Ground Improvement

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Types of Ground Improvement

Ground Reinforcement
- Stone Columns
- Soil Nails
- Deep Soil Nailing
- Micropiles (Mini-piles)
- Jet Grouting
- Ground Anchors
- Geosynthetics
- Fiber Reinforcement
- Lime Columns
- Vibro-Concrete Column
- Mechanically Stabilized Earth
- Biotechnical

Ground Improvement
- Deep Dynamic Compaction
- Drainage/Surcharge
- Electro-osmosis
- Compaction grouting
- Blasting
- Surface Compaction

Ground Treatment
- Soil Cement
- Lime Admixtures
- Flyash
- Dewatering
- Heating/Freezing
- Vitrification

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Haward Baker Site

About the Technology

Soil Reinforcement

Engineering Fills
- Reinforced Soil Steel
- Mechanically Stabilized earth Structure
- Geosynthetics
- Fiber Reinforcement
- Natural Reinforcement

Ground Reinforcement
- Soil Nailing
- Micropiles
- Soil and Rock Anchors
- Diaphragm Walls

Ground Improvement
- Dynamic Deep Compaction
- Vibro Compaction
- Vacume Consolidation
- Drainage
- Preloading
- Blasting
- Heating
- Ground Freezing
- Vibro-Replacement Stone columns
- Vibro-Displacement Stone Columns
- Lime Columns
- Elect.-Chemical

Grouting and Admixture

Grouting
- General Grouting
- Permeatation Grouting (chemical, microfine cement, bentonite,others)
- Compaction Grouting (displacement)
- Jet Grouting (replacement, erosion)
- Slurry Grouting (intrusion)
- Fracture Grouting (Soilfrac)

Mixed in Place
- Admixtures and Shallow Soil Mixing
- Deep Soil Mixing
  - Dry Jet Mixing
  - Lime Cement Columns
- Slurry Walls

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Dynamic Compaction

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Dynamic Deep Compaction

- Dynamic compaction was first used in Germany in the mid-1930's.
- Menard technique France
- Dynamic Deep Compaction is simply the dropping of heavy weights on ground surface to densify soils at depth

- Reduce foundation settlements
- Reduce seismic subsidence
- Permit construction on fills
- Densify garbage dumps
- Improve mine spoils
- Induce settlements in collapsible soils

Dynamic Deep Compaction Design Steps

1. Perform site investigation
2. Develop settlement influence diagrams
3. Develop initial DDC program
4. Develop numerical performance prediction
5. Develop QA/QC plans

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Important Construction Conditions

- The Drop Weights ranges from 8 to 200 tons
- Drop Heights ranges from 50 to 100 ft.
- Impact grids of 7 x 7 ft to 20 x 20 ft
- Minimum 100-150 ft clearance from any structure
- Review site for vibration sensitivity
- Primarily for silts and sands but also clays

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Limitations

- Problems near groundwater
- Multiple passes to compact at depth

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Important Terms

- Effective Depth -- Maximum depth of ground improvement
- Zone of Major Densification -- About upper 2/3 of effective depth
- Energy Level -- Energy per blow (weight times drop height)
- Energy Intensity Factor -- Involves energy level, spacing, and number of blows

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Depth of Influence

$$D = C\sqrt{wh}$$

w = Weight of drop (Tons)
h = Height of drop (m)
D = Depth of influence (m)
C = Factor= .3-.7 Depends on soil type

From Holtz and Kovacs, 1981

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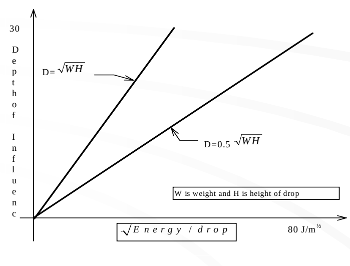
Dynamic compaction



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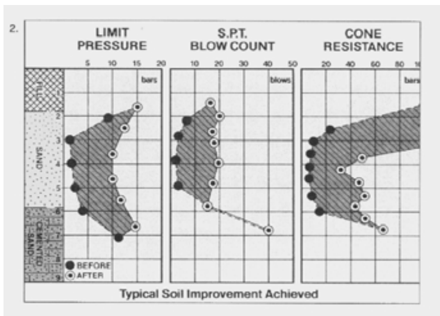
Dynamic Compaction



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Important Geotechnical Parameters

- Soil conditions
- Groundwater level
- Relative density
- Degree of saturation
- Permeability

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Quality Control

- Crater depths (map)
- Surface elevation monitoring
- Decrease in depth of weight penetration with successive drops
- Pore pressures
- Geophysical monitoring

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