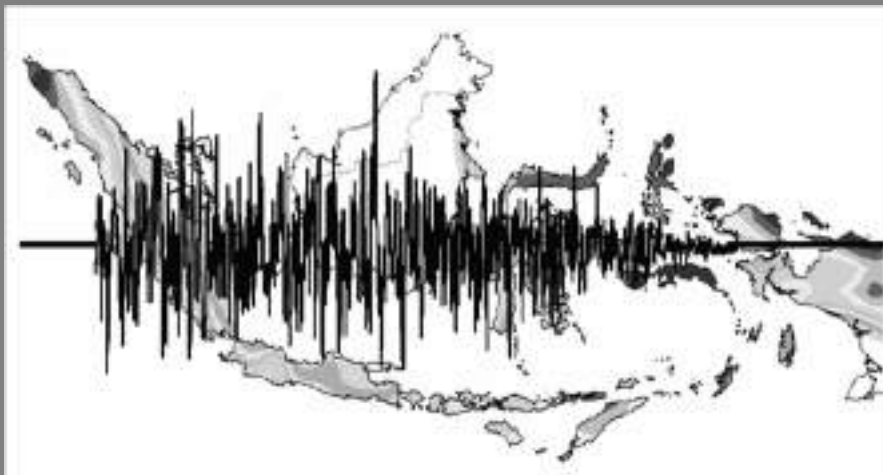


# Lessons Learned from Past Earthquake Disasters



Speaker:  
Ir. Jimmy Chandra, S.T., M.Eng., Ph.D.  
22 November 2018

1



**Earthquakes do not kill  
people, the buildings do!**

2

## Outline

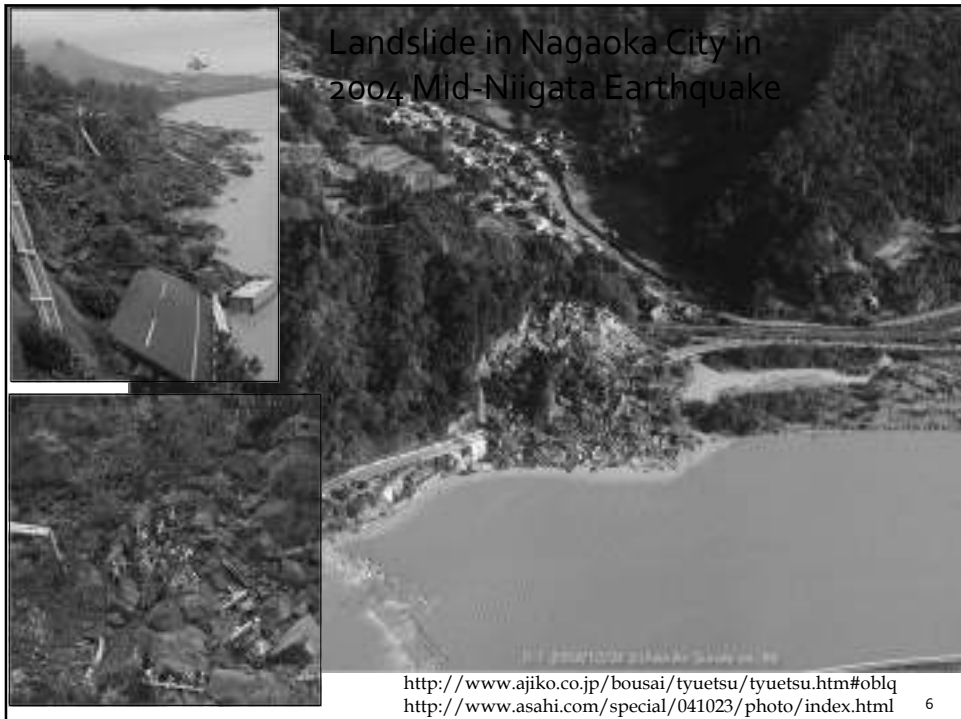
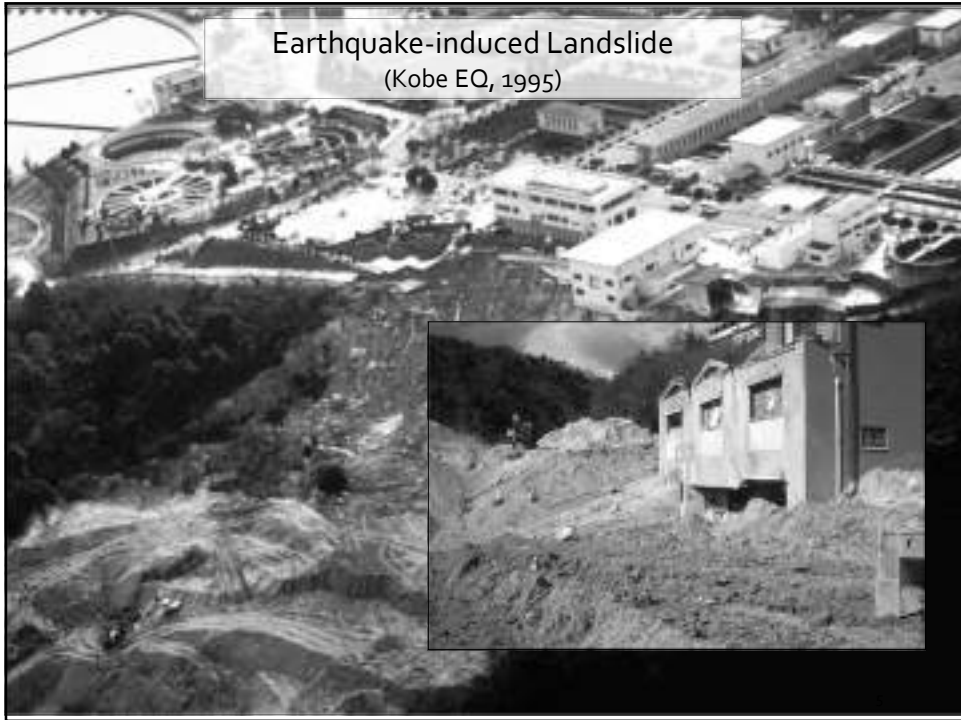
- What is an earthquake?
- Types/causes of earthquakes
- Consequences of earthquakes
- Lessons from recent Indonesian earthquakes
- World's largest earthquakes

3

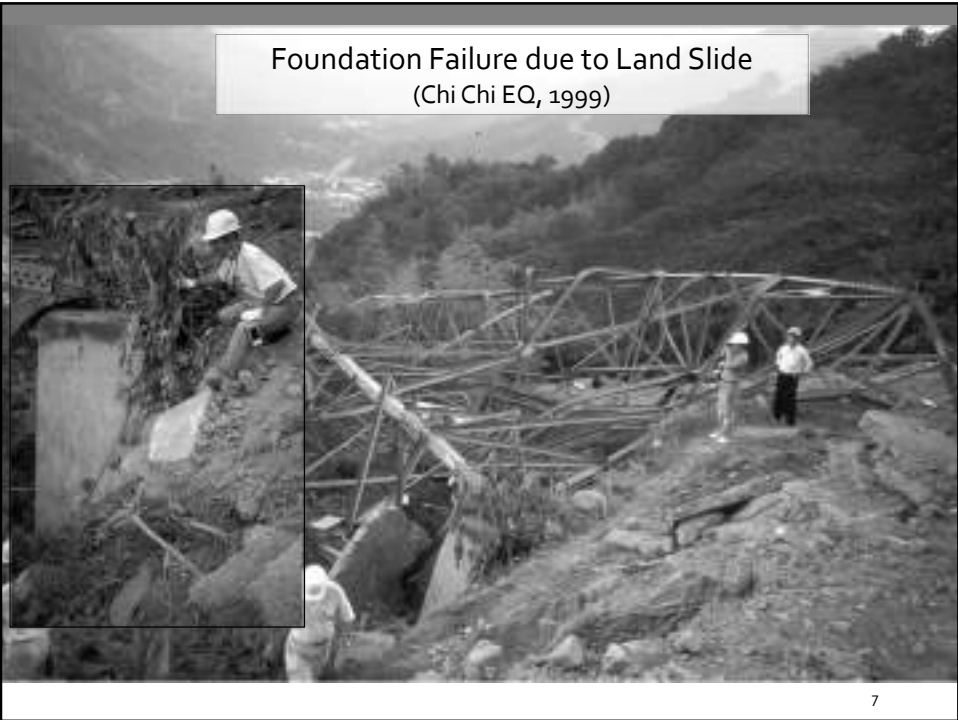
## What is an earthquake?

- Shaking and vibration at the surface of the earth which in turn can cause:
  - Ground failures (landslides, liquefactions)
  - Giant ocean waves (tsunamis)

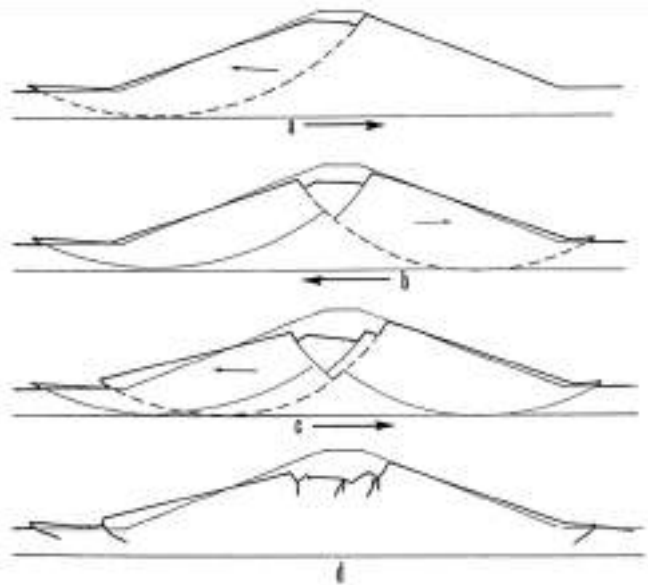
4



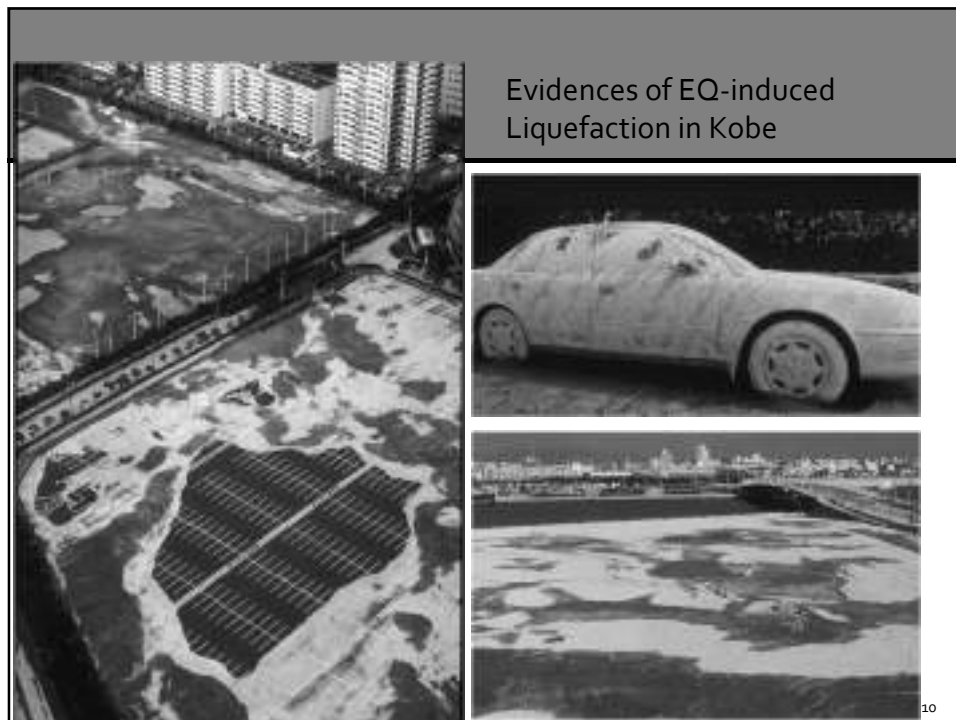
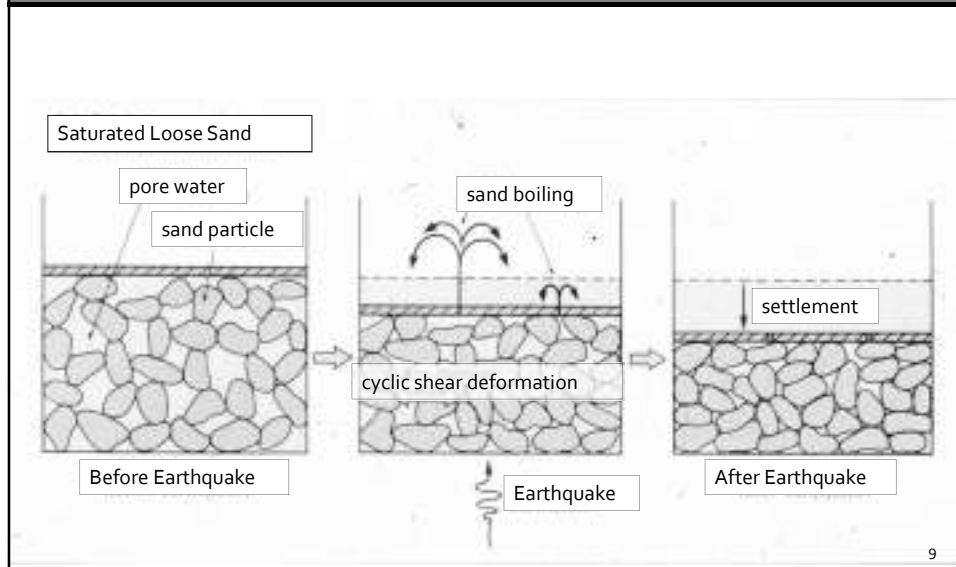
Foundation Failure due to Land Slide  
(Chi Chi EQ, 1999)



Dynamic Stability of Embankment



# Liquefaction



## Damage to Kobe Port due to EQ-induced Liquefaction



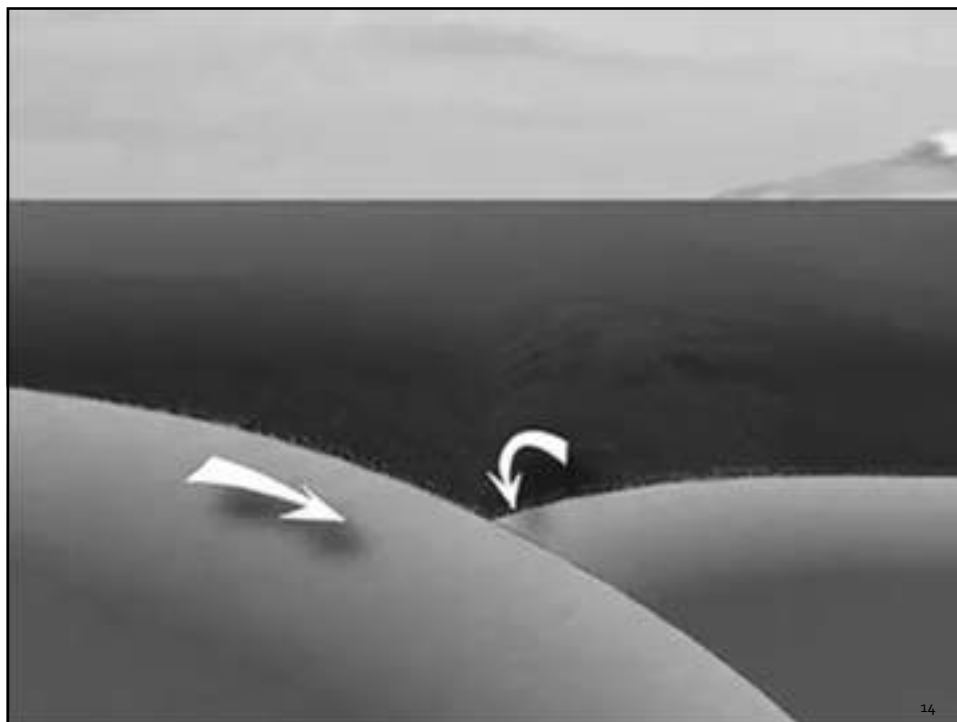
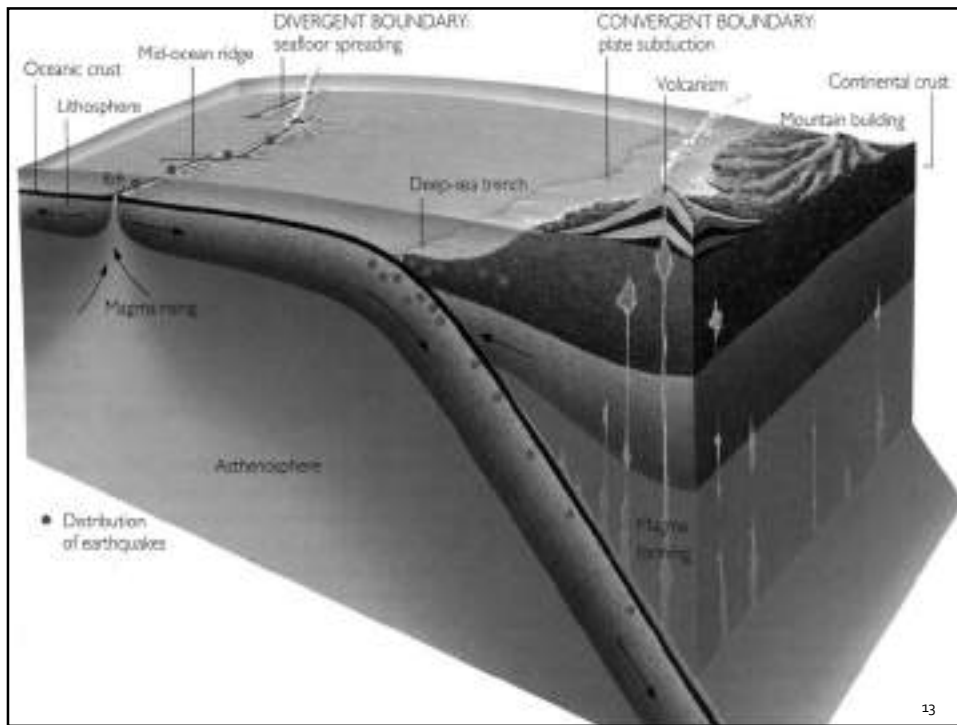
## Loss of Bearing Capacity

Due to Liquefaction

A building in Dagupan,  
Philippines after the  
1990 Luzon EQ



Overtumed building in  
Adpazari, Turkey in the  
1999 Kocaeli EQ













## Types/Causes of Earthquakes

- ***Tectonic earthquake***
  - The most common earthquakes.
  - Produced when rocks break suddenly in response to the various geological (tectonic) forces.
- ***Volcanic earthquake***
  - Earthquakes that occur together with volcanic eruptions.
  - Eruptions (of volcanoes) and earthquakes both result from tectonic forces in the rocks and need not occur together.
- ***Collapse earthquake***
  - Collapse of underground caverns and mines.
  - Produced by massive land-sliding.
- ***Humans cause explosion***
  - Produced by the explosion of chemical or nuclear devices.
- ***Meteor Impact***

23

## Consequences of earthquakes

- Human loss: death, injury, illness.
- Structural damage: houses, buildings.
- Infrastructure damage: highways, bridges, plumbing, irrigations, harbors, telecommunications, electricity, etc.
- Activities disturbance: business, education, social works, etc.

24



## Nias - 2005



Soft story of typical commercial buildings  
- failure of 1<sup>st</sup> story



## Nias - 2005



No steel inside concrete beam



Very...very...small amount of confining  
steel inside concrete column

## Yogyakarta - 2006



Buckling of corner column

29

## Yogyakarta - 2006



1<sup>st</sup> Building → Collapsed Roof Structure

30

## Yogyakarta - 2006



2<sup>nd</sup> Building → Failure of columns on the first floor

31

## Yogyakarta - 2006



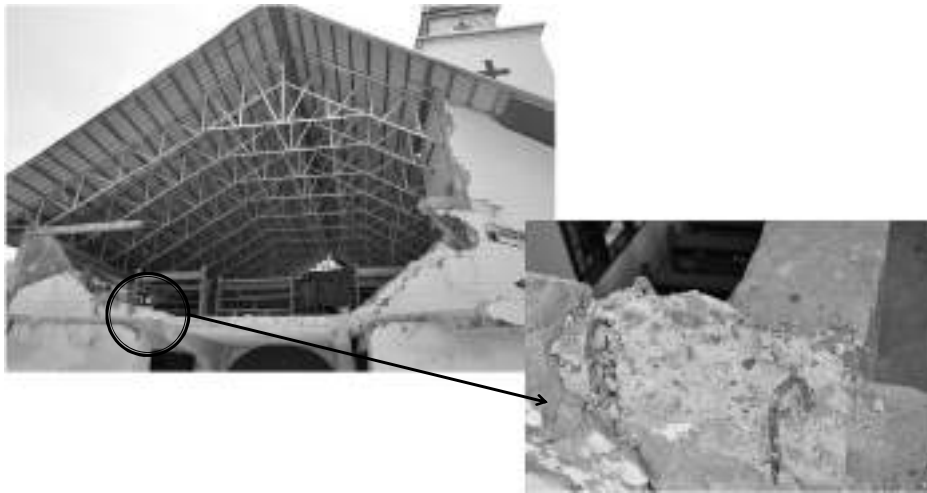
3<sup>rd</sup> Building → Only slight masonry wall damages

- Same location
- Same architect
- Same civil engineering consultant
- DIFFERENT contractor

32



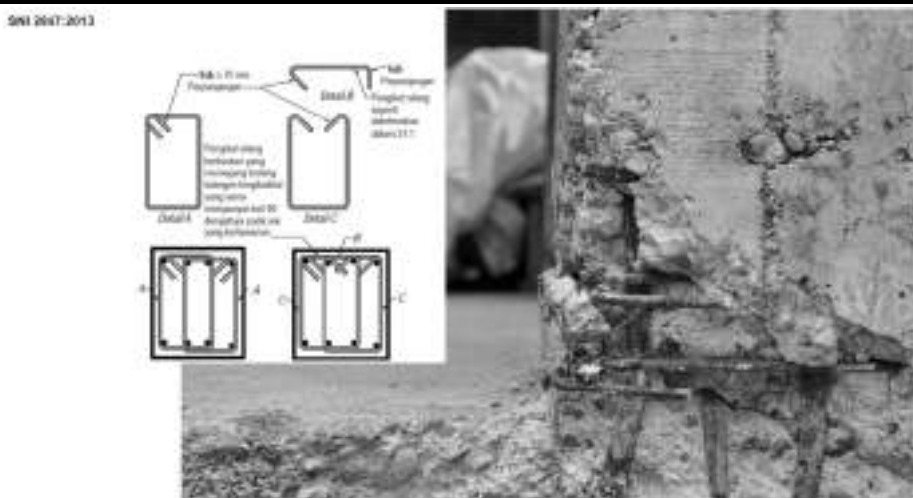
## Padang - 2009



Discontinued vertical steel reinforcement of concrete column

33

## Padang - 2009



Poor quality of casting work, non standard hook

34

## Padang - 2009



Even "small" seemed unimportant thing  
→ could cause a life

35

## Padang - 2009



Tied with wire after falling during  
earthquake event

Even "SMALLER" seemed unimportant  
thing → STILL could cause a life

36

## Lombok - 2018



Courtesy of: <http://www.kbknews.id/2018/08/10/bmkg-gempa-susulan-di-lombok-makin-sering-tapi-kekuatan-menurun/>

37

## Lombok - 2018



Courtesy of: <https://news.detik.com/berita/4158664/gempa-62-sr-di-lombok-robokkan-minimarket-di-mataram>

38

## Lombok - 2018



Courtesy of: <https://news.okezone.com/read/2018/08/07/65/1933005/pascagempa-lombok-aktivitas-universitas-mataram-kembali-normal>

39

## Palu - 2018



Courtesy of: <http://makassar.tribunnews.com/2018/09/30/hotel-roa-roa-ambruk-total-tamu-hotel-masih-tertimbun-runtuhan-bangunan>

40

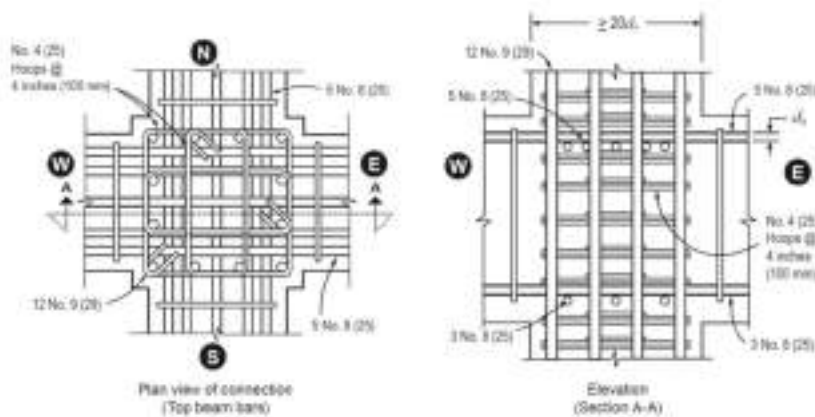
## Palu - 2018



Courtesy of: <https://www.liputan6.com/news/read/3655685/bnpb-ada-sekitar-50-orang-masih-tertimbun-bangunan-hotel-roa-roa-palu>

41

## Palu - 2018



Courtesy of: ACI 352R-02, *Recommendations for design of beam-column connections in monolithic reinforced concrete structures*

42

# World's Largest Earthquakes

## World's Big Earthquakes

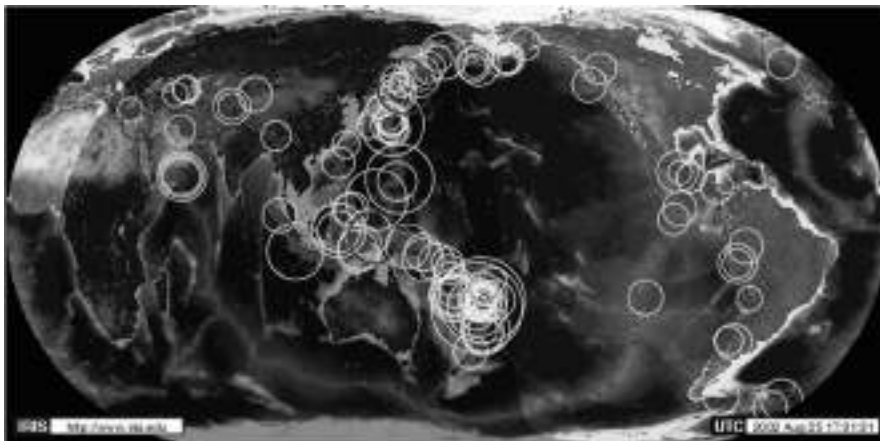
### LARGEST EARTHQUAKES IN THE WORLD AND CONTIGUOUS U. S.

#### WORLD

Magnitude	Date	Location
9.5	May 22, 1960	Chile
9.2	March 27, 1964	Prince William Sound, Alaska
9.1	December 26, 2004	West Coast of Northern Sumatra
9.1	March 5, 1967	Admiral Islands, Alaska
9.0	November 4, 1952	Kamchatka
8.8	January 31, 1906	Off coast of Ecuador
8.7	February 5, 1965	Rat Islands, Alaska
8.6	August 15, 1950	Assam, India-Tibet
8.5	February 4, 1933	Kamchatka
8.5	February 2, 1938	Banda Sea, Indonesia
8.6	October 13, 1963	Kail Islands

43

Unlike Lightnings, Earthquakes DO  
strike twice!!!



44

Thank You for  
Your Attention