Zeitschrift: IABSE surveys = Revue AIPC = IVBH Berichte

Band: 6 (1982)

Heft: S-21: Building physics: trends and future tasks for civil engineers and architects

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DOI: https://doi.org/10.5169/seals-47052

Building Physics: Trends and Future Tasks for Civil Engineers and Architects

Physique du bâtiment: tendances et tâches futures des ingénieurs civils et des architectes

Bauphysik: Tendenzen und Aufgaben für Bauingenieure und Architekten

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SUMMARY

Because of the urgent problems of energy saving, noise abatement and environment protection, the knowledge of building physics is getting more and more important for the profession of civil engineers and architects. For this reason, a IABSE Working Commission "Building Physics" has been set up. The present paper gives explanations of trends and future tasks in building physics, without claiming completeness.

RÉSUMÉ

Les problèmes urgents de l'économie d'énergie, la lutte contre le bruit et la protection de l'environnement, nécessitent de meilleures connaissances de la physique du bâtiment dans les professions des ingénieurs civils et des architectes. Pour cette raison, une commission de travail AIPC "physique du bâtiment" a été mise sur pied. Le présent rapport, sans prétendre à être complet, explique les tendances et tâches futures dans la physique du bâtiment.

ZUSAMMENFASSUNG

Wegen der dringenden Probleme der Energieeinsparung sowie des Lärm- und Umweltschutzes werden bauphysikalische Kenntnisse bei der Tätigkeit der Bauingenieure und Architekten immer bedeutsamer. Aus diesem Grund ist eine IVBH-Arbeitskommission "Bauphysik" gegründet worden. Der vorliegende Beitrag erläutert stichwortartig künftige Tendenzen und Aufgaben in der Bauphysik.

1. DELIMITATION OF THE FIELD OF BUILDING PHYSICS

In a fundamental way, the requirements of energy saving, noise abatement and environment protection are setting the tone of present and future building activities. At an early stage, building physics has started to take care of the problems of energy and environment; thus, building physics has developed into an important field capable of offering practical solutions for the problems of energy saving and environment protection. As per [1], the following definition of building physics has been formed according to the present state of this field of knowledge (see figure 1):

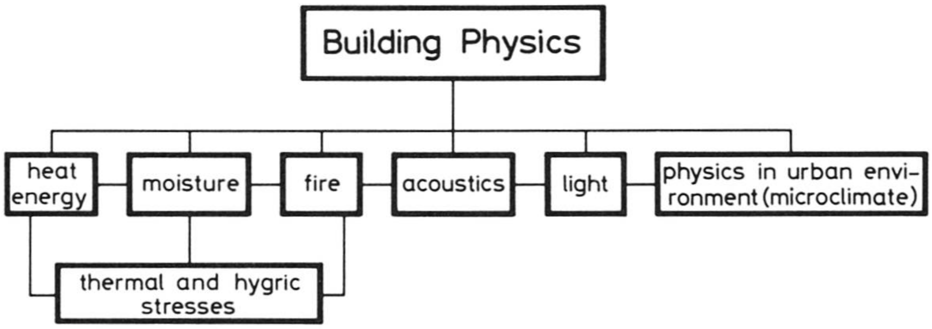

Fig. 1 Definition of the field of building physics. Schematical drawing of the various sections according to [1] [2].

Building physics includes the phenomena of heat (energy), moisture, air, acoustics, fire and daylight which may occur in the interior of rooms, in building and structure components and in the environment of buildings and structures (building physics in urban environment).

The importance of the different sections is clearly shown by the following short descriptions [2]:

Heat (energy)

Saving of energy becomes more and more necessary and is a problem which, in future, will be decisive in technical design of structures. It is a must for architects and civil engineers to have complete command of calculation, planning and execution of necessary thermal insulating measures in a building. In various countries, national thermal insulation decrees require respective detailed knowledge. Thermal insulation in connection with protection against moisture leads to comfortable and hygienic housing conditions.

Moisture

There are only few loads which have such intense effect on the function of a building and at the same time are a danger to it and its material durability like moisture. Architects and engineers must have complete command of questions of moisture sealing and problems of protection against moisture of any kind up to detail design.

Air

Air infiltration, air ventilation and energy recovery from used air are becoming of predominant interest in the field of energy conservation as well as in considering the indoor climate and in avoiding damage by moisture condensation. Both energy loss and moisture problems can often be attributed to different kinds of air infiltration or convection.

Fire

As a consequence of fire, millions of real values get lost each year. For protection of life and health, property and real values, architects and engineers are required to have knowledge of valid laws and regulations as well as of respective translation into planning and construction.

Thermal and hygric loads

The sections of heat, moisture and fire are subdivided according to figure 1; an important subchapter describes thermal and hygric loads of building components, not meaning those loads of purely mechanical nature such as own weight or users' loads, respectively, but physical loads by temperature and moisture. These loads are the main causes of cracking. Most cases of damage in practice are due to this. It is necessary to have a new philosophy of building security covering also heat and moisture movements of structures [3].

Acoustics

In our highly mechanized society, noise increasingly becomes a scourge to mankind. Recent discussions about noise abatement decrees in various countries have shown this drastically. Many millions of people are wishing for a "quiet" dwelling. In towns, between buildings and traffic areas, noise abatement more and more becomes one of the most important measures for protection of the environment. Architects and engineers must be in a position to take account of acoustic insulation measures in their planning and to materialize such measures.

Daylight

Because of the necessity of saving energy in services and finishings and of abating noise from outdoors, window design, natural lighting and incoming solar radiation are of particular importance in the planning of buildings. Daylight and solar radiation are indispensible for the psychic and physical comfort of man.

Physics in urban environment

With urbanization becoming denser and denser, the matters "ante portas" are of increasing importance. We are no longer content with the changes in the environment destroyed by buildings. We are getting more and more concerned about deterioration of climate and noise propagation in the close environment of our buildings.

Former plans for structures were based on stability requirements from a too much one-sided point of view [3], neglecting effects due to temperature, moisture and chemical influences from the environment. Leonhardt [4] puts this into clear words: "For a long time, in my opinion, building physics has been at least as important as statics, perhaps even more important". In practice, it has turned out that especially large building enterprises come more and more to the conclusion that the "primacy of static calculations" should be abandoned by civil engineers in favour of the problems of building physics [5].

In various countries of the world, the above mentioned sections have been dealt with partially for quite some time with different priorities given. For instance, as far as training of architects is concerned, in predominantly warm climatic regions (e.g. in Australia) much importance has always been attached to the questions of summer sunshading and daylight supply [6]. In these warm climatic regions as well as in other countries, the disciplines "Architectural Science", "Building Science" and "Environmental Science" cover part of those fields which are, according to the definition given, sections of building physics. Internationally speaking, it can be stated that also in the past - this mainly applies to architects, less to civil engineers - sections of building physics have been tought although these fields were not called "building physics". However, the recent rather dramatic development of the necessity of energy saving and noise control as well as environment protection requires concentration and intensification of these efforts. This was also an important reason for setting up the IABSE Working Commission "Building Physics".

2. PRIORITY TENDENCIES IN BUILDING PHYSICS

Analyzing obvious events in the present construction scene, certain priority tendencies in building physics become apparent which - somewhat abstracted and formulated in an exaggerated way - present themselves as follows:

2.1 Tendency 1: "The operating costs of structures eat us up"

Due to the dramatic increase of energy prices within the last few years, the operating costs of buildings have enormously increased; the increase will continue. The operating costs of structures which become more and more important on account of the rising energy prices have been badly neglected. Financial discussions between building owners and planners were mainly about investment costs; the operating costs were not interesting.

Figure 2 shows the prices for the main energies oil, coal, gas and electric current in the past, presence and future. Whereas, for instance, the price for 1 litre of oil was DM 0.10 in the past, the price nowadays is about DM 0.70.

type of energy	energy price		
	past	present	future
neutral [DM/GJ]	4	20 - 40	50
coal [DM/kg]	0,08	0,4 (-0,8)	1
fuel oil [DM/l]	0,1	0,6 - 1	1,25
gas [DM/m^3]	0,07	0,4 - 0,7	0,9
electricity [DM/kWh]	0,013	0,08 - 0,14	0,16

Fig. 2 Energy prices for the different types of energy in the past, presence and future. The first line shows the energy prices in a neutral way modified according to [7].

Speaking in neutral terms of energy, this means that the heating price has increased from 4 to about 35 DM/GJ. Calculated on the basis of coal (about 400 DM/ton), the energy price is about 20 DM/GJ at present. In the case of electricity (DM 0.08/KWh night tariff and DM 0.14/KWh day tariff), the price to be paid is between 20 and 40 DM/GJ. Price increases have already been announced and partly already took place. In all probability, an energy price of about 50 DM/GJ - depending on the kind of energy, sooner or later - will be reached in the near future.

With energy prices rising more and more, the operating costs of buildings will increase accordingly, coming up to or exceeding the investment costs [8]. This is shown schematically in figure 3, illustrating the development of the ratio between investment and operating costs in the past, presence and future. The figure does not show the exact ratio but only a tendency. Whereas, in the past, no importance had to be attached to the operating costs being less than 10 to 20 % of the investment costs, the ratio is, at present, already about 0.5. In future, unless drastic control measures are taken, the operating costs will exceed the investment costs (ratio more than 1). The same importance must be attached in future to this "explosion of operating costs" as well as to the control of construction (investment) costs.

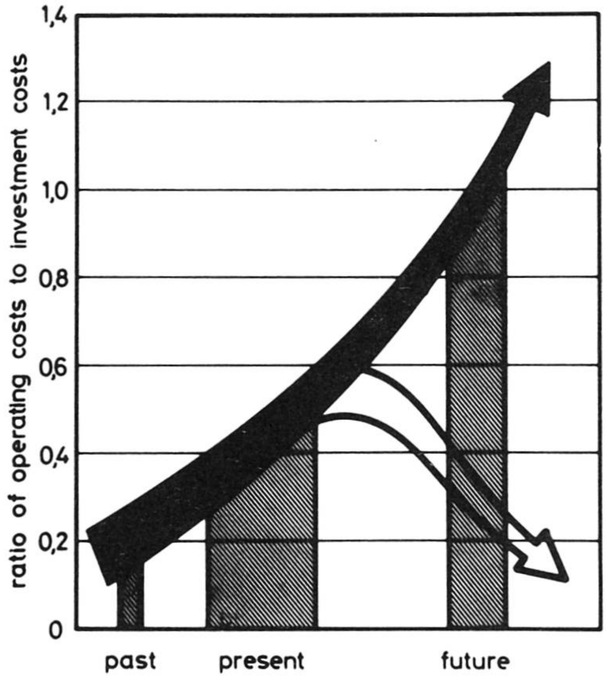

Fig. 3 Schematical drawing showing the ratio of operating costs to investment costs of buildings in the past, presence and future. By means of certain calculation methods [9] [10], future operating costs can be converted into presence and compared with investment costs.

In future, the (unfavourable) trend shown must be counteracted by all means. Aim: Future operating costs should be less then 20 % of the investment costs (ratio <0.2) - same as they were in the past, as per the white arrow.

It must, however, be checked whether this will result in a radical change of the optimization processes which are common practice in construction engineering. In future, single building elements (e.g. supporting structure) must not be "optimized" separately; it is rather necessary to have a useful optimization of whole buildings or structures oriented by the total costs [9] [10] [11]. In many countries, the decrease of operating costs due to measures in building physics with a view to saving energy is a decisive step towards the aim "away from oil". The structural measures to reduce operating costs must reasonably be coordinated with maintenance costs and modernization of structures [12].

2.2 Tendency 2: "People react more sensitively to noise from outside and inside"

The present and future noise situation has recently been described in a somewhat popular yet correct way by [13]. Unlike most other harmful environmental influences, people find noise to be very troublesome [14]. About every second inhabitant feels molested by noise. Figure 4 shows that most people feel molested by traffic noise; most complaints, however, refer - apart from traffic noises - to noise due to trade and industry in dwelling districts. This means that also the sound insulation in the interior of dwelling houses is still lower than wanted by many inhabitants [16]:

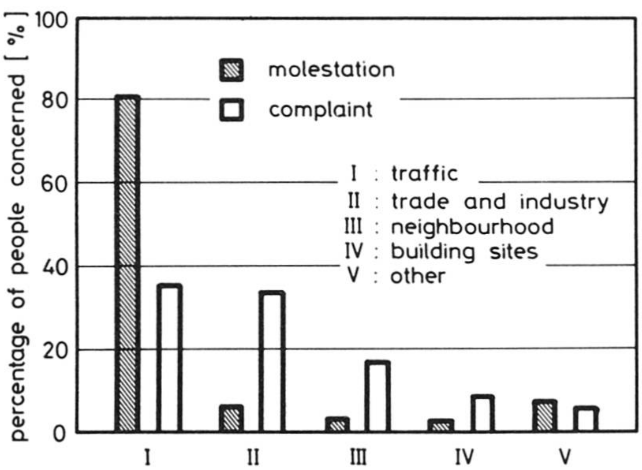

Fig. 4 Percentage of people molested by noise resp. complaining about it (as of 1976), according to [15, page 1031].

Two points of general social importance argue in favour of sound insulation:

- Families with children are often a "troublemaker" for other people on account of the noise which they produce. On the other hand, families with children are continuously under psychic pressure to "keep quiet", which is neither good for the children nor for the parents.

- An important argument in favour of one-family houses or one-family row houses is to become independent of neighbour noises and to be no longer restricted in one's own style of living (parties, noises of water services late in the evening and early in the morning) in order not to disturb neighbours. High sound insulation of multi-family houses would help very much to stop the trend "away from the multi-family house".

Improvements resulting from research and development in the field of building physics would help many millions of molested people.

2.3 Tendency 3: "The cases of construction damage increase alarmingly in number; in most cases it is cracking due to moisture, temperature and fire"

"Changes in construction technology; use of new and partly not tested materials; detrimental haste in reconstruction during the post-war period; construction boom of the sixties with partly not fully developed planning; strong pressure of time and financing on planning and construction; complexity of information; lack of feed-back between experience made with materials used and new plannings; insufficient training and development of knowledge; these are the reasons for a great number of cases of construction damage and for economical expenditure" [17]. Many technical and juristic authors have occupied themselves with the question of what is to be understood by construction damage (see the summary [18]). With regard to the construction of dwelling houses, detailed analyses of damage have been carried out [19]. The results achieved are supported by a Swiss poll held recently [20]. In the field of constructional civil engineering, statistical surveys of damage have meanwhile become known [21].

Figure 5 illustrates the frequency of causes of damage due to overstress and overstrain. It is to be seen that in the field of constructional civil engineering most cases of damage are caused by influences of building physics. In the first place, there are the cases of damage due to thermal and hygric loads as well as cracking because of movement impediment. Quite a lot of cases of damage are due to weather and environmental influences.

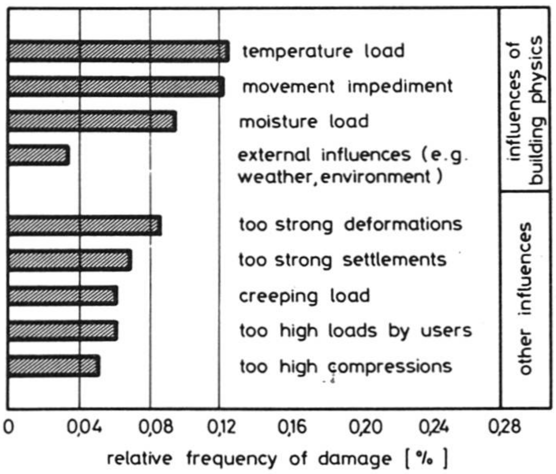

Fig. 5 Relative frequency of damage in constructional civil engineering, according to [21]. Cases of damage occurring with a frequency of less than 0.03 % have been omitted.

In dwelling houses and administration buildings cases of damage can be distinguished according to groups of building components. The importance of moisture damage and cracking due to thermal and hygric influences is underlined by systematical analyses of damage in house building [19]. As figure 6 shows, the most frequent cases of damage refer to walls, followed in the statistics by roofs, openings and cellars. Even installation systems rather often give rise to complaints.

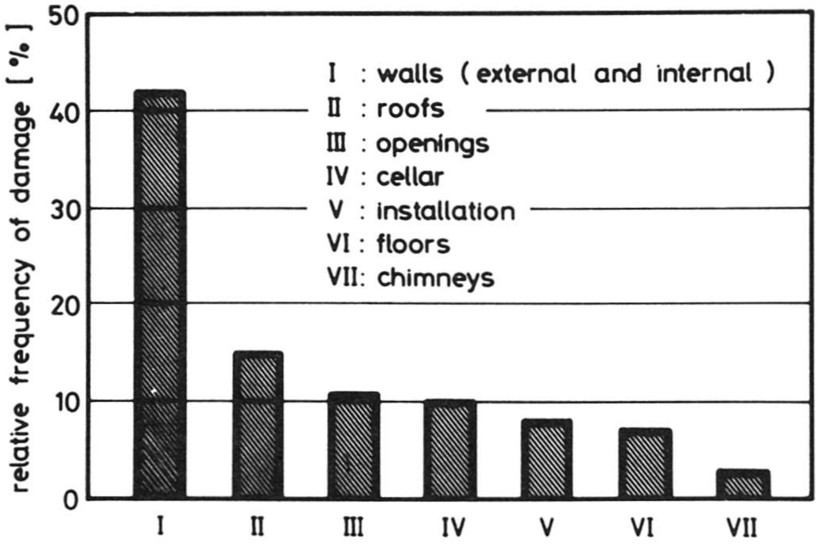

Fig. 6 Relative frequency of damage in dwelling houses differentiated by groups of building components, according to [22].

With a view to the frequency of damage in dependence on the age of a building, there are the connections shown schematically in figure 7 which - although only valid for buildings - can also be applied approximatively to structures of constructional civil engineering. It can be seen from figure 7 that at the time of

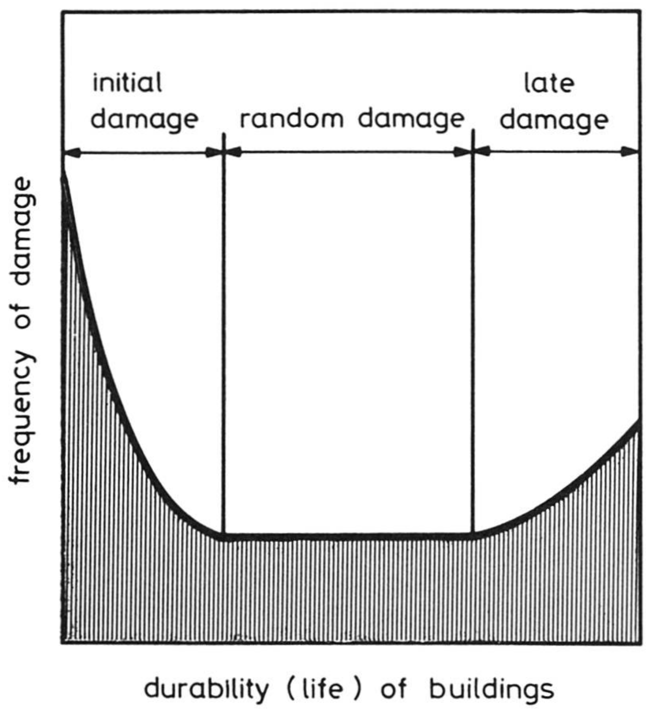

Fig. 7 Schematical drawing showing frequency of damage occurring in the course of the life of a building, according to [19] [23].

completion of a building there are many cases of damage (so-called "initial damage"), followed by a period of relatively small and almost constant numbers of cases of damage in middle-aged buildings, with rising curves of cases of damage in old buildings [23]. Initial damage covers all those defects which occur after exposure of the completed building for the first time to all loads (possibly in unfavourable combination); as a rule, there are the effects of temperature, moisture and settlement. Damage due to age, however, covers problems in connection with the age-resistance of building materials. It is, however, possible to largely avoid initial damage (and partly random damage) in many cases by means of building physics.

In spite of all efforts, the economic amount of damage cannot exactly be estimated at present. It is, however, certain that damage merely due to fire in the Federal Republic of Germany amounts to several milliards of DM per year. It is also quite certain that the sum of all other cases of construction damage exceeds the sum of the annual cases of damage due to fire.

3. FUTURE TASKS OF RESEARCH AND DEVELOPMENT IN BUILDING PHYSICS

The basic tendencies described and substantiated above will determine future tasks of research and development in building physics. Tasks of research and development should be given the more priority the more they are capable of counteracting the three mentioned (negative) tendencies. Thus, these tendencies supply the criteria of priority to be given to one task or the other. Priorities must be established in a way as to stop undesirable detrimental developments and to strongly force desirable developments. In order to efficiently counteract the three negative basic tendencies, the following three tasks in building physics should be started and solved:

1. In order to decrease the operating costs which have increased alarmingly on account of rising energy prices, the energy consumption of buildings should be reduced by all reasonable means of building physics and of technics (conclusion to be drawn from tendency 1).

2. In order to reduce noise pollution making suffer many millions of people, noise protection of housing areas and sound insulation of dwellings should be improved (conclusion to be drawn from tendency 2).

3. Construction damage, which in most cases is due to reasons of building physics and which is increasing alarmingly, should be reduced (conclusion to be drawn from tendency 3).

In this connection, the following proposals of solution are submitted, i.e. only basic tasks are shown, without giving details. Thus, these statements should not be regarded as far-reaching and complete suggestions to specialists but as catchwords for important general tendencies of research and development tasks in the field of building physics.

3.1 Decrease of the energy consumption of buildings

In order to decrease the energy consumption of buildings, considerable efforts have been made so far by the building industry and by manufacturers of insulating materials, by scientific researchers and by supporting resp. legislative authorities. However, this is not yet enough. Beyond the present starting situation, further measures must be taken.

First of all, building owners and building contractors must become clear of the fact that operating costs (often ignored) are as important as investment costs. This leads to the so-called "economically optimal thermal insulation" about which extensive investigations have been made. Thermal insulation of buildings must be improved remarkably. This requirement results in the following separate tasks:

Development of new, improved insulating materials

In connection with improved thermal insulation of external building components, at certain thicknesses of insulating materials there are problems which are more or less serious dependent on the insulating system. These problems can be solved satisfactorily only by the use of insulating materials with thermal conductivity below 0.03 W/mK.

Insulating materials with all-round properties

The development of multilayer building components has led to a "specialization" of the single layers, i.e. every layer has only one function - for instance, supporting, thermal insulation or moisture barrier. In order to save working processes, it is necessary to use multi-functional layers which have the same effect as the combination of single, special layers.

Insulating systems for large thicknesses

At present it is hardly possible to construct large thicknesses of insulating materials in practice, as far as external walls and roofs are concerned. Unless new insulating materials or insulating systems with the same insulating effect yet lower thicknesses of layers are available by mass production, the external walls and roofs must be capable of supporting insulating materials up to thicknesses of about 20 cm.

External wall systems

Rising energy prices force us to improve thermal insulation of external walls in existing houses. The expenses for this improvement strongly depend on wages; the material costs are negligible. Due to the development of less labour-intensive insulating systems, it would be possible to decrease the costs considerably, thus increasing the pay-back of such investments.

Do-it-yourself systems

In rented flats and especially in one-family houses, finishing work resp. insulating measures are often carried out by the inhabitants themselves in order to save money. As in most cases the inhabitants are no specialists being only more or less talented for craftman's work, simple and "foolproof" systems should be available.

Development of highly insulating windows

During winter days with little solar radiation, much energy is lost through windows and glazings as compared to the other facade area. It is, therefore, necessary to develop windows with high thermal insulation without causing increase of building expenses. The translucency of such windows should be guaranteed to be as high as possible in order to avoid decrease of daylight lighting and of energy gains due to solar radiation.

Thermally improved slatted roller blinds

As compared to the external wall, slatted roller blind housings are often a cause of increased heat losses due to transmission and infiltration. These losses of energy should be avoided by the development of other slatted roller blinds resp. other rolling systems or modified slatted roller blind housings.

Temporary thermal insulation

In case of favourable orientation of windows, heat gains would exceed heat losses even during the heating period if heat losses could be reduced strongly by covers or the like at night. Thus, windows - which do exist anyway - would become very appropriate solar collectors. It is, therefore, necessary to reduce heat losses during the night.

Heat storage systems

In Central Europe it is not necessary to have buildings heated during the whole year. In summer, there is an oversupply of energy. If this heat could be stored and utilized in winter, consumption of heating energy would decrease considerably. Besides such long-term heat storing capacity, it would also be possible to save heating energy by short-term heat storing capacity if there were high internal heat sources or if the heat stored could be used to reduce peak loads of heat.

Daily temperature variations in buildings resp. rooms - in particular in rooms with high short-term internal heat loads - can be reduced considerably by efficient heat storing systems. Thus, there are lower maximum indoor air temperatures in the daily cycle. A high heat-storing capacity of building components is still more efficient if the weather changes. The non-steady state thermal transient process is strongly influenced by the heat-storing capacity of building components. In case of high heat-storing capacity, there is a slower increase of indoor air temperatures than in case of low heat-storing capacity.

As heavyweight internal walls are more expensive than lightweight walls and as they are often made thermally ineffective by furniture, it is necessary to develop special highly effective heat-storing systems.

Primitive technologies for collector systems

The solar collectors used at present are relatively expensive and are by no means sufficient to heat buildings in Central Europe. Exportation of solar collectors to developing countries with higher solar radiation is only advisable if trained staff is available there for maintenance. Such equipments are inappropriate for use in large numbers. However, there is strong demand for the development of simple systems.

Systems for heat recovery from waste air

Heat losses due to ventilation result from the exchange of stale, warm air against fresh, cold air. If heat could be taken from the stale air and if this heat could be supplied to the fresh air, it would be possible to reduce heat losses due to ventilation. This requires ventilating equipments with mechanical or structural heat exchangers.

Structural recovering systems

During the heating period, there are heat losses due to transmission even in well insulated external walls and roofs so that heat is supplied to the environment and energy is lost. It would be desirable to utilize at least part of this energy by supplying it to the building.

3.2 Improvement of sound insulation

In order to improve sound insulation and to reduce noise effects on people at home and at work, considerable efforts have been made within the last few years. Noise pollution by streets, airports and industrial areas gave concrete reason for this. Quite a number of noise prediction methods have been developed helping town resp. traffic planners to decide on noise propagation to be expected. Planning measures, however, must be completed by effective noise control equipments. Further development of such equipments must be given priority although considerable activities have already been developed with good results in this sector in the more recent past.

However, the sound insulation of dwellings, in particular of multi-family houses, which has been improved considerably in the past, is still much lower - due to structural reasons - than wanted by many inhabitants. Regarding these future requirements, there is quite a number of tasks in the field of building physics falling within the scope of work of the constructional and civil engineer:

Improvement of shielding equipments accompanying thoroughfares

Investigations carried out so far about noise propagation in urban areas are very extensive. Structural shielding equipments are only one yet a very important measure to reduce noise. It is a fact that the thickness of an acoustic obstacle (e.g. shielding walls or ramparts) is not important but the height above the line of vision is decisive for the shielding effect. The material of the shielding equipment is also of secondary importance if the shield is dense and has a weight of at least 10 kg/m². A sound-absorbing lining on the surface turned towards the noise source is advantageous. Corresponding to these requirements, there is so far a wide range of practical solutions for noise shielding equipments, all being connected with more or less massive constructions of mineral building materials or steel, partly with plants. Starting from the fact that shielding equipments

- come up to the line of vision resp. obstruct the view, thus having relatively large dimensions

- must have an area weight of at least 10 kg/m², the material being of secondary importance,

lightweight area supporting elements should be developed in future, which are capable of accompanying and shielding relatively large areas of traffic facilities at proportionally low cost. In flanking investigations, sound reflection and sound transmission of membranes resp. membrane-covered nets and grids as well as the influence of curvatures, prestressing and surface structures would have to be examined.

Simple soundproof sluices

In general, noise-producing manufacturing processes take place in factories or plants at large distances from dwelling areas. New industrial zones are mostly separated from dwelling areas due to regional planning measures. However, there is quite a lot of small and middle-class enterprises which - partly by craftsmen's tradition and partly for infra-supply reasons - are situated in dwelling and office areas or nearby (e.g. service stations with car-wash). In such firms, there is noise of more than 80 dB which is extremely disturbing, especially in summer when windows of neighbouring dwellings or offices are opened for ventilation. As a rule, this noise passes through the gates which must be opened more or less frequently at certain intervals during business hours. Of course, sound-absorbing solutions (e.g. by sluices with double gates) are known which might prevent noise propagation. These devices, however, are not satisfactory because they are troublesome and time-consuming so that, as a consequence, they are mostly left open. Therefore, priority should be given in future to the development of sluices which are simple to handle and of high acoustical efficiency. It seems that the possibilities of acoustic "sealing" are not yet exhausted.

Sound insulation of dwelling houses: improvement of longitudinal insulation

The airborne sound insulation in multi-family houses (massive construction) cannot be carried out at present as high as it would be desirable. The cause for this is the sound transmission through the flanking building components. It is known that this deficiency can be eliminated by an additional lining of walls and ceiling. This must, however, be done in an economically reasonable way, i.e. instead of plaster by a lining which is attached elastically. By means of such lining, insulation can be increased by 10 to 20 dB. For instance, this would be a solution for certain low-priced constructions (wood wool haunching elements filled with concrete) the sound control values of which are near the admissible limits or somewhat below. This task is especially important and promising.

Thermal insulating layers on the inside surface of external walls

In particular in existing buildings, but also in new buildings, there is the need of increasing the insufficient thermal insulation by a lining on the inside surface of the external wall. The linings used (mostly composite boards of rigid foam) have resulted in deterioration of aireborne sound insulation between the rooms by about 10 dB, the cause of which being the rigidity of the insulating layers. There is a strong need for solutions which do not have this disadvantage and which are nevertheless low-priced. Summary: Development of a lining increasing the thermal insulation (primary task) and not decreasing the sound insulation within the house.

Improvement of the method of laying floating floor finishes

The insulating layers for floating floor finishes have been improved during the last two decades so that very high insulating values (improvement of impact sound by 35 dB and more) can be obtained with floating floor finishes if they are laid carefully. However, the insulating values actually obtained in buildings are often 10 to 15 dB lower. The reason for this is faulty laying work, i.e. there are fixed connections at some points between the floor finish and the floor resp. the walls. Such faults should be avoided by "foolproof" laying, using tougher cover foils, better edge strips and the like. For existing houses (modernization) as well as for new buildings, it is often desirable to lay dry-fixed finishes which, however, should have similar good sound insulation as the floating floor finishes. The solutions available so far do not meet the requirements regarding sound insulation; this is due to the insulating layers used. For this purpose, there would have to be developed special insulating layers combining both suitably low dynamic rigidness and sufficient compression strength.

Decrease of impact sound on stairs

In multi-family houses (without lift), there is considerable noise caused by people going upstairs and downstairs. More recent and not yet published investigations clearly show where insulating measures can start. However, translation into practice will be necessary.

3.3 Decrease of construction damage due to causes of building physics

The fact that problems of building physics are involved in cases of construction damage has been underlined in sub-chapter 2.3, where also the causes and the relative frequency of certain damage have been dealt with on the basis of analyses of damage carried out.

In connection with the causes of building physics mentioned before, this very bad result clearly shows where reduction of construction damage can be started, i.e.:

a) At the construction sites, work must be done carefully as far as building physics is concerned. The trend of a certain happy-go-lucky carelessness must be counteracted.

b) Knowledge and information of building physics must be improved.

This leads to the following priority tasks of research and development:

Improvement of measuring technique of building physics at site!

The conclusion to be drawn from a) is to improve control of the construction work, in particular with regard to facts or possible consequences in connection with building physics. For many years, in spite of high expenses, serious building contractors have made efforts in order to intensify controls of construction work. These efforts would be more successful if there were measuring and control instruments available to be handled simply and without difficulty (portable measuring instruments for quick measurements).

Improvement of knowledge of building physics!

Although there exists so far rather extensive literature specialized in building physics, there is a lack of summarizing standard and reference books of building physics to put all the various information in order, to select and evaluate it. Such books should contain the up-to-date state of knowledge clearly arranged and easy to understand with text and illustrations. It is also important that they should illustrate the practical use of the knowledge of building physics by means of representative examples of completed structures. Such manuals should serve as textbooks for students, guides for men in practice and reference books for a great number of people interested in and occupied with constructional engineering. There is a great need of such reference books for teaching and research, in architects' and engineers' offices as well as in firms of the building industry. Single parts of the urgently required standard books of building physics should be oriented by specific target groups, according to the following characteristics:

For designing architects

This part should include theory and practice of inter-disciplinary design with criteria of building physics, correct disposition of building volumes from the point of view of building physics as well as first optimization steps during the stage of preliminary design and early planning. For control of design, check-lists with illustrating examples would have to be developed to enable even the inexperienced planner (student) in normal cases to follow and evaluate each decision.

For civil engineers

This part should include fundamentals and methods for engineering work on problems of building physics. Principal items would have to be calculations and experimental methods concerning transmission of heat, moisture, sound and light in buildings.

For users

This part should include fundamentals of building physics for manufacture according to needs and for use of building components as well as the entire measuring technique and control for the construction sites. Furthermore, this part would have to be appropriate for routine training of experts practising their profession whose continued education must be carried out in future more quickly than up to now. The training for new professions, e.g. for the "consulting engineer for energy in buildings" urgently required in future, must be started already now.

4. CONSEQUENCES FOR THE IABSE WORKING COMMISSION "BUILDING PHYSICS"

Building physics is getting more and more important for planning, design, construction and maintenance of structures of any kind. As the numerous problems and cases of damage occurring in buildings and structures show, building physics has not yet sufficiently become an essential part of structural and constructional engineering.

The permanent tasks resultant from this are: To make building physics (as previously defined) better known within the IABSE and to exchange knowledge and experience in the field of application of building physics in practice. In future, the Working Commission would like to concentrate in particular on the subjects

- energy conservation by utilization of heat storage in concrete masses

- building and structure damage caused by moisture and by thermal respectively hygric load

relative to practical application. In order to make the importance of building physics clear to the professional public, it is further planned to issue memoranda on "The Status of Building Physics in Structure Design Practice" and on "Education in Building Physics".

5. LITERATURE

[1] IABSE Working Commission "Building Physics": Definition of Building Physics. Internal document, Vienna (1980).

[2] Ständige Konferenz der Hochschullehrer für Bauphysik an wissenschaftlichen Hochschulen Deutschlands: Hochschullehrer-Memorandum. Die Bauphysik muß fester Bestandteil der Architekten- und Bauingenieurausbildung werden. Bauphysik 2 (1980), H. 4, S. 137-143.

[3] Bub, H.: Sicherheitsanforderungen in Normen. Rundbrief des Obmanns des Ausschusses für Einheitliche Technische Baubestimmungen. Aug. (1980).

[4] Leonhardt, F.: Rückblick - Mut für die Zukunft. Vortrag Univ. Stuttgart (1979). Published by Offizin Chr. Scheufele, Stuttgart.

[5] Pause, H.: Die Baukrise als Herausforderung zu Innovation und Wandel begreifen. Handelsblatt (1982), H. 23, S. 19.

[6] Cowan, H.: Private correspondence (1980/81).

[7] Gertis, K.: Auswirkung zusätzlicher Wärmedämmschichten auf das bauphysikalische Verhalten von Außenwänden. Aachener Bausachverständigentage, S. 44-48. Bauverlag Wiesbaden (1980).

[8] Ohne Verfasser: Wer kann das noch bezahlen? CCI 14 (1980), H. 11, S. 1.

[9] Werner, H. und Gertis, K.: Zur Wahl von Kalkulationsmethoden bei der Ermittlung der Wirtschaftlichkeit von Energiesparmaßnahmen. Baumasch. u. Bautechn. 26 (1979), H. 2, S. 65-72.

[10] Gertis, K.: Kalkulationsmethoden bei der Ermittlung der Wirtschaftlichkeit von Wärmeschutzmaßnahmen. VDI-Berichte, H. 344, S. 3-9; BWK 31 (1979), H. 9, S. 347-350.

[11] Gertis, K.: Kosten für die Verbesserung des Wärmeschutzes von Gebäuden. Kosten-Nutzen-Analysen. Bauwirtschaft 32 (1978), H. 31, S. 1238-1240; Öl + Gas 25 (1980), H. 1, S. 25-29; japanisch: J. Jap. SHACSE 54 (1980), H. 7, S. 685-688.

[12] Diverse Autoren: Research on Maintenance and Modernization. CIB-Proceedings, H. 54. A.A. Damen, Rotterdam (1980).

[13] Schröder, E.: Lärmforschung - Viel erreicht, noch viel zu tun. Umschau 80 (1980), H. 18, S. 557-561.

[14] Hartkopf, G.: Die Lärmbekämpfung muß fortgesetzt werden. Kampf dem Lärm 25 (1978), H. 1, S. 5-8.

[15] Umweltbundesamt (Hrsg.): Projektgruppe Lärmbekämpfung beim Bundesminister des Inneren. 2. Aufl. Mercedes-Druck, Berlin (1979).

[16] Gösele, K.: Vorschläge für Innovations-Vorhaben zur Verbesserung des Schallschutzes bei Neubauten. Schriftliche Mitteilung (1980). Unpublished.

[17] Novotny, F.: Vorwort zur Bauschäden-Sammlung. Band 1. Forum-Verlag, Stuttgart (1974).

[18] Zimmermann, G.: Beeinträchtigung von Bauwerken. Bauschäden, Beschädigungen, Abnutzung und Alterung. Bauschäden-Sammlung. Band 2. Forum-Verlag, Stuttgart (1976).

[19] Schild, E. et al.: Untersuchungen über das Ausmaß und die Schwerpunkte der Bauschäden im Wohnungsbau. Bericht PM-47. RWTH Aachen (1973).

[20] Sommer, J.H.: Baumängel in der Schweiz. DBZ (1980), H. 2, S. 85-86.

[21] Schäfer, H. und Dahm, P.: Entwurf für eine systematisierte statistische Schadensanalyse im konstruktiven Ingenieurbau. Bericht Inst. f. Massivbau TH Darmstadt (1977).

[22] Schild, E. et al.: Schwachstellen. Band 1 bis 4. Bauverlag, Wiesbaden (1977) bis (1979).

[23] Oswald, R.: Bauschadenssystematik. Bauzentrum (1980), H. 3, S. 14-16.

[24] Gösele, K. und Schüle, W.: Schall, Wärme, Feuchte. 5. Auflage. Bauverlag, Wiesbaden (1979).

[25] Schild, E. et al.: Bauphysik. Planung und Anwendung. Vieweg-Verlag, Braunschweig (1977).