APPENDIX

D

Study Aids

The materials in this section are provided for readers to use in order to test their general understanding of the book presentations. It is recommended that, upon completion of reading of an individual chapter, the materials here be used as a review. Materials include terms for which a definition and general understanding of the significance should be developed and general questions regarding various issues. Answers to the questions are provided following the questions. Use the Glossary and Index to find the applicable book materials.

TERMS

Chapter 1

Allowable stress design method
Arch
Beam
Bending
Building–ground relationship
Combination of loads
Curtain wall
Dispersion of loads
Dome
Ductile material
Dynamic load
Equilibrium
Filter functions of the building exterior
Flat-spanning structure
Form–scale relationships
Framed structure
Fundamental period
Geodesic dome
Lamella frame
Lintel
Mast structure
Modulus of elasticity
Monopod unit
One-way spanning structure
Overturning
Partition
Post
Reaction
Rigid frame
Safety factor
Service load
Strain
Strain hardening
Strength design method
Stress
Structural wall
Surface structure
Truss
Two-way spanning structure

Chapter 2

Bending
Coefficient of thermal expansion
Combined stress (shear plus direct, in beams)
Composite structural systems
Composition and resolution of forces
Cut section
Equilibrium
Equivalent static effect
Force
Force polygon
Force systems (arrangement)
Free-body diagram

Friction, sliding, coefficient of
Harmonic motion: amplitude, cycle, period, frequency, damping, resonance
Internal force
Kinematics: displacement, velocity, acceleration
Lateral deformation, shear
Load-deflected structural profile
Maxwell diagram
Modulus of elasticity
Moment
Motion: translation, rotation, rigid body, of deformable body
Properties of a force: magnitude, sense, direction
Resultant
Shear: force, stress (direct, in beam)
Shear center
Shear modulus (of elasticity)
Space diagram
Strain (and deformation)
Stress: direct, shear, compressive, tensile, bending, torsional, unit, allowable, ultimate
Torsion: moment, stress
Unsymmetrical bending

Chapter 3

Arches, type: tied, fixed, two hinged, three hinged
Beam, type: simple, cantilever, overhanging, continuous, restrained, indeterminate
Bearing wall
Bent
Buckling (of beams): lateral, torsional (rotational)
Cable
Combined stress: tension plus bending, compression plus bending
Column
Cracked section
Determinacy and stability of trusses
Diagrams: loading and support conditions, shear, moment, deflected shape
Effective area (for tension development)
Effective buckling length, column
Interaction, compression plus bending
Internal forces in beams: shear, bending
Investigation of trusses, for internal forces, methods of: graphic (Maxwell diagram), joints, sections, beam analogy
Kern
Members of trusses: chords, web
Net section
Panel point, in truss
P−delta effect
Pier
Reactions
Rigid frame
Rotation: of beam cross section, of beam end
Slenderness of compression member
Support conditions: rotation free (simple, pinned), rotation restrained (fixed)
Tie
Truss, form of: gabled, flat (parallel chorded), bent (rigid frame), Vierendeel
X-brace

Chapter 4

Axial compression
Bearing
Blocking
Board deck
Built-up member
Chord
Common wire nail
Dimensional stability
Edge distance
Engineered wood products
Fastener
Glued-laminated products
Grade of structural lumber
Joist
Lag screw
Lateral load on nail
Lateral support requirements: bridging, blocking, depth-to-width ratio
Load-to-grain orientation: parallel, perpendicular, angled
Lumber, structural
Modification factors for design reference values
Moisture conditions
Nail, common wire
Net section for tension
Penetration, of nail or screw
Pitch of fasteners
Plies (plywood), face, core
Plywood
Pole structure
Rafter
Repetitive stress use
Sandwich panel
Size factors for wood beams
Slenderness ratio, column
Solid-sawn wood
Spaced column
Species, of tree
Stud
Veneer
Withdrawal resistance, of nail or screw
Wood fiber products

Chapter 5

Bearing, beam
Bending factor, column
Buckling: of column, of beam (lateral, torsional), of beam web, of truss

Built-up sections, columns
Cold-formed shapes
Compact section
Double-angle compression member
Ductility
Effective column length (K factors for columns)
Formed-sheet steel products
Lateral unsupported length
Least-weight design choice
Light-gauge steel products
Open-web steel joist
Rolled shape
Slenderness ratio, column
Strut
Torsional buckling
Web crippling
For Bolted Connections:
Double shear
Edge distance
Effective area (in tension)
Fastener
Framed beam connection
Gauge, for angles
High-strength bolt
Pitch
Single shear
Tearing

Chapter 6

Admixture
Aggregate: fine, coarse, lightweight
Air-entrained concrete
Balanced section, of beam
Bearing wall
Cast-in-place concrete (sitecast)
Cement
Composite construction
Cover
Creep
Curing
Deformed bars (reinforcement)
Design strength (ultimate compressive), specified as f'_c
Development, of reinforcement
Development length
Diagonal tension stress
Doubly reinforced section
Dowel
Effective depth, of beam
Elastic ratio, n
Factored load
Flat plate
Flat slab
Footing: wall, column
Forming
Freestanding wall
Grade, of reinforcement steel
Grade wall
Hook: standard, equivalent development length of
Interaction, compression and bending
Minimum thickness of slab; depth of beam
One-way solid slab
Pedestal
Peripheral (punching) shear
Precast concrete
Reinforcement
Retaining wall
Shear wall
Shrinkage of concrete
Shrinkage reinforcement
Sitecast concrete
Slab–beam–girder system
Spacing of reinforcement
Specified compressive strength of concrete, f'_c
Spiral column
Splice
Standard hook
Stirrup
Strength design (LRFD)
Strength reduction factor, ϕ
T-beam
Temperature reinforcement
Tied column
Two-way solid slab
Waffle construction
Water–cement ratio
Workability, of wet concrete

Chapter 7

Adobe
Architectural terra cotta
Beam pocket
Bond beam
Brick wall terms: wall, pier, column, pedestal
Clay tile
CMU
Course
Grouted void
Header (brick)
Lintel
Masonry
Masonry type: cavity, solid, grouted, unreinforced, reinforced, veneer
Masonry unit
Nonstructural masonry
Pedestal
Reinforced masonry
Specified compressive strength of masonry, f'_m
Unreinforced masonry
Veneer
Wythe

Chapter 8

Abutment
Active lateral soil pressure
Allowable bearing pressure
Atterberg limits
Backfill
Belled pier
Braced cut
Cantilever: footing (strap), retaining wall
Clay
Cohesionless soil
Cohesive soil
Combined column footing
Compaction
Compressibility of soil
Consolidation
Curb
Cut
Density
Dewatering
Downhill frame
Drilled pier
Equalized settlement
Equivalent fluid pressure
Expansive soil
Fill
Fines
Footing: wall, column, combined, cantilever, rectangular
Foundation wall
Gap-graded soil
Grade beam
Grain shape
Grain size
Gravel
Key (shear)
Liquid limit
Moment-resistive footing
Passive lateral soil pressure
Penetration resistance, *N*
Permeability
Pier: deep foundation, pedestal, wall
Pile: cap, end bearing, friction, sheet
Plasticity index
Preconsolidation
Presumptive bearing pressure
Rectangular (oblong) footing
Retaining wall
Rock
Sand
Sheet piling
Shrinkage limit
Silt
Soil
Soil structure: loose, dense, compacted, honeycombed, flocculent
Specific gravity, of soil solids
Surcharge
Unconfined compressive strength, of cohesive soil
Void, in soil
Void ratio

Chapter 9

Acceleration
Accidental eccentricity
Base isolation
Braced frame
Center of stiffness, of vertical bracing
Collector
Diaphragm: horizontal, vertical
Diaphragm chord
Drift
Eccentric bracing
Fundamental period
Horizontal anchor
Horizontal movement due to vertical load
Horizontal thrust: gabled structure, arch, cable, rigid frame, cantilevered structure
K-bracing
Lateral force of: thermal expansion, shrinkage, moisture change, soil pressure
Lateral resistive systems: box, braced frame, rigid frame, self-stabilizing structure
Liquefaction, of soil
Load sharing
Multimassed building
Overturn
Perimeter bracing
Regularity of building and structural form
Relative stiffness of: horizontal diaphragm, vertical bracing system
Rigid frame
Seismic separation joint
Shear wall
Site–structure interaction
Soft story
Three-sided building, lateral bracing system
Tiedown (hold-down)
V-bracing
Vulnerable elements
Weak story
Wind actions on buildings: sliding, uplift, overturning, torsion, clean-off effect, basic design pressure
Wind effects (general, direct) on any stationary object in the wind path: direct pressure (positive), negative pressure (suction), drag (wind shear, friction), gust, harmonic effects
X-bracing
Zones of probability (from codes): for windstorms, for earthquakes

Chapter 10

Building code: model, legal (locally enforced)
Construction (building) permit
Design; designing; designers
Industry standards
Planning of structures
Process of design of building structures

Appendix A

Centroid
Moment of inertia
Parallel-axis theorem
Radius of gyration
Section modulus

QUESTIONS

Chapter 1

1. What is the most direct way of implementing concern for structural safety in the building design process?
2. Why is design for fire safety in buildings viewed as a race against time?
3. What is the essential difference between the structural design methods called ASD and LRFD?
4. Describe some ways in which the building exterior shell serves as a selective filter.
5. Describe some basic structural functions for walls.
6. What are the architectural functions and construction considerations that differentiate between structural and nonstructural walls?
7. Both roofs and floors require spanning structures. What are some differences in design requirements for the spanning structure, depending on whether it supports a roof or a floor?
8. With regard to the building structure, what changes in design requirements are implied by the following changes in the building's form or scale?
   (a) Single-space building; change from short to long span.
   (b) Multiple linear space building; change from regular repeated unit size to multiple sizes of spaces.
   (c) Multistory building; change from low rise to high rise.
9. Buildings are mostly built above ground. In comparison to the usual forms of construction, what are some differences in structural requirements for buildings built below ground surface level?
10. Structural tasks are viewed primarily in terms of loads. What is the basic nature of the load derived from the following sources?
    (a) Gravity
    (b) Wind
    (c) Seismic activity
11. What are some significant structural concerns implied by the following types of loads?
    (a) Live load
    (b) Dead load
    (c) Dynamic load
    (d) Concentrated load
    (e) Multiple potential load combinations
12. Both loads and reactions are visualized as exterior forces on a structure. What is the essential difference between them?
13. How are internal resistive forces generated in a structure?
14. What stress–strain response characterizes a material that is described as ductile?
15. What are the essential structural properties of a material that relate to design of building structures?
16. For classification of wood as a structural material, what is the significance of the following?
    (a) Species
    (b) Grade
    (c) Moisture content
17. Although steel is an essential material for most structures, what are some of the basic, unavoidable difficulties in its use?
18. Concrete is a highly variable material. Describe some of the basic structural and general physical properties of finished concrete that are subject to variation during the production process.
19. As a finished structural material, masonry is similar to concrete. What are some of the basic differences?
20. Describe some of the basic structural functions that are required of structures.
21. An arch and a draped catenary cable are essentially similar in basic form in profile. What is the basic difference between them as it relates to the definition of their structural tasks?
22. Describe some specific examples of structures that relate to the following categories.
    (a) Solid structures
    (b) Framed structures
    (c) Surface structures
23. Describe some ways in which walls may be stabilized against loads that are perpendicular to the wall plane.
24. What are the ways that a post-and-beam frame can be stabilized against lateral loads in the plane of the frame?
25. What is the basic factor that makes a rigid frame different from a simple post-and-beam frame?
26. Depth (vertical dimension) is a critical factor for a flat-spanning structure. How can depth be obtained, other than by an increase of the solid mass of material?
27. What are the two basic structural characteristics that identify a typical trussed structure?

28. What is the basic relationship between rise and thrust in an arch?
29. Compression surface structures require a structural property that differentiates them from tension surface structures. What is it?

Chapter 2

1. Investigation of structural behaviors have some specific uses. What are they?
2. What basic means are used for performing structural investigations?
3. What aspects of structural behavior are determined through the use of the following?
   (a) A free-body diagram
   (b) A cut section
4. What are the basic vector properties of a single force?
5. Geometric classification of force systems is based on what three considerations?
6. With regard to force analysis, what is the difference between the following?
   (a) Composition and resolution
   (b) Component and resultant
7. For a system of coplanar, concurrent forces, what does the closing of the force polygon signify?
8. In algebraic analysis, what are the necessary conditions for equilibrium of a coplanar, concurrent force system?
9. What is the basic geometric principle of structural analysis that permits the use of a Maxwell diagram for investigation of internal forces in a truss?
10. For a coplanar, parallel force system, it is possible to have the sum of all the forces equal to zero without having equilibrium. Why is this?
11. Explain the difference between force and stress.
12. With respect to actions on a cross section, what is the basic difference between direct stress (tension or compression) and shear stress?
13. What is the difference between unit strain and total deformation?
14. What is meant by the term “double shear”?
15. What direct stress condition exists at the neutral axis of a cross section in a structural member subjected to bending?
16. How is member deformation measured in a structure subjected to torsion?
17. What is the significance of the yield point in stress−strain behavior?
18. How can thermal change produce stress in a structural member?
19. The difference in what structural property results in the nonuniform distribution of stress in a composite structural member?
20. Shear stress developed in one direction results in a secondary shear stress in a perpendicular direction. How are these two stresses related in magnitude?
21. Shear stress produces diagonal tension and diagonal compression stresses. How is the magnitude of the maximum diagonal stress related to the magnitude of the shear stress?
22. In addition to bending, what occurs in a beam when loads are not in the plane of the beam cross section’s shear center?
23. How does the distribution of shear stress on the cross section of a member subjected to direct shear force differ from that on a cross section in a beam?
24. What numerical relationship usually exists between a friction force and the force normal to the plane in which the friction is developed?
25. What generally distinguishes the difference between the fields of kinematics and kinetics?
26. How do the means of measurement differentiate motions of translation and motions of rotation?
27. How are work and energy related?
28. What is the usual reason for using the equivalent static force method for the investigation of dynamic actions on structures?

Chapter 3

1. With regard to load deformations in a beam, what is significant about the following support conditions?
   (a) Simple support
   (b) Restrained (fixed) support
   (c) Multiple supports (continuous beam)
2. What is indicated when a moment in a beam is described as either positive or negative?
3. What constitutes the complete external force system that operates on a beam?
4. What are the significant relationships between the shear diagram and the moment diagram for a beam?
5. What are the significant relationships between the moment diagram and the deflected shape for a beam?
6. What are the basic forms of buckling for an unbraced beam?
7. Pure axial tension action tends to produce what geometric responses in a linear structural member?
8. What is the significance of the net section in a tension member?
9. What is the basic relationship between the loads and the geometric profile of a flexible, draped, spanning cable?
10. What are the basic structural responses of short and long compression members?
11. How do end support conditions affect the buckling of columns?
12. The P−delta effect is sometimes described as being potentially accelerating. How does this occur?
13. What essential response characteristic of the material of a structure determines the development of a cracked section?
14. For planar trusses, what geometric condition is required in determining the arrangement of truss members to assure stability?

15. Why is it generally desired that trusses be loaded only at their panel points (joints)?
16. What essential interaction is required between members of a rigid frame?
17. A single-span rigid frame bent with fixed column bases is said to be indeterminate. Why is this?
18. The three-hinged arch is popular for medium-span buildings. What are some reasons for this?
19. What planning considerations make the use of two-way spanning systems feasible?

Chapter 4

1. How does moisture content affect design values for structural lumber?
2. What general qualification of loads permits the use of load duration modification factors for reference design values?
3. Why is the depth of a beam cross section more important than its width in determining bending resistance?
4. Why are heavy loads on short spans not often feasible for solid-sawn wood beams?
5. What is the purpose of bridging or blocking in joist and rafter construction?
6. Why is deflection of particular concern in the design of joists and rafters?
7. For structural purposes, what is the primary determining factor for the choice of thickness of a wood deck?
8. Why is the strength in compressive stress of the material not the major concern for a slender column?
9. Why is it not possible in most cases to simply invert the direct stress formula ($f = P/A$) for a solution in the design of a column?
10. Although the limitation for maximum slenderness of $L/50$ for a wood column would limit the height of a 2-by-4 stud to 75 in., what makes it possible to use 2-by-4 studs for greater heights?
11. When a column is subjected to bending, why is it not possible to simply add the maximum stresses due to axial compression and bending in order to find a load limit for the column?
12. Why is the two-member bolted joint not a favored form for development of force transfer?
13. Why is resistance to withdrawal not a reliable form of development of load resistance in nailed wood joints.
14. What is the reason for the difference in resistance of a bolted joint in wood based on the direction of the load with respect to the grain in the wood?
15. How is structural performance improved when a shear developer is added to a bolted joint between wood members?
16. Describe the factors that usually determine the general profile and the arrangements of members and joints for a truss.
17. What generally determines the selection of member form and the method of making joints for a truss?
18. What is structurally significant about the face plies of a plywood panel?
19. What advantages may be gained by the use of fabricated I-beams in place of solid-sawn rafters and joists?

Chapter 5

1. Why is the yield point generally of more concern than the ultimate strength of the steel for rolled structural products?
2. Why is the depth indicated in the designation for a W shape referred to as a nominal dimension?
3. Steel is generally considered to be vulnerable in exposed conditions. What are the primary concerns in this situation?
4. What single property of a beam cross section is most predictive of bending strength?
5. What is significant about the properties for a rolled W shape designated as L_p and L_r?
6. For shapes of A36 steel used as beams, what makes it possible to say that all beams of the same depth will have the same deflection at their limiting loads on a given span?
7. What is the most common means for dealing with torsion on a W-shape beam?
8. What single property of the cross section is most critical to the resistance of web crippling in a W-shape beam?
9. For evaluation of simple axial compression capacity, what are the most significant properties of the cross section of a steel column?
10. What makes it necessary to consider the effects of buckling on both axes of a W-shape steel column?
11. When so-called high-strength steel bolts are used for a lapped connection between steel members, what basic action develops the initial load resistance in the joint?
12. Tearing in a bolted connection is resisted by what combination of stress developments?
13. Other than spacing and edge distances, what basic dimension limits the number of bolts that can be used in a framed beam connection?
14. Why is it not desired to have supporting steel beams of the same depth as the beams they support?
15. What advantage is gained by the use of a so-called self-bracing form for a truss?
16. What are the usual reasons for using built-up sections, rather than single rolled shapes, for steel beams or columns?

Chapter 6

1. What is the primary structural limitation of concrete that generates the need for reinforcement?
2. What is the significance of having a well-graded range of size for the aggregate in concrete?

3. What is the primary determinate of the unit weight (density) of finished concrete?
4. What is the purpose of the deformations on the surface of steel bars used for reinforcing concrete?
5. What structural property is most significant for the grade of steel used for reinforcing bars for concrete?
6. During the curing period for concrete (after casting and before significant structural usage), what controls should be exercised?
7. What are the significant factors that determine required cover dimensions for concrete reinforcement?
8. Other than spacing limits and bar diameters, what factors establish the maximum number of bars that can be placed in a single layer in a reinforced concrete beam?
9. Why is compressive strength in the concrete generally not critical for T-beam sections in sitecast concrete construction?
10. For shear actions in concrete beams, what acts together with the vertical stirrups to resist the diagonal tension stresses?
11. Stirrups are designed to resist what portion of the total shear force in a concrete beam?
12. Why is development length generally less critical for small-diameter reinforcing bars?
13. Why are longer development lengths required for bars of higher grade steel?
14. In what form is the anchorage capacity of a hook expressed?
15. What is the basis for establishment of the required length of a lapped bar splice?
16. What are the usual considerations for determination of slab thickness in a slab–beam–girder framing system?
17. How is the minimum depth required for slabs and beams affected by span and support conditions?
18. What is the essential difference in structural action between concrete joist construction and waffle construction?
19. What structural improvements are achieved by the use of column capitals and drop panels in flat-slab construction?
20. What is the essential function of the shear developers (welded steel studs) in a composite structure with steel beams and a sitecast concrete deck?
21. With regard to effects on the vertical reinforcement, what is the primary purpose of the ties in a tied column?
22. With a column subjected to a large bending moment, why is a slightly higher moment possible with addition of a minor axial compression load?
23. What is the usual basis for limitation of the number of bars that can be placed in a spiral column?
24. Other than forming considerations, what favors the use of a square plan shape for a column footing?
25. What is the purpose of the longitudinal reinforcement (parallel to the wall) in a wall footing?
26. How is the choice of reinforcing bar size in a concrete column related to the thickness of the support footing?
27. How does the use of a pedestal result in the possibility of a thinner footing?

Chapter 7

1. Why is the quality of the mortar and the structural integrity of the units of less concern when concrete masonry units are used with reinforced construction?
2. What is the purpose of the brick headers in a multiple-whythe brick masonry wall?
3. Why are there usually fewer and larger voids in the concrete masonry units that are used for reinforced construction?
4. What is the basis for the old-time definition of mortar as a material used to keep masonry units *apart*?
5. What types of reinforcement or strength enhancement are possible with masonry wall construction in addition to the use of steel reinforcing bars?

Chapter 8

1. What are the basic purposes for site exploration to assist the design of building foundations?
2. What are the principal engineering properties of soils that most affect design of foundations?
3. What factors regarding a soil have major effects on building construction?
4. What two materials usually take up the void in a soil?
5. What condition makes it possible to estimate the void ratio of ordinary soils when only the dry unit weight is known?
6. What does it mean to say that a clay is “fat”?
7. Besides predominant grain size, what single property is most importane for distinguishing between silts and clays?
8. What condition qualifies a sand or gravel as clean?
9. Why is it desirable to keep the forces acting on a moment-resistive footing within the kern limit of the footing?
10. Why is a combined column footing sometimes not placed in a symmetrical position with respect to the columns it supports?
11. How does the depth of the footing below grade affect the general behavior of a laterally loaded, moment-resistive foundation?
12. What are the principal considerations that influence the decision to use a deep foundation instead of a shallow bearing foundation?
13. Why are piles usually used in groups?
14. What soil conditions make the installation of piles or drilled piers difficult?

15. What is the principal cause of the deterioration of the tops of wood or steel piles?
16. What is the difference between active lateral pressure and passive lateral pressure in soils?
17. How is frictional resistance determined for the following soils?
    (a) Sand
    (b) Clay
18. How is lateral soil pressure determined by the equivalent fluid pressure method?

Chapter 9

1. When wind forces act on a building, various elements of the building construction typically perform functions in the development of the building's response. Briefly describe the usual role of the following elements in this regard:
    (a) Exterior walls facing the wind
    (b) Exterior walls parallel to the wind direction
    (c) Roofs and upper level floors
    (d) Building foundations
2. Repeat question 1, except that the force is due to an earthquake, considered as horizontal movement in a single direction.
3. What basic forms of structural response are developed by the following bracing systems in resisting lateral loads?
    (a) Box system
    (b) Braced (trussed) frame
    (c) Rigid frame
4. Ordinary light wood frame construction may have some deficiencies with regard to resistance of seismic forces. Describe some of these potential weaknesses.
5. Why are horizontal, rather than vertical, effects of wind and earthquakes generally more critical for structural design?
6. What form of masonry construction is least desirable for resistance to earthquake forces?
7. Architectural design decisions greatly affect the determination of the character of response of a building to lateral loads. Describe some design features of buildings that may complicate or make difficult the design for lateral load responses.
8. What characterizes the structural nature of the so-called three-sided building?
9. What constitutes a so-called soft story?
10. Why are wind pressures greater on the upper portions of tall buildings?
11. What relationship exists between the magnitude of wind velocity and the resulting pressure on stationary objects in the wind's path?
12. How does wind or seismic force usually generate a torsional twisting effect on a building?
13. What basic dynamic properties of a building affect the building's response to an earthquake in terms of the magnitude of force exerted on the building?
14. What does a "seismic separation joint" usually separate?
15. What is generally required of a structural connection to qualify it as "positive"?
16. What does base isolation accomplish with regard to the total seismic force on a building?
17. What factors of the dynamic response of the bracing system are affected by an in-line shock absorber?
18. What basic function does a chord perform for a horizontal diaphragm?
19. Other than base anchorage, what resists overturn on a shear wall?
20. What is the significance of nail spacing at the edges of plywood panels in a horizontal diaphragm?
21. Why is a braced (trussed) frame considered to be a relatively stiff lateral bracing system?
22. What actions in the structure are added to the usual truss actions when knee bracing or K-bracing is used?
23. Why is the term "rigid" inappropriate in describing the so-called rigid frame bracing system for lateral loads?
24. When used in conjunction with a horizontal diaphragm, what does a "collector" usually collect?
25. From a structural viewpoint only, what is the usual simplest means for resolving horizontal thrust from an arch, a gabled frame, or a single-span rigid-frame bent?
26. Why are horizontal ties not required for domes or round suspension structures?
27. What is the basic method most often used to alleviate thermal expansion in a very long building?

Chapter 10

1. What is the function of a "model" building code?
2. Of what does the design dead load primarily consist?
3. What primary factor affects the percentage of live-load reduction?
4. Why is the achievement of optimal structural efficiency not always a dominant concern for control of the cost of building construction?

ANSWERS TO QUESTIONS

Chapter 1

1. Use of a safety factor in design computations.
2. Primary concerns are for getting the occupants safely out and letting firefighters work on the fire before the building collapses.
3. ASD is based on service conditions; LRFD is based on failure limits.
4. By controlling and/or preventing the passage of heat, air, light, people, and so on.
5. Major structural uses are for bearing walls, shear walls, and resistance of wind pressures (on exterior walls).

Nonstructural walls have many tasks—principally for enclosure and for definition and separation of interior spaces.

6. All walls have some form of structural task (such as holding themselves up), but use for major structural functions is another level of concern. See answer to question 5.
7. Roofs should slope for drainage; floors are usually dead flat. Floor live loads are usually greater. Floor spans are limited by deflection. Roof spans are sometimes the longest in building construction. Floors should not bounce; roofs are less critical in general to structural movements.
8. (a) Feasible systems change with span length; only a few, very efficient, systems are feasible for very long spans—arch, dome, cable, truss, etc.
   (b) Complicates choice of most feasible system for span; see answer to (a). Also makes use of a regular plan module difficult.
   (c) Columns and foundations become larger at ground and below-grade levels. Lateral bracing and resistance to overturn become critical factors for selection of structure, plan, and building form in general.
9. Roof with soil or terrace load becomes a very heavy structure, compared to the usual light roof structure. Wind is not a problem. Materials and details for building exterior (as basement walls) are drastically limited.
10. (a) Vertical only, of constant magnitude, enduring forever.
    (b) Fluid flow, producing aerodynamic effects: suction, drag, flutter, etc. Magnitude varies with height above ground. Upward force as well as horizontal. Major force is a short-duration gust, with a slamming effect.
    (c) Random in direction: up and down, back and forth in all directions. Cyclic, but irregular in magnitude. Occurs instantly, without warning. Static strength of building less important than nature of dynamic response: fundamental period, damping, etc.
11. (a) Random occurrence (magnitude and location); structure must accommodate various patterns of loading. Often quite arbitrary for quantification.
    (b) Long time effect, critical for sag of wood, creep of concrete, settlement of foundations.
    (c) Requires dynamic analysis for building response; static analysis very empirical.
    (d) May punch holes, cause major local effects.
    (e) Requires multiple analyses for load combination cases, with design for worst effects.
12. Loads are "active," basic source of forces on structure. Reactions—as the name implies—are "reactive," responding to need for equilibrium.
13. By development of stresses in the material.
14. Existence of a definite yield point (departure from pure elastic behavior) and a considerable range of deformation before fracture.
15. Major characteristics are strength, deformation resistance, hardness, time-dependent losses, uniformity of physical structure.
16. (a) Establishes basic identity of wood (family name), such as Douglas fir. Also establishes wood as softwood or hardwood.
    (b) Establishes identity for qualified design values for allowable stresses and modulus of elasticity.
    (c) Requires consideration for modification of design values.
17. Two major factors are rusting and rapid loss of strength when exposed to heat of fires. Also is very expensive, requiring attention to efficient use.
18. Strength is highly variable with changes in ingredients and curing conditions. Unit density (weight) is variable, mainly by choice of bulk aggregate (e.g., gravel). Also variable: color, surface finish, insulative character, porosity.
19. Masonry does not require forming but does involve extensive crafted hand labor. Dimensions of finished construction limited by modular sizes of units. Quality control of site work is critical.
20. Providing support, spanning, cantilevering, bracing, anchoring.
21. Same basic form (curved) but different in orientation to load. Arch is basically a compression element; draped cable is a tension element.
22. (a) Heavy pier or abutment, dam, massive retaining wall, Egyptian pyramid.
    (b) Multistory framework of columns and beams, trussed frame of transmission tower or bridge.
    (c) Shell-like dome, tent, inflated object, such as an automobile tire.
23. Add attached columns that span vertically; use braces (buttresses); use intersecting walls; curve or fold wall in plan.
24. Add moment-resistive connections to make a rigid frame; use X-bracing or other forms of trussing; fix column bases against rotation; use shear panels.
25. Use of moment-resistive connections and moment-capable columns.
26. By articulation of the cross section to obtain other than a solid profile. Stems to produce T-beams; hollow spaces to produce box; folded or corrugated profile (e.g., as steel deck).
27. Triangulation of the frame members: triangles in two dimensions, tetrahedrons in three dimensions. Use very little material with a lot of space between members to define a large structure with little mass of material.
28. The less the rise, the greater the horizontal thrust on supports.
29. Stiffness to resist buckling.

Chapter 2

1. To provide data for logical development of the structure and to assure the safety of its performance.
2. Visualization, mathematical modeling, physical modeling (scaled or full-size prototypes).
3. (a) Visualization of the support reactions or the general means required for stability of the body.
   (b) Visualization of internal force actions, stresses, and local deformations.
4. Magnitude, sense, and direction.
5. Determination as to whether the forces are coplanar, concurrent, or parallel—all three considered separately.
6. (a) Composition is the combination of a set of related forces to find their resultant; resolution is the breaking down of a single force into components.
   (b) A component is one of a set of forces that represents the partial effect of a force. A resultant is the single force that represents the total effect of a set of interrelated forces.
7. That the forces are in equilibrium.
8. The algebraic sum is zero; usually by adding separately the vertical and horizontal components.
9. Closing of a force polygon establishes equilibrium of the forces at a single truss joint. Close all the joint force systems and find all the internal forces.
10. The sum of the moments must also be zero.
11. Force is a cumulative, total effect. Stress is a unit of force, expressed as a total force divided by some area, to produce a quantity expressed as force per unit area.
12. Direct stress acts perpendicular to the cross section; shear acts in the plane of the section.
13. Unit strain expresses the percentage of material deformation in nondimensional terms; deformation refers to the total, cumulative effect, expressed as a total length change, rotation, or deflection.
14. The shear action involves two separate cross sections acting simultaneously to share a shear force.
15. Zero flexural stress.
16. As angular change (rotation).
17. It defines the end of the proportional stress–strain range and signals the onset of plastic deformation in a material that is ductile.
18. If the dimensional change is not allowed to freely occur.
19. Modulus of elasticity.
20. They are equal.
21. They are equal.
22. A torsional moment (twisting) on the beam.
23. Distribution is constant with direct shear; for a beam, it varies from zero at the edges of a section to a maximum value at the neutral axis.
24. In most cases the frictional force is considered to be developed in proportion to the magnitude of the normal force (the force that squeezes the two surfaces together). Lubrication messes this up, so foundations on wet, slippery clay are considered to have a single magnitude of friction resistance.
25. Kinematics involves only motion with time. Kinetics adds considerations for mass and force, with work accomplished and energy expended.
26. Translation is measured in length (inches, miles, etc.); rotation is measured as angular change.
27. Work requires, and uses up, energy; energy is quantified in units expressing capacity for accomplishing work.
28. The work for performing it is usually much easier, at least for hand computation. It is also easier to visualize combined load effects, such as gravity plus wind.

Chapter 3

1. (a) As a qualification of a single support, it indicates lack of resistance to rotation of the supported object. "Simply supported beam" is also used to describe the primary case of a single-span beam with no end restraint.
   (b) The support resists rotation, usually producing moment in the beam.
   (c) If the beam is continuous, it may rotate at the supports, but there will be moment in the beam at the supports where the beam is continuous.
2. Refers to the convention of relating the sense of the moment to bending stress conditions in the beam. For a horizontal beam, a positive moment indicates tension in the bottom of the beam; for a negative moment, tension is in the top.
3. The loads and the reactions.
4. Area of the shear diagram indicates moment changes, in both magnitude and sense. Points of zero shear locate peaks of moment magnitude.
5. Sign of moment relates to direction of curvature of the beam; zero moment indicates the location of inflection (change of direction of curvature).
6. Lateral (sideways) buckling of the compression side of the beam, in column-like action. Rotational (torsional) buckling at midspan or at supports.
7. Straightening of nonstraight elements. Deformation of lengthening (stretching).
8. It is usually the location of maximum tensile stress.
9. The highly flexible cable (rope, chain, etc.) forms a profile in direct response to the supports and loads.
10. Short members crush (a stress failure); long ones buckle sideways (a bending failure).
11. They may alter the effective buckling length of the column, either increasing or decreasing resistance to buckling. This is the basis for the K factor in KL/r.
12. The column deformation (the delta, for deflection) is usually a result of bending. The P–delta effect is the bending moment (P times delta) which adds to other bending and produces more delta—and may cause a continuation or progression that ends in failure.

13. Inability to resist tension due to a tension-weak material, or separation at the section which is actually a contact surface between two objects, such as a footing on the soil surface.
14. They must all form triangles.
15. To avoid shear and bending in truss members.
16. Transfer of bending moment from member to member through the connections.
17. Its structural response is not able to be determined by use of static equilibrium conditions alone.
18. For medium spans, the two parts may be shop fabricated or site assembled and erected, avoiding more difficult or costly procedures. Structural behavior is more easily and reliably determined.
19. Planning arrangements resulting in approximately square units for the two-way spans. Supports that avoid edge or corner concentrations of shear or bending. Form of the supports that reduces any punching shear effects.

Chapter 4

1. Tabular design values are based on a specific moisture content. If the structure is exposed to weather or other extreme moisture conditions, some values are reduced.
2. Modification relates to time of duration of the maximum effect of the load; the shorter the time, the less the load.
3. For bending stress, depth affects the section modulus by the second power (square) of the depth. For deflection it affects the moment of inertia by the third power (cube). Width affects both properties only in a linear proportionate manner.
4. These conditions imply very high shear forces, and wood beams are relatively weak in shear. Glue-laminated beams are stronger and steel beams the best.
5. They are required for lateral bracing.
6. Joists and rafters are often pushed to their span limits, and the lightly loaded, shallow-depth member is likely to be critical for deflection.
7. Spacing of the deck's supports, which determines the deck span.
8. Buckling, not stress, is critical. Resistance to buckling is essentially resistance to bending. Stiffness in bending is determined by the modulus of elasticity of the material and the radius of gyration of the member cross section.
9. Most columns are not designed for compression stress alone. Allowable stress that includes consideration for buckling is a function of the member stiffness, which is not known if the member is not known.
10. Wall-covering materials fastened to the studs usually brace the studs on their weak axis (1.5 in. direction). They are thus critical on the other axis, and the limit for the unbraced height is $50 \times 3.5 = 175$ in.
11. Bending and axial compression are two separate phenomena with separate allowable stresses and different behavior responses. The interaction formula allows for these factors.
12. Basic action of the joint involves a twisting of the joint. This response is not acceptable for major loads.
13. Shrinkage of the wood loosens the nails.
14. Different allowable values for the wood.
15. The connection is tighter, with less slippage under load; also, strength is greater.
16. Desired building form; loading conditions; type of span; size of truss.
17. Size of the truss and size of the members.
18. They contribute the most to bending resistance with spans in the grain direction.
19. Longer members with deeper cross sections are possible. Dimensional stability problems (e.g., warping) are reduced

Chapter 5

1. Deformation in ductile response is usually the practical limit for structures, so acceptable performance is based on yield stress.
2. True dimensions vary from this in most cases.
3. Rusting and failure in fire.
4. Section modulus
5. They indicate limits for forms of buckling response and allowable stresses.
6. In the elastic range, strain is proportional to stress, and stress is proportional to load magnitude. For the same depth, deflection will be proportional to beam depth and thus will be the same for all beams with the same limiting stress value.
7. Bracing of the beam to prevent its lateral rotation.
8. Thickness of the beam web.
9. Area and radius of gyration.
10. When KL/r is different for the two axes. The higher value must be used.
11. Friction between the two connected parts, created by the clamping action of the highly tensioned bolts.
12. Shear and tension.
13. Depth of the beam.
14. Both flanges of the supported beam must be cut back to achieve the connection; results in significant loss of shear capacity.
15. Possible elimination of the need for lateral bracing. Development of significant resistance to bending on more than one axis.
16. The desired shape or size of the section is not available as a single-piece, rolled shape.

Chapter 6

1. Low resistance to tensile stress, as generated mostly by bending and shear actions.
2. The aggregate, separately considered, will pack into the most dense bulk, with smaller pieces filling the voids between larger ones. This leaves the least void to be filled with cement and water, producing stronger and more economical concrete with less shrinkage.

3. The unit density (weight) of the concrete is primarily determined by the unit density of the coarse aggregate (usually gravel), which ordinarily constitutes from two-thirds to three-quarters of the volume of the concrete.
4. To enhance the grip of the surrounding concrete on the bar surface. This is critical to the anchorage of bars and to load sharing by the steel and concrete.
5. Yield strength.
6. Temperature, moisture content, lack of stress due to structural demands.
7. Size of the concrete member, fire resistance requirements, and exposure conditions for the concrete surface (to weather, soil contact, etc.).
8. Beam width, presence and size of stirrups, size of the aggregate (largest piece), and general code requirements for bar spacing.
9. Ordinary thicknesses of slabs and size of beam stems result in excessive compression area for development of stress necessary to balance the capacity of practical amounts of tension reinforcing.
10. Horizontal, tension reinforcing bars at the ends of the beam.
11. Shear in excess of that permitted to be resisted by the concrete.
12. Development occurs on the bar surface, to "develop" the strength of the bar in stress on its cross-sectional area. The smaller the bar, the greater the ratio of surface to area; increase the bar diameter and surface (circumference) increases only linearly, while area increases by the square of the diameter.
13. Required development relates to potential bar strength, which is greater if allowable stress (or yield strength) is higher.
14. In units of equivalent development length.
15. Development required for the bars being spliced.
16. Span of the slab, design loading, fire resistance requirements, and maybe the T-beam action of the framing beams.
17. These factors are the basis for recommended minimum dimensions in the ACI Code.
18. Joists form a one-way system; the waffle is a two-way system.
19. Slab clear span is slightly reduced and the bending and shear resistances of the slab are increased.
20. To make the steel beam and concrete slab work together as a single unit.
21. To prevent the bars from buckling and bursting sideways through the thin cover of concrete.
22. Code-imposed design limitations result in columns having yielding of the bars as the initial failure of the column. Adding a small axial compression load prestresses the bars in compression, permitting them to take some more tension to develop additional bending moment.
23. Spacing requirements for the bars.
24. Ease of placement of the reinforcing.
25. To resist shrinkage stresses and maybe develop some beam-spanning action over uneven soil.
26. Compression stress in the column bars must be developed by extension into the footing a distance as required for development length for the bars.
27. By reducing shear and bending in the footing and possibly relieving the development problem for the footing.

Chapter 7

1. The grout and reinforcement form a reinforced concrete frame structure inside the wall that may be very significant to the total structural capacity of the construction.
2. To tie the wythes together.
3. See answer to question 1. The role of the grout and reinforcement in the voids becomes a dominant concern.
4. Lack of faith in the bonding (tensile) capability of the mortar.
5. Concentration of mass (such as with a pilaster); use of form—arched or folded in plan; use of stronger units at strategic locations, such as corners and edges of openings.

Chapter 8

1. To determine the form of the site surface, the character and arrangement of surface and subsurface soils, and the condition of water in the ground.
2. Size of solid particles, in-place (undisturbed) density and hardness, water content, penetration resistance, potential instabilities, and presence of organic materials.
3. Ease of excavation, need for dewatering during construction, potential for use of excavated materials for fill, need for bracing of excavations, effects of construction work on soils.
4. Air and water.
5. Small range of the specific gravity of ordinary soil materials.
6. It is highly plastic (soft, oozing).
7. Plasticity.
8. Lack of significant amounts of fine soil particles (silt and clay).
9. To be able to use the full plan area of the footing for bearing and to keep soil pressure as uniform as possible.
10. The column loads are not always equal and the footing plan centroid should coincide with the column load center (resultant of the column loads).
11. The form of response will be more or less related to lateral passive soil pressure.
12. Limited usable bearing capacity or instability of soils near the ground surface; sensitivity of the building and its contents to settlements; ease of installation of deep foundation elements.

13. The precise location of the tops of driven piles cannot be controlled.
14. Presence of large rocks in the soil; effects of installation on neighboring properties (especially driving of piles); dewatering for drilled piers; highly unstable soils.
15. Fluctuating water level near the pile tops.
16. For active pressure the soil itself is the source as it pushes against restraints (basement walls, retaining walls, etc.). For passive pressure something else is pushing against the soil.
17. (a) On sand, friction is proportional to the load that produces bearing and is determined with a coefficient of friction.
    (b) On clay, friction is a fixed magnitude determined by the area of contact.
18. The soil is considered to act as a fluid with a density equal to some fraction of the soil weight. As for a fluid, pressure varies directly with the depth below the surface.

Chapter 9

1. (a) Exterior walls receive wind pressure directly, spanning between horizontal supports and delivering reaction forces to those supports (usually roof or floor edges).
   (b) Walls may act as shear walls. If not intended as shear walls, they may be structurally isolated from the bracing structure to prevent damage to them.
   (c) These normally function as horizontal diaphragms.
   (d) These receive the load from the building and transfer it to the supporting soil, mostly by development of lateral passive pressure in the soil.
2. (a) These are sources of lateral loads due to their weight. Load is transferred through the bracing system as for wind.
   (b) Walls are sources of lateral load; actions are as described for question 1.
   (c) These are sources of loads collected in the system; functions are as described for question 1.
   (d) As described for question 1. It is essential to tie the system together because of the rapid back-and-forth action of the earthquake. Base isolation—if any—will occur between the supported building and the foundations.
3. (a) Resistance to lateral effects in the planes of the diaphragms; edge-to-edge transfers between individual diaphragms.
   (b) Connected beams, columns, and diagonal members form planar trussed bents.
   (c) Connected columns and beams form planar rigid-frame bents through moment-resistive connections.
4. Anchorage of elements (roof to walls, walls to foundations, etc.) may not be adequate. Structural framing members may not be strong enough, have continuity through splices, or be attached sufficiently to diaphragm elements.
5. Buildings are routinely developed primarily in response to gravity loads.
6. Unreinforced masonry made with low-quality mortar and relatively soft and weak masonry units.
7. Unsymmetrical plans; abrupt changes in building form (setbacks, notched corners, etc.); use of rigid but nonstructural forms of construction (plaster, stucco, masonry veneer, etc.); creation of building profiles that produce soft stories; use of very heavy materials in upper levels of the building (tile roofs, concrete roof slabs, etc.).
8. Inability to develop lateral bracing in one exterior wall.
9. Relative stiffness of the vertical bracing is significantly less than the story above or below.
10. Wind velocity increases with distance above the ground, as ground surface drag decreases and the effects of sheltering by trees, hills, and surrounding buildings is less significant.
11. The magnitude of wind pressure is proportional to the square of the wind velocity (speed).
12. When the resultant of the horizontal force does not coincide with the center of stiffness of the lateral bracing system.
13. Mass, fundamental period of vibration, presence of damping sources, potential for resonance within the building bracing system, potential for resonant building−site interaction, effects of irregularity of building form.
14. Separate units of the building, when their interaction is potentially harmful during earthquake-induced movements.
15. Lack of potential for loosening or progressive fracture due to dynamic actions. Most critically during the repeated actions of seismic vibration or wind flutter.
16. Reduces the magnitude of movements and force transferred by the ground into the building mass and shortens the duration of continued vibration.
17. Same as base isolation, reduces force effects, reduces movements, and especially provides critical damping of single vibration cycle.
18. Development of tension and compression for resistance to the bending created by the spanning action of the diaphragm.
19. Dead weight of the wall and of any construction it supports or is attached to.
20. It indicates potential for transfer of diaphragm shear between adjacent panels.
21. Principal deformation of the frame is due to lengthening and shortening of the truss frame members—ordinarily very small dimensions. Trussed frames are therefore much stiffer than rigid frames, in which deformations are largely due to bending in the frame members. This relationship can change if truss

connections have a lot of deformation or rigid frame members are exceptionally stiff.

22. Essentially, rigid frame actions involving the bending of members.
23. See answer to question 21.
24. Shear in the diaphragm for transfer to vertical bracing.
25. A horizontal tie between the supports.
26. The circular edge support (ring) may be developed as a tension ring (for a dome) or a compression ring (for a draped cable system).
27. To isolate manageable units of the building with control joints that permit independent movement of units.

Chapter 10

1. To serve as a guide and reference for development of individual, local building codes.
2. Weight of the building construction.
3. Total area of the loaded surface carried by the member being considered
4. Structural efficiency, while an important basic concept for structural engineering design, may be less important economically than the effect of the structure on the cost of other elements of the construction and building services.