SEISMIC SHAKING, TSUNAMIS, AND GROUND RESPONSE (14)

I Main Topics

A Recognition of direct effects of shaking as a seismic hazard

B Recognition of tsunamis and seiches as seismic hazards

C Recognition of types of shaking-induced hazards

II Recognition of direct effects of shaking as a seismic hazard

A Shaking (and tsunamis) the most widespread seismic hazards

B Shaking generally causes the most damage and loss of life

C Unlike ground rupture, shaking is very difficult to avoid

D Shaking can be engineered against to a large extent

E Key factors controlling response of near-surface materials:

1 Thickness of Holocene/Quaternary deposits

2 Degree of consolidation (void ratio)

3 Degree of cementation

4 Depth to water table

III Tsunamis and seiches

A Tsunamis: seismic sea waves generated by sharp vertical displacement of the ocean floor

1 Can reflect dip-slip faulting or landsliding

2 Long-wavelength ("shallow-water") waves

3 Examples: Hilo, Hawaii, 1946; Lituya Bay, Alaska, 1958 (518m!), Sumatra, 2004; Japan, 2011

https://www.youtube.com/watch?v=chbbiSCczB8

III Tsunamis and seiches

C Lituya Bay, 1958

Location map

Site of slide

http://blogs.agu.org/landslideblog/2008/07/09/lituya-bay-50-years-on/

III Tsunamis and seiches

C Lituya Bay, 1958

Spur the wave overtopped at 518m

Scoured margin of Lituya Bay

http://blogs.agu.org/landslideblog/2008/07/09/lituya-bay-50-years-on/

III Tsunamis and seiches
C Lituya Bay, 1958

https://www.youtube.com/watch?v=2uCZjqoRLjc

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https://www.youtube.com/watch?v=yN6EgMMrhdI&index=2&list=PLFF513AD10F64B864

III Tsunamis and seiches

B Seiches: Shaking-induced oscillations of enclosed water bodies. Most destructive when strong shaking is at resonant frequency of water body.

https://www.youtube.com/watch?v=L44AoCIl0gU

IV Types of shaking-induced ground failures

A Settlement of cohesionless (sandy) alluvial materials

1. Vertical contraction resulting from loss of void space
2. Examples: Homer, Alaska, 1964; Japan, 2011

https://www.youtube.com/watch?v=j0sLyJpfTE8

2/4/15 GG303 9

B Liquefaction of cohesionless (sandy) alluvial materials

1. Loss of shear strength due to shaking; liquids have essentially no shear strength
2. Sands and silty sands most susceptible to liquefaction are:
   a. Well-sorted
   b. Very young (<100 years)
   c. Have a high water table (< 3 meters below surface)
   d. River deposits susceptible
3. Niigata, Japan, 1964

https://www.youtube.com/watch?v=KLZFInND0hA

2/4/15 GG303 10

B Liquefaction (Niigata, Japan, 1964)

http://en.wikipedia.org/wiki/1964_Niigata_earthquake#mediaviewer/File:Liquefaction_at_Niigata.JPG

B Liquefaction (New Madrid)

https://www.youtube.com/watch?v=KLZFlnND0hA

C Ground oscillation

1 Occurrence of large surface waves, without permanent lateral translation, as a surficial layer that overlies a liquefied layer fractures and blocks bob up and down. Sandblows form.

2 San Francisco, California, 1906, Japan, 2011

Ground Oscillation, Japan, 2011

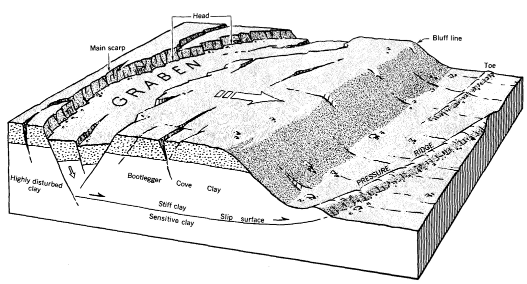
https://www.youtube.com/watch?v=rn3oAvmZY8k

D Lateral spreading (slopes <3°)

1 Horizontal translation of surficial blocks in response to liquefaction of underlying subhorizontal layers

2 Example: Anchorage, Alaska, 1964

General model for 1964 slides in Anchorage



From USGS Professional Paper 542a

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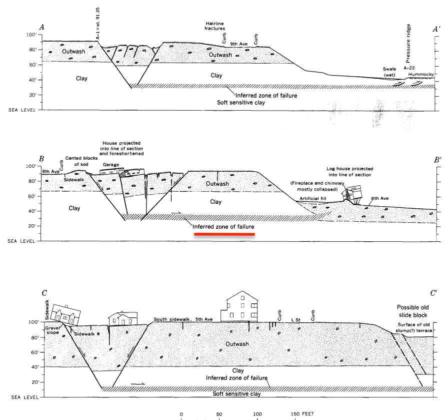


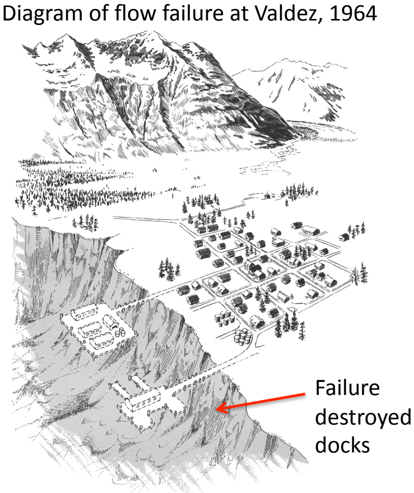
From USGS Professional Paper 542a

2/4/15 GG303 15

E Flow failure (slopes >3°)

1 Translation of surficial blocks in response to liquefaction of underlying inclined layers (Same mechanism as lateral spreading)
2 Examples: Kansu Province, China, 1920; Valdez, Alaska, 1964

Diagram of flow failure at Valdez, 1964



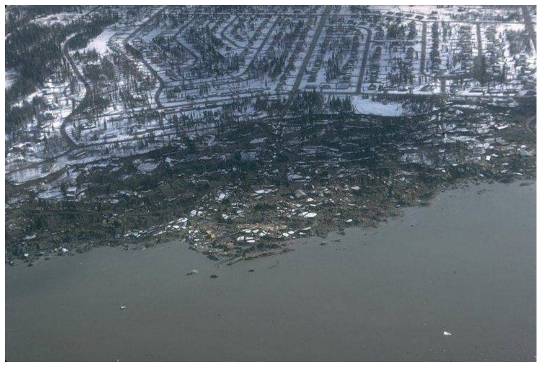
From USGS Professional Paper 542-C

2/4/15 GG303 16

F Failure of quick clays

1 Collapse of open clay structure and loss of shear strength

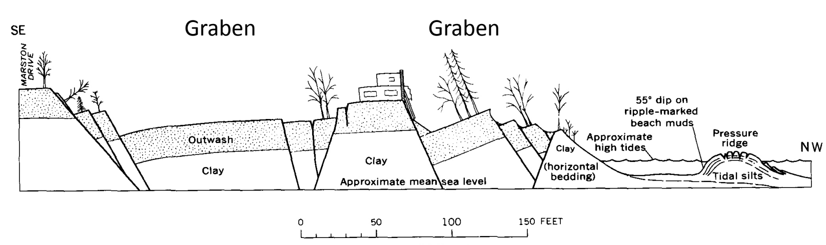
2 Example: Turnagain Heights, Anchorage, Alaska, 1964 (might have involved quick sands too)



http://www.ce.washington.edu/~liquefaction/html/quakes/alaska/alaska.html

F Failure of quick clays
(Turnagain Heights, Anchorage, Alaska, 1964)

Cross section through part of the Turnagain Heights slide



From USGS Professional Paper 542a

IV Types of shaking-induced ground failures

G Deep-seated landslide (to 100m depth)

1 Landslide mechanism not understood

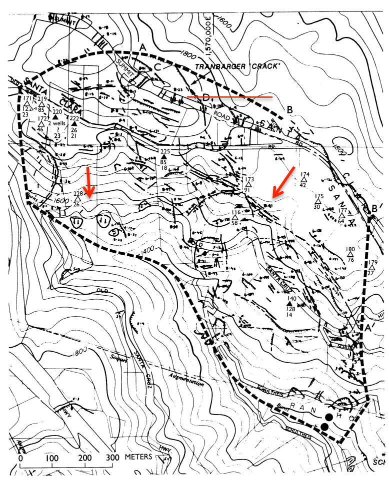
2 Example: Loma Prieta earthquake, 1989

Fissure at head of a deep-seated slide, Summit Road

2/4/15 GG303 19

G Deep-seated landslide (Loma Prieta, 1989)

Geologist discussing Summit Road fissure with reporter



Map of cracking in area of Summit Road fissure (from USGS Prof. Paper 1551-C)

2/4/15 GG303 20