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Ventilated façade retrofit problems

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Abstract: Ventilated facades are one of the most commonly used facade solutions. However, like any other building product, they deteriorate and become damaged over time. When the technical condition of a ventilated façade deteriorates, the building owner has to make a decision about its fate: can the ventilated façade be repaired or does it need to be demolished? This article discusses the key technical and functional factors that influence the classification of a ventilated façade for continued use, repair or demolition.

Keywords: ventilated façade, claddings, periodic inspections, technical condition assessment, bending strength.

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1. Introduction

Ventilated facades are one of the most commonly used facade solutions in modern construction. In Poland, they have been used extensively in their current form for at least 30 years [1]. Originally, due to their price, they were used on representative buildings in the form of stone facings. Later, as the choice of cladding increased, ventilated facades appeared on service buildings, road infrastructure (petrol stations, retrofitted railway stations), residential and industrial buildings. Currently, they are becoming more and more popular and more widely used, also due to their ecological and energy benefits (e.g. in the form of facade photovoltaic systems, the so-called BIPV) [2]. A conceptual diagram of a typical ventilated façade is shown in Figure 1.

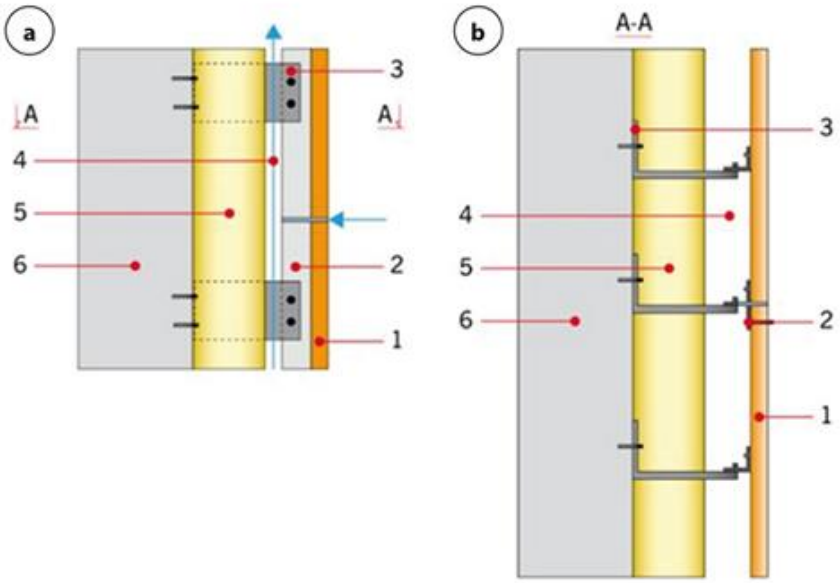

Fig. 1. Schematic diagram of a ventilated façade (drawing by the author): a- vertical cross-section; b- horizontal cross-section; 1 - cladding, 2 - profile, 3 - console, 4 - ventilated gap, 5 - thermal insulation; 6 – wall

30 years ago, ventilated façade systems, as a complete set of coherent products, were not covered by the only European technical specification [3 or 4]. In Poland, these products were very often marketed in the construction industry without verification of their basic technical-use properties (usually on the basis of rather opaque verification calculations), and in a few cases they had National Technical Approvals or German Technical Approvals.

Over time, the ventilated façades aged, were damaged, and the regulations regarding the requirements for thermal insulation of buildings and fire safety changed.

After several decades of using a ventilated façade, building owners very often ask themselves: is the façade system on the wall safe, usable and allows for the economical operation of the building? The answers to these questions will allow a rational decision to be made regarding the future fate of the facade systems in use: whether they are suitable for further upgrading or whether they should be dismantled. The purpose of this article is to outline the basic problems associated with the retrofitting of ventilated facades.

2. Technical condition assessment of a ventilated façade

When considering the refurbishment of a ventilated façade, the first step is to objectively assess its technical condition. This requires an assessment of the cladding, the substructure, the thermal insulation and the substrate to which the façade system is attached. In many cases, assessments of the technical condition of ventilated facades are unreliable and are based solely on visual inspection from ground level. Therefore, they do not provide a reliable basis for assessing the serviceability of the façade system.

The technical assessment of a ventilated façade should be carried out on the basis of visual inspection, openings, instrumental measurements, verification calculations and analysis of entries in the building book and records of periodic inspections of buildings [5].

The examination of the technical condition of ventilated facades should be carried out in four interrelated stages (Figure 2):

1) preparatory stage;

2) preliminary visual inspection;
3) detailed examination (using research and measuring instruments);
4) analytical stage.

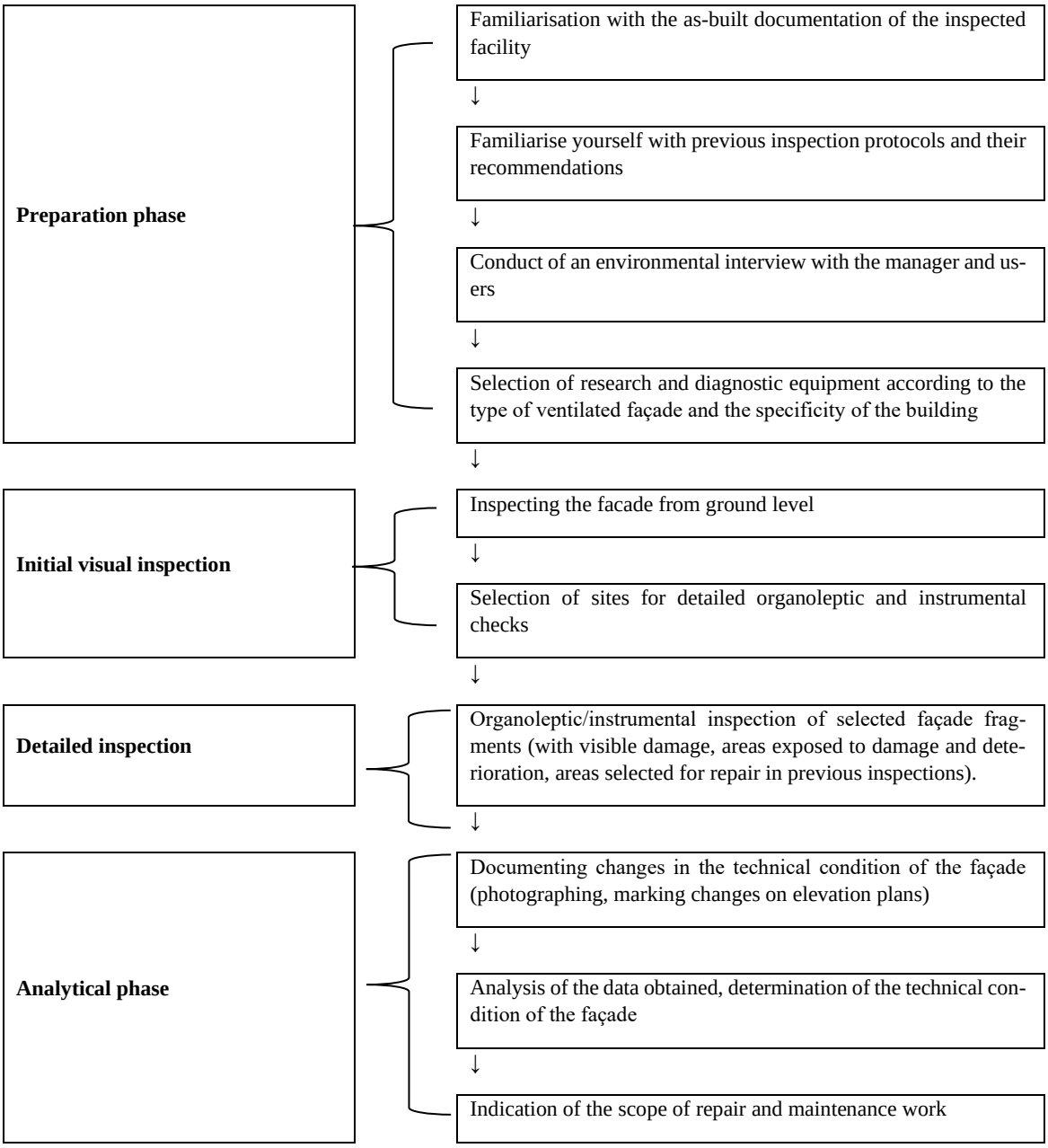

Fig. 2 Stages of condition survey of ventilated facades [5].

The preparation for the inspection and assessment of the technical condition of a facade includes the study of the building design, the as-built documentation, the results of previous periodic inspections and the reference documents of the facade system.

An analysis of the construction of the ventilated façade and the materials used in its construction is essential in order to select the correct methods and test and measurement equipment, as the scope of the

assessment is directly related to the type of construction and the materials used in the construction of the façade.

In the preparatory phase, environmental interviews should be conducted with the managers (owners) and, if possible, with the occupants/users of the properties to be assessed. As part of the above activities, the following should be identified

- intrinsic damage to the cladding;
- on the inside of the building - the presence of discolouration or dampness in the external walls;
- the influence of new buildings (built after the installation of the ventilated façade on the building walls) on the technical condition of the façade to be inspected;
- the influence of new, previously non-existent environmental factors (mainly chemical) on the level of aggressiveness of the environment (e.g. the construction of a chimney in the vicinity).

In addition to the above, the records of previous periodic inspections should be consulted at this stage of the assessment.

At the preparatory stage, by analysing the technical documentation of the building, the façade areas most susceptible to permanent wetting, anthropological effects (mainly impact), corrosive degradation, etc. should be selected for further investigation.

At the preliminary visual inspection stage, all anomalies that may have a negative impact on the durability and safety of the façade should be selected. Visual inspections of the façade should be carried out using binoculars or suspended scaffolding and, in justified cases where lifts and scaffolding are not possible, using drones.

During the visual inspection of the façade, attention should be paid to any discolouration of the cladding. In the case of fibre cement, concrete and ceramic cladding, discolouration may indicate permanent wetting due to loss of air space beneath the cladding, e.g. due to expansion of the mineral wool or dislodgement of the vapour control layer. Discolouration of fibre cement cladding may also indicate changes in its mechanical properties, with a risk of failure [6, 7, 8].

Detailed surveys should be carried out on selected sections of the façade during the following stages

- the preparatory stage - those most exposed to damage and deterioration, as indicated by the building's administrators and users;
- preliminary visual inspections - whose technical condition raises doubts;
- listed as needing repair in the previous periodic inspection protocols.

This stage of the inspection requires direct contact between the technical assessor and the cladding elements. For health and safety reasons, inspections are usually carried out from hoists in low and medium-rise buildings, and from suspended scaffolding in high-rise and high-rise buildings (the use of suspended platforms is not recommended due to the possibility of damage to the facade from the scaffolding support wheel).

If cladding with through cracks is found, it must be removed as it poses an immediate risk to human life and health.

Endoscopic inspections (or, if this is not possible, exploratory inspections) should be carried out on all areas of the cladding where changes in the thickness of the joints between adjacent claddings, damage to the cladding or evidence of moisture are found. The purpose of these inspections is to determine whether there is:

- internal damage to the cladding (Figure 3),

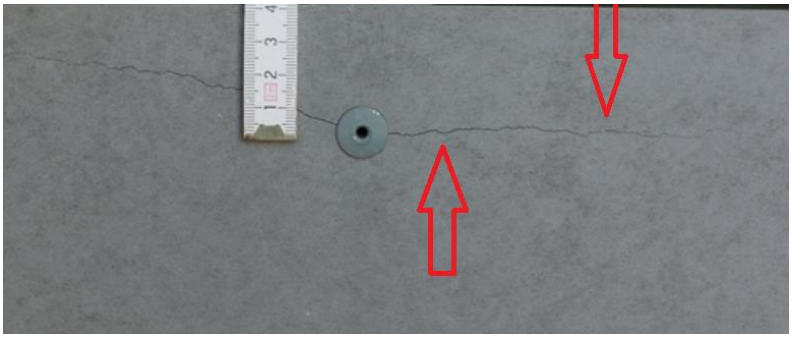

Fig. 3. Damage to ventilated façade cladding (Author's photo)

- reduction of the ventilated spaces between the cladding and the insulation (Figure 4),

Fig. 4. Expansion of mineral wool leading to disappearance of ventilated space (Author's photo)

- damage to the "grid - façade" connections (Figure 5),

Fig. 5. Damage to "grate - elevation" connections (Author's photo)

- damage to the grate (Figure 6).

Fig. 6. Damage to the ventilated façade grid (Author's photo)

The stability of the attachment of the cladding to the substructure should be assessed during the detailed tests. Firstly, the cladding should be inspected on those parts of the facade where changes in thickness or linearity of the joints are found.

If changes in the course of the joints are found on the surface of the façade and the endoscopic inspection does not reveal any damage to the substructure or the cladding to slab joints, it is necessary to assess the condition of the wall components to which the ventilated façade is attached.

The inspection of ventilated façades in attics is of paramount importance for the safe use of buildings. As part of the organoleptic inspection, the horizontal cladding attached to the parapets should be subjected to (manual) peeling and displacement tests.

When inspecting buildings in winter, it is recommended that thermal imaging of the façade be carried out. Thermal imaging allows the identification of those areas of the façade where changes have occurred in the thermal insulation layer: e.g. wetting or slippage of the mineral wool, etc.

Detailed inspections of ventilated façades with metal cladding or grilles protected by paint coatings should include an assessment of the technical condition of the coatings. These have a direct impact on the durability of the façade systems and also protect the systems from the effects of corrosion. The wear and tear of coatings can be determined by measurements using tactile sensors.

The technical condition of the ventilated façades is assessed and the degree of suitability for further use is determined on the basis of the expert activities carried out and the data collected.

The condition of a ventilated façade is considered to be good if it is found to be free from anomalies, defects and damage that reduce its serviceability and safety of use.

Ventilated facades are considered suitable for further use if some of the monitored technical-utility parameters of the facade do not meet the requirements of the design or the standards. At the same time, the detected violations of the requirements do not lead to malfunctions of the facade under certain operating conditions, and the technical-utility parameters required by the regulations can be renewed after uncomplicated repair works. The defects found during the inspection do not include: cracks in the cladding, damage to mechanical fasteners, damage to the substructure, deformation of the joint course. Damage to the paintwork that does not affect the durability of the façade system, minor dents in the metal cladding, dirt on the cladding are acceptable.

Limited suitability for further use of ventilated facades is determined in cases of significant reduction of their original technical and utility properties (e.g. in terms of thermal insulation, acoustics, slight reduction of the load-bearing capacity of the grid due to corrosion, reduction of the aesthetic value). At the same time, there is no risk of sudden deterioration of the façade (no cracks in the cladding, no damage to the grid, the mechanical fasteners that fix the cladding to the grid are intact). The technical and performance parameters required by the regulations can be restored after extensive repair work.

The technical condition of ventilated facades should be considered unacceptable in cases where a reduction in the load bearing capacity of the grid and other performance characteristics affecting the serviceability and safety of the facades are found. Such defects include: the presence of corrosion on the

studs and cladding, deformation of the cladding, erosion of the cladding reducing its cross-section, minor damage to fixings. Elimination of such defects in most cases requires technical documentation and is carried out during the renovation of individual building elements or the building as a whole. This technical condition indicates the existence of a risk to human life and health and requires immediate safety measures to be taken (exclusion of the ventilated facade from use, use of safety scaffolding, etc.) and the strengthening of the structure and components of the ventilated facade.

The technical condition of ventilated façades should be considered to be in a state of emergency if, during the inspection, damage and deformations are observed that indicate a loss of load-bearing capacity and stability of the façade systems, with a risk of façade collapse. The nature of the damage observed indicates that the load-bearing capacity of the ventilated façade substructures has been exhausted (manifested by intensive development of deformations, deformation of the façade, cracks in the cladding). If emergency conditions are identified, urgent remedial action is required for the individual façade areas at risk of collapse.

3. Compliance with current technical regulations

When analysing the possibility of continuing to use a ventilated façade or deciding to retrofit it, it is important to consider issues related to the regulations in force, such as those listed in the Regulation of the Minister of Infrastructure [9].

It is often the case that a ventilated façade, despite being in a very good state of repair, may have low energy efficiency compared to new buildings, resulting in high costs for the use of the property. National regulations [9] have changed the requirements for the thermal performance of walls several times over the last 20 years. Before the changes, the U-value for external walls was 0.30 W/(m2·K) as recently as 2013, and in 2014 the required U-value dropped to 0.25 W/(m2·K). Until the end of 2020, Poland had requirements where the U-value for external walls was 0.23 W/(m2·K), but now it is only 0.20 W/(m2 ·K).

Adapting ventilated facades to modern thermal insulation requirements means increasing the thickness of the insulation layer. This is not always possible due to the overhang of the brackets in the existing façade system, which determines the size of the ventilated space and the area filled with thermal insulation. Increasing the thickness of the thermal insulation can result in a break in the ventilation layer, which ultimately does not allow the desired thermal insulation performance to be achieved (without the ventilation layer, the thermal insulation is exposed to wetting).

For many years, ventilated façade systems did not take into account the effect of thermal bridging on the thermal performance of the envelope. When metal brackets are used (and these were the most common) without thermal breaks under the feet, a thermal bridge is created at the 'wall to bracket' junction. This can be eliminated by removing the cladding system and adding spacers.

At the beginning of the 21st century, ventilated façades were often marketed without prior testing, including testing for safety of use. When considering the fate of a ventilated façade (in the context of its replacement or repair), it is important to analyse its fire safety performance, primarily in terms of fire spread and compliance with the requirements of §225 of the regulation [9]:

"Façade cladding components shall be fixed to the building structure in such a way that, in the event of fire, they do not fall down in less time than that resulting from the required fire resistance class of the external walls".

It is often the case that a façade system (despite many years of trouble-free service) does not meet the fire safety requirements and may pose a potential risk to the life and health of the occupants. This factor must be taken into account when deciding whether to continue using a ventilated façade or to replace it.

In many cases, existing ventilated façade systems have not been tested for impact resistance. Impact resistance determines the applicability of a façade system in locations with different levels of operational risk:

- e.g. unmonitored locations open to the public where there is a risk of being hit, kicked or thrown heavy objects;

- places that are not accessible to the public.

Impact resistance testing can be carried out 'in situ' according to [4]. In many situations, it offers the possibility of avoiding dangerous accidents by excluding unsuitable (in terms of impact resistance) sections of ventilated façades from use (Figure 7).

Fig. 7. Result of the impact resistance test of the ventilated façade: the façade system cannot be used in areas accessible to people (Author's photo)

4. Selection of replacement materials

Ventilated façade claddings are exposed to variable climatic and anthropogenic influences that negatively affect their technical condition, leading to damage [1] and the need to replace individual panels. Recommendations for cladding replacement are often included in periodic building inspection reports [5].

In the case of cladding systems installed several years ago, it may not be possible to find the same cladding on the market for obvious reasons: withdrawal of the product from the manufacturer's range (the product has a life span of 5-7 years on the market) or liquidation of the company or cessation of its business activities on the domestic market. In this situation, a reasonable question for the building owner or the engineer preparing the repair project is: what technical parameters should the new (replacement) cladding meet? It would seem that the simplest answer is to choose a new cladding with technical and performance characteristics derived from a harmonised standard (allowing CE marking) that are no worse than those of the originally installed cladding.

Very often there have been numerous changes to the harmonised cladding standards over the years, and it is not possible to directly compare the performance of products marketed in different decades of the 21st century, as the scope of the standards and test methods have changed. In addition, in most cases, the harmonised cladding standards do not address the technical aspects associated with the use of cladding in a façade system. This applies to ceramic, fibre cement, concrete and HPL cladding. The aspects not covered in the standards related to their direct use on a ventilated façade have been covered in national or European technical assessments (formerly approvals) issued between 2004 and 2023 on the

basis of different documents: individual national guidelines; ETAG 034 [3] (document withdrawn); EAD 090062-00-0404 [4].

The issue of selecting replacement claddings for ventilated façade systems can be presented using the example of fibre cement boards, which are covered by the harmonised standard PN-EN 12467+A2:2018-06 [10]. The standard [10] has been amended several times in the last 20 years. In the declarations of performance issued between 2004 and 2023 (issued on the basis of EN 12467 [10]), manufacturers of fibre cement boards intended for use in façade systems have, in most cases, indicated the following essential characteristics

- the category of the panel;
- The type of panel;
- the declared dimensions and the level of shape and dimensional tolerance;
- The mechanical bending strength expressed as a class;
- The apparent density of the panel;
- Resistance to hot water and 'bath-dry' cycles;
- Resistance to heat-dry cycles;
- Reaction to fire.

It should be noted that the above technical performance characteristics of fibre cement panels derived from EN 12467 [10] do not cover the essential characteristics of the cladding related to the installation technique or the way the cladding is supported on a ventilated façade.

The essential technical and performance characteristics of fibre cement cladding related to the method of installation to the substructure of a ventilated façade are defined in ETAG 034 [3] (document withdrawn from use in 2018) and EAD 090062-00-0404 [4]. For façade systems with mechanical joints (the most common in construction), where the cladding is fixed to the substructure with mechanical fasteners (e.g. rivets), the above documents [3 and 4] pay particular attention to the following technical characteristics

- Shear resistance of the cladding-substructure joint;
-Pull-out resistance of the cladding-substructure joint;
- Impact resistance of the cladding fixed to the substructure.

The article "Technical conditions for replacing fibre-cement cladding during renovations of ventilated facades" [7], published in “Materiały Budowlane”, analysed the possibility of replacing fibre-cement cladding used in the ventilated facade system (with riveted cladding fixings), which is no longer in production, with alternative cladding. Laboratory tests carried out by the author of the above-mentioned paper on façade claddings produced by different manufacturers with comparable technical and operational parameters, based on the PN-EN 12467 standard [10], showed that these claddings may behave quite differently on a ventilated façade. Differences were found in the resistance to rivet pulling, shearing and impact. The greatest differences between the claddings compared occurred in the shear resistance tests of the "cladding - rivet - aluminium profile" joint after conditioning in water. In the context of the safe use of a ventilated façade, this property can have a decisive influence on the choice of cladding. Work [7] clearly shows that a direct comparison with the declaration of performance of fibre cement slabs resulting from [10] is not sufficient for the selection of replacement claddings for the repair of ventilated facades. Complementary tests on parts of the ventilated façade are required, including impact resistance, pull-out and shear resistance of rivets (after conditioning in water). Failure to consider these properties can have a significant impact on the safety and performance of the ventilated façade.

5. Conclusions

The decision as to whether a ventilated façade can continue to be used or needs to be replaced can only be made after a thorough assessment of its technical condition, which often requires specialised measurements and analysis.

In addition to assessing the residual mechanical performance of existing façade systems, it is important to analyse their fire performance in the light of current legislation: often failing ventilated façades can pose a potential risk to human life and health due to the properties of the façade (cladding, grilles, thermal insulation) in terms of fire spread, flammability and collapse in the event of fire.

When replacing individual claddings, it is very important to select components with similar technical performance based on the harmonised cladding standards and technical specifications [3, 4] for facades as a set of compatible products.

In many cases, the decision to remove a ventilated façade is based on economic considerations related to the thermal performance of the façade system. It may not be possible to improve the thermal performance of the façade by increasing the thickness of the thermal insulation layer due to the load bearing capacity of the wall or the limited overhang of the grid.

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