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COLUMN

Building science or building physics

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I like the ancient pattern, where and instead of one's title one tells the name of one's mentor. Three mentors shaped my professional life. The first one was in Warsaw, Poland, Prof. Bohdan Lewicki, whose books on concrete panels were translated in many languages. One day, after his class, he told me: "We need to evaluate hygrothermal performance of an experimental building with no-fine concrete,—if you would like to do it, I will provide you with all the money needed. From this day on, I have been learning Building Physics. My second mentor was Prof. Lars Eric Nevander in Lund, Sweden, one of the three Swedish professors who in 1972 introduced limit states method into the field of durability assessment, exactly 40 years before the first ISO standard did so. Lars Eric taught me that progress in construction depends on how strong is the continuum between industrial and academic domains in Building Physics.

My third mentor was Prof. Neil Hutcheon known in Canada as the father of building science. It is only fair that I start writing my column with his definition of Building Science.

> "*Knowledge about building, called, for convenience, building science, is valuable largely because it is useful in predicting the outcome of the result of some building situation. The prediction may involve the thermal pattern resulting from a particular wall construction in a given climate or the service to be expected from a particular kind of brick used in a given way in a particular location.*
>
> *The situation may be real, if the building already exists, or it may be posed in a hypothetical way in the normal course of building design. Rational design is possible only when there is the capability to establish, each time a choice is made, the probability of a particular result.*
>
> *It is widely acknowledged that* (*process of*) *building has been strongly based on tradition. This does not mean that it has proceeded without predictability, for tradition embodies prediction, embracing those things which have been shown by experience to produce a predictable result. Such experience very often has arisen from unintended, costly, full-scale experiments associated with failure of part or all of a building either during or after construction.*"

In this short passage, written 40 years ago, N.B. Hutcheon defined Building Science as a complex needed to achieve predictability of performance and stated that performance can only be defined when we know the limiting condition, i.e., the failure. Only then we can we measure the actual performance as a distance to the failure criterion.

N.B. Hutcheon continued:

> "*The experiments must be done if predictability is to be extended form the tradition. They can be done more economically and with greater return if devised and carried out in a systematic series, which, of course, is research.*"

This brings us to the **paradox of testing and knowledge** that may be stated as follows: *to design a performance-oriented test a lot of knowledge is needed and to accumulate this knowledge a lot of testing must be done*. Expanding from this simple statement we quickly realize that introduction of integrated testing and modeling approach is making a scientific revolution in building physics. If we

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can establish probability of a simulated failure we can talk about predicting performance. The modeling is needed to address probability of a specific weather and variability of material characteristics used as the input to the hygrothermal models.

So, while nobody in the academic community will disagree with the need for building science as a discipline taught to engineers, the critical relation between knowledge and predictability of performance that was so well articulated by N.B. Hutcheon is often neglected in building practice.

Speaking on a professional development seminar Max Baker (1971) said:

> "*Only with knowledge of science principles and an explicit philosophy can conflicts and inconsistencies in design, and misunderstood requirements, and faulty execution in construction, be eliminated from the present building industry, where there now is a proliferation of new building types, inadequately understood new methods and materials, and a quickened pace of construction.*"

In his 1973 lecture N.B. Hutcheon continued:

> "*The critical relation between knowledge and predictability can now be seen. Reliance upon direct experience as a basis of prediction is highly restrictive. Only with knowledge is it possible to assess the relevance of experience and thus to draw upon broader and more varied experience in the development of predictability. There is always a requirement for as much relevant or related knowledge as possible at the time the prediction is being made. These relatively simple propositions have far-reaching implications for research and education as well as for the management of technology.*"

Here is a good place to break the review of NBH's lecture and to examine development of Building Physics in Europe. It dates to 1930's in Russia, when "Stroitielna Tieplofysika" was first published and with focus on heat and moisture performance in various applications Russian literature exploded in 1950s and 1960s. In this time work of J.S. Cammerer in Germany and H. Johansson in Sweden created "Baufysik" and "Byggnadsfysik". Soon all these trends merged with the Architectural Science from UK and Australia. Thus, in 1970s an academic discipline of Building Physics was firmly established in Central and Northern Europe. Born as the academic discipline, for many years, the Europeans attempted to separate the industrial know-how from the academic knowledge. It was quite opposite to North America where (until recently) little or no building physics has been taught at the Universities and the progress in construction achieved by consultants was mainly based on the know-how.

In Canada, for years, N.B. Hutcheon tried to introduce building science (physics) to the schools. In his 1973 lecture he said:

But the mere existence of building science is not enough. It must be put to use throughout the building industry wherever technical decisions are made about building. It must be introduced appropriately into the education and training of all who are in a position to use it. There must be not only teachers but also teachers of teachers, for trades, technical and professional levels. ***There must also be a new kind of professional*** *who, for want of a better name, will be called a building engineer. It is not necessary that he should be a scientist, though he should be well versed in building science. He must be aware of the realities of the design office, the factory and the field and must have that judgment, which is essential in professional practice to proceed beyond the limit of what is well established in arriving at what is wanted. There is need, in addition, for this new profession to be truly a learned one, in the best engineering tradition, capable of teaching and research as well as practice, and capable also of identifying and recording what has been learned, as a contribution to the store of knowledge and to the advancement of professional capability.* ***This is the greatest need today in the building industry****.*

These words, spoken 40 years ago are as valid today as they were visionary 40 years ago. In a summary from the 1st Building Enclosure Science and Technology (BEST 2008) conference Onysko and Bomberg wrote:

The building industry is at the crossroads and the question is "where do we go from here?" The "green" train has left the station but the tracks are still being built. At the far end there is an American Institute of Architects commitment to achieve a 2030 carbon neutral future. At the beginning, just outside the station, there is a lot of good will but also a realization that the majority of highly inefficient buildings of today will be with us well beyond 2030. There is a chasm that must be bridged if the goals are to be achieved and there is confusion on how we can accelerate the process of renewal.

We agree with a UN report that stated:

> "*The good news is we have got a huge source of alternative energy all around us. It is called energy conservation, and it is the lowest cost new source of energy that we have at hand. Since 1973 alone, improvements in energy efficiency resulted in a 50% reduction of our daily energy use, which is the same as discovering 25 extra million barrels of oil equivalent every single day. Clearly saving energy is like finding it.*"

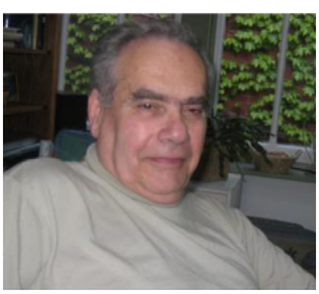
"It is not clear how to achieve the major change that is required. However, it is clear, based on past successful programs, that only a systems approach will achieve those goals in the future. We are past selling magic new materials and miraculous one-issue solutions. Every building, old or new, needs to be treated as a system in which every component is a piece of the puzzle. Quick fix efforts for one or more components in the building envelope, at best, may not achieve enough, and at worst, may cause damage. This requires advice from experienced practitioners of all types. The green value of actions is determined by the resulting building performance, not by the perception that an action is green."

In a paper reviewing history of Canadian residential housing, the same authors wrote:

"This paper reviewed the historic background leading to the current holistic approach to heat, air and moisture control of building envelopes. It showed that past building industry empiricism (learning from the field observations and forensic studies) was a slow process and the cost was high....This review also showed that by involving leading consultants and the academic community, Canadian Mortgage and Housing Council was able to develop a critical mass of information on the environmental conditions experienced in housing.''

So, in answer to the question–where are we today in the North America – the majority of people would agree that there is no schism between the building science and building physics. The traditional names remain different on both side of the ocean but the focus is the same because as NB Hutcheon said ''*only with knowledge is it possible to assess the relevance of experience*'' and our society's stress on sustainability causes all of us involving in construction to use the same language of field performance.

Effectively, we may answer the question asked during the closing discussion of BEST 3 conference (2012)—*who is the force capable facilitating switch to sustainable construction*? The answer is: architectural community. The building physics community, being it in the academic or consulting domain will assist architects in understanding the interrelation between building sub-systems and their integration in a system that considers energy efficiency, durability and good indoor environment. The name of such a system varies: High Performance Building is popular in the US, Equilibrium House in Canada, Active or Passive House in Europe but the objective is the same. A number of venues in which Architects can learn building physics in North America is large but their objectives are similar. So, in conclusion we may hope that for the 100 anniversary of establishing the field of building physics (2030) our buildings will be consuming near zero energy and emit very little of the green gas.



Mark Bomberg is a part time professor at McMaster University, Hamilton, Ontario, Canada and Southeast University in Nanjing, China as well as editor-in-chief of the Journal of Building Physics (Sage Corp. London, UK). His interest on the path from materials to sustainable buildings is possible because of his research background in heat, air and moisture transfer, material science and evaluation methodology with particular interest in durability of construction materials. Currently he is working on integration of HVAC and building enclosures (see Frontiers of Architecture and Civil Engineering in China 2010 4(4)).

Dr. Bomberg graduated as master of civil engineering at Warsaw Technical University, Poland, but never managed to start work as such. As a graduate student he became a technical assistant to Prof. Bohdan Lewicki, member of Polish Academy of Science, and started research in Building Physics. Later he became one of two people responsible for building the national laboratory and led development of test methods for the Building Physics Section of the Polish Research Insitute. He defended thesis in thermodynamics of irreversible processes receiving a title of Doctor of Science (Engineering). Awarded a post doctoral scholarship to Holland and Sweden he became technical assistant to Prof. L.E. Nevander at Lund University, Sweden and for 8 years worked on fundamentals of moisture transport in construction materials. Some findings served for thesis and he received the Swedish title of Doctor of Technology.

He emigrated to Canada, worked for 20 years for National Research Council of Canada, leading the field of thermal insulation. After early retirement from NRCC he taught at Condordia U (Montreal, 3 years) and Syracuse U (New York State 8 years) until the current, final choice.

He published over 200 papers and some books; is one of two people who instituted BEST Conferences in the US and received the highest awards in building physics in both USA and Canada namely Ontario Building Envelope Council (BECKIE, 1999) and Building Enclosure Technology and Environment Committee of the National Institute of Building Science, Washington DC (2012) in addition to awards from ASTM, Society of Plastic Industry (US), CGSB and ULC (Canadian standards), Canadian Plastic industry, NRCC, U. of Baja California, Mexicali, Mexico.