INDUSTRY-UNIVERSITY PARTNERSHIPS FOR CONSTRUCTION ENGINEERING EDUCATION

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ABSTRACT: Many construction engineering educators and construction industry leaders realize the value of establishing effective, working industry-university partnerships. By viewing the construction industry as its customer and by collaborating with industry leaders on matters influencing the undergraduate program, the university faculty can sustain and improve the quality of the educational program. The degree to which construction engineering graduates are prepared to perform well in practice can be enhanced by effective industry-university cooperation on such matters as the construction education mission and objectives, curriculum, course content, faculty qualifications and development, resources, co-ops and internships, and other issues. Based on 23 years of experience in Purdue University's Construction Engineering and Management program as well as on experience elsewhere, issues are discussed concerning ways of implementing effective industry-university collaboration in construction engineering education. Conclusions highlight some characteristics of a beneficial industry-university partnership: effective joint strategic planning; a separately administered construction engineering program; a committed, involved industry advisory committee; a student intership program; faculty experienced in the construction industry; and outcome-based measures of success.

INTRODUCTION

Purposes

The purposes of this paper are to describe the nature and features of the cooperation between the Purdue University Construction Engineering and Management program and the construction industry it serves, to discuss the key issues that an undergraduate construction engineering program must address in order to successfully collaborate with industry, and to identify the elements that characterize an effective industry-university partnership.

Background

Engineering educators and employers have long realized the value of establishing effective working relationships. Employers of engineers are the principal customers of schools of engineering. When graduates are well prepared to contribute to the success of the firms they join, universities have accomplished one of their essential missions. Hiring rates and the extent of satisfaction with graduates' performance in industry are clear indicators of the quality of a university's academic program, especially for undergraduate programs.

For decades there has been a call for effective collaboration between industry and universities (The Business Roundtable 1982, Matthews and Norgard 1984). This was emphasized in the 1994 report, "Engineering Education for a Changing World," which, among others summarized that "... partnerships are the key to ensuring U.S. engineering education is relevant, attractive and connected to its clients and stakeholders and to the nation at large" (ASEE 1994). Productive industry-university collaborations continue to be essential to the quality and effectiveness of engineering education in the future.

Many universities are adopting the concepts of total quality management (TQM) and outcome-oriented program evaluation. These approaches inherently focus on the firms that hire the graduates as the university's customer, with those firms' satisfaction important to the institution's success. Industry-university partnerships enable especially effective communication with those "customers," thereby promoting means for continuing improvements in program quality.

Civil Engineering Programs

Many civil engineering schools have established long-standing and valuable relationships with engineering practitioners. The American Society of Civil Engineers (ASCE) has long-recognized and encouraged these relationships. Civil engineering schools in the United States today typically collaborate—through advisory councils, practitioners in residence, co-op programs, and other means—with leaders and engineers in civil engineering practice.

Construction Engineering Programs

Before construction engineering became a separate baccalaureate degree program in the United States, the schools of civil engineering were the major source for engineers who became professional constructors (Harris 1991). Hence, the nature of the relationships today between the construction industry—in particular, the general and specialty contractors, construction managers, and others who hire engineers for professional positions in construction—and the universities follows generally the past models set by civil engineering practitioners and the schools of civil engineering.

As construction engineering in the United States has grown into a distinct undergraduate discipline during the past two decades, new collaborations between universities and construction organizations have emerged. It is valuable to understand what the elements for success in these collaborations are, and to evaluate the factors which influence future university-industry cooperation. What follows is an evaluation of one such collaboration—which took place for 23 years at Purdue University—and a summary of the elements and lessons learned which can be applied to other university-industry partnerships.

Construction Technology and Building Construction Programs

The university programs that educate construction technology and building construction majors supply an essential and generally well-qualified cadre who serve the construction industry well. There is clearly an ample market today for both

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Note. Discussion open until March 1, 1997. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on January 10, 1996. This paper is part of the ***Journal of Professional Issues in Engineering Education and Practice***, Vol. 122, No. 4, October, 1996. ©ASCE, ISSN 0733-9380/96/0004-0156–0162/$4.00 + $.50 per page. Paper No. 12298.

entry-level construction engineers as well as degree holders in construction/building technology. This paper focusses on construction engineering programs.

PURDUE UNIVERSITY EXPERIENCE 1972–95

Origin, Concept, and Objectives

Purdue University's program in Construction Engineering and Management (CEM) originated in 1972 with a visit by a delegation of Indiana construction industry representatives to the president and the provost of the university (Marion B. Scott, unpublished notes, 1979). A joint Industry-University Study Committee then deliberated for nearly two years in planning the new program. Following a survey of 300 construction firms in Indiana and interviews of a number of the principals of these firms, the Division of Construction Engineering and Management and its curriculum were activated in 1976. The first full class matriculated in 1980.

The major objective of the new CEM program, as requested by the Indiana constructors, was "to provide a program combining Engineering and Management education in a meaningful way to fill the leadership needs of this diverse and complex industry" (Scott 1979). It is significant that "to fill the leadership needs" of the construction industry was a founding objective, since many current construction firms still say that they desire leadership potential in entry-level engineering graduates.

A secondary objective from the outset was "to provide a unified educational program with a common core for all segments of the industry regardless of their specialty area." This "core" would be augmented with an educational stem in specific "specialty areas," such as building, heavy civil, electrical, and mechanical construction areas (Scott 1979). Another stated objective was to give students exposure to more than the academic aspect of the construction process. From the beginning, students were required to complete three internship periods, with construction organizations to gain practical experience in a wide range of construction activities (Scott 1979). As described later, the internship program that resulted from this foresight has proven to be uniquely valuable to all parties involved in Purdue's CEM program.

The original program design emphasized that industry required graduates who are educated in both engineering and management. The intent was to retain the essence of a classical civil engineering education, tailored to professional practice in construction, and to add education in relevant management principles and practices. This intent was carried out both in the curriculum described below and in the degree title: Bachelor of Science in Construction Engineering and Management (BSCEM).

Curriculum

From a series of meetings of the Industry-University Study Committee there emerged an understanding that industry should establish the capabilities needed by graduates and the university should establish the courses in the curriculum (Scott 1979). The curriculum was designed to satisfy, among other criteria, the requirements for new curricula of the Engineering Council on Professional Development (ECPD). The outcome was a relative curriculum content distributed in 1976 as shown in Table 1. As can be seen from Table 1, the current (1995) general curriculum content is quite comparable to that initially designed in 1976. Individual courses within the categories have been replaced, added, and modified considerably over the past 19 years.

Students currently select one of four options in which to specialize: building construction, heavy-highway, mechanical construction, or electrical construction. The current core curriculum, with the electives for the specialty areas, is shown in Appendix I. Educating students effectively in oral and written communications is emphasized. Beyond the required core courses in the areas of communications (freshman English and speech, and a course in communications for civil engineers in junior year), writing and speaking assignments are integrated into many engineering and management courses. Students work in teams in several courses, where they are often graded on team, rather than individual, performance on assignments that simulate "real world" work activities. The capstone senior "design" course is tailored to both Accreditation Board for Engineering and Technology, Inc. (ABET) criteria and industry guidance. This semester-long course comprises an open-ended construction project planning problem. It uses construction documents and other facts from an actual, constructed project and puts each student team in the role of a general contractor to plan, estimate, bid, and manage the construction of a facility.

TABLE 1. Relative Curriculum Content: Purdue Construction Engineering and Management (CEM) Program

Course (1)	1976 (2)	1995 (3)
Basic math and science	25%	25%
Engineering science	16%	21%
General education courses	16%	19%
Industrial management	12%	11%
Construction engineering	10%	10%
Technical electives	21%	14%
Internships (no credit hours)	0%	0%

Curriculum improvements in the way of "fine-tuning" have been made periodically, often as a result of Advisory Committee input. For example, in 1994 the Advisory Committee and faculty engaged in a day-long workshop devoted to considering the leadership content of the undergraduate education. The two outcomes were (1) the adoption of an organizational psychology course as a preferred elective in support of the leadership component of the curriculum, and (2) the addition of several lessons dedicated to leadership to the traditional labor-management-relations core course. The initial curriculum development process also generated the concept of the industrial internship, whereby the student would gain knowledge in those areas not suited for a formal classroom or laboratory presentation by completing intern assignments with construction firms.

Accreditation

The first ABET accreditation visit for the new program was in October 1983, leading to the new program's accredited status. Accreditation for another six-year period was granted in 1989, and the most recent ABET visit for the Purdue program was conducted in November 1995. Purdue considers it vitally important that the CEM degree be accredited and that the degree continue to enable graduates to gain professional engineering registration according to their career needs.

Administration

From the outset, the industry and university planners intended that the CEM degree program should be a separate division within the Schools of Engineering at Purdue. The CEM division reports to the Dean of Engineering as do the other engineering units in the Schools. Over the years this status has proved very valuable to the efficacy of the program. It particularly benefits the industry-university liaison by enabling an Industry Advisory Committee dedicated to this degree program and by enhancing the administration of the internship program which is unique to CEM.

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Industry Advisory Committee

The Construction Education Advisory Committee was initially composed of six representatives from construction firms in Indiana and six faculty members. Having evolved over its 17 years, the Advisory Committee is currently comprised of 13 construction executives from seven states. Advisory Committee meetings, held twice a year, have typically included review of curriculum matters, status of the summer internship program, recruiting of new internship sponsor firms, funding needs and sources, hiring trends, and certain faculty issues. Committee meetings have been, and continue to be, well attended. Matters of substance and consequence are dealt with, and CEM faculty respond positively to Advisory Committee input. Throughout the year CEM faculty frequently consult individual Advisory Committee members on a wide range of issues.

The Internship

As a requirement for the BSCEM degree, each student must satisfactorily complete three 12-week internships for a construction firm. The internships are arranged by the director of internships, a full-time, tenure-track faculty member who matches each student with their sponsor firm based on the director's knowledge of the firm's characteristics and needs as well as the student's aptitude and goals. By policy, each intern spends all three work periods witih the same firm. This policy, established in the initial 1976 planning, has proven very effective for the sake of the student's learning and development by enhancing both the variety and the progressive responsibility of assignments and experience received. Occasionally, for mitigating reasons, a student intern may change sponsor firms as an exception to the preferred practice.

The director of internships and his staff assistant serve as liaisons between the student and the sponsor firm prior to and during the first work period. In subsequent summers, the student and the sponsor firm coordinate directly on the timing, location, and details of the work period. The director of internships visits around half of the interns each summer at their worksites to monitor the quality of the experience. Other CEM faculty members occasionally augment this liaison with additional field visits.

The sponsor firm provides a written evaluation of the student's performance at the end of each work period. Students also submit a written evaluation of their internship experience and are required to submit a written report detailing the summer's activities and the goals for the next period. Beyond the value of the practical experience itself, the internship provides the student with a sound basis for approaching the academic work in the classroom. Students consistently comment that the summer work enabled them to approach and apply the classroom material more effectively. In particular, students realize, beginning with their first summer, that construction is a "people profession" and that learning to communicate effectively with people is an important part of their development.

As can be expected, the quality and value of the internship experience varies to some extent depending on the sponsor firm. Fifteen years of experience have shown that every kind of construction assignment and experience has proven to be of at least satisfactory value to the student. Almost every internship has met or exceeded the expectations that the students, faculty, and sponsor firms had that the internship would serve as a vehicle for valuable learning. The keys to success are sponsor firms that will provide the student with a well-planned and progressively more responsible experience as well as a supervisor who will act as a genuine mentor.

During September 1994 through August 1995, 115 Purdue CEM students worked their internship periods with 86 firms in 23 states. Of these, 106 worked during the summer and nine worked August–December or January–April.

Considerable faculty effort and resources are dedicated to directing and administering the internship program. Year-round effort is necessary to maintain contact with current and prospective sponsor firms. Sixty percent of one tenure-tracked, 12-month position is dedicated to the director of Internships' responsibility. This position requires an experienced individual with broad knowledge of the construction industry who can gain the confidence of construction executives across the country and who can also relate well to undergraduate students and their needs and/or problems. The faculty reports regularly to the Industry Advisory Committee on the status of the internships, including the outcome of the firms' evaluations of student performance. The Advisory Committee is an important resource for continued recruiting of new intern sponsor firms.

Students

Admissions into the CEM degree program are carefully regulated. Undergraduates apply (typically at the end of their first semester of freshmen engineering) and are then interviewed. The number of acceptances is governed by the number of internship positions available in the industry, which for the past several years has been around 40–45 new Purdue internships annually. This has permitted the acceptance of some 50–60% of students who apply. Students are evaluated for acceptance based on three criteria: academic ability, potential for the construction field, and personal aptitudes such as self-confidence, assertiveness, and maturity. Entering students, in order to succeed in the Purdue CEM program, need reasonably well-developed personal goals and a good initial understanding of the nature of the construction environment. Maturity and resourcefulness are also desirable assets. In their first summer internship, students must travel to a new city, find lodging, adjust, and start work within a few days. This is a formidable challenge to many third-semester undergraduates.

Faculty

The six-member faculty of Purdue's Division of CEM all have interests in subjects specific to the construction industry. Because of the practice-oriented nature of the program, teaching undergraduate courses is the principal faculty activity. Research, grantmanship, advising, and graduate coursework are expected and supported, but since each faculty member teaches at least two courses every semester, their overall demands are intense. Since experience in the construction industry is a particularly important qualification for CEM faculty, the Division Head took the exceptional step to include the chief executive office (CEO) of an Indianapolis construction firm on a 1995 search committee. That CEO's influence on the selection of an incoming assistant professor was significant and beneficial to the CEM faculty makeup.

Recruiting and Employment Trends

Graduates with Purdue's BSCEM degree have been actively recruited from the beginning. In most years, beginning in 1980 and for the past nine years running, every CEM graduate has been hired upon or shortly after graduation. Liaison between construction recruiters and the CEM Division is very effective at Purdue, in large part because of the internship program. Ongoing communications between CEM personnel and the roughly 100 intership sponsor firms provides those firms with especially effective recruiting communications. The close industry-university relationships and the unique qualities of the undergraduates' preparation contribute to the recent 100% placement rate previously cited.

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ELEMENTS OF AN EFFECTIVE INDUSTRY-UNIVERSITY PARTNERSHIP

Certain elements of industry-university cooperation in construction engineering education serve all parties well and add value to the respective organizations. These elements thereby constitute a model that could be consulted when any university or industry-university collaboration plans construction engineering programs.

Institutional Mission, Philosophy, Commitment

To serve the industry-university relationship well requires a clearly expressed mission statement to which the faculty, administration, and industry (through an advisory committee, suitably chartered) will university commit. An effective process for achieving consensus about the mission, vision, educational "charter," and resources is vitally important. Gaining such consensus is best done through a strategic planning process. Critical to success is a shared belief that the organizations that hire the graduates are the customers of the university.

Organization and Administration

For most universities, establishing a separate division or department for construction engineering will enable more effective industry-university collaboration. The faculty and administrators who plan, approve, and teach the courses in construction engineering and construction management must have sufficient latitude and authority to decide curriculum, resources, and other issues in response to recognized industry requirements. On the other hand, a construction engineering curriculum depends heavily on other core undergraduate courses, especially civil engineering. So the administration should facilitate close cooperation among the departments.

The optimum administrative organization for the program is often a complex issue. Chang and Cox (1995) observed that "... because the construction education program is unique, no matter where it is housed there are always problems of ideology, philosophy, and practicality." Budget and finance matters that impact the construction engineering faculty should be controlled by that faculty as much as possible. For instance resources such as classroom space, computer laboratories, and travel funds should be accessed and allocated for maximum benefit to the industry-university mission.

Industry Advisory Committee

The effectiveness of this leadership group is essential to the success of the collaboration. The role of an effective industry advisory committee approaches that of a governance or trusteeship board, where members accept some accountability for the outcomes of the program. Achieving appropriate influence depends upon the quality of leadership exercised by the senior players from both university and industry, and upon the mutual trust and respect established, over a period of years, among those involved. Committee members should be selected for their experience, their interest in the university and the quality of its graduates, and their willingness to contribute time to the committee's work. Senior construction executives who bring experience, a global view, and resources to support the construction engineering program of the university are sure to add the most value to the collaboration. Executives from firms that traditionally recruit program graduates and sponsor student interns and co-ops should particularly be sought.

The advisory committee must be expected to provide challenging, meaningful service. Well-planned meetings with focused agendas are imperative. The committee must receive feedback on the results of its advice. Committee members should be involved in a wide range of the university's year-round activities such as fund-raising, adjunct classroom teaching, providing project materials (documents, visual aids, etc.), and networking to expand industry support.

Strategic planning by the university administration should always include advisory committee participation. Retreats for curriculum planning, internship program issues, and program quality review are especially effective means for cementing committee-faculty relationships. A particularly valuable role for industry advisors is participation on faculty search committees. By this means the industry side of the collaboration can have its most profound, long-range impact.

Curriculum

The design and continuous updating of the construction engineering curriculum is a fundamental function on which the industry-university team should collaborate. Through periodic consultation with the advisory committee and other construction organization leaders, the faculty should assure that the educational content of the program is responsive to current and future requirements for graduates' knowledge.

Of course, for ABET-accredited programs the advisory committee should be knowledgeable of the accreditation criteria and process. Construction practitioners who are especially committed to quality in education should be encouraged to volunteer to serve as ABET evaluators.

The conceptual model for construction engineering and management curricula that will serve industry well combines a classic civil engineering core with a strong component of management courses tailored to the requirements for managing construction operations and organizations. General education electives remain essential to the liberal education of the engineer, and the teaching of writing and oral communication skills should be integrated throughout.

Internship Program

It is remarkable that more universities have not adopted the practice of mandatory internships in construction engineering education. The extraordinary benefits of the required internships to every part involved—the student, the industry, and the university—are inarguable. The needed funds and faculty time should generally be within reach, at least for many large public universities.

Suffice it to say that, where a university-industry community chooses to collaborate to provide three three-month internships dedicated to helping students gain construction engineering and management experience in the "real world" under competent mentors, the future of all parties is well served. Cooperative programs also go far to provide equivalent benefits. The key to the value gained is the extent to which the co-op students experience responsible, relevant, and challenging assignments.

Faculty

A model faculty for a construction engineering program would represent a cross-section of knowledge, experience, and interests typical of construction engineering and management. Programs offering the doctorate (Ph.D.) in construction engineering (even if titled otherwise) are available at some 20 universities (AGC 1992), and the number of doctoral graduates in construction engineering appears to be meeting current faculty needs nationally.

A factor that may constrain the future availability of construction engineering faculty is the chronically small amount of funded construction research nationally. Discussion of that issue is beyond the scope of this paper, but the paucity of funding for construction research may limit the attractiveness of the field to promising academics.

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Qualifications sought in establishing faculty positions and selecting professors clearly must include significant experience in industry. More so than in many disciplines, construction engineering and management educators must know how construction is practiced today and how it is dynamically continuing to evolve. The quality of a university's program and of the undergraduate education it provides depends greatly on the industry experience found in its faculty.

A beneficial approach when selecting faculty is to include on the search committee a construction industry leader, such as a person who serves on the university's industry advisory committee. Faculty should remain knowledgeable about current matters in the construction industry—engineering, operations, project delivery methods, technology, law, and research matters—as well as those broader issues that relate to the performance and management of people and organizations in construction. Examples of these issues are productivity, competitiveness, human resources, and ethics. Faculty service in the activities of influencial industry organizations such as ASCE, the Associated General Contractors of America, Inc. (AGC), the Construction Industry Institute (CII), and others, should be expected and rewarded, as well as should involvement in research activities that address stated construction industry needs.

Tenure and promotion systems in the university often constrain faculty involvement in industry activities. Undue emphasis on producing research can create priorities for faculty members that cause them to ignore industry involvement. When this situation impacts construction engineering faculty, the undergraduate education program can suffer because of the dynamic need for faculty members to keep themselves current about industry issues. Trustees and industry advisory committees can influence the university administration when tenure system practices fail to reflect the best interests of the overall industry-university community.

Practitioners in Classroom

Highly effective engineering education programs emphasize teaching by practitioners. Faculty leaders, advisory committees, and curriculum plans can all influence favorably the use of adjunct and guest instructors from among practicing constructors.

Indicators of Success

The quality of a construction engineering program can be evaluated through a number of success indicators. Recently, regional accrediting institutions and ABET have called upon university administrators to evaluate the outcomes of engineering programs. While these external initiatives have met with varying responses, those university administrators who deem industry to be the customer have meaningful ways available to them for evaluating the success of their construction education program. Some measures of success include:

- Rate of hire of graduates
- Number of firms recruiting, and feedback from them
- Feedback from graduates and their employers
- Advancement of graduates in industry
- Level of executive talent attracted to industry advisory committee
- Pass rate on Fundamentals of Engineering exam

SPECIAL CHALLENGE: STATURE OF THE DEGREE

To advance the benefits from industry-university collaboration calls for moving toward resolution of a particular issue not addressed before: the stature and prestige of the construction engineering degree. A relative newcomer to academe (roughly two or three decades young), the professional degree in construction engineering is not well understood nor universally accepted in many university circles. There is sometimes a misconception that construction engineering is somehow less academically illustrious or demanding than other engineering disciplines. The issue has been addressed [Harris (1991), Chang and Cox (1995)] but significant groundwork and communication is called for. Undergraduate students majoring in construction engineering must be confident that they are in a respected degree field. There should be no misperceptions, either in academe or industry, about the rigor of the program or the level of professional challenge for which the graduate must be prepared.

The practice of construction engineering and management in the United States increasingly demands professional engineers who are capable of solving technical, management, social, political, and leadership problems as tough as those faced in any other engineering discipline. Industry and university leaders together should make that case in the academic community. Construction engineering educators and their industry colleagues should integrate this special challenge into their leadership agendas.

SUMMARY AND CONCLUSIONS

Based on 23 years of construction engineering education experience at Purdue University and on evidence from elsewhere, the benefits of an effective industry-university partnership to an undergraduate construction engineering program are significant. The characteristics of an effective industry-university partnership, which will add value to all parties (hiring construction firms, students, faculty, and the university), would have positive, substantial activity in each of the following areas:

1. Institutional Mission, Philosophy and Commitment: Faculty, administration, and industry leaders need to commit to and publish a clearly expressed mission statement and program charter for the construction engineering program. These should be developed through a strategic planning process that involves top leaders from the university and from the construction organizations that hire the graduates.
2. Organization and Administration: A separately administered construction engineering department, with control of its resources and direct collaboration with industry, is desirable. Close cooperation between the construction engineering faculty and that of the other departments that teach courses in the construction engineering program is essential.
3. Industry Advisory Committee: An effective, committed group of construction executives who share accountability for program outcomes is essential. Faculty should seek their advice and respond to it. Advisory committee meetings, at least twice a year, should deal with the significant issues that affect the construction engineering program and the quality of the undergraduate education.
4. Curriculum: In consultation with industry representatives, faculty must design and continually update courses and their content to educate graduates to meet the stated needs of industry. The ABET criteria for construction engineering programs are generally appropriate.
5. Internship Program: Industry, university, and graduating construction engineers all benefit exceptionally if students are required to complete internships (i.e. working in construction) as part of the degree. The effectiveness of the industry-university partnership can be maximized by adopting a mandatory internship program.
6. Faculty: Construction engineering faculty need signifi-

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cant industry experience to be fully qualified. Close communication and involvement by faculty members with industry organizations should be expected and rewarded.
7. Practitioners in Classroom: Faculty, industry, and curriculum planning should achieve a significant extent of classroom teaching by construction engineering and management practitioners.
8. Indicators of Success: University leadership should evaluate the construction engineering program's effectiveness by using outcome-based measures of success. The best measures of success are those that reflect that the industry that hires the graduates is the university's customer as well as those that are interpreted by the industry advisory committee.
9. Attention to the Stature of the Degree: Leaders in construction engineering education and industry must resolve misconceptions about the construction engineering degree and establish its deserved stature as an esteemed degree field.

APPENDIX I. PURDUE UNIVERSITY CURRICULUM, BACHELOR OF SCIENCE, CONSTRUCTION ENGINEERING AND MANAGEMENT (ABET ACCREDITED)

Required Courses

First Year

First Semester:	Second Semester:
Plane Analytic Geometry and Calculus I	Plane Analytic Geometry and Calculus II
General Chemistry I	General Chemistry II
English Composition I	Fundamentals of Speech Communication
Computer Programming for Engineers and Scientists	Physics: Mechanics
Freshman Engineering Lectures	

Summer: Internship I

Second Year

First Semester:	Second Semester:
Multivarite Calculus	Linear Algebra and Differential Equations
Fundamentals of Surveying	Thermodynamics
Construction Management	Construction Plans and Estimates
Mechanics: Statics	Mechanics: Dynamics
Technical Graphics: Spatial Analysis; CAD	Construction Engineering Seminar
General Education Elective (1)	General Education Elective

Summer: Internship II

Third Year

First Semester	Second Semester:
Physics: Electricity and Optics	Engineering Materials
Introduction to Structural Mechanics	Construction Planning and Scheduling
Computers and Programs for Civil Engineers	Introduction to Accounting
Oral & Written Communication for Civil Engineers	Technical Elective (2)
Technical Elective	Technical Elective
General Education Elective	General Education Elective

Summer: Internship III

Fourth Year

First Semester:	Second Semester:
Human Resource Management in Construction	Legal Aspects of Engineering Practice
Design/Construction Integration	Technical Elective
Construction Cost Control Concepts	Technical Elective
Design of Construction Operations	General Education Elective
Technical Elective	
General Education Elective	

Electives

General Education Electives

Of the six general education electives, at least two must be courses in humanities and at least two in social sciences, and no more than three may be courses at an introductory level. Courses must be selected from a list of over 200 Purdue general education courses listed as approved electives by the Schools of Engineering.

Technical Electives

Students choosing the building construction/heavy highway specialty will take Hydraulics, Hydrology, and Drainage; Structural Analysis, and Theory of Reinforced Concrete, plus three additional courses from the list of objectives below.

Students choosing the mechanical construction option will take Fluid Dynamics and Linear Circuit Analysis I plus four additional technical electives from the list of electives below.

Students choosing the electrical construction option will take Linear Circuit Analysis I and II and Electronic Measurement Techniques plus three additional technical electives from the list of electives below.

Additional technical electives (list shows the most commonly elected; others among Purdue's numerous courses can be selected with faculty approval):

Route and Construction Surveying
Theory of Reinforced Concrete
Hydraulics
Structural Analysis II
Environmental Engineering
Architectural Engineering
Geotechnical Engineering I
Geotechnical Engineering II
Stochastic Concepts and Methods in Civil Engineering
Construction Project Control Systems
Civil Engineering Systems Analysis
Computer Applications in Construction
Civil Engineering, Ethics, and Economics
Selection and Utilization of Construction Equipment
Construction Cost Control Concepts
Construction of Temporary Facilities
Structural Design in Metals
Properties and Production of Concrete
Electromechanical Motion Devices
Electromechanical Energy Conversion
Electric Machines
Electric Power Systems
Elements of Power Systems Engineering
Thermodynamics II
Fluid Mechanics
Heat and Mass Transfer
Engineering of Environmental Systems and Equipment

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Power Engineering
Design of Machine Components
Transportation Planning

APPENDIX II. REFERENCES

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