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RAIL LINE ABANDONMENT AND HIGHWAY PRESERVATION: A CASE STUDY OF WASHINGTON STATE IN THE UNITED STATES

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Abstract

Rail line abandonment often, if not always, has some impact on roadway condition and needed investment. This paper examines that issue using a case study of the state of Washington in the United States. Two alternative techniques of determining potential highway impacts are described and applied to a short-line railroad, the Palouse River and Coulee City Railroad. The techniques are found to provide similar, dependable results of over \$50 million in total pavement costs, depending on the time of rebuilding the roadway.

Keywords: Road damage; Rail line abandonment; Investments
Topic Area: A1 Road and Railway Technology Development

1. Introduction

Highway and railroad investments are directly interconnected. The Palouse River and Coulee City Railroad (PCC) currently operates 372 miles of light-density lines in eastern Washington. The PCC has raised the possibility that these lines may be targeted for abandonment in the next five years. The purpose of this paper is to describe the potential highway impacts that would result if the existing volume is moved in trucks to river ports or inland terminals. Two alternative techniques are described in the report: an incremental pavement thickness method and an environmental analysis procedure that isolates load-related and non-load (environmental) effects.

The PCC network (Figure 1) consists of fours sets of lines or subsystems:

- The Cheney-to-Coulee City line
- The Marshall-to-Pullman line
- The northern division of the Blue Mountain Railroad (BLMR North)
- The southern division of the Blue Mountain Railroad (BLMR South)

If the PCC rail lines are abandoned, elevators now shipping by rail will truck grain to river ports, where it will be transferred to barge for downriver movement.

Shipper telephone surveys and interviews were conducted in eastern Washington in late 2001 and 2002. Using the survey information, a highway network model was developed. Routes were defined connecting each elevator and food processor to one or more river ports on a minimum distance basis. Abandonment of these PCC lines would result in more than 29,000 additional truck trips in eastern Washington each year.

If the PCC lines are abandoned, several types of heavy trucks will be used to move the commodities now moving by rail. Grain will be hauled in Rocky Mountain Doubles. Manufactured and processed goods would be transported in 5-axle tractor-semi-trailer trucks.

Figure 1 PCC Railroad Network in Eastern Washington Courtesy of PCC Railroad

The effects of different axle types and weights are accounted for by converting the axle weights to equivalent single-axle loads or ESALs. An ESAL represents the impact of a certain type of axle and load in comparison to the impact of an 18,000-pound single axle.

If the PCC lines are abandoned, the annual equivalent single-axle loads will more than triple on 33 miles of BST pavement. Annual ESALs will more than double on another 46 miles of BST pavement. Approximately 80 percent (or 219 miles) of all affected BST miles will experience at least a 10 percent increase in annual ESALs. Over half of the 355 miles of potentially impacted asphalt-concrete pavements will experience more than a 5 percent increase in annual ESALs. Altogether, nearly 7 million annual ESAL-miles will be added to the state highway system each year.

The primary analysis method used in this study is the incremental overlay thickness method. This method is an abstract representation of the pavement rehabilitation process using overlays. It is based on the American Association of State Highway and Transportation Officials pavement rehabilitation method and uses the AASHTO pavement design equations. The objective of this method is to determine the additional overlay thickness needed to provide the enhanced structural capacity necessary to accommodate the new truck traffic.

2. Incremental overlay thickness method

The incremental thickness method of estimating highway costs uses the AASHTO pavement design equations. The relationship between structural (SN) and ESALs is simulated for a range of potential designs. This simulation creates a set of “observations” of structural numbers and corresponding ESALs. The log of ESALs is then regressed against the log of SN to determine the slope coefficients.

Table 1 shows a set of slope coefficients or *elasticities* for structural classes of pavements. A coefficient in Table 1 represents the percentage change in structural number corresponding to a one percent change in ESALs. The slope coefficient for light-duty flexible pavements is .178. This means that when a one percent increase in ESALs occurs on a light-duty flexible pavement the structural number must be increased by .178 percent to maintain the same performance period.

Table 1. Elasticity of Pavement Structural Number with ESALs

Structural Class	**Flexible Pavement**		**Rigid Pavement**	
	SN Range	**Slope Coefficient**	**D Range**	**Slope Coefficient**
Heavy	4.6 – 6.0	0.142	9.1 – 14.1	0.149
Medium	3.1 – 4.5	0.167	7.1 – 9.0	0.166
Light	1.0 – 3.0	0.178	5.0 − 7.0	0.195

In order to implement this procedure, the current (design) ESALs and the current (design) structural number must be known for each impacted highway segment. Both inputs are derived from the Washington State Pavement Management System (WSPMS). The incremental cost procedure is then implemented as follows:

1. Dividing the ESALs generated from the potential abandonment by the existing ESALs and multiplying by 100 compute the percent increase in ESALs for an impacted segment.
2. The percent increase in structural number is computed from the appropriate slope coefficient in Table 1.
3. The numerical increase in structural number is computed by multiplying the design (current) SN by the percent increase divided by 100.
4. The incremental overlay thickness is computed by dividing the increase in structural number by .44 − the layer coefficient for new asphalt concrete.
5. The cost per inch for the type of impacted highway is computed from paving costs provided by the WSDOT East Region office.
6. The incremental cost is computed by multiplying the cost per inch by the incremental inches of overlay thickness needed for the additional traffic.

It is assumed that the incremental thickness is added at the time the pavement is scheduled for preservation resurfacing and that thickness can be finely adjusted. The only effect attributed to incremental truck traffic is the additional thickness required at the time the pavement is resurfaced.

3. Average/marginal cost method

Pavement costs are estimated using a second independent method. This method was developed originally by Federal Highway Administration in the 1982 Highway Cost Allocation Study for allocating pavement preservation (3R) costs among vehicle classes. FHWA referred to this method as a “marginal cost” approach.

In the average/marginal cost approach, structural capacity is defined as the maximum number of axle loads that a pavement can accommodate before it is rehabilitated. When a pavement reaches its terminal serviceability level, it is restored or rehabilitated through resurfacing. For a given functional class of highway, marginal pavement cost is assumed to be the same as average cost.

The portion of resurfacing cost that is unaffected by truck traffic is excluded from the marginal cost calculation. In a multi-year study, the relative shares of pavement rehabilitation costs attributable to environmental (non-load) and traffic (load-related) factors were estimated by FHWA using the National Pavement Cost Model (NAPCOM).

The non-load shares of pavement rehabilitation cost in Washington State were derived from FHWA's cost allocation spreadsheet. As described in the main report, the estimated contribution of non-load factors to pavement rehabilitation cost is less than 4 percent for Rural Interstate highways in Washington. However, the non-load contribution increases to 12.5 percent for Rural Other Principal Arterial highways and 16.7 percent for Rural Minor Arterial highways. The highest non-load cost responsibility is nearly 30 percent for Rural Major Collector highways. The increasing non-load cost responsibility for lower highway classes is primarily the result of PSR loss due to expansive clay soils.

After the contribution of environment to pavement rehabilitation cost has been isolated, the residual cost is traffic-related. The marginal pavement cost of a truck trip within a given functional class is estimated through a multi-step process:

1. The ESAL life is computed from AASHTO equations using the structural number of the segment as computed from WSPMS layer data.
2. The load-related share of pavement rehabilitation cost is estimated from the average rehabilitation cost per mile for the functional class.
3. An average (marginal) cost per ESAL is computed by dividing the load share of rehabilitation cost by the ESAL life.
4. The axle loads of a truck or a particular class of trucks are converted into ESALs.
5. For divided highways, the ESALs are converted to design-lane ESALs using a lane distribution factor.
6. The design-lane ESAL factor is multiplied by the cost per ESAL to yield a cost per vehicle-mile of travel (VMT).

The estimated Rural Interstate cost of 13 cents is very close to the FHWA marginal cost of 12.7 cents per truck-mile shown in the 1997 Highway Cost Allocation Study (Table 2).

4. Results of main scenario

The incremental thickness and marginal cost methods yield virtually identical results. Table 3 shows the results of the incremental thickness method for a 10-year period for the prime scenario: transshipment from stations located on the PCC to the river ports of Windust, Central Ferry, and Pasco. Resurfacing is assumed to occur in the year the pavement is due, as shown in the WSPMS database.

Table 2. Average Costs per ESAL and VMT for an 80,000-Pound 5-Axle Truck Traveling on Rural Highways in Eastern Washington

Functional Class	**SN**	**ESAL Life**	**Cost per ESAL**	**Cost per VMT**
Interstate	5.3	5,167,630	$0.06	$0.13
Other Principal Arterial	4.2	1,406,861	$0.13	$0.30
Minor Arterial	3.0	325,217	$0.47	$1.16
Major Collector	2.5	173,078	$0.46	$1.14

Table 3. 10-Year Incremental Pavement Cost Resulting from Potential Abandonment of PCC Railroad Lines

Main Scenario: Transshipment via River Ports		
	Thousands of Dollars	
Rail Subsystem	**Future Cost**	**Present Value**
BLMR North	$ 6,222	$ 5,619
BLMR South	$ 3,549	$ 3,071
Cheney-Coulee City	$ 31,890	$ 29,735
Marshall-Pullman	$ 5,965	$ 5,412
Total: PCC System	$ 47,627	$ 43,838

5. Conclusion

Two new analytical techniques are described in this paper. A new environmental analysis procedure has been developed that improves the average cost approach used in earlier studies. An incremental thickness method has been developed that simulates the overlay thickness approach used in pavement rehabilitation. The revised average cost and incremental thickness methods yield similar forecasts of future highway impacts in eastern Washington. Either of these procedures would be useful in future studies.

Abandonment of the Palouse River and Coulee City Railroad would increase heavy truck traffic in eastern Washington by more than 29,000 trips per year. In the current preservation cycle, WSDOT would incur costs because of the accelerated deterioration of pavements as a result of large percentage increases in ESALs. These costs could range from $1.1 to $14.7 million depending on the ability of WSDOT to find supplemental highway funds to move the impacted segments forward in the pavement preservation program.

In the most likely scenario, the impacted pavements will become past due and the $14.7 million cost will be incurred. This cost only restores the pavement to its normal structural capacity. Additional structural capacity will be needed to keep the pavement from continuing its accelerated rate of deterioration in future periods. The logical time to add this capacity is at the scheduled time for a preservation overlay. If this occurs, the additional cost (in addition to the past-due or build-sooner cost in the current resurfacing period) will be the cost of additional pavement thickness needed to provide the increased structural number necessary to accommodate the permanent increase in truck traffic.

Over a 10-year period, the estimated present value of this cost is $43.8 million. However, the incremental pavement cost is offset partially by incremental truck user fees of $5.5 million. Thus, the estimated net present value of this cost is $38.3 million. However, if the present value of potential past-due cost is considered, the total pavement cost resulting from the abandonment of PCC rail lines in eastern Washington may exceed $50 million.

In addition to pavement rehabilitation costs, other types of highway impacts could result from changes in freight traffic including:

- Higher routine maintenance costs (such as patching and spot maintenance)
- Capacity-related impacts resulting from a higher percentage of trucks on high-traffic highways
- Safety-related impacts from additional truck travel on rural two-lane highways
- Increased energy and emission of air pollutants as a result of shifting traffic from railroads to truck

References

Tolliver,Denver, Eric Jessup and Ken Casavant. 2003. New Techniques for Estimating Impacts of Rail Line Abandonment on Highways in Washington, SFTA Research Report # 7, School of Economic Sciences, Washington State University.

Tolliver,Denver, Eric Jessup and Ken Casavant. 2003. Implications of Rail Line Abandonment on Shipper Costs in Eastern Washington, SFTA Research Report # 8,School of Economic Sciences, Washington state University.