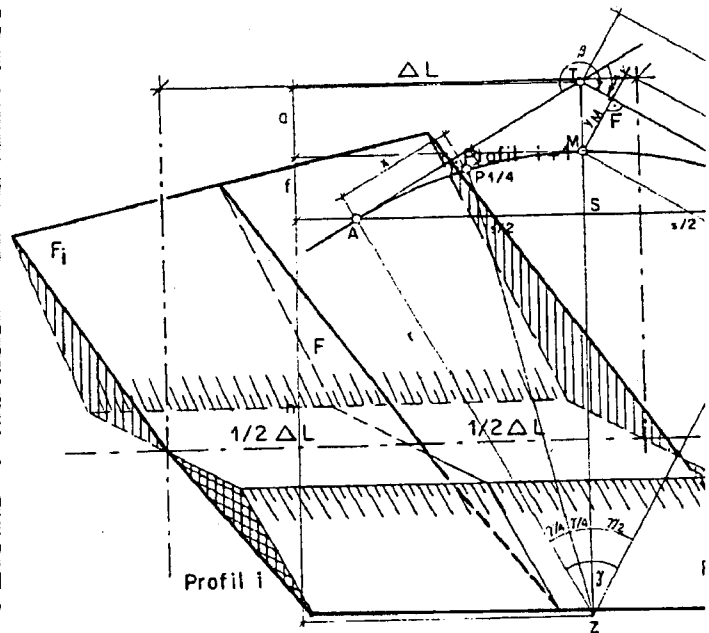




FOREST ENGINEERING DESIGN

FE 444

Forest Road Construction Cost Estimation



FOREST ENGINEERING
UW

INTRODUCTION:

It is important to know how road construction and maintenance costs are derived for financial management, planning and to communicate effectively with engineers. The basic elements of road construction costs will be addressed.

Road construction cost estimating is an important function for road construction contractors. They must make accurate cost estimates for the purpose of successful bidding on road construction contracts.

Construction Cost Development:

All construction costs are estimates because the cost of road construction projects are not known until the projects are completed. The road design engineer computes a cost estimate based on current equipment, materials, labor, and overhead costs applied to the site specific conditions. This information is developed from past costs applied to similar project and adjusted for inflation.

Construction Cost Elements:

A road construction project are broken down into major elements for cost estimating purposes. The two major elements are preconstruction and construction costs. The components of each are described:

Road Preconstruction:

Preliminary survey:

A survey of a road location that provides a road designer with the required information to execute a road design.

Design:

The process of designing a road to be constructed.

Cost and contract preparation:

Preparing a road construction cost estimate and a construction contract.

Road Construction:

Construction survey:

Ground location of road for road construction control.

Mobilization:

Moving construction equipment to construction site.

Clearing and Grubbing:

Preparation of the right-of-way for excavation and embankment by removal of right-of-way timber, stumps, and duff.

Excavation and Embankment:

Moving earth to construct a roadway.

Road Drainage:

Installation of culverts.

Structures:

Bridges, retaining walls, pipe arches.

Road Surfacing:

Rock or pavement road surface.

Erosion Control:

Seeding and mulching of cut and fill slopes.

Cost of Project Elements:

The following cost examples are taken from the U.S. Forest Service Region 6 Engineering Zone 5 Cost Guide. Region 6 is divided into five road construction cost zones. Zone costs are used by forests within a given zone. A team of engineers from each zone updates the cost guides annually.

Construction Survey Costs:

Survey will vary considerably depending on type and size of job, access, terrain, job location, traverse ties, etc. This is a prelim.

Daily Crew Rates:

<u>No. Per Party</u>	<u>Per Hour</u>	<u>Per 8 Hours</u>
2-person party	52.00	416.00
3-person party	67.00	536.00
4-person party	77.00	616.00

Above rates include material, transportation, and profit.

Production Averages - 4 person crew

Side Slope

+ 60%	large cuts and fills, heavy brush	110 - 110 points per day
45% - 60%	medium cuts and fills, medium brush	110 - 120 points per day
0% - 45%	low cuts and fills, light brush	120 - 130 points per day

Point Definition

P-line offset point (L-line)(1 point)

Slope stake (1 point/side)

R.P. stake with clearing flag (1 point/sidew/or w/o)

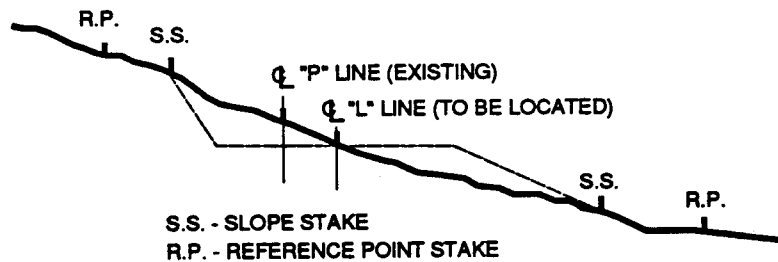


Figure 1. Diagram five point section.

Mobilization Costs:

<u>Distance</u>	<u>Equipment Size</u>	<u>Equipment Size</u>		<u>Equipment Size</u>		<u>Equipment Size</u>	
		<u>Dozers</u>	<u>Loaders</u>	<u>Dozers</u>	<u>Loaders</u>	<u>Dozers</u>	<u>Loaders</u>
One-way Move-in distance miles.	D-8 Dozer w/blade, Drum and Ripper bars, D-9	D-8 (Stripped)	988	D-6	966-C	D-4	Graders
		TD-25		D-7	980-B	TD-9	Loaders
		HD-21		TD-15	977-L	HD-6	(up to 2
				TD-18		Rollers	Cu.Yd.)
	wt. (lbs.)	wt. (lbs.)		wt. (lbs.)		wt. (lbs.)	
	<u>64,000 - 100,000</u>	<u>48,000 - 64,000</u>		<u>32,000 - 48,000</u>		<u>Up to 32,000</u>	
0 - 25	\$294	\$194		\$153		\$113	
25 - 50	\$336	\$228		\$161		\$141	
50 - 75	\$399	\$263		\$189		\$157	
75 - 100	\$424	\$309		\$211		\$175	
100 - 125	\$498	\$372		\$267		\$216	

Move-in and Setup for Rock Crusher Plants (50-70 Mi. Operating Radius)

Single Stage	\$2,100
Two Stage	\$4,200
Three Stage	\$5,200
Oil Storage Tanker	\$1,500

Clearing and Grubbing Costs:

Clearing Costs

Merchantable Timber (Stump to Deck Cost includes: falling, bucking, and yarding).

Side Slope	6" - 18" dbh or 5 - 36 M Volume per Acre	18" - 32" dbh or 48 - 54 M Volume per Acre	30" and over or 60 M and above Volume per Acre
0 - 30%	\$28.00 per M	\$32.00 per M	\$34.00 per M
30 - 50%	\$30.00 per M	\$34.00 per M	\$36.00 per M
50% and over	\$32.00 per M	\$36.00 per M	\$40.00 per M

Unmerchantable Timber:

Side Slope	X-light \$/Ac	Light \$/Ac	Medium \$/Ac	Heavy \$/Ac	X-heavy \$/Ac
0 - 30%	155	155-206	206-275	275-335	335-535
30 - 50%	177	177-240	240-308	308-377	377-600
over 50%	195	195-266	266-344	344-417	417-800
Extra Steep and Rocky	234	234-318	318-413	413-500	500-1000

Grubbing:

Side Slope	X-light \$/Ac	Light \$/Ac	Medium \$/Ac	Heavy \$/Ac	X-heavy \$/Ac
0 - 30%	396	396-602	602-826	826-1026	over 1026
30 - 50%	441	441-683	683-935	935-1166	over 1166
over 50%	518	518-812	812-1096	1096-1351	over 1351
Extra Steep and Rocky	609	609-973	973-1316	1316-1620	over 1620

Slash disposal:

Type of Clearing Operation	Extra Light \$/Ac	Light \$/Ac	Medium \$/Ac	Heavy \$/Ac	Extra Heavy \$/Ac
1-Windrow Const. slash	294	522	665	851	1036
2-Windrow Large Material	308	546	700	893	1089
3-Windrow and Cover	372	620	789	1104	1141
4-Scatter	434	602	788	1029	NA
5-Bury	665	844	1211	1488	1726
6-Chip	693	970	1537	NA	NA
7-Pile and Burn	658	921	1460	1789	2125
8-Decking Unmerch. Material	518	781	1320	1635	1985
9-Special Treatment of Cull Logs and Stumps	518	781	1320	1635	1985
11-Burying Const. Slash within Roadway	665	844	1211	1488	1726
12-Piling	435	650	950	1130	1465
13-Sidecasting	384	552	658	NA	NA

Excavation costs:

The base cost for roadway excavation is taken from average unit bids.

Type	Basic Unit Cost
Common	\$1.24
Rippable Rock	\$2.15
Solid Rock	\$3.97

In addition to the base cost calculated from above, the following items should be added as required for each road.

Item	Unit	Unit Cost
Tolerance Class	Cu. Yd.	Tolerance Class High \$0.06 Tolerance Class Low None
Compaction	Cu. Yd.	\$0.35 - \$0.40
Watering	M Gal.	

Surfaced or Unsurface w/o scarification

Single Lane w/o ditch	\$400-600/mile
Single Lane w/ditch	\$520-780/mile
Double Lane w/ditch	\$920-1380/mile

Unsurfaced with Scarification

Single Lane w/o ditch	\$860-1060/mile
Single Lane w/ditch	\$980-1240/mile

Haul costs:

Cat push included in Basic Excavation cost.
Loading cost is included in Basic Excavation.

Haul by scraper or trucks calculate by:

$$\text{Equipment Cost/hr} \times \frac{\frac{(\text{RTM} + \text{Delay Time})}{60}}{\text{Capacity} \times 0.85} = \$/\text{Cu.Yd.}$$

$$\text{RTM} = \frac{\text{Round Trip Miles}}{\text{Average Speed mph}} \times \frac{60 \text{ min.}}{\text{hr.}}$$

RTM = Round trip minutes

Delay time is load, unload, backing, turnaround, etc. in minutes.

Pipe installation costs:

Approx. End Area		Lbs./ Lin.Ft.	Install Only \$/L.F.	Prod. ft/hr	Furnish Only Thickness			
Dia	Sq.Ft.				.064" \$/L.F.	.079" \$/L.F.	.109" \$/L.F.	.138" \$/L.F.
					(16 GA)	(14 GA)	(12 GA)	(10 GA)
15"	1.2	13	8.44	15	5.70	6.83	---	---
18"	1.8	16 (.064)	8.44	15	6.55	8.21	---	---
24"	3.1	21 (.064)	9.47	13	8.86	10.80	14.99	---
30"	4.9	25 (.064)	11.51	11	10.95	13.46	19.35	---
36"	7.1	30 (.064)	12.66	10	12.90	16.19	21.75	---
42"	9.6	36 (.064)	14.07	9	14.90	19.55	25.90	---
48"	12.5	50 (.079)	15.48	8	17.50	22.30	29.98	36.00
54"	15.9	57 (.079)	16.88	7 1/2	---	24.60	33.12	40.90
60"	19.6	87 (.109)	18.29	7	---	27.80	37.50	46.00

L.F. = Linear Foot.

Example computation:

Installation includes: common excavation, assembly, backfill to 1 ft. above the top of the pipe inlet. Situations which require more or different excavation, water diversion, or steep grades (over 25%) etc. should be costed by time and equipment.

Culverts larger than 60" cost by time and equipment. Call suppliers for materials.

For any cost not shown contact one of the local pipe company representatives.

Example: Time and equipment figures for installation of 18" culvert. Culvert length 30', slope 15%, common excavation, backfill to 1' above CMP, production rate 15'/hr.

Crew:	2 laborers	=	\$46.12
	1 hoe operator	=	28.26
	215 hoe	=	49.54
	Compactor	=	<u>2.67</u>
			\$126.59 /hr.

15 L.F./hr rate = \$8.44 /L.F.

Seeding and mulching:

Costs by Materials and Application

	<u>Average Cost (on site)</u>	<u>Cost for Application</u>
Seed	\$ 1.65/Lb.	\$ 80/Acre
Fertilizer	\$ 0.22/Lb.	\$ 92/Acre
Hay mulch	\$50.00/1,000 Lbs.	\$ 52-96/M Lbs.
Hydro-mulch	\$48.00/1,000 Lbs.	\$155-180/M Lbs.

For costs of unusual types of mulches such as emulsified asphalt, burlap, jute, and paper or sisal, consult the appropriate supplier.

The cost of soil conditioners such as limestone or other minerals should be included when necessary.

Road construction cost estimate example:

Given Information:

A 0.5 mile single lane road in and out sloped road is to be constructed for a timber sale on the Siuslaw N.F. It is located on ground with average side slopes of 45%. The road will be used for dry weather haul. Zone 5 Engineering Cost Guide is used.

Construction survey cost:

4-Person Crew

Medium Cuts and Fills and Brushing - 110-120 Pts./day

Cost:

No. of points to survey: (45 cross sections) (5 pt/cross sect.) = 225 pts.

No. days to complete survey: (225 pts)/(115 pts/day) = 1.96 days

Use 2 days

Total Survey Cost: (\$616/day)(2 days) = \$1,230

Mobilization:

Mobilization Distance = 70 mi.

Equipment	
D8 Cat	- \$399
D7 Cat	- 189
D6 Cat	- 189
966 Cat Loader	- 189
Back Hoe	- 157

Total	<u>\$1,120</u>
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Example Cost Estimate:

Clearing cost:

Project length 0.5 mi.

Average side slope 40%

50 MBF/Ac

Clearing Medium

Grubbing Medium

Pile and urn disposal method

Costs:

Clearing Area

$(5,280 \text{ ft/mi}) (0.5 \text{ mi}) (50 \text{ ft.}) / 43,560 \text{ ft}^2 = 3.0 \text{ Ac}$

Merch Timber: $(\$34/\text{MBF}) (60 \text{ MBF/Ac}) (3 \text{ Ac}) = \$5,100$

Grubbing: $(\$809/\text{Ac}) (3 \text{ Ac}) = \$2,427$

Pile and Burn Slash: $(\$1,400/\text{Ac}) (3 \text{ Ac}) = \$4,200$

Select Snag Removal 30 in. avg DBH , 20 snags:

$(20 \text{ snags}) (\$11.87/\text{snag}) = \237

Total Clearing and Grubbing Cost:

$$(\$5,100) + (\$2,427) + (\$4,200) + (\$227) = \underline{\$12,000}$$

Excavation and haul cost:

Excavation: 18,700 yd³
Common 17,000 yd³
rippable 1,700 yd³
Waste: 2,000 yd³
Waste haul dist. one way 2.50 mi.
Average waste haul speed 15 mph
Excavation tolerance D

Excavation Cost:

$$\text{Common: } (\$1.24/\text{yd}^3) (17,000 \text{ yd}^3) = \$21,080$$

$$\text{Rippable: } (\$2.15/\text{yd}^3) (1,700 \text{ yd}^3) = \$3,650$$

$$\text{Surface finish w/o Ditch \& Scarification: } (\$600/\text{mi}) (0.50 \text{ mi}) = \$300$$

$$\text{Total Excavation Cost: } (\$21,080) + (\$3,650) + (\$300) = \underline{\$20,040}$$

Haul Cost:

12 yd³ Dump Truck
D6 Cat to spread waste
Waste Volume 2,000 yd³
One way haul dist. 2.5 mi
Haul speed 15 mph

Route Trip Minute (RTM):

$$[(2) (2.5 \text{ mi}) / 15 \text{ mph}] (60 \text{ min./hr.}) = 20 \text{ min.}$$

Delay Time: Load 5.0 min., Unload 3.0 min.

$$\text{Total delay time: } (5 \text{ min.}) + (3 \text{ min.}) = 9 \text{ min.}$$

End Dump Truck 12 yd³ @ \$66.54/hr.

$$\begin{aligned} \text{Haul Cost}/\text{yd}^3 &= \frac{(\text{Equip. Cst./hr.})(\text{RTM}) + (\text{Delay Time})(\text{hr./60 min.})}{(\text{Truck Capacity yd}^3 \text{ load factor})} \\ &= \frac{(\$66.54/\text{hr.})(20 \text{ min.}) + (9 \text{ min.})(\text{hr./60 min.})}{(12 \text{ yd}^3)(0.85)} = \$3.15/\text{yd}^3 \end{aligned}$$

Load factor 0.85 is to compensate for trucks loaded at 85 percent capacity

Total Haul Cost: $(\$3.15/\text{yd}^3) (2,000 \text{ yd}^3) = \$6,300$

Waste Spread Cost:

No. of Truck Trips: $(1,700 \text{ yd}^3) / [(12 \text{ yd}^3) (0.85)] = 196 \text{ trips}$

Time to place all waste material: $(196 \text{ trips}) (29 \text{ min/trip}) (\text{ hr}/60\text{min.}) = 95 \text{ hrs.}$

4 trucks used to haul waste

$(95 \text{ hrs}/4) = 24 \text{ hrs to complete job}$

Cat Cost = $(\$58.83/\text{hr}) (24 \text{ hr}) = \$1,412$

Total Haul and Waste Cost: $(\$6,300) + (\$1,412) = \underline{\$6,710}$

Culvert cost:

Sta	Dia in.	GA	Length ft.	Inst. (\$) \$/L.F.	Furnish (\$) \$/L.F.	Total Cst. (\$)
1+23	18	16	70	8.44	6.55	1,045
10+70	54	12	120	16.88	33.12	6,000
16+50	18	16	80	8.44	6.55	1,199
20+05	42	14	75	14.07	19.55	2,522
22+00	18	16	80	8.44	6.55	1,190
Total Cost:						<u>\$11,970</u>

Seeding cost:

Area to Treat:

Cut Slopes: 1.5 Ac

Fill Slopes: 1.8 Ac

Total Area To Treat: $(1.5 \text{ ac}) + (1.8 \text{ ac}) = 3.3 \text{ Ac}$

Seed Cost: \$80/Ac

Fertilizer Cost: \$92/Ac

Total Cost: $[(\$80) + (\$92)] (3.3/\text{Ac}) = \underline{\$570}$

Project cost summary:

Const. Survey	\$1,230
Mobilization	1,120
Clearing & Grubbing	11,960
Excavation	20,040
Haul and Waste	6,710
Culverts	11,970
Seeding	570
Total	<u>\$57,620</u>

HOMWORK

ROAD CONSTRUCTION COSTS

Name: _____

Given:

Average ground slope 80%, road width 16 ft. with no ditch, road surface cut slope at 5%, cut slope 3/4:1 soil surfacing (Figure 1). Full bench cut 0.30 mi. End haul distance one way from center of full bench area to waste site is 3.5 mi.

Average haul speed 20 mph, 12 yd³ end dump truck used for haul at \$58.85/hr., truck delay time 6.0 min.

Excavation: 80% common material at \$1.24/yd³, 20% rippable rock at \$2.15/yd³. Assume no swell factors for rippable rock material. Do not compute 5% outslope in earthwork computations.

Determine:

1. Volume of common and rippable material to be excavated and hauled.
2. Excavation cost.
3. Haul cost.
4. Total project cost

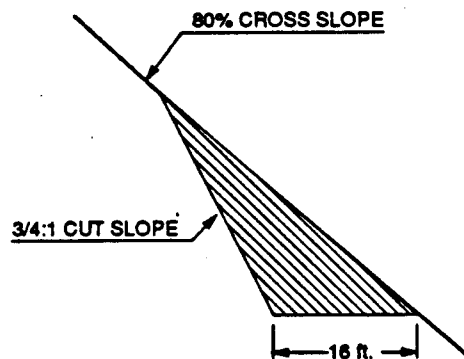


Figure 1. Cross section and road templet

NOTE: Use standard 5-inch engineering computation paper for this exercise. Scale your cross section to 1 in. = 5 ft. to determine end area for excavation quantities computation. Staple work to this sheet.