Introduction

ABOUT THIS BOOK

California Civil Seismic Principles Practice Exams contains two practice exams with problems that follow the multiple-choice format and the scope of topics on the California Civil: Seismic Principles exam. Like the actual exam, each practice exam contains 55 multiple-choice problems. The problems are similar in difficulty and complexity to actual exam problems. The practice exams are designed to be taken in the same length of time as the exam (i.e., two and a half hours). To simulate the flagging function on the computer-based test (CBT) exam, the answer sheets in this book also include a flag icon that you can use to identify the problems you want to come back to. Answer keys allow you to quickly score your exams, and complete solutions allow you to review and compare your own solving processes to identify errors and learn efficient solving approaches. Solutions and answer options are presented in customary U.S. units, with SI units provided where applicable.

This book uses the ~~2015 IBC~~ and the ~~2010~~ ASCE/SEI7 when referencing code provisions in problems and solutions, unless a more stringent statutory requirement exists. (For example, Title 24 of the California Code of Regulations requires that schools and hospitals be operational after an earthquake, and this requirement supersedes lesser code requirements.) Since the ~~2015~~ IBC contains the same material and section numbers as the ~~2016~~ *California Building Code* (CBC), you may reference either the ~~2015~~ IBC or the ~~2016~~ CBC.

ABOUT THE CALIFORNIA CIVIL: SEISMIC PRINCIPLES EXAM

If you are applying to be a civil professional engineer in California and Guam, you must take and pass the California Civil: Seismic Principles exam to become a licensed civil engineer. The exam is offered year round on a quarterly basis. The exam is open-book and covers the content areas as outlined in the exam's test plan. You may only bring in as many reference materials as one box and one trip will permit. The exam is two and a half hours. For each problem, you will be asked to select the best answer from four options. Though you can answer problems at your own pace and in any order you choose, plan to spend an average of two and a half minutes on each problem. There is no penalty for guessing. Only correctly answered problems will be counted toward your score.

The California Civil: Seismic Principles exam is a CBT exam administered at a Prometric testing center. Navigation through the exam using the CBT interface is fairly standard. While you don't have to move sequentially through the exam, you can if you wish to. You can navigate to a specific problem. You can skip a problem or flag it for later review. You can return to any problem and change your answer. The onscreen index (listing, directory, etc.) can be used to see the problems that have been answered, flagged for review, or skipped. In some cases, you may have to toggle back and forth between a problem and an on-screen illustration if the illustration takes up too much space. A timer on the screen indicates how much time remains. For more information about Prometric and the exam site, review the Civil Seismic: Principles Exam candidate information bulletin (CIB) available on the Board for Professional Engineers, Land Surveyors, and Geologists (BPELSG) website.

HOW TO USE THIS BOOK

Prior to taking these practice exams, locate and organize relevant resources and materials as if you are taking the actual exam. You should also have the IBC and ASCE/SEI7 to be able to easily and quickly cross-reference the exam-adopted codes. Refer to the Codes and References Used in This Book section for guidance on other references you may wish to have during the exam.

The two practice exams in this book allow you to structure your exam preparation in a way that is best for you. For example, you might choose to take one exam as a pretest to assess your knowledge and determine the areas in which you need more review, and then take the second after you have completed additional study. Alternatively, you might choose to use one exam as a guide for how to solve different types of problems, reading each problem and solution in kind, and then use the second exam to evaluate what you learned.

However, these exams will be most useful if you treat them in this book as you would your actual exam. Do not read the problems ahead of time, and do not look at the solutions until you've answered all problems. Taking the practice exams in this book under the same time constraints and with the same reference material as the actual exam will help you assess your level of preparedness.

Codes and References Used in This Book

The information that was used to write and update this book was based on the exam's test plan at the time of publication. However, as with engineering practice itself, the California Civil: Seismic Principles exam is not always based on the most current codes or cutting-edge technology. Similarly, codes, standards, and regulations adopted by state and local agencies often lag issuance by several years. It is likely that the codes that are most current, the codes that you use in practice, and the codes that are the basis of your exam will all be different.

PPI lists on its website the dates and editions of the codes, standards, and regulations that the exam is based on. It is your responsibility to find out which codes are relevant to your exam. In the meantime, here are the codes and references that have been used in writing this book.

CODES AND REFERENCES

Alquist-Priolo Earthquake Fault Zoning Act *California Public Resources Code* 2013, Title 14, Chap. 7.5, §2621–2630

ATC-20 Procedures for Postearthquake Safety Evaluation of Buildings and *ATC-20-1 Field Manual: Postearthquake Safety Evaluation of Buildings* 1995

Board Rules and Regulations Relating to the Practices of Professional Engineering and Professional Land Surveying. *California Code of Regulations* 2014, Title 16, Div. 5, §400–476

Building Code Requirements and Specifications for Masonry Structures (TMS 402-~~11~~/~~ACI 530-13~~/~~ASCE 5-13~~, TMS 602-~~11~~/~~ACI 530.1-13/ASCE 6-13~~)

California Building Code (CBC) ~~2016~~, California Building Standards Commission

California Health and Safety Code 2014, Title 8

International Building Code (IBC) ~~2015~~, International Code Council

Field Act *California Building Code* 2013, Part I, Title 24, §4-301, *et seq.*

Minimum Design Loads for Buildings and Other Structures (ASCE/SEI7) ~~2010~~, American Society of Civil Engineers

NEHRP Recommended Seismic Provisions for New Buildings and Other Structures (FEMA P-~~750~~) ~~2009~~, Building Seismic Safety Council

Professional Engineers' Act *California Business and Professions Code* 2014, Chap. 7, §6700–6799

Professional Land Surveyors' Act *California Business and Professions Code* 2014, Chap. 15, §8700–8805

Seismic Provisions for Structural Steel Buildings ~~2010~~, American Institute of Steel Construction (AISC 341)

Special Design Provisions for Wind and Seismic (AWC SDPWS) 2015

Practice Exam 1

1. Which California law requires the State Geologist to establish regulatory zones around all known active faults?

(A) Seismic Zone Act

(B) Alquist-Priolo Act

(C) Riley Act

(D) Special Studies Zones Act

2. The design earthquake motion per ASCE/SEI7 provisions corresponds to

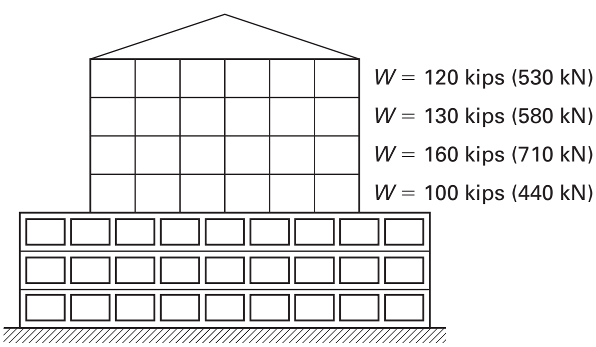
(A) 2/3 times the maximum considered earthquake design motion

(B) 2/3 times the earthquake that has a 10% probability of being exceeded in 50 years

(C) 3/2 times the maximum considered earthquake ground motion

(D) 3/2 times the earthquake that has a 10% probability of being exceeded in 50 years

3. The building shown has walls of uniform thickness.



What type of vertical structural irregularity is probable?

I. soft story

II. mass (weight) irregularity

III. in-plane discontinuity

(A) I only

(B) II only

(C) I and II only

(D) I, II, and III

4. A 155 ft (47 m) steel building in Los Angeles will be braced laterally by a steel eccentrically braced frame structure. The structure will be utilized as a communication center that can respond in emergencies. The geotechnical engineer estimates the S_1 and S_S values are 0.2 and 0.5, respectively. The design base shear using the equivalent lateral-force procedure is most nearly

(A) ~~0.038~~ W

(B) $0.044W$

(C) $0.057W$

(D) $0.088W$

5. The design base shear for an 80 ft (24 m) structure with eight stories of equal height and floor weight is 49,500 lbf (220 000 N). The fundamental period for this structure is 0.68 sec. The distributed base shear at level three is most nearly

(A) 4000 lbf (18 000 N)

(B) 4100 lbf (19 000 N)

(C) 7800 lbf (34 000 N)

(D) 8500 lbf (38 000 N)

33. Structures are most likely to be damaged by liquefaction if they are supported on which foundation and soil conditions?

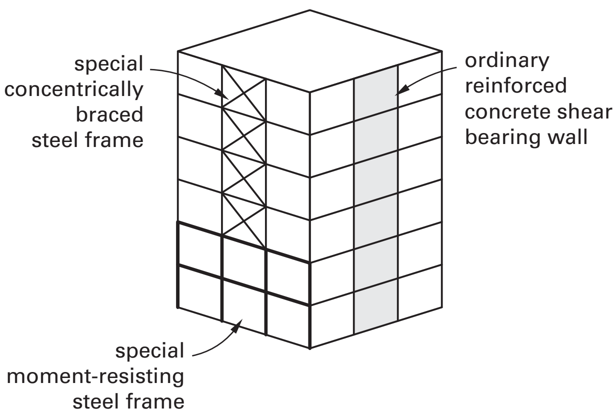
(A) isolated spread footings supported on a soil profile consisting of predominantly saturated cohesionless soil

(B) piles or drilled piers that extend through a soil profile consisting of deep saturated cohesionless soil and are supported on rock-like materials

(C) continuous spread footings supported on a soil profile containing a deep clay layer

(D) none of the above

34. A multi-story structure uses rigid diaphragms to transfer loads to the three different building systems illustrated.



Which of the following statements is correct?

I. The structure would be designated as a triple system according to ASCE/SEI7.

II. The structure would NOT be permitted in seismic design category D according to ASCE/SEI7.

III. The structure needs to be checked for accidental torsion according to ASCE/SEI7.

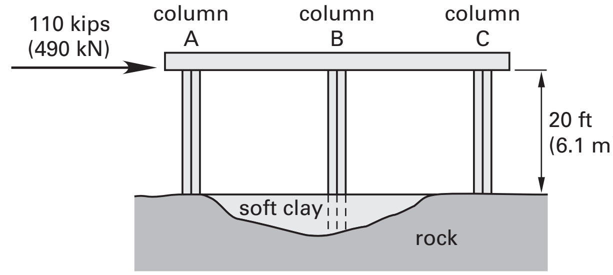
(A) I and II only

(B) I and III only

(C) II and III only

(D) I, II, and III

35. The bridge structure shown is subjected to a lateral load. Columns are square, the modulus of elasticity, E, is 29×10^6 lbf/in^2 (2.0×10^5 MPa), and the moment of inertia, I, per column is 19.5 in^4 (8.1×10^{-6} m^4). The supporting columns A and C are fixed at the tops and bottoms. The center column, B, is fixed at the top and pinned at the bottom.



The resisting force in column B will be most nearly

(A) 10 kips (50 kN)

(B) 20 kips (100 kN)

(C) 40 kips (160 kN)

(D) 50 kips (200 kN)

36. Which registered professionals can design and sign plans for a two-story single-family dwelling and a two-story four-unit condominium complex of wood-frame construction?

I. structural engineers

II. civil engineers

III. architects

(A) I only

(B) I and II only

(C) I and III only

(D) I, II, and III

37. What are the values of the site coefficients, F_a and F_v, for a building in site class D, and where $S_S = 0.9$ and $S_1 = 0.5$?

(A) 1.0 and 1.0

(B) 1.0 and 1.14

(C) 1.14 and 1.0

(D) 1.14 and ~~1.5~~

38. The stability coefficient is calculated using the equation shown.

$$\theta = \frac{P_x \Delta}{V_x h_{sx} C_d}$$

Solutions

Practice Exam 1

1. The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 as a direct result of the 1971 San Fernando earthquake. This earthquake was characterized by extensive surface fault ruptures that damaged numerous residential homes, commercial buildings, and other structures.

The Alquist-Priolo Earthquake Fault Zoning Act is intended to prevent the construction of buildings utilized for human occupancy on the surface trace of active faults. The provisions of this law require that buildings for human occupancy must be at least 50 ft (15.24 m) away from an active fault trace. Prior to January 1, 1994, Earthquake Fault Zones were called Special Studies Zones.

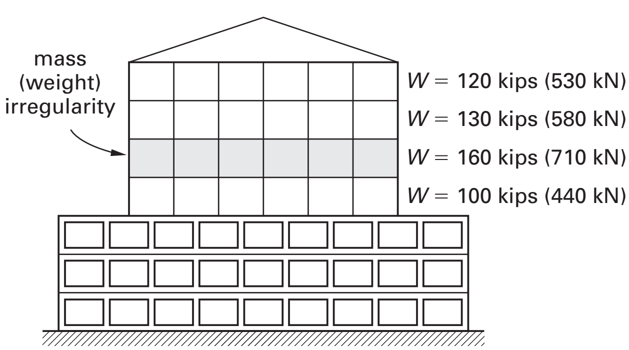
This act requires the State Geologist to establish regulatory zones around the surface traces of active faults and to issue the appropriate maps. Zone maps are available from the California Division of Mines and Geology, or they may be viewed at city or county planning departments and some real estate offices.

The answer is (B).

2. According to ASCE/SEI7 ~~Sec. 11.4.4~~, the earthquake design of a building is ²⁄₃ the maximum considered earthquake design motion. The maximum considered earthquake coefficients can be obtained from ASCE/SEI7 Fig. 22-1 through Fig. 22-6.

The answer is (A).

3.



ASCE/SEI7 Table 12.3-2 lists and defines the five types of vertical structural irregularities: soft-story irregularity, mass (weight) irregularity, vertical geometric irregularity, in-plane discontinuity irregularity, and discontinuity in lateral strength irregularity. Of these, the structure shown has a mass (weight) irregularity in the second story because the mass is more than 150% of the effective mass of the story below.

The answer is (B).

4. *SI Solution*

The mapped acceleration parameters are given in the problem statement as 0.2 and 0.5. The site class is not given, therefore, it is assumed to be site class D according to ASCE/SEI7 Sec. ~~11.4.2~~.

To obtain the site coefficients and the risk-targeted maximum considered earthquake (MCE_R) spectral response acceleration parameters, use ASCE/SEI7 Sec. ~~11.4.3~~. For $S_S = 0.5$ and site class D, the site coefficient, F_a, is 1.4 [ASCE/SEI7 Table 11.4-1]. For $S_1 = 0.2$ and site class D, the site coefficient, F_v, is ~~2.0~~ [ASCE/SEI7 Table 11.4-2].

The MCE_R spectral response acceleration for short periods, S_{MS}, and a 1 s period, S_{M1}, is given by ASCE/SEI7 Eq. 11.4-1 and Eq. 11.4-2.

$$S_{MS} = F_a S_S = (1.4)(0.5) = 0.7$$
$$S_{M1} = F_v S_1 = (\cancel{2.0})(0.2) = \cancel{0.4}$$

The design spectral acceleration parameters are given by ASCE/SEI7 Eq. 11.4-3 and Eq. 11.4-4.

$$S_{DS} = \tfrac{2}{3} S_{MS} = \left(\frac{2}{3}\right)(0.7) = 0.47$$
$$S_{D1} = \tfrac{2}{3} S_{M1} = \left(\frac{2}{3}\right)(\cancel{0.4}) = \cancel{0.27}$$

Determine the risk category for the building based on ASCE/SEI7 Table 1.5-1. For this building, the risk category is IV.

From ASCE/SEI7 Sec. 11.5.1 and Table 1.5-2, the importance factor, I_e, is 1.5. From ASCE/SEI7 Table 12.2-1, the response modification factor, R, is 8.

Determine the building's time period based on ASCE/SEI7 Sec. 12.8.2. From ASCE/SEI7 Table 12.8-2, $C_t = 0.0731$ and $x = 0.75$.

$$T_a = C_t h_n^x = (0.0731)(47 \text{ m})^{0.75} = 1.312 \text{ s}$$

ASCE/SEI7 Sec. 12.8 states the procedure for the equivalent lateral force method.

$$\begin{aligned} C_s &= \frac{S_{DS}}{\frac{R}{I_e}} = \frac{0.47}{\frac{8}{1.5}} \\ &= 0.088 \quad \text{[ASCE/SEI7 Eq. 12.8-2]} \\ C_{s,\max} &= \frac{S_{D1}}{T_a\left(\frac{R}{I_e}\right)} = \frac{\cancel{0.27}}{(1.312\ \text{s})\left(\frac{8}{1.5}\right)} \\ &= \cancel{0.038} \quad \text{[ASCE/SEI7 Eq. 12.8-3]} \end{aligned}$$

ASCE/SEI7 Eq. 12.8-3 is valid for $T \leq T_L$. (In California, T_L is either 8 s or 12 s, so ASCE/SEI7 Eq. 12.8-4 will not be valid.)

$$\begin{aligned} C_s &= 0.044 S_{DS} I_e \geq 0.01 \quad \text{[ASCE/SEI7 Eq. 12.8-5]} \\ &= (0.044)(0.47)(1.5) \\ &= 0.031 \quad [\geq 0.01, \text{OK}] \\ C_{s,\text{gov}} &= 0.031 \end{aligned}$$

Per ASCE/SEI7 Eq. 12.8-1, the base shear is

$$V = C_s W = \cancel{0.038} W$$

The answer is (A).

Customary U.S. Solution

The mapped acceleration parameters are given in the problem statement as 0.2 and 0.5. The site class is not given, therefore, it is assumed to be site class D according to ASCE/SEI7 Sec. ~~11.4.2~~.

To obtain the site coefficients and the risk-targeted maximum considered earthquake (MCE_R) spectral response acceleration parameters, use ASCE/SEI7 Sec. 1~~1.4.3~~. For $S_S = 0.5$ and site class D, the site coefficient, F_a, is 1.4 [ASCE/SEI7 Table 11.4-1]. For $S_1 = 0.2$ and site class D, the site coefficient, F_v, is ~~2.0~~ [ASCE/SEI7 Table 11.4-2].

The MCE_R spectral response acceleration for short periods, S_{MS}, and a 1 sec period, S_{M1}, is given by ASCE/SEI7 Eq. 11.4-1 and Eq. 11.4-2.

$$\begin{aligned} S_{MS} &= F_a S_S = (1.4)(0.5) = 0.7 \\ S_{M1} &= F_v S_1 = (\cancel{2.0})(0.2) = \cancel{0.4} \end{aligned}$$

The design spectral acceleration parameters are given by ASCE/SEI7 Eq. 11.4-3 and Eq. 11.4-4.

$$S_{DS} = \tfrac{2}{3} S_{MS} = \left(\frac{2}{3}\right)(0.7) = 0.47$$

$$S_{D1} = \tfrac{2}{3} S_{M1} = \left(\frac{2}{3}\right)(\cancel{0.4}) = 0.\cancel{27}$$

Determine the risk category for the building based on ASCE/SEI7 Table 1.5-1. For this building, the risk category is IV.

From ASCE/SEI7 Sec. 11.5.1 and Table 1.5-2, the importance factor, I_e, is 1.5. From ASCE/SEI7 Table 12.2-1, the response modification factor, R, is 8.

Determine the time period of the building based on ASCE/SEI7 Sec. 12.8.2. From ASCE/SEI7 Table 12.8-2, $C_t = 0.03$ and $x = 0.75$.

$$T_a = C_t h_n^x = (0.03)(155\ \text{ft})^{0.75} = 1.318\ \text{sec}$$

ASCE/SEI7 Sec. 12.8 states the procedure for the equivalent lateral force method.

$$\begin{aligned} C_s &= \frac{S_{DS}}{\frac{R}{I_e}} = \frac{0.47}{\frac{8}{1.5}} \\ &= 0.088 \quad \text{[ASCE/SEI7 Eq. 12.8-2]} \\ C_{s,\max} &= \frac{S_{D1}}{T_a\left(\frac{R}{I_e}\right)} = \frac{\cancel{0.27}}{(1.318\ \text{sec})\left(\frac{8}{1.5}\right)} \\ &= \cancel{0.038} \quad \text{[ASCE/SEI7 Eq. 12.8-3]} \end{aligned}$$

ASCE/SEI7 Eq. 12.8-3 is valid for $T \leq T_L$. (In California, T_L is either 8 sec or 12 sec, so ASCE/SEI7 Eq. 12.8-4 will not be valid.)

$$\begin{aligned} C_{s,\min} &= 0.044 S_{DS} I_e \geq 0.01 \quad \text{[ASCE/SEI7 Eq. 12.8-5]} \\ &= (0.044)(0.47)(1.5) \\ &= 0.031 \quad [\geq 0.01, \text{OK}] \\ C_{s,\text{gov}} &= 0.031 \end{aligned}$$

Per ASCE/SEI7 Eq. 12.8-1, the base shear is

$$V = C_s W = \cancel{0.038} W$$

The answer is (A).

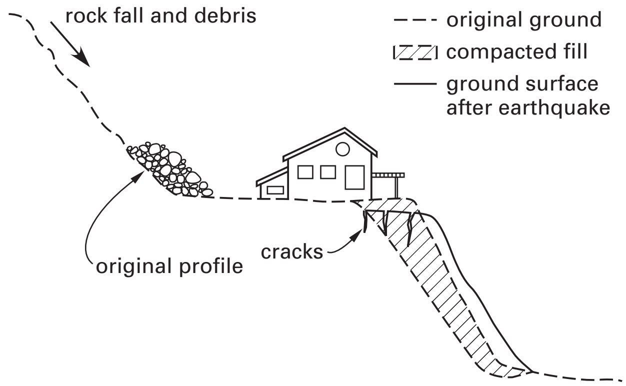
5. *SI Solution*

Use ASCE/SEI7 Sec. 12.8.3 and the equations shown to determine the distributed shear at level 3.

$$\begin{aligned} F_x &= C_{vx} V \quad \text{[ASCE/SEI7 Eq. 12.8-11]} \\ C_{vx} &= \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k} \quad \text{[ASCE/SEI7 Eq. 12.8-12]} \end{aligned}$$

From the problem statement, V is 220 000 N. The story height and weight are equal. Since the height of the structure is given as 24 m, each story height is 3 m. At each story, weight is w. h_x is the height from the base to

Slope failure causes foundation damage and/or loss of foundation support. Buildings may be damaged if they are located in the path of debris flows or rock falls. Seismically induced slope failures have been observed in nonliquefaction-susceptible soils, rock, slopes, and compacted fill slopes.



The answer is (D).

7. Use ASCE/SEI7 Sec. 13.3 to determine the seismic demands on nonstructural components. ASCE/SEI7 Eq. 13.3-1 gives a component's seismic design force, F_p, to be applied to the center of gravity.

$$F_p = \left(\frac{0.4 a_p S_{DS} W_p}{\frac{R_p}{I_p}} \right) \left(1 + 2\frac{z}{h} \right)$$

[ASCE/SEI 7 Eq. 13.3-1]

$$F_p = \left(\frac{0.4 a_p S_{DS} W_p}{\frac{R_p}{I_p}} \right) \left(1 + 2\frac{z}{h} \right)$$

[ASCE/SEI 7 Eq. 13.3-1]

F_p need not be greater than $F_p = 1.6 S_{DS} I_p W_p$, nor less than $F_p = 0.3 S_{DS} I_p W_p$ [ASCE/SEI7 Eq. 13.3-2 and Eq. 13.3-3]. a_p, the component amplification factor, is selected from ASCE/SEI7 Table 13.5-1 or Table 13.6-1 and varies from 1.0 to 2.5. R_p, the component response modification factor, is also selected from ASCE/SEI7 Table 13.5-1 or Table 13.6-1 and varies from 1.0 to 12. z is the height in structure of the point of attachment of component with respect to the base, and h is the average roof height with respect to the base. S_{DS} is determined based on ASCE/SEI7 Sec. ~~11.4.4~~.

The answer is (B).

8. Unreinforced masonry (URM) buildings, particularly bearing wall types, are considered the most hazardous form of construction not only in California, but also in other parts of the country and abroad. URM construction is no longer allowed in California, but many older URM buildings still exist. Buildings made of reinforced masonry have performed better.

Steel frame buildings have a good performance record, particularly in avoiding collapse. However, they are not damage-free during strong shakings because they absorb energy and deform. For braced steel frames, failed or buckled braces have been observed. For moment-frames, damage to primary members and distress at moment connections have been observed.

Prior to the use of ductile concrete (approximately the mid-1970s), concrete frame structures were made of nonductile concrete. Concrete structures are heavier and less yielding than similar steel structures. Past severe damage and collapse have been linked to design of joints and connections that lacked the necessary strength and ductility to withstand damage and separation forces.

Steel and concrete frame buildings with unreinforced masonry infill walls possess the additional hazard that the masonry walls can crack and fall on occupants or passersby.

The answer is (D).

9. *SI Solution*

ASCE/SEI7 Sec. 12.6 and Table 12.6-1 specify how to select an appropriate lateral-force procedure for the design of seismic force-resisting systems. The table lists three possible design procedures: the equivalent lateral-force procedure [ASCE/SEI7 Sec. 12.8], the modal response spectrum analysis [ASCE/SEI7 Sec. 12.9], and the seismic response history procedure [ASCE/SEI7 Chap. 16]. Which procedures are permitted or not permitted for a given structure depends on the seismic design category of the structure, the risk category of the structure, irregularities in the structure, and the fundamental period of the structure.

All three structures are seismic design category F and risk category III and have no structural irregularities, so the only unknown factor that could determine which analytical procedures are permitted for each structure are the fundamental period and the fundamental period over a short period.

From ASCE/SEI7 Sec. ~~11.4.5,~~ because S_{D1} and S_{DS} are the same for all three structures, the fundamental period over a short period is the same for all three structures. The fundamental period over a short period is

$$T_s = \frac{S_{D1}}{S_{DS}} = \frac{0.6}{0.75} = 0.8 \text{ s}$$

Customary U.S. Solution

For this building, the coefficient C_t is 0.028, and the coefficient x is 0.8. Using Eq. 12.8-7, the approximate fundamental period of the building is

$$\begin{aligned} T_a &= C_t h_n^x = (0.028)(120\ \text{ft})^{0.8} \\ &= 1.29\ \text{sec} \end{aligned}$$

Using Eq. 12.8-8, the approximate fundamental period of the building is

$$\begin{aligned} T_a &= 0.1N = (0.1)(8) \\ &= 0.8\ \text{sec} \end{aligned}$$

Use 1.29 sec as the approximate fundamental period of the building. From ASCE/SEI7 Table 12.8-1, the value of C_u for a structure with an S_{D1} value of 0.2 is 1.5. The maximum fundamental period of the building is

$$\begin{aligned} T &= C_u T_a = (1.5)(1.29\ \text{sec}) \\ &= 1.935\ \text{sec} \quad (1.9\ \text{sec}) \end{aligned}$$

The answer is (D).

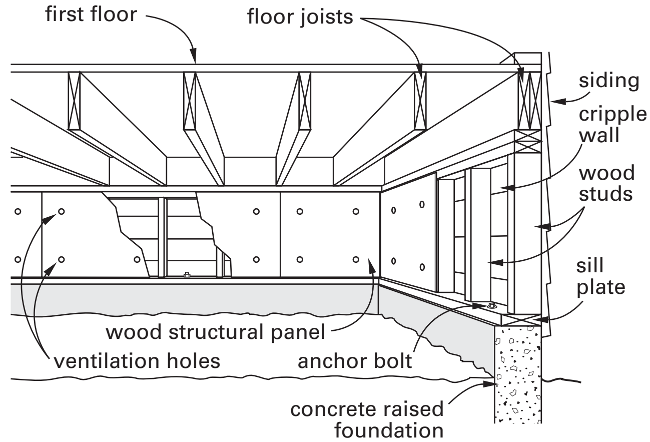
17. The foundation sill plate is a horizontal piece of wood (redwood or treated Douglas fir) that rests on the foundation and transfers the weight of the building to the foundation. The cripple wall is a short stud wall, not a full story in height, extending from the foundation sill plate to the first floor. In the wood-frame house shown, cripple walls support the first floor of the wood structure. The exterior face is finished with siding (e.g., wood, metal, or plaster) while the studs on the inside remain exposed.

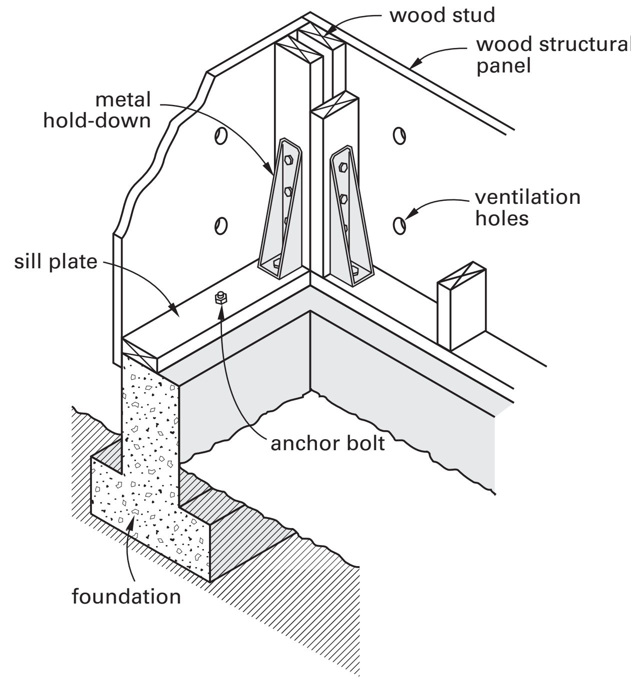
If the cripple walls are not adequately braced and strengthened, they can collapse in the event of an earthquake and the structure will fail, causing damage to the foundation, floors, walls, utility connections, and the contents of the structure. Damage may also result in fire from broken gas lines. In California, numerous cripple wall failures have been observed in previous earthquakes.

The deficient cripple walls can be strengthened in the following ways to enhance the seismic resistance of this building.

- Installing expansion sill anchor bolts at regular intervals to anchor the sill plates to the foundation.
- Installing steel hold-downs to anchor the wood stud walls to the foundation.
- Nailing wood structural panels to the inside of the cripple studs. The top edge of the wood structural panels should be nailed into the floor framing, and the bottom edge should be nailed into the sill plate.

It should be noted that horizontal or vertical exterior siding is not strong enough to brace cripple walls.





The answer is (D).

18. ASCE/SEI7 Table 11.4-1 gives $F_a = \cancel{1.1}$ for $S_S = 0.75$ and site class C. ASCE/SEI7 Table 11.4-2 gives $F_v = \cancel{1.4}$ for $S_1 = 0.4$ and site class C.

$$\begin{aligned} S_{MS} &= F_a S_S = (\cancel{1.1})(0.75) = \cancel{0.825} \\ S_{M1} &= F_v S_1 = (\cancel{1.4})(0.4) = \cancel{0.56} \\ S_{DS} &= \tfrac{2}{3} S_{MS} = \left(\frac{2}{3}\right)(\cancel{0.825}) = \cancel{0.55} \\ S_{D1} &= \tfrac{2}{3} S_{M1} = \left(\frac{2}{3}\right)(\cancel{0.56}) = \cancel{0.373} \end{aligned}$$

For structure I

Use ASCE/SEI7 Eq. 12.8-1 to calculate the base shear.

$$V = C_s W$$

From ASCE/SEI7 Table 1.5-2, for risk category III, the importance factor, I_e, is 1.25. From ASCE/SEI7 Eq. 12.8-2,

$$C_s = \frac{S_{DS}}{\frac{R}{I_e}} = \frac{\cancel{0.55}}{\frac{8.0}{1.25}} = \cancel{0.086}$$

From ASCE/SEI7 Eq. 12.8-3,

$$C_{s,\max} = \frac{S_{D1}}{T\left(\frac{R}{I_e}\right)} = \frac{\cancel{0.373}}{(0.88\ \text{sec})\left(\frac{8.0}{1.25}\right)} = \cancel{0.066}$$

From ASCE/SEI7 Eq. 12.8-5,

$$\begin{aligned} C_{s,\min} &= 0.044 S_{DS} I_e \geq 0.01 \\ &= (0.044)(\cancel{0.55})(1.25) \\ &= \cancel{0.031} \quad [> 0.01, \text{OK}] \end{aligned}$$

$C_{s,\min} = \cancel{0.031}$, which is smaller than $\cancel{0.066}$. Therefore, $C_{s,\text{gov}} = \cancel{0.066}$.

For structure II

Use ASCE/SEI7 Eq. 12.8-1 to calculate the base shear.

$$V = C_s W$$

From ASCE/SEI7 Table 1.5-2, for risk category II, the importance factor, I_e, is 1.0. From ASCE/SEI7 Eq. 12.8-2,

$$\begin{aligned} C_s &= \frac{S_{DS}}{\frac{R}{I_e}} = \frac{\cancel{0.55}}{\frac{6.0}{1.0}} \\ &= \cancel{0.092} \end{aligned}$$

From ASCE/SEI7 Eq. 12.8-3,

$$\begin{aligned} C_{s,\max} &= \frac{S_{D1}}{T\left(\frac{R}{I_e}\right)} = \frac{\cancel{0.373}}{(0.88\ \text{sec})\left(\frac{6.0}{1.0}\right)} \\ &= \cancel{0.071} \end{aligned}$$

From ASCE/SEI7 Eq. 12.8-5,

$$\begin{aligned} C_{s,\min} &= 0.044 S_{DS} I_e \geq 0.01 \\ &= (0.044)(\cancel{0.55})(1.0) \\ &= \cancel{0.024} \quad [> 0.01, \text{OK}] \end{aligned}$$

$C_{s,\min} = \cancel{0.024}$, which is smaller than $\cancel{0.071}$. Therefore, $C_{s,\text{gov}} = \cancel{0.071}$.

Structure I has a smaller base shear than structure II.

The answer is (A).

19. IBC Sec. 202 defines a diaphragm as a horizontal or sloped system acting to transfer lateral forces to the vertical-resisting elements. Statement II and statement III are both correct.

IBC Sec. 202 explicitly states that diaphragms are systems, not subsystems. Statement I is incorrect.

The answer is (C).

20. Diaphragms, both flexible and rigid, distribute lateral forces to vertical resisting elements (e.g., columns and shear walls). Flexible diaphragms are typically of wood or light steel construction and distribute lateral forces to vertical resisting elements in proportion to the tributary area of the elements. They are incapable of distributing torsional moments to vertical resisting elements. Rigid diaphragms are typically concrete slabs or concrete metal deck floor systems. They distribute lateral forces in proportion to the rigidities of vertical resisting elements and transmit torsion to the vertical resisting elements.

The answer is (C).

21. As defined in the Professional Engineers Act, which is contained in Business and Professions Code Chap. 7, Sec. 6703 and further clarified in Rules of the Board for Professional Engineers and Professional Land Surveyors Sec. 404.1, the term "responsible charge of work" for professional engineers means the independent control and direction of the investigation or design of professional engineering work by the use of initiative, skill, decision, and judgment. However, this phrase does not refer to the concept of financial liability.

The answer is (C).

22. ASCE/SEI7 Sec. 11.2 defines a *wall system, bearing* as a structural system with bearing walls providing support for all or major portions of the vertical loads. Shear walls or braced frames provide seismic force resistance. Structure I is constructed entirely of shear walls and, therefore, lacks a complete vertical load-carrying space frame.

Structure II is a moment-resisting frame. A *moment frame* is a frame in which members and joints resist lateral forces by flexure as well as along the axis of the members. Moment frames are categorized as

37. IBC Table 1613.~~3~~.3(1) and Table 1613.~~3~~.3(2) provide the values for the site coefficients F_a and F_v. Straight-line interpolation must be used for intermediate values.

For $S_S = 0.75$, $F_a = 1.2$.

For $S_S = 1.00$, $F_a = 1.1$. Therefore, for $S_S = 0.9$,

$$F_a = 1.2 - \left(\frac{0.9 - 0.75}{1.00 - 0.75}\right)(1.1 - 1.2) = 1.14$$

For $S_1 \geq 0.5$, $F_v = \cancel{1.5}$.

The answer is (D).

38. P-delta effects are related to the magnitude of the additional overturning moment that is generated when the drifts are large. Δ is the design story drift corresponding to the story shear, V_x. ASCE/SEI7 Sec. 12.8.7 provides the conditions when P-delta effects need to be considered. They do not need to be considered when the stability coefficient, θ, is less than or equal to 0.10.

The answer is (A).

39. *SI Solution*

For the east shear wall, the lateral force due to shear is

$$\begin{aligned} F_v &= V\left(\frac{R_{\text{tab,east}}}{\sum R_{\text{tab},i}}\right) \\ &= (220\,000 \text{ N})\left(\frac{3}{3+3}\right) \\ &= 110\,000 \text{ N} \end{aligned}$$

The moment due to torsion is

$$T_{\text{N-S}} = Ve \qquad \text{[Eq. 1]}$$

The actual eccentricity is

$$\begin{aligned} e &= \text{CM} - \text{CR} = 13.7 \text{ m} - 9.1 \text{ m} \\ &= 4.6 \text{ m} \end{aligned}$$

The accidental eccentricity required by ASCE/SEI7 Sec. 12.8.4.2 is 5% of the building dimension perpendicular to the lateral force.

$$\begin{aligned} e_a &= (0.05)(27.4 \text{ m}) \\ &= 1.37 \text{ m} \end{aligned}$$

The total eccentricity is

$$\begin{aligned} e_{\text{N-S}} &= e + e_a \\ &= 4.6 \text{ m} + 1.37 \text{ m} \\ &= 5.97 \text{ m} \end{aligned}$$

Using Eq. 1, the moment due to torsion is

$$\begin{aligned} T_{\text{N-S}} &= Ve_{\text{N-S}} = \frac{(220\,000 \text{ N})(5.97 \text{ m})}{1000 \ \frac{\text{N}}{\text{kN}}} \\ &= 1313 \text{ kN·m} \end{aligned}$$

The lateral force due to torsion is

$$F_t = T_{\text{N-S}}\left(\frac{R_{\text{tab,east}}\, d}{\sum R_{\text{tab},i}\, d^2}\right) \qquad \text{[Eq. 2]}$$

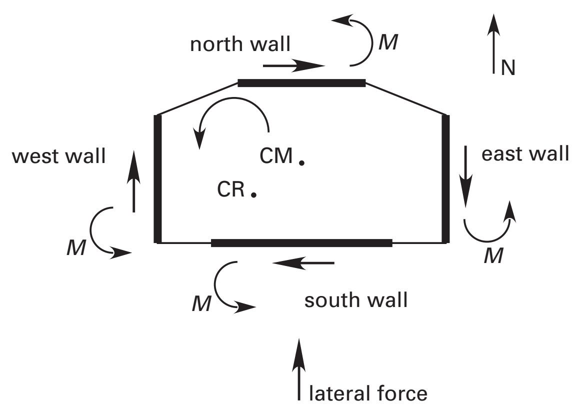
The sum of $R_{\text{tab},i}d^2$ can be obtained from the table.

$$\begin{aligned} \sum R_{\text{tab},i}\, d^2 &= 225 \text{ m}^2 + 127 \text{ m}^2 + 1000 \text{ m}^2 \\ &\quad + 248 \text{ m}^2 \\ &= 1600 \text{ m}^2 \end{aligned}$$

Using Eq. 2, the lateral force due to torsion is

$$\begin{aligned} F_t &= T_{\text{N-S}}\left(\frac{R_{\text{tab,east}}\, d}{\sum R_{\text{tab},i}\, d^2}\right) \\ &= (1313 \text{ kN·m})\left(\frac{54.9 \text{ m}}{1600 \text{ m}^2}\right)\left(1000 \ \frac{\text{N}}{\text{kN}}\right) \\ &= 45\,052 \text{ N} \end{aligned}$$

The lateral force resultant acts through the center of mass, while the resisting force resultant acts through the center of rigidity. Therefore, for an earthquake motion in the north direction, a torsional moment develops that has counterclockwise rotation; the building acts as though pinned at the center of rigidity.



The east wall receives positive torsional components.

Therefore, the total lateral force is the sum of the shear force and the torsional force.

$$\begin{aligned} F_{\text{total}} &= F_v + F_t = 110\,000\ \text{N} + 45\,052\ \text{N} \\ &= 155\,052\ \text{N} \quad (155\,000\ \text{N}) \end{aligned}$$

The answer is (D).

Customary U.S. Solution

For the east shear wall, the lateral force due to shear is

$$\begin{aligned} F_v &= V\left(\frac{R_{\text{tab,east}}}{\sum R_{\text{tab},i}}\right) \\ &= (50{,}000\ \text{lbf})\left(\frac{3}{3+3}\right) \\ &= 25{,}000\ \text{lbf} \end{aligned}$$

The moment due to torsion is

$$T_{\text{N-S}} = Ve \qquad \text{[Eq. 1]}$$

The actual eccentricity is

$$\begin{aligned} e &= \text{CM} - \text{CR} \\ &= 45\ \text{ft} - 30\ \text{ft} \\ &= 15\ \text{ft} \end{aligned}$$

The accidental eccentricity required by ASCE/SEI7 Sec. 12.8.4.2 is 5% of the building dimension perpendicular to the lateral force.

$$\begin{aligned} e_a &= (0.05)(90\ \text{ft}) \\ &= 4.5\ \text{ft} \end{aligned}$$

The total eccentricity is

$$\begin{aligned} e_{\text{N-S}} &= e + e_a = 15\ \text{ft} + 4.5\ \text{ft} \\ &= 19.5\ \text{ft} \end{aligned}$$

Using Eq. 1, the moment due to torsion is

$$\begin{aligned} T_{\text{N-S}} &= Ve_{\text{N-S}} = (50{,}000\ \text{lbf})(19.5\ \text{ft}) \\ &= 975{,}000\ \text{ft-lbf} \end{aligned}$$

The lateral force due to torsion is

$$F_t = T_{\text{N-S}}\left(\frac{R_{\text{tab,east}}d}{\sum R_{\text{tab},i}d^2}\right) \qquad \text{[Eq. 2]}$$

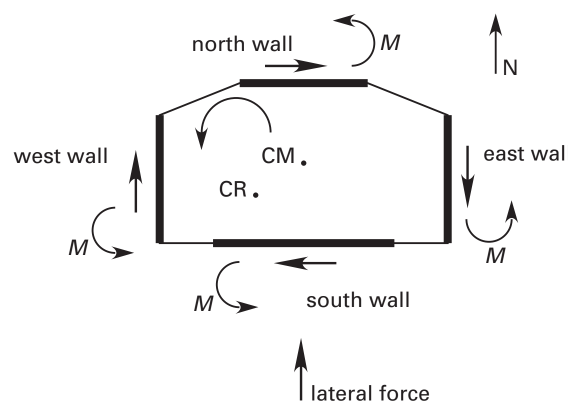
The sum of $R_{\text{tab},i}d^2$ can be obtained from the table.

$$\begin{aligned} \sum R_{\text{tab},i}d^2 &= 2450\ \text{ft}^2 + 1350\ \text{ft}^2 + 10{,}800\ \text{ft}^2 + 2700\ \text{ft}^2 \\ &= 17{,}300\ \text{ft}^2 \end{aligned}$$

Using Eq. 2, the lateral force due to torsion is

$$\begin{aligned} F_t &= T_{\text{N-S}}\left(\frac{R_{\text{tab,east}}d}{\sum R_{\text{tab},i}d^2}\right) = (975{,}000\ \text{ft-lbf})\left(\frac{180\ \text{ft}}{17{,}300\ \text{ft}^2}\right) \\ &= 10{,}145\ \text{lbf} \end{aligned}$$

The lateral force resultant acts through the center of mass, while the resisting force resultant acts through the center of rigidity. Therefore, for an earthquake motion in the north direction, a torsional moment develops that has counterclockwise rotation; the building acts as though pinned at the center of rigidity.



The east wall receives positive torsional components. Therefore, the total lateral force is the sum of the shear force and the torsional force.

$$\begin{aligned} F_{\text{total}} &= F_v + F_t \\ &= 25{,}000\ \text{lbf} + 10{,}145\ \text{lbf} \\ &= 35{,}145\ \text{lbf} \quad (35{,}000\ \text{lbf}) \end{aligned}$$

The answer is (D).

40. The Professional Engineers Act, California Business and Professions Code, "Professional Engineers," Chap. 7, ~~Sec. 6704~~, requires that any person who wishes to practice civil engineering must be appropriately registered. An applicant should submit an application to the Board to take the appropriate examinations for registration. The Board evaluates the applicant's professional experience and education and decides whether the applicant meets the Board's registration requirements. The applicant's experience and education should evidence that the engineer is competent to practice civil engineering based on Sec. 6750 through Sec. 6762 of the Professional Engineers Act. A civil engineering degree is

48. ASCE/SEI7 Sec. 12.2.2 allows different response modification factor, R, values for the x- and y-directions of a structure. ASCE/SEI7 Sec. 12.2.3.1 explains how to determine the R value if two different systems are used for different levels of a structure in the same direction (e.g., the y-direction). When the upper system has a lower value of R, this lower value should be used for the entire height of the structure. For the two steel systems shown, ASCE/SEI7 Table 12.2-1 lists an R value of 6 for the steel special concentrically braced frame (the upper system), and a value of 8 for the steel special moment resisting frame, (the lower system). Use the lower value of 6 for R in the y-direction.

The answer is (B).

49. Based on IBC Table 2306.3(1), a maximum allowable shear stress of 315 lbf/ft (4600 N/m) will be achieved when the staple spacing at the wood structural panel edges is 3 in (76 mm).

The answer is (B).

50. According to IBC Sec. 202 (Definitions), an approved agency is approved by the local building official or authority having jurisdiction for the purpose of conducting materials testing or inspection of civil engineering projects.

IBC Sec. 202 also states that an inspection certificate is applied on a product or material to indicate that it has been inspected and evaluated by an approved agency. An inspection certificate cannot be applied to an entire building.

According to IBC Sec. 202 (Definitions), continuous special inspection must be performed by a special inspector who is present when and where the work to be inspected is being done. A continuous special inspection may be performed by a part-time inspector as long as he or she fulfills this requirement.

IBC Sec. 202 (Definitions) explicitly does not permit structural observation to include or waive the responsibility for work performed by a qualified inspector.

The answer is (C).

51. IBC Sec. 1705.4.2 states that special inspections are required for vertical masonry foundation elements. IBC Table 1705.3 states that special inspections are required for anchors cast in concrete ~~where allowable loads have been increased or where strength design is used, or for anchors post-installed in hardened concrete members~~. IBC ~~Table~~ 1705.2.2 states that special inspections are required for cold-formed steel decks. Therefore, all three types of construction would require special inspection.

The answer is (D).

52. A diaphragm anchor resists an out-of-plane seismic load by connecting the structural wall to the roof diaphragm. The in-plane shear flow loads are not relevant. The design force on individual anchors is calculated in accordance with ASCE/SEI7 Sec. 12.11 and requires knowing the weight of the tributary portion of the wall. The redundancy factor is not needed to calculate the anchor design force.

The answer is (A).

53. ASCE/SEI7 Table 12.3-2 defines both weak and soft stories as types of vertical irregularities. Soft-story irregularity is related to story stiffness, and is not related to story strength (i.e., load-carrying ability). According to items 5a and 5b of ASCE/SEI7 Table 12.3-2, weak stories must be checked against the lateral strength of the story directly above it. Per item 5a of ASCE/SEI7 Table 12.3-2, a weak story exists if the lateral strength of a story is greater than 66% but less than 80% of the strength of the story directly above it. Under item 5b of ASCE/SEI7 Table 12.3-2, an extreme weak story exists if the lateral strength of the story is less than 65% of the strength of the story directly above it.

SI Solution

The first level of the building is the potential soft story. This first level must be checked against the story directly above it. The 80% and 65% limit values for the lateral strength of the lower story are

$$V_{\text{weak}} = (0.80)(1100\text{ kN}) = 880\text{ kN}$$
$$V_{\text{ext-weak}} = (0.65)(1100\text{ kN}) = 715\text{ kN}$$

Since the lower story strength of 800 kN is less than the 80% limit of 880 kN, but more than the 65% limit of 715 kN, the building is defined as a weak story irregularity.

The answer is (C).

Customary U.S. Solution

The first level of the building is the potential soft story. This first level must be checked against the story directly above it. The 80% and 65% limit values for the lateral strength of the lower story are

$$V_{\text{weak}} = (0.80)(250\text{ kips}) = 200\text{ kips}$$
$$V_{\text{ext-weak}} = (0.65)(250\text{ kips}) = 163\text{ kips}$$

Since the lower story lateral strength of 180 kips is less than the 80% limit of 200 kips but more than the 65% limit of 163 kips, the building has a weak story irregularity.

The answer is (C).

54. ASCE/SEI7 Sec. 12.2 describes eight major types of structural systems (bearing wall, building frame, moment-resisting frame, dual systems with special moment-resisting frames, dual systems with intermediate moment-resisting frames, shear wall-frame, cantilevered column, and steel systems without seismic detailing). The factors used to determine a structural

60. Any civil engineering document that conveys an engineering recommendation or decision should bear the seal and signature of a registered civil engineer who either prepared the document or supervised its preparation. Examples of civil engineering documents are "Project Study Report," "Drainage Report," "Design Exception Fact Sheets," "Project Plan Sheets," "Project Report," "Project Specifications," "Material Report," "Special Provisions," and so on.

If the final civil engineering plans, specifications, reports, or documents have multiple pages, the signature and seal or stamp should appear on the original of the plans and on the original title sheet of the specifications, reports, or documents.

The answer is (D).

61. ASCE/SEI7 Sec. 15.4 provides information regarding the seismic design requirements for nonbuilding structures. Section 15.4.1 states that nonbuilding structures must be designed to resist minimum seismic lateral forces as given in Sec. 12.8, with some exceptions.

Because the monument is a rigid nonbuilding structure with a fundamental period less than 0.06 sec, the base shear for the monument is found using ASCE/SEI7 Eq. 15.4-5 [ASCE/SEI7 Sec. 15.4.2]. The importance factor for a risk category II structure is 1.0 [ASCE/SEI7 Table 1.5-2]. Because the structures are assumed to have the same weight, the weight can be disregarded. The base shear of the monument is

$$\begin{aligned} V &= 0.30 S_{DS} W I_e = (0.30)(1.2)W(1.0) \\ &= 0.36W \end{aligned}$$

Because the amusement structure is a rigid nonbuilding structure with a fundamental period greater than 0.06 sec, the base shear of the structure is found using Eq. 12.8-1. To find the base shear using this equation, the value of C_s must be known. For an amusement structure, the value of C_s is found using Eq. 12.8-2. Because amusement structures are nonbuilding structures that are not similar to buildings, and because the value of S_1 for the site is less than or equal to 0.6, the minimum value of C_s can be found using Eq. 15.4-2 [ASCE/SEI7 Sec. 15.4.1]. Because the fundamental period is less than any of the long-period transition periods given in ASCE/SEI7 Sec. 22, the maximum value of C_s can be found using Eq. 12.8-3 [ASCE/SEI7 Sec. 12.8.1.1]. For monuments, $R = 2$ [ASCE/SEI7 Table 15.4-2], and for risk category II buildings, $I_e = 1.0$ [ASCE/SEI7 Table 1.5-2].

The minimum value of C_s is

$$\begin{aligned} C_{s,\min} &= \frac{0.8S_1}{\frac{R}{I_e}} = \frac{(0.8)(0.6)}{\frac{2}{1.0}} \\ &= 0.24 \end{aligned}$$

To find the maximum value of C_s, the value of S_{D1} must be found. Per ASCE/SEI7 Sec. 12.8.1.1, the value of S_{D1} is found using Eq. 11.4-4. This calculation requires the value of S_{M1}, which is found using Eq. 11.4-2. Per Table 11.4-2, the site coefficient F_v for site class C and $S_1 = 0.6$ is ~~1.3~~. The value of S_{M1} for the site is

$$\begin{aligned} S_{M1} &= F_v S_1 = (\cancel{1.3})(0.6) \\ &= \cancel{0.78} \end{aligned}$$

The value of S_{D1} for the site is

$$\begin{aligned} S_{D1} &= \tfrac{2}{3} S_{M1} = \left(\frac{2}{3}\right)(\cancel{0.78}) \\ &= \cancel{0.52} \end{aligned}$$

The maximum value of C_s is

$$\begin{aligned} C_{s,\max} &= \frac{S_{D1}}{T\left(\frac{R}{I_e}\right)} = \frac{\cancel{0.52}}{(0.05\ \text{sec})\left(\frac{2}{1.0}\right)} \\ &= \cancel{5.2} \end{aligned}$$

The value of C_s is

$$C_s = \frac{S_{DS}}{\frac{R}{I_e}} = \frac{1.2}{\frac{2}{1.0}} = 0.6 \quad \text{[governs]}$$

The base shear of the monument, disregarding the weight of the structure, is

$$V = C_s W = 0.6W$$

The monument has the smaller base shear.

The answer is (A).

62. Unreinforced masonry (URM) is perhaps the most dangerous type of construction in areas of high seismicity, such as California. The Federal Emergency Management Agency recognizes URM as one of the structure types most prone to failure during an earthquake. URM structures are made from brick, hollow clay tile, stone, or concrete blocks that are not strengthened by additional steel rods or bracings. The masonry is usually held together with weak mortar, making it unable to resist lateral forces. Wall and roof anchorages also tend to be inadequate, which allows roofs and floors to separate from the structure's walls and collapse. While not all URM buildings will collapse during a significant earthquake, most will have some degree of life-threatening failure. In California, the construction of unreinforced masonry buildings was banned after the 1933 Long Beach earthquake, which killed over 100 people.

Seismic anchor slab: The seismic anchor slab is used in a bridge structure retrofit to substantially stiffen the abutments. However, it is not an appropriate option for a bridge with inadequate columns, because the seismic anchor slab retrofit strategy draws larger seismic forces to the abutments. Seismic anchor slabs resist both longitudinal and transverse seismic displacements at each abutment. Each abutment should be evaluated for compression effects (e.g., bridge moving toward fill—anchor slab and abutment diaphragm activate large soil wedge) and tension effects (e.g., bridge moving away from fill—anchor slab is pulled across fill).

The answer is (B).

88. ASCE/SEI7 Sec. 11.2 defines moment-resisting frames. These frames resist forces in members and joints primarily by flexure, and rely on the frame to carry both vertical and lateral loads. The lateral loads are carried by flexure in the members and joints, and joints are theoretically completely rigid. Moment frames can be steel, concrete truss, or composite moment frames. They can also be categorized into ordinary moment frames (OMF), intermediate moment frames (IMF), and special moment frames (SMF). ASCE/SEI7 Table 12.2-1 notes the limits for the usage of these systems.

The answer is (C).

89. IBC Table 2306.3(1) gives a 170 lbf/ft (2480 N/m) allowable shear stress for 7/16 in (11 mm) structural I panels that are applied directly to framing and stapled with 1½ 16 gage staples at 6 in (152 mm) o.c. at panel edges, and at 12 in (305 mm) o.c. along intermediate supports.

The answer is (C).

90. ASCE/SEI7 Sec. 20.3.1 defines site class F as

1. soils vulnerable to potential failure or collapse under seismic loading (e.g., liquefiable soils, quick and highly sensitive clays, and collapsible weakly cemented soils)

2. peats and/or highly organic clays ($H > 10$ ft (3 m)) of peat and/or highly organic clay where H is the thickness of soil

3. very high plasticity clays ($H > 25$ ft (7.6 m) with PI>75)

4. very thick soft/medium stiff clays ($H > 120$ ft (37 m)) with $s_u < 1000$ lbf/ft² (50 kPa)

Where the total thickness of soft clay is greater than 10 ft (3 m) with $s_u < 500$ lbf/ft² (25 kPa), $w_{mc} \geq 40\%$, and PI > 20, the site class is defined as E, not F [ASCE/SEI7 Sec. 20.3.2].

The answer is (C).

91. ASCE/SEI7 Table 12.6-1 requires all irregular structures with horizontal irregularity type 1a to be analyzed using the modal response spectrum analysis or the seismic response history procedure.

The answer is (D).

92. In general, retrofit costs fall into two main categories: direct and indirect costs. The direct costs represent the sum of money a property owner spends to improve the building's deficiencies against earthquakes. An example of direct costs is a bill that a building contractor charges a property owner. The indirect costs arise as a result of a decision to proceed with the improvement of the building's deficiencies against earthquakes. Examples of indirect costs are construction permits, fees, and construction financing.

A building's structural system exerts the greatest direct influence on the amount of work required for seismic rehabilitation. Other factors can be location and the level of rehabilitation (retrofit) involved. Costs based on the building's structural system recognize the range of deficiencies inherent in a building's structural system.

For example, the typical seismic rehabilitation cost for frames with infill masonry is higher than the seismic rehabilitation cost for wood structures. The greater mass of the masonry building results in greater inertia forces that must be resisted. The perimeter of the masonry infill needs to be anchored to the frame to reduce the possibility of falling debris in the event of an earthquake. Furthermore, the building deflections need to be significantly decreased to reduce the loads unintentionally resisted by the infill material. The decrease in building deflection can be accomplished by increasing the building stiffness. All these seismic rehabilitation measures result in higher costs.

There is little or no correlation between the cost per square foot (square meter) and the height of the building or the building roof type. The building material influences the rehabilitation costs, but this is mostly accounted for by the structural system.

The answer is (A).

93. A post-and-pier foundation consists of posts that support the entire or portions of the building and that are, in turn, supported on isolated concrete piers (footings). This type of foundation system does not have continuous perimeter foundations or a substantial bracing system to resist earthquake forces. Although many houses on steep hills are built with this type of system, they are vulnerable to earthquakes unless specially engineered for the site.

For posts on piers, the top of every wood post should be reinforced at its connection to the beam with a steel strap on both sides of the post-and-beam connection. Steel T-straps or steel ledgers are preferred. In order to connect post and pier together where the post rests on the pier, a sheet-metal connector should be used on both sides of the post-and-pier connection.

engineers. Civil and structural engineers and architects can also perform structural damage inspections.

This specificity is necessary to exclude other disciplines of engineering, such as nuclear, chemical, and mechanical, that are not experienced.

The answer is (D).

98. Foundations with piles or drilled piers that lack lateral force capacity to adequately transfer the seismic shears from the pile caps and the piles to the soil (ground) can be improved by

- removing the existing pile caps, driving additional piles, and providing new pile caps of larger size.
- reducing loads on the piles or piers. This can be done by providing supplemental vertical-resisting elements (i.e., shear walls or braced frames) and transferring forces to other foundation members with reserve capacity.
- adding tie beams to adjacent pile caps. This measure causes the loads on pile caps to be reduced and distributed.

IBC Chap. 18 contains additional information about foundations.

The answer is (D).

99. ASCE/SEI7 Sec. 13.3 provides the requirement for the seismic demands on nonstructural components. These demands are imposed on elements of structures and their attachments, permanent nonstructural components and their attachments, and the attachments for permanent equipment supported by a structure, which should be designed to resist the total design seismic forces, F_p, obtained from ASCE/SEI7 Eq. 13.3-1, Eq. 13.3-2, and Eq. 13.3-4. F_p should not be less than $0.3S_{DS}I_pW_p$ or more than $1.6S_{DS}I_pW_p$.

The answer is (C).

100. Requirements for the seismic design of mechanical and electrical components are given in ASCE/SEI7 Sec. 13.6. HVAC ductwork requirements are given in ASCE/SEI7 Sec. ~~13.6.7~~, which states that as long the component importance factor, I_p, is 1.0, seismic supports are not required if one of the given conditions is met.

- *condition 1:* HVAC ducts are suspended from hangers 12 in (305 mm) or less in length.
- *condition 2:* HVAC ducts have a cross-sectional area of less than 6 ft^2 (0.557 m^2).

From the problem, case I—HVAC ducts suspended from hangers 6 in (153 mm) long—satisfies condition 1. Case II—HVAC ducts having a cross-sectional area of 4 ft^2 (0.372 m^2)—satisfies condition 2.

Requirements for HVAC components are also discussed in ASCE/SEI7 Sec. ~~13.6.7.~~ The code requires components, such as fans that weigh more than 75 lbf (334 N), to be braced.

The answer is (D).

101. For seismic resistance in a building, an adequate, complete, and sufficiently strong load path is a requirement. There should be a lateral-force resisting system that forms a direct load path consisting of elements within and between the vertical resisting elements, diaphragms, and foundations subsystems.

The lateral seismic inertia forces of an existing building are transferred from the floors and roofs through the vertical-resisting elements (e.g., shear walls, braced frames, and moment frames) to the foundations and into the ground. Gaps in the path cause a structure to fail under wind load and seismic forces. Examples of gaps are a discontinuous chord because of a notch in the diaphragm, a missing collector, or a connection that is not capable of transferring a diaphragm shear to a shear wall or frame.

The answer is (D).

102. *SI Solution*

ASCE/SEI7 Eq. 12.8-7 is used to solve for the approximate fundamental period, T_a. C_t and x are approximate period parameters determined from ASCE/SEI7 Table 12.8-2. h_n is the actual height of the building above the base on the nth level. For the structure given in the problem, and using ASCE/SEI7 Table 12.8-2,

$$\begin{aligned} T_a &= C_t h_n^x = (0.0724)(15\ \text{m})^{0.8} \\ &= 0.63\ \text{s} \quad (0.6\ \text{s}) \end{aligned}$$

The answer is (D).

Customary U.S. Solution

ASCE/SEI7 Eq. 12.8-7 is used to solve for the approximate fundamental period, T_a. C_t and x are approximate period parameters determined from ASCE/SEI7 Table 12.8-2. h_n is the actual height of the building above the base on the nth level. For the structure given in the problem, and using ASCE/SEI7 Table 12.8-2,

$$\begin{aligned} T_a &= C_t h_n^x = (0.028)(50\ \text{ft})^{0.8} \\ &= 0.64\ \text{sec} \quad (0.6\ \text{sec}) \end{aligned}$$

The answer is (D).

103. Both chord and collector elements are parts of the diaphragm of a structure. A chord operates as the tension strength for the diaphragm. A collector runs along the vertical plane of a wall or frame to collect diaphragm shear. Diaphragm materials (e.g., concrete slabs, plywood) are typically strong in compression, but weak in tension. Both chords and collectors are mostly for