

# ARE

## EXAM GUIDE

### Building Design & Construction Systems

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This document, effective August 2015, supersedes all previous editions of the ARE® 4.0 Exam Guide: Building Design & Construction Systems. Please check NCARB's website, [www.ncarb.org](http://www.ncarb.org), regularly for updates to the ARE 4.0 Exam Guides and for the most current information regarding the ARE.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

## OVERVIEW

## DIVISION STATEMENT

The application of knowledge and skills of building design and construction, including environmental, social, and economic issues, and project and practice management.

## Content Areas

1. **PRINCIPLES**  
(27-33 percent of scored items)
2. **ENVIRONMENTAL ISSUES**  
(6-9 percent of scored items)
3. **CODES & REGULATIONS**  
(10-13 percent of scored items)
4. **MATERIALS & TECHNOLOGY**  
(43-49 percent of scored items)
5. **PROJECT & PRACTICE MANAGEMENT**  
(4-7 percent of scored items)

## Vignettes

### ACCESSIBILITY/RAMP

Design a ramp and stairway connecting two levels that complies with accessibility and code requirements.

### STAIR DESIGN

Design a stairway connecting multiple levels that complies with accessibility and code requirements.

### ROOF PLAN

Design a sloped-roof plan for the removal of rainwater and locate accessories and equipment.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

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## KNOWLEDGE/SKILLS

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The division has been broken down into a listing of knowledge and skills directly related to each major content area.

### 1. PRINCIPLES

(27-33 percent of scored items)

- A. Incorporate the implications of human behavior, historic precedent, and design theory in the selection of systems, materials, and methods related to building design and construction.

#### 1. Building Design

Analyze and evaluate those tasks, procedures, and methodologies influencing building design during schematic design and design development, including building systems and materials.

#### 2. Design Principles and Design Impact on Human Behavior

Analyze and evaluate design principles that influence human behavior in the built environment.

#### 3. Building Systems and their Integration

Analyze, evaluate, and integrate appropriate building systems considering design and engineering principles.

#### 4. Implications of Design Decisions

Evaluate how decisions made in schematic design and design development, relating to orientation, area, materials, cost, code, sustainability, and/or phasing, impact later phases of design, construction, and building use.

#### 5. Space Planning and Facility Planning/Management

Utilize principles of space planning and facility planning/management.

#### 6. Fixtures, Furniture, Equipment, and Finishes

Evaluate and select fixtures, furniture, equipment, and finishes and determine the impact on building design.

### 7. Adaptive Reuse of Buildings and/or Materials

Evaluate constraints, issues, methodologies, programmatic concerns and cost impacts associated with adaptive reuse of buildings and materials.

### 8. Architectural History and Theory

Apply architectural history, precedent, and theory to building design.

### 2. ENVIRONMENTAL ISSUES

(6-9 percent of scored items)

- A. Consider the principles of sustainable design including adaptive re-use, thermal and moisture protection, and hazardous material mitigation.

#### 1. Hazardous Conditions and Materials

Survey and reconcile hazardous conditions and materials relating to building and site.

#### 2. Indoor Air Quality

Determine and assess factors that affect indoor air quality.

#### 3. Sustainable Design

Evaluate and apply principles of sustainability relating to building materials and construction.

#### 4. Natural and Artificial Lighting

Evaluate and apply natural and artificial lighting principles and their application to design and construction.

#### 5. Alternative Energy Systems and New Material Technologies

Select and evaluate emerging and alternative systems and new material technologies.

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## KNOWLEDGE/SKILLS

### 3. CODES & REGULATIONS

(10-13 percent of scored items)

- A. Incorporate building and specialty codes, zoning, and other regulatory requirements in building design and construction systems.

#### 1. Government and Regulatory Requirements and Permit Processes

Demonstrate comprehension of building codes and planning requirements and assess their effect on building design.

#### 2. Specialty Codes and Regulations including Accessibility Laws, Codes, and Guidelines

Demonstrate comprehension of specialty codes and guidelines, such as accessible design, seismic code, life safety, and fair housing requirements, and assess their effect on building design.

### 4. MATERIALS & TECHNOLOGY

(43-49 percent of scored items)

Analyze the implication of design decisions in the selection of systems, materials, and methods incorporated in building design and construction.

#### A. MASONRY

Identify the properties and characteristics of masonry structures and finish materials.

##### 1. Building Systems and their Integration

Analyze characteristics of masonry systems and materials and their appropriate integration into building design.

##### 2. Implications of Design Decisions

Evaluate the selection of masonry components to determine their effects on design, cost, engineering, and/or scheduling.

##### 3. Construction Details and Constructability

Demonstrate comprehension of masonry details and their application in building design and construction.

##### 4. Construction Materials

Determine the appropriate use of masonry in building design and construction.

##### 5. Product Selection and Availability

Evaluate and prioritize the selection of masonry systems, materials, and availability.

##### 6. Cost Estimating, Value Engineering, and Life-Cycle Costing

Demonstrate knowledge of cost estimating, value engineering, and life-cycle costing related to masonry.

##### 7. Thermal and Moisture Protection

Assess the use of masonry components in thermal and moisture protection.

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### B. METALS

Identify the properties and characteristics of structural and miscellaneous metals.

#### 1. Building Systems and their Integration

Analyze characteristics of metal systems and materials and their appropriate integration into building design.

#### 2. Implications of Design Decisions

Evaluate the selection of metal components to determine their effects on design, cost, engineering, and/or scheduling.

#### 3. Construction Details and Constructability

Demonstrate comprehension of metal details and their application in building design and construction.

#### 4. Construction Materials

Determine the appropriate use of metal in building design and construction.

#### 5. Product Selection and Availability

Evaluate and prioritize the selection of metal systems, materials, and availability.

#### 6. Cost Estimating, Value Engineering, and Life-Cycle Costing

Demonstrate knowledge of cost estimating, value engineering, and life-cycle costing related to metal.

#### 7. Thermal and Moisture Protection

Assess the use of metal components in thermal and moisture protection.

### C. WOOD

Identify the properties and characteristics of wood structures, rough carpentry, finish carpentry, and millwork assemblies.

#### 1. Building Systems and their Integration

Analyze characteristics of wood systems and materials and their appropriate integration into building design.

#### 2. Implications of Design Decisions

Evaluate the selection of wood components to determine their effects on design, cost, engineering, and/or scheduling.

#### 3. Construction Details and Constructability

Demonstrate comprehension of wood details and their application in building design and construction.

#### 4. Construction Materials

Determine the appropriate use of wood in building design and construction.

#### 5. Product Selection and Availability

Evaluate and prioritize the selection of wood systems, materials, and availability.

#### 6. Cost Estimating, Value Engineering, and Life-Cycle Costing

Demonstrate knowledge of cost estimating, value engineering, and life-cycle costing related to wood.

#### 7. Thermal and Moisture Protection

Assess the use of wood components in thermal and moisture protection.

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### D. CONCRETE

Identify the properties and characteristics of concrete structures and finishes.

#### 1. Building Systems and their Integration

Analyze characteristics of concrete systems and materials and their appropriate integration into building design.

#### 2. Implications of Design Decisions

Evaluate the selection of concrete components to determine their effects on design, cost, engineering, and/or scheduling.

#### 3. Construction Details and Constructability

Demonstrate comprehension of concrete details and their application in building design and construction.

#### 4. Construction Materials

Determine the appropriate use of concrete in building design and construction.

#### 5. Product Selection and Availability

Evaluate and prioritize the selection of concrete systems, materials, and availability.

#### 6. Cost Estimating, Value Engineering, and Life-Cycle Costing

Demonstrate knowledge of cost estimating, value engineering, and life-cycle costing related to concrete.

#### 7. Thermal and Moisture Protection

Assess the use of concrete components in thermal and moisture protection.

### E. OTHER

Identify the properties and characteristics of miscellaneous systems, assemblies, membranes, cladding, coatings, and finish materials (e.g., plastics, composites, glass, tensile, pneumatics, EIFS, etc.).

#### 1. Building Systems and their Integration

Analyze the relationship of building systems and materials (other than masonry, metal, concrete, and wood) and their appropriate selection and integration into building design.

#### 2. Implications of Design Decisions

Evaluate the selection of building components (other than masonry, metal, concrete, and wood) to determine their effects on design, cost, engineering, and/or scheduling.

#### 3. Construction Details and Constructability

Demonstrate comprehension of the relationship of building systems and materials (other than masonry, metal, concrete, and wood) details and their application in building design and construction.

#### 4. Construction Materials

Determine the appropriate use of building systems and materials (other than masonry, metal, concrete, and wood) in building design and construction.

#### 5. Product Selection and Availability

Evaluate and prioritize the selection of building systems and materials (other than masonry, metal, concrete, and wood) and availability.

#### 6. Cost Estimating, Value Engineering, and Life-Cycle Costing

Demonstrate knowledge of cost estimating, value engineering, and life-cycle costing related to building systems and materials (other than masonry, metal, concrete, and wood).

#### 7. Thermal and Moisture Protection

Assess the use of building systems and materials (other than masonry, metal, concrete, and wood) in thermal and moisture protection.

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### F. SPECIALTIES

Analyze and select accessories, equipment, and fittings.

#### 1. Building Systems and their Integration

Analyze the relationship of accessories, equipment, and fittings and their appropriate selection and integration into building design.

#### 2. Implications of Design Decisions

Evaluate the selection of accessories, equipment, and fittings to determine their effects on design, cost, engineering, and/or scheduling.

#### 3. Construction Details and Constructability

Demonstrate comprehension of the relationship of accessories, equipment, and fittings in details and their application in building design and construction.

#### 4. Construction Materials

Determine the appropriate use of accessories, equipment, and fittings in building design and construction.

#### 5. Product Selection and Availability

Evaluate and prioritize the selection of accessories, equipment, and fittings and their availability.

#### 6. Cost Estimating, Value Engineering, and Life-Cycle Costing

Demonstrate knowledge of cost estimating, value engineering, and life-cycle costing related to accessories, equipment, and fittings.

#### 7. Thermal and Moisture Protection

Assess the use of accessories, equipment, and fittings in thermal and moisture protection.

### 5. PROJECT & PRACTICE MANAGEMENT

(4-7 percent of scored items)

A. Determine the impact of construction sequencing, scheduling, cost, and risk management on selection of systems, materials, and methods.

#### 1. Construction Sequencing

Evaluate the selection of systems, materials, and methods and their impact on construction sequencing.

#### 2. Cost Estimating, Value Engineering, and Life-Cycle Costing

Demonstrate comprehension of cost estimating, value engineering, and lifecycle costing methods and principles.

#### 3. Project Schedule Management

Demonstrate comprehension and use of project scheduling, staffing projections, contracts, and project management principles.

#### 4. Risk Management

Apply risk management principles and demonstrate methods of conflict resolution.

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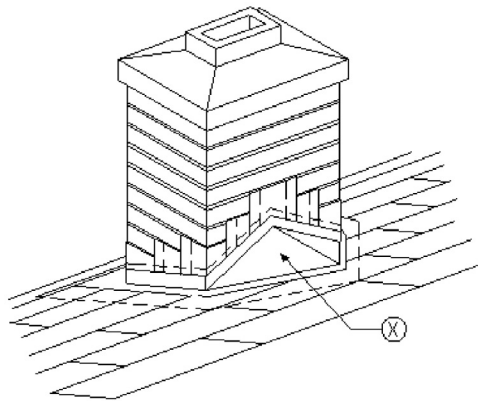
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References

- The primary purpose of panic hardware on exit doors is to
  - allow an alternate method of opening the door
  - allow easier access for disabled occupants
  - provide a method of controlling exit doors
  - provide easy release of the latch on the door
- Which of the following toilet partition finishes has the LOWEST initial cost?
  - Baked enamel
  - Laminated plastic
  - Stainless steel
  - Porcelain enamel
- What is shown at X in the drawing above?
  - A cricket
  - Base flashing
  - Cap flashing
  - Gable flashing
- To prevent it from deteriorating, copper should be isolated from direct contact with which of the following roofing materials?
  - Asphalt shingles
  - Red-cedar shingles
  - Built-up roofing
  - Mineral-fiber felts
- Which of the following are desirable qualities of windows to be selected for a new commercial building? **Check the four that apply.**
  - A. High visible light transmission value
  - B. High air leakage rate
  - C. Low solar heat gain coefficient
  - D. Low heat transfer coefficient
  - E. Low R value
  - F. High condensation resistance factor
- Which of the following occupancy classifications requires panic hardware at the required exits?
  - Manufacturing facility
  - Motel guest room
  - Movie theater
  - High-rise office suite
- Accessible ramp handrails shall extend beyond the top and bottom of the ramp a minimum of
  - 6 in
  - 9 in
  - 12 in
  - 15 in





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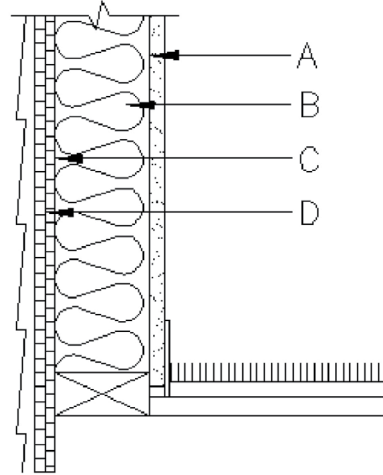
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References

Water Closets for an Assembly Occupancy

Number of Persons of Each Sex	Minimum Number of Water Closets	
	Male	Female
1 - 50	1	2
51 - 75	2	3
76 - 100	2	4
101 - 125	3	5
126 - 150	3	6
151 - 175	4	7
176 - 200	4	8
201 - 250	5	9
251 - 300	5	10
301 - 350	6	11
351 - 400	6	12
Over 400	7 plus 1 for each additional increment of 200 males in excess of 400	13 plus 1 for each additional increment of 100 females in excess of 400



8. Based on the table above, the minimum number of water closets required for women in a theater with a seating capacity of 4,000 is

9. In the detail above from an air-conditioned building located in a hot, humid climate, where should the vapor barrier be located?

- At A  
 At B  
 At C  
 At D

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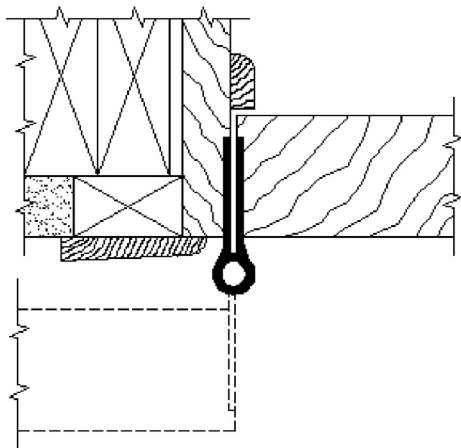
Roof Plan Vignette

References

10. A client is proposing to build a residence in an area where there is a high probability of the presence of radon gas. Which of the following are acceptable techniques of achieving radon-resistant construction for the building?

**Check the three that apply.**

- A. Automatic vent damper devices
- B. Sub-slab depressurization systems
- C. Drain tile loops
- D. Soil-gas retarders
- E. Mat foundation
- F. Dry well



11. The type of door hinge indicated above is a
- full mortise
  - full surface
  - half mortise
  - half surface

12. Which of the following types of portable fire extinguisher is appropriate for fires generated by electrical equipment?

- Loaded stream water base only
- Pressure water base only
- Carbon dioxide and dry chemical
- Loaded stream water base, carbon dioxide, and dry chemical

13. In a fast-track, single-story industrial project, which of the following schematic design and design development considerations is most likely to have a significant effect on the successful sequencing of the construction?

- Foundation design
- HVAC systems design
- Roofing materials selection
- Window design

14. Which of the following basic structural systems would be appropriate for a high-tech building with equipment and functions that are extremely sensitive to vibrations?

- Poured-in-place concrete beam-and-slab system
- Heavy steel frame with composite floor slab with rubber insulators
- Heavy (12) gauge metal studs with a long-span steel joist with a 5-inch-thick concrete slab
- Masonry bearing walls with wood joists and wood deck with a 4-inch-thick gypsum concrete topping slab

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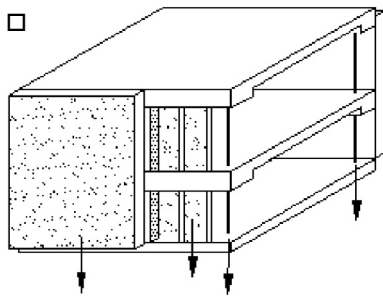
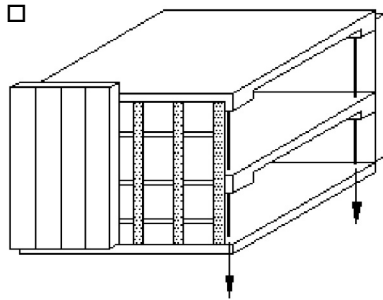
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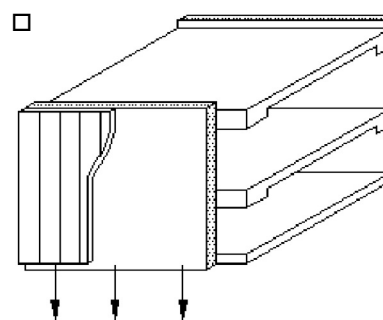
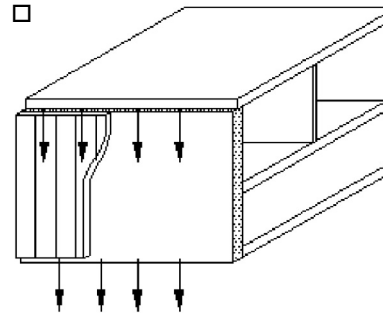
Roof Plan Vignette

References

15. Which of the following is the most effective method to control indoor air quality?
- Exhaust air
  - Source reduction
  - Air cleaning and filtration
  - Increased temperature and lowered humidity
16. Which of the following diagrams best indicates an exterior self-supporting non-load-bearing wall design?



17. Which of the following factors should be considered when selecting the type of elevator to use in a new building? **Check the four that apply.**
- A. Weight capacity of the elevator
  - B. Cab finishes
  - C. Height of the building
  - D. Speed of the elevator
  - E. Number of building occupants
  - F. Hoistway size



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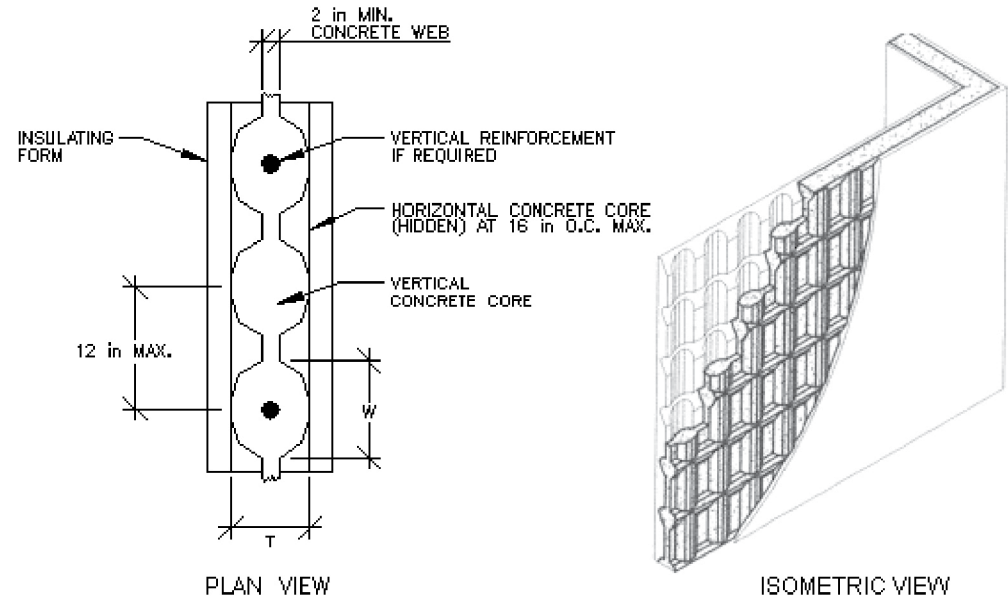
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18. When designing a residential development, which of the following is an example of the “Crime Prevention through Environmental Design” strategy of encouraging natural surveillance?
- Reducing the overall amount of site lighting
  - Visually screening parking areas with tall landscaping
  - Placing the majority of windows to the rear of residences
  - Providing a primary living space with a view of the street
19. Which of the following types of fasteners is at high risk of corrosion when used with wood treated with inorganic waterborne preservatives?
- Aluminum
  - Stainless steel
  - Hot-dipped galvanized
  - Hot-tumbled galvanized
20. When compared to a steel beam-and-bar joist floor system, the use of composite construction will likely result in which of the following? **Check the two that apply.**
- A. Stiffer floor
  - B. Heavier frame
  - C. Lighter frame
  - D. More expensive system
  - E. Increased fabrication time
  - F. Faster erection time



21. The figure shown above represents which of the following types of insulating concrete form (ICF) system?
- Waffle-grid
  - Waffle-core
  - Waffle-cast
  - Waffle-slab

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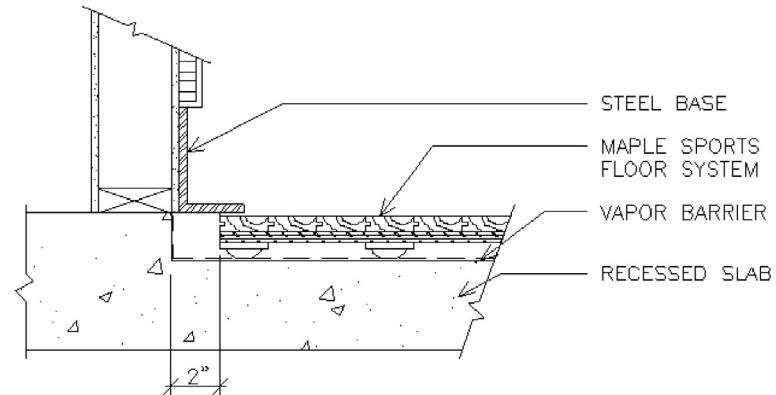
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22. Which of the following actions can achieve the most significant cost reduction in value engineering a precast concrete warehouse?
- Removing reveals in the panels
  - Changing the exposed aggregate in the concrete
  - Maximizing and standardizing the panel sizes
  - Removing the integral color from the concrete mix
23. A waterproofing treatment should be specified in lieu of a dampproofing treatment for subsurface masonry when which of the following conditions is present?
- Hydrostatic pressure
  - A low frost line
  - Sandy subsurface soils
  - Expansive subsurface soils
24. The passage of water under pressure through concrete cracks is defined as
- capillary action
  - seepage
  - saturation
  - leakage
25. An elevator hoistway would be constructed to which of the following model code standards for walls?
- Shaft enclosure
  - Occupancy separation
  - Area separation
  - Demising



26. The two-inch gap at the perimeter of the wood athletic floor shown above is provided to
- allow for proper alignment of the flooring system
  - allow air circulation
  - accommodate expansion and contraction
  - increase resiliency of the floor

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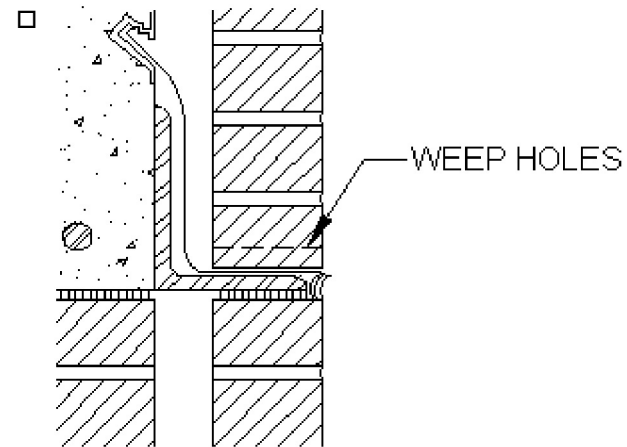
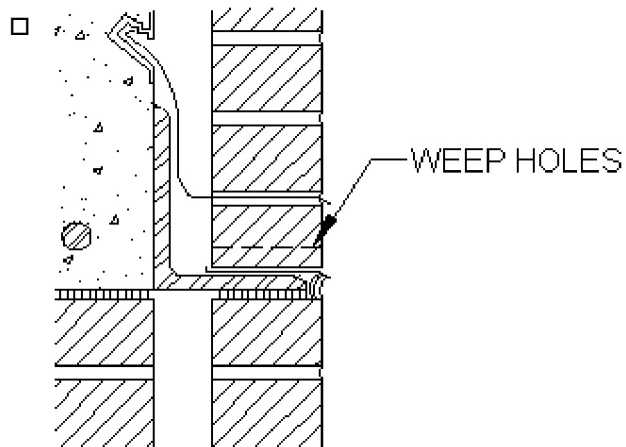
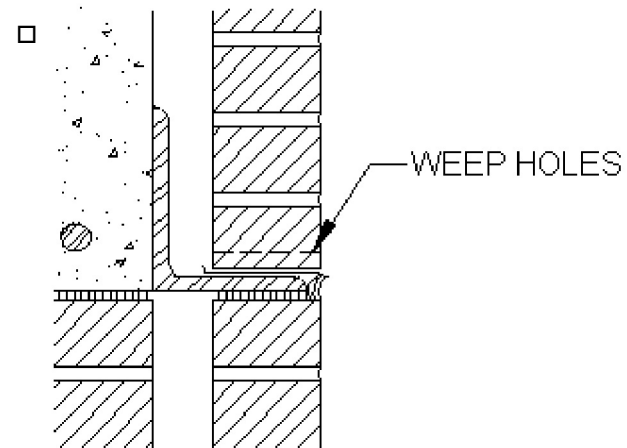
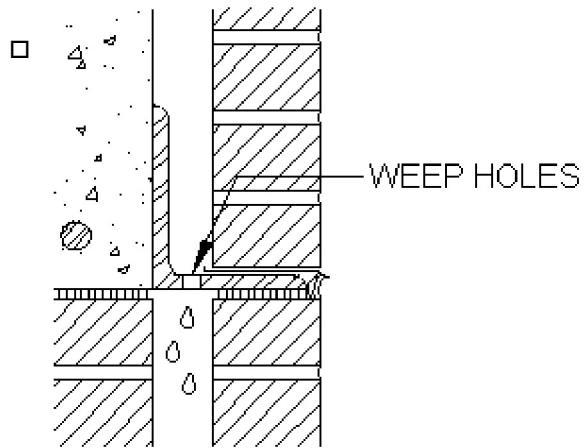
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27. Which of the following is the most appropriate flashing detail for the design of brick veneer (cavity) wall construction?



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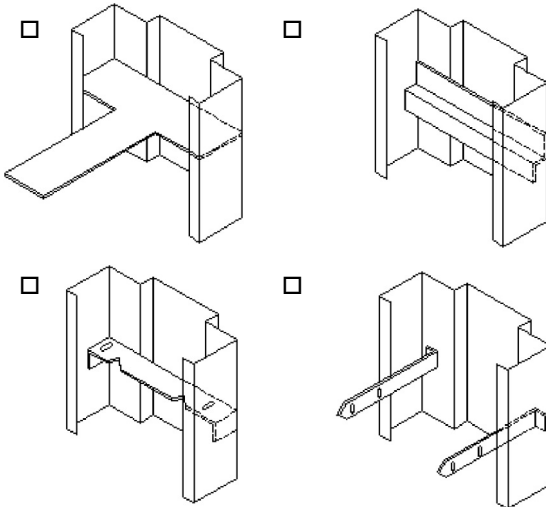
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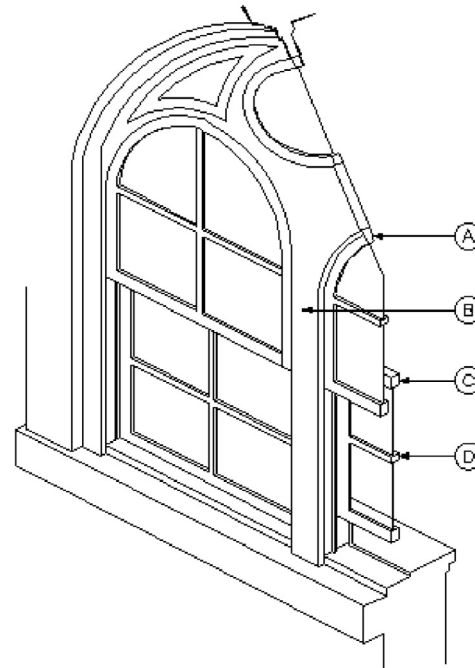
References

28. Which jamb anchor should be used for installation in a masonry wall?



29. The terms “scratch coat,” “brown coat,” and “finish coat” refer to
- painting
  - parging
  - paving
  - plastering
30. Which of the following types of concrete construction is reinforced with tensioned high-strength steel-wire strands?
- Tilt-up
  - Prestressed
  - Cast-in-place
  - Precast

31. Locating footings at or below the frost line is important because doing so
- promotes good drainage
  - makes perimeter insulation unnecessary
  - helps to stabilize the foundation system
  - simplifies excavation during winter construction



32. Which letter in the figure above indicates a muntin?
- A
  - B
  - C
  - D

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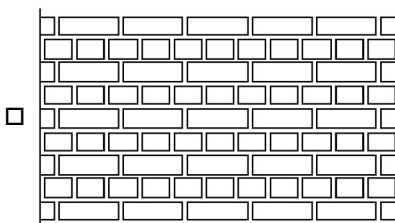
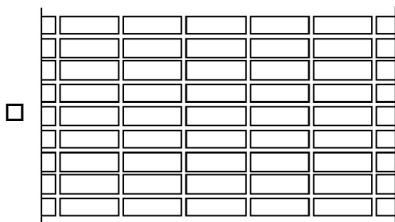
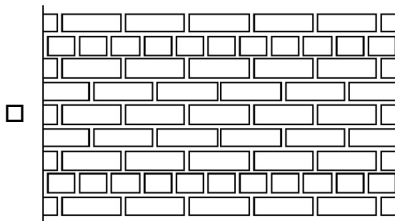
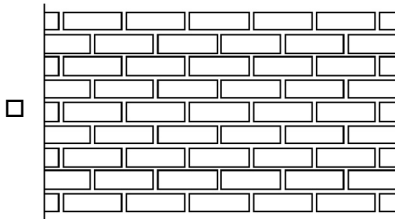
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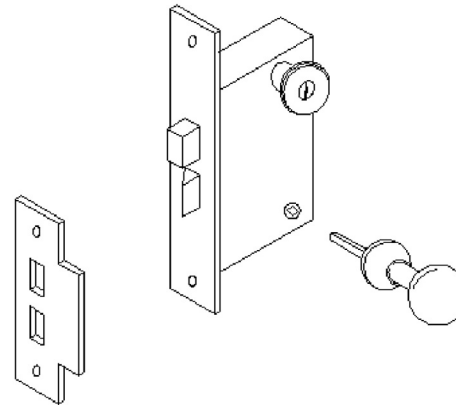
References

33. Which of the following brick veneer patterns is the most expensive per square foot?



34. What type of lockset is pictured below?

- Mortised
- Unit
- Cylinder
- Lever



35. Efflorescence on masonry walls is caused by water-soluble salts that are present in which of the following?

Check the two that apply.

- A. Mortar
- B. Sheathing
- C. Masonry flashing
- D. Masonry units
- E. Masonry ties
- F. Rigid insulation



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Sample Multiple-  
Choice Questions

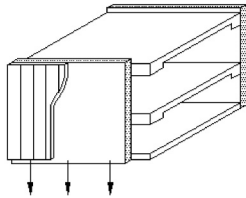
Accessibility/Ramp  
Vignette

Stair Design  
Vignette

Roof Plan Vignette

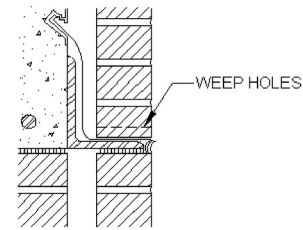
References

1. provide easy release of the latch on the door
2. Baked enamel
3. A cricket
4. Red-cedar shingles
5. A, C, D, F
6. Movie theater
7. 12 in
8. 29
9. At D
10. B, C, D
11. full mortise
12. Carbon dioxide and dry chemical
13. Foundation design
14. Poured-in-place concrete beam-and-slab system
15. Source reduction
- 16.

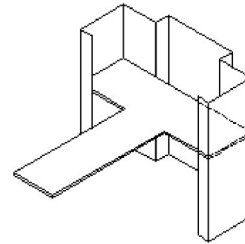


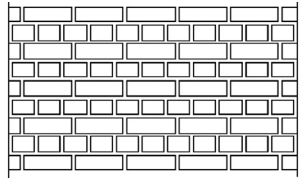
17. A, C, D, F
18. Providing a primary living space with a view of the street
19. Aluminum
20. A, C
21. Waffle-grid
22. Maximizing and standardizing the panel sizes
23. Hydrostatic pressure
24. leakage
25. Shaft enclosure
26. accommodate expansion and contraction

27.



28.



29. plastering
30. Prestressed
31. helps to stabilize the foundation system
32. D
33.
 
34. Mortised
35. A, D

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## ACCESSIBILITY/RAMP VIGNETTE

Knowledge/  
Skills

Sample Multiple-  
Choice Questions

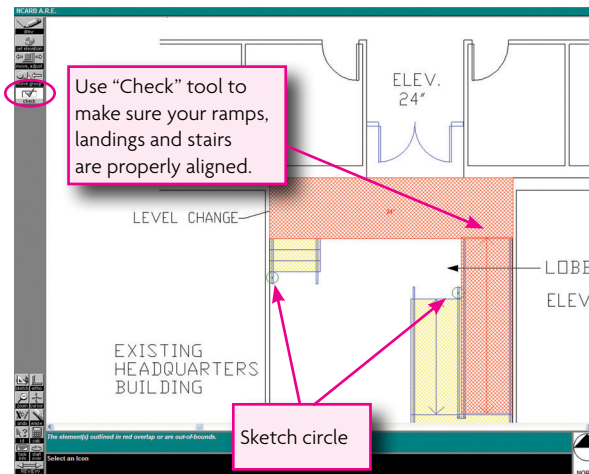
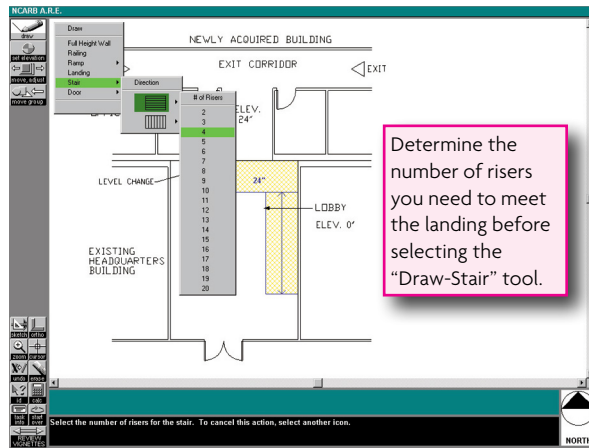
Accessibility/Ramp  
Vignette

Stair Design  
Vignette

Roof Plan Vignette

References

### General Tips for Taking Accessibility/Ramp



### Directions

Complete the floor plan shown on the work screen by developing a ramp and stair system in accordance with the given program information. Using the tools provided, indicate all ramps, stairs, railings, wall(s), door(s), and landings required to complete the plan and indicate all landing elevations.

The completed plan should reflect conformity to program and code requirements and to principles of design logic.

Before beginning your solution, you should review the program and code information that can be accessed through the Vignette Index screen and familiarize yourself with the floor plan on the work screen.

### Program

1. Two small office buildings on a sloped site are to be connected by a new lobby placed at the floor elevation of the lower building.
2. Provide an accessible circulation system with a ramp and a separate stair to connect the lobby and upper level corridor.
3. Place wall(s) and door(s) only on the existing upper level to separate the lobby and the upper level exit corridor.

In addition, the ramp and stair must conform to the following restrictions:

- ▶ No portion of the ramp or stair may encroach on the existing upper level.
- ▶ Indicate the elevation of all new landings.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

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References

## ACCESSIBILITY/RAMP VIGNETTE

### Code

Comply with the following code requirements. These are the ONLY code-related criteria you are required to use.

### Definition

1. **Accessible Means of Egress:** A continuous and unobstructed path of travel from an accessible space to a public way that is usable by a mobility impaired person. An accessible means of egress comprises the vertical and horizontal means of travel and shall include accessible exit routes, ramps, stairways, and doors.

### Maneuvering Clearances

1. The minimum width of an exit route shall not be less than 44 inches.
  - ▶ Projections into a required exit route width are prohibited, except for handrail projections.
2. The space required for a wheelchair to make a **180-degree turn** is a clear space of 60 inches in diameter, as shown in Figure 1.
3. Minimum maneuvering clearances at doors shall be as shown in Figure 2.
  - ▶ The floor or ground area within the required clearances shall be level.

### Ramps

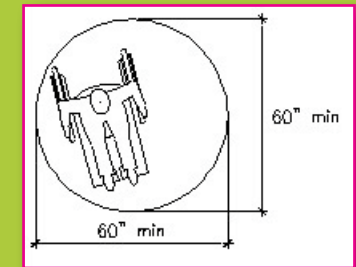
1. Floors or walks in an accessible means of egress path of travel having a slope steeper than 1:20 (one unit vertical in 20 units horizontal) shall be designed as ramps.

2. **Width:** The minimum width shall not be less than 44 inches.
  - ▶ Ramps shall not reduce in width in the direction of egress travel.
  - ▶ Projections into a required ramp width are prohibited, except for handrail projections.
3. **Slope:** The maximum slope of a ramp shall be 1:12 (one unit vertical in 12 units horizontal).
4. **Landings:** Ramps shall have level landings or floor surfaces at the top and bottom of each ramp run, all points of turning, entrance, exit, and at doors.
  - ▶ The least dimension shall not be less than the required width of the ramp.
  - ▶ The least dimension in the direction of travel shall be 60 inches.
  - ▶ If ramps change direction at landings, the least dimension shall be 60 inches.

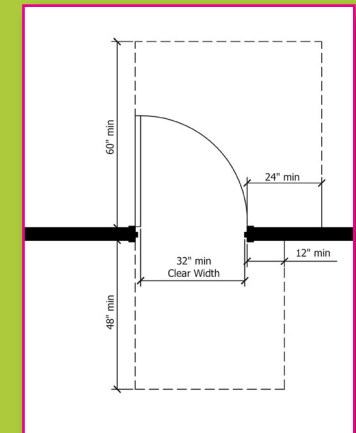
### Stairways

1. **Width:** The minimum width shall not be less than 44 inches.
  - ▶ Stairways shall not reduce in width in the direction of egress travel.
  - ▶ Projections into a required stairway width are prohibited, except for handrail projections.
2. **Landings:** Stairs shall have a level landing or floor at the top and bottom of each stair run.
  - ▶ The width of a landing shall not be less than the width of the stair.
  - ▶ The least dimension in the direction of travel shall be 44 inches.
  - ▶ If the path of travel changes direction between stair runs, the least dimension shall be the width of the stairs.

**FIGURE 1:  
TURNING SPACE**



**FIGURE 2:  
MANEUVERING  
CLEARANCES AT DOORS**



# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## ACCESSIBILITY/RAMP VIGNETTE

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- Treads and Risers:**
  - ▶ Minimum tread depth shall be 11 inches.
  - ▶ Maximum riser height shall be 7 inches and minimum riser height shall be 4 inches.
  - ▶ There shall be no variation in any riser height or tread depth within the complete stairway system.

### *Doors*

- Width:** Door openings shall have a minimum clear width of not less than 32 inches, measured between the face of the door and the opposite stop with the door open 90 degrees.
- Exit Doors:** Exit doors shall swing in the direction of egress travel.
- Double-leaf Doorways:** If doorways have two independently operated door leaves, then at least one leaf shall meet the requirements for clear width and maneuvering space.

### *Guardrails*

- Open sides of landings, floor surfaces, ramps, and stairways shall be protected by a continuous guardrail.

### *Handrails*

- Handrails shall be provided on both sides of ramps and stairs.
  - ▶ Exception: Handrails are not required on ramps where the vertical rise between landings is 6 inches or less.
- Handrails shall be continuous within the full length of each ramp run or stair flight.
- Inside handrails on switchback or dogleg ramps or stairs shall be continuous between runs or flights.
- Non-continuous handrails for ramps and stairs shall have extensions as follows:
  - ▶ Ramp handrails shall extend horizontally at least 12 inches beyond the top and bottom of the ramp run.
  - ▶ Stair handrails shall extend horizontally at least 12 inches beyond the top and bottom risers.
- Handrails may not project more than 4 inches into the required ramp, stair, or exit route width.
- Stairways more than 88 inches wide shall have intermediate handrails.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## ACCESSIBILITY/RAMP VIGNETTE – Sample Passing Solution

Knowledge/  
Skills

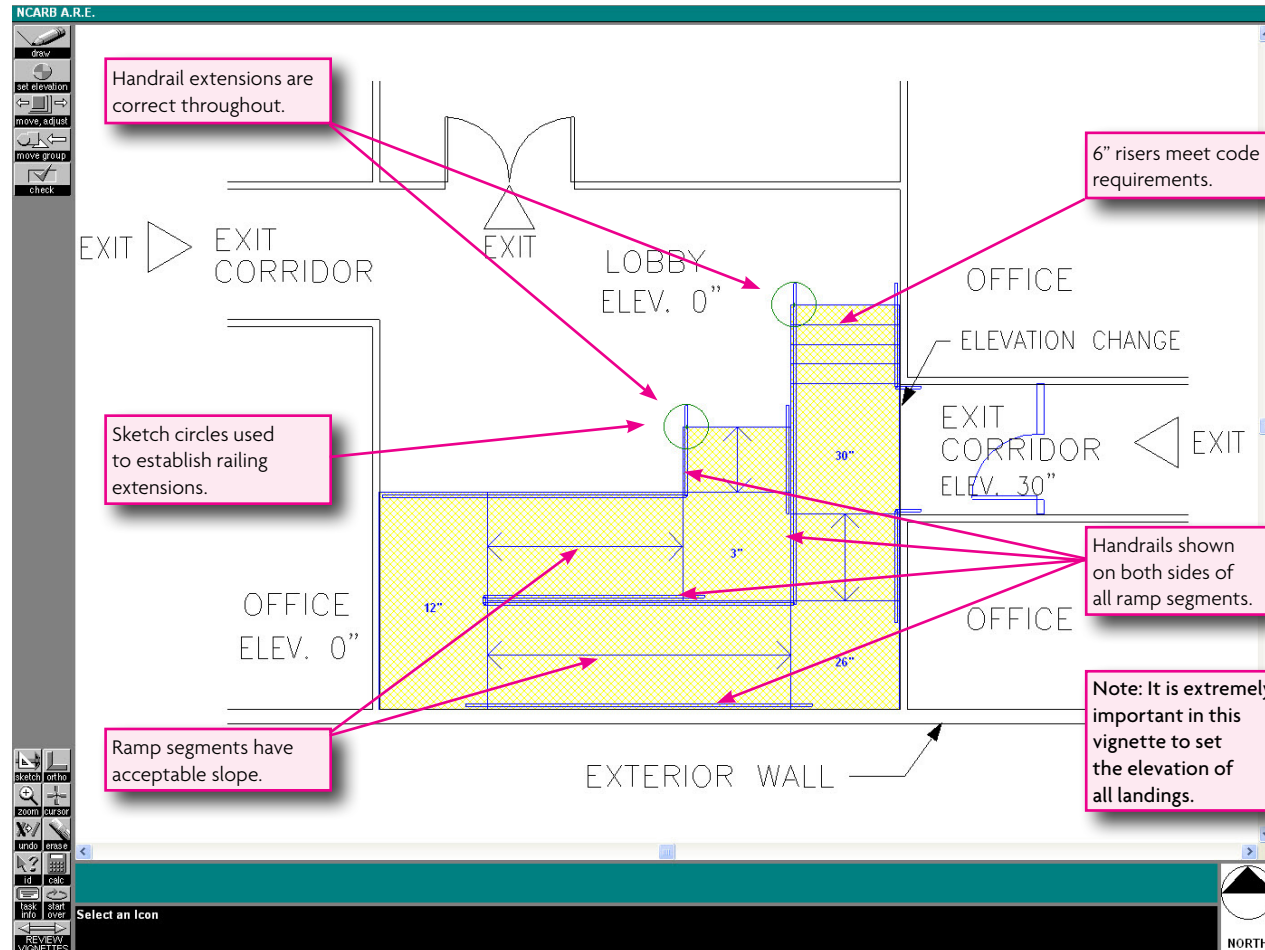
Sample Multiple-  
Choice Questions

Accessibility/Ramp  
Vignette

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References



This vignette requires the candidate to connect two levels by means of an accessible egress stair and ramp system. The uppermost landing is set at the same elevation as the existing upper level. A simple ramp and stair system is shown with

correct slopes for the ramps and the correct number of risers for the stairs. All necessary handrails are provided and extensions are correctly sized. The new door is the correct size and swings in the direction of egress travel.

### Procedural Tips

- ▶ Before you draw your stairs, you should calculate how many risers you need.
- ▶ While you are drawing the stairs, the tread depth will be automatically calculated for you. This measurement is displayed in the **element information area** at the bottom of the work screen.
- ▶ Be sure to keep scrolling until you have seen all of the Code information. Click on the down arrow on the scroll bar to ensure that you have seen all of the text.
- ▶ When elements overlap, you may have trouble selecting a particular element. If this happens, keep clicking (without moving the mouse) until the desired element highlights.
- ▶ Check overlaps while you are working through your solution.

### Warnings

- ▶ Be sure you are aware of the elevations of various parts of the base drawing.

### Tools You Might Find Useful

- ▶ Zoom
- ▶ Full-screen cursor
- ▶ Sketch measure or sketch line tools to lay out railings.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## ACCESSIBILITY/RAMP VIGNETTE – Sample Failing Solution

Knowledge/  
Skills

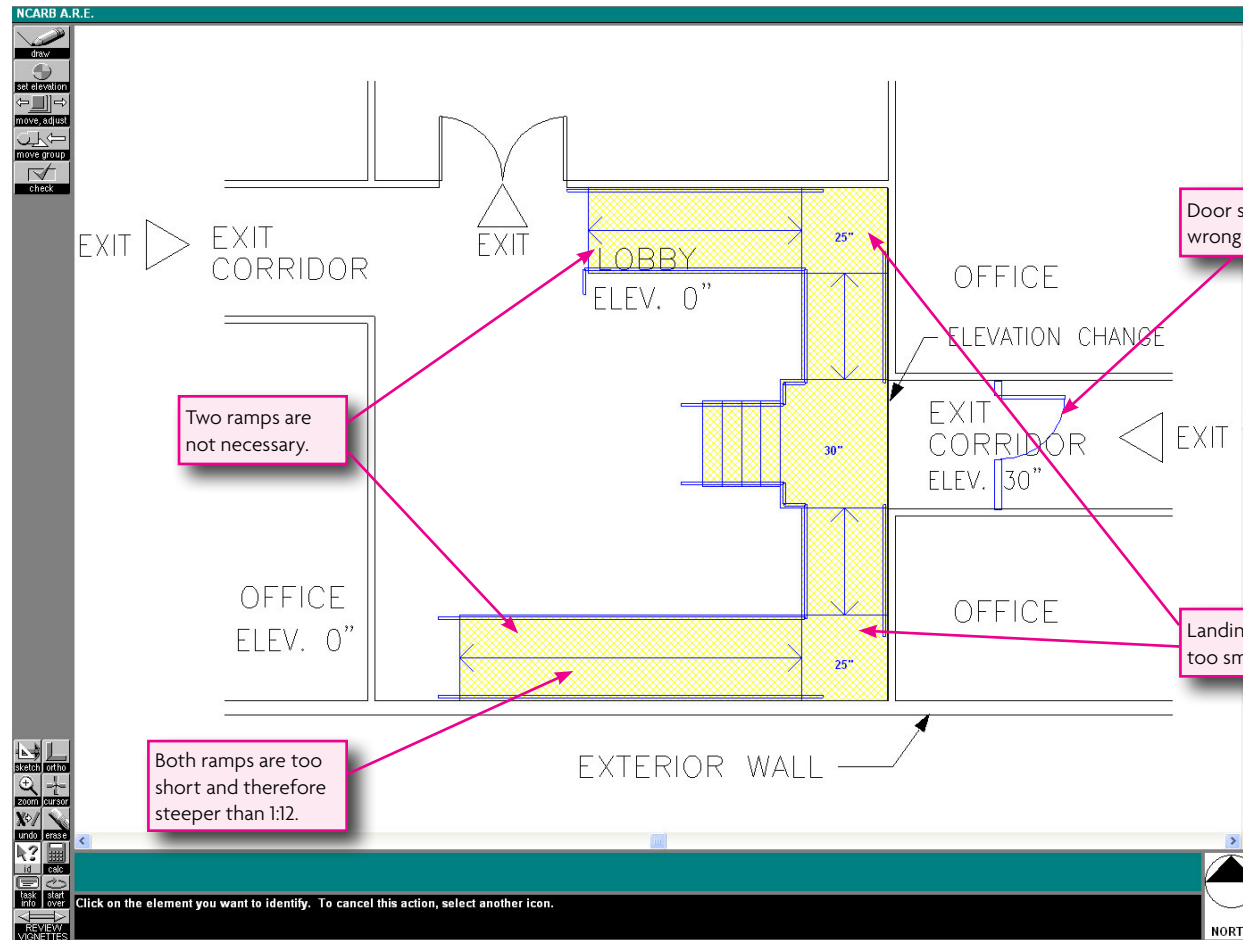
Sample Multiple-  
Choice Questions

Accessibility/Ramp  
Vignette

Stair Design  
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References



This solution creates an unusual system of two ramps with a stair between them. The ramps are both too short, making them steeper than the 1:12 maximum slope stated in the code. The top landings are too small and do not meet code requirements. Also, the new corridor door swings in the wrong direction.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## STAIR DESIGN VIGNETTE

Knowledge/  
Skills

Sample Multiple-  
Choice Questions

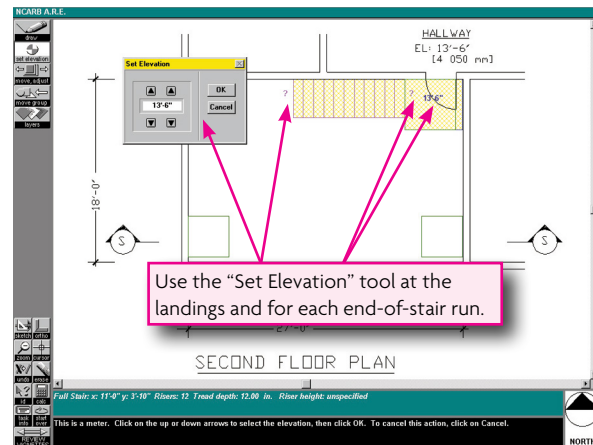
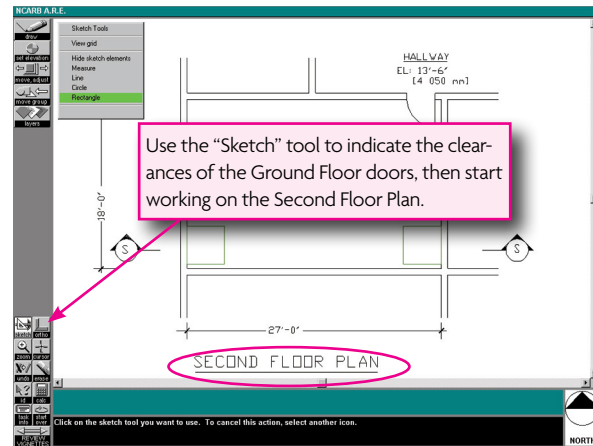
Accessibility/Ramp  
Vignette

Stair Design  
Vignette

Roof Plan Vignette

References

### General Tips for Taking Stair Design



### Directions

Using the tools provided, develop a design for an exit stairway within the existing two-story stairwell shown on the work screen. Draw the necessary components of the stairway on the two floor plans provided, and:

- ▶ Indicate the elevations of all landings.
- ▶ Indicate the elevations of all stair flights – at the top of the highest riser and at the bottom of the lowest riser – to match adjacent landing elevations.
- ▶ Include railings, i.e., guardrails and handrails.
- ▶ Connect stair flights to landings or the ground floor only.
- ▶ When using the cut stair tool, the flight of stairs should be drawn from landing to landing or from ground floor to landing.

You should develop a design that meets the given code and program requirements. Before starting to work on your stair design, you should familiarize yourself with the floor plans on the work screen as well as the program, the code, and the section that can be accessed through the Vignette Index screen.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

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## STAIR DESIGN VIGNETTE

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### Program

In order to meet new accessibility standards and increased occupant loads, schematic plans are being developed for a new exit located within an existing stairwell in a two story bank building. Second floor to have area of refuge. The design for the other building exits – a second stairway and the building's main entrance – has been completed.

- Design the stairway to serve as a means of egress from all three building levels leading into the stairwell and through the exit discharge door to the sidewalk at grade (a public way).
  - The stairway must provide a continuous path from Second floor to Ground floor exit that includes a landing at the Intermediate level.
- The total occupant loads and number of exits for each level of the building are as follows:

Building Level	Total Occupant Load	Number of Exits
Ground Floor	360	3
Janitor	9	1
Second Floor	180	2

- The stairs will be constructed from pre-cast concrete components with the following dimensions:
  - Landings: 12 inches deep between the landing soffit and the surface.
  - Stair flights/stringers: 12 inches deep between the stair nosings and the stringer soffit measured along a line perpendicular to the soffit.

### Code

Comply with the following code requirements. These are the ONLY code-related criteria you are required to use.

### Definitions

- Means of Egress:** A continuous and unobstructed path of travel from any point in a building to a public way. A means of egress comprises the vertical and horizontal means of travel and shall include exit stairways, passageways, and exit doors.
- Exit Stairways:** That portion of a means of egress which is separated from all other spaces of a building by fire resistance-rated construction to provide a protected way of travel to an exit door at grade. A stairway shall consist of one or more flights of stairs and the landings connecting them.

### Capacity of Exit Components

- Occupant Load:** The occupant load for each exit shall be determined by dividing the total occupant load for an individual floor by the number of exits serving that floor.
  - Where stairways serve more than one level, the capacity of the exit components shall be based on the individual floor with the largest occupant load, provided that the exit capacity shall not decrease in the direction of means of egress travel.
- Minimum Width:** The width of each exit component in inches shall not be less than the occupant load served by an exit multiplied by 0.3 nor less than the minimum width specified by this code for each component.



# BUILDING DESIGN & CONSTRUCTION SYSTEMS

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## STAIR DESIGN VIGNETTE

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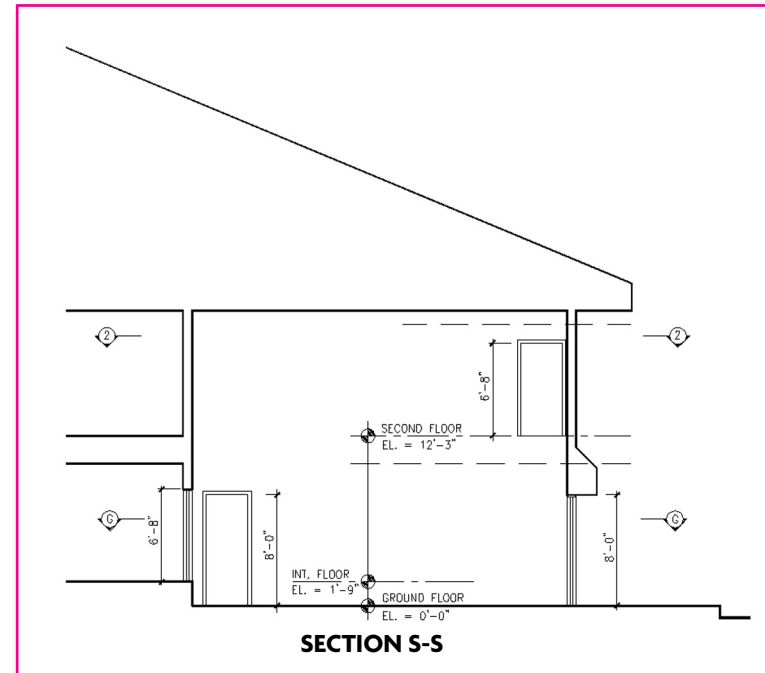
Stair Design  
Vignette

Roof Plan Vignette

References

### Stairways

1. **Width:** The minimum width shall be computed in accordance with Capacity of Exit Components, above, but shall not be less than 44 inches.
  - ▶ Stairways shall not reduce in width in the direction of egress travel.
  - ▶ Projections into a required stairway width are prohibited, except for handrail projections.
  
2. **Landings:** Stairs shall have a level landing or floor at the top and bottom of each stair run.
  - ▶ The width of a landing shall not be less than the width of the stair.
  - ▶ The least dimension in the direction of travel shall be 44 inches.
  - ▶ If the path of travel changes direction between stair runs, the least dimension shall be the width of the stairs.
  
3. **Headroom:** The minimum headroom of all parts of a stairway shall not be less than 80 inches measured vertically from the tread nosing or from any floor surface including landings.
  
4. **Treads and Risers:**
  - ▶ Maximum riser height shall be 7 inches and minimum riser height shall be 4 inches.
  - ▶ Minimum tread depth shall be 11 inches.
  - ▶ Treads shall be of uniform depth and risers of uniform height in any flight of stairs.



# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## STAIR DESIGN VIGNETTE

Knowledge/  
Skills

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### Doors

1. When opening, doors shall not reduce the width of landings to less than one-half of the required width.
2. There shall be a floor or landing on each side of a door and the floor surface on both sides of the door shall be at the same elevation.
3. Minimum maneuvering clearances at doors shall be as shown in Figure 1.

### Guardrails

1. Open sides of landings shall be protected by a continuous guardrail.

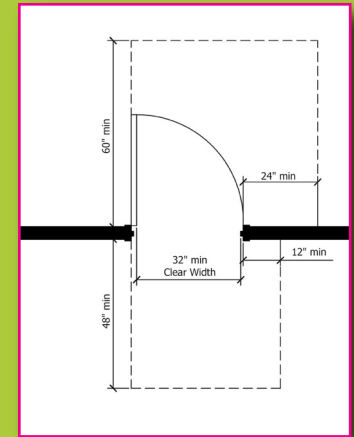
### Handrails

1. Stairways shall have continuous handrails on both sides.
  - ▶ At locations where handrails are not continuous between stairway flights, including the top and bottom of a stairway, at least one handrail shall extend horizontally at least 12 inches beyond the top riser and the bottom riser.
2. Handrails shall not project more than 4 inches into the required passageway and stairway width.

### Area of Refuge

1. An accessible area of refuge serving the second floor shall be provided within the stair enclosure.
2. The area of refuge shall be sized to accommodate one wheelchair space of 30 inches by 48 inches.
  - ▶ Such wheelchair spaces shall not reduce the required stair or landing width.
3. When areas of refuge are required, stairway width shall have a minimum clear width of 48 inches between handrails.

**FIGURE 1:  
MANEUVERING  
CLEARANCES AT DOORS**



# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## STAIR DESIGN VIGNETTE - Sample Passing Solution

Knowledge/  
Skills

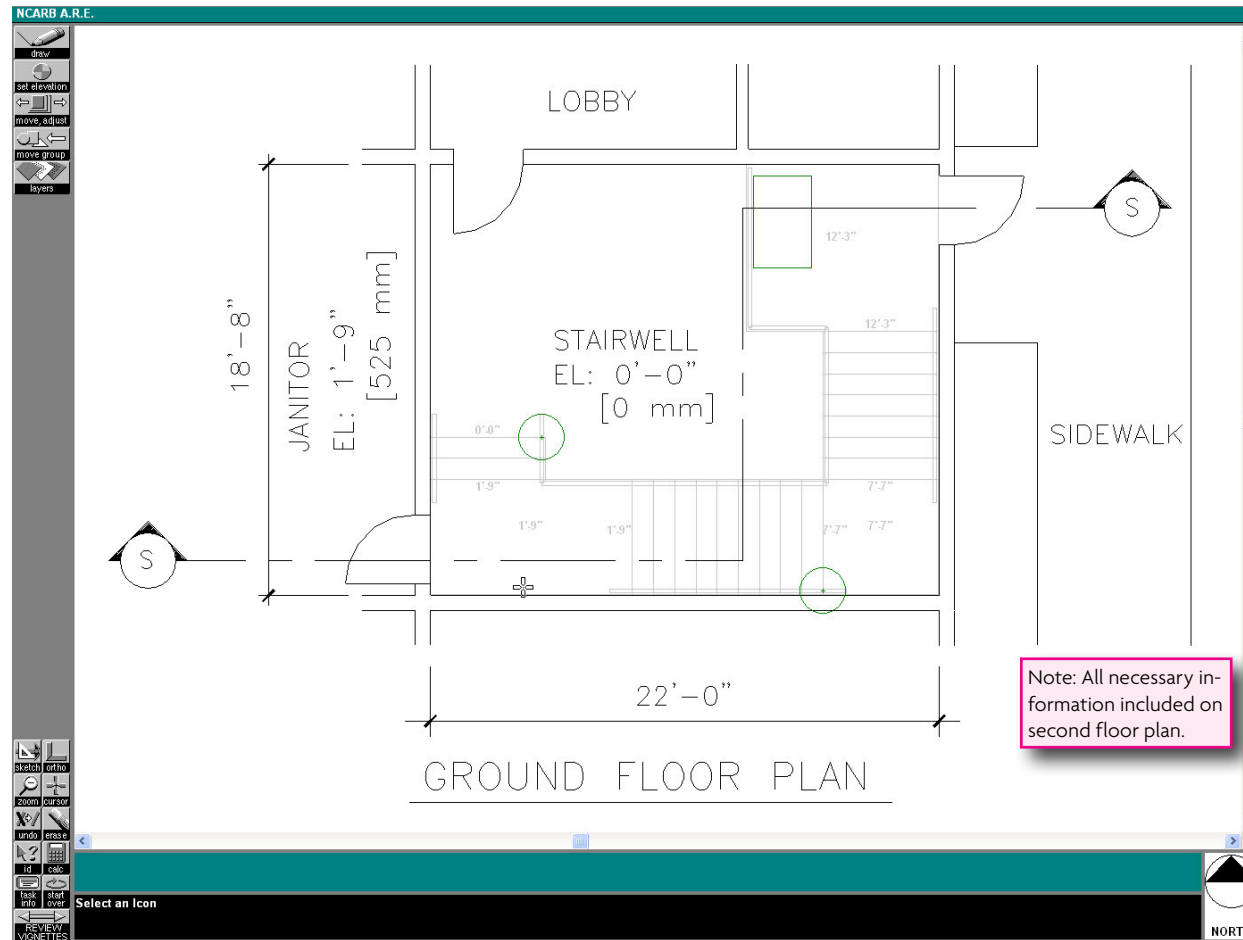
Sample Multiple-  
Choice Questions

Accessibility/Ramp  
Vignette

Stair Design  
Vignette

Roof Plan Vignette

References



### First Floor

Because the design of the stairs for this particular solution does not obscure other portions of the stair, all necessary information

can be created and displayed on the Second Floor Plan. It is not necessary to utilize the "Cut Stair" tool.

### Procedural Tips

- ▶ Pay attention to the order of tasks specified in the Vignette Directions.
- ▶ Calculate the number of risers you need before you begin to lay out your stairs.
- ▶ The tread depth is calculated for you. It appears in the **element information area** at the bottom of the work screen.
- ▶ The question marks at each end of the stair represent the elevations at the points of attachment of a stair to its landings.
- ▶ Change **layers** at the appropriate level as indicated by the ground-floor cut line in the section drawing.
- ▶ When elements overlap, you may have trouble selecting a particular element. If this happens, keep clicking (without moving the mouse) until the desired element highlights.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## STAIR DESIGN VIGNETTE - Sample Passing Solution

Knowledge/  
Skills

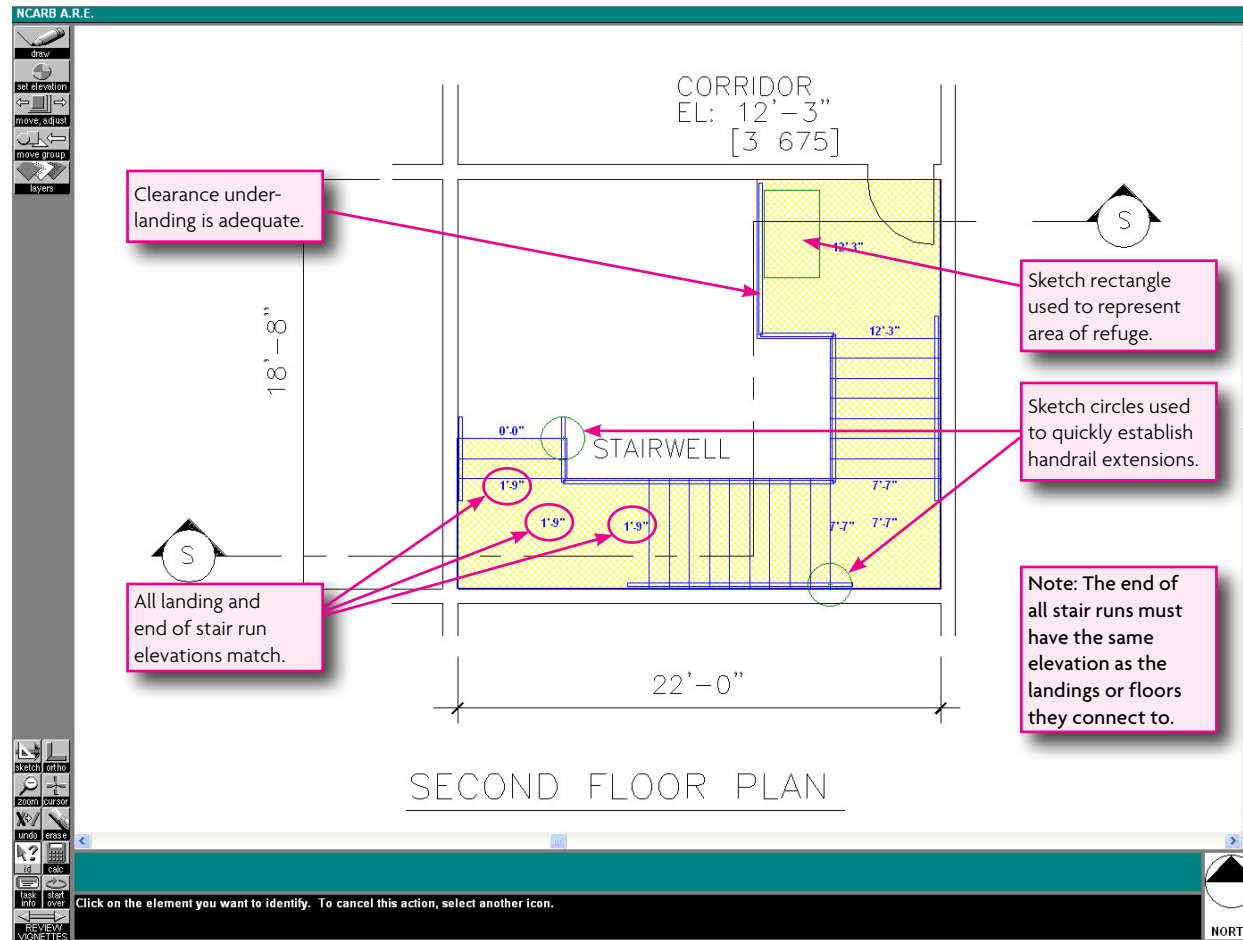
Sample Multiple-  
Choice Questions

Accessibility/Ramp  
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References



### Warnings

- ▶ If you do not draw a stair or a landing in a given location within a stairwell, the scoring mechanism will assume that the area is open to below.
- ▶ You must indicate the elevation of the stair and the landings separately even if the elevations are the same.
- ▶ Be sure you are aware of the elevations of various parts of the base drawing.

### Tools You Might Find Useful

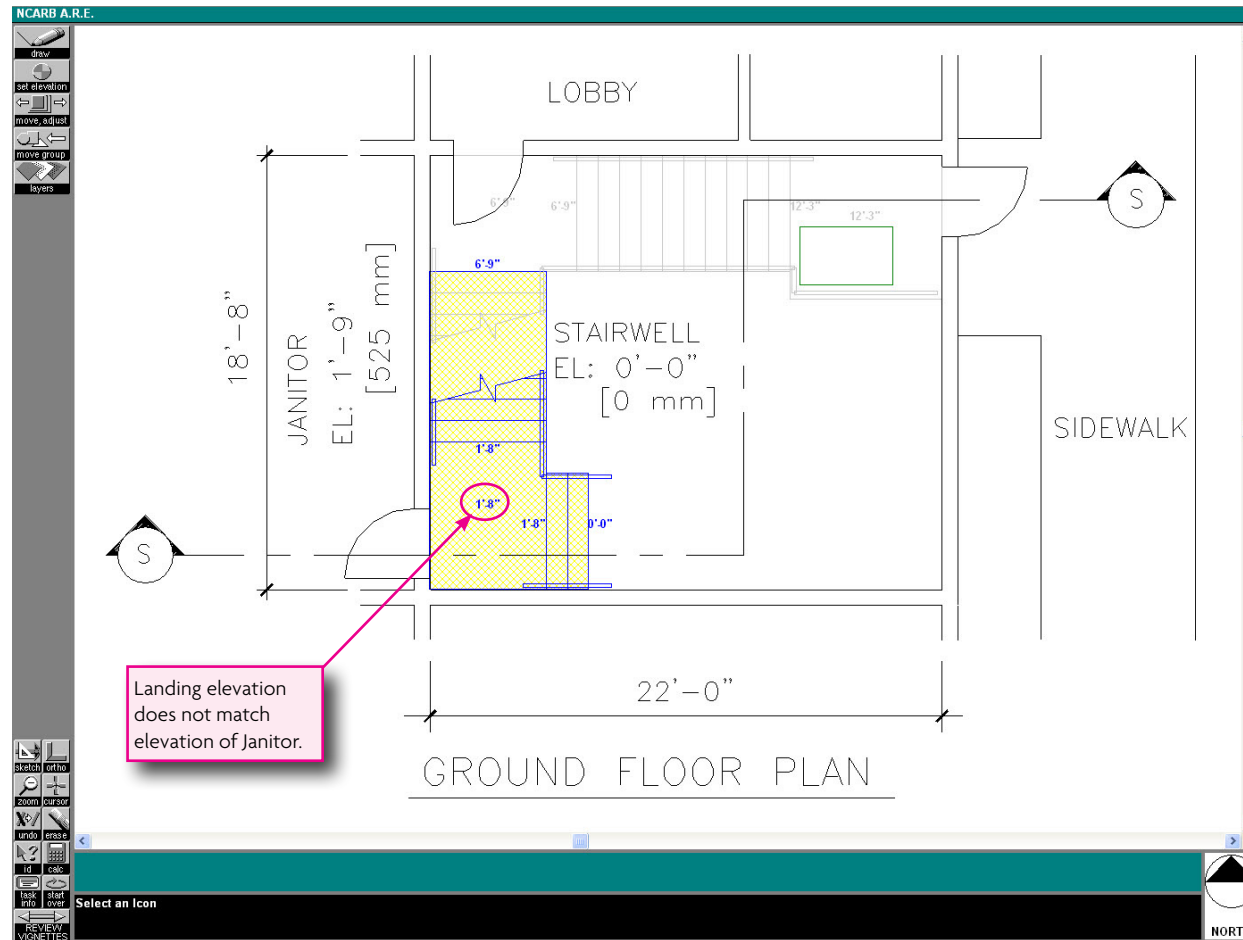
- ▶ Zoom

### Second Floor

This vignette requires the insertion of a new stair system connecting three levels in an existing space. In this solution, the stairs are wide enough at all runs, do not get narrower in the direction of egress, and do not block egress at the ground floor level. The intermediate landing is set at the same elevation

as the janitor room it serves as shown on the given section. The upper landing is located at the correct elevation and extends to allow for an area of refuge. The solution provides adequate headroom where required considering the thickness of the structure as given in the program.

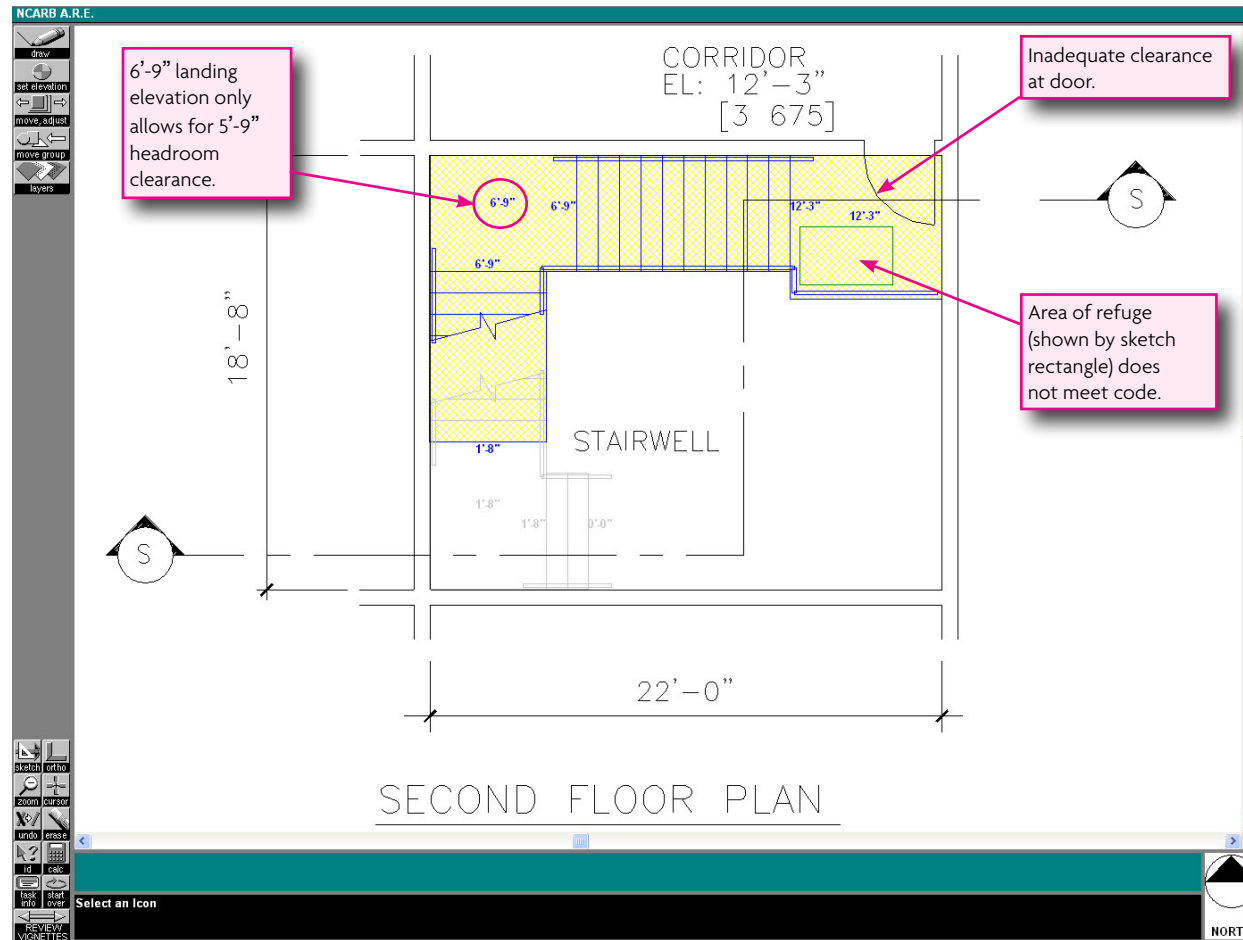
## STAIR DESIGN VIGNETTE - Sample Failing Solution



### First Floor

This solution also takes a simple approach to the same problem, but fails in three major areas. The landing located near the janitor room is not at the correct elevation.

## STAIR DESIGN VIGNETTE - Sample Failing Solution



### Second Floor

Additionally, the area of refuge indicated by the sketch rectangle on the upper landing is inadequate. A rectangle representing the area of refuge is not required to be shown, but the necessary space for the area of refuge must be

provided according to the code. Also, the upper intermediate landing only allows for 69 inches of headroom below. This does not meet the minimum code requirement for 80 inches of clear headroom.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## ROOF PLAN VIGNETTE

Knowledge/  
Skills

Sample Multiple-  
Choice Questions

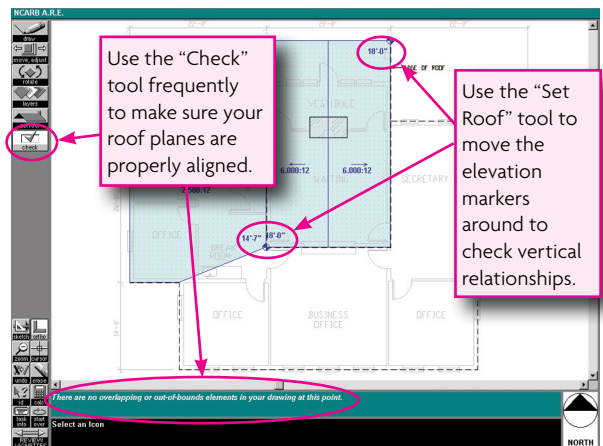
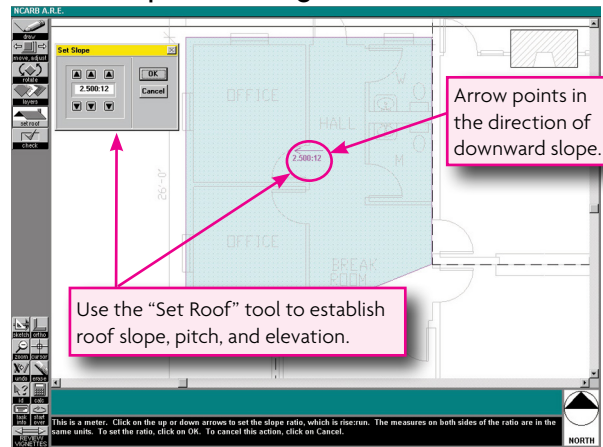
Accessibility/Ramp  
Vignette

Stair Design  
Vignette

Roof Plan Vignette

References

### General Tips for Taking Roof Plan



### Directions

The work screen shows the floor plan of a building and a simplified representation of its roof system. This representation consists of dashed lines that indicate the outermost edges of the two roofs that make up the system. When creating roof planes, confine your solution to the areas defined by the dashed lines (use no eaves or overhangs). Using the tools provided, configure these roofs for effective removal of rainwater, as follows:

1. For each roof area, define the extent, slope, and spot elevations of a plane or planes designed to remove rainwater by means of roof slope, gutters, and downspouts only and to allow for any required clerestory. The outside edges of the roof planes you define must coincide with the dashed lines indicating the outermost edges of the roofs; eaves or overlapping roof planes are not to be shown.
2. Indicate the location of the clerestory and all necessary gutters and downspouts by using the appropriate symbols.
3. Place on the roof the HVAC condensing unit and any necessary plumbing vent stacks, skylights, and exhaust fan vents.
4. Indicate any necessary flashing and crickets. The chimney shown on the plan should be considered to penetrate any roof plane that you draw over it.

Before beginning your solution, you should review the program that can be accessed through the Vignette Index screen and familiarize yourself with the plan on the work screen.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## ROOF PLAN VIGNETTE

Knowledge/  
Skills

Sample Multiple-  
Choice Questions

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### Program

Your office is designing a regional craft center. The following requirements must be considered in preparation of the roof plan.

### General

1. The building consists of two volumes, one high and one low. Each volume has a roof height and slope requirement.

### Roof Drainage

1. The building is located in a temperate climate with moderate annual rainfall.
2. Only roof slope, gutters, and downspouts are to be used for removal of rainwater.
3. Downspouts should not conflict with any door, window, or clerestory window.
4. Rainwater should not discharge from the edge of an upper roof directly onto a lower roof or from any roof or gutter directly onto the ground.

### Construction

1. Finished floor elevation is 0'-0". Minimum ceiling height is 8'-0".
2. All roof areas must have a positive slope.
3. The roof over the exhibition room shall have a slope between 6:12 and 12:12.
  - ▶ The roof and structural assembly is a total of 18 inches thick.

4. The roof over the remaining spaces shall have a slope between 2:12 and 5:12.
  - ▶ The roof and structural assembly is a total of 18 inches thick.
5. The exhibition room is to have a horizontal clerestory window 24 inches in height located in the existing west wall.
  - ▶ The clerestory sill is included in the overall height dimension.
6. Natural light must be provided for all rooms by means of windows, clerestory window, or skylight.
  - ▶ Skylights must be provided only where no windows are shown and no clerestory window has been specified.
  - ▶ Skylights are not required in halls, storage rooms, or closets.
7. Flashing must be provided at all roof/wall surface intersections, including chimneys.
  - ▶ HVAC condensing units, plumbing vent stacks, exhaust fan vents, skylights, and gutters are self-flashing and require no additional flashing or crickets.

### Mechanical

1. The HVAC condensing unit must be placed on a roof with a slope of 5:12 or less.
  - ▶ Maintain a minimum of 3 feet clearance from all roof edges.
  - ▶ Do not place in front of the clerestory window.
2. Provide one (1) exhaust fan vent for each toilet room.
3. Provide plumbing vent stacks through roof where required to vent plumbing fixtures.



# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## ROOF PLAN VIGNETTE - Sample Passing Solution

Knowledge/  
Skills

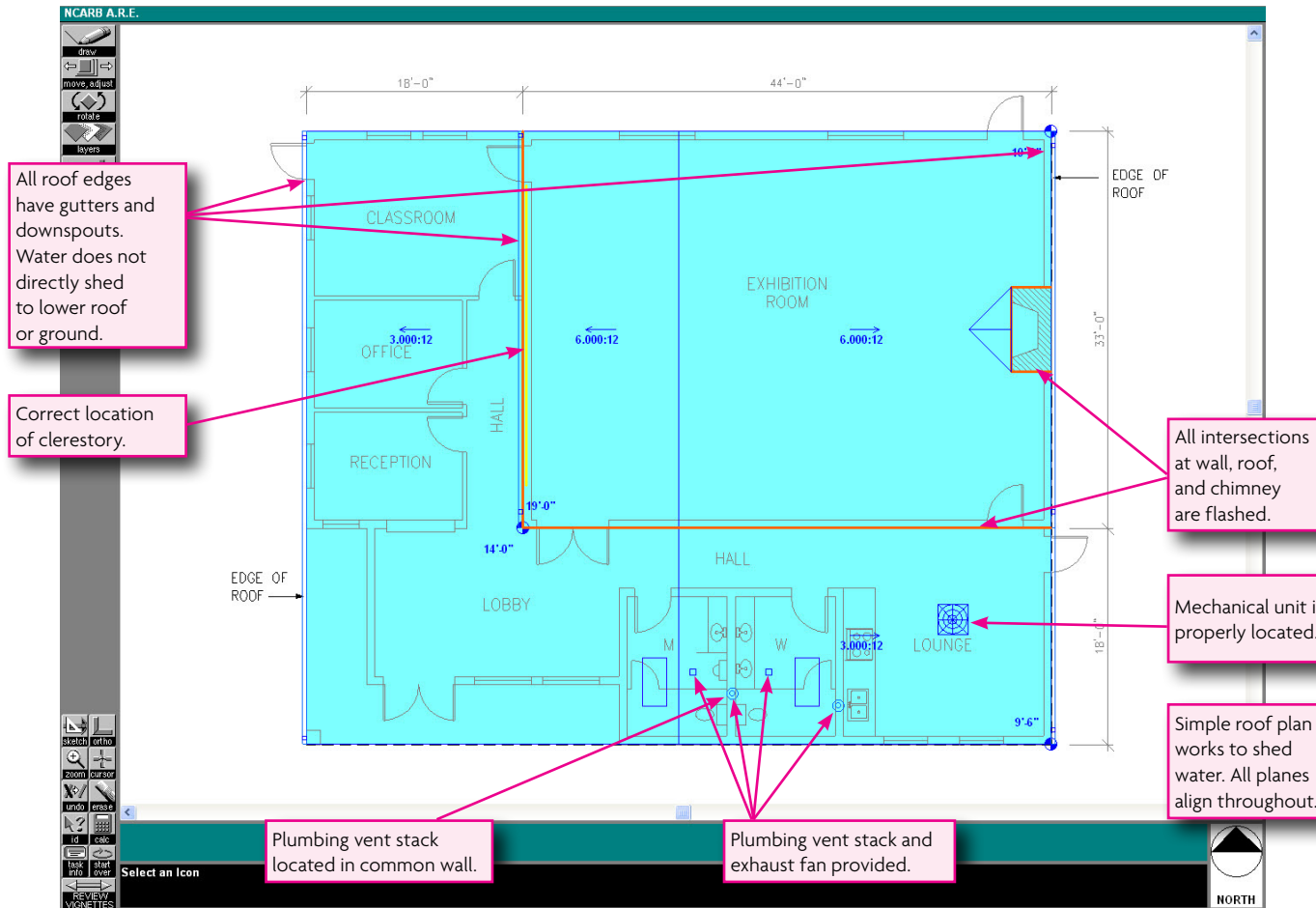
Sample Multiple-  
Choice Questions

Accessibility/Ramp  
Vignette

Stair Design  
Vignette

Roof Plan Vignette

References



In this solution, the slope of the upper roof is 6:12 and falls within the required slope. The roof elevations are correctly set at each corner of the roof. At the low corner of the upper roof, there is adequate difference between the two roof levels. This allows placement of the required 24-inch horizontal clerestory window on the west wall of the Exhibition Room and the necessary

18-inch roof structure above. The lower roof slopes are set at 3:12 with a low point at 9 feet 6 inches. Flashing is provided at all roof/wall surface intersections, and there are gutters and downspouts at the eaves. Skylights are provided in spaces with no exterior windows and all plumbing fixtures are close to a plumbing vent stack.

### Procedural Tips

- ▶ To see the limits of the roof, turn off **Display floorplan** under the **layers** menu.
- ▶ Use the **check** tool to ensure that your roof planes are drawn within the given limits of the roof.
- ▶ Where roof planes meet, the lines indicating the edges must coincide. The **zoom** tool may be helpful in accomplishing this.
- ▶ While working with the **set roof** tool, refer to the **instructions area** at the bottom of the work screen. The instructions will guide you in using this tool.
- ▶ Change the **cursor** to a full-screen crosshair to assist in aligning your roof plane with the given roof edge. **Ortho** is also helpful for aligning.
- ▶ When elements overlap, you may have trouble selecting a particular element. If this happens, keep clicking (without moving the mouse) until the desired element highlights.

### Note

Be careful to follow the perimeter edges for both the upper and lower roof planes. Use the "Check" tool frequently.

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

## ROOF PLAN VIGNETTE - Sample Failing Solution

Knowledge/  
Skills

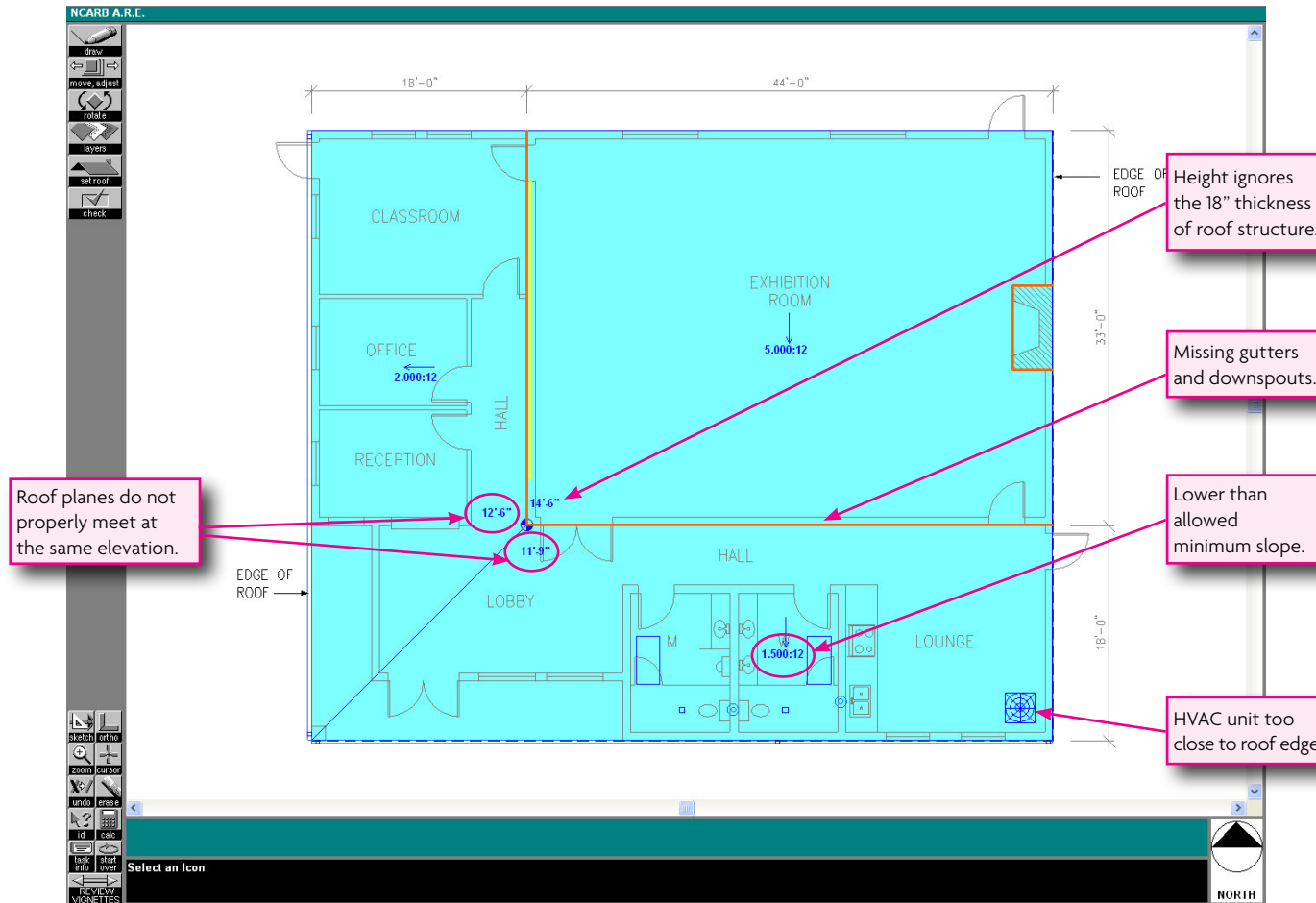
Sample Multiple-  
Choice Questions

Accessibility/Ramp  
Vignette

Stair Design  
Vignette

Roof Plan Vignette

References



This solution generally sheds water but has some major technical flaws. The main problems are with the roof slopes and corner elevations on the three roof planes that make up the roof system. The slope of the lower level, south-facing plane is set shallower than the program allows, and the top corners of

the two lower level planes do not align at the same elevation. The HVAC unit is too close to the roof edge. The upper roof is missing gutters and allows the water to shed off the roof directly onto the lower roof and ground.

### Warnings

- ▶ The dashed lines labeled Edge of Roof (on the work screen) are the outer limits of the roof. Do not extend your roof planes beyond these lines.
- ▶ Gutters and downspouts may be placed beyond the outer limits of the roof.

### Tools You Might Find Useful

- ▶ **Set roof** tool to make calculating a roof elevation easier

# BUILDING DESIGN & CONSTRUCTION SYSTEMS

Overview

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Vignette

Roof Plan Vignette

References

## REFERENCES

The following references are presented to assist candidates in preparation for the examination. This list represents texts that have content covered in this division of the examination. This is not intended to be an exhaustive list of all possible reference materials for the subject area. NCARB makes no guarantee that the various references are currently in print.

### **The Architect's Handbook of Professional Practice**

The American Institute of Architects  
John Wiley & Sons, 14th edition, 2008

### **Architectural Graphic Standards**

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John Wiley & Sons, latest edition

### **Building Construction Illustrated**

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### **Dictionary of Architecture and Construction**

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### **Fundamentals of Building Construction**

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### **HOK Guidebook to Sustainable Design, The**

Sandra F. Mendler, William Odell, and Mary Ann Lazarus  
John Wiley & Sons, 2nd edition, 2006

### **Olin's Construction Principles, Materials, and Methods**

H. Leslie Simmons  
John Wiley & Sons, latest edition

### **Time-Saver Standards for Architectural Design Data**

Donald Watson, Michael J. Crosbie, and John Hancock Callender, Editors  
McGraw-Hill, latest edition

### **Time-Saver Standards for Building Materials & Systems: Design Criteria and Selection Data**

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