SOIL LIQUEFACTION DURING EARTHQUAKES

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Introduction

Myanmar is located in a seismically active area, making it highly susceptible to serious damage and loss from earthquakes. With the recent increase in high-rise developments across the country, geotechnical investigations for all proposed structures must include an assessment of liquefaction potential.

SOIL LIQUEFACTION DURING EARTHQUAKES

What is Liquefaction?

Soil liquefaction occurs when saturated, loose sands lose their strength due to sudden dynamic forces like earthquakes, blasting, or pile driving.

The Mechanism: Sudden shaking causes the soil to compact, shifting the overlying weight onto the groundwater. This rapid spike in water pressure destroys the soil's internal stability, causing the ground to fail and flow like a liquid.

The Triggers: This hazard is highly likely in areas with low fine-content soils, low Standard Penetration Test (SPT) values, shallow groundwater levels, and high peak ground acceleration.

SOIL LIQUEFACTION DURING EARTHQUAKES

A. Liquefaction and its effect

B. Fundamentals of Liquefaction Behavior

C. Consequences of Liquefaction

D. Mitigation of Liquefaction hazard

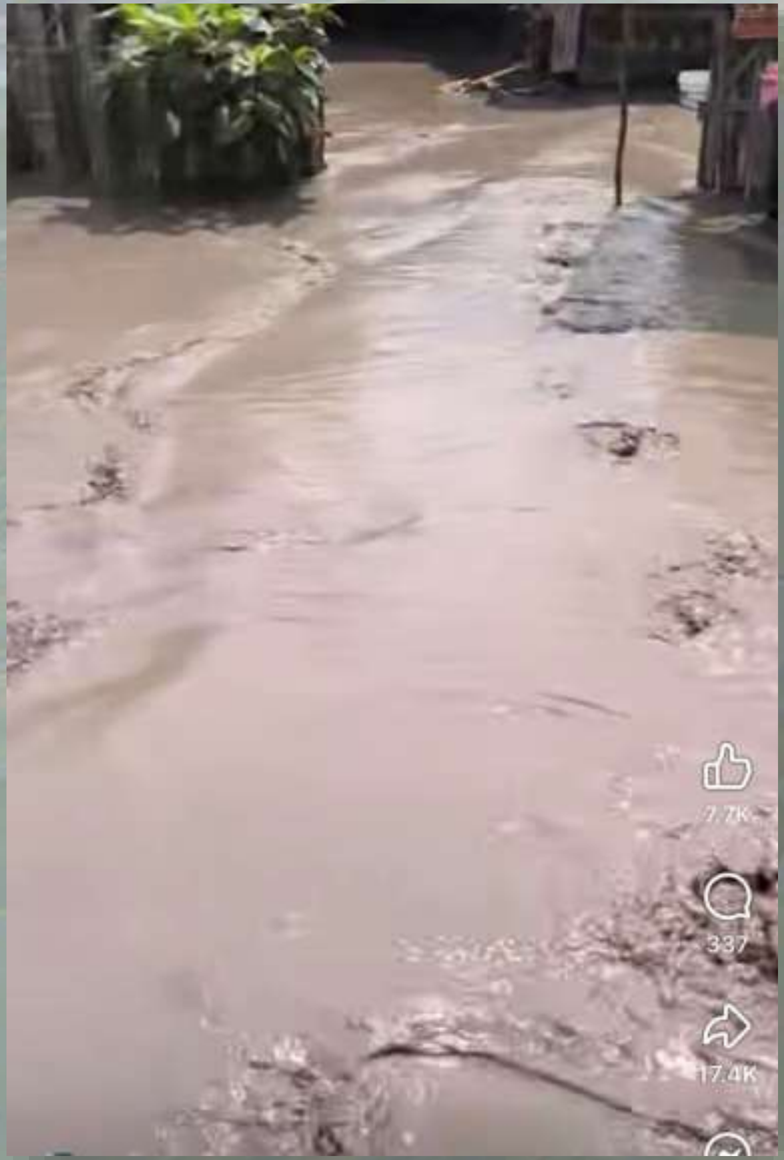
A. Liquefaction and its effect

- Appear at During Earthquakes

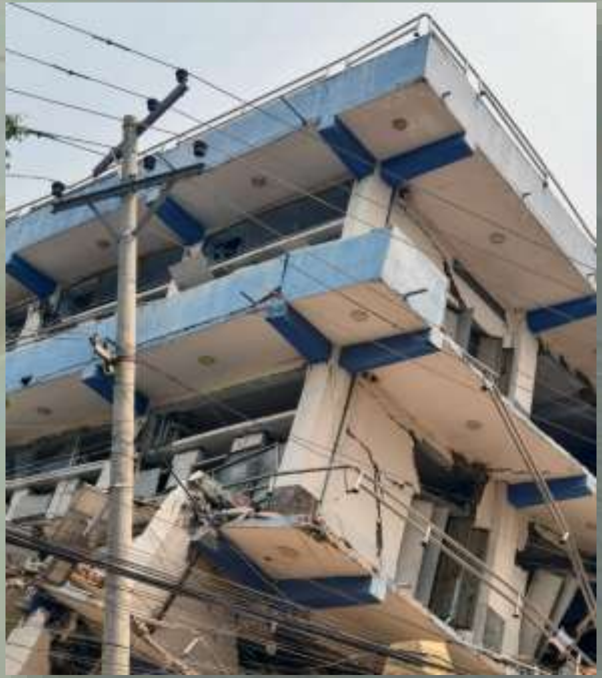
- Effects following Case

  1. Sand Boiling Case
  2. Floating Case
  3. Lateral Spreading Case
  4. Sliding Case
  5. Quay Wall deformation Case

1. Sand Boiling Case



2. Floating Case



3. Lateral Spreading Case

4. Sliding Case

5. Quay Wall deformation Case

B. Fundamentals of Liquefaction Behavior

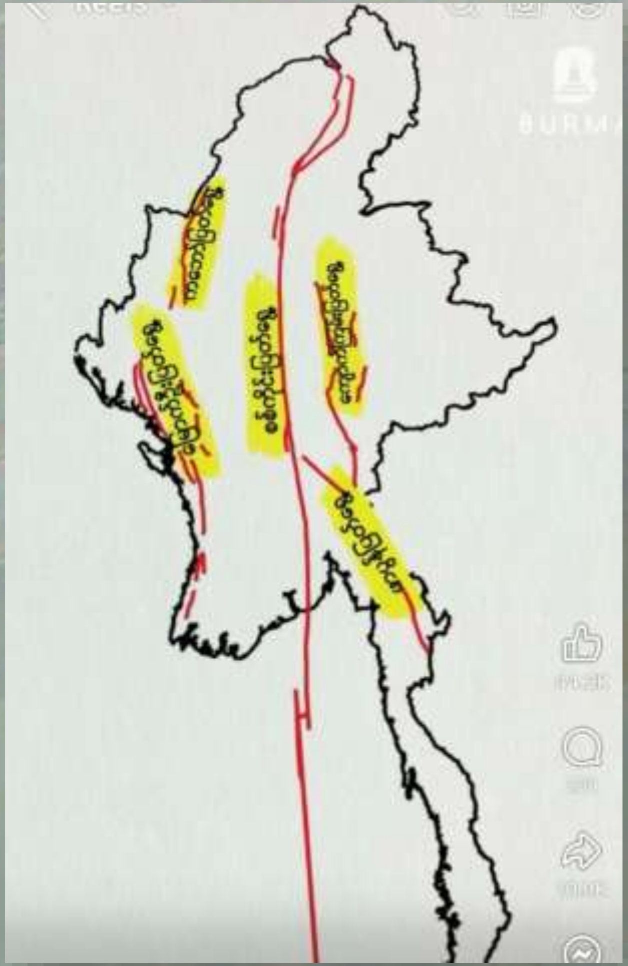
B.1: Liquefaction Hazard Area

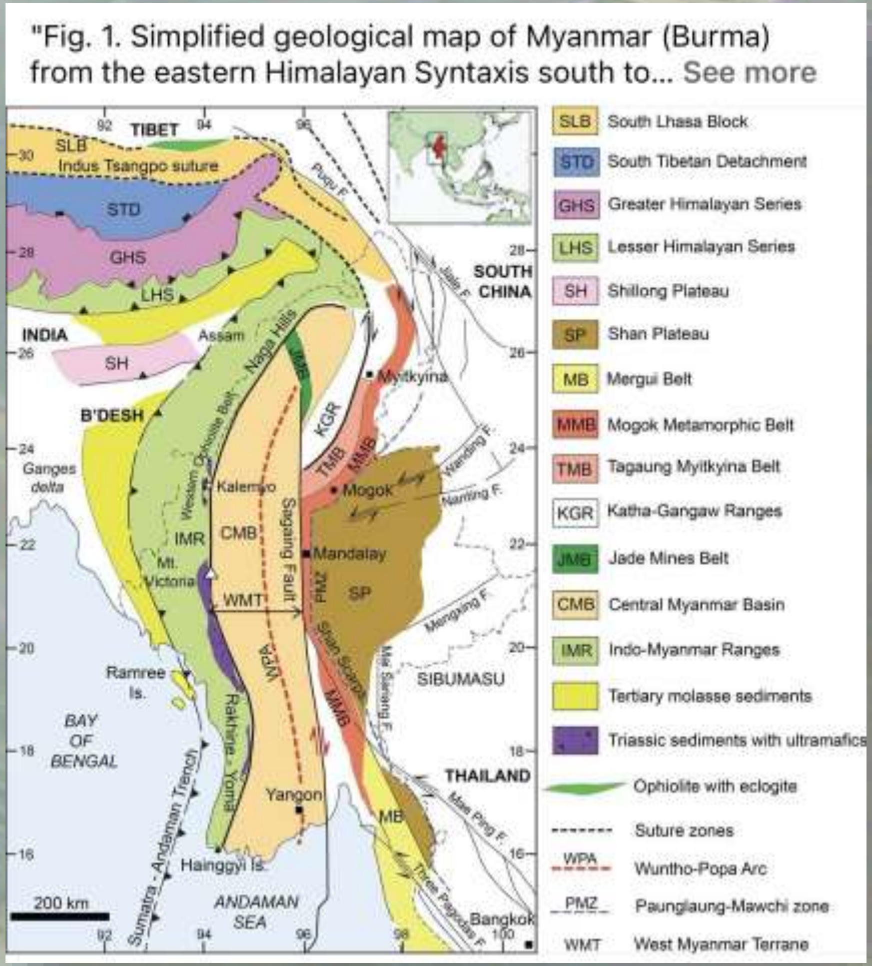
B.2: Most Liquefaction Subsurface soil condition Sand

B.1: Liquefaction Hazard Area

Depend on Geology Land Condition

- Major Fault (4.Faults in Myanmar)
- Minor Fault (Many in Fig Shown)





According to the Land Nature depend on Geology condition, and investigation of Subsurface Soil Condition Geo-Science tectonism were done Hazard Map of Earthquake.

Following of Myanmar Hazard Map

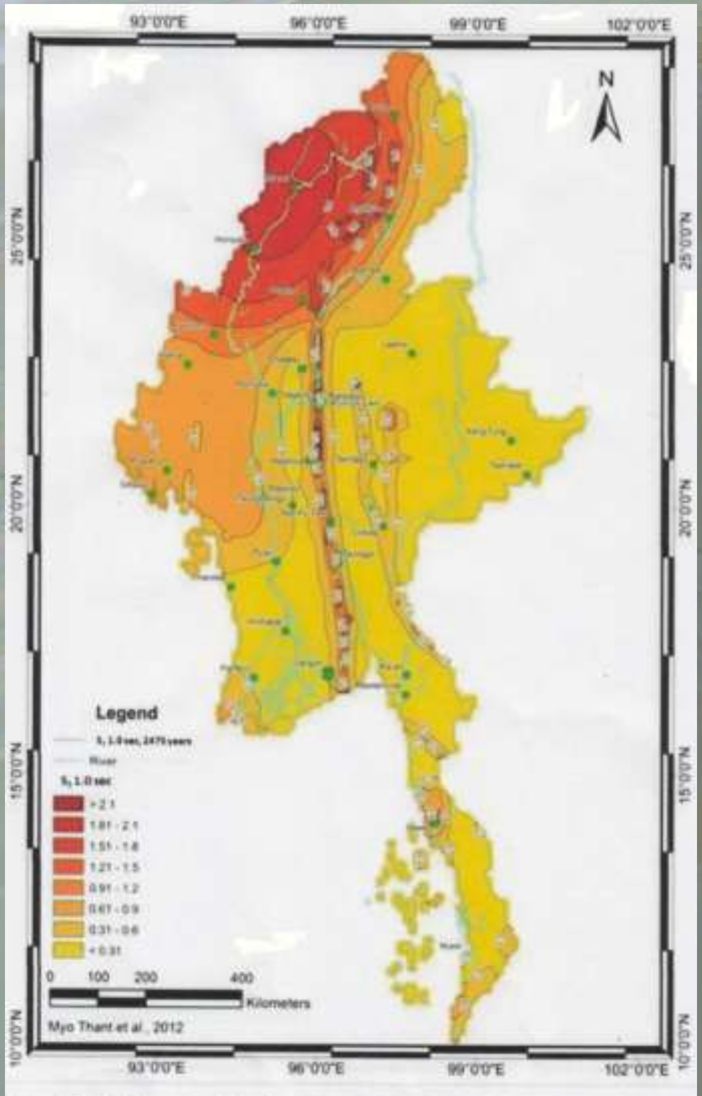


Figure 3.4.2: Maximum Considered Earthquake Ground Motion for 1 Sec Spectral Response Acceleration at 2% Probability in 50 Years with 5% Critical Damping, Site Class B

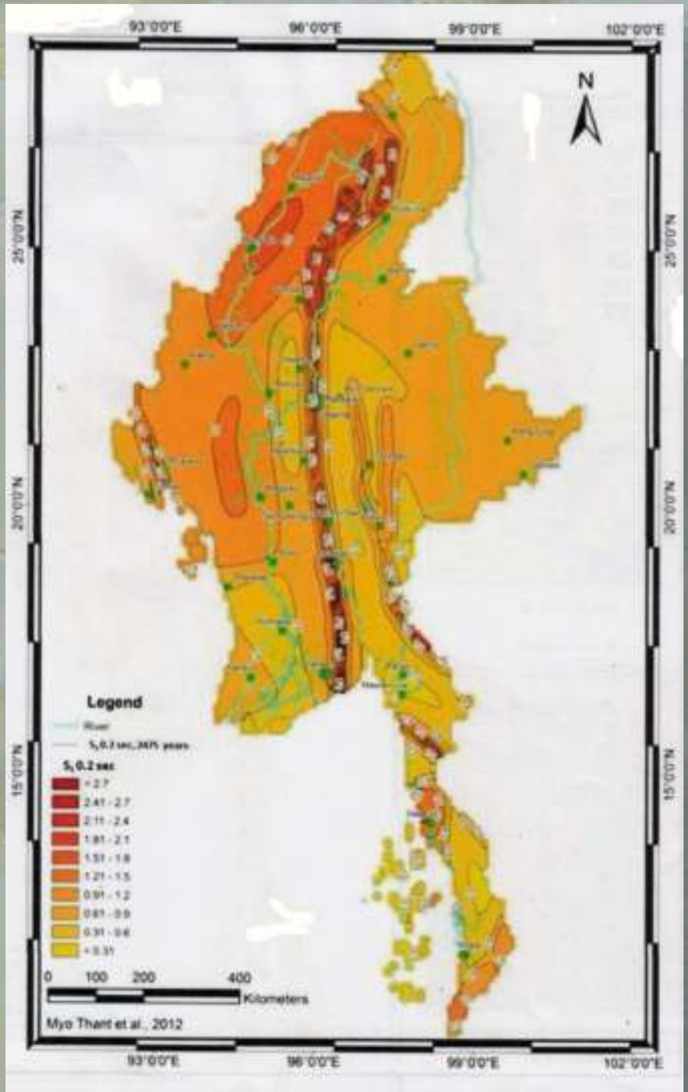


Figure 3.4.1: Maximum Considered Earthquake Ground Motion for 0.2 Sec Spectral Response Acceleration at 2% Probability in 50 Years with 5% Critical Damping, Site Class B

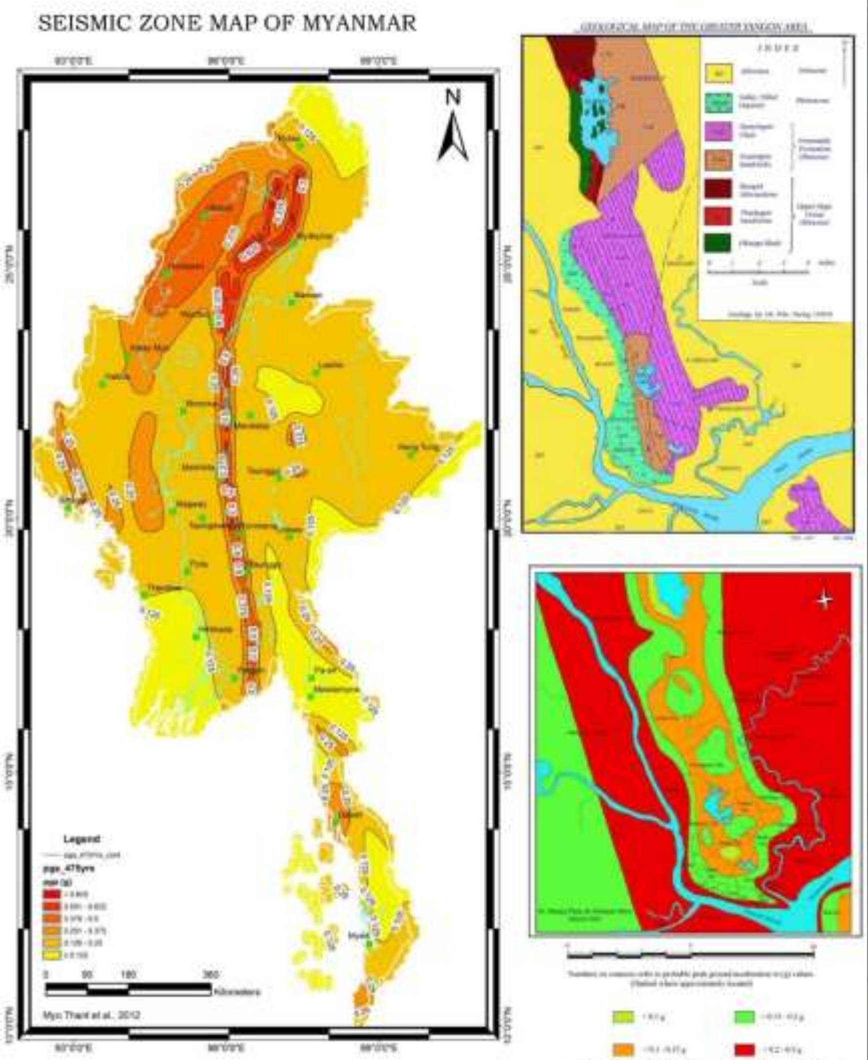


FIG : EARTHQUAKE HAZARD MAP OF YANGON AREA

B.2: Most Liquefaction Subsurface soil condition Sand

- Highly Susceptible Soil
- Uniformly-graded clean sand
- It's very loose to loose

2.2 Full Saturation saturated sand

- its Layer Under Ground Water Table

2.3 Cyclic softening of clays and plastic silts.

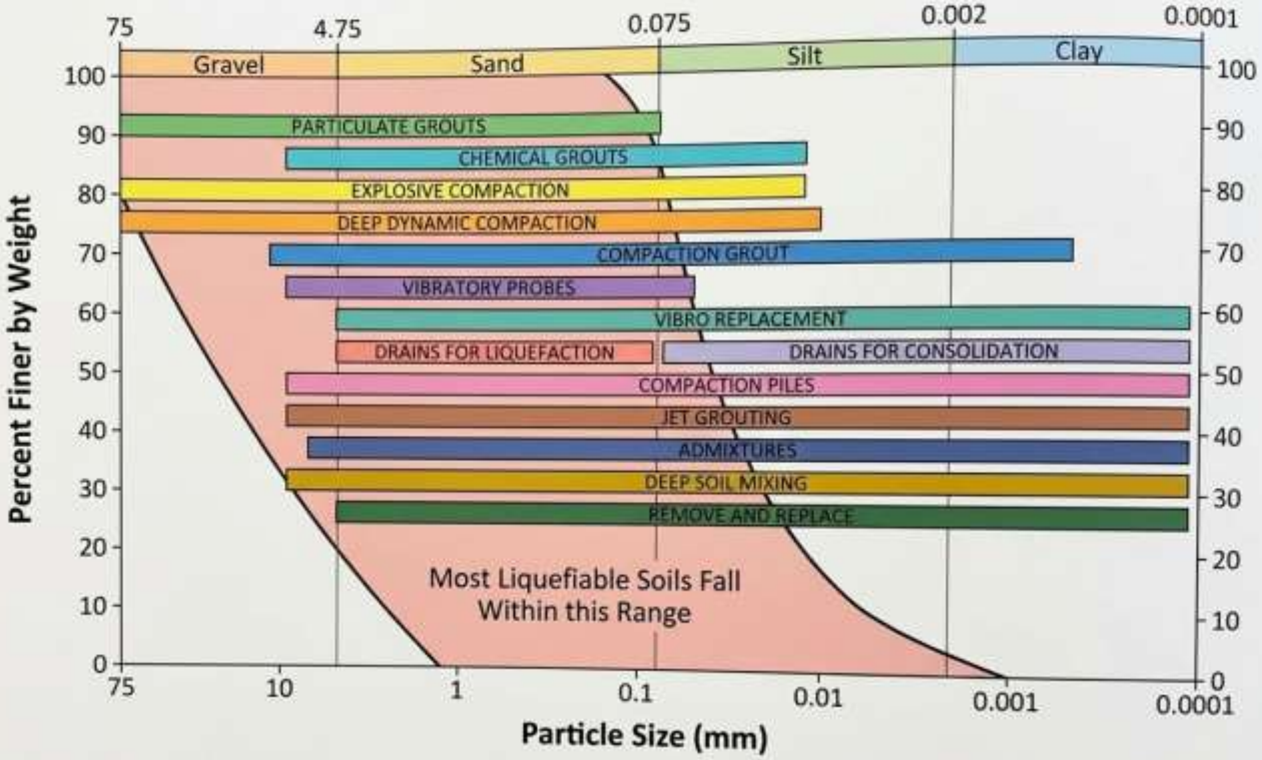


Figure 114. General applicability of ground improvement methods for soils of various grain-size distributions (Mitchell 2008, with permission from ASCE).

B.2: Most Liquefaction Subsurface soil condition Sand

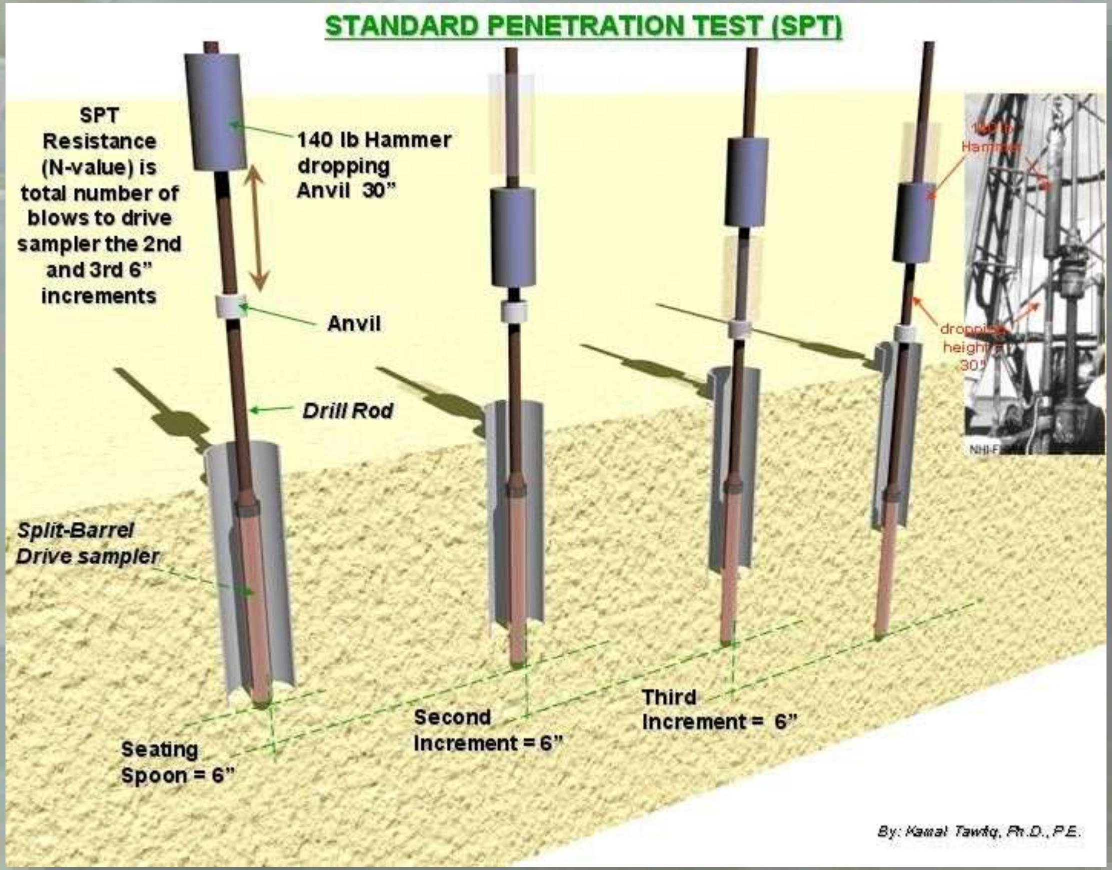
How to known this condition, it’s depend on

- Site Investigation
- Laboratory Investigation

Site Investigation

- SPT (Standard Penetration Test)
- CPT(Cone Penetration Test)
- BPT & LPT (Gravel & Cobbles)

SPT


STANDARD PENETRATION TEST (SPT)
SPT Resistance (N-value) is total number of blows to drive sampler the 2nd and 3rd 6" increments
140 lb Hammer dropping Anvil 30"
Anvil
Drill Rod
Split-Barrel Drive sampler
Seating Spoon = 6"
Second Increment = 6"
Third Increment = 6"
By: Kamal Tawfiq, Ph.D., P.E.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Laboratory Investigation to known effects liquefaction case

1. Grain Size Distribution
2. Plastic Limit
3. Relative Density
4. Confining Stress
   4.1. e.g. Triaxial Test for Residual Strength of liquefied Soil and the potential for slope stability
   4.2. Lateral spreading of gently sloping or nearly level ground profile
   4.3. Post- liquefaction settlement that is due to liquefaction beneath gently sloping or ground level profile.

How to Decide Appear of not Appear Liquefaction, Depend on Calculation

Analysis- (1) Analytical Analysis and Empirical Method

(2) PLAXIS 2D/3D, FLAC, DEEP SOIL

(1)Analytical and Empirical Method

- SPT& CPT Equipment Using
- Which Result data

Base on- Cyclic Resistance Ratio (CRR)

- Cyclic Stress Ratio(CSR)

Calculation depend on Ratio-CRR,CSR to Factor of Safety (FS)

Ref: SPT& CPT Comparison of SPT and CPT for Liquefaction Potential Analysis of 25th storeyed RCC Building, No 8, Zakawa Street, Dagon Township in Yangon, Myanmar.

The Building site is could not be occurred liquefaction.

SPT မှ တွက်ထုတ်ထားသောပုံစံများ

6. SOIL LIQUEFACTION POTENTIALS AT THE PROJECT SITE

Liquefaction potentials analysis related to SPT results, calculated formula by **Robert W - Day** and **Seed et al., (1985), ASCE.**

Recommended for computations leading to evaluation of liquefaction potentials are: (*) determine the cyclic stress ratio CSR to be caused by expected carthquakes using the relationship:-

$$CSR = 0.65 \times r_d \times (\sigma_v/\sigma'_v) \times (a_{max}/g)$$

CSR = Cyclic Stress Ratio

CRR = Cyclic Resistance Ratio (obtained from graph considering % fines, Seed et., al (1985)

σ_v = total vertical stress

σ'_v = effective vertical stress

g = acceleration due to gravity

a_{max} = Maximum earthquake acceleration expected

r_d = factor obtainable

Remarks: If **CSR > CRR** then liquefaction occurs; otherwise liquefaction does not occur.

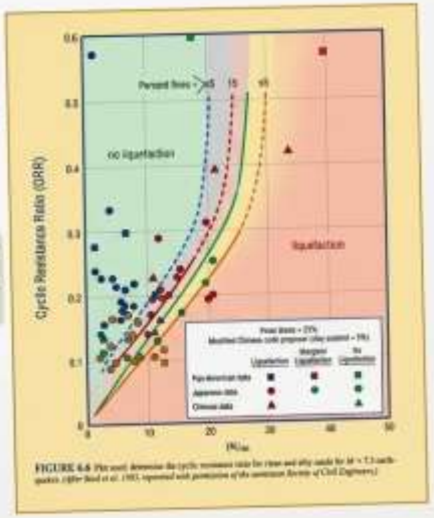
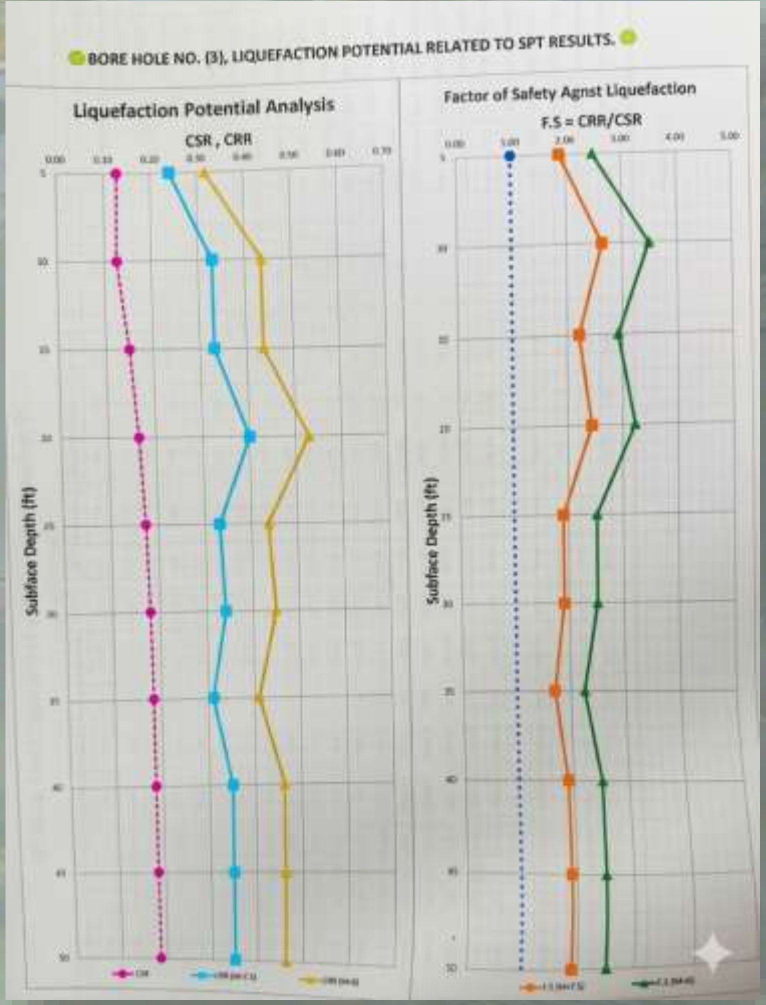
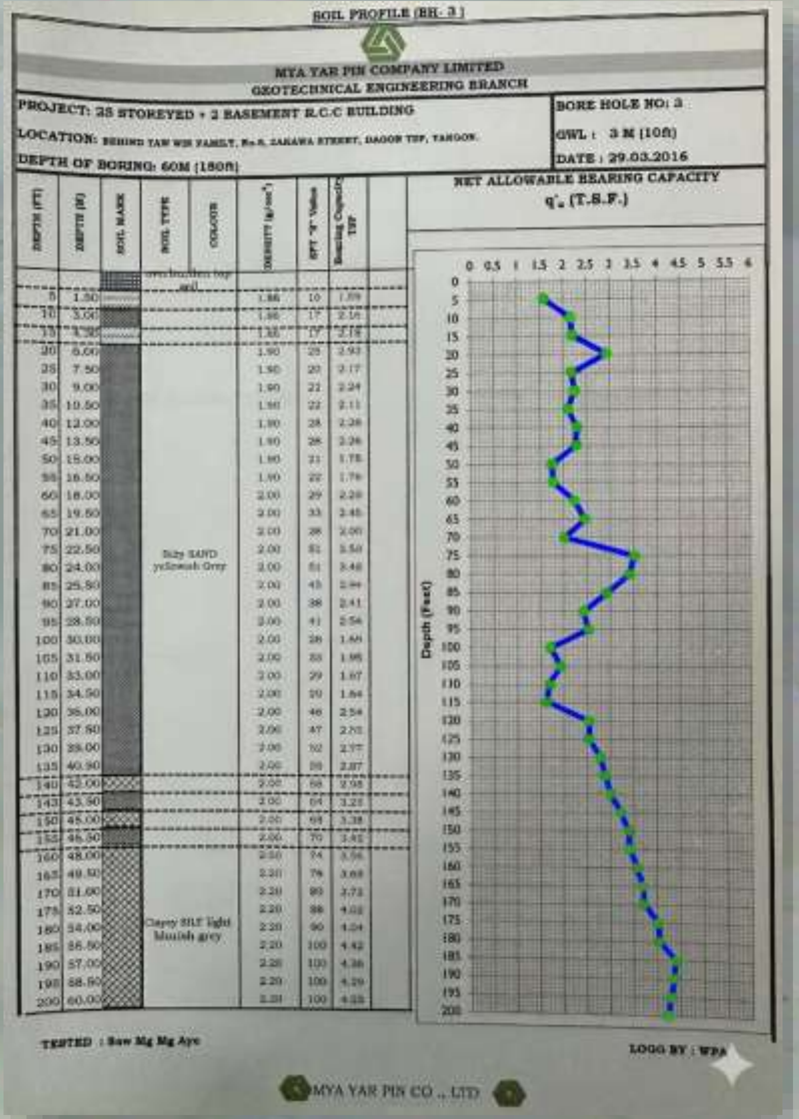
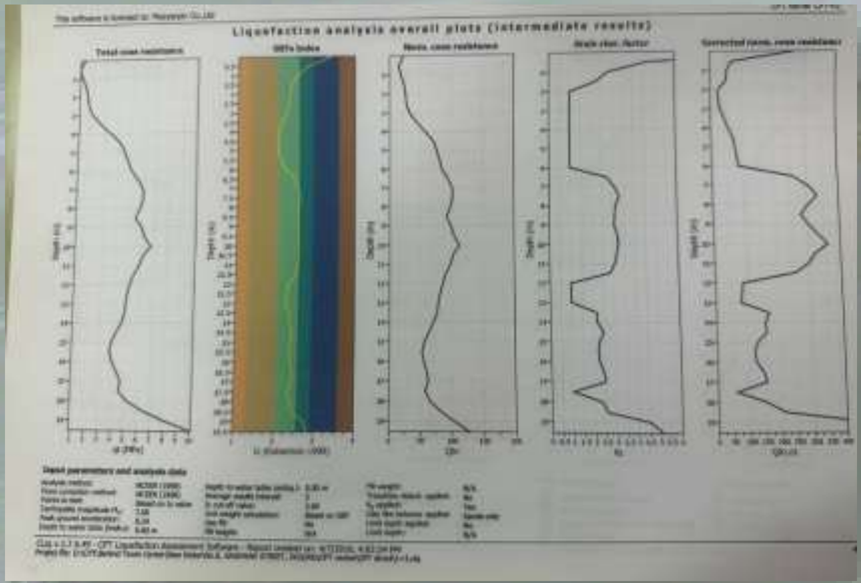


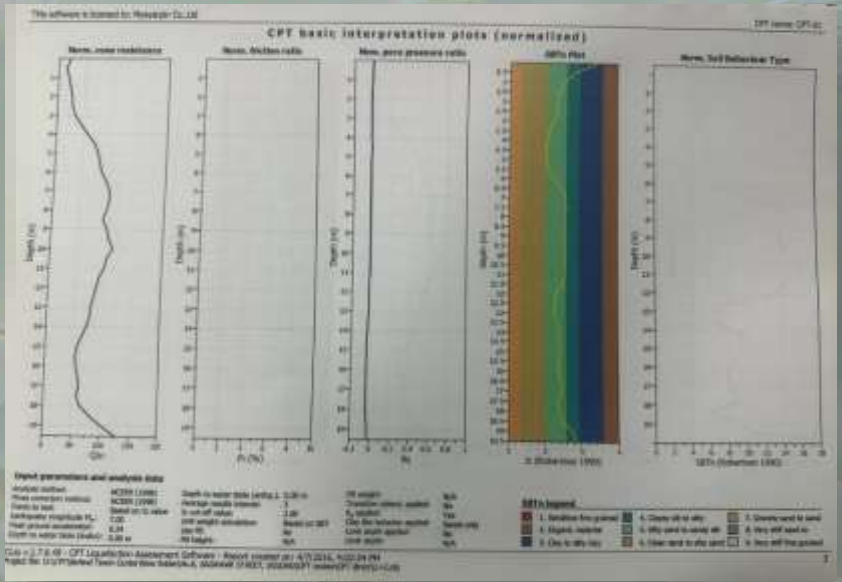
FIGURE 6.6

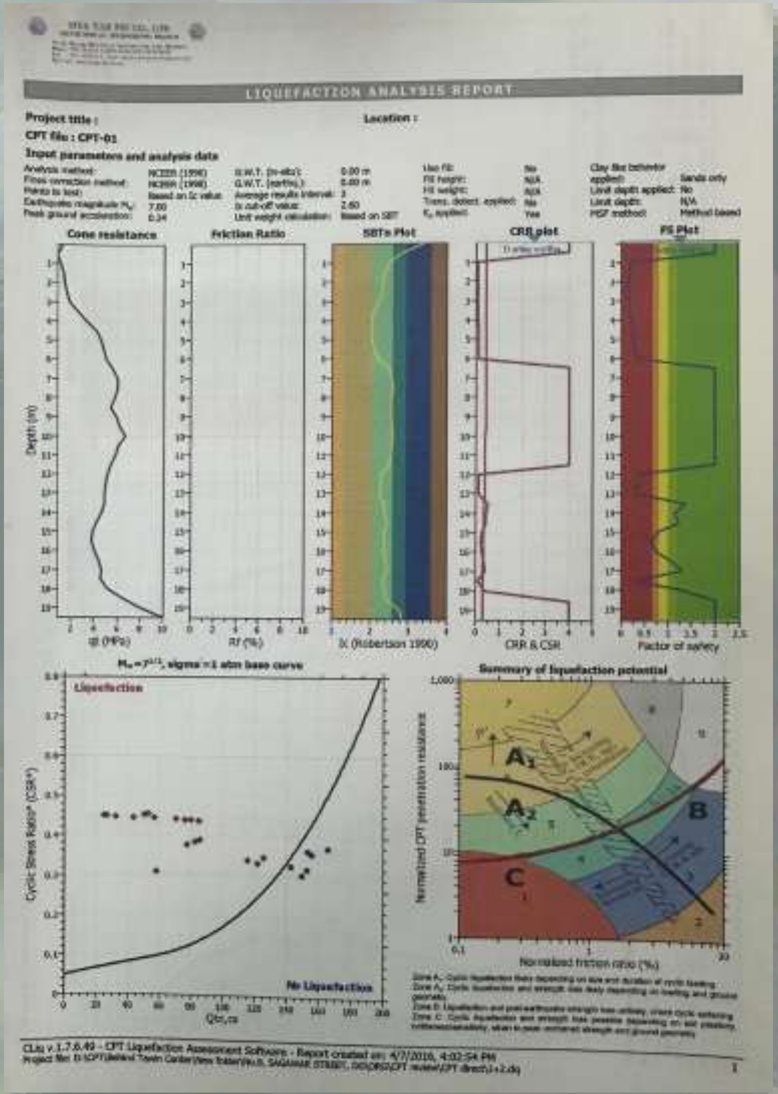


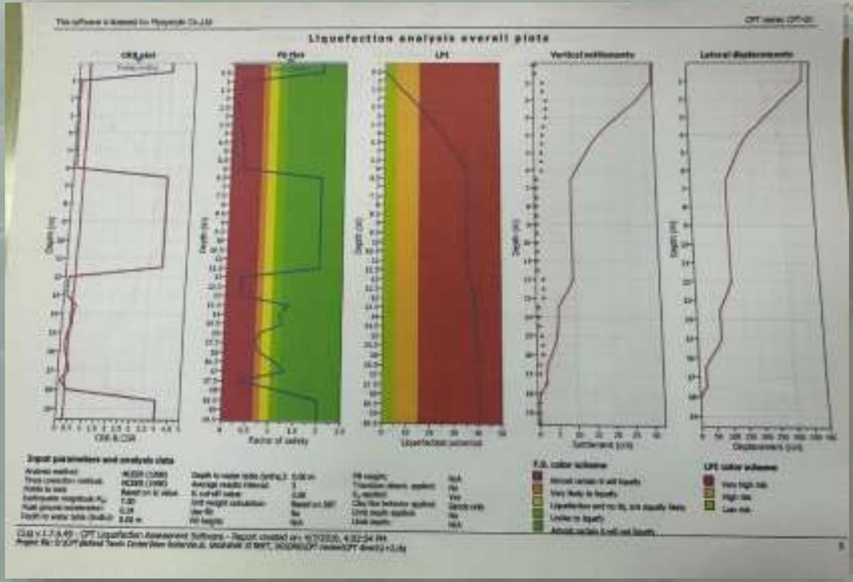


CPT မှ တွက်ထုတ်ထားသောပုံစံများ









Liquefaction Method (1) & (2) Explanation

(1) Analytical Analysis and Empirical Method

(2) PLAXIS 2D/3D, FLAC, DEEP SOIL

C. Consequences of Liquefaction

-General Consideration

(1). Site Conditions

1.1. Structures at sloping Ground or gently sloping of ground level Profile.

1.2. Structure of shallow or deep foundation at High Rise Building, Bridge, Dam, Tunnels and others Public building of Hospitals, Schools Hotels, House.

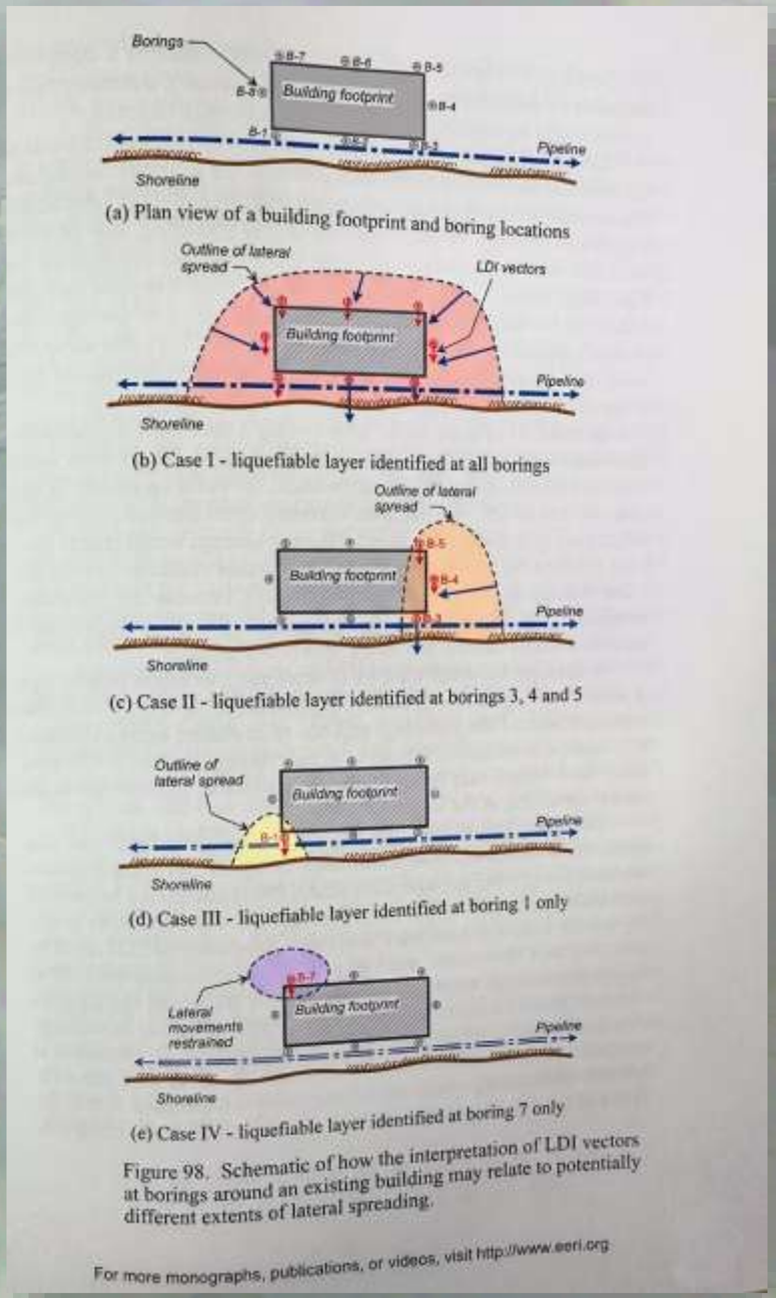


Figure 98. Schematic of how the interpretation of LDI vectors at borings around an existing building may relate to potentially different extents of lateral spreading.

D. Mitigation of Liquefaction Hazards

- Doing nothing and accepting the Potential damage and Risk
- Abandoning the project or choosing another site.
- Method of Ground improvement
- Modifying the design
- Method of Ground Improvement
- Vibro Method

Figure 116. Vibroflotation with a water jet to assist ground penetration during construction of a vibro-replacement stone eulunn.

Figure 115. Process for constructing a vibro-replacement stone column (Hayward Baker, Inc.)

- **Deep Dynamic Compaction**

- **Compaction Grouting**

➢ Deep Soil Mixing

Figure 119. The deep soil mixing process (Hayward Baker, Inc.).

➢ Drainage Page

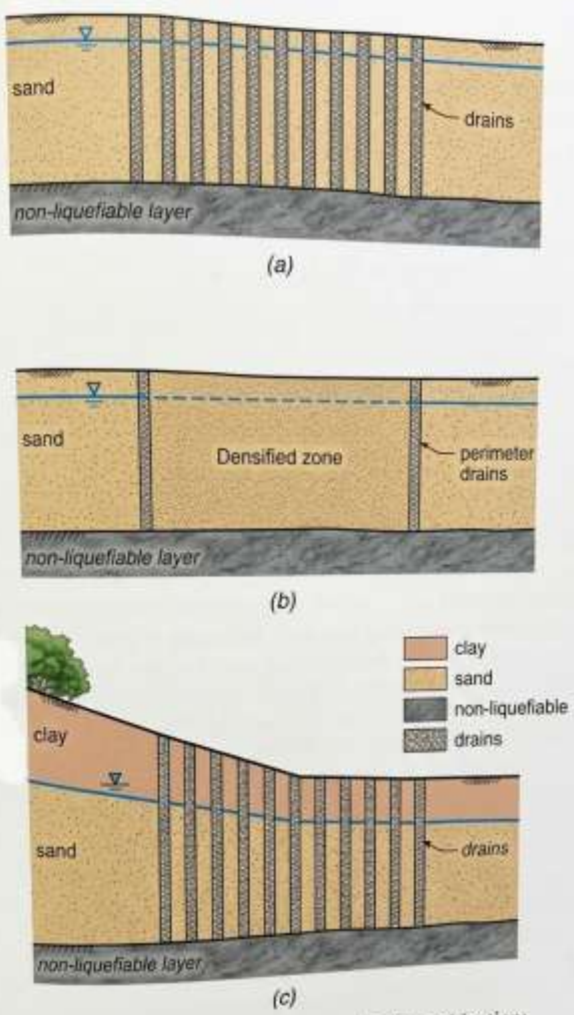


Figure 121. Gravel drains for liquefaction mitigation: (a) a grid of drains for controlling maximum r_u levels during earthquake shaking, (b) perimeter drains to prevent migration of high excess pore pressures from untreated zones into a densified zone, and (c) a grid of drains to prevent void redistribution or water film generation beneath a lower-permeability capping layer.

➢ Permeation Grouting

Figure 122. Soil that had been treated by permeation grouting before being exposed by excavation (Yamazaki et al. 2005).

➢ Jet Grouting

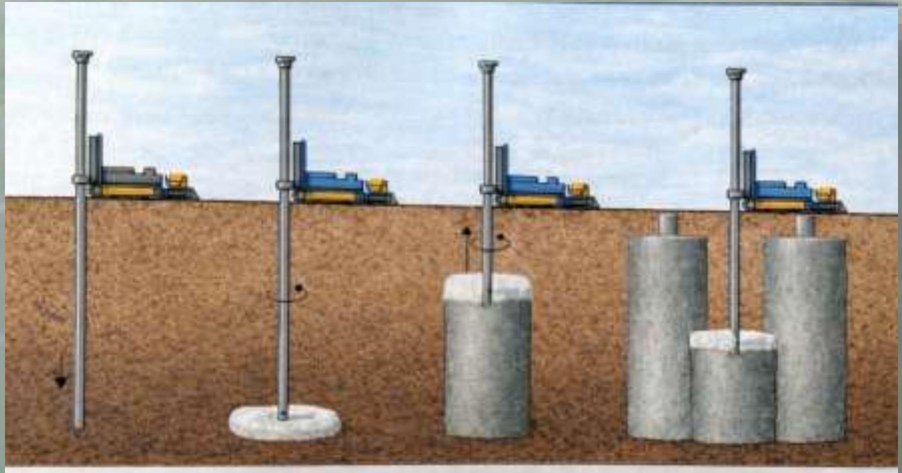
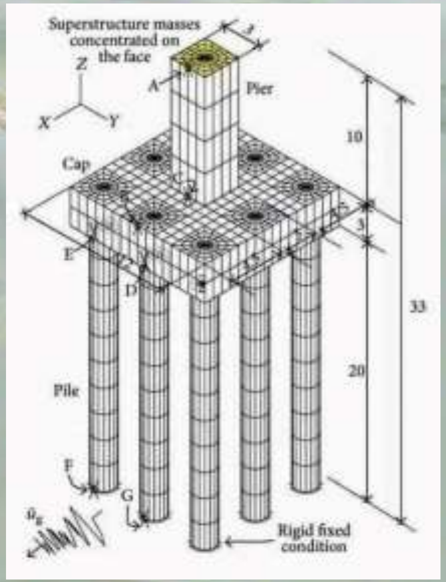


Figure 120. Using jet grouting to produce overlapping columns (Hayward Baker, Inc.).

➢ Explosive Compaction

Figure. Sand boil and ejected water caused by blasting-induced liquefaction.

- **Removal and Replacement**
- **General Design and Construction Consideration**



- **Removal and Replacement**
- **General Design and Construction Consideration**

THANK YOU

FOR

YOUR KIND ATTENTION