

**A MODEL FOR DEVELOPING AND IMPLEMENTING A MECHANICAL  
CONSTRUCTION MANAGEMENT SPECIALIZATION PROGRAM**

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## **Abstract**

Though graduates of construction management programs are finding many opportunities in the mechanical contracting industry, it is apparent that they are lacking the industry-specific skills and knowledge not commonly provided in traditional university-level, general construction programs. In recent years, the mechanical contracting industry has identified a growing need for industry-specific, mechanical construction management programs. To meet this need, Purdue University has developed a Mechanical Construction Management Specialization program. Presented here is a model for the development and implementation of an undergraduate specialization program in mechanical construction management.

*Key Words.* Mechanical construction, mechanical construction management, specialization, student chapter, estimating, project management

### **Developing a Mechanical Construction Management Specialization program**

Following the formation of the Mechanical Electrical Academic Consortium (MEAC) in 1996, several universities committed to developing specialization programs in mechanical and electrical construction management. The Consortium was formed with the support and participation of the Mechanical Contractors Association of America (MCAA), and the National Electrical Contractors Association (NECA), and is striving to provide national leadership in (1) the development of mechanical and electrical undergraduate specialization programs, and (2) the development of additional MCAA/NECA student chapters. Interest and commitment from the mechanical contracting industry and universities in developing undergraduate mechanical construction management specialization programs has never been greater. Mechanical contractors have historically drawn the majority of their project managers and estimators from the trades and from mechanical engineering programs. However, many contractors realize that both sources are producing an insufficient number of qualified people to supply future needs for qualified management personnel. The members of MEAC believe that the development of undergraduate specialization programs will provide industry with a new resource for recruiting future project managers and estimators. (Koontz, 1992)

Presented here are the steps identified and taken by the Purdue University Building Construction Management (BCM) program from 1992 to 1997 in developing a Mechanical Construction Management (MCM) Specialization program. The goal of the program is to provide a higher level of education for those students who are interested in the field of mechanical construction. Specific coursework in the areas of estimating, scheduling, project management, and design provides the student with the necessary skills required for entry-level positions in the mechanical construction industry. In Fall 97, over fifty students enrolled in the MCM program that has succeeded in capturing student and industry interest. Students are provided with a better base of knowledge

and are given an awareness of the many opportunities available in the mechanical construction industry.

Though the program is still in its infancy, and there are several areas which can be improved, it does provide a cursory successful model. In addition, this model for development and implementation of a mechanical construction management specialization program will certainly require modification by the individual university to be effective. Required modifications will depend entirely upon the specific needs and curriculum structure of each university.

The steps identified and utilized by our university to develop its mechanical construction management specialization program are as follows:

1. Acquire a faculty member with mechanical construction expertise (1992)
2. Develop a mechanical construction methods and materials course (1993)
3. Establish a student chapter of a major mechanical association (1993)
4. Assist students in acquiring summer internships and permanent employment (1992-97)
5. Prepare a plan of study for the specialization program (1993-94)
6. Develop and teach a course in mechanical construction estimating (1994)
7. Develop and teach a course in mechanical construction project management (1994)
8. Develop and gain university approval of the mechanical construction management specialization program (1995)
9. Identify students interested in the specialization and acquire their commitment (1996-97)

#### **Acquire a faculty member with mechanical construction expertise**

Faculty with significant mechanical construction industry experience are necessary to teach industry-specific courses in such a specialized curriculum. Although acquiring a faculty member with mechanical construction expertise is the first step, it is probably the most difficult step for most universities to achieve. Many universities can attest to this difficulty and are currently searching for a faculty member with mechanical construction expertise. University requirements of doctoral degrees for tenure-track positions precludes many potential faculty, from the ranks of mechanical contractors,

from entering academia. The Building Construction Management program at our university was able to acquire a tenure-track faculty member with mechanical expertise without requiring a doctoral degree.

The acquisition of a faculty member with a “fire in the belly” for mechanical contracting is crucial to the establishment and success of any MCM specialization program. This new faculty member must become the department’s “pied piper” of mechanical construction and maintain the following critical responsibilities, in no particular order, which will directly affect the success or failure of the specialization program:

- Develop and teach a majority of the specialization courses
- Found and advise a student chapter
- Solicit and acquire industry support
- Identify and advise students interested in entering mechanical construction
- Assist students in acquiring summer internships and permanent employment with mechanical contractors
- Develop and teach continuing education and training programs for contractors and industry associations
- Develop the specialization plan of study and acquire department and university curriculum committee approval

### **Develop a mechanical construction methods and materials course**

Most, if not all, construction management programs have a course which teaches some aspect of mechanical construction. However, many of these courses do not teach mechanical construction methods and materials, focusing, instead, on basic design principles that are most likely attributed to the mechanical engineering background of the instructor.

The study of methods and materials is often one of the first in the sequence of courses in a general-construction-based program. This is true because a student must have some familiarity with basic methods and materials before he or she can effectively learn higher level skills such as scheduling, plan and specification comprehension, estimating, materials handling, etc. The same is true with mechanical construction education. The learning of mechanical construction methods and materials is even more critical because most mechanical components in a building are not familiar to the students.

The mechanical construction methods and materials course is the first step in developing the specialization coursework. In 1993, two existing courses, each a combination of mechanical and electrical, were split into one mechanical course, and one electrical course. The mechanical course was developed to be *required* by all students in the Building Construction Management department at our university, and assists with capturing the interest of those students who will become enrolled in the specialization program. (Koontz, 1994; Koontz & Alter, 1996)

The primary goals of the Mechanical Construction Methods and Materials course are as follows:

1. Provide all students in the department with a basic understanding of mechanical construction methods, materials, and terminology
2. Capture students' interest so that they may be inclined to enter the mechanical construction management specialization program
3. Provide basic mechanical-construction-drawing comprehension skills

### **Establish a student chapter of a major mechanical contracting association**

Our university established the first Mechanical Contractors Association of America (MCAA) student chapter in October 1993. The establishment of this MCAA student chapter has been the foundation and key to the development of our Mechanical Construction Management Specialization program. The establishment of a national or local industry association student chapter is the key to bringing the students, the university, and the mechanical construction industry together. Without a mechanical construction student chapter, a specialization program would become a miserable failure. The student chapter is necessary to provide a common bond and is the ultimate in partnering the three entities. It provides contractors with an opportunity to learn about the students and their construction management education, while it provides students with an opportunity to learn about the mechanical construction industry "first-hand" from contractors. Other than the acquisition of a qualified faculty member, the establishment of the student chapter is definitely the key to developing the mechanical contracting specialization program.

The following are just a few of the benefits of developing a student chapter:

Student benefits:

1. Summer internship and permanent employment opportunities
2. Industry contacts

### 3. Education beyond the classroom

#### Contractor/Industry benefits:

1. Constant pool of potential summer interns and permanent employees
2. Contacts within university for training and business-development needs

#### Faculty/Department benefits:

1. Faculty consulting and research opportunities
2. Continuing education and training opportunities
3. Recruitment of new students (contractor sons/daughters/nephews/nieces)
4. Laboratory and curriculum development grants

Although there are numerous mechanical-construction-related industry associations, the following three organizations represent most major contractors and manufacturers who are most likely to have an interest in developing student chapters:

1. Mechanical Contractors Association of America (MCAA)
2. National Association of Plumbing, Heating, and Cooling Contractors (NAPHCC)
3. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

Currently, the MCAA is actively pursuing and assisting universities and local associations with the formation of new student chapters across the country. As with any student chapter, its strength and success depend largely upon the enthusiasm and interest of the faculty advisor, local industry support and involvement, and student interest and participation.

### **Assist students in acquiring summer internships and permanent employment**

The students' exposure to industry at student chapter functions provides a wealth of opportunity for summer internships and permanent employment. Over ninety percent of our students who have found summer employment with a mechanical contractor found permanent employment in the mechanical construction industry upon graduation. A positive summer internship experience for a student is a great way to "spark" a student's interest in mechanical construction. In addition, the summer internship can greatly enhance a student's learning of the "parts and pieces" of mechanical contracting. The methods and materials utilized in mechanical construction are extensive and nearly impossible to adequately cover in a single introductory course

and are best learned by the student in a summer internship experience. (Alter, Koontz, & Lew, 1997)

The mechanical contracting industry as a whole is relatively unfamiliar with hiring our construction management students and must be educated on the value and skills our students bring to both summer and permanent employment. Our experience has shown that many mechanical contractors are initially hesitant to offer students compensation comparable to that offered by general contractors, construction managers, and residential contractors.

Apparently unaware of the added value of our students, many mechanical construction industry contractors are hiring third-year internship mechanical contracting students to do low-level tasks at sub-standard compensation. The availability of such students, and the survival and flourishing of the specialization program will not occur if our students and graduates continue to be offered low-paying positions by the mechanical contracting industry. It is critical that we educate future mechanical employers on the professional and specialized education our students receive as well as provide information regarding competitive compensation.

For mechanical contractors who are contemplating the hiring of an MCM student for a summer internship, the following minimum wage scale is suggested. The mechanical contractors who have been successful in hiring our summer intern students are offering compensation similar to this scale. The scale is based upon a current starting average salary for a BCM graduate of \$34,000 per year and depends upon factors such as other types of compensation and geography.

Table 1.

Based on a starting average salary of \$34,000 per year and 2000 hours per year.

Grade Level	Percent of Graduate's Salary	Hourly Wage
Summer after freshman year:	70%	\$11.00
Summer after sophomore year:	80%	\$13.00
Summer after junior year:	90%	\$15.00
Upon Graduation:	100%	\$17.00

**Prepare a plan of study for the specialization program**

With the assistance of local and national industry, and alumni employed by mechanical contractors, a preliminary plan of study and course objectives for the mechanical construction management specialization must be established. The rudimentary types of courses to be included in a specialization are methods and materials, estimating, project management, and design.

In the early stages of development, it was determined that the specialization courses would not replace any of the required courses in the existing building construction management curriculum. The department was concerned that students would not be receiving the “traditional” BCM education if core courses were replaced. In addition, it was decided that students would not be required to take additional courses above and beyond the requirements of the normal course of study for the bachelor of science degree in Building Construction Management. To keep implementation of the plan of study simple, it was determined that students could use four of their junior and senior elective courses to fulfill the requirements of the specialization.

Our specialization program includes the following required courses:

BCM 215 Mechanical Construction

The course is an overview of practical applications of the terminology, drawing interpretation, methods, materials, and equipment used in the field of mechanical construction.

BCM 315 Mechanical Construction Estimating

The student will study the costs conditioned by the contract documents for the mechanical construction portion of commercial building projects and the techniques used by contractors to estimate these costs. The course will focus on the costs associated with commercial plumbing, heating, ventilating, and air conditioning.

BCM 415 Mechanical Construction Management

In this course the principles of project management are applied to a case study of an actual mechanical construction project. Topics include quantity survey, trade coordination, labor relations, scheduling, subcontractor management, project turnover, and labor productivity.

MET 421 Air Conditioning and Refrigeration Design I

A study of heat gains, heat losses, heat producing equipment, and cooling equipment, in addition to the design of the direct system. Includes controls and instrumentation for commercial, industrial, and

residential systems. (Hutzel & Koontz, 1996)

The limited faculty and classroom resources of our department prohibited the teaching of every specialization course every semester. To manage this burden, the courses are taught in alternating semesters:

1. The BCM 215 Mechanical Construction course is taught every semester by the BCM department
2. The BCM 315 Mechanical Construction Estimating course is taught only during the Fall semesters by the BCM department
3. The BCM 415 Mechanical Construction Management course is taught only during the Spring semesters by the BCM department
4. The MET 421 Air Conditioning and Refrigeration Design course is taught only during the Spring semesters by the Mechanical Engineering Technology department

In addition to the four required courses, the student pursuing a specialization in mechanical construction must complete one elective course which is related to mechanical construction, or to the student's particular mechanical-construction career objectives. Courses which are typically approved as electives are welding technology, computer-aided drafting, forensic engineering, thermodynamics, heat transfer, industrial construction, and mechanical-electrical-plumbing design-build.

To provide industry and students with basic information regarding the specialization plan of study, the department developed a "program guidelines and plan of study" sheet as displayed in Appendix A.

### **Develop and teach a course in mechanical construction estimating**

Nearly all students who return from a positive mechanical construction summer internship have an exciting thirst for additional knowledge in mechanical estimating and project management. This thirst for knowledge is a key to filling new specialization courses such as estimating and project management. The logical time to develop and teach a course in mechanical estimating is when the student thirst for knowledge is at this peak.

During the first semester that a course in mechanical estimating was offered, only eight students enrolled. The course is now offered in the Fall only and has full enrollment (24 students) with approximately 5-6 students on a waiting list. The enrollment of the course appeared to increase with the increased visibility of the specialization program

and the increased number of students who had completed summer internships with mechanical contractors.

The primary goals of a Mechanical Construction Estimating course are:

1. Increase the student's ability to interpret mechanical drawings and specifications
2. Provide the student with a clear understanding of the mechanical scope of work and potential problem areas
3. Provide the student with industry-specific mechanical estimating techniques and processes
4. Provide the student with an understanding of mechanical construction costs
5. Introduce the student to a widely-used computerized mechanical estimating software

The introduction of computerized and digitized mechanical estimating skills in the specialization program greatly enhances and increases a student's value to mechanical contractors. Mechanical contractors currently have a great need for employees who are familiar with computerized mechanical estimating.

The most widely-used mechanical estimating software packages are Estimation, Inc., and QuickPen, International. These two software packages are used by the majority of mechanical contractors who use computerized estimating. (Koontz & Richard, 1995)

Over seven thousand mechanical contractors in the United States use either Estimation or QuickPen. Both software companies are eager to assist universities in developing mechanical construction estimating laboratories and estimating courses. For example, in 1994, our university received a generous donation of software and digitizer boards from Estimation, Inc., for the development of an eight-station mechanical estimating laboratory. In addition, in 1996, we received a similar donation of eight stations from QuickPen, International.

There are many benefits to a university partnering with a software company such as Estimation or QuickPen. The following are several benefits that occurred from our experience:

1. Student recruiting and industry exposure at user conferences
2. Student summer internships and permanent employment with the software companies and their contractor users

3. Scholarships for student chapter members
4. Faculty and student software training
5. Assistance in acquiring industry continuing education programs
6. Laboratory technical support

### **Develop and teach a course in mechanical construction project management**

A course which provides basic mechanical construction project management skills is the natural capstone for a mechanical construction management specialization program. Industry-specific project management skills are crucial to a graduate's success because it is likely that a BCM graduate who enters mechanical construction will possess the full responsibilities of a project manager within one to two years following graduation.

The project management skills taught in the course must be primarily focused on managing labor rather than managing subcontractors due to the high percentage of labor and low percentage of subcontracts in mechanical contracts.

Like the estimating course, the project management course had only 8-10 students enrolled during its first offering. The course is now offered in the Spring only and has full enrollment (24 students) with approximately 6-8 students on a waiting list. This course enrollment also appeared to increase with the increased visibility of the specialization program and the increased number of students who had completed summer internships with mechanical contractors.

The primary goals of a mechanical construction project management course are to:

1. Provide students with skills in scheduling mechanical construction projects
2. Provide students with skills in solving mechanical construction coordination problems
3. Introduce students to the duties and responsibilities of a mechanical construction project manager
4. Develop skills in managing labor risk in mechanical construction

### **Develop and gain university approval of the mechanical construction management specialization program**

The process of developing and acquiring university approval of an MCM specialization program tends to be very specific to a university. Each university has its own procedures for the development and approval of new courses, curricula, and plans of study. The program at our university was developed and taught before acquiring university and school approval because the curriculum allows the offering and teaching of “experimental” courses as electives. In addition, the specialization program had the “unofficial” and full support of both the BCM Department Head, and the Dean of the School of Technology. The program began development in Spring 1993 and was not officially approved until Fall 1995. At many universities, it is possible that approval would be required in the very early stages of development. Nonetheless, the specialization program must be approved so that students receive a designator on their transcripts to mark their accomplishment, and to provide credibility to the mechanical contracting industry.

### **Identify students interested in the specialization and acquire their commitment**

The next step to be taken after the official approval of the program is the identification of students who intend to pursue the Mechanical Construction Management Specialization. It is necessary to obtain written commitment from interested students so that courses may be scheduled and students may be counseled as early as possible in their academic careers. Students who have entered the specialization may change their minds at any time without causing interruption to their BCM plan of study.

If interested students aren't identified and committed early in their academic careers, schedule conflicts may prohibit their enrollment in a given specialization course. Our university's program struggled with this problem because the specialization courses were offered as junior/senior electives and the first course in the plan of study, Mechanical Construction, was only available to junior students. To remedy this problem, our university moved the Mechanical Construction course to the sophomore year, changing it to a 200-level course.

In identifying students as early as possible and acquiring commitment, our university developed the specialization contract as exhibited in Appendix B. Student and advisor utilization of this document enhances the opportunity for all MCM courses to be taken in the order intended.

### **Conclusions**

Clearly, the most important and difficult step in developing the Mechanical Construction Management Specialization program is the acquisition of a dedicated, enthusiastic, and industry-experienced faculty member. The difficulty in acquiring such a faculty member can only be overcome by universities who are willing to use creative methods for

finding and attracting qualified people from industry. The doctorate requirement must be evaluated for relevancy, for there are very few potential faculty members from the mechanical contracting industry who have achieved the academic milestone of the doctoral degree. Universities must also reach out to associations such as the MCAA, NAPHCC, and SMACNA for assistance in their faculty searches. Advertisements in mechanical contracting publications must be used to find potential mechanical faculty. Advertisements placed in general construction or construction management publications are unlikely to be noticed.

After acquiring a qualified faculty member, it is crucial that a student chapter of a major mechanical contracting association be established. Without a student chapter, it is nearly impossible to acquire and incubate the interest of the mechanical construction industry and students. There must be a medium for students and industry to learn about each other outside of the classroom. The acquisition of student internship and employment opportunities flourishes upon development of a student chapter. If feelings of excitement and curiosity about the mechanical contracting industry aren't generated, the student will have no motivation for enrolling in specialization classes. Establishing and developing an active student chapter will largely determine the success or failure of the Mechanical Construction Management Specialization program.

The mechanical construction industry's need for our graduates has never been greater and those universities who meet this need will find a wealth of opportunities for themselves and their students.

## References

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## Appendix A

**SAMPLE UNIVERSITY  
BUILDING CONSTRUCTION MANAGEMENT PROGRAM  
SCHOOL OF TECHNOLOGY**

**PROGRAM GUIDELINES AND PLAN OF STUDY FOR:  
THE MECHANICAL CONSTRUCTION MANAGEMENT  
(MCM) SPECIALIZATION**

### **GOAL**

The goal of the Mechanical Construction Management (MCM) specialization program is to provide a higher level of education for those Building Construction Management (BCM) students who are interested in the field of Mechanical Construction. Specific mechanical coursework in the areas of estimating, scheduling, project management, and design will provide the student with the necessary skills required for entry level positions in the mechanical construction industry.

### **INFORMATION**

Upon completion of the following plan of study, and in conjunction with the core requirements of the BCM program, the student will receive the "Mechanical Construction Management Specialization" designation on their transcript. Students who choose to pursue the MCM will complete the core required course of BCM 215 Mechanical Construction (3 cr.) and complete an additional twelve (12) credit hours of courses which are specific to the mechanical construction industry.

For more information contact Marsha Freeland, BCM Academic Counselor, at 765-494-1371, or Prof. John R. Koontz, MCM Coordinator, at 765-494-5602.

### **PLAN OF STUDY**

3	BCM 215	Mechanical Construction
3	BCM 315	Mechanical Construction Estimating
3	BCM 415	Mechanical Construction Management
3	MET 421	Air Conditioning and Refrigeration Design I
3	_____	Mechanical Construction Elective

**15 Credit Hours**

## Appendix B

# Mechanical Construction Management (MCM) SPECIALIZATION CONTRACT

STUDENT NAME \_\_\_\_\_ STUDENT I.D.# \_\_\_\_\_

HOMETOWN(CITY/STATE) \_\_\_\_\_ ANTIC. GRADUATION DATE \_\_\_\_\_

SOURCE OF MECHANICAL CONSTRUCTION INTEREST \_\_\_\_\_

FAMILY MEMBERS IN MECHANICAL CONSTRUCTION? \_\_\_\_\_

IS STUDENT A MEMBER OF THE MCA? YES \_\_\_\_\_ NO \_\_\_\_\_ DATE JOINED \_\_\_\_\_

GEOGRAPHICAL PREFERENCE FOR SUMMER EMPLOYMENT? \_\_\_\_\_

GEOGRAPHICAL PREFERENCE FOR POST-GRADUATION EMPLOYMENT? \_\_\_\_\_

**MECHANICAL SUMMER WORK EXPERIENCE:**

	EMPLOYER	POSITION	LOCATION	YEAR
SUMMER #1	_____	_____	_____	_____
SUMMER #2	_____	_____	_____	_____
SUMMER #3	_____	_____	_____	_____

### PLAN OF STUDY

PLANNED SEM/YEAR	REQ'D	COURSE NO.	COURSE DESCRIPTION	CR	APPROVED BY	DATE APPROVED	GRADE
<b>CORE</b>							
		BCM 215	Mechanical Construction	3			
		BCM 315	Mechanical Constr. Estimating	3			
		BCM 415	Mechanical Constr. Management	3			
		MET 421	Refrig. & Air Cond. Design	3			
<b>ELECTIVES</b>							
		MET 248	Welding				
		BCM 430	Industrial Construction				
		BCM 499	MEP Design-Build				
		BCM 499	BCM 215 Teaching Assistant				
		BCM 499	BCM 315 Teaching Assistant				
		BCM 499	BCM 415 Teaching Assistant				
		TECH 581E	Forensic Engineering				
			<b>TOTAL CREDIT HOURS</b>	<b>15</b>			

I \_\_\_\_\_, intend to pursue and acquire a specialization in Mechanical Construction Management (MCM). I have reviewed the above plan of study with the MCM coordinator and understand that I will receive the MCM Specialization upon its successful completion.

\_\_\_\_\_  
Student Date

\_\_\_\_\_  
MCM Coordinator Date