Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

Building Science

Ventilation

www.buildingscience.com

Definition of a Problem

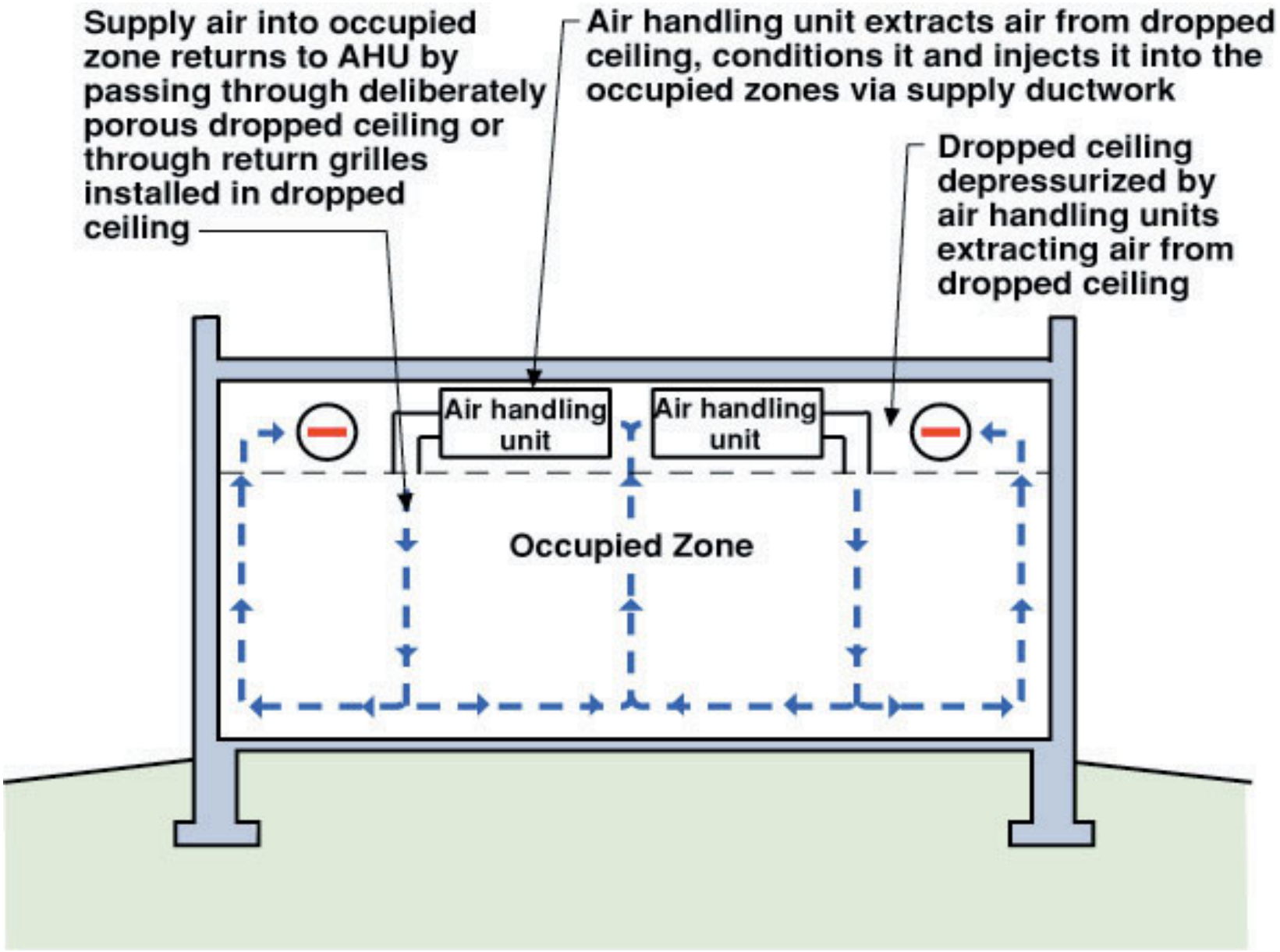
People

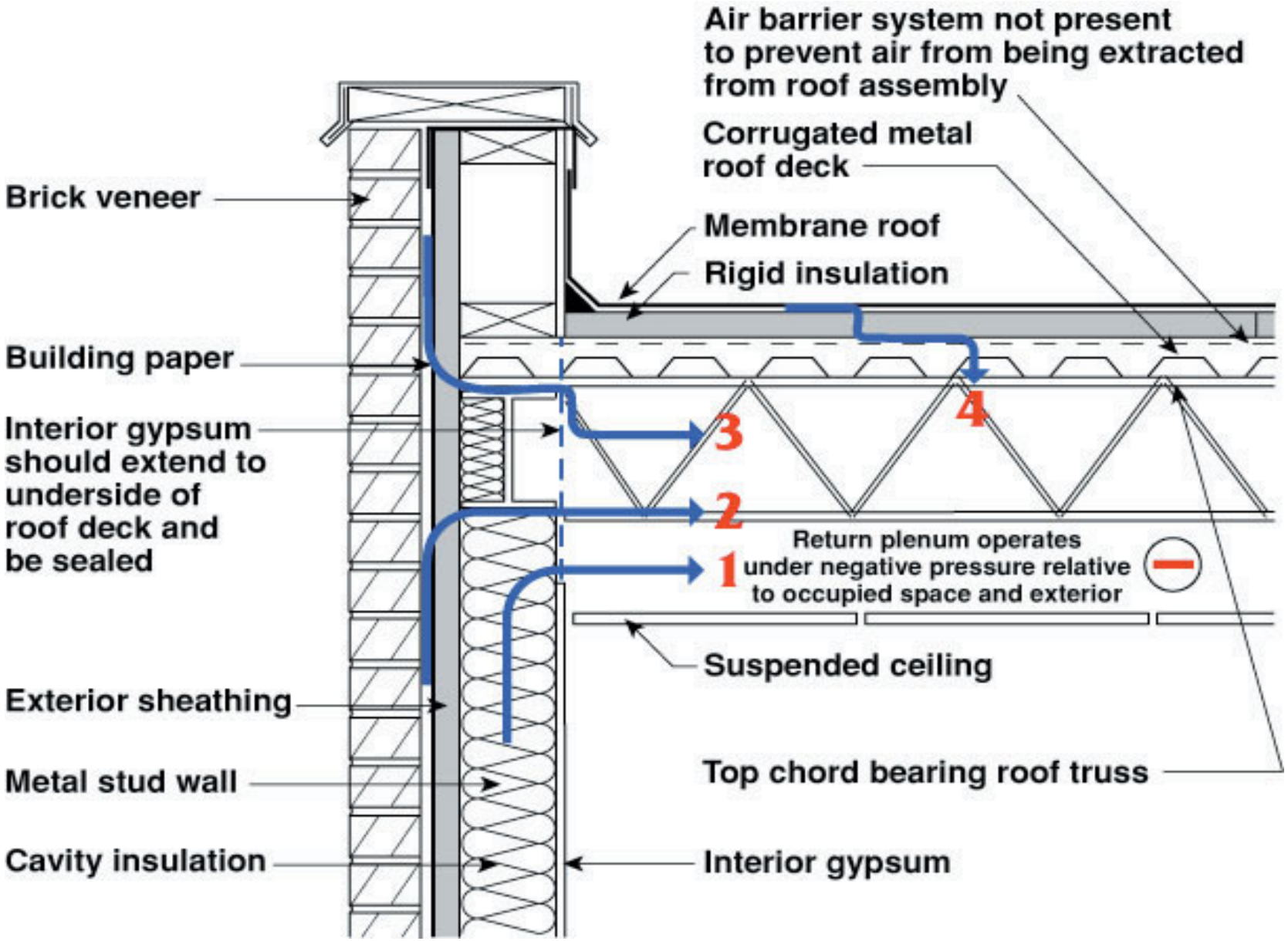
Pollutant (hot, wet, UV, ozone)

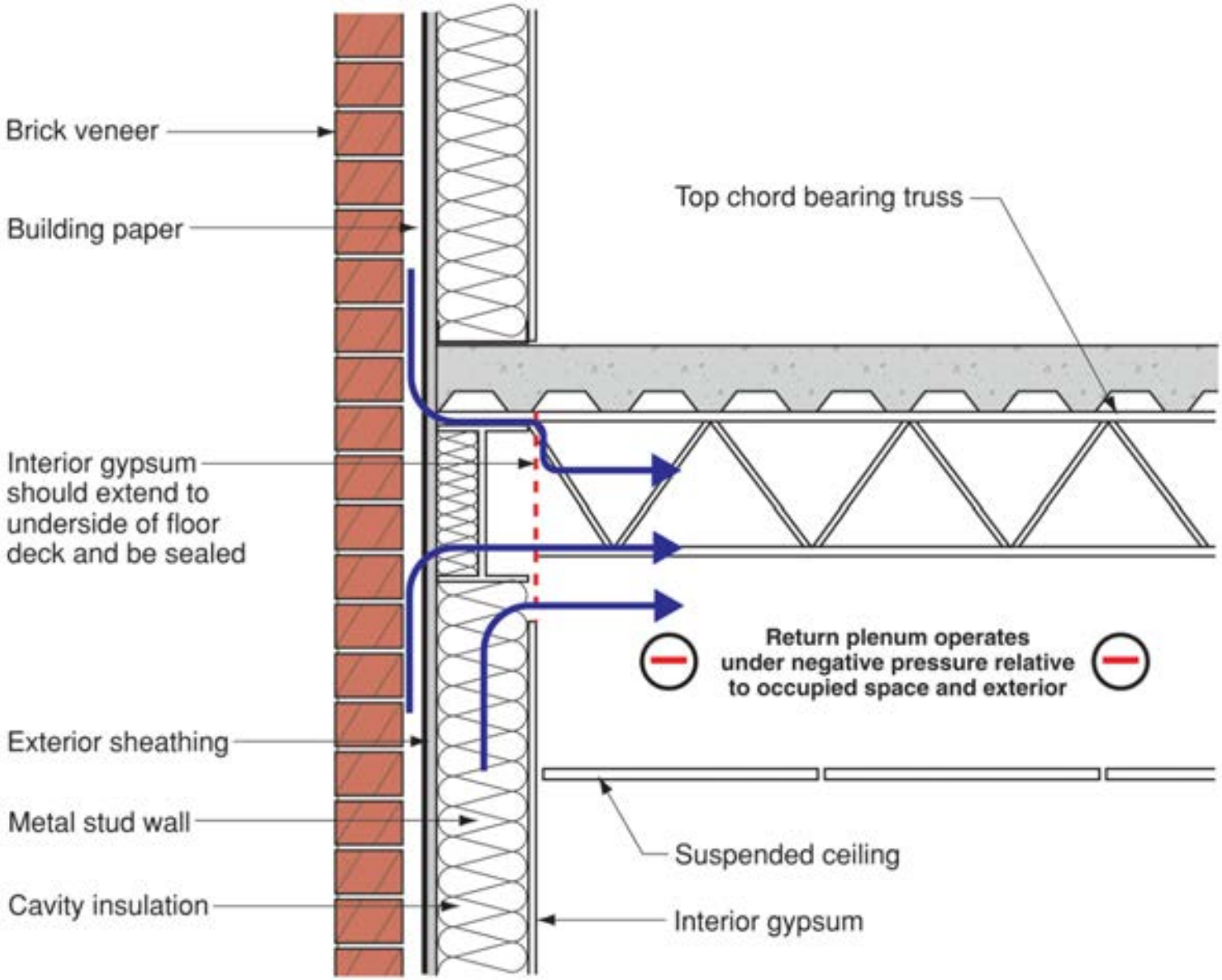
Path

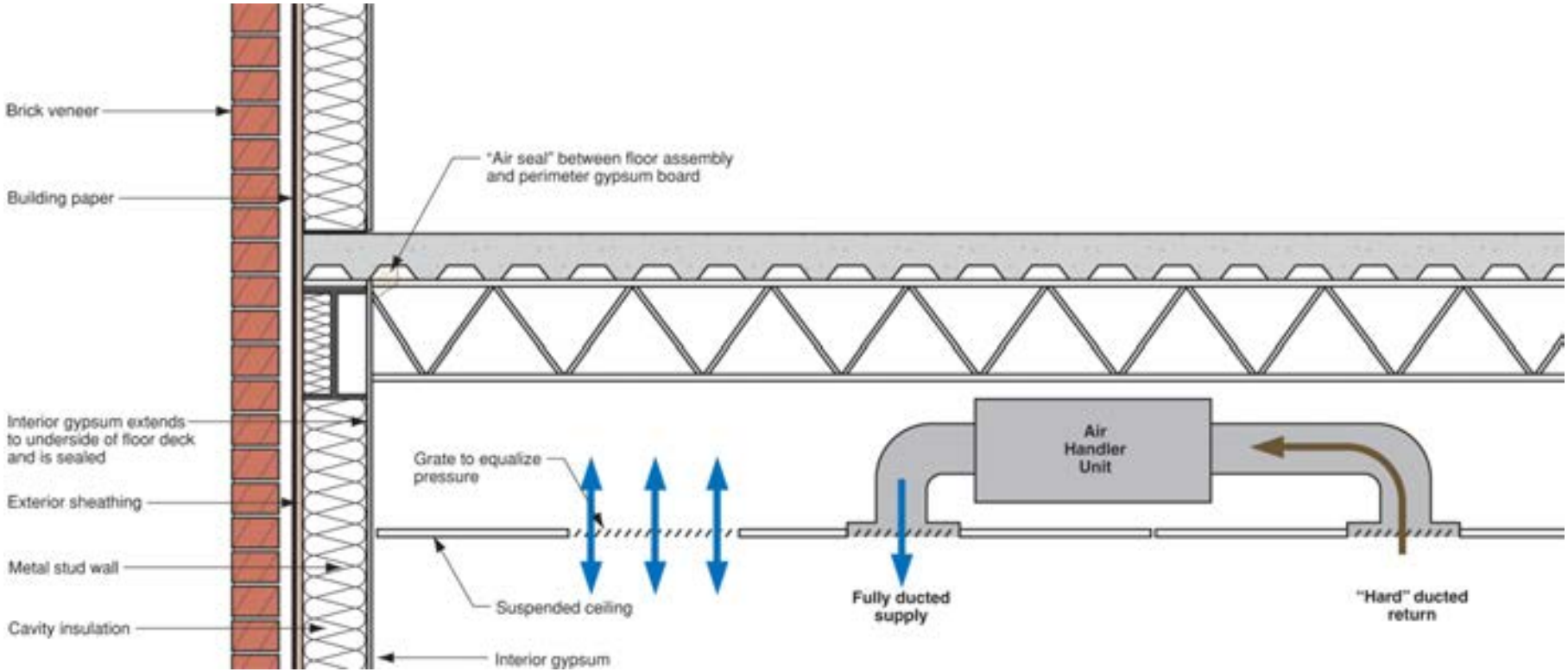
Pressure


EXIT


Supply air into occupied zone returns to AHU by passing through deliberately porous dropped ceiling or through return grilles installed in dropped ceiling
Air handling unit extracts air from dropped ceiling, conditions it and injects it into the occupied zones via supply ductwork
Dropped ceiling depressurized by air handling units extracting air from dropped ceiling
Air handling unit
Air handling unit
Occupied Zone


Air barrier system not present to prevent air from being extracted from roof assembly
Corrugated metal roof deck
Membrane roof
Rigid insulation
Brick veneer
Building paper
Interior gypsum should extend to underside of roof deck and be sealed
3
4
2
1
Return plenum operates under negative pressure relative to occupied space and exterior
Suspended ceiling
Exterior sheathing
Top chord bearing roof truss
Metal stud wall
Cavity insulation
Interior gypsum


Brick veneer
Building paper
Top chord bearing truss
Interior gypsum should extend to underside of floor deck and be sealed
Return plenum operates under negative pressure relative to occupied space and exterior
Exterior sheathing
Metal stud wall
Suspended ceiling
Cavity insulation
Interior gypsum


Brick veneer
Building paper
"Air seal" between floor assembly and perimeter gypsum board
Interior gypsum extends to underside of floor deck and is sealed
Exterior sheathing
Metal stud wall
Cavity insulation
Grate to equalize pressure
Suspended ceiling
Interior gypsum
Air Handler Unit
Fully ducted supply
"Hard" ducted return

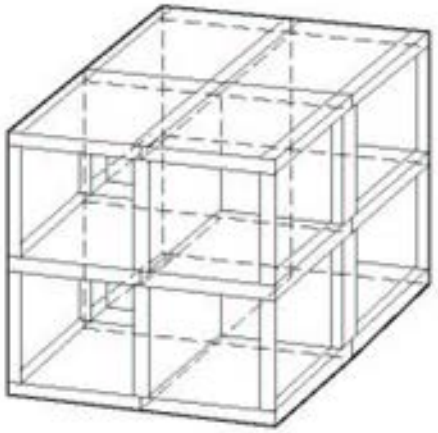


Figure 2.11
Three Dimensional Multi-Layer Multi-Cell Analogue

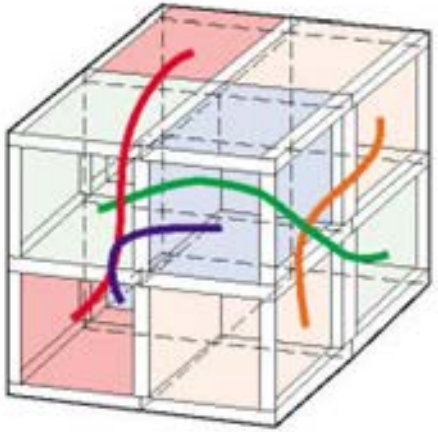


Figure 2.12
Three Dimensional Multi-Layer Multi-Cell Non-Contiguous Analogue

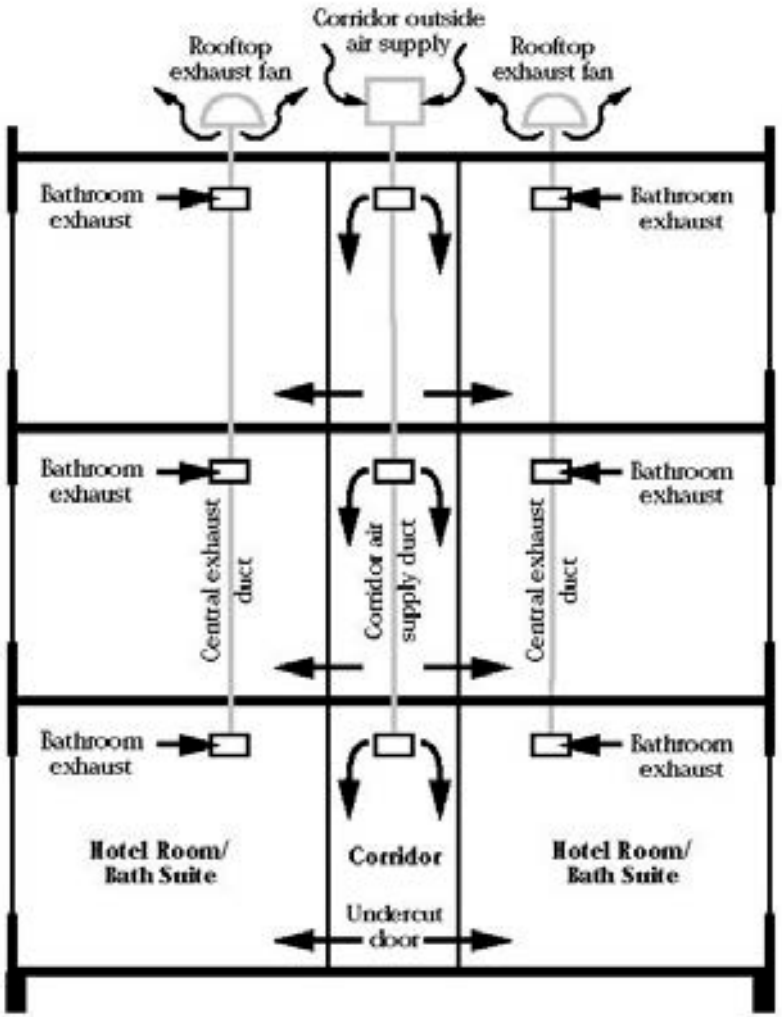
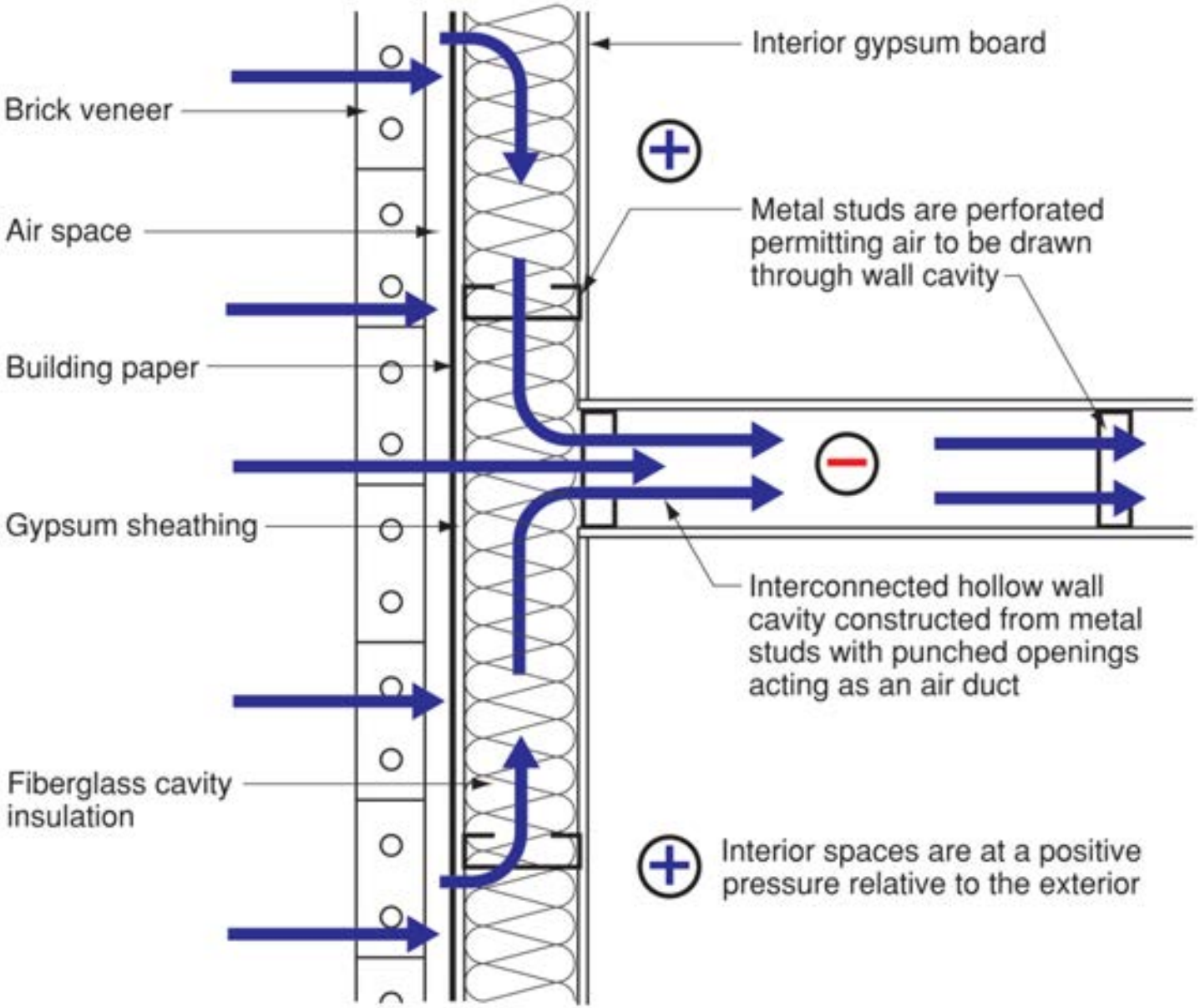
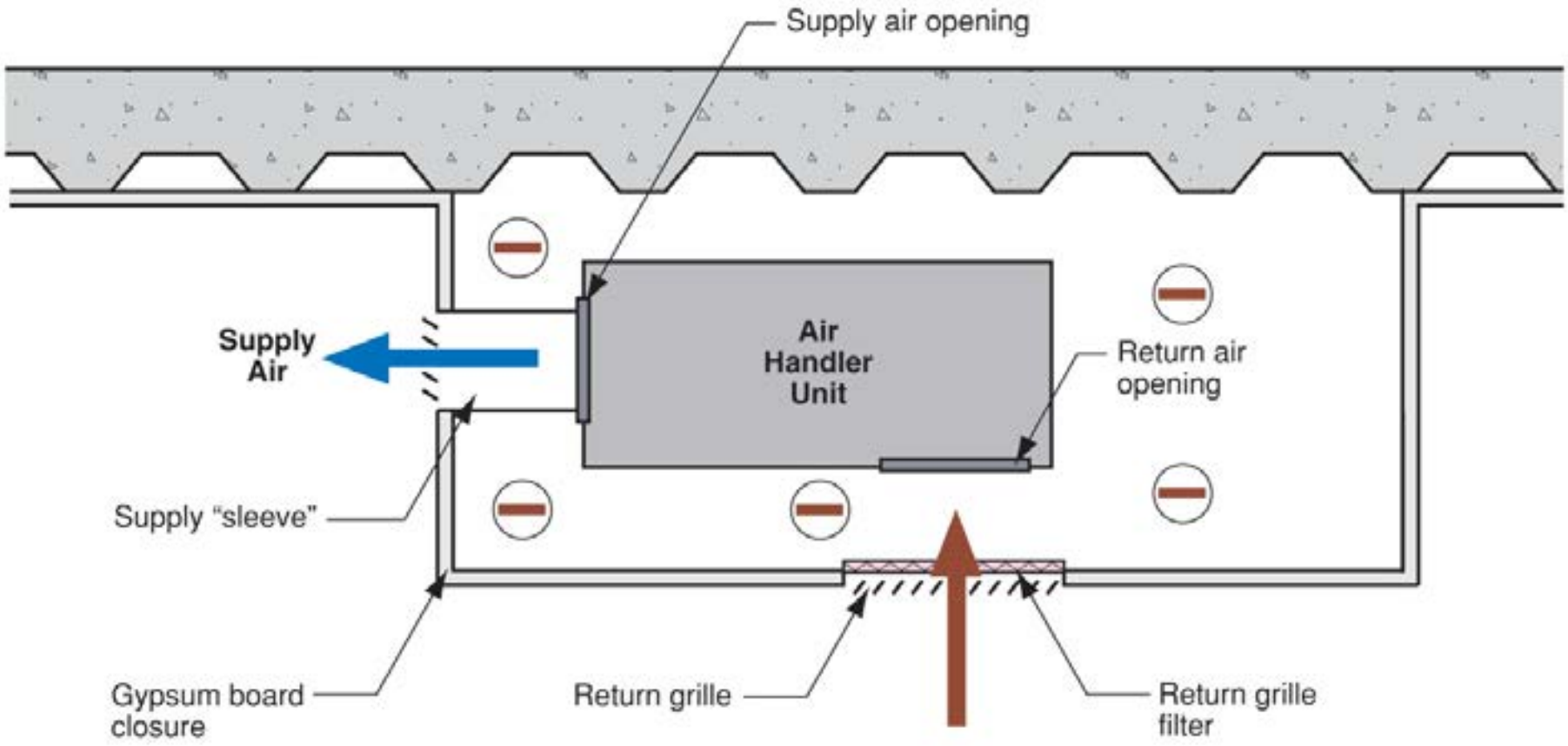


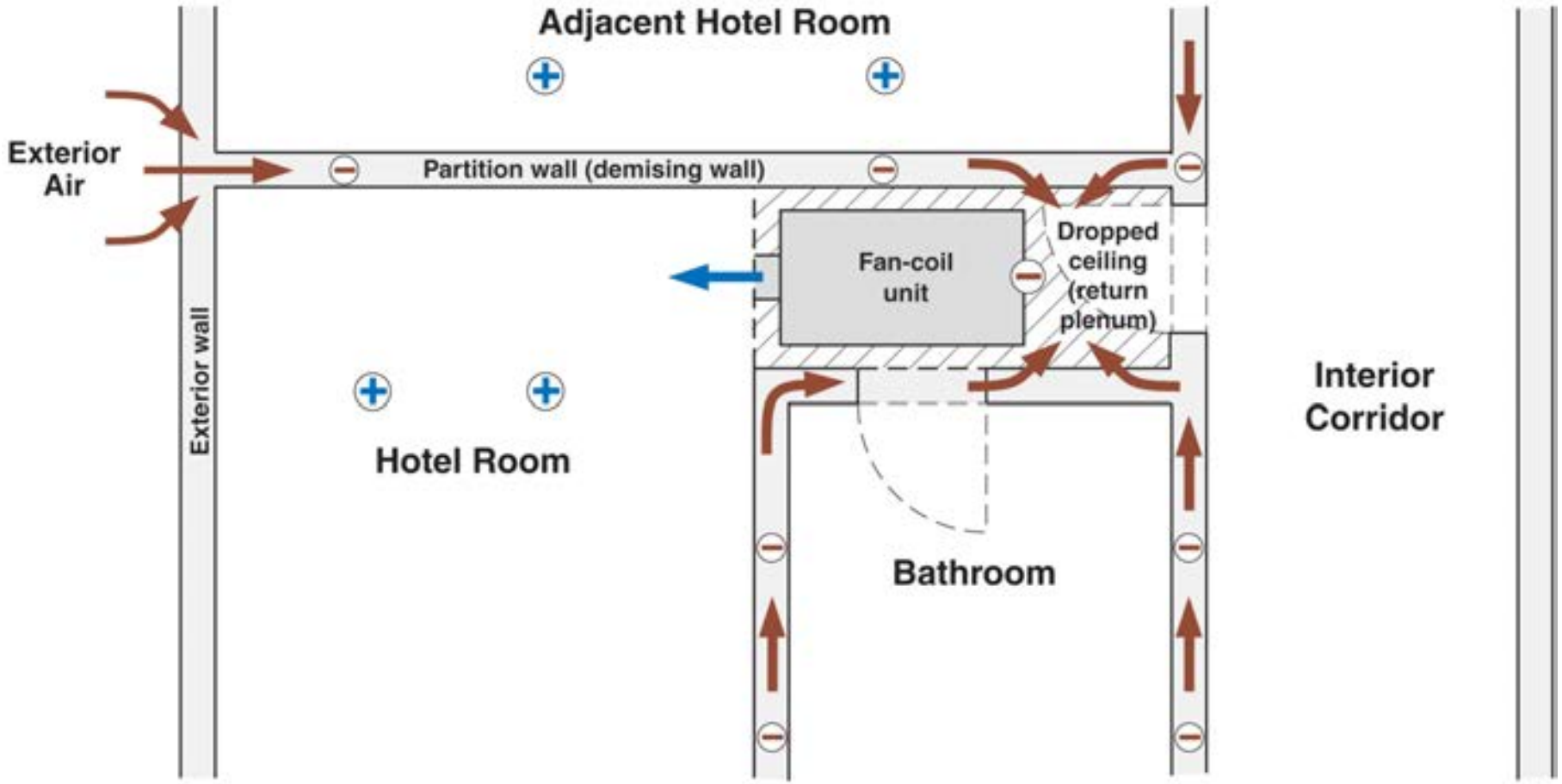
Figure 3.8

Hotel HVAC System

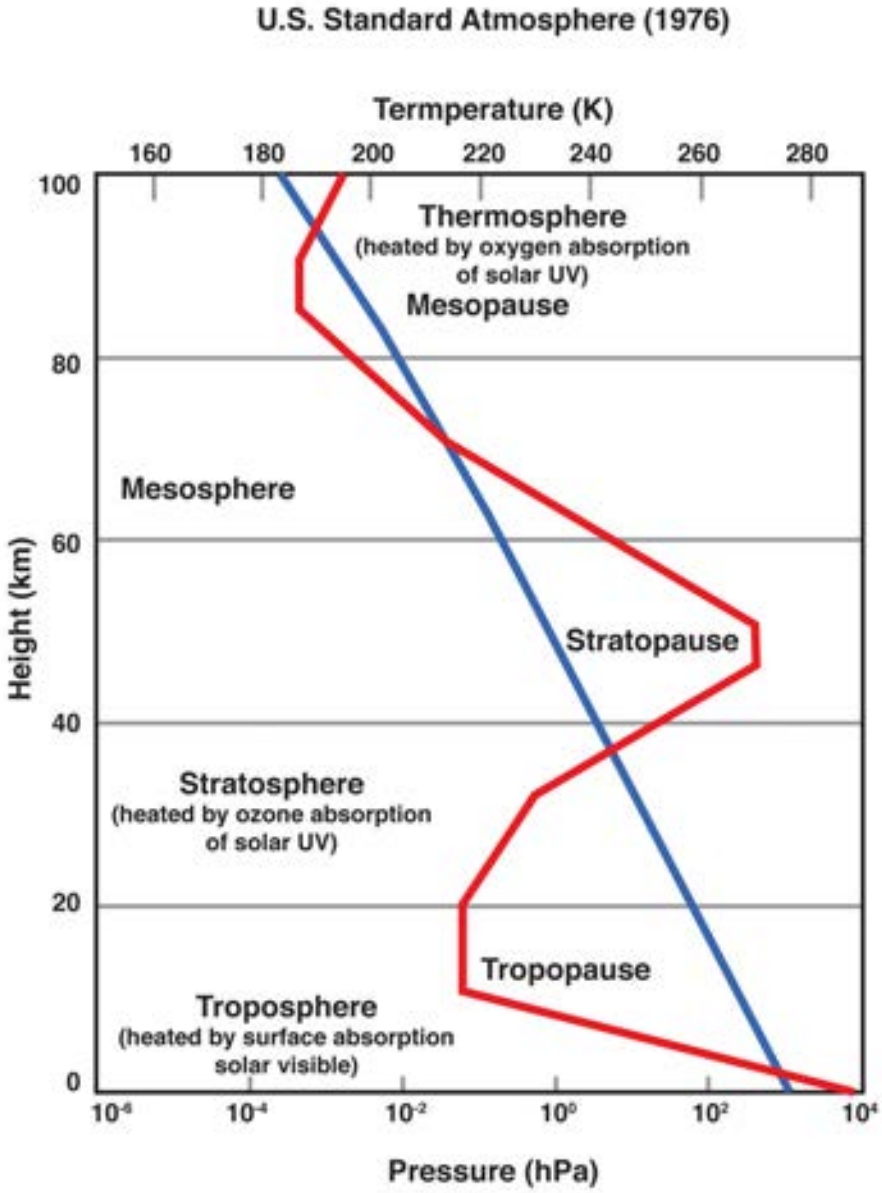
- Air exhausted from bathrooms via central rooftop exhaust fans
- Air supplied from corridors via undercut doors


Brick veneer
Air space
Building paper
Gypsum sheathing
Fiberglass cavity insulation
Interior gypsum board
Metal studs are perforated permitting air to be drawn through wall cavity
Interconnected hollow wall cavity constructed from metal studs with punched openings acting as an air duct
Interior spaces are at a positive pressure relative to the exterior


Supply air opening
Supply
Air
Air
Handler
Unit
Return air
opening
Supply "sleeve"
Gypsum board
closure
Return grille
Return grille
filter


Adjacent Hotel Room
Exterior Air
Partition wall (demising wall)
Exterior wall
Fan-coil unit
Dropped ceiling (return plenum)
Interior Corridor
Hotel Room
Bathroom

Lapse Rate


U.S. Standard Atmosphere (1976)
Termperature (K)
160
180
200
220
240
260
280
100
80
60
40
20
0
Height (km)
Thermosphere
(heated by oxygen absorption
of solar UV)
Mesopause
Mesosphere
Stratopause
Stratosphere
(heated by ozone absorption
of solar UV)
Tropopause
Troposphere
(heated by surface absorption
solar visible)
10^{-6}
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
Pressure (hPa)

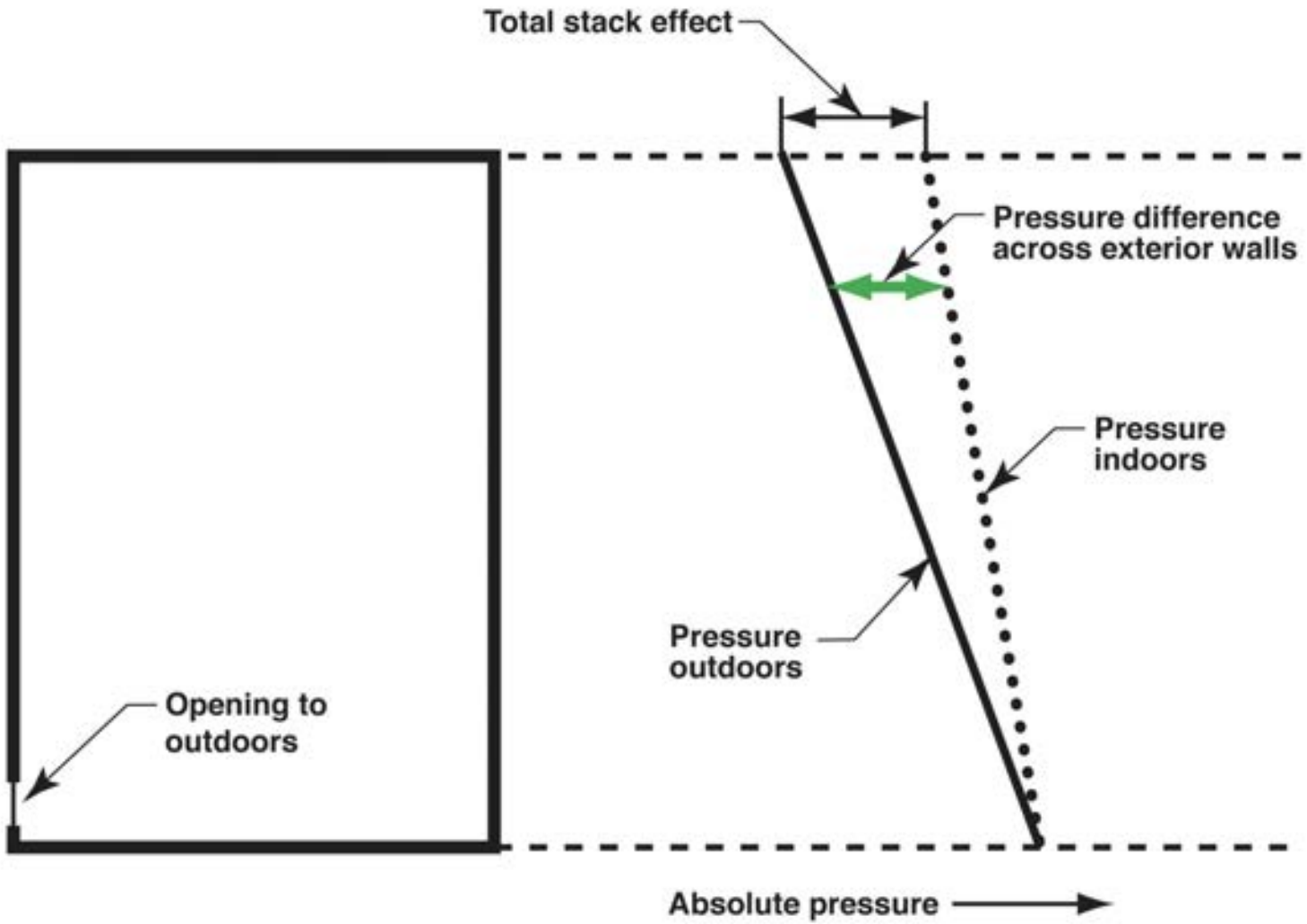


Figure 11.1: Building with no internal separations with opening at the bottom (Adapted from G.O. Handegord, 1998)

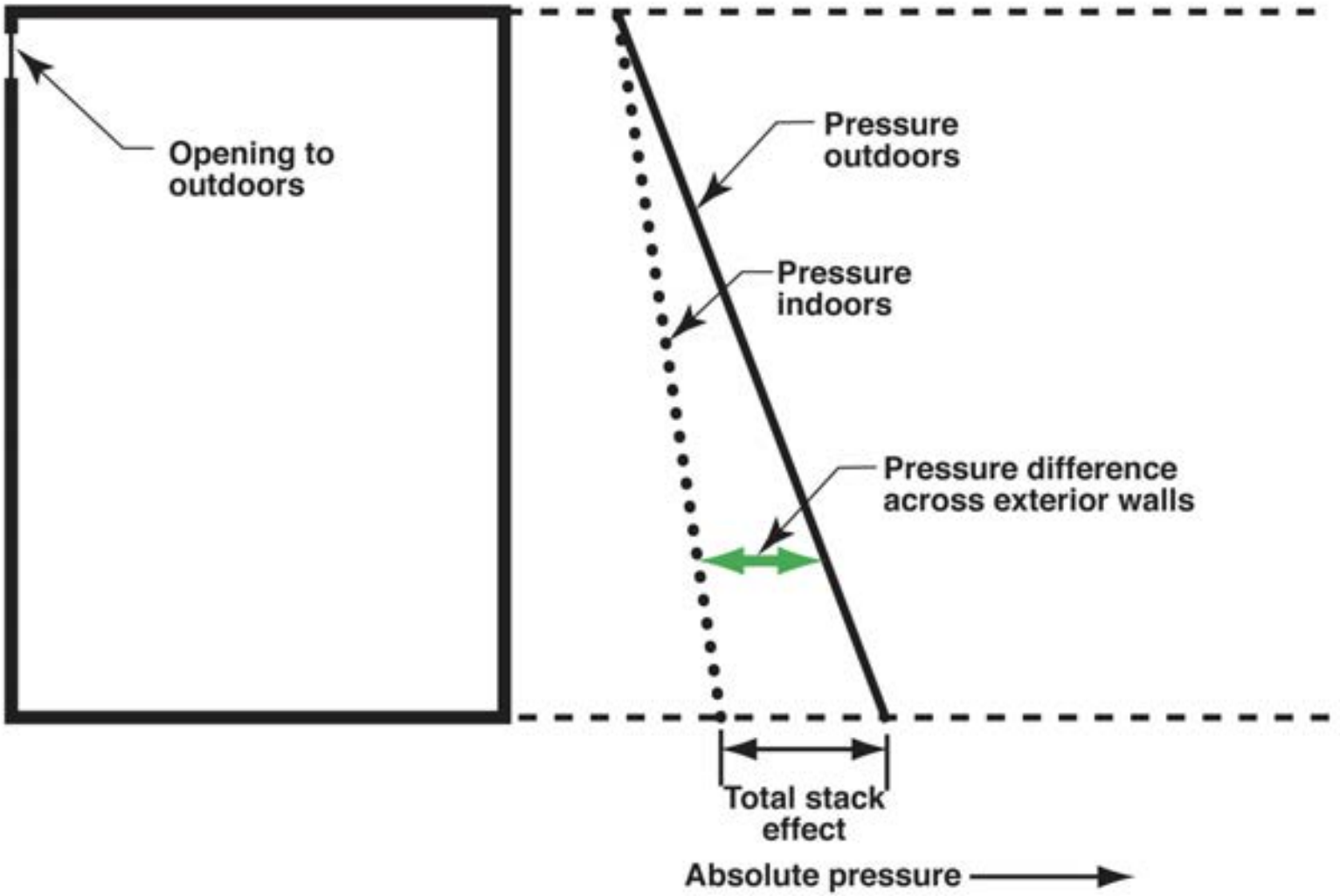


Figure 11.2: Building with no internal separations with opening at the top (Adapted from G.O. Handegord, 1998)

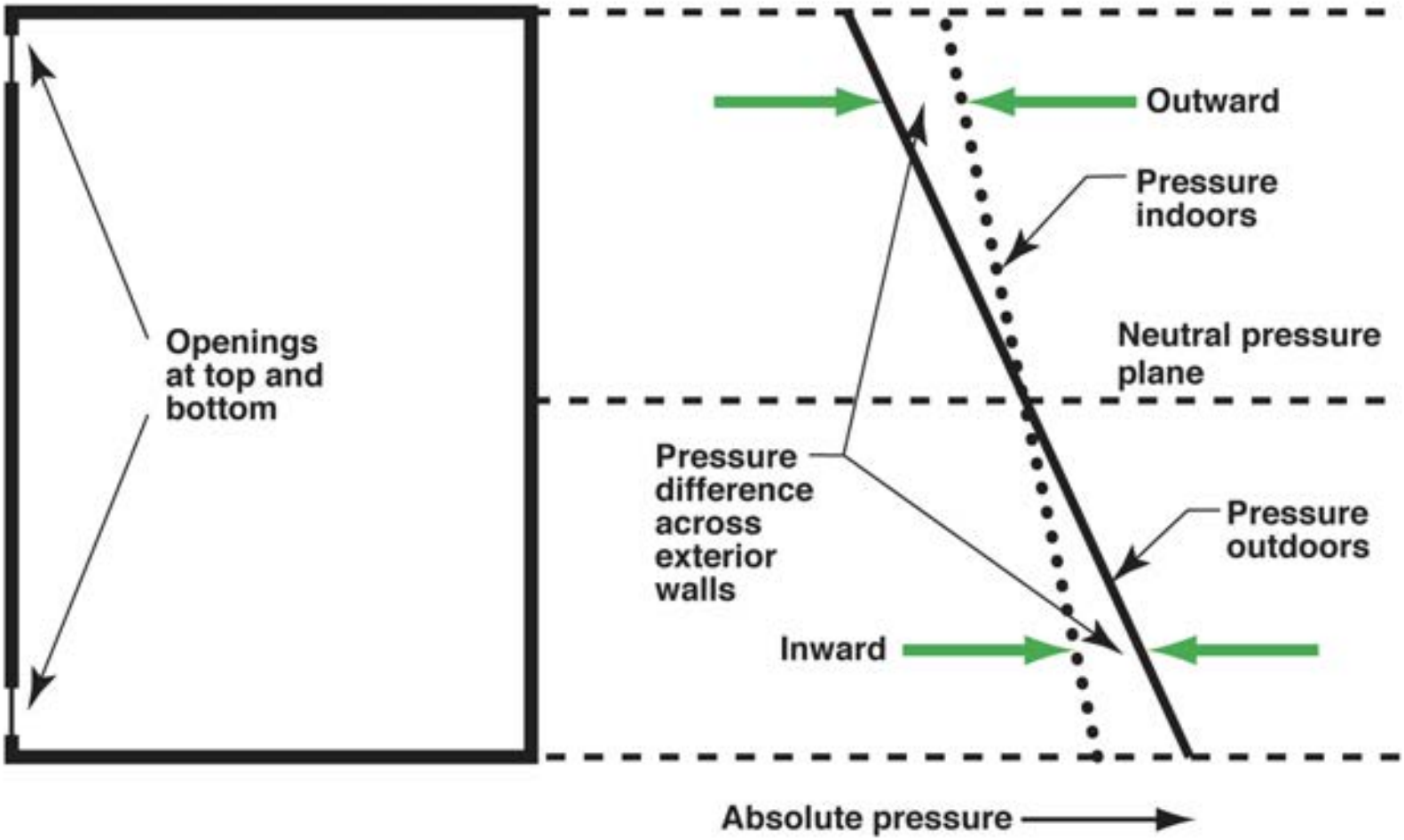


Figure 11.3: Building with no internal separations with openings at top and bottom (Adapted from G.O. Handegord, 1998)

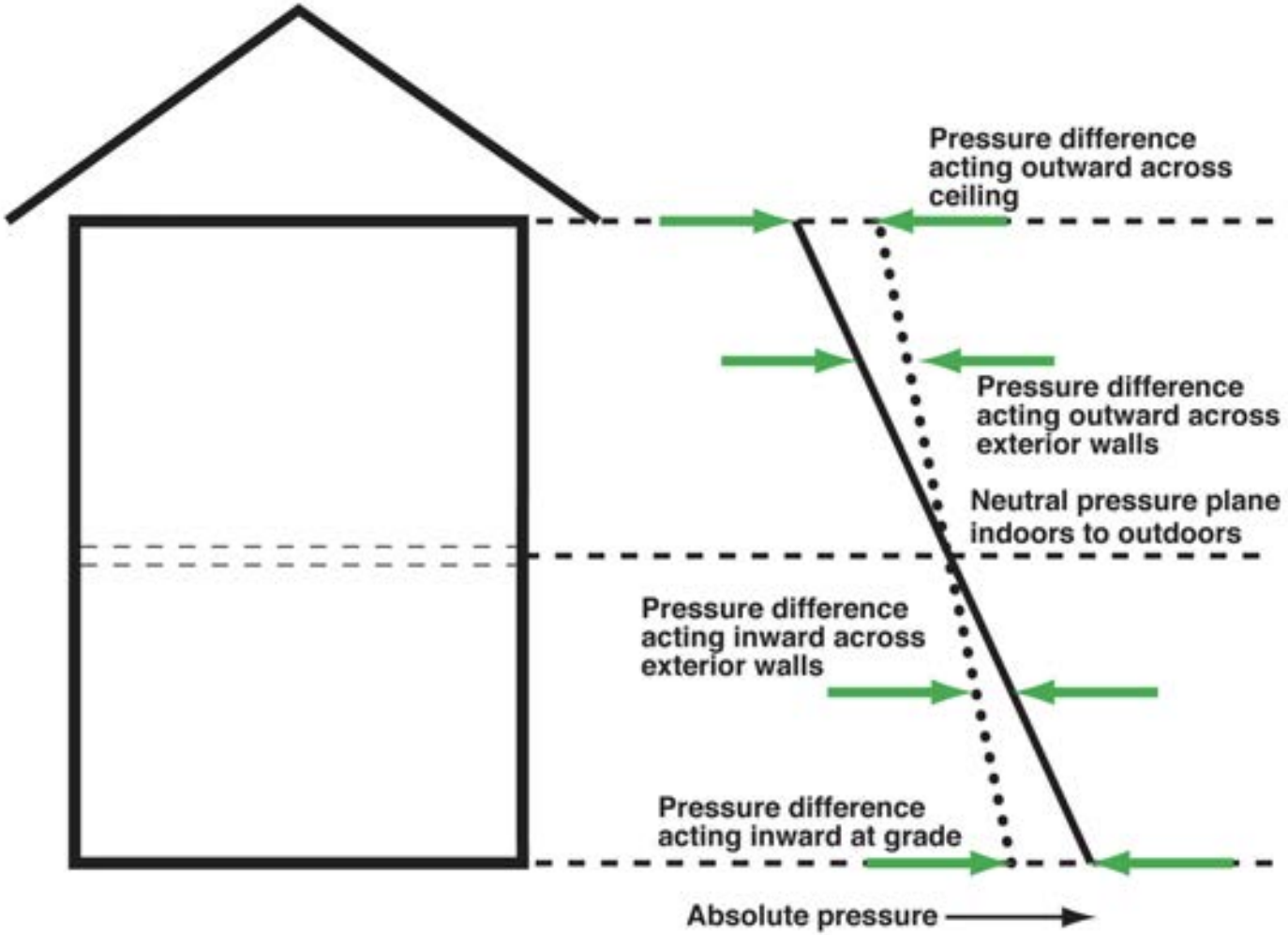
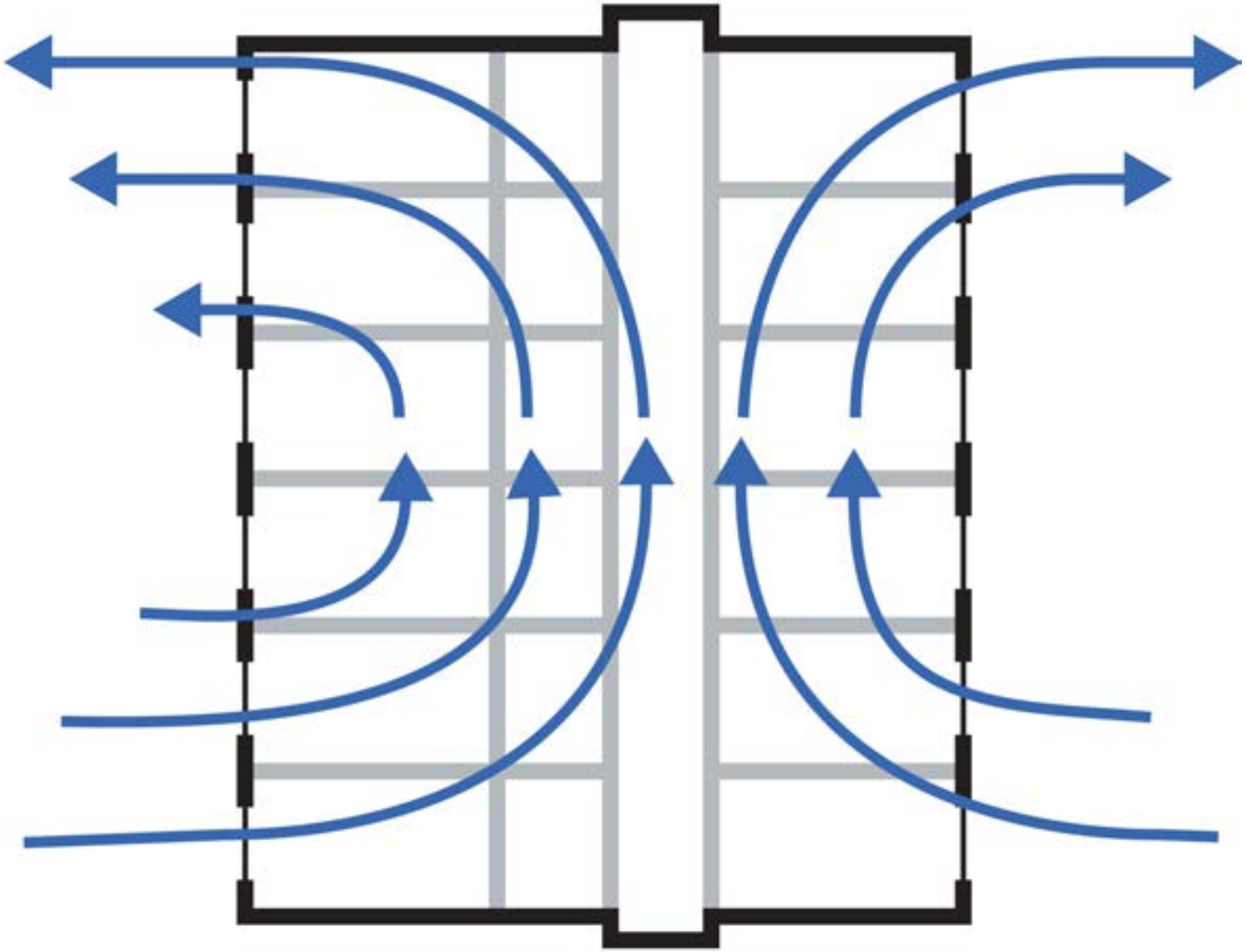
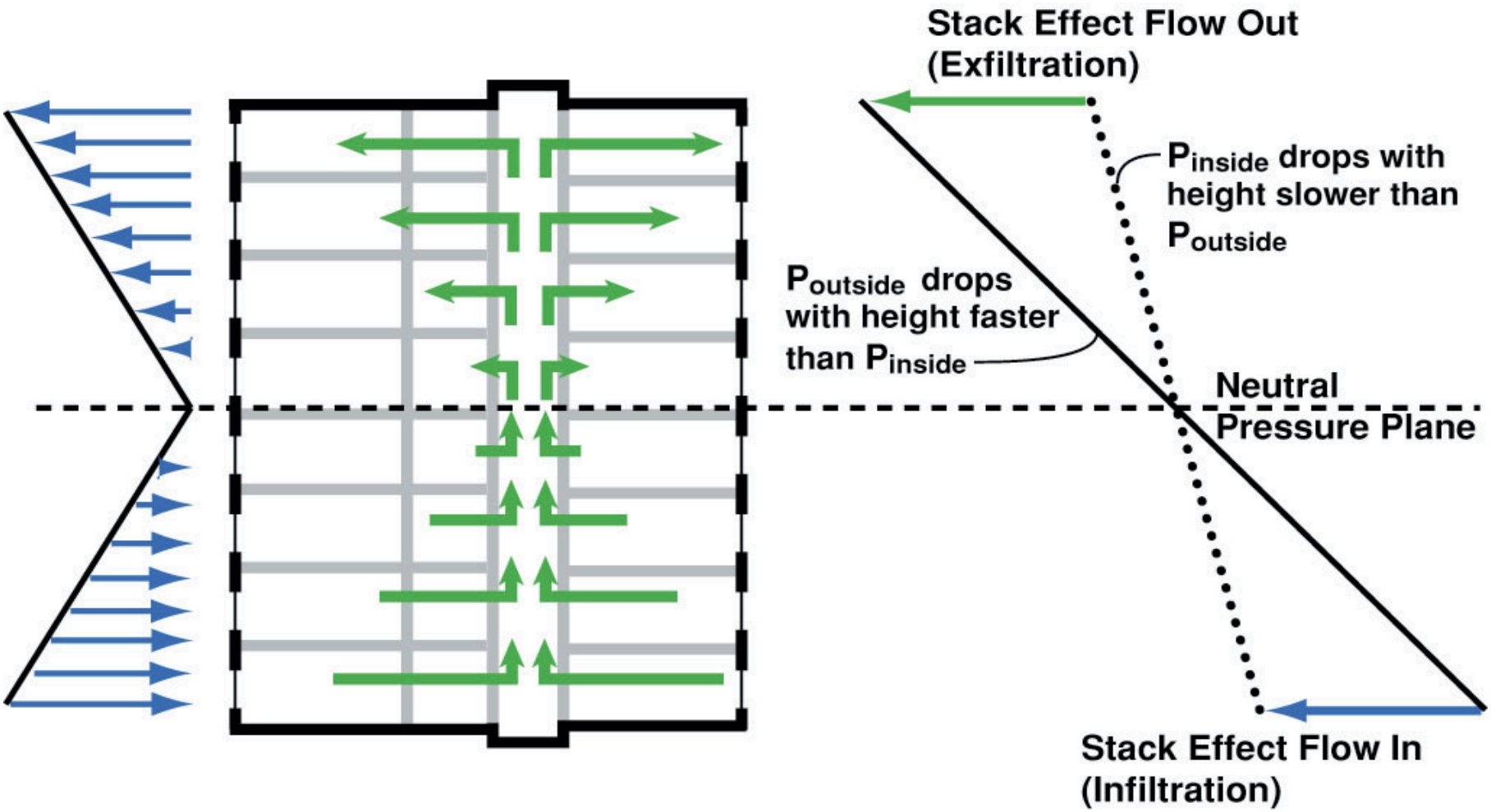


Figure 11.4: Basic two storey house with vented attic
(Adapted from G.O. Handegord, 1998)


POMPIERS NO. 3




Stack Effect Flow Out
(Exfiltration)
Pinside drops with
height slower than
Poutside
Poutside drops
with height faster
than Pinside
Neutral
Pressure Plane
Stack Effect Flow In
(Infiltration)

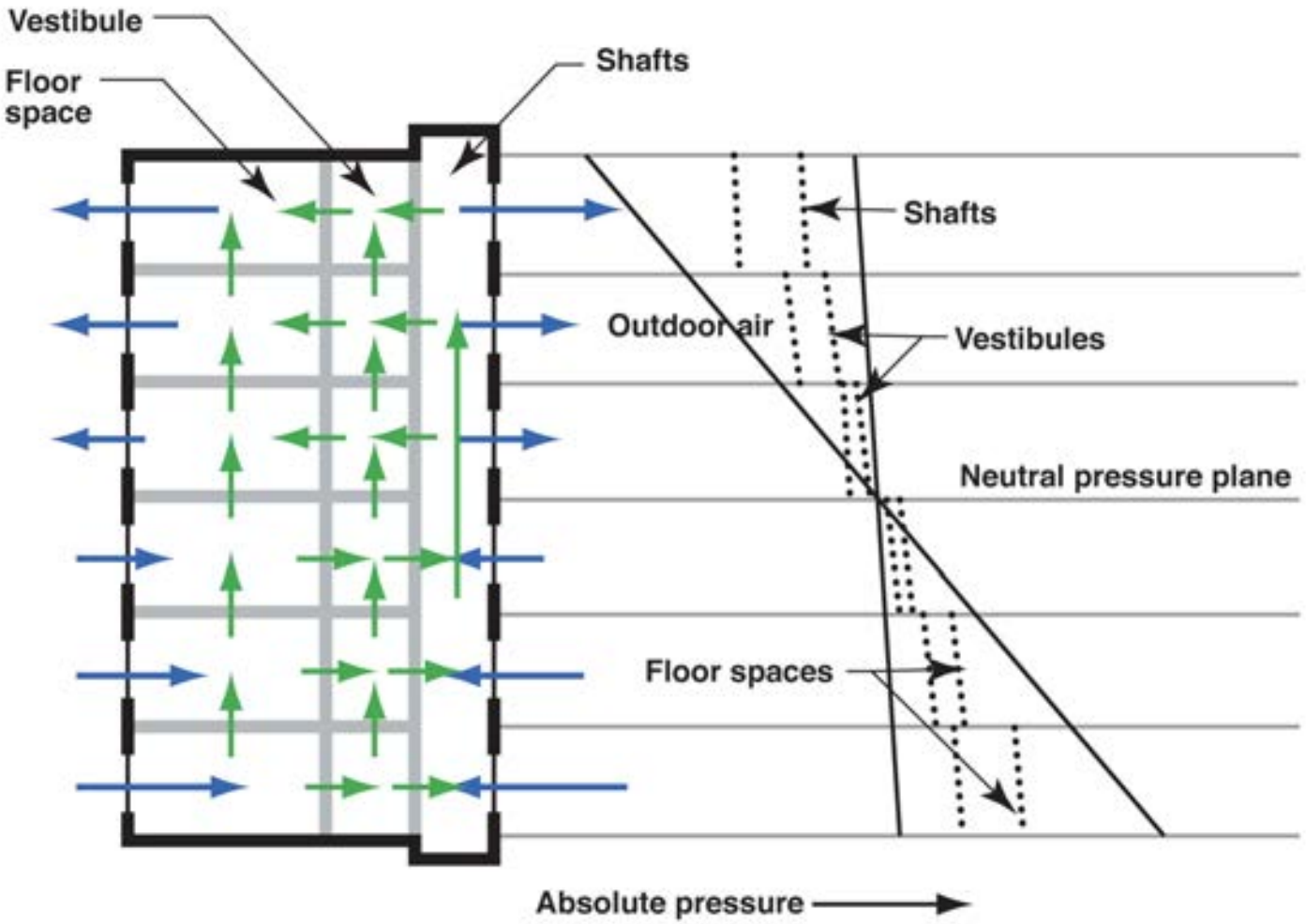


Figure 11.8: Stack effect pressures in high rise office building (Adapted from G.O. Handegord, 1998)

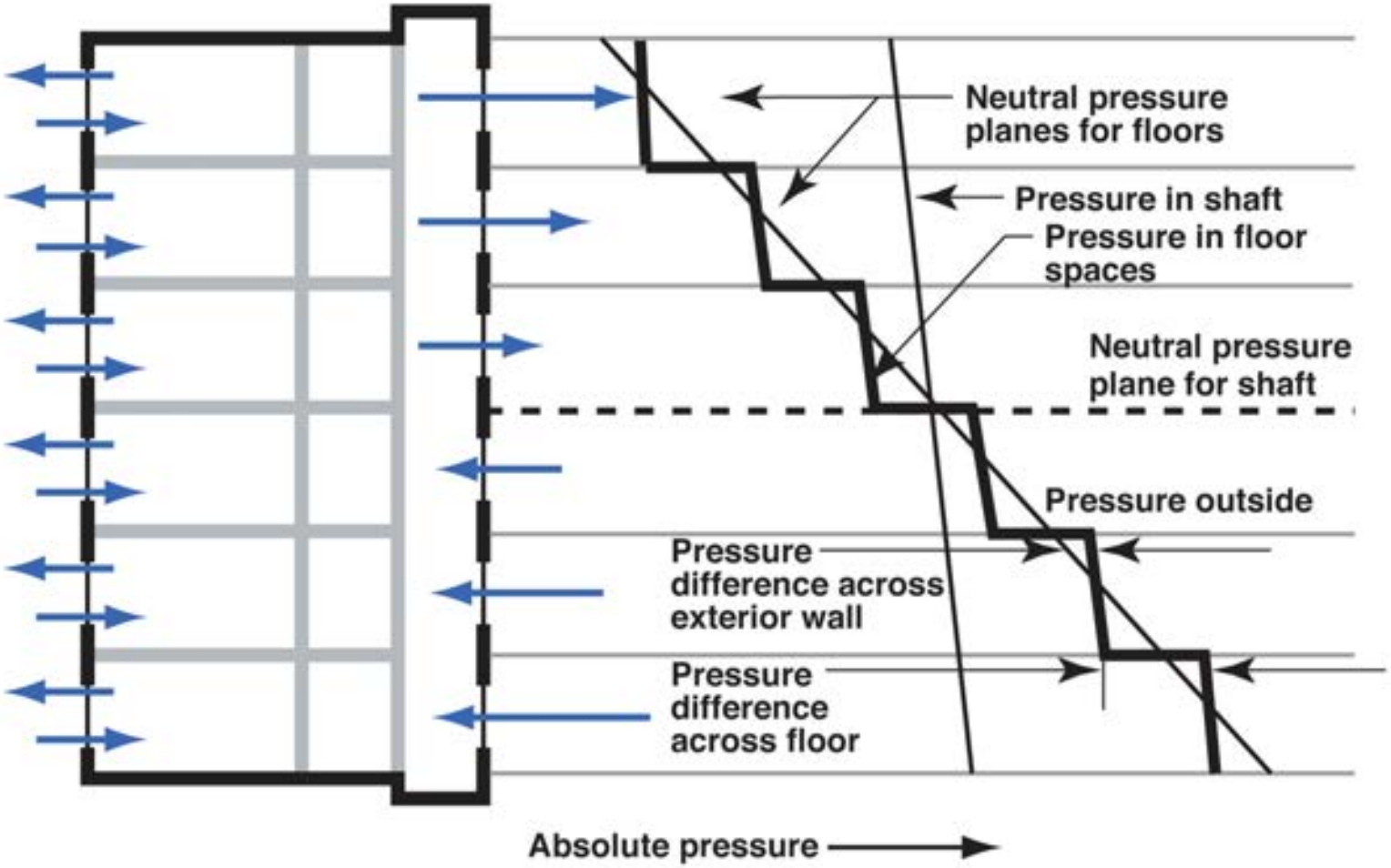


Figure 11.9: Multi-storey building with floor spaces isolated from vertical shafts (Adapted from G.O. Handegord, 1998)

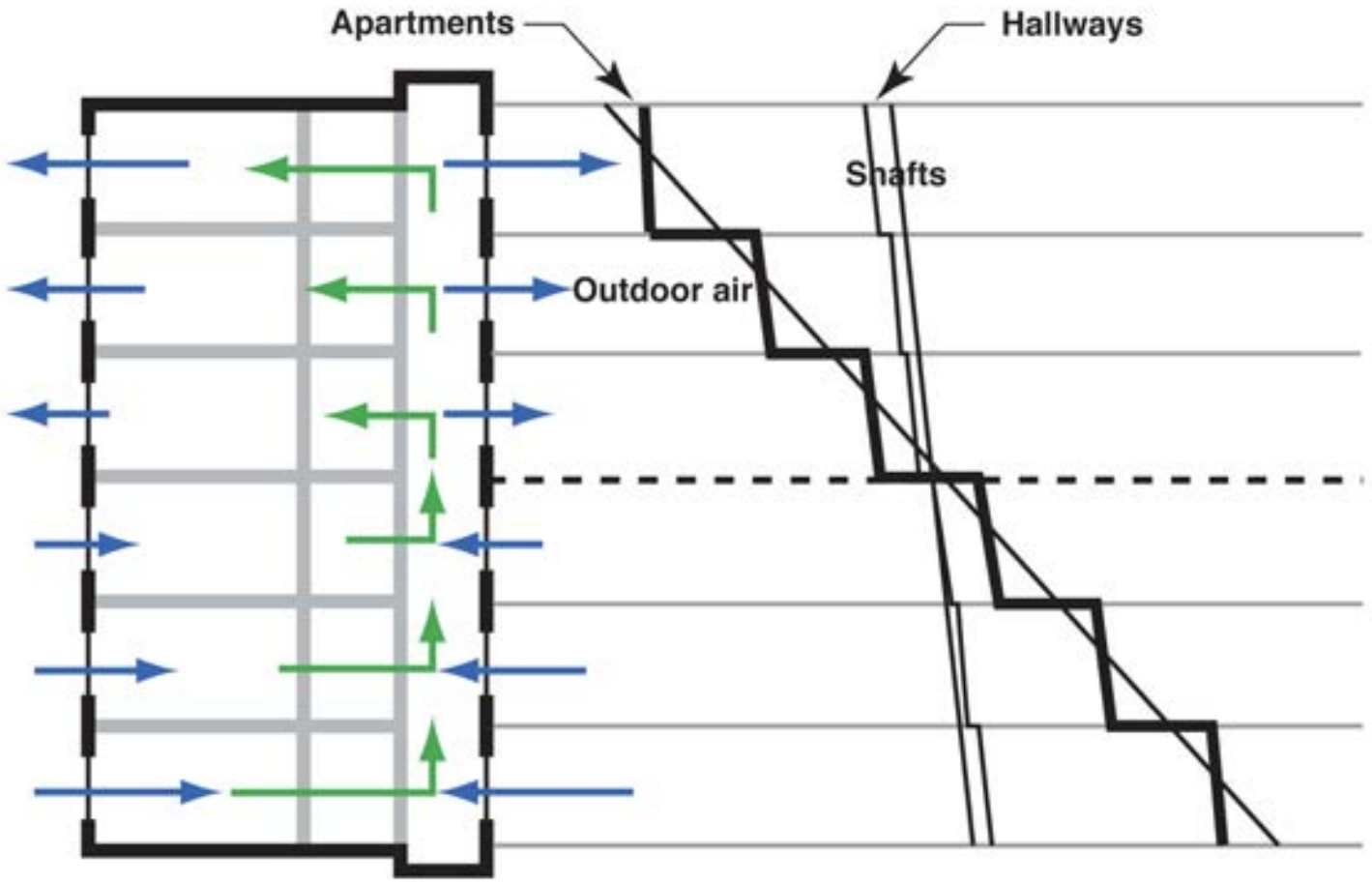
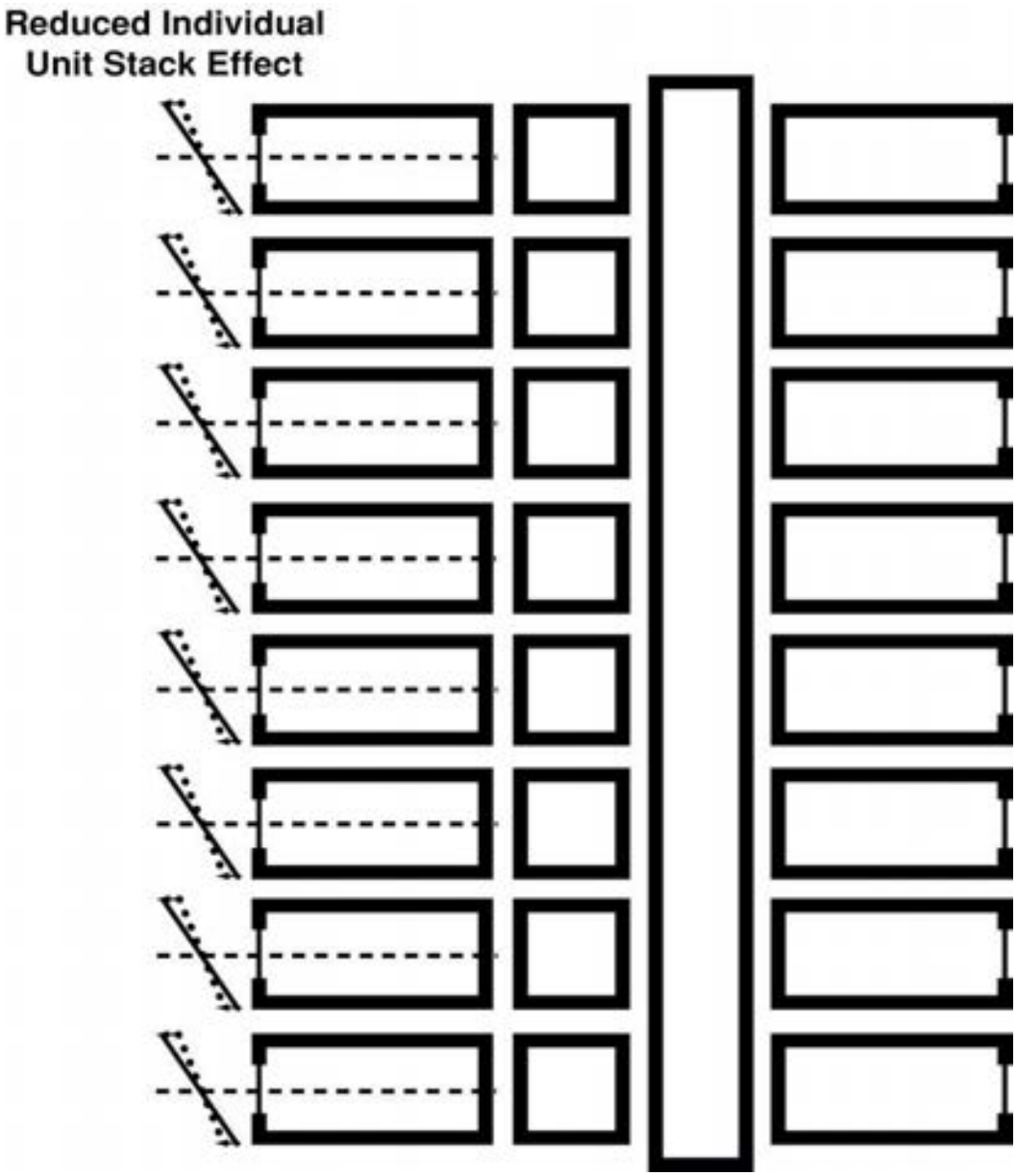
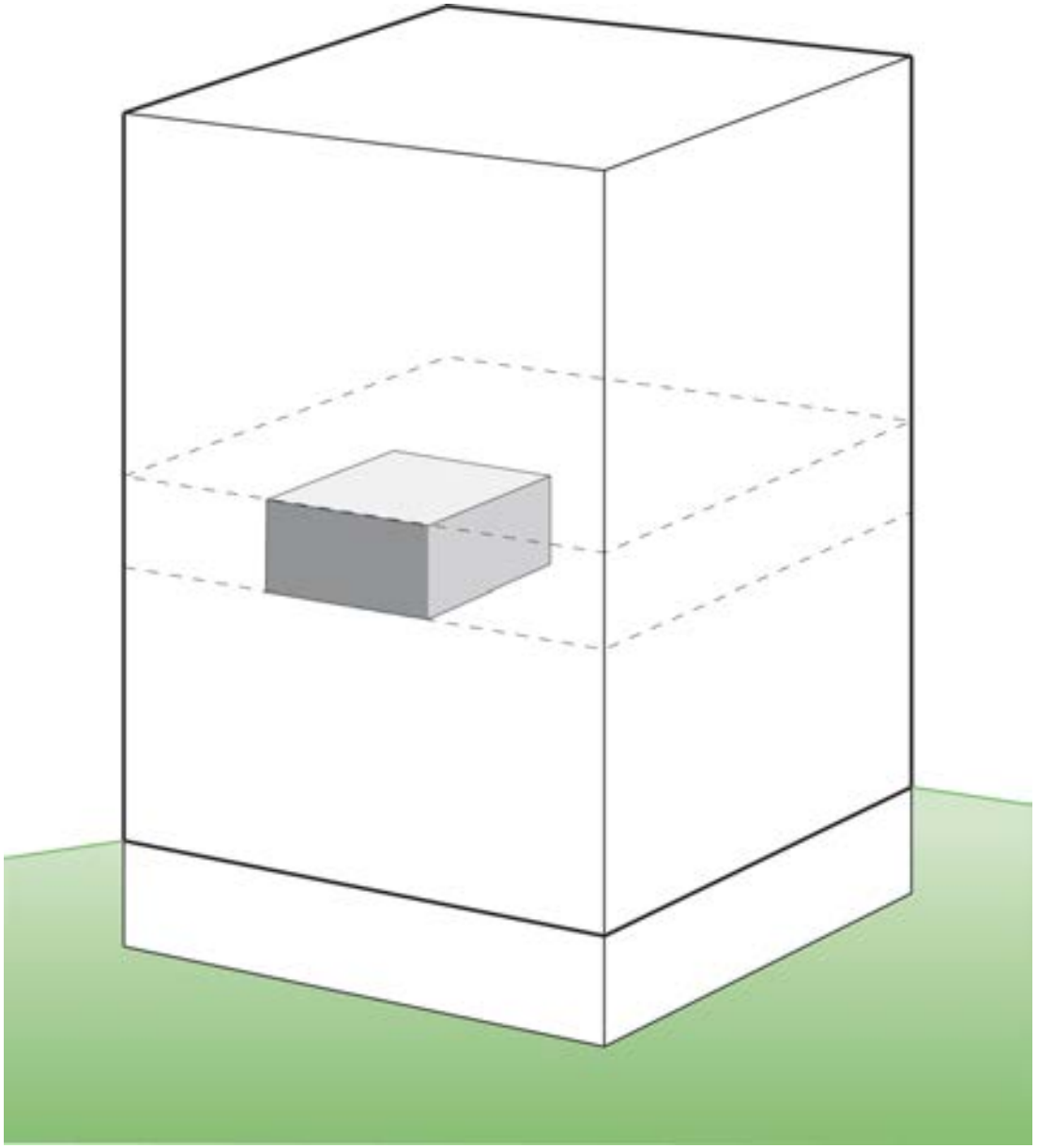


Figure 11.12: Apartment building with tighter apartment entry doors (Adapted from G.O. Handegord, 1998)


Reduced Individual
Unit Stack Effect



Build Tight - Ventilate Right

Build Tight - Ventilate Right

How Tight?

What's Right?

Air Barrier Metrics

Material	0.02 l/(s-m2) @ 75 Pa
Assembly	0.20 l/(s-m2) @ 75 Pa
Enclosure	2.00 l/(s-m2) @ 75 Pa
	0.35 cfm/ft2 @ 50 Pa
	0.25 cfm/ft2 @ 50 Pa
	0.15 cfm/ft2 @ 50 Pa

Getting rid of big holes	3 ach@50
Getting rid of smaller holes	1.5 ach@50
Getting German	0.6 ach@50

As Tight as Possible - with -

Balanced Ventilation

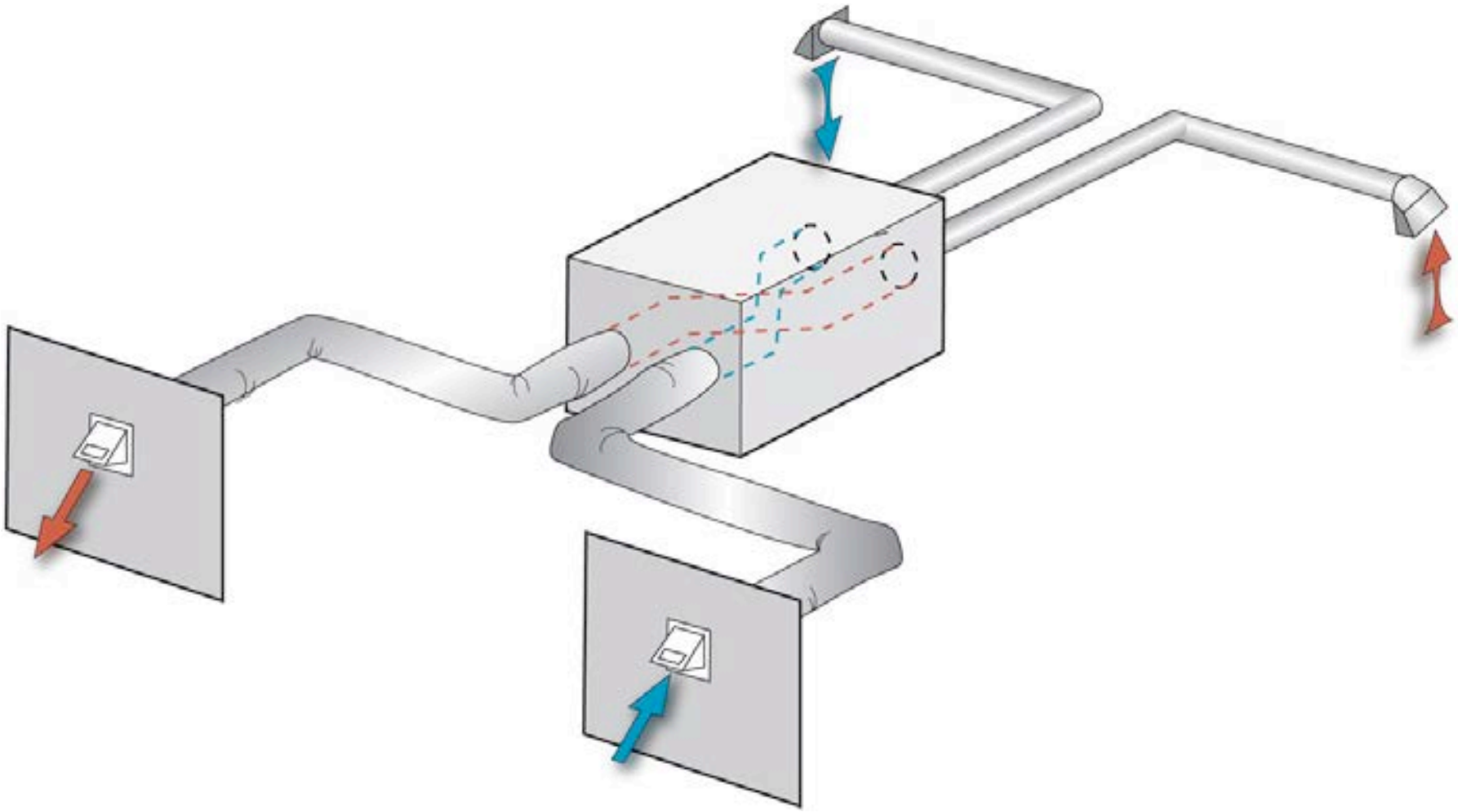
Distribution

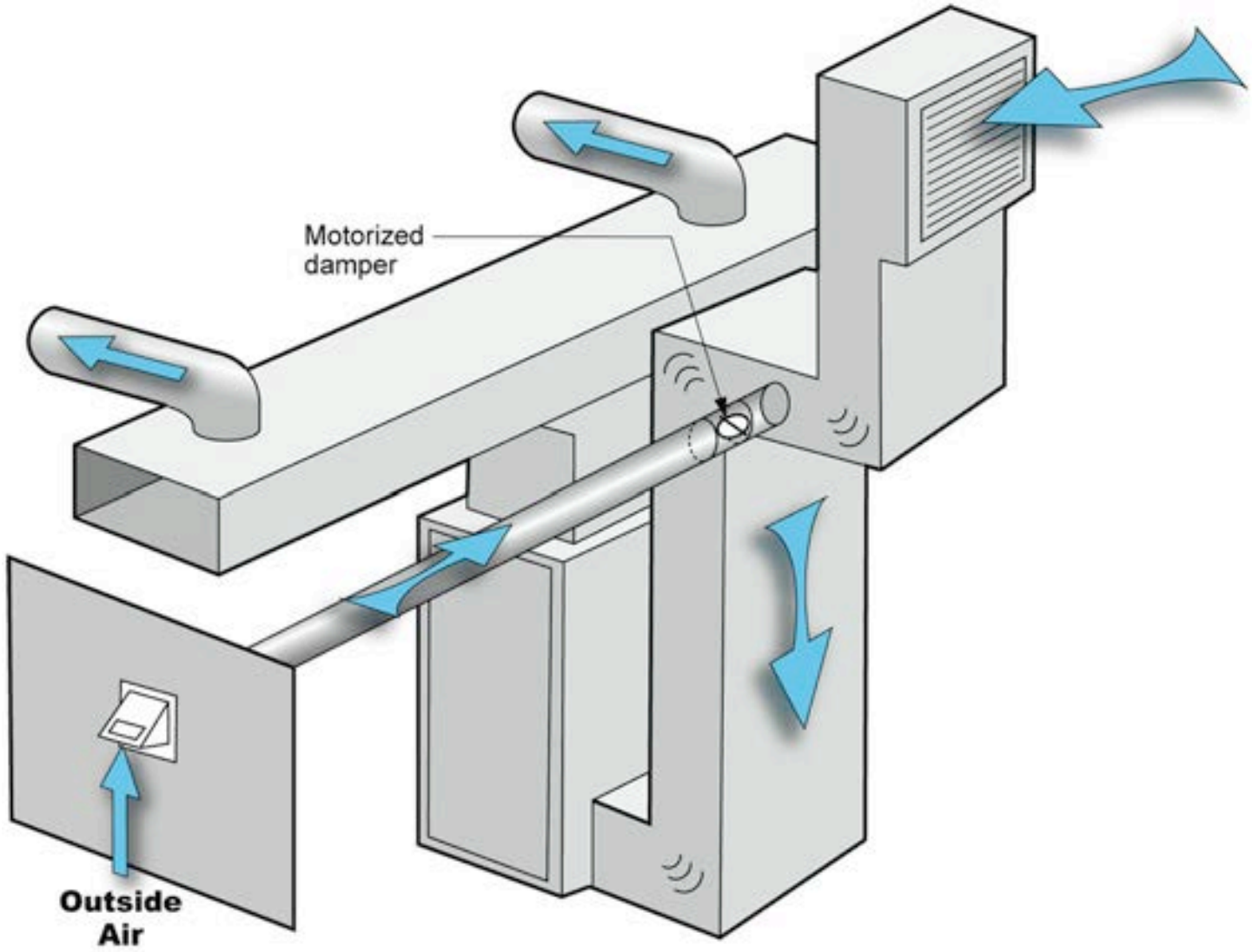
Source Control - Spot exhaust ventilation

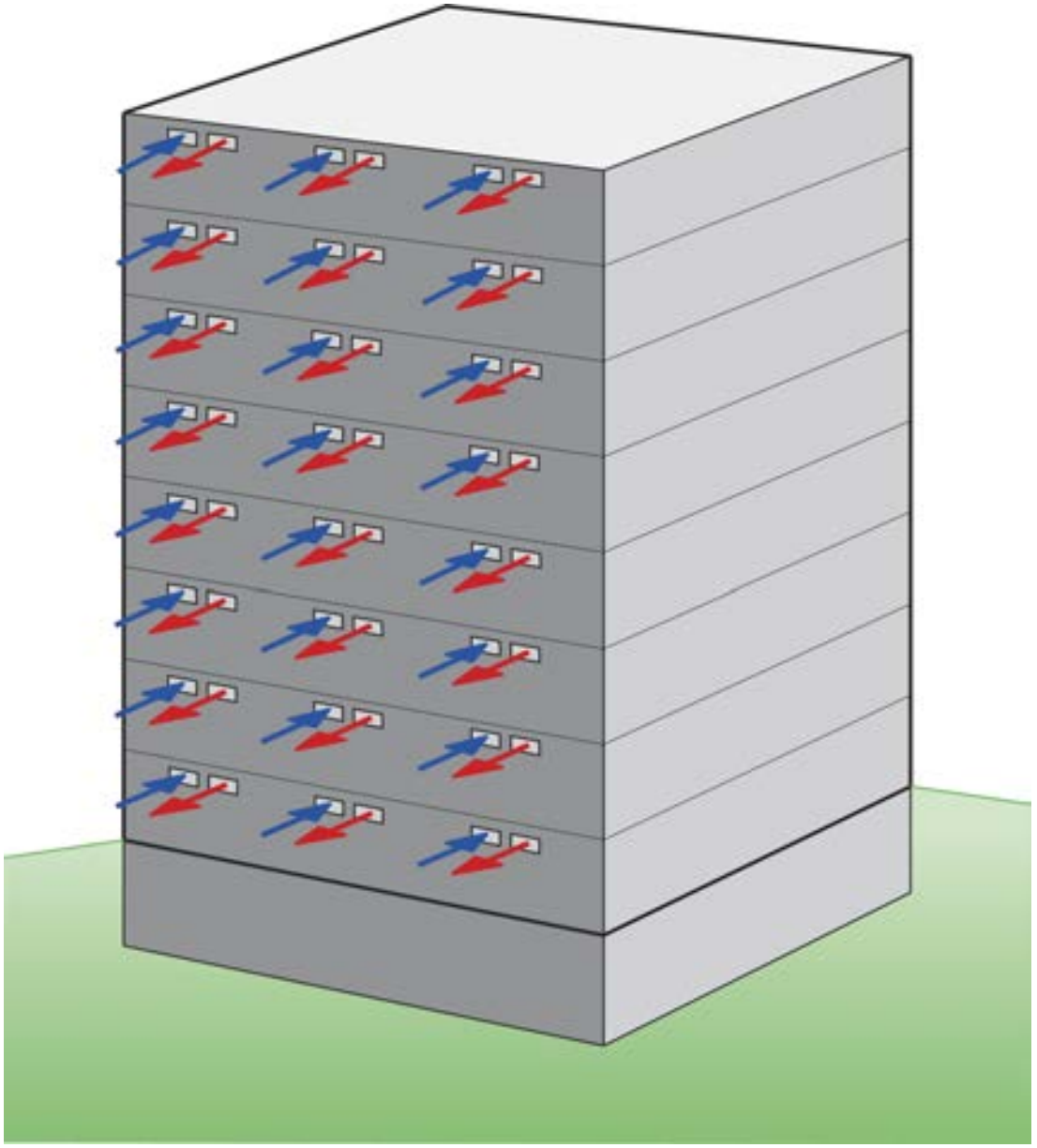
Filtration

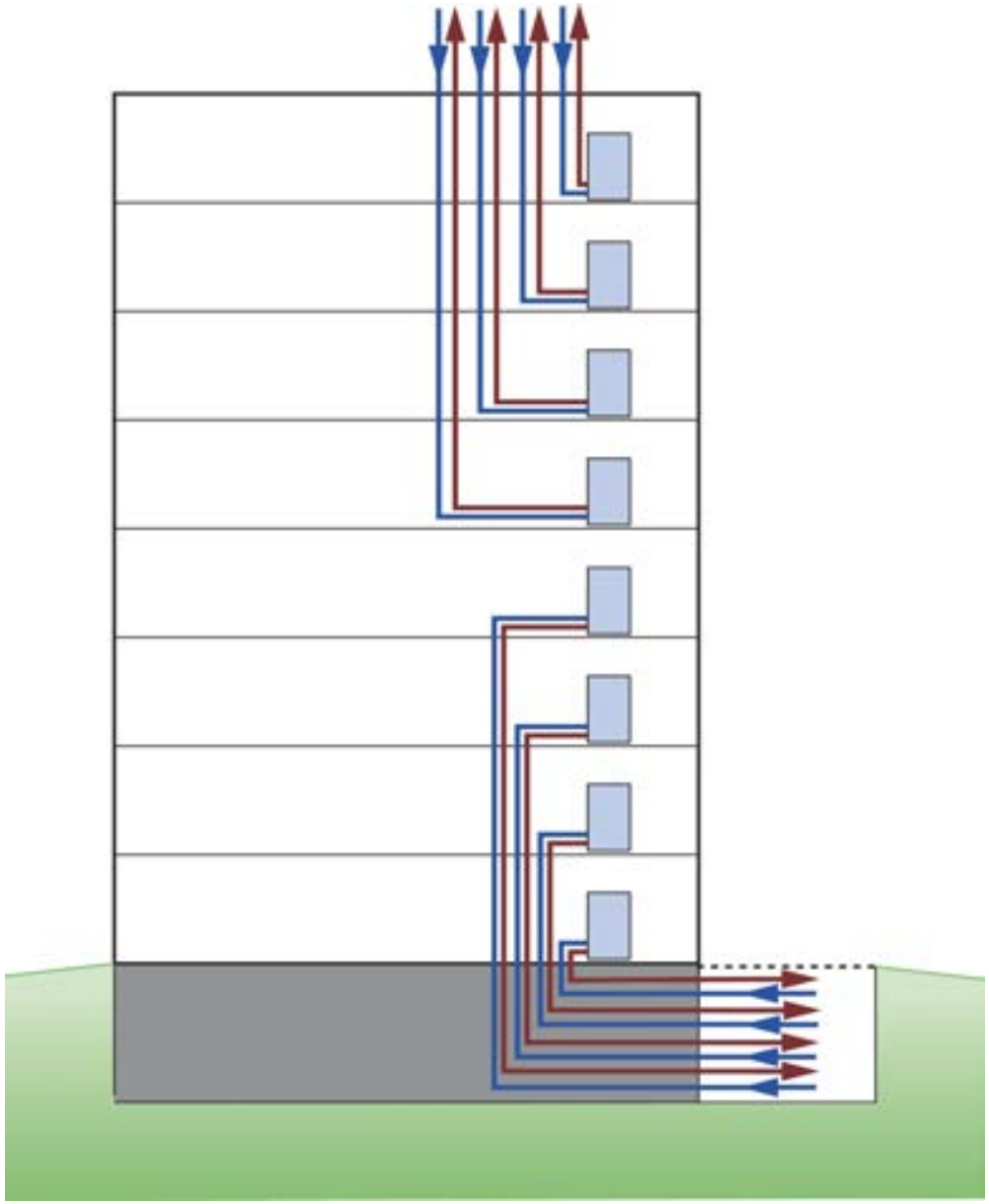
Material selection

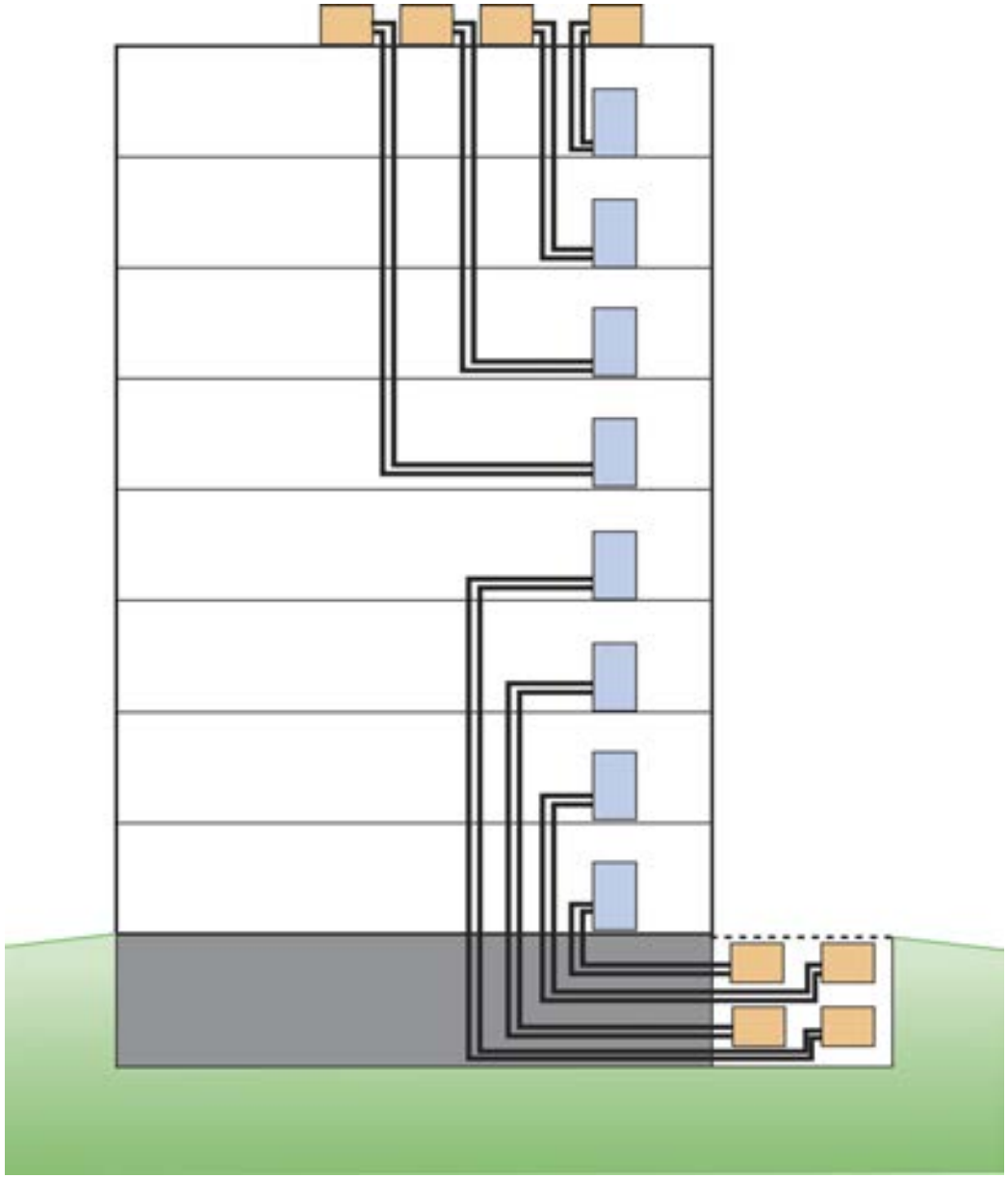
Energy Recovery

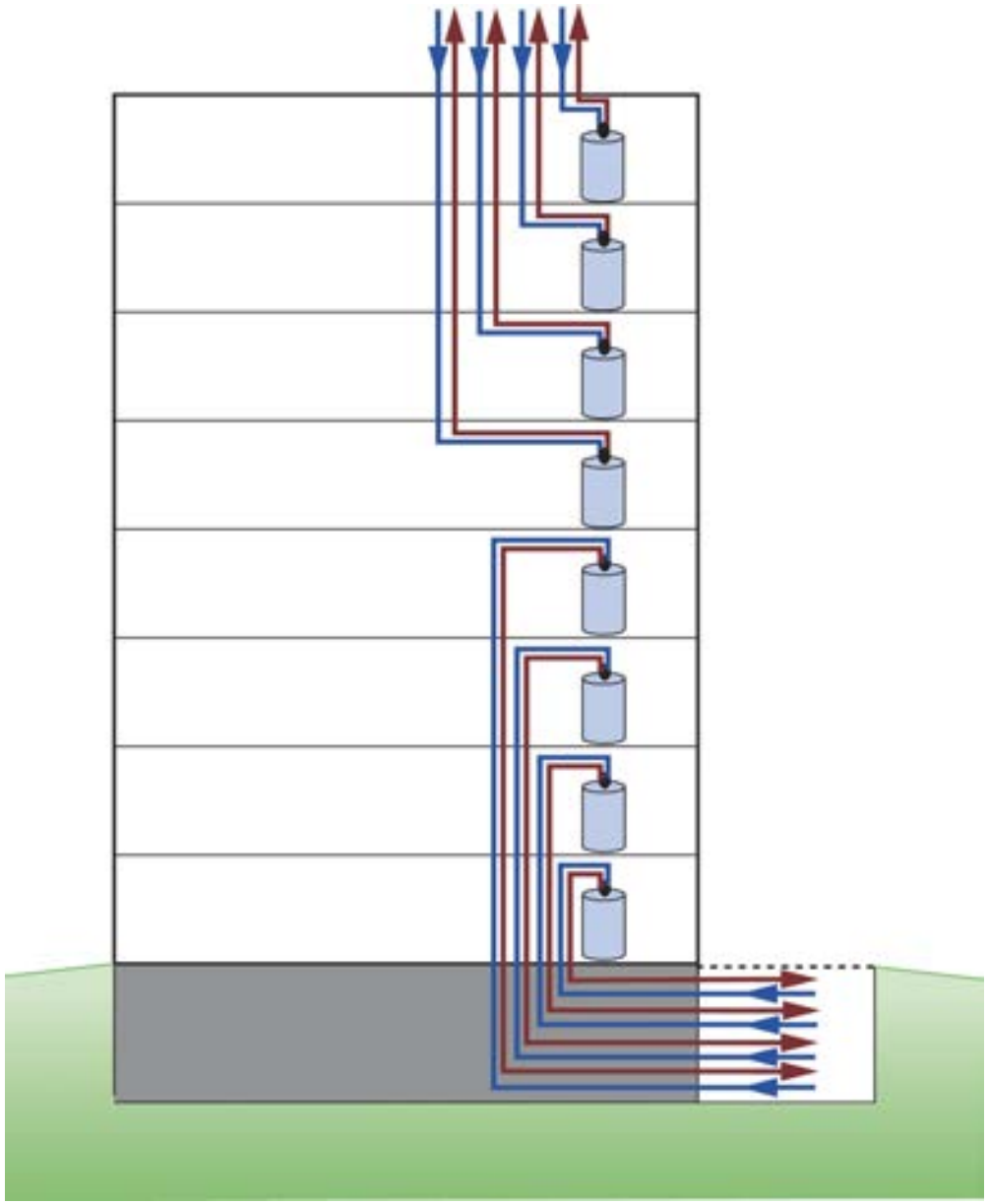



Motorized
damper
Outside
Air



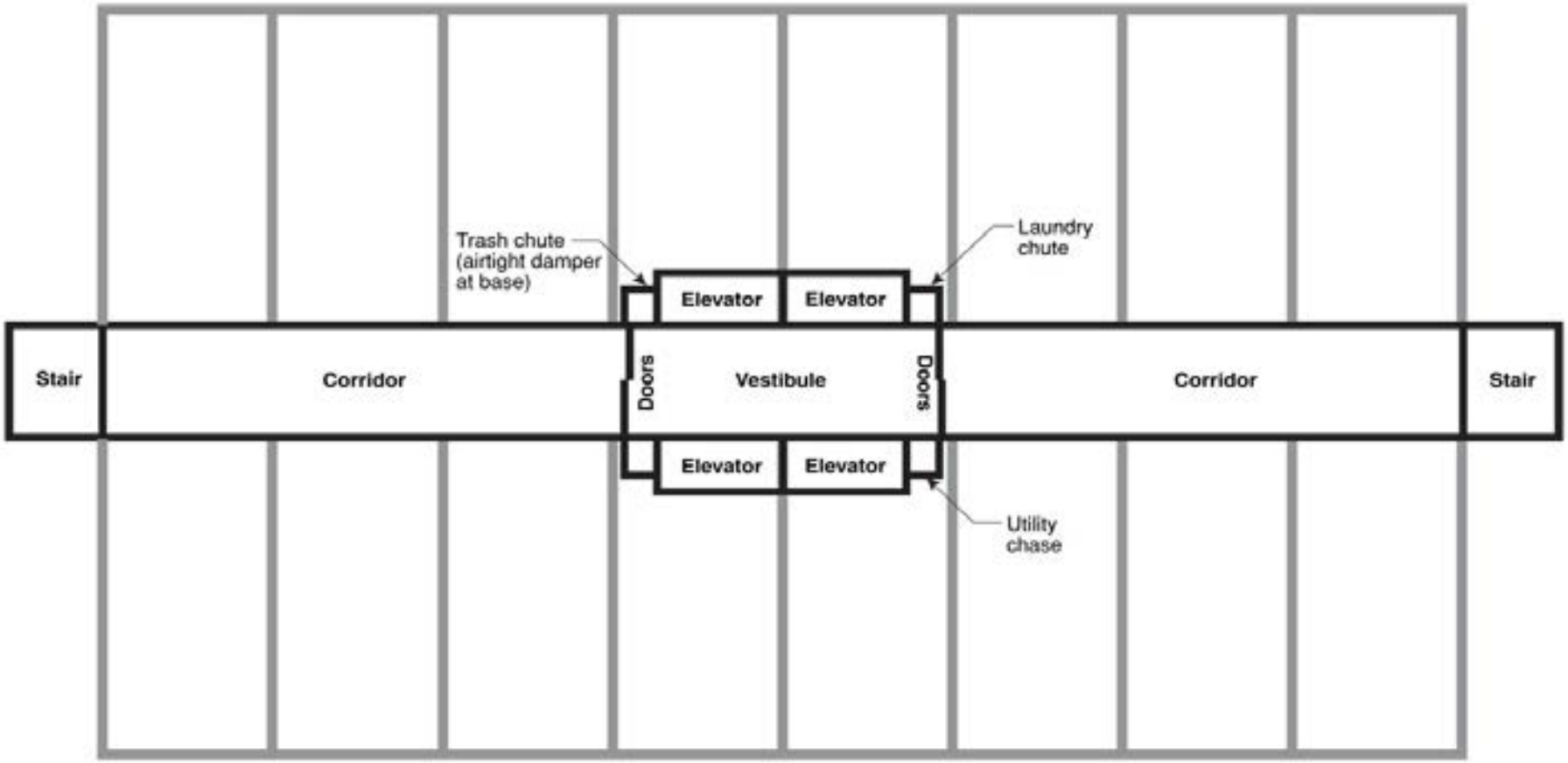


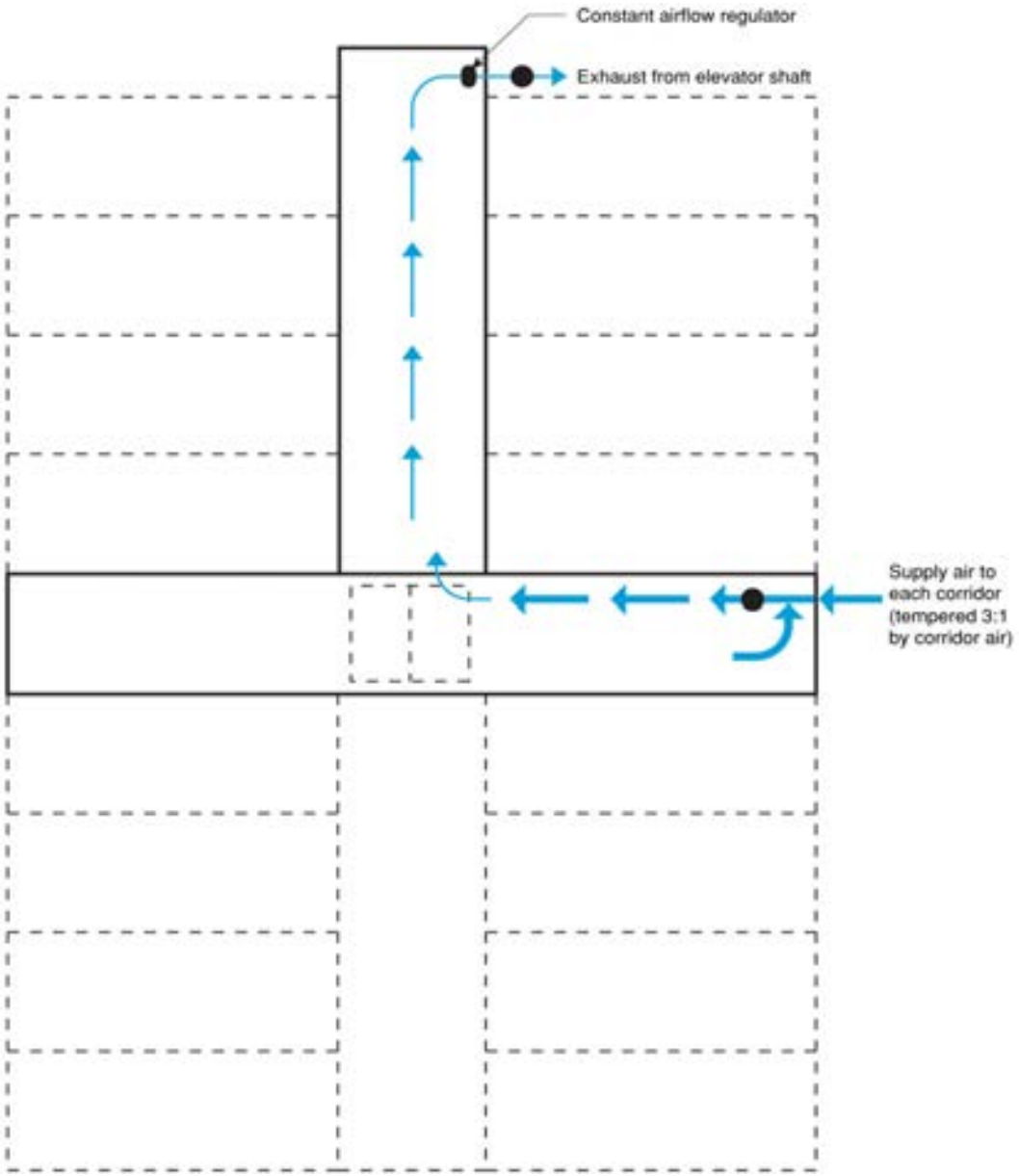


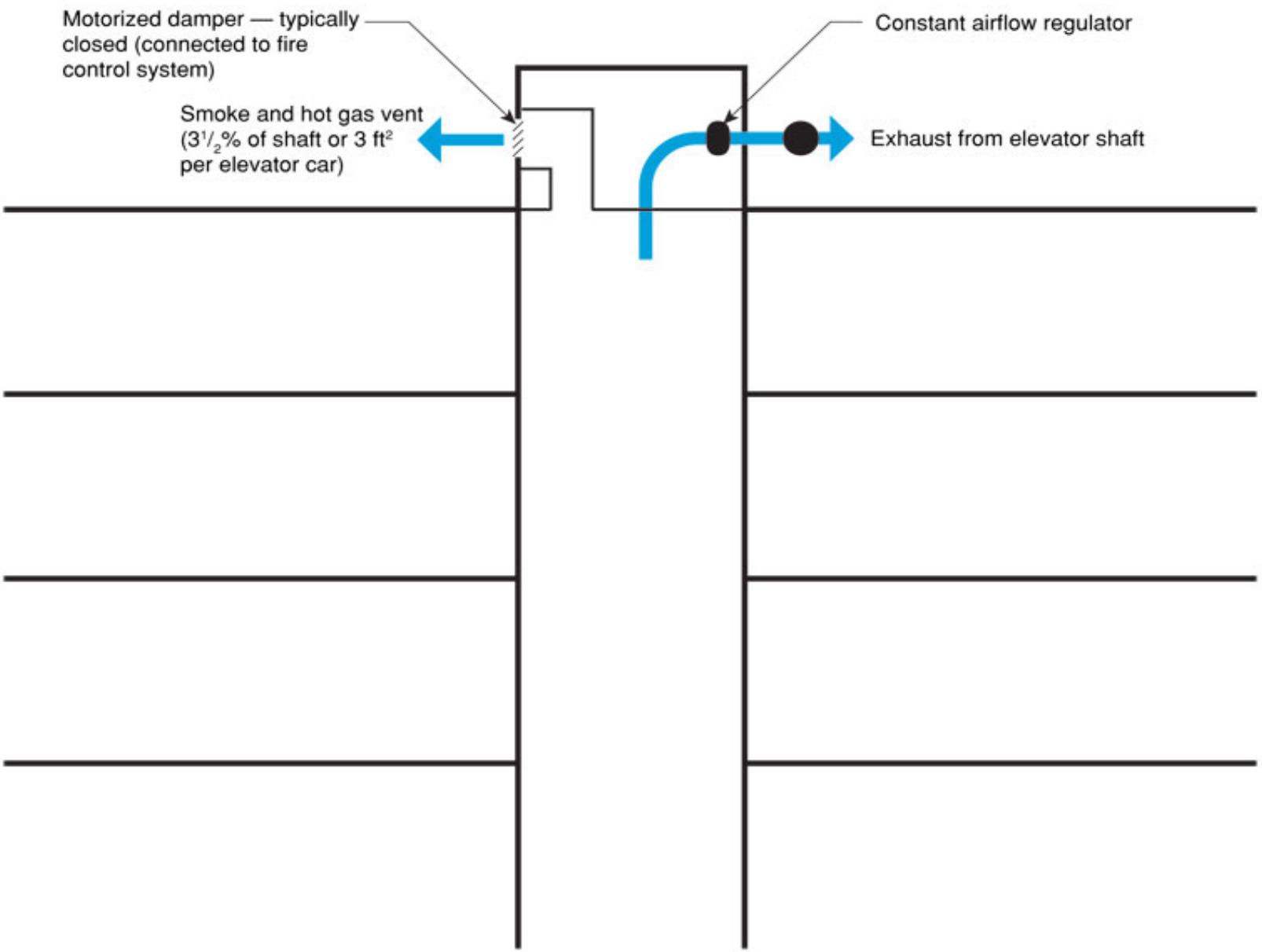


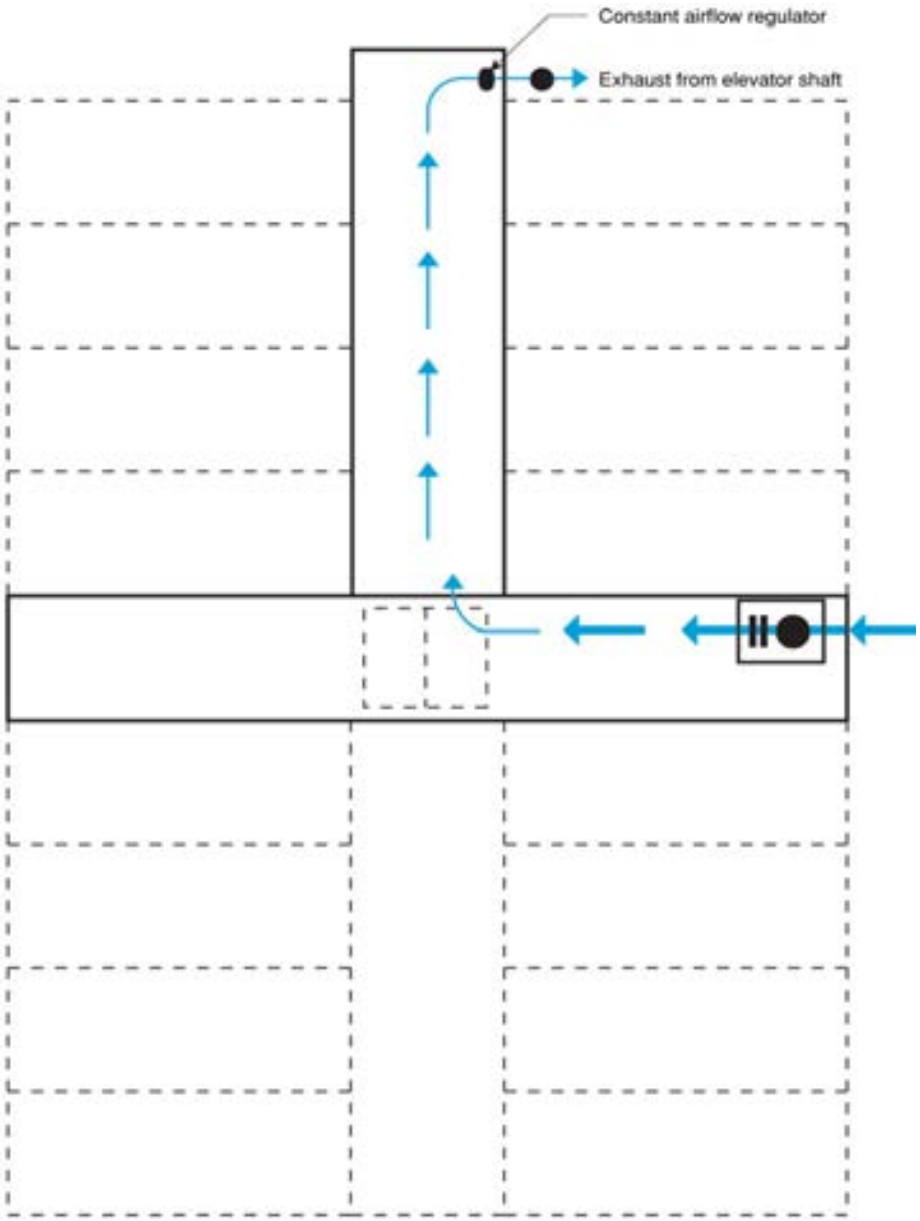

YORK
YORK

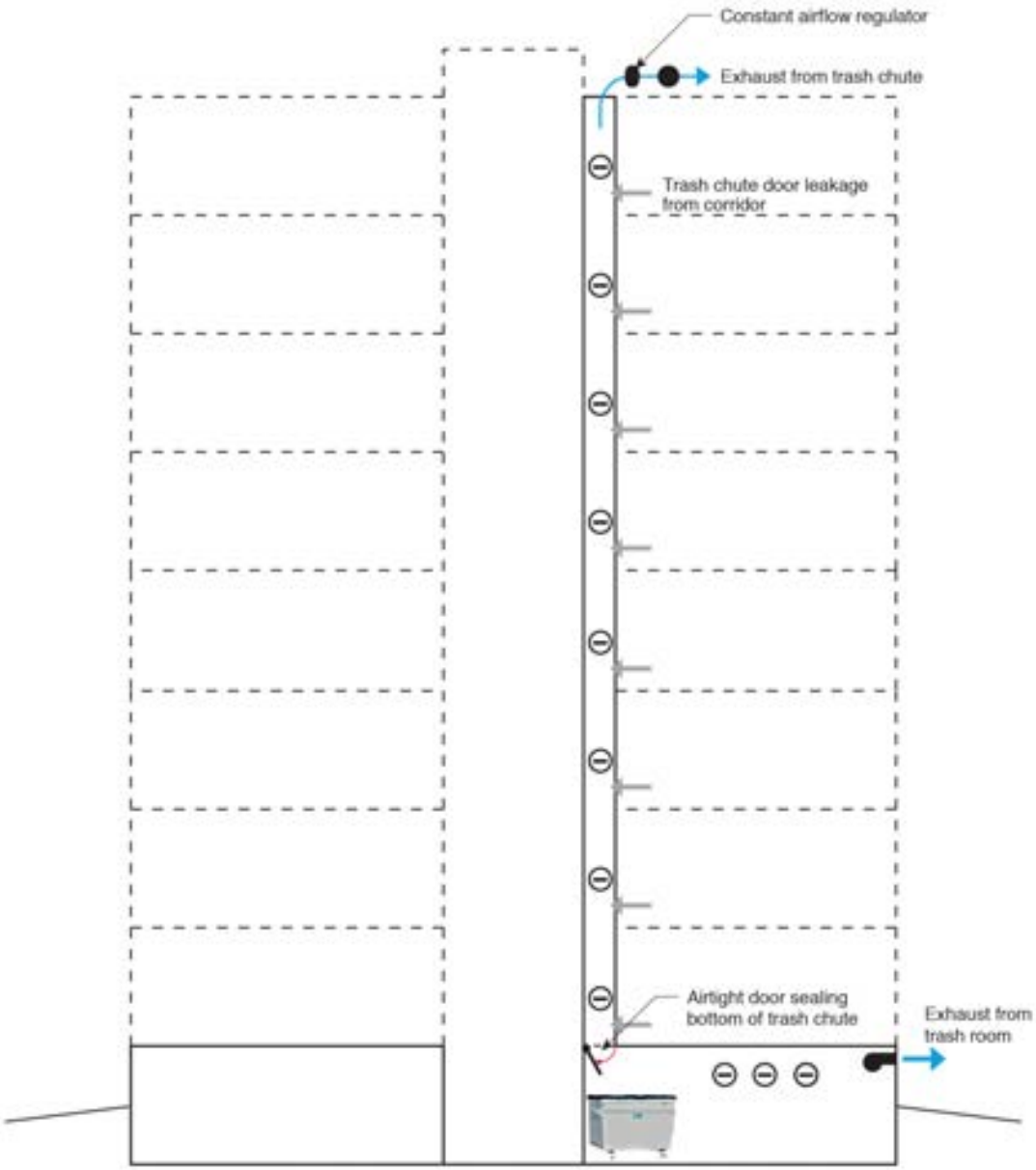

ANJAC FASHION BLDG

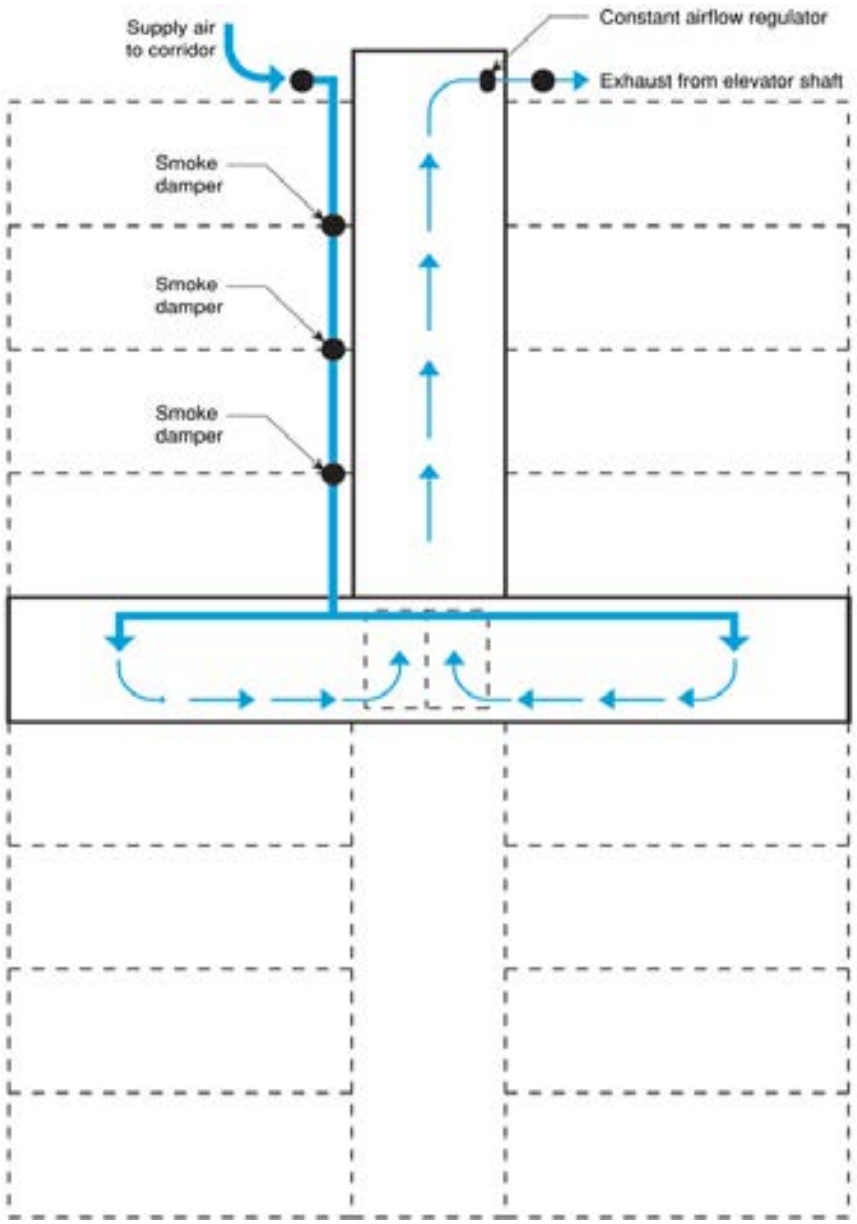

Trash chute
(airtight damper
at base)
Laundry
chute
Elevator
Elevator
Stair
Corridor
Doors
Vestibule
Doors
Corridor
Stair
Elevator
Elevator
Utility
chase

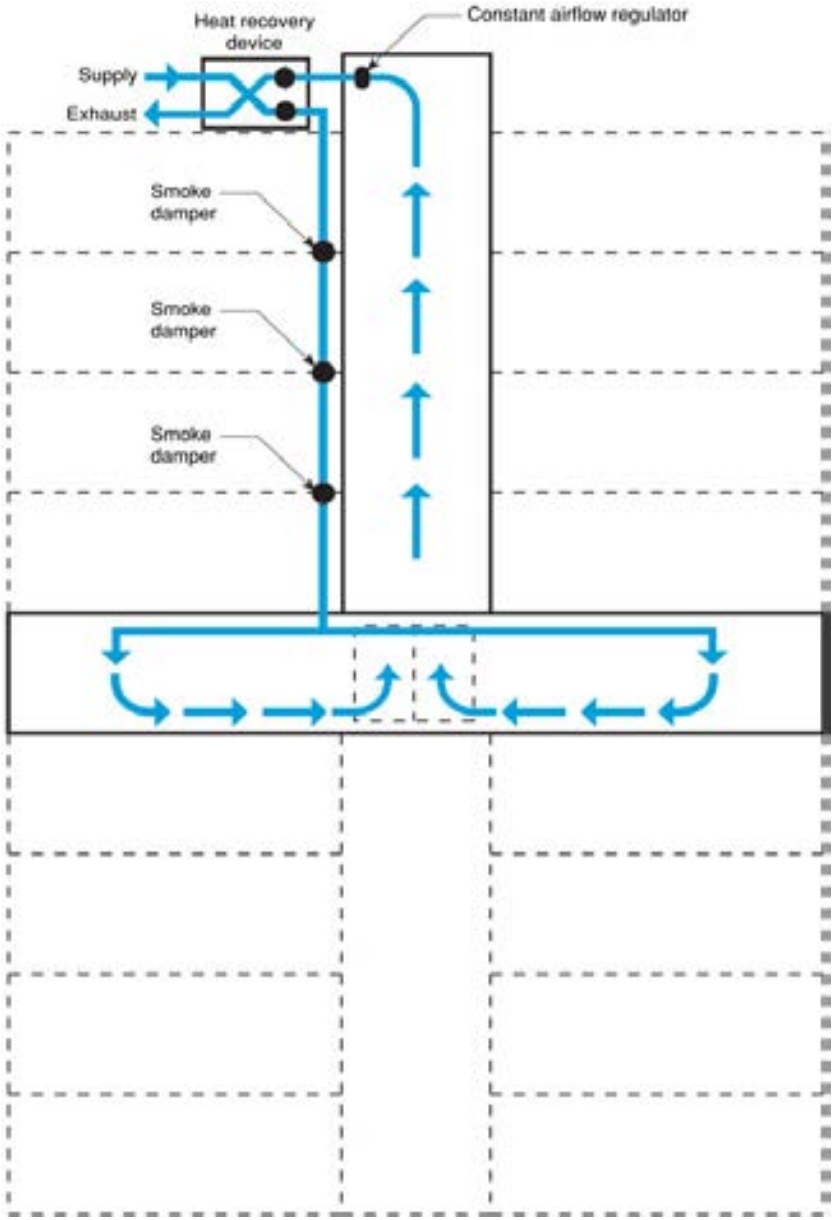

Constant airflow regulator
Exhaust from elevator shaft
Supply air to each corridor (tempered 3:1 by corridor air)

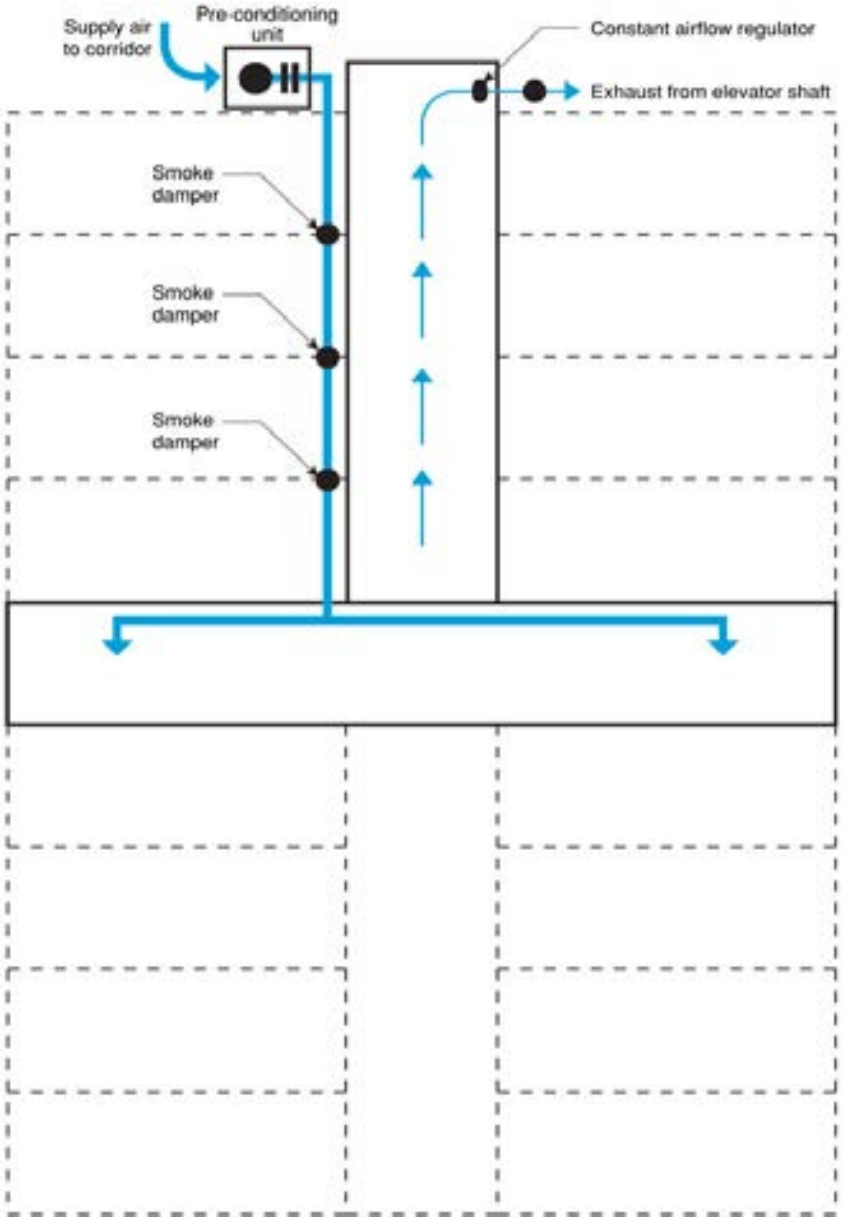

Motorized damper — typically closed (connected to fire control system)
Constant airflow regulator
Smoke and hot gas vent (3 1/2% of shaft or 3 ft² per elevator car)
Exhaust from elevator shaft

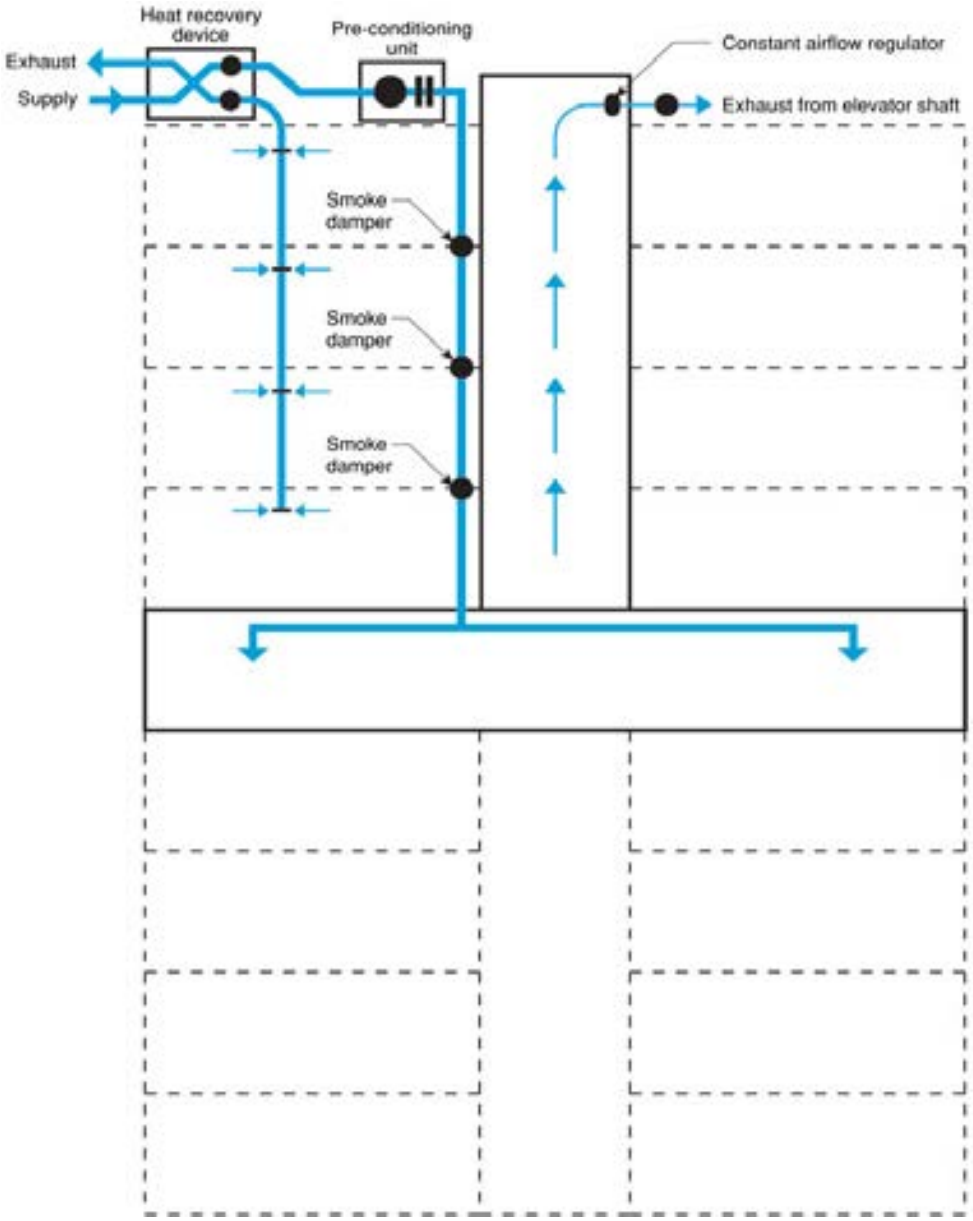

Constant airflow regulator
Exhaust from elevator shaft


Constant airflow regulator
Exhaust from trash chute
Trash chute door leakage from corridor
Airtight door sealing bottom of trash chute
Exhaust from trash room


Supply air
to corridor
Constant airflow regulator
Exhaust from elevator shaft
Smoke
damper
Smoke
damper
Smoke
damper


Heat recovery device
Constant airflow regulator
Supply
Exhaust
Smoke damper
Smoke damper
Smoke damper


Supply air to corridor
Pre-conditioning unit
Constant airflow regulator
Exhaust from elevator shaft
Smoke damper
Smoke damper
Smoke damper


Heat recovery device
Pre-conditioning unit
Exhaust
Supply
Constant airflow regulator
Exhaust from elevator shaft
Smoke damper
Smoke damper
Smoke damper


EXIT