Technical paper

Vertical Flow in High-rise Drainage Systems

How water and air interact

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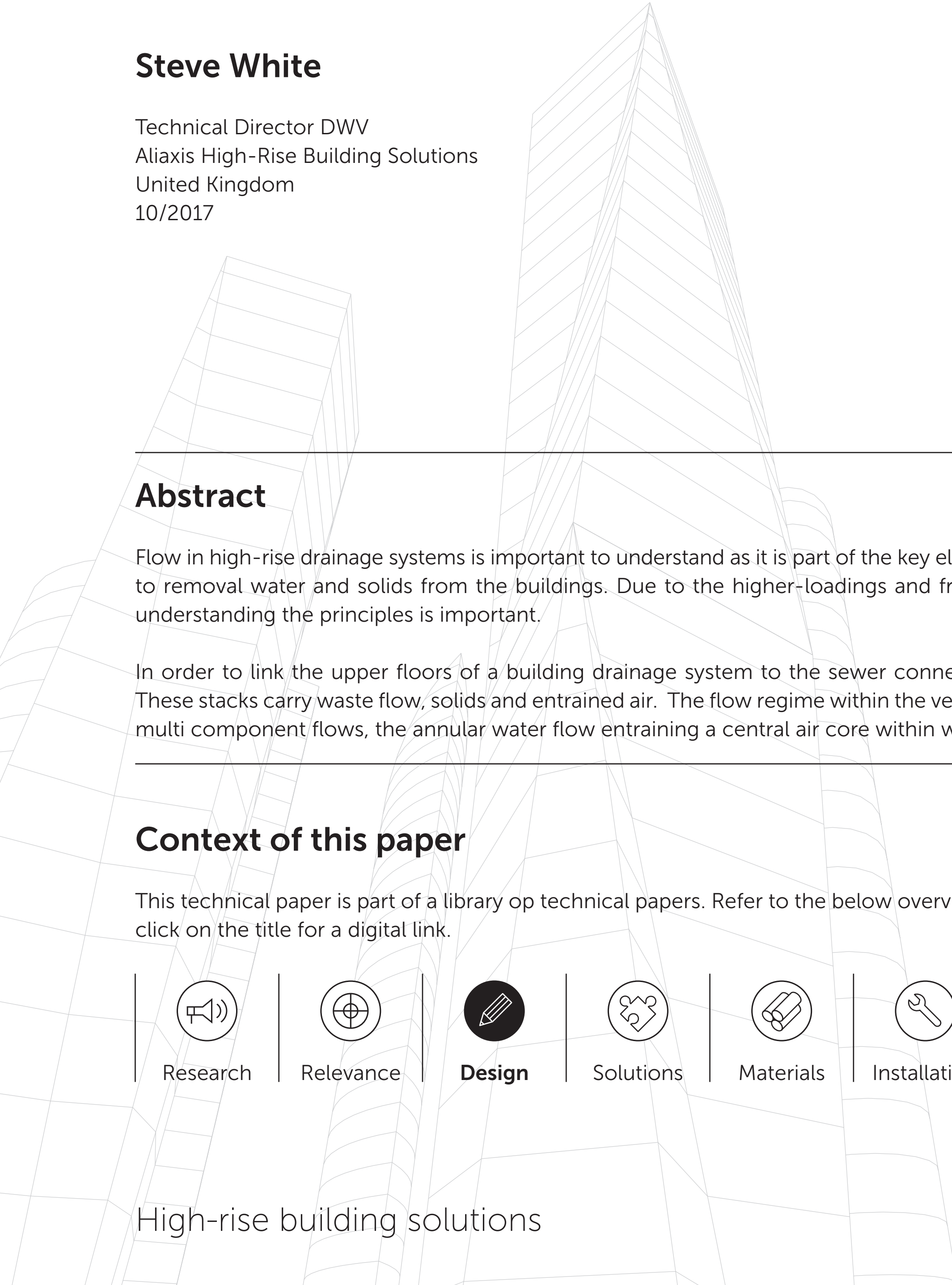

Abstract

Flow in high-rise drainage systems is important to understand as it is part of the key element in how the system operates to removal water and solids from the buildings. Due to the higher-loadings and frequency of use in taller buildings understanding the principles is important.

In order to link the upper floors of a building drainage system to the sewer connection vertical stacks are required. These stacks carry waste flow, solids and entrained air. The flow regime within the vertical stack is strictly unsteady with multi component flows, the annular water flow entraining a central air core within which any solids fall.

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Introduction

The vertical stack and its associated flows, plays an important role in a building drainage and ventilation system.

1. It provides a route down the building for discharged fluid and solid waste.
2. It provides a linkage between floors so that the discharge from each floor may be systematically combined prior to joining the main sewer connection.
3. It allows air movement into the network. The entrained airflow and the air pressure regime requires venting through passive venting using stack vents, stack-aerators or active venting using air admittance valves and P.A.P.A. to reduce the air pressure fluctuations within the system, to prevent the loss of water trap seals to the negative and positive transients generated by the unsteady flows.

Before any discharge into the system the drainage system is at atmospheric pressure. The air within the stack and the connecting pipe work on each floor is separated from the building by water trap seals.

Discharges from branch to vertical stack

Discharge of an appliance causes water flow into the branch pipe work. When this horizontal flow leading edge reaches the stack connection it arches across the diameter of the stack, impinges on the pipe wall opposite and initiates a downward flow that will initially have a high-degree of swirl.

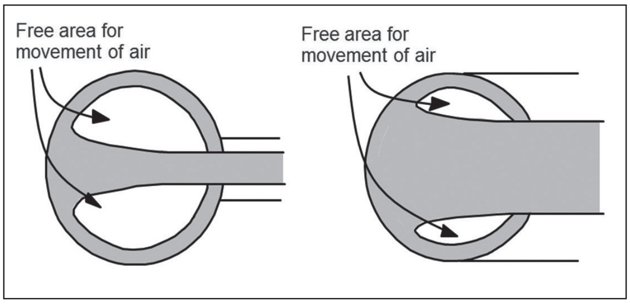

Figure 1.
Branch discharge

Higher discharges, for example a W.C, will have a greater potential to block the air path at any instant. Therefore it is recommended in the guidance that any discharge into the stack should be via a swept or angled inlet into the stack to reduce the blockage and therefore reduce any associated rate of change to the pressure regime and the air pressure transients.

One of the key principles of stack-aerators is that they prevent the closure of the air path from the branches by separating the flow from the horizontal to the vertical keeping the air paths open.

Figure 2.
Flow in a stack-aerator

For conventional connection national codes, place restricted zones for connection for the same reason so that the air paths are maintained

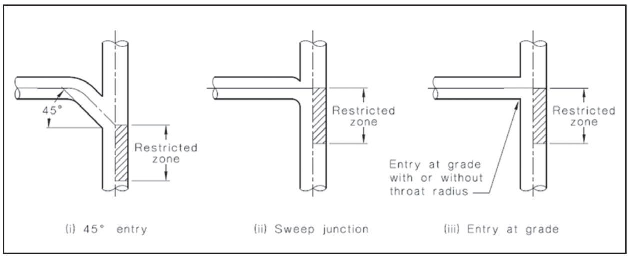

Figure 3.
Restricted zones below the branch entry point

As the flow from the branch, and once annular water flow is established, in both cases there are sections that are open allowing for air movement down the vertical stack.

Interruptions to the air path (entrained air) will generate air pressure transients that can deplete or blow out water trap seals. To protect against these air pressure transients the use of active drainage ventilation products will further protect the traps from changes to the pressure regime.

Annular Flow

Once the flow leaves the branch it adheres to the stack inside the wall surface and annular flow is established, this occurs within 1-3 meters from leaving the branch, it will have a terminal thickness of 4-6 mm and fall at terminal velocity of 3-6m/s until it changes direction by an offset or reaching the base of the stack. Solids will fall in the centre of the pipe.

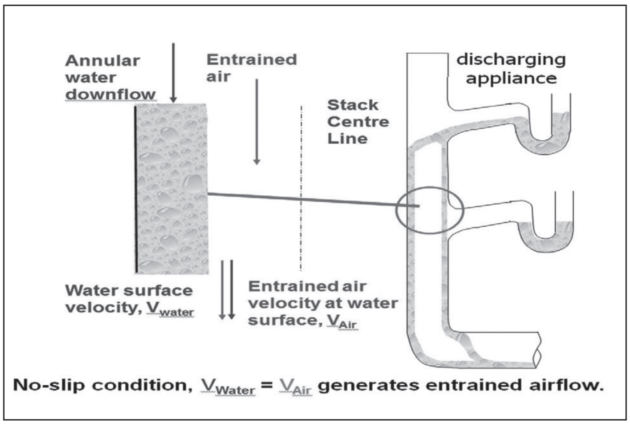

Figure 4.
Annular flow

Conclusion

In high-rise buildings with their increased loadings and high usage patterns, the flows within the stack have an influence on the operation of the drainage system. The flows from the appliance through its water trap seals enters the branch pipe work, the fittings from the branch to the stack must be correct to ensure that there is minimal air closure of the air path to reduce the pressure fluctuations within the system.

Using swept or angled fittings reduce the potential for the air path blockages, but higher discharge rates at any point in time may block the air path, generating air pressure transients that can deplete water trap seals. Using active drainage ventilation products will reduce the air pressure transients and their harmful effects ensuring that the water trap seals are maintained.

Using stack-aerators to separate the discharge from the branch to the vertical stack ensure that the air path is maintained within the vertical stack and reduces potential for the air path to be blocked.

Once the flow becomes annual it will fall at terminal velocity within one to two floors until it reaches the base of the stack. The terminal thickness of the annular flow will be 4-6mm, with the core of the pipe allowing for solids to fall and the air core for the entrained air flow until it reaches an offset or the base of the stack.

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