Rubber-Asphalt Pavements in the State of Washington

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16. ABSTRACT

This report overviews the experience of the Washington State Department of Transportation with asphalt pavements constructed with recycled scrap tire rubber. It documents the performance histories and construction costs for 21 projects constructed over a period of 15 years using both the wet and dry processes of adding the rubber to the asphalt mix.

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RUBBER-ASPHALT PAVEMENTS IN THE STATE OF WASHINGTON

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Special Technical Paper

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BACKGROUND

In July of 1991 the Washington State Legislature asked the Washington State Department of Transportation (WSDOT) to produce a report on the use of recycled materials for roadway construction. The major objectives of this effort were to examine: (1) the types of recycled materials that are appropriate and feasible as alternative paving materials, such as glass and tires; and (2) the types of recycled materials, such as mixed-plastics and compost, that can be utilized in all types of transportation applications other than pavements. This report was completed in January of 1992 and is available from the WSDOT Research Office, Transportation Building, Olympia, WA 98504 (ask for report number WA-RD 252.1).

One of the primary subject of the recycling report was the disposal of waste tires in pavements. The mounting disposal problem with used tires and the fact that they have been used in pavements have combined to produce increased pressure on state and local government organizations to increase the use of rubber-asphalt cements for pavement applications. It became apparent during this study that other states and federal agencies were also looking at the

same issue and that there was a need for a separate paper which summarized just this one aspect of the recycling problem. This paper is an attempt to fill this need and provide an overview of our experience with rubber-asphalt pavement materials.

INTRODUCTION

WSDOT has been constructing experimented projects using rubber-asphalt pavements for over 15 years. A tabulation of the projects and their performance history is included in Appendix A. The performance histories were derived from reports and other monitoring activities conducted on the various projects by the Special Projects section of the Materials Laboratory. The following subsections summarize WSDOT's construction experience with rubber-asphalt paving systems.

SAM PROJECTS

The initial use of rubber was with the wet process or "Arizona Process". Two SAM projects were constructed in 1978 and two in 1980 to assess the performance of these rubberized chip seals as a wearing surface. The two projects constructed in 1978 experienced problems almost

immediately after construction. The aggregate chips became embedded in the rubber-asphalt binder to such a depth that the surface of the roadway took on the appearance of a sheet of asphalt with no rock. These two applications were termed failures for this reason. The two subsequent projects built in 1980 experienced no problems and performed acceptably until they were overlaid with another standard chip seal. The service life for these four trial sections ranged from a low of 3 years to a high of 7 years with an average of 5.75 years. The normal life span for chip seals in Eastern Washington is 6.5 years (average life determined using data from the WSDOT Pavement Management System). The rubber-asphalt SAM's were 2.5 to 3 times more costly to construct than the normal chip seals used in Eastern Washington. Appendix C also contains a cost accounting for all of the rubber-asphalt projects.

The experimentation with SAM applications ended in approximately 1987 when it was concluded that the performance of the pavements constructed with rubber-asphalt did not justify the added expense of their construction.

SAMI PROJECTS

A total of 6 projects were constructed with rubber-asphalt binders used as Stress Absorbing Membrane

Interlayers in the years 1977 and 1978. The success of these applications was mixed. In general, the SAMI's were successful in retarding the reflection of alligator cracking, but were not successful in retarding reflection of longitudinal or transverse cracks.

One trial use is particularly important. The section from Wheeler Road to Adams County Line was designed as a rigorous experiment to determine the performance of the rubber-asphalt interlayers as compared with the performance of standard asphalt interlayers. The project included sections of each type of interlayer and a section with no interlayer to serve as a control. The control section experienced the reflection of all the underlying cracking very early in its life. The SAMI and the normal asphalt interlayers successfully retarded the reflection of alligator cracking, but were not successful in retarding longitudinal or transverse cracking. The SAMI was fractionally better at retarding the reflection of alligator cracking. The SAMI was 3.7 times as costly as the normal asphalt interlayer.

WSDOT has not constructed a SAMI since 1978 due to the much higher cost of the rubber-asphalt binder. The performance history has indicated that the SAMI is not a cure for the prevention of all types of reflection cracking, although it was successful in retarding the reflection of

alligator type cracking. The Wheeler Road to Adams County Line study showed that a interlayer constructed using normal asphalt binders was only slightly less effective than the more expensive SAMI. The SAMI, at a cost 3.7 times higher than a normal asphalt binder interlayer, was not cost effective when the life of the overlay placed on top of it was not increased over overlays constructed without interlayers. WSDOT continues to use normal asphalt interlayers under many of its overlays placed in the form of chip seals because of the added crack retarding benefit provided by the interlayer.

OPEN GRADED FRICTION COURSE PROJECTS

Five open graded friction course overlays have been constructed between 1982 and 1991 using the wet process to add the rubber to the pavement. The open surface texture characteristic of this type of pavement provides benefits in the form of decreased spray from vehicles under wet conditions and lower tire noise. They have the disadvantage of having a tendency to ravel. Ravelling is the gradual loss of the rock from the pavement due to the actions of traffic. The rubber-asphalt binder was used to increase the adhesion between the rock and the binder.

All of the projects are showing good to very good

performance with the exception of the I-405 bridge deck overlay which is showing some distress in the wheel path areas. All of the projects are located on heavily traveled routes so the good performance of these pavements are especially noteworthy.

The Columbia River to 39th Street project is especially significant. This is a 2-mile section of I-5 just north of the Oregon border and located within the city limits of Vancouver. In addition to the rubber-asphalt binder used on this project, a section of polymer modified asphalt was also constructed. The polymer used to modify the asphalt was a synthetic rubber added in liquid form to the asphalt cement. A short section of standard non-rubberized open graded friction course pavement was also constructed to serve as a control for the rubber and polymer modified sections. Recent visual surveys of all three sections indicated virtually no difference in performance between the various pavements after 5 years of service.

The cost effectiveness of this use of the wet process is still undetermined due to the relative youth of the sections under study. If they are to compete on an equal basis with conventional pavement systems they will need to show a significant increase in service life for their cost, which ranged between 1.1 and 3.7 times more than conventional mixes.

PLUSRIDE PROJECTS

WSDOT's initial experimentation with PlusRide (dry process) began in 1982 with the paving of a very short section of SR-97 in Yakima near the District 5 headquarters offices. Many problems were encountered in the construction of this section with the result being that WSDOT did not continue a rigorous monitoring of the project beyond the initial construction phase. One additional project was paved in 1982 on a bridge deck located just north of Yakima on I-82. An adjacent bridge deck was also paved with an open graded rubberized friction course mix (wet process) to serve as a control. The PlusRide lasted 8.5 years as compared to the open graded friction course mix which lasted 7 years. PlusRide was also used on a ramp leading to SR-18 near Auburn. This was a successful installation but not a good choice for a test application, due to the low traffic volumes on the ramp. The pavement is showing some ravelling but otherwise is performing adequately. The on-ramp lane of the project is experiencing extreme distress due to a lack of adequate subgrade strength.

Only one project was constructed in 1984 using PlusRide. The northbound bridge deck of the Renton S-Curves section of I-405 was constructed and a companion section of rubber-asphalt open graded friction course mix (wet process)

was used on the southbound deck. Difficulties were encountered in achieving the required compaction of the PlusRide mix, but representatives of PlusRide made the decision to leave it in place rather than replace it with new material, indicating that it would be satisfactory. The PlusRide section experienced ravelling and debonding of the pavement from the deck after only two years of service. The latest visual inspection revealed that the PlusRide mix was almost totally missing in the wheel paths and had been patched back with standard asphalt mix by our maintenance forces. The companion bridge, which was constructed with rubber-asphalt using the wet process, is showing some signs of wear, a minor amount of ravelling and flushing, and one small area of debonding. The PlusRide was 2.3 times more costly than conventional pavements constructed in the same year in the Seattle area.

Two projects were constructed in 1985, one is reasonably successful and one a disaster. The Marine Division of the DOT chose PlusRide for a ferry dock at the Fauntleroy terminal on the Vashon Island route. The PlusRide mix was placed on a new section of the dock and traffic was switched over so that the older section of the dock could be repaired and made ready for a new overlay of the same PlusRide pavement. The PlusRide pavement proved to be unstable with large ruts developing under traffic

loading almost immediately. WSDOT made the decision to remove the PlusRide and replace it with a standard paving mix. The cause of the failure is unknown. An investigation of other projects paved with asphalt from the same lot revealed no problems, which indicates that the asphalt was not the source of the problem. The pavement which replaced the PlusRide is still performing satisfactorily, which rules out the location as a possible cause of failure. The design of the asphalt mixture is proprietary in the PlusRide system so we must rely on those holding the licensing rights to supply us with the proper design. We, therefore, were unable to determine what went wrong with this design that would result in this magnitude of failure.

The other 1985 project was constructed on SR-530 near the town of Stanwood. The PlusRide section was placed along with a section of fiber reinforced pavement and a control section of standard mix pavement. The Federal Highway Administration is providing funding for the evaluation of these sections. In this case the PlusRide is doing slightly better then the standard mix and the fiber reinforced mix after 6 years of service. It is still too early to predict long-term performance or the cost-benefit ratio of the PlusRide as compared to the standard mix.

The final PlusRide project was built in 1986 on SR-513 between 35th Avenue and I-5. This is the largest project

WSDOT has built to date with 1.5 lane miles of the PlusRide pavement constructed. The PlusRide was placed over a badly cracked BST pavement. It is showing no signs of distress after 6 years of very light traffic. Long-term performance is still undecided.

COSTS

WSDOT has paved a total 228 lane miles with the various wet and dry processes of rubber-asphalt pavements. This represents an investment of about $1.5 million ($2.5 million in today's dollars) over the cost of conventional pavement mixes (see Appendix C). It is estimated that approximately 200,000 tires have been used in our trial sections which calculated to be a disposal cost of $12 per tire, in round figures.

CONCLUSIONS

The following conclusions are drawn on WSDOT's experience to date:

1. The SAM and SAMI processes are not cost effective. Currently, more economical asphalt binders give equal performance at about 1/3 the cost.

2. The open graded rubberized friction course process looks very promising at this time, but a longer evaluation period is necessary in order to quantify the cost effectiveness of this type of pavement.

3. PlusRide looks to be the riskier option at this point in time. Past performance has ranged from poor to average. Construction problems which may relate to the design of the mix have plagued several of the installations. The per ton costs on the projects have averaged almost twice that of conventional mixes.

   Added Note:

   The new management of the firm marketing PlusRide, which is now called PlusRide II have indicated a greater commitment to solve the design and construction related problems that plagued the original PlusRide installations. They have also added a 5-year performance guarantee on all new installations. These changes have yet to be evaluated on a project constructed in Washington.

APPENDIX A

Project Descriptions and Performance

WSDOT USES OF RECYCLED RUBBER TIRES IN HIGHWAYS

PROJECT TITLE (Report Number)	*LANE MILES*	*DATE CONSTRUCTED*	*PURPOSE FOR USE*	*PERFORMANCE EVALUATION*	*SUMMARY*
SAM					
Franklin Co. Line to Jct. SR-26 *	13.40	1978	Evaluate use of rubberized asphalt as a chip seal.	Failure due to loss of chips.	The average service life of these SAM's has been 5.75 yrs. Normal class C chip seals last 6.5 yrs. in Eastern Washington. The rubber-asphalt SAM's were 2.5 - 3 times as costly as class C chip seals.
Buena Loop Rd. to Roza Drive et al. *	34.20	1978	Evaluate use of rubberized asphalt as a chip seal.	Failure due to loss of chips.	
District 5 Rubberized Seal *	31.60	1980	Evaluate use of rubberized asphalt as a chip seal.	Performance was acceptable.	
37th Street to Rocky Reach Dam *	8.60	1980	Evaluate use of rubberized asphalt as a chip seal.	Performance was acceptable.	
Subtotal =	87.80 Lane Miles				
SAMI					
SR 5 to Napavine *	5.60	1977	Prevent reflection cracking.	Cracking reflected through overlay from underlying PCC pavement in 3 years.	The average service life of overlays with SAMI's has been 12.3 yrs. The average service life of 2 - 3 inch overlays statewide is 12.5 yrs.
Wheeler Road to Adams Co. Line (WA-RD 128.1)	36.80	1978	Prevent reflection cracking.	Successful in retarding alligator cracking but not long. or transverse. A test section with normal asphalt gave similar results.	
Jackson Highway to Beach Road (WA-RD 185.1)	22.20	1978	Prevent reflection cracking.	Successful in retarding the reflection of alligator cracking.	
Hillyard Jct. to M.P. 300.40 (Mats Lab Report 187)	4.60	1978	Prevent reflection cracking.	Successful in retarding cracking but did not totally prevent crack reflection.	
Morton to Packwood (WA-RD 185.1)	30.20	1978	Prevent reflection cracking.	Successful in retarding the reflection of alligator cracking.	
Paradise Road to Mullen Hill Road (Mats Lab Report 186)	6.60	1978	Prevent reflection cracking.	Not successful.	
Subtotal =	106.00 Lane Miles				

WSDOT USES OF RECYCLED RUBBER TIRES IN HIGHWAYS

PROJECT TITLE (Report Number)	*LANE MILES*	*DATE CONSTRUCTED*	*PURPOSE FOR USE*	*PERFORMANCE EVALUATION*	*SUMMARY*
OPEN GRADED RUBBERIZED FRICTION COURSE					
S-Curve/Cedar R. Bridge & RR Bridge (WA-RD 130.2)	0.60	1984	Used to increase binder to aggregate adhesion.	Successful after 7 years service under high traffic volumes.	The average service life of the three older open-graded pavements is 7 yrs. to date. They have performed well, but no better than standard open-graded pavements. It should take 8 - 10 yrs. to define performance.
Evergreen Point Br. to SR-908 (Report in preparation)	3.80	1982	Used to increase binder to aggregate adhesion.	Very good performance with only minor rutting noted and some pot holing after 9 years of heavy traffic volumes.	
Columbia River to 39th Street (WA-RD 131.1)	12.80	1986	Used to increase binder to aggregate adhesion	Very good performance after 5 years of service.	
Armstrong Road to Albion Road (No report to date)	7.44	1990	Used to increase binder to aggregate adhesion	No performance history to date.	
22nd St. to Little Hoquiam River Br. & Riverside Br. 101/125 (No report to date)	4.38	1991	Used to increase binder to aggregate adhesion	No performance history to date.	
Subtotal =	29.02 Lane Miles				
PLUSRIDE					
Main Street to South First Street (Mats Lab Report 184)	0.40	1982	First trial use of product in the state.	Flushing and rutting have occurred marring performance.	The performance of PlusRide pavements ranges from satisfactory to immediate failure and replacement with standard ACP. In WSDOT's experience, there is no indication of better performance or longer life. In fact, the opposite appears to be true. Maintenance forces note no savings in snow removal nor any less ice forming on rubber asphalt test sections.
Bridge No. 82/205 et al. (WA-RD 127.1)	0.90	1982	Trial use of product as a bridge deck overlay.	PlusRide on Br. No. 82/114N lasted 8 1/2 yrs. ACP Class D control on Br. No. 82/115N lasted 7 yrs. PlusRide cost 50% more than ACP Class D.	
84th Avenue S. I/C and Auburn Ramps (Mats Lab Report 185)	0.50	1983	Trial use of product.	Several large patches have been placed in the PlusRide section.	
S-Curve/Cedar R. Br. & RR Bridge (WA-RD 130.2)	0.60	1984	Used because of claims by supplier of greater service life.	Large sections of overlay ravelled and debonded in wheel paths after only 2 years of service.	

WSDOT USES OF RECYCLED RUBBER TIRES IN HIGHWAYS

PROJECT TITLE (Report Number)	*LANE MILES*	*DATE CONSTRUCTED*	*PURPOSE FOR USE*	*PERFORMANCE EVALUATION*	*SUMMARY*
PLUSRIDE					
Fauntleroy Ferry Dock (Immediate failure, no report published)	0.60	1985	Prevent reflection cracking from underlying wood deck.	Total failure due to instability of mix. Replaced with dense graded ACP.	
Skagit Co. Line to Dalgren Rd. (WA-RD 147.1)	0.80	1985	Prevent reflection cracking from underlying PCC pavement.	Performance satisfactory after 7 years of service. Some longitudinal cracking present.	
35th Ave. NE to SR-5 *	1.50	1986	Prevent reflection cracking from underlying BST pavement.	Performance satisfactory after 6 years of service.	

Subtotal = 5.30 Lane Miles

Grand Total = 228.12 Lane Miles

* Evaluations documented internally, no formal report published.

APPENDIX B

Project Costs

SAM PROJECT COSTS

PROJECT TITLE	UNIT COST RUBBERIZED Per Ton	UNIT COST NON-RUBBER Per Ton	ADDED COST OF USING RUBBER	COST ADJUSTED FOR INFLATION (see note below)
Franklin Co. Line to Jct. SR-26	$355.00	$114.00	$84,925.00	$178,172.65
Buena Loop Rd. to Roza Drive et al.	$300.00	$114.00	$105,090.00	$220,478.82
District 5 Rubberized Seal	$435.00	$191.00	$130,540.00	$211,996.96
	$545.00	$191.00	$46,374.00	$75,311.38
37th Street to Rocky Reach Dam	$470.00	$191.00	$54,963.00	$89,259.91
		TOTALS	$421,892.00	$775,219.72

Adjustment for inflation calculated using the Consumer Price Index for Seattle.

SAMI PROJECT COSTS

PROJECT TITLE	UNIT COST RUBBERIZED Per Ton	UNIT COST NON-RUBBER Per Ton	ADDED COST OF USING RUBBER	COST ADJUSTED FOR INFLATION (see note below)
Wheeler Road to Adams Co. Line	$426.00	$114.00	$355,056.00	$744,907.49
Jackson Highway to Beach Road	$330.00	$114.00	$75,600.00	$158,608.80
Hillyard Jct. to M.P. 300.40	$380.00	$114.00	$22,078.00	$46,319.64
Morton to Packwood	$415.00	$114.00	$34,615.00	$72,622.27
Paradise Road to Mullen Hill Road	$500.00	$114.00	$5,790.00	$12,147.42
		TOTALS	$493,139.00	$1,034,605.62

Adjustment for inflation calculated using the Consumer Price Index for Seattle.

OPEN GRADED FRICTION COURSE PROJECT COSTS

PROJECT TITLE	UNIT COST RUBBERIZED Per Ton	UNIT COST NON-RUBBER Per Ton	ADDED COST OF USING RUBBER	COST ADJUSTED FOR INFLATION (see note below)
S-Curve/Cedar R. Bridge & RR Bridge	$86.85	$23.25	$22,514.40	$29,358.78
Evergreen Point Br. to SR-908	$27.00	$24.00	$12,900.00	$17,711.70
Columbia River to 39th Street	$55.56	$36.80	$131,545.12	$165,746.85
Armstrong Road to Albion Road	$64.10	$35.00	$182,166.00	$192,913.79
22nd. St. to Little Hoquiam River Br. & Riverside Br. 101/125	$79.50	$35.00	$146,150.00	$146,150.00
		TOTALS	$495,275.52	$551,881.12

Adjustment for inflation calculated using the Consumer Price Index for Seattle.

PLUSRIDE PROJECT COSTS

PROJECT TITLE	UNIT COST RUBBERIZED Per Ton	UNIT COST NON-RUBBER Per Ton	ADDED COST OF USING RUBBER	COST ADJUSTED FOR INFLATION (see note below)
Main Street to South First Street	$41.00	$27.00	$5,600.00	$7,688.80
Bridge No. 82/205 et al.	$75.00	$50.00	$1,525.00	$2,093.83
84th Avenue S. I/C and Auburn Ramps	$53.60	$28.50	$12,550.00	$16,967.60
S-Curve/Cedar R. Br. & RR Bridge	$50.00	$21.80	$9,418.80	$12,282.12
Fauntleroy Ferry Dock	$68.50	$27.00	$36,769.00	$46,770.17
Skagit Co. Line to Dalgren Rd.	$55.00	$27.00	$18,060.00	$22,972.32
35th Ave. NE to SR-5	$52.50	$32.95	$24,906.70	$31,382.44
		TOTALS	$108,829.50	$140,157.27
		GRAND TOTAL ALL RUBBER PAVEMENTS	$1,519,136.02	$2,501,863.73

Adjustment for inflation calculated from the Consumer Price Index for Seattle.