Effects of Vibration on Concrete Mixtures

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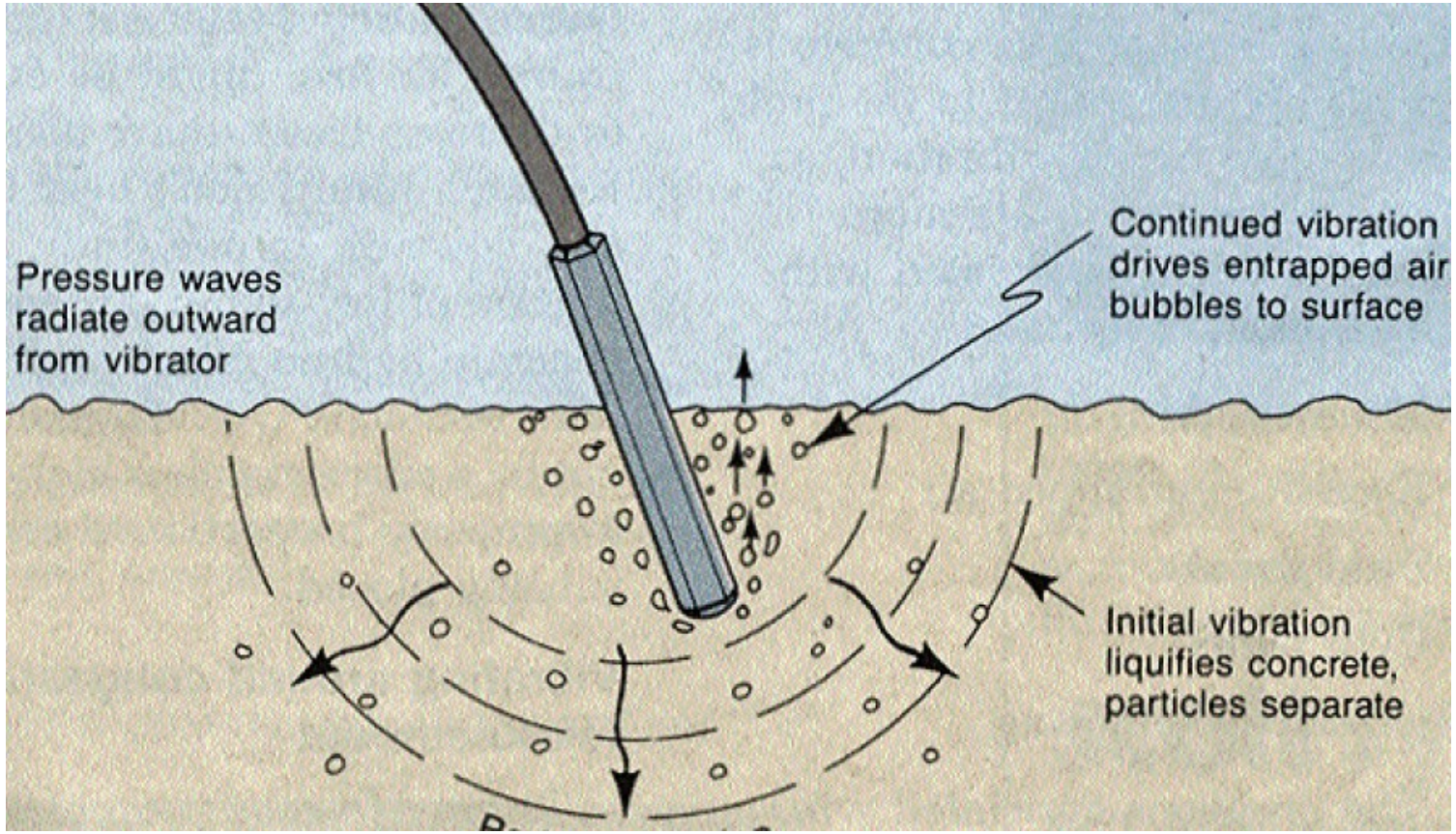
Thixotropy

A property of concrete to:

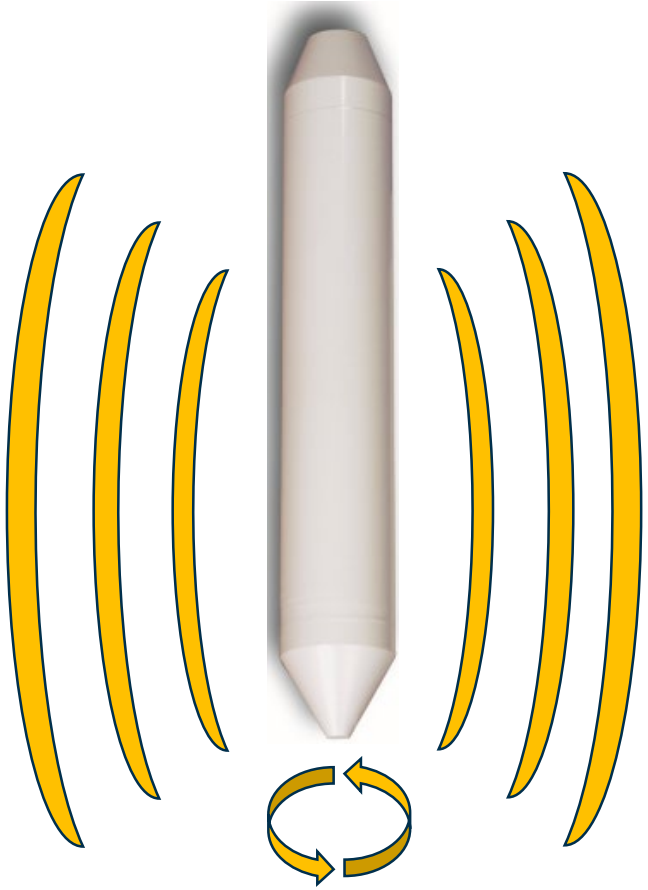
- Flow under vibration
- Stand up when stationary

Why does concrete need vibration?

- Remove entrapped air
- Assist with levelling



What Is Happening under Vibration?



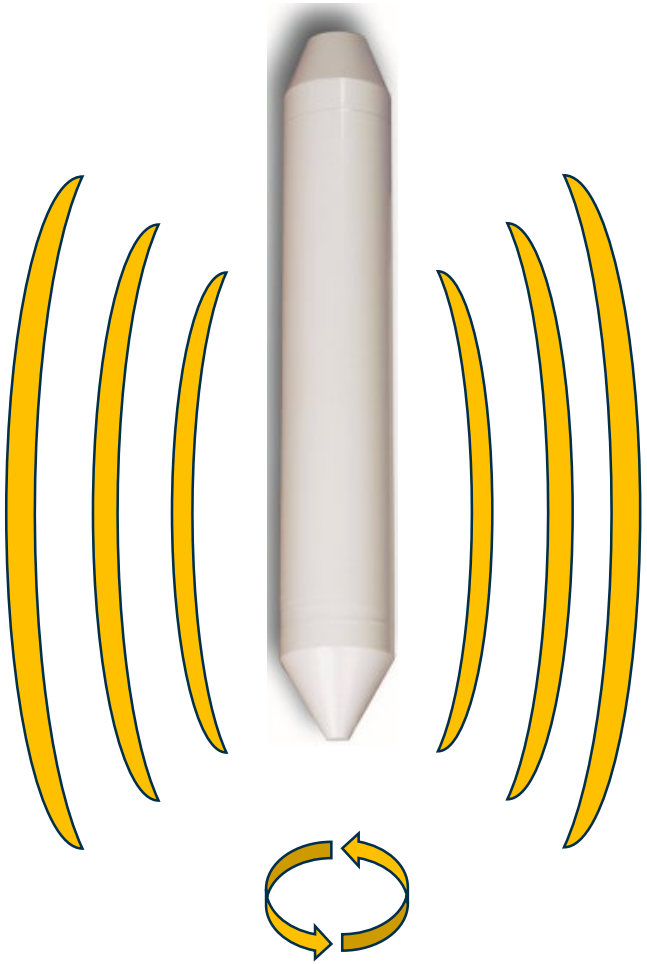
Shaft oscillates in a circle sending out compression waves

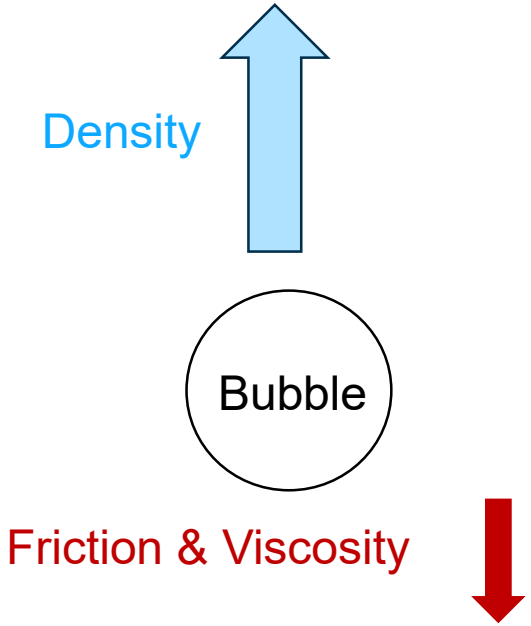
Acceleration >2g allows air to float up and out (Uplift > viscosity)

Water moves horizontally

Solids wobble And maybe rotate

What Is Happening under Vibration?



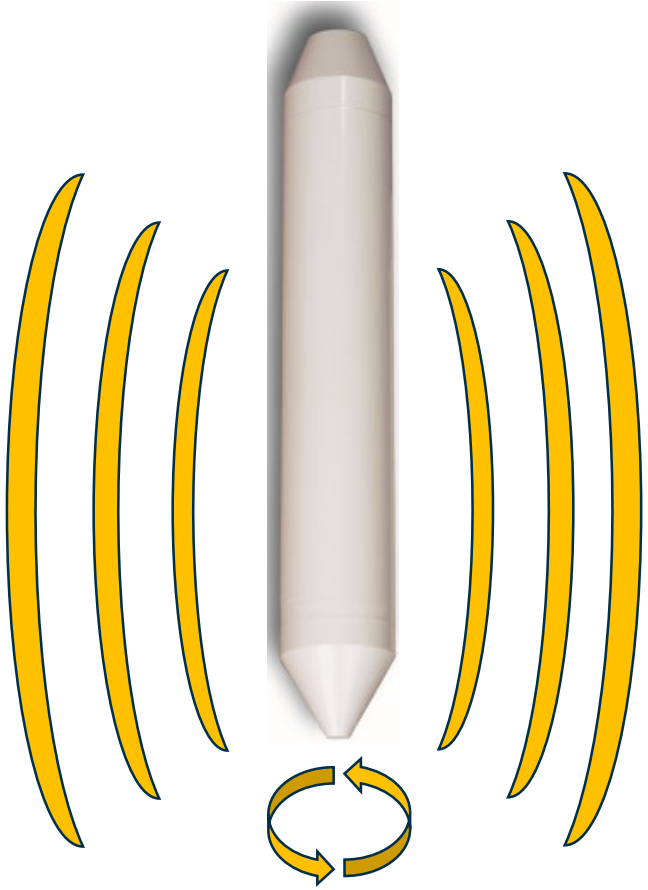


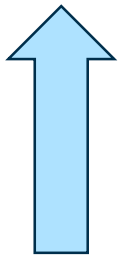
Acceleration >2g allows air to float up and out (Uplift > viscosity)

Assumed that bubble size affected is influenced by:

- G-force (energy)
- Time

What Is Happening under Vibration?





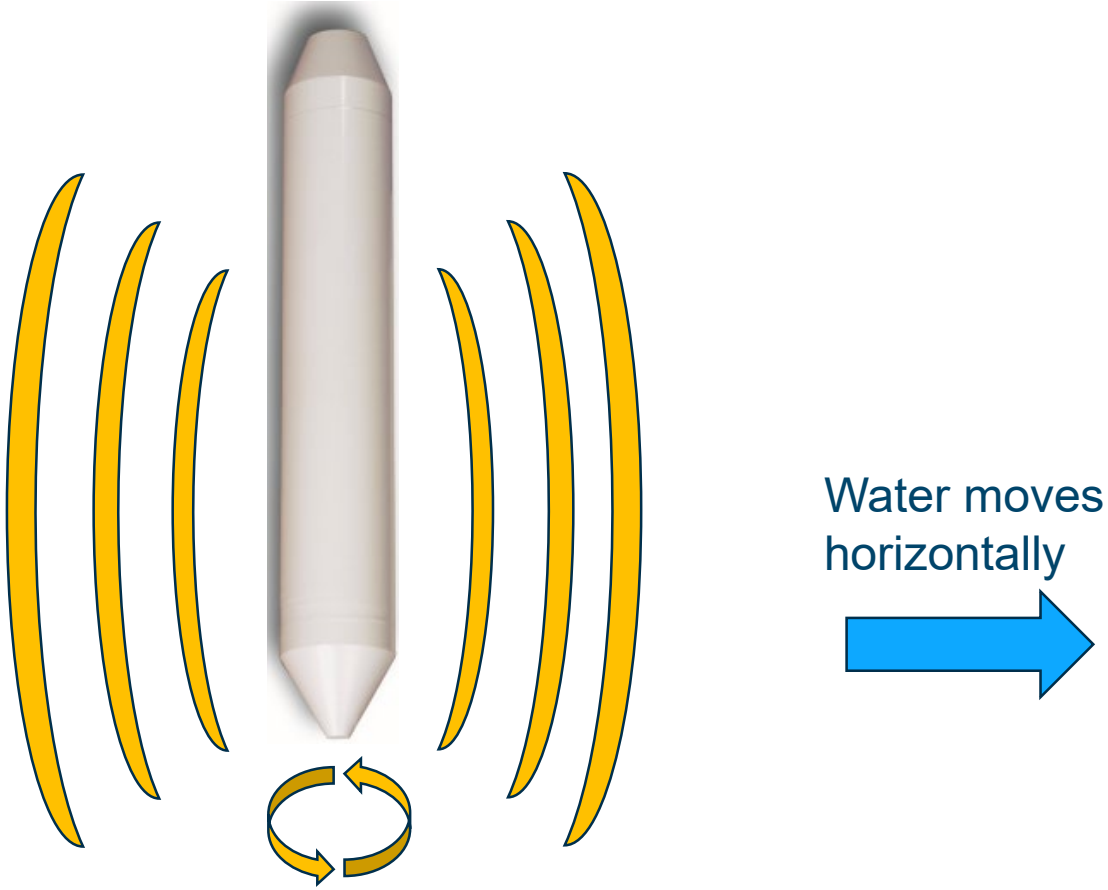
Acceleration >2g allows air to float up and out

Energy affected by:

- Amplitude (same in most devices ~0.075”)
- Frequency
- Mass of vibrator weight

Relationships are not understood

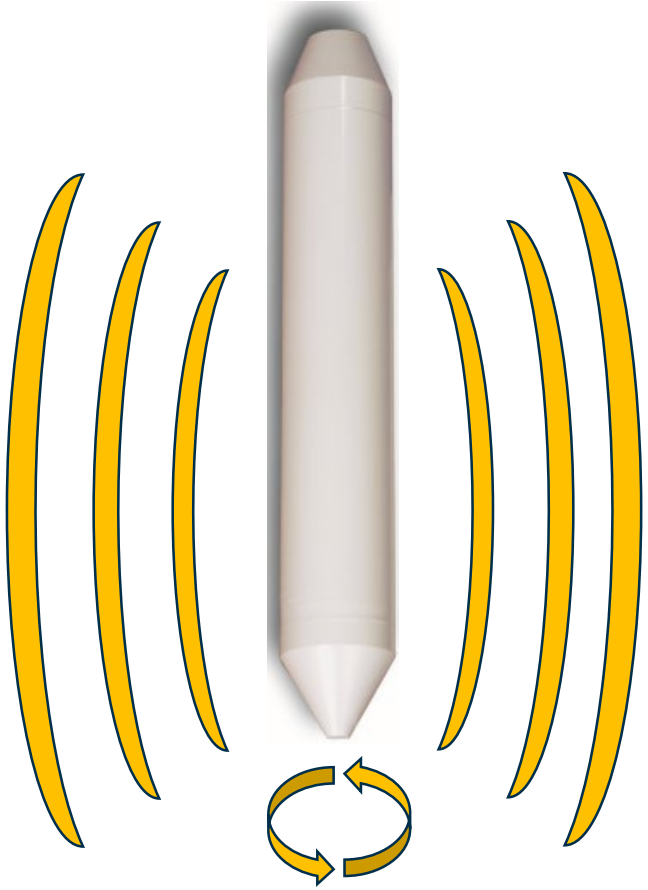
What Is Happening under Vibration?

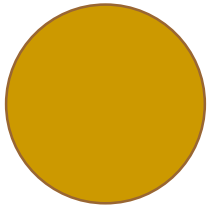


More frequency = more water

Not quantified

What Is Happening under Vibration?



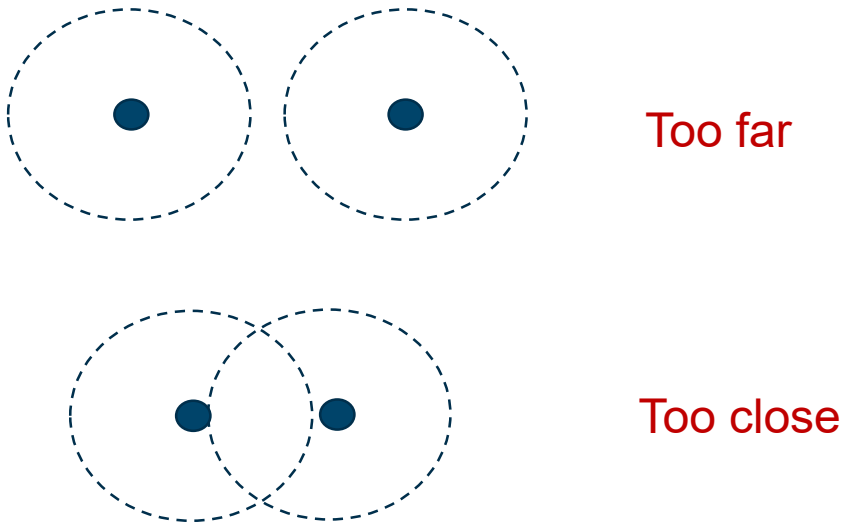


Solids wobble
And maybe
rotate

Not quantified

May not move back
after vibrator removed

What Is Happening under Vibration?



Radius of influence:

- Amplitude
- Frequency
- Mixture:
  - Water content
  - Workability

- Linear / logarithmic / other?
- Assumed to be about 8”

What is a good vibration?

- No segregation
- No entrapped air
- Retain entrained air
- No water movement

How much is enough?

- Rules of thumb (3 s/cu ft)
- Watch for bubbles…
- Listen to the sound…

Controlling Frequency

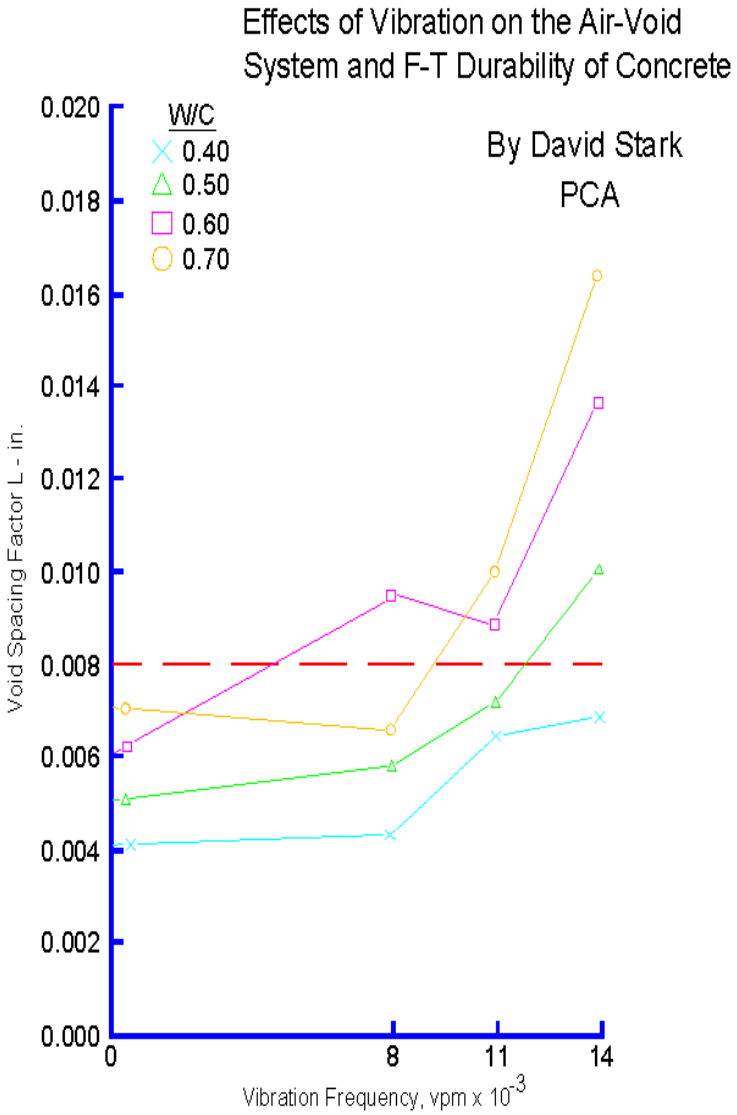
- Traditional vibrators change frequency under load
- CFV Systems now available

Vibrator Speeds by Brand			
Unit/2HP-1.5 linch-10 feet			
Brand	**No Load**	**High Slump**	**Low Slump**
A	17,200	16,000	13,400
B	14,500	14,500	13,500
C	14,000	13,500	13,100
D	12,200	11,700	11,200
E	11,600	11,100	10,500

Frequency Matters

- Vibrators in the right spot move cream to the surface
- Loss of air
- Water movement

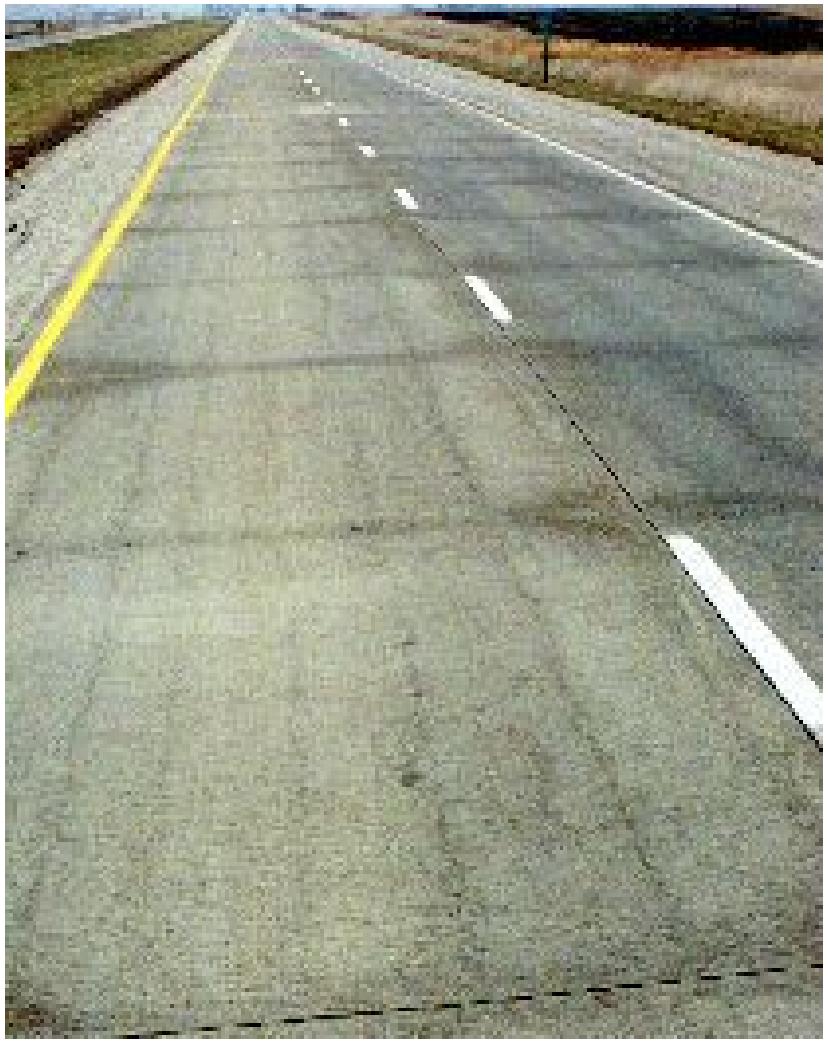
Effect of Frequency on Air



Air loss and segregation

- Aggregate segregation
- Poor air in vibrator track

High frequency leaves track



Air loss and segregation

- Unworkable concrete
- Beaten into place
- Distress observed after 5 years

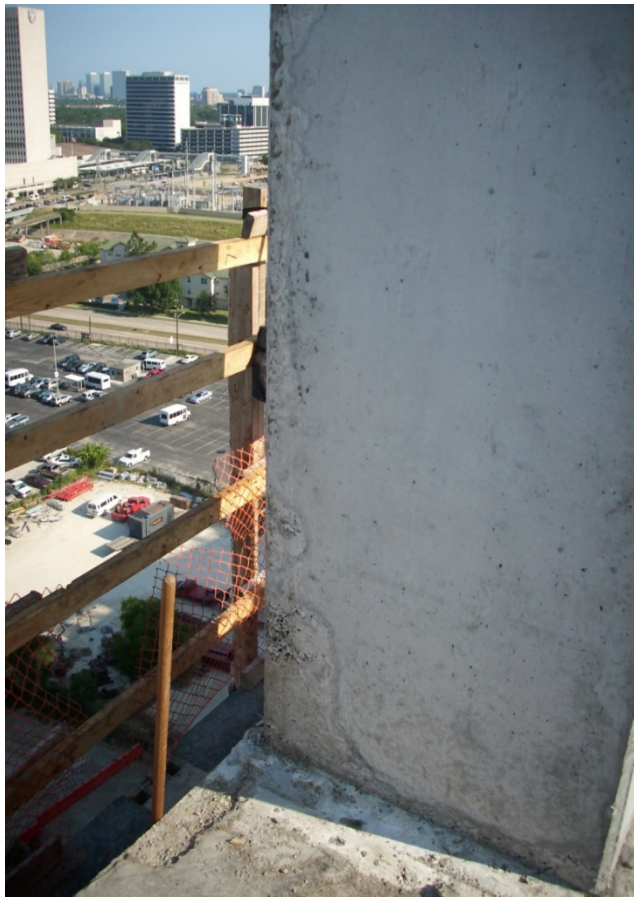
- Strength was fine!

Effect of Frequency on Water Movement

12,000 vpm

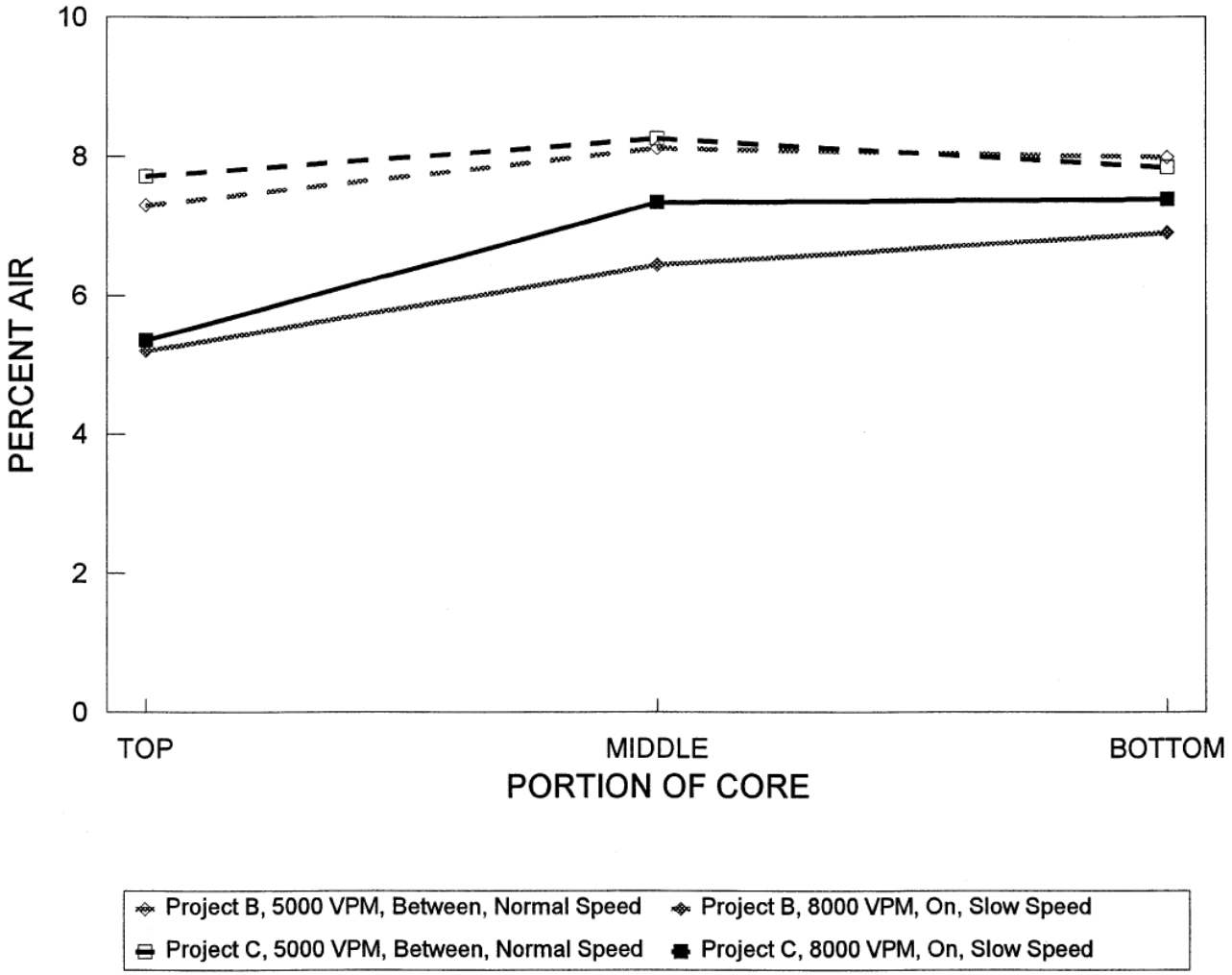
8,000 and 10,000 vpm

Water Movement



Air loss and segregation

- Paver speed matters
  - some



How to evaluate vibration?

Accelerometer

Vibration analyzer

- Vibration energy (RMS velocity amplitude, in/s) at a specific time period across the relevant frequencies

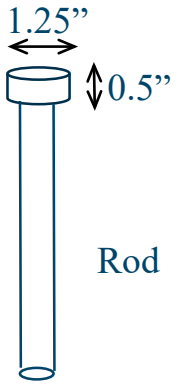
Therefore

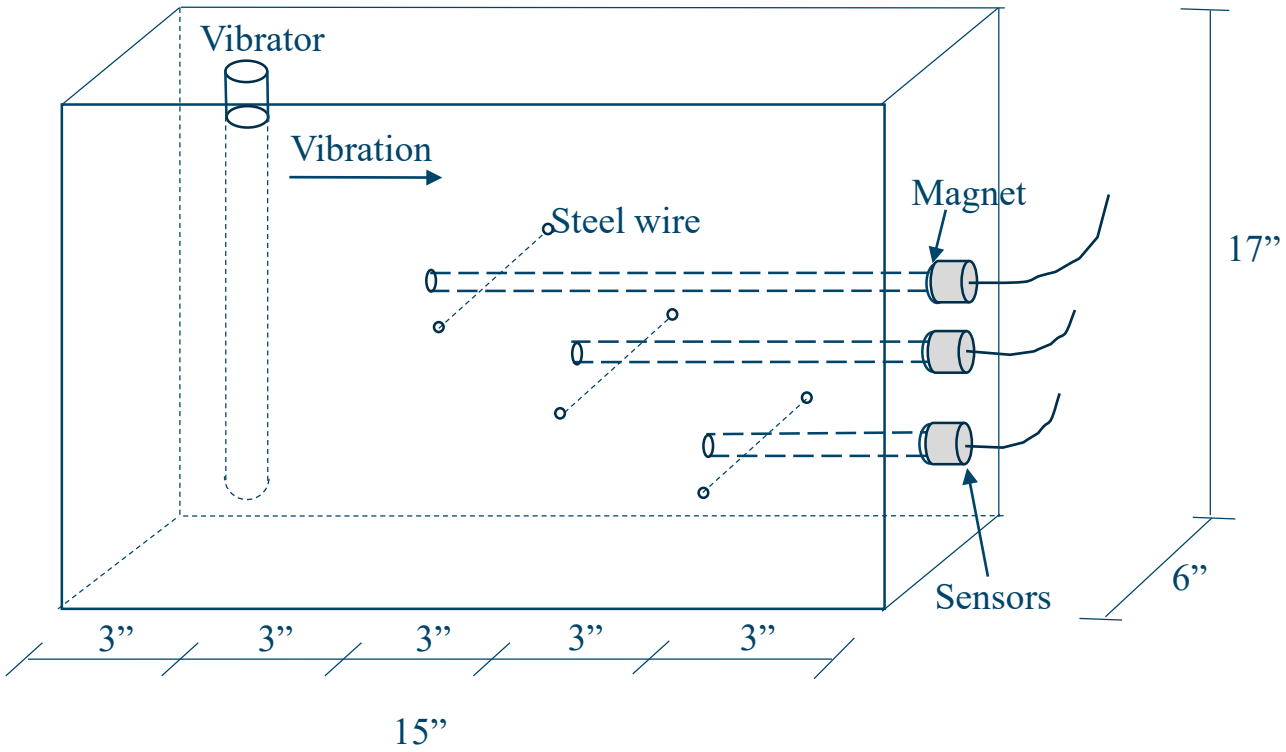
We need to understand

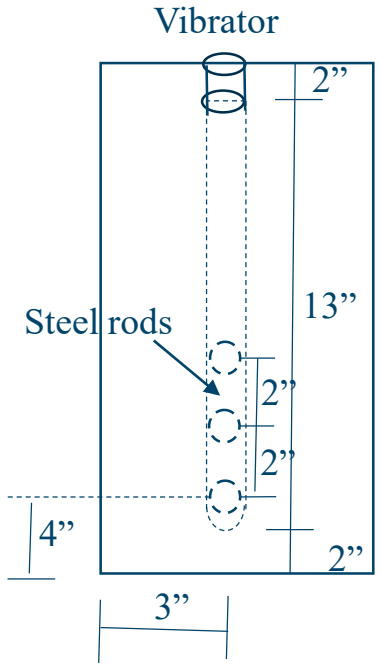
- The relationship between vibration energy and
  - Air movement
  - Water movement
  - Aggregate movement
- As a function of mixture
  - Water content
  - PSD
  - Workability
  - Thixotropy

Evaluating energy transfer

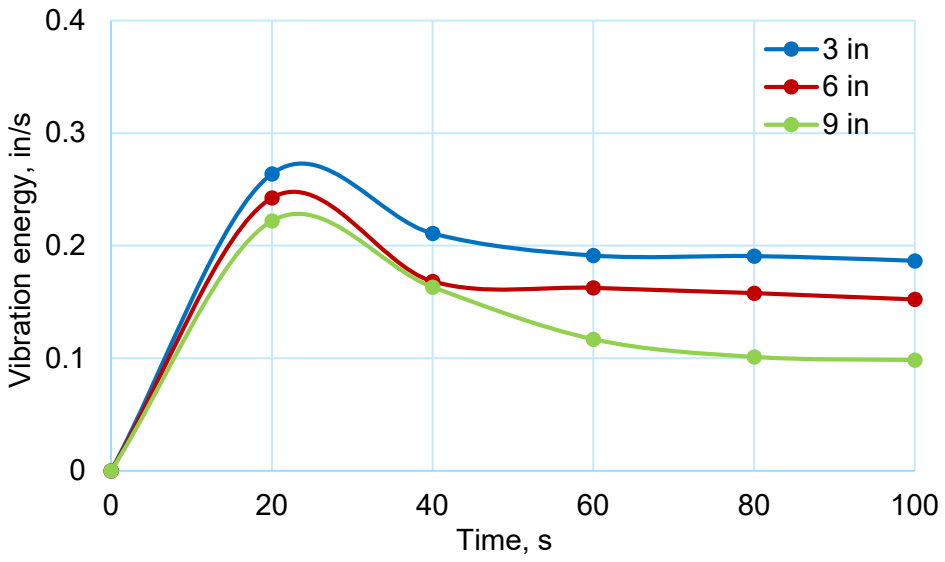
Steel rod diameter: 0.5”
Diameter of vibrator head: 0.9”



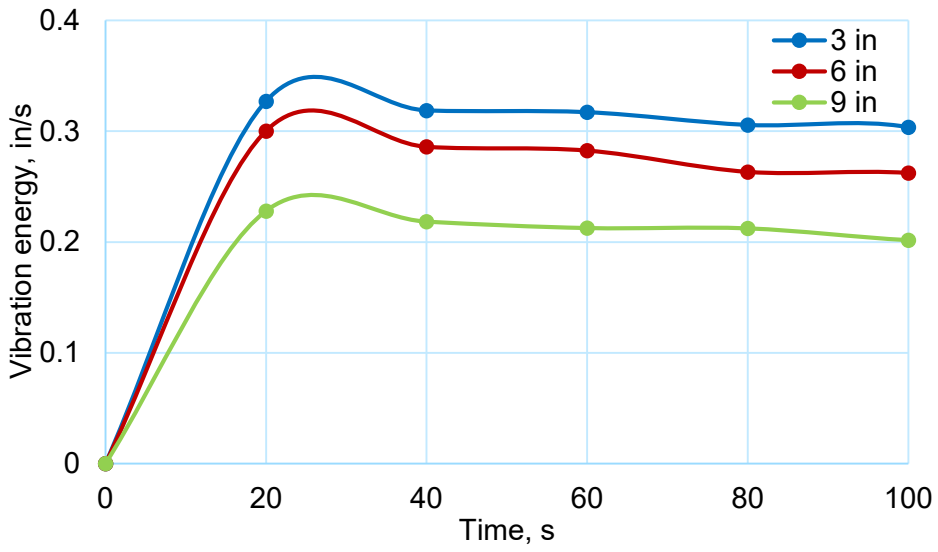




Vibration energy for different mixtures



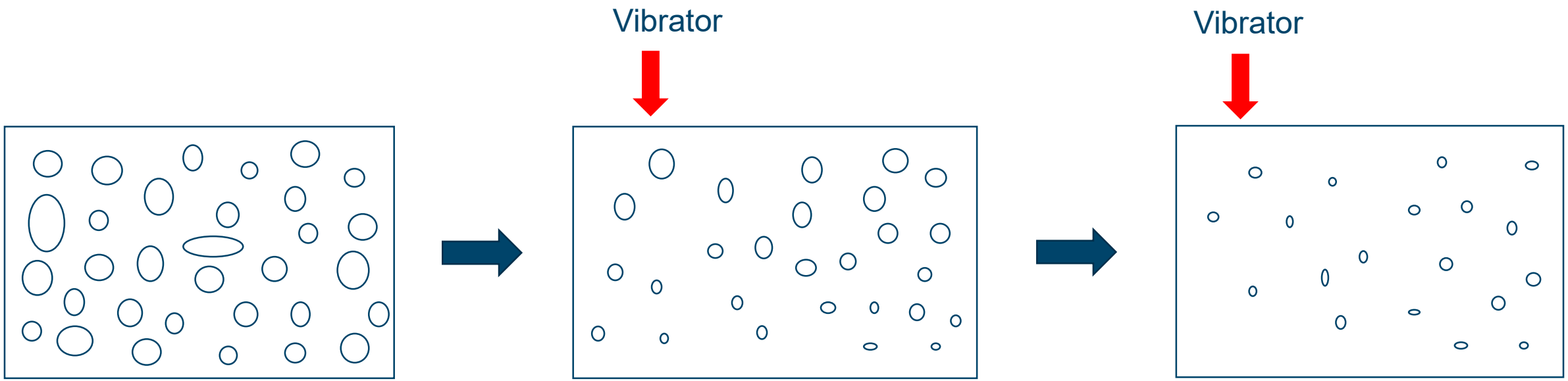
Slump: 1”



Slump: 4”

- Lower slump: less energy, more time to reach stability
- Longer distance: less energy

Hypothesis



Unconsolidated

Loose

Vibrating

Densifying

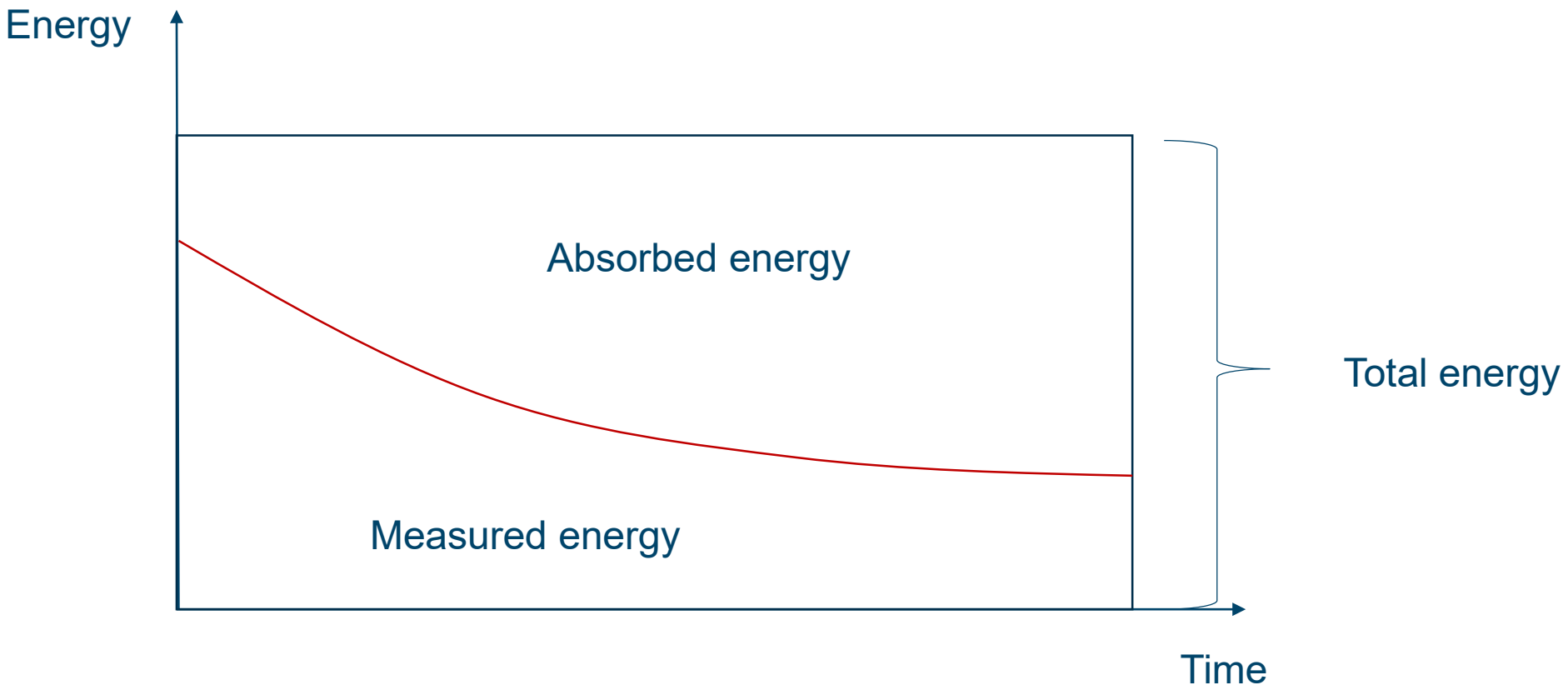
Absorbing Energy

Consolidated

Dense

More energy absorbed

Hypothesis



Next Steps

Vary:

- AEA dose
- WRA dose
- Aggregate type, shape and content

Measure

- Air void systems at different distances
- Evidence of water movement
- Energy transferred

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