Technical paper

Limiting roof penetrations in high-rise buildings

How to supply enough air to the drainage system

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Abstract

A building cannot function without a drainage system; it is a fundamental requirement, removing drainage waste and protecting the occupants from gases and pathogens. The drainage system requires air to balance the pressures, preventing water trap seals from being depleted. The method of bringing air into the system directly impacts the architecture of a building, providing a challenge for Mechanical, Electrical and Plumbing (MEP) design engineers to find ways of providing air for the drainage system without compromising the design aesthetically.
Bringing air into the drainage system has traditionally been achieved by the use of stack-vent pipes running from the highest branch connection of the stack to the top, protruding through the roof of the building. This is of particular concern in the design of tall buildings where, for health and aesthetic reasons, the large number of these unsightly pipes cannot be located near roof top pools, podiums, air handling units, etc.
To meet the architectural design of a building, MEPs often seek a solution to limit the roof penetrations by using linked vents and side venting. This paper addresses the limitations and risks of these methods and provides a solution using active drainage ventilation, which allows a building to fully function with limited drainage vents to atmosphere and removes any limitation on architectural design

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1. Introduction

All buildings are different, and developers and architects often wish their buildings to stand out aesthetically. While this is important for the overall look of the building it also means that the developer can charge more for the space. Space is a premium commodity. Building services engineers (BSE) and Mechanical, Electrical and Plumbing Engineers (MEP) are required to make their designs fit the ever decreasing allocation of space. Each engineering discipline provides solutions; this paper addresses the drainage ventilation, and the solution that public health and MEP engineers are using to limit the unsightly drainage vents that limit the aesthetics of the building. It is worth noting at this point that architects' drawings and models never show vent pipes as this is not part of their vision for the building (see Figure 1.)

Figure 1.
Typical architect model without drainage vent pipes

The main methodology that the public health engineers and MEPs currently use to hide the vent pipes involve linking the stacks at the top of the building so that three or more stacks have only one roof penetrations to atmosphere, as shown in Figure 2. The question is: does the solution work to protect the water traps seals in the building?

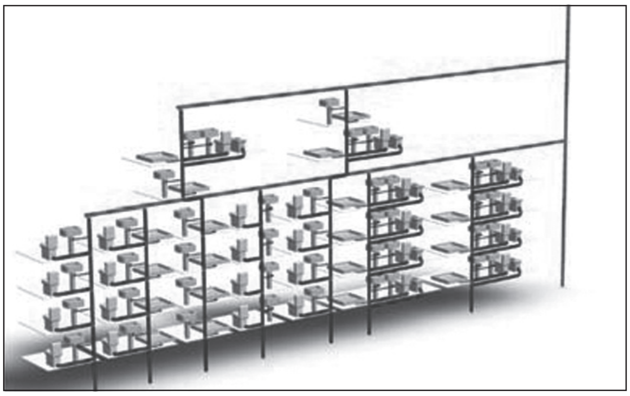

Figure 2
Linked Vents

2. Linked Vents

In practice every stack should be connected to atmosphere if passive drainage venting is used, the principle being that if there are discharges within the stack, the vent at the top of the stack will provide air through the drainage vent pipe network to relieve the negative transients generated in the system. The same vent pipe network is also perceived to provide relief paths for the positive transients generated within the drainage network to the vent at the top of the stack, however this is a less effective means of pressure surge alleviation.

The sizing and the efficiency of passive drainage venting has been discussed many times at CIB W062, the world's leading research forum in water supply and drainage. The use of computer techniques to predict the generation, propagation and alleviation of air pressure transients in buildings has been well discussed previously and the computer program AIRNET has been instrumental in the analysis and performance of passive venting and the correct sizing that is required for it to work efficiently for tall buildings. A full analysis of the problem is given by Swaffield (2010)(4), and this area of concern can be found in Chapter 5.7. of the Transient Airflow in Building Drainage Systems, published by Spon Press.

It should be remembered that all the research on passive drainage venting in the past and which has gone on to inform codes and standards worldwide has been based on the assumption that each stack is vented individually to atmosphere. Within plumbing drainage codes themselves, it is also assumed that each stack is individually vented, although there has been room in some codes to interpret that as long as the stacks are connected to atmosphere it will meet the requirement of the codes.

Engineers are using the interpretation that as long as the stacks are connected to atmosphere they can provide a cross link to connect a number of stacks to one open vent to meet the architectural requirements of the building.

To achieve this many engineers specify that the link vent used at the top of the stack is larger than the stacks in diameter. It is very typical for three to ten 100DN sized stacks, to have a 150DN linked vent running at the top of the building. In theory this will provide more air, however this arrangement interlinks all these stacks at the top and so facilitates the unwanted transmission of pressure transients from one stack to another.

This design principle is becoming more popular over the last five years but there is no evidence that it will work using passive venting principles due to the time dependency of the vent system to respond to the pressure regime within the system

2.1 Design example

A 24 floor building was assessed by numerical modelling to see how it performed when linked vents were used. The system is designed to EN12056 and simulations were carried out using AIRNET (Swaffield, 2010)

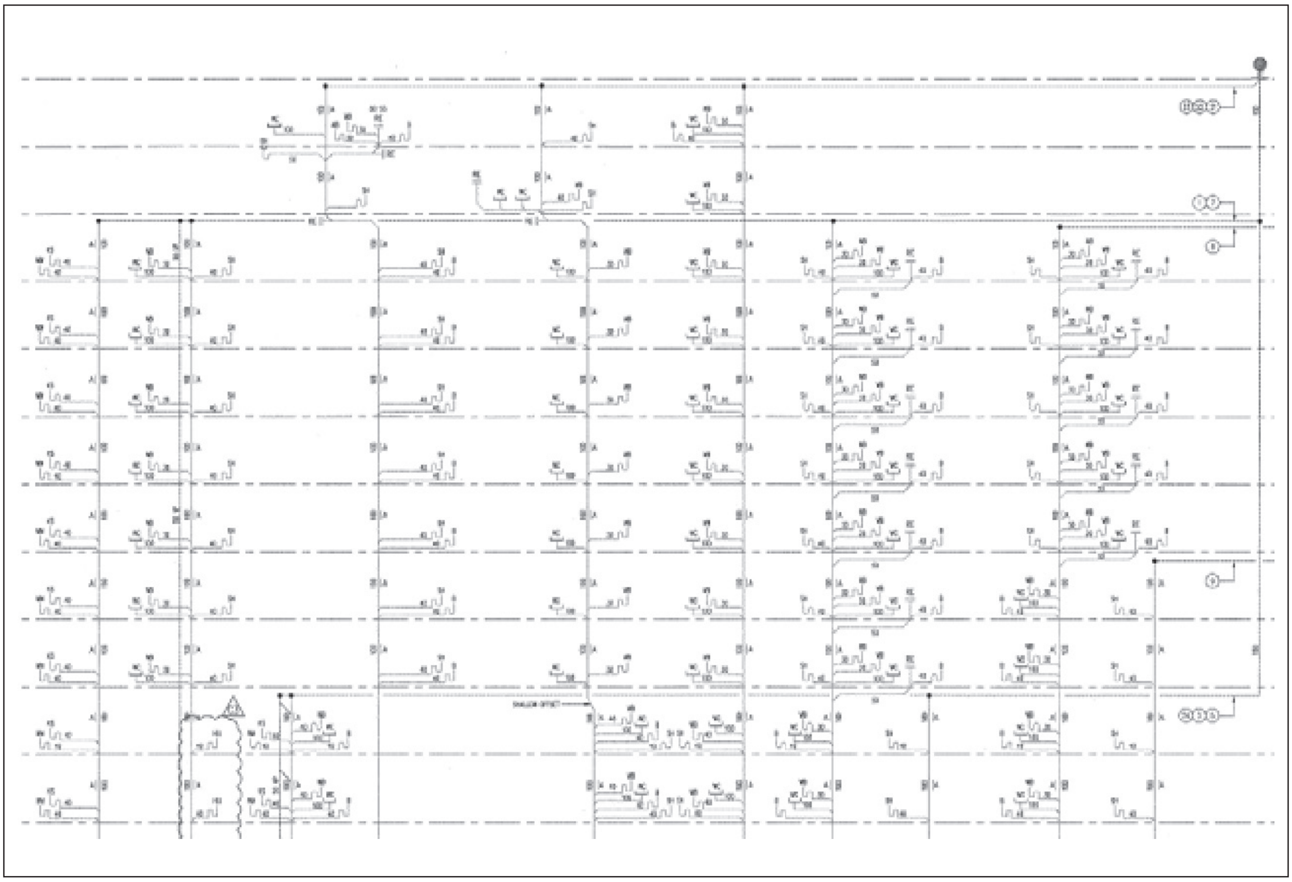

Figure 3.
Partial schematic of the building drainage design showing linked vents at the top

It can be seen from Figure 3 that in this building 10 100mm stacks have been cross linked using a 150mm stack-vent to provide a single penetration through the roof.

An AIRNET analysis of this building was carried out to see what would happen if the system was loaded to its design capacity. The building was designed to EN12056:2000 and so the maximum loading would be 5.2 l/s using swept entry T-branches. If one of these stacks was loaded to its maximum and there was some other activity in other stacks, would the single vent pipe be capable of proving the complex air requirements of the system?

The best way to assess the issue is to look at water trap seal retention in parts of the building which might be vulnerable under heavy usage load conditions.

Three loading profiles were used in the simulations: 5.2 l/s peak, 1.5 l/s peak, 2.5l/s peak and 1 l/s peak. This is shown in Figure 4. The flow rate is allowed to steadily increase over a period of 10 seconds to minimize the risk of pressure transient generation due to rapid increase in flow rate rather than the loading itself. Note that this is the total water input to the system accumulated across the height of the building to give the peak flowrate at the base of stack 1.

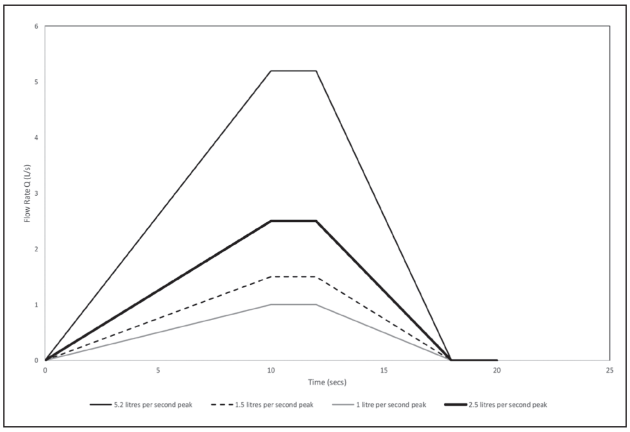

Figure 4.
Water input profiles

Simulations were run in AIRNET to ascertain the vulnerability of the trap at the bottom of Stack 1. This was considered to be a worst case scenario, since it is the furthest away from the vent pipe and so the effectiveness of any venting capability will be at its minimum.

The results are shown below in Figure 5. It can be seen that only the lowest flowrate (1l/s) results in a system which is not vulnerable to seal loss. Even at 2.5 l/s there is significant seal depletion, but the trap has still some water left after the event. It can clearly be seen that this system cannot cope with the fully loaded 100 mm pipe at 5.2 litres per second under these venting arrangements.

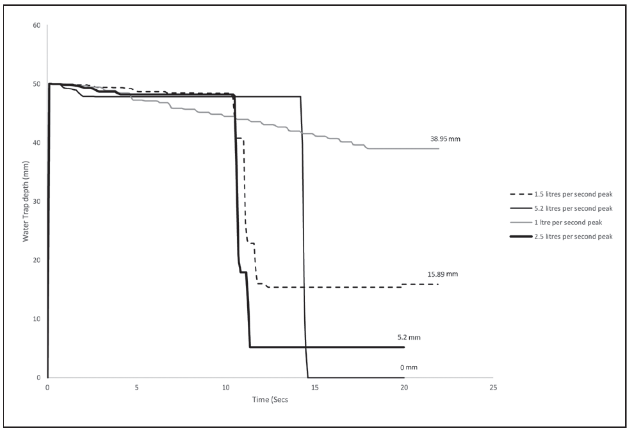

Figure 5.
Water seal retention after the system operation was simulated in AIRNET

It can clearly be seen from Figure 5 that there are issues with this arrangement. Further local venting using air admittance valves or other venting arrangements would overcome the issue.

Conclusion

Public health engineers and MEPs have to find solutions to meet the architectural requirements for their clients. In many cases they are trying to limit the drainage vents to atmosphere as well as hiding them from view. The approach of passive drainage venting can lead to the loss of water trap seals.

The architectural requirements can be met only when active drainage ventilation is used.

Linked venting arrangements seem to offer the perfect solution and a compromise between aesthetics and practical venting, however simulations show that this venting arrangement is lacking in that it increases water trap seal vulnerabilities. Maximum safe loadings reduce drastically (to about 1.5 litres/second peak) when this venting arrangement is used on its own.

To overcome this limitation, a passive linked stack-vent should use AAVs at the top of each stack to provide the air to the point-of-need. This reduces the pipe period and therefore the response time dependency requirement for each stack, allowing the loading back to their original flow capacities.

Therefore adding AAV's to a conventional passive systems would protect the traps seals from the negative transient pressures. AAVs applied to the stack-aerator system will provide the air requirement for each stack without the time dependency of the linked vent. Using a fully active drainage venting system using AAVs and the P.A.P.A. would allow designs to have limited roof penetrations, down to a single vent to atmosphere for the whole building, or the possibility to have a specialised system with no roof penetrations.

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