

Appendix 4. Work Forms

Excavator Endhaul Production Computation - CAT 235

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Loading Costs Instructions

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Pusher Production Sheet Instructions

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Scraper End Haul Production Instructions

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EXCAVATOR ENDBAUL PRODUCTION COMPUTATION - CAT 235

Sale Name _____ Date _____

Road Name _____

BUCKET PAYLOAD COMPUTATION

Average Bucket Payload = (heaped bucket capacity) x (bucket fill factor)

Heaped bucket capacity for a 48" cutting width = 1.5 cy. for rock and

1.88 cy for soil (1) _____

Bucket Fill Factor:

Material	<u>Fill Factor Range</u>	
Moist Loam or Sandy Clay	1 to 1.1	
Sand and Gravel	.95 to 1	
Hard, tough clay	.80 to .9	
Rock-Well Blasted	.60 to .7	
Rock-Poorly Blasted	.40 to .50	(2) _____
Average Bucket Payload = Line (1) x Line (2)		(3) _____

CYCLE TIME COMPUTATION

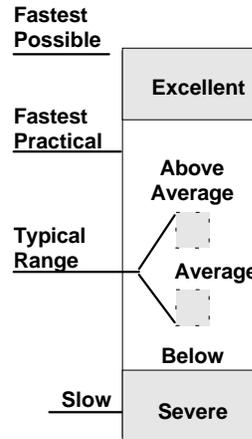
Cycle time Estimate from Chart	(4) _____	sec.
LINE (4) / 60 = CYCLE TIME (100% EFFICIENCY)	(5) _____	MIN.
Operator Efficiency Correction = Line (5)/ _____	(6) _____	MIN.
Job Efficiency Correction = Line (6)/ _____	(7) _____	MIN.
Swell Factor = Line 7/.80 (if bank yards are used)	(8) _____	MIN.
Time (min.) per cubic yard = Line (8)/Line (3)	(9) _____	MIN.

COST PER CUBIC YARD COMPUTATION

Cost of Excavator and Operator per Hr./60	(10) _____	\$/MIN.
Cost per cu. yd. = Line (9) x line (10)	(11) _____	\$/cy.

CYCLE TIME ESTIMATING CHART

CYCLE TIME ESTIMATING CHART					
CYCLE TIME	MACHINE SIZE CLASS				CYCLE TIME
	215 & 215 SA	225	235	245	
10 SEC.					10 SEC.
15					15
20 SEC.					20 SEC.
25					25
30 SEC.					30 SEC.
35					35
40 SEC.					40 SEC.
45					45
50 SEC.					50 SEC.
55					55
60 SEC.					60 SEC.



CYCLE TIME vs JOB CONDITION DESCRIPTION

- Easy digging (unpacked earth, sand gravel, ditch cleaning, etc.). Digging to less than 40% of machine's maximum depth capability. Swing angle less than 30°. Dump onto spoil pile or truck in excavation. No obstructions. Good operator.
- Medium digging (packed earth, tough dry clay, soil with less than 25% rock content). Depth to 50% of machine's maximum capability. Swing angle to 60°. Large dump target. Few obstructions.
- Medium to hard digging (hard packed soil with up to 50% rock content). Depth to 70% of machine's maximum capability. Swing angle to 90°. Loading trucks with truck spotted close to excavator.
- Hard digging (shot rock or tough soil with up to 75% rock content). Depth to 90% of machine's maximum capability. Swing angle to 120°. Shored trench. Small dump target. Working over pipe crew.
- Toughest digging (sandstone, caliche, shale, certain limestones, hard frost). Over 90% of machine's maximum depth capability. Swing over 120°. Loading bucket in man box. Dump into small target requiring maximum excavator reach. People and obstructions in the work area.

HAULING COST COMPUTATION SHEET

Sale Name _____ Date _____

Road Name _____

Time Computation

Basic haul cycle time per RT* for this job =
 2.4 min. X _____ MRT (1) _____ minutes

Road speed time factors:

- | | | | |
|----|----------------------------|-----------------|---------|
| 1. | 40 MPH (-0.90 X _____ MRT) | (2) _____ | minutes |
| 2. | 35 MPH (-0.69 X _____ MRT) | (3) _____ | minutes |
| 3. | 25 MPH | (4) <u>0.00</u> | minutes |
| 4. | 17 MPH (+1.13 X _____ MRT) | (5) _____ | minutes |
| 5. | 10 MPH (+3.60 X _____ MRT) | (6) _____ | minutes |
| 6. | 5 MPH (+9.60 X _____ MRT) | (7) _____ | minutes |

Dump or spread time per RT (8) _____ minutes

Total hauling cycle time for this setting
 100% efficiency (9) _____ minutes

Operator efficiency correction = line 9/ _____ (10) _____ minutes

Job efficiency correction = line 10/ _____ (11) _____ minutes

TIME per cubic yard:

Hauling only, per cubic yard = line 11/ _____
 cubic yard capacity of truck (12) _____ minutes

Delay time/cy for loading, line 10 from
 loading comp. form (13) _____ minutes

TOTAL TIME per cu. yd. = line 12 + 13 (14) _____ minutes

Cost per cu. yd. Computation

Cost of truck & operator per minute
 (cost/hour divided by 60) cost /hr. _____ (15) _____ \$/minute

Total cost per cy. yd. = line 15 X line 14
 \$/cy (16) _____

RT* = round trip

MRT = MILES PER ROUND TRIP

HAULING COSTS

The following figures assume a basic haul cycle time with 100% efficiency. They must be modified to conform to the variables on any particular project.

The basic time cycle in minutes required for a dump truck travelling at an average 25 MPH to make a round trip of 2 miles is 4.8 minutes or 2.4 minutes per mile.

The variables listed below show the time factors in minutes by which the basic cycle is to be increased or decreased. Numbers in parentheses coincide with those on the work sheet.

TIME Computations

(1)	Haul distance on this setting or project multiplied by the basic time cycle of 2.4 minutes per mile from above. <u>Road speed time factors (2-7)</u>	<u>Time (minutes)</u>
(2)	<u>Highway (State or Federal)</u> paved, up to 4%, good alignment, up to 50 MPH., Av. 40 MPH.	-0.90
(3)	<u>Highway (County)</u> paved with steep grades, poor alignment, up to 45 MPH., Av. 40 MPH.	-0.69
(4)	<u>Rocked State Forest mainline or Co. road</u> , grades up to 8%, fair alignment, up to 35 MPH. Av. 25 MPH.	0.00
(5)	<u>State Forest</u> , new or rough surface up to	+1.13
(6)	10%, 17 MPH AND 10 MPH respectively	+3.6
(7)	a. <u>State Forest road spur</u> , with some grades over 10%, up to 10 MPH. Av. 5 MPH.	+9.6
	b. <u>Backing</u> (usually end hauling) Av. 5 MPH	+9.6
(8)	Dump or spread time can vary from 0.2 to 0.5 minutes. Use least time for pile dumping, or spreading of rock, and the greater time where excessive maneuvering is needed to dump end haul material over a bank.	
(9)	Add above figures algebraically to obtain 100% efficiency total haul time.	
(10-11)	Corrections to obtain true haul time: Operator efficiency - average .75 Job efficiency - average .75 to .83	

LOADING COST COMPUTATION SHEET

Sale Name _____ Date _____

Road Name _____

TIME Computation

Basic loading cycle time	(1) _____ min.
Materials time factor (plus or minus)	(2) _____ min.
Pile type time factor	(3) _____ min.
Miscellaneous items time factor	(4) _____ min.
Travel distance time factor	(5) _____ min.
<u>Total</u> loading cycle time for this setting (100% efficiency)	(6) _____ min.
Operator efficiency correction = line 6 ÷ .75	(7) _____ min.
Job efficiency correction = line 7 ÷ .75	(8) _____ min.
TIME (minutes) per cubic yard = line 8 ÷ _____ (CY capacity of loader)	(9) _____ min.

COST PER CU. YD. Computation

Cost of loader and operator per hour	(10) _____ /hr.
Operating cost per minute = line 10 ÷ 60	(11) _____ /min.
Cost per cu. yd. = line 9 X line 11	(12) \$ _____ /cy

LOADING COSTS

The following instructions are compiled from information in a publication by Caterpillar Tractor Co. entitled Caterpillar Performance Handbook, Edition 3. These figures assume 100% efficiency and must be modified to conform to the variables on any particular project.

A basic loading time cycle in minutes is the time it takes for a loader to load, dump, go through four reversals of direction, a minimum cycle travel distance of loading and dumping within its turning area, and the complete hydraulics needed to accomplish the cycle. Numbers in parentheses coincide with those on the work sheet.

TIME Computations

- (1) Basic cycles are 0.40 minutes (24 seconds) for a wheel loader and 0.33 minutes (20 seconds) for a track type or an articulating type loader

Variables and the time factors in minutes by which the basic cycle is to be increased or decreased are listed below.

(2)	<u>Material type</u>	<u>Time (decimal of a minute)</u>	
	Mixed	+ 0.02	
(3)	<u>Pile type</u>		
	Piled 10' and up	0.00	
	Piled 10' or less	+ 0.01	
	Dumped by truck	+ 0.02	
(4)	<u>Miscellaneous</u>		
	Restricted maneuvering area	+ 0.00 to 0.04	
	Small Target (small hopper or truck)	+ 0.00 to 0.04	
	Fragile target (loading large stone)	+ 0.00 to 0.05	
	Normal or average digging	+ 0.06	
	Retaining material on road width or retrieving	+ 0.02	
(5)	<u>Loader travel distance in addition to basic cycle travel distance</u>	<u>Wheel Loader</u>	<u>Track Loader</u>
	0 - 25 ft. + 0.10	+ 0.15	
	25 - 75 ft. + 0.25	+ 0.28	
	50 - 100 ft.+ 0.45	+ 0.33	
	75 - 100 ft.+ 0.55	+ 0.45	
	100 - 125 ft.+ 0.75	+ 0.53	
	125 - 150 ft.+ 0.80	+ 0.70	

- (6) Add above figures algebraically to obtain 100% efficiency total loading time.

- (7-8) Corrections to obtain true loading time (self explanatory)

- (9) Time per cu. yd. to be used below in (12).

COST PER CU. YD. Computation

- (10) See equipment & labor rates

- (11-12) Self explanatory.

PUSHER PRODUCTION SHEET (For Assisting Scraper)

Sale Name _____ Date _____

Road Name _____

Equipment _____

TIME COMPUTATION

Basic pusher cycle time* (1) 1.09 min.

Operator efficiency correction = line 1 _____ (2) _____ min.

Job efficiency correction = line 2 _____ (3) _____ min.

Time (minutes) per cubic yard =
line 3 ÷ 16 (CY capacity of scraper) (4) _____ min.

COST PER CU. YD. COMPUTATION

Cost of tractor per hour \$ _____

Cost of operator per hour \$ _____

Total operating cost per hour (5) \$ _____ hr.

Operating cost per minute = line 5 ÷ 60 (6) \$ _____ min.

Cost per cu. yd. = line 4 X line 6 (7) \$ _____ cy.

*Pusher cycle time = 140% of basic load time from line 1 Scraper Endhaul
Production Sheet + 0.25 minute.

INSTRUCTIONS FOR PUSHER PRODUCTION SHEET

The following figures assume a basic pusher cycle time with 100% efficiency. They must be modified to conform to the variables on any particular project

The basic pusher cycle time consists of load, boost, return and maneuver time. Numbers in parentheses coincide with those on the work sheet.

TIME COMPUTATION

- (1) Basic pusher cycle time = 140% of basic load time + 0.25 minute.
- (2-3) Corrections to obtain true loading time (.75 = the average operator efficiency and the job efficiency range is .75 to .83).
- (4) Time per cu. yd. to be used below in line (7).

COST PER CU. YD. COMPUTATION

- (5) See equipment and labor rates section.
- (6-7) Self-explanatory.

SCRAPER END HAUL PRODUCTION SHEET

Sale Name _____

Date _____

Road Name _____

Equipment cu. yd. _____

TIME COMPUTATION

Basic load cycle time	(1) _____	min.
Materials time factor	(2) _____	min.
Miscellaneous items time factor	(3) _____	min.
Basic haul cycle time per *RT	(4) _____	min.
Dump or spread time	(5) _____	min.
<u>Total</u> loading and hauling cycle time for this setting (100% efficiency)	(6) _____	min.
 Operator efficiency = line 6 ÷ .75	(7) _____	min.
Job efficiency correction = line 7 ÷ .75	(8) _____	min.
Load factor (swell) = line 8 ÷ _____	(9) _____	min.
Time (minutes) per cubic yard = line 9 ÷ _____ (cy capacity of scraper)	(10) _____	min./cy

COST PER CU. YD. Computation

Cost of scraper and operator / hour	(11) \$ _____	hour
Operating cost per minute = line 11 ÷ 60	(12) \$ _____	min.
Cost per cu. yd. = line 10 x line 12	(13) \$ _____	/cy

Total cost per cu. yd. for end haul project line 13 from above + line 7 (from Pusher Production Sheet)	(14) \$ _____	/cy
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*RT - Round Trip

INSTRUCTIONS FOR SCRAPER END HAUL PRODUCTION

The following instructions are compiled from information in a publication by Caterpillar Tractor Co. entitled Caterpillar Performance Handbook, Edition 5. These figures assume 100% efficiency and Bank Cubic Yards. They must be modified to conform to the variables on any particular project.

A basic cycle time in minutes is the time it takes for a scraper to load, haul, maneuver and spread or maneuver and dump, and return. Numbers in parentheses coincide with those on the work sheet.

TIME COMPUTATION

- (1) Basic load cycle is 0.60 minutes (36 seconds) for a 621B scraper.

Variables and the time factors in minutes by which the basic cycle is to be increased are listed below.

- | | | |
|-----|---|---|
| (2) | <u>Material type</u>
Bank or broken
average | <u>Time (decimal of a minute)</u>
+0.04 and up (.10 normal or
for Elliott State Forest) |
|-----|---|---|

- | | | |
|-----|--|------------------------|
| (3) | <u>Miscellaneous</u>
Restricted maneuvering area
Normal or average digging | +0.00 to 0.04
+0.06 |
|-----|--|------------------------|

- (4) Basic haul cycle time per round trip is obtained from the scraper travel time table in this section.

- (5) Dump or spread time is 0.7 minutes (42 seconds) for a 621B scraper.

- (6) Add above figures algebraically to obtain 100% efficiency total cycle time.

- (7-8) Corrections to obtain true loading time.

- (9) Load factor considers material which has been disturbed and has swelled as a result of loading.

- (10) Time per cu. yd. to be used below in (13).

SCRAPER TRAVEL TIME IN MINUTES

#621B-16 CY

Haul distances Round trip in feet	Scraper Grade				
	2%	4%	6%	8%	10%
500	.49	.55	.60	.67	.73
1000	.69	.76	.86	.98	1.14
2000	.83	1.11	1.21	1.44	1.64
3000	1.54	1.82	2.22	2.78	3.30
4000	1.91	2.32	2.91	3.67	4.34
5000	2.26	2.75	3.55	4.49	5.37
6000	2.59	3.20	4.18	5.35	6.42
7000	2.94	3.66	4.80	6.21	7.47
8000	3.29	4.12	5.45	7.07	8.49
9000	3.66	4.56	6.06	7.91	9.49
10,000	3.98	5.01	6.89	8.25	10.66
12,000	4.67	5.90	8.00	10.56	12.80

The Caterpillar performance handbook may also be used for different sizes of scrapers and steeper grades than those listed above.

ROCK PIT DEVELOPMENT AND CRUSHING COST SUMMARY

Pit: _____ Location: _____ County: _____

Type and Size Rock: _____ Cubic Yards: _____

Scalp and Clear Overburden..... _____

Drill and Shoot \$_____/CU.YD. X _____ CU.YDS. = _____

Strip Rock Loose \$_____/CU.YD. X _____ CU.YDS. = _____

Load Crusher \$_____/CU.YD. X _____ CU.YDS. = _____

Crushing \$_____/CU.YD. X _____ CU.YDS. = _____

Load Dump Truck \$_____/CU.YD. X _____ CU.YDS. = _____

Msc. (haul, spread, \$_____/CU.YD. X _____ CU.YDS. = _____
 process, stockpile)

_____ \$_____/CU.YD. X _____ CU.YDS. = _____

Move in and Setup Crusher _____

Sub Total

Sub total ÷ Cu. Yd. = _____ Base Cost/Cu.Yd.

<u>Rd. Segment</u>	<u>Haul Cost</u> <u>Rock Cost</u>	+ <u>Processing Cost</u>	+ <u>Base Cost</u>	= <u>Cost/Yd.</u>	<u>No. Yds.</u>
_____	\$_____/YD. \$_____	\$_____/YD.	\$_____/YD.	\$_____/YD	___ YDS
_____	\$_____/YD. \$_____	\$_____/YD.	\$_____/YD.	\$_____/YD	___ YDS
_____	\$_____/YD. \$_____	\$_____/YD.	\$_____/YD.	\$_____/YD	___ YDS
_____	\$_____/YD. \$_____	\$_____/YD.	\$_____/YD.	\$_____/YD	___ YDS
_____	\$_____/YD. \$_____	\$_____/YD.	\$_____/YD.	\$_____/YD	___ YDS
_____	\$_____/YD. \$_____	\$_____/YD.	\$_____/YD.	\$_____/YD	___ YDS

_____ \$_____/YD. \$_____/YD. \$_____/YD. \$_____/YD ____YDS
\$_____

_____ \$_____/YD. \$_____/YD. \$_____/YD. \$_____/YD ____YDS
\$_____

STOCKPILE Haul Cost + Pile shaping cost + Base Cost = Cost/Yd.
Total Cost

_____ \$_____/YD. \$_____/YD. \$_____/YD. \$_____/YD
\$_____

TOTAL ALL ROCKING COSTS = _____

ROCKING COST COMPUTATION SHEET

Sale Name _____ Date _____

Road Name _____

HAULING TIME COMPUTATION

1. 50 MPH (1.20 x _____ MRT)* _____
Minutes

2. 40 MPH (1.50 x _____ MRT) _____
Minutes

3. 35 MPH (1.71 x _____ MRT) _____
Minutes

4. 30 MPH (2.00 x _____ MRT) _____
Minutes

5. 25 MPH (2.40 x _____ MRT) _____
Minutes

6. 20 MPH (3.00 x _____ MRT) _____
Minutes

7. 15 MPH (4.00 x _____ MRT) _____
Minutes

8. 10 MPH (6.00 x _____ MRT) _____
Minutes

9. 5 MPH (12.00 x _____ MRT) _____
Minutes

Dump or spread time per RT _____
Minutes

Total hauling cycle time for this setting _____
Minutes

(100% efficiency)

Operator efficiency correction = line 11 ÷ .75 _____
Minutes

Job efficiency correction = line 12 ÷ .75 _____
Minutes

Time per Cubic Yard:

Hauling only - per cubic yard = line 13 ÷ 12 _____
Minutes /cy

(CY capacity of truck)
Delay time (while loading = loading time per cubic yard) _____
Minutes /cy

Total Time per Cubic Yard = line 14 + line 15 _____
Minutes /cy

HAULING COST PER CUBIC YARD COMPUTATION

Cost of truck per hour (A) \$ _____/Hr.

Cost of Operator per hour (B) \$ _____/Hr.
Total Operating Cost per hour = A + B \$ _____ Hour
 Operating Cost per minute = line 17 ÷ 60 \$ _____
 Minute
 Cost per cubic yard = line 16 x line 18 \$ _____ cy

LOADING COST PER CUBIC YARD \$ _____ cy

SPREADING COST PER CUBIC YARD

Cost of Grader or Cat per hour \$ _____/Hr.
 Cost of Operator per hour \$ _____/Hr.
 Total Operating Cost per hour \$ _____/Hr.
 Cost per cubic yard = Cost per hour - 150 CY/Hr. \$ _____/cy

ROCK COST (From Summary of Rock Crushing Costs, or quote) \$ _____/cy

Total Rock Cost = lines 19 + 20 + 21 + 22 \$ _____/cy

_____ * MRT = Mile per Round Trip

SUMMARY OF ALL PROJECT CODES

Sale Name _____ Date _____

New Construction <u>Road Segment</u>	<u>Length</u>	<u>Cost</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
TOTAL	_____	_____
S	_____	_____

Improvements <u>Road Segment</u>	<u>Length</u>	<u>Cost</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
TOTAL	_____	_____
S	_____	_____

Special Projects		

TOTAL	_____	_____

Move In		

TOTAL	_____	_____

GRAND TOTAL _____

Compiled By _____ Date _____

