engineer:

(In many countries separated into: Heating engineer, sanitary engineer, electrical equipment and illumination specialist.) Designs and plans heating-, ventilation-, air conditioning systems (HVAC-systems), water services, electrical systems and illumination.

The different contractors:

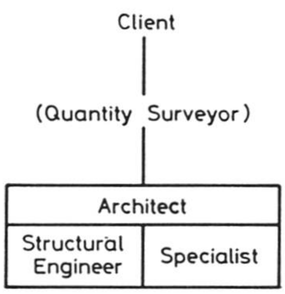
-Execute all the various craft jobs.
-Draw the detailed plans, choose materials.

It is well understood that the structure of responsibilities, liaison and team work of the engaged professions differ from one country to another country. For simple buildings the architect and the contractors often assume the responsibilities of the engineers and experts. For more complex buildings and HVAC-systems the different engineers and often experts are essential today.

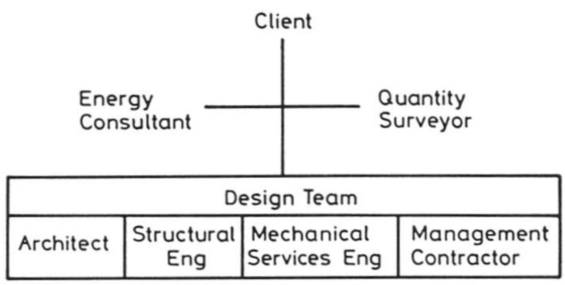
There are, however, significant differences between countries. In Japan, China and Korea, for example, the entire design of buildings is done by architects. Some of these architects are highly trained in civil or mechanical engineering and would be called consulting engineers in Europe and America. Also where hot-humid conditions are more important for the design of buildings than winter climates, when air conditioning is not used, or when in cold climates high passive solar gain can be achieved, the architectural decisions become more important and must be taken at the initial design stage.

The building physics problems touch all professions. Responsibilities must be clearly defined. This will also permit a clear structure of fees. There are certainly many different patterns for design and construction, depending on traditions, education, and size and complexity of the building. Where for simple buildings and constructions not necessarily requiring building physics analysis a pattern like (A) may be appropriate, for more complex constructions a pattern like (B) may become necessary, requiring sometimes additional experts to the disciplines in the design team.

A



B



5. CONCLUSIONS

Due to rapid development in building physics, its growing importance and higher demands, many architects, structural engineers and specialists are often overtaxed. Experts (e.g. building physicists) are then consulted. The goal - to be achieved by education - is certainly to enable the architects and engineers to solve the building physics problems within their team whenever possible and to appreciate when to seek expert advice.

Questions which can occur to the design team include:

- Who is responsible for the building physics problems; must a building physicist be consulted?
- Which criteria will govern the choice of the expert (building physicist; energy consultant)?
- How are the fees for solving building physics problems structured and paid?
- What are the building physicist's responsibilities and liabilities?

Each country's different traditions and building laws will have an influence. It is therefore not very useful here to classify problems and responsibilities in building physics together with the corresponding professions. But the motive is given here for the different countries not only to establish educational concepts for building physics but also to regulate the previously mentioned relationship, which is quite important in practice. This would also help in many controversies over building damage due to building physics deficiencies.