

GEOLOGY 240 EARTHQUAKES - FINAL EXAMINATION

Date/Time: May 10, 1999, 4:30 – 6:30 p.m.

Professor Teng

Directions

1. Place your name on the answer sheets. Do it now!
2. Two-hour time limit, open-book.

A. TRUE OR FALSE (one point each)

1. Earthquake control is an attempt to modify the nature of occurrence of earthquakes on known active faults.
2. The possibility of earthquake control was accidentally discovered at the Rocky Mountain arsenal where toxic waste was pumped deep into the ground under high pressure.
3. Radon concentration in ground water is being monitored as one possible earthquake precursor.
4. Special Studies Zone Act regulates the issuance of construction permits of structures for human occupancy across identified active faults.
5. Woodframe houses should anchor their structure to the foundation.
6. When a big (M=8) earthquake occurs along the southern section of the San Andreas fault, the destruction would be far bigger than a smaller (M=7) earthquake on the Newport-Inglewood fault.
7. During the 1971 San Fernando earthquake, the collapse of the pre-1933 portion of the VA Hospital accounted for most of the 64 lives lost.
8. An extensive fire broke out after the 1994 Northridge earthquake because of the Santa Ana condition with strong gusty winds up to 75 mph.
9. The Van Norman dam came to the brink of failure during the strong shaking of the 1971 San Fernando earthquake.
10. Recently, the Pacific plate plunged under California causing intermediate or deep earthquakes.
11. If an earthquake is large enough, the City of Los Angeles could sink into the Pacific Ocean due to liquefaction.
12. To the south of San Bernardino, the San Andreas fault splits off into several branches, one main branch is called the San Jacinto fault.
13. The San Andreas fault system terminates when it meets the Colorado River at the U.S.-Mexican Border.
14. Body waves are waves traveling in the earth's crust and mantle only.
15. Higher intensity means higher ground acceleration.
16. Aftershocks are caused by the return of the shock waves to the epicentral area after they have bounced off the other side of the earth.
17. Energy of a magnitude 6 earthquake is roughly equivalent to that of about 10 magnitude 5 earthquakes.
18. Scientists think that they can "lock" up a section of an active fault by pumping fluid into the fault zone.

19. Only rarely do earthquakes occur in the earth's lower mantle and core.
20. Epicenters always lie on the surface traces of faults.
21. There is a critical fluid injection pressure below which fluid injection into the fault zone will not trigger earthquakes.
22. Probabilistic earthquake prediction tells us the statistical aspect of earthquake occurrence.
23. Normal faulting is associated with horizontal extensional tectonic forces.
24. The largest, most violent tsunamis are created by strike-slip faults on the ocean floor.
25. Carbon-14 age dating of sag pond deposits along the San Andreas fault confirms that the recurrence interval for major earthquakes ($M=7.5-8.5$) on a given segment of the San Andreas fault is about 145 years.
26. For the most part, all earthquakes larger than $M=5.0$ have been shown to be preceded by at least one foreshock.
27. Earthquakes much larger than $M= 8.0$ have never been recorded due to the intrinsic sensitivity of modern seismometers.
28. The Special Studies Zones Act outlines the earthquake hazard zones in which people should not build structures for human occupancy.
29. Maps of the Special Studies Zones of California are available for general public; it can be purchased from the California Division of Mines and Geology.
30. The highest earthquake hazard areas are always on hard rock where structures are firmly coupled to all ground motions.
31. Any formal earthquake prediction in California, made by scientists or by laymen, must be submitted for State governmental evaluation by a team of experts.
32. Diagonal bracing in walls is effective in minimizing earthquake damage to structures.
33. While unreinforced masonry is particularly hazardous, reinforced concrete has been demonstrated in all cases to be the only better earthquake resistant construction material.
34. The Benioff zone refers to a major seismic belt in the western Pacific.
35. Despite of the fact that the Mexico City is about 200 miles inland, earthquakes that occur along the Mexico's southern coast have repeatedly caused severe damage at the Mexico City. Coastal cities such as Acapulco, much closer to the epicenter, have usually performed much better.
36. All school buildings are supposed to be earthquake proof to conform to the California Field Act.
37. In the Los Angeles basin, there are at least 14,000 buildings being designated as ones that do not meet the current earthquake building codes.
38. As soon as you have felt an earthquake, you should run out of the build to an open ground.
39. Fire is a real potential hazard for woodframe houses.
40. If the earthquake is large enough, a locomotive engine can be tossed into the air.
41. There is generally a 10% deductible allowance in earthquake insurance, which makes it difficult for the owner to collect if your damage is limited to a loss of a chimney or cracking of stucco.

42. Anchoring of the sill plate to the foundation and the use of plywood sheathing on woodframe house are two of the most important measures to improve the earthquake resistance of a woodframe house in southern California.
43. Since USC is built on sediment, liquefaction is sure to cause severe damage.

B. MULTIPLE CHOICE (1 point each)

44. An active fault is defined to be a fault that has movement during the past (a) 5000 years, (b) 150 years, (c) 11,000 years, (d) 2 million years.
45. The Special Studies Zone is a region within (a) 1/4-mile, (b) 1/2 mile, (c) 1/8 mile, (d) 1 mile from the fault.
46. For a 50-story high rise building, its natural vibration period is about (a) 0.5 second, (b) 2 seconds, (c) 5 seconds, (d) 50 seconds.
47. Massive tectonic uplift and subsidence occurred during (a) 1964 Alaska earthquake, (b) 1960 Chile earthquake, (c) 1964 Niigata earthquake, (d) 1906 San Francisco earthquake, (e) a and b above.
48. Which geological formation is the youngest? (a) Tertiary, (b) Quaternary, (c) Cambrian, (d) Precambrian.
49. Most of the earthquakes that have occurred in the world are (a) shallow earthquakes, (b) intermediate earthquakes, and (c) deep earthquakes.
50. The total horizontal displacement over all geological ages along the San Andreas fault has been (a) 550', (b) 2500', and (c) more than 350 miles, (d) more than 600 miles.
51. For a very large earthquake, the ground motion can reach (a) 1 g, (b) 0.3 g, (c) 5 g, (d) 50 g, where g is gravity.
52. The last magnitude 8 earthquake in California was (a) in 1936 at San Francisco, (b) in 1906 in San Francisco, (c) in 1971 at San Fernando, (d) in 1857 at Fort Tejon.
53. Earthquake control means (a) elimination of all earthquake occurrences, (b) to trade off large earthquakes for a great number of small and undamaging ones, (c) shifting the possible epicenters of large earthquakes away from the population, (d) to cement up the faults.
54. Which of the following structures is the least earthquake resistant (a) wooden frame, (b) unreinforced brick, (c) adobe, (d) reinforced concrete.
55. Damage of an earthquake can come from (a) strong shaking, (b) fire, (c) flood, (d) all of the above.
56. The objective of earthquake engineering is to design and construct (a) earthquake resistant structures, (b) earthquake proof structures, (c) structures that will remain stationary during an earthquake, (d) none of the above, (e) all of the above.
57. During the Peru earthquake of 1970, the town of Yungay was wiped out, mainly due to (a) severe shaking, (b) fire, (c) landslide, (d) tsunami.
58. The brittle outer layer of the earth, which is broken into more than a dozen plates, is called the (a) crust, (b) lithosphere, (c) asthenosphere, and (d) mantle.

59. Plate movement can be as fast as (a) a few millimeters per year, (b) a few centimeters per year, (c) a few meters per year, (d) about 1 km per year.
60. The highest point of the San Andreas fault, where you have visited in your Springfield trip, is near (a) Bishop, (b) Big Pine, (c) Palmdale, and (d) Gorman.
61. The duration of the strong shaking period during the 1971 San Fernando earthquake was about (a) 1 1/2 minutes, (b) 5 minutes, (c) a little more than 10 seconds, (d) 2 seconds.

C. FILL IN BLANKS (one point per blank)

62. A very important fault that goes through the west central portion of the Los Angeles basin is called (a)____. It is oriented approximately (b)____ (NE-SW, NW-SE, E-W, N-S). This fault is primarily a (c)____ fault (thrust, right-handed strike-slip, left-handed strike slip).
63. The 4 basic structural components of any building are 1. The distributing structural elements, such as (a)__, 2. The resisting structural elements, such as (b)__, 3. The (c)__, 4. The connecting elements such as nailing and joints. A shear wall belongs to the above components No. (d)_____.
64. In the United States, if your home is valued at \$250,000, your annual premium for earthquake insurance is approximately ____.
65. Scientists have demonstrated that earthquakes can be "turned-on" and "turned-off" by pumping fluid (a)__ and (b)__ the fault zone.
66. There are two problems that prevent actual experiments of earthquake control to be carried out along the San Andreas fault: The first is (a)____; and the second is (b)_____.
67. Earthquake insurance in wood-frame dwelling in Los Angeles metropolitan areas varies from (a) \$ _____ or less to about (b) \$ _____ per \$1,000 of coverage.
68. Scientists are studying 12 categories of earthquake precursors at the present. Name all of them:
(a)__, (b)__, (c)__, (d)__, (e)__, (f)__, (g)__, (h)__, (g)__, (h)__, (I)__, (j)__, (k)__, (l)_____.
69. Construction of a shear wall for woodframe house is accomplished by nailing plywood sheathing over the 2 x 4 wood frame, at a maximum nail spacing of _____ inches.
70. According to the Special Studies Zones Act of California, a active fault trace is bounded by zone boundaries positioned at about (a) _____ ft. or mile (circle one) on both sides of the fault trace. Such a map is obtainable from (b)_____ at nominal cost (a few dollars). (c) Give the name (c1) _____, (c2) _____, (c3) _____ of the three maps closest to USC.
71. What is the potential problem you may have to build a house on a view lot on the hills in California? Ans. _____.
77. Lines of equal shaking intensity are called ____.
72. Name five states in the US other than Alaska and California which are subjected to seismic hazards (a)__, (b)__, (c)__, (d)__, (e)_____.

73. Properties of the interior of the earth are derived by studying (a)___ of body waves, (b)___ of surface waves, and (c) ___ of free oscillations..
74. The four essential elements of a valid earthquake prediction include: (a)___, (b)___, (c)___, and (d)___.
75. Give the four basic structural components of a building: (a)___, (b)___, (c)___, and (d)___.

For questions 76 to 86, give the most important damage categories (A. Strong shaking; B. fire; C. liquefaction; D. tsunami; E. landslide; F. tectonic uplift/subsidence; G. Very light damage) of the following earthquakes

76. 1989 Loma Prieta earthquake _____.
 77. 1994 Northridge earthquake _____.
 78. 1995 Kobe earthquake _____.
 79. 1992 Landers earthquake _____.
 80. 1960 Chile earthquake _____.
 81. 1923 Tokyo earthquake _____.
 82. 1964 Niigata (Japan) earthquake _____.
 83. 1964 Alaska earthquake _____.
 84. 1971 San Fernando earthquake _____.
 85. 1970 Peru earthquake _____.
 86. 1985 Mexico City earthquake _____.
87. A V_p/V_s velocity ratio bay refers to _____.
 88. The duration time (or width) of the velocity ratio bay is believed to be proportional to _____.
 89. The return to normal value of the velocity ratio prior to an earthquake is believed to be caused by _____.
 90. The properties of radon that make it potentially useful for prediction of earthquakes are (a)___, (b)___, and (c)___.

D. QUESTIONS (5 points each)

91. Give the rationale that we only use the term “earthquake resistant structures” instead of the term “earthquake proof structures”
92. What is the message carried by the figure on top of page 95 of your textbook B?
93. What is the message carried by page 121 of your textbook B?
94. What is the message carried by page 118 of your textbook B?
95. What is the message carried by the map at the top of page 52 of your textbook B?
96. If it takes 30 magnitude (M+1) earthquakes to trade off a magnitude M earthquake, how many magnitude 4 earthquakes will it be necessary to trade off the forthcoming Big One (M=8) in Southern California along the San Andreas fault that may rupture from Carrizo Plain to San Bernardino?
97. For the above number of magnitude 4 earthquakes to happen during a period of ten years, what will be the average number of daily earthquake occurrence? .
98. Name the location and years of the three largest (M > 8) earthquakes in California

D. LESSONS LEARNED FROM DAMAGING EARTHQUAKES -- Describing the slides shown, one point each.

Answer following questions on the Scantron again, by multiple choices or true/false wherever appropriate. You should be able to answer each question in 10 seconds.

99. (a) a big strike-slip fault trace exposed on the Alaska beach
(b) a thrust fault showing the white portion of the beach being the subsiding block
(c) a thrust fault showing the white portion of the beach being the uplifted block
(d) the damage scene of a big tsunami
100. (a) severe earthquake damage due to foundation failure of poorly consolidated glacial moraine on which these wood frame houses are built. (b) liquefaction of water saturated soil, (c) land subsidence, (d) strong uplifting.
101. This is a famous destruction during 1964 Alaska earthquake in a district of Anchorage called (a) Glacier Height; (b) Turnagain Height; (c) Glacier Bay; (d) Columbia Bay.
102. The destruction of the Seward train station during the Alaska earthquake by (a) tectonic uplifting, (b) liquefaction, (c) strong shaking, (d) tsunami attack.
103. An important type of damage of the 1964 Niigata earthquake, that is due to (a) excessive shaking that has surpassed the strength of the buildings
(b) liquefaction that caused foundation failure
(c) poor engineering design that caused the weight imbalance of the buildings
(d) occupants put too much weight on one side of the buildings
104. These "sand boils" are indication of (a) water pipe ruptures, (b) liquefaction, (c) a landslide, (d) a tsunami attack.
105. During the 1964 Niigata earthquake, this bridge failed because of (a) earthquake induced flood, (b) vertical shaking toss the bridge spans off the support columns, (c) failure of the support columns due to liquefaction, (d) none of the above.
106. The town Yungay of Peru, full of adobe houses, was completely destroyed by exceptionally strong shaking during the big Peruvian earthquake of 1970.
107. This turns out to be a damage scene of (a) strong shaking, (b) a tsunami, (c) a landslide, (d) a traffic accident.
108. The motto of this picture, taken during the 1964 Alaskan earthquake, is: (a) "act fast during emergency!", (b) "get out of a falling building!", (c) "wait a minute!", (d) none of this nonsense.
109. A scene in the 1906 San Francisco earthquake, these dead horses remind us that during strong shaking, the downtown streets are not safe due to falling objects.
110. During the 1971 San Fernando earthquake, the collapse of the middle building of the VA hospital is a reminder of importance to bring buildings up to codes.
111. The orange grove shows the displacement of a fault motion that is (a) left-lateral strike slip, (b) right-lateral strike slip, (c) left-lateral reverse, and (d) left-lateral normal.
112. The collapse of this wood frame apartment during the 1971 San Fernando earthquake is because the tenants have overloaded the second floor with too many heavy appliances.

113. These exploded columns can be avoided by
 (a) increasing the spiral steel cross-ties, (b) increasing the size of the columns, (c) placing steel jackets around the outside of these columns, (d) all the above, (e) none of the above.
114. This is a picture showing a severe land subsidence problem that is widespread in the world due to (a) plate tectonic force slowly acting on landmass, (b) over use of ground water, (c) normal faulting that forms grabens or depressions, (d) none of the above.
115. During the 1960 Chilean earthquake, this bus is inundated by a muddy flood.
116. This is a scene from (a) Kobe, Japan; (b) Oakland, California; (c) Northridge, California; (d) Landers, California.
117. This is a scene from (a) Kobe, Japan; (b) Oakland, California; (c) Northridge, California; (d) Landers, California.
118. This is a scene from (a) Kobe, Japan; (b) Mexico City; (c) Northridge, California; (d) Niigata, Japan.
119. The Kobe destruction has a lot to do with these poorly constructed wood-frame houses.
120. This is a scene from (a) Kobe, Japan; (b) San Francisco, California; (c) Northridge, California; (d) Landers, California.
121. This is a picture you may see while you are flying from (a) LA to Las Vegas; (b) LA to San Francisco; (c) San Francisco to Salt Lake City; (d) Salt Lake City to LA. It is an excellent illustration of streams offset by a fault.

F. QUESTIONS (Only students with Engineering and Science Majors need to complete the following two questions.)

122. If a recording station registered the arrival times of a P wave and an S wave to be t_p and t_s , with corresponding velocity of V_p and V_s , respectively, show that the epicentral distance D is given by:

$$D = \frac{V_s V_p (t_s - t_p)}{(V_p - V_s)}$$

Hint: Assuming t_0 is the origin time, then we know:

$$D = (t_p - t_0) \times V_p \quad \text{and}$$

$$D = (t_s - t_0) \times V_s$$

Try to eliminate t_0 from the above two expressions.

123. Based on the result in question 122, if we assume that $V_p = 5$ km/sec, and $V_s = 3$ km/sec, estimate the epicentral distance for the seismic station that records the seismogram with the S wave being 10 s behind the P wave.

Geology 240 Lg Final Exam Spring 1999 Instrucor: Professor Teng

Your Name _____ **SS#** _____; **TA Name** _____.

C. FILL IN BLANKS (one point per blank)

62. (a) _____; (b) _____;

(c) _____.

63. (a) _____; (b) _____;

(c) _____.

64. (a) _____.

65. (a) _____; (b) _____.

66. (a) _____; (b) _____.

67. (a) _____; (b) _____.

68. (a) _____; (b) _____;

(c) _____; (d) _____;

(e) _____; (f) _____.

(g) _____; (h) _____;

(i) _____; (j) _____;

(k) _____; (l) _____.

69. _____.

70. (a) _____; (b) _____;

(c1) _____; (c2) _____.

(c3) _____; 71. _____.

72. (a) _____; (b) _____;

Geology 240 Lg Final Exam Spring 1999 Instructor: Professor Teng

Your Name _____; SS# _____; TA Name _____.

72. (c) _____; (d) _____;

(e) _____;

73. (a) _____; (b) _____;

(c) _____.

74. (a) _____; (b) _____;

(c) _____; (d) _____.

75. (a) _____; (b) _____;

(c) _____; (d) _____.

76. _____ . 77. _____ .

77. _____ . 79. _____ .

80. _____ . 81. _____ .

82. _____ . 83. _____ .

84. _____ . 85. _____ .

86. _____ . 87. _____ .

88. _____ . 89. _____ .

90. (a) _____; (b) _____.

(c) _____.

91. _____

_____.

92. _____

_____.

Geology 240 Lg Final Exam Spring 1999 Instructor: Professor Teng

Your Name _____ SS# _____; TA Name _____.

93. _____.

94. _____.

95. _____.

96. _____.

97. _____.

98. _____.

122.

123.