SPR 5273

A STUDY OF THE WEARING CAUSED BY STUDDED TIRES ON OREGON HIGHWAYS

SPR Project 5273, Phase II

by

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ABSTRACT

Oregon highways are experiencing significant wear damage in the wheel paths on both bituminous and concrete pavements. The main cause of this damage is from studded tires which creates the problem of wear rutting on road surfacing in the wheel path areas. In a field study of Oregon roads, sites which had a potential for damage by studded tires were selected and rut measurements were taken. This, together with traffic volume data, showed the extent of the damage in different parts of the state. The field study found that the wear rate (i.e. wear/year) is greater in high traffic volume roads. Furthermore, on multi-lane highways, the rut depth is normally greater in the fast traffic lanes rather than the slow lanes.

Aggregate types and quality is probably the most important parameter that can contribute to a mix in resisting wear. A good aggregate would have the following primary properties in AC and PCC pavements: high resistance to wear; good bond with the binder in AC mixes; and no adverse reactions in concrete.

In the above mentioned field survey of Oregon highways, rut depth measurements from the selected sites, located in various regions in Oregon, were performed using a straight edge. By comparing sites with similar pavement condition (i.e. equal age, traffic, climate and mix type), it was concluded that the aggregate type and quality are the most important parameters that influence the pavement resistance to wear.
The aggregate sources in each site were identified from construction records. Routine ODOT Specification testing and Nordic abrasion resistance testing (i.e. Ball Mill) were carried out to evaluate the properties of the aggregates. It was found that some of these tests (e.g. Los Angeles abrasion) do not correlate with the actual field wearing and the correlation of others (e.g. Ball Mill abrasion) were rather poor. In addition, a detailed petrographical examination was performed on the selected aggregates. Based on this latter and other laboratory test results, the selected aggregates were classified in different categories according to their qualities. Finally, the aggregate properties which resisted studded tire wear were determined and specific recommendations for aggregate type selection and wear testing were proposed.

1.0 INTRODUCTION

1.1 Background

Oregon is experiencing significant studded tire damage in the wheel paths on both bituminous and concrete pavements. Unlike a number of states which prohibit studded tires, they are allowed in Oregon with some restrictions. Current Oregon legislation prohibits the sale of tires which contain studs of over 1.5g (i.e. steel studs) and restricts the studded tire use from November 1 through April 30 (ORS 815.165 and ORS 815.167).

The primary damage caused by studded tires is the wearing of road surfacing. In asphalt pavements the deterioration is caused by either wearing of aggregates or by the debounding and picking up of aggregates from the road surfaces; although the damage caused by wearing of aggregates is seen more frequently. In PCC pavements, wear is also a problem but it does not exhibit much debounding and aggregate picking up distress.
In some high volume roads, the studded tire damage has caused rutting close to one inch deep. The wear ruts are observed in both asphalt and concrete pavements on Oregon highways; although rutting is greater in asphalt pavements. Rutting not only is a hazard to traffic safety but it weakens the pavement structure.

In order to predict the wearing of aggregates, the most widely practiced test method in the United States is the Los Angeles (LA) abrasion test (AASHTO T96). However, many researchers have confirmed that the correlation of LA abrasion with the wearing in the field is quite poor (*Smith, 1958 and Liu, 1981 and Meininger, 1994*). In this research methods of characterizing different aggregate sources in Oregon were also evaluated.

1.2 Project Objectives

The overall objectives of the research were the following:

1. To identify the dominant factors that affect the road wearing,
2. To evaluate different aggregate test methods, both from current ODOT specifications and other potential tests, which could indicate the wearing resistance of aggregates,
3. To evaluate aggregate properties that reduce wear caused by studded tires, and
4. To evaluate different aggregate sources in Oregon for wear resistance purposes.

1.3 Study approach

Several sites that were recognized to have had damages from the studded tires were selected throughout Oregon. The sites were selected from the various projects which had either been constructed or had been repaved during the past few years and their construction reports were available. Attempts were made to get a selection of sites from the state highway network so that all the five regions of the state were included. Figure 1.1 shows the site locations with the source numbers of the aggregates which had been used in the surfacing layer of each site. The three digits in each source number indicates, from left to right, the county designation code, the actual aggregate source and the region number.

1.3.1. Work Plan

In order to meet the objectives of this project, the following tasks were performed:

1. Selecting sites in Oregon that have studded tire damage,
2. Perform rut measurements on the selected sites,
3. Obtain aggregate samples from the quarries or site locations,
4. Site inspection for rut type recognition (i.e. separating studded tire ruts from those caused by heavy truck loading),
5. Perform various laboratory tests on aggregates
6. Perform a petrographic study of different aggregates in the State,
7. Look for a possible relationship between studded tire wear rut and aggregate properties,

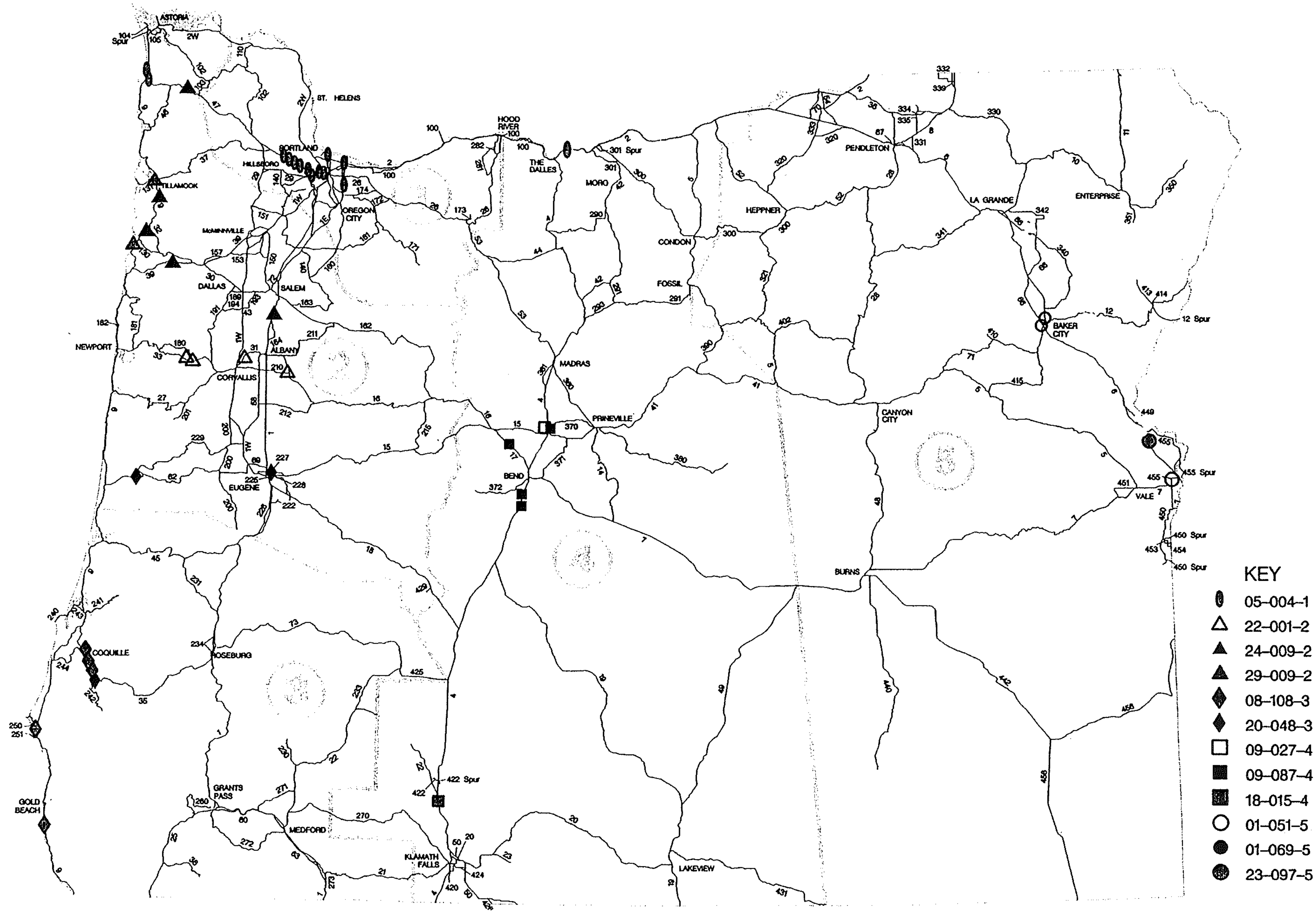


Fig. 1.1. Different aggregate sources and the site locations

8. Rank or classify the different aggregate sources which had been studied,
9. Recognition of the potential test methods which could predict better aggregate wearing, and
10. Conclusions and recommendations, and
11. Recommendations for further work.

2. WEAR RUTTING

2.1 Studded tire damage

The main damage of the studded tires to road pavements is wearing which will lead to wear rutting. Rutting affects motorist safety and the structural integrity of pavements. When the ruts fill with rain water the following problems occur:

a) The spray and splash reduces the driver visibility,

b) Hydroplaning prevents the proper contact between tire and road surfaces, reducing the skid resistance, and

c) Hydraulic pressure created from vehicle tires accelerates stripping and debounding of aggregates which will result in early disintegration of the pavement (Fig. 2.2).

In preliminary investigations of the above problem in Oregon the following points were noted:

1. In similar climatic and traffic conditions, Asphalt Concrete (AC) pavement surfaces wear faster than those of Portland Cement Concrete (PCC), and
2. It is the aggregate component of the mix which plays the major role in resisting to wear.

Because of the above points the aggregates were considered to be the major issue for the research. Therefore, their presence in AC mixes were looked at in detail in this study. It was assumed that if an aggregate exhibits a proper wear resistance in AC mixes, it would resist in PCC mixes with sure.

The formation of wear rutting is either the consequence of wearing of the surface aggregates or it is the result of aggregate loss (picking up) from road surfaces. This happens to both coarse and fine aggregates in the pavement.

2.1.1 Aggregate wearing

Aggregate wear or polishing or both occur when a rather low wear resistant aggregate is used in the road surfacing. Wear and polishing are two distinct phenomenons that occur in road

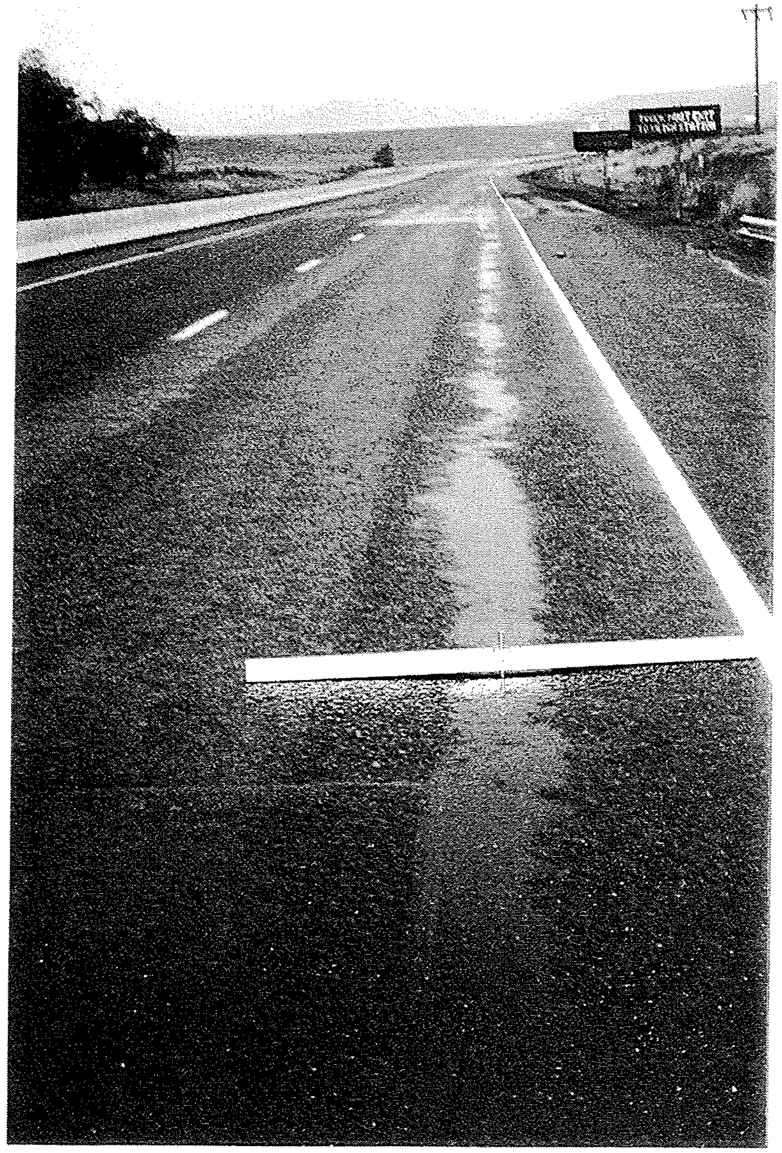


Fig. 2.1. Hydroplaning in a wheel track rut channel

Fig. 2.2. Pavement disintegration due to continous studded tire rut wear

pavements because of the ordinary wearing action of the vehicle tires. Wear refers to the gradual loss of material while polishing, still loss of material but refers to the smoothing of aggregate surfaces. In other words wearing may be defined as the loss of macrotexture, whereas polishing is the loss of microtexture. In a recent study, wearing was referred to the asperities and protrusions of 0.5 mm and larger and polishing was referred to the asperities smaller than 0.5 mm (Bruner et al, 1996).

Studded tires, unlike the rubber tires mostly wear the aggregates rather than polishing them. A typical case of aggregate wearing under the action of studded tires is shown in Fig. 2.3 (a and b). It can be seen from this figure that the continuos wearing action has brought about a pronounced rutting in the surfacing.

2.1.2. Aggregate picking up

In the case of hard aggregates that possess a high wearing resistance, if studded tire rutting occur, this would mainly be due to "stone picking up" phenomenon. This distress might occur in either of the following cases:

1. Aggregate interlock in the surfacing is weak or a great number of single aggregate particles are exposed out from the surfacing (i.e. with little embedment into the surfacing layer),
2. The bond between aggregate particles and the binder present in the mix is weak (i.e. low binder adhesion and/or low aggregate coating) or,
3. The winter temperatures increase the stiffness of the binder in the mix, making this latter more brittle.

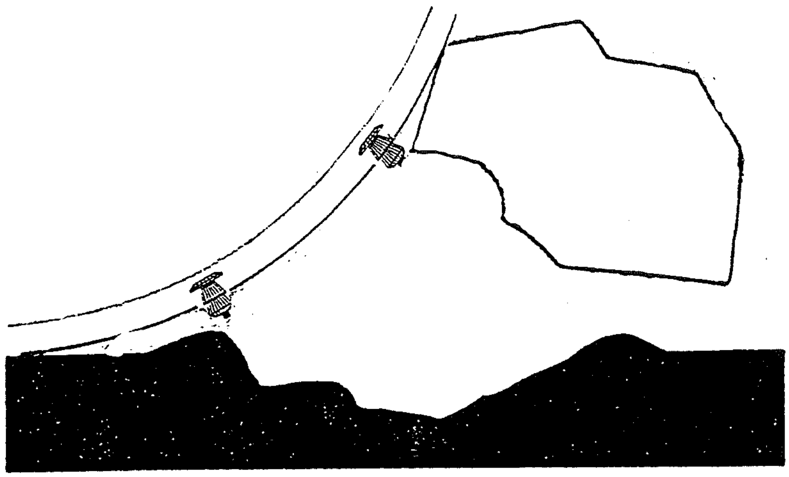
In all the above circumstances, the continuos hammering action of the studs will finally pick the loose or exposed particles up from the pavement (as it is shown schematically in Fig. 2.4). A field example of the stone picking up problem is shown in Fig. 2.5, taken from a rural highway in North-West Oregon.

2.2 Parameters contributing studded tire wear

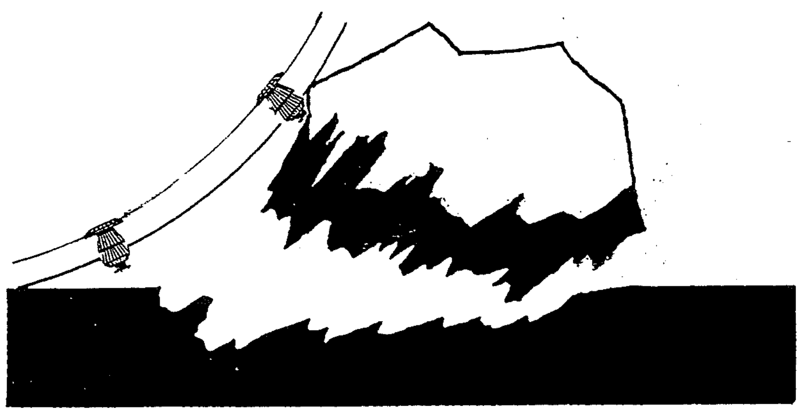
a) General view

b) Wear rutting

Fig. 2.3. Studded tire rutting due to wearing of aggregates



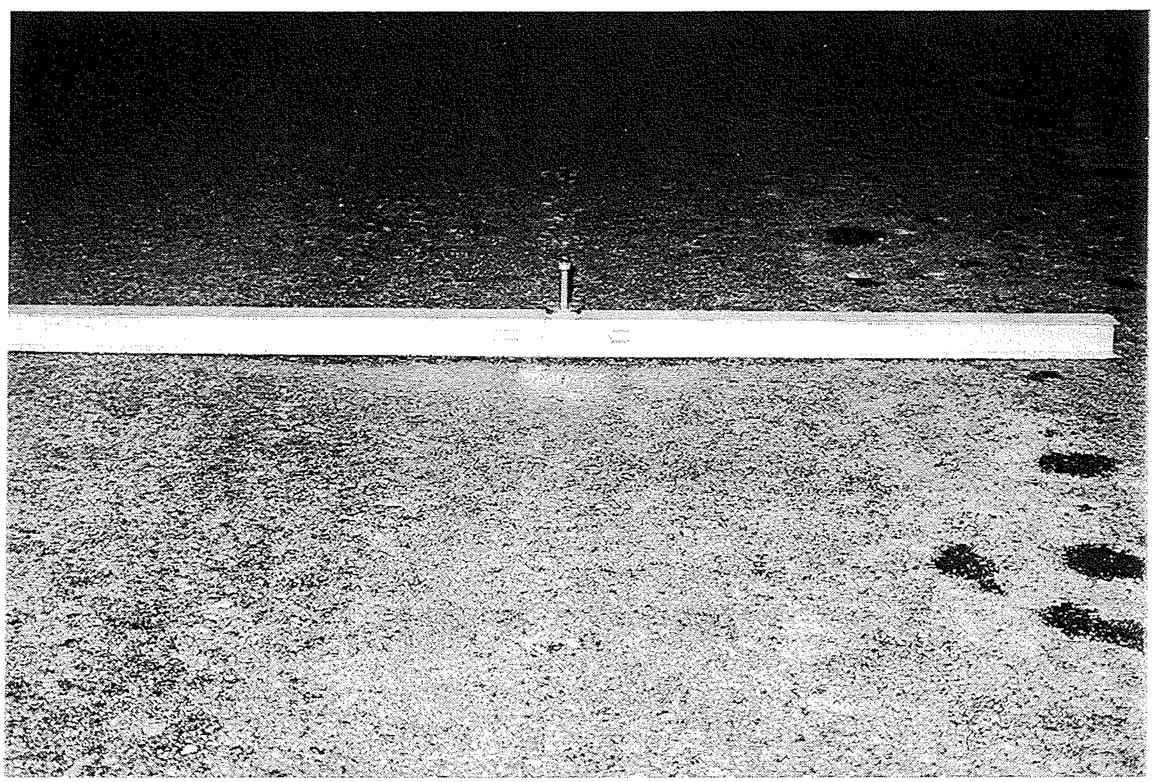
a) Lack od bound



b) Binder embrittlement

Fig. 2.4 Stone picking up due to hammering action of studded tires

a) General view



b) Stone picking up rut

Fig. 2.5. Studded tire rutting due to aggregate picking up from the road surface

Aggregate type and quality seem to be the major parameters in the pavement wear issue in Oregon. This is dealt with in detail in the next chapters. Apart from the important role of aggregates, there are several other parameters that could contribute road wearing. The most important ones are the following:

a) climatic conditions,

b) traffic type and volume,

c) road geometry,

d) mix type, and

e) characteristics of the binder used in the mix.

It should be mentioned that the phenomenon of stripping or debounding of aggregates in the presence of water, contribute the stone picking up phenomenon to a great extent. However, as this is a vast concept which has been dealt with extensively in the various literature, it was decided not to enter into this concept and make the emphasis of the research on other parameters, such as the intrinsic aggregate properties that contribute resistance to wear.

The effect of the above parameters, as seen in Oregon highways, are explained in the following:

2.2.1 Climatic conditions

The two major parameters that contribute road wearing are traffic loading and weathering. Weathering is defined as the adverse effects imparted from the climatic factors (such as rain, freeze and thaw) to road pavement.

The presence of high elevation roads in Oregon, particularly in and around the Cascades, have imparted particular circumstances. Long rainy seasons and in some places daily temperature changes, from moderate to cold temperatures and viceversa, have brought about very wet and freeze and thaw conditions. In fact, the winter season in Oregon is quite different than that in some other country, such as the Nordic countries and Alaska. The rather continuous rains and temperature variations have brought wet and freeze-thaw conditions in the winter period and just wet conditions in the other prevailing seasons of the year.

With regard to the effects of the climatic conditions the following points were noted:

1. In the roads located in the areas within the Cascades, the rate of wear is greater than the other parts,

2. In the shaded roads (i.e. the areas surrounded by trees), the stone picking up phenomenon is more pronounced. In these conditions continuos water droplets from the trees contribute the lower temperatures of the shaded areas.

A field example of the latter problem is shown in Fig. 2.6.

2.2.2 Traffic

In a general inspection of the various roads in the State and from the wear rut data which is periodically obtained for pavement management purposes it will result that :

1. The wearing is most pronounced in high traffic volume roads with channelized traffic, and
2. Studded tire rutting is mostly caused by the passenger cars, as on the multi-lane freeways the middle or fast lanes show more wear than the slow ones which are mainly trafficked by trucks.

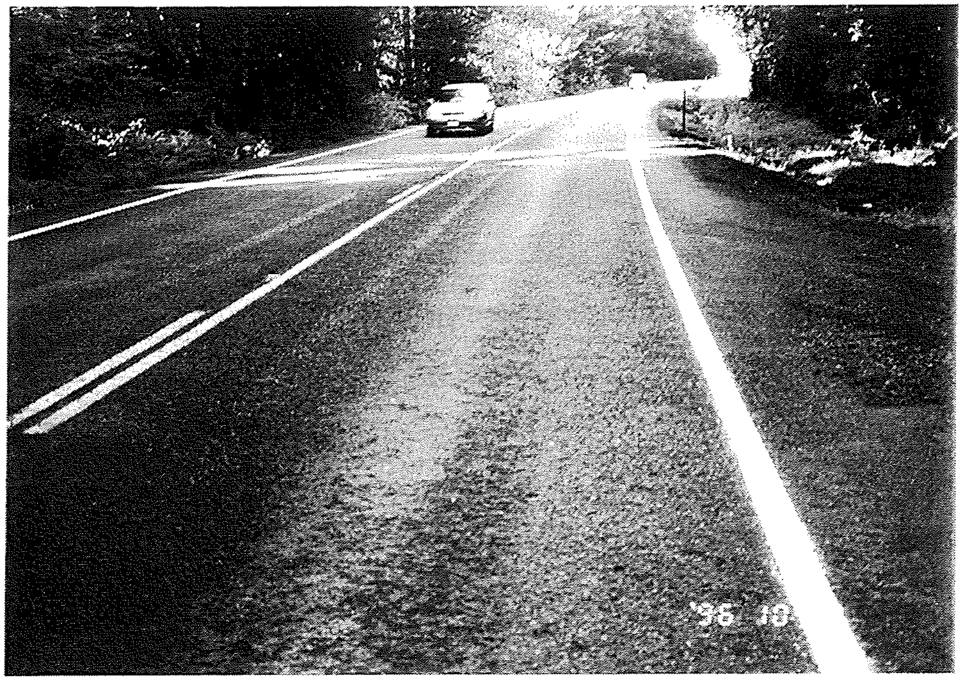
In some spot counting of vehicles equipped with at least one pair of studded tires in winter 1994, it was found that studded tires are used on about 20 percent of vehicles in Oregon (Brunette, 1995). This was the average result of vehicle counts in parking lots of some shopping centers located in the different localities. In the counting, a distinction was not applied between vehicles with one or two pairs of studded tires.

Comparing the counting in the localities at just east and west part of the Cascades, it was resulted that:

1. In these regions the percentages of vehicles equipped with studded tires is quite high (some %40), and
2. the numbers are some 10 to 15 percent higher in the eastern part.

In a general comparison of road surface wear at both sides, it can be stated that the rate of wear is also greater in the east part of Oregon.

2.2.3 Road geometry



a) General view

b) Close view

Fig. 2.6. Stone picking up problem in the shaded roads surrounded by trees

With regard to the effects of road geometry on the studded tire wearing in Oregon highways, the following points were noted:

1. The rate of wear is greater in the curved parts of roads and the rutting forms a wider channel (Fig. 2.7). This might be because of the applied sideway forces on vehicle turnings, and
2. On the steep roads the downhill lanes do wear more than the uphill ones (Fig. 2.8). The greater speeds and frequent breaking of vehicles could be the main reasons for this occurring.

2.2.4 Mix type

Studded tires normally wear all the components of a mix, including coarse and fine aggregate particles and the mortar that bonds them together. Whether the wearing starts from the coarse or fine aggregates or the mortar, depends on a number of factors. The grading, particle size and aggregate interlock are among these.

In this study, in the case of AC pavements, only two types of mixes were considered. These were namely Oregon "B" and "F" mixes which are used in most of Oregon highways. The gradation of these is reported in Table 2.1.

For the above mix types, when there occur a studded tire wearing, the reason could be explained as follows:

2.2.4.1. Dense graded B mixes- In the case of Oregon dense B mixes, wearing could occur in either of the following cases:

1. *The aggregates are of high quality, the mix has been compacted well and a good interlock exists between the aggregate particles:*

In this case it is expected that the very fine particles and the mortar surrounding the aggregates wear first. The larger aggregate particles would be exposed. As the wear progresses the matrix is eroded from between the harder coarse aggregate particles. On increase in exposure either the aggregate particles will be broken or these will be picked up from the road surfacing.

In the above conditions, the róad surface texture in the wheel path areas would be more rough, compared with that of the same surface but in the unaffected areas (such as centerline or the shoulders). If a texture depth measurement is performed in these conditions (e.g. a sand patch testing), a higher value will result in the wheel path areas.

Fig. 2.7. Aggravated studded tire wearing in the curved sections of roads

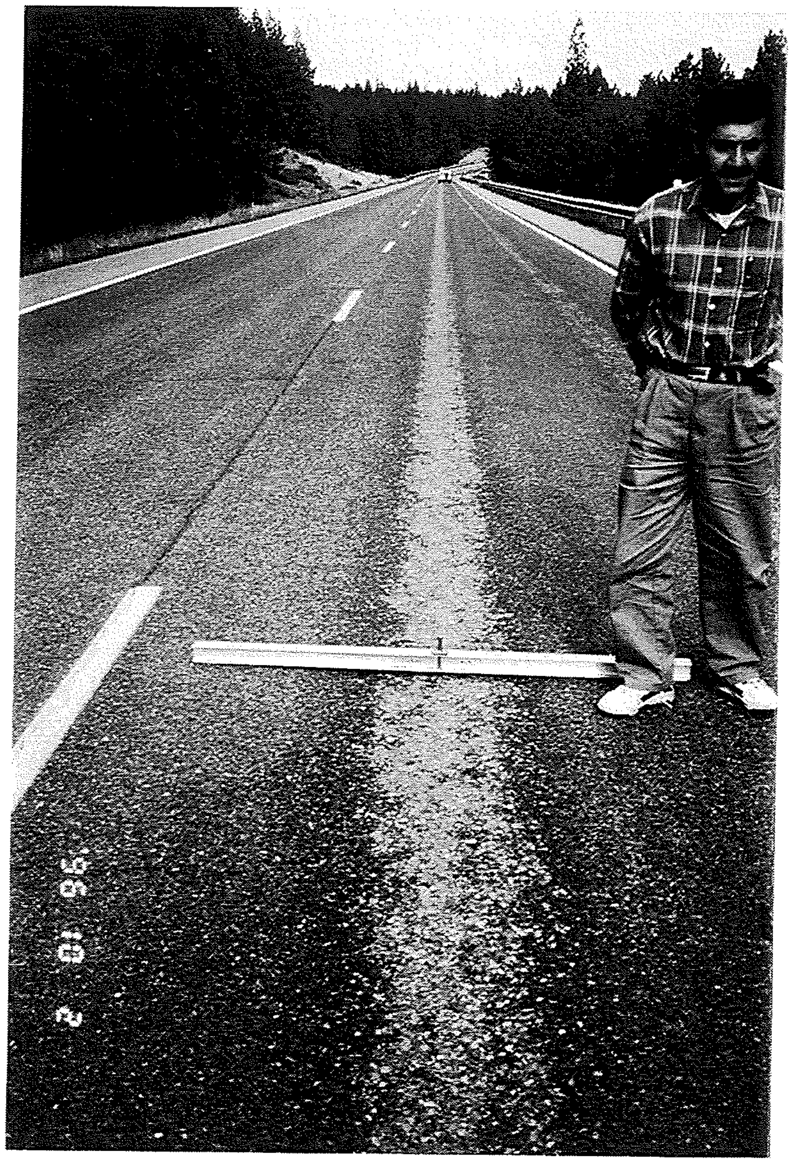


Fig. 2.8. More studded tire wearing in the down hill direction of steep roads

Table 2.1. Gradation of Oregon "B" and "F" Mixes

Sieve Size	ODOT "B" Mix (ODOT, 1996)	ODOT "F" Mix (ODOT, 1996)
1 in. (25mm)	99-100	99-100
3/4 in. (19mm)	92-100	85-96
1/2 in. (13mm)	75-91	55-71
1/4 in. (6mm)	50-70	15-30
No. 10 (2mm)	21-41	5-15
No. 40 (1mm)	6-24	---
No. 200 (0.075 mm)	2-6	1-6

2. *The aggregates are of lower quality with regard to resistance to wear:*
In this case if the mix compaction and the other mix components are good, the surfacing would wear almost uniformly (i.e. both coarse and fine particles and mortar would wear contemporarily). In these conditions the texture of the surfacing under the wheel paths will be smoother than those out of the wheel path areas. If a texture depth measurement is performed in these cases, the wheel path area would have a lower texture.

2.2.4.2 Open graded F mixes- Oregon open graded F mixes have much less fines, compared with the dense B mixes. This results in mixes with higher air voids and less aggregate interlock. In these cases, if there is a wear problem this could be because of either of the following conditions:

1. *The aggregates are of high quality but there is not enough interlock between the particles:*
In these cases the action of the studded tires would be to pick up the stone particles from the road surfacing. The consequence would be the formation of small separated holes on the surfacing (Fig. 2.6). If a sand patch texture measurements is performed in these sites, the wheel path areas will show a higher texture depth than the areas not weared by the studded tires.
2. *The aggregates are of poor quality and have a rather low wearing resistance:*
In these conditions if there is a good interlock between the aggregate particles in the mix and they are well bounded together, the surfacing is expected to wear almost uniformly. In these cases if a sand patch texture measurement is performed, the wheel path areas would have a lower texture depth, compared with the areas that were not weared (e.g. in the centerline or shoulder), and
3. *The aggregates are of low quality, the interlock is week and the bound between the particles are poor:*
In these conditions both the wearing and the stone picking up phenomenons would occur contemporarily, leading to an early disintegration of the pavement. In these cases performing a sand patch texture measurement would be insignificant.

The above points are the conclusions of performing some sand patch testing on some selected sites in various localities in Oregon. Table 2.2 reports the results. In this table a parameter named "Texture Index (TI)" is defined. This which is the ratio of the following parameters helps in distinguishing between "aggregate wearing" or "stone picking up" phenomenons.

Table 2.2. Sand Patch Texture Measurements on Same Stud Weared Surfaces

Site No.	Location	Rut Depth (in)		Texture Depth (in.)		Texture Index
		OWT	IWT	IWP	OWP	(OWP/IWP)
1	I-5 Terwilligger	0.00	0.20	0.072	0.079	1.10
2	I-5 Salem	0.10	0.25	0.085	0.081	1.10
3	1-5 Grants Pass	0.00	0.10	0.085	0.073	0.85
4	I-84 Pendelton	0.20	0.10	0.099	0.098	0.99
5	US 97 Bend	0.20	0.25	0.054	0.068	1.26
6	OR 138-Diamond Lake	0.35	0.25	0.051	0.054	1.06

Note: OWT = Outer Wheel Track; IWT = Inter Wheel Track; IWP = Inter Wheel Patch; OWP = Outer Wheel Patch

$$\text{Texture Index (TI)} = \frac{\text{Sand patch texture depth in areas outside the wheel path}}{\text{Sand patch texture depth in the wheel path areas}}$$

In fact, in this equation if:

TI< 1 : it can be assumed that the aggregates are wearing faster than the mix matrix, and, if

TI> 1 : it can be assumed that the mortar and the finer particles surrounding the larger aggregates wear faster, exposing the aggregate particles.

2.2.5 Binder characteristics

Although the binder in a mix does not seem to have a direct role in studded tire wearing, its adhesion and stiffness properties will have a major role in keeping the aggregate particles to the road surfacing. Enhanced adhesion properties and reduced stiffnesses would help to prevent or delay the "stone picking up" problem.

2.2.5.1- Adhesion

A binder with good adhesion properties that has well coated the aggregate particles, should be able to keep the mix components together. In these conditions the integrity of the mix would be maintained and problems such as aggregate stripping will be prevented.

The stripping itself is a major problem for road pavements when a continuous wet conditions prevails. Fig. 2.9 shows the schematics.

By enhancing both the adhesion and anti stripping properties of bituminous binders, the adverse actions of the studded tires in picking up stones from road surfacing will be reduced.

2.2.5.2 Stiffness

In cold temperatures bituminous binders get stiff and brittle. If the stiffness of the binder gets very close to thermal cracking conditions, the hammering action of the studded tires might break the mix apart. Fig. 2.10 shows an exaggerated schematic of excessive binder stiffness conditions.

The use of softer binders (if the stiffness values could meet the high temperatures in summer

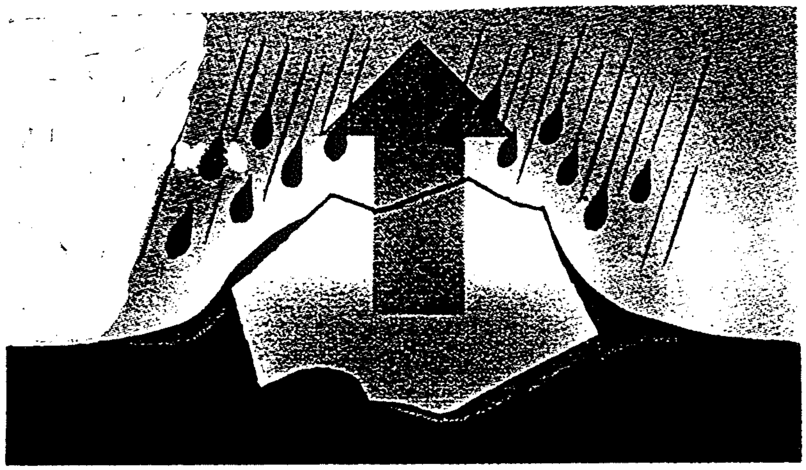


Fig. 2.9. Presence of water and the aggregate stripping problem

Fig. 2.10. Schematics of the excessive binder stiffness conditions

conditions) or polymer modified binders that could reduce the winter stiffnesses would be beneficial to prevent the above problems.

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APPENDIX A

SUMMARY OF AGGREGATE WEAR TESTS

AGGREGATE WEAR TESTING

TEST	*DESCRIPTION*

Los Angeles

TITLE:
Abrasion resistance of aggregates

TEST OUTLINE:
- 500 rev., material removed and sieved on No. 12.
- % passing this sieve is reported as wear

COMMON SPECIFICATION:

< 30% wear	→	use in surface
< 35% wear	→	use in base
< 45% wear	→	use in subbase
> 45% wear	→	not use

Micro-Deval

TITLE:
Abrasion resistance of aggregates

TEST OUTLINE:
- Samples soaked
- Placed in jar with 2 l of water, 5 kg of 9.5 mm steel balls
- Revolved at 100 rpm for 2 hours
- % passing 1.18 mm sieve is expressed as % loss

Aggregate Abrasion

TITLE:
Aggregate abrasion resistance

TEST OUTLINE:
- 16 pieces of approximately 8 mm aggregates

- Aggregates are glued to a card
- placed on a circular table on which a steel abrader is rotated over in the presence of grit.
- After a specified numbers of revolutions the weight loss is measured.

Ball Mill

TITLE:
- wearing resistance of aggregate

TEST OUTLINE:
- Single size crushed aggregates (11.2-16.0 mm)
- Placed in a rotating steel drum containing two liters of water and 7 Kg of steel balls & rotated for 5400 times.
- The % loss is determined (material less than 2 mm)

SPECIFICATION:
The Finnish standards have classified aggregates according to their Ball mill values as follows:

Class	**Ball mill value**
I	<7
II	<10
III	<14
IV	<17

S KR

TITLE:
wearing resistance of paving mixes under the action of studded tires.

TEST OUTLINE:
- Three studded rubber wheels are run around the outside of an asphaltic concrete core.
- The test is run at 5 C & for a specified number of revolutions.
- The percentage weight loss is determined.

SPECIFICATION:

- Finland specifies various levels of test values for different levels of traffic as follows:

Pavement class	***SKR***	**ADT/lane**
1	<25	>10000
2	25-40	5000-10000
3	40-60	1500-5000
4	>60	<1500

REPORT ON MINERALOGY OF ASPHALT AGGREGATE FROM SELECTED OREGON ROADS

Prepared for the Oregon Department of Transportation Research Unit
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December 5, 1996

Introduction

Background

Seven aggregate samples, taken from highway asphalt at various Oregon locations, were supplied to the Albany Research Center (ALRC) of the U. S. Department of Energy by the Research Unit at the Oregon Department of Transportation (ODOT). Each sample consists of four to seven rock specimens. Mineralogical studies, documentation of phases that affect competence as asphalt aggregate, photomicrographs of representative microtextures, and placement of the specimens into two aggregate classification systems were requested by ODOT. Summaries of the classification systems were provided to ALRC researchers by ODOT and are included as part of this report.

Methods

Macroscopic examination and transmitted light microscopy were used to determine the rock types and mineralogy. Mineral percentages were estimated visually under the microscope. Selected specimens were photographed using secondary electron imaging and backscattered electron imaging on a scanning-electron microscope (SEM).

Minerals reported

The minerals listed in this section are those identified in the specimens examined. They do not necessarily represent the full range of minerals present in the aggregate at the various sample sites. For reference and interpretation purposes, chemical formulae and Mohs' hardnesses (H) are given for each of the minerals.

Mohs' hardness scale:

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Orthoclase
7. Quartz
8. Tourmaline
9. Corundum
10. Diamond

Silica:

Quartz - SiO_2; (H = 7)
Chert - microcrystalline SiO_2; (H » 7)

Feldspars:

Plagioclase feldspars - contain different proportions of two molecules: albite ($NaAlSi_3O_8$) and anorthite ($CaAl_2Si_3O_8$)

Labradorite - contains 30 to 50% albite and 50 to 70% anorthite; (H = 6-6½)

Oligoclase - contains 70 to 90% albite and 10 to 30% anorthite; (H = 6-6½)

Albite - the sodium-rich end member of the plagioclase group; (H = 6-6½)

Orthoclase and microcline - $KAlSi_3O_8$ - they have different crystal structures; (H = 6-6½)

Ferromagnesian silicates:

Pyroxene family minerals:

Augite - $(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$; (H = 5½-6)

Pigeonite - $(Mg,Fe,Ca)(Mg,Fe)Si_2O_6$; (H = 6)

Olivine - generic composition $(Fe,Mg)_2SiO_4$. Most olivine seen in these samples is richer in Mg than Fe; (H = 7).

Crysolite - contains between 70 and 90% of the Mg_2SiO_4 molecule in the mineral with the remainder Fe_2SiO_4; (H = 7)

Amphibole family minerals:

Actinolite - $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$; (H = 5-6)

Hornblende - $NaCa_2(Mg,Fe,Al)_5(Si,Al)_8O_{22}(OH)_2$; (H = 5-6)

Oxides:

Hematite - Fe_2O_3; (H = 5-6; softer in massive, earthy varieties)
Magnetite - Fe_3O_4; (H = 5½-6½)
Ilmenite - $FeTiO_3$; (H = 5-6)
Goethite - $FeO(OH)$; (H = 5-5½)
Limonite - a general term for hydrous iron oxides
Manganese oxides - general term (H = 2-6 for massive, earthy varieties)

Micas and other phyllosilicates:

Muscovite - $KAl_2(AlSi_3O_{10})(OH)_2$; (H = 2½-4)
Biotite - $K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$; (H = 2½-3)
Chlorite - $(Mg,Fe,Al)_6(Al,Si)_4O_{10}(OH)_8$; (H » 2-3)

Clay - This generic term is used to indicate the presence of fine-grained alumino -silicate minerals. They have formed within the samples as a result of chemical alteration of pre-existing minerals, or were formed elsewhere, physically transported and deposited on the external surfaces of these samples. The identities of the clays found in the samples are known by recognizing their precursor minerals. Most of the clays are formed during alteration of feldspar minerals and are most likely to be kaolinite ($Al_2Si_2O_5(OH)_4$), not swelling clays. Kaolinite has a hardness of 2-2½.

Other minerals (present in trace amounts):

Apatite - $Ca_5(PO_4)_3(Cl,F,OH)_3$; (H = 5)
Sphene - $CaTiSiO_5$; (H = 5-5½)
Zircon - $ZrSiO_4$; (H = 7½)

Rock Textures

Basalt and gabbro samples have the same chemistry, but gabbro mineral grains are larger than those in basalt. Granite, syenite, and diorite specimens have similarly coarse grains. Representative grain sizes were measured for some samples and are given in descriptions of texture.

In igneous rocks that have distinctly bimodal grain sizes, the larger crystals are called phenocrysts, and the portion consisting of smaller grains is the groundmass. If more than 10% phenocrysts are present, the texture of the rock is referred to as porphyritic.

Figures

SEM photomicrographs are found in a section at the end of the report. Some have been enhanced to emphasize micotextural features. References to photos are made within the sample descriptions, and may include photos of samples with similar textures in addition to photos of the specific sample being described.

Results of Sample Analyses

Sample 1: 5 specimens (ALRC #ME3626)

Specimens A, B, C, and E: Vesicular Basalt

Mineralogy:

Fe and Ti oxides	30 - 50%
labradorite (feldspar)	40 - 50
olivine	1 - 10
augite (pyroxene)	Trace - 3
clay	5 - 10
devitrified glass	Trace - 3

Texture:

Pore space, in the form of vugs (gas bubbles), makes up significant portions of these specimens (figure 1). Specimens A and B have 20 - 30% vugs, specimen C 15 - 20% vugs, and E 25 - 35% vugs.

Feldspar is present both as crystals larger than the groundmass minerals (phenocrysts) and as fine-grained crystals in the groundmass. In specimen B, a porphyritic basalt, most of the feldspar is as phenocrysts. Most clay and much iron oxide are present as part of the fine-grained groundmass of the specimens (figures 2a and b).

Weathering, alteration, and factors affecting competence:

Exterior surfaces are coated with clay 0.1 mm or less in thickness. Interior vugs of specimens A, B, and E are also lined with this weathering debris. Fracture characteristics are pictured in figure 3.

Feldspar crystals are unaltered to slightly altered to clay. Ferromagnesian silicate mineral alteration is a source of some of the clay as well as some of the iron oxide (hematite). Other iron and titanium oxide minerals are primary.

These specimens have some decrease in strength and show a tendency to be slightly friable due to the clay in the groundmass.

Specimen D: Basalt

Mineralogy:

Fe and Ti oxides	15 - 20%
labradorite (feldspar)	60 - 70
olivine	3 - 5
augite (pyroxene)	3 - 5
clay	Trace

Texture:

Specimen D has a few percent of rounded vugs. In addition, about 5% of its volume is as much smaller, irregularly shaped pores with angular mineral crystals protruding into them.

Weathering, alteration, and factors affecting competence:

Feldspar grains are unaltered to slightly altered. This specimen differs from the others in this sample primarily in the relative amounts of feldspar, clay, and iron-titanium oxide minerals. Because there is less clay in this specimen it will probably show greater strength than the others in the same sample.

Models for Sample 1. All five specimens in this sample are basalt, and four can be called vesicular basalts. Differences between the specimens are in relative percentages of pore space (vugs), and quantities of Fe-Ti oxides relative to feldspars.

All except specimen D fit Model 7, Porous materials, on the table of aggregate models. Between the vugs, the surfaces of these specimens are rough when broken (Figure 3), and fit the Differential crystalline model (Model 3). Specimen D also is best placed into Model 3. In the classification system based on surface charges, all specimens are within the basalt field, although specimen D is at the low SiO_2 end of the basalt field because of its higher feldspar content.

Sample 2: 5 specimens (ALRC #ME3627)

Specimens A and B: Granite

Mineralogy:

quartz	35 - 40%
orthoclase and albite (feldspar)	50 - 60
chlorite/biotite	2 - 3
muscovite	1 - 2
zircon	Trace

Texture:

Most mineral grains are between 0.5 and 0.75 mm, although feldspar crystals can be up to 1 cm in length. Feldspar is primarily orthoclase; very small amounts of albite are also included.

Weathering, alteration, and factors affecting competence:

Part of a river cobble, its rounded surface has an alteration rind of iron oxide staining 1 to 1.5 mm thick. This was inherited from the time when it was a river cobble; the iron staining does not occur on other exterior surfaces.

Feldspar minerals are moderately altered to clays (as in figure 4). These do not change the strength of the rock much, but further weathering may do so.

Specimen C: Granite

Mineralogy:

quartz	35 - 40%
orthoclase and albite (feldspar)	50 - 60
chlorite/biotite	2 - 3
muscovite	1 - 2
zircon	Trace
magnetite (iron oxide)	Trace

Chemistry and texture:

Similar to that of specimens A and B, except that about 10% of the feldspar is albite.

Weathering, alteration, and factors affecting competence:

Like that of specimens A and B.

Specimen D: Granite

Mineralogy:

quartz	30 - 40%
microcline (feldspar)	60 - 70
muscovite	Trace

Texture:

Coarse grain size. There are no dark minerals present.

Weathering, alteration, and factors affecting competence:

Like that of previous specimens in the sample. Figure 5 shows typical surface fracture patterns in samples containing coarse-grained feldspar. Regular, abundant fractures form many small promontories which are more prone to breakage than large, flat fracture faces.

Specimen E: Altered granite

Mineralogy and texture:

Mineralogy as in specimens A and B. Quartz and feldspars grains are of finer size than other specimens in sample.

Weathering, alteration, and factors affecting competence:

Specimen has an alteration rim 1 mm thick, and iron-bearing minerals (biotite, magnetite) are oxidized throughout the specimen to earthy hematite. The feldspars are heavily altered to clay, and contain micropores of unknown origin (figure 6).

More intense feldspar alteration, with accompanying increase in clay content, gives this sample lower strength than specimens A through D. It is still relatively resistant to breakage.

Models for Sample 2. All specimens in the sample fit into the granite field on the surface charge classification system, and into Model 3, Differential crystalline, in the table of aggregate models. See figures 5, 10, and 11. Specimen E may have a tendency to lose grains with weathering and thus be more like Model 4, Sacrificial crystalline.

Sample 3: 6 specimens; all appear different (ME3628)

Specimen A: Quartz sandstone

Mineralogy:

quartz	95 -100%
hornblende (amphibole)	Tr - 1
clay	Tr - 1
limonite (iron oxide)	Tr - 1

Texture:

Grains are less than or equal to 1 mm in size. The quartz grains are strongly cemented with quartz, and traces of iron oxide.

Weathering, alteration, and factors affecting competence:

Most of the exterior surface is coated with weathering debris (clay and limonite). There is no alteration rind.

The pattern in which grains fracture in this specimen reflect the strength of bonding in quartz (figure 7). This rock strongly resists breaking.

Model for sample 3, specimen A. This specimen falls near the far right end of the classification system based on surface charges (silica field), and in Model 2, Monolithic crystalline, on the table of aggregate models. Also see figures 9a and b, of a similar SiO_2-rich sample.

Specimens B and C: Basalt

Mineralogy:

oxides of Fe, Ti, Mn	30 - 40%
labradorite (feldspar)	40 - 50
augite (pyroxene)	10 - 20
volcanic glass	1 - 2

Chemistry and texture:

Grains are less than 0.1 mm in size. Oxides are mainly non-magnetic (probably hematite, ilmenite, and manganese oxides).

Weathering, alteration, and factors affecting competence:

Specimen has a thin coating of clay weathering debris, and a mild alteration rind 1 mm thick. Feldspar grains are slightly altered.

Model for sample 3, specimens B and C. These specimens fall within the basalt field on the classification system based on surface charges. They also fit into Model 3: Differential crystalline, on the table of aggregate models. See figures 2, 12, and 13 for similar samples.

Specimen D: Basalt

Mineralogy:

oxides of Fe and Ti	20 - 30%
labradorite (feldspar)	20 - 30
augite (pyroxene)	15 - 20
olivine	15 - 20
volcanic glass	2 - 5
clay	3 - 5

Texture:

This specimen is porous under the binocular microscope. Its grains are somewhat larger than those in specimens B and C.

About half of the oxides are opaque (magnetite and ilmenite); the other half are hematite.

Weathering, alteration, and factors affecting competence:

The specimen has no visible alteration rind, but is mildly weathered throughout.

Because of its porosity, the rock will be subject to physical weathering during freeze-thaw cycles. Grains pushed out of place during freezing will be easily plucked and the specimen will disaggregate.

Model for sample 3, specimen D. This specimen falls into the basalt field on the surface charge classification system, and will fit into Model 4: Sacrificial crystalline, on the table of aggregate models. See figures 2, 3, 12, and 13 for similar samples.

Specimen E: Silicified volcanic rock

Mineralogy:

augite (pyroxene)	< 5%
quartz	40 - 50
hematite (iron oxide)	30 - 40
clay	10 - 15

Texture:

Specimen is very fine-grained. Hematite permeates the silica, giving it a reddish cast in hand specimen and making the quartz nearly opaque microscopically.

Weathering, alteration, and factors affecting competence:

There is only slight alteration of surfaces of this specimen due to weathering. Because of the intergrown nature of the quartz crystals in this rock, it is very tough and durable, and resists breaking. See figures 9a and b.

Model for sample 3, specimen E. The specimen falls near the lower end of the sandstone field on the surface charge classification system (60% SiO_2). It also fits into Model 2, or Monolithic crystalline, because the hematite is dispersed throughout the quartz, and the sample has uniform hardness.

Specimen F: Quartz diorite

Mineralogy:

quartz	50 - 60%
albite (feldspar)	5 - 10
actinolite (amphibole)	20 - 30
clay	3 - 5
chlorite	5 - 10

Texture:

The mineral grains in this specimen are from 0.5 to 5 mm in size, with feldspars being the largest. Microscopically, quartz crystal size varies widely, from very small intergrown crystals to large single crystals.

Weathering, alteration, and factors affecting competence:

The specimen has an alteration rind 0.1 to 0.2 mm in thickness, and interior alteration of actinolite to limonite. The feldspar mineral grains are pervasively clouded with clay minerals.

The mild alteration in this rock causes it to be slightly friable and will lead to plucking of grains.

Model for sample 3, specimen F. This specimen fits near the right end of the diorite field on the surface charge classification system. It can be described by Model 4: Sacrificial crystalline, on the table of aggregate models. See figure 8 for a similar sample.

Sample 4: 7 specimens (ALRC #ME3629)

Specimen A: Silicified arkosic sandstone

Mineralogy:

chert (microcrystalline SiO_2)	60 - 65%
quartz	10 - 20
albite and orthoclase (feldspar)	20 - 25
clay	Trace
iron oxides	Trace

Texture:

Broken, rounded river cobble.

Weathering, alteration, and factors affecting competence:

Only surficial weathering is evident. A physically tough rock that resists breaking.

Model for sample 4, specimen A. According to the composition of this specimen, it fits Model 3, Differential crystalline, on the table of aggregate models. However, because of its fine grain size and the similar hardnesses of its minerals, it may tend to be like Monolithic crystalline aggregate (Model 2). In the classification scheme based on surface charges, it will be near the right end of the graph, at approximately 90% SiO_2.

Specimens B and C: Syenite porphyry

Mineralogy:

orthoclase (feldspar)	55 - 60%
actinolite (amphibole)	25 - 30
chlorite	5 - 10
quartz	2 - 3
clay	Trace

Texture:

Weathered coarse-grained, porphyritic igneous rock. Most feldspar is as coarse grains (phenocrysts); a small amount is mixed with the clay and fine-grained quartz in the groundmass.

Weathering, alteration, and factors affecting competence:

Abundant iron staining on the exterior, somewhat less at grain boundaries throughout the interior of the specimen. Actinolite alteration is the source of some of this oxidized iron. Feldspar is moderately to intensely altered to clay.

The degree of alteration gives this rock lower strength than unaltered syenite. Evidence of iron oxide transport between mineral grains indicates that grain bonding may be affected, and minerals will have a tendency to pluck.

Model for sample 4, specimens B and C. Specimens fall near the SiO_2-rich end of the diorite field on the surface charge classification system. On the table of aggregate models, these rocks fit into Model 3: Differential crystalline, with some tendency to behave as Model 4, Sacrificial crystalline (see figure 8).

Specimen D: Alaskite granite

Mineralogy:

oligoclase and orthoclase (feldspar)	50 - 60%
quartz	40 - 50
sphene	Trace
apatite	Trace

Texture:

Coarse-grained igneous rock.

Weathering, alteration, and factors affecting competence:

Exterior weathering is seen in iron staining from surface inward 2 - 3 mm. The feldspar grains are unaltered.

Surface characteristics that lead to differential behavior of quartz and feldspar are shown in figure 10.

Model for sample 4, specimen D. This specimen falls in the granite field of the classification system based on surface charges. It also fits into Model 3: Differential crystalline, on the table of aggregate models. Also see figure 11 for a similar sample.

Specimens E and F: Altered granite

Mineralogy:

These are similar to specimen D, except that approximately 5 - 10% dark minerals were present; they have been altered to hematite.

Texture:

Coarse grain size (1 - 4 mm).

Weathering, alteration, and factors affecting competence:

About 10% of the feldspars near the margins of the rock are completely replaced by clay. The remainder are moderately to intensely altered to clay. There is also manganese oxide staining on fracture surfaces.

These rocks will have lower strength than specimen D, due to their higher clay content and iron oxide coatings on individual mineral grains.

The characteristics of fracture surfaces of quartz and feldspar in this specimen are shown in figure 11.

Model for sample 4, specimens E and F. Specimens fall within the granite field on the classification system based on surface charges. They fit into Model 3 or 4: that is, where iron oxide is less abundant, they behave as Differential crystalline, but where iron oxides coat individual grains, they will be prone to plucking and may behave as Sacrificial crystalline.

Specimen G: Silicified rock with quartz veins

Mineralogy:

quartz	65 - 70%
chert	8 - 10
oligoclase (feldspar)	15 - 20
biotite/chlorite	3 - 5

Texture:

Rock has quartz veins running through it.

Weathering, alteration, and factors affecting competence:

This specimen has an alteration rind 2 - 3 mm thick that is marked by iron oxide staining. Some of the fractures exposed on breaking are lined by limonite (iron oxide). The rock has been silicified.

This is a hard rock that resists breaking, due to the intergrown nature of the quartz crystals and the fine-grained chert.

Model for sample 4, specimen G. Strictly speaking, this specimen fits into Model 3: Differential crystalline, on the table of aggregate models; however, the low percentage of minerals other than quartz would make it tend toward Model 2: Monolithic crystalline. On the surface charges classification system, this specimen is at the low end of the silica field (90%+ SiO_2). See figures 9a and b for a similar sample.

Sample 5: 5 specimens (ALRC #ME3630)

Specimens A, D, and E: Fine-grained basalt

Mineralogy (of unweathered interior):

quartz	0 - 5%
magnetite and hematite (opaque iron oxides)	5 - 10
limonite and hematite (earthy iron oxides)	5 - 10
labradorite (feldspar)	20 - 30
undifferentiated ferromagnesian silicates	40 - 50
clay	2 - 3

Texture:

Grains are all less than 0.1 mm in size, with the feldspars and opaque iron oxides having the largest dimensions. Earthy iron oxides, ferromagnesian silicates, and clay are mixed in the finer groundmass of the rock.

Weathering, alteration, and factors affecting competence:

There is a narrow coating (<0.1 mm) of goethite on 50-75% of exterior surfaces. An alteration rind is formed on 40-100% of surfaces and has a thickness of 1 to 1.5 mm; it consists of increased clay and limonite particles in the basalt. The feldspar grains are unaltered to slightly altered to clay.

Due to a low degree of pervasive weathering, the minerals interlock tightly with one another and the specimens are hard. They have strong resistance to breakage with a geologic hammer.

Specimen C: Weathered basalt

Mineralogy (of interior of rock):

magnetite and hematite (opaque iron oxides)	10 - 15%
limonite and hematite (earthy iron oxides)	5 - 10
labradorite (feldspar)	15 - 20
undifferentiated ferromagnesian silicates	30 - 40
clay	20 - 30

Texture:

Mineral sizes in this specimen are similar to those in specimens A, D, and E, although the increase in clay means there is an overall decrease in the average grain size.

Weathering, alteration, and factors affecting competence:

A 1.5 to 2 mm thick weathering rind, heavily contaminated with limonite and clay, has formed on 50% of surfaces. On other surfaces, there has been less of an increase in these minerals. The specimen's groundmass is moderately to intensely altered to clay (figure 12), and feldspar phenocrysts show distinct clay alteration (figures 14a and b).

The degree of weathering in the groundmass causes this rock to break far more easily than specimens A, D, and E; it is slightly friable, crumbling on breakage rather than maintaining 4 or 5 competent pieces.

Specimen B: Gabbro

Mineralogy (of unweathered interior):

magnetite and hematite (opaque iron oxides)	5 - 10%
labradorite (feldspar)	40 - 50
augite (pyroxene)	40 - 50
undifferentiated ferromagnesian silicates	1 - 2
earthy iron oxide and clay	1 - 2

Texture:

Grains of feldspar and augite in this sample may be up to 1 mm in largest dimension, with opaque iron oxides about 0.1 mm. The remainder of the minerals are much smaller.

Weathering, alteration, and factors affecting competence:

A weathering rind about 1 mm thick is present in this specimen. In the interior, augite has been somewhat altered to a combination of iron oxide and clay minerals; the feldspars are clear and show minimal alteration.

This specimen is only slightly altered, with the exception of exposed surfaces. Constituent minerals are interlocked, and it shows strong resistance to breakage.

Model for sample 5. All of these specimens fit into the basalt composition field of the surface charge classification system, between 40% and 50% SiO_2. All except specimen C will behave as Model 3, Differential crystalline, on the table of models. Specimen C will be more like the Sacrificial crystalline model (4). Also see figures 2 and 3 for other similar samples.

Sample 6: 5 specimens (ME3631)

Specimens A and B: Basalt

Mineralogy:

oxides of Fe and Ti	20 - 30%
labradorite (feldspar)	40 - 50
augite (pyroxene)	20 - 30
devitrified glass	5

Texture:

Most feldspars are tiny microlites in the groundmass. A few percent are larger phenocrysts.

Weathering, alteration, and factors affecting competence:

Specimens have no consistent, recognizable alteration rind. Interior surfaces have some limonite staining on them. There is only slight clay alteration of the feldspars.

Rock is brittle and breaks readily. The degree of alteration is low. See figure 13.

Specimens C and E: Basalt

Mineralogy:

oxides of Fe and Ti	60 - 70%
labradorite (feldspar)	10 - 20
ferromagnesian silicates	5 - 10
devitrified glass	5 - 10

Texture:

Fine grained igneous rock. A few percent of amygdales (filled vugs) filled with devitrified glass are present. Ferromagnesian silicates were not identified conclusively because of their fine size.

Weathering, alteration, and factors affecting competence:

Low degree of weathering and alteration.

Specimen D: Basalt

Mineralogy:

oxides of Fe and Ti	50 - 60%
labradorite (feldspar)	20 - 30
augite (pyroxene)	15 - 20

Texture:

The feldspar minerals are primarily microlites, although a few percent are phenocrysts.

Weathering, alteration, and factors affecting competence:

Feldspars are unaltered to slightly altered. There is no indication of alteration sufficient to affect rock hardness.

Model for sample 6. All the specimens in this sample are basalts. Variations in grain size, pore space, and the relative percentages of minerals are the primary differences in the specimens. All fall into the basalt field on the system of classification by surface charges; all fit into Model 3: Differential crystalline, on the table of aggregate models, although some will probably be prone to losing grains during weathering and wear. This behavior would be more like Model 4: Sacrificial crystalline.

Sample 7: 5 specimens (ME3632)

All specimens: Gabbro

Mineralogy:

labradorite (feldspar)	40 - 50%
pigeonite (pyroxene)	30 - 40
oxides of Fe and Ti	10 - 15
crysolite (olivine)	2 - 3

Texture:

Coarse-grained igneous rock.

Weathering, alteration, and factors affecting competence:

There is a surficial accumulation of weathering debris on these specimens. The specimens are very tough and resist breakage.

Model for sample 7. These specimens fall into the basalt field on the surface charges classification system. They will behave according to Model 3: Differential crystalline, on the table of aggregate models. See figure 5 for a sample with similar texture.

Research Study Proposal for

The Role of Aggregates in Pavement Surfaces in Resisting to Studded Tire Wearing

SPR Project #5273

Phase II

prepared for

Oregon Department of Transportation
Engineering Services Section
Salem, OR 97310

December 1996

1.0 Identification

1.1 Title

The Role of Aggregates in Pavement Surfaces in Resisting to Studded Tire Wearing

1.2 Organizations Sponsoring Research

Oregon Department of Transportation
Engineering Services Section
2950 State Street
Salem, OR 97310
503-986-2700

Federal Highway Administration
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Washington, D.C. 20590

1.3 Principal Investigators

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Department of Civil Engineering
Oregon State University
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And,

1.4 Technical Advisory Committee (TAC)

Robert Edgar, Research Unit
Jeff Gower, Pavements
Gary Thompson, Operations
Doug Tindall, Operations
Chris Bell, OSU
Jim Huddleston, APAO
Randall Davis, Region 4
Anthony Boesen, FHWA
Amir Kavussi, OSU

2.0 Problem Statement

Rutting caused by studded tire wear has become a major issue in Oregon. In preliminary studies it was found that among the various parameters the aggregate type and quality have the most important role in pavements resisting to wear. Rutting is caused by aggregate wearing or aggregate picking up (or both) from the road surfacing. The variation of aggregates, mix type, traffic and climatic conditions have brought variations in surface wearing in Oregon highways. Wear ruts in addition to damaging roads and increasing the repairing costs, are major hazards to the traffic safety.

3.0 Objectives

3.1 Overall Objectives

The overall objectives of the research were the following:

1. To perform rut measurements of some selected sites in Oregon road network,
2. To identify the dominant factors that affect the road wearing,
3. To evaluate different aggregate test methods, both from current ODOT specifications and other potential tests, which could indicate the wearing resistance of aggregates,
4. To evaluate aggregate properties that reduce wear caused by studded tires, and
5. To evaluate different aggregate sources in Oregon for wear resistance purposes.

3.2 Specific Objectives

The specific objectives of this study was first; to recognize potential test methods which provide a timely prediction of wear resistance of aggregates. And second, to characterize the wear resistance of different aggregate sources in Oregon. In light of the objectives, the following queries were made:

1. To recognize the distress type and extent brought about by studded tires on Oregon highways,
2. To characterize the wearing resistance of the Oregon aggregates,
3. To perform a detailed petrographic study of different aggregate sources,
4. To establish potential laboratory test methods for wearing characterization, and
5. To propose a specification for aggregate testing with regard to wear resistance purposes.

4.0 Background and Significance of Work

Unlike a number of states which prohibit the use of studded tires, their use is allowed in Oregon with some restrictions. Current Oregon legislation restricts the sales of tires which contain studs of over 1.5g (i.e. steel studs) and allows the studded tires to be used only from November 1 through April 30 (ORS 815.165 and ORS 815.167).

The primary damage caused by studded tires is the wearing of road surfacing. In asphalt pavements the deterioration is caused by either wearing of aggregates or by the debounding and

picking up of aggregates from the road surfaces; although the damage caused by wearing of aggregates is seen more frequently. In PCC pavements, wear is also a problem but it does not exhibit much debounding and aggregate picking up distress.
In some high volume roads, the studded tire damage has caused rutting close to one inch deep. The wear ruts are observed in both asphalt and concrete pavements on Oregon highways; although rutting is greater in asphalt pavements. Rutting not only is a hazard to traffic safety but it weakens the pavement structure.

In order to predict the wearing of aggregates, the most widely practiced test method in the United States is the Los Angeles (LA) abrasion test. However, many researchers have confirmed that the correlation of LA abrasion with the wearing in the field is quite poor (*Smith, 1958 and Liu, 1981 and Meininger, 1994*). In this research methods of characterizing different aggregate sources in Oregon were also evaluated.

5.0 Benefits

The following benefits will result from this project:

1) In a detailed field investigation the various parameters affecting wear rutting will be presented,

2) A general characterization of Oregon aggregates will be performed and their resistance to wear will be studied in detail, and

3) A suitable test method for testing the wearing resistance of aggregates will be provided and specification limits will be proposed.

6.0 Implementation

The findings of this research will help in:

1) Recognition of studded tire wear in terms of the type and cause of damage, parameters affecting the wear, different tests for wear measurements and their suitability,

2) Characterizing various aggregates from different sources in Oregon,

3) Adopting one or more suitable test methods for quantifying the wear resistance of aggregates and pavement surfaces, and

4) Setting a specification proposal for mix design purposes.

The information will be documented in a report, which will assist the ODOT in implementing modifications that will reduce the wear of studded tires on pavements.

7.0 Work Plan

The following tasks will be conducted:

Task 1 - Identify the Studded Tire Rutting in the State

Pavements Unit has provided some rut data from different highways. In a detailed field investigation on these sites, the studded tire rutting will be distinct from deformation ruts which are generally produced by heavy truck loading.

Task 2 - Evaluate different Oregon Aggregate Sources

Aggregates from different sources, extended in different localities in the State will be sampled. The selection will be from those which have been used in roads during the past few years for which laboratory test results and field rut data are available.

Task 3 - Identify Aggregate Properties that Reduce Wear

A detailed petrographic study will be performed on some selected aggregates in order to find out the aggregate composition parameters that contribute the wear resistance.

Task 4 - Devise a suitable test method to measure wearing of different surfaces

A literature review of different surface wear tests will be conducted. Based on availability of the budget for equipment purchase a test equipment which can directly test surface wearing under wet conditions will be set up. Test method procedures and tentative specification limits for that will be provided.

Task 5 - Modify Oregon DOT's Aggregate Specifications

Recommendations on changes to the ODOT aggregate and mix design (if needed) specifications will be made. Consideration will be given to developing an aggregate and/or mix selection criteria based on their potential to resist wear.

Task 6 - Draft Final Report

The draft final report will be sent to the TAC for review by June 30, 1997. The final report will be published by August 15, 1997.

8.0 Staff and Budget Estimate

The study will be conducted by Amir Kavussi, Visiting Faculty at OSU, Department of Civil Engineering Rob Edgar, Research Coordinator of the Research Unit at ODOT. The Technical Advisory Committee (see section 1.4) will oversee the project.

This project will be funded under the SPR Program with FY'97 funds.

STAFF AND BUDGET ESTIMATE

	# ATE DAYS	COST/DAY	# TE2 DAYS	COST/DAY	TOTAL
TASK 1	30	$70	5	$100	$2,600
TASK 2	30	$70	5	$100	$2,600
TASK 3	30	$70	5	$100	$2,600
TASK 4				Lump Sum	$4,000
TASK 5	30	$70	5	$100	$2,600
TASK 6	30	$70	5	$100	$2,600
SUBTOTAL					17,000
40% OVERHEAD					6,800
TOTAL					$23,800

9.0 Time Schedule

TASK	FY'96 DECEMBER	FY'97 JANUARY	FY'97 FEBRUARY	FY'97 MARCH	FY'97 APRIL	FY'97 MAY
TASK 1						
TASK 2						
TASK 3						
TASK 4						
TASK 5						
TASK 6			DRAFT	REVIEW & REVISE	PUBLISH & DISTRIBUTE	

Draft study proposal

PILOT PROJECT ON I-5

(SPR 5273, Phase 3)

1- Introduction

A pilot project was performed on a section of Interstate 5 between mileposts 276 and 279 on the northbound lanes. This consisted of overlaying the existing portland cement pavement with various SMA and class "F" asphalt mixes. The purpose of the project is to identify an inexpensive technique to repair the wheel path ruts which are mainly caused by studded tires.

2- Pavement problems on the section

In a preliminary inspection of the road section, the following problems were recognized:

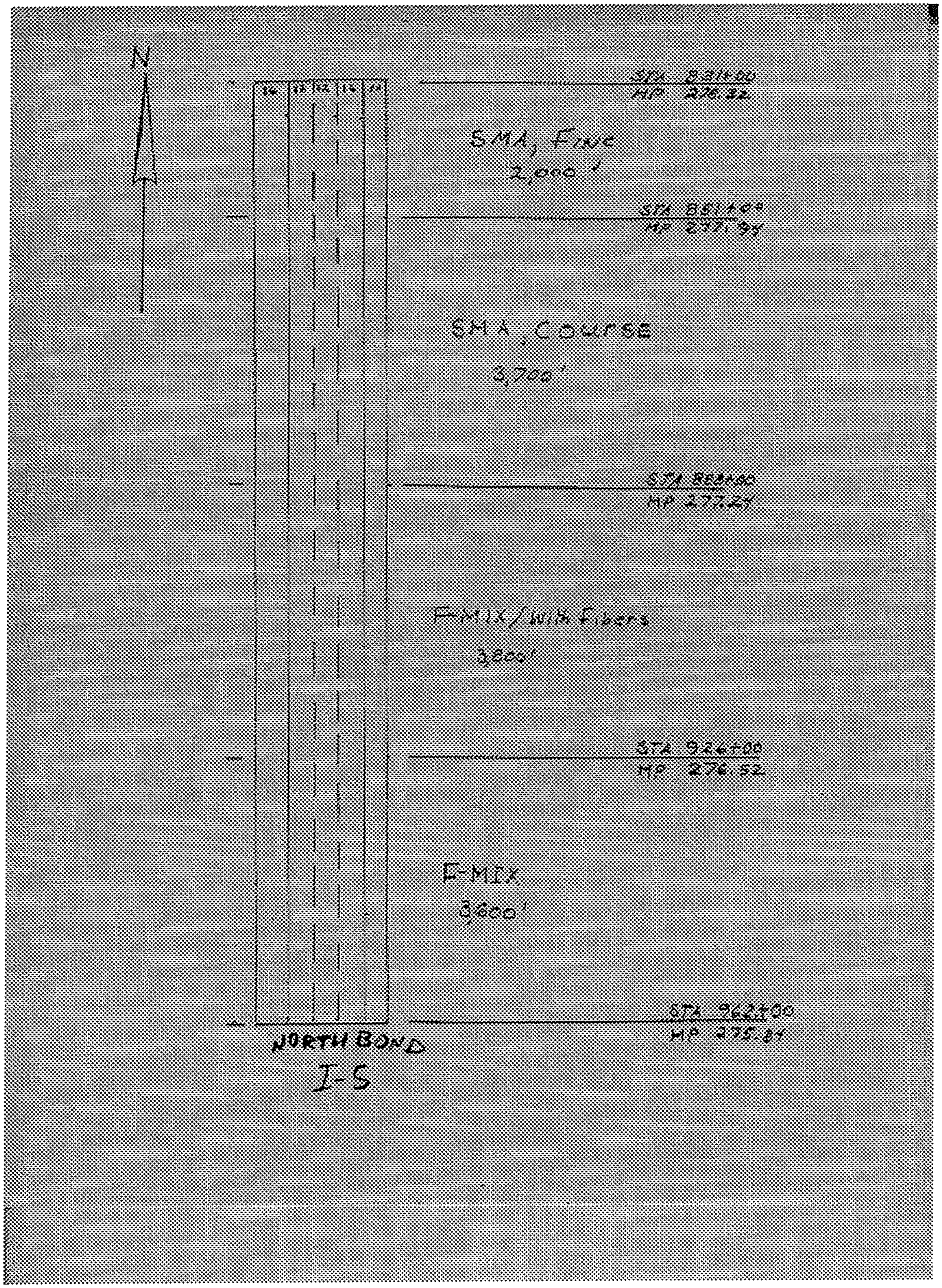
- Wear rutting in the wheel path areas (especially in the middle lane),
- Regular transverse cracking at intervals of 2 to 5 feet. These are mainly shrinkage cracks (some interconnected),
- Joint cracks at bridge-road intersections (impact panels and bridge sections joints), and
- Construction cracks (both longitudinal and transverse cracking).

From the above problems the first one is considered to be a great hazard for traffic safety while the others seem to have less impacts.

3- Overlays

The three miles overlay consisted of a regulating asphalt layer of Oregon "F mix". The top layer consisted of the following (as per attached map):

Section 1- From MP 275.84. to MP 276.52 (3600 ft.): 2 inches of F mix
Section 2- From MP 276.52 to MP 277.24 (3800 ft.): 2 inches of F mix containing Fibers
Section 3- From MP 277.24 to MP 277.94 (3700 ft.): 1.5 iches of SMA (Coarse)
Section 4- From MP 277.94 to MP 278.32 (2000 ft.): 1 inch of SMA (Fine)


N
STA 831+00
MP 276.22
SMA, Fine
2,000'
STA 851+00
MP 277.94
SMA, Course
3,700'
STA 888+00
MP 277.24
F-MIX/with Fibers
3,800'
STA 926+00
MP 276.52
F-MIX
3,600'
STA 962+00
MP 275.84
NORTH BOND
I-5

4- OBJECTIVES

- Monitor the performance of each section (i.e. each mix type)
- Establish a laboratory test method that can simulate field wearing
- Determine the most appropriate mix that can better resist studded tire wearing

5- WORK PLAN

In order to evaluate the effectiveness of the different techniques and monitor the project the following data could be collected:

5-1- Before construction

- Transverse profiles in some selected sections (to measure the rut depth, width and the distance between ruts) and,
- Cracking measurements at bridge joints (location and width).

5-2- During construction

- Note of the climatic conditions (e.g. air and surface temperature, humidity, wind speed, etc.),
- Mix temperature measurements (at asphalt plant, in front of paver and during compaction),
- Taking samples from the different mixes,
- Monitoring compacting process (i.e. rolling pattern, loading weight, etc), and
- Nuclear gage readings (by Pavement Services Unit),
- Lift thickness, and
- Interview inspectors and plant, paver and roller operators regarding mix and handling characteristics
- Summerize all field test results including the mix compositions (i.e. AC content, aggregate gradation, voids, PBA-6, etc.)

5-3- After construction

5-3-1- Field study

- Note climatic conditions (monthly rainfall, temperature variations, etc),
- Note traffic volumes and determine studded tire usage,
- Road profile measurements for rutting and ridding quality purposes (i.e. IRI). This should be done at monthly intervalls during the winter period,
- Other avement distress assessment at different time intervals (e.g. every 12 months), and
- Skid resistance measurements at three or six months intervals

5-3-2- Laboratory evaluation

- Set up a laboratory wearing test (possibly: ASTM-C 779, if not: ASTM-C 944)
- Test laboratory prepared samples with the same compositions as in the field and cores taking from field (all at wet conditions with some at dry)

5-4- Reports

1- Construction report
2- Interim report
3- Final report.