Disorders of the Green Roof of the Pool Lucenice

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Abstract. The main objective of the article is to inform about the construction-technical survey, which focuses on the existing roofing of a pool area. The pool area is a separate object annexed to the historic farmhouse dating from the mid-19th century. Roofing of the pool area is made of a green roof. The main research issues stem from the building-technical survey focused on the green roof disorders. After detecting the faults, we look for their causes and find out which faults are fatal to the building and which can be easily removed. From the evaluated constructions, we focus primarily on the solution of the green roof in terms of correctly executed roof slope, plating, thermal technical properties of the materials, inherent weight of the structure and execution of individual layers of the composition of the green roof. Furthermore, we focus on determining the compliance of project documentation with the construction. We assess the impact of failures on the structure and operation of the building. In the conclusion we propose measures based on the found failures and possibilities for the solved structure.

1. Introduction

Our task was to find out the condition and defects of the roof cladding and the whole area of the swimming pool building, which is located in the northern part of the eastern wing of the whole farm. Especially in areas where new steel roof structures were made and where these new structures meet the existing structure of the farm. The main objective is to focus on the extent of defects and possible damage, possible emergency and its reasons. We have also considered the possibility of eliminating these disorders.

The survey did not include any other defects in the original farm in Lucenice. This building as a whole is undergoing a gradual reconstruction according to the phasing of individual wings and at the present time it seems to be substantially completed and reconstructed. The original object of the farm dates back to the middle of the 19th century (about 150 years old) and its original, historical structures correspond to the time of its origin, both technically and morally, with the fact that in recent years they have undergone demanding construction work and got new features. The assessed part of the building was realized on the basis of project documentation [1].

2. Construction-technical survey

The basic inspection was carried out in February 2017 and local part of the roof cladding (green roof layer) was also discovered. Therefore, we also checked the external condition of the building and other

contexts that relate to the roof cladding in its entirety, not only above the problematic leaks into the building.

It was found out that the whole pool area was realized as a combination of masonry constructions, concrete constructions and these were subsequently supplied with a steel roofing with a proposed layer of composition. The project documentation does not show the scope of supply, but after the owner's interpretation of the building is a system of subcontracting, which delivered the individual building parts. Furthermore, it was found that the entire floor area of the interior of the swimming pool of approx. 6x17m shows a leak into the building in the form of dripping of rusted water. Drip most often occurs at the point of contact of steel rolled beams and galvanized trapezoidal sheet.

At the time of the local investigation, the pool was filled with clean water at a temperature of about 10-12°C and the temperature inside the room was about 15.5°C with a relative humidity of 37-40%. Furthermore, the pool level was covered with a bubble floating pool foil and suspended water buckets were installed at the dripping points. The exterior shell of the pool was finished with a wooden façade and a green extensive roof with some backlog in the form of missing plumbing elements at the attic, and in the absence of foil waterproofing, rainwater drainage, etc. Inside the pool area steel pool roofing is designed only as a technical appearance with exposed steel structures and trapezoidal galvanized sheet.

When examining the lower face of the trapezoidal sheets of the roof cladding, it can be stated that due to the pool environment and the solution of the space as such, there is clearly visible excessive condensation of water vapor, subsequent precipitation on the surface and gravity flow down a certain slope back into the pool area. This process is constantly manifested as dripping rusted water from various stabilized places where plastic buckets are suspended [2].

3. Assessment of research questions

In order to assess the condition of the roof cladding, a local investigation had to be undertaken in order to reach an unequivocal conclusion on the source of the problem by analysing the state of the environment [3].

3.1. Is the roof structure of the pool constructed in accordance with the provided project documentation? What differences, if any?

The submitted project documentation is kept as production in relation to the roof cladding in all its three execution dates. It is therefore not a classic building documentation with all connections and sorting according to the Decree as of the date of drawing up the project documentation [4].

On the basis of the above it can be stated that the roof construction and roof cladding made of steel construction and trapezoidal galvanized sheets are made in accordance with the submitted project documentation. This documentation is created mainly as a production and as such it does not deal with other building contexts and necessary interconnection with the original building and other professions on the construction site [5].

As the only differences, it shows at the prescribed slope of the glazed part of the roof, where the project documentation indicates a slope of 3% and an expert on the spot measured 2.5% slope, which is a negligible difference. Furthermore, there is a difference in the implementation of the green roof stack according to the project as a 100mm substrate, when this stack actually gets more to the edge of the attic glazed roof and also below the neck of the installed ventilation turbines. Furthermore, the axonometry of the pool area according to the submitted project documentation does not solve one actually realized narrow window opening from the hygienic and technological room of the pool

3.2. Do the design and the actual construction of the roof structure take into account the fact that the roof structure is built above the pool? Does the construction of the roof structure allow for proper use of the pool in the long term?

The main problem of project documentation is in the absence of interconnection with classical building documentation. It is this documentation that should give clear answers and set the entry conditions for the solution of the premises. In the pool area under consideration, the main source of the problem is the increased humidity and the subsequent precipitation of water on the face of the roof structure itself or partly in the layers of the designed shell structure. It can be assumed that in the pool area there will be, as now the pool is made of increased relative humidity and further possible aggressive environment in the form of chlorinated water, etc.

These internal influences have caused the simultaneous unexpected behavior of the roof cladding composition. In the construction, water vapor condensation, which is manifested to the surface by dripping of rusted water at the points of contact of trapezoidal sheets, is clearly taking place.

The design and subsequent construction of the roof structure and roof cladding does not take into account the constructional fact of the indoor pool interior, where the class of such an environment referred to for example to protect concrete structures against corrosion is like XD2 - wet and rarely dry (eg swimming pools). The design and actual constructional design could be used in this way if certain input conditions are met, but there are no important measures to avoid environmental impact.

In the long term, such a construction of the roof structure and roof cladding composition is unsuitable for the purposes of the pool area and the current situation without any necessary modifications of the whole situation will continue to deepen. If the investor is satisfied with the buckets installed, this internal corrosion will more attack the galvanized sheet of trapezoidal sheets and outside the composition, where it will degrade the sheet. Of course, the slow corrosion of other supporting steel structures, which are now sufficiently coated, will continue, and in the form of aesthetic maps, the interior will continue to be exposed to dripping water. The current state of the roof cladding and the roof structure therefore prevent the roof clad from being used properly as a defect-free item. The removal of the current situation and the remediation of some of the above-mentioned facts will be highly desirable from the point of view of future operation in the pool area, while maintaining the reality of the swimming pool.

3.3. If the design of the roof structure does not allow for proper use of the pool, are there any structural adjustments that could be made to the existing roofing to enable proper use of the pool? If such construction work exists, what is it?

It is necessary to immediately remove the main causes of water condensation above the trapezoidal metal sheet and, if necessary, to add new constructions and materials composition in parameters according to the original specification, that it is a swimming pool area with use all year round except winter. A more demanding solution would result from the need to replace the entire roof cladding composition, leaving only the supporting steel structure. In such a case, after removing or inspecting all long-term trapezoidal sheets exposed to moisture, it would be advisable to address the new roof cladding as a complex construction activity and to revise all related structures affected by repairs.

The current state of construction of the roof structure and the composition of the roof cladding does not allow for comfortable and full use of the pool area for its original purpose. The situation can only be solved by recommended completion of the composition towards the interior of the pool and revision of existing compositions in general. The desired goal of using the pool area for its main purpose is therefore not necessary to achieve by replacing all elements of the roof structure, but it is only possible to revise the composition of the roof cladding. It is definitely necessary to follow the

recommendations resulting from the architectural analysis of the situation and the subsequent proposed building modifications.

First, it is necessary to ensure sufficient forced dehumidification of the entire pool area by an oversized and correctly positioned pool dehumidifier or condensation dehumidifier with recuperation. The designed and realized spontaneous ventilation turbines cannot function in the pool area and can be a sufficient substitute for forced ventilation and dehumidification.

Another necessary measure is to partially cover the water surface with bubble foil or a possible swimming pool shutter when the pool is not in use. By preventing evaporation from the water surface, the effect of temperature differences between the pool water and the pool environment is eliminated.

Furthermore, it is ideal to work with the water temperature in the pool depending on the temperature of the pool area. It would therefore be advisable to consider a comprehensive heating control and regulation depending on the set temperature of the pool water and the current state of the indoor and outdoor environment.

Last but not least, it would be good to revise the current state of the composition, primarily from the interior of the pool area at the site of today's visible ceiling in the form of trapezoidal sheet metal. It is the critical point of the composition that is located above the trapezoidal sheet and vapor-proof foil. When designing the composition above the pool area defined by the final parameters, the overall thermal insulation layer should achieve such insulation that the thermal conductivity coefficient of the structure U does not exceed 0.24 W/(m^2.K). A good vapor barrier must be created under the thermal insulator so that the condensation in a 1 m^2 insulated construction does not exceed 0.1 kg/m^2/year. It must also be ensured that the condensation formed is not greater than the possibility of evaporation. Also, the composition as a whole should be airtight. The present state of all or substantial condensation takes place between the trapezoidal sheet layer and the vapor barrier, and in the form of running water, this is reflected in the overlapping sections of the individual trapezoidal sheet metal sections. Such a poorly chosen vapor barrier film and its placement complicates the basic consideration in the climate in the pool area (eg + 30°C/75% humidity), then the dew point of the structure is just behind the vapor barrier (in our case trapezoidal sheet). The same climate should be ensured in the vapor barrier behind the ceiling layer as in the indoor environment. Thus, the ceiling layer allows the air heated from the interior to flow beyond the ceiling layer into the gap between the vapor barrier and the ceiling layer. Thus, in contrast to the present state, a closed air gap would not form between the vapor barrier creating an additional thermal insulation layer of the structure.

3.4. Is the cause of leakage into the building the so-called "green roof" and its implementation? Or to what extent?

According to the project documentation, the "green roof" is defined by the composition as the last layer of the composition in the definition of "green roof stack (100mm substrate)". These tracks are described in sections and are not specified anywhere else. From this information we conclude that there are many types of "green roofs" and it can only be said from the local survey that this is the most economical variant of a green roof with a single layer with an extensive substrate.

It is apparent from the above answers that the main problem of the roof is not leaking into the building, but an inappropriate design of the roof cladding. It can therefore be said that the project documentation does not allow to know very much what the green roof is and therefore no related details in certain complicated places are further addressed. We only state that the implementation of about 4 layers of "green roof" is not only in 100 mm substrate, but the composition contains more elements, which are finally implemented as higher. Compared to the project documentation, the project implemented a layer for the "green roof" as a levelled layer in the attic and the flat glazing

collar. As a result, the ventilation turbines practically flush. In the case of ventilation turbines, it happens that the turbine stops in the event of snow and when it grows to the desired size of planted stalks-herb-grass, so the turbine finally stops and stops venting. The fact is that the ventilation design is completely inadequate and even designed in such a wrong way, because it rather causes permanent unwanted roof perforation and creates a local thermal bridge, and at this point there is some other induced condensation and freezing instead of ventilation and properly designed.

4. Conclusions

Given the available information and their evaluation, we are able to answer the questions as follows.

The roof structure of the pool is made in accordance with the project documentation provided. This documentation is created mainly as a production and as such it does not deal with other building contexts and necessary interconnection with the original building and other professions on the construction site. Implementation compared to the project documentation shows negligible differences that do not significantly affect the main and material errors.

The design and subsequent realization of the roof structure and roof cladding does not take into account the fact that the roof structure and roof cladding are built above the pool. The roof construction and roof cladding do not allow proper use of the pool in the long run.

The roof structure allows the building to be used as a construction base for the pool area. Furthermore, the roof cladding and its composition do not allow the use of the pool area for its main purpose without the need for the constructional modifications outlined in this assessment point. Thus, there are building modifications that could be made to the existing roof structure to allow proper use of the pool.

The green roof is not the main cause of leakage. Only the construction of the roof in terms of general technical requirements for construction is questionable in places where the details can be solved completely differently and better.

To ensure the perfect use of the swimming pool area in the building, the following modifications must be made:

- Based on the current state of the roof structure and roof cladding, it would be good to stabilize the state of the indoor environment (ventilation, dehumidification, heating, etc.)

- Ideally, re-design the project implementation documentation for state-of-the-art repairs to identify corrective actions and identify clear points of solution. There will probably be more significant system solutions for the new supplier of remediation work. The new project documentation will therefore contain consistent comprehensive solutions before the actual step of remediation of the current building modifications of the swimming pool area.

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