New Lithuanian Building Code Requirements on Energy Consumption

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ABSTRACT

The Institute of Architecture and Construction and building authorities in Lithuania have started for arrangement of building codes directed to decrease energy consumption in buildings in cooperation with Estonia and Sweden in 1994. The group of new Lithuanian Building Codes is being prepared in accordance with ISO and CEN standards for the purpose of decreasing the energy consumption in buildings. The new building code with requirements on building envelope U-value is based on principle of limiting heat losses from buildings. General requirements are laid down as well as thermal requirements for new designed buildings, requirements for buildings on rehabilitation, and calculation methods for determining a building elements design heat transmittance. A new Building Code with requirements for the quality control system of building materials and products, estimation of declared and design values of thermal properties for building materials and products is being prepared in parallel. In addition, a third Building Code provision concerning energy consumption and heat load calculation methods for buildings is being developed. In this report the main provisions of the adopted Building Code and related background information are discussed.

Introduction

Lithuania today is experiencing a rapid process of cooperation with the structures of the European Community. New joint ventures with foreign partners have been established, and the import of building materials is increasing. As part of this process, Lithuania is considering ISO and CEN standard requirements. At the same time, the control of the quality of products used in construction is quite necessary. And finally, the decrease in the energy use in buildings is highly important, as all the fossil fuel used in Lithuania is imported.

For these reasons, new Lithuanian Building Codes are under preparation with the participation of C. M. Hector from Swensk Byggledning AB, Sweden, and Dr. E.Jogioja from “Jogioja Consult Ltd,” Estonia. The aim of the new Building Codes is to determine thermal requirements for properties of building materials, building elements, and finally whole buildings and providing the supporting basic calculation methods.

As the first step, Building Code RSN 143-92 “Building Enclosure’s Thermal Technique“ has been introduced and after a transition period was in force in 1999. The basic approach of the former Soviet Union Building Codes have been used in this Code, but the requirements for U-values of building elements have been strengthened significantly. The U–value of walls, in dependence of indoor temperature, are not to exceed 0.5 - 0.35 W/($m^2 \cdot K$) according to the indoor temperature level instead former value of 1.2 W/($m^2 \cdot K$); and for roofs 0.25 W/($m^2 \cdot K$) and for windows 1.9 W/($m^2 \cdot K$), instead 2.4 W/($m^2 \cdot K$).

The former Building Code also included a lot of exceptions related to former construction industry requests. An examination of specific energy consumption in buildings, which were built according to it's requirements, showed unexpected high levels of energy consumption, comparing with projected values. The architectural explanation, when external surfaces were criticized as inadequately, was to say that too many broken window panes, were the reason for the heat losses.

The provisions of the new Building Code regarding the thermal properties of the building envelope have been discussed widely, because the concept of specific heat loss of a building was quite new for building designers. Also for first time, thermal bridges are included in the heat loss concept. The values of the U-values themselves were not discussed, as everybody recognized the motives and consequences of the changes. In addition to the basic requirements, annexes have been prepared with a short description of calculation methods and special data tables that can be used by designers and construction firms.

Similar Building Codes have been prepared in Estonia that have as their basis specific heat loss of a building. The regular U-values for estimation of required heat losses are slightly more severe than in the past, as is the Lithuanian. In Latvia, building authorities have been adopted the Lithuanian regulation

Description and Discussion

Determination of Laboratory, Declared and Design Values of Thermal-technical Characteristics

The values of characteristics of building components characteristics based upon laboratory tests are described as the **laboratory values**. The laboratory values of products are juridical legitimate based on the testing records given by an accredited laboratory. The laboratory values of characteristics can't be submitted to the consumer as the service-life and also these values can't be used as initial values for design. The laboratory values are used to establish the **declared values** of the product characteristics.

The **declared values** of product characteristics are representing within 90% probability the worst quantity of characteristic, with evaluation of the mean laboratory value, deviation of measurements (according to ISO 3207) and the changes of characteristic under aging (except characteristic of frost resistance). The mean impact of operation (exploitation) conditions, which can make worse or improve the particular characteristic, should be estimated. The declared values of **thermal conductivity** $\lambda_{dec.}$, W/(m·K), are determined (in conditions when middle temperature of testing material is 10°C and moisture content accordance to hygroscopic moisture content in 50% air humidity) by the equation (1):

$$\lambda_{dec.} \geq \lambda_{mean\ lab.} + \Delta\lambda_{dev.} + \Delta\lambda_{moist.} + \Delta\lambda_{age.} \qquad (1)$$

where: $\lambda_{mean\ lab}$ - mean laboratory tested value; $\Delta\lambda_{dev}$ - the deviation of laboratory tested measurements (correction due to the scattering of measurements); $\Delta\lambda_{moist}$ -correction due to the hygroscopic moisture content of material in laboratory conditions, if material is tested in dry condition; $\Delta\lambda_{age.}$- correction due to the aging of material.

The declared values of thermal conductivity shall be given as the nearest, higher value for thermal conductivity according to the rounding rules as follows and should ~~be~~ attributed to the class according to the Table 1.

Declared values of **other characteristics** are determined by the equation (2):

$$\mathbf{V_{dec} \geq V_{mean\ lab} + \Delta V_{dev} + \Delta V_{age}} \qquad (2)$$

where: $\mathbf{V_{mean\ lab}}$- mean laboratory tested value; $\mathbf{\Delta V_{dev}}$ - deviation of laboratory tested measurements (correction due to the scattering of measurements); $\mathbf{\Delta V_{age}}$ - correction due to the aging of material.

The declared values of product characteristics could be submitted to the consumer as the reference (representative) characteristics of the product.

The **design values of product characteristics** are determined by calculations, evaluating specific conditions of exploitation in the field.

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To calculate the design values of **thermal conductivity** $\lambda_{\mathbf{design}}$, W/(m·K), of materials the following equation (3) is used:

$$\lambda_{\mathbf{design}} \geq \lambda_{\mathbf{cl.}} + \Delta\lambda_{\mathbf{wet.}}, \qquad (3)$$

where: $\lambda_{\mathbf{cl.}}$ - declared value of thermal conductivity of product, by class; $\Delta\lambda_{\mathbf{wet.}}$ - correction due to the probable additional wetting of product in construction.

The correction factors of deviation, aging and moisture content values are presented in the Building Code for most common cases. The testing periodicity and order of specimen selection for building materials and products also are provided in the Building Code.

Table 1. Classes of Building Materials due to the Thermal Conductivity Declared Value

λ_{cl}, W·m^{-1}·K^{-1}								
0.016	0.02	0.03	0.042	0.05	0.06	0.07	0.11	0.2
0.018	0.022	0.033	0.045	0.055	0.065	0.08	0.12	0.22
	0.024	0.036				0.09	0.13	0.24
	0.026	0.039				0.1	0.14	0.26
	0.028						0.16	0.28
							0.18	0.3
								further with 0.1 interval

Required Heat Transmission Coefficients of Building Enclosures, U, W/(m^2·K), Linear Thermal Bridges Ψ, W/(m·K), and Heat Losses due to Heat Transmission H_T, (W/K)

The energy consumption used in the production of a certain building element and for heat transmission through it during the payback period for the building insulation system should be considered as a criterion for heat insulation requirements in buildings. The original data on energy consumption for material produced in the Lithuanian building industry in 1985-1991 have been used for this purpose. The energy consumption for heating is determined with regard to the heat transmission through the building elements, outdoor and indoor average climate data in Lithuania and effectiveness of heating equipment. The optimal values for basic building elements have been established on the basis of analysis of data collected. Results are the following: - <u>for roofs and ceilings</u> optimum value of heat transmission coefficient is near 0.18 W/(m^2·K), - <u>for external walls</u> optimal value of heat transmission coefficient is 0.26 W/(m^2·K). The results of this analysis are used as the background in estimation of required values in Building Code.

The heat losses in a building depend on the values of heat transmission coefficients as well as on the configuration of the building. It seems reasonable to establish requirements for buildings to restrict the heat losses in them. In the new Building Code heat transmission coefficients required could be corrected according to indoor air temperature. The values of heat transmission coefficient for a separate enclosure could be selected by a designer, but not larger than permissible, based on hygienic requirements. At the same time the specific heat losses of a building could not exceed the required value. The most important requirement for new buildings is limiting of heat demand for heating of buildings up to minimum required values.

Specific heat losses of a building must be less than required value:

$$\mathbf{H_T < H_{TN}} \tag{4}$$

Specific heat losses of a building $\mathbf{H_T}$ are determined by the expression, W/K:

$$H_T = \Sigma A_i \cdot U_i + \Sigma l_i \cdot \Psi_i, \tag{5}$$

where: $\mathbf{A_i}$ - area of a building element, m^2; $\mathbf{U_i}$ - heat transmission coefficient of considered building element, W/(m^2·K); $\mathbf{l_i}$ -length of a linear thermal bridge, m; $\mathbf{\Psi_i}$ correction factor of a linear thermal bridge, W/(m·K).

Required specific heat losses of a building $\mathbf{H_{TN}}$ are determined by expression,W/K:

$$H_{TN} = \Sigma A_i \cdot U_{RNi} + \Sigma l_i \cdot \Psi_{RNi}\ , \tag{6}$$

where: $\mathbf{U_{RNi}}$ - required heat transmission coefficient of considered building element, W·/(m^2·K$^)$; $\mathbf{\Psi_{Rni}}$ - required correction factor of a linear thermal bridge, W/(m·K$^)$.

Limited specific heat losses and hygienic condition to avoid "sick building syndrome" become the main requirement to be fulfilled according to a new document. Specific heat losses due to heat transmission through enclosures $\mathbf{H_T}$ are limited exclusively in dwelling houses, (the values are shown in Table 2, and required U-values to be used - in Table 3).

The U-values of every building enclosures should not exceed the corresponding maximum normative $\mathbf{U_{LN}}$ values, given in the same tables. The values could be corrected by the factor κ:

$$\kappa = 20/(\theta_i - \theta_e) \tag{6}$$

where: θ_i - internal control zone design mean temperature, °C, usually equal to 20 °C, θ_e - mean external temperature during heating season, °C, it can be assumed to be 0 °C for all ~~the~~ country, or design temperature in adjacent space.

Table 2. Required Specific Heat Losses H_{TN} in Dwelling Houses, W/K

No.	Description	Total heated area A_s, m^2	Specific building heat loss, H_{TN}, W/K
1	One-story family houses	60 120	95 190
2	One-two story, incl. mansard, family houses	100 250	130 310
3	One-two story, incl. mansard, of complicated shape and developed volume family houses	180 400	210 470
4	Two-story blocked houses	250 550	270 570
5	3-4 story apartment house	500 1800	470 1450
6	5 story apartment houses	1500 4000	1200 2750
7	9-12 story tower shape apartment houses	2500 5000	1900 3200
8	Large houses of various height (5-12 st.) and complicated shape	> 5000	0.6 A_s

Note: 1. Requirements of specific heat loss H_T for buildings in the middle of A_s range is determined by the way of interpolation.

Regular U-values are dependent on type and generalized position in building and indoor temperature. The design U-value of a separate building element could be less, than the maximum allowed value based on hygiene. The most severe requirements are obtained for dwelling houses, a little less – for public and industrial buildings, as there are more possibilities to change indoor regime.

Table 3. Required Values for Heat Transmittance Coefficient U, W/(m^2×K), and Correction Factor of Linear Thermal Bridge Ψ, W/(m·K), in Dwelling Houses

Type of enclosure	Required normative value U_{RN}	Maximum normative value U_{LN}
Roofs	0.18·κ	0.4·κ
Floor on the ground	0.26·κ	0.55·κ
Walls	0.26·κ	0.65·κ
Windows, doors and gates	1.9	2.7
Linear thermal bridge	$\Psi_{RN} \leq 0.18 \cdot \kappa$	$\Psi_{LN} \leq 0.30$

Specific heat losses including ventilation and heat gains **H** for public and industrial buildings should not exceed the values $\mathbf{H_{TN}}$, which can be achieved using the required normative $\mathbf{U_{RN}}$-values of all enclosures, presented in Tables 5 and 6.

The special requirements for floor heat receptivity and air permeability of whole building and separate building element are presented, as well as the calculation methods for determination of U-values, moisture regime.

Table 4. Required Values for Heat Transmittance coefficient U, W/(m²·K), and Correction Factor of Linear Thermal Bridge Ψ, W/(m·K), in Public Buildings and Offices

Type of enclosure	Required normative value U_{RN}	Maximum normative value U_{LN}
Roofs	0.20·κ	0.45·κ
Floor on the ground	0.30·κ	0.65·κ
Walls	0.30·κ	0.75·κ
Windows, doors and gates	1.9	3.0
Linear thermal bridge	$\Psi_{RN} \leq 0.20 \cdot \kappa$	$\Psi_{LN} \leq 0.25 \cdot \kappa$

Table 5. Required Values for Heat Transmittance Coefficient U, W/(m².K), and Correction Factor of Linear Thermal Bridge ψ, W/(m·K), in Industrial Buildings

Type of enclosure	Required normative value U_{RN}	Maximum normative value U_{LN}
Roofs	0.25·κ	0.55·κ
Floor on the ground	0.40·κ	0.65·κ
Walls	0.40·κ	1.0·κ
Windows, doors and gates	1.9	3.0
Linear thermal bridge	$\Psi_{RN} \leq 0.20 \cdot \kappa$	$\Psi_{LN} \leq 0.35$

Required Heat Transmission Coefficients for Building Enclosures, U, W/(m²·K), and Specific Heat Losses in Renovated Buildings, Determination of Optimal Values

New premises or annexes of renovated (overhauled) buildings must fulfill the corresponding requirements on specific heat losses $\mathbf{H_T}$. With the change of the separate enclosures, heat transmittance coefficient **U** and correction factor for linear thermal transmittance of thermal bridges Ψ of a considered enclosure must not exceed the required normative values presented in Tables 3, 4 or 5, if possible. The thermal resistance value of additional insulation R, $m^2 \cdot K/W$, for enclosures will be determined according to the payback period of maintenance costs.

The most correct method for determining the optimal design thermal properties is: to increase insulation thickness till such a level where the costs for energy consumption related to heating during the payback period of insulation system will be less than the price of the considered insulation system, that is, the total costs **TC** will be the least, as it is shown in fig.1. Methodologically the evaluation of the optimal thickness is clearer. This task is very difficult to carry out practically, as one must consider the forecast level of heat prices, bank interest rates in giving loans and some other important factors, which seem to be dependent on economic conditions in Lithuania and other broad factors.

The calculation method considers the mentioned quantities and it ought to be used in the renovation processes. The draft of EN Standard Thermal Insulation of Building Components and Equipment - Part 2: Calculation of Optimum Economical Thickness of Insulating Layers is used as the basis.

The general case for determination of optimum economical thermal resistance value of a building component and separate case for direct determination of insulation thickness according to least total costs **TC** during economical service period at certain time **AD** are considered.

The least value **ATC** is established for some different values of thermal resistance $\mathbf{R_t}$, if insulation price is not in the rectilinear dependence on thermal resistance value:

$$\text{Lt/(m·a)} \tag{7}$$

where: **AHC** - annual expenses for heating, Lt/(m·a), (Lt - Lithuanian currency, equal approximately to 0.25 USD); **AJ** - annual price of investments (investments divided by economical service life), Lt/(m·a).

The investments **J**, Lt/m2 for different values of thermal resistance $\mathbf{R_t}$, are to be known for successful solution of this task. The economically optimal value of thermal resistance at the selected insulation type would be at the least value **ATC**. If the dependence of investments **J** due to thermal resistance of insulation layer $\mathbf{R_{in}}$ is known or it can be estimated approximately, then the direct determination of optimal insulation thickness can be applied. In order to insulate the existing building additionally, the decrease in costs for heating is compared with the amount of investments supposed. If the insulation level of a new building is considered, the costs are compared with those for a building under necessary indoor and hygienic requirements. If the economic conditions are not stable, the calculations ought to be provided at different time period **AD**, estimating the most profitable level of insulation and its payback now and in future.

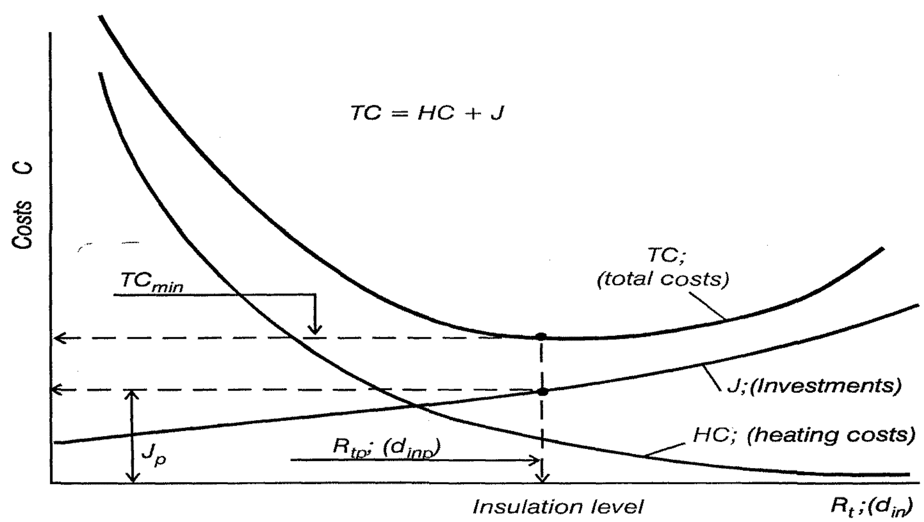

Figure 1. The Dependence of Costs due to Insulation Level [optimum economical $\mathbf{R_{tp}}$ $\mathbf{(d_{in.p})}$, $\mathbf{J_p}$]

Estimation of Annual Heat Consumption and Heat Load in Buildings

Calculation method and correction factors necessary at the evaluation of annual energy consumption and heating load in a building are to be presented in a separate Building Code. Energy consumption due to heat transfer through the building envelope, domestic hot water, ventilation, and heat gains due to solar radiation and human activities are considered. The computer calculation program is compiled in accordance with the method.

Conclusions

1. New Building Codes have slightly higher thermal requirements for dwelling houses than the former Building Code in Lithuania, applying quite a different model of a building. Separate thermal requirements for public and industrial buildings with regard to ventilation and heat gains are introduced for first in our country.
2. The suggested system of requirements provides more freedom for designers with the simultaneous achievement of results in energy consumption.

References

RSN 143-92 " BUILDING THERMAL TECHNIQUE ". Vilnius 1994, 75 p.

Draft prEN 832 : 1994E, 1994-10-Draft Standard.

CEN/TC89 N 293E, September 1993, final draft prEN 32573-1 valid as EN

CEN/TC 89/ W 92 N 355E

CEN/TC 89/ W 93 N 357E