April 16, 2013

BUILDING DESIGN AND CONSTRUCTION SYSTEMS
Presented by AIA-Pittsburgh’s Young Architects’ Forum (YAF)
Exam resources are available at AIA-PGH YAF ARE Review
http://yafpghare.wordpress.com/
Confidentiality Agreement

By taking divisions of the ARE, candidates are personally responsible for maintaining the confidentiality of all information relating to the exam. They may not discuss exam content in any manner with anyone, including but not limited to family, friends, other examinees, and test preparation providers. This agreement also covers internet chat rooms, mailing list servers, web sites, etc.

Any disclosure of ARE content is strictly prohibited and may result in severe disciplinary action, including the suspension of testing privileges, and/or the cancellation of scores.

Candidates choosing to decline the Confidentiality Agreement will have their exam session terminated before being exposed to any exam content. The exam fee for the division WILL NOT be refunded if a candidate chooses to decline the agreement and end his or her exam.
Division Statement
The application of knowledge and skills of building design and construction, including environmental, social, and economic issues, project and practice management.

Exam Structure
- 85 Multiple-Choice Questions
- 3 Graphic Vignettes
  - Accessibility/ Ramp
  - Stair Design
  - Roof Plan
Test Day...

- Introductory Tutorial 0:15
- Multiple-Choice Questions 1:45
- Scheduled (Mandatory) Break 0:15
- Introductory Tutorial 0:15
- Graphic Vignettes 2:45
- Exit Questionnaire 0:15
- TOTAL APPOINTMENT TIME 5:30
# Suggested Sequence

- Construction Documents and Services
- Programming Planning and Practice
- Site Planning and Design

<table>
<thead>
<tr>
<th>Block 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Systems</td>
</tr>
<tr>
<td>Building Systems</td>
</tr>
<tr>
<td>Building Design and Construction Systems</td>
</tr>
</tbody>
</table>

- Schematic Design
Content Areas

PRINCIPLES (27-36 percent of scored items)
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.

ENVIRONMENTAL ISSUES (11-17 percent of scored items)
Consider the principles of sustainable design including adaptive re-use, thermal and moisture protection, and hazardous material mitigation.

CODES & REGULATIONS (7-10 percent of scored items)
Incorporate building and specialty codes, zoning, and other regulatory requirements in building design and construction systems.

PROJECT & PRACTICE MANAGEMENT (7-13 percent of scored items)
Assess the implication of construction sequencing, scheduling, cost, and risk management in the selection of systems, materials, and methods.
Content Areas, continued

MATERIALS & TECHNOLOGY (31-40 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 structural and finish materials.

B. Metals Identify the properties and characteristics of structural and miscellaneous metals.

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

D. Concrete Identify the properties and characteristics of concrete structures and finishes.

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

F. Specialties Analyze and select accessories, equipment, and fittings.
By the numbers...

- 85 questions...
- 1 hour 45 minutes testing time...
  ...1 minute, 14 seconds per question

By content areas...

- Principles.................................................................23 - 31 questions
- Environmental Issues..............................................9 - 15 questions
- Codes/ Regulations...................................................6 - 9 questions
- Materials and Technology......................................26 – 34 questions
- Project/ Practice Management.................................6 - 11 questions
PRINCIPLES

Architectural Exemplars
Building Design Methodologies
The John Deere World Headquarters in Moline, Illinois (Eero Saarinen, 1964) pioneered the use of what material?

A. Post-tensioned concrete
B. Cor-Ten steel
C. Terra-cotta rainscreen
D. Triple-glazed curtain wall
ENVIROMNENTAL ISSUES

“Sustainability”
Vocabulary

Sustainability ≠ LEED
Sample Question

The planning phase of a sustainably designed architectural project should include which of the following elements?

I. Native landscaping that is aesthetically pleasing and functional;
II. Designing structures in the floodplain that can resist the forces of flood waters;
III. Consideration of sun orientation, topographic relief, and the scale of adjacent buildings;
IV. Locating projects within existing neighborhoods that are adjacent to public transportation.

A. I and II  
B. I and III  
C. I, III, and IV  
D. All of the above
Sample Question

- The Ahwahnee principles include which of the following ideas?
  I. Communities with only residential use should be relegated to areas outside of the central business district;
  II. Preserved open spaces should be either wildlife habitats or recreational areas;
  III. Transportation planning should include roads, pedestrian paths, bike paths, and mass transit systems;
  IV. Job creation and economic diversity is a desired goal.

A. I  B. II, III, and IV  
C. III and IV  D. None of the above
CODES AND REGULATIONS

Life Safety/ Egress
Accessibility
Means of Egress

- Three main components:
  - Exit access
    - Complete path from any location in the building to the EXIT
    - MOST complex portion of egress
  - Exit
    - Takes an occupant from the building or floor to a:
      - Vertical exit enclosure
      - Horizontal exit
      - Exterior exit ramp or stairway
  - Exit discharge
    - Opens to public right-of-way
Means of Egress

- Three main components:
Exit Access

- Defined by the following Building Code factors:
  - Occupancy (Chapter 3, modified by Chapter 4)  
    - which defines the...
  - Occupant Load (Chapter 10, Section 1004)  
    - which determines...
  - Egress Width (Section 1005)  
    - which is divided among...
  - Number of Exits (Table 1015.1 and 1019.1)  
    - The locations of which are controlled by...
  - Exit Separation Distance (Section 1015.2)  
    - which affects the...
  - Travel Distance to an Exit (Table 1016.1)  
    - which can be limited by...
  - Common Path of Travel Requirement (Section 1014.3)

- “Safest” Occupancy Type: Business (B)
Sample Question

Which of the following factors are to be considered in determining the allowable area of a building?

I. Occupancy
II. Type of construction
III. Percentage of building frontage accessible to a public way or open space
IV. Automatic sprinkler system
V. Number of stories in the building

A. I, II, and IV  
C. I, II, IV, and V  
B. I, II, III, and IV  
D. I, II, III, IV, and V
Sample Question

- Which of the following provide information for designing facilities accessible to persons with disabilities?
  I. ICC/ ANSI 117.1
  II. FHAG
  III. ADAAG
  IV. UFAS
  V. IBC
  VI. All of the above
PROJECT & PRACTICE MANAGEMENT

Contracts
Scheduling
AIA Documents

- **NOTE:** Since July 2010, the ARE references the 2007 edition of the AIA Documents.

- **A-Series – Owner-Contractor Agreements:**
  - **A101–2007** Standard Form of Agreement Between Owner and Contractor -- Stipulated Sum
  - **A102–2007** Standard Form of Agreement Between Owner and Contractor -- Cost of the Work Plus a Fee with a Guaranteed Maximum Price
  - **A103–2007** Standard Form of Agreement Between Owner and Contractor -- Cost of the Work Plus a Fee without a Guaranteed Maximum Price
  - **A105–2007** Standard Form of Agreement Between Owner and Contractor – Residential/ Small Commercial Project
  - **A107–2007** Standard Form of Agreement Between Owner and Contractor -- Limited Scope
  - **A201–2007** General Conditions of the Contract for Construction
AIA Documents

- **NOTE:** Since July 2010, the ARE references the 2007 edition of the AIA Documents.

- **B-Series – Owner-Architect Agreements**
  - B101–2007 Standard Form of Agreement Between Owner and Architect
  - B102–2007 Standard Form of Agreement Between Owner and Architect
    - No Predefined Scope of Architect’s Services
  - B104–2007 Standard Form of Agreement Between Owner and Architect --
    - Project of Limited Scope
  - B105–2007 Standard Form of Agreement Between Owner and Architect --
    - Residential/ Small Commercial Project
  - B195–2008 Standard Form of Agreement Between Owner and Architect --
    - Integrated Project Delivery
  - B202–2009 Standard Form of Architect’s Services: Programming
  - B211–2007 Standard Form of Architect’s Services: Commissioning
  - B214–2007 Standard Form of Architect’s Services: LEED® Certification
AIA Documents

- NOTE: Since July 2010, the ARE references the 2007 edition of the AIA Documents.

- C-Series – Other Agreements
  - C401–2007 Standard Form of Agreement Between Architect and Consultant

- G-Series -- Contract Administration and Project Management Forms
  - G701–2001 Change Order
  - G702–1992 Application and Certificate for Payment
  - G703–1992 Continuation Sheet
  - G704–2000 Certificate of Substantial Completion

- View a complete list of AIA Documents at http://www.aia.org/contractdocs/aiabo81445
Project Scheduling

Critical Path Method (CPM)

Three main components

• A list of all activities required to complete the project
  • Typically organized by Masterformat division or trade
  • Can become extremely complex (phased projects, multiple primes)
• The time (duration) that each activity will take to completion
  • Start date
  • Finish date
  • Milestone date(s)
• The dependencies between the activities.
  • Predecessors
  • Successors
  • Example:
    • Metal framing
    • Drywall installation
    • Paint
    • Ceramic tile
Project Scheduling

Gantt chart *(developed by Henry Gantt, 1910)*
Sample Question

- In the critical path method of project management (CPM), the amount of time that a task in a project network can be delayed without causing a delay to subsequent tasks or the project completion date is known as what?

A. Float
B. Limbo
C. Backlog
D. Change order
MATERIALS AND SYSTEMS

“Materials and Methods”
CSI Masterformat

- Division 03 — ?????
- Division 04 — ?????
- Division 05 — ?????
- Division 06 — ?????
- Division 07 — ?????
- Division 08 — ?????
- Division 09 — ?????
- Division 10 — ?????
- Division 11 — ?????
- Division 12 — ?????
- Division 13 — ?????
- Division 14 — ?????
Concrete
Vocabulary

Cement ≠ Concrete
Concrete consists of

- large aggregate
- small aggregate
- Portland cement
- water
- admixtures (optional)

- Curing of concrete is an EXOTHERMIC reaction
- Heat given off by this process is known as HEAT OF HYDRATION
Portland Cement

- Type I – Standard
- Type II – Modified
- Type III – High Early Strength
- Type IV – Low Heat
- Type V – Sulfate Resistant
Water-cement ratio

- Approximately 0.25 (25 parts water for every 100 parts cement) is required for all the cement particles to hydrate.
- Water beyond that is surplus and is used to make the plastic concrete more workable.
- Inverse relationship...
  - Higher water content = lower compressive strength
  - Lower water content = higher compressive strength
- Excess water can lead to chalky deposits on the surfaces of curing concrete known as... LAITANCE
Division 3 Sample Question

When concrete is scheduled to be poured in hot weather, the architect should specify what type of admixture be included in the mix design?

A. Retarding agent
B. Air-entraining agent
C. Hardening agent
D. Workability agent
Admixtures

- Accelerators
  - Speed up setting time
- Air-Entraining
  - Resist freezing
- Retarders
  - Slow down setting time
- Waterproofing
  - Decrease permeability
- Water-Reducing
  - Reduce water content (increases strength)
- Workability
  - Improve workability
Division 04 – Masonry
Brick Coursing Types

- Stretcher
- Header
- Rowlock
- Soldier
- Sailor
- Shiner
Masonry Mortar Joints

- Concave
- Weathered
- Flush
- Beaded
- Raked
- Struck
- Grapevine
- Extruded
Division 4 Sample Question

During a weekly job-site visit, the architect notices that the mason has used troweled joints on an exposed exterior masonry wall, instead of the weather-struck joints that were specified. In the interests of practicality, the architect should:

A. Accept this change, since there is little difference between the two joints;

B. Accept the change, because there is no practical way to modify troweled joints;

C. Reject the work and have the mason trowel additional mortar over every horizontal joint;

D. Reject the work and have the entire wall rebuilt.
Vocabulary

Precast ≠ Cast Stone ≠ Limestone
Division 05 —

Metals
Two Main Types

- **Ferrous**
  - contain high concentrations of iron
    - wrought iron (<2% carbon content)
    - cast iron (2% carbon content)
      - strong but brittle

- **Non-ferrous**
  - contain little to no iron
  - resistant to corrosion (ferrous oxide)
Vocabulary

Steel $\neq$ metal
Metal Alloys

Mixture of a base metal with another substance (usually another metal) to enhance its properties

- **Brass:** Copper and zinc
  - Finish hardware, plumbing/ heating components and fittings
- **Bronze:** Copper and tin
  - Decorative items (sculpture, ornament)
- **Monel:** Nickel and copper
  - Roofing, flashing, commercial kitchen equipment
- **Terne:** Lead/zinc and tin
  - Coating for roofing, including trim and flashing
Galvanic Action (aka Electrolysis)

Galvanic Series

Most noble (cathodic)
- Gold/ Platinum
- Titanium
- Silver
- Stainless Steel
- Bronze
- Copper
- Brass
- Nickel
- Tin
- Lead
- Iron/ Steel
- Cadmium
- Aluminum
- Zinc
- Magnesium

Least noble (anodic)
- “sacrificial anode”

Galvanic Action can be prevented by:
- isolation of dissimilar metals
- metal finishing processes
Metal Finishes

- Galvanized
  - Protective coating of zinc applied through a molten bath
- Anodized
  - Protective coating applied through electrolytic action
- Galvannealed
  - Galvanized and annealed
- Annealed (heat strengthened)
  - Metallurgical process... not a true “finish”
  - (Molten steel is supercooled, core cools slowly)
- Galvalume
  - Proprietary name (marketed by US Steel)
  - Proper name: Aluminum-Zinc Alloy-Coated Steel
Division 5 Sample Question

- Which of the following metals is MOST resistant to galvanic deterioration?

A. Bronze
B. Brass
C. Copper
D. Lead
Division 06 –

Wood, Plastics, and Composites
Typical Wood Defects

- Bow
- Twist
- Knot
- Cup
- Crook
- Checking
- Split
Cut Lumber
Plywood Veneer Slicing

Plain

Quarter

Rift

Rotary
If the architect wishes to use wood siding with a highly figured grain pattern, he/she would specify:

A. Rift cut lumber
B. Plain-sawn lumber
C. Quarter-sawn lumber
D. Factory and shop lumber
Division 07 –
Thermal and Moisture Protection
...includes, but is not limited to, the following:

- Waterproofing
- Dampproofing
- Thermal Insulation
- Fireproofing
- Expansion Control
- Joint Sealants
- Roofing
- Flashing *
Vocabulary

Flashing ≠ Waterproofing
Division 7 Sample Question

- Flashing is generally required to be installed at all of the following locations, EXCEPT:

  A. At the juncture of a masonry parapet and turned-up composition roofing material

  B. At the standing seams of galvanized metal roof

  C. At a plumbing-vent penetration of a sloping asphalt sheet roof

  D. At the head of a metal window frame in a masonry wall.
Fire-Rated Doors -- Labels

- Rule of thumb: door rating is typically 3/4 of the wall rating

- A: 3 hours (180 minutes) for 4-hour rated walls
- B: 1.5 hours (90 minutes) for 2-hour rated walls
- C: .75 hours (45 minutes) for 1-hour rated walls
- D: 1.5 hours (90 minutes) (exterior walls)
- E: .75 hours (45 minutes) (exterior walls)

- Rated doors and rated frames function together as a unit
Door Hardware

**LF2000 Entrance/Office**
Pushing and turning button locks outside lever requiring use of key until button is manually unlocked. Pushing button locks outside lever until unlocked with key or inside lever is turned.

**LF2100 Passage**
Both levers always free.

**LF2200 Privacy**
Pushbutton locking. Can be opened from outside in case of emergency by narrow tool.

**LF2400 Storeroom**
Outer lever fixed. Entrance by key only. Inner lever always free.

**LF2500 Classroom**
Outer lever locked or unlocked by key outside. Inner lever always free.

**LF2900 Institutional**
Both levers fixed. Entrance by key in either side.
Division 8 Sample Question

- The principal disadvantage of aluminum door and window sections is their:

  A. High initial expense
  B. Lack of durability
  C. Poor resistance to galvanic action
  D. Poor resistance to building stresses
Division 09

Finishes
Fire/ Smoke Propagation

- **Flame Spread Ratings**
  - Measured by ASTM E 84 (“Steiner Tunnel Test”)
  - Also known as NFPA 255 and/or UL 992

- **Classifications:**
  - Class A (formerly Class I): Flame Spread Index: 0 to 25
  - Class B (formerly Class II): Flame Spread Index: 26 to 75
  - Class C (formerly Class III): Flame Spread Index: 76 to 200

- **Smoke Development**
  - Measurement of smoke density generated by the above test(s)
  - Maximum smoke development of 450

- **Floor Finishes**
  - Tested under different criteria (ASTM D 2859/ NFPA 253)
Plaster

- Wet mixture of sand, water, and cementitious material
  - Interior applications: gypsum
  - Exterior applications: Portland cement and lime
- Can be applied directly over masonry
- Applied over LATH on framed walls
  - Metal mesh (galvanized for exterior applications)
  - Gypsum-based lathing board
- Applied in three coats:
  - Scratch coat 1/4” thick
  - Brown coat 1/4” thick (sand content 3:1)
  - Finish coat 1/8” thick (veneer plaster)

- Plaster work... Is extremely labor intensive and messy
  Involves significant curing time
  Requires a skilled applicator
Vocabulary

Level 5 Finish
≠
Plaster Skim Coat
<table>
<thead>
<tr>
<th>Type</th>
<th>Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-vitreous</td>
<td>7-15% absorption</td>
</tr>
<tr>
<td>Semi-vitreous</td>
<td>3-7% absorption</td>
</tr>
<tr>
<td>Vitreous</td>
<td>&lt;3% absorption</td>
</tr>
<tr>
<td>Impervious</td>
<td>virtually no absorption</td>
</tr>
</tbody>
</table>
Paint

- Powdered PIGMENT suspended in a BINDER/VEHICLE...
  - BINDER evaporates, leaving the PIGMENT behind as a thin film
  - SOLVENTS modify viscosity to improve workability
  - ADDITIVES enhance properties

- Paint finishes:
  - FLAT........ matte finish, no sheen; difficult to clean
  - SEMI-GLOSS....... mid-range sheen
  - EGGSHELL.......... “dimpled” appearance; easily cleaned
  - HIGH-GLOSS........ high sheen/ lustre easiest to clean

- Most important aspect of paint installation is SURFACE PREPARATION
Division 9 Sample Question

- Painting failures are most often caused by which of the following?

  A. Poor quality paint materials
  B. Faulty application methods
  C. Surfaces that are not clean, dry, and properly prepared
  D. Application during hot and humid weather conditions
Which of the following statements apply to the scratch coat of plaster?

I. It is generally the first plaster coat.
II. It consists of a mixture of portland cement, or gypsum and lime, with water and sand.
III. It is generally applied over gypsum lath.
IV. It is always applied by hand.
V. It is rarely less than ¾ inch thick.

A. I and II
B. I, II, and III
C. III, IV, and V
D. I, II, III, and IV
Sample Question

- The item marked “X” in the floor plan below would be found in which of the following specification sections?
  A. Division 10
  B. Division 11
  C. Division 13
  D. Division 26
Division 14

Conveying Equipment
(Vertical Transportation)
In the design of a three-story commercial building with a maximum height of 45 feet, the architect wishes to have a constant roof silhouette with no projections above the parapet. Consequently, the architect should choose:

A. An electric elevator with geared traction and operating machinery at the basement level
B. A gearless electric elevator with operating machinery in a four-foot high roof structure
C. A hydraulic elevator with operating machinery in a four-foot high roof penthouse
D. A hydraulic elevator with operating machinery located directly adjacent to the elevator pit.
General Tips…

- Study comprehensively… review content from related divisions!
- Save practice tests until the week before the exam.
- Don’t get stuck – mark questions for review.
- Answer every question!
QUESTIONS...?
Content Areas

- **Accessibility/ Ramp**
  - Develop a ramp and stair system that connects two distinct floor elevations. Indicate all required landings, handrails, guardrails, and rail extensions per programmatic requirements, a model code, and design logic.

- **Stair Design**
  - Develop a stair assembly that connects three distinct floor elevations. Indicate elevations of all landings and stair flights, and describe all required handrails, guardrails, and rail extensions. Provide proper headroom clearances at all floor levels. Completed solution must meet programmatic requirements, a model code, and design logic.

- **Roof Plan**
  - Design a roof for a building with multiple roof planes. For each roof area, define the extent, slope, and provide spot elevations for planes designed for effective removal of rainwater. Place all required programmatic elements such as clerestories and skylights, locate plumbing stacks and mechanical units, and provide all necessary flashing, crickets, gutters, and downspouts.
By the numbers...

- 3 vignettes...
- 2 hours 45 minutes test time...

55 minutes per vignette
Accessibility/ Ramp

Develop a ramp and stair system that connects two distinct floor elevations.
Indicate all required landings, handrails, guardrails, and rail extensions per programmatic requirements, a model code, and design logic.
Accessibility/ Ramp
Sample PASSING Solution
Accessibility/ Ramp Sample FAILING Solution

- Door swings the wrong direction.
- Landings are too small.
- Two ramps are not necessary.
- Both ramps are too short and therefore steeper than 1:12.
Stair Design

Develop a stair assembly that connects three distinct floor elevations. Indicate elevations of all landings and stair flights, and describe all required handrails, guardrails, and rail extensions. Provide proper headroom clearances at all floor levels. Completed solution must meet programmatic requirements, a model code, and design logic.
Stair Design
Sample PASSING Solution
Stair Design
Sample Failing Solution

- 6’-9” landing elevation only allows for 5’-9” headroom clearance.
- Inadequate clearance at door.
- Area of refuge (shown by sketch rectangle) does not meet code.

Second Floor Plan
Design a roof for a building with multiple roof planes. For each roof area, define the extent, slope, and provide spot elevations for planes designed for effective removal of rainwater. Place all required programmatic elements such as clerestories and skylights, locate plumbing stacks and mechanical units, and provide all necessary flashing, crickets, gutters, and downspouts.
Roof Plan
Sample PASSING Solution
Roof Plan
Sample FAILING Solution

- Roof planes do not properly meet at the same elevation.
- Height ignores the 18" thickness of roof structure.
- Missing gutters and downspouts.
- Lower than allowed minimum slope.
- HVAC unit too close to roof edge.
General Tips...

Clear your head.
Remember – it’s not AutoCAD...
... or design studio.
Practice makes perfect...
... but don’t over-practice!!
Take your time.
Follow all of the instructions!!
Don’t second-guess yourself.
THANKS!