ATLANTIS PRESS

Advances in Engineering Research (AER), volume 72

2016 International Conference on Architectural Engineering and Civil Engineering (AECE-16)

Development of Microbiological Vegetation on Facades of Thermally Insulated Houses Repairing a One Column Paper with MS-word for Windows

Veronika KUCERIKOVA
VSB Technical University Ostrava
VSB TU-O
Czech Republic, Ostrava
e-mail: veronika.kucerikova@vsb.cz

Magdalena KUBECKOVA
VSB Technical University Ostrava
VSB TU-O
Czech Republic, Ostrava
e-mail: magdalena.kubeckova@vsb.cz

Darja KUBECKOVA
VSB Technical University Ostrava
VSB TU-O
Czech Republic, Ostrava
e-mail: darja.kubeckova@vsb.cz

***Abstract*—In connection with the increasing number of facades additionally equipped with contact thermally insulated system the number of cases in which facades are depreciated with microbiological vegetation has raised. The vegetation of microscopic algae, fungi and blue-green algae on the outer surface of perimeter walls depreciates aesthetical function of facades and can also have a negative impact on the health of population of affected houses.**

Keywords-component; microbiological vegetation; facades; insulation; heat transfer formatting

I. GENERAL INTRODUCTION

In the 80s and 90s of the 20th century technical imperfection started to occur especially at high-rise blocks. Besides malfunction connected with the age of objects, such as gradual exposure of reinforcing bar of perimeter panels, leaking into flat roofs and the like, the professional public started to realize big imperfection in the sphere of thermal technology. Perimeter walls together with roof construction form perimeter covering, which protects the interior of a building from effects of the outer environment. In connection with legislation changes in the field of thermal insulation of buildings for the purpose of decreasing the consumption of heat on heating and by that protection of nature, demands on thermal and technological characteristics of building cover have been tightened up. [1] For this purpose, the Czech Republic issued a set of rules. The main requirement concerning building cover including perimeter walls is the achievement of the minimum recommended warm penetration coefficient. The recommended requirements on the value of warm penetration coefficient are reached especially by additional thermal insulation of facades. As far as insulating material is concerned, especially polystyrene boards or boards from mineral wool are used. These boards together with other components (anchoring part, reinforcing part, and plastering) form the so called ETICS. After application of this system on facade, composite contact thermally insulated system is formed.

The advantage of ETICS is besides the decrease of warm loss via the thermally insulated wall also the decrease or total elimination of condensation inside the construction, protection of perimeter construction from weather influences, improvement of aesthetical aspect of wall and overall increase of wall lifespan. Etics also showed its imperfection in the course of time. The causes of repeated disorders related especially to bad construction were solved by professionals. During the last years a new problem has occurred and that is devaluation of facade surface with space microbiological vegetation (Fig.1). In a simplified way it might be claimed that insulation prevents penetrating of the warm from the interior to the outer facade surface, which is the base for the formation of suitable life conditions for the growth of microscopical fungi, algae and blue-green algae.

Figure 1. Facade of a building with vegetation of microscopic fungi, algae and blue-green algae

II. PROBLEMS OF THERMALLY INSULATED FACADES WITH RESPECT TO THERMAL TECHNOLOGY

After the application on the perimeter wall, thermal insulating material prevents not only the warm penetration but also the humidity. The growth and expansion of fungi is dependant right on the presence of humidity. Water moves from the surface of plasterings, under which there is no polystyrene coating, in a capillary conductivity towards drier material (e.g. ceramic walls), by that the occurrence of water film considerably more short-term compared to thermally insulated facades.

If the wall is not thermally insulated, the warm from the interior can accumulate to the whole thickness of the outer wall during heat season and by warming it can prevent long-term influence of humidity on the façade surface. The basic part of ETICS system is boards of thermal insulation, which are mainly from polystyrene. Foam polystyrene, which is not water-soluble, has closed microscopic structure and so does not absorb almost any water. When water cannot penetrate into boards of insulating material it accumulates on the façade surface where there is only thin layer of plaster and reinforcing cleaner blade. With the warm penetration from the interior to the exterior the outer surface temperature of facade is related, which is according to the research of R. Büchli, a P. Raschle [2] an important factor in the process of condensation of water vapors, the so called supercoolling of facades [3]. This phenomenon happens especially during clear nights when the surface temperature of a facade falls below the temperature of the surrounding air and subsequently there is bedewing of facade and the formation of water film. Subsequently this water film secures a long-term supply of humidity for pests in a form of fungi, algae and blue-green algae. The reason for the fact that the green infestation has started to occur globally during recent years is also related to thickness of thermal insulation. In the 80s when thermal insulation started, the thickness of insulation was only 20 mm. With stricter requirements in the sphere of energy savings on heating, the thickness of insulation was expanded to 140-180 mm. The bigger thickness of insulation is the less warming of the outer part and so it has lower outer surface temperature.

If the facade of a building, which is surrounded by air environment of a certain temperature and relative humidity of the air, has a lower temperature than is the temperature of dew point, on its surface there happens condensation of water vapour. This phenomenon is based on the law of emission. It is stated that supercooling of the surface contrary to the air temperature is 3-4K.

Humidity is accumulated in a bigger amount and after a long period on walls which are better thermally insulated. Massively, thermally insulated buildings secure a basic condition for vegetation of microscopic organisms (Fig.2 and Fig.3).

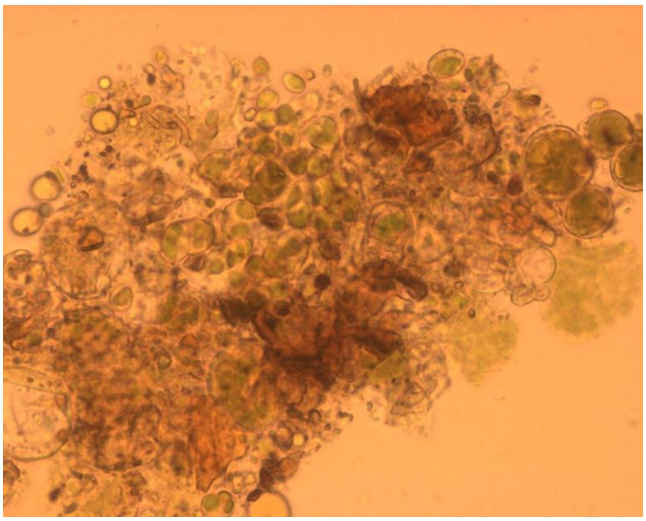

Figure 2. Microphotography of a sample infusion 400x

Figure 3. Microphotography of a sample infusion 400x

III. DEVELOPMENT OF VEGETATION OF MICROORGANISMS ON OBSERVED BUILDINGS

Since the year 2013 several facades of buildings, which were thermally insulated additionally, have been observed. It concerns high-rise blocks situated in a city built-up area in Ostrava region. The original facades formed perimeter panels from concrete with inner plastering and outer cultivated plastering thick 20-25 mm. Before the application of contact thermal insulation, the facades were without any sign of the occurrence of biotic pests. The insulating material thickness was between 100 and 160 mm. The surface was formed by thin layered plasterings. In the time of 1-4 years since the revitalization there started to occur greenly to red stains on new facades. From beautiful colorful facades became unattractively-looking surfaces. Samples which were taken from affected plasterings were analyzed. From the samples an extract was made, which was

placed in Eppendorf´s bowl and refilled with deionized water. The samples were left to infuse for 24 hours and 72 hours under laboratory conditions. Photic radiographic microscope with connected CCD camcorder which enabled to make a set of colorful microphotos at enlargement 400 x (Fig.2 and Fig.3). Thanks to the photos it was found out that there were green algae, blue-green algae, fungal spores and fungal hyphas in the samples. As far as blue-green algae are concerned, the kind Chroococcidiopsis was determined. Regarding green algae, it is not possible to find out the kind with regards to the character of samples. However, it is possible to say without any problems that they are green terrestrial algae (Chlorophycae).

The basic living condition for algae, fungi and blue-green algae is a sufficient supply of humidity. Vegetation of microorganisms occurred especially on northern sides where there is a long-term influence of humidity because they are dried by sun radiation at least. Other factors contribute to the long-term humidity influence at the observed facades. They are e.g. shadowing of the facades by the surrounding construction, structure of the façade, closeness of vegetation, closeness of water areas. On gable walls and facades without window opening the vegetation occurred on the whole surface evenly. These facades are a big catcher of rainfalls, spores and dust particles. On facades with located window openings the vegetation occurs especially in interfenestral parts. On the surface above and below windows they occur less or not at all. These places are protected by window ledge against water flowing down and thanks to the horizontal division of facade by windows, the length of the possible water influence is shortened (water is amounted less and dried faster). Another factor which increases the danger of infestation by green microorganisms is facade structure. Plastering with a very coarse-grained structure and sharp-edged grains (Fig.4), which is another strongly contributing factor for a successful growth of microorganisms on facade. The rougher surface, the more suitable one with respect to draining of vegetation and dust particles.

Figure 4. Strongly damaged by plaster with coarse grains

An important factor is also regional conditions. Ostrava as a smog area creates suitable microclimatic conditions for the growth of microorganisms compared to areas without smog strain. Rainwater with polluted air contains a big amount of dissolved nutrient matters. Dust particles in the air settle on facades and so create a suitable substrate.

From visual observing of the vegetation it can also be found out whether the infestation of facade is caused by bad performance of the ETICS system or not. If the occurrence of coloration of facade surface is extensive (Fig.1), we can exclude the fault in the thermal insulated system performance. The local occurrence of stains is mostly the consequence of a fault in thermal insulation performance.

Most often it concerns unsuitable detail solving – connection of tinsmithing elements to ETICS, or their total absence. Water is accumulated excessively in these places. This way the places become suitable for the growth of algae, fungi and blue-green algae. In that case it is the maker´s fault. An example of a strong local occurrence of green covering of microorganisms is also apparent in Fig.5. The cause here is the missing skirting in the place of connection of small roof to facade. During rainfalls, the water splashes on facade and rises to higher places.

Figure 5. False solutions detail on the facade

The density of vegetation on the observed facades got bigger during years. In Fig.6 there is pictured the condition of facade in the year 2013, in Fig.7 the condition of facade in the year 2016. Biotic infestation is currently more intensive and more extensive. Aesthetical function of the facade is totally devaluated and the health of all inhabitants of the building is at risk. During airing the spores of algae, fungi and blue-green algae can get easily into the interiors of buildings where they can cause e.g. allergies and breathing problems to sensitive people.

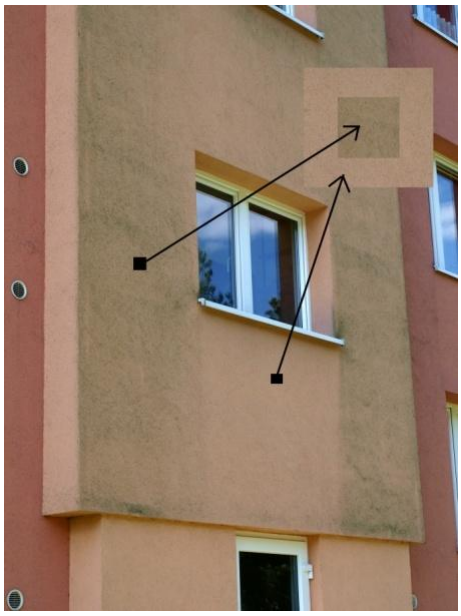

Figure 6. Facade of of a residential building in Ostrava in 2013

Figure 7. Facade of of a residential building in Ostrava in 2016

IV. CONCLUSION

Legislation and the need of savings on heating of buildings require decreasing of coefficient of warm penetration of perimeter constructions of object U [W.m-2.K-1]. In earlier periods better thermal insulations characteristics were reached by big thicknesses of walls which accumulated warm in a very advantageous way [4]. The change of thermally humid regime of facade after its thermal insulation enables super cooling of facade surface and formation of water film. Another development of the area is then influenced by side factors–type and structure of plastering, closeness of vegetation and its kind, closeness of water areas, architectonic solving of facade and last but not least the regional location of the building itself. It can be claimed that if better thermally insulated characteristics are reached by sticking the thermal insulating material (ETICS), is from the view of the presence of humidity formed one of the conditions for their growth. The proof is the occurrence of microorganisms on the observed objects till the thermal insulation. It must be said that not all thermally insulated facades are devaluated by microorganisms. Plasterings of old thermal insulating materials did not contain any biocide admixture within their composition. However, the disadvantage is that effective components are washed away gradually. The problems of biotic infestation of facades are in the course of research. With the possible infestation of facade it is necessary to calculate since the beginning of the project of thermal insulation and suggest not only preventive precautions by coating but also focus on factors enabling its growth in advance and eliminate them. In order to be able to deal with the problems of biotic infestation of facades it is necessary to cooperate with professionals in the field of phycology, microbiology, nanobiotechnology and the like. It is important to realize that these microorganisms not only devaluate our facades but they can also have a negative influence on our health. Algae and fungi are a natural part of our ecosystem. It is essential to search precautions which prevent them from becoming a natural part of our facades.

ACKNOWLEDGEMENT

The paper was supported by funds from project grant competition VSB – Technical University of Ostrava number SP2016/131.

REFERENCES

[1] D. Kubečková, V. Matějka, M. Kraus, M. Černá, J. Kukutschová, L. Žídek, Biotic Attack in Claddings of Prefabricated Buildings, in: Applied Mechanics and Materials, volume 372 (2013) pp. 189-194.

[2] R. Büchli, P. Raschle, Řasy a houby na fasádách, Nakladatelstv íMise, Ostrava, 2011.

[3] E. Barreira, J. M. P. Q. Delgado, N. M. M. Ramos, V. P. de Freitas., Exterior condensations on facades: Numerical simulation of the undercoolinf phenomenon, in: Journal of Building Simulation, volume 6 (2013) pp. 337-345.

[4] R. Wasserbauer, Biologické znehodnocen ístaveb, Praha ABF-Arch, 2000.

[5] ISBN 80-86165-30-2-59.