PŘEKRAČUJEME HRANICE
PRZEKRACZAMY GRANICE
2014—2020

EVROPSKÁ UNIE / UNIA EUROPEJSKA
EVROPSKÝ FOND PRO REGIONÁLNÍ ROZVOJ
EUROPEJSKI FUNDUSZ ROZWOJU REGIONALNEGO

TECHNOLOGICAL INNOVATIONS AND SUSTAINABILITY DEVELOPMENT IN ARCHITECTURE AND CONSTRUCTION

Monograph

Scientific Editor
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PhD architect

Racibórz 2017

Projekt „Edukacja i promocja w zakresie OZE na pograniczu polsko-czeskim” jest współfinansowany
ze środków Europejskiego Funduszu Rozwoju Regionalnego oraz z budżetu państwa RP
PRZEKRACZAMY GRANICE

ISBN: 978-83-64423-53-6

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SPIS TREŚCI

3. TECHNOLOGICAL AND MATERIAL INNOVATIONS IN CONTEMPORARY CONSTRUCTION

4. STIMULATORS AND BARRIERS TO THE SUSTAINABLE DEVELOPMENT OF URBANIZED AREAS

FOREWORD

Joanna Sokołowska Moskwiak
Director of the Instytut of Architecture
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Dear Sirs,

The initiative to organize an international conference on Renewable Energy Sources (RES) and Sustainable Development cannot be overstated. First I would like to express my appreciation and thanks to the initiators and organizers of this project, which has resulted in this publication. I believe the science and expertise in this conference will significantly contribute to the further development of RES in Poland.

The quality of the environment in which we live has already been degraded by the conventional fossil fuel-based power industry, which relies on coal, oil and natural gas. The way to stop further degradation is not only through conversion of conventional energy sources to renewable energies but also the gradual elimination of all fuels that contribute global warming. Renewable energy is generated from natural processes that are continuously replenished such as sunlight, geothermal heat, wind, tides, water, and various forms of biomass.

The city of Racibórz is well positioned in respect of the environment with its waste management, environmental education, environmental protection and promotion of environmentally friendly undertakings. These achievements include international conferences already belonging to cyclical events organized by the city covering issues in RES. Each conference has dealt with an aspect of RES-related issues and is of wide interest in the industry.

The IV RES 2016 International Conference on Renewable Energy and Sustainable Construction is an initiative of the City Racibórz, the Institute of Architecture of the State Higher Vocational School in Raciborz and the Czech partner VSB Technical University in Ostrava. Raciborz hosted the RES 2016 Conference and was the first city in Europe to receive the ISO 14001 Environmental Management Certificate, which implemented the Low Carbon Economy Plan and the creation of the "Energy Efficiency Innovation Platform". And there are companies in the city that produce 40% of the domestic volume of solar equipment production making Racibórz a key RES city in Poland.

It is noteworthy that the Conference, organized jointly by the State University of Applied Sciences in Raciborz, was extended to cover scientific issues. The aim was to bring together a wide range of international academics, researchers, and practitioners involved in topics on renewable energy sources and research into various aspects of sustainability. This included further discussions on how to improve sustainable design and construction from the perspective of both investor and user.

The participation of policy makers in the context RES decision-making was also considered a principal objective. Policy objectives must be carefully framed so as to deliver sustainable environmental outcomes. This is not always well understood.

This publication is a result of this conference. It presents 20 selected papers. Publishers of this proceeding aimed for wide presentation of up to date experiences and solutions in area of Renewable Energy Sources. The selected papers presented in this book focus on issues concerned with:

Energy saving and renewable energy sources in construction, technological and material innovations in modern construction, energy-efficiency and passive housing, technological innovation and implementation of new materials in the modernisation of existing residential housing, new technologies and protective materials in exploitation and protection of historic buildings, new construction and installation systems as an inspiration for modern architecture. Another important issue concerns problems of sustainable design, theory and practice.

New forms of architecture inspired by innovative technologies and materials were presented on the basis of student projects performed at State University of Applied Sciences in Racibórz.

Finally, the 2016 Conference presented an opportunity to provide feedback, discussions and exchange experiences in many Polish and European scientific professional circles. It has made an important contribution in terms of establishing the importance of RES in sustaining urban development. An outcome of the conference is the publication, which as we hope will contribute to wider popularization of RES idea.

1. ENERGY EFFICIENCY AND RENEWABLE ENERGY SOURCES IN THE CONSTRUCTION INDUSTRY

HEAT LOSSES IN EXTERNAL WALLS CAUSED BY BALCONIES AND LOGGIES

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ABSTRACT

The article presents the impact of how warming balconies and loggias in multi-family residential buildings retrofitted for the loss calculation of heat through external walls. Identify the components of diagnosing insulated on real objects, the occurrence of linear thermal bridges using thermography. Showing the possibility of calculating the numerical values of linear thermal bridges using a computer program THERM, and their impact on the calculation of heat loss

Keywords: Linear thermal bridges, thermal modernization, building insulation..

Introduction

When assessing the state of thermal protection of residential buildings undergoing thermal insulation modernization in the 1990s, cyclical recurrences can be identified. They are related to the lack of adequate protection of places known as thermal bridges. The condition of the thermal insulation of the external partitions of residential buildings is not only one of the basic issues related to energy saving, but also involves the thermal comfort of rooms reserved for the stay of people. The same thesis can be applied to the buildings constructed in recent years in traditional technologies, in particular using the reinforced concrete frameworks, where the walls are made of fine-grained elements (porous ceramics, lightweight concrete, etc.). On the basis of the literature data and own research, it can be stated that the most common errors are related to the thermal protection of balcony and loggias supporting plates (Dylla A: Praktyczna fizyka cieplna budowli. Szkoła projektowania złączy budowlanych, Wydawnictwo Uczelniane UTP, Bydgoszcz 2009).

This article presents the experiments related to the research and analysis of additional heat losses through external walls depending on the thermal condition of balconies and loggias.

CHARACTERISTICS OF BUILDINGS

The subject of the research involved multifamily residential buildings implemented in the industrialized technologies. Individual objects involve basements, multi-storey, multi-segment buildings. The buildings were erected in the mixed technology - a reinforced concrete framework with a traditional brick wall, in the years 2009-2011. The external walls were made as two-layer - a construction part as a 38-cm thick ceramic wall with thermal insulation. The external walls insulation of the buildings was made in the technology of the Thermal Insulation Composite Systems on a basis of polystyrene foam. On the basis of the macroscopic tests and the data obtained from the administrators of the objects, it was stated that BSO was applied with the following characteristics: acrylic/mineral plaster, reinforcing layer, adhesive layer, polystyrene boards. Thickness of thermal insulation on external walls did not exceed 12 cm.

Photo I1. View of the façade of a typical building for which this article was developed.

THERMAL IMAGING TESTS

The macroscopic tests were carried out in January 2012 to determine the current state of thermal protection of the external walls.

The scope of the research included:

1) Measurements of temperatures of external air.
2) The tests carried out using a thermal imaging camera.
3) Development of a thermographic documentation.
4) Development of a photographic documentation.

In order to determine the state of thermal protection of the building, the thermal imaging tests were carried out to visualize the temperature differences on the tested surfaces of the external partitions. The thermal imaging tests were carried out in January 2012, with favourable weather conditions.

The temperature distribution tests were carried out with the thermographic method using ThermaCAM thermal imaging device consisting of a thermal imaging camera and a monitor. The thermal imaging device enables visualization of the temperature field on a tested surface in a form of a thermal image - a thermogram.

Rated data:

Temperature measurement range	from -20^0C to 1200^0C
Camera vision angle	
(depending on a used lens)	25^0 x 19^0
Thermal resolution (at 30 ^{o}C)	0.05 K
Spacial resolution	1.36 mrad
Spectral range of sensitivity	7.5 – 13 μm.
Number of points on the line	approx. 175 x200

Temperature measurement

The internal air temperature tests were carried out using GANN HTR 300 test set with OT 100 probe for continuous air temperature measurements in a continuous system - sampling every 0.1 s. The range of a device temperature measurement from -10^0C to 90^0C. The external air temperature measurement was carried out using GANN HTR 300 test set with continuous air temperature probe. As measured values, mean values were measured at approximately 1.50 m above the ground level.

During the test, external air temperatures were measured before and during the test and internal air temperature measurements.

Measurement date	30.01.2012
Temperature of inside surrounding	-18.0 ^{O}C ÷ -16.0 ^{O}C
Temperature inside a building	20.0 ^{O}C ± 4.0 ^{O}C

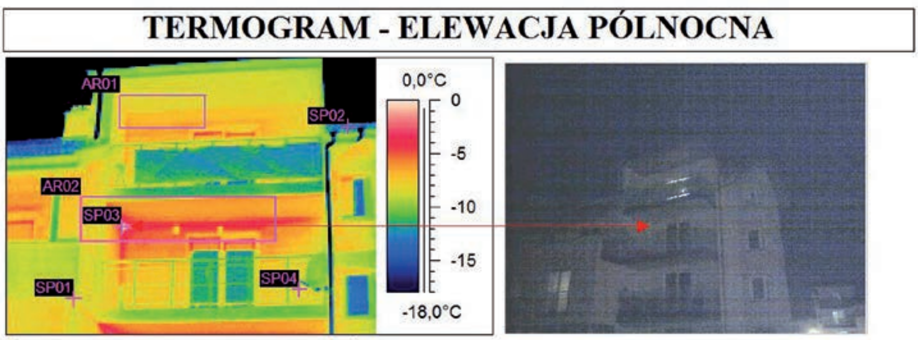
The thermal imaging measurements were carried out at a temperature difference of 38.0 K.

For the emissivity of the tests area, an average value of 0.92 was assumed. The temperature distributions on the tested surface were visualized and then significant thermal images were recorded directly from the monitor screen and a further quantitative analysis was recorded with a computer assisted processing. The test was carried out in accordance with the standards. Windless weather was during the test (wind speed less than 1 m/s).

As a result of the tests, the images were obtained to show the visualization of the temperature differences on the tested surfaces of the external partitions. The tests were carried out from the outside. The radiation energy emitted from the body surface is a function of the surface temperature of the body. The heat flux flowing through the partition encounters a certain thermal resistance of the thermal insulation layer. The analysis of the tests results consists of isolating places of varying degrees of image brightness, which corresponds to the variable thermal insulation of the partition. The thermal imaging device enables visualization of the temperature field on a tested surface in a form of a thermal image - a thermogram. On the basis of the thermogram, one can make an initial assessment of the presence of linear thermal bridges on the partition.

THERMOGRAPHIC DOCUMENTATION

The results of the tests are shown on the enclosed coloured thermograms (quantitative). The coloured thermograms represent the quantitative distribution of temperatures in a form of coloured isotopes, each representing a certain temperature range, given on the right side of the colour scale printout. The thermograms show the temperature values at several selected points, marked on the corresponding thermograms with a cross and a digit. On the thermograms, the areas corresponding to the characteristic temperature distributions on the partitions were separated. For such marked areas, extreme values were determined, i.e. the minimum and maximum temperature values. For easy identification, the thermal images are compiled with the photo of the carrying out place - as in fig. 1.



IR information	Value
Date of creation	2012-01-30
Object	**Value**
Atmospheric	-16,0°C
Label	**Value**
SP01	-9,3°C
SP02	-13,1°C
SP03	-1,4°C
SP04	-8,3°C

Label	Value
AR01 : max	-5,7°C
AR01 : min	-8,7°C
AR01: stdev	0,7°C
AR02 : max	0,6°C
AR02 : min	-11,4°C
AR02: stdev	1,6°C

Fig. 1. Sample thermogram of the analysed building - photo and thermogram - authors January 2012.

The principle of diagnosis of the insulation of the building partitions is:

Determining the actual temperature distribution on the test surface of the partition,

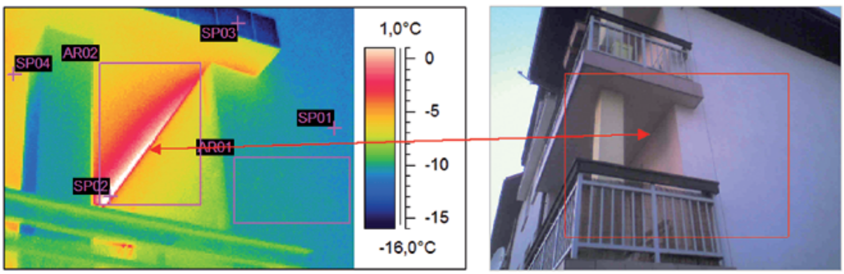
Determining whether the temperature distribution is correct or identifying thermal anomalies in a form of flat and spatial corners or anomalies associated with the construction of partitions (e.g. mechanical couplings, connectors), dampening of internal or external partitions of partition walls associated with operation of premises,

Assessment of the nature and extent of thermal defects.

The correctness of the tests of the temperature distributions on the partition surfaces can be determined by: comparing the thermogram obtained from the thermogram test considered as standard, obtained from the tests for an identical partition under similar test conditions, comparing the thermogram with the predicted temperature distribution obtained by other methods such as the calculation methods.

Thermal anomalies that cannot be explained by the geometric analysis, structural analysis, or other factors that can impact on the measurement result should be treated as a deviation from the design requirements of the construction art - defects. Figure 2 below presents the selected identified defects in a form of the linear thermal bridges on the connection of the balcony supporting plate with the external wall

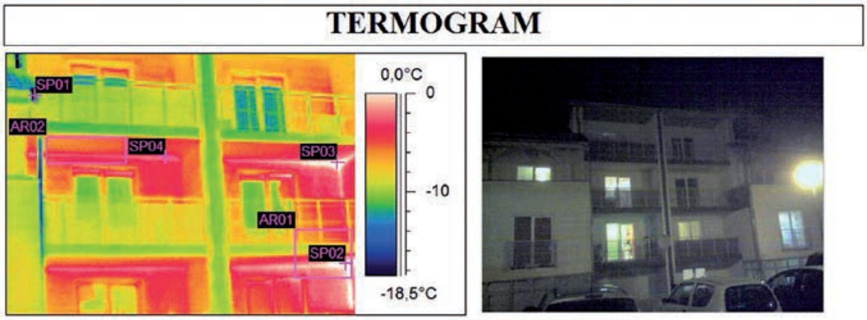
TERMOGRAM



IR information	Value
Date of creation	2012-01-30
Object	**Value**
Atmospheric	-16,0°C
Label	**Value**
SP01	-10,7°C
SP02	2,7°C
SP03	-14,2°C
SP04	-5,9°C

Label	Value
AR01 : max	-9,8°C
AR01 : min	-11,1°C
AR01 : avg	-10,4°C
AR01: stdev	0,2°C
AR02 : max	2,7°C
AR02 : min	-8,0°C
AR02 : avg	-4,6°C
AR02: stdev	2,3°C

Fig. 2. The balcony plate thermogram from below on the north façade - photo and thermogram - authors, January 2012



IR information	Value
Date of creation	2012-01-30
Object	**Value**
Atmospheric	-16.0°C
Label	**Value**
SP01	-15,5°C
SP02	2,4°C
SP03	1,7°C
SP04	-2,4°C

Label	Value
AR01 : max	3,0°C
AR01 : min	-9,3°C
AR01: stdev	3,0°C
AR02 : max	-2,3°C
AR02 : min	-6,6°C
AR02: stdev	1,0°C

Fig. 3. The balcony plate thermogram from below on south façade - photo and thermogram - authors, January 2012

The initial analysis of the external partitions of the buildings using the thermal imaging cameras revealed:

- thermally homogeneous surfaces of external walls,
- linear thermal bridges of significant intensity along the connection of the balcony plate with the external wall.

The linear thermal bridge intensity expressed by the linear heat transfer coefficient ψ, should be determined using a two- or three-dimensional wall model in accordance with PN EN **10211: 2008.**

ANALYSIS

PN-EN ISO 10211:2008 standard (Thermal bridges in the buildings. Heat fluxes and surface temperatures. Detailed calculations.) provides the computational algorithms including the thermal bridges. One can distinguish three main geometrical models related to:

- one-dimensional heat flux 1D (A),
- two-dimensional heat flux 2D (B),
- three-dimensional heat flux 3D (C).

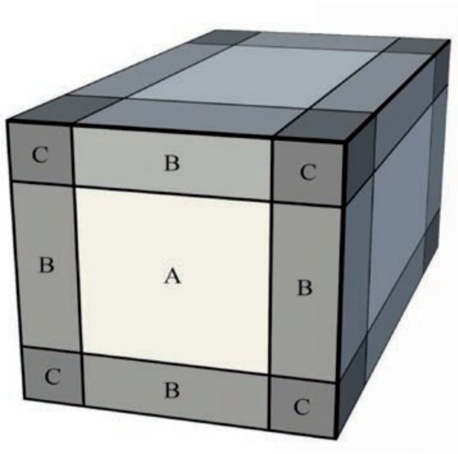


Fig. 4. Separation of the areas of heat fluxes for an exemplary structure - authors' figure.

One-dimensional thermal bridges, often referred to as 1D, are inter alia a consequence of a material differentiation of a part of the building partition (different coefficients of heat conduction). An example of such a thermal bridge can involve a reinforced concrete core in a one-layer outer wall. Two-dimensional 2D thermal bridge arise, for example, in places where the internal and external surfaces of building partitions are differentiated. In many cases, such thermal bridges are not possible to eliminate. One can only minimize negative effects of their occurrence.

Balconies are generally the linear thermal bridges because they are anchored in the external walls of cantilevered balconies, etc. Due to their location, the balconies are exposed to a greater effect of convection and wind than a full wall, which results in faster heat dissipation of their surfaces to the environment. Similarly, it is a case of loggia with the fact that due to the retraction of a plate element into the interior of a building, a surface cooling by wind is generally lower. The thermal bridge is formed at the contact point of a balcony plate with an external wall, both from above and below a plate. Therm 7.4 programme was selected for the calculation of the linear thermal bridge. THERM®.

The calculation results are:

1) graphic including:
   - isotherms distribution in a cross section of a modelled element,
   - a coloured temperature field in a cross-section,
   - a coloured density field of heat flux.
2) textual including:
   - heat transfer coefficient U W/(m^{2}K),
   - value of heat flux W/m,
   - value of stream density W/m^2.

Four geometrical models were selected for numerical calculations:

1) Basic model - in accordance with the design documentation of a building - a balcony plate without any insulation. For all models, the same construction of the external partition
2) The model with insulation of a reinforced concrete slab from the top.
3) The model with insulation of a reinforced concrete slab from the bottom
4) The model with insulation of a reinforced concrete slab from the top and bottom.

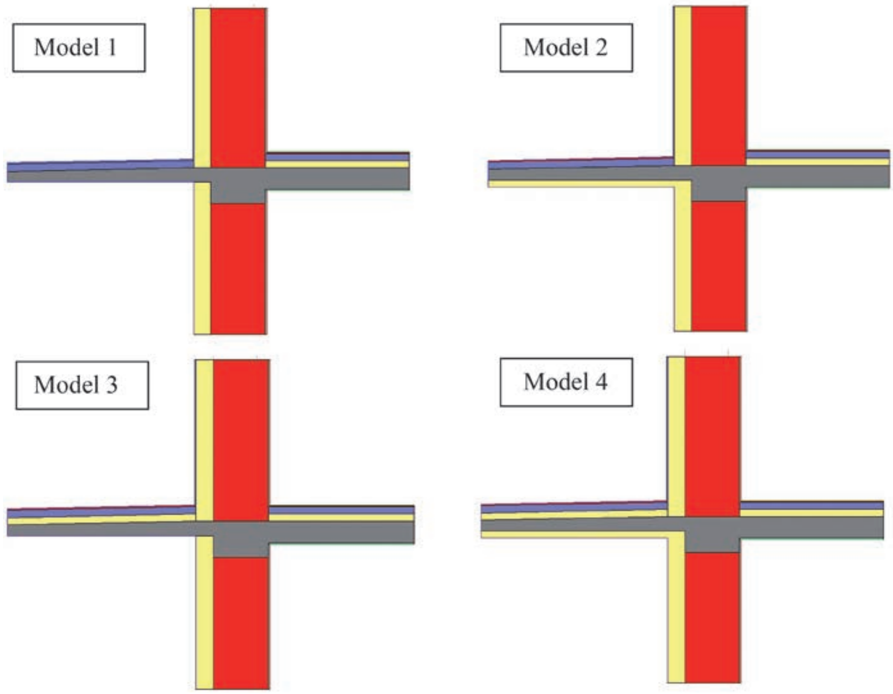


Fig. 5. The geometric models accepted for the calculations in THERM programme, authors' figure.

Initial and boundary conditions.

The following initial and boundary conditions were used to calculate:

ti = -20.0 °C ; te = +20.0 °C; hi = 25.0 W/(m^2K); he=7.7 W/(m^2K).

The calculation results for individual variants are presented graphically in Figures 6, 7.

The heat transfer coefficient calculated in accordance with PN EN ISO 6946 is:

- for a porous ceramic wall insulated with styrofoam EPS 040 - U = 0.280 W/(m^2K) - which met the requirements for the external partition of the design period, i.e. U <0.300 W/(m^2K).

The value of the linear thermal bridge was calculated in two variants:

- ψ_i for the completely internal partition dimensioning,
- ψ_e for the completely external partition dimensioning.

The value of the linear thermal bridge is calculated in accordance with standard PN EN 10211: 2008, in accordance with the formula: :

$$\psi = L^{2D} - \Sigma\, U{*}l \tag{1}$$

where: L^{2D} - thermal coupling coefficient for the model calculated using Therm 7.4 programme;

U [W/(m²K)] - heat transfer coefficient for the flat partition calculated in accordance with PN EN ISO 6946;

l[m] - linear dimension of the partition for which the heat transfer coefficient U of the analysed model is calculated, not less than 1 linear meter.

Numerical results are presented in Tables 1 and 2.

Table 1. Summary of the results for individual variants - Therm 7.4 programme.

Variant	The results obtained from the calculations in THERM 7.4 programme.			
	Heat flux qi [W]	Heat flux qe [w/m]	Linear dimension external li [m]	Linear dimension internal le [m]
1	22.6720	34.2550	2.108	2.000
2	22.4670	32.0580	2.059	2.000
3	22.0480	33.4960	2.060	2.000
4	21.7980	27.9490	2.010	2.000

Table 2. Summary of the results for individual variants - own calculations

Variant	The results from your own calculations.			
	L^{2D}_{i} [W/mK]	L^{2D}_{e} [W/mK]	Linear thermal bridge ψ_i [W/mK]	Linear thermal bridge ψ_e [W/mK]
1	0.5668	0.8564	-0.0234	0.2964
2	0.5617	0.8015	-0.0148	0.2415
3	0.5512	0.8374	-0.0256	0.2774
4	0.5450	0.6987	-0.0179	0.1387

Figure 6 graphically shows the cross-sectional temperature profiles for two extreme models, model 1 and model 4, in order to compare the impact of the insulation used in the model without insulation.

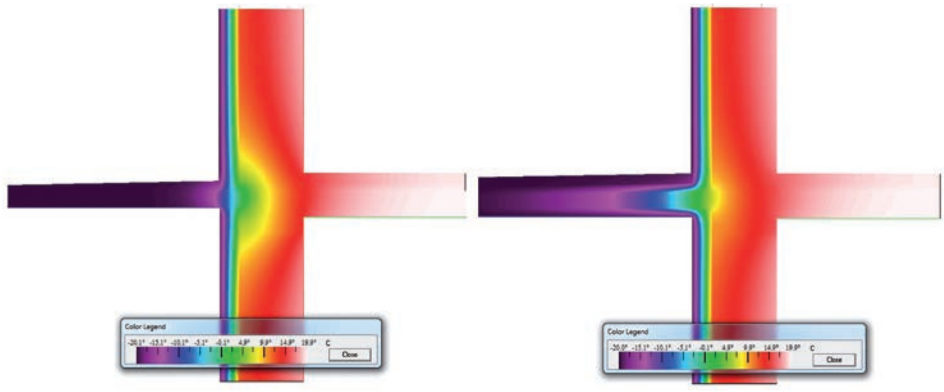


Fig. 6. Temperature field in a cross-section of the partition. On the left, the plate is not insulated, on the right - insulated from the top and bottom - generated from Therm 7.4 programme.

Heat losses generated by the linear thermal bridges can be expressed by giving the total heat transfer coefficient by penetration, $H_{tr,\,adj,}$ expressed in watts per Kelvin, calculated in accordance with PN EN ISO 13789, using the following equation:

$$H\mathrm{tr,adj} = H_D + Hg + H_U + H_A \tag{2}$$

where:

H_D Heat transfer coefficient by direct heat transfer to the external environment, expressed in watts per Kelvin;

Hg Coefficient of stationary heat transfer by penetration to the ground,

H_U Heat transfer coefficient by penetration by the areas without air-conditioning, expressed in watts per Kelvin;

H_A Heat transfer coefficient by penetration to adjacent buildings, expressed in watts per Kelvin;

If we consider only heat transfer through the partition in a full part, and we neglect the impact of point bridges, it will be possible to simplify the formula (2) to calculate only the values H_D (3)

$$H_D = b\mathrm{tr,}x\ [\Sigma i\ Ai\ Ui + \Sigma k\ lk\ \Psi k + \Sigma j\ \chi j] \tag{3}$$

where:

Ai area of a building's element and envelope, in square meters;

Ui heat transfer coefficient and building envelope,

lk length of the linear thermal bridg k, expressed in meters;

Ψk linear heat transfer coefficient of a bridge;

$b\mathrm{tr,}x$ factor of temperature correction, with value $b\mathrm{tr,}x \neq 1$ if a temperature on the other side of the partition element is not equal to the external environment temperature as in the case of a separating wall from the adjacent space with or without air conditioning or a floor on the ground.

For the considered case of the balcony, the following data were taken:

A - area of a part of the building in which there are balcony sections, less with the area of windows and balcony doors A = 37.8 m^2

L_C - total length of balcony plates on the considered part l_C = 45.0 linear meter *btr,x* =1.00

The surface and length data of the plates are provided for the complete internal dimensioning.

The calculation results for individual variants taking into account only values as for internal dimensioning are given in Table 3.

Table 3. The values of the heat transfer coefficient for the selected part of the building, for insulation variants of the balcony plate.

Variant	The results from your own calculations.			
	Linear thermal bridge ψ_e [W/mK]	btr [-]	*Ai x Ui*	H_D [W/K]
1	0.2964	1.00	10.584	23.922
2	0.2415	1.00	10.584	21.452
3	0.2774	1.00	10.584	23.067
4	0.1387	1.00	10.584	16.826

The graphic results are shown in Fig.

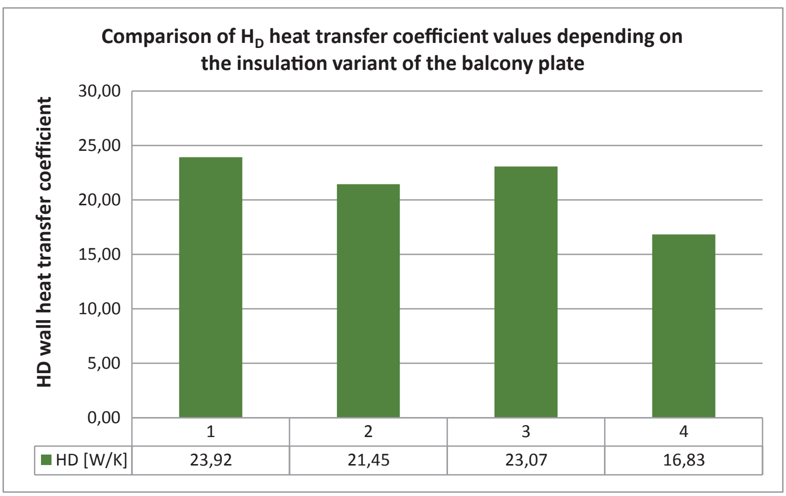


Fig. 7. The values of the heat transfer coefficient for the selected part of the building, for insulation variants of the balcony plate.

SUMMARY AND CONCLUSIONS

The analysed simple linear thermal bridge found almost in each multi-family building shows that the calculation of heat loss from the building to the environment depends largely on the dimensioning of the element and not on the degree of its thermal insulation. By using the external dimensioning system for heat loss calculations or more specifically for the calculation of the Primary Energy Index, we can omit the computational impact of such bridges, with a well-insulated wall. However, the reality shown by the thermal imaging camera is slightly different. On the façade of buildings, even well-insulated, we can notice the presence of linear thermal bridges using the thermal imaging camera. The lack of proper protection of concrete supporting elements - balconies and loggias plates, e.g. by using two-sided thermal insulation, together with an insert ensuring continuity of thermal insulation, causes local cooling of the element and, in many cases, condensation of moisture in the presence of such defects - the most often in the rooms with increased air moisture.

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SELECTED ELEMENTS INFLUENCING THE ENERGY CONSUMPTION OF BUILDINGS

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ABSTRACT

At present, the global trend in environmental policy is to reduce emissions of carbon dioxide emitted into the atmosphere. In many sectors of the economy are being sought new solutions, which will result in the protection of natural resources and protection of air quality. One of the sectors which highlighted the construction and the associated energy. The current Polish legislation significantly contribute to reducing the energy consumption of buildings. Formation of energy-efficient building is a complex process, which must take into account the various elements that affect the amount of energy consumed. At the same time, construction works should be designed so that it was possible to comfortable use of these buildings. The article focuses on two issues in the field of development of energy-efficient building, namely the external walls and on the development of internal microclimate of the building equipped with the gravitational ventilation..

Keywords: exterior walls, solar chimney, design heat loss, energy efficient house

Introduction

A large attention has been paid on the energy consumption of buildings for a number of years. The states' energy policy is to reduce the amount of energy required for the operation of the construction with the implementation of modern solutions for shaping the buildings, their envelopes and modern solutions. Directive 2002/91/EC obliges all Member States to improve the quality of the buildings through the enforcement of the obligation to hold the buildings energy certificates and energy control obligation imposed by the installation of heating and air conditioning systems. In addition, it requires the designers to use the systems based on the unconventional energy sources. The lack of such a certificate prevents from putting a new building into operation, and the existing buildings cannot be sold or rented. The changes implemented in Directive 2010/31/EU of the European Parliament and Council on the energy performance of the buildings involves the application of further higher requirements in terms of thermal protection of the buildings. The concept of a zero-energy building appears, while using the renewable sources and produced on a site or in the environment. The important fact is that from 31 December 2020, all newly designed buildings and the buildings subjected to thermal insulation will be designed using the "nearly zero energy use" standard. With regard to the public buildings, these provisions will come into effect from 31 December 2018.

In accordance with Regulation of the Minister of infrastructure of 5 July 2013 on the technical specifications, which should correspond to the buildings and their location, the buildings and their heating, ventilation, air conditioning, hot water should be designed and constructed in such a way as to meet the following minimum requirements:

1) the value of EP indicator [kWh/(m2 · year)] setting out the annual demand for non-renewable primary energy for heating, ventilation, cooling and domestic hot water preparation, and embedded lighting for specific buildings

$$EP(\text{calculated}) \leq EP\ (\text{maximum}) \tag{1}$$

2) partitions and technical equipment of the building correspond to at least the requirements of the thermal insulation specified in annex 2 to Regulation and window area corresponds to the requirements of the point 2.1 of Annex 2 to Regulation.

$$Uc \leq Uc(\text{maximum}) \tag{2}$$

3) in place of a thermal bridge - a temperature factor f_{Rsi} in order to test the risk of mould and fungi occurrence in accordance with PN-EN ISO 13788:2003.

On the basis of the analysis of legislation and additional requirements, it can be concluded that the classification of the building to a group of energy-efficient buildings depends on a number of factors:

- **Building architecture**
  - location of the building in relation to the world sides,
  - compact building (a minimum shape ratio A/V),
  - size and location of transparent partitions,
  - layout of rooms,
  - geometry of a roof.

- **Structural and material solutions of the construction partitions and their connectors**
  - the use of high quality materials,
  - the use of modern insulation materials, e.g. panels with polyurethane foams, aerogels, vacuum panels, transparent insulation,
  - design school of construction connectors in the thermal and humidity aspect with the use of numerical tools

- **Thermal insulation of the building partitions**
  - thickness of the thermal insulation (with commonly used materials) above 25÷30 cm,
  - getting the value of the heat-transfer coefficient U ≤ 0.10 w/(m2· K) for the non-transparent partitions and U ≤ 0.80 w/(m^2· K) for the transparent partitions,

- **Type and efficiency of the ventilation system**
  - hybrid or mechanical ventilation with heat recovery,
  - mechanical ventilation with heat recovery and heat exchanger in the ground,
  - high system efficiency (over 70%),

- **Type and efficiency of the central heating system and the hot water system of the alternative use of the (renewable) energy sources**
  - solar power,
  - wind power,
  - geothermal energy.

- **Building management system, which also allows to control the production**

In order to achieve a high standard of energy-efficient building, the cooperation in a number of fields such as architecture, construction, energy and environmental engineering must be involved.

SHAPING OF INTERNAL PARTITIONS

The material system of the partitions and their connectors play a very important role in the residential and public buildings. It impacts significant on the type of the physical processes that occur at the connection between two different centres separating these partitions from each other. The main task of the partitions is to ensure appropriate interactions if the external impacts on the interior of the building, so as to create a microclimate the most suitable for a man.

The external partitions must be provided the calculations to meet the primary criterion of heat protection Uc ≤ Uc(max), selecting the appropriate layout of the material layers. The applicable legal provisions relating to the protection of the thermal buildings are based on Regulation of the Minister of Infrastructure of 5 July 2013 on the technical specifications which should correspond to the buildings and their location. The values for the maximum heat transfer coefficients Uc (max) refer to the thermal insulation of the external walls, roofs, floors and windows and doors without distinction on the type of the partition (multi-or single-layer) and the use of the building (residential, public, storage, marketing, etc.). At the same time, one must meet the requirements in terms of the indicator of the annual energy demand EP [kWh/(m^2· year)]. In addition, the detailed requirements were developed in respect of the protection to eliminate condensation on the internal surface of the partition and inter-layer condensation.

The current thermal and humidity calculations should therefore benefit from an extensive database, which should be developed or supplemented in Poland, with the separation of the regional and individual climate zones. The determination of the temperature factor f_{Rsi} [-] in the analysed connector of the external partitions requires to specify a minimum temperature on the internal surface of the partition and the thermal bridge site, assuming the appropriate internal (t_i) and external (t_e) air temperature, and for the thermal bridges - the use of a spatial model of the partition in accordance with PN-EN ISO 10211:2008. However, the required value of the limit temperature factor $f_{Rsi\ (kryt)}$ is determined as a function of the temperature t_i and humidity content, φ_i for a room to which it refers. These parameters (the internal temperature and humidity content in a room) prejudge the values of the temperature factor $f_{Rsi\ (kryt)}$ impacting on the limit in assessing the correctness of the design solutions. In accordance with PN-EN ISO 13788:2003, the temperature factor $f_{Rsi\ (kryt)}$ is calculated or depending on the ventilation type of the building (gravity ventilation prevailing in the residential construction or mechanical ventilation, which is often a component of the air conditioning systems, allowing to shape in any way the properties of a microclimate inside). Table 1 summarizes the results of the calculations of the limit value of the temperature factor $f_{Rsi\ (kryt)}$ referred to different methods.

Table 1. Calculation of the critical temperature factor values for the three cases of the rooms ventilation - source (Dylla 2015)

method	m-c	t_e [°C]	φ_e [%]	p_e [Pa]	Δp [Pa]	φ_i [%]	t_i [°C]	t_{kr} [°C]	f_{Rsi} [-]
A	J	-3.0				55	20	14.1	0.743
A	II	-1.6				55	20	14.1	0.726
B	XII	-0.5	89	522	810		16	14.6	0.886
B	J	-3.0	87	414	810		16	13.3	0.858
B	II	-1.6	85	454	810		16	13.8	0.875
C	J	-4.8				50	24	16.4	0.736 0.72*)
- method: A (constant inside humidity - air conditioning), B (inside humidity changing as a function of the humidity room class - gravitational ventilation), C (inside temperature ti ≥ 20°C and humidity φ_i= 50% defined by [1] - gravitational ventilation) - location of the building (method A and B – Kraków, method C - Białystok, - room humidity class 4 (method B) *) the limit value specified by Regulation, the Journal of Laws 2013, item 926.									

In Regulation, the Journal of Laws 2013, item 926, despite the recognition of PN-EN ISO 13788 as in force in the design process, there is a derogation from the requirements of the average monthly relative humidity of inside air at a constant value of φ_i=0.50 (50%) (point 2.2.2 of Annex 2 to Regulation, the Journal of Laws 2013, item. 926) for the rooms with internal temperature equal to at least 20°C. At the same time, for these rooms, one allowed (without calculations) to assume the value of factor $(f)_{Rsi\ (kryt)}$ = 0.72, which means the resignation from determining the humidity classes of the rooms with gravitational ventilation. This derogation does not allow to include in the humidity calculation the real location conditions (climate) and microclimatic of the tested building, at least in respect of the rooms with the internal temperature $t_i \geq$ 20°C, quite drastically reducing the level of the requirements for protection against moulds of the buildings in Poland in harsher climates (IV and V zones).

SHAPING OF THE INTERNAL MICROCLIMATE

The concept of the inside microclimate means a complex of all physical and chemical parameters of a room, impacting on a human body and on the building. The main parameters of microclimate include: air temperature, average temperature of the partitions surfaces, air speed, air relative humidity. The factors complex, apart from the thermal ones, are: air pollution, air ionization, noise level, lighting, etc.

Since the innovative systems were implemented to the construction industry, shaping the internal microclimate of the rooms has become a task easier. However, there are problems on which special attention must be paid. First and foremost, the publication involves problem of air humidity and the impact of this parameter on the building.

Large fluctuations in relative humidity (within 30-70%) are not burdensome. The situation is different with the construction partitions. High relative humidity, especially in the winter, can cause water condensation on the surface of panes in the windows and on the external walls. This can result in moulds and fungi on the building partitions, especially on the thermal bridges. The problem of excessive relative humidity has occurred when the sealed windows without the possibility to provide the required amount of external air into a room were placed on the market. The production technology of windows changes all the time, and the currently installed window must have window diffusers. The problem of the appropriate use of the buildings appears here. The users incorrectly use the installed diffusers due to savings, which causes deterioration of the conditions of the inside microclimate. The solution to the problem is to design a proper ventilation system, which will not increase the energy intensity of the building, and at the same time, will provide comfortable conditions in the building. One solution involves the use of the assisted ventilation gravity.

In accordance with Regulation of the Minister of Infrastructure of 5 July 2013 on the technical specifications, which should correspond to the buildings and their location, ventilation should provide adequate inside environmental quality, including the size of the air exchange, its cleanliness, temperature, relative humidity, speed of air movement in the room. The ventilation system can be designed as mechanical or gravitational in the rooms intended for people in public areas without opening windows, as well as in other areas, in which for health, technological or safety reasons, it is necessary to ensure the exchange of air. Considering the amount of energy consumed in the mechanical ventilation systems, it is worth noting the alternative solutions, however, one must keep the existing legislation and ensure comfortable conditions in the areas. The first issue related to the ventilation system is the amount of ventilation air, which must be supplied to the rooms. Detailed information on this topic can be found in the Polish Standard PN-83/B-03430 and PN-83/B-03430/Az3:2000.

Due to the fact the pursuit of the sustainability in architecture and construction, in order to provide the appropriate amount of air, it is advisable to use the solutions that will allow for energy savings in the operation of the buildings. Therefore, the article will present the solutions to assist the convective system.

Air permeability coefficient for windows and balcony doors should be no more than $0.3 m^3 \cdot (m \cdot h \cdot daPa^{2/3})^{-1}$, at the same time, it is recommended that the tightness of the building with gravitational ventilation is $n50 \leq 3.0\ h^{-1}$. It is considered that the diffusers installed on door frames and windows leaves are the basic devices to supply air to the rooms.

The development of the construction industry caused the need to seal the buildings, which has weakened the flow of air into the rooms, and have changed the needs of the users. This resulted in an increase in the requirements and the search for the gravitational ventilation solutions. A number of the methods to assist gravity ventilation include:

- Chimney cowls
  The fundamental task of the cowl is to increase vacuum in the exhaust air duct, using the wind speed.
- Double glass walls
  Two layers of glazing, from several to tens of centimetres, form two glass walls. The internal layer can be traditional, and the external layer - a glass cover.
- Glazed atria and arcades
  Glazed atria are located in the internal zone of the building. Air heated at the top of the atrium is exhausted outside by circulation holes that are located in the roof.
- Trombe's wall
  Trombe's wall was patented in 1972. It is a dark colour wall, a few centimetres in front of which there is glazing. The principle of operation of Trombe's wall was described inter alia by Z. Pluta (2007)

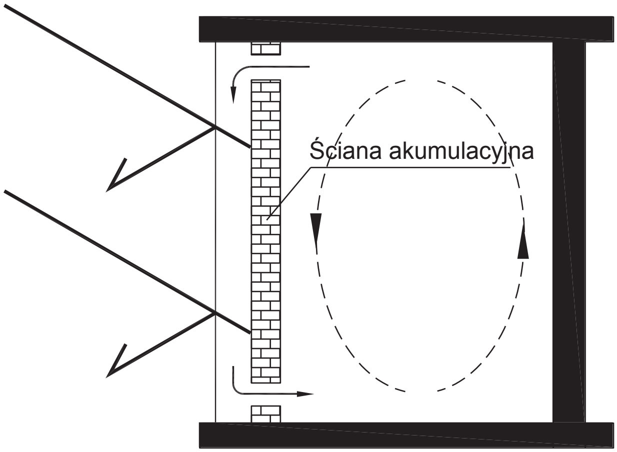

Fig. 1 Trombe's wall

Sunlight hit the pane, pass by it, and are stocked by the accumulating wall, increasing its temperature. Accumulated energy in a form of heat in the accumulating wall is provided to air flowing between the pane and the wall.

The question of the impact of the width between parallel boards on the natural convection is presented by E.M. Sparrow and L.F.A. Azevedo **Błąd! Nie można odnaleźć źródła odwołania.**. These tests are cited by G. Gan (1998) in his publication presenting the method of operation of Trombe's wall, using the computer methods based on the CFD technique (Computational Fluid Dynamics). The tests can be used to predict air flow depending on the geometry of the wall. The tests included considerations on the various parameters of Trombe'a wall, and the dependencies between them. One of the issues was the impact of a duct and an air inlet width on air flow at a given temperature. It has been shown that if a duct width (the distance from the wall glass) and a height of the lower hole are equal and equally increased, the speed of air flow will increase, but if an inlet height is always equal (assumed as 0.1 m) and only a duct width is increased, this will not impact on air flow.

- Solar chimneys

The solar chimney can be a device supporting gravitational ventilation in the building, due to the use the solar heated air convection effect (fig. 2).

The principle of operation of the solar chimneys is similar to the operation of the traditional chimneys. A distinctive feature is the strengthening of natural ventilation using passive solar heating. Energy is gained form solar radiation naturally, due to the phenomena of heat and mass exchange. The performance of the solar chimney depends on the air temperature in the chimney. The temperature value is directly impacted by the amount of penetrating heat from sunlight, and this is related to the angle of sunlight exposure to the surface. Therefore, the angle of inclination of the solar chimney is a very important parameter to determine the intensity of natural ventilation. Since the 1990s, the tests have been carried out on this issue. The scientists use different methods to determine optimum angles. However, this is a very complex issue, because the process of air flow is impacted not only by sunlight, but also other factors such as wind speed, air humidity.

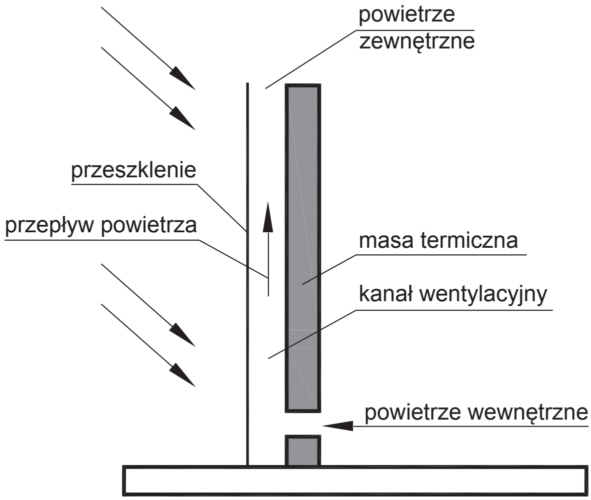

Fig. 2 Schematic of a solar chimney [own development]

CONCLUSION

Energy consumption of the building is shaped by a number of internal and external factors. Proper selection of the material systems of the external partitions and their connectors allows to limit heat losses at the penetration (heat transfer coefficient U_c W/(m²·K) for the full external partitions, the linear heat transfer coefficient Ψ W/(m·K) for the building connectors - thermal bridges) and avoid the risk of surface condensation (the risk of mould and fungi occurrence). Another element is the appropriate selection of the ventilation system together with the determination of the necessary air parameters. Important information on determining the amount of air required and the method of supplying into and discharging from the room impacts on the energy consumption of the building.

The selection of the renewable energy sources should be made after a detailed analysis of the physical parameters of the external partitions and their connectors and the technical parameters of the planned systems in the buildings.

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AUTONOMOUS HOUSE IN KUNČINA

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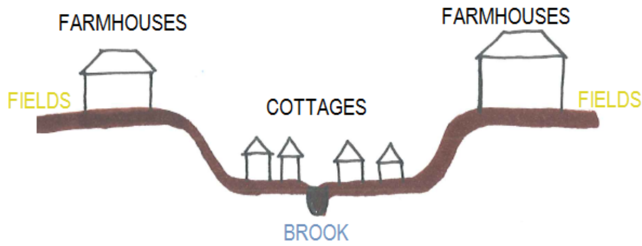
ABSTRACT

The article deals with the family house designed by architect Martin Nedvěd, which is being realized in the village Kunčina in East Bohemia. The object for a five member family is situated on the edge of the village near the biogas plant owned by an investor. It has its own well - a source of drinking water that will be infiltrated back into the soil after cleaning. Warmth for heating and hot water will be obtained from the biogas plant. The source of electricity will also be the biogas plant and a set of photovoltaic panels. Green roofs will protect the house from overheating. They will be continued by the terraced vegetable beds irrigated by rainwater. Rainwater will also fill the swimming pond (habitat), which will be filtered through the ornamental flower beds on one of the roof cascades. Floor plan of the atrial house reflects the original buildings in the village (farmyards), but green roofs and terraced gardens passes into the surrounding landscape. Thanks to its own water source (well), food source (the garden), source of heat and electricity (renewables), the house is fully autonomous.

Keywords: autonomous house, renewable energy,

CONTEXT

The village Kunčina (originally Kunzendorf) in eastern Bohemia was founded in 1270 by German colonists, who were exiled in 1945 and replaced by Czech citizens. Kunčina as road valley village has a characteristic arrangement of buildings by terrain morphology, stemming from the logic of its founding in the Gothic period. On the upper terraces above the valley, in direct contact with fields, there are freely distributed closed or half-closed "Frankish" farmhouses, while on the lower terrace of the valley, along the road and the creek were formed smaller cottages of auxiliary labourers, craftsmen and retired old people. (Il. 1)



Il. 1 Cross section of the village Kunčina. Drawing: M. Nedvěd

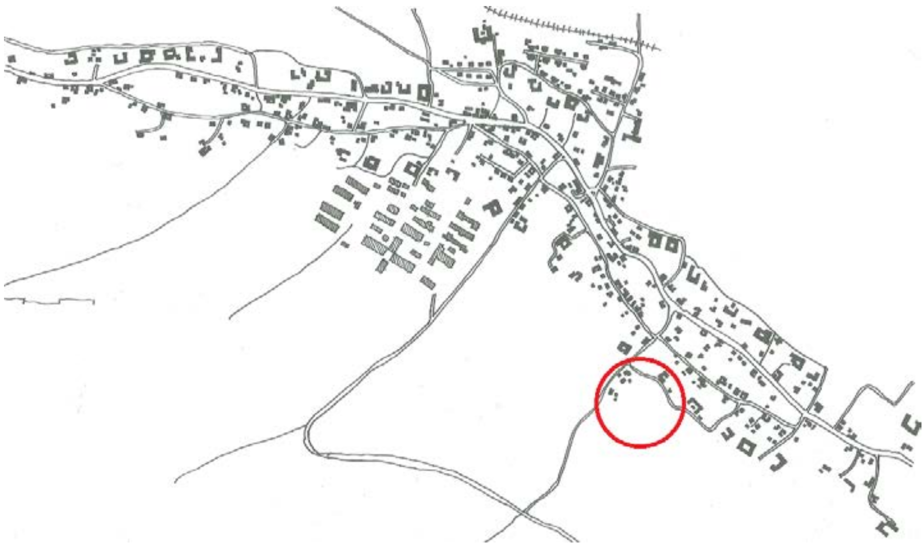
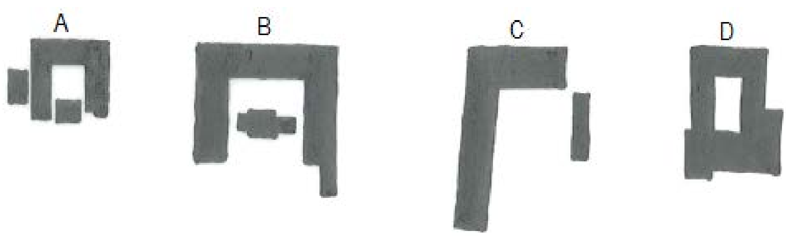
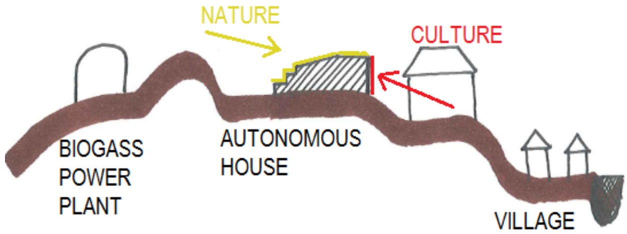


Figure.1 Kunčina – village in Eastern Bohemia (a building site in the ring). Drawing: M. Nedvěd

Building site was chosen by investor, because he wanted to live further away from the people and because his biogas plant (which he wanted to use as a source of heat and electricity) is staying there. Task was to propose a single-storey luxury house for a family of five with two cars. Proposal should include a swimming pool and guest house.



Il. 2 A comparison of the proposed building and the existing farms in the village (A – autonomous house, B - house registration number 372, C - house registration number 151, D - house registration number 361). Drawing: M. Nedvěd



Il. 3 The concept for the building's location between town and countryside. Drawing: M. Nedvěd

CONCEPT

Architect Martin Nedvěd (one of the authors of this article) had to solve the problem, how to design a building on the upper terrace of the village between existing farms and free landscape (fields, medows, forests, ...). Solution (presented on Il. 3) was to design a house that viewed from a village creates urban wall and viewed from the outside is a part of nature. This is possible thanks to the oblique side wings of atrium house with green roofs and thanks to cascades of flower and vegetable beds along the rear walls.

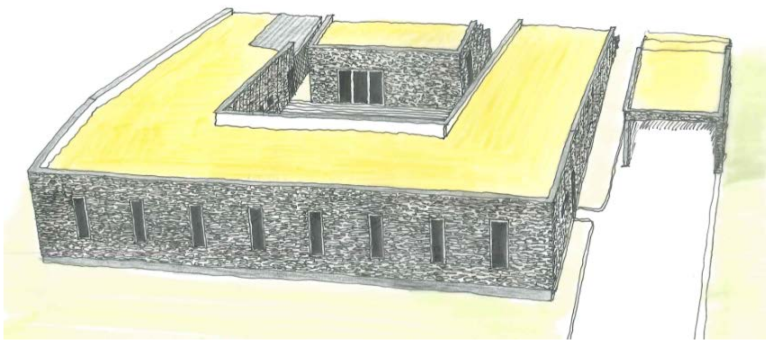


Figure. 2 Design of the proposed building. Design and drawing: M. Nedvěd

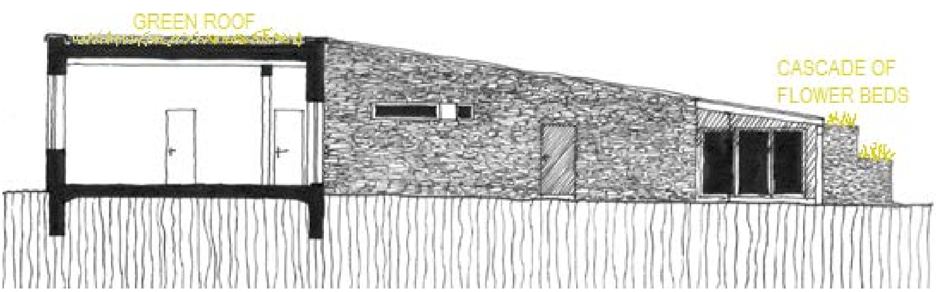


Figure. 3 Longitudinal section through the atrium. Design and drawing: M. Nedvěd

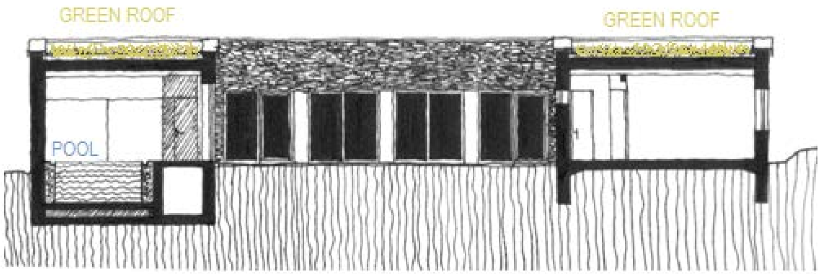


Figure. 4 Cross section through the atrium. Design and drawing: M. Nedvěd

The building in compliance with the surrounding buildings is designed as narrow, longitudinal mass, bent around a closed courtyard. Built up area fits into the average between the farmhouses in a similar position on the edge of fields. A comparison of the size of the proposed building with the largest farms in the village (Il. 2), or the situation of wider relations (Figure. 1) shows that the chosen scale is appropriate.

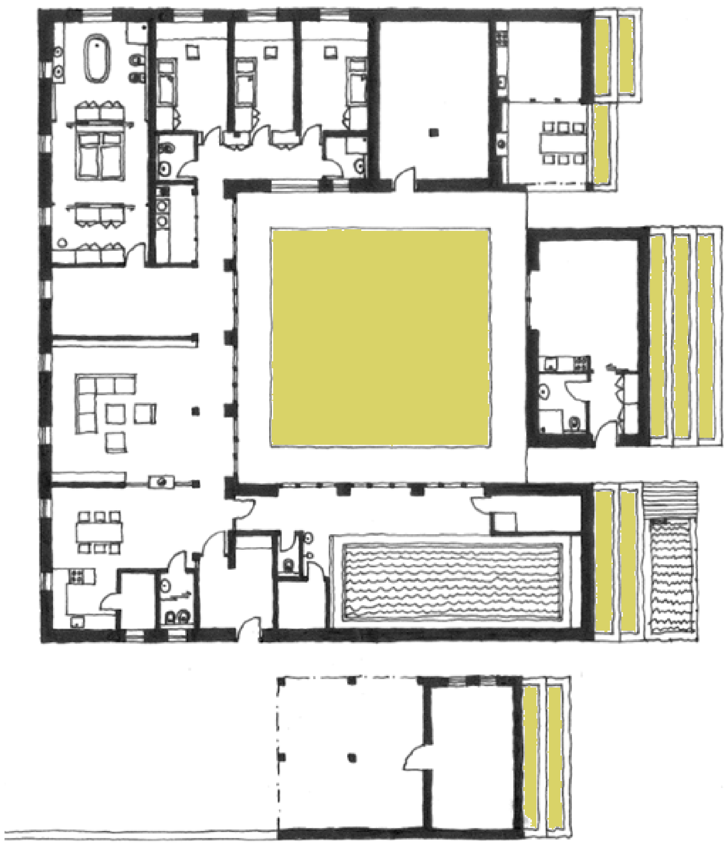


Figure. 5 Floor plan. Design and drawing: M. Nedvěd

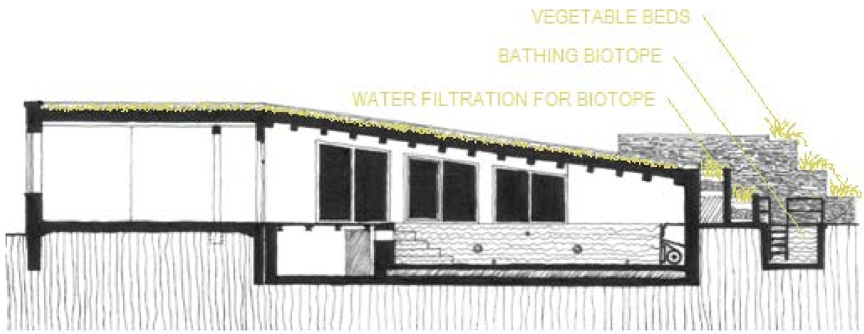


Figure. 6 Cross section through the pool wing. Design and drawing: M. Nedvěd

CONSTRUCTION AND MATERIALS

The building is based on concrete footings and slabs. The walls are constructed from ceramic bricks. Ceilings are made of local timber. The roofs are green - decking over wooden beams, vapor barrier, thermal insulation, hydro isolation, hydro-accumulation layer, geotextile, soil and grass. The windows are wooden - aluminum with thermal insulating triple glass. The facades are clad with local sandstone.

WATER MANAGEMENT

Water is extracted from own well. After use is cleaned in wastewater power plant and infiltrated back into the soil. Rainwater, not remain in layers of green roofs, flows through a cascade of flower beds, irrigate them and the rest is infiltrated into the soil. Cascade beside the bathing biotope is filled with plants, which act as a filter for this biotope (cleaned water is driven by a solar-powered pump).

ENERGY MANAGEMENT

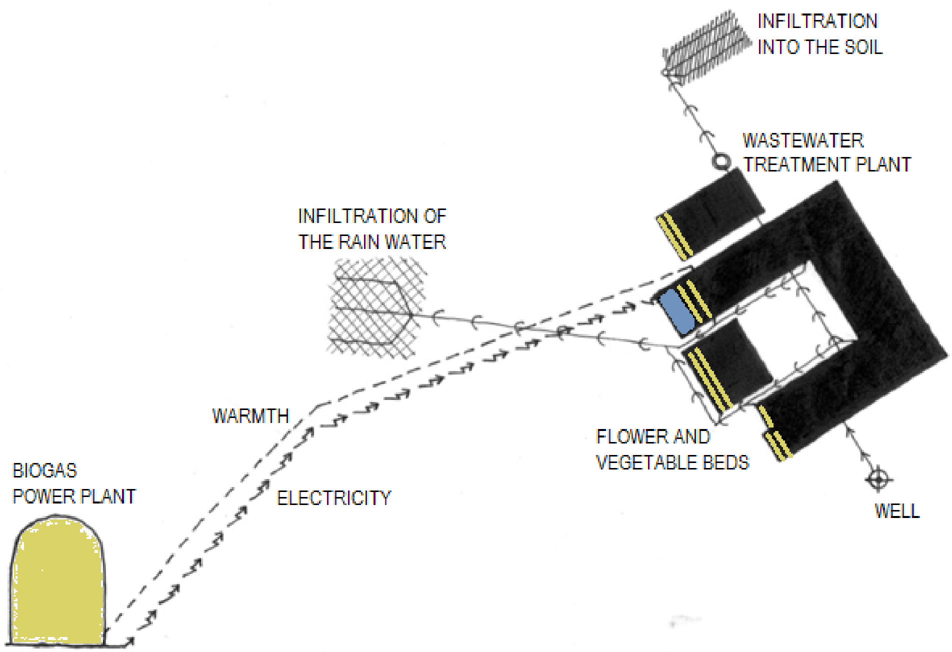
Electricity is obtained from a nearby biogas plant, which is a renewable source of energy. In the future is being considered the connection of solar panels. The biogas plant is also a source of heat for heating and hot water.

Parameters:

Heated area: 445 m^2

Heated space: 1482 m^3

Energy consumption: 73 MWh / Year



Il. 4 Site plan. Design and drawing: M. Nedvěd

CONCLUSION

"An autonomous building is a building designed to be operated independently from infrastructural support services such as the electric power grid, gas grid, municipal water systems, sewage treatment systems, storm drains, communication services, and in some cases, public roads." (Wikipedia)

House in Kunčina meets the idea of a closed system in terms of water, sewage, storm water, electricity, heating, and partially of the food (vegetable beds in the cascades and fruit trees in the garden do not cover the entire consumption of the family, but can be extended and included the animal farming if necessary).

Figure. 7 Construction in August 2016. Photo: M. Nedvěd

Figure. 8 Construction in September 2016. Photo: M. Nedvěd

AKNOWLEDGMENT

This contribution is the result of the research supported by Student Grant Competition VSB Technical University of Ostrava. Project registration number is SP2016/127.

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NUMERICAL SIMULATION OF WIND TURBINE USING MODERN SIMULATION TOOL

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ABSTRACT

This paper presents CFD (Computational Fluid Mechanics) simulation tools and chimera technique applied to configuration with rotating elements. For the calculation of the case with rotating elements, CFD analysis requires a definition of individual fluid domains. The calculation of CFD simulation is associated with rotating flow grid. Computational Fluid Simulation calculations for the rotating elements are not possible on single mesh. It is therefore necessary is to use the chimera method in these cases. This paper presents a solution to this problem on the example of wind turbine based on real configuration's geometry. The most challenging part of the calculation in this case is the process of deformation of the flow mesh at each time step. This approach was necessary due to the rotating elements and interpolation of the results between rotating element and fixed flow domain. Finally the authors present a response of CFD analysis for d rotating elements based on real geometry of the wind turbine.

Keywords: wind turbine, numerical simulation, chimera technique

Introduction

Computer simulations are used, and even necessary when designing building or mechanical structures. The physical construction phase begins only after a computer simulation that verifies that the required strength and safety standards are met. In the aerodynamics field, they are used inter alia to determine the values of parameters describing the geometry of an aircraft or its components (e.g. wings, ballasts). The values obtained after such a simulation include, but are not limited to, the values of the bearing force and air resistance (fluid), pressure values and flow velocities in the analysed geometry area.

The use of a computer is also very helpful in designing the geometry of an aircraft and its components (wings, ballasts, etc.). For virtual models, the value of aerodynamic resistance is checked so that the current geometry can be modified to minimize this resistance, and maximize the bearing force. Another use of the flow simulations is to analyse the whirls of the fluid generated behind and obstacle. It turns out that even slight changes in a geometric shape can significantly reduce the nature and size of the occurring whirls, and thus reduce the resistance. Practical examples of such geometries are e.g. passenger cars and trucks, where one strives to minimize traffic resistance.

Another example of the use of the computer simulation can be the simulation of airflow around a moving wind turbine, where the efficiency of the use of wind by windmill blades can be checked. The geometry of the blade should be shaped to get the highest possible force perpendicular to wind direction. It is also important that the angle of attack, i.e. the angle at which the blade's plane is aligned with respect to the line of action of the force coming from the wind.

The following thesis presents a modern way in which the computer simulation of the flow of fluid (air) around a moving wind turbine (fig. 1) can be obtained.

Fig. 1 Modern Vestas wind turbine [http://www.vestas.com]

STATE OF KNOWLEDGE

At the present time, the Finite Element Method (FEM) is the basic engineering tool for addressing computational tasks in various areas. The main idea of the FEM is to convert any continuous size (e.g. speed, pressure, temperature, etc.) into its discrete model. This model is based on a limited number of nodes that define a finite number of elements (hence the name of the method) (A. Milenin, 2008). The exact values are calculated only in nodes that fill the calculated area. Value outside of the nodes are enumerated, in turn, by means of interpolation using the appropriate functions. The application of FEM in a form of various software is often associated with the formation of the numerical errors. This method is an approximate method and its use requires a certain amount of theoretical knowledge.

The first step to carry out the virtual simulation of processes is replacing a calculated area (called the computational domain) on the model. This activity consists in generating a so-called calculation mesh (flow mesh), which has a key impact on the quality and reliability of the obtained solution. It also significantly impacts in the cost of numerical calculations, in terms of the required computing calculation power and the time it takes to complete the calculations.

The mesh generation process is already largely automated - the most commonly used algorithms are those that enable the generation of highly optimized flow meshes. The most commonly used algorithms are: Delaunay Triangulation and the Advancing Front Method. These algorithms allow the generation of a numerical mesh based on the information on the surfaces of the model and the calculation domain.

Despite significant automation of the calculation mesh generation process, a certain strategy and experience are required from the engineer to define finite element sizes on all surfaces. Too large will result in excessive simplification of the geometry. Consequently, the result of the calculation, although accurate, cannot take into account certain phenomena that occur with a complicated-shapes model. The definition of too small items will, in turn, cause rapid increase in the number of all the elements in the domain which directly translate into a longer calculation time.

It is also important to skilfully assign local densities in the calculation area. Especially, it is advisable to introduce these condensations in the areas where the shape of the model is complex, and in areas where the occurrence of different physical phenomena (e.g. air turbulence in aerodynamic shadow) is expected. It is necessary to ensure a smooth expansion of the size of the elements, starting with the largest densities.

The use of the above guidelines allows to generate the optimal numerical mesh. The "quality" of the mesh depends mainly on the shape of the individual finite elements. A perfect case would occur if all elements were polygons and regular polyhedra. This in most cases is impossible to obtain, due to the complexity of the tested geometry. A slight deviation of shape from the regularity does not, however, significantly impact on the deterioration of the mesh. The "quality" elements can be checked using the so-called mesh quality metrics. For tetrahedrons, they are the tetrahedron shape metric and the tetrahedron relative shape metric. The hexadecimal elements, in addition to two quadrilateral relative metrics, still have the quadrilateral skew metric (P. Knupp 2009).

AERODYNAMICS OF WIND TURBINES

Force P (fig. 2) act on a flat plate placed at an angle of alpha to the direction of air movement v. This force is decomposed into two components: force Px acting in the direction of wind speed v, and force Pz acting perpendicularly to Px (A. Flaga, 2010).

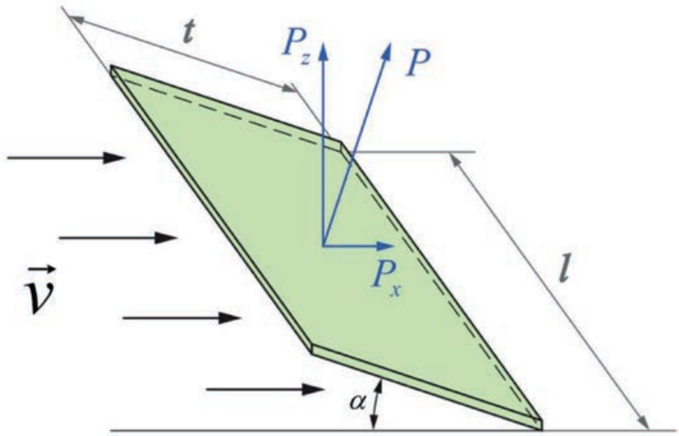


Fig. 2 Reaction forces for a flat plate (A. Flaga, 2010).

$$
\begin{aligned}
P_x &= \frac{1}{2} C_x \cdot F \cdot \rho \cdot v^2 [N] \\
P_z &= \frac{1}{2} C_z \cdot F \cdot \rho \cdot v^2 [N] \\
F &= l \cdot t
\end{aligned}
\tag{1}
$$

where:

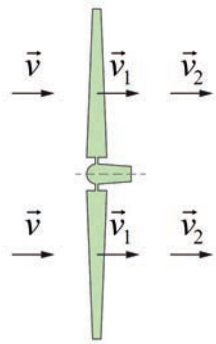
C_X – aerodynamic resistance coefficient,
C_Z – bearing force aerodynamic coefficient,
F – plate surface (panel) [m^2];
v – speed of air relative to plate (panel) [m/s];
ρ – air density [kg/m^3]

Different air profiles differ in shape in the XZ plane (a cross-section plane). The shape of these profiles is created in such a way as to minimize C_X while maintaining a relatively high C_Z value. The so-called excellence (K) is an important parameter determining the aerodynamic properties of the profile:

$$K = \frac{C_z}{C_x} \tag{2}$$

The angle of attack for which excellence is the highest is called the optimal angle of attack (α_{opt}).

If air stream flows to the wind turbine rotor at a speed of v, this will reduce the speed to v_1 and then beyond to v_2 (Fig. 3).



$$v > v_1 > v_2$$

Fig. 3 Reduced air speed in the wind turbine rotor (A. Flaga, 2010).

The decreased speed of incoming air can be observed in the carried out flow simulations.

Based on theoretical considerations, one can conclude (http://www.uwm.edu.pl/kolektory/silownie/aerodynamika.html):

- the largest possible utilization of wind energy in a single rotor is 0.59. This means that at most 59% of the kinetic energy of the wind velocity v and of the cross-section F equal to the area of the circle spanned by the wings can be converted into mechanical work;
- the highest efficiency is obtained when the speed of the air stream through the rotor $v_1 = 2/3v$ and the air speed behind the rotor $v_2 = 1/3v$;
- in the rotor there are various types of aerodynamic losses that reduce the amount of energy that can be obtained. As a result, the actual wind power factor is less than the theoretical and for modern windmills it is, depending on the design and size of the engine, between 0.3 and 0.45.

CONSTRUCTION OF CALCULATION MODELS

The first step in creating a flow simulation was to prepare a virtual geometric wind turbine model (Fig. 4). Already at the CAD design stage, the use of Chimera simulation for a flow analysis should be considered.

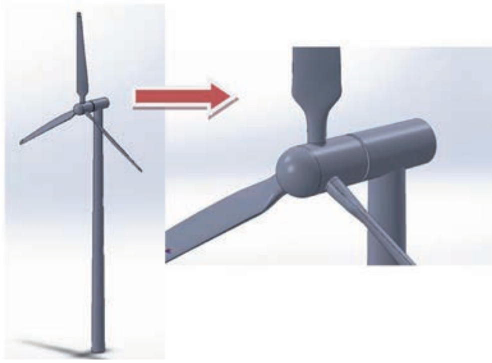


Fig. 4 Virtual wind turbine model.

The developed wind turbine model consists of three blades, a nacelle and a tower. Each blade has a length of 4 [m] and is intended for small wind turbines, up to 5 kW. The aerial profiles S823 (base) and S822 (top) were used to build a blade. The cross-sections of these profiles are shown in Figure 5.

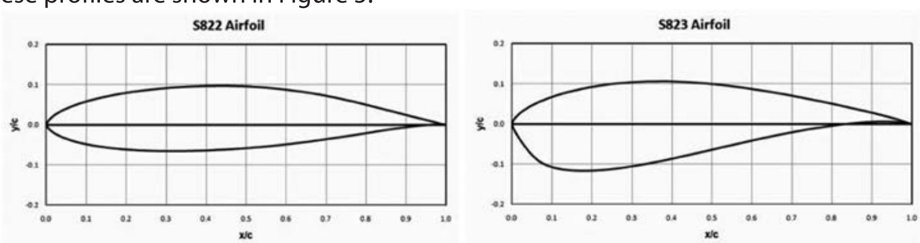


Fig. 5 Air cross-sections used in a blade of the wind turbine

Figure 6. shows the view of the wind turbine model taking into account the most important dimensions and the enlargement of the windmill nacelle with a visible gap (necessary in the Chimera technique). All dimensions are provided in [mm].

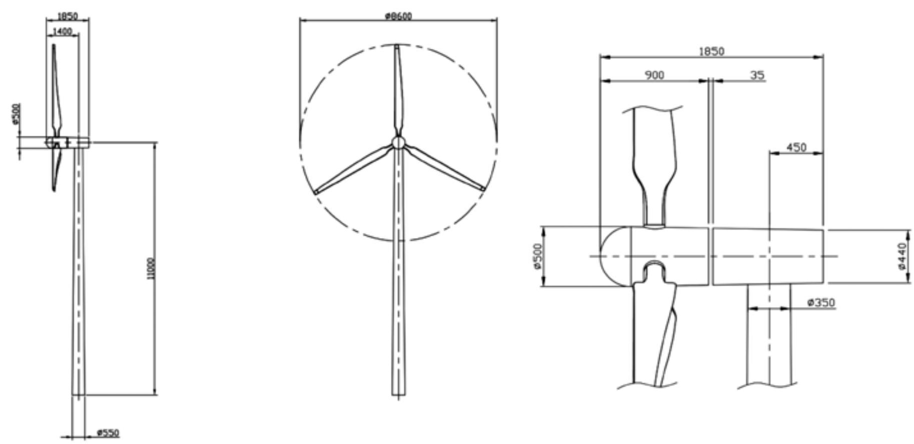


Fig. 6 Overall dimensions of the wind turbine (CAD model).

The wind turbine only rotates around one axis, defined by the windmill nacelle. For the modelling of the flow, two numerical meshes were used, based on two CAD models. In the model of the whole wind turbine, therefore, two smaller models were separated - rotary and stationary:

- the mobile element is a geometry containing the shape of the blades and the front part of the wind turbine nacelles (fig. 7);
- the stationary element is the geometry of the windmill tower, and the back part of the nacelle (fig. 7 from the right).

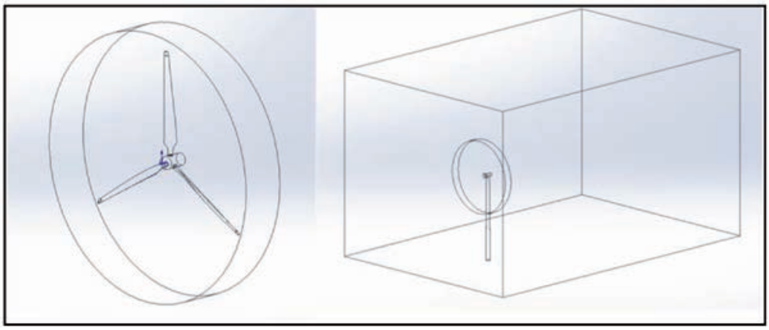


Fig. 7 CAD models used to build numerical meshes for Chimera's technique, the mobile element on the left, and the stationary element on the right.

The windmill nacelle was divided into two parts. The division is necessary in order to obtain a single, consistent data exchange area in Chimera technique. The gap width is also an important part.

Chimera technology requires the use of a single, closed area of the exchange of information between the areas. This means that the mobile part on each side must be in the fixed part. In order to obtain the correct simulation results, it was necessary to model a small gap between the turbine housing and the drive shaft (Fig. 8, details: A, B). This resulted in a single, closed loop of the exchange of information between the mesh. In fact, this gap does not exist, and therefore its size should be as small as possible so that it does not significantly impact on the results of the simulation. On the other hand, this size cannot be infinitesimally small, as the exchange of information is also required in the gap - several layers of finite elements are needed.

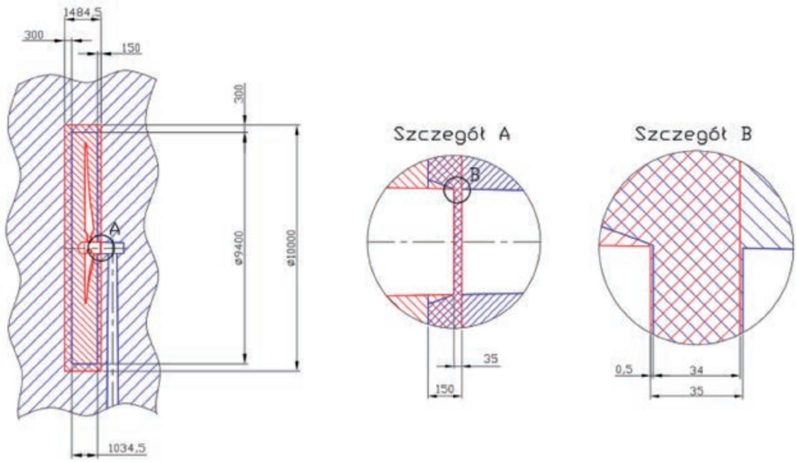


Fig. 8 Position the rotor (mobile element - red) in relation to the whole windmill (stationary element - blue).

CONSTRUCTION OF DISCRETE MODELS

For the developed CAD models, flow meshes were generated using Centaur soft software. In order to achieve optimum block integration, the same finite element sizes were used in the definition of the discretization parameters in the areas of mutual penetration of the mobile element areas with the stationary element. For such models, flow mesh for the rotor and fixed part were generated (9).

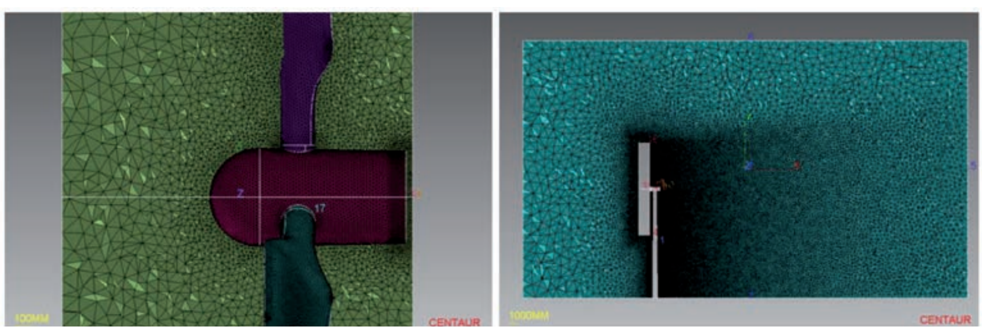


Fig. 9 Discrete models for the wind turbine: from the left - the rotor model, from the right - the stationary part with the simulation area.

The number of finite elements for each of the meshes is equal to: 6.20 m for the mobile element and 8.74 million for the stationary element.

Figure 10 shows the final spatial configuration of two meshes blocks to carry out the flow simulation for the wind turbine.

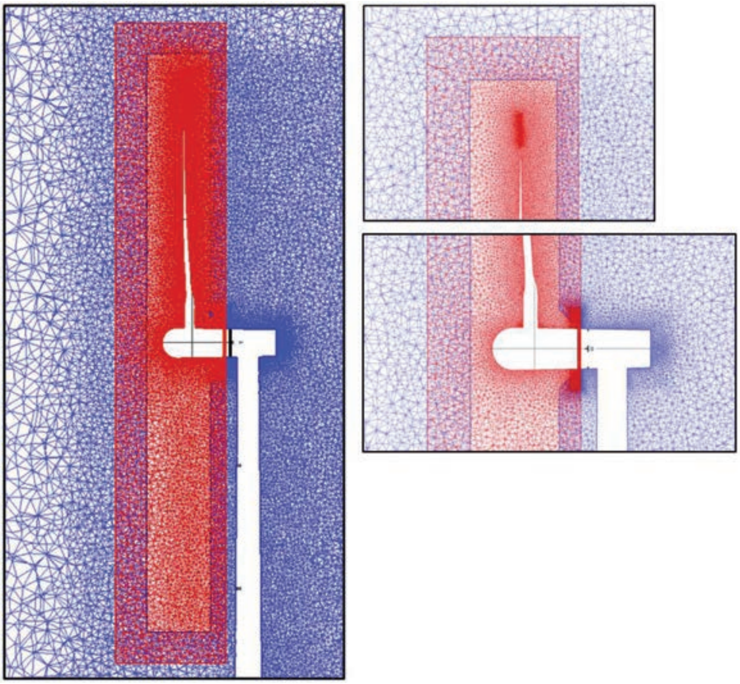


Fig. 10 Final spatial configuration of two meshes blocks for the calculations with the use of Chimera technique.

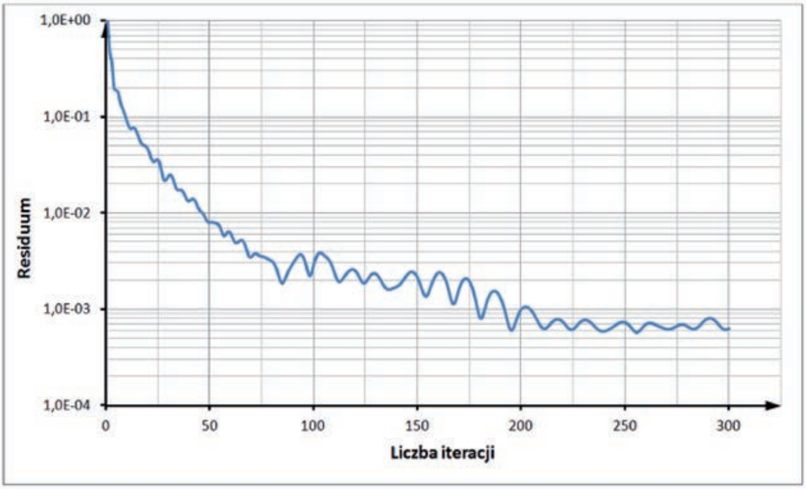
NUMERICAL CALCULATIONS RESULTS

The following parameters are assumed for the numerical flow calculations:

- Fluid flow rate - 13 [m/s] = 46.8 [km/h]
- Angle of attack - 0 [°]
- Fluid density (air) - 1.293 [kg/m^3]
- Ambient pressure - 101325 [Pa]
- Ambient temperature - 273.15 [K] = 0 [°C]

The non-stationary parallel calculations were carried out using specialized software developed by the German Space Agency DLR (*Deutsches Zentrum für Luft- und Raumfahrt*), the research centre for aeronautics, transport and energy. DLR TAU-Code is an advanced, modern system used to simulate viscous flows (based on Navier-Stokes equations) and non-viscous flows (based on Euler equation) around geometry of varying degrees of complexity. TAU-Code calculations (R. Roszak, 2009) can be run on structured, unstructured and hybrid meshes (T. Schwarz, F. Spiering, N. Kroll. 2010).

In the first stage of the calculations, the calculations results were obtained made for the stationary flow, in which the windmill did not carry out any rotational movement. Figure 11 (on the left) shows the convergence of the stationary solution indicating the correctness of discrete models. The second stage was to carry out the non-stationary calculations. In the first time step, the stationary solution was adopted as the starting value. Thus, the initial residuum is already much smaller than 1 (fig. 11 of the right) - and for the first non-stationary step it was already 3.39e-01. Thus, the convergence of results is achieved faster (with fewer iterations) - for the first step it was 265 iterations instead of 300, and the residuum was 9.96e-06. True was a condition of achieving the residuum below 1e-05.



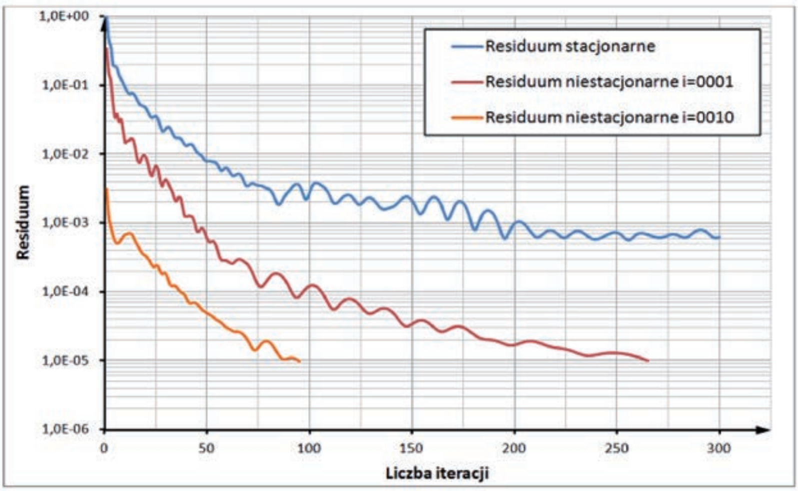


Fig. 11 Convergence of the stationary solutions (on the left) and the non-stationary solutions (on the right)

In order to illustrate the movement of the rotor, figure 12 (on the left) shows a visualization of 5 selected steps. In order to show the movement of the rotor with the flow speed distribution, every second step was used (the 2nd, 4th, 6th, 8th, and 10th step). The change of the position between adjacent blades is 2 [°]. Figure 12 (on the right) shows the speed distribution in the simulation area.

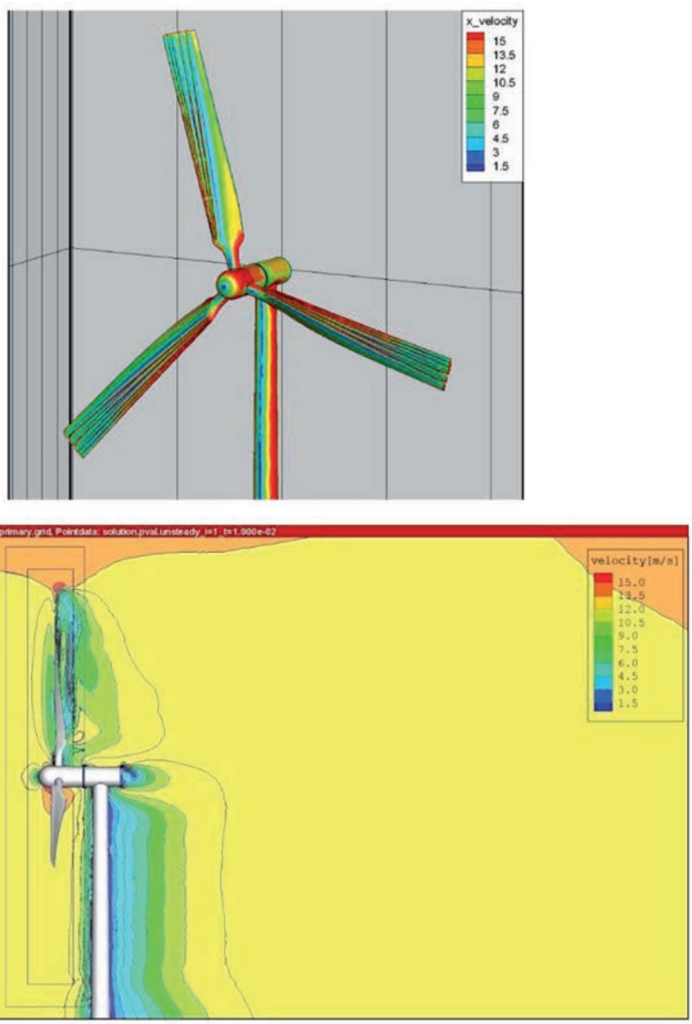


Fig. 12 The fan rotation (on the left) and the simulation area (on the right) with the speed distribution.

CONCLUSION

Chimera technique allows you simulate the movement of objects during the fluid flow. Its great advantage is the ability to change the definition of movement without re-generating the numeric meshes (the definition of movement at the flow calculations stage). The obtained results are numerically consistent. The speed distribution in the simulation area changes periodically, depending on the position of the rotor blades. A noticeable decrease in speed causes the rotor rotation. Chimera technique is a new tool in the field of virtual flow modelling. It is particularly used in the aerodynamics of mobile objects. For this reason, current flow parameters (e.g. resistance coefficients) can be monitored during the structure design.

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ENERGY AS A TOOL IN DECISION MAKING PROCESS

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ABSTRACT

The paper presents principles of a method of embodied energy, proposed by H.T.Odum, which allows to compare different systems, kinds of energies,, services or products considering all factors, including ecological ones, which could have impact on their actual value. The method can and should supplement conventional money-based on economical analysis, used in decision making process. The paper discusses some examples of application of the method also.

Keywords: energy analysis, sustainable development, decision making process

Introduction

The most important issue in assessing whether a product, project or service is sustainable and whether the used energy complies with the rules, is to find the right instrument and measure for comparing different options (Brown, 2000, Odum, 1991, Wójcik, 2006). For example, how to compare in terms of quantity the harmfulness of 1 tonne of carbon dioxide emitted into the environment with the harmful discharge of 1 kilogram of lead or zinc into water or soil. The necessity of such comparisons is due to the often-necessity of selecting between different technologies for the same product or service: one can lead to lesser amount of carbon dioxide, but the second will emit more carbon dioxide but less lead. This also applies to the selection of a source of energy. In particular, the difficulty of comparisons is quantitative rather than descriptive. For the authors, the most promising and the least defective is the emergy analysis (sometimes written with capital M) developed from the development of the energy analysis (Huang and Odum, 1997, Odum, 1996, Odum, 2000, Scienceman, 1987, Wójcik, 2014).

DESCRIPTION OF THE METHOD

It should be borne in mind that money used to compare, as a measure of the value of goods, services and information, circulates only in the sphere of economics (Fig.1), and the price that operates in economics is in the free market economy due to the abundance of resources and the availability of natural resources. That is, when resources are substantial, trade value and price are low, and vice versa, prices are increasing when there are no goods (e.g. raw material) - but from an environmental point of view, it is usually too late to take effective corrective activities. In addition, the work of nature (often of undetermined market value), which is used in the production of goods, must also be included in the value of an item or service. Money cannot therefore be used to assess the value of nature, including energy resources. It is necessary to develop another method for the combined assessment of the eco-system (nature) and in the assessment of the value of the acquired goods or services (eco-economy). According to the authors, the proposal to use the energy analysis proposed by HT Odum provides such possibilities (Odum, 1996, Odum, 2000, Odum, 1983; Brown, 2000). It is called emergy analysis method to inter alia emphasize the so-called "energy memory" (Scienceman, 1987). Substituting words are sometimes used, as well: emergy, energy memory, embodied energy. In accordance with the proposal of H.T. Odum, emergy can be defined as follows:

Emergy of a product or service is the sum of all the types of energy (energy of varying quality), used directly or indirectly, expressed as one type of energy (tab. 1).

It is very important to distinguish the different **quality of energy,** as for example electricity is qualitatively the same as energy of the solar radiation. Hence, the need for bringing different types of quality energy to any one type. It relates the most often to solar energy, that is, energy is transformed into the solar radiation energy and is expressed in solar equivalent joules (SEJ). Different qualities of energy and the need to transform it results from the fact that during the energy production processes a large amount of low-quality energy is used to produce smaller amounts of energy with higher quality - by what it has more embodied solar energy (fig. 2). In other words, a raw material or product "remembered" how much energy was spent for their production. In the example given in Figure 2, wood, coal or electricity "remembered" that at the earlier stages of the production, a certain amount of energy was directly or indirectly used. Approximately 40 000 J of solar energy (used directly and indirectly) was needed to produce biomass, the combustion heat of which would be 2 J (fig. 2a), which, through the geological processes, could be converted to coal with the combustion heat of 1 J.

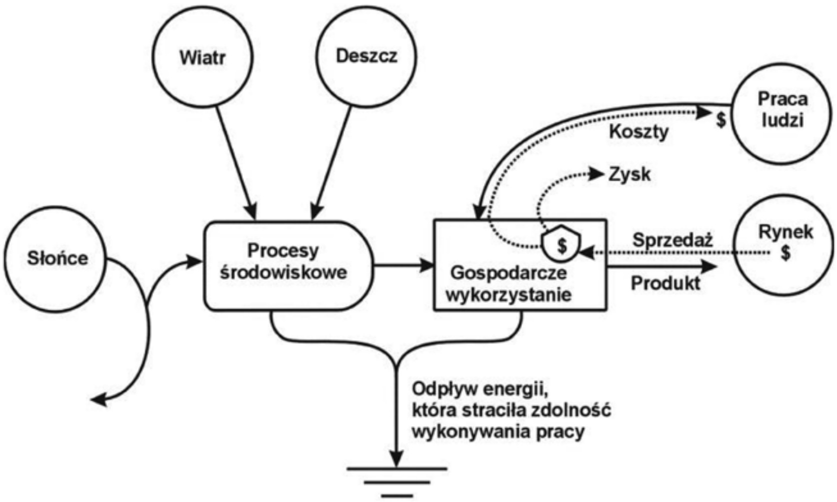
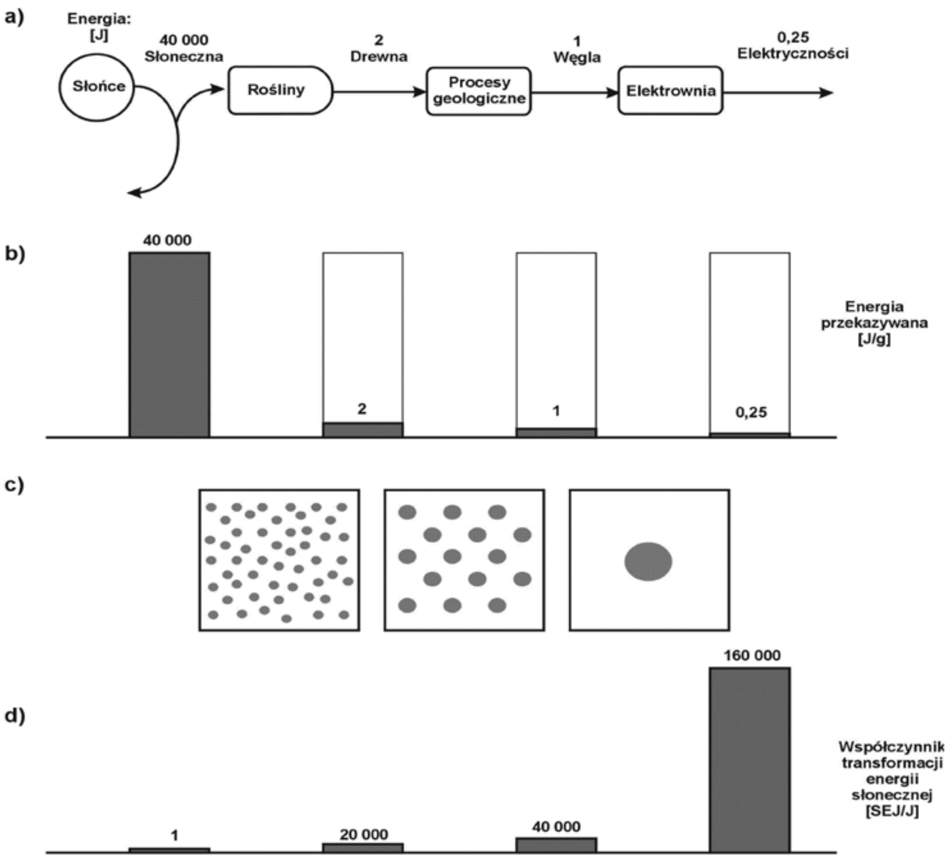


Fig. 1 The interaction of the environment and the economy (the development based on H.T. Odum, Wojcik et al., 2000)

Table 1. The most commonly used definitions in the analysis of emergy (Wojcik, 1998)

Unit	Definition	Unit
Emergy	Energy needed, directly or indirectly, by generating an item, converted to a single type of energy	emjoul [emJ]
Solar energy	Emergy transformed into solar radiation energy	sunny equivalent joule [SEJ]
Transformation coefficient	Energy per unit of an item or service	[emJ/J]
Solar transformation coefficient	Emergy of sunlight related to energy units of an item or service	[SEJ/J]
Emergy/mass coefficient	One type of energy needed for the accumulation of matter mass unit	[emJ/g]
Emergy/dollar coefficient	Factor taking into account the flow of emergy in relation to the movement of dollar in the system	[emJ/$]

Fig. 2 Energy transformation hierarchy (the development based on Odum, 1996; Odum, 1983):



a) transformation scheme
b) transferred energy amount
c) energy concentration
d) transformation coefficient

In turn, 1 J of energy derived from coal must be used for the production of 0.25 J of electricity. These proportions can be used for the conversion of energy of coal and electricity to the equivalent of solar energy – the equivalent of 1J coal energy is 40.000 solar emjoules (SEJ), and the equivalent of 1J electricity is 160.000 solar emjoules (Figure 2b). At each stage, energy is concentrated and thus the quality is increased (Fig. 2c). Thus, the plant biomass transformation coefficient obtained by dividing solar energy (40.000 J) by wood energy (2J) is 20.000 SEJ/J, while the CO conversion factor is 40.000 SEJ/J, and electricity is 160.000 SEJ/J (Fig. 2d). The examples of the transformation coefficient values are shown in Table 2.

Table 2 Examples of values of solar transformation coefficients (Wójcik, 1998)

Unit	**Transformation coefficient [SEJ/J]**
Solar energy	1
Geopotential rain energy	8.888
Geopotential rivers energy	23.564
Fuel	18.000 – 100.000
Services	80 000 – 5 billion
Fruit, vegetables, cereals	24.000 – 200.000
Nitrogen (in fertilizers)	$1.75 \cdot 10^6$
Pesticides	$1.50 \cdot 10^6$
Iron ores	$6.00 \cdot 10^7$

It should also be noted that in the energy chain with each transformation, some of energy is dissipated and cannot be used in a given system - resulting in energy being transmitted in smaller quantities to the next stage (Figure 2b). As already mentioned, its quality increases, which is related, inter alia, with the following properties:

concentration

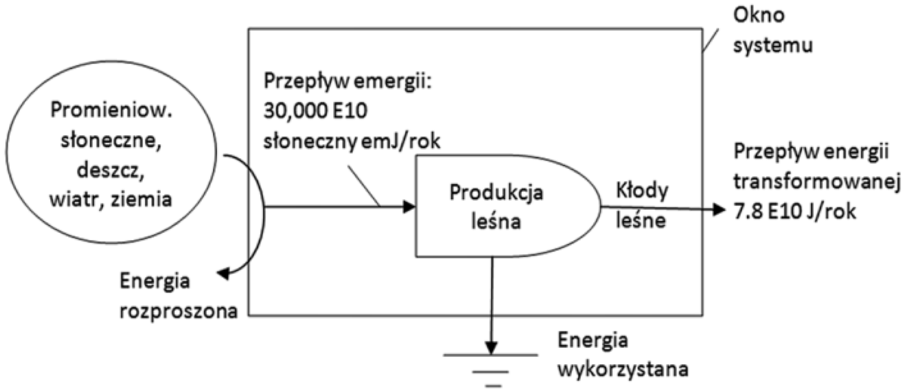
flexibility in use

easy transport

easy processing to another form.

This is another reason why the conventionally assessed energy value of a product does not fully reflect the total energy required to produce it, and it should be replaced by emergy. Another image example is the amount of heat energy that we can get by burning a pencil - it is much lower than the sum of energy specified as type of energy (e.g. solar) and consumed throughout its production cycle.

Figure 3 shows the diagram of energy flow during the production of spruce wood in Swedish forests (based on Odum, 1996). As you can see, the rectangle defined the boundaries of the scheme, within which there is only one component, that is, forest production. A circle on the left reflects energy flow to the system - because the energy used at an earlier stage was reduced to one type (solar energy), the diagram describes this flow as emergy flow. Approx. 30 000 E10 solar emjoules per hectare is annually consumed from solar radiation, rain, wind and soil. However, as a result of the "production" by the forest, 7.8 E10 joule per year is derived annually from 1 hectare of wood logs. The bottom of the diagram shows the outflow of used and diffused energy.



$$\begin{array}{c}\text{Współczynnik}\\ \text{transformacji}\\ \text{słonecznej kłód}\\ \text{drewna}\end{array} = \frac{\text{Przepływ emergii słonecznej}}{\text{Przepływ energii}} = \frac{30{,}000\ \text{E10 SEJ/rok}}{7.8\ \text{E10 J/rok}} = 3846\ \text{słonecznych emJ/rok}$$

Fig. 3 An example of the emergy specification in the production of spruce from 1 hectare in Sweden and the calculation of the transformation coefficient (based on Odum, 1996)

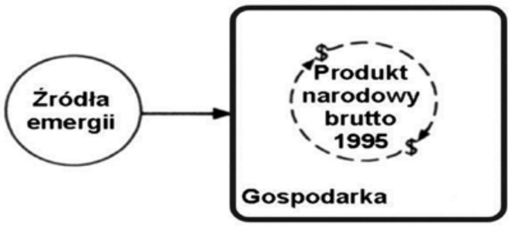
According to the definition, the calculation of the transformation coefficient of spruce wood produced in Sweden was carried out according to the formula:

$$\text{współczynniktransformacji} = \frac{\text{przepływ}\quad\text{energii}}{\text{przepływ}\quad\text{energii}} = \frac{30\ 000\text{E10}\frac{\text{SEJ}}{\text{rok}}}{7.8\text{E10}\frac{\text{J}}{\text{rok}}} = \mathbf{3\ 846}\,\frac{\textbf{emjouli}}{\textbf{J}} \qquad (1)$$

It should be noted in Figure 3 that, in the production process, some amount of energy is incorporated into a product and loses its ability to work in the system (it is most commonly dissipated in a form of heat). This energy is referred to as totally used and marked on the diagram in a form of flow down and outside, with the symbol of distributed energy (Fig. 1, Fig. 2, Fig. 3).

Based on the principles outlined above, the method was developed to analyse very complex systems and help in the decision-making process, including e.g. urban planning, regional planning, energy generation, etc.

A series of indicators to facilitate such analysis was also developed. For example, if we look at the whole economy of a selected country, we can calculate the emergy/money coefficient (Fig. 4) based on the total emergence needed to produce a gross domestic product of a specific market value. It can be seen that when the total used emery is 33 E^{24} SEJ/year and the gross domestic product is 28 E^{12} \$/year, then the emergy to dollar ratio is: 33 E^{24} SEJ/year/28 E^{12} \$/year = 1.2 E^{12} SEJ/\$. Thus, by dividing emergy by the obtained emergy to dollar ratio, we obtain a factor the unit of which can be emdolar. Depending on an analysed country, the local currency is taken into account in the calculations, and embezzle, emeuro or emrubel can be obtained. Having the cost of labour expressed in e.g. dollars, for the analysed case, then multiplying that cost by the above emergy/dollar ratio, we can obtain the information how much equivalent emergy was then consumed.



$$\text{Współczynnik emergia/pieniadz} = \frac{\text{Emergia wykorzystana}}{\text{Produkt narodowy brutto}}$$

$$\frac{33.6 * 10^{24}\ \text{SEJ/rok}}{28 * 10^{12}\ \text{\$/rok}} = 1.2 * 10^{12}\ \text{SEJ/\$}$$

Fig. 4 The circulation of money in the economy, and resulting source of emergy (used in the production process) (Brown, 1997)

This coefficient allows to rate emergy of an acquired service or work, when there is no more detailed data on energy use. Emergy and emdolar appear to be more useful for assessing and planning the social use of rare minerals, used so far of the economic analysis that uses money. Emergy can then be used to determine which assets are more valuable and less likely to occur, and therefore should be sparingly used. Emergy of a product determines its true value, which can better rate the cost of processing and indicate the best way to reuse. In addition, the costs incurred by the society from the environmental pollution can be calculated using emergy and then used to determine economic incentives (e.g. tax credits) used to support the environmental technologies. For example, large benefits of reuse of heavy metals and keeping them outside the environment can better justify the transfer of public subsidies. The emergy/dollar coefficient also points the extent to which the used stimuli are adequate for the obtained benefits.

As already mentioned, money is not the best measure of the value of an item; this also applies to trade. In order to consider such a situation, one can develop a diagram, as shown in Figure 5. On the left side, money is flowing from a purchaser for a barrel of rock oil supplied by a supplier. When the price per barrel is \$ 20 (as was the case in 1991), a purchaser, paying a seller \$ 20, provides it an emergy equivalent of 2.8 E13 SEJ, and receives a product emergy of which is 3.657 E14 SEJ, i.e. 13.1 times more. This trade would be equivalent and fair from the point of view of energy if the coefficient was 1, that is, if the price per barrel was \$262 (Fig. 5). To sum up, if the coefficient is higher than 1, then a purchaser gains, and if the coefficient is less than 1, then a seller gains.

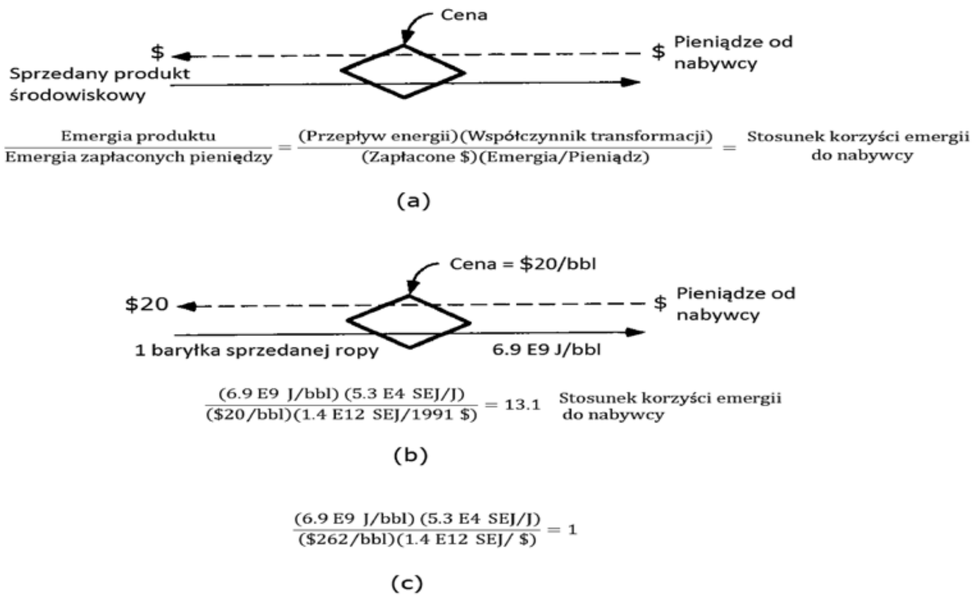


Fig. 5 Comparison of the specified values and emergy by trade (developed based on Odum, 1986)

It should be noted that it is not about replacing money with emjoules, e.g. in a vegetable shop in a residential district, but using the emergy analysis as a complement to the economic analysis.

In the biogeosphere, energy passes through a number of system components such as: atmosphere, oceans, continents, living organisms, industrial processes. Each unit transforms the available energy into less energy with better quality (more focused and easier to access) and passes it to the next level. Each element can also send small, controlled energy flows back, to a lower level. A series of such transformations creates **the hierarchy of energy** in which incoming energy is gathered and concentrated more and more by elements belonging to the next levels, giving at last a chain of low quality energy. This hierarchy of energy emerged in the course of millions of years of evolution on the Earth. Urban complexes of human civilization are placed at the top of the hierarchy of energy. This is due to the high concentration of matter and energy in the antroposphere, caused by industrial processes and the work of people (Brown and Uglliati, 2000).

The flow and transformation of energy cause the circulation of matter. In the universe, there is a natural tendency, due to the fundamental principles of physics, for dispersing concentrated substances. It is necessary to do the work to concentrate the matter and keep it concentrated, as opposed to the described tendency. As already mentioned, one value can be used for measuring different types of work, which is emergy, defined as the total energy required to produce a product directly or indirectly, transformed into one type of energy. Figure 6 shows the circulation of elements in the ecological system taking into account two levels. The diluted components on the left are concentrated and passed to the right. Then the materials are recycled back to the left and dissipated. The incoming energy is used to concentrate the matter in the centres of the hierarchy, where its concentration increases. The circulation closes when the concentrated materials are re-scattered in a larger area in the return flow. Figure 6b shows the circulation of nutrients through the centre of the tree hierarchy (McNeil, 1989). Concentration of the matter occurs in the biomass production process, and the dispersion occurs due to its decomposition. Solar energy plays a very important role in these phenomena the circulation of the matter and energy on the Earth. Solar energy interacts with ocean water to generate steam, clouds, waves, and ocean currents. Water falling in a form of rain or snow, connects with a land and forms ecosystems, soils and glaciers. The outflow of water transports the erosion material to the oceans, accumulating some of the substances in the selected locations. On the other hand, human activity involves the exploitation and subsequent processing of these raw materials into products, which results in re-scattering of the elements even if recycling is carried out partially.

One can see from a larger perspective that the universe is organized in such a way that it creates a number of levels of the hierarchy. The distributed matter is gathered and concentrated in small centres, which in turn connect into larger centres (Fig. 7). The increasing concentration of the matter while passing to the next higher levels of the hierarchy requires the use of ever-increasing amounts of energy. The spatial distribution of people with small centres in settlements and towns as well as cities and metropolises is an example of the hierarchization of the environment.

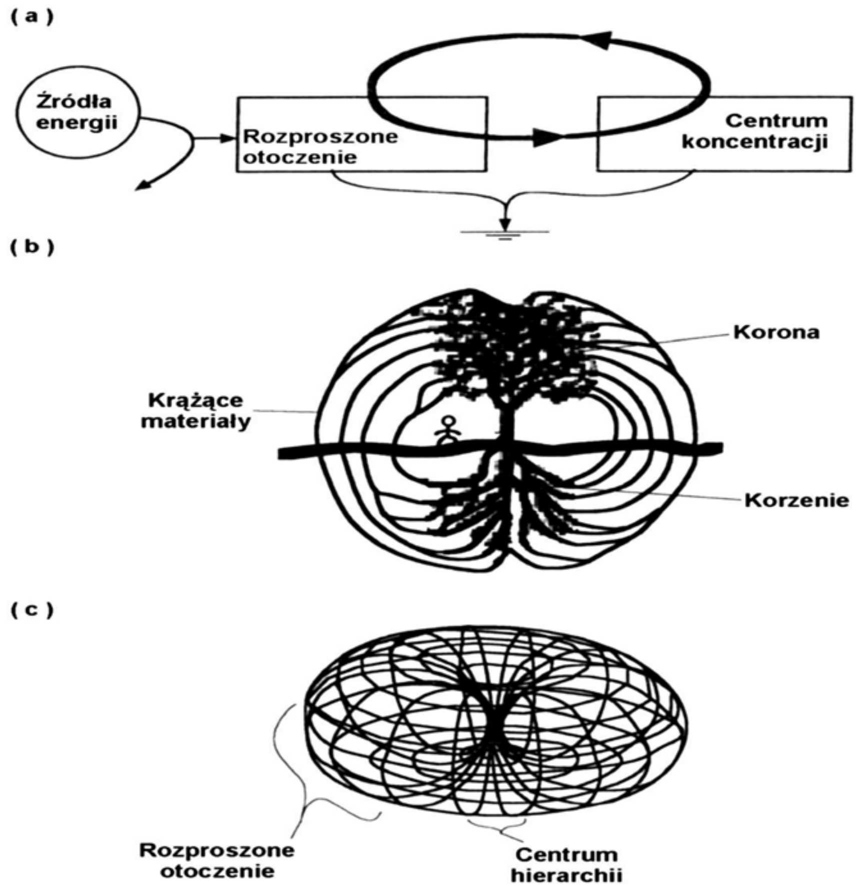


Figure 6 Two-element system of the circulation of the matter in nature (developed based on Odum 2000, McNeil 1989, Wójcik, 2014):

(a) the system diagram
(b) the concentration and dispersion of the nutrients circulating between a tree and its environment
(c) three-dimensional representation of the materials circulation

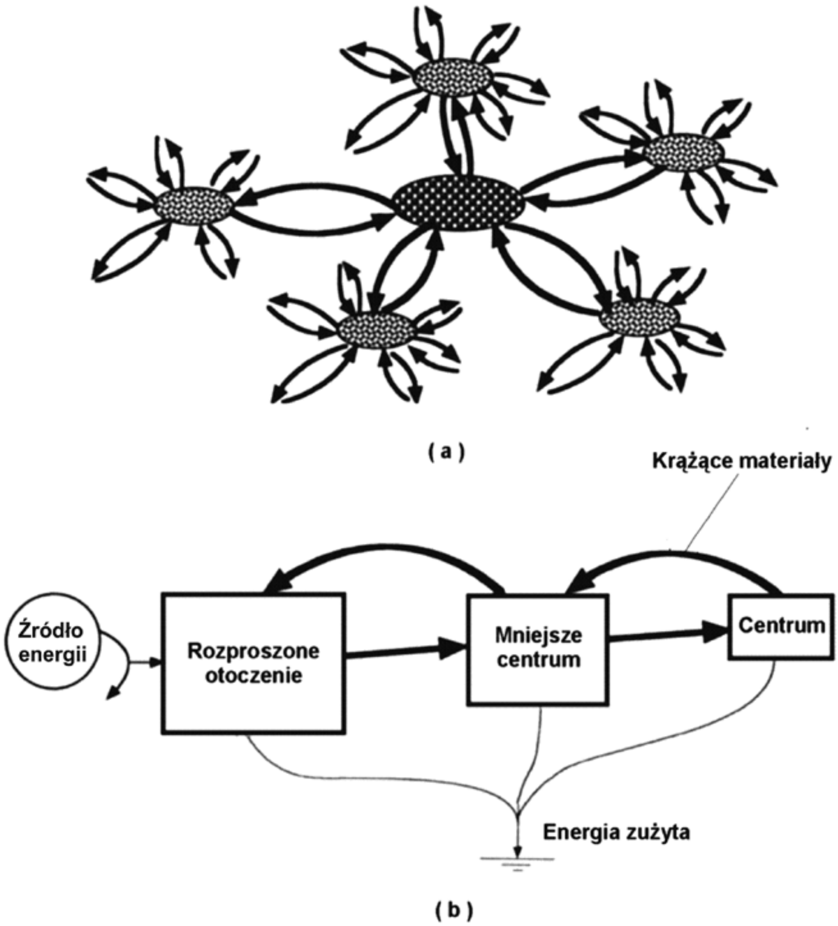


Fig. 7 Circulation of the matter between three levels of the hierarchy (development based on W. Wójcik, 2014): (a) spatial distribution, (b) system diagram

CONCLUSIONS

The presented energy analysis method, often referred to as emergy, is the most promising method for assessing how well a given product, service, energy source or type of energy complies with the principles of sustainability. It allows to analyse the complex systems taking into account sociological, economic and ecological aspects, especially when money does not fully reflect the real value of a product or human activity. It can also be used in the decision-making process for locating investments, including environmentally harmful investments, choosing the most favourable energy source, subsidizing or taxing products or business activities, etc.

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2. NEW CONSTRUCTION AND INSTALLATION SYSTEMS AS AN INSPIRATION FOR CONTEMPORARY ARCHITECTURE

INTELLIGENT FACADE AS A METHOD OF SAVING ENERGY AND A NEW ARCHITECTURE FORM

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ABSTRACT

Intelligent façades are a still developing section of building construction. They are different from regular facades in affecting on external conditions. The article shows a detailed mode of action such facades and their technology. Intelligent facades are strongly connected with smart buildings and their main common factor is saving energy, its optimal use and environmental protection. The article contains examples of exploiting intelligent facades during building designing which provides to arising new architecture forms. Examples from country and world are included.

Keywords: intelligent façade, saving energy, architecture form

Intelligence, from Latin, means understanding, according to the Polish Language Dictionary of PWN, "the ability to understand, learn, and use knowledge and skills in new situations". Façades are not able to "understand" and "learn" in the way people do, they do not belong to the group of animated objects, but some of them have been called intelligent.

WHAT IS INTELLIGENCE OF A FACADE

The façade intelligence primarily depends on their ability to adapt to the environment and the environment in which it is located, this is the main factor distinguishing façades of this type from other façades encountered on a daily basis. The surrounding differently impacts on façades, solar radiation is the most common external factor which naturally involves the building's zoning. Already in the early stages of the designing process, a building is oriented, so a designer can immediately predict the best place for a façade, which is impacted by sunlights.

Talking about the difference between the ordinary and the intelligent façade, one should consider where the "façade" intelligence limit is, whether the intelligent façade can be the one that is constantly regulated by a human. Going through this reasoning, the intelligent façades can include even the ones where a human manually sets shutters in the windows, the conditions are after all met - a building adapts to the environment by adjusting the amount of falling sunlight. However, this activity is not the same as programming a system that automatically obscures the shutter windows with a single click of a button on the control panel. Hence, the conclusion is that the façades can be called intelligent, when a human does not make changes directly, and through the intermediary of a control system or these are such façades, where the materials from which they are made ensure the desired effects; it also often happens that a human only at the very beginning of the use of such façades sets the programme so as to be able to observe the occurring changes.

The intelligent façades and the intelligent buildings have a lot in common. The operation of the façade can be used to improve the energy-efficient system, while minimizing energy costs. This involves the energy balance of the building: in the summer, it is cooler indoors, resulting in lower costs for air conditioning, and in winter the sun provides warmth, which also has its impact on the costs, but this time we talk about heating costs.

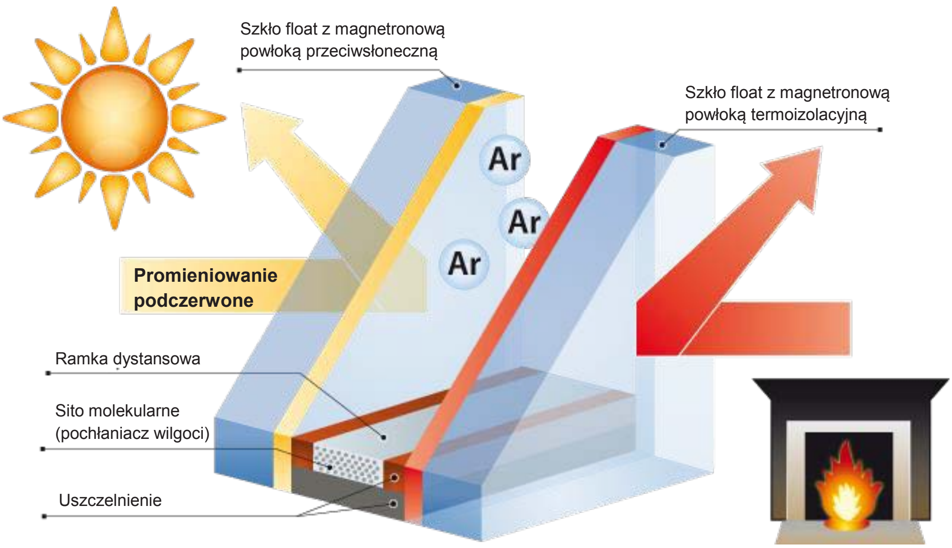
Not every intelligent building must have the intelligent façade, but also not every intelligent façade must be on the intelligent building. The operation of the façades can be assisted by the operation of a house, thus reducing the operation of the energy systems of the building. The systems governing the amount of flowing sunlight, which reduce energy costs of solar heating, must be re-stressed here.

TECHNOLOGIES USED IN THE INTELLIGENT FACADES

BUILDING GLAZINGS

Glazings are the most common component of the intelligent façades. At the time of heat, the users of the building look for cool, and at the winter time, they look for warmth. On the one hand, all this can be provided by such systems as air conditioning and central heating. On the other hand, when designing a new building, an architect tries not to use the old traditional ways of cooling and heating, and use modern, sustainable solutions. Keeping this in mind, one can come to the conclusion that all types of glazing largely impact on the acquisition of renewable energy.

There are a number of systems governing the impact of solar energy. One of them is the use of sun protection panes, which to some extent reflect or hold sunlight; hence, they can be divided into absorption, reflective and selective glass. Absorption glass holds a part of solar radiation with the additives tinting glass, included in it. In addition to the partial holding of solar radiation, it also holds visible radiation, which causes slight shadowing. In the case of reflective glass, thin layers of metals and metal oxides are applied on the surface of the ordinary glass. Depending on their composition, they reflect short- or long-wave heat radiation. Long-wave, low-emission radiation is produced by all types of radiators in the rooms, as well as people and animals. Reflective glass reflects such radiation, preventing it from escaping to the outside, resulting in a reduction of heat loss in the winter. In turn, short-wave radiation, i.e. infrared, comes from solar radiation. Panes reflect then such rays, protecting the building against excessive heating in public areas, which is desirable during the summer. The best solution is to combine two types of coatings, then selective glass is created, which performs its task in both the winter and the summer. To prevent from damage under weather conditions, it is preferable to use sun protection glass in glazing units.



Il. 1 The construction of a glazing unit with selective glass with reflective coatings (infrared) and low emissivity (emitted by heated objects). [11]

Windows using sunlight to drive the mechanism of opening and closing windows are a slightly different type of glazing Ventic Solar window drive has been created for wireless control of all windows in hard-to-reach places. The compact design of the window contains a drive, a solar panel and a battery pack, allowing for easy installation in areas where installation of the usual drives requiring power supply would be difficult and expensive. A provided remote control can be used for up to 10 windows. The system is mainly used in the roof and hard-to-reach windows. The use of solar energy is the ecological solution, desired in the design process, and the operation does not require additional costs.

Il. 2 Ventic Solar drive integrated with a solar panel [2]

A relatively innovative window solution involves the so-called i-Tec SmartWindow, controlled by a smartphone or tablet with the application. One of the features of this window is the ability to control ventilation integrated with the design of the window. On the one hand, it allows for the flow of fresh air into the room, and on the other hand, it recovers heat escaping in the winter by using a heat exchanger that recovers 86% of energy. Window shutters are another element subject to remote control. They are different from the usual shutters built into windows, and their solar energy does not require connection to the electrical system. The whole is based on Wi-Fi, and additionally installed weather station will allow for dependence of ventilation and shading from the weather. i-Tec windows allow you to keep healthy conditions in public areas due to their solutions. The ventilation system prevents from excessive cooling of air, as if it occurred at opening of the ordinary windows. Also in the case of pollen, especially burdensome for people with allergy, the installed filters prevent from flowing of allergens into the room. In addition, the ventilation has a built-in moisture sensor, which allows to automatically reduce its level, to prevent from the growth of mould and fungi. The cost savings of i-Tec Smart Window significantly outweighs the cost of electricity that ranges from 40 to 50 PLN a year.

Il. 3 Ventilation in the i-Tec Smart Window [12]

SHUTTERS

All types of shutters largely impact not only on the visual reception of the façade, but also on the adjustment of the supply of sunlight. These can be ordinary, internal window shutters, set manually or remotely controlled, and large shutters covering the whole glazing. The office building of Grupa Skalska in Kraków is the building which introduces the especially developed shutter system. It applies a double façade, which in conjunction with the shutters, is controlled using special KNX panel, independent of the powering system. In the double façade, the inner cover closes the building, and the outer cover protects it against intense solar radiation through the glass holding or reflecting the rays. The ventilation between the façades is provided by holes in the outer cover, causing the air circulation, and the ventilation inside the office building is provided by electrically opened windows. Due to small holes in glass partition walls, airing is possible throughout the building, without the use of air conditioning. This can be supplemented with shutters which additionally regulate light flow - they automatically change the angle of the lamellas, following a changing height of the sun during the day. Sunlight does not fall between the lamellas, but reflect from them towards the ceiling, providing light in the whole room, even in distant places, without dazzling the users. One can also adjust the opening to each room individually, the whole process is controlled by the administrator.

Il. 4 Coloured shutters are decorative and protect against sunlight due to the intelligent control, photo the archive of Grupa Skalska [10]

PHOTOVOLTAICS

Photovoltaic panels are a very important material for the energy balance of the building. They can be integrated with the building cover, they are the then unusual alternative to typical façade solutions, then they are called BPV, i.e. Building Integrated Photovoltaics. Integration involves the connection of a cover to form a functional and structural whole. The photovoltaic module, which is a hermetic panel with current generating cells enclosed in a protective housing, is the primary element. The modules are combined into larger structures to obtain the proper amount of power. This, produced in the cells, can be delivered immediately to the network by the inverter or stored in batteries. Depending on the needs, when selecting the photovoltaic system, one can create its own configurations, inter alia, material, size, shape, or colour is selected. Typical modules involve a regular grid of dark blue or black cells.

Il. 5 Research and Development Centre, Wuxi Suntech Power, Wuxi. BPV glass façade is created by 2552 semi-transparent photovoltaic panels with a total area of 20 000 m2. Photo Suntech [5]

There is the possibility of solutions in thin-layer technologies. Ultra-thin layers of a semiconductor material in a form of a mixture of copper, gallium indium and selenium (CIGS) or amorphous silicon (a-Si) are embedded in the course of the production on a glass substrate and laminated with another sheet of glass. The module will become light and flexible if steel tape or plastic is a carrier material. Energy efficiency of thin-layer materials is slightly lower than typical PV modules (approximately 5-13%); however, they are more suitable for the construction, due to the fact that they are less sensitive to temperature and function better in worse conditions of sunlight, and also stand out in colours: a-Si occurs in brown, CIGS - in black.

Il. 6 Black cladding of glass CIGS modules – Sulfrucell building in Berlin Adlershof [13]

The effectiveness of BPV depends largely on the appropriate shape of the façade or its relevant parts. The type and number of used modules, their orientation and inclination relative to the Sun can result in the amount of generated energy. The south is a natural direction for the European latitude, any deviation to the east or west can reduce the profits of energy up to a few percent. The slope of the panels is the most effective way for equal latitude at a given location, then the radiation falls on the modules at a straight angle. Energy gains will, of course, change in the daily and seasonal cycle due to the movements of the Sun. It is worth to carry out computer simulations during the design phase, taking into account, inter alia, the form and construction of the façade, the proximity to other buildings, greenery with the changes of the seasons, the daily and annual variability of the shadow and the layout of BPV.

UNUSUAL EXAMPLES FROM THE WORLD

In addition to the widely used façade systems, one can also meet the ones individually customized to particular buildings. There are so innovative solutions that one can specify them as unusual, not only because of the new approach to the intelligent façade, but also rarity of the occurrence. Some of the façades can be seen only on one building in the world, as in the below examples.

An interesting concept of the façade was presented by the designers of Media-TIC building in Barcelona. Cloud 9 architectural office proposed to install plastic pillows on the moving façade. Special protecting panels were placed on two façades exposed to sunlight the most. From the south-east side, some of them act like sunglasses, limiting the flow of light. From the south-west, pillows filled with water steam were installed, which reduces heating of the façade by up to 90%. This allowed to reduce energy consumption by 20%, and reduced the production of carbon dioxide by up to 95%. The office building won the title of the building of the year at the World Architecture Festival 2011 in Barcelona.

Il. 7 "Pillows" on one of the façades of Media-TIC. Photo Iwan Baan [14]

An innovative solution for the façades was created by the designers from Splitterwerk Architects and ARUP, who created the world's first algae façade, in cooperation with the scientists. The building, constructed for the international construction exhibition IBA in Hamburg, uses algae as a source of energy. The façade consists of bio-reactive shutters filled with algae. Heat generated by micro-algae in the photosynthesis process is captured by bioreactors that convert then into energy for the building. Moving green shutters can also be used as an aperture on hot, sunny days. Algae were selected because of their fast growth and low breeding requirements. It is the beneficial solution because energy produced from biomass is renewable, and in the proper conditions, algae can process solar energy more efficiently from than the solar panels.

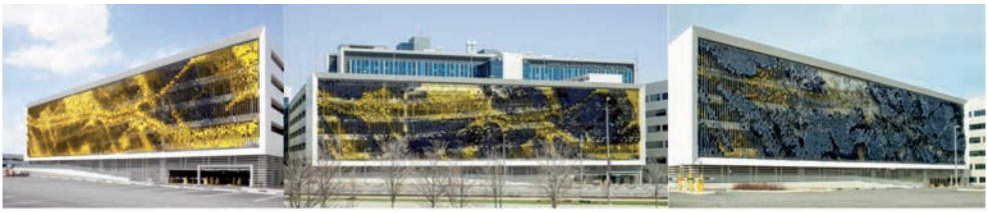
Il. 8 Algae façade on BIQ building [15]

The façade of Al Bahar towers in Abu Dhabi opens and closes. The workplaces must be protected from oppressive sunlight, when the temperature outdoors reaches 50oC. The façade is composed of two layers; inside, there is a glass cover closing the building; outside, there is a curtain wall installed to an independent frame, two meters from the building. It is formed by the triangles coated with fibreglass, and are programmed to track the movement of the Sun. Their appearance resembles the traditional Arabic moucharabieh, i.e. a decorative wooden grate covering the window. Each hexagonal component constructed of the triangles has its own actuator, i.e. a device setting a component on the basis of a control signal. A total number of 2100 components is on two towers, each measuring 4x6m, weighing 600 kg. One managed to reduce air-conditioning demand for electricity by 20%, and the average level of sunlight inside has fallen by 50%.

Il. 9 View of two towers of Al. Bahar and the components opening schema [16]

NEW ARCHITECTURAL FORMS

Other than the ordinary type of the façades builds new architectural forms. It is enough to change a colour of the façade, and the building looks different. Photovoltaic panels have not only an unusual colour, but also a structure, which provides the building with a bit industrial look. The systems, in which elements of the façade move, e.g. automatic shutters, make quite different designs, and a whole wall lives, providing the building with a fresh new look. One will be bored with the building; one can go next to it thousands of times and every time something else will be seen. The car park of the hospital in Indianapolis is the building of a seemingly variable form, where one of the façades is covered with approx. 7000 metal panels, set at different angles, on the one side in yellow, on the other side in black. Moving along the façade, one can feel that the whole façade waves.



Il. 10 View from different parts of the car park of Eskenazi hospital in Indianapolis [17]

Il. 11 Close-up on the metal panels on the façade of the car park of Eskenazi hospital in Indianapolis [17]

CONCLUSIONS

Discovering the architectural innovations, we hear about the intelligent façades more and more often. They will be selected by the designers more and more often, because they are a great source of support. The cost of the construction of the intelligent façades will pay off each day of the use of the the building. The diversity of the façades provides the ability to adjust them to the requirements of the environment, one should not be so worry that it is not worth to install them in a given location. The best practice is to use glazing, occurring in each building - it is enough to use the right type of glass and the difference in the energy balance will be observed. Installation of the shutter systems will be an additional factor reducing energy costs. Solar panels have been known for a long time, but they are still not integrated into the façade of the building very often. There are a number of methods to use the intelligent façades on the buildings, some can be seen more often, others are unique enough that the building is granted an award. The diversity of the intelligent façades and the changes occurring in them are still a fresh path, so it is important to promote environmentally friendly solutions, extremely valuable in the polluted world.

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APPLICATION OF THE PHOTOVOLTAIC INSTALLATIONS IN THE PROCESS OF RENOVATING HOUSING ESTATES IN GERMANY

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ABSTRACT

Today, innovative solutions in urban planning are inseparably linked to the use of green technologies in the entire world. Designs of modern buildings, neighborhoods and whole cities in Western Europe, the Middle East, China, Japan or the United States involve creating energy self-sufficiency, which could be achieved through the use of renewable energy and by reducing energy consumption. Examples from Germany show that the newly designed buildings can not only provide electricity for their own use but can achieve a surplus to sell outside. This approach can be applied to the existing settlements while renovating them to adapt to EU requirements of the energy policy. This can be done by upgrading existing systems with installations using energy from renewable sources. The goal of this paper is to give-examples from Germany aimed at energy efficiency, energy independence in urban multifamily settlements. Such practices have not been yet applied into practice and most remedial programs for multifamily housing in Poland from the 70s, 80s have been limited to the basic treatment such as wall insulation, window replacement, and renewal of facades. This approach is not sufficient, overall. In summary, presented is an attempt to identify opportunities for modernization of Polish appartments blocks including PV installations based on a very positive German experience.

Keywords: renovation of the housing estates, energy efficiency, solar energy, PV installations

Introduction

The sustainable development is the most closely associated in the public awareness of energy efficiency. If we comprehensively understand savings in the sustainable residential environment, then of course, we cannot omit the use of energy sources that allow to save non-renewable raw materials.

In the scale of the settlement, one of the main features of the sustainable residential environment is the infrastructure design with the use of the technology and technical systems for energy savings (m.in. passive and active gaining of solar energy). Currently, the efficient use of the energy of the Sun requires high technology. Undoubtedly, the future belongs to the photovoltaic cells, allowing to generate electricity, which is used in all areas of life [3]. The community integration of the energy solutions (e.g. roof or façade photovoltaic panels included into the energy system of the settlement) should allow to create the sustainable buildings and construction units self-sufficient in terms of energy.

In the economic range, the availability of residential buildings due to the prices and preferences of the green construction, the prices comparable with the traditional residential construction, provides a measurable profit as a result of the integration of the technological systems of energy and water savings. The systems to gain renewable energy contribute to significantly reduced operating costs, as well as to improve the residential environment and the quality of architectural space [1].

DIRECTIONS FOR THE APPLICATION OF THE PV TECHNIQUES IN THE MODERNIZATION OF THE SETTLEMENTS IN GERMANY

In Germany, the modernized large-board residential construction provides the users, apart from the improvement of the quality of places of residence, a higher standard of residential function that can also generate energy from the renewable sources. The leading cities that provide the energy renewal programmes are: Freiburg, Berlin and Stuttgart. The model for the adopted energy policy is the settlement in Vauban district of Freiburg, which has become the pioneer of the solution design, completed in accordance with the idea of energy-efficient houses supplied in energy from photovoltaics, where the technologies and practices have given impetus to the modernization of the existing settlements.

Vauban district in Freiburg in Germany consistent with the idea of sustainable development was established as a successful example of the eco-settlement, a model in terms of electricity supply from renewable sources. Photovoltaic panels, integrated into the roofs provide fully supply power to the buildings, and the surplus is sold to the city grid. In this case, the vision of the homes of the future is implemented, when they become the producers of pure energy, and not only their consumers. Such a designed system of the supply of electricity from the RES was possible due to the interdisciplinary cooperation of the specialists. The installation of the appropriate surface size of the solar or photovoltaic panels on multi-family houses requires the adaptation of architecture and urban planning of these buildings to such a project. The introduction of the Integrated Design Process and the Integrated Energy Design should take into account all aspects of the energy economy in terms of: location, position relative to the world, size of the development, possibility to apply the system to generate energy, both in the design phase as well as the modernisation of the existing settlement.

In the context of the revitalization of multi-family houses in Berlin, in the last few years, over 1.500 photovoltaic systems have been installed on roofs and façades of buildings.

The gained solar energy is transformed by the photovoltaic modules in alternating electric current that powers the public power grid, and the cost of its production is compensated in accordance with the provisions of the EEG (Erneuerbare Energien-Gesetz/ the Code of the Renewable Energies). The German Society for Solar energy (German: Deutsche Gesellschaft für Sonnenenergie) keeps the register of equipment and systems using solar energy at the order of the Administration of Berlin on the Development of the City. The registry is intended to allow access to verified and certain data, originating from the area around Berlin and on the amount of produced energy, the development of the energy market, the system life and long-term experience with their operation [4].

EXAMPLES OF THE MODERNIZED SETTLEMENTS WITH THE USE OF PV SYSTEMS ON THE BUILDINGS IN BERLIN

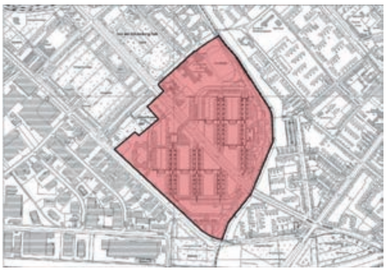
High-Deck settlement, Berlin-Neukölln

The settlement was established in 1970/1980 within the social construction. The concept of the development, as opposed to other large settlements of Berlin, had a lower population density and innovative solution for functional separation of movement of pedestrians and traffic at two levels. Pedestrian bridges (hence the name “high-deck”) provided to five- and six-story buildings, which have approx. 2400 homes, which gives the number of 6000 inhabitants. Parking spaces are located in the basements of houses, the streets are at the basement level (Il. 1, Il.2). Walking platforms are available from streets and parks by ramps and stairs. Between the buildings, there is a lot of greenery, gardens, children’s playgrounds, there is a full range of services in the settlement scale. In the 1970s, houses enjoyed great success due to the location on the green outskirts of West Berlin, which was considered as the perfect settlement. Today, the settlement, due to a number of its features, would be included in the sustainable residential environment trend.

Il. 1.; Il. 2. Street view of High-Deck settlement in Berlin. Source: photo by Joanna Biedrońska August 2015.

When the eastern and western sides were connected, the settlement lost its attractiveness and quiet. In 2007, the restructuring of old buildings was inevitable. The renovation costs exceeded the financial capacity of the city and country, and as a result, the settlement became the property of 3 owners. At that time, there was a complete renovation which involved inter alia the repairs of: concrete, façades and roof surface.

The task allowed to solve the issue of savings in energy costs, thanks to the integrated power grid for the whole settlement, generated from the renewable sources, i.e. from the Sun. In 2015, in the context of the modernisation on 32 roofs, one installed the PV systems with a total capacity of 1MGW created as a result of the connection of 4248 PV modules, satisfying the needs of the inhabitants in terms of eco-friendly electricity (Il.4, Il.5). The system covered the whole settlement, including 38 individual devices connected in the switchboard building, in the centre of the settlement [5]. The location of buildings on the north and south axis allowed to set the panels in a raw, towards the south.



Il. 3. Plan of High-Deck settlement in Berlin. Source: [6];

Il.4 Top view of High-Deck settlement in Berlin. Source: [5]

Il.5. View of the photovoltaic panels installed on the roof of the buildings of High-Deck settlement in Berlin.
Source: photo by Joanna Biedrońska August 2015.

Hellersdorf settlement - Berlin

Hellersdorf settlement in Gelben Viertel district, in Berlin, is another example of the modernization of the prefabricated residential buildings from the 70's and 80's, 20th century, located on the outskirts of the city, consisting of the introduction of the photovoltaic system on 50 roofs with total area size of 6 pitches, 800 polycrystalline PV modules were installed here (Il.6, Il.7). Since 2014, the whole photovoltaic system has produced 1.6 GWh, i.e. (= 1593000 kWh) of electricity per year. Depending on the production and demand, the inhabitants obtain 40-50% of energy from the Sun. The rest is provided by a certified supplier of eco-energy, Lichtblick. The tenants of the apartments in Hellersdorfer settlement who use electricity "from the roof" pay less than in terms of the ordinary green electricity tariffs. The net costs, reduced fees and low power control significantly reduce the price of electricity which can impact on the decisions to reside in this apartments complex [7].

The pilot project for the city of Berlin shows that solar energy "from the roof" in an urban multi-family house does not have to be only in the field of an experimental design, and can provide tangible economic benefits. The project in Hellersdorf settlement is of a great importance, because it is the largest solar system that was installed on the residential buildings complex in Germany.

The experts of solar energy in Germany believe that there is a huge potential of roofs to use them to install PV providing the building with electricity both locally and in the system of the connection of the whole settlement or district.

Il.6. Top view of Hellersdorf settlement - Berlin. Source: [8]

Il.7. View from the roof with the PV system in Hellersdorf settlement - Berlin. Source: [7];

Residential building at Helene-Weigel-Platz, Berlin-Marzahn

The alternative to gain energy from the Sun in the building can involve the energy active façade when the photovoltaic modules are installed on the façade. The performance is not as effective as in the case of the roof system, but there is no doubt that the south exposure, especially during the winter, provides an additional source of energy. The example represents the modernization of the multi-family building in Berlin at Helene-Weigel Platz 6/7. The centrally located skyscraper from the '80s, 20th century, in Marzahn settlement, Berlin, was completely rebuilt. In 1998, the modernization of the building included the use of the innovative technologies, i.e. covering the south façade to the height of 70 m with the PV panels on the surface of 426m^2 (Il.9). These panels replaced the conventional façade panels, which produced 25.000 kWh of solar energy. The energy is transferred to the public power grid in accordance with the Act of Energy Saving (EEG) to meet the demand for electricity needed to run elevators, ventilation, lighting, etc. In general, this reduces the operating costs of the inhabitants [9].

Il.8. Plan of the building at Helene-Weigel Platz;

Il.9. View of the façade. Source: [9].

THE SCOPE OF THE ACTIVITIES OF THE ENERGY REGENERATION OF THE POLISH SETTLEMENTS

The German practices aiming at energy efficiency, energy independence in the multi-family settlements, are not applied in Poland, and most repair programmes of the multi-family buildings from 70s, 80s, 20th century, define the basic activities to insulate walls, replace windows, renew façades. The modernization of the residential settlements made of large board: the imposition of additional layers of thermal insulation on the walls of the building and the modernization of the heating devices can achieve savings in energy consumption reaching 60% [2].

Using the experience of the German construction industry within the modernization of the residential settlements from large board must be analysed within the possibility to carry out similar activities in Poland. Would it be possible to provide a higher participation of the renewable energy systems in a form of roof and façade surfaces covered with the solar panels? The installation of the appropriate surface size of the solar or photovoltaic panels on multi-family houses requires the adaptation of architecture and urban planning of these buildings to such a project. The characteristics of the spacial formation of such a complex should correspond to the priorities of sunlight of the solar panels.

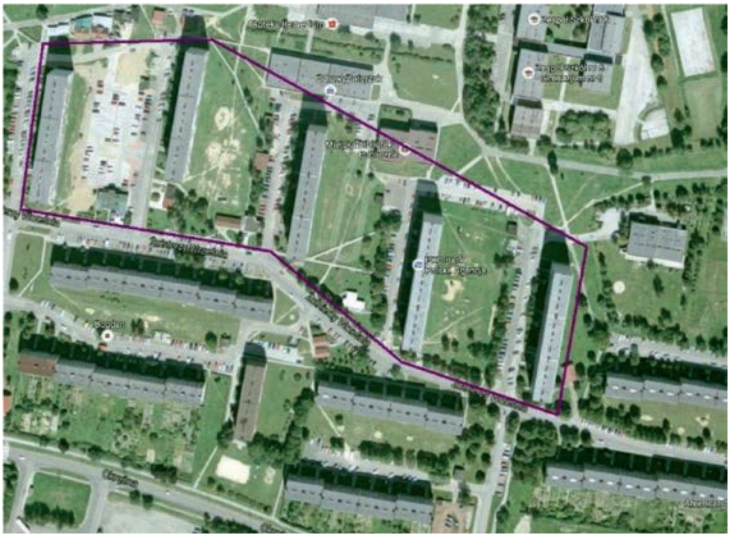
The data from the report "The Photovoltaics Market in Poland, 2016" developed by the Institute of Renewable Energy shows that: "In recent years, the market for the photovoltaic systems in Poland has continuously grown, despite the unclear legal situation of this sector. The total installed capacity of the photovoltaic systems connected to the grid is 119.2 MW. This involves 87.7 MW of the systems which have received the certificate of energy origin (at the end of the first quarter of 2016). The micro-systems were already 31.5 MW, i.e. 26% of the total installed power capacity (at the end of 2015). Only 2015, there was 77.2 MW of the PV system more. This involves approx. 8.8 MW from the Prosumer programme implemented by the National Fund for Environmental Protection and Water Management, financed by the BOŚ Bank. In addition, the REI estimates that approx. 8.3 MW of the installed capacity involves the off-grid systems. The value of the photovoltaics market in 2015 is estimated to be approx. 470 million (an increase of 60% compared to 2014.)" [10].

The report states that the photovoltaics market in Poland develops; however, to tend in the direction of the German standards, it is necessary to establish the RES Act providing the possibility to re-sell the power grids the produced excess electricity and reduce the cost of the PV installation devices so that they can be widely applied

POSSIBLE APPLICATIONS THE PV SYSTEMS IN THE MODERNIZATION OF THE MULTI-FAMILY BUILDINGS SETTLEMENTS IN POLAND. EXAMPLES

There are a number of settlements form PRL times, which due to their location could be subjected to the modernization taking into account the applications of the PV systems on roofs and façades. The solar systems installed on the façade provides not only energy from the Sun, but also meet the task of the building cover. The below 2 examples of the settlements from Żory and Miechowice show the possibility of renovation in order to improve the energy efficiency of the buildings taking into account their location and the availability of external partitions for the installation of the PV systems.

Example 1



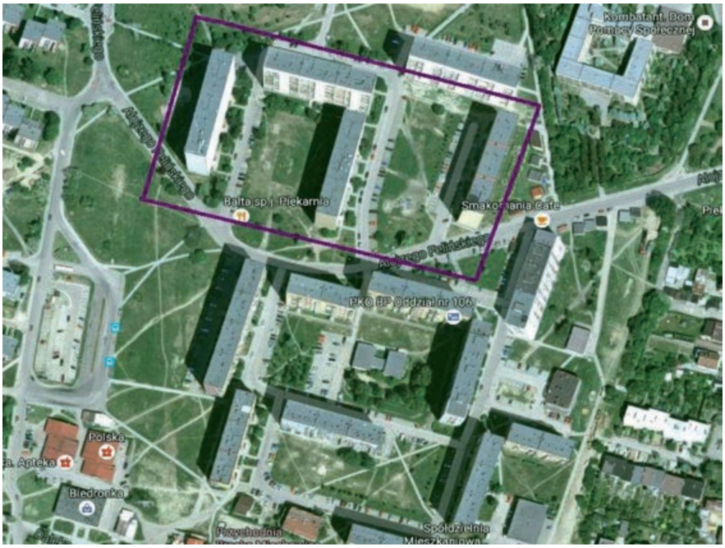
Il.10. Plan of the settlement in Żory at Żołnierzy Września Street. Source: google maps

The multi-family buildings placed in the eastern and western axis have free peak walls turned towards the south with a low deviation (Il.10, Il.13.) As in the case of a skyscraper in Berlin Marzahn, in which the façade was covered with the solar panels in the process of the modernization of the building, acting as the energy active façade.

Il.11. Peak wall of the building. Il. 12. View of the buildings of the settlement at Żołnierzy Września Street in Żory.

Source: photo by Joanna Biedrońska August 2016.

Example 2



Il.13. Plan of the settlement in Miechowice at Felińskiego Street. Source: google maps

Il.14. Peak wall of the building.

Il.15. View of the buildings of the settlement at Felińskiego Street in Miechowice. Source: photo by Joanna Biedrońska August 2016.

In both the similar examples, the buildings consist of 10 floors (Il.11, Il.14), in the peak wall, the surface is approx. 440 m^2; if it is covered with the PV KYOTO PURE 280/285 Wp-mono modular panels, sized 0.992 m x 1.666 m, this will provide a result of 224 PV panels with a capacity of 62720 Wp, which provides an annual electricity gain of 41.05 MWh/year in accordance with the calculations of the PV calculator, i.e. piTERN [11].

CONCLUSION

The introduction of the modernization process of the settlements of large boards seems to be justified in terms of energy in Poland, as well. The revitalization of multi-family houses in Berlin for the PV applications points to a possibility of such realization in our country, they are the base of the experience to be followed. We must seek to ensure a higher participation of the integrated renewable energy systems to ensure high energy and environment efficiency both in the design of new settlements as well as in the process of revitalization. The systems contribute to significantly reduced operating costs, as well as to improve the residential environment and the quality of architectural space [1].

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11. Kalkulator Fotowoltaiczny piTERN

INFLUENCE OF ENERGY COMPONENTS ON DEVELOPING GROUPS OF DOWNTOWN FLAT HOUSING ON THE EXAMPLE OF STUDENTS' PROJECTS

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ABSTRACT

The examples of students' projects presented in the article emphasize connection that exists between forming groups of downtown flat housing and energy management. They show that assumptions of energy strategy actually can determine introduction of functional and structural-material solutions both for single building and entire settlement. Renewable energy infrastructure to be considered as one with significant meaning. Usage of renewable energy sources has an utilitarian point, it also influences function, form and esthetics of urban planning.

Keywords: housing, energy efficiency, renewable energy infrastructure

INTRODUCTION

New national legislation, implementing the provisions of EU directive 2010/31/EU are aimed at gradually reducing heat demand in buildings and increasing the use of energy from renewable sources. In the case of the buildings complex, the achievement of such purposes cannot be carried out on the basis of the adopted in an arbitrary manner, without prior analysis, decisions regarding the functional solutions, it cannot also be limited to individual buildings. The imperative of energy efficiency requires more - a comprehensive recognition, which means the inclusion of the energy issues to the design process already at the stage of the urban formation.

The article describes the impact of energy issues on the functional and spatial shaping of the downtown residential buildings in the urban terms. The works of students of architecture in the State School of Higher Professional Education in Racibórz, developed under the direction of the authors of this study, were applied as a material for an analysis. Their task was to design residential complexes, taking into account the current spatial and technical solutions, gaining energy from the renewable energy sources (RES). The specific urban situations from the city of Racibórz were the basis for the design concepts. The purpose of the research is to determine the applicability of energy components from the RES range in this type of tasks and the assessment of their impact on the shaping of the city.

PLACES OF THE URBAN INTERVENTION

Three city locations were used in the designing activities. Two of them are typical downtown situations: Długosz square and empty quarter between Opawska, Lwowska and Warszawska streets. Their immediate surroundings have a quarter structure which is a fairly strong formal conditionality. This is especially important in the context of the underdevelopment of the modernist architecture in terms of the creation of the urban space. Historical factors are an additional feature. Racibórz has a lot of empty places, remaining after the damages caused during the World War II. A city that once had a clear, decisive quarterly structure lost it. In view of all the above, all urban and architectural activities should aim at supplementing the urban fabric covered by the urban rules, with the main elements being the development quarters, streets and free spaces such as sites, squares, parks, etc.

The third plot, situated at the entrance to Racibórz from the Gliwice side, has a different character. It is located in the area of the chaotic suburban development, so the quarter structure is less visible here. At this point other factors are gaining in importance. The nearby transit road should lead to apply the solutions eliminating or reducing this inconvenience. On the other hand, the location at the entrance to the city leads to the formation of the buildings, which could become a recognizable formal element.

SHAPING OF THE DOWNTOWN BUILDINGS COMPLEX IN THE LIGHT OF THE CONDITIONS

The downtown residential complexes are an essential component of any city. It is difficult to imagine the situation to omit them in the urban planning assumptions, limiting only to the public or industrial buildings. Therefore, despite the fact that the residential buildings are often an inconspicuous "filler" of the urban structure, they are the meaning and essence of the city.

The shaping of the urban buildings complexes has always been dependent on a number of factors. There are two distinct ways of the spatial organization in the urban development. The first deals with irregular, naturally occurring and spontaneous patterns, often derived from the rural structures. The second one concerns the "urban creation", which consists in shaping the structure of the city in accordance with the assumed plan. In most cases, the result was a regular grid of quarters, serviced by streets or other urban spaces (market, square, park, etc.). Both methods of the spatial organization have coexisted with each other from the earliest times. A number of the cities lost their character as a result of the development in accordance with the plan, while others, chaotically developed, tried to be adjusted. The above-mentioned forms, occurring in the various periods of historical development, often occur next to each other. Barcelona is a perfect example, where in the neighbourhood of the medieval district with small, narrow, irregular quarters, a nineteenth-century characteristic regular buildings, stretching in hundreds of hectares, was constructed. The most common planning rule in the history of the urban construction was the allocation of the quarters for the residential buildings in accordance with a previously agreed regulatory plan. The representative examples come from ancient Greece of the classical period (Milet, Priene), but the buildings were subject to the specific rules, earlier in Babylonia and Egypt. There are few examples with a completely freely shaped urban structure. They usually refer to the medieval cities. This is the consequence of the difficulties in maintaining a rigid spatial scheme in the realities of the time, where the defense considerations were required to be located in the difficult-to-access areas, such as hills. The formation and development of the cities were therefore determined by the topographical conditions and by the necessity of limiting the development of the interior space inside the walls. However, even under such conditions, the space was settled in accordance with the certain rules.

Apart from the spatial determinants of the character of the downtown residential buildings are impacted by: geographical location, culture, habits, technical possibilities. The climate is also important. The clear examples of the shaping subordinate to climatic conditions are well known. The urban solutions used in the city of Olynthus in the 5th century BC guaranteed everyone access to the sunny places. A similar approach, though in another spatial reality, was noted in distant Pueblo Bonito, Chaco culture city. The foundation of such activities was to make the building's internal conditions more independent of weather variability, as well as to generate solar radiation for heating purposes. Nowadays, it strengthens positively and reduces a negative impact of the climate, using a wide range of solutions as a result of the technical progress.

The incorporation of energy aspects often leads to the use of greenhouses, solar collectors and photovoltaic structures. They can create some problems in the conditions of the existing quarter buildings. They result from the difficulty of the optimal location of the buildings against the sun, as well as the dangers of the formal monocultures of the residential complex, completely subordinated to the energy requirements.

The increasing energy needs tend to find other sources of energy available in the environment. In addition to solar radiation, the area of interest involves the use of natural forces (e.g. wind blasts, water flow), electromagnetic or acoustic waves, chemical reactions, or the motion of living creatures. The technical solutions to obtain energy from these sources are still often in the experimental phase, especially in the context of their use on a wider scale in the urban areas. The determination of their impact on the adoption of the functional-spatial solutions has not yet been recognized. Their adaptation for the purpose of forming the concept of the downtown buildings complex is the content of the discussed designs.

ANALYSIS OF THE TECHNICAL SOLUTIONS

The solutions applied the student's designs can be divided into generally two groups subordinate to the requirements of the location. The first one includes the designs located outside the city centre, and the other - in the downtown area.

In the first group, the location and shape of the plot did not force the use of the quarterly structure, which does not mean that it was not usable. The approach is an attempt to create a clear formal element at the entrance to the city as one of the main communication arteries. The designed residential structures are of a free character in most cases. The pro-ecological components were the added value, and did not have a clear impact on the adopted functional and formal solutions. This is surprising since for this location the students had the greatest flexibility in shaping the building complex without having to subordinate the quarterly structure of the environment. Various measures were introduced in the design solutions to reduce the negative impact of traffic noise. They consisted of removing the buildings from a road and the construction of additional buildings complex with the accompanying low buildings (covered car parks), slopes, greenery. The energy aspects are disclosed in the adoption of the integrated photovoltaic structures and wind turbines with vertical axis of rotation. These solutions impacted on the design solutions in a variety of ways. In the concept of Kamil Jan (fig.1a), the bridges suspended between the buildings, containing the microturbin structures, are a strong formal accent emphasizing the sculptural character of the complex. In the project of Dominika Zawisza (fig.1c), the curtain shields the building from the noise, thus the communication gallery, defining the geometry of the complex with individualized features. In the design of Marcin Tomczyk (fig.1b), the acoustic insulation elements in a form of vertical structures were used on the side of a busy street, adjacent to the residential buildings. They were assigned an energy function (individual winter gardens, PV cells integrated with the façade). Generally, the solutions adopted for this area were conditioned by the specific character of the plot (the location in the structure of the city, shape) and problems resulting from the proximity of a busy road. The pro-ecological solutions, as an added element, had an impact on the formal image of the complexes, but they were not binding in making strategic decisions.

Fig.1 Design solutions located at the entrance to Raciborz: a) the concept of Kamil Jan, b) the concept of Marcin Tomczyk, c) the concept of Dominika Zawisza. The developments of the students of the fourth semester, academic year 2015/2016

A different group involves the designs located in the city centre. The consequence of this was the need to address the existing construction of the quarter's surroundings, and the requirement to maintain the urban character of the space. In most cases, the design concept shows the respect of the regulatory entry in a form of the quarterly structure. The whole range of the solutions covers the maintenance of the building line, creating a traditional quarter, as well as the concepts in which not only the residential buildings but also low accompanying buildings (trade, garages), tree stakes or elements of the RES infrastructure (solar ponds, wind turbines as independent architectural elements). In all the solutions, there are attempts to apply greenery as a tool of the sustainable design tool.

Among the concepts located in the city centre, there are two groups of solutions:

- Referring to the modernist tradition in a manner that takes into account the formal and functional requirements of the quarterly structure in the city centre;
- Referring to the classical quarter structure in a literal manner, tightly filling the space defined by the lines separating the quarter from a street.

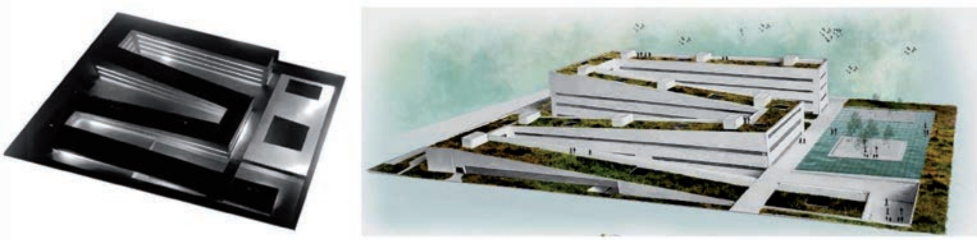

Fig.2 The concept of Klaudia Celińska-Spodar, the fourth semester, academic year 2015/2016

The first group represents the design of Klaudia Celińska-Spodar (fig.2). The whole plot was constructed with the RES infrastructure. The specially shaped building has the integrated photovoltaic cells and green roofs. The space around it, having the characteristics of the public space, was developed with a solar pond and pavements equipped with a piezoelectric installation. The whole must be associated with the modernist manner of the urban development. However, it was enriched with carefully designed public spaces and such a shape of the residential building that, despite its sculptural form, secures precise urban boundaries between the various functions of the quarter.

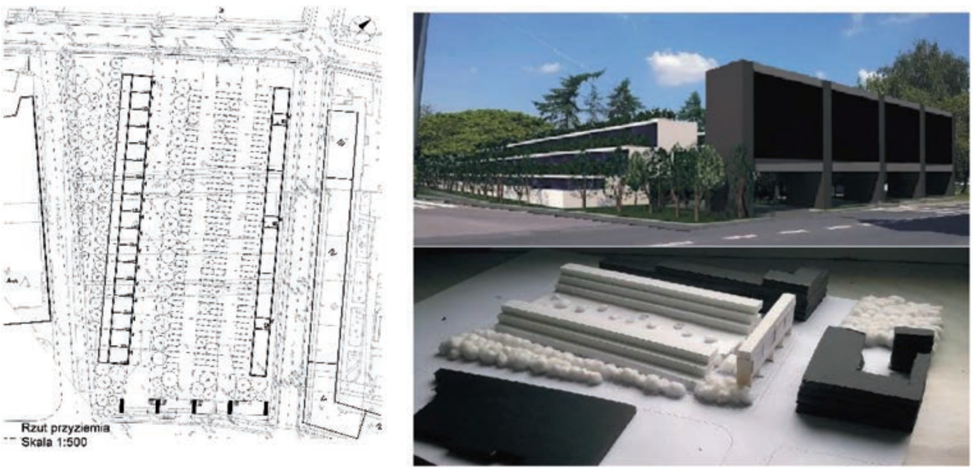

Fig.3 The concept of Jadwiga Wojcieszka, the fourth semester, academic year 2015/2016

In the project Jadwiga Wojcieska (fig. 3), the quarter is expressed in the terraced buildings, and its green nature is stressed with the green terraces. This configuration needs to be oriented towards the sun, so that the rich tectonics of the buildings is also clear from the inside of the quarter. Placing a multi-station garage between the residential buildings actually weakens this effect, but it can precisely define the boundaries of the whole complex. A vertical system consisting of wind turbines and fans with ventilators for air heat pumps closes the quarter from Opawska street. The devices were included in a similar plastic frames. In this way, the elements of the RES infrastructure were used to organize the urban space in a way that refers to the traditional urban solutions.

Fig.4 The concept of Aleksandra Mazur, the fourth semester, academic year 2015/2016

In the concept of Aleksandra Mazur (fig. 4), an attempt was made to diversify the energy sources within the quarter. The development of the system resulted in the arrangement of three irregular bands: external buildings with residential structures and a central recreation area. The buildings were divided with greenhouses, thus separating single residential segments. In the development of the recreational space, the innovative solutions in the field of the RES were introduced, adapted to the urban environment. The wind energy-oriented systems imitate large-scale reeds that move at every blow of wind. A newly developed "park" space opens to the city, and incorporates the traditional elements of the landscape architecture integrated into the reed-tree system.

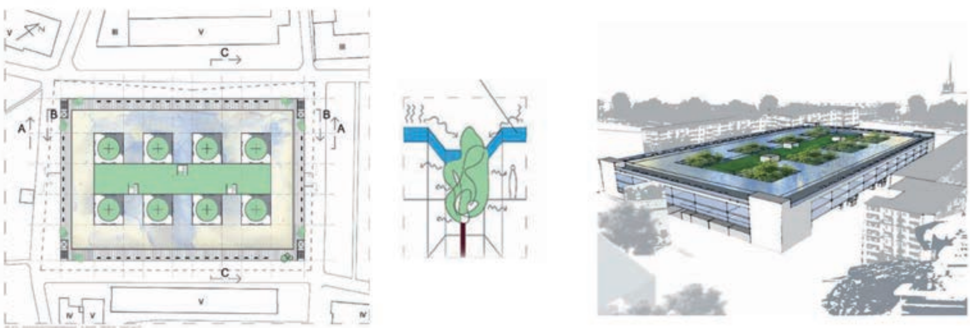

Fig.5 The concept of Sandra Pichlak, the fourth semester, academic year 2015/2016

The design of Sandra Pichlak (fig. 5) is a proposal of a multi-storey building, filling the whole quarter. Patios were used to provide additional lighting to all apartments. The downtown location justified the need to introduce trade and services on the ground floor. The concept includes, apart from the traditional trade, an advanced version of the urban market. The terrain is entirely designed as a roofed urban area, accessible from the outside streets anywhere. For the energy purposes, there is a swimming pool on the roof, acting as a solar pool, and to improve the microclimate of the interior, brine systems are designed in the atria. The roof was made available to the residents of the complex (internal communication divisions) and people from the outside (independent staircases available from the street level). In this way, the city centre gains a completely different public space - a square elevated to a few storeys, providing the opportunity to rest from the urban noise and look at the centre from a different perspective. The project can serve as an example of the implementation of the innovative energy solutions to the traditional formulation of the downtown quarter, resulting in a newly interpreted traditional public space that enhances the city centre's functional attractiveness.

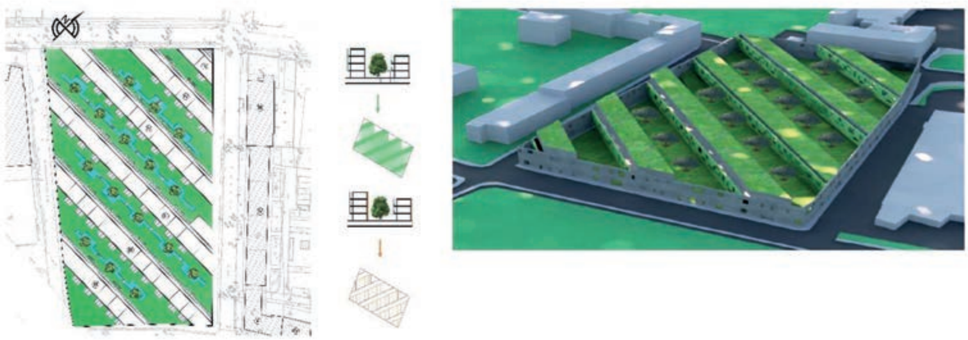

Fig.6 The concept of Paulina Skatula, the fourth semester, academic year 2015/2016

The design of Paulina Skatula (fig.6) confronts the existing urban situation, the records of which dates back to the nineteenth century, with the spatial shaping subordinated to the optimization of the energy solutions. A regular quarter was defined with a three-storey curtain wall, which neutralizes indoor activities. A structure composed of a number of buildings with maximum exposure to the sun was introduced to it. The southern façade has integrated PV cells. In the spaces between the buildings, semi-private recreational spaces with greenery and ponds were organized for the inhabitants. The basic value of the concept is a successful attempt to reconcile the different energy requirements with the requirements of the downtown regulatory plan.

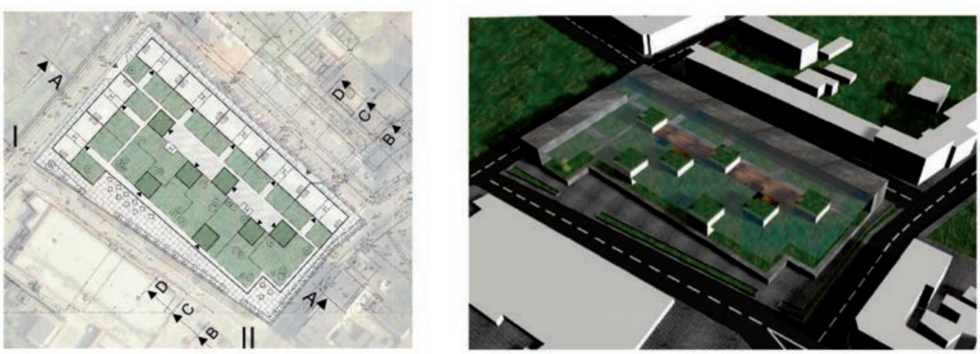

Fig.7 The concept of Sonia Merkel, the fourth semester, academic year 2015/2016

Another approach to the problem is revealed by the concept of Sonia Merkel (fig. 7). The development of the quarter has a clear functional division. The ground floor is designed for a garage zone and trade zone accessible from the street. The residential structure consists of two-storey residential segments located serially on the edge of the plot and free-standing buildings in the centre of the plot. The whole is covered by a transparent cover with integrated PV cells and elements for interior ventilation. It plays a dual role: protects and isolates against changing weather conditions, and also gains the energy of sunlight. As a result, instead of the individual winter gardens, each building received a "microscope", used together in the long term - the buildings were sunk in one common garden.

COMPREHENSIVE ACCEPTANCE OF THE ENERGY PROJECTS IN THE LIGHT OF THE ANALYSIS OF THE STUDENTS' DESIGNS

The concepts of obtaining energy from the renewable sources was stressed in the adopted urban solutions. They are based on various systems and tools in the field of the RES, used commonly or experimentally. Their selection is individual and tends to diversify these sources in order to cover the energy needs of the designed buildings complex and ensure its stability in this area. It depends on climatic conditions, location, physiographic terrain and functional cubature. Although the economic account was not taken into consideration, this factor emerged in a form of the space management. One of the assumptions was the assignment of the energy functions to the elements of the area development. Apart from sporadic cases of the standalone RES structures, bifunctionality of the surface (traditional - usable and energetic) was achieved, by carrying out the basic tasks using new technical and design solutions.

The land development stresses the energy issues by:

- solar exposure of the surfaces oriented towards the acquisition of energy directly from solar radiation or enhancement of the energy effects (acquisition of reflected energy from reflective surfaces, e.g. mirror of ponds);
- the acquisition of the basic public space functions by the system from the scope of the RES (solar pond as a pond remains, piezoelectric systems integrated with strings for pedestrians, PV systems with non-slip surface as walkways, piezoelectric systems that use air traffic visually imitating greenery, solutions using the strength of human muscles at the gym or playground);
- the use of the kinetic energy of the air flow induced by the surrounding traffic for acquisition of electricity (free-standing structure with micro-turbines within the borders of the plots, lanterns equipped with turbines with vertical axis rotation);
- the use of greenery for thermal protection of the buildings (natural protection against cold wind in the winter from the north or excessive insulation in the summer from the south);
- the use of plants and water for cooling the urban interiors.

The impact of the energy issues on the shaping of the buildings became clear as a result of the adoption of the following assumptions:

- the cubature contents - to minimize heat loss through the shape of compact buildings to obtain the beneficial surface ratio of external partitions to volume (A/V);
- the optimal orientation of the building relative to the Sun, the Earth and the prevailing winds, depending on the functional and energy needs. This has a significant impact on the evolution of the functional zones, the intermediate area (greenhouses), the deployment of storage partitions, the translucent and other technical solutions, impacting on a form of the building;
- the use of the phenomenon of wind nozzles between the buildings to gain wind energy - the construction of complex structures with micro-turbines with vertical axis rotation VAWT;
- the view perforation - the use of open or covered with glass atrial spaces to improve the microclimate as well as lighting and heat conditions inside (brine systems);
- the use of thermo-buffer areas - they are formed by the separated areas under glass, located on both sunny and shaded side, not subject to insulation. They are a thermal buffer between the internal and external environment, causing e.g. the reduction of heat loss in the winter;
- the energy activation of the external partitions of the buildings – the activities within the cover to increase energy efficiency by the use of passive solar heating solutions (glazed façades, large areas of glazing on the south roof, heat stores) and the active integrated solar and wind systems (BIST thermal systems, photovoltaic systems, BIPV/T photovoltaic-thermal hybrids, BIWT micro turbines);
- the development of the surfaces of the partitions by using the additive thermal or photovoltaic components to gain heat or electricity (solar panels, photovoltaic panels, PV cells integrated with technical hoods).

The attempts carried out in the students' designs to take into account the modern systems of passive and active with a range of the RES at the stage of the urban shaping of the downtown buildings complexes allow to formulate the following conclusions:

- the use of the energy components of the RES range has an impact on the urban shape of the building complexes. They depend on the type of energy sources, the specification of the energy acquisition-oriented systems and the degree of integration with the building. The optimization of the design solutions for energy can be the most "conflict" for the quarter structures in the case of the use of energy from solar radiation. The exposure to the Sun is required, which can lead to the adoption of the spatial solutions which are not always congruent with the structure of the environment. The use of the solar techniques in free-form system without any downtown construction rules does not cause any major problems. The use of wind power typically involves the use of turbines on the edges of the plot or requires generating the phenomenon of a wind nozzle in the buildings. However, the piezoelectric systems associated with the communication strings, which are subordinated to the adopted composition assumptions and require only the connection with the external communication system, do not significantly impact;

- The implementation of the active systems in the existing systems of the downtown buildings, despite the difficulties in reconciling all aspects relevant for both areas: urban planning and technology, can lead to a surprising, new interpretation of the known forms of the urbanism.

CONTEMPORARY DEVELOPMENT OF HISTORICAL BRICK NOGGED TIMBER WALL BUILDINGS INSULATION - CASES STUDY

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ABSTRACT

The article presents the example of contemporary development of the insulation of historical buildings, built in technology of half-timbered walls, preserved in Upper Silesia. There are trade objects among them, subjected to renovation treatments in the past, without the imrovement of partitions' insulation, but also the ones existing as uninhibited buildings of poor technical state. Effective improvement of thermal state of such buildings is possible by the use of modern materials, provided properly selected technology, precise diagnosis of the existing situation and application of appropriate design methods. Analysis of examples shows the possibility of obtaining positive thermal effects, improving the quality of use, but also the risk of occurrence of adverse tremperature and humidity effects in partitions. Their omission may result in deterioration of the technical condition and the conditions of use during the operation of facilities.

Keywords: brick nogged timber wall, historical buildings, internal insulation, buildings insulation

INTRODUCTION

The legal requirements in Poland for thermal protection impact on the shaping of activities related to the design of new buildings but also the maintenance and operation of the existing buildings. In newly designed buildings, proper insulation of the building partitions together with the required energy efficiency is possible due to the appropriate application of the modern technologies and materials by a designer. In the case of the existing buildings, which have been operated for years under certain climatic conditions, the improvement of the thermal parameters cannot be achieved by means of the thermal upgrading treatment without taking account of their existing condition. Currently, there are cases of humidity increase in the insulation of the external walls of the buildings, i.e. fungus visible from the premises side. The cause of this phenomenon should be seen in ignoring the initial moisture content of the partitions, the wrongly selected solutions or the use of the simplified calculation methods. As far as the buildings subjected to a conservator protection, the insulation is applied from the inside of the buildings. Such solutions require the use of more advanced design methods taking into account the nature of the building and its operation. The positioning of the insulating material on the inside is not correct from the construction physics point of view, e.g. because of the risk of condensation of diffusing water vapour. The contemporary material solutions will allow for an effective improvement of the thermal insulation of the building partitions through internal insulation provided that the calculations are correctly carried out prior to a detailed analysis of the existing condition, taking into account the actual external climate conditions and the conditions related to the use of the premises. A special case for this type of the solutions involves the buildings with heterogeneous construction of walls, e.g. made as a wooden frame with brick fillings, the so-called Prussian wall. Such constructions were used at the turn of the 19th and 20th centuries also in present areas of the Upper Silesia region.

SILESIAN HOUSES MADE OF THE PRUSSIAN WALL - EXAMPLES

Among the preserved examples of the Prussian wall houses in Silesia, a large group of buildings are constructed within the settlements constructed under the so-called patronage settlements. They come mainly from the turn of the 19th and 20th centuries, and their origin is mainly connected with the development of the industry in this region. Such examples involve Zandka settlement in Zabrze, constructed during the operation of Donnersmarck steelworks or the workers' colony in Zabrze Rokitnica, associated with Castellen coal mine of earl Ballestrem. These buildings were constructed within the settlements originally intended for the workers, with the whole sets of buildings and social facilities. The objects of such a structure are also found in the settlements of Bytom and Ruda Śląska. In Pyskowice, there is a preserved settlement, the development of which was conditioned by the events connected with the formation of the railway junction.

A wooden frame structure with ceramic brick fillings was found in Silesia as a standalone in the whole buildings or it characterized only parts of the objects. In multi-family houses, it was used in the upper parts of the buildings, mainly in non-usable attics, but also in staircases. It was used to construct the walls of the last floors, or the partitions of unheated spaces, such as staircases or sometimes attics.

An example of a building with the Prussian wall in Gliwice is the building of the present State Music School, dating back to the beginning of the 20th century. The frame structure occurs in the second floor walls; the ground floor is wholly made of brick. The rooms of the floor contain a library and music rooms for exercises.

Il. 1 View of the residential buildings in Zandka settlement in Zabrze, J. Dębowski, 2015

Il.2-4. Wooden details of the Prussian wall in the residential buildings in Zandka settlement in Zabrze, A. Szymanowska-Gwiżdż, 2016

Il.5-7. View of the residential buildings in the railway settlement in Pyskowice, an originally non-usable attic made of the Prussian wall, A. Szymanowska-Gwiżdż, 2014

Il.8. The Prussian wall in the building of the State Music School in Gliwice, A. Szymanowska-Gwiżdż 2015

CONSTRUCTION OF PARTITIONS - EXISTING CONDITION

The construction of the partitions made in the technology of the Prussian wall in Silesia depended on their location of the building. The residential and commercial floors of the multi-family and public buildings (floors and other stories) were made with a thickness of one brick. A wooden frame (the most common cross-sections of columns: 12/12cm - 16/16cm) visible from the façade side was filled with brick and enclosed on the side of the rooms with a layer of a flat-laying brick. In total, the partition thickness was approx. 25cm. This type of the partition occurs in Zandka settlement in Zabrze, both in the workers' houses as well as the officials' buildings, also in the storey of the floor of the State Music School in Gliwice (in the preserved condition of the primary condition). In the case of non-usable attics and staircases, the walls were made up to a thickness of 1/2 brick (12cm). In single-family buildings, the walls were construed with a thickness of 1 brick, insulated on the side of the rooms with cement-wood boards of suprema type, with a thickness of 5-10 cm.

The areas between a wooden frame were left as brick or covered with layered plaster, often with a texture. The spacing of the columns of a wooden frame was determined by the building, as well as the location of the window and door openings. Wood was also found in the façade decorative elements, in a form of richly decorated panels, cornice covers between the floors, balustrades, handrails, gable panels and shutters.

The insulation of the preserved wooden-ceramic partitions depends on the structure of the wall at the level of U = 1.9-2.7W/(m^{2}K). The values of the calculated heat transfer coefficient "U" of the outer wall can differ depending on the assumed thermal conductivity of the materials. While in newly-designed buildings this parameter is based on the standard or producer's declarations, it cannot be easy to select the relevant parameter in the existing buildings. The properties of the materials used in the past (brick and wood) can show differences. In determining the existing status, the sets of the parameters of historical material available in printed sources or computer programmes library bases can help a designer in the thermal simulations and physical calculations. They include the following sources[1]:

1. Kuzman R.: Thermal tables with charts.
2. Häuptl P.: BAUPHYSIK
3. DIN4108-4
4. Material base of WUFI programme

Tables 1 and 2 show the values of the thermal conductivity coefficient of wood and brick depending on the density of the material.

[1] A detailed description of the sources is provided in the references.

Tab.1 Summary of the thermal conductivity coefficients λ of wood

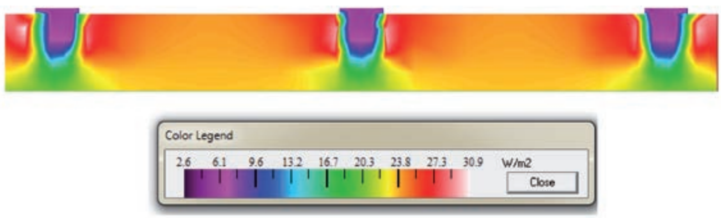
Name	Density [kg/m^3]	λ [W/mK]	Source
Pine, fir, spruce perpendicular to fibres	400	0.128	1
	600	0.186	
Spruce	550	0.130	2
Non-coniferous wood	700	0.201	
Oak across fibres	650	0.3	4
Soft wood	400	0.09	
Hard wood	650	0.13	

Tab.2 Summary of the thermal conductivity coefficients λ of ceramic bricks

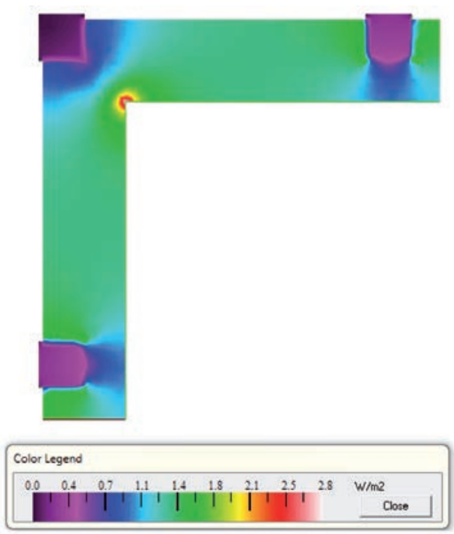
Name	Density [kg/m^3]	λ [W/mK]	Source
Old brick	1000	0.326	1
	1200	0.384	
	1400	0.442	
	1600	0.523	
	1800	0.733	
	2000	1.233	
Old clinker wall	2010	1.045	2
Old brick wall	1640	0.590	
	1810	0.705	
	1720	0.842	
Full brick wall	1950	0.960	
Typical brick wall	1792	0.555	
Semi-clinker brick	1800	0.81	3
Historical full brick	1850	0.60	4
Old brick	1670	0.40	

The calculation of the internal surface temperature values of the partitions of the building made of the Prussian Wall of the State Music School in Gliwice, using the selected parameters presented in Tables 1 and 2, showed differences of maximum value of 1.3^{0}C. For most calculations, these differences are not significant; however, in the case of coupled thermal and humidity calculations, this impact can be significant. For a part of the extreme cases, it can cause distortion of the final results.

The partitions made of the Prussian wall, due to their construction, are a special case. The wall elements are connected there with wood, mortar, sometimes plaster. These are the materials with different coefficients of thermal conductivity, thermal expansion, and with a different diffusion resistance. In addition, the characteristic feature of the partitions involves gaps between a frame and adjacent elements, allowing the penetration of rain water into the wall. It is thought that they can be due to, inter alia, the natural processes of degradation of wood and mortar. Such a phenomenon was described by Kozakiewicz (Kozakiewicz et. al. 2013), paying attention to the ageing processes and slow losses of cross-sections of the wooden elements. The places of the contact of a surface and a brick and the area around columns represent the zone of disturbance of heat flux density, which can impact on the durability of mortar in these parts of the partitions. Such disturbances were confirmed in the analyses carried out using Therm programme used to simulate the temperature field distribution of the partition cross-section, in the field of 2D model. The calculations were carried out for the external partitions of the building of the State Music School in Gliwice. The article presents the exemplary results of the calculations of the distribution of heat flux density in the partition cross-section in a graphical form, for a flat section and in a corner (Steidl et al. 2015).



Il.9 Distribution of heat flux density - a flat part of the partition of the Prussian wall in Gliwice, the existing state (Steidl et al. 2015)



Il. 10 Distribution of heat flux density - a corner of the partition of the Prussian wall in Gliwice, the existing state (Steidl et al. 2015)

POSSIBILITIES OF THERMAL INSULATION OF THE EXISTING PARTITIONS AND THEIR PHYSICAL EFFECTS

Current legal requirements in the field of energy performance of the buildings and external partitions, and the desire to improve the comfort of the rooms use force the need to carry out thermal upgrading works, also in the historical buildings of a complex structure of the partition, such as the Prussian wall. Thermal insulations are carried out from the inside of the rooms, and in this case it is particularly important to apply correctly selected solutions of non-accumulation of humidity in the partition. It can occur both as a result of the migration of water vapour from the inside, as well as from the outside, e.g. in connection with the occurrence of precipitation.

The investors and designers have the modern materials and technologies, inter alia the thermal insulation systems (e.g. mineral wool) with a tight vapour barrier from the inside, and allowing free diffusion through the partition. The properly selected insulation should not impede the migration of humidity from the partition towards the room (as is the case in the original, historical construction of the partitions, due to small thickness of the wall and the lack of the insulating covers). The requirements for the thermal insulations from inside the walls of the Prussian wall using mineral wool were included in the literature [Kunzel et al. 2004, 2006]. It was noted that if the walls of the Prussian wall are insulated with mineral wool, the optimal solution, from the point of view of the flow of water vapour and the possibility to decrease of humidity in the partition, will involve the use of the so-called humidity adaptive foil, not a traditional vapour barrier. It works by changing the diffusion resistance depending on ambient humidity. Low humidity of the rooms heated in the winter causes the increase of resistance and reduction of diffusion; while in the summer at much higher relative humidity inside the building, reduced foil diffusion resistance creates the conditions for drying of wood humidity towards the rooms. However, the problem can involve uninsulated wooden frames leaving from the outside, which being in a lower temperature can be subject to unfavourable phenomena related to freezing for wood and its increased humidity to a critical value of - 20%. For this reason, the thickness of the thermal insulation applied from the inside in the climatic conditions of Germany and Poland to 5-6 cm is indicated [Kunzel et al. 2006].

Currently, the insulating technologies based on the materials allowing for free diffusion of water vapour are available. These include the so-called climatic, lime and silicate plates, plates of light concrete, or mats with aerogel.

Lime and silicate plates are characterized with a microporous structure, due to which possible condensate is properly vented, and provided to the room in drying periods. The coefficient of thermal conductivity of such a material is at the level of the 0.0626-0.0727 W/mK, diffusion resistance coefficient μ = 3-6. Standard commercial plates thicknesses: 2.5cm, 3cm and 5cm.

Plates made of autoclaved aerated concrete for the internal insulation are produced with a density of up to 115kg/m^3. They are able to absorb humidity from the air and dry quickly. The basic parameters for the thermal and humidity calculations: coefficient of thermal conductivity - 0.042 W/mK, diffusion resistance coefficient - μ=3, commercial thickness of plates made of autoclaved aerated concrete: 5-20cm

Aerogel is a type of rigid foam, 90-99.8% of the mass of which consists of the air, the rest is a porous silica-based material. The value of the coefficient of thermal conductivity varies on the level of 0.013-0.016 W/mK. Aerogels are sold in a form of mats in rolls. They are produced in thickness of 5 mm and 10 mm.

Table 3 Comparison of the selected parameters of the materials used for internal thermal insulation

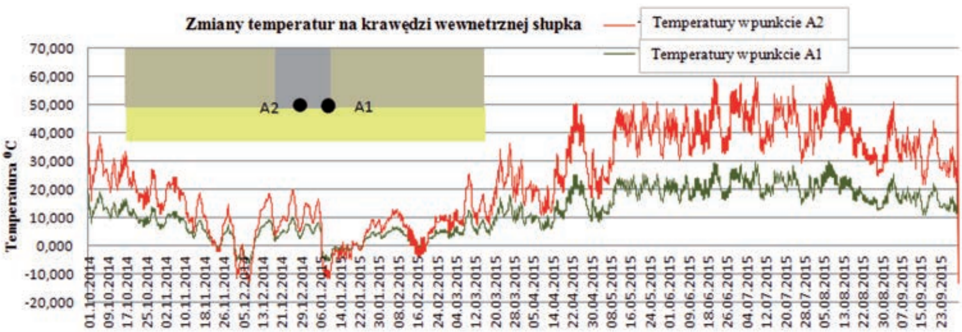
	Mineral wool	Silicate plates	Autoclaved aerated concrete	Areogel
Heat penetration coefficient declared declared by producers W/(mK)	0.030÷0.045	0.0626	0.042	0.014÷0.016
Volume density kg/m3	135÷170	180-300	115	117÷143
Diffusion resistance coefficient	1	3-6	3	5

The modern thermal insulation designs are supported by the computer calculation programmes. Most available programmes allow to calculate the heat transfer coefficient and check inter-layers condensation for flat sections of the homogeneous partitions. For the calculation of any two-dimensional model of a construction element, THERM programme is used, based on the use of the finite element method (FEM). It allows to obtain the heat transfer coefficient U (W/m^{2}K), total heat flux density and temperature values anywhere in the cross-section of the partition, so that it can be used to obtain the necessary data (temperatures on the inner surface of the partition) for the estimation of surface condensation and the likelihood of the emergence of mould.

Modelling of nodes in 2D programme allows only to approximate the real conditions. This is significant especially in the case of the structures with variable elements at the height of the arrangement of all elements in the partition. Such a situation occurs in the walls of a wooden frame, e.g. in the case of braces in the corners. In the vertical line of the corner, one can expect alternating temperature distribution. It is visible in the thermal images (Steidl et al. 2015). In the case of horizontal cross-sections of the partition (in 2D), temperature reading relates only to a specified plane of the cross-section. The impact of the elements adjacent to the node is not included: window openings, horizontal partitions, etc., although their distance the tested building is often less than the required standard (PN-EN ISO 10211:2008 Thermal bridges in buildings. Heat fluxes and surface temperatures. The calculation details). 2D models carried out in a vertical plane taking into account e.g. the stories, requires knowledge of their construction and in the case of the possibility of carrying out pits, which is not always possible.

In the design of the insulation, the possibility of theoretical confirmation of the effectiveness of the introduced solutions is important at a certain time of use, because dangerous accumulation of humidity can occur after several years of operation. To carry out a two-dimensional simulation, WUFI programme is used, with the use of a coupled model of heat and humidity transport phenomena. It allows to estimate the drying time of the partitions form the initial technology humidity, and the one resulting from the operation, an assessment of the danger of condensation of humidity inside the partition, e.g. taking into account the impact of heavy rain. The programme can be helpful when selecting a suitable solution of modernization of the existing partitions, taking into account the impact of climate factors.

Simulations in WUFI are carried out for the walls of the Prussian wall of the building from Zandka settlement in Zabrze, insulated from the inside with concrete with a thickness of 6 cm (Krause et al. 2016).

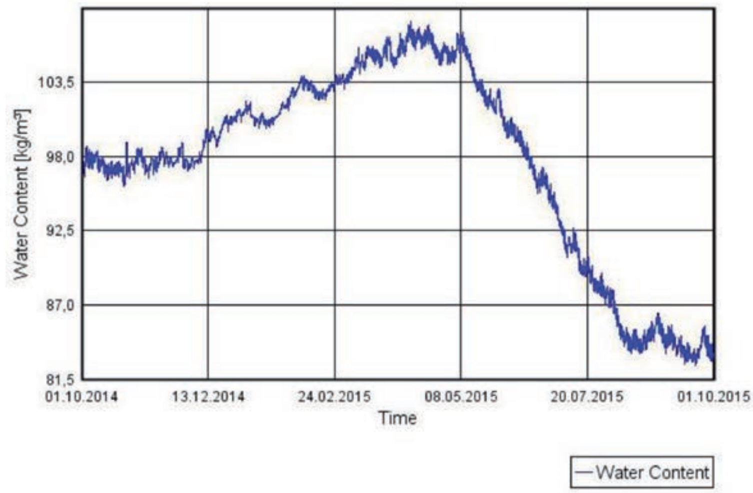


Il-11 Temperature changes in the given points on the internal edge of the partition column (Krause et al. 2016)

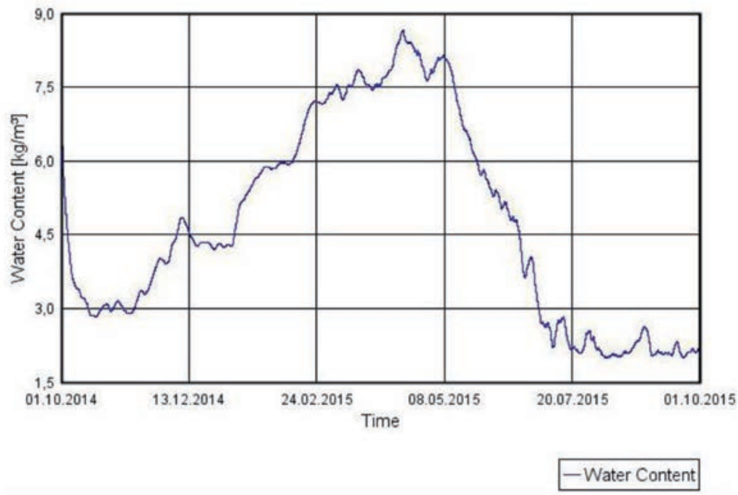
They allowed to determine the trend changes in the insulated partition. The final values that specify the water content in the insulation layer, after the annual period of simulation for the north and west walls do not differ significantly from each other. The analyses showed no worrisome accumulation of humidity inside the partitions or on its internal surface.

In this case, for a thin wall of the Prussian wall, insulated with the insulation material inside the rooms, providing the appropriate diffusivity of the partitions, the impact of higro-thermal changes on wood and the contacts of the columns with the ceramic material seems to be a larger threat for the historic layout of the partitions. The generated charts show also the changes in the level of humidity in the individual elements of the partition (fig. 12 and 13).

However, the concern seems to be the impact of the isolation of the external layers of the wall from a warm interior due to the application of the internal thermal insulation. The temperature on the surface of wood, in the contact with the internal layers, falls to a couple of degrees below zero during the winter months. The largest impact of the conditions of the external climate can be seen at the contact of wood with the wall brick, in a form of occurring negative temperatures, but also high temperatures during the summer. Fig. 11 shows the temperature changes in the selected locations of wooden columns in the interior and in the place of connection with brick parts. The carried out simulations provide a basis to believe that these places must be taken into special account, from the durability point of view, when designing the insulation of the partitions at the side of the rooms.



Il.12 Humidity content in wooden columns, the internal insulation of the wall of the Prussian wall in Silesia, the western wall (Krause et al. 2016)



Il.13 Humidity content in plates made of autoclaved aerated concrete, the internal insulation of the wall of the Prussian wall in Silesia, the western wall (Krause et al. 2016)

In that case, the analysis of the proposed solution did not show humidity accumulation inside the partition, for one calculated year. This does not mean, however, that it will not occur for a longer period of use. The calculations were carried out for the monthly average temperatures. Much more troubling results were obtained from the analyses carried out for the building of settlements in Pyskowice (the wall was of similar construction, but insulated with a panel of 8 cm thickness). For the minimum monthly temperatures, there was a constant annual increase in the wall dampness (Steidl et al. 2014).

CONCLUSION

Among the preserved Silesian buildings of the Prussian wall, a considerable part can be renovated, repaired or provided with thermal and modernization works in the near future. Due to the historical value of the objects, and the specific nature of the façade, the solutions with the internal location of the insulation will probably be designed for them. It is worth to include the measured material values, the current value of the thermal conductivity and humidity of the partitions (which are the value of baseline for the analysis) in the design. It is also worth to establish the actual conditions of the internal climate, consistent with current or planned functional use of the rooms, and consider longer than a year calculation period. In particular, one must observe the place of the connection of wood with the ceramic material to determine their condition, including the initial humidity of wood and brick wall. Such data will allow to carry out the appropriate thermal calculations and/or thermal and humidity calculations and, if necessary, a simulated behaviour of the masonry and wood elements in the period of the future use.

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DESIGN THINKING – TECHNOLOGY FOR CREATING INNOVATIVE PRODUCTS AND SERVICESS

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ABSTRACT

Design Thinking is defined as a new methodological approach in the process of creating all sorts of innovative products and services, in which human consumer is the central point of reference. Shared project teams, multi-analyzing the problem, modeling of proposed solutions, critical analysis at every stage of the design process, the main features of structured activities strive for success, mainly in the business world. The universality and popularity of this phenomenon, provokes to reflect on its effects on the activity of architects in designing and teaching curriculum design.

Keywords: Design Thinking, design process , innovations , architectural design , design teaching , creativity

Introduction

"Design Thinking" is the title of the book by architect G. Peter Rowe, former Dean of the Harvard Graduate School of Design, published in 1987 (Rowe, 1987)] The author described the specificity of the complex process in which the architectural project is being developed. Drawing on the experience of the architects - practitioners, he presented the strategies, methods, tools and techniques used by the designers to develop innovative solutions to design problems in architecture and urban planning (*Problem solving*).

The effectiveness of these systematized activities was supported by the thesis that the creativity and innovation are the attributes that can be developed, and the knowledge about them can effectively help in a creative activity.

The methodological aspects of the design process have always been present in the education of the architects, and design thinking is an integral property of a formed architect (Cross, 1998; Gasparski, 1988). In addition, a human (user) has always been and is at the centre of the architectural design activities.

The book has become a discovery not in the architectural environment, but in the business world. In recent years, the term "Design Thinking" has acquired there the status of autonomous "religion". Design Thinking has become a "miracle" method for innovative successes in various areas of commercial activity: trade, service, industry, social organizations, medicine, sport, media business, etc. (Dunne, 2008).

"Design Thinking" is also the title of the publication as of 2008 by Tim Brown, the founder of IDEO, a business world-renowned company involved in innovations and designs, with its registered office in Palo Alto, California. The author gained a guru's position among the followers of Design Thinking, and his saying that "*Thinking like designer can transform the way you develop products, services, processes and even strategy"* has become a motto for a number of activists of this movement. It is also worth to cite its definition: *„Design thinking can be described as a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity"* (Brown ,2008).

INNOVATION PURPOSES.

The movement of scientific research, methodological considerations, systematic analyses dynamically develops around these activities. Dozens of books and manuals have already been published to prove that "hunting big ideas" is reachable to everyone (Plattner 2011, Seidel 2013). Here are some distinctive titles that describe the essence of the phenomenon:

- *101 Design Methods: A structured Approach for Driving Innovation In Your* Organisation.(Kumar,2013),
- *This is Service Design Thinking: Basics, Tools, Cases.* (Stickdorn,2012),
- *Universal Methods of Design: 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions.*(Martin,2009),
- *Design Thinking: Interacting Innovation, Customer Experience and Brand Value* (Lockwood,2009),
- *Design thinking for strategic Innovation,* (Mootee, 2013), etc.

Design Thinking **(DT)** appears to be an irreplaceable method of an effective activity on the carrying wave of the motto "innovations, innovations, innovations...". Seminars, workshops, trainings are organized. Universities and research institutes are established. Stanford University is the leaser here, where the Hasso Plattner Institute of Design was established. On the European ground, the Hasso Plattner Institute at the University of Potsdam is its equivalent. Both universities are generously sponsored by a German magnate in the field of Hasso Plattner technology. Since 2013, Radford University in Virginia has offered the opportunity to gain Master of Fine Arts (MFA) in the field of design thinking, by fully on-line training on the web.

These universities are open for trainings (also at the Masters and Postgraduate levels) in the field of Design Thinking of anyone willing, regardless of their current professional profile. We will meet here managers, merchants, dancers, librarians, filmmakers, mechanics engineers, politicians, fashion designers, graphic designers, sometimes industrial designers, and architects the least often (Lamster, 2013). The qualified instructors and Design

Thinking teachers are professionals as above, with the lowest participation of educated methodologists and architects. A new profession is emerging: DESIGN THINKER. The name (title?) is used by a number of trainers and instructors, who are engaged in specialized companies, trainings, workshops, courses, etc.

Tim Brown identified five features that design thinkers should have. The first is empathy - the ability to perceive the world from different perspectives, with particular sensitivity to the needs and expectations of customers, ordinary users, consumers. The second feature is the interactive thinking, i.e. the ability to perceive non-obvious things in the analysed phenomena, contrary to previous experience, having the potential for desired changes. The third feature is optimism, which should be held by any person carrying out this profession. This attitude manifests itself in a specific attitude; there is no problem for which no solution could be found better than the previous one. The fourth feature is experimentalism; strong focus on creating risky, untested ideas that test the possibility of contradictions and non-obviousness. The last of these features is collaboration; the ability to resign from self-centred perception of a position, to collaborate in a multi-person team consisting of professionals representing different professions and qualifications.

Also in our country, we notice a clear fascination with this new form of activity in social movements and academia centres. On the Internet, Design Thinking opens dozens of offers for courses, trainings, workshops offering guaranteed (?) success in finding innovative solutions in any field. Only the proposals for architects are few and timidly articulated among many others. The idea to promote a new teaching method of creative thinking increasingly reaches to the Polish primary and secondary schools. The funds from the Ministry of Digitization helped the Centre for Civil Education to issue a teacher's manual entitled: *"Design thinking with Class"* (Kolowacik et al., 2013), modelled on the Stanford University training materials.

DT - DESIGN THINKING AS A METHOD.

What did Design Thinking use to seduce so many of its current followers? The question is worth answering in the broader development of the problem. Due to the limited nature of the present text, I present briefly only the most important arguments:

1. The Concept of Design Thinking is the adoption of a widely known (used by the architects for a number of years) iterative model of the design process, in which the sequential nature of the design stages orders the thinking process and leads to innovative solutions (Cross, 1998, Gasparski, 1988, Zubel, 2014). In this process, we can distinguish the following stages:
    - TASK
    - ANALYSIS OF CONDITIONS
    - DEFINITION OF A PROBLEM
    - VARIATION OF HYPOTHESIS
    - CRITICAL ANALYSIS, CREATION AND SELECTION OF THE CONCEPT
    - DEVELOPMENT

- REALIZATION
- VERIFICATION

2. The above, well known to architects design process was transformed into a model by the Stanford Institute of Design, consisting of the following steps:
   - E MPATHIZE - know and understand human needs and dreams, try to identify with them.
   - DEFINE - discover the essence of the situation being analysed, name the challenge with which you should face, ask questions, define problems.
   - IDEATE - come up with answers to the questions you have been asked, create ideas, do not limit your imagination, quantity is important, map the thinking process as "coloured cards on the wall".
   - PROTOTYPING - build physical models of ideas in every shape and form; it can be a model, mock-up, played roles, space remodelling, poster or advertisement, etc., use any materials and tools to visualize ideas.
   - TEST - present prototypes to the user, listen to comments and criticism, if necessary - change and improve, strive for realization.

   In the modified form, this model is enriched with one more step:
   - IMPLEMENT - try to realize the idea in the real world, be aware of technical, economic, social, aesthetic, marketing, business, etc. conditions.
3. In the implementation of Design Thinking, the following principles are strongly emphasized:
   - A future or potential user (customer) is the central character in the design process. Multi-person teams are created (not just specialists) to see a problem from the widest and various perspectives (a holistic approach). The participation and collaboration principle in the design team is a necessary condition (co-creation).
   - The heuristic techniques, such as brainstorming, are used to form creative ideas, and any available tools and techniques (graphs, sketches, diagrams, self-adhesive pieces of paper, photos, etc.) are used to write them.
   - Created ideas (concepts) are checked through physically executed models, mock-ups, simulations, prototypes.
4. Design Thinking is a methodological proposal for a number of organizations to develop their services, products, processes and strategies. It integrates three problem spaces: 1. Needs, expectations, and attractiveness are determined from a human point of view; user, client (DESIRABILITY). 2. Technical feasibility (FEASIBILITY). 3. Economic and social justification for ideas (VIABILITY).
5. Design Thinking, by using the design methods used in the general model of the design process, introduces methods, considered as its own, such as: interviews, creation of a user's profile, analysis of existing solutions, mental maps, development of prototypes, 5x why-questions, analysis of a situational context.

6. The implementation of the design process as well as the teaching of design is carried out in accordance with the principle of "learning-by-doing". This general postulate is dressed in various methodological approaches, such as: "action learning", "action research", "reflection in action", "knowing in action" (Meinel, 2011; Weinstein, 1995). A close relationship with practice is to replace the traditional Project Based Learning (PBL) based on "chalk and talk", i.e. a classic teaching with a chalk and a board. Instead of the current studios (design studio, atelier) conducted by a tutor (master), e.g. the concept of the DESIGN CHARRETTE is promoted. This is an intense session of the designers collaborating with each other (participants in a session, students) working on the solution to the design problem in a specific and limited time.
7. Design Thinking is to be a universal method of creating innovative solutions to the problems in the different areas of life (Owen 2006; Yen, 2012). This method is to convince anyone that the INNOVATION is: a discipline and not magic, requires a structured approach and system using different techniques and methods of work, requires team work of specialists of different disciplines, innovation is a creative achievement, which is formed by four forces: business, technology, design and society.

Taking into account all previous observations, it should be noted optimistically that we are all DESIGNERS, i.e. DESIGN THINKERS.

By reading these words, the architects - practitioners or teacher involved in the teaching of the architectural design, can say: And what is new? Exactly.

And yet, for many, THIS IS SOMETHING. For others, it is the subject of critical comments and negation.

ARCHITECTURAL DESIGN IS DT.

The architectural design is pure design thinking. It is carried out creatively; it must strive to achieve the effect of the innovation. Obtaining those new, not experienced so far, relationships, is the purpose of the innovative activity. Therefore, the innovation is a necessary feature of a creative activity. The complementary requirement involves the condition of readable values to be included in the design solution.

Design is a conceptual preparation of a change (activity) carried out in the course of the process of an informative structure. Design **(**Latin *projectus* = extended anteriorly) therefore includes the idealization of the designing procedure activities (designer), the morphology of the activities with its individualities and invariables, as well as the methods of a practical approach to the ideal by: design strategies, methods and techniques. **The design** is the result of the design process.

The design process, in turn, is considered as a manifestation of an orderly impact (relationship) of the designing system (designer) on the designed system (design subject), which determines the method of the designing process.

The design, in the light of the above, is a subject (or process) pattern that allows to facilitate the immediate implementation of this subject (or process), created within the grounds necessary to this implementation and to use this subject (or process).

DT - THINKING TECHNOLOGY

The word "*technology"* used in the title of the text determines the potential of Design Thinking, as something more than just the method of creative thinking. This concept is defined as the method for the preparation and implementation of the process of creating or processing for some good (including information) in a new form, e.g. a product, services. A widely concept of "*technology*" means the practical use of knowledge, with the use of appropriate tools and techniques (machines) to obtain the expected result in a form of a solution to the problem in the real world. Knowledge is the result of research and experience. The used tools and techniques do not have to be material; they can take a form of a virtual technology such as computer programmes, design methods, business methods or skills and experience. Technology can be seen as a type of activity which shape changes in the cultural environment (Arthur 2009, Wright 2008). The desired and expected characteristics of these changes should be: usability, functionality, security, aesthetics. The innovation should complement the criterion. Meeting all these demands together results in a solution to a design problem in a form of a product or service that is considered as an innovative solution. From this point of view, Design Thinking can be seen as a type of the production technology of a non-material form of any type of products and services.

CONCLUSIONS

Design Thinking, as a phenomenon, cannot to be treated dismissively, and one cannot look at it from the architectural pedestal. Design Thinking becomes a mainstream activity in education, liberal arts and business. A wide field of research of the phenomenon, developing in the world for several years, allows to formulate some proposals that can be useful both in the design practice of each architect and in the expanding field of the research design methodology. In addition, in the teaching of the architectural design, one should use the positive sides of these experiences.

1. Design Thinking creates a chance to promote in the society the awareness that design is not a "hit and miss" game, but the formal process, in which the knowledge about the process has the heuristic power and is necessary to obtain the expected innovative results.
2. Design Thinking builds the awareness that can contribute to a better understanding of the role and professional competence of the architect as a designer to solve various problems, which by their nature, impact on a human and the society.
3. Design Thinking will force the architects to deepen their knowledge about the various aspects of the design process, with particular emphasis on exploring new strategies, methods and design techniques.
4. Design Thinking indicates that the purpose of the design is always a demand for innovation (changes); what is not so obvious for all designers.
5. Design Thinking is a skill of a teamwork, which we all still need to learn and practice (in practice and teaching).

6. Design Thinking indicates the need for the revision of the teaching programmes in the schools of architecture, clearly emphasising the aspects of the design methodology as well as connecting the design teaching with practice.
7. Design Thinking also offer new forms in the architectural education, which should differently use the methods of a teamwork and an interdisciplinary work.
8. Design Thinking creates a new field of professional activity of the architects who should be actively involved in the promotion of Design Thinking through courses, trainings, workshops, lectures promoting design as a universal skill.
9. Design Thinking is also a danger of marginalizing of the profession of architect by creating a new profession of Design Thinker, which can appropriate the field of competence of the architect as a coordinator of multi-person and multi-tasking teams solving design problems in the future.
10. Design Thinking does not seem to be a transient fashion phenomenon. This general trend is to blur the boundaries between the fields of competence of the various particular specialities and using them to solve the design problems, thereby achieving a widely-awaited INNOVATION effect.

A dozen years ago, the potential of Design Thinking was seen by Rem Koolhaas, who, with his usual pragmatism and visionary, created the OMA/AMO - an institution (office) solving the tasks in a global scale, where architecture problems are connected with policy, management, marketing, etc. He stated prophetically: *„Maybe, architecture doesn't have to be stupid after all. Liberated from obligation to construct, it can become a way of thinking about anything – a discipline that present relationships, proportions, connections, effects, the diagram of everything"* (Koolhass 2004).

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3. TECHNOLOGICAL AND MATERIAL INNOVATIONS IN CONTEMPORARY CONSTRUCTION

SUSTAINABLE CONSTRUCTION AND RECYCLING OF WASTE OF BUILDING MATERIALS

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ABSTRACT

In recent years the development of the construction industry has gained tremendous momentum. There are many new facilities built, and many existing ones are modernized and renovated. There is huge amount of waste materials created, that usually cannot be reused and thus they become dangerous for the natural environment. Recycling is a very good solution, thanks to which the building waste materials can go back to use. For example, building rubble can be recycled. Such practices are widely used in increasingly popular sustainable building, or environmentally friendly building. It aims at reconciling the good of the environment with the constantly developing industry. Sustainable construction promotes the use of new building systems, which are aimed at creating the right conditions for the operation of buildings.

The article discusses: the contemporary threats to the natural environment, waste generated in the construction industry, the characteristics of construction waste, waste quantity, waste second life - recycling, recycling as an important element of sustainable construction, concrete as sustainable material, production of recycling aggregates in Europe, the characteristics of recycling aggregates and economic aspects of concrete recycling.

Keywords: sustainable construction, recycling of waste building materials

1. Introduction

In the recent times, the construction industry has been growing amazingly fast in Poland and around the world. More and more new buildings are constructed, all types of repairs and upgrades are carried out on a larger and larger scale. The demolition of existing buildings is more common now than in the past. As a result of these activities, a huge amount of waste is produced, which mostly are not re-used and persist, not only spoiling the landscape around us, but also seriously threatening the environment. The Earth is our home, for which we should care, and for which we take full responsibility. The care for home and the awareness of decisions are fundamental principles, which should guide us when taking any industrial activity. When creating elegant and comfortable in operation buildings, today's engineers are increasingly guided by the ecological aspects and sustainable construction is becoming more and more popular.

2. WASTE IN THE CONSTRUCTION INDUSTRY

2.1. WASTE CHARACTERISTICS

Construction waste materials include (Ajdukiewicz, 2009): various metals, concrete debris, bricks, wood, soil from excavations, plastics, glass, insulating materials and other finishing materials, debris from the road infrastructure. Photo II.1 presents a variety of construction waste materials. In accordance with the regulation (Regulation, 2014), waste in the waste catalogue have been divided depending on the source of origin into 20 groups. Any type of waste has its code. The Polish division was made on the basis of the European classification, which is the pattern of all classifications of the European countries.

II.1. Demolition of the building – the diversity of waste material, photo Mohamed Ahmad, 16.06.2016

The estimated amount of concrete waste produced in the world in one year is approximately 1.2 billion tons. In Europe itself, approximately 200 million tons of waste is produced per year. At the end of 2004, the weight of the construction industry wastes accumulated on the Polish landfills reached a value of 2 million tons. It is expected that in 2018 waste increases to 2.4 million. In turn, according to Japanese forecasts, waste growth in this country will be 170–250 million tonnes per year (till 2035). In accordance with these data, we can note that in Poland, the production of construction waste per capita is much lower than in Japan. This disparity does not necessarily prove less debris produced in our country, but it can show the fact of keeping unreliable records of waste (Zając et al., 2010). Figure 3.2 presents a chart illustrating the percentage share of waste produced by the construction industry (Ajdukiewicz, 2009).

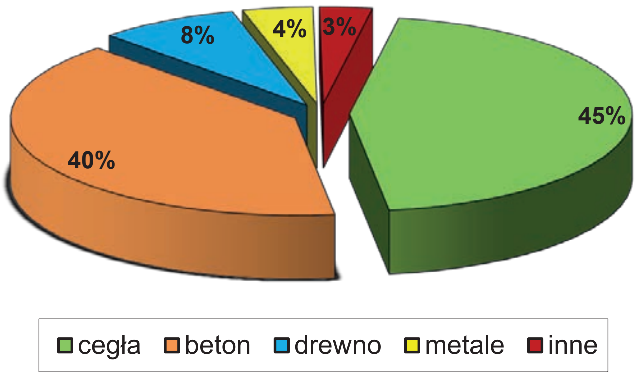

Fig. 1 Share of waste from demolition of buildings [1]

2.2. SECOND LIFE OF WASTE - RECYCLING

In the act (Act, 2012), recycling is presented as recovery in which wastes are reprocessed into products, materials or substances used in the original purpose or for other purposes. The essence of this process is to extract the different ranges of recycling: recycling of materials, raw materials, energy, chemical. The idea guiding by recycling process itself involves caring primarily for the Earth:

- environmental protection - continuous extraction and processing of raw materials for items of the consumption world is inseparable connected with the destruction and excessive burden of the environment,
- conservation of natural resources - re-processing and re-use of secondary raw materials will result in less demand for the extraction of primary raw materials, what makes natural goods rebuild,
- energy savings – secondary raw materials are so much more energy-prone than primary energy, as long as energy generated by them can be extracted from them with less effort than included in them.

There are three basic types of recycling:

- re-application – the use of the material for the same purpose, e.g. retreading of tires,
- re-use - recovery of chemical wastes and re-putting them into production, e.g. using of car wrecks in steel plants,
- other applications - wastes used in a new field after chemical, physical or biological treatment applied.

2.3. RECYCLING AS AN IMPORTANT ELEMENT OF SUSTAINABLE CONSTRUCTION

The main purpose of the sustainable construction is the creation of appropriate areas and manage them on a clean and efficient use of natural resources without missing aspects of quality of life and the environment. The generation of waste is an integral part of the functioning of modern society, especially in urban areas. Excessive accumulation of waste is a large threat to the environment. With this increase of waste, there is a problem with their storage, therefore, we are forced to look for ways that will limit their growth and existing quantity. Currently developing intensive construction additionally contributes to the problem of waste. The sustainable construction development includes such tasks (Wierzbicki et. al., 2002):

- reducing climate changes, mainly by reducing energy consumption,
- responsible and moderate use of natural resources, adapted to current needs,
- correct procedures in relation to public health threats,
- improving communications and storage of wastes, which will allow for greater use of a workspace.

Energy-efficient construction – as the name suggests, should strive for the most economical use of natural resources and energy to burden the environment as least as possible. Poland is still considered as one of the countries where recycling materials are used in very low amount.

2.4. CONCRETE AS A SUSTAINABLE MATERIAL

The sustainable construction is defined as the socio-economic development, which aims to integrate political, economic and social activities, while maintaining the balance of nature and the sustainability of natural processes. The purpose of this procedure is to guarantee today's and future society to satisfy its needs. The above definition, with respect to the construction sector, should be understood as a responsible attitude the purpose of which should involve carrying out of construction projects with the least burden of the environment. The correct application of energy used in the production of construction materials should be justified economically and exploit natural resources (http://www.muratorplus.pl/technika/zrownowazony-rozwoj/materialy-budowlane-w-zgodzie-z-idea-zrownowazonego-rozwoju_69787.html, access date 07.07.2016). Construction materials must meet specific conditions to join the group these sustainable. The factors that have the greatest impact on the assessment and qualifications are:

- durability - the more durable material is, the better.
- composition - the most natural materials are ranked the highest,
- waste generated in the production process, extraction of material as well as during the construction process,
- impact of material on indoor air quality (the least volatile emissions that negatively impact on human health and the environment is also important);
- type of material packaging (material should have no packaging or that is suitable for multiple use),
- maintenance - people responsible for the maintenance and cleaning of a material are not exposed to the harmful effects of cleaning and preserving substances in use,
- availability - regional materials for easy access and fast transport are appreciated more, which is undoubtedly important in terms of a cost of material and time of delivery;

- degree of difficulty of use - the best materials do not require the use of specialized heavy equipment during the assembly, which would generate costs and environmental damage in a form of carbon dioxide emitted by the equipment,
- utilization - reusable or biodegradable materials are the best.

It is concrete that is the material that meets the above criteria. Only the fact that aggregate obtained for the production of concrete is a natural aggregate and not a renewable source can raise some doubts. However, if we replace this raw material with aggregate produced in the recycling process, this negative factor will be eliminated, and concrete will be considered as a fully sustainable material. Concrete has a number of advantages. When producing concrete, it is possible to reduce pollutants emitted to the air. This process enables the exchange some clinker contained in cement into the secondary raw materials and other waste produced in other sectors of the economy. Such raw materials can be e.g. fly ash (power stations) or blast furnace slag (metallurgy). The use of this process allows to remove harmful compounds such as carbon dioxide from the concrete structure throughout the life cycle of the building. This process is called carbonation and occurs on the surface of concrete. The research has shown that concrete being a part of the structure has the ability to be removed from the atmosphere during its existence – 10% carbon dioxide, which was emitted during the cement production needed to produce concrete (http://www.polskicement.com/files/Pages/100/uploaded/15_103.pdf access on 07.07.2016). In accordance with the statistics, approx. 3 million tons of debris were produced in Poland in 2002. The use of the recycled methods can effectively contribute to reduce environmental pollution, but also provides the benefits for the construction companies. In the case of demolition of the old structure with the intention to construct a new one, the utilisation and use of debris foundation created during the demolition can significantly reduce the cost of future investments. Currently, more than 80% of recycled debris is re-used by the construction companies (www.terbet.com.pl access on 07.07.2016).

3. PRODUCTION OF RECYCLING AGGREGATES IN EUROPE

Poland, which is a developing country, cannot boast about highly developed construction waste recycling and their extensive use. The total amount of recycling aggregates produced in Poland is not known. The estimates in this matter are presented by the Polish Federation of Employers of Aggregate Producers, specifying the size of this product at the level of 4.5 million tons. The data show that this is approx. 2.5% of all aggregates currently used in Poland (Kozioł et al., 2008). For comparison, figure 2 shows the volume of the production of recycling aggregate in selected European countries.

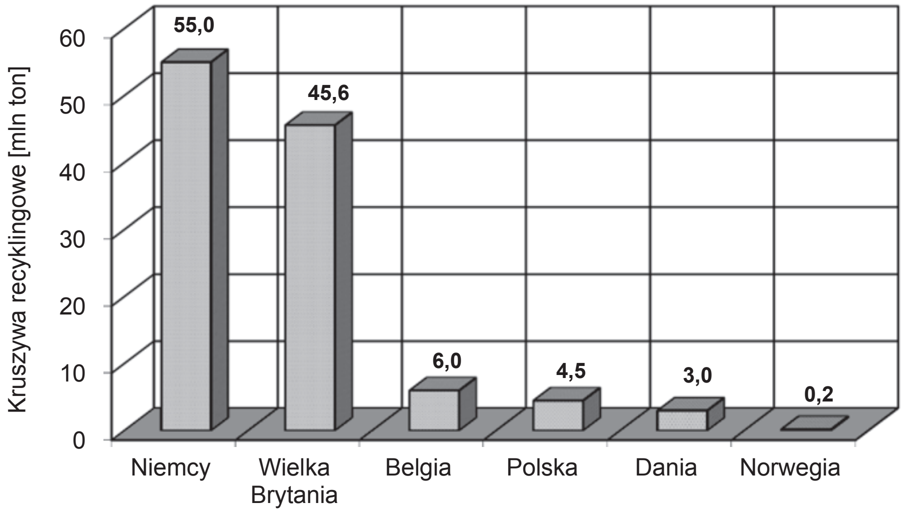

Fig. 2 Production of aggregates in selected countries,
Source: Own development

The countries that achieve high conversion of debris into recycling aggregate are among the developed countries. A large number of residents and high-level industry in a number of areas have made it very important to take activities on the management of waste, including those of construction. Further, vigorous development of the construction industry in these countries forced the obligation to treat construction waste as much as possible, resulting in the conversion of debris to recycling aggregates is increasing. Figure 3 clearly shows the difference between aggregate circulation in the underdeveloped and developed countries (Ajdukiewicz, 2009).

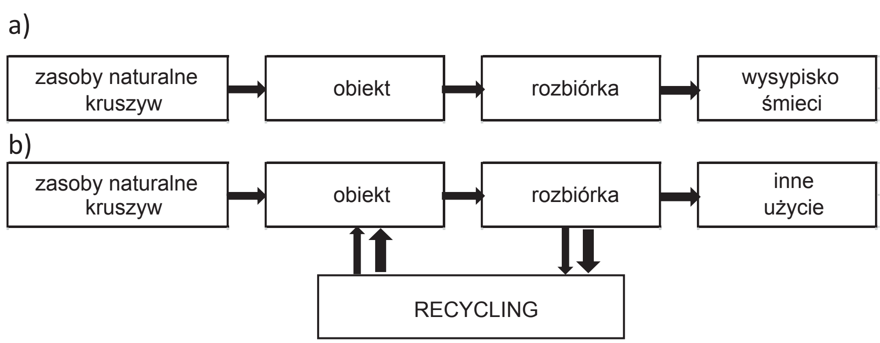

Fig. 3 Circulation of aggregates: a) the model used in the underdeveloped and developing countries b) The model used in the developed countries [1]

The current and future image of concrete recycling is described in the literature (Zając et al., 2010). In accordance with the authors, the recovered debris is used only as a material for foundations of roads. The authors predict a closed circulation of recycling aggregates.

It will allow to completely utilise construction waste, i.e. debris, to construct new buildings.

4. CHARACTERISTICS OF RECYCLING AGGREGATES

The whole construction industry is the raw material base for aggregates coming from recycling. The dependence is that the place of construction of a new building will also involve the demolishing processes, and recycling aggregate will be produced there, as well. The demolition of a building and the aggregate processing require the involvement of special enterprises. In order for the secondary aggregate to achieve the right quality while retaining its main properties from concrete debris, appropriate equipment and technologies for processing debris contaminated with waste are needed. Photo II.2 shows recycling aggregates from concrete and brick. Aggregates that can be used for the production of concrete are granular materials with specific properties. They can be natural, artificial and waste. The selection of the method of waste shredding (e.g. with impact, cylinder or jaw crusher) impacts on achieving the proper granulation of the secondary aggregate and its properties for stability and durability. Recycling aggregate is a heterogeneous material with high dispersion properties. For this reason, it must meet specific requirements that will ensure a sufficient level of structural safety.

Il.2. Recycling aggregate from concrete and brick, photo Mohamed Ahmad. 16.06.2016

These requirements concern the permissible amount of impurities, water absorption and density in dry state. The presence of old mortar, leaven or light impurities can cause a reduction in the density of recycling aggregates to the limits of 2500–2610 kg/m^3, which is lower than in conventional aggregates. Recycling aggregates have worse parameters of frost resistance and sulphate resistance to natural aggregates. Aggregates derived from recycled concrete are not chemically inert, which affects the behaviour of both hardened and fresh concrete in which the aggregate is contained. The secondary aggregates are fully suitable for the production of concrete, but the tests of aggregates and concrete containing aggregates should firstly be carried out (Wolska-Kotańska, 2004). Aggregates from the recovery of ceramic bricks can also be used to produce concrete. However, these aggregates have worse characteristics than natural aggregates and those from recycling concrete. These concrete also have a number of disadvantages, but they can be used to produce components that will not be used to build the structure. They are characterized by low weight and high fire resistance (Zając, 2008). The major disadvantages of recycling aggregates are, first of all, a large variability caused by the variability of waste and the content of a number of pollutants that can be harmful to concrete and humans. The advantages of recycling aggregates are primarily (Wiaderny, 1993): abrasion resistance, cementing properties, good anti-skid properties, non-slip, suitable dynamic load resistance, elution and erosion resistance, veneering resistance.

5. ECONOMIC ASPECTS OF CONCRETE RECYCLING

The research carried out in a number of countries around the world has shown that the viability of waste recycling companies is provided by certain conditions:

- easy disposal of produced aggregates,
- shortage or low availability of natural materials, resulting in high purchase and transportation costs,
- specified regular supplies of large quantities of a demolition material,
- good location of recycling plants, near large agglomerations would be the most beneficial,
- high storage costs of debris,
- good access to plants with larger tonnage.

The examples of locations for major recycling facilities in the countries such as Belgium, the Netherlands and Germany can confirm the above. Concrete from road pavements or runways from airports is the best material suitable for economic recycling, as it is relatively clean. However, the location of the plan allows to save the most, i.e. preferably in a place with natural aggregates shortage. It also requires the availability of large quantities of debris, pavements, road surfaces and demolition material from the structure. The economic analyses carried out in the USA show that a recycling plant is solvent if it processes 110–275 tons of wastes per hour. Annually, the plant should sell approx. 200.000 tons of aggregate. For this reason, its substrate is so important. Recycling aggregates should also have a good price to be competitive with natural aggregates, which is almost half the cost.

6. CONCLUSION

The construction industry with the mining, energy, metallurgical and chemical industries are economic sectors that cause a lot of environmental burden (Jaworski, 1999). Respecting the principles of the sustainable development requires the construction industry to construct buildings that meet certain social, environmental and economic criteria (Aysin, 2009). In Poland, natural aggregates are still used in the production of concrete, and the so-far research on the use of recycled aggregates has been insufficient. The analysis of the laboratory tests of a number of publications on both concrete and brick recycling aggregates confirms the suitability and possibility of obtaining low-strength concretes based on recycling aggregates. Properly managed construction waste management, if it does not completely solve the problem of waste, at least minimizes it and leads to savings in primary raw materials, energy and the protection of the environment.

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CONTROLLED VENTILATION OF DWELLING AND CO_2 CONCENTRATION DEPENDING ON AIR FLOW

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ABSTRACT

The carbon dioxide concentration in the environment where we live and spend long time of the day has a major impact on health and work performance. It is therefore essential factor that has a major impact on our quality of life. The legislative requirements prescribe the required quality of indoor microclimate and in terms of the CO_2 concentration, but the real experimental measurements of CO_2 concentrations with different fresh air flow rates in the passive house showed the deviation of these legislative requirements, according to which it proposes a device for forced ventilation of building.

The present article describes actual CO_2 level measurements made in the houses at different flow rates. Looking ahead it is visible that this topic will be still more important in the future because the population spends over two-thirds of the daily time indoors now and this proportion exhibits an increasing trend. Hence, from the long-term point of view, microclimate considerations should play the one of the primary role in building design.

Keywords: CO_2, microclimate, building, air-flow, experiment, building services

INTRODUCTION

This article is a continuation of an ongoing long-term measurement of CO_2 concentrations in residential areas and its impact on human health and the blood supply of oxygen [5], [1]. The issue of CO_2 concentration in residential areas is a growing trend not only low-energy constructions, as well as reconstruction and mainly by replacing old types of windows for new plastic air-tightness, more and more topical. This is due to continual pressure on the envelope air-tightness of this building´s type and decrease of energy performance of buildings as a whole.

Unfortunately this leads often to deterioration of the internal environment in apartments and houses. In poorly ventilated rooms accumulate harmful substances. One of these is just carbon dioxide. CO_2 concentration belong to among the basic indicators of the quality of the indoor environment. Elevated CO_2 concentration showing in human body signs of fatigue, malaise, headache etc. Healthy indoor environment can ensure an adequate exchange of outdoor fresh air, but however, this often requires in the refurbished buildings installing of the ventilation equipment.

In the Czech Republic is maximum limit CO_2 concentration in the living buildings prescribed by notice no. 268/2009 Col. specifically it's changing no. 20/2012 Col. Under this decree shall not exceed a CO_2 concentration of 1500 ppm. But this is the maximum limit! Note: Previously, the maximum limit set by decree at a concentration of 1000 ppm.

Tab. 1 Effects of CO2 on human body

Concentration	Description
cca 350 ppm	Level of outdoor environment
till 1000 ppm	Recommended level of concentration CO_2 in indoor areas
1200 – 1500 ppm	Recommended maximum level of CO_2 in indoor areas
2000 – 5000 ppm	Possibility of headache, maximum concentration, increased heart rate
> 5000 ppm	Critical concentration, uneasiness and increased heart rate. Start of the serious health problems
> 15 000 ppm	Breathing problems
> 40 000 ppm	Possibility of loss of consciousness

Air flow calculation from limits CO_2 concentration [2]:

$$V = \frac{m}{\rho_{\max} - \rho} = \frac{19 l / h}{(1200 - 350)\, ppm \cdot 10^{-3}} = 22{,}4 m^3 / h / person \tag{1}$$

Where:

- V - required amount of fresh air to maintain a maximum allowable carbon dioxide concentration [l/h/person]
- m - production CO_2 by breathing – 19 l [l/h/person]
- ρ_{max} – maximum concentration in the interior 1200 ppm according to standard EN CR 1752 CEN for category “C” [g/m^3]
- ρ - CO_2 concentration of the incoming outside fresh air - 350 ppm [g/m^3]

Maximum concentration of CO_2 in residential areas is regulated by European standard EN 15251:2011 Indoor environmental input parameters for design and assessment of energy performance of buildings- addressing indoor air quality, thermal environment, lighting and acoustics, which sets in the table B.5 three categories of indoor environment - Flow ventilation rates for residential homes, continuous ventilation.

Tab. 2 Ventilation air flow rates for residential homes, continuous ventilation [3]

Category	Living-room and bedroom, mainly outside air		
-	l/s/person	m^3/h/person (recalc. l/s/person)	l/s/m^2
I	10	36	1.4
II	7	25.2	1.0
III	4	14.4	0.6

In some states the requirements for the CO_2 concentration in residential areas and to provide ventilation regulated by national legislation, which takes precedence over EU legislation.

Tab. 3 Requirements for the CO2 concentration in selected countries, legislation [4]

State	Maximal concentration CO_2 [ppm]	State legislative
Czech Republic	1500	Public notice no. 20/2012 Col. About technical requirements for buildings
Germany	1000	Living room DIN 1946-6:2009 Ventilation and air conditioning - Part 6. n = 0.17 to 0.5 h^{-1}, 20 m^3 per person free ventilation, 30 m^3/h per person forced ventilation
Estonia	1000 – 1500	Minimum ventilation: 1.0 to 0.5 l/s/m^2
Finland	800	National building code, part D2, living room 14.4 m^3/h per person
Great Britain	1000	CIBSE Guidelines, living room 28.8 m^3/h per person
Norway	1000	Guidelines to Compulsory documents, REN §8-34.2 living rooms n = 0,5 h^{-1}
Ashrae Standard 62	1000	Living room n = 0.35 h^{-1}, 27 m^3/h per person

MEASUREMENT DESCRIPTION

Experimental measurements were performed during August 2015 in experimental passive house, at Faculty of Civil Engineering, VSB - Technical University of Ostrava in Ostrava city (about 205 m above sea level). Atmospheric pressure during the measurement was from 98.27 till 98.98 kPa. Experimental house is adjusted standardized house. It is a light wooden structure with diffusion-open envelope cover. Energy performance of the building is 10 kWh/m^2 heat loss is 2 kW and airtight object n_{50} = 0.45 h^{-1}.

Measurements were performed in the upper chamber, the volume of room was 50.2 m^3. Ventilation fresh air was controlled by using software Siemens Desigo and subsequently checked by flow gauges Testo in the tested room diffusers every ten minutes [5]. At measuring of internal CO_2 concentration was carried performed another subsidiary measurement with eight secondary sensors Comet T6450.

The air flow of fresh air was determined on the flows 15, 25, 40, 50 and 60 m^3/h to the room. Outer concentrations are variable according to the type of weather, location (country, city) and the season (summer, winter) in values of about 300 - 500 ppm routinely. During the measurement was in the room only one person! (Zdenek Galda). The outcomes are visible in the tables and graph below.

Figure. 1 Measurement of outer concentration CO2 on outlet (Testo 435-2 and sensor of IAQ)

Tab. 4 CO2 Concentration in tested room with variable flow of fresh air (with central CO2 sensor Siemens)

Outer CO2 [ppm]	330-340	370	355-440	395	370-500	385-430
Fresh air [m3/h]	15	25	50	50	40	60
0:00:00	582.4	652.4	596.0	636.0	802.0	783.8
0:10:00	603.4	694.2	616.6	677.2	823.0	763.2
0:20:00	707.2	715.2	637.4	677.2	823.0	763.2
0:30:00	791.0	735.8	679.2	719.2	823.0	763.2
0:40:00	853.2	776.8	701.0	739.4	844.0	804.4
0:50:00	916.0	839.0	701.0	739.4	864.6	804.4
1:00:00	978.8	881.0	701.0	739.4	885.0	804.4
1:10:00	1041.6	902.6	722.0	739.4	885.0	804.4
1:20:00	1062.4	943.8	742.2	760.2	885.0	825.0
1:30:00	1187.4	1005.8	742.2	760.2	885.0	804.0
1:40:00	1208.4	1005.8	763.0	781.0	926.8	802.1
1:50:00	1250.4	1026.6	784.0	781.0	968.8	804.0
2:00:00	1271.2	1047.6	784.0	781.0	978.2	804.0

Figure. 2 Controlling of flow volume on outlet (Testo 435-2, anemometer and Testovent 417)

Tab. 5 Average CO2 values calculated from the maximum values in tested room with variable flow of fresh air after two hours. Measurement was made by another subsidiary system with the eight sensors of CO2 concentration (Comet T6450)

Outer CO2 [ppm]	330-340	370	355-440	395	370-500	385-430
Sensor / Fresh air [m3/h]	15	25	50	50	40	60
CO2 1	1380.0	1103.0	906.0	870.0	1058.0	860.0
CO2 2	1295.0	1157.0	926.0	782.0	1020.0	838.0
CO2 3	1297.0	1147.0	977.0	882.0	1063.0	879.0
CO2 4	1392.0	1239.0	1012.0	929.0	1126.0	823.0
CO2 5	1225.0	996.0	868.0	820.0	991.0	848.0
CO2 6	1292.0	1139.0	926.0	844.0	1040.0	884.0
CO2 7	1271.0	993.0	908.0	795.0	980.0	819.0
CO2 8	1249.0	1092.0	912.0	834.0	1028.0	911.0
Average Values CO2 [ppm]	**1300.1**	**1108.3**	**929.4**	**844.5**	**1038.3**	**857.8**

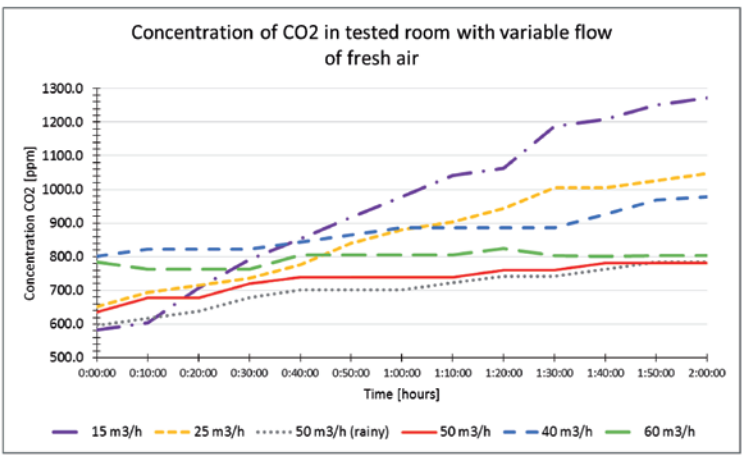

Figure. 3 Concentration of CO2 in tested room with variable flow of fresh air

CONCLUSION

From the measurement results, it is clear that the limit values of the CO_2 concentration was at low flow rates (15 and 25 m^3/h) achieved in a relatively short time, almost from 60 to 90 minutes. Measurements were carried out up to two hours, and it was obvious that the concentration was still increasing, while the flow rates above 40 m^3/h and more on the contrary stabilized at values below 1000, respectively, 800 ppm.

However, the crucial role has the outside air CO_2 concentration, which determines the calculation of the air flow for ventilation of buildings. This concentration of outdoor air is calculated on level 350 ppm and a maximum internal level 1200 ppm but in reality, and especially in winter, when the deteriorated dispersion conditions of outside air in cities and industrial areas often move above 500 ppm.

It is therefore very appropriate that when proper designing of ventilation equipment foreseen not only to overall numbers how show standards and regulations (mostly all similar, but not too much according to measurement the fair values), but in order to take into account the fundamental fact that the CO_2 concentration in outdoor environments is variable and in winter in urban areas is higher than 350 ppm. This would avoid distortion of air flow required for residential areas as it is still so far.

ACKNOWLEDGEMENTS

This post has been handled by Ministry of the Czech Republic of Education, Youth and Sports too, from grant Support at the VSB - Technical University of Ostrava from project "Fond rozvoje vysokych skol – University Development Fund IRP-FRVS 2016.

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WEATHERING STEEL STRUCTURES INFLUENCED BY CHLORIDE DEPOSITION FROM WINTER TREATMENT OF ROADS

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ABSTRACT

Program of experimental atmospheric corrosion tests carried out on weathering steel bridges in the Czech Republic is briefly introduced in this paper. Attention is paid to the evaluation of corrosion processes on load-bearing structures of girder bridges with the roadway above the supports.

The article presents selected results of experimental atmospheric corrosion testing aimed at the measurement of corrosion products thicknesses. It results from the tests that corrosion processes on weathering steels bridges are significantly conditioned by position and location of exposed surface within the structure. The impact of the chloride deposition on corrosion layers is evaluated in the paper as well.

Keywords: weathering steel, steel bridges, corrosion, chlorides

INTRODUCTION

Weathering steel is used for various types of outdoor structures around the world and also in the Czech Republic for more than 60 years [1-4]. In the Czech Republic weathering steel is used for construction like lattice transmission power, bridges, crane runways and also such as a decorative material for roofs, façade and many others. This steel belongs to low-alloy steel with a low amount of alloying components like chrome, phosphor, nickel, copper and others. The amount of alloying component is lower than 2 % wt.

On the surface of weathering steel is created a protection layer of corrosion products which is called "patina". The protective function of the patina depends on the exposure conditions such as temperature, pH and time moistening [5]. An important property of patina is its compactness, which is reduced in the case of high incidence of aggressive atmospheric agents such as sulfur dioxide and chlorides. It has been shown experimentally to create a sufficiently protective layer of patina in the concentrations of sulfur dioxide to 90 μg/m^3 [5]. Primarily a protective function of the patina provides to its compactness. From the beginning of the exposure the speed of development of corrosion products does not differ from carbon structural steels. The protective layer is beginning to create during the first 3-5 years of exposure. In Europe are used weathering steels with commercial brands Corten, Patinax, Coraldur, Intradur, Resista, Indaten. In the Czech Republic in the 1970s weathering steel was produced under the brand name Atmofix. The use of weathering steels will mainly benefit from the economic point of view. By creating a protective layer of corrosion products are experiencing cost savings for any corrosion protection or correction associated with corrosive attacks.

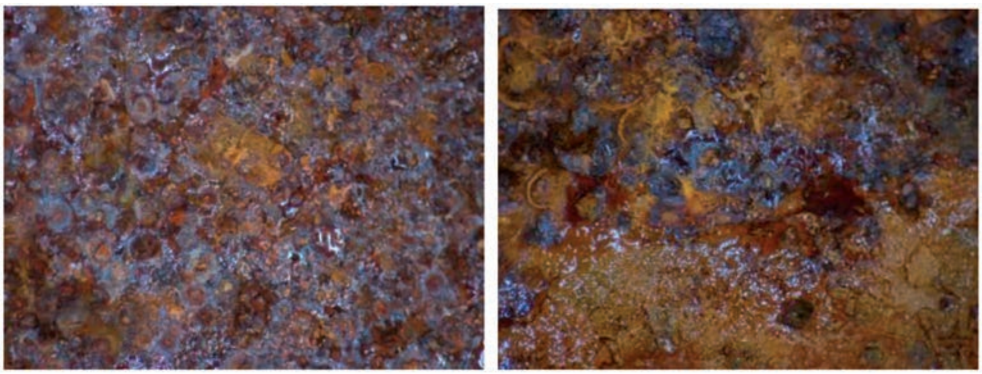

Figure 1: Detail on the surface patina layer samples after 3 years of exposure – 25 x magnified

CORROSIVITY IN ATMOSPHERE

The development of corrosion products on structures exposed to the outside environment is affected by all the parameters of the environment such as temperature, humidity, air pollution (chlorides, sulfur dioxide, NO_x), precipitation and more. The basic factors of atmospheric corrosion include deposition of chlorides, sulfur dioxide and time moistening of the exposed surface. Sulfur dioxide SO_2 together with other elements such as NO_x, NH_3 get to the air mainly from industrial production. The rate of sulfur dioxide pollution has declined substantially in the recent years and now the concentration is in most of the territory as low as 10 μg.m^{-3} [6]. Another significant corrosive stimulator in the atmosphere are chlorides, which do not affect the corrosion aggressiveness only in coastal areas but also outside these areas and as a result of the use of deicing salts in particular. Chlorides have the ability to absorb moisture from the corrosive environment even at low temperatures. Viability of the atmospheric corrosion depends on the humidity. In the atmosphere without high air pollution the corrosive process is activated with humidity around 60 and 80 %. In the atmosphere with the chlorides the humidity around 20 % launches corrosion.

In most cases, mainly local types of corrosion are caused by chloride corrosion attack as pitting and crevice corrosion that are very dangerous for construction. Chlorides get in the air in the Czech Republic mainly from salt spray from road communications in the winter or from industrial production. In the winter season it is all about dissemination of aerosol, which is in the spring time change on the dusty particles. The biggest effect of the corrosion can be expected during foggy weather.

ATMOSPHERIC CORROSION TESTS – DEVELOPMENT OF A PROTECTIVE LAYER OF CORROSION PRODUCTS

VŠB – Technical University of Ostrava investigates development corrosion products on the weathering steel using atmospheric tests applied to selected bridges. Up to 80 % of the use of metal structures is referred to atmospheric corrosion. The program of experimental tests, the development of corrosion products on constructions of the weathering steel was introduced in order to refine the prediction model intended for calculation of design values for corrosive metals [7]. Other results may refer to:

a) comparison of the development of the corrosion products with regard to the different location of the bridge structures;
b) the ability to assess the impact of orientation exposed area of atmospheric exposure;
c) analysis of the corrosion products – composition;
d) pay attention by designing the structure - the determination of the critical surfaces on bridge construction (for example, the possibility of leaking of a leaking system and its influence on the development of the corrosion products) [8].

An important parameter for the development of corrosion products in atmospheric corrosion is primarily a time of moisture. For this reason, it is necessary to situate the patterns on different areas of the main carrier bridge construction. At the end of the year 2016 there have been tested 76 specific areas of the surface on 8 selected bridge structures in total.

The samples must be placed on relevant specific surfaces so that the realistic conditions of exposure to particular surface parts of the structure are best characterized, and there is no way to influence the test results. For the experimental testing were chosen standard samples that are used for atmospheric corrosion tests according to ČSN ISO 8407 - flat panels with dimensions 100 x 150 mm, thickness 1.5 mm. Samples were made from sheet metal quality S355J2WP (Corten A) usually used for cladding structures [9, 10]. The back side of the used sample (page adjacent to the examinee of the surface structure) is masked because of the evaluation of corrosion surface on an exposed surface exposure to atmospheric conditions. Fixation of the corrosive samples is accomplished with the support of elements of stainless steel, see Figure 2, which allows close contact corrosion of the sample and the analysis of the surface. The contact can be regarded as a minimum. There is no effect on the development of corrosion products on the exposed surface. The advantage is also the property connections ensure copy thermal inertia of the tangible object [11].

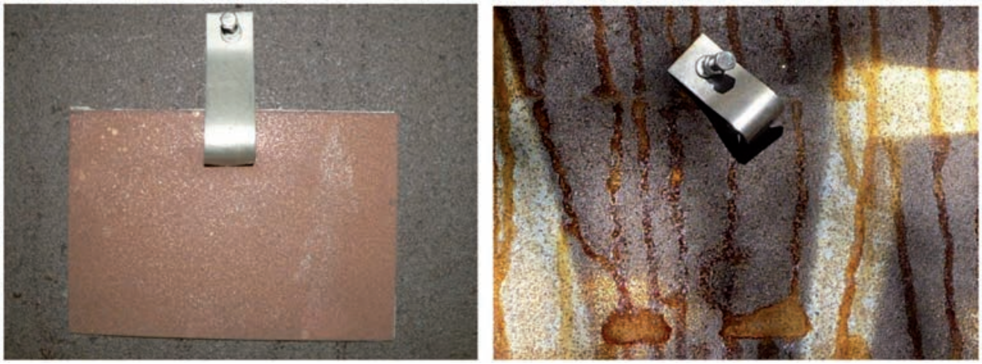

Figure 2: Fixation of corrosion specimen by using a pressing anchoring device made from stainless steel

For this article is selected a detailed interpretation of the applying atmospheric tests and applying a corrosive samples at the bridge in Prague - Motol.

Figure 3: Installation of corrosion specimens on the railway bridge in Prague - Motol

A total of three corrosion samples were exposed on each specific surface structure, of which material and method of mounting is described above. Subscription samples for determining the corrosive decreases according to ČSN ISO 8407 are planned after 1, 3 and 10 years of exposure. Specimens were withdrawn from each surface after one and three years of exposure. At the time of installation corrosion samples were detected by statistical characteristics thickness corrosion products of the examined surface. The thickness of the corrosion products can be measured by using a magnetic-inductive method by PosiTector Smartlink and PosiTector 6000 with probe (F) specified for ferrous metals. A total of 30 measurements of layers of corrosion products were performed for each specimen.

Tab. 1 Construction tested within the program of experimental atmospheric tests

ID	Type of surface	Orientation
P1	The external wall of northern main girder	north
P2	The external wall of southern main girder	south
P3	The external wall of main girder 5 cm above the bottom flange	north
P4	The bottom surface of upper flange of the main girder	north
P5	The upper external surface of bottom flange of the main girder	north
P6	The bottom surface of bottom flange of the main girder	north
P7	The internal wall of northern main girder	north
P8	The upper internal surface of bottom flange of the main girder	north

RAILWAY BRIDGE PRAGUE-MOTOL

The selected structure with corrosive samples for this article is a railway bridge over the Jeremiášova street in Prague-Motol. The supporting construction is created by four main I-sections girders and these girders are coupled with a concrete board deck. The bridge was built in 1981 with the subsequent installation of bridge body in 1983. The steel structure of the bridge is designed of low-alloy steel with Atmofix B. In contrast to the steel Atmofix A is mainly in the mass ratio of the quantity of alloying additives. In addition, Atmofix B contains about 0.04% wt. Nb and contains less Cr 0.4 – 0.8% wt.

The main structure of the bridge consists of four steel beams and cross section that are coupled together with a reinforced concrete slab bridge deck, see Figure 4. The bridge consists of three fields. The beams in each field are designed as simply supported with length 20 m (the distance between supports of bridge). Above the supporting points and in thirds margins of individual fields are placed reinforcing cross beams, which are not associated with the bridge deck. These reinforcing cross beams are bolted to the cross-section of the sloped reinforcements of the main beams. Single track is stored on a gravel bed. The weight of the steel structure is about 155 tons. View of the construction of the bridge is shown in Figure 5.

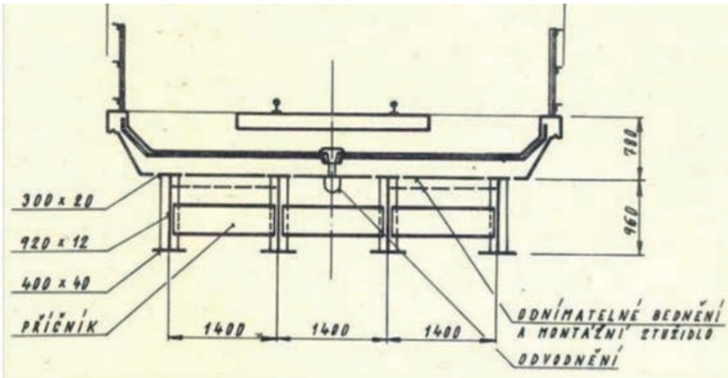

Figure 4: Cross sectional view of the bridge

Figure 5: Side view of the railway bridge in Prague

From each surface after one and three years of direct exposure one sample was removed, which was subsequently analyzed. For each sample, the measurement of corrosion product has been carried out using the magnetic-inductive method. The measured thickness values are listed in table 2. The highest increase in corrosion products is noticeable in the place of the upper outer flange of main beam. This surface may be affected by the resulting clumping of the dusty varnish with aggressive agents and prolonged moisture retention, any wetting rain precipitation – this represents the changing of the moistening and drying out. This area of the main beams structures generally exhibits the highest layer thickness of corrosion products.

Tab. 2: Thickness layer of corrosion products on different surfaces of bridge (after 1 and 3 years of exposure)

ID	Type of surface	thickness of patina (μm)	
		1 year	3 years
P1	The external wall of northern main girder	25,4	39,8
P2	The external wall of southern main girder	30,5	40,8
P3	The external wall of main girder 5 cm above the bottom flange	29,1	35,9
P4	The bottom surface of upper flange of the main girder	39,4	58,1
P5	The upper external surface of bottom flange of the main girder	87,4	117,2
P6	The bottom surface of bottom flange of the main girder	31,0	52,3
P7	The internal wall of northern main girder	23,7	29,9
P8	The upper internal surface of bottom flange of the main girder	54,1	73,9

Figure 6 displays the samples taken from the surface of the P4 after one and three years of exposure. The maximum thickness of the corrosion products was established on positions 5 and 8 – the upper surface of the lower flanges. In a layer of corrosion products is a distinctive white-colored spring. The thickness of the corrosion products on the outer wall of the main girder slightly exceeds the thickness of the inner wall. Corrosion losses were analyzed laboratory on specimen of each selected surface. The results of the corrosion of the weathering steel after decreases of one and three years of exposure are listed in table 3.

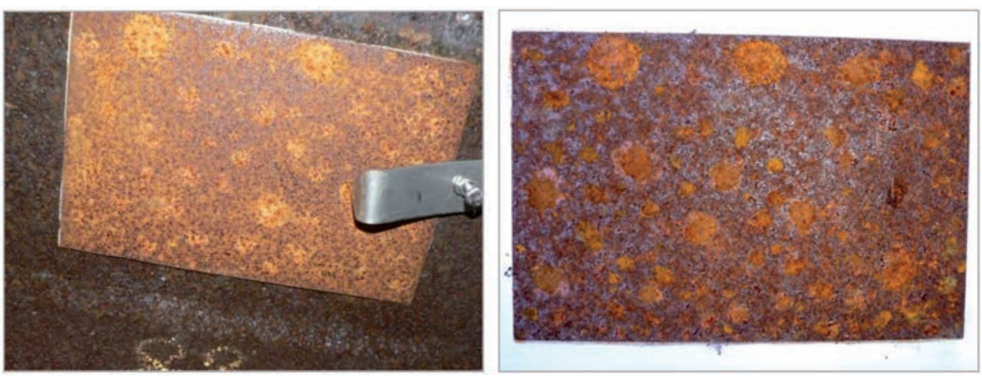

Figure 6: Samples of top flange bottom surfaces P4 after 1 year (left) and 3 years (right)

Tab. 3: Laboratory determined corrosion losses on different surfaces of bridge (after one and three years of exposure)

ID	Type of surface	corrosion losses (μm)	
		1 year	3 years
P1	The external wall of northern main girder	6,01	10,60
P2	The external wall of southern main girder	5,71	14,60
P3	The external wall of main girder 5 cm above the bottom flange	5,67	14,50
P4	The bottom surface of upper flange of the main girder	9,14	17,90
P5	The upper external surface of bottom flange of the main girder	19,11	34,00
P6	The bottom surface of bottom flange of the main girder	6,25	14,70
P7	The internal wall of northern main girder	4,50	12,10
P8	The upper internal surface of bottom flange of the main girder	9,33	21,00

The biggest corrosion losses were detected on the corrosion outside the upper surface of the lower flange of main beam (surface P5). A comparison between the surface P5 to the surface P1 (external wall of the main beam) shows that the annual corrosion loss of the outer flange is approximately 3,2x larger than the corrosion loss of external walls. Corrosion loss of the top surface of the outer flange of main beam (surface P5) is approximately 2x greater in comparison with the same inner flange of the beam (surface P8). Another thing is that the differences between the outside surfaces, oriented to the North (P1) and South (P2) are negligible. Between the measured average thickness of corrosion products formed on corrosion samples after one and three years of exposure and the corrosion were found significant decreases of the apparent correlation dependence between the two measured quantities, see Figure 7. Correlation coefficient between the two variables is $\rho = 0.92$.

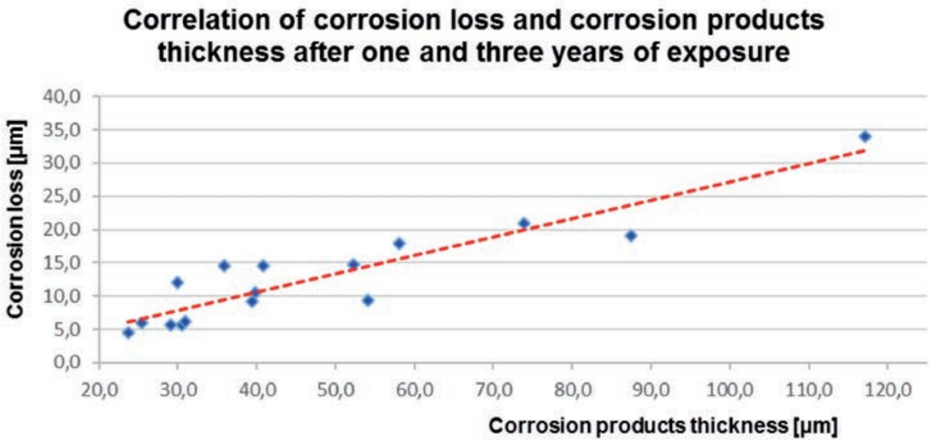

Figure 7: Graphic relationships between the measured corrosion losses and corrosion products thickness

The program of experimental atmospheric corrosion tests weathering steels is designed as a long-term project and the complete results will be evaluated after 10 years of direct exposure. At the end of the year 2016 have been deployed over 100 corrosion samples to specific surfaces of steel structures of weathering steel.

EFFECT OF CHLORIDE ON THE DEVELOPMENT OF CORROSION PRODUCTS

Chlorides are one of the main factors of the aggressiveness of the atmospheric corrosion. In our geographical area these occur mainly from deicing salt. During the winter period it is necessary to ensure the practicability of communications. Sledding is ensured by the use of gritting salt grit, which causes the melting of the ice and snow on road surface or deicing materials that make the surface rougher. In the Europe is used as a spreader material mainly sodium chloride NaCl, then calcium chloride $CaCl_2$, magnesium chloride $MgCl_2$, less often is used urea or various alcohols or liquid AQUA gelo [12]. The costs of urea and alcohols (in comparison with sodium chloride) are very high, for this reason urea is used only in specific cases.

In the Czech Republic sodium chloride is used up to 98% of cases, in other cases it is the use of magnesium chloride. Chlorides are challenging not only for the main supporting structure of the bridge but also for the amenities such as railings and other metal backing construction of the bridge. Environment with the deposition of chloride greater than 2,5 – 3,0 mg/m^2.d, is considered an environment with the influence of salinity on corrosion aggressiveness [6]. Movement of vehicles along the road disseminates aerosol deicing salt called tunnel effect, see Figure 8. The amount of chlorides that can pass reaches up to 1,9 km away from the road in the direction of the wind and up to 170 m [6]. The chlorides have the ability to absorb the moisture, which speeds up the progress of the corrosion process.

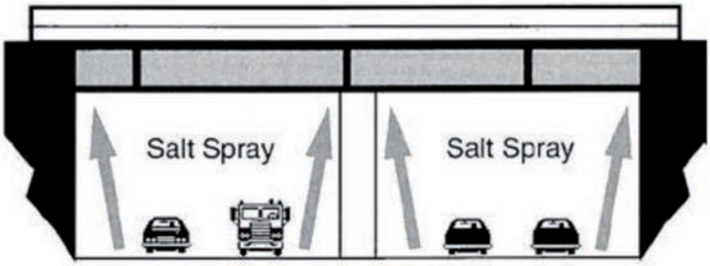

Figure 8.: Tunnel effect: the spread of aerosol from deicing salt in the winter period [6]

ATMOSPHERIC CORROSION TEST FOR THE DETERMINATION OF CHLORIDE DEPOSITION

As previously discussed, the significant effect on the progress of the atmospheric corrosion to aggressiveness of atmospheric substances is caused by chlorides Cl^- and sulfur dioxide SO_2. Currently the influence of the particular action of chloride ions outweighs the SO_2 due to the extensive use of the modern trend of deicing salt in the winter. It can be expected that the considerable influence of chlorides on the course and corrosion arises in the winter period of direct dissemination of electrolysis using the aerosol. This phenomenon is affected by many parameters — the size of the vehicles, their speed, the current state of the windy conditions. In the spring months the chloride deposition continues but with considerably smaller deposition. Chloride ions after winter become part of the dirt particles that form the breadth of the area. Therefore, it is necessary to apply the measurement of chlorides deposition in sufficient extent.

The first attempts of the measurement of chlorides deposition are already carried out in Japan [13]. It was examined a total of 9 bridges of the weathering steel, which were located far from the coast, with the expected effect of salt being spread by aerosol but especially chlorides from deicing salt. It has been shown that a substantial effect on the corrosion process takes two and a half months after the last use of deicing salt. Substantial alteration occurs on the outer surface of the outer beam. Additional measurements were carried out at a distance of 60 km from the coast [14] in order to avoid affecting the spread of aerosol chloride from sea water. In Japan, the use of the extension occurs grit salt since 1990. It was found that many more chlorides are present in the case of toll roads compared to classic roads. It is mainly affected by the traffic density and the subsequent enlargement of the salt. This applied measurement was carried out on the basis of the application of the method of dry plates.

Standard ČSN EN ISO 9225 - Corrosion aggressiveness atmospheres - measurement of factors affecting these corrosion aggressiveness atmospheres sets out two possible methods for measurement of chlorides deposition. The first way is the measurement method by using "wet candle". This method is based on the adherence of chloride on the moistened gauze, the subsequent dissolution of the chlorides and a move into the bottle containing the solution of glycerol and octanoic acid. An important parameter for the correct measurement is a sufficient humidity of the air due to avoid drying out the wick of the candle. Therefore, this method is suitable for the determination of chloride to deposition rate of coastal areas. The second method is currently the already mentioned method of "dry plates". The method represents the stretch gauze around which the air can flow spontaneously. This method works somewhat differently than the previous method, foremost to capture airborne fallout around the dusty roads. Both methods lead to the acquisition of chloride-containing aqueous extracts from which it can be determined the quantity of known chemical analyses.

VŠB – Technical University of Ostrava applied the first experimental measurements of deposition of electrolysis with both methods. The measurement aims to specify the appropriate structural adjustment and appropriate material, which will show the best results and choose the best way to exchange individual measuring methods (replacement of gauze, etc.).

The first test measurements were applied on June 3rd on the two selected bridges in the vicinity of Ostrava over and under the highway D1, see Figure 9 and 10. The testing bridge construction is a concrete bridge. Final measurements of chloride deposition will be carried out and will be applied to the selected bridge construction from the weathering steel. For the measuring method of the "dry plate" was made a temporary structure made of steel, which allows the plate to set the horizontal and vertical position. Both measuring equipment, the "wet candle" and "dry plates", were stored on supports bridge construction in the direction of travel of vehicles because of a possible check of the functionality of the device. This direction especially assumes the spread of chlorides with the passage of vehicles.

Figure 9: Concrete bridge construction across the street Vřesinská (the bridge is located below the D1)

Figure 10: The concrete bridge structure under the street Ostravská (located above the bridge D1)

After a month, the samples were removed or replaced, and the analysis was made of the amount of chloride in surgical gauze by using spectrophotometric method. From the method "wet candle" the first results could not be established, since damage has occurred to the measuring device. Deposition rate of chlorides contained in the surgical gauze of method of the "dry plates" was established in the value of 0,8 mg/m^2 for the month of May and in the value of 0,2 mg/m^2 for the month of June. This deposition rate is somewhat of low values. This may be due to the small amount of captured dusty soils that will bypass the surgical gauze of the reasons large perforation of the substance. For this reason, for the following exchange is deployed a new gauze in the form of industrial wipers with smaller holes' woven fabrics.

Figure 11: "Wet candle" method for the determination of chloride deposition

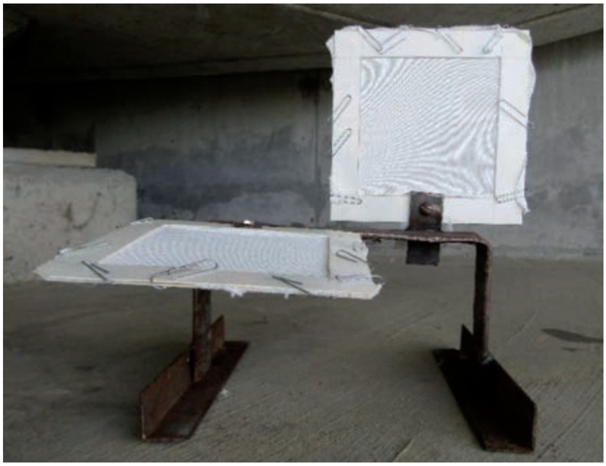

Figure 12: The method of "dry plates" for the determination of chloride deposition (horizontal and vertical position)

The measuring equipment is shown in figures 11 and 12. It is necessary that the gauze "wet candle" was sufficiently damp immediately prior to installation. During the random checks, it was found that the gauze over time dries up at the top, moisture is detained only over the seal. In this case, the "wet candle" method works on the same principle as the method of "dry plates" and the capture of dirt deposits from the air.

CONCLUSION

Up to 80 % of steel structures are damaged due to atmospheric corrosion in particular. The main actors in the air are aggressive sulfur dioxide SO_2 and chlorides. There are analytical relations for determination of corrosion loss of steel. With the advent of a new type of atmospheric corrosion resistant steels, the question arose of refining of the prediction model. This is used to refine atmospheric tests to give in the case of obtaining a sufficient number of rows which determine the dependency between the time of exposure and the thickness of the corrosion products and weight loss. The surface layer and the local corrosion are caused by chloride violations that occur in the corrosive environment. Currently, the trend of the use of deicing salts increases, there is a proliferation of chloride ion by using wet deposition in the winter period and the secondary dust in other periods of the year. To determine the deposition rate there can be used two methods of chlorides "wet candles" and "dry plates". The measuring of the deposition rate is tested on selected bridges. As soon as the instrument is tuned and selects suitable materials for deposition measurements of chlorides, the program will be introduced, under which a securities depository will be measured together with speed decreases weathering steels on selected steel bridge structures in the Czech Republic.

ACKNOWLEDGEMENTS

This paper has been achieved with the financial support of the Ministry of Education, specifically by the Student Research Grant Competition of the Technical University of Ostrava under identification number SP2016/141.

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THERMAL INSULATION OF EXTERNAL WALLS BRICK FROM THE INSIDE - SELECTED ISSUES THERMO MOISTURE

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ABSTRACT

The article discusses selected issues of insulating the inside of the walls of brick in construction and housing. On the basis of modeling and measurements they traced the action of two popular insulation material, ie. expanded polystyrene and slabs of lightweight concrete. The aim of the article is to evaluate the behavior of the brick wall in a climate of local assessment of changes in the moisture of individual layers of the wall flat by measuring the temperature and humidity equilibrium in the designated layers of the wall
Keywords: thermal insulation from the inside, the moisture content, lightweight concrete, expanded polystyrene

INTRODUCTION

The subject of the internal wall insulation has been known for several years. Many years ago, the internal insulation was carried out from the inside with clay and straw mixtures. These materials, in addition to important thermal insulation features, also functioned as the "humidity regulator" of the rooms. The solutions used many years ago, and based on the use of the natural construction materials are also used today more and more often. With the development of the material engineering, the thermal insulation unused so far or used occasionally, has appeared on the construction market. The design of new buildings or modernization with the improvement of the thermal protection of the existing buildings was predominantly associated with the use of thermal insulating materials from the outside. Since the beginning of the 50s of the 20th century, wood wool has been used in individual cases in West European countries. These were the first "contemporary" thermal insulations from the inside. The particular development of the thermal insulation applied internally has been observed since the 1990s. In the article, the authors reviewed the modern insulating materials, as well as the impact of the selected materials solutions on the humidity content of the partition. Based on the modelling and measurement, they have tested the operation of two common insulating materials, i.e. expanded polystyrene and cellular concrete slabs

MATERIAL SOLUTIONS USED IN THE INSULATION FROM THE INSIDE

By using the wall insulation solutions from the inside, one can select from three main concepts of the solutions (Orlik-Koździoń, 2016):

- Insulation from the inside preventing from condensation,
- Insulation from the inside minimizing the occurrence of condensation,
- Insulation from the inside allowing condensation to prove that the condensate produced during the unfavourable period evaporates during the calculation year.

Insulation from the inside, preventing from condensation can be carried out in several variants. The first variant is insulating from the inside with the use of the insulating material with very high diffusion resistance. Black foam glass is the example of this type of material. The thermal conductivity of the plates is $\lambda = 0.04$W/mK, the used thicknesses are from 4 to 18 cm, the diffusion resistance coefficient $\mu = \infty$ (Foamglas Materials. www.foamglas.de), and in practice $\mu = 100000$. Another solution is a partition with thermal insulation and the use of vapour barrier on the inside and a finishing layer in a form of e.g. plasterboard. Another variant is the use of heat insulating composite panels with a layer providing high diffusion resistance. The examples of this type of the solution are Intherm plate, consisting of EPS insulation with the additive of graphite and plasterboards, as well as optionally with vapour barrier, as an intermediate layer. The thermal diffusion coefficient of the plates varies depending on a plate type, i.e λ=0.032 - 0.042 W/mK - , plasterboards: λ=0,25 W/mK, relatively to a thickness of thermal insulation from 4 to 10 cm, coefficient of diffusion resistance of thermal insulation μ=30-70.

The material solutions allowing for condensation are produced from limestone silicate. Silicone crystals form a microporous skeleton, which allows for high capillary properties of the material. If there is moisture underneath the insulation layer, there is generally no risk of wall moulding and insulation degradation. Calcium silicate plates, because of their capillary activity, absorb humidity and disperse it all over its surface, from where it is evaporated. This material does not lose its thermal insulation properties. The thermal conductivity of the plates is $\lambda = 0.06$ W/mK, the used thicknesses are from up to 5 cm, the diffusion resistance coefficient μ=3-6 (Renovario Materials, www.ecovario.pl)

Mineral insulating plates made of very light cellular concrete are another thermal insulating material that allows condensation to occur. The material has the ability to sorpt and rapidly dry - provide humidity to air. This feature means that this material is recommended as thermal insulation from the inside provided that the layers with low diffusion resistance are applied. Heat conduction coefficient in dry state, $\lambda = 0.042$W/mK. These plates are characterized by very low diffusion resistance $\mu = 2$. Low diffusion resistance allows for free penetration of water vapour into the porous structure of the plates. Fixing of the plate to the wall is carried out using a system mortar. The mortar is applied to the whole surface of the plates. Thickness of the adhesive mortar layer should be 8 mm. The surface of the plate is covered with a layer of approximately 5 mm of the system mortar, fibreglass mesh is sucked in the mortar to prevent from cracking. The surface should be finished with mineral thin-layer plaster and appropriate paint.

Airgel is one of the materials with low thermal conductivity. This material is a type of rigid foam of low density, consisting of more than 90% of air. The rest is a gel forming a nano-structure. Heat conduction coefficient in usually l= 0.018W/mK. Insulated with airgel are also produced in a form of technical non-transparent insulation with a thermal conductivity coefficient $\lambda = 0.013$W/mK.

Il.1. The application of aerosol insulation in the place of external wall tinning (EnergieCluster. HLWD Course 2011 Innendämmung mit Aerogel. Training materials 2011).

Aerobic is the thermal insulating material made of a combination of mineral wool with aerogel. The material heat transfer coefficient is $\lambda = 0.019$W/mK, diffusion resistance coefficient $\mu > 3$ (Materials from Deutsche Rockwool Mineralwool. www.Aerowolle.de).

Il.2. Aerial as insulation from the inside (Materials by Deutsche Rockwool Mineralwool.www.Aerowolle.de)

Table 1. Selected insulations from the inside, materials and components (Orlik-Koždan, Steidl, 2013).

No.	Material	Thickness [cm]	λ [W/mK]	μ [ ]
1.	Limestone silicate	1.5-30	0.042-0.07	2-6
2.	Mineral plates	1.5-10	0.042	5-7
3.	Mineral heat-resistant plaster	2-10	0.070-0.090	7-8
4.	Wool wood + clay plaster	4-10	0.045	5
5.	Expanded clay aggregate and clay plates	up to 17 cm	0.200	5-10
6.	Plasterboard + EPS	3.3;4.3	0.25/0.04	40
7.	Plasterboard + XPS			
8.	Foam glass	4-18	0.040	∞
9.	Mineral wool + aerogel	1.6-5	0.019	>3
10.	Bubble foil	3	0.012	50.000
11.	XPS	0.3-0.9	0.030	650
12.	Wood wool	2-10	0.040	3
13.	Cork-clay plates	2-20	0.070	9-11
14.	Cork plates	2-10	0.040	25-30
15.	Hemp fibre plates	3-22	0.040	1
16.	Cellulose	6-8	0.052	2.4
17.	Resonant foam	3-14	0.022	38

The literature of the subject shows examples of insulating from the inside with vacuum insulation (so-called modular warming system from the inside). This insulation is characterized by an extremely low thermal conductivity $\lambda = 0.007$ W/mK, applied thicknesses usually up to 3.5 cm, diffusion resistance coefficient $\mu > 500.000$.

The ecological materials used for the interior insulation are e.g. wood wool and hemp fibre insulation. These are materials with very good thermal insulation properties and low diffusion resistance. In addition, these materials have similar characteristics for mineral plates or climatic plates for capillary activity. A summary of the selected thermal and humidity parameters of the thermal insulating materials used for the inside insulations is presented in Table 1.

TEST BENCH FOR TEMPERATURE AND HUMIDITY MEASUREMENTS IN THE PARTITION INSULATED FROM THE INSIDE

The authors (Orlik-Kożdoń B., Steidl T.) attempted to analyse the humidity content of the internal thermal insulation made of two insulating materials with varying coefficients of diffusion resistance. The purpose of the test is to answer the questions (Krause, Orlik-Koždan et al., 2016):

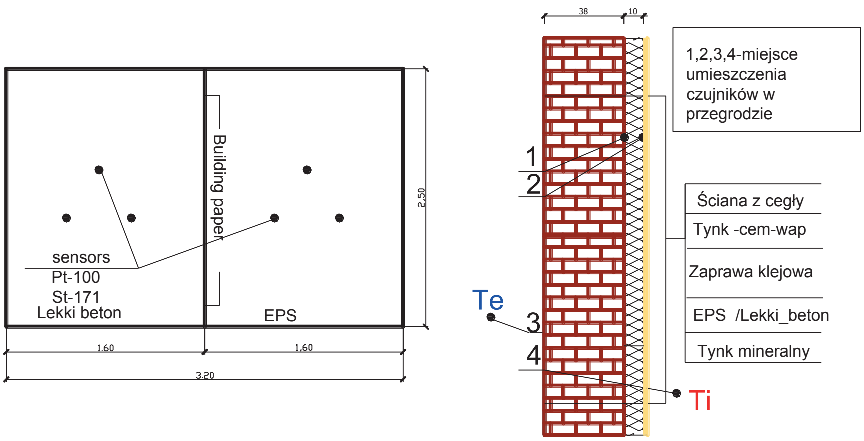
- does the type of the insulating material in the thermal insulation system from the inside of the brick walls impact on humidity of the partition layers, which and to what extent?
- how does the used insulating material impact on humidity flow in the brick wall and react to the varying thermal and humidity conditions of the surrounding environment?

The scope of the test included: in-situ tests, model tests - simulation using the WUFI programme.

The insulated partition, insulated from the inside, is located in a building built in the 1930s in traditional brick technology. The building is located in the Silesia Province, in Poland. The thickness of the external bearing walls is 38.0cm, and the outer covering wall is 25.0cm. All walls are plastered on both sides with cement-lime plaster with a thickness of 1.5cm. Ceilings in the building are made of wood - beams, with a blind roof. The test was carried out in a living room connected to a kitchen with gravity ventilation. The rooms in the building were normally used during the test.

One of the bearing walls on the south side of the building was adopted for the insulation. The wall was insulated from the inside with two material variants: (W_1) expanded polystyrene EPS with a thickness of 10cm and (W_2) light concrete block of 115 kg/m^3 and a thickness of 10cm. The material data were based on the producer's information, i.e. expanded polystyrene EPS: λ_D=0.040 W/mK, diffusion resistance coefficient μ=45; light concrete plate: λ_D=0.042 W/mK, diffusion resistance coefficient μ=4. The insulation was carried out on 9m^2 of the walls divided into two equal parts depending on the variant (the size of the measuring field was limited by the existing internal installation). In the partition layers, the measurement system was used to record data, i.e. relative humidity, equilibrium humidity (ST-171) and temperature distribution in individual partition layers and in the room. The additional measuring equipment installed on the building allows to measure the values characterizing the external environment: relative humidity and external air temperature. The measurement of all sizes was continuous, with a time step of one hour. The multichannel recorder type MA56902M09TG3, was used to measure temperature and humidity, and Pt-100 and ST-171 sensors to measure heat and humidity. Prior to the measurement, the wall humidity was measured using Testo 435-2. The average wall humidity was φ = 2.5%.

Il.3. The humidity of the wall and the heat transfer coefficient for a warmed wall were measured using Multifunction Testo 435-2.



Il.4. Diagram of the test bench with deployed sensors (Orlik-Koźdoń, Steidl, 2016)

THE TEST RESULTS AND ANALYSIS

In-situ tests

Continuous monitoring and measurement of temperature and humidity in the period of 2014-2015 were carried out in the partition. The results are presented for the selected test period i.e. from February to July 2015 (the series of 4000 measurements). The measuring step was 1 h. Several parameters were recorded, including:

- air external temperature (T_e)
- air internal temperature (T_i)
- air humidity on both sides of the partition

(H_e - relative humidity of external air, H_i - air relative humidity),

- humidity between the layers of the insulating material and internal plaster.

A part of the obtained results was shown in the following figures 1 and 2, 3 (Orlik-Kożdoń, Steidl, 2016).

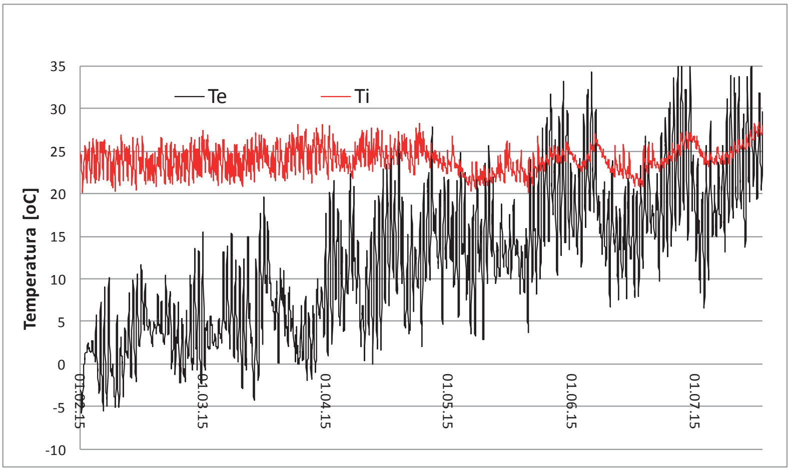


Fig. 1. Changes in time of the temperature in the environments surrounding the partition (Orlik-Kożdoń, Steidl, 2016).

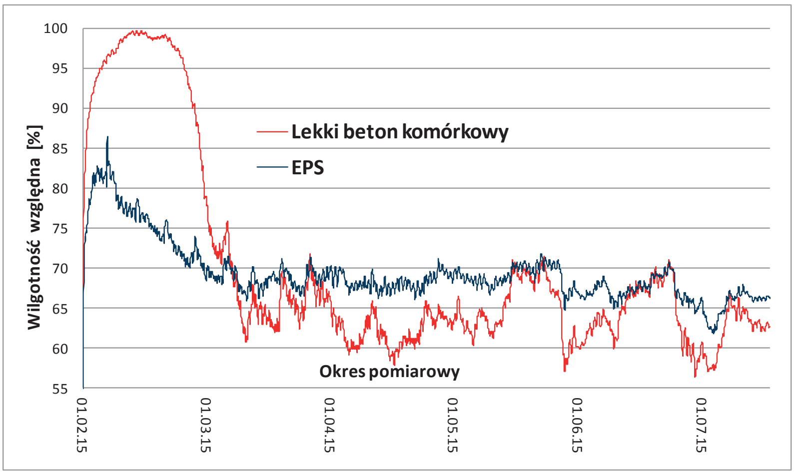
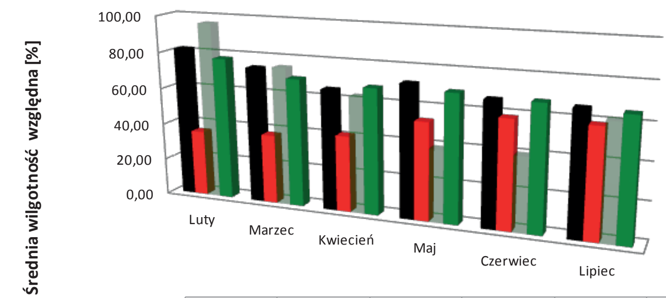


Fig. 2. Changes of moisture on the plane of the contact of the plastered wall and the insulating material (A.-Kożdoń, Steidl, 2016).

Cumulative results for the average values of the measured parts are shown in Fig. 3.



	Luty	Marzec	Kwiecień	Maj	Czerwiec	Lipiec
He	81,81	74,01	65,45	71,91	67,06	66,40
Hi	35,88	37,70	41,32	53,03	58,48	58,75
Lekki_beton_komórkowy	96,33	75,22	62,94	39,17	40,02	61,64
EPS	77,69	69,73	68,20	69,17	67,74	65,53

Fig. 3. Average humidity values in the selected months of the measuring period (A.-Kożdoń, Steidl, 2016). (H_i - relative humidity of internal air, H_e - relative humidity of external air),

On the basis of the analysis of the results, one can notice significant differences in the behaviour of individual materials of the insulating systems in the structure across the partition. In the field of the thermal parameters, both materials similarly isolate the partition, which is proven by the measurement result of the heat transfer coefficient (see thermal conductivity of both materials). In terms of the temperature distribution in the contact plane of the wall and the insulating material, one can observe similar temperature changes during the measurement period. The occurring differences in the range of 0.5-÷1 °C fall within the limits of the measuring error. In both cases, the temperature of the tested contact is much lower than the temperature in the room. Based on the temperature distribution of the chart, one can notice also that the impact of low temperatures of the external environment moves into the deeper plane of the partition in the direction of the internal environment. The partition is under large impact of the external environment, it is not able to accumulate heat and quickly cools down. Due to the low thickness of the partition, one can observe the situations in which the temperature approaches the temperature values of the external environment, at the contact between EPS with the wall and the concrete wall. This is a constant trend in the summer. In the winter months, on the basis of the value of the average temperatures, this phenomenon is not observed; however, it is clear that such temperature impacts of the external environment occur. In addition, the value of the average temperature for February is much higher than that which is given to the nearest weather station for this town (-2.3°C)). Therefore, one can conclude that the analysed winter period was much warmer than in other years. This type of the analysis should be carried out in the longer test term, e.g. 3-5 years, and not only to follow the advice of the standard (1 year). One can clearly state the increased temperature on the internal surface, and thus no risk of condensation of the surface - the surface temperature much higher than the dew point temperature (Orlik-Kożdon, Steidl, 2016)

SIMULATION OF THE BEHAVIOUR OF THE PARTITION INSULATED FROM THE INSIDE

The numerical analysis was used to see the state of the partition material humidity within a specified time period (Künzel et al., 1997, Künzel, 1995). The calculations for both materials (EPS-W_1 and light cellular concrete-W_2) were carried out using WUFI 5.3. PRO. This programme allows to carry out the calculations and presentations of the changes occurring in time, humidity changes in each layer of the external partition. The eternal climate was simulated based on the climate data of the nearest metrological station - Katowice. The internal climate - the calculation options were limited to dry areas with a normal way of life and conditions similar to the common calculation terms i.e. one assumed for the normal conditions the temperature changing in a sinusoidal way from 24°C in the winter and 26°C in the summer, and the relative humidity of air changing from 55% in the winter to 65% in the summer. In all cases, one adopted a dark-coloured top layer of the brick wall (Krause, Orlik-Kożdoń, 2016).

The simulation results are shown as graphs in figures: 4, 5, 6 (Krause, Orlik-Kożdoń, 2016).

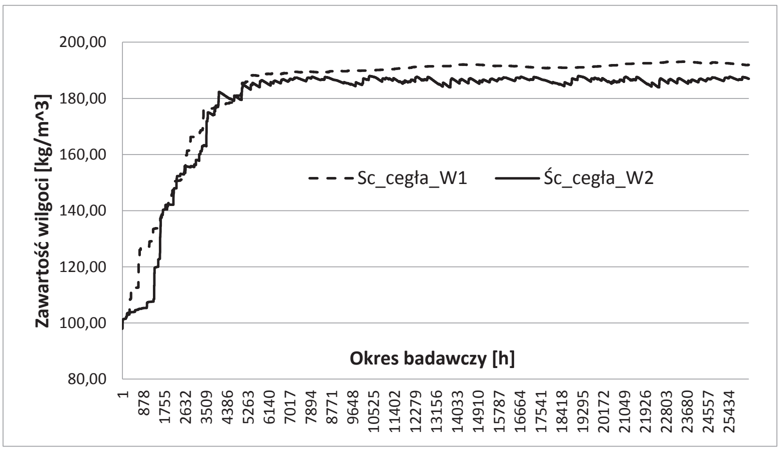


Fig. 4. The humidity content of the brick layer for variant W_1 and W_2 (W_1-expanded polystyrene EPS, W_2 plate made of light concrete)

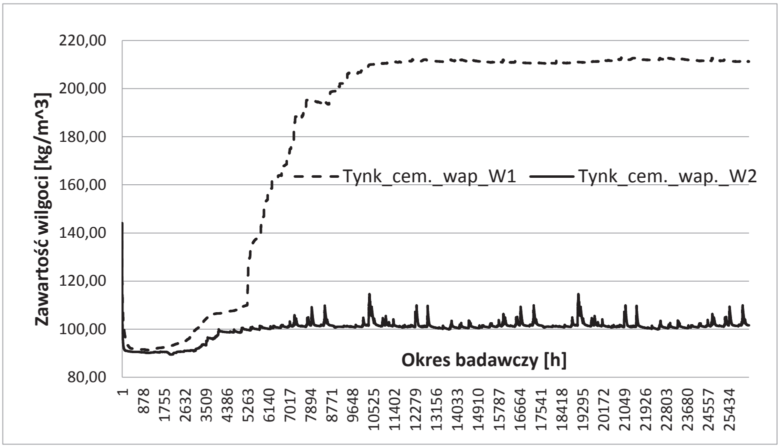


Fig. 5. The humidity content of the plaster (a layer between the brick and the styrofoam/light concrete) (W_1-expanded polystyrene EPS, W_2 plate made of light concrete)

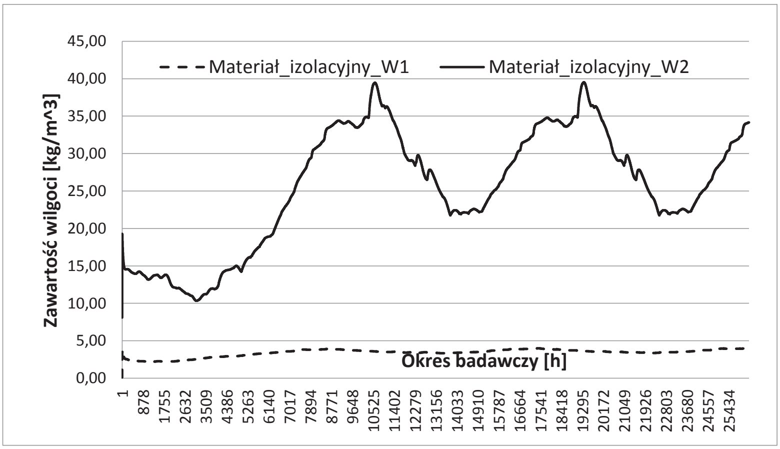


Fig.6. Dampness in a layer of styrofoam W_1 and light concrete W_2 (W_1-expanded polystyrene EPS, W_2 plate made of light concrete)

SUMMARY

The distributions of humidity in planes the partition show its dynamic growth between the insulation layer and the layer of the plastered ceramic wall. Humidity is sometimes higher than the relative humidity of the external environment and in the remaining winter months, i.e. at the level of 80%. In the summer months, in the partition insulated with light concrete cellular, humidity content decreases due to the characteristics of the insulating material, which actively participates in the process of change of humidity of the room. We observe the tend to block the impact of the internal environment on the contact with expanded polystyrene EPS. A high level of humidity on the contact of EPS/wall, equal to the outside air humidity, or sometimes in excess of this value, could be regarded as worrying. This condition can be considered to be alarming and would require a longer observation, even due to fairly high temperature for this period as the external environment. The simulation results confirmed the general trends of the changes of increased humidity over time. The differences which always occur in this type of the tests between the measurements and the values obtained by the simulation result from several factors include:

- the difference between the simulated external climate and the local climate in which the test was carried out,
- the possible differences between the actual parameters of the materials of each layer of the partition, including: heat conduction coefficients, capillary transport coefficients, sorption and desorption properties of the old brick wall, and parameters adopted in the calculation.

In addition, in the test period, the relative humidity in the room was at ~ 35% in the winter season, which can be regarded as beneficial from the point of balance of humidity in the partition (not necessarily because of the comfort to use the room), but less favourable because of the quality and representativeness of the results obtained.

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MOLDS IN RESIDENTIAL HUMAN

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ABSTRACT

Mould fungi are a colloquial phrase of the Sac Fungi, the isolated group of the imperfect fungi together with the class of mucous (Zygomycotina, Ascomycotina, and Deuteromycotina). These fungi are developed on every organic and inorganic substratum in the conditions of strong sogginess. Mould fungi can be developed on materials containing minimum nutrient substances. These fungi live on all kinds of organic substances (mostly cellulose), but also among others glue paints and impurities of the surface caused by organic dusts.

Keywords: sick building syndrome, biotic factors, mold fungi, health hazard

SICK BUILDING SYNDROME

In today's world, a number of people suffer from a disease that theoretically has no specific cause. The sufferers experience a number of symptoms resulting from sensitization to certain conditions of the wrong residential or office environment. This type of malaise, as well as the factors that cause it, is called the SBS (sick building syndrome) (Mikoś, 2000). The occurrence of ailments is mainly related to too little fresh air in a room and its poor quality. The sources of air pollution in a room can be living organisms (e.g. by-products of respiration, sweating, domestic and mould fungus, mites, etc.), building materials and interior fittings (e.g. solvents, wood impregnates, compounds emitted by paints and varnishes, asbestos etc.), the ventilation systems and the air conditioning systems (e.g. microorganisms living in non-disinfected ventilation ducts), external air (e.g. chemical and/or air pollution in large urban areas) or self-use of premises (e.g. tobacco smoking) (Rubin, 2007a). This type of factors as a function of time can also include odourless and colourless –radioactive noble gas, Rn-222 radon (Rubin, 2004). The SBS symptoms are: pain and dizziness, syncope and nausea, fatigue symptoms, mucosal irritation, difficulties in breathing, and other such discomforts (Rubin, 2007a). The problem of a "sick building" and its solution is a very important element in the civilization progress of the modern human world (Collective work, 2001).

BIOTIC FACTORS

The biotic factors, also known as biotic pests of a construction substance, are mainly in the Polish conditions (Rubin, 2013): home and mould fungi, algae and lichens, insects and bacteria, and bryophytes.

Bacteria (Schizomycetae) based on (Zyska 1977; Zyska, 1999) are the smallest living organisms (approx. 1μm). They can develop on organic construction materials such as wood and wood-based materials, etc. - especially in places where strong and permanent humidity is present. Bacteria cause the decomposition of organic compounds with a nature of wet rot, with simultaneous release of odourless substances.

Algae based on (Zyska, 1999) form a large and diversified group of plants that develop in terrestrial and aquatic environments. The basic condition is that these environments are subject to permanent or temporary dampness. Due to the fact that algae are "green" (contain chlorophyll), they have the ability to synthesize organic substances. Algae are able to widen the cracks in the substrate during their growth. Algae produce organic acids that dissolve calcium carbonate.

Fungi based on (Collective work, 2001) are characterized by the absence of chlorophyll, they belong to Thallophyta and, unlike plants, cannot extract carbon dioxide from the air and synthesize organic compounds from it. They eat ready-made organic substances. In the cubature construction, we distinguish the so-called home fungi and mould fungi. Home fungi can cause corrosion due to the ability of acidification of the environment, such as bricks and ceramic hollow blocks, construction mortar and cement concrete. Home fungi take food from decomposed organic matter and use it in a part to build new organic compounds and their cells, and the rest is produce in a form of numerous products of metabolism such as water, carbon dioxide, various organic acids, etc.

Bryophytes based on (Zyska, 1999) are self-sufficient terrestrial plants, forming a transitional group between the chloroplasts and organisms. From the point of view of their threats, bryophytes occur on all kinds of walls and old covers made of so-called cement tiles. Mosses make up turf that holds large amounts of water. In the winter time, this results in the fact that freezing water bursts the substrate on which they live.

Insects based on (Dominik, 1983; Collective work, 2001) is a group of arthropods. In nature, there are over a million species of insects. In the construction, there is the term "technical pests of wood", i.e. insects and their larvae preying on construction wood (so called "dead" wood). Insects cause mechanical devastations. They are caused by cutting of anatomical elements of wood while knocking on sidewalks.

Lichens based on (Zyska, 1999) are the organisms from the kingdom of fungi, which, due to their ability to coexist (so-called symbiosis) with assimilation algae, have gained new life opportunities. Fungi are the dominant organism in lichens. Some species of lichen are found on rocks, as well as on ceramic bricks and on concrete elements. Lichens contribute to the degradation of the outer surfaces of both contemporary and historic buildings.

THE KINGDOM OF FUNGUS - PROTISTA

Fungi occurring in nature are a widespread group of organisms that form a separate kingdom (Protista) (Jawetz, 1974). The organisms classified in this kingdom are characterized by simple construction. The kingdom of Protista is divided into (idem):

I. Higher Protista. The cellular structure is similar to the structure of plant and animal cells, called Eukaryota (inter alia algae and fungi).
II. Lower Protista. It has a simple type of the cell structure, so-called prokaryotic.

Fungi are filamentous, non-photosynthetic microorganisms growing in a form of tangled and branched hybrids, forming so-called mycelium. The eukaryotic type of the cellular construction creates the need to meet the energy and coal needs of "other" organic compounds derived from dead or living matter.

In addition to the mentioned nutrients, another necessary factor for the development of fungi is the appropriate environmental conditions of their life (Collective work, 2001). To take nutrients, fungi generally require the presence of an aquatic environment and therefore their occurrence is limited to damp environments such as host tissues (parasites or symbionts) or moist substrates, soils and walls (saprophytes). Drying of the environment causes the death of fungi as a function of time. Fungi also tend to occupy acidic environments, which can in turn further acidify. The optimal pH of fungi growth is 4÷6. In addition, temperature significantly impact on the development of fungi. They develop at different temperatures. And so: mesophiles– grow within the temp. limits 5 to 40°C; psychrophiles– grow in temp. below 5°C; thermotolerant or thermophilic– grow at above 50°C.

CONSTRUCTION AND MOULD FUNGI

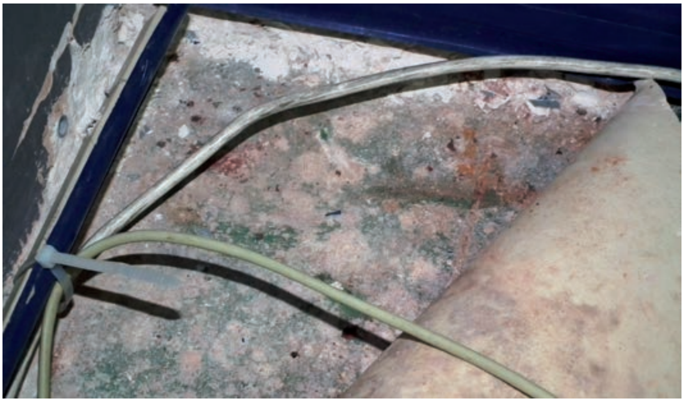
Fungi (Rubin, 2005) - due to morphological, biochemical and physiological characteristics, are dominant organisms in the broadly understood natural environment of human life. These fungi develop basically on all organic and inorganic substrates, under conditions of strong humidity. Unlike home fungi that require large amounts of nutrients, mould fungi can develop on materials with their minimal content. The source of food for these fungi involve all kinds of organic materials.

The occurrence and effective development of moulds on the surfaces and inside the building partitions is determined by a number of factors that can be divided into two main groups (Collective work, 2001; Stawiski, 2002):

I. Design and technical faults and lack of proper humidity insulation and poor ventilation.
II. Improper use of rooms; increased internal air humidity due to over-effective "thermal insulation" and excessive window tightness, which impedes the infiltration of outside air into these rooms.

Practically in every cubature building (idem), as a result of the disturbance of ecological balance by the aforementioned factors, fungi populations develop. Depending on the microclimate and the type of substrate, one or two moulds are dominant, corresponding to the enzymatic properties of the organism.

Mould fungi reproduce on the surfaces of the building partitions (Il.1.÷Il.5), they form coloured (e.g. red, black, etc.) mycelium mould. This colouring is caused by the presence of numerous conidia spores that grow on conidia. Moulds are related to the ground via specialized rag, ingrown small depth, i.e. 0.5÷1.0 mm.



Il. 1. Mould fungi occur under the carpeted floor; the ceiling over a damp cellar the most often (the author).

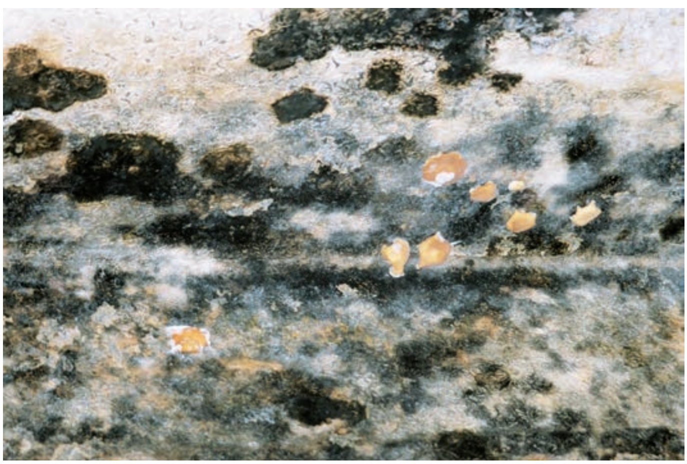
The most common fungi in the architectural objects are, based on J. Ważny (Collective work, 2001) the types and species listed in the following table (tab. 1.).

Table 1. The most common moulds in the architectural objects (idem).

No.	Type	Species
1.	Alternaria (Nees) Wiltshire	alternata, chartarum, humicola
2.	Aspergillus Micheli	niger, flavus, versicolor
3.	Aureobasidium pullulans (de Bary) Arnauld	–
4.	Chaetomium globosum (Kunze) Fr.	–
5.	Cladosporium Link ex Fries	herbarum, fulvum
6.	Fusarium Link	moniliforme, oxysporum
7.	Penicillium Link ex Fries	brevicompactum, cyclopium, commune
8.	Stemphylium Wallnoth	botryosum
9.	Trichoderma Persoon ex Fries	viride, koningii
10.	Turula Persoon	murorum, herbarum

Il. 2. Moulds around an electrical socket and skirting board on the ground floor (the author).

Il. 3. Moulds on a wall of a room under the ceiling - after "flooding" (the author).



Il. 4. Moulds on plaster of s room - after 'flooding" (the author).

Il. 5. Dampness and mould in a corner of a room on the ground floor (the author).

The studies carried out in various European countries show (Żakowska, 2002, Żakowska, 2004) that there are no special species of moulds that occupies building walls or various building materials. For example, on the surfaces of paint coatings, common moulds occurring in nature are developed, including mould of Stachybotrys atra, which are dangerous to human health due to produced mycotoxins. In turn, mould of Penicillium chrysogenum and Cladosporium herbarum type can develop at the temperature from – 10ºC to + 40ºC i in varying humidity, hence they occur on cold and damp walls throughout the year (idem).

In-situ tests carried out, inter alia, by the author of this article, allow to state that the most common causes of the emergence of moulds, e.g. in buildings made of so-called large plate (Steidl, 2015) are:

I. The so-called thermal bridges occurring in the buildings. A thermal bridge is a negative phenomenon occurring in construction consisting in the existence of places in the thermal partition of the building, the thermal conductivity of which is much larger than of the partition. At the bridges and in the vicinity of the bridge, a lower temperature of the internal surface is observed. Its cause involves an incorrect design or faulty execution of details of the building, which leads, inter alia, to mould fungi. Point and linear are the main types of thermal bridges.
II. In the thermal bridges, one can observe the phenomenon of the so-called dew point, i.e. the temperature, at which the gas condensation process can start at a given gas composition and set pressure. In the case of water vapour in the air, it is the temperature at which water vapour in the air becomes saturated, and below that temperature, it becomes supersaturated and condenses.
III. The lack of effective ventilation of living spaces leads to excessive internal air humidity.

RISKS FOR HUMAN HEALTH

The risks for human health posed by mould fungi developing in our residential micro-environment are due to three reasons: they are the basis of inhalation allergens; they produce toxic metabolites - mycotoxins; they emit to the environment a wide spectrum of volatile compounds that are harmful to people staying in it (Żakowska, 2002). The medical literature, inter alia, (Jawetz, 1974; Nicklin, 2000) describes the so-called extrinsic allergic alveolitis. The most common fungal pathogens that cause the EAA involve moulds of Aspergillus, Alternaria, Penicillium, Cladosporium and Trichosporan type (Żakowska, 2004). In addition, large amount of fungi found in the human environment have the capacity to produce the already mentioned mycotoxins, which can be divided into (Jawetz, 1974; Nicklin, 2000): Aflatoxins, Ochratoxins & Trichothecins.

Toxins are produced by moulds at the place of mycelium development and are accumulated in the substrate. Mycotoxins are low molecular weight compounds with different chemical structure and strong toxicity. Approximately known 350 species of fungi produce approx. 400 toxic compounds (Żakowska, 2004). The toxic effect on living organisms is wide, and mycotoxins have dermatotoxic, hepatotoxic, carcinogenic, mutagenic, neurotoxic, neurotoxic, teratogenic properties (Jawetz, 1974; Nicklin, 2000). Users of the rooms covered with fungi are exposed to the permanent effects of toxins that enter their body through inhalation, food, skin in case of the aforementioned diseases. The respiratory tract is the most dangerous for human health, because toxins can act on the so-called macrophages in pulmonary tissues, destroying them. Mycosis of the respiratory system increases. In case of ingestion of mycotoxins at high doses, they cause kidney, liver, stomach and blood disorders, they can also cause reproductive disorders (fetal death, birth defects) and rheumatoid arthritis (idem).

CONCLUSION

The results of the epidemiological tests indicate a strong causal relationship between –the occurrence of mould and the health status of people within their range of influence (Stramski, 1994; Żakowska, 2004). Therefore, it can be said with great probability that mould fungi occupy a significant place in the group of factors negatively impacting on human and animal health (Rubin, 2007b). Therefore, the occurrence of mould infestation of e.g. a residential building, requires to take immediate activities.

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SELECTED PROBLEMS OF FIBER CONCRETE SLABS

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ABSTRACT

Fiber-reinforced concrete (FRC) is material which consist from concrete and contains fibrous substances which increase structural strength and cohesion. Therefore FRC are used in ground-floor slabs to control cracks and increasing of bearing capacity. Different types of fibers can be used but steel fibers are used most often. Because FRC is actually used more and more it is necessary to known its real behaviour. There are standards for classic reinforced concrete. But for FRC do not exist some standards and therefore FRC floors often are designed empirically according to experiences from practice. Structures and using of FRC in general is now very modern and interesting topic of research but quality of FRC slab is strongly dependent on correct execution.

In this paper it will be described several real ground-floor slabs where FRC were used and their frequently failures. Then it will be presented what kind and what range of failure arose. This research deals with causes of this failure and therefore technical survey and laboratory test of concrete properties and amount of fibers were carried out and their results will be presented in this work. Also possible solution of problem will be designed if it exist.

Keywords: FRC testing, failure, amount of fibers, fiber concrete floors

INTRODUCTION

Industrial building with light or heavy traffic need quality floor which can withstand traffic load. Rules apply that the heavier traffic have the greater requirements on the floor. Somewhere is common concrete enough but heavy traffic need floor of very high quality. Industrial concrete floors influence running of production and poor quality or significant failures can cause significant financial loses. Failures of industrial floors are the most often claimed failures in civil engineering. This failures can have different causes but some causes are repeated more often than others. Worldwide many researches are performed

(Cajka et al. 2014, 2016 and Sorelli et al., 2006) because empirically design may not always be correct. In this paper three buildings with industrial floors are described and with their help three most often causes of failures are demonstrated.

STORAGE HALL AND QUALITY OF EXECUTED SLAB

Industrial floor in this building was designed for storage material and also for heavy traffic with forklift. Slab with thickness 200mm and from concrete FRC C25/30 with 20kg/m3 were designed for hall by dimension 30.5x16.5m. Reinforced steel mesh Ø6/100/100mm were designed at the upper surface of floor slab to carry tensile force. Technical survey on this building were provided because after one year of use of this hall a lot of microcracks arose. Crack are illustrated also on the Figure 1.

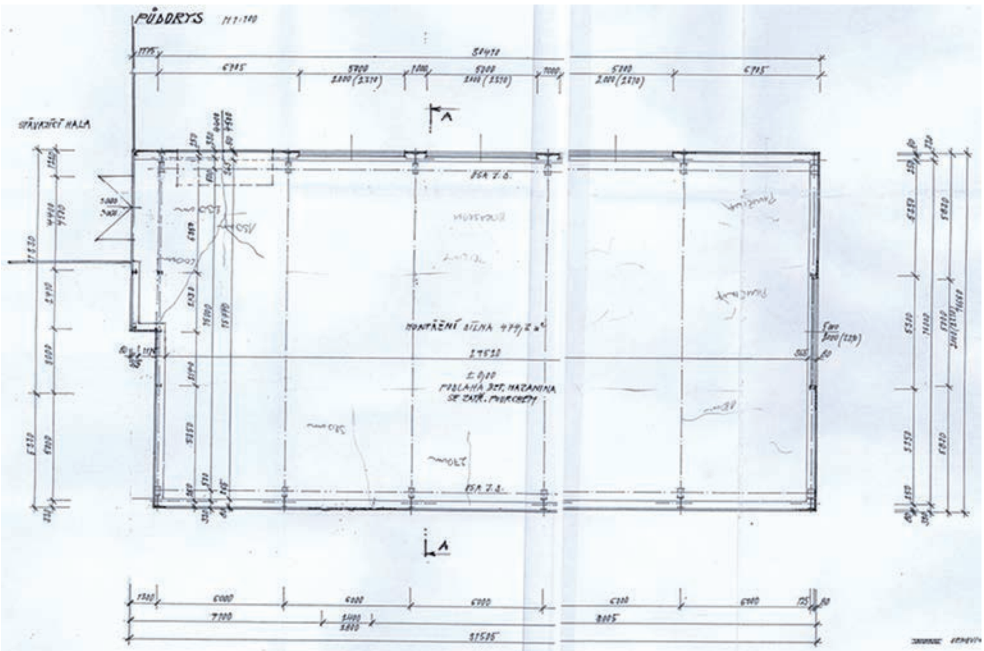


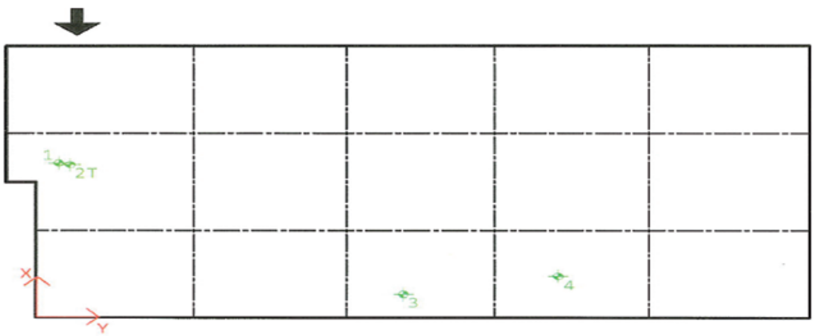
Figure. 1 Basic schema and basic cut of hall

Set of measurement was performed at selected dilatation unit (Fig.1 and Fig.2). Compressive strength was tested at four specimens and it was verified that the strength class of concrete C25/30 was observed. Then amount of fibres were controlled. Result from 3 specimens are shown in Table 1. Average value is 16.3 kg/m^3. On bores was also thickness of floor slab controlled (see Table 1) and it was found that thickness of slab does not match with static design.

Tests of subsoil were also performed and these tests has shown that subsoil do not exhibit volume changes which could be cause failures of floor. Influence of subsoil can be excluded. The most probably causes of cracks are deformation associated with shrinkage and creep of concrete as in the first case. Shrinkage and creep of concrete can be prevented by curing of fresh concrete and other provisions.

Figure. 2 Test specimen from FRC

One of this provision is just using of steel fibres. The above described slab was designed with amount of fibres 20kg/m^3. But identified amount of fibres using magnetic separation in the same way as in first case was between 12.2 and 18.5 kg/m^3 (see Table1) and average value was 16.3 kg/m^3. At the test was also placement of upper reinforcement controlled and it was found that reinforcement is rather at the lower surface. That means that the most probably cause of failures is insufficient reinforcement of slab and wrong placement of reinforcing mesh.



LOKALIZACE JÁDROVÝCH VÝVRTŮ:

VÝVRT	POLOHA	
	X [mm]	Y [mm]
1	9500	900
2T	9400	1350
3	1450	14 450
4	2550	20 500

LEGENDA ZNAČENÍ:

JÁDROVÝ VÝVRT V KONSTRUKCI DNA/PODLAHY

Figure. 3 Scheme of bores placement

Table 1 Amount of fibres and thickness of specimen

Number of specimen	Thickness of bore (mm)	Amount of fibres (kg/m^3)
1A	190	18.3
2A	192	--
3A	182	12.2
4A	160	18.5

PRODUCTION HALL AND AMOUNT OF FIBERS

Industrial floor in this building was designed for storage material and also for heavy traffic with forklift. Technical survey was performed at this building in 2010. Subject of assessment is FRC concrete floor by dimension 90.8 x 42.8 x 0.2 m. The building is clad whit metal sandwich panels in modular axis on 6m. The floor is created in the designed thickness 200mm according to static design. Concrete B30 (C25/30 according to actual standards) with fibers DRAMIX RL 45/50 in amount 20 kg/m^3 was designed. Floor is loaded with traffic, racks and stored material. On the Fig.1 is shown ground plan of hall with indicated cracks and bores. On the Fig. 5 is shown crack near hall entrance.

One reference section with most of failures was chosen where 15 bores were carried out (Fig.4 and Fig.6).

Among other things were carried out following activity:

– removing and preparation of test specimens (15 pcs)
– determination of density
– verification of strength of FRC
– destruction of specimens in a jaw crusher
– magnetic separation of fibers from concrete rubble (to verify of fiber amount)
– photodocumentation

Test specimens were tested at the Laboratory of building materials at the Faculty of Civil Engineering VSB TU Ostrava. Specimen of subsoil were also tested and researched but it is not subject of this paper.

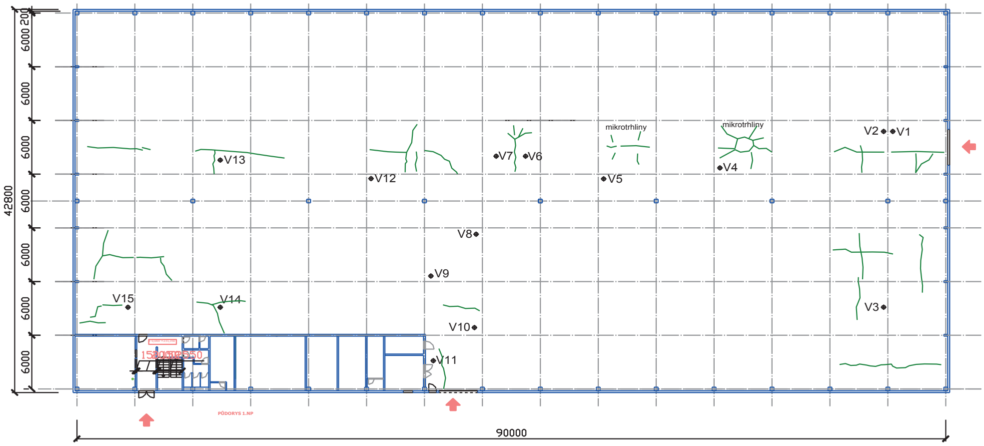


Figure 4 Scheme of hall with marked bores

Figure 5 Cracks near the entrance (V1 and V2)

Set of measurement was performed (Fig.6 and Fig.7). Compressive strength was tested and it was verified that the strength class of concrete C25/30 was observed. Then amount of fibres were controlled. Test samples were crushed after determining of compressive strength. Magnetic separation was used to separation of steel wires from crushed concrete (see Fig. 8). The weight of wires for each test specimen was calculated on dosage per 1m^3 concrete mixture. Results from 15 specimens with values of dosage are shown in Table 2. Average value was 16.84 kg/m^3.

Figure 6 FRC test specimen

Tests of subsoil were also performed and these tests has shown that subsoil do not exhibit volume changes which could be cause failures of floor. Influence of subsoil can be excluded.

The most probably causes of cracks are deformation associated with shrinkage and creep of concrete. Shrinkage and creep of concrete could be very danger and could cause great cracks. Shrinkage and also creep of concrete can be prevented by curing of fresh concrete and other provisions (Buchta et al., 2015; Cajka et al., 2016). One of this provision is just using of steel fibres. The above described slab was designed with amount of fibres 20 kg/m^3. But identified amount of fibres was between 6.39 and 26.77 kg/m^3 (see Table 2) and average value was 16.84 kg/m^3. That means that the most probably cause of failures is insufficient reinforcement of slab.

Figure 7 FRC specimen before test (left) and after test (right)

Figure 8 Determining of amount of fibers

Table 2 Amount of fibres

Number of specimen	Amount of fibres (kg/m3)	Number of specimen	Amount of fibres (kg/m^3)
1	6.39	9	17.01
2	14.43	10	26.05
3	21.34	11	20.43
4	26.77	12	9.48
5	25.97	13	13.09
6	16.92	14	13.54
7	13.72	15	15.92
8	11.58		

LIGHT STORAGE HALL AND SUBSOIL QUALITY

This is a hall which is intended to storage of electronic material and forklift travel. This hall has dimension of 34,5x25m and ground area of floor is about 860m^2. This hall is built as light steel structure based on concrete foundation belts and footings. Basic scheme and basic cut is shown on the Figure 9.

Industrial armour floor is comprised from FRC concrete and designed thickness was 250mm. Cracks have occured on this floor (Figures 10 and 11) and therefore technical survey was executed. Three concrete borehole core were drilled in predefined points see Figure 12 and Figure 13. It was tested quality of concrete, quality of slab and quality of subsoil. Height differences were also monitored. The biggest height difference was about 120mm according to geodetic survey.

Borehole core were modified to testing of compressive strength. Results from this testing are shown in Table 3. Strength class of concrete calculated according to relevant standards is C30/37. Tested sample were crushed after testing in jaw crusher. Then steel fibres were removed from concrete crush using magnetic separation. Amount of fibre in test sample was then convert to amount of fibre in 1m^3 of concrete mixture. Results are shown in Table 4.

It is clear from the test results that compressive strength of concrete used to industrial floor respond to concrete class C30/37 and has average amount of fibres about 14,1kg/m3. It approximately respond to designed values.

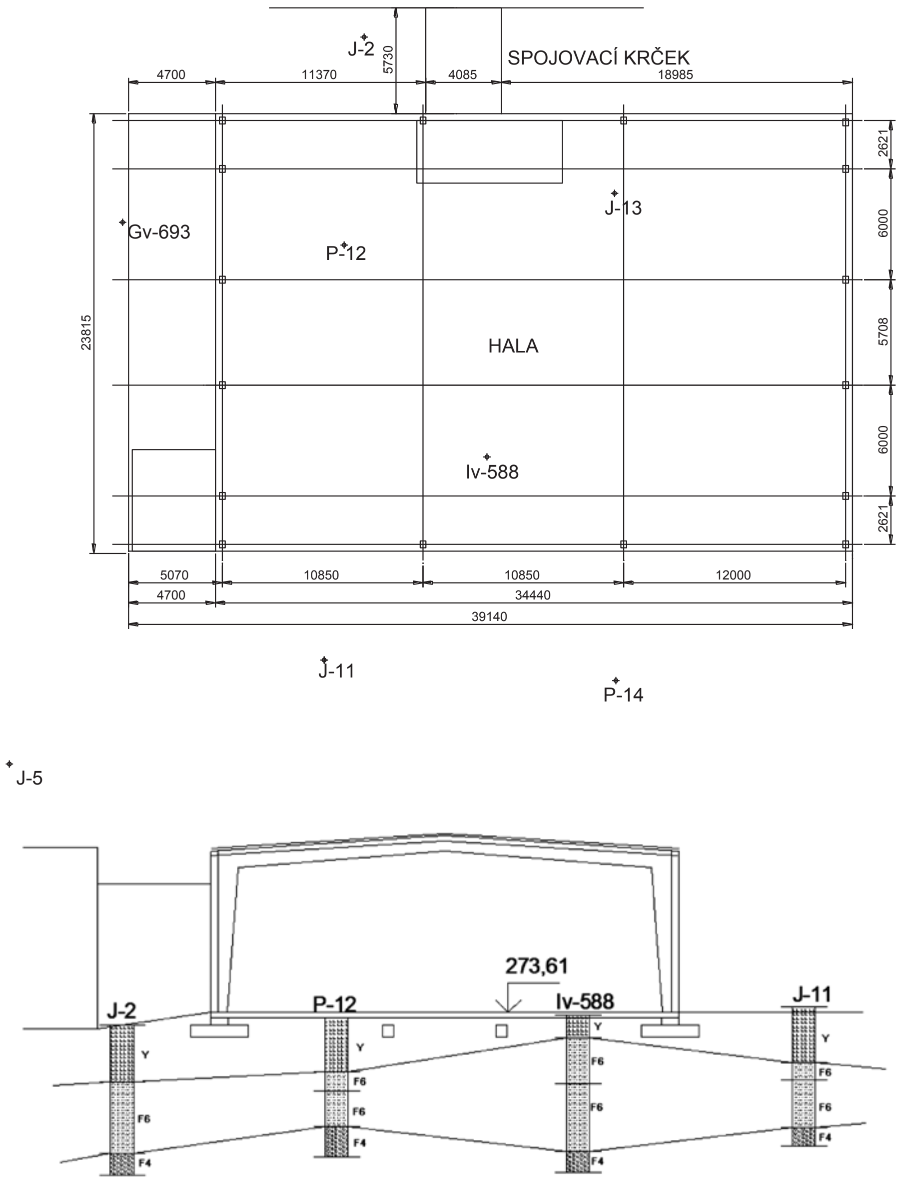


Figure. 9 Basic schema and basic cut of hall

Figure. 10 Cracks on the floor

Figure. 11 Cracks on the floor

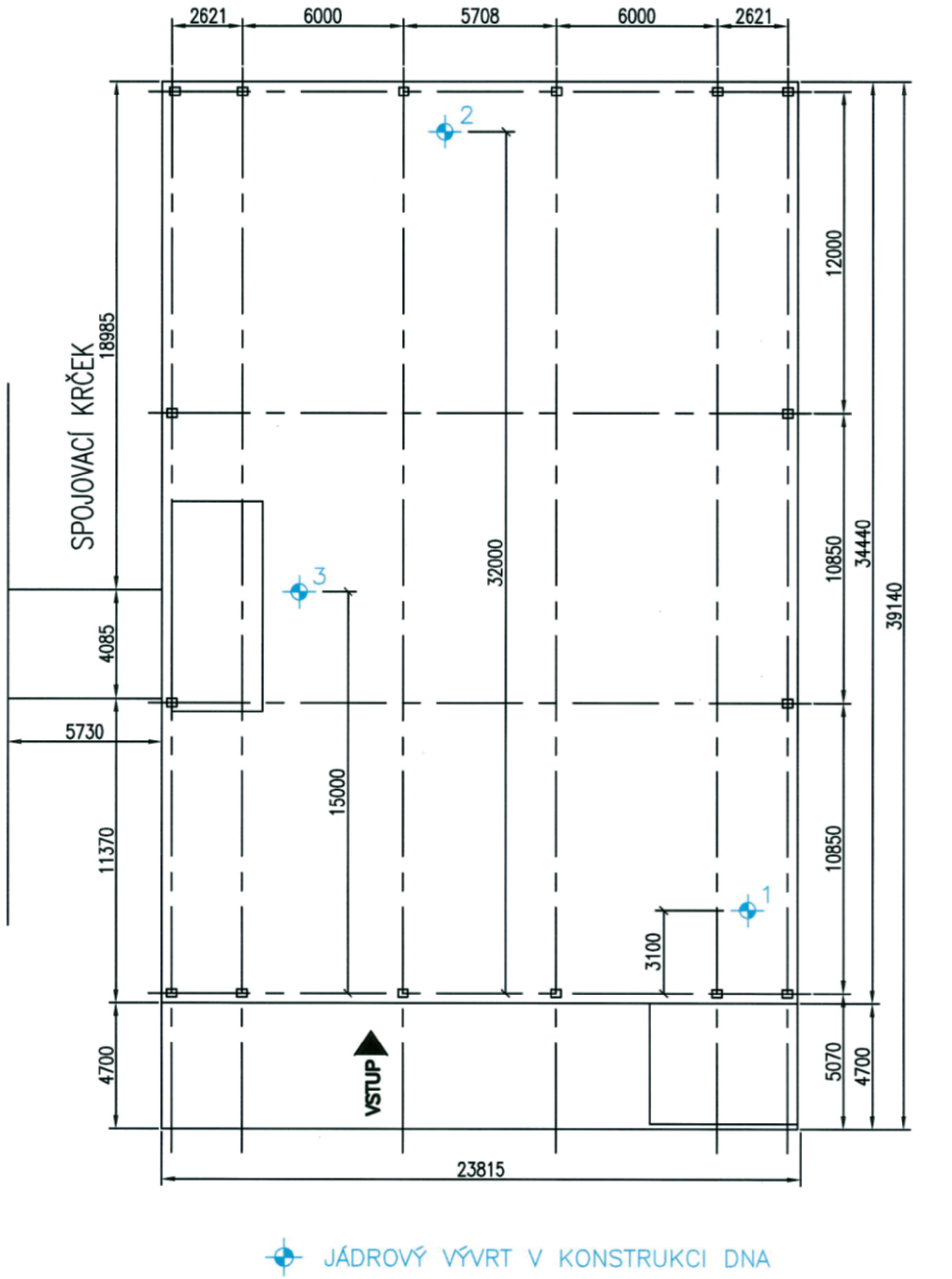


Figure. 12 Predefined points to bore drill

Figure. 13 FRC specimen

Tab.3 Title of Example Table

Borehole number	Diameter [mm]	Hight [mm]	Compressive strength	Corrected cylindric strength [MPa]	Cube strength [MPa]
1	143,2	199,5	32,18	29,93	37,3
2	143,2	210,6	35,93	33,77	42,0
3	143,3	180,9	48,10	43,77	53,9

Tab.4 Title of Example Table

Borehole number	Diameter [mm]	Hight [mm]	Amount of fibre in test sample	Amount of fibre in 1m^3 of concrete
1	143,2	199,5	16,5	5,1
2	143,2	210,6	64,2	19,0
3	143,3	180,9	53,3	18,3

Beside this bores three soil samples were also taken. Soil samples had diameter 150mm and was taken by core drilling without water using. Microscopic and macroscopic analysis were carried out. This analysis indicates composition of subsoil – a mixture of white and grey slag, slag conglomerate, ceramics and a mixture of waste material. The analysis also demonstrate that subsoil contains also minerals which causes volume changes. Unfortunately this changes are started but not completed. That means that volume changes and failures will be continue and it is impossible to predict behaviour of subsoil. Cause of failure at this construction are mainly volume changes in the subsoil. It is advisable to check condition of the pipes (water, sewer). In case of failure or leakages at is necessary to repair as soon as possible to avoid contact of water with the slag. The only one solutions of problems with this floor is to monitore other changes and partially repair. The best but the most complicated solution is demolition of the entire board, replacement the subsoil and concreting a new slab.

CONCLUSION

The most probably causes of cracks often are deformation associated with creep of concrete or volume changes of subsoil. Shrinkage and creep of concrete could be very danger and could cause great cracks. It is clear from performed technical survey that very often cause of cracks is wrong execution construction and failure to comply with the static design (lower amount of fibres, poor placement of reinforcement and inadequate slab thickness). The only one correct solution is demolition and concreting of the whole slab. Partial measures (for example crack injection) will be only temporary. The same rules apply by concrete floor on the subsoil which has problem with volume changes.

Structures and using of FRC in general is now very modern and interesting topic of research. But research of FRC slab carried out on real buildings shows that quality of FRC slab is strongly dependent on their correct execution.

ACKNOWLEDGEMENT

This outcome has been achieved with the financial support of the project GACR No. 16-08937S „State of stress and strain of fibre reinforced composites in interaction with the soil environment”.

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4. STIMULATORS AND BARRIERS TO THE SUSTAINABLE DEVELOPMENT OF URBANIZED AREAS

STIMULATING THE ENERGY EFFICIENCY OF BUILDINGS USING RENEWABLE ENERGY SOURCES AND RISK MANAGEMENT IN THE POLICY OF SUSTAINABLE DEVELOPMENT OF ZIELONA GORA

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ABSTRACT

Cities participation in the global energy consumption permanently increasing and there is no indication that the trend will change in the nearest futures. Population growth, rising demand for construction services and continuously improve the living standard, with the increase of time spending in buildings, ensure upward trend in energy demand. The common goal of all developed societies is the reducing the amount of energy required to ensure the thermal comfort. It is overarching because of the rising energy cost, such as reducing the carbon emissions. Isolation and control of the ventilation in buildings cannot be the sole source of reduction the level of consumption of heat and energy. According to EU requirements, we also need to increase the amount of consumed energy from natural and renewable sources. This article presents a proposal for stimulating the energy efficiency of buildings with using of RES in local politics on the basis of assessment of investment risk.

Keywords: energy efficiency in buildings, sustainable urban development, investment risk, multi-criteria analysis

THE STIMULATION OF THE INVESTMENT ACTIVITIES AND SELECTED TYPES OF RISKS

The implementation of the activities to increase energy efficiency and increase the use of renewable energy (green projects) requires not only the involvement of financial resources but also changes in the social mentality through the transfer of knowledge in the use of the eco-innovative technologies and the development of green attitudes. The promotion of the use of low-emission technologies and the production and distribution of renewable energy sources can be achieved through the implementation of the investment projects aiming at improving energy efficiency, e.g. public utility buildings owned or permanently managed by local governments or by analysing the cost-effectiveness of the renewable energy sources, the implementation of low-emission and energy-saving technology, and also by the production and distribution of renewable energy.

The risk analysis is a systematic approach, taking into account the full possible assessment of risk factors, applied in a transparent, comprehensive manner and taking into account the existing uncertainties or lack of knowledge (Aven, 2015; Jajuga, 2007). If we look at investments related to the use of the RES, we can distinguish the following groups of risks: technical risk, economic risk, social risk and political risk.

Technical risk. The RES have no universal technology. The used technologies are unique and specific depending on whether it is wind, water, solar or biomass. The investments in the RES are not carried out in Poland on a large scale. Therefore, the acquisition of the technology is relatively expensive. In addition, there are problems with connection to the transmission networks, as operators do not have sufficient transmission capacity for new sources. The technical problems also result in unstable power levels, which can adversely impact on the quality of the energy received, resulting in voltage fluctuations. The distribution and transmission networks in Poland are not adjusted to the connection of high power values. The technical risk of using the RES is related to the specific nature of renewable energy, location, existing infrastructure, operation and adaptation to the existing technology.

Economic risk. The economic risk relates to the financing and cost-effectiveness of the projects. The investments in the RES are characterized by a long repayment period and high investment costs. The profitability of the RES projects is very low. The price volatility of electricity is very important. The investors often do not have sufficient resources, which makes it necessary to look for external sources of investment financing - loans, EU funds. Despite the above, the funds are not enough. There is therefore a risk that the investor wishing to develop the RES will not receive capital support in Poland.

Social risk. The governments declare their support for the RES investments and systematically promote the need for renewable energy. However, practice shows that the local communities often protest against this type of the investments, guided by various fears, justified and unreasonable. Actually, they often lead to a hold off of the investment.

Political and legal risk. It is considered as the largest barrier of the investments in renewable energy. The public authorities should develop stable, transparent and effective legal frames to support the companies undertaking renewable energy production. The risk arises when the implemented legal basis is inadequate to the development of the market and the renewable energy sector, and when no legislative action is taken, and the relevant laws are not introduced. An additional problem is that there is no clear outline of future legislation. The political instability and the likely change of policy options in the EU institutions further intensify the uncertainty of directions and forms of support for the investments in the RES.

TESTS METHODOLOGY

In the test, the technical risk was identified in several ways. First, as the age of the object, which is related to the durability of the structure and its individual elements. The construction time impacts on the investment risk. The older the building is, the greater the risk is that the cost of carrying out potential repairs to the tested buildings to obtain full technical and functional efficiency will increase. Secondly, the buildings were classified based on the division involving the constructed in the traditional and industrialized technology or partially-industrialized technology. The industrialized technology reduces the investment risk by standardizing the region and country. The buildings constructed in the traditional technology are characterized by a personalized form, which increases the risk of optimal selection of the activities to increase energy efficiency. The price of energy largely depends on the heat source used to heat the building and prepare hot water. In Zielona Góra, the vast majority of multi-family and service buildings are powered by municipal heat and power, which produces combined heat with low market prices. For single-family buildings, gas is a dominant source of heat supply. The technical risk was considered as the technical requirements to ensure compliance with the EU energy efficiency requirements. All new investments will be unlikely to be taken into account in the course of the implementation of all national and EU regulations. The implementation of the public investments carries a low risk of non-compliance with the applicable regulations, as opposed to single-family buildings, where the risk of non-compliance is relatively high. There are currently few effective methods of controlling the individual investments.

The methodology adopted for the test was intended to assess the risk of achieving the purpose, which is to improve the energy efficiency of the urban development and to assess the potential for higher use of renewable energy generated through the use of new technologies.

The identified economic risk is primarily related to the price of energy. Energy prices are relatively stable. Analysts do not predict price increases. Diversification of supplies and sources can give hope for reducing, or at least steadiness in prices. In addition, the possibility of using the EU funds impacts on the local politics. The EU priority is to improve the energy efficiency of multi-family buildings. This is reflected in the support of this type of the investment from the EU funds. The problem, however, is that the resources compared to the needs are definitely too low. Therefore, the risk of not receiving funds is quite large. As a rule, the EU policy does not support single-family buildings in terms of energy efficiency. Therefore, the risk of not receiving support is very high. The improvement of energy efficiency of public buildings is still supported by the EU policies. However, more emphasis is placed on multi-family buildings. The risk of not receiving funds should be determined as averages. In turn, the support for energy efficiency is one of the EU's top priorities. The entrepreneurs have a number of opportunities to gain the EU support. Therefore, the risk of not receiving the funds is low.

The political and legal risk is connected with the state policy on the investments that promote energy efficiency. It depends on the development of plans and programmes to support the improvement of building efficiency and sustainability. Frequent political changes mean that there is a high risk of destabilization of activities in the areas of support and promotion. The activities related to single-family and production buildings are the least subjected to political changes, where the investors seeking to reduce their operating costs are determined and take measures to improve energy efficiency based on the economic considerations, in fact independent of the state and local government policies. This is not the case with the investments that improve energy efficiency of the public buildings. Co-financing of this type of objects is policy-driven and depends on frequent policy changes causing a high risk.

The risk of the investment in energy efficiency of the buildings and the increase of the RES utilization in the example of Zielona Góra is presented in Table 1, where four groups are presented: technical, economic, social and legal, of the factors impacting on the risk of the investments improving energy efficiency of the buildings in the urban development in Zielona Góra. In this area, one identifies the buildings corresponding to the four groups of the reference buildings, for which the tests of the final energy consumption based on the actual costs were presented in detail (EAM, 2011). The development division is as follows:

– Group 1 - developed area, mostly municipal and cooperatives multi-family buildings of low and medium standard, in the industrial or traditional technology, heat is provided from the urban power plants;
– Group 2 - developed area, mostly single-family buildings, detached and owned, in the traditional technology, where gas and solid fuels are used to generate energy needed to heat and produce hot water;
– Group 3 - developed area, mostly public buildings, provided with combined heat or gas, owned by the municipality of Zielona Góra;
– Group 4 - developed area, mostly with industrial, private and municipal buildings, in the partly-industrialized and traditional technology, provided with gas and solid fuels.

A multicriteria analysis was used to assess the risk in a multi-criterion decision-making process, where the multiple criteria are met, the main purpose of which is to achieve one result on the basis of held information (Heidenman, Hent, 2009). It is worth noting that the investment risk assessment criteria should be representative for the project concerned, sufficiently detailed and should be referred to the relationship between the criteria adopted for the analysis. In order to determine the investment risk to improve energy efficiency of the urban development, the mathematical methods were used as a group of algorithms in the method of the multicriterial comparative analysis. The mathematical methods are based on clear and well-known formulas and are among the most commonly used decision-support methods. In the process of the multicriteria analysis, it is possible to use both measurable and non-measurable qualities that are subject to the quantification process and are ultimately expressed in numerical quantities. In the mathematical methods, it is important to code the measures adopted for the analysis intended to replace the nominal value of the partial measure with the non-numerical value of a specified range (Swabowski, Rain, 2001). At work, the criteria coding was carried out by standardization in accordance with the following formulas:

- when the criterion is a stimulant:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \tag{1}$$

- when the criterion is a destimulant:

$$z_{ij} = (-1)\frac{x_{ij} - \bar{x}_j}{s_j} \tag{2}$$

where: xij-original variant measure i-based on this criterion j-this, zij-coded measure variant, xj-average measures analysed variants based on j-this criterion, sj-standard deviation. The standardized criteria values are summarised in table 2. In the next step, the risk assessment of the investment was carried out by calculating the synthetic indicator (table 2), using the formula:

$$J_i = \sum_{j=1}^{m} z_{ij} \tag{3}$$

After the risk assessment on the basis of the synthetic indicators, it is possible to take activities (reactions) aiming at reducing the impact of the risk on the investment decisions of the scope of energy efficiency and the RES. The risk responses can be as follows (Rudnicki, 2016): risk avoidance, risk control, risk transfer and risk retention. It is worth noting that the main approach of decision makers is an individual concentration on security (risk avoidance) or to use the occasion (risk controlling). In addition, the development of risk transfer instruments should be preceded by an analysis of the characteristics of the risk to which the transfer relates. Such an analysis and manipulation of risk will allow to correctly adjust the instrument for the purpose of which is to serve. The purpose of the design of these instruments is the successful implementation of risk transfer and the same stimulation of increased energy efficiency and the use of energy from the renewable energy sources.

TEST CONCLUSIONS

The presented tests aimed at assessing the risk of the achievement of the purpose, i.e. the improvement of energy efficiency of the urban development, and the increased use of the renewable energy sources on the example of Zielona Góra, as well as to define possible reactions to the risk. The tests were carried out in the following stages:

- indicating of the reference buildings,
- defining energy efficiency improvement measures to be applied in relation to the reference buildings,
- analysis of the final energy demand reduction, based on the calculations of the thermal insulation and energy audits of the reference buildings,
- estimation of the cost of increased energy efficiency of 1kWh/m2rok, in relation to the buildings,
- defining a set of criteria (technical, economic, social and legal) impacting on the risk of the investments to improve energy efficiency,
- risk assessment using the multicriterial analysis method.

The criteria taken into account were assessed in terms of the possibility of the risk, separately for each of the four groups of the buildings. On the basis of the opinion of independent experts and available documentation the following risk assessment were assumed:

- very high – very high probability of the investment risk and its severe effects,
- high - high probability of the investment risk and its severe effects,
- medium - low probability of the investment risk and its effects are less severe,
- low - means the acceptable investment risk.

In order to apply the mathematical methods for the risk assessments of this work in the linguistic form (very high, high, medium and low) were replaced by numeric values, determining the probability of the risk and its possible effects. Then, the criteria coding was carried out in accordance with the formulas (1) and (2), and eventually the synthetic assessment of individual solutions was specified in accordance with (3).

The assumptions to assess the investment risk in depending on the analysed factors for particular groups of the buildings are located in this quarter. The best solution for the actions taken to improve energy efficiency (the lowest investment risk) applies to the buildings category, for which the value of the synthetic assessment is the highest, the highest risk exists for the buildings category, for which the value of the synthetic assessment is the lowest (a selection of this type of the investment is the least beneficial taking into account the criteria in question). As you can see from the data contained in table 4, the most attractive option, with the lowest investment risk to increase energy efficiency is the improvement of efficiency of the buildings as defined in category 2 (single residential), while the highest risk occurs for category 4 of the buildings (industrial buildings).

Table 2. Standardized criteria values for the reference buildings of Zielona Góra

Criterion	selection of the reference buildings			
	multi-family buildings constructed in the pre-fabricated technology	single-family buildings constructed in the traditional technology	buildings of a service function constructed in the traditional technology	buildings on an industrial function constructed in the pre-fabricated technology
construction year	1.22	0.00	0.00	-1.22
construction technology	1.20	0.24	-0.24	-1.20
dominant heat supply source (media)	1.12	-0.84	0.56	-0.84
technical requirements to ensure compliance with the EU energy efficiency requirements	0.71	0.00	0.71	-1.41
differences in energy prices (from fossil sources and from the RES)	1.02	0.70	-0.86	-0.86
possibility of increasing the use of energy from the RES	0.35	-1.47	0.36	0.76
object function	0.87	0.87	-0.87	-0.87
property status	-0.85	1.04	-0.86	0.66
records of the planning documents	-0.39	1.51	-1.16	0.39
Synthetic assessment indicator	5.25	1.70	-2.36	-4.59

The strategy documents and the ones presenting the local policy should include tools to stimulate action and control of investment risks. The point risk assessment allows to organize the risks in accordance with their weighting or criteria. On the basis of such assessment, one can develop the hierarchy of the activities taken in order to reduce investment risk. The methods to respond to the risk are as follows: risk acceptance (monitoring of activities), risk minimizing (necessary preventive activities focused firstly on the consequences of the high level, or the likelihood of occurring of risk), risk avoiding, risk transfer or diversification (eliminated at its source or reduced) (Jajuga, 2007). The risk analysis is a systematic approach, taking into account the full possible assessment of risk factors, applied in a transparent, comprehensive manner and taking into account the existing uncertainties or lack of knowledge (Aven, 2015; Jajuga, 2007).

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ANALYSIS OF URBAN AREAS SOLAR POTENTIAL ON THE EXAMPLE OF BYDGOSZCZ

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ABSTRACT

Climate change is a reality and the priority for countries in the world is CO2 emission reduction. the European Union provides for a reduction in 40% CO2 emissions by same 2030. Poland in 2020 should produce 15% of electricity and heat gained from Renewable Energy Sources. For this reasons it is really important to solve problems of the energy-efficient buildings location, it is necessary to access to complete and current information about land development and harshness of the terrain, the arrangement of natural objects, environmental data and cadastral data. Therefore Geographic Information Systems (GIS) could be a useful tool to identify efficient energy urban areas. So GIS tool is an important element in this kind of process and it could relate: determination of the optimum elevation, analysis of insolation, visibility and overshadow analysis, variants visualization of environmental investment location. The purpose of this article is to show the possibility of using digital elevation model and insolation map. This connection could create some map of the solar energy potential, when it would be possible to plan the location of devices and to use solar energy in buildings in urban areas in Bydgoszcz.

Keywords: renewable energy sources, solar energy, GIS, map of solar energy potntil

INTRODUCTION

The natural energy has been used by a man for a long time; however, the rapid development of civilization and technology caused the decrease in the involvement of energy from the renewable energy sources. The energy-saving and zero-energy construction becomes a new trend, which produces more renewable energy than it consumes within a year. A growing number of the population in the cities of forces the use of a technology that does not cause a destructive impact on the environment (De Boeck, L., et al., 2016; Kopietz-Unger J, 2011). The Polish potential in the use of the renewable energy sources consists of: the balance of solar energy, wind power, water power, geothermal sources (hot water, hot rocks) and biomass energy (biogas, biofuels) (Redweik P., Catita, Brito M, 2013). In the Polish conditions, different technologies based on the RES can be used on the roofs of the buildings (Fig. 1).

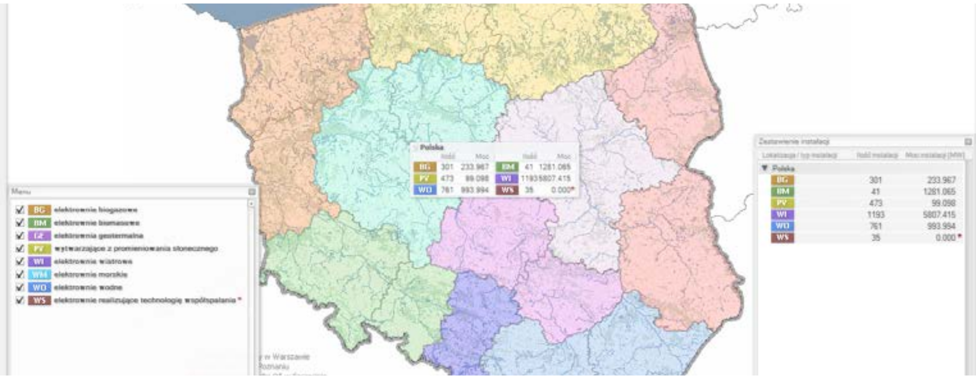

Fig. 1. Renewable energy sources in Poland (http://www.ure.gov.pl/)

Legal conditions are regulated by the Act on the renewable energy sources of 20 February 2015 (the Journal of Laws of 2015, item 478, 2365). Its purpose is to guarantee a sustainable economic development while enhancing the energy security and the environment.

Due to the geographical location, the conditions of sun exposure in Poland are regarded as beneficial. The overwhelming majority of the country is covered with sunlight over 1000 kWh/m2 over a year (Fig. 2).

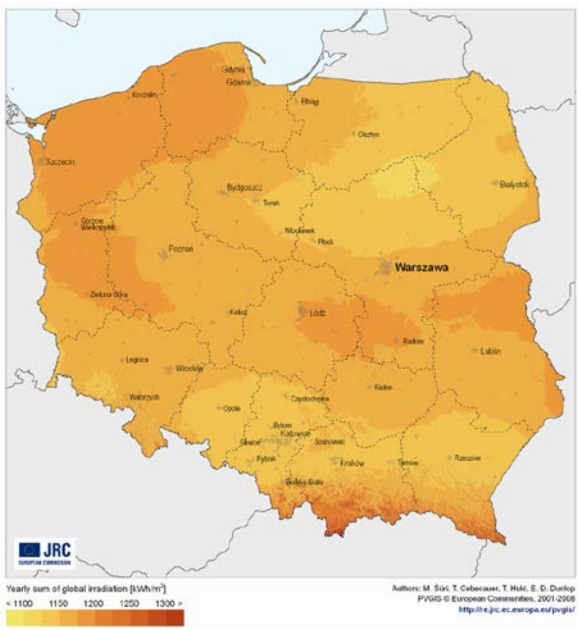

Fig. 2. The sunlight map for Poland (http://re.jrc.ec.europa.eu/pvgis/countries/europe/g13yopt_en.png)

These are primarily the coastal regions - up to 1137 kWh/m^2 and the south regions (1053 kWh/m^2). Central Poland has a sunlight value of 1022 kWh/m^2.

The simplest solar geoportals use the low-resolution climate data. The PVGIS portal is an example of such a geoportal used for Europe and Africa, and since September 2014 also for Asia. The user of this service must not only provide the approximate location of the building he/she is interested in, but also the roof and the type of the photovoltaic cells. As a result, he/she gets approximate information about the amount of energy that can be obtained in the roof area, unfortunately in units that are readable only by professionals (www.re.jrc.ec.europa.eu/pvgis).

APPLICATION OF GIS IN THE DEVELOPMENT OF SOLAR MAPS

The space around us is characterized by great diversity and variability over time. The Geographic Information Systems (GIS) is a tool that can be used to effectively plan space (Longley P.A., et al., 2006; Chow A., Fung A.S., Songnian Li, 2014).

One of a number of possible of the use of the GIS involves the spatial analyses to determine the value of solar potential of areas or objects (Mrówczyńska M., Wawer M., 2015). Currently, the most accurate and detailed data on the terrain and its cover are obtained in a mass way by means of the aerial scanning systems and the high resolution photogrammetric and remote sensing studies.

The Light Detection and Ranging, LiDAR, is one of the optical remote sensing methods for the terrain data acquisition. The aviation laser scanning allows to record a cloud of points with known terrain coordinates (X, Y, Z).

In Poland, the LiDAR data have been developed within the National Information System for the Protection of the Country against extraordinary threats (Wężyk P. ed., 2015). They were developed in accordance with LAS 1.2 standard published in 2008 by the ASPRS (the American Society for Photogrammetry and Remote Sensing).

The dynamic growth of the amount of public geospatial data is based, inter alia, on the provisions of Directive 2007/2/EC of the European Parliament of 14 March 2007 establishing the spacial information infrastructure in the European Community, abbreviated as the INSPIRE Directive. The act of 04.03.2010 on spatial information infrastructure (the Journal of Laws of 2010, No. 76 item 489), abbreviated as IIP Act, is its implementation into Polish law. These documents are the basis for the integration and harmonization of existing and emerging spatial information resources and define the method and extent to share them.

The databases and cartographic products containing the most spatial data useful for the analysis of the solar potential of the areas include:

- the database of topographic objects (BDOT10k) and the database of general geographic objects (BDOO) - available for free, to be downloaded or via the internet spatial data service in a raster form of Web Map Service (WMS) and published on the internet portal (geoportal.gov.pl),
- the orthophotomaps with pixel resolution of 0.1-0.5 m,

- the numerical altitude data: numerical terrain models and numerical terrain covering models. The numerical data models developed in a number of standards or the measurement data in the ASCII or LiDAR files can be obtained in Surveying and Cartographic Documentation Centre for a fee,
- the state records of borders and area of territorial units,
- the registration data for lands, buildings and premises, kept by the District Geodetic and Cartographic Documentation Centres,
- the climate database for Poland, developed by the Institute of Meteorology and Water Management and published by the Ministry of Infrastructure and Construction.

ANALYSIS OF SOLAR POTENTIAL FOR THE FRAGMENT OF BYDGOSZCZ

In the urban areas, due to a limited access to free undeveloped terrains, roofs or façades of the buildings are the only areas for solar photovoltaic systems (Redweik P., Catita C., Brito M., 2013). Therefore, the solar potential maps are developed for roof surfaces the most often. They are often referred to as a solar catastrophe. In cities, however, there are significant differences in the intensity of the development, the buildings have roofs of different designs and shapes.

In the analysis of the solar potential for the fragment of Bydgoszcz, three areas were compared, characterized by a different structure of development and location within the city. These are:

- a fragment of a single-family houses settlement, located on the periphery of the city,
- a fragment of multi-family houses settlement, and
- a fragment of the city centre with historically shaped downtown buildings (compact buildings).

The LiDAR measurement data recorded in the LAS format files corresponding to 1:1250 scale sheets and covering areas of 0.5 x 0.5 km were used for the analysis. Clouds of land coverage points for selected areas were characterized by an average density of 12 pts/m^2 and a mean height error of 0.1 m (Fig. 3).

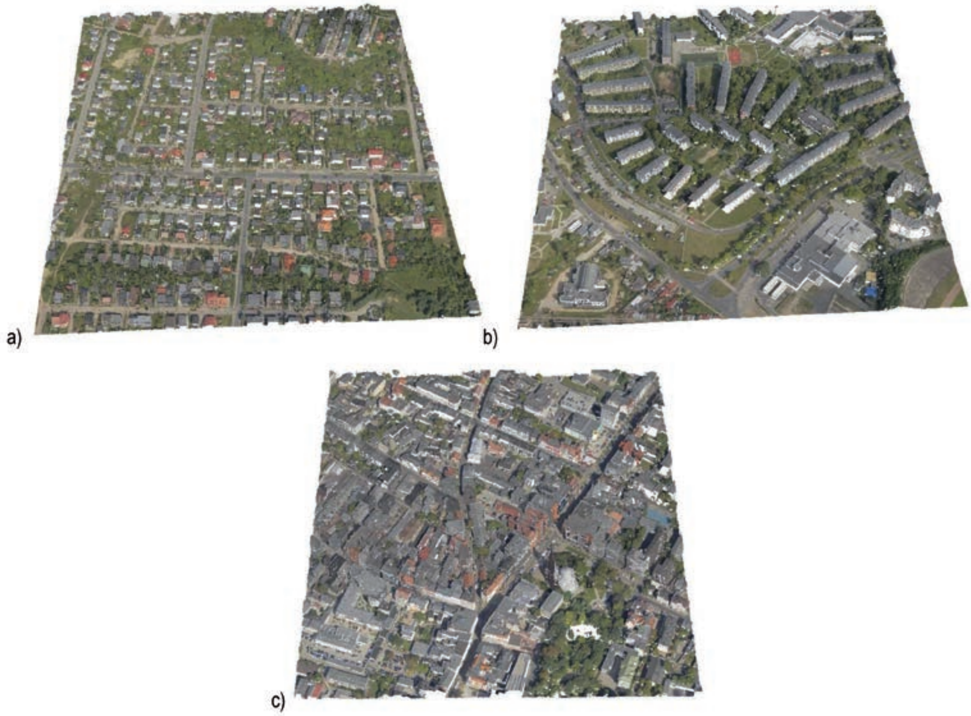

Fig. 3. The LiDAR measurement data presented as a point cloud in real RGB colours for a fragment of a single-family houses settlement (a), multi-family houses settlement (b) and the city centre (c) in Bydgoszcz

The calculations of the solar energy potential were carried out using ESRI's ArcGIS tools, using the methodology described in a number of publications (Mrówczyńska M., Wawer M., 2015, Redweik P., Catita C., Brito M., 2013). Fig. 4 shows the numerical terrain coverage models for the analysed areas, generated from the LAS cloud points.

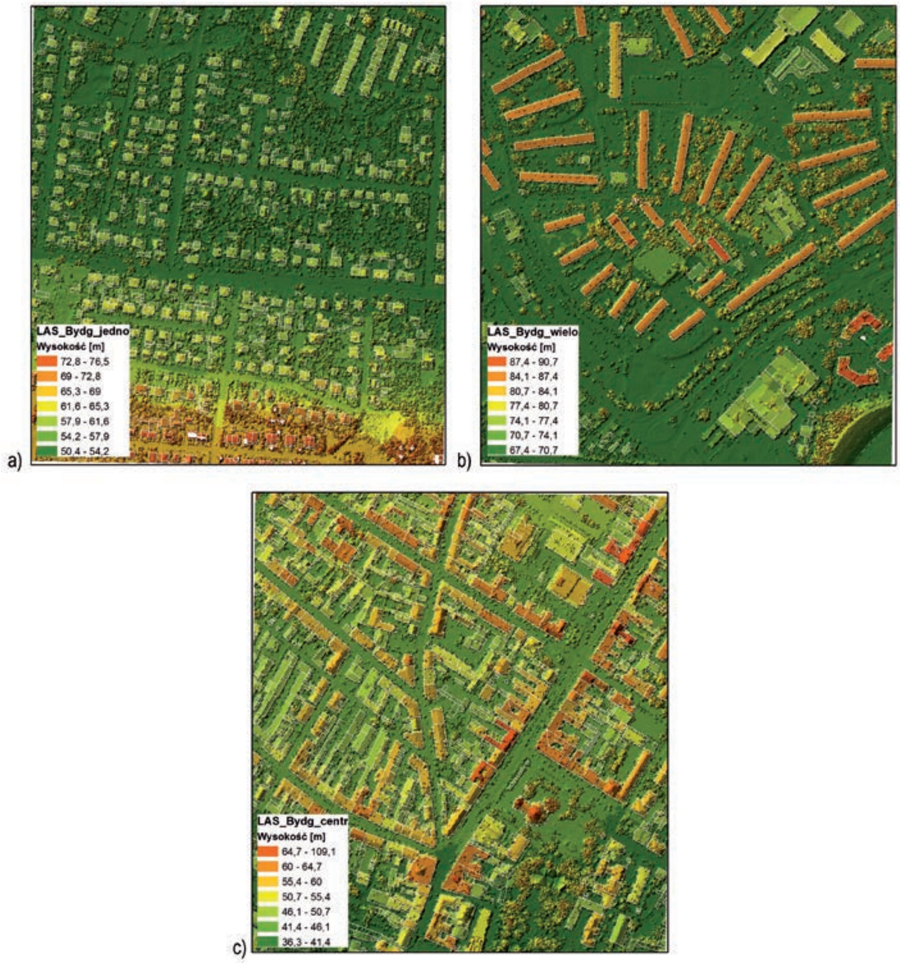

Fig. 4. The numerical model of terrain cover and the buildings contours for a fragment of single-family houses settlement (a), multi-family houses settlement (b) and the city centre (c) in Bydgoszcz

During the sunshine calculations, the geographic latitude of the tested area was taken into account, the uniform values of radiation scattering from all directions of the sky, the average atmospheric diffusion index of 0.3 and the transmittance index of 0.5 were assumed. For each area, year-round calculations with a monthly interval were carried out. The calculation result for each of the tested areas was recorded in a form of four rasters (Fig. 5):

- direct radiation time [h],
- scattered radiation [Wh/m^2],
- direct radiation [Wh/m^2],
- global radiation [Wh/m^2].

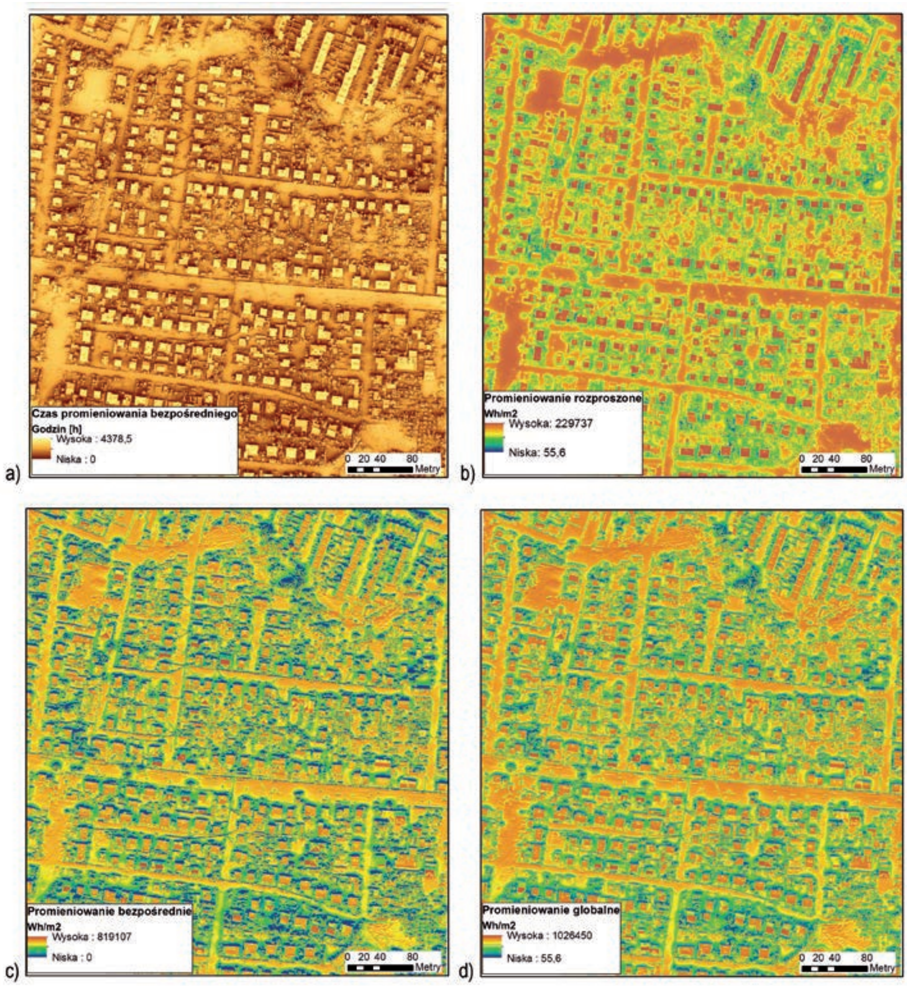

Fig. 5. The result of the solar calculations in the area of single-family houses settlement in Bydgoszcz: a) direct radiation time [h], b) scattered radiation [Wh/m2], c) direct radiation [Wh/m2], d) global radiation [Wh/m2].

The global radiation is taken into account for determining the solar potential, the sum of direct and diffused radiation. The presentation of the solar potential of the developed area is ultimately reduced to the definition of the global radiation on the roofs of buildings. For this reason, the fragment of rays of sunlight on the outlines of the buildings should be separated. The result of such spatial analysis is presented in Figure 6.

Fig. 6. The global radiation values for the roofs of the buildings on fragments of the analysed areas: a) single-family houses settlement, b) multi-family houses settlement, c) city centre.

Due to the fact that the images presented above can be unreadable to the ordinary recipient of the information - the owner of the property, the solar potential of the roofs is most often presented as the average value for the whole roof surface in a form of the average global radiation (Fig. 7).

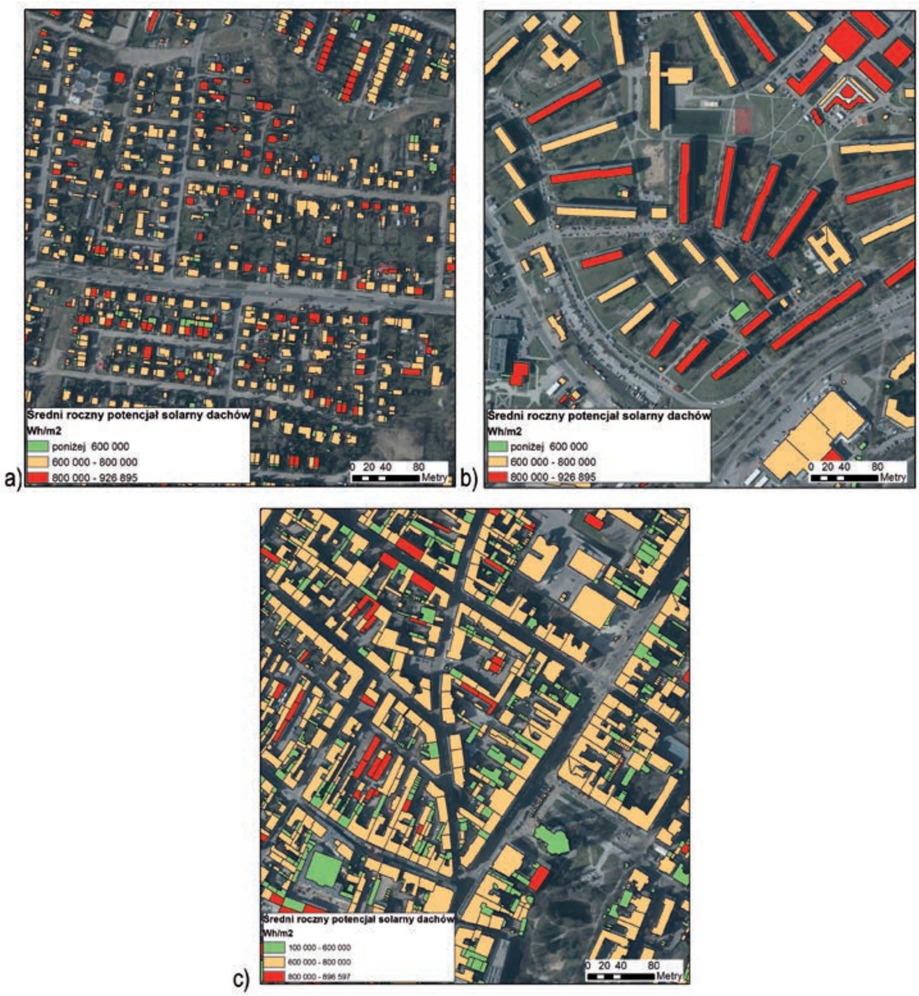

Fig. 7. The solar potential of the roofs of the buildings in Wh/m2 in Bydgoszcz: a) in single-family houses settlement; b) in multi-family houses settlement; c) in the city centre

In the urban areas, there are the areas of varied intensity and nature of the development. By assuming that the solar panels are fixed anywhere parallel to the roof, one can compare the amount of solar energy generated in the districts with varying intensity of the development. The comparative calculations were carried out for three equal areas corresponding to the range of the LiDAR measurement data sheets in 1:1250 scale: the first is a single-family house, the second is in the area of multi-family houses settlement consisting of 4- and 5-stories, and the third in the city centre with compact townhouses. Table 1 summarizes the radiation values of the roof surfaces in these areas.

Table 1. Summary of the results of the calculations of the solar potential for the analysed areas

	Single-family houses	Multi-family houses	Downtown buildings
Total radiation for all roof surfaces [kWh]	32 101 602	34 145 692	81 289 925
Total roof surfaces [m^2]	44 356	43 878	123 014
Average solar radiation [kWh/m^2]	689	725	569

As a result of the analysis, it was determined that the sum of the roof areas for single and multi-family buildings is similar (the difference is no more than 1%), i.e. the building density is similar. The difference between the average annual solar radiation calculated for the roofs of the buildings in these areas is 30 kWh/m^2.

The total amount of radiation falling on all roofs in a multi-family and single-family settlements differs by 6 percent in favour of multi-family houses. It can be stated that considering similar densities of the buildings in both areas, more favourable conditions for obtaining solar energy are present in multi-family houses. This is mainly due to the difference in height of the building and the shape of the roofs. On the other hand, for an area located in the city centre, with predominantly compact townhouses, the total roof area is three times larger than the rest, and the total radiation value for all roof surfaces is approx. 2.3 times higher. The average solar radiation for one roof is considerably lower than in single-family and multi-family houses. The interesting summary results were achieved only with such roofs the potential of which is higher than 800 kWh/m^2 (table 2).

Table 2. Summary of the calculation results on the analysed areas for the roofs with the average solar potential above 800 kWh/m^2

	Single-family houses	Multi-family houses	Downtown buildings
Total radiation for all roof surfaces [kWh]	6 334 269	14 376 943	7 942 064
Total roof surfaces [m^2]	7 732	17 487	9 679
Average solar radiation [kWh/m^2]	824	825	822

If we compare only the roofs with a sufficiently high average solar potential above 800 kWh/m^2 (table 2), this urban development is less favourable for the generation of energy from the photovoltaic cells than multi-family houses. However, it is more advantageous than single-family houses. This is mainly due to the difference in intensity of the development in these areas. The average solar radiation for the roofs with high solar potential is approximately 822 to 825 kWh/m^2 during a year.

CONCLUSION

The tests on the assessment of the solar potential in the annual cycle for selected fragments of Bydgoszcz showed the usefulness of the GIS in such studies. The analysis showed that the acquisition of solar energy in the urban space is very strongly dependent on the nature and intensity of the development. The areas of multi-family houses with high buildings and relatively low density of the buildings are the most advantageous in this respect. High intensity areas have very large roof areas where the photovoltaic cells can be installed, but their average solar potential is lower than in less developed buildings. Noteworthy here is also the shape of the roofs characteristic of the historical buildings in the city centre.

Acknowledgments: This research is supported by the project: "The implementation of the second stage of the Regional Center of Innovation" co-financed by the European Regional Development Fund under the Regional Operational Program Kujawsko-Pomorskie 2007-2013.

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INNOVATIVE UTILITARIANISM AS THE MAIN FEATURE OF THE PRESENT ARCHITECTURE DEVELOPMENT

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ABSTRACT

The sources of energy generating the so called renewable or green energy are very popular today. Their future is connected with the increasing demands and the further improvement along with the constant pressure of the economic factor. Moreover, the strong influence of these new technologies on the environment exists between these two aspects/poles, which are guaranteeing their survival. It refers to the aesthetical values of the surrounding cityscape and public space. Here, architecture as the art of building and urban planning concerning environment/nature may be included into the process of the space creation. It will show this way its utilitarian value as a discipline/field of art.

This necessity results from the menaces for our self-feeling and health. The new technologies are namely indeed useful. Nevertheless they are introducing the mentioned menaces into the human urban space.

The main threats/oppressiveness resulting from the application of these technologies for the environment are: noise (windmills and all mechanical facilities connected with the production of the wind energy), polluted air (biotechnologies using the biomass), decrease of the aesthetical values of the cityscape and landscape (the little perfect montage as well as forms of the solar installations).

The same way, the architectural interiors are losing its human character in consequence of introducing robots. Therefore, in the first instance, the neglected city areas and the abandoned, revitalized, revalorized buildings, as well as the urban and rural spaces should be dedicated for these innovative technologies.

Concluding, we can assume that the renewable energy sources and their effect – the new technologies – will be the impulse for the sustainable development of the environment. It will happen thanks to the transformation of the destroyed urban tissue by the application of these technologies. The authenticity of this thesis is confirmed by many realized projects.

Key words: architecture, urban planning, renewable energy sources, innovative technologies.

INTRODUCTION

The term "Utilitarianism" does not refer here its meaning as a philosophical doctrine and is considered in the general sense as a pursuit of a practical purpose. In the current discussion about the future of our surrounding environment, it involves the use of new technologies in the field of architecture, in the urban area and the urban landscape as well as in the furnishing of newly designed and revamped buildings

Referring to the analogy from the period of the introduction of such materials as iron, reinforced concrete, as well as the rich supply of chemical materials that contributed to the flourishing of architecture and urban planning, one can argue that new technologies of the future energy-based construction will also allow to flourish of the widely understood contemporary architectural creativity. The problem emerges: how to use the new technologies optimally in terms of architectural values of the constructed environment so that, when practically applied in the architectural creativity, it has become an impulse for its development.

Adding to it, it is worth noting that among the new technologies described as friendly and based on the so-called green energy, no mention is made of nuclear energy, but the sun, wind, water, biomass and geothermal energy are mentioned.

The use of these individual sources of energy creates a very rich array of proposals depending on geographical location and climatic zones. Sunlight can be seen as advantageous climate, however, there are areas on the globe where protection against sunlight is a very important function of the buildings. One should also mention the parts of the continents where it is difficult to get a drop of water.

The following presentation of examples is an attempt to show the works of architectural and urban implementing scientific and technical innovations in the area of the renewable energy sources (RES) of the real possibilities of success in this field.

EXAMPLES OF SOLUTIONS

1. MISSED OPPORTUNITIES

By introducing the practical application of technological innovations as initiators and inspirational architects, it is also important to note that the temptation to seek new formal solutions is sometimes more pronounced than the achievement of work excellence aimed at applying the innovative RES techniques These efforts could be described as missed opportunities.

This category of creative effects could include the concepts of caring for the façade formation in a form of a dead screen - a flat lining of the building, a plastic accent without the ambition of reaching for the technological innovation (Modern Museum Malmo - the museum of modern art, built on the site of a former power plant in Malmo, Uffelen Ch., 2011 p. 68,69,71). In urban terms; a complex of new buildings (House Benois in St. Petersburg, idem p. 290.291) using the decoration of the façade in the style associating with the "humanization of block of flats". On the scale of the landscape, this has often been and still is the opposite, the contrasting activities that do not take into account the spatial order, landscape-devastating wind power plants and energy networks such as from 80s of the last century in Australia (Wines J., 2008, p. 66).

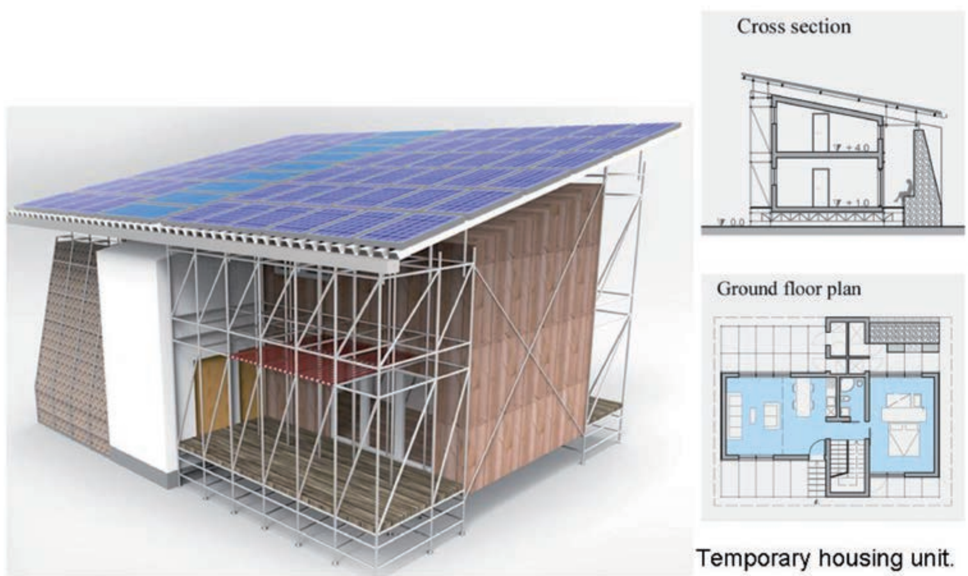
Interior design also provides a number of examples of revitalization of the buildings the arrangements of which are far from the achievements in the field of new technologies. There is a unique but only formalistic décor for a new hotel-conference function of former Manufaktura in Łódź (Uffelen Ch. 2011, p. 109).

2. INSPIRATIONS

The need to discover the perfection of architecture inherent in the technological innovation is an unintended but still value of the above examples, provoked by them. This can be traced by observing the essential fields of architects, so the examples of architecture, urban planning, landscape architecture and interior designs.

ARCHITECTURE

The architecture builds its value on the connection with the technical enhancements, the creativity, the organic part of the new technologies. One can find here a significant part of the cubic capacity of the residential buildings heating systems with centrally located heat silo-storage. These include single-family residential buildings with integrated multi-layer heating tanks with a volume of up to 15 m3. In moderately sized buildings, especially in emergency situations, an easy-to-follow pattern can also involve the proposal of a roof in a form of a photovoltaic plate separated by the diffusion from the parallel building plate (A „mine" for the sustainable buildings regeneration, Pescara, Italy, Il.1).



Il.1. Photovoltaic plates in emergency residential building (De Gregorio, 2014, p. 266)

For larger multi-family buildings in the downtown one can offer modernization, i.e. the development of south-facing and surfaces of the sections of façades or frequently occurring details such as balcony balustrades (Multi-Storey Building, Delft, Netherlands, Hermansdoerfer J., 2005, p. 75). For new public building, one can much more easily demonstrate the qualities inherent in new technologies in the field of colour and light effects. It is important to the media wall rich of colours to be powered from a self-sufficient energy system. "Zero energy media Wall" is the first in China photovoltaic system integrated into the façade with a glass curtain wall (Green Pix, Beijing, Feireiss K., 2009, p. 44).

A procedural difficulty is the use of new technologies in the world of antique objects. However, a number of the widely accepted uses of these technologies demonstrates that they are not a threat to the values of the cultural heritage (Kirchendaecher, Plauen, Dresden-Lobtau, Deutschland, Hermansdorfer J., 2005 p.54), Touristeninformation in Kirchenruine, Ales, Frankreich, idem p.84).

In this group of the solutions, the most mature implementation of new technologies, including the RES, are those that derive their creative ideas from the nature of these technical solutions.

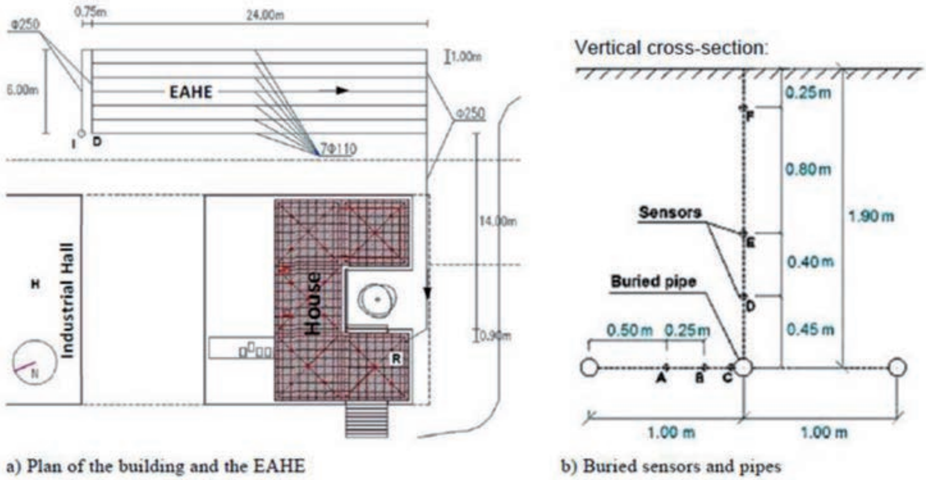
A very convincing example here is the building of a city bath with a rooftop swimming pool (The Hot Thermae, Bath, UK, Uffelen Ch. 2011 p. 336), residential structures in the urban development that harness their solar life and the associated aerodynamics of the surrounding space ("Casablancaflats" and Tremli-Siedlung, Zurich, Schweiz, Pfammatter U., 2012 p. 183)

The pavilion exhibited by the United Kingdom at the 2010 Schengen Expo is the contemporary crown for the symbiosis of the architectural creativity and the technical achievements. This 20 m tall building was made up of 60.000 optical bars of 7.5 m in length. During the day they led the daylight into the interior, at night they were a light illumination. When it is windy, the building moved to create a "glow" of lightly waving hair (UK Pavilion At the 2010 Shanghai Expo, Belhoefer K., 2011 p. 152,153).

URBANISM

The importance of implementations in the scope of using RES and new technical achievements in the urban scale is proportional to the area they concern. The solutions in the field of energy policy are directed to include the revitalization programmes of large sections of cities - urban districts. The first and foremost are the districts from the 70-80s of the past century, the significant number of which and flat roofs in the buildings, at their appropriate height (above the crowns of surrounding trees) are a very convenient spatial situation for the solar devices.

A deeper analysis of the urban environment causes us to distinguish two main applications of new technologies related to the renewable energy sources. Namely, one can distinguish between terrestrial, easily perceivable and underground constructed environment, the existence of which is mostly associated with the urban infrastructure. The underground part of the cities is seen due to the need of the surface which it generates. It involves the local heating and cooling systems that use the temperature of the ground to a suitable depth, in their balances (Il. 2 Modelling and Performance Analysis of an Earth-Toair Heat Exchange - EAHE, Coimbra, Portugal) .



Il. 2. A model showing the exchange of heat in the EAHE ground-air system; a) the EAHE plot plan, b) the vertical cross-section of the plot area: sensors and pipes (Costa J.J. 2014, p. 113)

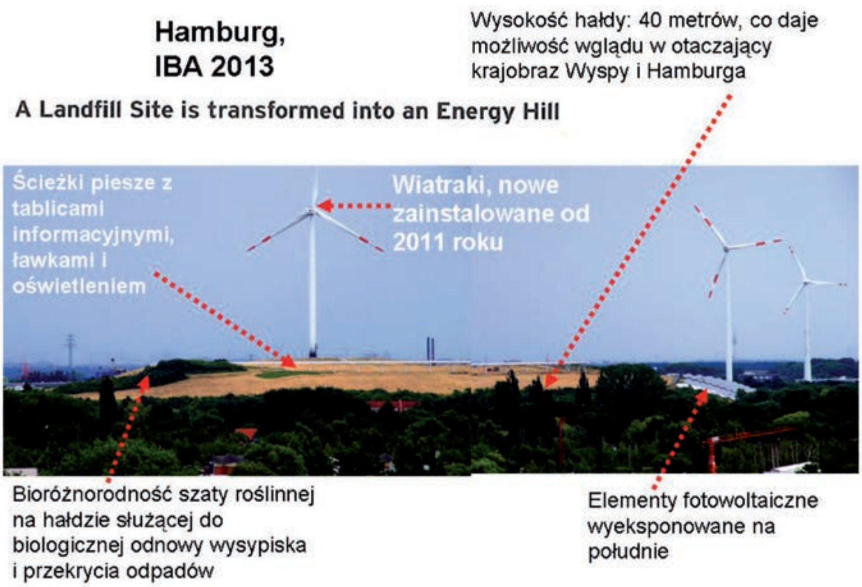
There is also a significant demand for the area of the biogas production systems. The terrestrial transport infrastructure is the widest field on which one can demonstrate the potential for using RES, especially solar energy. The roofs of the communication buildings are used the most often, e.g. photovoltaic elements on the glass roof of the central railway station in Berlin (Il.3) or canopies commonly constructed above parking spaces (Carports, Potenza, Italien, Hermansdorfer, 2005 p. 118).

Il.3. Photovoltaic components installed on the glass roof of the central railway station in Berlin. (photo Anna M. Włodarczyk, 2014)

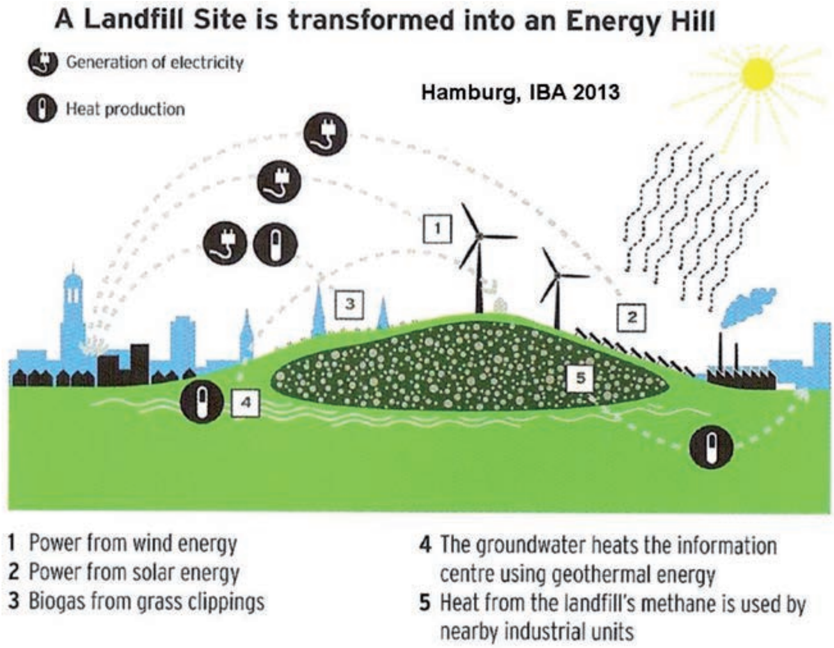
The excellence of new technologies consists, inter alia, of their multifunctional usability. An example involves solar photovoltaic panels operating as acoustic screens on motorways (Kombinierte Schallschutzwand Freising, Deutschland, p. 22).

However, new cities demonstrate the most inspirational innovation of new technologies. This occur especially in extreme climates where sunlight and shade are not treated as incidental events (Nasdar-City Innenstadt, Dannenberg M., 2012 p.146).

Considering the usefulness of the introduction of utilitarian value in shaping spatial order, it should be noted that the implementation of new technologies and the RES in the programmes and projects related to the revitalization of degraded brownfield sites are presented the fullest way. The Hamburg IBA 2013 project in the form of a Waste Landfill converted into Energy Hill can be a symbol of such activities on the European scale. As a result, electricity is generated there (windmills and solar photovoltaic elements exposed from the south side installed since 2011), produces heat (geothermal and methane from the landfill of existing waste), and biogas (from the fermentation of mown grass). The height of the heap reaches 40 m, which provides the opportunity to see the surrounding landscape of the island and Hamburg. A network of paths and lighting system allow to discover the biodiversity of the plant cover used for the renewal of this landfill (Hamburg IBA 2013, A Landfill Site is transformed into an Energy Hill, Internationale Bauasstellung Hamburg, 2012 p. 159).



Il. 4. Landfill of waste converted into "Energy Hill" - view. (Author's development in accordance with IBA prospectus, Hamburg, 2013)



Il. 5. Landfill of waste converted into "Energy Hill" - cross-section. IBA Folder. Hamburg 2013 (1-wind, 2-solar energy, 3-biomass energy, 4-geothermal energy, 5-methane generated from the heaps of waste, used by the adjacent industry).
(Author's development in accordance with IBA prospectus, Hamburg, 2013)

The inclusion of new technologies in the revitalization of degraded brownfield sites (former copper refineries) in Inujima Island, Japan, is equally ambitious. This area was converted into the New Museum of Art. The "life" programme of this object is based on a cycle of continuous processes, controlled by the natural activity of the local environment. According to the authors, the idea of the project is to express symbiosis with the environment, its decline and development. Two essential air conditioning systems are the cooling system through the earth and heat from the sun. Individual functional parts of the programme are: Earth Gallery, Sun Gallery, Energy Hall and Chimney Hall - the remaining parts of the former refinery adjacent to the chimney. Earth Gallery is a land-based steel structure that is supposed to keep the climate of the "earth warmth". Solar Gallery is a part of the former refinery with a glass roof that is pervaded by the warmth of the sun's rays. Energy Hall keeps the same temperature and humidity throughout the year. This is regulated by the opening of windows and corridor doors to Earth and Solar Galleries. In addition, the interior finishing materials are available: cedar wood with low heat capacity and, in contrast, granite from local decks operating on this island.

As a result, the air moves over the floor along the corridor by creating the effect of natural convection (New Museum of Art, Inujima, Japan, k. Feireiss 2009 p. 128-130).

To sum up, this part of the adorable urban planning aspect in the use of new technologies and "green energy" refer to the sketch of "towers - wind mills" by Richard Roger of the 90s of the last century. This urban vision of the cities for a small planet also strongly emphasises the use of wind and the sun in the landscape of the cities as a source of energy (Richard Rogers: Skizie zu einem „Windmuhlenturm", Cities for small planet, Pfammatter U. 2012 p. 218).

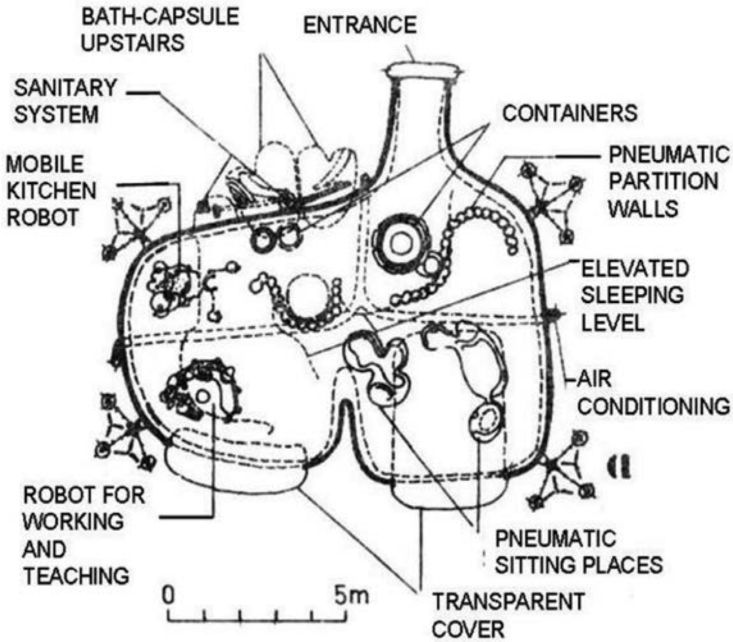
LANDSCAPE

Observation in the landscape of elements of new technologies using the sun, wind, water, biomass or geothermal is related to their scale and view ability. Geothermal pools incorporate into the landscape the most naturally (Geothermal in the landscape, Dannenberg M. 2012, p.127), but the aggressive pressure of high wind systems is the most noticeable in the landscape, especially because empty spaces are needed for their optimum efficiency to eliminate the lowest elements of the development in the surrounding space.

In spite of the large areas they occupy, due to the horizontal adhesion of their photovoltaic fields to the terrain, solar power plants do not pose a threat to this lack of aforementioned wide viewing accessibility (they can only be observed from an aircraft window, a railcar moving on an embankment or a tourist cable car) (Anda-sol 1 und 2 in Sued-Spanien, idem p.33), (Solarkraftwerk Waldpolenz bei Leipzig, idem p.57). Tower power plants are the only exception, but they create only single height accents in the landscape (Solarturmkraftwerke im Solucar Solar Park, idem p.37), (Grossie Solarturmanlage Deutschlands in Jilich, idem).

INTERIOR ARCHITECTURE

The renewable energy sources can also be used in the technical innovations in a form of equipment and products for the interior of the buildings. The above mentioned UK Pavilion at Expo 2010 exposes the scale of these opportunities. In reference to the pragmatism in the architectural art, it is impossible not to mention the flexible arrangement of the interiors in a form of the futuristic interior of the "living pod" from the end of the last century (Il. 6.).



Il. 6. "Living pod", an example of the use of new technologies in the interiors. (own development of the author based on David Green Living Pod with mobile and flexible arrangement, Bauen + Wohnen p.174).

Currently expected robots find a growing use in bioengineering. In addition, in the architecture of the residential interiors, especially in senior residential buildings, the works on the use of robots to care for seniors are very advanced.

CONCLUSION

The above examples show that new green technologies based on green energy inspire creators and contribute to the development of the architectural and urban art. Reflecting on the optimal use of this creative impulse, apart from pointing out the solution of the designs, we encounter certain difficulties, as well. Apart from the traditional limitation of formal excellence without the use of new technologies, they include:

– climatic conditions; the greater part of Europe, including Poland, lies in a cool climate with a relatively short summer and a yearly sunshine much lower than the sun at the equator, posing a high demand for the solar equipment,
– maintenance requirements,
– nuisance to the environment resulting from the use of green energy; smells in the case of biomass, biogas, unauthorized photovoltaic effects on residential buildings, noise and disturbance in the landscape caused by windmills, necessary felling of trees in the case of solar panels in low buildings, etc.

These are the conditions that need to be taken into account in the further broadening of the inclusion of new technologies in the process of shaping the environment around us.

On the one hand, the global model of the solutions helps us, e.g. for common, universal single -family residential buildings (Australian House of the Future, Wines J. 2008, p.168), on the other, the forecasts of the growth of green energy use encouraging us. For example, wind energy from 3% in 2015 to 26% in 2030 in the world's second largest Chinese economy.

There are also improvements in the field of management in the use of the RES. An example includes the world's largest 77-hectare solar field built in Arnstein, on the north from the city of Wurzburg in Germany. It has 1500 autonomous solar power plants ranging from 7 to 10 kilowatts. The ability to distribute all 1500 units between private investors is the innovative solution here. These mini-plants can be purchased for a relatively affordable price of 14.400 Euro.

In the European situation, it is also important to note that the largest part of the construction market (over 50%) covers the economic activity in the field of rehabilitation, modernization, reconstruction and extension of the existing buildings. This is an important indication for the direction of the development and deployment of the technological innovations and green energy.

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RENEWABLE ENERGY SOURCES AND PREVIOUSLY USED LAND

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ABSTRACT

Sources of renewal energy are often connecting with area – agricultural land which is affected by use for equipment of use solar energy, or for production of biomass. This process lead to destruction or degradation of soil. On one side is really positive affect on environment by use renewal energy sources on the other hand we can see really negative impact on one of the key natural sources. This negative feeling can be reduced by carefully choose the place or sites. One really positive way is to be focused on land which were degradated by previous use and cannot find yet any useful use This article will show a few examples how previously land can be used as a place of production power from renewal sources. It shows also several cases from Germany and shows one proposal idea from the Czech Republic. At the end some related problems are mentioned.

Keywords: renewable sources, brownfields, sustainable development

INTRODUCTION

The production of energy from renewable sources is now one of the major trends in the area of sustainable development. Although it is a major step to reduce the various adverse effects of other conventional energy sources, for their implemenation a space is necessary - land that must be occupied.

Soil is one of the fundamental components of the environment. It also presents one of the cornerstones of sustainable development. As stated by Fagan (2002), the soil is basically omnipresent and so we often forget its existence, its uniqueness and its difficulty to be revived. Still, it is inherently associated with our existence and its use is an integral part of the history of all mankind. In the history, and especially today, as mentioned by Ademola et al. (2008) land use is a continuous process of relationships among natural (biophysical) and human (social) subsystems. Land use practically combines the social and biophysical environment. It is therefore necessary to realize that if we change one ot the aspects, we change the other one as well. Therefore, this article focuses on the options which are related to utilization of the brownfields areas for production of energy from renewable sources, or to the possibility of biomass production at those locations. To better understand the problem, it is necessary to devote part of this introduction to information about the uniqueness of the land-agricultural land, for example and societal loss when we will use it for example for photovoltaic power plant.

If we would like to rate in a regional or global scale how significant is the possible impact of the loss of agricultural land (the difference in state before and after the investment), according to (Marcotullio, et al 2008) we can ask ourselves the question how much of the natural environment (not only land air and water, but) we need to survive. These questions are then linked to primary agricultural production and changes in the population. In 1972 the members of the Club of Rome spoke about the Limits of growth, today they have already been using the term Bankrupt nature (The Club of Rome, 2012)

As an illustration of the disparity between resources and needs (despite the improvement of technology and technological processes), it may be noted, as stated in Hurta (2014), the acreage of cultivated land has increased for 11 years on 2.6%, while the population of the earth during the same period increased by 14.2%. The food and Agriculture Organization of the United Nations estimates that the acreage of cultivated land will not be increasing further, on the contrary, the land is used and will be used for purposes other than the production of food (residential homes, industrial parks, athletic fields, urban greenery, amusement parks, coal mining, oil, gas, sand, minerals, roads, railways, etc.) (Hurta, 2014).

From the perspective of sustainability, it is appropriate to consider indicator of the Ecological Footprint, which can be understood as the ability of natural resources such as soil or water, which were used for production (both agricultural and industrial), to absorb wastes coming from this production. As Marcotullio (2008) quotes, in 2002, the ability of the biosphere to reduce harmful effects produced by humans per year was assessed to a period of 1.2 years. It is obvious that the whole society is heading into a trap in the form of the inability of the natural environment to respond to our interventions.

In the Czech Republic it is stated that the extent of built-up and other areas increased year to year (2010-2011) by 1 656 ha (0.2%), from the year 2000 in total by about 24 162 ha (3%). Built-up and other areas held in 2011 in the Czech Republic cca 834.2 thousands hectares, which represents 10.6% of the Czech Republic's territory. The population between 2000 and 2011 increased by 2.3%. It is therefore a situation where the built-up area is increasing faster than the population and so grows also the ratio of the built-up area per capita. (Czech Geodetical and Cadastral Institute, 2012). Reducing the amount of claiming agricultural land for building is therefore becoming an inevitable task.

Decrease of the arable land for further urban development has become an essential objective. The document Thematic Strategy for Soil Protection (International Year of Soils 2015) , published by the European Commission in 2006, can be used for initiation of the process. The mentioned document aims to define a common and comprehensive approach, focusing on the preservation of soil functions, based on the following principles:

Preventing further soil degradation and preserving its functions by acting on soil use and management patterns, when soil is used and its functions are exploited and by taking action at source, when soil acts as a sink/receptor of the effects of human activities or environmental phenomena.

Restoring degraded soils to a level of functionality consistent at least with current and intended use, thus also considering the cost implications of the restoration of soil.

The problem of the land reuse is the main issue of the CircUse project. In the CircUse project publication (Preuss et al., 2011)] it is explained that the circular flow land use management strategy primarily and systematically seeks to exploit the potential to develop existing building sites and reuse derelict land. It focuses solely on internal development (recycling abandoned sites, higher density development, infill development, multiple use, etc.).

On the one hand we need and we want to limit the production of energy from coal consuming power plants and replace it with energy from renewable energy sources, and on the other hand for these activities we have to often claim the agricultural land and essentially destroy or significantly degrade an important natural resource.

WHAT BROWNFIELDS ARE

Brownfields are inherently associated with changes that are happening in society as a whole. Human settlements are undergoing various transformations throughout its entire existence. Mostly in urban areas sites are appearing which for various reasons have lost their function. Reason behind the appearance of the deprived, abandoned and overall useless sites in towns can be found often in structural changes (Ferber, Grimsky, 2002, Votoček, 2011, Petrikova, 2011), that changed a prosperous factory into a non living jumble of buildings, turned lively railway stations with crowds of people passing through into hollow emptiness. For such places the term brownfield have become common. This is not a new term – used only in the last 5-10 years as mentioned by (Klusacek et al., 2015) the change in perception of brownfields happened in the Czech Republic in period of years 2000 and 2005. In addition to many definitions available (Ferber, Grimsky 2002), we encounter for example an explanation of what is a brownfield in the 1999's A Guidebook for Brownfields Property Owner, where owners ask themselves and answer two questions „Is my land idle, vacant. or less productive than it ought to be?" and „Are concerns about environmental contamination contributing to be problem?"

Brownfields as we are currently perceiving them are a relic of the changes in the economy and in the society in the last 40 years. As stated by Ferber (2006), the roots of the industrial Brownfields in Western Europe are in the 1970s. Years. Such brownfields are often referred to as the first generation brownfields. Dolezalova (2015) mentions that their existence is at first associated with unemployment, and is accompanied by the many rapid changes in society. These first generation brownfields tend to be the larger areas often in residential areas of cities.

Brownfield is a term, which has been associated with industrial cities and municipalities for several decades, as it is pointed out by e.g. Ferber (2006), with structural changes, such as decrease in production in traditional manufactures, or in mining, etc. However, there are many more causes to these changes including a whole range of economic-political transformations.

In the past several authors e.g.Bergat – Jackson. et al. (2011) observed that the European legislation in effect did not contain any unambiguous definition of brownfields. However, many countries use their own modified definitions in planning and development documents. Most of these definitions are more or less based on one of the first official definitions. This definition of brownfields was conceived within the framework of a European working group CLARINET (Ferber, Grimsky, 2002), and these same authors used the definition when preparing outputs of the CABERNET network.

Brownfield sites are defined as an area affected by past use or the past use of neighbouring lands, are abandoned and unused (or underused), have actual or potential problems with contamination, can be usually found in urban areas, but most of all, brownfield sites are sites, which require intervention in order to be effectively used again.

Brownfields cannot be considered merely as a problem associated with the surrounding land, but as (Ferber, Tomerius, 2003) or (Vojvodikova, Zamarský, 2014) point out, it is necessary to consider many different phenomena extending beyond the boundaries of the affected area.

these sites offer great potential, as, on a relatively small area, there are several smaller premises, which present right now a burden, but which are nevertheless well located and ready to perform a new function, which would otherwise be assigned to sites built on greenfield land (i.e. outside the municipality, on agricultural land).

How many Brownfields are in the territory of the Czech Republic is not entirely clear and conclusive as stated for example by (Frantál et al. 2013). Problems with incompatible and incomplete databases of brownfields is mentioned by Novosák et al. 2013). For example (Marsickova,2012) mentions with relation to the National Database of Brownfield Regenation that there are 494 sites for all the regions of the Czech Republic. While only in the brownfield database of the South Moravian region there are 362 sites mentioned, including 124 in the regional capital Brno. Only such sites were added to the database having the area of a minimum size of 1 or having built-up area of over 500 square meters as mentioned by (Frantál, B. et al. 2013).

Expert estimates therefore speaks of approximately from 10000 to 20000 sites that might be called brownfields. Not all are suitable to be used for the production of electricity from renewable sources, but at least some of them are.

POSSIBLE NEW USE - RENEWABLE SOURCES OF ENERGY

For many years there is a discussion about the question what is the possible use of brownfields. One of the possible utilizations of a brownfield area is for production or for preparation of the production of energy from renewable sources. Such use of Brownfields brings indisputable advantages. The first advantage is the regeneration of the brownfield as such with all the positives that this change brings to the brownfields surroundings, for the municipality and also for the wider area. The second advantage, which is, as it is suggested in the opening paragraph, is very important prevention of the greenfields claiming. For example when we place photovoltaic power plants on the brownfield site and not to the landscape we can talk about the significant reduction of negative influence on the landscape. Impact to the landscape can be quite significant and constitutes a specific atypical enclave in the landscape matrix, as we can see, for example, in Figure 1.

Figure.1., Plant for using solar energy near Slusovice – Czech Republic, Vojvodikova, 2015

Practically it is possible to divide the use of brownfield sites for renewable sources of energy to:

- permanent - especially when it is about the building of the equipment,
- temporary – if we are talking about e.g. the cultivation of biomass.

For the first category, this means the construction of the photovoltaic power plant or using this site as a place for a wind power plant. In this article we will address only the examples of use of solar energy. Walter, Seifried, D, (2010) mentions one of the first brownfield to greenfield redevelopments, the Leipziger Solar Power Plant, was installed upon 49 acres of a former lignite mine site in Espenhain, Germany. Investment was realised in 2004.

A similar investment is also Borna Solar Plant, installed at a cost of $28 million on the site of a factory that had produced lignite briquettes. It is a significant effect from the point of impact to the soil. The power station is located on 22 hectares with production of 3.4 MW (Buchsbaum, 2015). See Fig..2.

Figure.2 Locality of the current Borna Solar Plant during and after construction(Buchsbaum, 2015).

This example is included here mainly because it is first of all about utilization of a brownfield. More often we meet this device built on the heaps. (see example Photovoltaic Energy Plant) The second reason is the use of the premises as the plant and not just as the now standard add-on for the new construction. We can see a lot of such examples on brownfields. For example, in Figure 3.

Figure.3 New construction on site Ewald in the Herten - on the roof of the new object photovoltaic panels are placed, Vojvodikova, 2011

An example of building photovoltaic power plants mainly on the grounds of the heap is Photovoltaic Energy Plant Mellin, Sulzbach The projects are targeted to actively facilitate the change from fossil energy sources to renewable energy sources. The first construction phase of a photovoltaic energy plant on the site of the Mellin coal yard was initiated in August 2012, and it was already completed in September 2012, with a partial output of

3.542 MWp (megawatt peak) on a sub-area of approximately 7 hectares. The second construction phase completed the photovoltaic energy plant on the Mellin coal yard site in mid-2013. (Krumm, 2013)

Biomass – its growing as one of the appropriate ways to use brownfield sites

The cultivation of biomass is another of the possible use of brownfields. This can be made a permanent usage, or it may be a so-called temporary use.

Permanent use contributes to the greening of the site and it is possible to grow plants. For the temporary use, plants varieties can be used, which may also contribute to the phytoremediation. As stated by Mosey et al., (2007) the minimum extend for efficient use of site for the biomass production is 2 ha.

An example for the cultivation of biomass is a former mine of Hugo in Gelsenkirchen In Figure 4 you can see site's state in 2003. On the site of the former Bergwerk Hugo in Gelsenkirchen-Buer, is developing the Biomassepark Hugo. It is large-scale, short rotation forestry plantation in a European megalopolis setting on a former mining site in the Ruhr metropolitan area. A park-like area of approximately 22 hectares with fast growing crops is emerging (Timmerhaus, 2013)

Figure 4. Site of mine Hugo in Gelsenkirchen in 2003, Vojvodikova, 2003

Figure 5 shows the proposal presented on the website of the site's owner, how the site will be used for the cultivation of fast-growing tree species. This green area will be appropriately incorporated into the existing green.

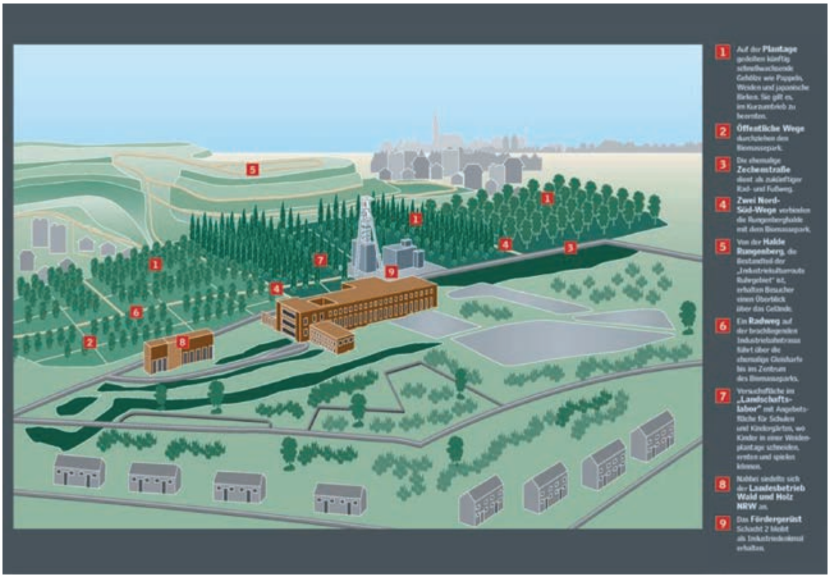

Figure 5 Proposal of the site's use for the cultivation of biomass (Timmerhaus, 2013)

Similar proposals – rather in the form of ideas appear in the Czech Republic.

For example, in 2013, a workshop was held in Ostrava by VŠB Technical university of Ostrava, Faculty of civil engineering with a focus on the use of the former chemical factory in Ostrava Hrušov. Site's status can be seen in Fig..6.

Figure.6 The former chemical factory in Ostrava Hrušov, Vojvodikova, 2013

The students prepared a few proposal ideas, one of which really counts with the planting green in the whole complex. Best then planting fast-growing species. (see Fig. 7). Students, however, did not take into account the degree of contamination of the site and the question was whether it might be better to use herbs rather than trees. However, the owner of the site is rather sceptical to this type of usage and is looking for an investor for the construction of a new industrial use.

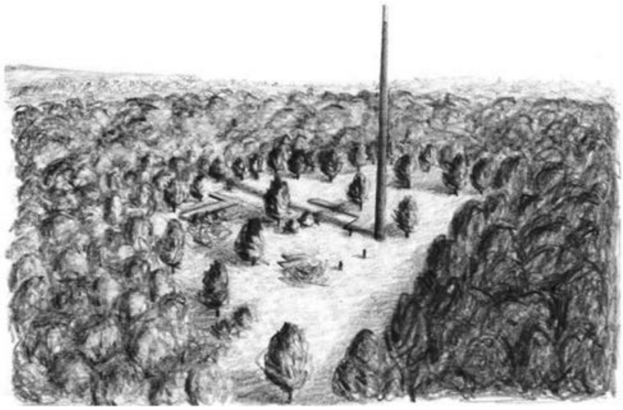

Figure 7 Student´s proposal 2013

CONCLUSIONS

Brownfields can today be perceived more as a potential for further development. In the past few years the negative image of these places has been improved and they are becoming once again an integral part of the planning and part of the sustainable development of the territory.

For usage of energy from the renewable energy sources are suitable previously used areas either as a location for photovoltaic power plants, where an important criterion is just protecting greenfields before claiming for construction, so the very beneficial use can be considered as use for the cultivation of biomass. The big advantage is just changing the ugly, abandoned or broken area with the ruins and the low prices of real estate into the area which is green, and the real estate prices are likely to grow. A special chapter is the cultivation of biomass with the possibility of using plants accumulating possible contamination. This type of use is of course linked to specific problems mainly in the volume of biomass production, when plants growing is often limited by present contaminants.

Though the environmental effect is obvious, it is necessary not to forget even the economic effects. Despite all the positives mentioned for the investor the reuse of brownfield without stimulation is difficult and often inefficient. It is therefore necessary to deal with support for such options of the reuse.

ACKNOWLEDGEMENT

The article was supported by a specific university research by Ministry of Education, Youth and Sports of the Czech Republic No. SP2016 / 29 Creation of a system for market analysis of industrial enterprises.

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SUMMARY

With respect to the assessment of energy resources, PL-CZ's development strategy is to use renewable energy resources rather than fossil fuels. Local plans for energy and climate together with the need for widespread energy savings, energy efficiency, and energy efficient infrastructure (defined by national standards and regulations in accordance with the EU) have contributed directly to the creation of this book.

The intention is to present a concept and real vision that integrates eco-energy with ecology and innovative energy technologies with low-energy construction. Both the study and articles are enriched with experience and examples of new RES technologies and their implementation. As the project develops, all the partners for future projects will share this knowledge. Thanks to the results of cooperation in the publication, this knowledge will also be consolidated and made available to a wide range of stakeholders. Current issues confirm the need for further initiatives of this kind because they will increase interest in new, unconventional energy sources and technologies for energy generation and the construction of renewable energy sources.

Similarity of problems related to Renewable Energy Sources in all industrialized countries made team of researchers on the initiative of the Mayor of Racibórz, Mirosław Lenk to organize together with Racibórz City Council and State University of Applied Sciences in Racibórz international conference RES and ways of addressing this problem.

I sincerely thank the reviewers of this book and especially Professor Ewa Stachura and Professor Jack Włodarczyk for their interest in this publication and constructive comments.

And thanks also must go to the active involvement of the architects of PWSZ in Racibórz, who initiated cooperation of the PL-CZ border Universities of the VSB in Ostrava. This will enable further scientific and research projects including this publication. It marks the beginning of the cooperation of many institutions for Renewable Energy Sources.

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