TECHNICAL TRANSACTIONS
CZASOPISMO TECHNICZNE

ARCHITECTURE
ARCHITEKTURA

ISSUE 7-A (14)
ZESZYT 7-A (14)

YEAR 2014 (111)
ROK 2014 (111)

WYDAWNICTWO POLITECHNIKI KRAKOWSKIEJ

TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE

ARCHITECTURE | ARCHITEKTURA

ISSUE 7-A (14) | ZESZYT 7-A (14)
YEAR 2014 (111) | ROK 2014 (111)

Pierwotną wersją każdego Czasopisma Technicznego jest wersja on-line
www.czasopismotechniczne.pl www.technicaltransactions.com

Architecture Series
7-A/2014

Editorial Board

ARCHITECTURE, CONSTRUCTION AND ECOLOGY

ARCHITEKTURA, BUDOWNICTWO I EKOLOGIA

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

JANUSZ BARNAŚ*

DOUBLE-SKIN FAÇADES – THE SHAPING OF MODERN ELEVATIONS – TECHNOLOGY AND MATERIALS

ELEWACJE PODWÓJNE – KSZTAŁTOWANIE NOWOCZESNYCH ELEWACJI – DOBÓR TECHNOLOGII I MATERIAŁÓW

A b s t r a c t

With the evolution of architectural form, the notion of the façade and its look undergoes changes as well. The paper discusses modern solutions applied in external curtain walls of buildings and presents new capabilities provided by new construction materials including double-skin façades. The paper presents buildings that achieved high energy efficiency due to, among other factors, adequate façade construction.

Keywords: curtain walls, double-skin façades, technology, architectural form, construction materials, scientific research

S t r e s z c z e n i e

Wraz z ewolucją formy architektonicznej i postępującym rozwojem architektury zmienia się zarówno pojęcie elewacji, jak i jej wygląd. W artykule omówiono nowoczesne rozwiązania zewnętrznych ścian osłonowych współczesnych obiektów architektonicznych, w tym elewacji podwójnych. Przedstawiono możliwości, jakie dają nowe technologie i materiały budowlane. Zaprezentowano obiekty, w których uzyskano wysoką efektywność energetyczną – m.in. dzięki odpowiedniej konstrukcji elewacji budynku.

Słowa kluczowe: ściany osłonowe, elewacje podwójne, technologia, forma architektoniczna, materiały budowlane, badania naukowe

* Ph.D. Arch. Janusz Barnaś, Institute of Architectural Design, Faculty of Architecture, Cracow University of Technology.

1. Introduction

the problems associated with energy efficiency of buildings, their resource needs, as well as attempts to reduce those needs stemming from the latest developments in the economy and the increasing role of alternative energy generation methods and renewable resources are becoming ever more important in the process of designing buildings and structures. These problems have a significant impact on the way an architect approaches his or her work and give rise to the ever wider adoption of the principles of sustainable architecture [1]. Designing modern structures, which must meet high quality standards in terms of energy efficiency, has become a challenge for architects and has forced them to seek the help of specialists in other fields of engineering and science. That which now shapes a buildings spatial form, its aesthetical character and architectural detail is more often tied to the way its ventilation works, how it provides optimal lighting conditions for its users, as well as the systems that allow it to achieve the highest possible energy efficiency. a good example of the rising importance of these fields of design is the awarding of LEED[1] certificates to currently designed and existing buildings. The role of a buildings exterior wall has undergone a certain degree of change. The definition of its purpose has evolved since the first half of the XIXth century, when it was thought of as a thick, solid barrier between the outside environment and a building`s interior [12], changing in the direction proposed by Mies van der Rohe [2] at the onset of the XXth century through his "skin and bones" concept. The double-skin facade is a clear continuation of this idea, which postulates a supporting structure of steel and concrete clad in glass. Double-skin facades, often abbreviated as DSF, are currently becoming more widespread due to the high demands placed on the reduction of energy used by buildings.

2. History of double-skin facade use

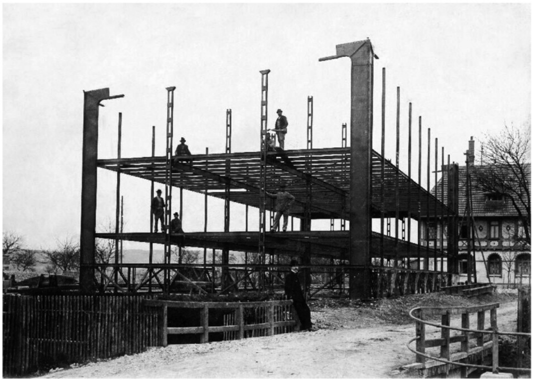
The exploitation of natural physical phenomena in order to improve the interior environment of a building is by all means not a modern concept. The peoples of the Middle East have used windcatchers (badgir in Persian or maqlaf in Arabic) [3]. The Villa Almerica Capra designed by Andrea Palladio has a natural ventilation system which cools its rooms. The first mentions of using design solutions typical of double-skin facades are dated to the XIXth century. In 1849 [4], Jean-Baptiste Jobard, the head of the Industrial Museum of Brussels, described a prototype of a mechanically ventilated multi-layered facade, which uses the space between two glass walls to provide warm air in the winter and cools the building in the summer. In 1903, the first true double-skin facade is built as a part of the Steiff toy factory in Giengen, Germany [5]. The innovative design solutions used in the construction of this building including twin layers of glass, were so effective that they were copied in 1904 and 1908. The exterior curtain wall constructed by Richard Steiff in Giengen is fully compatible with the modern definition that was formulated in 1961 by Rolf Schaal [6]. Fifteen years later Willis Jefferson Polk, designed his Hallidie Building in San Francisco,

[1] The LEED system (Leadership in Energy and Environmental Design) was created and developed in 1998 by the american non-government organization Green Building Council, which propagates the idea of Eco-Construction.

fitted with a glass curtain wall: probably the first one in America [7]. This feature has since dominated commercial architecture around the world. The Giengen toy factory, even after successive modernization, is still in use today in its original form.

In 1903, Otto Koloman Wagner, an austrian architect and urbanist won the design competition for the Postal Savings Bank in Vienna [14]. The building was constructed in two stages, from 1904 to 1912. The structure itself is simple in form and has quite a modern system of double skin walls incorporated into its main hall skylight [8]. In 1928 in Russia, Moisei Ginzburg made experiments in the use of double skin facades during the construction of the Narkomfin communal housing project. In the beginning of the XXth century, Le Corbusier experimented with systems that used natural physical phenomena that could possibly improve the indoor climate of his buildings. The idea of the *mur neutralisant* was first used in 1916 in his Villa Schwob, also called the Villa Turque (La CHaux – de Fonds, Rue de Doubs 167, Switzerland). In 1929, Le Corbusier introduced his La Cite de Refuge [9, p. 106] project in Paris, where he incorporated the idea. The system was also proposed for many other designs of structures constructed in the years 1928–1933 as part of the Centrosojuz [9, p. 104-105] in Moscow and his competition entry for the League of Nations building in 1927.

In 1957, the first design solution that featured the flow of air between two sets of windows was patented in Scandinavia. The first office building to make use off a system of ventilated



Ill. 1. The construction of factory buildings in Giengen, Germany, 1903 (source: [5])

Ill. 2. Current state of the Steiff toy factory in Giengen, Germany (source: [13])

windows was used in Helsinki, Finland in 1967, as the headquarters of the EKONO company. In the years 1973–79, during the rising energy crisis, an intensification of reasearch into energy rationalization and a decrease in overall energy use in the construction of buildings occurred. In the 70's and 80's of the XXth century more and more buildings were fitted with mechanically ventilated double-skin facades, especially in Europe. a good example of sucha building is the Brittish Sugar Company building in Peterborough. From the year 1980 onwards, a growing awareness of energy use and the newly formulated concepts in the field of ecology lead to a rise in the use of double skin facades. Multinational corporations, which wanted to be perceived as environmentally friendly, began searching for new architectural solutions for the buildings that were to be their headquarters. This trend was further magnified by the quick development of digital technologies, which delivered powerful tools to designers that greatly sped up the design process of creating a building's form, drafting complex technical schematics and calculating complex load bearing structures. Due to the large budgets involved in the construction of high rise buildings, new and expensive technologies were implemented, including the double skin facade. This lead to the comparably wide usage of double skin facades, which met the easthetical needs of corporations and firms, and at the same time provided, even in the case of really tall buildings, the possibility of openning windows. Due to very strong air currents at high altitues, this was practically impossible in single skin facades.

3. How double skin facades work

Modern double skin facades, depending on the setting of the louvres that regulate the flow of air through the interior space of the facade as well as the interior of the buildings itself, can be applied to:

1) create an external air barrier,
2) create an internal air barrier,
3) air supply,
4) air return,
5) air buffer.

4. Early examples of double skin facades

The Occidental Chemical Center – also known as the Hooker building – in Niagara Falls, NY in the United States, was the first building in North America fitted with the glazed double-skin facade [10]. The Hooker Building is still perceived as one of the most energy efficient commercial buildings in the world and has recieved the Energy Conservation Award from the Owens Fiberglass Corporation, as well as an EPA Energy star (EPA, 2001). Finished in 1980 [15], it became one of the oldest examples of a "modern" building with a glazed double-skin facade, which during its 30-year existance, has provided us with a wealth of information on the way this once controversial technology works. The building's facade was constructed as a double-skin glazed buffer facade, which utilizes

Ill. 3. View of the Occidental Chemical Center facade in Niagara Falls, NY, USA, 1980, design: Cannon Design Inc., Principal, Mark R. Mendel (source: [15])

an undivided space along the entire height of the structure with air supply inlets at ground level, fitted with mechanical dampers and air return outlets at roof level which allow the air to leave the buffer section of the facade.

The Commerzbank Tower in Frankfurt am Main, Germany, is a good example of new developments in the field of facade construction, as well as a system of ventilation that is integrated with it. Each floor of the building has access to daylight and openable windows that allow it to be naturally venitlated throughout the year. The building was designed with energy conservation in mind. Its energy use is half of what can be expected from a building that is comparable in size and scale. Its design incorporates an original idea of locating office floors around internal gardens roughly four stories high. These gardens are linked with the external facade of the building and are home to a diverse range of plants, depending on the orientation of the garden in relation to the direction it is facing. This idea has allowed the

a) b) c)

Ill. 4. Commerzbank Tower exterior facade, interior and ventilation scheme, Frankfurt am Main, Germany, 1997, design: Foster + Partners Ltd Riverside, 22 Hester Road London SW11 4AN (sources: a) author, b, c) [16])

achieving of spatial identification in a unified spatial structure of this large building and it creates an environment that fosters the creating of friendly interiors filled with natural light and with natural ventilation. These winter gardens are located around the internal atrium of the building and allow it to share these characteristics [16].

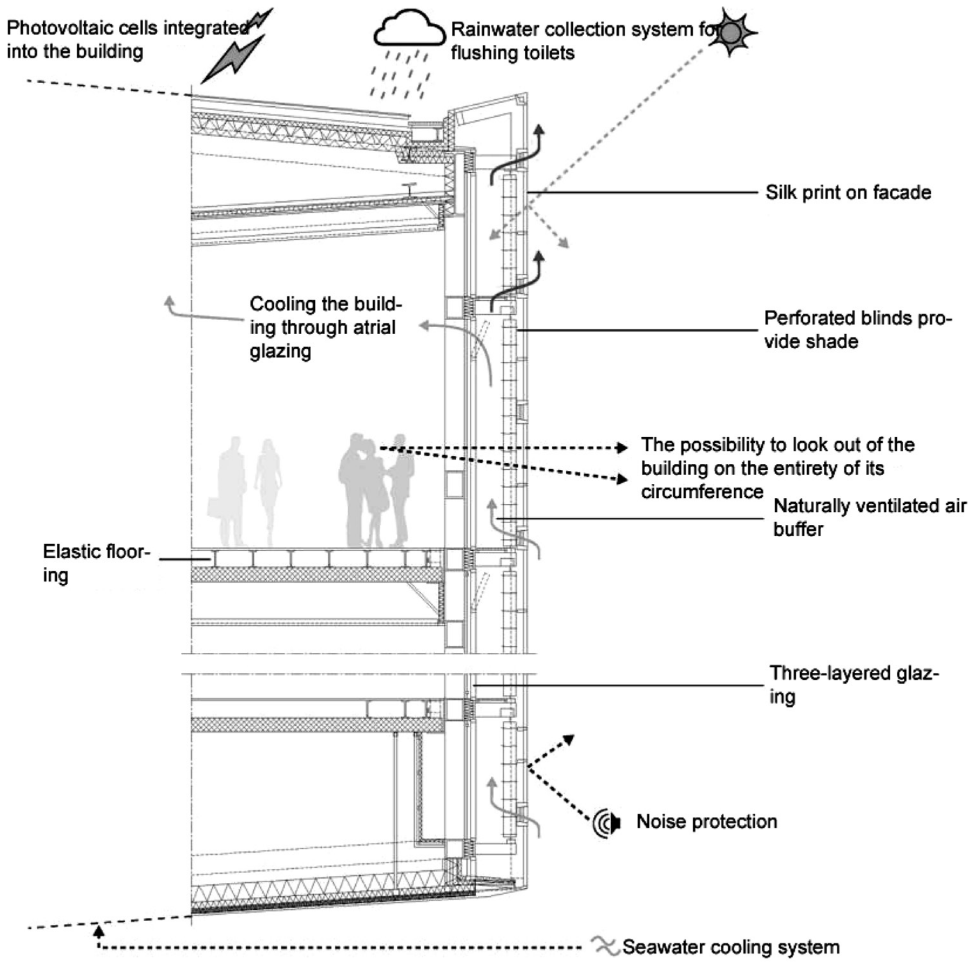
5. The evolution of the process of facade design, technological progress, new construction materials as the layers of the double skin facades

An interesting example of the approach to designing public service buildings using a synergy with renewable energy sources in order to increase its energy efficiency is the Nykredit bank building in Copenhagen, where the double skin facade is a part of an integrated HVAC system. The double skin facade of the building is composed of large, three-layered glazing sheets fixed to steel frames. The glazing has variously colored patterns printed onto it. They serve as elements that protect against the sun's rays. It is divided into two-storey segments with horizontally aligned, low-width ventilation mechanisms with louvres set in a fixed position.

Between the two layers of the facade is a space 70 cm wide, which protects against the outside environment.

This allows for the natural ventilation of offices, along with a far better acoustic insulation, improved cooling during the night with the use of natural air circulation that occurs inside the building due to the opennings in the facade and the return outlets at roof level. The building is also equipped with photovoltaic cells placed on the roof, which produce up to 80 000 kWh per year, a rainwater collection system which allows it to be used to flush toilets and the use of seawater as a component of the HVAC system. These are all parts of the energy efficiency improvement concept of the building, which brings its energy usage down to 70 kWh/m^2 per year. This is a very low figure [17], considering it is 25% lower than the current legal standard

Ill. 5. External view of the Nykredit bank building facade, which is an integral part of its integrated heating and HVAC system, design: schmidt hammer lassen architects, Aarhus
(source: [17])



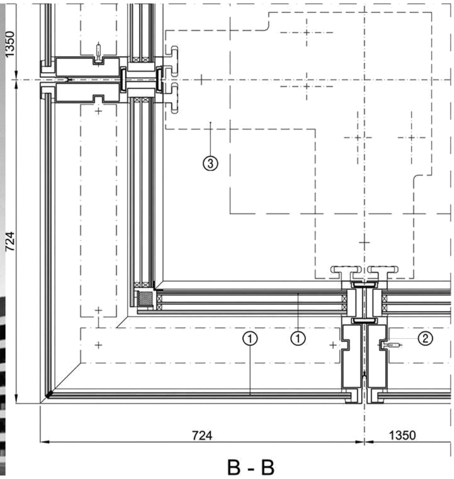
Ill. 6. Facade cross-section of the Nykredit bank building, which is an integral part of its integrated heating and HVAC system, design: schmidt hammer lassen architects, Aarhus (source: [17])

in Denmark. The building, widely named “Crystal” and finished in 2010, was awarded many prestigious prizes including the European Steel Design Award in 2011, as well as the IABSE Demnark’s Structure Award in 2013.

The Roche Diagnostics AG building in Rotkreuz, Switzerland, was designed with a combination of new technologies including the closed cavity facade variation of the double-skin facade (abbreviated to CCF) and a clearly percievable architectural form in mind. The double-skin CCF type facade has a high heat resistance, a high level of transparency, high sound insulating properties and the costs of cleaning it are half of those of a traditional double-skin facade. It also has a higher degree of protection against the sun’s rays and takes half the time to be fitted onto the building. The costs of cleaning a CCF type facade are comparable to those of cleaning a standard facade, with all the benefits of a typical double-skin facade.

a)

b)

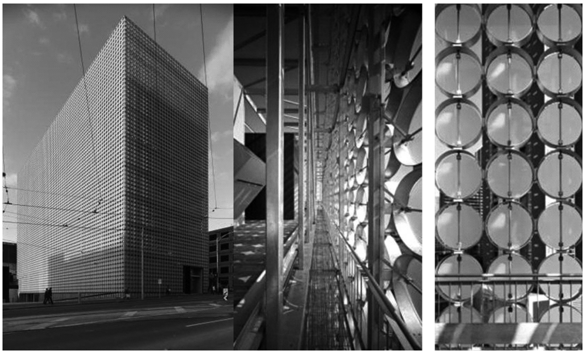


Ill. 7. Roche Diagnostics AG building in Switzerland, CCF type double-skin facade. Design: Burckhardt + Partner AG, facade design: Josef Gartner and Co, a) facade view (source: [19]), b) horizontal cross-section of the CCF facade: hardenned safety glass, laminated (1), aluminum structure (2), facade fastening (3) (source: [18])

The systems that control the functionning of a CCF facade are designed to provide the easiest possible maintenance of the wall. The CCF elevation allows the adjacent rooms to meet the requirements of clean, hygienic spaces and is meant to be used as a wall in laboratories. The economical effectiveness calculations have produced results that indicate that this new type of facade allows the attainment of an effective use period of 30 years [18]. The CCF system can be modified to allow natural ventilation using either of two technologies: decentralized ventilation devices or fully openable facade elements.

6. Double skin facades as an element of a buildings infrastructure

In the course of the development of new technologies and their implementation in the design of double skin facades, they are seen to become an ever more important part of the infrastructure of the building. The RMIT University building in Melbourne, Australia, has been fitted with a spatial structure on its facade that is separated into cell-like objects, which are influenced by the interior structure of the building, composed of laboratories of varying sizes within the tower building. The double-skin facade is composed of translucent, thermal insulating glazings, which are set 70 cm away and parallel to a structure made of 1.8 × 4.2 m panels, made of 21 galvanized steel cylinders 130 mm in diameter, which are, depending on their location, filled with matte glass discs or photovoltaic cells. These elements are steerable and can fulfill a number of functions, including protecting against sunlight, providing thermal comfort to its users and even generate power.



Ill. 8. View of the university building, RMIT University GPO Box 2476 Melbourne 3001, Australia, design: Sean Godsell (source: [20])

7. Comparison of double-skin facades and single-skin facades

An analysis of a number of examples of buildings from Europe proves that the results of comparing buildings with DSF against those with standard SSF glazed facades give rise to a number of interesting conclusions in regards to both of these types of structures [11].

- **Energy use for heating purposes** – DSF eqipped buildings have much better parameters of energy efficiency in the winter months than traditional buildings. Heating equipment can be very effective in maintaining the interior temperature in concert with louvre systems. The buffer effect of DSF is possible to achieve and can reduce the overall costs of heating a building.
- **Energy use for cooling purposes** – DSF equipped buildings have much better parameters regarding efficient energy usage for the purposes of cooling during the summer months, under the condition that they are also fitted with systems that protect against excessive heating (like louvres in the space between the facade layers). Thanks to the DSF buffer effect it is possible to reduce the costs of operating cooling systems.
- **The usage of integrated renewable energy generation systems** – the introduction of renewable energy generation systems is made easier due to the possibilities of integrating them into the structure and infrastructure of the DSF. It is especially true regarding photovoltaic cells.
- **Acoustics** – protection against noise is more efficient in buildings with DSF, especially in the case of lower frequency sounds in comparison to standard double glazing. In the case of a select number of technical solutions within the scope of DSF technologies, sometimes sound is carried more easily within the building itself.
- **Ventilation** – DSF facades can be used in concert with gravitational and mechanical ventilation systems; however, the overall problem of ventilating such buildings are more complex than in the case of single skin facades. Natural ventilation through openable windows is made much more feasible than when compared to single skin facades, even in the case of high rise buildings. High rise structures with single skin facades cannot have openable windows.

- **Fire safety** – the use of a DSF facade makes it impossible to naturally remove smoke from within the building without additional assistance from a proper mechanical installation.
- **Daylight penetration** – The achievement of good lighting conditions is possible in both cases (DSF and SSF). The increased area of glazing can cause problems with excessive illumination, which is a key element in designing open space offices, where the level of illumination can sometimes be detrimental to the working conditions in some areas of the office.
- **Aesthetics** – a key element in the discussion on DSF is the transparency effect, as well as the pragmatic and ideological transparency of a facade and the building as a whole. The additional feeling of the building being "high-tech" can also promote its positive image.
- **Maintenance costs** – the costs of cleaning and maintaining DSF facades are undoubtably higher than in the case of SSF. a separate matter is the CCF DSF type where the costs of cleaning of are comparable to those of SSF, while still maintaining all the benefits of a DSF facade.
- **System quality** – buildings fitted with DSF systems are, due to their relatively short time of operation, prototypes of sorts. The problems that have been observed thus far are mainly associated with the fastenning of glazing (which appears both in SSF and DSF facades) and the motor systems of the louvres. The DSF system is superior in regard to the detrimental effects of the environment on the structure of the facade, as most of the system's elements are shielded from the environment. The CCF facade type, thanks to its construction,is a uniquely durable system. It is estimated that this system has an operational use time of 30 years [18].

8. Conclusions

Clients order double skin facades due to their transparency and the image that they give to their building, while architects praise them for their unique lightness and expression, allowing the users better contact with the outside world. Design teams are currently striving to balance the challenges of simultaneously keeping the right interior climate of the building and providing the highest possible energy efficiency. It is extremely important that a building`s facade be treated as an integral part of it. An individual and holistic approach to design is the key to obtaining high quality end results.

The history of double-skin facades is surprisingly rich, and its beginnings are much older than one might anticipate. They were tied to attempts at regulating the interior temperature and inner environment of the building. Today, this technology has become one of the leading means of shaping these parameters.

References

[1] Celadyn W., *Energia w architekturze,* internet publication (yadda.icm.edu.pl/.../httpwww_kaiu_pan_plimagesstories3_2012w_celadyn).

[2] Blake P., *Mies van der Rohe*, "Architecture and Structure", Baltimore Penguin Books, 1964, 85-89.

[3] Jaworska-Michałowska M., *Środowisko zbudowane włączone do ekosystemu – wybrane problemy*, Czasopismo Techniczne, 4-A/2007.

[4] Heim D., Janicki M**.**, *Izolacyjność fasad podwójnych. Symulacje energetyczne wybranych przypadków*, Izolacje 7/8/2010**.**

[5] Fissabre A., Niethammer B., *The Invention of Glazed Curtain Wall in 1903 – The Steiff Toy Factory*, RWTH Aachen University, Aachen, Germany, III Międzynarodowy Kongres Historii Budownictwa, Congress on Construction History, Cottbus 2009.

[6] Schaal R., *Vorhangwände*, München, Callwey 1961.

[7] *Here Today: San Francisco's Architectural Heritage*, Chronicle Books, 1968.

[8] *Wagner: Werk, Museum Post parkasse* (http://www.ottowagner.com/assets/museumsinfo/Museums-Folder.pdf).

[9] Le Corbusier, *Le Corbusier mein Werk*, Fondation Le Corbusier, Paris und Hatje Cantz Verlag, Ostfildern – Ruit, 2001.

[10] Harrison K., Meyer-Boake T., *The Occidental Chemical Center*, *The Tectonics Of The Environmental Skin*, (http://tboake.com/ds/hooker.pdf).

[11] Streicher W., *Bestfaçade, Best Practice for Double Skin Façades EIE/04/135/S07.38652*, WP 1 Report "State of the Art", Institut of Thermal Engeneering, Graz University of Technology, 2005.

[12] Semper G., *Vier Elemente der Baukunst, ein Beitrag zur vergleichen Baukunde*, Semper G., Friedrich Verlag Und Sohn, Braunschweig, 1851, 55.

[13] http://www.panoramio.com/photo/13389760

[14] http://www.arscentre.com/2013/10/otto-wagner-osterreichische.html

[15] Cannondesign webpage (http://www.cannondesign.com/projects/project-catalog/office-expansion).

[16] Foster + Partners Ltd webpage, Riverside, 22 Hester Road London SW11 4AN (http://www.fosterandpartners.com/projects).

[17] Schmidt Hammer Lassen architects webpage, Aarhus (http://shl.dk/eng/#/home/about-architecture/commercial/krystallen-og-skyen/images).

[18] www.josef-gartner.permasteelisagroup.com

[19] http://www.detail.de/inspiration/bueroturm-im-minergiestandard-innovative-doppelfassade-mit-dezentraler-fassadenlueftung-100344.html

[20] http://filt3rs.net/case/automated-sunshading-facade-148

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

WACŁAW CELADYN*

DURABILITY OF BUILDINGS AND SUSTAINABLE ARCHITECTURE

TRWAŁOŚĆ TECHNICZNA BUDYNKÓW W ARCHITEKTURZE ZRÓWNOWAŻONEJ

A b s t r a c t

Life expectancy in architecture and construction is defined in different ways. Technical durability, which is crucial for the existence and usability of buildings, seems to be the most important of them. Designers and investors' attitude towards this problem is inconsistent. The paradigm of sustainable architecture brought a different approach to this issue and made it more significant both in professional discussion and practice. The durability of buildings with its relation to embodied energy in technologies and materials has become an important feature of architecture and brought substantial modification to the designing process. This paper presents different approaches to the problem in some countries as well as ambiguities and inconsistencies in pertinent views.

Keywords: durability of buildings, sustainable architecture and construction, building technologies and materials

S t r e s z c z e n i e

Trwałość w architekturze i budownictwie jest określana na kilka sposobów. Spośród nich najważniejsza jest trwałość techniczna decydująca o istnieniu obiektów oraz o ich cechach użytkowych. Można zauważyć niekonsekwentną postawę zarówno projektantów, jak i inwestorów wobec tej cechy budynków. Paradygmat architektury zrównoważonej spowodował odmienne od dotychczasowego spojrzenie na tę kwestię i przyczynił się do znacznego dowartościowania zagadnienia zarówno w dyskusjach profesjonalnych, jak i w praktyce projektowej. Trwałość techniczna budynków i jej związek z energochłonnością technologii i materiałów budowlanych stały się bardzo istotne, co spowodowało znaczące zmiany w procesie projektowania architektoniczno-budowlanego. Artykuł przedstawia zróżnicowane podejście do tego zagadnienia w niektórych krajach oraz niejasności i niekonsekwencje w panujących na ten temat poglądach.

Słowa kluczowe: trwałość budynków, architektura i budownictwo zrównoważone, materiały i technologie budowlane

* Prof. D.Sc. Ph.D. Eng. Arch. Wacław Celadyn, Faculty of Architecture, Cracow University of Technology.

1. Introduction

The capacity of buildings to offer functionally valuable spaces for a long time is defined as its durability or longevity. This parameter is usually used for determination of the real value of buildings, the rate of their depreciation and is included in insurance procedures. Durability or longevity in architecture and construction is not a simple and explicit issue. It can be considered in physical or abstract context. From the architectural and structural point of view in this discussion, the following could be considered:

– technical durability,
– functional longevity,
– aesthetical longevity

There are also other terms in use like operating durability or economic longevity, which are apparently less important for designers. Every aspect of durability in architecture is specific. For designers, durability of their products should be an important issue, mainly for ethical reasons. Their interest in longevity of buildings however, seems to be insufficient and so is their commitment to effectively resolve this problem. The technical durability in particular appears to be a negligible issue for architects as compared with aesthetic concepts and functional performance. It probably results from their incomplete knowledge concerning the effective methods to achieve durable technical solutions in buildings as well as from the ambivalent attitude of investors with regard to this feature of buildings. The methods of designing architecture however, have been recently subject to substantial evolution and modifications. Responsible for this is the dominating acceptance of the paradigm of sustainable architecture. It encourages designers to see buildings as works subject to steady destruction by the time. The paper focuses on the technical durability, which is nowadays one of the major problems of traditional and in the first place, sustainable architecture.

2. The meaning and the role of technical durability in architecture

The technical durability in architecture is an ambiguous and disputable issue. By and large, buildings are considered durable structures. Designers are generally responsible only for anticipated technical durability. For the operational or real longevity, being dependent on the intensity of use and the ways a building is used, they usually consider themselves unaccountable to investors.

The attitude of parties involved in construction procedures towards the problem of durability of buildings is ambiguous. The building owners repeatedly happen to undertake measures leading to the abatement of building`s longevity while using them. They have them rebuilt and reshaped or replace the old ones with new structures more appropriate for various functions promoted by the market. More often than not, investors envisage good performance of buildings for one generation only.

Every building material and component is subject to gradual destruction as a result of entropy and the impacts exerted by external and internal destructive factors. But the technical and functional longevity of buildings is continually less dependent on them. Presently, other factors increasingly assume the role of longevity reducers.

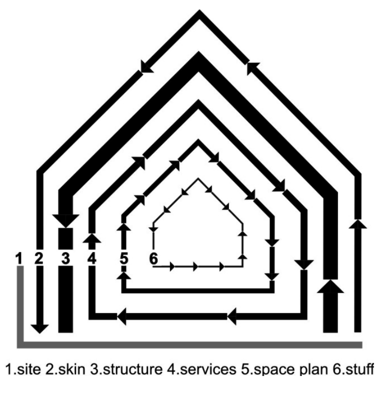
The durability of commercial buildings is gradually getting lower in Europe. This process has been stimulated by the need to adjust the buildings constructed in the 19th century to new functional requirements and legislative regulations. In some other countries however, quite the reverse occurrence can be seen. An interesting example of that is Japan, where the average durability of buildings reportedly comes to 30 years only. Such a short longevity results from local customs that demand the construction of new houses in every following generation. Moreover, in Japanese society the desire to own completely "fresh", modern houses is dominating. The new Japanese buildings get rapidly devalued and after 10 years of being in use are subject to total depreciation. Recently, however, experts indicate that the exchange of houses every 25 years carries with it enormous social and environmental consequences and costs. They recommend to speed up building production and to substantially increase the buildings' longevity.

It is widely assumed that the anticipated durability should be as long as 60 years. In the revised and updated relevant British Standard (BS ISO 15686) this clause has recently been bringing with it the depreciation of the idea of longevity in buildings. It seems that the durability does not present a serious problem for the legislature. The European trend to lessen the longevity of buildings to 50 years appears to be contradictory to the expected extension of their life- expectancy in sustainable architecture. The situation pertaining to the problem of buildings` durability can be perceived nowadays as confusing.

3. The building as a system and problems of technical durability

The analysis of the problem of technical durability of buildings indicates the need for a holistic approach. In consequence, the building needs to be seen as a logical system of connections between components of buildings and multiple factors that determine its longevity. This discussion should not be continued without making reference to the widely known diagram by S. Brand. It presents the layered structure of buildings, the shearing layers of change and their durability (Ill. 1, Table 1). The strongest impact on buildings` technical longevity have the skin and the structure. Other layers depend on them in terms of their durability.

The layered system of buildings has been accurately referred to by F. Duffy saying: "There isn`t such a thing as a building. A building properly conceived is several layers of



Ill. 1. Shearing layers of buildings
by S. Brand [1]

longevity of built components" [1]. Based on Brand`s diagram three derivative schemes can indicate the layers significant for the three aspects of durability: functional, aesthetical and technical (Ill. 3), the latter being obviously essential for the other two. The average longevity of buildings depends on the following factors:
1) function of the building,
2) applied technology,
3) environmental conditions,
4) local culture,
5) economic and political situation.

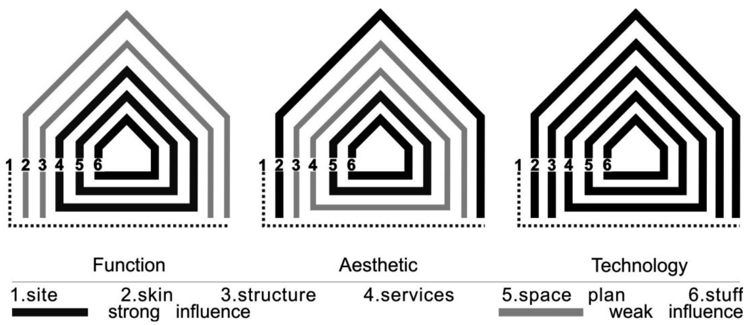
Table 1

Shearing layers of buildings and their longevity (based on S. Brand's diagram [1])

Layer	**Components**	**Useful Life** [years]
Site	Geographical setting,urban location	" eternal "
Structure	Foundation,load-bearing elements	30-300years,average 50-60years
Skin	Exterior surfaces	average 20years
Services	Technical installations	7 - 15years
Space plan	Interior walls,ceilings,floors,doors	commercial spaces 3years , homes 30years
Stuff	Furniture,appliances	weeks [10-20 years]

3.1. Function of the building

This is the basic feature of buildings which is tightly linked to their durability. For example, in the case of monumental edifices, the life expectancy is 1000 years, for residential and office buildings, usually 100 years. Commercial structures should perform usually for 50 years, but in practice they endure only 25 years [2]. After that period a thorough renovation including exchange of services, modification of interior arrangement and furniture is necessary in order to adjust the building to new functional requirements. This need reveals discrepancies between the anticipated and operational durability of buildings.



Ill. 2. The impact of building's layers on its functional, aesthetical and technical durability (based on the S.Brand's diagram)

3.2. Applied technology

The applied technology covers a wide range of problems pertaining to technical durability of buildings. Optimal selection of materials and methods of their installation, as well as initial state of the building structures, are crucial for their longevity. At the early operational stage the building can be subject to accelerated destruction due to such factors as for example, technological humidity contained within the materials freshly installed.

The materials or components can perform satisfactorily for a long time if they are autonomous within the structure, but coupled with other materials they might make up a new less stable system.

3.3. Environmental impact

The local environmental conditions often prevail over all others as destructors of buildings. Satisfactory performance of buildings in a dry cold climate may be dramatically impeded in a hot humid one leading to premature damage. Depending on the geographical location and climatic zone, buildings are subject to different rate of destruction, and in consequence, various technical durability. The most destructive relevant climatic factors are: precipitation, wind, solar radiation. The impact of some environmental factors on technical durability of basic building materials presents Table 2.

Table 2

Technical durability of some building materials and the impact of environmental factors (based on [2])

	Main material	Environment	Useful Life [years]
Base case	Reinforced concrete	Dry,non-aggressive	60
Variations in Material	Structural steel	Dry,non-aggressive	80
	Masonry and/or Timber	Dry,non-aggressive	100
Variations in Environment	Reinforced concrete	Wet,non-aggressive	40
	Reinforced concrete	Wet,non-aggressive	30

3.4. Local culture

Another factor significant for the durability of buildings is the cultural environment. Aforementioned Japan is very specific in this regard given that the customary cycle of demolishing houses, which is followed by consecutive construction of new structures, is a phenomenon based on traditional cultural principles. The Shinto shrines are also subjected to this process for symbolic religious reasons. The Ise Shrines are systematically demolished and rebuilt every 25 years. This procedure symbolizes the idea of constant renewal. The social and religious system in Japan has developed centuries-old symbolic longevity made possible by the use of specific technical solutions for religious buildings. They are based upon modular construction techniques which enable easy dismantling and reuse of building components.

According to Kisho Kurokawa, the Japanese culture accepts the aesthetics of death whereas the western culture, the aesthetics of eternity, the latter resulting in long-lasting durable European architecture and the way of treatment of building materials [3].

3.5. Economicand political conditions

A study has proved that the structural system has no clearly indicated influence on the long use of buildings. The dismantling of building structures is most frequently caused by non-technical factors like: change in the value of land and new investments (34%), inappropriate function for new emerging needs (22%), insufficient energy and ecological parameters, shortage of appropriate maintenance (24%) [4]. The enumerated factors, of mainly economic and legal character, are subject to fluctuations. Therefore the building should be designed as a set of components sensitive to changes in the real estate market. According to S. Brand, it exerts in reality a much more significant impact on architecture than all architectural and aesthetic theories, as it is in the case of technical durability. The previously Japanese example of increase in the production of buildings, as a result of the government`s policy, has also had an unexpected influence on the anticipated durability of buildings achieving currently 90 years. The opposite process could be seen in the command economies of the East European countries where the intensified construction industry brought significant deterioration of the

buildings' quality as well as the diminuation of their durability. The political factors turn out to be a significant stimulant of durability in construction.

4. Durability in sustainable architecture

Former views of the durability of buildings had to be changed because of the paradigm of sustainable architecture which assumes new methods of design and construction of buildings. The longevity in architecture is now comprehended as a broader and more complex issue than before in traditional architecture. Its significant meaning for sustainable architecture, especially the technical durability, has been emphasized for some time. Despite that, durability is the aspect of ecological assessment of buildings, which unfortunately, is still rarely discussed, compared with the dominating energy problems. Some difficulties in this regard result from emerging collisions between the striving after high commercial values of buildings and the principles of sustainability. The degree of sustainability of buildings and their components in design strategies is defined by many features related in some way to durability:

– functional effectiveness (low cost and simple technologies) – adaptability (easy change in function and potential for relocation in the future) – easiness of demountability and separation of combined materials or components for reuse
– selection of materials susceptible to recycling – aptitude for maintenance – transparency (clarity of applied technical solutions and easy inspection) – evolutive capacity (possibility of future improvements) – dynamism of systems allowing for ecological risks instead of their stability

The analysis of those requirements suggests that sustainable buildings should be constructed within a broad range of possibilities either as durable (permanent) or impermanent renewable, which is only an apparent contradiction. The durability should be considered in this case, not only as the feature of the integral building as a whole, but also as a set of components and materials designed for reuse in the reshaped original building or a new structure. Such a view allows for a flexible comprehension of the problem being different from the traditional.

The buildings that contain more long-lived components require less technical supervision and are considered more durable, in terms of sustainability, due to savings in energy and materials used for construction. The longer the period of time in which the building is used, the lower is its annual share of embodied energy used for construction. In consequence, the efforts to lower embodied energy of buildings should allow for the necessary increase in their durability. More and more often, it is acknowledged that sustainability of buildings is a function of their durability. The Bullit Center Building in Seattle, is considered the "greenest" structure in the world because of its designed durability defined as significantly longer than 73 years, which is the average for the USA [5].

The durability of buildings is being now and as it seems, will be steadily increased in the future steadily, because of improvements on technical solutions and energy efficiency. Form and function of buildings are being changed constantly due to the development of technology, economy and new styles in architecture. The character of these changes is unpredictable. But designers have to make some theoretical assumptions in this regard. If the evolution of a building has not been envisaged, its renovation, reshaping or dismantling in the future is bound to be costly, both financially and environmentally, due to the poor flexibility of design solutions. A study of this issue has indicated that the cost of modifications made in buildings during their 50-year operation are twice as high as the cost of the original construction. During that time the plans of buildings are subject to 6 and services to 4 changes [3]. Premature dismantling of structures is detrimental to the environment, due to the discharge of used materials to landfills and the need for the manufacture of new ones. The anticipation of future adaptations of buildings at the design stage would certainly result in financial savings.

The problem of durability in construction is gradually accepted in some regulations of sustainable architecture. The International Green Construction Code (IGCC) is a model document aimed at the promotion of legal acts concerning sustainable architecture as well as an encouragement for its introduction to national building codes. Recent updates therein recommend the service life plan (BLSP) to be added to design documents. It should cover the designed 60-year life span of buildings (Art. 505.1) and permit future reconfiguration, dismounting and disassembly of partitions, modifications of lighting and electrical systems, suspended ceilings, raised floors and interior air distribution systems for a minimum of 25 years. The document stipulates that interior materials, components, and assemblies have a minimum service life of 25 years and are adaptable to future reconfigurations within the interior spaces (Art. 505.1.2).

4.1. Adaptability of buildings

The term "adaptability" denotes the ability to adjust oneself readily to different conditions. In architecture, this means the susceptibility of buildings to changes. The easiness of modifications and reconfiguration is one of the basic elements of strategy for sustainable architecture. It allows buildings to be effectively used far beyond the planned life span of the original structure. Adaptability in architecture is then, its feature that permits to extend the durability of buildings and thus meets the relevant requirement for sustainable construction.

Many guidelines for the design “for adaptation” are in accordance with those of the design “for deconstruction” meaning focusing on easy dismounting, simplicity of construction, repetition and transparence. Complicated structural systems require costly expenditure and conservative technical solutions.

The need for functional and technological changes is characteristic of office buildings as well as industrial, school and religious architecture. Commercial malls are designed for a short period of time, and therefore should be built in conformity with the deconstruction strategy [4]. Adaptability in architecture means:

– accessibility (design of spaces accessible for all stages of use and different physical conditions),
– open plan (enables variable interior plans – mainly in offices),
– expansiveness (interactivity, reactivity to environmental changes through diversified mobility, location and geometry),
– effectiveness (relating to function and susceptibility to maintenance works).

4.2. Technologies and materials in sustainable construction

Applied technologies and materials condition technical durability of buildings. In the strategy for sustainable architecture this issue emerges as different from that in traditional construction. Preferred technologies should correspond with the idea of adaptability which is facilitated by orderly geometry of plans, modular and durable structure. Recommended are large-span prestressed, prefabricated systems. Priority is the application of building technologies characterized by low embodied energy and high durability. A major problem, within this context, is the search for appropriate balance between these two parameters. Materials of higher durability can be exchanged less frequently, and that results in reduced consumption of raw materials and energy. The most advantageous materials for sustainable constructions are those considered most ecological and most durable. During the last 35 years the durability of some building components has risen due to new advanced technologies, while that of some other has decreased. It has been indicated that the durability of buildings or their elements depends mostly on the quality of their maintenance. Durability of materials used in traditional and sustainable architecture is much the same, as they are more often than not, the same materials. The life span of traditional materials is diverse and dependent on the method of their application. As an example, durability of stone, brick or concrete is 75 years, structural steel 50–100 years, prefabricated reinforced concrete structures 100 years and wood 30–300 years [3]. It turns out that industrial methods of construction, offering modular building components recommended for innovative sustainable architecture, allow to attain higher quality of buildings, due to more advantageous climatic conditions outside the building sites. They also contribute to better workmanship and by that increase the life expectancy of buildings.

Some of building technologies are considered controversial in terms of their durability. One of them is the layered structure of exterior walls in the light framing systems, where the permeability of water vapor is a real nuisance, as it exerts a negative impact on the building’s longevity. In some opinions, the vapor barriers in these systems should be avoided in order to counter the problem and to increase their life span. The elimination of some sealing systems, in favor of controlled airflow and vapor penetration through building envelopes, is a promising idea however, it collides with the formerly applied strategy of air-tight sealing of interiors in traditional architecture. The strategy of sustainability assumes using if possible, reused materials and components. They can be disassembled and directly reinstalled. Another method is the use of materials or components after transformation in a recycling process. Research works have proved that the application of reused materials in construction is advantageous for the environment because its load is reduced by 70% [6]. This method however, should be combined with the analysis of potential durability of reused materials, as they can become "weak elements" within the building`s structure and in consequence, lower the operational durability of a building.

There are some guidelines for materials designed for future reuse, which recommend the application of:
– small size components susceptible to manual installation,
– modular measurement,
– removable connections,
– strong, demountable materials and components,
– layered systems instead of glued ones,
– setting up of storage spaces for dismantled materials and components.

Durable building materials should enable easy exchange within the components and effective maintenance. Their longevity can also be extended by susceptibility to repairs.

5. Durability versus building certification systems and design problems

Within the frames of multicriterial ecological certification systems for buildings, the problems of durability are hardly considered. In different systems it is variously placed and treated. The impact of certification methods on building parameters associated with durability is not the same. Construction experts for instance, claim the BREEAM has an impact on structure in 24%, on quality of materials in 59%, and on services in 63% of the cases [7]. The LEED neglects the values of design "for deconstruction" in the future. The LEED Canada grants only one credit for the durability of selected building materials. This underestimation of the issue of building`s longevity by the certification systems is incompatible with the requirements for ecological architecture, and is contradictory to the increasing role of durability in the design of buildings. The technical durability of buildings is one of their principal aspects considered in the life-cycle assessment method (LCA), being a basic tool for ecological evaluation. It is made out on the basis of assumed 50-year designed durability of buildings. The increase of buildings` sustainability, due to higher longevity, adaptability and easy dismantling characteristics, is seen as the principal task of environment-conscious designers. The integrated design method enables and facilitates the appropriate comprehension of durability problems and fosters optimal solutions . In the first place it is recommended for important and complex investments and is widely accepted for green constructions. According to this method, it is customary to form design teams including, besides the traditionally participating professionals , also experienced building managing staff . This guarantees the avoidance of serious errors at the design stage and promises both appropriate use and long durability of facilities.

6. Conclusions

As it has been stated, the durability in sustainable architecture is an important issue and sometimes also a major problem which needs to be solved both at the design and the execution stage of buildings. It is however, underestimated and its role in the design strategy for sustainable architecture is unsatisfactory, compared with the prevailing energy issues. The relations between embodied energy of materials and their durability characteristics has not yet been appropriately studied and recognized. Efforts to make the longevity of buildings more attractive and an important task for designers and other members of construction procedures should be undertaken. It is worthwhile to consider the suggestion of carrying out in-depth studies of the building performance long after its erection, and that by the designers. The feedback method would be of use in this case to the advantage of architects who would thus be able, to gain knowledge about errors and faults committed during the design procedure. Given the changing role of architects, as members of the multidisciplinary integrated design teams and the importance of architectural science being a valuable support in professional activity, the knowledge of durability problems should be better appreciated in architectural practice. It should also be taught as part of the architectural educational system.

References

[1] Brand S., *How Buildings Learn. What Happens After They Are Built*, Penguin, Books, 1994.

[2] Dias W.P.S., *Useful Life of Buildings*, Department of Civil Engineering University of Moratuwa, 4 June 2003.

[3] Flager F.L., *The Design of Building Structures for Improved Life-Cycle Performance*, MIT, June 2003.

[4] Kestner D.M., Webster M.D., *Achieving Sustainability through Durability, Adaptability, and Deconstructability*, “Structure” magazine, March 2010.

[5] Rbpen A., *Test of Time*, Arch[be]log, University of Washington, 16 April 2012, www.adaptablefutures.com, 2010.

[6] Khasreen M.M., BanfIll Ph.F.G., MenzIes G.F., *Life-Cycle Assessment and the Environmental Impact of Buildings: A Review.* Sustainability, 1, 2009674-701, doi:10.3390/su1030674.

[7] Parker J., *Where Breeam Influences* (www.bsria.co.uk).

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

RAHIMA USMANOVNA CHEKAEVA, FARID MNIROVICH CHEKAEV*

WSPÓŁCZESNA ARCHITEKTURA MIESZKANIOWA W ASTANIE

MODERN LIVING ARCHITECTURE IN ASTANA

A b s t r a c t

This paper characterizes the architecture of a new residential complex "On the green waterside boulevard". It is located in the most prestigious district of the capital city on the left bank of the River Yesil near the Presidential Palace, a circular layout and the "Baiterek" tower. The complex expresses a new era, various tastes as well as different aesthetical and moral values. Therefore, it surprises and dazzles onlookers with its unusual artistic expression and the unexpected technological imagination of its authors. The latest building materials and the applied technologies emphasize the innovativeness of the adopted solutions.

Keywords: architecture, modern housing architecture, technological imagination

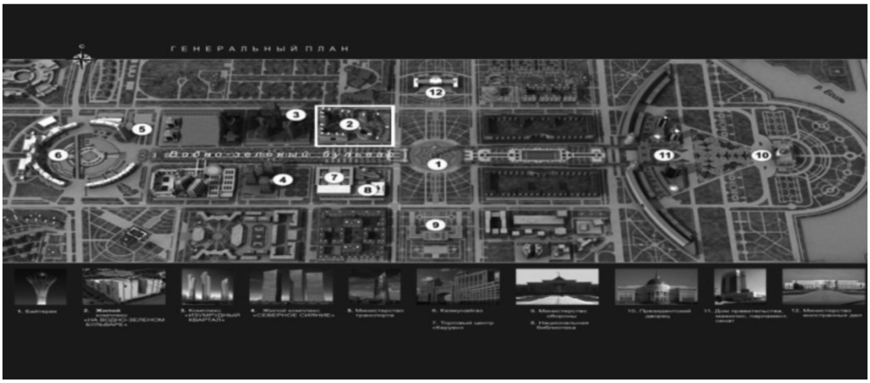
S t r e s z c z e n i e

W artykule niniejszym scharakteryzowano architekturę nowego zespołu mieszkaniowego „Na wodno-zielonym bulwarze". Jest on zlokalizowany w najbardziej prestiżowym rejonie stolicy – na lewym brzegu rzeki Iszym w pobliżu Pałacu Prezydenckiego, placu okrągłego i wieży „Baiterek". Kompleks ten stanowi wyraz nowej epoki, rozmaitych gustów, całkiem odmiennych wartości estetycznych i moralnych, dlatego zadziwia oraz poraża niezwykłością swojej artystycznej ekspresji oraz oryginalnością technologicznej fantazji autorów. Najnowocześniejsze materiały budowlane i zastosowane technologie podkreślają nowatorstwo przyjętych rozwiązań.

Słowa kluczowe: architektura, nowoczesna architektura mieszkaniowa, fantazja technologiczna

* Prof. D.Sc. Arch. Rahima Usmanovna Chekaeva, Assoc. Prof. D.Sc. Arch. Farid Mnirovich Chekaev, Faculty of Architecture and Construction, L.N. Gumilev Eurasian National University, Astana, Kazakhstan.

A new residential complex "On Water – Green Boulevard" is located in the prestigious district of the capital – on the left bank of Ishim river, near the Presidential Palace Square and circular "Baiterek". It fits in the overall landscape of the city center. In general, all these buildings create a unified architectural ensemble. Stylish and dynamic, the complex most fully expresses the idea of combining modern technological era buildings with the dream of humanity in a wonderful distant future. The integrated construction and infrastructure make it attractive and comfortable for living, and the proximity of parks and magnificent fountains only emphasize the advantages of the complex.



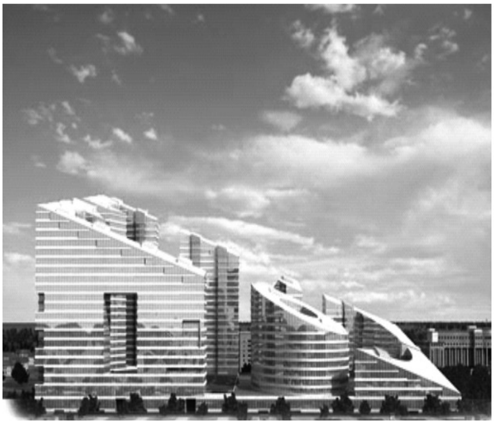
Ill. 1. Water – Green Boulevard (source: [1])

It is best to visit here during the day, to see the magnificent play of light of the rays of the midday sun on the glaring chrome and metal surfaces. In the evening, when the city is artfully illuminated by numerous spotlights, the complex looks like a grand structure.

There is always plenty of sun, light and air, and from the river Ishim, blows a fresh cool breeze. The residential complex "On Water – Green Boulevard" is for those who love our young and wonderful capital, who enjoy its internal energy and x appreciate the comforts of the present.

The residential complex "On Water-Green Boulevard", built in a "high-tech" style, is a fantastic spectacle that cannot be immediately covered by the eyes. It is amazing! The clear form of construction, gives the composition conceived by the authors, the effect of a special technogenic appearance. Endless repetition of quite simple elements create the most complex shapes. Rapid, straight lines are complemented brilliantly by glass and metal parts. The complex is like a new era of different tastes with completely different aesthetic and moral values, as is the surprising and striking singularity of its artistic expression and unexpected technological fantasy of its authors.

A bold technical design is made with exceptional perfection and elegance [2]. The "high-tech" style, not only captures the look of the buildings in its orbit, but also the environment, landscaping elements and scenery, which lie near the set of paths, playgrounds and parks; ironically their smooth, fluid shapes contrast with the pointed geometric shape of the building. Engineering shape admiresx the image of something "unpresentable" that "does not happen in reality" and looks calm and harmonious, just like the natural habitat of man.




Ill. 2, 3. Residential complex “On Water – Green Boulevard” (photo by authors)

The air architectural design of the new complex of the capital was built on the principles of dynamics, transparency and monochrome. Stylish and extremely easy, impressive and elegant, the residential complex is at the same time a step into the unknown arousing curiosity and admiration and presenting a wonderful synthesis of high technology and the arts.

Emotional delight in the perception contributes to placing songs in the middle of a single integrated development of the city center. Impression is reinforced by the fact that the walls are almost devoid of any ornaments. The huge complex was conceived as an image of the real future, which heard the echoes of ancient wonders. These live trees, like the “hanging gardens” of ancient Babylon, are the only decoration of the walls.

Ill. 4. “Hanging Gardens” (photo by authors)

The composition is of asymmetric buildings. The complex is appealing with simple clear lines and volumes. The advantage of the architectural composition and the complexity of constructive solutions is a clear structuring of the image.

Each one of the 1, 2, 3, 4 bedroom apartments ranging in size from 45 to 160 square meters of the residential complex “On Water – Green Boulevard” have unique planning solutions which are non-standard and unlimited in any incarnation. Lovers of modern design trends or adherents of the traditional can create according to personal taste and desire. Minimum load-bearing walls allow zoned space as desired and any apartment can be a true masterpiece of design art. The solid glass facade visually extends the room allowing life to be more comfortable and harmonious. The apartments open to luxurious panoramic views [3].

The residential complex “On the Water – Green Boulevard” has all the necessary ingredients for a comfortable life. The complex will provide the opportunity to be happy, live life to the fullest, always smile and feel fit. There is a gym, billiards, virtual golf course and swimming pool. The pool water is crystal clear and a gentle blue. A cozy small apartment cinema designed for 15 people, relax every cell of the body. Sitting in a comfortable chair, one becomes fully aware of the unusual ideas of the creators of this beautiful room. The children’s two-part game room provides space to have fun for playful children. In addition, there is no worry about where to come with guests. The hotel complex design has eight rooms, which include all the conditions in order to have a good time and relax. It offers an unforgettable atmosphere of coziness and comfort with the unique combination of excellent quality and great hospitality.


Ill. 5, 6. A general view of a residential complex on the “On the Water – Green Boulevard” (photo by authors)

Accommodating parking lots located on two floors of the stylobate are provided for the tenants and enough sites for guest parking, which is important due to increasing traffic flow in the city center and the lack of parking spaces. An hourly security surveillance of the surrounding area will be carried out using a multi-level electronic security system: access control, concierge in the lobby, surveillance cameras around the perimeter of the building and grounds, computer control of all life-support systems of the complex.

The complex “On the Water – Green Boulevard” meets all the requirements in the age of high technology [1]. The latest technical solutions make life comfortable and cozy. For the comfort and convenience of home owners the best equipment for heating systems were selected. All apartments have heat counters. Modern heating systems are equipped with high quality heaters with thermostats. Even on the hottest day, a single air-conditioning system will create an atmosphere of freshness and coolness in the appartment. Due to these systems the required temperature is reached and supports a freshness of air necessary for normal human life. On request, the temperature can be set for personal comfort. For quick access to the Internet a special line is dedicated. Excellent call quality is carried through fiber-optic lines. High-speed silent elevators from well-known manufacturers smoothly and quickly service the floors.

The main task of the services used "On the Water – Green Boulevard" is to create a welcoming and friendly atmosphere. This means that you do not have to worry about everyday minutiae. All the trouble of cleaning and minor repairs of the buildings will be taken over by the operation of the service team with vast experience in the operation of elite buildings. Every day, in-house and on-site immaculate cleanliness and order is provided. Master gardeners with special diligence and zeal monitor vegetation, plant flower beds and trees and trim shrubs. The courtyard is always well maintained and blooming. Highly skilled service professionals, electricians, plumbers and lifters survey the clock engineering systems of the buildings, elevators, air-conditioning, electricity and water supply.

Today the residential complex "On the Water – Green Boulevard" is not only one of the most extraordinarily beautiful architectural complexes of the capital, and even the whole of Kazakhstan, but also is the most unique building in terms of infrastructure. Being the home of a new generation of residential complexes "On the Water – Green Boulevard", always gives the impression of being the most ideal place in the entire city with unique opportunities for leisure and recreation.

Conclusions

Studies have shown that the architecture of modern residential buildings is an attempt to take into account regional peculiarities:

- This period is characterized by the principle of the location of residential buildings along the main squares of the city in the form of creating architectural planning units and complexes;
- Despite the originality and uniqueness of each unit, the buildings are in total harmony with art, subject to the overall planning concept and fold into a single expressive architectural ensemble;
- The architecture of the building combines, modernity and ethnic elements (colored in blue);
- The use of modern construction techniques and the latest technical solutions make life comfortable and cozy; the architectural design of the new complex of the capital is built on the principles of dynamics, transparency and monochrome;
- It provides comfortable parking.

References

[1] Kurokawa K., *Architect and assisiations*, Project Solutions of New City: Astana, 15.08.1998.

[2] Kurokawa K., *On the basic concept of general plan of Astana*, June 2001, General explanatory, note 3.3, pp. 3-34.

[2] Chekaev F.M., *The problems of the development of architecture in the early twentieth century (for example, Astana)*, Herald ENU, L.N. Gumileva, No. 3, 49, 2006, pp. 313-321.

[3] Chekaeva R.U., *Architecture of Astana City of the 21st century*, Architecture, Building and Transport: Problems and Prospects of Materials republican scientific – practical conference – ENU, Astana, 5–6 May 2010, pp. 70-74.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

FARID MNIROVICH CHEKAEV*

INNOVATION IN MODERN ARCHITECTURE ASTANA

INNOWACJE WE WSPÓŁCZESNEJ ARCHITEKTURZE ASTANY

A b s t r a c t

This paper analyzes the development and application of new modern eco-friendly building materials. Owing to innovative architects, engineers found an unusual material: ETFE. It is often called a miracle constructional material characterized by sufficient strength, a special surface, self-cleaning, the ability to withstand sun exposure as well as heat-insulating properties.

Keywords: architecture, new modern eco-friendly building materials, ETFE

S t r e s z c z e n i e

Artykuł zawiera analizę rozwoju i zastosowania nowych ekologicznych materiałów budowlanych. Dzięki innowacji architektów inżynierowie odnaleźli materiał niezwykły: ETFE. Jest on często nazywany cudownym materiałem budowlanym. Charakteryzuje go odpowiednia moc, specjalna powierzchnia, samooczyszczanie, odporność na promieniowanie słoneczne oraz właściwości izolacyjne.

Słowa kluczowe: architektura, nowoczesne ekologiczne materiały budowlane, ETFE

* Assoc. Prof. D.Sc. Arch. Farid Mnirovich Chekaev, Faculty of Architecture and Construction, L.N. Gumilev Eurasian National University, Astana, Kazakhstan.

The project is the unique complex “Khan Shatyry” with a giant transparent tent. It has become a leisure center in Astana with a mini-golf course, a small lake, botanical gardens, indoor beaches, beauty centers and salons, concert halls, luxury condominiums, offices, a five-star hotel and a shopping center. “Khan Shatyry” is considered one of the biggest in the world at a height of about 200 m and a volume of 1.5 million kub.m.raspolozhen on 50 acres of land. This project is original in that the climate within the “city” is governed by internal modern automation .

Ill. 1. Botanical garden and an indoor beach
(source: Conceptual design of Khan Shatyr, Foster and Partners)

It was conceived by Norman Foster and thanks to a special coating and air conditioning system in x harsh climatic conditions, especially in the winter, the temperature at the mall throughout the year is optimal for family walks and shopping.

“Khan Shatyry” is two-thirds covered with a transparent coating of a special hollow plastic etilfluoretilenovoy film ETF, the material of the new generation, thanks to which the inside of the building will always have the same temperature and daylight. To heat a tent in 30 – degree weather is not difficult [1]. ETFE appeared in the 70s of the last century when the DuPont corporation invented a marvelous film for aviation (protection from sun exposure); however, it was a German student named Stefan Lehnert who studied engineering and business management that turned it into an architectural material. He worked on the topic of unclaimed commercial know-how.

Later, in 1982, Stefan founded the production company Vector Foiltec, which became a major manufacturer of architectural membrane in Europe (trade name Texlon). Of course, ETFE manufactures and American pioneer and Japanese glass company Asahi, which partly explains the particular fondness Kurokawa.

Ill. 2. Resting place in the winter time
(source: Conceptual design of Khan Shatyr, Foster and Partners)

Ill. 3. A general view of the "Khan Shatyry" during the construction period
(source: Conceptual design of Khan Shatyr, Foster and Partners)

Ill. 4. A general view of the “Khan Shatyry” during the night
(source: Conceptual design of Khan Shatyr, Foster and Partners)

ETFE is quite simply, etilfluoretilen. Production of etilfluoretilen films brings to mind the environment as it occurs in a closed cycle and furthermore, can be fully disposed. The obvious advantages of the membrane is light weight (weighing 100 times less than glass), high speed of installation, ease of transportation and a self-cleaning surface. It was originally founded for its ability to resist insolation x and its thermal insulation properties depend on the number of layers of air sealed within. The economic benefit has recently been called into question, but today it is already clear that the use of membranes in general is less expensive than glass, as the design becomes easier and the installation costs are reduced by at least 25 and at most by 70%. The service life today is 50 years (Kurokawa, among others, was forced to go to the cabling structure because of durability).

ETFE, a fluorocarbon-based polymer, opens new horizons for architects and designers in Kazakhstan and around the world. Imagine swimming in an arena made of bubbles or a stadium connected with steel beams like a bird’s nest, or even a huge tent proudly covering over a million square feet of space. Ten years ago, such a building may have existed only in the imagination. Today, they are constructed in Beijing: China’s new National Stadium and National Aquatics Center. All, thanks to x innovative architects, engineers and the unusual properties of a material called ETFE. ETFE is often called the miracle material of construction: sufficiently durable material to withstand 400 times its own weight, can be stretched to three times its own length without loss of elasticity, has a special surface that resists dirt, durability of about 50 years.

Weighing about 1% of the weight of glass, single-layer ETFE membrane is very light. This, in turn, gives a reduction in the weight of frames and imposes significantly less dead loads on the supporting structure. This reduction in the requirements for steel structures, provides many cost benefits to customers and is a key advantage when replacing glass in structures in order to meet current building regulations [2].

ETFE is an environmentally friendly building material. While being a 100% recycled product, the minimum consumption of energy for transport and installation means that it makes a significant contribution to the transition of a green building.

One of the major works of the architects of this century is the “Water Cube” in Beijing. You can start with the fact that this “pool” built of tetrafluoroetilena (ETFE), the durable, lightweight and transparent polymer that can withstand heavy loads, when a nearby fire does not smoke and does not light up – it just is formed hole. One could say that the polymer can be stretched over a frame of steel wire. The walls of this remarkable plastic look amazing: a pillow. Instead, they represent bubbles in water, as suggested by their numbers, but most of all they resemble lather. All the bubbles are of different sizes and shapes. Being in size from 1 to 70 m^2, they are independent of each other and if one bubble is damaged, the rest will be able to maintain the building in good working condition.

Ill. 5. The National Aquatics Center
(source: Conceptual design of The National Aquatics Center)

Ill. 6. The building of the Faculty of Law
(source: Conceptual design of Faculty of Law)

In the British city of Salford, the architectural firm Broadway Malyan designed and constructed the building of the legal department. It is interesting from many points of view, but it is most evident thanks to the lecture room, wrapped in ETFE and back-lit led- lights mounted in the gap between the walls and membranes.

These are not just simple decorative elements. Their interior space is filled with air, which is excellent thermal insulation as the space will not overheat and supercool. If for some reason the temperature in the building x falls below normal, the x electronically controlled pumps will make the adjustment by pumping warm air from inside the bubbles. At high temperature, the ventilation system will use the external air and not that from the membranes. Another remarkable feature of the "cube" is its seismic resistance.

Polymer coatings ("film") is constantly being improved in scientific laboratory programs: Dupont, Foster + Partners, Skidmore, Owings & Merrill (SOM) and Gehry Partners. By increasing the number of layers, including a special layer of «nanogels» gives the opportunity to increase the thermal properties of ETFE membranes. Along with its low weight , the main advantage is its high ETFE trasparency. Knowing its property to transfer up to 95% of the light, it is easy to see why it was chosen to build the Eden Project Biomes in 2000 and most recently the biopark tank in London (completed in 2011), where the full spectrum of natural light and UV is essential to plant health.

Independence from ultraviolet radiation, air pollution and other forms of environmental weathering makes ETFE membrane a very durable material . The structure of the plates has evolved for more than twenty-five years and extensive laboratory and field studies have shown that the material has a shelf life of more than 40 years.

A lot has happened very quickly in the development of ETFE. For thirty years, it worked its way from creation to one of the most popular building materials, but there is still much that needs to be done. The preference of ETFE, as a durable building material will lie in the development of various high-tech membranes and methods of coating which will alter not only the transparency but also the thermal and acoustic properties of the tissue itself [3].

Thus, the following conclusions can be drawn: the advantages of the membrane is its light weight (weighing 100 times less than glass), high speed of installation, ease of transportation, self-cleaning surface, the ability to resist insolation, thermal insulation, the use of membranes in general, less expensive, life of about 50 years. ETFE is also an environmentally friendly building material and the massive use of these polymer coatings must be developed for the construction of railway stations, sports facilities, large barns, shopping centers, etc.

References

[1] Norman + Partners Design Service (site).
[2] Chekaeva R.U., *Architecture unique structures Astana Herald ENU*, No. 5, 66, Astana 2008, 206-213.
[3] Rühle M.K., Gosstroyizdat M., *Modern building materials*, 2003.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

JAN CREMERS*

ENVIRONMENTAL IMPACT OF MEMBRANE AND FOIL MATERIALS AND STRUCTURES – *STATUS QUO* AND FUTURE OUTLOOK

WPŁYW MEMBRAN ORAZ MATERIAŁÓW I STRUKTUR FOLIOWYCH NA ŚRODOWISKO – *STATUS QUO* I PERSPEKTYWY

Abstract

In early times and until the 1970s most of the membrane structures built were meant to be temporary. This applies to early Roman shading systems, military, nomad and circus tents, as well as to Frei Otto's early oeuvres. The global building sector as a whole, is of great importance with regard to a future sustainable use of our planet's resources: Here, approx. 50% of all primary resources and 40% of all primary energy are used, and 30% of all green house gases are produced. Also, the sector is responsible for up to 40% of all solid waste[1]. This paper[2] provides an overview on the complex aspects of environmental impacts of membrane materials and structures, and how to meassure them using life cycle assessment methodology. It briefly shows where this kind of information is used (e.g., for building assessment systems/rating schemes) and finally indicates the current status in the membrane sector.

Keywords: Membranes, PTFE/glass, ETFE Foil, PVC/PES, Photovoltaics (PV), Life Cycle Assessment (LCA), Grey Energy, Environmental Product Declaration (EPD), Building Assessment Systems, Building Rating Schemes

Streszczenie

Aż do 1970 roku większość konstrukcji membranowych było traktowanych jako tymczasowe. Odnosi się to do wczesnych rzymskich systemów osłon przeciwsłonecznych, wojskowych, pasterskich i cyrkowych namiotów, jak również do wczesnych konstrukcji Freia Otto. Globalny sektor budowlany jawi się jako niezwykle istotny w kwestii przyszłego zrównoważonego wykorzystania zasobów naszej planety. Jest odpowiedzialny za wykorzystanie około 50% pierwotnych zasobów naturalnych, 40% pierwotnej energii i za produkcję 30% gazów cieplarnianych. Z nim jest związana również produkcja 30% stałych odpadów. Artykuł stanowi kompleksowy przegląd aspektów wpływów środowiskowych materiałów i konstrukcji membranowych, jak również porusza zagadnienie sposobu ich charakterystyki metodą oceny ich cyklu życiowego. Wskazuje również, gdzie taka informacja jest wykorzystywana (np. w systemach oceny budowlanej, metodach klasyfikacji) i ostatecznie ocenia obecny status sektora membran.

Słowa kluczowe: membrany, PTFE/szkło, folie ETFE, PVC/PES, ogniwa fotowoltaiczne, ocena cyklu życiowego (LCA), szara energia, deklaracja produktu środowiskowego (EPD), systemy oceny budynków, systemy klasyfikacji budynków

* Prof. Ph.D. Eng. Jan Cremers, University of Applied Sciences, Stuttgart.

[1] According to M. Atif, Chairman IEA Buildings & Communities, CISBAT 2007.

[2] This paper builds on material partly published before in [1–4], it reflects the status on the subject of mid 2013.

1. Introduction, key environmental issues affecting architectural fabric structures and the global picture

Increasing energy efficiency in the operation of buildings is a major challenge of our time. This normally refers to the energy demand (non-renewable) to run the building. But we also have to focus on the energy consumption ("grey energy") and environmental impact of the materials and structures used for our buildings, with regard to their full life cycle, from the production to recycling or disposal. This means, to add the topics of limited resources, waste and environmental impacts of materials and processes to the balance sheet and therefore, to the agenda. It is important to understand that the effects of our planning decisions extend deeply into the future. And with increasing energy efficiency, the relative impact of 'grey energy' of building materials and processes becomes much more important (cp. Ill. 2).

Most buildings using foil and coated textile materials today are meant to last for decades. The membrane industry is proud to also offer this perspective to its clients when they embark on its materials and structures. In parallel, the planet's resources are shrinking and become more and more contested and hard-fought. Compared to other industry branches, the building sector is still lacking efficiency in the use of materials and rationalization because the overall recycling rate is very low.

With regard to the membrane industry we see a two-faced discussion:
On the one hand, we apply polymers that use of the enormous amounts of energy for their production. They contain a high amount of primary energy in relation to their mass and emissions from some of the materials, can present dangers for the environment and users. This is a global issue: Membrane materials a perceived as being part of the world of polymers ("plastics"). And plastic debris is everywhere – on land and at sea, and on different scales: from big and visible things like PET bottles and plastic bags to extremely small, sand-sized things which get into the food chain and become a threat to many animals (fish, birds and others). And in contrast to a common expectation, polymers in the environment are a very long lasting type of material.

On the other hand, they have an undoubted potential for generating resource and energy savings through types of construction that utilise these materials very efficiently.

2. Traditional reasoning why membrane strcutures are beneficial to the environment

When it is argued that membrane structures and materials are environmentially friendly, people commonly refer to the very low mass per area of membrane material. There is a significant weight reduction compared to alternative transparent or translucent materials:

ETFE foil	~ 0,5 kg/m^2
coated fabric	< 1,8 kg/m^2
PC/PMMA (6–8 mm)	~ 5 kg/m^2
glass (10 mm, laminated)	~ 25 kg/m^2
membrane/foil vs. PC	~ 1:3 up to 1:10
membrane/foil vs. glass	~ 1:10 up to 1:50

But there are more reasons why the use of membrane material potentially reduces the weight of a building structure per square meter:
The use of membranes as a cover material allow for high deflection within the primary structure. This applies to the buidling envelope, i.e. facades, but most of all to roof structures. Membrane materials themselves are far lighter than rigid alternative materials. This leads to a reduction of downloads, also in combination with snow loads and thus to a lighter primary structure. Compared to other translucent materials, secondary structures can be significantly reduced (due to larger span potential and/or reduced safety issues). Typically, increase of secondary steel of a non-membrane solution[3]: 100–200%.

Combining membrane materials with cable structures, offer a high potential for further optimizing: Soft membrane materials allow for larger deflections compared to glass or polycarbonate (PC). They allow for large span widths of main trusses. No expansion/movement joints are needed within membrane covering compared to rigid solutions. Membrane cable structures can be designed to be virtually maintenance free depending on the proper choice of materials (e.g., aluminium extrusions, stainless steel fittings), installation procedures, etc. This might be a key benefit, as later maintenance work on conventional structures tend to be a great deal and effort (for example, at the interface of trusses and covering materials). These benefits of combined cable and membrane structures are commonly used and have lead to a great variety of projects using this technology (cp. Ill. 1).

Here, some selected stadium examples are listed. When looking at the resulting figures for roof area related weight, different boundary conditions have to be taken into account: Differences in size of the roof, in applying snow loads (Maracana: none, Warsaw: very high), additional loads (video screen cube at Warsaw) or fixed/retractable roof structure. As a result, the weight figures provided can not be compared one to one. The sample projects also show very clearly that the 'engineering intelligence' of a structure, additionally holds a high potential to save weight (and therefore drastically reduces its environmental impact).

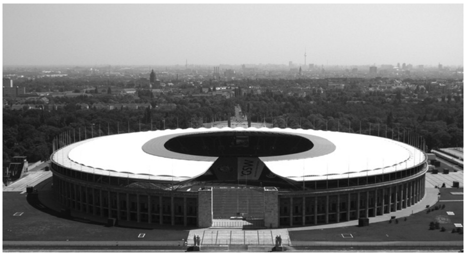
Other aspects of membrane structures also have an influence on the life cycle assessment of a membrane structure. These are, for example, the expected life-time, demand on cleaning and maintenance:

- Service life-time of different potential cover materials:
  - Polycarbonate (in challenging climate like Middle-East, Brasil) < 15 years,
  - PTFE/glass, ETFE foil ~ 30 years,
  - Glass lasts longer, but requires complex and costly sub-structure,
  - Metal sheet roofs are cheap, but not translucent and therefore require artificial lighting, also maintenance for water proofing,
- Cleaning/Maintenance;
  - PTFE/glass and ETFE foil are 'self-cleaning' (if there is rain),
  - other materials which require cleaning (water, energy, cleaning agents), might lead to faster aging (PC, for example),
  - Glass and PC roofs might need significantly more maintenance after 10–15 yrs, compared to PTFE/glass and ETFE (mainly due to aging of the watertight joints, as compared to a homogeneous membrane surface).

---

[3] Sample calculation based on: Main trusses at a distance of 15 m, membrane arches ~10 kg/m^2, PC incl. sec. struct. ~30 kg/m^2.

Olympic Stadium, Berlin (2004)



- 27 000 m² PTFE-coated glass fabric, 28 000 m² Mesh fabric, 6000 m² glass
- cantilevered structure, two membrane layers
- weight of support structure excluding cladding (33 000 m² roof)

~ 106 kg/m²

Gottlieb Daimler Stadium, Stuttgart (1993)

- 34 000 m² PVC-coated polyester fabric
- spoked-wheel structure, secondary arch structure
- weight of support structure excluding cladding (incl. compression ring)

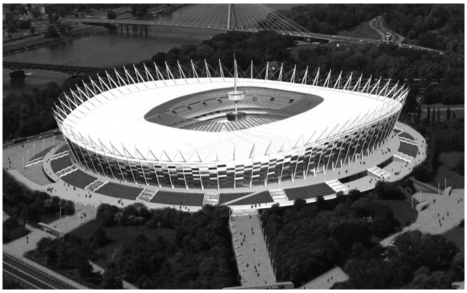
~ 91 kg/m²

Stadium Mário Filho (Maracanã), Rio de Janeiro (2013)

- 43 800 m² PTFE-coated glass fabric/roof area 45 500 m²
- steel and cable structure 2900 t + 840 t = 3740 t
- weight of support structure excluding cladding (incl. compression ring)

~ 82 kg/m²

National Stadium, Warsaw (2011)

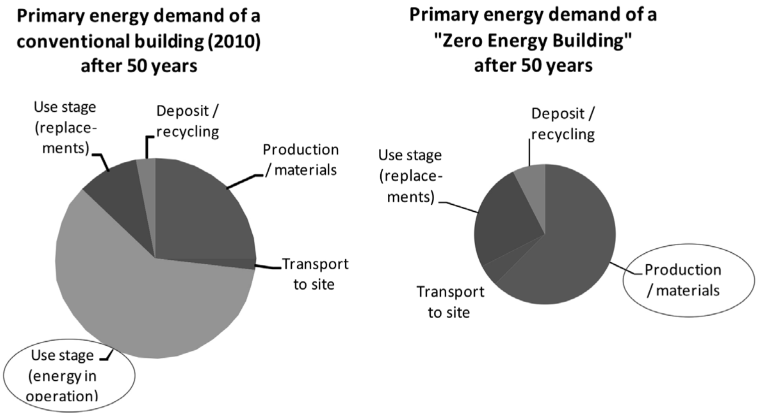


- 55 000 m² PTFE-coated glass fabric, 10 000 m² PVC-coated polyester fabric
- spoked-wheel structure, secondary arch structure, large retractable roof
- weight of support structure excluding cladding, including pillars and facade substructure

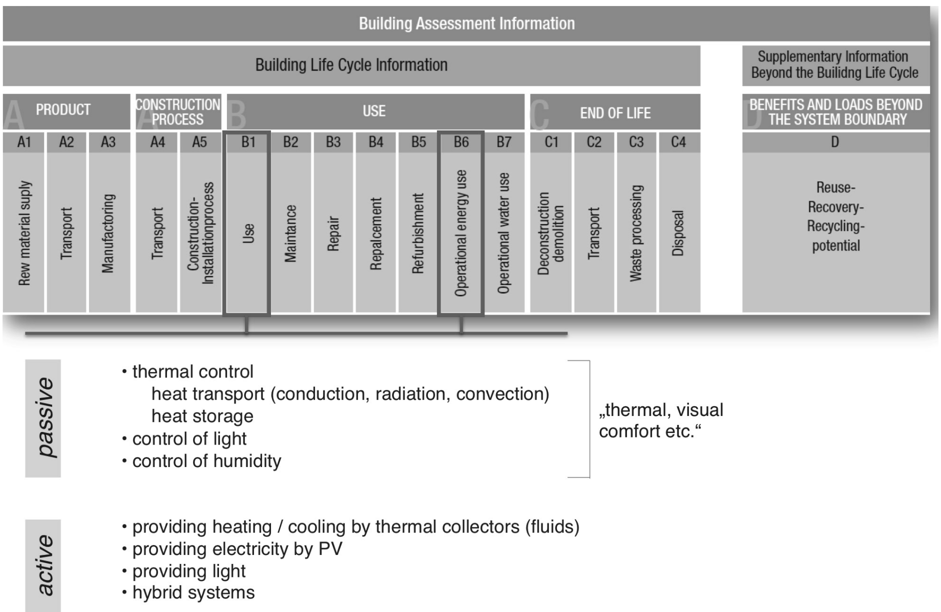
~ 200 kg/m²

Ill. 1. Comparison of selected stadia projects: Weight of roof structure per area. Data Source: Hightex GmbH and Knut Göppert, sbp – Schlaich Bergermann und Partner (5–2013)

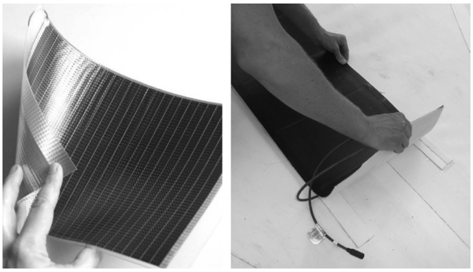
In the discussion of life cycle assessment, energy efficiency etc., the aspect of a material or technology's performance, must not be forgotten. This represents the one side of the coin which could be called 'value' (vs. 'price' on the other side). The performance is part of the 'use' stage (cp. Ill. 3). Here, membrane materials provide a lot of potential which can not be described here (e.g., light transmission in a broad range, high strength, durability, etc., cp. [5]). This includes innovative functional coatings on membranes (e.g., transparent low-E-coatings), even active solar technology which can be integrated in coated textiles and ETFE foils (cp. Ill. 4).



Ill. 2. The Relevance of construction materials grows
(source: J. Cremers/ PE International 2012)



Ill. 3. Aspects and Importance of the Use Stage for Membrane Materials and Structures
(source: J. Cremers)



Ill. 4. Flexible PV integrated on ETFE (left) and PTFE/glass (right) (source: J. Cremers/Hightex GmbH)

Ill. 5. Shopping Mall Dolce Vita Tejo, desgined by Promotorio Architects. Realized and low-E-ETFE-development by Hightex GmbH. Photograph: Hightex GmbH, Bernau

2. Life Cycle Assessment (LCA)

In 2011, a new Tensinet working group has been founded by an initiative of the author, which focuses on the subject of Life Cycle Assessment (LCA) in the membrane industry. The aim of this group is to review the current status on membrane materials and typical membrane structures with regard to LCA issues, which can be used as a key evaluation criterion, in the objectification of the discussion on membrane materials that the industry is based on. The LCA approach aims for a transparent evaluation of the complex environmental impacts of products and processes involved. It looks at the stages of material or structure's life, such as obtaining the raw materials, production, processing and transport, and also use, reuse and disposal if applicable. LCA measures environmental impact across a range of issues such as impact: on air quality, on water usage and water quality, on toxicity to human life and to ecosystem functioning, on impact on global warming as well as resource use (cp. Ill. 6). There are not only "cradle-to-grave" assessments that investigate the entire life cycle of a product, but also "cradle-to-gate" assessments that consider only the life of a product up to the time it leaves the factory. DIN EN ISO 14040 describes the LCA method which can be split into four phases: definition of goal and scope, inventory analysis, impact assessment and interpretation. Finally, all results like reports and declarations have to be scrutinised by an independent group of experts, which is essential, if comparative statements, e.g., with respect to rival products, are to be made or the results to be publicized.

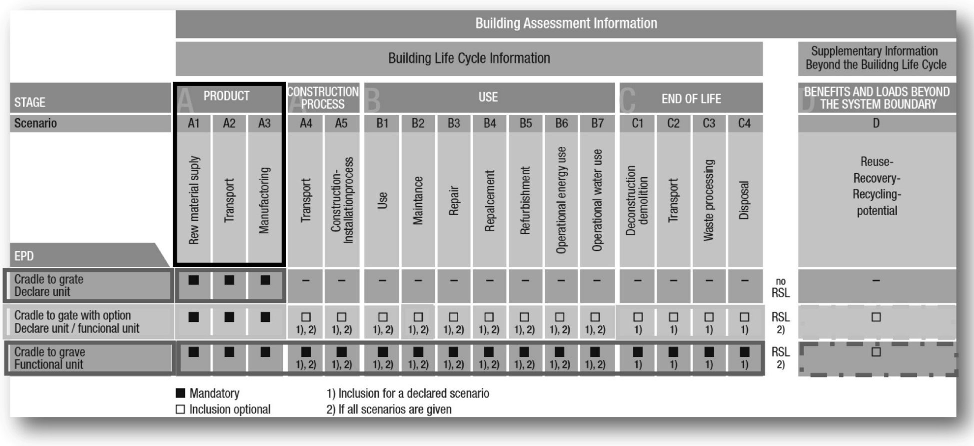
3. Environmental Product Declarations (EPD)

Drafting a product LCA is a time-consuming and expensive process that is generally carried out for the product manufacturer or a group of manufacturers by a specialist company. The ecological characteristics of a product are communicated in the form of environmental declarations. According to the ISO 14020 family, these environmental product declarations (EPD) are classified as so called “type III” environmental labels, which are highly regulated. Here, the most important environmental impacts of products are described systematically and in detail. The starting point is a product LCA, but further indicators specific to the product (e.g., contamination of the interior air) are also included. In this form of declaration, it is not the individual results of measurements that are checked by independent institutes, but rather conformity with the product category rules (PCR) drawn up to ensure an equivalent description within that product category. An EPD describes a product throughout its entire life cycle – all relevant environmental information (cp. Ill. 7. They are third party verified and guarantee reliability of the information provided. Calculation Rules for EPDs are defined by EPD program holders – for building products, EN 15804 is introduced as a respective standard in Europe.

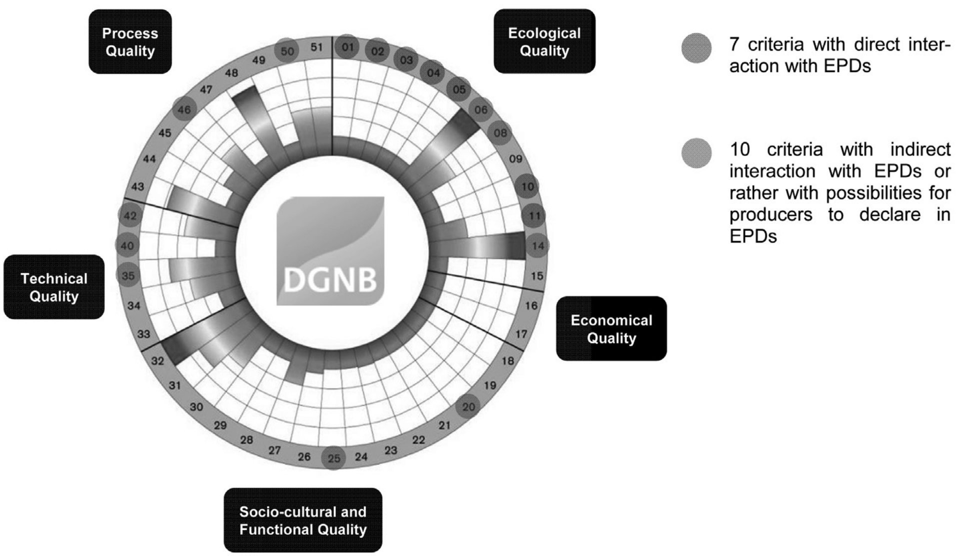
Life cycle impact assessment indicators	Global warming potential (GWP) Depletion potential of the stratospheric ozone layer (ODP) Acidification potential of land and water (AP) Eutrophication potential (EP) Summersmog potential (POCP) Abiotic depletion of non fossil resources (ADP elements) Abiotic depletion of fossil resources (ADP fossil fuels)
Energy indicators	Non renewable primary energy, excluding feedstock Input of non renewable feedstock Total input of non renewable primary energy Renewable primary energy, excluding feedstock Input of renewable feedstock Total input of renewable primary energy
Water indicator	Input of net fresh water
Use of recycled materials	Input of secondary material Input of renewable secondary fuels Input of non renewable secondary fuels
Waste indicators	Hazardous waste disposed Non hazardous waste disposed Radioactive waste disposed
Exported materials	Components for re-use Materials for recycling Materials for energy recovery Exported energy

Ill. 6. Life Cycle Impact Assessment/Environmental Indicators according to EN 15804
(source: J. Cremers, EN 15804)

EPDs help in early planning stage, they show environmental performance of a product or a product group, they are often used in political discussion and can be a basis for a company's internal benchmark and improvement.



Ill. 6. EPD Framework – EN 15804 (System boundary and modularity of product life cycle). Types of EPD with respect to life cycle stages covered and life cycle stages and modules for the building assessment (source: Jan Cremers/PE International)



Ill. 7. Sample Result of DGNB assessment and interaction of criteria with EPDs (source: DGNB/PE International)

4. Impact of LCA to the Membrane Sector

There are a number of drivers to pre-actively address the LCA issue now, for example:

- Building assessment systems with country-specific priorities for indicating the building's, like for example, LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method) and DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen/German Sustainable Building Council). The latter, was one of the first methods to prescribe a certification system that looks at the entire life cycle of a building and also includes a type of building LCA based on EPDs of the individual construction products (cp. Ill. 8). This puts the focus of planners, users and investors to the environmental impact of a whole building (including the LCAs of construction products). "Green Building" is a highly growing market share.
- Competitive situation by comparing membrane materials and structures to alternatives with LCA data available.
- Defence against prejudices based on missing, insufficient, misleading or wrong LCA data.
- Customers awareness. Communication, on environmental product performance, gains importance for manufacturers and will strengthen customer relationship.
- LCA data will become more and more important in tendering and award procedures. This also applies to the use for Construction Product Regulation (CPR).
- Existing and future legal regulations on waste concerning the building industry.

Although, the importance of the various sustainability criteria may vary, issues considered to be important include:

- Energy and carbon dioxide emissions (from building operation).
- Materials and resource use (including embodied energy).
- Waste minimisation, including recycling.
- Transport (in relation to the use of the building).
- Water conservation and use (within the building).
- Land use and ecology.
- Minimising pollution.
- Construction and building management (including security).
- Health and well-being within the building.

Material and building component selection has a direct impact on the building design and performance, and hence affects the operational energy use and the health and well-being of its occupants. Therefore, the membrane industry needs to quantify these benefits in order to maximise its sustainability credentials.

5. Additional Political Background Information

With the advent of the European single market for construction products, the European Commission became concerned that national EPD schemes and building level assessment schemes would represent a barrier to trade across Europe. The EU therefore, sought a mandate from the EU Member States to develop European standards for the assessment of the sustainability performance of construction works and of construction products. This mandate is called CEN/TC 350. From 2010, European standards began to emerge from this process and Standard BS EN15804 was published in February 2012 providing core rules for construction product EPD.

The Construction Products Directive of 1989, was one of the first Directives from the EU Commission to create a common framework for the regulations on buildings and construction products. It has been replaced by the Construction Products Regulation (CPR) and is legally binding throughout the EU. The CPR includes requirements for the sustainable use of natural resources, the reduction of greenhouse gas emissions over the life cycle and the use of EPD for assessing and reporting the impacts of construction products. If an EU Member State wishes to regulate in these areas of sustainability, it must use European standards where they exist when regulating and must withdraw national standards. This means, that in the case of the CPR, a Member State must use the CEN/TC 350 suite of standards.

An EPD provides robust and consistent information that can be used in building level assessments and the guide elaborates on the variety of ways that this can be done. In addition, a number of building level tools are emerging aimed at improving decisions at the design stage by combining embodied environmental impact data and whole life cost data (i.e., economic) and link them to BIM (Building Information Modelling) data.

Across Europe, the various environmental rating schemes are seeking to harmonise the ways in which they assess products and buildings. Increasingly, models are emerging to link embodied impacts with operational data thus enabling a better understanding of the trade-off between operational and embodied impacts, and in time, benchmarks for different types of buildings will emerge. All of which contributes greatly to the goal of a low carbon, more resource efficient, sustainable built environment [7].

6. Current status on LCA on membrane materials and structures

With regard to the status on scientific research on LCA on membrane materials and structures, it can be stated that some recent publications address the issue [1, 4, 5, 12–19], but the number of publications is still very low. Also, and maybe most importantly, it becomes obvious from a study on existing literature that there seems to be a high uncertainty in the usability of the LCA data worked with. For example, the values for, total input of non renewable primary energy' for ETFE foil that can be found, differ significantly: From 26.5 MJ/kg [16:325] to 210 MJ/kg [15]. The values provided in the only EPD on ETFE published so far[4] is even higher (> 300 MJ/kg). Whereas the data situation on PCV/PES is comparably satisfying, there still is hardly any data available on PTFE/glass.

With regard to full LCA and EPDs, there are some forerunners, for example, there is a first company specific EPD on ETFE by the companies VECTOR FOILTEC, NOWOFOL and DYNEON (mentioned before). For PVC/PES, LCA-information has been already provided in 2009 provided[5] by SERGE FERRARI and was compiled by EVEA according to ISO 14040. This company is also strongly promoting a recycling process for PVC/PES called

[4] EPD-VND-2011111-E, 10-2011, Source: Institut Bauen und Umwelt e.V., Webpage: http://ibu-umwelt.de [5-2013].

[5] Life cycle assessment of PRECONTRAINT® 1002 S according to ISO14040 (by EVEA, 2009) (source: Serge Ferrari).

“TEXILOOP”, which is already in operation for years already and which helps to improve LCA-values. A specific website for the recycling process [10] shows the potential of the subject for marketing including a comparison-tool to show the benefit against an incineration scenario (conventional end-of-life).

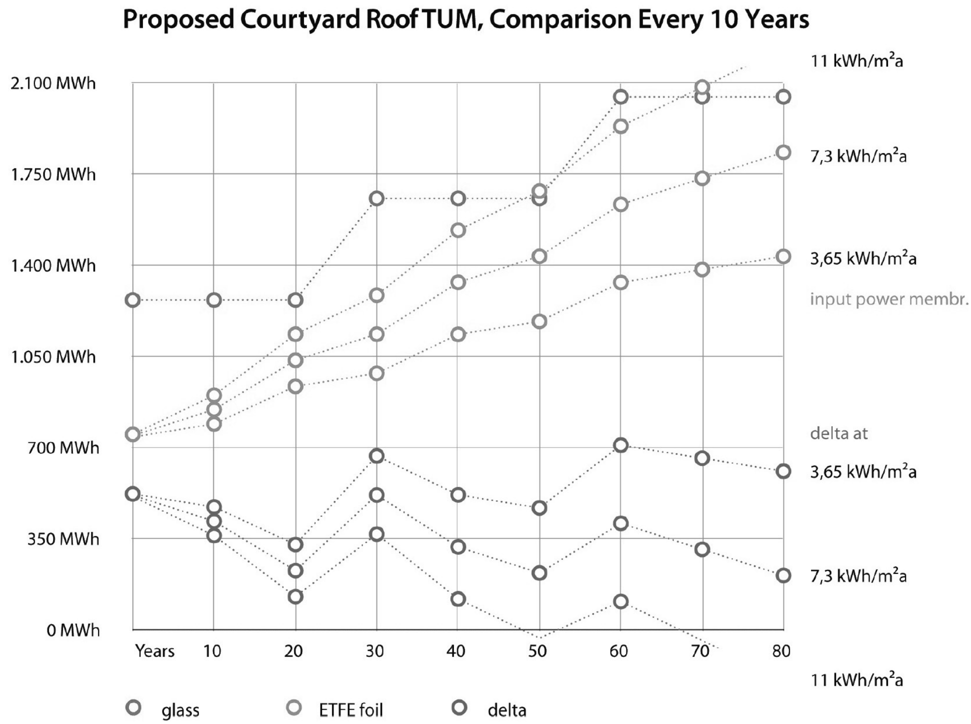
The current status (mid 2013) on the subject of recycling of the most important membrane materials is as follows: For PVC/PES there is a recycling process available which is also in use (e.g., the TEXYLOOP process which is also open to Ferrari’s competitors). ETFE, as a copolymer, can be recycled in principle. Currently, we see only downcycling from ETFE foil cut-offs and waste to ETFE tubes such as dirt, dust, etc., would limit the optical and mechanical properties of the ETFE foil. For PTFE/glass there is a lab-scale process (developed by Dyneon/3M and Bayreuth University), which is commercially not active so far, but shows the future potential. Currently, PTFE/glass, being an inert material, is currently landfilled.

On the level of structure types, there is very little published information available so far. Some single project-based calculations have been carried out, but due to the lack of proper LCA data, they are difficult to assess and compare. One example for this appoach has been conducted within a large R&D-project, in which the author has been involved in[6]. Here, a comparing calculation on primary energy intensity has been carried out for a glass-roof vs. an ETFE-cushion-roof including specificly optimised steel sub-structures (roof area of approx. 27 × 33.5 m):

	Mass incl. substructure	Primary Energy “invest” (excl. operation and replacment)
Glass-roof	180 t	1 270 000 kWh
Steel and substructure	114 t	880 000 kWh
Glazing layer	66 t	390 000 kWh
ETFE-roof	**80 t**	**693 000 kWh**
Steel and substructure	78 t	640 000 kWh
ETFE-cushions	1.3 t	53 000 kWh

In both scenarios, there is a need for maintenance, repair and typical replacement during the period of operation. Additionally, the ETFE-roof variant has a quasi constant energy demand for the cushion air supply system (keeping-up internal pressure and dehumidification). This demand highly depends on project-specific issues, i.e., fabrication quality (seam tightness), cushion geometry, type of clamping, air supply system (w/o air circulation). In the study, the energy demand therefore has been considered in three different variants (3.65/7.3/11 kWh/m^{2}a). The significance of this assumption on an 80-year-LCA calculation is depicted in Ill. 9.

[6] Cp. project website at http://www.mesg.info [6-2013].



Ill. 8. LCA-results of ETFE and glass roof variants of MESG project[7]

References

[1] Cremers J., *Energy Issues and Environmental Impact of Membrane and Foil Materials and Structures – Status Quo and Future Outlook, Conference sb13 munich*, Implementing Sustainability – Barriers and Chances, April 2013, Germany, Proceedings.

[2] Cremers J., *Environmental Impact of Membrane Materials and Structures – Status Quo.*, Tensinet Symposium 2013 [Re]thinking lightweight structures, Proceedings, Mimar Sinan Fine-Art University, Istanbul, May 2013, 447-456.

[3] Cremers J., *Environmental Impact of Membrane Materials and Structures – the new Tensinet Working Group on Life Cycle Assessment (LCA) for Membranes*, Tensi News Newsletter 23 – Sept 2012, Newletter of the European based Network for the Design and Realisation of Tensile Structures, www.tensinet.com, 2012, 12-14.

[4] Knippers J., Cremers J., Gabler M., Lienhard J., *Construction Manual for Polymers + Membranes*, Institut für internationale Architektur-Dokumentation, Munich/ New York: DETAIL/BIRKHÄUSER, 2011, cp. Chapter 7, 124-131.

[5] Mollaert M., *Environmental aspects in textile architecture*, TeniNet/Vrije Universiteit Brussel, TRA2003.

[7] Source: original graph by Klaus Puchta (LHR) published in [8, German], this updated version in [9, English].

[6] Cremers J., *Soft skins – innovative foil and textile architecture', Proceedings*, vol. I, 21–29, IX-th International Scientific Conference "New building technologies and design problems", Technical University of Cracow, Poland, 2011.

[7] Anderson J., Thornback J., *A guide to understanding the embodied impacts of construction products*, Construction Products Association, 2012.

[8] Manara J. et al., *Schlussbericht des BMWi-geförderten Projekts "Membrankon-struktionen zur energetischen Sanierung von Gebäuden"* ("MESG"). F 12 B 2437, TIB Hannover, 2012, 10-15.

[9] Lang W., Rampp T., Puchta K., Cremers J., *Examination of Membrane Structures in Building Exteriors Using Typological and Constructive Considerations*, Structural Membranes 2013, VI International Conference on Textile Composites and Inflatable Structures, Proceedings, Munich, 2013.

[10] Website for the Texyloop process by Serge Ferrari SA, http://www.texyloop.com (captured in 4.12.2012).

[11] Cremers J., *Kapitel 'Textiles for insulation systems, control of solar gains and thermal losses and solar systems' im Buch 'Textiles, polymers and composites for buildings'* (Ed. by G Pohl), Woodhead Publishing/UK, 351-374.

[12] Monticelli C. et al., *Life cycle assessment of textile façades, beyond the current cladding systems*, Tensinet Symposium 2013 [Re]thinking lightweight structures, Proceedings, Mimar Sinan Fine-Art University, Istanbul, May 2013, 467-476.

[13] Chilton J., Pezeshzadeh S., Afrin S., *Embodied energy in ETFE foil construction*, Tensinet Symposium 2013 [Re]thinking lightweight structures, Proceedings, Mimar Sinan Fine-Art University, Istanbul, May 2013, 457-466.

[14] Fournier F., LCA of precontraint, composite membranes & Texyloop recycling cases studies. Tensinet Symposium 2013 [Re]thinking lightweight structures, Proceedings, Mimar Sinan Fine-Art University, Istanbul, May 2013, 487-496

[15] Monticelli C. et al., *Environmental load of ETFE cushions and future ways for their self-sufficient performances*, Domingo A. and Lazaro C. (eds.), Evolution and Trends in Design, Analysis and Construction of Shell and Spatial Structures, Proceedings of the International Association for Shell and Spatial Structures (IASS) Symposium 2009, Universidad Politecnica de Valencia, Spain, 2009, 754-766

[16] Robinson-Gayles S. et al., *ETFE foil cushions in roofs and atria,* Construction and Building Materials, Elsevier, 15, 2001, 323-327

[17] Ashby M.F. et al., *Materials: Engineering, Science*, Processing and Design, Butterworth-Heinemann, 2007.

[18] Fernandez J., *Materials Architecture Emergent Materials for Innovative Buildings and Ecological Construction*, Elsevier, Oxford 2006, 169.

[19] Monticelli C., *Environmental assessment of ultralight roof structures built with new materials: the case of the ETFE cushions*, Proceedings of IASS WG18 Colloquium, 2010.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

BOGDAN DZIEDZIC*

VENTILATED PLINTHS OF MODERN AND MODERNIZED HISTORIC BUILDINGS

COKOŁY WENTYLOWANE WSPÓŁCZESNYCH I MODERNIZOWANYCH OBIEKTÓW ZABYTKOWYCH

Abstract

The paper focuses on the necessity of using ventilation slots in plinth areas of buildings. The main purpose of these slots is to reduce the amount of the capillary rising of water. At the same time it is important to draw attention to the lack of knowledge in the area of basic physics among construction companies; building renovations conducted by them, not only of historical buildings, but also of new ones, lead to serious failures. The moist air discharge through the cracks in the plinth areas presented in this article is one of the methods allowing for proper moisture reduction and for making renovations in damp underground parts of historic buildings. Additionally, this method allows to create a proper plinth area in the modern building industry.

Keywords: drainage, horizontal waterproofing, vertical waterproofing, plinth, ventilation, capillarity

Streszczenie

Artykuł ma za zadanie podkreślić konieczność stosowania szczelin wentylacyjnych w strefie cokołowej budynków, których głównym celem jest obniżenie wysokości podciągania kapilarnego. Jednocześnie zwraca on uwagę na brak podstawowej znajomości fizyki budowli przez firmy budowlane. Dokonywane przez nie renowacje obiektów zarówno zabytkowych, jak i nowo wznoszonych, prowadzą do szeregu zaniedbań. Przedstawiona w artykule metoda odprowadzania zawilgoconego powietrza przez szczeliny w partii cokołowej jest jedną z niewielu, która pozwala na obniżenie strefy zawilgocenia i dokonanie renowacji zawilgoconych podziemnych części zabytkowych budowli. Dodatkowo metoda ta daje możliwość wykonania prawidłowej strefy cokołowej w budownictwie współczesnym.

Słowa kluczowe: drenaż, hydroizolacja pozioma, hydroizolacja pionowa, cokół, wentylacja, podciąganie kapilarne

* Ph.D. Eng. Arch. Bogdan Dziedzic, Institute of Building Design, Faculty of Architecture, Cracow University of Technology.

1. Introduction

In a heavily urbanized construction environment, basement levels of existing and newly constructed buildings are becoming increasingly important. For economic reasons, underground spaces have multiple uses. This encourages investors, designers and contractors to look for increasingly better building materials, in order to ensure optimum conditions and climate for rooms below ground level. An important aesthetical problem in historic building is damaged and corroded plinths. This phenomenon is a real challenge for both the owners and the contractors. The undertaken restoration work often relies on masking effects without eliminating the causes, which in a short time, leads to the destruction of the newly modernized plinths. Common ad hoc repair work involving the application of new plaster should be mentioned here. Lack of knowledge of the craft in this field means that a new layer of plaster is of much greater resistance than the structure of the wall that needs renovation. Consequently, such action will reduce water vapour permeability and scorch–loosening the new layer of plaster, causing damage to the structure of a new wall. There are a few reasons of plinth corrosion and one should look for them under the ground, usually at the level of footings. Water molecules having a negative potential, tend to its alignment with the consequent need to increase the moisture zone by the upward water pressure. As a result of such action, the evaporation zone moves to the higher parts of the wall, which moves moisture from the plinth area to the ground floor walls area. Despite the substantial financial resources invested in the latest restoration materials, plinth parts are still exposed to moisture, eruptions and devastating effects of the crystallizing salt in the capillary rising water. The height of capillary action is often significantly enhanced. This happens due to the ignorance of the building physics by companies engaged in the restoration. The use of modern materials in the form of sealed plasters and paints reduces the diffusion process of water vapour. Tight materials (plaster, paint, foil, stone) on walls and plinths make evaporation impossible and as a result , the moisture which wants to evaporate moves to higher parts of the wall. The reason for this is the potential difference between the negative pole at the footings located in damp ground and the positive pole, which are the dry parts of the wall.

2. The cause and source of plinth moisture

Capillary transport of water occurring in the walls causes the moisture at their base. The most important causes of plinth corrosion are:
- the lack of horizontal ventilation,
- the lack of vertical ventilation,
- the lack of perimeter drain,
- the lack of peripheral ventilation,
- the lack of plinth ventilation.

The vast majority of historic buildings have never had horizontal insulation neither at the footings nor at the floor on the ground. When there is a high level of groundwater in the area of the modernized buildings, protection against destructive effects of water rises to the rank of a gigantic and costly undertaking. In most cases, the first step should be to reduce the said level of groundwater in the immediate vicinity of the modernized building by digging drainage wells. These wells allow the land around the building to dry and to uncover the walls at the basement level in the ground with stable humidity, which then allows for the estimation of the structure of the walls below ground level. When no repair work without the knowledge of building physics had been carried out previously, x there is no need to remove unwanted masses and materials, which did not fulfill their task of protection against water pressure. At the moment when the drain wells provide moisture stability in the ground and allow full control of the water which flows into them giving the opportunity to pre-dry the walls of the basement, the application of the methods of capillary action shutoff can proceed. One of the simplest and most effective methods is the segmental undercutting of foundation walls from the inside and from the outside in order to introduce sheet or plastic membrane (Ill. 1). Such methods are quite expensive as they require the use of the already mentioned wells, but they ensure full satisfactory protection against capillary action as one of the very few.

Ill. 1. Corrugated sheet drain membrane, Olomouc, the Czech Republic

Another cause of plinth corrosion is the lack of vertical isolation. After lowering the groundwater in modernized buildings, one can proceed to apply the correct vertical isolation after cleaning and drying the walls first. Before applying the waterproofing to the walls at the basement levels, they can be protected with a hydrophobic, or if necessary, fungicidal agent. A prerequisite for this type of work is the assessment of the load-bearing capacity and consistency of the walls as their coefficient could have been considerably reduced in the case of decay and corrosion of the material from which the walls are made. Correctly completed horizontal and vertical waterproofing allows to make further renovation work to improve the structure of the building and underground indoor climate. In both modernized and newly built buildings, particular attention should be paid to accuracy in the performance of the waterproofing layers while maintaining the instructional grace period in applying successive layers. The order and period of time of applying successive layers also applies to plaster, which is often forgotten by contractors. Precision and great care in the performance of waterproofing is the basis of success in this type of repair work. Without proper and permanent supervision, all such work leads to the formation of moisture and consequently to fungus and corrosion of the material structure of the walls of underground floors. Failures of incorrectly performed waterproofing and improper supervision, both in the case of new and modernized buildings, cause destruction of plinths and basement walls. Consequently, this leads to a deterioration of the building aesthetics and reduction of its utility value due to the creation of a hostile environment in its underground interiors.

3. Ventilation of the plinth construction and space

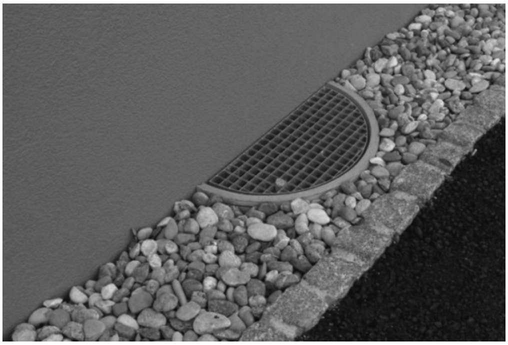
A professionally made perimeter drain along with a backfill of thick rinsed stones up to the level where the plinth begins, should be an important supportive element complementary to correctly performed horizontal and vertical insulation (Ill. 2).

Ill. 2. Sandstone plinth in a new building with a rim of pebbles, Zurich, Switzerland

A well-made drainage enables to drain water from the close proximity to the foundations away to the well and the proper backfill of coarse pebbles allows for stable ventilation and reduction of water pressure on the vertical waterproofing layer. The thick pebbles allow for the ventilation of underground space around the waterproofing layer acting as a layer of perimeter ventilation around the basement walls (Ill. 3 and 4).

Peripheral ventilation is a known but often neglected additional layer of ventilation. An often committed executional mistake of using polyethylene damp-proof course as the only layer of waterproofing should be mentioned here. The dimpled membrane should never be treated as waterproofing. It constitutes of one of the layers accompanying waterproofing and is an integral part of peripheral ventilation. Together with a properly made backfill of pebbles in the collar of fleece or other geotextile, it is the basis for walls drying. Frequent absence of fleece as a sliding layer at the interface between the dimpled membrane and backfill ground, leads to creases and damage. This leads to a total loss of properties and limitation of the task which a damp-proof course was to perform as a vent membrane and not, as it is often mistakenly assumed, waterproofing.

Properly designed peripheral ventilation ensures the soundness of waterproofing, which protects the building from the harmful effects of capillary action and resilience of water from the ground for many years. Finely ground aggregate and fine sand or sandy gravel should never be used to perform a backfill while designing the peripheral ventilation layer.

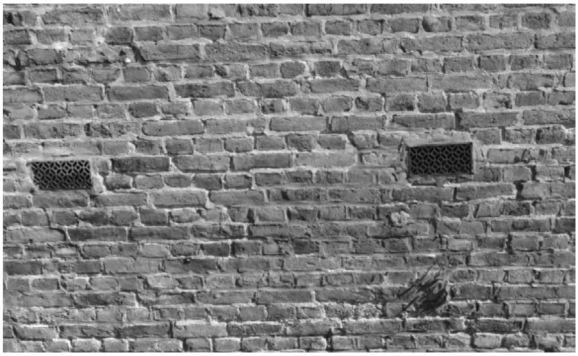


Ill. 3. Plinth of a new building with the rim of pebbles, Zurich, Switzerland

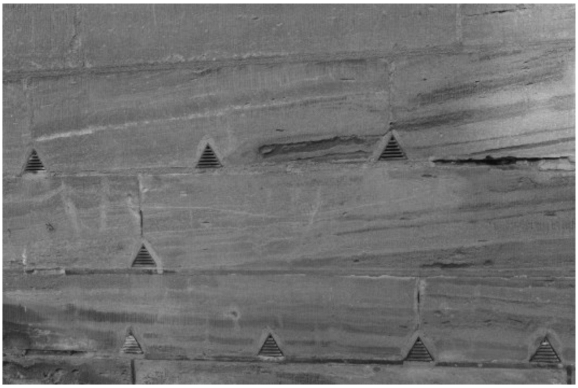
Ill. 4. Plinth of a new building with the ventilation rim of pebbles, Zurich, Switzerland

The first of these materials may damage the dimpled membrane and the others are factions, which retain moisture in their own layer for a long time, preventing the drying of the vertical waterproofing.

In view of the properly executed modernization of the building, in particular the part of the basement, plinth ventilation should be remembered. The said peripheral ventilation layer must be equipped with exhaust openings in the plinth construction (Ill. 5 and 6).



Ill. 5. Modernized plinth of an old tenement house
(salt glazed decorative airbrick), Amiens, France



Ill. 6. Ventilated sandstone plinth of the modernized
gothic cathedral in Bayeux, France

It often happens that a properly executed vertical and horizontal insulation assisted by the dimpled membrane does not guarantee the prevention of plinth corrosion. Moist air from underground layers gets into the higher parts of the plinth. Caverns beneath sandstone slabs (Ill. 7), of which old buildings plinths were usually made, fill up with moisture from the water vapour condensation in a year and lead to a change in the dew point of the wall.

There is flaking paint and plaster and salt efflorescence on damp walls. Moisture introduced into the wall structure is conducive to the formation of mould, the growth of fungi, mosses and lichens that destroy the structure of the plinths. Contemporary plinths are equipped with ventilation elements allowing for a significant reduction of the impact of manufacturing defects caused by ignorance of building physics. Many respectable contractors specializing in building renovation began to commission the monitoring of the layers of waterproofing, which did not provide plinths' protection, to be made correctly.

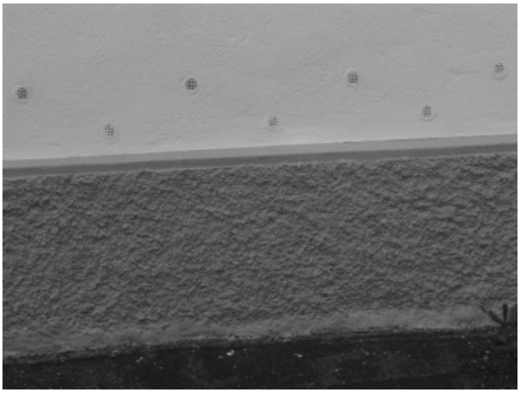
Ill. 7. Sandstone plinth. Eroded slab due to water vapour condensation, Olomouc, The Czech Republic

Ill. 8. New ventilated brick plinth in a monastery, Cracow-Mogiła

Thermal imaging studies have proved to be helpful in this type of work. They have shown the need for a modernized system of layers of warming in the plinth space with ventilation. Based on years of experience, it was found that the use of space allowing for the free flow of air with high moisture protects against plinth corrosion more effectively and significantly reduces the harmful effects of capillary action.

The study has also shown that properly constructed water insulation, with no outlet of moist air, can have an equally destructive effect on raising the level of moisture zones of walls and plinths. Thus, in the latest building projects (Ill. 8, 9 and 10) and modernization works of historic buildings (Ill. 5 and 6), ventilation systems under the plates and plinth elements are introduced. These systems permit some exchange of air, allowing for the free flow of air with high moisture. This shortens the process of evaporation as the moisture does not have to extend towards the dry parts of the wall which are located high above ground level. Additionally, this allows for maintaining relatively moderate air pressure in the structure and the base plates, reducing the condensation, efflorescence and spatter zone.

Ill. 9. Plinth of a new building with vent, Martini, Switzerland



Ill. 10. Plinth of a new building with ventilation elements, Zurich, Switzerland

Peripheral ventilation with the exhaust elements in the plinth area does not limit and does not replace the need for waterproofing, but emphasizes that even well-made waterproofing does not guarantee the preservation of the aesthetic appearance of the plinth for many years.

4. Thermal insulation of the plinth and tie beam above the basement

The increasing worldwide demands for thermal insulation of buildings showed numerous shortcomings at the junction of the building, ground and below the ground level. In most buildings, the use of basements as interior utility rooms with rational, functional, economic and technological solutions requires professional isolation: both waterproofing and thermal. Ground water, rain, capillary action, and often water spatter form streets and sidewalks devoid of drainage, contribute to the destruction of plinths in both modernized and newly constructed buildings. Lack of horizontal waterproofing, which did not exist in old buildings, has a destructive effect on construction tissue through the moisture of walls and consequently, the underground premises. In this way it contributes to the decline in the comfort of building usage. Leaving the building unsupervised in such a state for a longer period of time leads to a reduction in its construction value. The use of XPS waterproof extruded polystyrene thermal insulation boards, during a single assembly process, allows for the solution of many technical and engineering problems which used to trouble the builders, investors and users of objects with underground levels. Securing basement walls requires proper waterproofing. Due to the lack of one hundred percent supervision of backfill ground, the cover of XPS boards allows for full protection against punctures and mechanical damage to waterproofing. Another aspect of the use of XPS boards as a protective shield for perimeter waterproofing, is the creation of a stable environment with plus temperatures. Thus, the harmful effect on the waterproof layer is reduced, providing higher values of thermal conditions for moist air, allowing for its free flow in the backfill rim (Ill. 3). The use of XPS does not only act as x protective waterproofing, but it also allows for more efficient drainage of rainwater from the immediate vicinity of the building to the drainage system. The plinth area is an important element in the thermal protection of the building. Not only the physic-chemical aspects but also the aesthetics become particularly important in the case of a plinth as an architectural detail. STYROFOAM IB insulation boards become undeniably important in the insulation work due to significant aesthetic qualities and the problems associated with the proper performance of the insulation. Owing to their rough surface it becomes possible to provide adequate adhesion between the plinth base and the finishing material such as clinker, stone, resin plaster, etc. The boards are resistant to moisture and frost while maintaining complete thermal insulation properties allowing for stable and efficient implementation of plinth areas. Professional thermal and waterproof insulation of the plinth of a building, allows for comfortable health conditions in basement interiors through:

– reduction of water vapour condensation in the contact zone between tie beam and basement or foundation walls,
– reducing the temperature differences between the floor areas fitting tightly to the outer walls and areas adjacent to the inner wall (elimination of spontaneous gusts which are very unfavourable for the mental sensation of thermal comfort in the interiors).

Existing thermal bridges in uninsulated plinth area, decrease the surface temperatures of both walls and floors, thereby adversely affecting the comfort of people staying in the interiors. Due to faulty thermal insulation, further problems arise, such as uncontrolled condensation, dampness and mildew growth and cracks and corrosion in the longer term. Destructive symptoms in the plinth area reduce the construction value of the building in a significant way, as well as its further technical condition, thus reducing the aesthetic values. Plinth area requires the use of materials with higher thermal insulation performance values from adjacent partitions, which is dictated by the specific geometry of the plinth node: the tie beam above the basement. Currently, it is recommended to use thermal insulation with higher parameters (higher ratio λ) due to the future thermal insulation requirements to be met by the building. This may prevent thermal modernization in the future. Thermal insulation in the plinth area is exposed to ground moisture, rain, splashing water, mechanical pressures and impact, as well as humic acids. Therefore, the plinth area requires a special insulating material that will provide durable and effective solutions. STYROFOAM IB boards seem to be suitable for such applications as they are a very good solution in the plinth area. Long-time use of the above products in extreme conditions is the evidence for this. Specific construction of STYROFOAM IB boards predisposes them for use in aggressive environments of plinth areas. It is characterized by:

– closed cell structure, insensitive to moisture,
– high resistance and elasticity, resistance to mechanical,
– rough, specially shaped surface providing high adhesion for mortars, plasters and solvent-free adhesives.

Thermal insulation of the plinths should be an integral part of the overall concept of the thermal modernization of a building. Therefore, it requires a detailed study of the aspects of the connection of thermal insulation of plinths and peripheral thermal insulation of the building, including both the basement walls and floors above ground. The layer of thermal insulation of the plinth should extend at least 30 centimetres above the level of the surrounding terrain.

5. Conclusions

Repair of plinths corroded due to moisture, salinity and lack of ventilation in the construction space creates many problems in building physics and chemistry. The basic condition for the successful revitalization of the plinth is the selection of appropriate materials and technologies along with careful execution of repair works. An important element preceding restoration work should be drainage of basement or foundation wall structures by restoring or applying new layers of horizontal and vertical insulation. One should also note that the renewal of historic buildings in the plinth area requires and imposes a change in the conditions of temperature and humidity. Only professional repair work preceded by a preliminary chemical, temperature and humidity analysis together with permanent supervision can guarantee proper plinth repair. No signs of condensation, efflorescence and moisture in the plinths, allows for the adaptation of basement premises for office, residential and service areas, offering true aesthetic and functional foundations.

R e f e r e n c e s

[1] Żenczykowski W., *Budownictwo ogólne (General Construction)*, Vol 1., Arkady 6th edition, Warszawa 1967.

[2] Żenczykowski W., *Budownictwo ogólne (General Construction)*, Vol 4., Arkady 6th edition, Warszawa 1967.

[3] Borusiewicz S., *Konserwacja zabytków budownictwa murowanego (Conservation of historic brick building)*, Warszawa 1971.

[4] Mączeński Z., *Elementy i detale architektoniczne w rozwoju historycznym (Architectural elements and details in the historical development)*, Warszawa 1956.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

TOMASZ GACZOŁ*

SCHOOL BULDINGS IN GANDO. BURKINA FASO

BUDYNKI SZKOŁY W GANDO. BURKINA FASO

A b s t r a c t

School buildings in Gando, Burkina Faso, Africa have been designed by Diébédo Francis Kéré. The architect, who comes from this area, has been designing objects making the most of the available local material and local labour force. The simple architectural forms, clear function and technical solutions stay in perfect harmony with the issues of the climate prevailing there, as all the buildings were based on the idea of natural ventilation. Awarded numerous times, they are an example of sustainable architecture serving the local community.

Keyworks: natural ventilation, airing, microclimate

S t r e s z c z e n i e

Budynki szkoły w Gando w kraju Burkina Faso w Afryce zostały zaprojektowane przez Diébédo Francis'a Kere'a. Pochodzący z tego rejonu architekt projektuje obiekty, wykorzystując dostępność lokalnego materiału oraz miejscowej siły roboczej. Proste architektoniczne formy, jasna funkcja oraz techniczne rozwiązania doskonale współgrają z zagadnieniami panującego tam klimatu. Wszystkie budynki powstały bowiem w oparciu o ideę naturalnej wentylacji. Wielokrotnie nagradzane są przykładem prostej zrównoważonej architektury, służącej lokalnej społeczności.

Słowa kluczowe: naturalna wentylacja, przewietrzanie, mikroklimat

* Ph.D. Eng. Arch. Tomasz Gaczoł, Faculty of Architecture, Cracow University of Technology.

1. Diebedo francis kéré

Diébédo Francis Kéré is an architect from Burkina Faso. He was the first from his village to be sent to Europe where he studied at the Technische Universität in Berlin. He knew well that only he could have a positive impact on improving teaching conditions in his village and across the country. He felt responsible for the entire community of the village and he knew that in order to repay a debt of gratitude, he should help those people. Therefore, his main objective was the development of education. The aim of Kéré's designs are: climatic adaptation, low cost of construction and his own labour during the construction works. In carrying out their projects he involved the local community, which taking part in the building process, can maintain and spread the word about these objects. While he was studying, he set up an association called "Schulbausteine für Gando eV", was already collecting funds to finance his first project, a primary school in his home village. The building was completed in 2001 and received the Aga Khan Award for its concise and elegant architecture, created with the use of basic tools. The school is the result of a vision, initially verbalised by the architect, but ultimately realised by the community. The jury assessed the great potential of the design, which helps the community develop a healthy sense of pride, hope and unity, while creating a solid foundation for the development of the society. The fact that Kéré built a primary school for Gando exemplifies his commitment to education.This was the first of many awards, while others included the Global Award for Sustainable Architecture in 2009 and the BSI Swiss Architectural Award in 2010. Awarded many times, Kéré combines research and experience as a lecturer at the Technische Universität in Berlin and as an architect in his own studio. His research contributes to the impartial development of strategies for architecture with local character. Kéré has defined himself as "a cultural bridge between technically and economically" developed countries and less-developed African countries

2. Primary school in Gando, Burkina Faso

In 2008, a new primary school, intended to accommodate 280 pupils from the village and the surrounding areas, was built in the village of Gando in Burkina Faso. It is It was designed by Kere, an architect living in Berlin, who comes from Burkina Faso and very well knows the climatic conditions prevailing in that part of the world very well. A simple form of the object, based on a rectangular plan, is made of compressed earth blocks – a material characteristic of the region, which serves as an excellent heat insulating barrier between the interior of the object and the external space. The building is characterized by a narrow and elongated shape, and the classes inside, thanks to the window openings, are aired throughout. The windows are fitted with openwork, colourful, folding shutters. Their main advantage is to allow the air to permanently flow freely, in spite of the closure. In the gable walls, and in the first layer of the clay roof, there are large vents for the drainage of waste and hot internal air. In the middle of blocks, which he designed, there is a roofed, open space where, in a small amphitheatre-like cavity, children can play between lessons. Presumably, this cavity acts as a reservoir for the coolest air where the children and teachers can rest. The whole building is covered with a barrel roof made of the same material as the walls. A lightweight steel truss dominates above the brick structure of the object, lifting the corrugated metal roof with wide, shading eaves. It is a ventilated roof that functions perfectly well on hot days (Ill. 1–7).

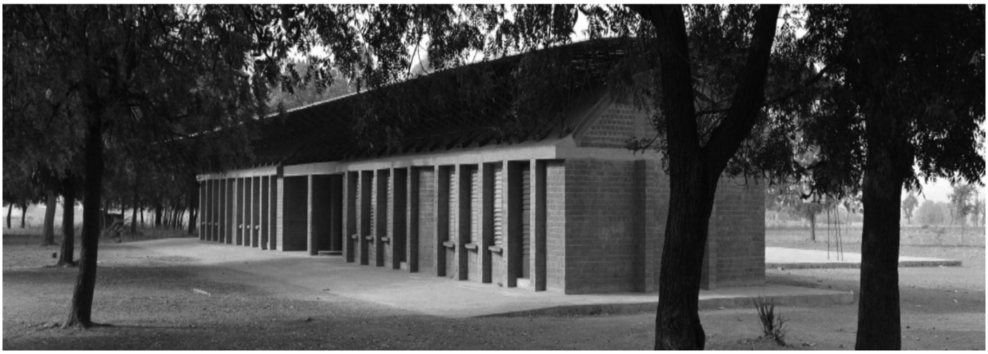
Ill. 1. School in Gando, Burkina Faso. Ventilated roof space
(source:[1])

Ill. 2. School in Gando, Burkina Faso. Colourful, openwork shutters
(source: [1])

Ill. 3. School in Gando, Burkina Faso. Classroom with a prominent barrel vault, which contains ventilating holes
(source: [1])

Ill. 4. School in Gando, Burkina Faso. The facade of the building
(source: [1])

Ill. 5. School in Gando, Burkina Faso. The amphitheater recess, covered with steel roof truss – a playground and a meeting place for children
(source: [1])



Ill. 6. School in Gando, Burkina Faso. A view of the object
(source: [1])

Ill. 7. School in Gando, Burkina Faso. A view of the object
(source: [1])

3. Lower secondary school building, Burkina Faso

An increase in government funding for secondary education in 2010, enabled fifty students to begin classes. While waiting for the new school building and new classrooms, their lessons were held in the primary school. The construction of a secondary school building began in May 2011 and was finished in 2013. This is Kéré's biggest project up-to-date. The new building complex consists of twelve classrooms, a library, an administrative building and several sports fields. It will be able to accommodate approximately 1000 students. The arrangement is inspired by the traditional rural households in Burkina Faso: the classrooms are set out in a circular fashion forming a courtyard, shielding it at the same time from the dust and sand brought by the winds. The structure is open on its west side, allowing a cool breeze to enter the area. High temperatures, large class sizes and lack of air conditioning in Burkina Faso make it very difficult for students to concentrate during classes. Therefore, an innovative air cooling system was developed making use of only natural ventilation. The school is surrounded by a bank of earth, on which trees providing shade were planted. Rainwater for watering plants is gathered by a perforated pipe in the ground. The air flowing through the piping system is also cooled and emerges in the classrooms through the holes designed in the floor. The use of the same steel roof construction as in the primary school building, in the form of a wide corrugated iron roof raised above a clay ceiling vault, sets the circulation of heated air between ceiling and roof in motion, creating a suction current. This causes that the cool air flowing from the under-floor pipes to rise, reducing the room temperature by about 6–8°C (Ill. 8–10). With simple yet effective methods such as these, the school requires little electricity both in construction and maintenance.

Ill. 8. Lower secondary school in Gando. Burkina Faso. Schematic natural ventilation school (source: [6])

Ill. 9. Lower secondary school in Gando. Burkina Faso. School building during construction (source: [6])

Ill. 10. Lower secondary school in Gando. School building during construction. Photo from the embankment (source: [6])

4. Teachers housing in Gando, Burkina Faso

The teachers' houses were designed to attract teachers out to the countryside, as well as to promote the use of earth as a sustainable and durable building material. Single modules can be combined in various ways into a larger composite whole in order to obtain additional living space. The simplicity of the design and minimal use of bought materials means that the objects can easily be constructed. The six houses for teachers and their families are arranged in a wide arc to the south of the school complex. . The roofs are barrel vaults constructed from stabilized earth blocks. This construction method, previously unheard of in this region, causes local resources to be used and this is the right direction in the process of building. To protect the building from rising dampness, the 40 cm thick adobe walls stand on a foundation of cast in-situ cement and stones. A tie beam connecting the walls bears the roof load in each module. The roof is a layer of reinforced concrete poured in situ into a permanent shuttering of compressed stabilized earth blocks (CSEBs). For better thermal insulation clay elements are laid on reinforced concrete structures. The steel roof construction height alternates between 100 cm and 150 cm and serves as a means of natural ventilating and shading of the front facades creating a friendly microclimate inside. Wide roof overhangs protect the walls from moisture and rain. The walls of traditional houses are impregnated with a mixture of vegetable juice and cow dung. Unfortunately, these treatments are of little use in the rainy season and attract termites which can eventually destroy the walls. In these buildings, the traditional protection against dampness was replaced with bitumen laid at the intersections of the barrel roofs. The culmination of building work is the tamping of the clay floor to create a smooth, homogeneous surface. The enthusiastic involvement of the people of Gando was the key to the success of this project. The villagers gained not only new skills, but also a sense of responsibility, awareness and sensitivity to both the traditional and the innovative building techniques (Ill. 11–13).

Ill. 11. Teachers housing in Gando, Burkina Faso. Openwork, ventilated front elevation (source: [8])

Ill. 12. Teachers housing in Gando Burkina Faso. Visible channels to drain and collect rainwater (source: [8])

Ill. 13. Teachers housing in Gando, Burkina Faso. Double-layer barrel ventilated roofs (source: [8])

5. Library building in Gando, Burkina Faso

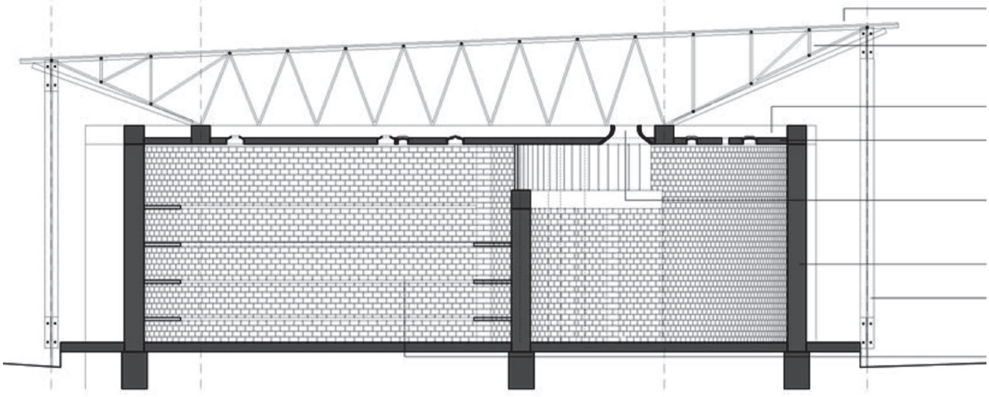
A public library was designed next to the school by the same architect. The building has an elliptical shape and is made of clay brick, an accessible, local material. Thick walls are virtually devoid of windows, thus creating a human friendly microclimate inside the building. Additional interior lighting is achieved by designing round holes in a flat roof, performing the function of ventilation ducts and natural ventilation. The shape and structure of the roof covering, make this a very interesting object due to the material used and the architect's unique idea. The use of traditional clay pots to create holes for light and ventilation is a unique phenomenon in the world. The clay pots were brought to the site by local people, then cut appropriately and placed on the formwork between the structural beams. Once prepared, the roof was covered with concrete, thus creating the possibility of vertical ventilation of the building and its indirect illumination. A rectangular lightweight steel ventilated roof sits above the whole structure and extends out beyond the library. The contour of the roof is connected to the vertical, openwork, eucalyptus elements. They provide additional shade and favourably influence the microclimate of the interior favorably (Ill. 14–17).

Ill. 14. Library in Gando. Burkina Faso. Top view of a ventilated roof
(source: [2])

Ill. 15. Library in Gando. Burkina Faso. From left: Main room of the library with a perforated, ventilated roof, rural community carrying clay pots used to build the library (source: [2])

Ill. 16. Library in Gando. Burkina Faso. From left: Arranging trimmed ceramic vessels in the reinforcement of the floor slab and the finished floor (source: [2])

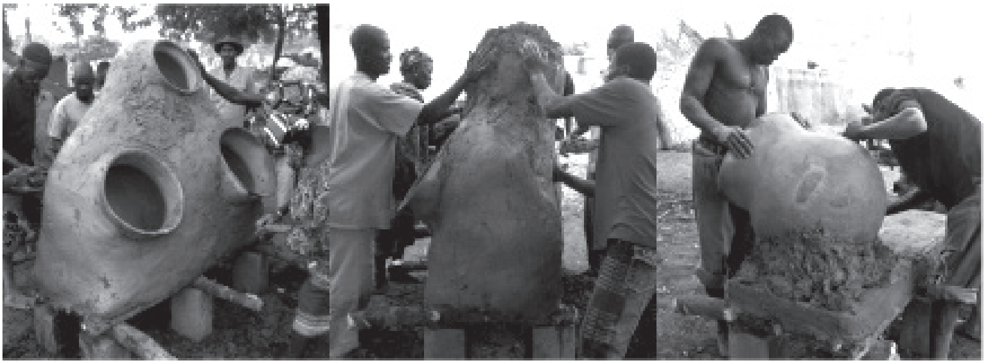
Ill. 17. Library in Gando. Burkina Faso. Computer visualization of the facility and its cross-section (source: [2])



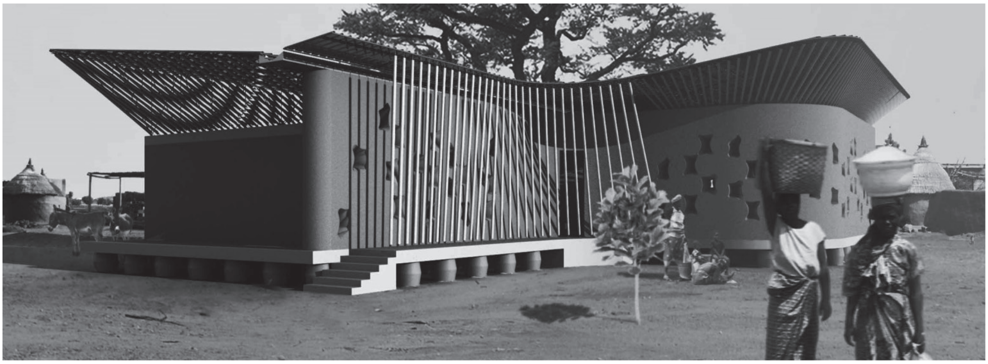
Ill. 17. continuation

6. Women's association centre, Gando, Burkina Faso

A new Kere's project, which was launched in 2012, is a building designed for women. The programme of the building includes a classroom, a meeting room, an office, a kitchen and sanitary latrines. Furthermore the centre contains a storage room for agricultural goods and household effects. This offers new possibilities for the women to store their harvested goods, then process them further and sell them later at the market to secure their own incomes. Designed in an interesting way, big clay pots are contained in the thick, massive, earthen walls. They are like shelves for storing food products. Steel roof structure supported by wooden beams, on which there are also laid open-work earthen vaults, creates a thermal barrier. Voids located in ceiling gaps, allow air to circulate through the interior storage and meeting places. From October to May, the building will be used for educational purposes. Classes for adults will take place from 7am to 2pm. In the afternoon until sunset, the building will be open to the village community and used especially by the women's association for various activities. During the rainy season from the end of May until the end of September, which is the high season for agriculture, the building will be used for information and campaigns which can be initiated by the village community, the regional government or foreign organisations. During the rainy season, the women's centre will be the only facility that will provide a dry space for the storage of goods and social events related to this. The building should incentivise the government and other non-governmental organisations to allocate more funds essential to educate professionals in the fields of healthcare, development, agricultural technology, education, water management and forestry. The target group of the project is a community of up to 300 women from the village of Gando and the surrounding area in the province of Boulgou in Burkina Faso. This area includes about 2,500 people, most of whom make their livings as subsistence farmers. In this region, women are bearing the brunt of poverty as up to 97% of the women over 15 years old are illiterate. To effectively combat this, the women want to form a strong social and economic union. The women's association centre will improve their quality of life in a sustainable way by providing a platform for them to develop their economic and educational situation, health, nutrition and agriculture. The village community will contribute to the building through voluntary efforts, which will keep construction costs low. (Ill. 18–19).



Ill. 18. Women's Association Centre in Gando. Burkina Faso. Casting of clay vessels used to store food products in the wall (source: [7])



Ill. 19. Women's Association Centre in Gando. Burkina Faso. Computer visualisation (source: [7])

7. Conclusions

The conclusions that come to mind are first of all: proper selection of appropriate design solutions to the prevailing climate. The correct choice of building materials, minimized the costs involved in the creation of these objects. Local availability of materials and the use of local community's labor, which after appropriate training in construction techniques, was able to participate in the creation of these objects, and of many more in the future. Obviously, a sense of responsibility and an awareness of a job well done, are the elements that allow you to break out of the generally prevailing poverty, frustration, despondency and depression. This aspect is the most important one in the whole project.

The whole building complex is an example of contemporary architecture with very interesting forms, which were created from building materials available in the area, gathered by the local community during its construction. Climatic conditions imposed a method of architecture, which shaped the author to these objects. Simple form and construction techniques are the answer to the question: "How should buildings be designed in this area?" It is the idea and direction worth following, which can also function well, in other geographical, cultural and social areas.

References

[1] http://www.kerearchitecture.com/projects/school-extension-gando/
[2] http://www.archdaily.com/262012/in-progress-school-library-gando-kere-architecture/
[3] http://archleague.org/2012/02/francis-kere/
[4] http://www.e-architect.co.uk/events/diebedo-francis-kere-lecture
[5] http://lc-architects.blogspot.com/2013/01/escuela-de-tierra-gando-burkina-faso.html
[6] http://en.wikipedia.org/wiki/File:Kere_Secondary_school_gando.JPG
[7] http://www.kerearchitecture.com/projects/womens-association-centre-gando/
[8] http://www.kerearchitecture.com/projects/teachers-housing-gando

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

ALEKSANDRA GŁUCHOWSKA*

WIND TECHNOLOGIEST IN BUILDING CONSTRUCTION – PROBLEMS AND SOLUTIONS

TECHNOLOGIE WIATROWE W BUDOWNICTWIE – PROBLEMY I ROZWIĄZANIA

A b s t r a c t

The energy efficiency of a building has become a superior objective in the processes of design and construction. Rapid development of the wind power industry and the related technologies enables us to use wind systems in modern construction projects. The innovative nature of these solutions however, give rise to various cumbersome issues. They are mostly related to the structure of the building, its influence on the natural environment and interactions between the structure and the wind system on the use of the building. The solution often depends on interdisciplinary cooperation, which begins at the stage of design and construction of the wind turbines. This cooperation is also essential during the selection of wind power devices, designing the building and the construction process itself. As a result, increasingly efficient wind systems are implemented.

Keywords: renewable energy sources, wind turbines, energy-saving buildings

S t r e s z c z e n i e

Energooszczędność obiektu budowlanego staje się dziś nadrzędnym celem w procesie projektowania i wykonawstwa. Gwałtowny rozwój energetyki wiatrowej i związanych z nią technologii umożliwia zastosowanie systemów wiatrowych we współczesnym budownictwie. Innowacyjność tych rozwiązań pociąga jednak za sobą wiele problematycznych kwestii. Najczęściej związanych z konstrukcją budynku, wpływem na środowisko naturalne, oddziaływaniami pomiędzy obiektem, a instalacją wiatrową oraz z użytkowaniem budynku. Ich rozstrzygnięcie często zależy od współpracy interdyscyplinarnej zaczynającej się już na etapie projektowania i wykonawstwa turbin wiatrowych. Współpraca ta staje się nieodzowna również w trakcie doboru urządzeń wiatrowych i projektowania obiektu budowlanego oraz samej budowy. Wynikiem takiego współdziałania staje się wdrażanie coraz to sprawniejszych systemów wiatrowych.

Słowa kluczowe: odnawialne źródła energii, turbiny wiatrowe, budynki energooszczędne

* M.Sc. Arch. Aleksandra Głuchowska, Ph.D. Studies, Faculty of Architecture, Cracow University of Technology.

1. Introduction

The issue of energy-efficient architecture, passive houses and use of renewable energy is undertaken more frequently. We develop building technologies whose main aim is to get energy from renewable resources. Recently one could observe the phenomenon of rapid development of the wind power industry and related technologies for use in construction. The wind turbines which generate energy for buildings are more modern. Owing to such thriving development, we have at the present a wide range of wind turbines which may be adapted to a particular building and working conditions. However, the variety of available devices result in many problems with their usage or installation.

2. The most common problems of wind architecture

There are numerous problems related to the issue of wind technologies in construction. Three main groups may be distinguished here:

influence on the building – related to oscillations which occur when the turbine moves. The greatest oscillations are generated by large-size turbines. This phenomenon extorts the necessity of using appropriate connections between turbines and the building, which could prevent oscillations or decrease the ones which occur. These turbines also limit the use of facade materials. One should not use moving facades which could easily come into resonance with the turbine and could be damaged after a certain time.

influence on the natural environment – to which the so-called syndrome of wind turbines belongs. It is a syndrome of complaints which are not proved scientifically (such as disorder and aggravation of sleep, headache, tinnitus, dizziness etc.), which may purportedly occur in case of persons who live around wind farms and disappear spontaneously when they move away. The notion was created by Nina Pierpoint, PhD. She describes the influence of wind turbines on the condition of human health with the following statement: "noise or low-frequency oscillations cheat the system of balance of the organism thus it thinks that it is in movement[1]". Nina Pierpoint's research begins the debate on the health of people who reside in the area where wind turbines are located. Despite the fact that scientific and technical circles criticised Pierpoint's research (the disease which she claims to result is not proven scientifically), it seems necessary to conduct multilateral interdisciplinary studies into this problem.

Other negative results of the influence of wind turbines on human health include excessive exposure to infrasound (0–20 Hz) and low-frequency noise (20–500 Hz), which may lead to vibroacoustic disease.

Another important aspect of the influence on the natural environment is also the influence of wind turbines on animals, including birds and bats. There is a possibility of fatal collision with turbines as well as negative influence on nesting sites.

---

[1] N. Pierpoint, *Wind Turbine Syndrome: A Report on a Natural Experiment*, Santa Fe 2009, p. 294.

Analyses of the effects of the operation of wind turbines on human health, which have been conducted so far, as well as their influence on the environment, are insufficient, which makes it necessary to conduct further research in this scope.

structural problems – resulting from the installation of large-size turbines, structure of the building with which they are connected and the layout of the installation in the case of dynamic architecture.

A part of the above problems were solved, which improved particular turbine systems. Some of them are still being designed and their completion depends on whether the current problems are solved.

3. Examples of solutions

The following buildings are examples of certain technologies currently used for the purpose of obtaining energy for particular buildings and concepts of dynamic architecture with the main aim of getting wind energy by means of the entire volume of the building. Their designers faced many complications at the stage of design and construction.

They were mostly connected with excessive loads which resulted from the size of turbines being part of the given building. One example is the Razor skyscraper in London, which was designed by the Atkins workroom.

There are three turbines on the top of the skyscraper which are a part of the facade and which are to deliver 8% of the energy demand of the building. The building is significantly higher than the surrounding structures, which allows for a complete utilisation of wind speeds reaching up to 56 km/h in this area and height. It was assumed that the turbines would produce up to 50 MWh of energy per year. Each of them has 5 vanes, rather than 3 as the most popular ones, which is to significantly reduce noise generated in the process. It is very important because the building is located in a dense urban area. Not only the construction processes of the skyscraper was challenging but especially the design of its foundations.

Ill. 1. The Razol in London [3]

The designers of the Bahrain World Trade Centre in Manama, also coped with the problem of oscillations caused by the operation of large-size wind turbines. The BWTC is a complex of 50 storey twin skyscrapers with a view overlooking the Persian Gulf. There are three wind turbines between two triangular top tapered towers. Each of them has a diameter of 29 meters and in full operation they may deliver 11–15% of the towers' energy requirement. Two skyscrapers resembling sails and creating with their form a funnel, use their shape to increase the flow of wind which drives the turbines. The shape of the building also levels the speed of wind (winds closer to the territory are weaker which could cause uneven use of the turbines). The important issue in the construction of the BWTC was the problem of linking the turbines with the building. A large team of specialists working on the projects for many months perfected the structure of the turbines as well as the bridges hanging between the towers to which the turbines were fixed. Regular rotation of the turbines could cause the bridges to oscillate, which would weaken the structure and could lead to damage of the building. The problem was resolved among others, by proper shaping of the bridges. The BWTC is undoubtedly a milestone in the field of environmentally friendly architecture and the attempts of linking it with the technologies of generating wind energy. It was one of first such completed projects and became an inspiration for architects and constructors from all over the world.

Ill. 2. Bahrain World Trade Centre in Manama [4]

The producer of the Architectural Wind turbine, Aero Vironment, coped with the negative influence on the environment as a threat to animals. The company responds to the needs of the urban wind power industry. The turbines are small, silent and do not need any towers. Moreover, they may be installed in clusters. They were provided with screens which prevent birds from colliding with the rotors. The system is designated for installation on the top of the buildings and to use their aerodynamics in order to utilise wind power as fully as possible. Turbines operate even at low windspeeds, which guarantees the possibility of generating significant amounts of clean energy. They are able to operate separately or in cooperation with other technologies of renewable energy (for example solar thermal collectors). Architectural Wind turbines are available in various sizes ranging from 6 kW, measuring 1.2 m × 1.2 m

Ill. 3. Architectural Wind turbines by AeroVironment [5]

and 200 kg in mass. These turbines have a negligible influence on the structure of existing buildings and comprise an attractive architectural detail.

The so-called dynamic architecture belongs to the newest concepts of wind architecture. These are mostly tower blocks whose main goal is to obtain electric energy from wind and they are (for the most part) turbines themselves. Dynamic architecture introduces three leading innovations to the skyscraper of the traditional type, which are: variable shape, clean energy production and energy self-sufficiency. Buildings designed according to this trend are to 'follow' the sun taking advantage of its light as much as possible and move together with the wind converting its power into electricity. These assumptions are to cause modern architecture to be more efficient and environmentally friendly.

Ill. 4. David Fisher's Rotating Tower [4]

David Fisher, who is an Italian-Israeli architect, presents a totally new dimension of wind architecture. In his projects he implements two concepts: a prefabrication, which assumes the wide use of finished components in construction and Dynamic Architecture, which means introducing time as the fourth dimension to the architecture. The Rotating Tower in Dubai, which is to be its own wind plant, is one of his recent projects. There will be separate turbines with vertical rotational axis extorting the rotation of the entire floor between particular storeys of the 420-metre skyscraper. Each floor is to rotate with a maximum speed of 6 m/min or make one full rotation in 90 minutes. The central axis of the building will be an immovable concrete core, on which previously installed and prefabricated components of particular modules composing floors will be 'hoisted'. Horizontal turbines placed between the floors are to be almost invisible. They will be made of carbon and their shape and modern technology of workmanship are to provide the solution for acoustic problems.

Communicating the matter of centrifugal force arising in the building, which operates in such a way, as well as laying out and operating sanitary and electrical installations, are interesting problems with which designers have to wrestle.

4. Conclusions

Difficulties resulting from the introduction of new technologies are an inevitable element of development and their solution and implementation of increasingly more efficient systems, provides and drives progress. It refers in particular to complex systems, to which one may include wind technologies in the construction process. They require interdisciplinary cooperation beginning at the stage of design, which enables skilful synchronisation of turbines with the building and its territory as well as a solution to the created problems. Such cooperation results in the implementation of more efficient wind systems.

These conclusions concern turbines integrated into the building structure as well as autonomous structures related with other energy sources and wind farms.

References

[1] Knopper L.D., Ollson C.A., *Health effects and wind turbines: A review of the literature*, „Environmental Health", 10, 2011, 78.

[2] Soliński I., Ostrowski J., Soliński B., *Energia wiatru*, Wydawnictwa AGH, Kraków 2010.

[3] Inhabitat.com

[4] purpose.com.pl

[5] Aero Vironment (avinc.com).

TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
ARCHITECTURE | ARCHITEKTURA
7-A/2014

ARTUR JASIŃSKI*

MODERN OFFICE BUILDINGS ACCORDING TO SHELL AND CORE STANDARD – DESIGN EXPERIENCE 1995–2013

NOWOCZESNE BUDYNKI BIUROWE W STANDARDZIE SHELL AND CORE – DOŚWIADCZENIA PROJEKTOWE Z LAT 1995–2013

Abstract

Kraków has become the second largest concentration of office businesses in Poland. The modern office building industry is rapidly developing here; by the end of 2012 the total office stock exceeded 600 000 m^2. It is estimated that about 50 000 m^2 of new offices are being constructed here each year, mostly by developers who specialize in the office market. As the needs of future tenants are unknown at the design and construction stage, office buildings are erected as unfinished and empty boxes. This allows developers to avoid bearing unnecessary risk and labour, and to ensure that the construction is completed, including structure, enclosure and vertical core, prior to the tenant's finishing touches (furnishing and fittings). The basic challenge for architects in this field is the necessity to harmonize the conflicting needs of investment effectiveness with design flexibility.

Keywords: outsourcing, modern office buildings, shell and core standard

Streszczenie

Kraków stał się drugim po Warszawie największym w Polsce obszarem koncentracji firm prowadzących działalność w branży outsourcingowych usług biurowych. Rozwój budownictwa biurowego jest tu prawdziwym fenomenem: pod koniec 2012 roku krakowskie zasoby powierzchni biurowej przekroczyły wartość 600 000 m^2, szacuje się, że co rok przybywa tu nowych budynków biurowych o powierzchni około 50 000 m^2. Obiekty te wznoszone są przez wyspecjalizowanych deweloperów. Aby dostosować je do zróżnicowanych i nieznanych na etapie projektowania potrzeb przyszłych najemców, redukując przy tym nakłady inwestycyjne, czas i ryzyko straconych robót, obiekty te wznosi się jako niewykończone, puste w środku. Zasadniczym wyzwaniem, przed którym stoi projektant budynków biurowych na wynajem, jest pogodzenie wymagań dotyczących efektywności inwestycji z uniwersalnością i elastycznością projektu, która umożliwi realizację zróżnicowanych potrzeb ich przyszłych najemców.

Słowa kluczowe: outsourcing, budynki biurowe, standard shell and core

* D.Sc. Ph.D. Eng. Artur Jasiński, Professor of Andrzej Frycz Modrzewski Krakow University.

1. Introduction

Most building development projects now constructed in Poland are of a speculative nature. They are designed and built without the final user's involvement. This is how almost all residential buildings, shopping centres and modern office buildings to let, which are probably the most typical examples of this phenomenon, are built. To adjust them to the diverse needs of future tenants, which may still be unknown in the design phase, and to reduce investment outlays, time and the risk of unnecessary work, the buildings are offered unfinished and empty inside. The development industry, with its characteristic straightforwardness, coined the term *Shell and Core* for this standard. It is difficult to find the Polish equivalent for this concept. Perhaps it should be termed as a "partly finished roofed building shell" or a "finished building with space to let in the form of a shell", so the original term *Shell and Core* is simply used in the Polish investment market and by the construction industry. Similarly, to international corporations, the development industry often uses definitions, terms and standards in their original language, which by the way, can sometimes lead to mistakes and confusion[1].

In *Shell and Core* office buildings, only façades and the central core in which there are service risers, lift shafts, and common space, i.e., corridors and stairways, are finished. Building surroundings, access roads and underground garages are finished, whilst office space which accounts for the largest part of the usable area is finished and furnished only after the contract with the tenant is signed on the basis of separate design documentation (interior design phase). The phase of finishing the office space, known as *Fit-Out*, is completed either when the construction is about to be ready or when the building has been already given up to use. With the profitability of investment in mind, a very important feature of design is minimizing common space, installations and construction elements to the benefit of the space to let. In a well-designed office building the ratio of the total office area to the net usable area (to be let) on a given floor, i.e., the effectiveness indicator of the office floor, must exceed 80% and sometimes even reaches 90%. Another commonly used effectiveness indicator is the so-called *Building BOMA Ratio*, which represents the ratio of the total area to let to the total usable area of the building. This indicator should be higher than 0.80. For this very reason unfinished office buildings, in which the area to let forms a vast majority of the building's projection, look like empty shells with façades.

2. The phenomenon of office building development in Kraków

The capital of the Małopolska region has become Poland's second largest concentration of modern office facilities after Warsaw. Most firms located in these office buildings are in

[1] Polish PN-ISO construction standards for calculating area differ in some detail from those used by western developers, e.g. US BOMA (*Building Owners and Managers Association*), RICKS (Britain's Royal Institute of Chartered Surveyors) or the German GIF.

business support services, chiefly in the BPO[2], SCC[3] and IT sectors[4]. At the end of 2012, Kraków's office space exceeded 600 000 m^2; it is estimated that around 50 000 m^2 of new office buildings are added every year to the area. This trend, typical of post-industrial cities, will continue in the near future [CBRE 2013].

The assets of Kraków as one of Poland's largest business, administration and academic centres include the availability of human capital such as graduates of local universities (to which 200,000 students attend), convenient national and internal transport connections, high living standards, modern office infrastructure and – paradoxically – the concentration of outsourcing companies which offer increasingly more experienced local human resources. The city has already attracted major investors: AON Hewitt, Capgemini, Capita, Cisco, Delphi, Google, Heineken, IBM, Lufthansa, Motorola, Shell, State Street. The business service industry is the youngest and most rapidly developing business sector in the city; 80 specialist firms employ as many as 26 000 people. The average age of employees in this service sector is 28 [Żurawik 2013]. Due to system transformation, which has resulted in the replacement of industrial activities by specialized IT services, Kraków has joined the new generation of cities; hubs of the world's economic information which are characterized by the high dynamics of spatial systems. At the same time it should be noted that Kraków is a conservative city zealously protecting its heritage, which sometimes leads to disputes and conflicts, when it comes to the planning of new investment. The development of office construction is rather spontaneous in Kraków; office buildings are scattered and no *Central Business District* has been created as is the case of many other metropolises.

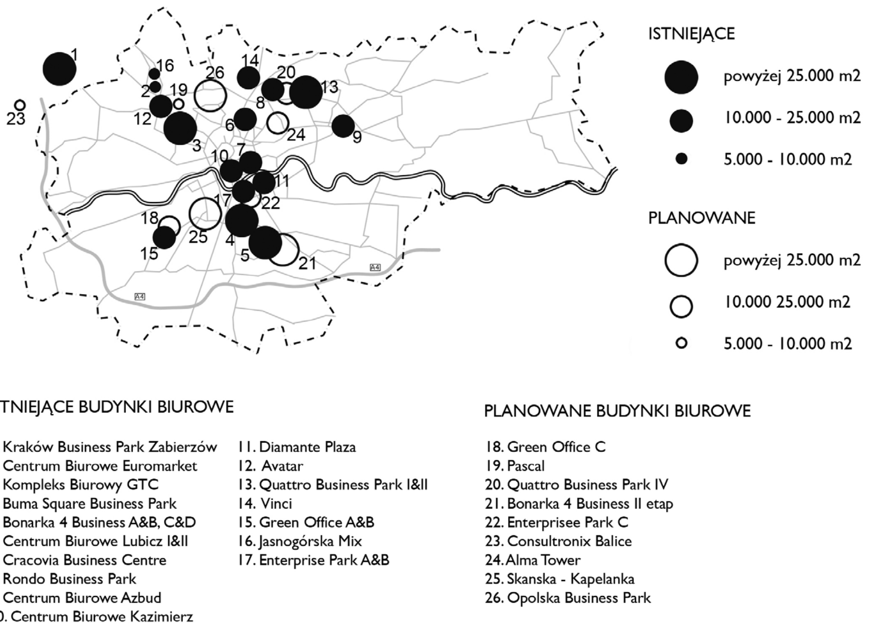
The first modern A-class office buildings began to spring up in Krakow in the late 1990s, chiefly in Poland's reviving banking sector. At that time the largest office tenant in the city was the Przemysłowo-Handlowy Bank, which rented two modernized large office buildings: the tall building in Bohaterów Getta Square and the former office building of RSW "Prasa" at Grzegórzeckie Roundabout (now: the Cracovia Business Centre, commonly known as *błękitek* [the Blue House]). Another major office development project, in this case in the form of offices to let, was the Lubicz Office Centre, with an area of around 20 000 m^2. It was built in the years 1999–2000 by a company created by the BPH Bank and Mostostal Export Warsaw, especially for this purpose[5]. In 2002, the first office building opened in the suburban community of Zabierzów, which initiated a series of several Kraków Business Park facilities, now offering a total area of 75 000 m^2. At the beginning of the 21st century and in line with t he dynamically developing firms of the new business service sector, western developers

[2] *Business Process Outsourcing* – firms offering specialized office services to other companies, chiefly in the area of finance, accounting and HR.

[3] *Shared Service Centres* – centres offering shared services within a capital group, delocalizing some areas of the company's operation to other countries to benefit from qualified but cheaper workforce, chiefly in the IT, finance, accounting and client service area.

[4] *Information Technology* – firms specializing in IT services.

[5] The Lubicz Office Centre was originally designed as the headquarters for BPH Bank, hence its classical façade and monumental interiors – elements rarely seen in office buildings designed to let. However, after obtaining a building permit, BPH Bank withdrew its decision to house its headquarters in the building, so its interiors were re-designed as offices to let, without modifying the external appearance of the building and without changing the building permit conditions (design: Biuro Architektoniczne DDJM, Marek Dunikowski, Artur Jasiński, Jarek Kutniowski, Piotr Uherek, 1995–1998).



Il. 1. Existing and designed office buildings in Kraków. Compiled by the Author

appeared in Kraków, e.g., GTC which built a new complex of office buildings (Newton-Galileo-Edison) on Armii Krajowej Avenue, covering a total area of over 30 000 m^2. In their vicinity, the Zasada Deweloper company built the "Mercedes" complex of office buildings in the years 1999–2000 and the Echo Investment company (Avatar) building in 2008–2010 which replaced the demolished seat of Hydrokop. This has now been entirely rented out to BNP Paribas.

The first decade of the 21st century was a period of prosperity for developers of office buildings in Kraków. Despite the economic slump in the years 2008–2009, several thousand square metres of new office space was made available on the market. In that period, another office building complex was built by GTC in the vicinity of the Kazimierz shopping centre (12 600 m^2, 2009), as well as many other office facilities, including, inter alia: Buma Square (28 000 m^2, 2006), Diamante Plaza (10 000 m^2, 2007), Rondo Business Park (7400 m^2, 2007–2008), Onyx (6000 m^2, 2008), CBL 2 (7,000 m^2, 2009), Da Vinci (20 000 m^2, 2011) and Bonarka 4 Business office park, comprising a total area of 33 200 m^2 (2009–2013). Among the largest office investment projects now underway is the Quatro Business Park which is being built by Buma. An area of nearly 50 000 m^2 of office space to let will soon be available in four buildings under this project. Rents in office buildings, which meet the requirements of BPO/SSC firms, range from about 13.50 to 14.50 EUR/m2/month. In the case of larger clients, developers are ready to offer extra packages or a period of release from rent [Ober Haus 2012, p. 9].

The new actor on the Kraków market is the Swedish developer Skanska, now building a 30 000 m^2 office building in the Kapelanka Street and planning other development projects.

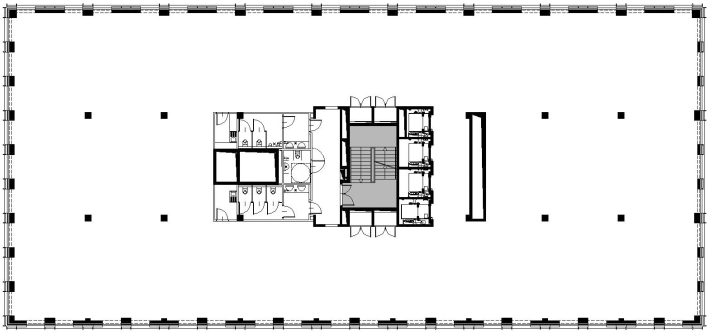
New sets of office buildings are being built on the edge of the City Centre (the Old Town itself being unfit for the development of large-size office buildings in view of its historic architecture, protected urban layout and inaccessibility to car transport), as well as in peripheral zones. A location is usually selected if it is a good address and has good traffic connections. In most cases, office buildings are built on brown field post-industrial plots. In many cases investment is hampered by the lack of local land-use plans, which is particularly troublesome, if the tenants need to modify their plans and thus obtain a new building permit or modify an existing one.

Recently, the trend for integrating office parks with large shopping centres has been seen. The GTC-built Kazimierz Shopping Centre and a complex of office buildings at the Bonarka Commercial Centre, built by the Hungarian developer Tri Granit can serve as examples in this respect. In the latter case, next to the already completed four office B4B buildings, more development covering an area of about 50 000 m^2 is planned. The combination of a large shopping centre with an office park, offers mutual synergic benefits; on work days, the office staff can use park grounds, shops, bars and restaurants at the shopping centre, bringing life to rather empty shopping centres during office hours, whilst at night and on free days, parking stalls for shoppers are made available. A large office building is also being planned near the Galeria Krakowska shopping centre, which itself offers over 5000 m^2 of office space. An inner city residential and commercial complex (the Lubicz Brewery) is now being built in the vicinity.

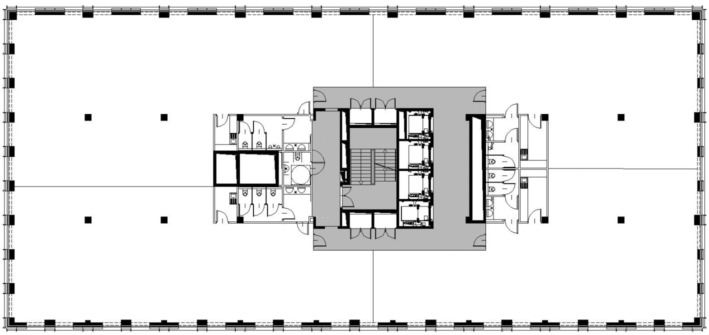
3. Characteristic features of office buildings to let

In the 1990s, there were no uniform standards for office buildings. An office building was considered A-class when: first it was situated on a main street; secondly – it had high class technological facilities, such as air conditioning, teletechnology and specialist low-voltage installations, including the BMS system, and “top-shelf” materials were used for its finish. This gap was filled only when, at the turn of 2008/2009, the Rolfe Judd Architecture and CB Richard Ellis consortium published *Modern Office Standards – Polska*, initially available in English and currently also in Polish. It is an industry recognized set of design guidelines and specifications for office buildings. Thanks to this, the standards have been harmonized and frequent misunderstandings and controversies between international partners of the investment process working on the basis of their own standards and traditions were eliminated. In addition to standardization, the standards, which were developed in cooperation with Poland’s largest office space developers, are aimed at ensuring the effectiveness of planning office space for rent.

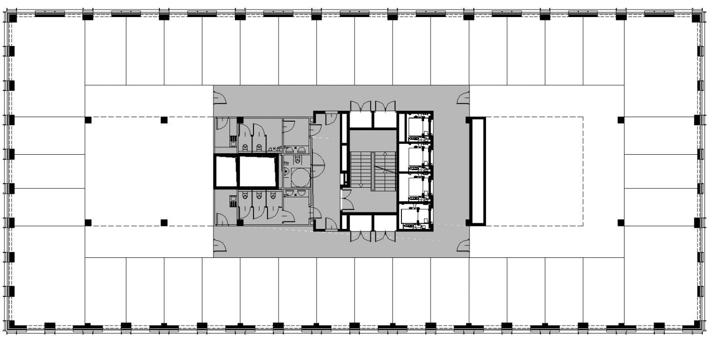
Modern Office Standards has set 20 qualitative and 3 location criteria, according to which buildings are classed A, B or C. To be classed A, the building must meet at least 17 qualitative criteria and to have an appropriate location. Detailed analysis of the standards brings interesting conclusions. For example, the first mandatory criterion is the building’s high-profile image, which can be ensured by its fine architectural design, particularly prominent location or simply its size dominating over the neighbourhood, and enhance the position of its tenant(s), visualized by the monumental emblem or the company’s logo on the building.



Rzut budynku biurowego w standardzie shell & core - wariant dla jednego najemcy na piętrze
(na szaro zaznaczono powierzchnie wspólne).



Rzut budynku biurowego w standardzie shell & core - wariant dla czterech najemców na piętrze
(na szaro zaznaczono powierzchnie wspólne).



Rzut budynku biurowego w standardzie shell & core - wariant dla wielu najemców na piętrze, układ korytarzowy
(na szaro zaznaczono powierzchnie wspólne).

Il. 2. Variants of the floor layout depending on the number of tenants. The change of proportions between common spaces depending on the number of tenants is noteworthy. Compiled by the Author

In many countries, the designed module based on the 1.50 m × 1.50 m grid is considered to best suit the needs of office building planning, as it makes it possible to build the smallest office rooms, 3.00 metres wide (measured in module axes), whilst the main construction grid of the buildings is 9.00 × 9.00 m. In Poland, the optimal module is 1.35 × 1.35 m, which gives the module width of 2.70 m, so the frame structure of the building is planned on the 8.10 × 8.10 m grid. It meets the requirements for garage space (3 parking stalls between pillars and optimal planning of parking stall ranges and passages). The effective slab and column construction devoid of binding joist is also possible. Lower standards applicable to office rooms might be of little importance in Poland because most office spaces are *open plan*, so that workstations can be densely planned. In order to calculate the capacity of air conditioning systems, lift programming and calculating the width of emergency exits, it is assumed that the area for rent can offer 5–8 m^2/person. In practice, these values are usually a little higher, but the "rescaling" of ventilation systems and wider up to standard emergency exit roads, will ensure higher comfort of work and security for people.

In Poland, the height of rooms in office buildings are a little below standard. The minimum nominal height for A-class buildings is 2.80 m from the floor to the ceiling (some investors even accept 2.70 m). Obviously, it is measured in the room when it is already finished. Considering the space for ceiling structures (installations which run over the ceiling and raised floors) the overall height of the floor in office buildings is usually well above three metres, generally measuring between 3.50–3.80 m (of course excluding the ground floor if commercial or catering services are envisaged). In this case the height of the interior of more than 3.0 m needs to be ensured (some investors even require 3.30 m).

4. Shell and Core design challenges

From the author's experience of designing office space, it seems that the smaller and the more "local" the tenant's firm is, the more likely the space rented is to be divided into a larger number of small rooms, micro-offices, irregular meeting rooms and cramped auxiliary annexes. Large international corporations are fond of open and transparent interior layouts, usually supplemented with a few rooms for the management staff, glazed conference rooms and more cozy rest and refreshment rooms. Naturally, in the case of the open-plan model, the effectiveness of the use of space is higher and the cost of adapting the office space to the tenant's needs is reduced. This is why office space developers spare no effort to attract large western companies as tenants and are reluctant to construct cellular layouts designated for smaller tenants. The use of an office building occupied by small companies, where the tenants' rotation is rather high, large numbers of visitors and constant remodelling of the offices differ from the building with large, corporative and usually stable tenants.

The inadequate number of parking stalls is a common problem when office buildings are constructed in Kraków, which results in overcrowding the neighbouring streets with the parked cars of employees. In most cases, for A-class buildings one parking stall is planned per 50 m^2 of office space. This standard results from the optimization of the usually high costs of building underground garages for the needs of a relatively small number of management staff, as companies are only ready to hire expensive garage stalls for the management. For a corporation employees, having their own garage stalls has a double meaning: functional, as it gives them fast and convenient transport access to work, and that of a status symbol – testifying to their high position in the company.

Theoretically, other employees should go to work by bike or public transport. But in practice it is totally different: there are 5–10 employees per 50 m^2 of office space and they usually have cars. Due to the intensive work schedule the corporation imposes on its staff, they are constantly in a hurry to meet their family obligations, so they are generally forced to go by car if they want to drop off their children to kindergarten or to school on the way, to do the shopping, etc. This leads to the situation in which the streets around large office buildings, even if well connected with public transport, are crammed with parked cars. As it happens, some people hurrying for a meeting just leave their cars wherever they can, thus increasing traffic chaos. Hence, moving the office function outside the overcrowded inner city districts and combining office complexes with shopping centres, where the deficit of parking stalls can be overcome thanks to underground garages, is advisable.

A prevailing trend which is now seen in the Kraków market is the certification of office buildings which should achieve LEED[6] (Gold) or BREEAM[7] (Very Good) levels. This is connected with increasing corporate awareness and responsibility among both developers and tenants. International outsourcing companies which are leading clients in Kraków's real estate market of office space "go green", preferring energy efficient and environmentally friendly projects. Certification is more than a marketing tool and a method to meet environmental protection requirements; certified, energy efficient buildings bring the tenant long-term economic benefits in the form of lower utility bills. According to the report, *Going Green in Eastern Europe*, modern office buildings will have to be "green" and sustainable, and energy efficiency will soon become a legal requirement [Jones Lang LaSalle 2012].

The main challenge for the designer of office buildings to let, is how to conciliate the investor's requirements to have an adequate return on investment , with the universality and flexibility of design to meet the diverse needs of future tenants. Design standards are becoming more precise and there is increasingly greater awareness of office space developers' and tenants' needs, which helps to meet sometimes conflicting goals. In view of the competition in the market of properties for rent and the striving for maximum profit, developers are forced to optimize the use of their property. These activities run in parallel: the maximization of the area for rent, reducing the investment cost and tightening its timeframes. In other words, the developer will always try to achieve maximum profit at minimum cost. Certainly, the success of an office building project does not depend only on the cost and time of its development. The investment's success depends on the building's success in terms of lease, which in turn depends on meeting the needs of prospective tenants.

Unfortunately, designers are unable to foresee the number and the type of requests prospective tenants may have, so they should be striving for project optimization, first of all by ensuring the high effectiveness and flexibility of the space to let. This can be achieved when the floor area can be flexibly divided between several tenants, whilst the planning of service risers and common space remains the same: through the use of routes which allow enough daylight at work stations and the planning of office space depending on the strategy

[6] The LEED (*Leadership In Energy and Environmental Design*) certification programme was created by the U. S. Green Building Council in 2000.

[7] The British certification programme: BREEAM (*Building Research Establishment Environmental Assessment Method*) was launched in 1990.

Il. 3. *Shell and Core* office building – before the interior was arranged by the tenant (Photo from the archive of the Artur Jasiński i Wspólnicy design office)

Il. 4. *Shell and Core* office building – after the interior was arranged for the tenant (open-space model) (Photo from the archive of the Artur Jasiński i Wspólnicy design office)

of lease (corridor, open-space or mixed model), through the maximum simplification of constructions and installations (regular construction and functional grids, modular and well-planned installation systems). The studies of planning options for the space to let, which are already developed at the initial phases of design work and verify the assumptions as to the functionality and space in view of the various layouts needed by tenants and various renting strategies, are useful for the project's optimization. It needs to be noted that the client's striving for prestige and quality of architecture in A-class, offers a little more space for the designer's creativity to give the architecture its individual expression, usually with regard to the building façade and common space detail, and with special stress on the entrance hall and reception, which may be the smallest in terms of area, but nevertheless the most representational interiors of the office building. The design and furnishing, of the remaining, several times larger part of the building, will be up to the future tenants.

References

[1] CBRE Polska, *Krakowski Rynek Nieruchomości Komercyjnych*, 2013.
[2] Jones Lang LaSalle, *Going Green in Eastern Europe*, March 2012.
[3] Ober Haus Agencja Nieruchomości, *Raport z Rynku Nieruchomości – Polska*, 2012.
[4] Rolfe Judd Architecture and CB Richard Ellis, *Modern Office Standards – Polska*, November 2010 (www.mosp.pl).
[5] Turkawka K. (ed.), *Biurowce w Polsce – wiosna 2013*, nowyadres.pl, Warsaw 2013.
[6] Żurawik M., *Korporacje chcą Krakowa*, Gazeta Wyborcza Kraków, 18 March 2013.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

MAREK KAMIENIARZ*

BURIAL MOUND IN KARNIOWICE – A STRUCTURE OF THE 21ST CENTURY, PART 1

KURHAN KARNIOWICKI – BUDOWLA XXI WIEKU, CZ. 1

A b s t r a c t

This paper discusses an unconventional final resting place called a burial mound, built in Karniowice near Trzebinia. This is the first such structure in Poland and Europe which fulfils both sacral functions for celebrating masses and predominantly acts as a burial place of the dead. The aim of the construction was to limit the cemetery area, which constitutes a significant worldwide precursor in the field. The burial mound gives, in comparison with the traditional cemetery, a 30-fold saving of space and after special treatment that will mineralize bodies, as much as 100-fold: 1 600 burials in five ares of land. This unique structure can be a good future option to build cemeteries in cities where there is not enough space in the existing ones. Because of its uniqueness and prototype character, only the design basis has been presented, which in the construction phase was partially modified. The changes will be described in detail in Part 2.

Keyword: burial mound

S t r e s z c z e n i e

W opracowaniu omówiono niekonwencjonalne miejsce spoczynku zmarłych zwane kurhanem, wybudowanym w Karniowicach koło Trzebini. Jest to pierwszy w Polsce i w Europie obiekt, spełniający funkcję sakralną, gdzie można odprawiać Msze Św., ale przede wszystkim pełniący funkcję pochówku zmarłych. Celem budowy było ograniczenie powierzchni cmentarnej, co stanowi godne uwagi prekursorstwo na skalę światową w tej dziedzinie. Kurhan, to w porównaniu z tradycyjnym cmentarzem, 30-krotna oszczędność miejsca, a po specjalnych zabiegach, które spowodują mineralizację ciał, nawet 100-krotna: 1600 pochówków na 5 arach ziemi. Ta unikatowa budowla może być w przyszłości dobrym rozwiązaniem budowania cmentarzy w miastach, w których brakuje miejsc na cmentarze. Ze względu na swoją unikatowość oraz prototyp, przedstawiono jedynie założenia projektowe, które w fazie budowy zostały częściowo zmodyfikowane. Zmiany zostaną opisane szczegółowo w części 2.

Słowa kluczowe: kurhan

* Ph.D. Eng. Arch. Marek Kamieniarz, Department of Civil Engineering and Building Physics, Faculty of Civil Engineering, Cracow University of Technology.

1. Short overview of the history of burial mounds

A burial mound is a building often called a mound-shaped, conical or semi-circular grave. Most often it was a burial mound constructed of earth or stones, with elements of wood, stone or wood and stone. It was constructed above the grave (or graves), measured several meters in height and contained a chamber for inhumation or cremation. The tomb chambers, often very complex, were usually stone or wooden structures, sometimes forged in solid rock. The genesis of building round mounds is connected with communities colonizing mainly steppe areas of south-eastern Europe, Asia and America in the Neolithic and Iron Age (e.g., Unetice, Trzciniec or pre-Lusatian culture, and also some local groups of the Lusatian culture). Less commonly they were also found in Roman and early medieval cultures. The term "burial mound" in Eastern Europe corresponds to the word "tumulus" in Western European languages [1].

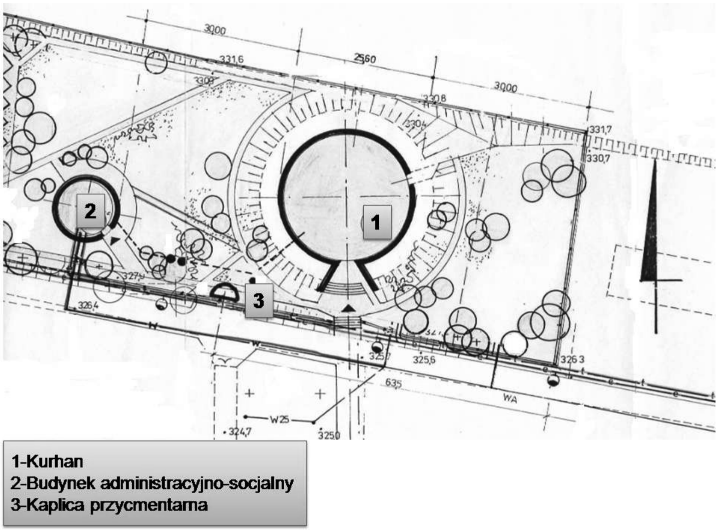
2. General characteristics

2.1. Introduction

The founder and creator of the first Polish Parish Memorial Centre (Ill. 1), where the burial mound discussed in this article remained a focal point, was the priest Stanislaw Fijałek, a very modest man, but stubborn as highlanders often are. He was an excellent organizer, able to win over and convince the people. He also initiated the construction of several churches, including the church in Laliki near Koniaków, church in Górna Kamesznica and the church in Karniowice, where he also built the first clay house in this area. He initiated a centre for the deaf-mute in Pcim and was the inventor of several patents, including an ecological oven. What is more, he founded two cemeteries, but the one in Karniowice, as he claimed, is the culmination of his priesthood.

2.2. The founder's ideological concept concerning the burial mound

The parish, when fulfilling the mission of the Church, provides special care to the suffering and ill people offering them spiritual comfort: the sacramental ministry. From the moment of one's death, it takes over the body and moves it to a special crypt in the burial mound. The body is then moved from the above crypt to a suitable space in the facility building located next to the mound, where through the specialized equipment of vacuum pumps a trained doctor (holding a certificate) mineralizes the body (thanatopraxy). As a result, the body is dehydrated and the lymph is replaced with special chemical solutions, which embalm and mineralize the body. As a result of this process, the body retains the look of the living, sleeping person, which is particularly important in the Christian culture where family says goodbye to the deceased. After mineralization and cosmetic treatments, the dead body is clothed black and purple vestments and a ceramic medal is placed on his/her neck. The medal contains a five-digit code precisely pointing to the burial place in the Centre of the Dead. What is more, the digital code makes it possible to obtain further biographical information about the deceased person, stored in a computer memory. A collection of all the data of the deceased will in the future become a reliable source of ethnographic research on the culture of the region. When the body is prepared, it is placed into the metal coffin, which together with flowers is then put in the central place close to the altar where the funeral mass will be conducted.



Ill. 1. Part of the land development plan of the Parish Memorial Centre in Karniowice

The coffin will be covered with a specially for the occasion prepared cloth adorned with religious and national emblems. Its role will be to make all the lying dead materially equal. The mourners taking part in this sad ceremony, will be able to leave their cars in the car park near the burial mound. They will be able to pay their respects to the deceased and in a special facility room solidify memories, view photographs, images, recall the biography and other memorabilia/or even drink tea or coffee with their loved ones.

After the funeral the coffin will be carried to the family crypt on a special trolley. The coffin will be placed on the appropriate shelf made of reinforced concrete and will be capped with a plate made of the same material. The plate will be then sealed with clay so that the mineralized remains could be transferred in a few years to a common urn, located in the depths of the tomb. It should be noted that due to the mineralization process, the body will completely powderize after five years and it will be possible to transfer it to the above-mentioned family urn. Powderizing of bodies will greatly prolong the life of the tomb and the epitaphs written on it will show a genealogical tree of each family. The chapel inside the burial mound will consist of the ground floor and two upstair choirs through which the relatives of the deceased will be able to reach the deceased person's resting place and on a special plate below the epitaph they will be able to light oil lamps and leave potted flowers. The epitaph will be inscripted in gold letters on a black marble plate. It will contain the name of the deceased and the dates of his birth and death and optionally, include a ceramic picture.

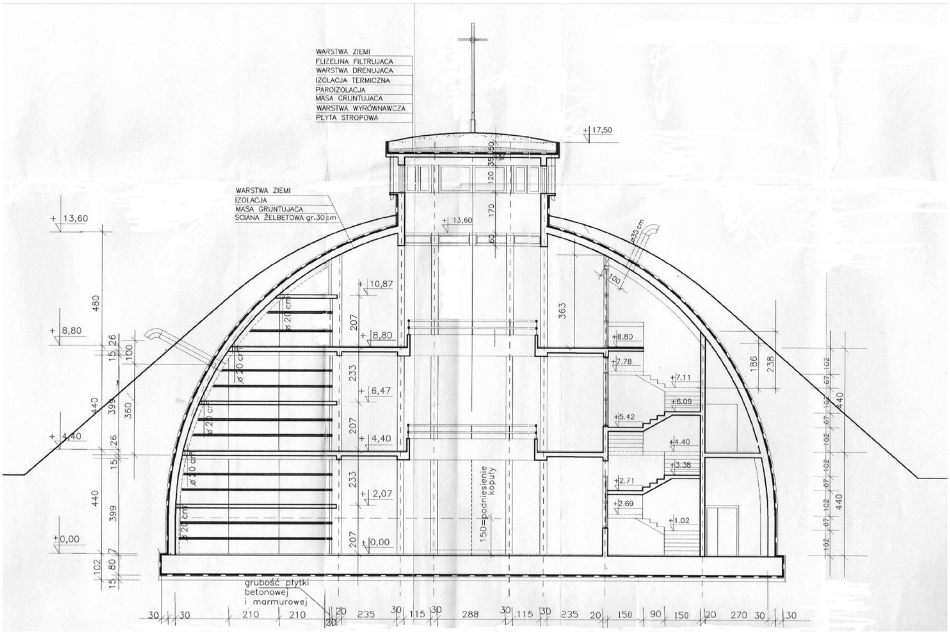
Epitaphs and altars with burning lamps and flowers will form the inner wall of the chapel, and the ground floor and upstair choirs will enable visitors (after turning around) to participate in the holy mass (Ill. 2).

Ill. 2. A part of the mound's interior showing the epitaph on the chapel's wall

The interior of the chapel is decorated in such a way that it will attract families of the deceased to visit their loved ones and participate in the mass liturgy. Spherical reinforced concrete construction containing the chapel and crypt will be covered with layers of loamy earth and flowers, which will make the burial mound both ecological and very economical. The star-shaped window in the ceiling will naturally light the interior of the mound – regardless of the rich artificial lighting – and due to this solution it will remain in harmony with both the altar cross and the cross located at the top which also acts as a vent. The property will be fenced with a hedge in which ceramic statues of saints will be placed every three meters. The area between the fence and the walls of the mound will be covered with grass and planted with low ornamental shrubs, and the building will look like a big bouquet of flowers.

3. Functional layout according to the design

The Parish Memorial Centre is modelled after ancient catacombs and burial mounds. It will fulfil all requirements for burial and storage of the dead as well as for celebrating masses. In the middle of the wide and spacious ground floor area of about 100 m^2, a chapel with an altar, catafalque and benches for people taking part in the funeral have been designed. At the main entrance there will be rooms for the preparation of the bodies and thanatopraxy with a sanitary unit for the staff and storage of coffins, and at the rear: the sacristy. All three storeys surround the crypt for burial and are arranged on a number of levels between the bearing walls. In the niches of the balconies there are spaces for urns and storage. The transportation of coffins to upper floors will be provided by a manually-operated lift, located behind the altar. At the top of the dome there is a circular stained glass window filled with religious themes. Such a way of storing corpses around the chapel provides high liturgical cult of the dead and a huge space saving: 3 coffins on 1 m^2 of the mound, while at the municipal cemeteries a simple tomb takes about 4 m^2. This fact clearly shows the undeniable superiority of a burial mound over a traditional cemetery. The additional elements of the mound in the second stage, are the facility object and an existing field altar for the more massive religious celebrations. The facility will contain rooms for the memory of the dead, a café and public toilets, all designed for the participants of funerals.

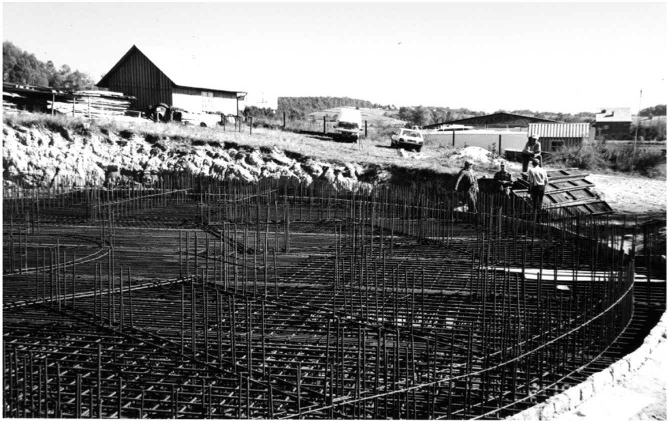


Ill. 3. Vertical section of the designed burial mound

4. Architectural and construction layout according to the design

The construction of the burial mound was designed in the form of a spherical dome with an internal diameter of 25 m (Ill. 3). At the bottom of the mound's pit 25 cm of dry concrete will be placed. A circular foundation of a reinforced concrete slab with a diameter of about 26 meters is designed for the previously prepared ground. Due to fourth category mining damages, the slab is 80 cm thick (Ill. 4), locally thinned to 60 cm in order to include the plumbing installation below the ground floor. The materials used were concrete class B25 and reinforced ribbed steel Class A – II of a total weight of 120 tons.

On a slab prepared in this way, a reinforced concrete ring plate of 1.5 m in height and a length of about 81m has been designed to encircle the structure. On the ring plate a reinforced concrete dome will be constructed using a method derived from American technology. A polyvinyl balloon filled with air (Ill. 5) will be strengthened with foam in which steel anchors will be attached to secure the subsequent reinforcement of the dome.



Ill. 4. Reinforcement of circular foundation slab under the burial mound

Then, by means of compressed air at a pressure of 20 atm., the steel structure will be covered with concrete consisting of several layers which will eventually stiffen the whole structure of the dome. For sealing and the protection of concrete, a micro-mortar WANDEX-SUPER was used, which is based on special cement activating chemical constituents of the concrete. This eliminates the penetration of liquid water, but allows water vapour. The preparation also protects the concrete from chlorides, nitrates and sulphates as well as carbon dioxide which causes the carbonation of concrete and is responsible for the loss of the anticorrosion capacity of reinforced steel. The outer 30 cm thick dome-shape will be made and reinforced with bars arranged parallelly and meridionally. The layer will be supported with 30 cm thick concrete outer walls and in the inner part with reinforced concrete posts. The walls and posts are also the bearing elements for ceiling of each 20 cm thick storey plate. The dome is surmounted with large skylight windows giving natural light inside the burial mound. The internal cubature amounts to as much as 5000 m^3. The ceiling, after the appropriate finishing with plasterboards and lighting, gives a vivid picture of a star and remains in harmony with the interior of the mound and altar cross. Outside the building, wide steps together with a ramp for the disabled lead to the entrance and then the entrance hall of the mound. On the right side of the entrance hall a staircase has been designed. Due to the shape of the dome the staircase is slightly set back from the construction line which gives easy access to every storey. Due to the fire hazard category, the staircase is surrounded from three sides by walls of reinforced concrete and from the central part of the mound it is separated by fire-resistant glass (fire resistance of 60 min.). Such a solution provides natural lighting of the staircase and maintains high aesthetics appropriate for the liturgical character of the interior.

The interior has been divided into three storeys separated by 20 cm thick reinforced concrete floors, based on six concrete posts with a diameter of 30 cm, arranged in a circle of 6.08 m in diameter and 30 cm thick bearing walls.

The first and second floor were designed in the balcony system, which provides natural light for all three storeys of the mound from the top window. All storeys surrounding the crypt are made of 6 cm thick reinforced concrete walls with an inner section of 60 to 70 cm.

Ill. 5. Air-filled polyvinyl balloon creating the later shape of the burial mound

They are enclosed with concrete and marble tiles containing the names of the dead. After applying adequate insulation to the reinforced concrete dome, it is covered with a layer of clay loam and fertile earth. The layer of earth covering the dome is suitable for a special type of grass, flowers, ornamental perennials and low growing shrubs thriving well on steep slopes, and due to the dense root system, preventing the ground from slipping.

5. Conclusions

The design of the burial mound was ready in August 1998. The work began in April 1999 and the construction was completed in 2006. The first burial took place in 2006. However, the original plan of using thanatopraxy was eventually not approved by church authorities. In this situation, it was decided that the crypt will contain urns with the ashes of the dead after cremation. This was not in line with the original intention of the priest Fijałek who suggested that the bodies should undergo thanatopraxy and be put to the mound's alcoves in coffins and then after the total mineralization stored in a smaller urns. At the moment however, this is the only possible solution.

Parish materials and photographs have been used in the text.

References

[1] Makarowicz P., *Kurhany i obrządek pogrzebowy w IV–II tysiącleciu p.n.e*, Kraków, Warszawa 2011.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

PIOTR KUCZIA*

„EDUCATING BUILDINGS" – LEARNING SUSTAINABILITY THROUGH DISPLAYED DESIGN

„KSZTAŁCĄCE BUDYNKI" – EDUKACJA PRZEZ EKSPOZYCJĘ ROZWIĄZAŃ ZRÓWNOWAŻONYCH W BUDYNKACH

A b s t r a c t

Technical development, legal requirements, economic impulses and public awareness lead to increased demand for sustainable buildings. Constantly developing increasingly sophisticated technologies become more and more incomprehensible and unfamiliar to occupants and visitors. Exposing sustainable solutions attractively and presenting corresponding information about them directly in the buildings, will increase the knowledge of sustainability. As a result, acceptance will rise, occupants are inspired to proper use and encouraged to future sustainable constructions. Based on analyses of built examples and planning an innovative model building, new concepts and project recommendations for exhibiting sustainable solutions and techniques have been developed. They are compiled in a bilingual compendium "Educating Buildings".

Keywords: sustainable architecture, education for sustainable development

S t r e s z c z e n i e

Postęp techniczny, wymogi prawne, bodźce ekonomiczne i wzrost świadomości społeczeństwa podnoszą wymagania w stosunku do rozwiązań zrównoważonych w budynkach. W efekcie wzrasta ich kompleksowość i pojawia się konieczność implementacji nowych technologii. Dla użytkowników stają się one coraz bardziej niezrozumiałe i obce. Przez atrakcyjne wyeksponowanie rozwiązań zrównoważonych i udostępnianie informacji o nich bezpośrednio w budynkach możliwe jest podniesienie stanu wiedzy w tej dziedzinie. Prowadzi to do wzrostu stopnia akceptacji rozwiązań zrównoważonych, stymuluje do prawidłowego ich użytkowania i obsługi oraz zachęca do powielania. W oparciu o analizę istniejących obiektów i modelowy projekt opracowano uniwersalne wytyczne projektowe dotyczące przedsięwzięć ekspozycyjnych, które opublikowano w dwujęzycznym kompendium pt. Educating Buildings.

Słowa kluczowe: architektura zrównoważona, edukacja dla zrównoważonego rozwoju

* Ph.D. Arch. Piotr Kuczia, Verein fuer Oekologie und Umweltbildung Osnabrueck c/o University Osnabrueck, Germany.

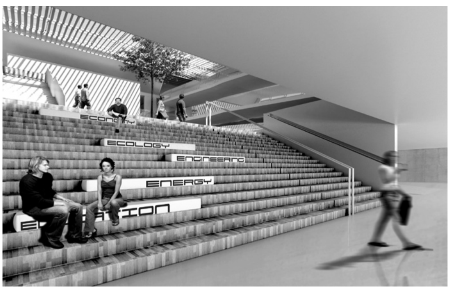
1. Introduction

Buildings, especially modern public buildings, are increasingly complex and technical structures. They contain, or rather they are constructed from, quite a number of cutting edge clever facilities and controlling installations. When one thinks of sustainable construction, these modern building systems play a central role. Their tasks as the key to sustainability consist however, not only of resource saving energy production and efficient energy use, but also increasing comfort for both the occupants of and visitors to a building. For this reason, it is important that they be understood, correctly used and operated.

2. The concept of a building as a self explanatory display piece

Detailed instructions booklets for buildings (like for every newly purchased gadget) would most likely be impossible to compose for highly complex buildings with all their components. When selected problem areas and solutions are concentrated on illustrating and explaining them in generally understandable terms within the context of the building itself, chances increase for occupants and visitors from outside the building to understand and through this, to competently use a building's varied technical possibilities. As a general rule, without such noticeable indicators and explanations, non-professionals are unable to access innovative environmentally technical measures installed in a building.

In this area, the large potential of possible knowledge communication stands opposite a considerable deficit of real, accessible explanations whereby at the same time, economic and ecological side-effects are more positive the higher the awareness for the complexities of the buildings are. In this way, buildings that educate can be used as an innovative and up to now unutilized element for informative learning. In this exceptional educational zone, learning takes place more or less incidentally during everyday use, to which however, in the context of educating about sustainable development, scientists have attested an ever greater importance.



Ill. 1. The concept of an educating building –
3E building Wrocław, arch. P. Kuczia

The boundaries of informal learning are crossed when educating buildings are used for employee training or for working with classes of school children. What is understood is easier to accept. People's reactions to the built environment follow this principle in the following steps: recognition of the problem, understanding said problem and finally taking action.

A problem then, must first be recognized in order to be understood. Occasionally, people's attention must be enticed to the subject matter, which in turn must be explained in a suitable fashion, so that deeper awareness can be drawn achieving a desired level of understanding. With this understanding the acceptance of eventual limitations caused, grows. Acceptance also creates the necessary requirements for competent future use, in this case, for correct operation and use of a building's technical systems. This in turn positively influences user costs and environmental impact.

Awareness of issues involved in sustainable construction and the positive attitude created through understanding these issues can bring profitable multiplier effects: Some occupants may be future owners of buildings built to their requirements, while others may be educators. When these individuals transmit their positive insights about sustainable solutions, they can sensitize some to build according to the principles of sustainable construction and animate others to careful utilization of building technology.

For sustainable operation of buildings, energy efficient and resource saving heating, ventilation, cooling or lighting are indispensible. These technical systems are on the one hand forced by ever stricter legal codes and on the other hand, done on a voluntary basis leading to an increase in investment costs as a rule. In addition to this, restrictions or higher outlays are demanded of occupants while restrictions of decision making possibilities for building occupants can stand in the way of acceptance. In this case also, a better understanding of the measures for sustainability can, especially in the case of publicly owned structures, reduce opposition and create acceptance for corresponding expenses or minimal restrictions and increased expenditures. In effect, building owners, occupants and visitors will profit.

Ill. 2, 3. Exhibited real existing objects – IBA Dock Hamburg (photo P. Kuczia)

Unlike typical themed exhibitions, in which the contents to be exhibited must be acquired before further steps such as defining the core statement or the communicative goal can be considered, in the case of educating buildings the contents already exist and quite often real objects can be used. Here then, the task lies in exhibiting and explaining existing relationships, systems and solutions, which communicate their function and effect to occupants in an interesting and understandable way thus, steering attention to the underlying topic of sustainability.

3. Suitable Building Types

Government bureaus and other state or municipal facilities with visitor intensive zones (municipal buildings, unemployment offices, visitor's centers) are excellently suited for display measures as well as kindergartens, waiting halls, and waiting zones in buildings of public transport, hospitals and other social or medical facilities, culture centers, food service, sport centers, airports, etc.

The well trafficked, public intensive areas of all of these structural objects are generally best suited to install information. In this way entrance halls, foyers or waiting areas where visitors can spend time or have to wait, where they are not forced to hurry and in passing, out of boredom or curiosity, can have a look at exhibits and explanations.

Along with public buildings, the measures can also be successfully used in private and commercial buildings, especially in industries whose areas of business are related to the themes introduced. In this way structures can effectively and profitably self advertise.

A special group of buildings are those whose specific purpose is education, training and the transmission of information in all fields of the subject matter of energy and building technology.

4. What can be displayed

There are many sustainable measures and elements of the building which can be dsipalyed and explained in educated buildings. Typical are the building materials, structures, functional solutions, technical building services, or even the constellation of the rooms.

5. Target groups

In order to develop a conclusive concept with regard to display measures in differing buildings, it is initially necessary to designate the respective target groups. The more exactly the target groups are defined, the better the communicative content can be formulated and shaped, and the more effective and well targeted the exhibits become. To be considered are characteristics such as educational level, age, income, profession, social background or group affiliation.

The analyses help to define what information each group needs for each topic. Sporadic, as well as permanent occupants and visitors to a building belong to the typical target group. According to each object's function, these groups differ greatly; occasionally one and the same building has several groups of persons with deviating characteristics.

In schools, they include students, teachers and other educational professionals, technical personnel such as the maintenance supervisor as well as cleaning personnel, and of course the parents who are involved in school affairs or those who simply bring their children to school or take part in events offered in the school.

6. How to exhibit

This principle of clarity, simplicity and visibility should be followed for displays planned to exhibit the systems for sustainability in buildings. The message to be communicated by educating buildings should be as simple, graphic and comprehensible as possible. This takes place in several steps:

In the first step, the display in question attracts the attention of visitors or occupants so that they pause to satisfy their interest. The intended signal effect can be achieved through various methods: through light, color, contrast and unusual form. Additionally, atypical positioning or a change of perspective draws attention to the desired position. On the one hand, mounting displays at eye level is effective, but on the other however, explanations in surprising places (ceiling, floor, window panes, etc.) draw particular interest. It is also recommendable to place displays where individuals spend time anyway (i.e., outlandish, by grabbing attention using the space over the urinal in the toilet). The objects exhibited, along with their corresponding information, must be durable and long lasting.

Ill. 4. Exposed facade with photovoltaics –
Plus-energy-house, arch. P. Kuczia

Formulate texts short and to the point, without unnecessary foreign words or technical terms. In order to assure understanding, a central order for texts, logically structured and properly outlined, should be formulated. References to everyday practice-oriented questions to introduce a topic, eye-catching key words and distinctive provocative expressions increase interest. Moving objects, subtlety blinking lights, changing colors, quiet sporadically transmitted sounds (should not be irritating or bothersome!) and other similar measures draw the attention of passersby to a display. Audio material common in trade exhibitions should only be used in special cases, and even then more in the form of short interactive statements, rather than detailed explanations as for example, a talking trash can. An attractive option are surprising, movable and time controlled digital projections on objects of interest or near them (wall, ceiling or floor).

While the first step is to capture attention, in the second step the cognitive level of information transmission is reached. Here, content and core message can be transmitted through pictures, texts, audio-visual material, interactive computer programs or models. Ideally, the actual building or real objects should be used when possible. Real components of a building or detailed reproductions when exhibited, are more memorable than illustrations of them would be. Tactile anchoring can be strengthened when objects can be touched.

Ill. 5. Detailed reproduction of buildings walls – HBZ Münster (photo P. Kuczia)

Faced with the complexity involved in a number of the topics exhibited, reduction of most of the contents to their fundamental core message is unavoidable. In depth information does not have to be sacrificed entirely; however, further information can be offered in the form of additional material such as flyers, brochures, books or explanations on the internet. Additionally, further programs can be developed such as guided tours through the building or open house campaigns, depending of course on personnel and budget available. The use of computer based electronic media opens many additional possibilities to communicate.

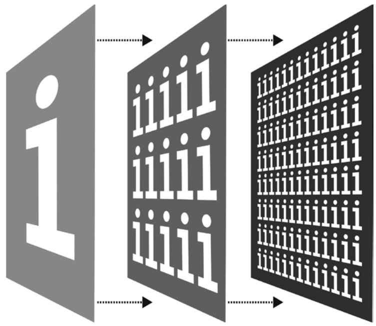
7. Target group adapted depth of information

The target groups for the planned display measures are often difficult to define in advance. Thus, flexibility of composition and depth of information are therefore a necessity. This is only possible if the design approach allows for a certain amount of 'multi-layeredness' in the messages offered. Ideally, three levels of information can be offered:

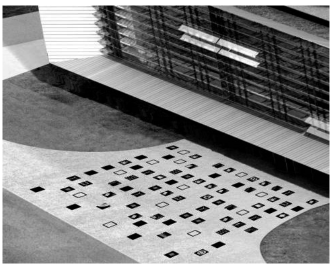
At the primary level the topic is defined and its solution shown. This simplest level is targeted towards groups of casual observers or non-experts who are drawn into the subject matter in passing, so to speak. Designers are well served to use a vivid, intuitively descriptive text and imagery characterized by short, simple expressions and sentences, as well as memorable, clear logos, symbols, and pictures.

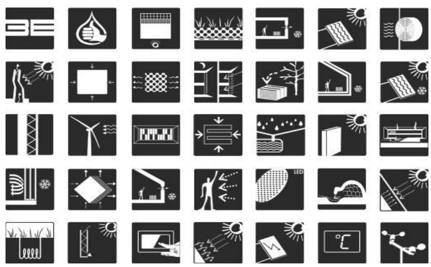
The next level already begins to make further explanations available. As before, simple understandable forms of presentation are used; however now, the topic is explored in further depth explaining relationships and giving background information. The target audience here overlaps with that at the primary level in that displays appeal to those actively seeking further information on a topic without neglecting the coincidentally interested passers-by.

The third level of information transmission contains high content and further explanations aimed particularly at those familiar with the subject matter involved. As a rule, due to the extent of information involved, content is presented in electronic form to be called-up on screens on site or on the internet. QR-codes, offering fast access to desired links via smart phone or tablet PC, are a convenient and fast method of calling up information.



Ill. 6. Three levels of information (P. Kuczia)





Ill. 7, 8. Corporate design with recognizable logos, 3E building Wrocław, arch. P. Kuczia

Educating buildings depend on coherent, conclusive and adequate communication concepts. These are the basis for design of presentation measures about the sustainable aspects of a building. The communication concept serves as a guideline for all further implementation.

The communication concept must be translated into a unified, clearly understandable and recognizable image. The trick lies in finding the right balance between 'eye-catching' and 'complementary/appropriate'. This is only possible through individual design attuned to the particular communication concept and the unique characteristics within a structure.

Ideally, corporate design for display measures should be developed during the planning phase of construction and can be included in corresponding interior design concepts, eventually involving existing master control systems. Information transmitting measures should not be haphazardly added, but rather harmonically integrated into existing surroundings. Requirements of differing target groups should be considered when developing graphic design for a building.

8. Conclusions

Modern, sustainable buildings of differing types can be turned into broadcasters of knowledge and thus become multipliers in the process of educating towards sustainable development. Aspects of building technology can be placed into a context of ecological, economical, social and cultural relationships – set against a background of resource protecting and energy saving.

It is a completely new and innovative approach to informal learning in the context of the global principles of education for sustainable development.

Based on analyses of built examples and planning an innovative model building 3E for the University of Technology Wrocław, new concepts and project recommendations for exhibiting sustainable solutions and techniques have been developed. They are compiled in a bilingual compendium "Educating Buildings – Learning Sustainability Through Displayed Design".

References

[1] Pyhel Th., *Faszination Ausstellung*, Edition Leipzig, Leipzig 2003.
[2] Kuczia P., *Educating Buildings – Learning Sustainability through Displayed Design*, NUSO Verlag, Osnabrück 2013.
[3] Becker G., *Urbane Umweltbildung im Kontext einer nachhaltigen Entwicklung. Theoretische Grundlagen und schulische Perspektiven*, Opladen 2001.
[4] BMVBS (Bundesministerium für Verkehr, Bauen und Stadtentwicklung), *Leitfaden Nachha1tiges Bauen*, Berlin 2012.
[5] Brodowski M. (Hg.), *Informelles Lernen und Bildung für eine nachhaltige Entwicklung. Beiträge aus Theorie und Praxis*, Opladen 2009.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

JAN KUREK*

OD CRYSTAL PALACE DO GLASS HALL – NOWE MOŻLIWOŚCI ZNANYCH MATERIAŁÓW

FROM CRYSTAL PALACE TO GLASS HALL – NEW POSSIBILITIES OF WELL-KNOWN MATERIALS

S t r e s z c z e n i e

Projektowanie wielkoskalowych centrów i pawilonów targowych ma swoją własną specyfikę – „technologie" powiązań funkcjonalnych i uwarunkowania konstrukcyjne, związane ze znacznymi rozpiętościami stosowanych przekryć. Po latach, jakie minęły od pierwszych własnych doświadczeń projektowych w tej dziedzinie[1], jest odpowiedni moment na refleksje nt. historii i perspektyw tej architektury. Ciekawym i pouczającym przedmiotem takiej analizy jest niewątpliwie Centrum Kongresowe w Lipsku, będące swoistą kontynuacją światowych tradycji targowych i historycznych przestrzeni handlowych tego miasta. Po 17 latach od rozpoczęcia użytkowania nowych hal targowych Lipska można dziś podjąć próbę oceny ich funkcjonowania i nowatorstwo zastosowanych rozwiązań konstrukcyjno-materiałowych. Porównanie tych budowli z architekturą innych pawilonów projektowanych na historyczne i współczesne wystawy światowe, wskazuje przewagę prostoty, konstrukcji i uniwersalności form, nad wybujałymi ambicjami twórców architektury „jednej wystawy".

Słowa kluczowe: centra targowe, projektowanie, Glass Hall Lipsk

A b s t r a c t

Designing large-scale shopping centres and exhibition pavilions is governed by its specificity: the "technology" of functional connections and structural determinants related to considerable spans of coverings. After years that have passed since the author's first design experience in this field[1], it is now a good time to reflect on the history and prospects of this architecture. An interesting and instructive subject of such an analysis is undoubtedly the Leipzig Trade Fair, being a continuation of the world fairs' tradition and the city's historical commercial space. After 17 years since the opening of new exhibition halls in Leipzig, one can now attempt to assess their functionality and innovation of construction and material solutions. a comparison of these structures with the architecture of other pavilions designed for historical and contemporary exhibitions worldwide demonstrates the advantage of simplicity, construction and versatility of forms over the exuberant ambitions of the "one exhibition" architecture's creators.

Keywords: exhibition centres, designing, Leipzig Glass Hall

* Prof. Ph.D. D.Sc. Arch. Jan Kurek, Institute of the Builder's Designing, Cracow University of Technology.

[1] The author participated in a national architectural competition for the design of a new centre of Poznan International Fair in Poznan–Strzeszyn in 1978.

1. Origins of the fair

Fair and marketplace is a form of the transaction of purchase and sale of goods known for millennia. Initially it was a simple barter i.e., non-cash exchange of goods for goods or goods for services; later base and precious metals became a means of payment. In time, after a stamp or ruler image had been stamped on a piece of metal, money became the universal means of payment[2].

In Greek architecture a type of free-standing, elongated column hall *(stoa)* was shaped. Not only was it a place of trade, but it also served administrative and leisure purposes and as a shelter against adverse weather conditions. These buildings usually bordered with the agora and were also built in palestras and gymnasiums. The famous Athenian stoa[3] was built by Cimon around the year 450 BC and decorated with colourful paintings of Polygnotus, Micon and Panaenus.

Commercial function was usually served by marketplaces, forums[4], roofed shopping galleries bringing together a variety of shops and shopping arcades[5]. The Milanese gallery[6] is the oldest and most elegant shopping centre of the city. Its construction, designed by Giuseppe Mengoni, started in 1865. Laid out in the shape of a cross, with 196 and 105.5 m long arms and a large glass dome in the middle, it connects two Milanese squares.

The first written mention of trade fairs in Poland can be found in a document from 1065. The next document is a medieval record of 1278. In 1496 the right of free fair in the city was established. With time, however, this trade encased charges (taxes) in cities, e.g., for the king. For some time the fair tax was not collected from the clergy and nobility; later rural fairs were forbidden to return to the taxation of trade by the venal and noble craftsmen and exempted those peasants "who sell and buy their own things or the things they need" [1] from fees.

2. Permanent fairs and exhibitions areas

Regardless of the method of payment for the goods, there was always the need for the functioning of well-known places where the presentation of the goods offered for sale could take place, "equipped" with additional spaces (premises) to celebrate among other things successful transactions. Trade fairs are usually established with a long tradition, as well as bound by more or less formal trade rules.

---

2 The creators of the coins were probably Phoenicians, also known as Sidonians in the Old Testament, known for their active trading (about 3000 BC). The oldest find of an ancient "coin" (7th century BC) is a lump of electrum (an alloy of gold and silver) bearing the stamp of a goldsmith of Ephesus. Paper money appeared in China and then in Europe in the seventeenth century. Currently popular means of payment is electronic money stored in a computer memory bank accounts.

3 S*toa poikile* was the location from which Zeno of Citium taught and hence his philosophical school of Stoicism took its name; source: wikipedia.

4 The oldest forum in Rome was the *Forum Boarium* (beef market – 6th century BC), next to which functioned *Forum Holitorium* (vegetable market). Today, the term forum is sometimes used in the names of shopping malls – e.g. Forum Shopping Centre in Gliwice, CH Forum Koszalin, etc.

5 An arcade is a shopping centre with retail stores, with a total area usually up to 2000 m^2.

6 Milan will host the 2015 World EXPO. Also the name "gallery" is currently popular in regards to modern department stores with spaces rented by agents.

Spaces and various commercial facilities of all sizes operate successfully today as they are simply essential for the proper functioning of society in different cultural formations. Local, national or international trade requires more solid grounds and facilities in which it is possible to present the offers of individual producers, to individual visitors as well as resellers and wholesale customers. In addition to typical trade events, fairs and exhibitions may also present technical or cultural achievements of individual countries or producers such as World Fairs[7] (known as EXPO today), motor shows (e.g., Poznan Motor Show, Geneva Motor Show) or electronics fairs (International Photographic Trade Fair in Cologne).

3. World exhibitions

World exhibitions, a place of self-presentation and specific rivalry between states and nations, were organized since 1751 (London) in the capitals and major cities in Europe, Asia, Australia, USA and Canada[8]. The exhibition in 1851 took place in London's Hyde Park and especially for that purpose, Joseph Paxton designed the steel-and-glass pavilion – called the Crystal Palace. After the show the palace was moved to current Upper Norwood, where it burnt down in 1936.

The organization of trade fairs and exhibitions and gathering many participants and exhibitors, requires preparation of exhibition spaces and additional spaces such as the auxiliary space connected with their service and the space needed for handling crowds of visitors to the fair. Having already established position and tradition, fairgrounds, should be equipped with such permanent capacity buildings (pavilions) which would provide exhibitors with diverse needs. Simultaneously, fair objects and their complexes should enable the organization of different events at the same time. This, then, raises the need to build enclosed structures with adequate functional flexibility and to take into account the above requirements of a management plan with commuting, parking, etc. In the case of very complex and extensive exhibition fairgrounds, it is also necessary to supplement the exhibition infrastructure with additional elements for the service and "distribution" of the public such as travellators, minibuses, aerial cable cars, etc.

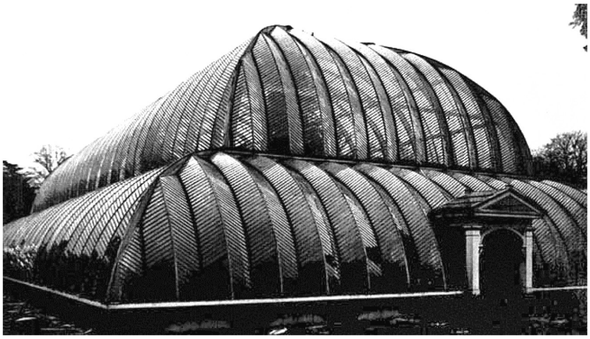
4. Crystal palaces

Since the invention of the light bulb took place only in the mid-nineteenth century, exhibition spaces had to be illuminated primarily with natural light i.e., day light. Therefore, exhibition pavilions resembled conservatories and palm houses of botanical gardens at the time. They were undoubtedly inspired by such projects as Joseph Paxton's Large Greenhouse (1836–1841) in Chatsworth and Decimus Burton and Richard Turner's Palm House at the Royal Botanical Garden at Kew/Surrey (1844–1848), Francois Jean Delannoy's Galerie Vivienne in Paris (1823–1826) and Charles Rohault de Fleury's pavilion of Jardin des Plantes in Paris (1833–1836).

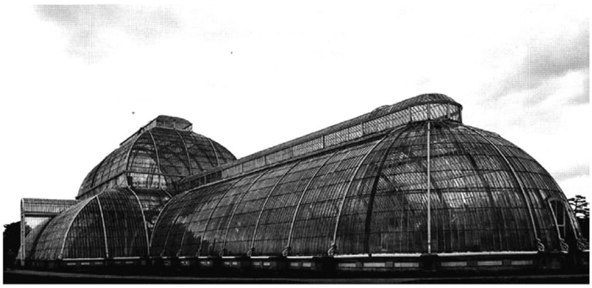
---

7 The term "World Exhibition" refers to cyclic expositions presenting cultural, scientific and technical heritage of nations and peoples of the world. International Exhibitions Bureau was founded in 1928.

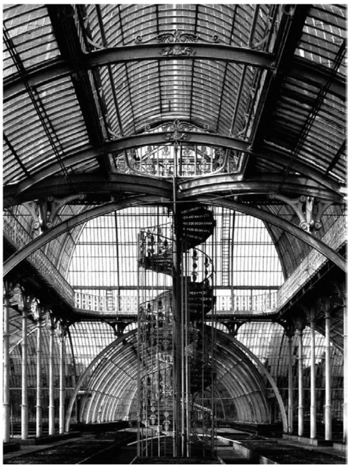
8 *The Great Exhibition* organized in London in 1851 is considered to be the first truly international exhibition.



Ill. 1. Joseph Paxton, The Large Greenhouse at Chatsworth/ Derbyshire, England, 1836-1841 (source: http:// icancauseaconstellation.tumblr.com/page/35)



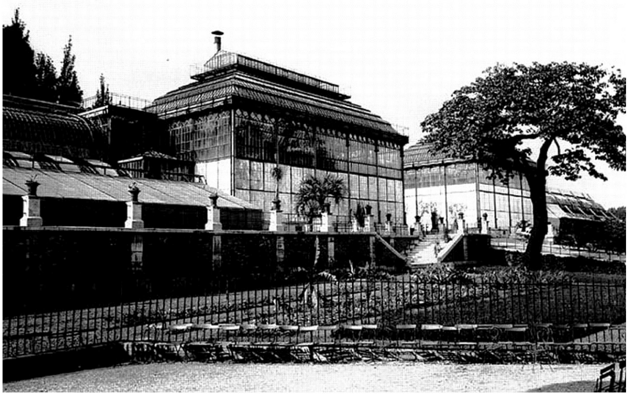
Ill. 2. Decimus Burton and Richard Turner – the Palm House in the Royal Botanical Gardens in Kew/Surrey, England, 1844–1948 (source: http://rubens.anu.edu.au/htdocs/ laserdisk/0231/23117.JPG)



Ill. 3. Decimus Burton and Richard Turner – the Palm House in the Royal Botanical Gardens in Kew/ Surrey, England – the interior, constructed between 1844 and 1948 (source: http://www.all-art.org/ Architecture/22-11.htm)

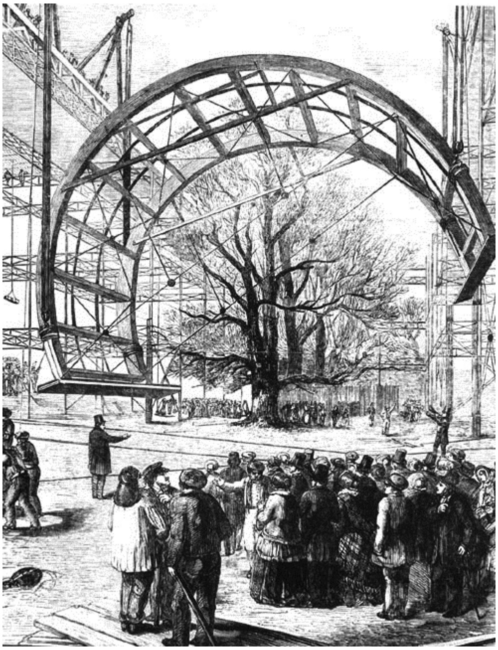
Ill. 4. Galerie Vivienne in Paris, 1823–1826,
designed by Francois Jean Delannoy
(source: http://commons.wikimedia.org/wiki/
File:P1040471_Paris_II_galerie_Vivienne_rwk.JPG)

Ill. 5. Paris, Les Halles – the interior; designed by
V. Baltard and F. Callet
(1853–1870) (source: http://rubens.anu.edu.au/
htdocs/laserdisk/0231/23127.JPG)



Ill. 6. Paris, Conservatories in the "Jardin des Plantes" –
designed by Charles Rohault de Fleury (1833-1836)
(source: http://www.all-art.org/Architecture/22-11.htm)

1

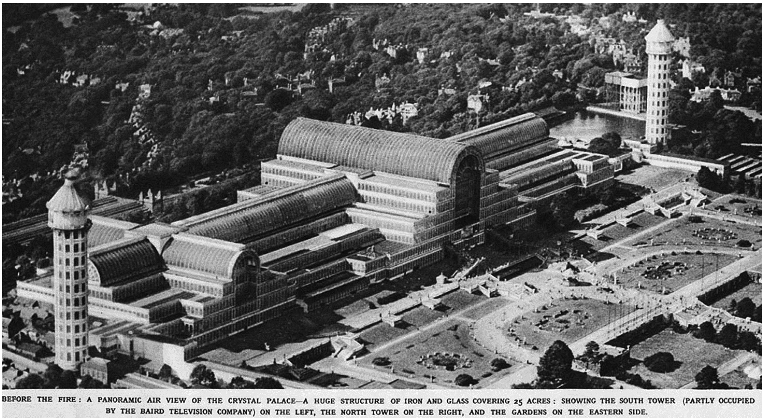


2

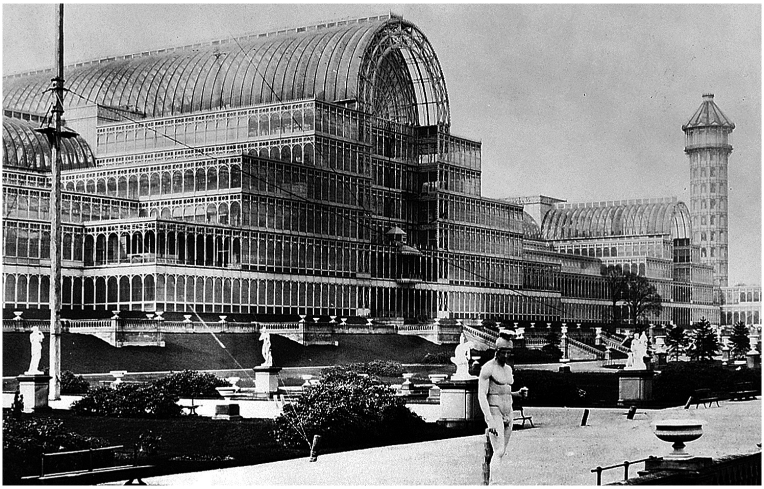
3

4

Ill. 7, 8, 9, 10. The Crystal Palace in London – designed by Joseph Paxton (1851) – the building and constructional-architectural details (source: http://www.crystalpalacemuseum.org.uk)



Ill. 11. London, aerial view of the Crystal Palace and the gardens, 1936 (source: http://www.ideal-homes.org.uk/bromley/assets/galleries/crystal-palace/aerial-view)



Ill. 12. The Crystal Palace in London before 1936 – view from the gardens (source: http://classconnection.s3.amazonaws.com/650/flashcards/701650/jpg/paxton21323456777900.jpg)

The experiences of these realizations were later used by Joseph Paxton in the project of the Crystal Palace. This 549 m long and 43 m high structure, sadly not preserved today, was built of steel and glass prefab mutually juxtaposed, which consisted of a glass and steel set of deep beam structures and provided the spatial rigidity of the whole arrangement.

Brilliant simplicity and elegance of the skeletal structure became the model for many other exhibition and trade buildings. The examples include: the Galleria Vittorio Emanuele II in Milan (1867–1878), the Grand Palais in Paris by Charles Girault (1900), New York Crystal

Palace (1852), The Palacio de Cristal in Buen Retiro Park in Madrid (1887), Alexandra Palace (the People's Palace – 1862) in London, the Palace of Industry in Toronto (1858), indoor agriculture Picton Fair in Ontario (1890–1894), exhibition halls in Paris (1936), Botanical Garden in Buffalo, NY (designed in 1868, constructed between 1897 and 1899), buildings of the industrial trade fair in Munich (1853–1854), the market hall in Berlin (1865–1868), The Infomart in Dallas (1985), Glass Hall in Leipzig (1992–1996)...

5. Glas hall: functional, spatial and constructional innovation

The Leipzig Trade Fair is recognized as the oldest fair in the world[9], moreover, 30 fair houses were built in the city until 1917[10]. In 1920, the fair took place at a new location – near the Monument to the Battle of the Nations, in the south-eastern part of the city. As a result of the war most of the halls and rooms of the fair had been destroyed; however, the fairs in Leipzig gradually regained their former rank, transforming themselves into the Leipzig Messe GmbH (Ltd.) in 1990.

In 1996, a new fairground on the north-eastern outskirts of the town was opened at the former Leipzig-Mockau airport. The exhibition grounds now belong to some of the most modern exhibition complexes in the world.

The international Fair and Congress Centre in Leipzig is characterized by spatial and functional clarity and harmony between construction (steel, glass) and nature. The winning project, designed by Gerkan, Marg and Partner Studio, presented compact structural concept of the whole – so that the exhibition halls, restaurants, the Congress Centre and the administration building could be reached without going outside. The Congress Centre was calculated on 2600 seats – in seven conference rooms and fourteen smaller rooms where host all kinds of events can be held.

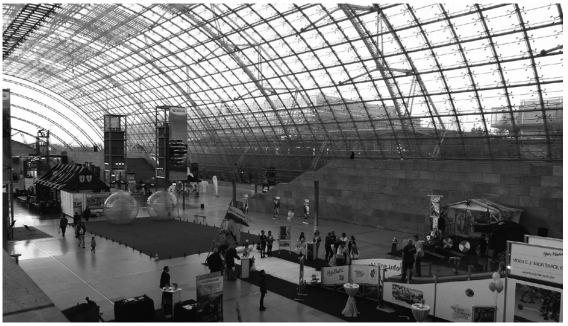
The complex of trade fair halls is connected with the centrally located main entrance hall of an arcuate structure, 80 m wide, 234 m long and 30 m high at the apex. Glass and steel have been already known and used for 150 years, but the form of arcuate steel-and-glass roof covering of the central Leipzig hall is characterized by an unexpected freshness and boldness of architectural vision. The basic construction of the hall is formed by arched beams (of lattice structure) to which a cylindrical mesh of a steel-glass curtain "wall" is attached. The glazing is double glazed (2×10 mm) and the contacts are filled with silicone. The fixing of glass elements compensate for any possible movements[11] (and related internal stresses) in two directions: see [2, 3].

Designers have used experimental hall solutions to ensure its proper microclimate, adjustable air supply and exhaust together with water cooling using special sprinklers. Also the hall floor, equipped with underfloor heating supporting wall convector heating system, possesses much heat accumulation. In addition, massive objects embedded in the hall are heated or cooled

[9] Leipzig received city rights around 1165, confirmed in 1497 by Emperor Maximilian I, who also organized Imperial Fairs (Reichsmessen) in the city centre. After the model fair in the city centre (1895 – Mustermesse),

[10] Including Mädler-Passage, Petershof, Handelshof, Specks Hof, Drei Könige.

[11] These movements under the influence of temperature differences can be over 250 mm long (i.e., 125 mm on each end!).



Ill. 13. Leipzig, the Glass Hall – the interior of the main hall (photo by the author)

Ill. 14. Leipzig, Glass Hall – the access to the main hall (photo by the author, 2012)

Ill. 15. Leipzig, the Glass Hall – a fragment of the construction of the gable end (photo by the author)

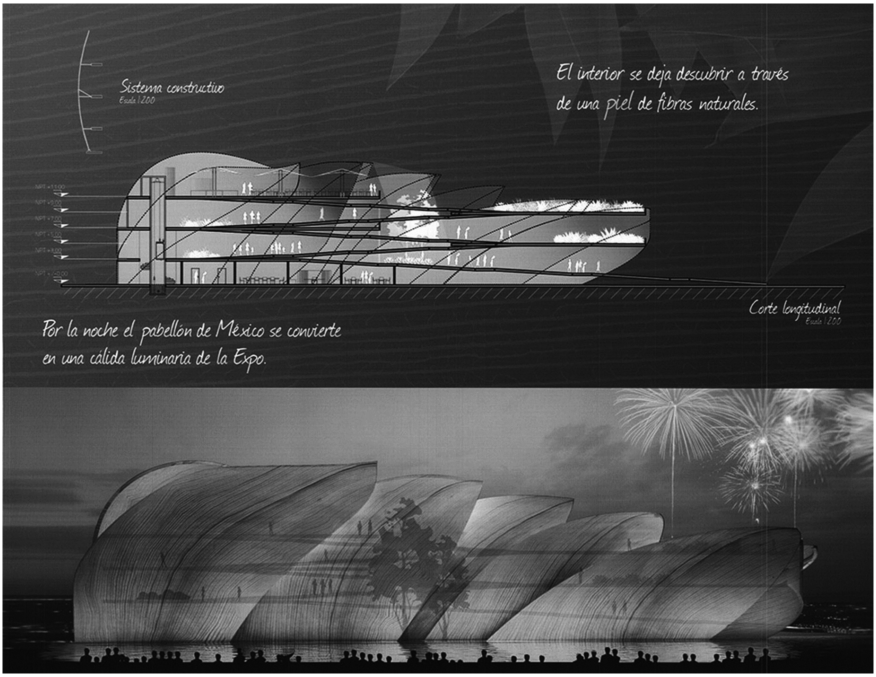
with air at a controlled temperature. The hall is obviously equipped with additional sources of artificial light. Maintenance of the hall is performed by using the water carried in each carrier girder with specially constructed mechanical devices and by movable bridges.

6. Conclusions

Designing large-scale shopping centres and exhibition pavilions has its own specificity: the "technology" of functional connections and structural determinants related to considerable spans of covering. After years that have passed since the author's first design experience in this field, it is a good time to reflect on the history and prospects of this architecture. An extremely interesting and instructive subject of such an analysis is undoubtedly The Leipzig Trade Fair. After 17 years from the beginning of its use, one can now assess its functioning and innovation of applied constructional and material solutions. It is also instructive to compare these buildings, especially the main hall, with the program and individualization in form and design, with the architecture of many pavilions designed for world expositions in the past decades.

This architecture is commonly dominated by the tendency to emphasize national identities of exhibitors in structures and forms of representative exhibition pavilions. As a result, we are dealing with a riot of forms, colours and materials that symbolize different countries and continents. The unsatisfied ambitions of individual designers, who want to enter in the annals of the history of contemporary architecture, also play a significant role. Moreover, current trends encourage the use of natural materials (e.g., timber: Hungarian and Swiss pavilion and the great timber structure in Hannover, vertical gardens at the Chinese exposition and wicker – Polish pavilion in Aichi as well as "paper", the shell of the Japanese pavilion in Hannover). The latest example of "green" project activities is the concept of the Mexican pavilion –

Ill. 17. Studio Link-Arc, the project of the Chinese exhibition hall at Expo 2015 in Milan (source: http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2014/03/China-Pavilion-Expo-Milano-2015-Studio-Link-Arc-2.jpg)



Ill. 18. F.L.G. Almada – the project of the Mexican exhibition hall at Expo 2015 in Milan (source: http://aasarchitecture.com/2014/05/mexico-pavilion-expo-2015-francisco-lopez-guerra-almada.html/mexico-pavilion-expo-2015-by-francisco-lopez-guerra-almada-04)

inspired by the form of a translucent husk of the corncob – designed by F.L.G. Almada for next year's Expo in Milan. It is worth noting that the Polish proposal for the same event is a project[12] inspired by the production of apples – in the form of a stack of wooden crates for the fruit, with a tour composed of multimedia and interactive installations... Although it is also possible to use reinforced concrete structures, their use in the architecture of usually temporary exhibition halls is sporadic. The problem of construction and materials used in the halls of exhibition pavilions is undoubtedly worth a separate study.

Comparison of the aforementioned design "visions" with the logic and clarity of the Leipzig Hall concept, demonstrates (in the author's opinion) the advantage of simplicity, design and versatility of forms over the exuberant ambitions of "one exhibition" for architecture's creators.

After many years of experience, one can observe a clear advantage of proven classical forms in the Glass Hall, which reached their most sophisticated form in an arcuate covering. Only technical, constructional and material possibilities have changed enabling to create new aesthetic and architectural visions.

[12] It is designed by Warsaw-based "2PM Studio".

References

[1] Gloger Z., *Encyklopedia staropolska (Encyclopedia of Old Polish)*, vol. III i IV, 1900-1903.
[2] Schittich C., Staib G., Balkow D., Schuler M., Sobek W., *Glasbau Atlas*, Edition Detail – Institut für internationale Architektur-Dokumenttion GMBH, München 1998.
[3] Schultz H.C., Sobek W., Habermann K.J., *Stahlbau Atlas*, Edition Detail – Institut für internationale Architektur-Dokumenttion GMBH, München 1999.

TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
ARCHITECTURE | ARCHITEKTURA
7-A/2014

DOMINIKA KUŚNIERZ-KRUPA*

NEW BUILDING TECHNOLOGIES IN THE CONTEXT OF REVALORIZATION OF A HISTORIC BUILDING
(ON THE EXAMPLE OF CONVERSION OF AN OLD DORMITORY INTO AN ADMINISTRATIVE OFFICE)

NOWE TECHNOLOGIE BUDOWLANE W KONTEKŚCIE REWALORYZACJI OBIEKTU ZABYTKOWEGO
(NA PRZYKŁADZIE ADAPTACJI BUDYNKU DAWNEJ BURSY NA POTRZEBY FUNKCJI BIUROWO-ADMINISTRACYJNEJ)

A b s t r a c t

Historic building adaptation connected with changing its use often makes architects apply modern building technologies, including latest materials and furnishing. It should be emphasized that nowadays adaptation of a historic building and introducing a new function into it, is often the only way to save it. This new function frequently requires a high level of finishing and furnishing the building in such a manner that it would fulfill current regulations. Such an investment is the revalorization of the old high school dormitory in Nowy Targ which is under conservation protection because of its location, form and architectural details characteristic for that part of Poland.

Keywords: historic building adaptation, new function in historic building, revalorization

S t r e s z c z e n i e

Adaptacja obiektów zabytkowych związana ze zmianą sposobu ich użytkowania często wymusza na projektancie zastosowania współczesnych technologii budowanych w tym nowoczesnych materiałów, a także elementów wyposażenia obiektu. Należy przy tym podkreślić, iż w obecnych czasach adaptacja obiektu zabytkowego i wprowadzenie doń nowej funkcji jest często jednym sposobem na jego uratowanie. Funkcja ta pociąga za sobą określony, niejednokrotnie bardzo wysoki poziom wykończenia budynku oraz wyposażenia go w taki sposób, aby spełniał wymogi obowiązujących przepisów. Przykładem takiej inwestycji jest rewaloryzacja budynku dawnej bursy szkolnictwa ponadgimnazjalnego w Nowym Targu, będącego z racji położenia oraz charakterystycznej dla tej części Polski formy i detalu architektonicznego pod ochroną konserwatorską.

Słowa kluczowe: adaptacja obiektu zabytkowego, nowa funkcja w obiekcie zabytkowym, rewaloryzacja

* Ph.D. Arch. Dominika Kuśnierz-Krupa, Institute of History of Architecture and Monument Preservation, Faculty of Architecture, Cracow University of Technology.

1. Introduction

Currently, there has been a noticeable increase in the number of historic objects requiring revalorization, whose technical condition needs almost immediate conservation intervention. Such intervention necessitates investing considerable financial outlays, potentially exceeding the cost of erecting a new object with a higher standard of finishing and better technical parameters. Sometimes however, one cannot make a simple comparison between the historic and the new object, since the former possesses primarily non-material values such as its history, tradition and customs, concealed within its old walls. Besides those values, there are also several other arguments justifying protection and conservation of such a building [1]. They certainly are: historic, often practically unique architectural detail used within a specific region in the past, the building's location on a characteristic site in a given city or its shape designed in accordance with specific rules. Because of the high costs of modernization of historic objects, occasionally the only way to "encourage" an investor to carry out such a renovation is to convert the object and introduce a new function into it. Such a compromise between the investor, the owner of the historic building and the authorities responsible for its conservation protection has been accepted all over the world. For instance, in Germany and the Netherlands, it is allowed to convert unused sacred objects, thus saving them from falling into disrepair [2]. In Portugal, unused storehouses, post-industrial objects [3], tenement houses [4] and even whole quarters in city centres abandoned by their residents because e.g. too high cost of renovation, are being revalorized. Frequently, the only way to rescue such objects is to obtain permission from the conservation authorities to introduce a new function into the building, which would ensure a potential income for the new owners [5]. In most cases, those functions require a very high standard of building finish applying modern building technologies including the newest materials and elements of furnishing. Such a building, also has to meet all the current regulations.

2. The old dormitory building in Nowy Targ. History and description of its condition before project intervention

The building of the old dormitory in Nowy Targ is an example of an investment which was revalorized and its regional forms and details were highlighted again, owing to its adaptation and introduction of a new function into the building. The object is located in the city centre on the main street: Aleja Tysiąclecia. Because of its location within the conservation protection zone, just outside the city centre on the border of the downtown zone, the object is under protection of the director of the branch office in Nowy Targ, Lesser Poland Voivodeship Monument Protection Office (Ill. 1). The masonry building was erected in the mid-20th century, with a basement and 4 storeys (+ 1 subterranean storey). it was designed in the traditional style of regional architecture with distinct elements of Zakopane style [6]. That trend commonly occurs in the architecture of the Podhale region and the Nowy Targ Valley, and creates the characteristic features of the cultural landscape in that region. Since the moment of its erection, the building has served as a school dormitory for high school students from outside Nowy Targ. In recent years, its technical condition deteriorated (Ill. 2) and the old-fashioned infrastructure could no longer ensure appropriate accommodation or studying conditions for young people. Therefore, the object owner, the local administration authorities, decided to relocate the dormitory to another building. The situation caused the object, which for several decades had been an important element of the cultural landscape of the city, to lose its functions and users. One should add however, that the building has been a symbolic gateway into the city from the east.

Ill. 1. Old dormitory in Nowy Targ on the orthophotomap, [in:] Geoportal

Ill. 2. View of the dormitory building in Nowy Targ from the south (from Al. Tysiąclecia) before project intervention, November 2008 (photo: D. Kuśnierz-Krupa)

3. Object revalorization and adaptation

The object owner, the local administration authorities, decided to modernize the unused building, so that in future it can serve new office – administrative functions, as a seat of the County Starost. The investor set several very detailed requirements that the object was to meet after its adaptation had been completed. The building was to fulfill a formal function, while at the same time the costs of its realization and further exploitation had to be rationalized. It was assumed that the object revalorization would be carried out in two stages. In the first stage, work connected with the elevation modernization was completed and in the second, work inside the building was carried out.

3.1. Stage one of investment

The first stage of work connected with adapting the building to serve the office – administrative function was carried out from August till December 2012. Then, on the basis of project documentation[1] prepared by ZERIBA Designing Group, the object elevation was modernized and the roof covering was replaced. The colour scheme of the facade was kept in shades of grey. It was insulated by applying the Termo Organika system: 'Termonium plus fasada', using silver-grey panels 1000 mm long, 500 mm wide and 15 cm thick; produced on the basis of innovative raw material refined with a graphite composition, which added to granules during the polystyrene production process, it improves the insulating properties of panels, thanks to which better results of thermal insulation can be achieved. The roof was covered with roofing shingle-like sheets and painted granulated stone imitating traditional shingles, which covered the building roof in the past. Dormers and upper parts of gable walls were lined with wooden siding, which was painted and impregnated with water-soluble grey paint, to be applied outside. Window openings of the 1st floor were highlighted with light-grey 20 cm wide bands. In contrast, the window openings in the attic were highlighted with black bands. The stone facing on the ground floor, characteristic for the Podhale region, was cleaned and filled in. The main entrance from Al. Tysiąclecia was emphasised by a glass roofing spot-fixed to the elevation, which does not disrupt the architectonic composition of the south facade of the building. The entrance on the north side was emphasized with an openwork wooden construction (painted the same shade of grey as the dormers and roof gables) alluding to the architecture of the region.

[1] Grupa Projektowa ZERIBA (dr inż. arch. Dominika Kuśnierz-Krupa, dr inż. arch. Michał Krupa, dr inż. arch. Łukasz Wesołowski), Design documentation entitled: Transformation, modernization and altering the function of the school boarding house to serve the administrative-office purposes of the county administration, Kraków 2012, [in:] Archiwum Wydz. Administracji Bud.-Arch., Starostwa Powiatowego w Nowym Targu, s.v.

Ill. 3. Visualization of the revalorization project for the dormitory in Nowy Targ. View from the south-east, [in:] Archive of ZERIBA DG

Ill. 4. Visualization of the revalorization project for the dormitory in Nowy Targ. View from the north-east, [in:] Archive of ZERIBA DG

Ill. 5. Dormitory building from the south (from Al. Tysiąclecia) after revalorization, 2014 (photo: D. Kuśnierz-Krupa)

3.2. Stage two of investment

Stage two of the work connected with adapting the building to fulfill the office – administrative function commenced in May this year. The work has been carried out based on the above mentioned documentation prepared by the ZERIBA Designing Group. According to the project, after the investment has been realized, the building will have a total capacity of 12 816.5 m^3 and the utility space of 4273.2 m^2. The functional layout of the object will provide the best accessibility for prospective clients, while at the same time optimally using the existing space to serve office needs. In accordance with the functional programme, the basement was designed to house: archive rooms, storage rooms, a boiler room, maintenance rooms, utility rooms and server rooms. The ground floor encompasses: information desk and correspondence register, the County Council conference room, catering zone and office rooms. On upper storeys there are office and conference rooms allocated to particular departments.

Detailed guidelines from the investor and the designers' vision determined the need to use the latest technologies as far as building materials and system elements (plumbing and wiring) are concerned. On the other hand, the level of architecture is raised by appropriately applied natural materials, such as stone and timber, which allude to the architecture of Podhale. In the architectonic project of the interiors, the motif of original stone facing from the ground floor outside walls was repeated e.g., in general communication routes. The fact that the corridors were relatively narrow, it not only negatively influences their functionality, but also posed a problem in the safety regulations of evacuation routes. Using traditional stone tiles would have narrowed them additionally by at least a few centimeters (on each side) and in some places would have required providing an additional substructure. Hence it was decided that another material would be used, which has recently been introduced to our market, although e.g., in Germany it has been already used for several years. Stone veneer is produced in typical format sheets of 120 × 60 cm or bigger and up to 3 mm thick. Fiberglass mats are bound to the surface of a stone block (slate) using polyester resins. The binding force is so great that when torn off, a layer of natural stone remains stuck to the mat surface. Each sheet has a unique appearance, thanks to which surfaces lined with veneer look natural. Besides their aesthetic value, the sheets are flexible (can be laid on arched curves, especially after heating), light and easy to assemble. Because of their thickness, the sheets are easy to process and after impregnation they are also 100% waterproof.

In selected rooms of particularly formal character (such as the County Council conference room or the Starost's office with the meeting room) it was decided to finish the walls with wooden panels. High aesthetic requirements, as well as those technically connected with fire hazard (fire resistance) enforced the use of the latest technologies. Materials classified as A2-s1, d0 (the highest class of non-flammability for flammable materials) were selected. While selecting concrete products, as a reference point, the designers chose Gustafs panels, which apart from their high quality and technical parameters matching the project requirements, allowed for using identically looking elements in 3 different variations – typified by higher fire resistance and "acoustic" (perforated panels with various degree of sound absorption).

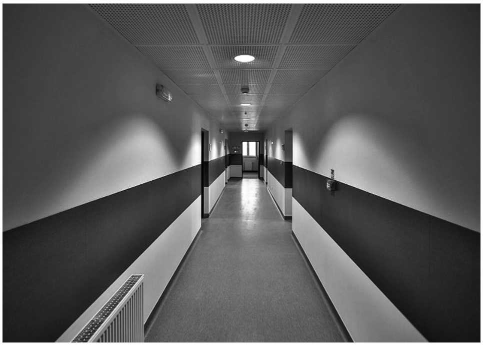
Finishing materials, used in the project on a larger scale because of their properties of increasing user's comfort, were suspended ceilings and fitted flooring. Naturally, system suspended ceilings are nothing new. Nevertheless in this case, the investor accepted the designers' arguments that in a building of such function and architecture, noise will be an issue significantly influencing the quality of work. That is why perforated soundproof ceilings have been fitted in almost all rooms meant for people and along the main communication routes. For similar reasons e.g., fitted tufted carpets were selected, which apart from muffling sounds, are very resistant to mechanical damage caused by office equipment or moisture. Moreover, they disperse electrostatic charges generated by electronic appliances.

Apart from building materials, an important issue are the proposed solutions concerning system installations and furnishing elements. Some of those will have a direct impact on saving energy or water etc. The project involves fitting solar panels on the south slope of the roof, which will help to provide hot utility water and central heating. It was decided that flat panels will be used, since their efficiency considerably exceeds that of the most frequently applied vacuum panels. Non-contact, photocell-controlled taps fixed on all the washbasins should help to limit the use of running water and therefore, the amount of produced sewage. It is estimated, that it will allow saving approximately 30–40% in comparison to traditional installations.

Ill. 6. View of the object interior after modernization – hall on the ground floor, 2014 (photo: D. Kuśnierz-Krupa)

Ill. 7. View of the object interior after modernization – County Council meeting room, 2014, (photo: D. Kuśnierz-Krupa)

Ill. 8. View of the object interior after modernization – customer service desk, 2014 (photo: D. Kuśnierz-Krupa)



Ill. 9. View of the object interior after modernization – hall on the 1st floor, 2014 (photo: D. Kuśnierz-Krupa)

Ill. 10. View of the object interior after modernization – County Administration Board meeting room, 2014 (photo: D. Kuśnierz-Krupa)

Ill. 11. View of the object interior after modernization – toilets on the ground floor, 2014 (photo: D. Kuśnierz-Krupa)

4. Conclusions

Summing up the above considerations, it should be observed that although designing new buildings **creates an opportunity** to apply new technologies, paradoxically conversions of existing buildings, particularly those of historic value, **frequently force** architects to use such solutions. It results from discrepancies between current regulations, requirements which particular functions have to meet nowadays and standards binding at the time when the building was erected. Suitably selected and applied technologies, including the latest finishing materials, offer designers a wider range of possibilities to highlight the most important and valuable elements of a historic object bearing evidence to its eventful past and rank.

References

[1] Jasieńko J., Kuśnierz K., Rouba B.J., *Konserwacja zabytków jako proces interdyscyplinarny – badania, nauka, technika, praktyka*, [in:] Kongres Konserwatorów Polskich, Publ. DWE, Warszawa 2005.

[2] Kuśnierz-Krupa D., Krupa M., *Nowe życie średniowiecznych kościołów z Maastricht*, „Wiadomości Konserwatorskie" 24/2008, Publ. ZG SKZ, Warszawa–Wrocław 2008, 103-106.

[3] Kuśnierz-Krupa D., *Portugalska szkoła konserwacji" – Muzeum Transportu i Komunikacji Eduarda Souto Moury w Porto*, „Wiadomości Konserwatorskie" 32/2012, Publ. ZG SKZ, Warszawa–Wrocław 2012, 31-38.

[4] Kuśnierz-Krupa D., *Konserwatorski profesjonalizm w Lizbonie*, [in:] *Karta Krakowska 2000 – 10 lat później*, A. Kadłuczka (Edit.), Monografia PK, Seria Architektura nr 400, Kraków 2011, 175-181.

[5] Kuśnierz-Krupa D., *„Portugalska szkoła konserwacji" – kwartał das Cardosas w centrum Porto*, „Wiadomości Konserwatorskie" 33/2013, Publ. ZG SKZ, Warszawa–Wrocław 2013, 39-46.

[6] Jabłońska T., *Styl zakopiański Stanisława Witkiewicza*, Publ. Bosz, 2008.

[7] Grupa Projektowa ZERIBA (dr inż. arch. Dominika Kuśnierz-Krupa, dr inż. arch. Michał Krupa, dr inż. arch. Łukasz Wesołowski), Design documentation entitled: Transformation, modernization and altering the function of the school boarding house to serve the administrative-office purposes of the county administration, Kraków 2012, [in:] Archiwum Wydz. Administracji Bud.-Arch., Starostwa Powiatowego w Nowym Targu, s.v.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

PAWEŁ KWASNOWSKI*, MAŁGORZATA FEDORCZAK-CISAK**

METHODOLOGY OF SPECIFICATION AND DESIGN OF PUBLIC UTILITY BUILDINGS TO REACH THE MAXIMUM ENERGY PERFORMANCE ACCORDING TO EPBD AND EN 15232:2012 STANDARD

METODYKA PROJEKTOWANIA BUDYNKÓW UŻYTECZNOŚCI PUBLICZNEJ W CELU MAKSYMALIZACJI EFEKTYWNOŚCI ENERGETYCZNEJ W ŚWIETLE DYREKTYWY EPBD ORAZ NORMY PN-EN 15232

A b s t r a c t

New EPB Directive and standards based on this directive in the area of energy performance of buildings generate many changes in the building industry. In the article, the difference will be shown between "classical" and new methodology of design and specification of buildings with required energy performance, where automation systems and technical management use synergy of all technical systems to increase the energy efficiency of buildings.

Keywords: energy efficiency of buildings, building automation systems, BAS, BMS, EN 15232 Standard, impact of BAS on energy efficiency of building, design and specification

S t r e s z c z e n i e

Dyrektywa EPBD stawia nowe wzywania przed architektami i projektantami zarówno konstrukcji i przegród zewnętrznych budynku, jak i wszystkich instalacji technologicznych oraz systemów automatyki i sterowania budynków, a także systemów technicznego zarządzania budynkami. W artykule przedstawione zostanie porównanie między klasyczną metodyką projektowania, w której systemy sterowania instalacjami technologicznymi budynku są dostosowywane do tych instalacji i metodyką uwzględniającą osiągnięcie wysokiej efektywności energetycznej dzięki wykorzystaniu synergii pomiędzy wszystkimi technologicznymi instalacjami budynkowymi, w której instalacje technologiczne muszą być dostosowane do maksymalizacji wpływu systemów sterowania i automatyki na efektywność energetyczną budynku.

Słowa kluczowe: efektywność energetyczna, system automatyki budynku, BAS, BMS, norma EN 15232, wpływ BAS na efektywność energetyczną budynku, projektowanie budynków

* M.Sc. Eng. Paweł Kwasnowski, Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering, AGH University of Science and Technology.
** Ph.D. Małgorzata Fedorczak-Cisak, Faculty of Civil Engineering, Cracow University of Technology.

Acronims

BACS – Building Automation and Control System
TBM – Technical Building Management
BMS – Building Management System

1. Introduction

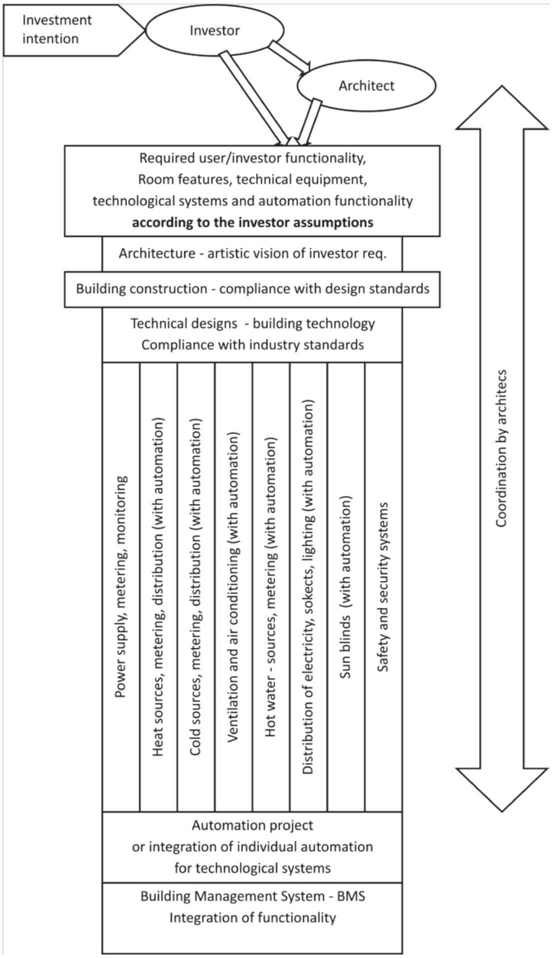
The requirements to provide high energy effectiveness of the buildings, arising from the EPBD Directive and the industry standards worked out on its basis, present new challenges for the architects and designers of both constructions and exterior partitions (walls, windows, roofs) of a building, as well as all technological installations and building automation and control systems (BACS), and also systems of technical building management (TBM). In order to provide high energy effectiveness of a building and at the same time usage comfort, it is necessary to use not only proper construction materials, but also proper technological installations, which would make possible control of energy distribution according to the current demand for specific forms of energy in particular to the rooms of the building, as defined in detail in EN 15232 standard.

In the authors' opinion, the most important conclusion of [1] standard, should be the statement that the quality of impact of automation and control systems and technical building management on the energy effectiveness of buildings, depends directly on the proper construction of the basic technological installations in a building, which have a decisive influence on different forms of energy consumption. To obtain the highest influence of BACS and TBM systems on the energy effectiveness, the construction of such technological installations is necessary that would allow to supply any form of energy individually to each room, depending on the real needs. Coordination of all the technological installations should also be assured, so that all the installations would cooperate in economical energy usage. Integration on the object level seems to be especially important, both in automation and control systems of particular technological installations, as well as safety systems which provide information about the presence of the users in the rooms, thus allowing to control energy supply precisely according to the needs (on demand).

These simple demands cause fundamental changes which should absolutely be implemented in the process of preparation and designing of the investments, and which strictly fulfill the demands in respect of energy effectiveness.

2. Classical process of designing a building

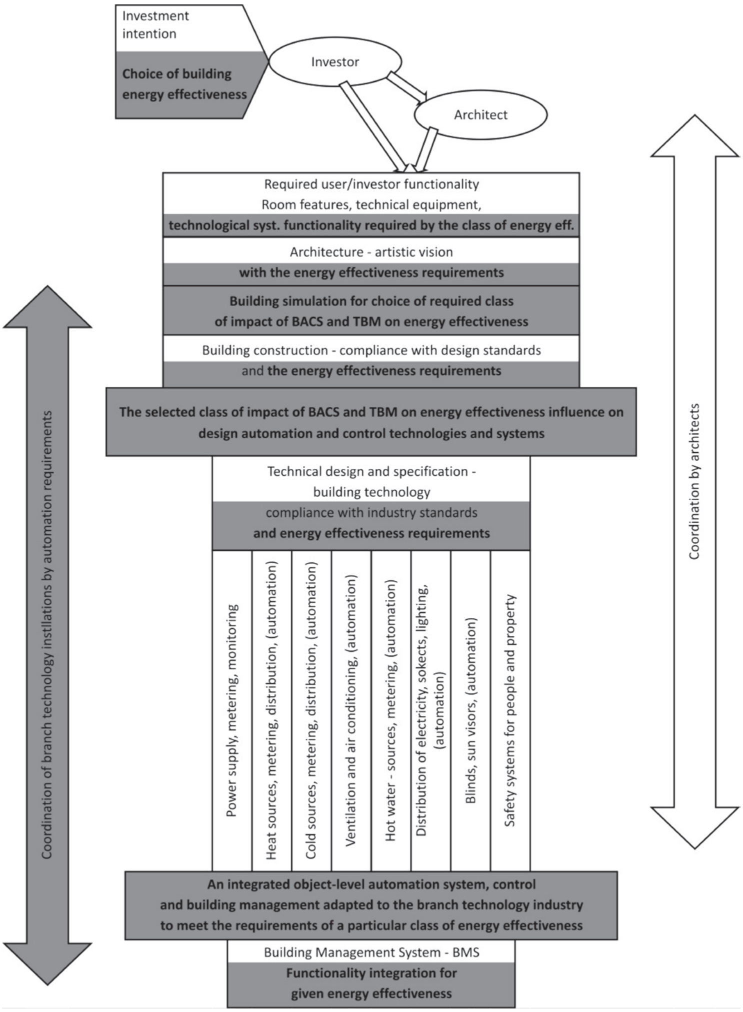
A scheme of a classical designing process of a building is shown in Fig. 1. In this process particular demands concerning energy effectiveness are very often not taken into account, the exception being the demands determined in the present technical conditions of the binding building law. When defining the functional and utility programme of the building and functionalities of rooms and their technical equipment, the investor's demands and assumptions have to be taken into account as well as the binding building and sanitary regulations. Having decided upon the functional and utility programme and an architectonic vision, there comes a stage of multi-branch designing, which theoretically should be coordinated by the design office responsible for the project. All branch installations, in the detail mentioned in Ill. 1 on vertical rectangles, are designed by branch designers, often with little exchange of information among them. Having completed branch specifications and designs for the basic sanitary installations, HVAC and others, the automation branch starts their part of designing. They usually have to fulfill the demands defined by particular technological branches. Due to this process, the system of building management integrates the functionalities resulting from the branch designs, but the branch designs themselves do not take into consideration the necessity of inter-branch cooperation. Having such a classical attitude to designing, it is difficult to speak about the realisation of energy effectiveness of the building; we should rather speak about the result effectiveness, which is in fact accidental.



Ill. 1. Diagram of the classical process of designing of building with consideration of investor requirements

3. Integrated designing process of a building, oriented towards obtaining specific energy effectiveness

The scheme of an integrated designing process of a building taking into consideration target energy effectiveness is presented in Ill. 2. In the figure, all the differences in relation to the classical designing process are shaded. The whole of the designing process is closely subordinated to achieve a particular, presumed energy effectiveness of the object. On the basis of energy simulations of the building [6], we should determine the class of influences of the BAC and TBM systems on energy effectiveness. The choice of target energy effectiveness of the building is of fundamental importance to the whole ongoing designing process, both in



Ill. 2. Diagram of the integrated process of designing and specification of a building with consideration of the final energy performance

building construction and technological installations as well as the functionality of the BAC and TBM systems. The decision has influence on:

– the engineering process of erecting the building, which must meet specific demands indispensable to achieve high energy effectiveness,
– the choice of technological installations functionality which would enable the realisation of automation and control functions required for a given class on the impact of the BAC and TBM systems on energy effectiveness,
– the necessity of implementing particular functionalities by automation, control system and technical management of a building that requires a definite structure of technological installations,
– designs and construction of all branch technological installations, which must make possible the realisation of particular automation, control and management functions,
– the necessity of integration on the object level of the automation and control functions of all technological installations having influence on energy consumption, among them safety systems, in order to provide synergy of all the installations to minimise energy usage.

The result of the integrated designing process, is obtaining such functionality of the technological installations, automation and control systems as well as technical building management, that they guarantee the programmed and planned class of the BACS and TBM systems influence on the building energy effectiveness.

The basic condition to achieve such a result, is to involve the automation branch designer in a very early phase of designing, already at the stage of defining the functionality of the systems and technological installations, because these are just functionalities of technological installations that decide whether it is possible to implement particular functions of the BACS and TBM systems, which in turn determine the affiliation of the automatic system to a given influence class on energy effectiveness.

4. Conclcusions

The presented discussion clearly shows that achieving a definite degree of automation and control system influence on the energy effectiveness of the building does not only depend on the automation system functionality, but first of all on the way the technological installations are constructed. They have to be designed in such a way as to allow implementing definite, required functions of the automation, control and management systems for a given class influence of the BACS and TBM systems on energy effectiveness. This means that it is necessary to change the attitude to the building designing process. Firstly, in the initial phase of designing, after having chosen the programmed energy effectiveness of the building, simulations must be carried out in order to determine the necessary degree of influence of BAC system and TBM on the total energy effectiveness of the building.

On the basis of those simulations [6], a definite, indispensable for application BAC and TBM class of systems influencing the energy effectiveness of a building should be chosen. This choice decides the necessary realisation of particular technological installations, which must be susceptible to a definite, standardized, control and management method. The role of the automation system designer cannot be limited to working out automation for already designed technological installations (what is now a common practice), but after having defined the building's required class influence of automation, control and management systems on energy effectiveness, the whole process of designing technological installations and their control and management systems, must be subordinated to this decision. It can be concluded from the above, that on the basis of the investor's decision about the expected energy effectiveness of the building and determined on the basis of simulation, the indispensable class of influence of the BAC and TBM systems on energy effectiveness, the automation designer has to be involved right from the beginning in the designing process; he has to participate in formulating the assumptions of the technological installations designers and to coordinate the designed solutions paying special attention to their susceptibility to integrated controlling, which is indispensable for achieving an adequate influence of the BAC and TBM systems on energy effectiveness, and not as it used to be in former designing practice, to yield to the demands of the branch designers.

References

[1] CEN TC 247 Energy performance of buildings – Impact of Building Automation, Controls and Building Management – European Standard EN 15232:2012, European Committee for Standardization, 2012.

[2] Energy Performance Building Directive 2010/31/UE dd May 19, 2010.

[3] Kwasnowski P., *Ocena wpływu systemów automatyki na efektywność energetyczną budynków w świetle normy PN-EN 15232 – część 1*, Inteligentny Budynek 1/2013 (9), 34-37.

[4] Kwasnowski P., *Ocena wpływu systemów automatyki na efektywność energetyczną budynków w świetle normy PN-EN 15232 – część 2*, Inteligentny Budynek 2/2013 (10), 36-42.

[5] Kwasnowski P., *Ocena wpływu systemów automatyki na efektywność energetyczną budynków w świetle normy PN-EN 15232 – część 3*, Inteligentny Budynek 3/2013 (11), 32-37.

[6] Fedorczak-Cisak M., Furtak M., *Multicriteria and multilevel optimization tasks application to choose building energy standard*, Sustainable Building Conference, Praha 2010.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

BEATA MAJERSKA-PAŁUBICKA*

NEW METHODS AND DESIGN TOOLS AS A BASIS FOR CREATING A SUSTAINABLE BUILT ENVIRONMENT

NOWE METODY I NARZĘDZIA PROJEKTOWE JAKO PODSTAWA KREOWANIA ZRÓWNOWAŻONEGO ŚRODOWISKA ZBUDOWANEGO

A b s t r a c t

Searching for harmony between a built and natural environment requires, quoting the demand of the National AIA Convention from 2011, "an innovative approach towards planning, designing and building as well as an evolutionary or revolutionary approach towards practice, cooperation and partnership". It is possible by the Integrated Design Process (IDP) method, which involves clear specifying of: What (in the context of sustainable development), Who (in the context of team composition and cooperation between its members) and When (in the context of process stages completion) things should be done in the design process. The aim of the paper is to present: the method, basic principles of IDP implementation, co-operation in a team and crucial differences between IDP and the traditional design process, as well as an analysis of general rules to be observed by a design team.

Keywords: sustainable built environment, Integrated Design Process, digital design tools

S t r e s z c z e n i e

Poszukiwanie harmonii pomiędzy środowiskiem zbudowanym a środowiskiem naturalnym, cytując postulat Narodowej Konwencji AIA z 2011, wymaga: *innowacyjnego podejścia do planowania, projektowania i budowania, wraz z ewolucyjnym lub rewolucyjnym podejściem do praktyki, współpracy, partnerstwa*. Metodą, która to umożliwia, jest Zintegrowany Proces Projektowy (ZPP), który polega na jasnym sprecyzowaniu: Co (w kontekście zrównoważonego rozwoju), Kto (w kontekście składu i współpracy zespołu) i Kiedy (w kontekście etapów realizacji procesu) ma wykonać w trakcie procesu projektowego. Celem artykułu jest przedstawienie metody, podstawowych zasad wdrażania ZPP, współpracy w zespole i różnic pomiędzy ZPP a tradycyjnym procesem projektowym.

Słowa kluczowe: zrównoważone środowisk zbudowane, zintegrowany proces projektowy, cyfrowe narzędzia projektowe

* Ph.D. Eng. Arch. Beata Majerska-Pałubicka, Faculty of Architecture, Silesian University of Technology.

1. Introduction. Sustainable design

The idea of sustainable development combines ecological, environmental, social and economic issues; it is also present in architectural design where sustainable development, quoting the words of prof. Barbara Jękot: "consists in finding appropriate means of expression – an architectural concept – while reasonably exploiting the resources and eclaiming degraded areas as well as following a direction of technological and institutional development which strengthens the current and future potential based on the needs of present and future generations. It requires intellect activation. Building/architecture and technologies must change the mentality of 'nature transformation' into "society transformation", in which balance means a better quality of life and better mutual relations between the urbanized and natural environment" [3].

In order to achieve the aforesaid assumptions, it is necessary to re-evaluate design goals comprising of the requirements related to economy and ecology (promotion of innovative technologies, systems of exploitation, production, construction and utilization of facilities) as well as social needs; another important issue is reference to form and beauty, the elements without which we cannot talk about in architecture. According to Thomas Herzog: "Success in sustainable design depends on consumer properties, which can be summed up and defined as sustainable. However, beauty is as important as utility. Only beautiful buildings enrich our environment and should be protected. By way of example, introduction of technology based on renewable energy consumption provides a chance for creating new forms of architectural expression, which are closely related to local conditions, such as microclimate, topography, natural resources and cultural heritage of a given region" [7].

2. The Integrated Design Process (IDP) concept

Re-evaluation of design goals within the framework of sustainable design involves submitting and analysing a large number of criteria on the influence exerted by the built environment on the natural environment and man. It should be characterised by a holistic approach, expressed in the integration of environmental, social-cultural and spatial-technical issues. It is aided by the concept of gradual selection of design solutions, proposed by prof. A. Baranowski, which is based on ecological, economic, social and spatial criteria. [1] According to A. Baranowski: **ecological criteria**, which consist in eliminating the negative influence exerted on the natural environment, should be based on the use of economic and cultural solutions that are optimal in particular conditions, **economic criteria** should take into consideration an increase of investment expenditure compared to conventional solutions and return of additionally incurred costs at a given time, the aim of **social criteria** related to knowledge dissemination and education is to encourage the use of new technologies, whereas **spatial criteria** should promote renovation, modernization, revitalization of spatial structures and technological systems. For this reason, current designing becomes a more complex process than in previous years. Classic elements included in design are now subject to new requirements. Also completely new elements are emerging. Proper optimization of buildings' energy, which is required in accordance with sustainable development assumptions, based on an **Life Cycle Analysis (LCA)**, cannot be conducted without a comprehensive analysis of benefits, losses, causes and effects [4], and most importantly, without understanding the reasons for their occurrence. The above mentioned assumptions have a lot in common with the principle of sustainable design, based on understanding the following points, which have been presented by Samuel Mockbee from Auburn University [6]: **understanding the place**, as a basis for sustainable design, **understanding nature**, by finding one's own place in it, **understanding the environmental influence**, in the context of search for a balance between the destructive influence exerted by the building sector's activity on the environment and the activities aimed at neutralising such effects, as well as **understanding the people**, in the context of a broadly understood cultural heritage.

With such a wide range of activities and co-dependencies included in the concept of sustainable design, the previous inter-branch co-operation is no longer sufficient and does not ensure proper integration of teams and an optimal result in the form of an effective built environment. For this reason, in the 1990s the concept of **Integrated Design Process – IDP** was born. The aim of IDP is to construct a building and consequently, a built environment characterised by an effective use of energy as well as an optimal internal comfort and minimal influence on man and the natural environment. It is worth emphasising at this point the fact postulated by prof. A. Baranowski, that "an increasing variety of criteria for taking pro-ecological design decisions and many directions of activities in this field require a system approach, based on an acceptable hierarchy of values" [1].

IDP, as opposed to previous co-operation between branches, should be characterised by continuity and dynamics. It should consist in multi-criteria optimization of solutions and cannot finish when a building has been rendered for use. Co-operation of all members in a design team, starting with the early concept stage, through multi-stage verification of the assumed parameters and finishing with the final version of the design and a possibility to check the correctness of the adopted solutions in the process of **building monitoring**, is a novelty in the principles of co-operation and in the design process.

The concept, the technical and economic assumptions, the construction design, remaining the design process elements, are subject to formal and factual changes related to the necessity of adapting them to the principles of sustainability and **systems of buildings evaluation/certification**.

New procedures enabling the principles of sustainable development to be implemented in a built environment, require in the first place reevaluation of needs making their scope more realistic as well as adjusting to an economic and social context. This entails defining real "customized" assumptions as well as strategies and methods necessary to achieve the planned solutions (urban planning, architectural, building, constructional, technological, communications, energetic, social, economic etc.), which create a sustainable built environment, such as location requirements, Area Development Plan [2], legislative requirements and branch directives.

Optimization, understood as a choice of the most favourable solution with regard to the fulfilment of the adopted assumptions from among the analysed existing admissible solutions to the problem, becomes a vital element of IDP strategy. Continuous stimulation results in adopting more favourable materials, solutions and systems, which unfortunately are often more expensive than the typical ones. This increases the costs at a given stage, which according to design assumptions, are supposed to be offset in other stages owing to the effects achieved by using such solutions [4].

A broad, holistic approach being a part of IDP, requires crossing certain boundaries and going beyond certain habits. It necessitates the co-operation of interdisciplinary designer teams and is based on theoretical simulations as well as on studies conducted in the erected facilities, where apart from theoretically predictable correlations, one can also observe dependencies that cannot be forecast in theoretical considerations, as they result from dynamic, changeable conditions of the context and co-operation of elements combined at the site.

3. Integrated Design Team (IDT) and co-operation strategies

The process of designing invariably involves the co-operation of a specialist team whose composition is currently changed in accordance with IDT requirements. IDT assumptions can be professionally implemented (in terms of knowledge, experience and competence) in an optimal way if the composition of a classical design team is extended with new members and branches. Apart from architects, urban planners, constructors, installation designers, it should also include: a co-ordinator running the design process, a building evaluation/certification expert, energy simulation experts, digital design systems experts, clients and users, facility managers, building acceptance consultants and experts as well as specialists and experts in the area of monitoring and system integration, interior microclimate and natural lighting; finally, experts in the field of energy, environment (ecologists, biologists) and costs as well as service staff, equipment fitters and suppliers should be included in the design team [4, 5].

With such a large group of people involved in the process and the necessity of close co-operation, the following question comes to mind. How should one work in an IDT team to achieve an agreement and fulfill the goals set by IDT?

The basic pre-condition of integrated design process success, is being aware of the fact that each member of the team influences sustainability aspects and environmental effectiveness as well as establishing general principles of project implementation, which regulate such issues as **what, who, how and when** things should be done in order to achieve the planned goal. For this reason, members of a design team must feel collectively responsible. They should also be aware of differences in their preferences and be convinced of the results of research and negotiation methods; they should skilfully use IDP support tools, among others such as computer technologies, parametric, generative, commutative methods as well as BIM technological design and others.

An issue gaining considerable importance in IDP, is the collection of information regarding the building's behaviour when transfer of collected information is utilized for conceptual models of all design levels and its analysis and re-use as an experience gained on the basis of the effects of the previously adopted solutions.

Apart from team work, efficient functioning of advanced systems requires communication with external databases. In this case, support provided by digital programmes and technology is very helpful. When working on a common project, they can communicate via the net, where in the digital database environment, all information about the building is correlated. Co-ordination and transfer of data take place automatically, supported by digital programmes and technologies. Information processing during design works can be divided into three stages [8]:

- **data collection** – selection, sorting and comparison of data which determines boundary conditions, concerning the real and intellectual context of creative activities,
- **collaboration, information exchange** – dialogue with co-operating specialists, visualisation of dependences, explanation of codes characteristic of the branches,
- **model construction** – supporting the construction of the main model (BIM database) containing information on the geometry, technology, processes of erection, use and simulation of states.

The IDP standard enables all team members to participate in the design process and allows achieving comprehensive technical solutions at the conceptual stage. Creativity is the basic feature which should characterise IDP participants; everybody can make remarks and come up with proposals, but according to Thom Mayne, it is the architect who takes the final decisions.

The final, comprehensive design documentation (concept, design, completion, use) and conclusions on the important process points (simulations, decisions, monitoring of the building's effectiveness in use), containing data on the course of the design process, should be prepared and stored for further use and analysis, as an experience gained in the process, feedback information and as a "guidebook" for subsequent design tasks. In this case, an important issue is wide distribution of materials for didactic and informative purposes.

4. New design tools

The effectiveness of the exchange of information from various sources is currently a basis for the co-operation of design teams. All the stages: the recording of conceptual thought, the transfer of information and in consequence, interpretation, reading and understanding of solutions, are very important. The precision and clarity of recording, speed of transfer and information exchange are the most important, as they directly influence the reading, interpretation and understanding of solutions. The design method selection, depends on architectsx as in the case of Frank Gehry, starting with traditional methods (handwritten conceptual sketches) and finishing with advanced digital design techniques.

The designed buildings are more and more frequently treated as a set of information (data) which defines their particular constituents: construction, materials, functional-spatial solutions, equipment etc. For this reason, computer technologies, which enable the storage of a large amount of data and fast information exchange, are a useful design tool. It is the computers that have a huge potential enabling most innovative spatial visions to be realized, like e.g., Phare Tower in La Defense designed by Morphosis Thom Mayne – the winner of the Pritzker Prize 2005.

LEED evaluation systems, 3D database – driver BIM platform, Autodesk Revit, Graphisoft's ArchiCAD, Autodesk Architectural Desktop, Bentley Systems and other systems streamline the process of designing; architects can co-operate with constructors, mechanics and electricians achieving the highest efficiency and sustainability.

BIM – Building Information Modelling is a process enabling an extensive exchange of information, which includes: building information modelling, virtual presentation of a building, intelligent simulation of architecture, platform for information storage and exchange as well as a source of data on all the construction elements which can be used according to established principles.

The pioneer of BIM implementation is Frank Gehry and his co-workers from Gehry Partners LLP and Gehry Technologies. The systems they use, like CATIA and new Digital Project, are tools which enable an automatic co-ordination of information, access to an extensive database, high effectiveness in the process of designing and conducting of simulations and results analyses, and in consequence, the erection of buildings such as: Guggenheim Museum in Bilbao, Experience Music Project in Seattle or Walt Disney Concert Hall in Los Angeles.

By the process of solving design tasks in a virtual environment (simulations and analyses) aimed at determining optimal constructional solutions, the shape of the building can be assisted by the helpful tool of **parametric modelling,** which enables optimization of construction and building elements having very complicated geometrical shapes, and allows adopting effective, economically justified solutions.

In the case of co-operation with BIM, subsequent iterations, which involve changing the shape of a building due to subsequent corrections of relations between buildings and model points resulting from an analysis of strong and weak sides of the solution, can concern the whole database – construction, materials, physics of the building and economy. Thus the advantage of BIM over traditional methods of designing and creating drawing documentation on the design process, is based on the integration of information within one database (or different, but compatible databases) and the possibility to automatically identify the changes and evaluate the benefits and drawbacks. Moreover, the use of virtual 3D models reduces the time necessary for analysis and interpretation of two-dimensional drawings. Application of **BIM + parametric design** makes it possible to take conscious decisions on the basis of the results of numerous conducted analyses, allows checking a larger number of variants and reduces the working time.

In the future, traditional design methods will most probably be combined with advanced solution modelling techniques (3D) and tools for creating documentation (2D), as for example, the Guggenheim Museum in Bilbao by F. Gehry, using BIM.

The construction of **Swiss R3 Tower** at St. Mary Axe in London, designed by Norman Foster, in which the characteristic shape of the solid with an oval line of the projection of subsequent storeys generated on the basis of simulations and aerodynamic analyses of wind flows and air whirls, was supported by a group of architects, programmers and mathematicians: The Specialist Modelling Group, SMG. The team used Bentley Systems to conduct a quick analysis of design options, which owing to the parametric approach and interface scenario writing, are fast and suitable.

The design of the Swiss Re Tower x surrounded the office spaces with a glass coating having a smooth and free form, thus creating a building with an optimal microclimate. The double curved building, based on advanced digital technology, is an extension of ideas proposed in the 1970s, in B. Fuller's designs.

Swiss Re Tower consumes 50% less energy compared to a building having a similar capacity and function which has been designed with traditional methods. Energy benefits result from the use of natural air circulation for ventilation purposes owing to triangular atria (the shape and capacity calculated on the basis of iteration processes of parametric models), located spirally around the outline of the building. Benefits related to economic effectiveness result from simple repeatable elements: facade geometric optimization based on iteration processes and analyses, repeatable panels having a rhombic form.

The Olympic Stadium in Beijing, designed by the team of Herzog & De Meuron in co-operation with constructors from Ove Arup and Gehry Technologies, was based on construction optimization: a small number of typical repeatable modules and two types of connections determined on the basis of iteration analyses, form the base of the building structure, i.e. plate girders joined at the building site into pipes having a rectangular cross-section.

The glass roofing of the **British Museum** in London, designed by Foster & Partners in co-operation with The Specialist Modeling Group (SMG), which consists of a steel and glass structure network spread over a spacious courtyard, is one of the most interesting and subtle examples of using iteration processes in parametric modelling.

5. Conclusions

Observations of architecture in the last decade, allow to conclude that it is aimed at effectiveness and creating a healthy internal environment for residential and working purposes, which is achieved by integrating the design systems and methods with environmental control systems. The basic principle in IDP is the assumption of a sustainable design objective (objectives), based on experience and knowledge gained in previous designs, simulations, research as well as on evaluation and certification systems and the principle of assessing a building after its use has begun. Introduction of proper assumptions at the early conceptual stage is characterized by the highest effectiveness. The existence of new paradigms in architectural design resulting from IDP influences, need to support design processes with IT technologies – parametric, generative, additive, BIM and other.

Despite the fact that currently only a small number of architectural studios are implementing design support computer systems (Data – Driven Design), their application is already resulting in high effectiveness of designing. New tools enable management of design data and building information, ensure quick analysis of information and data as well as good communication within design teams.

A combination of sustainability, a highly effective design strategy and BIM modelling has a potential to bring about a considerable change in the profession and contribute a higher quality to the mainstream of architectural practice. The system of building evaluation and BIM remote platform (Autodesk Revit, Grahisoft's ArchiCAD, Autodesk Architectural Desktop, Bentley Systems) can ensure a better methodology in practice.

Computer technologies themselves are not a panacea, but when combined with tested sustainable design methods, they become an important tool that can be effectively used for creating a built environment and improving the methods of co-operation in design teams.

References

[1] Baranowski A., *Projektowanie zrównoważone w architekturze*, Gdańsk 1998.

[2] Celadyn W., *Architektura Energooszczędna w Planowaniu Przestrzennym*, Czasopismo Techniczne, 8-A/2010.

[3] Jękot B., *Rozwój oceny/certyfikacji budownictwa: od kalkulacji częściowych do całościowych*, University of Pretoria, 2010.

[4] Kujawsk i W., *Zintegrowany Proces Projektowy, czyli jak możemy projektować lepiej*, [w]: Zawód: Architekt, #19 1/11, 2011.

[5] Larsson N., *IDP – Integrated Design Process* – Workshop Materiale, Ottawa 2004.

[6] Mikoś-Rytel W., *O Zrównoważonej Architekturze Ekologicznej i Zarysie jej Teorii*, Wyd. Pol. Śl., Giwice 2004.

[7] Robert s B., Architectural Design, 4/2001.

[8] Słyk J., *Źródła architektury informacyjnej*, Prace Naukowe Pol. Warszawskiej, Seria Architektura, Zeszyt 7, Oficyna Wydawnicza PW, Warszawa 2012.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

TOMASZ MALCZYK*, ALEJANDRA SAYANS JIMENEZ**

THE TECHNICAL, LANDSCAPE AND BIOCLIMATIC APPROACH TO THE PROCESS OF DESIGNING DETACHED HOUSES ON THE BASIS OF VILLARINO DE SANABRIA, ZAMORA, SPAIN

TECHNICZNE, KRAJOBRAZOWE I BIOKLIMATYCZNE PODEJŚCIE W PROCESIE PROJEKTOWANIA DOMÓW WOLNOSTOJĄCYCH NA PRZYKŁADZIE VILLARINO DE SANABRIA, ZAMORA, HISZPANIA

Abstract

The paper presents the results of the work which inherently makes use of the coherent approach to the process of designing single-family detached housing. In the process of architectural planning, the authors have considered the analysis of the location, environmental and landscape qualities, renewable energy installation as well as construction materials along with the technology of erecting single-family houses. The design concept presented in the paper is of interdisciplinary character and integrates the design parameters belonging to the following fields: technology, landscape architecture, bio-climatics and renewable energy.

Keywords: architecture, building, landscape, renewable energy

Streszczenie

W artykule przedstawiono wyniki pracy, które w sposób immamentny korzystają ze zbornego podejścia w procesie projektowania jednorodzinnego budownictwa wolnostojącego. W procesie projektowania architektonicznego uwzględniono analizę miejsca, walory środowiskowe i krajobrazowe, instalacje energii odnawialnej, a także materiały budowlane z technologią wznoszenia domów jednorodzinnych. Przedstawiona koncepcja projektowa wykonana jest z uwzględnieniem pełnej interdyscyplinarności i integralności parametrów projektowych z obszarów: technicznych, architektury krajobrazu, biolkimatyki i energii odnawialnej.

Słowa kluczowe: architektura, budownictwo, krajobraz, energia odnawialna

* Prof. Ph.D. D.Sc. Eng. Tomasz Malczyk, Institute of Architecture and Urban Planning, University of Applied Sciences in Nysa.

** Alejandra Sayans Jimenez, Technical University of Madrid, EU Technical Architecture, Spain, Erasmus Student.

1. Introduction

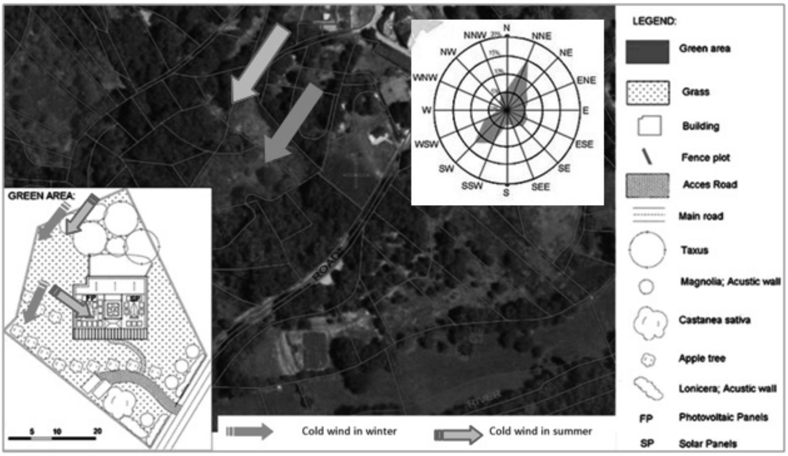
The methodology of construction design requires the integration of knowledge and experience of many elements which are parts of this process. The mutual interaction, implementation and permeation of particular activity stages make it possible to devise an attempt to define the holistic methods of achieving the design and final execution goal. The area of science dealing with construction design is very vast and on a common ground it combines many sciences which are fundamental to designing and especially in engineering. At the same time, the outcome of large-scale scientific exploration points to the need of including additional aspects in designing. They are connected for example,with respecting energy both in the production of construction materials, object erection, its use, modernization and finally, its liquidation. The process of design and construction execution should therefore be characterised by particular sensitivity and susceptibility to the changes which are the essence of various fields of science and experience while at the same time they are praxeologically implemented in the stages of both science and practice. The article presents the results of the work which inherently makes use of the coherent approach to the process of designing single-family detached housing.

2. Materials and methods

2.1. Methods and characteristics of the study area

In the process of architectonic designing account was taken of the analysis of the location, environmental and landscape qualities, renewable energy systems, as well as building materials in the technology of erecting detached houses [6, 24]. The presented concept is made with emphasis on the full interdisciplinary nature and integrity of design parameters from the: technical, landscaping, bio-climatic and renewable energy areas [3, 18, 28]. An exemplification of the article's assumptions is the design concept of the facility located in the town of Villarino de Sanabria (province of Zamora, Spain) [8]. The data taken into account in the article characterize the area selected for research, located in north-western Spain (they include: environmental, landscape, climatic, installation, functional and material parameters) and became the basis for conducting a broader analysis resulting in the elaboration of an organizational model solution. The town is located in the neighbourhood of the border with Portugal (north-western part of Zamora province) in a region which is characterized by diverse land shape, in terms of altitude and environmental qualities. Villarino de Sanabria is in a climatically diverse area i.e., on the borderland of zone I with a continental climate in and zone IV with a mountain climate. Zone I characterized by parameters of an ocean climate is also nearby. This area is dominated by variable winds with a south-west and north-eastern direction [23]. In the process of location and management of the plot (being the basis of the study along with the design concept of the facility), methods typical for landscape evaluation were applied, thanks to which the completed design is a coherent architectonic-construction-landscape whole (Ill. 1). This involved the use of the methods of: the value matrix by Bajerowski [1, 14], the impression curve by Wejchert [26], Visual Impact

Assessment (VIA) [2, 15], Zone of Visual Influence (ZVI) [17, 27], Viewpoints (as a part of Visual Impact Assessment) [10, 16]. The methods used have characterized and described the location parameters, emotional and aesthetic perception of the value and composition of the landscape.

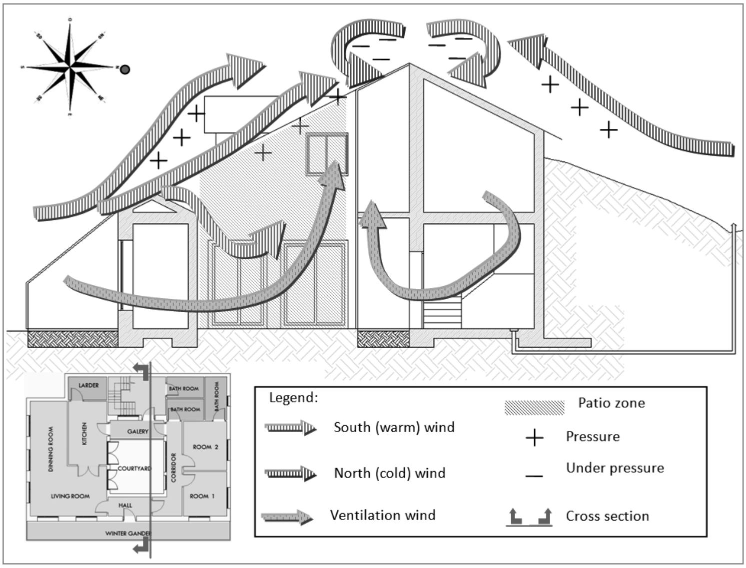


Ill. 1. Location of the facility and development of the plot (source: individual work on the basis of: SIG PAC, Junta de Castilla y Leon system)

3. Results and discussion

In connection with the implemented adopted research methodology, an analysis was carried out, which included coherent landscape, environmental, as well as material and architectural assessment. The adopted solutions are convergent with typical projects applied in this region while additional emphasis is placed on the consideration of the concept of selected methods of acquisition of renewable energy, as well as climatic and locational conditions. The whole is supposed to indicate a possibility of linking the needs of the inhabitants with the models of architectonic-material solutions [3, 5, 13, 20, 22, 24]. As a result, several aspects were enumerated, which refer to the selected problems. They include in particular the analysis of the possibilities of natural wind management in combination with the suggested functional-spatial solution for the house and its location in the area (Ill. 2) [21]. The use of the shape of the house and proper location of the facility on the plot taking into account the environmental parameters (height of location of the plot, planting greenery, open area, etc.), contributes a great potential of bioclimatic area [19].

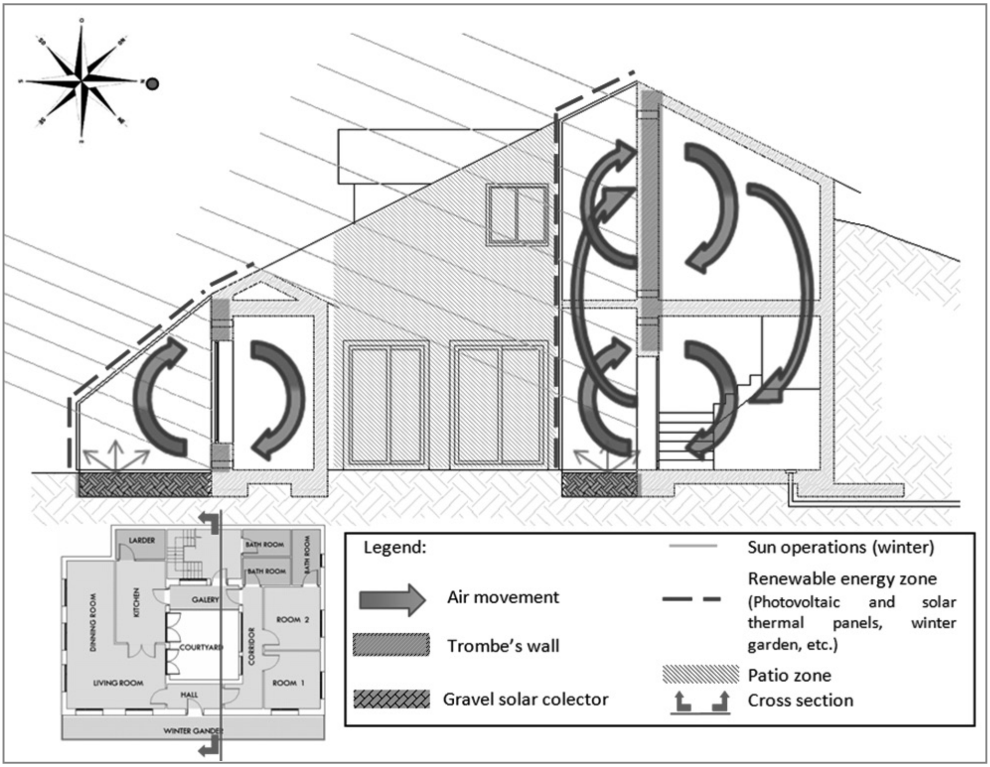
Pressure and negative pressure exerted by the wind become a natural driving force for gravitational air movement inside the facility [4, 9]. Thanks to combining this phenomenon with the designed spatial-construction solutions, it is possible to improve the living conditions of the house's inhabitants. This applies in particular to zones with prevailing directions of winds; in the analyzed case these are southern and northern directions. The body of the designed facility reflects the nature of the optimum trend in designing in this region. Reduction



Ill. 2. Projection and section of the house with wind movement zones
(source: individual work)

in the southern part of the facade and elevating it towards the north leaving l internal open patio, enables control and prediction of the line of air movement inside particular modules of the house. This also applies to the northern side, where a particular problem may be cool winter winds. A similar procedure was applied for an analysis of the passive heating system. The diverse height of the particular parts of the facility, emphasizes in relation to the sun ray incidence angle, a large flat, oblique and vertical area, used in the implementation of several solutions of eco-energetic nature. They include photovoltaic cells and solar collectors [12], winter gardens, heat reservoirs (in the form of gravel tanks and accumulation walls), as well as multi-layer walls in the Tromba system (Ill. 3) [20]. The active surface is increased by the adopted modularity of the solution (joint use of various solutions), along with the patio forming an additional three glazed surfaces of walls (southern, eastern, western).

Owing to the geographic location of the assumption (warm climate), there is a need for cooling the facility, especially in the southern zones where there is a parallel increase in the level of natural humidity inside the rooms. For this purpose, an attempt was made to use solutions supporting cooling of the house with simultaneous reduction in demand for energy (Ill. 4). A hybrid solution was planned based on: a) combination of the force of natural wind (phenomenon of diverse pressure on both sides of the house and internal partitions), b) strengthening the speed of air movement inside rooms (in rooms equipped with reservoirs accumulating heat from solar radiation and with Tromba wall, c) air infiltration with reduced temperature and increased humidity coming from the northern side (sucked-in in a natural way and flowing from the place shielded by the house and greenery, and additionally cooled in the pipe placed a few meters under ground), d) cooling (in the summer) and heating (in the winter) with a layer of ground at the northern external partition (the ground is adjacent to the

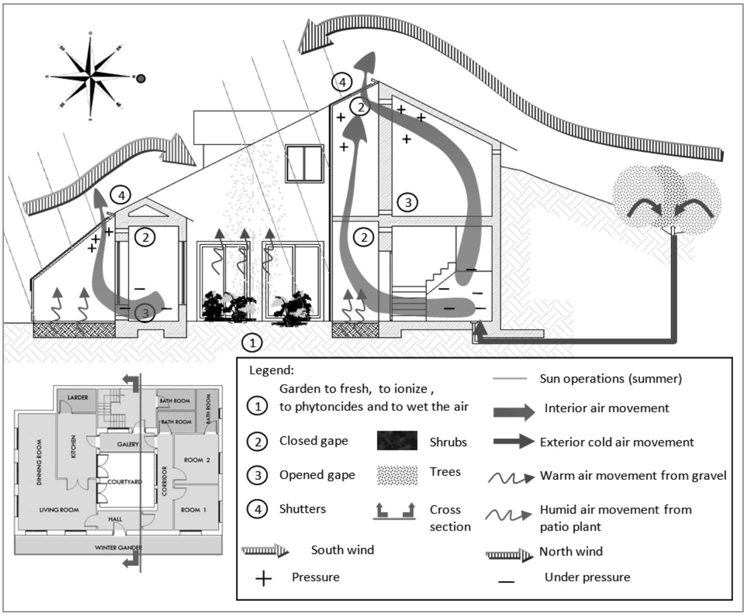


Ill. 3. Projection and section of the house with possible passive heating zones (winter)
(source: individual work)

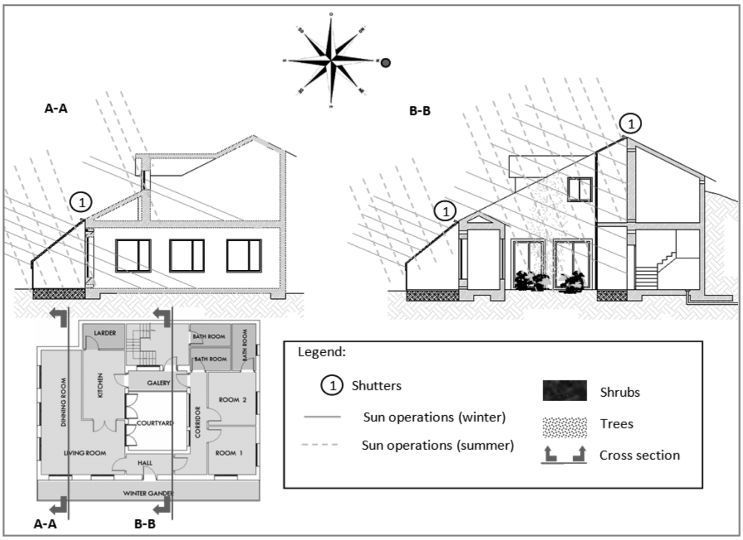
partition, which at the same time is a retaining wall, with the assumption that the facility is located in the area with a southern inclination), e) cooling, and at the same time, humidifying the air inside the patio (through the phenomenon of vaporization of water gathered in plants and lawns). The phenomenon of movement of air passing through intentionally (with regard to quality and place) planted plants, additionally ionizes the air and enriches it with phytoncides [3, 11, 17, 19, 20, 25].

An important aspect of the bioclimactic solution of the designed facility is the opportunity to make use of solar energy for lighting the interior. In the presented solution, analysis was made based on the possibilities of additional lighting in the all-season period (Ill. 5). Owing to the cascade nature of the solution and the application of surrounding glazed walls to the patio, considerable horizontal and vertical surfaces were obtained, on which direct and/or reflected solar radiation falls. In areas of excessively intensive solar radiation increasing room temperature, the possibility of covering with glazed surfaces is envisaged [4, 17].

A facility without a basement and with a partial attic requires a relatively large building area. It creates additional opportunities for the use of the ground area under the buildings for implementation of supporting devices and heating and air-conditioning solutions based on renewable energy areas (e.g., heat pumps).



Ill. 4. Projection and section of the house with possible passive cooling zones (summer) (source: individual work)



Ill. 5. Projection and section of the house with possible additional natural lighting zones (summer, winter) (source: individual work)

4. Conclusions

Data analysis and thematic query of the literature, indicate the need to define broader problematic fields accompanying the complex process of designing in architecture, construction, landscape, environment and eco-energy. The level of mutual relations in particular areas is individually estimated and matched to certain needs (including among others, the investor, the place, the environment) on the basis of the following remarks:

– bioclimate is immanently consistent with the process of interdisciplinary architectonic-construction designing,
– interdisciplinary approach to designing includes the analysis of environmental and landscape conditions,
– the main aspect when designing is to examine a possibility to introduce diverse methods of acquiring energy for renewable sources, with simultaneous respect for energy,
– each process of architectonic-construction designing should include a wide range of *ex-ante* analysis in the scope indicated in the article and *ex-post* analysis which will enable identification of a holistic design-executive method.

References

[1] Bajerowski T., Biłozor A., Cieślak I., Sanetra A., Szczepańska A., *Ocena i wycena krajobrazu*, Wydawnictwo Educatera, Olsztyn 2007, 30-59.
[2] Buchan N., *Visual Assessment of Windfarms: Best Practice, Scottish Natural Heritage*, Edinburgh 2002.
[3] Bosqued A., Palero S., San Juan C., Soutullo S., Enríquez R., Ferrer J.A., Martí J., Heras J., Guzmán J.D., Jiménez M.J., *Arfrisol, bioclimatic Architecture and solar cooling Project*, PLEA, 2006.
[4] Cañas I., Núñez P., Martín-Ocaña S., Mazarrón F.R., García-Grinda J.L., *Bioclimatic passive designs rural buildings, International conference on Innovative Methods in Product Design*, 2011.
[5] García L.D., *Arquitectura bioclimática, Viviendas bioclimáticas en Galicia*, 2002.
[6] García-Moruno L., Montero-Parejo M.J., Hernández-Blanco J., López-Casares S., *Analysis of lines and forms in buildings to rural landscape integration*, Spanish Journal of Agricultural Research, 8 (3), 2010, 833-847.
[7] Grimm B., *Quantifying the Visual Effect of Wind Farms. A Theoretical Process in an Evolving Australian Visual Landscape*, School of Architecture, Landscape Architecture and Urban Design, University of Adelaide, 2009, 33-57.
[8] Hernández J., Garcia L., Ayuga F., *Methodologies for Visual Impact Assessment of Rural Buildings by Geographic Information Systems*, Biosystems Engineering 88 (2), 2004, 255-263.
[9] Afshari H., Design *Fundamentals in the Hot and Humid Climate of Iran: The Case of Khoramshahr*, Asian Culture and History Vol. 4, No. 1, 2012.
[10] Horner & Maclennan, Envision, *Visual Representation of Windfarms. Good Practice Guidance*, 2006, 53-76.

[11] Kerimova N., Nefedov V., Sotnikova I., Morozova M., *Biotope-based approach for mixed-use office building landscape*, Landscape Architecture and Art, Vol. 1, No. 1, 2011, 30-36.
[12] Krajewska Ludwiczak A., *Solar Architecture as an ethical trend in architectural design practice*, Architectus, 2 (30), 2011.
[13] La Roche M.P., Machado V.M., Mustieles F., De Oteiza I., *El dispositivo habitable, Instituto de Investigaciones de la Facultad de Arquitectura*, Univ. del Zulia, Venezuela 1999.
[14] Litwin U., Bacior S., Piech I., *Metodyka waloryzacji i oceny krajobrazu*, Uniwersytet Rolniczy w Krakowie, 2009, 14-25.
[15] Lothian A., *Scenic Perceptions of the Visual Effect of Wind Farms on South Australian Landscapes*, Geographical Research, 46, 2007, 196-207.
[16] LUC Land Use Consultants, *Landscape Sensitivity Analysis for Wind Energy Development in Bath and North East Somerset*, London 2010, 7-22.
[17] Malczyk T., *Zieleń w krajobrazie terenów inwestycyjnych*, OW PWSZ w Nysie, 2012.
[18] Mavrogianni A., Tsoukatou M., *The bioclimatic dimension of educational buildings in Greece, International Workshop on Energy Performance and Environmental Quality of Buildings*, 2006, 1-6.
[19] Michael A., Hadjichristos C., Bougiatioti F., Oikonomou A., *Bioclimatic parameters in the design of contemporary buildings: the proposal for the new Town Hall of Deryneia*, Cyprus, International Conference on Renewable Energies and Power Quality, 2010.
[20] Morillón Gálvez D., *Introducción a los sistemas pasivos de enfriamiento*, Universidad Nacional Autónoma de México, 2002.
[21] Nefedov V., *Landscape and Architecture: Interacion for Sustainability*, Vol. 1, No. 1, 2011, 44-47.
[22] Palero S., San Juan C., Enríquez R., Ferrer J.A., Soutullo S., Martí J., Bosqued A., Heras J., Guzmán J.D., Jiménez M.J., Bosqued R., Porcar B., Heras M.R., *Thorough Study of a Proposal to Improve the Thermal Behaviour of a Bioclimatic Building*, Conference on Passive and Low Energy Architecture, Geneva 2006.
[23] Pérez-Bellaa M.J., Domínguez-Hernándeza J., Rodríguez-Soriaa B., del Coz-Díazb J.J., Cano-Suñéna E., *Estimation of the exposure of buildings to driving rain in Spain from daily wind and rain data*, Building and Environment, Vol. 57, 2012, 259-270.
[24] Pilar Solis Martinez M., *Bioclimatic architecture*, Architectural Technology and Construction Management, Denmark 2012.
[25] Sandifer A.S., *Using the Landscape for Passive Cooling and Bioclimatic Control: Applications for higher density and larger scale*, Conference on Passive and Low Energy Architecture, Quebec City, Canada PLEA 2009.
[26] Senetra A., *Wpływ metodyki oceny walorów krajobrazowych na wyniki szacowania nieruchomości*, ACTA, Administratio Locourum, 9 (2), 2010, 113-128.
[27] University of Newcastle,*Visual Assessment of Windfarms: Best Practice, Edinburgh*, University of Newcastle, 2002, 10-15, 17-20.
[28] Wheeler B., *The University of Arizona College of Arohiteoture and Landsoape Arohiteoture*, Tuoson, Arizona, Ökologie Teohnologie, architektur. aktuell, No. 340, 341, 2008, 7-8.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

MAŁGORZATA MEŁGES*, HUBERT MEŁGES**

BUILDINGS IN CONSERVSATION AREAS IN CRACOW – TECHNICAL AND AESTHETICAL SOLUTIONS ON EXAMLPE OF BUILDING OF ST PADRE PIO'S WORKS AT SMOLEŃSK 4 STREET

BUDYNKI W STREFACH OCHRONY KONSERWATORSKIEJ KRAKOWA – ROZWIĄZANIA TECHNICZNE I ESTETYCZNE NA PRZYKŁADZIE REALIZACJI BUDYNKU DZIEŁA POMOCY ŚW. OJCA PIO PRZY UL. SMOLEŃSK 4

Abstract

While designing new structures in urban conservation areas, one should: respect the context of a place, the character of a building resulting from the urban analysis and a variety of existing urban and historical themes and details. One example of these issues is the newly established facility in Krakow at 4 Smolensk Street. It is the next stage of the expansion of the Holy Padre Pio's Work Foundation and it will be open for public use. The building is located in a conservation area of the city. Processes: the design and realization of the investment were subordinated to the aforementioned criteria, but in a manner congruent with contemporary design and technological solutions.

Keyworks: conservation thought, renovation, infill buildings, revitalization

Streszczenie

Projektując nowe obiekty budowlane w strefach ochrony konserwatorskiej miast, należy: uszanować kontekst miejsca, charakter zabudowy wynikający z analizy urbanistycznej oraz różnorodność istniejących wątków historycznych i detali. Przykładem wymienionych zagadnień jest nowo powstały obiekt w Krakowie przy ul. Smoleńsk 4. Stanowi on kolejny etap rozbudowy Dzieła Św. Ojca Pio i przeznaczony zostanie na cele użytku publicznego. Obiekt usytuowany jest w strefie ochrony konserwatorskiej. Procesy: projektowy oraz realizacyjny inwestycji, podporządkowane zostały wyżej wymienionym kryteriom, jednak w sposób przystający do współczesnych rozwiązań projektowych i technologicznych.

Słowa kluczowe: budowla, kontekst, technologia

* Ph.D. Eng. Arch. Małgorzata Mełges, Institute of Structural Design, Faculty of Architecture, Cracow University of Technology.

** Ph.D. Eng. Arch., Hubert Mełges, Institute of Urban Design, Faculty of Architecture, Cracow University of Technology.

1. Cracow – a city inscribed on the UNESCO list

In the scale of our country Cracow is considered priceless when it comes to its historical past and the accumulation of material culture. Here, as in hardly any other city, you can visually encounter a one hundred-year-old urban and architectural stratum. It is no wonder then that this royal city, a symbol of the Polish state and the place of coronation and royal tombs, was inscribed as one of the first cities on the UNESCO World Cultural and Natural Heritage[1] list in 1978. Since 1257, when Boleslaw the Chaste gave it the rights, the city has been developing, gathering talents, skills and experience of successive generations of builders and artists of many disciplines. In this way, an excellent urban planning idea has survived hundreds of years and today serves as an excellent model. But to what extent does it meet the requirements and various (how different from the ones in the past) needs of the twenty-first-century man? How far can these new needs be adapted to the existing and historic reality?

2. Monument protection and conservation development in Poland throughout time

It should be mentioned that the royal city of Krakow also served a special role in monument protection in the history of the Polish nation and especially, in the partitions. However, it can be admitted that the first steps in conservation in Poland took place in the mid-seventeenth century after the Swedish wars. From the point of view of history of monument conservation, one can distinguish five phases corresponding to the periods from 1840 to the last one in 1945 after World War II,[2] when massive war destruction in Poland forced Polish conservation ideas to develop a new general concept. It took into account all restorational treatments, as well as the reconstruction of entire complexes of historic buildings. After World War II, from 15 February 1962, the *Act for the protection of cultural heritage and museums* came in force. Since 17 September 2003, there is the new Act of July 23, 2003 on the conservation and care of monuments, which repealed the existing law in force for over forty years.[3] Bearing in mind the wealth of ideas in conservation in Poland and without going into an analysis of its development, but only to emphasize the climate in which the foundations of our thinking on conservation, it seems appropriate to recall the words of Artur Potocki in 1825 during the Sejm of the Republic of Cracow, addressed to the Governing Senate: "… Order in the country and the good name of the residents provide one of the important objectives of any government. I am glad therefore, that we care about them well, however, there still remains a holier obligation to fulfill (while we are debating in Cracow), guard and preserve the monuments of the past with responsibility. In this classic land of native memorabilia,

[1] The convention concerning the Protection of World Heritage was adopted in Paris in 1972. The Paris Convention is one of the most universal normative acts that were introduced by the United Nations system. Adam Bujak, World Heritage. *Poland on the UNESCO list*, Biały Kruk, Kraków 2004, 6.

[2] It was assumed that the individual conservation periods are distinguished on the basis of George Frycz's research, [1, p. 47].

[3] "…The new statutory regulation concerning monuments in the very name divides the whole sphere of activities devoted to their preservation into two basic ranges: 1) monuments protection and 2) the care of monuments" [2, p. 9].

we were surrounded with monuments of great times, and the future taught stones how to speak. I'm afraid that one day our successors would not cry for us as we have done a lot for convenience and our own benefit and have not done anything for the past and for what we have inherited in the monuments" [1, p. 47].

3. Preparatory processes for project activities in conservation areas

If a necessity or possibility of construction (patching losses or free places with infill buildings) or of making any renovations or revitalization occurs in conservation areas, it is necessary that these works are performed with the best possible creative and implementing possibilities. These must be guided by the idea of special respect for tradition that reflects the past and cultural identity. These requirements and challenges typically require careful urban and architectural discernment, as well as many of the necessary arrangements, including ongoing consultation with the conservator. Only as a result of these arrangements, is it possible to obtain permission to conduct these works issued by a competent restorer [3, item 39]. We briefly highlight here the atmosphere related to the design and the responsibility of the designer in such a delicate matter, which conditions of such a historic city rich in the traditions of conservation of the Cracow School of Conservation create.

4. The building of St Padre Pio's Works at 4 Smoleńsk Street in Cracow, the types of functions and location of the building in the context of the existing historic building and architectural reference to the Smoleńsk Street archetype

The conclusion is that all design decisions must be repeatedly reviewed and considered. The authors of the design[4] and construction of the public building at 4 Smoleńsk Street in Cracow, in order to exchange experiences, wish to share such reservations and thoughts. The building was located behind the wall and within the convent of the Sisters of St. Felix of Cantalice (Felician Sisters). It has a very diverse function, designed for the purpose of serving the poor, the needy and the homeless in various ways. The investors of the investment are two congregations: the already mentioned Congregation of the Sisters of St. Felix of Cantalice (Kraków, 6 Smoleńsk Street) and St Padre Pio's Relief Work of Help St. Padre by the congregation of Friars Minor Capuchin (11 Loretańska Street in Cracow). The basic functions of the building include: a kitchen and social diner with a cold store and food warehouse, bath with storage of clothes for the poor, two laundry rooms (laundry for the poor and laundry facilities run by the staff of the building), medical clinic, rooms for teaching and training activities, administrative rooms and offices. The building was constructed as a free standing building with three storeys, a basement and an attic. It partly adheres to the household buildings behind the wall of the convent along Smoleńsk Street. In the surroundings of the building on the south side, there is a local building block with the urban dominant? of the middle segment of the Krakow Philharmonic Hall located at 18

[4] The authors of the project are the architects: Hubert Melges, Małgorzata Melges, Przemysław Bigaj and Paweł Mika (staff of the Faculty of Architecture at the Technical University of Cracow).

Straszewskiego Street and 1 Zwierzyniecka Street[5]. In the immediate vicinity of the area of this object, on the opposite side of Smoleńsk street, there is the building of the former Museum of Science and Industry built in the years 1912–1914 (now the building is used by the Academy of Fine Arts)[6]. From the west, within a distance of about 100 meters, there is a neo-Gothic church of the Immaculate Heart of the Blessed Virgin Mary with the entrance through the gate in the wall at Smolensk Street (which is also the fencing wall of the convent)[7].

Ill. 1. View of the building with the church in the background from the perspective of Smolensk Street

5. Stages of design activities in accordance with the intended utilitarian function of the object

In the context of this historic part of Kraków and with reference to it, first a design concept maintaining the tradition of monastic buildings was created. A kind of "quarter building" was designed with a glazed courtyard: the atrium, reminiscent of the traditional monastic

[5] The building of the Krakow Philharmonic Hall with a distinctive mansard roof built in 1931 was designed by Cracovian architects Józef Pokutyński (1859–1929) and Stanislaw Filipkiewicz (1885–1925).

[6] The architects of the Museum of Science and Industry were: Tadeusz Stryjeński (1849–1943) i Józef Czajkowski (1872–1947).

[7] The designer of the church was Feliks Księżarski (1882–1884).

Ill. 2. View of the building from the depths of the convent garden

viridarium, glazed at the third level. The building's projection is as mentioned, a rectangle with an inner atrium from the south-west. The side of the rectangle is extended and completed with a semicircular form.

This shape is the dominant of the building, and in a horizontal projection it optimally fits the shape of the building and at the same time it fits the transportation system around the building. It must also be noted that at the design stage comprehensive arrangements concern all the functions of the building and its infrastructure. However, from an architectural point of view, apart from all the other arrangements, the most important element of those consultations was to develop and establish the form of the building, which after numerous drawing simulations could only be finally approved by the Regional Monuments Conservator. We should also mention that on the basis of the "decision on establishing the building conditions", the main determinants of location, dimensions, heights and formal ones related to the building were clearly defined. The building had to meet the requirements of performing several complex tasks addressed to different groups of people of special character. At the same time the building had to be constructed in such a way (have such construction and planning solutions) that none of these groups had a direct contact with each other (for example, kitchen facilities with the bath, laundry, doctor's surgeries or rooms used for educational programs). In particular at the design stage it was necessary to take into account the fact that the building would be designed primarily for poor people, sometimes living on the border of the so called margins of society. The scale and form of the building is a continuation of the size and form of the existing building at Smolensk Street and relates to the tradition of monastic buildings.

6. Solutions of external and internal communication of the object (elimination of architectural barriers for people with disabilities)

Access and entrance to the building leads from the lane on Smolensk street. In the case of the road, the communication entrance to the monastic property will be conducted as a five-meter wide pedestrian and road way, along the pre-existing monastic way, taking into account the adjustments to adapt to the parameters of a new building. It should be noted that this road also serves as a fire route as well as for delivery purposes. The so called “turning point” for cars is incorporated in it. Entrances to the building and independent exits are situated on the east, from the courtyard of pedestrian communication and adjacent to the said road communication. For safety reasons pedestrian communication is separated from the circular communication with a fence and gates. Two separate entrances to rooms with different functions and an independent exit from the canteen lead from that part of the external communication of the building. It should be stressed that the building has been adapted to the needs of people with disabilities and therefore the following aspects were taken into account: width of the main entrance openings, width of corridors, levels of the ground floor with external levels of land development, toilets with the requirements for disabled people and a special universal cubicle with a shower installed in a bath with shower cabins, toilet and washbasin for disabled people. There are also properly adapted elevators with inscriptions in Braille. Outside, next to a small car park for five vehicles, a separate parking space for a disabled person was alloted.

7. Cubature and types of functional zones and sectors in the facility

In order to illustrate the approximate scale of the building, the following main numerical parameters are provided. For example, the building area with the inner atrium is 655 m^2, usable surface is 2432 m^2 and the cubature is 9733 m^3. The building was divided into five separate zones. These zones are separated on five floors. For the operation of the building divided into individual zones, the essential role is that of the ground floor area. Here the main entrance is located with a hall and the so called “control wicket” or the information-reception area and a control point in the building (as it is needed for people with different credentials for obvious reasons). As already mentioned, the building has two entrances located in the eastern part. One of these entrances leads to the bath area located in the basement and a medical clinic on the first floor. The second entrance is provided for people who use a social diner on the ground floor and a training area on the second floor, as well as for staff and volunteers having room in the attic. The third door on the east side provides a collision-free exit from the social diner (with a barge crossing to the pavement at Smolensk street). In the exit zone there are toilets and a toilet for the disabled. On the west side there is a door with an entrance to the so called delivery courtyard which among other things provides food products to the warehouses. In this part of the courtyard there is also the door for the staff leading through the annex, where a social room and a household exit of the kitchen are located. Independently, in the southern part of the building, there is the emergency door coming out of the universal mobile space room, which can act as an internal chapel. The ground floor, mostly functions as the kitchen with a canteen. It is anticipated that about three hundred meals a day in a 50-people cycle (because that many people could be seated for a diner at one time) will be given out. The kitchen has the necessary equipment and technological, health and communication solutions concerning processes of food preparation and dishwashing. In the central part of the building there is a multi-purpose space “atrium” covered with a glass roof.

Ill. 3. Glazed atrium at the level of the second floor

Ill. 4. Fragment of the illumination of the atrium

In the area of the first floor, surgeries for individual specialists are arranged, such as a cardiologist, dermatologist, internist, surgeon, gynecologist and dentist. For the smooth functioning of the clinic, there is a separate room to test urine, blood, etc., and a room for pressure measurement. In this section there is also a reception desk, waiting room, internal storage of medicines, cloakroom, separate toilets for patients together with a toilet for a disabled person and independent toilets for staff, a social room for staff and an office for the head doctor. The second floor sector is devoted to the function of teaching and training along with supporting spaces like a lobby with reception, cloakroom, self-service cafe, social room for staff, toilets and sanitary appliances for the disabled and independent ones for the personnel. Above part of the atrium a multifunctional footbridge connects the opposite sides of the building: the north with the south.

Ill. 5. View from the communication bridge at the atrium in the direction of the classrooms

In the sector of the attic there are office rooms, a handy office magazine, social rooms and toilets including one for a disabled person. In this part of the attic there is also a separate gas boiler room. It supports a universal system of building heating using heat pumps and solar collectors located on the southern slope of the roof on the south side (in a part of the atrium). In this way the disfigurement of the southern elevation with solar panels was avoided. In the basement zones there is a bathroom with shower booths including a cabin for a disabled person. There is also a zone for storage facilities with a supply of clean clothing. In addition, a special sanitary-hygienic room for separating people with the so called "isolated incident". In this section there is also a laundry room with a towel drying-room. For people in need, an independent laundry room with a dryer and laundry ironing was arranged. Additionally, in the basement area a technical room with a heat pump for heating the building and preparing hot domestic water was located. In a separate basement area there are also food warehouses and cold storage. This part is supported by a bisected service lift. For the purposes of the kitchen an independent laundry room for towels and such items as aprons (clean and dirty) is provided.

8. Construction issues – types of technologies used

The building was built in mixed technology: the basement and ground floor in a monolithic and traditional brick technology. The ceilings are made of reinforced concrete technology (based on the external walls, internal structural walls and reinforced concrete pillars in the atrium). Due to the nature and strength of the soil (glacial valley of the Vistula) for the foundation of the building, a monolithic reinforced concrete plate with waterproof concrete was used.

9. Conclusions – aesthetical issues

The building is topped with a hip roof (resembling the mansard type) resembling the archetype of characteristic adjacent buildings (the building of the Philharmonic Hall, the building of the Academy of Fine Arts). The main rationale for determining the form of the building was the compositional and scenic aspects, dimensions and constituent materials. The front elevation facing Smolensk street resembles the building of the Academy of Fine Arts by the use of clinker brick and stone for the wall facing.

The continuation of the crenellation of the convent's wall is introduced in the form of a cornice on the front elevation. The roof was covered with patina copper double seam sheet metal.

Characteristic elements of the mansard roof are stylized roof dormers with wooden windows; the style of the division corresponds to the historical style of windows in the frontages of Smolensk street. As it turns out, these basic elements and finishing details of the roofing lead to the overall effect that even the very modern building, in terms of technology, is still integrated into the whole of the street and monastic buildings.

Ill. 6. The main facade facing
Smolensk street

Ill. 7. Fragment of a part of the roof dormer covered
with plate

References

[1] Małachowicz E., *Ochrona środowiska kulturowego*, tom 1 (Protection of the cultural environment, vol. 1), Państwowe Wydawnictwo Naukowe, Warszawa 1988, 47.

[2] Golat R., *Ustawa o ochronie zabytków i opiece nad zabytkami (Act on the conservation and care of monuments)*, Zakamycze 2004.

[3] Prawo budowlane i inne teksty prawne (Construction law and other legal texts), C.H. BECK Publishing House, Warszawa 2007, item 39.

TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
ARCHITECTURE | ARCHITEKTURA
7-A/2014

PAWEŁ MIKA*

CONCRETE – THE DESIGN OF PUBLIC SPACES IN TERMS OF MATERIAL AND TECHNOLOGY ENERGY EFFICIENCY

BETON – PROJEKTOWANIE PRZESTRZENI PUBLICZNYCH W ASPEKCIE ENERGOOSZCZĘDNOŚCI ZASTOSOWANEGO MATERIAŁU I TECHNOLOGII

A b s t r a c t

Based on executions of contemporary designs in the field of landscape architecture, an attempt has been made in the following article to identify the properties of concrete which can help reduce energy consumption throughout the life cycle of a building and its immediate surroundings. The projects selected for the analysis included such urban public spaces as parks, squares, plazas and passageways, where the basic material, determining their aesthetic appeal, is concrete. To provide the widest possible range of issues discussed, construction works located in different climatic zones have been chosen. The properties of the material described in the text have been compiled with the exemplary executions of designs, depicting a creative approach to issues related not only to functionality and aesthetics but also to energy efficiency of the applied solutions.

Keywords: landscape architecture, prefabrication, concrete, sustainable construction

S t r e s z c z e n i e

Bazując na współczesnych realizacjach z dziedziny architektury krajobrazu, w artykule podjęta zostaje próba wskazania tych właściwości betonu, które mogą przyczynić się do ograniczenia zużycia energii w całym cyklu życia samej budowli oraz jej najbliższego otoczenia. Do analizy wybrane zostały projekty miejskich przestrzeni publicznych takich jak parki, skwery, place czy ciągi komunikacyjne, w przypadku których podstawowym tworzywem decydującym o wyrazie estetycznym jest beton. Aby przedstawić możliwie szerokie spektrum omawianych zagadnień, posłużono się obiektami zlokalizowanymi w różnych strefach klimatycznych. Opisane w tekście właściwości materiału zostały zestawione z przykładowymi realizacjami obrazującymi twórcze podejście projektantów do zagadnień związanych nie tylko z funkcją czy estetyką, ale również energooszczędnością wybranych rozwiązań.

Słowa kluczowe: architektura krajobrazu, prefabrykacja, beton, budownictwo zrównoważone

* M.Sc. Arch. Paweł Mika, Institute of Construction Design, Faculty of Architecture, Cracow University of Technology.

1. Introduction

Until the twentieth century, concrete had been used mainly as a construction material. Its aesthetic qualities became recognized relatively late, among other things, owing to Frank Lloyd Wright (textile block houses – 1923) and Le Corbusier (e.g. Marseille Housing Unit – 1947–1952). In recent years, it has been promoted intensively as an environmentally friendly material to comply with a popular strategy for sustainable development[1].

The term “sustainable construction” refers to all industries related to construction and is associated with continuous efforts to maximize energy efficiency, reduce CO_2 emissions, reduce the amount of waste, reuse it, recycle material from demolition sites, etc.

Over the past few years, concrete has earned a reputation as one of the most environmentally friendly building materials. It is difficult to say whether this phenomenon is a result of very efficient marketing efforts or rather intensely developed new technologies that continue to expand the range of its application.

There is no doubt, however, that concrete possesses a number of properties[2], which, used knowingly, can help maintain the eco-efficiency indicators[3] at the level required by the standards of modern construction.

Today, the producers of building materials compete with each other in search for new concrete mixtures increasing the attractiveness of this material at all levels. They are successful in terms of its useful life, product aesthetics and structural strength. Contemporary methods of shaping the forms and textures of the surface caused that concrete has also become a very popular material also among landscape architects.

In spite of numerous advantages[4], small elements in the form of prefabricated blocks, do not necessarily have to be the only common solution. Increasingly more attractive but also more efficient, environmental and human friendly resources aimed at shaping and developing open spaces are being looked for.

2. Useful life of the material

On October 12th, 2010 a public debate “Concrete and sustainable construction” was held in Wisla. **Stefan Kuryłowicz**, an architect present there, said: “In my opinion, there is no such thing as sustainable development and zero harm. We are the aggressor each time and the only thing we can do is to be relatively little less harmful. (…) It is possible to re-use of

---

[1] The opening sentence of “Our Common Future” report developed by the WCED (Word Commission on Environment and Development) is a summary of the idea: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [11].

[2] The main advantages include: longevity of the material, the possibility of using additives, high durability, the growing popularity of architectural concrete’s aesthetics, the possibility of prefabrication, and resistance to sunlight. All of these issues are further discussed in the article.

[3] Eco-efficiency indicators such as MIPS (Material Intensity per Service Unit), CERA (Cumulative Energy Requirements Analysis), embodied energy indicator, material ballast or carbon footprint [8] .

[4] Among the main advantages of such a solution there are: the ease of implementation and maintenance, durability, product availability, a wide range of colours and the repetition of elements [6].

materials, to reduce the amount of water used, the possibility of providing additional jobs, to decrease the amount of energy consumed or produced” [10].

Indeed, production of cement and aggregates, transport, mixing and pouring concrete are energy-intensive processes and they pollute the environment[5], but in the case of acquisition or manufacture of any building material a huge amount of energy must be taken into account and the environment will suffer to some extent[6]. One must, therefore, consider the long-term benefits: the durability of the building[7] or street furniture and their long-term ability to generate economic and ecological profits.

Due to climatic changes and the increasing occurrence of disasters, durability of the work, might prove to be crucial. Concrete is non-combustible (without any additional chemical impregnates), water resistant and at the same time a still economically competitive material; especially if its long-term exploitation at a low-cost maintenance is considered. In Poland, one still takes into account primarily the costs of construction while starting any investment. Few investors are aware enough to determine the choice of a particular technology based on the experience telling us how the material ages, the extent of its energy consumption in the production, environmental impact and maintenance costs over the next few decades. It is assumed that the life of a concrete structure is about 100 years at a minimum cost of maintenance [7.]. Therefore, even at the design stage, it is worth considering the construction of a permanent object with staged expansion as well as the possibility of demolition allowing for the reuse of the elements without destroying them. By avoiding the need for the next “from scratch” investment there is a chance to protect the environment from degradation.

3. The use of additives

As it has been written in the definition of concrete, its composition may comprise of various types of additives and mineral admixtures. They are improving the properties of the material used, depending on the intended purpose.

The already cited norm: PN-EN 206-1:203 Beton – część 1: Wymagania, właściwości, produkcja i zgodność (Concrete – vol 1: Specification, properties, production and conformity) distinguishes two types of additives:

– Type I – almost inert – mineral fillers (e.g., limestone dust) or dyes/pigments,
– Type II – of pozzolanic or latent hydraulic properties – granulated blast furnace slag, fly ash or silica fume [3].

Both fly ash (formed in combustion processes in coal boilers) and silica fume (formed during the production of metal silicon) or blast furnace slag are by-products of the energy industry and metallurgy. Using them as concrete ingredients is aimed primarily at improving the material properties, such as: resistance to aggressive substances, reducing the shrinkage of concrete, tightness. However, it is difficult not to draw attention to other aspects of the

[5] According to the Earthjustice’s report from 2008, 150 cement plants operating in the United States emit approx. 10 tons of mercury compounds into the atmosphere [15].

[6] The report of the World Business Council for Sustainable Development from 2012 states that the industry related to cement production is responsible for up to 5% of the total CO_2 emissions resulting from human activities [12].

[7] Structure – every construction work which is not a building or a piece of street furniture [13].

operation. It uses substances considered as waste, which would cause pollution of the natural environment. Also, being an essential component of the mixture, they reduce the consumption of cement itself and thereby reduce the need for its extraction. In some cases, they also contribute to reducing the necessary amount of mixing water. This reduces both energy consumption and CO_2 emissions of the construction process and at the same time fitting in the strategy of sustainable construction.

4. Durability

Striving to increase the strength of concrete mixes, also has an ecological aspect. High Performance Concrete or HPC is gaining increasing popularity, characterized by an even longer life and greater density [14], due to the addition of a reinforcing fibre, nanomodifiers or reactive powders, which allow the formation of a structure with a much smaller cross section of structural elements. In this way, the amount of extracted raw materials and consequently greenhouse gas emissions are limited. An excellent example of the use of modern concrete UHPC (Ultra High Performance Concrete) is experimental and minimalist in its form of street furniture and is the fruit of the cooperation between two departments of the University of Kaiserslautern. The mix that was used in the casting of the components is a kind of self-compacting concrete with fine aggregate fraction not exceeding 2 mm. The compressive strength is estimated at 100 N/mm^2 and due to the reinforcing steel fibers, the tensile strength is 25 N/mm^2. Such parameters allowed us to make prefab construction, combined with a tongue and groove, with a thickness of only 3 cm.

5. Aesthetics – concrete as a finishing material

Since its invention, in the first half of the last century, concrete was a very popular and readily used building material. However, it had always given way, in terms of nobility, to stone, brick or even steel. It was not until the twentieth century that its aesthetic appeal was fully appreciated. In an article entitled *The ethics of concrete brutalism*, M. Charciarek writes „Le Corbusier and the masters of late modernism created objects which, through the so-called honesty and unfinished material formula spilled viewers into the world of original and pure form of architecture. For the first time they ennobled concrete, saying it is “cast stone”, its nobility and rank was recognized, using it in the significant realizations of public facilities” [4].

The aesthetics of exposed concrete surfaces goes hand in hand with the strategy of sustainable development. Resigning with the use of additional finishing materials, one limits their production (and thus the emission of pollutants into the atmosphere) and receives the durable, timeless and stately architecture, since concrete gained a reputation of a noble material. The use of this material, currently fashionable among landscape architects, has resulted in many extremely interesting realizations in recent times. One can include here for example, High Line Park in New York, designed by **Diller Scofidio + Renfro** studio in cooperation with **Piete Oudolf**. The paving used here does not resemble in any way the commonly used small-sized cubes, covering the squares and pavements tightly. There is no clear boundary in the form of curbs, between the pedestrian zone and the lawn. Their form has been so conceived as to create visually interesting smooth transition between the hard, artificial concrete hardscape and the natural planting embedded between them. A completely different approach was presented by Chyutin Architects, designing the square in front of the entrance to the University of Ben-Gurion, in the Israeli city of Be'er Sheba. In this case, the composition, though free, results from very consistent geometric divisions. The authors have used concrete slabs not only as a finishing of sidewalks, but also made use of them to create a modular grid, where strips of lawn interspersed with low perennials, strings of lights, trees and benches in the form of a monolithic concrete blocks are distributed. The whole, due to the material used, fits perfectly with the surrounding buildings.

Ill. 1. Park High Line in New York. Diller Scofidio + Renfro + Piet Oudolf (photo by Iwan Baan)

Ill. 2. The square in front of the entrance to the University of Ben-Gurion. Chyutin Architects (photo by Sharon Yeari)

Ill. 3. Weinerberghaus: an experimental piece of street furniture (photo by Sven Paustian)

6. The advantages of prefabrication

A number of advantages flowing from the initial preparation of building component off-site implementation of the object has already been recognized by the first builders who have had contact with investments carried out on a large scale. It was much more profitable, for example, to prepare the building material in a quarry and transport it, already hewn, without unnecessary ballast and avoiding the subsequent littering of the site. No one called this process prefabrication or sustainable construction at the time. This approach simply seemed the most logical.

The quality of the finished products is among other things, what speaks for the use of prefabrication. They were manufactured in optimal conditions in a facility designed for that purpose. Another very important factor is the reduction of the cost of realization. Serial production, reuse of high quality molds and formwork and almost total mechanization of the production process, greatly accelerate the production while the abandonment of preparing formwork shortens the duration of the object's construction.

All these advantages are not the only economic benefits. The high quality of the product means its long useful life without, the already mentioned, outlay for its maintenance. It is connected with the protection of the environment by reducing energy-intensive maintenance work. Reusable formworks reduce the consumption of material required for their production, which is also part of a sustainable development strategy. Likewise significant savings stem from the possibility of exact calculation of the demand for building material and an ideal balance of ingredients in the concrete mix. There is no waste in a factory operating on a large scale. The amount of prepared material is dictated by demand. There is a slightly different situation on the site. Spare building material is often ordered. Sometimes, though, it also runs out and additional transportation has to be ordered involving a financial and energy outlay. At other times a certain amount, which is difficult to manage, is left and has to be used by force. Prefabrication technology is based on the accurate calculation of the demand for the materials; therefore, it does not generate losses caused by approximate estimates. It also allows the rational organization of transport facilities, resulting in the reduction of its energy consumption.

It is becoming quite widespread in international architecture to prefabricate even these pieces of street furniture which had been designed for a single implementation. This was the case of the Holocaust monument in Berlin, designed by Eisenman Architects. It is a kind of square, filled with 2,770 hollow reinforced concrete slabs with lateral dimensions 238 × 95 cm and 18cm-thick walls. These were arranged in a grid pattern, providing a passage of 95 cm width between them. The slabs, or stelae, differ only in height so their upper surfaces create something like a wavy surface. The formation of such a number of items that have the same dimensions, in accordance with the adopted module, as well as of the same hue of the material, was only possible thanks to the production in the facility designed for that particular purpose [5].

7. Concrete recycling

In accordance with the strategy of sustainable development, one should aim to design durable buildings and equipment, offering the ability to easily adapt to the changing function. There is no doubt, however, that the demolition of existing buildings, of those being built or only designed, will always be necessary. Despite all efforts, nothing will last forever. Trends in architecture, the needs of investors, site development plans, etc. are constantly changing. One must therefore take into account the materials that can be reused. Concrete is undoubtedly one of them. At present, debris from a demolition is most often used as a foundation for roads, squares or filler of excavations. The reasons for this are obvious: “The use of secondary aggregates as a substitute for natural aggregates for concrete production provides mainly environmental benefits, however it is clear that immediate economic benefits are not to be expected soon. As time passes, the landfilling cost will grow. The costs of transport to more distant landfills will also increase. Processing and reuse of concrete rubble will also reduce the costs of restoring depleted areas of aggregates mines, as well as the costs of building new landfills” [1].

It is therefore expected that in the near future the situation will change radically. Technologies that enable the processing of rubble to secondary aggregates, which are a component of the concrete, are being developed (and even already used). This will significantly limit the environmental degradation caused by the extraction of natural aggregates, which are not renewable. An excellent role model here are such countries as the Netherlands and Belgium, where up to 90% of waste from demolition is re-used [3] Yet, we must remember about the deterioration of the properties of concrete with the addition of recycled aggregates – particularly in terms of frost resistance (due to higher water absorption) and compressive strength. Currently, research is conducted and successful in improving the mix with the addition of secondary aggregates.

11. Shield against solar radiation

Good architecture, is not only visually appealing, but it also creates the right living conditions. Interesting aesthetic properties, great capabilities of shaping the form and unusual resistance to weathering, are the main factors that contributed to the popularization of this material among designers involved in the shaping of urban interiors.

An interesting example, illustrating the possibilities of concrete in creating the climate of public space, is the school building: Flor del Campo, along with its surroundings, designed by **Giancarlo Mazzanti**. The basic idea in this case, was to create a complex, as a sequence of cells of a living open organism. The perforated wall, like a transparent veil wraps the school and squares, giving them identity and combining various educational functions into one complex: kindergarten, primary school, lower and upper secondary school. Each of them faces its individual inner courtyard. Four fences arranged in rows seem to divide but not to close square spaces. Thanks to an interestingly and formally designed filing of spans, this solution creates the much desired shade, while allowing the free flow of air. The described wall is both a fence and facade of the building. It is made of prefabricated modular concrete panels in various shades of gray and several widths. Specific perforations were inspired by the model of fences made from branches [2].

12. Conclusions

The results of the research lead to the conclusion that what can help reduce the total energy expenditure of a design execution is not so much the material or technology but rather the way in which they are applied.

Eco-efficient awareness of the designers as well as excellent knowledge of the unique properties of the materials used, turns out to be the basis for such action.

As the above examples illustrate, the use of concrete in landscape architecture can be justified not only by aesthetic considerations but also ecological ones. The most important include:

– reduction in material and energy consumption of products and services owing to prefabricated building elements, an opt-out from additional treatment, finishing or maintenance processes,
– an increase in the amount of recycled materials where as much as 90% of the concrete can now be processed; modern technologies allow to the use of material from demolitions not only as a foundation for squares and roads but also as a valuable addition to the mix,
– an increased product durability such as high resistance to weather conditions allows to use roads and street furniture for many years so the need for their re-production becomes limited.

These actions, "contribute to an increased efficiency of resources obtained from the environment and reduction of pollutants emitted into it" [8]. They are particularly important in the case of concrete, since its energy-consuming production contributes to environmental degradation due to exploitation of non-renewable resources or emission of significant quantities of carbon dioxide and mercury compounds into the atmosphere. With conscious and reasonable design, there are possibilities to reduce these costs while long-term utility of the completed projects constitutes a chance for their partial recovery.

Aesthetically, concrete in the landscape should be considered as an artificial stone. Available technologies have made it in many cases, extremely difficult or almost impossible to distinguish concrete from natural stone. Combined with the tremendous freedom in shaping the form, its excellent structural characteristics and resistance to atmospheric agents, we obtain the ideal material for creating buildings complying with the rules of Vitruvius – beautiful, durable and functional.

It should be remembered that currently promoted energy-efficient construction is not only found in tightly insulated houses with relevant installations or certified office buildings and public spaces. It also entails the energy and raw materials consumption used during their design, implementation and exploitation which can be significantly reduced.

References

[1] Ajdukiewicz A., Kliszczewicz A., Recykling betonu konstrukcyjnego – cz. I (Construction concrete recycling – vol. 1), Civil Engineer, February 2009, 67.

[2] Argenti M., *Giancarlo Mazzanti Felipe Mesa/Plan:B Arquitectos, Scuola Flor del Campo*, Materia No. 70, 2011 06, 102-111.

[3] *Beton Przyjazny Środowisku (Environmentally-friendly concrete*), Stowarzyszenie producentów betonu towarowego w Polsce (Association of ready-mix concrete producers in Poland), Kraków 2008, 67, 92.

[4] Charciarek M., *Etyka betonowego brutalizmu (The ethics of concrete brutalism)*, Budownictwo, Technologie, Architektura (Construction, Technologies, Architecture), October–December 2011, 26.

[5] Elias H., *Standing stones as a Jewish memorial*, Concrete Quarterly 212, summer 2005, 9-13.

[6] Kuc S., *Betonowa kostka brukowa – kicz czy oryginalność?* (*Concrete paving blocks - kitsch or originality?)*, Budownictwo, Technologie Architektura (Construction, Technologies, Architecture), special issue 2005, 18-22.

[7] Krechowiecki G., *Beton a zrównoważony rozwój – rozwiązanie z przyszłością (Concrete and sustainable development – a solution with the future)*, Budownictwo, technologie, architektura (Construction, Technologies, Architecture), January-March 2009, 66-69.

[8] Kronenberg J., Bergier T. (Ed.), Challenges of Sustainable Development in Poland, Fundacja Sendzimira (Sendzimir Foundation) 2010, 127-128, 126.

[9] Kysiak M., *Stuck in the system*, Materiały Budowlane (Building Materials), 01.2005.

[10] Piestrzyński P., *Debata „Beton a zrównoważone budownictwo", (A debate, "Concrete and sustainable construction")* Budownictwo, Technologie, Architektura, (Construction, Technologies, Architecture) October-December 2010, 15.
[11] Report of the World Commission on Environment and Development: Our Common Future. Chapter 2: Towards Sustainable Development.
[12] *The Cement Sustainability Initiative*, World Business Council for Sustainable Development 2012, 12.
[13] Ustawa z dnia 7 lipca 1994 r. – Prawo budowlane. Dz.U. Nr 243 poz. rozdz. 1 art. 3 tekst jednolity
[14] Weinerberghaus – an Experimental Building outside Worrstadt, Detail, 11.2012, 1262-1263.
[15] http://earthjustice.org/news/press /2008/mercury-pollution-from-cement-kilns-double-previous-estimates

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

YELENA MOROZOVA*

TECHNICAL AND TECHNOLOGICAL FACTORS IN INDUSTRIAL ARCHITECTURE FORMS CREATION: HISTORICAL REVIEW

CZYNNIKI TECHNICZNE I TECHNOLOGICZNE W TWORZENIU FORM ARCHITEKTURY PRZEMYSŁOWEJ: PRZEGLĄD HISTORYCZNY

A b s t r a c t

This paper concerns technical and technological impacts on the process of the formation of industrial architecture. All the formational factors from the 18th to the 20th century – in the epoch of industrial architecture – are examined with special emphasis on technical and technological aspects. In the course of various historical periods, these factors changed their influence. Some of them had a dominating position while others – only a corrective status. In this way, the evolution of the impact of technical and technological factors is observed.

Keywords: industrial architecture, impact of technical factors, impact of technological factors

S t r e s z c z e n i e

Artykuł dotyczy wpływów techniki i technologii na proces tworzenia architektury przemysłowej. Wszelkie czynniki formacyjne na przestrzeni XVIII–XX wieku – w dobie architektury przemysłowej – badane są ze szczególnym uwzględnieniem aspektów technicznych i technologicznych. W różnych okresach historycznych zmieniał się wpływ tychże czynników. Niektóre z nich zajmowały pozycję dominującą, inne natomiast posiadały zaledwie status korekcyjny. W ten sposób obserwuje się ewolucję wpływu czynników technicznych i technologicznych.

Słowa kluczowe: architektura przemysłowa, wpływ czynników technicznych, wpływ czynników technologicznych

* Prof. Ph.D. Eng. Arch. Yelena Morozova, Department Architecture of Industrial Objects and Architectural Construction, Belarusian National Technical University, Minsk, Belarus.

As an independent type of the art of building, industrial architecture appeared relatively recently in the 18th century. It was a result of the introduction of a new production method: machine production. Historical research of the industrial architecture development process is quite justified by almost three centuries of its existence. In this connection, it becomes important to determine the dynamics of formative factors, whose continuous interaction has ensured the change of the space planning structure, emergence and transformation of different types of industrial architecture objects.

Factor determination is always relative and can rely on various approaches allowing for the characteristics of the time period and the research object itself. Assuming that the presence of two systems, the machine and the man, is peculiar to industrial architecture, the existing diversity of factors can be split into two groups. The first group comprises of the factors connected with the machine system: technical and technological factors (manufacturing process and process structure, equipment and transportation used, the sources of power and its transmission mode, materials, structures and building methods). The second group comprises of the factors conditioning the presence of the man at industrial objects: the factors of location and time of erection (natural and climatic and town-planning conditions, the speed of construction and service life, aesthetic preferences in the society) and the factors of internal environment (labor conditions and working environment structure).

In 1700–1840s, during the first development stage of industrial architecture, the influence of factors connected with the machine system was determinative. It is quite explainable because it is exactly this system that caused the emergence of industrial architecture.

Among the principle factors, the sources of power (the consecutive introduction of water and steam power) and the method of its transmission (shaft system) should be named. Water power had been used in industrial production since the 1700s. The power output depended on the strength of water stream and the design of the water-wheel, which developed from a simple wheel using the energy of a running or falling stream to a complex hydraulic turbine. The impressive size of wheels (the wheel diameter at Cyfartha plant in South Wales, England, is 50 feet, the width 6 feet and the weight is a 100 tons) and their installation on the lower floor were taken into consideration in the space planning of the building [1]. Moreover, the buildings were located on a bank of a river or a flume and they either dammed the watercourse or adjoined it.

Steam power had been used in industrial production since 1770–80s. The steam turbine was supposed to be placed in the central part of the lower floor for the most efficient distribution of power. Steam energy promoted an increase in the number of machines and their capacity, which also meant an increase in their size and weight, and therefore, initiated designing of building structures with a higher bearing capacity [2]. There was no more need to locate factories in the proximity of water, however, on the whole the transition to steam power did not change the approaches to architectural and layout design of buildings. By 1840s, both power sources (water and steam) were practically equally productive because by that time the efficiency of water-wheels reached its peak and the efficiency of steam turbines was still at the beginning of its development [3].

The biggest influence on the inner space organization of industrial buildings was that of the shaft system of power transmission patented by the Englishman Arkwright, and remained the only one till the 1860s. [1]. The system was based on the necessary connection of the power source with all the floors of the building and functioned well in a vertical direction, which immediately predetermined the appearance in industrial architecture of many-storied buildings (5–8 floors) with multilevel structure of inner space. Substantial losses of power (from one third at the time of introduction of the shaft system to one fifth at the final stage of its use) and the impossibility to transmit power further than 100 feet, conditioned the construction of relatively narrow and short buildings. The shaft system required massive support provided by the building's bearing constructions closely aligned with the equipment used [4].

Since the 1770s, cast iron, a new construction material was used to substitute wooden structures in the inner fabric of buildings. The principal reason for its introduction was the endevour to reduce the buildings' vulnerability to fire [5]. The new materials and the inner fabric system were innovative not only for industrial architecture, although here they were the most widely used. On the other hand, their influence was not revolutionary because the transition to these materials did not change the appearance and internal design of industrial buildings.

With regard to the factors related to man's presence, their influence was practically unnoticeable, and where it occurred, it was mediated by technological factors. Thus, the construction of first factories in rural areas on the banks of rivers and flumes made it unnecessary to take into account the town-planning situation because it was not the building that was integrated into the settlement planning pattern, but the settlement was developing around the building. To construct the first tier of the building, where water wheel installation, the natural parameters of the river were allowed for, however, they were of secondary importance because the technical requirements for water-wheel installation were more important and the watercourse of the river or the flume was adjusted to the process.

Natural and climatic factors and labor conditions related to them were not taken into account, the facilities were not heated, no premises for workers were provided (not even bathrooms) though the buildings themselves were many-storied and substantial in size. To a certain extent, the works building width and the story height were determined by one of the internal environment factors: the lighting, which at that time was mostly natural. However, the principal factor was the capabilities of the shaft system of power transmission and the capacity of the water-wheel.

The aesthetic preferences of the society were not reflected at all in the industrial buildings, which were purely utilitarian and only started to edge their way into being called architectural objects. However, it should be noted that by the end of the period in question, industrial buildings had substantially changed the rural landscape, particularly in England, standing out for their massive scale, enormity, ascetic and uniform interpretation of volume. In no other branch of architecture were the objects so similar to each other.

The second development stage of industrial architecture, 1840–1910s, was characterized by the extension of the list of factors related to the machine system. In the same period, for the first time the factors related to the presence of the man at the industrial objects came out.

The source of power and the method of its connection still had a significant influence on the shaping of objects. During this period, steam became the principal source of power, even though water power still had been used until the 1860s. In the USA, water powered factories had been used for a particularly long time[3]. Steam turbines had been upgraded and their position in the casing had been changed: one centralized machine, then a number of separate ones and finally, a combination of the centralized machine with dispersed smaller machines.

The increased engine capacity caused substantial growth in the size of industrial buildings and facilities.

The shaft system of power transmission was superseded by the wire-rope method, invented in Europe in the 1850s but applied industrially for the first time in the USA in the 1860s. The distinction of the system lay in the possibility to connect power both in vertical and horizontal planes over big distances of up to three miles, allowing the connection to be more flexible and customized [2]. For many-storied buildings, a mixed wire-rope and shaft system was used; to accommodate the power connection mechanisms an addition to the structure was made at the gable facade, with a gradient plane at the full height of the building. The fully wire-rope system, which did not require additional facilities to place mechanisms, entailed the appearance of single-storey buildings with large area used predominantly in the weaving industry.

The influence of a new factor in the form of lifting equipment, started to emerge. With the appearance of the crane bridge (late 1840s – England and France, 1875 in the USA), spans began forming in buildings, the crane span becoming the principal one organizing the whole plan. The crane bridge found its application in constructions with different numbers of storeys; in particular, it was widely used in single-storey buildings.

The combination of new materials (cast iron, iron, steel, reinforced concrete) with a new design-built system and full framework, which was first used exactly in industrial objects, became a crucial factor in the development in the period under review.

Full frame buildings appeared in the USA and Europe (England, France) practically at the same time: 1849 – a foundry in New-York, engineer J. Bogardus, 1840–54s – printing houses Sun Iron Building in Baltimore and Harper & Brothers in New-York, engineer J. Bogardus, architects R.G. Hatfield and J.B. Corlies, 1858–60s – a blacksmith shop Boathouse in the territory of the sea docks in Sheerness, engineer G.T. Greene, 1864–65s – warehouses St Quen Dock in Paris, 1869–72s – a chocolate factory Menier in Noisiel-sur-Marne, architect J. Saulnier [1, 5, 6].

Two tendencies could be noted in the use of full framework structures. “Cast iron facades” by American engineers J. Bogardus and D. Bagder represented a combination of the framework and prefabrication construction ideas. The whole building was assembled of prefabricated bearing and fencing elements, included decor elements [6]. Another tendency that spread predominantly in Europe was the use of brick infill for outside walls. The most striking example was the chocolate factory Menier, defined by S. Giedion as the first objectively frame building in the world [5, p. 288]. However, one can agree with it inside the boundaries of only one of the framework structure development tendencies in architecture.

The structural novelties changed not so much the layout and space organization of factory buildings as their exterior. The wall was liberated from the necessity to bear load, which caused taking the framework elements out to the facade and made it possible to increase the number of windows and their size, and made the separation wall thinner [1].

It should be noted that frame structures and the new construction technologies in Europe (England and France) related to them were introduced into large scale construction at a much slower pace than in the USA. The slow introduction of structural novelties was due to the insufficient engineering knowledge of the architects causing misunderstanding of the necessity to work jointly with engineers. In the USA, industrial engineering was becoming a field involving many specialists; in architecture, it was the first example of really synthetic work guided by the "readiness to experiment and adopt new ideas rather than be governed by rigid traditions" [2, p. 12].

During the period under review, for the first time the influence of the factors related to the presence of man at industrial objects, came out. Thus, due to the movement of industrial establishments into cities that began in the early 19th century, they started in some cases taking into consideration the town-planning factors. It applied to luxuriant decorative elaboration of the facades of buildings located in the central districts of cities. According to the remark of H. Brockman, a researcher, some of them "looked like palaces" [7].

The paternalism movement among industrialists brought attention to the creation of an environment for the workers. Personnel facilities to serve the workers' needs were introduced into industrial buildings (showers, bathrooms, canteens); their much larger scale and planning characteristics were changing the space arrangement of buildings. A group of buildings, not intended for the production process, but to serve the workers, was forming.

Such internal environment factor as lighting considerably influenced the formation of industrial building types. Along with the progress of gas and later, electric lighting, the design of industrial buildings allowed for less natural lighting, which was then not considered a principal factor, was now viewed equally with artificial lighting. It encouraged a practically unlimited increase in the width of the industrial building. An iron foundry works in Stanton, England, built in 1877, was the first example of complete transition to electric lighting [8].

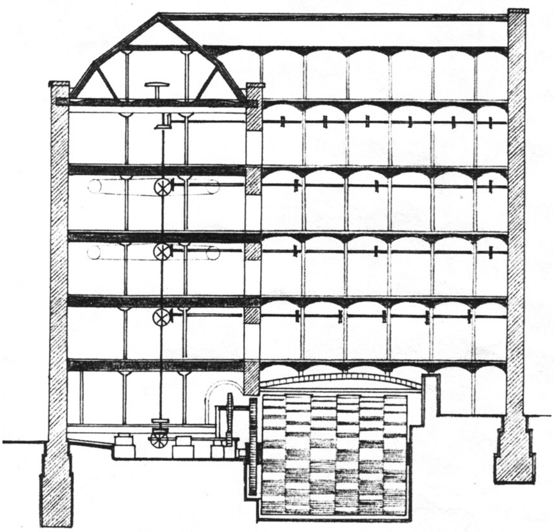
In the third period of industrial architecture development (1910–1920s – late 1970s), a sharp increase in the role of factors related to man`s presence at industrial objects was peculiar. Their influence in the process of formation of individual types was becoming determinative. At the same time, the machine system maintained its importance; however, significant changes were taking place.

In the group of technological factors, the transition to electric energy not only for lighting but for machinery work became a breakthrough (one of the first factories in England – Acme Mill, 1905) [1]. The use of electric power increased the performance by 15% and became an important incentive for production concentration. The production capacities and size of factory buildings and industrial sites, which had been increasing even earlier, started growing dramatically with the introduction of the electric motor. It became possible to concentrate the whole process under one roof and in the same space.

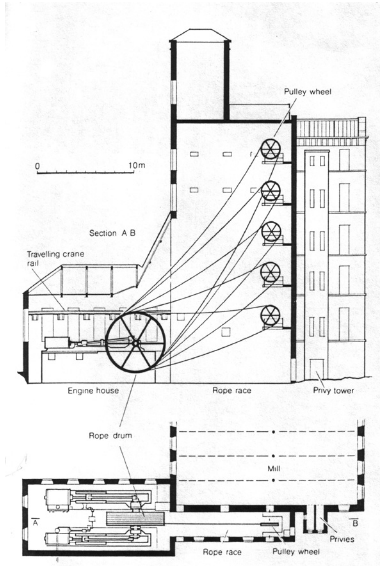
The use of the electric motor signified a new principle of power transmission – its supply going directly to the needed point. With that, the necessity to arrange power transmission systems vanished. At that point, the buildings design could freely follow the production process and not the one of power transmission. The age of the dependence of industrial object formation on the source and transmission method of power, lasting over two hundred years, came to an end.

Labor and production process organization, the factors belonging simultaneously to two groups: the machine system and the man system, were at that time the principal ones interacting closely with each other. These factors became of key importance along with the transition to large-scale production, which was characterized by splitting operations into sections and worker focused specialization. In 1913 at the G. Ford plant, a conveyor was launched, representing at that time, the most efficient organizational system, which required extensive (not less than 300 m) spaces free from supporting elements.

A new approach was formed in the creation of a “rational factory”, where the building became an instrument and an essential prerequisite for the maximal efficiency of the production process. If in earlier times the building was viewed as a space for machinery, workers and production process, from the 1920s it became “the master machine”, being a machine itself, where all elements including workers were supposed to function accurately and predictably [9]. According to such approach, the workers were viewed as a supplement to the machine or as an independent machine and the enterprise success depended not on the equipment, but on the equipment, worker arrangement and their joint work as a whole.



Ill. 1. Shaft system transmission of power (J. Blackner, The History of Nottingham, embracing its antiquities, trade and manufactures/J. Blackner, Nottingham: Printed by Sutton and son, 1815, 459 p.)



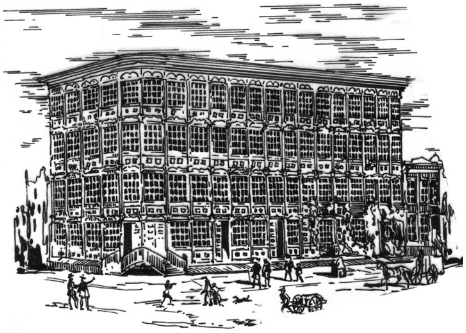
Ill. 2. Wire-rope transmission of power. (Серк, Л.А. Архитектура промышленных зданий /> Л.А. Серк., М.-Л., Гос. изд-во, 1928, 419 с.)

The idea of a “rational factory” originated from European theoretical thought of 18–10 centuries: the discussions of French engineers of the 1750s on “culture in science” and the works of English scientists A. Smith of the 1770s and A. Ure of the 1830s. The idea had finally formed in the USA by the 1920s and was best implemented in the plants of the Ford Motor Company, where an architect A. Kahn and a manufacturer G. Ford contributed equally into their creation. In the USA, the idea of a rational factory had incarnated by that time and returned to Europe.

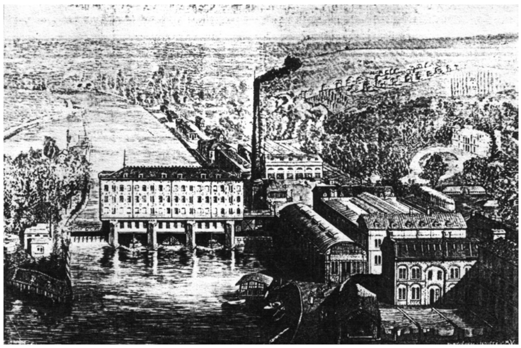
Viewing the worker as a machine in the context of a rational factory urged active development of studies on the formation of a production environment. If in the 19th century the paternalist ideas of industrialists were aimed to create a worker friendly environment, as this environment was not viewed in terms of comfort for the man, but in terms of labor efficiency. From 1910 to 1920, many enterprises had invited medical doctors and other specialists to organize an efficient working environment. In 1927, R. Dana published his book “Human Machine in Production”; industrial engineers were then trained as specialists not in “materials engineering, but human engineering” [9].

In the group of technological factors, the leading factor was reoriented. The influence of structures was overcome by the influence of new materials. Its impact was especially strong on certain building types and in particular, on the single-storey building. The introduction and further development of internal transport – crane bridge, overhead conveyor, allowed arranging various technological processes in the single-storey option, which turned out to be more cost-efficient and lead to the reassessment of the many – and single-storey buildings in favor of the single-storey.

For the first time, the influence of the artistic and world-view factor appeared. New attitude towards the machine, poetization of equipment, belief in its endless possibilities drew attention to industrial architecture. It gained the right to participate in the artistic formation of the environment.



Ill. 3. Foundry in New-York, USA, engineer J. Bogardus (drawing of the author)



Ill. 4. Chocolate factory Menier in Noisi-el-sur-Marne, France, architect J. Saulnier (Серк, Л.А. Архитектура промышленных зданий/> Л.А.Серк., М.-Л.: Гос. изд-во, 1928, 419 с)

By the 1980s, the fourth contemporary development stage of industrial architecture was prepared by the technological changes signifying forward motion towards the information-oriented society. It caused the naturally determined dying out of some industry branches and downsized the number of employees, the reassessment of the production concentration principle and, as a result, the reassessment of the optimal enterprise size under the conditions of the competitive market. For the first time throughout the history of industrial architecture, the growth in size of its objects (buildings, constructions, facilities) stopped and the advantages of small and middle-sized enterprises were admitted. The complication of production equipment caused an increase in the cost of internal systems of the building and its further operation. If at the beginning of its history the construction part of the building made three thirds of the total cost, today it makes only one fifth. In industrial architecture, these objective processes entailed stagnation in the development of industrial building types and the use of simplified architectural and artistic solutions in large-scale construction.

A separate study shall be dedicated to the factors influencing the formation of industrial architecture objects in the modern period. However, at the moment it can be stated that their influence has been split: part of the objects are determined almost completely by the technical and technological groups of factors, the other and much larger part increasingly depends on the group of factors caused by the man presence. With that, a transition is observed from the approach where man is viewed as an appendix of the machine, to man as a man with a glance to the development of individuality and personal responsibility.

Summing up the review of the historical development of the forming factors in industrial architecture, it can be concluded that in different periods their influence was unequal. In different periods of time, dominant factors initiating the formation of certain object types can be singled out; the influence of other stabilizing factors was only correcting. With that, part of the factors could transfer from the dominant group to the stabilizing one and vice versa for example, such factors as power source and labor organization. Other factors never entered into the leading group, among which are natural and climatic or town-planning conditions; this is why their influence on the architecture of industrial objects never materialized. The tendency to shift priorities can be traced in the development of industrial architecture objects: from the complete dominance of the machine system forming factors (technical and technological) over the factors conditioning the presence of man at industrial objects to their levelling, parity and subsequent dominance of the latter.

References

[1] Winter J.A., *Industrial architecture: a survey of factory building*, Studio Vista, London 1970.

[2] Bradley B.H., *The Works: the industrial architecture of the United States. New York*, Oxford University Press, Oxford 1999.

[3] Giles C., *Yorkshire textile mills: the buildings of the Yorkshire textile industry, 1770–1930*, HMSO, London 1992.

[4] Ackermann K., *Geschossbauten fkr Gewerbe und Industrie*, Deutsche Verlags-Anstalt, Stuttgart 1993.

[5] Pevsner N., Sir, *A history of building types*, Thames and Hudson, London 1976.

[6] Bergeron L., Maiullari-Pontois M.T., *Industry, architecture, and engineering: American ingenuity, 1750–1950*, Harry N. Abrams, Inc., New York 2000.

[7] Brockman H.A.N., *British architect in industry, 1841–1940*, Allan & Unwin, London 1974.

[8] Drury J., *Factories: Planning, Design and Modernization*, The Architectural Press, London 1981.

[9] Biggs L., *The Rational Factory: architecture, technology, and work in America's age of mass production*, Johns Hopkins University Press, Baltimore 1996.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

BOGUSŁAWA KONARZEWSKA, LUCYNA NYKA*

NEW SCOPES OF FACADES' DESIGN AS A RESULT OF THE APPLICATION OF OPTICAL FILTER TECHNOLOGIES

NOWE ZAKRESY KREOWANIA WIZERUNKU FASAD PRZY ZASTOSOWANIU TECHNOLOGII FILTRÓW OPTYCZNYCH

A b s t r a c t

Modern facades, whether made of glass or including transparent, translucent or reflective elements, let through a particular light spectrum or change its intensity in many different ways. "Filtering facades" may change the image seen through them or change the colour of passing light according to specific circumstances: the angle of observation or temperature. These indicated properties of facades acting as "filters" were made possible due to the great technological development observed in the last two to three decades, though the general characteristic of this phenomenon of *optical filters* had already been explored since the XVII century by Newton, and later on by Fresnel, Fraunhofer, Maxwell and Planck. Thanks to material engineering today it is possible to create unique glass facades with great functional properties, yet architects, engineers and artists do not stop at this point. The experiments undertaken in these fields explore transparency, reflection, refraction and diffusion and lead to fascinating effects that are worth examination.

Keywords: optical filters, glass facades, filtering façade

S t r e s z c z e n i e

Nawiązując do zasady działania filtru optycznego, współczesne fasady przeszklone oraz fasady zawierające elementy przezroczyste lub przeświecające przepuszczają określony wycinek widma optycznego ze światła o barwie złożonej lub zmieniają wartość natężenia przechodzącego przezeń światła na wiele różnych sposobów. Fasady „filtrujące" mogą przetwarzać obraz lub zmieniać barwę, na przykład zależnie od kąta patrzenia na nie czy zmiany temperatury. Wymienione właściwości fasad działających na zasadzie filtru optycznego osiągane są dzięki przyspieszonemu postępowi technologicznym ostatnich dekad, chociaż specyfika zjawisk optycznych badana była już od XVII wieku przez Newtona, a później Fresnela, Fraunhofera, Maxwella czy Plancka. Dziś chociaż dzięki inżynierii materiałowej możliwe stało się projektowanie wyjątkowych fasad przeszklonych o wyrafinowanych właściwościach funkcjonalnych, to architekci, technologowie i artyści nie zatrzymują się na tym. Eksperymenty podejmowane przy tworzeniu fasad filtrujących skierowane są na osiągnięcie zjawisk załamania, rozszczepienia, dyfrakcji, ugięcia czy interferencji światła, doprowadzając do niespotykanych, wartych przebadania efektów estetycznych.

Słowa kluczowe: filtr optyczny, fasady szklane, fasada filtrująca

* Ph.D. Arch. Bogusława Konarzewska, Assoc. Prof. D.Sc. Lucyna Nyka, Faculty of Architecture, Gdansk University of Technology.

1. Introduction

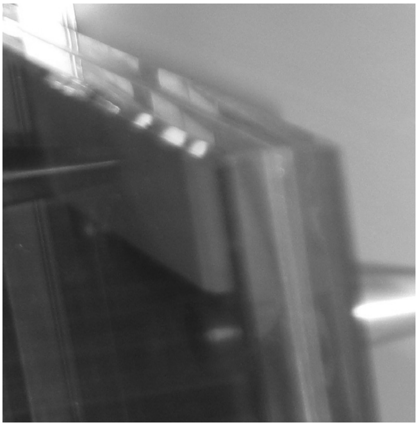
The spectacular evolution that glass and synthetic materials have undergone during recent decades has opened up new possibilities for the ~~creation~~ design of facades making use of filtering technologies. This is not the first time in history when architects are involved in developing such type of facades. The use of filtering building envelopes to let light into the building in a controllable manner, and "frame" the views thanks to different perforations or the semi-transparent materials, had already existed in the Middle Ages and was very popular in gothic and baroque as church stained-glass windows, translucent marble and alabaster. The numerous discoveries and inventions in material engineering together with advances in computer aided design and innovative prefabrication methods were all crucial phenomena that allowed for the creation of new types of filtering facades.

As a direct result of that historical development, the new generation of filtering facades can pass a particular section of the optical complex light spectrum or change the intensity of light in many different ways. Filtering facades may change the perceived image or colours according to the observation point or fluctuations in temperature. Contemporary experiments with these facades cover the design of singular or multi-layer flat surfaces, but additionally rely on the analysis of proportions, angles of particular glass elements or even non-linear structures in a way to create unique conditions for the refraction, reflection, diffraction, deflection or interference of light waves. All experiments that are undertaken today use the latest materials technology achievements.

The foundations for today's experiments on filtering surfaces in architecture have been established by researchers studying specific optical phenomena. These kind of studies have been carried on since the seventeenth century by Newton, and later on by Fresnel, Fraunhofer, Maxwell and Planck. These scientists tried to describe the phenomenon they observed with the corpuscular theory, then the electromagnetic wave theory of light and finally the quantum theory of radiation. Thus in the second half of the twentieth century, in which progress in materials technology has accelerated significantly, further studies on optical transmittance, heat transfer control problems, radiation or the ability to process the image seen through the façade have become even more intensive. As a result of these studies, filtering facades created today perform several functions simultaneously.

The primary objective of creating glass facades: perfectly smooth, big size, transparent glazing, which having improved thermal insulation that was clearly visible in the 80s and 90s, today has been extended to develop individual original glass features realized by using screen printing, an additional layer (double facade [2]), moving blinds or solar cells. The functional glass characteristics as for example energy transmission (g-value) were still improved, but in parallel, designers and engineers began to use translucent and filtering facade materials such as: milky and patterned glass, white and colored polycarbonate panels or acrylic glass that have undergone a variety of treatments to gain individual aesthetic features.

Today, due to the technological revolution in the field of materials science, filtering technologies such as printing or etching are used less, in favour of the technologies based on the internal design structure of materials. This is the way a new generation of filtering facades is being born. Precisely designed filtering facade properties can be achieved by applying polymer films onto the surface of the facade in a micro-or nano-scale, by making micro or nano grooves and by using diffraction gratings or materials with chemical composition. All these technologies change the visual aesthetics of facades by making them more dynamic and allow the creation of new aesthetic features that would have been impossible to achieve before.



Ill. 1. Optical and colouristic phenomenon when uniting a few glass layers and special polymer film (photo by B. Konarzewska)

Ill. 2. Radiant colour film (photo by B. Konarzewska)

2. A new generation of filtering facade

Nowadays, it is possible to precisely distinguish the methods that allow designers to create a "new generation" of filtering facades. Firstly, it is possible by forming specific, static micro or nano structures on the facade surface that creates dynamic patterns when seen from different points of view or depending on the angle of incidence of light. Another way to design the facade using the optical filter technologies is to design such a chemical composition of façade material that changes in response to external impulses, thus activating the specific filtering characteristics. Thanks to the achievements of materials science, the observer is unable to distinguish whether the dynamic changes that are actually observed are the result of active processes within the structure of the material, or whether these changes are supposable and only perceived visually, while the structure of the material remains static. Of these new types of filtering facades, it is possible to indicate two main groups: facades activated by environmental factors and facades activated as a result of energy supply.

The technology of polymer films, which dominates in the creation of filtering facades activated by environmental factors, relies on the application of one or more layers of thin films having different properties to glass or plastic surfaces. Polymer films can be divided into two groups: those that have a static structure, which remains unchanged under the influence of environmental factors, and films that have the ability to change the arrangements of micro scale particles under the influence of catalysis through environmental stimuli.

Radiant colour video, which is one of the most popular polymer films of static structure used now in architecture, consists of thin layers of films having different reflectivity characteristics while maintaining overall translucency (Ill. 2). The colour seen through this coating depends on the angle from which the observer looks at the facade and on the angle of the incident of light. Even a seemingly small change in the view angle can cause the surface colour that is perceived by the observer to appear totally different.

View directional film, also called light control film or privacy film, is another film that could potentially find many practical applications. When this film is applied onto the façade and depending on the change of position of the observer, the façade surface becomes more or less transparent so the observer can see through it. Thanks to micro-channels shaped in the polymeric material, the designer can determine visual accessibility to the interior by the proper formation of microscopic shutters, which are created in the process of photo polymerization usually through the use of ultraviolet light. Image redirection film (redirect the image film) is created in a similar manner: by extrusion of special grooves formed on a sheet of polymeric film. This film allows the viewer to "look" around the corner or "behind" the wall and see the object that is not visible when standing in front of the façade [3].

HDS holographic diffraction structures are among the popular "new generation" optical filters that have "entered" the field of architecture, but most of them are still prototypes. The phenomenon of refraction in various HDS structures results from a diffraction effect, similar to that created by mirrors, lenses, prisms and other optical devices. HDS is a three-dimensional pattern created by a laser light on high-resolution photographic film, which is later placed between two glass panes. Such structures can be used on the facade of the building to produce dynamically variable effects [4]. These designed surfaces reveal a variety of patterns, grids and lines in a wide range of colors depending on the angle of incidence and reflection of light, light intensity and the amount of artificial light sources. Although the creator of the facade may design some of these effects, parts of them are unpredictable as they depend on unforeseeable environmental influences. In this way, the use of filter technologies activated by environmental factors enables architects to introduce an "event" into architectural design, which has become an important factor in affecting the final impression gained by the observer when looking at the facade.

A noticeable group of experiments on filtering façades that is expanding impetuously today is the one based on materials that change thanks to chemical reactions inside their structure. Temperature change, as in the case of thermochromic and thermotropic glass or the amount of incident sunlight (photochromic glass), may have a decisive influence on the activation of filtering properties. The incident of sunlight on the façade activates filtering features that make use of phase changing materials – PCM. Façade insulating glass called GLASSXcrystal, already available on the market, is one such active filtering system, which comprises PCM that use solar energy for storage in the process of melting salt hydrate particles sandwiched between panels [5]. As the temperature decreases, the phase change material used for the façade as a result of the crystallization process releases heat.

The technologies presented above, which are used to stimulate the filtering properties of building surfaces, do not allow for the achievement of fully controllable results because the necessary stimulation dependent on environmental factors is unpredictable. However, with the provision of electricity, full control over precise reactions that take place on translucent façades becomes possible. By activating the facades electrically, parameters such as color, degree of transparency and graphics may be changed. These facades offer the possibility to comprehensively control light transmission through their surface or effect the process of colour reversibility. To achieve such effects, designers may use three general classes of materials: electrochromic, liquid crystals, and suspended particles.

Although electrochromic glass is still most commonly used for functional purposes especially in office spaces, its integration with architectural objects of irregular multi-dimensional surfaces has made it possible to achieve a new kind of effect that is broadening the idea of how this material may look as an active filtering facade. The electrochromic outer shell of *Chromogenic Dwelling*was formed in this way. Designed by Thom Faulders for the Octavia Boulevard Housing competition in San Francisco, the translucency of the individual elements of the façade are controlled by the user, depending also on the weather, sunlight or personal preferences. Similarly, liquid crystal technology can also be used to achieve unpredictable effects.

Liquid crystal technologies used on facades can take the form of computer controlled systems, thus making it possible to program the time and rate of translucency change for separate glass façade elements. In this way, the building envelope, like in the project of Michael Silvera`s, Liquid Crystal Glass House [6] that has a computer control system, may be a filter responsive to changes in environmental parameters. The polymer composite called SmartWrap, which was designed by Kieran Timerlake Associates LLP, is one of the most technologically advanced filtering façade materials.

SmartWrap is a very thin material formed on the basis of polymers whose structure comprises a substrate and layers that together form the composite film. It allows the climate to be controlled in the interior, is a source of light and electricity, has the ability to change colour and translucency, and may also be treated as an independent building envelope. It does not have to be provided with traditional window openings to let the sunlight in or to ensure a view to the outside. Instead, the architect can design printed and non-printed areas on the surface of the film to determine their rhythm [7].

3. Filter between interior and exterior

The potential for controlling the penetration of light and images into the building and creating non-traditional outside views are two very important attributes of facades acting as optical filters. A façade, which filters light optically, weakens the delineation of the natural border forming the outer barrier of the building with a specific, outwardly perceived and invariable aesthetic. It provokes and enhances the optical phenomena of reflection, refraction or image deformations and gives the impression of depth, such facades become indeterminable, but “inconspicuously” so. Because these various optical effects may overlap, we can receive the views of the external world from within the interior of the building as the original animation of light, shade or color, all of which are not fully predictable. On the other hand, images seen outside the building are framed and static, but present a heightened, more “essential” vision of what is outside through the effect of the optical filter facade.

These visual results may be gained through the realization of experiments that involve: nonlinear shaping of the facade surface: a nonstandard compilation of several filtering layers, integration within the façade structure of prisms or lenses, precision in the designing of fragments of glass surfaces with different angles and finally, the creation of moving filtering parts of various shapes and functional features.

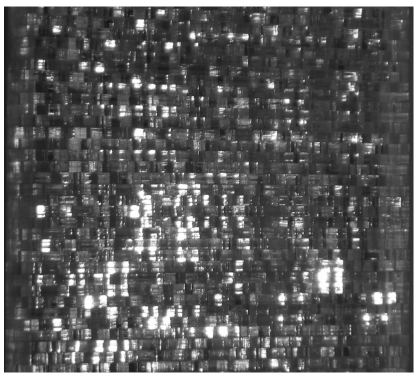
The Driving Test House by Paul van der Erve and Gerard Kruunenberga, which is a prototype house whose walls are entirely made of glass, is one of the most well-known, pioneering experiments based on a combination of translucent panes of glass or polycarbonate layers. [8].Thanks to various wall thicknesses and depending on the “depth” of the rooms, it was possible to achieve the effect of unreal depth, intensified by reflections and refraction of light inside the building. Different degrees of translucency and unique sea-green shades typical for these walls depend upon the angle of incident light and the place of observations (Ill. 1).

Glass or plastic plates are also specially “bent”, molded or deformed to create the effect of a continuous transformation of the image being perceived through the filtering surface. Thanks to advanced manufacturing technology, it is even possible to produce single-layer crystal-like structures consisting of convex, concave or flat glass polygons. Herzog and de Meuron realized such a project for a Prada boutique in Tokyo. Glass facades of diamonds in varying curves “crop” and “convert” images of urban life seen through the openings, causing them to undergo constant distortion and dynamic deformation.

Thanks to facades filtering such attributes of urban life as traffic or dynamics, into which pulsating streetlights can “penetrate” , thus creating unpredictable light “projections”. To use the dynamic character of the city, while creating an atmosphere of intimacy inside the building, the architects of the residential loft of Howard Street House in San Francisco [9], treated its facade as a multi-layer filter. Taking advantage of dynamic images of urban street life, the designers “let them through” a punched, layered barrier, behind which they placed a milky glass plate that became the focal plane. So depending on the traffic outside, blurry, dreamlike, almost abstract projections were created in the interior as a result of optical manipulation.

The fascination with the phenomena of fission and refraction of light, and ~~trials~~ attempting to design the geometry of patterns of light that penetrate the interior, perfectly illustrate the work of artist and architect James Carpenter, and in particular Sweeney Chapel and Periscope Window. In the Sweeney Chapel in Indianapolis, a glass “truss” of vertical and horizontal bands of dichroic glass formed in the shape of a box – like kind of vertical coffer, creates a rhomboid grid of light patterns in shades of green, blue, yellow and violet on the wall of the presbytery that light off, depending on the time of day and light intensity. It was designed almost with “laboratory” lighting patterns, which are being constantly “disordered” by a nearby tree that interferes with the light flow and light reflections created by the dichroic bands.

Ill. 3. Almere Business Center
(photo by L. Nyka)



Ill. 4. Sensi Tilesurface
(photo by B. Konarzewska)

The fascinating dynamic of the transient phenomena of light and the desire of designers to strengthen it may be revealed in other architectural projects. The result of this fascination appears in attempts at designing the interaction of light in connection with the filtering plane of the façade. Two good examples include the Periscope Window containing glass lenses by James Carpenter or the Rainbow church by Tokuin Yoshioka [10], which is a project consisting only of prisms.

4. Towards capturing environmental features

Materials as a type of optical filter are used in architecture to exploit the potential of natural light. The sun's rays interacting with the rain or clouds form short-term transitory but phenomenal results. Architects, in their attempts to imitate these effects, design material structures so that it becomes possible to experience these unique phenomena observed in nature, in an architectural or built environment. Patterns that designers intend to reflect are those characteristically found in the natural world: the smooth transition of colours, soft shades and unpredictable light reflections. Thanks to innovative technological solutions, diffraction and reflection of light or colour changes appearing on the filtering facades can be intensified and take an even more dynamic form than what is apparent in nature. Due to the nature and characteristic of the partial unpredictability, the designed graphical and textural effects are usually realized in the form of irregular organic compositions.

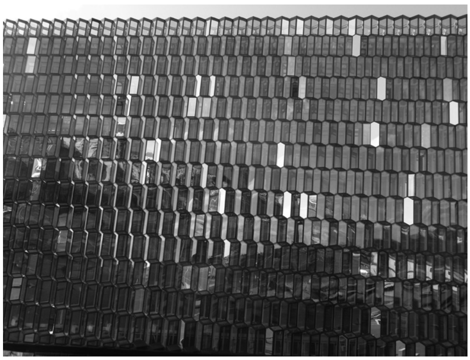
Advanced material engineering processes are responsible for the achievement of these imitative compositional solutions. Sensi Tiles [11] (Ill. 4) already existing on the market, which change under the influence of incident light, "spotting out" colours from the environment and reflecting or scattering them on the surface, is an example of one such architectural material solution. The process of melting fiber optics in a resin substrate and additionally treating the materials with the use of reflective or matte surfaces, etching or staining treatments for individual fragments of the base substrate, have created the impression that a living reaction to the surrounding surfaces is occurring. On these tiles, dynamic light, movement and touch induce hopping, colorful "sparks". Similar special effects have been achieved by architect and artist James Carpenter over many years of research and experiments with the use of dichroic glass, and by UN Studio with the use of the patented prototype multicoloured foil, as seen in The Gallery in Seoul, and Business Centre Almere in the Netherlands.

Architects may also include such unpredictable components as water within the façade structure to heighten the sense of depth, instability and prismatic reflections that would bring the created filtering facades closer to the natural world. An example of such a project using water, is the Africa Pavilion built for the exhibition EXPO 2008 in Zaragoza [12]. The main structure of the facades form square, semi-transparent plastic printed sheets, mounted only in the upper parts so they are movable by a breeze. These tiles are coated with a filtering membrane, which controls the degree of absorption and reflection of light. Additionally, the water "wall", whose fully reflective shining plane suggestively combines with the small moving tile of the proper façade, was created in front of the façade to become the unpredictable active filter, perceptible as an obvious reference to the natural landscape.

Harpa Concert Hall and Conference Centre [Photos 5 and 6], is one of the latest realizations of a filtering facade and actually of a whole complex filtering structure, for which, according to the artist, Olafur Eliasson, the inspirations were looked for in the "northern lights and the dramatic landscapes of Iceland" [13]. The main aim was to build the envelope of the building, which would create an unclear boundary between the interior and the exterior, by reflecting changing light and weather conditions. The envelope of Harpa Centre was actually created to be formed by light and its reflections reinforced by the delicate optical filters used in selected planes of the facade structure. It not only refers the building to, but also actually "blends" it, into the variable natural landscape. The prize of the Mies van der Rohe Award 2013, confirms the importance of values inherent in such projects [12].

5. Conclusions

The recent use of optical filter technologies has opened up new possibilities for creating an image of the building facade as an envelope that deepens the sense of light and its variability, and consequently broadens the use of natural phenomena to create new aesthetics in architecture. Thanks to the new generation of optical filters that were created as a result of progress in materials science, facades that initiate a new relationship between inside and outside are being created; building envelopes are sensational transitory compositions of light and colorful landscapes whose common feature is volatility and unpredictability. The unique levels of sophistication of these heterogeneous para-natural compositions found on the facades, bring the built environment closer to natural conditions. By the visualization of and interaction with such facades, the range of aesthetic stimulus offered by architecture, can be greatly extended.



Ill. 5, 6. Harpa Concert Hall and Conference Centre (photo by L. Nyka)

References

[1] Trepka E., *Historia kolorystyki*, Państwowe Wydawnictwo Naukowe, Warszawa 1960.

[2] Leon Crespo A.M., *History of the Double Skin Facade* (www.envelopes.cdi.harvard.edu/envelopes/content/resources/PDF/doubleskins.pdf – 27.05.2008).

[3] Addington M., Schodek D., *Smart Materials and Technolgies,*Architectural Press, Elsevier, Oxford 2005, 144.
[4] www.hspace.com, 26.11.2006
[5] www.glassx.ch, 13.02.2009
[6] Kolarevic B., *Material Effects: Rethinking Design and Making in Architecture*, Routledge, Nowy Jork 2008.
[7] Timberlake K., *SmartWrap: Building Envelope of the Future* (www.kierantimberlake.com – 20.08.2007).
[8] Donatello D.A., *Laminata – House of Glass* (www.materiamagazine.com – source: 9.06.2007).
[9] Person C.A*., Howard Street House*, Architectural Record 04/2002, 103-107.
[10] SchropferT., *MaterialDesign*,Birkhauser Basel, Basel 2011.
[11] LathA.,*Design Life Now: National Design* Triennial (www.triennial.cooperhewitt.org – source: 26.03.2008).
[12] Konarzewska B.,*Aktywność współczesnych fasad w konteście rozwoju innowacyjnych technologii*, praca doktorska, Politechnika Gdańska, Gdańsk 2010.
[13] www.henninglarsen.com

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

IWONA PIEBIAK*

THE IMPACT OF GREEN SOLUTIONS ON SHAPING THE ARCHITECTURE OF BUILDINGS

WPŁYW ROZWIAZAŃ PROEKOLOGICZNYCH NA KSZTAŁTOWANIE ARCHITEKTURY BUDYNKÓW

Abstract

One of the basic guidelines of modern architecture is designing buildings in line with the rules of sustainable development. Architecture and sustainable development refer to the process of planning, programme, design, construction and management of the building throughout the time of its existence as well as its demolition carried out with respect for the natural environment. A building designed in compliance with the guidelines of sustainable architecture is consistent with green principles and uses green solutions. Green solutions contribute to the picture of the building, which apart from proper choice of materials and technologies, its strict inclusion in the context of the place and shaping of the interior space, should also be highly aesthetic in its body. The article analyses the impact of particular green solutions on the aesthetics and the body of buildings.

Keywords: sustainable development, energy efficient buildings

Streszczenie

Jedną z podstawowych wytycznych współczesnej architektury jest kształtowanie obiektów zgodnie z zasadami zrównoważonego rozwoju. Architektura i budownictwo zrównoważone odnoszą się do procesu planowania, programowania, projektowania, wznoszenia, zarządzania budynkiem przez cały czas jego istnienia, jak również jego rozbiórki, przebiegających z poszanowaniem środowiska naturalnego. Budynek zaprojektowany zgodnie z zasadami zrównoważonego rozwoju to taki, który spełnia założenia proekologiczne, z zastosowaniem rozwiązań proekologicznych. Rozwiązania proekologiczne składają się na obraz budynku, który oprócz stosownych rozwiązań materiałowych i technicznych, ścisłego wpisania w kontekst miejsca, ukształtowania przestrzeni wewnętrznej, powinien również cechować się bryłą o wysokich walorach estetycznych. W artykule przeanalizowany został wpływ poszczególnych rozwiązań proekologicznych na estetykę i bryłę obiektów.

Słowa kluczowe: rozwój zrównoważony, budynki efektywne energetycznie

* Ph.D. Eng. Arch. Iwona Piebiak, Institute of Structural Design, Faculty of Architecture, Cracow University of Technology.

1. Introduction

Ecological context of architecture is now one of the design guidelines. The use of green solutions affect the respect for the environment, economic savings and the improvement of the buildings' utility. Endorsing ecological solutions in the design process has a significant impact on shaping the architecture of the buildings and leads to the construction of objects of characteristic spatial properties.

Green solutions in architecture are associated with an appropriate choice of:
- construction materials and technologies,
- installation

and with the shaping of the building structure consisting of the appropriate tasks such as:
- determining the relation of the building with its surroundings,
- distribution of functions and the internal space of the building,
- shaping the body of the building.

2. Construction materials and technologies

Selection of suitable building material has a significant impact on the primary energy content of the building, its energy consumption and utilization. The energy required to obtain raw materials, their processing, manufacturing, and transportation is referred to as the internal energy primary energy input [1]. Ecological materials are characterized by a low level of energy. The low energy content of the material is affected by the consumption of natural resources in the production process, the degree of processing of these raw materials, transportation, installation and durability of the material in relation to the period of the existence of the building.

An ecological building designer should include the use of low energy building materials in the design process. The use of local building materials (reduction of transport), the possibility of using recycled materials and traditional materials (low-processed) has a major impact. The impact of the production of construction material on the environment is also significant.

A design trend based on the use of traditional materials (low-processed) such as clay, wood, stone and the simplest technology can be observed in contemporary architecture. Low-tech architecture, also referred to as no-tech, is based on a conscious resignation from the achievements of modern technology (Paolo Soleri, Arcosanti, Arizona). A design trend of environmental humanism or environmental minimalism is characterized by the balanced use of traditional materials and innovative products. Combining local materials with industrialized ones such as brick, clay tiles, concrete, steel or glass can be observed in those trends (Gűnter Behnisch, Schaudt Architekten, OVO Grąbczewscy Architekci). High-tech and eco-tech architecture introduces highly developed technologies together with industrialized materials and high-performance materials such as composites, nanomaterials and smart materials with the ability to respond to changes in the environment (Norman Foster, Thomas Herzog, Gilles Perraudin). The eco-tech trend is based on the inclusion of active sustainable energy systems in the structure of the building [2].

The choice of material has a major impact on the appearance of the façade and the body of the building, especially when they are placed in the finish of the façade and internal partitions.

The use of natural materials in the building partitions often serves to emphasize the ecological nature of architecture. Highly industrialized materials (photovoltaic cells, solar panels, transparent thermal insulation) also bring about ecological associations. A major challenge for designers is also combining traditional materials with highly industrialized technologies.

The choice of material and construction has a major influence on the thermal capacity of the building structure. Materials of high heat capacity (e.g. brick, concrete, stone, clay) serve as a thermal mass. An important issue is the distribution of accumulation layers in relation to the functional layout of the building. An accumulation layer system should in due course allow for the free flow of the obtained thermal energy to the relevant rooms.

3. Installations

The dynamic technological development in the architecture of the twentieth century contributed to the introduction of installations that were to improve the comfort of the facilities. As a result, increasingly more complex installation systems (excessive use of air conditioning and artificial lighting of buildings) led to the development of disease symptoms of the so called "sick building syndrome" among the users. Today green installation solutions are based on environmentally friendly solutions (energy coming from renewable sources, energy recovery from internal systems), elimination of harmful phenomena associated with the operation of installations and limiting their impact on users (increase in the hygienic standard of installation e.g., the use of filters or silver additives in installation pipes) as well as an increase in device efficiency (optimizing the functioning of the installation, integration of internal systems, the introduction of operational control systems and the control systems themselves).

Ecological systems affect the architecture of the building (e.g., equipping a single-family building with mechanical ventilation instead of a gravity one requires more space for the passage of wires, which results in an increase in the amount of stories – and thus has a major impact on the body of the building). It is also necessary to design space for the components of the system. Particular devices, which are integral parts of the system, may be located in the buffer zones designed from the north or in the central part of the building. A large heat storage location has a major impact on the body of the building and the structure of the building`s functions.

4. Building surroundings

The design of green buildings cannot take place without their integration with the environment. Each building is unique because of the different location, climatic conditions and the surrounding urban infrastructure. There is the exchange and flow of energy between the environment and the building. An environmentally friendly building design concept requires a thorough analysis of the environmental conditions including: the type, shape and development of land, technical infrastructure, availability of media and renewable energy sources, sunlight, prevailing winds and the outside air temperature. The architectural consequences of green building design in relation to the environment are reflected in the formation of objects with a compact block (reducing heat loss by penetration) and with a longer south elevation (increased exposure in the direction of the most favorable insolation).

There may be some deviations from this rule due to the shape of the plot, adjacent buildings, communication system and the surrounding infrastructure. Design constraints dictated by urban circumstances do not disqualify ecological solutions. However, with the increasing urbanization of the land, designing optimal green solutions becomes more difficult and requires customized solutions.

A green building is in harmony with the environment. The area surrounding the building is not just a plane on which the building is constructed, but it is also a natural extension of the interior space of the building. Therefore, the development of the area surrounding the building conforms to the rules of inner space design. Zoning of outer spaces is carried out in a similar way as is the internal space (a buffer zone on the north side, i.e., parking lots, technical areas). The relation of the building with the surrounding area occurs also through the merging of inner and outer spaces: use of conservatories, opening of elevation in the direction of green areas and facing the south, eye contact with the environment, the introduction of greenery on roofs and facades of buildings. In the area surrounding the green building there may appear different infrastructural elements connected with the functioning of the building such as: air intakes, short-term reservoirs of heat, elements of the solar panels or photovoltaic panel installation unrelated to the body of the building.

5. The functional layout. The interior of the building

The configuration of the function and the distribution of internal partitions in an environment-friendly building is extremely important due to the fact that the interior space of the building should allow for the free flow of air, natural light and heat obtained from solar radiation. This space is not only designed to meet all the functional and aesthetic requirements, but it is also used for obtaining, storing, circulating and recovering energy. It becomes essential to form it skillfully in terms of building physics, the use of natural phenomena such as the greenhouse effect, convection (solar chimneys) and absorption or heat transmission.

Thus, the zoning of the premises on the basis of their usable temperatures becomes crucial. Technical and economic premises, communication zones, and auxiliary facilities are located on the north side, creating buffer zones. On the southern side there are rooms for which thermal energy from solar radiation is recommended due to their high demand for thermal energy: living rooms, offices, dining rooms. A characteristic of the ecological building floor plan formation (and hence, the body of the building) are additional profit zones (buffers located to the south side of the building), greenhouses and conservatories integrated with the body of the building. In addition to the aesthetic advantage of the opening to the building being on the south side, this zone has the task of extracting heat energy during the heating season. Thermal zoning of rooms occurs also vertically and is dependent on the density of the surrounding buildings and obstruction by surrounding elements (a zone with the greatest demand for heating energy should be in the most advantageous position in terms of insolation e.g., in the case of a single family building with a high density of the surrounding buildings, the location of the living room may be more favourable on the upper floors and not on the ground floor).

The formation of functions and the interior of the ecological building should allow for the use of natural lighting, ventilation, cooling and heating of the building in an optimal way. It becomes reasonable to create clear functional systems with narrow tracts in order to provide better access to light and to group rooms with the same demand for internal microclimate parameters. Deep building tracts necessitate the use of courtyards and solar chimneys.

6. The body of the building

The ecological structure of the building should be characterized by its compact form due to the reduction in heat loss by penetration through the building envelope. However, an ecologically friendly building is characterized by its close connection with the surrounding area and its adjustment to the parameters of the external environment. Therefore, the body of the building fitting naturally with the surrounding landscape can be characterized by fragmentation, low building height, an extensive area of the ground floor and other individual spatial characteristics.

A characteristic of a building gaining energy from solar radiation is an adjustment of the solutions of the body of the building to the external climate. For this reason, an ecological building is characterized by the presence of spatial elements in the form of: conservatories, glazed or open courtyards, atriums, solar chimneys, moving facade elements that enable adjustment of solar profits. The body of the ecological building is very often characterized by elevation variability depending on the time of day and year (adjustable movable sun visors, interactive elevations and intelligent elevations). The outer shell of the body of the building also gains a different importance as it is not only to protect it from the elements, but also above all, to let the factors influencing the improvement of the microclimate into the interior and to keep the climate worsening factors out. The use of an external facade sunshade system gives rise to the "multi-layered" partition effect and the ambiguity of the external borders of the building.

A green building is characterized by the opening to the south (large amount of glazing) and the reduction of glazing on the north side i.e., differentiation of the glazing on the basis of the orientation of the facade in relation to the cardinal directions. Due to the formation of the details of the facade preventing the occurrence of thermal bridges, the body of the building is usually devoid of elements which would break its continuity. On the south side of the building, there may be additional visors in the form of balconies, galleries or bays, which also enable functional opening outdoors. A green building envelope can be actively integrated with components of the system acquiring renewable energy. These elements are properly exposed with respect to the cardinal directions – in a southern direction.

The architectural consequence of the use of ecological solutions in the facades of buildings is to increase the thickness of the external walls in order to achieve the desired heat transfer coefficient. This may result in the apparent sturdiness of the body of the building and reduced visibility through the windows. The choice of materials used in green building facades may be based on traditional or modern solutions. It is also possible to combine both of these trends.

7. Conclusions

Ecological building is a system of closely interrelated solutions, the choice of which is dictated by taking consideration of the external environment and the intended use and function of the building, with particular emphasis on solutions which promote respect for the environment. Energy management is the priority in the design of such buildings. Distribution of functions, the use of appropriate building materials, technology, construction, installation, shaping of the body of the building is done on the basis of an analysis of a number of environmental conditions; it cannot be considered in isolation from them, as well as from other building elements included in the eco-friendly building. The use of green solutions in architecture involves the creation of objects with characteristic spatial features which serve to achieve an adequate comfort of the building.

References

[1] Marchwiński J., Zielonko-Jung K., *Współczesna architektura proekologiczna (Contemporary green architecture)*, Warszawa 2012.
[2] Piebiak I., *Transparentne izolacje termiczne w kierunkach estetycznych architektury solarnej (Transparent thermal insulation in the aesthetic trends of solar architecture),* VIII Międzynarodowa Konferencja Naukowo-Techniczna Problemy projektowe w kontekście nowych technologii budowlanych (The eighth International Scientific and Technical Conference Design problems in the context of new construction technologies), Kraków 2009.
[3] Ryńska E.D., *Bioklimatyka a forma architektoniczna (Climate physics and architectural form)*, Warszawa 2001.
[4] Tymkiewicz J., *Funkcje ścian zewnętrznych w aspektach badań jakościowych*, *Wpływ rozwiązań architektonicznych elewacji na kształtowanie jakości budynku*, Wydawnictwo Politechniki Śląskiej, Gliwice 2012.

TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
ARCHITECTURE | ARCHITEKTURA
7-A/2014

ADAM PODHALAŃSKI*

SUBURBS AND GREEN ENERGY

SUBURBIA A ZIELONA ENERGIA

A b s t r a c t

The projects for the development of suburbs in large cities are technologically advancing. With new solutions to roofing, achieving better energy efficiency is prime. To quote; "the use of the ground twice" focuses on both economical and ecological dimensions, allowing the use of land in an effective manner, so as to invest future goals in environment and energy.

Keywords: renewable energy, energy efficiency

S t r e s z c z e n i e

Projekty rozwoju suburbiów wielkich miast są technologicznie zaawansowane. Osiągniecie lepszej efektywności energetycznej jest głównym celem nowych rozwiązań przekryć dachowych. Hasło „skorzystaj z gruntu dwukrotnie" skupia się na obu wymiarach: ekonomicznym i społecznym, pozwalając na wykorzystanie terenu w najbardziej efektywny sposób, tak aby inwestować w przyszłe cele środowiskowe i energetyczne.

Słowa kluczowe: energia odnawialna, efektywność energetyczna

* M.Sc. Arch. Adam Podhalański, Institute of Urban Development in Cracow.

1. Introduction

Suburbs are not a new settlement project in large cities. Throughout our architectural history, it has become a dynamic main transport route to major urban centres, later emerging into cities; thus Suburbia. Because of its dynamic and temper-mental development and land surveys, building suburbs usually consists of many characteristics.. With this said each suburban home is compact, while being diverse in natural architectural forms. Gradually, suburban homes and surrounding areas adapt to these characteristics and form neighbourhoods. Major districts, i.e.; Krakow, have a historical background of its creation such as: Stradom, Piasek diff. Garbarze or Pędzichów providing evidence of lifestyle in the suburbs, which are part of the city [3, 4]. Progress in the development in economical and industrial areas has caused the spatial dimension of the characteristics of the suburbs to change, thus transforming cities into a more compressed environment. Peripheral districts of large cities began to replace the economic zones of production facilities, negatively affecting the environment. Suburbs have become more mono-functional and their spatial structure predictable, given the potential of its development direction in the future. Issues relating to land prices become more stable by this effect and can develop with investments in infrastructure. By building a more predictable manner in any potential suburb development, technical infrastructures become more consistent. Furthermore, let's focus on the issues of infrastructures and their efficient use. In most suburbs, buildings are powered by non-renewable sources of energy. Pro-development direction introduces such technologies and methods for the development of energy supply, making the greatest possible use for renewable energy sources. Like buildings of the suburbs, the current infrastructure development is chaotic. To some degree this is due to the scattering of buildings, which in turn hampers (mainly for economic reasons) the planning and construction of large and complex solutions central distribution systems that use renewable energy sources. Tracing the path of development of the situation in individual solutions, based on the so-called, green renewable energy is the key. Due to their much lower investment costs, and faster savings, it is a must to focus on returning invested funds and simultaneous improvement of ecological conditions, and not only the immediate environment, and/or the entire urban organism. Development of private - individual or group (f. e. cooperative type) activities, focusing on building and broadly advertising the idea of local renewable energy sources in suburbs of polish cities, is very necessary now.

2. Energy efficiency and renewable energy sources

Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, begins the first legislation on the subject. The adoption by the European Union of the Directive resulted in the coordination of efforts to create a legally defined area. These regulations have caused changes in Polish law. Energy Efficiency Act of 15th April 2011, is an essential tool to manage leading the way to better energy performance. In addition, the amended construction law, i.e.; new law passed 7th July 1994. The Act (amended) introduces an obligation to conduct energy performance certificates, given types of buildings, in relation to which the obligation relates, and also determines who can draw up the certificate.

The method and methodology defined in the Regulation of the Minister of Infrastructure of 6th, November, 2008 calculates the energy performance of the building and dwelling and/or part of a building constituting an independent whole technical - utilitarian, preparation, and design of energy performance certificates. Do not confuse that verifying the energy performance of a building with an energy audit; due to different legislation it is used for the thermal modernization. Reference is made herein the Regulation of the Minister of Economy of 10th August 2012, the detailed scope and method of preparation of energy efficiency audit, design cards energy efficiency audit and the methods for calculating energy savings. Understaning the Regulation and knowledge before performing technical functions in construction, can identify and fulfill expectations reflected in these acts. Standard issues related to the calculation of the total energy consumption in buildings such as Polish Standard PN- EN ISO 6946.

Directive of the European Parliament and of the Council 2009/28/EC of 23 April 2009 outlines the direction of the European Union, the Polish, and the issue of a new energy policy. The New Energy Policy provides a further diversity of the renewable energy sector over the period 2010–2020. Up to 2020, provides for the intensification of development in the following technologies: biogas, wind power, and solar power. Directive 2009/28/EC 2009/28/EC of 23th April 2009, on the promotion of renewable energy sources (RES) in Poland, translates that even things which are not moving forward, or even noted, that “going in the right direction”. Parliament on 44 Meeting on November. 06.21.2013 passed an amendment to the Act – Energy Law. The Act includes separation of supervision over distribution and trading of gas and introduces more comprehensive manners than the current EU legislation on common rules for the internal market in electricity and natural gas, promoting the use of energy from renewable sources. The solution adopted by the Parliament of the solution is complete, which does not solve current problems concerning the liberalization of the following market segments. There is not also any records of specific procedural facilitation on the RES.

Directive 2010/31/EU of 19th, May, 2010, of the European Parliament on the energy performance of buildings introduces changes in relation to the Directive 2002/91/EC of the European Parliament and of the Council of 16th, December, 2002, the aim of the new Directive is totaling 20% reduction of energy consumption in the building sector of the framework of the European Union. Beginning 1st January, 2013, modification in accordance with the provisions of the directive energy certificates, will enable the tenant/owners of the premises/building to evaluate terms of energy performance. Certificates will include recommendations for optimizing the energy performance of the facility and - actions to be taken to achieve of recommended standards. So far, the solutions adopted are only palliative, which are not solving the most important problems.

3. Prospects for the use of green energy in the suburbs. Energy efficiency and renewable energy sources

3.1. Planning

A comprehensive management plan for green energy in a given area will be difficult to implement. The nature of existing suburb building is dispersed and disorganized. The direction of the development in energy performance will be shaped individually. Strengthening the regulation of energy will result in delamination of the energy performance in buildings. Quality determines the order of building space, including the anthropogenic city. In the process of shaping the city, Franta asks; about the quality of the space, which creates a "lack of human activities", and it is "a framework for supporting quality of life, arising out of the use of economic mechanisms and respecting social conditions; fully aware of the difficulties and limitations" boils down to a dilemma on how to develop a modern city suburbs, where they can be, if only structure that creates a vast suburbs, whether or not they boldly create public spaces and social?

3.2. Building

Characteristics of a building in the suburbs is more mono- functional promoting the development of green energy. Potentially, there are two forms of the use of property. Both groups, and single-family housing, building services and commercial productions have a limited number of co-owners. There are large residential communities and cooperatives. Characteristics of such ownerships results in a search of clear cost savings and the ability to use a long time refund. Individual Investor assumptions, which mostly focuses on single-family homes has a large percentage of consumers in green energy. The assumption that the investor group will form a major part of the green energy sector clients, seems to be plausible which most newly established buildings that will soon meet the criteria of energy efficiency and renewable energy sources. Celadyn [1] notes that "among all types of building single-family housing are associated with relatively major energy losses. Therefore, the problem to reduce energy demand and obtaining energy from local renewable sources for their needs is a matter of the most current and worthy of further consideration".

Solutions for the application of strategies aimed only at saving energy can lead to the improvement of architectural forms, optimizing thermal insulation reducing caricature of simple forms. Single-family housing is "... a kind of building that is most demanding in terms to prevent field and the least rational. Ensuring the adequate records in local development plans seems to keep use of – cal energy sources for their needs should be considered in locally available energy. Ensuring the adequate records in local development plans" [1]. Installation of retail services, production and consumption are large costs associated with the purchase of energy from non-renewable sources. Objects located on the outskirts of cities are objects potentially negatively affecting the environment, usually having larger areas for investment. Companies exploiting such buildings can be in the future interested in having independent sources of energy.

3.3. Tendency for growing green energy plants by local governments.

In accordance with the directives implemented by the EU, there will be a separation of infrastructure managers and media suppliers, which will have a big impact on energy investment planning. Communal media owned by municipal governments are significant for the strategic planning and ensure security of energy supply introducing a degree of consistency in development of the city. They may be potentially interested in entering the market infrastructure managers. Independent and decentralized energy supply from indigenous sources of energy, especially renewable energy, are an invaluable tool that allows a municipality to strengthen local development programs. It is obvious, that perspectives of development of local renewable energy sources, according to local ecological conditions and possibilities, starting from fotovoltalic farms to many different kinds of fotovoltalic cell types as well as all other renewable energy producing methods might be implemented easier in suburbs then in city cores.

In the suburbs area it is enough space for city-agriculture, then inside polish cities. This type of agriculture has a biomass production possibility, for renewable energy production purposes. Analysies of Polish newest buildings and settlements supplied with self-produced, renewable energy sources will be subject of following this, separate paper.

4. Conclusions

Aforementioned regulations are only the beginning of the investment process being associated with energy efficiency and renewable energy sources. Unfortunately, the current state of affairs in Poland are effectively halting investment in this area. Cumbersome procedures used by the administrators of the media, and the costs associated with the suspension of the supply of energy for a fixed term to the building, dissuades potential supporters of green energy from its actual use in detached homes. State policy encourages the use of renewable energy sources, but ignores real possibilities and difficulties of its implementations on a large scale. Solutions for the use of green energy will only be effective if the actual profit from it will be available at a reasonable level. The costs of being associated with the introduction of new, green technologies must also be enducted by the State. To achieve eco-friendliness, concern for the natural environment, and the regulations of the European Union, can not have all the problems dropped and costs of the process only to citizens. The aim of action can not be a large profit in energy producers and suppliers, but instead in the development of new environmentally friendly technologies. The real profit from driving green innovation for the citizens will take some time, mainly due to lower distribution costs and energy production. To achieve this, action is required and stable introduction of legislation governing the legal aspects of the green energy market. The development of suburbs may become an interesting testing ground and a market that is potentially able to absorb new technologies more quickly and efficiently due to its nature, flexibility and multi-million dollar potential, very much so in southern Poland. In turn this will tackle the problems of air pollution of the city and surroundings of Krakow which show that this problem is already present in media and will require decisive action in the near term.

References

[1] Celadyn W., *Architektura energooszczędna w planowaniu przestrzennym*, Czasopismo Techniczne, 8-A/2010.

[2] Franta A., *Kultura miasta*, Czasopismo Techniczne, 2-A/2008.

[3] Petrus K., *Największe przedmieście Krakowa. Zarys rozwoju przestrzennego Garbar, cz. I i cz. II*, Czasopismo Techniczne, 5-A/2011.

[5] http://www.wnp.pl/polska_efektywna_energetycznie/efektywnosc-energetyczna-zielona-rewolucja,197872_1_0_0.html

[6] http://gazownictwo.wnp.pl/sejm-znowelizowal-prawo-energetyczne,200539_1_0_0.html

[7] http://energetyka.wnp.pl/krakow-dostanie-miliony-zl-na-wymiane-piecow-weglowych,200589_1_0_0.html

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

BOGUSŁAW PODHALAŃSKI*

OPTIMIZING ENERGY CONSUMPTION IN THE METROPOLIS

OPTYMALIZOWANIE ZUŻYCIA ENERGII W METROPOLIACH

Abstract

The proliferation of building management systems is limited only by the imagination of their developers as well as by technological progress, which allows for the remote control of all the available systems that aid us in making buildings more energy efficient, due to the fact that energy prices continually rise. The maximizing of a building's energy efficiency has now become an inseparable component of their design. Due to the comparison of the two constituents of the sum of a building's use of energy: that of the building itself and that of the user, an optimized energy efficiency scenario allows us to foresee the need for energy and its future costs. On the metropolitan scale, with tens of millions of structures, hundreds of millions of users and distances that greatly affect transportation costs, large amounts of energy are consumed. It is of great importance to pursue the development of intelligent systems that will be capable of minimizing energy use with intelligent building management systems, seemingly predestined for this role.

Keywords: energy efficiency, metropolitan scale

Streszczenie

Nasycenie systemami sterowania w budynku ogranicza jedynie wyobraźnia oraz postęp technologiczny, który pozwala na zdalne sterowanie wszystkimi dostępnymi systemami wspomagającymi oszczędne funkcjonowanie budynku, ponieważ koszt energii nieustannie rośnie. Maksymalizacja efektywności energetycznej obiektu, staje się niezbędnym elementem projektowania. Wynikający z zestawienia dwu składowych sumy energii niezbędnej do funkcjonowania samego budynku i jego użytkownika, zoptymalizowany scenariusz energetyczny pozwoli na prognozowanie zapotrzebowania na energię a także przyszły jej koszt. W skali metropolitalnej, przy dziesiątkach milionów obiektów, setkach milionów użytkowników oraz odległościach generujących kosztowny transport, konsumowane są ogromne ilości energii. Niezbędne jest poszukiwanie nowych technologii i sposobów minimalizowania jej zużycia, dla którego to celu inteligentne sterowanie systemowe wydaje się posiadać już obecnie wystarczające predyspozycje.

Słowa kluczowe: efektywność energetyczna, skala metropolitalna

* Ph.D. D.Sc. Eng. Arch. Bogusław Podhalański, Institute of City and Region Design, Faculty of Architecture, Cracow University of Technology.

1. Introduction

Every building that is designed with energy efficiency in mind, is in terms of cybernetics, a complex system based on a set of design solutions and the internal and external factors that stem from these solutions. In order for the system to work in an optimal fashion on multiple levels, such as the purely functional, those that originate from the environmental and urban context of its localization and those that arise from the philosophical principles of designing architecture, each level needs to be logical and controllable at the least. Only when these criteria which seem simple at a glance, but which in practice are repeatedly proven to be quite problematic are met, can the adaptation of the building (an autonomic, internally complex, but controllable system) to the role of an active element of the larger energy optimization system on a metropolitan scale, be accomplished. Zipser [1] compares the metropolis to a living organism, due to the multitude and mutability of the inter and extrametropolitan relations between its constituent parts: its sectors and entire clusters of buildings and "urban organisms". The functioning of such an "urban organism" requires vast amounts of energy. Its acquiring in traditional economic systems is tied to equally vast costs in each of its stages of production, not to mention the costs of distribution and preventive action against shortages. Attempts made towards the reduction of the need for energy have a very large impact on the functioning of the entire ecosystem on a global scale, due to the metropolises being the largest energy consuming entities in all of its available forms.

2. Local or central energy production and distribution

Assuming that a certain amount of energy, regardless of its form, is crucial for an individual to function within an urban environment, a straightforward relation can be observed between the amount of required energy and the number of persons that consume it. In relation to centers of population density, the targets of energy distribution are set, while its flow is different when it comes to the seasons of the year, weather conditions, geographical location and urban density. Taking into account the difficulties that arise from the necessity of producing energy and the costs that are required for its distribution, two strategies for its production are seen to emerge: one that relies on a central, focused production method with high parameters, losses and costs of distribution and one that is decentralized, locally based and diverse in terms of energy production methods with local consumption, low quantity and parameters regarding distribution and with smaller distances that lead to lower losses and costs. Each of these two systems has its advantages and disadvantages. The system that is currently in use around the world is widely known, which is why this work will go into the finer details of only the local method of energy production and distribution. Paradoxically, the central energy production system is far more manageable, allowing for the precise measurement and supervision of energy use regarding its changes due to atmospheric conditions. This system however, is highly dependable on the performance of its distribution sector and its susceptibility to failure and external threats (earthquakes, terrorist or military aggression). The local system, which is based on the production of small amounts of energy close to its receiving end, is harder to manage in a coherent way, whilst it is far more resilient to outside factors. A combination of this way of thinking about energy production with optimization of its use, allows for the creation of a multitude of design solutions that increase energy efficiency. It also allows energy producers to utilize a distributed control system which oversees the various subsystems of a building. One of the more useful ideas to be implemented in the field of distributed energy production is the combination of designing passive buildings with a low or very low energy consumption with diverse, distributed means of energy production from a variety of sourcessuch as solar power. The prices of solar power generation systems are becoming more and more affordable, which along with the development of local power production and storage, may lead to a future where the development of large and costly energy generation and distribution systems is at least lessened. The controlling of a decentralized network of individual energy sources would be necessary only if overproduction resulted in the necessity of redirecting surplus power to other receivers. This could be achieved with the existing system of power distribution. Decentralized energy production systems, while more difficult to manage, are more resilient to outside threats than central systems.

3. Maximizing a building's thermal insulation and its impact on health

This problem really comes down to one question. Is living in a thermos really healthy? While discussing the problems of the extremes of energy efficiency, Kusionowicz [2] describes in her work the various dangers that arise from insufficient ventilation which commonly occurs in the increasing pursuit of more draconic forms of saving energy. Presently, the technical solutions used in air conditioning rely on external power sources, most notably from the public power grid. The wide use of heat recuperators causes more of the air that is used within a building to be reused, which in turn reduces the amount of external air being supplied to it. In the event of a power outage, buildings fitted with this technology are highly susceptible to being insufficiently ventilated due to the level of insulation and air-tightness that is becoming commonly associated with these technologies. This situation can cause the emergence of moulds, fungi and other allergens, which may pose serious health hazards to a building's users and inhabitants. One must also consider the somewhat peculiar design solutions regarding the form of passive buildings, which might prove troublesome to the building's users and diminish their functionality. Passive houses have been in use for a relatively short amount of time, so the field of studying their impact on the long term health of their inhabitants is still quite undeveloped. By analogy to the results of research into other new building technologies that have an impact on the climate of building interiors, we can assume that passive houses will not be entirely neutral to our health.

4. Energy efficient urban planning

In order to better illustrate the problem, I will demonstrate a simple example. Assuming that an average sized metropolis is home to around a million inhabitants, which under the assumption of it having an evenly distributed built environment, gives us around 200 000 "building units" (for further simplicity they will be considered as free-standing single family houses). It is approximated that the yearly power demand for a single family home[1], in a climate similar to that of Poland and located in an averagely shielded space, amounts to around 24 500 kWh. By extending that demand to our theoretical metropolis, its power demand can be calculated as 4 900 000 000 kWh. According to internet sources, a passive house needs about four times less energy than a regular one[2]. These simple calculations indicate that energy efficient buildings used on a metropolitan scale could result in a decrease in energy use by three quarters of the present level, which, assuming that 1 kWh = 1 PLN, could amount to savings of up to 3 675 000 000 PLN per year. Savings of this magnitude are worth considering, especially when we take into account the present existence of metropolises with 20 million inhabitants, not to mention the planned mega-metropolises of China that are estimated to have a population of 250 million! Passive and energy efficient buildings however, are not the complete answer to the problem due to the fact that the reality of the urban environment is much more complicated than the theoretical musings presented above. Attempts to design[3] and construct[4] energy efficient and ecologically friendly cities are currently being undertaken with varying degrees of success. The basic obstacle to the idea of energy efficiency are the high costs of constructing such buildings, their fittings and infrastructure, as well as the human factor: the habits of the general population, which often stand in opposition to the comparably high standards required of them by the machinery that makes their dwellings more energy efficient in terms of their operation and regular maintenance. There is also one far more significant problem. Energy producers and distributors are not interested in the development of alternative energy sources, as they undermine their market position. The wide use of photovoltaic cells in Germany has already exposed the danger to large energy companies.

5. Structure of an energy efficient city

In order to design the urban layout of an energy efficient city one needs to thoroughly research the technologies used to produce energy that is needed for the functioning of such a settlement. One must also pick a particular technology, the requirements of which will be taken into consideration when developing the layout. The urban designer has complete freedom when it comes to atomic energy, not taking into account the appropriate safety zones, however, as the events in Japan unfold, there is currently no completely safe technology that allows us to “forget” the dangers of its failure, produces a continuous supply of energy and has no considerable impact on our environment. Depending on the choice of a primary energy source for the city, its urban form will need to be adapted to its means of generating power. In the case of a distributed system of various renewable energy sources, the urban

---

1 The average single family house with an area of 150–200 m^2, which does not have electric heating, a heat pump or air conditioning should use up around 12.5 Kw of electric energy. The average energy use of such a home is estimated at 1030 kWh [4].

2 While analyzing the energy demand of a passive house it turns out that it is four times smaller than that of a typical housing structure and consumes 15 kWh/m^2 per year, which is around 1.5 l of fuel oil or 1.5 m^3 of earth gas per 1 m^2 of the building per year [5].

3 Cities by Foster, OMA and other authors.

4 Masdar City in the UAE.

layout will have to be different for each of these systems. In terms of volume geometry, an ideal city from the point of energy conservation would be a sphere, due to the fact that it provides the smallest amount of exterior surface for the largest volume. This allows for optimum energy retaining properties, however it also means that most of the city would be deprived of daylight. From the point of view of absorbing sunlight energy, an urban form ideal for this process would require shaping its structures in a way that provides optimum exposure to light from at least four directions. The use of wind generators, tidal waves of water bodies or geothermal energy, would in each of these cases require an adaptation of the urban form to properly suit the energy generation method. Thus, the question arises whether there is an existing ideal urban form, which could theoretically provide optimal working conditions for each of the presently known forms of acquiring renewable power? Quite possibly such a form does exist, however it is not certain that currently an example of a metropolitan city that meets the requirements of a truly energy efficient city can be found. We do know however, that the attempts to create one in China [6] have been a commercial failure. This has not deterred this country from its course in attempting to build cities that are self-sustainable [7] in terms of power.

6. Conclusions

It is necessary to conduct multidirectional research in the field of increasing the energy efficiency of existing buildings, as well as in the field of developing urban forms and layouts that are aimed at aiding the technologies used to generate renewable energy adapted to their local environments and climates. The process of gradually depleting fossil fuels on a global scale requires that this research be intensified. This is also true of technical and technological research into better management of renewable energy in the daily lives of communities and individuals. The higher the population and urban densities, the more potential there is in thinking along the categories of increasing energy savings in multiple fields and in different sectors of the economy and our daily lives.

References

[1] Zipser T., Lecture „The Idea of the City. Machine or Tissue" from the conferrence „The Idea of the City – Time, Place, Form", Kraków 2013, CD.
[2] Kusionowicz T., *The Problems of Designing Human Habitation Structures: A Selection of Issues. Monography: Architecture*, Wydawnictwo Politechniki Krakowskiej, Kraków 2008.
[3] Celadyn W., *Energy Concepts For Builidngs. Methods of Presentation (Koncepcje energetyczne budynków. Metody prezentacji)*, Czasopismo Techniczne 2-A/2/2011, 15-25 (http://suw.biblos.pk.edu.pl/resourceDetails&rId=829).
[4] http://www.a-zero.pl/zapotrzebowanie-na-energie-elektryczna.html
[5] http://styl-zycia.ekologia.pl/ekologiczny-dom/Dom-zuzywa-najwiecej-energii-na-ogrzewanie,12043.html

[6] http://www.chronmyklimat.pl/gospodarka-rynek-co2/16034-chinski-plan-uzdrowienia-srodowiska
[7] http://termodom.pl/epbd/energooszczednosc/habitat_2020___samowystarczalne_miasto

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

ELŻBIETA PRZESMYCKA, ZUZANNA NAPIERALSKA*

ADVANCED TECHNOLOGIES AND REVITALIZATION OF THE SINGLE-FAMILY RESIDENTIAL ARCHITECTURE FROM THE POLISH SOCIALISM PERIOD. THE EXAMPLES OF REALIZATIONS

NOWOCZESNE TECHNOLOGIE A REWITALIZACJA JEDNORODZINNEJ ARCHITEKTURY MIESZKANIOWEJ Z OKRESU PRL. PRZYKŁADY REALIZACJI

A b s t r a c t

The idea of modernization and reconstruction of the buildings from the socialism epoque is undertaken in many works. Very often however, the subject divides public opinion. Many people are unaware of the architectural potential of those buildings, considering them mainly as evidence of the communistic system. Unfortunately, there is still no protection policy for the modern architectural heritage, which would include objects from the 50s to 80s of the 20th century (monuments protection statute). The article presents the results of the research into the present state of the conservation of selected single family housing types from Polish socialism. The types of housing chosen for the research were realized with the *Typical Single Family Residential Catalogue.* Projects presented in the catalogue were included into a bank credit program. The types of credits were analyzed by the compliance of the final realization and the original project. The result of the research will attempt to establish the direction of a typical single-family building transformation over the last 20 years. The study will also aim to create the criteria for the evaluation process of modernization such as: technical condition of the building and media, the possibility of adapting a functional scheme to the changing social needs, new building regulations and economics.

Keywords: modernization, polish socialism architecture, single-family buildings

S t r e s z c z e n i e

Temat modernizacji i przebudowy budynków epoki socjalizmu jest dziś podejmowany w wielu pracach. Bardzo często jednak dzieli on opinię publiczną. Wiele osób nie dostrzega jej potencjału, uważając, że ta architektura jest przede wszystkim świadectwem epoki komunizmu. Nie została jeszcze niestety wypracowana polityka ochrony dziedzictwa architektury współczesnej, do której można zaliczyć wiele obiektów z lat 50–80. XX w. W artykule przedstawiono wyniki badań nad stanem zachowania wybranych typów budownictwa jednorodzinnego powstałego w okresie PRL. Wybrano przykłady zabudowy realizowanej na podstawie projektów z Katalogów Domów Typowych, opracowanych przez Ministerstwo Gospodarki Komunalnej. Wynikiem badań będzie próba określenia kierunków przekształceń zabudowy typowej jednorodzinnej w ostatnich 20 latach. Również określone zostaną kryteria oceny sposobu modernizacji, którymi będą niewątpliwie: stan techniczny budynku i instalacji, a także jego sposób adaptacji do zmieniających się potrzeb nowych użytkowników i przepisów budowlanych.

Słowa kluczowe: modernizacja, powojenne budownictwo, zabudowa jednorodzinna

* Prof. Ph.D. Eng. Arch. Elżbieta Przesmycka, M.Sc. Eng. Arch. Zuzanna Napieralska, Faculty of Architecture, Wrocław University of Technology.

1. Introduction

Architecture during the Polish communist period was derived from the modernism style, which was defined by simple form that evolved from a functional scheme, responding to social demands and using modern technologies. Unfortunately not all of the new technologies of those times were effective. Because of the intensified house building and lack of financial support after the Second World War, the new material and construction solutions seemed cheap and efficient. The new technologies of the building industry were not sufficiently examined in terms of their durability. As a consequence, architecture from this period is rapidly ageing which causes many technical problems with its upgrading. It is hard to modernize those buildings by means of minimal intervention i.e., trying to restore most of the existing material. Usually it is necessary to replace most of the elements that are simply too damaged to restore them.

Lack of systematic building conservation is the biggest problem of the architecture from the 1949–1989 period. Systematic conversion would be more cost-efficient and could provide better quality of materials and elements for the construction.

Nowadays, modernism is given more and more attention in the architects' environment. After years of being ignored, modernism in architecture is being re-appreciated. It is important however, to identify buildings that account for the heritage of socialism and to decide how they should be protected. How to adapt this architecture created half of the century ago to the present needs, without changing its modernistic form, is the question [1]? Currently upgrading large panel buildings or public buildings from the Polish communist period is a popular endeavour. However, little consideration is given to the modernization of post-war single-family housing, which is present in every Polish city as a characteristic element of the post-war heritage.

2. Single-family house building in 1949–1989 in Poland

Single-family house building started to become more popular in 1956 [2]. In this year the legislation regulations have helped to obtain credits from the government for house projects. An example is the ministry council resolution no. 81 from 15 March 1957, concerning material aid from the State, for house building. For the purpose of the resolution a detached house is a house, a single component or serial semi-detached house with a total floor space of residential units not exceeding 110 m^2.

The resolution refers to: withdrawing from the building plots, providing long-term loans (up to 90% of investment costs), sharing typical – house projects, facilitating the material supply for the project, promoting the use of building materials from local raw material supplies, entrusting construction and installation works to state contractors, supporting cooperative construction enterprises, counselling and coaching, supporting reconstruction and capital repairs of disused houses, supporting major repairs of houses [3].

The first catalogue of typical houses was established in 1957 and consisted of 17 developed construction projects, another one that was created in June 1958, on behalf of the Ministry of Municipal Affairs and President of Architecture and Urban Planning presented 60 projects of typical houses. Each sheet of the catalogue has presented one type of house giving the building's footprint, floor spaces, cubic volume, costs and construction materials. All of the projects have had specific numbers that simplified its verification [4].

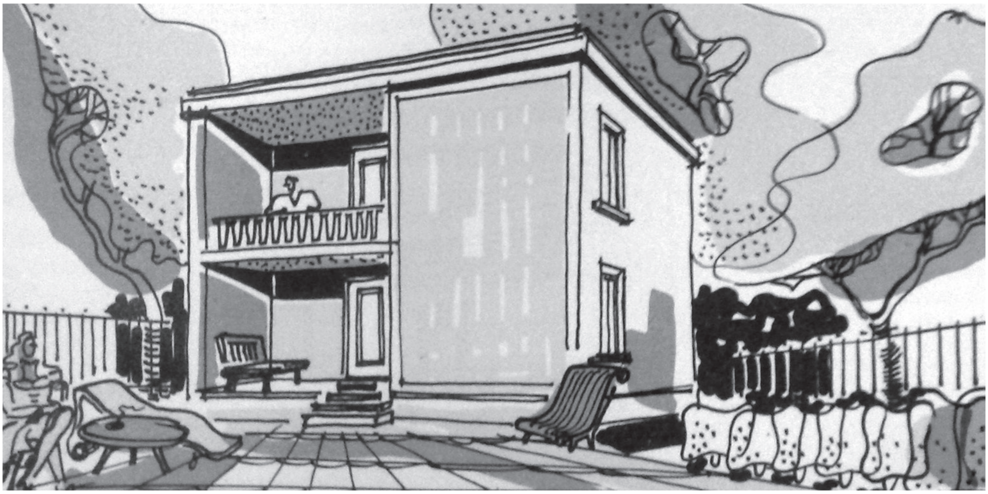
Different types of houses from the catalogue from each category: detached, semi-detached and terraced are presented below.

Ill. 1. Terraced house type no. 0004, *Katalog Domków Typowych*, Warsaw 1958

Building footprint	56.00 m^2; 4.40 m × 12.08 m
Total floor residential units	84.43 m^2
Building construction (with basement)	Walls: AAC blocks Floors: concrete panels Roof: slag concrete

Ill. 2. Semi-detached house type no. 0213, *Katalog Domków Typowych*, Warsaw 1958

Building footprint	94.36 m^2; 7.25 m × 9.00 m
Total floor residential units	101.39 m^2
Building construction (with basement)	Basements walls: brick Walls: slag concrete airbricks Floors: suspended beam and block floor Roof: slag concrete panels



Ill. 3. Detached house type no. 0145, *Katalog Domków Typowych*, Warsaw 1958

Building footprint	76.50 m^2; 9.00 m × 8.50 m
Total floor residential units	100.80 m^2
Building construction (with basement)	Walls: slag concrete airbricks Floors: suspended beam ang block floor Roof: slag concrete on suspended beam and block floor

3. The current condition of the post-war housing estates

At one time, post-war housing estates of detached houses were built in suburban areas, while the growth of urban space had been absorbed. Today, they are linked with the city centre and have a comprehensive infrastructure. Usually those residential communities have regular urban layout and a legible system of streets. Thanks to the similar volume of buildings, the rhythm of the houses is distinct. Thus the estate harmoniously connects detached, semi-detached and terraced buildings. Another advantage of those estates is an abundance of high vegetation along the communication routes and in private gardens. The disadvantage of the typical house building is an unfavourable functional system, that doesn't meet modern requirements. Narrow hallways and stairs and small rooms are a challenge for an architect today. However, a small floor area that usually hasn't exceeded 110 m^2 is attractive nowadays.

3.1. Modernization of the post-war Polish housing estates

There are neither good examples of upgrading post-war architecture, nor specific statements in the local area development plan that would control any individual repairs and renovations.

As a consequence, this typical house building systematically loses its modernistic character [5]. Detached buildings, popularly called *cubes*, are usually transformed by remodelling and as a result it is difficult to identify what the basic catalogue project was.

Lack of social awareness of taking responsibility for the aesthetics of the neighbourhood has the following effects: each part of a semidetached house may have different colour, roof, windows or even size (height). This disorder and chaos affects our perception in a negative way [6]. Restoring and upgrading of those houses is inevitable, but it is possible to avoid wrong decisions, which consequently would be perceptible for the next years. The incompetently maintained modernizations are the fundamental problem of the post-war housing estates. Deciding on temporary and cheap solutions with a low aesthetic value or hiding the modernistic character of the building raises some questions [7].

The beginnings of the modernization of post-war houses were associated with a certain fashion and trends in architecture. In the 90's it was popular to clad the facades with a *siding*, which was produced of a plastic plank. It was a cheap solution that also provided insulation of the building and helped to hide unattractive façades. Unfortunately after 10 years of use, the material needed replacing because of its degradation. Another method of upgrading those buildings was remodelling them into an old Polish manor house style. This involved building pitched roof, porches with columns or golden grilles in the windows.

a)

b)

Ill. 4. a) a post-war building covered with *siding*, b) a post-war house rebuilding by changing a roof shape

3.2. Modernization of the post-war Polish housing estates by using new technologies and contemporary material solutions.

The current upgrades put on modern design solutions include good and sustainable materials and technologies. They are mainly caused by the fact that advanced restorations often occur while changing the house owner. The new proprietor usually can afford comprehensive modernization [1].

Contemporary modernizations is using ventilated facades with modern materials such as cladding of fibre-cement panels, HPL slabs or aluminium panels. This type of renovation provides comfort by keeping the exterior walls dry, helps to maintain a constant temperature inside and also provides additional sound insulation. It is also common, to design large glazings in the facades but it requires the use of glass with low heat permeability. a relatively new solution is using a profile glass, which diffuses the light and gives good acoustic and thermal insulation.

Because the majority of installations in the building need to be replaced (due to their poor state of repair), people usually choses innovative central heating and ventilation system solutions, heat pumps, heat recovery units and BMS systems: intelligent building management system.

3.2.1. House upgrading by rebuilding

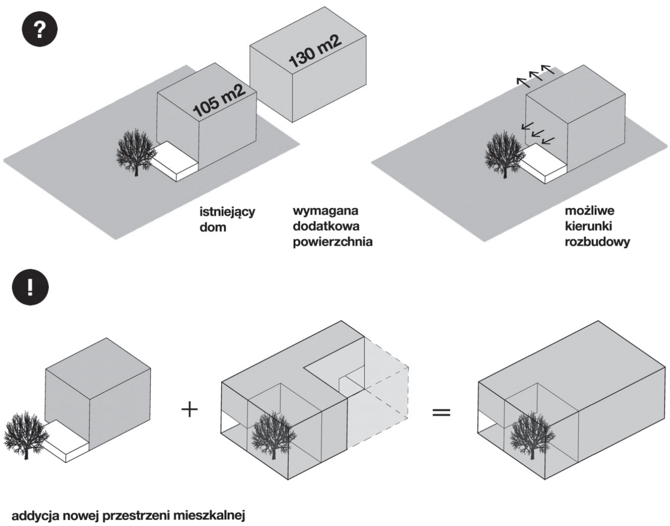
Modernization by rebuilding is extremely invasive for the building structure. It changes the shape and the size of the building because of enlargement. The problem with this type of modernization is to combine an old construction with the new one. a good example of such an upgrade, commended by the architects, is the “Black Cube” project designed by Kameleonlab studio from Wroclaw.

a) b)

Ill. 5. a) a post-war house before the upgrading, b) the realization of the modernization project (source: [8])

The building was enlarged by an addition of the elements. The existing part was built using traditional technology – with a solid brick of 38 cm. The extension, also designed with traditional technology used silicate blocks of 18 cm. and mineral wool insulation of 12 cm. An important change was replacing all of the floors due to the low height of the rooms. The investor acquired more space and comfort by raising ceilings from 2.6 m to over 3.0 m. New floors have been designed as cast in situ floor of 16cm. a problematic issue was the non-ventilated flat roof over the existing part of the house; it was necessary to replace most of the wooden beams. The new part of the building was covered with a cast in situ floor and a skylight was built over the living room. An interesting project idea was to keep an existing tree and to compose it with a building. Unfortunately, during construction, the tree was damaged and had to be to removed. Most of the elevations have been covered with wooden vertical planks in a dark colour, but in contrast and to avoid monotony, the architects used an intense light green colour to accent the entrance of the building. Regarding the wooden planks, vertically placed planks have a longer life span and effectively preserve joints from water penetration. The new staircase has been glazed with profile glass, which is a good alternative to the glass bricks, popular in post-war designing. Profile glass

Ill. 6. „Black Cube" - view from the terrace
(source: [8])



Ill. 7. „Black Cube" – sketches of the building shape formation
(source: [8])

is a good solution for large glazing where it is important to provide high thermal insulation and additionally, it also protects from excessive solar access to a building and assures good acoustic parameters. a steel openwork structure in the back of the building surrounds a terrace. It is possible to fix the vertical wooden blinds or curtains to the construction and reduce sunlight penetration in the living room [8].

3.2.2. New quality of building – modern form

Creating a new quality of buildings by changing facade aesthetics is one of the most popular forms of upgrading the post-war architecture. The basic advantage is good relation between the price and the final effect. Usually with this kind of modernization there is no need to include any construction changes. The main emphasis of renovation work is put on restoring the existing building elements by repair and renovation: steel fencing and railings sandblasting, impregnation of wood cladding and joints, cleaning stone cladding facades.

One successful example of this type of modernization is a semi detached house project designed by ISBA studio from Wroclaw. Cooperation among the neighbours was fundamental for this project. The aim of the project was to increase house thermal performance by technical solutions that would let the building envelope have better thermal parameters. The upgrading has also assumed to improve aesthetics of the building by changing the colours and creating new architectural details.

a)

b)

Ill.8. a) a post-war building before the upgrading, b) the realization of the modernization project; (source: [9])

An existing building is an example of typical polish architecture from the 60's XX – a simplified modernism. To give a building more geometric aspect the architect decided to remove the cornice from the top of the flat roof. At the concept stage, all of the elements extending beyond the general construction, such as entrance vestibule or the balcony, were to be plastered and painted in a different colour, but in the end it was decided to cover them with plywood. Originally the base of the building was covered with anthracite tiles. After thermal insulation the tiles were replaced by a scratch pattern plaster, which eventually gives the effect of distinguishing the base from the rest of the building. During the restoration work, the problem of accessibility to the garden from the terrace has been solved by designing openwork metal stairs. Railings and home fencing have been designed in a similar light industrial style, which gives a compact final effect [9].

4. Conclusions

At the present time, entirety and the modernistic character of the post-war residential housing is brought into question. It might be a *to be or not to be* for this architecture. Numerous upgrades of these types of buildings, due to the generation change or just an individual need, are systematically and permanently changing the character of residential communities [10].

New technologies in the construction industry are surely improving the quality and durability of the renovations. Putting on good materials is becoming increasingly popular, even at the price of higher costs. Temporary solutions sink into oblivion but they are still present in local spaces. In the modernization process, an important issue is to keep the simple and modernistic character of the building block, even when the construction rebuilding.

We haven't yet developed a recipe for healing and effective modernization of post-war urban spaces. The method of do's and don'ts by providing strict guidelines in LDP wouldn't necessarily bring the desired effect and it may even aggravate an aversion to this type of architecture. It is important therefore, to develop the knowledge of the aesthetic values among people, the ability to recognize it and practice [4, 11].

Single family housing is just a little part of the post – war building industry. Public buildings or blocks of flats from this period arouse more emotions among the architects and society, but detached houses shouldn't be treated with neglect. Its strength and potential lies in a complex of residential community.

References

[1] Pokrzywicka K., *Rozważania o dynamice przemian architektury XX w.*, Gdańsk 2010, 122-139.

[2] Masztalski R.P., *Przeobrażenia struktury przestrzennej małych miast Dolnego Śląska po 1945 roku*, Wrocław 2005, 49-50.

[3] Uchwała Nr 81 Rady Ministrów z dn. 15.03.1957 w sprawie pomocy Państwa dla budownictwa mieszkaniowego ze środków własnych ludności, Monitor Polski Nr 22 poz. 157.

[4] *Katalog domków typowych*, Warszawa 1958.
[5] Urbaniak J., *Granice modernizmu – niechciane dziedzictwo – problemy dotyczące rewaloryzacji architektury powstałej po II wojnie światowej w Polsce*, Teka Kom. Architektury, Urbanistyki i Studiów Krajobrazu O. PAN Lublin, IVA, 62-74.
[6] Przesmycka E., *Budujemy nową przesztrzeń*, Scriptores nr 3/2005 (29).
[7] Piątek G., *Snobizmy: modernizm od stylu na przemiał do stylu na sprzedaż* (www.dwutygodnik.com).
[8] www.kameleonlab.com
[9] www.isba.com.pl
[10] Zabłocka-Kos A., *Architektura dwudziestego wieku w Polsce*, Wrocław 2011.
[11] Przesmycka E., *Przeobrażenia zabudowy i krajobrazu miasteczek Lubelszczyzny*, Lublin 2001.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

DAMIAN RADWAŃSKI*

SUPERPOSITION OF FACADE IN ARCHITECTURE IN THE BEGINNING OF THE 21ST CENTURY

SUPERPOZYCJA FASADY W ARCHITEKTURZE POCZĄTKU XXI WIEKU

Abstract

The superposition of a facade in architecture in the early 21st century, is the merit of contemporary marketing mechanisms which function in architecture. The distinct relation between the exterior side of the building and the brand take effect in choosing advanced, already existing and available systems and architectural engineering, which are far from the classic process of project implementation. Investors often decide to make an effort in creating unique, innovative solutions of extreme technical and esthetic features in order to intensify the visual impression.

Keywords: facade, innovation, brand image

Streszczenie

Superpozycja fasady w architekturze początku XXI wieku to w dużej mierze zasługa współczesnych mechanizmów marketingowych funkcjonujących również w tej dziedzinie. Bardzo silne powiązanie fizyczności budynku z wątkiem wizerunkowym marki coraz częściej pociąga za sobą działania wybiegające daleko poza odtwórczy proces klasycznej implementacji w projekt dostępnych i funkcjonujących, wysoce zaawansowanych systemów i technologii budowlanych. Coraz częściej na potrzeby wzmocnienia i utrwalenia wizualnego przekazu inwestorzy decydują się na podjęcie wyzwania, jakim jest z całą pewnością tworzenie jednorazowych i innowacyjnych rozwiązań o wysoce ekstremalnych cechach technicznych i estetycznych.

Słowa kluczowe: fasada, innowacja, wizerunek marki

* Ph.D. Eng. Arch. Damian Radwański, Faculty of Architecture, Silesian University of Technology.

Along with the development and creation of more and more complex social structures, the significance of the outside form of the building also began to increase. The main catalyst of the process connected with assigning appropriate meanings to the physicality of the building was most of all the expanding catalogue of functions applied into its interior. In a natural way this process developed visual methods of codifying the basic information in this scope. Another important factor was the increasingly common process of social hierarchization in which the physicality of the building became one of the mediums of information concerning the position and social status of its owner.

A particular increase of interest in the phenomenon of the conscious awakening of marketing architectural potential was observed at the beginning of 1990s. The main reason for this still lasting megatrend was the phenomenon of globalization, which was gathering a momentum that had not been known before. A great pretext for also using means from the field of architecture (which were to serve this purpose), appeared to be different new investments usually dictated by the necessity of expansion and construction of new infrastructure on almost all the continents. Thus contemporary architecture became in a conscious way, a medium of one of the most important marketing and market mechanisms called 'branding'. Its essence comes down to integration of attributes of distinctive and unique visual medium with attributes, as is widely understood, of the greatest value [1]. Despite the ambiguous evaluations of many aspects of globalization, the spectacular building became an ideal formula for the needs defined in this way [2]. A specific role in the process of perception of each thing and each object including a building, is played by its exterior form defined by the attributes of material of which it is made. Shape, scale, material, structure, texture, colour etc. define the physicality of each building and together create its final image, which is saved and recorded in the observer's consciousness. Both type and quality of the aroused emotions and the permanence of the record, depend on the strength and type of stimuli sent towards the recipient.

During 13th International Exhibition of Architecture, which took place in 2001 in Venice, a dozen or so models of particularly spectacular facades made of real materials in actual scale were presented among others. Constructed according to the current canons of multilayer elevations, they represented two fundamental groups of solutions.

The first group consisted of those that were constructed mainly from the very advanced technologies and systems then available on the market. A more thorough analysis made it possible to isolate two different categories from this group. One of them included solutions which may be described as classical, well-tried and functioning compilations of facade systems and isolation products, which guaranteed great functional value and predictable visual and aesthetic effects. An example of such a solution was a facade designed by UN Studio as a part of the x Mercedes-Benz Museum project, the facade of the BMW Museum designed by Coop Himmelblau and the facade of the Walt Disney Concert Hall designed by Frank Gehry. A similar concept of articulating a very expressive and dynamic form of these buildings suggests that it is the geometry of their shapes that was to dominate the perception of their peculiar nature, pushing other attributes of their physicality into the background, including those formal and aesthetic ones. A definitely more sophisticated category in this group was represented by examples of two solutions which admittedly used equally recognized and well-tried systems, but thanks to an exceptionally well thought out strategy of uniting them with very innovative spatial, functional, constructive and technological solutions of the buildings, they eventually became an important part of the structures determining totally new and unprecedented models of balanced architecture. One of these examples was the facade of the Hearst Tower and the other was the facade of Swiss Re, both designed by the studio Foster and Partners.

The main seat of the Insurance Company Swiss Re was the first such sophisticated and balanced high building in London. This unique status results from a very radical and consistent approach by the authors to architectural, technical, engineering, ecological and social issues. Using fully parametric design methods made it possible to draw up an exceptionally precise and coherent concept of the fundamental assumption, which turned out to be the circular shape of the projection of the building. On account of a very well thought out strategy of shaping the vertical section of the skyscraper, consisting of an exceptionally refined selection of diameters of particular storeys, the building reacts to the effects of the sun and wind in a groundbreaking way. A relatively low coefficient of air resistance obtained in this way translates measurably into reduction of energy consumption in the period when it is used. Angiograms of the wind profile of this skyscraper confirm not only a very clear reduction (in comparison to a linear building) of disturbances of airflow in the ground zone, which has a crucial meaning for creating a microclimate in the city, but also indicates an exceptionally favorable layout of pressures in the upper parts of its structure. It is important for the development of alternative and innovative systems of natural ventilation, thanks to which the building at 30 St Mary Axe, uses 50% less energy than any other typical office block for this purpose [3].

a) b) c)

Ill. 1. Swiss Re Headquarters: a) night view, b) view of a fragment the facade, c) facade section (source: [4])

A key role in this system is played by the multilayer facade of the skyscraper which reacts actively in real-time to the constantly changing atmospheric conditions. Its outer layer is constructed on a diamond warp, which not only covers the building with flat sheets of glass in a way most appropriate for the cylindrical shape of the building, but also overcomes the hegemony of the omnipresent rectangle shaping elevations of all the neighboring buildings.

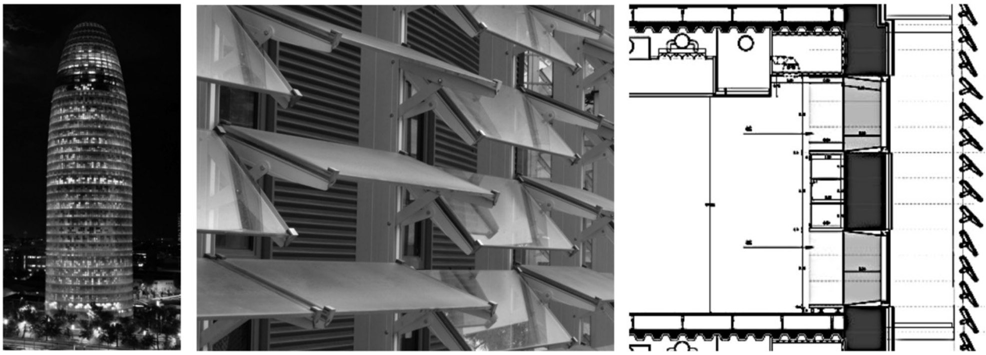
Two-colored sheets of glass represent the twisted nature of the functional and formal layout of the interior, thus emphasizing the dynamism of the whole form even more. The inside facade with classical divisions is constructed about one meter deeper. Mutual relations of the outer facade, the emptiness between the two facades, the inner facade, floors and ceilings as well as the technical solutions applied to them, play a crucial role in the aforementioned system of cooling, heating and ventilation of the building [4]. At present the building is the most characteristic element of the panorama of the capital city of Great Britain.

The other group of solutions concerning elevations, were examples which already at the moment of the first contact with the onlooker aroused in them some kind of curiosity resulting mainly from the mysterious nature of their construction. A lot of people were enthusiastic about and delighted with them. Thus the elevations already indicated that at least similar reactions will also be invoked by buildings covered with them. Similarly, as it was in case of the first group of solutions, the other ones also made it possible to define two categories.

The first category concerned solutions the idea of which was totally subordinated to the aesthetic vision intended by the author at the beginning. The vision was to be implemented by means of non-standard and innovative means of expression. All the other functional aspects of those facades such as thermal, wind and humidity insulation, were implemented with observance of very high normative standards, but without any elements of innovative solutions in this scope. This group included: the facade of Kunsthaus Graz, covered with bent, acrylic, sky blue glass designed by Peter Cook and Colin Fournier, the facade of Matsumoto Performing Arts Center by Toyo Ito with its concrete slabs embedded with 'slivers' of matt glass, snow white panels of wavy acrylic constituting a reminiscence of fabric blown by the wind on the facade of the building of Christian Dior by Kazuyo Sejimy i Ryue Nnishizawa, the rhomboidal structure of the self-supporting facade of the glass and diamond building of Prada and the pumice and glass facade of purple concrete of the Catalonia Forum by Herzog and De Meuron.

However, an outstanding solution was the unique design of the facade of Torre Agbar by Jean Nouvel, which as the only one from among all the solutions presented then, combined the features of a highly advanced technological structure with the aesthetics of an exceptional nature. The 142-metre-high office block being the seat of Aguas de Barcelona (AGBAR), put into operation in 2005, is now the third biggest building in the city [5]. The most characteristic feature of this skyscraper is its oval shape tapering towards the peak, and topped with a dome, as well as its exceptionally sophisticated aesthetical and technological elevation. The well-balanced characteristics of the building, based mainly on the bioclimatic energetic concept, made the office block shape both its external relations with the natural environment and the internal functional conditions in an exceptionally sensitive and optimal way. One of the most important elements of the whole system is the multilayered elevation of the building. Its main load-bearing wall was made in the reinforced concrete technology (50–30 cm thick). Its 'surface without the beginning and the end' includes about 4400 square, abstractly arranged windows. [6] The outer surface of this wall is covered with a ventilated facing of red and black fine-wave metal sheets. A system of horizontal blinds made of transparent and matt glass is placed about 80 cm under its surface. The blinds react appropriately to the changing weather conditions, disrupt the sharp shapes of the windows and soften and blur the color boundaries of the wave facing.

a) b) c)



Ill. 2. AGBAR Tower: a) night view, b) view of a fragment the facade, c) facade section (photo by W. Radwański, drawing source: El Croquis 112/113, Jean Nouvel 1994–2002, Madrid 2002)

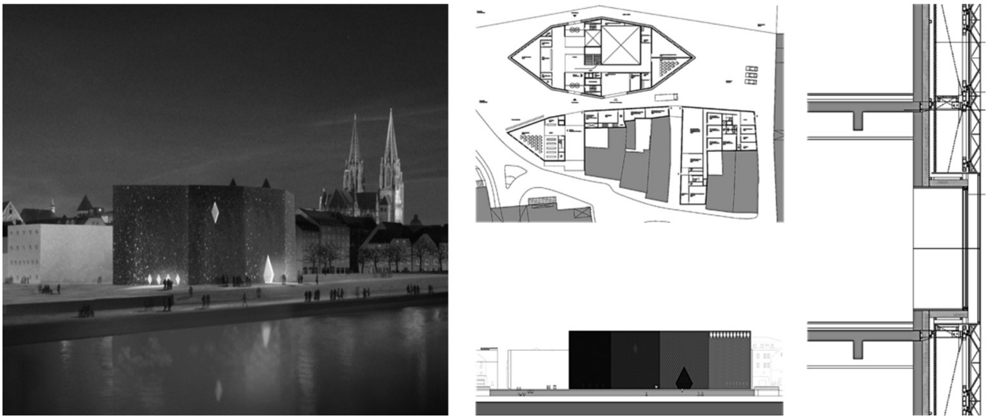
Regulation of the airflow and natural ventilation by the multilayer structure of the dome additionally contributes to a reduction of temperature in the whole building. The incorporation of these elements into the central control and energy management system, facilitates the whole cooling and ventilating system optimization, which significantly improves the energetic balance of the skyscraper [7]. This structure, constituting a very exceptional example of a building shaped by the concept of balanced bioclimatic development, that 'every day wakes up to life' just after dark, offering the inhabitants of Barcelona a spectacular and sophisticated show. Sending bright signals to the city, this building very effectively attracts attention of all those who take part in the city's nightlife. Since its construction, the AGBAR Tower has been honoured with numerous prestigious awards, most of them for the innovative way of combining art, technique and nature [8].

A new international architectural competition for a new seat of the Museum of Bavarian History [Neubau Museum der Bayerischen Geschichte (MdBG)] was announced in 2012. The building is to be constructed in the next couple of years in Regensburg. Unofficial materials published in the local media informed that before the final decision to place the museum in the former Ratisbonne was made, the city authorities had for several years been competing with other centres such as Munich, Nuremberg or Wurzburg.

Because of the existing historical buildings in this area, the plot designated for constructing this building is of quite irregular shape. Searching for information extending the scope of knowledge about Bavarian history, we have come across e.g., materials regarding the history of the Wittelsbach dynasty, which had reigned in Bavaria since 1118. Among numerous interesting pieces of information, there was also mention of one of the largest and most precious diamonds ever named after a dynasty, the Blauer Wittelsbacher. In this way our new building MdBG became an architectural metaphor for this Bavarian crown jewel and the octagonal heart of the geometric structure of the drawings of the Wittelsbach's blue Diamond's cut, gave the shape to the building's design.

The concept of the facade of this building constitutes a consistent development of the idea of integrating the blue diamond into the world of architecture. Its main element is a reproducible, spatial, one-compartment panel of acrylic glass in the shape of a truncated

a) b) c)



Ill. 3. Museum the History of Bavaria (MDBG), Competition Project, D. Radwanski, J. Muszyński, T. Berezowski, P. Fojcik

rhomboidal pyramid which is installed on a steel grill 110 cm distant from the building structure. A wall made of reinforced concrete is covered with a 20-centimeter layer of polyurethane and a sky-blue wave metal sheet, is spread across its own grillage. A lighting system was constructed in the 90-centimeter empty space separating the outer surface of the metal sheet from the inner surface of the glass panels. The light, directed towards the wavy surface of the blue metal, makes the reflected, diffused rays of blue light penetrate the transparent space of the glass panel of the facade, resulting in the whole building emanating a blue glow.

Rivalry is an important part of human nature and the physical image of the world which we have created over thousands of years and in which we now live is largely its result. Since the Neolithic Revolution buildings have been an important field of manifesting this feature. At the turn of the 20th and 21st centuries, in the period of clear acceleration of globalization processes, buildings significantly strengthened the status of marketing material, increasingly aspiring to the title of the symbols of states, regions, cities, districts, companies and corporations. The synergy of the latter and representing all the trends of modern architecture, design studios aspiring to this title have made it possible over the last two decades to implement plenty of exceptional projects, a huge part of which stuns with innovative aesthetic and formal quality of the facades. On the 2nd April, 2001, two Swiss architects: Jacques Herzog and Pierre de Meuron received the Pritzker award. During the ceremony the president of the jury, J. C. Brown said, “It’s hard to find other architects in history who turned towards the outside, the skin of the building with such great imagination and such virtuosity” [9]. Twelve years after that event we may certainly say that the superposition of the facade in architecture at the beginning of 21st century seems to be firmly established.

References

[1] Wheeler A., *Designing Brand Identity: A Complete Guide to Creating, Building, and Maintaining Strong Brands*, John Wiley & Sons 2006.
[2] Kaika M., *Architecture and crisis: re-inventing the icon*, re-imag(in)ing London and re-branding the City, 453-472.
[3] Alcelor Mittal (http://www.constructalia.com).
[4] Foster and Partners (http://www.fosterandpartners.com).
[5] Torre AGBAR (http://www.torreagbar.com).
[6] PERI (http://www.peri.es).
[7] El Croquis 112/113, Jean Nouvel 1994–2002, Madryt 2002, 238-251.
[8] Jena Nouvel (http://www.jeannouvel.com).
[9] Leśniak D., *Pritzker 2001 dla Herzoga i de Meurona*, Architektura & Biznes, 2001/5, Kraków 2001, 12–15, [by:] Press Service The Prizker Architecture Prize.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

SARAH SHANGEREEVNA SADYKOVA*

AVANT-GARDE TENDENCIES IN THE DESIGN AND CONSTRUCTION OF CONTEMPORARY ISLAMIC COMPLEX BUILDINGS IN KAZAKHSTAN

AWANGARDOWE KIERUNKI W PROJEKTOWANIU I BUDOWANIU WSPÓŁCZESNYCH OBIEKTÓW KULTURY ISLAMSKIEJ W KAZACHSTANIE

A b s t r a c t

This article considers the current problems of modern tendencies in the formation of the architecture of new mosques in Kazakhstan. The boldest inclinations in the architectural designs of contemporary Islamic cultural buildings by Sh. Yusupov, T.S. Abilda, Zh.N. Sharapiyev and N.S. Tokayev are described. Pioneering trends are defined on the basis of the architectural image and a planning analysis.

Keywords: architecture, architecture of new mosque

S t r e s z c z e n i e

W niniejszym artykule przedstawiono bieżące problemy współczesnych kierunków tworzenia architektury nowych meczetów w Kazachstanie. Opisano w nim najodważniejsze tendencje w projektach współczesnych budynków kultury islamskiej autorstwa takich architektów jak Sh. Yusupov, T.S. Abilda, Zh.N. Sharapiyev czy N.S. Tokayev. Pionierskie trendy oparto na wizerunku architektonicznym oraz na analizie planistycznej.

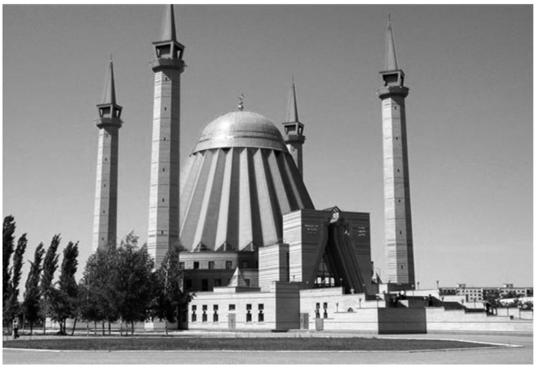
Słowa kluczowe: architektura, architektura nowego meczetu

* Prof. D.Sc. Arch. Sarah Shangereevna Sadykova, Faculty of Architecture and Construction, L.N. Gumilev Eurasian National University, Astana, Kazakhstan.

The architecture of contemporary mosques of Kazakhstan is evolving in a strong competition of extraordinary tendencies. These mostly follow different historical styles. Influenced by the objective processes of social development and the progressive dissemination of ideas, pioneering tendencies appear in the architecture. Constantly changing construction structures reveal an inexhaustible potential of perspective development and emotional richness of the mosques' architecture. Traditional techniques of the decoration of religious structures are no longer applied. Having persisted through the struggle with eclecticism and traditionalism, new tectonic principles have arrived. Rational forms of the architecture of religious buildings based on the artistic understanding of new constructive systems, express those principles.

The objects of such famous architects of Kazakhstan as S. Zhusupov, T.S. Abilda, Z.N. Sharapayiev, N.S. Tokarev represent the boldest tendencies in contemporary Islamic architecture.

The Mashkur Zhusip mosque in Pavlodar [5], designed to serve 1500 visitors at a time and built in 2001, demonstrates an interesting, avant-garde approach. The authors of the mosques's project are architects T.S. Abilda, S. Zhusupov, M.Z. Kabdualiev; the chief engineers were B.K. Musurgaliev, as well as ASO-3 and "Almatygiprogor" Ltd companies. The customer was Pavlodar Head Mosque and a branch of the religious association "Ecclesiastic management of the Muslims of Kazakhstan" (Ill. 1).



Ill. 1. The Mashkur Zhusip mosque in Pavlodar (source: [5])

Ill. 2. Tastak micro district mosque in Almaty (source: [6])

The mosque has an octagonal layout and consists of three growig narrow parts, holding the plicate conical roof and crowned with a dome. The roofing of the mosque is the building's aesthetic focus. In the four corners the building are four minaret towers, crowned with pointed tops in the Ottoman style. The building of the mosque has three floors and one underground. The main volume of the mosque's layout is taken up by the space under the circular dome, 31 meters in diameter and 41 meters high. Sixty-four meter high octagonal minarets can be inscribed into a 5 meters in diameter circle at +0.000 level. The height of the minaret towers was not taken occasionally and symbolizes the prophet Mohammed's age.

The mosque is an example of a multi-functional building, which makes it stand out among the new religious buildings of Kazakhstan. The ground floor of the mosque has an area of

2850 square meters and houses the following rooms: madrash for 25 people, consisting of four blocks, female prayer hall, a bathroom, a hall for wedding ceremonies with a lobby, wardrobe room and toilets. The first floor of 1810 square meters includes the main prayer hall, imam's rooms, reception hall, a room for reading the Koran, donation giving room, the Museum of Islamic culture, the library, a video – conference hall, the mihrab and utility rooms. The second floor is a circular gallery of 660 square meters housing the male prayer hall. The project of Pavlodar mosque is distinguished for its extraordinary constructive resolution and applied innovative construction technologies. The mosque is built with the partial inclusion of a system of frameworks. The pillars of the framework are placed at the intersection of the inner ring and radial axes. Exterior walls are concrete bellow 0.000 level and brick above the ground level. The bearing walls hold the metallic and ferroconcrete radial beams. The framework's overall stability is provided by the radial and circular placement of the bearing frames. The transfer of the horizontal wind load upon the framework is maintained throughout the construction of the hard discs, ferroconcrete floors, the anchored connection between ferroconcrete pillars of the framework with building's foundation and the construction of a central supporting ferroconcrete beam at the base of the metallic structures of the dome. The floors of the mosque are made of assembled ferroconcrete 12 centimeters-thick plain slabs. The dome is made of metallic structures. The external surface of the dome is made of 3 millimeters-thick metal plates with a covering and a layer of "ISOVER" heat-insulation on the inner side and covered with plaster on the interior part. The roofing is made of 4 millimeters-thick steel plates and is supported on metal pillars and wells. The external surface of the mosque's walls and dome is faced with aluminum composite panels.

The Pavlodar Mosque is an overall positive example of the new Islamic cultural building formation in present day Kazakhstan. It does not imitate traditional mosque shapes, but it is rather a contemporary interpretation of them. The authors have created a bold, pioneering and unique aesthetic image of the mosque, using national traditions.

Another project showing the new tendencies in the mosque's image is a mosque in Tastak micro distrist in Almaty [6], designed for 100 visitors at a time. The author of the project is architect Zh.N. Sharapiev, the chief engineer was V.V. Grebenev (also"Almatygiprogor" Ltd. and "ASO-4" companies).

The mosque has a square layout of 16.8 meters on each side. The mosque's overall area is 327.72 square meters. By its volumetric composition, the mosque relates to the centralized dome building. The mosque includes the following venues: the prayer hall (131.97 square meters at 0.000 mm.level), bathrooms (25.13 square meters) and utility rooms (64.42 square meters at – 3.000 mm. level) (Ill. 2).

The volumetric composition of the mosque is quite laconic and embodies a cubic structure of a prayer hall covered with a hipped roof, which is the main outstanding element of the building. The mosque also includes a four-tier single minaret tower, which paired with the hipped roof of the mosque, demonstrates the new approach in mosque's design. The design approach here is analogous to one in King Feisal's mosque in Islamabad (1970–1986, arch. Vedat Dalokoi).

All entrances to the mosque including the main one are designed in the form of overhanging sheds in the image of an arrow. The light in the prayer hall is provided by windows of rectangular shaoe located in the roof. The mosque wall structure is a ferroconcrete framework with a filling of bricks. The basement walls are made of monolith concrete.

The roofing structure is metal framework covered with green seismic-resistant tiles. The walls of the minaret tower are made of monolith concrete, and the tower is crowned by a small spherical dome sitting on a metal framework. The architecture of the Tastak micro district mosque in Almaty represents one of the few examples of the new approach to traditional, canonic architecture. The new approach was reflected in the unusual resolution of the roofing and facade.

The new Islamic cultural center "Nurdaulet" in Aktobe, is an example of the harmonic synthesis of traditional and new approaches in mosque designing. The Islamic center is an asymmetrical composition of rectangular shapes of the prayer hall and utility part of the building. The mosque has added the grandeur and dynamism by its volumetric composition, consisting of several growing tiers of shapes. Such structure is characteristic of middle-age Ottoman mosque models (e.g., middle-age mosques in Sianna, Turkey). Two large semi-spherical domes on top of the building are the focus of the mosque. Their dominating role in the mosque's composition is accentuated by the sx small domes on the tops of short towers. The mosque has large windows with a large area of glazing, giving the mosque a modern look (Ill. 3).

3

4

Ill. 3, 4. Islamic cultural centre "Nurdaulet" in Aktobe (source: [7])

The four-tier minaret room form reminding the ones of middle-age Egyptian mosques is a contrast against to the building's modern fasdes and domes' design. Thus, the image of "Nurdaulet" Islamic cultural center in Aktobe combines traditional and modern approaches to mosque designing, giving the mosque an overall contemprorary look. Another example of the modern approach to mosque design is the Vainachs' community mosque, built in 2001 in Almaty's Ryskulov avenue. The mosque was designed for 600 visitors at a time by the architects T.S. Abilda and Sh.Z. Yusupov. The engeneer in chief was A.P. Martynov. Construction of the mosque was initiated by the Vainach's community of Almaty. The mosque's architecture is an example of the synthesis of the new and historic architecture. The seven domes of the mosque recall the middle-age Ottoman mosque's images and cogged eaves of the mosque's roofing and the buildings's asymmetric composition is characteristic of Egyptian mosque architecture. In the latter, architects did not aspire much to symmetry, locating the entrance in one of the building's corners and not marking the portal to the planes of the facades.

The interior design of the Vainach's community mosque includes a system of some of the historic symbols, yet it looks modern. The mosque's contemprorary look was intensified

5

6

Ill. 5, 6. Vainach's national community mosque in Almaty (source: [8])

by the modern plasticity of the facades' few elements, the form of the minaret and by the contemporary finishing agents applied (Ill. 4).

A new and a positive element in providing comfort to the mosque's visitors is the floor heating of the main and female prayer halls as well as the bathrooms. The bathrooms in the mosque perform an important role in fullfilling Muslim rituals and the floor heating facilitates their use in the climatic conditions of Kazakhstan. Modern video eqipment is used in the mosque`s female prayer hall for broadcasting Friday and other feasts' prayers there in.

The landscape of the mosque's territory is well organized. The pathways are paved, and some rare tree breeds and flowerbeds are planted on the site. In front of the mosque's main entrance, a traditional octagonal fountain is located. A small summerhouse for the visitors' recreation is one of the garden's focal points. The Vainach's community mosque relates to the modern type by its design despite of the precence of traditional symbols of the mosque's architecture, such as the domes and the minaret. The building overall represents the pioneering approach in the mosque's new architectural development in Kazakhstan. The architecture of the considered mosques demonstrates a general positive shift in search of the mosques' new architecture in Kazakhstan; although, the search process is complex and varied.

Conclusions

An analysis of the architecture of new mosques' in Kazakhstan indicates two main tendencies in the choice of the religious building's new image:

– The stylization based on the contemprorary interpretation of the system of Islam's historic symbols represented by domes, the roofing and decorative elements.
– The revision of the mosque's architectural, constructive and volumetric composition features in modern conditions, taking into consideration the style of established regional architecture.

References

[1] Yusupov Sh., A new mosque of Atyrau, Kumbez, 9 (10), 2001–2002, 22-23.
[2] The overall architecture history. The architecture of Mediterranean countries. Africa and Asia of 6–19 centuries, Moscow, Stroyizdat, Vol. 8, 1969, 490.
[3] A mosque presented to the city, Kazakhstanskaya Pravda, 6th September 2003, 6.
[4] Yusupov Sh., Yusupov R.,. The Yusupovs. A creative dynasty, Kumbez 2003, 64.
[5] www.artfile.ru
[6] infokz.com
[7] awaytravel.ru
[8] mecheti.azan.kz

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

BOGDAN SIEDLECKI*

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

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

A b s t r a c t

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

S t r e s z c z e n i e

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.

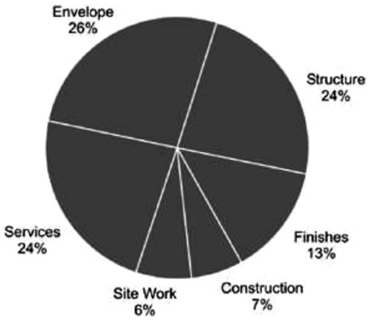
Słowa kluczowe: budownictwo, technologia, elewacja

* 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.



Il. 1. Average Total Initial Embodied Energy 4.82 GJ/m^2

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[1] and the differences between them and in this regard, are presented in the table below.

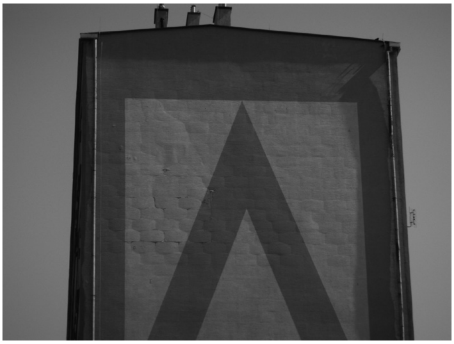
[1] According to data Department of Resources, Energy and Tourism, GPO Box 1564 CANBERRA, ACT 2601.

Material	[MJ/kg]	[MJ/m^3]	Material	[MJ/kg]	[MJ/m^3]
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^{2}K. So a heavy and massive window requires special reinforcement for its frame and sash. Morover, 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.

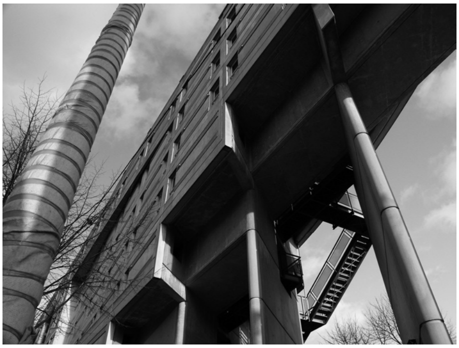


Ill. 2. The defects of technologies and execution (photo by B. Siedlecki)

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

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

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



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

Ill. 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.

A b s t r a c t

[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.

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

MICHAŁ SITEK*

THE IMPACT OF NEW AIRPORT PASSENGER SERVICE TECHNOLOGIES ON THE SHAPING OF TERMINAL BUILDING LANDSIDE AREAS

WPŁYW NOWYCH TECHNOLOGII OBSŁUGI PASAŻERA PORTU LOTNICZEGO NA KSZTAŁTOWANIE PRZESTRZENI STREF „LANDSIDE" W BUDYNKACH TERMINALI

A b s t r a c t

The changes that are taking place in the airport passenger service technology allow for the increase of passenger traffic in terminal buildings. Novel technologies in identification, check-in and security control in passenger service areas impact the way architectural spaces are being shaped. This article describes an algorithm for analysing a terminal building space with respect to passenger service area standards, taking into account new technologies and through put-change assessment.

Keywords: airport, terminal, capacity, technology, passenger

S t r e s z c z e n i e

Zmiany zachodzące w technologii obsługi pasażera portów lotniczych umożliwiają zwiększenie przepustowości obiektów terminali. Nowe technologie identyfikacji, odprawy bagażowej i kontroli bezpieczeństwa w strefach obsługi pasażera zmieniają sposób kształtowania przestrzeni architektonicznej. Artykuł jest opisem budowy algorytmu umożliwiającego analizę przestrzeni budynku terminala, w odniesieniu do standardów obowiązujących w strefach obsługi pasażera z uwzględnieniem nowych technologii i oceną zmian przepustowości.

Słowa kluczowe: lotnisko, terminal, przepustowość, technologie, pasażer

* Ph.D. Eng. Arch. Michał Sitek, Faculty of Architecture, Silesian University of Technology in Gliwice.

1. Introduction

Passenger service spaces at airport terminals are founded on technologies. The facilities where the passengers and their baggage pass from the "land side" to "air side" may be divided into zones defined by service tasks performed by the airport personnel. In a classic arrangement, they include baggage and ticket check-in, control of safety and entrance gates from the terminal (through waiting lounge, air jetty, shuttle buses transferring passengers onto the plane deck). Each zone is equipped with the technologies enabling the performance of the service tasks that require the participation of both parties concerned. As far as passengers are concerned, there are different sub-types and categories: travel classes[1], carriers/ airlines, plane crews, privileged passengers (VIPs, special need passengers). At the other side there are carrier's staff, border guards, customs officers, immigration offices, safety and technical service staff such as baggage sorting workers. Both parties are supported by technical systems involving information exchange, enquiries, transport and control. All technologies utilized at the airport terminal need specific installation space, operation and maintenance. To be properly designed, the systems require the definition of specific conditions and maximal values of their operation. In the case of the airport, the value that defines the scale of the complexity of the infrastructure elements is the quantity of passengers (PAX) serviced by the airport per year and at "peak" times. The peaks are specified on the grounds of the maximal number of passengers flowing through the airport in a time unit, such as an annual or a daily peak, irrespective of particular service zones. The number of passengers is very important for programming the size of passenger service zones in a terminal or terminals of the airport. Newly designed terminal facilities must be described in terms of surface area and cubic capacity that secures passenger service at peak times forecasted for many years ahead. The existing facilities frequently reach their maximal throughput earlier that the predicted simulation values and calculations. Therefore, the existing structures require organizational intervention and modernization schemes to look for reserves and to postpone or plan extension investments in due time. Hence, airports strive x to increase their throughput during continuous processes of the optimization of personnel work and technical infrastructure operation in specified architectural space. Airport management often encounters the problem of the necessity of modernization or extension without the possibility of closing down the facilities while maintaining the required throughput.

The passenger service systems at the terminal, involve the zones supporting the work of the personnel. According to the above description of the zones, the following types of technologies may be distinguished:

- for the baggage and ticket check-in information systems (terminal access to databases of airlines), baggage service system (weighing, identification, transport to baggage stock) and the information system for identifying the destination check-in stand,
- for the safety control zone information system supporting the technologies of identifying threats, scanning and screening equipment (usually the magneto-metric gates for personal passenger check and hand baggage screening),

---

[1] Passenger classification depends on the service standard of economy, business and first classes. The classes are defined by the standards set forth by International Air Transport Association = IATA).

- for the boarding gates information system (terminal with access to the databases of airlines) and destination gate identification.

Each of these systems must be integrated and embedded in the terminal building space. The presented equipment options may be evolutionarily different in a wide range of functional models, especially as far as the safety control zone is concerned, where various models are applied[2], for example:

- safety control at the Boarding Gate before entering the airplane deck (without departure lounge),
- safety control before entering the departure lounge in the so called "Holding Area",
- safety control before the hall leading to the check-in gates in the so called "Concourse Area (centralized system).

Manufacturers of furnishings, technical and informational equipment for airports are working on new ranges of products to provide user comfort, reliability, flexibility and increased efficiency. The introduction of new technologies and their elements, requires spatial adjustments involving refurbishing works, reorganization of the existing space, extension and construction works to enhance the flexibility of the space that has become inefficient and technically inadequate. New products entail new forms of use. For the baggage and ticket check-in zone, they may include self-check in stands/kiosks and "self bag-drop solutions".

2. Kiosks/Stands

Kiosks are multifunctional systems. Their main advantage is the option of increasing the number of ticket check-in stands and accelerating the activities associated with the service of departing passengers. An additional benefit for the airport and airlines is the possibility of staff downsizing and consequently, employment costs reduction. The kiosks enable a wide range of service activities and their functionality depends on the installed system software, which may be easily and conveniently updated and remotely controlled at nighttime without significantly hindering the efficiency of the system. The kiosks enable a number of tasks:

- departing passenger identification (on the bases of passport data, reservation code or other information),
- confirmation of reservation for a selected flight with options for changes planned by the airline for given reservation types,
- printing of the boarding pass,
- obtaining the information on the departure, gate number, boarding time and other activities to be performed before passing through the successive service zones,
- availability of a wide range of information and service activities (internet access, xx hotel booking, transport reservations, banking services, etc.).

---

[2] *Currently there are no rigid rules obliging design architects or airport management to use uniform schemes, or safety control models. The crucial obligation is to subject the passengers and their baggage to safety checks before boarding the plane. Accordingly, there are several "safety control structures"* – Piotr Uchronski, *Wpływ infrastruktury terminalowej na ochrone lotnictwa cywilnego (influence of the airport terminal infrastructure on civil aviation protection)*, Silesian University of Technology 2011, Transport, 72/1860

The range of services offered by the kiosks depends on the software and additional equipment such as printers or other I/O options (credit card readers). The installation of the elements making up the system of the kiosks, requires access to the infrastructure of the facility and appropriate spatial layout with extra space for users. The space provided for one kiosk should secure free accessibility and a guarantee of minimal privacy in the course of using the system. The spatial layouts of the kiosk installation zones (Ill. 1) are conditioned by the dimensions of the space selected from the classic waiting hall and communication in the direct vicinity of the baggage check-in.

Ill. 1. Kiosks at the international air port in Hong Kong (source: http:// upload.wikimedia.org, author: Mike Goch, Creative Commons license)

Ill. 2. Scan&Fly baggage service system – identification and marking of the baggage is done by the passenger. One of the advantages of this system is easy integration with the existing check-in stands (source: advertising materials of Scan&Fly, http://www.scanfly.aero)

3. Baggage service systems

Baggage service systems are developed towards shifting the moment of baggage transfer from the passenger at the early stage x of boarding the airplane, to reduce the check-in time at the airport. Currently available systems of baggage transfer are available at three travel stages:

- before starting air travel in the departure city at the selected “check-in” points, usually situated at public transportation junctions such as the railway station and communication line to the airport,
- at the car parking lot in the “airport city” before reaching the terminal,
- upon arrival to the terminal.

Each of the above may function on the grounds of classic “check-in” solutions with the participation of the airline or supported by innovative automatic self-service systems. The two examples discussed in the paper differ in the manner of interference with the existing infrastructure of the airport.

The Scan&Fly (Ill. 2) system operates the most important functions concerning baggage, enabling passengers to mark their baggage with an identification number, to print the boarding pass, scan, read and compare the data on the baggage identification card and the boarding pass, and make excess baggage limit payments. The system is easy to operate and is integrated with the existing baggage receipt system already functioning as classic "check-in" stands, for example: Rotterdam, The Hague.

Ill. 3. ALSTEF baggage control system – the identification and marking of the baggage is performed in a self-service manner. The system requires adjustments, re construction and architectural design of "check-in" to meet new solutions (source: ALSTEF advertising materials, http://www.alstef.com)

Ill. 4. Scanning gate, system ProVision® 2 (source: L-3 Communications Security and Detection Systems advertising materials, http://www.sds.l-3com.com)

In another of the discussed systems (Ill. 3), a solution is dedicated to the newly constructed terminals or "check-in" zones subjected to profound modernization, integrating stand, self-check identification and baggage transfer at the airport. Such solution modules can perform all basic tasks and initial safety assessments of the deposited baggage. See Paris Orly West Terminal operating since 2011.

4. Personal control zone

The safety control zones are equipped with complex information and technological systems supporting the tasks of identifying the threats to which airplanes, passengers and crews are exposed during the flight. The threats involving bringing hazardous objects onboard may be reduced by advanced threat detection techniques. After several acts of terrorism, international aviation organizations and agencies of the countries that are particularly exposed to such terrorist attacks have undertaken efforts to improve the standards in the areas of implementing new methods of detecting and identifying objects, materials, substances and devices that may constitute elements of explosives or weapons used for attacking the plane crew or the passengers. The events of 09.11 have evoked many discussions on techniques and methods of personal control, leading to public debates on the infringement of personal rights as a result of too detailed screening of passengers in the course of passport and border control procedures.

The majority of the existing control zone types operate on the basis of the scheme presented in Dr. Antonio A. Trani "Advanced Airport and Airspace Capacity" seminar materials [1].

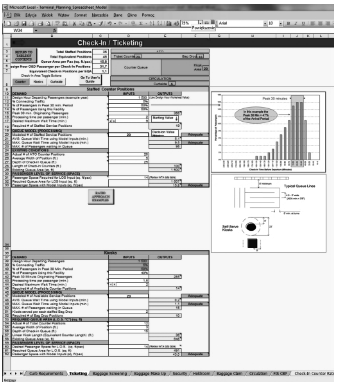
Similar sources designate different values of the surface area destined for organizing one control stand. The required space ranges from $36m^2$ to even $130m^2$. Surely, by introducing new technologies and optimizing the time required for verifying safety hazard, in the course of passenger passage through the control zone, the objective is to achieve the throughput of the system at the concurrent reduction of the demand for the space where the task is performed. The scanner presented in Ill. 4 is characterized by a high efficiency of hazards detection and their instant identification with simultaneous restriction of the information on the personal features of a passenger that undergoes the verification. Such solutions minimize the space required for the performance of personal control tasks and eliminate additional processes involved in the passage through magneto-metric gates, resulting in time reduction and possibility of compacting the number of check stands, which in view of the absence of spatial reserves at terminals, increases the throughput.

5. Algorithm

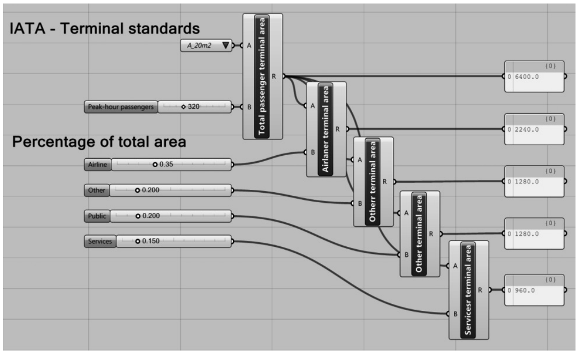
The search for methodologies of programming the size of the functional zones of airport terminals has been spurred by the problem of processing statistical and computational information to the form of graphic representation in terms of a simplified model of an object in a linear system. Accordingly, the author utilized a widely applicable tool to construct an algorithm for testing various options of detailed architectural solutions and design decisions. The possibility of testing various partial solutions, should enable changes in the results of calculating the throughput of the terminal in relation to its size, with specific consideration of the passenger service zones. The tests of the solution are based on the following tools:

- Input data in the form of numerical information on the infrastructure, standard and estimated throughput of the terminal are calculated by means of the Terminal Planning Spreadsheet Model (Ill. 5) devised by Transportation Research Board of the National Academies under the framework of the Airport Cooperative Research Program, sponsored by the Federal Administration of the USA Aviation, Report No. 25, Volume 2, 2010, supplemented by the devised calculation tool and made available to all stakeholders.
- The algorithm importing the input data contained in the calculation model is processed in the Grasshopper environment. The tool is currently developed by the author to be applied for transforming the numerical data to optional forms on the bases of given geometrical representation criteria and their arrangement in mutual spatial interrelations (a part of the devised algorithm– analysis of the size of the functional zones in relation to IATA standards and the number of passengers at the throughput peak (Ill. 6).
- CAD – Rhinoceros, version 5.

The entire elaboration is currently prepared and shall be based on a case study reusing the numerical data on one of the regional EU airports. The conducted experiments of processing the numerical data into their graphic representation are utterly simplified diagrams of the functional zones of a linear system of an airport terminal. The next step is to devise more detailed solutions for specific zones of the terminal and to test the elaborated solutions in view of the theoretical model relation and in-situ observations of the existing terminal.



Ill. 5. Spreadsheet for Check-in zone, a part of ACRP – Terminal Planning Spreadsheet Model (source: elaborated by the author)



Ill. 6. Fragment of the calculation algorithm (source: elaborated by the author)

6. Conclusions

New technological solutions introduced into the space of airport terminals, should optimize the processes of transferring passengers through different service zones, to achieve economic and organizational benefits and improve the quality of passenger service. More passenger service points increase the throughput of the zone. Nevertheless, to balance the relation between the number of service points and the number of passengers served in a given time unit, tests of the functional efficiency of the system are required. The calculations performed on the grounds of the data provided by manufacturers of the systems, often overestimate their real capacity. Therefore, new solutions are continuously monitored to verify their effectiveness and availability. In consideration of limited space provided for passenger service at airport terminals, new technical solutions enable changes of the factors that are variables in the function of system efficiency. They include:

- Quality of passenger service in space (LOS – Level of Service), described as;
  - surface area of the zone calculated into the number of served passengers,
  - ease of passenger flow through the zones and the so called, “bottlenecks”,
  - waiting time;
- Number of service points,
- Accessibility of service.

Self-service kiosks and self bag-drop solutions have altered passenger service processes, bringing about the following advantages for airports:

- reduction of check-in time, increasing throughput,
- reduction of manned service points, lowering staff employment costs,
- spatial efficiency,
- dispersal of waiting lines.

The introduction of the latest standards, is often hindered due to psychological resistance of users who must learn to use the new solutions. Interaction with service staff is still considered more convenient and safer for many air travelers. Each new technology, when first encountered, tends to evoke discomfort because it requires users to acquire new skills. Passenger service at airport terminals, which involves information exchange, should be uncomplicated. However, limited options of languages for communication with the system is often a barrier for users. The discussed algorithm devised for the analysis should be a very complex model for testing various options applicable to the needs of researchers and users. Its construction and testing is conditioned by the opportunities for collecting the data required for simulations. The expected results should enable a graphic representation of design decisions and modifications of the arrangement of the terminal space proposed by clients, with special consideration of passenger flow through different service zones.

References

[1] Trani A.A., *Associate Professor of Civil and Environmental Engineering Virginia Tech*, Airport Landside Analysis and Modeling, Advanced Airport and Airspace Capacity Seminar, June, 2002.
[2] Uchroński P., *Wpływ infrastruktury terminalowej na ochronę lotnictwa cywilnego*, Silesian University of Technology, Transport 72/1860, Gliwice 2011.
[3] ACRP (Airport Cooperative Research Program) Raport nr 25, *Airport Passenger Terminal Planning and Design*, Transportation Researche Bard of the National Academies (TRB), 2010 National Academy of Sciences, Washington D.C. 2010.
[4] ACRP (Airport Cooperative Research Program) Raport nr 10, *Innovations for Airport Terminal Facilities*, Transportation Researche Bard of the National Academies (TRB), National Academy of Sciences, Washington D.C. 2008.
[5] ACRP (Airport Cooperative Research Program) Raport nr 68, *Guidebook for Evaluating Terminal Renewal Versus Replacement Options*, Transportation Researche Bard of the National Academies (TRB), National Academy of Sciences, Washington D.C. 2012.
[6] http://www.scanfly.aero, day 28.06.2013
[7] http://www.alstef.com, day 28.06.2013
[8] http://www.sds.l-3com.com, day 28.06.2013

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

ANETA SZYMAŃSKA-STACHURA, MICHAŁ REPELEWICZ*

DESIGN AND ASSEMBLING PROBLEMS ON THE EXAMPLE OF DENVER'S INTERNATIONAL AIRPORT DEVELOPMENT AND THE POSSIBILITY OF SOLUTIONS IN DESIGN STAGE

PROBLEMY PROJEKTOWO-REALIZACYJNE NA PRZYKŁADZIE ROZBUDOWY MIĘDZYNARODOWEGO PORTU LOTNICZEGO W DENVER I MOŻLIWOŚCI ICH ROZWIĄZANIA NA ETAPIE PROJEKTOWANIA

A b s t r a c t

In the paper a process of designing and assembling complicated steel structure is described. The object is a glass roof over the railroad terminal. The object's body makes it impossible to assemble elements of the structure on the building site just having a structural 2D drawing. It was essential to create visual animation illustrating the chronology, in what way the particular elements of the structure should be assembled to achieve the effect assumed by the architects. However, the architectonic form of the whole object was so interesting and valuable that it is worth to destine investment means and time to achieve the desired aim.

Keywords: designing, assembling, steel construction, visual animation

S t r e s z c z e n i e

W artykule opisany został proces projektowania i montażu skomplikowanej konstrukcji stalowej. Obiekt jest przeszklonym dachem nad stacją kolejową. Bryła uniemożliwia „złożenie" elementów konstrukcji na budowie na podstawie rysunków konstrukcyjnych. Niezbędne było stworzenie animacji obrazującej, w jaki sposób należy nasuwać na siebie części konstrukcji, aby osiągnąć efekt założony przez architektów. Jednak forma architektoniczna całego obiektu jest na tyle ciekawa i wartościowa, że warto zainwestować ogromne środki pieniężne i czasowe, aby osiągnąć zamierzony cel.

Słowa kluczowe: projektowanie, montaż, konstrukcje stalowe, animacja

* M.Sc. Aneta Szymańska-Stachura, M.Sc. Michał Repelewicz, Faculty of Civil Engineering, Cracow University of Technology.

1. Introduction

Imagination and creativity of the architects has no limits and modern engineering tries to keep up with them. More and more often structures are erected that until recently we all could only dream of. Construction engineering moves with time and structures are no longer erected on the basis of drawings, but thanks to animation.

On the example of the development of the international airport in Denver it can be easier to understand where the modern world is, in possibilities to erect complicated and difficult architectural forms. Engineers and designers (also from Poland) concentrate not only on the project of the structure and assembling its elements, but also on creating animations, on the basis of which particular elements of the structure are "put together" on the building site.

When erecting such a difficult structure as the Denver Airport, apart from the people professionally involved in civil engineering, engineers specializing in quite different branches must have also participated in the project. These were mainly IT specialists whose abilities and knowledge allowed to create an original structure.

2. History

The International Airport in Denver was built in 1995. It caused the closing down of another international airport: Stapleton International Airport. The planned cost was an enormous $1.7 billion yet in the end it rose several times more.

Denver International Airport is currently fifth in the United States in terms of the number of passengers. Up till now, as one of the few in the world, it is not connected with the city by railway.

Thus, when planning the development and extension of the terminal, building a railway line was suggested, with a final station right next to the newly built hotel, which is planned to be an integral whole with the objects of the airport. Within the whole complex a conference centre as well as many trading and service points will be built.

The project was conceived in Gensler, having its headquarters in Denver. One of the designers was Santiago Calatrava.

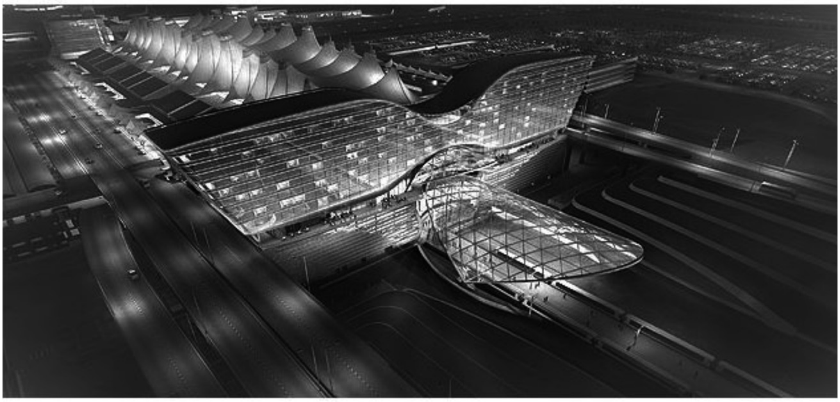
3. Investment Components

The whole complex consists of several parts being separate wholes of completely different functions. A railway arch bridge, forming a symbolic gate, leads to the port. The rails stop just before the hotel building whose solid form reminds a bird with outstretched wings, getting ready "to take off". Over the railway station there is a arch steel arch roof, finished in glass. Over it there is a similar but smaller roof, situated in the central, bottom part of the hotel, forming a smooth visual passage between the railway station and the hotel building.

The extension of the airport takes place in a few stages. The first one was completed in 2012 and included building a railway bridge and a hotel. At present, construction of the railway station and the vaults over it are being realized. The project is to be completed in

2014, and its cost is planned to be $650 million. The next stage will include renovation of the existing terminal (plus $250 million). The whole airport should be put into operation in 2016.

Ill. 1. Hotel and a roof over Railway Station – view at a day – visualization Gensler



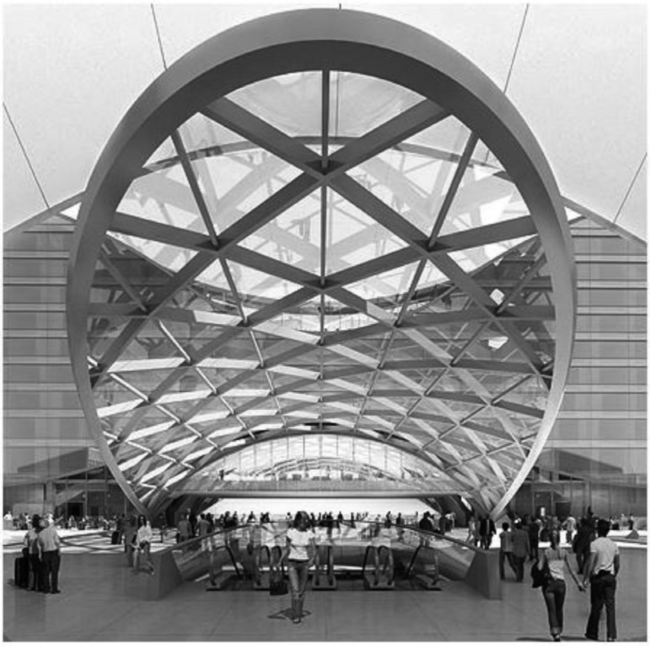
Ill. 2. Hotel and a roof over Railway Station – view at night – visualization Gensler

4. Cooperation when realizing the project

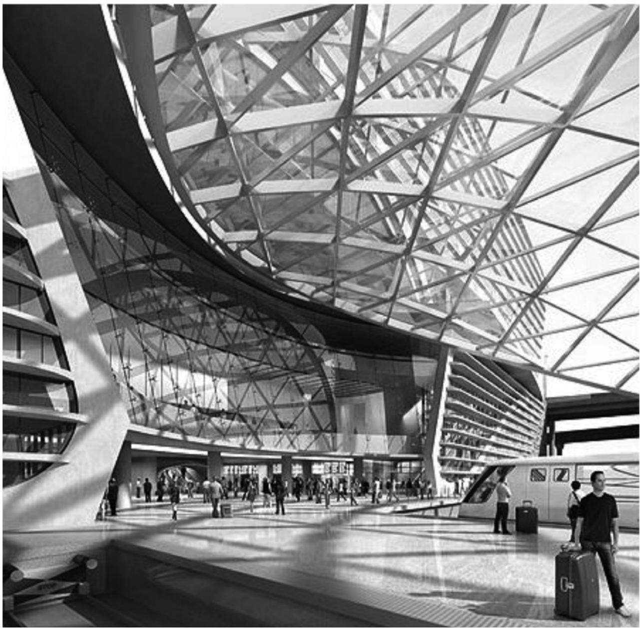
The investment is of great interest because of its architecture, huge dimensions, very high cost and a great number of people (6.6 thousand) involved in completing the project.

In designing a beautiful roof structure over the final railway station were engineers from Cracow Anatomic Iron Steel Detailing office involved. Project documentation is created in Tekla Structures Programme.

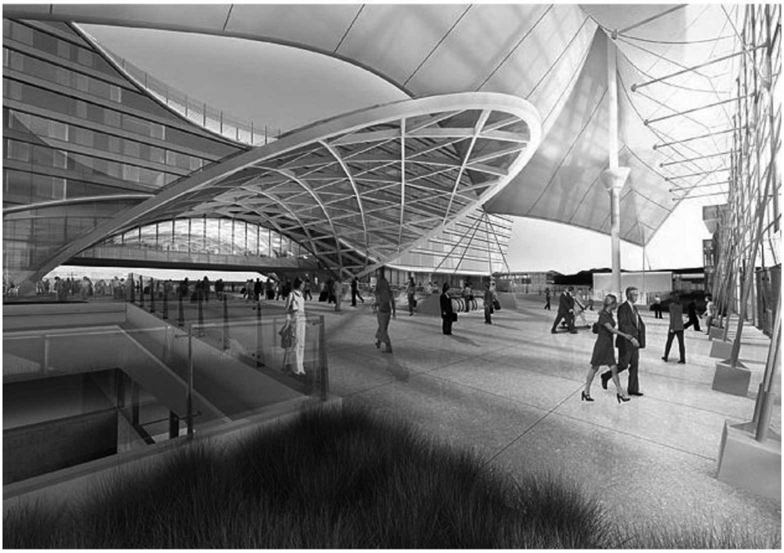
The office is responsible for the load bearing construction of the steel roof. The construction project was performed by engineers from the United States and passed on to Polish designers who were detailing the structure. For example, the three-dimensional model with the solutions of connection details was made by them.



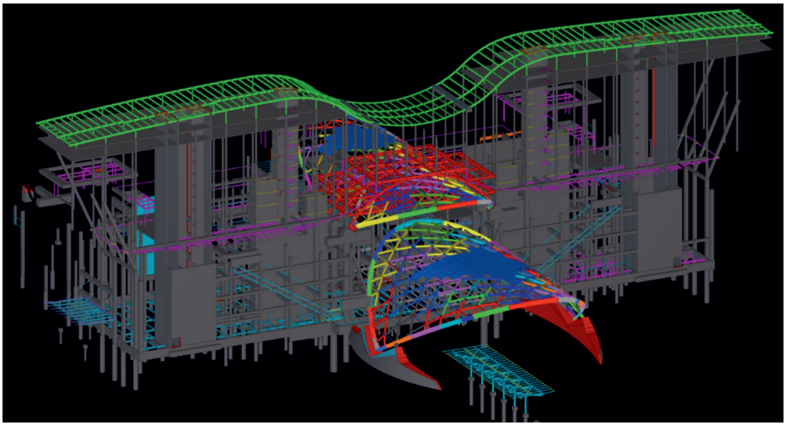
Ill. 3. The final station International Airport In Denver – front view – visualization Gensler



lll. 4. The final station International Airport In Denver – bottom view – visualization Gensler



Ill. 5. The final station International Airport In Denver – side view – visualization Gensler

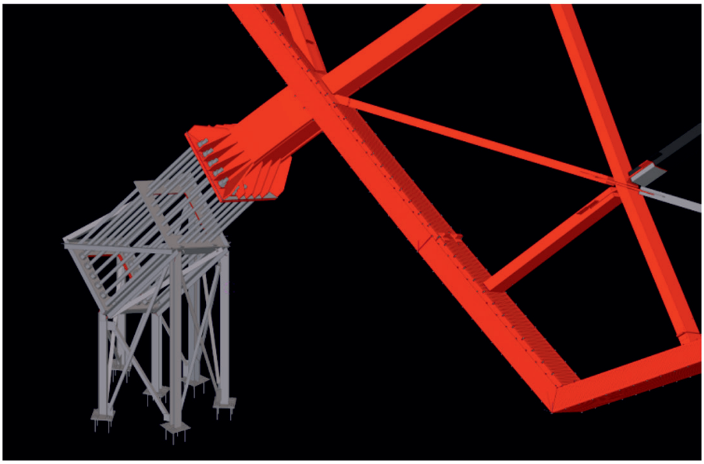


Ill. 6. Computer model of the steel roof structure – Anatomic Iron

5. Modeling and detailing

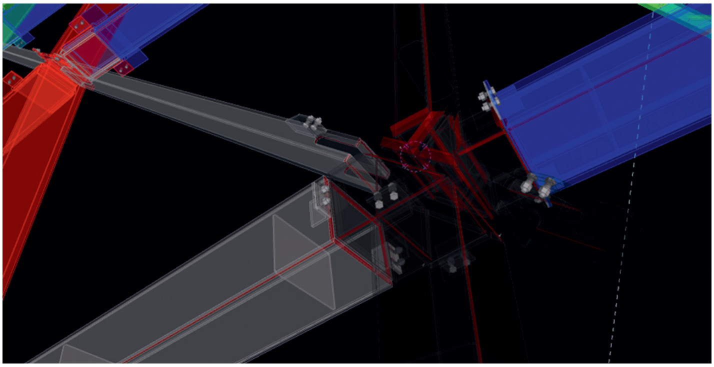
The process of detailing roof construction began by modeling bearing elements of the structure.

The first problem to solve was to fasten the steel structure of the roof to the foundation. The vault is supported on two massive foundation blocks and fastened at four points. The supporting planes are at a proper angle to allow fastening a steel box being an external contour of the solid. The forces exerted on the foundation are caused by a huge steel and glass overhang of arch cross section.



Ill. 7. Anchorage structure to the foundation – Anatomic Iron

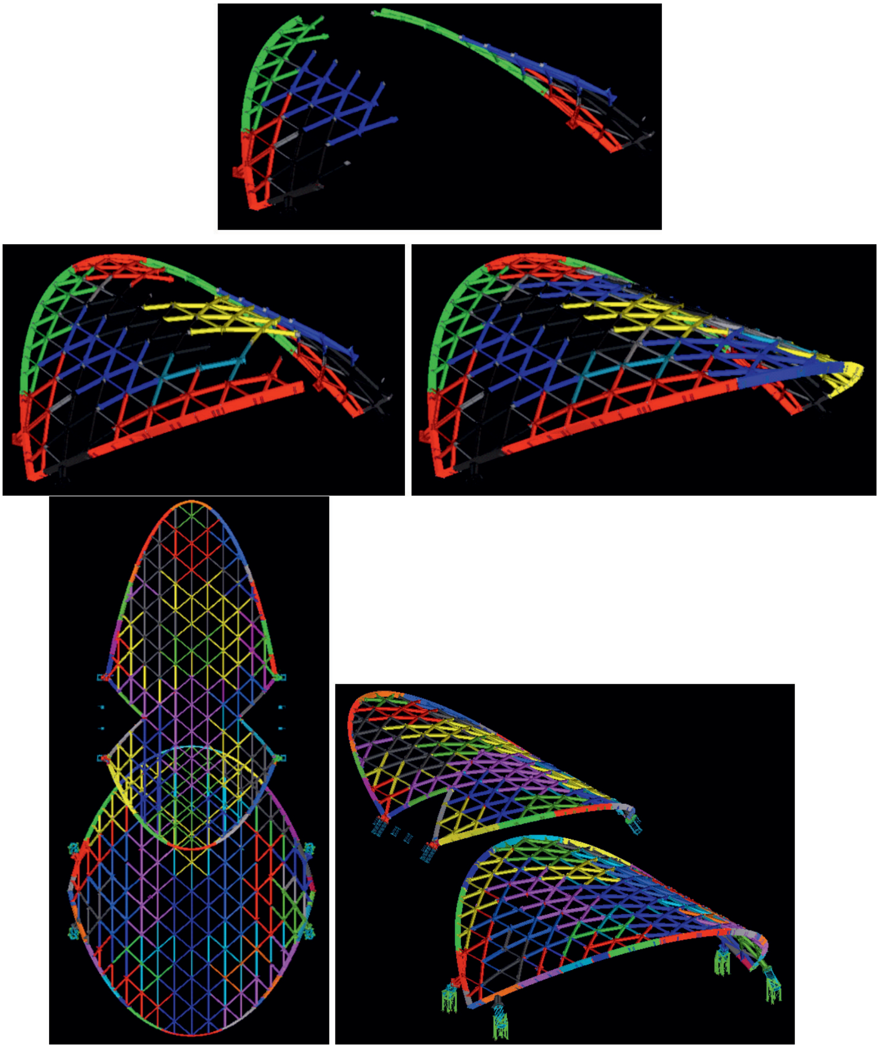
Because of the roof shape each bar is under a different angle. Each joint is individually considered and solved. Just creating a spatial model and checking whether the particular construction points are placed correctly was a great challenge for the Polish engineers. A great help in this was an advanced software programme, among others the Tekla Structures programme. It helped considerably in the designing and structure realization process. The engineers from Poland and the USA had to cooperate at all times. Creating a 3D model in Cracow took place simultaneously with making calculations in Denver. The two teams had simultaneous access to the same virtual model so that they were able to introduce changes (continuous mutual control helped to minimize the number of errors).



Ill. 8. Node – a combination of design elements – Anatomic Iron

Complications appeared when it came to determine the construction schedule. It became clear that the construction cannot be assembled in a random and comfortable way. Each detail of assembling was to be well thought over and planned with a precision rarely met in building today. Each step had to be made according to the previously established rules.

Particular construction parts, suitably cut, bent and prepared for assembling were then joined into modules which were next put together into larger units and assembled onto the earlier prepared elements. The process was to be well thought over, planned and checked. It was necessary not only to determine the sequence and depth of inserting the bars and joints, but also the angle of sliding the modules one over another.



Ill. 9. Installation steps – Anatomic Iron

Construction drawings, which are the basis for each construction work, proved insufficient. It was necessary to create animation, thanks to which the contractor is able to put up the bearing structure. The constructors, making use of Tekla Structures programme, planned and presented what the whole process should look like. Having analyzed it in detail, it appeared that that a change in assembling just one small element may result in making subsequent bar assembling impossible. Then it was decided to create an animation on the basis of which the construction was made.

6. Fabrication

Steel profiles were specially ordered in a steelwork and are produced from high strength steel. Each element is cut, bent and prepared for assembling. The producer received the whole documentation in an electronic version. Thanks to the Tekla programme it is possible to generate all kinds of reports, lists and to compose especially enlarged files. They are compatible with the producer's machines. Owing to such a method each side can check whether the model is correct (3D) and correct mistakes. The precision of designing and realization here is remarkable.

Having suitably prepared particular elements they are joined into larger modules (earlier determined by the designers) on the building site. Such sets are then in their proper order (shown in the film) slid over one another to form one huge whole.

7. Final effect

After having set the modules, welding joints are made. Because of the demands and quality the object must acquire, the welds were worked and ground to make the final effect perfect.

8. Conclusions

The project will be completed in 2014. Then the whole group of Denver International Airport buildings will be opened. With new possibilities and achievements of science (computer programs, modern materials used in construction, development of computers), collaboration of specialists from around the world is possible and its results are structures that could not have been realized before. Assembling of the International Airport in Denver is one of many examples the effects of which bring a combination of experience with modernity and creativity.

References

[1] Anatomic Iron Steel Detailing – Denver International Airport Expansion.
[2] Specification for Structural Steel Buildings (ANSI/AISC 360-10).
[3] http://www.gensler.com

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

JOANNA TYMKIEWICZ*

TECHNOLOGICZNA ESTETYKA WSPÓŁCZESNYCH FASAD

TECHNOLOGICAL AESTHETICS OF MODERN FACADES

A b s t r a c t

The beauty of modern architecture and especially its external image, is achieved by various means, but one can venture to say that real beauty is created only in accordance with the current state of technical knowledge. The author specifies elements which characterize contemporary facade solutions, namely: modern, ecological materials, energy-efficient systems of double glass facades, sun shading devices and multimedia technologies, creating desirable features of facades in the modern world, such as dynamics, movement and information transfer. The aesthetical impact of the elements listed above, as well as their utility functions and relationships with the creation of sustainable architecture, was traced on the example of the Museum of Modern Art Building in Bolzano. Remarks and conclusions contained in the paper are based on the research literature and the author's own observations.

Keywords: double skin facades, media facades, sun-shading systems

S t r e s z c z e n i e

Piękno współczesnej architektury, a zwłaszcza jej wizerunku zewnętrznego, osiągane jest różnymi środkami, jednak można zaryzykować stwierdzenie, że prawdziwe piękno powstaje tylko w zgodzie z aktualnym stanem rozwoju techniki. Autorka wyróżnia elementy, którymi charakteryzują się współczesne rozwiązania elewacyjne, a mianowicie: nowoczesne, ekologiczne materiały, energooszczędne szklane systemy dwuwarstwowe, systemy osłon przeciwsłonecznych, a także technologie multimedialne nadające fasadom cechy pożądane we współczesnym świecie, takie jak dynamika, ruch, przekaz informacyjny. Siłę oddziaływania estetycznego powyżej wymienionych elementów, a także ich funkcje użytkowe i związki z kształtowaniem architektury zrównoważonego rozwoju prześledzono na przykładzie budynku Muzeum Sztuki Nowoczesnej w Bolzano. Uwagi i wnioski zawarte w artykule sformułowano na podstawie badań literaturowych i obserwacji własnych autorki.

Słowa kluczowe: fasady dwuwarstwowe, fasady medialne, systemy ochrony przeciwsłonecznej

* Ph.D. D.Sc. Eng. Arch. Joanna Tymkiewicz, Department of Design Strategies and New Technologies in Architecture, Faculty of Architecture, Silesian University of Technology.

1. Introduction

The beauty of modern architecture is achieved by diverse means, including daring organic forms created with the support of advanced software, for example, the designs by F. Gehry, Zaha Hadid, Daniel Libeskind, or UN Studio. At the other side of the spectrum there are still designs following the trend of modernism, grounded on the simplicity of form and attempts at obtaining perfect proportions of the solid body. The aesthetic effect is achieved by novel technological solutions, the impact of which may be definitely assessed by contemplating structures of pure simplicity, such as a cube. One of the examples of such buildings is the Museum of Modern Art in Bolzano, the "technological beauty " of which, involves the use of several elements typical of modern facades, such as:
– new materials,
– double-skin facades,
– sun shading systems,
– multimedia technologies,

The concept of "technological aesthetics" used in the title of this paper is understood as the beauty achieved by conscious application of the potential of modern technologies and the beauty that has a functional dimension shaped by novel means, which at the same time enable explicit classification of the architectural structure at the time of its construction. This beauty is consistent with the Sustainable Development concept. The building of the Museum of Modern Art in Bolzano, seems to be endowed with such qualities.

2. Characteristics of the building

Museion – i.e., The Museum of Modern Art in Bolzano, commissioned in 2008, was the outcome of the international competition proclaimed in 2001 and won by Krüger, Schuberth, Vandreike (KSV), a design office from Berlin [10].

Due to its specific location, the building is a token of a specific dialogue between the compact historic urban tissue of Bolzano and the modern quarter with its natural environment: the meadows along the Talvera River and the Dolomites. The architecture of the building was to bestow the old city with a new character [9]. The building has the shape of an elongated container (54 m long, 25 m high, 23 m wide) with two glazed walls providing a splendid view of the city and the mountains. Thanks to such a solution, it does not set the boundary between the two environments: the historic and modern surroundings, urbanized and natural space, but to the contrary, merges and intertwines them. Despite the term "container" the Museum is not only a "receptacle for works of art", but a venue for interdisciplinary events, installations, discussions, debates that inspire and entice creative energy, and last but not least, a leisure site housing permanent and temporary exhibitions, a specialized bookshop, educational laboratories, cafeterias, etc. The entire architectural and urban outlay, apart from the main building, includes a smaller workshop facility for artists and two dynamically curved bridges over the river which complement the entire composition [10, 11].

3. New materials

The external image of the Museum of Modern Art in Bolzano is comprised of two types of materials: aluminum and glass. The metal "shell" of the lateral walls and the roof, perfectly discernible from the neighboring mountain range, consists of 4.8 m long and 80 cm wide shinning aluminum panels making up a continuous surface with an irregular pattern of slats, which according to the architectural concept of the designers, refer to the chiaroscuro of Ionic columns [11].

The external laminated panels used in the double-skin facades were selected by Vega Systems (North Italian specialists) in cooperation with architects from the Cattivelli Engineering Office, as DuPont™ SentryGlas® 1.52 thick laminate interleaves (spacers, separators). Standard safety glass, produced from polyvinyl butyral (PVB) interlayers would have to be considerably thicker to provide long-term resistance to the power of the winds prevailing in the Bolzano region. In addition, considering the large dimensions of particular panels (width up to 1.75 m, height up to 2.4 m), expensive supporting structures would be required to withstand the load of the panes and the wind power. However, in comparison with traditional PVB materials, the strength of DuPont™ SentryGlas® is one hundred percent greater (for more details – see [5]), while meeting the requirements concerning the safety of use. Accordingly, the properties of the laminate made it possible to construct relatively thin, 25 m high panes, which even in the sections set diagonally above the users' heads, fulfill the rigid safety requirements and enable good performance of small point slats, supporting the panels in a discreet, but safe manner during high wind power loads. The glazed facades of the building are made of laminated glass compiled in the following sets:

– 12 mm tempered glass, 1.52 mm interlayers, 12 mm thermally strengthened glass in the lower perpendicular parts of the facades,
– two 12 mm thermally strengthened pane surfaces and 1.52 mm interlayers in the upper, diagonally suspended glazed surfaces.

The laminated glass provided with interlayers, renders the performance similar to monolithic glass, even at high temperatures and under direct impact of sunrays. The glazed walls with minimal slats placed at the corners of the glass surfaces highlight the perception of "visual artistry". Other advantages include high transparency, resistance to yellowing, as well as the stability of the edges (thanks to avoiding delamination at the edges of the surfaces), creating a sense of lightness, which is further emphasized by the prevalence of the white exteriors and interiors. Concave front and rear walls made of laminated safety glass strengthen the transparent nature of the building, inviting or even "drawing in" passersby inside [8, 7, 13].

4. Double-skin facades

According to Niezabitowska E. and Winnicka-Jasłowska D.: "Ecological and Sustainable Development concepts have provided the latest link in the evolution of buildings, giving, nowadays priority to environmental protection, care of users' needs and cost-efficiency" [3]. This statement may be referred not only to office buildings, but also to all other facilities, including in particular, the intelligent building of the Museum of Modern Art in Bolzano. The two glazed facades, the eastern and the western, consist of two-layered ventilated parts, separated by a 1 m intermediate cavity, containing a system of movable sun blinds (described in the next section). This interlayer space functions as a ventilation channel; the air is sucked from the top through the covers and directed downwards to the technical rooms located underground. Hence, in order to control the temperature within the facade, the air is supplied to the side of the building that is exposed to the impact of changes in the external environment at given moments. The interior facade is a steel post and beam structure, whereas the external glass facade is literally "suspended" on it by means of slats without any vertical support [11].

5. Sun shading systems

As mentioned above, the ventilated double-skin facades are equipped with movable, mat white sun protection blinds placed in an interlayer space having a double function: to adjust the access of sunlight to the interiors of the art gallery at daytime and to serve as a screen for multimedia projections at night [11].

The sun blinds are divided into sections (each section has 10 blinds) controlled by separate drives and IP address. They may be operated by means of a laptop. It is possible to program different options of the lamellas set-up, depending on the time of the day and the needs of the specific nature of organized exhibitions [6].

6. Media facades

The enclosed metal shell of the elongated lateral walls and of the roof, contrast with the two funnel-shaped light glass facades. Such form would not seem to facilitate the use of the screens displaying films, graphics, photographs and animations customized by design artists for this specific building. Nevertheless, the decision was made to implement such a solution. After sunset, the advanced computer system closes the blinds on the two glazed facades, raises additional curtains used at daytime to shade selected exhibition spaces and activates 36 video projectors located on particular floors [12].

The New building of the Museum of Modern Art in Bolzano utilizes cutting edge audio and visual technologies for the creation of Video Art in urban space. According to the main contractor responsible for the integration of AV system and 3P technology, initially the request formulated by the KSV architects seemed easy: to transform two huge glazed facades of the Museion into multimedia projections screens. However, their architectural form posed a problem, which specifically, was the different angles of the set-up of particular surfaces that constitute the concave funnel-shaped facades. The selection, proper layout and inclination of the projectors enabling even coverage of the facades was a real challenge (for more technical detail, see [6]).

At nighttime the lighted facades dominate the neighboring buildings that fade away in the dark. In the course of testing the assumed technical solutions, a problem of a logistics nature was encountered. As the installation was carried out in April and May, the contractors were forced to wait until dusk to perform the required calibration and tests of the equipment [6].

1

2

3

4

Ill. 1–4. Museum of Modern Art in Bolzano – details of facades (photo by J. Tymkiewicz)

7. Conclusions

The elements combining the facade solutions in the building of the Museum of Modern Art in Bolzano, were presented in the successive sections of the paper, with special focus on some technical and material aspects, their functionality and impact on the aesthetics of the entire building. Some of the discussed features and solutions apply not only to the discussed building, but also should be taken into consideration in shaping the facades of modern public utility buildings, namely:

– **The architectural and urban context**, is a harmonious insertion of the building into the existing urban tissue and/or the natural environment, respect for the cultural values prevailing in a given region, which does not necessarily entail sheer imitation; the discussed building in Bolzano shows a daring and novel approach to the continuity of architecture by erecting among the historic urban structure a simple form that is by no means overshadowed by the formal richness of historic or semi-historic facades of the neighborhood.
– **The simplicity of the external form of the building**, which is a well-proportioned solid and does not stand in any visual competition to subtle technological solutions, does not steal attention from the sometimes detailed façade systems with openwork structure that frequently induce admiration for their visual lightness.
– **Noble materials of the facade**, which similarly to clothing material, shape the elegance of the exterior image of the building endowed with eye-pleasing colors, delicate partitions and texture of the exterior walls (thanks to aluminum panels with funnel-like shape) and perfect quality glass used in the Museion building, reflecting like a mirror, the surrounding landscape; furthermore, the image of the building is subject to change at different times of the day, depending on the weather conditions (for more information on glazed structures, see [1]).
– **Double-skin facades**, make the impression of spaciousness and expose the elements of the supporting structure and technical equipment in the interiors, facilitating their proper performance and contributing to the form as technological details; the decision to implement a double skin facade is very complex, especially in energy-efficiency aspects (you can read more about this problem in [4]).
– **Sun shading systems**, are elements that influence the variability of the form of glazed facades, depending on the time of the day and on the conditions of the external environment, as well as on the current function of the interiors contributing to the explicitly of horizontal partitions and their open or closed character.
– **Multimedia technologies** Although the equipment is installed in the interiors of buildings, their effect is admired in the exterior space; multimedia projections on facades provide direct contact with art in public space on a large scale; such visual media are attention-drawing and evoke continuous interest, shaping the movement, dynamics and changeability of the facades of intelligent buildings (you can see picture of Museion media facade on the website [14]).

These elements pertain to the architecture of Sustainable Development, not only due to their functionality in terms of energy-efficiency, but also due to the presence of people who are the main subject of all activities such as: creation of places that enable the experience of beauty, contact with art and culture, provision of attractive space for leisure, display of novel and innovatory solutions that familiarize the public with modernity in architecture, creation of "the facades of signs", landmarks of a given city and tourist attractions that facilitate orientation in the city [4]. All these aspects providing specific education by means of architecture, may exert an impact on the taste of the public and an open attitude towards new, not always commonly accepted aesthetic solutions.

References

[1] Celadyn W., *Przegrody przeszklone w architekturze energooszczędnej"* (*Glazed partitions in energy-efficient architecture*), Publishing House of Cracow University of Technology, 2004.

[2] Jodidio P., *Architecture now! Museums*, Museion Bozen, Taschen Verlag.

[3] Niezabitowska E., Winnicka-Jasłowska D., *Evolution of the office building in the course of the 20th century. Towards an intelligent building*, Intelligent Buildings International, Vol. 3, Issue 4, 2011, 238-249 (www.tandfonline.com/doi/abs/10.1080/17508975.2011.606361).

[4] Tymkiewicz J., *Funkcje ścian zewnętrznych w aspektach badań jakościowych. Wpływ rozwiązań architektonicznych elewacji na kształtowanie ja kości budynku* (*Functions of the exterior walls of buildings in view of quality analyses. The impact of architectural design solutions of facades on the quality of building*) Publishing House of the Silesian University of Technology, Gliwice 2012, (http://repolis.bg.polsl.pl/dlibra/docmeta-data?id=17876&from=pubstats).

[5] Welle B., Wünsch J., Härth K., *Badania eksperymentalne różnych materiałów stosowanych w szkle laminowanym w charakterze przekładek* (*Experimental studies of various materials used in laminated glass as spacers*) Świat Szkła 2/2006 (http://www.swiat-szkla.pl/component/content/article/1761).

[6] *A modern masterpiece* (www.installation-international.com/c/document_library/get_file?uuid=45087486-a5bf-48b8-80c6-f46327afd7f9&groupId=10402).

[7] DuPont Glass Laminating Products and Project News, *Bolzano's new art museum features a layered facade with minimally supported SentryGlas* (www2.dupont.com/SafetyGlass/en_US/whats_new/sentryglas-bolzano-museum.html).

[8] DuPont SentryGlas Case Study Clear, minimally-supported facade glass adds to the visual artistry at the "Museion" in Bolzano, Italy, (docs.google.com/viewer?url=http%3A%2F%2Fwww2.dupont.com%2FSafetyGlass%2Fen_US%2Fassets%2Fpdfs%2Fbolzano-museum-facade.pdf).

[9] www.bolzano.net/english/museum-modern-art.html

[10] www.ksv-network.de/en/portfolio/architektur/2010-2006/77/

[11] www.modelsystemitalia.it/en/projects_gallery/great_architecture/56-Museion__Bolzano/

[12] www.museion.it/?page_id=677&lang=en

[13] www2.dupont.com/SafetyGlass/en_US/whats_new/sentryglas-bolzano-museum.html

[14] www.domeprojection.com/wp-content/flagallery/museion/museion-bozen-mediafacade-01.gif

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA

7-A/2014

ŁUKASZ WESOŁOWSKI*

THE USE OF GLASS CURTAIN WALLS AS PARTITIONS WITH FIRE RESISTANCE IN RESIDENTIAL BUILDINGS – CASE STUDIES

STOSOWANIE PRZESZKLONYCH ŚCIAN OSŁONOWYCH JAKO PRZEGRÓD O ODPORNOŚCI OGNIOWEJ W BUDOWNICTWIE MIESZKANIOWYM – WYBRANE ASPEKTY

A b s t r a c t

While analysing the available systems of glass curtain walls one can identify potential problems with their use as partitions with fire resistance. In most cases the metal support structure is made of aluminium. Due to its adhesive and separating interlayer made of plastic materials susceptible to the influence of temperature laminated glass, it does not work well in fire prevention. Manufacturers have products with the required parameters to use in fire partitions and qualified in terms of EI. Currently there are post and transom solutions available on the market which possess a certificate to use the whole system in EI60 fire rating. Internal spaces of posts and transoms in metal support structures are equipped with a filling: a reinforcement made of aluminium. Posts, transoms and thermal strips connecting the clamp strip with a support frame and faying surfaces integrating metal structure are subjected to special protection and safeguarding with thermo-expandable material. Additional protection allows for load-bearing parameters of up to one hour on the weakest link in the system. Producers of glass attest their products in classes from E15 to EI 180, so integrity and fire insulation lies within the aluminium support structure in the whole post and transom glass curtain wall system.The analysis of issues related to the use of glass curtain walls in residential buildings will determine the pattern of wall technology selection to the specific fire prevention requirements.

Keywords: fire-rated glass curtain walls, fire protection class of curtain walls, destruction of curtain walls during fire

S t r e s z c z e n i e

Analizując dostępne na rynku systemy szklanych ścian osłonowych, można zidentyfikować potencjalne problemy stosowania ich jako przegród o odporności pożarowej. Metalowa konstrukcja nośna w większości przypadków wykonana jest z aluminium. Szkło klejone ze względu na warstwy klejące i oddzielające wykonane z tworzyw podatnych na wpływ temperatury źle znosi zastosowania z zakresu ppoż. Producenci dysponują produktami posiadającym odpowiednie parametry do zastosowań w przegrodach oddzielenia przeciwpożarowego i kwalifikowane w kategoriach EI. Obecnie na rynku dostępne są rozwiązania słupowo-ryglowe legitymujące się atestem do stosowania całego systemu w parametrach pożarowych EI60. Wewnętrzne przestrzenie słupów i rygli nośnych konstrukcji metalowej wyposażone są we wkładkę – wzmocnienie profilu wykonane z aluminium. Szczególnej ochronie i zabezpieczeniu z materiałem termo-rozszerzalnym poddane są słupy, rygle, listwy termiczne łączące listwę dociskową z profilem nośnym oraz węzły montażowe scalające konstrukcje metalową. Dodatkowa ochrona pozwala na uzyskanie parametrów nośnych rzędu jednej godziny na najsłabszym ogniwie systemu. Producenci szkła atestują swoje produkty w klasach od E15 do EI 180, więc w obrębie całego systemu przeszklonych ścian osłonowych słupowo-ryglowych szczelność i izolacyjność ogniowa leży po stronie aluminiowej konstrukcji nośnej. Analiza problematyki związanej ze stosowaniem przeszklonych ścian osłonowych w budownictwie mieszkaniowym pozwoli określić schemat doboru technologii ściany do konkretnych wymogów pożarowych.

Słowa kluczowe: przeszklone ściany osłonowe do zastosowań pożarowych, klasa odporności pożarowej ścian osłonowych, zniszczenie ściany osłonowej podczas pożaru

* Ph.D. Eng. Arch. Łukasz Wesołowski, Institute of Structural Design, Faculty of Architecture, Cracow University of Technology.

1. Introduction

Architectural and building design is sanctioned by legislation to provide uniform requirements of utility with particular emphasis on the use of the best practices to ensure the safety of people, animals and property. The basic regulation, concerning architectural design issues in Poland is the *Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their location (Dz. U. (Journal of Laws) No. 75, item 690 from 2002 and amended)* describing the technical requirements for walls, joints and brittle structures installed at high altitudes. The regulations also apply to the issue of health and safety for users of glass-walled rooms.

The modern nature of the partition and its share in the potential energy gains cause more and more frequent presence of such solutions in residential architecture. A glass curtain wall must comply with the relevant mechanical parameters as well as being a safe element, also in terms of fire protection. It is described in the following paragraphs of *Technical conditions…*:

"§216.1 Depending on the height of the building, residential buildings and collective dwellings, are to be erected in fire resistance classes ranging from [A] to [D]. External walls – excluding structural ones – have to ensure tightness (E) and fire insulation (I) from 30 up to 120 minutes. By definition curtain walls do not serve a structural function – i.e., they do not carry the load of the roof, acting only as a barrier to external atmospheric conditions. Three-storey buildings are exempt from fire rating – including single family, farm and individual recreation buildings (§213.1.a), residential-administrative in forestry holdings (§213.1.b) as well as detached two-storey buildings with a capacity of up to 1500 m^3 intended for the purpose of tourism and leisure (§213.2.a), with a capacity of up to 1000 m^3 with a residential part (§213.2.c)". Due to the level of technological advancement and significant complexity of glass curtain wall systems, obtaining a certificate of fire rating for the entire set requires the use of additional, costly security. In order to reduce production costs and to popularise solutions, the standard catalogue solutions in this area do not possess fire parameters, as in most applications they tend not to be required by law.

2. Technical solutions in glass curtain walls

Due to its adhesive and separating interlayer made of plastic materials susceptible to the influence of temperature, laminated glass does not perform well from the viewpoint of fire prevention. Manufacturers possess products with the required parameters to use in fire partitions and qualified in terms of EI. Fire windows are divided into fire-resistant and fire-retardant categories. Both types of glazing provide protection against heat radiation (defined by "E" parameter of fire rating), while fire-resistant ones serve also as a mechanical barrier to a fire (defined by "EI" parameter of fire rating) [5, 6].

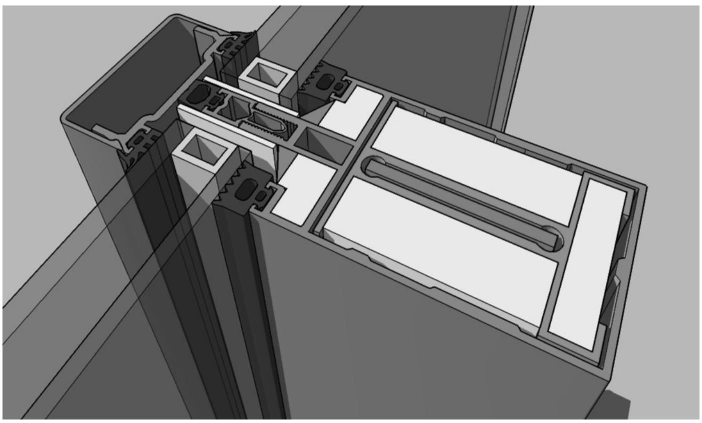
Research on the development of technology of glazing resulted in attempts to fill the interspaces of glazing with a transparent gel-like substance. The gel allows to transfer the heat from the outer to the inner pane of the thermo insulated glazing, thus reducing the temperature and stresses in the glass. Fire-rated glass is about four times more expensive than building glass. Solid laminated glass structures easily exceed 40kg/m^2 weight, which causes that the weight of this type of partitions together with the supporting structure, could reach 100 kg/m ^{2} –

a threshold defined as a light structure. The use of a special gel-filled fire glazing can increase the weight of the glazing up to more than 100 kg/m^2 (for example, a set of pyro EI120 – 108 kg/m^2). Additionally, the profiles of the metal support structure with a fire-rating significantly increase the weight of the glazed system. They must carry a greater load of windows and swelling masses, which thermally secure the internal structural core used in them.

While analysing the available systems of glass curtain walls, one can identify potential problems with their use as partitions with fire resistance. In most cases the metal support structure is made of aluminium. A few years ago, due to the shortage of raw materials for the production of aluminium, manufacturers were trying to replace it with a much more accessible steel. Technologically, steel as a less malleable material, was less susceptible to profiling treatment (production of highly complex extruded closed profiles), therefore cold-formed profiles were developed: open and welded ones. The structure's weight showed a significant increase in comparison with the structures of welded aluminium and cost calculation allowed for slight savings, but the more important aspect was the raw material availability factor. Natural landform has also proven problematic; extruded aluminium profiles had smooth walls of equal thickness and the edges were rounded to a rounding with a very small circular radius. As a result, the structures of this alloy showed a greater predisposition for their use as final finishing elements. Steel rolling in hot profiling has characteristic surfaces of low smoothness. The edges are rounded with radiuses two or three times greater than for aluminium. The corrosiveness of the material was also considered, again with an indication of a lighter alloy. Using steel it was potentially possible to achieve better fire resistance, thanks to a thicker material; however, due to the problematic treatment, the little "technicality" of aesthetics and the problems of degradation of the material, the solution has not gained popularity.

Currently there are post and transom solutions available on the market which possess a certificate to use the whole system in EI60 fire-rating [7].

They provide tightness and fire insulation for about 60 minutes, but do not provide sufficient mechanical strength; curtain walls must be anchored to the load-bearing elements



Ill. 1. Strengthening the support structure and thermal protection in fire--ranked post and transom systems (yellow color indicates swollen thermal liner, orange and red – proper support layer during fire), own work

of the building and they only provide a filling wall and not possess a structural character. Internal spaces of posts and transoms in metal support structures are equipped with an infill: a reinforcement made of aluminium (Ill. 1). It provides transfer of loads and maintenance of structural rigidity while losing the bearing capacity of an external profile for a certain time. The external profile is in the shape of a box, the inner profile is ribbed and the spaces between them are filled with sealing tapes made of swelling materials. During a direct or indirect fire, a significant increase in the temperature inside the carrier profile, causes swelling of the insulating material to occur. Its task is to protect the internal carrier profile from the increase of temperature outside the carrying capacity of the protected item. An additional security is to fill the joints and larger mounting slots with swelling tapes and the use of steel washers of increased resistance under the bolts. Posts, transoms and thermal strips connecting the clamp strip with the support frame and faying surfaces integrating metal structure are subjected to special protection and safeguarding with thermo-expandable material. Additional protection allows for load-bearing parameters of up to one hour on the weakest link in the system.

An important aspect of the development of a fire near the glass curtain wall is the issue of the spread of hot air inside the structural profiles (Ill. 2, 4). Closed chambers heat up extremely effectively, causing a rapid increase in temperature and air pressure within the posts and transoms of the curtain wall. Spontaneous combustion of materials in the vicinity of the partitions may occur on the upper floors of the building. If curtain walls are one system on the large surface of the facade, then the load-bearing structure is a joint and continuous element at the height of its occurrence. The use of swelling tapes at high temperature, closes and causes “congestion” of spaces inside the metal profile and limits the spread of fire outside the protected area.

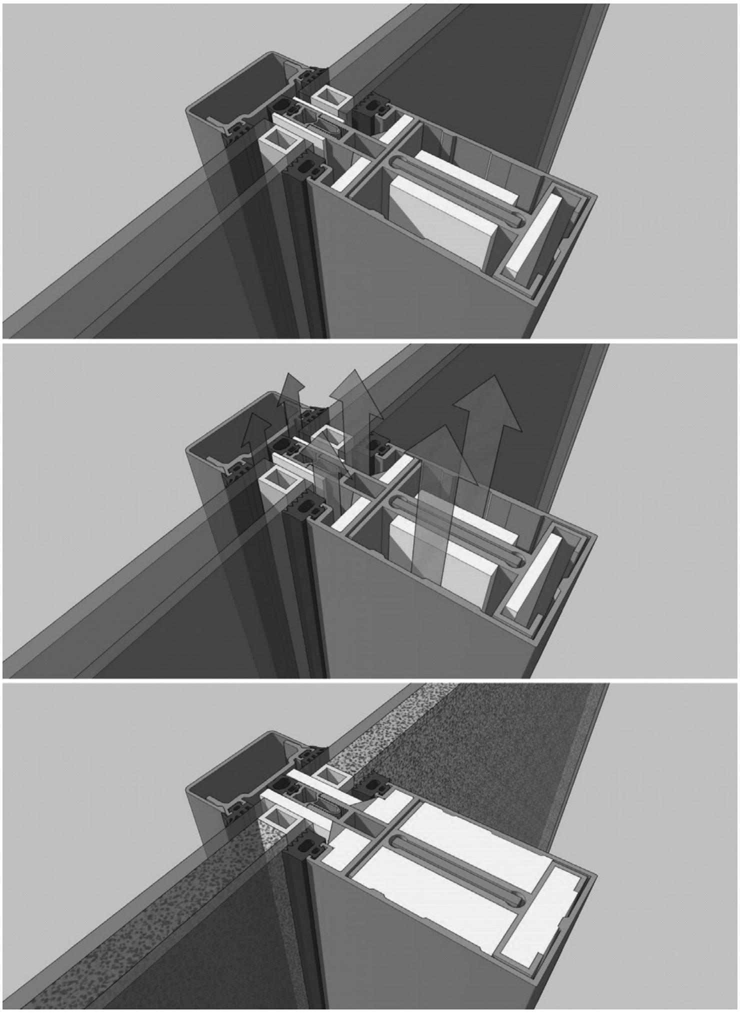
The aesthetic criterion for the use of fire protection glazing options is also worth mentioning. Because there is security inside the structure, external dimension, colour and shape does not require any changes. Hence there is the possibility of combining fragments with fire-rating with

Ill. 2. The impact of fire on the curtain wall, visible movement of hot air and gases inside the carrier profiles (source: B. Sędłak, *Fire resistance tests of glass curtain walls*, part 2, in Świat Szkła (The World of Glass) 10/2012)

parts of the façade which do not possess it, without any visible external change. Moreover, it is possible to protect the selected nodes or strip of the desired width of the facade.

Double glazing used in fire-rated partitions must come from an assortment providing the appropriate parameters. Producers of glass, attest their products in classes from E15 to EI 180. Fire glazing elements differ from standard solutions in the use of solid transparent substance (gel) between the panes of glass set. The role of the additional security is the absorption and distribution of excess temperature and cooling of the glass surface subject to fire. Reception of temperature enables to preserve the strength of the glass for the required

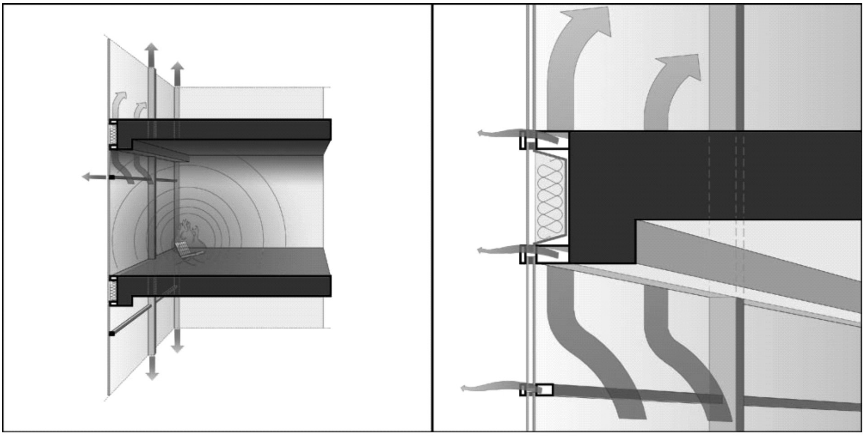
A) B) C)



Ill. 3. The impact of fire on the curtain wall components: A) reinforcements and thermal protection seating, B) a hot air flow in the ducts of internal structural posts, C) swelling of thermo-expandable materials and overheat of the gel in IGU, own work

time. Even the gel filling of the inter-chamber also reduces the possibility of the formation of local destructive stresses in the glass, which are the result of point changes in the power balance inside the material. A side effect of overheating the fire glass is a loss of the inter-suspension's clarity. It allows rescue teams to determine whether there is a fire on the other side of the partition and forces investors to exchange the item for a new one, enabling the restoration of protection against fire. Like other known security systems, fire windows are disposable elements.

The whole pole and transom glass curtain wall system integrity and fire insulation depends to a decisive extent on the aluminium support structure elements, sealing the glass seating in the metal structure.



Ill. 4. The problematic node common curtain wall connecting rooms with different ownership structure or in different fire zones – roads conducive to the transmission of fire, own work

In the event of damage or interruption of flexible seals around the perimeter of the glass sets, the transfer of hot gases, smoke and fire to the mounting spaces and the unconstrained heating of the curtain wall structure upwards from the penetration occurs. It is followed by further degradation of the structure of the wall and byo the escape of fire and smoke to the upper rooms (Ill. 4). The air trapped inside the carrier profiles is also heated, pressure increases and the weakening of the structure in parts unsecured against fire occurs. The presence of swelling insulators under the influence of temperature inside the profiles can create a "cork" for the free movement of hot air and reduces the spread of fire and deterioration of the carrying capacity in the whole structure of the curtain wall.

A common aesthetic procedure is used by architects to design large-area glazing over large parts of the facade. In commercial buildings, it is most often the administrative unit in charge of the fire information systems which include smoke, fire and temperature detectors, and integrated evacuation support systems or even fire extinction systems. The ownership structure is not fragmented and the hierarchy of decision-making and management of efficient evacuation is clear and described in detailed procedures. This looks quite differently in residential buildings and especially in collective residential buildings. The ownership structure is very fragmented; individual housing units are adjacent to each other at the interface of the surfaces of walls and ceilings. They often have common, in the physical and static term, outer wall formed as a glass curtain wall. The need to preserve the environmental separation and individual character within the building, causes that the sensors responsible for the early detection of fire are located at some distance from the potential sources of the fire. Also, evacuation procedures are not periodically inspected so that evacuation can be characterized as a set of individual actions, uncoordinated in time, scope and with a strong likelihood of a panic outbreak. The very shape of the facade as a single system is conducive to the spread of fire upon the premises, inside the structural profiles and after the interruption of continuity in glazing gaskets.

It is an extremely important issue; therefore, it is necessary to select available solutions appropriately in order to maintain the basic principles of fire safety. Definitely, the interfaces between ownership structures should be carried out as fire-rated partitions. Such a treatment will reduce the scope and speed of the spread of fire in the vicinity of the curtain wall.

4. Conclusions

Due to their complexity and mounting method, glass curtain walls possess a lot of aesthetic advantages. Unfortunately, they also have drawbacks, such as a low fire resistance. A relatively early stage of development of this type of building skins results in their slow evolution and continuous search for new materials to improve their performance. Currently, in residential single and multi-family buildings of up to three storeys and in buildings with living quarters of capacities specified in §213.2.a and c of *Technical conditions…*, one can apply all kinds of glass curtain walls. In all the remaining residential buildings, exterior curtain walls have to be post and transom systems with a certified fire resistance class. With currently available technologies, fire considerations only allow for the use of post and transom walls in places that require fire classification of partitions. Special variants of curtain walls have appropriate certificates. The aesthetics of the wall is not changed, since the fire protection technology is hidden inside the structural profiles. It is therefore possible to designate the protected areas equipped with the system components, with the appropriate “EI” parameters within a single curtain wall system. This enables the aesthetic integration and cost optimization without the use of fire-ranked elements over the entire surface of the facade. The aesthetic determinant, results in that the advanced systems of glass curtain walls with structural glazing and point mounting as well as the fully glazed ones, do not possess appropriate fire certificates. Glass of possible high fire resistance classes is a construction material and a filler and connectors cooperating in the wall statics are made of metal. A reduction in the size of the rotula prevents the use of internal security and external connector protection technologies would significantly affect the aesthetics of the partition, thus conflicting with the basic premise for the choice of this type of technology: the high aesthetics of the glazing.

References

[1] Bauen mit Glas – DETAIL 7/9 2009.
[2] Loughran P., *Falling glass: problems and solutions in contemporary architecture*, Birkhauser Publisher, Basel 2003.
[3] Sędłak B., *Fire resistance tests of glass curtain walls, part 2, in Świat Szkła (The World of Glass)*, 10/2012.
[4] Weller B. et al., *DETAIL Practice – Glass in Building*, Dresden 2009.
[5] *Glaspol's Technical data SGG PYROSWISS*, 2008.
[6] *Glaspol's Technical data SGG CONTRAFLAM*, 2008.
[7] *Technical data of YAWAL System's manufacturer (45.E0 07/08) – 50 EI60 façade.*

TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
ARCHITECTURE | ARCHITEKTURA
7-A/2014

DOROTA WINNICKA-JASŁOWSKA*

TECHNICAL AND TECHNOLOGICAL FACTORS AND SOCIAL INTERACTION AS A PRIORITY IN SHAPING MODERN UNIVERSITY FACILITIES

CZYNNIKI TECHNICZNE I TECHNOLOGICZNE ORAZ INTERAKCJA SPOŁECZNA JAKO PRIORYTETY W KSZTAŁTOWANIU WSPÓŁCZESNYCH OBIEKTÓW UNIWERSYTECKICH

S t r e s z c z e n i e

Współczesne uniwersytety to nowoczesne obiekty, w których znajdują się nowe funkcje umożliwiające interakcje społeczne, sprzyjające m.in. edukacji przez kontakty nieformalne, współpracy interdyscyplinarnej itp.

Słowa kluczowe: obiekty uniwersyteckie, środowisko pracy, przestrzenie społeczne, aspekty technologiczne

A b s t r a c t

Present day universities are modern buildings accommodating new functions, facilitating social interactions, supporting learning by means of informal contacts and promoting interdisciplinary cooperation etc.

Keywords: university facilities, work environment, social spaces, technological aspects

* Ph.D. Eng. Arch. Dorota Winnicka-Jasłowska, Faculty of Architecture, Silesian University of Technology.

1. Introduction

For several years Poland has witnessed a dynamic development of the infrastructure of tertiary education. The changes were initiated at the end of the 20th century when Polish universities underwent complex renovation schemes, followed by introducing new functions into their facilities. The factors that spurred the transformations comprise: legislator changes in the sector of Science and Higher Education, adoption of new curricula (the Bologna process) [1, 2], changes in the organizational structure, quantity of staff and students, and finally, in the manner of the educational process, the complexity of teaching activities, cooperation with external partners, new objectives and tasks set for tertiary education (continuous learning), technical and technological advancement, including IT, IBS and BMS implementation.

2. A modern university. Changes in higher education and their impact on the new quality of university facilities

There have been significant changes in the Polish education system following the reforms of science and tertiary education [1], changes in curricula in compliance with the Bologna process [3] and restructuring of universities. The teaching staff are presently faced with higher requirements concerning the quality of their professional output. Thus, moving goalposts enforces the improvement of the work mode, cooperation with external partners, interdisciplinary research and consequently, intra-faculty and broader external collaboration. The dynamic advancement of information technology has significantly influenced the research and teaching methods, introducing new manners of learning and offering new supporting tools. Present-day scientific activity requires interdisciplinary research and teaching has become more practical than theoretical, enforcing new relations and interactions occurring in the space of university facilities and adopting a fresh approach towards shaping their space. Communication, cooperation, joint undertakings and initiatives have changed their character and the process of knowledge acquisition is not only taking place in lecture rooms and classes, but everywhere.

In accordance with the principles adopted by the Member States, the manners of teaching and learning have changed, resulting in the demand for new quality of space and infrastructure of university facilities.

The scope of the paper is limited to these technical, technological and functional elements of university facilities that have a direct impact on the quality of the work environment. The main users of the facilities are students and academic staff and accordingly, these two target groups are considered in the author's research.

The needs of the former group is almost intuitively understood; the latter does not always seem so obvious. According to worldwide research, social interaction is very important to the academic environment [4] and social contacts occurring in the university space enhance the level of knowledge and education by exchange of ideas [5, 6]. Hence, the chief role of university buildings is to secure the work conditions in consideration of the following aspects: proper selection of the functional space, comfort of work in view of functionality, comfort of work in view of social relations, standard of technical and technological systems

(IBS) customized to the needs of a given organization, standard of technical equipment, research tools and apparatus, access to the functions of the building that are essential for conducting research works, availability of the equipment and tools for students to support the teaching process, ergonomic solutions in the furnishing of the interiors, proper microclimate of functional zones and rooms[1].

3. Technical and technological factors determining the new quality of work in university facilities

Recently erected university facilities in Poland ar+e examples of providing good quality standards[2]. After numerous modernization schemes of older university buildings, new facilities have been constructed, offering good quality and functional comfort. The author's studies carried out at several new and older university facilities and university space[3] indicate that the new facilities enable faster development of the already existing universities by providing additional space and new functions, and highlighting the prestige of a given university. The respondents who are not professionally involved in architecture and other related fields have an intuitive impression that the new buildings are better, more attractive and positively contribute to the image of the university (above 80% of the respondents[4]). Aesthetics and prestige are important in the face of competition among universities however, the crucial aspects seem to be spatial flexibility of the new facilities and availability of equipment, securing better work conditions for several years. These features supported by IT, enable decent work conditions and good results. This does not necessarily mean that old buildings are bad, but their poor flexibility hinders the implementation of changes.

One of the best examples of the university facilities in Silesia studied by the author, is the Faculty of Theology at the University of Silesia (2004)[5], where innovative functional and spatial solutions of classrooms, offices and multi-functional public space secure good quality of work and social space (Ill. 1, 2). The building is also advanced in terms of intelligent systems. While considering IBS in relation to the comfort of work, the microclimate of particular functional zones should be mentioned. People feel best in constant ambient temperature and when given an option of airing the rooms. The interviews with users of university facilities prove that people feel comfortable in proper temperature and having the possibility of individual temperature reduction by for example, opening or closing the windows. These findings are confirmed by the results of research conducted by Tymkiewicz J. [8, p. 232], who in the course of analyzing the above mentioned facilities of the Faculty of Theology, indicated the problems involved in the impossibility of opening the

---

[1] Systematized on the bases of the author's research (2007–2012).

[2] Approximate date based upon the date of commissioning the new buildings of the University of Silesia in Katowice (Faculty of Law and Administration (2003), Faculty of Theology (2004), and Wroclaw University of Technology (Integrated Student Centre (2007).

[3] Studies carried out by the author since 2007 described In the publications specified in References.

[4] The author's studies carried out at the Campus of the University of Silesia in Katowice (2012).

[5] The author's studies conducted at the Faculty of Theology of University of Silesia in Katowice (2008).

windows by the users themselves and inadequate set-up of the air conditioning parameters. Unfortunately, users are not always offered the option of adjusting the microclimate in modern university buildings.

Another aspect of the microclimate conditions is proper lighting of rooms and workplaces. The lighting conditions depend on the systems installed in the interiors, façade systems adjusted to the functional layout of the building, internal functions and geographical orientation [7, 8]. As far as the results of the author's own studies are concerned, it seems relevant to mention the Integrated Student Centre at Wrocław University of Technology (C-13) (Ill. 3).The building is appealing in view of its functions and applied technological solutions, surrounded by facades that look like old generation computer perforation cards. It has become a token of the student environment and a landmark of the facilities of the University of Wroclaw, photogenic in day and at night. The interiors hold modern flexible public spaces that may be used for various purposes and that are crowded by students. However, in the course of the conducted interviews, students complained about the light in the interiors (Ill. 4). Some parts are excessively lighted and due to round windows installed at random, the light does not always fall at the right place. The parts of the building that are too exposed to sunlight are subject to big contrast and condensed dazzle. Other interesting phenomena have also been observed, but their nature is more aesthetic than functional. It may be concluded that facades should be designed to facilitate undisturbed work in the building, both as far as the microclimate (airing, temperature, light, acoustics) and the functionality of use are concerned. The aesthetics of the facades should follow the functional layout of the interiors [8, p. 104].

A similar design has been implemented in the Library of the University of Silesia and University of Economics in Katowice (Ill. 5, 6), but due to obscuring of the walls and windows (openings) by bookshelves, the above mentioned effects do not have such negative impacts as in the case of building C-13. Currently, in view of providing "comfortable" workplaces, the design of "appropriate" facades poses a big challenge.

Ill. 1. Faculty of Theology, University of Silesia in Katowice (2004). Entrance facade (photo D. Winnicka-Jasłowska, 2013)

Ill. 2. Faculty of Theology, University of Silesia in Katowice (2004). Interior entrance space (photo D. Winnicka-Jasłowska, 2013)

Ill. 3. Integrated Student Centre at Wrocław University of Technology (C-13) in Wrocław (2007) (photo D. Winnicka-Jasłowska, 2013)

Ill. 4. Integrated Student Centre at Wrocław University of Technology (C-13) in Wrocław (2007). Student's public zone (photo D. Winnicka--Jasłowska, 2013)

Ill. 5. Library of the University of Silesia and University of Economics in Katowice (2012) (photo D. Winnicka-Jasłowska, 2013)

Ill. 6. Library of the University of Silesia and University of Economics in Katowice (2012). Interior public space (photo D. Winnicka-Jasłowska, 2013)

4. New types of space and new role of old functions

Recently, traditional lecture rooms are becoming less important than generally accessible spaces, referred to as public or social spaces. Worldwide changes in the approach to university education resulted in new functions of the university space. Spaces of typically academic nature should be adjacent to less obvious and previously marginal functions, such as the cafeteria or sitting rooms. The spaces that were previously used for catering or waiting for lectures and classes are nowadays not functioning as purely academic, but as places for education through informal contacts. Cafeterias and similar outlets are meeting places for students and staff and are becoming more important in the hierarchy of university space than previously. The academic landscape involves a combination of the functions in the building to enable the learning process to take place everywhere and the arrangement of seminar and lecture rooms to support social contacts that promote knowledge acquisition [5].

University halls and corridors are crowded by students who consciously occupy this "students' space" for gatherings, meetings, resting, waiting for classes, learning, working on-line, etc. Hence, in the design solutions of university facilities, such type of space is intentionally increased and includes the corridors which are not only used for moving around, but also for gathering before lecture rooms. The buildings of Integrated Student Centre in Wroclaw and the Academy of Music in Katowice, are examples of such functions of space. The latter building has been modernized and extended to provide public space in the form of an atrium which is a central place connecting the "old" building with the "new" extension[6].

Each university building should have integration and social space, where as far as the space of the student campus is concerned, this function may be served by a university library as for example, the new Library of the University of Silesia and the University of Economics in Katowice opened up in 2012. The Library integrates the student environment with university teaching and research staff. From the point of view of the users of other faculty buildings, it is well located. It has a modern public space in the form of an entrance hall connected with a cafeteria and exhibition foyer. The hall is adjacent to two exterior pre-entrance squares designed as a meeting and resting place for the academic environment.

5. University offices and didactic rooms. Demand for creating efficient workplace for the teaching and research staff and students

The approach to university office design has also changed, but it is difficult to give a precise time and direction to this change. Surely, this process is determined by many economic, cultural and social aspects. For dozens of years, the offices of research and teaching staff functioned in accordance with the same previously adopted pattern, where their main focus was on individual work and limited contacts with colleagues and students. In contrast, a modern office of a research and teaching worker has a new form, due to the awareness of the specific needs and nature of teacher's and researcher's work. These days the office of academic staff has different functions and should meet the following demands: ease research work, reflect the rank of the university institution, provide the staff with a sense of allegiance by the comfort and layout of the interiors, enable contact with other team members. According to the findings of the studies on the academic staff value, the following aspects of their working environment were noted: opportunities for formal and informal communication, privacy of work that requires concentration, acoustic insulation securing the confidentiality of conversation, visual privacy, high quality of the work environment, proper heating and ventilation, high aesthetic appeal, modern interior arrangement, comfortable furniture, place for relaxing and resting away from the office desk with possibility of contact with colleagues, convenient place for storing materials within reach of the work stand, availability of individual space for projecting research and teaching materials [11]. The current design trend in Western Europe and the USA are combined offices, i.e., joining smaller rooms , for one or two staff members for individual work, with bigger rooms for team work and contact with co-workers. In Poland, the prevailing model is still a corridor office, which does not provide sufficient space for team work and informal contacts. This problem is encountered even in new facilities. An interesting solution is to join offices with an internal corridor and provide direct access to seminar rooms (Faculty of Theology, University of Silesia).

---

[6] The building of the Academy of Music In Katowice has been broadly described by the author [10, p. 251].

Modern lecture rooms, classrooms and seminar rooms have a certain flexibility of arrangement. On the bases of a common module, rooms are designed to enable free space arrangement in view of new manners of teaching. The old model has been subjected to alterations depending first and foremost, on the following factors: type of university and study discipline, methods of working with students devised and proved by a given university or faculty, student-professor relations, use of practical methods of knowledge transfer (classes in laboratories, technological halls, collaboration with external partners). The above factors have an impact on the arrangement of rooms, their size, furnishing and location in the building. In the phase of architectural programming, it is essential to analyze the options of connecting functional zones. The relations among the zones depend on the planned use of the building (rent of its parts, organization of conferences and exhibitions, etc.) and possible development extension phases. Furthermore, they should be legible to each user, which is one of the elements of the way finding strategy, easily locating the destination and information. The best solutions for the comfort of use, visual information, ease of understanding the spatial layout and moving around the building are proposed.

6. Conclusions

Dynamic advancement of Information Technologies has an impact on education and forms of teaching instruction. Traditional lecture rooms and class rooms do not suffice. Working on the internet with access to thousands of servers, changes the image of the modern university. Also, cooperation between various fields of science and growing awareness of the demand for interdisciplinary research have caused the evolution of research work places, which change their shape and profile.

The processes connected with education and research work have become more complex. The advancement of engineering and information technologies has influenced the modes of teaching and learning and modernized the supporting and aiding tools. Nowadays, science is interdisciplinary, which results in new relations and interactions in the space of buildings. The process of knowledge acquisition can take place anywhere. Modern buildings should be designed to enhance the development of science and consequently, improve the level of education and research.

References

[1] Dz. U., Nr 164, poz. 1365/ Amendments to the Polish Law on Science and Higher Ed¬ucation.
[2] Higher Education in Europe. Developments in the Bologna Process (http://ec.europa.eu/education/higher-education/doc).
[3] Proces Boloński/Bologna Process (http://www.nauka.gov.pl).
[4] DEGW Studies (http://www.degw.com).
[5] Winnicka-Jasłowska D., *Potrzeba kształtowania nowej jakości przestrzeni publicznej i dydaktycznej we współczesnych obiektach wyższych uczelni. Wnioski z badań prze-*

prowadzonych metodą POE, Referat na konferencję, Tom. CXXI, Wyd. PAN, Łódź 2008, 81-91.

[6] Winnicka-Jasłowska D., *Internet – Based Study On Users' Needs. Students' functional And Spatial Needs In facilities Of Architecture Faculties At Technical Universities In Poland*, ACEE Architecture, Civil Engeneering, Environment, vol. 1 1/2008, pod red. A. Ajdukiewicza, The Silesian University of Technology, Gaudeo, Gliwice 2008, 47-53.

[7] Celadyn W., *Przegrody przeszklone w architekturze energooszczędnej*, Wydawnictwo PK, Kraków 2004.

[8] Tymkiewicz J., *Funkcje ścian zewnętrznych w aspektach badań jakościowych. Wpływ rozwiązań architektonicznych elewacji na kształtowanie jakości budynku.* Monografia habilitacyjna, Politechnika Śląska, Gliwice 2012.

[9] http://www.degw.com/researchpdf/LearningLandscape_HigherEducation

[10] Winnicka-Jasłowska D., *Jakość przestrzeni publicznej w budynkach wyższych uczelni. Praktyczne zastosowanie metody POE w badaniach jakościowych w architekturze*, Czasopismo Techniczne, 2-A/1/2011.

[11] Harrison A., Cairns A., *The changing academic workplace* (http://ipddirectedstudies.files.wordpress.com/2011/01/the-changing-academic-workplace-degw).

[12] Niezabitowska E., Winnicka-Jasłowska D., *Evolution of the office building in the course of the 20th century: Towards an intelligent building*, Intelligent Buildings International, Vol. 3, Issue 4, Ertscan 2011.

CONTENTS

TREŚĆ

CONTENTS

TREŚĆ