Appendix M

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) YOUTH APPRENTICESHIP

ENGINEERING & TECHNOLOGY PATHWAY CIVIL ENGINEERING (UNIT 5)

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency
1. Apply structural & building principles

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Demonstrate Structural and Building Construction principles understanding based on ***current knowledge and training***
- Comply with specifications, regulations, and codes during the design process

Learning Objectives

STRUCTURAL

- Define a structure
- Explain multidirectional forces applied to structures
- Identify categories of loads acting on structures
- Explain how load-bearing factors are considered in structural design
- Describe the physics of structures to bear loads via walls, columns, and beams
- Explain the characteristics of structural beams, cables, trusses, and other structural forms

BUILDING & CONSTRUCTION

- Recognize how construction skills can aid those in a civil engineering role
- Describe the common processes used in the following construction processes:
  - Steel welding
  - Carpentry
  - Plumbing
  - Roofing
  - Walls & insulation
  - Power generation
  - Highway & road construction
  - Skyscraper construction

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

2. Interpret civil engineering technical drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Interpret civil engineering technical drawings accurately as needed for job task
- Use appropriate terminology
- Identify basic elements of civil engineering technical drawings
- Identify lines, views, symbols, and representations on the drawings as applicable
- Interpret dimensions and scale on the drawings as applicable
- Utilize a metric scale to properly read a drawing

Learning Objectives

- List types and purposes of engineering technical drawings
- Describe the common conventions of civil engineering technical drawings for such things as layout, terminology, interpretation, appearance, size, etc.
- Compare standard views required for civil engineering technical drawings such as multiview, section, detail schedules, etc.
- Identify structural symbols
- Identify site water supply and drainage symbols
- Identify electrical systems connection symbols
- Identify land contour and use symbols
- Explain how site and system design changes are indicated and tracked on civil engineering project plans
- Identify welding joints and welding terms & symbols

Comments:

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Civil Engineering

Competency
3. Research code & site requirements

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the civil engineering plan with the worksite professional
- Identify site location, building systems, and structures designated in the plan
- Consult with customers, architects, construction professionals, landscape architects, environmental scientists and/or government officials
- Determine categories of applicable codes required by site, systems, and structures
- Locate resources to conduct code and site research
- Look up codes, zoning ordinances and regulations to determine the applicable requirements for a project
- Review research with worksite professional

Learning Objectives

- Describe the resources and process to be followed to research required codes and site restrictions at your facility
- List sustainable building principles and how to apply them to civil engineering projects
- Site
  - Explain general environmental codes and requirements for a civic project
  - Discuss the need to prevent/control wind, water erosion and/or flood plain analysis in land development and construction
  - Interpret and explain code requirements and constraints as they pertain to the installation of services and utilities
- Structures
  - Explain the purpose of building codes
  - Identify the national codes typically used in the United States and know who is responsible for determining which code is applied to the process
  - Recognize the potential dangers of built structures, particularly structures that do not follow code
  - Define easement, buffer area and setback as they relate to local codes and construction sites
  - Classify a building according to its use, occupancy, and construction type using International Building Codes
  - Discuss the Wisconsin energy code and code requirements
  - List common building codes that apply to areas such as soil, footing, windows, foundation, ventilation, roofing, masonry, drainage, fire prevention, etc.
  - Discuss the difference between habitable and non-habitable spaces
  - Analyze risks associated with natural disasters including wind, earthquake, fire and floods, and design

Comments:

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Civil Engineering

Competency
4. Conduct site analysis with team

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Identify the boundaries of a property based on its legal description
- Visit site to gather information pertinent to the viability of a project on the site
- Participate in surveying to lay out installations and establish reference points, grades, and elevations to guide construction
  - Take measurements of structures, distances, length, width, height, perimeter, and area
  - Determine elevations and contour lines
  - Establish a point of known elevation for a project
  - Read gauges and measurement instruments accurately
  - Document measurements accurately
- Schedule or conduct land surveys
  - Arrange for evaluation of basic service & utility systems needs including service capacity, service entrance, meter base, and distribution panel locations
  - Arrange for geological and geophysical investigations
  - Obtain soil samples & send for analysis
  - Arrange studies of water & utility needs
  - Arrange studies of air, water and solid waste pollution assessment
  - Conduct studies of traffic patterns or environmental conditions to identify engineering problems and assess the potential impact of projects
  - Arrange topographical surveys

Learning Objectives

- Describe criteria for building site selection
- Discuss the impact of zoning in site selection
- Explain how to identify the boundaries of a property based on legal description
- Explain how maps and aerial photos are used in site determination and measurement
- Explain how property lines, utilities, building line, setback, building corners, and elevation are indicated in land maps
- Explain general survey methods used to obtain site measurements
- Explain how to locate and identify an elevation level
- Describe how elevation reference points and footing grades are established
- Discuss how GIS (Geographic Information Systems), GPS (Global Positioning Systems), and lasers are used to measure sites
- Identify site factors which affect the layout of a site and design of a structure
- Identify climatic and geographic criteria that impact the civil engineering project
- Explain the importance of the location and accessibility of the structure to the property

Comments:

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Civil Engineering

Competency

5. Assist to compile & analyze site measurements & other data

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Obtain survey information on a site from documented resources and/or survey measurements
- Obtain site analysis information from documented resources and/or site testing
- Identify measurements and elevations from site
- Collect data from all surveys, testing and analyses completed
- Analyze measurement, service, utility, zoning & coding, and ecosystem data
- Evaluate site feasibility with civil engineering project team
- Document site analysis and feasibility decision

Learning Objectives

- Determine environmental impacts of civil engineering project sites
- Describe how to determine the most suitable foundation for a proposed structure based on the site constraints
- Discuss service and utility requirements
- Discuss criteria and constraints to layout energy and utility systems for a civil engineering project
- Explain how the United Soil Classification System designation determines soil characteristics important to the design and construction of a building on the site
- Describe the impact of passive energy, sustainability and landscaping on site selection
- Discuss common methods for site preparation
- Explain the process for demolition of old structures prior to repair or new construction

Comments:

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Competency
6. Research structural requirements

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain/contact appropriate resources for researching structural requirements and efficiency
- Analyze what structural load the site can bear
- Research structural constraints such as
  - Forces, stress, shear, inertia, and moments acting on a structure
  - Statics
  - Equilibrium
- Use graphical and mathematical analysis to identify structural requirements
- Review research and conclusions with worksite professional
- Document structural requirements as required

Learning Objectives

- Force & Statics
  - Define force, shear, statics, and moments
  - Identify forces acting on the object in a diagram
  - Explain transmissibility of forces
- Analyze forces applied to structures
- Determine the forces in each member of a truss
- Determine the forces in each member of a frame
  - Review the concepts of tension and compression and how they relate to statics
- Stress & Shear
  - Define stress, sheer stress, bending stress, combined stress
  - Identify principle stresses on an object
  - Identify the basic stress and vibration equations
  - Determine shear and moment forces in a diagram
  - Define torsion
  - Examine the distribution of stress in an object subjected to bending moments
- Strain
  - Define strain
  - Explain relationship between stress and strain
- Inertia
  - Define moments of inertia
  - Explain the use of standard structural shape tables
  - Define the purpose and use of the section modulus
- Equilibrium
  - Define equilibrium
  - Use equations of equilibrium to calculate unknown forces

- Math Analysis
  - Describe common units of measure used in engineering
  - Explain number rounding rules
  - Review the laws of sine, cosine and tangent

Comments:

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Civil Engineering

Competency

7. Assist to create materials specifications

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- ***Research structural requirements***
- Utilize appropriate reference handbooks
- Test selected materials if needed
- Compile materials testing results if applicable
  - Identify strength
  - Identify stress/strain relationships
  - Identify continuity, ferrous metal, hardness, and flexure
- Compute materials stress factors
- Select structural and construction materials and assemblies that meet project specifications
- Use appropriate combinations of building materials and components that satisfy the requirements of the civil engineering project
- Review research, testing, and conclusions with worksite professional
- Select materials to fit design specifications with worksite professional
- Document material specification research as required
- Prepare materials specifications documents

Learning Objectives

- Classify and describe the typical physical and chemical characteristics of metals, alloys, ceramics, glass, polymers and composites
- Explain typical physical & chemical properties considered for materials used in civil engineering
- Explain how to conduct typical materials tests for strength, stress/strain relationships, hardness, flexure, etc.
- List common calculations completed to determine materials stress factors
- Identify the four most common materials used in the construction of structures: wood, steel, masonry, and concrete
- Explain criteria used for building materials selection
- Describe applications and restrictions pertaining to the use of construction materials
- Discuss the use of sustainable construction materials and products
- Compare wood and steel frame construction requirements
- Compare typical foundation materials and when each is preferred
- Compare common framing materials and when each is preferred
- Cite typical floor materials
- Distinguish between control, construction, and isolation joints

Comments:

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Civil Engineering

Competency
8. Design site structure(s)

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review site analysis and structural requirements with worksite professional
- Calculate the structural efficiency of a structure
  - Compute load requirements
  - Determine loads using load tables and appropriate mathematics
  - Trace a gravity load imposed on a structure to the ground through all structural elements that contribute to supporting the load
  - Analyze simply supported beams to determine maximum shear and bending moment
  - Calculate moment of inertia of structural members
  - Calculate the location of the center of gravity for a rigid body
- Complete other engineering calculations
  - Compute grade requirements
  - Estimate the amount of cut and/or fill necessary to build a structure
  - Compute impact of site development on water drainage
  - Compute water pressure and water flow rates
  - Evaluate whether structures will be able to withstand earthquakes, wind, gravity, snow and other natural forces
- Design structural elements *as applicable* to the civil engineering project
  - Design the foundation, framing, supports, floor, walls, roof as applicable to required structures
  - Design a spread footing for a given loading condition

Learning Objectives

- Discuss reasons for structural failure
- Explain how load-bearing factors are considered in structural design
- Describe the physics of structures to bear loads via walls, columns, and beams
- Explain how to perform common engineering calculations for such characteristics as
  - Fill needed
  - Drainage
  - Water Pressure and head loss
  - Structural efficiency
  - Bend allowances
  - Loads
  - Critical load on a column
  - Stress/strain
  - Statics
  - Thermal Dynamics such as contraction, expansion, deflection
- Foundation

- List common foundation types and describe their use
- Define cantilever

- Framing & Walls
  - Identify common components of a framing system
  - Distinguish among fixed, free, and pinned columns
  - Examine beam design
  - Understand what factors provide strength in a beam
  - Identify the forces that bend a beam
  - Compare common wall systems
  - Distinguish between bearing and non-bearing walls
- Roof
  - Compare common roof systems
  - Define truss
  - Identify basic truss types
  - Identify and explain framing terms common to both conventional and trussed roofs

Comments:

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Civil Engineering

Competency
9. Draw a working site plan

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- ***Compile site measurements & other analysis data***
- Review site analyses data and dimensions of site layout
- Select size and scale for plan
- ***Use engineering drafting software*** OR draw manually
- Identify parcel features
  - Indicate existing ground features on drawing (e.g., utilities, contours, landscape features, etc.)
  - Indicate boundaries, easement, buffer areas, and established setbacks of site
  - Draw existing structures
  - Locate and identify bench mark and elevation level
- Indicate modifications of any existing site elements
  - Draw proposed contour lines and indicate any new grade elevations
- ***Design site structure(s)***
- Place proposed structure(s) on site with favorable orientation considering site-specific information
  - Draw utility lines and connections
  - Incorporate required site elements such as power systems, water supply & drainage, sewage systems for roads, airports, dams, bridges and other structures
  - Draw additional construction extending beyond structure(s) (e.g., driveways, sidewalks, roadways, proposed utilities, etc.)
  - Draw landscaping elements
- Estimate the amount of cut and/or fill necessary to build structure(s)
- Estimate the increase in storm water runoff from a site
  - Apply Low Impact Development techniques to reduce the impact of development on the storm water runoff quantity and quality
- Indicate scale of drawing and view title
- Indicate north arrow
- Check drawing

Learning Objectives

- Interpret factors that influence site plan
- Describe the process to draw a site plan
- List and identify site plan abbreviations
- Explain the purpose of contour lines
- Describe how choice of structure placement on site relates to energy, utility, sanitation, and drainage requirements

- Classify a roadway, bridge, dam, airport according to its level of use
- Explain the information and calculations needed to plan for a roadway, bridge, dam, airport design
- Discuss how to design appropriate pedestrian access, vehicular access, and parking for a commercial site
- Explain how common site and system designs incorporate energy conservation techniques
- Compare water waste management types
- Discuss issues of storm water run-off
- Estimate the increase in storm water runoff from a site
- Explain Low Impact Development techniques to reduce the impact of development on the storm water runoff quantity and quality

Comments:

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Competency

10. Construct a Bill of Materials

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the working site plan with worksite professional
- Utilize appropriate reference handbooks
- Convert civil engineering drawing scale to full dimensions for the project
- Calculate the required materials needed
- Select materials and assemblies that meet project specifications
- Use appropriate combinations of materials and components that satisfy the requirements of the construction process

Learning Objectives

- Explain how to assign numbers to materials required for construction
- Describe the calculations used to calculate the amount of materials needed
- Explain criteria used for construction materials selection
- Discuss the use of sustainable materials and processes

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

11. Assist to create a project plan

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Review the civil engineering project, project instructions, and specifications requirements with worksite professional
  - Identify the engineering structure/process to be designed
- ***Research codes & site requirements*** to determine the applicable requirements
- Identify the criteria and constraints of the project to be designed
- Brainstorm possible solutions to meet project specifications with engineering team
- Identify & plan project requirements with the civil engineering team
  - Identify critical features on the project
  - Identify the critical milestones
  - Develop detailed programs for the construction process
  - Develop detailed programs for the coordination of site activities
- Analyze and interpret reports on loading, labor, and materials
- ***Research structural requirements*** and ***create materials specifications*** documents
- ***Draw working site plan***
- ***Design site structures(s)***
- ***Construct a Bill of Materials***
- Prepare cost estimates
- Verify site plan with worksite professional
- Obtain bids and prepare contract documents
- Obtain approvals and permits from relevant authorities
- Assist to conduct public surveys and hold public forums
- Document project plan as required
- Modify technical drawings and plans as required
  - Review drawing revision (change) procedures
  - Construct a revision table on drawing
  - Record changes properly

Learning Objectives

- Compare civil engineering to other types of engineering and architects
- Compare types of civil engineering specialties
- Discuss the role of the civil engineer in project design and construction
- List common research strategies used by civil engineers approaching a project
- Explain criteria and considerations when reviewing loading, labor, and materials reports
- List common documents associated with civil engineering projects
- Explain how to generate a cost estimate for a civil engineering project

- Explain how drawing revisions are tracked to other connected technical documents and materials specifications documents
- Discuss the impact on resources of revisions to completed plans
- Explain the purpose of contracts
- List common contractors employed on civil engineering projects
- Describe the engineering bid process
- Discuss how deeds, environmental impact statements, right of way descriptions, and permits impact project design and implementation

Comments:

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Competency

12. Assist to coordinate project activities

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Review project plans with civil engineering team periodically
- Assist to monitor activities associated with the project plan and critical milestones
- Communicate regularly with project managers and construction crew
- Organize the delivery of materials and equipment needed
- Review and record information for reports on productivity, quality, and performance

Learning Objectives

- Discuss common critical milestones in typical civil engineering projects
- Explain how civil engineers monitor site activities
- Discuss criteria and considerations when organizing construction building, materials and equipment
- Describe typical reports and measures taken to indicate productivity and performance at a civil engineering project site

Comments:

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Civil Engineering

Competency

13. Apply quality concepts to project

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Apply quality concepts/standards at all stages of civil engineering design and project
- Follow written standards and procedures for all protocols and troubleshooting
- Communicate progress at each step of process
- Ensure decisions are justified with data
- ***Coordinate and monitor project activities***
- Periodically inspect civil engineering projects
- Document errors
- Evaluate errors for corrective actions taken
- Document all research, design, testing, and project activities
- Follow the process for change control of design, process and final product
- Verify project is within specifications, contract terms and regulations

Learning Objectives

- Discuss the concept of quality assurance
- Explain key features of a quality assurance system
- Compare quality assurance to quality control
- Define ISO 9000
- Explain the importance of documentation
- Discuss the importance of change control
- Identify types of changes that are typically made in a civil engineering project
- Define risk analysis
- Discuss factors considered in risk/benefit analysis

Comments: