AACE® International Educational Practice No. 01E-14 (Formerly Recommended Practice No. 12R-89)

PROPOSED CURRICULUM FOR A MASTER OF SCIENCE DEGREE IN COST ENGINEERING

TCM Framework: General Reference

April 26, 2014

INTRODUCTION

This recommended practice represents proposed curriculum for a master of science degree program with emphasis on cost engineering. The purpose of this document is to support post-graduate education in cost engineering by providing the following:

- Guidance to faculty and students in the formulation of master's degree programs that will concentrate on cost engineering.
- A basis for course selection or self-study where no such college program exists.

The curriculum for this course of study is based upon the content of *The Total Cost Management (TCM) Framework*, and AACE recommended practice 11R-88, *Required Skills and Knowledge of Cost Engineering*.

A master's-level curriculum in cost engineering should include prerequisite undergraduate courses that are identified in this RP. The institution may allow professional experience to serve as a substitute for formal course work. This proposed curriculum provides course descriptions and outlines components of each subject.

The proposed curriculum focuses on cost engineering and is in alignment to Engineering, Procurement, Construction, and Management (EPCM) as well as in Manufacturing. The recommended program of study offers a logical progression in formal education. As there are many bachelor's degree and master's degree programs that offer as a part of their scope a study of project controls courses through a Construction Management or Engineering Management Programs. In many cases these programs are accredited in North America and internationally by the American Council for Construction Educators (ACCE).

The objective of this RP is to present to Universities that have Construction, Project or Engineering Management, a degree program, that is in line with industries on the next level of education, the master's degree, appropriately offers study of management at a level above that of projects and control systems.

PROPOSED CURRICULUM

A. Undergraduate Prerequisite Subjects
Credits/course

3 Engineering Economics
3 Cost Estimating
3 Planning and Scheduling
3 Project Controls or Management Relations
3 Business/Construction Law
3 Building Systems or Financial Accounting
3 Technical Writing
3 Speech Communication

21-24 credits

B. Cost Engineering Required Subjects
(15 credits in these subjects)

3 Motivational Management
3 Statutory Aspects of Personnel Management
3 Fundamentals for Business/Project Management
3 Advanced Economic Analysis
3 Advanced Cost Estimating

15 credits

C. Cost Engineering Elective Subjects
(Minimum of 15 credits from this group of subjects)

3 Management Information Systems
3 Organizational Theory
3 Operations Research (Operations Management)
3 Statistics
3 Value Engineering
3 Methods and Productivity Improvement
3 Applied Project Management
3 Contract Documents
3 Contract Administration
3 Special Topics in Cost Engineering

15 credits minimum

D. Capstone Project (3 credits)

- Thesis or graduate report on a cost engineering subject

E. General Electives

- Subjects as locally approved to round out degree program

COURSE CONTENT

A. Undergraduate Prerequisite Subjects

These subjects are normally considered to be undergraduate level. An incoming candidate for a master's program who does not have college credit for any of these subjects should either add them to his/her total degree program or demonstrate proficiency in them to the satisfaction of the university. The institution may allow professional experience to serve as a substitute for formal course work.

1. Engineering Economics.
The equivalent of a 2- to 3-credit course in the fundamentals of economic analysis in which the program should encompass at least these subjects:

- Time value of money
- Equivalence
- Present value, future value
- Rate of return
- Depreciation/depletion
- Methods for comparison of economic alternatives
- Break-even analysis
- Budgeting and cash flow

2. Cost Estimating.
   The equivalent of a 3-credit course built around construction or manufacturing cost estimating which provides an introduction to definitive estimating. It should include these subjects:

   - Interpreting drawings and specifications
   - Labor costs
   - Determination of work-hour requirements
   - Determination of materials requirements
   - Materials costs
   - Determining equipment requirements
   - Equipment costs
   - Equipment productivity
   - Overhead, indirect, and distributable costs
   - Risk costs and contingency
   - Inflation/Escalation
   - Profit
   - Practical exercise in pricing a construction project or a manufactured product
   - Introduction to cost estimating software

3. Planning and Scheduling.
   The equivalent of 3-credit course designed to provide basic proficiency in common scheduling techniques. These subjects should be included:

   - Bar chart (Gantt) scheduling
   - CPM Scheduling
   - Time-scaled networks
   - Linear Scheduling
   - Introduction to Planning and Scheduling Software

4. Project Controls and Management Relations.
   The equivalent of a 3-credit course designed to provide project controls or management skills. It should include these subjects:

   - Earned Value Management Principles
   - Work Breakdown Structure
   - Organizational Breakdown Structure
   - Management Theory
   - Analysis theory and principles of reporting
   - Risk Management
   - Introduction to applicable software

5. Business or Construction Law.
   The equivalent of a 3-credit overview of the body of law and case studies relating to construction or business organizational forms, contracts, financing sources, documents of title, secured transactions, investments, business taxation, insurance and bonding, bankruptcies and related subjects.

6. Building Systems or Financial Accounting.
   The equivalent of a 3-credit course in basic financial accounting.

7. Technical Writing
   During the graduate study program the student must demonstrate competency in written communication gained through prior formal instruction or experience. Any deficiencies should be remedied through addition of formal classes to the degree program on these subjects.

8. Speech Communication
   During the graduate study program the student must demonstrate competency in oral communication gained through prior formal instruction or experience. Any deficiencies should be remedied through addition of formal classes to the degree program on these subjects.

B. Cost Engineering Required Subjects.

Subjects in this category are intended to provide a basic background in business or project management and are considered essential for the professional cost engineer. It is estimated that the equivalent of approximately 15 credits of the degree program will be devoted to pursuing these subjects.

1. Motivational Management.
   A course in which the student is introduced to behavioral science theories and their application to effective management of personnel and typically included subjects such as:

   - Behavioral science theories
   - Motivators and de-motivators of personnel
   - Effective communication
   - Leadership/management styles
   - Progressive, corrective discipline
   - Conflict management
   - Team building
   - Participative management
   - Practical applications through case studies

2. Statutory Aspects of Personnel Management.
   This course is intended to supplement the Motivational Management course by presenting statutory/regulatory factors which affect personnel management, the knowledge of these factors being essential as a "cost avoidance" tool. Included topics are:

   - Unions and collective bargaining
   - Equal Employment Opportunity, Affirmative Action, and similar statutory programs
   - Policies involving alien workers
   - Termination policies and Unemployment Compensation
   - Occupational Safety and Health Act
   - Worker's Compensation
   - Special hiring/training programs involving disadvantaged population groups

- Current legal atmosphere relating to special personnel management matters (smoking, sexual harassment, substance abuse, etc.)

3. Fundamentals for Business/Project Management.
   This course covers internal organizational forms (functional, task force and matrix); management under union, merit and open shop conditions; employee benefit programs; planning and marketing of services; budgeting and cost control; business insurance and bonding; procurement practices; quality control; health, safety and morale programs; substance abuse control; environmental protection; programs for small, minority-owned, female-owned, and disadvantaged businesses; financial statements and other financial reporting.

4. Advanced Economic Analysis.
   This course is designed to demonstrate and apply principles of economic analysis to a variety of business situations and case studies. Typical of included subjects are:

   - Life-cycle cost analysis
   - Evaluation of purchase, lease, and rental options
   - Profitability studies
   - Cost-Benefit studies
   - Value analysis
   - Budgeting and cash flow analysis
   - Inflation/Escalation

5. Advanced Cost Estimating.
   This course is designed to demonstrate cost estimating techniques and applications not covered in Basic Cost Estimating. Included subjects are:

   - Approximate estimating techniques
   - Capital cost estimating
   - Manufacturing and product cost estimating
   - Operating cost estimating
   - Indexes
   - Risk analysis
   - Integration of estimating with cost and schedule control
   - Computerized estimating systems
   - Probabilistic estimating

C. Cost Engineering Elective Subjects

Students will select a minimum of 15 credits from this group of subjects.

1. Management Information Systems.
   This subject area includes the following possibilities:

   - High-level programming languages
   - Database management
   - Artificial intelligence
   - Computer modeling
   - Hardware design
   - Software program development

2. Organizational Theory.
   This subject area deals with practical applications of the organization including management theories, organizational principals, and relations on the project team.

3. Operations Research (Operations Management).
   This subject area includes many topics which may be combined into one or more courses or included as portions of other courses. Potential topics are:

   - Decision theory
   - Systems theory
   - Linear and dynamic programming
   - Learning curves
   - Queuing
   - Optimization
   - Forecasting
   - Statistical quality control
   - Inventory control

4. Statistics.
   A traditional course in statistics which includes these topics:

   - Probability
   - Data collection
   - Frequency distribution
   - Sampling
   - Variance analysis
   - Correlation and regression

5. Value Engineering.
   Using life-cycle costs as a basis for evaluations, this course explains value engineering techniques. A practical exercise in which techniques are applied is normally a major element in this course.

6. Methods and Productivity Improvement.
   This subject area provides special tools to evaluate and improve project performance. Potential included topics are:

   - Time and motion studies
   - Constructability, operability, and maintainability analysis
   - Work sampling and time-lapse photography
   - Foreman and worker delay reporting
   - Quality circles and problem-solving teams
   - Suggestion programs

7. Applied Project Management.
   Topics in this group apply the principles of earlier subjects to a type of project. Potential topics include:

   - Project stakeholders and interests
   - Contract approaches for engineering, construction, and other services
   - Organizational structures for project management
   - Insurance and bonding
   - The impact of governmental regulation

- Risk identification, evaluation, and control
- Work breakdown structures and charts of accounts
- Control schedules and budgets
- Project plans:

    - Project controls
    - Materials management
    - Quality management
    - Subcontracting
    - Safety/loss control
    - Environmental protection
    - Construction equipment, tools, and heavy rigging
    - Security
    - Document control
    - Startup (if applicable)

- The special challenges of the fixed-price contract
- The special challenges of "fast tracking"
- In-process management:

    - Short-range planning
    - Constructability
    - Status reporting
    - Schedule management
    - Earned-value control
    - Analysis, trending, and forecasting
    - Change administration
    - Contingency management
    - Management reporting
    - Historical data files

- Claims administration
- Project closeout

8. Contract Documents.
   This is a detailed study of standard (AIA, AGC, U.S. Government, FIDIC etc.) and selected user-prepared contract forms to include bid forms, contract forms (short and long), general conditions, special or supplementary conditions, drawings, specifications and addenda. Special attention is given to key contract clauses. Variations of these contract forms for common methods for contracting work, materials, or services are covered.

9. Contract Administration.
   This subject area provides an understanding of the administration of contracts for engineering, construction, other services, equipment, materials, and supplies. Coverage includes roles and responsibilities of contracting parties, organizations for contract administration, contractor/vendor qualification, risk allocation, procurement strategies, incentive contracting, liabilities of contracting parties, change processing, document control, claims, and disputes.

10. Special Topics in Cost Engineering.
    Universities normally have a "Special Topics" course category which enables a student to pursue one or

more credits of study in a subject area agreed to between the student and the advisor. Those involving a cost engineering topic may be credited to the electives group.

D. Capstone Project

1. Thesis or graduate report on a cost engineering subject.

E. General Electives

Other elective courses would be akin to those offered in many Masters of Business Administration (MBA) or the Master of Science in Project Portfolio Management degree programs, but with a bias to construction industry specifics and applications.

1. Business Strategy and Policy
   Formulation and implementation processes for competitive and collaborative business strategies. Role of disciplined policy development and implementation to attain strategic success as well as Analysis of technological, economic, social, demographic, and political trends to determine their implications for business strategies and policies.

   - Learning objective: correctly explain the development of policy for effective business strategy implementation in a commercial enterprise.
   - Learning objective: correctly describe the impact of typical technological factors on policy development for a commercial enterprise.
   - Learning objective: correctly describe the impact of typical economic factors on policy development for a commercial enterprise.
   - Learning objective: correctly describe the impact of typical social factors on policy development for a commercial enterprise.
   - Learning objective: correctly describe the impact of typical demographic factors on policy development for a commercial enterprise.
   - Learning objective: correctly describe the impact of typical political factors on policy development for a commercial enterprise.

2. Environmental Law and Policy
   Current status and trends for environmental laws and government policies and their economic impact on commercial portfolios and programs as it relates and supports the limited history of the development of conservation and environmental protection law and policy, primarily in the US but also internationally.

3. Real Property Finance and Management
   Fundamentals of real property management and associated financial instruments and procedures, which would include details such as Tenant-management relationship, property maintenance, leases, real property insurance, commercial property, industrial property, and marketing; sources of financing, mortgages, liens, foreclosures, principles of value, and insurance.

4. Labor Relations
   Introduction to U.S. labor law and the development of public and private sector unions: right to organize, management rights, arbitration, and grievances. Includes contract negotiation and work management under a union contract. Students simulate negotiation.

REFERENCES

- Hollmann, John K., Editor, *Total Management Framework: An integrated Approach to Portfolio Program and Project Management, 1st Edition, Revised*, AACE International, Morgantown, WV, 2012.

- AACE International, Recommended Practice No. 11R-88 *Required Skills and Knowledge of Cost Engineering*, AACE International, Morgantown, WV, (latest revision).

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(EP 01E-14 April 26, 2014 Revision)

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