

Research Report
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ECONOMIC ANALYSES OF MILLINGS

by

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in cooperation with

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and

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U.S. Department of Transportation

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16. Abstract Economic analyses were made using 1984 and 1985 contract bid data. Data were identified as to who retained ownership. Recommendations as to who retains ownership are made based upon factors prevalent for a specific candidate pavement and other circumstances.					
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INTRODUCTION

PROBLEM STATEMENT

Section 412.03.08 of the 1985 Standard Specifications states, "Unless otherwise specified, the cuttings shall become the property of the Contractor and shall be disposed of off the project. When the contract specifies that all or part of the cuttings are to remain the property of the Department, the Department's cuttings shall be delivered to the Department of Highways' Maintenance lot nearest the project. The Department will be responsible for stockpiling the material at the lot." A systematic approach is needed to determine when cuttings should remain the property of the Department.

REVIEW OF CURRENT PRACTICES

The Washington State Department of Transportation (1) has determined that recycling asphalt pavement on interstate highways is cost effective. Approximately 560 lane-miles have been rehabilitated by this method. On the last contract of 48-lane miles, the pavement was milled to a depth of 1.8 inches. The contractor used a blend of 60 percent reclaimed asphalt pavement (millings) and 40 percent new aggregate blended with a medium grade of hot recycling agent, RA-250, in a continuous drum-mix plant operating at 450 tons per hour. The recycled mix was placed on the milled sections to a depth of 1.8 inches and overlaid with an open-graded plant mix friction course. "The option of allowing hot-mix recycled asphalt concrete to be used has proven most cost effective" ... and "is anticipated that this process will continue to play a major role in the rehabilitation of asphalt pavements in the State of Washington."

Approximately 60 lane-miles of an interstate in Maryland (2) were milled to a depth of 2 inches to remove ruts and to return the pavement to its original line and grade. The 2 inches were replaced with a surface mix and sealed with 3/4 inch plant mix. Milling eliminated the need for repaving the shoulder and median areas so that existing drainage structures did not have to be altered.

Another Maryland interstate pavement (3) was milled to a depth of 2 inches for 8.5 miles and involved 350,000 square yards. The contract provided that all existing bituminous pavement removed from the roadway became the property of the contractor.

SOURCES OF DATA

The Division of Maintenance compiled a list of all construction projects during 1984 and 1985 involving milling. Bid prices and quantities for each of these projects were obtained from the Division of Contract Procurement (Table 1). Unit bid prices for bituminous materials were obtained from Systems Information, Department of Finance, Finance and Administration Cabinet (Table 2). The Division of Maintenance furnished information on typical crew sizes, wages, and equipment that would be used in paving shoulders when using millings. Hourly rental rates for equipment were obtained from the Division of Equipment (Table 3).

ANALYSES AND RESULTS

MILLING CONTRACTS

For the contractor-retained millings, the bid item does not provide information on whether the contractor will, or will not, recycle the millings, or to what use he expects to apply the millings.

Bids for milling operations were separated by year and according to who would retain ownership of the millings. Data for each year and by the party retaining the millings were plotted (bid price per ton versus tonnage) and found to be similar. However, the 1985 bids were not adjusted for inflation. The trend for the unit cost for milling in 1985 was lower than for 1984. The lower trend in 1985 probably is more a reflection of gaining experience with bidding a new procedure during 1984 than for other reasons. Thus, the data for the two years were combined into one data set according to who would retain the millings (Figures 1 and 2). Regression analyses were performed on the two sets of data and the trend lines are shown in Figure 3.

Figure 1 presents data for cases where contractors retained the millings. There were very few bids for projects producing less than 600 tons of millings. One regression equation fitted the data for quantities greater than 600 tons.

Figure 2 presents data for cases where the Department retained the millings. The following observations were noted:

1. There is a distinct break in slope at approximately 300 tons.
2. For less than 300 tons, the cost per ton decreases much more rapidly with increasing tonnage than for quantities greater than 300 tons.

Figure 3 compares the slopes of Figures 1 and 2. The slope of the regression line in Figure 1 (contractors retain millings) intersects the two slopes shown in Figure 2 (Department retains millings). Figure 3 indicates the following:

1. For a project involving 300 tons of milled material, the average unit bid would be approximately \$28.00 per ton if the contractor retained ownership of the millings and \$22.50 per ton if the State retained ownership;
2. At approximately 950 tons, the unit bid prices are identical regardless of who retained ownership of the millings;
3. At 3,000 tons, the unit bid price per ton where the state retained ownership would be approximately \$16.30 versus \$12.00 if the contractor retained ownership; and
4. At 10,000 tons, State retained ownership would have an a unit bid price of \$14.50 per ton versus \$7.70 per ton if the contractor retained ownership. During 1986, a unit bid of \$13.95 per ton was received for milling 11,739 tons in a three-county area and hauling the millings to two designated State-owned storage yards.

A different procedure for using millings was incorporated in three projects during 1986. The procedure called for the contractor to excavate a trench in the shoulder next to the

mainline pavement and place the millings from the mainline directly into the trench to a specified compacted depth. A bituminous shoulder mix using new limestone aggregate was placed as a surface mix over the compacted millings. The economic analysis was influenced greatly by the cost of the trenching. The unit bid price for trenching on two of the three projects was nearly five times the unit cost for the third project. Construction of shoulders only on these three projects involved 19,832 tons of material at a total materials and trenching cost of \$473,347.35 yielding an average unit cost of \$23.87 per ton in place. However, the average unit cost per ton of material on given projects varied from \$22.50 to \$28.99.

BID PRICES FOR BITUMINOUS MIXES DURING 1985

Unit bid prices for bituminous mixes to be used on a specific construction contract is a combination of materials and transportation costs. Thus, separate costs for materials and transportation are not available under current bidding procedures.

Data relating price versus total tonnage were plotted for each type of bituminous mix. The price decreased slightly as the tonnage increased for the bituminous base mix. The rate of decrease in price per ton of bituminous binder mix was less favorable than for the base mix. For bituminous surface mix, the price decrease was even less than for the bituminous binder mix. There was no discernable trend between price per ton and quantity for bituminous shoulder mix. Variation in price may have been related more to the haul distance from the plant to the project site than to production quantities of shoulder mix.

COST TO STORE MILLINGS

The Department does not assign a cost for storing millings at maintenance yards. The bids did not contain an item for costs related to storing the millings at contractors' facilities. No data are available for determining storage costs.

COSTS FOR STATE FORCES TO PAVE SHOULDERS WITH MILLINGS

Table 3 contains the daily costs for equipment (other than trucks) and a crew of nine persons. Excluding the costs of obtaining the millings initially and assuming the crew size will not vary, variation in paving cost is a function of distance from the maintenance lot to the project site (Table 4). Equipment rental rates remain constant for all equipment except dump trucks, for which the rate is based on mileage. Thus, cost variations are related to distance traveled by the dump trucks. Distance from storage yard to project site largely governs the number of trips per day per truck, the total tonnage placed per day, and ultimately the in-place unit cost (excluding the costs of obtaining the millings). The total cost of using millings to pave shoulders is the initial cost of the millings plus the costs of the crew, equipment, and fuel to construct the shoulders.

RECOMMENDATIONS

1. The contractor should retain the millings when
 - a) there is no place to store the millings on state property,
 - b) there is no anticipated use for the millings by the Department, or
 - c) the cost of the millings exceeds the costs of purchasing new shoulder-mix material from the hot-mix plant.
2. The Department should retain the millings when
 - a) an overall plan is in effect for the use of the millings,
 - b) milling projects will produce quantities sufficient to complete the anticipated project, and
 - c) milling projects will produce sufficient quantities to lower the unit costs below the cost of purchasing new shoulder-mix material.

It is suggested that modification of bid proposals be considered for projects potentially involving milling. Bids could be received with unit costs for milling with the contractor retaining the millings and then unit costs for milling with the contractor delivering the millings to Department maintenance yards. Thus, costs of ownership of the millings may be more readily determined by the "market place".

The economic analysis reported herein is based upon the utilization of millings by the Kentucky Department of Highways solely for paving shoulders. However, bidding documents would have to be worded carefully to preclude court suits by unsuccessful bidders. It is suggested that there is a potential, possibly a significant potential, for the use of millings from highways and streets for purposes of surfacing or resurfacing low-volume low-type roadways. The utilization of millings for this purpose would enlarge the potential number of projects upon which these materials could be applied and therefore possibly could alter somewhat the economics of retaining ownership of the millings.

LIST OF REFERENCES

1. J. P. Walter, "Hot-Mix Recycling Keeps Interstate Rehab Costs Down in Washington State", The Asphalt Institute, College Park, MD, Asphaltnews, Vol 8, No. 3, August 1985.
2. "High-Speed Pavement Profilers Star in Major Milling Project", Better Roads, Vol 53 No. 11, November 1983.
3. "I-95 John F. Kennedy Memorial Highway Resurfaced Using Recycled Asphalt", Maryland Asphalt Association, Incorporated, Maryland Asphalt Paver, August 1983.

TABLE 1. BIDS FOR MILLING CONTRACTS DURING 1984 AND 1985

COUNTY	CONTRACT NO.	MILLINGS TONS	DOLLARS PER TON	OWNERSHIP	
				CONTRACTOR	STATE
1984					
ALLEN	MP 002-031E-009-012	452	22.00		X
BRECKENRIDGE	MP 014-0060-013-016	600	17.50		X
HARDIN	MP 047-031W-015-018	1200	21.50		X
JEFFERSON	SSP 56-0150-000-002	4121	18.10		X
JEFFERSON	MP 056-2801-000-001	402	20.00	X	
SHELBY	MP 106-0060-009-012	856	15.00		X
FAYETTE	MP 034-3363-011-013	44	50.00	X	
SCOTT	MP 105-0062-006-008	409	22.50		X
BOYLE	MP 011-0150-013-015	327	23.00		X
FAYETTE	MP 034-0421-002-004	945	16.25		X
FAYETTE	MP 034-0060-007-009	18	50.00		X
CUMBERLAND	MP 029-0061-012-015	2065	18.00		X
PULASKI	MP 100-0080-000-010	2789	16.20		X
ROWAN	MP 103-0060-007-011	3226	19.50		X
ROWAN	MP 103-0032-005-009	5036	15.50		X
BELL	MP 107-025E-003-013	7797	13.80		X
BARREN	MP -0068-014-017	992	19.00		X
CHRISTIAN	MP 024-0107-008-018	52	75.00		X
GREEN	MP 044-0031-008-011	200	34.00		X
HENDERSON	MP 051-0351-000-001	278	21.00		X
HOPKINS	MP 054-041A-119-011	792	15.25	X	
LYON	MP 072-0062-010-015	1440	15.50	X	
MCLEAN	MP 075-0085-000-003	17	95.00	X	
MUHLENBERG	MP 089-0181-000-012	43	75.00	X	
OHIO	SSP 6R84 0000007	4727	13.50	X	
MCCRACKEN	SSP 6R84 0000008	2192	16.10		X
NELSON	SSP 6R84 0000010	88	47.50		X
JEFFERSON	SSP 6R84 0000013	2770	10.44	X	
UNION	MP 113-0109-001-014	496	24.00		X
BATH	SSP 6R84 0000019	16	200.00		X
JOHNSON	SSP 6R84	511	20.00		X
1985					
MCCRACKEN-					
MARSHALL	IR 24-1 056-016	4367	13.00	X	
HICKMAN	MP 056-0051-006-008	3424	11.50	X	
MUHLENBERG	MP 089-0277-000-002	1788	16.00		X
HOPKINS	MP 054-041A-006-009				
	MP 054-041A-014-016	450	15.75		X
CHRISTIAN	MP 024-041A-015-016				
	MP 024-0107-018-019				
	MP 024-0041-011-013				
	MP 024-0068-010-011	1955	15.00		X
NELSON	MP 090-031E-014-015				
	MP 090-0062-024-028	718	17.5	X	
GRAYSON	MP 043-0062-018-022	2100	13.50	X	
BOYLE	MP 011-0033-000-001				
	MP 011-0034-012-014				
	MP 011-0037-015-017	1679	14.35	X	
CLARK	MP 025-0060-006-008	914	14.35	X	
MONTGOMERY	MP 087-0060-005-009	639	19.50	X	
FAYETTE	MP 034-0421-003-006				
	MP 034-0922-002-006				
	MP 034-1623-000-002	1805	8.50	X	
MADISON	MP 076-0388-008-013				
	MP 076-0169-000-009	1275	13.00	X	
RUSSELL	MP 104-0127-017-021	2448	18.25	X	
MASON	MP 081-0062-015-018	939	14.25		X
NICHOLAS	MP 091-0032-008-009	673	19.90	X	
WHITLEY	SSP118-0312-000-003	120	41.50	X	
ANDERSON	SSP003-0062-018-021	122	23.50	X	
BUTLER	SSP003-0231-010-012	286	20.00		X
CLAY	SSP026-0421-017-019	357	20.00		X
PIKE	SSP 6R85 0000018	703	25.00	X	

TABLE 2. STATEWIDE AVERAGE UNIT BID PRICES PER TON

ITEM NO.	DESCRIPTION	PRICE	
		1984	1985
2677	BIT PAVE MILLING TEXTURING	17.30	13.19
120	BIT CONC BASE - CRUSHED LIMESTONE	26.39	25.56
130	BIT CONC BIND - CRUSHED LIMESTONE	27.12	26.60
150	BIT CONC SURF - CRUSHED LIMESTONE	28.16	28.92
263	BIT MIX SHLDS - CRUSHED LIMESTONE	25.65	29.03

TABLE 3. CREW AND EQUIPMENT REQUIREMENTS TO PAVE SHOULDERS USING MILLINGS (1985 RATES)

DESCRIPTION	NO.	NO. OF PEOPLE	UNIT RENTAL RATE
MOTOR GRADER	1	1	\$21.50 / MILE
DUMP TRUCK, 4 YARD	2	2	\$0.75 / MILE
DUMP TRUCK, 10-12 YARD	1	1	\$1.12 / MILE
SELF PROPELLED SPREADER	1	3	\$20.00 / HOUR
ROLLER, 4-6 TON	1	1	\$10.95 / HOUR
FRONT-END LOADER	2	2	\$18.00 / HOUR
FOREMAN		1	
TOTAL CREW SIZE		11	\$10.00 / HOUR
COSTS PER 8-HOUR DAY			
EQUIPMENT			\$707.60 / DAY
CREW (11 x 8 HOURS x \$10.00 / HOUR)			\$880.00 / DAY
TOTAL COST / 8 HOUR-DAY			\$1,587.60 / DAY

TABLE 4. IN-PLACE COST PER TON AS A FUNCTION OF ROUND-TRIP MILEAGE

ROUND TRIP MILEAGE	NO. OF TRIPS PER DAY	TONS PER DAY*	MILEAGE COSTS PER DAY	CREW AND EQUIPMENT COST/DAY	TOTAL COSTS PER DAY	COST PER TON IN PLACE
6	9	342	\$141.48	\$1,587.60	\$1,729.08	\$ 5.06
15	7	266	\$275.10	\$1,587.60	\$1,862.70	\$ 7.00
20	6	228	\$314.40	\$1,587.60	\$1,902.00	\$ 8.34
30	5	190	\$393.00	\$1,587.60	\$1,980.60	\$10.42
50	4	152	\$524.00	\$1,587.60	\$2,111.60	\$13.89

* APPROXIMATE TONNAGE PER TRIP:

4-YD: 27 CF/YD x 150 LB/CF x 4 YD / (2000 LB/TON) = 8 TONS

10-12 YD: 27 CF/YD x 150 LB/CF x 11 YD / (2000 LB/TON) = 22 TONS

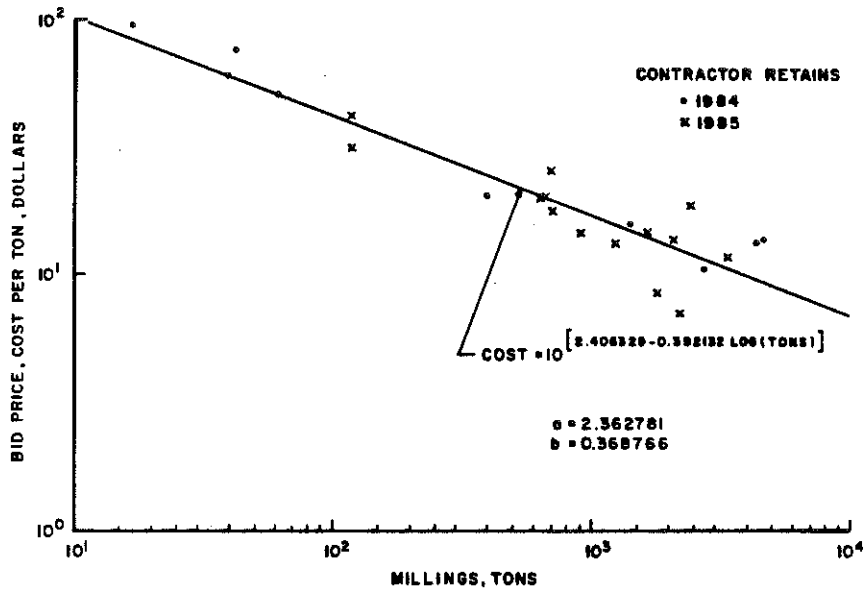


Figure 1. Unit Bid Price versus Tonnage of Millings When Contractor Retains Millings.

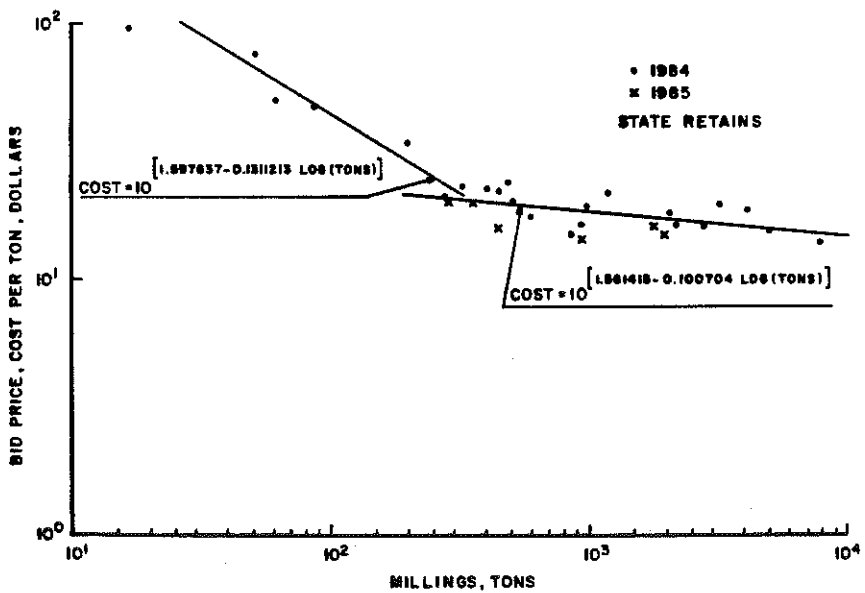


Figure 2. Unit Bid Price versus Tonnage of Millings When Department Retains Millings.

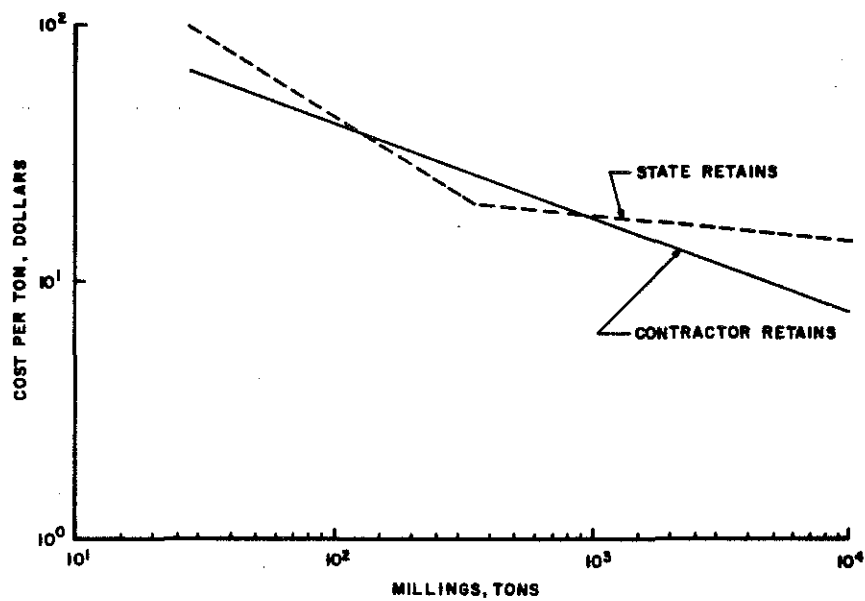


Figure 3. Comparison of Unit Bid Price versus Tonnage of Millings and Who Retains Millings.