Earthquakes, Structural Defects, Structural Damages, and Possible Solutions

An Online Continuing Education Course for Engineers

Course Number: S-2030

Credit: 2 Hours / 2 PDH / 2 CPD

Earthquakes, Structural Defects, Structural Damages, and Possible Solutions

Ibrahim M. Metwally, Ph.D., P.E.

Introduction

Earthquakes are the most destructive natural hazards throughout human history. Hundreds of thousands of people have lost their lives, and the loss of billions of dollars in properties occurred in these disasters. Medium- or high-intensity magnitude earthquakes in the last twenty years have shown that these losses continue.

For reinforced concrete (R/C) buildings, inappropriate design such as soft and weak stories, strong beam–weak column, short column, hammering, unconfined gable wall, and in-plane/out-of-plane movement of the walls results in damage. These are the main reasons. In addition to this, low quality of structural materials, poor workmanship, lack of engineering services, and construction with insufficient detailing of the structural elements are other reasons for damages.

The main reasons for masonry building damage in terms of design faults are heavy earthen roofs, inappropriate detailing of wall-to-wall connections and wall-to-roof connections, absence of bond beams, and large openings. The construction of buildings by using local materials with poor workmanship on the base of traditional rules is another reason for the failures of these buildings. In this course, earthquakes and reasons for damages that arose from earthquakes for reinforced concrete and masonry structures are presented. In addition to this, appropriate solutions are suggested.

The purpose of this course is to present earthquake characteristics and structural defects, damages, and methods to prevent earthquake damage. The content of the course is divided into five sections as follows:

Section 1: gives information about recent destructive earthquakes.
Section 2: shows the earth's structure, plate tectonics, seismic waves, faults, and effects of earthquakes.
Section 3: presents failure reasons for reinforced concrete (R/C) buildings.
Section 4: presents the failure reasons for masonry building damages.
Section 5: lessons learned from earthquake damage, failures experienced from this type of natural hazard, and methods to prevent earthquake damage.

Section 1: gives information about the last destructive earthquakes.

Earthquakes are one of the most destructive natural hazards that cause huge amounts of loss of life and property. Nearly 10,000 people are killed every year because of these hazards. Moreover, annual economic loss is in the billions of dollars. In the last quarter century, severe earthquakes in the world like 1995 Kobe, Japan, 1998 Afghanistan, 1999 Kocaeli, Turkey, 2001 Gujarat, India, 2003 Bam, Iran, 2004 Indian Ocean, 2008 Wenchuan, China, 2009 L'Aqulia, Italy, 2010 Haiti, 2010 Chile, and 2011 Van earthquakes experienced construction industry to take severe measures to prevent collapse and to decrease damages of the structure; for example, after 1995 Kobe, Japan earthquake, it was reported that more than 6434 people lost their lives; nearly 4600 of them were from Kobe. In 1999 Kocaeli earthquakes, more than 17,000 people were killed and more than 40,000 people were injured and 300,000 people became homeless. In the year 2008, an earthquake hit the Sichuan China. The measured magnitude of an earthquake from the surface is 8.0. It was reported that nearly 70,000 people were dead, 95% of this death toll is in Sichuan province. In addition, more than 370,000 were injured, and 18,000 people were missing. In Italy, 308 people were killed and more than 1500 people were injured after the L'Aquila earthquake in 2009. However, the total economic loss was 16 billion dollars during this earthquake. Many historical structures collapsed and were heavily damaged. The last earthquake tragedy for Turkey, very close to the present time, is Erciş (Van) and Edremit (Van) earthquakes. These earthquakes struck Erciş (Van) district and Edremit (Van) district in 2011. After these earthquakes, 604 people were killed and 4852 people were injured, among of them 1301 people were seriously injured. A total of 2307 multistory structures collapsed. In addition, nearly 8% of the total province population became homeless.

<u>Section 2</u>: Earthquake Characteristics: shows the structure of the earth, plate tectonics, seismic waves, faults, and effects of earthquakes.

2.1. Structure of the Earth

The earth consists of layers which have different properties. The outer layer of the earth is called as “crust.” The thickness of this layer is between 35 and 70 km for continents, and this thickness varies between 5 and 10 km thickness for ocean floor. The mantle layer, existed under the crust, is divided as lower mantle and outer mantle. This layer is approximately 2900 km thick. Convection current occurred in the mantle causes plate tectonics in the crust. Core is the innermost layer and divides into two parts as fluid outer core and solid inner core. The outer layer is 2300 km, and inner layer is 1200 km thick. The internal structure of the earth is shown in Figure 1.

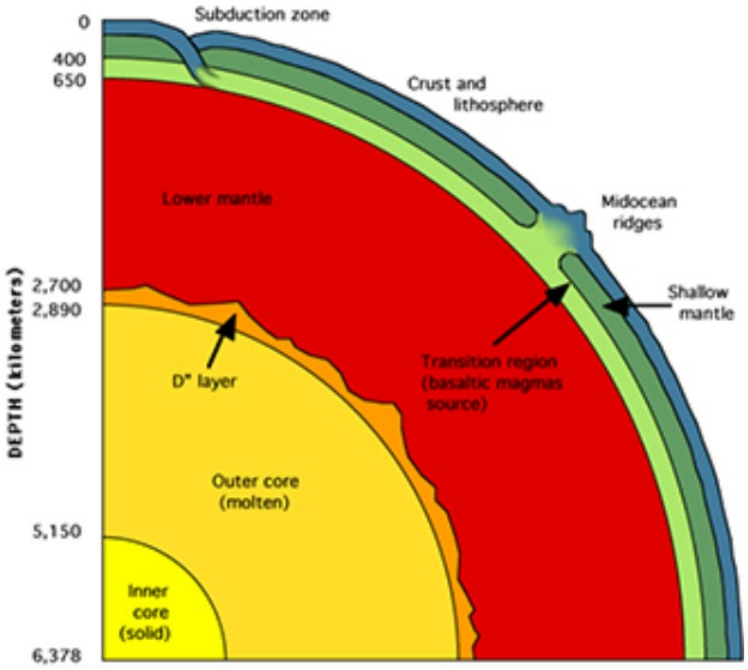


Figure 1- The internal structure of the earth

2.2. Plate tectonics

Plate tectonic deals with movement and strain of earth crust. According to the state of the art of Plate tectonic, earthquakes occur in some parts of the plate and these parts act relative to each other. Pressure shift arose from these action and cooling stages in mantle causes stresses in the earth crust. When the increased stresses reached the bearing capacity of the crust on faults, this event causes sliding (breakthrough). Sliding movement spreads outward starting from hypocenter. Strain energy, which cumulated for a long time, discharges with sliding and causes earthquake shaking. Propagation of wave from hypocenter that results surface sliding is perceived as earthquake. Figures 2 and 3 show the tectonic plates and worldwide earthquake distribution, respectively.

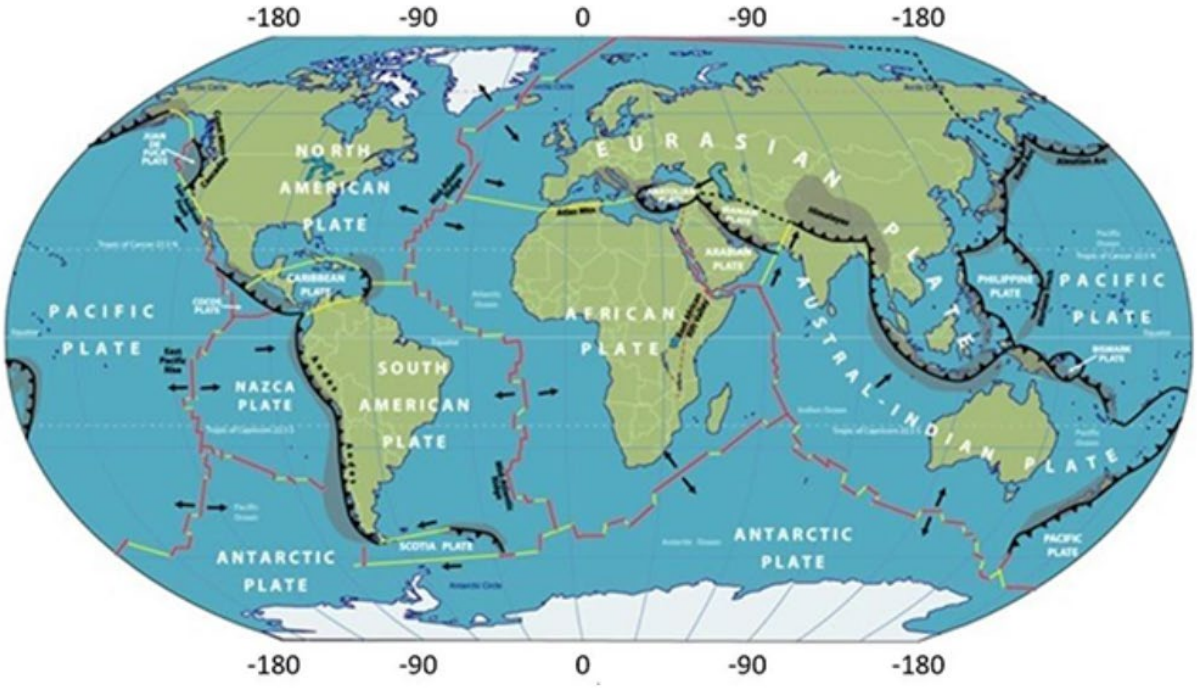
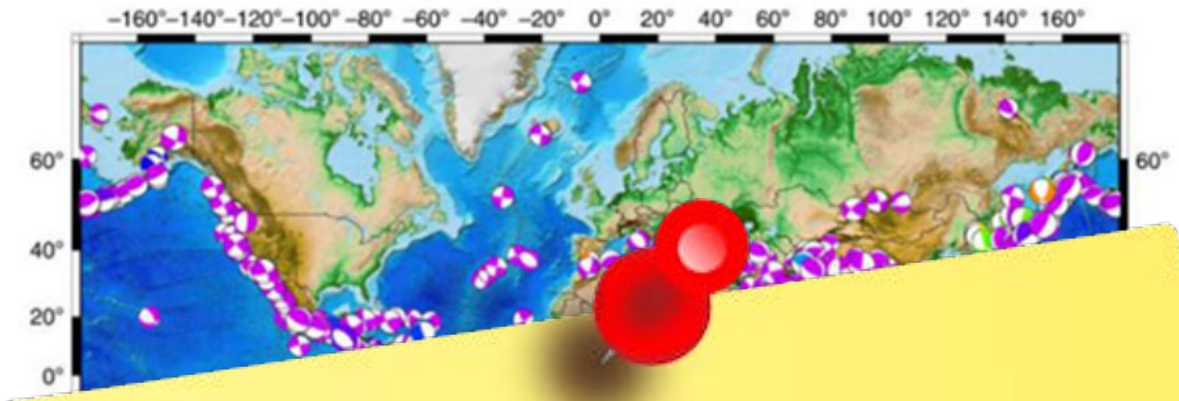


Figure2-Tectonic plates



To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.

Close this window and click "Add to cart" on the product page.

2.3. Faults

When two
result of tec
interface zo
result of thi
rebound" the
Figures 4–6 sh
as "fault".