University of West Hungary

Ph.D. degree thesis

Summer thermal comfort of
light-weight buildings in Hungary

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Presentations connected to the topic:

Péter Szabó: Solar Possibilities in New Lanark - (seminar)
Heriot-Watt University, Edinburgh, UK. 1992.

Péter Szabó: Passive Solar Tourist Hostel in Sopron - (poster)
Solar Word Congress - Budapest, 1993.

Péter Szabó: Passive Solar Buildings in Hungary - (seminar)
Folkecenter for Renewable Energy, Hurup, Thy, Danmark, 1993.

Péter Szabó: Környezetbarát építőanyagok - Solar technology
University of West Hungary, Sopron, 1994. (Ph.D. seminar)

Péter Szabó: A modern épületek nyári túlmelegedése - (survey: 34-36. pages)
XXI. Building Construction Conference - Pécsvárad, 1996.

Péter Szabó: Az ökologikus építészet gyökerei - (survey: 68-79. pages)
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Péter Szabó, Ferenc Oszvald: Egységes épületszerkezetek az európai éghajlati viszonyok tükrében, ... - (survey: 76-88. pages)
XXIV. Building Construction Conference - Győr, 1999.

My designs related to the research:

- Sopron, Ravazd street 19. (Hrsz.:5236/17) 1994. - (Private home with Porotherm wall)
- Sopron, Csalogányköz 3. (Hrsz.:7471/3) 1995-2001. - (Dwelling with Porotherm wall)
- Sopron, Rauch András street (Hrsz.:5236/85) 1995. - (Dwelling with Porotherm wall)
- Sopron, Hátulsó street 5. (Hrsz.:277) 1996. - (Private home with Porotherm wall)
- Sopron, Újsor (Hrsz.:8497) 1999. - (Private home with Porotherm wall)
- Sopron, Kitaibel Pál street (Hrsz.:6647/4) 1998. - (Private home with Porotherm wall)
- Sopron, Kertvárosi street (Hrsz.:8528/7) 1998. - (Light weight structure dwelling)
- Sopron, Kisház street 17. (Hrsz.:7929) 1999.- (Private home with Porotherm wall)
- Sarród, Hátsó street 2. (Hrsz.:172) 1999.- (Private home with Porotherm-adobe wall)
- Sopron, Kelénpatakil street (Hrsz.:8528/271) 1998.- (Private home with Ytong wall)

Publications connected to the topic:

Articles about building physics:

- Passive Cooling of Buildings, PASCOOL - Handbook
  C.U.E.P.E. University of Genova 1993-95.
  Editor: M. Santamouris
  Survey team-Sopron: Zöld András, Szabó Péter, Várfalvi J., Orbán T., Szikra Cs.
  P.E.M. version 1.2 (CD ROM)

Péter Szabó: Hőkomfort a faházban
Magyar Asztalos 1995./04 - (76-77. pages)

Péter Szabó: Nem zörög a faház, ha ...
Magyar Asztalos 1995./06 - (70-71. pages)

Péter Szabó: Anyagvédelem a faházban
Magyar Asztalos 1995./09 - (84-85. pages)

Péter Szabó: Burokban a faház
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Péter Szabó: Árnyékvető szerkezetek hatékonyságának meghatározása
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Péter Szabó: A soproni Sörgyár építéstörténete
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Péter Szabó: Faházépítés Magyarországon
Magyar Asztalos 1995./03 - (74-76. pages)

Péter Szabó: Fa-kul-túra (a faházak kultúrális megítélése)
Magyar Asztalos 1995./12 - (94-95. pages)

Péter Szabó: Az első korszerű magyar nyelvű építészeti tankönyv újabb kiadása
Magyar Építőipar 1999. 7-8. - (238-241. pages)

Gábor Winkler: Építészettörténet
Péter Szabó CD ROM - SZIF, Győr, 1999.

Premises of the research:

Throughout the last few years, the Hungarian construction habits went through significant changes. New, light-weight, large size masonry blocks came out, which have prosperous heat insulation properties. Near the traditional buildings, more and more people choose light-weight buildings which can be constructed quickly. Due to the increasing property prices, building into the attic became a general procedure. Heat insulation has more and more emphasized role because of the continuously increasing energy prices and the more rigorous building standards. More and more demand is drawn on against residential areas. The highest demand is among the principles: the convenient layout, the sunny room, and the low heating cost. To reach these aims, we use large windows and heat insulation. Finishes and walls are not capable of storing the heat energy coming through the oversized windows of rooms.

The goals set could be achieved in the cold winter time, but the real problems come up in the summer time. Heat insulated walls are not capable of storing solar energy coming through the rooms' oversized windows, so the air becomes extremely overheated inside. This is mostly seen as if it would be only the timber buildings' problems, which could be true comparing them with the traditional masonry elements (small size masonry block, concrete), but it is not true for buildings made of light porous masonry elements, and it is definitely not true for attics. Today 70-80 percent of the traditional family houses are built using the attic, that is identical with a „timber structured" house by structure and building physics.

Summer overheating develops in high extent only buildings having none or only a weak thermal capacity. Primarily, good heat insulation, laminated structures, so as the light-weight buildings and attics belong to this category. In this view, not the materials of the structures are dominant, but the rooms' thermal capacity. The building type mentioned above well represents comfort problems arising summer time; therefore, analysis of this kind of buildings helps discovering this problem area.

We rather heat more in winter than we would put on a heat insulating shutter for the night; we rather open the window if there is overheating due to the the solar gain. We pay even less attention to our comfort in summer time: we sleep next to closed windows at night, but daytime we open all the windows and doors letting the air circulate. In the design phase, buildings almost never have any kind of detail that would be helpful for the owner to put on shading devices. This details are often not appropriate esthetically, and many times they shelter the interior against solar radiation only by full darkening. New building structures and architectural habits demand a well-considered structural detailing from the designers and the residents as well.

„... solar radiation, light, heat are materials of the new architecture, which should be treated with the same care like steel or concrete."

(M. Papadopoulos)

Goals of the research:

Summer and winter comfort parameters of different residential areas differ remarkably. Different technics are required due to the differing characteristics of climate. Often, it is hard or even impossible to fit to the different expectations at the same time. Challenges must be answered in the designing phase, an incorrect, indeliberate design results malefficient buildings of which modification is difficult and expensive afterwards. For buildings, it must not be the goal to operate building engineering equipment because of design mistakes. Hungarian population uses already more than 54 percent of its energy consumption for heating.

Since the high heating costs, engineers are designing buildings for winter weather conditions mostly. So comfort problems arising inevitably in summer time can be responded with costly building engineering solutions only. The present situation is worsening even more because clients do not urge designers for a better approach, and the national technical literature does not pay enough attention to this area either. It is fashionable nowadays to build solar homes using solar energy, so architects put larger and larger windows in. Misusing the shading devices can make residents' lives hell in a sunny summer day.

By way of excuse, there is very few literature which is talking about thermal capacity, sizing of shadowing structures, or solar radiation acting on surfaces. There is just a few comparison data that could be used to support opinions on heavy- or light-weight buildings. The area of inquisiting attics and light-weight buildings is a neglected segment of science.

Since the above mentioned comfort problems come forward at the construction of small scale light structures, I have chosen this area for research topic. Metal panels, timber structures, various light-weight buildings, and attics belong here. The categories, mentioned above, mean mostly differences in construction technology; the residents comfort feeling does not differ, since the walls laminated structures are built from the same modern materials almost in the same way. Overlooking this area of science, I set the following goals:

- **to create design aids for helping to plan for summer condition**

- to examine summer conditions developing in a light-weight building
- to calculate the thermal capacity of used structures
- to size favorably stratificated building structures
- to determine radiation data for Hungarian conditions
- to determine radiation falling onto variously oriented steep surfaces
- separating components of solar radiation falling onto different surfaces
- to elaborate a representing method that makes the results useful
- to determine shading coefficients of steep windows
- to elaborate a method for sizing shading devices and overhangs

Results of the research:

According to my examinations, it can be stated that the difference in building physics between timber and masonry buildings built with modern building materials, is very low. The results of comparison give conclusion that summer comfort problems are similar. From the data it can be deduced that a building without shading devices is not appropriate.

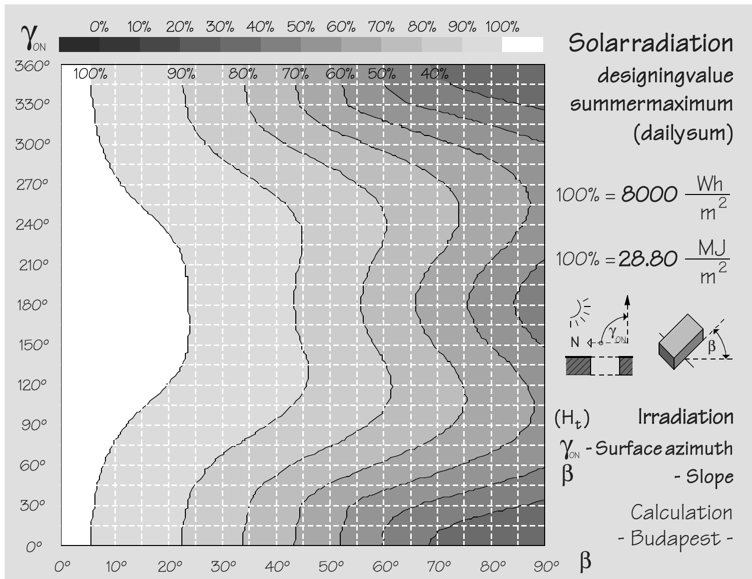
Summer overheating problems come forward in an emphasized manner when attics are built that can be shaded hardly. The developed theory provides opportunity for designers to define better roof window ratios for certain orientations. Design parameters of solar radiation (figure 2.) depend more on the angle of the surface than the orientation. For a low angle attic, the least possible value is almost twice as much as the higher value for a steep angle attic. This fact makes it reasonable that a future building code should deal with summer heat comfort of attics.

Design parameters of shading devices can be found in various catalogues, yet there is not even a theory for the description of shading devices. Completion of theory and graphs of relation among shading devices, plants, and windows puts planning opportunities on a new basis for architects and engineers dealing with solar energy.

„The shading device ... is so important element of our architecture that it can develop into such a characteristical form as the Doric columns“ *

(Marcel Breuer)

figure 2.



Thesis points:

6. **I developed a computing and a description procedure which are appropriate for determining the shading coefficient for the shading devices considering the continuously changing shade** (figure 1.) **as well.**

7. **Examining the overhang shading devices, I proved that also a shaded window receives significant radiation, so a shading device's shading coefficient is always above 0.3.**

This is why conclusions excluding the direct radiation based on the shading masks suggest misleadingly prosperous situation.

8. **Based on my calculations, I stated that (g) value, used by foreign technical literature, depends on dip angle and orientation, so it should be used only with regard for specific intervals especially at roof windows.**

9. **My research data proved that for transparent steep surfaces the Hungarian standards specifications (MSz-04-140-2:1991) for summer heat comfort are not eligible; they must be adjusted for orientation and dip angle as well.**

The realization of the necessary (~ 6000 kg/m²) specific heat capacity mass practically can not be done, so heat comfort must be satisfied by other (architectural, mechanical) devices.

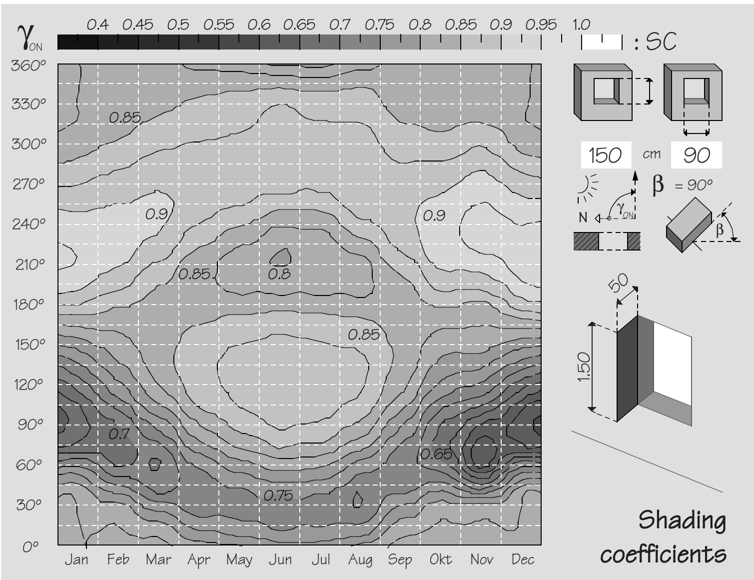


figure 1.

Research methodology:

Literature review:

I collected, sorted, and compared Hungarian and foreign technical literature before I started the survey and computations. During the preparation, I reviewed articles, home pages, and meteorological data related to the research topic. I continuously compared my result with the technical literature's concerning chapters.

Measuring building physical parameters:

The basis of the topic was made available by the PASCOOL Program's 1994 survey series announced by the European Union. The survey was done with the help of the Building Physics Laboratory of the Technical University of Budapest. The chosen building was a panel-structured, plastered, timber building which is most common nowadays. One unit of the family houses, that was used for office space, was empty at the time of the survey. We got typical data about a used and an empty appartement at the same time surveying both wings. So the choice was ideal from different view points.

During the survey, we checked a room in the attic primarily, but still we put further surveying points into several rooms. Based on practical considerations, we set most measuring equipment and the computer, which was registering the data, into an empty room. The survey took place in 1994; it lasted for almost a month. During the survey the computer registered temperature, humidity, and air flow data with a ten minutes interval. Data concerning the exterior air and length of sunshine was bought from the National Meteorological Service.

Computer simulation:

The European Union's PASCOOL program was brought up not only for the analysis of measured data, but it includes a system for verifying the modeling software which was developed to the survey. This software was introduced at the Technical University of Budapest. After completing the building data recording phase, we prepared simulations for the interior space by changing various parameters. A heavy structure building replies to changes more slowly, so its temperature is more straightened. A heavy structure building replies to changes much more slowly, its temperature is more smoothed out. This "lazy" behavior also means that the building can not be cooled by night-time airing, so heat is distributed evenly. There are no temperature peaks, so the rooms are more comfortable.

The software gave different results when assuming shading; this made it clear that checking the effects in another way was needed.

Methodology of the research:

Calculation of heat capacity of building structural stratification plans:

Considering the (MSz-04-140-2:1991), I calculated the heat capacity for the most widely used structures and the thickness of the active zone. Based on my design experiences, I determined the specific heat capacity mass of average residential areas considering different structural schemes. Every grouping confirmed the importance of shading.

Elaboration of a mathematical method for determination of radiation data:

It is difficult to get to the Hungarian solar radiation data; therefore, designers use generally total radiation data only. But it is necessary to know the direct and the diffuse components of shading devices at each points of the examination. In the foreign literature more mathematical models can be found to the determination of radiation data of geographical areas, but this can be used for Hungary only with concerns. I nationalized the methods by examining the Hungarian statistical data.

Practically, there are no data for steep angle surfaces, computing methods can be found are not appropriate for examining the shading, so a new mathematical method was needed. The technical literature deals only with sizing shading devices, for sizing overhangs only comparison tables can be found. Its reason is that in every geographical location and in every time overhangs give different shades. Shadow can be drawn, but a total theoretical background had to be done to the diffuse shadow. The developed theory can be seen as a graphical integral based on measured data. I used computer to the calculations since the large amount of data.

Computer program for the examination of shading devices:

I made a HyperTalk program for the examination of the radiation data, for the calculation of the heat capacity, and for the determination of the shading devices' solar coefficients. The program uses analitycal geometry to calculate the needed parameters. It uses unitycal separation principle. The software includes the necessary meteorological data. Geometrical data of the shading devices and the overhangs can be added by coordinates. Data input makes it possible to determine the the shading effects of the surrounding land, buildings, and plants, as well.

Elaboration of graphical appearance:

Only multidimensional functions would be appropriate for representing the data. These are difficult to use in design aids, therefore, isopleths were drawn to show the results clearly.

Thesis points:

1. **I proved with calculations and survey data analysis that considering the present market's average building materials and building habits, practically the standards (MSz-04-140-2:1991) specifications for summer heat comfort and the residents real expectations can not be satisfied without using shading devices.**

This statement is totally opposite with the architectural community's present practice. Designers are usually not aware of the fact that a traditional masonry house requires more shading than a simple curtain. Attics' summer protection is well undersized by even the most watchful designers.

2. **Examining the possibilities of heat capacity mass at timber structure buildings, I developed a phase changing heat capacity charged structure with which I proved the technical possibilities of this kind of solution.**

The practical adaptation depends on the future market prices.

3. **Based on foreign computing methods of global radiation (I_0) and Hungarian survey data, I worked out new relationships according to the clearness index ($k_T = I/I_0$). I checked the correctness of the method using the diffuse data being accessible. Relationships concerning the diffuse radiation (I_d) are the followings:**

if $k_T \leq 0{,}273 \Rightarrow I_d/I = 1 - 0{,}249 \cdot k_T$ (I - total radiation)
if $0{,}273 < k_T \leq 0{,}692 \Rightarrow I_d/I = 1{,}425 - 1.804 \cdot k_T$
if $k_T > 0{,}692 \Rightarrow I_d/I = 0.177$

In case there will be more detailed survey data then the formula can be refined.

4. **For isotropic sky-model, I proved with calculations that a (β) dipping surface covered by shading device receives a proportional amount of the total diffuse radiation according to the (I_d) angle.**

The proportional coefficient is: $(180-\beta)/180$ based on the 3D-geometry.

5. **I proved that energy stream going through the slope surfaced (γ-azimuth, β-angle) etalon window structure (3mm flat glass) is proportional to the total radiation (I_T) affecting the surface.**

The proportion coefficient: H_{SRG}/H_T
H_{SRG} - daily amount of energy stream going through the etalon structure
H_T - daily total radiation of given structure