The possibility of application of bonded joints on different facade systems

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Abstract. Bonded joints in the construction industry have a rich history dating back to ancient civilisations, where they were mainly used to join materials such as wood or stone. In particular, natural materials such as bitumen or natural resins were used for this purpose. In the present modern era, with the development of adhesive technologies and synthetic adhesives, they have become an essential part of construction industry practice. Within facade cladding, bonded joints are becoming key to achieving high thermal insulation performance and overall building energy efficiency. The correct design of the building envelope is increasingly relevant in the context of the geopolitical situation starting with the global pandemic COVID-19 and the two conflicts between Russia and Ukraine and between Israel and Palestine that resulted in energy crises [1]. The paper summarizes the potential applications of adhesive bonded joints on facades, the types of adhesives used at different joints and their ability to provide strong and durable joints when exposed to different climatic conditions during summer and winter months.

1 Introduction

In the construction industry and especially in facades, many materials are used and there is an increasing focus on precise and efficient anchoring of facade materials. Anchoring, the process of joining and securing these elements to the supporting building structures, is the key step in the construction process that significantly influences the stability, safety and overall durability of façade systems. Galyamichev describes the possibilities of visible anchoring of sandwich construction [2].

However, architectural design often comes into the process of façade implementation from an aesthetic point of view, with hidden load bearing and anchoring structures as a modern element. From this point of view, bonding appears to be a highly effective option, which results in the displacement of the visible anchoring elements, which normally run through the entire structure, below the top visible surface [3,4].

There is a wide range of materials used as exterior layers for facades. Facade materials include:

- Brick cladding,
- Wooden cladding,

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- Metal panels,
- Glass panels,
- Mineral plaster.

One of the currently most widespread facade materials is mineral plaster in combination with External Thermal Insulation Composite Systems (ETICS) [5]. This system originated in Europe but quickly spread worldwide. Hongtao addresses the issues of ETICS and its standardization in their work, describing differences in the perception of the issue in Europe, China, and according to ISO standards [6].

The most commonly used facade plasters are:

- Acrylic,
- Silicate,
- Silicone,
- Silicate-silicone,
- and mineral (lime-cement).

Each of these plasters has specific features such as vapour permeability, water repellency, UV resistance or abrasion resistance.

However, these systems are subject to ageing and according to the European regulations should have a minimum lifetime of 25 years, as long as the ETICS is integrated into the structure in an appropriate way and according to the regulations [7]. The ageing of this layer is described in an article by Bochen, who carried out artificial conditioning tests on all the above mentioned types of facade plaster and concluded that ageing due to weather conditions is the main factor in the reduction of service life. [8]

2 Methodology - research

The methodology of bonded joint anchoring of façade elements is primarily concerned with the correct and efficient attachment of these elements to the supporting structure of buildings, where it plays a key role in the overall stability and durability of the façade system, and therefore it is necessary to pay sufficient attention during planning, implementation and possible repairs.

Hastuti in his paper examines the application of mixed bonded joints in the context of joining aluminium alloys. The advantages of bonded joints are discussed, in particular low manufacturing cost, simplicity, environmental resistance and suitability for different material combinations. Two types of adhesives are investigated: a strong and fragile epoxy adhesive and a flexible and stretchable silyl-modified polymer (SMP)-based adhesive, and their suitability for aluminium-aluminium joints and the effect of different adhesive compositions and thicknesses on shear strength are examined [9].

Ahmed's work deals with the bonding of stainless steel with polyethylene in the context of oxidation, resulting in lightweight structures with high strength and durability. However, this method is tied to a high performing temperature of around 500 °C [10].

Silvestru's research focuses on transparent facades, which are often used in modern office buildings. These facades often use glass panels and metal elements. The study explores the possibility of creating a composite structural behaviour between glass panels and metal frame in order to make efficient use of materials and achieve elegance in design. Based on the results, it describes that the bonded joints can sustain both tensile and shear loads in the plane of the façade [11].

Machalicka describes structural bonded joints on building facades from the perspective of aging of bonded joints on aluminum and galvanized substrates. The paper also describes the conditioning of specimens to simulate plaster ageing and then evaluates the results with specimens without exposure to ageing [12].

The Niklish study addresses the need for improved window and façade design to meet the demand for energy efficient buildings. It focuses on two joining technologies: bonding the glass unit to the wooden part of the profile and a specific rolling technique for joining the wooden part to the aluminium element. The final composite frames offer a sustainable and durable solution with a lower energy footprint compared to standard alternatives, contributing to a shift in the use of wood in facades [13].

The bonded sealing joints of façade cladding and their resistance to water and air are the subject of Chew's article and he discusses common defects in joint sealants and the movements they are exposed to. He also discusses the effect of weather conditions on the ageing and failure of these joints [14].

3 Results

The short literature survey above shows that bonded joints have a wide range of applications, but not all bonding options have been explored yet. In particular, bonding directly to the facade plaster on the ETICS system. The load-bearing capacity of the actual facade layer and the bonded joint seems to be a crucial factor. The individual parts must therefore be subjected to shear and tensile strength tests and eventually a shear-tensile combination. These tests have already been determined on the previous investigation and have been described on the basis of the Czech technical standards [15-17].

Another factor resulting from the research and our own experience are the weather conditions of the given location, i.e. the Czech Republic. These weather conditions and their influence can be investigated by two methods - artificial conditioning and testing in real weather conditions. Artificial conditioning is prescribed by Czech technical standards, which deal with changes between frozen and defrosted conditions and sudden temperature changes from sun exposure, which Nečasová referred to in her paper [18]. These methods were also described by Alachek with a difference in in temperature range and cycle count [19]. Other methods of artificial conditioning and ageing were discussed by Machalicka, who described two methods ETAG 002 - Exposure to neutral salt spray and ISO 9142 - E4 - elevated temperature and humidity [20].

However, only one test can demonstrate the real effect of ageing and that is based on real outdoor weather conditions. This method is the most accurate, but the most time consuming, as it requires samples to be left outdoors for several years.

As a result of the research activity, it was found that the bonding to the top layer of ETICS, namely the plaster, was not investigated and therefore brings new research opportunities.

4 Discussion

For bonded joints, in the context of the effective attachment of elements to the building structure and their key role in the overall stability and durability of the façade system, it is worth highlighting the significant advantages of this technology. Low production costs, simplicity, environmental resistance and suitability for different combinations of materials are among the main positives of bonded joints. Based on the above review, it can be concluded that bonded joints bring a wide range of benefits in the field of façade construction, leading to more sustainable and energy efficient buildings.

5 Conclusion

The conclusion of the article highlights why the choice of anchoring the metal elements using bonded joints to the ETICS facade plaster with silicate plaster was made. First and above all, this method brings significant time and cost savings, while ensuring a reliable and solid connection to the façade plaster. The use of bonded joints eliminates the need for traditional anchoring, minimising distractions on the façade surface and providing an aesthetically pleasing appearance. In addition, bonding allows excellent adhesion to the silicate plaster, which is key to weather resistance and durability of the entire structure. The choice of this anchoring method represents an innovative approach to the installation of sheet metal elements on the façade and can serve as inspiration for other ETICS plastering projects.

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