

건설관리학특론

강의노트

2023년 3월 1일

충북대학교 공과대학
토목공학부

정근채 교수

- 목차 -

- 강의계획서
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- 보고서 양식(출석 인정용 보고서 #01 ~ #13)

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
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제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

강의계획서

출력일시 : 2023-02-07 16:41:06

1. 교과목 정보

개설연도-학기	2023년	1학기	개설학과	토목공학과
교과목번호-분반번호	8935321	01	교과목명	건설관리학특론
이수구분	전공공통		학점/시수	3-3-0
강의시간/강의실	월 11, 12, 13 [E8-6-323(49-323)]			
수업방식				
강의언어		담당교수	정근채(전임교원)	
전화	043-261-2401	E-mail	kcjeong@cbnu.ac.kr	
강의정원		학과전화	043-261-2380	
선수과목		수강대상	통합(전학년)	
강의 맛보기	http://kcjeong.cbnu.ac.kr/working/acm/index.html			

2. 교과목 개요

강의개요	- 프로젝트 관리, 설계관리, 원가관리, 공정관리, 품질관리, 안전관리, 계약관리 등 건설공사의 기획 단계부터 설계, 계약, 시공, 시공 후 단계까지 전 건설 공사 수명 주기 동안의 종합적인 건설 관리 분야를 학습한다.					
학습목표	- 건설을 계획하고 관리함에 있어서 개별적인 요소기술에 대한 부분최적화에 그치지 않고 총합적 최적화를 실현할 수 있는 다양한 관리기법에 대한 이해도를 제고한다.					
문제해결방법	- 해당사항없음					
수업진행방법	강의	토의/토론	실험/실습	현장학습	개별/팀별 발표	기타
	70%	30%	0%	0%	0%	0%
	상세정보	- 강의의 70%, 강의내용에 대한 질의 응답 30%				
평가방법	중간고사	기말고사	출석	퀴즈	과제	기타
	40%	40%	20%	0%	0%	0%
	상세정보	- 중간고사(40%) + 기말고사(40%) + 출석(20%)				
프로그램 학습성과의 평가	- 해당사항없음					
교재 및 참고문헌	1. 주교재 : Construction Management Fifth Edition, Daniel W. Halpin and Bolivar A. Senior, John Wiley & Sons, Inc., 2018 2. 부교재 : 건설관리학 강의노트, 정보기술기반 건설경영연구실, 충북대학교 토목공학부, 2023					
핵심역량과 연계성						

3. 주별 강의계획

주차	수업내용	교재범위 및 과제물	비고
1	강의소개	주간보고서 #01	
2	파나마운하 건설관리 사례분석	주간보고서 #02	
3	1. History and Basic Concepts, 2. Preparing the Bid Package	교재 1, 2장, 주간보고서 #03	
4	3. Issues during Construction. 4. Contracts	교재 3, 4장, 주간보고서 #04	
5	5. Legal Structure, 6. Impact of Taxes	교재 5, 6장, 주간보고서 #05	
6	7. Project Planning, 8. Project Scheduling	교재 7, 8장, 주간보고서 #06	
7	9. Scheduling: Program Evaluation and Review Technique Networks and Linear Operations, 10. Resource-Related and Advanced Linear Scheduling Techniques	교재 9, 10장, 주간보고서 #07	
8	중간고사		
9	브룩클린교 건설관리 사례분석	주간보고서 #08	

강의계획서

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10	11. The Mathematics of Money, 12. Project Cash Flow	교재 11,12장, 주간보고서 #09	
11	13. Project Funding, 14. Equipment Ownership	교재 13, 14장, 주간보고서 #10	
12	15. Equipment Productivity, 16. Construction Labor	교재 15, 16장, 주간보고서 #11	
13	17. Estimating Process, 18. Cost Control	교재 17, 18장, 주간보고서 #12	
14	19. Materials Management, 20. Safety	교재 19, 20장, 주간보고서 #13	
15	기말고사		
16			
17			
18			
19			
20			
21			
22			

4. 장애학생을 위한 학습 및 평가지원 사항

<ul style="list-style-type: none"> - 학습지원: 강의 파일 제공, 대필 도우미 및 속기 지원 허락, 강의 녹음 허락, 과제 제출 기간 연장(시각, 손사용 불편 학생), 보조기구 사용 가능 등 - 평가지원: 영어교과 듣기 시험 대체(청각장애학생), 장애종류 및 정도에 따라 시험 시간 1.5배 ~ 1.7배 연장, 별도 시험장소 및 시험지 제공, 필요한 경우 학습기자재 사용을 허용

5. 수강에 특별히 참고하여야 할 사항

<ul style="list-style-type: none"> - 해당사항없음
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건설관리학특론 주별 강의내용

수업 일정	월요일 7시 ~ 10시	동영상 강의	과제	제출기한
1주	3월 6일	강의소개	주간보고서 #01	3월 13일
2주	3월 13일	파나마운하 건설관리 사례분석	주간보고서 #02	3월 20일
3주	3월 20일	1. History and Basic Concepts 2. Preparing the Bid Package	주간보고서 #03	3월 27일
4주	3월 27일	3. Issues during Construction 4. Contracts	주간보고서 #04	4월 3일
5주	4월 3일	5. Legal Structure 6. Impact of Taxes	주간보고서 #05	4월 10일
6주	4월 10일	7. Project Planning 8. Project Scheduling	주간보고서 #06	4월 17일
7주	4월 17일	9. Scheduling: Program Evaluation and Review Technique Networks and Linear Operations 10. Resource-Related and Advanced Linear Scheduling Techniques	주간보고서 #07	4월 24일
8주	4월 24일	중간고사		
9주	5월 1일	브룩클린교 건설관리 사례분석	주간보고서 #08	5월 8일
10주	5월 8일	11. The Mathematics of Money 12. Project Cash Flow	주간보고서 #09	5월 15일
11주	5월 15일	13. Project Funding 14. Equipment Ownership	주간보고서 #10	5월 22일
12주	5월 22일	15. Equipment Productivity 16. Construction Labor	주간보고서 #11	5월 29일
13주	5월 29일	17. Estimating Process 18. Cost Control	주간보고서 #12	6월 5일
14주	6월 5일	19. Materials Management 20. Safety	주간보고서 #13	6월 12일
15주	6월 12일	기말고사		

주간 보고서 #01 : 건설관리학특론 수강 계획

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> 이번 학기 건설관리학특론 수업에 대한 강의계획서, 주별 강의 일정, 강의 소개 영상을 바탕으로, 건설관리학특론 수업에 대한 수강(학업)계획을 수립하시기 바랍니다. 형식은 따로 없으니 여러분의 학업 계획을 자유롭게 서술하여 제출하시기 바랍니다.

주간 보고서 #02 (1/1) : 파나마운하 건설관리 사례분석

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

동영상 메모란

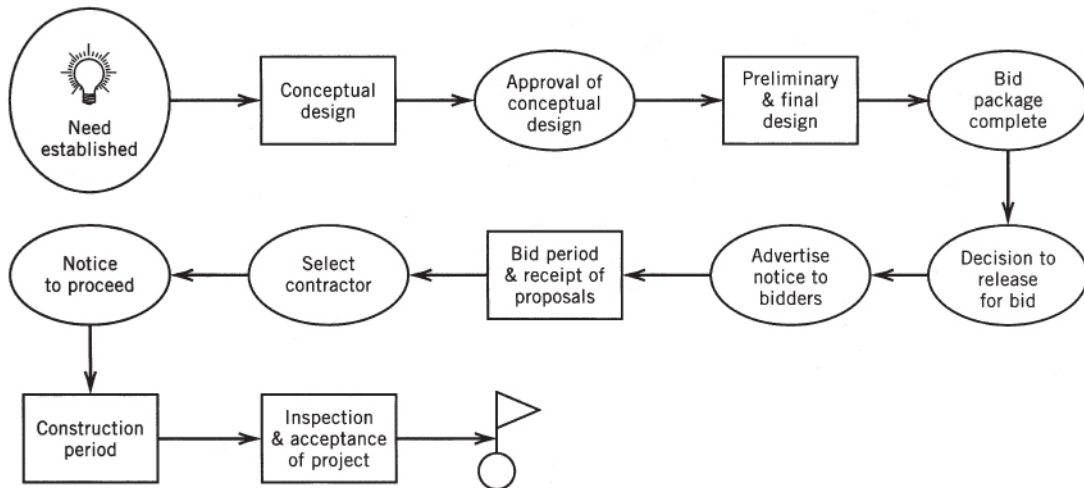
느낀점 작성란

주간 보고서 #03 (1/1) : 1장, 2장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> 건설기술과 건설관리의 차이에 대해 설명하시오.

<문항 2> 다음 그림을 참조하여 신규 프로젝트에 대한 프로젝트 개발 생애주기를 설명하시오.



주간 보고서 #04 (1/2) : 3장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> 가치공학 개념을 이용하여 최적대안을 평가하기 위한 다음 표를 완성하십시오. 최적 대안은 무엇인가?

Weighted Evaluation

Project:

Architectural Structural Mechanical Others

Date: _____

Sheet No.: _____

Criteria

Criteria Scoring Matrix

How Important:

- 4 - Major Preference
- 3 - Above Average Preference
- 2 - Average Preference
- 1 - Slight Preference
- Letter / Letter
- No Preference
- Each Scored One Point

A. Cost (LCC)								
B. Aesthetics	A-2							
C. Space	B/C	A-2						
D. Performance	D-1	D-1	A-1					
E. Safety	E-1	E-1	E-1	A/E				
F.								
G.								
		G	F	E	D	C	B	A

Analysis Matrix
Alternatives

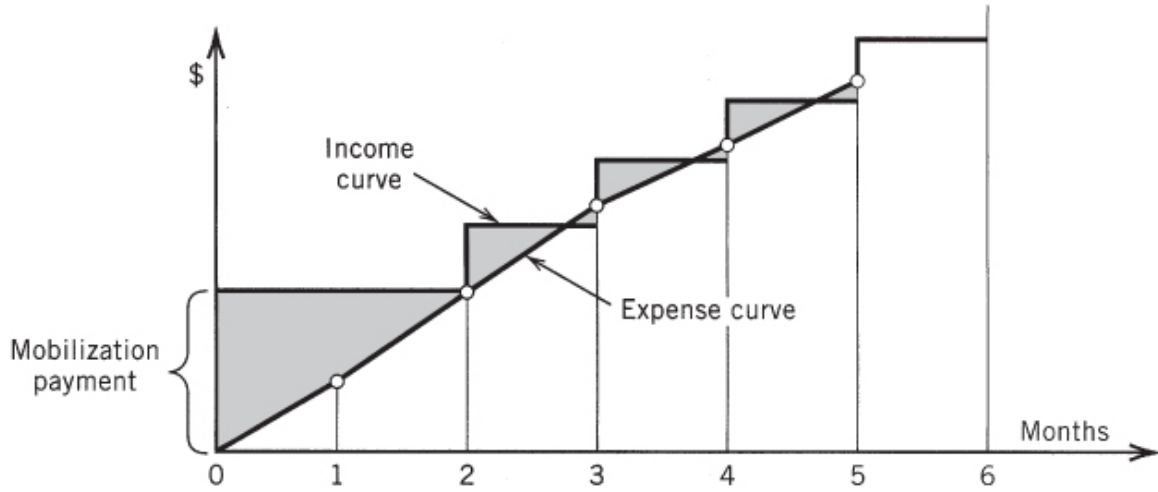
Raw Score			5	2	1	1	6	
Weight of Importance (0-10)			9	4	2	2	10	
								Total
1. Original Solution			3	3	2	2	4	
2. Alternative No. 1			3	2	4	3	5	
3. Alternative No. 2			4	5	5	5	1	
4.								
5.								

* Selected based on weighted evaluation
5-Excellent 4-Very Good 3-Good 2-Fair 1-Poor

주간 보고서 #04 (2/2) : 4장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 2> 다음 그림을 참조하여 동원 지불의 개념에 대해 설명하시오.



주간 보고서 #05 (1/1) : 5장, 6장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> 개인회사, 합명회사, 주식회사의 차이점에 대해 설명하시오.

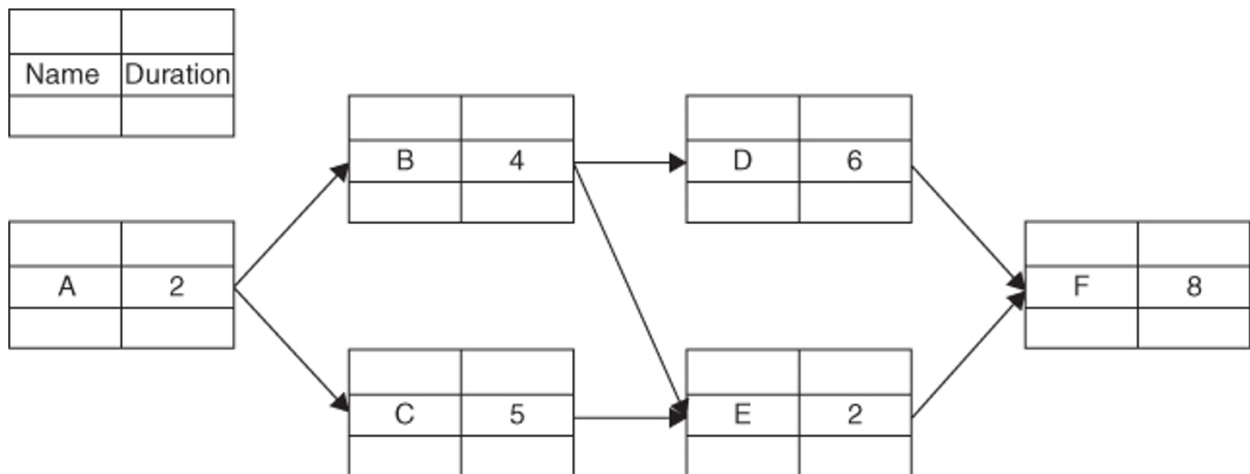
<문항 2> 건설 기업에 있어서 감가상각의 중요성에 대해 설명하시오.

주간 보고서 #06 (1/1) : 7장, 8장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> Deming의 PDCA 사이클에 대해 설명하시오.

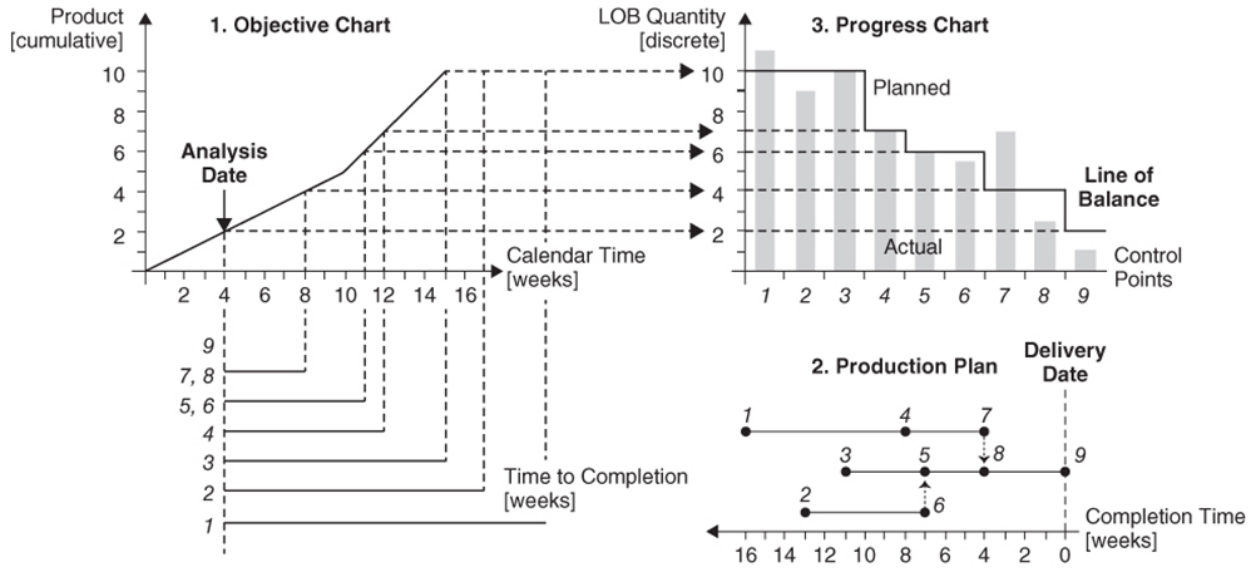
<문항 2> Critical Path Method를 이용하여 다음 네트워크의 빈칸을 채우고 주공정로를 구하시오.



주간 보고서 #07 (1/2) : 9장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

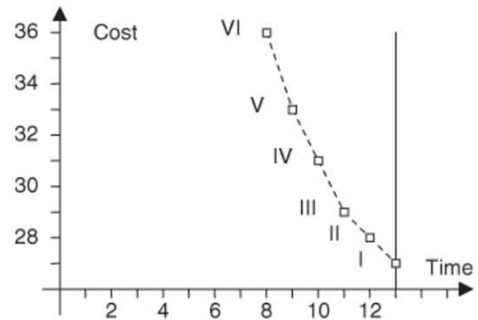
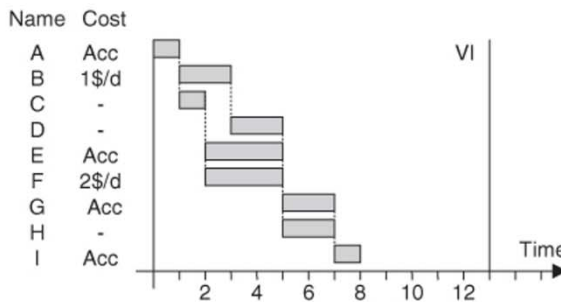
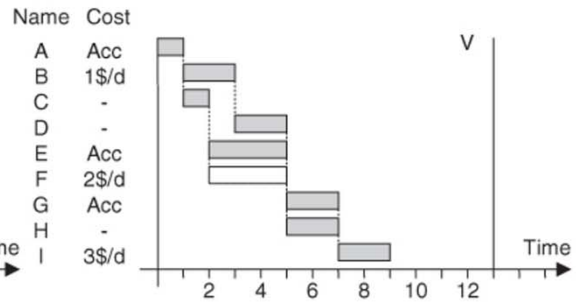
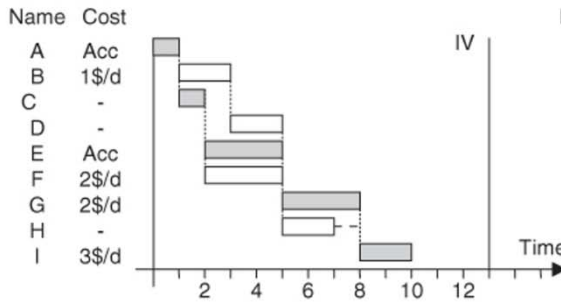
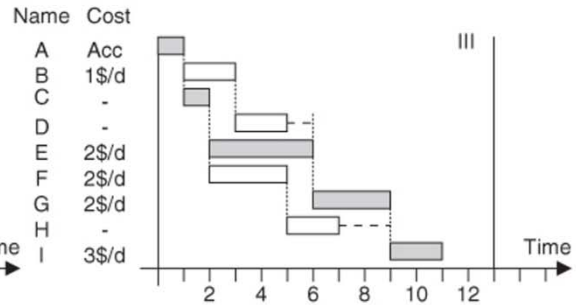
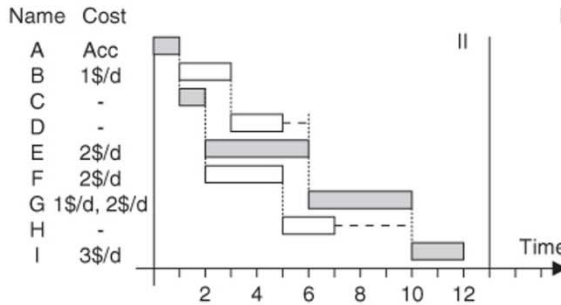
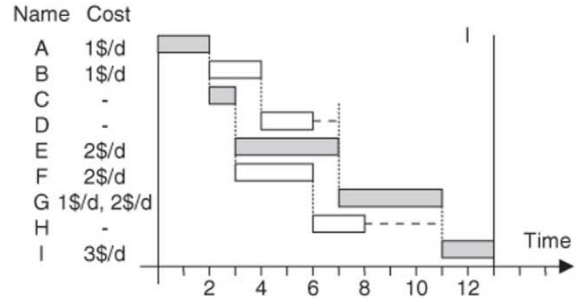
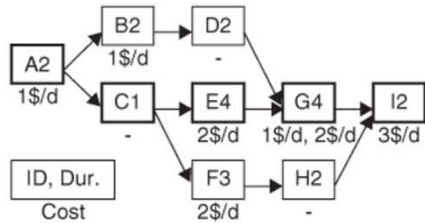
<문항 1> 다음 Line of Balance Chart를 보고, 전체 9개의 체크 포인트 중 작업진도가 빠른, 딱 맞는, 느린 체크 포인트를 찾아 나열 하시오.



주간 보고서 #07 (2/2) : 10장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 2> 다음 그림을 참조하여 프로젝트의 공기가 단축되는 과정을 설명하시오. 또한 전체 공정이 모두 정상 공기를 사용하는 경우와 특급 공기를 사용하는 경우, 프로젝트의 공사비와 공사기간은 각각 얼마인가?



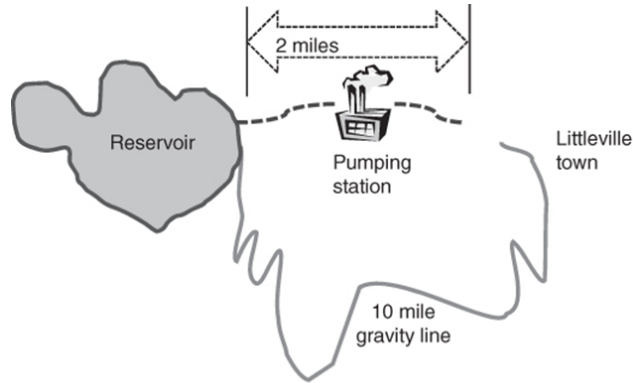
주간 보고서 #08 (1/1) : 브룩클린교 건설관리 사례분석

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

동영상 메모란

느낀점 작성란

<문항 1> 다음 그림과 같이 배수지와 마을을 잇는 상수도 공사를 위한 두 가지 대안 A와 B가 있다. 두 대안 관련 비용정보가 다음과 같을 때 어느 대안이 경제적으로 더 우수한지 대안별로 현재등가와 연등가를 구하여 분석하시오. 단, 경제성 평가 기간은 총 40년임.



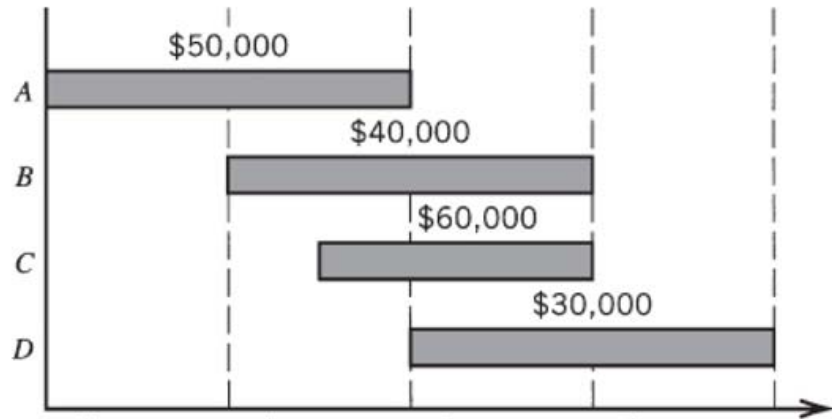
Plan A – Gravity Line Plan; Plan B – Line Using Pumping Station

Item	Pipeline A Costs (\$)	Pipeline B Costs (\$)
Initial investment pipeline	2.8 million	1.5 million
Cost of pumping station	0	500,000
Annual operation and maintenance (O&M) costs	30,000	60,000
Annual power costs during first 10 years	0	40,000
Annual power costs after 10 years	0	120,000

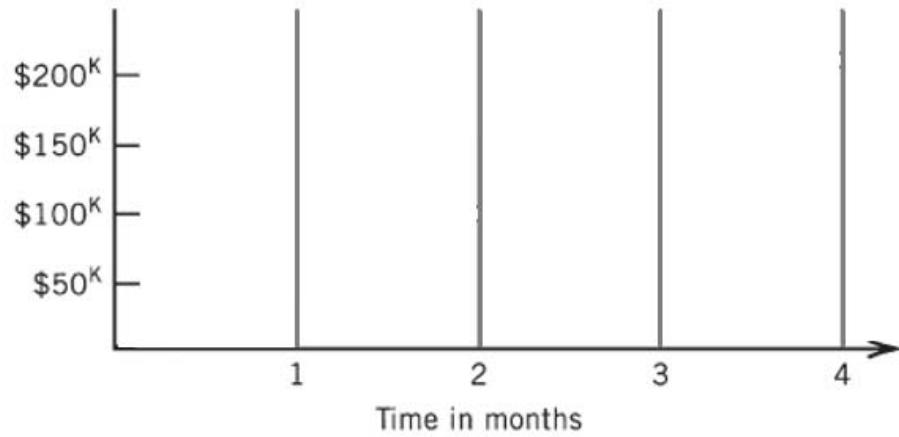
주간 보고서 #09 (2/2) : 12장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 2> 다음 바차트를 이용하여 직접비, 간접비, 총비용, 누적비용을 구하고 이를 바탕으로 S-curve를 완성하시오.



Monthly direct costs	\$	\$	\$	\$
Monthly indirect costs	\$ 5,000	\$ 5,000	\$ 5,000	\$ 5,000
Total monthly costs	\$	\$	\$	\$
Cumulative monthly costs	\$	\$	\$	\$



주간 보고서 #10 (1/1) : 13장, 14장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> Build, Operate, and Transfer (BOT) 사업방식에 대해 설명하시오? 또한, BOT와 BTO의 차이는 무엇인가 설명하시오.

<문항 2> 장비의 경제 수명을 어떻게 결정할 수 있는지 설명하시오.

주간 보고서 #11 (1/2) : 15장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> 다음과 같은 자료가 주어졌을 때, 작업물량을 수행하기 위해 필요한 총 작업시간을 산출하시오.

- A front-end loader (200 bank yd³/hour).
- It loads a fleet of four trucks (capacity 18 loose yd³ each), which haul the earth to a fill where it is compacted with a shrinkage factor of 10%.
- Each truck has a total cycle time of 15 min.
- The earth has a percent swell of 20%.
- The job requires a volume of 18,000 compacted yd³.
- How many hours will be required to excavate and haul the material to the fill?

주간 보고서 #11 (2/2) : 16장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 2> 건설 인력관리와 관련된 다음 용어들을 설명하시오.

● Yellow-dog contracts

● Union shop

● Closed shop

● Union hiring halls

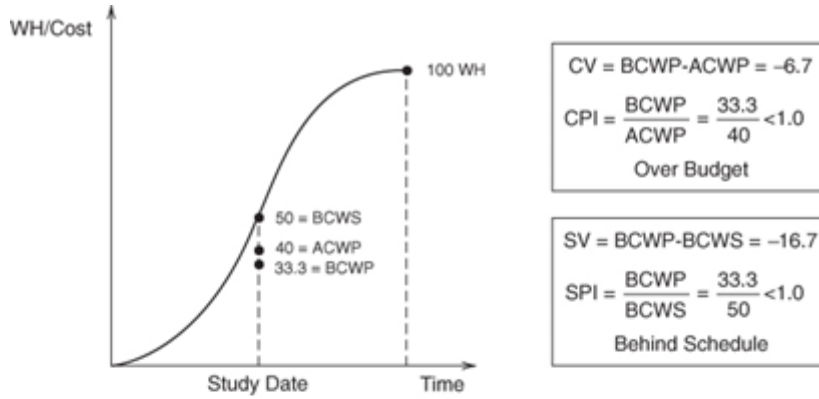
● Secondary boycott

주간 보고서 #12 (1/2) : 17장

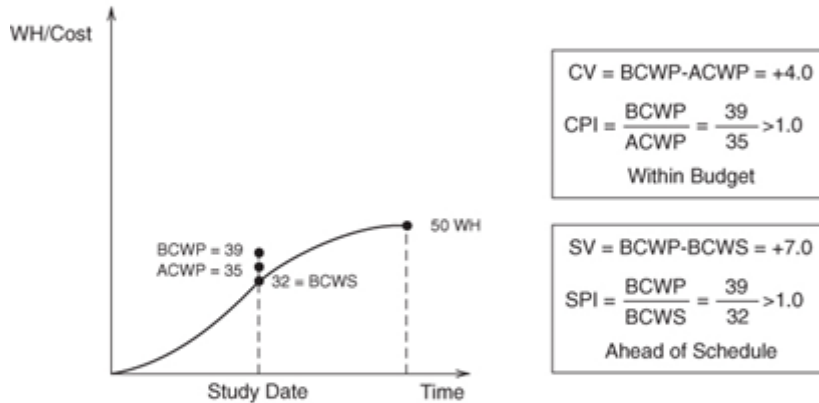
제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> 개선견적, 예비견적, 상세견적을 비교하여 설명하시오.

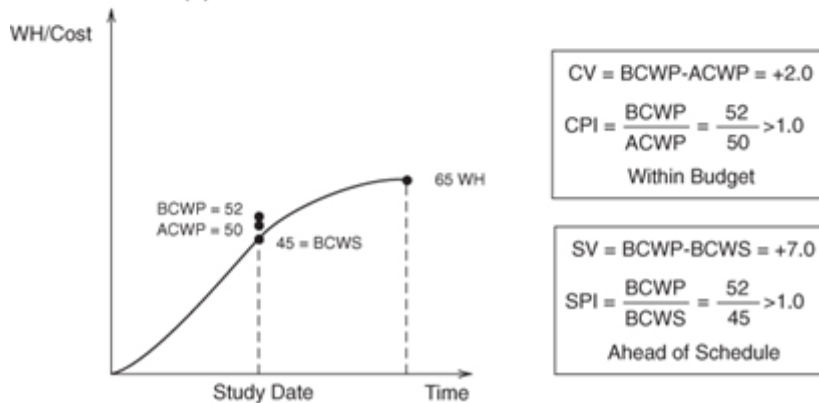
<문항 2> 다음 자료를 바탕으로 공정, A1, A2, B의 공기 및 공사비 현황에 대해 설명하시오.



(a) Baseline for A.1



(b) Baseline for A.2

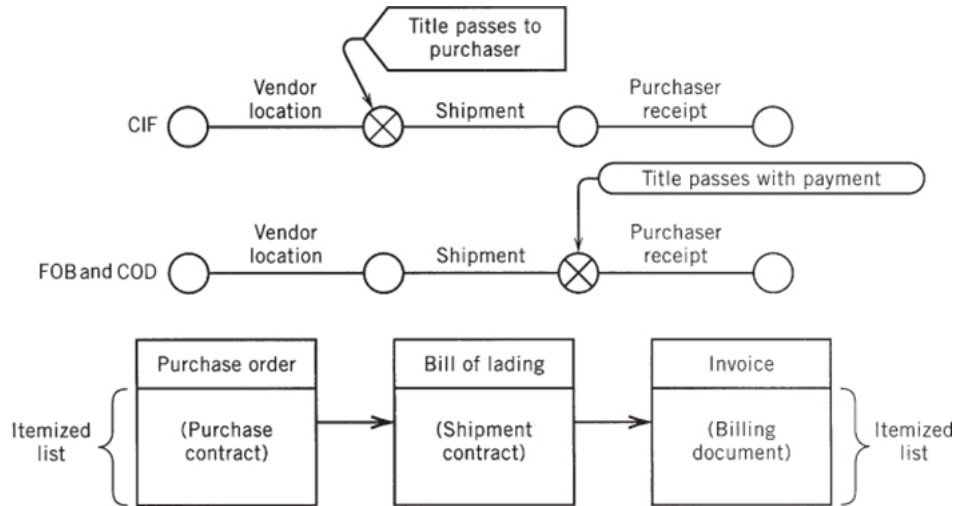


(c) Baseline for B

주간 보고서 #13 (1/1) : 19장, 20장

제출일 : 2023년 __월 __일 학번 : _____ 이름 : _____

<문항 1> 다음 그림을 바탕으로 CIF와 FOB and COD 주문 방식의 차이에 대해 설명하시오.



<문항 2> 안전과 관련된 세 가지 범주의 비용에 대해 설명하시오.

CHAPTER 1

HISTORY AND BASIC CONCEPTS

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
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제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

1.1 Bridges and History



FIGURE 1.1 Roebling Bridge, Cincinnati

- 세상에서 가장 오래된 현수교: PM의 이름을 따서 교량의 이름을 지음
 - ✓ 미국 오하이오주 신시내티에서 존 A. 로블링 (John A. Roebling)이 **남북 전쟁** 중에 건설
American Civil War : 1861-1865
 - ✓ 1856 년에 공사가 시작, 1866 년에 완성
 - ✓ 2개의 주탑 사이 1,000 피트의 경간
 - ✓ 상판의 높이는 최소 100 피트 이상

2

1.2 The Historical Impact of Construction



FIGURE 1.2 The Parthenon in Athens

- 건설하는 능력은 인간의 가장 오래된 기술 중 하나
 - ✓ 브루클린 다리
 - ✓ 파나마 운하
 - ✓ 프로젝트의 성공을 위해서는 건설기술 외적인 요소인 **혁신과 리더십**이 중요

3

1.3 Great Captains of Construction

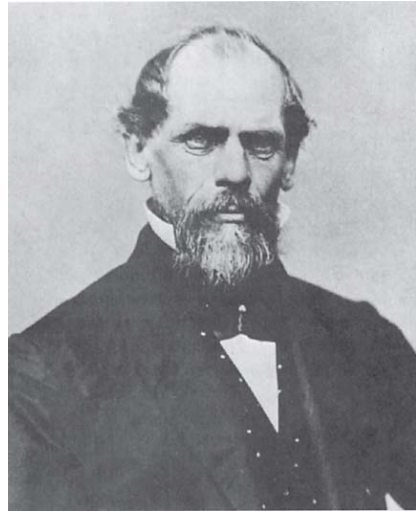


FIGURE 1.3 John A. Roebling, designer of the Brooklyn Bridge

□ 아버지 로블링

- ✓ 케이블 지지 현수교 개념 확립
- ✓ 브루클린교 프로젝트 시작 후 사고로 사망
- ✓ 아들이 프로젝트를 이어 받음

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1.3 Great Captains of Construction



FIGURE 1.4 Washington A. Roebling, chief engineer of the Brooklyn Bridge

□ 아들 로블링

- ✓ 케이슨 작업 현장 관리
- ✓ 잠수병을 얻음
- ✓ 아내를 통해 프로젝트를 간접적으로 관리

5

1.3 Great Captains of Construction



FIGURE 1.5 Emily Warren Roebling, wife of Washington Roebling

□ 아내 로블링

- ✓ 감독관에게 남편의 지시를 전달
- ✓ 수석 기술자 대리 역할 수행

6

1.4 Panama Canal



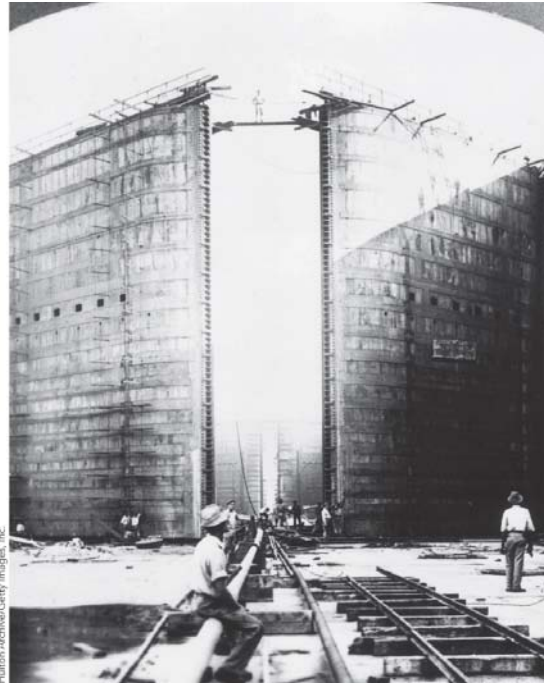
FIGURE 1.6 John F. Stevens, chief engineer of the Panama Canal

□ 존 F. 스티븐스 (John F. Stevens)

- ✓ 대서양과 대평양 사이의 바다 길 연결
- ✓ 프랑스가 시작한 후, 미국이 이어 받음: 루즈벨트의 무력외교를 통한 파나마공화국 건국
1903년 미국의 지원을 받아 콜롬비아로부터 분리 독립
- ✓ 스티븐스는 철도 기술자
- ✓ 작업환경 제고를 위해 숙소와 음식을 개선, 황열병 통제를 위해 월터 리드 박사 영입
- ✓ 이후 프로젝트 기술적 문제에 본격적으로 착수 → 프로젝트 체계 확립
- ✓ 대규모 댐, 계단형 운하, 대규모 토공 기계(증기 구동 식 굴삭기 Culebra Cut)

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1.4 Panama Canal



Culebra Cut(절토)



Railroad

Chagres Dam(성토)

처음부터 세심하게 계획되지 못한 채, 상황에 따라 조금씩 진행되는 방식이 아닌, 처음부터 철저한 계획하에 수행하는 방식이 프로젝트 성공의 열쇠

FIGURE 1.7 Construction of a lock at the Panama Canal

1.5 Other Historic Projects

- 콜로라도 강 (Colorado River)의 후버 댐 (Hoover Dam)
- 샌프란시스코 골든 게이트 브릿지 건설
- 14개월에 엠파이어 스테이트 빌딩 건설
- Eurotunnel 영국 제도와 프랑스를 연결



1.6 Construction versus Manufacturing Processes

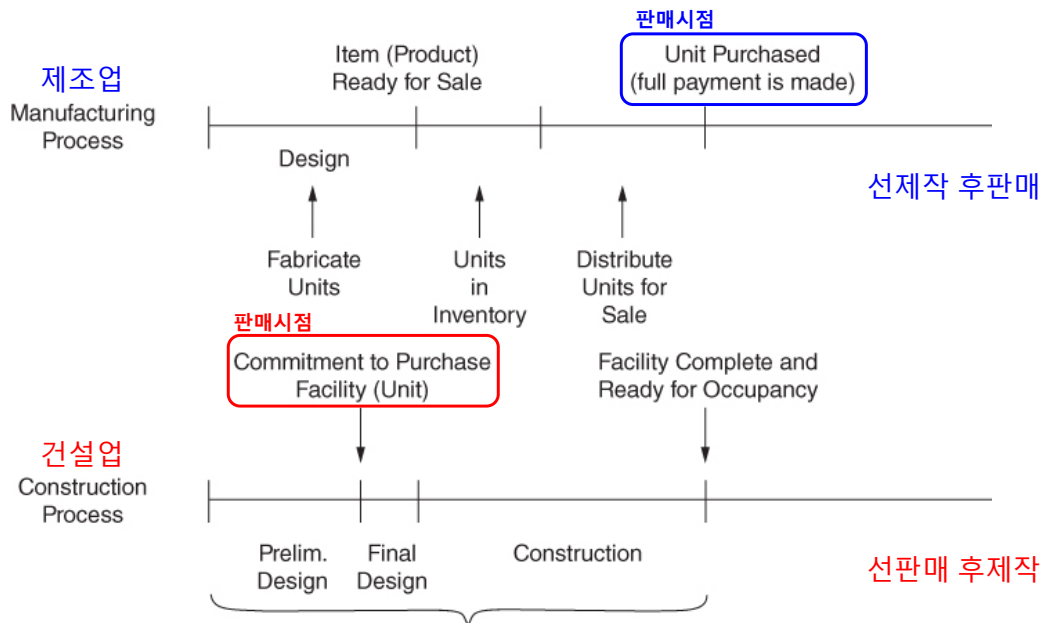


FIGURE 1.8 Manufacturing versus construction process

1.7 Project Format

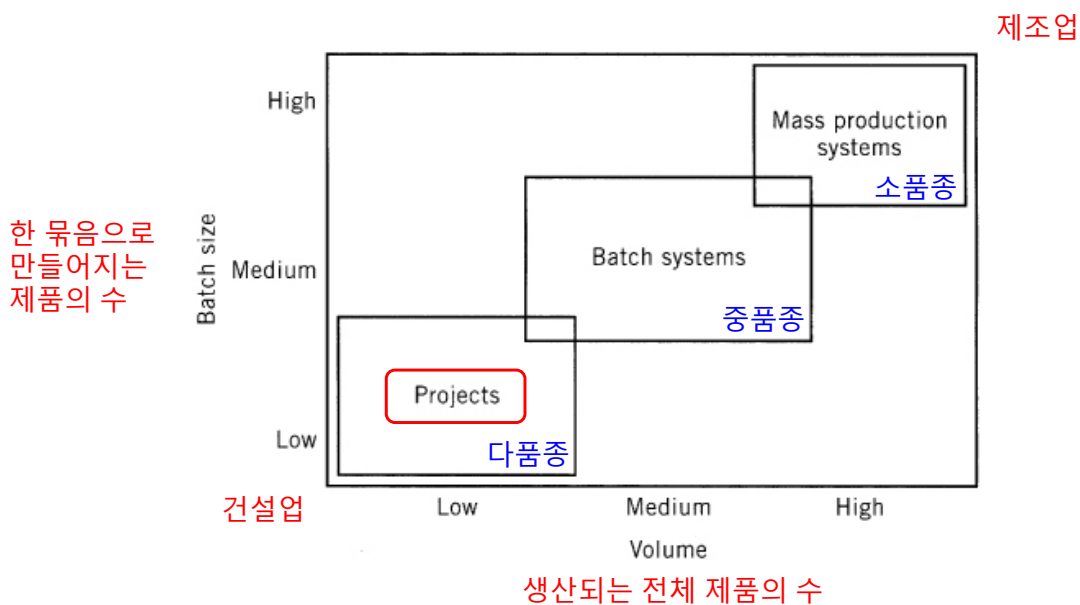


FIGURE 1.9 Comparison of production systems

1.8 Project Development

□ 프로젝트 수행 절차

1. 시설에 대한 건설주의 요구사항 파악
2. 초기 실현 가능성 검토 및 비용 예측
3. 개념 설계 진행을 위한 설계 전문가 고용
4. 개념설계 진행 및 비용 추정
5. 상세설계 진행 및 비용 추정
6. 최종 설계도서를 바탕으로 프로젝트 발주 및 견적 요청
7. 제안서에 따라 시공사 선정 및 계약
8. 시공
9. 시운전을 통해 설계대로 작동하는지 검증
10. 시설 운영 및 유지보수 관리
11. 폐기

1.8 Project Development

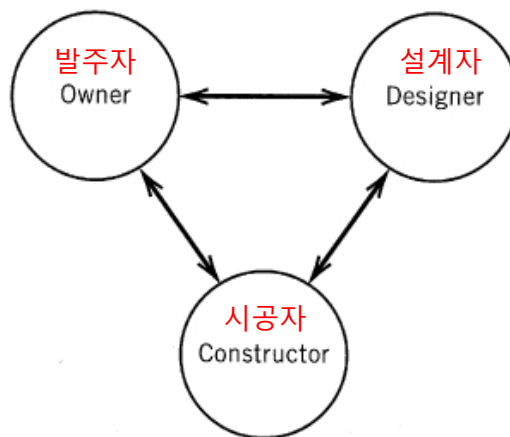


FIGURE 1.10 Relationship between owner, designer, and constructor

1.9 Construction Technology & Construction Management

- **건설기술** : 구조, 수공, 토질, 측량 → 시공 기술과 공법의 선택
- **건설관리** : 건설관리 및 시스템 → 주어진 **자원**의 최적 활용

- **자원** : Four **Ms** of construction: **M**anpower, **M**achines, **M**aterials, and **M**oney

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1.10 Construction Management Is Resource Driven

- The job of a **construction manager** is to efficiently and economically **apply the required resources** to realize a constructed facility of acceptable quality within the time frame and budgeted cost specified. **건설관리자의 임무는 비용 한도내에서 주어진 공기 안에 수용될 수 있는 품질의 시설을 건설하기 위해 가장 효율적이고 효과적으로 자원을 활용하는 것**
- “a quality facility **on time and within budget**”
- A manager must be like a **decathlon** athlete.
10종 경기 선수
- A strong ability in **many areas** is a necessity. **다양한 능력이 필요**

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1.11 Construction Industry

- 건설 산업은 전반적인 경제를 이끄는 엔진
- 1980년대 초반까지, 건설업은 미국 국내 총생산 (GDP)에서 가장 큰 비중을 차지
- 경기 침체 이후, 2000년대 후반, 건설업은 GDP의 약 4%를 차지 대한민국 : 4.2~4.5% 수준
- 건설 기업의 2/3 이상이 5명 미만의 직원으로 구성
- The American **infrastructure**
 - ✓ Roads, tunnels, bridges, communications systems, power plants and distribution networks, water treatment systems, and all of the structures and facilities
 - ✓ The infrastructure is constructed and maintained by the **construction industry**

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1.12 Structure of the Construction Industry

- Construction projects
 - ✓ **Building construction**
 - ✓ **Engineered construction** (highway construction, sewage plants, flood protection projects, dams, transportation projects (other than highways), pipelines, and waterways → 작은 정부에 대한 추구로 인해 사회간접자본 설계 능력을 상당부분 민간에 의존 하수처리장)
 - ✓ **Industrial construction**

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1.13 Differing Approaches to Industry Breakdown



FIGURE 1.11 Breakdown of construction industry segments

1.14 Management Levels of Construction

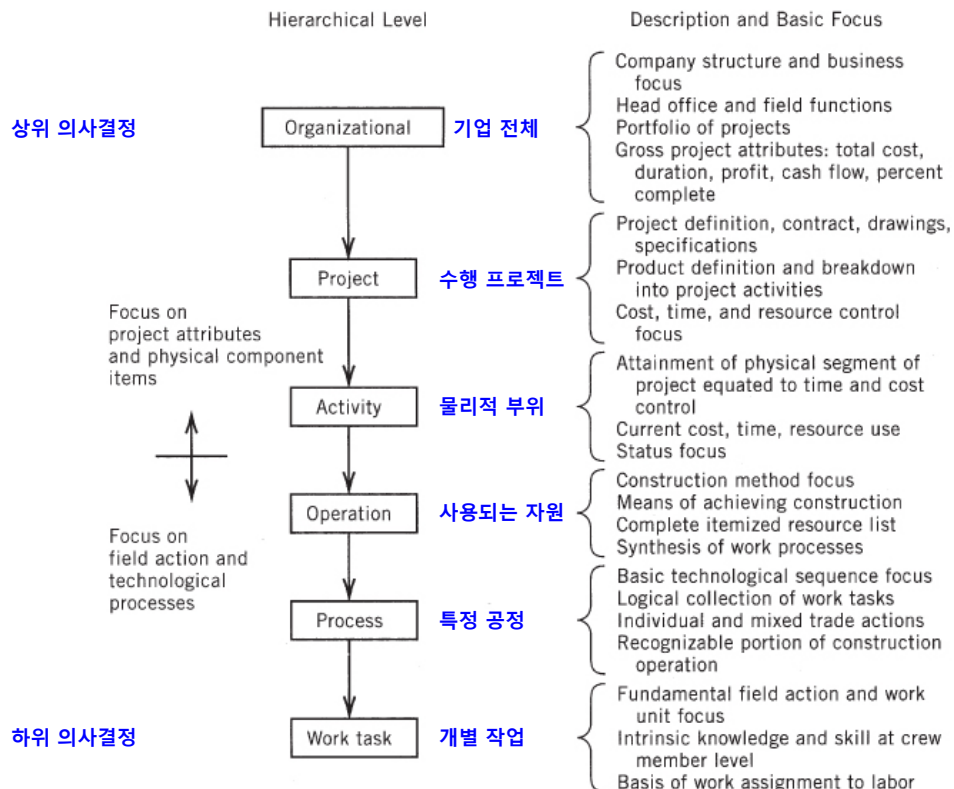


FIGURE 1.12 Management levels in construction

1.14 Management Levels of Construction

공항의 중앙 홀 빌딩 건설 프로젝트 사례

- ❑ **Project** : Installation of all exterior glass and panel wall construction on the Concourses of the Hartsfield International Airport, Atlanta, GA
- ❑ **Activity** : Glass and panel installation on Concourse A, Bays 65-72
공항의 중앙 홀
- ❑ **Operation** : Frame installation to include preparation and installation of five panel frames in each concourse bay; column cover plate installation
- ❑ **Process** : Sill clip placement; mullion strips installation. Glass placement in frame; move and adjust hanging scaffold
- ❑ **Work task** : Locate and drill clip fastener; unload and position mullion strips; strip protective cover from glass panel; secure scaffold in travel position

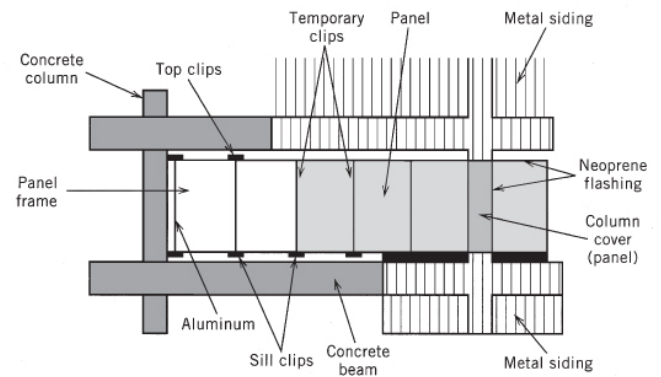
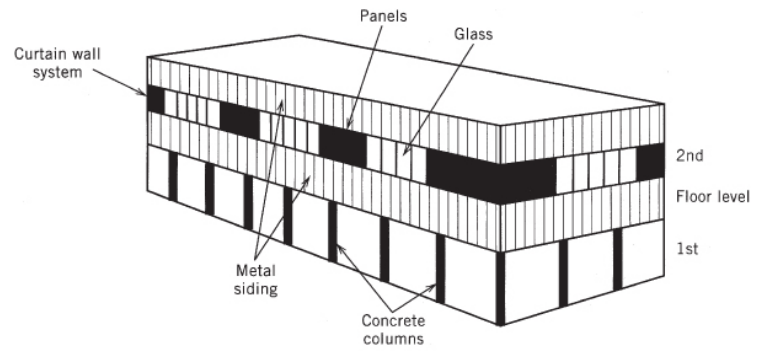


FIGURE 1.13 Schematic of concourse building

CHAPTER 2

PREPARING THE BID PACKAGE

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
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제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
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제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

2.1 Project Concept and Need

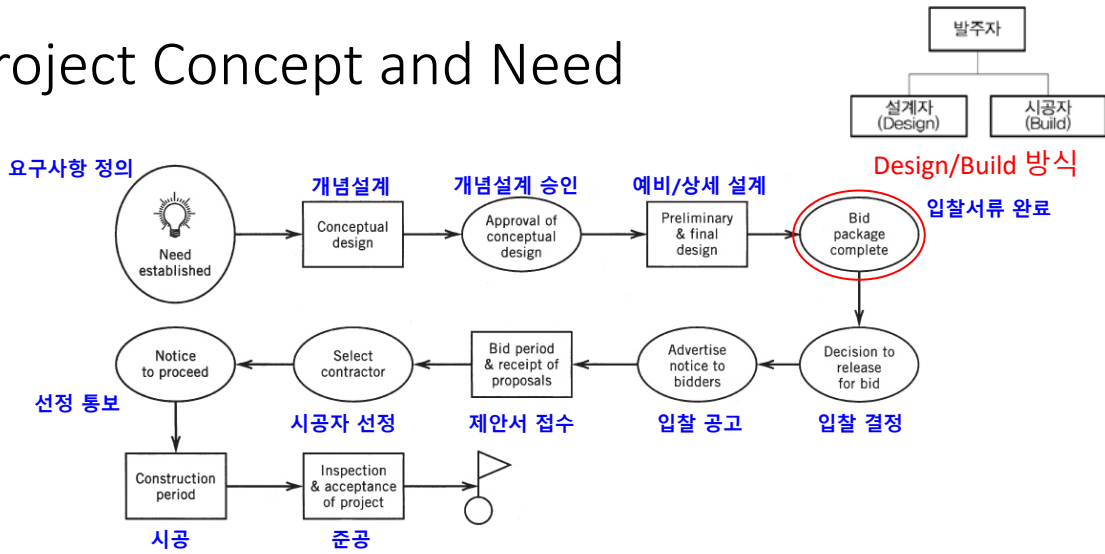


FIGURE 2.1 Project development cycle for new project

□ Private & public projects

- ✓ **Private** : Manufacturing plants, hospitals, research laboratories, hotels and commercial buildings, communications networks etc.
- ✓ **public** : Bridges, tunnels, transportation facilities, dikes, and dams etc.

2.2 Establishing Need

- The first step in any project is the **establishment of a need and a conceptual definition and refinement of the facility that will meet that need.** 첫번째 단계는 요구사항 정의와 그 요구사항을 충족시키기 위한 시설에 대한 명확한 서술을 마련하는 것
- 제품수요·시장 조사, 타당성분석(**Feasibility Study**), 비용분석
- 자금제공자(재무적 투자자)의 요구에 의해 타당성 분석의 내용이 결정: 자금제공자가 사업 타당성에 대한 근거를 요청

2.3 Formal Need Evaluation

- ❑ Deciding **whether or not to proceed** with the preliminary and final design
 1. **Cost/benefit analysis**
 2. **Graphical representation of the project** (e.g., sketch or artist's rendering) and a layout diagram of the facility
 3. **Cost estimate** based on the conceptual-level information available

- ❑ Benefit
 - ✓ Tangible (직접적인 효과)
 - ✓ Intangible (간접적인 효과)

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2.4 Conceptual Drawings and Estimates

- ❑ **Conceptual documentation to potential funding sources** (e.g., banks and investors)
잠재적 투자자에게 제공하는 개념적 수준의 문서(기획안)

- ❑ A **cost estimate** based on the **conceptual drawings and other design information** (e.g., square footage of roof area, floor space, size of heating and air-conditioning units, etc.) is prepared. 개념적 설계에 근거한 비용 추정

- ❑ A **projection of cost** to the future date on which construction will begin is required. 프로젝트 실행 시점의 돈의 가치로 비용을 추정하는 것이 필요(물가인상률 필요)
 - ✓ The projection is made using the **Engineering News-Record (ENR)** indexes of basic construction cost.

Construction Cost Index				Building Cost Index				Material Cost Index			
ANNUAL INFLATION RATE				ANNUAL INFLATION RATE				MONTHLY INFLATION RATE			
1913=100	INDEX VALUE	MONTH	YEAR	1913=100	INDEX VALUE	MONTH	YEAR	1913=100	INDEX VALUE	MONTH	YEAR
+3.6%				+2.5%				+0.4%			
NOV. 2016				NOV. 2016				NOV. 2016			
CONSTRUCTION COST	10442.61	+0.1%	+3.6%	BUILDING COST	5690.35	+0.12%	+2.5%	MATERIALS COST	3149.55	+0.4%	+3.7%
COMMON LABOR	22172.53	0.0%	+3.7%	SKILLED LABOR	9927.94	0.0%	+2.3%	CEMENT \$/TON	109.74	-0.9%	-5.1%
WAGE \$/HR	42.53	0.0%	+3.7%	WAGE \$/HR	54.92	0.0%	+2.3%	STEEL \$/CWT	49.96	+0.1%	+0.8%
								LUMBER \$/MBF	518.41	+1.5%	+8.8%

The Construction Cost Index's annual escalation rate slid to 3.6% from 3.7% the previous month, as the labor cost component held steady.

The Building Cost Index's annual escalation rate slipped to 2.5% from 2.6% in October as the labor component showed no gain.

The MC rose 0.4% this month, based on the strength of a 1.5% increase in lumber prices.

5

2.4 Conceptual Drawings and Estimates

군 우체국 프로젝트 사례

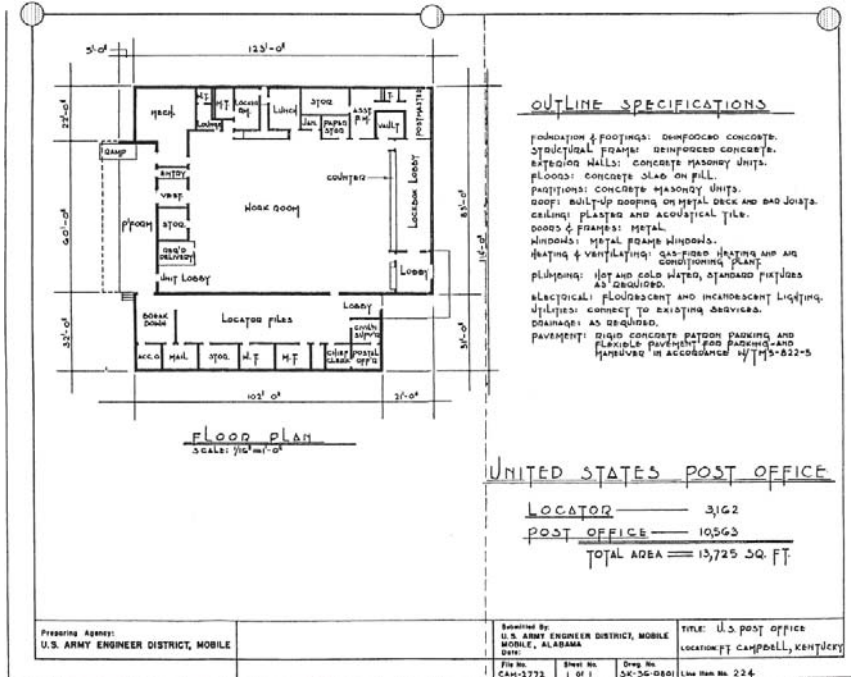


FIGURE 2.2 Project proposal: layout sketch and outline specification
Military Post Office Project

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2.4 Conceptual Drawings and Estimates

군 우체국 프로젝트 사례

TO: Chief of Engineers Department of the Army Washington, D.C.		FROM: Louisville District Corps of Engineers Louisville, KY		TO: Chief of Engineers Department of the Army Washington, D.C.		FROM: Louisville District Corps of Engineers Louisville, KY		6. Landscaping						
Fiscal Year 2XXX		Date Prepared: 14 Oct 2XXX		Description		Quantity	Unit	Unit Price	Totals (\$000)	Description	Quantity	Unit	Unit Price	Totals (\$000)
Name and Address of A.E. N.A.		A.E. Fee N.A.		3-in. duct conc. enclosed U.G. Subtotal		100	lin ft	4.75	0.5	Sprigging and seeding Landscaping Subtotal	1.6	Acre	\$1500.00	2.4
Basis of Estimate Budget Sketch & 1391		Type of Construction Permanent		b. Water		365	lin ft	8.60	3.1	a. Telephone		LS	\$1400.00	1.4
Name and Location of Installation Ft. Campbell, Kentucky		Status of Design Preliminary 0% complete		3-in. Gate valve and box		1	Each	200.00	.2	b. Support (within building)				
Line Item Number 224		Description of Facility Post Office		Fire hydrants		2	Each	1000.00	2.0	100 Pr. DB Pic Cable	600	LF	1.26	0.8
Final Design Completion Date Not Authorized				Connections to existing lines		3	Each	500.00	1.5	51 Pr. DB Pic Cable	550	LF	0.72	0.4
				Subtotal					6.8	Splicing sleeves and material		LS	\$900.00	0.9
				c. Sewer		215	lin ft	12.00	2.6	Labor		LS		2.5
				6-in. sanitary sewer		375	lin ft	14.00	5.3	Subtotal				6.0
				8-in. sanitary sewer		2	Each	1000.00	2.0	Total estimated cost (excluding design, but including reserve for contingencies and supervision and administration (S&A))				1054.75
				Manhole		2	Each	1000.00	2.0	1. Estimated contract cost				909.05
				Connection to exist. manhole		1	Each	250.00	.25	2. Reserve for contingencies	10	percent		90.90
				Subtotal					10.15	3. Supervision and administration (S&A); total estimated cost (excluding design, but including reserve for contingencies and supervision and administration)				54.8
				d. Gas		1,000	lin ft	6.00	6.0	4. Design District expenses (preliminary and final) Subtotal				70.0
				1 1/2 in. gas line		1	Each	200.00	0.2					70.0
				8-in. plug valve and box		1	Each	237.60	0.2					
				Connect to existing street and parking area crossing		280	lin ft	2.0	0.6					
				Subtotal					7.0					
				3. Site Work		2.4	Acre	500	1.2					
				Clearing and grubbing		10,000	cu yd	8.00	80.0					
				Borrow excavation		1,070	sq yd	4.00	4.3					
				Remove B. T. paving					85.3					
				Subtotal										
				4. Paving										
				Paving-1 1/2 A.C. and 8-in. stab.		3,950	sq yd	10.00	39.5					
				aggr. base		2,250	lin ft	8.50	19.2					
				6-in. P.C. concrete paving		380	sq yd	20.00	7.6					
				3-in. painted parking lines		1,680	lin ft	8.50	0.9					
				Concrete sidewalk		440	sq yd	18.00	7.9					
				Subtotal					75.1					
				5. Storm Damage										
				15-in. concrete Cl. II pipe		40	lin ft	18.00	0.7					
				15-in. concrete Cl. III pipe		20	lin ft	20.00	0.4					
				Reinf. drainage structure concrete		8	cu yd	300.00	2.4					
				C.I. grates and frames		1,900	lb	1.00	1.9					
				Subtotal					5.4					

FIGURE 2.3 Current working estimate for budget purposes

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2.4 Conceptual Drawings and Estimates

Construction Cost Index History

How ENR Builds the Index: 200 hours of common labor at the 20-city average of common labor rates, plus 25 cwt of standard structural steel shapes at the mill price prior to 1996 and the fabricated 20-city price from 1996, plus 1.128 tons of portland cement at the 20-city price, plus 1,088 board-ft of 2x4 lumber at the 20-city price.

ANNUAL AVERAGE										ANNUAL													
										JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	AVG.	
1919	198	1938	236	1957	724	1976	2401	1991	4777	4773	4772	4766	4801	4818	4854	4892	4891	4892	4896	4889	4835		
1920	251	1939	236	1958	759	1977	2576	1992	4888	4884	4927	4946	4965	4973	4992	5032	5042	5052	5058	5059	4985		
1921	202	1940	242	1959	797	1978	2776	1993	5071	5070	5106	5167	5262	5260	5252	5230	5255	5264	5278	5310	5210		
1922	174	1941	258	1960	824	1979	3003	1994	5336	5371	5381	5405	5405	5408	5409	5424	5437	5437	5439	5439	5408		
1923	214	1942	276	1961	847	1980	3237	1995	5443	5444	5435	5432	5433	5432	5484	5506	5491	5511	5519	5524	5471		
1924	215	1943	290	1962	872	1981	3535	1996	5523	5532	5537	5550	5572	5597	5617	5652	5683	5719	5740	5744	5620		
1925	207	1944	299	1963	901	1982	3825	1997	5765	5769	5759	5799	5837	5860	5863	5854	5851	5848	5838	5858	5826		
1926	208	1945	308	1964	936	1983	4066	1998	5852	5874	5875	5883	5881	5895	5921	5929	5963	5986	5995	5991	5920		
1927	206	1946	346	1965	971	1984	4148	1999	6000	5992	5986	6008	6006	6039	6076	6091	6128	6134	6127	6127	6059		
1928	207	1947	413	1966	1019	1985	4182	2000	6130	6160	6202	6201	6233	6238	6225	6233	6224	6259	6266	6283	6221		
1929	207	1948	461	1967	1074	1986	4295	2001	6281	6272	6279	6286	6288	6318	6404	6389	6391	6397	6410	6390	6334		
1930	203	1949	477	1968	1155	1987	4406	2002	6462	6462	6502	6480	6512	6532	6605	6592	6589	6579	6578	6563	6538		
1931	181	1950	510	1969	1269	1988	4519	2003	6581	6640	6627	6635	6642	6694	6696	6733	6741	6771	6794	6782	6695		
1932	157	1951	543	1970	1381	1989	4615	2004	6825	6861	6957	7017	7064	7109	7126	7188	7298	7314	7312	7308	7115		
1933	170	1952	569	1971	1581	1990	4732	2005	7297	7298	7309	7355	7398	7415	7422	7479	7540	7563	7630	7647	7446		
1934	198	1953	600	1972	1753			2006	7660	7689	7692	7695	7691	7700	7721	7723	7763	7883	7911	7888	7751		
1935	196	1954	628	1973	1895			2007	7880	7880	7856	7865	7942	7939	7959	8007	8050	8045	8092	8089	7967		
1936	206	1955	660	1974	2020			2008	8090	8094	8109	8112	8141	8185	8293	8362	8557	8623	8602	8551	8310		
1937	235	1956	692	1975	2212			2009	8549	8533	8534												

Base: 1913=100

FIGURE 2.4 Engineering News-Record construction cost indices

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2.5 Preliminary and Detail Design

- The **drawings** are a graphical or schematic indication of the work to be accomplished.
→ 설계도
- The **specifications** are a verbal or word description of what is to be constructed and to what levels of quality. → 시방서
- When completed, they are included as **legally binding elements of the contract**. → 설계도서 : 법적 부속 서류로서 계약에 포함
- The **design team leader coordinates** the efforts of architects and engineers from differing **disciplines**.
- The disciplines normally identified are **architectural, civil and structural, mechanical, and electrical**.

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2.6 Notice to Bidders

- ❑ Because of his commitment to the owner to design a facility that can be constructed **within a given budget and at an acceptable level of quality**, the architect/engineer wants to be sure that **the lowest bid price is achieved**. 최저가입찰 ← 예산 제약
- ❑ 입찰 제공 정보 : **the general type and size of the project, the availability of plans and specifications for review, and the time, place, and date of the bid opening**.
- ❑ In some large cities, a **builder's exchange** may operate to serve the contracting community. → 예) 나라장터를 통한 공공공사 입찰 공고 (FedBizOpps.gov)
- ❑ Paid services such as **Dodge BidPro** (©Dodge Data & Analytics) provide detailed information customizable by **date, geographic area, type of project**, and other customizable parameters. → 유료 입찰 서비스



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2.6 Notice to Bidders

병원 하수도 개선 프로젝트 사례 Notice to Bidders
FOR
CONSTRUCTING SEWERAGE SYSTEM IMPROVEMENTS
ST. VINCENT HOSPITAL
FOR THE
FRANCONIA MONTANA BUILDING AUTHORITY
CITY BUILDING - FRANCONIA, MT

Sealed proposals will be received for Constructing Sewerage System Improvements, Contract A, for the Franconia Montana Building Authority at Room 938, City Building, 123 Courthouse Square, Franconia, MT until Noon, 29 September _____, at which time and place they will be publicly opened and read. Bidding information on equipment in Section No. 6 shall be submitted on or before 15 September _____.

과업 범위 **Work to Be Done** The work to be done consists of furnishing all materials, equipment, and labor and constructing:
Approximately 12,400 L.F. 36" Sewer Pipe, 5,600 L.F. 30" Sewer Pipe, 7,300 L.F. 24" Sewer Pipe, 324 L.F. 30" C.I. Force Main, 50 L.F. 8" C.I. Force Main and all other appurtenances for sewers.

제안서 작성 요령 **Proposals** Proposals shall contain prices, in words and figures, for the work bid and must be accompanied by a certified check or bid bond of a reputable bonding company authorized to do business in the State of Montana, in an amount equal to at least five (5%) percent of the total amount of the bid.
Upon the proper execution of the contract and required bonds, the checks or bid bonds of all bidders will be returned to them.
If Proposals are submitted via mail rather than hand delivery they should be addressed to Mr. A. J. Smith, Director, Dept. of Administration, Franconia, MT, Room 512, City Building, 123 Courthouse Square, Franconia, MT.
Performance and Payment Bonds: A contract performance bond and payment bond, each in an amount equal to one hundred (100%) percent of the contract amount, will be required of the successful bidder.

제안 철회 방법 **Withdrawal of Bids** No submitted bid may be withdrawn for a period of sixty (60) days after the scheduled closing time for the receipt of bids.
Plans, Specifications and Contract Documents: Plans, Specifications and Contract Documents are available for inspection online at www.franconstruct.mt or at the offices of Senior Consulting Services, 695 Pinehurst Drive, Franconia, MT. Copies may be obtained for a deposit of \$250 for all plans and specifications. Deposits will be returned for documents returned in undamaged condition within thirty (30) days after the date of bid opening.

근로자 급여 책정 : 연방 노동성 기준 적용 **Wage Schedule** Since this job is partially federally funded, Davis-Bacon requirements for minimum wages are in effect. Minimum wages for all workers must be paid as determined by the Secretary of the U.S. Department of Labor, Decision No AI-xxx, and included in the General Conditions of this Contract.

입찰 수락 또는 거부 권리 명시 **Acceptance or Rejection of Bids** The right is reserved to accept or reject any or all bids and to waive informalities.

SINCE THIS PROJECT IS PARTIALLY FEDERALLY FUNDED BIDDERS WILL BE REQUIRED TO COMPLY WITH ALL RELEVANT FEDERAL EXECUTIVE ORDERS AND REQUIREMENTS. THESE ORDERS AND REQUIREMENTS ARE EXPLAINED IN THE CONTRACT SPECIFICATIONS.
FRANCONIA MONTANA BUILDING AUTHORITY
SIGNED G. LUCKO, Sec. Treasurer

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FIGURE 2.5 Typical notice to bidders

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2.6 Notice to Bidders

Opportunity	Agency/Office/Location	Type / Set-aside	Posted On
 Herbert Hoover Dike Rehabilitation Structure Replacements, S-291 (IP-3), Reconstruction, Glades County, Florida W912EP-16-R-0010 Y -- Construction of structures and facilities	Department of the Army U.S. Army Corps of Engineers USACE District, Jacksonville	Presolicitation (Modified)	May 17, 2016
 Narrows Access Bridge Rehabilitation, U.S. Army Corps W912EE-16-R-0014 Y -- Construction of structures and facilities	Department of the Army U.S. Army Corps of Engineers USACE District, Vicksburg	Presolicitation	May 17, 2016
 FC MR&T, Yazoo River Basin, Black Creek & Abiaca Creek Watersheds, Carroll County, MS, Mississippi Delta Headwaters Project, Bank Stabilization, BS-11-01, Little Creek, Riser Pipe Grade Control Structures, RP-10-04 W912EE-16-B-0007 Y -- Construction of structures and facilities	Department of the Army U.S. Army Corps of Engineers USACE District, Vicksburg	Presolicitation / Competitive 8(a)	May 16, 2016
 Repairs to the Plymouth Long Beach Dike, Plymouth, W912WJ-16-B-0011 Y -- Construction of structures and facilities	Department of the Army U.S. Army Corps of Engineers USACE District, New England	Presolicitation / Total Small Business	May 13, 2016
 Cowhouse Creek Bridge Fort Hood, Texas W9126G-16-R-0079 Y -- Construction of structures and facilities	Department of the Army U.S. Army Corps of Engineers USACE District, Fort Worth	Presolicitation / Total Small Business	May 13, 2016
 ILLINOIS RIVER BASIN, LaGRANGE LOCK AND DAM, W912EK-16-R-0013 Y -- Construction of structures and facilities	Department of the Army U.S. Army Corps of Engineers USACE District, Rock Island	Presolicitation	May 12, 2016

FIGURE 2.6 Example of FedBizOpps.gov available project listing

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2.7 Bid Package

- ❑ The documents that are available to the contractor and on which he must **make a decision to bid or not to bid** are those in the bid package. 입찰서류를 바탕으로 입찰 참가 여부 결정
- ❑ In addition to the **plans and technical specifications**, the bid package prepared by the A/E consists of a **proposal form**, **general conditions** that cover procedures common to all construction contracts, and **special conditions**, which pertain to procedures to be used that are unique to this particular project.
- ❑ **All supporting documents** are included by reference in the proposal form.

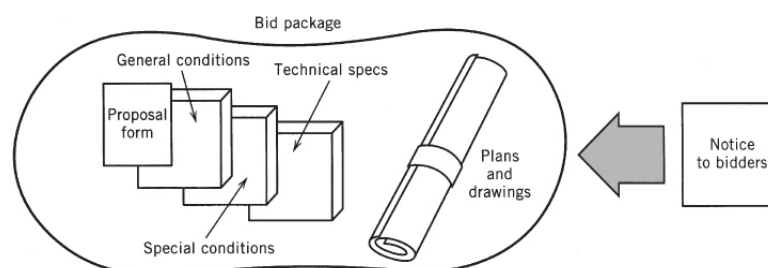


FIGURE 2.7 Bid package documents

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2.7 Bid Package

☐ Bid package → Bid Form → Award of Contract(Notice of Award) → Notice to Proceed

Builder Contractor Builder Contractor

☐ The prices at which the work will be constructed can be stated either as lump-sum or as unit-price figures. 총액 또는 단가 기준 가격 제시

☐ In many instances, the project duration in working or calendar days is specified in the special conditions portion of the bid package. 근무일과 달력일(근문일 + 비근무일) 기준으로 공사기간 제시

2.7 Bid Package

PROPOSAL
TO THE FRANCONIA MONTANA BUILDING AUTHORITY
CITY BUILDING
FRANCONIA, MT

Submitted - DATE _____, 20XX

The undersigned, as Bidder, hereby declares that the only person or persons interested in the Proposal as principal or principals is or are named herein and that no other person than herein mentioned has any interest in this Proposal or in the Contract to be entered into, that this Proposal is made without connection with any other person, company, or parties making a bid or Proposal; and that it is in all respects fair and in good faith without collusion or fraud.

The Bidder further declares that he or she has examined the site of the work, and informed himself or herself fully in regard to all conditions pertaining to the place where the work is to be done; that he or she has examined the plans and specifications for the work and contractual documents relative thereto, and has read all Special Provisions and General Conditions furnished prior to the opening of bids; and that he or she has satisfied himself or herself relative to the work to be performed.

The Bidder proposes and agrees, if this Proposal is accepted, to contract with the Franconia Montana Building Authority in the form of contract specified to furnish all necessary material, equipment, machinery, tools, apparatus, means of transportation, and labor, and to finish the construction of the work in complete accordance with the shown, noted, described, and reasonable intended requirements of the plans and specifications and contract documents to the full and entire satisfaction of the Authority with a definite understanding that no money will be allowed for extra work except as set forth in the attached General Conditions and Contract Documents, for the following prices:

CONSTRUCTING SEWERAGE SYSTEM IMPROVEMENTS
CONTRACT A
ST. VINCENT HOSPITAL

단가 기준 가격 공사 Section 1: Unit Price Work

(For part payment—except rock excavation—by unit prices, to establish price for variation in quantities, include balance of quantities for these items—except rock excavation—in lump sum bid for Section 2)

Item #	Quantity	Unit	Description	Unit Price	Total Price
1.	550	cu yd	Rock Excavation	\$ _____	\$ _____
2.	50	lin ft	8" C.I. Force Main	\$ _____	\$ _____
3.	20	cu yd	Trench Excavation	\$ _____	\$ _____
4.	200	sq yd	Paving	\$ _____	\$ _____
Subtotal Section 1, Item Nos. 1 to 4, Inclusive				Total	\$ _____

총액 기준 가격 공사 Section 2: Lump Sum Work

Item #	Description	Total Price
5.	Excavation and Fill	\$ _____
(a)	Access Roadway	\$ _____
(b)	Structure Excavation and Backfill	\$ _____
(c)	Finish Grading	\$ _____
Total for Item No. 5		\$ _____
6.	Paving	\$ _____
(a)	Access Roadway	\$ _____

(b) Station Area	\$ _____	\$ _____
Total for Item No. 6	\$ _____	\$ _____
7. Concrete Work	\$ _____	\$ _____

The Bidder further proposes and agrees hereby to commence work under the contract, with adequate force and equipment, on a date to be specified in a written order of the Engineer, and shall fully complete all work there under within the time stipulated, from and including said date, in 300 consecutive calendar days.

The Bidder further declares that he or she understands that the quantities shown in the Proposal are subject to adjustment by either increase or decrease, and that should the quantities of any of the items of work be increased, the Bidder proposes to do the additional work at the unit prices stated herein; and should the quantities be decreased, the Bidder also understands that payment will be made on the basis of actual quantities at the unit price bid and will make no claim for anticipated profits for any decrease in quantities, and that actual quantities will be determined upon completion of the work, at which time adjustment will be made to the Contract amount by direct increase or decrease.

The Bidder further agrees that, in case of failure on his or her part to execute the Construction Agreement and the Bonds within ten (10) consecutive days after written notice being given of the award of the Contract, the check or bid bond accompanying this bid, and monies payable thereon, shall be paid into the funds of the Franconia Montana Building Authority, Franconia, Montana, as liquidated damages for such failure, otherwise the check or bid bond accompanying his or her Proposal shall be returned to the undersigned.

Attached hereto is a bid bond by the _____ in the amount of _____ Dollars (\$ _____) made payable to the Franconia Montana Building Authority, Franconia, MT, in accordance with the conditions of the Advertisement for Bids and the provision herein.

Submitted: _____ L.S. (Legal Signature)
By: _____ L.S.
Title: _____

Note: If the Bidder is a corporation, the Proposal shall be signed by an officer of the corporation; if a partnership, it shall be signed by a partner. If signed by others, authority for signature shall be attached.

Address: _____

FIGURE 2.8 Example proposal form

2.8 General Conditions

- 표준계약문서 제공 위원회 구성 : A committee for engineer documents has been formed jointly by the **American Consulting Engineers Council**, the **National Society of Professional Engineers**, and the **American Society of Civil Engineers** to prepare **standard contract documents**.
- The committee is called the **Engineers Joint Contract Documents Committee (EJCDC)**.
- 표준계약문서 승인처 : These documents have been endorsed by the **Associate General Contractors (AGC) of America** and the **Construction Specifications Institute (CSI)**
- 권리, 특권, 책임 명시 : The **rights, privileges, and responsibilities** that accrue to the primary contractual parties in any construction contract are also defined in the general conditions. Therefore, sections pertaining to the **(1) owner, (2) architect (or architect/engineer), (3) contractor, and (4) subcontractors** are typically found in the general conditions.
- 국가를 당사자로 하는 계약에 관한 법률, 시행령, 시행규칙

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2.8 General Conditions

- American Institute of Architects (AIA)'s general conditions are listed below:
 1. Definitions 정의
 2. Preliminary matters 기본 사항
 3. Contract documents 계약 서류
 4. Bonds and insurance 보증 채권 및 보험
 5. Contractor's responsibilities 시공자의 책임
 6. Owner's responsibilities 발주자의 책임
 7. Engineer's responsibilities 설계자의 책임
 8. Changes in the work 과업 변경
 9. Change of contract price 계약금액 변경
 10. Change of contract times 계약기간 변경
 11. Test and inspections 시험 및 검사
 12. Payments to contractor and completion 공사대금 지불 및 준공조건
 13. Suspension of work and termination 작업 중단 및 종료
 14. Dispute resolution 분쟁 해결

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2.9 Supplementary Conditions

- ❑ **Modifications** to the basic articles of the general condition in the form of additions, deletions, or substitutions. 일반 조건에 대한 수정 : 추가, 삭제, 대체
- ❑ **Additional articles** of a contractual-legal nature that may be desirable or necessary for a particular project. 법적 성격의 추가 문서

2.9 Supplementary Conditions

PART II SPECIAL CONDITIONS INDEX			PART II SPECIAL CONDITIONS INDEX		
Paragraph No.	Title	Page No.	Paragraph No.	Title	Page No.
SC-1.	Commencement, Prosecution, and Completion of Work	SC-1	SC-36.	Sequence of Operations	SC-20
SC-2.	Liquidated Damages	SC-1	SC-37.	Acceptance of Work	SC-21
SC-3.	Contract Drawings, Maps, and Specifications	SC-1	SC-38.	Insurance Policies to Be Furnished to the Government	SC-22
SC-4.	Construction Drawings	SC-4	SC-39.	Payment	SC-22
SC-5.	Physical Data	SC-5			
SC-6.	Rates of Wages	SC-6			
SC-7.	Variations in Estimated Quantities	SC-6			
SC-8.	Government-Furnished Property	SC-7			
SC-9.	Water	SC-7			
SC-10.	Electricity	SC-7			
SC-11.	Layout of Work and Surveys	SC-7			
SC-12.	Payments for Mobilization and Preparatory Work	SC-8			
SC-13.	Damage to Work	SC-8			
SC-14.	Funds Available for Payments	SC-8			
SC-15.	Additional Supervision of Subcontracted Work	SC-11			
SC-16.	Scheduling and Determination of Progress	SC-12			
SC-17.	Performance of Work by Contractor	SC-12			
SC-18.	Certificates of Compliance	SC-12			
SC-19.	Plant Lay-out Drawings	SC-12			
SC-20.	Approved Aggregate Sources	SC-13			
SC-21.	Testing	SC-14			
SC-22.	Work Areas	SC-14			
SC-23.	Work under Other Contracts	SC-14			
SC-24.	Permits	SC-14			
SC-25.	Products and Parts of Standard Manufacture	SC-14			
SC-26.	Protective Headgear	SC-15			
SC-27.	Inspection and Testing of Construction Equipment	SC-15			
SC-28.	Work to Be Done by Other Agencies	SC-15			
SC-29.	Protection of Constructed Facilities	SC-16			
SC-30.	Protection of Utilities	SC-16			
SC-31.	Use of Local Roads and Streets	SC-16			
SC-32.	Maintenance of Street Traffic	SC-16			
SC-33.	Requirements of Pennsylvania Railroad Company and Westinghouse Electric Corp. Pertaining to Construction Work Within the Limits of Railroad Right-of-Way and Westinghouse Electric Corp. Property	SC-16 SC-17			
SC-34.	Cofferdams and Flood Stages	SC-19			
SC-35.	Watchmen and Danger Signs	SC-19			

FIGURE 2.9 Special conditions: typical index of special conditions

2.10 Technical Specifications

- ❑ The contract documents must convey the requirements of the project to potential bidders and establish a legally precise picture of the **technical aspects of the work to be performed**. 계약 시 수행될 과업의 기술적 측면을 정확히 서술할 필요가 있음
- ❑ This is accomplished visually through the use of **drawings**. 설계도
- ❑ A **verbal description** of the technical requirements is established in the **technical specifications**. 기술 시방서

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2.10 Technical Specifications

- ❑ A typical index of specifications for a **heavy construction project** might appear as follows:
 1. Clearing and grubbing
 2. Removal of existing structures
 3. Excavation and fill
 4. Sheet steel piling
 5. Stone protection
 6. Concrete
 7. Miscellaneous items of work
 8. Metal work fabrication
 9. Water supply facilities
 10. Painting
 11. Seeding
- 토목공사표준일반시방서
1. 총칙
 2. 토공사
 3. 구조물 기초공사
 4. 콘크리트공사
 5. 일반 강구조물공사
 6. 방수 및 지수공사
 7. 부지시설공사

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2.10 Technical Specifications

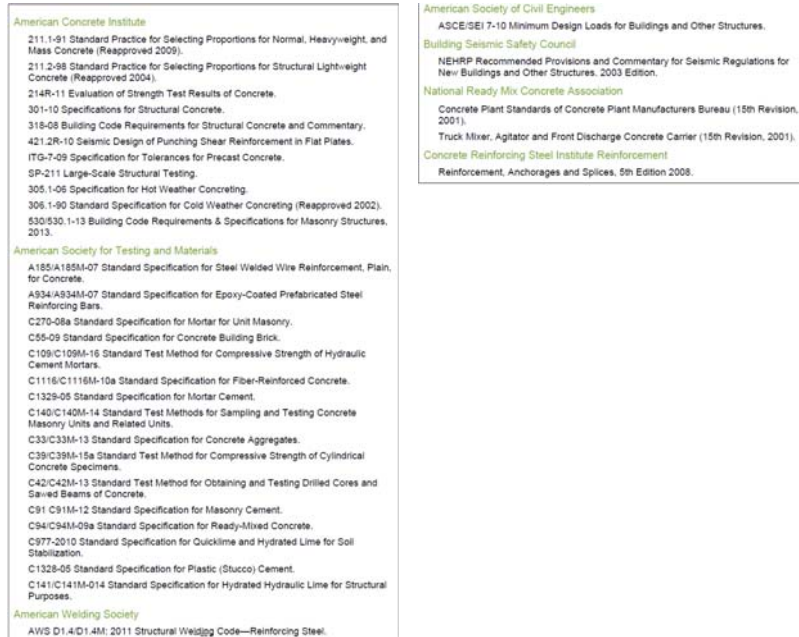


FIGURE 2.10 Typical references to structural inspection and testing standards

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참고. 국내 건설공사기준

표준시방서

1. 가설공사 표준시방서
2. 강구조공사 표준시방서
3. 건설공사 비탈면 표준시방서
4. 건설환경관리 표준시방서
5. 건축공사 표준시방서
6. 건축기계설비공사 표준시방서
7. 건축전기설비공사 표준시방서
8. 공동구 표준시방서
9. 농업토목공사 표준시방서
10. 도로공사 표준시방서
11. 도로교 표준시방서
12. 도시철도공사(지하철) 표준시방서
13. 산업·환경설비공사 표준시방서
14. 상수도공사 표준시방서
15. 조경공사 표준시방서
16. 콘크리트 표준시방서
17. 터널 표준시방서
18. 토목공사 표준일반시방서
19. 하천공사 표준시방서
20. 항만 및 어항공사 표준시방서
21. 하수관거공사 표준시방서

전문시방서

1. LH 전문시방서
2. 고속도로공사 전문시방서
3. 농어촌정비공사 전문시방서
4. 댐 및 상수도공사 전문시방서
5. 서울특별시 전문시방서
6. 철도공사 전문시방서
7. 항만 및 어항공사 전문시방서
8. 행복도시건설공사 전문시방서
9. 일반국도 전문시방서

설계기준

1. 강구조 설계기준
2. 건설공사 비탈면 설계기준
3. 건축 구조기준
4. 건축기계설비 설계기준
5. 건축전기설비 설계기준
6. 공동구 설계기준
7. 구조물기초 설계기준
8. 농업생산기반정비사업계획 설계기준
9. 댐 설계기준
10. 도로 설계기준
11. 도로교 설계기준
12. 상수도 시설기준
13. 조경 설계기준
14. 철도 설계기준
15. 콘크리트 구조기준
16. 터널 설계기준
17. 하수도 시설기준
18. 하천 설계기준·해설
19. 항만 및 어항 설계기준

- 국토교통부 건설기술정보시스템 <http://www.codil.or.kr/>
- 한국건설기술연구원 국가건설기준센터 <http://www.kcsc.re.kr/>

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2.11 Addenda 부록

- 변경사항 공지
- The **bid package documents** represent a **description of the project** to be constructed. They also spell out the **responsibilities of the various parties** to the contract and the manner in which the contract will be administered. 입찰서류 : 프로젝트 서술과 더불어 프로젝트에 관련된 이해당사자들의 책임에 대해 서술
- Any **changes in detail, additions, corrections, and contract conditions** that arise **before bids are opened** that are intended to become part of the bid package and the basis for bidding are incorporated into the bid package through **addenda**. 변경사항을 추가된 부록을 통해 공표 → 부록도 법적 효력을 갖는 입찰서류의 일부

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2.12 Decision to Bid

- **Estimating** is the process of looking into the future and trying **to predict project costs** and various resource requirements. 프로젝트 비용 추정
- Studies reveal the fact that the most frequent **causes of contractor failure** are **incorrect and unrealistic estimating and bidding practices**. 부정확한 비용 추정 → 가장 큰 실패 요인
- Quantities of Materials → Direct Cost → Indirect Cost → Management and Overhead Cost → Total Cost
- A common rule of thumb states that the contractor's estimating cost will be approximately **0.25% of the total bid price**. 입찰 준비 비용은 프로젝트 비용의 0.25%
- 만약 평균적으로 4번 중 1번 낙찰이 된다면, 낙찰되는 계약 건에 응찰 시 3번의 비낙찰 시 소요된 비용을 포함하여 견적 제출 → 총 입찰 비용의 **1%** 만큼을 추가

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2.13 Prequalification

- 발주자는 프로젝트를 수행할 능력이 없을 것 같은데 최저가를 제출한 계약자에 대해 고민!
- Each contractor interested in preparing and submitting a bid is asked to submit documents that establish his firm's **expertise and capability in accomplishing similar types of construction**. 발주자는 시공자에 대해 유사 공사에 대한 시공 사례를 요구



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2.14 Subcontractor and Vendor Quotations/Contracts

- Prime Contractor 주계약자
- Subcontractor(특수 공사: 터널, 교량, 전기, 기계, 통신 등) + Vendor(자재 공급)
- The contractor integrates these **quotations from subcontractor and vendors** into the total bid price. 주계약자는 하도급자와 자재공급자의 견적을 종합하여 입찰에 응함

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2.15 Bid Bond 입찰보증금 : 낙찰자 계약 체결 거부 대비

- A **construction bond**, therefore, involves a relationship between three parties: the principal or party who might default, the obligee or party who may be damaged or lose some advantage, and the surety who will offset the damage or loss of advantage.
발주자, 시공자, 보증자 사이의 손해 발생가능성을 대비한 보증 체계
- 만약 어떤 Contractor가 \$3,000,000에 낙찰 받은 후 이행을 포기하여, 차 순위자인 \$3,080,000에 응찰한 Contractor에게 낙찰되었다면, 발주자의 손해액 \$80,000을 입찰보증금에서 충당.
입찰보증금은 통상 공사금액의 5% 수준.

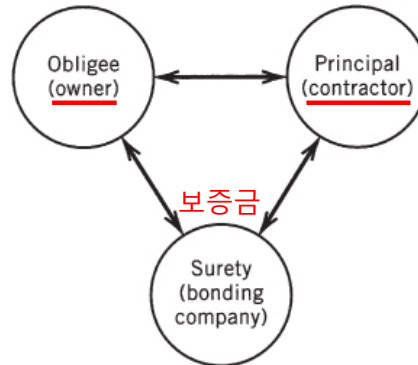


FIGURE 2.11 Bonding relationship (three-party)

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2.16 Performance and Payments Bonds

- If the contractor is awarded the contract, **performance and payment bonds** are issued.
- A performance bond (**이행보증금: 낙찰자 공사 수행 거부 대비: Owner & Contractor**) is issued to a contractor to guarantee the owner that the contract work will be completed and that it will comply with project specifications. **Contractor → 이행보증금 → Owner**
- In other words, a performance bond **protects the owner against default on the part of the contractor in performing the project as required.**
- A payment bond (**지불보증금: 주계약자의 공사대금 지불 불능 상황 대비: Prime Contractor & Subcontractor, Vendor**) is issued to guarantee the owner protection against any liens or charges against the project that are unpaid as a result of the contractor's default. **Prime Contractor → 지불보증금 → Subcontractor, Vendor**
- Contractor 파산 시 Subcontractor와 Vendor에게 대금 지급용으로 사용, Contractor 유동성 위기 시 자금 지원
- 보증사는 해결사(Troubleshooters) DB를 보유 → 문제 발생 시 해결사를 즉시 투입하여 공사가 계속될 수 있도록 조치를 취해 Owner를 보호

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2.17 Cost and Requirements for Bonds

- ❑ **Performance and payment bonds** are issued for a service charge. The **common rate is 1%** or \$10 per \$1,000 on the first \$200,000 of contract cost. At higher contract costs, the rate is reduced incrementally.
- ❑ 보증보험 회사는 이행보증금 집행 시 보험 가입자 및 관계자에게 구상권을 청구한다.
- ❑ The Miller Act (enacted in 1935) establishes the level of bonding required for federally funded projects. **Performance bonds**(이행보증금) must cover **100%** of the contractor amount while **payment bonds**(지불보증금) are required based on a sliding scale as follows:
 1. **50%** if the contract is \$1 million or less 전체 공사 금액의 50%를 커버할 수 있는 보증보험 요구
 2. **40%** if the contract is between \$1 and \$5 million
 3. **Fixed amount of \$2.5 million** if the contract is greater than \$5 million

CHAPTER 3

ISSUES DURING CONSTRUCTION

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

3.1 Acceptance Period/Withdrawal

- ❑ Bid Package에 문제 발생 시, 단순 실수는 인정, 인위적 조작은 불인정.
- ❑ Prior to the close of the bidding period (i.e., bid opening), **contractors are free to withdraw** their bids without penalty. 입찰 기간 중에는 언제나 제출한 입찰을 철회할 수 있음.
- ❑ 만약 발주자가 정해진 기간 내에 낙찰자를 선정하지 않는다면, 응찰자는 자신의 입찰을 철회할 수 있음.

Project Cycle—Construction Phase

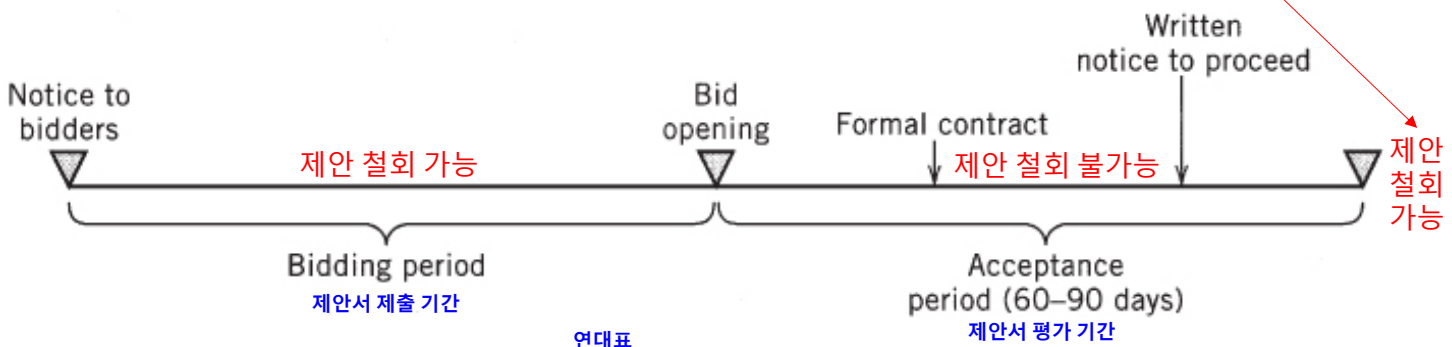


FIGURE 3.1 Chronology of bid procedure

3.2 Award of Contract/Notice to Proceed

- ❑ Provisions of the contract usually direct that selected bidders commence **work on the site within a specified period of time**, such as 10 days. 계약 후 일정 기간 내에 착공을 해야 함.
- ❑ 개시일에 프로젝트 기간을 합산하여 종료일 계산.
- ❑ 단, 모든 방해요소가 해결되어 현장에 Contractor가 진입할 수 있어야 개시 가능.

3.3 Contract Agreement

- ❑ Although the issuance of the notice to proceed establishes the elements of a contract, this is **formalized by the signing of a contract agreement**: 공사의 진행은 계약에 서명을 함으로써 공식화 됨. 계약의 체결은 시공자의 공사 제공과 발주자의 보수 제공을 공식화 함.
- ❑ It pulls together under one cover all documents to include **계약 시 첨부 문서**
 - (a) the **drawings** 설계도
 - (b) the **general conditions** 일반 조건
 - (c) the **supplementary conditions** 특수 조건
 - (d) the **technical specifications** 시방서
 - (e) any **addenda** describing changes published to these original contract documents. 변경사항
- ❑ Standard forms of agreement developed by the **Engineers Joint Contract Documents Committee (EJCDC)** → 표준 계약서 이용, 국가를 당사자로 하는 계약에 관한 법률 시행규칙 → 별지 7호 서식 : 공사도급표준계약서

4

3.4 Time Extensions

- ❑ In case of **delay**, the contractor will request an **extension of time** to offset the delay.
- ❑ Delays that result from **design errors or changes are typical of owner-assignable delays** and are not uncommon. → 설계변경에 의한 지연 발생: Owner의 책임
- ❑ 날씨 문제: 예상되는 공사 불가 날짜는 계약기간 연장의 구실이 될 수 없음. 국토교통부, 공공건설공사의 공사기간 산정기준 참조
- ❑ 준공 → 검사 → 불량(하자)리스트 → 수선 → 만족이면 종결, 불만족이면 분쟁

TABLE 3.1

Average Percent Extension by Extension Type

Source: Halpin, D. W. and Neathammer R. D. (August 1973). *Construction Time Overruns*. Technical Report P-16, Construction Engineering Research Laboratory, Champaign, IL.

Facility 시설	원인 Design Problem	Owner Modification	Weather	Strike	Late Delivery	Other
Airfield paving/lighting	7.2	1.3	2.3	0	10.5	4.9
Airfield buildings	12.1	2.3	3.7	3.2	0.8	29.9
Training facilities	6.2	20.8	2.9	0	0.6	4.6
Aircraft maintenance facilities	12	2	8.4	1	2.2	0.2
Automotive maintenance facilities	12.9	2.3	3.4	1.4	0.7	0.4
Hospital buildings	16	3.4	2.6	0.6	0.6	0.9
Community facilities	6.7	5.4	2.3	1.7	1.5	0.3

TABLE 3.1 Average Percent Extension by Extension Type

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3.5 Change Orders

- 발주자 요청 설계변경
- These **modifications to the original contract**, which themselves are small augmenting contracts, are called **change orders**. 최초 계약 시와 달라진 요청 사항
- Usually, the contractor is justified in **increasing the price** to recover costs due to disruption of the work and possible loss of job rhythm. → 공사비 증액 초래

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3.6 Changed Conditions

- 계약 조건 변경
 - 지반조사 결과: 흙 → 바위, 지하수 층의 존재 → 클레임 제기 → 공사비 증액
 - **Boring logs: 2,000 cubic yards of soil excavation, 500 cubic yards of rock**
 - **After work commences, 1,000 cubic yards of soil, 1,500 cubic yards of rock**
- Substantially affects the price of excavation and would be the basis for **claiming a changed condition**. → 조정, 중재 등을 통해 공사비 증액 필요

7

3.7 Value Engineering

- ❑ Value engineering (VE) was developed during World War II in the United States. 가치공학
- ❑ This initiative showed that innovation can yield products that **cost less** but **maintain** the expected levels of **performance** → 성능을 동일하게 유지하면서 비용을 줄일 수 있는 대안 개발
- ❑ The construction contractor to **share 50%** or more of the net savings. → 원가 절감 성과 공유
- ❑ The idea behind VE is the **improvement of design** by encouraging the contractor to make suggestions during construction. → 가치공학의 궁극적 목표는 설계 개선

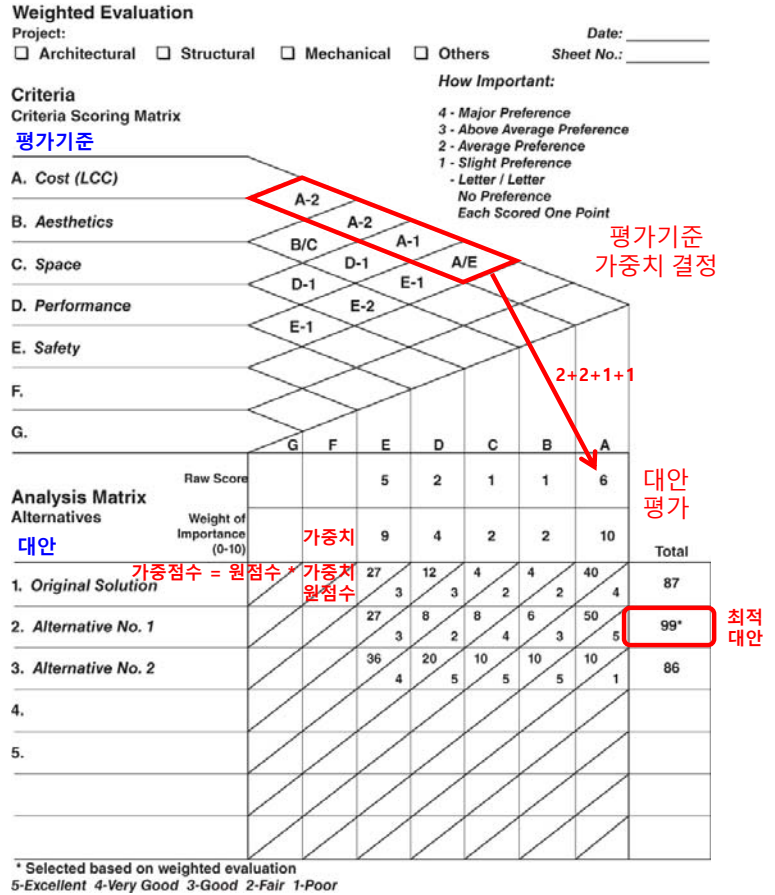


FIGURE 3.2 Critical evaluation matrix 8

3.7 Value Engineering

건설기술 진흥법 시행령

제75조(설계의 경제성등 검토) ① 발주청은 다음 각 호의 어느 하나에 해당하는 경우에는 설계 대상 시설물의 주요 기능별로 설계내용에 대한 대안별 경제성과 현장 적용의 타당성(이하 "설계의 경제성등"이라 한다)을 직접 검토하거나 건설기술용역업자 등 전문가로 하여금 검토하게 하여야 한다. <개정 2014. 12. 30.>

1. 총공사비 100억원 이상인 건설공사의 기본설계 및 실시설계를 하는 경우
 2. 총공사비 100억원 이상인 건설공사의 시공 중 총공사비 또는 공종별 공사비를 10퍼센트 이상 조정(단순 물량증가나 물가변동으로 인한 변경은 제외한다)하여 설계를 변경하는 경우
 3. 총공사비 100억원 미만인 건설공사에 대하여 발주청이 필요하다고 인정하는 건설공사의 설계를 하는 경우
- ② 설계의 경제성등 검토의 시기·횟수·대가기준, 구체적인 검토 방법 및 절차 등에 관하여 필요한 사항은 국토교통부장관이 정하여 고시한다.
- ③ 발주청은 설계의 경제성등 검토의 결과로 제시된 설계의 개선 제안 내용을 적용하는 것이 기술적으로 곤란하거나 비용을 과도하게 증가시키는 등 특별한 사유가 있는 경우를 제외하고는 해당 설계내용에 이를 반영하여야 한다.
- ④ 발주청은 제1항에 따라 설계의 경제성등을 검토한 경우에는 그 결과를 국토교통부장관에게 제출하여야 한다.

3.8 Suspension, Delay, or Interruption

- 발주자 측의 문제로 인한 일시정지, 지연, 영구 중단
- The owner (i.e., the government) is **required to pay** an adjustment for “unreasonable” suspensions → 발주자는 시공사의 손해에 대한 보상 의무를 갖는다.

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3.9 Liquidated Damages 손해보상

- Contractor가 제때 완공하지 못함 : 지체보상금
- The legal precedent(판례) established is that if the owner desires to specify a penalty for overrun (rather than liquidated damages), **he or she must offer a bonus** in the same amount for every day the contractor brings the project **in early**. 지체보상금을 명시적으로 계약에 포함하기 위해서는 조기 준공 시 보너스를 함께 명시해야 함.
- For example, if the contractor completes the project three **days late**, he or she must pay a **penalty of \$60,000**. 지체보상금
- On the other hand, if the contractor completes the project three **days early**, he would be entitled to a **bonus of \$60,000**. 조기준공보너스

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3.10 Progress Payments and Retainage 유보금

- ❑ By withholding or escrowing a certain portion of the monies due to the contractor as **retainage**, the owner has a “carrot,” which can be used at the end of a project.
 시공자에게 완벽한 공사 마무리를 요구하기 위해 볼모로 일부 공사비 지불을 유보함.
- ❑ The owner can say essentially, “Until you have completed the project to my satisfaction, I will not release the retainage.”

3.11 Progress Reporting

- ❑ This provision is fairly broad and could well be interpreted to require only grossly defined **S-curves or bar charts**.
- ❑ The **Critical Path Method** (see Chapter 8) provides greater early warning of the impact of delays on total project completion.

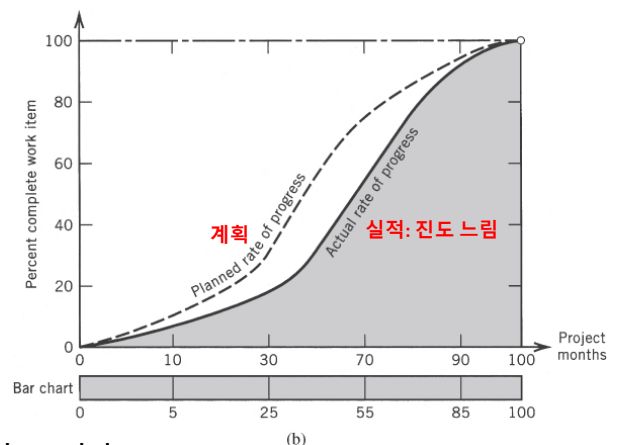
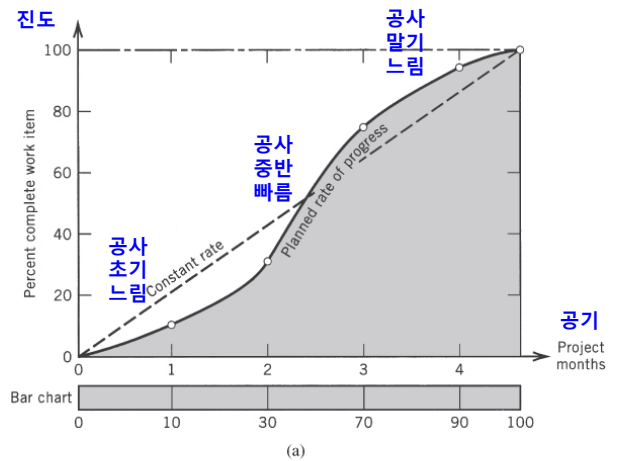


FIGURE 3.3 Bar chart planning and control models: (a) planned rate of progress and (b) actual rate of progress

3.11 Progress Reporting

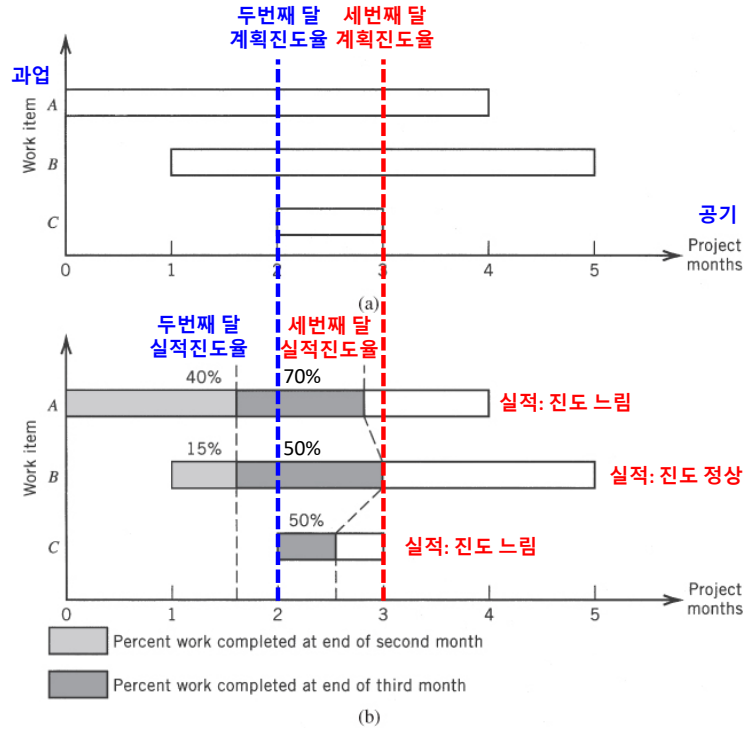


FIGURE 3.4 Bar chart project models: (a) bar chart schedule (plan focus) and (b) bar chart updating (control focus)

3.12 Acceptance and Final Payment

- ❑ The owner’s representative notes **deficiencies** that should be corrected, and the contractor makes note of the deficiencies. 하자 목록 작성
- ❑ These are generally detail items, and the list generated by the joint inspection is called the **deficiency, or punch, list**.

<p>May 20, 2XXX</p> <p><u>Punch List</u> Items Acme Plastering Co.</p> <p>Barfield-400 Project</p>
<p>Larger Building</p> <ol style="list-style-type: none"> 1. Caulking required between stucco and brick on the lower level. 2. Streaks and cracking on stucco must be remedied.
<p>Smaller Building</p> <ol style="list-style-type: none"> 1. Very noticeable line of stucco in rear of building. 2. Streaks and cracking on stucco must be repaired. 3. Exterior bridge entrances: patch stucco must be made uniform. 4. Areas of excess spalling must be corrected.

FIGURE 3.5 Typical **punch list** 미결 사항표

3.13 Summary

- This chapter has presented an overview of the cycle of activity that moves a project **from the bid award stage through construction to acceptance** by the owner or client.
낙찰 후부터 시공까지 발생 할 수 있는 이슈들

CHAPTER 4

CONTRACTS

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
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제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

4.1 Contract Environment

- ❑ The central role played by contracts is reflected by the fact that **construction firms** are referred to as “**contractors.**” 건설사 → 계약자로 호칭
- ❑ In addition to the contractual relationship with the **owner/client**, construction managers supervise contracts with **subcontractors**, **specialty firms** such as scheduling services, **labor unions**, as well as **equipment and materials vendors**. CMer는 발주자/시공사 계약 이외에도 하도급사, 건설노조, 자재공급사 등과의 계약을 관리
- ❑ **Insurance and bonds** as well as the documents establishing the legal structure of a company have the elements of contractual requirements. 보험사, 보증사 참여
- ❑ The **courts** are often called upon to determine: 분쟁 발생 시 → 법원 판결 대상
 1. Who are the **parties to a contract**? 계약 당사자는?
 2. What are their **promises**? 계약 사항은?
 3. What are other aspects of the **contractual agreement**? 합의 사항은?

2

4.2 Process of Purchasing Construction

- ❑ Two major aspects of this process contrast with the way in which we “buy” construction. 제조업 제품의 특징
 1. We have the **finished product** available for our inspection, and we can decide whether it meets our requirements. That is, the manufactured product is available for our inspection prior to purchase. 완제품 구입 (구입 전에 요구사항을 충족하는지 판단 가능)
 2. Because the final product is available, we purchase it from a **single individual** or source. 단일 공급처로부터 구입 가능
- ❑ In construction, the **facility is purchased before** it is “manufactured” based on a set of drawings and work descriptors. 소형 주택은 미리 만들어 놓고 판매할 수 있지만, 대부분의 토목 프로젝트는 이러한 선제작·후판매 방식이 불가능함.
- ❑ **Project delivery systems** have been developed to provide the construction buyer (i.e., the client) with a **single point of contact or source of purchase**. 건설업에서도 제조업과 마찬가지로 단일 접촉점을 요구 → 주계약사 (Contractor)
- ❑ The two major varieties of contract formats “**one-stop shopping**” :
 - (a) **Design-build** contracts 설계시공일괄계약 (Turnkey) (참고: DBB Design-Bid-Build)
 - (b) **Construction management** contracts. 건설사업관리 계약 (발주자 대리인으로서의 CMer)

3

4.3 Major Construction Contract Types

- ❑ The most widely used format of contract is the **competitively bid contract: low and competitive price (Fixed Cost)** 경쟁입찰을 통한 최저가 낙찰
 - (a) **Lump sum contract** (also called **stipulated sum** contract): 총액계약
 - (b) **Unit-price contract**: 단가계약
- ❑ The second most widely used contract format is the **negotiated contract**: risk is greatly reduced, cost-plus contract 협상에 의한 계약
 - Cost of doing the work plus a fee (Cost + Fee)**

4

4.4 Competitively Bid Contracts

- ❑ 최저가부터 최고가까지 줄을 세운 후, 최저가부터 자격 체크 후, 자격이 있으면 선정, 자격이 없으면 후 순위 입찰자를 체크하는 과정을 반복 수행하여 낙찰자 선정.
- ❑ The factors that affect whether a contractor can be considered responsible are the same as those used in considering a contractor for **prequalification**: 사전자격심사
 1. **Technical** competence and experience 기술 능력
 2. Current **financial** position based on the firm's balance sheet and income statement 재정 건전성
 3. Bonding capacity 보증 능력
 4. Current amount of work under way 현재 수행 중인 공사
 5. Past history of claims litigation 소송 이력
 6. Defaults on previous contracts 이행 포기 이력
- ❑ 장점: 수행능력을 가진 저가 입찰자 선정, 모든 입찰자에게 공정한 기회 제공.
- ❑ 단점: 설계도서에 문제가 있는 경우, 이를 악용하기 위해 저가로 낙찰한 후 Change Order를 통해 계약 금액을 증액시키는 경우가 있기때문에, 설계 도서가 완벽해야 함. 시공에서 설계로의 피드백 기회 단절. 설계 후 시공으로 공기의 증가.

5

4.5 Stipulated-Sum Contracts

- ❑ A lump-sum, or stipulated-sum, contract is one in which the contractor quotes **one price, which covers all work and services** required by the contract plans and specifications. 총액 계약: 모든 공정을 묶어서 한 덩어리로 계약
- ❑ 장점: 개별 공정의 실적이 아닌 전체 진도에 맞춰 기성 지급 가능. 개략적인 진도 체크 가능 → 관리 공수의 감소.
- ❑ 단점: 완벽한 설계도와 시방서가 사전에 준비되어야 함. 총액으로 계약되는 공사의 특성 상 유연성이 부족하여 설계 변경에 따른 계약 변경에 대처하기 어려움(예, 특정 공정의 공사량 증가).

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4.6 Unit-Price Contracts (1/5)

- ❑ In contrast to the lump-sum, or fixed-price, type of contract, the unit-price contract allows some **flexibility** in meeting variations in the amount and quantity of work encountered during construction. 단가계약: 총액계약에 비해 물량변경에 대한 유연성을 가지고 있음
- ❑ In this type of contract, the **project is broken down into work items(물량의 단위)** that can be characterized by units such as **cubic yards, linear and square feet, and piece numbers**.

	물량		×	단가	=	금액
Item Number	Quantity	Unit	Description	Unit Price		Total Amount
1	550	cubic yard (cu yd)	Rock excavation (for structures and pipes only)	\$_____		\$_____
2	50	linear foot (lin ft)	8-in. C.I. force main	\$_____		\$_____
3	20	cubic yard (cu yd)	Trench excavation for pipes	\$_____		\$_____
4	200	square yard (sq yd)	Paving	\$_____		\$_____

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4.6 Unit-Price Contracts (2/5)

□ 규모의 경제가 가능: 수량이 많아지면 간접비(고정비)를 감소시켜 단가를 낮출 수 있음.

□ 장점:

1. 계약 단가 조정이 용이함 → 예측 공사량과 실제 공사량에 차이가 발생할 때, 실제 공사량이 증가하면 단가를 낮추고 실제 공사량이 감소하면 단가를 높임.
2. 공사량에 대한 매우 정확한 예측이 필요 없음: **heavy and highway construction contracts** where earthwork and foundation work predominate. 토공과 기초공사가 지배적인 공사계약에 적합

□ 단점:

1. 프로젝트 종료 시까지 정확한 공사 금액을 알 수 없음. 총 공사 물량이 사전에 정해져 있지 않기 때문
2. 기성 지급을 위해서는 **정확한 진도 체크**가 필요함.
3. 공사를 위해 비용을 먼저 지출하고 기성을 지급 받으므로 Contractor 입장에서는 **자금 운용 상의 Time Lag**가 발생함 → 이를 커버하기 위해 초기 공정에는 높은 단가를 적용하고 말기 공정에는 낮은 단가를 적용하는 보완책을 사용할 수 있음.

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4.6 Unit-Price Contracts (3/5)

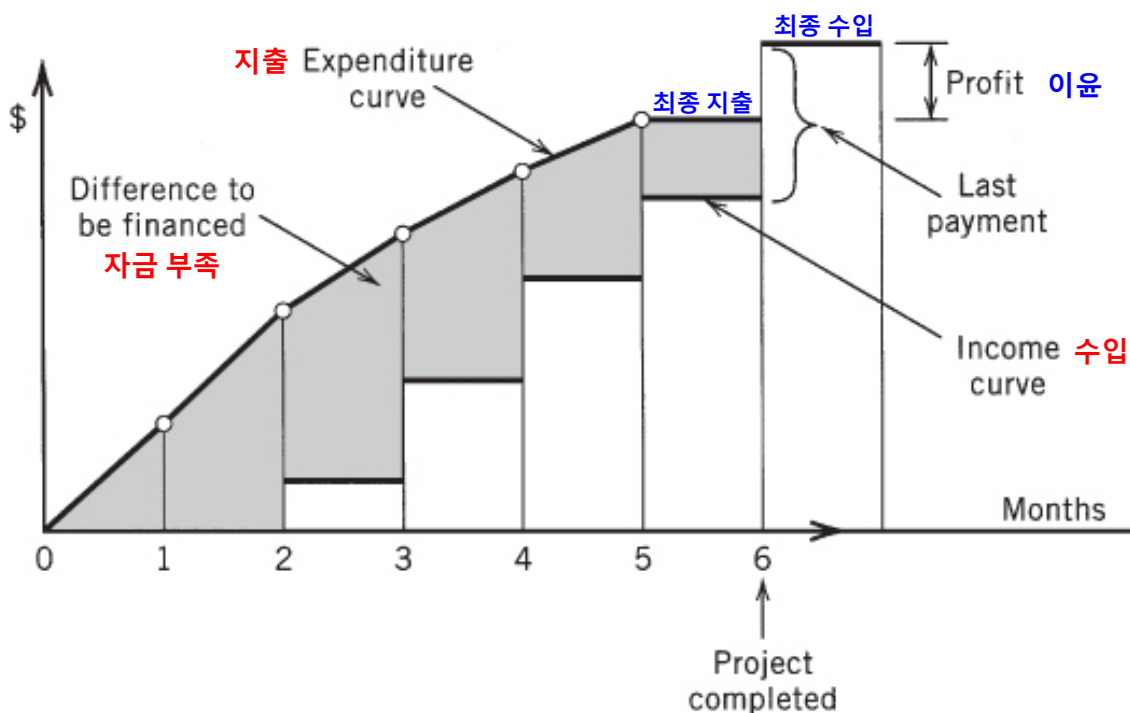


FIGURE 4.1 Project expense/income curves

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4.6 Unit-Price Contracts (4/5)

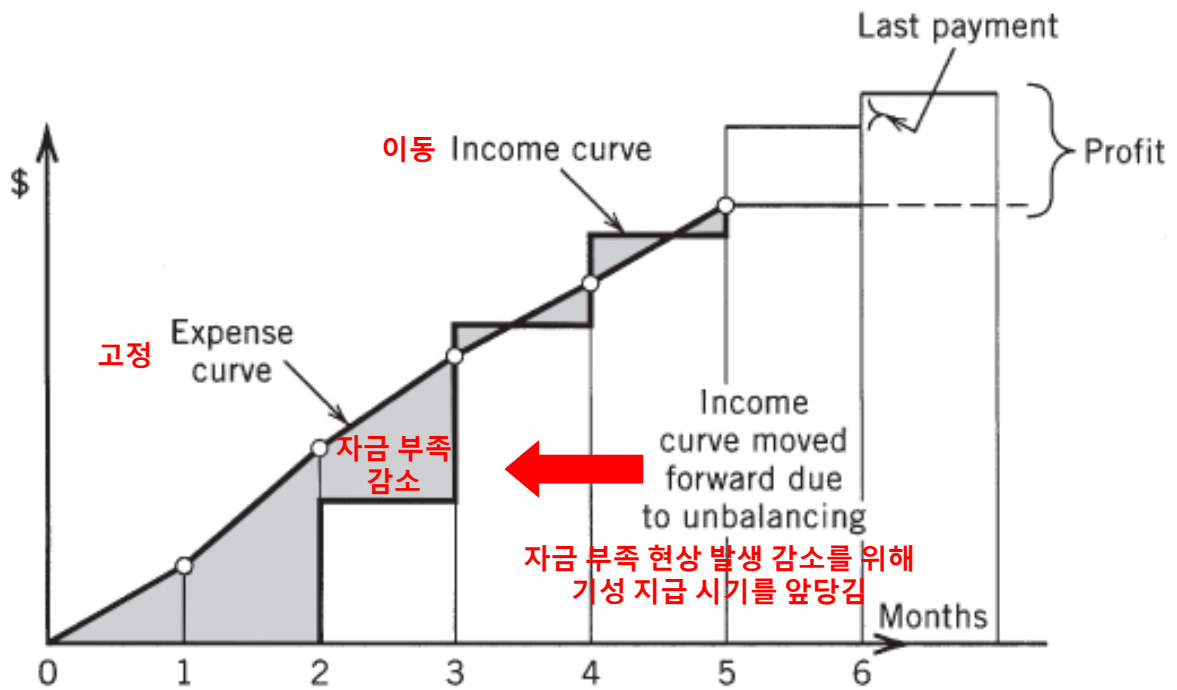


FIGURE 4.2 Unbalanced bid income profile

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4.6 Unit-Price Contracts (5/5)

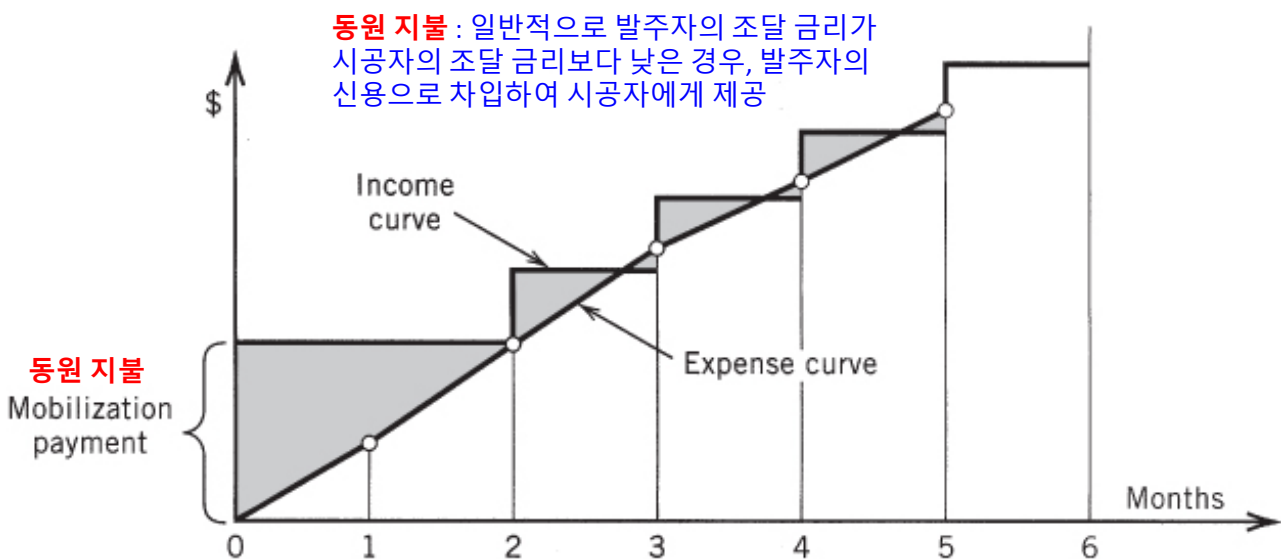


FIGURE 4.3 Income profile with mobilization payment

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4.7 Negotiated Contracts (1/2)

- ❑ An owner can enter into contract with a constructor by **negotiating the price and method of reimbursement**. 공사대금과 지불방법을 협상을 통해 결정
- ❑ In some cases, public owners will negotiate with the three low bidders on **prices, materials, and schedule**. 최저 가격, 최저 자재, 최단 일정 등을 제시한 복수의 입찰자와 협상
- ❑ The owner evaluates the **experience, reputation, facilities, staff available, charge rates, and fee structures** of the various bidders participating. 응찰자 중 가장 좋은 조건을 검색
- ❑ Normally, all direct expenses for **labor, equipment, and materials** as well as **overhead** charges required to properly manage the job are reimbursable. 인건비, 장비, 자재, 경비 등은 모든 실비 처리 In addition, the contractor receives a **fee for his expertise and the use of his plant** in support of the job. 전문지식에 대한 대가를 지급 받음

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4.7 Negotiated Contracts (1/2)

- ❑ Four types of **fee structure** are common.
 1. **Cost + percent of cost** : 공사비가 증가하면 Fee도 올라가는 모순 존재
 2. **Cost + fixed fee** : 공기를 단축하면 빨리 Fee를 수령할 수 있으므로 고가의 자재와 장비를 사용하는 부작용 발생
 3. **Cost + fixed fee + profit-sharing clause** : 목표 공기와 목표 공사비를 설정한 후 절감액에 대한 이익 공유
 4. **Cost + sliding fee** : 설계·시공 동시 진행 가능, 장기·민간 공사에 적합
$$\text{Fee} = R(2T - A) \text{ where } T = \text{target price} \text{ 목표 비용}$$
$$R = \text{base percent value} \text{ 대가 요율}$$
$$A = \text{actual cost of the construction} \text{ 실제 비용}$$
- ❑ In some cases, the **target value** is used to define a **guaranteed maximum price (GMP)**. 최대공사비 상한 보증

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4.8 Project Delivery Methods

- ❑ In ancient times, great structures were constructed by “master builders” who developed the project concept, designed the appearance and technical details of the finished building or monument, and mobilized the resources needed to realize the final structure. **고대에는 설계·시공 통합**
- ❑ Over the past 100 years, the processes of designing and building were gradually separated. **근대에는 설계·시공 분리 → Design-Bid-Build (DBB).**
- ❑ Over the past 30 years, **design and construction proceed simultaneously.** → **현대에는 설계·시공 동시 진행**
- ❑ Project delivery systems or methods:
 1. Competitively bid contracts: **DBB**
 2. Negotiated contracts: **DBB**
 3. Design Build (**DB**) contracts
 4. Construction Management (**CM**) contracts : The emphasis is on optimizing parameters other than **cost** (e.g., **quality, time of completion, meeting market needs, and safety**). **비용 외의 요소(품질, 공기, 요구사항 충족, 안전 등)를 강조하는 경우**

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4.9 Design-Build Contracts

- ❑ It is advantageous from the client’s point of view to have a **single contractor** provide the entire project as a **single contract package**. **단일 접착점**
- ❑ **DB 방식은 1970년대 복잡한 산업건설 프로젝트에서 활용되기 시작:** It eliminates disputes between designer and constructor. **설계자와 시공자 간 분쟁 제거**
- ❑ **설계·시공간 기술 교류 촉진**
- ❑ **건설 공기의 단축**
- ❑ This allows for “**phased construction,**” or a “**fast-track**” approach as described previously and a compression of the schedule because design must not be totally complete prior to commencement of construction. **설계와 시공 동시 진행 가능**
- ❑ Projects built with a single DB contractor were often referred to as “**turnkey**” projects because the owner dealt with only one contractor and that contractor was charged with the completion of the facility so that the project was ready to be placed in operation with the “turn of a key.” **발주자는 아무런 신경을 쓰지 않고 단지 완공 후 열쇠만 돌리고 들어가면 끝.**

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4.10 Design-Build in a Consortium Format

- ❑ The owner/client contracts with the **consortium as a single group** providing the total project package (e.g., design, construction, procurement, etc.). **턴키 팀을 컨소시엄으로 구성**
- ❑ 설계가 30~40% 정도 진행(예비설계 종료)되면 총 프로젝트 금액을 알 수 있다 → 발주자 예산 수립에 유리 → 공사비 변동에 따른 리스크는 시공사인 컨소시엄의 몫
- ❑ 민간 부문의 경우 큰 경쟁은 없으나, 공공 부문의 경우 많은 경쟁이 있음 → 제안서 평가가 중요.
- ❑ 수주에 실패한 컨소시엄은 심한 타격(손해)을 입는다.

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4.11 Construction Management Contracts

- ❑ In **construction-management (CM)** type contracts, **one firm is retained to coordinate all activities** from concept design through acceptance of the facility. **CM사가 전체 공사를 조정 및 통제**

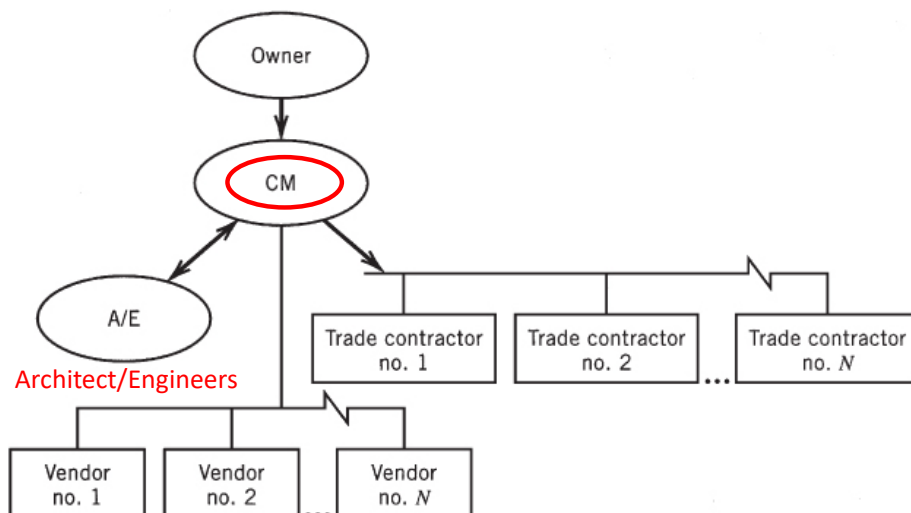


FIGURE 4.4 CM contract format schematic

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4.12 Construction Management At-Risk

- ❑ **Agency construction managers** are coordinators working on behalf of the client and are not contractually liable for the successful completion of the work. 발주자를 대리하여 공사를 관리하는 전문 대리인의 역할로 공사의 성공에 대한 직접적인 책임은 없음.
- ❑ **CM contract format** has become popular in which the construction manager not only coordinates the project but also assumes **responsibility for the construction phase of the work**. 공사의 성공에 대한 직접적인 책임을 갖는 형태로 발전.
- ❑ In the **CM at-risk contract**, the CM firm assumes **the same risk that a construction contractor in the DBB format** would assume for the successful completion of the project. Prime Contractor와 동일한 책임을 가짐.

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4.13 Comparing Project Delivery Methods

TABLE 4.1				
Project Delivery Methods				
Acronym	Contract Type	Single or Multiple Contracts to Owners	Selection Criteria	Phased Construction 설계/시공 기간 중복
DBB	Competitively Bid	Multiple-Design Contract and Construction Contract	Low Construction Cost	No
	Negotiated	Multiple Design and Construction	Low Cost or Other	Possible
DB	DB	Single Contract with DB Firm	Usually Not Low Cost—Based on Performance	Yes
CM	CMagency	Contracts Held by Owner—CM, Design, Construction, and Vendors	Based on Performance Expectations	Yes
	CM at Risk	Same as CMA Above Except CM and Construction Contracts Are Combined	Based on Performance Expectations	Yes

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CHAPTER 5

LEGAL STRUCTURE

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

5.1 Types of Organization

- ❑ One relates to the **legal organization** of the company and the second focuses on the **management organization**. 법적 측면의 조직 & 경영 측면의 조직
- ❑ **Legal organization** : how the firm will be taxed, the distribution of liability in the event the firm fails, the state, city, and federal laws that govern the firm's operation, and the firm's ability to raise capital. 세금, 파산 책임, 자본 마련 등
- ❑ **Management organization** : establishes areas and levels of responsibility in accomplishing the goals of the company and is the road map that determines how members of the firm communicate with one another on questions of common interest. 기업 경영 상의 책임과 권한

2

5.2 Legal Business Forms (1/3)

- ❑ In situations in which a single person owns and operates a business activity and makes all of the major decisions regarding the company's activity, the company is referred to as a **sole proprietorship**. 비법인 개인기업
- ❑ If a young engineer with management experience and a job superintendent with field experience decide to start a company together, this firm is referred to as a **partnership**. (로펌 등 기술회사의) 합명회사
- ❑ Corporations in which a small number of persons hold all of the **stock** in the firm are referred to as **close or closely held corporations**. 유한회사 (한정된 인원만이 주식을 소유)
- ❑ A **public corporation**, in contrast to a closely held corporation, allows its **stock** to be bought and sold freely. 주식회사 (주식 소유가 모두에게 개방되어 있음)
- ❑ A **joint-venture** organizational structure is used when a large project is to be constructed and requires the pooling of resources or expertise from several companies. 합작투자: 2개 이상의 건설회사가 임시로 결합, 조직, 출자하여 유한회사 형태의 (단일)법인을 만든 후 공사를 수주하고 준공 후 해산하는 방식(컨소시엄: 복수의 독립된 법인의 연합)

3

5.2 Legal Business Forms (2/3)

- **대한민국의 상법은 사원의 책임의 형태에 따라 회사를 다음의 네 가지로 나누고 그 밖에 회사는 인정하지 아니한다(상법 170조).**
- **주식회사:** 주식의 인수가액을 한도로 하는 유한의 간접책임을 부담하는(331조) 사원, 즉 주주만으로 성립하는 회사이다. 주주는 간접, 유한책임이라는 데 비추어, 주주총회의 결의에는 참가하나 업무집행에는 당연히 참여하지 못한다. 또 주식양도는 원칙으로 자유이고, 사원의 개성이 문제가 되지 아니하므로 **사원의 수가 많고 대자본이 필요한 대기업에 적합하다.**
- **유한회사:** 주식회사의 주주와 같이 출자액을 한도로 하는 간접의 유한책임을 부담하는(553조)사원만으로 성립하는 회사이다. 중소기업에 적합하도록 주식회사의 복잡한 조직을 간단하게 하여 합명회사와 같은 점을 가지고 있는 점에서 주식회사와 다르다. 따라서 이것은 **중소기업의 경영에 적합한 회사이다.**
- **합명회사:** 모든 사원이 무한책임사원으로서 회사채권자에 대하여 직접, 연대, 무한의 책임을 부담하고(212조), 원칙으로 회사의 업무를 집행할 권리와 의무를 가지며(200조), 그 지위를 타인에게 자유로이 이전할 수 없는(197조)회사이다. 따라서 **사원의 회사에 대한 관계가 깊고, 인적 신뢰관계가 있는 소수인의 공동기업에 적합하다.**
- **합자회사:** 합명회사와 같은 무한책임사원과 회사채권자에 대하여 출자액을 하도록 하는 유한책임을 부담하는 (279조)사원으로 성립되는 이원칙 조직의 회사이다(268조). 무한책임사원은 기업경영을 담당하나, 유한책임사원은 업무집행에 참여하지 아니한다. 그러나 회사채권자에 대하여는 모두 직접, 연대책임을 부담한다. 따라서 사원은 인적으로 결합되어 있고 사원수가 적다.

4

5.2 Legal Business Forms (3/3)

□ 일반건설업 (면허 종류)

업종	업무내용	건설공사의 예시
토목공사업	종합적인 계획, 관리 및 조정하에 토목공작물을 설치하거나 토지를 조성, 개량하는 공사	도로, 항만, 철도, 댐, 하천등의 건설, 택지 조성, 간척, 매립 공사등.
건축공사업	종합적인 계획, 관리 및 조정하에 토지에 정착하는 공작물중 지붕과 기둥(또는 벽)이 있는 것과 이에 부수되는 시설물을 건설하는 공사.	아파트, 빌딩, 병원, 호텔, 학교, 상가, 공장시설등의 건설공사
토목건축공사업	토목공사업과 건축공사업의 업무내용에 속한 공사.	토목공사업과 건축공사업의 건설공사
산업환경설비	종합적인 계획, 관리 및 조정하에 산업의 생산시설, 환경오염을 제거, 감축하기 위한 시설, 에너지등의 생산, 저장, 공급시설등을 건설하는 공사.	제철, 석유화학공장 등 산업생산시설, 소각장, 수처리설비 등 환경시설공사, 발전소 설비공사등.
조경공사업	종합적인 계획, 관리, 조정하에 수목원이나 공원의 조성등 경관 및 환경을 조성하는 공사.	수목원, 공원, 숲등의 조성공사

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5.3 Proprietorship

- ❑ In this form of business ownership, an **individual** owns and operates the firm, retaining personal control. 개인 소유의 기업
- ❑ The **proprietor makes all decisions** regarding the affairs of the firm. 개인이 모든 의사결정 수행
- ❑ The proprietor is, therefore, **taxed as an individual** and there is no separate taxation of the firm. 개인으로서 소득세 납부
- ❑ 회사의 손해 = 개인의 재산 손실

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5.4 Partnership

- ❑ The partnership is similar to the proprietorship in the sense that liabilities of the firm are directly transmitted to the **partners**. 개인 → 파트너 집단
- ❑ **General partners**: There is **no limitation of liability**. 무한책임
- ❑ **Limited partners**: They are liable only to the **extent of their investment**.
 1. 손해가 최대투자액까지만이라는 점에서 주식회사의 주주와 같다.
 2. 경영권은 없음
 3. 투자자로서의 파트너
 4. Tangible Asset(유형 자산)만 투자 가능 (equipment, cash, notes(어음), and shares of stock in a corporation).
- ❑ **General partners** who are actively involved in the day-to-day management of the firm may decide to **pay themselves a salary**. 급여지급 가능

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5.5 Corporation (1/2)

- ❑ A **corporation** is a separate legal entity and is created as such under the law of a state in which it chartered. **주식 발행**
- ❑ Par value: 액면가, Book value: 장부가 = 자산/주식수, Traded or market value: 시장가
- ❑ In fact, most construction firms hold their stock closely and **do not trade it publicly**.
건설 기업은 통상 주식을 주식시장에 상장하지 않음 : 기업 미공개
- ❑ 주식회사의 장점: 투자한 범위 내에서만 손실을 입을 뿐 개인 자산에 영향은 없다. 절세 효과(개인 소득세 → 법인 소득세). 유상증자를 통해 자본을 확충할 수 있음.
- ❑ Proprietorship format: Tax would be 25% of \$147,000 minus \$12,000 in deductions and exemptions. 25% of \$135,000 = **\$33,750** in tax.
- ❑ **Corporation** format: Tax will be \$15,500 + \$15,330 = **\$30,830** in tax.

\$147,000

– \$85,000 (Fudd 's salary, which is an expense)

= \$62,000 Gross income of corporation

Corporate tax = 0.25(62,000) = \$15,500

Personal tax = (0.21) { \$85,000 – 12,000 (deductions and exemptions) } = \$15,330

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5.5 Corporation (2/2)



FIGURE 5.1 Example of stock certificate

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5.6 Comparison of Legal Structures (1/4)

□ Specifically, an owner contemplating a **legal structure for the firm** must **consider**:

1. Taxation. 세금
2. Costs associated with establishing the firm. 기업 설립 비용
3. Risk and liability. 위험과 책임
4. Continuity of the firm. 기업의 영속성
5. Administrative flexibility and impact of structure on decision making. 의사결정 효율성
6. Laws constraining operations. 법적 제약
7. Attraction of capital. 자본 조달

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5.6 Comparison of Legal Structures (2/4)

	개인기업 Proprietorship	합명회사 Partnership	주식회사 Corporation	
Tax 세금	Tax on personal income; tax on earnings whether or not they are withdrawn	Tax on personal salary and earnings 배당금	Lower taxes in some cases. ⁴ Dividends are not deductible; double taxing. Taxes on dividends, that is, money actually received	小
Costs and procedures in starting 기업 설립 비용	No special legal procedure; apply for licenses; register with IRS	General: Easy—oral agreement Limited: More difficult—must closely adhere to state law	More complex and expensive. Meeting must be held	大
Size of risk 위험과 책임	Personal liability	Personal liabilities: Extent of personal fortune. Limited: Each partner is protected; loss of limited partner cannot exceed initial investment	Limited to assets of corporation	小
Continuity of the business 기업의 영속성	No continuity on death of proprietor	Dissolution: No continuity on death of partner. Surviving partners can buy share if in agreement	Perpetual unless charter is explicitly dissolved by owners	大
Adaptability of administration 의사결정 효율성	Simplicity of organization; direct control	Decisions and policies implemented by oral agreement	Directors—good if involved. Policy decisions predefined by bylaws	低
Influences of applicable laws 법적 제약	Laws are well defined; no limit on doing business in various states	Laws are also well-defined; a license may be required	Foreign corporation status; requires legal counsel on permanent basis	복잡
Attraction of additional capital 자본 조달	Limited potential for capital expansion. Borrowing; line of credit; personal fortune investment	Better; more capital; limited partner concept 담보	Issue securities; collateral provided by corporate assets; issue stock	수월

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5.6 Comparison of Legal Structures (3/4)

구분	개인사업자	법인사업자	
대표자 책임	대표자는 채무에 대해 무한 책임	대표자는 회사 운영에 책임을 지며 주주는 주금 납입을 한도로 유한책임	小
자본 조달	대표자 개인의 자본	소액으로 분리된 주식을 통해 자본조달 가능	수월
세금 부담	소득이 많은 경우 소득세 부담이 큼	소득이 많은 경우 개인사업자에 비해 세금이 적을 수 있음 (소득액수에 따라 법인사업자가 더 큰 경우도 있음을 유의)	小
이익금 사용	사업자의 이익을 개인이 자유롭게 사용	법인 대표가 개인용으로 사용하면 회계상 법인 대표가 회사로부터 금전을 차용한 형태를 취하므로 회사에 이자를 지급해야 함	자유롭지 못함
사업의 영속성	대표자가 바뀌는 경우 폐업 후 신규로 사업자등록	주식양도에 의해 사업양도가 가능하며 기업주가 바뀌어도 법인의 계속성 유지	大

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5.6 Comparison of Legal Structures (4/4)

개인사업자 : 종합소득세율 → 과세표준이 2,160만원 이하면 개인사업자가 유리

과세표준	세율	세금 계산
1,200만원 이하	6%	$0.06 \times (\text{과세표준})$
1,200만원 초과 4,600만원 이하	15%	$72\text{만원} + 0.15 \times (1,200\text{만원 초과분})$
4,600만원 초과 8,800만원 이하	24%	$582\text{만원} + 0.24 \times (4,600\text{만원 초과분})$
8,800만원 초과 1억 5,000만원 이하	35%	$1,590\text{만원} + 0.35 \times (8,800\text{만원 초과분})$
1억 5,000만원 초과 3억원 이하	38%	$3,760\text{만원} + 0.38 \times (1\text{억 } 5,000\text{만원 초과분})$
3억원 초과 5억원 이하	40%	$9,460\text{만원} + 0.40 \times (3\text{억원 초과분})$
5억원 초과	42%	$1\text{억 } 7,460\text{만원} + 0.42 \times (5\text{억원 초과분})$

법인사업자 : 법인세율 → 과세표준이 2,160만원 이상이면 법인사업자가 유리

과세표준	세율	세금 계산
2억원 이하	10%	$0.10 \times (\text{과세표준})$
2억원 초과 200억원 이하	20%	$2,000\text{만원} + 0.20 \times (2\text{억원 초과분})$
200억원 초과 3,000억 이하	22%	$39\text{억 } 8,000\text{만원} + 0.22 \times (200\text{억원 초과분})$
3,000억 초과	25%	$655\text{억 } 8,000\text{만원} + 0.25 \times (3,000\text{억원 초과분})$

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5.7 Joint Venturing

- **합작투자:** 2개 이상의 건설회사가 임시로 결합, 조직, 출자하여 유한회사 형태의 법인을 만든 후 공사를 수주하고 준공 후 해산하는 방식
- Larger and complex projects often exceed the capability of a single firm or contractor to do the work. In such cases, a **team or group of contractors** will combine their resources to bid and execute the work.
- A famous example of this situation is the **construction of the Hoover Dam** during the 1930s, in which a group of six of the largest contractors in the United States banded together to build this project. 1930년대 하버댐 건설을 위해 6개 대형 건설사가 연합
- **Joint ventures** are also referred to as consortia (a single team or group is a **consortium**).
- **합작투자**는 단일 법인, 컨소시엄은 독립된 법인의 연합
- Joint ventures differ from proprietorships, partnerships, and corporations in that they **exist for a fixed period of time** defined by the duration of the project being undertaken. **합작투자**사는 프로젝트 기간 내에만 존재

CHAPTER 6

IMPACT OF TAXES

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

6.1 Society and Taxation

- ❑ One of the **first documented tax systems** was implemented in ancient Egypt. **Farmers paid their taxes** in kind to scribes appointed as tax collectors. The tax owed was determined in **proportion to the area** and location of the farm. 이집트 - 최초의 세금 기록, 농민들이 농지 경작 면적에 따라 세금 납부
- ❑ **Citizens** were able to pay their taxes by performing **corveé duty** (부역 의무), which consisted of working in public works (such as the Pharaoh's burial monument) 시민들은 부역 의무를 가짐 : 스피нк스나 피라미드 건설 부역



FIGURE 6.1 The Sphinx and Pyramid II

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6.2 Business Impact of Taxation

- ❑ The **profitability** of any construction company is significantly affected by the **amount of taxes** it is required to pay. 수익성은 납입해야 할 세금의 액수에 영향을 받음
- ❑ Conceptual outline of the **U.S. tax system**.

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6.3 Why Taxes?

- ❑ Taxes are primarily designed **to finance government operations** and to meet societal needs. 정부 운영 재정 마련을 위해, 사회적 요구사항을 충족시키기 위해, 세금 필요
- ❑ 자원 마련 및 캠페인 목적 (고울의 담배세, 기부금 공제 등)

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6.4 Types of Taxes

- ❑ A tax levied on the net income realized by a company or individual is called an **income tax**. 개인이나 법인의 소득에 부과되는 세금 : 종합소득세, 법인세
- ❑ Income taxes are referred to as **direct taxes**. 직접세 : 소득이나 재산에 직접 부과되는 세금 (ex. 소득세, 재산세)
- ❑ **Indirect taxes**, in contrast, are levied on the cost, price, or value of products or services (e.g., sales tax) 간접세 : 제품이나 서비스에 부과되는 세금 (ex. 부가가치세)
- ❑ **Tax deductions** 세금 공제(연금, 보험, 교육비, 의료비 공제 등)

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6.5 Income Tax Systems

- ❑ The corporate form of legal organization leads to **double taxation** because the **corporation** is taxed as a **business entity** and the **stockholders** are taxed separately as **individuals** for profits distributed to them as dividends.
- ❑ 이중과세 = 법인세 + 배당금 소득세 (법인의 국내원천소득 중 배당소득에 대한 이중과세에 대해 개인주주의 경우 Gross-up 제도, 법인주주의 경우 수입배당금 익금불산입제도를 두어 이중과세를 조정 → 법인의 소득에서 배당금 소득세 과세 부분의 배당금을 공제)
- ❑ $\text{Income} = \text{Revenue} - \text{Expenses}$ 소득 = 매출 - 비용
- ❑ $\text{Taxable Income} = \text{Revenue} - \text{Expenses} - \text{Deductions}$
- ❑ $\text{과세소득} = \text{매출} - \text{비용} - \text{공제} = \text{소득} - \text{공제}$

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6.6 Taxation of Businesses (1/2)

- ❑ In business organizations, the **definition of revenues and expenses** becomes more important and must conform to **guidelines established by tax law**. 매출과 비용의 정의 필요
- ❑ **Revenue** is, in effect, the summation of all amounts due and payable to a company from clients or other financial sources for work performed, **sales and services supplied**, and other financial transactions. 매출: 판매액(기성)
- ❑ **Direct expenses**: These expenses are incurred in operations that lead to the realization of the physical facility being constructed. Typical direct expenses are **job payroll**, project related **equipment costs**, the **cost of materials** used for construction of the project, and **subcontractor payments**. 직접비: 인건비, 장비비, 자재비, 하도급
- ❑ **Indirect expenses**: This term relates to costs incurred for the management support of the job site and for home office general and administrative costs (e.g., **senior management and staff salaries**, **office equipment costs** such as computer and copying charges, and costs related to the **ownership or rental of office space**). These types of indirect expenses are often referred to as “**overhead**” or “**overhead expenses**.” 간접비: 본사 임직원 인건비, 사무실 운영비, 사무실 임대료 등 경비

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6.6 Taxation of Businesses (2/2)

Income Statement, Fudd Construction Co. 3rd Qtr, 2XXX			
매출	Net Sale (Revenues)	\$21,427,610	
직접비	Cost of Sales (Direct Expense)		
	1. Materials	\$10,139,130	
	2. Labor (Includes all payroll taxes & fringe)	\$5,482,71	
	3. Subcontracts	\$514,500	
	Total Cost of Sales	\$18,159,320	
이익	Gross Profit	\$3,283,290	
	Job Related Indirect Charges		
	1. Salaries	\$276,640	
	2. Job Office Costs	\$190,430	
	3. Transportation (Travel, Meals, etc.)	\$80,710	완전(전액) 공제 불가
	4. Interest Charges (Job Carrying Costs)	\$12,750	
	5. Miscellaneous	\$2,130	
	Total Job Indirect Charges	\$562,660	
	Fixed (Home Office) Overheads		
	1. Salaries—Home Office Staff	\$234,180	
	2. Salaries—Office	\$384,100	
	3. Home Office Admin Cost (Equipment etc.)	\$516,950	
	4. Legal and Audit	\$23,150	
	5. Rent	\$25,060	
	6. Depreciation	\$82,380	감가상각
	Total Fixed Overheads	\$1,265,820	
경비	Total Overheads	\$1,828,480	
세전이익	Net Profit before Taxes	\$1,454,810	
세금	State and Federal Taxes	\$509,183	
(세후이익)순익	Net Profit	\$945,627	

FIGURE 6.2 Income Statement for Fudd Construction Co., 3rd Qtr, 2XXX

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6.7 Business Deductions in General

- ❑ Most firms try to **reduce their amount of taxable income** as much as legally possible.
모든 기업은 과세 대상 소득을 줄이고자 함
- ❑ **Deductions** allow companies to reduce the amount of income subject to taxation.
소득공제 (과세 대상 소득 : 소득 - 공제)
- ❑ Probably the most significant deduction available to construction contractors is that given for the **loss in value of company equipment over time** → **Depreciation**. 건설 기업에 있어서 가장 큰 비중을 차지하는 공제 항목 : 보유 장비의 가치 하락에 따른 감가상각

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6.8 Taxable Income: Individuals

- ❑ For tax purposes, individuals are classified into the following filing statuses: 납세자 유형
 1. **Single**: Unmarried individual generally pay the highest amounts of tax compared to the other categories. 미혼 개인 : 일반적으로 다른 유형보다 더 많은 세금 납부
 2. **Married filing separately**: A married couple may decide to pay taxes separately, filing their tax returns as essentially two single individuals. 결혼 개별 : 고액 연봉자들이 선호, 개인으로 세금을 내는 것 보다는 경제적
 3. **Married filing jointly**: This filing status comprises the traditional married couple and children, choosing to use a single tax return for the couple and dependents. 결혼 합산 : 부부 또는 가족으로 합산하여 세금 납부
 4. **Head of household**: This is the one category that is given some tax benefits: **single parents**, single children supporting their parents, and similar individuals frequently under financial duress. 세대주 : 미혼모, 미혼부 등 재정 압박을 받고 있는 개인들

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6.9 Itemized Deductions, Standard Deductions, and Personal Exemptions (1/2)

- ❑ Every individual (or family, if filing jointly) can deduct certain items from their income, thus reducing the tax basis on which their taxes will be computed. **Contributions to charity, medical expenses** over a certain threshold, the **interest paid on the mortgage loan** for the individual's residence, and other deductions can add up to a substantial amount of money. 소득 공제: 기부금, 의료비, 주택대출상환이자 등
- ❑ One of the most important deductions available to construction contractors is the **depreciation of property**. 건설사업자: 감가상각 공제가 중요
- ❑ This item-by-item reporting is called the **itemized deduction approach**. 개별 공제 : 개별 항목별로 공제를 받음
- ❑ Alternatively, individuals can choose to subtract a **standard deduction** from their income instead of performing an itemized deduction calculation. 표준 공제 : 개별 항목별로 공제액을 계산하지 않고, 유형별 표준 공제액을 공제 받음 → 일종의 유형별 평균 공제 금액 개념

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6.9 Itemized Deductions, Standard Deductions, and Personal Exemptions (2/2)

TABLE 6.1	
Standard Deduction and Personal Exemptions, 2015	
Standard Deductions	
Status	Amount
Single	\$6,300
Married Filing Jointly	\$12,600
Married Filing Separately	\$6,300
Head of Household	\$9,300
Surviving Spouse	\$12,600

생존 배우자

Note: Personal exemption \$4,000 per person
인당 세금 공제액(기초공제)

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6.10 The Tax Significance of Depreciation 감가상각의 중요성

- ❑ **Depreciation** reflects the loss of value and obsolescence of property (e.g., equipment) involved in the operation of a business. 감가상각은 장비 등 자산의 가치 하락을 반영
- ❑ Depreciation applies to **all property required for the operation of a business**. 사업 수행을 위해 필요한 모든 자산에 감가상각 적용
- ❑ **Computers, office furniture, heavy equipment, and real estate** are all depreciable assets. 감각상각 가능 자산 : 컴퓨터, 가구, 중장비, 부동산 등

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6.11 Marginal Tax Rates (1/3)

- The **income tax** depends on two main factors: the **filing status of the taxpayer** (i.e., corporation, single individual, married filing jointly, etc.), and the **taxable income** on which the tax is computed. **세율은 납세자의 유형과 과세소득 수준에 따라 상이함**

미혼개인 소득세율

TABLE 6.2		
Tax Table for Single Taxpayers, 2015		
Taxable Income of <u>Single Taxpayers</u>		
From	To	Tax
0	9,225	10%
9,226	37,450	\$922.50 + 15% of amount over \$9,225
37,451	90,750	\$5,156.25 + 25% of amount over \$37,450
90,751	189,300	\$18,481.25 + 28% of amount over \$90,750
189,301	411,500	\$46,075.25 + 33% of amount over \$189,300
411,501	413,200	\$119,401.25 + 35% of amount over \$411,500
413,201	Above	\$119,996.25 + 39.6% of amount over \$413,200

우리나라 : 6% ~ 42%

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6.11 Marginal Tax Rates (2/3)

TABLE 6.3		
Personal Income Tax Brackets and Tax Rates, 2015		
Taxable Income of <u>Married Individuals Filing Jointly or Qualifying Widow(er)</u>		
From	To Under	Tax
0	18,450	10%
18,451	74,900	\$1,845.00 + 15% of amount over \$18,450
74,901	151,200	\$10,312.50 + 25% of amount over \$74,900
151,201	230,450	\$29,387.50 + 28% of amount over \$151,200
230,451	411,500	\$51,577.50 + 33% of amount over \$230,450
411,501	464,850	\$111,324.00 + 35% of amount over \$411,500
464,851	Above	\$129,996.50 + 39.6% of amount over \$464,850
Taxable Income of <u>Married Individuals Filing Separately</u>		
From	To Under	Tax
0	9,225	10%
9,226	37,450	\$922.50 + 15% of amount over \$9,225
37,451	75,600	\$5,156.25 + 25% of amount over \$37,450
75,601	115,225	\$14,693.75 + 28% of amount over \$75,600
115,226	205,750	\$25,788.75 + 33% of amount over \$115,225
205,751	232,425	\$55,662.00 + 35% of amount over \$205,750
232,426	Above	\$64,998.25 + 39.6% of amount over \$232,425
Taxable Income of <u>Heads of Households</u>		
From	To Under	Tax
0	13,150	10%
13,151	50,200	\$1,315.00 + 15% of the amount over \$13,150
50,201	129,600	\$6,872.50 + 25% of the amount over \$50,200
129,601	209,850	\$26,772.50 + 28% of the amount over \$129,600
209,851	411,500	\$49,192.50 + 33% of the amount over \$209,850
411,501	439,000	\$115,737.00 + 35% of the amount over \$411,500
439,001	Above	\$125,362.00 + 39.6% of the amount over \$439,000

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6.11 Marginal Tax Rates (3/3)

법인 소득세율

TABLE 6.4		
Corporate Income Brackets and Tax Rates, 2015		
Taxable Income		
From	To Under	Tax
0	50,000	15%
50,000	75,000	\$7,500 + 25% of the amount over 50,000
75,000	100,000	\$13,750 + 34% of the amount over 75,000
100,000	335,000	\$22,250 + 39% of the amount over 100,000
335,000	10,000,000	\$113,900 + 34% of the amount over 335,000
10,000,000	15,000,000	\$3,400,000 + 35% of the amount over 10,000,000
15,000,000	18,333,333	\$5,150,000 + 38% of the amount over 15,000,000
18,333,333	Above	35%

우리나라 : 10% ~ 25%

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6.12 Tax Credits

- ❑ A **tax credit** (세액공제) is an allowance that can be deducted from the tax as computed in the previous section (Deduction : 소득공제), instead of from the individual's or corporation's taxable income.
- ❑ It must be repeated that credits are subtracted from the computed tax and not from the income. 세액공제는 소득이 아닌 세금에서 차감

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6.13 Tax Payroll Withholding 임금 소득자 원천징수

- ❑ Employers are required to **retain an amount from each paycheck** that is roughly enough to cover the employee's projected tax liability at the end of the year. 임금 소득자 → 소득세 선납입 후정산
- ❑ It is possible that the total amount withheld exceeds the total tax owed, in which case the IRS **refunds the amount of overpayment** to the individual taxpayer 임금 소득자 → 소득세 연말정산을 통해 과납분/미납분 세금 정산

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6.14 Tax Payment Schedules

- ❑ Corporations and some individuals must pay their taxes in **quarterly installments** (분할 납입금) (roughly every three months). 분기마다 소득세 납부
- ❑ This **avoids the shock of paying a single large balloon payment** at the end of the tax period. 분기마다 소득세를 정산함으로써, 연말정산금액 변동성을 최소화
- ❑ First three installments (**15th of April, June, and September**) but pay the last installment on **January 15th** of the following year. 세금 납부일 : 4, 6, 9, 1월 15일

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6.15 Marginal, Average, and Effective Tax Rates

- ❑ The **average tax rate** (평균세율: 우리가 알고 있는 세율) compares the tax paid to the taxable income:

Average Tax Rate = Tax Paid / Taxable Income 분모 : 과세 소득

- ❑ The **effective tax rate** (유효세율: 감춰진 세율) is the ratio between tax paid and income prior to subtraction of deductions and exemptions: 세액공제와 소득공제로 인해 세율 감소

Effective Tax Rate = Tax Paid / Gross Income 분모 : 전체 소득

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6.16 Summary

- ❑ This chapter has discussed issues related to **taxation** that influence the bottom line of a construction company and impact financial decisions.
- ❑ The company's top management and particularly the **chief financial officer (CFO)** must continuously study and analyze the impact of taxation on all financial and organizational decisions. 세금 관리 : 최고회계관리자의 역할

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CHAPTER 7

PROJECT PLANNING

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

7.1 Introduction

- ❑ **Cost, time, and scope** are the essential elements constantly juggled by each participant in any project. 건설 프로젝트의 주요 관리 대상 : 공사 비용, 공사 기간, 공사 범위
- ❑ This chapter discusses tools for **planning and managing a project**. 프로젝트 계획 및 관리

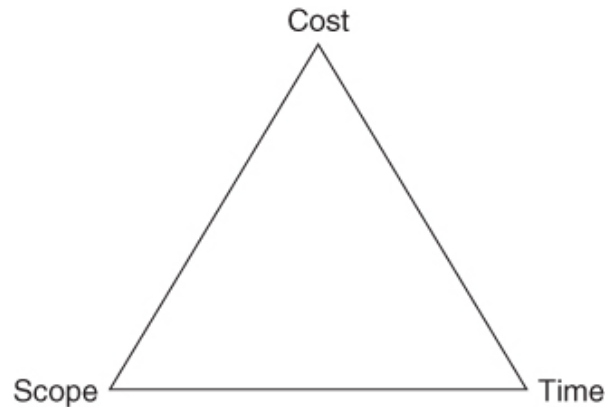


FIGURE 7.1 Cost-time-scope triangle

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7.2 Work Breakdown Structure (1/3)

- ❑ The **bid package** consisting of the plans and specifications establishes **the scope of work to be performed**. 입찰 서류에 공사의 범위가 명시된 도면과 시방서가 포함됨
- ❑ To be properly managed, the scope of work must be broken into components that define **work elements or building blocks (sub-elements)**. 관리를 위해 전체 공사를 작은 과업 단위로 분해
- ❑ The **sub-elements** are often referred to as **work packages**. 과업(Task)
- ❑ The summation of the work packages can be shown in a hierarchical format called a **work breakdown structure (WBS)**. 작업 분류 체계 : 수행해야 할 과업을 계층적으로 나열한 체계 (MECE 원칙 : Mutually Exclusive and Completely Exhaustive, 상호 배제와 전체 포괄 - 서로 겹치지 않으며, 모으면 전체가 되도록)

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7.2 Work Breakdown Structure (2/3)

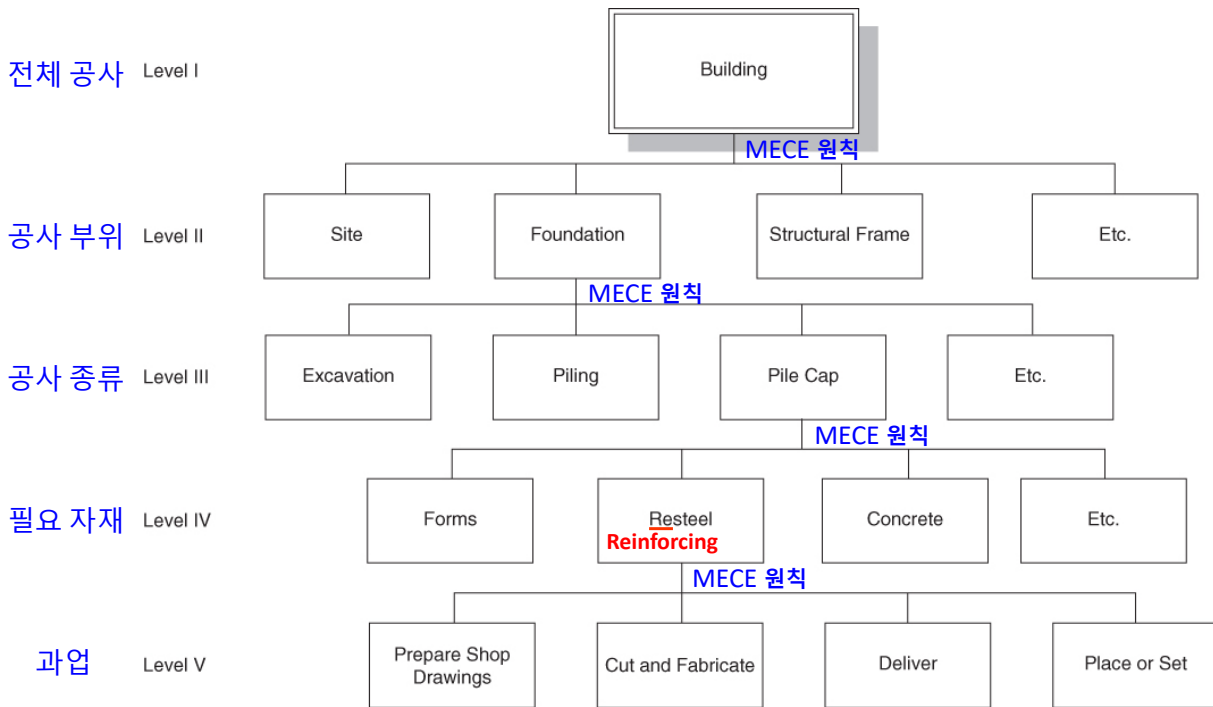


FIGURE 7.2 Work breakdown structure (WBS) example for a small building

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7.2 Work Breakdown Structure (3/3)

- Planning can be thought of as the **definition and sequencing of the work packages** within a given project. 계획(과업의 정의 및 작업 순서 결정): 작업 분해 & 순서 결정

Planning = **Work Breakdown** + **Work Sequencing**

- **Plan → Do → Check → Action: PDCA Cycle**
일반적 관리 절차: 계획 → 실행 → 검토 → 조치

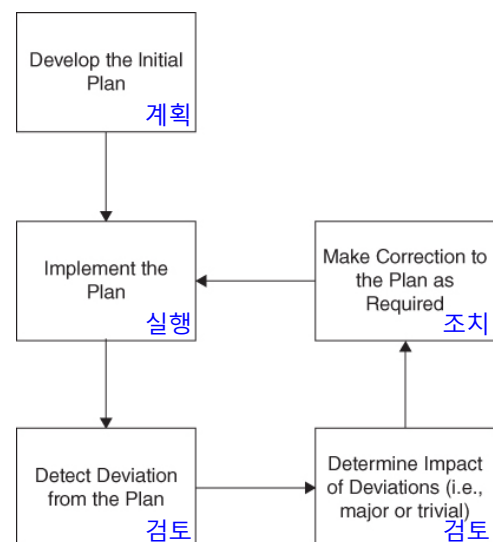


FIGURE 7.3 Deming cycle

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7.3 Developing the Work Breakdown Structure

□ In establishing the **WBS**, the following **guidelines** need to be considered:

1. Work packages must be clearly **distinguishable** from other work packages. 하나의 과업은 다른 과업과 명확하게 구분되어야 함
2. Each work package must have a **unique starting and ending date**. 각 과업은 고유한 시작시간과 종료시간을 가져야 함
3. Each work package should have its own **unique budget**. 각 과업은 자신만의 고유한 예산을 가져야 함
4. Work packages should be **small enough** that precise **measurement of work progress** is possible. 각 과업은 작업 진도를 측정할 수 있을 정도로 충분히 작아야 함

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7.4 A Work Breakdown Example (1/2)

□ In construction, the various **aspects of the work** that contribute to breakdown of the project into packages relate to: 작업 분해의 기준이 될 수 있는 특성

1. **Methods** used to place the work. 공사 종류
2. **Skills** needed for the work. 필요 기술
3. **Craft workers** involved. 관련 숙련공
4. **Critical resources** (e.g., cranes, crews, etc.) 핵심 자원(장비, 인력)

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7.4 A Work Breakdown Example (2/2)

□ **Small gas station project** example 주유소 건설 예제

□ For this example, the following four categories (유일성을 유지하기 위해 범주화) have been defined:

1. **Location or area within the project** (e.g., foundation–pile cap). 공사 내의 위치(공사 부위)
2. **Material type** (e.g., concrete, reinforcing steel, etc.). 필요 원자재
3. **Method of installation** (e.g., excavation). 공사 종류
4. **Types of resources required** (e.g., labor and equipment needed). 필요 인력 또는 장비

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7.5 Work Packages for the Gas Station Project (1/2)

1단계: **Location** 범주만 고려

1. Parking and service area

2. Foundation

3. Building walls/structural panels

4. Building roof

5. Interior floors/slabs

6. Interior finishes

7. Exterior finishes

8. Electrical systems

9. Mechanical systems

2단계: **Material** 범주 추가

TABLE 7.1
Work Packages for Gas Station Project

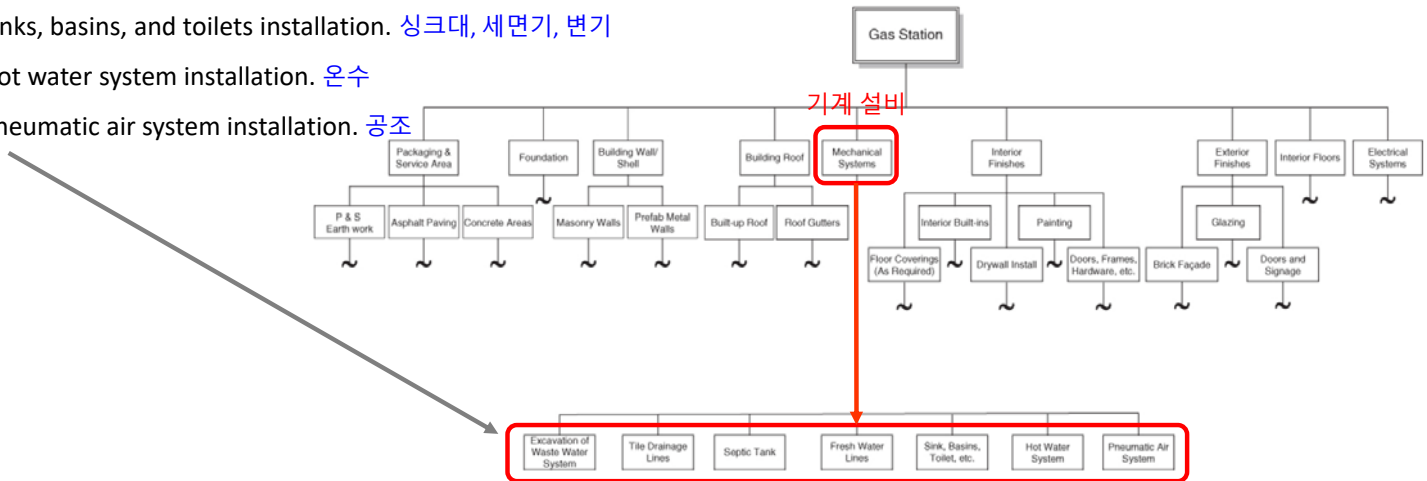
No.	Item		No.	Item
1	1 Earthwork for Parking and Service	토공	11	Interior Painting
	2 Asphalt Paving for P&S Area	아스팔트	12	Interior Drywall
	3 Concrete Hardstands in P&S Area	콘크리트	13	Interior Doors, Frames, Hardware, etc.
2	4 Concrete Foundations		14	Interior Floor Coverings (if required)
3	5 Walls—Masonry Bearing Walls		15	Exterior Brick Facade
	6 Walls—Prefab Metal Sandwich Panels		16	Exterior Glazing
4	7 Interior Concrete Floors		17	Exterior Doors and Signage
	8 Built-up Roof		18	Mechanical Systems
6	9 Roof Gutters/Drainage		19	Electrical Systems
	10 Interior Built-ins (e.g., Cabinets, etc.) (P&S) Area	N/A	N/A	

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7.5 Work Packages for the Gas Station Project (2/2)

3단계: Method and Resource 범주 추가

1. Excavation of waste water system. 하수도 터파기
2. Drainage tile installation—waste water. 하수도 배수구
3. Septic tank installation. 오수 정화조
4. Fresh water lines (piping). 상수도
5. Sinks, basins, and toilets installation. 싱크대, 세면기, 변기
6. Hot water system installation. 온수
7. Pneumatic air system installation. 공조



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7.6 Determining Sequence of Work Packages (1/2)

- ❑ Having broken the work into work packages, activities that facilitate **time management and control** can be defined and logically placed in **sequence**. 작업 분해 → 작업에 대한 관리 시작 : 작업 순서 결정
- ❑ The word **activity** is generally used when discussing time control or scheduling. WBS : 과업(work packages, sub-elements, task) → 공정 관리 : 액티비티
- ❑ In arranging the work package sequence for time control, the criteria of (a) **location**, (b) **material**, (c) **method**, and (d) required **resources** must be reconsidered. 작업 순서 결정 요인 : 위치(부위), 자재, 공법, 자원(장비, 인력)
- ❑ **Physical constraints** or **physical logic** are common and characteristic of construction operations (e.g., **the floor must be completed before installing the floor covering**, etc.). 물리적 제약으로 인한 작업 선후행 관계 발생 : 바닥 작업 완료 후 바닥 마감재 작업 가능
- ❑ **Management decision** (e.g., **the fixture subcontractor is available first and is instructed to proceed**) and the sequence is driven by **management logic**. 관리적 목적으로 인한 작업 선후행 관계 발생 : 불박이 가구 시공자가 먼저 일정이 맞아서 작업을 진행하도록 함

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7.6 Determining Sequence of Work Packages (2/2)

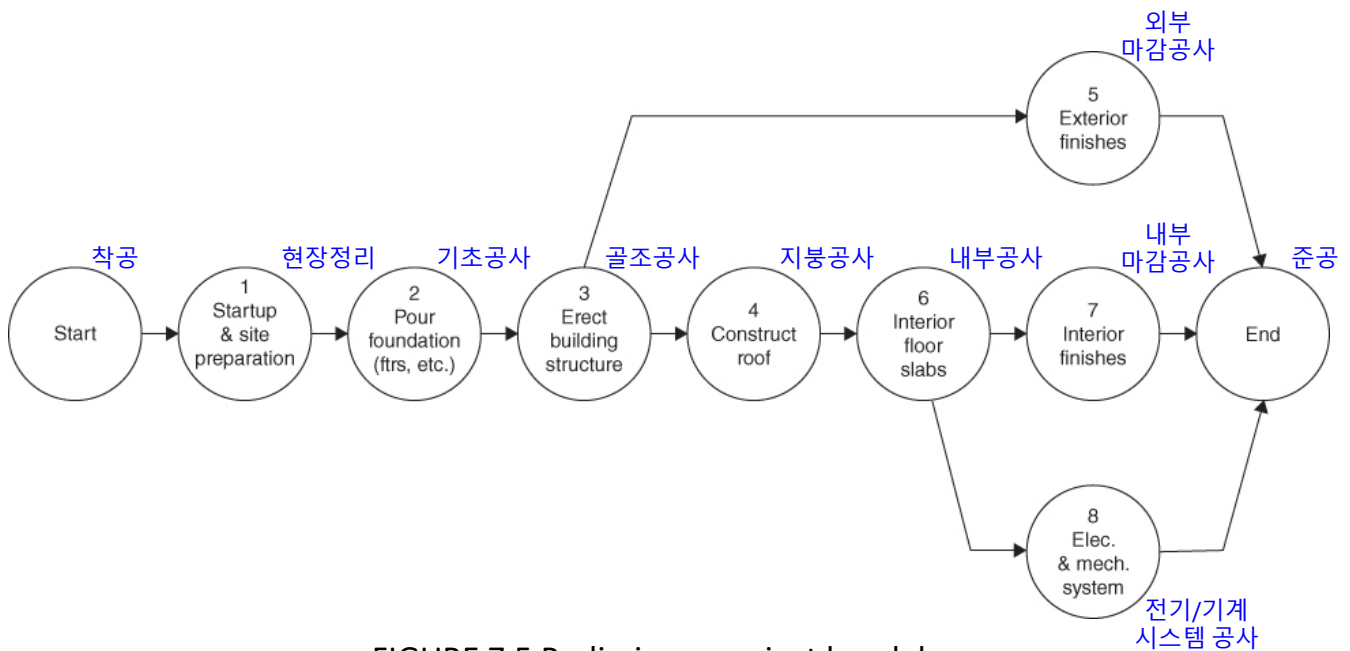


FIGURE 7.5 Preliminary project breakdown

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7.7 Estimate Development and Cost Control Related to the Work Breakdown Structure (1/2)

- ❑ A good WBS facilitates **cost control** during the life of the project. 작업 분류 체계를 원가 관리를 위해 사용
- ❑ **Work packages** are defined so that they have their own **unique budgets**. 과업은 자신만의 고유한 예산을 가짐
- ❑ When referring to work packages in the context of cost control, the terminology **cost accounts or control accounts** is often used. 원가(비용) 관리 계정
- ❑ To provide consistency and structure to the management of large cost control systems, a **code of accounts** is used as a **template** or guide in defining and cataloging the cost centers within a project. Several **cost coding systems** are presented in Chapter 17. 원가(비용) 계정 코드 → 원가 관리 시스템
- ❑ WBS 체계 구축 → Work Package 정의 → Work Package에 일정과 비용을 할당 → 공정(일정관리) & 비용(원가관리) 수행

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7.7 Estimate Development and Cost Control Related to the Work Breakdown Structure (2/2)

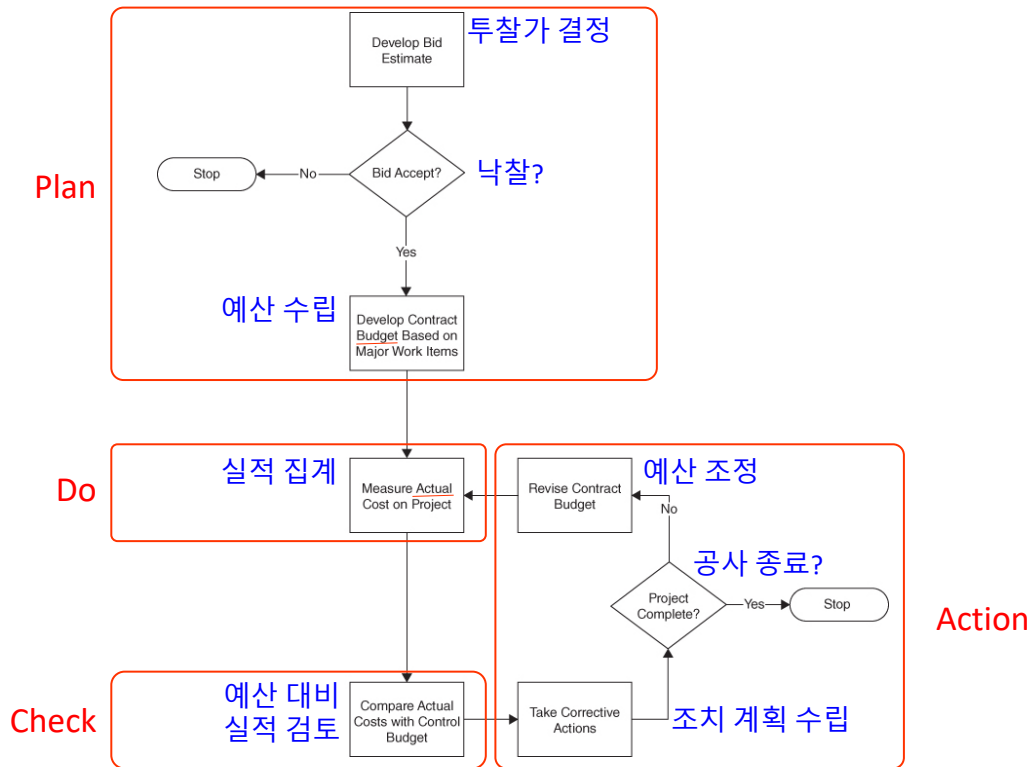


FIGURE 7.6 Cost control cycle (PDCA Cycle)

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7.8 Role of Code of Accounts (1/2)

- A typical cost code might define **원가 (비용) 계정 코드**는 다음 코드들의 결합으로 정의됨
 - (a) the project designator **프로젝트 코드**
 - (b) area of work **위치 코드**
 - (c) work discipline (e.g., civil, mechanical, electrical, etc.) **공사 종류 코드**
 - (d) the trade specialty (**세부 공정 전문 영역**) required. **세부 공사 종류 코드**

Level	Project	Area	Discipline	Trade
1	21300			
2		804		
3			724	
4				112

Cost Code = 21300.804.724.112

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7.8 Role of Code of Accounts (2/2)

Work Package Identification 06-123 Description: Concrete Placement Interior Floor Slabs						
자재	Materials					Actual Productivity
	Resource Code	Description	Unit	Qty	Unit Cost	Extension
	101	Concrete, 2500psi	CY	30	40.00	1200.00
Installed Equipment						Notes
인력	Crew Labor		NR	Hours	Cost/Hr	Extension
	020	Foreman	1	8	30.00	240.00
	029	Laborer	4	8	15.00	480.00
	022	Finisher	1	8	20.00	160.00
	063	Pump Operator	1	8	25.00	200.00
Total						1080.00
장비	Equipment Not Charged As Indirects					
			NR	Hours	Cost/Hr	Extension
	505	Vibrator	1	8	10.00	80.00
	517	Finisher	1	8	15.00	120.00
	308	Concrete Pump	1	8	150.00	1200.00
Total						1400.00

Actual Cost
Labor =
Materials =
Equipment =
Variation from Budget

FIGURE 7.7 Work package control account sheet
(CII Cost/Schedule Task Force, 1988)

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7.9 Summary

- In order to **manage**, one should be able to **control**.
- In order to **control**, one should be able to **measure**.
- In order to **measure**, one should be able to **define**.
- In order to **define**, one should be able to **quantify** (정량화).
- 정량화 → 지표 정의 → 측정 → 통제 → 관리
- The following is a partial list of other plans that must be developed: **Procurement** plan, **Safety** plan, **Subcontracting** plan, **Quality** plan, **Communication** plan, **Organizational** plan, **Completion and start-up** plan 조달계획, 안전계획, 하청계획, 품질계획, 조직계획, 완료 및 착수 계획

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CHAPTER 8

PROJECT SCHEDULING

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
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제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

8.1 Introduction

- A project's **work breakdown structure (WBS)** defines **work packages** that can be **sequenced (scheduled)** to coordinate the project construction. 작업 분류 체계 → 작업 순서 결정
- A project schedule is developed in the following order: 일정 계획 수립 단계
 1. **Breaking down** the scope of the work into manageable portions, namely its **activities**. 관리 가능한 크기인 액티비티 단위로 분해
 2. Estimating each activity's **duration**. 액티비티 공기 추정
 3. Establishing **sequence relationships** among activities. 액티비티 간 선후행관계 정의
 4. Finding the **earliest and latest possible times** for the execution of each activity. 액티비티별 가장 (빠른/느린) (시작/종료) 가능 시간 계산
 5. Calculating the project's **critical sequence** of activities and the **leeway** (여유가 있는 액티비티) that activities not included in this sequence can have. 주/부공정 액티비티 결정
 6. **Reviewing**, optimizing, communicating, updating, and in general, using the schedule. 일정계획 검토 및 수정·보완 → 최적화

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8.2 Estimating Activity Durations

- The duration of any activity is largely determined by: 액티비티 공기 결정 요인
 1. **The nature of the work that the activity entails**. A concrete pour in the 50th floor vs. 2nd floor. 액티비티의 속성. 50층 vs 2층 콘크리트 공사
 2. **The quantities of the work**. 6,000 square feet of formwork vs. 3,000 square feet. 작업의 양. 6,000 평방피트 거푸집 공사 vs 3,000 평방피트 거푸집 공사
 3. **The technique used for the task**. A concrete pour using a tower and buggies (수레를 끌어서) vs. concrete pump. 사용 기술. 펌핑카를 이용한 타설 공사 vs 수레를 이용한 타설 공사
 4. **The resources used to perform the work**. Twenty masons (석공) vs. 15 masons. 공사에 사용되는 자재(자원). 20명의 석공 투입 vs 15명의 석공 투입
 5. **The working hours for the resources**. 10-hour shifts vs. 8-hour shifts. 근무시간. 10시간/일 vs 8시간/일
- 부하 균형화: 토공장비 1대의 작업량을 트럭 5대가 커버한다면, 트럭의 대수를 7대로 늘려도 생산용량 향상에 전혀 도움이 되지 않음.

3

8.3 Using Historic Productivity Data (1/2)

□ Productivity data can be obtained in publications such as **R. S. Means Building Construction Costs**. 상용 데이터베이스를 이용하여 생산성데이터 획득

- 일감 : 6,000 SFCA(Square Feet of Contact Area)
- 3개의 거푸집을 사용하는 경우 하루 작업량 : 470 SFCA/인.일
- 인부 1명 고용 시 공기 : $6,000 / 470 = 12.76$ 일
- 인부 2명 고용 시 공기 : $12.76 / 2 = 6.39$ 일 → 7일
- 액티비티 공기 예측 오차는 서로 상쇄되는 경향이 있음

03 11 Concrete Forming		03 11 13 - Structural Cast-In-Place Concrete Forming		03 11 13.45 Forms In Place, Footings		Crew	Daily Output	Labor Hours	Unit	Material	2008 Bare Costs Labor	2008 Bare Costs Equipment	Total	Total Incl O&P
0010	FORMS IN PLACE, FOOTINGS		R031113-40											
0020	Continuous wall, plywood, 1 use					C-1	375	.085	SFCA	5.25	3.08		8.33	10.60
0050	2 use						440	.073		2.89	2.63		5.52	7.25
0100	3 use		R031113-60				470	.068		2.10	2.46		4.56	6.15
0150	4 use						485	.066		1.71	2.38		4.09	5.60

FIGURE 8.1 Productivity data

4

8.3 Using Historic Productivity Data (2/2)

일위대가: 특정 공종에 대한 단가 산출 근거													
호 표	품 명	규 격	수량	단위	합 계		재료비		노무비		경 비		비 고
					단 가	금 액	단 가	금 액	단 가	금 액	단 가	금 액	
제1호표	합판거푸집	1회(제물지장)		m'		85,129		26,215		58,914			0
	합판거푸집	1회재료비	1	m'	24,641	24,641.	24,641	24,641.	0	0.	0	0.	0. 일위7참조
	소모자재(박리제등)	주재료비의	4	%	24,641	985.6	24,641	985.6			0.	0.	0.
	형틀목공		0.23	인	189,303	43,539.6	0	0.	189,303	43,539.6	0	0.	0.
	보통인부		0.14	인	109,819	15,374.6	0	0.	109,819	15,374.6	0	0.	0.
	공구손료 및 경장비의 기계경비	노무비의	1	%	58,914	589.1	58,914	589.1			0.	0.	0.

- 품셈제도 : 품셈(자재/인력/장비 사용량) X (자재단가(19,345품목), 노임단가(307품목), 기계경비(968품목)) → 단가산출(1,182품목) → 일위대가(1,113호표)
- 품셈 : 한국건설기술연구원
- 자재단가
 - ✓ 가격정보 : 2018년 2월조사(조달청 나라장터)
 - ✓ 물가자료 : 2018년 2월호(사단법인 한국물가협회)
 - ✓ 유통물가 : 2018년 2월호(사단법인 한국응용통계연구원)
 - ✓ 물가정보 : 2018년 2월호(사단법인 한국물가정보)
 - ✓ 거래가격 : 2018년 2월호(대한건설협회)
- 노임단가
 - ✓ 건설업 노임 : 대한건설협회
 - ✓ 제조업 노임 : 중소기업중앙회
 - ✓ 엔지니어링기술자 노임 : 한국엔지니어링협회
 - ✓ 측량기술자 노임 : 공간정보산업협회
 - ✓ 건설사업관리기술자 노임 : 한국건설기술관리협회
 - ✓ 소프트웨어기술자 노임 : 한국소프트웨어산업협회
- 기계경비: 환율, 휘발유 가격, 경유 가격, 중유 가격
- 표준시장단가제도(2,759품목)
 - ✓ 토목, 건축, 기계설비 : 한국건설기술연구원
 - ✓ 어항 및 항만공사 : 한국항만협회

구분	품셈제도	표준시장단가제도
내역서 작성 방식	설계자 및 발주기관에 따라 상이	표준 분류 체계인 '수량 산출 기준'에 의해 내역서 작성 통일
단가 산출 방법	품셈을 기초로 원가 계산	계약단가를 기초로 축적한 공종별 실적 단가에 의해 계산
직접공사비	재료비, 노무비, 경비 단가 분리	재료비, 노무비, 경비 단가 포함
간접공사비 (제경비)	비목(노무비 등)별 기준	직접공사비 기준
설계 변경	품목 조정 방식, 지수 조정 방식	지수조정방식(공사비지수 적용)

5

8.4 Bar Charts (1/3)

- Time scaled bar, the **bar chart** acts both as a **planning–scheduling model** and as a **reporting–control model**. The length of the bar has two different meanings:

The **planned duration of the work item** & The **percentage complete**.

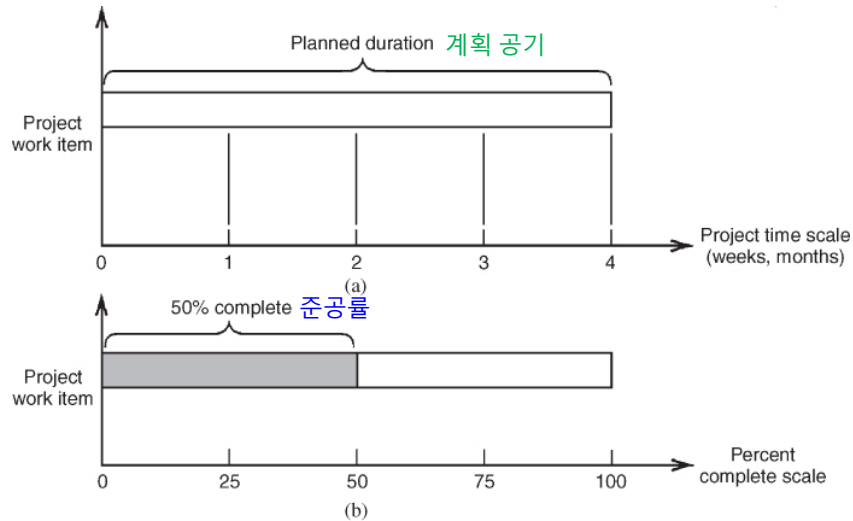


FIGURE 8.2 Bar chart model: (a) **plan focus**; (b) **work focus**

6

8.4 Bar Charts (2/3)

- By using **different shading patterns**, the bar chart can indicate **monthly progress** toward physical completion of the activities. **다른 음영 패턴을 이용하여 월별 실적을 표시**

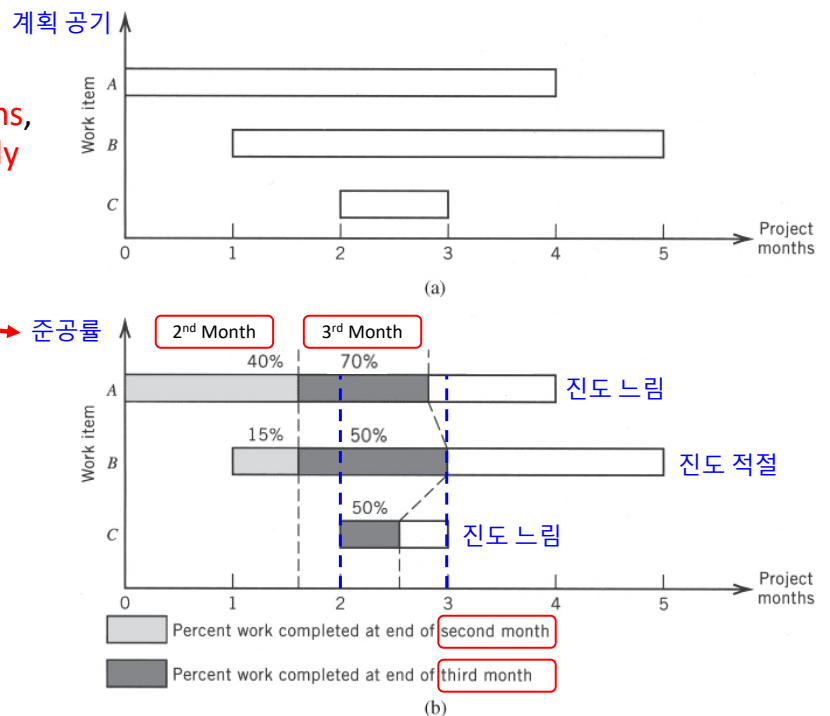


FIGURE 8.3 Bar chart project model: (a) bar chart schedule (plan focus); (b) Bar chart updating

7

8.4 Bar Charts (3/3)

- ❑ Establishing the exact **sequence** between activities: using directional **links or arrows** connecting the bars: **Bar-net**. 화살표를 이용하여 작업 간 선후행 관계를 명확하게 표시

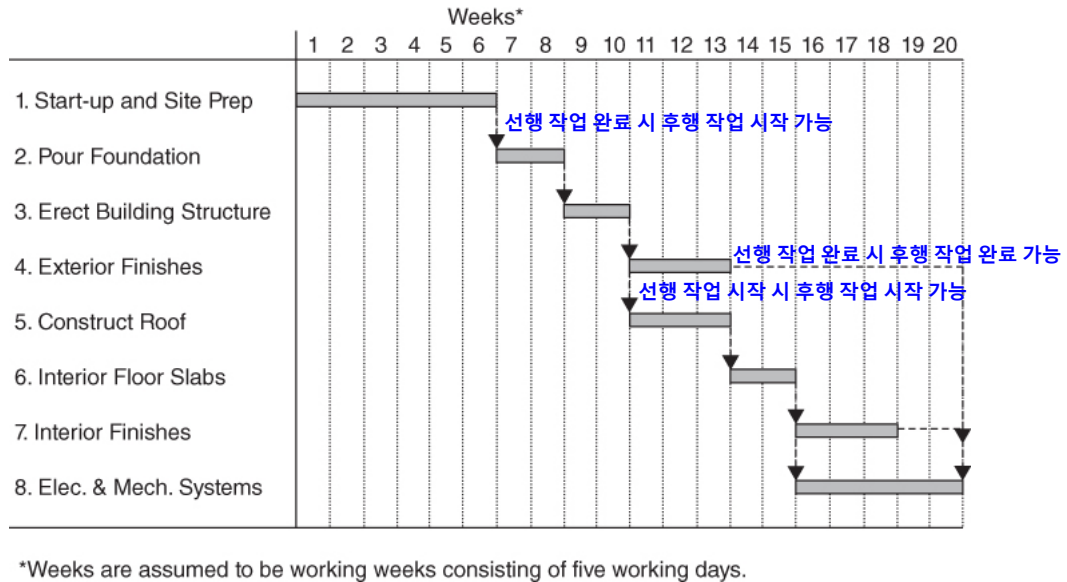


FIGURE 8.4 Preliminary connected bar chart schedule for small gas station

8

8.5 Scheduling Logic (1/5)

- ❑ Consider a simple pier (부두) made up of two lines of **piles** with connecting **headers** and simply supported **deck slabs**.
- ❑ An exploded view of the pier shows each **physical component** individually separated.

부두 = 파일(6개) + 헤더(3개) + 상판(2개)

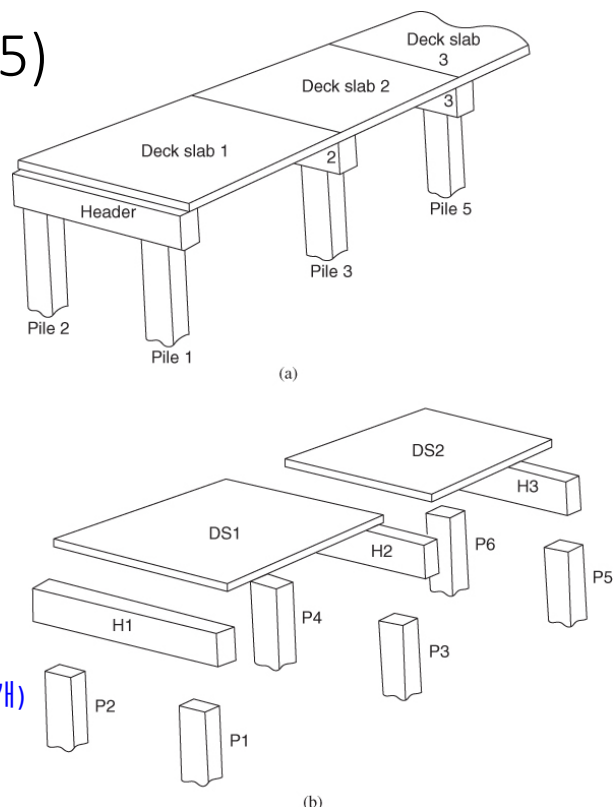


FIGURE 8.5 Simple schematic model (Antill and Woodhead, 1982): (a) schematic view of pier; (b) exploded view of pier

9

8.5 Scheduling Logic (2/5)

- Now suppose that **each component or element is represented by a labeled circle (or node)**. 파일, 헤더, 상판 등 각 부위를 원으로 표시
- Figure 8.6 gives a **plan view of the pier components** shown in Figure 8.5.

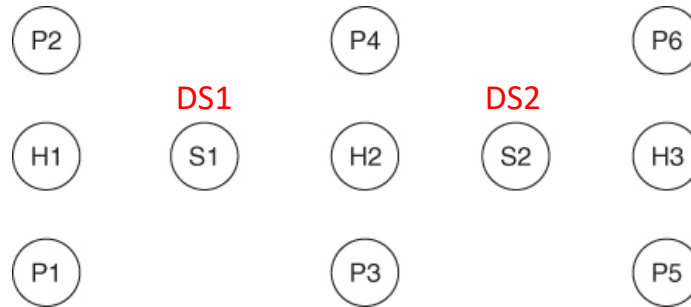


FIGURE 8.6 Conceptual model of pier components

10

8.5 Scheduling Logic (3/5)

- Graph structure portraying the physical component **adjacency or contact** (인접 또는 접해 있는) nature of the pier.
- **Not in contact**, a **directional arrow** such as that shown in Figure 8.7(c) may be necessary.

화살표 : 물리적 인접 관계 표시
P1 → H1 인접



(a)

점선 화살표 : 논리적 작업 순서 표시
P1 → P2 순으로 작업



(c)

화살표 : 물리적 구조 관계 표시 : P1, P2 → H1 지지



(b)

FIGURE 8.7 Logical modeling rationales: (a) **adjacency** (인접) of contact modeling; (b) physical structure **order** modeling; (c) physical construction **order** modeling

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8.5 Scheduling Logic (4/5)

- Adjacency or contact (인접 또는 접해 있는) nature of the pier.
- Header 1 (H1) can only appear (i.e., be built) after piles 1 and 2 (i.e., P1, P2) appear; in fact, H1 is built around, on top of, and therefore in contact with P1 and P2.

화살표 : 물리적 구조 관계로부터 도출된 작업 순서 표시 : 파일 → 헤더 → 상판

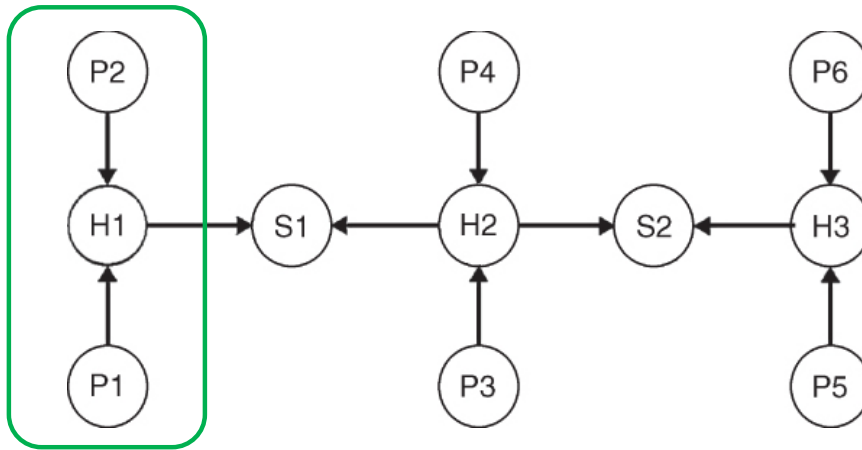


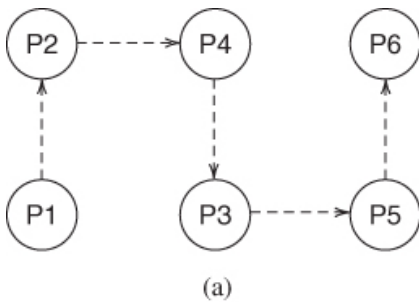
FIGURE 8.8 Conceptual model of pier component relationships

8.5 Scheduling Logic (5/5)

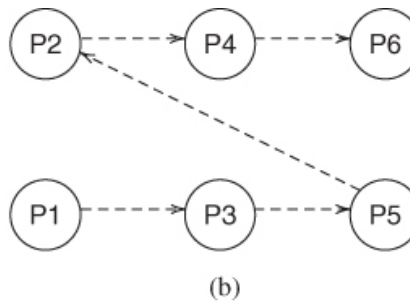
- Not in contact, a directional arrow

점선 화살표 : 논리적 작업 순서 표시
교각 건설 순서 표시

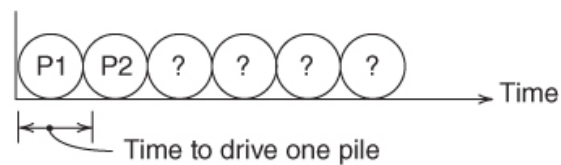
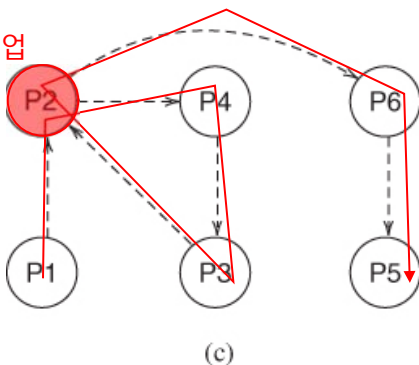
왼쪽, 오른쪽을 번갈아 작업



왼쪽 작업 후 오른쪽을 작업



P2: 두 번 작업 (재작업)



바차트
파일 간 작업 순서 미표시

FIGURE 8.9 Construction sequence and activity modeling (Antill and Woodhead,1982): (a) alternate row pile driving; (b) sequential row pile driving; (c) field mishap alteration to pile-driving sequence; (d) bar chart model of pile-driving operation

8.6 Scheduling Networks

- A scheduling network consists of **nodes and links(arrow, arc)**, in which the nodes represent **activities** and each link indicates the two activities are related in their mutual **sequencing**: **Activity On Node (AON)** diagrams, **precedence** diagrams.

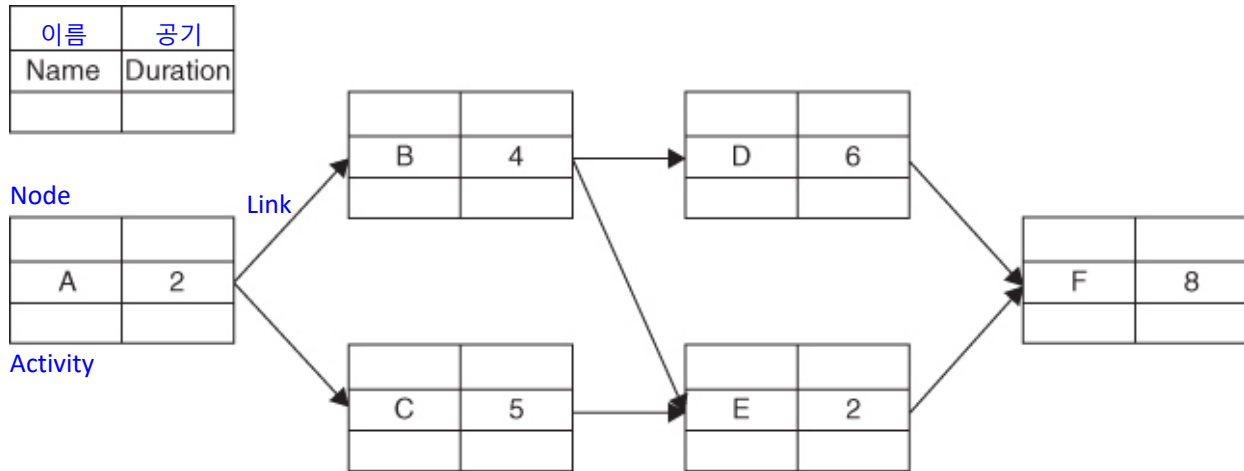


FIGURE 8.10 Precedence notation scheduling network

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8.7 The Critical Path Method

- The **critical path method (CPM)** is widely used for project scheduling including for projects not related to the construction industry. **주공정법**: 프로젝트 일정계획에 많이 이용
- CPM was developed in the late 1950s by James Kelley and Morgan Walker (**DuPont Corporation**).
- Specifically, the objectives of analyzing a project network are to: **분석 목적**
 1. Find the set of **critical activities** that establishes the **longest path** and defines the **minimum duration of the project**. **가장 긴 공기를 갖는 주공정 파악** → 프로젝트 공기 산정
 2. Calculate the **Earliest Start Times (EST)** for each activity. **작업을 가장 빨리 시작할 수 있는 시작 시간 파악**
 3. Calculate the **Latest Start Times (LST)** for each activity. **작업을 가장 늦게 시작할 수 있는 시작 시간 파악**
 4. Calculate the **float or time available** for delay for each activity. **작업 별 여유 시간 파악**

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8.8 Forward Pass (1/2)

- Calculate the (earliest start times; EST) and (earliest finish times; EFT) for each activity.
- EST : 선행 작업의 가장 빠른 종료 시간들 중 최대치
- EFT = EST + Duration

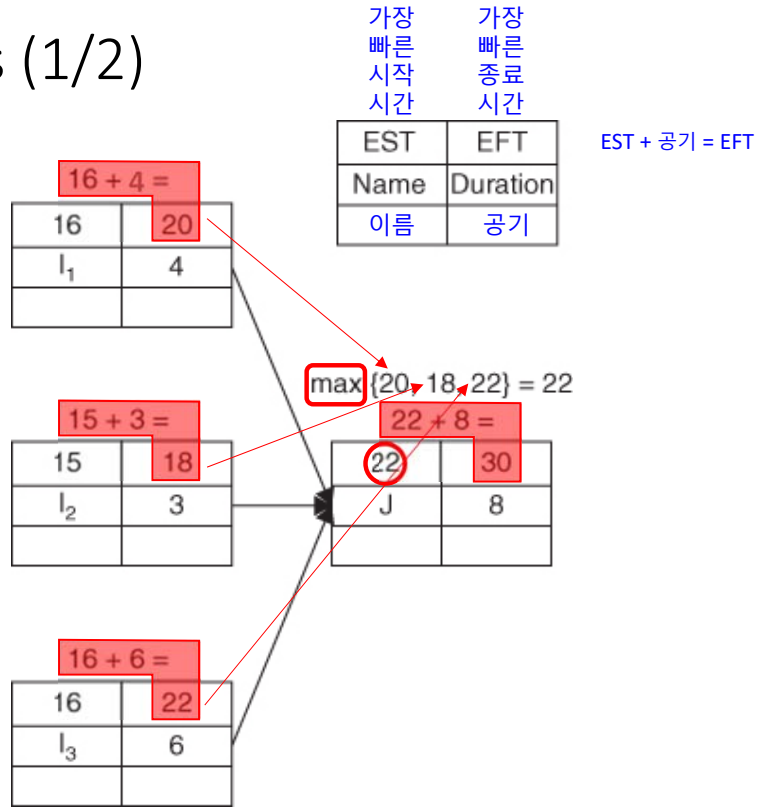


FIGURE 8.11 Calculation of EST(J)

8.8 Forward Pass (2/2)

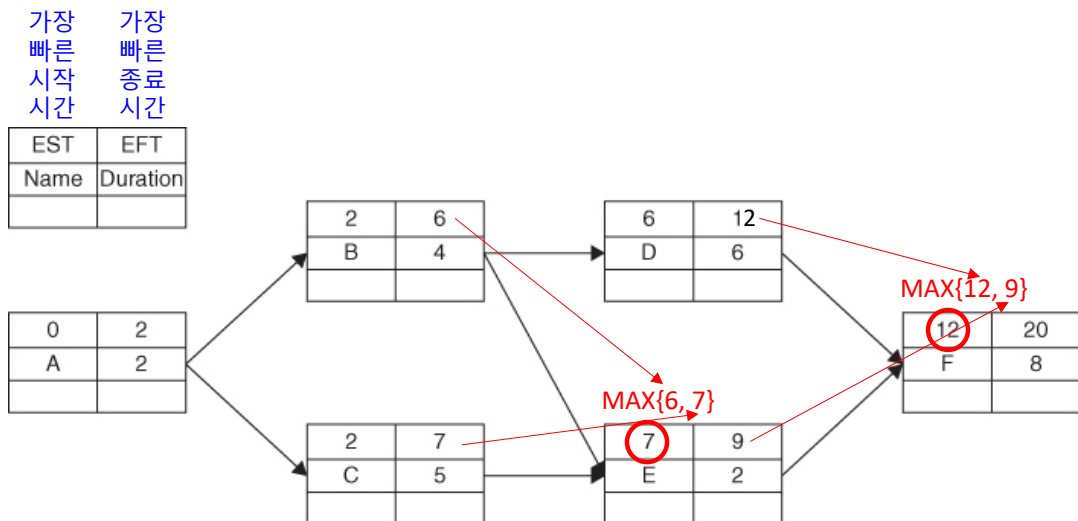


FIGURE 8.12 Calculation of EST and EFT

8.9 Backward Pass (1/2)

- Calculate the (latest start times; LST) and (latest finish times; LFT) for each activity.

- LFT : 후행 작업의 가장 늦은 시작 시간들 중 최소치

- LST = LFT - Duration

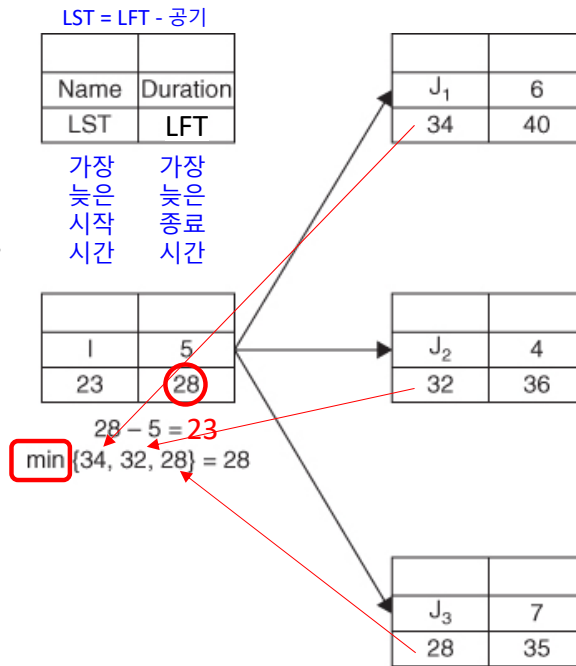


FIGURE 8.13 Calculation of LFT(I)

8.9 Backward Pass (2/2)

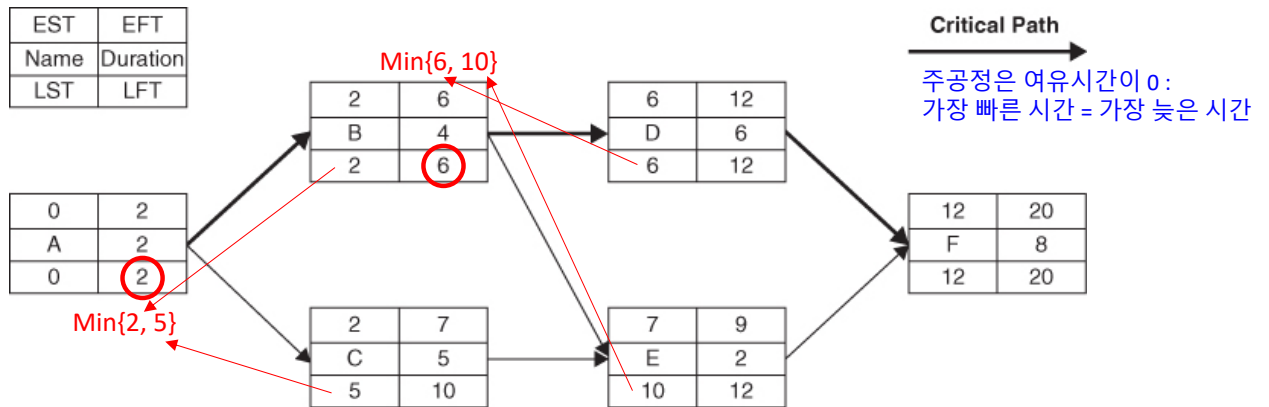


FIGURE 8.14 EST, EFT, LST, LFT results

8.10 Activity Floats

Total Float (TF)

$TF(I) = LFT(I) - EFT(I)$
 $= LST(I) - EST(I)$
 where I is current activity

총 여유시간

주공정은 총 여유시간이 0: 가장 빠른 시간 = 가장 늦은 시간

Free Float (FF)

$FF(I) = \min \{EST(J_i)\} - EFT(I)$
 where I is in its earliest position
 and J_i are all successors of I

자유 여유시간

후속작업의 EST를 침해하지 않는 범위에서의 여유시간

Interfering Float (IF)

$IF(I) = TF(I) - FF(I)$
 where I is current activity

간섭 여유시간 = 총 여유시간 - 자유 여유시간

후속작업의 EST를 LST로 미루는 경우의 여유시간

Independent Float (IndF)

$IndF(I) = \min \{EST(J_i)\} -$
 $DUR(I) - \max \{LFT(H_i)\}$
 where H_i are all predecessors of I
 and J_i are all successors of I

독립 여유시간

선행: 최대한 늦게 LFT에 종료하는 경우의 여유시간

후행: 최대한 빠르게 EST에 시작하는 경우의 여유시간

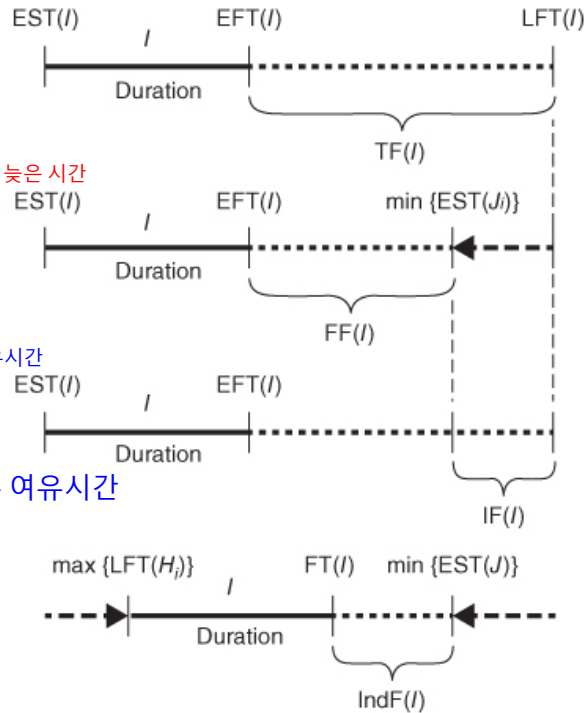


FIGURE 8.15 Four types of activity float

8.11 Working to Calendar Dates (1/2)

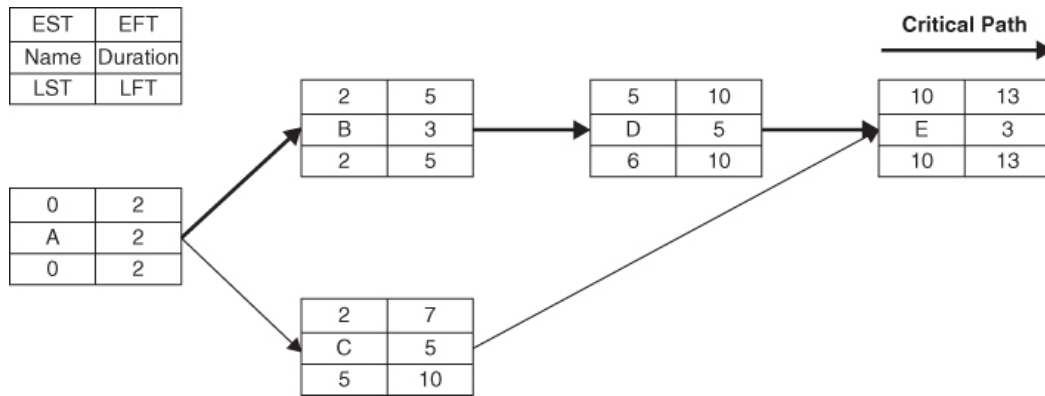
Working days versus calendar days. 공사 기간 : 13일 vs 12월 23일 ~ 1월 12일

The calendar for a project with a start date of December 23. Its contractor has chosen not to work on Saturdays and Sundays, as well as on December 25 and January 1. 토요일, 일요일, 공휴일 제외

Sun	Mon	Tue	Wed	Thu	Fri	Sat
20-Dec	21	22	23 WD1	24 WD2	25	26
27	28 WD3	29 WD4	30 WD5	31 WD6	1-Jan	2
3	4 WD7	5 WD8	6 WD9	7 WD10	8 WD11	9
10	11 WD12	12 WD13	13	14	15	16

FIGURE 8.16 Project calendar with working days

8.11 Working to Calendar Dates (2/2)



Activity	EARLY DATES				LATE DATES			
	ESD		EFD		LSD		LFD	
	Working Days	Calendar Date	Working Days	Calendar Date	Working Days	Calendar Date	Working Days	Calendar Date
A	0	23-Dec	2	24-Dec	0	23-Dec	2	24-Dec
B	2	28-Dec	5	30-Dec	2	28-Dec	5	30-Dec
C	2	28-Dec	7	4-Jan	5	31-Dec	10	7-Jan
D	5	31-Dec	10	7-Jan	5	31-Dec	10	7-Jan
E	10	8-Jan	13	12-Jan	10	8-Jan	13	12-Jan

8.12 Example: Scheduling the Small Gas Station (1/2)

TABLE 8.2
Durations of Activities for Small Gas Station

Activity	Title	Duration (Days)
1	Mobilize	10
2	Obtain permits	15
3	Site work	8
4	Exterior utilities	12
5	Excavate catch basin	2
6	Excavate footers	5
7	Excavate foundation piers	6
8	Pour footers, etc.	8
9	Erect bldg. frame	10
10	Exterior brick facade	14
11	Exterior fascia panels	4
12	Roof construction	15
13	Landscaping	12
14	Pour interior slabs	10
15	Glazing and doors	6
16	Interior walls	10
17	Elec. & mech. Systems	25
18	Shelves	3
19	Floor coverings	6
20	Interior finishes	8
21	Final inspection	1
22	Demobilization	3

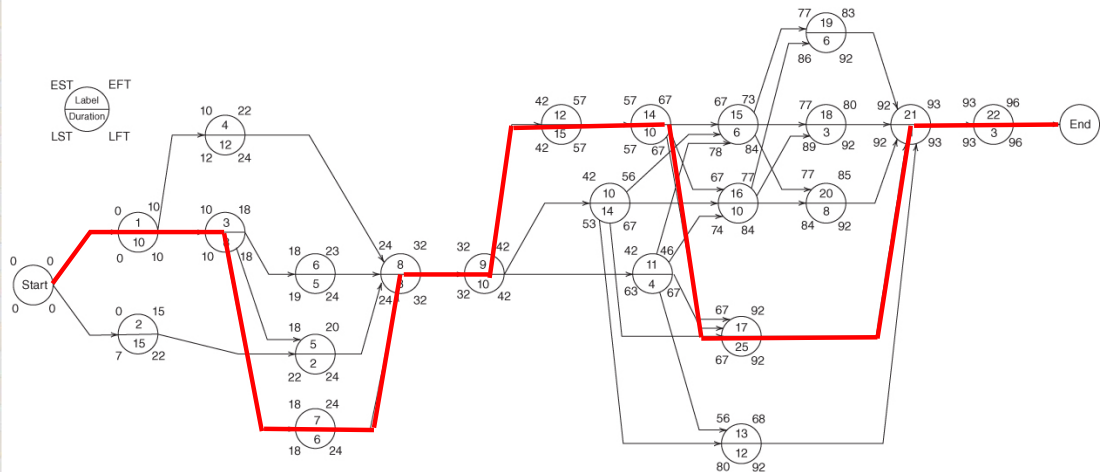


FIGURE 8.18 Expanded network schedule for small gas station

8.12 Example: Scheduling the Small Gas Station (2/2)

TABLE 8.3
Float Values for Small Gas Station

Activity	Total Float	Free Float	Interfering Float
* 1	TF(1) = 10-10 = 0	FF(1) = 10-10 = 0	IF(1) = 0-0 = 0
2	TF(2) = 22-15 = 7	FF(2) = 18-15 = 3	IF(2) = 7-3 = 4
* 3	TF(3) = 18-18 = 0	FF(3) = 18-18 = 0	IF(3) = 0-0 = 0
4	TF(4) = 24-22 = 2	FF(4) = 24-22 = 2	IF(4) = 2-2 = 0
5	TF(5) = 24-20 = 4	FF(5) = 24-20 = 4	IF(5) = 4-4 = 0
6	TF(6) = 24-23 = 1	FF(6) = 24-23 = 1	IF(6) = 1-1 = 0
* 7	TF(7) = 24-24 = 0	FF(7) = 24-24 = 0	IF(7) = 0-0 = 0
* 8	TF(8) = 32-32 = 0	FF(8) = 32-32 = 0	IF(8) = 0-0 = 0
* 9	TF(9) = 42-42 = 0	FF(9) = 42-42 = 0	IF(9) = 0-0 = 0
10	TF(10) = 67-56 = 11	FF(10) = 56-56 = 0	IF(10) = 11-0 = 11
11	TF(11) = 67-46 = 21	FF(11) = 56-46 = 10	IF(11) = 21-10 = 11
* 12	TF(12) = 57-57 = 0	FF(12) = 57-57 = 0	IF(12) = 0-0 = 0
13	TF(13) = 92-68 = 24	FF(13) = 92-68 = 24	IF(13) = 24-24 = 0
* 14	TF(14) = 67-67 = 0	FF(14) = 67-67 = 0	IF(14) = 0-0 = 0
15	TF(15) = 84-73 = 11	FF(15) = 77-73 = 4	IF(15) = 11-4 = 7
16	TF(16) = 84-77 = 7	FF(16) = 77-77 = 0	IF(16) = 7-0 = 7
* 17	TF(17) = 92-92 = 0	FF(17) = 0-0 = 0	IF(17) = 0-0 = 0
18	TF(18) = 92-80 = 12	FF(18) = 92-80 = 12	IF(18) = 12-12 = 0
19	TF(19) = 92-83 = 9	FF(19) = 92-83 = 9	IF(19) = 9-9 = 0
20	TF(20) = 92-85 = 7	FF(20) = 92-85 = 7	IF(20) = 7-7 = 0
* 21	TF(21) = 93-93 = 0	FF(21) = 0-0 = 0	IF(21) = 0-0 = 0
* 22	TF(22) = 96-96 = 0	FF(22) = 0-0 = 0	IF(22) = 0-0 = 0

총여유시간 =
자유여유시간 + 간섭여유시간
7 = 3 + 4

*주공정

24

8.13 Summary

□ Summarizing the discussion to this point, such **schedule** will provide: **공정계획**

1. A clear definition of the work to be performed, divided into the assignable segments, constituted by the **project activities**. **프로젝트 액티비티 단위로 분해**
2. A precedence diagram showing assumptions and strategic decisions about the **sequence of activities**. **CPM 다이어그램은 액티비티 간의 선후행관계 표시**
3. **Start and finish dates** for each activity. **액티비티의 시작과 종료 시간을 결정**
4. The number of days that each activity can be delayed before resulting in a delay in the overall project: **주공정 결정 : 부공정 → 여유시간 발생**

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CHAPTER 9

SCHEDULING: PROGRAM EVALUATION AND REVIEW TECHNIQUE NETWORKS AND LINEAR OPERATIONS

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

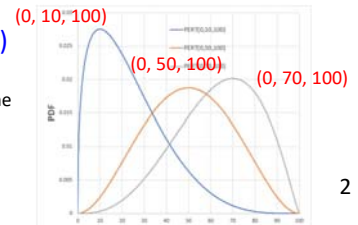
9.1 Introduction (1/3)

- ❑ Bar charts and **critical path method (CPM)** networks assume that all **activity durations are constant or deterministic**. CPM: 공기가 일정하다는 가정
- ❑ The **variability of project activities** is addressed in a method developed by the U.S. Navy at approximately the same time as CPM. This method was called the **Program Evaluation and Review Technique (PERT)**. PERT: 공기가 변동 가능하다는 가정
- ❑ The duration of some or all of the project activities can be variable. The variability is defined in terms of **three estimates of the duration** of each activity as follows: 3가지 공기
 1. Most **optimistic** duration (t_a) 낙관적 공기 → 짧은 공기
 2. Most **pessimistic** duration (t_b) 비관적 공기 → 긴 공기
 3. Most **likely** duration (t_m) 가장 가능성이 높은 공기 → 최빈 공기

→ 평균 공기: Expected duration, $t_e = [t_a + 4 t_m + t_b] / 6$ (PERT 분포(수정된 베타 분포)를 가정)

→ 공기의 분산: $\sigma^2 = [(t_b - t_a) / 6]^2$ (PERT 분포(수정된 베타 분포)를 가정)

In probability and statistics, the **PERT distribution** is a family of continuous probability distributions defined by the minimum (a), most likely (b) and maximum (c) values that a variable can take. It is a transformation of the **four-parameter Beta distribution** with an additional assumption that its expected value is $(a + 4b + c) / 6$. The four-parameter beta distribution is indexed by **two shape parameters (P and Q)** and **two parameters representing the minimum (A) and maximum (B)**.



2

9.1 Introduction (2/3)

- ❑ **Central Limit Theorem** 중심극한정리 → 확률변수 합계의 분포는 확률변수의 원래 분포와 상관없이 충분한 개수를 합하면 (보통 $N > 30$) 근사적으로 정규분포를 따른다.
- ❑ Suppose **m independent tasks** are to be performed in order; (one might think of these as the **m tasks that lie on the critical path of a network**). 주공정선에 포함된 m개의 액티비티들에 대한 공기들의 합 → 프로젝트의 공기 → 정규분포를 따름
 - ❑ $T = t_1 + t_2 + \dots + t_m$ → T는 주공정 상 작업들의 작업시간의 합계 시간
 - ❑ $E_T = \mu_T = E_{t_1} + E_{t_2} + \dots + E_{t_m}$ → E_T 는 주공정 상 작업들의 작업시간의 합계 시간의 평균
 - ❑ $V_T = \sigma_T^2 = V_{t_1} + V_{t_2} + \dots + V_{t_m}$ → V_T 는 주공정 상 작업들의 작업시간의 합계 시간의 분산
 - ❑ $T \sim N(\mu_T, \sigma_T^2)$ → T는 평균이 μ_T 이고 분산이 σ_T^2 인 정규분포를 따름

3

9.1 Introduction (3/3)

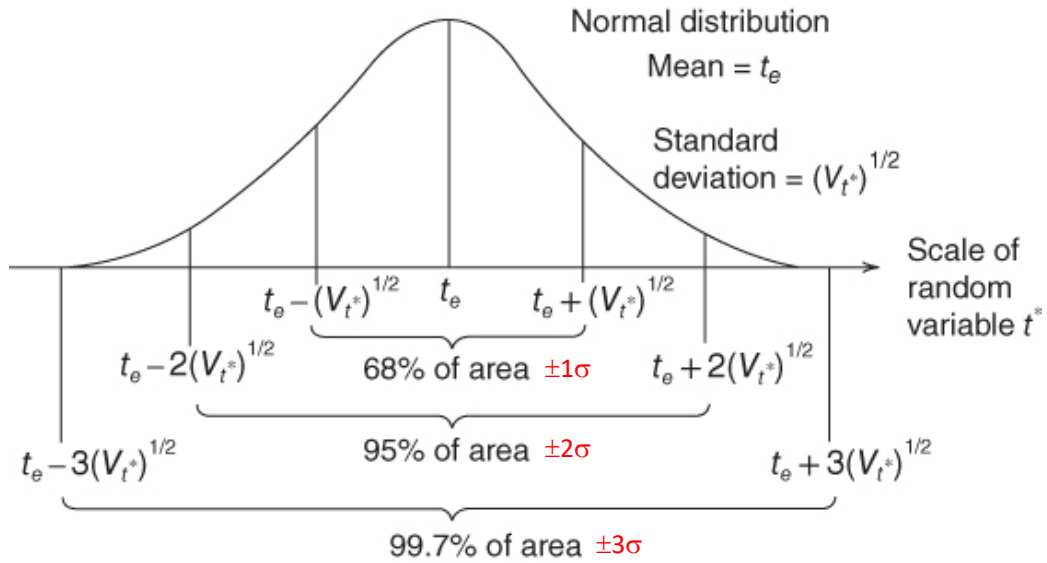


FIGURE 9.1 Selected areas under normal distribution

9.2 An Example Program Evaluation and Review Technique Network (1/5)

평균: $t_e = [t_a + 4 t_m + t_b] / 6$
 분산: $\sigma^2 = [(t_b - t_a) / 6]^2$

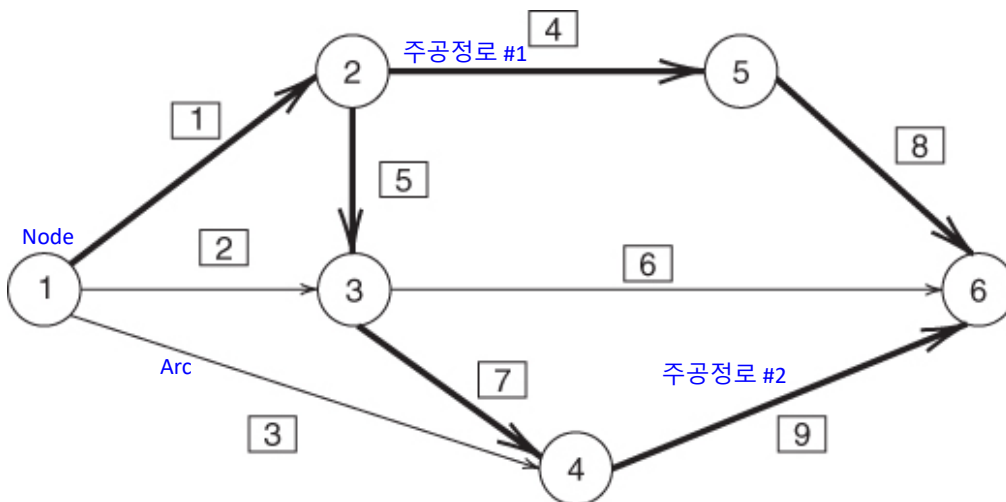


TABLE 9.1					
Three Estimate Values and Calculated Values for Each Activity					
Activity	t_m	t_a	t_b	t_e	Var
1	3	1	5	3	0.44
2	6	3	9	6	1.00
3	13	10	19	13.5	2.25
4	9	3	12	8.5	2.25
5	3	1	8	3.5	1.36
6	9	8	16	10	1.23
7	7	4	13	7.5	2.25
8	6	3	9	6	1.00
9	3	1	8	3.5	1.36

FIGURE 9.2 Small PERT network

Activity on Arc (AOA) 방식
 (참고: Activity on Node (AON) 방식)

9.2 An Example Program Evaluation and Review Technique Network (2/5)

- ❑ The variance of path two (5.416) is greater than that of path one (3.694).
- ❑ Because this means a **greater spread of the probable total project durations**, the variance of path two is selected as the variance to be used for further PERT calculations. 평균이 같다면 분산이 더 커 변동성이 더 큰 주공정로를 선택하여 분석

	Path	Activities	Duration	Variance
주공정로 #1	1	1-4-8	$3 + 8.5 + 6 = 17.5$	$\text{Var} = 0.444 + 2.25 + 1.0 = 3.694$
주공정로 #2	2	1-5-7-9	$3 + 3.5 + 7.5 + 3.5 = 17.5$	$\text{Var} = 0.444 + 1.361 + 2.25 + 1.361 = 5.416$

6

9.2 An Example Program Evaluation and Review Technique Network (3/5)

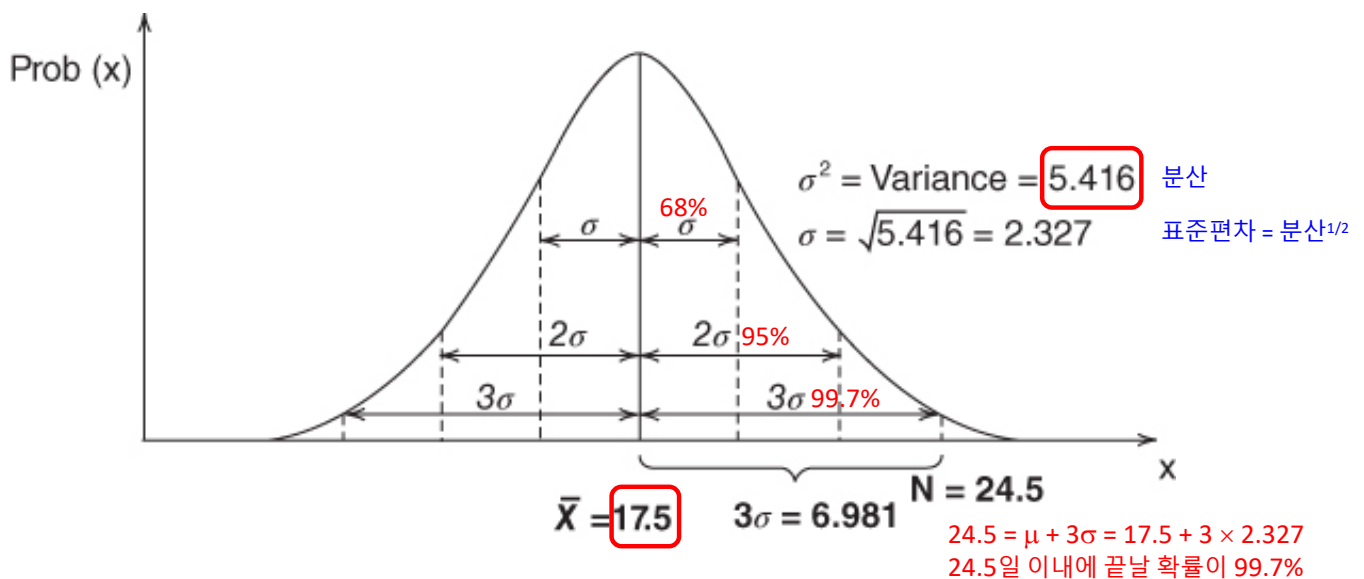


FIGURE 9.3 Normal distribution of total project durations for small PERT network

7

9.2 An Example Program Evaluation and Review Technique Network (4/5)

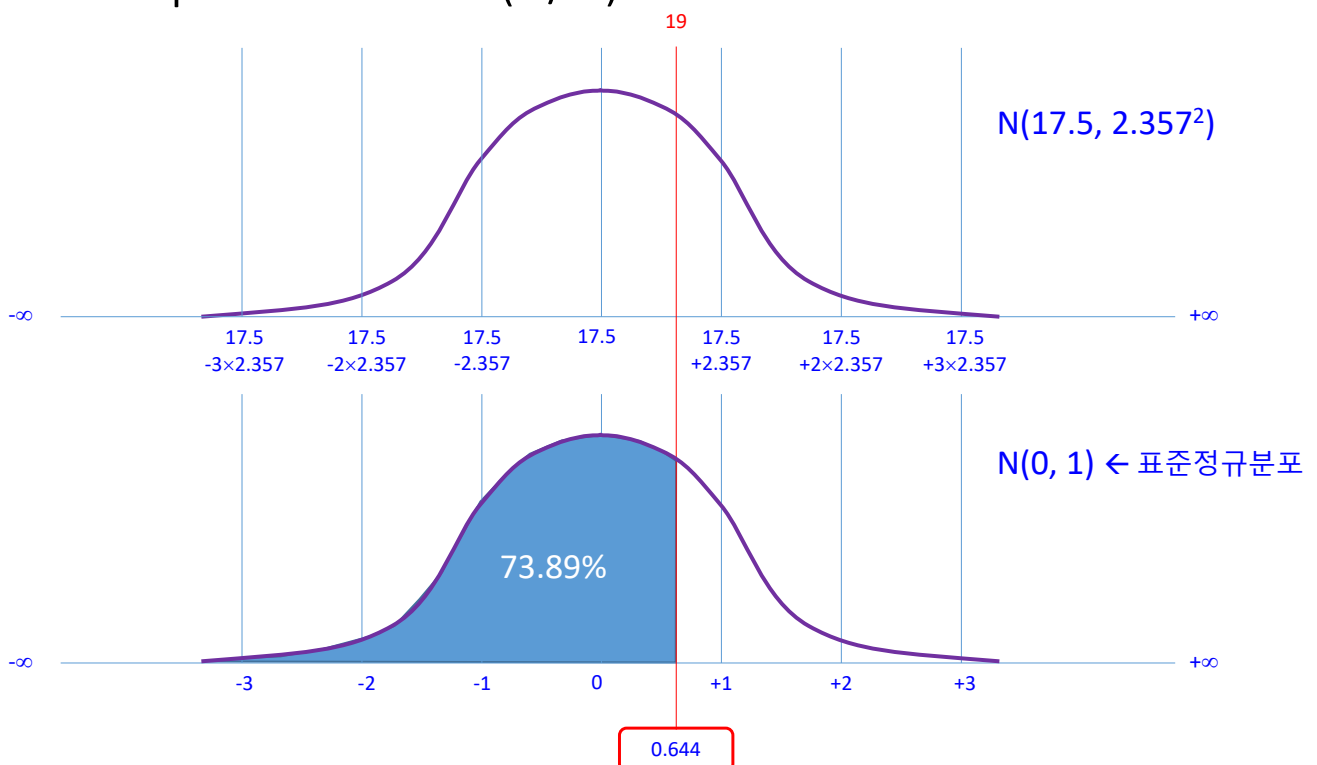
- ❑ What would be the probability of completing the project in **17.5 days**? 50% : 정규분포는 좌우 대칭
- ❑ What would be the probability of completing the project in **16 days**? 50% 미만 ← 평균 이하
- ❑ What if we want to know the probability of completing in **19 days**? 19일 이내에 끝날 확률?
- ❑ Consulting the cumulative normal distribution function table given in the appendix with a **Z value of 0.644**, yields a value of 0.7389 or **73.89% probability** of completing the project in 19 days. Z값을 구한 후 정규 분포를 이용하여 확률 계산

$$Z = \frac{\text{Mean} - x}{\sqrt{\text{Variance}}} \quad \text{or} \quad Z = \frac{\bar{X} - x}{\sigma}$$

$$Z = \frac{|17.5 - 19|}{\sqrt{5.416}} = \frac{1.5}{2.327} = 0.644$$

8

9.2 An Example Program Evaluation and Review Technique Network (5/5)



9

9.3 Program Evaluation and Review Technique Shortcomings

- ❑ In fact, the PERT results are **too optimistic**. PERT 예측 공기는 지나치게 낙관적
- ❑ The method of using the t_e value to determine the longest path through the project network and assuming that the duration of this path is **the most probable value for the total project duration is not totally accurate**: 프로젝트의 공기는 보통 PERT 예측 평균치보다 길다.
- ❑ Merge Event Bias: 주공정 상에 우연히 일찍 끝나는 액티비티가 있는 경우, 다른 경로가 주경로가 될 수 있으나, 이런 경우는 PERT에서 고려하지 않는다. → Monte Carlo Simulation 이용.
- ❑ Activity가 서로 독립이라는 가정

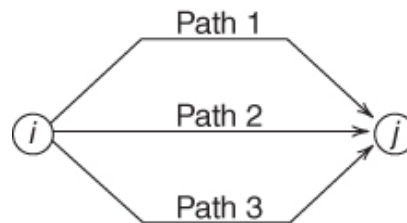


FIGURE 9.4 Merge event bias

9.4 Linear Construction Operations

- ❑ Often construction sites have **linear properties** that influence the **production sequence**.
건설공사의 선형성 : 층별 구역별로 동일 순서의 작업이 반복적으로 수행됨
- ❑ A **road job** may be subdivided into 14 sections that must be completed

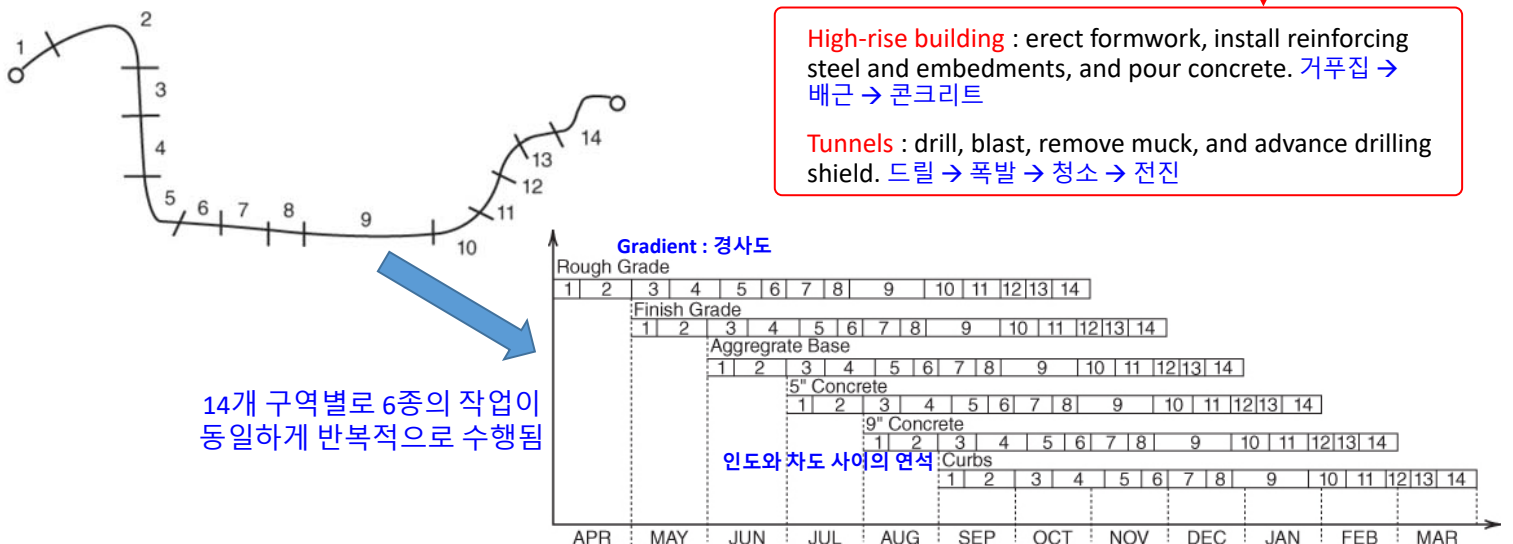


FIGURE 9.5 Road project divided into 14 sections

9.5 Production Curves (1/3)

□ Production curve reflect the production rate or speed with which sections or units are being processed. **시공 속도를 나타내는 그래프**

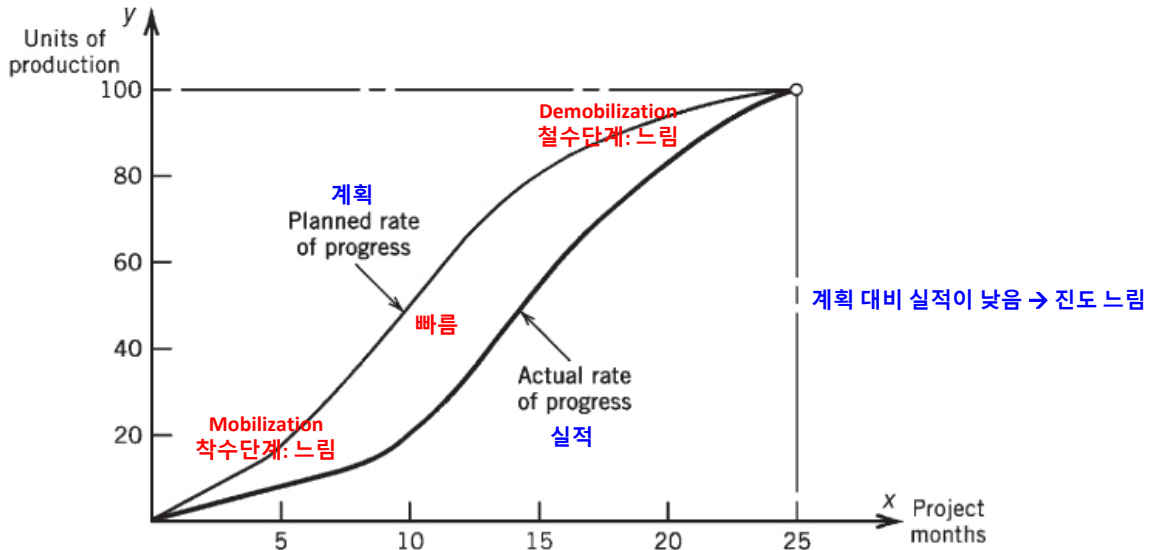
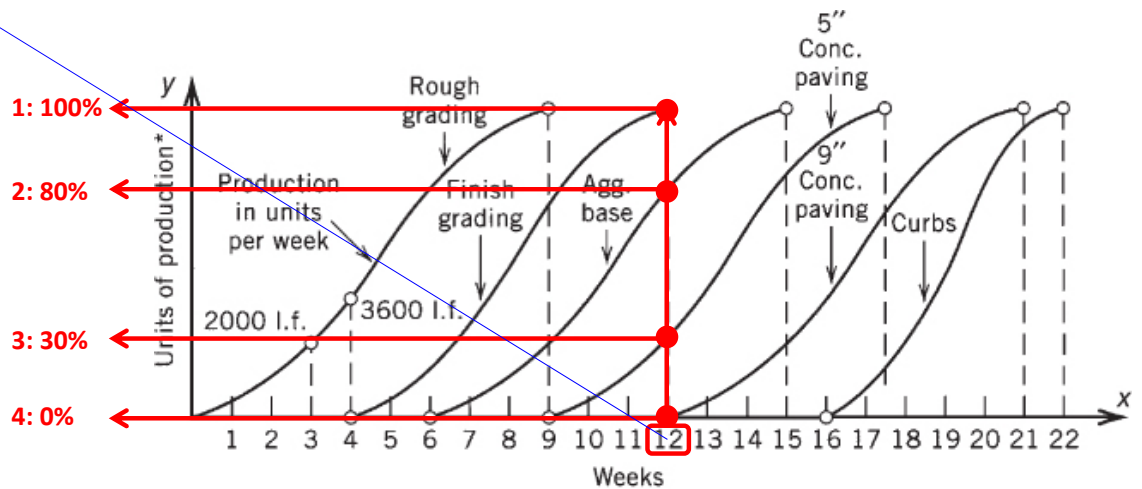
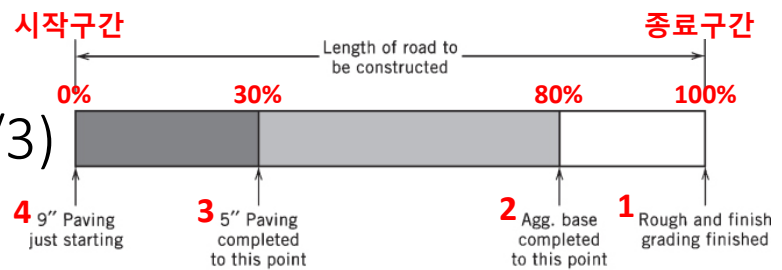


FIGURE 9.6 Production curve

9.5 Production Curves (2/3)

12주차의 진도

- Both rough and finish grading should be completed.
- Approximately 80% of the aggregate base has been placed.
- Placement of the 5-inch concrete base is approximately 30% complete.
- Placement of 9-inch concrete is just commencing (개시).



* Units of production (e.g., l.f. for rough and finish grading, tons of aggregate base, cu. yd. or sq. ft. of paving, etc.)

FIGURE 9.7 Velocity diagrams for a road construction project

9.5 Production Curves (3/3)

❑ **Ripple effect** (파급효과) causes shutdowns of process B and C. 연속되는 A, B, C 작업 간의 간섭 : A → B → C

❑ **Slopes** of the curves are **parallel** : 작업 중단을 방지하기 위해 작업 속도를 균일하게 유지

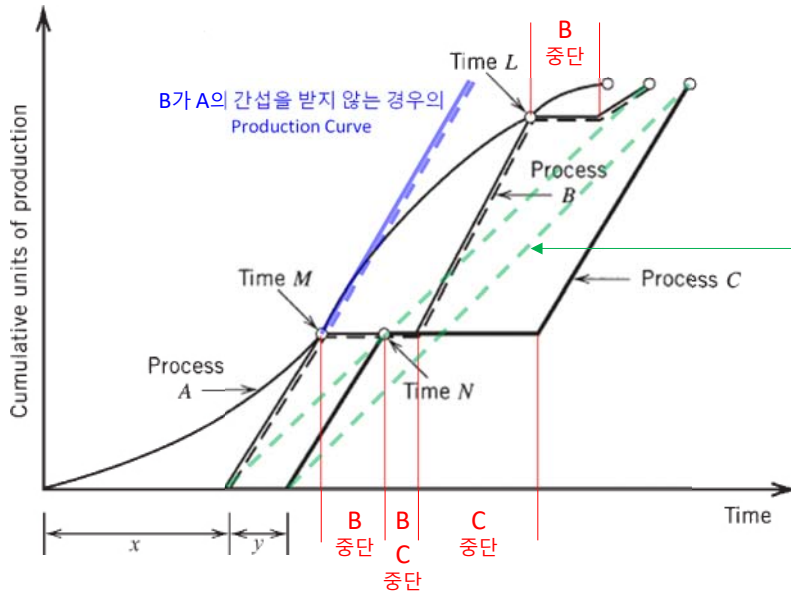


FIGURE 9.9 Unbalanced process production rates

오늘 4번 공정을 마친(4번 체크포인트를 통과한) 주택들은 8주 후, 즉, 12주 차에 완공되어야 한다. (지연시간) → 따라서 오늘 시점에 8주 후 완공될 주택 수만큼의 물량(7채)이 4번 공정을 마친 채 대기하고 있어야 한다.

9.6 Line of Balance 적정 진도선

❑ 1940s, **line of balance (LOB)** was first used in the manufacturing industry 제조업에서 시작

❑ **10 apartments** are supposed to be created over the course of **15 weeks** 15주 동안 10채의 주택 공사(9개 공정으로 구성)

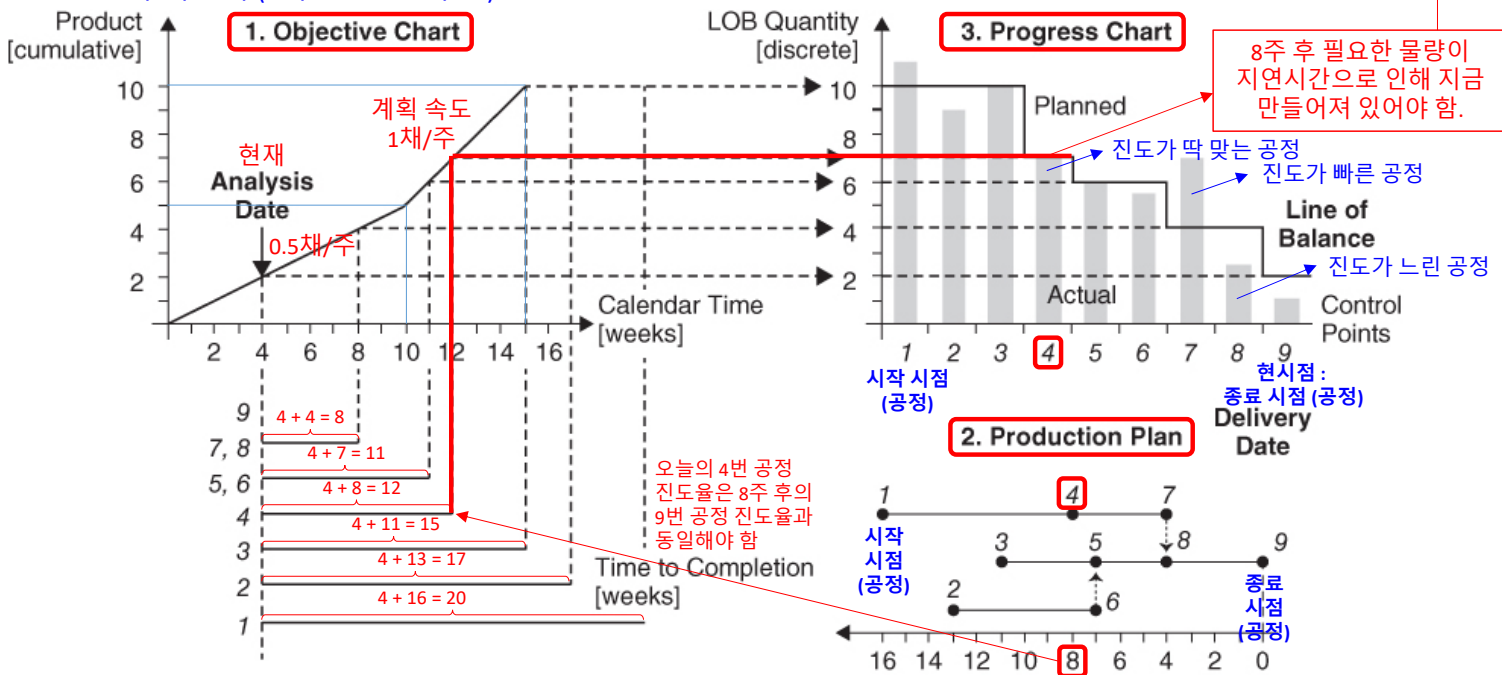


FIGURE 9.10 Line-of-balance example

Lead Time 지연시간 : 4번 공정은 준공 8주전에 완성되어 있어야 함

9.7 Line of Balance Applied to Construction (1/3)

High-rise building example

Each floor section must be processed through the following work activities: **각 층 각 구역에 대해, 다음 공정 반복 수행**

1. Erect forms 거푸집 짜기
2. Place reinforcing steel 배근
3. Place concrete 콘크리트 타설
4. Dismantle forms 거푸집 제거
5. Place curtain wall 커튼월 설치
6. Place windows 창문 설치

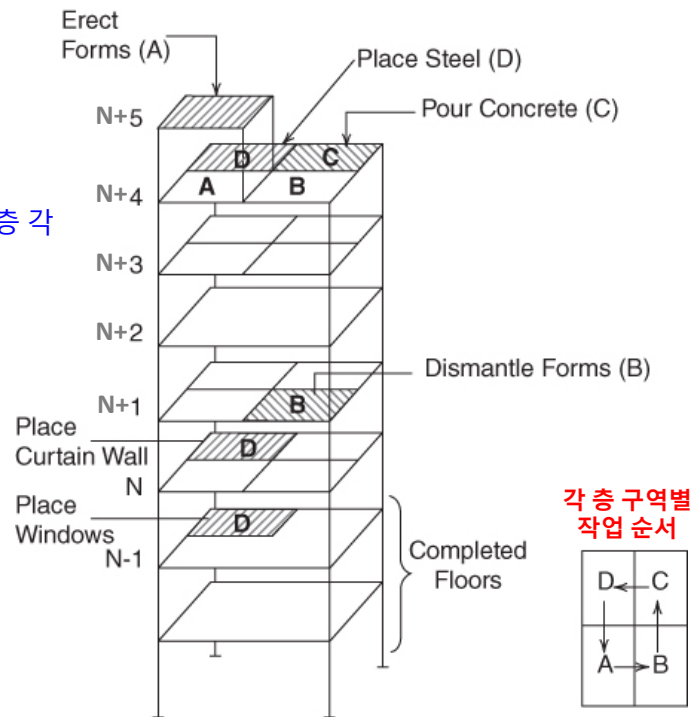


FIGURE 9.11 Schematic of floor cycle work tasks

9.7 Line of Balance Applied to Construction (2/3)

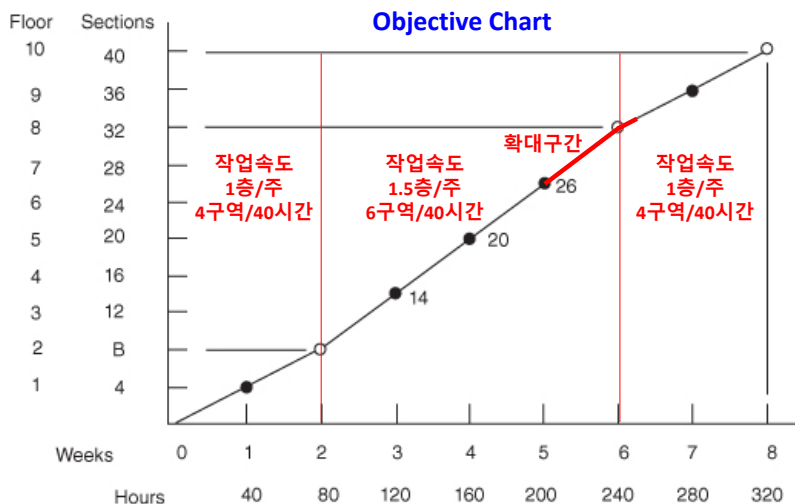
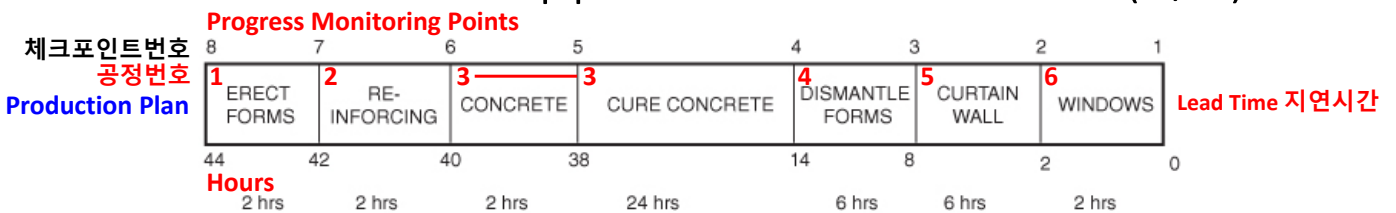


FIGURE 9.12 Program chart and objective

9.7 Line of Balance Applied to Construction (3/3)

- ❑ $LOB(1) = 26$
- ❑ $LOB(2) = 26 + (6/40)2 = 26.3$
- ❑ $LOB(3) = 26 + (6/40)8 = 27.2$
- ❑ $LOB(4) = 26 + (6/40)14 = 28.1$
- ❑ $LOB(5) = 26 + (6/40)38 = 31.7$
- ❑ $LOB(6) = 26 + (6/40)40 = 32$
- ❑ $LOB(7) = 32 + (1/10)(42 - 40) = 32.2$
- ❑ $LOB(8) = 32 + (1/10)(44 - 40) = 32.4$

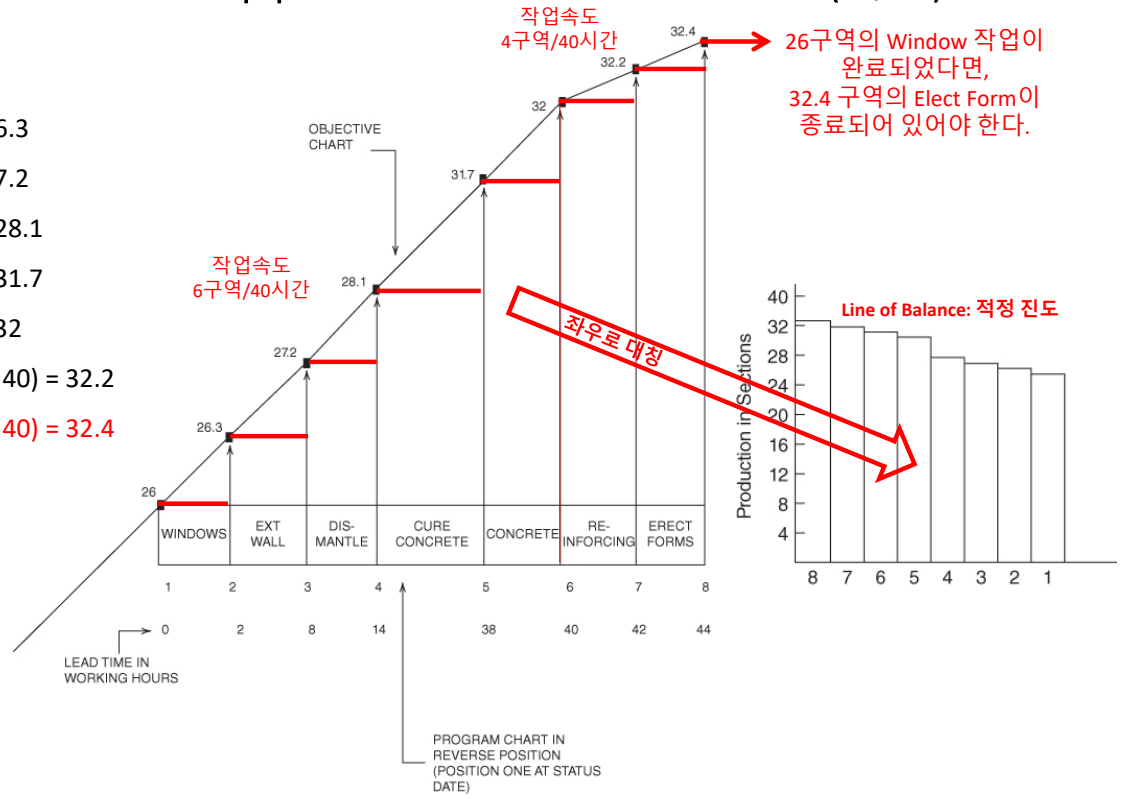


FIGURE 9.13 Enlarged projection of program chart onto objective chart

CHAPTER 10

RESOURCE-RELATED AND ADVANCED LINEAR SCHEDULING TECHNIQUES

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
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제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

10.1 Resource Scheduling

- ❑ The term **resources in construction planning and scheduling** can refer to the “triplet” of **materials**, **labor** (i.e., workers), or **equipment**, or even crews, which are combinations of equipment with their operators. 건설 계획 분야의 자원: 자재, 인력, 장비
- ❑ It is necessary to carefully **consider resources** when developing a **realistic schedule**. 실행 가능한 일정계획 수립을 위해서는 자원을 고려하는 것이 중요함
- ❑ **Resource allocation** to adhere to a given availability. 자원 할당: 자원 → 공정
- ❑ **Resource leveling** to improve the workflow. 자원 부하 균형화: 공사 기간 중 필요 자원의 수를 가능한 한 일정하게 유지

10.2 Resource Allocation

주공정선 A-C-E-G-I
 프로젝트 공기(자원 제약이 없는 경우): $2+1+4+4+2 = 13$

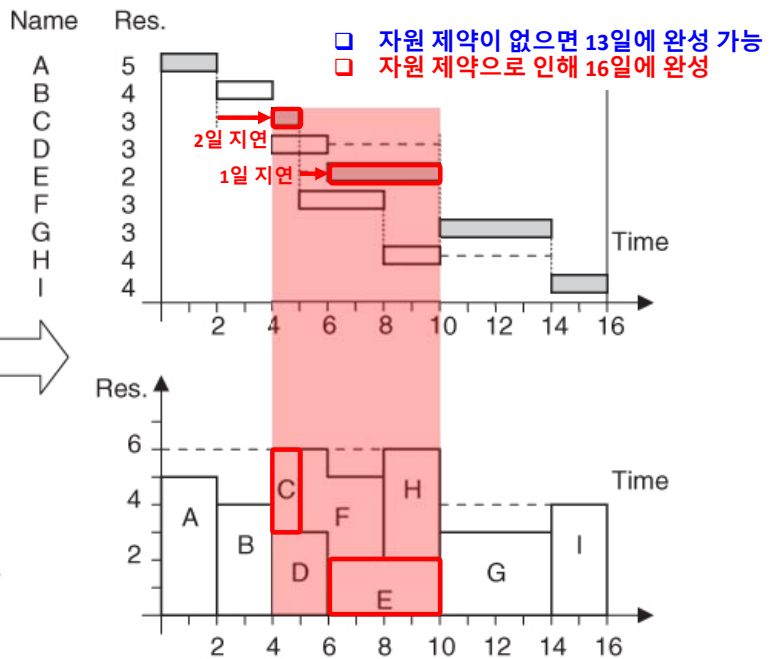
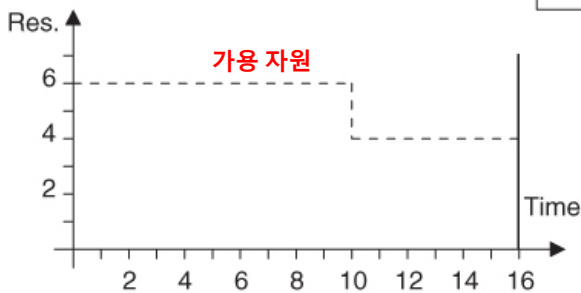
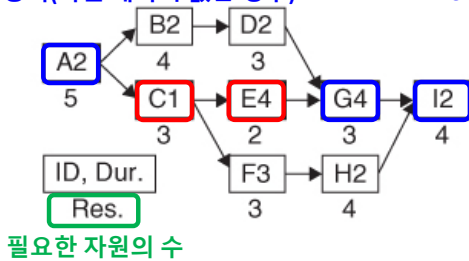


FIGURE 10.1 Example 1: Resource allocation to minimize project duration

10.3 Resource Leveling

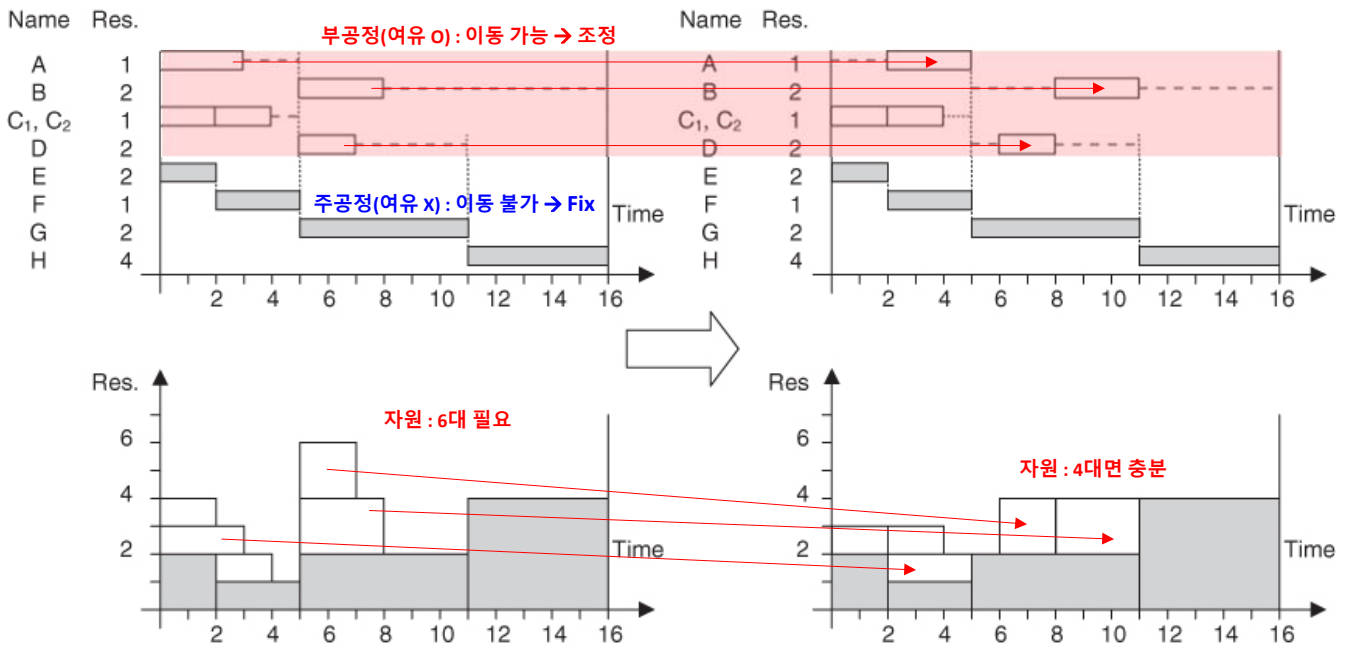


FIGURE 10.2 Example 2: Resource leveling to optimize labor assignment (Heuristics: Rule of thumb)

10.4 Time–Cost Trade-off

- Time, cost, and the scope of work (with its quality requirements) are related in what has become known as the “triple constraint” or “iron triangle” in project management to indicate their close relationship.
- Trade-off between the duration of a project and its cost must be analyzed 공기 vs 공사비
- The initial duration and cost, and the accelerated (crashed) duration and cost.

Normal vs. Accelerated
\$27 for 13 days vs. 8 days at \$36

		정상 공기		특급 공기		비용 구배	
Name	Res.	Initial Time	Initial Cost	Accelerated Time	Accelerated Cost	Cost Slope	
A	1	2	\$3	1	\$4	1\$/d	
B	2	2	\$5	1	\$6	1\$/d	
C ₁ , C ₂	1	1	\$2	-	-	N/A	
D	2	2	\$4	-	-	N/A	
E	2	4	\$4	3	\$6	2\$/d	
F	1	3	\$2	2	\$4	2\$/d	
G	2	4	\$3	3	\$4	1\$/d	
H	2	2	\$1	-	-	N/A	
I	4	2	\$3	1	\$6	3\$/d	

주공정

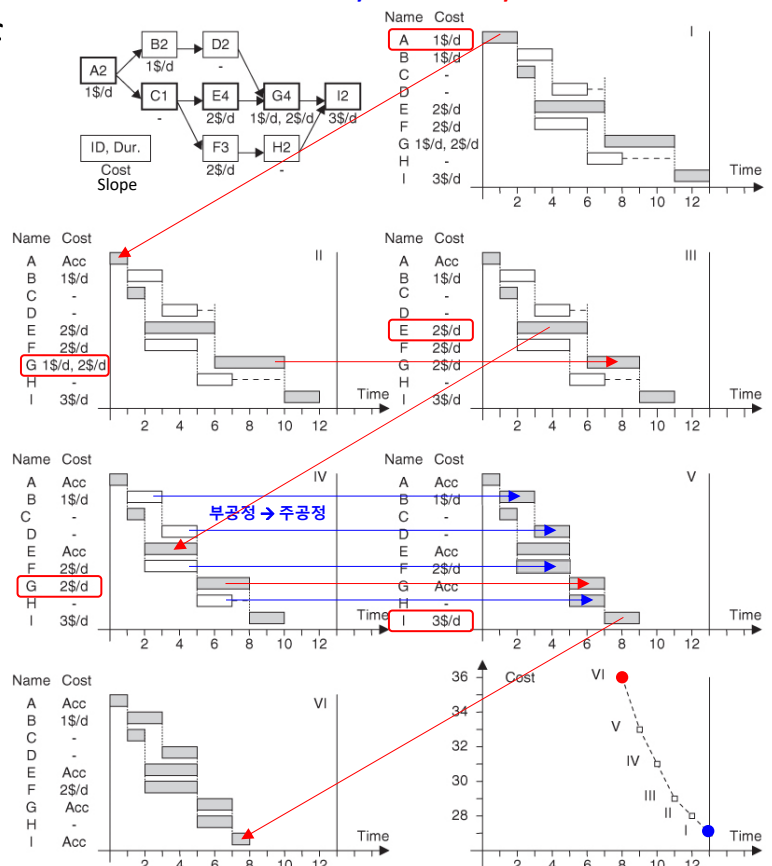


FIGURE 10.3 Example 1: Time–cost trade-off curve

10.5 Linear and Repetitive Scheduling Techniques

- ❑ From cost estimating five basic types of measures are familiar: **length, area, volume, weight, and count** 공사 진도 체크 단위: 길이, 면적, 부피, 무게, 개수
 1. **Length** of road that has to be paved 도로의 길이
 2. **Weight** of steel that must be erected 세워질 철골의 무게
 3. The **number** of faucets that are installed 설치될 수전의 개수
- ❑ More generic measures that can always be applied to any type of work: **일반적 단위**
 1. **Monetary** value (in dollars) 금액으로 환산된 진도
 2. **Percent complete** at a particular time 준공률
- ❑ Construction projects are mostly **horizontally linear** (e.g., roads, tunnels, and bridges), **vertically linear** (e.g., high-rise buildings) 건설 진도는 수평적으로 또는 수직적으로 선형성을 띠

10.6 Linear Scheduling Method (1/2)

- ❑ **Linear scheduling** has been developed for project control since the early 20th century.
- ❑ The **linear scheduling method (LSM)** resembles the first of the three **LOB** charts, but can show significantly more details. LSM은 **Objective Chart(Production Curve)**와 유사하지만 좀더 다양한 정보를 제공함

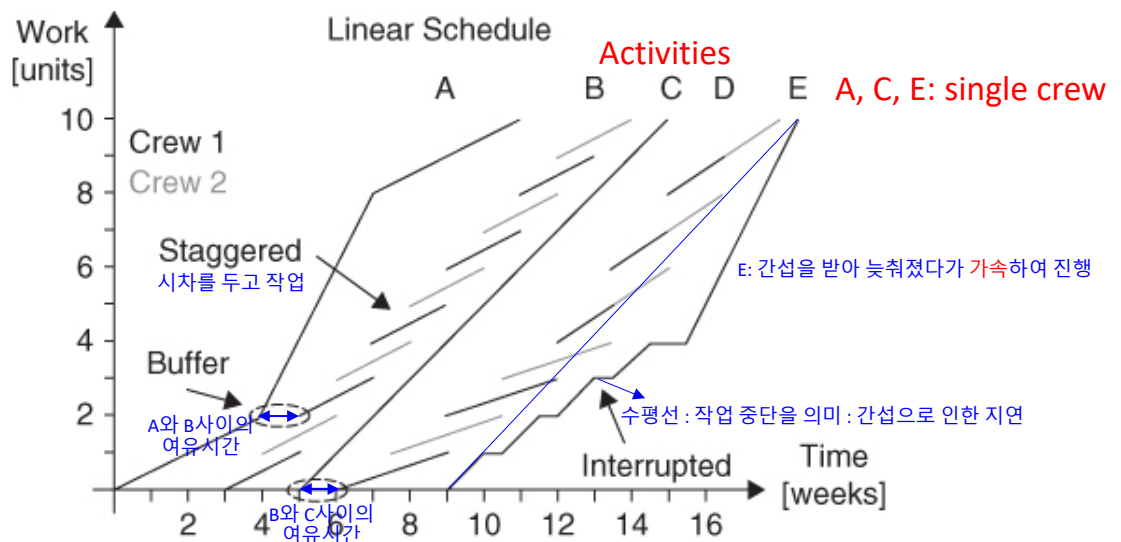
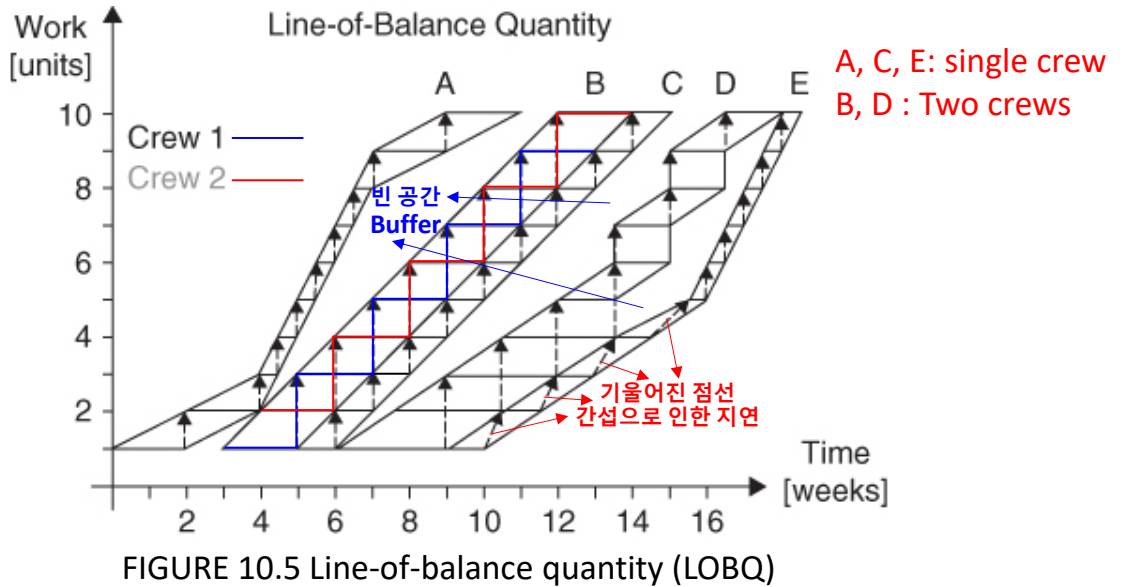


FIGURE 10.4 Linear scheduling method (LSM)

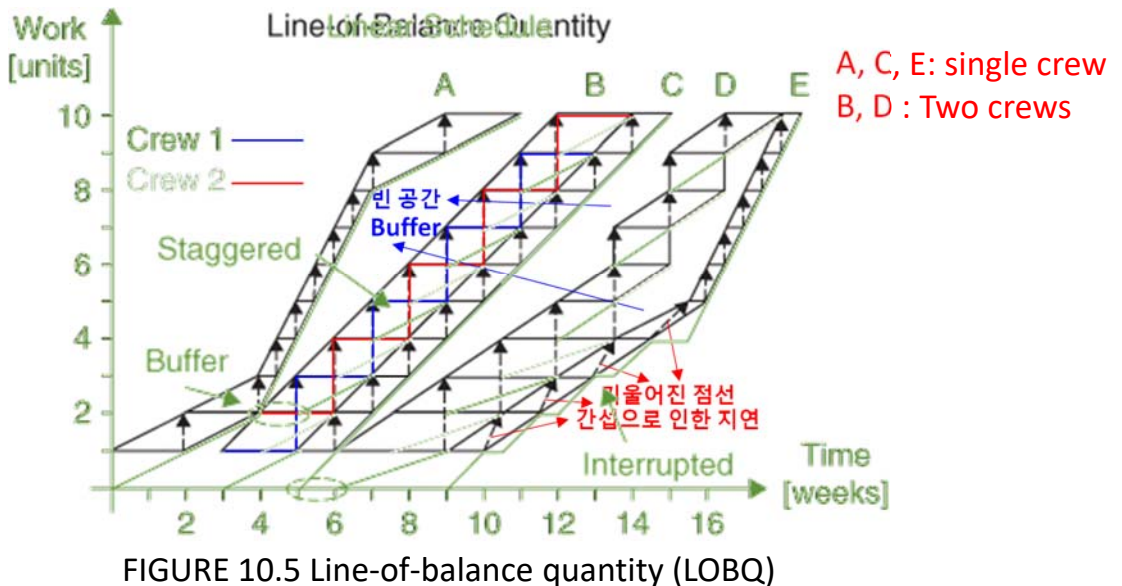
10.6 Linear Scheduling Method (2/2)

- ❑ Line-of balance quantity (LOBQ) chart and was introduced by Lumsden (1968), but is not found in the original U.S.
- ❑ Each activity is represented with one diagonal line (unless interrupted) in the LSM chart, but with two enveloping lines in LOBQ. Buffer(여유)와 Delay(지연)의 명확한 표시



10.6 Linear Scheduling Method (2/2)

- ❑ Line-of balance quantity (LOBQ) chart and was introduced by Lumsden (1968), but is not found in the original U.S.
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10.7 Case Study of a Linear Project (1/4)

- ❑ Consider the example of a **10-floor office building** for which we will create a linear schedule.
- ❑ The building has **two levels of underground** parking and mechanical and cooling equipment in a **roof penthouse** for a **total of 13 levels**. 지하 2층, 지상 10층, 펜트하우스: 총 13층

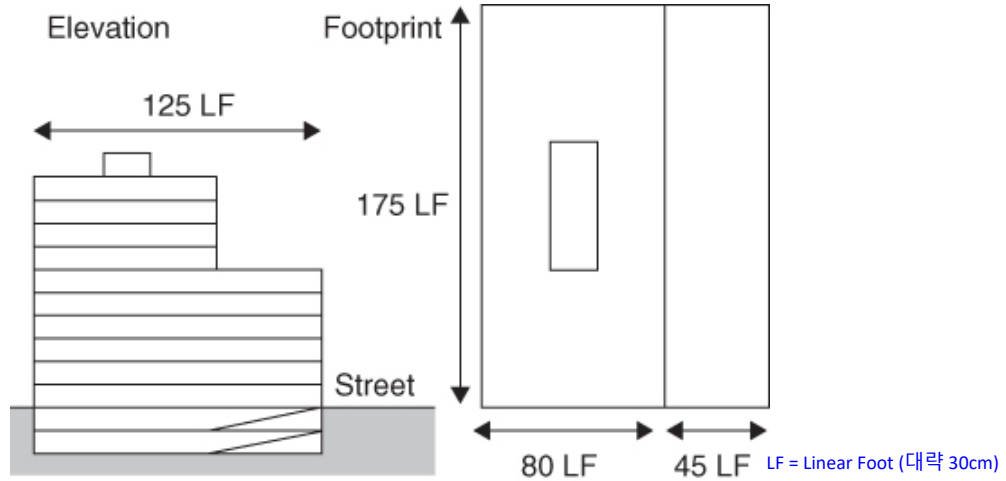


FIGURE 10.6 Schematic elevation and footprint

10.7 Case Study of a Linear Project (2/4)

two levels of underground

10-floor office building

roof penthouse

공통

Linear Schedule Activities					
Activity	Sequence	Productivity	Resources	Quantity	Duration
Demolition	1	21,875 SF/wk	Excavator	21,875 SF	5 d
Soldier piles	2	300 LF/wk	Pile driver	600 LF	10 d
Excavate/lagging	3	5,000 CY/wk	Excavator	25,000 CY	25 d
Temporary ramp	3	1 wk	Excavator	1 EA	5 d
Erect tower crane	4	1 d	Mobile crane	1 EA	1 d
Slab-on-grade	5	2 wk	Tower crane	6 pours/floor	10 d ^a
Perimeter walls	6	150 LF/wk	Tower crane	600 LF	20 d
Backfill perimeter	7	300 LF/wk	Excavator	300 LF	10 d
Column concrete	7	15 EA/d	Tower crane	30 EA/floor	4 d ^a
Core masonry	7	1,500 SF/wk	Material hoist	1,200 SF/floor	4 d
Scaffold/formwork	8	2,000 SF/d	Tower crane	3 (2) pours/floor	4 d/pour ^b
Reinforcing/sleeves	9	2,500 SF/d	Tower crane	3 (2) pours/floor	3 d/pour ^b
Pour concrete	10	1 d/pour	Tower crane	3 (2) pours/floor	1 d/pour ^b
Cure concrete	11	3 d	N/A	N/A	3 d/pour
Stress cables	12	1 d/pour	Hydraulic jack	3 (2) pours/floor	1 d/pour ^b
Strip/reshore	13	4,000 SF/d	Tower crane	3 (2) pours/floor	2 d/pour ^b
Façade panels	14	200 LF/d	Tower crane	350 LF/floor	2 d
Install windows	15	75 LF/d	Material hoist	300 LF/floor	4 d
Install roofing	15	1,500 SF/d	Tower crane	7,300 (14,600) SF	5 (10) d ^b
Mechanical penthouse	16	5 d	Tower crane	1 EA	5 d
Dismantle tower crane	17	1 d	Mobile crane	1 EA	1 d
Building systems	16	3 (2) wk/floor	Material hoist	N/A	15 (10) d/floor
Framing/drywall	16	2 (1) wk/floor	Material hoist	N/A	10 (5) d/floor
Install elevators	16	8 wk	N/A	N/A	40 d
Occupancy certificate	18	2 d	N/A	N/A	2 d

10.7 Case Study of a Linear Project (3/4)

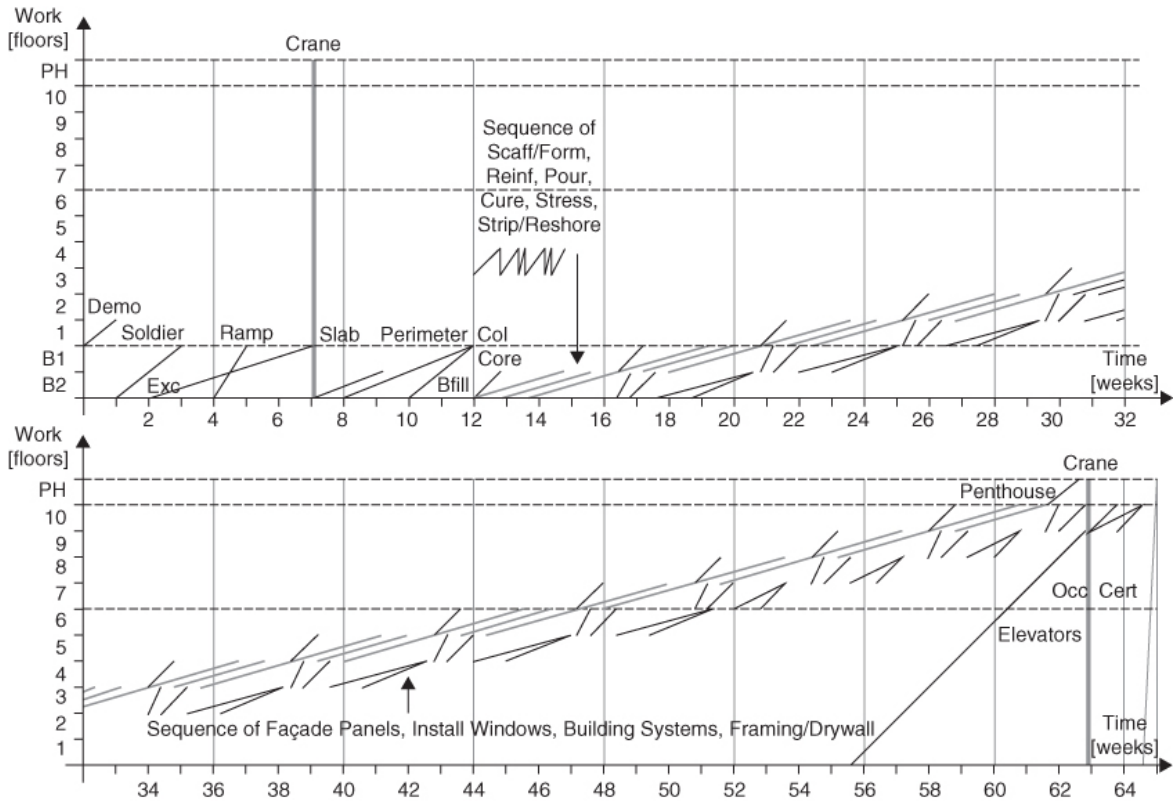


FIGURE 10.7 Linear schedule for case study project

10.7 Case Study of a Linear Project (4/4)

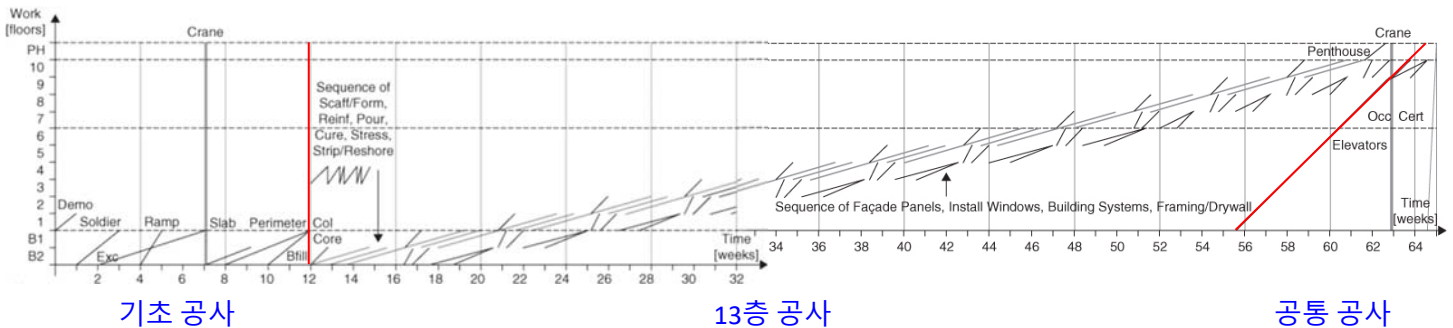


FIGURE 10.7 Linear schedule for case study project

CHAPTER 11

THE MATHEMATICS OF MONEY

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

11.1 Introduction

- ❑ **Management of money** is critical to the success of any company. 기업 경영의 성공을 위해서는 자금관리가 매우 중요
- ❑ **Inventory financing**: 선투입 → 후정산 → 항상 자금이 필요함 → 자금 조달 문제가 발생함
- ❑ When **money is borrowed**, the lender will require a **fee** for the use of the borrowed funds. This fee is called the loan's **interest**. 이자 : 차입금에 대한 사용료 개념
- ❑ **Engineering Economics**: 공학경제 or 경제성공학

2

11.2 Time Value of Money

- ❑ **Time Value of Money (TVM)**: **One dollar** available **right now** is more attractive than one dollar offered to be available at a **future time**. 돈의 시간적 가치 : 현재 시점의 돈의 가치는 미래 시점의 같은 금액의 가치보다 크다
- ❑ Any decision involving the **acquisition or payment of money over time** must consider TVM. 장 기간에 걸쳐 돈의 흐름이 발생하는 프로젝트에 대한 경제성 분석 시 반드시 돈의 시간적 가치를 고려해야 함.

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11.3 Factors Determining the Time Value of Money

- ❑ Three factors must be considered to analyze the **value of money over time**: 돈의 시간적 가치에 따른 미래가치 결정 요소
 1. The **amount's principal**, which is the value of the investment at present time. 원금
 2. The **interest rate**, that is, the interest over a unit of time. This rate is expressed as a percentage. 이자율
 3. The **time** involved. 기간 (현재와 미래와의 시점 차이)
- ❑ Many **factors influence the interest rate** charged by a lender. 이자율 결정 요소
 1. The degree of investment **risk** 프로젝트에 대한 투자 위험
 2. The **creditworthiness** of the borrower 채무자의 신용도
 3. The **inflation** rate 물가상승률
 4. The stability of the market where the money will be used 시장 안정성
 5. The level of competition among lenders 대출자 간의 경쟁
 6. The cost of the money to the lender. 대출자의 자금 조달 비용

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11.4 Simple and Compound Interest

- ❑ There are two fundamentally different ways to **compute interest**. 두가지 이자 계산 방법
- ❑ Total interest depends on the type of interest: whether it is **simple or compound**.
단순이자 vs 복합이자(복리)

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11.4.1 Simple Interest

- ❑ Paying simple interest means that you pay interest on the principal, but **not on the interest accumulated from previous periods**. 원금에만 이자가 붙는다.
- ❑ The future value F_n of a principal P borrowed over n periods at an interest rate i can be computed as $F_n = P \times [1 + in]$, F_n (n 기 후의 미래가치), P (현재가치), n (기간), i (이자율)

이자율 $i = 10\%$

Year (n)	Base for Applying i	Interest for Period	Total Owed (F)
0 (now)			10,000
1	10,000	$10,000 \times 0.10 = 1,000$	11,000
2	10,000	$10,000 \times 0.10 = 1,000$	12,000
3	10,000	$10,000 \times 0.10 = 1,000$	13,000

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11.4.2 Compound Interest

- ❑ When using compound interest, the interest owed after each time period is computed by adding the interest accumulated from previous periods to the loan principal, and then multiplying this total by the interest rate. 원금과 축적된 이자 모두에 이자가 붙는다.
- ❑ The future value F_n of a principal P borrowed over n periods at an interest rate i can be computed as $F_n = P \times (1 + i)^n$, F_n (n 기 후의 미래가치), P (현재가치), n (기간), i (이자율)

이자율 $i = 10\%$

Year (n)	Base for Applying (i)	Interest for Period	Total Owed (F)
0 (now)			10,000
1	10,000	$10,000 \times 0.10 = 1,000$	11,000
2	11,000	$11,000 \times 0.10 = 1,100$	12,100
3	12,100	$12,100 \times 0.10 = 1,210$	13,310

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11.5 Nominal and Effective Rate

- ❑ **Annual Percentage Rate (APR)** : lenders clearly indicate interest rates as an annual percentage of each received dollar. 소비자 보호를 위해 1년 단위의 명목 이자율을 공시토록 함.
- ❑ It is possible to find the effective annual rate that you pay on a loan (usually called its **Annual Percentage Yield or APY**) if you know its APR and the **number of times per year that the interest is compounded**. 1년에 이자를 몇 번 따져주는가에 따라 실효 이자율이 결정됨.

$$APY = \left(1 + \frac{APR}{C}\right)^C - 1$$

In the previous example, APR = 12% compounded monthly. Its APY is

$$APY = \left(1 + \frac{0.12}{12}\right)^{12} - 1 = 12.6825\%$$

For $i = 12.0000\%$: $F = \$100,000 \times (1 + 0.120000)^{15} = \$547,356.57$ 연복리(12%, 1번/년)

For $i = 12.6825\%$: $F = \$100,000 \times (1 + 0.126825)^{15} = \$599,580.20$ 월복리(1%, 12번/년)

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11.6 Equivalence and Minimum Attractive Rate of Return

- ❑ **Equivalence** (경제적 등가) is usually considered in terms of interest rates instead of total interest. 경제적 등가는 총 이자가 아닌 이자율로 표현
- ❑ If a person or company considers it equally attractive to have **\$100 now** or to get **\$150 a year from now**, the interest rate that this person considers **equivalent would** $\$50/\$100 = 50\%$. \$100를 쥐주고 1년 후에 \$150을 돌려 받는다면, 이 거래는 이자율 50%에서 경제적 등가임 (이 거래는 이자가 \$50인 경우 경제적 등가임)
- ❑ This particular interest rate is called the **minimum attractive rate of return (MARR)** (최소요구수익률) for that person or company. 투자를 위한 최소한의 기대 수익률 → 현재가치, 연등가, 미래가치 등을 구하는 경제성분석을 위한 이자율

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11.7 Discount Rate

- ❑ What we have called so far **interest rate** is sometimes called **discount rate**. 이자율은 종종 할인율로 불림
- ❑ When the value in the future of a given sum is known and what is required to know is its equivalent value now, the amount **F is discounted to find its present value P**. 미래가치를 할인하여 현재가치를 구함
- ❑ $P = F_n / (1 + i)^n$, F_n (n기 후의 미래가치), P(현재가치), n(기간), i(이자율)

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11.8 Sunk Costs

- ❑ Any **cost that has already been expended** is called a **sunk cost** (매몰비용). 의사결정 전에 이미 지출된 비용 → 예: 건설이 중단된 건물에 대해 지금까지 투자된 비용
- ❑ As such, it cannot be revoked and, therefore, **is irrelevant to future decisions**. 매몰비용은 미래 의사결정에 영향을 끼치지 못함 → 분석에 포함시키지 않음
- ❑ You purchased a new computer two months ago for \$2,000. However, a new model with the same features is available now for \$1,000. If you are offered \$1,200 for the old computer, should you sell the old computer and purchase the new model? **Yes : \$200 profit**. 두 달 전에 \$2,000을 주고 컴퓨터 구입, 현재는 동일한 컴퓨터를 \$1,000에 구입 가능, 구입한 컴퓨터를 \$1,200에 팔 기회가 있다면 팔아야 할까? **팔면 \$200 이득? or \$800 손해?**
- ❑ 의사결정 시 지나간 일은 모두 무시 → 현재의 상황만 중요 → 기존 컴퓨터 팔아서 + \$1,200, 새 컴퓨터 구입하는데 - \$1,000 → \$200 이득, "\$2,000을 주고 산 컴퓨터인데 \$1,200을 주고 파니 \$800이 손해네!" ← 이런 생각은 의미가 없음.
- ❑ 10,000원을 주고 산 주식이 8,000원이 되었다. 이 주식을 보유해야 하는가? → 현재 8,000원이 있다면 그 주식을 사겠는가? 이 질문만이 의미가 있다. 예전에 10,000원이었다는 사실은 의사결정에 아무런 영향을 미치지 못한다.

11

11.9 Cash Flow Diagrams

- ❑ **Cash flow diagrams** provide a graphical means for describing situations in which interest and time interact. 현금흐름도: 프로젝트 자금 흐름을 시각적으로 나타냄
- ❑ Developing the appropriate cash flow diagram is often the critical step in solving an engineering economy analysis. 현금흐름도 작성은 경제성 분석의 출발점
- ❑ Specifically, it consists of the following:
 1. A **timeline** consisting of a horizontal line 가로축은 시간
 2. Arrows placed on the tick marks show each sum of money. An **inflow** of money is shown as an **arrow pointing up** at the point the money or value of an asset was earned; similarly, the arrow for a money **outflow** is drawn **pointing down**. 현금 유입은 위쪽 화살표, 현금 유출은 아래쪽 화살표
 3. **Comments and additional data** are written near the main timeline and arrows. 주석

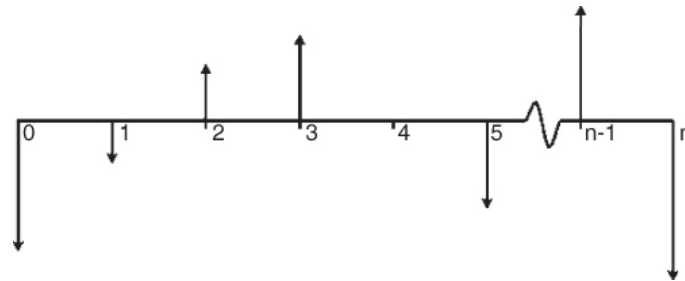
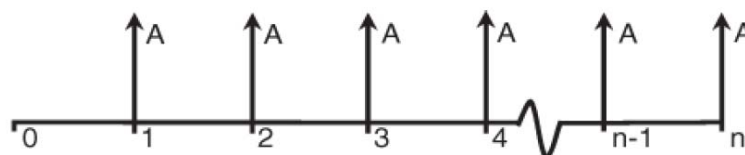


FIGURE 11.1 Structure of a cash flow diagram

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11.10 Annuities

- ❑ An **annuity** (연등가) is a series of equal payments paid out or received in a sequence over a period of time. → **uniform payment series** 연등가: 매 기간 일정한 현금흐름
- ❑ 예: 대출 상환액 또는 정기 적금액 등



a. Standard Annuity

FIGURE 11.2 Standard and defective annuity schemes

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11.11.1 Present Value of an Annuity: Finding P Given A

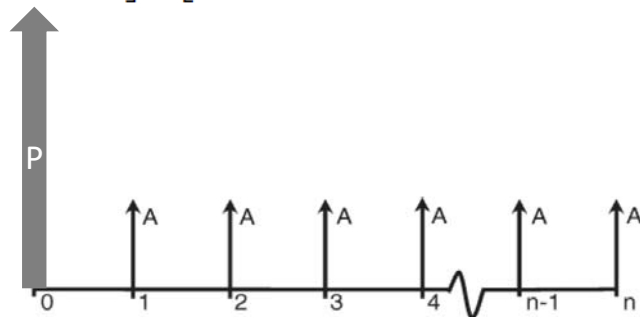
- The present value P of an annuity A is the amount of money that is equivalent to the entire flow of payments considering an interest rate of i over n time periods. To find P given A , n , and i the following formula is applied:

$$P = A \times [(1 + i)^n - 1] / [i \times (1 + i)^n]$$

- As an example, 36 monthly payments of \$968 each at an APR of 10% compounded monthly will have the following present value ($i = \text{APR}/12 \text{ months} = 0.8333\%/\text{month}$)

$$P = \$968 \times [(1 + 0.008333\%)^{36} - 1] / [0.008333\% \times (1 + 0.8333\%)^{36}]$$

$$P = \$30,000$$



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11.11.2 Installments Paying for an Item: Finding A Given P

- The formula to convert P to A can be written as follows, which is the inverse of the formula for finding A giving P discussed in the previous section:

$$A = P \times [i \times (1 + i)^n] / [(1 + i)^n - 1]$$

- For an item selling at \$30,000 at $i = 0.008333\%/\text{month}$ and $n = 36 \text{ months}$, the A to P formula is applied as follows: 할부, 대출

$$A = \$30,000 \times [0.008333\% \times (1 + 0.8333\%)^{36}] / [(1 + 0.008333\%)^{36} - 1]$$

$$A = \$968/\text{month}$$

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11.12 Future Value of a Series of Payments: Finding F Given A

- The formula to apply here, where the objective is to find F given n payments of A dollars each at an interest rate of i is

$$F = A \times \left\{ \frac{[(1 + i)^n - 1]}{i} \right\}$$

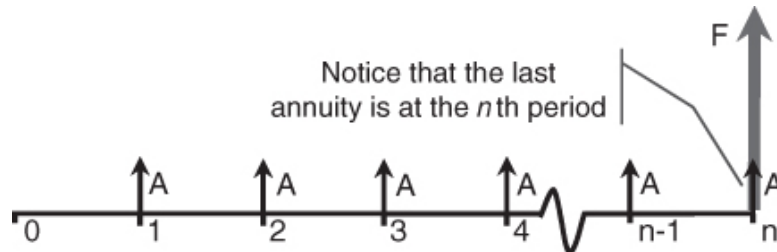


FIGURE 11.3 Future value of an annuity

- 매달 \$1,000씩 10% 이율로 20년을 적립하는 경우,

$$F = \$1,000 \times \left\{ \frac{[(1 + 0.10)^{20} - 1]}{0.10} \right\} = \$1,000 \times 57.2749995$$

$$F = \$57,275.00$$

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11.13 Annuity Required to Reach a Goal Amount: Finding A Given F

- A person may want to know how much to save every month to reach a given bank account balance after n years by a bank that offers an interest rate of i. The scenario can be described as finding A given F over n periods at an interest rate of i. The formula used in this case is

$$A = F \times i / [(1 + i)^n - 1]$$

- As an example, to find the annual payment that would result in a balance of \$500,000 after 20 years at 10%:

$$A = \$500,000 \times \left\{ 0.10 / [(1 + 0.10)^{20} - 1] \right\}$$

$$A = \$8,729.81/\text{year}$$

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11.14 Summary of Equivalence Formulas

TABLE 11.1

Interest Factors						
Type of Cash Flow Name	Single Payment		Uniform Series (Annuities)			
	Compound Amount Factor	Present Worth Factor	Compound Amount Factor	Sinking Fund Factor	Present Worth Factor	Capital Recovery Factor
Description	Find F given P (F/P)	Find P given F (P/F)	Find F given A (F/A)	Find A given F (A/F)	Find P given A (P/A)	Find A given P (A/P)
Formula	$(1 + i)^n$	$\frac{1}{(1 + i)^n}$	$\frac{[(1 + i)^n - 1]}{i}$	$\frac{i}{[(1 + i)^n - 1]}$	$\frac{[(1 + i)^n - 1]}{i \times (1 + i)^n}$	$\frac{i \times (1 + i)^n}{[(1 + i)^n - 1]}$

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11.15 Worth Analysis Techniques: Rationale and Vocabulary

❑ Example: \$3,000 every year for the next 10 years vs. \$20,000 now. MARR is 10%

❑ Three techniques can be used:

1. If the present value of a \$3,000 annuity over 10 years at your MARR is greater than the \$20,000 that Thaddeus will borrow from you. The approach of finding the net present value of an investment is called the **present worth (PW) method**. 현재가치법
2. If the \$3,000 per year is greater than the annuity resulting from investing \$20,000 over 10 years at your MARR. This approach to assess the value of an investment is the **equivalent worth analysis (EWA)**. 연등가법
3. If the interest that yields 10 payments of \$3,000 from an initial investment of \$20,000 is greater than your MARR. This approach seeks to find the implicit interest rate of an investment, which is called the **internal rate of return (IRR)** of the investment. 수익률법

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11.16 Present Worth Analysis

- ❑ The **present worth** of an investment is the sum of the present value at a given interest rate i of all amounts involved in the investment. 모든 현금흐름을 현재 시점으로 변환
- ❑ **Inflows** (i.e., the money earned by the investor) are considered **positive** and **outflows** (i.e., the money invested) are considered **negative**. 현금유입은 양수, 현금유출은 음수 → 순현재증가 계산
- ❑ If **this sum is negative**, the present value of the investment's inflows is not enough to recover the present value of its outflows. The investment is therefore **not attractive** at an interest rate of i . 순현재증가 < 0 → 경제성 없음
- ❑ If **the sum is positive**, the investment generates inflows in excess of the target interest rate of i and is **attractive** to the investor. 순현재증가 > 0 → 경제성 있음

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11.16.1 Example: Small Excavator

- ❑ A machine will give net benefit of \$5,000 for the next four years vs. Another contractor offers to purchase the machine for \$15,000 now. MARR: 13.0%. 중고 기계: 지금 \$15,000을 받고 팔까? vs 기계를 운용하여 향후 4년간 매년 \$5,000의 이익을 실현할까?
- ❑ Should he sell the machine, or keep using it for the remaining of its economic life?
- ❑ Using the formula for the PW of an annuity (\$5,000/year in this case) we find that: **PW** of \$5,000 over four years at $i = 13.0\% = \$14,872$. 4년간 매년 \$5,000의 이익 = 현재의 \$14,872
- ❑ Fudd **should sell the machine**, because the present value of the money that he would get by using the machine for the next four years is less than the \$15,000 offered now. 파는 것이 이득

Find P given
 A (P/A)

$$\frac{[(1+i)^n - 1]}{i \times (1+i)^n}$$

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11.17 Equivalent Annual Worth

- ❑ The **Equivalent Annual Worth (EAW)** of an investment is its value expressed as a uniform dollar amount over a time period. 모든 현금흐름을 연등가로 변환
- ❑ More concisely, it is the **equivalent annuity of an investment**.
- ❑ When the **cost of an investment** is the main issue under consideration, then the term **equivalent annual cost (EAC)** instead of EAW is frequently used.

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11.17.1 Example: Best Job Offer

- ❑ Greg is undecided between **two job offers**. MARR : 12%
- ❑ **Fudd Associates, Inc.**, offers a **\$10,000 sign-up bonus** and 계약금 \$10,000, 연봉 \$50,000
- ❑ **ABC Contractors, Inc.**, offers an annual salary of **\$54,000/year** 연봉 \$54,000
- ❑ Based on the salary offer, which offer is better?
- ❑ The question is whether the extra salary of **\$4,000/year** offered by ABC is more attractive than the initial **\$10,000 bonus** offered by Fudd. 계약금 \$10,000 vs 연봉 차이 \$4,000
- ❑ The EAW for the \$10,000 is the annuity resulting from $P = \$10,000$, $n = 3$ years, and $i = 12\%$. 계약금 \$10,000 → 3년 동안 연봉 \$4,163.5만큼의 차이에 해당

$$EAW = 10,000 \times (A/P, 12\%, 3) = \$10,000 \times 0.41635 = \$4,163.50$$

- ❑ Fudd Associates, Inc. is better

Find A given $P (A/P)$
$\frac{i \times (1+i)^n}{[(1+i)^n - 1]}$

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11.18 Internal Rate of Return

□ The IRR of an investment is the **interest rate** at which the investment has a **net present value of zero** (i.e., $PW = 0$). 수익률은 순현재증가를 0으로 만들어 주는 이자율, 수익률 > MARR (최소요구수익률) → 경제성 있음

□ Suppose that an investment consists of the following:

Initial cost: \$100,000

Net benefits: \$27,057/year

Investment span: 5 years

Find P given $A (P/A)$
$\frac{[(1+i)^n - 1]}{i \times (1+i)^n}$

□ The PW of this investment can be expressed as: $PW = -100,000 + 27,057 \times (P/A, i, 5)$

$$(P/A, 12\%, 5) = 3.60478 \quad PW_{12\%} = -\$100,000 + \$27,057 \times 3.79079 = -\$2,465$$

$$(P/A, 11\%, 5) = 3.69590 \quad PW_{11\%} = -\$100,000 + \$27,057 \times 3.69590 = \$0$$

$$(P/A, 10\%, 5) = 3.79079 \quad PW_{10\%} = -\$100,000 + \$27,057 \times 3.79079 = \$2,567$$

→ IRR > MARR = 10% → 경제성 있음

IRR < MARR = 12% → 경제성 없음

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11.19 Limitations of the Internal Rate of Return Method

□ The IRR method has some **limitations**. 수익률법 단점 → 복수 대안 평가 시 사용불가 → 증분 분석 필요

□ This is frequently the case when there are **large differences in the size of the investments**. 초기 투자액에 큰 차이가 있는 경우, 현재가치법과 수익률법(증분분석을 사용하지 않고 단순히 높은 수익률의 대안을 선정하는 경우)의 결론이 달라지는 현상 발생

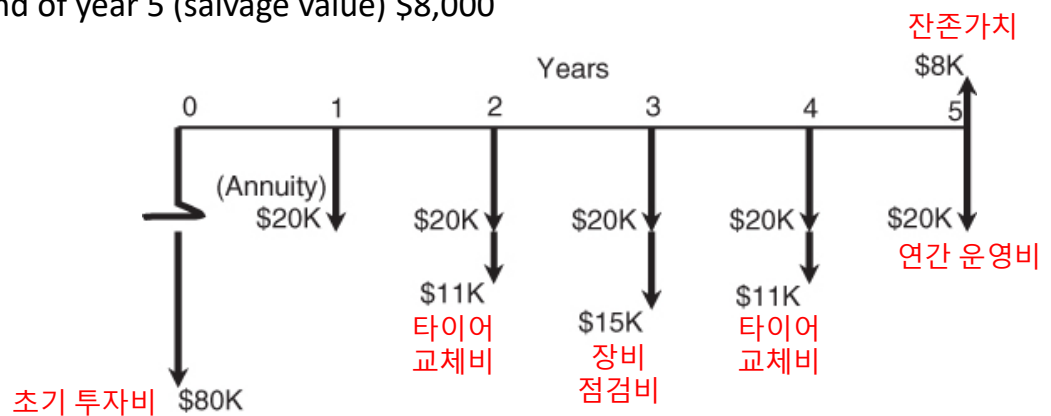
□ If we need to choose among two investments A and B, **A may have the higher IRR**, but **B might have the larger PW** of the two when computed using MARR as the interest rate. → 상호 배타적인 복수 대안 평가 시 현재가치법을 사용하는 것이 편리함

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11.20 A Practical Example Using Present Worth Analysis (1/3)

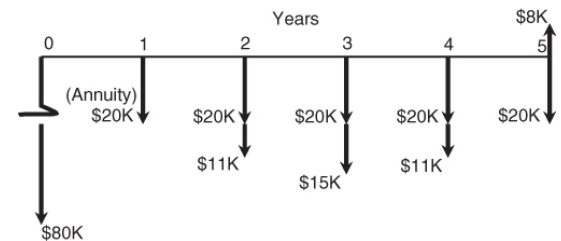
□ Purchase of equipment, MARR of 10%.

1. Initial cost \$80,000
2. Annual operational costs (operator, fuel, oil, etc.) \$20,000
3. Tire replacement at the end of years 2 and 4 \$11,000
4. Major overhaul at the end of year 3 \$15,000
5. Sale at the end of year 5 (salvage value) \$8,000



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11.20 A Practical Example Using Present Worth Analysis (2/3)



$$\frac{[(1+i)^n - 1]}{i \times (1+i)^n}$$

1. The cost of the unit—**\$80,000**—is at present value
2. Therefore, A is \$20,000 and P is calculated. Find P, given A : $P = A(P / A, 10\%, 5) = \$20,000(3.7905) = \mathbf{\$75,820}$
3. The tire replacement costs of \$11,000 are assumed to occur at the end of years 2 and 4: $P = F((P / F, 10\%, 2) + (P / F, 10\%, 4)) = \$20,000(0.8264 + 0.6830) = \mathbf{\$16,603}$
4. The major overhaul occurs at the end of year 3: $P = F(P / F, 10\%, 3) = \$15,000(0.7512) = \mathbf{\$11,200}$
5. The resale or salvage value represents revenue: $P = -8,000(P / F, 10\%, 5) = -\$8,000(0.6209) = \mathbf{-\$4,967}$ (잔존가치 : 부의 비용)
6. Summation of the values calculated in (1) through (5) yields: $P = \$80,000 + \$75,820 + \$16,693 + \$11,270 - \$4,967 = \mathbf{\$178,726}$
7. To find the **amount that must be recovered each year** from clients: $A = P \times (\text{capital recovery factor}) = \$178,726 \times (0.26380) = \mathbf{\$47,100}$ 적어도 매년 \$47,100을 벌어들여야 함

$$\frac{i \times (1+i)^n}{[(1+i)^n - 1]}$$

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11.20 A Practical Example Using Present Worth Analysis (3/3)

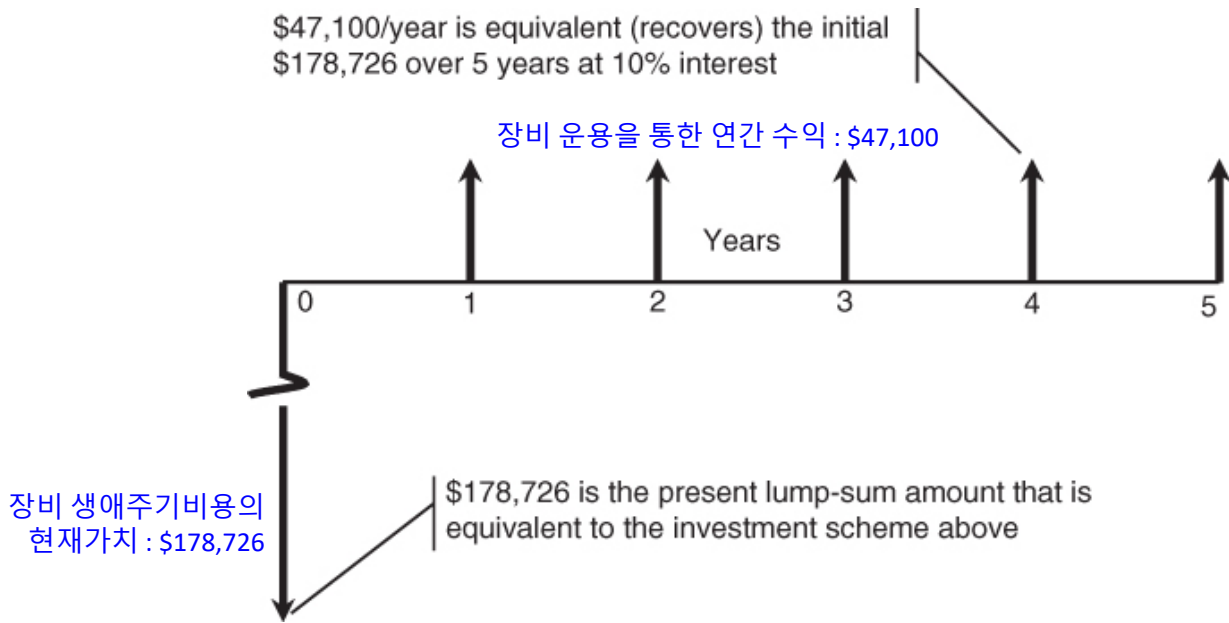


FIGURE 11.5 Distribution of costs/revenue using A/P

11.21 Comparison Using Equivalent Annual Worth (1/4)

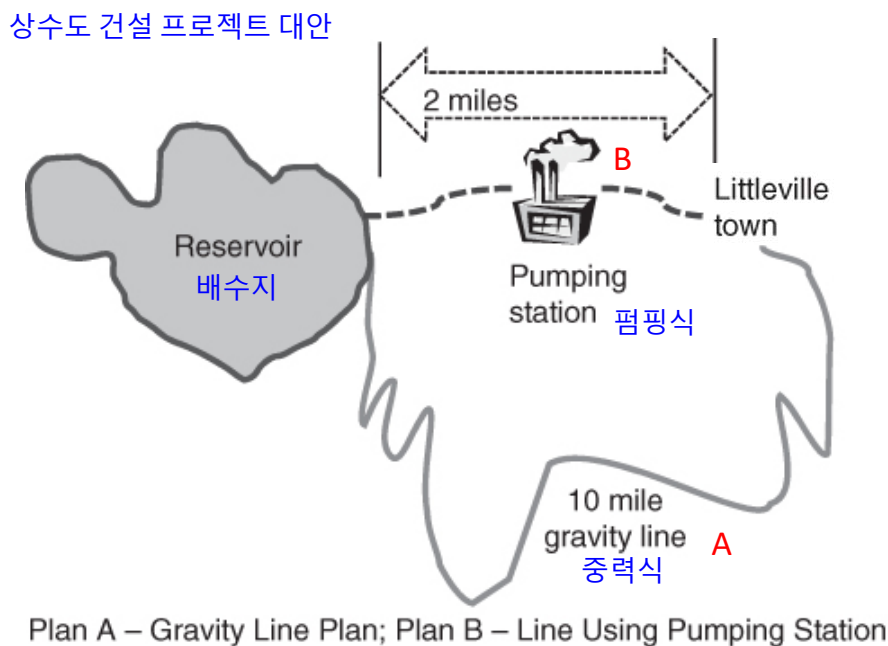


FIGURE 11.6 Alternatives for Littleville water supply

11.21 Comparison Using Equivalent Annual Worth (2/4)

Item	Pipeline A Costs (\$) 중력식	Pipeline B Costs (\$) 펌핑식
Initial investment pipeline 파이프라인 설치비	2.8 million	1.5 million
Cost of pumping station 펌핑장 초기투자비	0	500,000
Annual operation and maintenance (O&M) costs 연간 유지보수비	30,000	60,000
Annual power costs during first 10 years	0 10년 동안 연간 전기세	40,000
Annual power costs after 10 years	0 10년 이후 연간 전기세	120,000

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11.21 Comparison Using Equivalent Annual Worth (3/4)

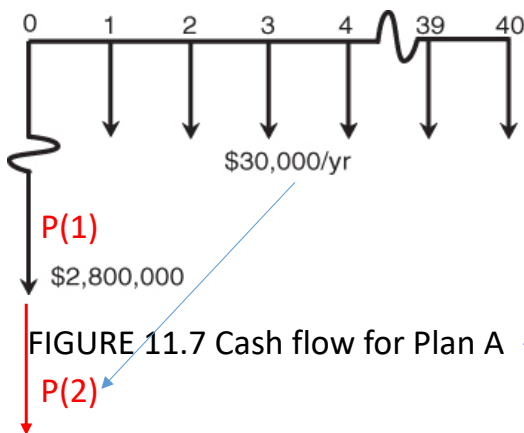


FIGURE 11.7 Cash flow for Plan A 중력식

$$P(1) = \$2,800,000$$

$$P(2) = \$30,000(P/A, 7\%, 40) \text{ [Using the tables in Appendix G]}$$

$$\text{Therefore, } P(2) = \$30,000(13.332) = \$399,960$$

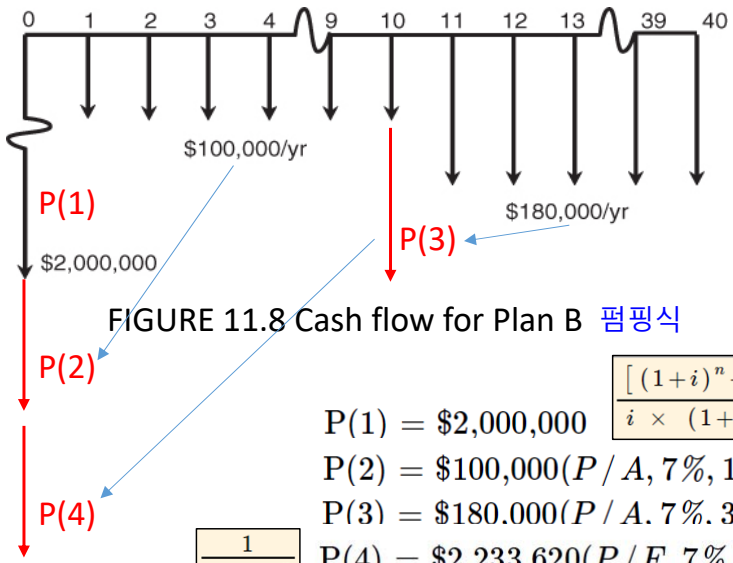
$$P(\text{total}) = \$2,800,000 + \$399,960 = \boxed{\$3,199,960}$$

The EAW is

$$\text{EAW} = \$3,199,960(A/P, 7\%, 40) = \$3,199,960(.07501) = \boxed{\$240,029.00}$$

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11.21 Comparison Using Equivalent Annual Worth (4/4)



중력식 펌핑식
 Because \$240,029 is < \$287,886,
 Option A is less expensive and should be selected.
 중력식의 비용이 더 낮음 → 중력식 선택

FIGURE 11.8 Cash flow for Plan B 펌핑식

$$P(1) = \$2,000,000 \frac{[(1+i)^n - 1]}{i \times (1+i)^n}$$

$$P(2) = \$100,000(P/A, 7\%, 10) = \$100,000(7.024) = \$702,400.00$$

$$P(3) = \$180,000(P/A, 7\%, 30) = \$180,000(12.404) = \$2,233,620$$

$$P(4) = \$2,233,620(P/F, 7\%, 10) = \$2,233,620(0.5084) = \$1,135,572.$$

$$P(\text{total}) = P(1) + P(2) + P(4) = \$2,000,000 + \$702,400 + \$1,135,572 = 3,837,972$$

$$EAW = \$3,837,972(A/P, 7\%, 40) = \$3,837,972(0.07501) = \$287,886.31$$

11.22 Summary

- ❑ No enterprise can survive the modern business environment without a good grasp of **the concepts and techniques of the time value of money.** 돈의 시간적 가치를 잘 이해해야 함
- ❑ Time value of money and the mathematical techniques available for considering value in various borrowing and repayment sequences are important concepts that assist **construction managers as well as engineers in dealing with financial issues.** 건설기술자나 건설관리자 모두 올바른 의사결정을 위해 경제성 분석 기법을 익혀야 함

CHAPTER 12

PROJECT CASH FLOW

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

12.1 Cash Flow Projection (1/2)

- ❑ The **projection of income and expense** during the life of a project can be developed from several **time-scheduling aids** used by the contractor. 스케줄링 도구를 이용하여 프로젝트 기간 내 발생하는 수입과 비용 추산 가능
- ❑ The owner requires the contractor to provide an **S-curve** of estimated progress and costs across the life of the project. 발주자는 시공사에 시간 축과 준공률 축을 갖는 S-Curve (Production curve, Objective chart) 제공을 요구
- ❑ The contractor develops this by constructing a simple bar chart of the project, **assigning costs to the bars**, and smoothly connecting the projected amounts of expenditures over time. 시공사는 공정별로 바차트에 비용을 할당한 후 이를 스무딩(Smoothing)하여 S-Curve를 작성

12.1 Cash Flow Projection (2/2)

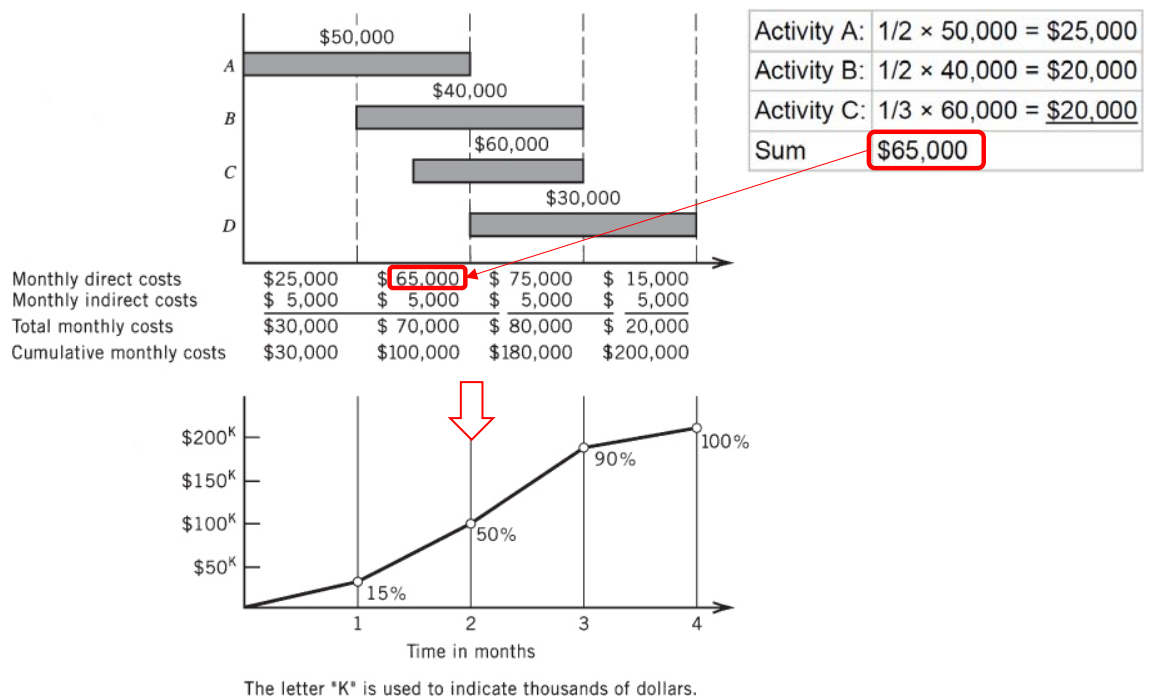


FIGURE 12.1 Development of the S-curve

12.2 Cash Flow to the Contractor (1/2)

Profit or markup: 25%

Retainage: 10% 지불유예금: 공정이 50%를 넘어서면 부과하지 않음

$$\text{Pay} = 1.25(\text{indirect expense} + \text{direct expense}) - 0.10[1.25(\text{indirect expense} + \text{direct expense})]$$

$$= 1.125(\text{indirect expense} + \text{direct expense})$$

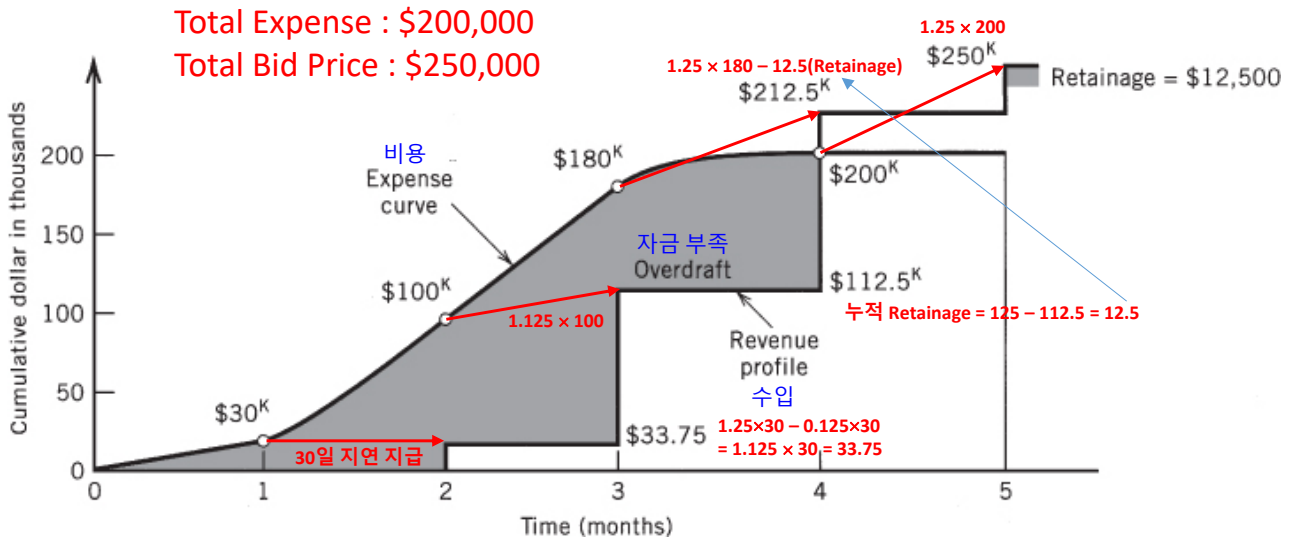


FIGURE 12.2 Expenses and payments profiles

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12.2 Cash Flow to the Contractor (2/2)

- ❑ The **prime rate** is the interest rate charged preferred customers who are rated as **reliable** and who represent an extremely small risk of default. 기본 이율: 최소의 위험을 가진 고객에 대한 이자율
- ❑ Construction Contractor = Prime Rate + Customer Risk. 대출 이율 = 기본 이율 + 위험 할증
- ❑ 선수금, 착수금 지급: 시공자에 대한 신뢰가 있는 경우 금융비용 절감을 위해 발주자가 지급 → 금융비용 절감으로 인해 원가절감 효과 발생

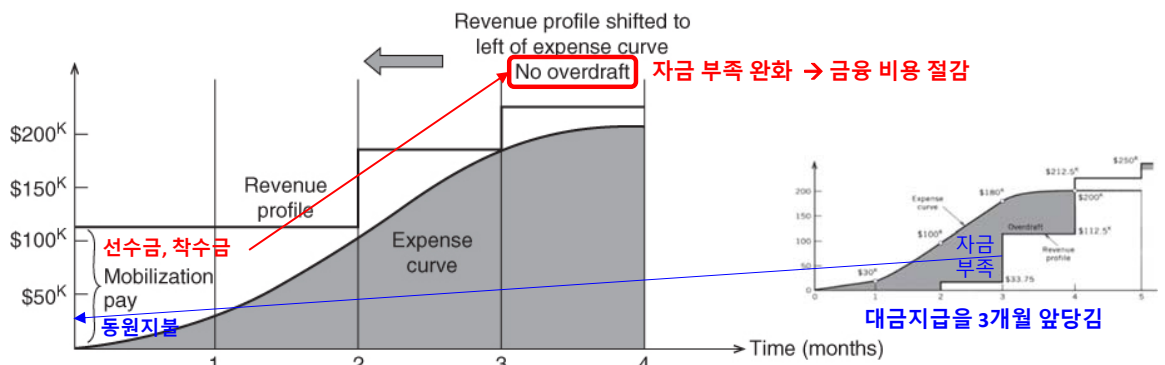


FIGURE 12.3 Influence of front (or mobilization) payment on profiles

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12.3 Overdraft Requirements (1/3)

Table 11.1 Overdraft Calculations

	기간	시점	기간	시점	기간	시점	기간	시점	기간
	2월중	2월말 3월초	3월중	3월말 4월초	4월중	4월말 5월초	5월중	5월말 6월초	6월중
	1	2	3	4	5	6			
Direct cost	\$25,000	\$65,000	\$75,000	\$15,000					
Indirect cost	5,000	5,000	5,000	5,000					
Subtotal 비용	30,000	70,000	80,000	20,000					
Markup (25%)	7,500	17,500	20,000	5,000					
Total billed	37,500	87,500	100,000	25,000					
Retainage withheld (10%)	3,750	8,750	0	0					
Payment received 수입			\$33,750	\$78,750	\$100,000	\$37,500			
Total cost to date	30,000	100,000	180,000	200,000	200,000	200,000			
Total amount billed to date	37,500	125,000	225,000	250,000	250,000	250,000			
Total paid to date									
Overdraft end of month	30,000	100,300	147,553	90,279	(8,818)^b	(8,818)^b			
Interest on overdraft balance^a 이자	300	1,003	1,476	903	0	0			
Total amount financed	30,300	101,303	149,029	91,182	(8,818)	(8,818)			
			최대 신용 규모						

^aA simple illustration only. Most lenders would calculate interest charges more precisely on the amount/time involved employing daily interest factors.

^bParentheses indicate a positive balance in this case.

$$250,000 - 200,000 \rightarrow 50,000 - (300 + 1,003 + 1,476 + 903) = 46,318$$

$$101,303 - 33,750 + 80,000 \rightarrow 147,553 + 1,476 = 149,029$$

$$2월 잔고 - 3월 수입 + 3월 비용 \rightarrow 3월 부족 자금 + 이자 = 3월 잔고$$

2월 대출 필요 잔고
(필요 신용)

3월 대출 필요 잔고
(필요 신용)

12.3 Overdraft Requirements (2/3)

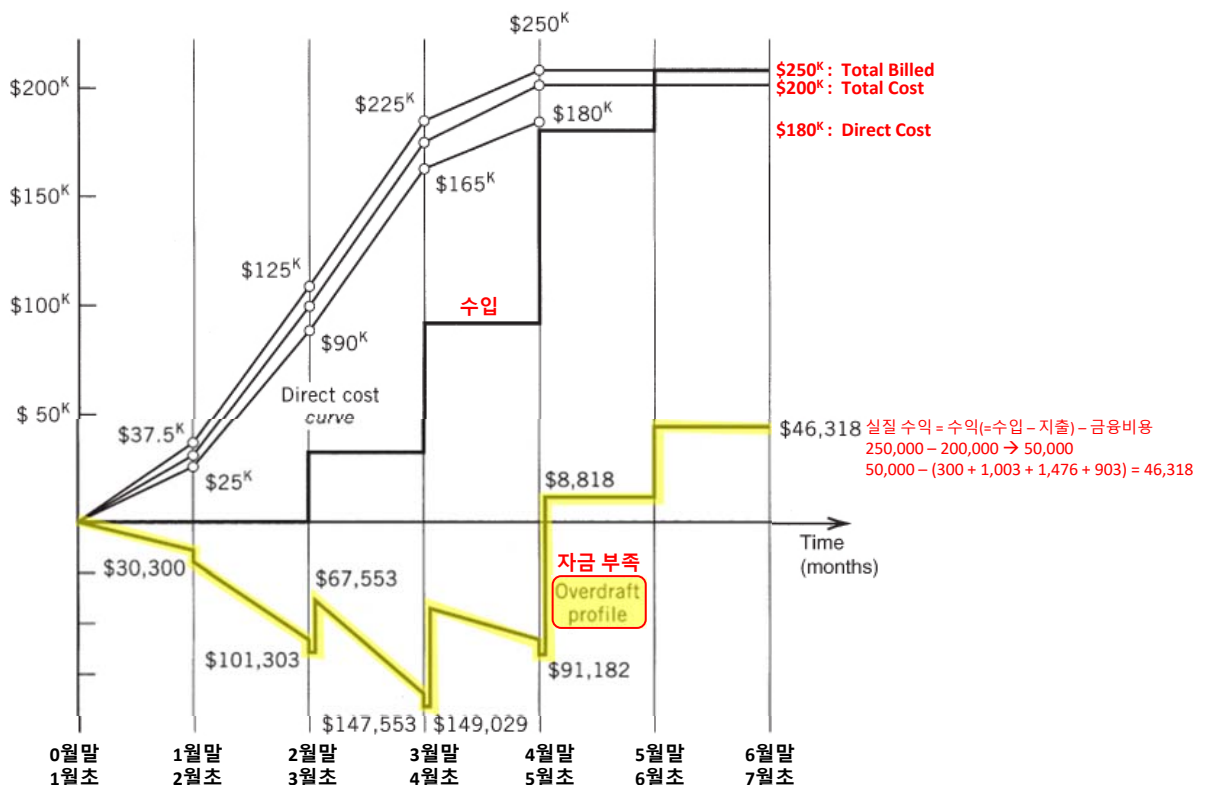


FIGURE 12.4 Plot of maximum overdraft

12.3 Overdraft Requirements (3/3)

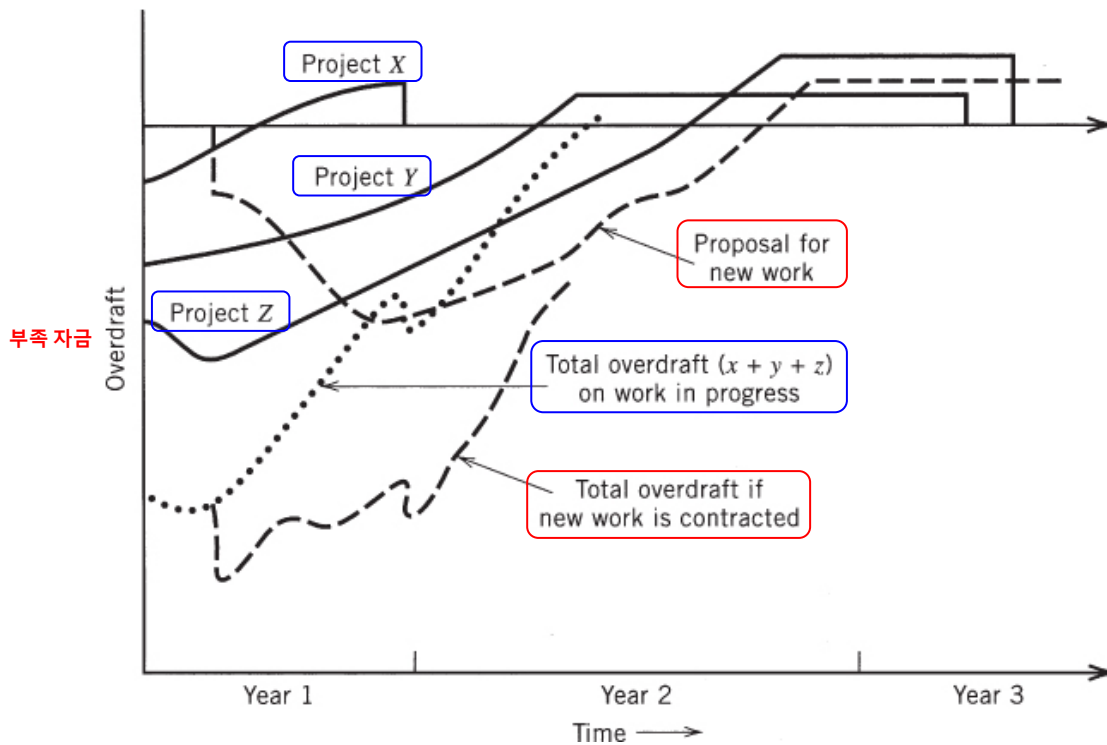


FIGURE 12.5 Composite overdraft profiles

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12.4 Comparison of Payment Schemes (1/4)

The IRR for a given sequence of payments and expenditures

$$\sum^{all I} PW[Rev(I)] - \sum^{all I} PW[Exp(I)] = 0$$

Where

Rev(*i*) = revenue for period *i*

Exp(*i*) = expenditure for period *i*

PW = present worth of these values

수익률은 수익의 현재가치와 비용의 현재가치의 합을 0으로 만들어 주는 이자율

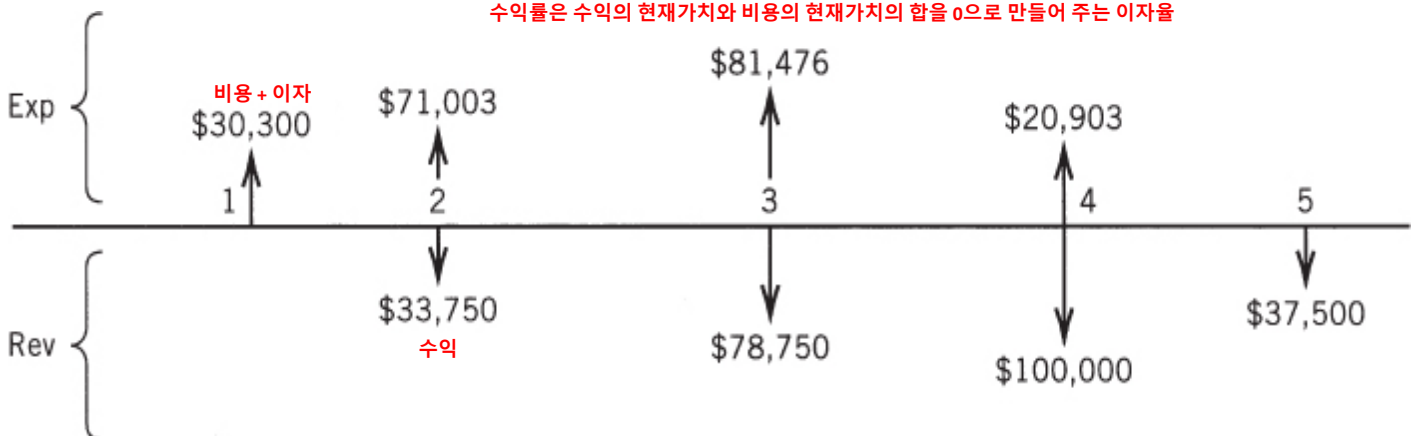


FIGURE 12.6 ROR for small bar chart problem

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12.4 Comparison of Payment Schemes (2/4)

TABLE 12.2

ROR Calculations for Small Project

N	NET ^a	PWF ^b @ 20%	Total @ 20%	PWF @ 25%	Total @ 25%	PWF @ 22%	Total @ 22%
1	-30300	0.8333	-25249	0.8000	-24240	0.8196	-24834
2	-37253	0.6944	-25868	0.6400	-23842	0.6719	-25030
3	-2726	0.5787	-1577	0.5120	-1396	0.5507	-1501
4	79097	0.4822	38140	0.4096	32398	0.4514	35704
5	37500	0.4019	15071	0.3277	12289	0.3700	13875
			Σ = + 517		Σ = - 4971		Σ = - 1786

$$\frac{X}{2\%} = \frac{517}{(1786 + 517)}$$

$$X = 0.45\%$$

ROR = 20% + 0.45% = 20.45%

^a A negative net value indicates expenses exceed revenue for this period.

^b PWF = Present Worth Factor.

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12.4 Comparison of Payment Schemes (3/4)

	Month					
	1	2	3	4	5	6
Direct cost	\$25,000	\$65,000	\$75,000	\$15,000		
Indirect cost	5,000	5,000	5,000	5,000		
Subtotal	30,000	70,000	80,000	20,000		
Markup (25%)	7,500	17,500	20,000	5,000		
Total billed	37,500	87,500	100,000	25,000		
Retainage withheld (10%)	3,750	8,750	0	0		
Payment received	\$20,000	\$33,750	\$ 78,750		\$100,000	\$ 17,500
Total cost to date	30,000	100,000	180,000	200,000	200,000	
Total amount billed to date	37,500	125,000	225,000	250,000	250,000	
Total paid to date		\$20,000	\$53,750	\$132,000	\$232,500	\$250,000
Overdraft end of month	30,000	80,300	127,353	69,877	(29,424) ^a	(46,924) ^a
Interest on overdraft balance	300	803	1,274	699	0	0
Total amount financed	\$30,300	\$81,103	\$128,627	\$70,576	(29,424)	

^a Parentheses indicate a positive balance.

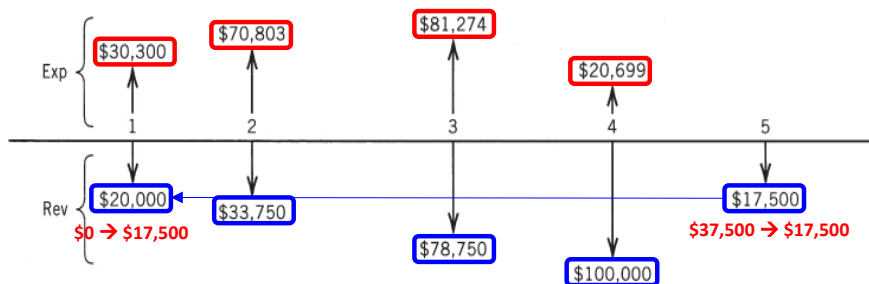


FIGURE 12.7 ROR for small bar chart problem with mobilization payment : 동원 지불 \$20,000

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12.4 Comparison of Payment Schemes (4/4)

TABLE 12.4							
ROR Calculations to Include Mobilization Payment							
N	Net ^a	PWF ^b 30%	Total @ 30%	PWF 32%	Total @ 32%	PWF 34%	Total @ 34%
1	-10300	0.7692	-7923	0.7575	-7802	0.7463	-7687
2	-37053	0.5917	-21925	0.5739	-21265	0.5569	-20635
3	-2524	0.4552	-1149	0.4348	-1097	0.4156	-1049
4	79301	0.3501	27765	0.3294	26122	0.3101	24591
5	17500	0.2693	4713	0.2495	4366	0.2315	4051
			$\Sigma = 1482$		$\Sigma = 324$		$\Sigma = -729$
			$\frac{X}{2\%} = \frac{324}{(324 + 729)}$ $X = 0.62\%$		$\text{ROR} = [32 + 0.62]\%$ $= 32.62\% \uparrow \text{수익률 증가}$		

^a A negative net value indicates expenses exceed revenue for this period.

^b PWF = Present Worth Factor.

20.45% → 32.62%

CHAPTER 13

PROJECT FUNDING

제1장	History and Basic Concepts
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제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

13.1 Money: A Basic Resource

- ❑ The **essential resource** ingredients that must be considered in the construction of a project are usually referred to as the **four Ms**. 건설을 위한 기본적인 자원
- ❑ These basic construction resources are (a) **money**, (b) **machines**, (c) **manpower**, and (d) **materials**. 자금, 장비, 인력, 자재
- ❑ In this chapter, the methods by which the owner/entrepreneur acquires project funding will be considered. 자금 조달에 대해 논의

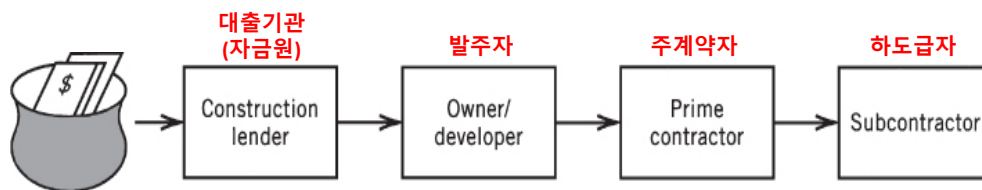


FIGURE 13.1 Project money flow

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13.2 Construction Financing Process (1/2)

- ❑ The owner's financing of any significant undertaking typically requires two types of funding: **short-term** (construction) funding and **long-term** (mortgage) funding. 단기 자금(건설 공사 시 대출 자금, 예: 분양사업), 장기 자금(준공 후 부동산 담보 대출, 예: 임대사업)
- ❑ The short-term funding is usually in the form of a **construction loan**, whereas the long-term financing involves a **mortgage loan** over a term ranging from 10 to 30 years. 단기 건설 자금 대출 vs 장기 부동산 담보 대출
- ❑ 자금원: real estate investment trusts (REITs), investment or merchant banks, commercial banks, savings and loan associations, insurance companies, governmental agencies (e.g., Veterans Administration, Federal Housing Administration), or, in special cases, from one of the international development banks. 다양한 자금원: REITs, 투자은행, 상업은행, 보험사, 정부기관, 세계개발은행 등

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13.2 Construction Financing Process (2/2)

□ **Loan application** (대출신청서) includes:

1. A set of **financial statements for the firm**. 기업의 재무제표
2. **Personal financial statements** from the principals of the firm. 기업 대표의 재무제표
3. Proof of clear **title to the land** (부동산 등기권리증) for the project and documentation that it has an appropriate zoning.
4. Preliminary **floor plans** and elevations (입면도, 정면도) for the project.
5. Preliminary **cost estimates**. 프로젝트 소요 비용 추정치
6. A **market research** study to verify expected income. 프로젝트 예상 수입 검증을 위한 시장조사 결과
7. A detailed pro forma (견적) indicating projected **income and expense** throughout the life of the mortgage loan. 비용과 지출로 구성된 프로젝트의 현금 흐름

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13.3 Long-Term Pro Forma Example (1/3)

□ Example: **75-unit apartment complex**. 필요한 대출금은 \$2,422,000

Market rent for subject property (unfurnished) 55 two-bedroom A, B, or C units—1167 sq ft @ 41.0 cents/sq ft = \$478.47/mo or \$480 × 55	\$	26,400.00	2 Bed 타입 55채 월 임대 수입
20 three-bedroom A, B units—1555 sq ft @ 37.3 cents/sq ft = \$580.00/mo \$580 × 20		11,600.00	3 Bed 타입 20채 월 임대 수입
Total estimated monthly income	\$	38,000.00	총 월 임대 수입
Other income: Coin laundry, vending machine		150.00	월 기타 수입
	\$	38,150.00	총 월 수입
× 12 = annual total		457,800.00	총 연 수입
Less vacancy factor of 5% (based on historical data)		-22,890.00	공실로 인한 수입 감소
Adjusted gross annual income		434,910.00	조정된 총 연 수입
Less estimated expenses @ 29.45% 운영 비용은 임대 수입의 29.45%		-128,080.00	운영비
Net income before debt service	\$	306,830.00	순수입
Capitalized value @ 9.5% = \$3,229,789.00 = $\frac{306,830.00}{(0.095)}$			자본화 가치
Requested loan value	=	\$2,422,000.00	
Loan/value ratio	=	75% (high) governed by law = $\frac{2,422,000}{3,229,789}$	
Long-term debt service @ 9.75% constant	=	\$236,145.00 = $2,422,000 \times 0.0975$	
Debt service coverage ratio	=	1.3 = $\frac{306,830}{236,145}$	
Loan per unit	=	\$32293.33 = $\frac{2,422,000}{75}$	
Loan per square foot	=	\$25.42 = $\frac{2,422,000}{(1167 \times 75 + 1555 \times 20)}$	

FIGURE 13.2(a) Pro forma for 75 apartment units

견적서

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13.3 Long-Term Pro Forma Example (2/3)

- ❑ Developer들은 재무적 투자자를 모집하여 초기투자비를 충당 → 자기자본 또는 대출 최소화 → 자신의 위험을 최소화하기 위한 목적
- ❑ The developer tries to expand a **small initial asset** input into a **large amount of usable money**. 시행사들은 최소한의 자기 부담으로 최대의 사업 자금을 마련하려고 함
- ❑ This is called **leverage**. 차입자본활용(소액 착수금 투자로 고수익을 노리는 것)
- ❑ **Small amount** → **lever or amplify** → **Large amount**

	1. Excavation and grading	\$ 67,500
	2. Storm sewers	48,000
	3. Sanitary sewers	84,030
	4. Water lines	28,000
	5. Electric lines	14,000
	6. Foundations	31,000
	7. Slabs	96,000
	8. Lumber and sheathing	185,000
	9. Rough carpentry	185,000
	10. Finish carpentry	81,362
	11. Roofing and labor	20,055
	12. Drywall and plaster	70,000
	13. Insulation	28,888
	14. Millwork	140,556
	15. Hardware	8,813
	16. Plumbing	165,000
	17. Heating and air conditioning	95,025
	18. Electrical	90,350
	19. Linoleum and tile	17,752
	20. Carpeting	101,881
	21. Kitchen cabinets	62,075
	22. Painting and decorating	107,000
	23. Masonry, block	20,680
	24. Masonry, brick	100,200
	25. Ranges and hoods	29,638
	26. Disposals	3,139
	27. Exhaust fans	1,022
	28. Refrigerator	35,040
	29. Paving	20,915
	30. Walks and curbs	20,792
	31. Landscaping	30,000
	32. Fence and walls	36,792
	33. Fireplace	51,100
	34. Cleanup	29,200
	35. Lender's fee	32,000
	36. Surveyor's fee	1,000
	37. Architect's fee	12,500
	38. Land cost	80,000
	39. Attorney's fee	7,500
	40. Title insurance premium	5,762
	41. Other closing costs	150
	42. Hazard insurance premium	4,780
	43. Construction loan interest	120,000
	44. Appraisal	750
	45. Building permit	1,500
	46. Tax	50,000
	Total	\$2,422,000

Construction Related Costs: 1-35
Non-Construction Costs: 36-46

Total \$2,422,000 = 요청대출금 → 자기자본 = 0

FIGURE 13.2(b) Construction cost breakdown for 75 apartment units

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13.3 Long-Term Pro Forma Example (3/3)

- ❑ The amount the lender is willing to lend as long-term funding is derived from two concepts: **the economic value of the project** and **the capitalization rate** (일종의 자본 수익률). 대출금은 프로젝트의 경제적 가치(예: 연간임대수입)와 자본 수익률(예: 자본화 비율)에 의해 결정됨
- ❑ **The economic value of the project = The expected net income / Capitalization rate**
- ❑ 초기 투자 부담 내역: Lender(타인자본) 75% + Developer(자기자본) 25%
 - Lender 대출 이자율 : 8.5%
 - Developer MARR (자본 수익률) : 12%
 - **Capitalization rate = 8.5% × 75% + 12% × 25% = 9.375%**
- ❑ **Lender** ← Mortgage Broker (2% agency fee) → **Developer**. 대출 중계 수수료 발생

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13.4 Mortgage Loan Commitment 담보대출

- ❑ The agreed-upon amount of funds will be provided at the stated **interest rate** for the stated **period of time**. 정해진 기간 동안 정해진 이자율로 대출 제공
- ❑ The formal commitment will define the **floor and ceiling amounts of the long-term loan**. 최종적으로는 장기 대출금의 상한과 하한을 정의
- ❑ 시공 중에는 **Short Term Fund(Construction Loan)**로 충당 → 완공 후 **Long Term fund (Mortgage Loan)**로 전환
- ❑ As noted previously, the **actual amount of funds** provided generally is **less than the entire amount needed for the venture**. This difference, called **owner's equity**, must be furnished from the entrepreneur's own funds or from some other source. 일반적으로 실제 대출금은 필요한 자금보다 작으므로, 부족분 만큼은 발주자 자체 자금으로 충당해야 함.

13.5 Construction Loan

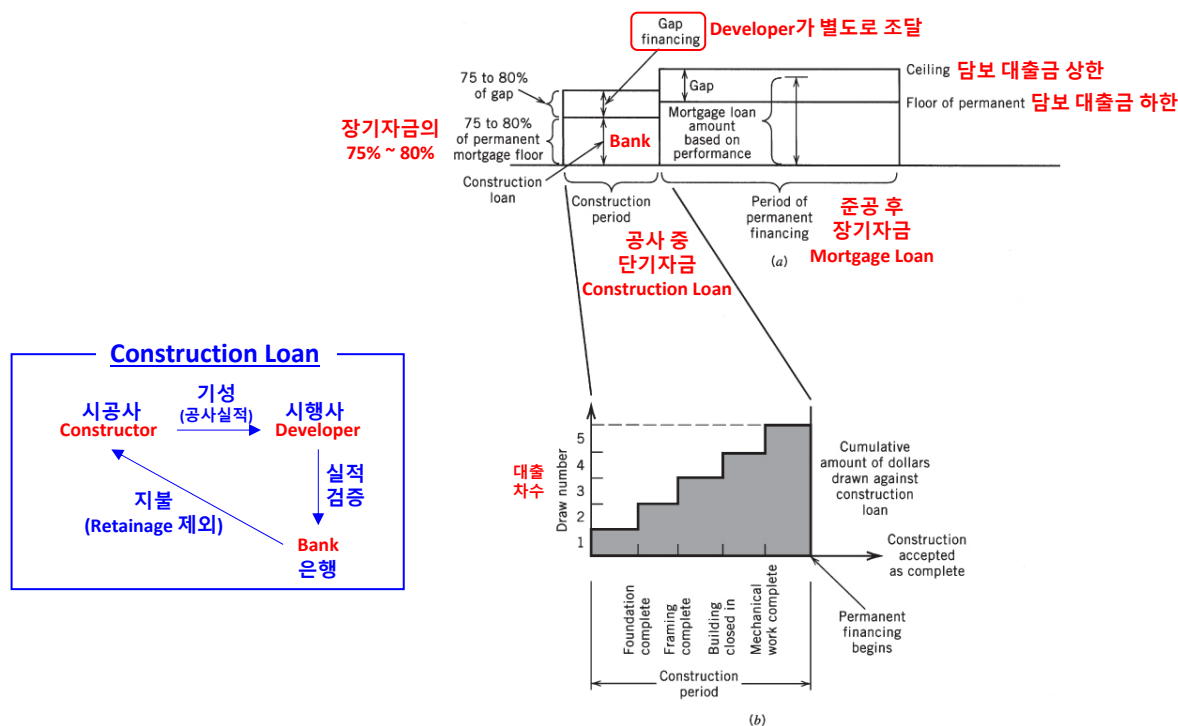


FIGURE 13.3 (a) Profile of project financing by entrepreneur and (b) draw schedule

13.6 Owner Financing Using Bonds (1/2)

- Large corporations and public institutions commonly use the procedure of **issuing bonds (채권)** to raise money for construction projects. 대기업들은 건설 자금 마련을 위해 채권 발행
- A bond is promising to **pay back** a sum of money at a future point in time. 채권: 일정 기간 후 원금과 이자를 돌려준다는 증권

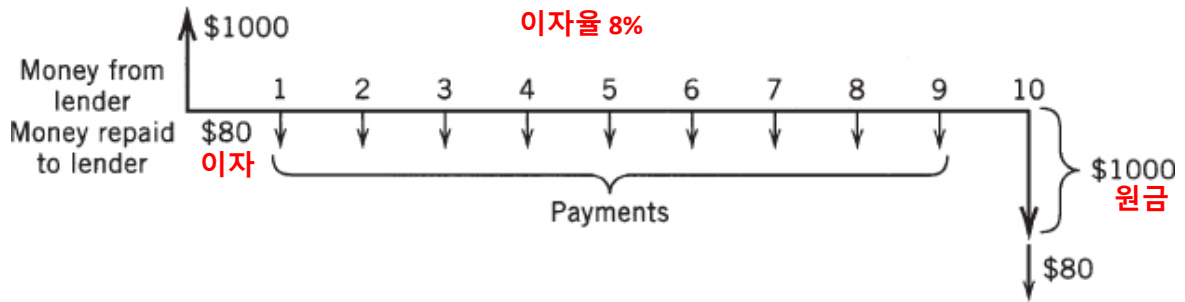


FIGURE 13.4 Sequence of payments for a bond

13.6 Owner Financing Using Bonds (2/2)

채권을 발행하여 $\$42 \times 10^6$ 을 조달: 이자율 5% 불변, 응찰자는 채권 구입 가격을 제시 → 최고액 제시 투자자 낙찰

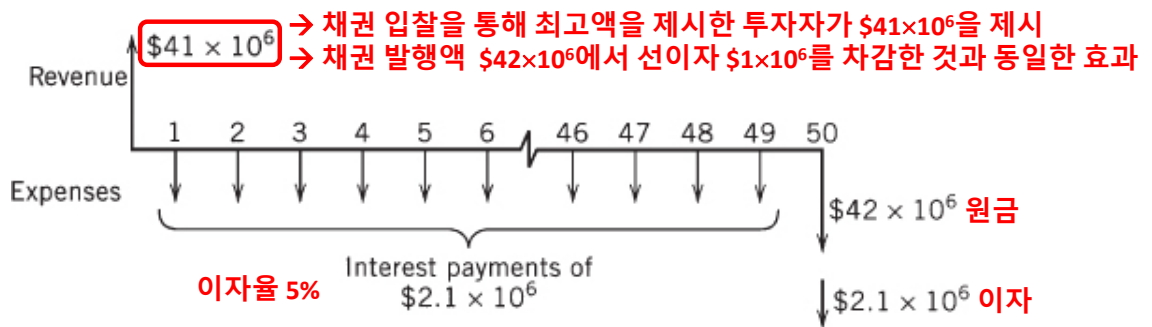


FIGURE 13.5 Profile of revenues and expenses for a bond issue

$$\$41,000,000 = \$2,100,000(P/A, i, 50 \text{ yr}) + \$42,000,000 (P/F, i, 50 \text{ yr}) \rightarrow i = 5.15\%$$

명목 조달 금리 5% → 실질 조달 금리 5.15%

13.7 Build, Operate, and Transfer (BOT) (1/2)

- ❑ Public Private Partnership (PPP)
- ❑ BOT was initiated in Turkey starting in 1984.
- ❑ Suez Canal by the French in the 19th century.

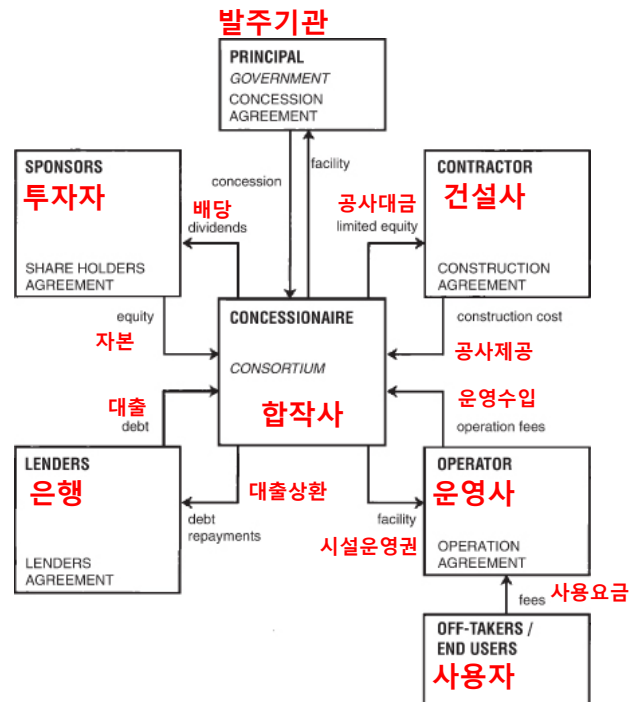


FIGURE 13.6 Stakeholders in BOT funding

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13.7 Build, Operate, and Transfer (2/2)

- ❑ The Confederation Bridge linking New Brunswick with Prince Edwards Island in Canada is an example of a BOT infrastructure project.
- ❑ 캐나다 동부의 15km 해상 교량 (통행료 : C\$47.75)



Russ Heinl/Getty Images



Andre Jenny/Alamy Stock Photo

FIGURE 13.7 Confederation Bridge Crossing, Prince Edwards Island, Canada

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CHAPTER 14

EQUIPMENT OWNERSHIP

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

14.1 General (1/3)

- ❑ The **manager's goal** is to select the equipment combination that yields **the maximum production at the best or most reasonable price**. 합리적 가격에 최대 생산성을 갖는 장비 선택
- ❑ 가격: \$500/hour, 용량: 750yard³/hour → 단가: 500/750 = \$0.66/yard³
- ❑ Construction equipment can be divided into two major categories: **건설장비 범주**
 1. **Productive equipment** describes units that alone or in combination lead to an end product that is **recognized as a unit** for payment: **pavers, haulers, loaders, rollers, and trenchers**. 주 장비 : 기성으로 연결되는 작업들을 담당 (건설 작업 수행)
 2. **Support equipment** is required for operations related to the placement of construction such as movement of personnel and materials and activities that influence the placement environment: **hoists, lighting sets, vibrators, scaffolds, and heaters**. 지원 장비 : 기성으로 연결되는 작업들을 지원 (건설 작업 환경 구축 담당)
- ❑ **Heavy construction** : 장비가 중요 → 장비 임대보다는 직접 소유가 유리
- ❑ **Building and industrial construction** : 인력이 중요 → 직접 소유보다는 장비 임대를 선호

14.1 General (2/3)

pavers



trenchers



rollers



loaders



haulers



14.1 General (3/3)

vibrators

hoists



heaters



lighting sets



scaffolds



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14.2 Equipment Ownership and Operating Costs

- ❑ The costs associated with construction equipment can be broken down into two major categories: Certain costs (**Fixed** or ownership **costs**; 고정비) & Operating costs (**Variable costs**; 변동비) **건설 장비 비용 = 고정비 + 변동비**
- ❑ Equipment cost: 미사용 시에는 일반 경비에 간접적으로 부과, 가동 중에는 해당 프로젝트에 직접 부과
- ❑ The hourly charge for a piece of equipment is made up of **four elements**: **ownership costs, operating costs, overhead costs, profit**. **장비 사용료 구성요소**

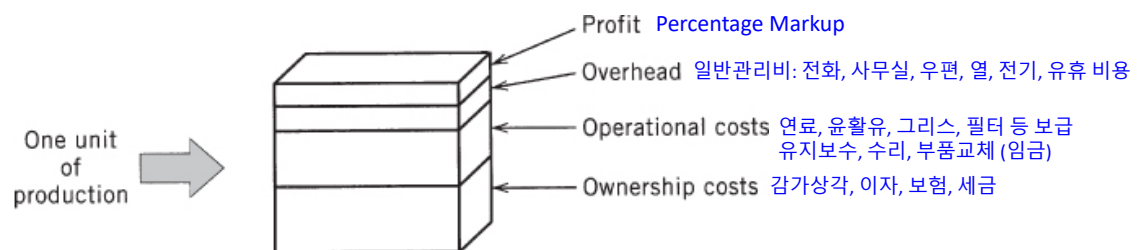


FIGURE 14.1 Cost components in a production unit

14.3 Depreciation of Equipment (1/3)

□ The three major factors form the three sides of the depreciation “box” : **initial cost or basis in dollars, service life in years or hours, salvage value in dollars.** 감가상각 결정 요인: 구입비용, 내용년수, 잔존가치

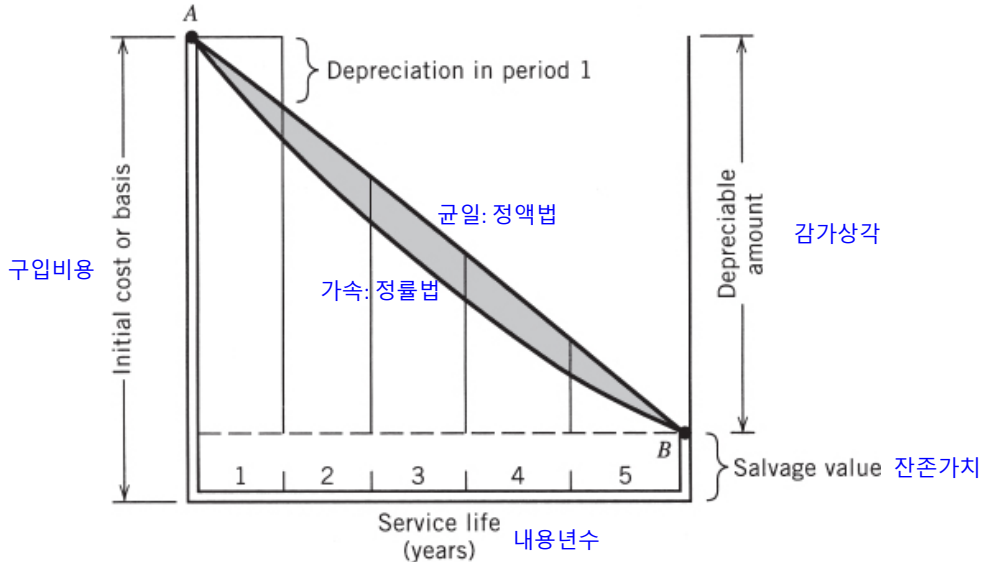


FIGURE 14.2 Factors in depreciation

14.3 Depreciation of Equipment (2/3)

□ 구입비용이 \$86,800인 장비를 최고세율 34%가 적용될 수 있도록 감가상각 한다면, 장비 전 생애에 걸쳐 총 $\$86,800 \times 0.34 = \$29,512$ 의 절세 효과를 얻을 수 있음.

Purchase price	\$84,000	(Price at factory, FOB, which means free on board)
Less tires	\$ 4,000	타이어는 장비비가 아닌 소모품비로 처리 → 당기의 비용으로 처리
	<u>\$80,000</u>	
Plus tax at 5%	\$ 4,000	
Plus freight	\$ 2,800	운송비
Net first cost	\$86,800	→ 감가상각 대상 금액

14.3 Depreciation of Equipment (3/3)

□ 사용 시간(양)에 비례하여 감가상각.

사용 시간 당 감가상각비
 Depreciation cost per hour = $\frac{\text{Purchase price} - \text{Tire value}}{\text{Estimated service life in hours}}$ 구입비 - 타이어 값 / 서비스 수명(총 사용 가능 시간)

TABLE 14.1

Estimated Service Life Table (Caterpillar Tractor Co.)

Type of Equipment	Excellent Conditions: Hours <small>좋은 작업 환경</small>	Average Conditions: Hours <small>보통 작업 환경</small>	Severe Conditions: Hours <small>나쁜 작업 환경</small>
Track-type tractors Traxcavators Wheeled loaders Wheeled tractors Scrapers	12,000 	10,000	8,000
Motor graders	15,000	12,000	10,000



14.4 Straight-Line Method (정액법) (1/2)

□ Initial cost : \$16,000 & salvage value : \$1,000 & The service life : 5 years

□ The amount of annual depreciation claimed each year is \$3000 = $(\$16,000 - \$1,000) / 5$

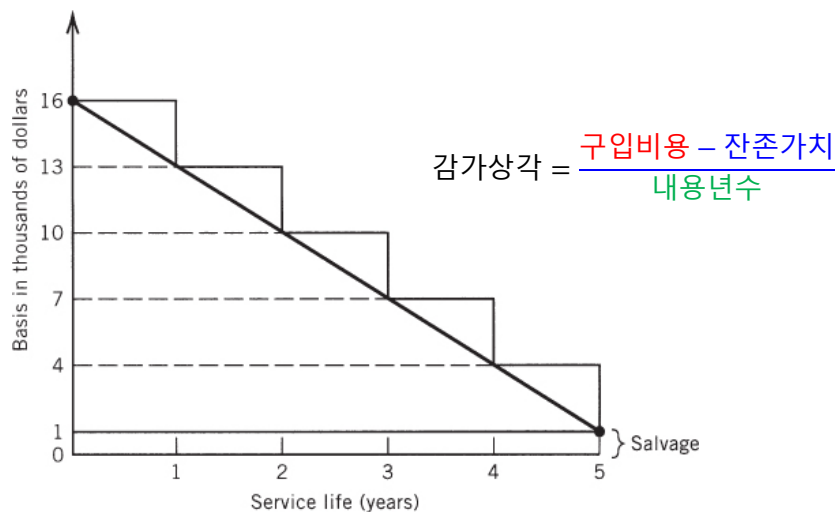


FIGURE 14.3 Straight-line depreciation

14.4 Straight-Line Method (2/2)

- 3년 차에 장비를 중고로 판매
- 3년차 Book Value : \$10,000
- 중고시장 판매가 : \$12,000
- 장비를 판매하여 \$2,000의 이익을 얻었으므로 이익에 대한 세금이 발생함 (고정자산처분세)

- 3년 차에 장비 가치가 변화: \$3,000를 들여 엔진을 교체
- Book Value : \$10,000 → \$13,000
- 감가상각 대상이 \$3,000 만큼 증가함
- 내용년수 : 5년 → 6년

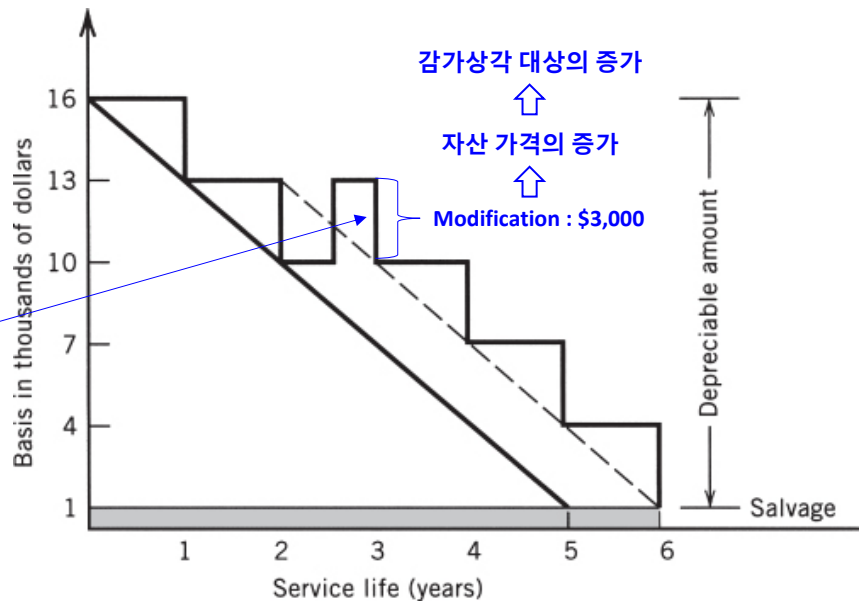


FIGURE 14.4 Adjustment of basis

14.5 Declining Balance (정률법) [= Double-Declining Balance (DDB)] (1/2)

두배 200% TABLE 14.2
Double Declining-Balance Method

SLY	Rate Applied to Balance (%)	Book Value End of Previous Year (\$)	Depreciation for this Year (\$)	Book Value End of this Year (\$)
1	40	16,000.00	6,400.00	9,600.00
2	40	9,600.00	3,840.00	5,760.00
3	40	5,760.00	2,304.00	3,456.00
4	40	3,456.00	1,382.40	2,073.60
5	40	2,073.60	829.44	1,244.16
		TOTAL	\$14,755.84	

(100% / 5년 = 20%/년)의 두배 → 40% 감가상각
매년 동일하게 40%씩 가치를 감소시킴 → 정률법

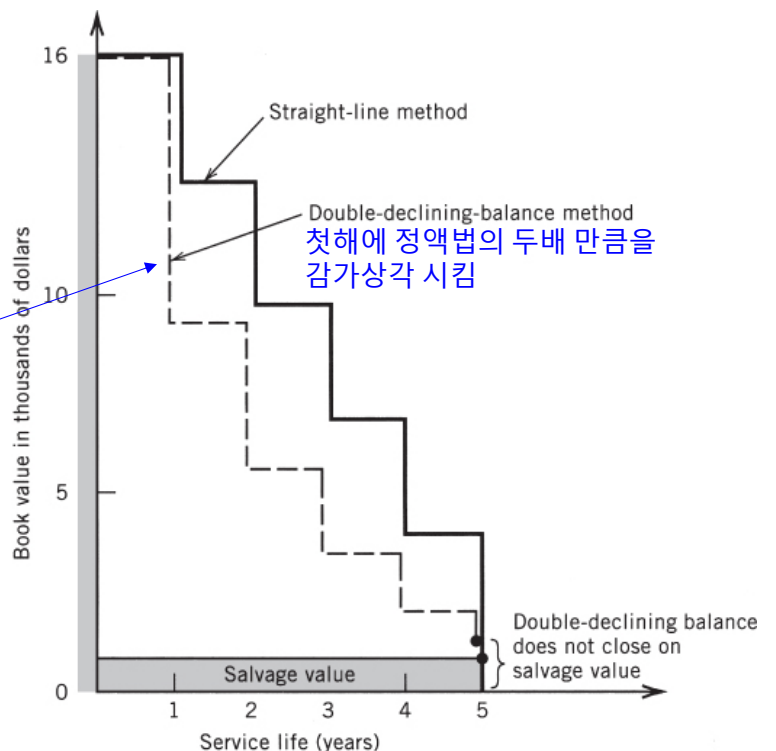


FIGURE 14.5 Comparison of double-declining balance and straight-line methods

14.5 Declining Balance (2/2)

TABLE 14.3

150 Declining-Balance Method

SLY	Rate (%)	Book Value End of Previous Year (\$)	Depreciation for this Year (\$)	Book Value End of this Year (\$)
1	30	16,000.00	4,800.00	11,200.00
2	30	11,200.00	3,360.00	7,840.00
3	30	7,840.00	2,352.00	5,488.00
4	30	5,488.00	1,646.40	3,841.60
5	30	3,841.60	1,152.48	2,689.12
		TOTAL \$13,310.88		

(100% / 5년 = 20%/년)의 1.5배 → 30% 감가상각
첫해에 정액법의 1.5배 만큼을 감가상각 시킴

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14.6 Production Method (사용량 비례법)

- 사용량 비례법 → 소기업에서 주로 사용 → 장비를 사용하는 기간에 이익이 발생할 가능성이 높다는 가정(실제 장비를 사용할 때만 감가상각 시킴)
- 감가상각 방법 선택은 세금을 최소화 하는 방향으로...
- 가스관 프로젝트 → 설치 후 몇 년간(건설기간)은 이익이 미 발생 → 이 기간에는 감가상각을 하고 싶지 않다 → 가스가 흐르기 시작할 때부터 감가상각 실시 → 사용량 비례법 사용
- 수명이 10,000 시간인 장비가 1년에 500시간밖에 사용되지 않는다면 감가상각이 완료될때까지 20년의 세월이 필요하다. → 사용량 비례법이 불리할 수 있음 (감가상각은 돈의 시간적 가치를 무시 : 미래에는 돈의 가치가 감소하기 때문에, 동일한 세금 절감 효과를 보더라도 현재 혜택을 보는 것 보다 돈의 가치가 떨어짐)

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14.7 Depreciation Based on Current Law

- Standard depreciation system is referred to as the **Modified ACRS (Accelerated Cost Recovery System)** or **MACRS**. 표준감가상각법
- DDB based method 정률법 기반
- Half-year convention: 첫해는 절반(DDB의 50%)만 감가상각
- \$100,000 장비 감가상각 사례

Year	Depreciation (\$)	Book Value (\$)
1	\$20,000	\$80,000
2	\$32,000	\$48,000
3	\$19,200	\$28,800
4	\$11,520	\$17,280
5	\$11,520	\$ 5,760
6	\$ 5,760	\$ 0

MACRS Table for Accelerated Depreciation						
Recovery Year	Annual Recovery (Percent of Original Depreciable Basis)					
	3-Year Class (200% d.b.)	5-Year Class (200% d.b.)	7-Year Class (200% d.b.)	10-Year Class (200% d.b.)	15-Year Class (150% d.b.)	20-Year Class (150% d.b.)
1	33.00	20.00	14.28	10.00	5.00	3.75
2	45.00	32.00	24.49	18.00	9.50	7.22
3	15.00	19.20	17.49	14.40	8.55	6.68
4	7.00	11.52	12.49	11.52	7.69	6.18
5		11.52	8.93	9.22	6.93	5.71
6		5.76	8.93	7.37	6.23	5.28
7			8.93	6.55	5.90	4.89
8			4.46	6.55	5.90	4.52
9				6.55	5.90	4.46
10				6.55	5.90	4.46
11				3.29	5.90	4.46
12					5.90	4.46
13					5.90	4.46
14					5.90	4.46
15					5.90	4.46
16					3.00	4.46
17						4.46
18						4.46
19						4.46
20						4.46
21						2.25

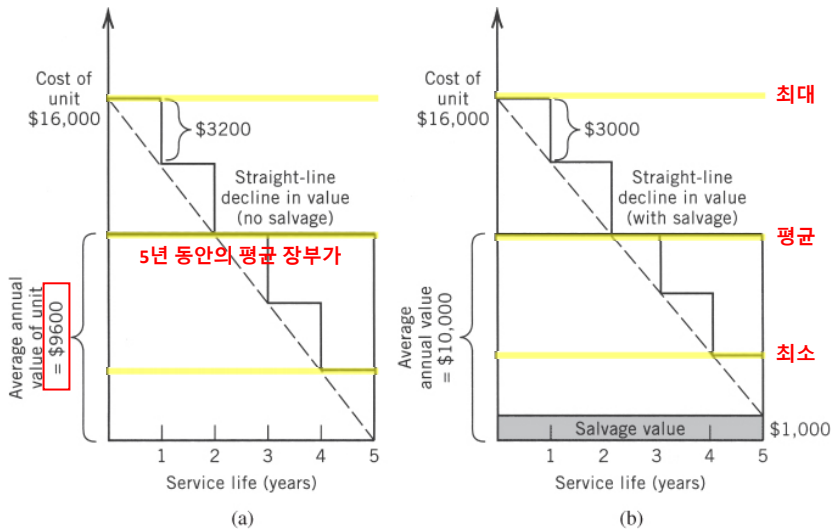
100%/5년 × 2배 = 40%/년
 1년차: 장부가 100% × 40% = 40% 중 절반인 20% 감가
 2년차: 장부가 80% × 40% = 32% 감가
 3년차: 장부가 48% × 40% = 19.2% 감가
 4, 5년차: 정액법으로 전환:
 장부가 28.8% × 40% = 11.52% 감가
 잔존가치: 5.76% ← 11.52의 절반 (6년차에 감가상각)

14.8 Depreciation versus Amortization

- This practice of charging clients an amount to be used to purchase replacement equipment is referred to as **amortizing** (분할상환, 점진상각) the equipment. 장비 교체 시 활용
- \$100,000 가격의 장비 활용 경우 (세율 34% 가정): Depreciation 34%, Amortization 66%
- 미래 새 장비 구입을 위해 필요한 금액 : 장비구입비 \$100,000에서 감가상각(Depreciation)을 통한 세금 절감분 \$34,000을 차감한 금액 \$66,000 → 새 장비 구입에 필요한 금액을 내용년수로 나누어 고객에게 미리 청구 (Amortization) → 내용년수가 지난 후 적립된 자금과 감가상각을 통한 세금 절감분을 활용하여 새 장비 구입
- Amortization** : 미래의 장비 구입비에서 감가상각을 통한 세금 절감분을 뺀 순 필요 금액을 내용년수 동안 분할하여 사전에 고객에게 청구 → 건설사 매출(수입) 증가 → 건설사 세금 증가

14.9 Interest, Insurance, and Tax Costs (1/2)

- \square Total ownership costs = $\frac{\$66,000 + \$34,000}{\text{장비구입비}}$ + interest, insurance, and tax (IIT) costs. 이자, 보험, 세금
- \square Average Annual Value (AAV) : 전체 수명 기간 동안 장비가의 평균액
- \square IIT는 AAV에 대한 백분율로 표시



14.9 Interest, Insurance, and Tax Costs (2/2)

- \square IIT는 AAV에 대한 백분율로 표시

Interest = 8% of AAV
 Insurance = 3% of AAV
 Taxes = 2% of AAV
 Total = 13% of AAV

$$IIT = 0.13(AAV) / \text{사용시간} = \frac{0.13(9600)}{2000} = \$0.624 \text{ or } \$0.62 \text{ per hour}$$

Percentage of AAV (%)	General Provision for IIT Costs (\$)	Hourly Rate (Base 2,000 hours, \$)
13	1,248	0.62
14	1,344	0.67
15	1,440	0.72
16	1,536	0.77
17	1,632	0.82
18	1,728	0.87

14.10 Operating Costs (1/3)

- ❑ The major components contributing to the **operating or variable costs** are **Fuel**, **Oil** (which includes filters), and **Grease (FOG)** as part of regular scheduled maintenance, **tire** (on rubber-wheeled vehicles) or **track replacement**, and **normal repairs**.
- ❑ Normally, **historical records** (e.g., purchase vouchers) are available **고장 이력 데이터 활용**
- ❑ Because **repairs** come in **discrete amounts**, the function has a **stepwise** appearance.

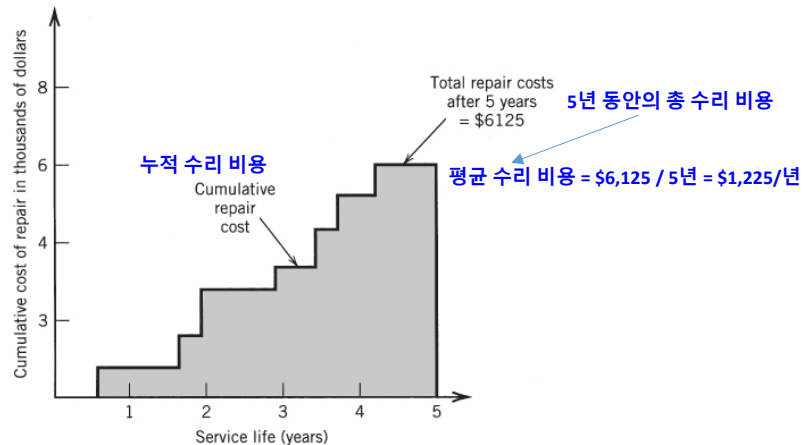


FIGURE 14.7 Repair cost profile

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14.10 Operating Costs (2/3)

- ❑ **타이어 이외의 시간당 수리비용**

$$\text{Repair factor} \times (\text{Delivered price} - \text{Tires}) / 1,000 = \text{Estimated hourly repair reserve}$$

작업 환경

	Operating Conditions		
	Excellent	Average	Severe
Track-type tractors	0.07	0.09	0.13
Wheel tractor scrapers	0.07	0.09	0.13
Off-highway trucks	0.06	0.08	0.11
Wheel-type tractors	0.04	0.06	0.09
Track-type loaders	0.07	0.09	0.13
Wheel loaders	0.04	0.06	0.09
Motor graders	0.03	0.05	0.07

- ❑ **타이어의 시간당 수리비용 :**

Initial cost : \$15,000 & service life : 5,000 hours

Hourly cost of tires = \$15,000/5000 = \$3.00

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14.10 Operating Costs (3/3)

- What is the optimum duration for **economic life of the machine**? 장비의 경제 수명

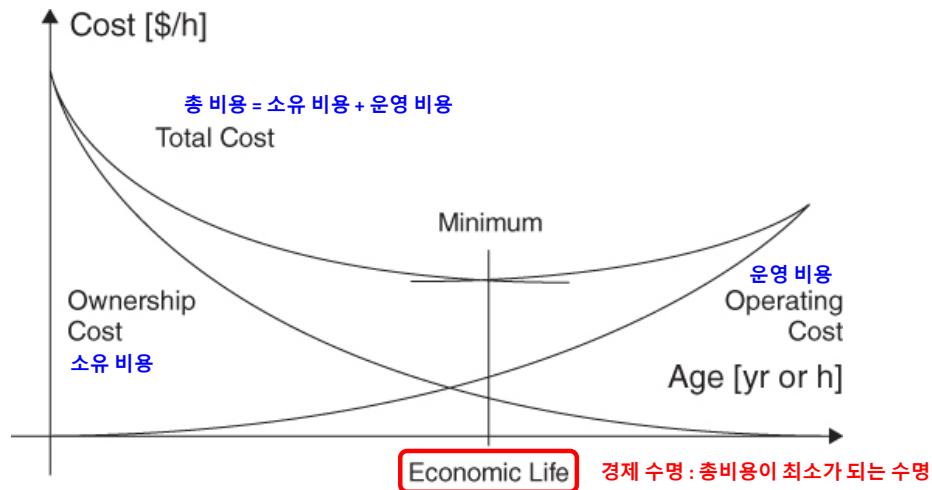


FIGURE 14.8 Ownership, operating, and total cost of economic life

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14.11 Overhead and Markup

- In addition to the **direct costs of ownership and operation**, **general overhead costs** must be considered in recovering costs associated with equipment ownership and operation. 소유 비용과 운영 비용 이외에 간접비(경비) 발생
- Overhead charges include items such as the **costs of operating the maintenance force and facility** including: 경비는 유지보수 관련 비용 포함
 - (a) **wages of the mechanics and supervisory personnel** 정비사 급여
 - (b) **clerical and records support** 보조원 급여
 - (c) **rental or amortization of the maintenance facility** (i.e., maintenance bays, lifts, machinery, and instruments) 유지보수 장비/시설 임대료
- **Overhead rates** 경비율로 반영
- **Markup or profit**: competitive may be only **1 or 2%**. 경쟁력을 갖기 위한 마진(margin)를

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CHAPTER 15

EQUIPMENT PRODUCTIVITY

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

15.1 Need for Heavy Equipment

- ❑ Heavy **construction equipment** is needed to **amplify human reach, speed, and capacity**. 건설업에서는 장비로 인력 수요를 대체하는 것이 가능
- ❑ The manager's goal is to **select the equipment combination** that yields the **maximum production at the best or most reasonable price**. 최저 가격에 최대 생산성을 가진 장비 조합 결정
- ❑ The cost and the rate of production combine to yield the **cost per unit of production**.
 Cost of a particular fleet of haulers and loaders is **\$500 per hour** → **\$500/hour**
 Production rate is **750 cubic yards per hour** → **750yard³/hour**
Unit price is \$0.66 per cubic yard (= \$500 / 750yard³)
- ❑ Equipment can be classified by the nature of its work: It typically **Transforms** and **Transports** material. 변환 장비 vs 수송 장비
- ❑ Construction equipment can be divided into two major categories: **Productive** equipment and **Support** equipment. 주장비 vs 지원(보조)장비
- ❑ In heavy construction, **large quantities** of fluid or semifluid materials such as earth, concrete, and asphalt are handled and placed, **leading to the use of machines**. Heavy construction operations are referred to as being **equipment intensive**. 토목 분야 → 대규모 물량 공사 위주 (토공사, 콘크리트공사, 아스팔트포장공사 등) → 장비가 중요

15.2 Productivity Concepts (1/5)

- ❑ The **rate of output (capacity)** for equipment: 작업능력 = 작업량 × 작업률 = 작업량 / 작업시간
Cyclic capacity : the number of units produced per cycle: 작업량 (한번에 처리하는 양)
Cyclic rate : speed of an equipment piece : 작업률 = 1/작업시간 (단위 시간당 처리 회수)
- ❑ Different weight-to-volume ratio: **three types of measure** 밀도에 따라 구분
 (a) bank cubic yards, (b) loose cubic yards, (c) compacted cubic yards.

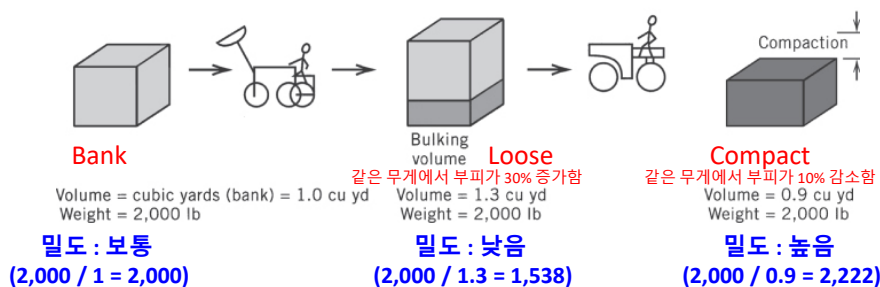


FIGURE 15.1 Volume relationships

15.2 Productivity Concepts (2/5)

- ❑ The relationship between the **bulk or loose** volume and the bank volume is defined by the **percent swell**. (예제: percent swell 30% → 같은 중량에 대해 부피가 30% 증가함)
- ❑ The **shrinkage factor** relates the volume of the **compacted** material to the volume of the **bank** material. In the example, the shrinkage factor is **10%** (같은 중량에 대해 부피가 10% 감소함)

$$\text{Percent swell} = \left[\left(\frac{1}{\text{load factor}} \right) - 1 \right] \times 100$$

Load factor = 1 → Percent swell = 0%

$$\text{Load factor} = \frac{\text{pounds per cubic yard - loose } \frac{1,538}{2,000}}{\text{pounds per cubic yard - bank}} \rightarrow 0.77$$

$$\text{Percent swell} = \left[\left(\frac{1}{0.77} \right) - 1 \right] \times 100 = 30\%$$

Load factor ↓ → Percent swell ↑
 Load factor ↑ → Percent swell ↓

15.2 Productivity Concepts (3/5)

$$\text{Percent swell} = \left[\left(\frac{1}{\text{load factor}} \right) - 1 \right] \times 100$$

$$\text{Load factor} = \frac{\text{pounds per cubic yard - loose}}{\text{pounds per cubic yard - bank}}$$

Table 14.1 Approximate Material Characteristics^a

Material	Pounds per Cubic Yard—Bank	Percent of Swell	Load Factor	Pounds per Cubic Yard—Loose
Clay, natural bed	2,960	40	0.72	2,130
Clay and gravel				
Dry	2,960	40	0.72	2,130
Wet	2,620	40	0.72	2,220
Clay, natural bed				
Anthracite	2,700	35	0.74	2,000
Bituminous	2,160	35	0.74	1,600
Earth, loam				
Dry	2,620	25	0.80	2,100
Wet	3,380	25	0.80	2,700
Gravel, 1/4-2 in.				
Dry	3,180	12	0.89	2,840
Wet	3,790	12	0.89	3,380
Gypsum	4,720	74	0.57	2,700
Iron ore				
Magnetite	5,520	33	0.75	4,680
Pyrite	5,120	33	0.75	4,340
Hematite	4,900	33	0.75	4,150
Limestone	4,400	67	0.60	2,620
Sand				
Dry, loose	2,690	12	0.89	2,400
Wet, packed	3,490	12	0.89	3,120
Sandstone	4,300	54	0.65	2,550
Trap rock	4,420	65	0.61	2,590

15.2 Productivity Concepts (4/5) 예제 (1/2)

- ❑ A front-end loader (200 bank yd³/hour). 1 loader : 200 bank yd³/hour
- ❑ It loads a fleet of four trucks (capacity 18 loose yd³ each), which haul the earth to a fill where it is compacted with a shrinkage factor of 10%. 4 trucks : 18 loose yd³
- ❑ Each truck has a total cycle time of 15 min. 트럭 운송 시간 : 15분
- ❑ The earth has a percent swell of 20%.
- ❑ The job requires a volume of 18,000 compacted yd³. 총 작업량 : 18,000 compacted yd³
- ❑ How many hours will be required to excavate and haul the material to the fill? 총 작업 소요 시간?
- ❑ Then the loader productivity (given 20% swell) is:

$$200 \text{ cu yd (bank)}/\text{hr} = 1.2(200) \text{ or } 240 \text{ cu yd (loose)}/\text{hr} \quad \text{병목장비: 생산용량을 제약하는 장비}$$

- ❑ The truck fleet production is:

$$\begin{aligned}
 4 \text{ trucks} &\times \frac{60 \text{ min}/\text{hr}}{15 \text{ min}/\text{cycle}} \times 18 \text{ cu yd (loose) truck} \\
 &= 72 \text{ cu yd (loose)} \times 4 \text{ cycle}/\text{hr} \\
 &= 288 \text{ cu yd (loose)}/\text{hr for 4 trucks}
 \end{aligned}$$

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15.2 Productivity Concepts (5/5) 예제 (2/2)

Because the loader production is lower, it constrains the system to a maximum output of 240 cu yd (loose)/hr. We must now determine how many loose cubic yards are represented by 18,000 cu yd (compacted).

$$18,000 \text{ cu yd compacted} = \frac{18,000}{0.9} \text{ or } 20,000 \text{ cu yd (bank)} \quad \text{shrinkage factor : 10\%} \quad \text{Compacted} \rightarrow \text{Bank}$$

$$20,000 \text{ cu yd (bank)} = 24,000 \text{ cu yd (loose) required} \quad \text{Bank} \rightarrow \text{Loose} \quad \text{percent swell of 20\%}$$

Therefore, the number of hours required is

$$\text{Hours} = \frac{24,000 \text{ cu yd (loose)}}{240 \text{ cu yd (loose)}/\text{hr}} = 100$$

This problem illustrates the interplay between volumes and the fact that machines that interact with other machine cycles may be constrained or constraining.

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15.3 Cycle Time and Power Requirements (1/4)

- In the case of heavy equipment, the **speed of the machine** is governed by : 장비 속도 결정 요인
 - (a) the **power required** 요구 출력
 - (b) the **power available** 가용 출력
 - (c) the **usable portion** of the power available 유효 가용 출력
- 요구 출력 결정 요인 : **rolling resistance (RR; 회전저항) & grade resistance (GR; 경사저항)**

TABLE 15.2

Typical Rolling Resistance Factors (Caterpillar Tractor Co.)

A hard, smooth, stabilized roadway without penetration under load (concrete or blacktop)	40 lb/ton
A firm, smooth-rolling roadway flexing slightly under load (macadam or gravel-topped road)	65 lb/ton
Snow-packed	50 lb/ton
Loose	90 lb/ton
A rutted dirt roadway, flexing considerably under load; little maintenance, no water (hard clay road, 1 in. or more tire penetration)	100 lb/ton
Rutted dirt roadway, no stabilization, somewhat soft under travel (4–6 in. tire penetration)	150 lb/ton
Soft, muddy, rutted roadway, or in sand	200–400 lb/ton

노면 상태가 무를수록 더 큰 힘이 필요함

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15.3 Cycle Time and Power Requirements (2/4)

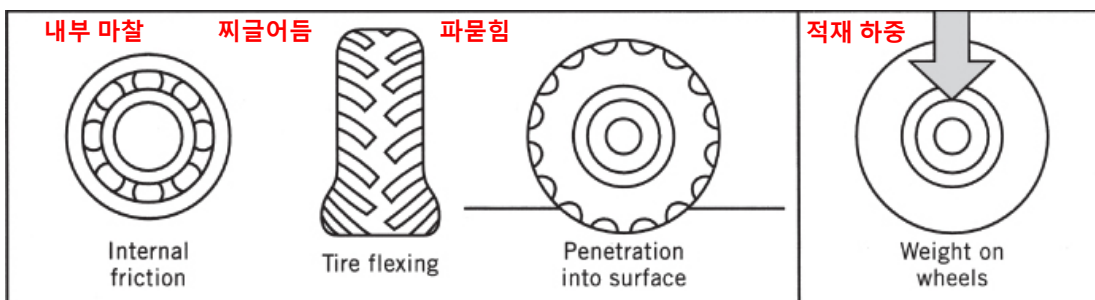
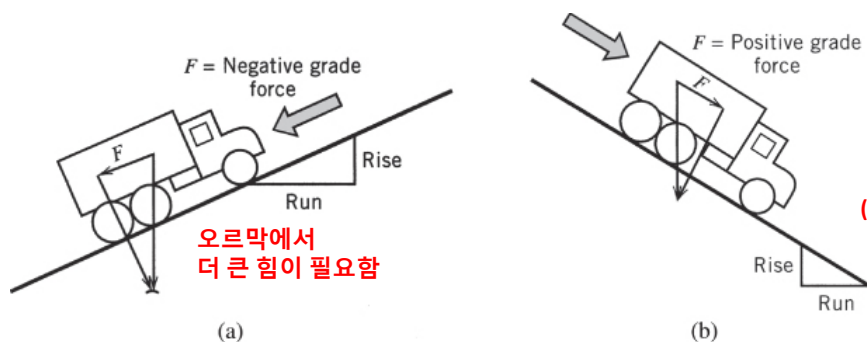


FIGURE 15.2 Factors influencing rolling resistance (4개 요인 → 회전저항의 크기 결정)

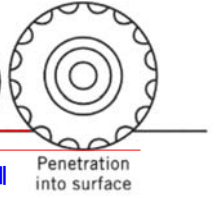


(노면 경사 → 경사저항의 크기 결정)

FIGURE 15.3 Grade resistance: (a) negative (resisting) force and (b) positive (aiding) force

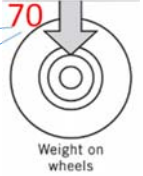
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15.3 Cycle Time and Power Requirements (3/4)



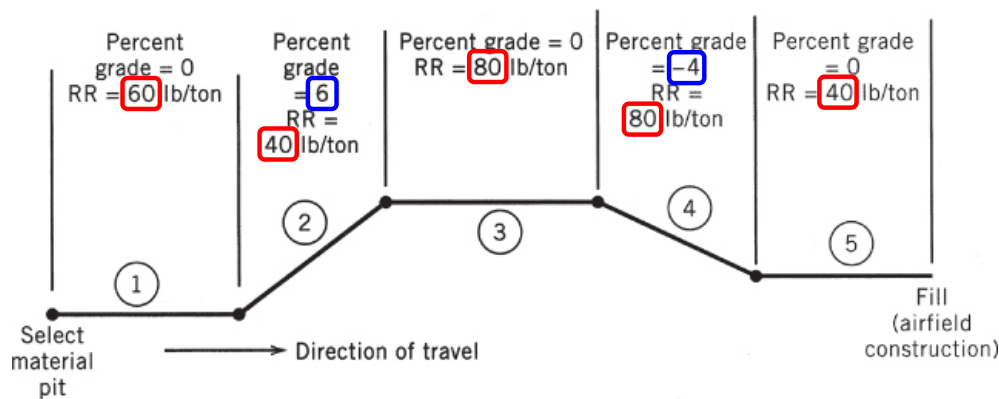
회전저항은 바퀴가 잠기는 높이에 비례

- ❑ The rule of thumb states that the RR is approximately 40 lbs/ton plus 30 lbs/ton for each inch of penetration of the surface under wheeled traffic.
- ❑ If the estimated deflection is 2 inches and the weight on the wheels of a hauler is 70 tons, we can calculate the approximate RR as:
- ❑ $RR = [40 + 2(30)] \text{ lb/ton} \times 70 \text{ tons} = 7,000 \text{ lb}$



- ❑ A slope rises 6 feet in 100 feet of horizontal distance, the percent grade is 6. 경사 : 6%
- ❑ Percent grade is used to calculate the GR using the following relationship:
- ❑ $GR = \text{percent grade} \times 20 \text{ lb}/(\text{ton} \times \% \text{ grade}) \times \text{weight on wheels}(\text{tons})$
- ❑ $GR = 6\% \text{ grade} \times 20 \text{ lb}/(\text{ton} \times \% \text{ grade}) \times 70 \text{ tons} = 8,400 \text{ lb}$
- ❑ Power required = $RR + GR = 7,000 \text{ lb} + 8,400 \text{ lb} = 15,400 \text{ lb}$ ← 오르막
- ❑ Power required = $RR - GR = 7,000 \text{ lb} - 8,400 \text{ lb} = -1,400 \text{ lb}$ ← 내리막

15.3 Cycle Time and Power Requirements (4/4)



Section	Percent Grade (%)	Grade Resistance (lb) / 경사 저항	Rolling Resistance (lb) / 회전 저항	Power Required (lb)
1	0	0	4,200	4,200
2	6	8,400	2,800	11,200
3	0	0	5,600	5,600
4	-4	-5,600	5,600	0
5	0	0	2,800	2,800

GR = # % grade × 20 lb/(ton × % grade) × 70 tons
 RR = # lb/ton × 70 tons

15.4 Power Available (1/3) 가용 출력

□ The power available is controlled by the **engine size** of the equipment and the **drive train** (동력 전달축). 가용 출력 결정 요인: 엔진 크기, 기어 비율

기어 전진속도 후진속도 정상출력 최대출력

Speed and Drawbar Pull (270 hp) (Track-Type Tractor)								
Drawbar Pull Forward ^a								
Gear	Forward		Reverse		At Rated rpm		Maximum at Lug	
	mph	km/h	mph	km/h	lb	kg	lb	kg
1	1.6	(2.6)	1.6	(2.6)	52,410	(23,790)	63,860	(28,990)
2	2.1	(3.4)	2.1	(3.4)	39,130	(17,760)	47,930	(21,760)
3	2.9	(4.7)	2.9	(4.7)	26,870	(12,200)	33,210	(15,080)
4	3.7	(6.0)	3.8	(6.1)	19,490	(8,850)	24,360	(11,060)
5	4.9	(7.9)	4.9	(7.9)	13,840	(6,280)	17,580	(7,980)
6	6.7	(10.8)	6.8	(10.9)	8,660	(3,930)	11,360	(5,160)

10,000 lb의 출력이 필요할 때 최대 가능 속도는?

Pounds Rimpull			
Gear	Speed	Rated	Maximum
1	2.6	38,670	49,100
2	5.0	20,000	25,390
3	8.1	12,190	15,465
4	13.8	7,185	9,115
5	22.6	4,375	5,550

^aUsable pull will depend on traction and weight of equipped tractor.

15.4 Power Available (2/3)

회전저항을 경사저항으로 변환하는 식

Route	Distance	RR	Equivalent Percent Grade
1	4.6 miles	50 lb/ton	2.5 → 2,500 lb, 41 mph
2	2.8 miles	90 lb/ton	4.5 → 5,500 lb, 19 mph

① Equivalent percent grade = (RR) / (20 lb/ton / % grade) Gross weight

35-ton, off-highway truck

경로 선택 문제

경로 #1:

4.6 miles (24,344 feet)

RR = 50lb/ton

경로 #2:

2.8 miles (14,784 feet)

RR = 90lb/ton

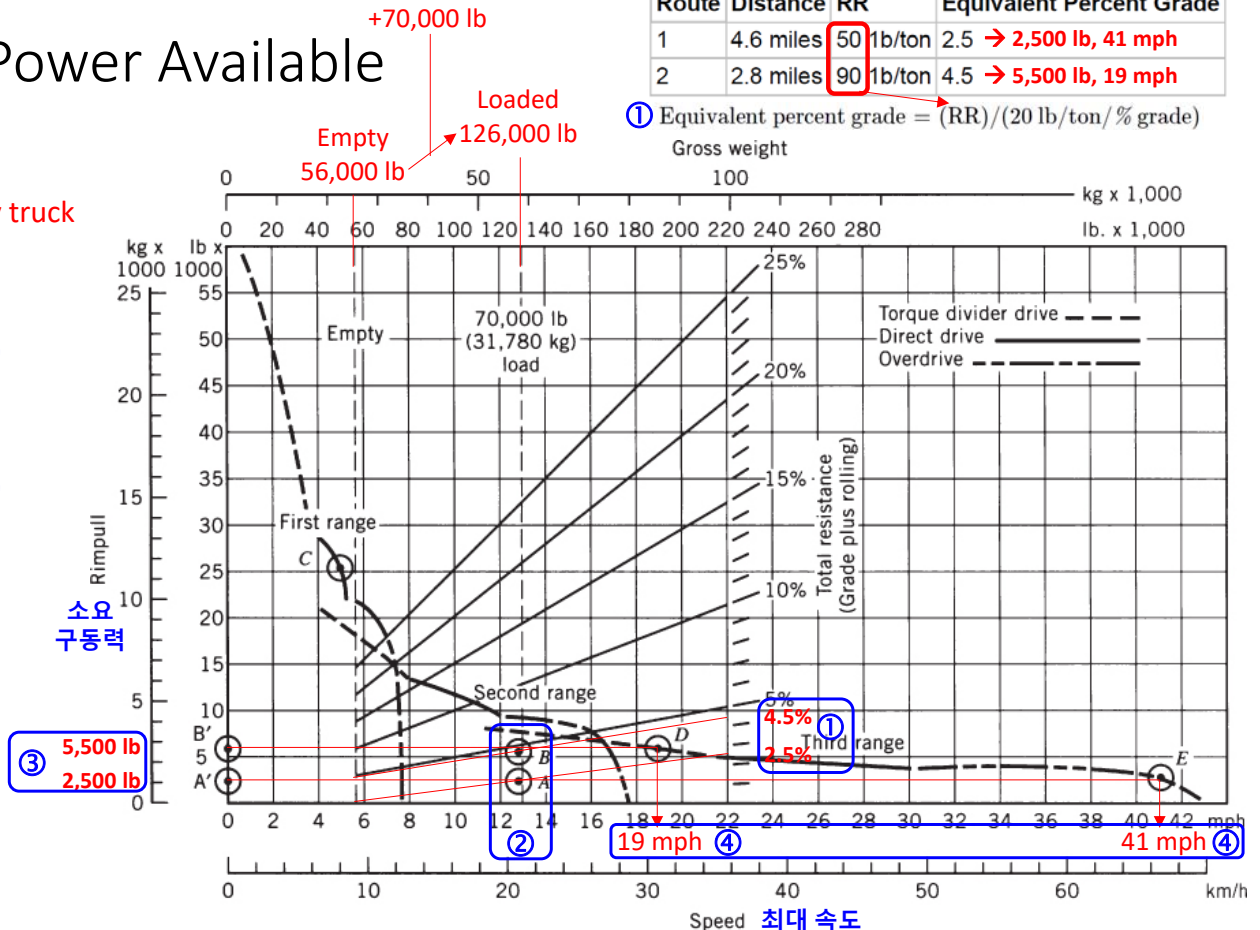


FIGURE 15.5 Gear requirements chart for 35-ton off-highway truck (Caterpillar Tractor Co.) 13

15.4 Power Available (3/3)

To break the 24,344 into two segments: 9.51분

(a) 16,000 ft : 7.2분

(b) 잔여 8,344 ft : 2.31분 (최대 속도 운행 가정)

$$= [8,344 \text{ ft} / (41 \text{ mi/h} \times 5,280 \text{ ft/mi})] \times 60 \text{ min}$$

운송 시간 추정

경로 #1: 9.51분

경로 #2: 9.5분

두 경로 모두 9.5분으로 동일한 운송시간 소요
→ 다른 요인을 고려하여 결정

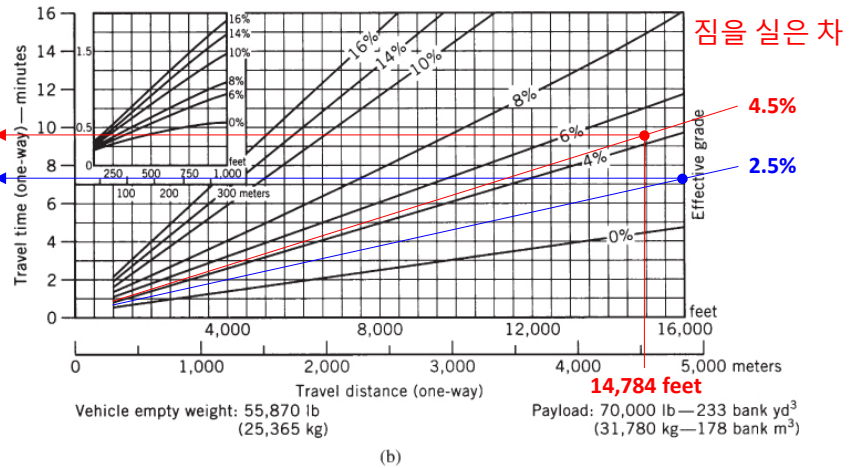
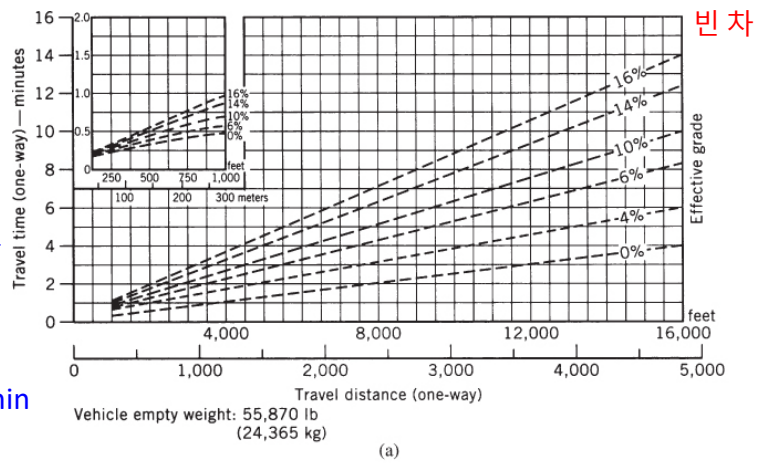


FIGURE 15.6 Travel time: (a) empty and (b) loaded (Caterpillar Tractor Co.)

15.5 Usable Power (1/4) 유효 가용 출력

□ Typical values for rubber-tired and tracked vehicles on an assortment of surface materials. 견인력 계수는 노면 종류에 따라 결정됨

Usable pounds pull
= (coefficient of traction) × (weight on drivers)

TABLE 15.5		
Coefficients of Traction 견인력 계수		
Materials	Rubber Tires	Tracks
Concrete	0.90	0.45
Clay loam, dry	0.55	0.90
Clay loam, wet	0.45	0.70
Rutted clay loam	0.40	0.70
Dry sand	0.20	0.30
Wet sand	0.40	0.50
Quarry pit	0.65	0.55
Gravel road (loose, not hard)	0.36	0.50
Packed snow	0.20	0.25
Ice	0.12	0.12
Firm earth	0.55	0.90
Loose earth	0.45	0.60
Coal, stockpiled	0.45	0.60

물 뿌리기

15.5 Usable Power (2/4)

Usable pounds pull = (coefficient of traction) × (weight on drivers)

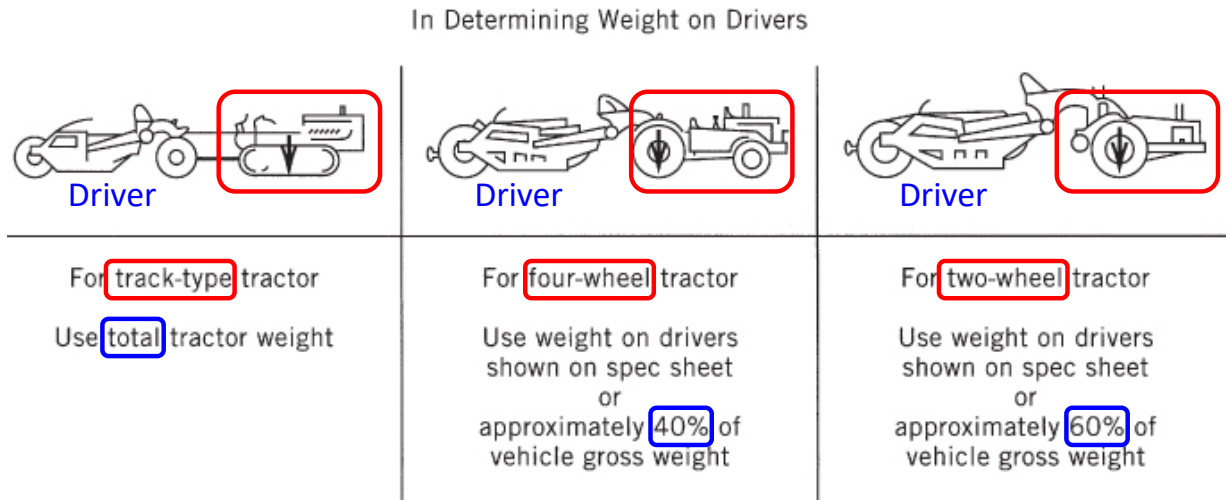


FIGURE 15.7 Determination of driver weights

15.5 Usable Power (3/4)

- ❑ High RR of the sand (RR = 400 lb/ton), 26-ton loads
- ❑ The **weight distribution** characteristics of the 30-yard tractor-scraper are as follows:

	공차 중량 분포		적재 시 중량 분포	
	Empty Weight (lb)	Percentage (%)	Loaded Weight (lb)	Percentage (%)
Drive wheels	50,800	67	76,900	52
Scraper wheels	25,000	33	70,900	48
Total weight	75,800	100	147,800	100

차이 = 147,800 - 75,800 = 72,000 pound = 36 ton (최대 적재량)

- ❑ The difference between the total weight empty and loaded is **72,000 pounds**, or **36 tons**. The loaded weight with **26-ton loads would be 127,800 pounds**.
 $75,800 \text{ pound} + 26 \text{ ton} \times 2000 \text{ pound/ton} = 127,800 \text{ pound}$

	Percentage (%)	Weight in Pounds
Drive wheels	52	66,456
Scraper wheels	48	61,344
Total	100	127,800 63.9 ton

Pounds required = 400 lb/ton × 63.9 tons = 25,560 lb

Usable power = 0.20 × 66,456 lb = 13,291 lb

Usable power = 0.40 × 66,456 lb = 26,582 lb > 25,560 lb

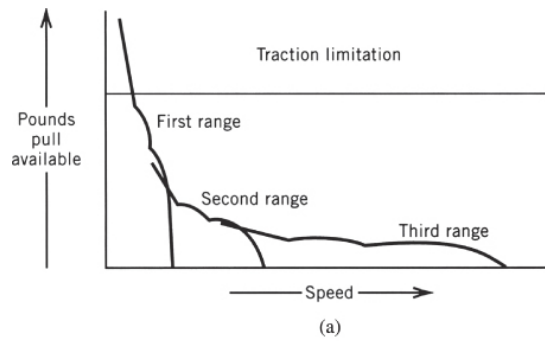
필요 출력

마른 모래
제공 출력

젖은 모래
제공 출력

현장에 물을 뿌림으로써 필요 출력을 제공할 수 있음

15.5 Usable Power (4/4)



고산지대의 경우, 산소 부족으로 출력 감소 현상 발생
 Decrease pounds pull 3% for each 1,000 feet (above 3,000 feet).
 If a tractor is operating at 5,000 feet above sea level, its power will be decreased by 6%.

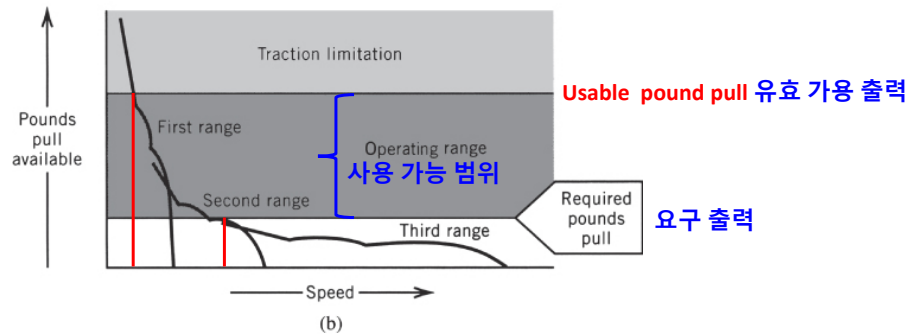


FIGURE 15.8 Impact of usable power constraints

15.6 Equipment Balance (1/5)



Two types of equipment work together: a 30 cubic yard scraper & a 385-horsepower pusher dozer

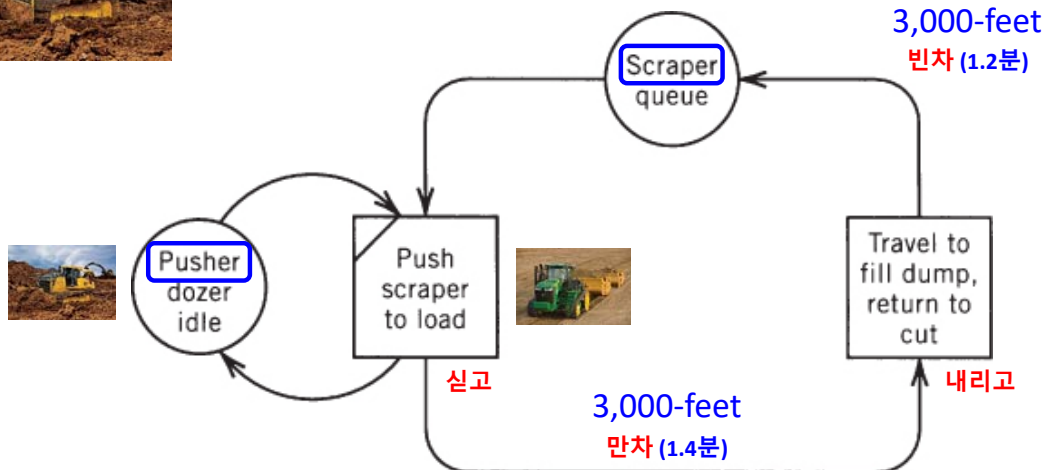


FIGURE 15.9 Scraper-pusher dual-cycle model

15.6 Equipment Balance (2/5)

Assume that in this case the 30-cubic yard tractor **Scraper** is carrying rated capacity and operating on a 3,000-foot level haul road where the RR developed by the road surface is 40 lb/ton.

Effective grade 회전저항 → 경사저항
 = (RR)/(20 lb/ton/% grade)
 = (40 lb/ton)/(20 lb/ton/% grade) = **2%**

Pusher
 Load time = 0.70
 Boost time = 0.15
 Transfer time = 0.10
 Return time = 0.28
 Total = **1.23 minutes**

(만차 : 1.4분)

(공차 : 1.2분)

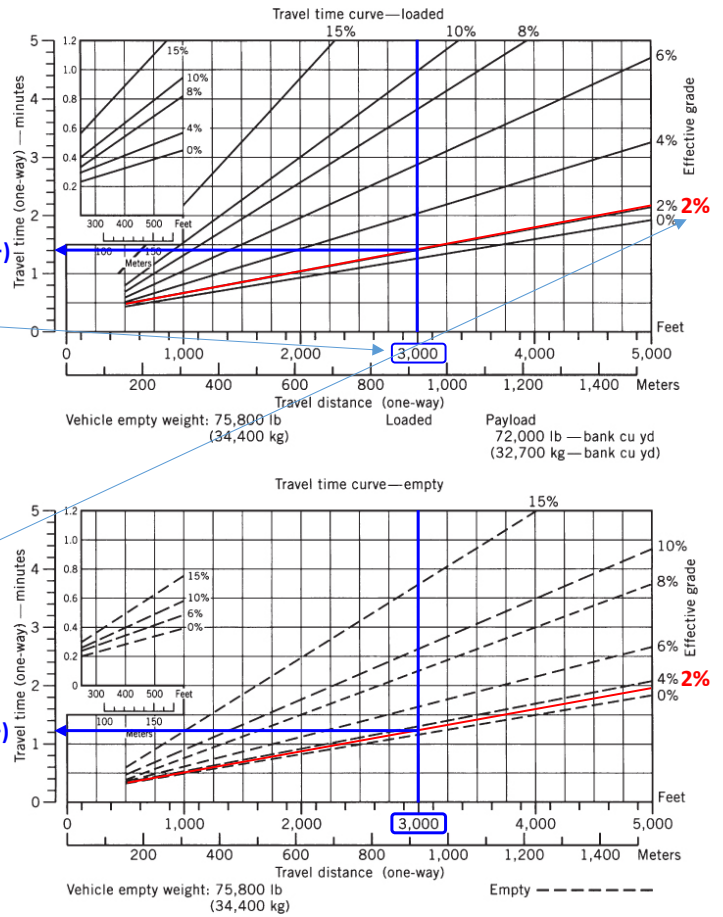
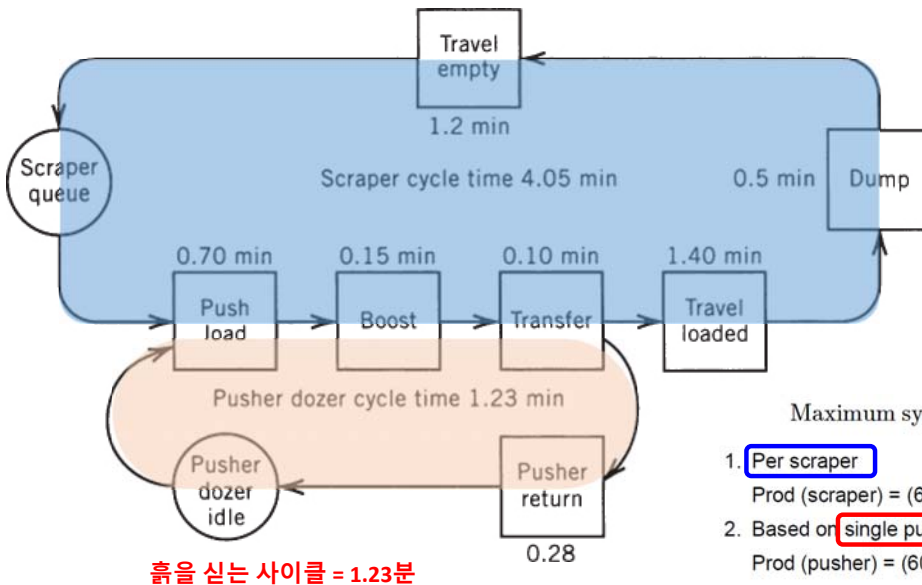


FIGURE 15.10 Travel time nomographs (Caterpillar Tractor Co.) 20

15.6 Equipment Balance (3/5)

흙을 운반하는 사이클 = 4.05분



흙을 싣는 사이클 = 1.23분

Maximum system productivity (assuming a 60 - min working hour)

1. **Per scraper**
 Prod (scraper) = (60 min/hr / 4.05 min) × 30 cu yd (loose) = **444.4 cu yd (loose)/hr**
2. Based on **single pusher**
 Prod (pusher) = (60/1.23) × 30 cu yd (loose) = **1,463.4 cu yd (loose)/hr**

FIGURE 15.11 Scraper-pusher cycle times

15.6 Equipment Balance (4/5)

Maximum system productivity (assuming a 60 – min working hour)

1. **Per scraper**

Prod (scraper) = (60 min/hr 4.05 min) × 30 cu yd (loose) = **444.4 cu yd (loose)/hr**

2. Based on **single pusher**

Prod (pusher) = (60/1.23) × 30 cu yd (loose) = **1,463.4 cu yd (loose)/hr**

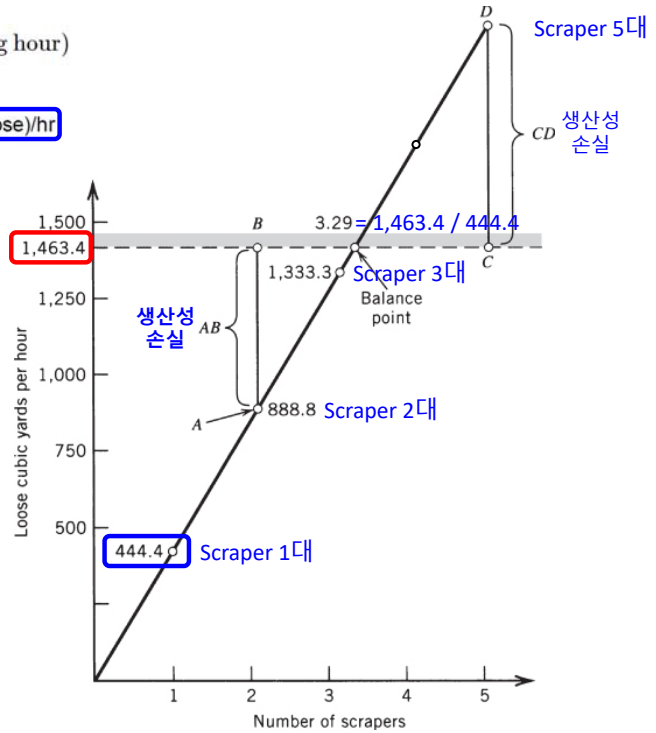


FIGURE 15.12 Productivity plot

15.6 Equipment Balance (5/5)

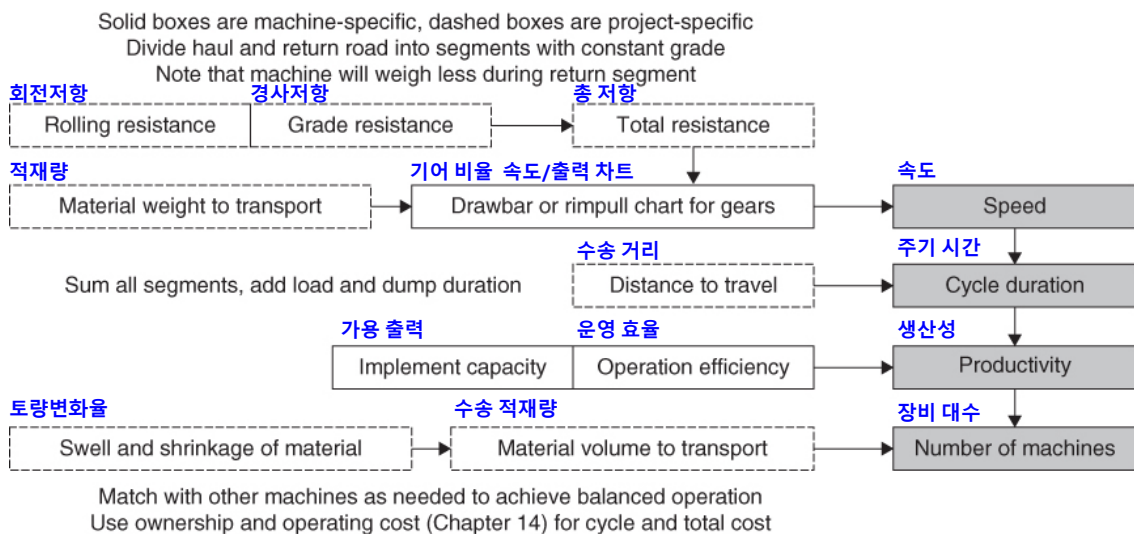


FIGURE 15.13 Flow of equipment operations calculation

15.7 Random Work Task Durations (1/3)

- The influence of random durations on the scraper fleet production: the **reduction in production** caused by the addition of **random variation of cycle activity times**. 작업시간 변동성 → 생산성 하락 요인

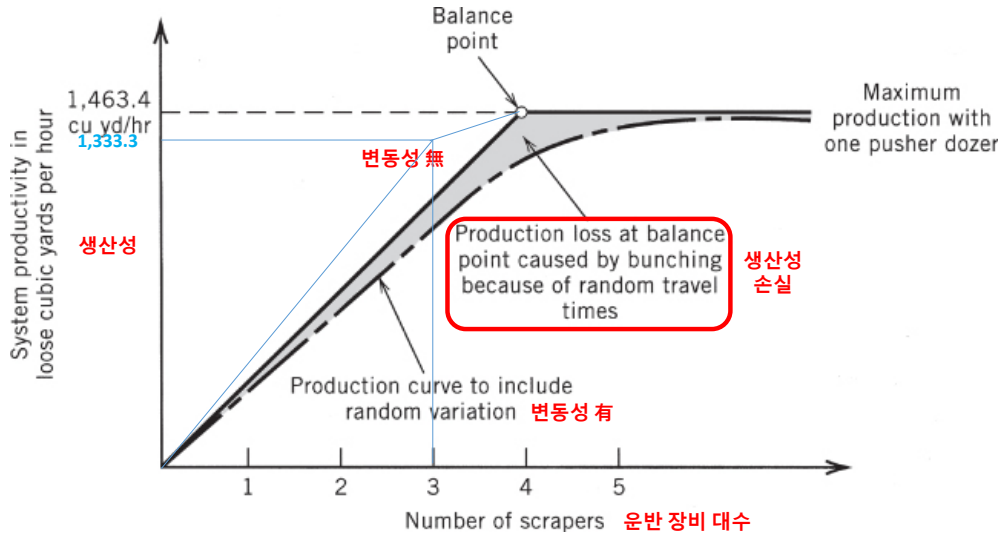


FIGURE 15.14 Productivity curve to include the effect of random cycle times

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15.7 Random Work Task Durations (2/3)

- 3대의 Scraper가 동일 간격으로 움직이고 있어야하나, Random한 요소로 인해 간격이 달라지면 Pusher에 Idle Time이 발생함 → 생산성 저하 발생

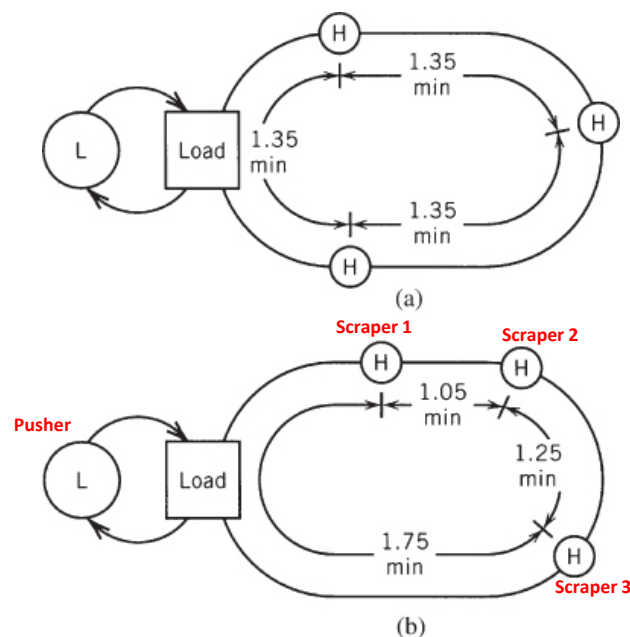


FIGURE 15.15 Comparison of haul unit cycles

25

15.7 Random Work Task Durations (3/3)

□ Coefficient Of Variation (COV) : 변동계수 또는 변이계수 = 표준편차 / 평균 → 평균 대비 표준편차의 크기

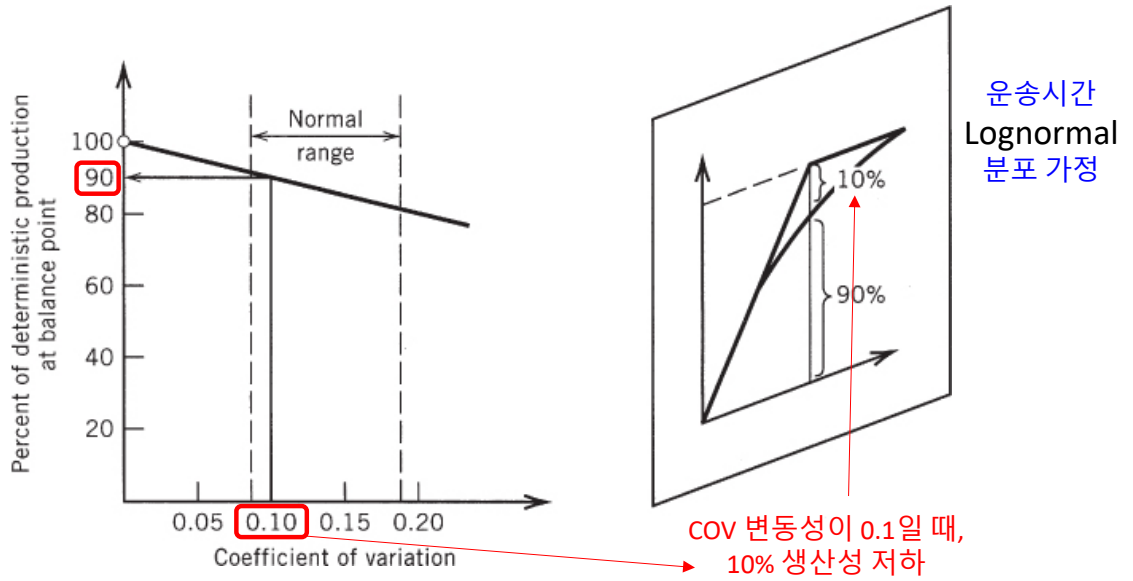


FIGURE 15.16 Plot of cycle time coefficient of variation

CHAPTER 16

CONSTRUCTION LABOR

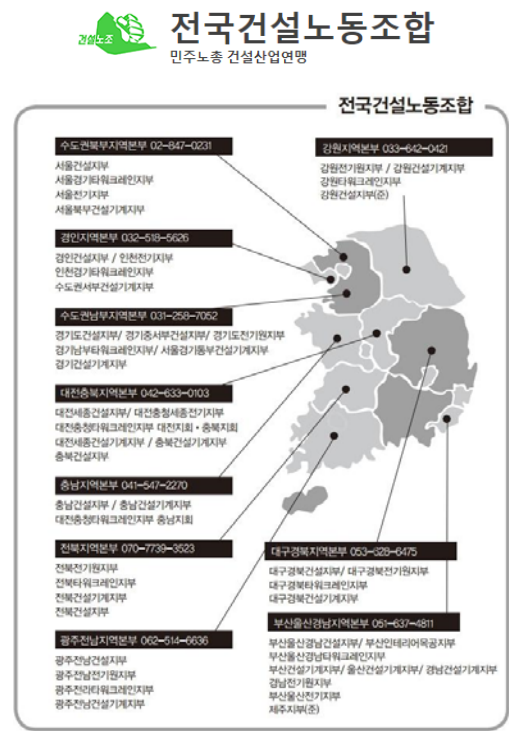
제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

16.1 The Labor Resource

- ❑ The **manpower** component of the four Ms of construction is by far the most **variable** and **unpredictable**. 건설을 위해 필요한 4가지 자원 “4M” 중 하나인 노동력은 가장 변화무쌍하며 예측 불가능한 요소
- ❑ Manager must be aware of the interplay among the following elements: **건설관리자는 다음 요소 간 상호작용에 대한 이해가 필요**
 1. Labor organization **노동조합**
 2. Labor law **노동법**
 3. Labor cost **인건비**
 4. Labor productivity **노동 생산성**

16.2 Short History of Labor Organizations

- ❑ **American Federation of Labor (AFL) : 숙련 기술자 노동조합**
- ❑ **Committee for Industrial Organizations (CIO) : 단순 노동자 노동조합**
- ❑ 1955년에 **AFL-CIO로 통합**
- ❑ This organization remains the **major labor entity** in the United States today. **미국의 주요 노동조합 지위를 유지하고 있음**



16.3 Early Labor Legislation (초기 노동법)

- ❑ Sherman Antitrust Law (1890) : 독점 금지법을 적용하여 노조 설립을 막음
- ❑ Clayton Act (1914) : 고용주와의 협상을 위한 조직 구성 허용

4

16.4 Norris-LaGuardia Act 1932

- ❑ 힘의 중심이 고용주에서 노동자로 옮겨가는 시기
- ❑ 노조에 가입하지 않겠다는 서약서를 작성하고 회사에 고용되는 계약(yellow-dog contracts)을 작성
→ 불법화

5

16.5 Davis-Bacon Act 1931

- 공공 프로젝트에 표준 임금 지급
- 표준 임금은 가장 최근에 임금협상이 끝난 회사의 임금을 준용하여 결정됨

6

16.6 National Labor Relations Act 1935

- 노조 전임자와 참여자에 대한 차별 금지법 : 노조의 대표 선출 → 협상이 가능해짐
- **National Labor Relations Board (NLRB)** : 전국 노동 관계 위원회 : 감시자 역할을 할 수 있는 조직 설립
- **Concept of a closed shop** : 모든 노동자는 반드시 노조에 가입해야 한다 → 이후 “일할 권리” 와 “선택의 자유” 개념에 반해 불법화 됨.

7

16.7 Fair Labor Standards Act 1938

- 최저 임금 규정
- 1938년 최대 근로시간 제한 : 주당 40시간
- 동일 노동 동일 임금 개념

8

16.8 Union Growth

- 1938년 전시 파업 금지법
- 노조의 권력화 → 노조 간부 사무원들이 일반 노동자를 갈취하는 행위를 금지

9

16.9 Labor Management Relations Act 1947

- 노동자의 권리와 노동자의 불법행위를 동시에 기술 (예를 들면, 80일간의 쟁의조정기간 후 파업 가능)
- 노동자와 자본의 균형점을 찾아가는 과정
- 피고용인과 고용인 간의 힘의 균형점을 50:50으로 이동시킴
- **Union shop** : 전 종업원의 고용조건이 사용자와 노동조합 간의 협정으로 정해지는 기업체 (주마다 법이 다름 : 일리노이에서는 합법, 조지아에서는 불법)
- 노조에 가입하지 않더라도 조합비에 해당하는 부담금 납입 ← 노조로 인해 이득을 보는 대가를 지불해야 한다는 논리 적용
- 모든 노동자가 반드시 노조에 가입해야 하는 기업(**Closed Shop**)은 법률로서 금지됨

10

16.10 Other Labor Legislation

- 1991년 민권법 : 인종, 피부색, 종교, 성별 또는 출신 국가를 이유로 한 차별을 금지
- 고용 기회 균등화 위원회 (**Equal Employment Opportunity Commission, EEOC**) : 고용, 해고, 고용 조건 및 분류에서의 차별을 금지
- 개별 건설 노동자는 노조의 부당행위에 대해 EEOC에 제소 가능 → 유죄의 경우, EEOC는 부당 노동 행위에 대한 중지 명령을 내릴 수 있음

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16.11 Vertical versus Horizontal Labor Organization Structure

- ❑ The traditional craft unions are normally referred to as **horizontally structured** unions (지역 분산형 기술 조합). This is because of the strong power base that is located in the union local. 숙련 노조 **AFL (American Federation of Labor)**
- ❑ **Vertically structured** unions tend to concentrate more of the power at the national level(중앙 집권형 노동 조합). 비숙련 노조 **CIO (Committee for Industrial Organizations)**

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16.12 Jurisdictional Disputes 관할권 분쟁

- ❑ 특정 공종이 어느 기술 조합의 영역인지를 가지고 분쟁이 발생할 수 있음
- ❑ 사례: 전통적 창호(목공) vs 철재 창호(커튼월)(철공)
- ❑ 공종에 대한 임금 체계는 영역 다툼이 없는 반면, 사용기술에 대한 임금 체계는 영역 다툼이 심함 (같은 공사를 하되 다른 기술을 이용하는 경우, 공사의 종류에 따라 임금이 결정되면 아무 문제가 없지만, 공사에 사용된 기술에 따라 임금이 결정된다면 다른 기술을 가진 기술자들간의 다툼이 발생할 수 있음)
- ❑ 미국 건설 노조 - 수평적 - 개별 임금 체계
- ❑ 유럽 건설 노조 - 수직적 - 단일 임금 체계

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16.13 Union Structure

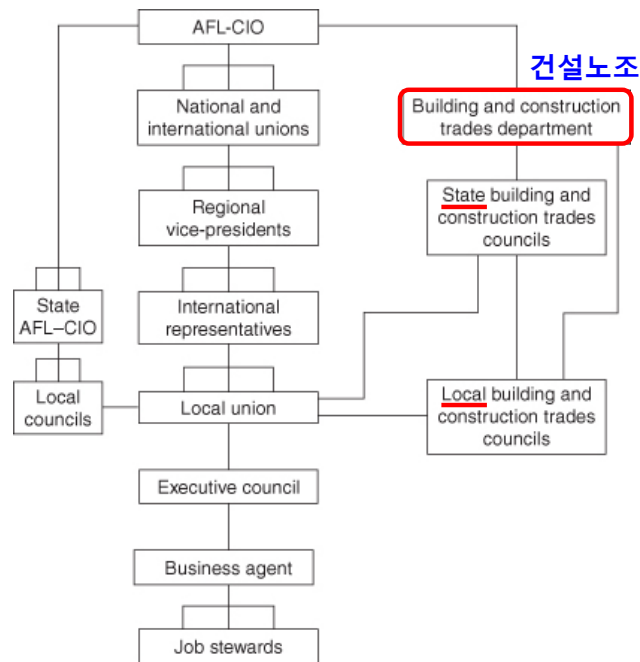


FIGURE 16.2 Structure typical of an affiliate of the Building and Construction Trades Department, AFL-CIO

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16.14 National Unions

- ❑ National Unions vs. Local Unions 전국 조합 vs 지역 조합
- ❑ National Unions : 일반적으로 지역 조합보다 강력한 영향력 보유
- ❑ National Unions → 정책 수립, 정보 제공 등 지도 관계 → Local Unions
- ❑ 건설 분야는 타 산업 분야와 달리 지역 조합의 영향력이 전국 조합의 영향력보다 큼

15

16.15 State Federations and City Centrals

- 노동조합의 위계
- National Unions → State Federations and City Centrals → Local Unions
- 주 단위의 입법 로비 존재

16

16.16 Union Locals

- The locals are the **smallest division of the national union**. 노조의 가장 작은 단위
- The **most important local official** is the **business agent**, a full-time employee of the local. (노동조합) 교섭위원의 역할이 가장 중요 – 공식 조직
- The **shop steward** is not a union official but is the representative who comes in closest contact with the members. 노조 대표 – 비공식 조직

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16.17 Union Hiring Halls

- 대한민국 : 새벽 인력시장
- 미국 : **Union Hiring Halls** (노조 고용장) → **Agreement between union and the contractor.**
- 노동조합에 가입한 노동자들에게 일자리를 알선



16.18 Secondary Boycotts

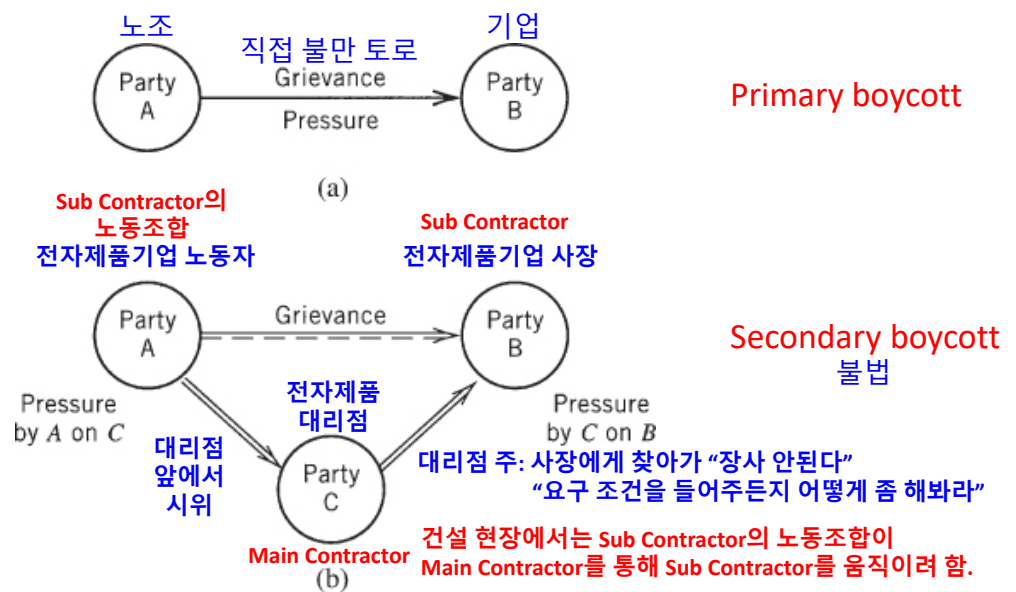


FIGURE 16.3 Types of boycotts: (a) primary boycott and (b) secondary boycott

16.19 Open-Shop and Double-Breasted Operations

- 모기업 아래에 두개의 자회사를 둠
- 하나는 조합원 고용 회사, 다른 하나는 비조합원 고용 회사로 운영
- 조합원을 고용한 회사만이 응찰할 수 있는 공사 건 → 조합원 고용 회사 이용
- 그 밖의 공사 건 : 비용이 더 저렴한 비조합원 고용 회사 이름으로 응찰

20

16.20 Labor Agreements 노동 협약

- 주계약자가 하도급업체 (노동조합에 가입한) 근로자와 노동조건에 대한 계약을 맺어야 함.
 1. Maintenance of membership (노동 조합의) 조합원 자격 유지 협정
 2. Fringe benefits 고용주가 임금 외에 주는 부가 혜택
 3. Work rules 고용 규칙
 4. Apprentice (도제) program operation
 5. Wages (addendum) 급여
 6. Hours 근로시간
 7. Worker control and union representation 근로자 통제 및 노동조합 대표성
 8. Operation of the union hiring hall 노조 직영 직업 소개소 운영
 9. Union area 노조 공간
 10. Subcontractor clauses (see Section 16.18) 하도급자 규정
 11. Special provisions 특례 규정

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16.21 Labor Costs

- ❑ The **hourly average cost of a worker** to the contractor consists of the following components: **시급의 구성**
 1. Direct wages **직접 임금**
 2. Fringe benefits **복리 후생**
 3. Social security contributions (**FICA**) **사회보험**
 4. Unemployment insurance **실업보험**
 5. Workmen's compensation (**WC**) insurance **상해보험**
 6. **P**ublic **L**iability and **P**roperty **D**amage insurance **주계약자가 드는 면책보험 (보상금액 마련을 위한)**
 7. Subsistence pay **생활임금: 집에서 멀리 떨어진 곳에서 근무하는 경우 지급**
 8. Shift pay differentials **야간 근무, 주말 근무 수당**

16.22 Average Hourly Cost Calculation (1/2)

Doubled

- ❑ Compute the average hourly cost to a contractor of an **ironworker** involved in structural steel erection in a subsistence area. **철공**
- ❑ The ironworker works on the **second shift** of a three-shift job and works **six 10-hour days per week**. **주당 60시간 2교대 근무**
- ❑ The workers work 7 hours and are paid 8 hours under the shift pay agreement. **7시간 일하고 8시간 임금 수령 (주휴수당)**
- ❑ Additional PL and PD insurance for \$50,000/\$100,000 coverage is desired. **면책 보험 필요**
- ❑ Use 6.2% FICA and 5.0% for unemployment insurance. **사회보험 6.2%, 실업보험 5%**

	Hours Worked	Straight Time-Hours (ST)	Premium Time (PT)
Monday -Friday	5 × 7 = 35	5 × 8 = 40	
	5 × 3 = 15	5 × 3 = 15	1 × 5 × 3 = 15 야간근무
Saturday	1 × 7 = 7	1 × 8 = 8	1 × 1 × 8 = 8 주말근무
	1 × 3 = 3	1 × 3 = 3	1 × 1 × 3 = 3 2배 지급
	60	66	26
Base Rate	\$19.20		
ST 66 hours @ \$19.20 =	\$1267.20		
PT 26 hours @ \$19.20 =	\$499.20		
Gross Pay	\$1766.40		
Fringes:	Health and Welfare	1.30 × 66 = \$85.80	
	Pension	1.14 × 66 = \$75.24	
	Vacation	1.00 × 66 = \$66.00 (deferred wage)	
	Apprenticeship training	0.14 × 66 = \$9.24	
		3.58 × 66 = \$236.28	
WC = \$29.18	WC, PL, and PD = \$36.39 × $\frac{1267.20}{100} =$		\$461.13
PL 1.59 × 3.00 = \$4.77	합계: \$36.39		
PD 1.30 × 1.88 = \$2.44	Total = \$36.39 per \$100.00 of Payroll		
FICA = 0.0765 × (\$1766.40 + \$66) =	\$140.18		
Unemployment = 0.05 × (\$1766.40 + \$66) =	\$91.62		
Subsistence = 6 days × \$20.00/day =	\$120.00		
Total Cost = Base + Fringes + WC, PL, PD + UNEMPL + FICA + SUBS =	\$2815.61		
Average Hourly Cost (to contractor) = $\frac{\$2815.61}{60} =$	\$46.93		

상해보험

면책보험

사회보험

실업보험

생활임금

16.22 Average Hourly Cost Calculation (2/2)

직접 임금	Gross pay	\$1766.40
복리후생	Fringes	\$ 236.28
상해보험, 면책보험	WC, PL, PD	\$ 461.13
사회보험	FICA	\$ 140.18
실업보험	Unemployment	\$ 91.62
생활임금 (파견수당)	Subsistence	<u>\$ 120.00</u>
	Total	\$2815.61
Hourly rate = \$2815.61/60 = \$46.93 or approx.		\$47.00

CHAPTER 17

ESTIMATING PROCESS

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

17.1 Estimating Construction Costs

- ❑ **Estimating** is the process of looking into the future and trying to predict **project costs** and **resource requirements**. 견적 : 미래의 공사비와 소요 자원을 사전에 예측
- ❑ **Project costs** and **Resource requirements** → 정확한 예측은 손해를 예방하고 이익을 증가시킴

2

17.2 Types of Estimates (1/3)

- ❑ 설계 완료 전 → **개산 견적** : 공사 수량 × 공사 단가 → ±10% 정도의 오차 → 설계 완료 후 폐기
- ❑ 전체 설계의 40% 완료 : 예비(기본)설계 완료 후 → **예비 견적 산출**
- ❑ 상세 설계 완료 후 → 설계도 및 시방서 작성 완료 → **상세 견적 산출** → ±3% 정도의 오차
- ❑ 공사가 발주자의 예산 범위 내에 있는지, 시공자의 견적이 적절한지 체크하는 용도로 사용
- ❑ 견적 비용은 전체 공사비의 0.25% 정도
- ❑ In building construction, the four types of estimates are commonly used: **견적 종류**
 1. Conceptual estimate : **설계 없이 개산 견적**
 2. Preliminary estimate : **기본 설계 후 예비 견적**
 3. Engineer's estimate : **상세 설계 후 상세 견적**
 4. Bid estimate : **입찰 견적**

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17.2 Types of Estimates (2/3)

50 17 Square Foot Costs										
50 17 00 S.F. Costs			UNIT	UNIT COSTS			% OF TOTAL			
				1/4	MEDIAN	3/4	1/4	MEDIAN	3/4	
01	0010	APARTMENTS Low Rise (1 to 3 story)	S.F.	62.50	78.50	105				01
	0020	Total project cost	C.F.	5.60	7.40	9.15				
	0100	Site work	S.F.	5.35	7.30	12.80	6.05%	10.55%	14.05%	
	0500	Masonry		1.23	2.86	4.94	1.54%	3.67%	6.35%	
	1500	Finishes		6.65	9.10	11.25	9.05%	10.75%	12.85%	
	1800	Equipment		2.04	3.09	4.60	2.73%	4.03%	5.95%	
	2720	Plumbing		4.86	6.25	7.95	6.65%	8.95%	10.05%	
	2770	Heating, ventilating, air conditioning		3.10	3.81	5.60	4.20%	5.60%	7.60%	
	2900	Electrical		3.61	4.79	6.45	5.20%	6.65%	8.40%	
	3100	Total: Mechanical & Electrical		12.50	15.95	19.90	15.90%	18.05%	23%	
	9000	Per apartment unit, total cost	Apt.	58,000	89,000	131,000				
	9500	Total: Mechanical & Electrical	"	11,000	17,300	22,600				
02	0010	APARTMENTS Mid Rise (4 to 7 story)	S.F.	83	100	124				02
	0020	Total project costs	C.F.	6.45	8.90	12.20				
	0100	Site work	S.F.	3.31	6.55	11.80	5.25%	6.70%	9.15%	
	0500	Masonry		5.50	7.60	10.80	5.10%	7.25%	10.50%	
	1500	Finishes		10.40	14.50	17.10	10.55%	13.45%	17.70%	
	1800	Equipment		2.51	3.88	4.94	2.54%	3.48%	4.31%	
	2500	Conveying equipment		1.87	2.27	2.75	1.94%	2.27%	2.69%	
	2720	Plumbing		4.85	7.80	8.60	5.70%	7.20%	8.95%	
	2900	Electrical		5.45	7.80	9	6.65%	7.20%	8.95%	
	3100	Total: Mechanical & Electrical		17.45	22	26.50	18.50%	21%	23%	
	9000	Per apartment unit, total cost	Apt.	93,500	110,500	183,000				
	9500	Total: Mechanical & Electrical	"	17,700	20,400	25,800				
03	0010	APARTMENTS High Rise (8 to 24 story)	S.F.	94	114	138				03

FIGURE 17.1 Costs based on a representative unit. **단가표**
From Building Construction Cost Data 2008.

17.2 Types of Estimates (3/3)

ESTIMATE CLASS	Primary Characteristic	Secondary Characteristic			
	LEVEL OF PROJECT DEFINITION Expressed as % of complete definition 설계 완성률	END USAGE Typical purpose of estimate 용도	METHODOLOGY Typical estimating method 견적 방법	EXPECTED ACCURACY RANGE Typical variation in low and high ranges 정확도	PREFERENCE EFFORT Typical degree of effort relative to least cost index of 1 투입 노력
Class 5	0% to 2%	Concept Screening 기획 평가	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility 타당성 평가	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control 예산 수립	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/Tender 입찰 참여	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender Tender: 입찰	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

정확도 증가

17.3 Detailed Estimate Preparation (1/3)

- The preparation of a detailed bid-level estimate requires that the estimator **break** the project into **cost centers** or **cost sub-elements**. 비용 센터 : 전체 프로젝트를 비용 추정이 가능한 작은 비용 단위로 분해
- **Resource** : man hours, materials, subcontracts, equipment hours, and dollars needed to accomplish the work or meet the requirements associated with the cost center. 비용 센터 요구사항 충족을 위해 소요되는 자원 정의
- The cost center relates to some **physical subcomponent** of the project, such as **foundation piles, excavation, steel erection, interior dry wall installation**, and the like. 비용 센터는 일반적으로 프로젝트 대상 구조물의 부위를 의미
- Certain **nonphysical components** of the work generate costs, however, and these cost centers must also be considered. 구조물의 특정 부위와 관련되지 않는 비물리적 비용 센터도 존재
- Many of the items listed as **"indirects"** are typical of costs that are not directly connected with physical components or end items in the facility to be constructed: **insurance, bonding premiums, fees, expense, home office overheads**. 비물리적 비용 센터는 간접비(경비)로 계상

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17.3 Detailed Estimate Preparation (2/3)

- The process of estimating: **견적 절차**
 1. Break the project into **cost centers**. 비용 센터로 분해
 2. Estimate the **quantities** (quantity takeoff) required for cost centers that represent **physical** end items (e.g., **cubic yards of earth, linear feet of pipe**, etc.) For **nonphysical** items, determine an appropriate **parameter** for cost calculation (e.g., **the level of builder's risk insurance required by the contract or the amounts of the required bonds**). 물리적 비용 센터 : 소요 자원 수량 추정, 비물리적 비용 센터 : 요율 추정
 3. **Price out the quantities** determined in Step 2 using historical data, vendor quotations, supplier catalogs, and other pricing information. → **Price per unit** (unit cost) basis or a **lump-sum** (one job) basis. 소요 자원에 대한 단가 산출
 4. **Calculate the total price** for each cost center by **multiplying the required quantity by the unit price**. This multiplication is commonly called an extension, and this process is called running the extensions. (물량 × 단가) 방식으로 비용 센터 별 원가 산출

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17.3 Detailed Estimate Preparation (3/3)

Owner: NASA					Date: 1 August 2xxx Project: Admin Building	
Code Description	LH	Labor	Material	Sub	Owner	Total
01 Site improvements					Subcontractor	
02 Demolition						
03 Earthwork						
04 Concrete						
05 Structural steel	8,265	93,840	+75,665			= 169,505
06 Piling						
07 Brick & masonry						
08 Buildings						
09 Major equipment	11,240	130,295	8,970			139,265
10 Piping	14,765	172,590	287,085	7,500	172,705	639,880
11 Instrumentation				165,000		165,000
12 Electrical				632,710		632,710
13 Painting				70,170		70,170
14 Insulation				21,150		21,150
15 Fireproofing			2,650	5,550		8,200
16 Chemical cleaning						
17 Testing						
18 Const. equipment					178,330	178,330
19 Misc. directs	5,040	53,040	10,250		10,000	73,290
20 Field extra work						
Subtotal Direct Cost	39,310	449,765	384,620	902,080	361,035	2,097,500
21 Con. tools/sup.			36,805			36,805
22 Field payroll/burden					82,900	82,900
23 Start-up asst.						
24 Ins. & taxes					26,340	26,340
25 Field sprvsn.	2,400	36,000			10,190	46,190
26 Home off. exp.					12,270	12,270
27 Field emp. ben.					51,975	51,975
Subtotal Indirect Cost	2,400	36,000	36,805		183,675	256,480
Adjustment Sheets						
Total Field Cost	41,710	485,765	421,425	902,080	544,710	2,353,980
28 Escalation						
29 Overhead & profit		41,710	25,285	45,105	50,950	163,050
30 Contingency						90,380
31 Total Project Cost						2,607,410

물리적 비용 센터 : 직접비

간접비를
항목별로
따로 계산

비물리적 비용 센터 : 간접비

총공사비
물가상승분
경비 & 이윤
예비비
총사업비

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17.4 Definition of Cost Centers

□ The **subdivisions (cost centers)** into which the project is divided for detailed cost estimation purposes are variously referred to as **비용 센터 동의어**

1. **Estimating accounts**
2. **Line items**
3. **Cost accounts** → 공사가 시작된 이후 관리 목적으로 사용: 비용 센터라 할 수 없음
4. **Work packages** → 원가관리와 일정관리를 위해 사용

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17.5 Quantity Takeoff (1/4)

- ❑ The development of the quantities of work to be placed in appropriate units (e.g., square feet cubic yards, etc.) is referred to as the **quantity takeoff** or **quantity surveying**. 수량 조사 → 특정 물량 단위(ft², yard²)로 표현된 작업 물량 산출
- ❑ The **first step** in the quantity takeoff procedure is to **identify the materials required** by each estimating account or work package. → 작업 물량 산출은 자재 소요량 파악으로부터 시작

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17.5 Quantity Takeoff (2/4)

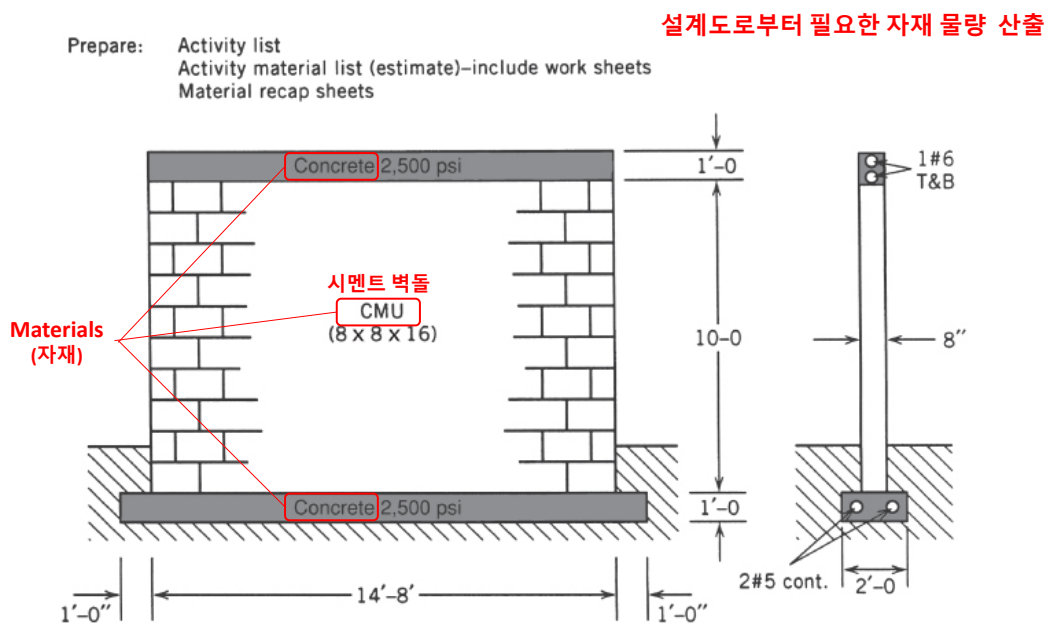


FIGURE 17.4 Small wall construction (CMU is concrete masonry unit)

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17.5 Quantity Takeoff (3/4)

비용 센터 ←

Project	과업	자재	소요량		
Activity code	Activity description	Material description	Quantity	Unit	Cost code
1	Layout	Stakes 2 × 4 × 24 8 EA.	10.3	BF	0100
3	Place rebar	#5 st. 2 PCS 16 – 2	32.3	LF	0320
		Tie wire	1	Roll	0320
4	Cost and cure	Footing			
		Concrete	1.23	CY	0330
		Curing compound	0.25	Gal	0337
5	Erect CMU wall				
		CMU 8 × 8 × 16 stretcher	143	EA	0412
		CMU 8 × 8 × 16 corner	14	EA	0412
		CMU 8 × 8 × 16 corner	16	EA	0412
		Scaffolding 4' × 4' × 6'	2	Sec.	0100
		Mortar	0.27	CY	0412
7	Form bond beam				
		2 × 4 (4 – 15' – 0")	43.5	BF	0310
		2 × 2	12.7	BF	0310
		1 × 2	2.0	BF	0310
		3/4" ext ply	60.3	SF	0310
		Snapties 8"	24	EA	0310
		Nails 8d	1.5	LB	0310
		Nails 6d	0.4	LB	0310
		Form oil	0.07	Gal	0310
8	Place bond beam rebar				
		#6 rebar (str.)	28.67	LF	0320
9	Cost and cure	Bond beam			
		Concrete	0.35	CY	0330
		Curing compound	0.05	Gal	0337
10	Strip forms and rub bond beam				
		Grout	1	CF	0339.2

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17.5 Quantity Takeoff (4/4)

Recap Sheet

여유율을 감안하여 소요량 산정
(공사 중 파손되어 못 쓰는 양 포함)

Description	Activity code	Sub-quantity	Waste	Total quantity	Unit	Cost code
2 × 4 Lumber	Total	53.8	10%	60.0	BF	
	1	10.3	60개중 10% 낭비 → 54개 유효			0100
	7	43.5				0310
2 × 4 Lumber	7	12.7	10%	14.0	BF	0310
1 × 2 Lumber	7	2.0	10%	2.25	BF	0310
3/4" Exterior plywood	7	60.3	10%	66	SF	0310
Curing compound	Total	0.30		1	Gal	0337
	4	0.25				
	9	0.05				
Snap ties 8"	7	24	5%	25	EA	0310
Nails 8d	7	1.5		3	LB	0310
Nails 6d	7	0.4		1	LB	0310
Form oil	7	0.07		0.25	Gal	0310

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17.6 Methods of Detailed Cost Determination (1/2)

□ The **two methods of cost determination** most frequently used: **두가지 비용 추정 방법**

(a) unit pricing → **공종에 대한 단가 개념**

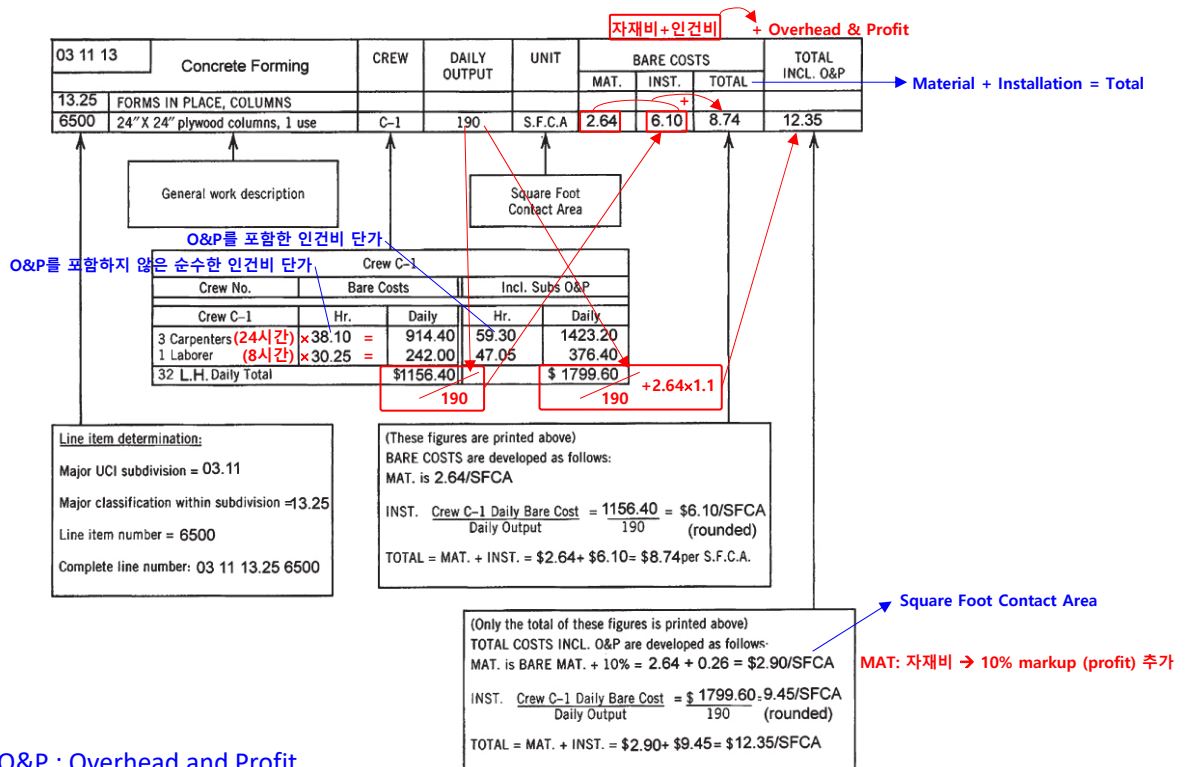
(b) resource enumeration → **소요되는 자원을 일일이 계산**

□ **Quantity take off(물량) × Unit price(단가) = Estimate(견적) → 100 lineal feet × \$65/lineal feet = \$6,500**

□ 단가 제공 기관

1. **R. S. Means** Company's Building Construction Cost Data
2. R. Walker's Building Estimator's Reference Book
3. Richardson Construction Estimating Standards

17.6 Methods of Detailed Cost Determination (2/2)



O&P : Overhead and Profit

FIGURE 17.7 Line item cost development using R. S. Means data.

17.7 Problems with Unit-Cost Method (1/2)

- ❑ Cost / unit: 평균 단가라는 문제 → 생산성 반영 → 단가 조정 필요
- ❑ Resource hours (RH) per hour / Units per hour = **RH / unit** : 공사 단위 당 소요 자재
- ❑ Cost / unit = **RH / Unit** × Cost / RH : 단위당 비용보다는 단위당 소요 자원 예측이 보다 안정적임 ← 물가 상승의 영향을 덜 받음(변경된 자재 단가를 적용함으로써)

17.7 Problems with Unit-Cost Method (2/2)

- ❑ 단가에 생산성 Factor를 고려하여 조정 단가를 생성
- ❑ 모든 영향요인이 완벽(High)하면 100% 생산성 발휘
- ❑ 일부 영향요인이 열악(Low)하면 생산성 하락

Production Range Index				
생산성 요소(영향 요인) Production Elements	Production Efficiency (%)			
	25	35	45	55 65 75 85 95 100
	Low	Average	High	
1. General Economy	Prosperous	Normal	Hard times	
Local business trend	Stimulated	Normal	Depressed	
Construction volume	High	Normal	Low	
Unemployment	Low	Normal	High	
2. Amount of Work	Limited	Average	Extensive	
Design areas	Unfavorable	Average	Favorable	
Manual operations	Limited	Average	Extensive	
Mechanized operations	Limited	Average	Extensive	
3. Labor	Poor	Average	Good	
Training	Poor	Average	Good	
Pay	Low	Average	Good	
Supply	Scarce	Average	Surplus	
4. Supervision	Poor	Average	Good	
Training	Poor	Average	Good	
Pay	Low	Average	Good	
Supply	Scarce	Average	Surplus	
5. Job Conditions	Poor	Average	Good	
Management	Poor	Average	Good	
Site and materials	Unfavorable	Average	Favorable	
Workmanship required	First rate	Regular	Passable	
Length of operations	Short	Average	Long	
6. Weather	Bad	Fair	Good	
Precipitation	Much	Some	Occasional	
Cold	Bitter	Moderate	Occasional	
Heat	Oppressive	Moderate	Occasional	
7. Equipment	Poor	Normal	Good	
Applicability	Poor	Normal	Good	
Condition	Poor	Fair	Good	
Maintenance, repairs	Slow	Average	Quick	
8. Delay	Numerous	Some	Minimum	
Job flexibility	Poor	Average	Good	
Delivery	Slow	Normal	Prompt	
Expediting	Poor	Average	Good	

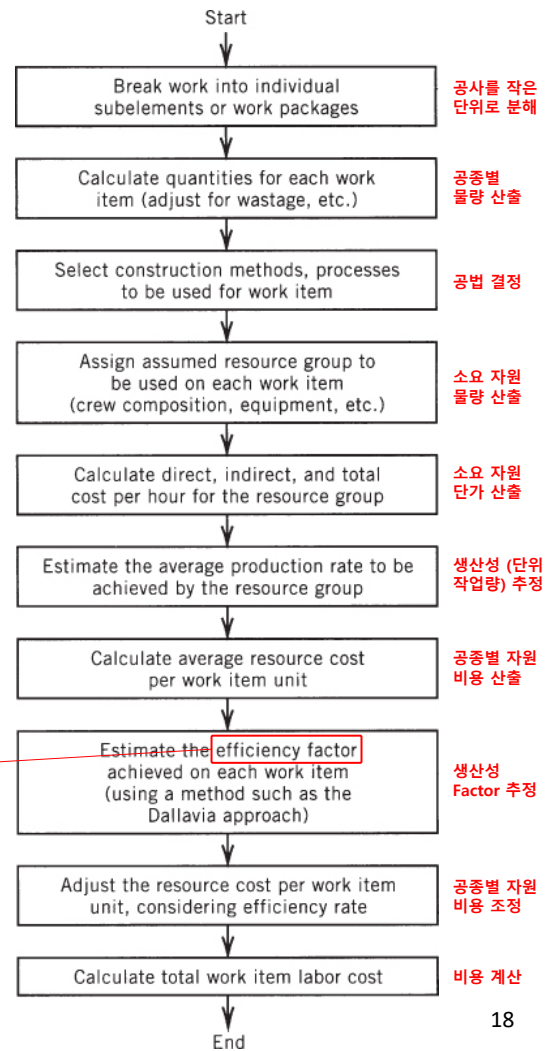
Example: After studying a project on which he is bidding, a contractor makes the following evaluations of the production elements involved:

Production Element	% Efficiency
1. Present economy	75
2. Amount of work	90
3. Labor	70
4. Supervision	80
5. Job conditions	95
6. Weather	85
7. Methods and equipment	55
8. Delays	75
Total	625

As the total of the eight elements is 625, the average value will be 625/8, or 78%.

17.8 Resource Enumeration (1/2)

- Almost every project has unique or special features for which **unit-pricing data may not be available**. 공중에 대한 단가가 존재하지 않는 경우
- Cost center** → 개별 하위 구성요소(자원)로 분해
- Resource Enumeration** : 보다 세부적인 요소로 분해한 후, 세부 요소 단위로 비용을 추정하는 방법 (과거 자료 기반, 공학적 직관 기반 추정)
- Efficient factor**가 90%라면, 인건비 \$30.83는 \$34.25 (= \$30.83/0.9)로 반영되어야 함



17.8 Resource Enumeration (2/2)

- 장점:** 정확한 추정 가능
- 단점:** 보다 많은 시간과 노력 필요
- 활용 사례**
 - 단가가 존재하지 않는 경우에만 사용
 - 예산에서 차지하는 비중이 높아 정확한 원가 추정이 필요한 Item에만 사용
 - 기존 사례를 참조할 수 없는 새로운 유형의 프로젝트에만 사용

Concrete Placing Crew

Quantity	Member	Rate	Total/Hour
1	Carpenter foreman	\$40.00	\$ 40.00 인부
2	Cement masons	\$36.00	\$ 72.00 자재
1	Pumping engineer	\$38.00	\$ 38.00 인부
7	Laborers	\$28.00	\$196.00 인부
1	Concrete pump	\$24.00	\$ 24.00 장비
	Crew hourly rate		\$370.00

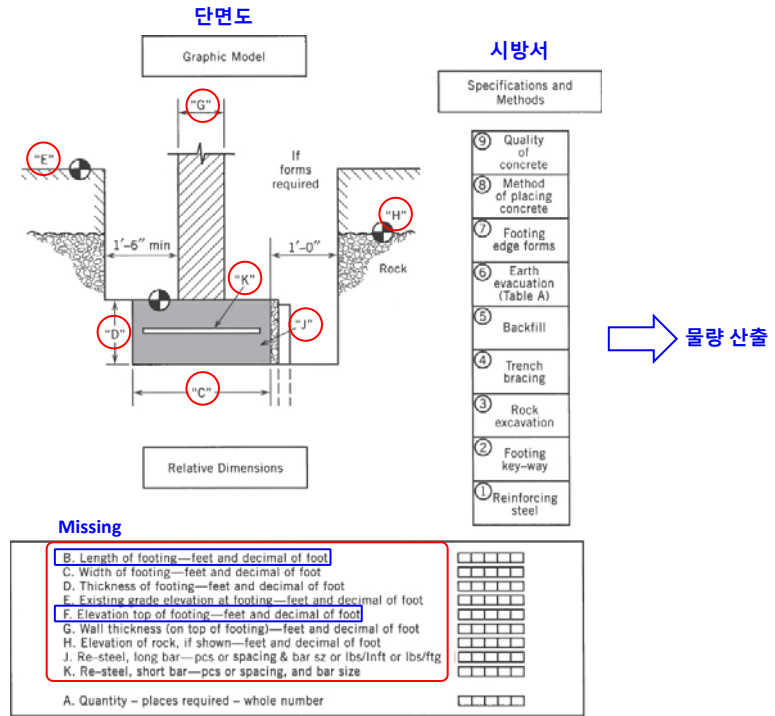
Production rate of crew under normal circumstances (efficiency factor 1) = 12 cu yd/hr.

Average labor cost/cubic yard = \$370/12 = \$30.83 → \$30.83/0.9

Area	Quantity	Percent Waste	Efficiency Factor	Labor Cost/Cubic Yard	Activity Cost
1. Foundation	53.2	15	0.9	\$34.25	\$ 1,822 = 53.2 × 34.25
2. Wall to elevation 244.67	52.9	12	0.8	38.54	2,039
3. Slab 10 in.	1.3	30	0.3	102.77	134
4. Beams elevated 244.67	10.5	15	0.7	44.04	462
5. Beams elevated 245.17	9.1	15	0.7	40.44	401
6. Slab elevation 244.67	8.7	10	0.7	40.44	383
7. Interior wall to 244.67	5.5	15	0.4	77.07	424
8. Slab elevation 254.17	6.3	10	0.75	41.11	259
9. Walls 244.67-254.17	57.2	10	0.8	38.54	2,205
10. Walls 254.17-267	42.0	10	0.8	38.54	1,619
11. Floors elevated 267	8.9	10	0.9	34.25	305
12. Manhole walls	27.3	10	0.85	36.27	990
13. Roof	14.0	15	0.7	44.04	617
14. Headwall	8.5	10	0.8	38.59	328
Total direct labor cost for concrete				\$11,988 say \$12,000	

17.9 Work Package or Assembly-Based Estimating (1/4)

- Work Package 단위의 원가 추정
- 컴퓨터를 이용한 자동화
- 모수(Parameter) 기반 추정법 : 모수가 결정되면 미리 구축된 컴퓨터 프로그램을 통해 자동으로 물량을 산출한 후, 단가 데이터베이스에 저장된 자료를 이용하여 비용 산출



- A, B, ..., K 값만 입력하면 앱을 통해 콘크리트 기초공사 물량이 자동으로 산출됨

FIGURE 17.11 Construction systems concept—concrete footing

17.9 Work Package or Assembly-Based Estimating (2/4)

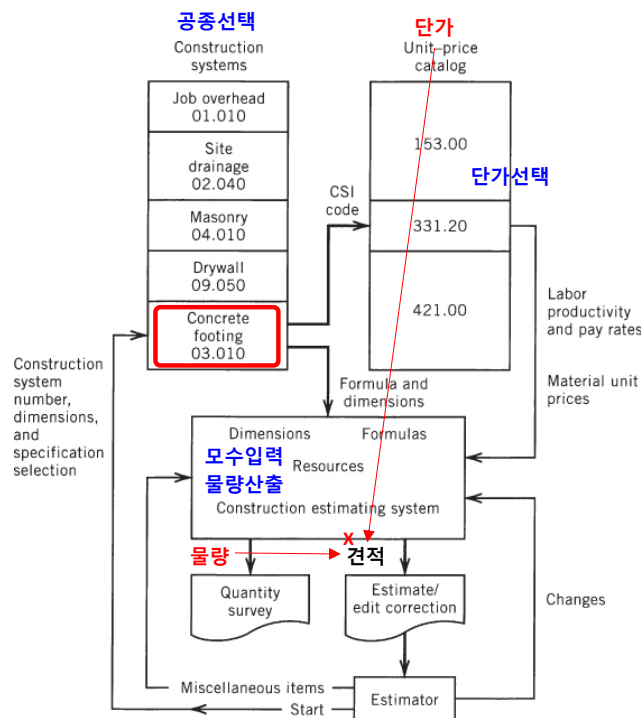


FIGURE 17.12 Work package concept

17.9 Work Package or Assembly-Based Estimating (3/4)

수작업 양식

WORK PACKAGE COLLECTION SHEET									
System/Structure Identifier		Crew Level Work Package Identifier		Description					
02 • 133		03 • 131		CONCRETE PLACEMENT, FLOAT FINISH GROUND SLAB, BUILDING 2					
Resource Code	Description	Permanent Materials (PM)			Extension	Productivity			
		Unit	QTY	Unit Cost		Base Unit for Productivity	Low	Target	High
1 3 2 5	CONCRETE, 2500 PSI	CY	135	30	80	4171.50	CY CONCRETE		
	+5% WASTE INCLUDED						128 CY		
							Duration (Crew-Hours)		
							Escalation Rates (%)		
							Notes		
							DURATION = 128 CY / 22 CY/HR = 6 HRS		
							ALLOW 8 HRS WITH STARTUP AND CLEANUP		
							Cost Summary:		
							PM = 4171.50		
							M&S =		
							IE =		
							L = 831.20		
							CE = 96.00		
							TOTAL = 5098.70		
							831.20		
							96.00		
							96.00		

FIGURE 17.13 Work package collection sheet—concrete slab

17.9 Work Package or Assembly-Based Estimating (4/4)

수작업 양식

WORK PACKAGE COLLECTION SHEET									
System/Structure Identifier		Crew Level Work Package Identifier		Description					
01 • 200		02 • 111		EXCAVATION, AREA 3, AND DISPOSAL W/O COMPACTION					
Resource Code	Description	Permanent Materials (PM)			Extension	Productivity			
		Unit	QTY	Unit Cost		Base Unit for Productivity	Low	Target	High
							BANK CY		
							24,000 BCY		
							Duration (Crew-Hours)		
							Escalation Rates (%)		
							Notes		
							LF = 0.8 CYCLE=6.3 MIN; ASSUME 45 MIN HOUR BCY/HR = (45 MIN / 6.3 MIN) (22CY) (0.8LF) (6 SCRAPER) = 75.4 BCY/HR DURATION = 24,000 BCY / 75.4 BCY = 32 HOURS ADD 1 DAY FOR BAD WEATHER PROJECT WILL LAST ONE WORK WEEK		
							Cost Summary:		
							PM =		
							M&S =		
							IE =		
							L = 5,398.40		
							CE = 22,775.20		
							TOTAL = 28,173.60		
							5,398.40		
							22,775.20		
							22,775.20		

FIGURE 17.14 Work package collection sheet—excavation

17.10 SUMMARY

Three estimation methods 세가지 견적법

단순한 프로젝트

1. Unit-pricing or catalog lookup method

복잡한 프로젝트

2. Resource enumeration

3. Work package/assembly method

최소의 비용으로 최대의 정확도를

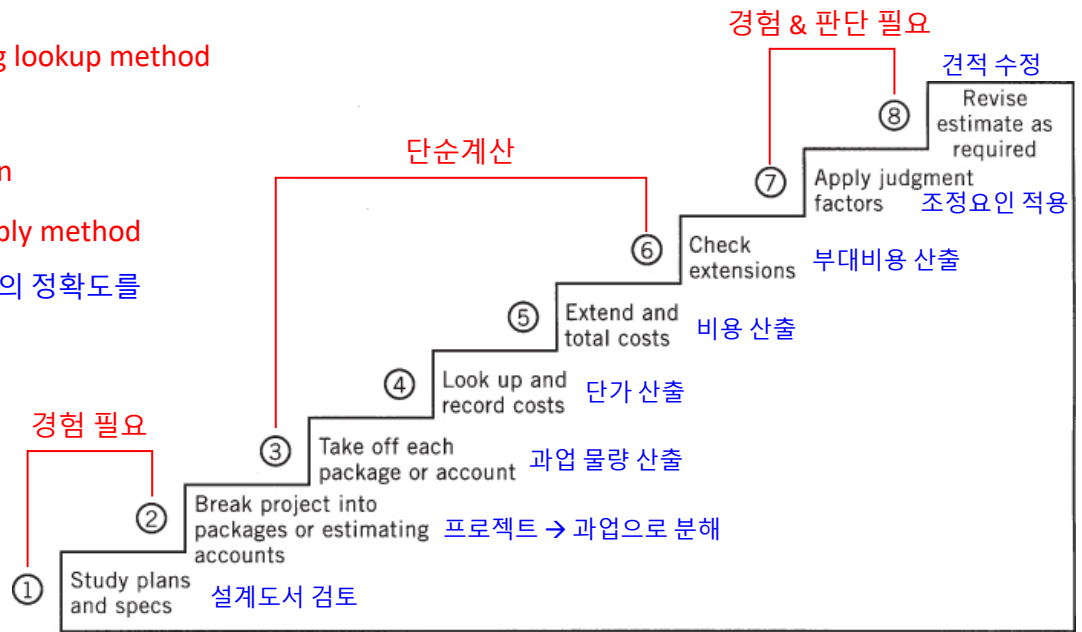


FIGURE 17.15 Steps in the estimating process

CHAPTER 18

COST CONTROL

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

18.1 Cost Control as a Management Tool

- ❑ The **early detection** of actual or potential **cost overruns** (비용초과) in field construction activities is vital to management. 관리의 핵심은 자금이 모자라는 상황을 조기에 파악하는 것
- ❑ **Cost control** eliminates such overruns or minimizes their impact. 원가관리는 비용초과를 예방하거나, 비용초과가 발생하는 경우 그 영향을 최소화 함
- ❑ 원가관리 자료는 미래 견적을 위한 기초자료로 활용될 수 있음

18.2 Project Cost Control Systems

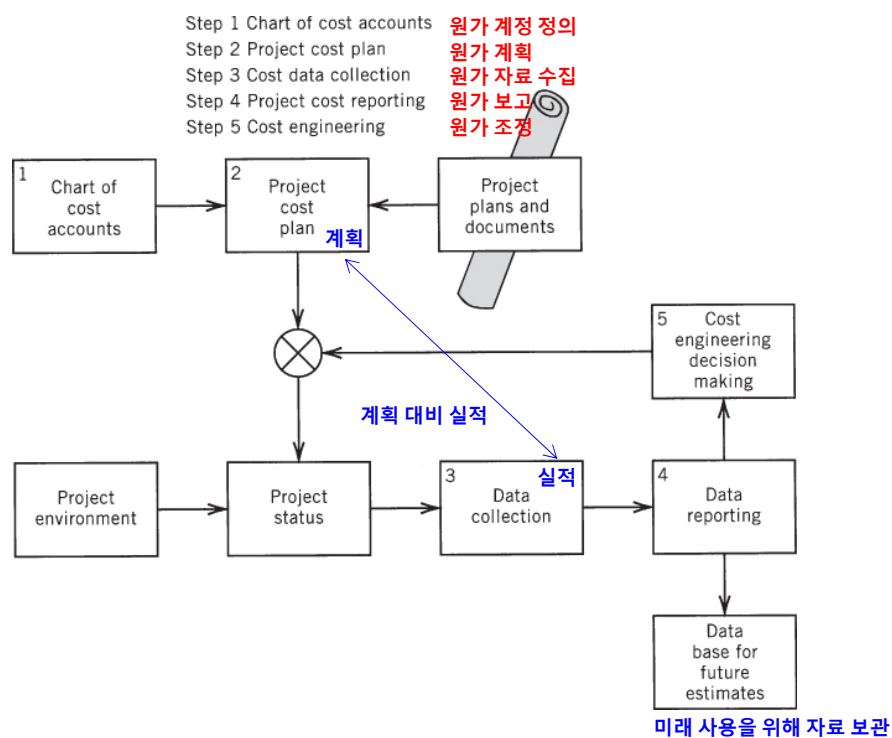


FIGURE 18.1 Steps in cost control

18.3 Cost Accounts

- ❑ The **first step** in establishing a cost control system for a construction job is the **definition of project-level cost centers**. 첫 단계는 비용센터 정의
- ❑ Cost center → **Cost account**. 비용 계정
- ❑ Cost account → **Cost code**. 비용 코드

MASTER LIST OF PROJECT COST ACCOUNTS				
Subaccounts of General Ledger Account 80.000 거래내역을 적은 원장				
직접비 계정 PROJECT EXPENSE				
간접비 계정				
Cost Code	Project Work Accounts 100-699	Cost Code	Project Overhead Accounts 700-999	
100	Clearing and grubbing	700		Project administration
101	Demolition	.01		Project manager
102	Underpinning	.02		Office engineer
103	Earth excavation	701		Construction supervision
104	Rock excavation	.01		Superintendent
105	Backfill	.02		Carpenter foreman
115	Wood structural piles	.03		Concrete foreman
116	Steel structural piles	702		Project office
117	Concrete structural piles	.01		Move in and move out
121	Steel sheet piling	.02		Furniture
240	Concrete, poured	.03		Supplies
	.01	703		Timekeeping and
	.05		.01	security
	.07		.02	Timekeeper
	.08		.03	Watchmen
	.10	705		Guards
	.11		.01	Utilities and services
	.12		.02	Water
	.16		.03	Gas
	.20		.04	Electricity
	.40	710		Telephone
	.50	711		Storage facilities
	.51	712		Temporary fences
	.60	715		Temporary bulkheads
	.90	717		Storage area rental
245	Precast concrete	720		Job sign
260	Concrete forms	721		Drinking water
	.01	722		Sanitary facilities
	.05	725		First-aid facilities
	.07	726		Temporary lighting
	.08	730		Temporary stairs
	.10	740		Load tests
	.11	750		Small tools
	.12	755		Permits and fees
270	Reinforcing steel	756		Concrete tests
	.01	760		Compaction tests
	.12	761		Photographs
280	Structural steel	765		Surveys
350	Masonry	770		Cutting and patching
	.01	780		Winter operation
	.02	785		Drayage
	.06	790		Parking
	.20			Protection of adjoining property
	.60	795		Drawings
400	Carpentry	796		Engineering
440	Millwork	800		Worker transportation
500	Miscellaneous metals	805		Worker housing
	.01	810		Worker feeding
	.20	880		General clean-up
	.50	950		Equipment
560	Finish hardware		.01	Move in
620	Paving		.02	Set up
680	Allowances		.03	Dismantling
685	Fencing		.04	Move out

18.4 Cost Coding Systems (1/3)

- ❑ 건설 특성에 따라 다양한 코드체계 존재.
- ❑ 빌딩 건설 : **MasterFormat (MF) Uniform Construction Index (UCI)**
- ❑ 도로 건설 : **American Road Builder (ARB)**

18.4 Cost Coding Systems (2/3)

TABLE 18.1 Major Divisions in CSI's MasterFormat Uniform Construction Index 2014 Revision → 건축에 특화된 코드 체계 Construction Specifications Institute

- Procurement and Contracting subgroup
 - 00 – Procurement and Contracting Requirements
- General Requirements subgroup
 - 01 – General Requirements
- Facilities Construction subgroup
 - 02 – Existing Conditions (Site Work)
 - 03 – Concrete
 - 04 – Masonry
 - 05 – Metals
 - 06 – Wood, Plastics, and Composites
 - 07 – Thermal and Moisture Protection
 - 08 – Openings
 - 09 – Finishes
 - 10 – Specialties
 - 11 – Equipment
 - 12 – Furnishings
 - 13 – Special Construction
 - 14 – Conveying Equipment
 - 15 – Reserved for future use in Mechanical
 - 16 – Reserved for future use in Electrical
- Facilities Services subgroup
 - 21 – Fire Suppression
 - 22 – Plumbing
 - 23 – Heating Ventilating and Air Conditioning
 - 25 – Integrated Automation
 - 26 – Electrical
 - 27 – Communications
 - 28 – Electronic Safety and Security
- Site and Infrastructure subgroup
 - 31 – Earthwork
 - 32 – Exterior Improvements
 - 33 – Utilities
 - 34 – Transportation
 - 35 – Waterway and Marine Construction
- Process Equipment subgroup
 - 40 – Process Integration
 - 41 – Material Processing and Handling Equipment
 - 42 – Process Heating, Cooling, and Drying Equipment
 - 43 – Process Gas and Liquid Handling, Purification and Storage Equipment
 - 44 – Pollution Control Equipment
 - 45 – Industry-Specific Manufacturing Equipment
 - 48 – Electrical Power Generation

18.4 Cost Coding Systems (3/3)

Figure 18.3 Detailed codes for classification within Uniform Construction Index (UCI)

<i>0 Conditions of the Contract</i>		0270.	Site Improvements
0000-0099.	unassigned	0271.	Fences
<i>1 General Requirements</i>		0272.	Playing fields
0.100.	Alternates of Project Scope	0273.	Fountains
0.101-0109.	unassigned	0274.	Irrigation systems
0110.	Schedules and Reports	0275.	Yard improvements
0111-0119.	unassigned	0276-0279.	unassigned
0120.	Samples and Shop Drawings	0280.	Lawns and Planting
0121-0129.	unassigned	0281.	Soil Preparation
0130.	Temporary Facilities	0282.	Lawns
0131-0139.	unassigned	0283.	Ground covers and other plants
0140.	Cleaning Up	0284.	Trees and shrubs
0141-0149.	unassigned	0285-0289.	unassigned
0150.	Project closeout	0290.	Railroad Work
0151-0159.	unassigned	0291-0294.	unassigned
0160.	Allowances	0295.	Marine Work
0161-0169.	unassigned	0296.	Boat Facilities
<i>2 Site Work</i>		0297.	Protective Marine Structures
0200.	Alternates	0298.	Dredging
0210-0209.	unassigned	0299.	unassigned
0210.	Clearing of Site	<i>3 Concrete</i>	
0211.	Declination	0300.	Alternates
0212.	Structures moving	0301-0309.	unassigned
0213.	Clearing and grubbing	0310.	Concrete Formwork
0214-0219.	unassigned	0311-0319.	unassigned
0220.	Earthwork	0320.	Concrete Reinforcement
0221.	Site grading	0321-0329.	unassigned
0222.	Excavating and backfilling	0330.	Cast-in-Place Concrete
0223.	Dewatering	0331.	Heavyweight aggregate concrete
0224.	Subdrainage	0332.	Lightweight aggregate concrete
0225.	Soil poisoning	0333.	Post-tensioned concrete
0226.	Soil compaction control	0334.	Nailable concrete
0227.	Soil stabilization	0335.	Specially finished concrete
0228-0229.	unassigned	0336.	Specially placed concrete
0230.	Piling	0337-0339.	unassigned
0231-0234.	unassigned	0340.	Precast Concrete
0235.	Caissons	0341.	Precast concrete panel
0236-0239.	unassigned	0342.	Precast structural concrete
0240.	Shoring and bracing	0343.	Precast prestressed concrete
0241.	Sheeting	0344-0349.	unassigned
0242.	Underpinning	0350.	Clementitious Decks
0243-0249.	unassigned	0351.	Poured gypsum deck
0250.	Site drainage	0352.	Insulating concrete roof decks
0251-0254.	unassigned	0353.	Cementitious unit decking
0255.	Site utilities	0354-0399.	unassigned
0256-0259.	unassigned		
0260.	Roads and Walks		
0261.	Paving		
0262.	Curbs and gutters		
0263.	Walks		
0264.	Road and parking		
Appurtenances			
0265-0269.	unassigned		

18.5 Project Cost Code Structure (1/2)

- ❑ The **MasterFormat** code as used by the R. S. Means Building Construction Cost Data identifies **four levels of detail**. MasterFormat 4 계층으로 세분화 가능
 - ❑ **Level 1:** 03 concrete items, **Level 2:** 03 11 concrete forming, **Level 3:** 03 11 13 structural cast-in-place concrete forming, **Level 4:** 03 11 13.25 forms in place
- l1. 콘크리트 공사 → l2. 콘크리트 성형 → l3. 현장 타설 → l4. 현장 거푸집

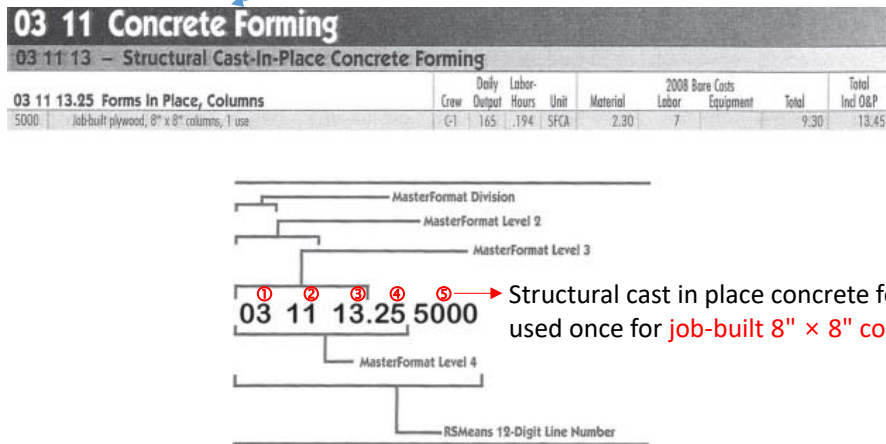


FIGURE 18.4 UCI cost (line item) structure in the **MasterFormat** code

18.5 Project Cost Code Structure (2/2)

1. **Year** in which project was started (2014)
2. **Project control number** (15)
3. **Project type** (5 for power station)
4. **Area** code (16 for boiler house)
5. **Functional division** (2, indicating foundation area)
6. **General work classification** (0210, indicating site clearing)
7. **Distribution code** (6, indicating construction equipment)

- 1. Labor
- 2. Permanent materials
- 3. Temporary materials
- 4. Installed equipment
- 5. Expendables
- 6. **Construction equipment**
- 7. Supplies
- 8. Subcontract
- 9. Indirect

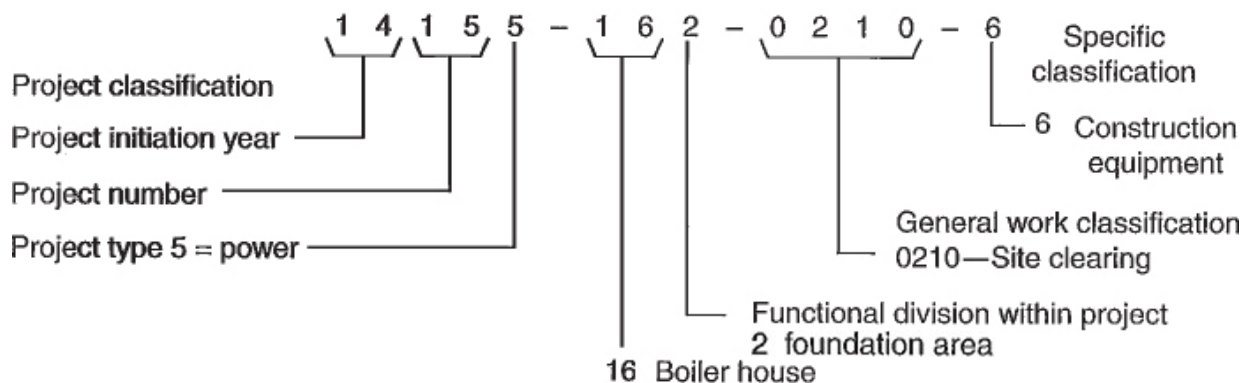


FIGURE 18.5 Classification of accounts: typical data structure for a computerized **cost code**

18.6 Cost Accounts for Integrated Project Management (1/4)

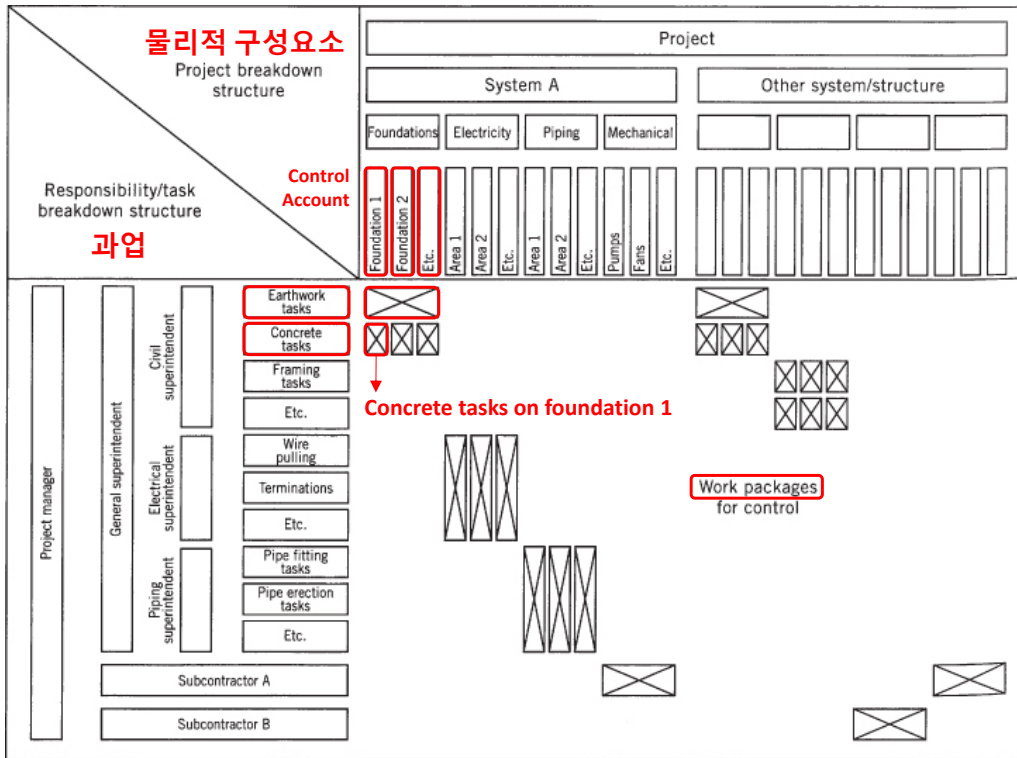


FIGURE 18.6 Project control matrix

18.6 Cost Accounts for Integrated Project Management (2/4)

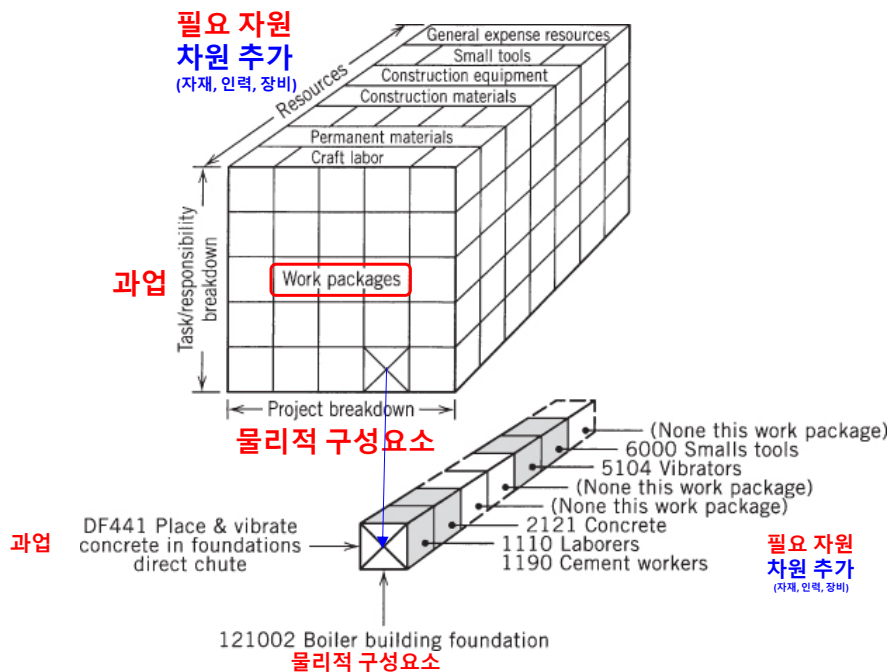


FIGURE 18.7 Three-dimensional visualization of work package-oriented cost accounts

18.6 Cost Accounts for Integrated Project Management (3/4)

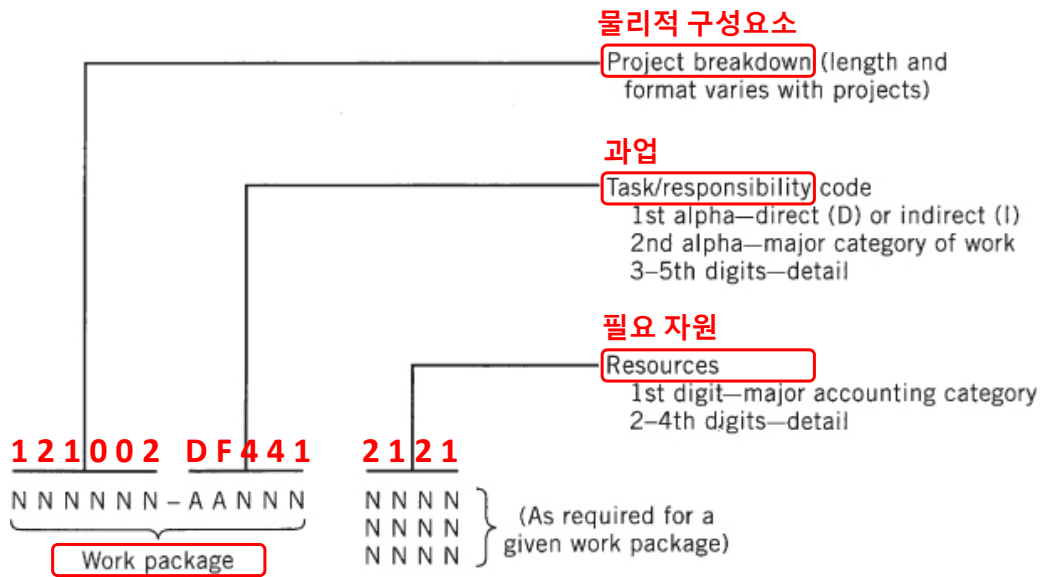
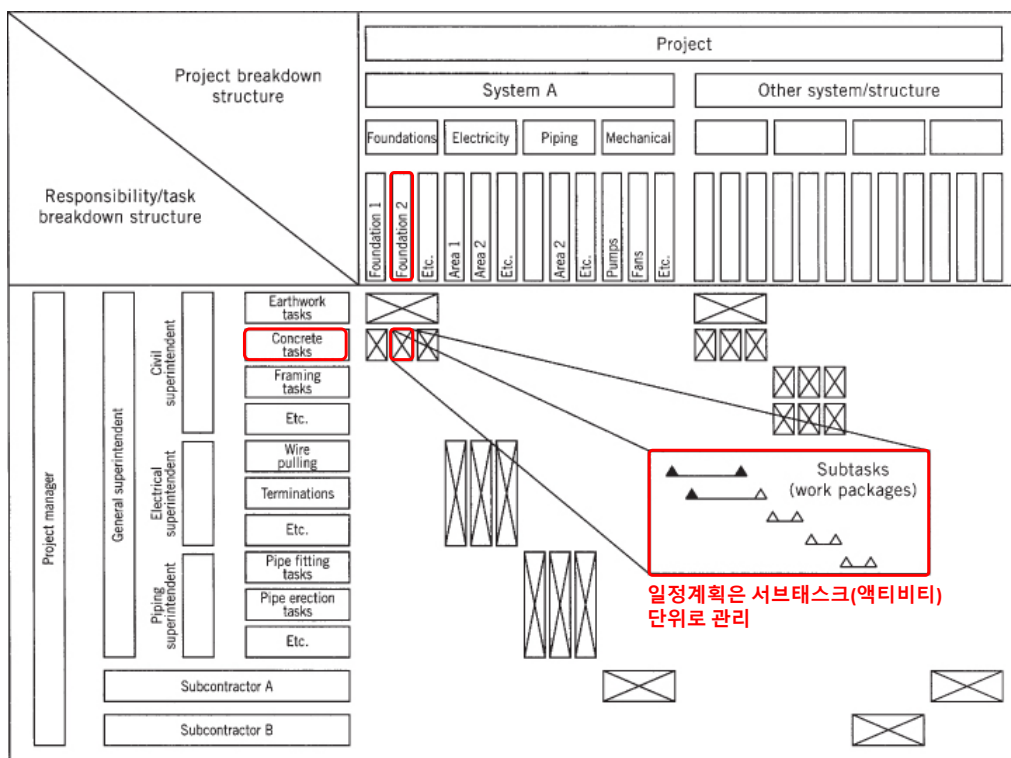


FIGURE 18.8 Basic cost code structure

18.6 Cost Accounts for Integrated Project Management (4/4)



18.7 Earned Value Method (1/7) 공정원가 통합 관리 방안

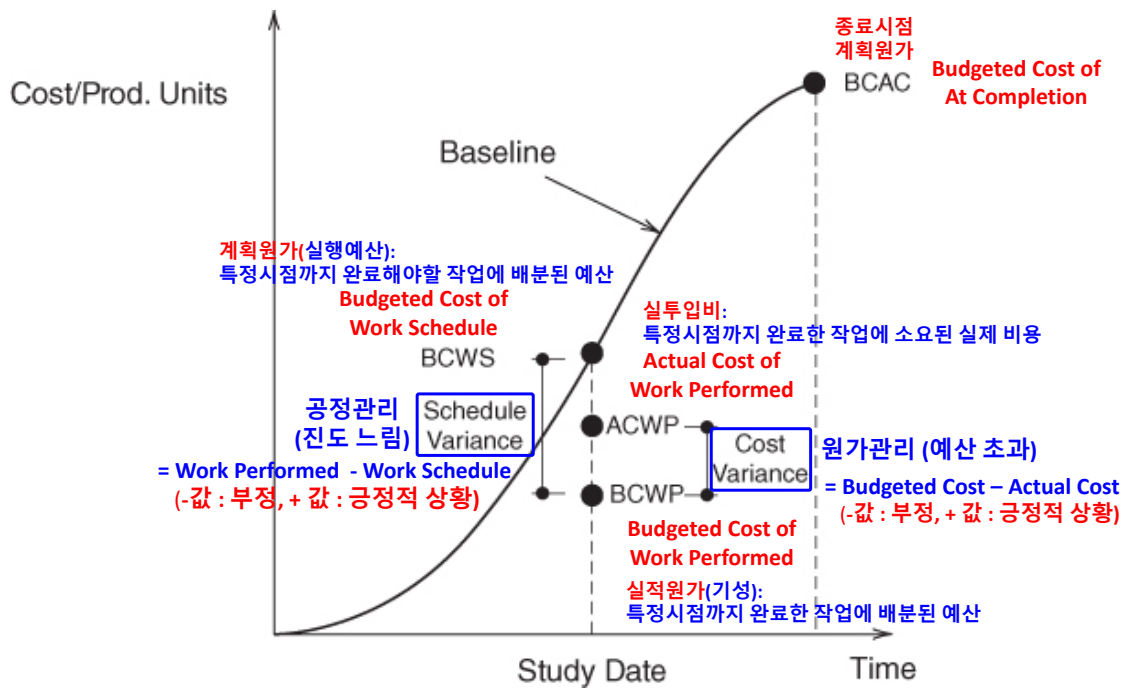


FIGURE 18.10 Control values for earned value analysis

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18.7 Earned Value Method (2/7)

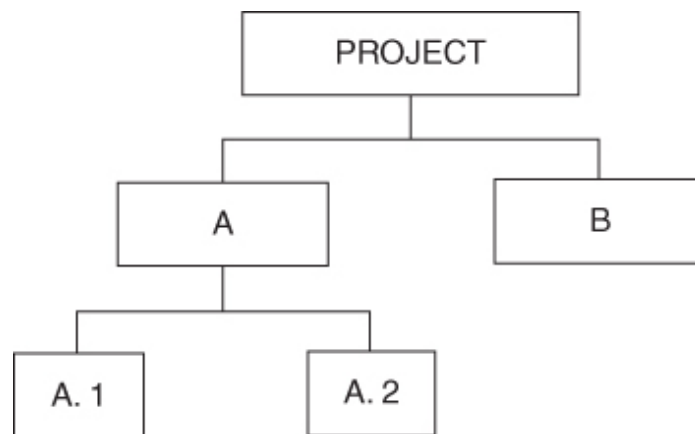


FIGURE 18.11 A simple project hierarchy

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18.7 Earned Value Method (3/7)

	중료시점 계획원가 BCAC	실투입비 ACWP	중료시점 계획물량 BQAC	실작업량 AQWP	Actual Quantity of Work Performed Budgeted Quantity At Completion $\frac{AQWP}{BQAC}$ PC (%)	BCAC-PC BCWP	중료 시점의 원가 추정치 BCAC $\frac{ACWP}{BCWP}$ ECAC	중료 시점의 원가 추정치 Estimated Cost At Completion
A					물량진도	실적원가		
A.1	100	40	105	35	$33.3 = 35/105$	$33.3 = 100 \times 0.33$	120	$= 100 \times (40/33.3)$
A.2	50	35	77	60	$78.0 = 60/77$	$39.0 = 50 \times 0.78$	45	$= 50 \times (35/39.0)$
B	65	50	125	100	$80.0 = 100/125$	$52.0 = 65 \times 0.80$	62.5	$= 65 \times (50/52.0)$
TOTAL	215	125	—	—	$57.8 = 100 \times 124.3 / 215$	124.3	227.5	

Project PC (PPC) = Total BCWP ÷ Total BCAC = 124.3 ÷ 215 = 57.8%
 ECAC_i = Estimated Cost at Completion for Work Package i = ACWP_i ÷ PC_i

현재 생산성으로 진행되어 프로젝트가 종료되면 원래 예산 215보다 12.5가 증가한 227.5의 비용이 소요될 것으로 추정됨.

18.7 Earned Value Method (4/7)

- 비용차이 CV, Cost Variance = $BCWP - ACWP$ - 값 : 부정, + 값 : 긍정적 상황
- 일정차이 SV, Schedule Variance = $BCWP - BCWS$
- 비용지출지수 CPI, Cost Performance Index = $BCWP / ACWP$ < 1 값 : 부정, > 1 값 : 긍정적 상황
- 일정수행지수 SPI, Schedule Performance Index = $BCWP / BCWS$

CV (A.1) = BCWP (A.1) - ACWP (A.1) = 33.3 - 40 = -6.7 - 증가 : 예산 초과

CV (A.2) = BCWP (A.2) - ACWP (A.2) = 39 - 35 = +4

CV (B) = BCWP (B) - ACWP (B) = 52 - 50 = +2 + 절감 : 예산 범위 내

CPI (A.1) = $33/40 < 1.0$ A value less than 1.0 indicates cost overrun of budget < 1 : 예산 초과

CPI (A.2) = $39/35 > 1.0$ > 1 : 예산 범위 내

CPI (B) = $52/50 > 1.0$ Values greater than 1.0 indicate actual cost less than budgeted cost

SV (A.1) = BCWP (A.1) - BCWS (A.1) = 33.3 - 50 = -16.7 - 지연 : 일정 밖

SV (A.2) = BCWP (A.2) - BCWS (A.2) = 39 - 32 = +7

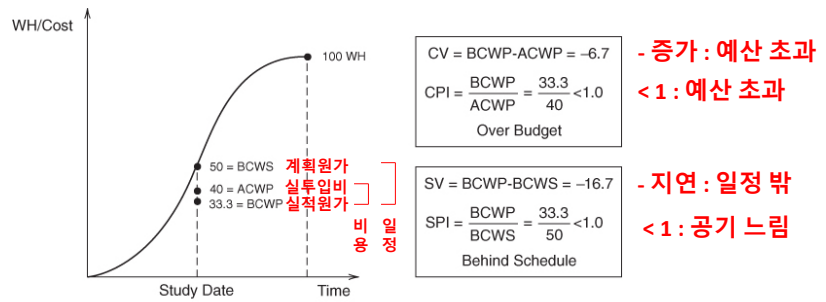
SV (B) = BCWP (B) - BCWS (B) = 52 - 45 = +7 + 빠름 : 일정 내

SPI(A1) = $BCWP(A1) / BCWS(A1) = 33.3 / 50 = 0.66 < 1$ < 1 : 공기 지연

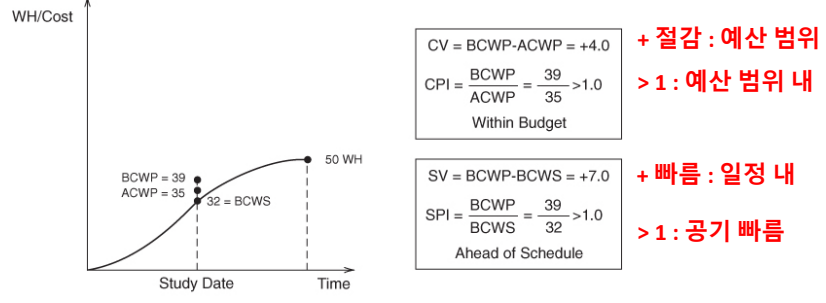
SPI(A2) = $BCWP(A2) / BCWS(A2) = 39.0 / 32 = 1.22 > 1$ > 1 : 공기 빠름

SPI(B) = $BCWP(B) / BCWS(B) = 52.0 / 45 = 1.16 > 1$

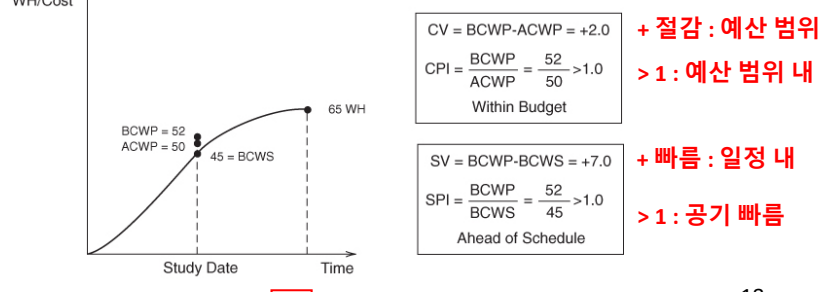
18.7 Earned Value Method (5/7)



(a) Baseline for A.1



(b) Baseline for A.2



(c) Baseline for B

FIGURE 18.12 States of control account for single project

18.7 Earned Value Method (6/7)

		비용 초과	비용 절감
Cost		Overrun	Underrun
Schedule			
Delay		I, IV	II
Advantage		V	III, VI

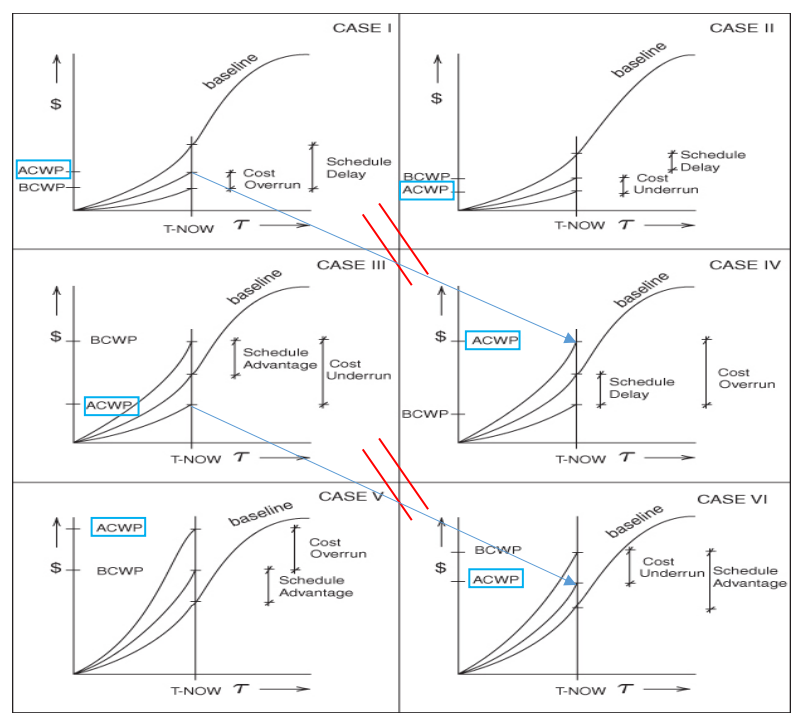


FIGURE 18.13 Scenarios for permutations among ACWP, BCWP, and BCWS

18.7 Earned Value Method (7/7)

		비용 초과	비용 절감
기림	Cost	Overrun	Underrun
	Schedule		
기름	Delay	I, IV	II
	Advantage	V	III, VI

$CPI < 1$ $CV < 0$	→	overrunning cost	$CPI > 1$ $CV > 0$	→	within budget
$SPI < 1$ $SV < 0$	→	behind schedule	$SPI < 1$ $SV < 0$	→	behind schedule
CASE I			CASE II		
$CPI > 1$ $CV > 0$	→	within budget	$CPI < 1$ $CV < 0$	→	overrunning cost
$SPI > 1$ $SV > 0$	→	ahead of schedule	$SPI < 1$ $SV < 0$	→	behind schedule
CASE III			CASE IV		
$CPI < 1$ $CV < 0$	→	overrunning cost	$CPI > 1$ $CV > 0$	→	within budget
$SPI > 1$ $SV > 0$	→	ahead of schedule	$SPI > 1$ $SV > 0$	→	ahead of schedule
CASE V			CASE VI		

TABLE 18.3 Values of CPI, CV, and SPI, SV for the Six Scenarios (Singh, 1991)

18.8 Labor Cost Data Collection (1/2)

□ 비용계정별로 인건비 집계

Dewey, Cheatum, and Howe
Company

Report No. 16 Date 12 September XX
 DAILY LABOR DISTRIBUTION REPORT Job No. 101
 Foreman's signature Sam Deuck Location Peachtree Corners Shopping Mall

Employee or badge number	Name	Code	Craft or union	Rate	비용계정					Total hours		
					80,103	80,104	80,260.01	80,260.07	Hours	Hours	ST	PT
65	Adam Apple	ST	15	16.50	4	4					8	0
		PT										
14	Ella Del Fabbro	ST	10	12.50			8				8	0
		PT										
22	Charles Hoarse	ST	10	12.50			6	2			8	0
		PT										
		ST										
		PT										
		ST										
		PT										
		ST										
		PT										
		ST										
		PT										
Approved by <u>Worf</u> Totals					4	4	14	2			24	0

FIGURE 18.14 Foreperson's daily labor distribution report

18.8 Labor Cost Data Collection (2/2)

□ 급여정보 집계 체계

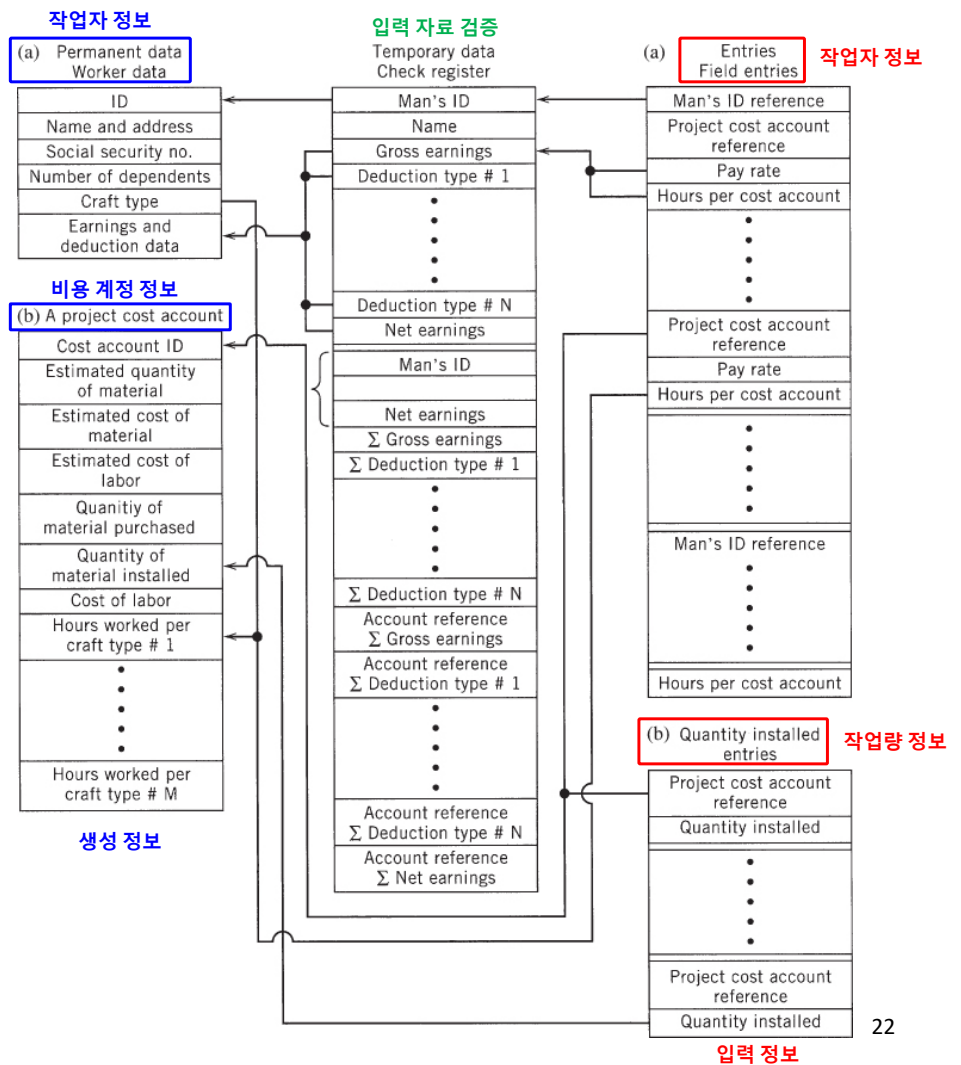


FIGURE 18.15 Payroll data structure

18.9 Charges for Indirect and Overhead Expense

□ Contractor-incurred expenses associated with the construction of a given facility relate to: 건설에 소요되는 비용은 직접비와 간접비로 크게 나뉘볼 수 있음

1. **Direct cost** consumed in the realization of a physical sub-element of the project (e.g., labor and material costs involved in pouring a slab). **직접비: 인건비, 자재비, 장비비 등**
2. **Production support costs (Indirect cost)** incurred by the project-related support resources or required by the contractor (e.g., superintendent's salary, site office costs, various project-related insurances) costs associated with the operation and management of the company as a viable business entity (e.g., home office overhead, such as the costs associated with preparation of payroll in the home office, preparation of the estimate, marketing, and salaries of company officers). **간접비: 관리자 급여, 현장사무소 경비, 보험료, 본사 경비 등**

18.10 Project Indirect Costs

□ The contractor calculates the **direct costs** (as defined previously) and multiplies these charges by a **percentage factor** to cover both project indirects and home office fixed overhead. 일반적으로 간접비는 직접비에 대한 비율로 표시 → 직접비 : 200,000, 간접비 비율 : 20%, 간접비 = 200,000 × 20% = 40,000, 이윤 : 10%, 총입찰액 = 240,000 * 1.1 = 264,000

CENTURY CENTER BLDG #5				LABOR COST REPORT				WEEK 57		WEEK ENDING 10/11	
ATLANTA, GA				HALCON CONSTRUCTORS, INC.				PAGE 1		PROJECT NUMBER 13-5265	
Cost Code	Cost Code Information			Quantity		Unit Price		Cost		Projected Cost	
	Description	Units	% Comp	Estimated	Actual	Estimated	Actual	Estimated	Actual	To Date Over/Under	To Complete Over/Under
111	**This Week** 쓰레기 수거 Haul Trash	Wk	68	50	34	200.000	248.000	10,000	248	3,646-	1,716-
112	**This Week** Daily Clean	Wk	68	69	47	217.391	543.000	15,000	543	4,428	2,072
115							311.596		1,747	1,747	No Budg.
130	**This Week** Safety	Wk	81	69	56	217.391	13.000	15,000	13	621-	144-
131	Protect Trees	Ls	100	18	18	1,388.889	206.304	500	11,553	204-	
132	Shoring	Ls	100	18	18	1,388.889	1,345.389	25,000	24,217	783-	Comp.
307	**This Week** Hand Exc	Cy	97	725	705	18.793	19.569	13,625	19.600	98	4
310	Dewater	Ls	100	6,000	5,000	1.500	1.291	2,000	13,796	547	15
312	Bkfl Hand	Cy	83	6,000	5,000	1.500	1.291	9,000	2,060	60	Comp.
316	Fine Gr	Sf	99	15,000	14,830	.167	.135	2,500	6,453	1,047-	209-
									1,999	501-	Comp.

FIGURE 18.16 Labor cost report (some typical line items)

18.11 Fixed Overhead

□ The calculation of the **home office overhead allocation factor**: 본사 경비 비율 추정 : 전년 실적 → 후년 예측

General & Administrative

Step 1: Estimate of Annual Overhead (G & A Expense)

전년도 비용	Last year's G & A	\$270,000
물가 상승	10% inflation	27,000
기업 규모 증가	Firm growth	23,000
추정 G&A	Estimated G & A	\$320,000 부과 해야할 경비 추정

Step 2: Estimate of \$ of Cost Basis for Allocation

예상 매출	Estimated volume	\$4,000,000
이윤	Gross margin	20% = \$800,000
예상 원가 = 예상 매출 - 이윤	Labor and material	\$3,200,000 부과 대상 예상 원가(직접비) 추정

Step 3: Calculate Overhead Percentage

Overhead costs estimated (G & A)/Labor and material estimate = 320,000/3,200,000 = **10%** **부과 비율 결정**

Step 4: Cost to Apply to a Specific Project

Estimated labor and material costs	\$500,000
경비 : 직접비의 10% 부과	Overhead to apply (@ 10 percent) 50,000 경비 결정
	\$550,000

18.12 Considerations in Establishing Fixed Overhead (1/2)

- 고정비: 간접비 성격, 변동비: 직접비 성격
- $PC = PS / (100 - PS)$
- 직접비에 대한 경비 부과 비율(경비비율) = 총비용 중 경비 비중 / (100% - 총비용 중 경비 비중)
- PC = percentage applied to the project's total direct cost for the coming year (경비/직접비)
- PS = percentage of total volume in the reference year incurred as G & A expense (경비/총비용)

- 경비(간접비) : 800,000, 총물량: 4,000,000, 직접비: 3,200,000
- 경비비율(PC) = $800,000 / 3,200,000 = 25\%$ ← 경비비율은 직접비에 대한 경비의 비율: 분모가 직접비
- 총비용 중 경비 비중(PS) = $800,000 / 4,000,000 = 20\%$: PS가 주어져 있는 경우
- 직접비에 대한 경비 부과 비율, $PC = 20\% / (100\% - 20\%) = 25\%$

- 직접비: \$1,000,000, 경비(25%): \$250,000, 이익률: 10%
- 총입찰액 = $\$1,000,000 + \$250,000 + (\$1,000,000 + \$250,000) \times 0.1 = \$1,375,000$

18.12 Considerations in Establishing Fixed Overhead (2/2)

			20% on Total Direct	25% on Labor and Equipment; 15% on Material and Subcontracts
			경비 추정 방법 I 모든 항목에 동일 비율 적용	경비 추정 방법 II 항목마다 다른 비율 적용
Job 101	Labor and equipment	\$ 800,000	\$160,000	\$200,000 -25%
	Materials and subcontracts	\$1,200,000	240,000	180,000 -15%
			\$400,000	\$380,000
Job 102	Labor and equipment	200,000	\$ 40,000	\$ 50,000 -25%
	Materials and subcontracts	2,000,000	400,000	300,000 -15%
			\$440,000	\$350,000
Job 103	Labor and equipment	700,000	\$140,000	\$175,000 -25%
	Materials and subcontracts	700,000	140,000	105,000 -15%
			\$280,000	\$280,000

Comparison of Fixed Overhead Rate Structures

CHAPTER 19

MATERIALS MANAGEMENT

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

19.1 Material Management Process

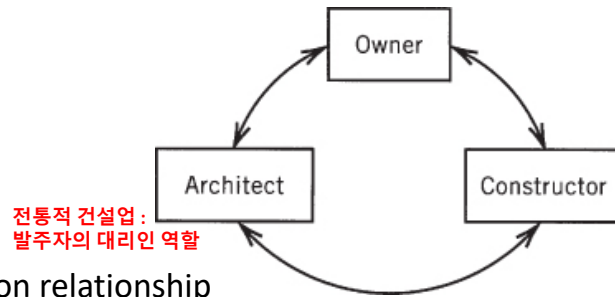


FIGURE 19.1 The owner-architect-construction relationship

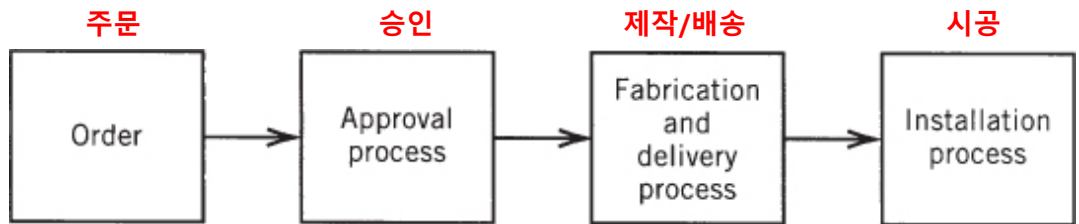


FIGURE 19.2 Material life cycle 자재 생애 주기

19.2 The Order (1/6) 주문

- 주계약자가 공사를 나눠 하도급자들에게 총액 기준으로 분배
→ 총액 공사비 내에서 공사를 마무리 할 수 있도록 함

FIGURE 19.3 Field purchase order
→ Simple Contract (약식계약)

FIGURE 19.4 Formal purchase order
→ Complex Contract (정식계약)

19.2 The Order (2/6)

- Regardless of the complexity of the transaction, certain basic elements are present in any purchase order. (자재 구매 주문에 꼭 포함되어야 하는 내용)
 1. Quantity or number of items required. 요구 수량
 2. Item description. This may be a standard description and stock number from a catalog or a complex set of drawings and specifications. 자재 스펙
 3. Unit price. 단가
 4. Payment terms specifying the timing of payment for the goods purchased. 대금 지불 방법
 5. Special instructions. 특수 조항
 6. Signatures of agents empowered to enter into a contractual agreement. 서명
- 구매 주문: Buyer 작성 → Vender 수정 → Buyer 승인

4

19.2 The Order (3/6)

- Vender(판매자) → Carrier(배송사) → Purchaser(구매자)
- 계약방식에 따라 소유권이 판매자로부터 구매자에게 넘어가는 장소가 달라짐
- CIF (Cost, Insurance, Freight) : 제품 구입비, 배송과 관련된 보험비와 운송비
- Free On Board (FOB) & COD (Cash On Delivery) : 배송 완료 시 구매 대금을 지급하는 방식

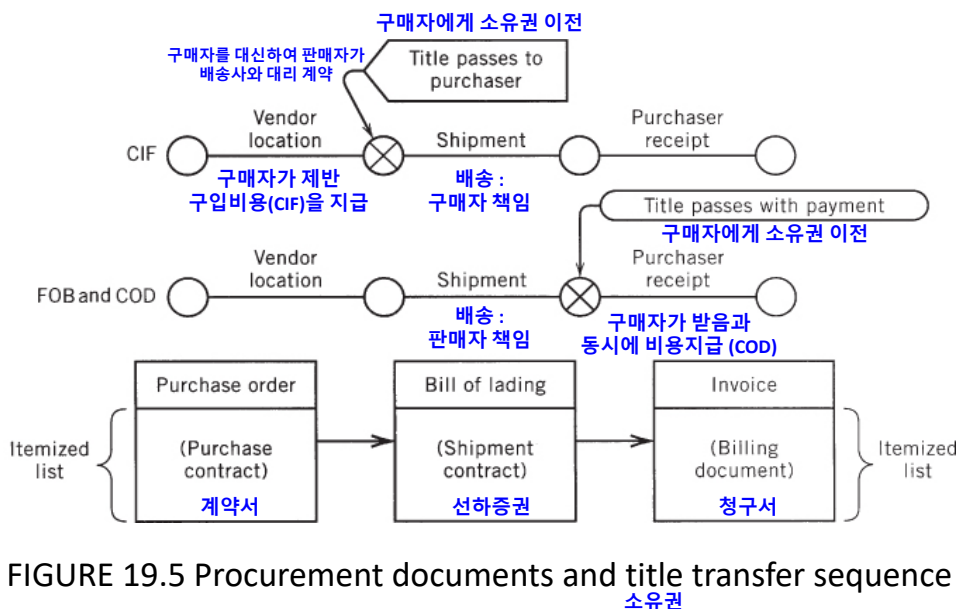


FIGURE 19.5 Procurement documents and title transfer sequence

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19.2 The Order (6/6)

□ **Terminology** relating to trade **discounts** is as follows: 할인과 관련된 용어

ROG/AOG: The discount period begins upon **receipt of goods (ROG)** or **arrival of goods (AOG)**. 대금 지급 조건과 관련된 다른 표현들

- ✓ **2/10 NET 30 ROG**: This expression appearing on the invoice means 2% can be deducted from the invoiced amount if the contractor pays within 10 days of AOG/ROG. Full payment is due within 30 days of AOG/ROG. 도착 후 10일내 지급하면 2% 할인, 도착 후 30일 내 지급하면 정상가
- ✓ **2/10 PROX NET 30**: A 2% cash discount is available if invoice is paid not later than the 10th of the month following ROG. Payment is due in full by the end of the following month. 물건이 도착한 다음 달 10일까지 지급하면 2% 할인, 다음 달 말까지 지급하면 정상가
- ✓ **2 EOM**: The discount (2%) is available until the end of the month (EOM) following ROG payment in full is due thereafter. 물건이 도착한 달 말까지 지급하면 2% 할인, 그 이후에 지급하면 정상가

□ 레미콘 차량이 현장 진입 시 가스 관로를 밟아서 파손이 되었다면... 이 건에 대한 책임은 누구에게 있는가?
“Hold Harmless(면책: 계약의 한 쪽이 상대방의 계약상 손실 따위를 대신 떠맡는)”에 따라 Vender 또는 Purchaser에게 있을 수 있음 ← Purchase Order에 “Hold Harmless”에 대해 서술

8

19.3 Approval Process 승인

- The contract drawings prepared by the architect are generally not specific enough to facilitate accurate fabrication of the materials involved. 계약 시 첨부된 설계도면 만으로는 정확하게 어떤 자재가 사용되는지 파악하기 어렵다.
- Therefore, to produce the necessary materials for a project, **subcontractors** and **suppliers** must provide details that further amplify the contract drawings. These details can be classified into three groups: (a) **shop drawings**, (b) **product data**, and (c) **samples**. 하도급사나 자재 공급자로부터 시공 도면, 제품 자료, 견본 등의 정보(submittals)를 제출 받아야 함. → 이후 시공자나 설계자가 submittals를 검토 후 승인 → 미승인의 경우 수정·보완 후 다시 제출

9

19.4 Fabrication and Delivery Process 제작/배송

- **Submittals** (Shop drawings, Product data, Samples) 승인 → 납품 일정 결정 → 제작
- 주계약자가 공장 방문을 통해 진도 관리 (**Expediting**) → 승인된 **Submittals**를 이용하여 입고 물품 품질 검사

10

19.5 Installation Process 시공

- Depending on **how effectively materials are scheduled** and expedited, materials arriving at the job site may be **installed immediately, partially installed and partially stored, or completely stored** for later installation. 납품 일정이 얼마나 효과적으로 결정되었는가에 따라 즉시 시공, 부분 시공, 부분 보관, 전체 보관 등의 상황 발생 → 즉시 시공이 가장 바람직함 → 재고관리 필요
- 추후 사용을 위해 자재를 보관하는 경우, 날씨로부터 자재를 안전하게 보호해야 하며, 도난을 방지해야 함.

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19.6 Material Types (1/4)

□ **Building construction materials** can be logically grouped into **three major categories**:
건설 자재는 통상 3등급으로 나누어 관리

(a) **Bulk materials** that require little or no fabrication → 1~5일 정도의 **Delivery Time**
(배송시간: 주문 후 자재가 현장에 도착하는 데까지 걸리는 시간): 제품·성능 자료 등의 **Submittals** 필요

(b) Manufacturer's **standard items** that require some fabrication (표준 자재) → 3~12주
정도의 **Delivery Time** (배송시간): 제품·성능 자료, 시공 도면, 샘플 등의 **Submittals** 필요

(c) **Items that are fabricated or customized for a particular project** (맞춤 자재) → 2~12주
정도의 **Delivery Time** (배송시간): 제품·성능 자료, 시공 도면, 샘플 등의 **Submittals** 필요

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19.6 Material Types (2/4)

Typical Bulk Materials

Paving materials
Fill materials—crushed stone, soil, sand, etc.
Damproofing membrane
Lumber and related supplies
Form materials—plywood, post shores, etc.
Ready-mix concrete
Wire mesh
Stock reinforcing steel and accessories
Masonry
Stock miscellaneous metals
Soil and waste piping
Water piping
Electrical conduit
Electrical rough-in materials—outlet boxes, switch boxes, etc.
Caulking and sealants

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19.6 Material Types (3/4)

Typical Standard Material Items

General Materials

- Fencing materials
- Formwork systems—metals and fiberglass pans, column forms, etc.
- Brick paving
- Brick or ceramic veneers
- Standard structural steel members
- Metal decking
- Waterproofing products
- Insulation products
- Built-up roof materials
- Caulking and sealants
- Standard casework and millwork
- Special doors
- Metal-framed windows
- Finish hardware and weather-stripping
- Ceramic and quarry tile
- Flooring materials
- Acoustical ceilings
- Paints and wall coverings
- Lath and plaster products
- Miscellaneous specialties
- Equipment—food service, bank, medical, incinerators, etc.
- Building furnishings
- Special construction items—radiation protection, vaults, swimming pools, integrated ceilings
- Elevators, escalators, dumbwaiters, etc.

Mechanical and Plumbing Equipment and Materials

- Fire protection equipment
- Water supply equipment
- Valves
- Drains
- Clean-outs
- Plumbing fixtures
- Gas-piping accessories
- Pumps
- Boilers
- Cooling towers
- Control systems
- Air-handling equipment
- Refrigeration units (chillers)

19.6 Material Types (4/4)

Typical Standard Material Items

Electrical Equipment and Materials

- Busduct
- Special conduit
- Switchboards and panels
- Transformers
- Wire
- Trim devices
- Lighting fixtures
- Underfloor duct
- Communications devices
- Motors and starters
- Motor control centers
- Electric heaters
- Fire alarm equipment
- Lightning protection equipment
- Concrete reinforcement
- Structural steel
- Precast panels and decks
- Stone veneers
- Miscellaneous and special formed metals
- Ornamental metals
- Millwork
- Custom casework and cabinetwork
- Sheet metal work
- Sheet metal veneers
- Hollow metal doors and frames
- Wood and plastic laminate doors
- Glass and glazing
- Storefront
- Window walls and curtain walls

CHAPTER 20

SAFETY

제1장	History and Basic Concepts
제2장	Preparing the Bid Package
제3장	Issues During Construction
제4장	Contracts
제5장	Legal Structure
제6장	Impact of Taxes
제7장	Project Planning
제8장	Project Scheduling
제9장	Scheduling: Program Evaluation and Review Technique Networks and Linear Operations
제10장	Resource-Related and Advanced Linear Scheduling Techniques
제11장	The Mathematics of Money
제12장	Project Cash Flow
제13장	Project Funding
제14장	Equipment Ownership
제15장	Equipment Productivity
제16장	Construction Labor
제17장	Estimating Process
제18장	Cost Control
제19장	Materials Management
제20장	Safety

20.1 Need for Safe Practice

- ❑ Out of **4,379** worker fatalities in private industry in the calendar year 2015, **937 (21.4%)** were in construction; that is, **one in five worker deaths were in construction**. 2015년 전체 산재 사망자수는 4,379명, 이 중 중 건설업 종사 사망자수의 비율이 21.4%
- ❑ 2003년도 건설업 산재 사망자 수가 이라크 전쟁 18개월 동안의 전사자 수보다 많았다고 함.
- ❑ The factors that motivate safe practices: 안전이 중요한 이유
 1. Humanitarian concerns 인도주의
 2. Economic costs and benefits 경제적 이유
 3. Legal and regulatory considerations 법적 이유

2

20.2 Humanitarian Concerns 인도주의

- ❑ Particularly at the level of the work site, society has defined the principle that the **employer** is responsible for **providing a safe environment** for the work force. 고용주는 근로자에게 안전한 작업환경을 제공할 의무를 갖는다.
- ❑ The current **safety legal framework** is summarized by the General Duty Clause of the United States **Occupational Safety and Health Act (OSHA)**. 미국 안전 관련 법규 : OSHA
- ❑ 1800년대 후반 ~ 1900년대 초반, 공공복지 측면에서 산업재해 보상법 제정

3

20.3 Economic Costs and Benefits (1/3)

□ **Safety costs** can be broken into three categories: 세가지 범주의 안전 관련 비용

1. Direct cost of previous accidents 과거 사고로부터의 직접적인 손해
 - a. Insurance premiums and ratings 보험료 인상
 - b. Mandatory accident prevention methods 사고 예방 비용
 - c. Records, safety personnel 안전관리 인건비
2. Direct cost of each accident occurrence 해당 사고로부터의 직접적인 손해
 - a. Delay to project 공기 지연
 - b. Uninsured damages 보험으로 보상받지 못하는 손해들
3. Indirect cost 간접적인 손해
 - a. Investigation 안전 점검
 - b. Loss of skilled workers 숙련공을 잃음
 - c. Loss of equipment 장비 손실
 - d. Lost production 작업 손실

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20.3 Economic Costs and Benefits (2/3)

□ 산업재해 보험료 결정 방법

□ **Manual rating** is based on the past losses of the industry as a whole. 산업별 표준 보험
요율 사용 - 모든 기업이 평균적인 동일 보험료를 부담

□ The **premium rate** for compensation is normally set by the individual state
Compensation Rating Bureaus. 동일 지역 & 동일 공종 → 동일 보험 요율

□ **Metric rating**: 개별 기업의 실적에 기반하여 보험료 결정 → 안전사고 기록을 보험료 할증 결정에
이용하는 두가지 방법: 과거 실적 기반 vs 미래 실적 기반

□ **Experience rating methods**: 바로 전년을 제외한 과거 3년간의 안전 사고 실적으로 결정,
Experience Modification Rate (EMR)을 표준 보험 요율에 곱하여 보험 요율 산정, 공사 규모: \$2.5
Million, 표준 보험 요율: 8%, **EMR: 0.7** → 보험료 = \$2.5 Million × 8% × 0.7 = \$140,000
소급

□ **Retrospective rating methods**: 정해진 기간 동안에 발생한 안전 사고 실적을 보험료에 소급하여
적용 → 미래 실적을 바탕으로 보험료가 조정됨 → 만약 연말에 예상보다 사고가 적게 발생했다면 일정
금액의 보험료를 환불 받는 방식

□ 안전 유지 → 보험료 인하 → 수익성 향상 → 보다 저가로 입찰에 참가하는 것이 가능해짐

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20.3 Economic Costs and Benefits (3/3)

State	공사의 종류																			
	Carpentry — general	Concrete Work — NOC	Concrete Work — flat (flr., sdwk.)	Electrical Wiring — inside	Excavation — earth NOC	Excavation — rock	Glaziers	Insulation Work	Masonry	Painting & Decorating	Pile Driving	Plastering	Plumbing	Roofing	Sheet Metal Work (HVAC)	Steel Erection — structure	Steel Erection — NOC	Tile Work — (interior ceramic)	Waterproofing	Wrecking
CA	30.29	11.42	11.42	7.84	13.27	13.27	17.86	12.98	17.53	16.24	15.03	27.23	12.47	51.93	18.17	17.31	20.57	8.69	16.24	20.57
CO	12.76	13.19	7.46	5.18	10.35	10.35	9.79	13.91	14.30	10.29	15.08	9.00	8.45	23.95	11.46	35.52	15.85	8.60	5.74	15.85
DC	10.82	9.43	12.00	6.35	12.14	12.14	17.96	9.67	15.03	8.37	14.12	12.98	11.77	21.47	8.93	43.78	18.27	21.67	4.05	43.78
FL	18.25	18.38	8.91	7.48	9.33	9.33	14.41	11.19	13.96	13.51	38.24	25.08	8.13	28.05	12.68	35.41	23.49	8.34	6.22	35.41
GA	24.91	14.49	10.83	9.87	17.01	17.01	15.94	22.44	19.68	18.93	26.79	18.55	10.89	44.56	20.76	52.69	41.28	10.07	8.65	52.69
IN	7.45	5.04	3.48	2.74	4.62	4.62	5.59	6.77	5.15	4.77	8.47	3.83	2.85	11.36	4.45	15.75	7.98	3.09	2.27	15.75
KY	22.00	15.75	8.00	6.00	10.40	10.40	20.44	20.69	9.50	12.50	25.37	15.33	7.00	45.00	19.58	46.98	23.88	11.89	6.75	46.98
NY	12.39	17.19	11.26	6.69	8.37	8.37	10.18	9.91	15.70	10.41	15.68	9.04	7.33	33.39	12.79	21.77	15.20	8.72	6.92	10.56
WY	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	16.00	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93
AVG.	18.31	15.22	9.42		10.46	10.46	14.15	15.12	14.80	12.86	21.48	14.39	8.11	32.94	11.88	40.12	23.82	9.47	7.07	36.28

FIGURE 20.1 Compensation insurance base rates for construction workers (Selected states and crafts—these rates do not purport to be current but are shown here only as indicative of the rate structure.)

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20.4 Uninsured Accident Costs 사고로 인한 간접 손실 비용

- 사고로 인한 공기 지연의 효과는 무시된 채, 자재 및 근로자의 인건비 정도만이 보험으로 처리될 뿐임.
- 눈에 보이지 않는 간접적인 손실이 보험에 의해 보상 받는 직접적인 손실보다 9배나 크다

Injuries 사고 처리 관련 손실	Associated Costs 부대 비용
<ol style="list-style-type: none"> 1. First-aid expenses 2. Transportation costs 3. Cost of investigations 4. Cost of processing reports 	<ol style="list-style-type: none"> 1. Difference between actual losses and amount recovered 2. Rental of equipment to replace damaged equipment 3. Surplus workers for replacement of injured workmen 4. Wages or other benefits paid to disabled workers 5. Overhead costs while production is stopped 6. Loss of bonus or payment of forfeiture of delays
Wage Losses 인건비 관련 손실	Off the Job Accidents 숙련공 손실 비용
<ol style="list-style-type: none"> 1. Idle time of workers whose work is interrupted 2. Man-hours spent in cleaning up accident area 3. Time spent repairing damaged equipment 4. Time lost by workers receiving first aid 	<ol style="list-style-type: none"> 1. Cost of medical services 2. Time spent on injured workers' welfare 3. Loss of skill and experience 4. Training replacement worker 5. Decreased production of replacement 6. Benefits paid to injured worker or dependents
Production Losses 생산 관련 손실	Intangibles 기타 사회적 손실 비용
<ol style="list-style-type: none"> 1. Product spoiled by accident 2. Loss of skill and experience 3. Lowered production of worker replacement 4. Idle machine time 	<ol style="list-style-type: none"> 1. Lowered employee morale 2. Increased labor conflict 3. Unfavorable public relations

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20.5 Federal Legislation and Regulation (1/2) 법률과 규칙

□ Occupational Safety and Health Act (OSHA) : mandatory safety and health procedures to be followed by all firms operating in interstate commerce. 직업 안전 위생법

Volume I: General Industry Standards

Volume II: Maritime Standards

Volume III: Construction Standards 건설 관련 표준

Volume IV: Other Regulations and Procedures

Volume V: Field Operation Manual

Volume VI: Industrial Hygiene Manual

□ Occupational Safety and Health Administration (OSHA) : 직업 안전 위생 관리국

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20.5 Federal Legislation and Regulation (2/2)

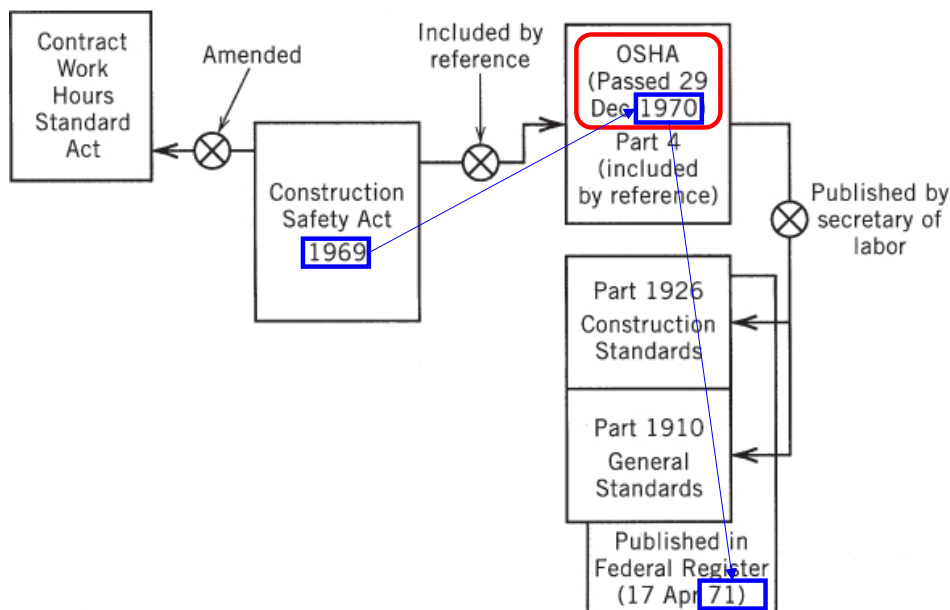


FIGURE 20.2 Development of OSHA legislation : OSHA 법령 유래

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20.6 Occupational Safety and Health Administration Requirements (1/3)

- 고용주는 사업장에서 발생한 사고와 질병을 반드시 OSHA에 보고해야 함
 - 사고는 발생한 시점으로부터 8시간 이내에 OSHA에 보고해야 함
 - 사고에 대한 보고서는 발생한 시점으로부터 5일 이내에 OSHA에 제출해야 함
1. OSHA 300: 사고 보고서
 2. First report of injury/illness: 부상/질병 보고서

20.6 Occupational Safety and Health Administration Requirements (2/3)

OSHA's Form 300 (Rev. 01/2004)
Log of Work-Related Injuries and Illnesses

Attention: This form contains information relating to employee health and must be used in a manner that protects the confidentiality of employees to the extent possible while the information is being used for occupational safety and health purposes.

Year 20 **X1Z** Company
 Establishment name: XYZ Company
 City: Anytown State: MA

Identify the person		Describe the case			Classify the case				Enter the number of days the injured or ill worker was:		Check the "injury" column or choose one type of illness:					
(A) Case no.	(B) Employee's name	(C) Job title (e.g. Welder)	(D) Date of injury or onset of illness	(E) Where the event occurred (e.g. Loading dock work area)	(F) Describe the injury or illness, parts of body affected, and object/substance that directly injured or made person ill (e.g. Second degree burn on right forearm from oxy-acetylene torch)	Remained at Work				Away from work	On job transfer or restriction	(M) Injury	(N) Skin disorder	(O) Respiratory condition	(P) Hearing loss	(Q) Eye injury or illness
						(G) Days away from work	(H) Job transfer or restriction	(I) Other recordable cases	(J) Other recordable cases	(K) Days away from work	(L) On job transfer or restriction	(1) Injury	(2) Skin disorder	(3) Respiratory condition	(4) Hearing loss	(5) Eye injury or illness
1	Mark Bagin	Welder	5 / 25 morning	basement	fracture, left arm and left leg, fell from ladder	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	12 days	15 days	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Shana Alexander	Foundry man	7 / 2 morning	pouring deck	poisoning from lead fumes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	30 days	30 days	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Sam Sander	Electrician	8 / 15 morning	2nd floor storeroom	broken left foot, fell over box	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7 days	30 days	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Ralph Borella	Laborer	9 / 17 morning	packaging dept	Back strain lifting boxes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3 days	days	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Jarrod Daniels	Machine op.	10 / 23 morning	production floor	dust in eye	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	days	days	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Be as specific as possible. You can use two lines if you need more room.

Revise the log if the injury or illness progresses and the outcome is more serious than you originally recorded for the case. Cross out, erase, or white-out the original entry.

Choose ONLY ONE of these categories. Classify the case by recording the most serious outcome of the case, with column G (Death) being the most serious and column J (Other recordable cases) being the least serious.

Note whether the case involves an injury or an illness.

사고 보고서 샘플

FIGURE 20.3 OSHA Form 300

20.6 Occupational Safety and Health Administration Requirements (3/3)

부상/질병 보고서 샘플

FIGURE 20.4 Typical first report of injury/illness form

INDIANA WORKER'S COMPENSATION FIRST REPORT OF EMPLOYEE INJURY, ILLNESS				FOR WORKER'S COMPENSATION BOARD USE ONLY	
State Form 34401 (R10 / 1-02)				Jurisdiction	Jurisdiction claim number
Please return completed form electronically by an approved EDI process. NOTE: Your Social Security Number is being requested by this state agency in order to pursue its statutory responsibilities. Disclosure is voluntary and you will not be penalized for refusal.				Process date	
PLEASE TYPE or PRINT IN INK					
EMPLOYEE INFORMATION					
Social Security number	Date of birth	Sex <input type="checkbox"/> Male <input type="checkbox"/> Female <input type="checkbox"/> Unknown	Occupation / Job title	NCCI class code	
Name (last, first, middle)	Marital status <input type="checkbox"/> Unmarried <input type="checkbox"/> Married <input type="checkbox"/> Separated <input type="checkbox"/> Unknown		Date hired	State of hire	Employee status
Address (number and street, city, state, ZIP code)			Hrs / Day	Days / Wk	Avg Wg / Wk
Telephone number (include area code)			Wage	Per	<input type="checkbox"/> Hour <input type="checkbox"/> Day <input type="checkbox"/> Week <input type="checkbox"/> Month <input type="checkbox"/> Year <input type="checkbox"/> Other
EMPLOYER INFORMATION					
Name of employer	Employer ID#	SIC code	Insured report number		
Address of employer (number and street, city, state, ZIP code)		Location number	Employer's location address (if different)		
		Telephone number			
		Carrier / Administrator claim number	OSHA log number	Report purpose code	
Actual location of accident / exposure (if not on employer's premises):					
CARRIER / CLAIMS ADMINISTRATOR INFORMATION					
Name of claims administrator	Carrier federal ID number	Check if appropriate <input type="checkbox"/> Self Insurance			
Address of claims administrator (number and street, city, state, ZIP code)		<input checked="" type="checkbox"/> Insurance Carrier	Policy / Self-insured number		
Telephone number		<input type="checkbox"/> Third Party Admin.	Policy period	From	To
Name of agent McGowan Insurance Group, Inc.		Code number			
OCCURRENCE / TREATMENT INFORMATION					
Date of Inj. / Exp. <input type="checkbox"/> Cannot be determined	Time of occurrence <input type="checkbox"/> AM <input type="checkbox"/> PM	Date employer notified	Type of injury / exposure		Type code
Last work date	Time workday began	Date disability began	Part of body		Part code
RTW date	Date of death	Injury / Exposure occurred on employer's premises? <input type="checkbox"/> Yes <input type="checkbox"/> No	Name of contact		Telephone number
Department or location where accident / exposure occurred			All equipment, materials, or chemicals involved in accident		
Specific activity engaged in during accident / exposure			Work process employee engaged in during accident / exposure		
How injury / exposure occurred. Describe the sequence of events and include any relevant objects or substances.					Cause of injury code
Name of physician / health care provider					
Hospital or offsite treatment (name and address)					
Name of witness		Telephone number	Date administrator notified		
Date prepared	Name of preparer	Title	Telephone number		
INITIAL TREATMENT <input type="checkbox"/> No Medical Treatment <input type="checkbox"/> Minor: By Employer <input type="checkbox"/> Minor: Clinic / Hospital <input type="checkbox"/> Emergency Care <input type="checkbox"/> Hospitalized > 24 Hours <input type="checkbox"/> Future Major Medical / Lost Time Anticipated					
An employer's failure to report an occupational injury or illness may result in a \$50 fine (IC 22-3-4-13).					
WC 7703f (1-02) UNIFORM INFORMATION SERVICES, INC.					

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20.7 How the Law Is Applied (1/2)

- 주마다 연방법을 그대로 준용할 수도 있고, 아니면 자체적으로 법을 마련한 경우도 있음
- 작업자·노조·안전관리자 등에 의해 작업 현장 안전에 문제가 있다고 판단되면, 불시에 OSHA의 현장방문조사가 실시됨.
- The inspection is divided into four parts: 조사 절차
 1. An opening conference with the employer. 조사 시작 회의
 2. Selection of a representative of the employees and of the employer to accompany the inspector on a tour of the workplace. 동행할 고용주와 근로자 선정
 3. The walk-around inspection. 현장 조사
 4. The closing conference. Safety Orders will follow via U.S. mail 2 weeks to 3 months after the actual inspection. Fines may be proposed with the citations. 마무리 회의. 조치 사항 전달. 벌금 부과.

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20.7 How the Law Is Applied (2/2)

1	1926.5	Fall Protection (C)	추락 방지
2	1910.12	Hazard Communication	위험 (물질) 관리 방안 전파
3	1926.45	Scaffolding (C)	비계
4	1910.13	Respiratory Protection	호흡기 보호
5	1910.15	Lockout/Tagout	위험장비 잠금/표식
6	1910.18	Powered Industrial Trucks	지게차
7	1926.11	Ladders (C)	사다리
8	1910.31	Electrical, Wiring Methods	전기 배선
9	1910.21	Machine Guarding	장비 안전 펜스
10	1910.3	Electrical, General Requirements	전기 일반 요구 사항

TABLE 20.2 OSHA's 2015 Top Ten Most Frequently Cited Violations
가장 빈번한 법규 위반 행위

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20.8 Safety Record Keeping (1/2) 재해 기록

- **Williams-Steiger Act:** Every employer who is covered under this act must **keep occupational injury and illness records** for his employees in the establishment in which his employees usually report to work. 반드시 발생했던 사고/질병 관련 기록을 유지관리 해야 함
- Reporting at the job site level breaks into six reporting levels as follows: 재해의 경중 단계를 6개로 구분 → 단계별로 다른 유형의 재해 보고서를 제출
 1. First aid log. 가장 가벼운 재해
 2. First report of injury log.
 3. Supervisor's accident investigation report.
 4. Project accident report.
 5. OSHA required Injury Report (OSHA 300).
 6. Fatality or major accident report. 가장 심한 재해

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20.8 Safety Record Keeping (2/2)

4단계 보고서 샘플

FIGURE 20.5 Project accident report

<p>Job Name <u>Peachtree Shopping Mall</u> Job No. <u>10-100</u> Location <u>Atlanta, Georgia</u> Month <u>April 20xx</u></p> <p>This report should be completed and mailed to the Safety Branch of the Industrial Relations Department in the Atlanta office by the fifth day of the month. Project Superintendent _____</p> <p>This figure may be taken from payroll records. In the case of fractions use the nearest whole number. Do not include subcontractors or others.</p> <p>Figure actual hours worked whether straight time or overtime. Includes only those on our payroll.</p> <p>Record only those injuries that cause death, permanent disability (loss of a finger, etc.), or loss of time beyond the day on which the accident occurred. No matter what time of day the injury may occur, if the employee returns to his regular job at the start of his next regular shift, the injury is not counted. If he does not return at that time, it must be counted as a disabling injury.</p> <p>For temporary injuries, count the actual calendar days lost, excluding the day of injury. If the injured employee has not returned by the end of the month, make an estimate of projected number of lost days. For deaths and permanent injuries, use the number of days specified in the standard table.</p>	<p>1. Average number of employees _____</p> <p>2. Total hours worked by all employees _____</p> <p>3. Number of: Temporary disabling injuries _____ Permanent disabling injuries _____ Deaths _____ Total disabling injuries for this month _____</p> <p>4. Number of days lost as a result of: Temporary disabling injuries _____ Permanent disabling injuries _____ Death _____ Total days lost attributable to this month _____</p>
--	--

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20.9 Safety Program (1/4)

- A good job site **safety program** should be founded on: **안전관리 프로그램 구성요소**
 1. Safety **training** of all new personnel arriving on the site. **안전교육**
 2. Regular and frequent **inspections** for possible safety hazards. **안전 점검**
 3. Regular **briefings** to increase the safety awareness of personnel at all levels. **안전의식 제고를 위한 정기적 브리핑**
 4. Written programs and **documentation** specifying all safety activities. **모든 안전 활동의 문서화**

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20.9 Safety Program (2/4)

August 2, 20xx

PEACHTREE SHOPPING MALL
Atlanta, Georgia

Welcome to the job! ABC Construction Company is interested in you, and during your employment with us, we will exert every effort to make this job pleasant, with a good working atmosphere. On the other hand, your skills, ability, and performance are most important and essential to the successful completion of the project. To set up and complete a good job, certain rules and regulations must be established. For our mutual benefit, the rules and regulations are as follows:

WORKING RULES AND REGULATIONS

Employment
The Project Manager, or his duly authorized representative, will do all the hiring on the job.

Identification
Employees shall wear a company badge at all times, in full view, above the waist, on an outer garment. Badge numbers will be used in gate clearance, payroll, and timekeeping identification.

Hours of Work
The regular workday will begin as per individual instructions, with a lunch period of one-half hour at a designated time. The workweek shall be five days, Monday through Friday. All employees will be at their work locations, ready to start work at work time. All employees are expected to remain at work until the authorized quitting time, at which time they may put up their tools and leave their place of work. Loitering in the change rooms and/or other places during working hours, or late starting of work and early quitting of work will be subject to proper disciplinary measures.

Checking In and Out
Employees are to check in and out at starting and quitting time. Infractions of this rule will be treated with appropriate disciplinary measures. Employees authorized to leave the project during regular working hours must check out with the timekeeper.

Issuing, Care, and Use of Tools
Certain company tools will be issued to journeymen and apprentices, or the foreman on a check or receipt system. Tools (while issued) must be properly used and maintained. A toolroom clearance will be required on termination. Loss or damage of tools will be noted on the employee's record.

A Day's Work
Each employee on the job is expected to perform a full day's work. Your willingness, cooperation, and right attitude will go a long way in accomplishing this objective.

Conduct on the Job
Good conduct on the job is essential to the overall welfare of all employees and the daily progress of the job. Therefore, conduct including, but not limited to, the following violations will be subject to appropriate disciplinary action or discharge.

Theft of company's or employees' property
Recurring tardiness
Leaving company's premises without proper permission and/or use of intoxicants and
Willful damage to company's materials,
Engaging in horseplay (including shouting)
Insubordination
Gambling
Fighting on company premises
Sleeping on the job
Failure to observe established safety rules

Housekeeping
Good housekeeping is essential to the safe responsibility of each employee. Work areas shall be kept clean at all times.

Safety Rules
Established safety rules and regulations will be in the best interest of accident-free operation. All unsafe working conditions should be reported to the company safety engineer. All employees will be required to wear proper hard hats must be worn by all employees and

Pay Period
Wednesday through Tuesday is the pay period.

Use of First Aid Facilities
First aid facilities are available at the job site with local doctors, hospitals, and emergency crews for accidents of a serious nature. All injuries, regardless of severity, must be reported to the employee's supervisor, field safety supervisor, and/or first aid immediately upon occurrence. Insurance regulations make this requirement mandatory.

Sanitary Facilities
Adequate sanitary facilities are provided on the job site and are to be used by all employees. We request your cooperation in maintaining these facilities in a clean and orderly condition.

Raincoats and Boots
Raincoats and boots are supplied to employees where the conditions of the job being performed require them.

Remaining in Work Areas
Each employee must remain on the job site and at his work location at all times during regular working hours, unless authorized to leave by his supervisor.

Absenteeism
Unauthorized absenteeism will result in termination of employment. An employee who must be absent or late should call 999-9000 and report to timekeeper.

Your cooperation in observing the rules and regulations for the job will show proper consideration for other employees and will be appreciated by the company.

If you agree to and will abide by the above, please sign and return to our field supervisor, Charles Hoarse.

cc: Employee File

FIGURE 20.6 Job briefing sheet 안전하게 업무를 수행하는 방식을 종업원에게 설명

20.9 Safety Program (3/4)

<p style="text-align: center;">ABC Contractors and Engineers 760 Spring Street, N.W., Atlanta, Georgia 30308 (404) 999-9000 July 30, 20xx</p> <p>Re: OCCUPATIONAL SAFETY & HEALTH ACT 1970 (Construction) (OSHA)</p> <p>Employers, owner, contractors, subcontractors, superintendents, or foremen in charge shall not direct or permit an employee to work under conditions that are not in compliance with the above code.</p> <p>Where one contractor is selected to execute the work of the project, he shall assure compliance with the requirements of this code from his employees as well as all subcontractors.</p> <p>Every employee shall observe all provisions of the above codes that directly concern or affect his conduct. He shall use the safety devices provided for his personal protection and he shall not tamper with or render ineffective any safety device or safeguard.</p> <ol style="list-style-type: none"> 1. Overhead Hazards All employees shall be provided with HARD HATS and shall use HARD HATS. 2. Falling Hazards Every hole or opening in floors, roofs, platforms, etc., into or through which a person may fall shall be guarded by a barrier sufficient to PREVENT FALLS. 3. Slipping Hazards Scaffolds, platforms, or other elevated working surfaces covered with ice, snow, grease, or other substances causing slippery footing shall be removed, turned, sanded, etc., to ensure safe footing. 4. Tripping Areas where employees must work shall be kept reasonably free from accumulations of dirt, debris, scattered tools, materials, and sharp projections. 5. Projecting Nails Projecting nails in boards, planks, and timbers shall be removed, hammered, or bent over in a safe way. 6. Riding of Hoisting Equipment No employee shall ride on or in the load bucket, sling, platform, ball, or hook. 7. Lumber & Nail Fastenings Lumber used for temporary structures must be sound. Nails shall be driven full length and shall be of the proper size, length, and number. The proper use of double-headed nails is not prohibited. 8. Guard Rail or Safety Rail Should be 2 x 4 at a height of 35"-37" plus a midrail of 1 x 4. The hand rail shall be smooth and free from splinters and protruding nails. Other material or construction may be used provided the assembly assures equivalent safety. 9. Toe Boards Shall extend 4" above platform level and shall be installed where needed for the safety of those working below. 10. Protection Eye Equipment Eye protection shall be provided by employers and shall be used for cutting, chipping, drilling, cleaning, buffing, grinding, polishing, shaping, or surfacing masonry, concrete, brick, metal, or similar substances. Also for the use and handling of corrosive substances. 11. Protective Apparel Waterproof boots where required shall have safety insoles unless they are the overshoe type. Waterproof clothing shall be supplied to the employee required to work in the rain. 	<ol style="list-style-type: none"> 12. Safety Belts & Lines Shall be arranged so that a free fall of no more than 6' will be allowed. 13. Stairways Temporary stairways shall not be less than 3 feet in width and shall have treads of no less than 2 inch x 10 inch plank. Must have hand rails. (See #8.) 14. Smoking Prohibited in areas used for gasoline dispensing and fueling operations or other high hazard fire areas. 15. Flammable Flammable liquid shall be kept in safety cans or approved use and storage containers. 16. Sanitation Suitable grounding to prevent the buildup of static charges shall be provided on all flammable liquid transfer systems. 17. Drinking Water Toilet facilities shall be provided and made available in sufficient number to accommodate all employees. 18. Salt Tablets A supply of clean and cool potable water shall be provided in readily accessible locations on all projects. 19. Excavations Shall be made available at drinking stations when required. Material and other superimposed loads shall be placed at least 3 feet back from the edge of any excavation and shall be piled or retained so as to prevent them from falling into the excavation. Sides and slopes of excavation shall be stripped of loose rocks or other material. Slopes shall be at an angle of 45 degrees or less (1 on 1 slope). 20. Structural Steel Erection When erection connections are made, 20% of the bolts in each connection must be drawn up wrench tight. At least 2 bolts must be used at each end of the member. No loads shall be placed on a framework until the permanent bolting is complete. Only employees of the structural steel erector engaged in work directly involved in the steel erection shall be permitted to work under any single-story structural steel framework that is not in true alignment and permanently bolted. 21. Use of Ladders Ladders shall be provided to give access to floors, stagings, or platforms. Ladders shall be maintained in a safe condition at all times. Ladders shall be securely fastened top and bottom as well as braced where required. Ladders leading to floors, roofs, stagings, or platforms shall extend at least 3 feet above the level of such floors, stagings, or platforms. 22. Scaffolds All scaffolding shall be constructed so as to support 4 times the anticipated working load, and shall be braced to prevent lateral movement. Planks shall overhang their end supports not less than 6" or more than 12". 2" planking may span up to and including 10'. The minimum width of any planked platform shall be 18 inches. Guard rails and toe rails shall be provided on the open sides and ends of all scaffold platforms more than 8' high (see #8). 23. Rigging, Ropes, and Chains All rope, chains, sheaves, and blocks shall be of sufficient strength, condition, and size to safely raise, lower, or sustain the imposed load in any position. Wire rope shall be used with power-driven hoisting machinery. No rope shall be used when visual inspection of the rope shows marked signs of corrosion, misuse, or damage. All load hooks shall have safety clips. Loads that tend to swing or turn during hoisting shall be controlled by a tag line whenever practicable. 	<ol style="list-style-type: none"> 24. Welding and Cutting Oxygen from a cylinder or torch shall never be used for ventilation. Shields or goggles must be worn where applicable. Cradles shall be used for lifting or lowering cylinders. 25. Cranes & Derricks All cranes and derricks shall be equipped with a properly operating boom angle indicator located within the normal view of the operator. Every derrick and crane shall be operated by a designated person. A copy of the signals in use shall be posted in a conspicuous place on or near each derrick or crane. Cranes and derricks shall have a fire extinguisher attached. 26. Trucks Trucks shall not be backed or dumped in places where men are working nor backed into a hazardous location unless guided by a person so stationed on the side where he can see the truck driver and the space in back of the vehicle. <p>The above items do not encompass all the construction safety regulations as they pertain to OSHA but are intended as a guide to the ever present hazards and primary causes of accidents in our industry.</p>
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FIGURE 20.7 Job safety rules and regulations 안전관리 규정

20.9 Safety Program (4/4)

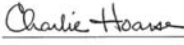
ABC Construction Company Job 10-100 Peachtree Shopping Mall Atlanta, Georgia Sept. 1, 20xx							
GENERAL SAFETY MEETING #7							
Safety Slogan for the Week: "Be Alert, Don't Get Hurt."							
C. Hoarse—Safety Supervisor A. Apple—Carpenter Foreman D. Duck—Surveyor M. Maus—Laborer D. Halpin—Field Engineer R. Woodhead—Tool Room							
Subcontractors Present: Live Wire Electric Henry Purcell James Wallace							
The First Aid Report for August 15 to August 31 Was Given. There Were: <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>First Aid</td> <td style="text-align: center;">7</td> </tr> <tr> <td>Doctor's Cases</td> <td style="text-align: center;">0</td> </tr> <tr> <td>Lost Time Injuries</td> <td style="text-align: center;">0</td> </tr> </table>		First Aid	7	Doctor's Cases	0	Lost Time Injuries	0
First Aid	7						
Doctor's Cases	0						
Lost Time Injuries	0						
SHORTCUTS							
All of us, supposedly, at one time or another, have been exposed to possible injury by short cutting when a few extra steps would have meant the safe way. We did so as kids when we jumped the fence instead of using the gate and we do so as men when we cross streets by jay-walking instead of using the intersection. Accident statistics plainly indicate the fact that people disregard the fact that minor safety violations may have very serious results. In construction work, short cutting can be deadly. All of us know of cases in which this kind of thoughtless act resulted in a serious injury. For instance, an ironworker tried to cross an opening by swinging on reinforcing rods, his hands slipped, and he fell about 20 feet to a concrete floor. If he had bothered to take a few moments to walk around the building, he would still be tying rods. The safe way is not always the shortest way and choosing the safe way is your <i>Personal Responsibility</i> . When you are told to go to work in a particular area, you are expected to take the safe route, not an unsafe short route. We cannot be your guardian angel; that is one thing you will have to do for yourself. If you are told to go to work in some place that has no safe access, report this fact to your foreman so that necessary means of access can be provided. Ladders and scaffolds are provided for high work; use them. Even though a high job may take only a few moments, DO NOT CLIMB ON FALSE WORK, or on some improvised platform. Your first responsibility is to yourself. Remember that ladders, steps, and walkways have been built to save you trouble and to save your neck, too. Use them always.							
ABC Construction Company Job 10-100 Peachtree Shopping Mall Atlanta, Georgia Sept. 1, 20xx							
Gambling a few minutes and a little energy against a possible lifetime of pain and misery is a poor bet.							
GENERAL DISCUSSION Flagmen must control all the back-up operations on this job. Traffic—Be on the alert for moving vehicles, our area is slippery. Don't walk beside moving equipment. Injuries—Report all injuries to your foreman immediately.							
							
C. Hoarse, Safety Supervisor							

FIGURE 20.8 Safety meeting minutes 안전관리 회의록