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COMFORT OF USE ASSESSMENT IN BUILDINGS WITH INTERIOR WALL INSULATION BASED ON SILICATE AND LIME SYSTEM IN THE CONTEXT OF THE ELIMINATION OF MOULD GROWTH

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In the article, the authors presented the results of microbiological air quality studies in selected buildings with additional thermal insulation applied from the inside using a silicate and lime system, as well as the results of a survey study concerning the comfort of use of said buildings. The microbiological air quality studies, conducted in buildings immediately prior to and after the application of additional thermal insulation using silicate and lime sheets, demonstrated a significant decrease in the number of mould spores in interior spaces. This was also reflected in the results of a survey study. The survey study was conducted with users of public and commercial buildings and municipal housing buildings in Krakow. Thanks to the additional insulation applied from inside using the silicate and lime system, all of the utilitarian parameters of internal spaces had improved. The most significant changes concerned parameters like comfort of use, the aesthetic of the spaces and breathing comfort. According to experts, the silicate and lime system was also rated highly in terms of the analysed parameters.

Keywords: energy retrofitting of historical buildings, application of internal wall thermal insulation, mould

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1. INTRODUCTION

The technology in which a building has been constructed in and its current technical condition affect the decision concerning the scope and technology of renovation work. Furthermore, in the case of historical buildings, the scope of construction work is subjected to formal and legal regulations that stem from the Construction Law Act [1] and the Act of the 23rd of July 2003 on the Protection and Preservation of Historical Monuments [2]. Technical and construction conditions concerning both new buildings and those subjected to renovation and thermal modernisation work were listed in [3].
In the case of renovating and thermally modernising historical buildings or structures placed under conservation, the achievement of parameters that are typical of energy-efficient buildings leads to maintenance costs on the one hand, while on the other it is associated with, among other things, reducing usable floor area due to the necessity of applying additional thermal insulation from the inside as there is no possibility of doing this from outside due to the building's architectural or historical value or the protection of cultural heritage.
The comfort of the internal environment should be determined in relation to purpose of the building [4-6]. The technical condition of a building, as well as the comfort of the use of a building by its residents or people who work in it is significantly affected by the possible presence of fungi.
The control of the occurrence of fungi in buildings and limiting it requires a holistic approach to the construction process and occupancy, one that takes into consideration, among other things, the aspects of thermal insulation, heating, ventilation, finishing materials, as well as the appropriate maintenance of interior spaces [7, 8]. In many cases the development of mould on elements of a building is downplayed by users and administrators. The cause of this state of affairs is primarily a lack of knowledge concerning the complexity of this problem. An excessive development of mould in interior spaces can be the cause of health problems in users, as well as of a decrease in the comfort of use of internal spaces [9]. The infectious agent in the form of spores, the mycelium or fungus metabolites, enters the human body through inhalation, ingestion or skin contact. The consequences of the effects of these factors are not always immediate, with many manifesting themselves much later in the form of mycosis (either cutaneous or systemic), mycotoxicosis, or allergies [10]. Studies have shown that in many cases a concentration of airborne pollutants in the internal environment is much greater than in the exterior one. Humans spend an increasing amount of time indoors (87 % on average), which is why indoor air quality is so important [11]. Microbiological pollutants, e.g. mould,

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can be present in structural and finishing materials. Wallpapers, fibrous materials, insulating materials and drywalls can all be the source of living airborne microorganisms [12].

One of the comprehensive solutions that can improve the conditions of the use of interior spaces is the use of an external wall interior thermal insulation application system that employs silicate and lime sheets, which is the subject of research in the project entitled „Opracowanie i wdrożenie zintegrowanych metod trwałej likwidacji przyczyn i skutków powstawania pleśni w budynkach o różnym przeznaczeniu i sposobie użytkowania z zastosowaniem nowych kompozycji materiałów oraz technik aplikacyjno-wykończeniowych" (application no. POIR.01.01.01-00-0535/17), qualified for funding as a part of the competition 3/1.1.1/2017 POIR 2014-2020 organised by the NCBR. The goal of the project was the development and implementation of a service providing long-term elimination of the cause and effects of the occurrence of mould in buildings by using new compositions of materials and finish application techniques, developed as a result of industrial research and development activities.

The paper presents the partial results of studies performed as a part of this grant. The work focused on aspect of the comfort of use of buildings in which additional thermal insulation had been applied from the inside using the proposed system. An assessment of thermal comfort was performed on the basis of microbiological air quality tests and survey studies concerning the assessment of user satisfaction with the interior spaces where additional thermal insulation had been applied.

2. THE PERFORMANCE OF THE STUDY

2.1. CHARACTERISTICS OF THE PROPOSED SILICATE AND LIME SYSTEM

Several dozen samples were prepared in laboratory conditions, using various finishing materials (mortars, thin coat plasters, paints), while the base consisted of silicate and lime sheets of varying thickness (ranging from 15 mm to 100 mm). The proposed thermal insulation sheets include silicone in their composition, which gives them hydrophobic properties, which makes them more resistant to dampness and therefore the development of microorganisms. The resistance of the analysed sheets to the effects of moulds was also a result of the existence of conditions that are unfavourable to the development of these microorganisms, particularly stemming from the alkaline character of the proposed set of materials, e.g. their high pH value of 12-14. In addition, based on laboratory studies, a lack of application differences was observed in the case of using these material compositions in atmospheric conditions, i.e. in temperatures ranging between 5˚C and 30˚C, with a relative air humidity of 40 % to 80 %. The materials used in the system are mineral products, composed of lime, quartz sand and water, which results in a lack of toxins or other substances that are not allowed in construction [13-16]. The technical parameters of the discussed material composition were analysed as well (i.e. density, tensile strength, compression strength, water absorption), in addition to defining the optimal sheet thickness at 50 mm. One of the assumptions of the project was to develop a method of long-term mould removal in variously used internal spaces, one that could be implemented on the construction market. Over the course of laboratory research, material compositions with the greatest resistance to mould growth were selected and then various methods of applying them in actual construction conditions were analysed. An analysis of the method of base surface preparation for the application of the system's sheets was performed, as well as that of their finishing depending on the type of internal space and the manner of its use.

The appropriate preparation and application of thermal insulation is very important. Performing the application of additional thermal insulation using the proposed system should be performed as follows. The base surface should have an appropriate load-bearing capacity and be clean. Uneven base surfaces should be smoothened with appropriate mortar, e.g. lime mortar or renovation mortar. Any existing mould should be removed using biocides. The sheets should first be primed and cut depending on the required size. Adhesive mortar should be thoroughly mixed and left to settle for around 2 minutes, then mixed thoroughly again. The thickness of the adhesive should make it possible to set the sheets in a stable manner on the adhesive base. The mortar should be spread with a teethed plasterer's trowel (with 10-12 mm teeth), with the sheet then being set and pressed into the adhesive base. The spaces between the sheets should not be filled with mortar. After 48-72 hours the sheets should be completely covered with lime and cement mortar. In the case of critical bases, a fiber mesh immersed in the mortar can be used. The assumed time of mortar setting is 1 mm per 24 hours. After drying, the mortar should be covered in a paint that has alkaline properties and a high diffusion resistance factor. Paint should be applied onto the dry surface using a roller, brush or paint dispersal machine a low degree of dusting spread.

The analysed system positively affects the comfort of use of spaces in the context of interior temperature and humidity. The excess interior humidity does not precipitate on the wall surfaces, but is absorbed and released in appropriate conditions by the pores in the sheets. Humidity is released slowly until the moment when the interior climate normalises. The external part of the sheet remains dry and free of mould.

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The selected technology of thermally insulating walls using a system of silicate and lime sheets is not inconvenient to the users of interiors in which it has been applied and does not cause problems during assembly.

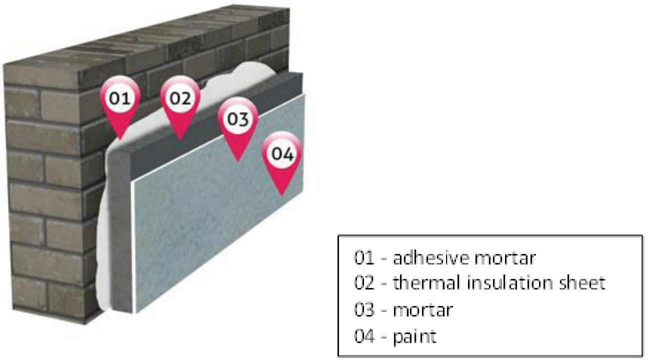

Fig. 1. Layers of the proposed interior thermal insulation application system (www.eximreno.eu)

2.2. MICROBIOLOGICAL AIR QUALITY STUDY IN BUILDINGS SUBJECTED TO THE APPLICATION OF THE THERMAL INSULATION

The air quality study was performed using the aspiration method using mycological growth mediums: Sabouraud Glucose Agar (SGA) (Biomaxima) and Rose Bengal Agar (RBA) (Biomaxima). Air samples were collected using the impactor method with the aid of the MAS 100 Air Sampler (Merck). The air sampler was placed at the centre of the studied interior spaces at a height of 1,3 m above the floor. During the test 200 L of air were aspired.

The mediums were transported to the laboratory and inserted into an incubator, where the samples were incubated for 7 days at a temperature of 27˚C. The microbiological study covered determining the number of microfungi colonies, which were counted 3 days after incubation. Identification was performed using microscopic methods after observing good conidiogenesis. Recommendations according to PN-89/Z-04111/03 [17] regulate the permissible fungus spore content in the air

(Table 1).

Table 1. Assessment of fungal air pollution

Overall number of fungal spores (CFU·m^{-3})	Air pollution level
3 000–5 000	Moderately clean air
5 000–10 000	Pollution that can negative affect the natural environment of humans
>10 000	Pollution that threatens the natural environment of humans

Source: original work based on [17]

2.3. STUDY OF THE SATISFACTION OF USERS OF BUILDINGS SUBJECTED TO THE APPLICATION OF ADDITIONAL THERMAL INSULATION

Telephone interviews were conducted with the users of buildings subjected to the application of additional thermal insulation, and who had worked at 4 buildings in Krakow (2 museums and 2 hostels), as well as residents—the users of 7 municipal dwellings, immediately after the application of additional thermal insulation in interior spaces (2-3 weeks after the application procedure), as well as with 4 residents who were users of interior spaces that had been subjected to the application of the additional thermal insulation using the silicate and lime sheet system at least 2 years prior. In addition, interviews were conducted with 4 experts (Inspectors of the Construction Supervision Authority) concerning the assessment of the parameters of the concluded thermal insulation application projects in which the insulation was applied from the inside using the silicate and lime sheet system.

It was decided to use the telephone interview method due to the low number of respondents and the fact that the users of municipal dwellings are often seniors who do not use the Internet (the online computer survey was eliminated). The telephone interview was a quick and comfortable technique—both to the respondents and interviewers.

The type and number of respondents was a direct result of the number of thermal insulation application projects that had been performed in Krakow as a part of the project. The study covered the users of buildings which were thermally insulated as a part of the project. Furthermore, the number of all projects featuring the application of thermal insulation to external walls from the inside is minuscule in Poland when compared with the number of projects where the additional insulation is applied from the outside. Although the study conducted by the authors does not provide a full result, instead providing only an approximate image of the situation, it does indicate a trend.

The respondents were tasked with assessing the feeling of comfort prior to and after the thermal insulation had been applied in the interior spaces. A five-grade rating scale was used, where 1 was a low rating, and 5 was a high rating. The users found characteristics that improve the comfort of use of internal spaces in terms of health, warmth and acoustics to be significant. In the case of the Inspectors of the Construction Supervision Authority, the characteristics that were assessed included: the competitiveness of the proposed product relative to other thermal insulation methods, warranty, durability, completion time, ease of assembly and effectiveness in safeguarding against moulds. The results of the study were analysed in four thematic groups:

1. Opinions of users of the buildings in which additional insulation had been applied, the employees of museums and hostels;
2. Opinions of users of the residential interiors in which additional insulation had been applied, immediately after the application procedure;
2. Opinions of users of the residential interiors in which additional insulation had been applied using the Epatherm silicate and lime thermal insulation system at least two years prior;
4. The opinions of experts—Inspectors of the Construction Supervision Authority who supervised the work on applying additional thermal insulation to buildings.

3. RESULTS OF THE STUDY

3.1. RESULTS OF THE MICROBIOLOGICAL AIR QUALITY STUDY IN THE SELECTED BUILDINGS

In order to verify the effectiveness of the application and finishing techniques that had been used, the results of a quantitative fungal colony concentration test performed prior to and after the application of the system have been presented (Fig. 2). The greatest mould emission prior to the application of the thermal insulation system was observed at the first measurement site where it amounted to 5000 CFU/m^3. This indicates a significant degree of air pollution in the building and the number of spores in the air sample that had been collected was within the acceptable standards for residential and public spaces. Based on the observed concentration, it should be assumed that, according to Polish Standard PN-89/Z-04111/02, the air was to be considered polluted and could negatively impact man's natural environment. The results that were obtained confirmed that each of the tested buildings featured perfect conditions for the dwelling of microorganisms. Among the mould fungus species identified in first building object, the presence of the following was observed: ca. 40% *Aspergillus versicolor* and ca. 30% *Penicillium* spp. Fungus species such as *Penicillium* spp. and *Aspergillus* spp. are fungus species considered to be a part of the second risk group—factors that can be harmful to humans. The most often encountered fungi from the genus *Aspergillus* are considered allergenic and toxic factors (*A. flavus*), as well as causes of infectious and invasive diseases (*A. fumigatus, A. niger*).

The qualitative assessment of the tested buildings yielded a predominance of moulds typical of indoor spaces from the genus *Cladosprium*, which are common allergens, as well as *Penicillium*, *Alternaria*, *Cladosporium*, *Fusarium* and *Curvuralia*.

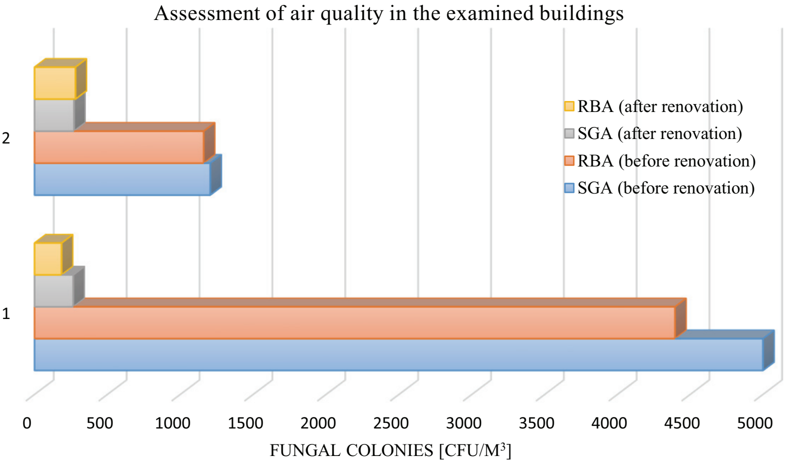

Fig. 2. Air quality assessment results in the selected buildings

In the second building in Krakow it was observed that from the 1200 CFU/m^3 found in the tested air, as much as 90 % of the number of fungus colonies were members of the genus *Cladosprium*. Figure 2, shown below, presents the air quality assessment prior to the application of the system. The measurements performed after the application of the analysed materials showed that the application of the sheets improves microclimatic and microbiological conditions in the spaces they had been applied in (Fig. 2). A significant reduction in airborne colonies in the air inside the tested building was observed. The qualitative and quantitative analysis was performed by breeding colonies on two microbiological growth mediums: RBA and SGA. The observable significant reduction in the number of counted mould colonies in the case of the second building object went from ca. 1200 CFU/m^3 down to ca. 275 CFU/m^3, while in the case of first one, from ca. 5000 CFU/m^3 to ca. 225 CFU/m^3, confirming the effectiveness of the developed technology under actual working conditio

3.2. RESULTS OF THE USER SATISFACTION SURVEY CONDUCTED AMONG THE USERS OF THE BUILDINGS IN WHICH THE THERMAL INSULATION WAS APPLIED

3.2.1. OPINIONS OF USERS OF PUBLIC BUILDINGS IN WHICH THE THERMAL INSULATION WAS APPLIED

The individual parameters associated with the use of interior spaces in public buildings prior to the application of the additional thermal insulation were rated poorly in all cases. The lowest rated parameter prior to the application of the thermal insulation was comfort of use (a rating of 1), while acoustic and respiratory comfort were rated the highest (a rating of 2.25). After applying the thermal insulation, all of the utilitarian parameters of the interior spaces improved. The lowest rated parameter was the thermal comfort of the internal spaces (a rating of 3,5), while the highest rated parameters were comfort of use and the aesthetic of rooms (a rating of 5) (Fig.3).

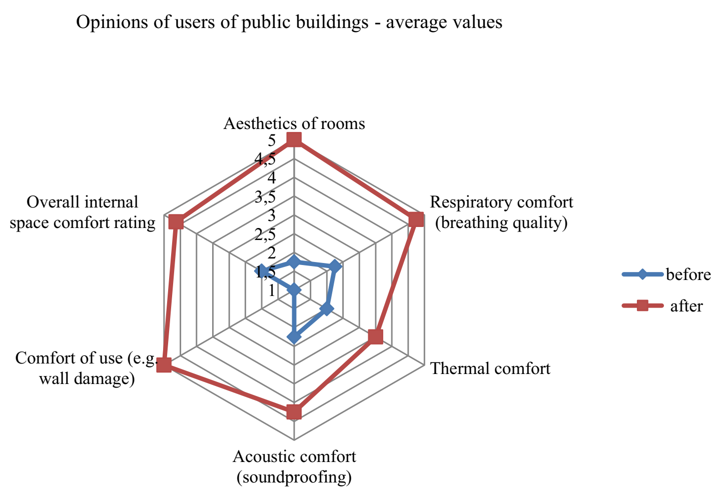

Fig. 3. Assessment of the comfort of use of internal spaces prior to and after the application of thermal insulation, as rated by users of public buildings

The greatest improvement after the application of thermal insulation was noted in comfort of use (from an average rating of 1 to that of 5).

3.2.2. OPINIONS OF THE USERS OF INTERIOR SPACES IN RESIDENTIAL BUILDINGS IMMEDIATELY AFTER THE APPLICATION OF THE THERMAL INSULATION.

Taking into consideration the opinions of the users of the second group of internal spaces (immediately after the application of the thermal insulation), a significant improvement in the utilitarian parameters of the internal spaces was reported in comparison to the conditions prior to the application (Fig. 4). The highest rated parameter after the application of the thermal insulation was the aesthetic of the internal spaces (a rating of 4.71), while the lowest rated parameter was respiratory comfort (a rating of 4.14). The parameter rated the lowest prior to the application of thermal insulation was the aesthetic of the rooms (a rating of 1.14), while the highest rated parameter was acoustic comfort (a rating of 3.71).

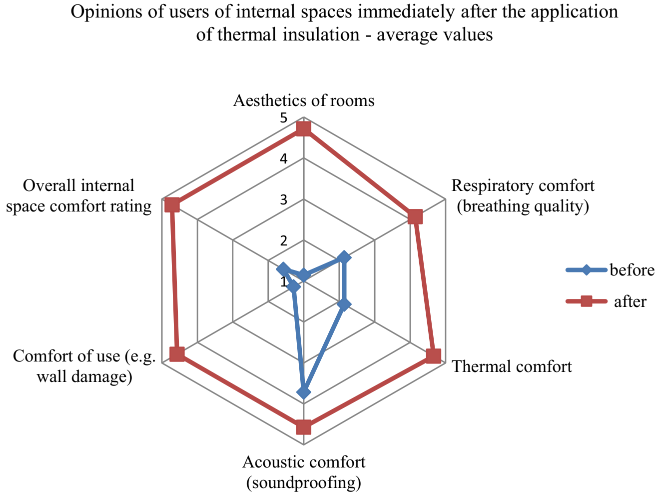

Fig. 4. Assessment of the comfort of use of internal spaces prior to and immediately after the application of the thermal insulation, rated by the users of interior spaces in residential buildings

In the opinion of users, the greatest improvement after the application of the thermal insulation relative to the previous state was noted in two parameters: the aesthetic of the rooms (from an average rating of 1.14 to 4.71) and comfort of use (from an average rating of 1.29 to 4.57).

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3.2.3. THE OPINIONS OF USERS OF INTERNAL SPACES IN RESIDENTIAL BUILDINGS WHERE THE THERMAL INSULATION WAS APPLIED AT LEAST TWO YEARS PRIOR

In the case of internal spaces where the application of thermal insulation using the Epatherm silicate and lime system was performed at least two years prior, a significant improvement in all of the rated parameters was observed (Fig. 5). The highest rated parameter after the application of the thermal insulation was comfort of use (an average rating of 5), while the lowest rated parameter was respiratory comfort (an average rating of 4). The parameter that was rated the lowest prior to the application of thermal insulation was comfort of use (an average rating of 1), while the highest-rated parameter was acoustic comfort (an average rating of 2).

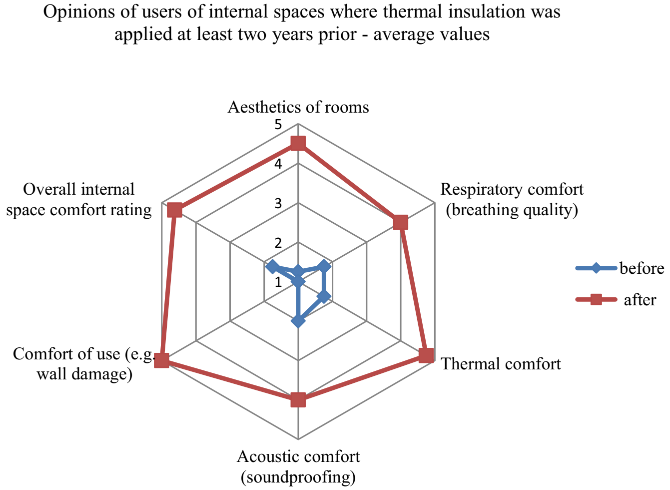

Fig. 5. Assessment of the comfort of internal spaces prior to the application of internal spaces and at least two years after its application, as rated by users of internal spaces in residential buildings

The parameter that improved the most after the application of thermal insulation when compared to the value of the parameter prior to the application of thermal insulation (an average rating of 1) was comfort of use (an average rating of 5 after the application of thermal insulation).

Although the survey study does not provide a complete image of the problem due to the low amount of respondents, only producing an approximate result, it does constitute a strong indicator of a trend.

3.2.4. THE OPINIONS OF EXPERTS (INSPECTORS OF THE CONSTRUCTION SUPERVISION AUTHORITY)

In the opinion of experts (Inspectors of the Construction Supervision Authority), the silicate and lime system was rated highly in terms of the analysed parameters (Fig. 6). The lowest-rated parameter was the system's competitiveness (a rating of 4.25), when compared to other systems that are generally available on the market. This is probably related to the relatively high price of the product, however, the effectiveness of the method as a form of permanently addressing the cause and effect of the presence of mould in buildings was rated very highly.

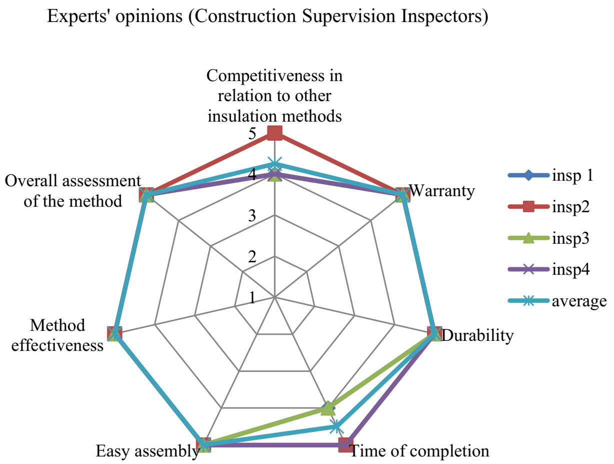

Fig. 6 Assessment of the parameters of the method of the application of thermal insulation by experts

4. CONCLUSIONS

The microbiological air quality tests that were performed point to the high effectiveness of the sheets that had been used in the context of the removal of mould from buildings. This was also reflected in the results of survey studies.

Taking into consideration the statements of users—the residents and persons who worked at the buildings that had been subjected to the application of the thermal insulation, we should note the fact that, thanks to application of the silicate and lime system in the buildings from the inside, all of the respondents reported an improvement in all of the interior space utilitarian parameters. The most significant changes were observed in the case of parameters such as comfort of use, the aesthetic of internal spaces and respiratory comfort. The low ratings of these parameters prior to the application of thermal insulation are strongly tied to the presence of microfungi in the internal spaces, causing a discomfort in terms of aesthetics and posing a health risk. The improvement of the thermal parameters of internal spaces and the composition of the materials comprising the thermal insulation system makes it possible to eliminate the harmful factor that are microfungi.

Despite the fact that, according to the principles of construction and specialist literature, including works on building physics, the application of thermal insulation from the inside is not recommended, the survey study performed among both users and experts has confirmed the justification of carrying out a project that featured the application of additional thermal insulation from the inside, using the proposed silicate and lime system.

The possibility of the implementation of such a solution and the ease of applying thermal insulation inside buildings has a profound significance in the case of historical buildings, which are under the supervision of a conservator, and in the case of which the application of thermal insulation from outside is not always possible.

REFERENCES

1. Dz. U. 1994 Nr 89 poz. 414 Ustawa z dnia 7 lipca 1994 r. Prawo budowlane.
2. Dz.U. 2003 nr 162 poz. 1568 Ustawa z dnia 23 lipca 2003 r. o Ochronie zabytków i opiece nad zabytkami.
3. Obwieszczenie Ministra Infrastruktury I Rozwoju z dnia 17 lipca 2015 r. w sprawie ogłoszenia jednolitego tekstu rozporządzenia Ministra Infrastruktury w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie (Dz. U. Nr 75, poz. 690), z uwzględnieniem zmian wprowadzonych.
4. Fedorczak-Cisak, M.; Kowalska, A.; Radziszewska-Zielina, E.; Śladowski, G.; Pachla, F.; Tatara, T. (2019). A multicriteria approach for selecting the utility function of the historical building "Stara Polana" located in Zakopane. MATEC Web Conf. 262, 07002.
5. Fedorczak-Cisak, M., Kowalska-Koczwara, A., Nering, K., Pachla, F., Radziszewska-Zielina, E., Śladowski, G., & Ziarko, B. (2019). Evaluation of the Criteria for Selecting Proposed Variants of Utility Functions in the Adaptation of Historic Regional Architecture. Sustainability, 11(4), 1094.
6. Radziszewska-Zielina E., Rumin R., (2016). Analysis Of The Profitability of Investment In Renewable Energy Sources On The Example of A Semi-Detached House, International Conference on the Sustainable Energy and Environment Development, SEED 2016, E3S Web Of Conferences, 10, 00079.
7. Amman H.M. (2006). Czy zanieczyszczenie pleśniami wewnątrz pomieszczeń jest niebezpieczne dla zdrowia? W: Grajewski J. (Ed) Mikotoksyny i grzyby pleśniowe − zagrożenie dla człowieka i zwierząt. Wyd. Uniwersytetu Kazimierza Wielkiego w Bydgoszczy. Bydgoszcz, 35-45.
8. Gutarowska B., Piotrowska M. (2007). Methods of mycological analysis in buildings. Building and Environment 42: 1843-1850.
9. Guo H., Lee S.C., Chan L.Y., (2004). Indoor air quality investigation at air-conditioned and nonair-conditioned markets in Hong Kong, Science of the Total Environment 323, 87-98.
10. Buchmiet E., Żakowska Z. (2009). Toksynotwórczość pleśni na materiałach budowlanych. V Konferencja Naukowa Rozkład i korozja mikrobiologiczna materiałów technicznych, Łódź: 129.
11. Guo H., Lee S.C., Chan L.Y., (2004). Indoor air quality investigation at air-conditioned and nonair-conditioned markets in Hong Kong, Science of the Total Environment 323, 87-98.
12. Maus R., Goppelsroder A., Umhauer H., (2001). Survival of bacterial and mold spores in airfilter media, Atmospheric Environment 35, 105- 113.
13. Hippelein M., Rügamer M. (2004). Ergosterol as an indicator of mould growth on building materials. International Journal of Hygiene and Environmental Health 207: 379-385.

14. Gutarowska B. (2010). Metabolic activity of moulds as a factor of building materials biodegradation., Polish Journal of Microbiology, 59 (2): 119-124.
15. Nielsen K.F., Gravesen S., Nielsen P.A., Andersen B., Thrane U., Frisvad J.C. (1999). Production of mycotoxins on artificially and naturally infested building materials. Mycopathologia 145: 43-56.
16. Pasanen A.L., Kasanen J.P., Rautiala S. Ikaheimo M., Kaariainen H., Kalliokoski P. (2000). Fungal growth and survival in building materials under fluctuating moisture and temperature conditions. International Biodeterioration and Biodegradation 46: 117-127.
17. Krzysztofik B. (1992). Mikrobiologia powietrza. Wydawnictwo Politechniki Warszawskiej, Warszawa, 19-20.

LIST OF FIGURES AND TABLES:

OCENA KOMFORTU UŻYTKOWANIA OBIEKTÓW DOCIEPLONYCH OD WEWNĄTRZ SYSTEMEM SILIKATOWO-WAPIENNYM W ASPEKCIE LIKWIDACJI PLEŚNI

Keywords: *płyty silikatowo-wapienne, pleśń, komfort użytkownika*

SUMMARY :

W przypadku remontu i termomodernizacji użytkowanych budynków zabytkowych lub obiektów objętych ochroną konserwatorską, dążenie do uzyskania wartości parametrów charakterystycznych dla budownictwa energooszczędnego, z jednej strony przekłada się na oszczędności eksploatacyjne, z drugiej jednak strony, wiąże się np. z ograniczeniem powierzchni użytkowej, z uwagi na konieczność docieplenia ścian od wewnątrz.

Kontrola występowania zagrzybienia w budynkach oraz jego ograniczenie, wymaga całościowego podejścia do procesu budowlanego i eksploatacyjnego, uwzględniającego m.in. aspekty termoizolacji, ogrzewania, wentylacji, materiałów wykończeniowych jak również odpowiedniej konserwacji pomieszczeń. Nadmierny rozwój grzybów pleśniowych w pomieszczeniach użytkowych jest przyczyną problemów zdrowotnych użytkowników oraz pogorszenia się stanu komfortu użytkowania pomieszczeń. Ludzie spędzają coraz więcej czasu w pomieszczeniach, dlatego jakość powietrza jest tak ważna.

Jednym z kompleksowych rozwiązań dotyczących poprawy warunków użytkowania pomieszczeń jest zastosowanie systemu dociepleń od wewnątrz płytą silikatowo-wapienną, będącą przedmiotem badań w projekcie pt. „Opracowanie i wdrożenie zintegrowanych metod trwałej likwidacji przyczyn i skutków powstawania pleśni w budynkach o różnym przeznaczeniu i sposobie użytkowania z zastosowaniem nowych kompozycji materiałów oraz technik aplikacyjno-wykończeniowych" (nr wniosku POIR.01.01.01-00-0535/17), zakwalifikowanym do dofinansowania w ramach naboru konkursu nr 3/1.1.1/2017 POIR 2014-2020 ogłoszonego przez NCBR.

W artykule przedstawiono jedynie część, spośród obszernych, przeprowadzonych w ramach projektu badań. W niniejszej pracy skupiono się na aspekcie komfortu użytkowania obiektów docieplonych od wewnątrz proponowanym systemem. Ocenę przeprowadzono na podstawie badań czystości mikrobiologicznej powietrza. Podjęto również próbę określenia subiektywnej oceny ogólnego komfortu odczuwanego przez użytkownika. W tym celu przeprowadzono badania sondażowe wśród użytkowników lokali docieplonych proponowanymi płytami silikatowo-wapiennymi.

W pierwszym etapie badań laboratoryjnych wyselekcjonowano materiały budowlane, spośród dopuszczalnych, o największej odporności na rozwój grzybów pleśniowych i sprawdzono różne sposoby ich aplikacji w warunkach rzeczywistych. Dokonano analizy sposobu przygotowania podłoży pod montaż płyt silikatowo-wapiennych oraz wykończenia w zależności od rodzaju pomieszczenia i sposobu jego użytkowania.

Badania mikrobiologicznej czystości powietrza w wytypowanych obiektach wykonano metodą aspiracyjną z użyciem podłoży mykologicznych: SGA i RBA. W etapie tym poddano ocenie mykologicznej lokale, w których wdrożone zostały rozwiązania w badanym systemie wykończeniowym. Badania polegały na pobraniu próbek powietrza i określeniu czystości mykologicznej przy użyciu metody aspiracyjno-zderzeniowej próbnikiem MB-MAS.

Badania stopnia zadowolenia użytkowników docieplonych budynków przeprowadzono na podstawie wywiadów telefonicznych z użytkownikami. Przeprowadzono ankiety z użytkownikami 4 obiektów użyteczności publicznej (pracownicy) (w tym 2 muzea, 2 hostele) oraz 7 mieszkań komunalnych (mieszkańcy), bezpośrednio po dociepleniu pomieszczeń (2/3 tygodnie po) a także z 4 użytkownikami pomieszczeń (mieszkańcy) powyżej 2 lat po dociepleniu od wewnątrz systemem silikatowo-wapiennym. Dodatkowo przeprowadzono wywiady z 4 ekspertami (Inspektorzy Nadzoru

Budowlanego) w zakresie oceny parametrów przeprowadzonych inwestycji docieplenia ścian od wewnątrz systemem silikatowo-wapiennym.

W pomiarach czystości mikrobiologicznej powietrza, stwierdzono znaczącą różnicę, na korzyść pomieszczeń zabezpieczonych płytami, w poziomie zawartości zarodników pleśni. Biorąc pod uwagę wypowiedzi użytkowników - mieszkańców i pracowników w docieplonych pomieszczeniach, należy zwrócić uwagę na fakt, iż dzięki dociepleniu od wewnątrz wytypowanym systemem, we wszystkich analizowanych przypadkach poprawie uległy wszystkie parametry użytkowe pomieszczeń. Najistotniejszymi zmianami charakteryzowały się parametry takie jak komfort użytkowania, estetyka pomieszczeń oraz komfort oddechowy. Niskie oceny tych parametrów przed dociepleniem są silnie związane z występowaniem w pomieszczeniach mikrogrzybów, powodujących dyskomfort pod względem estetycznym oraz zagrożenie dla zdrowia. Poprawa parametrów cieplnych pomieszczeń oraz skład systemu pozwalają na eliminację czynnika szkodliwego, jakim są mikrogrzyby.

Analizując wyniki badań przeprowadzonych w ramach projektu, stwierdzono skuteczność proponowanego systemu silikatowo-wapiennego w zwalczaniu i ograniczaniu występowania grzybów pleśniowych w budynkach. Na uwagę zasługuje również poprawa warunków klimatycznych, akustycznych oraz walorów estetycznych w budynkach po zastosowaniu systemu. Dodatkowo łatwość oraz możliwość stosowania docieplenia od wewnątrz obiektu ma zasadnicze znaczenie w przypadku budynków historycznych, będących pod nadzorem konserwatora zabytków, gdzie docieplenie obiektu z zewnątrz nie zawsze jest możliwe. Korzystne zastosowanie zaproponowanego systemu polega na kompleksowej likwidacji przyczyn oraz zwalczaniu i zabezpieczaniu przed występowaniem grzybów pleśniowych w budynkach. W przypadku stosowania proponowanego systemu nie jest konieczne stosowanie dodatkowych preparatów chemicznych zawierających fungicydy, nierzadko mających również wpływ na samopoczucie i zdrowie użytkowników.

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