The foam is allowed to remain on the surface for at least an hour and preferably longer. It is then removed with a wet-vacuum and a foam suppressant such as Turco Liquid Lid. This product was not developed as a foam suppressant, but it apparently works better than products that were. A standard mobile vacuumized street sweeper will work for foam pickup. Liquid Lid costs about $10 per gallon.

The prices of the chemicals given here are prices F.O.B. at the Turco plant. Shipping costs will vary according to the distance shipped, of course, and also by the direction shipped, the type of chemical shipped, and the total size of the shipment. Turco estimates shipping charges on the basis of a price scale for different zones. The cost per gallon ranges from $0.60 for shipments going to a zone 1 destination, to $1.20 for shipments destined for locations in zone 6. On the basis of these figures, we assumed an average shipping charge of $1.00 per gallon and $0.10 per pound. This raises the total costs of the chemicals as shown in Table A.1.5.5.1.

The diluted 4512A solution will cover about 200 to 250 sq feet. At $14.00 per gallon, this is equivalent to $0.0753 per sq meter using a coverage of 200 sq feet per gallon. The 4306D solution has a similar coverage so that the cost per sq meter is $0.0363. Since this is less costly than the 4512A, further cost calculations are based on use of 4306D. The foaming agent 5865 mixed 1:10 with the 4306D solution will cover 2000 sq feet per gallon. This yields a figure of $0.0390 per sq meter. One pint to one quart of Liquid Lid is adequate for 20 gallons of 4306D solution. At one quart to 20 gallons, one gallon of Liquid Lid will be required for every 1488 sq meters. The cost per sq meter is, therefore, $0.0074. The total chemical costs per sq meter are shown in Table A.1.5.5.2.

The foam could be applied with equipment very similar to the tank truck with pump and spray bar arrangement used for high-pressure water washing of pavement. For the purpose of applying foam, the spray bar or row of nozzles would be mounted across the rear bumper rather than the front. Since lower pressure and lower volume pumping are required, a smaller pump could be used. On the other hand, the nozzles must be such that they will mix the foaming agent with the acid-based decontamination chemical. Such nozzles must be manually set, but once set they seldom need readjustment. A ten-foot row of nozzles may require another person per truck in addition to the driver. Finally, separate tanks must be provided for the foaming agent and the decontaminant.

TABLE A.1.5.5.1. Chemical and Shipping Costs for Foam Decontamination

	Costs (1982 $)		
Chemical	Price, F.O.B. Plant	Shipping Cost	Total Price, Shipped
4512A	$ 13.00/gal	$1.00/gal	$ 14.00/gal
4306D	$180.00/cwt	$0.10/lb	$190.00/cwt
5865	$ 6.25/gal	$1.00/gal	$ 7.25/gal
Liquid Lid	$ 10.00/gal	$1.00/gal	$ 11.00/gal

TABLE A.1.5.5.2. Total Chemical Costs for Foam Decontamination

Chemical	Cost (1982 $/m^2)
4306D	0.0363
5865	0.0390
Liquid Lid	0.0074
Total	0.0827

We estimate the capital cost and the operation and maintenance cost of this equipment to be ten percent higher than required for a high-pressure water wash. Also, we assume two people per truck will be necessary. Using the representative cost data described in the section on high-pressure water washing of pavement, we get $30.11 per hour for equipment. With two workers, the hourly labor cost comes to $39.50. The total hourly cost is $69.61.

If the truck applies foam at five miles per hour, the proper pump rate is 22 gallons per minute. At this rate a tank load will be sprayed in about three hours and 45 minutes. Estimating half an hour for refilling, about 1.5 tank loads can be applied in the seven production hours per eight-hour shift, the extra hour being set aside for equipment and personnel decontamination measures. This means that in an eight-hour shift there will be 5.6 hours of actual foam application time. The coverage will be:

$$5.6 \text{ hr} \times 5 \text{ mi/hr} \times 5280 \text{ ft/mi} \times 10 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft}^2$$

$$= 137{,}491 \text{ m}^2/\text{shift}$$

The average coverage per shift-hour will be 17,186 sq meters. The cost per sq meter will be:

$$\frac{\$69.61/\text{hr}}{17{,}186 \text{ m}^2/\text{hr}} = \$0.0041/\text{m}^2$$

As for removing the foam, mobile vacuumized street sweepers can be used. Their cost was calculated separately in Section A.1.5.1 dealing with vacuumized street sweepers. The rate of surface coverage for a vacuumized street sweep is one-half the rate of foam application. Thus, for each spray truck there would be two vacuumized street sweepers. The rate for the entire operation would be 17,186 sq meters per hour.

Table A.1.5.5.3 summarizes the costs of chemicals, application, and removal. The last line of the table presents the combined costs based on these data. According to these figures, the great preponderance of cost lies with the chemicals.

TABLE A.1.5.5.3. Cost Summary of Foam Decontamination of Pavement

Item	Rate (m^2/hr)	Cost (1982 $/m^2)			
		Total	Labor	Equipment	Materials
Chemicals					
4306D	--	0.0363	--	--	0.0363
5865	--	0.0390	--	--	0.0390
Liq. Lid	--	0.0074	--	--	0.0074
Total Chemicals	--	0.0827	--	--	0.0827
Application	17,186	0.0041	0.0023	0.0018	--
Removal	8,632	0.0043	0.0021	0.0022	--
Total All Items	17,186	0.0911	0.0044	0.0040	0.0827

A.1.5.6 Strippable Coating

Several manufacturers produce what is referred to as strippable (or peelable) coatings. These coatings can be sprayed on with a nonaspirated spray to a particular thickness. After drying, the material can be peeled off like cellophane tape. In addition to coatings that are physically or mechanically strippable, there are related coatings that can be removed with a chemical solution.

This material can perform three desirable functions. The first is that the material works as a fixative. On essentially any surface, the coatings will hold the contamination in place. The second function is that in removing the coating, much of the surface contamination is removed as well. The third function of this product is that it can be used to protect surfaces from contamination. By applying a coating before exposure to radiation, the radioactive particles can be prevented from becoming embedded in the surface. This last function is currently the most important one from a commercial standpoint. So-called "Grafitti Shield" is a chemically strippable coating.

The method of application can vary as long as a nonaerosol spray is used. Layers can be built up to the necessary thickness even if successive layers are allowed to dry before the application of the next layer.

Information on costs of strippable coating was supplied by Turco Products. The company sells three strippable coatings. Turco 5561 is pigmented yellow to facilitate complete removal. Turco 5931 is white and Turco 5931-C is clear. With a quantity discount, the material costs $16.48 per gallon. For use on smooth surfaces, one gallon would be applied to 600 to 800 sq feet.

However, for asphalt roads and similarly rough surfaces, a thicker coating is necessary. This source recommends an application of a gallon for every 100 sq feet. The material cost per sq meter is

$$\frac{\$16.48/\text{gal}}{100\ \text{ft}^2/\text{gal} \times 0.093\ \text{m}^2/\text{ft}^2} = \$1.77/\text{m}^2$$

Using a tanker truck with pump and rear-mounted spray bar as described in Section A.1.5.3, the liquid could be applied at a vehicle speed of five miles per hour and pump rate of 44 gallons per minute. One 5000-gallon tanker load would keep the truck applying for about 110 minutes. Assuming 50 minutes for refilling the tank, and ignoring the problem of fractional tank loads, about 2.6 tank loads per shift could be applied, with about 4.8 hours of actual coating application. These calculations include one hour per shift allocated for equipment and personnel decontamination. Total coverage per shift would be:

$$4.8\ \text{hrs} \times 5\ \text{mi/hr} \times 5280\ \text{ft/mi} \times 10\ \text{ft wide}$$

$$\times\ 0.093\ \text{m}^2/\text{ft}^2 = 117{,}850\ \text{m}^2$$

One-eighth of that amount, or 14,731 sq meters, is the average hourly production per shift hour.

Referring to the representative data for high-pressure water, we note that the total cost per hour is $47.11. This means that the cost of application per sq meter is $0.0032. Labor's share is $0.0013 per sq meter, and the equipment cost is $0.0019.

Any cost estimate for large-scale removal of peelable coating is highly conjectural since this has never been done before. A source at Turco suggested a method for large-scale, rapid, and economical removal of the coating. A pickup truck would be fitted with a front-mounted take-up spindle with electric motor drive. Ahead of this, two small circular knife blades at the end of metal arms would roll across the coated pavement, cutting the coating. The two blades would be about ten feet apart. Presumably this would allow a ten-foot wide strip of coating to be continuously lifted up from the pavement and rolled onto the take-up spindle.

Mike McCoy of Battelle Pacific Northwest Laboratories, Richland, Washington, is familiar with fixatives and strippable coatings. He said such a system might work but that it would probably require some experimentation before it became fully functional.

Assuming that this system could be made to work, but at a very conservative speed, we can estimate the cost of coating removal. The operation and maintenance cost of a pickup truck according to Means' Building Construction

Cost Data 1982 is \$4.42 per hour plus a monthly rental cost of \$275. We assume that the modifications to the pickup truck increase its capital cost and its operation and maintenance cost by one third. On this basis, the cost of ownership is:

$$\frac{\$275/\text{mo} \times 4/3}{43 \text{ shifts/mo} \times 8 \text{ hr/shift}} = \$1.07/\text{hr}$$

The cost of operation and maintenance is:

$$\$4.42/\text{hr} \times 4/3 = \$5.89/\text{hr}$$

The total equipment cost is, therefore, \$6.96 per hour. Additionally, there is the cost of the driver and another worker at \$17.45 per hour each. The total hourly cost is then \$41.86, and for an eight-hour shift the cost would be \$334.88.

If this equipment can remove a strip ten feet wide at an average pace of one mile per hour, during the seven hours of production of an eight-hour shift, a total of 34,373 sq meters will be removed. Over eight shift hours, this represents an hourly rate of 4297 sq meters. Thus, the total cost per sq meter for removal is \$0.0097. Labor would cost \$0.0081 per sq meter, and equipment would cost \$0.0016 per sq meter.

Table A.1.5.6.1 presents the preceding information in summary form. Perhaps most striking is how costly the strippable coating is, relative to the other inputs. Since removal is the more costly procedure per sq meter, the number of application crews is adjusted to conform to the removal rate. This means that 4,297 ÷ 14,731 = 0.29 application crews will be used for every removal crew. Thus, the inputs for this operation are 0.29 heavy-truck drivers, 0.29 5000-gallon spray trucks, two building laborers and one modified pickup truck.

TABLE A.1.5.6.1. Summary of Cost and Productivity Data for Decontamination of Paved Surfaces with Strippable Coating

Item	Rate (m^2/hr)	Total	Cost (1982 \$/m^2) Labor	Equipment	Materials
Chemicals	--	1.77	--	--	1.77
Application	14,731	0.0032	0.0013	0.0019	--
Removal	4,297	0.0097	0.0081	0.0016	--
Total	4,297	1.7829	0.0094	0.0035	1.77

A.1.5.7 Planing

Planing or grinding is a method of removing a surface layer of pavement. Planing machines are available in different sizes with different productivity rates. Some large "road profilers" can grind one lane wide, one inch deep, and advance at a rate of one mile per hour. These machines can be operated to remove essentially any thickness of pavement desired. They do so by abrading rather than by cutting the top surface off.

The Washington State Department of Transportation advises that equipment for a planing crew consists of one planer machine, a rotary broom mobile street sweeper, a front-end loader, and ten trucks for hauling away the debris. Many planers have conveyor systems to feed heavy debris directly into a dump truck. The personnel requirements are four equipment operators, one laborer, and ten truck drivers. However, when this method is used for decontamination, some additional equipment may be required.

While removing the top layer of pavement would generally seem like an effective way to remove the attendant contamination, the grinding action by which some planers operate creates a lot of dust. Newer planers spray the road surface with water to prevent excessive dust. Another way to limit resuspension of contaminants would be to treat the road surface with road oil, a sealer, or some other fixative. Still another possible method of dust control which two sources (Washington State Department of Transportation and Los Angeles Department of Public Works) agree may be effective is to contain the dust at the base of the planer with rubber skirts and to remove this dust with a high-power mobile vacuum hose intake. It is not clear if a standard vacuumized street sweeper would have adequate power and capacity. If not, then larger equipment such as a Super Sucker or Peabody mobile vacuum could be used. These machines are quite powerful. Power Master, Inc. in Portland, Oregon, which uses this type of equipment for contract industrial cleaning, provided information on these machines. The vacuum pumps on them are rated at 4500 cubic feet per minute, and the dump box has an effective capacity of 12 cubic yards. They cost $160,000 new, and Power Master's rental rate, including the driver-operator, is $144.50 per hour. For continuous dust control operation, two vacuums per planer would be required. In some cases these vacuums may actually make some of the other pick-up equipment unnecessary.

The Washington State Department of Transportation estimates the cost of planing off one to 1.5 inches of asphalt at $1.00 per sq yard, including rubble removal. Since the cost of hauling away contaminated materials is estimated separately in this report (see Section A.6.2), it is necessary to remove the cost of hauling from the $1.00 per sq yard cost. We assume that hauling comprises one half of the planing costs, giving a net planing cost of $0.50 per sq yard. After adjusting for radiation control measures, the total costs is

$$\$0.50/\text{yd}^2 \times 1.196\ \text{yd}^2/\text{m}^2 \times 8/7\ \text{adj} = \$0.68/\text{m}^2$$

This source reports that their planers can cover three lane miles per eight-hour day. With seven hours of actual planing for every eight-hour shift, the average production per shift-hour is 1611 sq meters. In one shift the total production is 12,890 sq meters.

Dust control for eight hours, using two high-power vacuums at $144.50 per hour each, raises the daily cost by $2312. The cost per sq meter at this rate is $0.18.

The City of Los Angeles Department of Public Works said the major equipment necessary for a planing crew consists of a planer, a skip loader, a dump truck, and a motorized sweeper. The personnel required includes one planer operator, one loader operator, one truck driver, one sweeper operator, and two laborers.

The Department's cost for planing asphalt averages $0.25 per sq foot, which is equal to $2.69 per sq meter. However, for our purposes, it is necessary again to remove the cost of the dump truck and driver, because hauling costs are handled separately. Here we assume that hauling away the rubble comprises 25 percent of the total cost. With the additional adjustment for radiation control measures, the cost per sq meter is

$$(\$2.69/m^2 - 0.25 \times \$2.69/m^2) \times 8/7 \text{ adj} = \$2.31/m^2$$

The Department's equipment will plane a width of six feet to a depth of one inch at a rate of one mile per hour. With seven hours planing per eight hour shift, the average hourly production rate is 2578 sq meters. The added cost for dust control at this rate is $0.11 per sq meter.

Table A.1.5.7.1 summarizes the foregoing information. These data pose two principle difficulties. One is that the Los Angeles Department of Public Works cost per sq meter is more than three times greater than that from the Washington State Department of Transportation. The second is that the implied cost per hour for both data sets is very high. The Washington State Department of Transportation data yield an hourly planing cost of $1095, and the hourly planing cost consistent with the Los Angeles Department of Public Works data is $5955. For comparison, the hourly cost of the inputs (without hauling) specified by the Washington State Department of Transportation can be estimated directly using data from Means' Building Construction Cost Data 1982 and from data elsewhere in this report. This crew differs from the one specified by the Los Angeles Department of Public Works only by the inclusion of one additional laborer. This crew is described in Table A.1.5.7.2. The cost of the planer is estimated at $100 per hour, since Means had no listing for that type of equipment. The cost of the street sweeper was taken from the representative cost data in Section A.1.5.1. The 2.25-cubic yard front-end loader is a medium sized loader according to Means.

TABLE A.1.5.7.1. Summary of Asphalt Road Planing Cost and Productivity

Procedure and Source	Rate (m^2/hr)	Cost (1982 \$/m^2) Total	Labor	Equipment
Planing				
Wash. Dept. of Trans.	1611	0.68	--	--
Dust Control				
Power Master	--	0.18	0.06	0.12
Total	1611	0.86	--	--
Planing				
L.A. Public Works	2578	2.31	--	--
Dust Control				
Power Master	--	0.11	0.04	0.07
Total	2578	2.42	--	--

TABLE A.1.5.7.2. Hourly Cost Estimates of Inputs Specified by the Washington State Department of Transportation for Asphalt Road Planing

Input	Cost (1982 \$/hr)
Labor	
3 Medium-equipment operators @ 24.95/hr (Means)	74.85
2 Building laborers @ \$19.40/hr (Means)	38.80
Total Labor	113.65
Equipment	
1 Planer (est.)	100.00
1 Vac. street sweeper (Section A.1.5.1)	37.12
1 Front end loader, 2-1/4 yd^3 (Means)	51.70
Total Equipment	188.82
Total Input Cost	\$302.47

The three hourly cost estimates are summarized in Table A.1.5.7.3. The explanation for this wide discrepancy is not known. One possibility is that the Washington and Los Angeles sources include unspecified administrative, supervisory, engineering and support costs. Another possibility is that operation of the planer is much more costly than the estimated \$100 per hour. In general, the Means input costs seem reasonable, though perhaps a foreman (\$22.53 per hour) and a pickup truck (\$6.06 per hour) should be added.

TABLE A.1.5.7.3. Summary of Hourly Cost Estimates for Asphalt Road Planing

Source	Cost (1982 $/hr)
Sum of input costs	302.47
Washington State Department of Transportation	1,095.48
Los Angeles Department of Public Works	5,955.18

bringing the total hourly cost to $330.58. However, at the coverage rates specified by the two other sources, the cost works out to $0.21 per sq meter or less, an amount which appears unreasonably low. Any resolution of these inconsistencies must be somewhat arbitrary. The approach used here is to make the major adjustment in the rate of coverage. We assume an hourly coverage rate of 750 sq meters per hour, an hourly cost of $400.00, and a cost per sq meter of $0.53. The cost per sq meter is broken down between labor and equipment in the same proportion as the Means cost data in which $135.90 of $330.78 is for labor. Thus, the labor cost per sq meter is $0.22 and the equipment cost is $0.31.

At a rate of 750 sq meters per hour, dust control costs $0.38 per sq meter. Of this amount, $0.13 is for labor and $0.25 is for equipment. Table A.1.5.7.4 summarizes this representative cost information. As can be seen, the total cost, including dust control, is $0.91 per sq meter.

TABLE A.1.5.7.4. Representative Asphalt Road Planing Cost Data

Procedure	Rate (m^2/hr)	Cost (1982 $/$m^2$)		
		Total	Labor	Equipment
Plane	750	0.53	0.22	0.31
Dust Control	--	0.38	0.13	0.25
Total	750	0.91	0.35	0.56

A.1.5.8 Tack Coat

From the standpoint of radiation decontamination, there are three reasons to coat or resurface a road. The first is that a quickly applied thin coating may be desired as a fixative. The second reason is that a new surface will be required if the old one has been removed or planed. The third possible reason for resurfacing a road is that a new pavement layer over the existing contaminated pavement may provide sufficient shielding from the radiation, obviating the need for the actual removal of the radioactive particles.

As the reasons for surfacing a road are numerous, so too are the possible materials with which this can be accomplished. In addition to the basic materials with which roads are paved, asphalt and concrete, roads may also be coated with such materials as road oil, tar, tack coat, or slurry seal. In

this and the next few sections, the costs and other important aspects of applying different surface coatings to pavement are discussed. First to be considered are minimum-thickness surface coatings. Second, thin-pavement coating data are presented. Finally, complete repaving is discussed.

Frequently the cost of applying some surface coating to a road is expressed in terms of the volume of the coating material. In part, this reflects the fact that materials make up the largest share of the total costs. The significance of this, with respect to the calculations being made for this report, is that costs are more closely tied to the unit of output than to time.

Means' Site Work Cost Data for 1982 lists tack coat as the least costly of the seal coatings at $0.34 per sq yard. The crew for this operation consists of one foreman and two building laborers. The billing costs for these types of workers are $22.25 and $19.40, respectively. The total three-man crew costs $61.05 per hour. The total cost per hour is found by multiplying the rate (525 sq yards per hour) by the unit cost ($0.34 per sq yard), yielding $178.50 per hour. Subtracting the labor cost from this amount gives the hourly material cost ($117.45).

The given rate can be converted to sq meters per shift-hour in the following manner:

$$\frac{4200 \text{ yd}^2/\text{day} \times 0.836 \text{ m}^2/\text{yd}}{8 \text{ hr/day}} \times 7/8 \text{ adj} = 384 \text{ m}^2/\text{hr}$$

Dividing the rate into the hourly costs gives the sq-meter costs for total ($0.46), labor ($0.16), and materials ($0.30). Means indicated no significant equipment for this operation. This probably accounts for the relatively low application rate.

According to the Washington State Department of Transportation, a "tack coat" is a thin layer of asphalt. This is sprayed on by a truck at 0.2 gallons per sq yard, or 6 tons per lane mile. It is frequently used to bind one layer of asphalt to the next. At $250 per ton (applied), the cost per lane mile is $1500. The cost per sq meter is:

$$\frac{\$250/\text{ton} \times 6 \text{ tons/mi}}{5280 \text{ ft/mi} \times 10 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft}^2} = \$0.3055/\text{m}^2$$

With seven hours operation per eight hours, the average coverage per shift hour is:

$$\frac{3\ \text{mi/hr} \times 7\ \text{hr} \times 5280\ \text{ft/mi} \times 10\ \text{ft wide} \times 0.093\ \text{m}^2/\text{ft}^2}{8\ \text{hr/shift}} = 12{,}980\ \text{m}^2/\text{hr}$$

No information was provided by this source with respect to the costs for the various inputs; however, these can be estimated using Means data. The cost of a 3000-gallon distributor truck is given as $31.12 per hour. The personnel required for this type of operation according to Means include one medium equipment operator and one heavy-truck driver. The total billing costs for these workers are $24.95 and $19.75, respectively. The total is $44.70. The hourly labor and equipment costs are easily converted to costs per sq meter by dividing by the hourly coverage rate:

Labor: $44.70/hr ÷ 12,890 = $0.0035

Equipment: $31.12/hr ÷ 12,890 = $0.0024

Subtracting the sq meter costs for labor and equipment from the total sq meter costs leaves the cost per sq meter of the material:

Material: $0.3055 - ($0.0035 + $0.0024) = $0.2996

The Means and the Washington State Department of Transportation data are summarized in Table A.1.5.8.1. As can be seen, the material costs are essentially identical. The major cost difference lies in the labor cost for Means as opposed to the very low labor and equipment costs for the Washington State Department of Transportation. The obvious explanation for this difference lies in alternative methods of application. The Means data are for manual application as indicated by the relatively high labor costs and the low application rate. The Washington State Department of Transportation data,

TABLE A.1.5.8.1. Summary of Data for Tack Coat Application to Asphalt Roads

Source	Rate (m^2/hr)	Cost (1982 \$/m^2) Total	Labor	Equipment	Materials
Means	384	0.46	0.16	--	0.30
Wash. Dept. of Trans.	12,890	0.3055	0.0035	0.0024	0.2996

however, are for a high volume operation. The former method is appropriate for smaller, restricted areas, while the latter is appropriate for large paved areas, such as roads and parking lots. For this reason, the Washington State Department of Transportation data are taken as representative. Further, the Means data are taken as representative for application to "other paved surfaces" (see Sections A.1.6 and A.1.8).

A.1.5.9 Sealer

The Los Angeles Department of Public Works occasionally applies a coating of slurry seal to asphalt. This material is an emulsified asphalt. It is mixed with sand and water and is described as looking like paint. For coatings that are to remain for some time without further treatment and that may be required to carry traffic loads, a sealer like slurry seal appears to be an attractive option.

Slurry seal is applied with a mobile slurry seal machine. Besides the slurry seal machine and its driver-operator, this operation also calls for a mixer-man, two asphalt rakers with hand tools, one laborer, and two or three trucks with drivers to keep the slurry seal machine supplied. Not necessary for radiation decontamination are workers and equipment for traffic control.

The daily coverage is 36 feet wide by one mile long. Adjusting for one hour per shift for radiation decontamination of equipment and personnel, the hourly coverage is:

$$36 \text{ ft wide} \times 5280 \text{ ft long} \times 0.093\text{m}^2 \times 7/8 \text{ adj} \div 8 = 1933 \text{ m}^2/\text{hr}$$

The cost of slurry seal applied is \$0.45 per sq yard. This is equal to \$0.54 per sq meter.

Coert Engelsman's 1981 Heavy Construction Cost File lists (p. 141) the total cost of surface preparation and application of surface sealer as \$0.82 per sq yard. Labor accounts for \$.30 per sq yard, equipment \$0.09 per sq yard and materials \$0.43 per sq yard. Total daily production is given as 1000 sq yards. Considering no production for one hour per shift, the output per shift hour is

$$1000 \text{ yd}^2/\text{shift} \div 8 \text{ hr/shift} \times 0.836 \text{ m}^2/\text{yd}^2 \times 7/8 \text{ adj} = 91 \text{ m}^2/\text{hr}$$

The adjusted cost per sq meter can be found by multiplying the cost per sq yard by the unadjusted hourly rate to get the hourly cost of labor and equipment.

This is then divided by the adjusted hourly coverage in sq meters. The unadjusted hourly coverage rate is

$$1000 \text{ yd}^2 \div 8 \text{ hr/shift} = 125 \text{ yd}^2\text{/hr}$$

The labor and equipment costs are, therefore:

$$\text{Labor: } \frac{\$0.30/\text{yd}^2 \times 125 \text{ yd}^2/\text{hr}}{91 \text{ m}^2/\text{hr}} = \$0.41/\text{m}^2$$

$$\text{Equipment: } \frac{\$0.09/\text{yd}^2 \times 125 \text{ yd}^2/\text{hr}}{91 \text{ m}^2/\text{hr}} = \$0.12/\text{m}^2$$

Since the material cost per sq meter is not affected by the hour lost per shift, the cost per sq meter is calculated more simply:

$$\text{Material: } \$0.43/\text{yd} \times 1.196 \text{ m}^2/\text{yd} = \$0.51/\text{m}^2$$

Adding the costs of the three inputs, the total cost per sq meter is found to be $1.04.

For comparison, the Engelsman data for tar and asphalt surface treatments are also given. Both of these coatings are applied at 1.5 gallons per sq yard, and the coverage rate is listed at 1500 sq yards per shift for both. The adjusted hourly coverage rate is:

$$1500 \text{ yd}^2\text{/shift} \div 8 \text{ hr/shift} \times 0.836 \text{ m}^2/\text{yd}^2 \times 7/8 \text{ adj} = 137 \text{ m}^2\text{/hr}$$

Following the same calculations as for surface sealer, the sq meter input costs for tar are calculated as shown:

$$\text{Labor: } \frac{\$0.13/\text{yd}^2 \times 187.5 \text{ yd}^2/\text{hr}}{137 \text{ m}^2/\text{hr}} = \$0.18/\text{m}^2$$

$$\text{Equipment: } \frac{\$0.06/\text{yd}^2 \times 187.5 \text{ yd}^2/\text{hr}}{137 \text{ m}^2 \times /\text{hr}} = \$0.08/\text{m}^2$$

$$\text{Material: } \$1.00/yd \times 1.196\ m^2/yd = \$1.20/m^2$$

$$\text{Total: } \$0.18/m^2 + \$0.08/m^2 + \$1.20/m^2 = \$1.46/m^2$$

The same cost calculations for asphalt are:

$$\text{Labor: } \frac{\$0.13/yd^2 \times 187.5\ yd^2/hr}{137\ m^2/hr} = \$0.18/m^2$$

$$\text{Equipment: } \frac{\$0.06\ yd^2 \times 187.5\ yd^2/hr}{137\ m^2/hr} = \$0.08/m^2$$

$$\text{Material: } \$0.92/yd^2 \times 1.196\ yd^2/m^2 = \$1.10/m^2$$

$$\text{Total: } \$0.18/m^2 + \$0.08/m^2 + \$1.10/m^2 = \$1.36/m^2$$

Comparing the Los Angeles Department of Public Works data with the Engelsman sealer data shows a considerable difference. The first source has a total cost of $0.54 per sq meter versus $1.04 per sq meter from the second source. The apparent explanation for this difference is in the method and scale of operation. This is reflected in the much higher rate reported by the Los Angeles Department of Public Works as compared to the one from Engelsman: 1933 sq meters per hour versus 91 sq meters per hour.

There remains the problem of estimating the input costs for the Los Angeles Department of Public Works data. The first step is to estimate labor and equipment costs per sq meter using hourly cost figures in Means' Building Construction Cost Data 1982 for the inputs specified by the Los Angeles Department of Public Works. The total hourly labor and equipment costs are estimated as shown in Table A.1.5.9.1. Means has no listing for labor costs for a mixer-man or an asphalt raker. Their wage rates are estimated. Also, the hourly cost of a slurry seal machine is estimated using the hourly cost of a 3000-gallon distributor tank truck. The cost of a heavy dump truck is used for the cost of a nurse truck.

TABLE A.1.5.9.1. Total Hourly Labor and Equipment Cost Estimates for Surface Sealing

	Cost (1982 $/hr)
Labor	
1 Driver-operator	24.95
2 Heavy-truck drivers @ $19.75	39.50
1 Mixer man (est.)	20.00
2 Asphalt rakers @ $20.00 (est.)	40.00
1 Building laborer	19.40
Total labor	143.85
Equipment	
1 Slurry seal machine (est.)	31.12
2 Nurse trucks @ $35.72	71.44
Total equipment	102.56

Dividing the hourly labor cost by the hourly coverage rate of 1933 sq meters gives a cost of $0.07 per sq meter for labor. The equipment cost is $0.05 per sq meter.

Subtracting labor and equipment from the total cost per sq meter leaves $0.42 per sq meter for material. This is somewhat less than the cost specified by Engelsman and slightly less than similar surface coating material costs specified by Means. The reason for this difference could be due to overestimation of combined labor and equipment costs, underestimation of total costs, or because material costs are in fact less per unit area than indicated by the published sources. Here it is assumed that, either because the Los Angeles Department of Public Works is able to acquire the material at a lower price or because of thinner application, this material cost estimate is reasonable.

The costs and rates of various surface coatings are summarized in Table A.1.5.9.2.

A.1.5.10. Road Oil

Road oil would be appropriate as a temporary fixative preliminary to either planing or removal of existing pavement. There are other materials which could also be used as fixatives. These are described in Section A.1.1.2. According to the Washington State Department of Transportation, the cost of applying road oil is $270 per ton. It is applied at 0.4 gallons per sq yard at a speed of about three miles per hour with a swath about 12 feet wide. Since there are about 250 gallons of road oil per ton, the cost per sq meter is

$$\frac{\$270/\text{ton}}{250\ \text{gal/ton}} \times 0.4\ \text{gal/yd}^2 \times 1.19599\ \text{m}^2/\text{yd}^2 = \$0.52/\text{m}^2$$

TABLE A.1.5.9.2. Summary of Surface Coating Data for Asphalt Roads

Source and Coating Type	Rate (m^2/hr)	Cost (1982 $/$m^2$) Total	Labor	Equipment	Material
L.A. Pub. Works					
Sealer	1933	0.54	0.070	0.05	0.42
Englesman					
Sealer	91	1.04	0.41	0.12	0.51
Tar	137	1.46	0.18	0.08	1.20
Asphalt	137	1.36	0.18	0.08	1.10
Representative					
Sealer	1933	0.54	0.02	0.01	0.51

The rate of coverage is

$$3 \text{ mi/hr} \times 5280 \text{ ft/mi} \times 12 \text{ ft wide} \times 0.093 \text{ m}^2/\text{ft}^2 \times 7/8 \text{ adj} = 15{,}468 \text{ m}^2/\text{hr}$$

Unfortunately, this source was unable to supply information regarding the separate costs of the various inputs.

While Means' Building Construction Cost Data 1982 does not include road oil application as a specific entry, an estimate of the cost of this operation can be developed from the Means volume. Page 11 gives the cost of a 3000 gallon distributor tank trailer with a 38-horsepower diesel motor to operate the pump. This distributor is for asphalt, but it is assumed that the cost of an oil distributor would not be greatly different. In addition, a truck tractor (p. 13) would also be necessary. The hourly cost of this equipment is calculated as shown in Table A.1.5.10.1. The rent in dollars per hour is based on 336 hours (2 shifts) per month.

TABLE A.1.5.10.1. Hourly Equipment Cost Estimate for Road Oil Distribution

Equipment	Oper. Cost ($/hr)	Rent ($/mo)	Rent ($/hr)	Total ($/hr)
Distributor	4.66	2500	7.44	12.10
Tractor	10.80	2350	7.00	17.80
Total				29.90