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Technical paper

Current venting diameters for high-rise drainage ventilation

Available research, simulation data and code guidance

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Abstract

In the last 20 years the Drainage Research group of Heriot Watt University as well as other leading research universities around the world have been researching the venting requirements for high-rise drainage and in particular the correct requirements for drainage venting of these buildings. The current findings of the research proves that the current guidance with national codes do not meet the requirements for safe venting in high-rise buildings.

Context of this paper

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Introduction

The requirement for research is always important in every aspect in a developing world. In the construction industry one of the least invested and researched disciplines is the above ground drainage and in particular the venting requirements for high-rise buildings, verses other disciplines - for example structural and heating and ventilation.

The current national regulations and code guidance is based on research carried in the 1950s-1960s and changes to the guidance in the codes takes many years to achieve. For codes and guidance to be changed research is required, and this can only be achieved with industry support.

The Drainage Research Group at Heriot Watt University is one of the world's leading institutions in researching drainage and drainage ventilation. The ability to model what happens in the drainage system is a key tool to help understand what is or will happen in drainage systems and the requirements for a safe working system, tools such as AIRNET allow modeling of high-rise systems and much of the research has been peer reviewed and published. This paper is focusing on the findings of the research in regards to the correct requirements for passive drainage venting requirements for tall buildings, based on modelling and the fluid mechanical calculations behind the research.

AIRNET

In 1989, Heriot Watt University developed the mathematical simulation model AIRNET. The development and research for the simulation model undertook extensive site testing to build a database of system pressure in response to applied flows; the development from the database of fundamental shear force relationships that define entrained airflows; the development and incorporation of a database of system boundary conditions compatible with a method of characteristics of network operation, into AIRNET.

This now provides a comprehensive simulation methodology that provides the system designer with the means to predict the likely pressure regime and entrained airflows conditions. This will also allow a re-elevation of the codified design guidance currently available in national codes for high-rise buildings.

Current Guidance for High-rise Drainage Venting

Code guidance in the main recommends drainage ventilation with the vent pipes smaller or at the most the same diameter as the wet stack and all represent 'passive' control and suppression, as there is no interaction between the control mechanism, the fixed in place vent, and the transient. Two basic principles of surge suppression have been identified –

1. Transients may be attenuated by reducing the rate of change of flow velocity. This implies that the flow should be diverted in the case of a positive transient or, in the case of a negative transient added through an adjacent inlet.

2. The second basic principle is that the surge alleviation should be positioned between the source of the transient and the equipment to be protected.

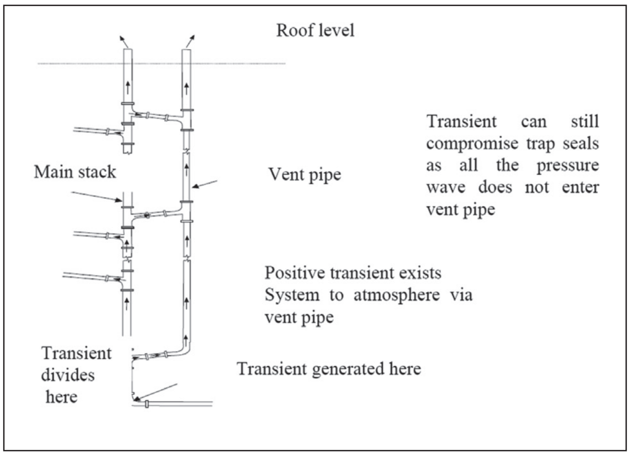

Figure 1.
Traditional drainage ventilation

While the fixed in place vent solution provides a degree of flow diversion or addition, criteria 1 above, its efficiency in this role is limited by fundamental misunderstandings of the operating mechanism of the vent stack currently embedded in the codes.

Fixed in place vents do not meet the second criteria in any way. The source of any relief to offset the pressure regime imposed on the system by the passage of the transient is the reflection of the transient at the upper open termination of the vent system. Thus the potentially trap seal depleting transient pressures have already passed all the traps to be protected before any relieving reflection can be generated by the open termination.

Current research

The pressure transient transmission and reflection coefficients at junctions may be determined from the following expressions (Swaffield and Boldy 1993).

$$C_{Transmission} = \frac{2\frac{A_1}{c_1}}{\frac{A_1}{c_1}+\frac{A_2}{c_2}+\frac{A_3}{c_3}} = \frac{2}{1+\frac{A_2}{A_1}+\frac{A_3}{A_1}} = \frac{2}{1+\frac{A_{Branch}}{A_{Incoming}}+\frac{A_{Continuation}}{A_{Incoming}}} \quad (8)$$

$$C_{Reflection} = \frac{\frac{A_1}{c_1}-\frac{A_2}{c_2}-\frac{A_3}{c_3}}{\frac{A_1}{c_1}+\frac{A_2}{c_2}+\frac{A_3}{c_3}} = \frac{1-\frac{A_2}{A_1}-\frac{A_3}{A_1}}{1+\frac{A_2}{A_1}+\frac{A_3}{A_1}} = \frac{1-\frac{A_{Branch}}{A_{Incoming}}-\frac{A_{Continuation}}{A_{Incoming}}}{1+\frac{A_{Branch}}{A_{Incoming}}+\frac{A_{Continuation}}{A_{Incoming}}} \quad (9)$$

A- Pipe cross sectional area, m^2
A_1, A_2, A_3 - Pipe cross sectional at junction m^2
c- Wave speed in m/s

Figure 2.
Transient transmission and reflection coefficients

It will be seen from equations 8 and 9 that the wave speed in each pipe or duct is included in the coefficient determination, however in the case of low amplitude air pressure transient propagation in building drainage and vent systems the pipework may be taken as rigid and the wave speed in air as constant, simplifying the equations.

Similarly it will be seen that the transmission and reflection coefficients depend upon the identification of the pipe carrying the incoming transient. The junction will present different coefficients for transients arriving along the branch or the continuation pipe. Thus equations 8 and 9 have been re-cast in terms of the pipe carrying the incoming transient (pipe 1 in Figure 3), the branch (pipe 2 in Figure 3) and the continuation pipe (pipe 3 in Figure 3) as this will make calculation of the coefficients easier.

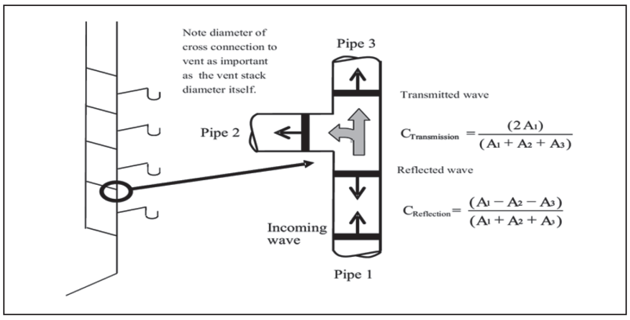

Figure 3.
Transmission and reflection of a transient at a three pipe junction.

The transmission coefficient at a junction of three equal diameter pipes is 66% of the incoming wave, Figure 4. A -33% reflection of the incoming is also generated. If the branch vent, Pipe 2 in Figure 3, is reduced in diameter then the transmitted wave strength increases - e.g. if the vent is half wet stack diameter then the transmitted wave is increased to 90% of the incoming wave. This offers no reduction in the transient propagating up the wet stack. If the vent has a greater diameter than the wet stack then the vent system starts to have an influence on the transient propagated up the building, e.g. if the vent stack is double the wet stack diameter then the transmission reduces to 33%. Note that the diameter of the cross vent, Figure 3, is as important as the vent diameter in restricting wave attenuation.

All national plumbing codes suggest equal or smaller diameter vent stacks compared to the wet stack, hence there is a fundamental misunderstanding of the mechanism of surge protection embedded in the design codes.

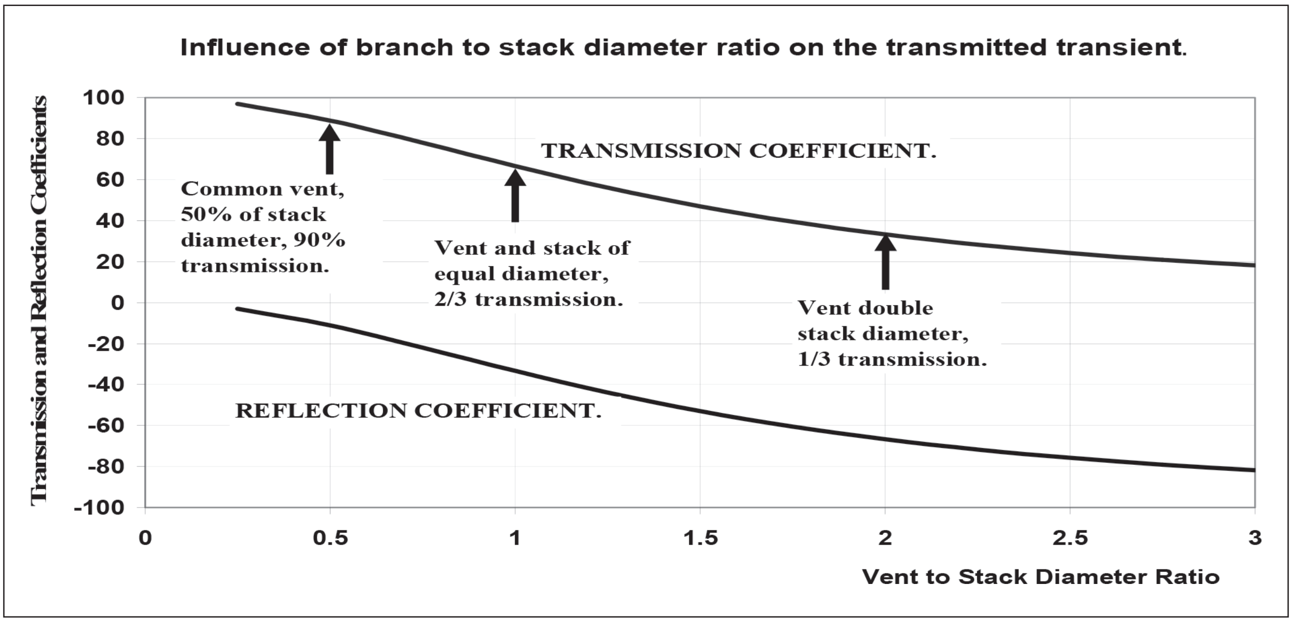

Figure 4.
Influence of branch to stack diameter ratio

The transmission and reflection coefficients at a three pipe junction depend upon the relative area ratios of the joining pipes. Figure 3 illustrates the necessary equations defining these coefficients.

It is the ratio of the pipe cross sectional areas that determines the coefficients rather than actual pipe diameters. If the traditional passive venting of individual traps back to the vent stack is considered, Figure 5, then it will be appreciated that a small diameter vent connected into the trap branch will have little effect.

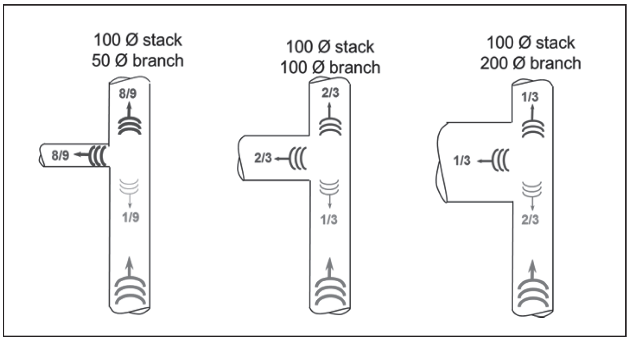

Figure 5.
Different pipe cross sectional areas

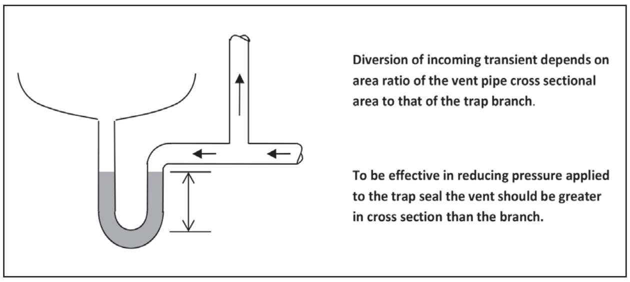

Figure 6.
Effectively reducing pressure

Conclusion

Using current research and tools for modelling drainage systems such as AIRNET, provide evidence that there is a requirement to re-evaluate the requirements of the size of venting for passive drainage ventilation. The undersizing of the vents, do not meet the basic two principles of surge suppression. Only by increasing the size of the vents so that they are larger than the wet stacks will the principles be met for passive venting in high-rise building. Alternately active drainage ventilation and stack-aerators, both single stack high-rise drainage stack system could be used and meet the requirements of the two key principles without the need to the vent pipes and the requirement to enlarge them.

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