The National Council of Structural Engineers Associations (NCSEA) recommends that structural engineering students receive instruction on the following twelve courses as part of their education. The NCSEA structural engineering curriculum was developed by practitioners and educators to improve the quality of structural engineering education.

NCSEA RECOMMENDED STRUCTURAL ENGINEERING CURRICULUM:

1. Analysis 1
2. Analysis 2
3. Matrix Methods
4. Steel Design 1
5. Steel Design 2
6. Concrete 1
7. Concrete 2
8. Technical Writing
9. Timber
10. Dynamic Behavior (including seismic)
11. Foundation Design / Soil Mechanics
12. Masonry

NCSEA RECOMMENDED STRUCTURAL ENGINEERING CURRICULUM COURSE CONTENT:

1. Analysis 1

Analysis 1 Recommended Course Topics:

a. Introduction to Structures
b. Forces
c. Moments/couples
d. Equilibrium and stability
e. Concept of stress
f. Concept of strain
g. Stress-strain relationships
h. Plane trusses - method of section and method of joints
i. Frames
j. Shear and bending moment diagrams - focus on the relationship between load, shear, moment and deflection
Analysis 1 Recommended Course Objectives:

a. Identify stable structures
b. Develop and use free-body diagrams
c. Evaluate the internal actions (shear, bending, and axial) in commonly used planar structural systems (trusses, frames, and beams)
d. Draw shear and bending moment diagrams

2. Analysis 2

Analysis 2 Recommended Course Topics:

a. Introduction and review of statics
b. Axially loaded members including indeterminate problems
c. Bending of beams
d. Shear and bending in beams
e. Torsion including indeterminate problems
f. Compressive members/instability
g. Formulate and apply stress transformations and related extensions to principal stresses and maximum in-plane shear stress
h. Compute shear flow and location of shear center for any thin-wall cross-section
i. Understand the derivation and application of flexural deformation using basic principles
j. Slope and displacement of a beam by integration
k. Slope and displacement of a beam by moment-area
l. Indeterminate beam reactions using moment-area
m. Formulation and application of the Euler buckling formula
n. Stress transformation, Mohr’s circle
o. Beam deformations: double integration, moment-area, and indeterminate beam analysis
p. Stability, morphology, and analysis of statistically determinate two- and three-dimensional structural systems
q. Analysis of articulated beams and frames
r. Slope-deflection method
s. Moment distribution for beams and frames
t. Virtual work—trusses, beams, and frames
u. Approximate Methods
v. Influence lines

Analysis 2 Recommended Course Objectives:

a. Compute deformations (axial, shear, and bending) in statically determinate structures using Virtual Work
b. Compute member actions in statically indeterminate structures using Virtual, Work, Slope-Deflection, and Moment Distribution
c. Distinguish between different methods and judge when it is appropriate to use each of the methods
d. Approximate actions in statically determinate and indeterminate structures and judge when it is appropriate to use approximate methods. Use approximate methods to verify computer analysis results
e. Draw influence lines for statically determinate and indeterminate structures and use these influence lines to specify critical loading combinations
f. Determine internal stress distributions at discrete points in the beam
g. Apply relationships between stress and strain under individual and combined loading and determine deformations due to tension
h. Calculate moments of inertia of regular and irregular shapes
i. Evaluate determinacy (including degrees of indeterminacy) and stability
j. Draw deformed shapes for beams and frames

3. Matrix Methods

Matrix Methods Recommended Course Topics:

- a. Review of matrix algebra
- b. Basic concepts: Flexibility versus stiffness
- c. Flexibility method
- d. Stiffness method: Trusses
- e. Stiffness Method: Beams and Frames
- f. Stiffness Method: Three Dimensions
- g. Stiffness Method: Special Topics
- h. Introductions to Finite Element Analysis and Nonlinear Analysis

Matrix Methods Recommended Course Objectives:

- a. Understand the theoretical basis of matrix methods
- b. Model and analyze real-world structures appropriately
- c. Understand advanced analysis methods such as finite element analysis and nonlinear analysis

4. Steel Design 1

Steel Design 1 Recommended Course Topics:

- a. Historical development of steel as a building material
- b. Loading of steel building structures
- c. Properties of structural steel
- d. Design stresses and factors of safety
- e. Design of laterally braced and unbraced beams
- f. Design of beam-columns, use of AISC interaction equations.

Steel Design 1 Recommended Course Objectives:

- a. Understand the use of steel as a building material
- b. Understand the properties of steel including the manufacturing process and types
- c. Analyze and design tension members, beams, and compression elements
- d. Understand the application of the American Institute of Steel Construction Manual of Steel Construction
- e. Recognize, analyze and design combined stress elements

5. Steel Design 2

Steel Design 2 Recommended Course Topics:

- a. Structural design computations for beams, girders, columns and beam-columns
b. Design of connections (bolted and welded)
c. Structural working drawings (plan, elevation and connections details)
d. Overview of failure mechanisms and design procedures for plate girders
e. American Institute of Steel Construction requirements for prevention of various failure mechanisms
f. Design of flanges, web, stiffeners and welds
g. Philosophy of energy absorption in a shear mechanism
h. Requirements for the design of a link, the adjacent beam and the diagonal bracing of an eccentric braced frame

**Steel Design 2 Recommended Course Objectives:**

a. Develop framing schemes for steel structures
b. Design moment and braced frame systems
c. Detail structural steel
d. Design composite sections
e. Design plate girds design (buckling shear)

6. Concrete 1

**Concrete 1 Recommended Course Topics:**

a. Materials
b. Flexural behavior and design
c. Deflections
d. Shear
e. Development of reinforcement
f. Columns

**Concrete 1 Recommended Course Objectives:**

a. Understand material properties of reinforced concrete. Understand concrete member strain and stress states
b. Analyze and design reinforced concrete beams subject to bending, shear, and axial load, including combined stresses
c. Analyze and design reinforced concrete columns for bending, shear and axial load including combined stresses
d. Detail reinforcement to develop required strengths
e. Understand the application of ACI-318

7. Concrete 2

**Concrete 2 Recommended Course Topics:**

a. Introduction, general design principle, materials and anchorages
b. Loss of prestress
c. Analysis of flexural sections
d. Design of flexural sections
e. Design of composite sections
f. Design of shear
g. Prestress transfer bond, anchorage zone
h. Cable profile, deflection
i. Partial prestressed and non-prestressed reinforcement
j. Design of continuous beams
k. Post-tensioning two-way slabs

**Concrete 2 Recommended Course Objectives:**

a. Understanding the reasons and process for selecting prestressed and precast concrete for building systems/elements/architectural use
b. Understand prestressing and precast materials and manufacturing processes
c. Understand structural systems using prestress and precast concrete members and the importance of connections
d. Design of basic structural members using both pre- and post-tensioning
e. Design of connections

8. Technical Writing

**Technical Writing Recommended Course Topics:**

a. Review of basic grammar
b. Report structure
c. Report execution
d. Communicating with lay people

**Technical Writing Recommended Course Objectives:**

a. Craft a technical report/paper, well written and prepared for the target audience.

9. Timber

**Timber Recommended Course Topics:**

a. Properties of wood and lumber/grades
b. Design of members to resist bending
c. Design of members to resist axial forces
d. Design of shear walls and diaphragms
e. Configuration of timber buildings
f. Design of connections

**Timber Recommended Course Objectives:**

a. Understand the material characteristics of timber
b. Design timber beams and columns for axial, shear, bending, and combined stresses
c. Design plywood shear walls and horizontal diaphragms
d. Understand the capacity of connectors (nail and bolts) used in timber construction
e. Understand timber properties that affect its structural performance
f. Develop conceptual designs for timber structural systems that are stable under vertical and lateral loads
g. Describe the load flow through timber structural systems for vertical and lateral loads
10. Dynamic Behavior (including seismic)

**Dynamic Behavior Recommended Course Topics:**

- a. Kinematics of a particle
- b. Kinetics of a particle: Force and acceleration
- d. Kinetics of a particle: Impulse and momentum
- e. Planar kinematics of a rigid body
- f. Planar kinetics of a rigid body: Force and acceleration
- g. Planar kinetics of a rigid body: Work and energy
- h. Planar kinetics of rigid body: Impulse and Momentum
- i. Characteristics of earthquakes; causes, faults, seismic waves, plate-tectonics, magnitude and intensity; strong ground motion, etc.
- j. Response of single-D.O.F. structural systems to earthquake ground motion; concept of response spectra; design spectra; damping, damping ratios
- k. Response of multi-D.O.F. structural systems subjected to earthquake ground motion; mode shapes and frequencies; earthquake response analysis by mode superposition
- l. Inelastic seismic behavior and design of structural systems; concept of ductility
- m. Behavior of building structures under earthquake loading including reinforced concrete, prestressed concrete, steel, masonry and timber structures.

**Dynamic Behavior Recommended Course Objectives:**

- a. Develop a dynamic mathematical model for a rigid body
- b. Write the equation of motion for a rigid body
- c. Determine the response of a rigid body
- d. Apply building code principles to seismic analysis both empirical (static analysis) and modal
- e. Understand response of buildings, influence of soil, principles of damping
- f. Understand lateral forces on parts of buildings and contents

11. Foundation Design / Soil Mechanics

**Foundation Design / Soil Mechanics Recommended Course Topics:**

- a. Description and properties of foundation bearing materials
- b. Field exploration
- c. Lateral earth pressure
- d. Slope stability
- e. Shallow foundation (footings, rafts, mats)
- f. Pile foundations
- g. Caisson foundations
- h. Retaining walls

**Foundation Design / Soil Mechanics Recommended Course Objectives:**

- a. Understand material properties of soils and ledge
- b. Understand the relationship between in-situ foundation bearing materials and allowable foundation and lateral pressure values presented in NFPA/IBC codes
- c. Be able to determine the empirical strength for in-situ bearing material, and design an appropriate deep or shall foundation
d. Understand the effect of seismic forces and liquefaction on foundations

12. Masonry

*Masonry Recommended Course Topics:*

a. Introduction: types of masonry, masonry construction, properties of masonry, grout, mortar, and reinforcement
b. Design and Analysis of Beams and Lintels
c. Design and Analysis of Columns and Pilasters
d. Design and Analysis of Reinforced Masonry Walls; bearing walls and shear walls

*Masonry Recommended Course Objectives:*

a. Identify the unique characteristics and behavior of masonry
b. Analyze and design columns/pilasters, beams/lintels, bearing walls, and shear walls.

The National Council of Structural Engineers Associations values your opinion concerning the NCSEA Recommended Structural Engineering Curriculum. Please provide your input to the NCSEA Basic Education Committee by contacting Brent Perkins, NCSEA Basic Education Committee Chair, at bperkins@dwase.com.