

Technological solutions in residential building to improve quality of life and the environment

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Abstract

The establishing of a dynamic of consolidated growth in the demand for housing, both public and private, continues to support both the market and the value of investments in housing. In Europe this pressure has stimulated the development of various experiments on the theme of housing. In particular, the “sustainable” push has provided an important acceleration for housing research in all the aspects of the building organism involved in the control of energy consumption, in the reduction of human impact and of the urban weight of installations on the environment and in improving the level of comfort for the inhabitants.

Current market demand is no longer aimed at satisfying a basic need for economic housing at a limited cost, but it is a more complex demand which refers to an “additional requirement” which is not met in existing building structures, that are no longer capable of satisfying a picture of needs which has changed profoundly.

It is important to study the development of technical-construction solutions for housing which don't propose radical change in the know-how of those involved in the process, but are able nonetheless to have a significant impact on the quality of life of the inhabitants and on the environmental impact of the whole supply chain of production.

The current legal situation lays down minimum values in terms of thermal conduction that characterise the energy performance of the building, in an attempt to obtain envelope solutions that are able to guarantee increasingly significant levels of thermal comfort within buildings.

From this approach, which links the choice of technical solutions and the materials used exclusively to thermal isolation, a tendency sprung up to plan increasingly isolated envelopes, capable of preventing as much as possible the movement of heat, overlooking other strategic parameters for the environmental quality of internal and urban environments, especially in the summer and in hot regions.

Building materials on the market in reality, beyond their satisfying legal requirements, demonstrate mixed characteristics relating to the type of product chosen. Some of these are capable of producing positive effects, such as the possibility of guaranteeing good levels of acoustic isolation, others may contain unknowns, such as those related to the life cycle of the product and the possibility that they may have a negative impact on the environment.

Turning to the substantial thickness of synthetic materials such as polystyrenes and other derivatives of the petro-chemical industries, they can create problems linked to their means of production, use and disposal. In global terms, the impact of the manufacture of some petrol derivatives may even cancel out any eventual benefits accruing from their use.

Promoting energy conservation within a building by the use of high-impact and polluting materials is a paradox that can be avoided by using criteria that are able to guide the selection of materials, in particular for isolating materials, with regard to:

1. Comfort-efficiency conditions evaluated on the basis of their use in improving internal comfort in the building (acoustic and thermal isolation); analytical-quantitative evaluation given the readings of thermal conduction values λ and volume mass.

2. A regime of preferential-compatible use in virtue of weather conditions and seasonal changes. Multicriteria evaluation connected to the mass volume value, which contributes to delay the passage of heat through a wall thermal lag, with beneficial effects on the internal comfort of the building in summer. This

parameter assumes fundamental importance in the optimisation of management in summer, minimising or indeed rendering superfluous the use of air-conditioning plant.

3. Environmental impact – an evaluation of the consequences related to the production and use of a given product in terms of its manufacture and disposal.

A multicriteria evaluation on the total environmental impact of a material, looking at the quantity of energy required to produce a building product starting from the LCA (life cycle assessment) and considering its PEI (potential environmental impact) value which refers to a partial evaluation of its life cycle, from the total of its production cost, transport and positioning on-site.

This type of research on materials and solutions can lead to the development of technical-building solutions that are technologically and morphologically innovative and intelligent, as well as being sustainable in economic and management terms for low- or controlled-cost projects.

Introduction

New researches about housing consider sustainability issue to get a general improvement of people's quality life. Recent laws on energy requirement for buildings, the application of EU Directive 2002/91/CE, and the consequent fall-out on building activities are coming together to create an awareness of the added economic value of a building's improved energy effectiveness; this driven effect will tend to act as a lever to trigger more appropriate responses in terms of setting as well as structures, involving the evaluation of energy consumption, the level of comfort of the inhabitants, the production of harmful substances and rubbish, and the rationalisation of the use of water resources.

All this however is meeting a certain resistance on the production side, in particular with the baggage of skills and capabilities of builders and planners who often approach residential building, drawing on an inheritance of well-established technological and morphological solutions, thus rendering banal the technical offer of the market and standardising the panorama of the expanding city. Current market demand is no longer aimed at satisfying a basic need for economic housing at a limited cost, but it is a more complex demand which refers to an "additional requirement" which is not met in existing building structures, that are no longer capable of satisfying a picture of needs which has changed profoundly.

The establishing of a dynamic of consolidated growth in the demand for housing, both public and private, continues to support both the market and the value of investments in housing. In Europe this pressure has stimulated the development of various experiments on the theme of housing.

It is important to study the development of technical-construction solutions for housing which don't propose radical change in the know-how of those involved in the process, but are able nonetheless to have a significant impact on the quality of life of the inhabitants and on the environmental impact of the whole supply chain of production.

The current legal situation values envelope solutions in terms of thermal conduction, without consider characteristics of materials that constitute it.

From this approach, which links the choice of technical solutions and the materials used exclusively to thermal isolation, a tendency sprung up to plan increasingly isolated envelopes, capable of preventing as much as possible the movement of heat, overlooking other strategic

parameters for the environmental quality of internal and urban environments, especially in the summer and in hot regions.

The market offers a lot of solutions for insulating materials, different for typology, performances, possibility of use and production system. For this reason, it's necessary to promote an evaluation of the general characteristics of the products. It's necessary to value the satisfaction of inside comfort's levels of the building reported to thermal and acoustic isolation's performances; and also it's important to consider the possibility to use the material in different way according to building's orientation and climatic area.

Finally, it is necessary to value how much the production and the use of a material can produce consequences on the surrounding environment. The PEI value of the material, consequential from the LCA, offers information about the consumption of primary energy and available resources utilized to produce and use the material.

Materials and technical solutions evaluated according to these criteria may contribute to improve the energy efficiency of the building system and, at the same time, can be evaluated, also observing the consequences which the use of a solution may have on the environment and the ecosystem, beyond a simple evaluation of their use in thermal insulation.

The contribution of the building envelope to energy efficiency in the building system

The first researches about insulation of the buildings derives from the North Europe, and they reflect the necessity, typical of those climatic zones, to defend buildings and the activities internally developed from the cold. This same model has been transported, initially with few variations, to our latitudes.

From this approach, that connect the choice of the technical solutions and the materials used only to the value of thermal conductivity, is developed the tendency to design envelopes more and more insulating, able to oppose the more possible the passage of the heat.

In reality, the impelling necessity mostly of the latitudes typical of the Mediterranean area, is that to defend themselves respect summer conditions. Buildings in the city of Rome, as in Italy and the centre-south of Europe, due to environmental conditions in the Mediterranean basin, which is characterized by mild winters and hot summers, present a greater need to defend themselves from hot temperatures and presents the need to minimize the use of artificial air conditioners during the summer season and finally to limit energy consumption and create good internal conditions of comfort.

The correct functioning of a building's "frontier" element that controls the relationship between interior and exterior offers a fundamental contribution for the control of heating efficiency and the attainment of comfort levels within the environment it encloses. The possibility of guaranteeing ideal conditions for operating inside a building and thus the wellbeing of all the users therein depends on the attainment of these comfort levels.

So the envelope, therefore, defines, contains and protects the activities that take place within the building; the protective role that is made explicit by the envelope provides the building with the possibility of functioning, to carry out the role for which it was planned and built. Connecting two neighbouring environments that respond, nonetheless, to very different logics and control systems, such as the exterior and interior of a building, means planning in an intelligent way the element that render the connection possible. This operation of understanding outlines the limits that identify and design the framework of the building.

Planning a framework means, furthermore, not only relating to the users who are able to carry out their indoor activities thanks to levels of comfort guaranteed by the framework's characteristics, but also relating to how much the technological planning of the envelope element might influence, at a morphological and perceptual level, the envelope's external environment.

To plan correctly the building envelope define the possibility of defining and identifying the characteristics of the internal environment, carrying out action to guarantee suitable levels of thermal, acoustic and visual comfort, and the possibility of increasing the energy efficiency of the building system.

A multicriteria evaluation for the choice of insulating materials.

Contemporary to the development of the thematic connected to "sustainability" issue, thanks to the evolution established during the last years in chemical industry and materials technology, were born and developed different studies about insulating materials, aimed to increase the performance levels of the solutions offered by the market and parallelly to investigate the possibility to use material not traditionally employees in building market (derived, from example, to industrial sector) to get the performance levels required by the law.

About this question we can distinguished two different way of thinking. On a side, the supporters of the biocompatible and natural materials, consider solutions that takes into examinations materials derived from the natural, vegetable or mineral world. From the other hand we can consider the solutions developed by chemical industry, totally artificial, in degree to raise the performance level and to create innovative technical solutions.

These two school of thought seem to be in contrast; or we makes reference to the constructive systems and traditional techniques, with consequent absence of formal innovation or we entrust to the hard technology of the chemical industry, whose level of development has not allowed the attainment of a good cost benefits assestment. We can't utilize these solutions on large scale, because the use of these solutions (like nanotecnologies, the creation of artificial thermal inertia, etc.) related to the performances improvement, introduce some complex process in reference to the industrial production, with still a little convenience to economic level.

To promote the containment of the energetic consumptions inside a building through the use of polluting and strongly impattive technologies is a paradox that can be avoided through a careful evaluation predisposing criteria able to direct the choice of the insulating materials.

Proposed analysis concerns the elaboration of criteria for the evaluation and choice of the insulating materials. Inside the solutions offered by the market, different for typology, performances, possibility of use and way of production, is necessary to make an evaluation of the general characteristics of the products.

Building materials on the market beyond their satisfying legal requirements, demonstrate mixed characteristics relating to the type of product chosen. Some of these are capable of producing positive effects, such as the possibility of guaranteeing good levels of acoustic isolation; others may contain problems, such as those related to the life cycle of the product and the possibility that they may have a negative impact on the environment

Some synthetic materials such as polystyrenes and other derivatives of the petrochemical industries, can create problems linked to their means of production, use and disposal.

In global terms, the impact of the manufacture of some petrol derivatives may even cancel out any eventual benefits accruing from their use.

An approach to the problem is that to establish some parameters for choice of the insulating materials to be able to furnish a guide to address planners, builders, buyers and to satisfy the end users of the good, with an attention to the performance levels, to the possibilities of use, to the costs and all the parameters of evaluation able to address an aware choice and contemplated by chance case. Such criterions can constitute one "grate" in degree to allow the best choice to effect according to the situations.

Necessity to create some parameters of evaluation of the insulating materials is a segment of a complex research session.

The proposed analysis established four selection levels, defined to satisfy the need for good physical-technical performance, but at the same time guarantee a low impact on the atmosphere.

Selection considered the thermal conductivity of material, the volume mass and the PEI value, that and offers a partial value of the product's life cycle This constitutes a further parameter of comparison; it is always preferable, when possible, to use a material that is able to develop a low consumption of energy in productive phases, because of the overall minor impact on the surrounding atmosphere.

Level selection regards:

- First selection level: thermal and acoustic performance.

The evaluation takes place on materials that are able to guarantee performance of good thermal and acoustic isolation. Comfort-efficiency conditions are evaluated on the basis of their use in improving internal comfort in the building (acoustic and thermal isolation); analytical-quantitative evaluation given the readings of thermal conduction values λ and volume mass.

To the good thermal behavior of the materials that you/they have a tall value of volumic mass it associates him a best sound-insulating power. The noise's attenuation, measured in decibel, it grows in relationship to the mediate mass between the source of the noise and the environment to protect. To a good ability of acoustic isolation of the materials, it corresponds a greater level of comfort of the internal spaces.

- Second selection level: a regime of preferential-compatible use in virtue of weather conditions and seasonal changes.

Multicriteria evaluation connected to the mass volume value, which contributes to delay the passage of heat through a wall thermal lag, with beneficial effects on the internal comfort of the building in summer. This parameter assumes fundamental importance in the optimisation of management in summer, minimising or indeed rendering superfluous the use of air-conditioning plant.

This second level considers also the volume of the material. The thermal inertia or mass effect uses the physical property of the materials to increase the time (thermal lag) that the heat wave takes to cross the walls; this produces a stabilization of the temperature, guaranteeing a lower internal temperature during the day as well. Along with the good thermal qualities materials with large mass are associated with a better capacity for noise reduction. The attenuation of noise, measured in decibels, grows in relation to the mass interposed between the source of the noise and the environment to be protected. A decent

quantity of acoustic isolation material leads to a greater level of internal comfort and quality of life of the space.

The data relating to volume mass is moreover connected with the regime of preferred use. This regards the difference of performance offered in case of either summer or winter. In the city of Rome, as in Italy and the centre-south of Europe, due to environmental conditions in the Mediterranean basin, which is characterized by mild winters and hot summers, present a greater need to defend themselves from low temperatures, the need to minimize the use of artificial air conditioners during the summer season and finally to limit energy consumption and create good internal conditions of comfort

- Third selection level: environmental impact.

Is necessary an evaluation of the consequences related to the production and use of a given product in terms of its manufacture and disposal. A multicriteria evaluation on the total environmental impact of a material, looking at the quantity of energy required to produce a building product starting from the LCA (life cycle assessment) and considering its PEI (potential environmental impact) value which refers to a partial evaluation of its life cycle, from the total of its production cost, transport and positioning on-site

- Fourth selection level: costs

To these three categories we can approach a fourth grade, that concerns the economic aspect and that it corresponds to the parametric cost of every single insulating material: this last parameter is useful to the goals of a general evaluation of the technical solution to use, also considering the destination of use of the building that he will go to realize.

The three levels of evaluation don't answer definitively the question of what would be the best solution; they supply some indications which provide the possibility to make a choice with the aim of arriving at technological solutions that adhere to the principles of sustainable construction.

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