Measures to Improve Health Performing of an Accommodation Building. A Study Case

Isabel Bentes[1], Sandra Pereira[1(✉)], Teixeira Carla[2], and Jorge Pinto[1]

[1] UTAD/CMADE, Vila Real, 5000-801 Vila Real, Portugal
{ibentes,spereira,tiago}@utad.pt
[2] Módulo Curioso, Gabinete de Arquitetura, 5100-065 Lamego, Portugal
geral@arquitetacarlateixeira.pt

Abstract. Tourism has been a promising activity in Portugal. There has been an increasing interest in the interior part of this country as a destination. At the same time, there is still a lack of accommodation buildings to follow this trend. Therefore, rehabilitating traditional buildings has been a wise option to deal with this problem. During the rehabilitation process, several challenges emerge because each building has its specification. Thus, this research focuses on the relevance of ventilation to guarantee an adequate healthy environmental habitat. A study case of an accommodation building in Lamego city, Portugal, is used to give more practicality to this topic. At the same time, a ventilation solution is presented as a measure of assuring proper adequate inner air and some future works about automatic control/predictions are delivered. The presented results may give guidance for future rehabilitation processes or may have to solve existing problems concerning this issue.

Keywords: Inner air · Ventilation · Rehabilitation · automatic control

1 Introduction

Traditional dwellings can be rehabilitated for tourism accommodation purposes [1]. Several technical aspects, such as health and comfort in living, are still more critical in this context.

Some technical aspects that must be considered are the views, natural light, space, ventilation, thermal behaviour, acoustic, humidity, and smell.

Considering that traditional dwellings are likely to be placed in the city centres, these concerns tend to increase.

The main goal of this research is to emphasize a natural ventilation system proposed in a rehabilitation process of a traditional Portuguese dwelling in the North of the country that will be used as a tourist accommodation and to present the automatic control system used to manage the temperature, ventilation, and lightning.

The proposed ventilation solution ensured the air quality in the tourism accommodation building. The adopted solution was validated and can be applied in other future

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works of rehabilitation projects - the air quality achieved in the studied building guaranty the health requirement standards of this type of building.

Therefore, this document is structured as follows. After this introduction, a brief description of traditional natural ventilation solutions is done. The introduction of the building used as a study case is presented afterwards, followed by the explanation of the ventilation solution applied in the study case. At this stage, the necessity of the required ventilation system is identified. The description of the adopted technical solution is delivered, and the evaluation of its efficiency is estimated. Finally, the main conclusion is also presented.

2 Traditional Natural Ventilation Solutions

In terms of ventilation, it can be natural or forced. Natural can be considered more sustainable. In contrast, a forced ventilation system may be more high-tech, requiring mechanical devices and energy consumption [2]. On the other hand, forced ventilation may be the only solution considering the specificities of traditional buildings. For instance, the existence of underground floors, the lack of windows or doors, the density of construction, the morphology of the landscape and the insulation can contribute to different ventilation system requirements (natural or forced).

A proper ventilation system allows good air quality in a building and contributes to accommodation comfort. It avoids inconvenient smells and health-related problems such as allergies and breathing difficulties.

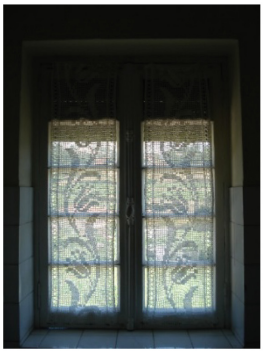
At the same time, a proper ventilation system may avoid accidental scenarios such as high carbon monoxide levels that can cause death [3].

Systems like control and prediction are needed to detect other hazards like radon or gases that can be dangerous to health [4–6]. The comfort level of the accommodation is also a concern, and having some control over temperature, humidity, smell, and noise can also help [7–12].

Among traditional Portuguese dwellings, several building technical aspects guarantee natural ventilation. For instance, conventional timber frame windows and doors usually have poor isolation, Fig. 1a. The typical kitchen chimneys allow air circulation from inner and exterior spaces, Fig. 1b. The traditional fireplaces may achieve the same feature, Fig. 2a. Meanwhile, the typical timber pavements and roofs (Fig. 2b) are poorly isolated, allowing natural ventilation through different rooms. Thus, traditional dwellings may guarantee natural ventilation, even if inefficient.

On the other hand, new construction may behave differently, considering that they are much more isolated. Pavements tend to be reinforced and made of concrete, windows and doors are more sealed, and walls and roofs are more insulated. Therefore, there is a need to build proper ventilation systems using pipe networks and grills. Level differentiation off entrance and exit of air is recommended. For instance, bathrooms, closets or storerooms may require this type of system because they tend to be unprovided by a window.

When this type of natural ventilation is insufficient thus, it may be reinforced by forced ventilation which relies on a mechanical extractor.



a) Traditional window

b) Traditional kitchen chimney

Fig. 1. Traditional natural ventilation solutions. Windows and kitchen chimneys.

a) Fireplace chimneys

b) Timber roofs

Fig. 2. Traditional natural ventilation solutions. Fireplace chimneys and roofs.

3 Study Case

The traditional Portuguese dwelling used as a study case during this research work is shown in Fig. 3. It is a two-floor building located in the Lamego city centre, particularly in the historical part of this city near the castle.

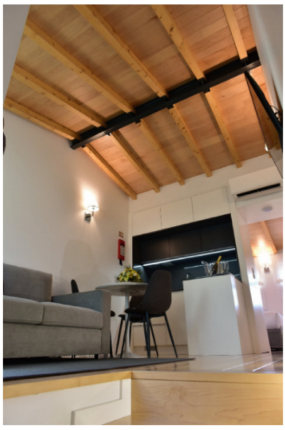
Meanwhile, Lamego is located in the Douro Valley, rich in baroque architecture and religious buildings. It is an international tourist attraction.

As a typical dwelling of the North part of Portugal, it was built with exterior granite masonry and *tabique* walls. The pavements and roof were built with timber. Windows and doors were made with timber frames. The cover of the roof was made of ceramic tiles.

On the other hand, the building presented a lousy level of conservation in which the main structural elements were almost destroyed. There was no point in rehabilitating or reinforcing most of the building. Only the external walls were maintained Fig. 4.

At the same time, the municipality regulations only allow the use of timber or steel as structural building materials for this type of rehabilitation process in this area. Therefore, steel frames, glulam pavements and roofs were used, Fig. 3b.

a) Before rehabilitation. Exterior



b) After rehabilitation. Interior of the top floor flat

Fig. 3. The study case building.

4 Ventilation Solution Applied in the Study Case

4.1 The Problem

At this stage, it is worth mentioning that this building was rehabilitated to be converted into a three-floor flat tourism accommodation (Fig. 3b and 5b).

This specific building is lacking in terms of space. It is placed between two other traditional buildings and shares the same lateral walls, Fig. 4. Therefore, only two exterior walls are allowed to have windows, Fig. 5b. Thus, natural light and natural ventilation can be potentiated by these two walls and the roof, where it will be possible to place windows and grills.

At the same time, approximately one and a half of the building is under the level road, Fig. 4 and 5b.

These building aspects created several difficulties concerning the air ventilation of the house and lighting.

Musty smell, humidity, stagnant air and dark spaces resulted from these building constraints and resulted in an unhealthy living dwelling. Thus, the original building could not meet the actual requirements of living comfort with quality.

Fig. 4. Some highlights of the building constraints.

4.2 The Solution

Based on the above explanation, some building challenges existed during this rehabilitation process. Thus, the building solution proposed to solve the above-identified living problems consisted of having an atrium on the left side of the building and next to the façade facing South, Fig. 5a.

This atrium connects all the floors (from the basement to the first floor), Fig. 5b.

The roof of the atrium is made of double glass to allow natural light entrance, Fig. 6a. This roof has surrounding grills in connection with the structure of the atrium. This structure ensures air circulation from the inside to the exterior and vice-versa.

At each floor level (e.g. ground floor and first floor), each flat has a door and balcony connecting the atrium, Fig. 5b. On these floors, the atrium has windows placed in the main façade of the building, Fig. 5b and 6a.

It is relevant to add that each balcony is built with a steel grid pavement to allow air circulation and natural light passage between floors, Fig. 6b.

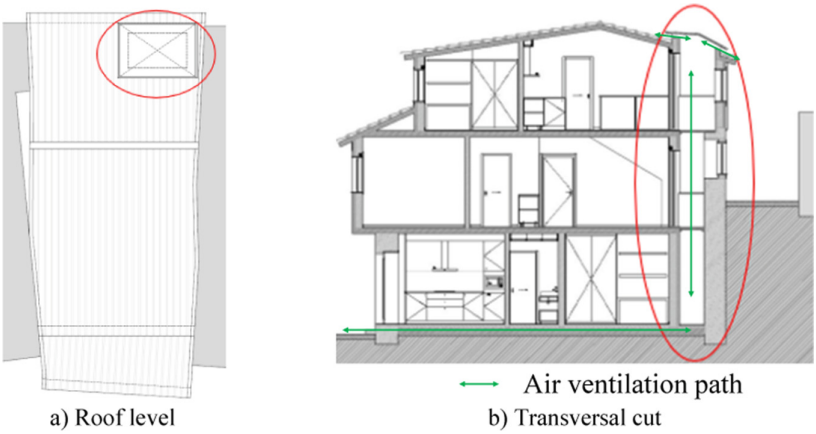


Fig. 5. Atrium position.

a) Roof window b) Main structure of the balcony

Fig. 6. Building details of the atrium.

At the basement pavement, a 200 mm diameter pipe network of PVC was considered to allow the air circulation between the interior of the atrium and the North face façade at this level, Fig. 7. There is approximately a 9 m height path to take into account. Therefore, the air circulation path of the atrium is graphically presented in Fig. 5b.

This air circulation path can have two directions throughout the year, depending on the temperature. Suppose the temperature at the top of the atrium is higher than the bottom (which is likely to occur during the warm temperature period of the year): in that case, the air tends to circulate from the bottom to the top of the atrium. On the other hand, the air will likely circulate from top to bottom. This last scenario may occur during autumn and winter. In addition, if the temperature reaches a high value at the top of the atrium (e.g. summer time), it can generate conditions that stop the natural circulation of the air. The above-identified problems may emerge in this case, particularly an unacceptable musty smell. It was noticed that this problem affects all three floors.

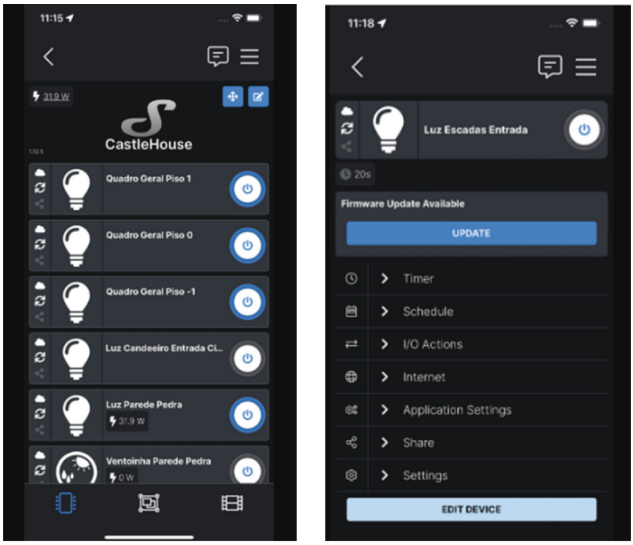
So the proposed natural air ventilation system had to be reinforced with a forced air ventilation system (another pipe network and an electrical extractor are the components of this additional forced air ventilation system). This reinforcement was also placed on the basement pavement floor and nearby the back window of this floor, Fig. 7b.

4.3 Remote Control Options

In this rehabilitation process, other technical aspects were also concerned with using the rehabilitated building during its lifetime, which required additional care. It is not an intelligent house, but it uses technology to reduce energy costs, increase comfort and facilitate management like touristic accommodations. For instance, to have more efficient energy-rehabilitated buildings, the air conditioning system of each flat is remote-controlled. It is possible to switch (on or off) the air conditioning devices using an online platform, Fig. 8. It is also possible to know the temperature of each flat remotely. The light system is also remote controlled as well as the ventilation. In this way, it is possible, without going to the place, to turn on the air conditioning before guests arrive, to have a cosy atmosphere. It is also possible to turn off all or part of the electrical system, namely the sanitary hot water heating systems when guests leave the apartments.

a) Ventilation pipe system b) Back window of the abasement floor

Fig. 7. Additional building details of the atrium.



a) Option b) Light of the stair

Fig. 8. Remote control platform

In addition, the blackout curtains are also remote-controlled. The respective device is shown in Fig. 9.

With this technical solution, it was possible to obtain a more technologically rehabilitated building and take a step toward innovative construction and an intelligent building approach.

4.4 The Degree of Satisfaction

To evaluate the efficiency of the built air ventilation, we are using the results of the typical inquiry of the booking companies concerning this specific tourism accommodation,

Fig. 9. Blackout curtain control devices

Fig. 10. The topic of the comfort of this inquiry indirectly indicates this ventilation solution may be efficient.

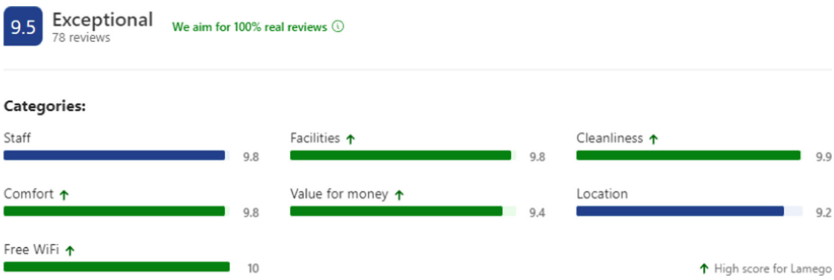


Fig. 10. Evaluation of the quality and comfort of the accommodation.

Based on the guest's degree of satisfaction, we may conclude that the ventilation system is working correctly [4]. Thus, health conditions have been guaranteed.

5 Main Conclusions

There has been an increasing demand for tourism accommodation, and rehabilitating traditional dwellings for tourism can help solve this problem.

However, the rehabilitation of traditional dwellings for accommodation purposes may present additional technical aspects to consider. Health issues are fundamental to avoid in this context. Also, good quality of the inner air is one of the aspects that is fundamental to guarantee.

A natural ventilation system may be a good option because it may be more environmentally friendly. When not enough, reinforcement with a forced ventilation system may be the required building option.

The remote-control options such as thermal control, ventilation control and access to accommodations have shown interest because they are energetically more efficient, less time-consuming and more convenient.

With this paper, the authors also intend to alert to the importance of using systems of control and prediction that can detect hazards, like the presence of dangerous gases that can bring health problems.

In this paper, a natural ventilation system solution was presented and described. It also introduced the required reinforcement of these systems. The success of the adopted technical solutions is shown by the satisfaction degree of the guests, which is quite positive.

The proposed solution may be applied in future rehabilitation processes.

As future works it is intended to undertake, a campaign of measurements over time of variables like outside/indoor temperatures, humidity and presence of CO/CO_2 gases. Another possibility is implementing a system of control and prediction that can provide quality health and comfort to the users.

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References

1. Teixeira, C., Moutinho, A., Bentes, I.: Reconstruction of “the castle house” in Lamego. In: Proceedings of the 8th International Conference on Safety and Ductility of Structures. ICOSADOS 2018. 23–25 May 2018. LLU, Latvia (2018)
2. Cardoso, P.J.S., et al.: Monitoring, Predicting, and optimizing energy consumptions: a goal toward global sustainability. In: Chapter 5 in Smart Systems Design, Applications and Challenges, pp. 80–107. IGI Global (2020). https://doi.org/10.4018/978-1-7998-2112-0.ch005
3. Pinto, J., Vasconcelos, V., Monteiro, R., Tapa, S., Bentes, I.: Um contributo na temática dos riscos tecnológicos em ambiente urbano. In: CONREA 2021 - O Congresso da Reabilitação. Livro de atas. UA Editora. 1ª edição - junho de 2021, pp. 127–133 (2021). ISBN 978-972-789-699-8. https://doi.org/10.48528/gy68-v843
4. Casado-Vara, R., et al.: Demand control ventilation strategy by tracing the radon concentration in smart buildings. In: Herrero, Á., Cambra, C., Urda, D., Sedano, J., Quintián, H., Corchado, E. (eds.) SOCO 2020. AISC, vol. 1268, pp. 374–382. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-57802-2_36
5. Fromreide, M., Henne, I.; Smart control of HVAC based on measurements of indoor radon concentration. In: TOS Forum 2022, p. 441 (2022). https://doi.org/10.1255/tosf.172
6. Valcarce, D., Alvarellos, A., Rabuñal, J.R., Dorado, J., Gestal, M.: machine learning-based radon monitoring system. Chemosensors **10**, 239 (2022). https://doi.org/10.3390/chemosensors10070239
7. Bazzi, A., et al.: IoT-based remote health monitoring system employing smart sensors for asthma patients during COVID-19 pandemic, p. 6870358 (2022). https://doi.org/10.1155/2022/6870358. 1530-8669, Wireless Communications and Mobile Computing, Hindawi
8. Wu, Y., et al.: Effects of temperature and humidity on the daily new cases and new deaths of COVID-19 in 166 countries. In: Science of The Total Environment, vol. 729, p. 139051 (2020). https://doi.org/10.1016/j.scitotenv.2020.139051. ISSN 0048-9697

9. Kwon, N., Park, M., Lee, H.-S., Ahn, J., Shin, M.: Construction noise management using active noise control techniques. J. Constr. Eng. Manage. **142**(7) (2016). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001121
10. Schieweck, A., et al.: Smart homes and the control of indoor air quality. Renew. Sustain. Energy Rev. **94**, 705–718 (2018). https://doi.org/10.1016/j.rser.2018.05.057. ISSN 1364-0321
11. Gao, G., Li, J., Wen, Y.: DeepComfort: energy-efficient thermal comfort control in buildings via reinforcement learning. IEEE Internet Things J. **7**(9), 8472–8484 (2020). https://doi.org/10.1109/JIOT.2020.2992117
12. Ramos, C.M., Andraz, G., Cardoso, I.: The role of ICT in involving the tourist and in sustainability of tourism destinations. In: Ratten, V. (eds.) Technological Progress, Inequality and Entrepreneurship, on Entrepreneurship, Structural Change and Industrial Dynamics, pp. 29–45. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-26245-7_3. ISBN 978-3-030-26244-0