CHAPTER

0

Construction Planning, Equipment, and Methods — Sixth Edition

CONSTRUCTION EQUIPMENT AND METHODS

A. J. Clark School of Engineering •Department of Civil and Environmental Engineering

By

Dr. Ibrahim Assakkaf

ENCE 420 – Construction Equipment and Methods

Spring 2003

Department of Civil and Environmental Engineering

University of Maryland, College Park

Course Syllabus

UNIVERSITY OF MARYLAND

Department of Civil and Environmental Engineering

College Park Campus

Spring Semester 2003

ENCE 420 – Construction Equipment and Methods (3 credit)

MW 2:00 pm – 3:15 pm, CHM 0119

INSTRUCTOR:

Name:	Dr. Ibrahim A. Assakkaf
Office Hours:	MW 11:00 am - 12:00 pm and 1:00 pm - 2:00 pm
	F 12:00 noon -1:00 pm, and by appointment
Room	0305, Engineering Classroom Building (EGR)
	Center for Technology and Systems Management (CTSM)
Telephone:	(W) 301-405-3279
Email:	assakkaf@eng.umd.edu
URL:	http://ctsm.umd.edu/assakkaf

Course Syllabus

TA & GRADER:

Name:	*to be added and revised*
Office Hours:	M 2:00 pm – 3:15 pm
Room	EGR 1107
Telephone:	(123) 123-4567
Email:	TA@domain.com

Course Syllabus

TEXTBOOK: "Construction Planning, Equipment, and Methods," by Peurifoy, R., and Schexnayder, C., 2002.

REFERENCES:

1. "Construction Planning, Equipment, and Methods," by Peurifoy, R., Ledbetter, W., and Schexnayder, C., 1996.
2. "Modern Construction & Ground Engineering Equipment & Methods," by Harris, F., 1994. Also, Instructor's Notes and Handouts.

GRADING: HW (20%), Midterm Exam (25%), Final Exam (30%), Project (20%), and
Quizzes (5%).

Course Syllabus

PREREQUISITES:
•ENCE 320, Permission of Department
•Senior Standing

COURSE WEBSITE:
https://www.ajconline.umd.edu/ ENCE 420: Construction Equipment and Methods – Spring, 2003.

GENERAL COURSE DESCRIPTION (UM SCHEDULE OF CLASSES):
ENCE420 Construction Equipment and Methods; (3 credits) Grade Method: REG/P-F/AUD. *Prerequisite: ENCE 320 and permission of department. Senior standing.* Evaluation and selection of equipment and methods for construction of projects, including earthmoving, paving, steel and concrete construction, formwork, trenching, cofferdams, rock excavation, tunneling, site preparation and organization. Design of formwork, trench supports, and cofferdams.

Course Syllabus

COURSE OUTLINE & SCHEDULE:

Week	Date	Topic of Discussion	Source
1	W, Jan. 29	Introduction to Course (General Overview)	Chapter 1
2	M, Feb. 3 W, Feb. 5	Introduction Equipment Cost	Chapter 1 Chapter 3
3	M, Feb. 10 W, Feb. 12	Equipment Cost (cont'd) Geotechnical Materials	Chapter 3 Chapter 4
4	M, Feb. 17 W, Feb. 19	Geotechnical Materials (cont'd) Compaction and Stabilization	Chapter 4 Chapter 4
5	M, Feb. 24 W, Feb. 26	Compaction and Stabilization (cont'd) Machine Power	Chapter 4 Chapter 5

Course Syllabus

COURSE OUTLINE & SCHEDULE (cont'd):

Week	Date	Topic of Discussion	Source
6	M, Mar. 3 W, Mar. 5	Dozers Scrapers	Chapter 6 Chapter 7
7	M, Mar. 10 W, Mar. 12	Excavators Finishing Equipment	Chapter 8 Chapter 9
8	M, Mar. 17 **W, Mar. 19**	Trucks and Hauling Equipment **MIDTERM EXAM**	Chapter 10
	Mar. 24-30	**** S P R N G B R E AK (NO CLASSES) ****	
9	M, Mar. 31 W, Apr. 2	Trucks and Hauling Equipment Compressed Air	Chapter 10 Chapter 11

Course Syllabus

COURSE OUTLINE & SCHEDULE (cont'd):

Week	Date	Topic of Discussion	Source
10	M, Apr. 7 W, Apr. 9	Compressed Air Drilling Rock and Earth	Chapter 11 Chapter 12
11	M, Apr. 14 W, Apr. 16	Drilling Rock and Earth Blasting Rock	Chapter 12 Chapter 13
12	M, Apr. 21 W, Apr. 23	Aggregate Production Cranes	Chapter 14 Chapter 17
13	M, Apr. 28 W, Apr. 30	Draglines and Clamshells Piles and pile-Driving Equipment	Chapter 18 Chapter 19

Course Syllabus

COURSE OUTLINE & SCHEDULE (cont'd):

Week	Date	Topic of Discussion	Source
14	M, May. 5 W, May 7	Equipment for Pumping Water Belt-Conveyer Systems + Review	Chapter 20 Handout
15	M, May 12 W, May 14	Project Presentations (Groups 1, 2, 3, and 4) Project Presentations (Groups 5, 6, and 7)	
16	**Tu, May 20**	**FINAL EXAM (Tuesday, 1:30 pm – 3:30 pm, CHM (0119)**	

Course Syllabus

HOMEWORK ASSIGNMENTS:

Professional presentation of homework assignments is required. Professional presentation consists of neat and organized solution of problems on one side of 8.5"x11" papers. Any homework not complying with professional standards will not be graded and will be assigned zero credit. The homework assignments are due one week after they are assigned. Homework will be assigned as the material is covered and will be collected every Monday at the beginning of the lecture period. Assignments turned in late will be docked 10% for each day it is late past the original due date. Solutions will be available from the TAs and on the class website after the problems are returned. No assignment will be accepted after the answers have been posted. Students are encouraged to discuss and formulate solutions to the problems by working in teams. However, assignments must be completed and submitted individually. Simply copying the answers from another student or from a solutions manual is not acceptable and will not be tolerated.

Course Syllabus

HOMEWORK ASSIGNMENTS (cont'd):

Guidelines for homework are given below:

1. Use good quality paper, such as engineering graph paper or college-ruled paper any color, with no spiral edges.
2. Write on only one side of the paper.
3. Either pen or pencil is acceptable.
4. Include your name, section, and page number (e.g. 1/3 means 1 of 3) on each sheet.
5. Staple all pages together in the upper left corner.
6. Neatly box all answers, and include appropriate units for numerical answers.
7. Show all work (e.g. no work means no credit will be given).

Course Syllabus

EXAMS:

All students must take all exams including the final exam. Only extenuating circumstances will be accepted as excuse for missing an exam. Health related excuses require **medical reports** and the **signature of a physician** that provided treatment.

PROJECT (Term Paper): To be announced and discussed.

Objectives

"Learn how to apply engineering fundamentals and analyses to the planning, selection, and utilization of construction equipment."

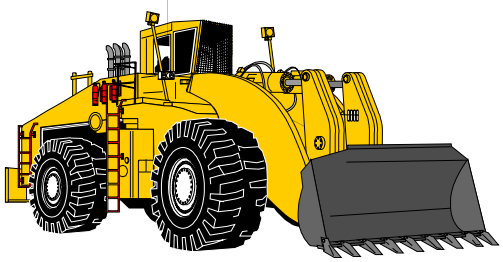
Engineering Concepts

This course uses concepts from various engineering disciplines :

- Engineering Economics
- Geotechnical Engineering (Soil Mechanics)
- Mechanical Engineering (Construction Equipment)
- Structural Engineering
- Environmental Engineering
- Others

Underlying Concepts

Construction of engineered facilities requires the utilization of construction equipment.



Purpose of the Course

Learn to apply engineering fundamentals and analyses to the planning, selection, and utilization of construction equipment.

Through understanding of:

(1) The total construction process, from inspection of the idea through construction and start up, and

(2) How construction equipment should be selected and used to produce the intended quality in the most cost-effective manner.

Course Outline & Topics

Introduction (Chapter 1)

- Construction Contracts
  - Lump-sum contract
  - Unit-price contract
  - Cost-plus-fee contract
- Performance Guarantee
  - Contractor is to furnish a performance bond for a project
- The Time Value of Money
  - Money has a time value.
  - One dollar today is worth more than $1 tomorrow.
  - Failure to pay the bills results in additional charge.

Course Outline & Topics

- Discounted Present Worth Analysis
- Rate of Return Analysis
- Equipment Planning and Estimating

Course Outline & Topics

Equipment Cost (Chapter 3)

- Equipment cost rank second to labor. Machines and equipment can be:
  - Purchased
  - Leased
  - Rented (short time)
- The Cost of Construction Equipment
  - Ownership Cost
  - Depreciation
  - Operating Cost (maintenance, repairs, fuel, etc..)
- Economic Life of Engineering Equipment

Course Outline & Topics

The Planning Process for Equipment and Methods

- Planning process for equipment and methods is necessary both prior to and during the actual construction of a project
- The planning is required for:
  - Production
  - Achievement
  - Cost Control
  - Coordination of the project and the parties involved in the project

Course Outline & Topics

- Formal Planning involves the following steps:
  - Analysis of a Project (Time, Money, Location, etc..)
  - Identification Project Activities
  - Estimate of cost, time, resources to perform each activity
  - Development of Plan Network
  - Application of Realistic Limitations to activities

Course Outline & Topics

Geotechnical Materials, Compaction, and Stabilization (Chapter 4)

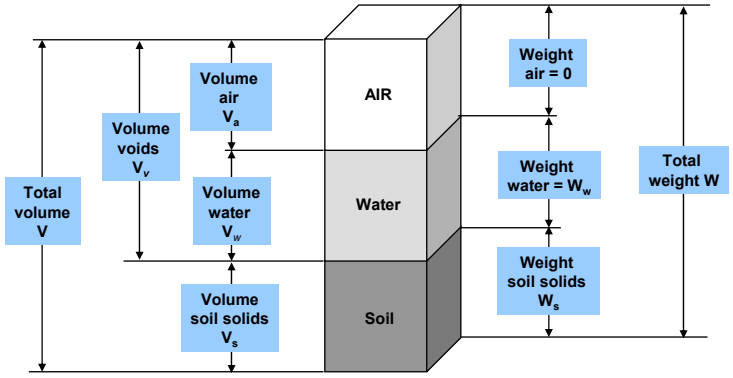
"Persons in a construction industry, including constructors (*contractors*) and *engineers, should understand the affects of which the selection of equipment and method have on the cost of handling these materials"*

Course Outline & Topics

- Material Properties:
  - The actual construction process of any project is really a material-handling problem.
  - On heavy construction projects the major portion of the work consists of handling and processing bulk materials.
  - Excavation
    - Common Excavation
    - Rock Excavation(drilling and blasting)
    - Muck Excavation (soft organic material)
    - Unclassified excavation (materials that cannot be defined as soil or rock)

Course Outline & Topics

Soil mass weight and volume relationships



Course Outline & Topics

Soil mass weight and volume relationships

Unit weight (γ)	= total weight of soil/total soil volume	= **W/V**
Dry unit weight (γ_d)	= weight of soil solids/total soil volume	= **W_s/V**
Water content (ω)	= weight of water in soil/weight of soil solids	= **W_W/W_s**
Void ratio (e)	= volume of voids/volume of soil solids	= **V_v/V_s**
Porosity (n)	= volume of voids/total soil volume	= **V_v/V**
Specific gravity (G_s)	= weight of soil solids/volume of solids/unit weight of water	= **$W_s/V_s/\gamma_w$**

Total soil volume (V) = volume voids (V_v) + volume solids (V_s)

Weight of solids (W_s) = weight of soil (W)/(1+water content (ω))

or

$\gamma_d = \gamma/(1+\omega)$

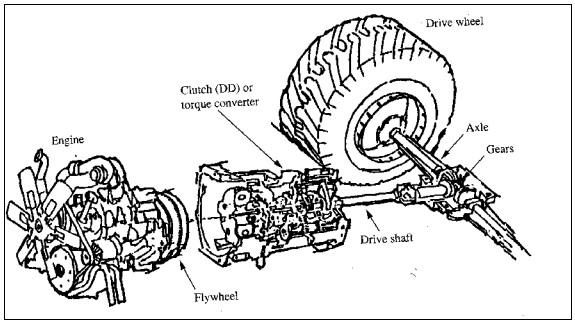
Course Outline & Topics

Compaction and Soil Stabilization

- Soils are the principal component of many construction projects.
- Soils are used to support:
  - structures - static load
  - pavements for highways and airport runways - dynamic loads
  - dams and levees, as impoundment - to resist the passage of water.
- Some soils may be suitable for use in their natural state, whereas other, must be excavated, processed, and compacted in order to serve their purposes.
- Knowledge of the properties, characteristics, and behavior of different soil types is important to those persons who are associated with the design or construction of projects involving the use of soils.
- R. R. Proctor initiated a scientific study to determine the density-moisture relationship of soils.

Course Outline & Topics

- Machine Power (Chapter 5)



Course Outline & Topics

- **Rimpull**
  - The usable power at the point of contact between the tire and the ground for a wheel machine.
- **Drawbar Pull**
  - The available usable power (pull) which a crawler tractor can exert on a load that is being towed.

$$F_w = \frac{33{,}000 \times \text{fwhp} \times E}{v}$$

Course Outline & Topics

Dozers and Tractors(Chapter 6)

- *Tractors* are self-contained units that are designed to provide tractive power for drawbar work.
- Consistent with their purpose as a unit for drawbar work, they are low center of gravity machines. This is a prerequisite of a good machine.
- The larger the difference between the line-of-force transmission from the machine and the line of resisting force the less effective the utilization of developed power.
- Typical project applications are land clearing, bulldozing, ripping, and towing other pieces of construction equipment.

Course Outline & Topics

Course Outline & Topics

Scrapers (Chapter 7)

- Tractor-pulled scrapers are designed to load, haul, and dump loose materials.
- The advantage of tractor-scraper combinations is their versatility.
- They can be used in a wide range of material types (including shot rock) and are economical over a wide range of haul lengths and haul conditions.

Course Outline & Topics

FIGURE 6-1
Single-powered axle wheel-tractor scraper.

Course Outline & Topics

Excavators (Chapter 8)

- Excavating equipment is used to excavate earth and rock in construction operations.
- The equipment includes the following machines:

1. Draglines
2. Clamshells
3. Hydraulic excavators
   a. Front shovels
   b. Hoes
4. Loaders
   a. Wheel
   b. Track
5. Trenching machines

Course Outline & Topics

Finishing Equipment (Chapter 9)

Rollers

Course Outline & Topics

Trucks and Hauling Equipment (Chapter 10)

- Trucks may be classified according to a number of factors including:

1. The **size and type of engine**-gasoline, diesel, butane, propane
2. The **number of gears**
3. The **kind of drive**-two-wheel, four-wheel, six-wheel, etc.
4. The **number of wheels and axles** and **arrangement of driving wheels**
5. The **method of dumping the load**-rear-clump, side-dump
6. The **class of material hauled**-earth, rock, coal, ore, etc.
7. The **capacity**, in tons or cubic yards

Course Outline & Topics

Compressed Air (Chapter 11)

- Compressed air is used extensively on construction projects for:
  - Drilling rock
  - Loosening earth
  - Operating air motors
  - Hand tools
  - Pile drivers
  - Pumps
  - Mucking equipment
  - Cleaning.

Course Outline & Topics

Course Outline & Topics

Drilling Rock and Earth (Chapter 12)

- Drilling equipment and methods are used by the construction and mining industries to drill holes in both rock and earth.
- Purposes for which drilling are performed vary a great deal from general to highly specialized applications.
- It is desirable to select the equipment and methods that are best suited to the specific service:

Course Outline & Topics

Blasting Rock (Chapter 13)

- Blasting" is performed to break rock so that it may be quarried for processing in an aggregate production operation, or to excavate a right-of-way.
- Blasting is accomplished by discharging an explosive that has either been placed in an unconfined manner, such as mud capping boulders, or is confined as in a borehole.

Course Outline & Topics

The Production of Crushed-Stones Aggregates (Chapter 14)

- The production of crushed-stone aggregate involves:
  - Drilling,
  - Blasting,
  - Loading,
  - Transporting,
  - Crushing,
  - Screening, and
  - Product handling and storage.

Course Outline & Topics

Cranes (Chapter 17)

Course Outline & Topics

- Cranes are a broad class of construction equipment used to hoist and place loads.
- Each type of crane is designed and manufactured to work economically in a specific site situation.
- The most common types are:
  1. Crawler
  2. Hydraulic truck
  3. Lattice-boom truck
  4. Rough-terrain
  5. All-terrain
  6. Heavy lift
  7. Modified cranes for heavy lift
  8. Tower

Course Outline & Topics

Hydraulic Truck Crane

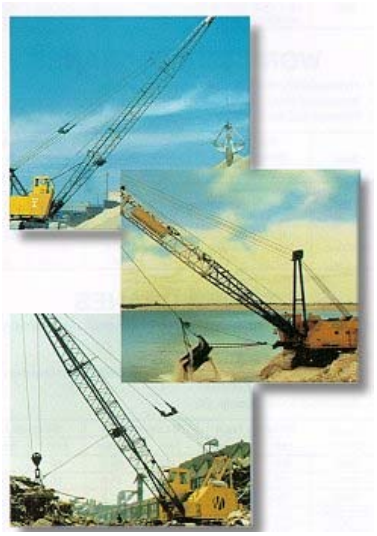
Crawler Crane

Course Outline & Topics

Draglines and Clamshells (Chapter 18)

- Excavating equipment is used to excavate earth and rock in construction operations.
- The equipment includes the following machines:
  1. Draglines
  2. Clamshells
  3. Hydraulic excavators
     a. Front shovels
     b. Hoes
  4. Loaders
     a. Wheel
     b. Track
  5. Trenching machines

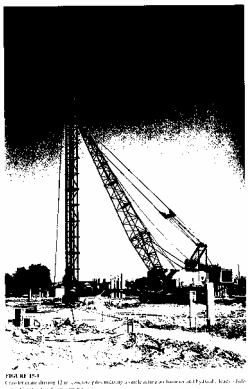
Course Outline & Topics



Course Outline & Topics

Piles and Pile-Driving Equipment (Chapter 19)

- Load-bearing piles, are used primarily to transmit structural loads, through soil formations with poor supporting properties, into or onto soil strata that are capable of supporting the loads.



Course Outline & Topics

Equipment for Pumping Water (Chapter 20)

Pumps are used extensively on construction projects for:

1. Removing water from pits, tunnels. and other excavations.
2. Dewatering cofferdams.
3. Furnishing water for jetting and sluicing.
4. Furnishing water for many types of utility services.
5. Lowering the water table for excavations.
6. Foundation grouting.

Course Outline & Topics

Belt-Conveyor Systems (Handout)

- Belt-conveyor systems are used extensively in the field of construction.
- Belt-conveyor systems frequently provide the most satisfactory and economical method of handling and transporting materials, such as earth, sand, gravel, crushed stone, mine ores, cement, concrete, etc.
- Because of the *continuous* flow of materials at relatively high speeds, belt conveyors have high capacities.

Note: During the construction of the Channel Tunnel (between England and France) conveyors were used to move up to 2,400 tons of spoil per hour from the tunnel headings.

Course Outline & Topics

Course Outline & Topics

Ruhrkohle, Germany

Newman, Western Australia