Statyba

ISSN: 1392-1525 (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tcem19

CRITERIA OF ADEQUACY FOR BUILDING THERMAL BEHAVIOUR

V. Barkauskas

To cite this article: V. Barkauskas (1998) CRITERIA OF ADEQUACY FOR BUILDING THERMAL BEHAVIOUR, Statyba, 4:3, 173-177, DOI: 10.1080/13921525.1998.10531400

To link to this article: https://doi.org/10.1080/13921525.1998.10531400

ISSN 1392-1525. STATYBA - CIVIL ENGINEERING - 1998, IV tomas, Nr. 3

CRITERIA OF ADEQUACY FOR BUILDING THERMAL BEHAVIOUR

V. Barkauskas

The required values of thermal transmittance through building elements are defined by Building Code RSN 143-92. However, the specific heat losses in buildings related to 1 m^2 of heated area or 1 m^3 of indoor volume are very different even at required and equal for all building elements thermal transmission values. For example, the specific heat losses in the buildings when thermal insulation is not installed, and heated area is up to 300 m^2, can differ from 470 to 580 kWh/m^2 per heating season, and in the buildings with heated area from 2500 to 5000 m^2 - from 215 to 260 kWh/(m^2·a). The difference is 1,8 - 2,7 times. If the buildings are insulated according to the requirements of RSN 143-92, the specific heat losses in the first case will reach the 170-200 kWh/(m^2·a), in the second 120-130 kWh/(m^2·a). The difference is changed by 1,3-1,7 times, but still very large. If to compare buildings in the whole possible scale according to the heated area, the difference in specific heat losses will be even greater. The inadequacy in specific heat losses is stipulated by unequal areas of building elements and their total amount for unit of building heated area or volume (see Fig 1). The thermal transmittance of building elements is different as well, and total heat losses (from the point of view of the whole building) or differentiated for separate types of building elements can have even larger difference (Fig 2).

By grouping the buildings into types with regard to the parameters of adequate thermal behaviour, at first in empirical way, then after a wide analysis, it has been determined that two main criteria can be picked out. Applying them, buildings can be divided into 8 groups with sufficient accuracy (from ±2 to ±10 %),

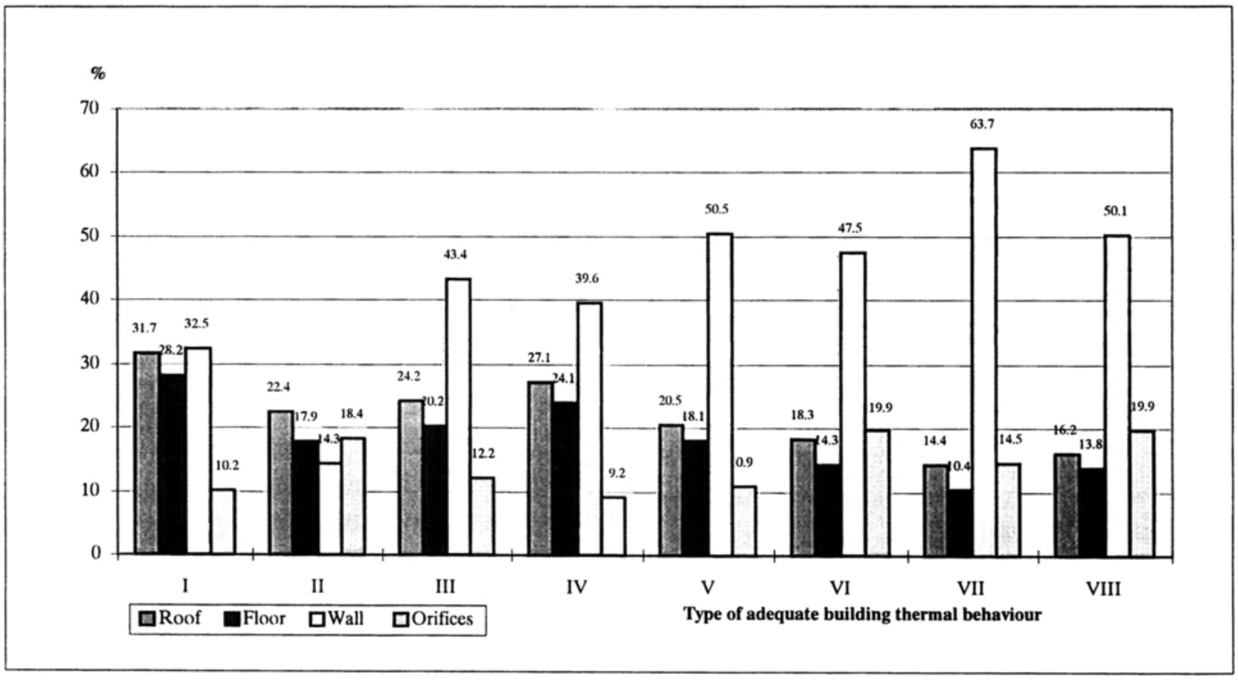


Fig 1. Comparative area of main building elements in building envelope

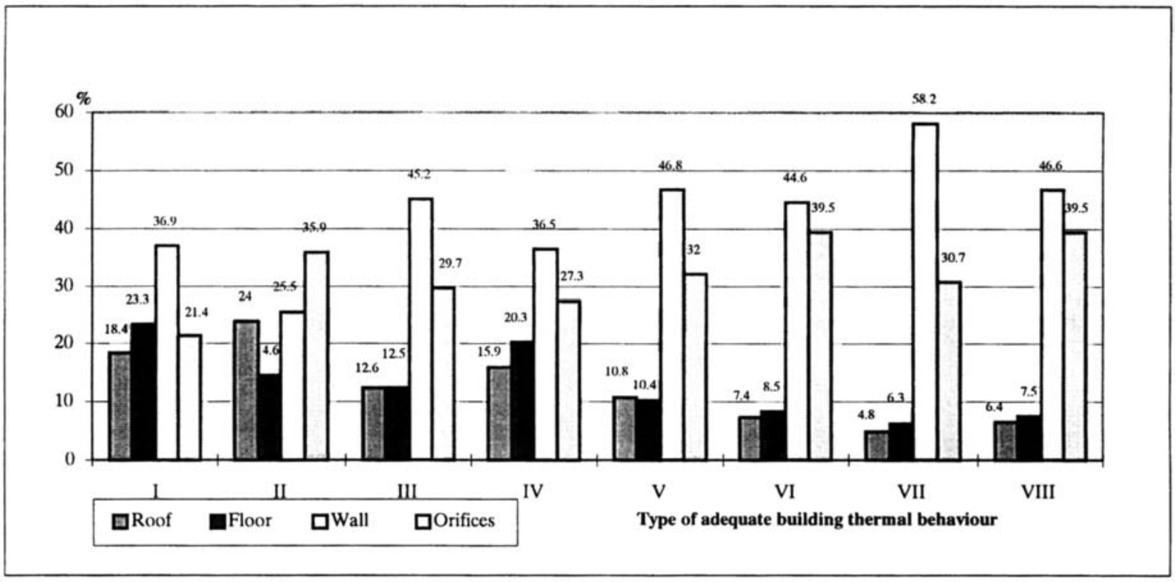


Fig 2. Specific heat losses through building elements, %

see Fig 3. One of the criteria (***K$_b$***) mentioned describes heat losses of the building, another - the similarity of building size ratio (***K$_e$***). All the buildings grouped according to the considered criteria are in close correlation. Practically there are no buildings which could take intermediate position between the indicated groups according to their form and size.

Size ratio similarity criterion ***K$_e$*** describes the ratio of the total area of main building elements (windows, walls, roofs, etc), through which the heat exchange with environment could be performed, with the registered heated area, m^2/m^2:

$$K_e = \frac{a_r + a_f + a_w + a_o}{A_h}, \qquad (1)$$

where

a - area of building element, m^2;

A_h - registered heated area of the building;

r, f, w, o - the corresponding indices for roofs, floors, walls and orifices.

According to this criterion, the designed and existing buildings could be grouped into types of buildings with relatively large, medium, and moderate heat losses in regard to their objectively real plan - volume structure, even if all the building elements are adequate for every considered type. If K_e >2,5, the heat losses in the building will be relatively large, if 2,5>K_e>1,5, then - the medium, if K_e< 1,5, - moderate.

Designed and constructed building elements can be of different insulation level and structure because of various technical and economical reasons. The criterion ***K$_b$*** describes the similarity of heat losses in the building:

$$K_b = ln\left(0{,}5\frac{\Sigma a_i R_i}{A_h \cdot r} \cdot \frac{H_{T\,NR}}{H_{T\,hg}} \cdot 10^3\right), \text{ m}^2\text{·K/W}, \qquad (2)$$

where

$H_T = \Sigma U_i A_i$ - specific heat losses of the building, W/K;

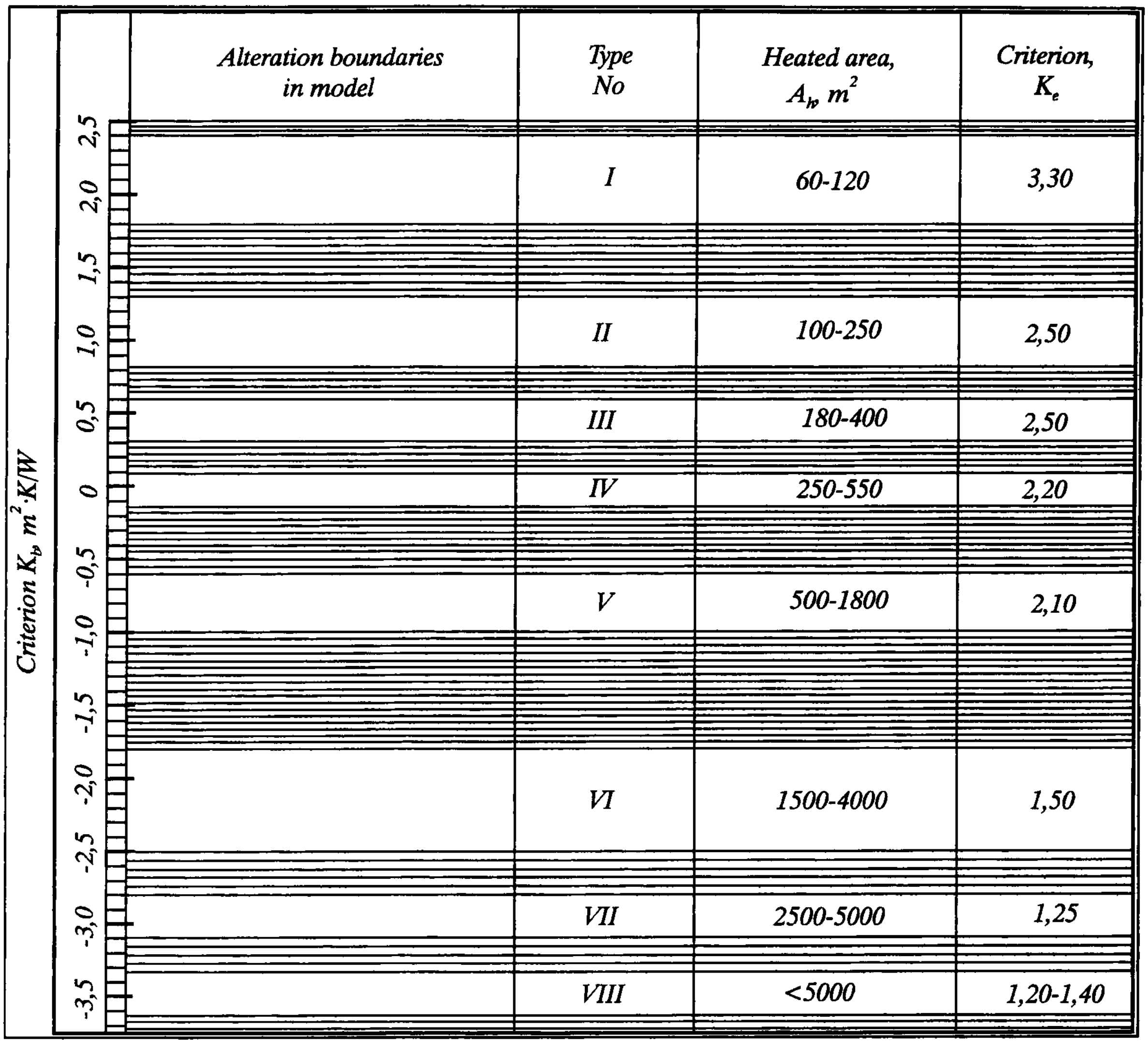
U_i - thermal transmittance coefficient for considered building element, W/(m^2·K),

A_i - area of considered building element, m^2;

r - form factor of the building; for the second group of buildings r = 0,8, for the third r = 0,9, for others $r \approx 1{,}0$;

NR, hg - the indices of heat losses, determined according to the requirements of Building Code RSN 143-92 and hygienic requirements (maximum allowed).

The types of buildings according to the criterion ***K$_b$*** of adequate thermal behaviour are presented in Fig 3. In the bright band 90 % (2σ - square deviation) of the buildings allocated to the certain type are situated. If buildings are designed according to the architectural laws, they practically could not be included into the dark band. There is a probability of 10 % that a building in the dark band of especially complicated



Alteration boundaries in model	Type No	Heated area, A_h, m^2	Criterion, K_e
	I	60-120	3,30
	II	100-250	2,50
	III	180-400	2,50
	IV	250-550	2,20
	V	500-1800	2,10
	VI	1500-4000	1,50
	VII	2500-5000	1,25
	VIII	<5000	1,20-1,40

Fig 3. Grouping buildings according to adequacy of thermal behaviour (model)

volume and form, extraordinarily designed will take an intermediate position between the types.

94 % of existing dwelling buildings in Lithuania were designed and built between the world wars or in the Soviet period according to the Building Codes on building thermal physics in force at that time. The Building Code was based on minimum material consumption as the end task, to fulfill only obligatory hygienic requirements in dwellings. So, for example, the thermal resistance of external walls varies from 0,8 to 1,4 $m^2 \cdot K/W$, in average, not exceeding the 1,0. Energy consumption for heating of unit heated area during heating season then can be expected to be 230 - 550 $kWh/(m^2 \cdot a)$, in 90 % of cases.

The recommended values of energy consumption for heating [1] have been established and legitimated by [2] since 1992 on the analytical basis of rational energy consumption in buildings [3, 4]. The function $q = f(A_h)$ with relationship between the size of the building, thermal insulation level of building elements and energy consumption for heating has been obtained [5]. Rational energy consumption for heating with regard to the adequate thermal behaviour type is evaluated to be from 115 to 195 $kWh/(m^2 \cdot a)$. It is not worth economically to have these values decreased. It is determined that allocating adequate thermal behaviour types of buildings into alteration curve of function $q = f(A_h)$, continuous alteration of the curve is interrupted by grouping the buildings with the adequate thermal behaviour according to the parameter of heat losses as a function and size as well as form of the building as an argument, which define the alteration areas of parameters considered (Fig 4).

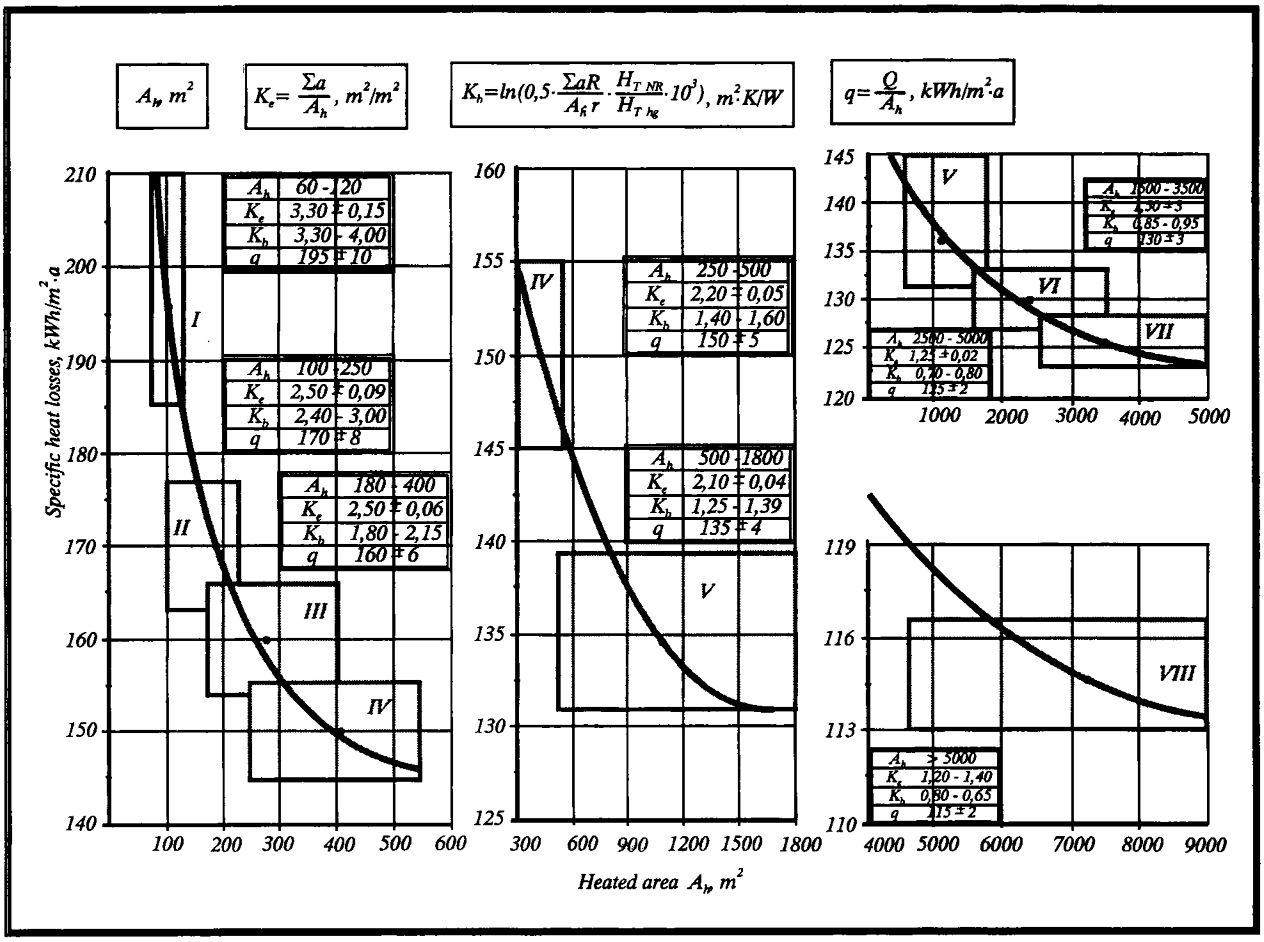


Fig 4. Fields of alteration for specific building heat losses at adequate thermal behaviour when heat losses - function and argument - size and form of building

Table 1. Main and derivative data for grouping buildings due to adequate thermal behaviour

Type No	Characteristic of adequate thermal behaviour type	Heated area, A_h, m²	Criterion K_e		Criterion K_b, m²·K/W	Specific heat losses, W/K		q, kWh m²·a
			regarding to area	regarding to volume		av. H_{Thg}	av. H_{TNR}	
I	One-storey family house	60 - 120	3,3	1,20	1,80 - 2,4	310 630	95 190	195
II	One-two storey, incl. mansard, family houses	100 - 250	2,5	0,90	0,85 - 1,30	320 780	130 310	170
III	One-three storey, incl. mansard, of complicated shape and developed volume family houses	180 - 400	2,5	0,85	0,30 - 0,65	530 1200	210 470	160
IV	Two-storey blocked houses	250 - 550	2,20	0,80	-0,15 -+0,20	600 1350	270 570	150
V	3-4 storey apartment houses	500 - 1800	2,1	0,70	-1,0 - -0,40	1000 3060	470 1450	135
VI	5 storey apartment houses	1500 4000	1,5	0,50	-2,50 - -1,30	1800 4100	1200 2750	130
VII	9-12 storey tower shape apartment houses	2500 4000	1,25	0,30	-3,10 - -2,85	2400 4500	1900 3200	125
VIII	Large houses of various height (5-12 st.) and complicated shape	>5000	1,20 - 1,40	0,27 -0,45	-3,05 - -3,10	-	0,6 A_h	1150

Fig 4 can prove that the specific energy consumption for heating decreases at the increase of the interval for heated area of the building and vice versa (q_{max} ±10%, q_{min} ±2%). The grouping of the buildings according to the adequate thermal behaviour criteria is useful not only from the point of view of energy consumption, but it corresponds to the experience of plan-volume structure design of the buildings as well.

The summary data (main and derivative) of grouping according to the adequate thermal behaviour of buildings are presented in Table 1.

Conclusions

1. The energy consumption for unit heated area or volume of buildings could significantly vary at the same insulation level of building elements.
2. Criteria are established to divide buildings according to the adequate thermal behaviour.
3. The grouping of the buildings according to the adequate thermal behaviour should allow to estimate in a different and objective way the energy consumption values in regard to the considered group.
4. The grouping of the buildings according to the adequate thermal behaviour corresponds to the settled schemes of plan-volume structure of the buildings.

References

1. V. Stankevičius, J. Karbauskaitė. Pastatų šilumos nuostolių normavimas 1 m^2 bendrojo ploto // Konferencijos "Šilumos taupymas pastatuose" pranešimai ir tezės. Vilnius, 1994, p. 125.
2. Pastatų atitvarų šiluminė technika. RSN 143-92. Vilnius, 1994. 75 p.
3. V. Barkauskas ir J. Sabaliauskas. Atitvarinių konstrukcijų šiluminės savybės ir jų ekonomika // Gyvenamųjų namų statybos klausimai. Vilnius: Valst. polit. ir moksl. lit. leid., 1962, p. 166-177.
4. CEN/TC89 No 357E Thermal Insulation of Building Components and Equipment - Part 2: Calculation of the Optimal Economical Thickness of Insulating Layers. 8 p.
5. V. Stankevičius ir J. Karbauskaitė. Energijos suvartojimo normos gyvenamųjų patalpų šildymui ir kitoms ūkinėms reikmėms tenkinti, atsižvelgiant į gyvenamųjų namų tipus/ASI. Mokslinio darbo ataskaita, 1993. 38 p.

Įteikta 1998 06 22

PASTATŲ GRUPAVIMAS PAGAL ŠILUMINĖS BŪSENOS KRITERIJUS

V. Barkauskas

Santrauka

Statybinės normos (RSN 143-92 /94) reglamentuoja leistinas atitvarų šilumos perdavimo koeficientų vertes. Tačiau net ir nustačius visoms atitvaroms vienodas šilumos perdavimo koeficiento vertes, atskirų pastatų savitieji šilumos nuostoliai šildomojo ploto ar tūrio atžvilgiu iš esmės skiriasi. Šis skirtumas svyruoja nuo 1,3 iki 2,7 karto. Tai dideli skaičiai.

Empiriškai ir analitiškai nustatyta, kad yra du kriterijai, kurie leidžia gana tiksliai klasifikuoti pastatus į 8 grupes pagal jų šiluminės būklės ir savitųjų šilumos nuostolių panašumą. Vienas iš jų (K_e) rodo pastatų atitvarų matmenų santykių panašumą, kitas (K_b) - šilumos nuostolių panašumą. Visi pagal šiuos kriterijus sugrupuoti pastatai sklandžiai koreliuoja. Įrašant pagal kriterijų K_b panašias šilumos režimo grupes į funkcijos $q=f(A_h)$ (ši funkcija aprašo pastato savituosius šilumos nuostolius šildomojo ploto atžvilgiu) kreivės trajektoriją, nustatyta, kad panašios šiluminės būklės pastatai glaudžiai grupuojasi atskiruose šios kreivės taškuose į šilumos nuostolių (funkcijos) ir pastato dydžio bei formos (argumentas) apibrėžtus laukelius. Sklaidos ribos siekia nuo ±2% iki ±10%.

Išvados

1. Pastatų, suprojektuotų su analogiškomis ir lygiavertėmis atitvaromis, šiluminės energijos sąnaudos vienetinio šildomo ploto (ar tūrio) atžvilgiu gali labai skirtis.
2. Egzistuoja kriterijai, kurie leidžia skirtingų ar analogiškų atitvarų pastatus grupuoti į panašios šiluminės būklės pastatų grupes.
3. Pastatų grupavimas leidžia skirtingai ir objektyviai reglamentuoti šiluminės energijos suvartojimo dydžius priklausomai nuo pastato grupės.
4. Pastatų grupavimas į panašios šiluminės būklės grupes atitinka susiklosčiusias pastatų planinės-erdvinės struktūros schemas ir joms neprieštarauja.

Vytautas BARKAUSKAS. Doctor, Merited Architect. Institute of Architecture and Construction. Tunelio 60, Kaunas LT-3035, Lithuania.

Author of more than 50 reports. Co-author of 3 monographs, 2 studies guides and 3 Lithuanian Building Codes. He has designed and built a number of dwelling houses and some building renovation projects. Author of architectural acoustic design for a number of public buildings. Research interests: technical progress in architecture, thermal building physics and durability forecast of external finish layers.