Technical paper

Active air pressure suppression of drainage systems

From research to the marketplace

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Abstract

An insight into the post-development and operational issues related to active air pressure suppression is the utilisation of Air Admittance Valves (AAVs) together with the Positive Air Pressure Attenuator (P.A.P.A.) to provide full protection to a building's drainage system. They provide protection to the water trap seals within the drainage system by dealing with the negative and positive transient pressures at source so they no longer become harmful to the trap seals. Negative and positive transient pressures are routinely generated within building drainage systems and their consequent harmful effects are well documented. Continuous research in this area has resulted in the P.A.P.A. and how it works alongside AAVs to provide active air pressure suppression. This paper focuses on the device's acceptance into the marketplace and what the accepted solutions were throughout the world before the development of active air pressure suppression. This paper also considers the inherent dangers associated with an ad-hoc approach to the design of high-rise buildings in the absence of a workable standard.

Context of this paper

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Research | Relevance | Design | **Solutions** | Materials | Installation | Terminology | Standards

Introduction

This paper focuses on the acceptance in the market place of active air pressure transient control and suppression; how it can provide superior protection to trap seals within high-rise buildings and the role that continuous research provides to the industry with design solutions that provide designers and contractors with up-to-date research, enabling engineers to design safe and effective solutions for high-rise drainage systems. The current design practices utilised for the design of high-rise building drainage and vent systems tend to fall outside many regional standards or codes and rely on the engineers to adapt the standard or code for their designs. The general understanding of the requirement for transient suppression in the industry tends to be limited, with the codes and standards not providing sufficient information for transient relief in the system. This leads to a number of designs being adapted with an ad-hoc approach and, in some cases, to a less efficient transient relief; thereby resulting in less protection for the trap seals within the system that is the only barrier between the drainage system and the living space. There is also concern that some of these designs are becoming standard practice and are then adopted as the basic standard or code for the region and, in some cases, becoming enforced by inspectors within the region. The market is generally traditional and change is sometimes hard to accept even though the research provides strong evidence that current practice is unsafe.

Active air pressure transient control

Active control uses a single stack design by utilising Air Admittance Valves (AAVs) to deal with the negative air pressures and the Positive Air Pressure Attenuator (P.A.P.A.) to attenuate any positive air pressure transients generated within the system.

Further research carried out by the drainage research group of Heriot-Watt University using AIRNET, a mathematical simulation model for air and pressure regimes in building drainage and ventilation systems, for a 50-storey building produced some surprising results, which are illustrated in Figures 1 and 2, especially considering that the conventional system analysed is very typical of high-rise drainage designs.

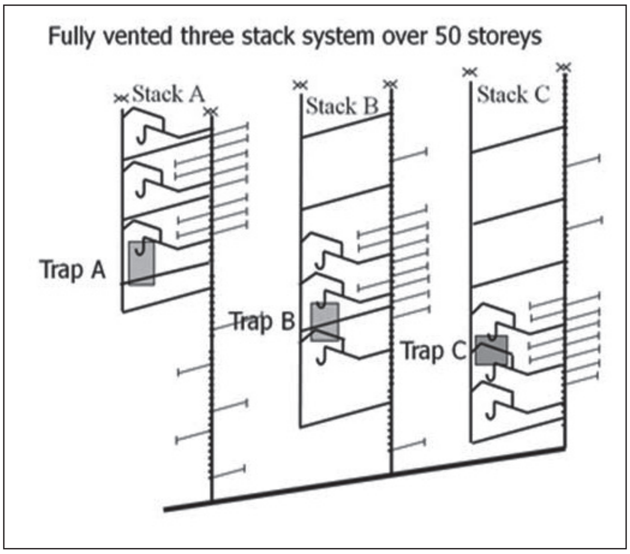

Figure 1.

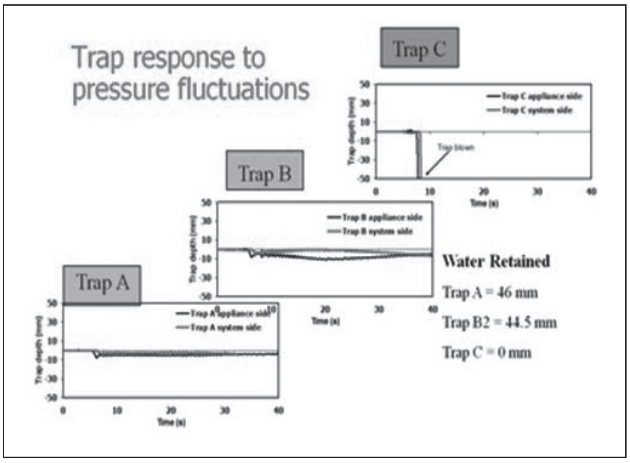

Figure 2.

Trap C has siphoned at 8 seconds, at which point the system has approximately 4.5l/s in the system. This simulation has demonstrated that although the drainage system design is fully vented with a 100mm relief vent pipe and 100mm cross vents with a 150mm wet stack the trap seal at the lowest point of the building is subjected to negative transients that have depleted the trap. It can be assumed that due to the height of the building in the simulation the height of the building has a major impact in the communication times for the system to respond to the pressure needs of the system.

Figures 3 and 4 illustrate the results when the same 50-storey building is vented using AAVs. It can be seen in Figure 4 that when AAVs are installed at the point of need (throughout the system) pressure relief is provided throughout the system. The reason that the system in the simulation now provides protection to the trap seals is due to the fact that AAVs installed on each floor respond typically at around -80Pa to the pressure in the system to relieve the negative pressure and keep the system within -110Pa. This is well below the point that traps will siphon from -400Pa to 500Pa and return the system back to atmospheric pressure.

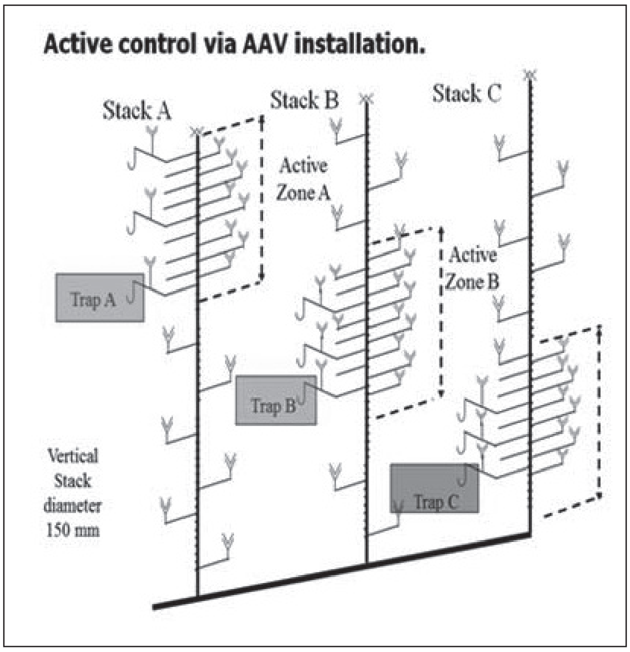

Figure 3.

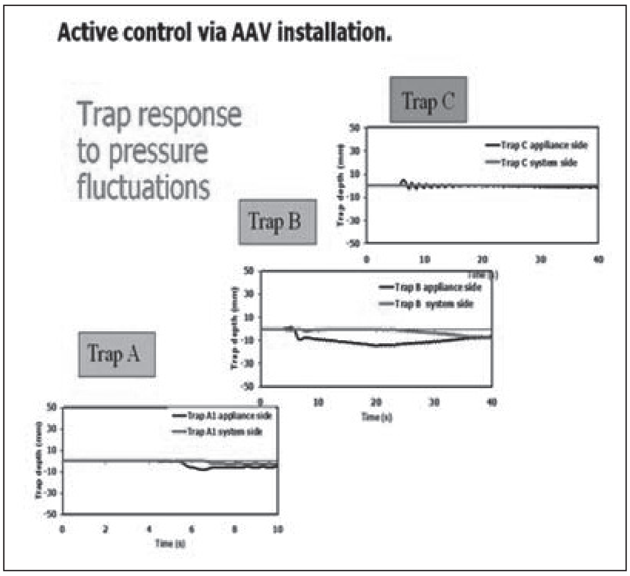

Figure 4.

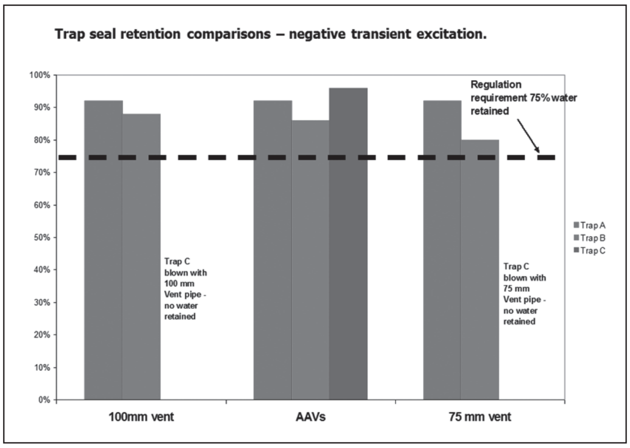

Figure 5.

Figures 5 and 6 below illustrate the results when the same 50-story building is simulated by AIRNET for positive transients with half the hydraulic loading of 6.5 l/s. It can be seen by the simulation results that trap C has depleted due to positive transients. This indicates that the 100 mm relief vent which is in the design and commonly used is insufficient in diameter to divert the positive transient that is moving at 320 m/s away from the trap seals in the system. Further research is required to determine why a commonly sized venting system in high-rise buildings and its code does not provide the protection for which it is designed.

When the 50-storey building is designed as an active controlled system it can be seen that protection is provided throughout the system, as illustrated in Figures 7 and 8 below. By using AAVs and P.A.P.A. placed throughout the system the simulation results provided by AIRNET show the provision of the trap seals throughout the system with protection from negative and positive pressures. It is the concept of using AAVs and P.A.P.A. together that keeps the system pressure below -110Pa and thus the trap seals within the system are not subjected to the harmful pressures of over +- 400Pa.

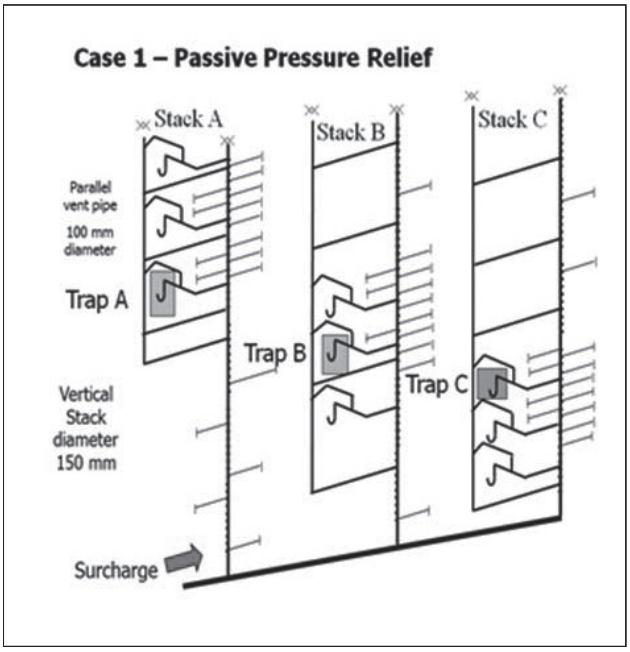

Figure 6.

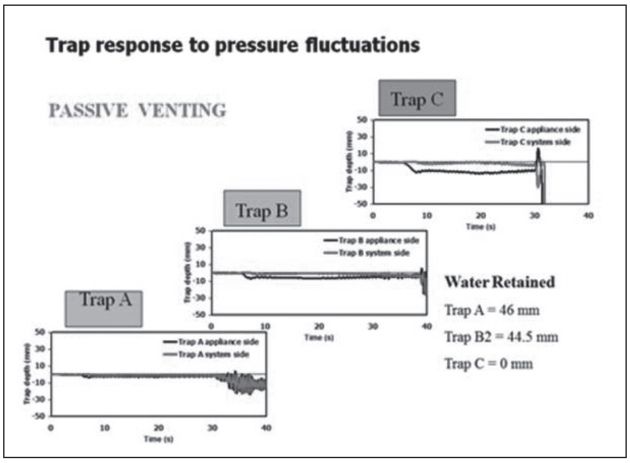

Figure 7.

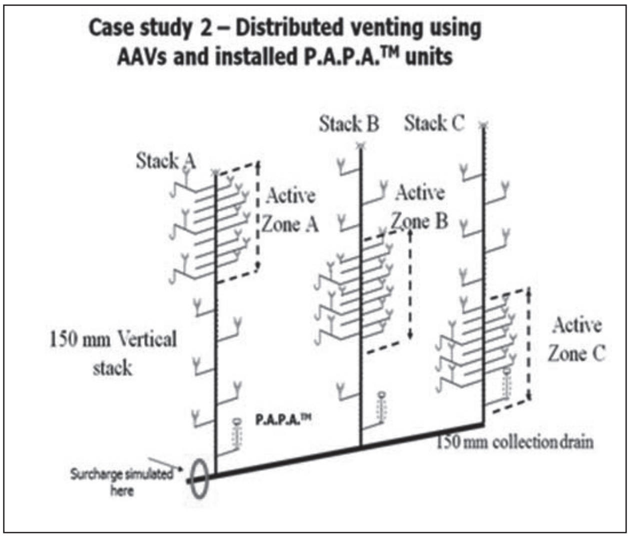

Figure 8.

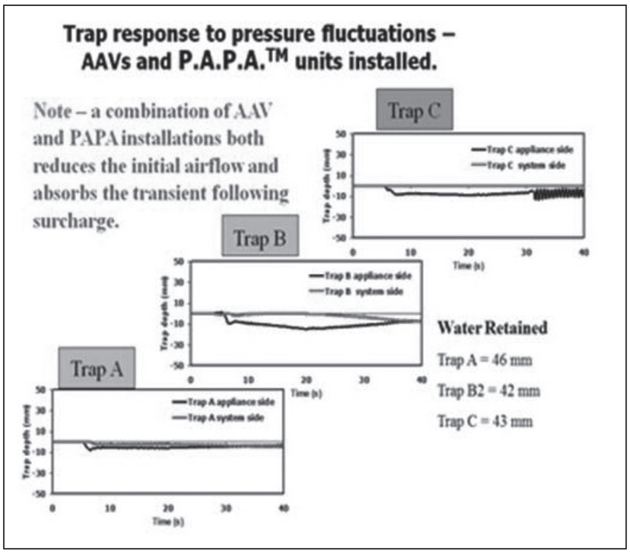

Figure 9.

The involvement of research has demonstrated two major factors; firstly that high-rise buildings designed conventionally can be affected by negative and positive transients; and secondly that working with the industry there is a safe and practical solution to designing a high-rise building drainage and vent systems.

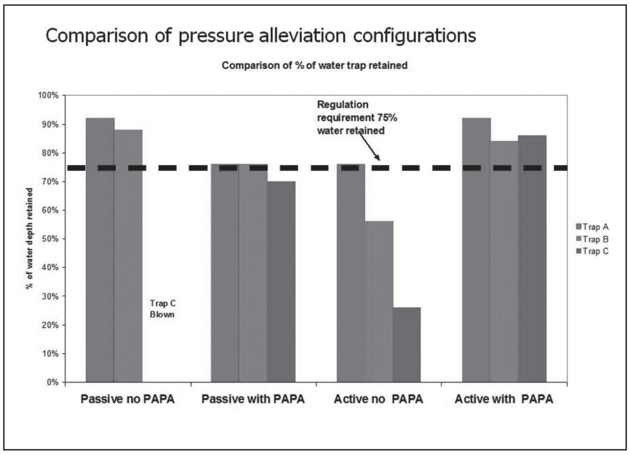

Figure 10.

Active control - is it a solution?

This paper has demonstrated that there is sufficient data for multiple-flush situations where active control provides superior protection to the system, as seen in the results of the simulations in Figures 4 and 8 from the 50-story Heriot-Watt study and that active control has been used to rectify problem systems by adding AAVs and P.A.P.A. to deal with positive and negative pressures in the system.

Taking the two factors of the scientific research carried out in active control and the fact that utilising AAVs and P.A.P.A. can problem solve existing systems, it is logical to design systems as fully active ventilated drainage systems from the start to provide the system with:

- reduced system complexity;
- reduced time of installation and labour;
- reduced material used in the system, bringing sustainability to the design;
- increased predictability of system operation;
- ability to place suppression between transient source and appliance trap seals to be protected;
- interception of transients prior to propagation throughout the network and impact on all connected appliance trap seals.

The drainage system becomes a single stack system that can vent buildings from 10 floors to over 100 floors in height and keeps the system pressures in the region of +- 110Pa; well below the +- 400Pa that affect the trap seals in the system designed in Figure 15.

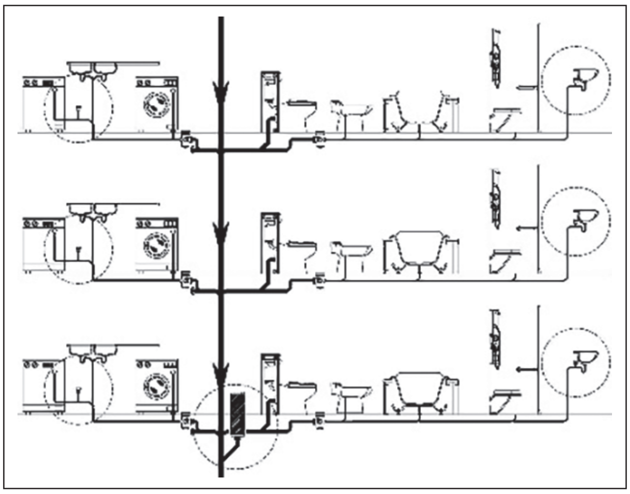

Figure 11.

Conclusion

Over the last decade there has been an unprecedented increase in high-rise buildings around the world requiring engineering disciplines to meet the requirements in structural and system operation to these types of buildings. In regards to drainage, has this been met? This paper highlighted and asked the question if the standards and codes meet these demands for high-rise building designs. The leading research carried by Heriot-Watt University has demonstrated that the current standard and code requirements may not be sufficient in their recommendations to provide effective guidance to the engineering community to design workable safe systems. There are many cases where the recommendations in the standards have been modified by the engineers as they have experienced problems in previous designs and wish to engineer out problems in future buildings. Sometimes this has been restricted by the regulators within different states due to their insistence that the code is followed as it is written, and therefore engineers are unwilling to deviate from this even if it means that the system may become susceptible to fail. Drainage is a relatively easy system to understand for any type of building design: Hydraulic loading for the sizing of pipes; and a venting system that keeps the pressures below +- 400Pa throughout the system. If the pressures are kept well below this, in the region of +- 200Pa, there is less stress placed on the water trap seals within the system. With a passive system there is a single limitation in that the only way to relieve the transient pressures is through a network of ventilation pipes that terminate at the top of the building. Is the sizing of these ventilation pipes sufficient for the demands of a high-rise building? The research shows through the simulations for high-rise buildings that with vents smaller than the stacks the system will fail. It also proves that active drainage ventilations work for the same loadings. There is also a lack of education within the industry as to how the drainage system operates and more is needed to improve this by providing up-to-date research and improvement in the education of the engineers. Active control of drainage systems has been thoroughly researched and with over 50 high-rise buildings operating to this principle without issues, this system meets the demands of high-rise drainage ventilation. At present it is the only system that is proven to do this and this could only be achieved by the cooperation of researchers and industry working together to provide a solution that meets the demands of the buildings being built.

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