Soil Dynamics

Lecture 11

Seismic Codes

California Building Code – Part I

In a Problem Format

List of Symbols.

- ***ap*** **is the in-structure component of the amplification factor.**
- ***Ca*** **is the seismic response coefficient for proximity.**
- ***Cp*** **is the horizontal force factor.**
- ***Ct*** **is a numerical coefficient for the period.**
- ***Cv*** **is the seismic response coefficient.**
- ***Fp*** **is total (design or service) lateral seismic force.**
- ***Ft*** **is the concentrated force at the top of the structure.**
- ***hn*** **is defined as the height of the building above the base to the nth level.**
- ***I*** **is the seismic importance factor.**
- ***Na*** **is the near source factor for *Ca*.**
- ***Nv*** **is the near source factor for *Cv*.**
- ***R*** **is the response modification factor; it reflects the inherent over-strength and global ductility capacity of different lateral-force resisting systems.**
- ***Rp*** **is the component response modification factor; the horizontal force factor.**
- ***S*** **is the soil profile classification, such as, *SA*, *SB*, *SC*, *SD*, *SE* and *SF*).**
- ***T*** **is the fundamental period.**
- ***V*** **is the base shear force.**
- ***W*** **is the weight of the entire structure (dead + live loads).**
- ***Z*** **is the seismic zone influence factor.**
- ***Ωo*** **is the seismic force amplification factor.**
- **Δs is the inter-story drift.**

Question #01.

The California Building Code (CBC) bases its seismic zone factor on the effective peak ground acceleration (EPA) that has a 10% chance of being exceeded in 50 years.

What is this EPA intended to represent?

A. The maximum probable earthquake.

B. The minimum considered (capable) earthquake.

C. The maximum predictable earthquake.

D. The minimum theoretical earthquake.

Answer to #01.

A.

The CBC's provisions are set as *minimum requirements*.

Section 1627 defines the design basis ground motion (maximum probable) as that ground motion with a 10% chance of being exceeded in 50+ years, as determined by a site specific hazard analysis or from a seismic hazard map.

Question #02.

In designing and detailing structures, the purpose of complying with the CBC seismic requirements is to prevent which of the following in the event of an earthquake?

A. Structural damage.

B. Architectural damage.

C. Loss of life.

D. Disruption of business.

Answer to #02.

C.

The purpose of CBC, Section 101.2, is to prevent loss of life in the event of an earthquake.

Although the seismic codes affect the performance of structures and tend to prevent structural damage during an earthquake, this is not the main intent of the codes.

According to CBC's Section 1626.1, the primary purpose of earthquake provisions is to avoid major structural failures in order to safeguard lives, not to limit damage or maintain function.

Question #03.

In what amount does the actual seismic force that can be developed in a structure exceed the design seismic force calculated using CBC principles?

A. Between 1.0 and 1.3.

B. Between 1.3 and 1.6.

C. Between 1.6 and 2.0.

D. Between 2.0 and 2.8.

Answer to #03.

D.

In a linear elastic structure, the force in the structure reaches *R* times the calculated design seismic force where *R* is the global ductility factor of the structure and has a value between 2.2 and 8.5, depending on the structural system.

However, because of the inelastic behavior of the actual structure, the natural period and the damping ratio increase and seismic energy is dissipated. This reduces the actual seismic force that can be developed to Ω_0 times the design seismic force, where Ω_0 is the force amplification factor that varies between 2.0 and 2.8 depending on the structure.

Question #04.

The CBC seismic provisions are intended as minimum requirements. The level of protection and safety can be magnified by increasing which of the following?

A. The inherent over-strength and global ductility.

B. The design lateral force.

C. The redundancy.

D. All the above.

Answer to #04.

D.

The level of protection and safety applies to the seismic resistance of the structures, which can be increased by increasing the following:

- *R* (the inherent over-strength and global ductility capacity of a lateral-force resisting system);

- the design lateral force;

- the quality of the construction materials;

- the quality of the construction methods.

Question #05.

An engineering firm is designing a family dwelling in seismic zone 4. This area is subjected to very strong winds. What loads should the firm consider in designing and detailing the structure?

A. It should design for only wind load and comply with CBC seismic detailing requirements.

B. It should design only for seismic load and comply with CBC seismic detailing requirements.

C. It should design for the combination of both loads.

D. It should design for the larger of the two loads and comply with CBC seismic detailing requirements.

Answer to #05.

D.

CBC Section 1626.3 requires that the firm should design for the larger load and comply with the detailing provisions of the seismic codes.

Question #06.

Which of the following statements is not correct?

A. Wind loads may govern over seismic loads.

B. Seismic loads may govern over wind loads.

C. Seismic loads are inertial in nature.

D. Wind loads are inertial in nature.

Answer to #06.

C.

CBC Section 1626.3 states that the larger load, wind or seismic governs the design.

Wind loads are applied over the exterior surface of the structure, while the seismic loads are inertial in nature.

Question #07.

A site is subjected to liquefation and earth-slides and is located on an active major fault line. The CBC prevents construction on this site due to the following:

A. Liquefation.

B. Earth-slides.

C. The fault lines.

D. The CBC does not prevent construction on this site.

Answer to #07.

D.

This site is subject to liquefation, earth-slides and major ground acceleration. The CBC does not prevent construction on this site. However, as a minimum requirement the code provisions must be followed.

To increase the level of protection *R*, the design lateral force, redundancy and the quality of the construction materials and methods should be increased. Other state and local codes may be applicable.

Question #08.

For reinforced concrete, when considering earthquake forces with the alternative basic load combinations, what percentage increase for all allowable stresses and soil bearing values does the CBC specify for the working stress design method?

A. 25%.

B. 33%.

C. 50%.

D. 66%.

Answer to #08.

B.

With the alternative basic load combinations for reinforced concrete design, the CBC, Section 1612.3.2, allows for a ⅓ increase when considering the earthquake force, either acting alone or when combined with vertical loads. In the case of vertical loads acting alone, this increase is not permitted.

Question #09.

Under what section of the CBC is the *Deformation compatibility* defined?

A. Section 1633.

B. Section 1633.2.

C. Section 1633.2.4.

D. Section 1633.2, Item 4.

Answer to #09.

C.

The *Deformation compatibility* is defined in the CBC Section 1633.2.4.

Question #10.

Which of the following facilities must remain operational after an earthquake?

A. Police training centers.

B. Dairies.

C. Bakeries.

D. Hospitals with surgery rooms.

Answer to #10.

D.

Per CBC Table 16-K, only those facilities that are categorized as occupancy category I (Essential Facilities) need to remain operational after an earthquake. Hospitals with surgery and emergency rooms are essential facilities and should remain open.

Question #11.

A small hospital equipped with a surgery room is located in a small town in California (seismic zone 4).

Based on CBC requirements, how is this facility best identified?

A. Hazardous.

B. Essential.

C. Standard.

D. Special.

Answer to #11.

B.

CBC Table 16-K shows that the occupancy category I includes hospitals having surgery and emergency treatment areas are considered essential facilities.

Question #12.

According to CBC, what values should be used for the coefficients C_a and C_v when the soil type is unknown in a seismic zone 3?

A. 0.24 and 0.24.

B. 0.33 and 0.45.

C. 0.36 and 0.54.

D. 0.36 and 0.84.

Answer to #12.

C.

Soil profile types S_A, S_B, S_C, S_D, S_E and S_F are defined in CBC Table 16-J and soil profile type S_F is defined as soils requiring site-specific evaluation.

CBC Section 1629.3.1 identifies soils that can be classified as the soil profile type S_F.

Question #13.

What does the *R* factor account for?

A. The resistance of the structural system.

B. The energy absorption capacity of the structural system.

C. The stiffness of the structural system.

D. All the above.

Answer to #13.

B.

The response modification factor *R* accounts for the energy absorption capacity.

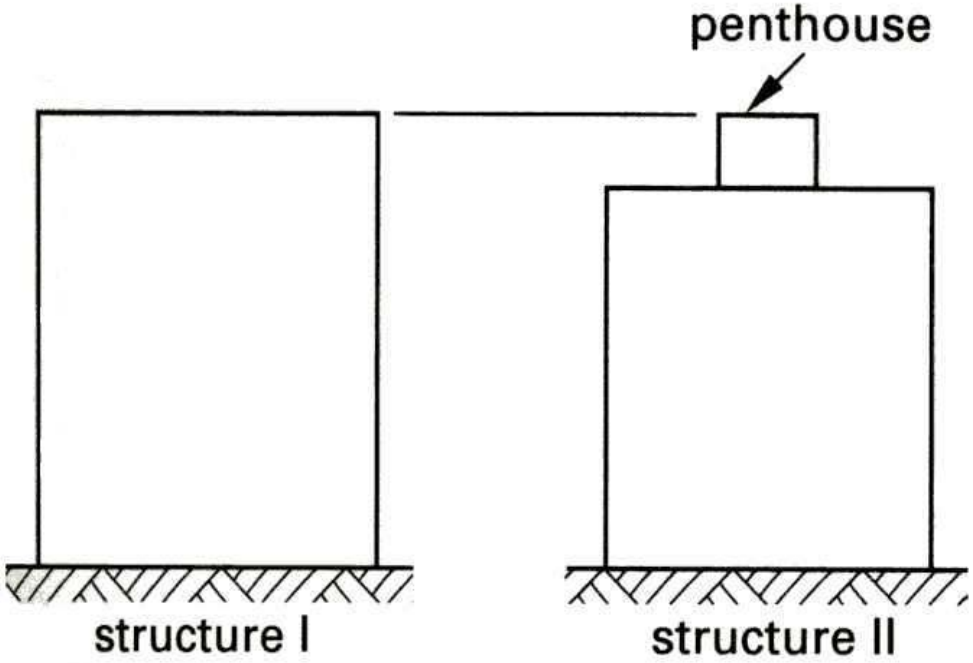
In CBC Section 1628, *R* is a numerical coefficient representative of the inherent over-strength and global ductility capacity of lateral-force resisting systems.

The *R* values are tabulated in CBC's Table 16-N for various types of building structural systems, and in Table 16-P for non-building structures.

As the value of *R* increases, the ductility of the structure increases.

Question #14.

The value of h_n for the following structures is,



A. **h_n is larger for structure I.**

B. **h_n is larger for structure II.**

C. **h_n is equal for structures I an II.**

D. **Δ_M multiplied by the number of stories.**

Answer to #14.

A.

CBC Section 1628 defines h_n as the height in feet above the base to the n^{th} level. The n^{th} level is the uppermost level in the main portion of the building. The penthouse is not considered part of the main portion of the structure.

Therefore, h_n is larger for structure I.

Question #15.

For steel eccentric braced frames, what is the value of C_t ?

A. 0.020.

B. 0.030.

C. 0.035.

D. 0.075.

Answer to #15.

B.

CBC Section 1630.2.2, Item 1 gives the value of 0.030 for the value of C_t for eccentrically braced steel frames.

Question #16.

The total seismic dead load should include,

A. Anything suspended inside the building from the roof.

B. Anything mounted on the upper half of the walls.

C. Permanent equipment on the upper half of the walls.

D. All of the above.

Answer to #16.

D.

CBC Section 1630.1.1 states that the total seismic dead load of the structure includes the following,

- All the elements of the structure that are permanent, such as roofs, walls, floors and equipment.

- All elements suspended inside the building from the roof or the ceiling, or mounted on the upper half of the walls.

- Applicable portions of the other loads, such as floor live loads, partition loads and snow loads.

Question #17.

For the base shear calculation of a building, an engineering firm needs to consider the 40 psf of snow load with respect to the total weight *W*.

Which of these statements is correct?

A. The snow load can be excluded.

B. Only 30 psf of snow load shall be included.

C. Snow loads can be reduced by 25%.

D. Snow loads may be reduced up to 75% with approval of the building official.

Answer to #17.

D.

Where the snow load is greater than 30 psf, the CBC Section 1630.1.1, Item 3 specifies that the design snow load should be included in the total seismic load.

However, with the approval of the building official, the design snow load may be reduced up to 75%.

Question #18.

The weight *W* used in the base shear *V* calculation,

$$V = \left(\frac{C_V I}{RT} \right) W$$

excludes which of the following,

A. 110 psf of the floor live load in a warehouse.

B. 10 psf of the floor partition load.

C. 40 psf of the snow load.

D. None of the above.

Answer to #18.

D.

CBC Section 1630.1.1, Items 1, 2 and 3 for the base shear calculation, the weight *W*, should include a minimum of 25% of the floor live load in a warehouse, a minimum of 10 psf for floor partitions, and the snow load if it is greater than 30 psf.

Question #19.

When designing a storage warehouse, what percent of live load must be included in the value of the total weight *W*?

A. 0%

B. 25%

C. 75%

D. 100%

Answer to #19.

B.

CBC Section 1630.1.1, item 1 states that for warehouse occupancies, a minimum of 25% of the floor live load must be accounted for in the value of the total weight *W*.

Question #20.

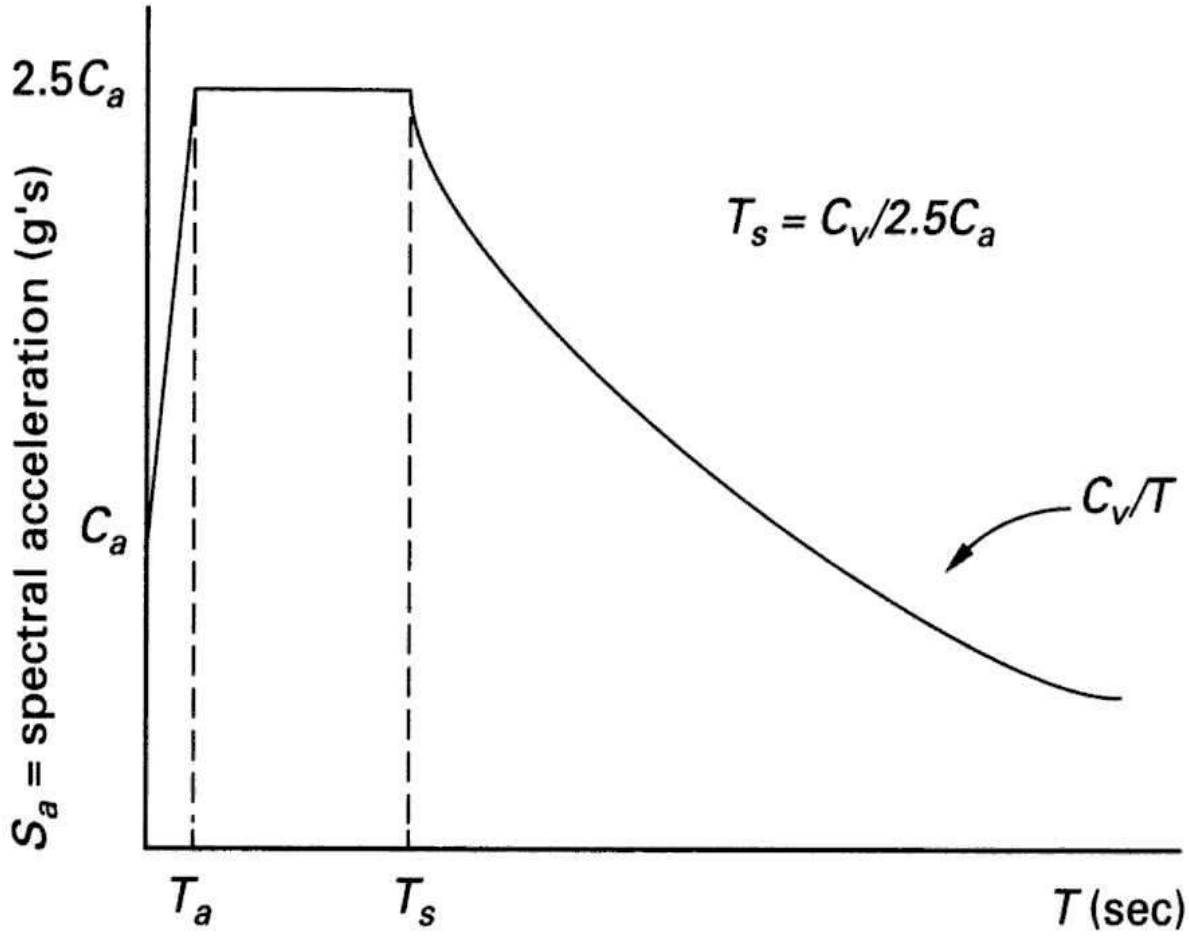
A building is being designed in a seismic zone 4. The site is on a hard rock. The elastic fundamental period of vibration for the building is 1 second. Using the spectral shape shown below, what will the corresponding value of the spectral acceleration S_a be?

A. 0.32

B. 0.43

C. 0.54

D. 0.64



Answer to #20. **The answer is D.**

CBC Table 16-J shows that the soil profile for a hard rock is S_A. CBC Table 16-Q shows that for a seismic zone 4 and a soil profile of S_A, the seismic response coefficient $C_a = 0.32\ N_a$. Similarly, the value of the seismic response coefficient C_v is obtained from the CBC Table 16-R as $0.32\ N_a$.

The near-source factor used in the determination of C_a in a seismic zone 4 is related to both the proximity of the building to known faults with magnitudes and slip rates as given in CBC Table 16-S and 16-U. Since this information is unknown in this problem, from CBC table 16-S, the maximum near-source factor of $N_a = 1.5$ should be used to find the maximum value of C_v. Therefore, $C_a = (0.32)(1.5) = 0.48$.

Similarly, from Table 16-T, $N_v = 2.0$ therefore $C_v = 0.32N_v = (0.32)(2.0) = 0.64$.

From the given spectral shape, $$T_S = \frac{C_V}{2.5C_a} = \frac{0.64}{(2.5)(0.48)} = 0.533 \text{ seconds}$$

and since $T_s = 0.533$ is less than the elastic fundamental period of vibration for the building,

$$S_a = \frac{C_V}{T} = \frac{0.64}{1.0\ sec} = 0.64$$