



# Building Inspection Engineers Certification Institute

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## CERTIFICATION STUDY GUIDE PROLOGUE

Certification as a Building Inspection Engineer demonstrates a high level of expertise in an engineering specialty that was created approximately fifty years ago. Just as the pathologist is a licensed physician who specializes in the diagnosis and management of human disease, the Certified Building Inspection Engineer is a licensed Professional Engineer or Architect whose education, training and experience qualifies him or her to evaluate building systems and gather information relevant to the building's existing condition and performance level. Once the Board-Certified Building Inspection Engineer has developed that information, it may be used for many purposes. Most often the information is transformed into economic quantities that may help the engineer's client arrive at a perception of value regarding the subject building. In other cases, the information becomes the basis for a program of problem remediation.

Buildings, like the human body, are a complex amalgam of many systems and subsystems. Considerable training and experience beyond an engineering or architecture degree and licensure as a Professional Engineer or Architect is required to accurately assess the interaction and performance of these systems and subsystems. Identifying, diagnosing, and managing deterioration and loss of performance in buildings is a unique engineering specialty in which the practitioner must have specialized system and subsystem expertise as well as the skill to gauge the adequacy of the integration of these systems and subsystems in the complete building.

The Building Inspection Engineers Certification Institute has identified twenty-one major areas of competence, known as the Body of Knowledge, for the Professional Engineer or Architect seeking certification in this field. The purpose of this study guide is to offer to the certification exam candidate a means to better understand each of the twenty-one areas and material that may be queried on the examination.

The candidate must keep in mind that simply reviewing the Study Guide will not necessarily allow successful completion of the test. Body of Knowledge topics are only mastered through a combination of education, training and experience. Each topic describes an area of Building Inspection Engineering that must be understood not only as a stand-alone subject but also as a component of a fully integrated engineering specialty.

One excellent reference text applicable to this engineering specialty is entitled *Building Pathology: Deterioration, Diagnostics, and Intervention*. Written by Samuel Y. Harris, PE, AIA, Esq., it is published by John Wiley and Sons, Inc. Professor Harris is an architect, engineer, and attorney and teaches at the University of Pennsylvania and Goucher College. Familiarization with, and an understanding of, the text's material offers a fine insight into the skills and work of the Board-Certified Building Inspection Engineer.

The following listing of the Body of Knowledge topics includes a brief summary of the major items within each topic that is considered to be of prime importance to the Building Inspection Engineer. A listing of relevant reference material is provided along with specific subtopics that are represented in the examination question database.

## **1. BODY OF KNOWLEDGE - HISTORY OF BUILDING CONSTRUCTION, INCLUDING HISTORIC PRESERVATION**

The certification candidate should be thoroughly familiar with:

1. Primary phases of residential construction techniques in the 19th century and earlier
2. Primary phases of commercial construction techniques in the 19th century and earlier
3. Primary phases of residential construction techniques in the 20th century and to the present
4. Primary phases of commercial construction techniques in the 20th century and to the present
5. Overview of construction labor evolution
6. Review of typical construction organizational structures
7. Regional variations in construction
8. Significance of historic preservation efforts
9. Authority and jurisdiction of historic preservation organizations
10. Primary state and national preservation organizations

Applicable study references might include, but are not limited to:

- *A Field Guide to American Houses* as published by Knopf
- *Architectural Graphic Standards* as published by John Wiley and Sons
- *Historical Building Construction: Design, Materials, and Technology* as published by Norton
- *The Investigation of Buildings* as published by Norton

The certification candidate can expect exam questions to focus on such areas as:

- American architectural styles and their purpose
- Structural system evolution
- Common problems in historic buildings
- Construction means and methods in American buildings
- Agencies and organizations administering historic preservation efforts

## **2. BODY OF KNOWLEDGE - CONSTRUCTION MATERIALS**

The certification candidate should be thoroughly familiar with:

1. Concrete
2. Masonry
3. Metals
4. Woods and plastics
5. Thermal and moisture protection
6. Doors and windows
7. Finishes

Applicable study references might include, but are not limited to:

- Civil engineering handbooks
- Wood engineering and construction handbooks
- Residential construction handbooks
- Building codes

The certification candidate can expect exam questions to focus on such areas as:

- Fenestrations
- Components of concrete
- Asbestos-containing materials
- Engineered wood products
- Sawn lumber commonly found in residential construction
- Delamination of concrete
- Water vapor migration and condensation
- Exterior cladding materials
- Fireplace construction
- Mortar
- Structural steel
- Connection materials

### **3. BODY OF KNOWLEDGE CONSTRUCTION DETAILING/TECHNIQUES AND REPAIR PRACTICES**

The certification candidate should be thoroughly familiar with:

1. Working knowledge of construction and repair requirements for residential and commercial buildings as contained in the International Building Code
2. Interpretation of construction drawings
3. General knowledge of construction management issues
4. Working knowledge of construction and repair cost estimating

Applicable study references might include, but are not limited to:

- Civil engineering handbooks
- Foundation repair handbooks
- Building codes
- Wood engineering and construction handbooks

The certification candidate can expect exam questions to focus on such areas as:

- Common methods of construction for residential and commercial structures
- Methods of repair for foundations that have settled, wracked or buckled
- Repair of engineered wood products
- Installation of brick veneer
- Repair of concrete slabs

#### **4. BODY OF KNOWLEDGE - STRUCTURAL ANALYSIS AND THEORY OF STRUCTURES**

The certification candidate should be thoroughly familiar with:

1. Strengths of materials
2. Section properties
3. Bending, shear and axial stresses
4. Allowable stresses in materials
5. Load paths
6. Dead and live loads
7. Gravity and lateral loadings
8. Deflections
9. Failure modes
10. Simple beam analysis

Applicable study references might include, but are not limited to:

- *Structural Engineering Handbook* as published by McGraw Hill
- *Wood Engineering and Construction Handbook* as published by McGraw Hill
- *Design of Wood Structures Handbook* as published by McGraw Hill
- *Structural Analysis* as published by Harper & Row
- ATSC Steel Construction Manual
- CRSI Handbook

The certification candidate can expect exam questions to focus on such areas as:

- Rigid frame analysis
- Moment and shear diagrams
- Design values for species of wood used for residential framing
- Equations for stresses and deflection
- Modes of structural failure

## **5. BODY OF KNOWLEDGE - THERMAL SYSTEMS**

The certification candidate should be thoroughly familiar with:

1. HVAC fundamentals
2. Load estimating
3. Air distribution
4. Piping design
5. Refrigerants
6. Cooling towers
7. Water conditioning
8. Corrosion
9. Auxiliary equipment
10. Systems and applications
11. Fuels
12. Solid fuel burning equipment
13. Liquid fuel burning equipment
14. Gaseous fuel burning equipment
15. Safety components
16. Insulation
17. Inspection techniques, equipment and measurements
18. Indoor air quality

Applicable study references might include, but are not limited to:

- ASHRAE Handbooks on *Fundamentals*, *HVAC Applications*, and *HVAC Systems and Equipment*

The certification candidate can expect exam questions to focus on such areas as:

- Thermodynamic terms and definitions including entropy, enthalpy, vapor pressure, density, latent heat, sensible heat, pressure, heat transfer, surface conductance and heat of vaporization
- Air flow through ducts including friction loss, dynamic loss and duct air velocity
- Theoretical operation of commercial and residential air conditioning equipment, types of coolant, flow of coolant, coolant piping including sizing and NABIE Standards of Practice regarding inspection of equipment
- Cooling tower types, evaporation rates, and air flow rates
- Water treatment including scale and corrosion control
- Galvanic corrosion
- Centrifugal pump operation, capacity, horsepower and amperage
- Heating value of fuels, efficiency, and products of combustion
- Sick building syndrome

## **6. BODY OF KNOWLEDGE - SURVEYING ENGINEERING**

Surveying Engineering (or Engineering Surveying) is defined by ASCE Policy Statement 333 as “*those activities involved in the planning and execution of surveys for the location, design, construction, operation, and maintenance of civil and other engineered projects.*”

In keeping with that definition the building inspection engineer should be knowledgeable of the aspects of this topic relating to measurement and quantification of land and spatial features of the built environment.

The certification candidate should be thoroughly familiar with:

1. General aspects of property boundary surveys
2. Topographic surveys
3. Global positioning systems (GPS) theory and usage
4. Knowledge of surveying equipment such as total stations, GPS units, etc.
5. Building layout

Applicable study references might include, but are not limited to:

- *Building Design and Construction Handbook* as published by McGraw Hill, Section 18, “Surveying for Building Construction”
- ASCE Policy Statement 333

The certification candidate can expect exam questions to focus on such areas as:

- Surveying measurement techniques
- Land quantification criteria
- Application of various surveying methods
- Limitations of surveying equipment
- Cut and fill volume calculations

## **7. BODY OF KNOWLEDGE - TIMBER AND WOOD-FRAMED STRUCTURES**

The certification candidate should be thoroughly familiar with:

1. Strengths of materials/common timber species
2. Section properties of common members
3. Bending, shear and axial stresses
4. Allowable stress in species
5. Advantages and disadvantages of timber as a structural material
6. Common means of deterioration; pests, moisture, fungus
7. Investigation methods
8. Lateral bracing methods
9. Common floor and roof decking
10. Connections

Applicable study references might include, but are not limited to:

- *Wood Engineering and Construction Handbook* as published by McGraw Hill
- *Design of Wood Structures* as published by McGraw Hill
- *Dwelling House Construction* as published by MIT press
- Residential Building Design and Construction
- Building codes

The certification candidate can expect exam questions to focus on such areas as:

- Shear capacity of wood-framed structures
- Common materials of construction
- Allowable deflection
- Types of framing for residential construction
- Moisture content of wood
- Shrinkage of wood
- Visual grading of lumber
- Design loads for residential structures
- Truss configurations, construction and characteristics
- Engineered wood products including I-joists and laminated veneer lumber

## **8. BODY OF KNOWLEDGE - STEEL STRUCTURES**

The certification candidate should be thoroughly familiar with:

1. Material properties
2. Construction uses in buildings
3. Construction procedures (installation techniques)
4. Structural properties
5. Interaction with other common building materials
6. Connections
7. Detailing
8. Inspection techniques (destructive and non-destructive)
9. Deterioration causes and symptoms
10. Common repair methods
11. Relative costs

Applicable study references might include, but are not limited to:

- AISC Steel Construction Manual
- Civil engineering handbooks
- *Structural Engineering Handbook* as published by McGraw Hill
- Construction manuals

The certification candidate can expect exam questions to focus on such areas as:

- Yield capacities
- Common steel shapes and nomenclature
- Bracing techniques
- Fireproofing
- Design methods
- Connections

## **9. BODY OF KNOWLEDGE - CONCRETE AND MASONRY STRUCTURES**

The certification candidate should be thoroughly familiar with:

1. Concrete and masonry material and structural properties
2. Applications of concrete and masonry in buildings
3. Standard construction techniques for concrete and masonry
4. Concrete and masonry reinforcement
5. Historic applications of concrete and masonry in buildings
6. Deterioration of concrete and masonry in buildings
7. Inspection procedures for concrete and masonry
8. Repair methods for concrete and concrete masonry

Applicable study references might include, but are not limited to:

- American Concrete Institute Manual of Practice
- AC1318
- National Concrete Masonry Association Handbook
- *Building Design and Construction Handbook*, Section 4; “Building Materials” and Section 9; “Concrete Construction”

The certification candidate can expect exam questions to focus on such areas as:

- Knowledge of ACI, NCMA standards
- Basic reinforced concrete design theory and practice
- Basic reinforced and unreinforced concrete masonry design theory and practice
- Reinforced concrete construction procedures for building structures
- Reinforced and unreinforced concrete masonry construction procedures for building structures
- Methods of concrete and masonry deterioration and repair
- Investigative testing for concrete and masonry

## **10. BODY OF KNOWLEDGE – PLUMBING / FIRE PROTECTION SYSTEMS / SOLID WASTE MANAGEMENT**

The certification candidate should be thoroughly familiar with:

1. Basic principles of residential and commercial fire protection design and construction
2. Various types of residential and commercial fire suppression systems
3. Functional requirements for on-site fire protection equipment and systems
4. Design and construction requirements for plumbing systems as contained in the International Building Code
5. Basic design principles for potable water and waste water systems
6. Basic principles of various on-site sanitary waste disposal systems
7. Functional requirements for operation of potable water and waste water systems

Applicable study references might include, but are not limited to:

- International Fire Code
- International Plumbing Code
- International Private Sewage Disposal Code
- *Standard Handbook for Civil Engineers* as published by McGraw Hill
- *Standard Handbook for Mechanical Engineers* as published by McGraw Hill

The certification candidate can expect exam questions to focus on such areas as:

- Fire rated assemblies
- Sprinkler system components
- Fire detection systems
- Fire suppression systems
- Sprinkler system design
- Pipe pitch requirements
- Various types of drain traps
- Venting: plumbing, water heater, fireplace
- Pressure relief valves
- Ejectors
- Residential, on-site septic systems
- Lightning protection

## **11. BODY OF KNOWLEDGE - BUILDING ELECTRICAL SYSTEMS**

The certification candidate should be thoroughly familiar with:

1. Basic understanding of electrical theory, including: Ohm's Law, AC and DC power, units of electricity (power and energy)
2. Basic calculations involving voltage, current, resistance and power
3. Working knowledge of electrical power distribution from generator to local building load center
4. Working knowledge of residential and commercial wiring design and construction requirements as contained in National Electric Code
5. Working knowledge of interior building wiring and components
6. Working knowledge of electrical safety requirements such as grounding, bonding, ampacity, ground faults, etc.

Applicable study references might include, but are not limited to:

- National Electrical Code
- International Code Council Electrical Code
- Residential and commercial wiring guides and handbooks

The certification candidate can expect exam questions to focus on such areas as:

- Single- and 3-phase power wiring configurations
- System capacity ratings
- Wire size requirements
- Grounding and Bonding
- Electrodes
- Grounded vs. Ungrounded Disconnects
- Reverse polarity
- 3-phase power use
- Hot, neutral and ground conductors
- Transformers
- Electrical outlets, ground fault circuit interruptors, arc fault circuit interruptors, switches and breakers
- Non-metallic wiring
- Wiring systems found in residential construction
- Color coding of wiring
- Lightning protection

## **12. BODY OF KNOWLEDGE - INTEGRATED BUILDING SYSTEM DESIGN**

The certification candidate should be thoroughly familiar with:

1. HVAC and electrical systems interaction and integration
2. HVAC and plumbing systems interaction and integration
3. Plumbing and electrical systems interaction and integration
4. HVAC and building envelope/structural systems interaction and integration
5. Benefits of systems integration
6. Disadvantages of systems integration
7. Responsibility for systems integration

Applicable study references might include, but are not limited to:

- *Architectural Graphic Standards* as published by John Wiley and Sons
- *Mechanical and Electrical Equipment for Buildings* as published by John Wiley and Sons

The certification candidate can expect exam questions to focus on such areas as:

- Mini-cases to be judged
- Building envelope/structural issues related to other systems
- Engineering diagnostic capabilities

### **13. BODY OF KNOWLEDGE - GEOTECHNICAL ENGINEERING**

The certification candidate should be thoroughly familiar with:

1. Engineering properties of soils and soil exploration
2. Consolidation of soil and settlement of structures
3. Shallow foundations
4. Pile foundations
5. Drilled caissons
6. Retaining structures
7. Expansive soil
8. Lateral movement and slope stability
9. Causes of foundation failure
10. Groundwater and moisture problems
11. Repair methods

Applicable study references might include, but are not limited to:

- *Essentials of Soil Mechanics and Foundations* as published by Pearson Prentice Hall
- Geotechnical engineering handbooks
- Foundation design handbooks
- Foundation repair handbooks
- *Design and Repair of Residential and Light Commercial Foundations* as published by McGraw Hill

The certification candidate can expect exam questions to focus on such areas as:

- Categories of soil
- Causes of settlement and slope failure
- Bearing capacity of piles, caissons, and various repair piers
- Foundation failure

#### **14. BODY OF KNOWLEDGE - BUILDING MECHANICAL SYSTEMS**

The certification candidate should be thoroughly familiar with:

1. Vertical transportation types
2. Traction equipment
3. Hydraulic equipment
4. Safety devices
5. Hoistways
6. Pits
7. Moving walkways
8. Safety codes governing vertical transportation (ANSI/ASME)
9. Inspection of vertical transportation systems
10. Boiler types
11. Boiler design
12. Steam generating equipment
13. Liquid fuel-fired boilers
14. Gas-fired boilers
15. Boiler ratings
16. Applicable codes and standards
17. Boiler and pressure vessel safety devices
18. Boiler inspection
19. Building HVAC systems and ancillary equipment
20. HVAC system performance

Applicable study references might include, but are not limited to:

- Applicable ASME and ANSI standards
- *Mechanical and Electrical Equipment for Buildings* as published by John Wiley and Sons

The certification candidate can expect exam questions to focus on such areas as:

- Building elevators
- HVAC system performance issues
- HVAC equipment issues
- HVAC system operational aspects
- Code-based issues

## **15. BODY OF KNOWLEDGE - SITE FEATURES, INCLUDING SECURITY**

The certification candidate should be thoroughly familiar with:

1. Site planning, zoning, property boundary and easement issues
2. Site hydrology including pervious/impervious coverage and drainage features
3. Site access, driveways, walkways and ADA accessibility
4. Site security issues
5. Site development and construction issues

Applicable study references might include, but are not limited to:

- GSA Site Security Standards
- *Standard Handbook for Civil Engineers*, Merritt, Section, "Site Design"

The certification candidate can expect exam questions to focus on such areas as:

- Standard site planning criteria
- Site construction standards
- Security considerations in site layout
- Site grading and drainage structure construction
- Legal issues relating to site development
- Code requirements relating to site development
- Building structure site location
- Features affecting site hydrology

## **16. BODY OF KNOWLEDGE - BUILDING CODES AND STANDARDS, INCLUDING ADA COMPLIANCE**

The certification candidate should be thoroughly familiar with:

1. Building code objectives
2. Adoption and enforcement of codes
3. Applicable codes
4. Building code creation
5. Relationship of building codes and construction quality
6. When do codes apply?
7. Where do codes apply?
8. Residential and commercial code enforcement and compliance differences
9. ADA and its enforcement issues
10. ADA standards applicable to buildings
11. ADA jurisdiction

Applicable study references might include, but are not limited to:

- Code manuals as published by the International Code Council

The certification candidate can expect exam questions to focus on such areas as:

- Common specific code requirements
- Incorporation of industry standards into building codes
- Purpose of certain code features
- Agencies having enforcement powers
- Model codes
- Professionals involved with building codes

## **17. BODY OF KNOWLEDGE - ENGINEERING ECONOMICS**

The certification candidate should be thoroughly familiar with:

1. Engineering economics and the requirements of economic studies
2. Value analysis
3. Interest and money time relationships
4. Depreciation
5. Cost estimating
6. Basic methods for economic studies
7. Replacement and reserve studies

Applicable study references might include, but are not limited to:

- Engineering Economics textbooks
- P.E. Exam Study Guides

The certification candidate can expect exam questions to focus on such areas as:

- Present worth, future worth and sinking funds
- Equivalence calculations
- Cash flow diagrams
- Present worth calculations
- Salvage value for replacement studies
- Income tax considerations
- Estimating economic life

## **18. BODY OF KNOWLEDGE - INVESTIGATIVE METHODS AND FORENSICS**

The certification candidate should be thoroughly familiar with:

1. Scientific methods of analysis
2. Impartial and ethical conduct
3. Legal procedures and perspectives
4. Review of building design, construction and maintenance records
5. Site observations and gathering of facts
6. Documentation of site conditions, damage, and defects
7. Probable causes of failure or defects
8. Report with clarity and precision
9. Deposition testimony
10. Court testimony
11. Inspection tools and procedures

Applicable study references might include, but are not limited to:

- *Cross-Examination from the Comprehensive Guide for Experts* as published by Seak, Inc.
- Forensic engineering handbooks
- Guides for expert witnesses
- Civil engineering handbooks
- *Forensic Engineering Investigation* as published by CRC

The applicant should also be familiar with the following:

- Types and causes of cracking in foundations
- Tools and methods for evaluation of concrete and reinforcement
- NABIE Standards of Practice
- Destructive and non-destructive test methods

## **19. BODY OF KNOWLEDGE - ENVIRONMENTAL ISSUES**

The certification candidate should be thoroughly familiar with:

1. Establishment and enforcement of environmental standards
2. Standards applicable to commercial buildings
3. Standards applicable to residential buildings
4. Definition of hazardous materials
5. Common hazardous materials found in buildings
6. Relationship between environmental issues and personal health
7. Relationship between environmental issues and national or global air quality
8. Significance of indoor air quality (IAQ)
9. Relevant ASTM and ASHRAE standards

Applicable study references might include, but are not limited to:

- ASHRAE Handbooks on *Fundamentals*, *HVAC Applications*, and *HVAC Systems and Equipment*
- ASTM environmental assessment standards

The certification candidate can expect exam questions to focus on such areas as:

- Knowledge of relevant standards and subject matter
- Familiarity with indoor contaminants and mitigation
- Familiarity with site contaminants and mitigation
- Qualified professionals in environmental issues
- Familiarity with applicable legislation and requirements of same

**20. BODY OF KNOWLEDGE – WRITTEN COMMUNICATION FOR ENGINEERS, INCLUDING LIABILITY ISSUES AND STANDARDS OF PRACTICE**

The certification candidate should be thoroughly familiar with:

1. National Academy of Building Inspection Engineers (NABIE) Standards of Practice
2. ASTM and ASCE requirements
3. General requirements of state with inspection licensing laws
4. General requirements of other organizations representing aspects of non-engineering based inspection

Applicable study references might include, but are not limited to:

- ASCE standards applicable to structural condition assessment of existing buildings
- ASTM standards applicable to property condition assessments
- *EXPERT: A Guide to Service as a Forensic Professional and Expert Witness* as published by ASFE: Professional Firms Practicing in the Geosciences
- NABIE Standards of Practice
- Professional Engineering ethics codes as promulgated by NSPE, other engineering organizations, or states

The certification candidate can expect exam questions to focus on such areas as:

- Building inspection engineering services
- Liability issues related to inspection engineering services, and liability mitigation
- Inspection engineering services as distinguished from other inspection services
- Findings disclosure as required by applicable standards and laws
- Liability insurance applicable to inspection engineering
- Contract and report structure and language
- Use of written reports

## **21. BODY OF KNOWLEDGE - PROFESSIONAL PRACTICE AND ETHICS**

The certification candidate should be thoroughly familiar with:

1. Ethics
2. Liability issues
3. Professional engineering judgment and analysis
4. Inspection engineering criteria
5. Contracts

Applicable study references might include, but are not limited to:

- *EXPERT: A Guide to Service as a Forensic Professional and Expert Witness* as published by ASFE: Professional Firms Practicing in the Geosciences
- *Modern Engineering Practice* as published by Garland STPM Press
- Professional Engineering ethics codes as promulgated by NSPE, other engineering organizations, or states

The certification candidate can expect exam questions to focus on such areas as:

- Work of expert witnesses
- Work of Professional Engineers
- Requirements for inspection engineering services and the use of practice standards
- Issues that must be ethically avoided or disclosed
- Mini-cases that must be judged
- Torts and criminal actions