Salahaddin University – Erbil
College of Engineering
Department of Civil Engineering

Course Book

Methods of Construction and Estimating

Class: 4Th year

Academic Year 2019-2020

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Objectives

The objective of this subject is to guide students in planning, estimating, and directing construction operations in a manner that will attain the best possible results. It will assist the student in more fully understanding the total construction process, from inception of the idea through startup. So, civil engineering students should be required to complete a basic course in construction as a part of their professional studies. Because construction is the product of all design, no design can be a good one unless it can be readily and safely constructed.

Overviews

The subject covers four parts including eight chapters:

Part 1: Project Planning : Chapter 1 provides an overview of construction project management. It covers the nature of construction industry, an outline project development process, and the role of designer and contractor in construction economy.
Chapter 2 describes the methodology for breaking down project work into activities and for activity estimation. Also it covers the methodology for modeling and time analysis of critical path method (CPM), PERT, Gantt method , precedence networks, and resource allocation.

Part 2: Estimating of Quantities in Civil Engineering Works: Chapter 3 includes of methods of estimate and numerous techniques of estimate on buildings, reinforced concrete works, roads, culverts, irrigation channels, water supply and sanitary works, and septic tanks.
Basis of calculation of materials and analysis of rates of works have been included.

Part 3: **Earthmoving and Heavy Construction (Equipment Production)**: Chapter 4 covers the selection of construction equipment and equipment cost, Chapter 5 deals with earthmoving concepts, soil classification, soil-change characteristics and spoil banks. Chapters 6, chapter 7 and chapter 8 cover excavating and lifting operations with equipment productions. involves compacting and finishing concepts. Chapter 9 , procedures, methods and productions, production of aggregate, concrete and asphalt mixes.

Part 4: **Building Construction**: Chapter 10 presents the design of concrete formworks.

Part 5: Conditions of Contract for Civil Engineering Works and Specifications (Technical Requirements of Civil Works): Clause 2 Duties and Authorities of Engineer's Representative, General Obligations (of Contractors and Owners), Tests (Clause 37), Extension of Time for Completion, Penalty for Delay (Clause 48), Variations and Variation Orders, Terms of Payment, Final Acceptance, Termination of Contract. Tests: Cement, Water, Aggregate, Bricks, Concrete, Tiles, Plastering, Road Construction Tests: Sub base, Base Courses, Hot Mix Asphaltic Concrete Pavement, Selected topics.

Forms of Teaching

Different tools and techniques will be used to attain goals and objectives. The following forms are used:

1. Power point for main parts (head titles, definitions, objectives, cases, design tables and charts ..etc.) each subject if required.
2. White board will be used for presenting mathematical equations and solving examples
3. Students will be called to submit assignments defined in advance.
4. Students have to participate in classroom discussions. Also the attendance (as much

as possible) will taken in consideration for students.

5. Visiting to the field site of projects will be done at least one per semester which will be considered for student evaluations.

Grading

The students have to do two semester examinations and 4-5 quizzes besides assignments and their attendances. The final grade is based on following:

First Exam.	15%
Second Exam.	15 %
Quizzes, assignments, and attendances	10%

Total (Annual Effort)	40%
Final Exam.	60 %
Final grade	100%

Program for Academic Year 2019-2020

Date	Week No.	Name of the Chapter	Name of the Topics
October 2019	Week 1	1.Introduction	General and phases of construction of the project, the engineer & construction, the construction industry, contract types , performance bond, contractor types. Roles of Engineer and Contractors in construction economy.
	Week 2	2.Project Planning and Scheduling	General information, construction activities, methods of scheduling: project network analysis (CPM): the activity-on-arrow (AOA) type commonly called arrow diagramming, Quiz . Duties and Authorities of Engineer's Representative Clause 2……Clause 14.
	Week 3	2.Project Planning and Scheduling	Example (AOA diagram)
	Week 4	2.Project Planning and Scheduling	the activity –on-node (AON) type commonly called precedence diagramming. The time-grid diagram method. Quiz PERT, Gantt (bar-chart) diagram.
November	Week 1	2.Project Planning and Scheduling	Resource allocation. Computer program (Microsoft Project Management, Application of Microsoft Project Program.
	Week 2	2.Project Planning and Scheduling	Bar (Gantt) Chart Method, S- Curve for Progress and Cost Calculations.
	Week 3	3.Estimating of Quantities in Civil Works	General, purposes of estimate, types of estimate, Quiz.
	Week 4	3.Estimating of Quantities in Civil Works	Detailed estimate …….
December	Week 1	3.Estimating of Quantities in Civil Works	Quantity estimate (of construction materials)
	Week 2	3.Estimating of Quantities in Civil Works	Water Supply and Sanitary Works
	Week 3	4.Selection of Construction Equipment and Equipment Cost	Introduction, standard and special types of equipment, owing and operating costs. ……..?

	Week 4	Holidays	Holidays
January 2020	Week 1	4.Selection of Construction Equipment and Equipment Cost	depreciation and methods of depreciation. Quiz
	Week 2	5.Erthmoving Materials and Operations	Introduction, production of earthmoving equipment, soil volume-change characteristics.
	Week 3	5.Erthmoving Materials and Operations	Swell, shrinkage, load and shrinkage factors, spoil banks. Quiz
	Week 4	……..	1st Seasonal Examinations
February	Week 1	……..	1st Seasonal Examinations
	Week 2	6.Excavating and Lifting	Introduction, production of shovels, backhoes
	Week 3	6.Excavating and Lifting	draglines, clamshells.
	Week 4	7.Loading and Hauling	Production of Dozers and Loaders
March	Week 1	7.Loading and Hauling	Production of scrapers
	Week 2	……..	Holidays of Nawroz
	Week 3	……	Holidays of Nawroz
	Week 4	7.Loading and Hauling	Production Management for Loading and Hauling Equipment.
April	Week 1	7. Loading and Hauling	Trucks and Wagons and their Required Numbers, and Production of Combined Equipment.
	Week 2	8. Compacting and Finishing	Principles of compaction, compaction equipment and procedures, estimating compactor production, grading and finishing and estimating grader production.
	Week 3	……..	2nd Seasonal Examinations
	Week 4	…….....	2nd Seasonal Examinations
May	Week 1	9. Production of concrete and asphalt mixes	Production of concrete, estimating mixer production. Production of asphalt mixes, estimating asphalt plant production.
	Week 2	10.Concrete Form Design	Design principles, design loads, floor and slab forms. Lateral loads, slab form design Wall form design
	Week 3	10.Concrete Form Design	Wall form design
	Week 4		

References

1. Peurifoy Robert L, and Ledbetter, William B. " **Construction Planning, Equipment & Methods**" 4th Edition, , McGraw-Hill, 1985.

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3. Nunnally, S. W. " **Construction Methods and Management**", 7th Edition, Upper Saddle River, New Jersey: Prentice Hall, 2007.

4. Dutta, B. N. " **Estimating and Costing in Civil Engineering- Theory and Practice**", 24th Edition, USB Publishers' Distributors Ltd., New Delhi, 1999.

5. Gurcharan Singh, and Jagdish Singh " **Estimating Costing And Valuation**" 1st Edition, Standard Publishers Distributers, 1705-B, SARAk, Delhi, 2008.

6. Roy Pilcher " **Principles of Construction Management**", 2nd Edition, McGraw-Hill Book Company, UK, 1976.

7. . Bhattacharjee S.K. " Fundamentals of PERT/CPM and Project Management", Khanna Publishers, 2-B, NATH MARKET, NAI SARAK, DELHI- 110006, 2008.

8. Hinze, Jimmie W. " **Construction Planning and Scheduling**" 2nd Edition, Upper Saddle River, New Jersey: Prentice Hall, 2004.

9. Meredith, Jack R. and Mantel Samuel J " **Project Management a Managerial Approach – International Student Version**", 7th Edition, John Wiley & Sons, Inc. 2010.

10. Ministry Of Planning- Legal Department " **Conditions of Contract for Civil Engineering Works**", 1987.

11. Al-Fao General Engineering Company " **General Technical Conditions and Specifications – Book- 1 /2, Specification of Materials Workmanship of Civil Engineering Works**" , Second Edition, 2002**.**

Some Selected Problems & Worked Examples

Chapter 2 (Project Planning and Scheduling)

(a)Prepare an arrow (AOA) diagram showing ES, LS, EF and LF times and the critical path for a project involving the activities listed in following:

(b) Draw Time-grid diagram.

Activity	Duration	Activity which immediately	
		Precede	Follow
A	3	None	B, C
B	5	A	D, E
C	4	A	F, I
D	7	B	G
E	6	B	H
F	11	C	H
G	6	D	J
H	4	E,F	K
I	3	C	K, L
J	6	G	M
K	5	H, I	N
L	7	I	O
M	5	J	P
N	3	K	P
O	2	L	P
P	4	M, N, O	None

Solution

(a)

Critical path: A – B- D – G – J – M – P

Project duration = 36 time units (week)

Activity	Duration	ES	EF = ES + D	LS = LF – D	LF = LS + D	TF = LS-ES LF-EF	FF= ES(smallest following)- EF
A	3	0	3	0	3	0	0 *
B	5	3	8	3	8	0	0 *
C	4	3	7	5	9	2	0
D	7	8	15	8	15	0	0 *
E	6	8	14	14	20	6	4
F	11	7	18	9	20	2	0
G	6	15	21	15	21	0	0 *
H	4	18	22	20	24	2	0
I	3	7	10	20	23	13	0
J	6	21	27	21	27	0	0 *
K	5	22	27	24	29	2	0
L	7	10	17	23	30	13	0
M	5	27	32	27	32	0	0 *
N	3	27	30	29	32	2	2
O	2	17	19	30	32	13	13
P	4	32	36	32	36	0	0 *

Chapter 3 (Estimating)

Figure below represents the simple sketch (plan) of an office building with internal dimensions of rooms and corridors. Draw a plan representing the superstructure (or foundation) then estimate the quantities of the following items using long and short wall method.

(1)Excavation (cu. m), (2) Lean concrete for the foundation (cu. m), (3)Brickwork under DPC, (4)Reinforced concrete of the roof slab (cu. m).

Use following information:

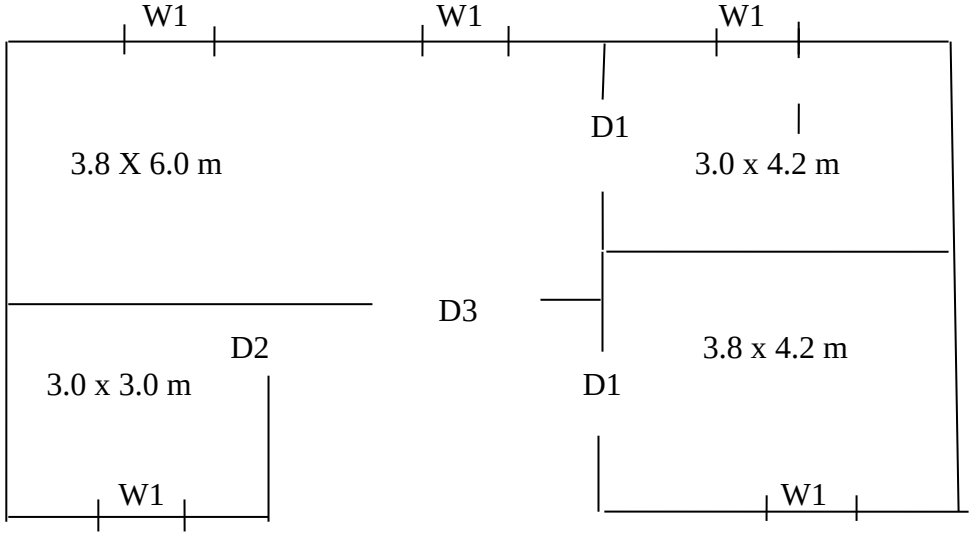
Foundation: width = 70 cm and depth = 60 cm, Concrete of foundation = 30 cm depth.

Brickwork under DPC: 1st step 48 cm width and 30 cm height, 2nd step: 36 cm width; 25 cm height.

Brickwork above DPC: 36 cm width and 3 m height.

Roof: extended 50 cm out of the external faces of the walls.

Others: shown on the figure



Chapter 4 (Selecting Construction Equipment)

Consider a new crawler tractor. Its purchase price is $100,000 and the assessed resale value after using for 5 years is 25% of the delivered price. Determine the depreciation and book value for each of 5 years using
(a) straight-line method, (b) double declining balance method, (c) sum-of-the-years-digits method
(d) Internal Revenue Service (IRS) method.

Solution

(a) $D_n = (P - S) / N$

$S = 0.25 \times 100{,}000 = \$25{,}000$

$D_n = (100{,}000 - 25{,}000) / 5 = \$15{,}000$

Year	BV n-1	Dn	BVn
0	-	0	$100,000
1	$100,000	$15,000	85,000
2	85,000	15,000	70,000
3	70,000	15,000	55,000
4	55,000	15,000	40,000
5	40,000	15,000	25,000

(b) .Declining-Balance (DB) Depreciation Methods

$R = 2/N = 2/5 = 0.40$

$D_n = BV_{n-1} \times R$ $BV_n = BV_{n-1} - D_n$

Year	BV n-1	Dn	BVn
0	-	0	$100 000
1	$100 000	$40 000	$60 000
2	$60 000	$24 000	$36 000
3	$36 000	$14 400($11 000)	$(21 600)25 000*
4	$25 000	$0	$25 000*
5	$25 000	$0	$25 000*

*Note that book value cannot go below the salvage value

(c) Sum-of-the-Years-Digits Method

$D_n = (\text{year digit}) / (\text{sum of years' digits}) \times (P - S)$

Sum of digit in 5 year life = 5 +4 + 3+2+1 = 15

D1 = 5/15 x (100 000 – 10 000) = $30 000
D2 = 4/15 x (100 000 – 10 000) = $24 000
D3 = 3/15 x (100 000 – 10 000) = $18 000
D4 = 2/15 x (100 000 – 10 000) = $12 000
D5 = 1/15 x (100 000 – 10 000) = $6 000

Year	Dn	BVn
0	0	$100 0000
1	$30 000	$70 000
2	$24 000	$46 000
3	$18 000	$28 000
4	$12 000	$16 000
5	$6 000	$10 000

(d)IRS- Prescribed Methods

D1 = 0.2 x $100 000 = $20 000
D2 = 0.32 x $100 000 = $32 000
D3 = 0.192 x $100 000 = $19 200
D4 = 0.1152 x $100 000 = $11 520
D5 = 0.1152 x $100 000 = $ 11520
D6 = 0.0576 x 100 000 = $5 760

Year	Dn	BVn
0	0	$100 0000
1	$20 000	$80 000
2	$32 000	$48 000
3	$19 200	$28 800
4	$11 520	$17 280
5	$11 520	$10 000 ($5 760)

Chapter 5 (Earthmoving materials and operations)

A soil weighs 1163 kg/ LCM, 1661 kg/BCM, and 2077 kg/CC., (a) Find the load factor and shrinkage factor for the soil. (b) How many bank cubic meters (BCM) and compacted cubic meters (CCM) are obtained in 1 million loose cubic meter of this soil?

Solution

(a)Load factor = 1163/1661 = 0.70

Shrinkage factor = 1661/2077 = 0.80

(b)Bank volume = 1 000 000 x 0.70 = 700 000 BCM

Compacted volume = 700 000 x 0.80 = 560 000 CCM

Equations ……

$$\text{Swell (\%)} = [(\gamma B) / (\gamma L) - 1] \times 100$$

Where γB = bank unit weight (BCM)
γL = loose unit weight (LCM)

$$\text{Shrinkage} = [1 - (\gamma B) / (\gamma c)] \times 100$$

Where γc = compacted unit weight (kg/m^3)

$$\text{Shrinkage factor} = (\gamma B) / (\gamma C) \quad \ldots\ldots(5\text{-}8)$$

or

$$\text{Shrinkage factor} = (V_C / V_B)$$

or

Shrinkage factor = 1 – shrinkage)

Chapter 6 (Excavating and Lifting)

Production Estimating of Hydraulic Excavators

The production may be estimated by using Eq6-1 and together with Tables 3-3 and 3-4, which have been prepared from manufacturers' data.

$$\text{Production (LCM/h)} = C \times S \times V \times B \times E$$

where C = cycles/h (Table 3-3)
S = swing-depth factor (Table 3-4)
V = heaped bucket volume (LCM)
B = bucket fill factor (Table 6-2)
E = job efficiency

Find the expected production in loose cubic meters per hour of a small hydraulic excavator. Heaped bucket capacity is 0.57 m3. The material is sand and gravel with a bucket fill factor of 0.95. Job efficiency is 50 min/h. Average depth of cut is 4.3 m. Maximum depth of cut is 6.1 m and swing angle is 90.

Solution

Cycle output = 250 cycles/60 min (Table 3-3)
Depth of cut (% of maximum = (4.3 / 6.1) x 100 = 70%
Swing-depth factor = 1.00 Table (3-4)
Bucket volume = 0.57 LCM
Bucket fill factor = 0.95
Job efficiency = 50/60 = 0.833
Production = 250 x 1.00 x 0.57 x 0.95 x 0.833 = 113 LCM/h

Chapter 7 (Loading and Hauling)

A power-shift crawler tractor has a rated blade capacity of 7.65 LCM. The dozer is excavating loose common earth and pushing it a distance of 61 m. maximum reverse speed in third range is 8km/h. estimate the production of the dozer if job efficiency is 50 min/h.

Solution

Cycle time = Fixed time + Variable time

Fixed time = 0.05 min (Table 4-4)

Dozing speed = 4.0 km/h (Table 4-5)

Dozing time = 61 / (4 x 16.7) = 0.91 min (1 km/h = 16.7 m/min

Return time = 61 / (8 x 16.7) = 0.45 min

Cycle time = 0.05 + 0.91 + 0.45 = 1.41 min

Production = 7.65 x 50/ 1.41 = 271 LCM/h (Eq. 5-1)

Chapter 8 (Compacting and Finishing)

Estimating Compactor Production Fifteen kilometers of gravel road require reshaping and leveling. If a motor grader requires two passes of 4.8 km/h, two passes at 6.4 km/h, and one pass at 8.0 km/h to accomplish the work. Estimate the production (km/h) of the motor grader if the job efficiency factor is 0.83.

Solution

Time (h) = [(2 x15/ 4.8) + (2 x 15 /6.4) + (1 x 15 / 8.0)] / 0.83 = 15.44

Production = 15 / 15.44 = 0,97 kph

Following equation may be used to calculate compactor based on compactor speed, lift thickness, and effective width of compaction.

Production (CCM/h) = (10 x W x S x L x E) / P

where P = number of passes required
W = width compacted per pass (m)
S = compactor speed (km/h)
L = compacted lift thickness (cm)
E = job efficiency