Resolution of Deficiencies in Engineering Education

By Kevin Dong, P.E., S.E.

This is the second article in the Engineering Education series, focused on education requirements and lifelong learning for structural engineers. The series provides suggested self-teaching course content outlines for Structural Steel, Reinforced Concrete, and Timber and Masonry prepared by the Basic Education Committee of NCSEA. The author has prepared the **Concrete Design** curriculum outline in this article for those needing guidance in selecting a course that will help them become a more rounded structural engineer.

Concrete Design Course Content

- Mechanics and assumptions of reinforce concrete design
  - Whitney stress block
  - Reinforcement ratios and the balanced condition
  - Cracked section properties
- Gravity load resisting systems
  - Column design
    - Premise of design equations
    - Un-braced length, slenderness ratio, and second order effects
    - Ties and cross ties to achieve confinement
    - Reinforcement ratios and limits
    - Deformation compatibility and ACI Chapter 21 requirements
  - Beam/one-way slab design
    - Limit states, such as tension control, and its relationship to the steel ratio
    - Tee-beams
    - Shear design
    - Deflection and serviceability limits
      - Cracked section properties, creep, and compression reinforcement
  - Beam-column elements
    - Combined stresses – P vs. M diagram
      - Compression controlled, balance point, and tension controlled regions
    - Second order effects and slenderness
  - Basic connection principles
    - Development length, splices, and hooks
- Lateral load resisting systems
  - Understand the failure mechanisms and required detailing to ensure the failure mechanism can be formed. The system proposed for study: special concrete walls
  - Special Concrete Walls
    - Statics and basic wall thickness considerations
    - Web reinforcement – "code" level and capacity level
    - Shear friction at construction/ pour joints
    - Boundary elements
    - Amplified loads per ASCE 7versus designing for flexural yielding
    - Computer analysis and modeling to "match" proposed design philosophy and wall detailing
  - Diaphragms
    - Diaphragm shear
    - Drags and chords
    - Amplified loads and capacity-based design
    - Deformation compatibility
- Foundations
  - Shallow footings
    - Design of a simple pad footing for beam shear, punching shear, and flexure. Plus introduction of simplified design methods
    - Constructability considerations and construction sequencing
  - Shear wall footing
    - Applicable load cases
    - Overturning and bearing
    - Stress distribution when axial and moment are considered
    - Potential failure mechanisms or critical sections for shear and bending
    - Transverse reinforcement and strong band concept
- Construction Documentation
  - General Notes
    - Relation to project specifications
    - Content and purpose of general note sheets
  - Framing Plans and "industry standards" for notation
    - Line weights, line types, hatching, dimensioning, text work
    - Information required to build, such as openings, dimensioning, and misc. framing members for items such as a roof screen
  - Frame elevations
    - Walls – detail references, framing members intersecting walls, and considerations for splice locations, mechanical couplers, boundary zones, and starter dowels
  - Detailing
    - Load path and detailing for typical gravity elements: slab-on-grade, pad footings, beam to girder (reinforcement layering), beam to columns (reinforcement congestion), and column schedules
    - Load path and detailing for diaphragms and shear walls: collectors and tension reinforcement, boundary zones, wall sections at base, floor, and roof
    - The bread and butter of the industry, but again, academia does not adequately cover this topic and this is integral to design and ultimately building performance
- Elective Topics – not necessary to achieve the goal of life long learning, but helpful to integrate into practice
  - Two-way slab design: flat slabs and plates
    - Direct design method
    - Equivalent frame method
    - Drop panels/shear panels
    - Moment frames
  - Strong column – weak beam concept
    - Beam shear and column moment
    - Joint shear

The full Basic Education for Structural Engineers program containing curriculum, course content and desired outcomes can be viewed at the STRUCTURE website, **www.STRUCTUREmag.org**. (see the "Education" pages) Structural steel curriculum was discussed in the June 2011 issue of STRUCTURE. The third and final article in this series will address **Timber and Masonry design**. Kevin Dong and the Basic Education Committee of NCSEA welcome your comments.▪

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