

BOGDAN SIEDLECKI\*

## FORMATION OF THE DETAIL OF BUILDING SKINS – ENERGY GAINS AND LOSS. THREATS

### KSZTAŁTOWANIE DETALU BUDOWLANEGO ELEWACJI BUDYNKÓW – ZYSKI I STRATY ENERGETYCZNE, ZAGROŻENIA

#### Abstract

The modern market of construction materials allows a more perfect execution of the external structure of buildings shortening simultaneously the time of their realization; however, the selection of technology is not indifferent to future users, independently of the function of buildings, the manner of their use, technological equipment and the amount of users. Microclimatic requirements aside, the technical reliability of building skins is one of most important issues. The uncontrolled penetration of water through the building skin or the existence of thermal bridges are the cause of the appearance of biological corrosion of building components as well as their equipment. Comparative tests of project solutions relating to analyses of damage in buildings, helps improve the situation and reduces the threats to which buildings and their users can be exposed.

*Keywords: building technology, elevation, building skin*

#### Streszczenie

Współczesny rynek materiałów budowlanych pozwala na coraz doskonalsze wykonanie struktury zewnętrznej budynków, skracając równocześnie czas ich realizacji. Dobranie technologii nie jest jednak obojętne dla przyszłych użytkowników niezależnie od funkcji, sposobu wykorzystania, wyposażenia technologicznego, ilości osób. Jednym z najważniejszych zagadnień przy wznoszeniu budynków jest zapewnienie bezawaryjnego działania ich powłoki zewnętrznej, bez względu na poszczególne parametry mikroklimatu. Doprowadzenie do niekontrolowanej penetracji wody czy przypadkowych „mostków termicznych” stwarza korzystne warunki dla korozji biologicznej zarówno samego budynku jak i jego wyposażenia. Przeprowadzając testy porównawcze rozwiązań projektowych w odniesieniu do analiz konkretnych uszkodzeń budynków, można ograniczyć negatywne zjawiska skutkujące zagrożeniami technologicznymi, na jakie możemy narazić zarówno użytkowników, jak i sam budynek.

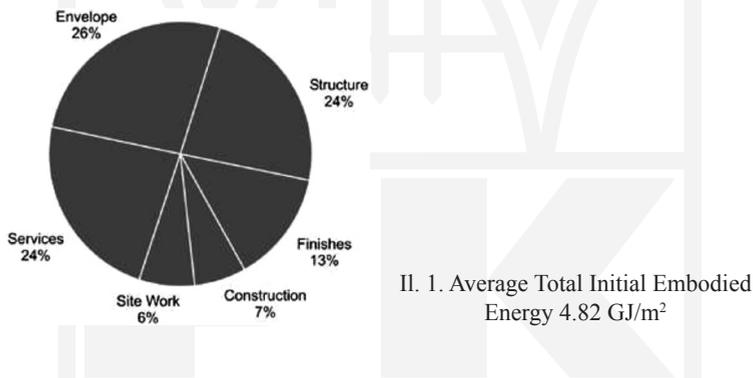
*Słowa kluczowe: budownictwo, technologia, elewacja*

\* Ph.D. Eng. Arch. Bogdan Siedlecki, Faculty of Architecture, Cracow University of Technology.

## 1. Details of building skins

The correct workmanship of external walls of buildings is a guarantee for their longevity and for keeping proper hygienic standards in their interiors. The building envelope is subject to many aggressive factors including the whole spectrum of solar radiation, acoustic waves and chemically polluted air. Given the complex character of related phenomena, I will analyze solely the problems of thermal energy and humidity in buildings. The principal catalyst which generates physical and chemical reactions in walls is thermal energy and is closely tied to solar radiation.

The incidence of solar radiation on a building can be used in many ways. First of all, it delivers the thermal energy which can be stored in massive building elements or can be transformed into electrical energy. It is also a source of daylighting. Before the solar beams reach the building and are reflected to the environment, their energy can be absorbed by the building elements and they can be transferred to the interiors through the glazed skins. The effective use of solar energy in buildings requires special treatment of their elevations and sometimes also their roofs. Forms of buildings play an important role in this regard also. Some of them, better than others, allow to utilize the solar energy. Important is the method of energy transfer through the glazed walls, which occurs due to the physical process of conduction, radiation and convection.



Active systems of solar energy gain allow to transform it into other forms like: thermal, mechanical or electrical. These forms of transformed energy can be used in different devices characterized by:

- low temperature (collectors and solar ponds),
- high temperature (solar farms and power stations), pumps,
- other (heat pumps, energy storages, thermal diodes, transparent insulations, etc.).

Many of the technologies, mentioned above, are usually installed on the exterior walls of buildings, thus they have a significant impact on their resulting forms. At present, one of the strongly recommended methods of construction allowing for the use of unconventional energy are so called passive houses. The operation of passive systems relies on the interception of solar radiation and its transformation into thermal energy. Eventually, it is stored in massive and accumulative walls and floors only to be consecutively released back to the interior for heating. The experiences with building structures presently go much further towards the zero-energy buildings and thus energy-independent buildings gradually come into light. The

building materials are in close relation with energy issues as they are gained and produced with the use of some amount of energy. Every material is characterized by a certain amount of so called embodied energy. As the illustration above depicts, about 26% of total embodied energy in buildings refers to exterior walls and this is why the issue of building skins is so crucial when discussing the problems of energy in buildings.

During the realization of the plastic concept of a building through the application of materials to its exterior walls, we cannot omit the technical aspects of adequate and stable mounting of particular layers of elevation. The diversity of building skin` structures (Il. 3), makes it unavoidable to work out all crucial construction details at the joints of the materials and to indicate the methods of their attachment. The most advanced systems of building technology are very demanding and require an individual approach of the designers in every case of their application. A much more complicated issue is the reconstruction of existing buildings, especially in the case of those under the protection of the conservation authority. The principal problem is sometimes the necessity for the adoption of solutions contradictory to basic rules of building physics. An example of this, can be the idea of locating the insulation on the internal surface of the exterior walls, which is against the standard proceeding. The reversed position of insulation is disadvantageous, as it does not allow the heat to accumulate in massive walls and also threatens them with water condensation from within. Another problem with existing buildings subject to reconstruction or modification is of legal character and relates to their location at the border of a building lot. Every additional insulative layer attached to the exterior surface of the wall can infringe on the property rights of the neighbours.

The analyses of documentation from the research done with the use of infrared cameras reveal that old buildings with one-material-walls, especially those built with brick, are not threatened with an accelerated destruction process. The dew point or the zone of water condensation, even if it does occur, can be detected predominantly in “safe” places which do not lower the quality of building`s use; however, if the insulation is applied to the exterior wall on its internal surface, special attention should be turned to the bearing of structural decks supported by this wall. The inner insulative layer hampers the heat transfer to the wall and thus leads to the excessive cooling of the building structure. The uninsulated deck brings about the formation of thermal bridges resulting in the loss of energy from the building. The beam pockets in walls along with the beam ends are then in extremely disadvantageous thermal and humid conditions. The increased temperature and humidity favor the process of biological corrosion of wooden beams and contiguous zones of exterior walls. Every decision concerning the proposed system of thermal modernization of exterior walls should be preceded with in-depth research of the existing structure of the walls as well as of the close structural joints.

## **2. The economics of solution**

It happens that energy saving and ecology cause a paradox in the aspect of balance of primary energy in relation to the assumed operational austerity of buildings. The materials of elevation used for its construction can be characterized by their embodied energy<sup>1</sup> and the differences between them and in this regard, are presented in the table below.

---

<sup>1</sup> According to data Department of Resources, Energy and Tourism, GPO Box 1564 CANBERRA, ACT 2601.

Material	[MJ/kg]	[MJ/m <sup>3</sup> ]	Material	[MJ/kg]	[MJ/m <sup>3</sup> ]
Straw bale	0.24	31	glass	15.90	37 550
Stone	0.79	2030	steel	32.00	251 200
Concrete	2.00	2780	zinc	51.00	371 280
Wood	2.50	1380	copper	70.60	631 164
Brick	2.50	5170	polystyren	117.00	3770
Plywood	10.40	5720	aluminium	227.00	515 700
Mineral wool	14.60	139			

A good example of the relations mentioned above, is a four-pane-glazed window representing the structure 3-12-3-12-3-12-3 with 90% crypton gas and the Uk value of 0,3 W/m<sup>2</sup>K. So a heavy and massive window requires special reinforcement for its frame and sash. Moreover, it is also necessary to use a complicated three-layer mounting system, in order to achieve good energy performance. All this questions the economical effectiveness of this system and its ecological and energy-related values.

### 3. Real threats

Theoretical consideration and available analyses of the newest building systems, often faultless and patented, usually testify to their adequate performance and reliability. In practice however, they happen to be smashed by the lowest level of technological evolution in building, namely: the construction workers. In many cases, they lack the basic professional knowledge and skills due to the failure and decline in the professional education system resulting, as an example, in their problems with the proper execution of building details. An exact analysis of the project's individual solutions, enhanced by virtual simulations and infrared scanning of existing building details, significantly increases their faultless performance. It helps also to define which construction stages require more attention and constant supervision. The quality of detailing appears to be a crucial factor in the whole construction process. Basic knowledge is essential in this regard; for example, the flat roof plane waterproofing is usually not penetrated by water, whereas all bends of membranes or passages of different installations through them are the places of potential defects and damage. Another cause of faults in buildings is the unclear and inconsequent assignment of particular tasks to construction crews. This leads directly to confusion and as a result, to unresolved problems. Thermal bridges are usually responsible for the unsatisfactory energy performance of buildings and sometimes, to premature deterioration of building elements which appear after a few years of functioning. The areas of vapor condensation usually are formed in inaccessible places, which makes them difficult to detect. As a result , biological corrosion takes place and the building is threatened with temporary malfunction or in extreme cases with demolition.



III. 2. The defects of technologies and execution  
(photo by B. Siedlecki)



III. 3. The variety of building skin structures  
(photo by B. Siedlecki)



III. 4. The envelope of a building structure  
(photo by B. Siedlecki)



III. 5. The adjustable wooden internal panels  
(photo by B. Siedlecki)



III. 6. The interlacing of structure and elevations  
(photo by B. Siedlecki)



III. 7. The damages of parapet walls of flat roofs  
(photo by B. Siedlecki)

#### 4. Conclusions

The only way to assure adequate workmanship in the construction process is its proper supervision by qualified professionals at every stage of the building's work. The design stage should be based on the creation of multidisciplinary documents and then submitted to the building authorities for verification. The principle, "builds the less expensive contractor", applied as a rule, should be abandoned. The multitude of building materials, offered on the market, requires their careful selection for building construction as their properties in combined systems may turn out to be unexpected and ineffective. Their unwary application can bring negative results, which can go unnoticed after being covered and thus become invisible.

#### Abstract

- [1] Berge B., *The Ecology of Building Materials*, Oxford Architectural Press 2001
- [2] Cole R.J., Kernan P.C., *Life-Cycle Energy Use in Office Buildings*, Building and Environment, 1996,
- [3] Jencks Ch., *Le Corbusier – tragizm współczesnej architektury*, Wydawnictwa Artystyczne i Filmowe, Warszawa 1982.
- [4] Pokrzywnicka K., *Kontrasty, metamorfozy, styl – czyli Rozważania o dynamice przemian architektury XX wieku*, Wydaw. PG, Gdańsk 2003.
- [5] Runkiewicz L., *Wykonywanie obiektów budowlanych zgodnie z zasadami rozwoju zrównoważonego*, ITB 2010.
- [6] Górzyński J., *Obciążenia środowiska w produkcji wyrobów budowlanych*, Prace naukowe ITB, Warszawa 2004.