Tall Buildings Conference & Awards

25.06.2024

CENTRAL LONDON

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Drainage Design Flexibility In Tall Buildings

Design for modern building requirements

Technical concepts and considerations

High Rise solutions

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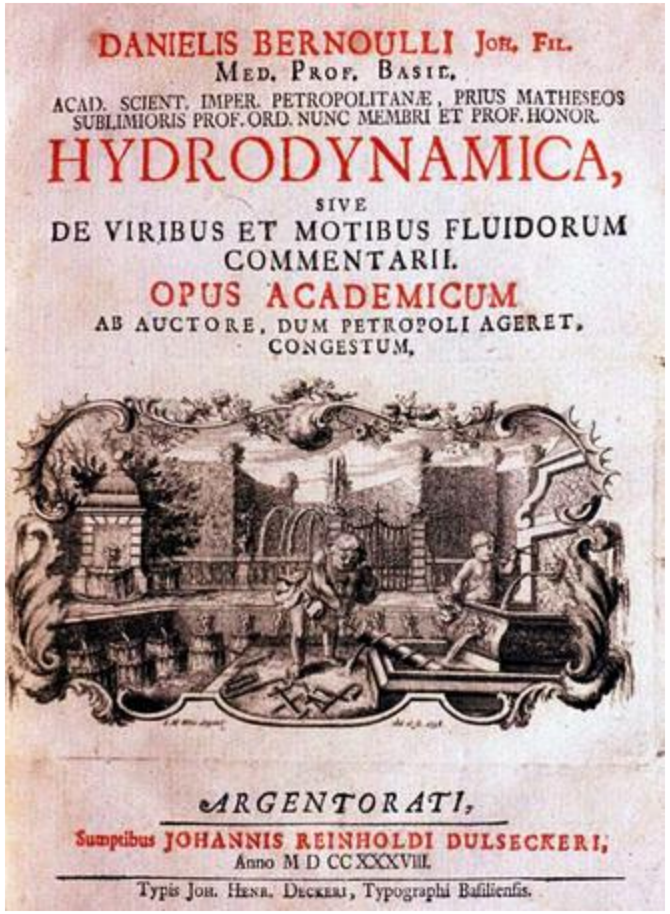
07834430872

Daniel Bernoulli

1700 - 1782



DANIELIS BERNOULLI Joh. Fil.
Med. Prof. Basil.
ACAD. SCIENT. IMPER. PETROPOLITANÆ, PRIUS MATHESEOS SUBLIMIORIS PROF. ORD. NUNC MEMBRI ET PROF. HONOR.
HYDRODYNAMICA,
SIVE
DE VIRIBUS ET MOTIBUS FLUIDORUM COMMENTARII.
OPUS ACADEMICUM
AB AUCTORE, DUM PETROPOLI AGERET, CONGESTUM.

ARGENTORATI,
Sumptibus JOHANNIS REINHOLDI DULSECKERI,
Anno M D CC XXXVIII.
Typis Joh. Henr. Deckeri, Typographi Basiliensis.

1738

Velocity

- Falling velocity in stacks

- Basis for the determination of terminal velocity in drainage stacks is the Equation of Bernoulli:

$$p_1 + \rho g h_1 + \frac{\rho}{2} {v_1}^2 = p_2 + \rho g h_2 + \frac{\rho}{2} {v_2}^2 + \Delta p_L$$

$p = pressure,\quad \rho = density,\quad h = height,\quad g = gravity,\quad v = velocity,\quad \Delta p_L = pressure\ loss$

- For a free fall, the falling velocity increases as a function of the height of fall h:

$$v_2 = \sqrt{2 g h_1}$$

$v{=}velocity,\ \ h{=}height,\ \ g{=}gravity$

- For a fully filled vertical pipe, the falling velocity stays almost constant after a certain height of fall. The falling velocity of a fully filled vertical pipe can be determined by the Equation of Bernoulli :

$$\rho g h_1 = \frac{\rho}{2} {v_2}^2 + \Delta p_L = \frac{\rho}{2} {v_2}^2 + \lambda \frac{h}{d} \frac{\rho}{2} {v_2}^2 \rightarrow \quad v_2 = \sqrt{\frac{2gh}{1+\lambda\frac{h}{d}}}$$

$v{=}velocity,\ \ h{=}height,\ \ g{=}gravity,\ \ d{=}pipe\ diameter,\ \ \lambda{=}f(Re,\ d,\ k),\ \ Re{=}Reynolds\ number\ k{=}roughness$

THE ISSUES

1. Do increasingly large buildings require increasingly complex drainage designs and hydraulic calculations?

2. What are the actual functions of a drainage system?

3. How to minimise pipe sizing concerns to release more architectural freedom

4. Discussions of potential drainage and hydraulic problems and how to mitigate them

5. Increasing sizes for ventilation pipes when common venting within the roof spaces

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Considerations of a drainage system (BS EN 12056 – 1)

Function

Safety			Location	Performance				Stability	
Fire	Tightness	Hygiene	Access	Capacity	Condensation	Noise	Ventilation	Chemical	Physical

Fresh water comes from the pipe…

…Dirty water disappears down the drain

SIMPLY THE WAY IT WORKS

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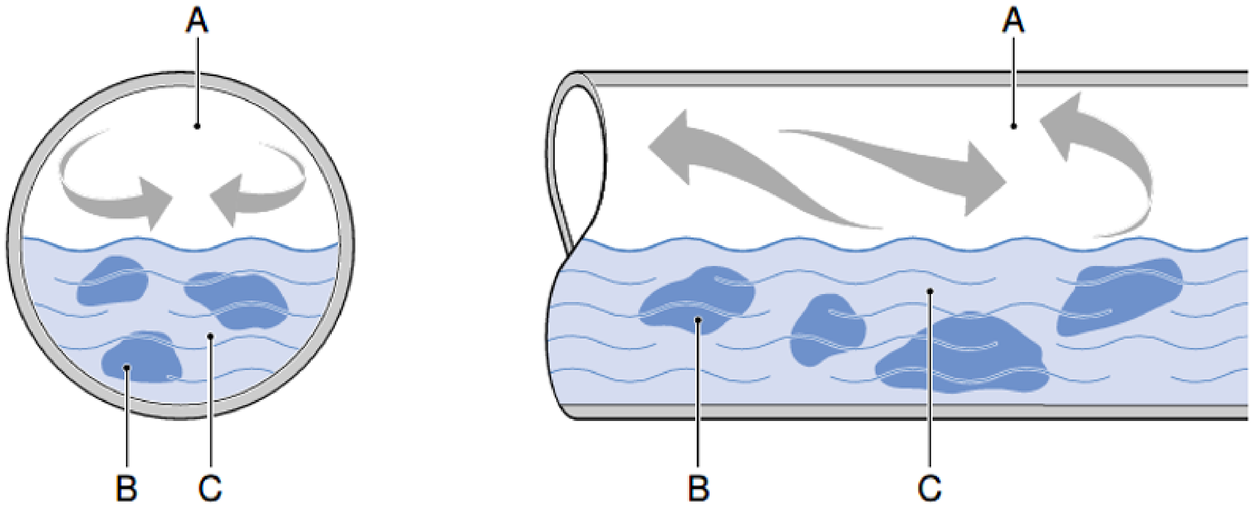
The function of drainage systems

The **main** requirement of a drainage system is that waste-water (solids and liquids) should be carried away quickly, without blockage and without the escape of foul air into the building.



A Air
B Effluent / Solids
C Water

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Purpose of drainage systems

Function

- Safety
  - Fire
  - Tightness (Air & Water)
  - Hygiene (Gradient)
- Location
  - Access
- Performance
  - Capacity (Size)
  - Condensation
  - Noise (Acoustics)
  - Ventilation (Air)
- Stability
  - Chemical
  - Physical (Gradient)

Once the hydraulics are optimised… these concerns can be addressed

- Space is limited and expensive
- Planning is often very complex
- Installation can be time-consuming

System Types (BS EN 12056-2)

System I (German / Swiss / Austrian Practice)

- Single stack system with partly filled branch discharge pipes.
- Sanitary appliances are connected to partly filled branch discharge pipes, are designed with a filling degree of 0.5 (50%) and are connected to a single discharge stack.

System II (Scandinavian Practice)

- Single discharge stack with small bore discharge branch pipes.
- Sanitary appliances are connected to small discharge pipes. The small bore discharge pipes are designed with a filling degree of 0.7 (70%) and are connected to a single discharge stack.

System III (UK Practice)

- Single stack system with full bore branch discharge pipes.
- Sanitary appliances are connected to full bore discharge pipes. The full bore branch discharge pipes are designed with a filling degree of 1.0 (100%) and each branch discharge pipe is separately connected to a single discharge stack.

System IV (French Practice)

- Drainage systems type I, II & III may also be divided into black water stack serving WC's and urinals and a grey water stack serving other appliances.

BRITISH STANDARD

BS EN 12056-2:2000

Gravity drainage systems inside buildings —

Part 2: Sanitary pipework, layout and calculation

— Bend and branch connections at base of discharge stack

Legend:

$L \geq$ 450 mm (for single houses up to three storeys high)

or $L \geq$ 740 mm (for multi-storey systems up to five storeys high)

or $L \geq$ one storey height (for multi-storey systems higher than five storeys), i.e. no connections on ground floor level

ND.3.5.3 Branches at the base of stacks (primary ventilated stack system)

Generally, for systems up to five storeys, the distance between the lowest branch connections and the invert of the drain should be at least 750 mm, but 450 mm is adequate for low rise single dwellings. For larger multi-storey systems, it is better to connect the ground floor appliances to their own stack or the horizontal drain and not directly to the main stack. For buildings over 20 storeys high, it may be necessary to connect both the ground and first floor appliances in the same manner.

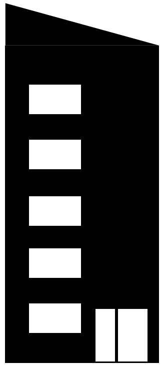
No Chapter 9 3/4

Maintaining air flow to optimise hydraulics

Primary vent

- The bare minimum requirements

Maintaining air flow to optimise hydraulics



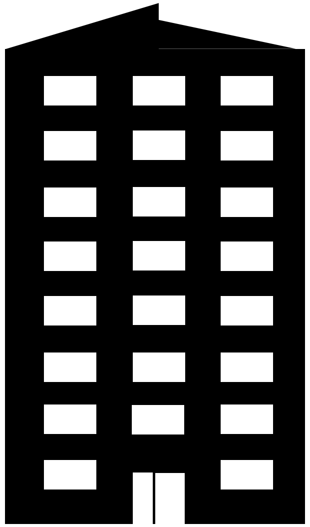
Increase pipe size

- For increased volume flow requirements

Primary vent

- The bare minimum requirements

Maintaining air flow to optimise hydraulics



Secondary vent

- Required under guidelines in (BS) EN 12056-2 to allow for higher flow rates without increasing size
- System III (UK) has values for square and swept entries
- Main stack sizes may need to increase as well as adding in a secondary vent

Increase pipe size

- For increased volume flow requirements

Primary vent

- The bare minimum requirements

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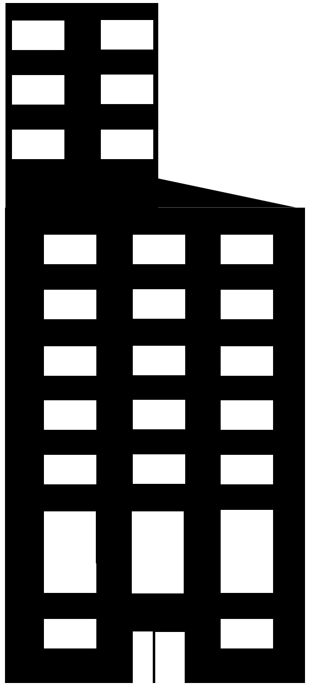
Maintaining air flow to optimise hydraulics



Air admittance valve

- Mechanical – often used as retro-fit when systems are not functioning correctly
- When designed in, are used in relief lines and in floors above direction changes

Secondary vent

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Increase pipe size

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Primary vent

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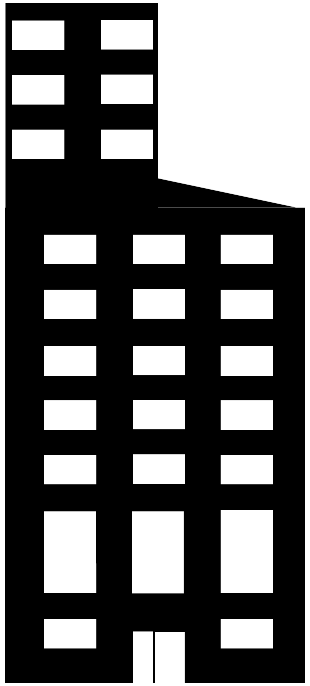
Maintaining air flow to optimise hydraulics



In-line pressure relief valve

- Mechanical - pressure attenuation devices manages pressure fluctuations
- Mitigates pressure issues in a malfunctioning system
- Used in conjunction with air admittance valves

Air admittance valve

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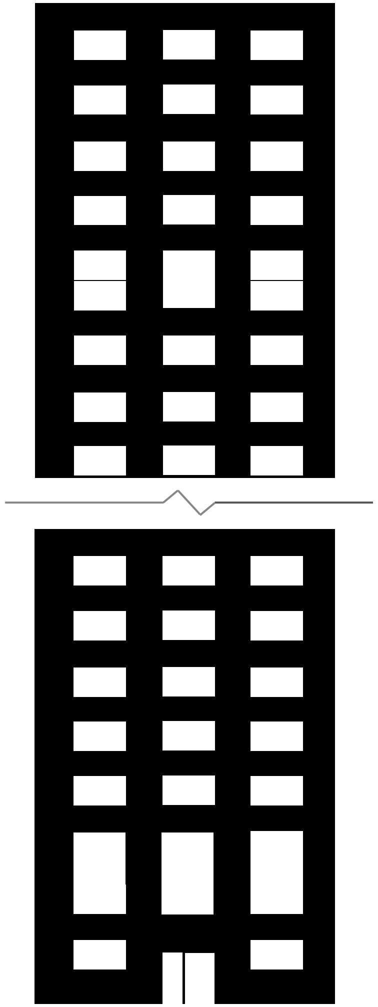
Primary vent

- The bare minimum requirements

Maintaining air flow to optimise hydraulics



Flow optimisation technology	• Advanced geometry in design of fittings allows stack sizes to remain at DN 100 • Maintains higher flow rates of water in direction changes • Design circumnavigates unanticipated malfunctions • Allows continuous free air movement instead of relying on reactive mechanical devices
In-line pressure relief valve	• Mechanical - pressure attenuation devices manages pressure fluctuations • Mitigates pressure issues in a malfunctioning system • Used in conjunction with air admittance valves
Air admittance valve	• Mechanical – often used as retro-fit when systems are not functioning correctly • When designed in, are used in relief lines and in floors above direction changes
Secondary vent	• Required under guidelines in (BS) EN 12056-2 to allow for higher flow rates without increasing size • System III (UK) has values for square and swept entries • Main stack sizes may need to increase as well as adding in a secondary vent
Increase pipe size	• For increased volume flow requirements
Primary vent	• The bare minimum requirements

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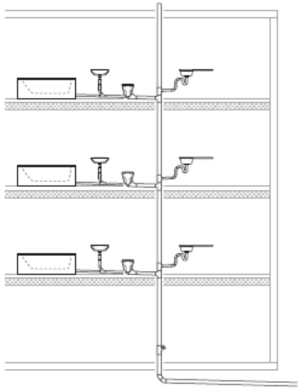
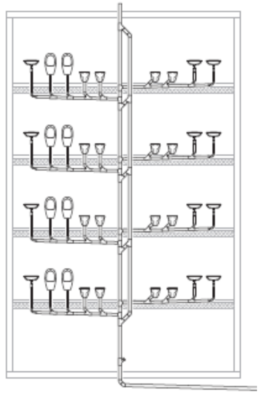
Choosing the right drainage system

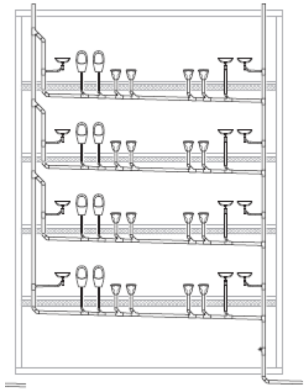
1 Single Stack system



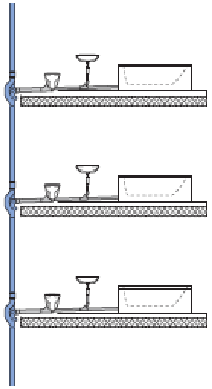
2 Parallel vented system - direct



2 Parallel vented system - indirect



3 Flow optimisation system



Drainage system	Dimension d	Dimension d of the secondary ventilation	Maximum load in DU (K = 0.5)	Maximum load in l/s
1: Stack vent system with 88.5° branch fitting	110	–	64	4.0
	125	–	135	5.8
	160	–	361	9.5
1: Stack vent system with 88.5° branch fitting swept entry	110	–	108	5.2
	125	–	231	7.6
	160	–	615	12.4
2: Secondary ventilation system, direct or indirect, with 88.5° branch fitting	110	56	108	5.2
	125	75	231	7.6
	160	90	615	12.4
2: Secondary ventilation system, direct or indirect, with 88.5° branch fitting swept entry	110	56	185	6.8
	125	75	400	10.0
	160	90	1037	16.1
3: Flow optimisation with engineered branches and bends	110	–	576	12.0
	160	–	1156	17.0

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Terminal velocity of drainage stacks

- Bernoulli proved that for a fully filled vertical pipe the falling velocity stays almost constant after a certain height of fall.
- Compared with a fully filled vertical pipe - in a drainage stack the waste water flows along the pipe wall as a water jacket, creating an air core in the middle.
- Due to pipe friction and air resistance the terminal velocity is reached after the terminal length of the stack pipe. The terminal velocity in a drainage stack is lower than the terminal velocity in a fully filled pipe.
- The following two parameters influence the terminal velocity:
  - Pipe diameter d
  - Volumetric flow rate Qmax

Front view

air
water

Top view

fully filled

partly filled

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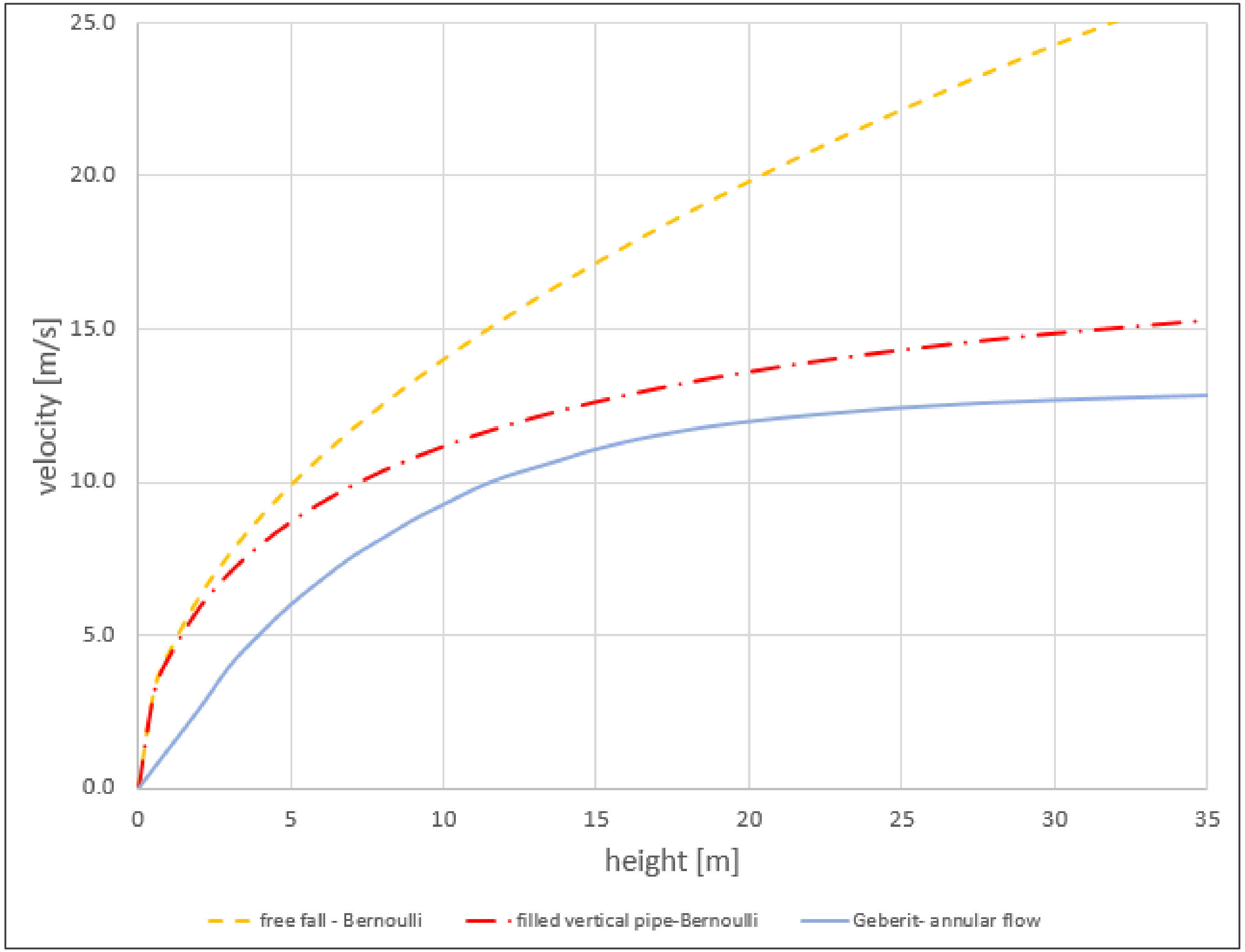
Bernoulli theoretical velocities and achieved velocities



Terminal Velocity 13.5 m/s

@35m

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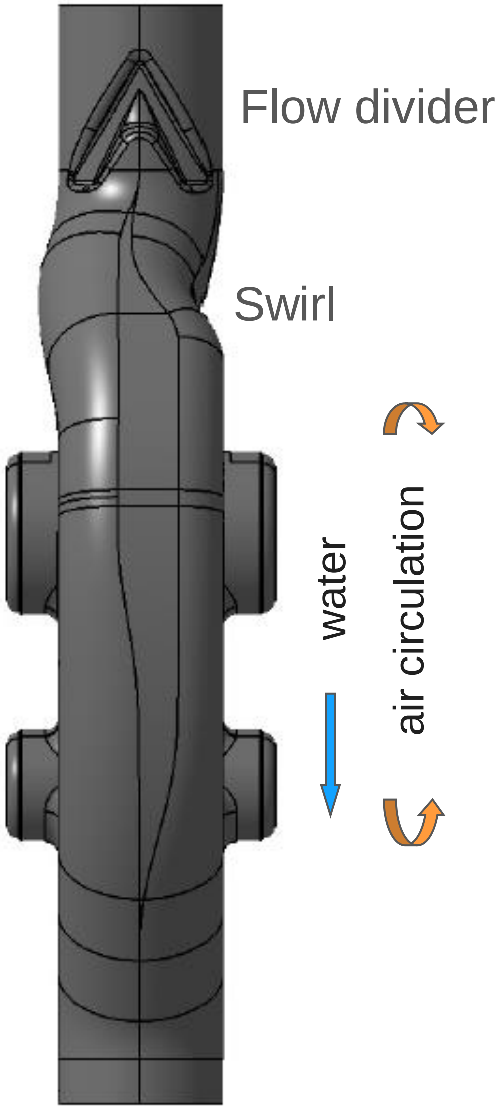
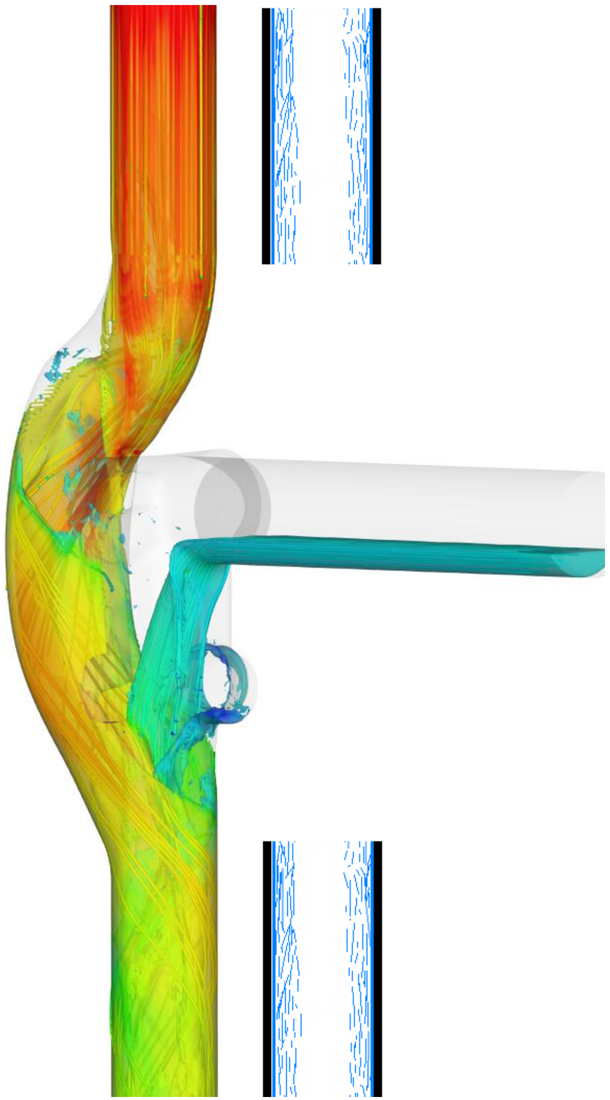
Velocity

Flow diagrams

This fitting ensures a **continuous air column** in stacks.

- The **flow divider** directs the water when it enters the fitting.
- The special shape of this fitting leads to a **swirl effect** and the water continues to flow along the wall.
- The **annular flow** in the stack continues without interruption.

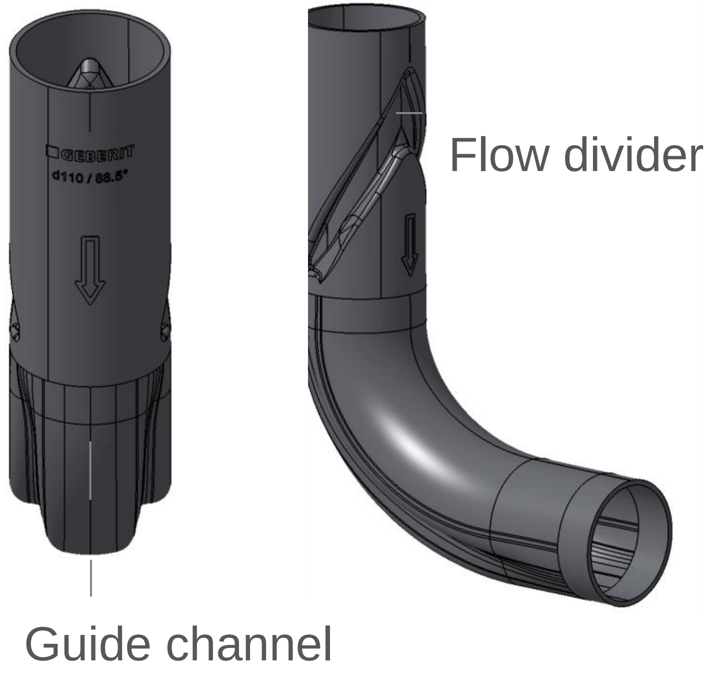


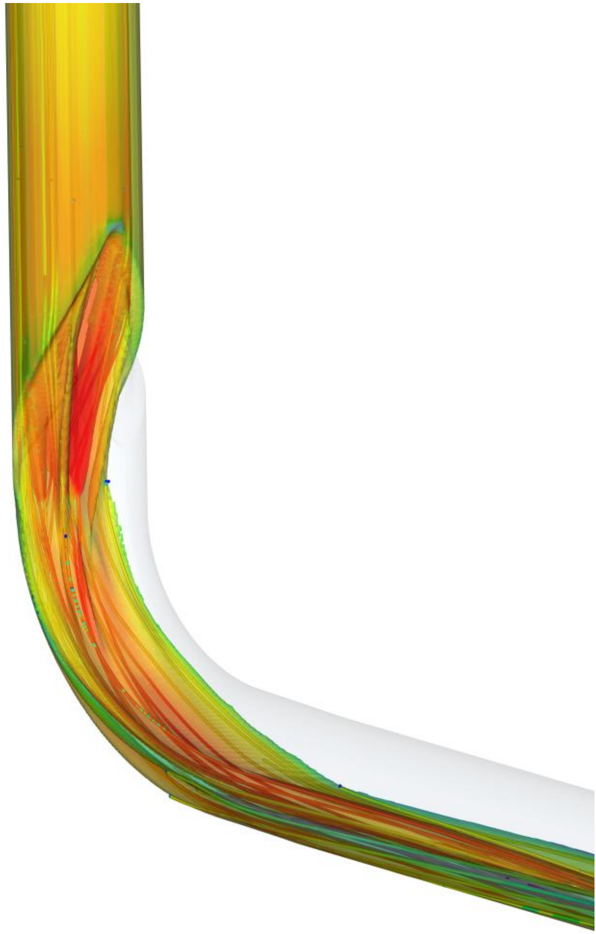


Function
Advanced geometry base of stack bend

This bend ensures a **continuous air column** in stacks.

- The **flow divider** directs the water when it enters the bend. The water curtain in the stack breaks just before the change of direction.
- The **optimised bend** guides the water. Water isn’t dammed (or backed) up and therefore a high-pressure fluctuation is prevented.
- Maintained velocities prevent build-up of silt
- A change in direction causes the wall of water to break and the **annular flow** to become a **layered flow** without disrupting the column of air.





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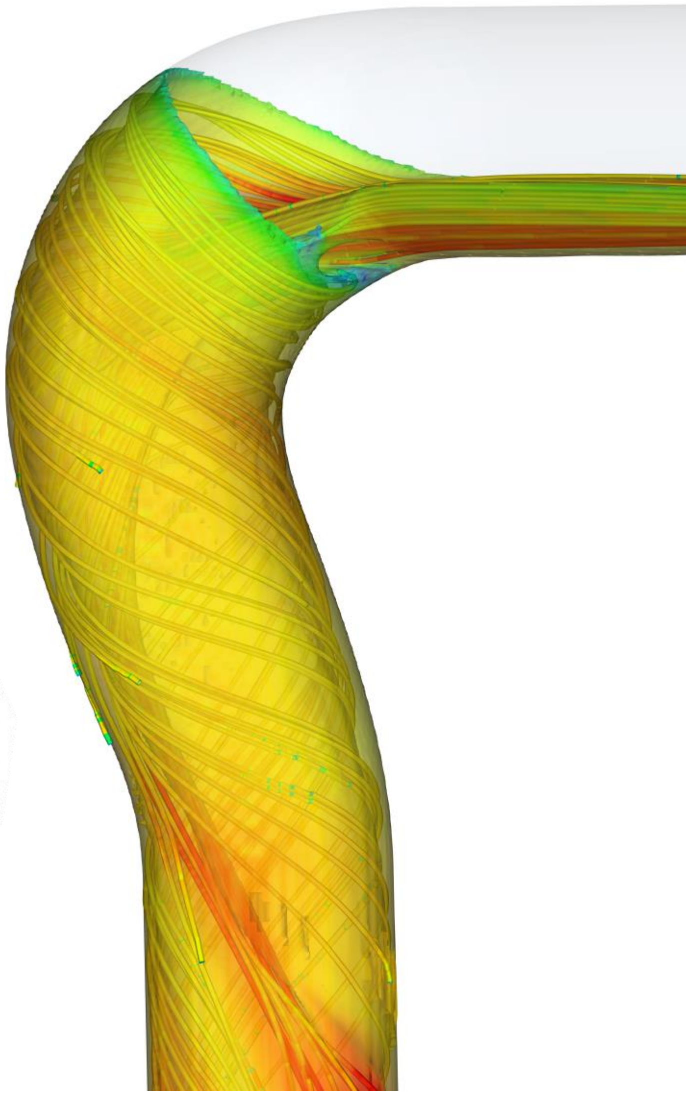
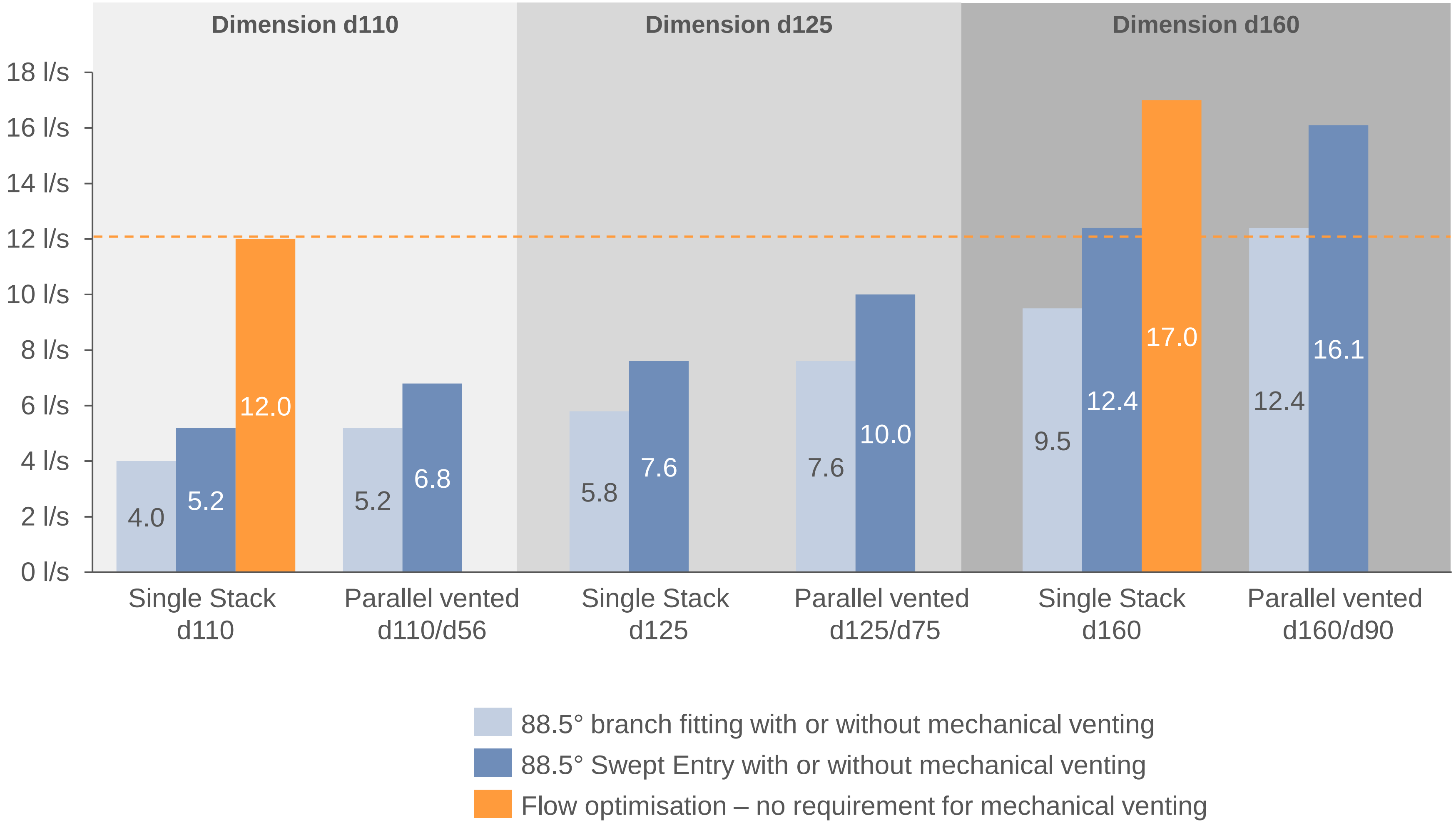
Function
Advanced geometry transition to vertical bend

Advanced geometry bends ensure a **continuous air column** in stacks.

- At the end of the stack offset, the **layered flow** of waste-water is directed back into an **annular flow** and the column of air remains intact.
- The **special shape** of this bend guides the water flow along the wall. This leads to an optimised transition from the horizontal to the vertical pipe.



Comparative water volumes flow rates



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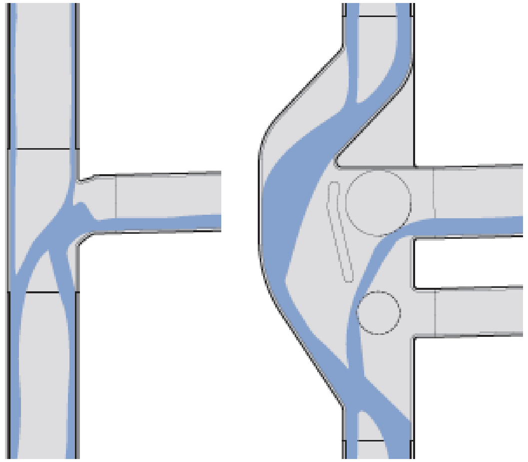
Consider the rules of installation

Drainage optimised

- With these fittings, more design freedom is possible for the entire structure

- Possibility of less pipework, and in tighter duct spaces, no additional vent requirements
- Brackets reduced due to fewer stacks
- Built in redundancy on branches if something changes in design during or after construction
- Client/building owner can future proof the buildings application as the system has the potential for large flows with the same size pipe
- Installation itself has proven to be simple for contractors. It is possible to overcome tricky installation parameters that are not usually picked up until actual installation.



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Greater hydraulic capacity with a d110 stack

Geberit International AG
Schachenstrasse 77
8645 Jona
Switzerland

Tel: 01926 0516800
e-mail: enquiries@geberit.co.uk
website: www.geberit.co.uk

BBA APPROVAL INSPECTION TESTING CERTIFICATION
TECHNICAL APPROVALS FOR CONSTRUCTION

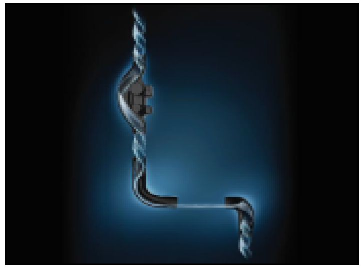
Agrément Certificate
19/5706
Product Sheet 1

GEBERIT DRAINAGE SYSTEMS

GEBERIT HDPE ABOVE GROUND DRAINAGE SYSTEM

This Agrément Certificate Product Sheet[1] relates to the The Geberit HDPE Above Ground Drainage System, comprising pipes, adaptors and fittings for the conveyance of surface water and sewage in domestic, commercial and public buildings.

(1) Hereinafter referred to as 'Certificate'.



CERTIFICATION INCLUDES:
- factors relating to compliance with Building Regulations where applicable
- factors relating to additional non-regulatory information where applicable
- independently verified technical specification
- assessment criteria and technical investigations
- design considerations
- installation guidance
- regular surveillance of production
- formal three-yearly review.

KEY FACTORS ASSESSED

Strength — the system has adequate strength to resist the loads associated with installation and subsequent use (see section 6).

Performance of joints — the connections between the pipes and fittings are watertight under normal service conditions (see section 7).

Flow characteristics — the system using the pipes, couplings and fittings will have satisfactory flow characteristics (see section 8).

Resistance to elevated temperatures — the system has adequate resistance to the temperatures likely to be found in domestic waste water (see section 10).

Durability — the system will have a service life in excess of 50 years (see section 13).

The BBA has awarded this Certificate to the company named above for the system described herein. This system has been assessed by the BBA as being fit for its intended use provided it is installed, used and maintained as set out in this Certificate

On behalf of the British Board of Agrément

Date of First issue: 28 October 2019

Paul Valentine
Technical Excellence Director

Claire Curtis-Thomas
Chief Executive

Originally certificated under BBA Certificate 92/2796
Certificate amended on 19 December 2019 to update sections 1, 8 and 17.

The BBA is a UKAS accredited certification body – Number 113.
The schedule of the current scope of accreditation for product certification is available in pdf format via the UKAS link on the BBA website at www.bbacerts.co.uk
Readers MUST check the validity and latest issue number of this Agrément Certificate by either referring to the BBA website or contacting the BBA directly.
Any photographs are for illustrative purposes only, do not constitute advice and should not be relied upon.

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- Single stack, same as primary vented, across many *many* more floors

- Buildings aren't getting shorter; space is a cost premium; service space is fully utilised

- The ability to keep stacks at d110 but having a higher volume flow allows for much less dead space; i.e. more saleable space for the building owner.

- Having a greater hydraulic capacity allows for more architectural freedom in building design

- The ventilation branch fittings can be used throughout on their own; the flow optimised bends, which must be paired, can be added where off-sets are required

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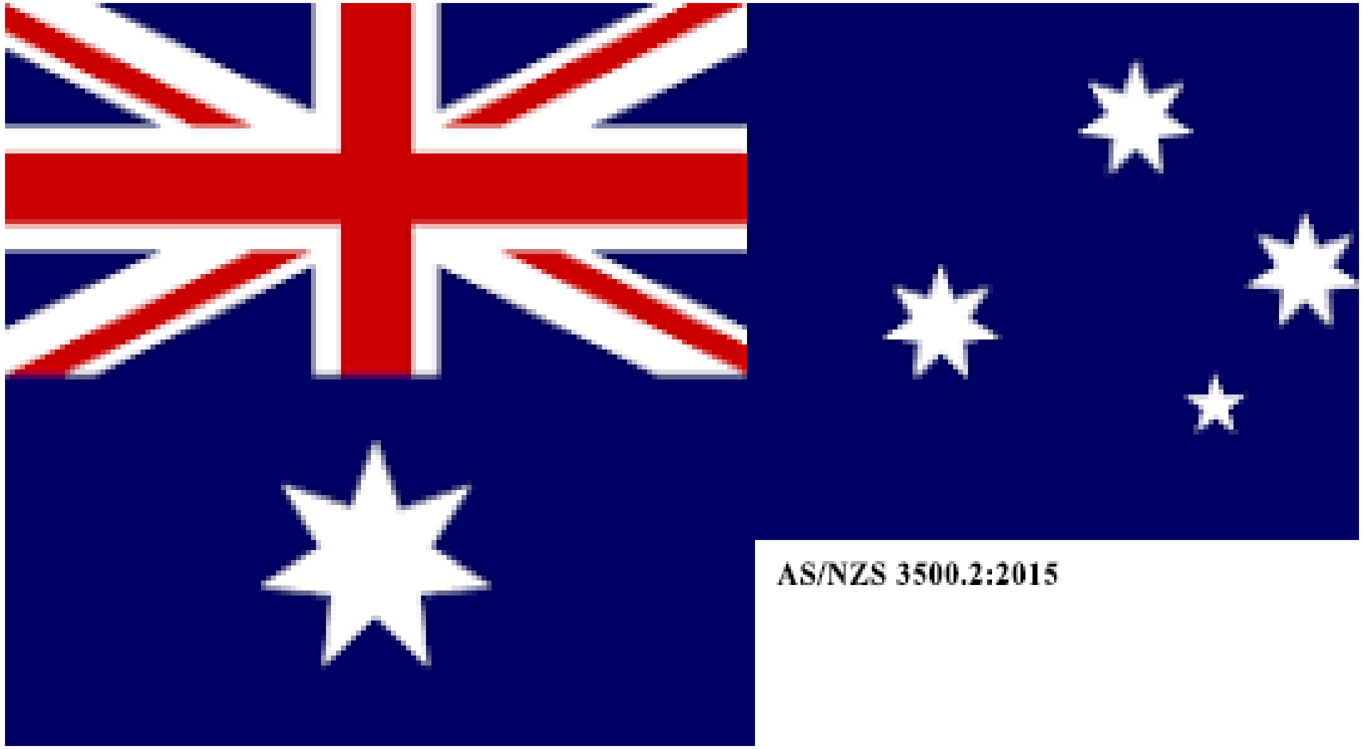

AS/NZS 3500.2

SECTION 11 REDUCED VELOCITY AERATOR STACK SYSTEM

11.1 SCOPE OF SECTION

This Section specifies design and installation requirements for the reduced velocity aerator stack system for sanitary plumbing.

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180 George Street Parramatta NSW

180
GEORGE
Parramatta


180
GEORGE
Parramatta
Elders

180 GEORGE Parramatta

- Developer: Meriton Group
- Architects: Woods Bagot
- Hydraulics: Ilias Design Group
- Plumber: K-MAC Plumbing
- Plumbing Supplies: Reece Group
- Height: 186 and 211 m
- Floors: 56 and 67 floors – 123 total
- Buildings: 2 towers
- Completion: 2022

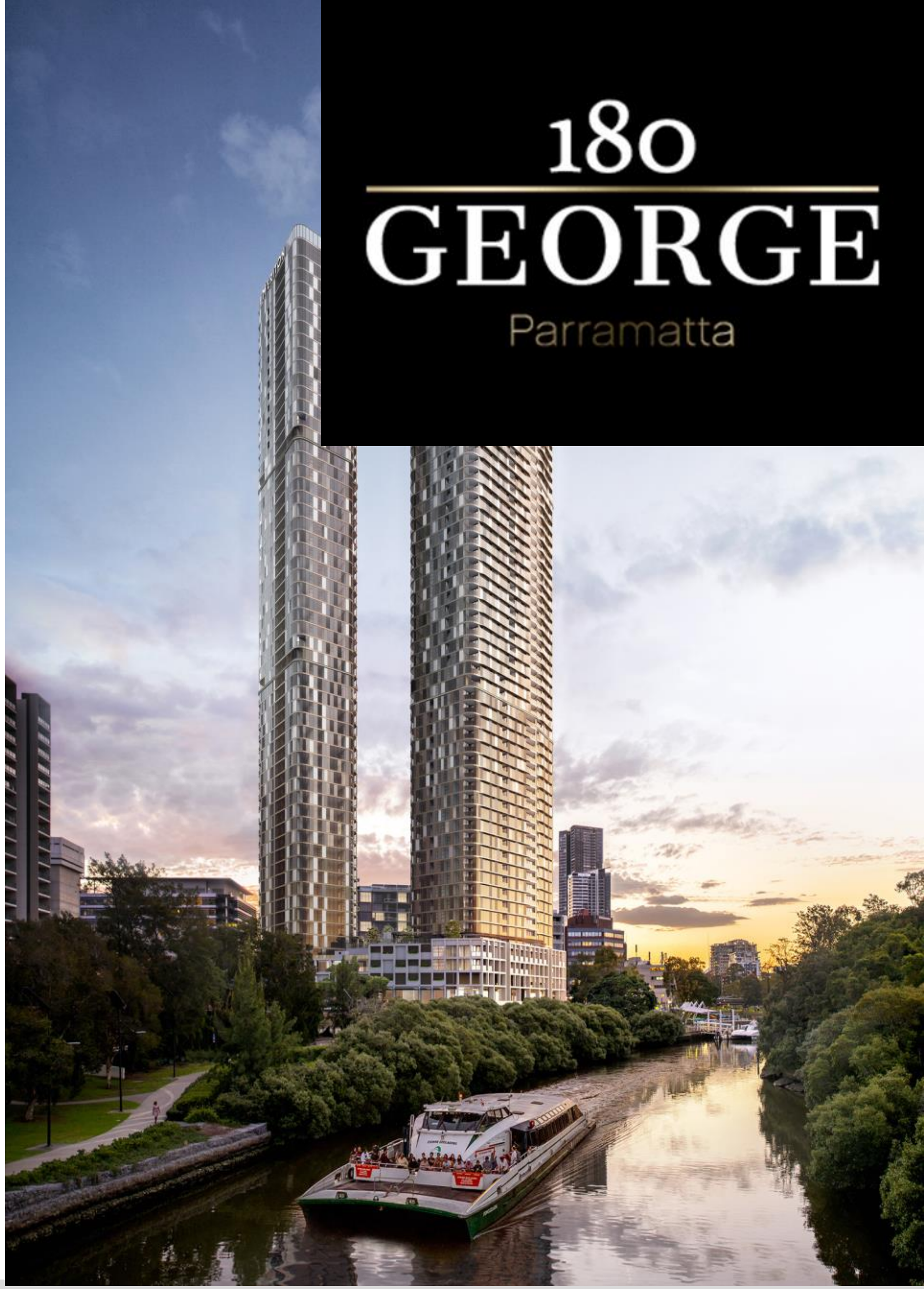
THE CHALLENGES

ICONIC, LANDMARK DESTINATION - the tallest buildings in Western Sydney.

LANDMARK DESTINATION = LANDMARK STYLE and PRICE. Beyond 5-star accommodation.

522 Luxury apartments – views of the Parramatta River and the CBD (between Au$ 600K – Au$ 4m

Living Space m^3 needs to maximised – increased revenue, and increased end user satisfaction



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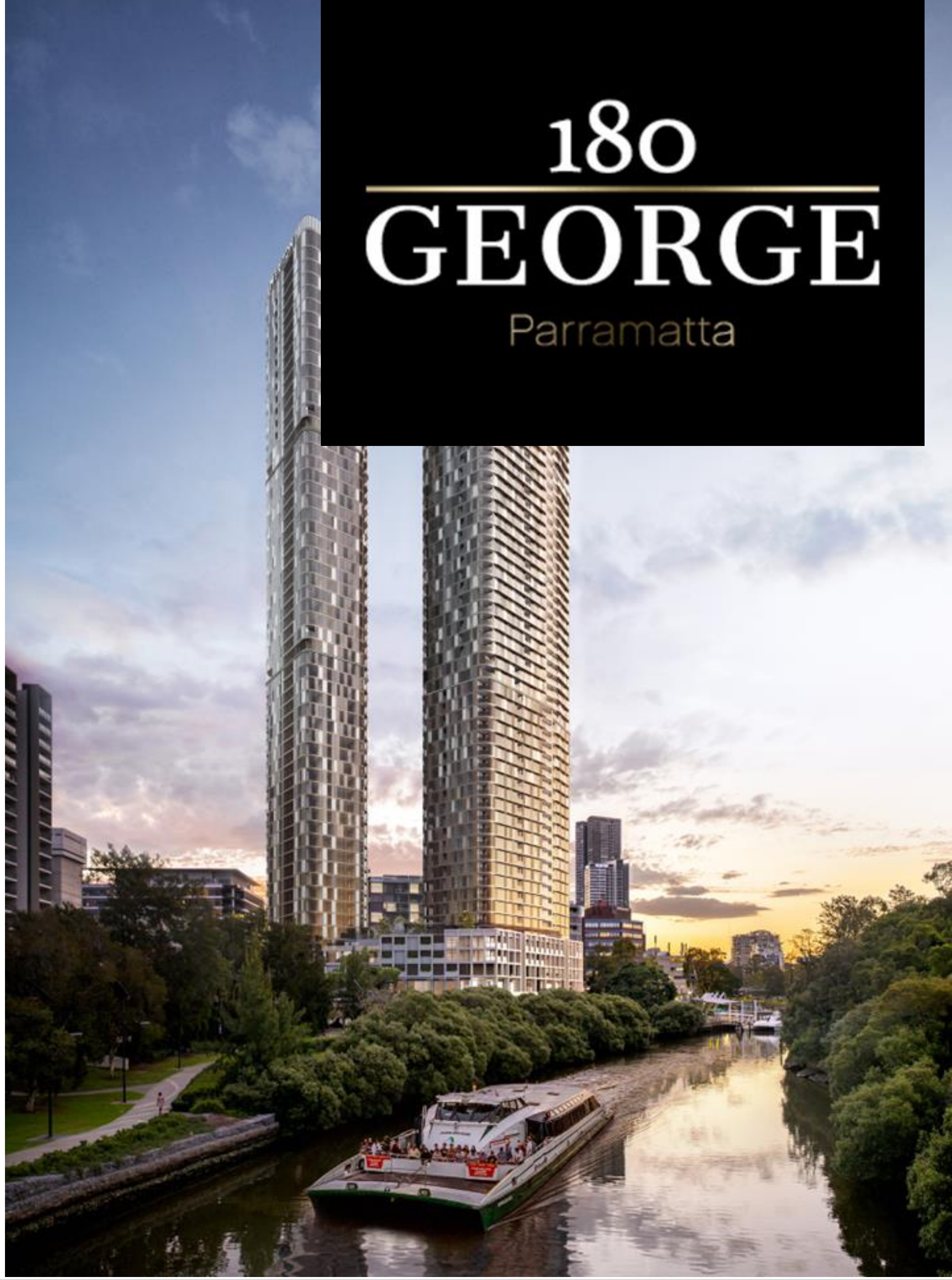
THE CHALLENGES

60 stack offsets

2 bathrooms per apartment min. demanding discharge environments.

Optimised flow performance without encroaching on space.

Out of sight out of mind



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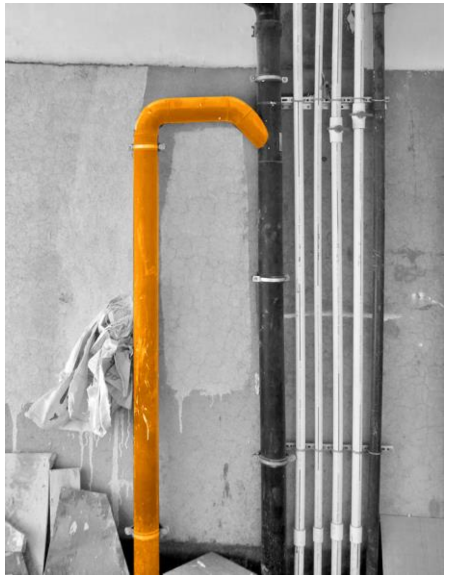
Traditional Solution

180 GEORGE
Parramatta



160mm SVP, 110mm Vent.

2 floor penetrations

Offsets require separate pressure relief=3 pipes

3 floor penetrations

The Geberit Solution

180 GEORGE Parramatta

Space saving in high-rise buildings

- Increase of net floor area
- Increase of room height

Easy planning

- Time saving in the planning and coordination process

Fast installation

- Smaller pipe dimension
- No ventilation pipe

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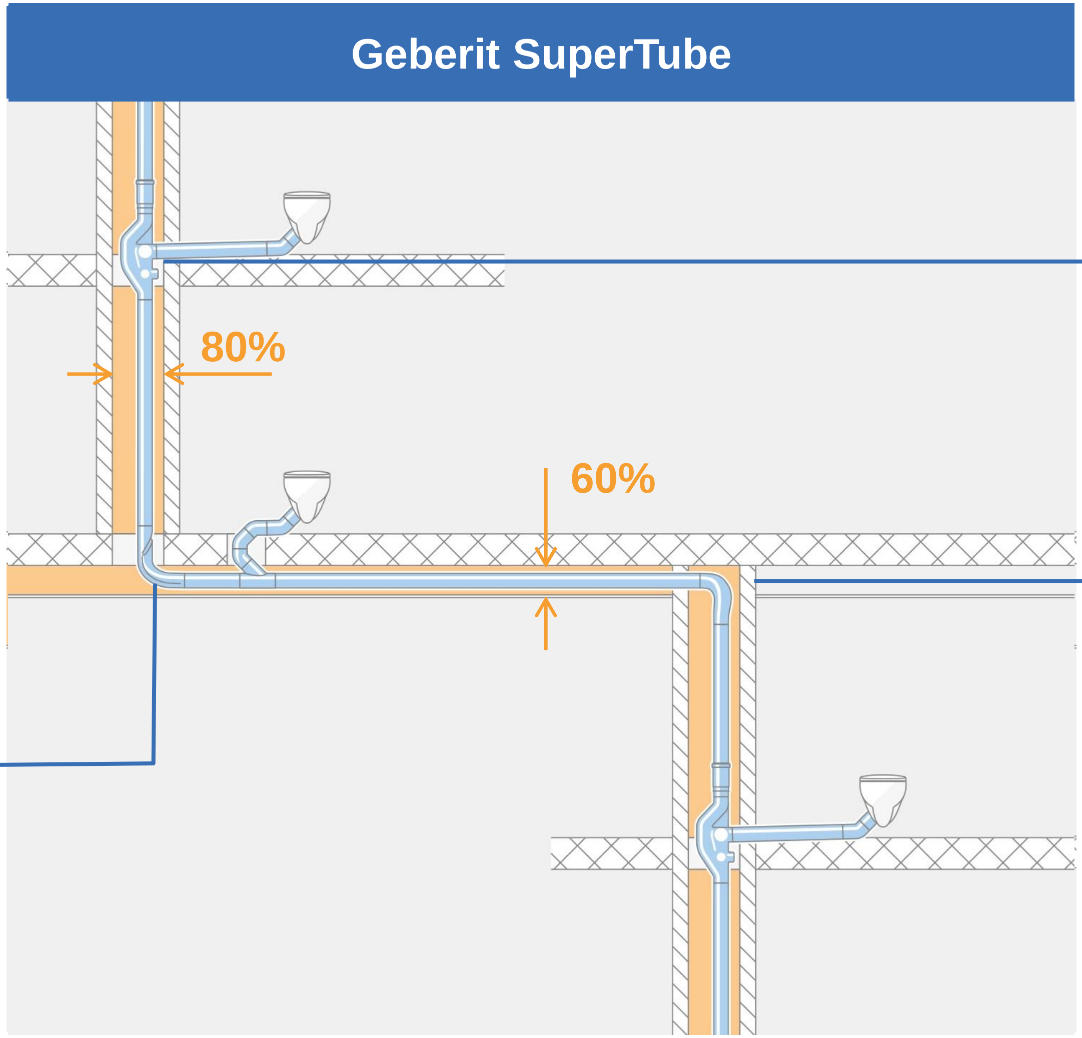
Increase of net floor area and room height with Geberit SuperTube



Geberit PE Sovent fitting

Geberit PE BottomTurn bend

Geberit PE BackFlip bend

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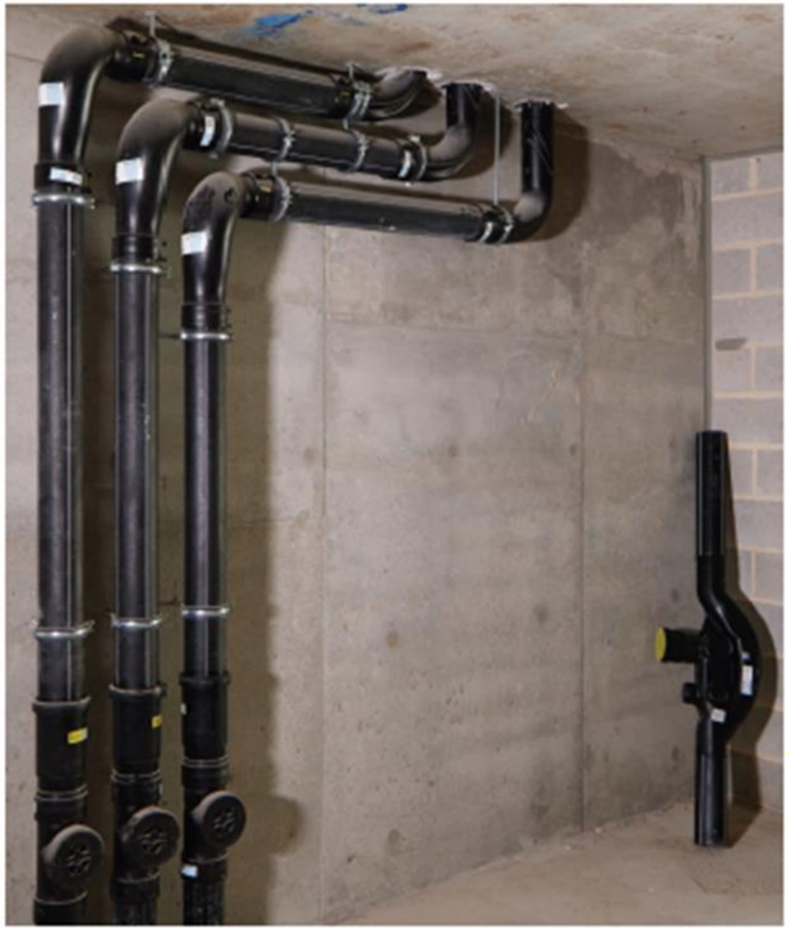

180 GEORGE Parramatta

Only 21 stacks

Ceiling void reduced from 400mm to 200mm

110mm single pipe throughout – no upsizing

Stack shaft sizes reduced from $0.39m^3$ to $0.21m^3$ – 46% space saving

$134m^2$ gain per apartment

Subsequent reduction on fire collars

180
GEORGE
Parramatta

Simple Installation

Single pipe – huge reduction on slab penetrations

Use of prefab – one electrofusion joint per floor per stack

180 GEORGE
Parramatta

Greater design flexibility

Significant gains in living space

Significant cost savings, on materials and installation

Greater durability, longevity and sustainability with an HDPE system

GEBERIT SUPERTUBE

THE HYDRAULICALLY OPTIMISED, SPACE-GAINING SYSTEM