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SPIS TREŚCI

SELECTED DIRECTIONS IN SHAPING THE HOUSING ARCHITECTURE OF THE FUTURE

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ABSTRACT

The main goal of the housing of tomorrow is to create a friendly, safe and healthy environment for residents. Some of the important aspects of designing residential buildings of the future are: technological advancement, sustainability, ecology and circular economy. These issues seem to be relevant in every building typology nowadays. As housing has crucial role in the life of every human being, it is also necessary to search for other aspects that are important in shaping it. Significant element of the housing environment of the future is its social aspect, which affects interpersonal relations. There has also been a recent shift towards working and living spaces in residential environments. The presented conclusions are the result of analysis based on literature research, field studies and an interview. Various examples of residential buildings are examined to present possible solutions in the housing architecture of tomorrow, indicating the directions of its development observed recently.

Keywords: housing, residential architecture, cohousing, sustainability, work-live space

INTRODUCTION

The way the housing environment is shaped is very important as people spend there most of their time during the day and night. It has influence on the quality of life of its inhabitants and adapts to new circumstances and residents' needs. These circumstances might be related to the dynamically changing socio-cultural, technological and safety situation. The future of housing architecture should focus on different issues, connected not only with the technology, circular economy and ecology, but also with the social aspect. It is important to observe the changes in lifestyle in cities and shape residential areas and buildings in a way that meets the needs of their users, e.g., by creating common spaces or combining housing with offices.

As nowadays the principles of the circular economy in the design of buildings and the implementation of ecological solutions seem to be already obligatory in the architecture of the future (not only the residential one), it is important to mention also other factors and features that might have influence on shaping the housing environment.

SOCIAL ASPECT IN RESIDENTIAL BUILDINGS AND NEIGHBORHOODS

One of the important aspects of residential neighbourhoods is the social one, as good relations with the neighbours have a positive effect on well-being. It is possible to enhance the interpersonal relations just by the way the outdoor spaces and entrance areas are designed, as it might affect the chances and frequency of meetings [3].

Fig. 1. View towards the floating houses in the Schoonschip neighbourhood in Amsterdam. Photo: Agnieszka Kurowska

Some of the types of the residential areas in which the social aspect plays crucial role are cohousing and Collective Private Commissioning (CPC/CPO) buildings and neighbourhoods. Within co-housing and CPC/CPO solutions the social aspect is visible not only in the physical arrangements outside the building, but also in the real relationships between its residents, as they are very often involved personally in the entire process. The four common characteristics of cohousing are: participatory process, intentional neighbourhood design, extensive common facilities and complete resident management [11]. In the future, there might be a need for these kind of solutions not only because of the social aspect, but also economical one, as sharing different facilities in the building can make housing more affordable.

Schoonship in Amsterdam is an example of a floating neighbourhood in post-industrial district Buiksloterham. It was initiated by one of its inhabitants Marjan de Blok, who was inspired after the GeWoonboot at the NDSM wharf in Amsterdam (not so far from where now the Schoonship is located). The first houseboats arrived at Schoonschip at the end of 2018, about 10 years after the first idea. The 30 residential buildings are divided into 5 groups of 6 – connected with each other by the floating jetties, which also serve as the social space for the inhabitants.

The main goal of the Schoonship was to build a self-sufficient neighbourhood and to apply many pro-ecological solutions (also those technologically advanced). The entire Schoonschip neighbourhood was possible to be realised by its future inhabitants and, according to Marjan de Blok, that was the greatest strength of this project. Creating the community of the future inhabitants, involved in the entire process, divided into groups responsible for the different aspects of the project, made that investment possible. The other advantage of the Schoonship is its flexibility in terms of location – since it is a floating neighbourhood, it might be moved elsewhere, which is also a vital feature intoday’s and future problems with rising sea level. In the Schoonship neighbourhood there is also a building called Het Ruim, that serves as a common space for all inhabitants – for community gatherings, and also for meetings with people from the outside, as the Schoonschip community has also an educational function about these types of solutions.

Capitol Hill Urban Cohousing is an example of the cohousing building at 12th Avenue in Seattle. It was designed by Schemata Workshop – Grace Kim and Mike Mariano, who while spending some time in Copenhagen in 2004, had the opportunity to study cohousing ideas [13]. They currently live in Capitol Hill Urban Cohousing building, which is home to 9 families (17 adults and 11 children) [9]. Although every apartment has its own kitchen and bathroom, there are many common spaces within the building, typically for the cohousing solutions. There is a large kitchen and dining room with a table with seats for at least 30 people. These spaces are used to organise culinary evenings for inhabitants who can spend time together, as it is one of the features of cohousing. Those events take place three times a week, giving residents the feeling that they live in a community. There are also other common spaces, such as a laundry room, bicycle storage, and an additional bedroom and bathroom that can be used by guests visiting any of the families living in the Capitol Hill.

Another example of the implementation of the common and innovative forms of housing ideas is the Kalkbreite Cooperative in Zurich in Switzerland. That multifunctional building, located above the tram depot, combines various functions, but the most important of them is housing. There are 82 apartments of various types and sizes arranged around the inner courtyard [21]. The designed housing typologies are the reflection of various needs of inhabitants and the particular emphasis is placed on the innovative forms of living. There are small flats and the larger ones for the families. Some of the apartments form larger clusters of 9 flats, where every inhabitant has its own kitchen and bathroom in the flat, but all residents within the cluster also share a larger space for cooking and recreation where they can spend time together. People in these clusters are of different ages, which also enhances the interpersonal relations. There are also some flats for young individuals between 16 and 25 years old. Another interesting option is the Joker rooms, which are additional spaces for rent, primarily for the residents of the Kalkbreite. They might be used by young members of the families from Kalkbreite, who start living alone but still close to the parents [15].

Fig. 2. View towards the floating jetties between the houses
in the Schoonschip neighbourhood in Amsterdam. Photo: Agnieszka Kurowska

ADJUSTMENTS DURING PANDEMIC

One of the main ideas and advantages of co-living, CPC and cohousing communities is the social aspect of living in the community which was challenged during the COVID pandemic.

During COVID pandemic at Schoonschip the use of Het Ruim was forbidden, so there was no indoor area for community gatherings. Also in Capitol Hill Urban Cohousing many changes had to be implemented. As Grace Kim said in the interview, many aspects had to be adjusted to the restrictions due to the pandemic situation [6]. The common spaces such as the kitchen and dining room were no longer used, and also the shared cooking was cancelled.

Later, during the summer 2020, it was partially moved outdoors to the rooftop terrace (where an urban farm is also located), but the amount of participants was limited and also each of them had to cook separately. Meetings were moved online. Several months after the outbreak of the pandemic, it was observed that older residents began to feel very isolated. Therefore a couple of families let them into their neighbourhoods – this way it turned out that the social aspect was confirmed as very important and made those individuals feel much better mentally. Also one of the families of 6, who live in the apartment of 79 square meters, was offered exclusive use of the guest bedroom, as the parent had to work from home. Due to the pandemic some of the common rooms gained a new function, so the whole building layout turned out to be flexible. Also, the functional plan of the building, in which the apartments are arranged around the inner courtyard, allowed residents to communicate inside their apartments. So living in a cohousing building proved to be a major social asset at a time when isolation was needed.

Also in Kalkbreite some adjustments were implemented. As there are Joker rooms within the building, one might think that they could have served as rooms for work or isolation. But even before the pandemic all of them have been already disposed, so only those who rented them could decide on their way of use. Fortunately there is also a co-working space in the building and since the beginning of the pandemic the bigger interest in hiring workplace there was noticed. Also monthly gatherings of the community have been moved to the virtual space. Common spaces had to be adjusted according to the federal guidelines. The number of chairs and tables in the shared kitchen used by commercial tenants and inhabitants has been removed to reduce seating. Also the seating places in the entrance halls library

Fig. 3. View towards the inner terrace visible from apartments located on the various floors at the Capitol Hill Urban Cohousing building in Seattle. Photo: Agnieszka Chydzińska

Fig. 4. View towards the inner courtyard of the Kalkbreite building in Zurich.
Photo: Bub37, source: https://upload.wikimedia.org/wikipedia/commons/0/09/Kalkbreite.jpg
(CC BY-SA 4.0 https://creativecommons.org/licenses/by-sa/4.0, via Wikimedia Commons)
(2021.06.21)

have been removed. As some common rooms are not managed by Kalkbreite Genossenschaft, they have not directed changes to them [16].

The study in psychology conducted by researchers from Argentina demonstrated *"that the residents of cohousing communities have, from various points of view, a better state of mental health and,* (…) *they seem to have better tools to also cope with the difficult situations associated with social isolation due to the Lockdown"* [14]. Also Carrere, Reyes and Oliveras confirmed that different studies resulted in a *"relatively consistent picture of the increased psychosocial health benefits of the community dimension and the emotional and social bond of this model of housing (cohousing)"* [1]. Those results might prove the importance of the social aspect in housing environments in terms of mental health of their inhabitants in general and during the lockdown.

Also, the analysis of selected cohousing communities and shared living cooperatives revealed that these buildings offer some flexibility in changing the functions of common rooms, when necessary. The situation described by Grace Kim shows the strength of the living in the cohousing building in which there was a possibility of controlled and safe social interaction between the inhabitants during the lockdown.

LIVE-WORK SPACES

In residential buildings there might be multifunctional spaces that combine living with working. That typology might be realised in various ways: as additional rooms within apartments, workplaces in the same building on another floor, or offices within walking distance in the same urban quartier.

The idea of combining housing with working is nothing new. It was very popular till the industrial revolution. Nowadays, we can observe that more and more people work from home (which was especially noticeable during the pandemic). According to those working from home, this gives them more control over their lives. They also commute less, so it has a positive effect on the environment. Working from home might become an important aspect in housing of tomorrow [5].

An example of a building that combines working with living is Kalkbreite. There are various types of workplaces inside the building. On the second floor there are 4 studio apartments where people live and work. 12 out of 32 cluster apartments with an area of more than 44 m^2 can be used as a living or living-working spaces (the decision is up to their users). There are also 3 studio/office rooms (called Ateliers) with an area of 33–67 m^2, that might be rented by the inhabitants of the Kalkbreite. On the second and third floor there are two rooms available as co-working space (together there are 15 workstations). Also the Joker rooms (16 m^2) can be used as work spaces [22, 23]. During the pandemic, interest in hiring a workplace was greater than before.

Also in Capitol Hill Urban Cohousing there is a work space – Schemata Workshop, an architectural office responsible for design of the building is located on its groundfloor [7]. Its owners Grace Kim and Mike Mariano live in Capitol Hill, so they actually combine working and living in the same building. Inside the building there are no additional work spaces for rent but during the pandemic an additional guest room (usually used as a common space) was disposed as work space to one of the inhabitants, so that is a sign that such a space could be useful in cohousing communities.

MODULAR FLEXIBILITY

One of the currently noticed directions of shaping housing is giving its future inhabitants the opportunity to decide on the layout of their flat. That idea is developed by Marc Koehler from MKA in Amsterdam, under the name Superlofts [19]. It is a modular system that is meant to give the possibility to create a flexible living space able to be adapted over time to changing needs [8]. This solution is supposed to offer future residents also the possibility to co-create common areas in the building – to select their typology and shape them. These can include roof terraces, gardens, work studios, guest spaces, and shared services such as electric cars and charging points.

The first Superlofts buildings were constructed in 2016 on the 3 sites in Houthavens, that is a post-industrial district in Amsterdam. Even though there is a great potential in co-creating common spaces in the building, in reality it turned out that there are not so many of them. Inside the Superlofts Houthaven in Amsterdam there are only common car parks, roof terraces and gardens on the roof above the car park [4]. Nevertheless, inhabitants are satisfied with living in those buildings and have a feeling of being part of the community. Many of them think of their lofts as apartments of their dreams. The freedom of creating own apartments resulted in many unusual floorplans and designs realised in accordance with the wishes of the residents. Some ideas were possible to happen thanks to the double-floor height of the modules. One apartment is dived into two separate flats for parents and children. Another one is customised into the chef's atelier, where cooking classes and workshops are held. There is also one where there is no door inside it.

Fig. 5. View towards the façade of the Superlofts Houthavens buildings located in Amsterdam. Photo: author

One of the inhabitants of the Houthaven Superloft lacks social diversity in terms of social class and income [4], as was also mentioned in case of Schoonship [10] – these neighbourhoods are exclusive to people who can afford it.

Superlofts provide great flexibility and after construction of first building there is an interest in such solution. This resulted in realising of further Superloft buildings in other locations in the Netherlands and abroad.

SUSTAINABILITY

Designing buildings in accordance with the guidelines of sustainable development and circular economy rules is nowadays observed in every building typology, not only housing. The awareness of the climate change is so great that implementation of various technological solutions increasing buildings climate neutrality is an obvious fact, not a choice anymore.

The ambition of Schoonship community is to be an energy-independent floating neighbourhood. Despite the very important social aspect of the Schoonship, that made the whole project possible to be realised, there are also other sustainable solutions implemented. As Schoonship is located in Buiksloterham, it was designed according to the rules of circular economy, which is one of the principal guidelines for that area [2]. This floating neighbourhood was planned by Space&Matter that decided on using building materials that are as sustainable as possible, such as cork, bamboo and wood. There were also some guidelines from the city governors such as the minimum surface of roofing allowed for vegetation (which was a third of each roof). The electricity is produced by 500 solar panels, that are also connected to the municipal electricity grid which gives an ability to exchange electricity in a smart way [12, 18]. All of the water pipes and other installations run under the piers.

Kalkbreite aims to promote sustainable living in various aspects: economic, social and ecological [15]. Despite the low average area consumption per person, including shared spaces (33,5 m^2 comparing to the usual 45 m^2 in Switzerland or 41 m^2 in Zurich), there are also technological solutions implemented. Heat pumps are used to produce hot water, there is a comfort ventilation system and part of the electricity is produced by the photovoltaic system. In 2017, Kalkbreite was certified as a 2000 Watt site in operation, which means that its average energy consumption per capita is 2000 Watt, while in Zurich it is 4000 Watt. In order to achieve the certificate 5 areas were investigated and evaluated. The first one is communication and cooperation which has been awarded with high value. Other aspects taken into account are: supply and disposal, mobility and management system. The last one was building construction from the beginning (also with planning process) and its operation. The 2000 Watt Area certificate is valid for four years and in 2017 the Kalkbreite was one of the 5 sites that received it [20].

Also the Houthaven Superlofts are designed to be climate neutral [17]. To achieve that goal various solutions were implemented. The prefabricated façade, that consists of aluminium frame and triple-glazing infill, has integrated solar shading, drainage system and air ventilation. There is also an option of adding an extra green house for air filtering in each apartment. Each of the owners can decide on the layout of the windows in the apartment. Also the size and configuration of the concrete balcony can be customized. The sun shutters are controlled remotely. Inside the buildings there are also other smart systems such as solar panels for electricity, mechanical ventilation and geo-thermal pumps. Water from the canals is used in floor cooling system.

CONCLUSION

Housing is the reflection of what is happening in society and culture. While the interpersonal relations and cultural issues are changing, it is also necessary to change the way of life and, later, the way in which the housing environment is shaped, as it should be adapted to the needs of the inhabitants. While changes are fast, the responses should also be. There are many aspects that seem to be important in creating residential architecture of the future. Technological solutions related to ecology in architecture seem to be already an obvious issue in terms of the climate change – it is also visible in the presented in the article examples. The common feature of the selected buildings, which may be representative of the trends in shaping the residential architecture of the future, is the social aspect, which is their great strength. It is significant in the cohousing and CPC/CPO buildings, where future residents are involved in the entire process. It has been proved that those solutions give the inhabitants the sense of being part of the community, which is very important, also during a pandemic. The other important factor of housing of tomorrow is flexibility, that might be considered in different scales. It may give residents the ability to shape the internal layout of their apartments (e.g., Superlofts Houthaven). They can also decide on the type of the common spaces in the building and change their function when such an adjustments is needed (e.g., additional workplaces in Kalkbreite and Capitol Hill).

To sum up, the social aspect seems to be important, especially recently, as it gives residents a sense of belonging to a larger group, that might enhance their mental health. What is also present and perceived and may be important in shaping the residential architecture of tomorrow, despite the ecological solutions related to the circular economy, is its flexibility, which allows for functional changes, e.g. to combine working and living when needed, as the most important goal of housing should be the ability to respond to lifestyle changes.

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WYBRANE KIERUNKI KSZTAŁTOWANIA ARCHITEKTURY MIESZKANIOWEJ PRZYSZŁOŚCI

Głównym celem mieszkalnictwa przyszłości jest tworzenie przyjaznego, bezpiecznego i zdrowego środowiska dla mieszkańców. Niektórymi z ważnych aspektów w projektowaniu budynków mieszkalnych przyszłości są: zaawansowanie technologiczne, zrównoważony rozwój, ekologia i gospodarka obiegu zamkniętego. Te zagadnienia wydają się być aktualne w każdej typologii budynków. Przestrzeń mieszkalna odgrywa kluczową rolę w życiu każdego człowieka i z tego powodu konieczne jest zwrócenie uwagi także na inne aspekty, które są ważne w jej kształtowaniu. Istotnym elementem środowiska mieszkaniowego przyszłości jest jego aspekt

społeczny, który wpływa na relacje międzyludzkie. Ostatnio można zaobserwować także tworzenie w środowisku mieszkaniowym przestrzeni do pracy. Przedstawione w artykule wnioski są wynikiem analizy opartej na badaniach literaturowych i terenowych oraz wywiadzie. Przeanalizowano różne przykłady, aby przedstawić możliwe rozwiązania w architekturze mieszkaniowej przyszłości, wskazując kierunki jej rozwoju zaobserwowane w ostatnim czasie.

SELF-ORGANIZATION OF LOCAL COMMUNITIES – A MODEL SCHEME OF DEVELOPMENT BASED ON CASE STUDIES FROM THE UK, GERMANY AND POLAND

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ABSTRACT

The article presents self-organization of local communities in the context of traditional methods of participation and bottom-up revitalization, and focuses on its specific type which is established around a space important for the residents. The aim of the article is to show the evolution of self-organization in interaction with local government, private investors and a wider group of inhabitants, which leads to major socio-spatial changes. The analysis of five selected case studies from the UK, Germany and Poland allows to capture common patterns of behavior beyond geographical and administrative differences and, as a result, create a model scheme of self-organization development, which may become a guideline and inspiration for local communities and governments in other locations.

Keywords: self-organization, social participation, bottom-up revitalization, grassroots initiatives, activism

INTRODUCTION

Spatial planning, which for centuries has been an exclusively top-down process, has undergone a transformation in recent years. The growing role of capital has changed cities into huge enterprises where growth has become more important than development. A consequence of the neoliberalization of urban policy was a gradual loss of the leading role in creating space by public entities to the “invisible hand of the free market”. In a city where financial capital plays an increasingly important role, the market value of space outweighs its utility value, losing its relationship with the real needs of the inhabitants [1]. Thus, neoliberalization has become one of the main reasons for the crisis of representative democracy which is based on the transfer of decision-making power to the elected representation of the community [2].

In the context of the crisis of trust in local governments and the growing civic awareness, the way residents are involved in urban policy is changing. They demand the possibility of influencing decisions on their own terms, cooperating with public entities and using available tools to achieve their goals [3]. Inhabitants self-organize around issues and problems that are important to them, thus avoiding the "nightmare of participation" as a top-down and unfair process [4].

The article presents a specific type of self-organization[1] established around an important for the community space, which evolves in interaction with formal government institutions, private investors and a wider group of residents. A self-help group formalizes and takes over real estate endangered with demolition or sale, thus initiating a bottom-up revitalization[2] in its neighborhood. The analysis of case studies from the UK, Germany and Poland allow to capture common patterns of behavior beyond geographical and administrative differences and create a model scheme of the self-organization development. The analysis of recurring, bottom-up activities can be useful in the process of redefining traditional participatory methods, and the scheme itself can become a guideline for self-help groups and local governments that would like to cooperate with them.

THE CONCEPT OF SELF-ORGANIZATION

The concept of self-organization comes from natural sciences and refers to "the emergence of an overall order in time and space of a given system that results from the collective interactions of its individual components" [5]. The process of self-organization is spontaneous and requires no control by any external factor. The organization of the resulting system is decentralized, scattered over all components, therefore it is able to repair itself and survive considerable difficulties. By analogy, it has also found application in sociology, economics and anthropology.

In the article, self-organization is defined as a grassroots initiative of a community that associates because of a problem and comes up with a proposal and idea for solving it to local authorities. Self-organizing residents will be called a self-help group.

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1 A specific type of self-organization arising from dissatisfaction and concerning the space that is important to the community. It differs from the NIMBY (Not In My Backyard) initiatives, which are organised to block the city's activities. The described self-organizations come up with an idea and initiative to use a given space and cooperate with the city and other actors of public life.

2 Bottom-up revitalisation - community activity and ability to mobilize in order to improve living conditions and the quality of space (Przywojska 2016, p. 17).

THE CAUSES OF SELF-ORGANIZATION

The visibly increased need for self-organization of communities results from the crisis of representative democracy, which is caused, among others, by neoliberalization of urban policy [2], [6]. “Strong involvement of municipal authorities in working towards economic development, and, consequently, dependence on the activities and interests of the private sector undermined faith in the adequate representation of residents’ interests in politics” [2]. The social costs of the financialization of cities become more pronounced in times of recession, as it was after 2008, and is likely to be due to the post-pandemic crisis. The crisis on the market reveals the administrative problems of cities and leads to budget cuts, privatization, redundancy and under-financing of public services. This deepens the gap, existing even in a relatively stable situation, between the way institutions operate, their readiness as well as the ability to respond to residents' needs and real demand. People’s needs change so quickly that institutions are unable to keep up with modifying their structures and methods of operation [7]. In such a situation, some residents will strive to improve their living conditions in order to reduce anxiety resulting from the failure to meet their essential needs.

Self-organization also emerges as a reaction to flawed and limited procedures for involving citizens in public life and decision-making. Traditional participation, including public consultations, panels and civic budgets, was created to involve residents in decision-making processes, but only on terms set by the authorities. As Markus Miessen [4] points out, designating unambiguous ways and forms of implementation of participatory involvement, in advance excludes spontaneous, bottom-up co-creation of democratic power. What is more – “the procedures of civic participation are inscribed in a coherent system of neoliberal society and legitimize the democratic dimension of public sector decisions – in fact made in the interest of market solutions” [2]. The most conflicting situation is when the community is not informed about the course of procedures concerning it, especially those contrary to its interests. The residents are able to react at the final stage of the process, when the most important decisions have been made and their verification is administratively much more complicated than at the stage of creating assumptions [8]. The apparent participation[3] leads to the implementation of revitalization projects that are inadequate and do not respond to the needs of the inhabitants, which increases tension between the authorities and the community and causes frustration of the inhabitants. An alternative may be self-organization, which differs from the traditionally understood civic participation. It is the inhabitants who take the initiative and define the content – the subject, priorities, plans and processes within which their involvement will take place [3]. They establish grassroots, more or less formalized organizations to be directly involved in public administration.

[3] Apparent participation - carried out to justify the opinion of the authorities, to give credibility to decisions already taken or simply to meet the participation requirement (Kwiatkowski 2017, p. 17).

THE IMPORTANCE OF SELF-ORGANIZATION

The potential of residents ready to engage in the renewal of their neighborhoods is not sufficiently used in the revitalization strategies or participatory procedures. Successful examples of self-organization show how significant this omission is and prove that bottom-up revitalization can have a positive impact on the development of a district. According to Iwona Sagan [2], bottom-up revitalization initiatives are much more economically effective than top-down actions, they reduce the risk of gentrification processes, stabilize and strengthen mixed social structures, and contribute to building community ties and civic attitudes. In this scheme "society plays a double role in repair processes: it is both the initiator of these processes, plans them, controls their course, monitors the effects and is subject to their influence" [9]. Such a strong residents involvement in the renewal process gives a chance for an appropriate response to their needs, identification with goals and development plans, and as a result, the complexity and durability of positive changes [10]. Self-organization is also an investment in social capital – these activities are the seeds of civic movements that lead to the creation of initiatives of social involvement in politics and city management [11] and regaining a sense of agency and belonging.

CASE STUDIES

The article examines five examples of self-organization from Great Britain, Germany and Poland from the last two decades which lead to the creation of a model scheme of self-organization development. Although generalizing in a matter as dynamically developing and unpredictable as social interactions and behaviors is an obvious simplification, in the case of the following studies it is important to find patterns that will allow a better understanding of the phenomenon and will become a guideline for local communities and authorities that will cooperate with self-help groups. It seems interesting to compare examples with different geographic and administrative conditions (although located in a relatively culturally homogeneous area), because finding repeatable actions in communities from different countries may suggest the potential possibility of implementing the created model scheme of development in other locations.

1. Bramley Baths, Leeds, Great Britain[4]

The Bramley Baths is the last Edwardian Bath in Leeds, Great Britain, which today functions as a public swimming pool. Due to significant budget cuts in March 2011, the city authorities announced planned restrictions on the operation of the baths to 29 hours/week.

[4] Official website of the self-organization: https://bramleybaths.com/

Groups of opponents formed spontaneously - residents organised a tweet up[5] to publicize the problem, created a petition to the city authorities, children from local schools wrote letters to officials and protested in front of the bathhouse. The social campaign became so visible in the media that it attracted the attention of MP Rachel Reeves, who raised the issue of Bramley Baths in parliament [12]. The public pressure was so strong that in June 2011 the Leeds authorities proposed to hand over the management of the facility to the local community. To complete this process, a group of residents supported by local organizations worked on a form of formalization of self-organization, a business plan and methods of obtaining funds. The new chapter in the history of Bramley Baths officially began on January 1, 2013 with the establishment of a non-profit organization in Industrial Provident Society formula. The community not only managed to keep the space alive, but also expanded its sports and recreational functions with a social function [13] (Table 1).

Table 1. Scheme of the evolution of self-organization around Bramley Baths (by Z. Kasperczyk)

I. Endangered space	1. The city plans to limit the working hours of local baths
II. Reaction of residents	2. The residents' fear of the complete closure of the baths
III. Neighborhood initiatives	3. Organization of the tweet up 4. Petition 5. Protest of children from local schools
IV. Broadening the outreach	6. Support from MP Rachel Reeves
V. Negotiations with the city	7. Invitation from the city authorities to cooperate
VI. Formalization of self-organization	8. Creating a business plan by a group selected 9. Establishing a non-profit organization in the Industrial Provident Society formula
VII. Agreement with the city	10. 50-year lease agreement with the city
VIII. Space in the hands of residents	11. Expansion of sports and recreational functions with social functions, creating a profitable business

2. Stretford Public Hall, Stretford, Great Britain[6]

The Stretford Public Hall is a listed property dating from 1878, which housed the local library and a theater. In 2013, Stretford officials announced their plans to sell a decaying building. Residents responded by forming the Friends of Stretford Public Hall group to restore the facility to the community. The activists held open meetings where they discussed the future of the facility, created a petition and organized an Open Day, during which residents could visit the building and integrate. With the help of local specialists and organizations, they created a business plan and registered the property as an Asset

[5] Tweet up – a meeting or other gathering organized by means of posts on the social media application Twitter (Oxford Languages).

[6] Official website of the self-organization: https://www.stretfordpublichall.org.uk

of Community Value. To buy the building from the city, they formalized the organization in the Charitable Community Benefit Society formula. On March 25, 2015, the building was officially handed over to the residents. The Stretford Public Hall space is rented to artists, there are also offices and co-working spaces [13]. The newly renovated ballroom acts as a place for social events and art classes (Table 2).

Table 2. Scheme of the evolution of self-organization around Stretford Public Hall (by Z. Kasperczyk)

I. Endangered space	1. The building falls into disrepair, risk of closure and sale
II. Reaction of residents	2. Establishing Friends of Stretford Public Hall
III. Neighborhood initiatives	3. Organization of open meetings/consultations 4. Petition 5. Organization of the Open Day
IV. Broadening the outreach	6. Support from local specialists, businesses and organizations
V. Negotiations with the city	7. Registration of the facility as Asset of Community Value
VI. Formalization of self-organization	8. Establishing an organization under the Charitable Community Benefit Society formula
VII. Agreement with the city	9. Formal handover of the building to residents (Community Asset Transfer)
VIII. Space in the hands of residents	10. Obtaining financing in the share offer formula 11. Renovation of the facility 12. Creating a community center important for the community

3. Granby Triangle, Liverpool, Great Britain[7]

Liverpool's Toxteth is a space marked by a conflict between government and community from the 1980s, struggling with high levels of unemployment and decaying buildings. The long-term lack of funding for the renovation of old tissue and the promotion of its replacement with new objects led to the degradation of the area and the abandonment of the district. But despite the ongoing depopulation of the area, residents of four streets near Granby Street decided to react. In order to maintain their properties, they began tidying up the area, repainting the facades and planting plants. They organized a market that became a regular event and attracted people from all over the city. Small neighborhood actions have built up social capital over the years, which in 2011 led to the creation of Granby Four Streets Community Land Trust – a non-profit organization that manages the area on behalf of the community. Activists tried to cooperate with the city presenting their plan to revitalize the area, but officials agreed on serious negotiations only when an investor offering a loan of 500,000 emerged.

[7] Official website of the self-organization: https://www.granby4streetsclt.co.uk

Table 3. Scheme of the evolution of self-organization around Granby Triangle (by Z. Kasperczyk)

I. Endangered space	1. Demolition of buildings in the Toxteth area of Liverpool
II. Reaction of residents	2. Activists from Granby Street want to stop the process
III. Neighborhood initiatives	3. Guerilla gardening 4. Tidying up of the area, renovation of the facades 5. Granby Street Market
IV. Broadening the outreach	6. Local initiatives attracts people from all over the city, the risk of liquidation of the district reaches many people
V. Negotiations with the city	7. Contact with the city council, presentation of the revitalization plan
VI. Formalization of self-organization	8. Establishment of Granby Four Streets Community Land Trust
VII. Agreement with the city	9. £ 500,000 loan from Steinbeck Studio 10. Handing over 10 buildings to the Trust
VIII. Space in the hands of residents	11. Cooperation with the Assemble architectural office – renovation of buildings and construction of apartments for sale and rent, Granby Workshop ceramic studios and Granby Winter Garden

Ultimately, the trust took possession of 10 properties near Granby Street [14]. The renovated properties, designed by the Assemble architectural office, have space for apartments for sale and rent, a ceramic studio and a winter garden. The area has become so famous and attractive that instead of depopulating it attracts new residents (Table 3).

4. Rotaprint Fabrik, Berlin, Germany[8]

The Rotaprint Fabrik is a printing machines factory complex in Berlin functioning from 1904 to 1989. The buildings were severely damaged during World War II, but were rebuilt in the 1950s in the style of post-war modernism to a Klaus Kirsten design. After the declaration of bankruptcy in 1989, the abandoned space began to be used by small entrepreneurs, artists and social organizations. In 2002, the city decided to sell the factory buildings, which aroused opposition from tenants. The initiators of the self-organization were the artists Daniela Brahm and Les Schliesser, who created a folder presenting an idea for preserving, promoting and expanding the factory space.

Then they invited other users to found the ExRotaprint association, which started negotiations with the city. The land sales company was not interested in social and public functions and, behind the association's back, negotiated with an Icelandic investor planning to buy 45 properties. Ultimately, the investor gave up the purchase, which allowed activists to negotiate a very favorable price. ExRotaprint established a non-profit company that started cooperation with foundations supporting social initiatives

[8] Official website of the self-organization: https://www.exrotaprint.de/en/

and preventing land speculation. On October 1, 2007, the complex was officially handed over to the Stiftung trias and Stiftung Edith Maryon foundation, with which ExRotaprint signed a perpetual usufruct agreement (Erbbaurecht). The buildings of the Rotaprint factory have become an important space for residents, where cultural and social initiatives as well as small enterprises operate [15] (Table 4).

Table 4. Scheme of the evolution of self-organization around Rotaprint Fabrik (by Z. Kasperczyk)

I. Endangered space	1. The city plans to sale the factory buildings
II. Reaction of residents	2. Initiation of self-organization by artists Les Schliesser and Daniela Brahm
III. Neighborhood initiatives	3. Interviews with tenants 4. Folder presenting the idea for the preservation, promotion and expansion of the complex
IV. Broadening the outreach	5. Establishing the ExRotaprint e.V. associatione
V. Negotiations with the city	6. Negotiations with a land sale company
VI. Formalization of self-organization	7. Establishing of a non-profit limited liability company ExRotaprint gGmbH
VII. Agreement with the city	8. Purchase of real estate with help of the Stiftung trias foundation and Stiftung Edith Maryon 9. Signing a perpetual usufruct agreement with foundations (Erbbaurecht)
VIII. Space in the hands of residents	10. Activation of the entire complex, rental for cultural, social and production purposes

4. Osiedle Jazdów, Warsaw, Poland[9]

Osiedle Jazdów is a colony of 90 wooden, prefabricated houses, which was established in 1945 for the employees of the Capital Reconstruction Office. Finland donated the houses to the USSR as a war contribution, and some of them were sent to Poland. After the war, the number of houses gradually decreased, giving way to the Łazienkowska Route and the embassies of France and Germany. The risk of liquidation of the housing estate appeared in 2010 with the Resolution of the Śródmieście District Board on the tidying up of the Jazdów area. In order to save the neighbourhood, in 2011 the residents established the Association of the Residents of Jazdów Finnish Houses. The grassroots social campaign reached the Finnish ambassador, Jari Vilén, who convinced the city to keep a few houses for social and cultural purposes. The social campaign gained momentum and an idea to animate the decaying space emerged – Osiedle Jazdów was opened to visitors for the first time during the 2013 Night of Museums, and in the following months it hosted dozens of organizations, actions and educational, social and cultural events. Then an Open Jazdów social initiative was created, which together with the Residents' Association started negotiations with the city. The several-month-long

[9] Official website of the self-organization: https://jazdow.pl.

process of public consultations revealed a social attachment to Jazdów and the common need for a multifunctional green area in the center of Warsaw. In 2015, the city recognized the result of the consultations as binding and activists created the Open Jazdów Partnership Association. The partnership is a recognized representation of Osiedle Jazdów and is working on a model of social co-management. It also works for conservation and planning arrangements to ensure the space of the Jazdów neighbourhood with hard legal protection [16] (Table 5).

Table 5. Scheme of the evolution of self-organization around Osiedle Jazdów (by Z. Kasperczyk)

I. Endangered space	1. The city plans to liquidate the Finnish houses
II. Reaction of residents	2. Establishing the Association of the Residents of Jazdów Finnish Houses
III. Neighborhood initiatives	3. Protest in front of the Office of the Capital City of Warsaw 4. Establishing the Open Jazdów initiative 5. Nongovernmental organizations and informal groups are starting to operate in abandoned houses, social, cultural and educational projects
IV. Broadening the outreach	6. The intervention of the Finnish ambassador Jari Vilén
V. Negotiations with the city	7. Conducting official public consultations
VI. Formalization of self-organization	8. Working on the structure of the organization, goals and form of cooperation 9. Establishing the Open Jazdów Partnership Association 10. Working on an innovative model of co-management of the estate
VII. Agreement with the city	–
VIII. Space in the hands of residents	11. Despite no agreement with the city, the facilities are still in use and works as an important social and cultural center of Warsaw

CROSS-CASE OBSERVATIONS

All analyzed examples of self-organization have developed in a specific social and institutional context and have their own unique features. However, despite the obvious differences, there are some repeating patterns that may suggest broader trends and lead to create a model scheme of self-organization evolution.

Endangered space

Self-organization is often born out of dissatisfaction or discontent and this also applies to the examples discussed above. In each of them, the community came together to express its opposition to local government plans that threaten the future of important spaces for them and to develop an alternative action plan. It was the space that became the bonding element of people with different backgrounds, features and skills, and for space they were able to “fight” over divisions. The residents of Leeds did not want to allow the authorities to close the swimming pool, activists from Stretford and Berlin were afraid of the sale and commercialization of an important space for them, and in Warsaw and Liverpool the buildings used by the community were threatened with demolition. The examples described above show that “discontent can morph into positive and productive initiatives with citizens taking the lead in developing alternative policies and engaging in public administration” [3]. This proves that civic initiatives are not only inhibiting and hindering the actions of local governments, but may also include constructive actions aimed at improving the situation in the public sphere.

Neighborhood initiatives

After the phase of formulating the objection and the first attempts at organization, the action phase follows. Neighborhood initiatives arising in this phase can be divided into protest actions and promoting space actions. Protest actions include all publicly and collectively expressed forms of opposition, such as: tweet up, petition, protest in front of the government building. At the same time, residents promote the endangered space, thus publicizing the problem and gaining new allies. The promotion may take the form of a folder presenting the idea for space (Rotaprint Fabrik), guerrilla gardening (Granby Triangle), open days with sightseeing (Stretford Public Hall, Osiedle Jazdów) or social and cultural events (Osiedle Jazdów, Granby Triangle). These low-cost, bottom-up activities integrate and strengthen the self-help group, but also reveal the functional and social potential of a given space. The publicized topic reaches a wider group of residents and local authorities, but also potential sponsors and politicians who want to be involved in the process of “saving” space. Small interventions initiated by individual residents build social capital and, as a result, lead to much greater changes.

Negotiations with the city

The described examples prove how important for the development of self-organization is cooperation with local authorities [2], [3]. Residents expressing their opposition are often regarded as an obstacle in carrying out the administrative process, also active self-help groups are still isolated cases, which explains the lack of experience in community-local government cooperation. The commencement of negotiations with self-organization requires changes in municipalities’ previous plans, which is often associated with the rejection of lucrative proposals from private investors. In such a situation, despite the planned social, activating and attractive for residents functions, self-organizations must compete with commercial offers and only the emergence of financial support convinces the authorities (Granby Triangle, Rotaprint Fabrik). On the other hand, if the city has not had an idea of what to do with a given property, the proposal of self-organization is received rather favorably (Bramley Baths, Stretford Public Hall). In the case of Osiedle Jazdów, an agreement between the self-organization and the city has not been concluded yet, which may suggest that on Polish administrative ground it is still difficult to conduct such a cooperation.

Formalization of self-organization

There is a common opinion that only professionals can operate in the public sphere. The examples above prove that the inhabitants are capable of involvement and during the evolution of self-organization they develop, acquire new skills and learn new things [14]. Of course, support from experts is needed to pass on knowledge, improve the organization of the self-help group and make it a serious negotiating partner, but it is the involvement of individual residents that drives the whole process. Mobilization and unwavering faith in achieving the goal is all the more important as the forms of formalization available and beneficial to self-organization are often pioneering or rarely used in a given country. It is important to protect real estate against commercialization and keep it in the hands of the community, that is why self-help groups function as many different types of non-profit community associations.

Space in the hands of residents

Taking over the endangered space by residents is an opportunity to restore it to the community and to manage it more effectively. All properties described above, after being taken over by residents, became some form of community center – a recognizable and important space for the community, filling some functional gap. The whole process of “fighting” for space changed the social perception of a given property – it appeared again or in a new form in the minds of people who often expressed a desire to support or commitment. In this way, the community united and integrated even before the space was officially handed over to non-profit organizations, which was a very good starting point for further development.

CONCLUSIONS

The analysis of five examples of self-organization led to the finding of repetitive actions and behaviors that were collected in the form of a model scheme for the development of self-organization. The process consists of eight steps, from endangered space to space in the hands of residents. The scheme (Table 6) shows a universal cause and effect sequence that can be implemented in different locations and in different administrative contexts.

Table 6. Model scheme of self-organization development (by Z. Kasperczyk)

I. Endangered space
a) the risk of restricting access b) the risk of sale and commercialization c) the risk of demolition
II. Reaction of residents
III. Neighborhood initiatives
a) protests b) actions promoting space
IV. Broadening the outreach
V. Negotiations with the city
VI. Formalization of self-organization
VII. Agreement with the city
a) long-term rental/lease b) ownership
VIII. Space in the hands of residents

The reason for the emergence of each of the described self-organizations was the disagreement with the decision made by the authorities regarding the space that was important for residents. In all cases, they were old or historic objects that became a permanent part of the community's awareness and were located in attractive locations. Maintaining such a space requires large financial outlays from the city, which often becomes unprofitable under economic and political pressure. Especially in a crisis and lack of funds, local governments decide to limit the financing of public services, privatize municipal real estate, demolish degraded buildings and sell empty land. The stage of social consultations is then omitted, and the inhabitants are faced with a fait accompli, which arouses dissatisfaction and leads to a conflict.

However, it cannot be concealed that it was the breaking of the status quo and the fear of losing a given space that mobilized and integrated the group of activists. Probably even the best civic consultation would not create the kind of stimulating pressure that was the leaven of such social and spatial changes. Although the achievements of the described self-organization are impressive, they are individual examples that were the result of a combination of favorable attitude of the authorities and strong social commitment. In hundreds of other cases, attempts at self-organization have not occurred or have been unsuccessful, leading to the irretrievable loss of many properties. Therefore, the aim of urban policy should be to create an environment in which proactive activity is supported, residents have space for their own initiatives, but without pressure and fear of losing important places.

The still binding neoliberal urban policy is widely criticized for its anti-social approach and for placing growth over development. "Development should be understood as a combination of an efficient public sector, taking into account market mechanisms, and the civic sector" [6]. The examples of self-organization described above prove the effectiveness of the civic sector - the activities of each group initiated bottom-up revitalization, saved the endangered space from commercialization and gentrification, and had a beneficial effect on the activation of residents and the long-term development of the district. "The space produced by social entities can therefore be understood as a pro-development stimulating factor, modeling sustainable, socially responsible urbanization" [6].

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SAMOORGANIZACJA SPOŁECZNOŚCI LOKALNYCH – MODELOWY SCHEMAT ROZWOJU NA PODSTAWIE STUDIÓW PRZYPADKÓW Z WIELKIEJ BRYTANII, NIEMIEC I POLSKI

Artykuł prezentuje samoorganizację społeczności lokalnych w kontekście tradycyjnych metod partycypacji i oddolnej rewitalizacji oraz koncentruje się na jej specyficznym rodzaju, który tworzy się wokół ważnej dla mieszkańców przestrzeni. Celem artykułu jest próba ukazania ewolucji samoorganizacji we współpracy z samorządem, prywatnymi inwestorami i szerszą grupą mieszkańców, która prowadzi do istotnych społeczno-przestrzennych zmian. Analiza pięciu wybranych studiów przypadku z Wielkiej Brytanii, Niemiec i Polski pozwala uchwycić wspólne wzorce zachowań wykraczające poza różnice geograficzne i administracyjne, a w efekcie stworzyć modelowy schemat rozwoju samoorganizacji, który może stać się wskazówką i inspiracją dla społeczności lokalnych i samorządów w innych lokalizacjach.

TEMPORARY ARCHITECTURE IN THE 21st CENTURY AS AN EXPRESSION OF CHANGES TAKING PLACE IN CONTEMPORARY SOCIETY

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ABSTRACT

Architectural structures have accompanied mankind since time immemorial. They are places of refuge, worship, learning, play; manifestations of wealth and poverty, power and dependence, creative thought, and economics. Architecture influences the life of man and society, just as man and society influence architecture. New styles, trends, or fashions shape current architectural forms, depending on the condition of a given society. In the 21st century, the post-modern society of highly developed countries, characterized by individualism, loneliness, life in constant motion, and consumerism, considers short-termism a safe form of making all kinds of "deals". Contemporary temporary architecture, it seems, is a response to this kind of social need. Based on case studies, the various relationships between the phenomenon of temporary architecture and the needs of postmodern society as seen by Zygmunt Bauman will be presented.

Keywords: temporary architecture, pop-up, postmodernity, fluid modernity, liquid modernity

INTRODUCTION

Contemporary society, according to the diagnosis of Zygmunt Bauman, defined as post-modern society, has completely new features in relation to traditional and modern society. Let us list a few of them, that best define this kind of society and will be useful in the analysis of contemporary architecture of a temporary nature.

First of all, it is a society of individualists who pursue not common, but individual, goals, caring not too much about what is happening around them. As Bauman said: *What we do and see is called "individualization". And we would need to try really hard to spot a gardener who contemplates a pre-designed harmony beyond the fence of his private garden and then goes out to bring it about* [1].

The second feature is consumerism, it is society of fashion, fast changing trends and ever new skills. Contemporary society is shaping not self-aware citizens, but consumers who will fulfil their intended role perfectly. According to Bauman, even culture is no longer a place of value creation, but becomes a part of the market game: *Culture is now turning into one of the departments in the "all you need and dream of" department store into which the world inhabited by consumers has turned. As in other departments of that store, the shelves are tightly packed with daily restocked commodities, while the counters are adorned with the advertisement of latest offers destined to disappear soon together with the attractions they advertise. Liquid-modern culture has no "people" to "cultivate". It has instead clients to seduce. And unlike its "solid modern" predecessor, it no longer wishes to work itself. Its job is now to render its own survival permanent through temporalizing all aspects of life of its former wards, now reborn as clients* [2].

The next characteristic is flexibility, it is a society that changes quickly and always starts over when needed. One should avoid permanent declarations and long-term commitments. In the words of Bauman we are living in a "fluid modernity" and: (...) *a society of "fluid modernity" is a society in which the conditions of action change before the modes of action can become established in customary and routine formulas.* (...) *A fluid life, like a fluid society, cannot hold its shape for too long or maintain a stable course* [3].

Summarizing, the main new and important features of contemporary society are as follows: individualism, consumerism, constant change and movement, short-term experiences based especially on emotions. This society lives quickly, usually alone, rejects restrictions and permanent declarations and long-term commitment.

Postmodern society created, in the 21st century, a new form of temporary architecture which, unlike the previous examples of non-permanent architecture, is mainly to shock, surprise, provoke, fuel consumerism, and above all, to be short-lived, to appear in a different, new form the next time. Current observations and research show that, in the 21st century, interest in temporary architecture has increased, both in terms of use and design. This is also confirmed by the words of an internationally known art, architecture and design critic and writer Aaron Betsky, who in 2016 noticed: *Architecture is going pop. It is finally sloughing off its ridiculous obsession with eternity, and learning to live in and for the moment. Pop-up architecture, temporary structures, and other ephemeral frameworks for equally evanescent events have become all the rage, especially in Europe* [4]. In addition, the words of the writer and historian of architecture and design Tom Dyckoff, from 2018 also accurately reflect contemporary reality: *In the twentieth century,* (...) *architecture became another medium, and the building – a "representation mechanism". The postmodern battle of styles was won by the architecture that – in times of instant global communication – is the most efficient at communicating, the most visible, the most exciting and the most profitable. Welcome to the Wowhaus age* [5]. These words can be an introduction to further research. On a few examples of temporary architectural structures, the contemporary temporary architecture will be verified in terms of the possibility of responding to (postmodern) social needs.

While the topic of interim architecture is still a new and not fully explored topic, there are attempts to catalog temporary architecture and the like. It took place, inter alia, in

Rebecca Roke's book NANOTEKTURA. TINY BUILT THINGS [6], where the smallest architectural forms have been divided into the micro, mini, midi, macro and maxi structures. On the other hand, THE NEW PAVILIONS [7] by Philip Jodidio divides different kinds of pavilions into objects for gathering, d'art, learning, displaying, seeing/listening, living/working/play or shelter. Other works usually come down to the presentation of selected temporary objects, which we can see, for instance, in TEMPORARY architecture [8] by Lisa Baker or TEMPORARY ARCHITECTURE NOW! [9] by Philip Jodidio. This article will attempt to formulate a sketch of typology of all contemporary objects of temporary architecture and distinguish among them a new category of postmodern temporary architecture. These works will be continued in further scientific research.

TYPOLOGY OF CONTEMPORARY TEMPORARY ARCHITECTURE

Among all objects of contemporary temporary architecture we can find examples of objects in the following types: objects with a residential function, objects with educational function, exhibition pavilions, service and/or commercial facilities, objects and/or treatments to organize the space, artistic objects and finally other temporary cubature. Each group will be briefly presented and discussed on the basis of selected examples. The group of "objects with a residential function" is a diverse group, represented both by spontaneously created objects and well-thought-out constructions, and sometimes even prototypes.

Favela (favella), as an example of unsustainable architecture, is a name for Brazilian slums located generally in Rio de Janerio and Sao Paulo, as well as within or outside the country's other major cities. This type of development usually arises when wild tenants occupy empty land on the outskirts of large cities, building houses from stolen or recovered materials. These are usually makeshift structures, reinforced over time with more durable materials, such as brick or sheet metal. A feature of this type of development is the lack of technical infrastructure, instead they are equipped with improvised plumbing and electrical installations, and the waste disposal methods used pose a health risk. Unhygienic living conditions, poor nutrition and pollution, among other things, are the main causes of the spread of many diseases.[10]

The first aid architecture, as the another type of the discussed group, is an architecture that reduces, the effects of natural disasters or the effects of wars, pandemics and others. Better Shelter is the structure designed and produced by Ikea Foundation. The IKEA Foundation gave rise to the Housing for All Foundation, a non-profit organization that started a social enterprise called *Better Shelter*, from which this temporary facility was named. Better Shelter is a temporary shelter for basic needs, equipped with a solar panel and a lamp to provide light in the dark. No special tools or additional equipment are required for its assembly. The object is delivered in flat packages, which is the result of a project taking into account in particular its basic parameters, including volume, weight, price, safety for health and ease of transport. Thanks to the cooperation of the IKEA Foundation and UNHCR (The UN Refugee Agency), Better Shelter can ensure the safety and dignity of life for millions of refugees who have found themselves in exceptional circumstances while fleeing violence, armed conflicts or natural disasters [11].

When cities around the world are facing an enormous pressure on available and affordable housing, Urban Rigger seems to be an answer by building mobile communities on water. It is a unique, floating, flexible, mobile property improving the environmental footprint of our way of living in the city. The Urban Rigger, designed by Bjarke Ingels, was built based on the principles of building with LEGO bricks. This facility, depending on the needs, can be easily recreated in any size, placed in any place with access to water and used for various purposes. This is evidenced by the already commenced projects in Cork, Rotterdam and San Francisco. In Copenhagen, the current design community includes 12 apartments ranging from 23 to 30 square meters, and each housing unit can accommodate approximately 100 students. In addition to the residential part, which takes up approx. 300 square meters, twice as much is intended, among others, on the green courtyard located in the central part for recreation, bicycles, a bathing pier and a canoe marina. Additionally, approx. 220 square meters is occupied by a basement with a large lounge, kitchen, laundry room, technical and storage rooms. On the roof there is an observation deck, a green roof and a place for solar panels. *In the summer of 2019 an additional 5 Riggers joined the first one in Copenhagen, and we now have a fully functional floating village, consisting of 72 apartments* [12].

Fig. 1. Urban Rigger/ BIG, Bjarke Ingel's/ Floating student housing/ Copenhagen <https://www.dezeen.com/2016/09/22/big-bjarke-ingels-shipping-containers-floating-student-housing-urban-rigger-copenhagen/> [accessed: 17.05.2021]

An example of a mobile home, designed by The People's Industrial Design and People's Architecture Office in Beijing, for the 2012 Get It Louder Exhibition, is Tricycle House. This structure was created for people who cannot afford their own home. By choosing the presented solution, they can count on a universal interior equipped with a bed that transforms into a dining table or bench, a bathtub, a stove and an integrated water tank. The house is mounted on the frame of a tricycle, its housing is made of translucent material transmitting both sunlight and city lighting, the modular structure of which allows for expansion and connection between additional units of the facility [13]. *Reducing private living to the smallest footprint, the nomadic system promotes sustainable living by taking advantage of public resources. Public parks replace personal gardens, public toilets replace private toilets, parking places replace land ownership* (...) [14].

Speaking of objects with residential function we cannot ignore social housing support structures. Solutions of this type, more and more willingly introduced, especially in highly developed countries, are aimed at helping the homeless.

Fig. 2. Tricycle House/ People’s Industrial Design, People’s Architecture Office/ Beijing. https://popupcity.net/observations/the-new-nomads-temporary-spaces-and-a-life-on-the-move/ [accessed: 17.05.2021]

All of the above examples show the variety of described type, in which we can distinguish, for instance, objects from unsustainable architecture, so called “first aid architecture”, objects built from sea containers, mobile houses or assistance in the field of social housing. Each of the examples, despite its temporary nature, fulfills the functional assumptions of a residential building.

Another type, from the temporary structures classification, is "educational objects". This group of objects will be briefly presented and discussed on the basis of selected examples.

Hello Wood will be the first to be discussed as an international, independent learning platform that teaches through experience. Hello Wood began its educational activities in 2010, turning into an art camp and festival covering 20 universities and 30 countries in the following years. Every year, students participating in the workshops have a week to make wooden architectural installations on a given topic and under the guidance of previously selected tutors. In 2014, the leitmotif was "playing with balance". One of the ideas that has been implemented, next to e.g. facilities such as Cornwalk, Playground, SPACEship, Spikefort and Force, was the one called FAbrik, designed by MOOMOO Architects from Łódź. The resulting facility was created using only waste material created by other teams participating in the event. In this way, FAbrik was the result of a balance of wasted material ordered for the workshop. The project assumed the creation of two walls with a clearly marked contrast between the sharp edges and the smooth surface of the walls inside the structure [15].

On the other hand, Mediated Matter scientists from the MIT Media Lab created a project to investigate the possibility of combining digital and biological techniques for producing architectural structures. As part of the research, a dome of silk fibers woven by a programmed robotic arm was created. This arm has been programmed to mimic the way the silkworm is depositing silk. The arm then placed a kilometer long silk fibers on flat polygonal and metal frames, thus forming 26 panels which were arranged in a dome and suspended from the ceiling. The last stage of the project was to place, on the structure prepared in this way, 6,500 live silkworms, which, crawling on the dome, supplemented the structure with the missing silk fibers. This is how The Silk Pavilion was created [16].

In 2014, the New York studio The Living, with its own structure called Hy-Fi, won the annual Young Architects Program (YAP), competition organized by MoMA PS1. In this competition, young architects propose their vision of a temporary structure, which then becomes, in a way, the host of the museum's summer events. Hy-Fi was a structure made entirely of biodegradable materials. It was a set of circular towers made of bioblocks grown using a combination of agricultural byproducts and mushroom mycelium, which in this case acts as a natural digestive glue. Some of them, ultimately placed in the upper part of the structure, have been covered with a light-refracting coating, thanks to which the light reflects inside. The gaps in the brick layers additionally help ventilate the entire structure, using gravity [17]. The estimated lifetime of the installation is 60 days [18].

Among the presented examples illustrating the types of temporary architecture from the collection named as "educational objects" can be distinguished: objects created during educational workshops, prototypes and eco-structures. Such facilities, thanks to their characteristics of temporary structures, contribute to the development of science, setting its new directions and boundaries.

Fig. 3. Hy-Fi/ The Living/ Young Architects Program 2014/ The Museum of Modern Art., MoMA PS1/New York. <https://www.cladglobal.com/CLADnews/architecture-design/Eco-friendly-mushroom-tower-installation-opens-at-MoMA,-New-York/310076> [accessed: 08.06.2021]

Next type of temporary architecture objects classified as "exhibition pavilions", includes the following examples. *World's fair* [as a first example is a] *large international exhibition of a wide variety of industrial, scientific, and cultural items that are on display at a specific site for a period of time, ranging usually from three to six months* (...). *Since the mid-19th century more than 100 world's fairs have been held in more than 20 countries throughout the world. Generally speaking, these events are called world's fairs in the United States, international (or universal) expositions in continental Europe and Asia, and exhibitions in Great Britain. The term expo has also been applied to many expositions in various locations* [19].

An example of other exhibition facilities was the Nomadic Museum designed by Shigeru Ban Architects. It was a mobile traveling photo gallery by Gregory Colbert entitled Ashes and Snow, built of sea containers and so characteristic of this designer paper tubes. Despite the different configuration, depending on the location, the basic elements of the structure remained unchanged. Its main element was a checkered stack of shipping containers, grids of metal and paper pipes, and two rows of paper columns. The building was complemented by sloping sections of white PVC filling the spaces between the containers, the roof made of PVC membranes and the natural floor cut by the main communication route, made of recycled wooden boards from construction scaffolding [20].

Fig. 4. Nomadic Museum/ Shigeru Ban Architects.
<https://www.archdaily.com/777307/ad-classics-nomadic-museum-shigeru-ban-architects>
[accessed: 08.06.2021]

Exhibition pavilions and among them: pavilions for World Exhibitions (EXPO) or other exhibition facilities are one of the most visible and therefore well-known representatives of temporary architecture objects.

Among the objects presented to a wider part of the society, we can certainly find service and/or commercial facilities, for instance store interior po-ups. Usually it is a commercial function introduced for a specific period of time in the interior, focusing on unusual aesthetic solutions aimed at attracting and surprising the customer.

Pop-up structures have a similar effect. In 2015, the NIKE AMD pop-up space was opened to celebrate the world-famous sneaker on Air Max Day in Shanghai. This space was closed in a large, steel Nike box created by the London agency Rosie Lee with transparent walls, in which the display element were plastic air bubbles filled with rare copies of the legendary sneakers. This structure, combined with interactive events presenting the history of Air Max's heritage, was an informative experience for the customer taken quite literally into the world of the popular brand [21].

Another example of the same type are all kinds of mobile and food truck stands. In 2011, as part of the rejuvenation of the market for Lower Marsh in Waterloo, London, a tiny mobile performance venue designed by the Aberrant Architecture studio was presented. This unusual structure, based on 16th-century stalls, called Roaming Market, was made of steel and mounted on the trailer's chassis. At the two-story stand, steel stairs lead to the platform on the roof intended for the event space and the viewing terrace. Below is a covered seating area with a built-in chessboard [22].

Fig. 5. Nike's Shoe Box Pop-Up/ Rosie Lee/ Shanghai.
https://www.urdesignmag.com/design/2015/03/27/nike-air-max-day-pop-up-space-in-shanghai-by-rosie-lee/> [accessed: 17.05.2021]

Store interior pop-ups, freestanding pop-up structures, mobile stands, food trucks or objects built from sea containers, that have already permanently anchored in commercial public space, are service and/or commercial facilities, which just like the previous group of temporary facilities, provides not only commercial but also architectural variability and diversity.

"Objects and/ or treatments to organize the space" is the next type of temporary architecture examples, and temporary insertion of a function into the existing volume or temporary way of organizing space and landscape architecture represent this group.

Nocny Market was opened in 2016 and was the first initiative of this type in Poland. For his first season, he was awarded in the following plebiscites: Best Of Warsaw – Warsaw Insider (category: Game Changer), Nocne Marki – Aktivist (category: Place of the Year) and nominated for Wdech 2016 – Co Jest Grane24 (Place of the Year) and the President's Architectural Award st. Warszawy (The Best Architectural Event). It is an initiative that gives a second life to the abandoned platforms of the Warszawa Główna Osobowa railway station and a space created by a project that combines food, music and promoting a new lifestyle. In one place, the organizers gathered the most interesting street food and food truck exhibitors as well as music and art creators. Over the years, the Night Market has become one of the most attractive places on the capital's map, conducive to gatherings and relaxation in the atmosphere of the fair in summer evenings [23].

Noma Tulum is the third-ever full-size pop-up of this famous restaurant. The first took place in Tokyo in 2015, the following year in Sydney, and in 2017 Noma, led by René Redzepi, reached Mexico, where it opened its doors in exceptional circumstances for a period of seven weeks. The new, temporary headquarters of Noma was located between the jungle and the Caribbean Sea and was completely open to its nature and climate. The aim of this activity was to introduce new fresh local ingredients and culinary styles, which is what this world-famous Danish restaurant is famous for as an attraction for new and regular customers [24].

Landscape architecture, which is an inseparable element of every architectural and urban design, has a special place in contemporary society. Parklets and other elements of urban furnishing, which are gaining in popularity, encourage city residents to use public spaces and build interpersonal relationships. Next to "temporary insertion of a function into an existing volume" and "temporary way to organize the space" it is also one of the best ways to activate abandoned or yet unexplored places.

"Artistic objects" is the following type distinguished from the collection of contemporary temporary architecture, which will be briefly discussed below.

Fig. 6. NOMA/ Tulum.
<https://www.gq.com/story/photos-noma-mexico-behind-the-scenes>[accessed: 17.05.2021]

Serpentine has been presenting pioneering exhibitions of emerging practitioners to the work of recognized artists around the world since 1970, that is for half a century. In

London's Kensington Gardens you can see a year-round program from exhibitions, live events, education to architecture itself. The Serpentine Pavilion is an annual temporary structure designed by well-known and respected architects selected by an architectural commission. The temporary pavilion is open every year throughout the summer and is a venue for organized events [25].

Installations just as scenography facilities are a combination of elements of an architectural function with the artistic vision of the designer. The former are often independent compositions, while the scenery is usually the background for the organized event.

The Burning Man Festival is an annual festival held in the Black Rock Desert of northern Nevada. The organized event lasts 8 days during which the gathered community builds Black Rock City from scratch as an artistic form of self-expression. After a week, everyone leaves the desert, leaving it in its original state. In 2006, the contemporary artist Arne Quinze built a structure called *Uchronia* for this festival. 150 km of wooden beams were used to build this pavilion, and the resulting sculpture gave people a sense of security. The final act of the building's life was its grand finale, so the author himself set fire to his work of art, thus fulfilling the main assumption of the festival [26].

Fig. 7. Uchronia/ Arne Quinze/ Black Rock Desert/ Nevada.
<https://www.arnequinze.com/art-and-exhibitions/uchronia> [accessed: 08.06.2021]

In 2017, at the Dutch Design Week festival in Eindhoven, the MVRDV studio and think thank The Why Factory created a multicolored hotel in the tetris convention, as one of the festival facilities. The main theme of the festival was to answer the question;

what the city of the future should look like in the face of diminishing natural resources, climate change and an ever-growing population. According to MVRDV, the answer is architectural flexibility. The facility presented at the festival was composed of nine apartments in one of many possible configurations. Each unit that builds it has a different character, referring to the personality of its user, including for instance a lime-colored space with a hammock and ladders or a lemon-yellow privatized penthouse. Entering this world, one should remember that when deciding about one's own desires, one must come to terms with the spatial needs of others [27].

Presented examples of artistic objects like: Serpentine Galleries (Serpentine Pavilions), installations, scenography and other festival facilities show that usually they deal with a deeper topic, a contemporary problem, provoke reflection and sometimes they are only an aesthetic form accompanying the viewer for a moment.

Fig. 8. Multicolored Tetris Hotel by MVRDV for Dutch Design Week 2017. <https://www.archdaily.com/882300/mvrdv-designs-multicolored-tetris-hotel-for-dutch-design-week-2017?ad_medium=gallery> [accessed: 17.05.2021]

The last of the types of contemporary temporary architecture presented in this article concerns other temporary objects and one of the most interesting is among others cubature objects.

In London, a group of architects and artists from The Decorators and Atelier Chan Chan launched a temporary dining experience called Ridley's in 2011. It was a structure built on an abandoned plot of land at Ridley Road Market that involved marketers at a nearby market in the food preparation process, while encouraging gatherings. By participating in the event, consumers are led upstairs to a common table, while their selected dishes are prepared on the ground floor, which is also a place to exchange products purchased at the bazaar for a meal. When the order is ready, the mechanical table serves it to the guests upstairs. The temporary structure of the restaurant was designed mainly from metal scaffolding, wood-based panels and corrugated sheet. This summer installation showed a new way of using a deserted space, emphasizing its value and new potentials also in the context of building local communities [28].

Fig. 9. Ridley's/ The Decorators/ Atelier Chan Chan/London.
<https://architizer.com/projects/ridleys/> [accessed: 17.05.2021]

Another cubature project called AEROPOLIS appeared in 2013 at the Metropolis Festival in Copenhagen. It was designed by the Plastique Fantastique group in collaboration with Københavns Internationale Teater. This temporary space enclosed in a pneumatic shell, with an area of 100 square meters, has been designed with two optional surfaces allowing for even greater adaptation of the facility to its function. Thanks to its structure, Aeropolis changes its shape, being an independent form or squeezing between elements of the urban or natural environment. As part of the festival, the mobile space, prepared in this way, offered 13 different urban activities, from kindergarten, through yoga, martial arts, to silent disco, each in a different setting. This temporary form changes the perception of space, showing its new possibilities and encouraging communication with others by active participation in planned activities [29].

In "other objects" type we can also find traditional or more modern versions of yurts, tipis, wigwams, igloos and all kinds of temporary huts, as well as markets, circuses or portable restrooms. All known for ages and still just as needed.

Fig. 10. Aeropolis/ Plastique Fantastique/ Copenhagen.
<https://plastique-fantastique.de/AEROPOLIS> [accessed: 17.05.2021]

CONCLUSION

The above examples are just some from the collections of contemporary temporary architecture objects and already show the enormous variety of both their forms and functions, as shown in the Table 1, below.

In order to distinguish a new category of postmodern temporary architecture, we must recall the basic needs of the postmodern society that we have identified along with these that are, in a way, a side effect of liquid modernity. We talked about consumerism, endless changes, living in a constant movement, need for strong emotions and the deep but short-term experiences, as well as the need for closeness and connection. By eliminating, among the above, the kinds and distinguished types that do not meet the criteria of postmodernity, we obtain a new category of temporary architecture, deeply rooted in the times in which we live, among them: objects built from sea containers, mobile houses, store-interior pop-ups, pop-up structures, mobile stands, food trucks, temporary insertion of a function into existing volume, temporary way of organizing space, landscape architecture, and other cubature objects along with facilities enabling the life of modern nomads.

Table 1. Typology of contemporary temporary architecture

TYPOLOGY OF CONTEMPORARY TEMPORARY ARCHITECTURE	**Objects with a residential function.**	• Favelas, unsustainable architecture. • Assistance in the field of social housing. • First aid architecture. • Objects built from sea containers. • Mobile houses.
	Objects with an educational function.	• Workshops • Prototypes • Eco-structures.
	Exhibition pavilions.	• Pavilions for World Exhibitions / EXPO. • Exhibition facilities.
	Service/ commercial facilities.	• Store interior pop-ups. • Pop-up structures. • Mobile stands, Foodtrucks. • Objects built from sea containers.
	Objects/ treatments to organize the space.	• Temporary insertion of a function into the existing volume. • Temporary way of organizing space. • Landscape architecture.
	Artistic objects.	• Serpentine Galleries/ Serpentine Pavilion. • Installations. • Scenography. • Festival facilities.
	Other.	• Cubature objects. • Yurts, tipis, wigwams, igloos, huts, etc.. • Markets. • Circuses. • Portable restrooms.

A significant increase in popularity and the development of this type of contemporary temporary architecture can be observed in the 21st century. Architecture as one of the services or products has always been tailored according to the consumer's needs. The observations show that the temporary architecture of the 21st century seems to complement the contemporary world of architecture, filling the gap that has arisen in it. Permanent architecture that fulfills the basic needs of human existence does not take into account the new "whims" and the temporary needs of its user. This role is taken over by postmodern temporary architecture.

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WYBRANE KIERUNKI KSZTAŁTOWANIA ARCHITEKTURY MIESZKANIOWEJ PRZYSZŁOŚCI

Obiekty architektoniczne towarzyszą ludzkości od zawsze. Są miejscem schronienia, kultu, nauki, zabawy; przejawem bogactwa i nędzy, władzy i zależności, myśli twórczej i ekonomii. Architektura wywiera wpływ na życie człowieka i społeczeństwa, podobnie jak człowiek i społeczeństwo oddziałują na architekturę. Nowe style, nurty czy mody kształtują bieżące formy architektoniczne, w zależności od kondycji danego społeczeństwa. W XXI wieku ponowoczesne społeczeństwo krajów wysokorozwiniętych, nacechowane indywidualizmem, samotnością, życiem w ciągłym ruchu i konsumeryzmem, uznaje krótkoterminowość za bezpieczną formę zawierania wszelakich „umów”. Współczesna architektura tymczasowa, jak się wydaje, jest odpowiedzią na tego rodzaju społeczną potrzebę. Na podstawie studiów przypadków przedstawione zostaną różnorodne relacje między zjawiskiem architektury tymczasowej a potrzebami społeczeństwa ponowoczesnego w ujęciu Zygmunta Baumana.

MYCELIUM-BASED MATERIALS IN ARCHITECTURE. A CRITICAL REVIEW

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ABSTRACT

Mycelium composites are a pro-ecological and sustainable alternative to conventional building materials. They present promising performance results and have the potential to revolutionize the construction industry. Their particularly advantageous parameter is thermal conductivity that may enable the replacement of commonly used insulations with high environmental impact. The contribution of this research is twofold. Firstly, the paper contains an overview of fungal-based products and a comparison of their properties with commonly used insulation materials. Secondly, the proposals for the use of the mycelium composites in practical design solutions were indicated. The paper displays the recommendations for the future implementation and directions for further research.

Keywords: mycelium, mycelium-based materials, bio-insulations, bi-based materials, bio-architecture

INTRODUCTION

The high-carbon and high-energy building industry is, along with transport, the main contributor to the global energy consumption and CO_2 emissions [1]. One of the measures taken to decarbonize the sector is the tightening of the legislation oriented towards reducing the energy inputs for heating and cooling of the buildings [2]. In order to meet these requirements, larger amounts of insulation materials or insulation materials with lower thermal conductivity parameters are used both during the design process for the new buildings and as a factor in improving energy efficiency within the existing ones. The production of building insulation materials has a devastating impact on the environment and their expected decomposition is predicted for hundreds of years (Fig. 1). The search for environmentally friendly materials that can be disposed uncomplicatedly at the end of their lifecycle may contribute to improvement of the unfavorable ecological balance.

Bio-based architectural materials and low-tech components, characterized by simple processing methods and possibilities of reuse or natural decomposition fit into the principles of sustainable development [3].

One of the promising ecological alternatives are mycelium-based materials, whose properties have only been analyzed for a few years. Considering the favorable results of research on their properties [4] and the output of this paper, their implementation in construction would represent a shift towards the natural and environmentally friendly materials that contribute to the reduction of the CO_2 emissions and lowering the amount of construction sector waste production [5].

The aim of the paper is to evaluate and compare the properties of mycelium-based materials with conventional materials used in the construction industry in order to identify recommendations and propose implementations.

STATE OF THE ART

The cultivation of bio-based materials for architecture fits into the trend of design for sustainability; it stands on the borderline between the futuristic architectural concepts like bio-architecture, biophilic design and low-tech architecture based on naturally-sourced materials. The literature dealing in detail with mycelium-based materials and components in architecture is mainly focused on single case studies [6]. Mycelium-based materials can be distinguished by production methods: (A) which kill the mycelium during the manufacturing process, and (B) which seek to maintain the mycelium as a living organism [7]. In the past years, prototypes and projects have been made that consider applications of the material in construction using its structural and insulating properties, e.g., Mycotecture Alpha (2009), Hi-Fi (2014), Mycelium-Mockup (2015), Myco-Tree (2017) or The Growing Pavilion (2019). The application potential of mycelium-based materials is shown to be growing due to their physical properties, which however vary depending on the substrates used, growth conditions provided, selection of mycelial species and others [8]. The search for architectural applications shows the potential of the materials in space architecture [9], historic buildings preservation, temporary structures and pavilions, exhibitions and educational elements [10]. So far, there have been few scientific articles published in Poland on the subject of this work [11] [12].

Mycelium belongs to the group of pleomorphs – organisms whose structure cannot be divided into tissues and organs. It is composed of loosely intertwined filaments that form a plectenchyma growing on an available medium [4]. The mycelium organically grows as askeletal structure; this mode of growth allows the mycelium to entwine, penetrate and bind mixture of substrates, turning them into compact matter when dried. The fungal mycelium under the right conditions is capable of the independent growth on the given substrate. For the same reason, mycelium may prove to be a practical material also in the conventional construction industry minimizing not only economic but also environmental costs. The utility potential of the mycelium as an insulating material is manifested in its targeted, dried form, that prevents from uncontrolled growth [4]. The implementation of mycelium biocomposites in the construction market in terms of economic competitiveness shows growing potential. Volume specific costs, compared to polystyrene, are 6 to 12 times cheaper than EPS [13]. Considering relatively cheap raw materials used in the manufacturing process, the main price of biobased insulation is labor associated – roughly 90% and therefore it is susceptible to change when taken to the industrial scale [14].

METHODOLOGY

A case study was undertaken to evaluate the potential of using mycelium in architecture. An accepted way of inducting theory from qualitative information, embedded in practice, is through case studies [15]. Case study research is often used in new topics [16] and when one is attempting to explore and understand, rather than to quantify and confirm.

Case studies were selected by using a purposive (expert) selection method, which is typically used in the pilot and comparative studies. For the purpose of this work, 5 case selection criteria (features) were identified:

1. Availability of technical characteristics based on certification specific to the country of production;
2. Availability on the commercial market;
3. Poduction process based on methods inhibiting mycelium growth;
4. Approval for use in public buildings;
5. Willingness of designers/manufacturers to participate in the interview.

Publicly available data (primarily from Internet sources and open-source databases of scientific publications) were collected from February through April 2021. To obtain detailed information, interviews with designers and manufacturers of mycelium-based insulation were conducted from March through May 2021. The interviews addressed the following issues: dimensions, density, fire resistance, water resistance, thermal insulation, sound insulation, ductility, biodegradability, growth and production time, prefabrication potential, carbon footprint, toxicity, allergenicity of mycelium products and price.

Based on the collected information, a comparative case study was conducted in two scopes:

A. between the properties of mycelium-based products for thermal insulation,
B. between the properties of mycelium-based insulation and conventional building materials: mineral wool, glass wool, wood wool, polystyrene EPS, XPS, PU- polyurethane (PUR, PIR), phenolic foam (PF), cellular glass.

Based on the in-depth literature analysis and technical values in terms of dimensions, density, fire resistance, water resistance, thermal insulation, acoustic insulation, plasticity, biodegradability, growth and production time, prefabrication potential, carbon footprint, toxicity, allergenicity of materials, we have estimated the potential of mycelium-based insulation products in architecture. The results of the research are practical proposals and recommendations for the use of mycelium in building technologies: masonry, frame, sandwich panels, prefabricated panels, 3D printing with admixtures of other materials. Additionally, the directions for further research have been set.

Products meeting the criteria derive from the United States (Mycelium.CO, Mushroom® Packaging, Grown.bio) and Europe: Italy (MOGU Fire Proof, MOGU Natural Touch) and the United Kingdom (Biohm). Hence, the declared technical properties correspond to different certification systems: in the USA to ASTM standards (American Society for Testing and Materials), in Europe to BS EN 13501-1 (reaction to fire), ISO 16000-10 (VOC), BS EN 12087:2013 (moisture permeability), BS EN 622-5:2006 (fibre building board). There are also differences in the units used: in continental Europe SI units are used, in insular Europe and in the USA imperial units are used, which leads to significant difficulties in material comparisons. For comparison purposes, the properties expressed in different units or presented in classes as described by different standards are compared to conventional reference materials. Nowadays, there are no generally available mycelium-based insulation materials and construction products manufactured in Poland.

PHYSICAL CHARACTERISTICS

The physical properties of mycelium are dependent on a number of factors: species, substrate and substrate type, supplementary materials used, processing technology, growth conditions, drying method [5]. After drying, mycelium acquires its final technical properties, its resistance to external influences such as water and fire, as well as a measurable and controllable hardness. Due to the large number of variables, the final material properties must be determined on the basis of specific product data (Table 1). Previous research proves the possibility of using mycelium products in the construction industry, and the parameters meet or exceed widely used conventional materials, including synthetic [17].

Mycelium-based insulations achieve thermal conductivity values comparable to those of currently used insulation materials [18]. Most of them rank just above the average values for the most common insulations – foamed polystyrene (EPS, XPS), fibreglass or mineral wool (Fig. 1). Although mycelium-based components are considerably heavier than synthetic insulations such as EPS or poliurethane foams, they are in the same range as commonly used materials such as rock wool, phenolic foam or cellular glass. Mycelium components are also highly variable due to the type of growth substrate used. Combination of various materials, including wood pulp, wheat bran, millet grain, natural fibre, calcium sulphate and others alters the performance and characteristics of a final product. These findings thus imply that there is huge potential to further develop and optimize such materials to further increase their competitiveness as a viable alternative [14].

Table 1. Technical parameters of mycelium-based materials

Name		Biohm	Mycel-lium CO	Mushroom® Packaging	Grown. bio	MOGU fire proof	MOGU Natural Touch
Standard		UK	USA	USA	USA	EU	EU
1		**2**	**3**	**4**	**5**	**6**	**7**
Physical perfor-mance	density **[kg/m^3]**	**128**	**180** (ASTM C303)	**120** (ASTM C303)	**115,5** (AVANS)	**180**	**180**
	thermal conduc-tivity **[W/mK]**	**0.024** (LBU Labs)	**0.059** (ASTM C518)	**0.039** (ASTM C518)	**0.058** (ASTM C155)	**0.05** (UNI EN12664-2)	**0.05** (UNI EN12664-2)
	com-pressive strength **[MPa]**	**0.12 – 0.14**	**0.172** (ASTM C165)	**0.124** (ASTM C165)	**0.0021–0.046** (10% com-pression) **0.49–1.79** (50% com-pression) (ASTM D695)	**0.01072** (UNI EN 826)	**0.01072** (UNI EN 826)
	acoustic characte-ristics **[NRC]** (ISO 354)	data not available	**0,.53** at 2000 Hz	data not available	data not available	**0.4–0.6** at 2000 Hz (depending on shape)	**0.4–0.6** at 2000 Hz (depending on shape)
Fire per-formance	Fire reaction (UNI EN 13501-1)	data not available	data not available	data not available	data not available	**B-s1-d0**	**D-s2-d0**
	Heat of com-bustion **[MJ/kg]** (EN ISO 1716)	**16.36**	data not available	data not available	data not available	data not available	data not available
	flame spread **[m^2/m^2]** (ASTM E84)	data not available	**18** class A	**20** class A	**20** class A	data not available	data not available
	smoke emission **[m^2/m^2]** (ASTM E84)	data not available	data not available	**50**	**50**	data not available	data not available

Table 1 countinued

1		2	3	4	5	6	7
Water reaction	Water vapor permea-tion **[dry cup]** (ASTM E96)	data not available	**30** permeable	**30** permeable	data not available	data not available	data not available
	moisture storage **[%]** (ASTM C1498)	data not available	**8** at 60% RH **12** at 80% RH	**8** at 60% RH **12** at 80% RH	data not available	data not available	data not available
	short term water ab-sorption **[kg/m³]**	**7.07 ± 1.82** (5.5–6.9%)	data not available	data not available	data not available	data not available	data not available
Other	compo-stability **[days]** (ASTM D6400)	data not available	**35**	**30**	data not available	data not available	data not available
	VOC emission	TVOC **A+** (EN ISO 16000 10:2006)	VVOC **75** [μg/m²h] (chamber testing)	data not available	Aldehyde & VOC **<0,01-0,03** [ppm] (ASTM E1333)	TVOC **10** VVOC **91** SVOC **<2** [μg/m²h]	TVOC **10** VVOC **91** SVOC **<2** [μg/m²h]

Due to the differentiated standards, specific for each national market the best method is to use comparative analysis. Mycelium insulations originating from the EU are classified in the B-s1 d0 and D-s2-d0 class (EN 13501-1). Euroclass B-s1 d0 is expanded as: combustible material – very limited contribution to fire, quantinity/speed of smoke emission absent or weak, no production of flaming droplets. Euroclass D-s2-d0 is expanded as: combustible material – medium contribution to fire, quantinity/speed of smoke emission of average intensity, no production of flaming droplets. This classification places fire reaction of mycelium products in the middle of the scale between non-combustible, class A rated materials – mineral wool and cellular glass, and highly combustible, class E rated synthetic materials – EPS, XPS, PIR, PUR. Mycelium products in the terms of fire reaction, are similar to wood wool – another bio insulation material. The similarity, besides the origin, is based on the susceptibility of both materials to impregnation and therefore variability of fire performance. In the

US standards (ASTM E84) regarding fire performance fungal insulations are assigned to the safest class A.

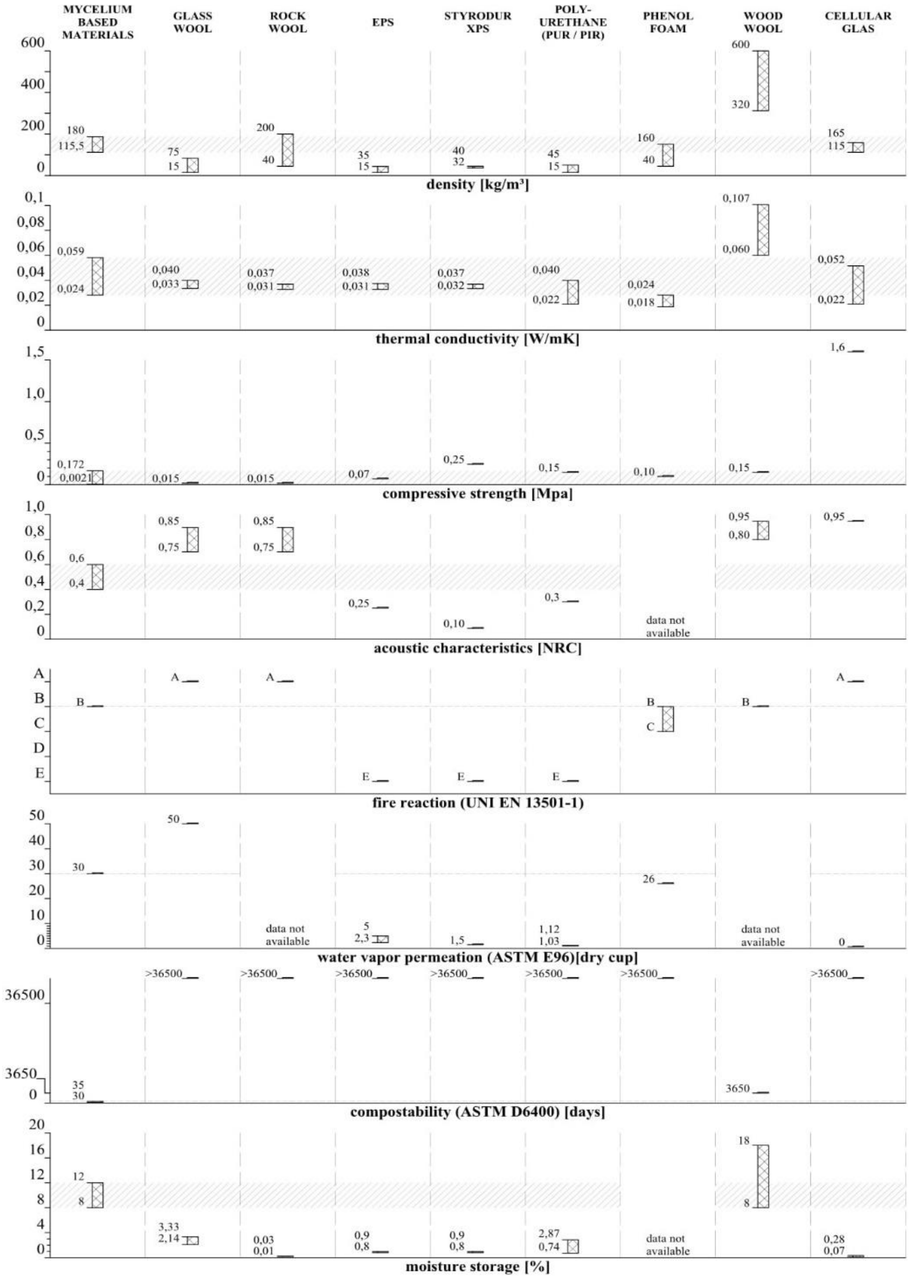

Fig. 1. The technical properties of mycelium-based materials and conventional insulation materials

Manufacturers who use other than US standards do not declare the vapor permeable properties of their products. Due to International Code Council (ICC) building codes [20] vapor retarders have to be rated maximum 10 perms, which means that mycelium insulations allow a considerable amount of water vapor to pass through them. Fungal insulations can be treated analogously to mineral wool, which means great design flexibility in relation to the location of the vapour control layer, depending on whether water vapor accumulation or removal is required.

Moisture storage is determined in accordance with the American Standard ASTM C1498 for Mycellium.CO, Mushroom® Packaging products ranges from 8% to 12% and the short-term absorbency parameter is certified for the Biohm product. The declared absorbency properties range from 5.5% to over 6.9%. At the moment, mycelium-based products claiming these properties differ significantly from alternative insulation materials used in construction except for wood wool (Fig. 1), which leads to the conclusion that building layers containing mycelium should be insulated particularly carefully or should not be exposed to water. This is perhaps the largest issue preventing their wider adoption into a commercial market. However, as acoustic or thermal insulation is typically used in internally dry locations this may arguably not be a significant problem [14].

Besides thermal insulation, acoustic insulation is the second most promising technical parameter of mycelium-based materials (Table 1). Normative values for this category are known for four of the six products, coming from both continental Europe, the United Kingdom and the United States.

Depending on the shape of a component, the Noise Reduction Coefficient (NRC) ranges from 0.4 to 0.75, which places these materials at a high level among other materials (mineral wool, cellulose, foams).

IMPACT ON HUMANS AND THE ENVIRONMENT

Past experience with fungi in a construction is not positive, as their presence is highly undesirable because of the damage they cause to materials and the negative impact on allergy sufferers [21]. However, these disadvantages concern the living form of fungi. Both allergic reactions and uncontrolled growth are caused by spores, which are inactivated in the dried mycelium form. In addition, some mycelium exhibit entomopathogenic properties – they can eradicate insects that are undesirable in construction [22]. Another advantage of the material is that it is built on the basis of waste-degrading organisms, so that the decomposition time of the material at the end of its life cycle is counted in weeks rather than hundreds of years (see Table 1). Additionally, mycelium is a renewable material, so there is no pressing need to recycle it. This avoids, among others, the legal difficulties associated with hygienic approvals for products that are partially made of the recycled material.

The main drawbacks of mycelium-based insulation are susceptibility to biological corrosion and harmful effects of water (Table 1), so the possibility of using them outside of the building is limited. Due to a number of technical parameters, the tested insulations have many characteristics in common with wools which indicates that the potentially optimal application technologies may overlap with those in which wools are traditionally used, in three-layer, ventilated walls, and in most internal partitions.

PROPOSED IMPLEMENTATION

In comparison with conventional building materials, commercially available products based on mycelium present promising properties of thermal conductivity, acoustic characteristics and compostability. On the strength of the comparative analysis performed, a number of possible applications of mycelium-based materials can be indicated, based on commonly used technological solutions allowing direct implementation in the construction market without the need to interfere with existing construction methods and habits of contractors. Due to the water performance fungal-based materials have the direct application potential within vertical and horizontal internal partition technologies: masonry, framing, sandwich panels, prefabricated panels, 3D printing and internal insulation e.g. in buildings with facades where standard external thermal insulation cannot be carried out to improve the energy balance of the building. In these cases, the insulation material is shielded and its susceptibility to biocorrosion and moisture is not a technological problem.

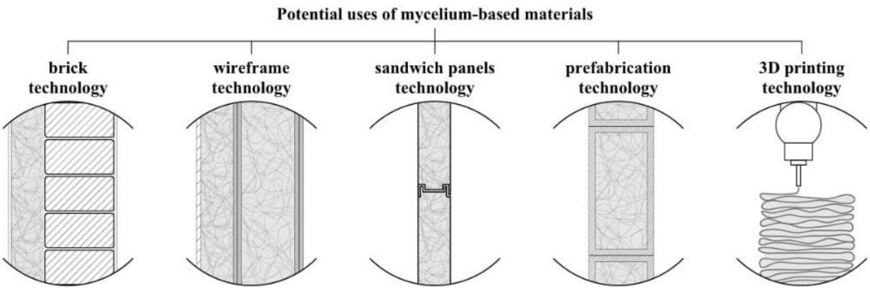

Fig. 2. Potential uses of mycelium-based materials

SUMMARY AND RECOMMENDATIONS

Housing the social aspect seems to be important, especially recently, as it gives residents a sense of belonging to a larger group, that might enhance their mental health. What is also present and perceived and may be important in shaping the residential architecture of tomorrow, despite the ecological solutions related to the circular economy, is its flexibility, which allows for functional changes, e.g., to combine working and living when needed, as the most important goal of housing should be the ability to respond to lifestyle changes.

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MATERIAŁY NA BAZIE MYCELIUM W ARCHITEKTURZE. PRZEGLĄD KRYTYCZNY

Materiały na bazie grzybni są proekologiczną i zrównoważoną alternatywą dla konwencjonalnych materiałów budowlanych. Prezentują one obiecujące właściwości fizyczne i mają potencjał na zrewolucjonizowanie przemysłu budowlanego. Szczególnie korzystnym parametrem jest niska przenikalność cieplna, która może umożliwić zastąpienie nimi powszechnie stosowanych izolacji o niszczącym wpływie na środowisko. Wkład niniejszych badań jest dwojaki. Po pierwsze artykuł zawiera przegląd produktów na bazie grzybni oraz porównanie ich właściwości z powszechnie stosowanymi konwencjonalnymi materiałami izolacyjnymi. Po drugie praca zawiera propozycje praktycznego zastosowania materiałów na bazie grzybni w prostych metodach budowlanych. W pracy przedstawiono zalecenia dla przyszłych wdrożeń oraz kierunki dalszych badań.

THE END OF COMMUTING? FUTURE OF OFFICE BUILDINGS IN THE POST-COVID WORLD

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ABSTRACT

The subject of the following paper is to investigate the impact of the pandemic on the design of office space and commercial buildings. The familiar types of moves taken to improve epidemic safety are procedural actions, modifications of technical solutions: architectural and services installation, as well as the topic of remote work. Solutions in the field of office space architecture are the following: reducing density, introducing mobile partitions, eliminating multi-person desks, using materials that are easy to disinfect, openable windows. Beneficial solutions introduced in the future will be those in which the arrangement of offices will be flexible, allowing for changes in the future, enriched with biophilia and focused on health and well-being. In terms of services, air quality improvement, filtration and disinfection systems as well as systems of telecommunication installations supervising the use of the building are being introduced. What can be noticed is during the lockdown, the remote work of employees was a highly popular solution. Despite its many ad-vantages, what could have been expected is that it will not be widely introduced, and the preferred form of employment will be hybrid work carried out remotely on average 2–3 days a week. As a result, the designs of buildings and office spaces introduced will include more places for meetings, spontaneous interactions, mutual inspiration of employees and the strengthening their identification with the employer especially those unavailable for remote work. The structure of the building will change to a richer in regards to better amenities, a co-working aspect and flexible office space, as well as a traditional part of office space for lease, if such office buildings will still be needed.

Keywords: post-covid architecture, office space, office buildings, impact of Covid-19

INTRODUCTION

The Covid-19 pandemic has effected most sectors of the economy, including the commercial market and that of offices buildings. In this regards, it can be observed that the situation has caused significant changes in the way we operate. Observing the events that have taken place, it should be reckoned that the impact of the pandemic will be long-lasting, and future changes in the real estate market and design of offices will be significant. Therefore, the question which comes up is: what changes await offices and commercial buildings in the future due to the Covid-19 pandemic, and furthermore – will office buildings as we know them today still be needed, and if so – to what extent?

DISCUSSION

Presently sanitary regulations and medical indications related to limiting the spread of the pandemic have become the recognized course of action, and are accepted by employees and office administrations as strict guidelines of behaviour. The epidemic threat affects our way of working and triggers both the need of redefining the strategy of maintaining large, centralized offices owned by institutions, as well as the need of determining the necessary change in the operation of commercial buildings. Alterations of the current course of action result from the following factors: the actual will to protect health, direct legal conditions, the need to change the behaviour of employees, and to protect staff from forced quarantine as a result of contact with an infect-ed person.

The primary effect of the pandemic is the expansion of the paradigm underlying the de-sign of buildings and office spaces. In this regard, the existing strategy focused on employee satisfaction, motivation and productivity (Boland et al. 2020) has been enriched with an increased care for their health and well-being (Parker 2020). In a situation of limitations related to epidemic rigor, we also affix greater importance to the quality of the surrounding space (Zoppi 2021).

In a lock-down situation, it turns out that nearby surroundings, that we have not been noticing, have gained more importance – both the apartment in which we spend more time and the im-mediate vicinity in which we begin to require the presence of the necessary functions and services.

This translates into the recognition of the role of a plethora of services in each area of the city, so that the required program can be found at least within a walking distance of 10–15 minutes. The consequence is also understanding the office building as part of the urban fabric and striving to ensure greater diversity and quality of the common space of office buildings and offices, as well as enriching what they have to offer in regards to places for meetings, meals, rest and combining it with a richer program of services, also available to city residents.

Even before the pandemic, it was known that remote office work was not associated with a decrease in the efficiency and quality of work performed, but the slow practice of introducing changes in corporations, caused by the fear of the “lack of control” over the employee and the lack of appropriate infrastructure, made this type of work marginal. This was changed as a result of the lockdown, which forced the dynamic introduction of new solutions (Poly 2020). In this respect, it can be seen that the situation related to the Covid-19 epidemic accelerated the introduction of the existing trends and forced the emergence of new solutions that would affect the design of office work space and the office buildings themselves.

This paper is dedicated to diagnosing the directions of all of these changes.

The research method was to collect literature, reports and professional publications, and follow and participate in the ongoing debate. The collected source material of professional literature was examined in terms of identifying leading trends and determining conclusions regarding the subject. The results are organized into the basic type of response applicable to problem solutions. Additionally, the conclusions collected during the author's professional work related to the design of office buildings, which concerned the protection of the office environment due to the unfavourable epidemiological situation, were useful to formulate the research results. The development of the topic both by analysing the literature and searching for original design solutions with the participation of representatives of developers and commercialization specialists is the basis for this text and the conclusions drawn.

Based on the analysis carried out, the following three groups of solutions in the field of changing the working environment in the office space can be distinguished, which are a response to the pandemic threat.

– A group of administrative solutions that takes into account actions consisting in trans-forming the operation of offices through organizational changes in the field of management.

An example made by 90% of employers has been to reduce the number of employees who stay indoors at the same time (Bojec et al. 2021), and the use of rotational work for some employees or the limitation of the use of common parts by the building administration (Sochacka 2020). The information policy in relations between tenants of office space and landlords has also changed, developed and has been expanded. Between them, there was a flow of data on the density of users, cases of infections and contacts between infected and non-infected people, which was to limit the spread of the epidemic.

The procedural solution used, apart from the control and compliance with the sanitary regime imposed by legal provisions, the introduction of internal rules and regulations by the managers of individual buildings and office spaces has also took place. New measures were introduces, such as checking body temperature, controlling meetings and guests, more frequent cleaning and disinfecting rooms (Bojec et al. 2021). Some property managers introduced a centralized collection strategy of parcels for all tenants at the reception desk and the organization of mail rooms or allocating separate entrances and exits to buildings to limit contacts.

– A group of technical solutions, including architectural ones consisting in reconstruction, modernization or re-arrangement of office space.

The architectural solutions that have been used in the first place are those that can be made in a simple way, non-invasively and the improvement of sanitary conditions in a short time, especially those carried out in a low budget. These include the reorganization of office space, reducing con-gestion, the introduction of lightweight partitions, panels and walls, and the elimination of multi-person desks, especially workplaces located opposite each other. Individual stands for online training have been used, acoustically separated rooms for videoconferences and spaces for quick meetings. The type of equipment useful in the event of the need to introduce partitions are mobile partitions and modular furniture, allowing for re-arrangement and easy reconfiguration, because they can be set up, put together or partially disassembled and even rented to employees for organizing their home office (Property News 16/02/2021). Observing these activities, it can be concluded that the space and equipment in the near future should not be designed including rigid solutions in mind (Sochacka, 2020). In terms of additional improvements which will be introduced in the future a favourable solution will be to limit the use of materials that are difficult to disinfect – for example, materials with interwoven fibers or coated surfaces limiting the multiplication of microorganisms such as mites, and the use of openable windows will become a standard (Bojec et al. 2021). As a result of the pandemic, nearly 70% of companies want to pay more attention to the health and well-being of employees after the pandemic ends (Knight 2020). Furthermore, what follows is that the solutions favourable to this, for example green roofs and terraces, natural light, rich elements of biophilia - greenery in the office, spaces for quiet work and relaxation rooms will be common practice in future office space arrangements.

The conducted studies show that it is also possible to introduce solutions favouring incoming rules of sanitary safety in the very structure of the office building. These can be introduced in newly designed buildings and are related to the improvement of circulation such as the introduction of one-way corridors and a different arrangement of common spaces. Their purpose will be to easily introduce appropriate social distancing if necessary, or they may include increasing the volume of meetings spaces in order to reduce airborne infections. The conventional scheme of vertical circulation in office buildings consists of one elevator lobby from which a group of elevators is available which serves all floors. This boosts the transmission of the virus because all users of the building can potentially meet in the elevator lobby space and can come into contact with each other while riding the lift. This solution, which was a result of a variant studies and turned out to be beneficial in terms of limiting virus transmission, was the separation of elevators into groups serving separate parts of each storey and the introduction of escalators which connect the ground and the first floor. This limits possible contacts of users of all floors in elevators, gives the possibility of keeping a distance for users using the escalators and, if the elevator lobby is divided into more than one, it limits the transmission of the virus in its space. The above strategy, in the case of using an underground parking, should be combined with the separation of parking zones for servicing individual floors and separate tenants, in order to limit the possibility of accidental contacts between users of different floors in this area of the building. Research has shown that a good solution which can be used in the future is the use of emergency staircases as part of the day-to-day vertical circulation. In this the case of such form of movement between floors it is possible to maintain social distancing, which is unreachable in the case of using elevators. To create a greater amount of staircases form of vertical circulation, it is beneficial to locate them in front of the elevator lobbies, rather than traditionally hidden behind them, and to open them with glass walls facing the entrance hall. The conducted studies on possible modifications to the lease space in the office building have shown that a positive solution from the point of view of limiting virus transmission is the separation of the lease space during the design works in which meeting rooms can be arranged and increasing volume to, for example, two-storeys. This allows for more air volume per person in such a space and, together with an appropriate installation solution ensures the right amount of air exchange per hour, which has a positive effect on the dispersal of aerosol containing virus particles, and leads to a reduction in the number of user infections.

– Service installation solutions are another group of technical categories introduced and considered for implementation.

In this respect, air purity is of key importance for the quality of work, the well-being of employees and the reduction of epidemiological risks. It results directly from the role of micro-pollutants and air humidity in the transmission of viruses and microorganisms. An example of a solution for air purification systems in an office space is, e.g., the RCI Active Pure technology implemented by Echo Development, also UV decontamination systems (Bojec et al. 2021) or the installation of additional air filters, e.g., HEPA or EAC. Installation solutions include: complete resignation from air recirculation, increasing ventilation with external air, increasing the level of air filtration to MERV-13 (90% of particles 3–10 ppm are filtered), ensuring the operation of the installation for longer periods (optimally 24/7), equipping the space with portable air purifiers, if necessary, adding local devices with UV decontamination (e.g. lamps) in the rooms, maintaining the temperature and humidity in the range appropriate to reduce transmission by a given aerosol (for Covid-19 the optimal air humidity preventing virus transmission was assumed to be in the range of 40%–60%).

After ventilation, the next type of services installation that improve the operation of offices in an epidemiological situation are low-voltage installations. In order to minimize the transmission of the virus, modern control systems (e.g., infrared cameras for temperature screening tests, cam-eras for detecting masks) and advanced digital solutions will be introduced. Control solutions are aimed at creating a contactless office, in which the need to use handles, buttons (e.g., for elevators, control systems) is eliminated, and control is possible thanks to an application installed on the phone or contactless cards. Digital solutions will consist in the integration of all building systems with the installation of additional sensors (e.g., sensors for humidity, CO_2 concentration, dust, volatile particles, occupancy sensors) and cameras. By connecting devices in the Internet of Things with built -in systems in a network supported by monitoring applications, it will be possible to gather information for building management and sanitary safety in a more extensive and precise manner. The system will recognize and send information about disturbing events and allow to react to them. Control and monitoring can relate to, for example, air quality and quantity, temperature and humidity levels, contact tracking, transmission of data on the density and location of people in building zones so that the user can, e.g., find a free workstation, route or conference room. The current situation in the building will be monitored in terms of the set parameters and visualized in the manager's application and in applications made available to users on mobile phones. As a result, the use of the office will become safer as well as more comfortable and optimized. The operating system will, for example, be able to inform attendees during the meeting about exceeding the time or the number of people in the room, and after the meeting as well as block the room and turn on local UV disinfection systems. An example of an application monitoring the use of an office on mobile devices is, for example, Symbiosy – an application implemented by the developer HB Reavis in office buildings, collecting information about the location of employees via a net-work of sensors, which allows monitoring and maintaining social distance, booking rooms, finding free space and the identification of people with whom a person infected with Covid-19 had con-tact. The application integrates the technical resources of the office. When installed on a smartphone, it is a contactless key to the building and office space. It integrates all building systems - cameras, information about parking spaces, access control, compaction and operation of installation systems.

– Remote work and home office is the last group looked at in regards to solutions introduced in an epidemic situation in office buildings.

The basis of this solution, has been the intro-duction which in Poland was directly provoked by the provisions of the special act of April 8, 2020 (Ustawa 2020), giving the employer the opportunity to delegate an employee to remote work by direct order. After its introduction, in Poland, the percentage of people working remotely more than doubled for all labour sectors – from 4.6% before the pandemic to 13.1% in the second quarter of 2020 (Bojec et al. 2021). A significant scale of this phenomenon also took place abroad – e.g., in the United States, in June 2020, the percentage of people working remotely reached 62% of office workers (Boland et al. 2020). The first experiences of remote work turned out to be positive for employers - who according to research in 85% stated that the flexibility of the workplace leads to greater efficiency (74% of CFOs declared that they intend to permanently implement remote work of employees (Poly 2020)), as well as employees who in the surveys stated that they are more or equally productive, respectively, 41% and 28% in the United States (Boland et al. 2020) and 43% and 41% in Poland (Bojec et al. 2021).

Most of the employees would like to partially work remotely in the future (Poly 2020; Bojec et al. 2021). They consider the saving of time on commuting to work to be a great value of remote work (Economist 2020). At the same time, in the case of commuting to the office, employees in-creased the use of means of transport limiting social contacts, e.g., bicycles or scooters, and decided to go for walks in favourable locations (Arup 2020). This feature of remote work is important for the performance of the city as a system – the reduction of commuting to work, while choosing a bicycle, scooter, or even walking if necessary, has a positive effect on the city's operation. It reduces car traffic, thus reducing pollution, congestion and the amount of energy used for transportation. Despite the statistics showing the benefits, there are signs that a complete transition to remote work does not seem possible. In the queries, negative factors are indicated by the respondents as unfavourable for remote work: lack of direct contacts, isolation and loneliness, the feeling of being constantly at work and imbalance between work and home. As many as 37% of respondents declare that in this form of work they work all day (Bojec et al. 2021). Among the respondents, 34.7% stated that the hindrance in remote work is the lack of direct contact with a human being, and 30.2% indicated a lack of a sense of relationship with the organization (Bojec et al. 2021). In terms of research on the future amount of time dedicated to remote work which employees find good, inquiries show that of people working remotely during a pandemic, up to 79% declare that in the future they would like to work in this way more less than 2–3 days a week (Leesman 2021) with the prospect of working in average offices, and this percentage increases to 92% for work in offices of the highest standard. This means that remote work cannot be the only form of employment in corporations which they decide to introduce in the future.

Due to the lockdown, limited work in company headquarters and the transition to remote work, it can be observed in Poland that during the pandemic, office tenants have largely revised their rental policy. It follows that remote work and a change in the form of employment will contribute to changes in the area of office space. Part of the office space was considered unnecessary in the situation of remote work, and the conditions of uncertainty meant that a large group of organizations decided to renegotiate lease agreements or sublet office space. Flexible offices and coworking were gaining popularity, where, apart from freelancers, work was often carried out by people employed in corporations (Magazif 2020). The possibility of access to flexible offices and potential, as the situation develops, resignation from renting them has become, in addition to subscriptions in co-working spaces, an attractive form of providing jobs for many organizations (Knight Frank 2021). In this situation, a large group of developers also decided in Poland to purchase or create their own co-working brands (e.g., Echo Investment – City Space, HB Reavis – HubHub, Skanska – Business Link, Adgar – Brain Embassy). The format of the coworking space has therefore become more favourable and it is estimated that in the coming years its number will increase globally by 40% (Global Coworking Growth Study 2020).

The threat of a pandemic changed the current perspective on the way we design as well as the way we locate office buildings and their fit-out. The pressure of corporations to overpopulate office spaces has certainly decreased, as well as the principle of work organization consisting in locating workplaces opposite each other. There is a return to the employee's desk module – 1.8 m in width instead of the smaller dimension introduced in the pre-pandemic era – 1.4 m. During the pandemic, changing workplaces and hot-desks, along with space congestion, proved to be unfavourable to limiting virus transmission. The situation in which office work was perceived as carried out in one seat of a single organization was largely questioned by the remote work strategy. In the future, post-covid work organization will rely more on a smooth transition from stationary and re-mote work within the network of connections that make up the work system. Within this network, the physical location of the headquarters will be of less importance. More important than the workplace will be the efficiency and effectiveness of communication and the ability to transfer ideas within the organization and its clients based on the introduced IT systems. The employer's approach to staff will also have to change. Employees must be given greater trust in hybrid work, and the work culture must change towards greater employee inclusiveness and an emphasis on teamwork. Observation of trends hint that the future will bring greater integration of living spaces and offices – dedicated workplaces built into apartments and flexible work carried out in many locations, e.g., houses, cafes, scattered coworking hubs. There will be an increase in the share of hybrid work with the probable model of work at home and meetings with colleagues and clients at the company's headquarters as well a reduction in the layout of office space occupied by the organization with its dispersion into many locations. It is possible to imagine that companies will become involved in organizing transport for employees between the elements of the organization system: fleets of bicycles, electric scooters, shared trips by company electric cars will be introduced, and cooperation will be established between corporations and transport providers such as Uber or ViaVan. The use of remote work will be expanded, and the technology of its implementation will also include mobile devices. The very word “work” will cease to be synonymous with a place of human actions in the long run – it will first of all become a synonym for activity.

CONCLUSIONS

Research shows that it is unlikely that office buildings will no longer be needed. This therefore indicates, inter alia, through thorough analysis the shortcomings of remote work. Therefore, a complete or a large-scale transition to remote work does not seem entirely possible in the future. The model of work that will be adopted in the future will probably be hybrid work – partially carried out remotely, with a certain period of work in the office. Office buildings which contain the central spaces of the organization will exist but undergo amendments. Offices rented by companies will become limited in terms of space and their role will change. First of all, an important function of offices in the future will be to offer employees meetings, spontaneous interactions conducive to direct, mutual inspiration that cannot happen during remote work situations. This will change the way office space is arranged – there will be a decrease in individual workplaces in favour of common spaces, meetings and the exchange of ideas. Offices made up from unified layouts with many workstations will undergo a change in the direction towards made to measure; individualization, choice, contrast and diversity of space, the role which will also be to motivate and in-spire employees, in addition to providing them with comfort and ergonomics unavailable in the case of remote work. A very important role that the office will have to play in the event of partial remote work will be to bolster the feeling of identification with the employer. The office should become a place where culture and values of the organization are created and displayed, and in the future it should become a place with which the employee will want to identify with. This endeavour will, in turn, increase the pressure of employees to implement the principles in which they believe, especially those among the new generation entering the labour market, valuable to the employer because of their talents and skills. An example is the attitudes of ecological responsibility, dominant in the young generation. Therefore, most offices under construction will be subject to high LEED or BREEAM certification for the implementation of pro-environmental policy as well as those regarding the well-being of users, e.g., WELL and Fitwell. In terms of improving the comfort of work for employees, a suitable environment, air quality and humidity, a large amount of natural light, ecological materials and biophilic design will become a standard. Existing buildings will be simultaneously modernized and certified to maintain their competitiveness in the rental market. Future office building designs will have to provide for quick and easy adaptation – office buildings will have to become more flexible and allow tenants to increase and decrease the amount of space. This will have an impact on the way of designing the floor plans of office buildings in terms of the possibility of introducing much smaller tenants per floor and combining or dividing the leasable space between tenants. The floor plan layout will have to be flexible – e.g., to adapt to a situation when, for example, a tenant decides to vacate half of its space. The vacated half should allow the introduction of an independent, different tenant, and the building solutions should also provide for these kind of changes The structure of the office building would be likely a subject to change. It should be concluded that in the coming years the amount of coworking space in the office building will increase, and in the future it can be expected that the office building will consist of a more prestigious part offered to corporate tenants as offices for rent, perhaps in smaller than before office units(consisting of; for example, several on one floor), and a large part of coworking spaces or flexible offices offered as additional workplaces for employees. It will be very important to be able to offer services available in the building for employees and unavailable to them in the case of working from home. The standard will be to use the tactic of creating "great-user experience" – the range of additional amenities offered by the building for tenants will increase and they can benefit from it. The service part of the office building will therefore increase its multi-functionality – in addition to gastronomy and cafes, it will be enriched with, for example, trade, gymnasiums, wellness, event spaces, training rooms and meeting places. The lesson for the on-going pandemic situation is that office buildings and commercial spaces need to be prepared for the coming of an emergency and other unexpected situations. This means thinking about flexibility in the future and considering normal operation during: a pandemic, climate change as well as multi-hazard scenarios when designing. However, it should be expected that in the near future changes will take place slowly, when most of employees work remotely. The following years will be a period for introducing modifications to the designs of buildings and rearranging office spaces, which no matter how however in a different in nature they are, will still be needed as a space for irreplaceable activities and social interactions for all, and as an important component of the city connected to the public space with a better range of services than today.

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KONIEC DOJAZDÓW DO PRACY? PRZYSZŁOŚĆ BIUROWCÓW W POST-COVIDOWYM ŚWIECIE

Przedmiotem poniższego artykułu jest zbadanie wpływu pandemii na projektowanie przestrzeni biurowych i budynków komercyjnych. Znane rodzaje ruchów podejmowanych w celu poprawy bezpieczeństwa epidemicznego to działania proceduralne, modyfikacje rozwiązań technicznych: architektonicznych i usługowych w instalacjach, a także temat pracy zdalnej. Rozwiązania w zakresie architektury przestrzeni biurowej to: zmniejszenie zagęszczenia, wprowadzenie mobilnych ścianek działowych, eliminacja wieloosobowych biurek, stosowanie materiałów łatwych do dezynfekcji, otwierane okna. Korzystnymi rozwiązaniami wprowadzanymi w przyszłości będą te, w których aranżacja biur będzie elastyczna, pozwalająca na zmiany w przyszłości, wzbogacona o biofilię i nastawiona na zdrowie i dobre samopoczucie. W zakresie usług wprowadzane są systemy poprawy jakości powietrza, filtracji i dezynfekcji, a także instalacje teletechniczne nadzorujące użytkowanie budynku. W czasie lockdownu dużą popularnością cieszyła się praca zdalna pracowników. Mimo wielu zalet tego rozwiązania, można było się spodziewać, że nie zostanie ono wprowadzone na szeroką skalę, a preferowaną formą zatrudnienia będzie praca hybrydowa wykonywana zdalnie średnio 2–3 dni w tygodniu. W efekcie wprowadzane projekty budynków i przestrzeni biurowych będą uwzględniały więcej miejsc do spotkań, spontanicznych interakcji, wzajemnego inspirowania się pracowników i wzmacniania ich identyfikacji z pracodawcą, zwłaszcza tych niedostępnych do pracy zdalnej. Struktura budynku zmieni się na bogatszą pod względem lepszych udogodnień, aspektu co-workingowego i elastycznej przestrzeni biurowej, a także tradycyjnej części powierzchni biurowej na wynajem, o ile takie biurowce nadal będą potrzebne.

EQUAL FOOTING IN DESIGNING PROCESS – ON COMMON GROUND FOR SOCIAL RESEARCH AND ARCHITECTURE

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ABSTRACT

Nowadays architecture faces the challenge of responding to the needs and requirements of different urban actors – many more than investing authorities and developers. More and more often elements of social research and consultations are introduced in processes of designing public spaces in order to meet those demands. The paper's aim is to present a model of cooperation between architects and social researchers in which research is an integral part of a designing process.

Commonly data based on social research plays a servant role in interdisciplinary cooperation: data grounded in social research is used by architects for designing. Instead, we propose a model that includes researchers into a process of architectural design in order to create an environment for close cooperation: constant exchange of questions and answers on every stage of the process. This model is an opportunity for both groups to benefit from each others' potential. The paper is based on experiences of the academic project of interdisciplinary cooperation grounded in this method: *Anthropology and architecture*.

Keywords: anthropology, architecture, cooperation, consultation, urban design, participatory design

INTRODUCTION

Nowadays urban architecture faces the challenge of responding to the needs and requirements of different urban actors – many more than only developers or investing authorities.

According to applicable law in Poland it is required to consult proposals for strategic documents of spatial Planning and Land Development [1]. In many cases those consultations take the form of public discussion or simply making documentation available for public inspection and comments.

To meet demands of different urban actors, processes of designing public spaces more and more often include participatory design methods. They are based on involving stakeholders and users into design processes by consultation – often legally required by act or resolutions – or diverse social research.

However, as architect Dariusz Hyc described, the designers often don't have the required tools and knowledge to execute such a process [2]. Thus important roles in those processes may play social researchers: sociologists, anthropologists, psychologists. Their task is to examine the needs and opinions of users and stakeholders. Then they deliver results to designers who should use it in their work.

What's important, this process allows to incorporate knowledge, experience and needs of present and future users into a process of designing urban spaces and places. However, it is not easy to implement and use it in a way that engages all groups involved and meets their expectations. Often it leads to misunderstandings between all actors included in the process: architects, researchers, users and developers.

In this paper we would like to indicate and describe various problems and shortcomings of implementing collaboration between researchers and architects. Moreover, we would present a model of cooperation that is based on our experience as academic teachers and urban researchers and have a chance of avoiding many of the issues pointed earlier.

CHAPTER 1

The model presented in this paper evolved during our work as researchers and it is based on our professional and educational experience. We carried out research and consultations for Warsaw municipality in collaboration with urban planners and architects. Additionally, between 2017 and 2020 we coordinated an academic project called Anthropology and Architecture [3] in cooperation with architects from Warsaw University of Technology: Dariusz Hyc, Maciej Kowalczyk, Agnieszka Lewandowska and Warsaw University of Life Sciences: Krzysztof Herman. During each year of the project two groups of students from different faculties – architects and social researchers – worked together on the case of urban planning in Warsaw.

The aims of the project (among others) were theoretical and practical reflection on cooperation of specialists of various disciplines (especially social researchers and architects) in the process of participatory planning and developing practical skills among students of both disciplines, including urban space research and support in implementation of such kinds of research as applied knowledge. During the project we tested different approaches to cooperation to check their strong and weak sides and to work out some good practices.

CHAPTER 2

The model presented in this paper is grounded in a few recognitions.

First of them is the conviction that architecture – buildings and space in between – does not consist of two separate elements: material objects and people among them. Both: urban space and its usage are bonded as one. Thus, the approach presented in this paper is supposed to reflect features of urban space which is mental, causative, material, emotional, sensuous [4]. It means that urban space is material, social and cultural at once.

What's more, the relation between those two parts of urban space – material and social – is not necessary. There's no necessary logical link between them, which means that one cannot assume particular social results when designing a particular environment. As Kacper Pobłocki notices: "there's no mechanical connection between spatial forms and social relations – thus, reading the space itself, apart from the fact how it is used by particular people seems to be useless" [5]. Therefore architectural solutions for urban space cannot be based exclusively on architectural knowledge, the social research on every case is needed.

Authors of the text *Improving social competencies of architecture students through participatory design of marketplace regeneration* recognise it as important as well. According to them the role of architect is not to design space but a place – what requires them to take into account the socio-economic aspects of changing space [6].

Second, urban space – understood as a multifaceted knot described above – is not universal. It always emerges as a result of local circumstances. Therefore there cannot be universal solutions for problems appearing in urban space. Each case needs to be considered as an individual and unique problem. What's more it happens quite often that architectural designs are solutions for non-architectural problems. It's rather rare that the problem is lack of appropriate infrastructure. That's why it's important to identify "soft spots of the city" [7] and propose adequate solutions.

Third, is the recognition that crucial for perception of urban space and therefore for understanding it is practice and experience. Knowledge about how to live in the city: how to move within it, how to use particular spaces and what meanings do they have is practical knowledge. It means that it's not only learnt by social practice but also generated by it. In consequence there's no one proper way of using spaces that were similarly designed. World is full of affordances [8] not objectively given features. It depends on the users'– physical and psychological and cultural – of perceiving and practicing it.

Therefore, in a social context urban space cannot be treated as a ready-made object. It's not finished at the moment it was built. Inhabiting it – with everyday activities – is a part of creating it as important as a design and material construction themselves [9]. It means that when urban space is designed, this social aspect should be also taken into consideration and it can't be done without knowledge about users and social circumstances of the area.

Fourth, seemingly obvious, but extremely important: architectural knowledge and social research skills are different and separate competences. Thus, we cannot expect architects to propose adequate architectural solutions if we do not provide them with data from the social field. We cannot expect them to magically figure it out on their own and we definitely cannot force them to guess it. If we want to have architectural designs that deliver solutions to problems of urban space, we need to create conditions for cooperation of professionals of different fields. As Agnieszka Lewandowska notices: "Interdisciplinary cooperation creates the opportunity of establishing a city which reflects dynamic movements inseparably bonded with society, for which architecture serves" [10].

According to Architect Alejandro Aravena the relationship between designers and users is partnership – in which both sides have unique knowledge and experience. Connecting them in the project is one of the crucial parts of responsible design [11]. Architects and university scholars from Gdańsk notice: "Nowadays, architects are involved in a much broader range of issues. They work as participants in planning and developing regional policies, as administration officials, policy negotiators, investment managers and social activists. Professional engagement in any of the above roles requires the architect, apart from having the necessary technical qualifications, to display a high level of social competencies" [12]. It means that architects are more and more often expected to have a wide range of competences that are not strictly connected with architectural design itself. From our point of view, instead of broadening the range of competences and responsibility of specialists of one field, a much more reasonable solution is to create an interdisciplinary team of specialists working together.

CHAPTER 3

In the popular model of collaboration between researchers and architects the research simply precedes the design (Fig. 1). Social researchers gain knowledge from users, interpret it and report it to architects who are supposed to include it in their work. This exploration can take different paths. Researchers can talk directly with present or future

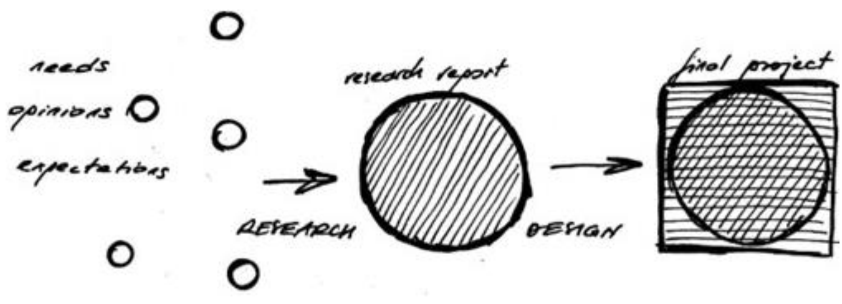

Fig. 1

users of the area that is supposed to be changed. They might observe practitioners in their use of this part of the city, they can research the social context as well. And they can combine all these methods.

Afterwards architects receive research results as knowledge input that should be taken into account in their work. It might take the form of requirements or guidelines or be less specific data that are supposed to be included in urban and architectural analysis.

Obviously, this kind of process has many variations and in particular cases might bring separate processes of research and design closer or further from each other. In some cases researchers and architects never personally meet and knowledge they have about the project between them is passed on in the form of written documents: research reports or guidelines for the project. In other cases, researchers that are cut off from the design process might make themselves defenders of the voice of users. The voice that consists of the data that was gathered before the start of the design process and thus cannot answer new questions or evaluate new ideas.

This process goes in only one direction – from the users to the researchers and from the researchers to the designers. The same happens to the knowledge itself – it is transferred along the same vector. Dariusz Hyc, who described the gap existing between architects and users, claims that it can be reduced by social research [13]. However – in our opinion – cooperation with researchers designed this way is filling this gap only partially.

This model often puts researchers in a situation, when they see that the conclusions of their research have been omitted or misunderstood. Moreover, they do not have architectural knowledge that is required from them in that type of consultation when they are the only link between users and the project. They often cannot properly inform engaged people about project limitations and requirements which often leads to collecting knowledge that is too vague or too specific.

Architects, on the other hand, receive knowledge that may seem useless. It does not correspond with project aims and boundaries. Furthermore, architects might feel that researchers would challenge their competences by simply demanding to introduce solutions directly proposed by users or stakeholders.

Similarly, the third party, the users, often feel that their voice has been ignored and their ideas have not been used. They have resentments because they do not know information about the whole project with its aims, boundaries and limitations.

According to our experience, this model of linking research and design leaves little room for cooperation – and thus does not use the full potential of this kind of collaboration. Knowledge transmitted in such, one-sided way does not allow recognition of each group's needs and aims. As a result each group of professionals might focus their efforts on different matters. This situation creates more problems and misunderstandings than wider cooperation or deeper participation, which can have a negative impact on the quality of the final project, as is presented on the next graph (Fig. 2).

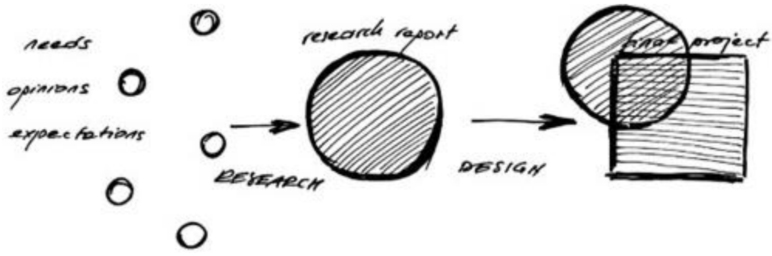

Fig. 2

This model of collaboration separates knowledge from research and design understand as a practices – processes that develop in time. In early stages of the process the knowledge grounded in social research becomes a monolith – a closed unit that is treated as data in its final form. On the one hand, in this way the potential of wide social research remains unused. Potential that is in its best form when researchers are able to go back into the field for further query or make additional observations that answers questions that inevitably arise as the process goes on. On the other hand ,this model limits the possibilities of architectural work in research results that are too vague – and therefore useless – or too specific – and often impossible to implement. Both of those situations limit the competences of both engaged groups of specialists. As Lewandowska points out, sometimes research data lacks the answer for even the most basic questions that would help architects in better understanding local context and its practitioners [14].

Moreover, in this mode of cooperation architects lack an opportunity to effectively test their design solutions, because after the study is completed contact with users is no longer maintained. Thus research data may become more of a problem than a help when they are difficult to use in the design process.

CHAPTER 4

In this part of the paper, we would like to present a model of cooperation that, in our opinion, responds to the problems characterised above. In this model architects and designers are not two separate parties but create one team that works together from the very beginning – from premises to final realisation (Fig. 3).

This kind of research-design process is based on constant cooperation. Instead of separate stages of the project there is a combination of two processes: research and design. Both of them develop in time: research knowledge changes accordingly to field data and design develops according to research knowledge and appearing requirements.

This model does not require dividing the whole process into consecutive parts and closing one stage to begin another. It treats both – research and design – as processes that develop in time. It is crucial to combine those developments – to conduct the research so that it could respond to design requirements and to proceed with the design in a way that is based on the research results. This kind of two-fold knowledge is based on continuous contact between both sides of the process and is also procesual.

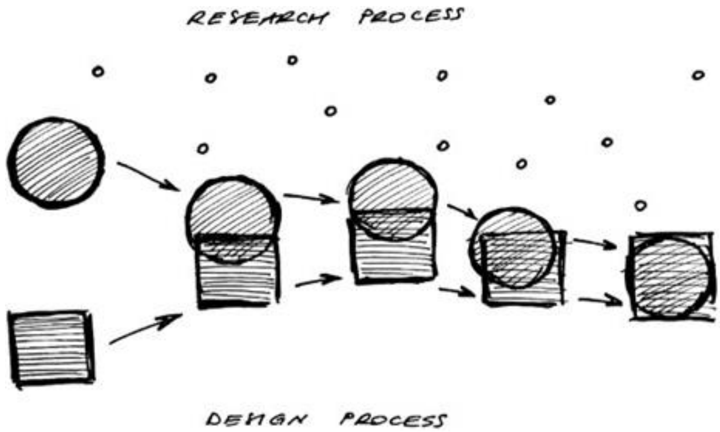

Fig. 3

In this method problems that should be solved are defined and identified by the whole team. Researchers' task is to take them into the field and to find out users' perspective, their needs and opinions. Architects' role is – knowing this social context – to offer solutions that will work not only as well designed buildings and spaces between them, but as spaces for urban life.

This kind of cooperation is some kind of circular process. Specialists of different fields do not pass the knowledge they have, but they share it and use it in the whole process. Thanks to their cooperation on every stage of this work they benefit from each other's contribution.

Therefore, this model of cooperation is not just a simple exchange and cumulation of knowledge, a combination of independent elements grounded in separate fields, but a shared understanding of the topic developed, which enabled both sides together to acquire problems and propose adequate solutions.

What is important, this model of cooperation leaves space for including problems emerging in the process – those that cannot be assumed in the very beginning. It also gives the possibility to test some draft solutions – confront them with future users and receive feedback in the designing phase, when it still can be included in the project. It helps to avoid the situation in which consultation of a ready project reveals that it misses the point – doesn't respond to users' needs and not much can be done about it.

In fact, this kind of cooperation brings the whole process closer to methods already successfully used in other sectors. Instead of a waterfall approach to project management that requires dividing the whole process on successive stages like planning, analysis, design, application, tests and implementation it proposes agile methods that are characterised by flexibility and consists in iterative mode of operation. In fact this kind of approach is not new – it's basis was already expressed in an article *The New New Project Development Game* by Hirotaka Takeuchi and Ikujiro Nonaka in 1986 [15].

In 2001 *A Manifesto for Agile Software Development* was published It was created by supporters of agile methods in IT industry, but in fact it briefly expresses most important ideas presented above: "individuals and interactions over processes and tools; working software over comprehensive documentation; customer collaboration over contract negotiation; responding to change over a following plan" [16].

The model of cooperation presented here must be established anew each time. It's impossible to give strict parameters of how this cooperation should look like, because it's main principle is to be agile in order to respond to requirements of each case. What is possible is to give some guidespots and designate milestones to enhance cooperation in a transdisciplinary team.

In practice it means that the whole team should have regular meetings to discuss ongoing research and designing processes. It enables architects to confront their work in progress with the users and other actors and to correct some parts while working on it. We propose this instead of waiting for the very end of the consultation process, when not much can be changed or further developed.

Regular discussions on ongoing research and design allows to orient them in direction that will respond to requirements of the project. Necessity of explanation and justification of activities on every stage of the project to other team members gives the opportunity to challenge chosen solutions and control if it still responds to the needs.

It gives the researchers an opportunity to go back to the field with new questions emerging during the whole process. Thanks to knowledge of architects they are informed what are boundary conditions for consultation and what can still be changed and thus can be consulted or what is already decided due to legal or architectural guidelines.

CHAPTER 5

The process described above enables the exchange of knowledge and, what's more important, its effective use. Gaining knowledge is a process which is extended in time and bound up with practices of involved people. The questions that guide the process arise from shared understanding of the matter and emerging issues – they cannot be based only on initial assumptions.

This way researchers are able to understand the requirements of the project. They receive feedback questions to the research results on a regular basis and can go deeper into topics that become crucial for design at any point. Moreover, they can fully use their research experience to gather information important for the project. They can look for answers for architectural questions using the whole spectrum of their field experience and familiarity with research methods.

In the process organised that way designers have influence on topics developed during the research. They can draw particular architectural and legal boundary conditions at every stage of it. Thus it's possible to focus on those areas that are possible to be influenced or changed. Architect Alejandro Araveda described the participatory design as primarily the process of communicating limitations. According to him the first step in this process is to inform users. Only then it is possible to determine the project requirement and priorities [17].

Moreover, architects here are much closer to emerging social knowledge in the context of research carried out as an open process. They – thanks to their contribution – are incorporated into gathering the social data. In this way they don't get only the final report with results and guidelines, but they can understand what leads to the specific conclusions. On one hand obtained results respond to the limitations of the project, on the other, it remains close to the requirements of their own work.

In addition to this, Dariusz Hyc described collaboration between architects and scientists from social fields as a situation that can be an impulse "to create significant, original new solutions" [18]. According to him the knowledge and competences of the architects are not contested or questioned. On the contrary, in a situation of collaboration with researchers and participation of users Hyc sees potential for the development of the architecture closer to people for whom it is created.

This way knowledge and competences of both sides – architects and social scientists – are used in order to understand the problem and give adequate solutions. Shared knowledge is used to improve work of both sides of the process – research using architectural experience and urban planning benefiting from the potential of research. Thus researchers do not need to be experts in the field of architecture – they should understand needs and requirements of both users and architects and use it according to their experience. Similarly for architects who do not need to know the social research methodology or ways of interpreting gathered data. Moreover, in our opinion, this process avoids the situation in which architects are bound by too general or too specific consultation results thanks to wider user involvement in the whole process.

CHAPTER 6

As we stated at the beginning, the main goal of this paper is to describe collaboration between architects and social researchers in the urban design process. In the following paragraph we briefly talk into account the third, equally important group in this situation – users and recipients of projects.

Model of cooperation described above is – in our experience – beneficial for the users and project recipients as well. It gives them the opportunity to observe the whole process thanks to contact with the researchers on different stages of the project and thus to understand it better. It is a solution for the situation that is often criticized in which users are included in the very beginning of the process, asked about their needs and opinions and after that confronted with the ready-made design that surprises them and raises their doubts. Giving the users an opportunity to be in contact with researchers during the whole process helps them to understand what it is about, what could be done and how their voice influences the project.

This involvement may be developed by further implementation of participatory design methods such as workshops, architectural meetings, prototypes testing and prototyping in the real space. Those methods can be used more efficiently through close collaboration between researchers and architects. The former becomes intermediaries in the direct contact between practical and local knowledge of the users and architectural experience of the designers. The latter are able to use this to better understand the local and social context of their work and to be involved directly in the consultations of their work.

The advantages of this are twofold. On one hand, as we described above, crucial parts of understanding the urban space are practice and direct experience. The users have the best knowledge about places that they are using everyday and – in the case of developing new spaces – what are the shortcomings of the city in actual local context. As described by Jane Jacobs – American activist that is often recognised as the godmother of participation in urban planning – this practical knowledge about parts of the city can be quite counterintuitive to specialist architectural experience [19].

What is more, collaboration with users has benefits for architects as well. It helps to build trust for architects as designers and for their work as a service for users [20]. Moreover, those meetings may be necessary in the near future due to the way the profession of urban planner is developing [21]. In this case the presence of social scientists and their support can be crucial in developing and using the collaboration between architects and users.

CONCLUSIONS

Urban architecture that faces the challenge of responding to the needs and requirements of different urban actors would greatly benefit by including social research methods in the process of designing urban space.

Simultaneously expectation that architects would broaden the range of their competences so that they will include those domains seems to be an impossible task. What's more, this kind of expectations enforce a shift in architectural practice – instead of on designing, architects are required to focus on many other matters, which sometimes are far beyond their architectural work. This situation also results in transfer of responsibility as well – architects are treated as liable for a whole process that requires multifaceted insight grounded in many disciplines.

The solution for those problems may be multidisciplinary cooperation involving specialists of various fields. This kind of cooperation should not be a simple exchange of knowledge, specialists of different fields should not take over each others' competences either. Instead, it should be organized in a way that respects boundaries of different disciplines and their specificities are used as an advantage to understand multifaceted urban space. Based on regular communication and participation of a whole team from the very beginning to the end of the project, this kind of process enables all actors involved to benefit from the cooperation to improve their work in the framework of their disciplines. This in our opinion and experience can lead to formation of common ground for social research and architecture described in the title and premise of this paper.

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RÓWNE SZANSE W PROCESIE PROJEKTOWANIA – WSPÓLNA PŁASZCZYZNA DLA BADAŃ SPOŁECZNYCH I ARCHITEKTURY

W dzisiejszych czasach architektura staje przed wyzwaniem odpowiadania na potrzeby i wymagania różnych aktorów miejskich – znacznie więcej niż władz inwestycyjnych i deweloperów. Aby sprostać tym wymaganiom, coraz częściej do procesów projektowania przestrzeni publicznych wprowadza się elementy badań i konsultacji społecznych. Celem artykułu jest przedstawienie modelu współpracy architektów i badaczy społecznych, w którym badania stanowią integralną część procesu projektowego.

Powszechnie dane oparte na badaniach społecznych odgrywają służebną rolę we współpracy interdyscyplinarnej: dane oparte na badaniach społecznych są wykorzystywane przez architektów do projektowania. Zamiast tego proponujemy model, który włącza badaczy w proces projektowania architektonicznego w celu stworzenia środowiska ścisłej współpracy: ciągłej wymiany pytań i odpowiedzi na każdym etapie procesu. Model ten jest szansą dla obu grup na wzajemne wykorzystanie swojego potencjału. Artykuł opiera się na doświadczeniach akademickiego projektu współpracy interdyscyplinarnej opartej na tej metodzie: *Antropologia i Architektura*.

PROTECTION OF HISTORIC FACADES MADE OF GRAY CEMENT BRICK IN THE REVITALIZATION PROCESS OF SELECTED POST-INDUSTRIAL AREAS OF PRAGA DISTRICT IN WARSAW

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ABSTRACT

The aim of the paper is to present the need for protection of historic facades made of gray cement brick of the interwar period in the context of the future revitalization of the post-industrial areas of Warsaw's Praga district. This requires an individual conservation approach. As a result of revitalization activities related to facade renovation, historic buildings very often lose their original architectural detail irretrievably. Preserving the authentic architectural expression and historic values of these buildings in the face of constant investment pressure is one of the most difficult challenges in the revitalization of modern cities.

Keywords: revitalization, Kamionek, Warsaw, post-industrial heritage, gray cement brick, interwar period

INTRODUCTION

The protection of cultural heritage is one of the most important goals of the revitalization process in modern cities. From the point of view of revitalization, the basic sources of knowledge about monuments in Poland are documents that constitute the basis for determining the revitalization program of a given area, including register of monuments, municipal register of monuments, study of the protection of cultural values of the commune, etc. Number, scope, level of detail of such studies most often results from the specificity of a particular commune [1]. It happens, however, that within the boundaries of the area covered by the revitalization program, there are objects included in the municipal register of monuments, which are subject to protection only if they are included in the arrangements, inter alia, local spatial development plan. An example is Warsaw, which is currently implementing the so-called Integrated Revitalization Program, for which slightly more than 300 local plans have been adopted, which still accounts for only about 40% of the city's area. In the case of areas marked as crisis in the regeneration programs, a significant part of the historic resource is post-industrial heritage. Post-industrial monuments as documents of the past largely determine the preservation of the element of identity and the specific character of a given district. Preserving their authentic architectural expression in the face of constant investment pressure is one of the most difficult challenges of modern cities. The right part of the Vistula bank – the Praga district, in particular the Kamionek subarea (Fig. 1), has been an example of the crisis area of the capital city of Warsaw for many years. The potential of this area is manifested in the largely preserved urban layout and post-industrial buildings [2]. Unfortunately, as Anna Majewska writes, the lack of an approved local plan for this area is one of the main reasons for the gradual degradation of its post-industrial character, the loss of clarity of the functional and spatial structure and the loss of local identity [3]. This article will be an attempt to draw attention to the need to protect authentic post-factory buildings as the main carriers of historic values. The case study will cover a few selected facades made of gray cement brick of the interwar period, occurring in the Warsaw Kamionek area and shaping its unique post-industrial character.

SHORT CHARACTERISTICS OF THE ANALYZED CRISIS SUB-AREA

Kamionek is located on the right bank of Warsaw and administratively belongs to the Praga-Południe district. Its name comes from the name "Kamion" – a church village that in the 11th century was an important center for the exchange of goods and an area for crossing the river. The settlement survived until the mid-16th century, when it was destroyed during the war with the Swedes. Its complete destruction took place at the end of the 18th century as a result of the slaughter of Prague by the Russian army. The Russians then changed the name of the town and began the process of its reconstruction and industrialization [4]. In the area of Kamionek, numerous factories, manufactories and a railway station were built soon, some of which have survived to this day (including Tannery of Chrome and Fancy Leather "Gemza"). Kamionek was incorporated into Warsaw in 1889. As an important industrial region in the interwar period, it quickly became the leading production center of the capital city. At that time, many factories were located on its premises, among others, by engineer Kazimierz Szpotański's Electric Apparatus Factory and Emil Wedel's Chocolate Factory. During the occupation, most of the factory buildings were destroyed, but shortly after the war, the district's industry revived. The development of the factories did not last long, because after the fall of communism, during the period of rapid economic changes, many of them stopped to function.

Since then, Kamionek's post-industrial identity has been slowly lost and is no longer legible in the landscape of today's streets.

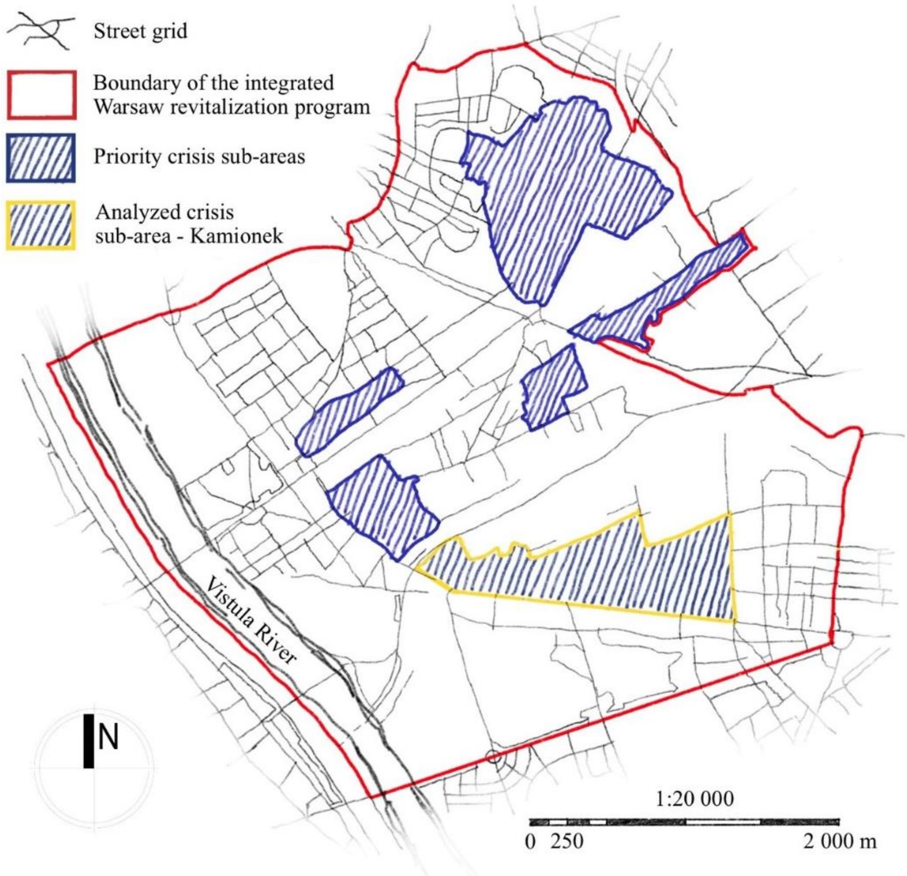

Fig. 1. Map illustrating the boundaries and sub-areas of revitalization activities implemented under the Integrated Revitalization Program for the Capital City of Warsaw until 2022. The yellow line shows the sub-area of Praga - Kamionek district analyzed in this article. Author: K. Szumiński on the basis of priority area maps (source: http://europa.um.warszawa.pl/sites/europa.um.warszawa.pl /files/zpr_maly_rozmiar15.06.2015.pdf)

The last examples of original facades made of gray cement brick from the interwar period are one of the few remaining carriers of the post-industrial identity and historic values of the district that have survived to this day. Their preservation and proper protection should be in the interest of all residents of Warsaw, as they constitute an exceptionally valuable document of the past, proving the nature of the buildings at that time.

A CASE STUDY OF SELECTED FACADES OF POST-INDUSTRIAL BUILDINGS

The first example that has been analyzed is the complex of office, production and residential buildings of the former Chromic and Haberdashery Tannery "Gemza" by Bolesław Krassowski and Sons. It mainly offered multi-coloured and black leather. It was one of the oldest factory plants of this type, combining as many as three different functions. The complex consists of two administrative buildings flanking the tannery's production hall situated with its gable facing Kamionkowska Street (currently numbered 43 and 45). On the side of Groszowicka Street (at number 9), a two-story residential house has been preserved, which used to be inhabited by former employees of the factory [5].

Fig. 2. The plastered facade of factory buildings from the side of Kamionkowska Street. The buildings have lost their original brick character. The authenticity of the former function has been lost. Photo: K. Szumiński, June 2021

All buildings were originally faced with gray cement bricks, which made them one of the most interesting examples of functional factory architecture in Warsaw. In the 1990s, the former tannery was bought by the "Murator" publishing house. During the adaptation of the hall building and residential buildings for the company's headquarters, unfortunately all authentic brick facades were plastered (Fig. 2).

Out of the entire complex of post-industrial buildings, only a residential house located at Groszowicka 9 Street has retained its original character and architectural detail of the façade [6]. Like the administrative buildings, it is two-story, five-axis. The four axes of its façade are accentuated with double-leaf windows, while the fifth, slightly offset axis is formed by three-leaf windows framed with decorative bricks (carts) protruding in every second row in front of the building face. The fields between the windows on the other axes of the building were developed in a similar way (Fig. 3). The technical condition of the bricks is mostly good. There are few cracks in the part of the ground floor.

Fig. 3. View of the brick facade of a residential building from the side of Groszowicka 9 Street.
The building is an authentic document of the past telling about the industrial character of the district.
Photo K. Szumiński, June 2021

Another example of post-factory buildings in Kamionek, which contributes to the identity of the district, is the former Electrical Apparatus Factory of engineer Kazimierz Szpotański. It was the first factory of electric switches, and during the interwar period it was the largest factory of this type in Poland. The buildings were erected in two stages in the years 1928–1936 according to the design of the architect Feliks Sztompke on the plot occupying the entire quarter between the streets: Drewnicka, Kałuszyńska and Rybna [7]. The original buildings of the complex were four rectangular solids of production halls with flat roofs, which were located along the streets. Single-space brick halls of reinforced concrete structure were divided by rows of columns with capitals resembling inverted pyramids. The factory building located at the intersection of Kałuszyńska and Rybna Streets had a truncated, uniaxial corner. Next to the factory, there was a two-story villa of the owner – engineer Kazimierz Szpotański (currently no longer existing). Archival photos from the 1930s document the original appearance of the simple brick façades of the complex. The walls of the buildings were faced with gray cement brick, which was diversified by rhythmically arranged square window openings, filled with rows of small panes closed in iron trusses (Fig. 4).

Fig. 4. View of the buildings of the K. Szpotański factory along ul. Kałuszyńska in 1937. Neg. PKZ No. 153949. Source: E. Pustoła-Kozłowska, Map of industrial construction in Warsaw, Catalog Volume I, Warsaw 1983

The factory operated during the occupation, but in August 1944 the retreating Germans blew up the buildings at Kałuszyńska Street. The factory facilities rebuilt after the war, to a small extent, have adapted the relics of the old buildings. The expansion of the complex covered mainly the eastern part of the quarter from Chodakowska Street. A contemporary building with a completely new architectural design was created. A significant part of the buildings was intended for teaching purposes of the University of Social Sciences and Humanities. In 2015, the university authorities started the process of thermomodernization of post-industrial buildings. The owner of the building used building permits issued before the buildings were entered into the municipal register of monuments [8]. The decision to cover the brick facade with polystyrene meant that there is no trace of the industrial character of this place (Fig. 5). This procedure completely obliterated the style features of a unique example of factory architecture across the country. The only left witness to the history is the fragment of the exposed authentic brick façade of the wall of the entrance gate from the side of

Gocławska Street (Fig. 6). The remaining walls were covered with a layer of insulation with plaster or whitewashed with lime.

Fig. 5. View of the facade of the K. Szpotański factory during thermo-modernization works in 2015. Source: https://www.fakt.pl/wydarzenia/polska/warszawa/swps-zdewastowal-swoja-siedzibe/26tgn9m#slide-1

Fig. 6. View of the only authentic fragment of the grey cement brick wall at the entrance gate to the premises of the former K. Szpotański factory complex. Photo: K. Szuminski, June 2021

The third and last analyzed example is the apartment house of former employees of the Kazimierz Szpotański Electrical Apparatus Factory located at ul. Kamionkowska 27 Street.

It was erected around 1935. It is a two-story building preceded by a front garden with a seven-axis facade with double-leaf windows. The entrance door to the building is located on the fourth axis of the facade. The entrance area has been highlighted with characteristic rounded jambs and a roof over which a fanlight was placed. As in the case of the factory, the facade of the building was faced with gray cement bricks. The only difference is that the house still survives unchanged (Fig. 7). The structure has retained its industrial character. Only the original window and door joinery was replaced. The facade brick is in good technical condition. Currently, it does not require conservation works.

Fig. 7. View of the preserved brick facade of a residential house located at 27 Kamionkowska Street. Photo: K. Szumiński, June 2021

The research on the brick threads used to build the façades of the previously analyzed post-industrial objects has shown that their design is almost identical. The dimensions of the bricks used are very similar to each other and range between 26.5–27 cm × 12.5–13 cm × 6–6.5 cm. The widths of the joints are in the range of 1–2 cm. For the construction of all analyzed façades, a modern head-stretcher thread consisting of successive layers of heads and stretchers was used [9]. It occurs in the variant of the so-called cross, as evidenced by the shift of the joints by $^1/_2$ of the width of the brick and the method of binding the corner of the wall with the so-called “Nine”, that is, a brick of the length of the entire brick (Fig. 8).

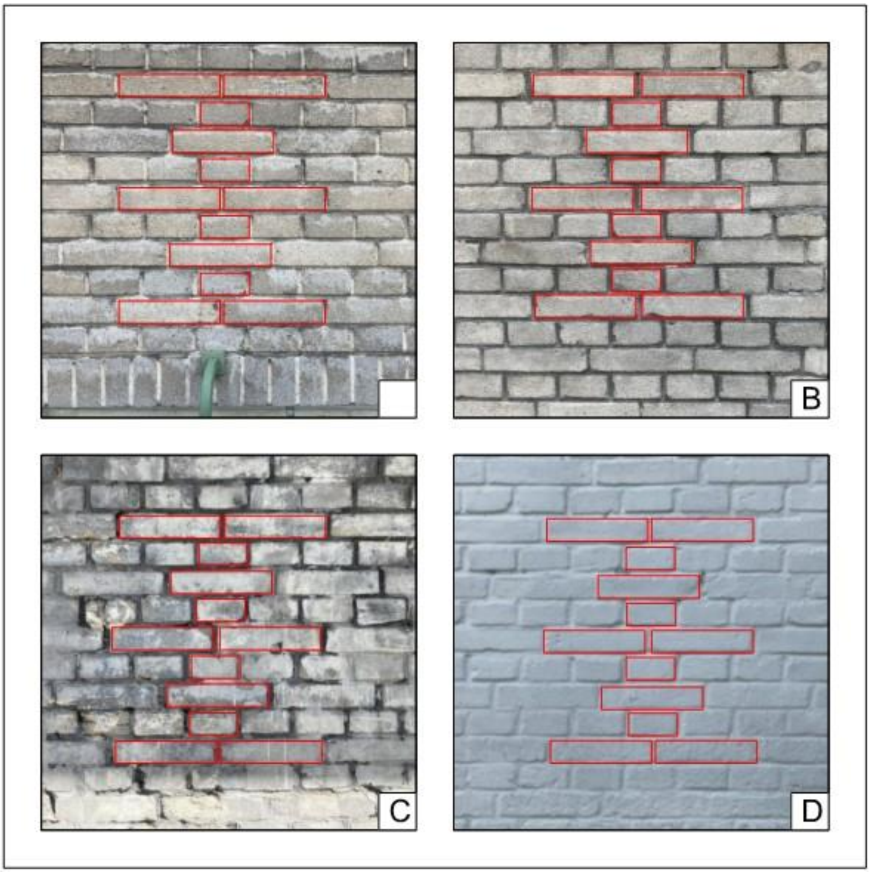

Fig. 8. Comparison of the brick facades. The red color shows the brick pattern that proves the cross thread used.
A – Kamionkowska 45 Street (27 × 13 × 6 cm, 1.5 cm joint), B – Kamionkowska 27 Street (27 × 12.5 × 6.5 cm, 1–1.5 cm joint), C – Gocławska 12–14 Street (26.5 × 13 × 6.5 cm, 1.5–2 cm joint), D – Gocławska 12–14 Street – walls from the inner courtyard (27 × 12.5 × 6 cm, joint 1 cm).
Author: K. Szumiński, June 2021

CONCLUSIONS

The preservation of the authentic post-industrial buildings proving its industrial character is significantly important in shaping the identity of Praga district in Warsaw. An important carrier of the identified historic values in the structure of the district are the original facades made of gray cement brick, which have undergone major transformations in recent years. One of the greatest threats to preserving the stylish features of the few remaining post-factory buildings is inadequately carried out renovation works on the facades, including plastering and thermal modernization. The issue of thermal insulation of historic buildings is an extremely difficult and complicated issue. It requires a separate conservation approach consisting in proper recognition of the technical condition of the partitions and carrying out analyzes of the energy balance of the entire building in order to individually determine its characteristics. It is worth remembering that there are various methods of insulating buildings. A more expensive alternative to the most commonly used in Poland BSO method (polystyrene finished with thin-layer plaster on a mesh) may be the application of insulation on the inside of the walls or the application of a special thermal insulation paint [9]. The priority in choosing the appropriate method should always be the good of the monument and respect for its original structure, which is the carrier of historic values.

Another common problem that affects monuments is poor identification and lack of attempts to organize their resource. The architecture of Warsaw made of gray cement brick of the interwar period and its conservation issues are still unknown. It is necessary to thoroughly examine the historical conditions and catalog all the preserved examples of gray brick architecture, and then carry out their evaluation, determine the conservation issues, formulate conservation recommendations and guidelines for future design interventions in their historic substance. The gray cement brick impresses with the richness of the threads used and the plasticity of expression. Extremely valuable facades with multiple brick threads deserve a separate, individual conservation approach in order to survive for future generations.

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OCHRONA ZABYTKOWYCH ELEWACJI Z SZAREJ CEGŁY CEMENTOWEJ W PROCESIE REWITALIZACJI WYBRANYCH OBSZARÓW POPRZEMYSŁOWYCH DZIELNICY PRAGA W WARSZAWIE

Istotne znaczenie w kształtowaniu tożsamości Pragi w Warszawie ma zachowanie autentycznej zabudowy pofabrycznej świadczącej o jej przemysłowym charakterze. Ważnym nośnikiem zidentyfikowanych wartości zabytkowych w strukturze dzielnicy są oryginalne elewacje wykonane z szarej cegły cementowej, które w ciągu ostatnich lat zostały poddane poważnym przekształceniom. Jednym z największych zagrożeń dla zachowania cech stylowych niewielu pozostałych obiektów pofabrycznych są nieodpowiednio przeprowadzone prace remontowe na elewacjach, w tym prace tynkarskie i termomodernizacja. Architektura Warszawy z szarej cegły cementowej okresu dwudziestolecia międzywojennego i jej problematyka konserwatorska wciąż pozostaje nieznana. Konieczne jest rzetelne zbadanie uwarunkowań historycznych i skatalogowanie wszystkich zachowanych przykładów architektury z szarej cegły, a następnie przeprowadzenie ich wartościowania, określenie problematyki konserwatorskiej, sformułowanie zaleceń i wytycznych konserwatorskich dla przyszłych ingerencji projektowych w ich zabytkową substancję.

PRINCIPLES OF DESIGNING PASSIVE BUILDINGS – AN ANALYSIS OF SELECTED ISSUES

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ABSTRACT

The contemporary design of buildings should strive to improve their energy efficiency to reduce the energy needed for heating and air conditioning. To this end, technologies used in low-emission construction are developed, with an example being the concept of passive buildings with 15 KWh/m^2 consumption of energy per year. Therefore, an important scientific issue is to develop the concept of Passive building, which will allow properly designing objects in accordance with its basic principles. The main purpose of this work is to discuss the basic principles of designing Passive buildings. To achieve the basic assumption, the work was used: (i) analysis of literature on the design of passive buildings, (ii) research analysis 81 examples of passive buildings implemented in 2001–2017, (iii) the professional experience of the author when designing sustainable buildings and Passive buildings. The research article will discuss the selected research principles of Passive building: (i) building shape, (ii) the location of the building, (iii) construction partitions, (iv) foundations, (v) thermal bridges, (vi) windows and doors, (vii) tightness of the building. Analysis of issues related to the principles of Passive buildings confirms that thanks to their use, it is possible to reduce the energy needed, which will allow to reduce the negative impact on the natural environment.

Keywords: passive building, low energy building, energy efficiency

INTRODUCTION

Design of contemporary buildings and modernization of existing should consider the climate change caused by i.a. human’s activity in the construction sector. Building designers should strive to improve their energy efficiency to reduce the energy needed for heating or air conditioning. These are the basic principles of low-energy buildings, in which to strive to maintain the continuity of thermal insulation considering potential heat loss places through thermal bridges. Design considering thermal bridges is the basic task in the implementation of buildings in the passive standard [4]. Wolfgang Feist, author of the concept of Passive building, defines them as buildings that combine high comfort of use with very low energy consumption (at 15 kW h/(m^2a) [5]. The construction of buildings in accordance with the passive standards belongs to sustainable methods, thanks to which it is possible to reduce the negative impact on the natural environment.

Construction of low energy buildings and Passive building design belongs to the relatively new method used to build housing in Poland. The first passive house in Poland was certified only 14 years ago, in 2007 in Wólka near Warsaw [13]. Since then, the subject of Passive building in Poland develops, but there are deficiencies on the implementation of concepts in Polish natural conditions in literature. The main objective of this paper is to discuss the basic principles of designing Passive buildings. For this purpose, literature research and research analysis of passive buildings in Central Europe will be carried out.

MATERIALS AND METHODS

To achieve the basic assumptions of this paper, the research work takes into account three basic elements: (i) an analysis of literature on the design of passive buildings, taking into account climatic conditions in the region of Central Europe; (ii) research analysis of 81 examples of passive houses realized in the years 2001–2017 in the region of Central Europe (published on passivehouse-database.org); (iii) the author's professional experience in the design of sustainable buildings and Passive buildings. Thanks to the presented analysis and experience of the design authors, it was possible to present and discuss the selected principles of designing Passive buildings.

LITERATURE REVIEW

In recent years, there has been an increase in the number of publications on the design and implementation of Passive buildings [11, 15]. Certainly, the development of Passive buildings is possible thanks to the Passive House Institute (PHI) activity. This organization, operating since 1996, and was founded by Dr. Wolfgang Feist. The PHI organization publishes systematically the latest research on designing or monitoring existing Passive buildings [7, 8].

A key issue in disseminating the concept of Passive building is to present scientific work presenting the possibility of adaptation to data climatic conditions. Such works show that, the Passive building in a various climate zone – can reduce energy by 80–90% [9, 16]. It should be proved that the idea of designing Passive buildings can be used for all regions and climates of the world. The factors that need to be considered are local construction traditions and specific climatic conditions, which is why specific construction details must be adapted to each area and climate individually. While physical processes remain the same, regardless of location and climate [6, 9].

Table 1. Criterion of passive houses [5]

Number	Criterion of passive houses	Description criterion
1	Space Heating Demand	not to exceed 15 kWh annually OR 10W (peak demand) per square metre of usable living space
2	Space Cooling Demand	roughly matches the heat demand with an additional, climate-dependent allowance for dehumidification
3	Primary Energy Demand	not to exceed 120 kWh annually for all domestic applications (heating, cooling, hot water, and domestic electricity) per square metre of usable living space
4	Airtightness	maximum of 0.6 air changes per hour at 50 Pascals pressure (as verified with an onsite pressure test in both pressurized and depressurised states)
5	Thermal comfort	must be met for all living areas year-round with not more than 10% of the hours in any given year over 25°C

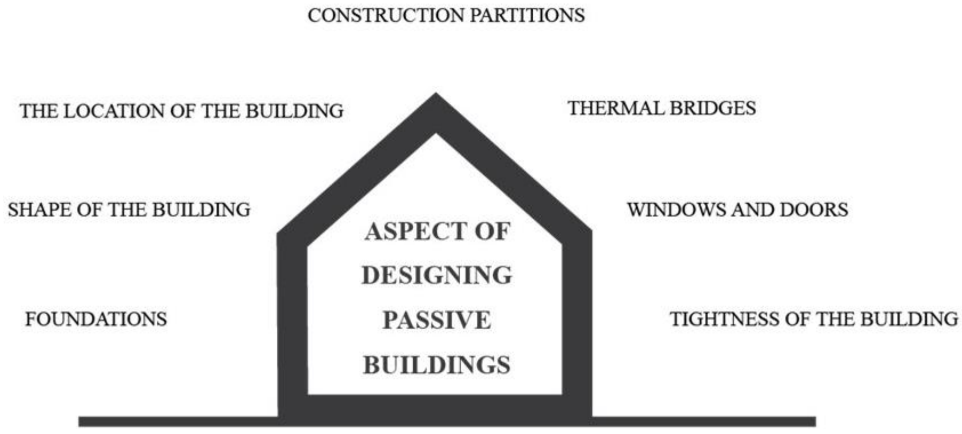

Fig. 1. Aspects of designing passive buildings
(author's drawing)

In analyzing the Passive building, it was important to read publications discussing the design details of Passive buildings. Design details are located in various types of architectural albums or published materials in Passive House Database (Passivehouse-database.org) [1, 2]. In the further part of the work, examples of the design rules for the design of Passive buildings were selected on the basis of the review of the subject literature, analysis of examples of Passive buildings, and the professional experience of the author when designing Passive buildings.

PRINCIPLES OF DESIGNING PASSIVE BUILDINGS

Shape of the building

The shape of the building may improve the energy efficiency of the building, which is why the low-energy building will mostly be designed in a compact block similar to the cube. The heat from the heated building gets out through all external divisions and through the thermal bridges occurring in them. The larger the surface of the partition, the more heat can get outside. At the design stage, we can check the shape of the heat loss (HLFF) – this is the ratio of the surface area of the external building (EA) to the net floor area (NFA). It is calculated as HLFF = EA/NFA. The lower the number, the building is more compact – for Passive buildings, this coefficient should be 3.0 or less. The shape of the heat loss is a useful measure of the building's compactness. And the more compact is the building, the easier it is to be energy efficient. And vice versa, the less compact building, the more insulation will be required for the building to be energy efficient [10].

The location of the building

Implementation of a Passive building requires to analyze the possibilities of using the shape and location of the building plot. One of the basic aspects will be the location of the building on the plot to use the maximum solar energy and minimize potential heat losses. In this respect, the most reasonable solution is the location of the living room with a large number of glazing from the south (in Poland). On the other hand, on the side of the northern building, we should limit the number of windows – but in practice it turns out that on this side of the building is checked by the entrance zone to the building [5].

Construction partitions

In an energy-saving building, it is essential to obtain the proper comfort of thermal rooms for all external partitions. The building's energy efficiency determines, i.a., the heat transfer coefficient of each of its elements, such as foundation, walls, roof, windows and doors.

Thermal insulation is one of the most important elements of Passive buildings. It is essential in every construction starting from the floor on the ground and ending on the roof. It is important to choose such technology and thickness of isolation to best fulfil the requirements for it. Vertical partitions are definitely easier for isolation by the level of difficulty. A bigger problem is the roof, where the roof truss determines the shape and dimension of the material need to use. Thanks to the dynamic development of this field, we have not only styrofoam or mineral wool, but also sprayed polyurethane foams (PUR) and polyisocyanurate (PIR), which accurately fill all spaces between the elements of the roof truss.

Design of external wall Passive buildings is part of the key issues which must be calculated using the heat transfer coefficient U [W/(m²·K)]. The building should have a designed a closed thermal coating that will include all rooms where the temperature will be over 15°C. The discussed thermal shell of the Passive building should be for external partitions $U \leq 0{,}15$ W/(m²·K), and glazed surfaces $U \leq 0{,}8$ W/(m²·K). In practice, it is recommended to design a higher performance heat transfer coefficient U for the walls in the range of about 0.10 W/(m²·K) [3]. This means selecting a thermal insulation about 30–40 cm depending on λ of the selected material. In Poland, for external walls in single-family Passive buildings, a two-layer wall system is typically used. This solution belongs to the frequently selected because the price ratio to the possible obtaining the thermal parameter is optimal.

The construction of the roof of energy-saving buildings is an important construction partition, in which, as in the case of external walls, the continuity of thermal insulation should be maintained. In the case of a roof, experts estimate that the potential losses can reach up to 30% heat, which is why it is important to properly execute and choose the right thickness of thermal compartment insulation. All more so that analyzing the behavior of warm air inside the object, it is known that the warm air always floats to the highest room point. For this reason the tightness of the roof, thermal insulation should be taken and prevented to escape warm air from the building. In addition, it should be remembered that with the shape of a roof and just as in the case of the shape of the entire building, simple solutions to minimum places for potential thermal bridges are best suited. Therefore, flat roofs are well checked, where it is possible to use thicker thermal insulation (less expensive) and the continuity of insulation [10].

Foundations

Designing buildings in the standard passive brings significant changes in the way implementation of foundation buildings. Until for a long time, the problem of heat loss through the foundations to the earth was not significant analyzed. Experts estimate that as a result of improperly isolation of the foundations of the building may result in energy loss at 5–15% heat loss from the entire building – depending on the climate zone of the designed building. Therefore, the correct thermal insulation of all edges of the basement walls, foundation walls and the foundations of the building belong to an important task. One of the basic and most difficult tasks is to maintain the thermal insulation continuity on the foundations of the building. In this case, the foundation plate is most checked for low-energy and Passive buildings, which limits thermal bridges to a minimum [3, 12].

The foundation plate does not require traditional excavation and in contrast to the foundation bench (in Poland climate zone) does not require the appropriate depth depending on the grounding zone (in Poland it is from 80 cm to 140 cm).

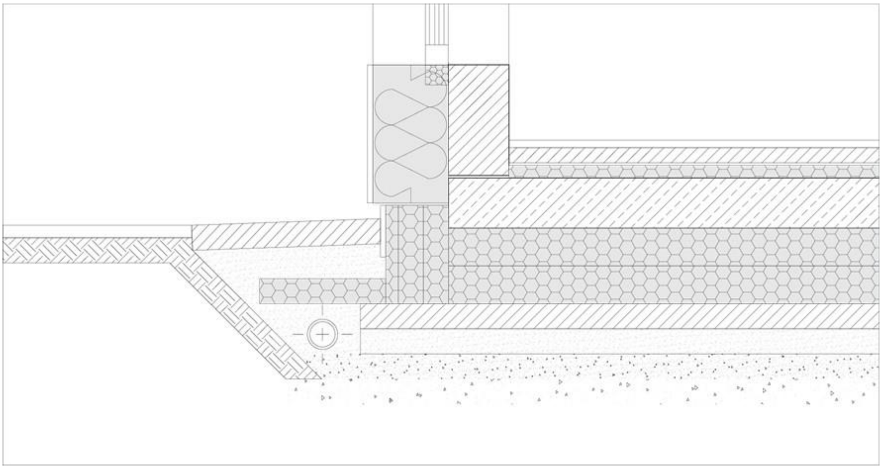

Fig. 2. Example of the foundation of a single-family building made in a passive standard. In the figure, thermal insulation has been marked with gray color (author's design)

Thermal bridges

At the basis of the concept of Passive building lies the idea of heat behavior in the building and limiting its uncontrolled escape outside. Thanks to which it is possible to reduce the energy and costs of heating the building, thanks to the analysis of all weak places in the building, through which energy can escape. Such places are called thermal bridges, they arise in places where thermal insulation is interrupted, or significantly reduced, which worsens its efficiency. Thermal bridges can be created in places where there combine construction elements or on the corners of the building. The most common places of thermal bridges can include, e.g., connection of a foundation plate with an external wall, floor connections on the ground with a foundation wall, the place of installation of windows and doors, balcony plates. The elimination of existing thermal bridges is very complicated and must be considered in most cases individually. Passive houses are designed so that at least theoretically eliminate all thermal bridges [10].

Windows and doors

The difference between designing single-family houses in passive building technology and a traditional construction can be seen when choosing a window and door carpentry. Passive construction forces the use of high-quality building materials that meet the relevant thermal requirements that are much higher than the requirements set for objects in a traditional structure. Window carpentry in Passive buildings must meet two basic tasks: (i) reduce heat losses; (ii) light the rooms and use solar energy to warm them. For this purpose, at the design stage, it is essential to select an appropriate system of window and door frames: check their quality and heat transfer coefficients, verification permeability coefficient, sunlight, and adequate planning of a building facade. In addition, the costs associated with the design of large glazing used in Passive buildings are related to the design. It is estimated that the costs of window and door joinery constitute about 10–13% of the costs of the whole house in traditional construction – in the Passive buildings, these costs may increase to over 20%. Therefore, the design of windows, their location on façade and indoors, the choice of adequate material, and its correct warm assembly should be solved in detail at the design stage [3, 12].

Tightness of the building

The effectiveness of Passive buildings consists in providing a proper amount of energy to warm the room and limit the loss of this energy through, e.g., uncontrolled spills in the outer shell of building. For this purpose, it is important to define the proper tightness of the building, in the form of a vapor barrier, which will hermetically close the building and will not allow the warm air to escape. The heat transfer may additionally lead to condensation of water vapor, deterioration of thermal insulation, and durability of the outer partition. The design and realization of a stable air tightness allows: (i) reduction of heat losses, (ii) maintaining the heat comfort of the building and the vapor barrier prevents air movement through cracks and openings, (iii) maintaining a healthy microclimate by avoiding entering the external impurities, dust, and exhaust facilities, (iv) increasing the durability of external partitions, where in the event of damage it can by collecting moisture and heat loss [4].

In Passive buildings, the building tightness test is carried out by the Blower-Door--Test method, in accordance with the PN-EN ISO 9972: 2015-10, which consists in a tight closure of the building and checking in which air escapes. A windmill pumping air inside the building is usually assembled in the door in a special windproof sheet. The next step is to use smoke to look for a leak at the door and windows.

CONCLUSIONS

The fact is that construction is responsible for the use of non-renewable energy sources and effects on the degradation of the natural environment. Nowadays, the construction industry – investors and designers are increasingly aware of this situation. Ecological and sustainable construction is of paramount importance, which is an attempt to change the environmental degradation so far by the construction industry [14]. New technologies, innovative building materials, and concepts are increasingly implemented – an example is Passive design. Passive buildings are particularly interesting because it is developing in single-family housing construction, where such innovation is needed.

The concept of Passive buildings is constantly developing, new technologies arise, currently valid assumptions are subject to verification. Thanks to which, the currently implemented Passive buildings gain for profitability – consuming less and less energy. The research article presents principles of passive buildings: (i) building shape, (ii) the location of the building, (iii) construction partitions, (iv) foundations, (v) thermal bridges, (vi) windows and doors, (vii) tightness of the building. According to the author, these aspects are crucial to properly design a Passive building and developing them in theoretical and practical work will certainly increase the quality of modern and ecological buildings.

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ZASADY PROJEKTOWANIA BUDYNKÓW PASYWNYCH – ANALIZA WYBRANYCH ZAGADNIEŃ

Współczesne projektowanie obiektów budowlanych powinno dążyć do poprawienia ich wydajności energetycznej, w celu zmniejszenia potrzebnej energii do ogrzewania i klimatyzacji. W tym celu rozwijają się i nabierają na znaczeniu technologie stosowane w budownictwie niskoemisyjnym, którym przykładem jest budownictwo pasywne o zużyciu 15 kWh/m^2 energii w ciągu roku. Dlatego ważnym zagadnieniem naukowym jest rozwijanie koncepcji budownictwa pasywnego, która pozwoli prawidłowo projektować obiekty zgodnie z jego podstawowymi zasadami. Głównym celem pracy jest omówienie podstawowych zasad projektowania budynków pasywnych. W celu zrealizowania podstawowego założenia w pracy wykorzystano: (i) analiza literatury dotyczącej projektowania budynków pasywnych, (ii) analiza badawcza 81 przykładów budynków pasywnych zrealizowanych w latach 2001–2017, (iii) doświadczenia zawodowe autora przy projektowaniu budynków zrównoważonych a w szczególności budynków pasywnych. W artykule badawczym zostaną omówione wybrane zasady budownictwa pasywnego: (i) kształt budynku, (ii) usytuowanie budynku na działce, (iii) przegrody budowlane, (iv) fundamenty, (v) mostki termiczne, (vi) stolarka okienna i drzwiowa, (vii) szczelność budynku. Analiza zagadnień związanych z zadami projektowania budynków pasywnych, potwierdza że dzięki ich stosowaniu możliwe jest zmniejszenie potrzebnej energii, co pozwoli na zmniejszenie negatywnego oddziaływania na środowisko naturalne.

MODELLING OF TIMBER STRUCTURES IN THE CONTEXT OF ARCHITECTURAL AND STRUCTURAL COLLABORATION

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ABSTRACT

The development of sustainable trends in modern architecture results in an increasing interest in timber structures. This phenomenon leads to the development of digital tools for designing timber and wood-based material structural forms. Constant improvement in the programs for building digital models and analyzing them creates new possibilities in design collaboration between the architect and the structural engineer. The article contains considerations on interdisciplinary design interactions at various stages of designing process. Its essential focus consist of an overview of the chosen programs for analyzing timber structures in reference to the tools used by architects. Interdisciplinary design deliberations are also included the study of some selected objects in which structural solutions synergy has been achieved.

Keywords: timber structures, interdisciplinary design, wooden gridshell, architectural and structural collaboration

INTRODUCTION

Prominent representatives of the Renaissance, such as Leonardo da Vinci and Michelangelo, combined in their works various disciplines in the field of art and engineering, being at the same time creators-artists – they acted as sculptors and inventors in the technical category. Along with the development in science and technology worldwide, an increasingly advanced division into specializations emerged and it still continues. Nowadays, architects and engineers who constitute part of project teams are educated at the same technical universities but at different faculties. Their education and professional skills are becoming increasingly polarized, whereas the currently designed facilities are being implemented as a result of the cooperation between architects, engineers and a variety of industries. The success of a given project depends not only on the professionalism displayed by all participants in the process, but also on their ability to cooperate while constructing a work at various stages of its implementation. An additional, significant factor that influences the efficiency of project solutions lies in the commencement of joint activities at the initial stage of the concept [3]. At present, creativity and respect for functional-spatial and technical-material requirements constitute an important method with which to shape rational architecture. Faced with the task of arriving at a joint creation, representatives of the world of science and technology become indispensable to each other, whereas their effective and efficient cooperation proves crucial for the success of the project. In addition to tasks related to establishing the principles of cooperation, the selection of tools to be applied in the design process becomes vital. In the past, the tools were of analog nature and comprised mostly drawing accessories, mechanical machines, slide rules and physical models made in a variety of techniques. Currently, however, with digital tools at their disposal, designers tend to choose compatible software systems for creating graphics, as well as cloud-based platforms that enable cooperation (collaboration). The cooperation between an architect and a constructor in shaping a structural form seems particularly interesting. The quality of this interaction, namely their mutual understanding, including the manner of communication and information exchange exert a significant impact on the artistic expression of an architectural form. This happens owing to the fact that the design concept is materialized by means of material-related and implementation technologies. The situation is expressly described by Jorg Schlaich, who states that: [2] *"A good architect welcomes technical discipline, order through structural intelligence. And a good engineer will take interest in the architect's affairs as well, and follow him or her through the functional, conceptual design of building."*

Nowadays, increasing numbers of designers collaborate remotely, whereas the digital work environment is becoming a "place" for creative activities. In this context, progressive development of digital modelling tools presents an integral part of the engineer's work. The expanding specialization proves the need for attention to be paid also to the construction material. This results from the directions of modern construction optimization which strive at reducing unnecessary construction geometry and minimizing energy consumption [4]. Such activities require greater awareness in the scope of material properties, manufacturing technologies, as well as tools for modelling and analyzing structural forms. In the context of pro-ecological concepts, a more widespread use of construction timber seems interesting. Natural origin, accumulation of carbon dioxide, as well as high strength in relation to its weight – these significant advantages have contributed to an upward surge in an interest taken in timber recently.

MODERN MODELLING TOOLS

Considerations on how to model and shape structural forms in the interdependent architectural-construction action should be started with explaining how individual industries define this activity. To an architect, to create a form is to shape the geometry of spatial, functional, aesthetic solutions and suchlike. To model a structure means to define the loads and to analyze specific solutions for the adopted structure (supports, material, sections, etc.). The actions taken are of complementary nature, their goal is common as well, but ways of conducting the search differ. In this context, the creation of tools and methods for interdisciplinary cooperation provides the basis for rational project activity.

It is worth reminding that the beauty and logic behind structural forms are not determined exclusively by the design tools, but rather by the awareness and ability to assume and solve complex issues. Multihalle Manheim, established in the 1970s when architects and constructors still relied on physical models, may be seen as an example of such action. Analytical methods were obviously very advanced then, yet the support of digital machines could be counted on to a very limited extent. The facility was constructed in Germany in 1974 as a result of the cooperation between architects – Carlfied Mutschler and Winfried Langner, and Otto Frei, a design engineer. The structural form was developed based on the chain model. The method for shaping the roof structure relies heavily on the fibrous nature of the timber and depends on the natural elasticity of boards made of it. The design authors managed to shape the structure effectively in accordance with the course of membrane driving forces, obtaining large open spaces with no need for intermediate supports to be introduced. The entire structure measures 160 × 115 meters; the highest dome point stands at 20 m above the ground. Its widest span equals 60 m, whereas the longest one is 85 m. This spectacular project would not have been possible had the authors lacked advanced knowledge on building mechanics, as well as on the mechanical properties of timber. Their perfect understanding of the material properties is demonstrated by the use of a pre-bent (compressed) bars consisting of four layers of slats, 50 × 50 mm in section each, as the main structural element. The resulting multi-branch bar construction element was characterized with a more effective section than the full section.

It is a relatively difficult and arduous task to define structural forms in which the course of internal forces is logical. However, this action is essential if synergy of design solutions is the goal to be achieved. Determining the field of optimal solutions provides the basis for cooperation, regardless of the adopted methods and digital tools in place. Among the selected geometric forms, those that offer effective solution are easily distinguishable during the static-endurance analysis, e.g., in terms of material consumption. Engineers who participate in the design process along with architects shape the form of an object by creating static models. The variety of software available on the market makes it possible to conduct analysis of even the most geometrically complex cases. For instance, FEM (Finite Element Method) analyses bar structures and gridshell structures, as well as structural nodes modelled with the use of solid elements.

In the context of modelling timber structures, several important issues are worth noting. Initially, the standard construction software is equipped with modules for the dimensioning of timber sections. A database of timber materials and profiles is defined in the endurance simulation programs. The choice of appropriate section is made by adapting to the requirements of a given standard (e.g. EN 5). The database of timber materials and profiles is defined in endurance simulation programs. Their scope is limited and usually consists of softwood timber, hardwood timber and elements made of glued laminated timber (GL - Glue Laminated), or CLT (Cross Laminated Timber).

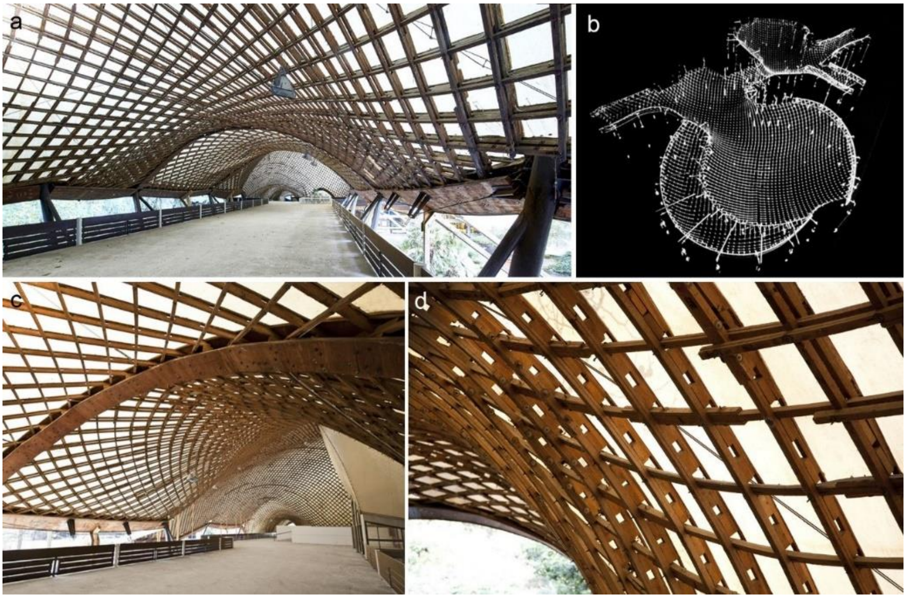

Fig. 1. Multihalle Mannheim, Germany, 1974; design by: Carlfied Mutschler, Winfried Langner, Frei Otto: a – general view of the structure with the support ring; b – general view of the structure with the reinforcing ring in the foreground; c – conceptual model made of mosquito net; d – view of the multilayer bar structure; source: a) b) photo: Daniel Lukac, "Architecture – Mannheim Multihalle", <https://mannheim-multi-halle.de/en/architecture/> [accessed: 20.05.2021]
source: c) d) "WOOD – building the future", Multihalle Mannheim, <https://www.wooddays.eu/en/architecture/best-practice-architecture/detail/multihalle-mannheim/index.html> [accessed: 20.05.2021]

Stand-alone application software

In the design process, a modern architect shapes the form of a building facility with the use of a range of software currently available on the market. Simultaneously, he/she focuses on the graphic aspect of the design. The use of 3D graphic modelling software such as Sketchup, Autocad, Archicad, Revit, Tekla is possible. In search for more sophisticated and complex forms, methods with which to generate geometry and its parameterization are applied. Therefore, tools for creating (generating) parameterized structures, such as Rhino-Rhinoceros 3D with its integral part - Grasshopper or the Dynamo plugin to support design in the Revit environment (Autodesk) are gaining increasing popularity. Acting on the basis of a parametric model enables dynamic modifications. For instance, modification of the input data leads to a real-time change in the result (structural solutions). Such an action can be compared to an animation that shows multi-variant solutions for the assumed parameters. Each of these solutions requires design analyzes to be conducted. This can be done in two ways. Firstly, by the exchange of compatible formats between the architect's software and the design engineer's software. Among numerous available software systems intended at structural analysis, Robot Autodesk Structural Packages by Autodesk, SCIA Engineer, Tekla Structures or RSTAB or RFEM from the package offered by Dlubal enjoy greatest popularity.

As an example of architectural-construction cooperation based on independent software, the 14-storey "Treet" residential building implemented in Bergen (Norway) may be provided. The building was erected in 2015 and resulted from the cooperation between the Artec architectural office and the SWECO company responsible for technical design and management. In addition, the construction team was supported by a research team from the Norwegian University of Science and Technology (NTNU in Trondheim). The designed timber structure of the building, 52.8 m in height, consists of wooden panels made with the use of the CLT technology, which constitute the structure of the walls of the building's communication core, and of bar elements made in the GL technology, which form a glulam truss. Despite the fact that the project was developed with the use of the BIM platform, additional endurance analyzes were conducted with independent software. The "Treet" structure consists of prefabricated glued laminated timber and CLT modules. In the case of considerably high structures, the use of timber, which is a relatively light material, leads to the phenomenon of intensifying problems generated by vibrations resulting from wind operation. In order to understand the static and dynamic behavior of the prefabricated modules better, tests were performed. Then, a FEM analysis model was generated in Robot Structural Analysis [1]. Independently, the "Treet" construction was also subject to scientific research conducted at NTNU – the building model was analyzed in terms of material damage in the Abaqus/CAE program [6].

The team of designers proposed the load-bearing structure, which was subsequently implemented as a prefabricated one, consisting of several modules. The analytical model made it possible to analyze the erected structure on the basis of individual modules in accordance with the step by step principle. Thanks to the geometry optimization, the process of prefabrication and assembly of the entire structure was developed. Prefabrication of individual elements and integration of modules was possible owing to the assembly design conducted, which accounted for assembly tolerances. For elements made of CLT timber, a manufacturing tolerance of 10 mm was assumed. This, in turn, resulted in a perfect implementation of the building – the deviation for the 15-storey staircase was only 3 mm! The facility designed by teams of architects and constructors with the use if stand-alone software applications wins respect when it comes to its form and construction solutions applied. The precise prefabrication process deserves recognition.

Fig. 2. Multi-family housing building “Treet” in Bergen (Norway), 2015; Architectural design: Artec; Structural Design: Sweco AB; a – general view of the building; b – FEM numerical model; c – structure node view. Source: a) b) Rune B Abrahamsen, Kjell Arne Malo, Structural design and assembly of “treet” – a 14-storey timber residential building in Norway, WCTE 2014 (World Conference on Timber Engineering), <https://www.woodworks.org/wp-content/uploads/Strucural-Design-and-assembly-of-Treet.pdf> [accessed: 20.05.2021]; source: c) “Council on Tall Buildings and Urban Habitat”, Treet Bergen, <https://www.skyscrapercenter.com/building/treet/16540> [accessed: 20.05.2021]

The development of digital tools leads to the improvement in computing methods, greater accuracy of simulations and results. These will likely be followed by the optimization processes of building structures and further specialization of the engineering professions.

Software integration systems

Nowadays, it becomes increasingly common for an intelligent machine, that is an automatic machine, to assume the role of a specialist constructor who qualifies individual geometric forms in terms of economic solutions. Software that makes it possible to generate a geometric form and, at the same time, to perform static analyzes for a finite number of generated stages is becoming more and more widespread in the world of architecture and engineering. Generative methods of creating construction grids together with parallel static analysis enable automatic selection of optimal solutions in terms of parameters set by designers. The set criterions may include the amount of material used, the total length of construction bars or the surface area of the material applied. The Form-finding optimization method, known since the 1970s, remains one of the most mathematically advanced forms of cooperation in the field of searching for a structurally logical form. When it comes to timber construction, the field of Form-finding methods include Geometric Stiffness and Dynamic Equilibrium. In order to benefit from these methods, in-depth knowledge of mathematics and mechanics of buildings, as well as more and more often IT knowledge, is required from the user. Advanced algorithms for Form-finding methods are generally readable to the design engineer, and he/she is and will remain professionally responsible for the safety of the computer-generated structure. The Downland Gridshell at the Weald and Downland Open Air Museum (2002) by architect Edward Cullinan, engineer Buro Happold may be presented as an example of implementation based on DR (Dynamic Relaxation) analysis. With the application of the Form-Finding method, an area of 15.2 × 50.0 m was obtained.

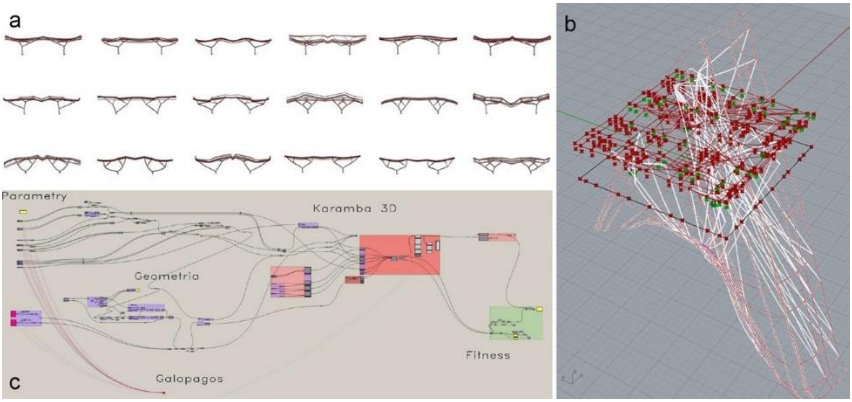

Fig. 3. Student work done at WA WUT as part of the 'Modeling and Optimization of Structures' seminar, 2020/21; software: Grasshopper/Galapagos/Karamba 3D; authors of the work: Igor Panuszewski Igor, Angelika Pluta, Anna Przybyła; a - deformation animation; b - deformation of the structure; c - view of the script to generate the structure geometry
source: a) b) c) archival materials of the Department of Structure Design, Construction and Technical Infrastructure, Faculty of Architecture of the Warsaw University of Technology

An available market tool which performs material optimization based on the Form-finding method is the Karamba 3D program compatible with the Grasshopper software. The program is based on the finite element method (FEM) and enables cooperative work between architects and engineers. Supported by overlays (Galapagos), the program leads to obtaining the desired set of solutions with the use of a set method for parameter change and with set optimization criteria (Fitness component). A team of architects makes the final choice from all the solutions selected by the program. In terms of aesthetics and functionality of the form, it is for the architect to decide, whereas the verification of formulas used to arrive at the structure dimension becomes the domain of the design engineer. Even though representatives of the architectural and construction industries work together on a single parametric model, each engineer has, in fact, a clearly assigned set of tasks. The Seine Musicale in Boulogne-Billancourt, France (formerly known as Cité Musicale), designed by Shigeru Ban and Jean de Gastines, stands as an example of interdisciplinary collaborative projects. The facility includes a classical music auditorium with 1,150 seats and the Grande Seine concert hall which can house approximately 6,000 people. Its maximum structural spans reach 70 m along the longitudinal axes and 45 along the horizontal axes, whereas the structure height equals 27.5 m. A computer analysis of the form and its topological optimization in the Design-to-Production formula was conducted by the Swiss Hanno Stehling/Fabian Scheurer office.

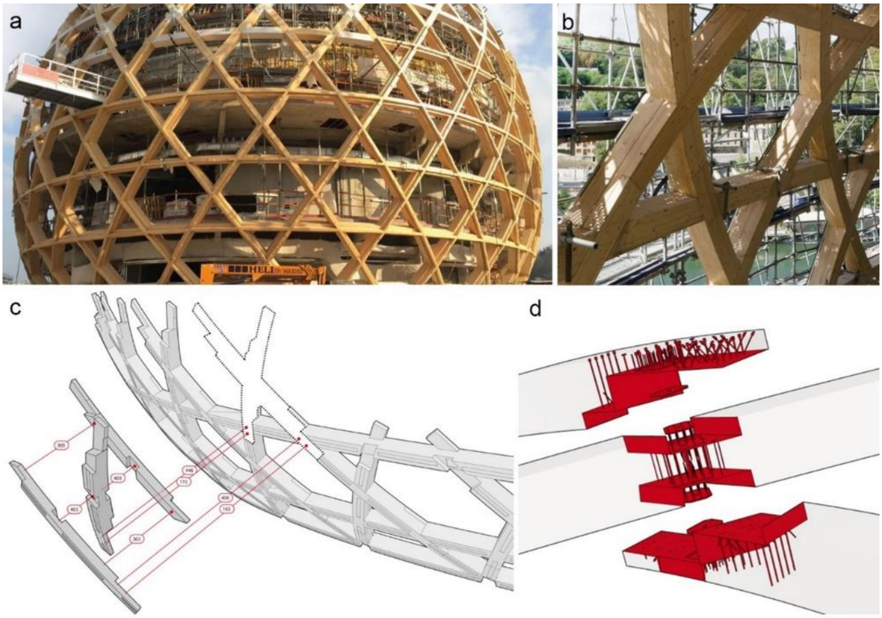

Fig. 4. The Seine Musicale in Boulogne-Billancourt (France), design by Shigeru Ban and Jean de Gastines, 2017: a – general view of the wooden structure in the implementation phase, b – view of double-curved elements, c – the principle of merging construction modules; d - connection principle in the construction node; source: a) b) H. Stehling, F. Scheurer, J. Roulier, H. Geglo, M. Hofmann, From lamination to assembly: modelling the seine musicale, "Fabricate 2017" – A. Menges, B. Sheil, R. Glynn, M. Skavara, pp. 258–263, Published by: UCL Press, 2017; source: c) d) F. Scheurer, BIM to Fabrication – Durchgehende Digitale Planungsprozesse bis zur Montage, 23. Internationales Holzbau-Forum IHF 2017, pp. 6–8, <https://www.forum-holzbau.com/pdf/17_IHF2017_Scheurer.pdf> [accessed: 20.05.20121]

The HESS TIMBER company was involved in the design, production and assembly of the facility structure. The numerical optimization was aimed at outlining a logical structure shape and at defining nodal points with which it would be possible to maximize the properties of beech timber and minimize the need for steel joints. In the design, toothed joints were shaped in a wooden structure in order to absorb compressive and shearing forces. The entire structure consists of hexagonal areas outlined by 15 latitudinal rims and 86 diagonal elements all of which form a distinctive oval shape. When laminating and processing the timber elements, double-curved elements were introduced. The entire process of erecting the object was supported by tools based on 3D CAD.

Another example of modelling a structural form based on architectural and construction parameters are the ESO (Evolutionary Structural Optimization) digital optimization tools, with their subsequent modifications, such as AESO Additive Evolutionary Structural Optimization (AESO) or BESO (Bi-directional Evolutionary Structural Optimization). These methods, used to select the optimal structure shape in terms of the course of material stress, employ iterative algorithms [7]. With a set load-bearing method and support conditions, the selection of structurally optimal shape for the structure is significantly facilitated. Irregular forms are made of solid timber (natural, glued, CLT) in the form of panels processed with CNC milling machines. These methods seem specially applicable in multi-modular timber structures for which light prefabricated elements are employed.

TRENDS IN DIGITAL MODELLING

The interactive collaboration between the architect and the design engineer is being constantly improved and is gradually transferred to the BEAM platforms. As part of the work on a shared model, data exchange takes place on the platform. The division of tasks between the architect and constructor is clear. However, the development of digital work environment is aimed at facilitating integration of activities at all stages of the building construction. An interesting aspect is progressive integration of solutions to issues related to the structure implementation, in particular with reference to fabrication technology. Such action naturally leads to the continuation of the project concept, that is to the implementation of a structural form with the use of a specific material and technology. In modern construction, fabrication methods defined as subtractive or additive that originate from the 3D printing technique, are increasingly applied. Subtractive methods aim to minimize the material by eliminating unnecessary spaces with a low level of material stress or by removing unnecessary elements. In the case of subtractive methods, a programmed machine, specifically a 3D machine tool, removes unnecessary material. The Swoosh Pavilion may be put forward as an example. The structure was implemented in 2008 at the Architecture Festival in Hooke Park, Great Britain, by Valeria Gracia Abarc under the supervision of Charles Walker and Martin Self. The 653 timber elements were cut with a 3D printer and then assembled in the form of a spiral structure whose length equalled approx. 60 m. Additive methods, on the other hand, are based on the principle of adding extra material. This principle, used in 3D printers, can also be adopted to automated implementation of models from repeating modules. From the point of view of work efficiency, it is crucial to ensure cooperation between the architect and the engineer designer who strive at optimizing the structural form in terms of the capabilities of the machine-robot operating the design. An example of such an implementation may be sought in the case of “The Sequential Roof of the Institute of Technology in Architecture, ETH Zurich”, the first roof made with the application of the automated technique by robots. The geometry, the covering area of which equalled 2,308 m^2, was created as a result of a parametric architectural and structural analysis, and was implemented with the use of prefabricated merged elements manufactured in an automated production process. In the optimization process, the amount of patterns of individual nodes was minimized and their geometry simplified.

Fig. 5. The Sequential Roof of the Institute of Technology in Architecture, ETH Zurich, design by Arch-Tec-Lab AG and manufactured by ERNE AG Holzbau, 2016: a, b – structural element in automated production, c – ready-made prefabricated element during the assembly of the structure; source: a)–c) photo by Gramazio Kohler, “ETH Zurich – ITA Institute of Technology in Architecture”, Arch_Tec_Lab/ Roof, <https://ita.arch.ethz.ch/archteclab/sequential-roof-.html/> [accessed: 20.05.2021]

The consistent efforts made by a team of specialists from the ETH in Zurich to automate the production processes of timber structures deserve recognition. The Institute undertakes multidisciplinary analyses, whereas implementations are preceded by analysis of the structure at all stages of the building’s construction (from outset to completion). In addition, the capabilities of individual construction modules are also tested on prototype models [5]. In this way, it is possible to experimentally verify new concepts.

The ETH Zurich team arrived at some noteworthy implementations with the use of the robotic additive fabrication technique, which enables prefabrication of structures that consist of typical modules.

Owing to the increasingly common possibilities to exercise automated control over the production of both, timber structural elements and entire timber load-bearing structures, methods of structure optimization are gaining popularity. Such action draws the designers’ attention to the material and its properties, especially its endurance parameters. Timber, being a natural matter, is special, hence the methods of processing this material are constantly being improved in order to make it possible to use its potential more fully. Acquiring interdisciplinary knowledge in the field of timber structures should, therefore, take place already at the research stage. An example of this approach is to be found in the curriculum for students at Campus Hooke Park. One of the most interesting projects by Timber Seasoning Shelter was created under the supervision of Martin Self (Program Director), under the engineering supervision of Arup. A group of students, supported by professionals knowledgeable in engineering, conducts experiments with the use of timber. Students learn the specificity and possibilities of beech timber material in practice. As part of a program in a forest in Dorset, UK, a modular structure was erected that consisted of double-layer elements pre-bent on presses and connected with high-strength bolts. During assembly, elements that consist of several connected modules were connected at the construction site. The completed structure could cover an area of approximately 150 square meters. When discussing the achievements of the students participating in the Timber Seasoning Shelter project, it is worth mentioning the growing popularity of structures erected spontaneously of timber materials typical for a given region. For example, erecting buildings made of bamboo wood must be preceded by knowledge, e.g., in the field of structural statics or aerodynamics, but the success of one or the other undertaking is determined by an experiment, e.g., by performing test loads.

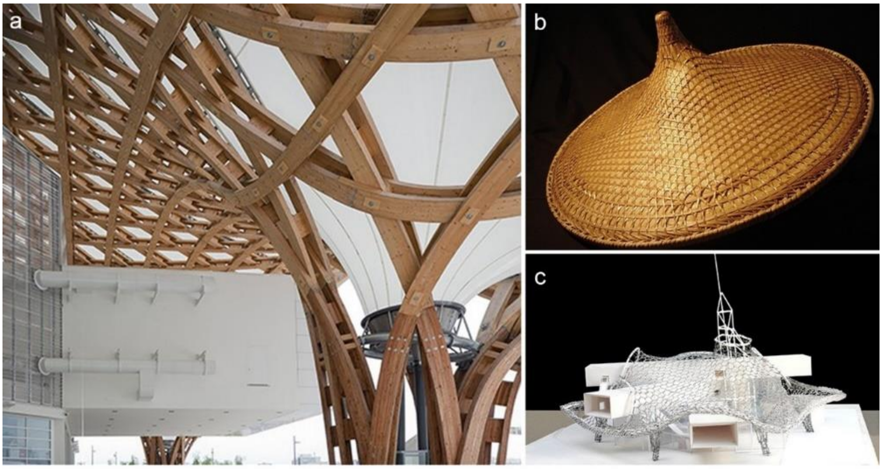

Fig. 6. Center Pompidou - Metz, France; design by Shigeru Ban and Jean de Gastines, Paris (France), structural design: Ove Arup; 2010: a – view of the structure built of double-curved bars, b – inspiration: Chinese bamboo woven hat, c – the physical model of the object;
source: a)–c) “The Architectural Review”, Centre Pompidou-Metz by Shigeru Ban Architects & Jean de Gastines Architectes, France, Will Hunter, 24.03.2014, < https://www.architectural-review.com/architects/shigeru-ban/centre-pompidou-metz-by-shigeru-ban-architects-jean-de-gastines-architectes-france> [accessed: 20.05.2021]

In the field of timber constructions, active-bending system constructions are gaining popularity. Such systems take advantage of the possibility of pre-compressed elements by being given initial curvature. In order to obtain ever more effective forms, elements bent on presses are used during the production of timber glued along one or two curves. An example of the above- mentioned systems may be found in the case of The Center Pompidou-Metz, France, built in 2010; designed by Shigeru Ban and Jean de Gastines and structurally designed by Ove Arup and Herman Blumer. The design uses a supporting structure with GL double-curved beams. Modern CNC machine tools (Computer Numerical Control) based on the 3D CAD model allowed for the prefabrication of elements, which were then assembled at the construction site. Numerical analysis requires the use of more sophisticated tools in order to model this type of structure. The SOFISTIK program with the ACTB-Active Bending Module can be used to solve active bending tasks. Various competences of an architect and an engineer acquired at universities are also very clear in the case of modelling in the field of Active Bending structures. The use of these programs requires the design engineer to display extensive knowledge in the field of statics, with regard to nonlinear analyses, as well as being familiar with programming.

SUMMARY

Despite the significant progress that has been seen in the quality of the tools at their disposal, the cooperation model between an architect and a design engineer has not significantly changed. The division of tasks and roles was and still remains visible, regardless of whether the designers use a pencil and a chain model or rather apply software supported by numerical optimization methods. The progress in specialization leads to an increase in work efficiency, but also strengthens mutual professional ties and the need for creative cooperation. The use of increasingly unrestricted geometric, spatial and material solutions by architects generates complex construction issues. With the development of software with which to operate graphics and to analyze statics and dynamics, it may seem that the work of specialists can be replaced by a machine. Nevertheless, the debate on the possibility to replace the designer with a self-controlling machine is definitely too far-fetched today. The development of a professional workshop towards the broadly understood optimization of construction processes should be seen as the main challenge for a modern architect and design engineer. In order to achieve this goal, it is necessary to improve the methods and tools applied for structure shaping. In the context of a wider use of construction timber, the deepening of research into the field of material structure ought to pose one of the key issues that require analysis, with account to features such as, e.g., anisotropic nature of the material in endurance simulations. The growing need arises to create a digital base of materials, so as to include various tree species or timber-based materials. The need is also resultant from the development of new implementation technologies, especially manufacture-related ones. Such technologies may not yet have been defined by the regulations of the construction law. In this context, the achievements in the field of building prototype load-bearing structures are invaluable and highly prospective, as they result from interdisciplinary design as part of research experiments.

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MODELOWANIE KONSTRUKCJI DREWNIANYCH W KONTEKŚCIE WSPÓŁPRACY ARCHITEKTONICZNO-KONSTRUKCYJNEJ

Wraz z rozwojem idei zrównoważonego rozwoju w architekturze współczesnej obserwujemy wzrost zainteresowania drewnem konstrukcyjnym. Takie działanie daje impuls dla rozwoju narzędzi do projektowania form strukturalnych z drewna i materiałów drewnopochodnych. Doskonalenie programów do budowania cyfrowych modeli, a także ich analizowania daje nowe możliwości we współpracy architekta i konstruktora. Artykuł zawiera rozważania na temat współdziałania tych dwóch dyscyplin na różnych etapach projektowania obiektu. Istotnym elementem opracowania jest przegląd wybranych programów do analiz wytrzymałościowych konstrukcji drewnianych w odniesieniu do narzędzi, jakimi posługują się architekci. Rozważania na temat interdyscyplinarnego kształtowania form strukturalnych zostały poszerzone o studium wybranych obiektów, w których uzyskano synergię rozwiązań strukturalnych.

LIGHT AND SHADOW DYNAMICS OF MODULAR BUILDING FAÇADES

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ABSTRACT

Modular architectural elements placed on the façades show the beauty of the dynamics of chiaroscuro. This paper is an overview of modular facades in architecture and the relationship between objects and light. Studies shows various aspects of shaping the modular façade in terms of references to history, tectonics, structure, illumination, ecology, material solutions and innovation. The research was conducted among students, and then detailed data on selected modular objects were compiled and published in the text of the work. On the basis of the list, qualitative and quantitative analyzes based on examples of global implementations were prepared and the current trends in architecture were presented. The analyses show how contemporary architects use light as a multidimensional medium to support architecture and site function as well as new dimensions of contemporary design. The study demonstrates the validity of the multi-faceted design of building façades and the adaptation of modules to multiple functions.

Keywords: façade, module, illumination, texture, aesthetic

INTRODUCTION

The beauty of architecture [1], manifests itself not only in the harmony of the composition, but also in the construction and structure of a building. Elevations are a visiting card of a buildings and the "skin" of its form [2]. Modular façades have different functions, and their aesthetics and beauty is manifested in precisely designed details, while their construction and the type of materials used affect the dynamics and plasticity of the body. A quantitative and qualitative analysis of selected examples of architectural realizations across the globe, made it possible to define current trends in façade design. Creation of chiaroscuro by optimal daylight management and innovative ways of illuminating with artificial light of selected parameters, together with selected control systems, constitute their fascinating variability, which is the subject of this article.

RESEARCH METHODOLOGY

The research presented in this article was compiled from data available in book publications and scientific articles. The table presenting data on modular façades is a summary of the research work of students of the Faculty of Architecture of the Poznań University of Technology. Initially, the students were asked to indicate 5 examples of modular façades. Afterwards, the respondents were asked to choose 2 the most interesting examples in terms of the object-light relation. The choice of 2 examples was also preceded by a discussion and brainstorming conducted during the classes, after explaining the students the available heuristic methods. The most interesting examples have been supplemented with detailed data. A comparative analysis was made and quantitative and qualitative data were collected. Some of this information was based on the basis of scientific sources, but also information and figures: plans, sections, axonometry, visualizations, photographs, available on the websites of architectural offices. In some cases, the data has been specified as estimates. Finally, after eliminating duplicate examples, a representative sample of 71 buildings listed in the table (Table 1) was selected.

The dynamics of light on the façades over the centuries

The beauty of architecture, or the aesthetics of architecture as some would have it, brings to mind harmony and the Vitruvian Triad. Throughout history, architectural structures have undergone a number of transformations and have been assessed for their durability, usefulness and beauty on the basis of variables which changed over time, reflecting civilisational requirements and technical criteria [3].

Vitruvius' earliest notes on good rhythms, show the importance of proportion and appropriate numerical ratios in buildings. Modules forming clear principles have persisted in architecture since antiquity, and can still be seen in the works of Le Corbusier [4].

We define architecture as the science and art of designing, constructing and then erecting spatial structures, which we recognise by their forms consisting of a skeleton (structure) and an outer shell – the skin. This means that apart from the form itself, often an architectural sculpture (Figure 1) whose "crystalline geometry changes perpetually its appearance in the shifting play of light" [5, p. 130], it is the façade that is one of the most important recognisable and remembered architectural elements. And still today, as users of architectural space, we judge it subjectively in terms of beauty and ugliness, qualities which affect our mood, emotions and the atmosphere of a given place. Therefore our perception of architecture begins with the formal aspects: form and façade as well as the structure.

Fig. 1. Unusual sculptural form of the Amsterdam Film Museum
(designed by Delugan Meissl Associated Architects); photo: H. Michalak

Fig. 2. Forms and their skins: China Central Television Headquarters, Beijing, arch. Rem Koolhas, Beijing (left); Phoenix Centre (arch. Shao Weiping, Beijing Institute of Architectural Design, BIAD UFo.) in Beijing (designed by Delugan Meissl Associated Architects) (right); photo: H. Michalak

Buildings change over time to reflect the latest fashion (architectural styles) and technical capabilities, and it is a constant process, although it seems that the transformations described by Kuc-Słuszniak are an ongoing process that affects the perception of space. The dynamism of the outer shell of the building depends on the relationship between light and shadow on the surface of the façade, the relationship between darkness and lightness dictated by a variety of details: cornices, ornaments, window and door openings, pilasters, reliefs and all other concave or convex sculptural elements. These details changed with the prevailing fashions, but the construction materials remained almost unchanged for centuries until the industrial revolution. The dynamics of light and shadow on the façades was associated with the number of sculptural elements and their depth in successive spatial façade scenography plans. It changed with the time of day and year, and with changing lighting conditions, light intensity during the day (sunlight) or night (moonlight).

Modern architecture brought another revolution associated with the dominance of structural form, where component parts of a building's structure played both a decorative and a technical role [6]. Together with the departure from historical styles, building façade ceased to be just a surface with a composition of windows and doors and all sorts of ornamentation. They became minimalistic, but not devoid of the play of lights and shadows. In classical designs with planned rhythms, heavy stone columns are the main structural elements. In the Athenian Parthenon, columns were 10 m high and 1.7 m in diameter, and were spaced every 4 meters. In more recent times columns vary in diameters and spacing within a single building. For example in The Alluminium Knowledge and Technology Centre in Utrecht, the Netherlands (arch. Micha de Haas), columns are 6 m high and the spacing between them varies from as little as 0.9 m to 2.1 m [7, p. 40]. Despite a completely different expression, it cannot be said that these solutions are without harmony. There is also a completely new element, hitherto impossible to implement for technical reasons, which creates a building's night-time image. "The use of artificial light as an integral element of architectural design was pioneered by Richard Kelly in the Seagram Building (the work of architects Ludwig Mies van der Rohe and Philip Johnson), built over half a century ago, in 1958 in New York. The illusion of a levitating building achieved by illuminating the ground floor is still considered exemplary in terms of the use of artificial light in the construction of spatial scenography" [8, p. 157]. In architecture light is both a tool and a material [9]. The building's façade was accentuated using artificial light, turning the building into a luminous sculpture. And thus, with the development of lighting techniques, a trend started 30 years earlier by Laszlo Moholy-Nagy who (Licht-Raum Modulator) introduced kinetics and the use of light to a stage prop, set new directions in art and consequently in architecture [10].

Aesthetics and beauty of modular façades, composition, textures, tectonics

The aesthetics and beauty of the often multi-layered textures of modular façades, which serve different functions, are reflected in the precisely designed details, while their structure and the type of materials used drive the dynamics and plasticity of the spatial form. "The use of moving elements on façades, including those articulated by pneumatic systems which push the other skin of a building, is not the only way to achieve variation in the image of a spatial form through light" [11, p. 41].

In their projects, architects use new tools, including parametric design [12], in the BIM environment mainly based on ARCHICAD and Grasshopper [13], to put new pattern geometry solutions into practice and test innovative materials depending on the needs related to the location of a building (sunlight, humidity, wind, temperature, etc.), the desired texture, the degree of transparency or light reflection, but also economics, ecology and optimisation. "This approach contributes to an understanding of form, material and structure, not as separate elements, but interrelated in a polymorphic system" [14, p. 148].

The Building the dynamics of light

Very frequently modular façades form the skin for a highly functional space. The use of modern materials and methods in the design and construction of façades demonstrates an architect's mastery in working with feasible applications for innovation in their work.

Such design work is not just a game with form and content, but rather a conscious, pro-ecological work, affecting both the human being, user of the designed space, but also the environment within which it is situated. The aforementioned multifunctionality of modern façades, capable of both impressing with their beauty and harmony as well as their proficiency in achieving technical and environmental objectives, means buildings designed using modular façades are unique.

Selected representative examples for research

A large part of the façades being designed are modular. Repeat elements are developed individually for each building. This article presents the similarities and differences they exhibit. The following table (Table 1, see below the table for an explanation) lists 71 examples of modular façades. The representative sample shown in the table is compiled from publications and interesting projects chosen by the authors and proposed by students as the world's best examples of modular façades. Originally there were many more items in the table, however repeat items were excluded.

Overview of architectural structures with multiple quotations

Using buildings that have been cited several times can yield an indication of the most important features of contemporary architecture. The Arab World Institute, BIQ house, SDU Campus Colding and Al Bahar Towers were repeatedly pointed out as the most interesting. The aforementioned buildings stand out in terms of the quality of the materials used as well as architectural details designed by world-renowned architects. They feature elements of innovative kinetic connections and bespoke material solutions. In one of the buildings which crops up a number of times, a façade was built from seaweed, never previously used in engineering. Other façades are constructed out of modules that are movable in relation to different axes, which accounts for the high degree of adaptation of a building’s skin to exposure and the elements, and testifies to the precision seen in various elements. The identified properties point to architecture of the highest quality.

Advanced façade kinetics can be a factor increasing the grandeur and impact of a project while maximising the economic benefits in the building’s operation. The fascinating façade of the Arab World Institute comprises movable elements that allude to the culture of the Middle East and embellish the interior with diverse light and shadow contrasts. The south façade of the building uses a mashrabiya pattern and is based on the principle behind the human eye [15]. The façade of Al Bahar Towers uses a specialised module for energy-efficiently control of the amount of light entering the building and to adjust the temperature. The repeat elements are made of origami modules comprising 6 triangles set in motion by actuators. The frame of the kinetic structure is filled with a mesh, partially allowing daylight to enter the rooms [16]. The SDU Campus Colding façade shows an image changing dynamically using kinetics of perforated panels according to the time of day and sunlight intensity. The University Campus Colding building is found in Denmark. A horizontal kinetic façade system was chosen due to the low angle of the sun over the site [17]. The constantly changing building effect is helpful in identifying and recognising modular buildings. The striking façade of the BIQ house, equally often cited by students in the study, uses the action of living organisms and stands testament to the allure of using modern materials in architecture.

Living modular façades

The BIQ house is a significant example of a living building façade. Algae were inserted between glass panes which constantly move along the panels, establishing irregular patterns. The modules are a source of renewable energy, producing biomass as the algae heats up under the influence of the sun. The repeat elements constitute 0.7 × 2.5 m panels, arranged vertically. Energy is collected from an area of over 200 sq m [18]. The building's façade is constantly changing, resembling a living organism against the background of the surrounding urban development. Although the plant material has been enclosed in a regular framework, the façade exudes the beauty of nature.

Building façades featuring greenery, thanks to their benefits and despite the disadvantages, are not only an eco-friendly fashion, but a necessity and a real opportunity to expand biologically active areas, especially in metropolises and cities which are turning into heat islands [19].

The design of living façades has to incorporate the right conditions for the given type of plant to grow. One of the decisive factors in the choice of plants is the sunlight received by a given green façade, as it plays a key role in photosynthesis [20]. Illumination of green façades is possible, but special care must be taken when it comes to the plants' light exposure in terms of time, quantity and spectrum of light itself, so as not to adversely affect the growth processes.

Managing solar energy

Protecting a building from the external environment is one of the primary roles of façades. Modular façades are designed not only to protect but also to use and manage the energy that a building is exposed to [21]. Solar energy is one such inexhaustible resource that reaches the building. According to standard guidelines [22], a building should be designed to make use of sunlight and provide daylight to its occupants. The electromagnetic wave generated by daylight has a direct effect on the interior of a building and the comfort of its users. Wave radiation is perceived by humans directly in two of its spectra [23]: visible radiation, with wavelengths between 380 nm and 780 nm (perceptible by sight), and infra-red radiation, with wavelengths between 780 nm and 1 mm (perceptible as heat). Solar radiation also carries ultraviolet light (wave-length between 280 nm and 380 mm), which reaches the earth and is not directly felt by humans, but its effects certainly are. Overexposure to UV-A radiation can have very negative effects on both living organisms and materials used in the construction of a building and its interior finishing. Solar energy can also be used by photovoltaic panels to generate electricity. These operate in the 300–1200 nm spectrum.

Illuminations as an element of a building's image

Creating an attractive night image of a building absorbs the observer's attention and the space in darkness seems non-existent [24]. Such a building, in the absence of illuminated structures in its vicinity, plays a dominant spatial role, a night monodrama drawing all of the observers' attention. By day, the same building, even if located in an urban desert, will be surrounded by roads, other buildings or nature, the sky and the environment stretching all the way to the horizon. Perhaps it will be a dominant spatial feature, but it will always be a dominant feature embedded in space. Façade illumination should follow a lighting strategy of the given location and comply with standard guidelines [25] as well as those defined in the local lighting plan [26].

Illuminations [27] can have different purposes and can be design by using different methods, but whatever the intention, infallibly their task is to make a building visible at night in a special way [28]. Modern modular façades can take advantage of all known methods of incorporating illumination (Fig. 3).

Floodlight allows for an unobstructed perspective of the building's daytime face. Spotlights authorises the sculpting of a façade in relation to its daytime appearance and provide an opportunity to highlight its details and adjust the perception. The linear method [29] is a new method of illuminating an object that is becoming more widely used due to the availability of LED technology and the manufacture of linear light sources. Thanks to the so-called "direct view" method, the illuminated building can be dressed in a kind of luminous jewellery, creating a distinctive night-time character. By combining different technologies in a mixed method, we often obtain very versatile images that enhance a building regardless of the perspective and distance from which we look at it.

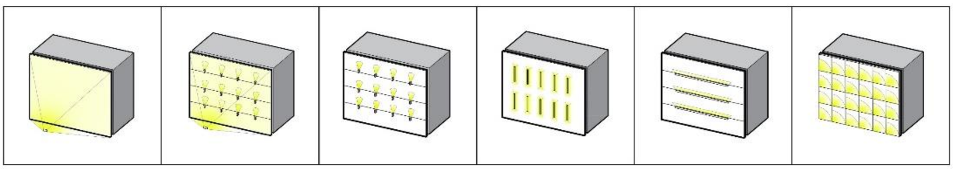


Fig. 3. Methods for incorporating illumination. From the left: flood method, combined method, spot method, direct method, linear method, modular method

Ways for managing daylight

Daylight energy in the form of thermal energy, visible light and UV radiation has an impact on occupant comfort and on the building itself and measures must be taken to manage it. Most designers of the surveyed buildings reached the same conclusions. As shown in Fig. 7g, frequency of the function, where the management of daylight and its derivatives is the most common function of modular façades and together accounts for nearly 70% of buildings subject to the research: protection against excessive sun exposure: 37%; maximising the use of daylight: 19%, power generation – 7%, protection against the Sun's thermal energy – 6%.

A façade module, designed to manage daylight [27], can be used to protect or channel daylight. It may be constructed according to the use of light to illuminate interiors with sunlight and/or sky light. Sunlight itself, which carries the above-mentioned energy, can be categorised into three basic types: direct light, diffused light and reflected light. A high proportion of daylight in interior lighting makes it possible to limit the illumination of rooms with artificial light to the values required by standards [30], which directly affects the building's electricity consumption. The modular façade of the PKP main train station building (Fig. 4) in Poznań can serve as a good example of the use and management of daylight at the façade design level. The façade is constructed out of triangular-shaped modules, some of which have a glass-restricted transparency for visible and thermal radiation, allowing daylight to be used to illuminate the main hall of the station during the day. A glare-reducing raster module is part of the façade's load-bearing structure, thereby improving visual and living comfort in the hall.

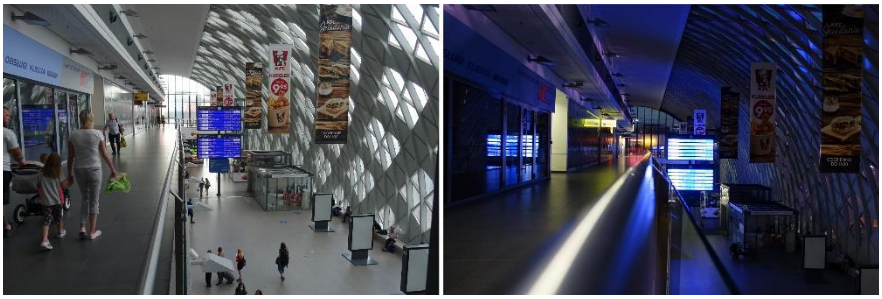


Fig. 4. Railway Station PKP, POZNAŃ PL, Bose International / Pentagram Architekci, photo: P. Ratajkiewicz

Illumination methods

Analysing the illumination of façades, some common features have been found, which make it possible to define a new method for illuminating modular façades. This method has been provisionally called "modular". It may employ different illumination techniques, but with regard to the way it shines, it always uses an analogy attributed to a single module, which the façade is composed of. In this method, the image is built from individual modules, but does not always use all the elements of the façade. This approach is often combined with dynamic lighting control systems to create impressive light spectacles or a subtle play of lights and shadows. Changeability, like that of sunlight which falls at different angles, is intended to add variety to the night view and significantly ennoble the building. Use of the modular method allows the designer to have full control of light, not only in illuminating the building structure itself, but also over diffused light, thus reducing the phenomenon of "lighting pollution" – or littering the sky with light [31].

Malta shopping centre in Poznań is an architectural example where we can find the use of the modular method for façade illumination (Fig. 5). A light module comprising a linear luminaire was used there, whereby indirect lighting of the façade proper was provided from the module of the aluminium and glass part of the façade. Here such an implementation delivered effective and attractive lighting and façade depth in a much more expressive way than during the day.

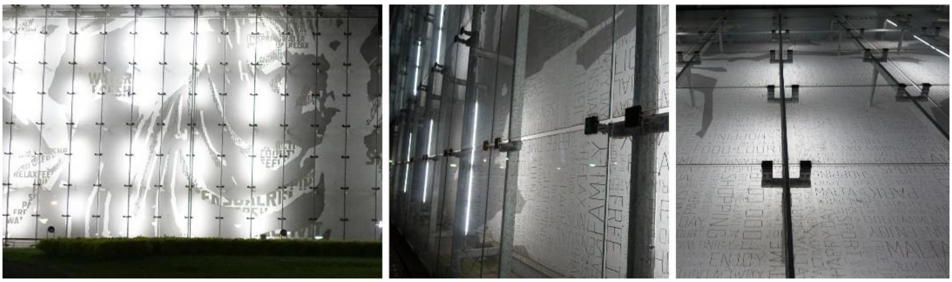


Fig. 5. Shopping Mall MALTA, POZNAŃ PL, Pracownia Ewy i Stanisława Sipińskich,
photo: P. Ratajkiewicz

During the day, natural light causes variations in the perception of a façade. The changing direction of sunlight results in a play of lights and shadows on spatially structured façades. At night, artificial lighting can be used to set the façade in motion, creating an impression of dynamism and mobility. Façade kinetics can be static for the façade itself, and the movement will then be executed by artificial light operating at night.

A possible ways to add dynamism to a façade are: use of different light directions, different colours of light, use of colour, lighting scenarios, application of dimming systems, lighting of kinetic façades, use media façades [32], GOBO projections, video projection. The many possibilities offered by a modern lighting technologies provoke overuse in potential designers. As the research illustrated in Fig. 7a shows, the trend in the use of coloured lights is increasing and is close to 40% in the sample.

Lighting of modular façades is an essential part of façade construction and should be an integral part of the façade design from the design stage of the façade itself, for both daytime and night-time illumination. Full integration of lighting control with building systems can be ensured by standardising solutions to the BMS system, which integrates the building's technical functions' control systems. This allows for the control of comfort control subsystems such as air conditioning, ventilation, heating, lighting, car park systems, or weather system, to be integrated with each other and facilities efficient energy use for needs of the building and its users. The building's lighting control system should allow the management of calendars and the creation of lighting scenarios [33] to meet needs changing over time.

Fig. 6. Examples of buildings with daylight and artificial light together with the applied illumination method. From the left: PKP train station, Poznań PL (flood method); Malta Office Park, Poznań PL (point method); ETHOS office block, Warsaw PL (linear method); Posnania Shopping centre, Poznań PL (mixed method); Stary Browar, Poznań PL (direct method); Malta Shopping centre, Poznań PL (modular method). Photographs by P. Ratajkiewicz, STUDIO DL

A practical use of illumination to create a night-time image of a building is shown using examples (Fig. 6). By comparing the same buildings during the day and at night, as shown in the images, we can directly see how illumination affects the perception of a given building. Today, almost any illumination can be designed using equipment based on LED technology [34]. Floodlight illuminations, which required high-power projectors, can now be constructed using energy-efficient LED sources, which are particularly effective and easy to control when using modules with variable RGB colours – this is how the façade of the façade of the main railway station in Poznań is illuminated. The use of coloured light allows for additional effects in terms of building colour contrasts and chiaroscuro, as well as deepening the colour perspective of the illuminated building [35]. Through the miniaturisation of luminaires and the development of optical systems, spotlights offer the possibility of achieving almost any sculptural effect. Modern systems also make it possible to create uninterrupted lines, which contributed to the development of the linear method – the method used by the ETHOS office building presented here. Direct techniques very often comprise bespoke constructions illuminated from the inside, as is the case with Stary Browar. The discussed illumination methods may be used together. Such a technique was used for the Posnania shopping centre, where the plaster wall of the building was floodlit, showing a mesh construction in negative contrast, onto which direct view type LED linear luminaires with individually controlled sections were installed. Linear luminaires facilitate lighting scenarios by creating together with backlighting a highly cohesive, yet intriguing and attractive night-time image. Modular lighting in itself is based on the inherently interesting structures of modular façades. This offers enormous design possibilities for illuminating buildings. Sometimes, however, very simple measures, such as the use of fluorescent luminaires in the Malta shopping centre, can create a high-quality visual experience and enhance a building in a special way.

These examples show the wide range of possibilities in lighting design. The architect and lighting designer will have to create work together to come up with the building's illumination [36]. Such synchronisation makes it clear how light can enhance the beauty and attractiveness of architecture and how it can build and control the moods of observers [11].

RESULTS AND DISCUSSION

Table 1 contains basic data on the 71 buildings and details of the modules on the façades of these buildings. The list includes names of the architectural works (column 2), information on the location of the building (column 3), together with the name of the design studio or designer (column 4), the year of construction (column 5) and information on the approximate total area of the property (column 6). Data on the function that the façade fulfils is also included (column 7). Also included are the (sometimes estimated) façade module sizes (column 8), the actual or approximate number of repeat elements (column 9). The final columns show the way the modules are connected (column 10) and façade mobility (column 11).

The A–M designations describe the function of the façade modules (A – daylight maximisation, B – protection from excessive sun exposure, C – insulation, D – ventilation, E – air purification, F – heat rejection, G – sound dampening, H – electricity generation, I – wind protection, J – enhanced aesthetics, K – water collection facility, L –symbolism, M – use of local materials). Connections between modules (T) were also classified (X – rigid connection, Y – articulated, Z – other connection). Façade mobility (M) was determined on a scale of 0–2 (0 – façade immobile, 1 – façade mobile in one axis, 2 – façade mobile in 2 axes). The following façade types have been identified: kinetic façade (* building name), modular façade – mesh (** building name), green façade (*** building name). Shaded lines signify RGB lighting illumination.

Table 1. Modular façades in architecture – a case study

No.	Building name	City, country	Architect	Year	Building area [m²]	Façade function	Module dimensions [mm]	Number of modules	T	M
1	30 St Mary Axe	London, GB	Foster & Partners	2004	46400	C, J	3800x2000	24,000	X	0
2	727 W. Madison St. Parking	Chicago, US	FitzGerald Associates Architects	2018	~1000	B, H, J	900x3000	1000	X	0
3	Administrative Center YJP	Tianjin, CN	HHD_FUN	2009	18000	B, J	140x140	4000	X	0
4	*Al Bahar Towers	Abu Dhabi, AE	AEDAS	2012	32000	B, F,L	4200x4200	2098	Y	2
5	*Apple Dubai Mall	Dubai, AE	Foster+Partners	2014	2538	B	~5500x11000	18	Y	2
6	Bank building	Frankfurt, DE	TEK TO NIK	2016	5226	J	~3000x2500	60	X	0
7	*Ballet Mechanique	Zurich,CH	Manuel Herz	2017	600	B	~2500x3500, 5000x3500, 7500x3500	15	Y	2
8	***BIQ house	Hamburg, DE	Splitterwerk Architects	2013	1350	H	700x2500	129	X	0
9	*Brisbane Airport Parking	Brisbane, AU	Ned Khan + UAP	2011	16500	J	~150x200	118000	Y	1
10	Bulgari shop	Kuala Lumpur, MY	MVRDV	2018	103	A, J	~250-270	9	X	0
11	**Cabin of 3D Printed Curiosities	Oakland, US	Emerging Objects	2018	11	B, J, K	100x100	4500	X	0
12	CCTV Headquarters	Beijing, CN	OMA	2012	473000	J	6000x6000 12000x12000 24000x24000	~800	X	0
13	***CDL Tree House	Singapore, SG	City Developments Limited (CDL)	2013	2289	B, C, G, E	~4000x6000, 15000x19000	36	X	0
14	Centrum fitness Le Nuage	Montpellier , FR	Philippe Starck	2015	3000	A, J	main ~9500x25 00	42	X	0
15	China Steel Corporation Headquarters	Kaohsiung, TW	Kris Yao | Artech Architects	2012	81054	C	3000x1500	~8450	X	0
16	City View Garage	Miami, US	IwamotoScott	2015	1403	D	1000x1400	990	X	0
17	Competition pavilion	Edynburg, GB	Doepelstrijkers, M. Brus, R.Brokking, Jaap van Dijk	2016	25	K, J	d=100-200	2400	X	0
18	Cubitt House	Londyn, GB	Satellite Architects Ltd	2016	~ 2500	B, J	400x400x 400	4000	X	0
19	Doha High Rise Office Tower	Doha, QA	Ateliers Jean Nouvel	2012	60000	A, B	depends on the sun	~10000	X	0
20	Elbphilharmonie	Hamburg, DE	Herzog & de Meuron	2016	120000	A, B, J	1500x3000	3 600	X	0
21	Entertainment Complex, Xicui	Beijing, CN	Simone Giostra & Partners Architects	2008	6100	H, J	1000x1000	2292	X	0
22	Ethos	Warsaw, PL	maas projekt	2017	15808	J	~1000x1500	~160	X	0
23	EWE & Bursagaz Headquarters	Bursa, TR	tago architects	2016	9500	B, D, J	~600x500	~16500	X	0
24	***Firma Casa Store	Sao Paulo, BR	SuperLimão,Campana Brothers	2011	500	B, D, K	~300x450	900	X	0
25	FRAC Marseille	Marsylia, FR	Kengo Kuma & Associates	2013	5757	B	1000x2000	150	X	0
26	Futurium	Berlin, DE	R. Musikowski, JUCA	2017	14007	A	700x700	8000	X	0
27	**Garage Façade P22a	Kolonia, DE	wulf architekten	2017	4900	A, D	~3000x1500	3000	X	0
28	Ginza Place	Tokyo, JP	Klein Dytham, Taisei Design	2017	7350	J, L	~300x300-3000	5315	X	0
29	**Golf's Tower	Lima, PE	Hackenbrioch Architekten	2008	7000	B,D	~1000x1500, ~500x750	~100,~22 0	Y	1
30	Granger Bay Garage	Cape Town, RPA	Shaakira Jassat	2019	V&A 460000	K	100x30	~100/pan el	X	0
31	GSK Asia House	Singapur, SG	HASSELL	2017	15000	D, J	3000x3000	350	X	0
32	Hala Gliwice	Gliwice, PL	Perbo Projekt, Modern Construction System	2018	65,890	B, J	~800x1500	~4000	X	0
33	Hangar H16	Cannes, FR	Comte & Vollenweider	2016	10250	B	1500x1500	~900	X	0
34	Hanwha Headquarters	Seul, KR	UNStudio	2013	57700	A, H	d=1400	1500	X	0
35	Harpa	Reykjavik, IS	Henning Larsen	2011	28000	A, J	2000x1000	~5000	X	0
36	Head Office FITECO	Change, FR	Colboc Franzen & Associés	2010	~2000	A, B	~3000x500	~200	X	0
37	Hermes Store	Amsterdam, NL	MVRDV	2016	~500	A, J	250x120x60	~2500	X	0
38	Hospital 'Dr M. Gea Gonzalez'	Mexico, MX	Elegant Embellishments	2013	35000	E	100x100	~2300	X	0
39	*IMA	Paris, FR	Jean Nouvel	1987	26900	B, J	~2500x2500	240	Z	1
40	Jean-Marie Tijbaou Cultural Center	Numea, NC	Renzo Piano	1998	8550	A,B,D, I	~900x2000	100-200	Y	1
41	Le Prisme Concert Hall	Aurillac, FR	Brisac Gonzalez Architects	2013	320	C, L, J	500x500	1800	X	0
42	***LINQ apartment	Dubaj, AE	Project of students	2014	65	F	300x200	~800	X	0
43	Malta Shopping Mall	Poznań, PL	Ewa i Stanisław Sipińscy	2009	162000	B, J	1500x1500	1500	X	0
44	Media TIC	Barcelona, ES	Enric Ruiz Geli	2011	~ 3572	B	3000x3000	104	Y	1
45	Metropol Parasol	Seville, ES	Jürgen Hermann Mayer	2011	5000	J	1500-16500x68-311	3400	X	0
46	*Municipal Stadium	Poznań, PL	Modern Construction Systems	2010	250000	A, B, I, J	~9000x4000	920	Z	1
47	SPG	Geneva, CH	G. Vaccarini	2016	385	A, B, J	1500x4000	~2000	X	0
48	Parking Garage	Boston, US	Arrowstreet	2016	6330	C,D	62x62	48,000	X	1
49	Parliament building	Valletta, MT	Renzo Piano	2015	23000	B,J, M	50x100	5500	X	0
50	Pearl River Tower	Guangzhou, CN	G. Gill, B.Wilkins, A. Smith, R.Forest	2011	214100	H, B	~1000x3000	~12000	X	0
51	*Pixel	Melbourn, AU	Studio505	2010	1136	J, H	many types	~500	Y	1
52	Printworks building	Dublin, IE	ecoLogicStudio	2018	10600	E	200x700	16	Y	1
53	**Posnania Shopping Mall	Poznań, PL	RTKL	2016	230000	J	~1800x1800	Front 620	X	0
54	Poznań Congress Center	Poznań, PL	W.Tkaczyk ADS	1994 2008	5700	J	in interior △1800x3600	~154	X	0
55	Poznań Main Train Station	Poznań, PL	Pentagram Architekci	2012	60000	A	~750x1500	4870	X	0
56	Q22	Warsaw, PL	APA Kuryłowicz & Associates	2016	91164	A, F, G	4740x2540	2100	X	0
57	*RMIT Design Hub Gallery	Melbourne, AU	Sean Godsell Architects	2012	1300	H, J	d=600	774	Y	1
58	Ryerson University	Toronto, CA	Zeidler Partnership Architects + Snøhetta	2015	14000	A,B,C,F,G	2600x3600	1000	X	0
59	S2OSB Headquarters	Hendek, TR	Binaa	2016	3000	B, L	1500x3000	600	X	0
60	SAHMRI	Adelaide, AU	Woods Bagot	2014	25000	A, B, F	~1400x1400	15000	X	0
61	School Les Trèfles	Anderlecht, BE	Arter Architects	2016	800	D, J	2500, 3050x1200	~1600	X	0
62	SDU Kampus	Kolding, DK	Henning Larsen	2014	13700	A,B,F	2000x600	1600	Y	1
63	Sidney & Lois Eskenazi garage	Indianapolis, US	Rob Ley Studio	2014	14500	B, J	810x406, 610x406, 406x406	6500	X	0
64	Simens HQ	Masdar, AE	Sheppard Robson	2013	22800	B, D	1500x3750	216	X	0
65	Stary Browar Shopping Mall	Poznań, PL	ADS	2003 2007	130000	J	glass planks 262, 331, 232	~8000	X	0
66	The Broad Museum	L.A., US	Diller, Scofidio + Renfro	2015	~11,150	B, J	~1000x500	2500	X	0
67	ThyssenKrupp Quarter	Essen, DE	Chaix & Morel et Associes, JSWD	2010	Campus 160000	B	~900x3500	400,000	Y	1
68	*Warsaw UNIT	Warsaw, PL	Projekt PBPA	2020	57000	B	~100x100	90000	Y	1
69	Welbeck Street car park	Londyn, WB	M.Blampied and Partners	1970	13500	B	2000x2000	80	X	0
70	Wuhan Center Tower	Wuhan, CN	ECADI	2019	3900	B	3500x2000	~9000	X	0
71	Złote Tarasy Shopping Mall	Warsaw, PL	Partnerstwo Jerde	2007	205000	A, B, J	△2500x3000	7000	X	0

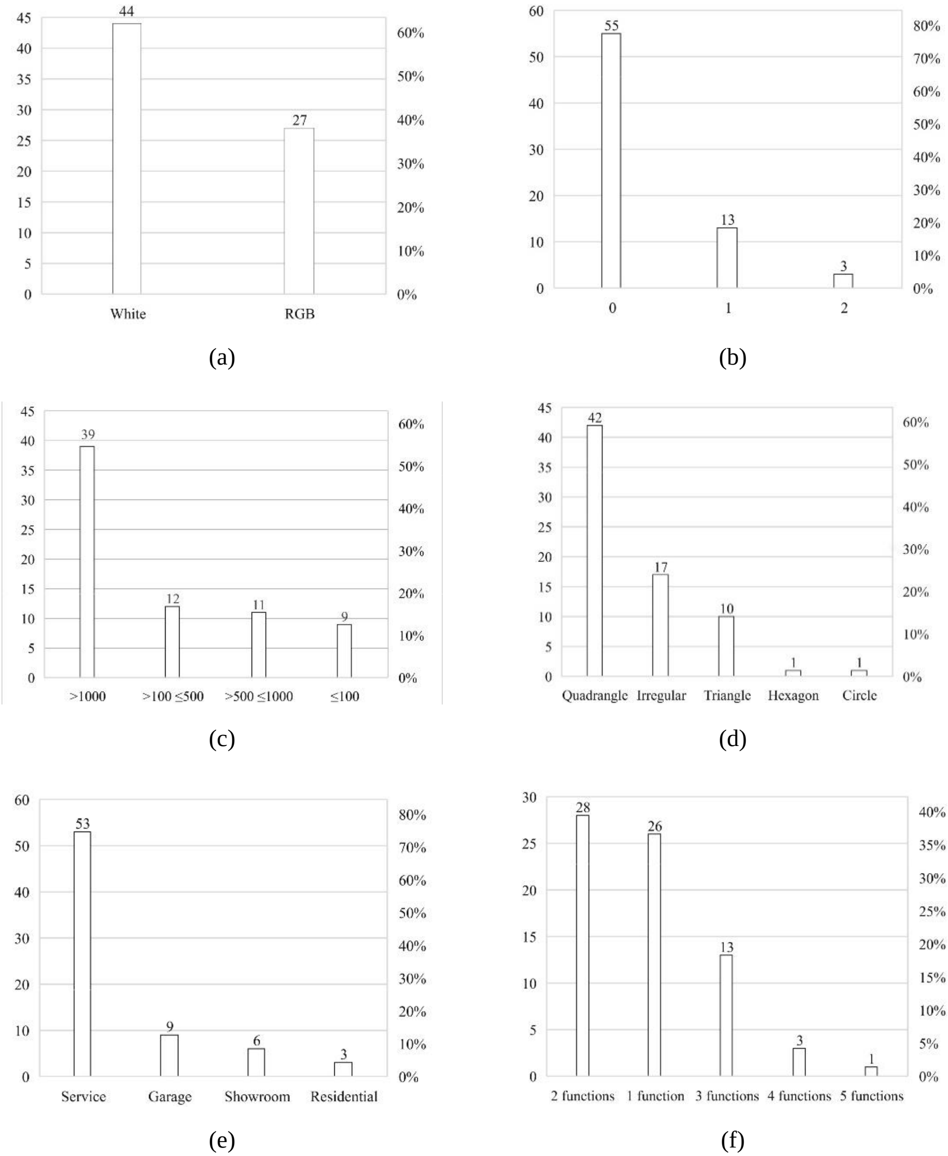
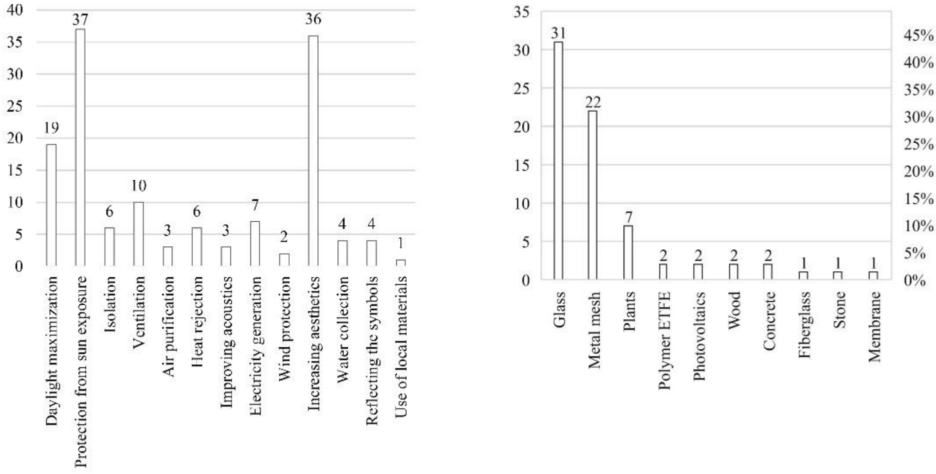


Fig. 7. A graphical analysis of qualitative and quantitative data using selected examples of architectural projects. The graphs depict the following: (a) Façade illumination, (b) Mobility of the façade, (c) Number of modules, (d) Shape of modules, (e) Object function, (f) Number of functions



(g) (h)

Fig. 7 continued. (g) Frequency of the function, (h) Façade cover

CONCLUSIONS

Today, buildings and the construction industry are responsible for 38% of CO_2 emissions. The present definitely forces the need not only to implement sustainable construction [38]. This also applies to the new understanding of the building as a link between nature and infrastructure – man and nature. Well-designed building façades are a feast for users of those spaces and affect our well-being through emotions caused by the dynamics of daylight [39] and artificial light [40]. Their creation entails a collaboration between industries, an interdisciplinary effort that can produce surprising effects associated with aesthetics and beauty. Wiesław Rokicki and Ewelina Gawell rightly sum up their reflections on the structuralism of contemporary architectural details with the words of Jean-Antoine-Gabriel Davioud "There will never be a true, complete and fruitful agreement until the day the engineer, the artist and the scientist are united in one person" [6, p. 192]. Combining knowledge of contemporary technologies and materials with respect for the identity of a place and its cultural heritage as well as innovative thinking is the best way to create interesting façades [41]. Will the dynamic, modular building façade designed in the first half of the 21st century go down in architectural history and be judged in Vitruvian terms as beautiful... that is for the future generations to decide.

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DYNAMIKA ŚWIATŁA I CIENIA NA MODUŁOWYCH ELEWACJACH BUDYNKÓW

Piękno architektury, przejawia się nie tylko w harmonii kompozycji, ale i w konstrukcji oraz w strukturze budynku. Wizytówką i „skórą" formy są elewacje, które poddane działaniu światła naturalnego i sztucznego, dziennego i nocnego stanowią o odbiorze i czytelności formy. Estetyka i piękno modułowych fasad pełniących różne funkcje, przejawia się w precyzyjnie zaprojektowanych detalach, a ich konstrukcja i rodzaj zastosowanych materiałów ma wpływ na dynamikę i plastykę bryły. Analizy ilościowe i jakościowe wybranych przykładów światowych realizacji architektonicznych, pozwoliły na określenie współczesnych trendów w projektowaniu elewacji. Kreowanie światłocienia przez optymalne zarządzanie światłem dziennym oraz innowacyjne sposoby iluminowania światłem sztucznym o wybranych parametrach wraz z dobranymi systemami sterowania, stanowią o ich fascynującej zmienności, co jest przedmiotem niniejszego artykułu.