

# CURRENT RESEARCH DIRECTIONS IN BUILDING PHYSICS IMPROVING PERFORMANCE LEVELS FOR NEW OR RENOVATED BUILDINGS

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**Abstract:** In the present climatic, social and political conditions, the EU energy independence is emerging as a priority. Therefore, it set new levels of thermal protection minimum required and adapting buildings architecturally to achieve a maximum of energy efficiency. In this context and not only, thermal insulation market is shifting towards the use of materials made from renewable resources such as sheep's wool and vegetable waste. Also, it turns out that the national building stock does not meet current comfort levels, current performance levels far exceeding the performance offered by the existing buildings, built during the communist era and the dawn of the '90s. Besides this, there is a change in the population structure, with an increasing number of disabled persons, victims of car accidents or other causes and old, categories of population that cannot easily use the stairs, especially if they are balanced and have not hand current or handrail on both sides. Thus, many people become prisoners, sentenced to can't leave their home for life. Finding solutions to these contemporary issues should concern Romanian architect and engineer. Current paper presents some research directions for the coming years and offer suggestions for adapting civil buildings at modern user requirements.

**Keywords:** buildings, research directions, performance levels, buildings modernization.

## 1. INTRODUCTION

The latest report on the state of global climate changes and its influence on society approved by Working Group I of the IPCC [1] present the saddest scenarios regarding the future of the planet. It points out that what is forecast in the past in terms of climate change has come true. Climate change has become reality, the effects of which are becoming more visible. At the same time, Europe geopolitical situation was tense, the armed conflict in Ukraine tensing the relations between the EU and the main gas supplier, Russia.

In this context, the EU policy should be directed to the acquisition of autonomy in terms of energy, which requires, first, reducing energy consumption for heating and cooling civil buildings. Thus, one of EU targets specified in the sixth report published in July [2], is energy efficiency.

Energy efficiency in buildings is achieved through a proper conformation in terms of architecture and the use of thermal insulation. In Romania, to achieve minimum levels of thermal protection of residential buildings are required thermal insulation thickness exceeding 15 cm for exterior walls, 30 cm for the roof and 20 cm to the lower – floor [3]. Using polystyrene and mineral wool, materials with high embodied energy, can be avoided by using thermal insulation made from renewable resources. This paper presents a number of research directions imposed by the current economic and political context.

Furthermore, present era of the "technological civilization" is a period of extensive advances made possible by the application of the results obtained in various sciences. In this time, where goods are replaced at an accelerated pace, constructions, which have always been designed to withstand indefinitely, are the exception to this general rule. Some of them become historical monuments and therefore are kept as true museum objects, particularly valuable. Ordinary residential buildings considered definitive, which in principle are designed to be used on average over 50 years, often end up being useful even after a century, and finishes, fittings and furniture over 20 ... 30 years.

It is always required the adaptation to a higher level of performance for new or renovated buildings, as is done now in order to reduce specific energy consumption obtained by burning fossil

fuels with a release of pollutants, and to readjust for different actions. Strengthening the buildings is a part of the buildings modernization to cope with predictable earthquakes and also with aging of materials. In this regard, by applying the progress made in structural dynamics it can be considered whether some buildings must be demolished. In this paper are presented some cases of this type, which covers some basic requirements for civil building performance (provided by Law No. 10 on the quality of construction) taking into account that buildings must be adapt to user requirements and environmental conditions, which can change with time. Law no.10/1995 including its amendment in 2007 [4] establishes a list of essential requirements for performance:

- mechanical resistance and stability;
- fire safety;
- hygiene, health and environment;
- operational safety;
- noise protection;
- energy saving and thermal insulation,

but not secure the necessary performance levels, which is the role of technical regulations. Now, their application is required to ensure sustainable development.

## **2. CURRENT RESEARCH DIRECTIONS IN BUILDING PHYSICS**

In the last century, theoretical basis for mass and heat transfer were substantially developed many of the concepts learned can be verified and completed using current methods of testing and measuring, as climate chambers designed to test building elements at full scale.

Thus, using full-scale tests and numerical modelling programs, we can investigate in detail the energy efficiency of new and existing buildings and also the possibilities hygrothermal modernization of the building stock in order to achieve performance levels close to those of Positive energy buildings or Passive houses. In these type of buildings it can be use only electric heating.

For older buildings, stated as historic monuments, facades modifications are prohibited. In this situation, hygrothermal modernization of exterior walls raises issues to be investigated in depth, to find solutions adapted to the specific climatic conditions of our country. Designed solutions can be verified using numerical programs that can simulate under accelerating condition the behaviour of construction at combined mass and heat transfer, such as WUFI program created by IBP Holtzkirchen.

Considering the fact that in Romania the projects for condominium buildings erected before 1989 are replicated and with the express purpose to prevent fraud of public funds and thus to reduce public investment, it is recommended to create directories technical documentation for expertise, auditing and energy certification, which can be used by public authorities to obtain the required level of energy efficiency. These projects are specific to every climate zones separately.

Performant thermal insulation ( $\lambda = 0.04$  W/mK) widely available are limited at expanded and extruded polystyrene, mineral wool and polyurethane foam and are made from materials that embody large amounts of conventional energy. Therefore, it becomes a solution using thermal insulation made from renewable resources, with low embodied energy [5], such as vegetable waste available in large quantities.

In new buildings, new technical solutions for envelope elements are required, adapted to passive house or positive energy levels, especially in the tertiary buildings with discontinuous occupancy.

Condominium buildings with multiple levels (SB + GF + 10 ... 12 floors) must be architectural and structural designed to have envelope elements of high thermal resistance and structural frame structures with thermal massiveness, so it may accumulate and return significant quantities of heat. Structural frame should be dimensioned in accordance with seismic zone. Such a structure can be as follows (Fig. 1):

- Two longitudinal load-bearing walls, with the space created between the two walls being used for the stairwell, elevator shaft, ventilation channels and spaces with different functions (service

bathrooms, storage) without natural light, and cross load-bearing walls, with concrete bulbs at the ends to create on the plan of facades reinforced concrete frames.

- The envelope, generally made with considerable thickness of 50-60 cm, is supported by concrete console on each floor, protected by rigid mineral wool, with the role of prevent the spread of fire. The envelope must be protected from the weather. The thermal resistance of exterior joinery to be raised to higher levels, for this purpose it can be use external shutters.

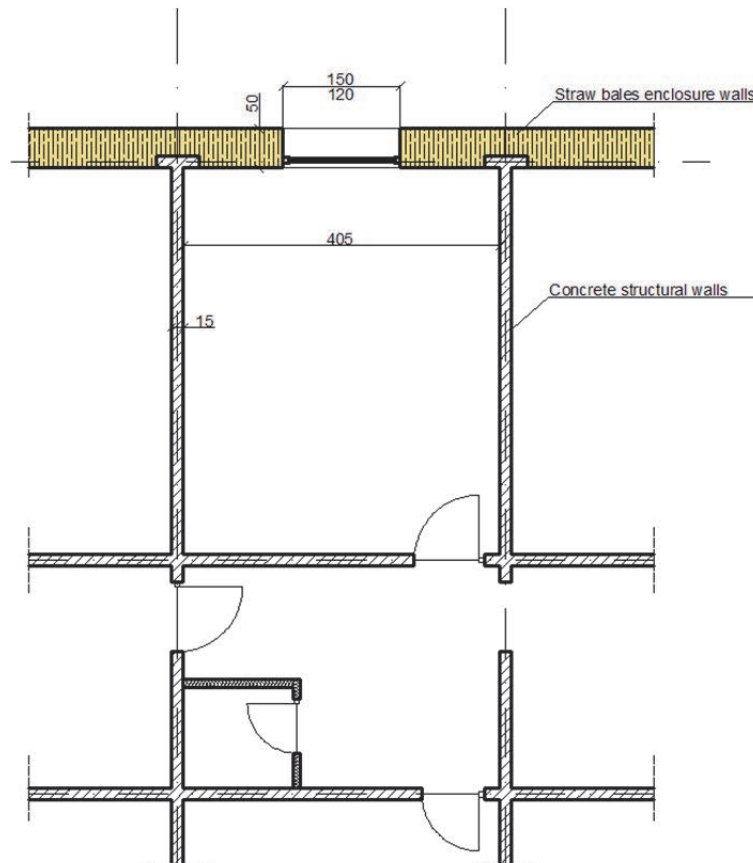


Fig. 1. Suggested structural frame.

### 3. IMPROVING PERFORMANCE LEVELS FOR NEW OR RENOVATED BUILDINGS

Technological progress has required a development in human life. This also has led to additional user requirements on the construction. Furthermore, the transition from communism to capitalism was performed and user emancipation, it needs currently being aligned to the needs of Western Europe citizens. Thus, it requires an update to performance levels, which further approach what existing buildings provides, after upgrading, or even the new ones by tenant claims. Hereinafter, it is presented a number of suggestions to improve performance levels, grouped by performance requirements to which it relates.

#### 3.1. Fire safety

Under current conditions, taking into account the increasing number of buildings levels, the addition of attics and of spaces for parking in the basement of the building, specific rules must be strictly observed and sometimes completed based on numerical fire simulation of specific construction which may develop particular conditions.

Thermal insulation systems must be performed in compliance with the regulations in force, greater attention must be attributed to facades protected with continuous polystyrene insulation, where

fire spread is facilitated. It requires a drastic control by the competent institutions on achieving grid with strips of mineral wool arranged horizontally next to every slabs and vertically every 6 m.

### **3.2. Hygiene, health and environment**

Providing indoor comfort, while maintaining low energy consumption, must be considered together with the requirement of hygiene, health and environment. Natural ventilation provides the necessary fresh air and exhausts water vapours and pollutants resulting from the use of living space. Indoor air refreshing operation becomes restrictive and sometimes deficient in the case of exterior joinery fitted with gaskets and few movable sashes. Ventilation flaps solutions, adjustable constant flow ventilation devices and triple opening of sashes are rarely applied because of high costs. Condensation situations or illness due to inadequate ventilation are very common.

For reasons of hygiene, comfort, safety etc., ventilation solution of an apartment located in a condominium must be determined completely separated from any other apartment and the stairwell.

Kitchen, bath and shower rooms must have opening outwards, through building facades, otherwise requires installation of ventilation systems.

Vertical channel ventilation to the accommodation can be a disused chimney or a 15 cm diameter PVC tube, embedded in a wall or attached to its tangent. Natural draft is ensured throughout the winter, because the building is warmer than outside. In summer season, this type of draft exists only at night and at early morning. A single vertical tube may be enough for 2 or 3 bedrooms apartment. Interior doors should have a little distance from the floor. Windows, even with PVC frames and double glazing still have little air permeability. In summer, natural ventilation is ensured by open windows anyway.

### **3.3. Operational safety**

**Building access.** With few exceptions, access and egress of civil buildings, especially in collective buildings with at most GF + 4 floors is made only by stairs, and recently was approved addition of attics, so the actual number of levels increased with one or two floors. Also, should be considered that some changes occurred in population structure. Nowadays, there are more and more disabled, victims of traffic accidents or other causes and elders, over a certain age, which cannot go alone on the stairs, especially if they are balanced and with no handrail or balustrade on both sides. The descent is the most difficult and the wheelchair is not useful. Thus, many people become prisoners sentenced to life of not be able to leave home.

**Difficulties encounter also mothers and grandparents with small children.** Execution of access ramps is useful, but still did not solve the problem. Only install a lift to every stairwell may be sufficient. In France some modern, light types of elevators appeared, that can be attached next to the stairwells, supported by a metal structure attached to the building. These types of lifts are now necessary in our country to help people who would otherwise be convicted to imprisonment. Meanwhile, in buildings with a height of over GF + 6 Floors equipped with lifts outdated, it is necessary to replace them with new, energy efficient ones, studies in this regard being made at European level [6]. The stairs are still good for muscle training but also in cases when the lift will not operate.

**Flooring.** In present, it can be observed the fashion to replace the old wooden and mosaic floors with aesthetic floors in kitchens, bathrooms and hallways crossing. It is a mistake if new floors are slippery, due the possibilities to cause home accidents. It should be mentioned the error of cover entire flooring of a dwelling with carpet and rarely even of an entire floor, as it creates a serious risk of the spread of a fire.

Given climate changes that are increasing, all buildings must have the flooring of ground floor at least 60 cm above the sidewalk level. In floodplains this height must be exceeded and a flooded area, through which water can drain freely, can become useful.

**The bathroom.** This room is important for family comfort and should include sink, tub, toilet, bidet, washing and drying machine. In addition, is required a separate room for a shower, wash basin and toilet, imposed by the need of the wife, who must be able to simultaneously prepare to go to work. If there are children, this is even more useful. From a certain age, the elderly, the sick, the disabled etc., cannot use the bathtub and the shower is compulsory.

**Built sub-basement.** The built sub-basement stalls were intended for storage, designation that is now no longer necessary, so that they can be replaced at will and opportunities of the owners, but also in relation to existing technical and economic possibilities.

In the sub-basement the stalls can be converting in workout room, administration offices and even medical cabinet. In new projects, built sub-basement shall be provided with a car parking.

### 3.4. Energy saving and thermal insulation

**"Thermal rehabilitation".** The choice of this name become classic, taken from legal vocabulary, is not corresponding to the objective and it was probably more appropriate to be adopted the term "energy efficiency" or „Hygrothermal modernization" to include the use of various new resources, clean, instead of the ones based on fossil fuels. In this area, revolutionary innovations are possible, innovations that would radically change the objectives of building energy modernization.

Nowadays, it can be foresee opportunities that would sensitive change the current situation, where polystyrene and mineral wool are used excessively. Various proposals are based on the existence of atmospheric carbon dioxide and hydrogen in water. So we found a way to combine carbon from the air and hydrogen from water which may be obtained by electrolysis, electricity necessary resources being provided clean. Thus it appears two beneficial effects: decreased concentrations of CO<sup>2</sup> in the atmosphere and a more convenient source of hydrocarbons. If we think, is what plants do every day: absorb air with carbon dioxide, sunlight and water from the ground, causing fuel mass.

Creation of facilities of this type could change the position in the energy efficiency of buildings and more. For the moment, in the struggle between fossil fuels energy and solar and wind energy the costs in favour of the first, and the EU is in an unfavourable situation. However, supplementation of thermal protection level to all buildings remains necessary. It must be seen German recommendation stating that a positive energy building should not consume more than 120 kWh.pe / m<sup>2</sup>.y (primary energy per square meter and year) of which the heating energy is 15 kWh. pe/ m<sup>2</sup>.y and the rest for home appliances, lighting, lifts etc. In comparison, the French regulations provides for rehabilitated buildings 50 kWh / m<sup>2</sup>.y heating energy.

**The kitchen.** This room is very much influenced by the change of living schedule and by the new household appliances needed in the kitchen. In place of the old fridge Fram, now requires combine refrigerator with two compartments, each of 150 ... 180 litres, for family's weekly supplies from one supermarket, caused by the fact that they have no time to go more often to market and want to buy at low prices. In kitchen is necessary a working table, used in cocking activities, but also for taking breakfast and dinner. In addition to the cooker stove it is longer required dishwasher, toaster, microwave and even a TV. All this implies adequate space so often kitchen becomes open to the living room. In our tradition, close to kitchen was placed unheated pantry for storing food that does not require refrigeration (jams, juices, wine etc.) and should be reinstated for comfort and energy savings.

**Curtains and shutters.** The windows have very important functions for living space quality. For this reason and for aesthetic reasons, architecture use increasing glass surfaces. But the windows have a resistance to heat transfer (even if the frame and sash having multiple rooms including reflective triple glazing) smaller than opaque walls. Therefore, for comfort and energy savings, it is necessary to additionally coated with extra coverings that can be ordered on:

- Outside, as the traditional shutters that can be lined with 1...2 cm of polystyrene or as plastic or wooden louvers that are wrapped around a horizontal axis;

- Inside, as curtains [7] [8] in two rows, the first, transparent and thin, and second, thick and opaque. Thermal resistance is provided by two or three layers of glass and unvented air layer, but especially by thick curtain. In winter, it must cover the window at nightfall. In summer, it can prevent morning sunlight, when residents will still sleeping. It should be noted that both sets of curtains must not exceed the heating element, situated under the window. It is best to get the curtains between the wall and radiator, limiting convection. The windows have the largest heat loss on the joinery and therefore, it is recommended that curtains will cover the wall on both sides of the windows.

Another useful measure is the placing a thermal insulation and reflective boards between the wall and the heating element, that can be removed to be cleaned periodically to dust deposits. Dust can reduce the reflection capacity of the surface.

**Photovoltaic panels.** Using PV becomes profitable when a building's heat loss is minimal. In this case, space heating may be accomplished by electrical radiant panels. However, using batteries to store excess energy produced during the warm season, when energy demand for space cooling is reduced, lead to a high cost, due to reduced battery life. It is necessary to align our country with European countries that allow energy storage of energy in the national electricity system, regardless of the amount of energy produced. For that purpose are required serious investments in the modernization of existing power grids. The exploitation of solar energy through the use of small systems is aligned with the efforts to achieve energy independence.

#### 4. CONCLUSION

Climate changes and social disorders push the Europe's energy autonomy on the top levels of strategic priority. This goal cannot be achieved without a corresponding modernization of the building stock and without imposing similar levels of energy efficiency in all EU States Member, the alignment being made keeping as reference standards from Germany, Switzerland and the Nordic countries. Meanwhile, the former Communist countries are witnessing a performance gap between the needs of tenants and buildings used by them. As is known buildings are durable goods, but population trends and progress of the technical means, requiring significant changes along the current levels of construction quality performance. This creates additional costs which cannot be neglected.

Hygrothermal modernization of the built and achieve higher levels of insulation in new buildings can be made in parallel with the buildings modernization in terms of operational safety, fire safety, hygiene, health and environmental and noise protection. This requires new performance levels, adapted to the current user.

The issues mentioned above are not related to the transition to a level of luxury but only to meet the new requirements of the middle class, become important in current time.

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## TENDINȚE ACTUALE DE CERCETARE ÎN FIZICA CONSTRUCȚIILOR. ÎMBUNĂTĂȚIREA NIVELURILOR DE PERFORMANȚĂ PENTRU CLĂDIRILE NOI SAU RENOVATE

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**Rezumat:** În actualele condiții climatice, sociale și politice, independența energetică a UE se conturează ca o prioritate. Prin urmare, se vor stabili noi niveluri de protecție termică minim necesar și niveluri de adaptare arhitecturală a clădirilor de pentru a se obține un maximum de eficiență energetică. În acest context și nu numai, piața de izolare termică se mută spre utilizarea de materiale fabricate din resurse regenerabile, cum ar fi lâna de oaie și deșeurile de origine vegetală. De asemenea, se pare că parcul național de construcții nu corespunde nivelului de confort actual, nivelurile de performanță actuale depășind cu mult performanțele oferite de clădirile existente, construite în perioada comunistă și la începutul anilor '90. În afară de aceasta, există o schimbare în structura populației, cu un număr tot mai mare de persoane cu handicap, victime ale accidentelor auto sau de alte cauze și vârstnici, categoriile de populație care nu pot utiliza cu ușurință scările, mai ales dacă acestea sunt echilibrate și nu au mână curentă sau balustradă pe ambele părți. Astfel, mulți oameni devin prizonieri, condamnați la care nu pot pleca de acasă. Găsirea de soluții la aceste probleme contemporane ar trebui să reprezinte preocuparea arhitectului și inginerului român. Lucrarea de față prezintă o serie de direcții de cercetare pentru următorii ani și oferă sugestii pentru adaptarea clădirilor civile la cerințele utilizatorilor moderni.