

## **Surfacing Selection Guide for High Impact Locations** (Portland Cement Concrete Pavement versus Hot Mix Asphalt Pavement)



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**Surfacing Selection Guide  
for  
High Impact Locations**

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# Surfacing Guide for High Impact Locations

## Introduction

As Montana's metropolitan areas grow, and traffic loading on the roadways increase, designers, planners, and administrators are faced with new and increased challenges. In addition taxpayers and road users are demanding longer lasting and smoother pavements. Motorists will tolerate only minimal road construction closures and delays. Our customers want us to get in, get out, and stay out. This guide is intended to help the decision process, and promote long-term pavement performance for urban intersections, junctions, connections, roundabouts, and heavily impacted roadways.

It has been estimated that by the year 2020, the U.S. population will grow by 50 million people. Automobile travel will increase by 42 percent and truck travel will increase by 49 percent. For various reasons, at this time the trend is to not increase the footprint of our highway system. Without additional lane capacity and considering the predicted trends, a lane mile of pavement built or reconstructed in 2015 will carry 70 percent more trucks than a lane mile built today! <sup>(1)</sup> While these predictions are looking at national trends, and Montana's growth rate might be less than the National average, we can count on increasing impacts to our road system. It is in everyone's best interest that designers and planners consider designing pavements with 50, 60 or 70-year design life.

Poor roads have a negative impact on our economy and our daily lives. We should be aware that a 20-year design life will not meet everyone's future needs, and will negatively impact future generations.

This guide is intended to promote long-term pavement performance by analyzing the impacted riding surface, and help determine when Portland Cement Concrete Pavement (PCCP) is the preferred paving material.

## Scope

High impact intersections and roadways are often repaired frequently because of plant mix rutting and shoving, resulting in the user's inconvenience, negative impact to budgets, and often a hazard to motorist and pedestrians.

This help guide is intended to assist the reader in identifying high impacted locations, and help the decision process of when PCCP or Whitetopping should be considered as a surfacing treatment. This paper will primarily focus on asphalt pavement rutting and shoving. A complete and precise assessment of the in-place pavement should include evaluations for other pavement distresses such as fatigue cracking (alligator cracking), thermal cracking, transverse and longitudinal cracking, raveling, bleeding and potholes.

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<sup>(1)</sup> Reference FHWA publication HRT-05-052

Typically high impact locations are at controlled intersections that increase dynamic braking actions and fast acceleration. Other high impact locations include curves, ramps, roundabouts, bus stops, bus/truck lanes and routes, scale sites, and parking lots or where heavy vehicles travel at slow speeds.

Pavement deformations that help identify rutting, and shoving include wavy pavement markings, deep troughs and/or formed ridges. The overall ride quality is generally poor.



Figure 1 Idaho Street in Kalispell, MT.

### **Surfacing Observations**

At the time of the Preconstruction field review or earlier, study the pavement distress and type of pavement failures. It is recommended that core samples and soil samples be obtained. Note the pavement condition along with the pavement thickness. Rut measurements should be recorded. Observe and record the rut depth approaching and leaving the intersection. This will help the designer determine the required length of the PCCP approach and departure slabs.

Study the past pavement performance, and review the paving history. Consider the repair frequency and the type of pavement preservation repairs completed, including milling, overlays, mill and fill, rut filling etc... Contact the person responsible for maintaining the section. Keep in mind drainage and snowdrift issues. Review the pavement history. Consider the impacts of frequent repairs to the road user, and the adjacent businesses, residents, and commuters. It not only costs the owner agency money to repeatedly repair a roadway section but it also costs the road users and adjacent businesses.

## Long Term Pavement Performance In High Impact Areas

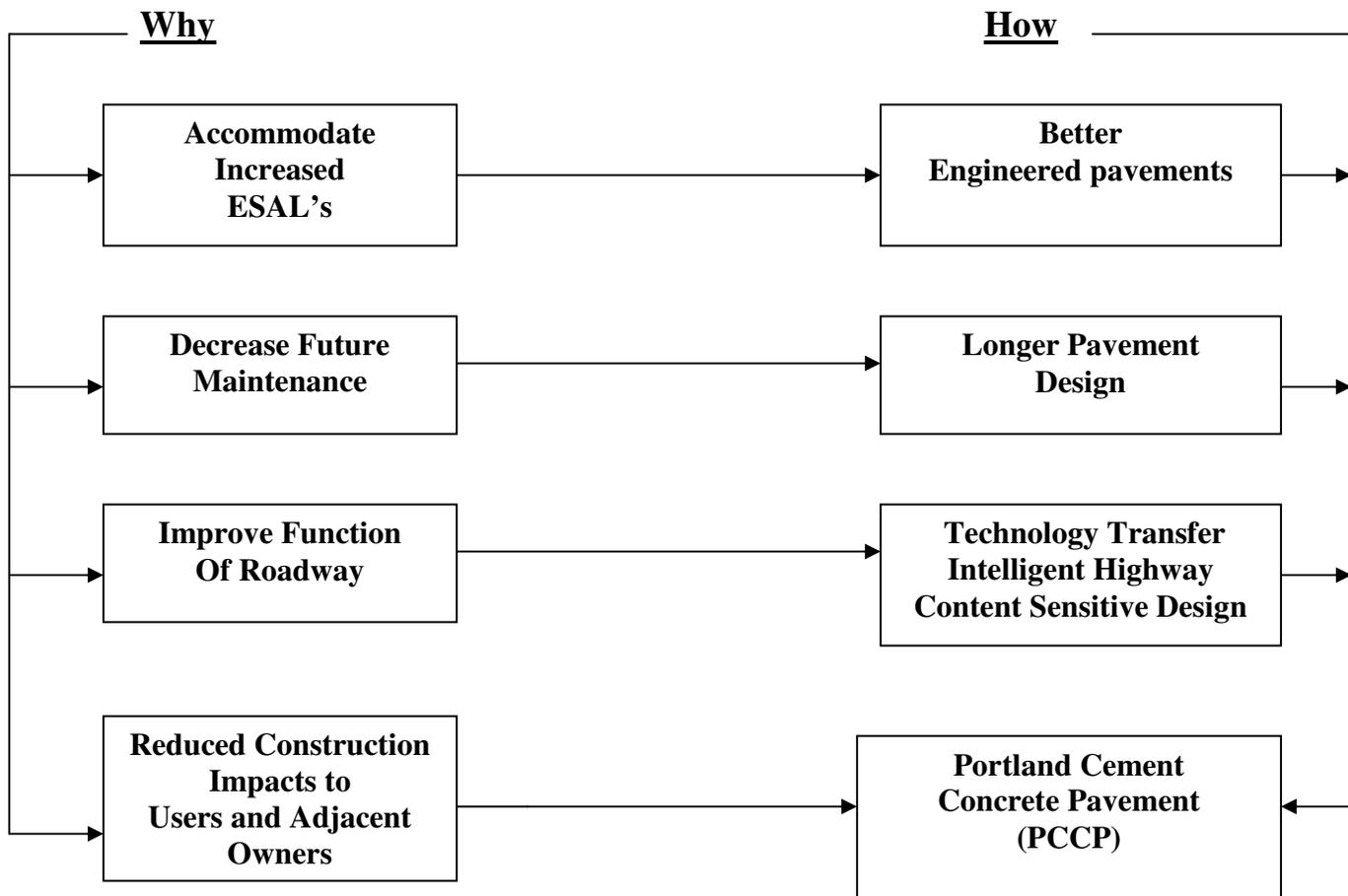


Figure 2

The proper selection of projects and selection of rehabilitation alternatives for high impact areas is of paramount importance. For an existing HMA pavement nearing the end of its functional life the selection of the most appropriate rehabilitation alternative should be based on a number of criteria. In many cases the selection will be balanced by competing factors including: traffic, existing pavement performance, construction costs, user costs, time factors, corridor impact, material availability, and contractor availability.<sup>(2)</sup>

It is worth noting that consideration of Life Cycle Costs should be encouraged. However, if up front construction costs continue to drive the decision process, consideration should be given to use more Thin Whitetopping (TWT) overlays. TWT is less expensive to design and construct than conventional PCCP, but also provides better resistance to pavement distress than HMA.<sup>(2)</sup>

<sup>(2)</sup> Reference NCHRP synthesis 333 Thin and Ultra Thin Whitetopping

## **Long Term Pavement Performance In High Impact Areas**

High Impacted Areas with chronic rutting should be examined in detail to determine the cause of the rutting, and to consider alternate pavement types. Contact the Surfacing Design Section in the Materials Bureau for assistance.

Some pavement defects may only require surface course treatment or other routine maintenance repair. Surfacing structure deterioration is a defect of the whole pavement structure and repairs may require more extensive rehabilitation. Knowing the difference between the two types of pavement deterioration is important in order to design and plan a pavement with longer durability or pavement life.<sup>(3)</sup>

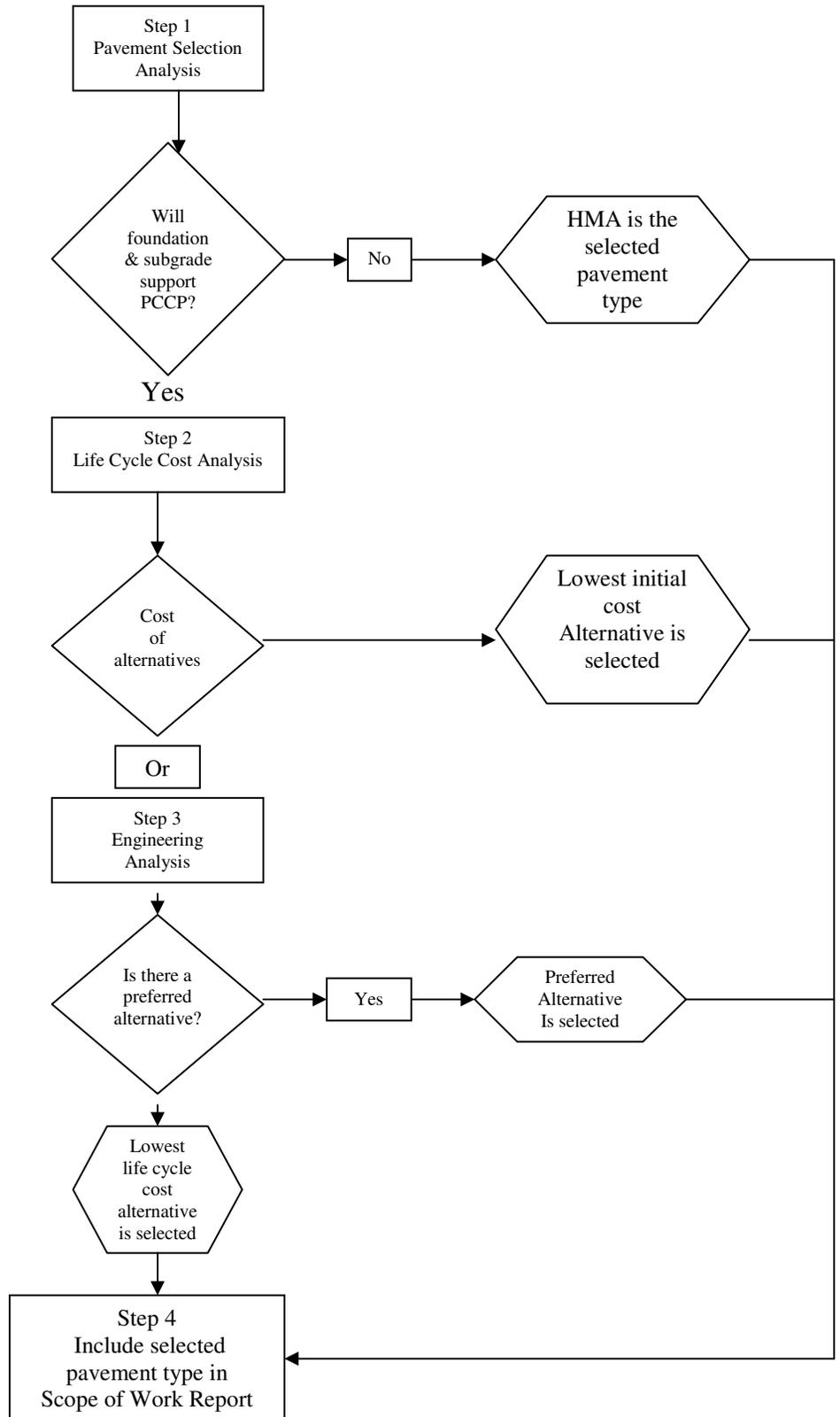
Past performance with a particular pavement should be considered in conjunction with traffic, changes in traffic, loading, and environmental conditions. The performance of similar pavements under similar conditions should also be considered. Information from past designs, materials and pavement management data can help identify specific materials suitability for a pavement application.<sup>(3)</sup>

Subgrade support might be the most important analysis and decision to be made with pavement design analysis. It is not recommended to use PCCP to bridge poor subgrade. If poor subgrade conditions are encountered and will not be improved, long-term settlement should be expected. Because of simplified patching, material availability and costs, HMA tends to perform better on poor subgrade materials. If new subgrade or gravel base improvements will not be constructed, it is also likely the pavement design will preclude the need to continue pavement performance or life cycle cost analysis. However, if the engineering evaluation of the subgrade indicates that either pavement type could be used successfully, or the subgrade and/or base gravel will be improved, then proceed with a more detailed pavement selection.<sup>(3)</sup>

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<sup>(3)</sup> Pavement Type Selection Protocol WSDOT Douglas MacDonald

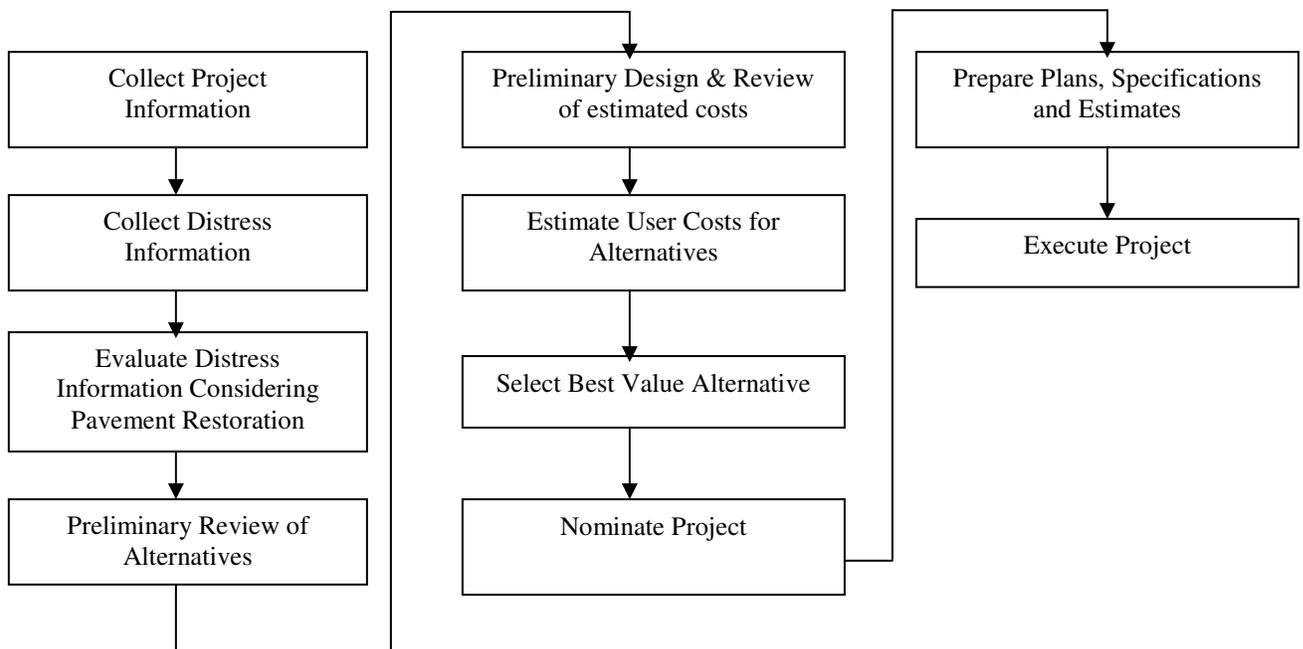
### Long Term Pavement Performance In High Impact Areas



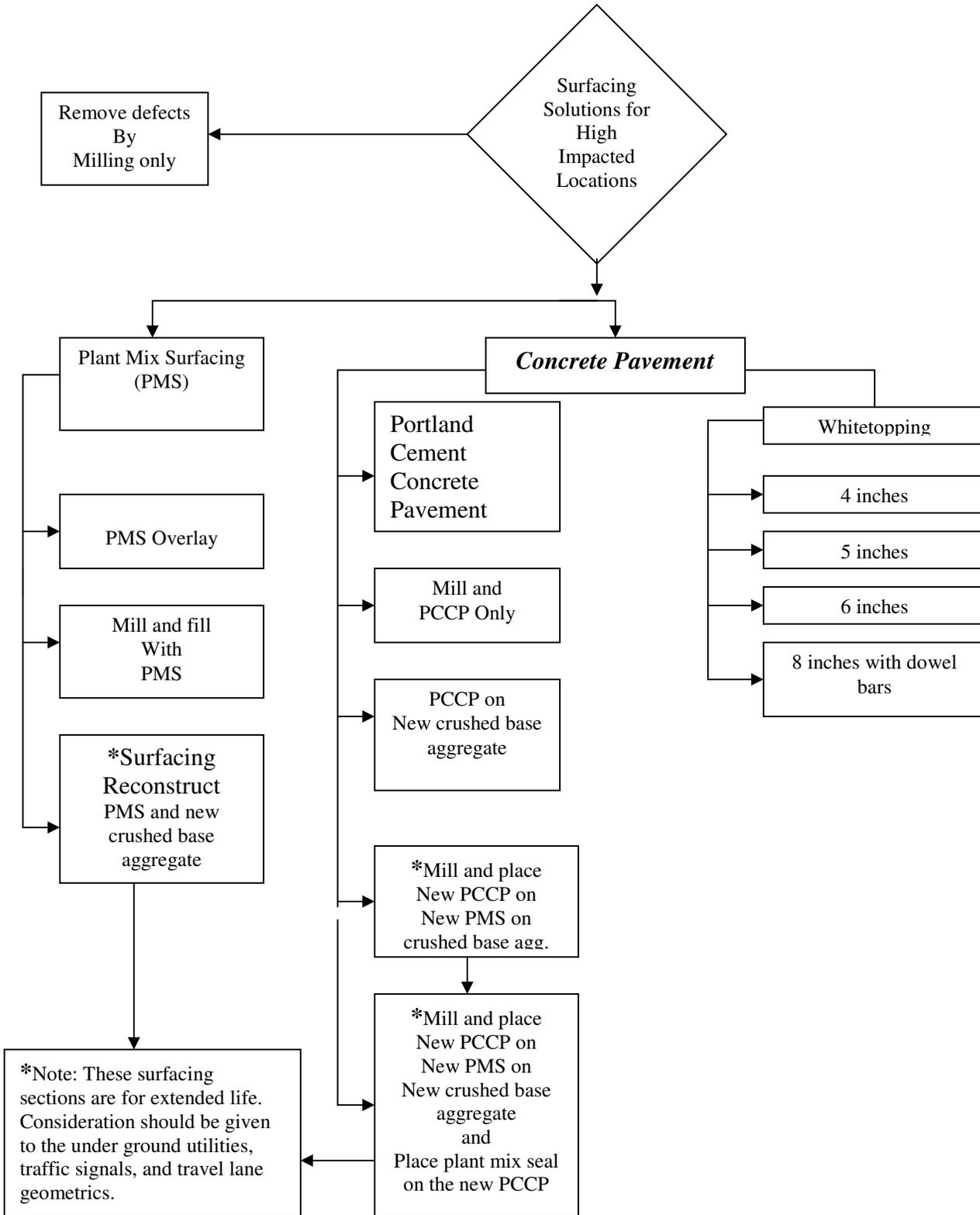
## Review Check List

In order to help determine what is causing the surfacing problems and to determine if the pavement is in a high impact corridor, consider the following:

- A) Pavement distortion indicators
- 1) Rutting
  - 2) Shoving
  - 3) Wavy distorted pavement markings
  - 4) Poor ride
- B) Past pavement performance
- 1) Review surfacing history
  - 2) Note, Frequency of repairs including
    - Overlays
    - Milling and grinding projects
    - Mill and fill
    - Rut filling project
  - 3) Review roadway maintenance
- C) Review Costs including:
- 1) Life cycle costs
  - 2) Design life
  - 3) User costs
  - 4) Impact costs to adjacent owners
- D) Study traffic issues:
- 1) Slow moving
  - 2) Slow moving and heavy loads
  - 3) Stopping and turning movements
  - 5) ADT and ESAL data



## Surfacing Option Decision Tree



## **Application of PCCP and Long Term Pavements**

### **Roundabouts:**

Recently Montana has considered more contemporary intersection designs, such as roundabouts. Portland Cement Concrete Pavement is the preferred riding surface for roundabouts. The design and function of roundabouts lends itself to PCCP. The repeated slow frequency loading and constant directional force will likely cause the pavement to shove and/or rut, particularly when the roundabout is in a high traffic area. PCCP will provide a long service life, with minimal maintenance, and easier construction. Restoration of a roundabout does not lend itself to the use of PMS. Milling machines and plant mix paving machines do not function very efficiently in tight turning radii.<sup>4</sup>

### **At Grade Intersections:**

Heavy loads and high traffic volumes damage HMA pavement at intersections and industrial arterial routes. Generally closing these roads and intersections for frequent pavement repairs creates costly traffic delays and interruptions to local businesses. HMA pavement deformities not only cause disruptions to traffic but also can become a safety concern. Concrete pavements can withstand the loading and turning movements of heavy vehicles better than HMA. PCCP can also provide a longer service life at major intersections.

### **Main Line and Interstate Pavements:**

As traffic volumes, ESALS, legal load limits, and tire pressure increases, long term pavement life becomes more difficult to obtain. For these reasons some states such as Minnesota and Washington have started using composite pavement sections, stainless steel dowel bars, and continuous reinforced concrete pavements. Federal Aviation Administration has included a bituminous surface treatment on PCCP sections on some runways. This type of composite section of PCCP and PMS has provided outstanding pavement performance. Turner Fairbanks and other research facilities have demonstrated that composite pavements can provide 50 to 70 years of functional service. A study comparing main line paving operations in Iowa in 2000 concluded that a single pass of PCCP paving is about three times faster than multiple passes with asphalt paving.<sup>5</sup> This lends itself to the practice of “get in, get out and stay out”.

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<sup>4</sup> Surface Transportation ACPA, Fourth quarter 2005, volume 1, no.1  
ACPA R&T Updates 2005 Update 6.03

American Concrete Pavement Association \*\*ACPA\*\*

<sup>5</sup> IOWA SCENE Project Report #25, November 2001

## **Riding Surfaces and Risk Management**

Diversification of money assets is a well-accepted concept in the financial investment community. The same logic can be applied to pavement management. MDT is heavily invested in asphalt pavements and decisions regarding pavement selection rely heavily on first cost, often ignoring Life Cycle Cost Analysis (LCCA). LCCA is under utilized but is a proven method to reduce risk in decision-making.

Overall the time to first rehabilitation after construction is much longer and less variable for PCCP than for asphalt pavements. Not using LCCA to its full potential and investing in primarily one paving product leaves MDT exposed to unnecessary risk.

To help minimize risk and maximize pavement management, the pavement portfolio should include a percentage of PCCP. Pavement diversification would help reduce pavement rehabilitation needs occurring at the same time. Likewise, it is not possible or advantageous to have 100% of the pavement portfolio in PCCP for the same reason. However, investing a portion of our pavement money strategically in PCCP would help minimize the risk of a large amount of pavement needing rehabilitation at the same time. The same strategic management should be used throughout Montana from our most populated cities and metropolitan areas to rural areas or small towns.

Pavement diversification is a strategic method to avoid crisis management. As an example the Interstate system has benefited from some pavement diversification. In most cases sections constructed with PCCP have exceeded both design life and ESAL's. Longer lasting pavements have helped to prevent forced re-investment of large amounts of money into repeated rehabilitation. In most cases as the PCCP nears the end of its functional life it continues to provide an acceptable level of service that allows the managers to select when to make the rehabilitation investment, and not let the roadway dictate to the manager when the investment will be made. On other portions of the interstate system that did not include any PCCP pavements, managers have been forced to make large reinvestments in pavement rehabilitation more frequently and at times before the pavement reached the expected life or ESAL's. In some respects the pavements manage the managers, not the managers managing the pavements.

In the 1960's and 70's Montana's pavement designers designed PCCP pavements to last 20 years, or about 2.5 million ESAL's. These projects, designed for 2.5 million ESAL's have lasted 31 years, and have carried 15 million ESAL's. These pavements have carried approximately 6 times the design ESAL's and have lasted ten years longer than expected and are still in service at this time.

When PCCP reaches the end of its functional life it continues to provide dividends in the form of simple and economical rehabilitation. In most cases in Montana PCCP rehabilitation includes crack, seat, and overlay with PMS. This practice saves milling costs and provides a base to support the PMS overlay.

## Composite Surfacing Section For Extended Service Life

A composite surfacing section is similar to plywood. In plywood, the layers are bonded together in opposite directions of the grain. When individual components are combined together they develop superior strength over the individual component. In addition to support value, each layer or component of the composite surfacing section provides a specific function so that, much like plywood, the individual components when combined form a superior surfacing section. It should be noted the bond that develops between the PCCP section and PMS section provides additional load carrying capacity.

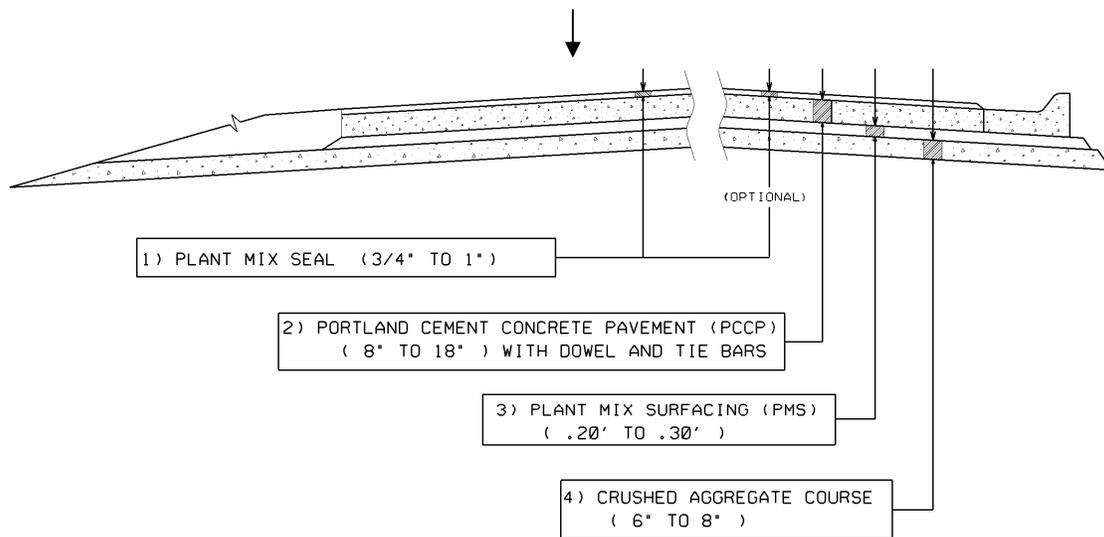


Figure 5

The typical section shown in figure 5 is to provide detail of the composite sections; the thicknesses shown are for illustrative purposes only.

Listed below are descriptions of each component of a composite typical surfacing section. Two projects in the Kalispell area have used similar composite sections. (The plant mix seal was not placed on the PCCP)

### 1) **Plant Mix Seal**

Plant mix seal functions as a sacrificial wearing surface that provides a protective barrier from de-icing chemicals, stud wear, chain and plow damage. Plant mix seal will also provide a riding surface that is smooth, quiet, with reduced water spray, improved skid resistance, and will enhance the reflective pavement markings. Plant mix seal protects the PCCP, which is the big investment.

2) **Portland Cement Concrete Pavement (PCCP)**

PCCP provides the majority of the load carrying capacity of the composite surfacing system. Include dowel bars and tie bars. The dowel bars provide load transfer from panel to panel. Surfacing Design unit provides the PCCP thickness.

In most cases bonding between the PCCP and the PMS is not required for design purposes. However, the bond will provide additional load carrying capacity that equates to a longer pavement service life.

3) **HMA, Plant Mix Base**

HMA base serves multiple functions in the composite pavement structure. Plant mix surfacing is a waterproof layer that provides a non-erodable base section, long-term structural support, and load transfer from panel to panel. The non-erodable base prevents fines from migrating and reduces faulting. In addition HMA base helps develop a smooth riding surface and provides long term structural support along with additional load carrying capacity. A smooth riding surface starts with a smooth base. HMA base provides a smooth and stable work platform. The HMA provides a sturdy foundation for attaching dowel baskets, and a stable track line for PCC paving equipment. A smooth, firm, well-graded surface reduces the corrections by the automated grade control system. At the time of construction HMA base provides a protective barrier for the CAC reducing loss of fines from erosion, reduces dust, and increases structural support for construction equipment. HMA also provides a clean temporary riding surface for the traveling public.\*

4) **Crushed Aggregate Course (CAC)**

The Crushed Aggregate Course is the foundation of the composite surfacing system. CAC provides load carrying capability, a filter or cushion from the sub-grade, and drainage. CAC helps prevent movement from frost, sub-grade reflective cracking, and faulting. In order to provide passive drainage the CAC must be day lighted out to the face of the embankment.

5) **Edge Drains**

Edge drains are a component that is often overlooked, but should be considered, particularly in curb sections. In most cases CAC provides enough passive drainage to drain non-curb and gutter sections. However, if ground water is a concern, edge drains should be considered. Even with a composite surfacing section or any other surfacing material a method of providing drainage should be considered.

As with any pavement section the Surfacing Design Section provides the recommended surfacing thickness. Surfacing Design unit can also provide the recommended thickness for each component of the composite surfacing section.

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\* Two projects have been constructed by MDT that included placing the PCCP on HMA.  
NH5-3(66)109F Ashley Creek-Kalispell [1012]  
STPP NH 52-1(20)0 Polson-East [4036]

## **Full Depth Portland Cement Concrete Pavement (PCCP)**

Today, in most cases PCCP is designed with a 30 year design life or projected loads. As previously mentioned in this paper, Montana has sections of PCCP on the Interstate system with 8 inches of PCCP (without load transfer devices), placed on .35' of PMB, on .50' of CBC that was built in 1976. Considering the past performance of these types of PCCP sections, new concrete pavement can be designed to last longer than 30 years, and be smoother and quieter than past concrete pavements. Contemporary PCCP designs that include load transfer devices, new joint designs, and aggregate gradations designed for PCCP, and using PMS as a base on CBC could extend PCCP life to 60 or 70 years.

Progress and changes have been made that will increase the service life of PCCP, and improve ride. Changes to PCCP designs including aggregate gradation, joint design, load transfer, longitudinal tining, and base support. Detail examples of these changes include the follow:

- Many of the older PCCP used 1 ½" aggregates. The aggregate gradation used today typically uses ¾" aggregates. The significant difference is ¾" aggregate incorporates more mortar paste, and increases the percentage of fractured faces. Increase fractured faces increases aggregate interlock improving flexural strength and joint strength. Increased cement paste reduces permeability, and increases long-term durability.
- The importance of controlling faulting and cracking. Dowel bars are used at the sawed joints to provide support for load transfer.
- PCCP needs to be placed on a solid foundation. In the past PCCP was placed on a small amount of gravel base or no base at all.
- PCCP should be placed on HMA. Plant mix can provide a solid foundation that provides a uniform non-erodable base, providing load transfer and additional structural support.

### **Whitetopping**

Whitetopping is a surfacing treatment that is recommended for use to correct rutting and shoving. Whitetopping surface will not correct subgrade or base problems. As with any pavement or surfacing Whitetopping requires a good foundation.

Things to consider before placing a Whitetopping surfacing section:

- 1) The in-place plant mix must be of good sound quality that is not stripping.
- 2) The Whitetopping must be placed on at least 4 inches of good Plant mix
- 3) Existing section needs to be adequate.

## **Future Trends**

### **Preparing for the Future**

There are other possible concerns on the horizon that might force agencies to use paving materials other than asphalt binders. Refineries that have traditionally produced asphalt binders for road building are beginning to reduce asphalt production. Economics is driving this trend. Simply put, a refinery can make more money by refining the asphalt further to make products that provide a greater return on the refining investment, with fewer specifications and requirements. An example of this trend is currently taking place in Montana. Several local refineries have changed operations to reduce the asphalt product output. The Conoco Refinery in Billings has not sold paving grade asphalt for about nine years. Cenex Refining in Laurel, MT intends on reducing asphalt production by 75 percent and no longer ships asphalt out of state. Exxon Refining has also reduced asphalt production. At the time this paper was being prepared Montana Refining in Great Falls is the only refinery in Montana that has not reduced asphalt production rates. As explained, more money is available in the products that are left remaining in paving grade asphalt. After removing the products in the remaining asphalt through further refining, the low-grade asphalt that remains is used as burner fuel to generate electricity.

### **The Future is Now**

Comparing the 2005 and 2006 construction seasons demonstrates that the future is now. Asphalt prices escalated at an alarming rate. In 2005 overall asphalt prices for PG 70-28 averaged \$275.57 per ton, and the average price for PG 70-28 in 2006 was \$420.96 per ton. Owner agencies should be prepared for asphalt prices to continue this trend.

As refineries become more efficient, and the demand for other hydrocarbon products increases, paving grade asphalt products will become more expensive and harder to find simply because of the demand for other products such as fuels, lubricants, plastics, and the BTU's left in the remaining asphalt. It is likely at some point in the future Montana and other states will be paying high prices for paving grade asphalt and it is also possible the asphalt will be imported. Also, as other sources for fuels are developed such as liquefied coal, liquefied natural gas, and bio-fuels, paving grade asphalts will not be readily available because the asphalt byproduct is reduced or eliminated.

## **Definitions:**

### **Continually Reinforced Concrete Pavement:**

Concrete pavement with continuous longitudinal steel reinforcement and no intermediate transverse expansion or contraction joints. <sup>(4)</sup>

### **Fatigue Cracking (alligator cracking):**

Fatigue cracking is identified by 4 to 8 inch square or rectangular pieces of PMS and the cracks are generally interconnecting, ranging from 1/8 to 1/4 inch wide, in a block pattern, with an overall appearance of alligator skin. Identifying the causes of Fatigue Cracking failure can be complex. Fatigue cracking can develop several ways. Fatigue Cracking is generally caused by a combination of weak sub-grade support, aging (stiffening) of the asphalt binder, moisture intrusion, and repeated loading. <sup>(2) (3)</sup>

### **Footprint:**

Footprint is the volume of land that a roadway occupies from right-of-way fence to right-of-way fence. Highway footprint includes all the features of a roadway that occupies the space, such as travel lanes, bridges, drainage structures, fences, ditches, bike paths, pedestrian walkways.

**Jointed-Plane Concrete Pavement (JPCP):** Concrete pavement containing enough joints to control all natural cracks expected in the concrete; deformed steel tie bars are generally used at longitudinal joints to prevent joint opening, and smooth steel dowel bars may be used to enhance load transfer at transverse contraction joints, depending upon expected traffic and loading. <sup>(4)</sup>

### **Jointed Reinforced Concrete Pavement (JRCP):**

Concrete pavement containing some joints and embedded steel mesh reinforcement (sometimes called distributed steel) to control expected cracks; steel mesh is discontinued at the transverse joint locations. <sup>(4)</sup>

### **Life Cycle Costs Analysis:**

The process used to compare projects based on their initial cost, future cost, and salvage value, which accounts for the time value of money. <sup>(4)</sup>

### **Portland Cement Concrete Pavement (PCCP)**

Portland Cement Concrete Pavement is a rigid pavement that uses a Portland cement or blended hydraulic cement consisting of inorganic ingredients to bind mineral aggregates. PCCP can be continuously reinforced with rebar or partial reinforced with dowel bars over the transverse joints and is generally placed between 8 to 18 inches thick. <sup>(2) (3) (4)</sup>

<sup>(2)</sup> Reference, Montana Department of Transportation Distress Identification Manual for Pavement Performance

<sup>(3)</sup> Reference NCHRP synthesis 333 Thin and Ultra Thin Whitetopping

<sup>(4)</sup> American Concrete Pavement Association (ACPA)

**Rutting:**

Rutting is a permanent deformation or plastic movement of the plant mix surfacing in the wheel path. Localized repeated loading generally causes rutting. Rutting is generally the densification and shearing of the various pavement layers. Rutting is visually identified by the surface depressions in the pavement surface in the wheel paths. In severe cases pavement ridges may occur along the sides of the wheel rut. Rutting is generally measured transversely across the depression using a string line or other approved straight edge. In most cases rutting is considered significant when it approaches .5 inches deep. Note: The presence of rutting may or may not indicate a stress location. Circumstances resulting from faulty plant mix surfacing could contribute to rutting. <sup>(2) (3) (5)</sup>

**Shoving:**

Shoving is the longitudinal displacement of a pavement surface and is generally easily identified by distorted pavement markings, and/or vertical displacement such as a dip, bump, or a bulge. A repeated traffic movement such as stopping or a continuous load in the same direction generally causes shoving. Bulging of the pavement is in the same direction as the load pressure. Severe shoving can affect ride quality, and safety. Shoving is usually caused by a surface section that is too soft to resist horizontal pressure and/or has a poor bond with the underlying section. However, the presence of shoving may or may not indicate a stress location. Circumstances resulting from faulty plant mix surfacing could contribute to shoving. <sup>(2) (3) (5)</sup>

<sup>(2)</sup> Reference, Montana Department of Transportation Distress Identification Manual for Pavement Performance

<sup>(3)</sup> Reference NCHRP synthesis 333 Thin and Ultra Thin Whitetopping

<sup>(4)</sup> American Concrete Pavement Association (ACPA)  
Pavement Technology, Technical glossary

<sup>(5)</sup> Reference, Ohio Department of Transportation Pavement Guidelines for Treatment of High Stress Locations

**Whitetopping:**

Whitetopping is a Portland Cement Concrete Pavement layer placed over an existing Hot Mix Asphalt layer. Modern Whitetopping overlays are generally classified into three (3) categories by thickness.<sup>(3)(4)</sup>

- 1) Conventional Whitetopping is PCCP 8 inches or thicker placed on a new or preexisting plant mix base, without consideration of a bond between the concrete and the underlying hot mix asphalt. Conventional Whitetopping can be reinforced with dowel bars.
- 2) Thin Whitetopping (TWT) is an overlay of PCCP between 4 and 8 inches thick placed on milled or new hot mix asphalt. Thin Whitetopping is designed and constructed with an intentional bond between the PCCP and the HMA layer. Thin Whitetopping is generally jointed plain concrete with fibers required.
- 3) Ultra Thin Whitetopping (UTW) is an overlay of PCCP between 2 and 4 inches thick placed on a milled hot mix asphalt pavement. UTW requires a bond between the HMA and the PCCP. Note: at this time the thinness section placed in Montana is 3.5-inch experimental section. Four (4) inches of PCCP Whitetopping is the minimum recommended section, and is placed as a jointed plan concrete and must include fibers.

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<sup>(3)</sup> Reference NCHRP synthesis 333 Thin and Ultra Thin Whitetopping

<sup>(4)</sup> American Concrete Pavement Association (ACPA)  
Pavement Technology, Technical glossary

## **Contacts**

It is anticipated there will be numerous questions dealing with special circumstances. Technical assistance with these guidelines is available by contacting the following individuals:

Dan Hill, P.E. Surfacing Design Engineer (406-444-3424)

Mike Lynch, Helena Material, Concrete and Cement Testing Supervisor (406-444-6294)

John Huber, Construction Engineering Services Bureau (406-538-1324)

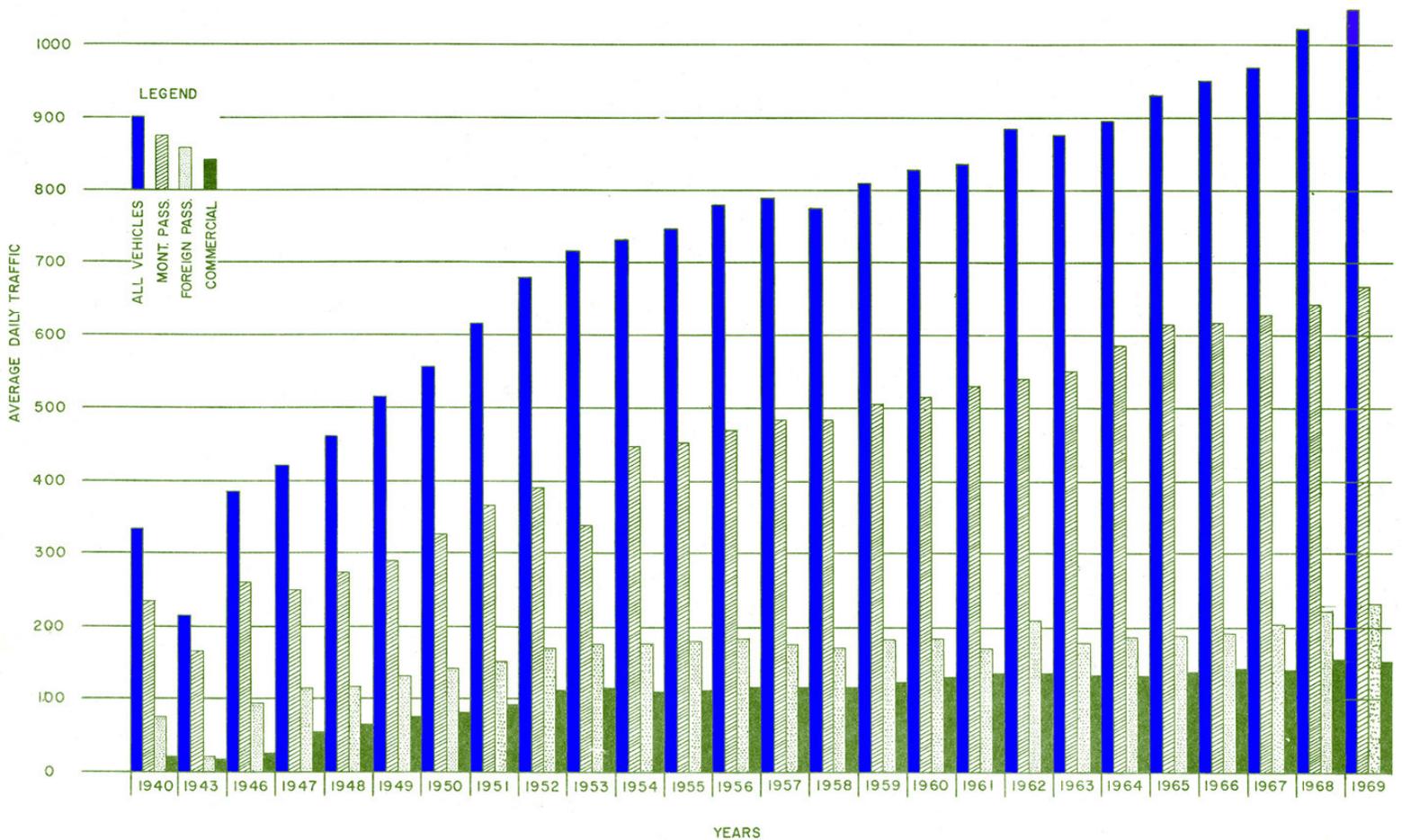
Bob Weber, Construction Engineering Services Bureau (406-444-6014)

Paul Ferry, P.E. Highways Engineer (406-444-6244)

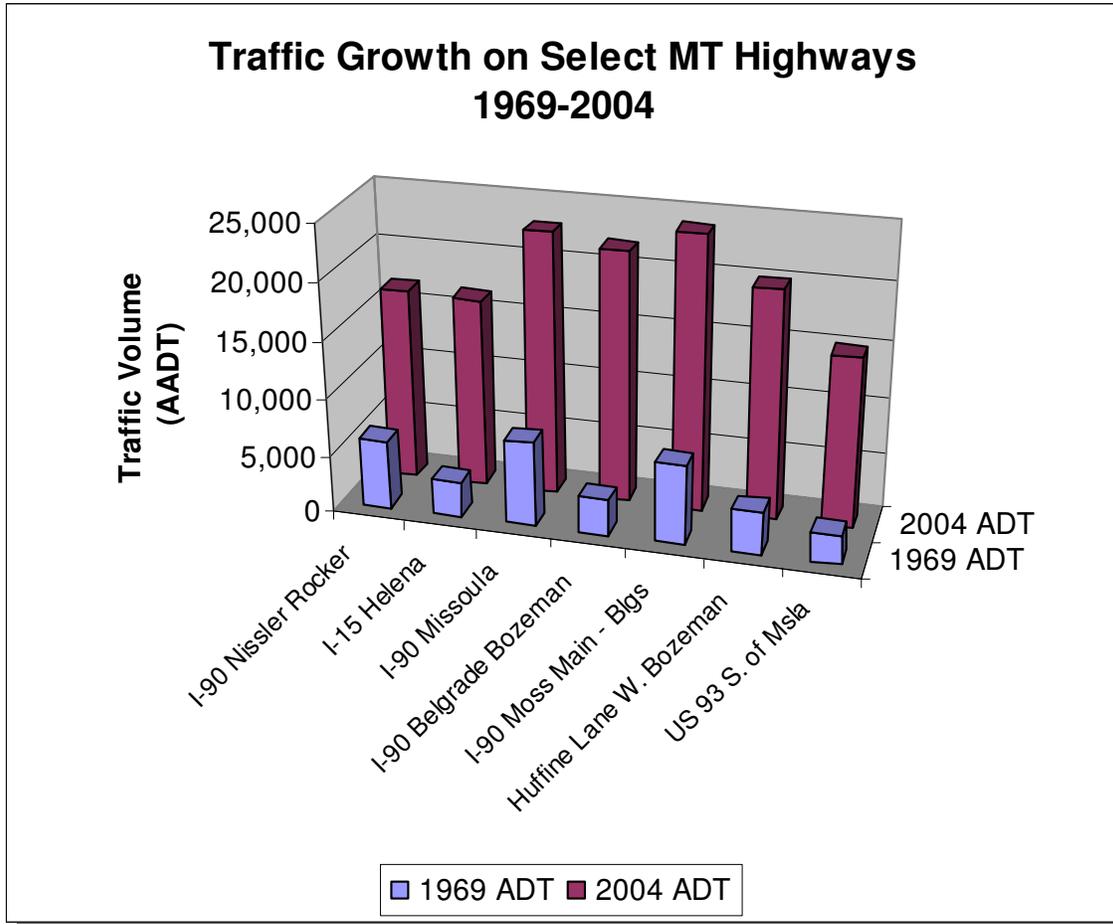
## **Glossary of Acronyms**

ADT	average daily traffic
ESAL	equivalent single axle load (18-kip or 80-kN)
HMA	hot-mix asphalt
PMS	plant mix surfacing
PCC	Portland Cement Concrete
PCCP	Portland cement concrete pavement
TWT	Thin Whitetopping
UTW	Ultra Thin Whitetopping
CAC	Crushed Aggregate Course
ACPA	American Concrete Paving Association
LCCA	Life Cycle Cost Analysis
PMB	plant mix base
JPCP	Jointed Plain Concrete Pavement
CRCP	Continuously Reinforced Pavement

MONTANA TRAFFIC BY SECTIONS  
 COMPARISON OF AVERAGE DAILY TRAFFIC  
 RURAL PRIMARY & INTERSTATE HIGHWAYS  
 1940 - 1969



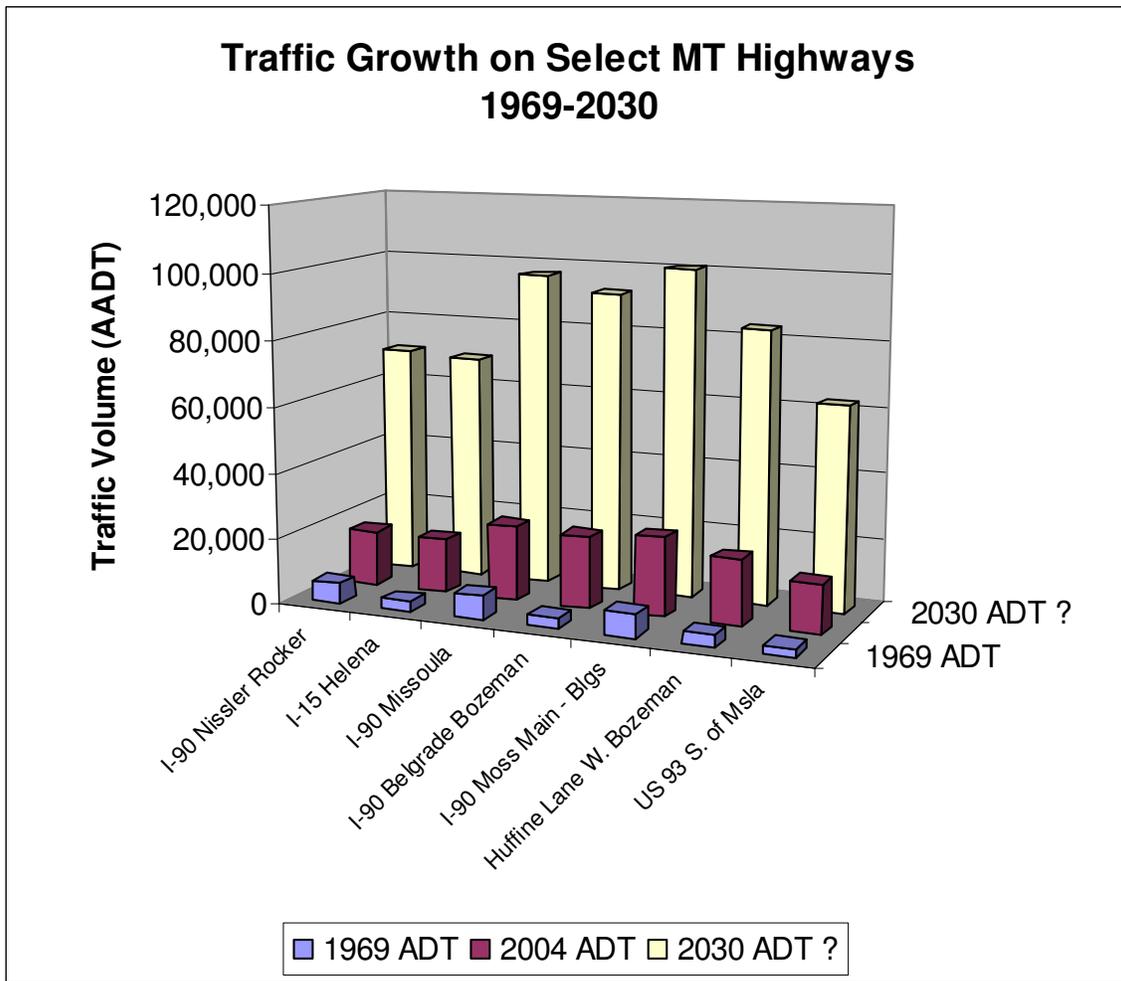
The above is a graphic example of 4-fold increase in traffic over a 30-year period.  
 (Graph provided by Lloyd Rue, FHWA)



Graph provided by Lloyd Rue, FHWA

## Changing Montana Landscape

- **1969-2004, 2-1/2 to 7 fold increase 7 critical Montana highway segments**
- **Future projection 2004-2030**
  - *Assumed 5 fold increase in 30 year period projects to:*
    - 85,000 on I-15 Helena
    - 110,000 on I-90 Bozeman
    - 115,000 on I-90 Missoula
    - 120,000 on I-90 Billings



Graph and statistics provided by Lloyd Rue, FHWA