4. Damage Consistent with Science

Wind (the movement of air) produced pressures on surfaces.

It also creates flying debris.

Wind damage can be “predictable” as seen on other properties when wind was determined to be the cause of damage. (expected outcome)

There is some variation in wind speed and direction, but when wind is strong enough to cause damage, it normally damages certain items similarly from place to place.

Wind Velocity / Wind Pressure

- We can measure some wind speeds
  - Straight line – weather station instrument Local Airport
  - Tornadoes – no
  - Hurricanes – yes

- Structural Engineers like winds speed because wind speeds can be converter to wind pressures
- Why are pressures important?

Static Pressure = Force / Area

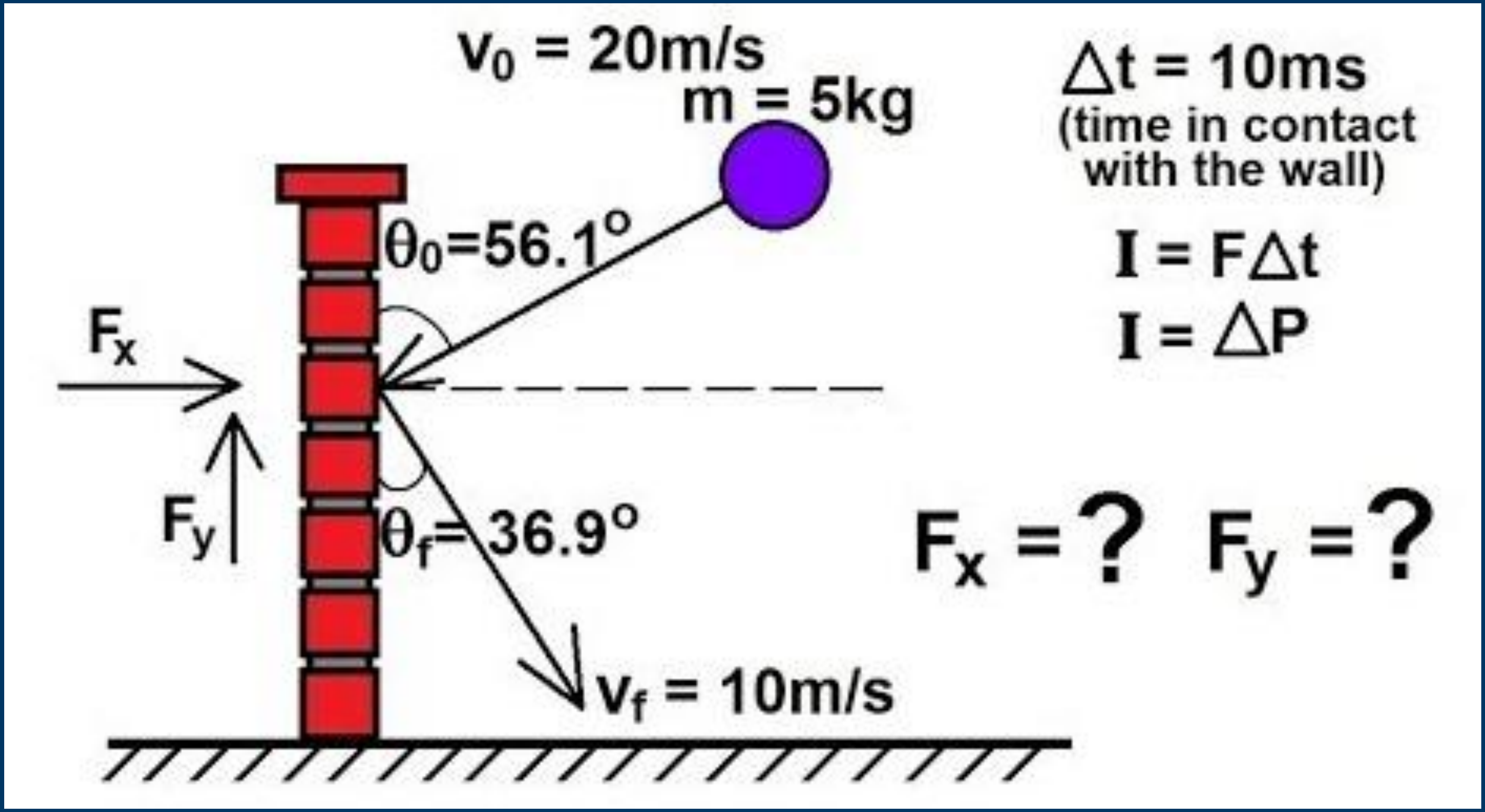
Force = 190 lbs

Area = ¼ x ¼

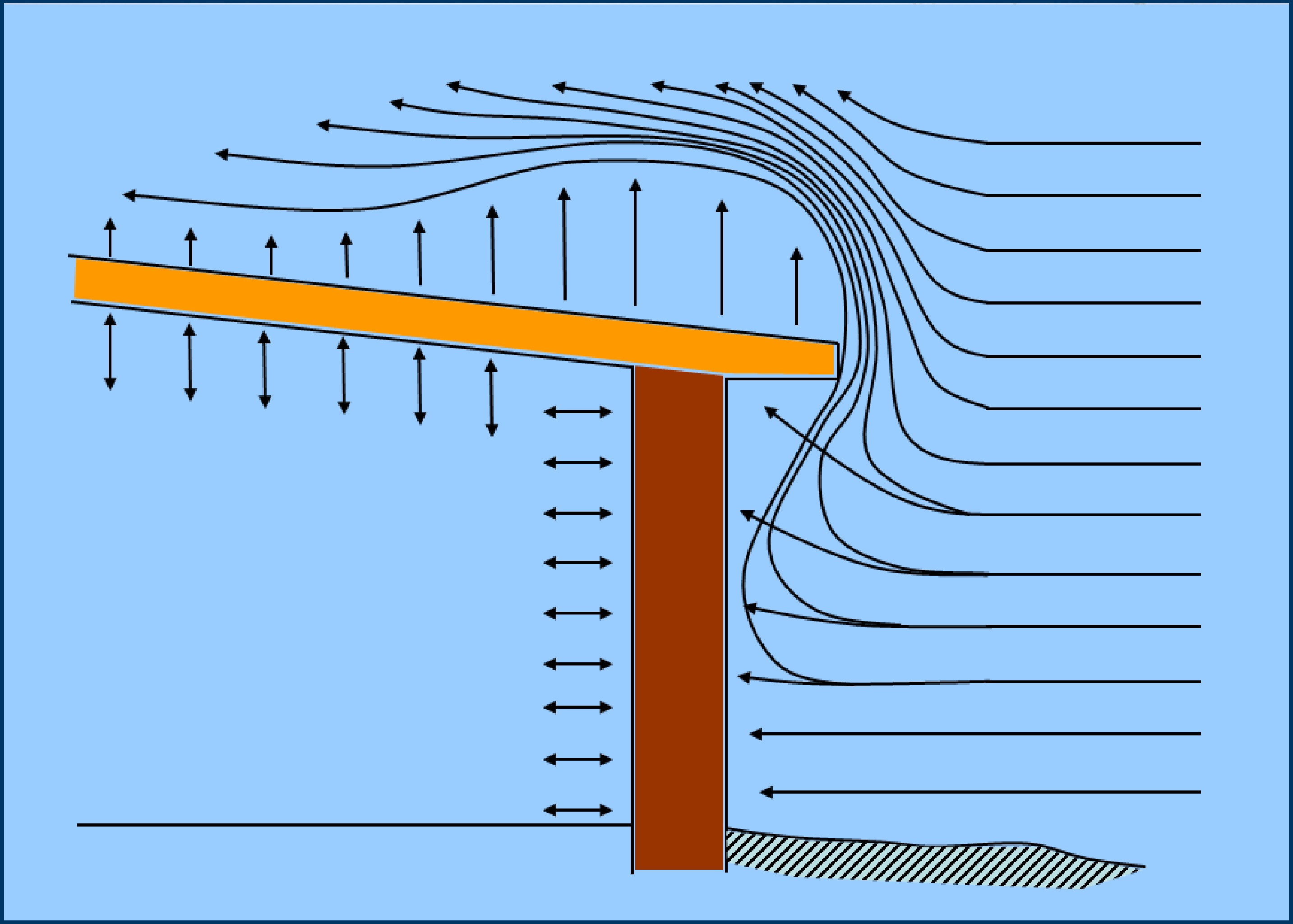
Pressure = 190 / ¼ x ¼ = 3000 psi

Pounds per square inch

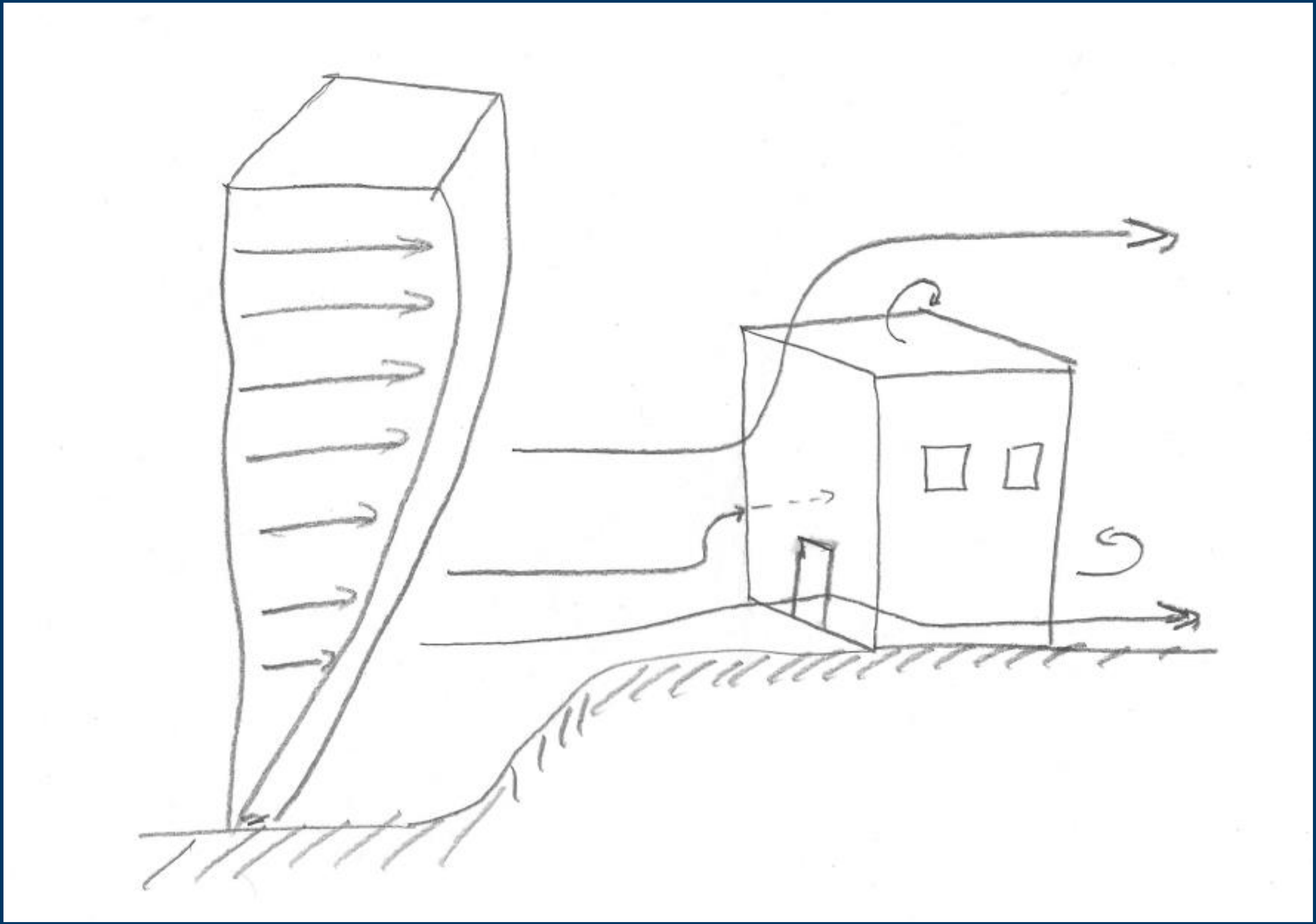
Elastic Impact Force

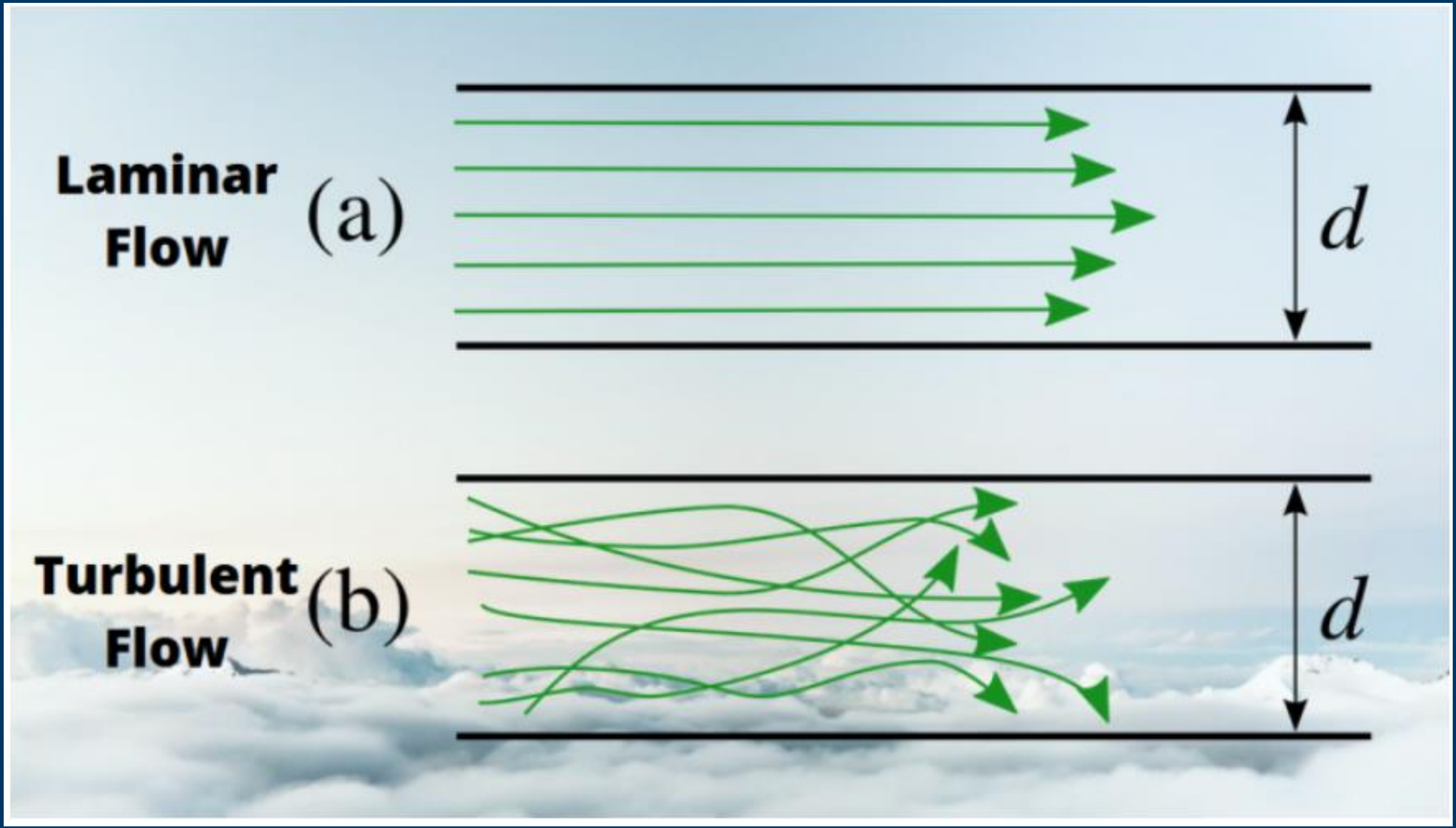


4a - Uplift Increase at Roof Edge



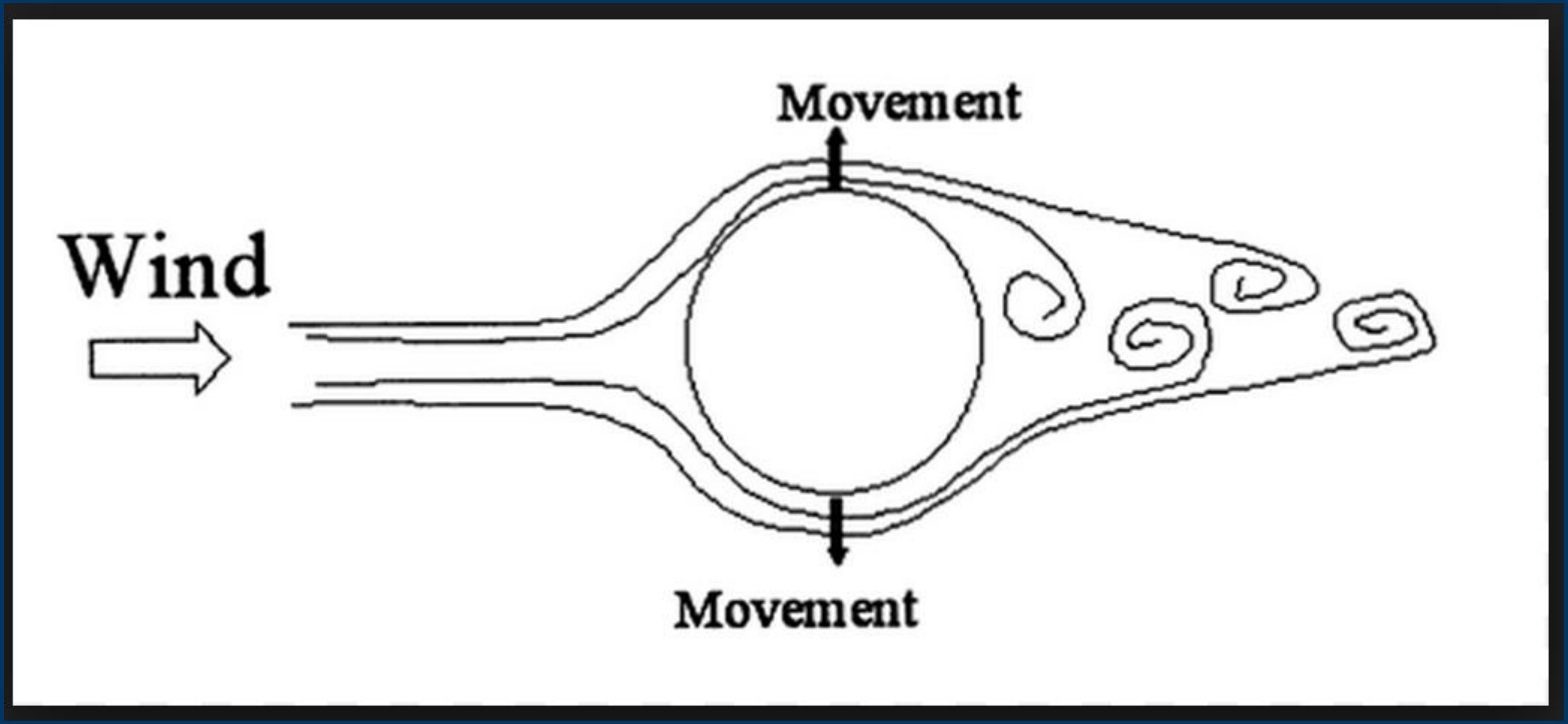
4a – 3D Pressures - Reality




Laminar
Flow
(a)
d
Turbulent
Flow
(b)
d

4a - More Complex Wind Issues

- Vortex Shedding (chimneys, poles, smooth & slender structures)



Wind - Direct Wind Pressure

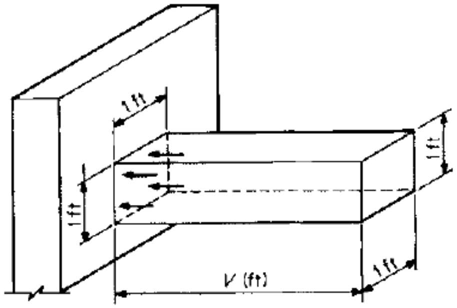


Figure 7.4 Static pressure q exerted against a wall by a prism of moving air can be computed by a formula derived as follows:

$$E_k = qs\int \frac{M\,dV}{dt}\cdot V\;dt = \int MV\;dV$$

For a velocity change from V to o:

$$E_k = \int_V^o MV\,dV = \frac{MV^2}{2} = \frac{WV^2}{2g}$$

where E_k = kinetic energy of moving air mass (ft · lb)

q = static pressure (psf)

W = 0.0765 (lb/ft³) at 59°F (15°C) × V (ft)

g = gravitational acceleration = 32.17 ft/s²

V = distance traveled by air prism in 1 s

For a 1-s interval:

$$E_k = qV$$

$$q = \frac{E_k}{V} = \frac{0.0765V\cdot V^2}{2g\cdot V} = \frac{0.0765V^2}{2\times 32.17} = 0.00119V^2$$

Convert wind velocity to mph:

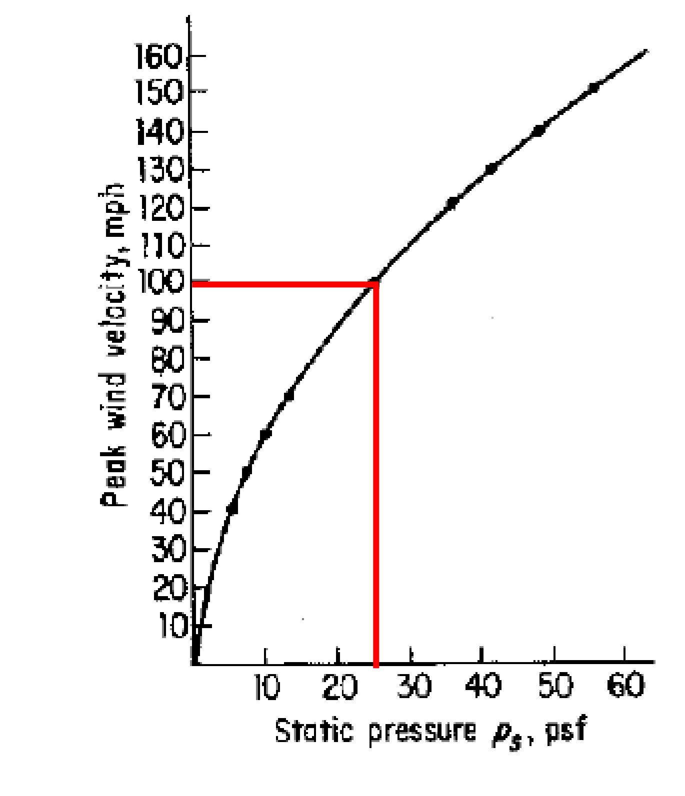
$$1\text{ mph} = 5280/60^2 = 1.4667\text{ ft/s}$$

$$q = 1.4667^2 \times 0.00119V^2$$

$$= 0.00256V^2$$

Pressure = .00256V^2

25.6 psf = .00256(100 mph)^2

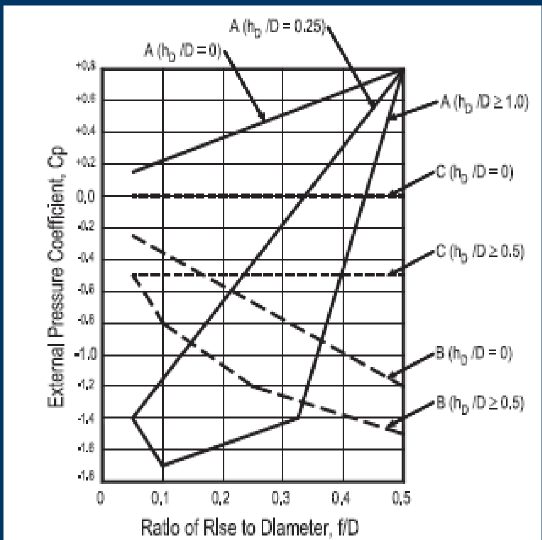


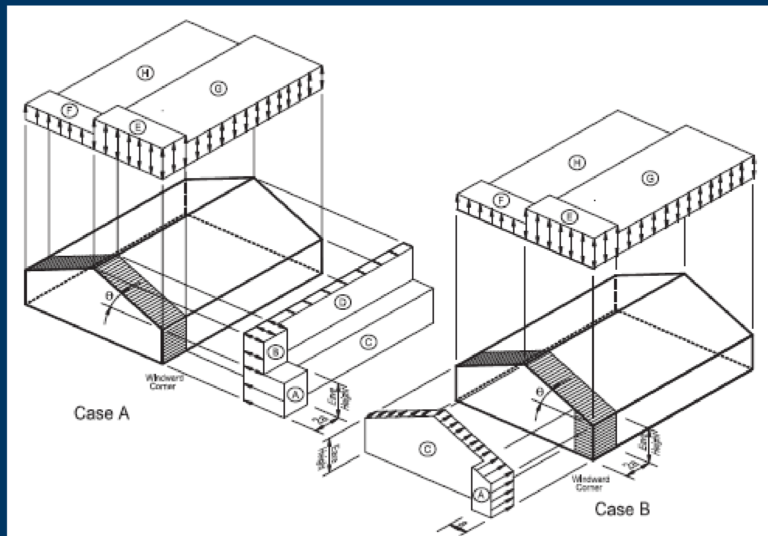
15 psf = 75 mph **160 psf = 250 mph** **25 psf = 100 mph**

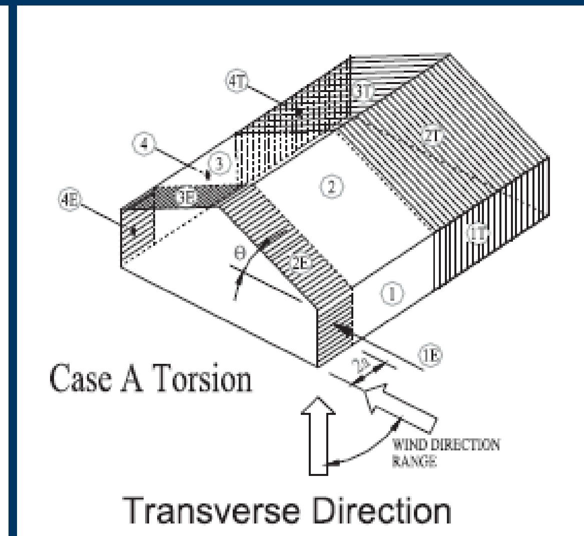
Bernoulli's Principle

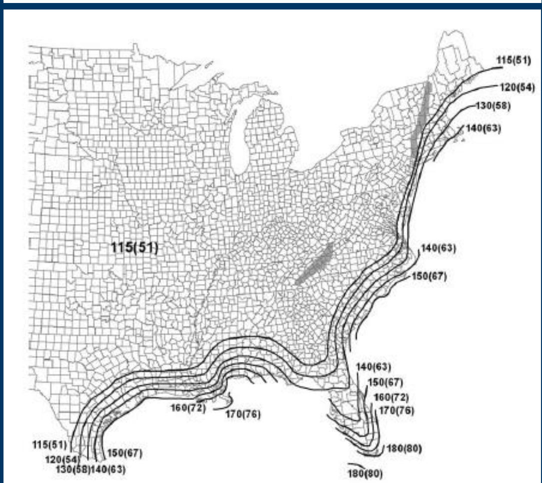
- Daniel Bernoulli (1782)
- Bernoulli - Fluid Mechanics
- Provides scientific explanation for "wind uplift"

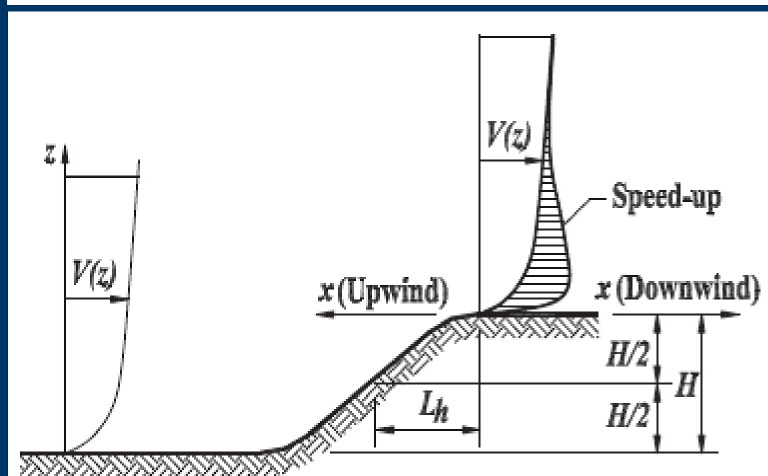
ASCE 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures

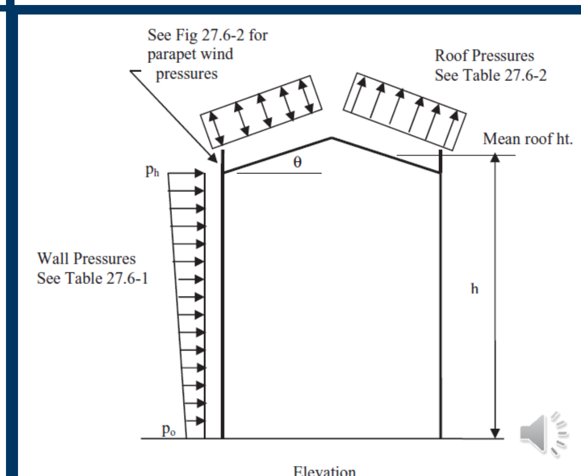












4a - More Complex Wind Issues


cpp
CERMAK
PETERKA
PETERSEN
N
270°
240°
210°

4c - Loads - ASCE-7

• Dead Loads	1 page	
• Live Loads	3 pages	
• Flood Loads	3 pages	
• Wind Loads	60 pages	29%
• Snow Loads	3 pages	
• Rain Loads	1 page	
• Ice Loads	3 pages	
• Seismic Loads	130 page	63%

4a - Wind Pressure

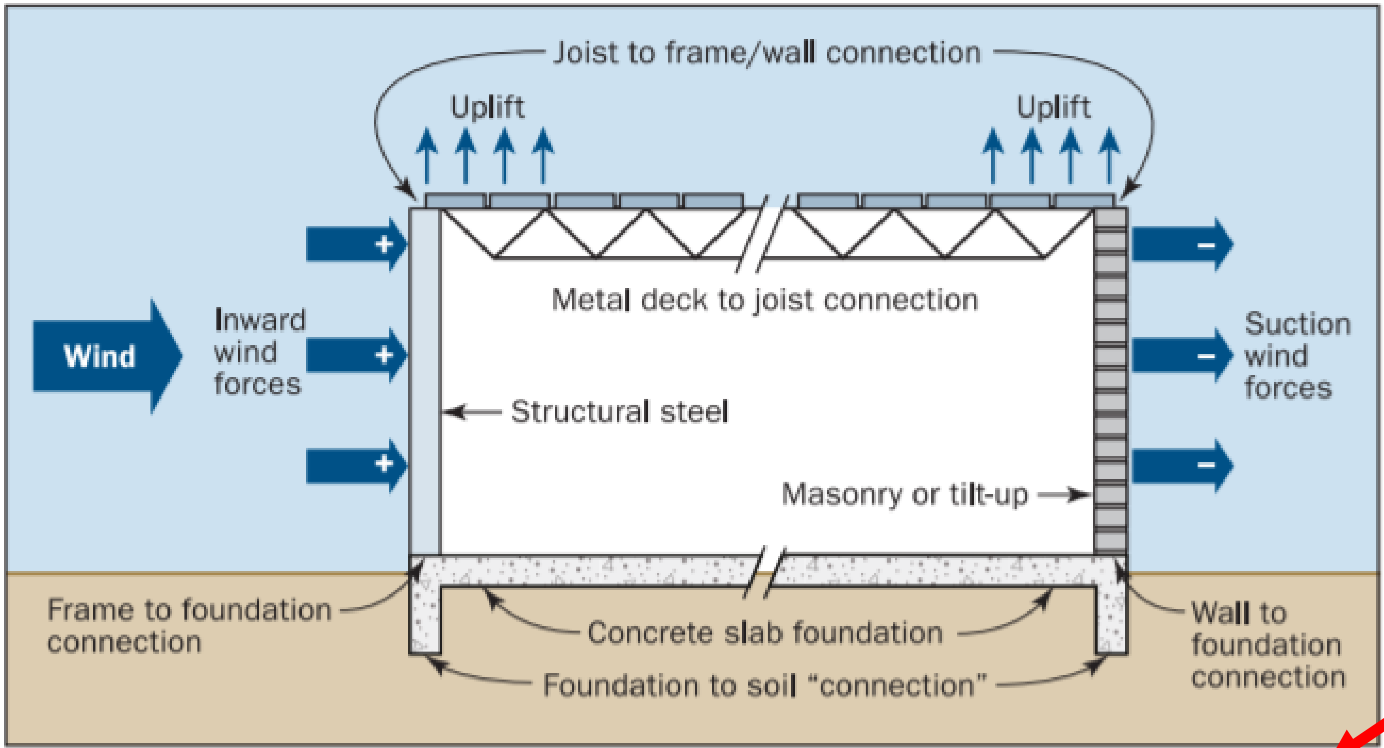


Figure B3-6. Critical connections important for providing a continuous load path in a typical masonry, concrete, or metal-frame building wall (for clarity, concrete roof deck is not shown)

Safe Rooms for Tornadoes and Hurricanes (FEMA 361, July 2021)

https://www.fema.gov/sites/default/files/documents/fema_safe-rooms-for-tornadoes-and-hurricanes_p-361.pdf

4c – Design Manuals

AMERICAN WOOD COUNCIL
https://awc.org/about

NDS National Design Specifications for Wood Construction

American Concrete Institute
https://www.concrete.org/aboutaci.aspx

Building Code Requirements for Structural Concrete (ACI 318)

https://www.aisc.org/

AISC Steel Construction Manual

THE MASONRY SOCIETY
https://masonrysociety.org/product/tms-402-602-2016/

TMS 402/602-16 Building Code Requirements and Specification for Masonry Structures (ACI 530)

THE BRICK INDUSTRY ASSOCIATION
https://www.gobrick.com/read-research/technical-notes

NCMA TEK
NATIONAL CONCRETE MASONRY ASSOCIATION
https://ncma.org/resources/tek-solutions-center/

4c – Connections

The Devil is in the Detailing