IPA DEBATE CLUB QUESTION 6 (IPADCQ - 6)

Compiled by: BSA Narayan, Convener, IPA Technical Committee

IPA DEBATE CLUB QUESTION 6 (IPACQ-6)

1. **What is Terminal Velocity and Terminal Length in designing of High-Rise Drainage, Waste and Vent (DWV) and Storm Water System. How do we calculate the same?**
2. **Will excessive velocities occur/develop in the DWV stack of high-rise buildings and as a plumbing engineer how are you going to take care of these velocities at the base of the stack to prevent being broken or blow out.**

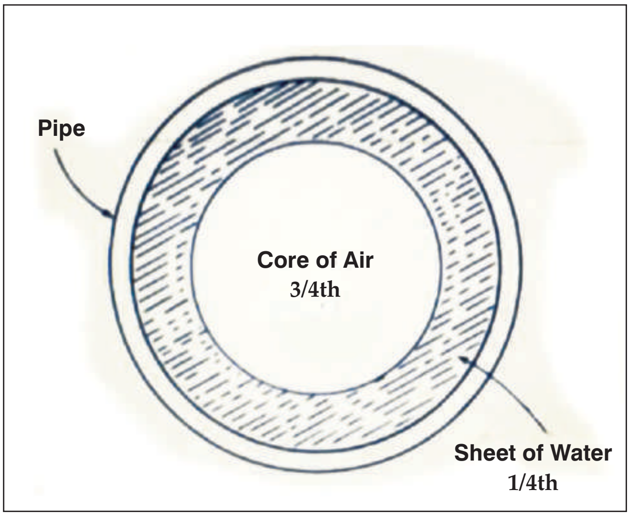
Response 1:

As soon as the soil or waste water enters the vertical stack, it is immediately accelerated at higher velocity (at the rate of 9.8 meter per second) and in a very short distance it forms a sheet around the inner wall of the pipe. It can be simply described as a hollow cylinder of water. This sheet of water, with a core of air in the center, continues to accelerate until the frictional force exerted by the pipe wall on the falling sheet of water equals the gravitational force. The frictional force varies as the square of the velocity and thus resistance to flow is very rapidly increased.

From the point where frictional force equals gravitational force, the sheet of water will continue to fall at a velocity which remains practically unchanged. This ultimate vertical velocity is called "terminal velocity," and the distance in which this maximum velocity is achieved is called the "terminal length".

Terminal length indicates that the sheet of water falling through the height of one story (one floor height) or a little more, attains its terminal velocity in all practical cases which simplifies the application of the theory presented.

Also for more clarity following image represent cross section of stack flowing at design capacity in which three fourth (3/4) filled with air and one fourth (1/4) filled with sheet of water.



Cross section of stack flowing at design capacity

To put it in a nutshell,

> When the water flows into a stack then it sticks to the pipe wall in the form of a sheet with a central core of air. The sheet of water continues to accelerate downward and achieve a velocity known as Terminal Velocity.
>
> The distance that the sheet travels to achieve the terminal velocity is known as Terminal Length.

Calculation of Terminal Velocity and Terminal Length:

Following are the formulae used to determine the terminal velocity and terminal length in the stack:

Terminal velocity formula:

VT = 3.0 x (Q/d) 2/5

where
VT = Terminal velocity in stack (metre/second)
Q = Quantity rate of flow (litre /second)
d = Diameter of stack (millimeter)

Terminal Length formula:

LT = 0.052 x VT2

where
LT = Terminal length below point of flow entry (metre)
VT = Terminal velocity in stack (metre/second)

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Note: Terminal velocity is approximately 3 m to 4.50 metre/second and this velocity is attained at 3.0m to 4.50 m) of the fall from the point of entry which is terminal length

Dr. S. Virapan
Chairman and Managing Director
Sanvir Associates Building Services Consultant
Life Member IPA Code: L158

Response 2:

The terminal velocity(V) & terminal length(L) in DWV & storm water system is calculated by following formula:

V=3*(q/d)^(2/5)
L=0.052*(V^2)

where
V=terminal velocity(FPS)
L=terminal length below point of flow entry(ft)
q= flow rate (gpm)
d= stack dia (inch)

Applying above formulas for various pipe sizes & flow rates, it can be established that terminal velocity is achieved at approximately 10-15 FPS i.e. 3-4.5 m/s. And the same is achieved within 10-15 ft i.e. 3-4.5 mtrs of fall from the point of entry.

Niraj Choudhary
Designation: Sr. Executive at Astral Pipes
IPA Professional Membership No. : PM/03/2021/78

QUESTION 2: Will excessive velocities occur / develop in the DWV stack of high rise buildings and as a plumbing engineer how are you going to take care of these velocities at the base of the stack to prevent being broken or blown out?

No, Excessive velocities will not develop in the DWV stack of high rise buildings.

Response 1: No special provisions are required for tremendous velocities and no special precautions are required to protect the base fitting. Excessive velocities just do not occur! Depending upon the rate of flow from the branch drain into the stack, the type of stack fitting, the diameter of the stack, and the flow down the stack from upper levels, the 'discharge from the branch may or may not entirely fill the cross-section of the stack at the point of entry.

Applying the formulas indicated in Question number 1 for terminal velocity and terminal length for various size stacks it is found that terminal velocity is achieved at approximately 3 to 4.5 metre per second and this velocity is achieved within 3 metre to 4.5 metre of fall from point of entry.

Researches demonstrate that the terminal velocity in high rise buildings does not increase very greatly. The velocity at the base of the stack in 100 storied building which is 300 m high is only slightly greater than the terminal velocity in a three-storied building which will be 9m height.

Therefore, it destroys the myth that water falling in a stack from a great height will destroy the fitting at the base of the stack.

Concerns: Stack will have more water and the pipe with greater weight requires more support with proper clamp at each floor level. Hence Plumbing engineer to ensure proper support at each floor level to take care of weight.

References:

1. S.G. Deolalikar – Plumbing Design and Practice
2. F. M. Dawson and A. A. Kalinske -- "Report on Hydraulics and Pneumatics of Plumbing Drainage System"
3. R. S. Wyly and H. N. Eaton -- "Capacities. of Plumbing Stacks in Buildings"

Dr. S. Virapan
Chairman and Managing Director
Sanvir Associates Building Services Consultant
Life Member IPA Code: L158

Response 2 : From the above analysis, it can be concluded that max. velocity reached by waste water in stack is 4.5 m/s & the same is attained within 4.5 mtrs (1.5 floors) after entry. As soon as the water enters the stack, it is immediately accelerated downward by the force of gravity and in a very short distance it forms a sheet around the inner wall of the pipe. This sheet of water continues to accelerate until the frictional force exerted by the pipe wall on the falling sheet of water equals the gravitational force. From this point downward, the sheet of water will fall at a velocity that remains practically unchanged. So, the velocity at the base of high rise stack is only slightly greater than the velocity at the base of a three-story stack. This proves that excessive velocities will not occur in high rise stacks & no special measures are required to prevent pipes from being broken or blow out. Velocity breakers which are often provided in high rise stacks, are therefore not actually required. Rather, they act as point of blockage & create pressure imbalances inside stack.

Niraj Choudhary
Sr. Executive at Astral Pipes
IPA Professional Membership No. : PM/03/2021/78

CONCLUSION

- The frequently asked question for plumbing Design Engineers is that extremely high velocities develop in the stack of high rise buildings and how do you take care for these velocities at the base of the stack.
- Mr. Virapan and Mr Niraj Choudhary clearly explained the question no. 1 and Question no 2 very elaborately with all the formulae used to determine the Terminal Velocity and the distance in which this maximum velocity is achieved i.e. Terminal Length.
- Utmost care to be taken by the Design Engineers not to provide stack offsets at an angle greater than 45 degrees. At this point, the flow will be at a relatively high velocity and if the slope of horizontal pipe is not adequate to maintain the velocity of flow, the depth of flow suddenly increases and fills up the cross sectional area of the pipe. This sudden rise in depth causes hydraulic jump, less jump occurs if the horizontal drain is larger in size than the stack. This can be avoided by providing proper venting to the system.
- It is also very important that the fixtures on the floor above (i.e one floor above)the offset should not be connected to the stack. It has to be brought separately and connect to the horizontal pipe.
- These fixtures should be separately piped and connected to the horizontal offset more than 10 stack diameter downstream of the horizontal pipe or the vertical pipe therein with 600mm below the horizontal offset. These are clearly explained in the NBC and any other standard books.

B. S. A. NARAYAN
Convener, Technical Committee (TC)

About Debate Club

Questions of importance to plumbing professionals would be published periodically in IPT, with the view to get opinions/ clarifications.

IPA Debate Club was an established column earlier but was discontinued for some time.

Through the Debate Club, IPA wants to involve all for the benefit of the plumbing fraternity. Answers duly vetted by IPA Technical Committee would be published in IPT. The decision of IPA TC would not be subject to any challenge or counter claim.

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Convener, IPA Technical Committee

IPA DEBATE CLUB QUESTION 7 (IPADCQ-7)

Q. 1 What are the criteria for selection and installation of water hammer arrestor in and hydraulically designed water supply distribution system for large facilities.

Q. 2 Design criteria to be adopted for connecting symphonic drainage piping outlet to rainy filters prior to connecting terrace rain water to the collection sump @Ground / basement level.

Please send in your replies (along with full Name, Designation, IPA Membership No. and contact details) latest by 30th April to

acep@indianplumbing.org
with a cc to
vicepresident@indianplumbing.org