Ground Improvement –
A Discussion on Dynamic Compaction

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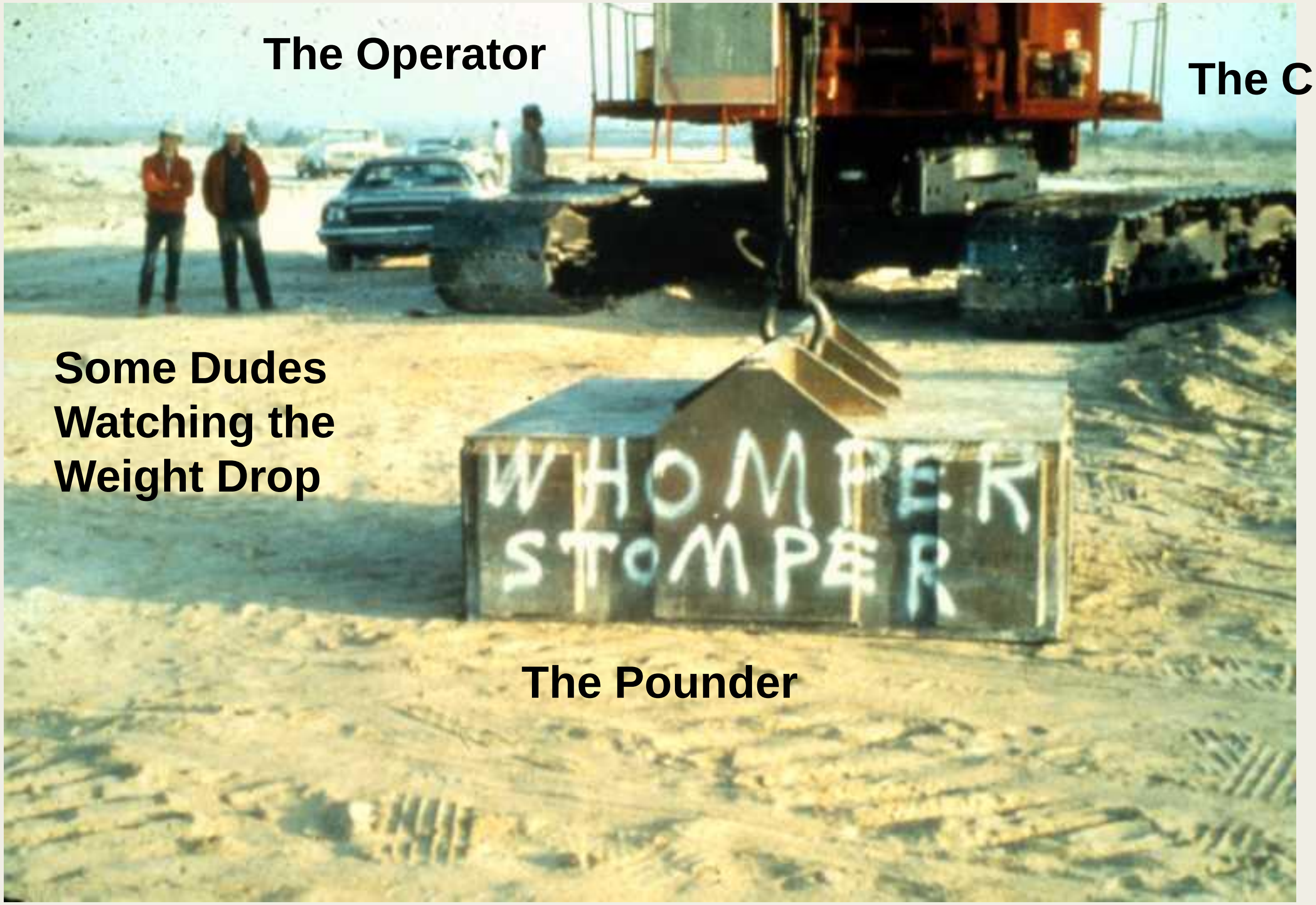
Presentation Outline

- Provide a basic understanding of the principles involved in the design and implementation of a dynamic compaction program.
- Discuss construction-phase issues that can arise.
- Illustrate some case histories and highlight the various soil types that are conducive to improvement by dynamic compaction.

Dynamic Compaction



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Typical Dynamic Compaction Program

- Consists of the repeated dropping of a 5 to 20 ton weight from heights varying from 60 to 100 feet on a grid pattern.
- Most applicable to granular fill materials and sandy deposits.
- Depth of improvement is generally limited to about 25 to 30 feet or less.
- Shallow groundwater table not ideal for schedule, as energy is lost at the soil/water interface and pore pressures build up, requiring more time to complete the program.
- Generates very high vibration levels, not ideal for sites in close proximity to sensitive existing structures (less than 50 feet or so).

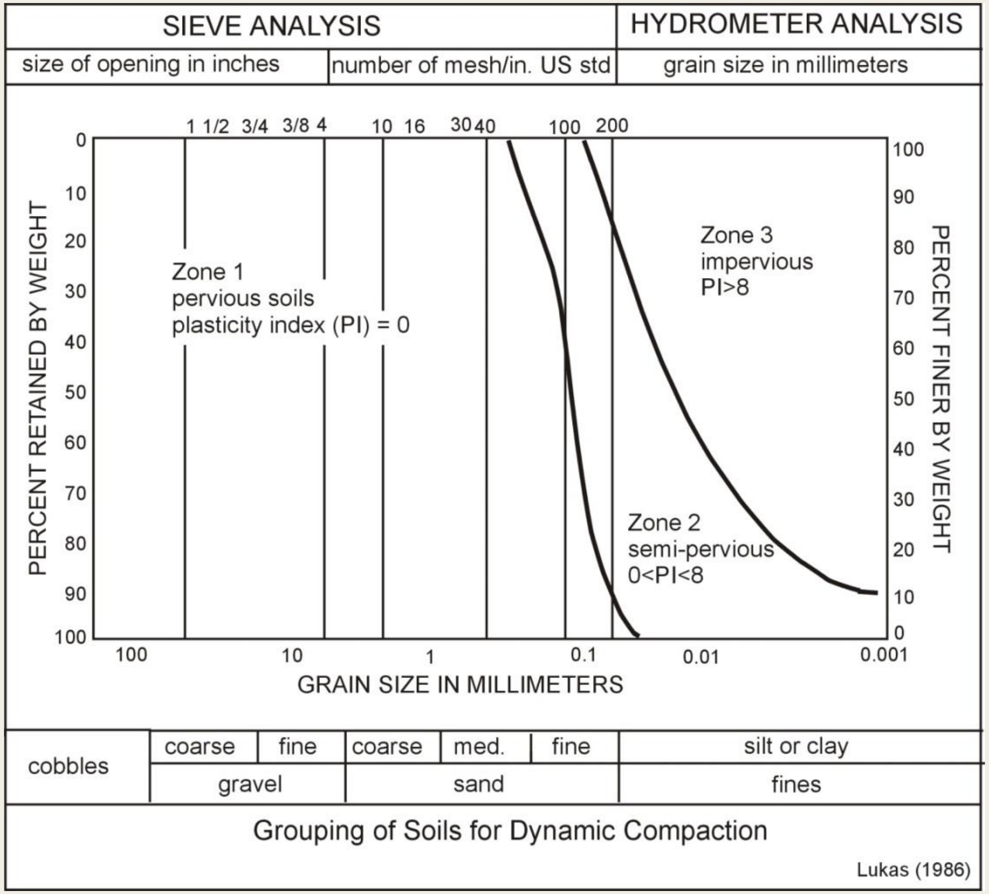
Advantages to DC

- Allows conventional spread footing foundations
- Replaces expensive deep pile foundations
- Helps mitigate deep foundation costs in liquefiable areas
- Highly cost-effective when compared to other forms of ground improvement.
- Reduces settlement
- Increases bearing capacity
- Eliminates risk of hazardous waste exposure resulting from conventional undercut and replace (stays buried)
- Self-compensating – Softer areas are immediately apparent: and additional energy can be applied

Soils Conducive to Dynamic Compaction Improvement

- Loose Sands
- Uncontrolled Fills
- Debris Fills
- Mine Spoils
- Sanitary Landfills
- Old Sand / Clay Pits
- Boulder Fills
- Liquefiable Soils
- Sinkhole / Mines
- Collapsible Soils
- Landfill Liner Preparation

Important Geotechnical Design Parameters



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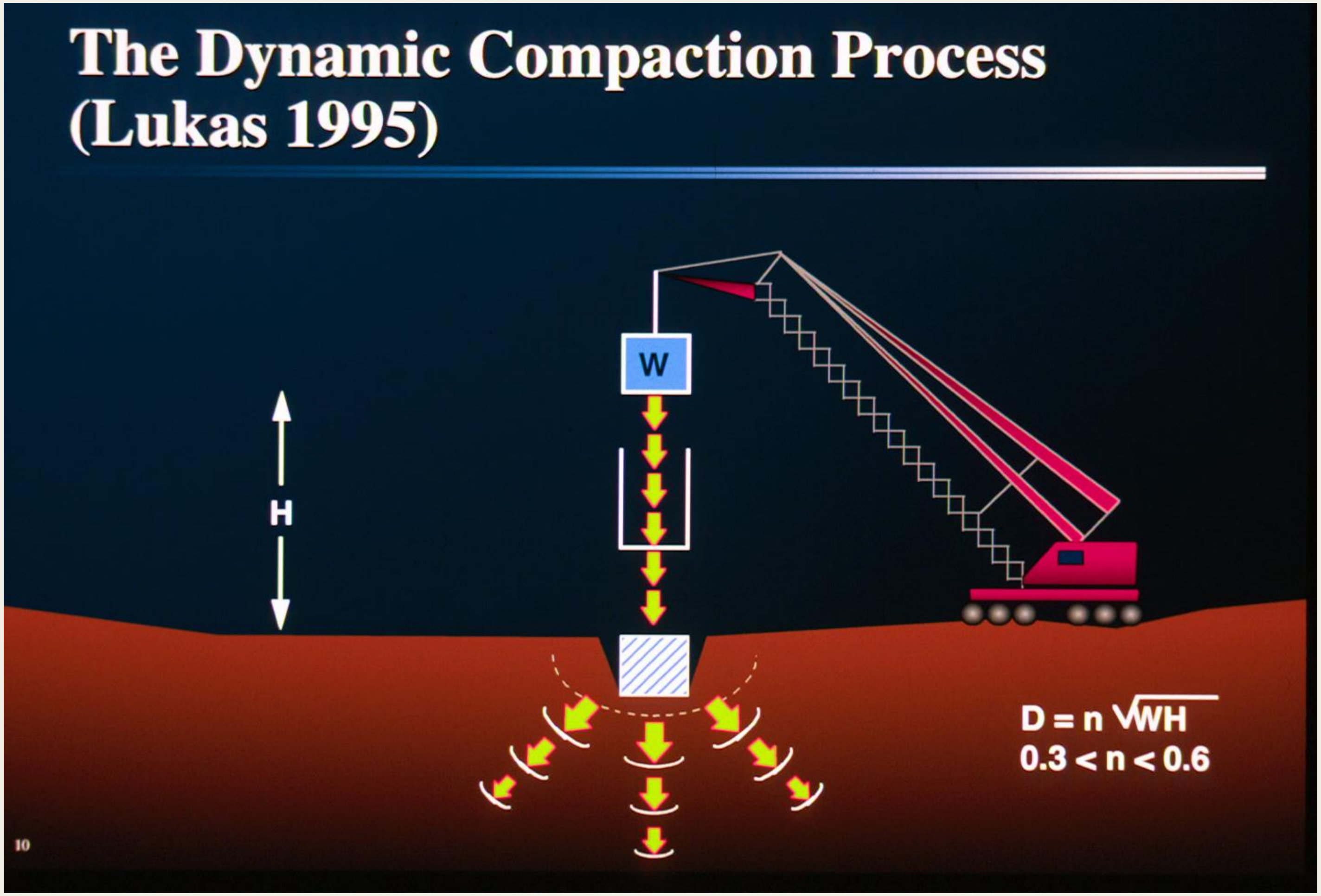
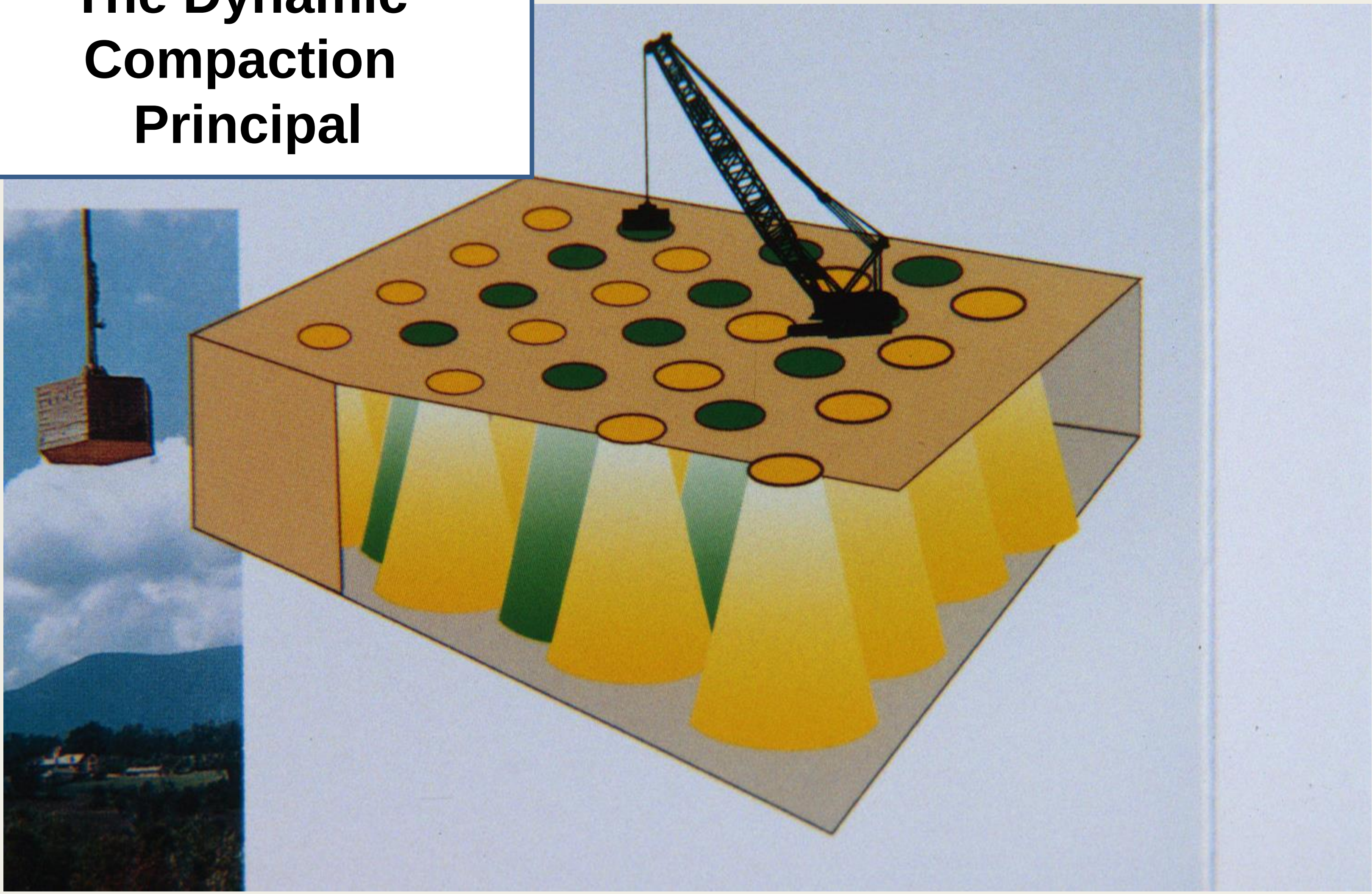
Depth of Improvement



The Dynamic Compaction Principal



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Governing Design Formulas

Depth of Influence:

$$D = n * \sqrt{W * H}$$

n - an empirical value based on soil type and varies from 0.35 to 0.6

W - weight in Mg

H - drop height in meters

Governing Design Formulas

Applied Energy (AE):

$$AE = (N * W * H * P)/(grid\ spacing)^2$$

N is the number of drops
W is the weight in Mg
H is the drop height in meters
P is the number of passes

Note: What's not in here is the contact pressure of the tamper.

Recommended Applied Energy

Recommended Energy Levels based on soil type are as follows:

Pervious Coarse-Grained Soils (Zone 1) – 200 to 250 kJ/m^3

Semi-Pervious Soils (Zone 2 and 3) – 250 to 350 kJ/m^3

Landfill Material – 600 to 1,100 kJ/m^3

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Pounder Contact Pressure

- Although not accounted for in design formulas, contact pressure of the pounder is a vital component to successful program.
- Example:
  - 16-ton weight, 7-foot round, 889 psf contact pressure.
  - 15.3-ton weight, 5-foot octagon, 1,417 psf contact pressure
- Higher pressure better for punching; lower pressure better for uniformly lowering a site.

Design Considerations

- Historic Site Usage
- Subsurface Conditions
- Settlement
  - Long term and short term
- Schedule

Design Considerations

- Historic site usage
  - Understanding the prior use of a site can easily rule out the use of a specific type of ground improvement.
  - Specifically, old foundations, structural elements, etc. can prohibit the ability to fully implement the recommended program.
  - Environmental concerns can also be of significance when it comes to on-site soil handling concerns.

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Design Considerations

- Subsurface Conditions
  – Highly plastic soils likely not the best application for DC.
  – Shallow groundwater may require more phases to the program to allow for dissipation of pore pressures.
  – Variable fill materials may require granular material to stabilize.

Design Considerations

- Settlement
  - Granular soils will generally demonstrate post-construction settlement during building construction.
  - Perhaps most importantly, it should be understood that ground improvement generally does not <u>eliminate</u> settlement. It minimizes it to tolerable levels. The anticipated settlements need to be discussed early between the geotechnical and structural engineers and accounted for in the design.

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Design Considerations

- Schedule
  - Dynamic compaction can generally be implemented at a pace of 5,000 to 10,000 square feet per day, per rig, making it a relatively schedule-friendly form of ground improvement.
  - Winter weather can impact the schedule in the same way that it can a traditional earthwork program.
  - Tighter sites require more surgical approach, meaning a longer schedule.

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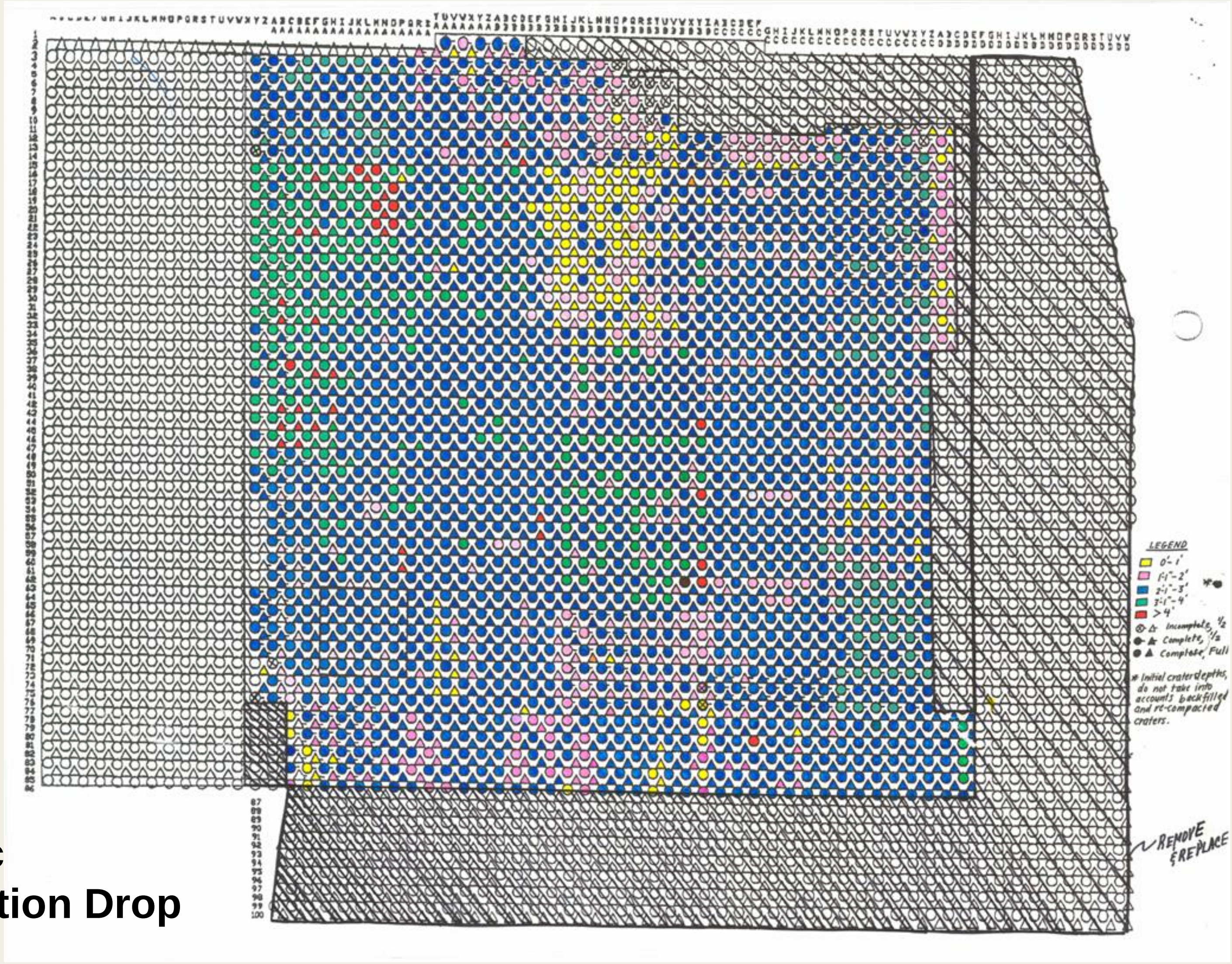
Real-Time Quality Control

- On-site inspection
- Crater depths (mapping)
- Surface elevation monitoring (settlement vs. heave)
- Decrease in depth of weight penetration with successive drops
- Pore pressures



Dynamic Compaction Drop Plan

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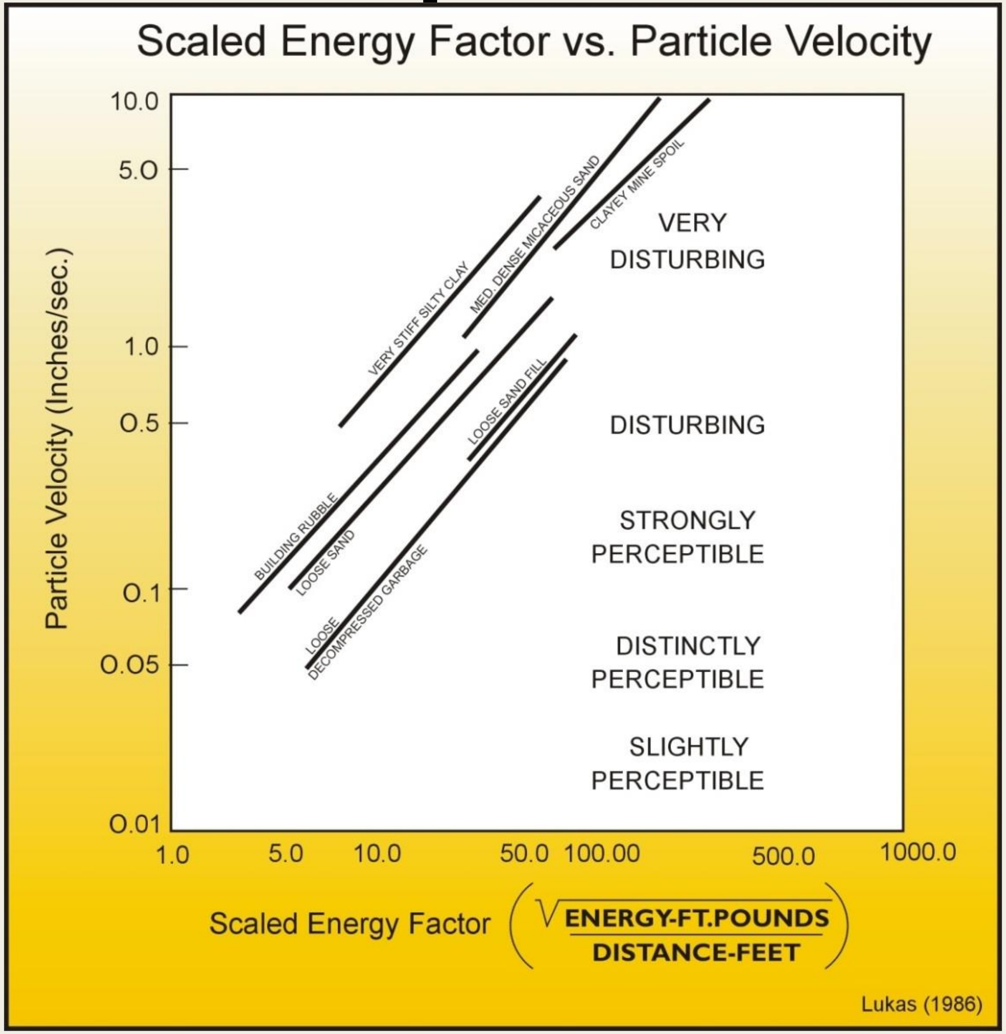
Post-Improvement Acceptance Testing

- Large-Scale Load Test (where CPT & SPT are unreliable i.e. construction rubble and cobbles)
- Standard Penetration Test (SPT)
- Cone Penetrometer Test (CPT)
- Pressuremeter Test (PMT)
- Dilatometer Test (DMT)
- Shear-Wave Velocity Profiling

KEY IS TIME!!

Vibrations

Dynamic Compaction Vibrations



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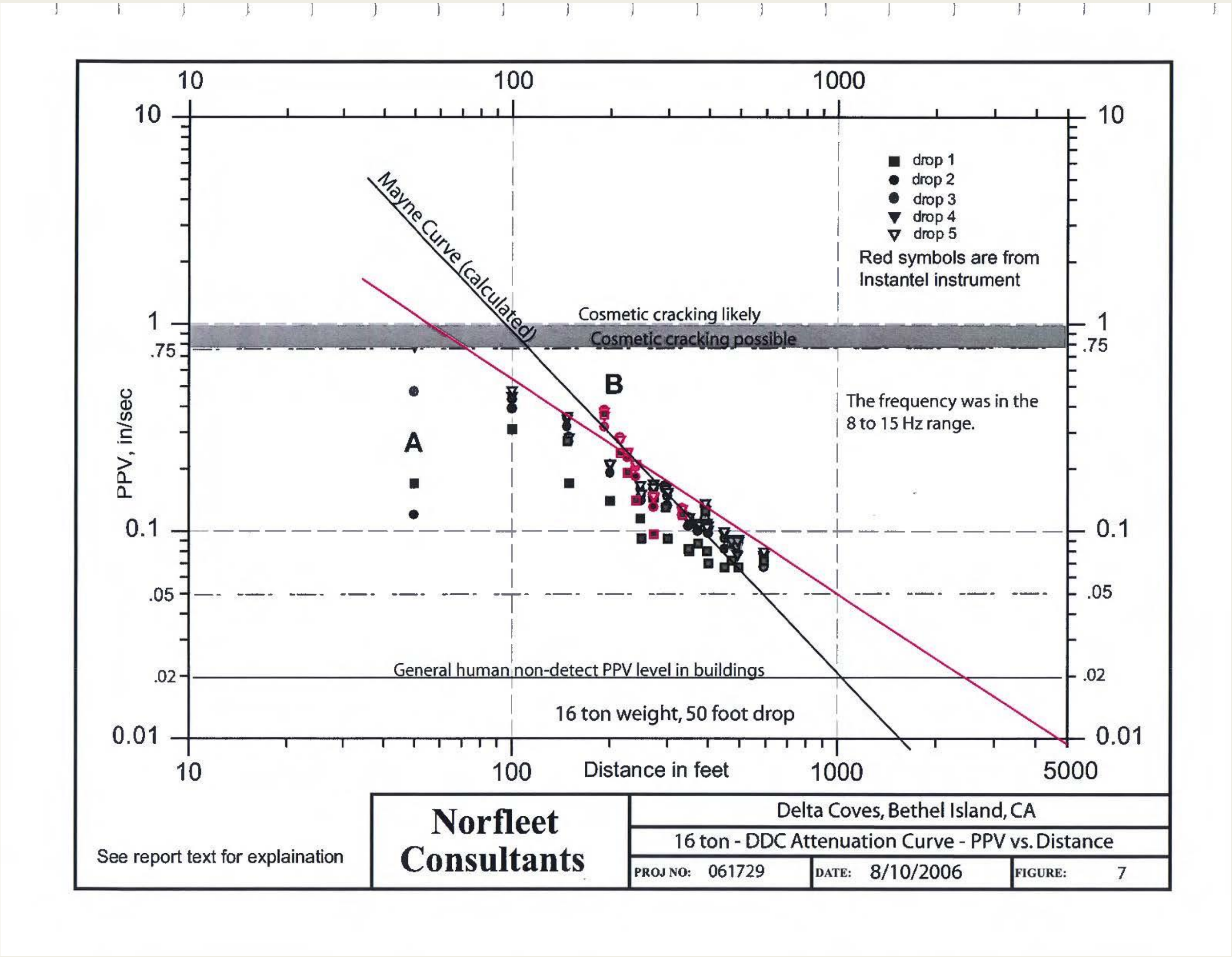
Dynamic Compaction Vibrations
16-ton Weight Attenuation Curve



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Vibration Reduction Measures

Isolation

Trench

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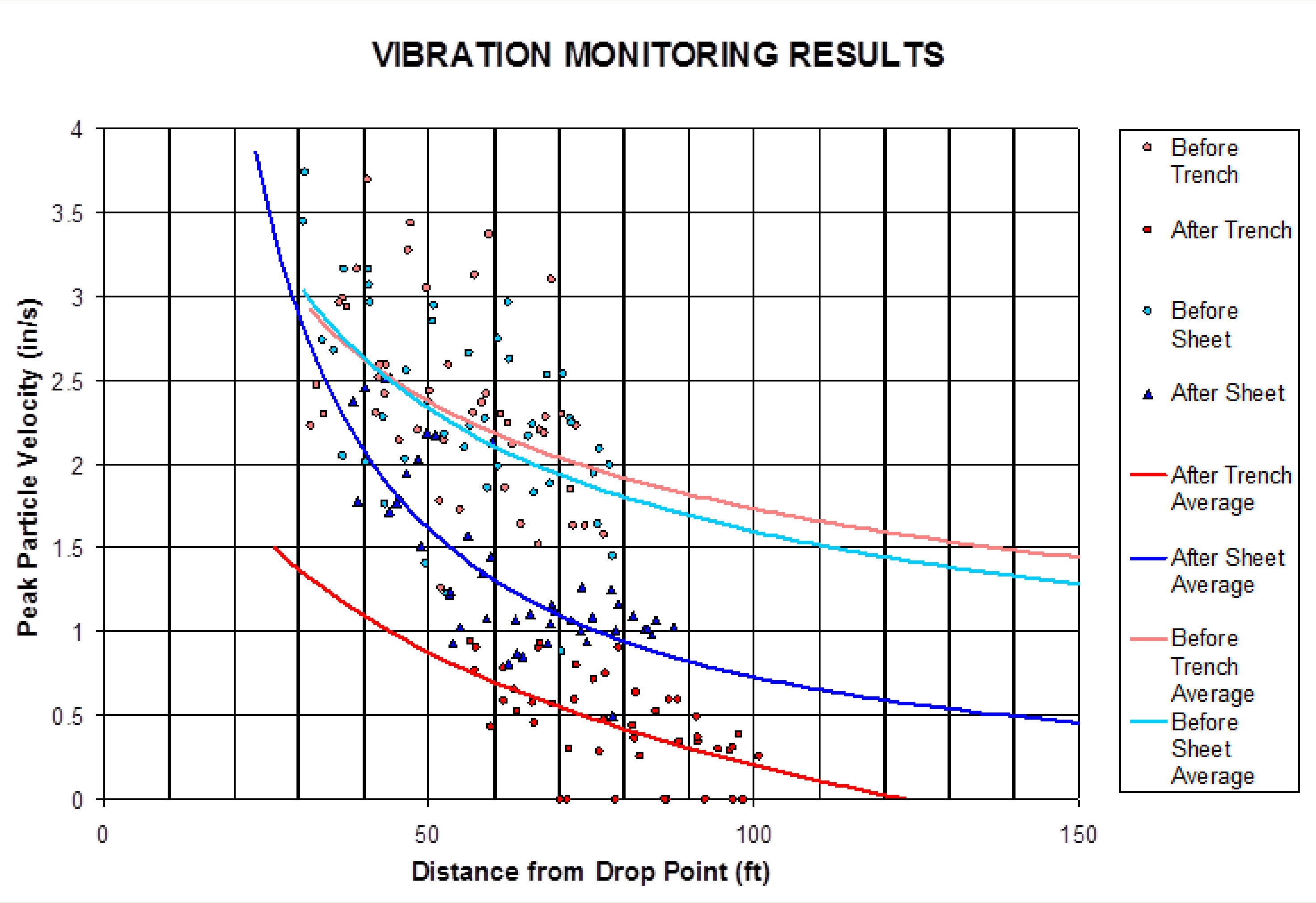
Vibration Reduction Effectiveness



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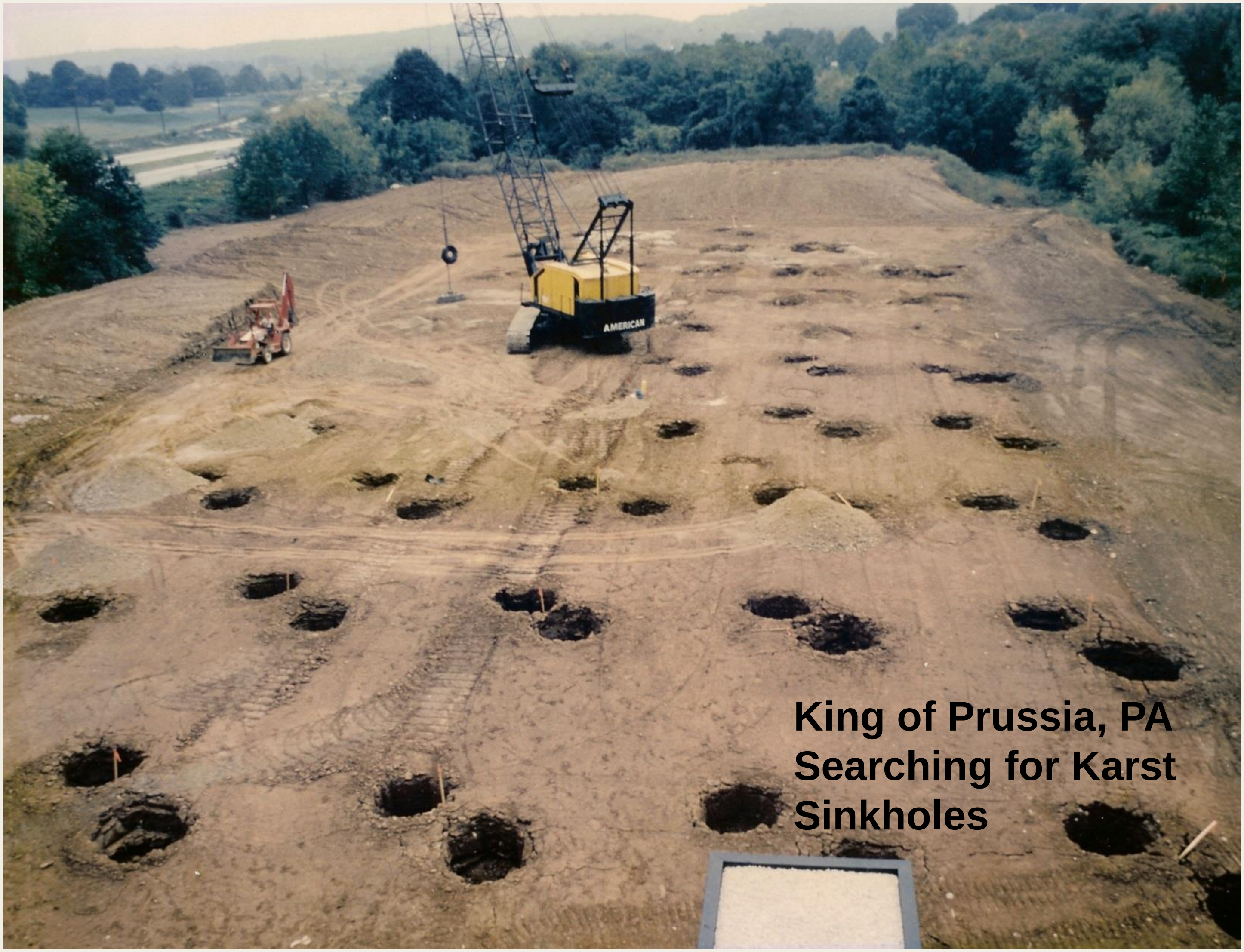
Project Examples



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Springdale, AR
Landfill

Saratoga Springs, NY
Loose Sands

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JFK Airport,
Queens, NY
Liquefiable Sands

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Lake Shore Drive
Chicago, IL
Ash Fill from Coal Tunnels beneath the City

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Yoloten, Mary, Turkmenistan
Leveled Dune Sands


Prudential Center
Newark, NJ
Fill Material

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Questions??

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