Reactivat ion of Historic Natural Ventilation in the Hofburg, Vienna, with Proof of its Functioning by Measuring Campaign and Application of the Results in Schönbrunn Castle, Vienna

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1. Abstract

To reanimate a historic ventilation means to stick more to the old craftsmanship techniques in order to learn that we have to consider a building and the building services as a cybernetic system, instead of impose the services onto the building without integrating them.

When using integrated building services with an effective, inert embedded wall heating system, the results for users and artefacts are evident:

There will be a maximum of comfort with a minimum of investment and energy cost. Moreover the artefacts will be kept in optimal condition (preventive conservation). In cases where the usual "technoide" solution is applied regarding building services in the form of standard heating and air conditioning, a non-damaging micro-climate cannot be achieved.

The reactivation of the natural ventilation in the historical building of the "Corps de Logis" (CdL) in the Vienna Hofburg shows, even after about 100 years the effectiveness of this simple technology: An air inlet from a near-by park into a tunnel-labyrinth in the basement of the building compensates the outer ambient air temperature and humidity. From the basement, air is brought through stack by large air ducts into the showrooms. Any warm air from the showrooms will flow outside due to the difference in temperature. Otherwise ventilators keep this circle going.

In Vienna's Schloß Schönbrunn the air-exchange rate was more or less defined by the difference in air pressure on both sides of the building and the resultant air leakage of the gaps of the castle, or stack in the existing chimneys, or just by the staff opening the windows.

In order to optimize the micro-climatic situation in the castle by using a controlled air exchange rate, a similar natural ventilation system is planned with stack or mechanical ventilation, which provokes the continued flowing of ambient air which will be let in through a tunnel-system embedded in the earth of the park in front of the castle.

With this temperature-exchange system, the air conditioning could be reduced to a minimum. As a result of the controlled and filtered air flow, the micro-climate of the showrooms with their precious contents will be stabilized.

Keywords:

Natural ventilation, air-flow pattern, preventive conservation, embedded wall heating, air conditioning, sick building syndrome, radiative heat transfer.

2. Introduction

Historic buildings often have fascinating technology, which is convincing by its simplicity. There are simple technologies like historic "box windows" which were opening towards the outside and allowing a natural ventilation when it is not windy outside, through the gaps of the window. When the winds blows against the windows, the gaps close. In this way, a certain air exchange rate was guaranteed in the building, in correspondence with the wind speed.

Another example of a very intelligent way of using elementary physics is the system used by the Swiss, who used to put up three flagpoles in front of their buildings towards the main direction of the wind in order to break the wind. With these obstacles, they improved the micro-climate of the houses.

The author was asked to reactivate the natural ventilation of the historical building of the CdL in the Vienna Hofburg by analysing the historical system. A theoretical presumptive model of the ventilation was worked out and tested with smoke detectors.

The reactivation of the historical ventilation will be executed by adding modern security and control engineering systems and the latest technical components and improvements to finish, with an optimal room climate and a minimum of investment, energy and maintenance costs.

The most positive result will be that this technology is extremely simple and can be surveyed by anyone, not requiring highly sophisticated technicians.

During this reconstruction work, the following hypotheses were postulated:

Building services can only be planned as supplement to the building - never “against” the building. Techniques and building should be a cybernetic system. You cannot impose the building services on an object regardless of the reaction of the building and its thermal mass.

When building services are planned in this way, they will tremendously reduce investment costs as well as energy consumption and provide simple technology which can easily be handled, even by non-technicians.

Natural ventilation, combined with an efficient embedded, inert and stable wall heating system and a minimum of air conditioning, is the best way of preserving our cultural heritage.

The complete reactivation of the historic natural ventilation in the Hofburg will prove the asserted hypothesis. The measurement campaign during the autumn and winter of 1997/98 did, indeed, prove the effectiveness of the natural ventilation system.

As generally known and thoroughly described and discussed in historic and modern technical literature (Dietz, 1920; Buderus, 1994; Liddament, 1996; et al), the natural ventilation concept is, in principle, based on the physically-proven fact that warm air is lighter than cold air. Consequently, stack effect will build up.

It is more than a coincidence, therefore, that natural ventilation is currently the ”dernier crie“ in housing services, because of the bad experience made by unreflectedly “adding” “technoide” building services in buildings, instead of applying an integrated approach.

Furthermore, the conventional services are far too complicated, tremendously expensive with high energy consumption. Mainly, they cause bad comfort which is known as the ”sick building syndrome“.

3. Historical Review

In 1881 the architects Semper and von Hasenauer started building the southern wing of the Hofburg and the CdL. In 1901, the CdL was finished, and, in 1928 the etymological museum was transferred to the Hofburg. Figure 1 gives an outside view of the building.

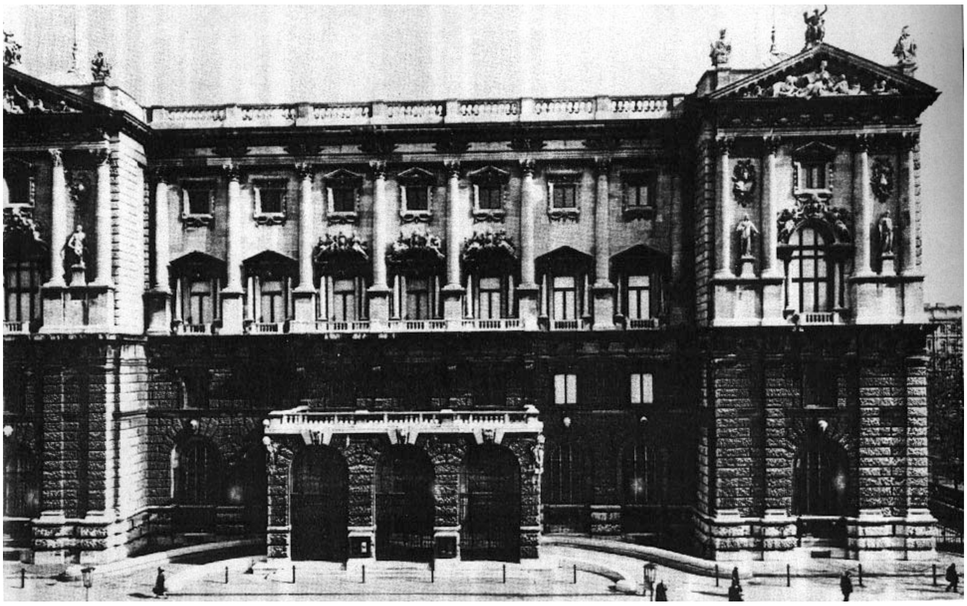

Figure 1

Figure 2 shows the principle system of the chimneys. Every room is connected to a "warm chimney" which, by natural stack, brings about low pressure in the room and leads the room air towards the outside. The "warm chimney" is closed in the basement.

The second, so-called "cold chimney" is closed in the roof and leads the conditioned air from the basement to the showrooms.

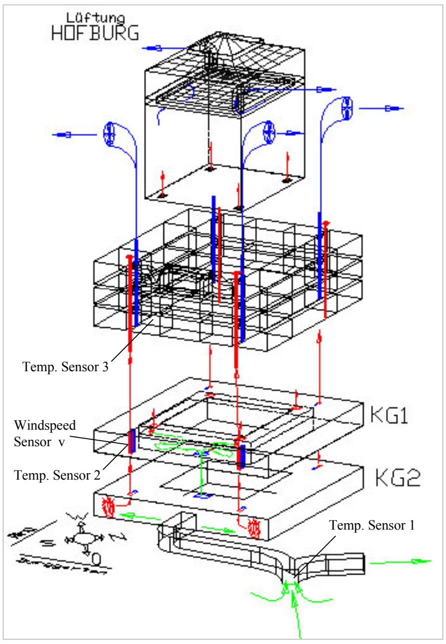

Figure 2

In the winter, natural ventilation works automatically in view of the difference in temperature inside and outside the building, whereas, in the summer, a system of mechanical fans, as is documented by historical plans and authentic relicts of remaining "Blackman fan wheels", provided for low pressure inside the building. As no effective fans existed in the past, all ducts had enormous dimensions and there was almost no loss of pressure.

A similar situation prevails in the big entrance hall of the CdL with its glass ceiling. A second layer of glass covers the hall as a dome (see fig. 2). In the summer, the air between the two glass layers is warmed up and escapes through an air outlet in the roof. A type of “venturi nozzle” in the connecting air duct provokes low pressure in the hall. Cold air from the basement will flow into the hall.

In the winter, the space between the two glass layers operates as a buffer. Only the heated air in the entrance hall, coming from the basement, is led to the air extract through natural ventilation.

4. Methods

4.1 Description of the Natural Ventilation System

The CdL, as part of the Vienna Hofburg had a very intelligent and simple natural ventilation system with a huge inlet from a near-by park transporting the air through a kind of labyrinth of brick walls which used to be covered with lime colour and lime plaster to compensate the SO^2 pollution from the outside. This labyrinth of ducts and tunnels was built around a “corpus” of earth. The whole construction consists of two storeys. Since the walls were build in brick, they absorbed the humidity of the air, stored it and gave it back when the air outside was too dry. This system compensates all the peaks of humidity and temperature. Figure 3 shows the situation.

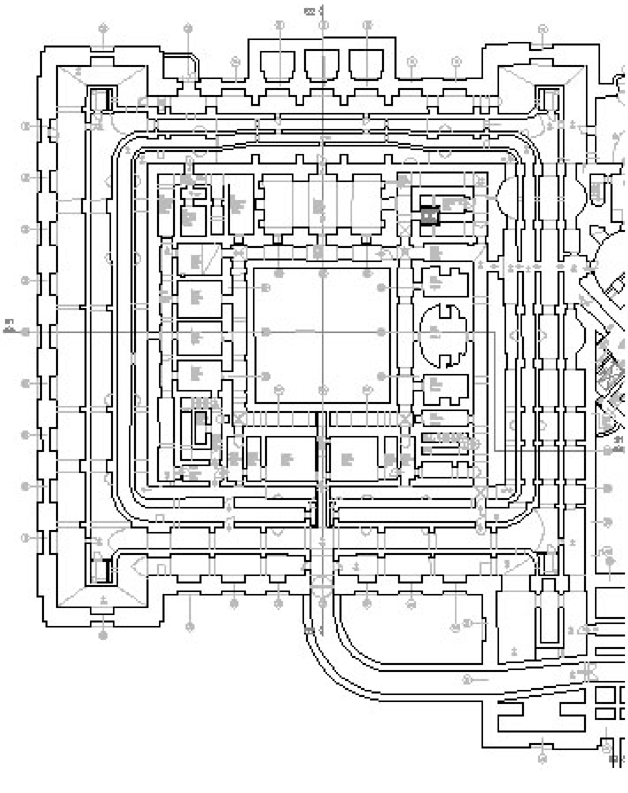

Figure 3

This form of natural ventilation was very energy-economical, simple and easy to be surveyed. It never caused as big damage as modern heating, ventilation and air-conditioning systems, when the electronic conditioning controls do not react as they are supposed to react. It is worth mentioning that other buildings of the same time had similar ventilation systems.

4.2 Model of the calculated air flow

Figure 4 shows the calculation of the airflow based on an air-exchange rate (ach) of 1. The entire volume of the building amounts to approx.32.500 m³, which means that one-fourth of this amount of air, i.e. 8.000 m³, corresponds to the quantity of one of the 4 “cold” vertical ducts in each corner of the building leading to the showrooms.

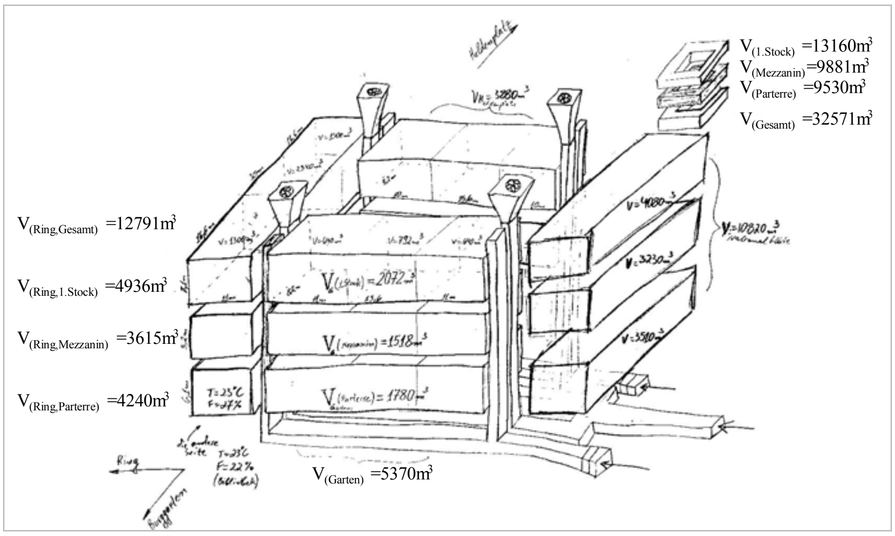

Figure 4

The main air inlet in the basement has a diameter of about 2,5m x 4,5m=11m². The measured average wind speed in this tunnel is 0,8m/sec, and the resultant air volume is about 31.680m³/h. This shows a balanced air flow calculated with an ach of 1.

Figure 5 also shows in detail a standard showroom with all the air openings and their dimensions. These calculations are based on ach of 1, show the correspondence of the calculated air volumes, size of the openings and presumed wind speed for the historic displacement air distribution in the room.

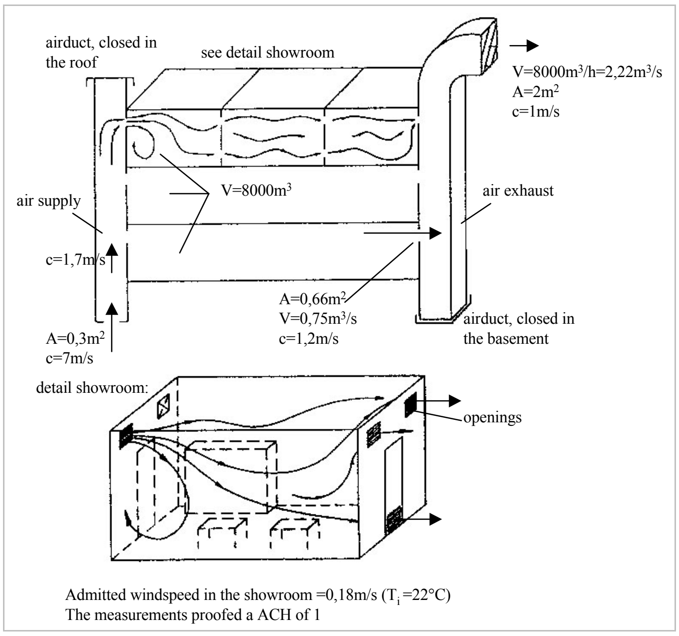

Figure 5

In principle, the historic air conditioning system in the CdL was based on the elements of a radiator heating system in the form of a gravity heating and the inflow of fresh air which was “conditioned” in the basement.

The reconstruction of the natural ventilation in the CdL results in an air exchange rate of one, which, according to the latest technical handbooks, is a sufficient air exchange rate in historical buildings.

In England, at Montfort University, a computer model of natural ventilation was created (Building Services, Oct. 1993). Despite the general uncertainty about the results of computer models, this computer model proved in advance what reality had shown afterwards when the building was used. Under any weather conditions, the building's natural ventilation for the building was sufficient and resulted in good air hygiene for students and teachers.

During the testing phase in the CdL when all air inlets were configured on the air flow model, trials with smoke detectors showed the presumed air flow in the showroom and affirmed the model.

4.3 Air Flow Measurements

As shown in figure 2, temperature (and humidity) sensors were put in the main air inlet near the park (1), in the main vertical "cold " air duct, in the showrooms (2) and in one showroom on the ground floor ("Bibliothek" 3). A wind speed sensor (v) was put in the "cold" air duct. Figure 6 shows the results of the measuring campaign during the winter season 1997/98. It shows a natural stack effect of about 1 m/sec, depending on the outer ambient air temperature. The colder the outer air temperature, the higher the stack effect in the "warm chimney".

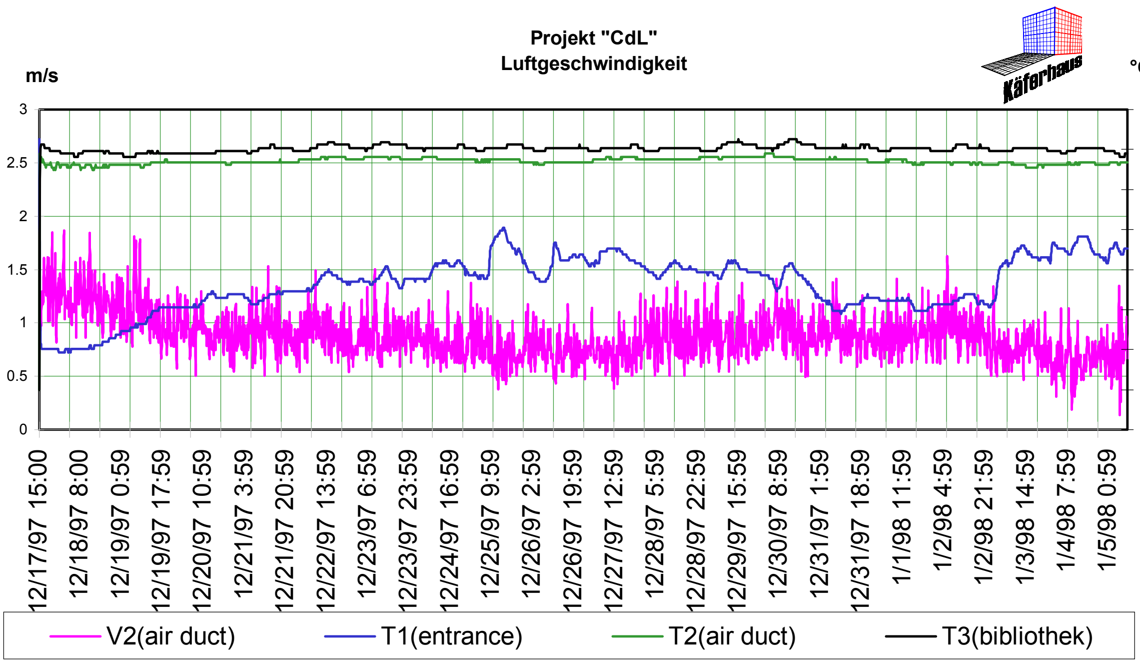

Figure 6

5. Result

The measurement campaign as well as the smoke tests approved both the assumed air flow model with an ach of 1 and the stated hypothesis:

The combination of a very stable heating system of the building's external walls and natural ventilation ensures a stable and comfortable internal environment in most historic buildings or museums.

According to the second hypothesis, a naturally ventilated building entails for less energy consumption and maintenance costs. Moreover the investment cost for housing services is considerably lower. Also in the main hall of the CdL with the "venturi nozzle, the natural ventilation system works perfectly.

6. Implementation of the Results to Schönbrunn Castle

The situation at Schönbrunn is the following:

A rather high ach in the castle due to leakage in walls and windows provokes an unstable micro-climate in the showrooms and brings pollution from the outside.

To reduce the uncontrolled ach to a sensible level, the following 4 steps are proposed:

- Sealing the gaps of the inner wings of the "box-windows" and the main leakage.
- Activating all existing chimneys of the showrooms.
- Installing claps and fans in the chimneys to regulate the stack effect in the chimneys.
- Channelling filtered air from the outside through an air duct in the earth to "pre-condition" the air.

The quality of the incoming air should be controlled in accordance with the natural/mechanical stack effect: In the winter, during the day a maximum ach of 1, to be reduced to ½ at night. In the summer, an ach of 1 is recommended during the day, whereas, at night, it could be increased to 2 so as to take advantage of using the "free" cooling.

At only rate, absolute humidity, inside and outside the building, should be controlled to ensure that the defined limits of the micro-climate for the artefacts are not exceeded. The ambient air is brought in through large displacement outlets in the staircases. It is most important that all ventilation activity is closely monitored in respect of the micro-climate and thermal masses of the castle, so as to ensure very minimal deviations from the desired micro-climate occur. Figure 6 shows schematically the described situation.

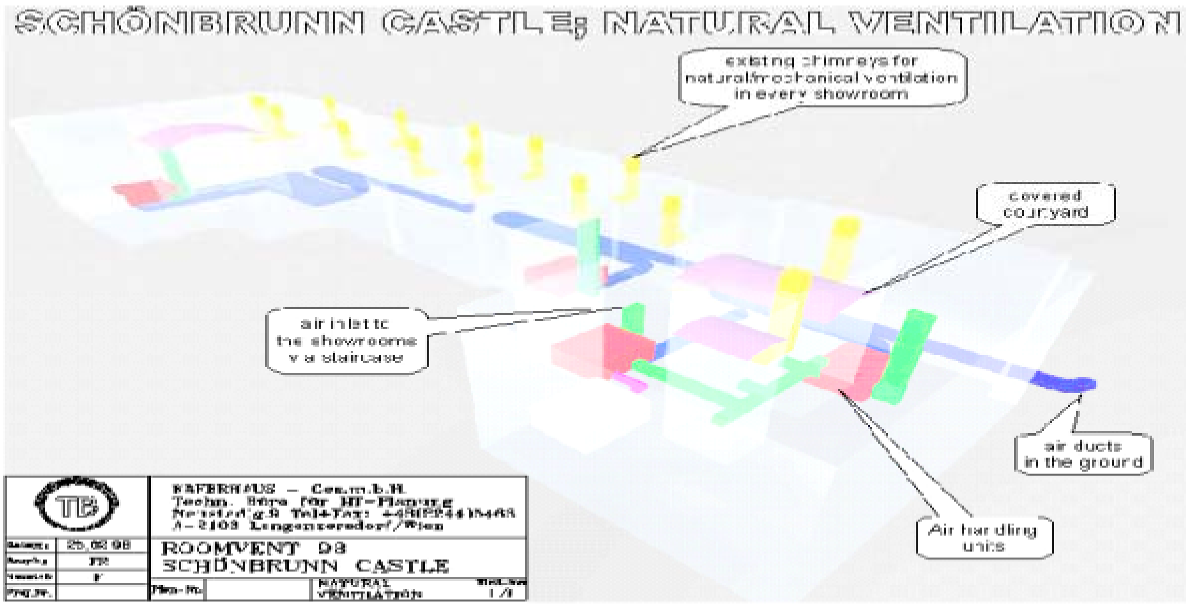

Figure 7

Since there is no basement in the castle, an "energy-collector" in the form of an inlet air duct is dug in the ground in order to use the constant temperature of the earth for "pre-conditioning" the in flowing air. Thus, the planned capacity of the cooling unit could be reduced. Since the dust pollution is the major problem in the castle, the proper filtering of the incoming air is an important feature of the planned air-handling unit.

Acknowledgements

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7. References

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