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Teaching Cold-formed Steel Design to Technologists

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TEACHING COLD-FORMED STEEL DESIGN TO TECHNOLOGISTS

by

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The four-year Civil Engineering Technology curriculum is designed to produce a graduate who is able to significantly contribute to an engineering team with a minimum of orientation, whether their activities be in engineering design or in industrial or construction project control. The "hands-on" experience obtained in laboratories which stress the importance of in-depth report preparation, combined with the practical approach to analysis and design in lecture and recitation classes, provide the graudate with many of the attributes needed by today's changing companies. An important feature of these curricula is their ability to attract the more practical, productivity-oriented individuals to the program. The tendency of engineering curricula to gravitate toward higher mathematics and highly theoretical courses has created a gap between the newly-graduated engineer and the two-year engineering technician which has been bridged by the enigneering technologist. Engineering technology faculty, recruited for their practical experience and teaching ability, usually do not have the Ph.D. required of research-oriented faculty. Thus, the engineering technology student receives an insight into his future career normally not available from the Ph.D. instructor who may have limited practical knowledge.

In recognizing the need in the real world for the baccalaureate graduate in Civil Engineering Technology to function in a broad spectrum of engineering activities, the curriculum at Old Dominion Univeristy, as presently approved by the Accreditation Board for Engineering and Technology (formerly Engineer's Council for Professional Development), requires each student to acquire an understanding of practical problems in the areas of structures, water resources, environmental technology, surveying and inspection of construction and related materials. In addition, the undergraduate is permitted at least eight hours of electives to enable him to take technical courses supporting his specific area of interest.

Realizing the increasing use of cold-formed steel in construction and in industry, yet operating under the constraints of the established curriculum, a plan has been devised to include cold-formed steel design into the program without introducing a specific course or option as such.

The first exposure for the ODU student to cold-formed steel is in the junior year in the course entitled "Civil Engineering Technology Laboratory." Originally intended to function presumably as a buffer course for the large percentage of transfer students entering from two-year, associate degree programs, the course also serves to give an insight to all students into

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their career opportunities in Civil Engineering Technology. The treatment of statics and strength of materials problems utilizing the computing facilities of both the department and the university serves to coalesce the diverse mechanics backgrounds of the students, so that each is better prepared to handle the upcoming courses in structural analysis and foundations. A study unit devoted to cold-formed steel design, as well as various other units, is added to provide an exploratory experience related to typical project assignments. The coverage, including the concepts of thin material as opposed to thicker steel elements, introduces the student to the AISI Design Manual, Specification and Commentary. Several problems similar to the illustrative problems in the Manual are assigned to the students. These include the concept of effective width, and calculation of section properties.

During this same semester the student is taking a course in construction materials systems. Here he studies not only the basic roll-forming process, but also specific applications for the cold-formed steel products. The roll-forming process and the apparently limitless proliferation of available shapes through this process along with their advantages and disadvantages are introduced in the construction materials system class. Systems comprised of various combinations of steel roof deck and floor deck, open web joists, C-section joists, and studs provide a broad spectrum of applications for cold-formed products. An emphasis is placed on the wealth of technical information and assistance that can be received from associations such as AISI and from responsible manufacturers.

To complete this initial exposure to practical, career-related activities, the student must take a laboratory in the testing and inspection of construction materials. Here the student actually conducts tests involving steel components, including the effects of cold forming on the mechanical properties, and must prepare comprehensive reports covering the experimental findings.

Although the structural analysis course in the spring of the junior year is a typical analysis course covering elastic materials in general, there are areas which tie into cold-formed steel design. In studying truss analysis, an open-web steel joist is treated. Since available computer programs relieve the structural designer of many laborious calculations and represent the present state-of-the-art, the structural analysis course introduces the student to the many computer programs available. Thus, it is appropriate to include exposure to the hyperbolic-paraboloid roof system analysis available in the AISI computer program library, DEBU and STAN.

The steel design course in the first half of the senior year, traditionally devoted to hot-rolled steel, has been modified to include cold-formed steel design as well. Not only are open-web joists and roof deck included, but cold-formed C-sections for joists and studs as well. The AISI computer program STUD is utilized in wall design. Cold-formed box sections are also treated along with space frame applications of light-gage tubular sections.

Connections are of extreme importance in any structure. The coverage of connections has been expanded to consider the various methods available to connect gage material including both welding and high-strength bolting. The benefits of diaphragm action in the design of steel structures and the design of the details necessary to insure diaphragm action are also included in the senior course in drafting systems. This particular course not only familiarizes the student with reinforcing steel details and structural steel details but includes contract drawings for open web joists, steel decking, and cold-formed structural shapes. The course also introduces the student to computer drafting and detailing.

Utilization of a product in construction requires that it be specified either on the design drawings or in the specifications. The final course incorporating cold-formed steel deals with contract documents. Included in this course is an exercise in specification writing. Thus, the proper documents are prepared to assure the usage of cold-formed steel in a construction project. These elements of construction management are most important to the civil engineering technologist, i.e., contracts, bonds, insurance, specification writing, the assembly of bid documents, bidding procedures and arbitrations.

Figure 1 shows the four-year curriculum in Civil Engineering Technology with the courses highlighted which involve exposure to cold-formed steel. Figures 2 through 8 give the course descriptions and brief outlines of their contents, again with the cold-formed steel areas highlighted. Typical problems from these courses are found in the Appendix.

Thus, without compromising the Civil Engineering Technology curriculum by creating numerous options, cold-formed steel design has been accommodated. The graduating technologist is properly prepared to use cold-formed products in a practical and economical way.

SIXTH SPECIALTY CONFERENCE

CIVIL ENGINEERING TECHNOLOGY

(An ABET Accredited Curriculum)

1st Semester

ENGL	110	English Composition	3
MATH	102	Algebra & Trig I	3
MET	100	Engineering Graphics	2
MET	102	Engineering Graphics Lab	1
MET	110	Technical Processes	2
MET	112	Technical Processes Lab	1
____	___	Social Studies	3
			15

2nd Semester

MATH	103	Algebra & Trig II	3
CS	155	Fortran Programming	3
MET	120	Technical Drawing	2
MET	125	Technical Drawing Lab	2
____	___	Laboratory Science	4
____	___	Social Studies	3
			17

3rd Semester

CET	200	Statics	3
CET	210	Elementary Surveying	3
CET	215	Elementary Surveying Lab	1
MATH	205	Calculus I	3
PHYS	111	General Physics	4
____	___	Humanistic Studies	3
			17

4th Semester

CET	220	Strength of Materials	3
CET	240	Advanced Surveying	3
CET	245	Advanced Surveying Lab	1
ENGL	235	Technical Writing	3
MATH	206	Calculus II	3
PHYS	112	General Physics	4
			17

5th Semester

CET	300	Civil Engineering Technology Lab	1
CET	310	Construction Systems	3
CET	345	Testing & Inspection of Construction Materials	1
MATH	304	Math for Technologists	3
MET	300	Thermodynamics	3
SPCH	395	Technical Communication Workshop (1) + Free Elective (2)	
OR			3
SPCH	101	Public Speaking	
____	___	Humanistic Studies	3
			17

6th Semester

CET	301	Structures	3
CET	340	Soil Mechanics & Foundations	3
CET	341	Soils Testing & Inspection	1
MET	330	Fluid Mechanics	3
MET	335	Fluids Laboratory	1
MET	310	Dynamics	3
____	___	Humanistic Studies	3
			17

7th Semester

CET	410	Concrete	3
CET	420	Water Resource Technology	3
CET	450	Structural Steel Design	3
CET	455	Drafting Systems	1
CE	485	Engineering Economy	
OR			3
MET	400	Industrial Operations	
____	___	Free Elective	3
			16

8th Semester

CET	440	Contract Documents	3
CET	430	Environmental Technology	3
CET	435	Environmental Lab	1
EET	350	Fund of Electrical Technology	3
EET	355	Electrical Lab	1
____	___	Technical Elective	3
			14

Figure 1

CET 300
CIVIL ENGINEERING TECHNOLOGY LAB

Catalogue Description

Laboratory 3 hours; one credit. Prerequisite: MET 120, CET 220. Introduction to Civil Engineering Technology as a professional career. Application of selected problem solving techniques.

Textbook

Instructors' Notes and Handouts

Topics	Hours
Structural Engineering Technology	
Reactions	3
Truss Analysis	6
Beam Analysis	6
Column Design	9
Construction Engineering Technology	
Planning Exercise	2
Formwork & Shoring	1
Transportation Engineering Technology	
Right of Way Staking	1
Quantity Takeoffs	2
Environmental Engineering Technology	
Fluid/Electrical Flow Analysis	3
Ecology Report/Environmental Impact Statement	3
Architectural Engineering Technology	
Model Construction/Pictorials	3
Geotechnical Engineering Technology	
Geology, Soil Mechanics Interaction	3
Final Examination	3
	45

Figure 2

CET 301
STRUCTURES

Catalogue Description

Lectures 3 hours; 3 credits. Prerequisite: CET 300. Determination of shears, moments and stresses in statically determinate beams, frames, and trusses due to various combinations of possible loading conditions. Calculation of resulting deflections. Introduction to the analysis of statically indeterminate structures using approximate and computer methods.

Textbook

J. C. McCormac, Structural Analysis, 3rd Edition, International Educational, 1975.

Topics	Hours
Design Codes and Loading	2
Influence Lines for Beams Including Moving Loads	2
Approximate Analysis of Building Frames	4
Conjugate Beam Method	2
Indeterminate Beams	2
→ Truss Types	1
Influence Lines for Trusses	1
Deflections by Energy	2
Internal/External Indeterminate Trusses	5
Three-moment Theorem	1
Slope Deflection	2
Moment-Distribution	4
Plastic Analysis	4
→ Computer Methods of Analysis - Stiffness and Flexibility	6
Quizzes	4
Final Examination	3
	45

Figure 3

CET 310
MATERIALS OF CONSTRUCTION SYSTEMS

Catalogue Description

Lectures 3 hours; 3 credits. Preerquisite: CET 220. Corequisite: CET 345. Introduces the student to various materials available for design and construction. Covers application and combination of these materials in systems. Traditional materials and recent innovation in construction systems will be covered.

Textbook

Topics	Hours
Foundations	5
Structural Systems	3
Masonry	3
Steel	6
Reinforced Concrete	6
Timber	5
Floor Systems	4
Roof Systems	4
Curtain Walls	2
Quizzes	4
Final Examination	3
	45

Figure 4

CET 345
TESTING & INSPECTION OF CONSTRUCTION MATERIALS

Catalogue Description

Lectures 3 hours; one credit. Prerequisite: CET 220 and Egnl 235. Course includes standard methods of inspecting and testing structural materials used in construction. Students follow ASTM Standards using typical industrial test equipment. Emphasis is placed on student participation and report writing.

Textbook

ASTM Standards.

Department Laboratory Manual.

Topics	Hours
Introduction	3
Verification of Testing Machines	3
Tension Test	3
Compression and Flexure Tests of Wood	3
Torsional Shear Test	3
Hardness Test of Steel	3
Impact Test	3
Fatigue Test	3
Concrete Mixes	3
Column Testing	3
Connection Testing	3
Concrete Beam and Cylinder Tests	3
Non-Destructive Testing	3
Field Trip	3
Final Examination	3
	45

Figure 5

CET 440
CONTRACT DOCUMENTS

Catalogue Description

Leetures 2 hours; 2 hours lab; 3 credits. Prerequisite: CET 455 or permission of the instructor. The writing of contracts and specifications, consideration of planning, estimating and scheduling relationships between those involved in construction projects. Coordination of drawings and specifications.

Textbooks

Jack R. Lewis, Construction Specifications, Prentice-Hall, 1975.

Richard C. Vaughn, Legal Aspects of Engineering, 3rd Edition, Kendall/Hunt, 1977.

AISC Code of Standard Practice.

ASTM Specifications.

Topics	Hours
Construction evolution	2
Preliminary Documents	4
Working Drawings	3
Specifications & Standard Writing	15
Bonds	4
Contracts	6
Estimating & Bidding	3
Schedules & Payments	3
Arbitration Hearing	9
Office Practices	2
Field Trip	3
Quizzes	3
Final Examination	3
	60

Figure 6

CET 455
DRAFTING SYSTEMS

Catalogue Description

Laboratory 3 hours; one credit. Corequisite: CET 450, CET 410. Preparation of drawings for the construction and manufacturing industry. Structural steel and reinforced concrete detailing practice; fabrication methods and print interpretation, computer detailing.

Textbook

Industry Standards

Topics	Hours
Design Drawings	3
Erection Drawings	3
Structural Steel Details	15
Reinforcing Steel Details; Beams and Slabs	9
Computer Drafting; Programming and Plotting	15
	45

Figure 7

CET 450
STRUCTURAL STEEL DESIGN

Catalogue Description

Lectures 3 hours; 3 credits. Prerequisite: CET 301. Fundamental techniques necessary for the design of simple steel structures including tension and compression members, connections, beams, composite sections, built-up beams and plate girders, roof trusses, and rigid frames, using working stress design, plastic design and LRFD.

Textbooks

Salmon, C. G. and Johnson, J. E., Steel Structures Design and Behavior, 2nd Edition, Harper & Row, 1980.

AISC Manual of Steel Construction, 8th Edition, American Institute of Steel Construction, 1980.

Topics	Hours
Introduction	2
Tension Members	3
Compression Members	4
Design of Beams	6
Bending and Axial Stresses	6
Bolted Connections	3
Welded Connections	3
Building Connections	3
Composite Design	3
Built-Up Beams and Plate Girders	3
Design of Rigid Frames	2
Quizzes	4
Final Examination	3
	45

Figure 8