DOWEL BAR RETROFIT

I-90, Kachess River to Yakima River

WA-RD 346.1

Post-Construction Report
February 1994

Washington State Department of Transportation

Washington State Transportation Commission
Transit, Research, and Intermodal Planning (TRIP) Division
in cooperation with the U.S. Department of Transportation
Federal Highway Administration

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16. ABSTRACT

This report documents the rehabilitation of a faulted Portland cement concrete pavement with epoxy coated dowel bars. The dowel bars were installed parallel with centerline at each joint to reestablish panel to panel interlock. The construction project also included the trial installation of tied PCC shoulders as a means of stabilizing the panels. Diamond grinding was also included in the contract to bring the retrofit pavement back to a smooth longitudinal profile.

Early performance results indicate that the retrofit dowel bars are performing better than the tied shoulders with regard to preventing the reoccurrence of faulting.

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DOWEL BAR RETROFIT

I-90
Kachess River to Yakima River
Contract 4107

Post-Construction Report
Federal Aid No. IR-90-2(167)
Experimental Feature WA 92-04

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and in cooperation with
US Department of Transportation
Federal Highway Administration
February 1994

DISCLAIMER

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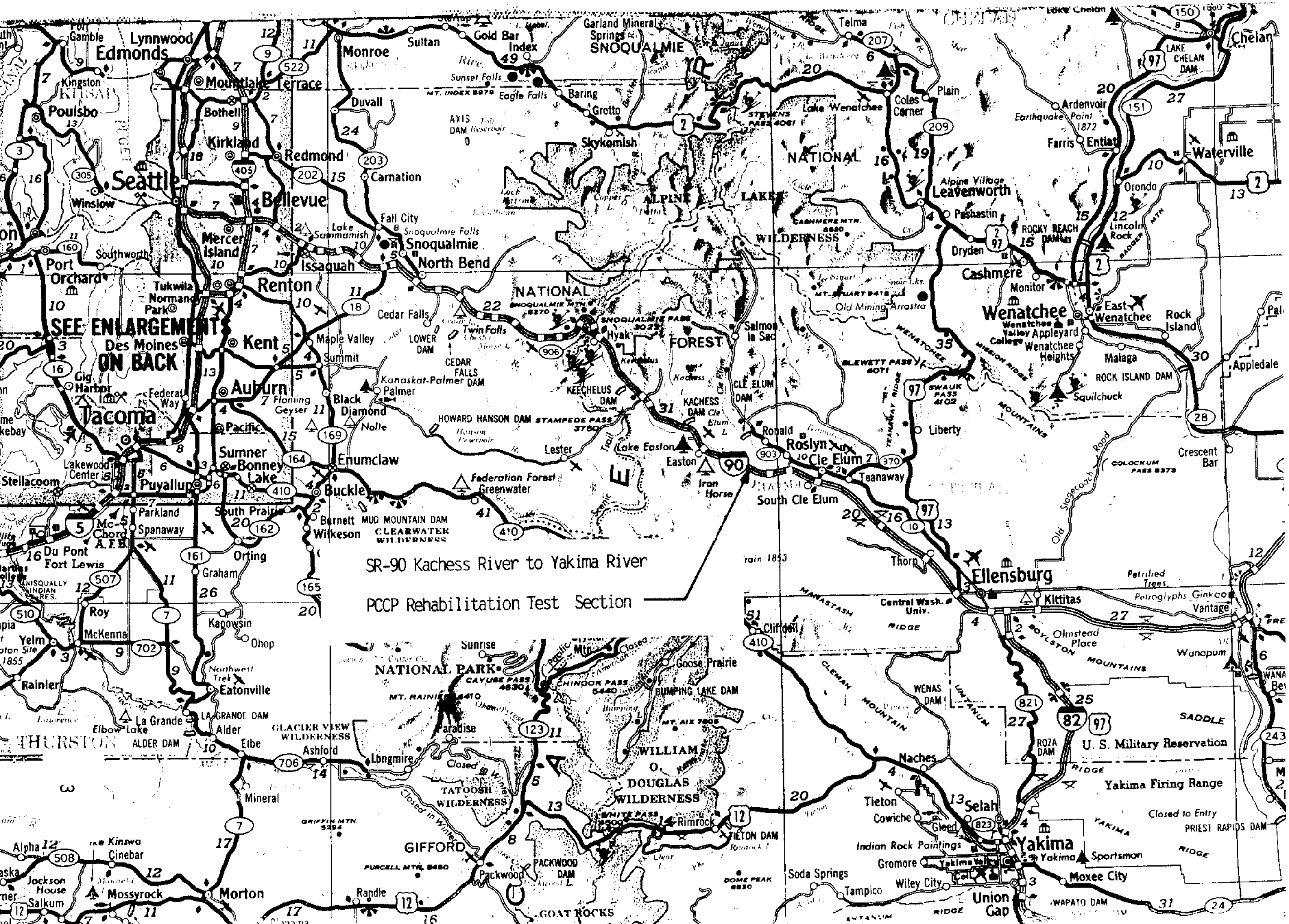

SR-90 Kachess River to Yakima River
PCCP Rehabilitation Test Section
SEE ENLARGEMENTS ON BACK
Seattle
Tacoma
Edmonds
Lynnwood
Bellevue
Kirkland
Redmond
Renton
Kent
Auburn
Puyallup
Issaquah
Snoqualmie
North Bend
Enumclaw
Buckley
Ellensburg
Cle Elum
Roslyn
Easton
Wenatchee
Leavenworth
Cashmere
Yakima
Selah
Union Gap
Naches
Morton
Packwood
SNOQUALMIE
NATIONAL
FOREST
ALPINE LAKES WILDERNESS
NATIONAL PARK
WILLIAM O. DOUGLAS WILDERNESS
U. S. Military Reservation
Yakima Firing Range

OBJECTIVE

Washington, as other states, is nearing the completion of the Interstate Highway construction program. This extensive highway building program has taken over thirty years to complete. Since the pavement design period for this system was only twenty years, Washington, like all states, is experiencing an ever increasing need to rehabilitate the pavements constructed in the early years of the Interstate program. A large and ever increasing proportion of the Interstate PCC pavement system is past the design age of 20 years (as of 1993 over 50 percent, or approximately 1,050 lane-miles (650 lane-km), of Interstate PCC pavements have been in service for 20 or more years).

To date, the main forms of distress for the Interstate PCC pavements in Washington State has been in the form of joint faulting and longitudinal cracking in the wheel paths. Typically, in areas with base materials consisting of asphalt treated base or selected gravel borrow (pea gravel) the slabs are distressed with longitudinal cracking but no significant faulting (0 to 1/8 inch (3 mm)). Though after minimal evaluation, it appears that the underlying ATB has a potential for stripping and may lead to faulting of the PCC joints.

The longitudinal cracking found in Washington state appears to be load-related rather than caused by other factors, such as improperly sawed longitudinal joints. WSDOT's and California's experiences have shown that longitudinal cracking appears frequently in the inner wheel path, as well as the outer wheel path. Additional details of longitudinal cracking in PCC pavements may be obtained from References 1 and 2.

Of the PCC pavements that are fatigued (longitudinally cracked), the cracks developed within 10 to 15 years of construction and have not resulted in a decrease in the overall pavement performance. The faulted PCC pavements, on the other hand, have deteriorated at such a rate that rehabilitation of approximately 50 to 100 miles (30 to 60 km) is currently required and approximately the same length will need to be rehabilitated within the next five to ten years. Therefore, the main concern for WSDOT, for the rehabilitation of PCC pavements, has been to better understand the mechanism of faulting and the most appropriate and cost effective rehabilitation method.

STUDY SITE

There are approximately 200 lane-miles (125 lane-km) of PCC pavement within District 5's jurisdiction. All of these roadways are four lanes or more and were constructed between 1952 and 1992. Similar to other areas within the state and the nation, portions of the older roadways are heavily faulted. The PCC pavements are unreinforced 0.75 ft (230 mm) thick pavements with perpendicular 15 ft (4.6 m) joint spacing. Base materials consist of crushed surfacing top course (CSTC) and ballast and are 0.75 ft (230 mm) to 1.00 ft (305 mm) in depth.

In the late 1980's a request was made to each District within the state of Washington to submit a corridor plan to assist in the planning of future rehabilitation alternatives for interstate pavements. As part of the District 5's PCC pavement rehabilitation and/or preservation corridor plan, work on I-90 has been initiated. This work is being performed to restore ride quality by diamond grinding the existing faulted PCC pavement and to research test solutions to restore joint load transfer. The test section included four experimental design features:

1. retrofitting dowel bars,
2. retrofitting dowel bars and a 4 ft (1.2 m) tied concrete shoulder beam,
3. a 4 ft (1.2 m) tied concrete shoulder beam and
4. a control section which received no load transfer restoration treatment.

The entire test section was included in the diamond grinding project which was from MP 67.20 to MP 102.49 (westbound only). See Appendix C for test section layout and roadway sections. In addition, two concrete panels were lifted so that fault development could be further evaluated.

CONSTRUCTION SUMMARY

Panel Lifting

Present concrete pavement rehabilitation guides describe the faulting mechanism as a displacement of fines across the joint from the leave slab to the approach slab (see Figure 1).

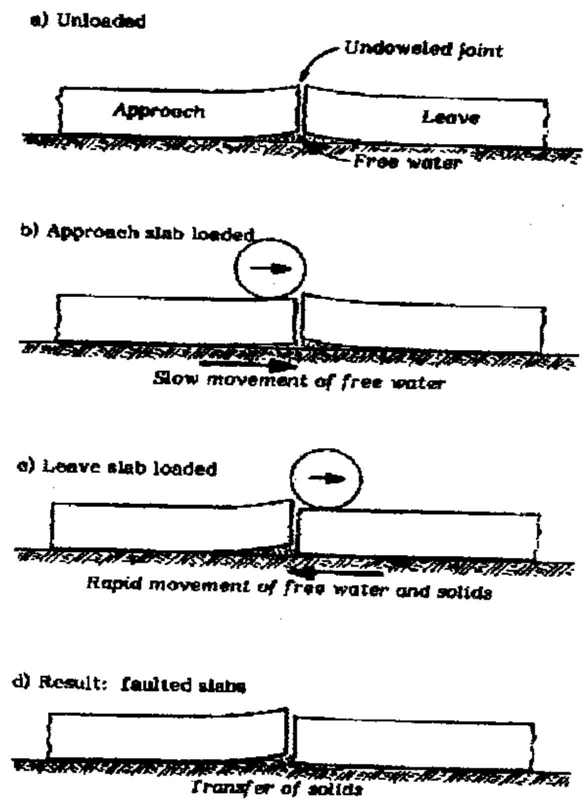


Figure 1. Joint Faulting Mechanism [3].

It is also believed that this displacement of fines lifts the approach slab and results in the development of an unsupported area (void) beneath the leave slab. In order to verify void presence and the fault development concept, WSDOT decided to lift/remove the concrete slabs at two locations on this project. At MP 72.20 and MP 98.70, the concrete panels were removed so that the underlying base material at the transverse joint could be viewed. This was accomplished by sawing the slab on either side of the transverse joint at approximately mid-slab, longitudinally at the lane/shoulder edge and at the longitudinal joint (for details, see Appendix D). The sawed panels were then lifted slowly in a vertical direction to avoid disturbing the CSTC around the transverse joint.

Visual examination verified that voids did not exist at the joint locations. Close inspection of the CSTC beneath the removed panels indicates that a different mechanism is responsible for the faulting of I-90 pavements. The fine material appears to be migrating upward, in addition to, horizontally across the joint. A wedge of material, whose surface is parallel to the top surface of the faulted panel is formed and indicates that faulting can develop due to a soil-jacking mechanism.

The above hypothesis is also supported by gradations of samples collected from the fault wedge, CSTC and ballast material (Appendix D). CSTC was sampled on both the approach and leave side of the transverse joint. Without exception all tests showed that the CSTC beneath the approach slabs was finer than the material beneath the leave slab. At MP 72.20 the material beneath the approach slab was 2.5% finer on the #40 sieve and was 2.0% finer on the #200 sieve than the material beneath the leave slab. At MP 98.70 the approach slab material was 4.7% finer on the #40 sieve and was 6.0% finer on the #200 sieve. It is probable that the CSTC was originally placed with about 6% passing the #200 sieve, and of the samples taken, the average percent passing the #200 sieve was approximately 16% with a standard deviation of 3.7%. The CSTC of the shoulder was tested and found to be within specification, with 8.3% passing the #200 sieve. Therefore, contamination of the CSTC by upward migration of fines due to hydraulic pressure, and/or degradation of larger particles from within the CSTC itself is considered to have occurred.

Minimum sampling of the ballast was also performed. Of the four samples tested, only one was out of specifications with 12.5% passing the #200 sieve. This may suggest that contamination of the CSTC is due to the degradation of CSTC and not the pumping of subgrade fines. Additional testing and study is needed to confirm this hypothesis.

A particle size analysis (Appendix D) was performed on the wedge material with 16% to 36% of the material passing the #200 sieve. However, the method of sampling may have influenced the results. Samples were taken at the transverse joints with no offset. This resulted in some concrete particles that had been spalled due to the working of the joint being included in the sample. Since faulting at MP 98.70 is only 1/4 inch and spalling of the joint face is much less severe, samples from this location are considered to be most representative of the wedge material. The wedge material is estimated to have approximately 35% to 50% passing the #200 sieve with the remainder smaller than a #10 sieve. This grading is conducive to the formation of a stable, compacted material that will support the panel in its faulted position.

Relative dry density testing of the CSTC was also performed. The results exhibited no pattern as to position ahead of or back of the joints. Dry densities varied from 135.3 to 142.5 lb/ft^3 which is a typical dry density for CSTC. Moisture contents varied from 5.0% to 9.8%.

Attempts were made to demonstrate that the warp of the concrete panels is induced by the wedge formation. The top surface of the faulted panels and the underlying wedge were string lined. The topography of the panels was then compared to the topography of the wedge material. Although the results are based on a limited sample group, it does appear that the panels are deformed in such a manner that the top surface of the PCC slab is roughly congruent to the surface of the supporting wedge. Measurements were obtained in mid-summer with an ambient temperature of 80°F (27°C). Pavement temperatures were considered to be lower. It is reasonable to assume that the slab temperature was close to the neutral temperature of 60°F. If this was the case, thermal curling of the panels is improbable. If any minor curling did occur, it would create a convex warp in reverse of the fault warp. No depressions can be detected in the panel area, indicating that all panel movement is upwards.

Construction of Load Transfer Restoration Test Section

Dowel bars used in retrofitting were epoxy coated, 18 inch (457 mm) long and 1-1/2 inch (38 mm) in diameter. Four bars per wheel path were placed at mid-panel depth in the outside lane. Slots for insertion of the bars were 2-1/2 inch (64 mm) in width by 5-3/4 inch (146 mm) deep.

Dowel bar slots were cut with a diamond saw. Each longitudinal side of the slot was cut to the required depth and the concrete was removed with a 30 lb (14 kg) pneumatic hammer. Prior to the insertion of the dowel bars, all concrete surfaces in the slot were sandblasted and blown clean. Dowel bars were inserted and held in position by supporting chairs. The slot was then backfilled with Burke Fast Patch 928 grout. A mastic filler was placed in the joint to prevent the grout from entering the joint.

Research has shown that 2 ft (0.6 m) of additional concrete is adequate for load transfer. However, for economic reasons a concrete shoulder beam of 4 ft (1.2 m) was specified so that a standard slip form paver could be used.

To provide maximum load transfer, the concrete shoulder beam was tied to the outside lane using epoxy coated #5 reinforcing bars, 30 inch (762 mm) in length. The tie bar holes were pneumatically bored into the existing concrete with a backhoe mounted device which is capable of boring three holes at a time. The tie bars were then epoxy grouted into the concrete panels. Three epoxy coated dowel bars were also utilized in the transverse construction joints.

A Gamaco slip-form paver was utilized for concrete paving. The bid price for placement of the PCCP was $55.00/sy. This price is not indicative of large scale work, with anticipated prices for large scale paving to be $20.00/sy to $22.00/sy.

The in-place cost of the tie bars was $10.00 each. The cost of the shoulder beam dowel bars was $6.50 each. Again, these prices reflect the small quantities of work and would be expected to be lower for larger jobs.

A few problems were encountered during the placement of the retrofitted dowel bars and the concrete shoulder beam. Alignment of the retrofitted dowel slot was sometimes incorrect. The small concrete saw tended to wander off line resulting in a slot whose longitudinal axis was not parallel to the centerline. The chairs used for the positioning of the dowels within the slot were also not adequate. They were not specifically manufactured for 1-1/2 inch (38 mm) diameter bars and in many cases failed to hold the dowel bar in the correct position while backfilling. Roughness of the slot bottom aggravated the problem with the chairs. Poor alignment of the slot and the inadequate supporting chairs resulted in poor alignment of the dowel bars. The intended placement of the dowel bars is parallel to centerline or perpendicular to the joint and parallel to the ground concrete surface. Therefore, it is important that these problems be rectified on future contracts.

To avoid alignment problems of the retrofitted dowel on future contracts the following procedures are recommend:

1) Specify a supporting chair whose width is the same as the sawed joint, and whose legs only bear load on the sides of the sawed slot.
2) Specify a tolerance for alignments of the dowels with the longitudinal and vertical limits being plus or minus 1/4 inch (6 mm).
3) Use the elevation of the ahead panels to control the depth of the cut for the dowel slots. (Employ a 1 ft (0.30 m) zone from the joint.)

Another problem that became evident was the placement of the grout. Sawing and removal of the PCC material for the dowel bar slot exposes the existing transverse joint along the inside of the slot. As the grout material is being placed, it enters the open joint, this may result in a critical joint failure problem. It is important that the cracked portion of the transverse joint not be filled by the grout material and that the sawed portion be re-sawed. Joint lock-up may result if the grout is allowed to infiltrate the joint area. Joint lock-up is the inability of the joints to open in response to cooling temperatures. Joint lock-up can cause high tensile stresses in the grout material and the surrounding concrete slab, resulting in numerous cracks around the joint and the dowel bar slots.

Since retrofitting of dowels is recommended prior to grinding, no special care is needed in finishing the surface of the patch. However, as indicated before, the joint must be kept clean.

End caps were not placed on the dowel bars, but will be specified on future jobs due to the potentially varying temperatures when dowel bar retrofitting will be performed. The potential failure of the pour back material due to thermal joint contraction further emphasizes the necessity of end caps.

Specifications called for the placement of 3 dowel bars in the transverse joints of the concrete shoulder beam. The first dowel was to be placed 6 inch (152 mm) from the longitudinal joint between the beam and existing lane. In most cases this was not possible due to the fact that during construction of the existing highway, a lip of excess concrete was created. This lip of concrete prevented the proper placement of the dowel bar holder (see Figure 2). Construction personnel elected not to remove the excess concrete and as a result the first dowel was placed 8 inch to 13 inch (203 to 330 mm) from the longitudinal joint.

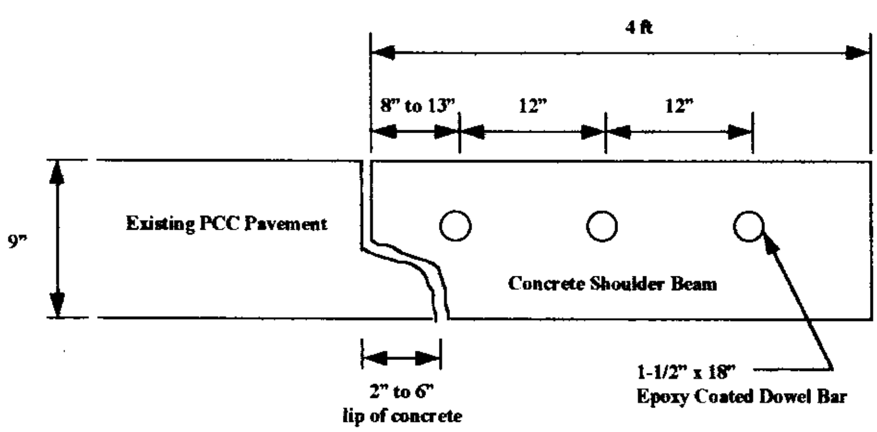


Figure 2. Dowel Bar Placement Detail for Concrete Shoulder Beam.

It is unknown what effect this procedure will have on the test section. If placement of a concrete shoulder beam or full width concrete shoulder is considered, it is recommended that if a concrete lip exists that it be removed which will allow consistent placement of the dowels at the transverse joints.

Diamond Grinding

Faulting on this section of I-90 varied from an average of 1/8 inch to 5/16 inch (3 to 8 mm) per mile. Average faults were based on 4 measurements per mile. The maximum fault recorded was 7/8 inch (22 mm).

Grinding was initially specified to be of sufficient depth for complete removal of the fault. Actual grinding resulted in the removal of at least 1/16 inch (1.6 mm) of material from all surfaces. A 1/4 inch in 10 ft (6 mm in 3 m) straight edge specification was used for transverse and longitudinal control. Specification grinding at the joints was 1/8 inch in 3 ft (3 mm in 0.9 m).

Prior to the start of this job, demonstration grinding with a Keystone rotomill was performed. Based on the results of this operation, some type of joint treatment to control spalling was deemed necessary. The original contract allowed this type of grinding, however, during the ad period the decision was made to specify diamond grinding as the only allowable method of grinding.

Since concrete pavement grinding has not been performed extensively in Washington State, no contractors within the state had adequate equipment to do the work. Highway Services Incorporated of Minnesota, who does extensive concrete grinding, therefore submitted a bid and was awarded the contract. As the prime contractor, Highway Services used up to 5 grinders with 3 ft (0.9 m) heads. Three passes of the grinders were needed to grind the 12 ft (3.7 m) lane. As mentioned previously, the entire surface of the panels were ground to improve ride quality. The contractor pointed out that contract specified profile grinding would result in the best ride at little additional cost. Profile grinding specifications will therefore be included in future jobs and are recommended.

Bid price for grinding was \$3.40 per square yard. Project grinding cost was approximately \$700,000 or \$23,936 per mile. Once the contractor had determined the best method of grinding, approximately 1000 ft per day (305 m per day) was accomplished, which is based on 12 ft lanes and a 24 hour working day. The total time for pavement grinding was 54 working days.

Allowing the grinding operation to continue over 24 hours did cause one problem. The high pitched sound produced during the grinding process is especially distressing to property owners when grinding through city limits or adjacent to homes. For this reason night time grinding should not be allowed when the roadway is located through cities or is adjacent to any homes.

Load Transfer Analysis

FWD testing was conducted prior to construction in July 1992, within two weeks following construction in September 1992, March 1993 and in July 1993. On the FWD test days, the deflection measurements were obtained such that large thermal gradients in the slabs were avoided. The more critical condition (large deflections) at the transverse joints occurs when the slabs are warped upward due to a lower surface slab temperature and a higher bottom slab temperature. Monitoring of slab temperature was accomplished by placing a thermometer at the bottom of the slab and at the top of the slab. Testing was conducted such that the air temperature was less than 80°F (27°C). Testing was terminated when thermal gradient between the top and bottom temperature of the slab equaled 30°.

All FWD testing was performed in the outside lane (I-90 is a four lane divided highway at this location). As noted in Figure 3, Row 1 was located on the outside edge of the PCC slabs, Row 2 the outside wheel path and Row 3 the inside wheel path.

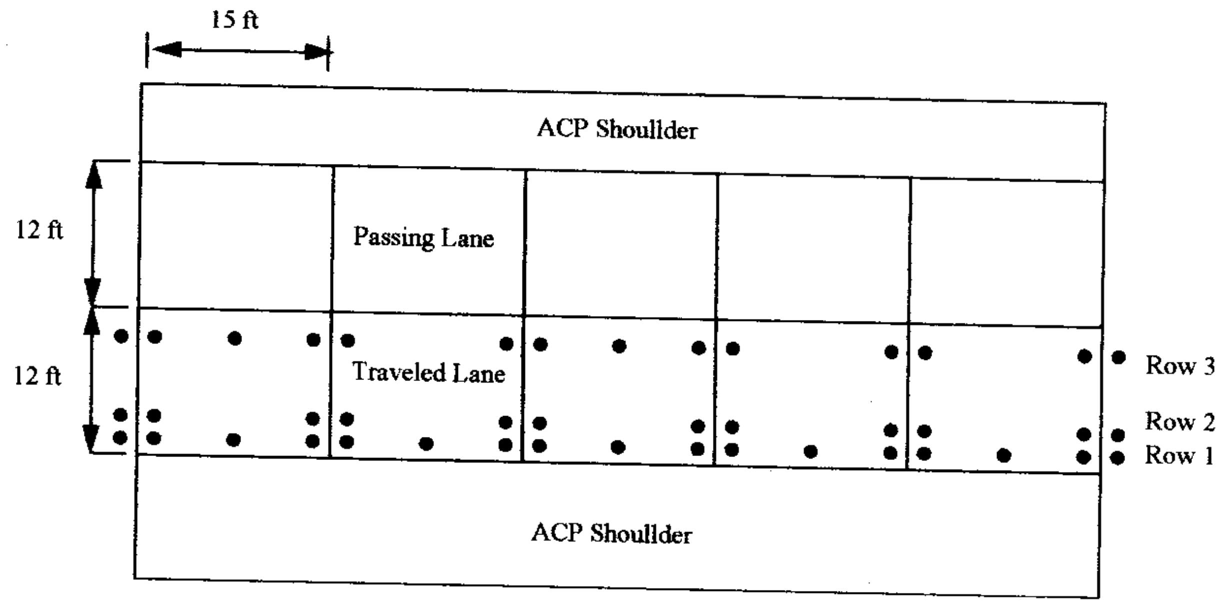


Figure 3. FWD Testing Locations.

One method of evaluating joint performance is by calculating load transfer efficiency across a joint or crack using measured deflection data. Load transfer efficiency is normally defined as the ratio of the deflection of the unloaded slab to the deflection of the loaded slab. The concept of joint load transfer efficiency is shown in Figure 4. Load transfer efficiency can be calculated using the following equation:

$$\text{Load Transfer} = \frac{\text{Deflection of Loaded Slab}}{\text{Deflection of Unloaded Slab}} \times 100$$

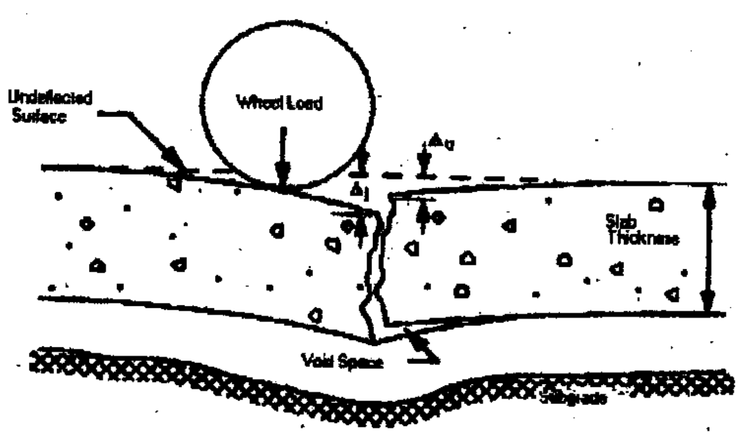


Figure 4. Joint Load Transfer Efficiency

As outlined above, the deflection data was evaluated by determining the load transfer efficiency (a summary of these results is shown in Table 1). The retrofitted dowel bars in Section A and B generally increased the load transfer efficiencies from an average of approximately 40 percent to 85 percent. The tied PCC shoulders without retrofitted dowel bars (Section C) increased the load transfer efficiencies from an average of approximately 30 percent to 70 percent.

	Row 1			Row 2			Row 3		
Section	**7/92**	**3/93**	**7/93**	**7/92**	**3/93**	**7/93**	**7/92**	**3/93**	**7/93**
Dowel Bars Only									
Average	33	82	85	37	89	93	29	92	93
Std Deviation	15	5	5	18	6	3	11	3	3
Dowel Bars & Shldrs									
Average	41	88	86	38	90	92	39	91	92
Std Deviation	23	4	7	25	4	4	21	3	3
Shoulders Only									
Average	27	72	74	22	63	69	41	79	82
Std Deviation	14	17	17	11	19	21	24	15	15
Control									
Average	52	50	42	45	58	50	58	79	77
Std Deviation	24	15	17	14	16	16	24	10	18

Table 1. Summary of Load Transfer Efficiencies.

COST COMPARISON

For estimating purposes, the cost comparison will be based on bid items that would be expected for a large scale rehabilitation project. Specifically, the bid items used in the analysis were taken from Contract 4235 "Easton Hill to Yakima River - EB". The cost comparison is based on the rehabilitation of two 12 ft (3.7 m) lanes, a 10 ft (3 m) right shoulder and a 4 ft (1.2 m) left shoulder (total pavement width of 38 ft (11.6 m)). Rehabilitation considerations include three alternatives:

1. Retrofitting right lane with dowel bars and pavement grinding,
2. Tied concrete shoulder beam and pavement grinding, and

3 0.35 ft (110 mm) ACP overlay.

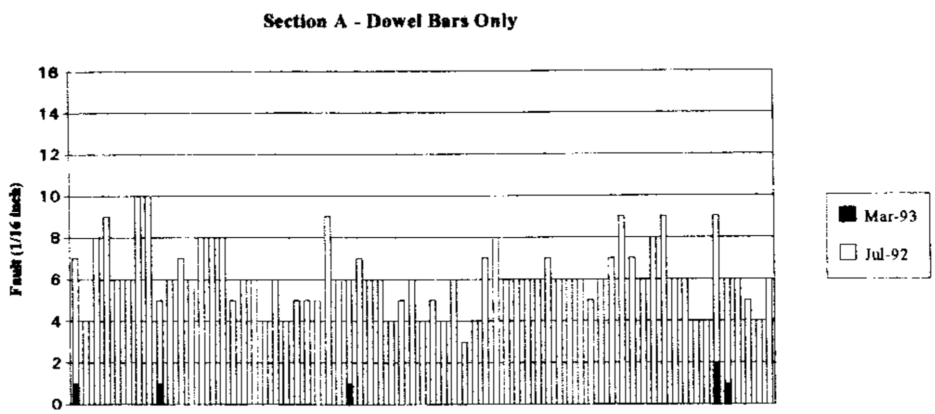
All three alternatives include rehabilitation of the ACP shoulders by removing and replacing 0.25 ft of ACP. For Alternatives 1 and 2 pavement grinding is in the right lane only. Refer to Table 2 for bid items and construction costs for each option.

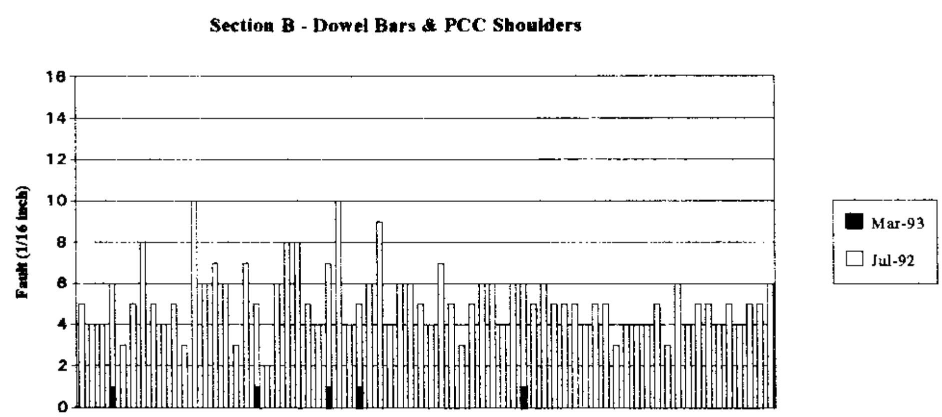
Alternative	Bid Item	Unit Measure	Unit Price	Total Quantity	Total Cost
1	Remove ACP - Shoulders	SY	$1.75	8,213	$14,373
	PCCP Grinding	SY	$3.40	7,040	$23,936
	Dowel Bar Retrofit	Each	$34.40	2,112	$72,653
	Clean & Reseal Joints	LF	$0.59	9,504	$5,607
	ACP Class B - Shoulders	Ton	$26.00	1,266	$32,913
	Total Cost				$149,482
2	Remove ACP - Shoulders	SY	$1.75	8,213	$14,373
	PCCP Grinding	SY	$3.40	7,040	$23,936
	PCC -- Shoulder	SY	$21.00	2,347	$49,280
	Dowel Bars - Shoulder	Each	$5.25	1,056	$5,544
	Tie Bars - Shoulder	Each	$6.25	4,563	$28,519
	Clean & Reseal Joints	LF	$0.59	9,504	$5,607
	ACP Class B - Shoulders	Ton	$26.00	904	$23,509
	Total Cost				$150,769
3	Asphalt for Tack Coat	Ton	$195.00	140	$27,300
	Anti-Stripping	Estimate			$16,000
	Crack Sealing	Estimate			$20,000
	ACP Class A	Ton	$37.00	4,810	$177,983
	Total Cost				$241,616

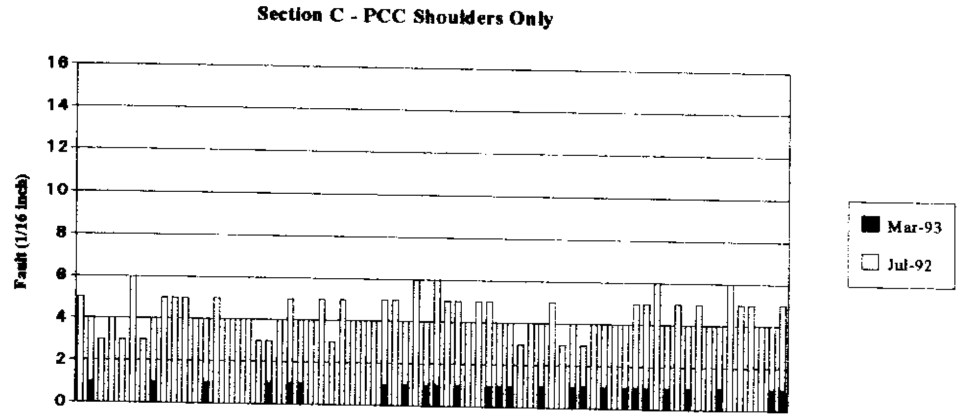
Table 2. Construction Cost Comparison of Alternatives.

CONCLUSION

The rehabilitation of PCC pavements in Washington State has been investigated through the use of a test section that incorporated the use of retrofit dowel bars, tied PCC shoulders and pavement grinding. Over the past year the test sections has been evaluated for levels of cracking, the reoccurrence of faulting, and joint load transfer. The results of pavement faulting can be seen in Figure 5. After 9 months of service, the dowel bar retrofit sections, (Sections A and B) have approximately 7 percent of the slabs with a 1/16 inch fault, approximately 38 percent of the slabs in the concrete shoulder beam only section have a 1/16 inch fault, and approximately 80 percent of the slabs in the control section are faulted 1/16 inch to 3/16 inch.







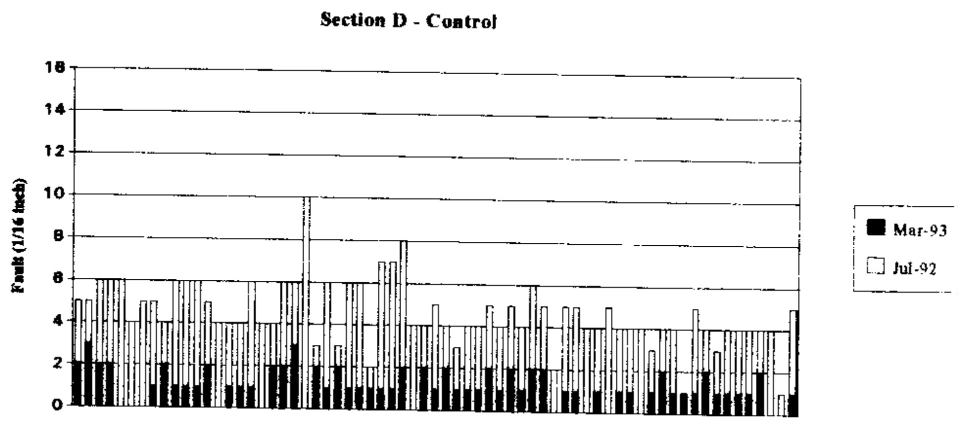


Figure 5. Fault Measurements

From this early analysis, it appears that retrofitted dowel bars are an effective PCC pavement rehabilitation treatment. The addition of tied PCC shoulders is of marginal benefit as characterized by the initial FWD testing and fault measurement for this project. Based on the cost comparison, the dowel bar retrofit and tied PCC shoulders have similar costs. The cost effectiveness of each of these options will be dependent on their continued performance. Long-term performance may indicate a different conclusion (both about tied PCC shoulders and retrofitted dowel bars). Only time, traffic and more FWD measurements will verify or modify these initial observations.

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2. Pierce, L. M., "PCCP Rehabilitation in Washington State (a case study)," paper No. 940247 submitted for publication, Transportation Research Board, TRB, National Research Council, Washington, D. C., 1994.
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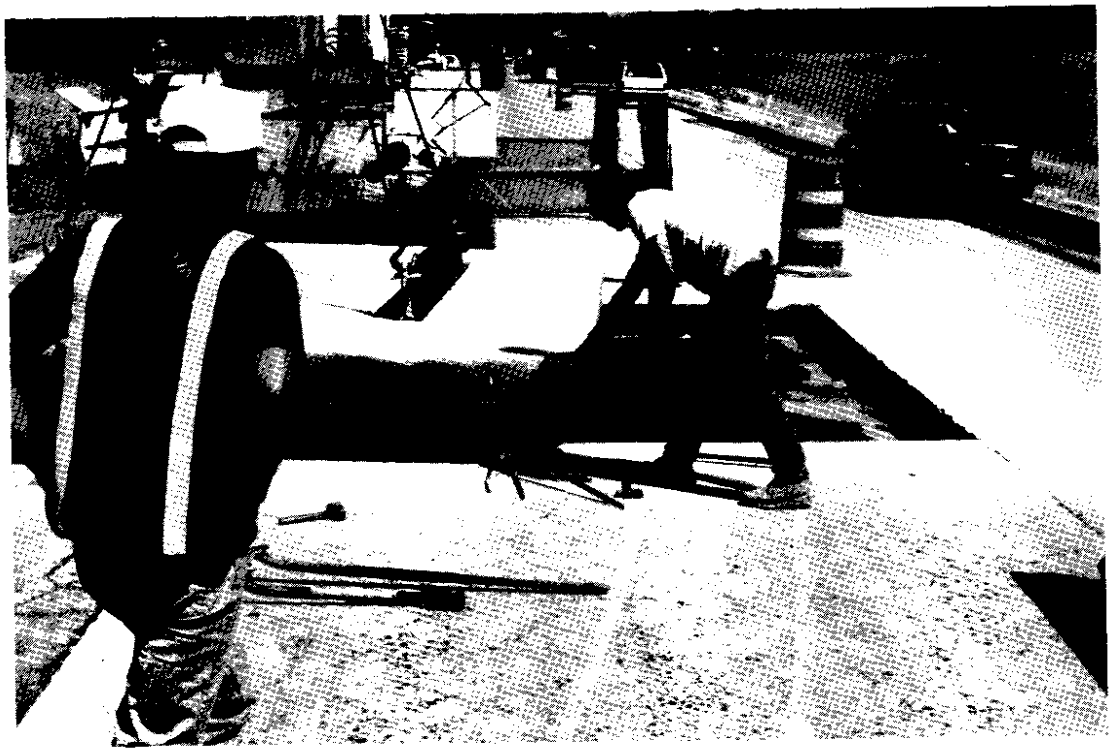
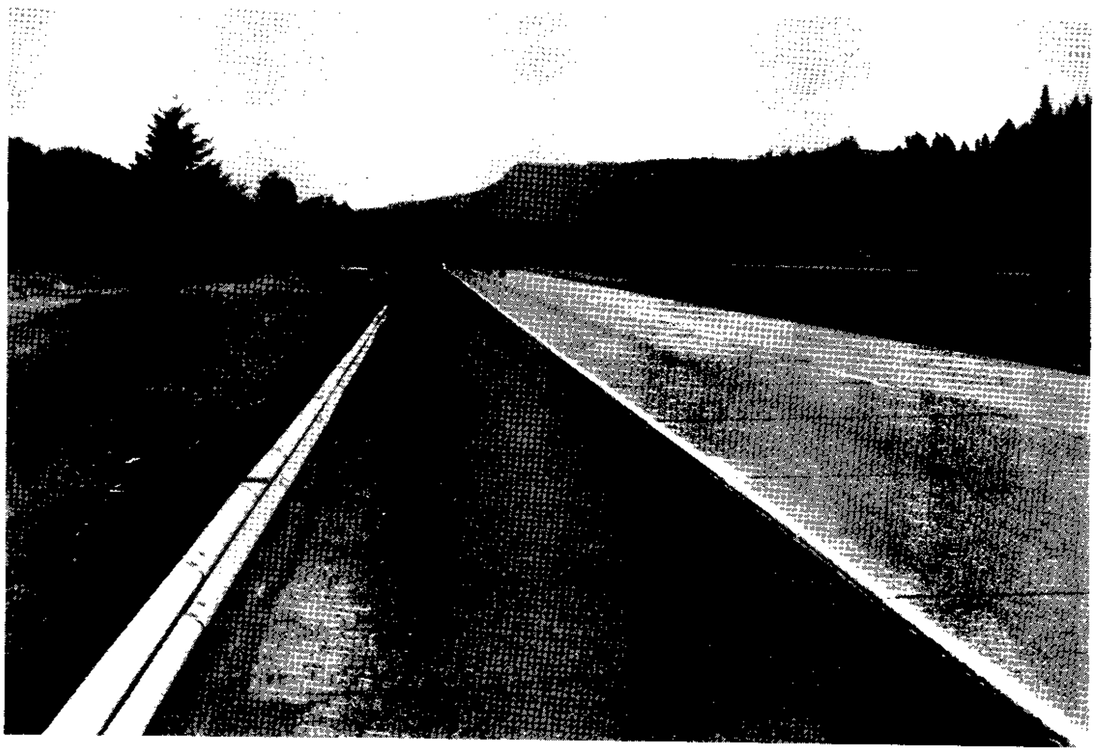
APPENDIX A - PHOTOGRAPHS

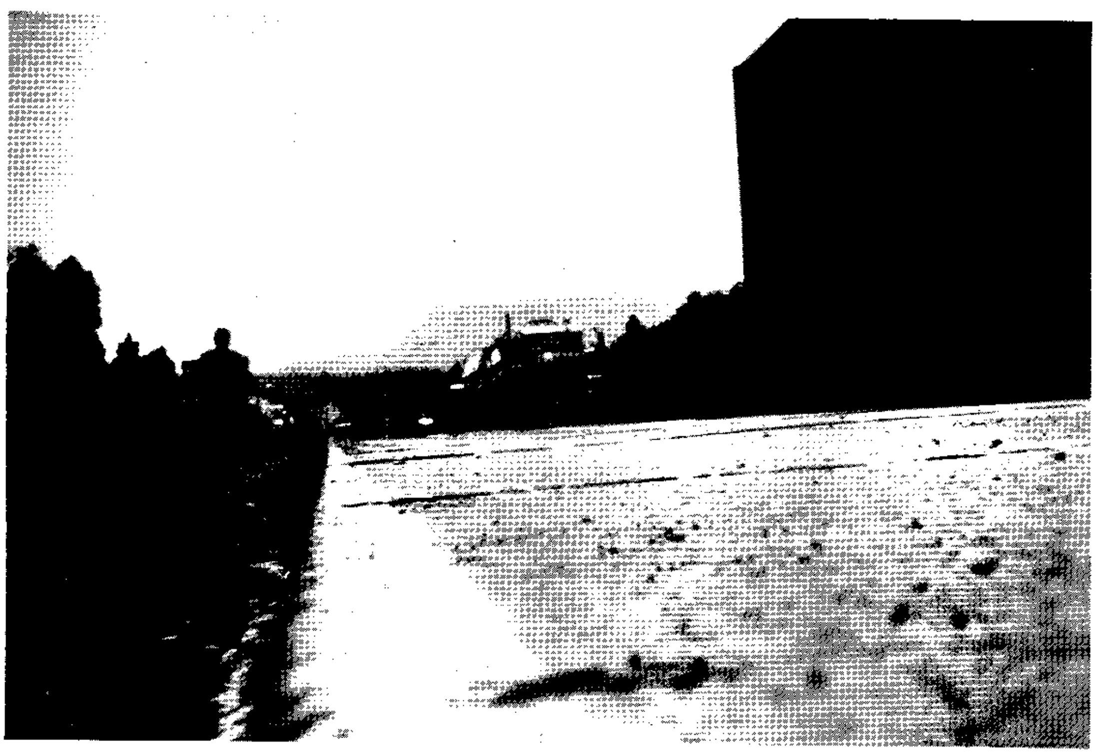


Picture 1. Panel lifting operation.

Picture 2. Transverse joint showing top of base coarse, the fine grained soil wedge and build up of fine material along the transverse joint and lane/shoulder joint and coarse material apparent at all other locations.

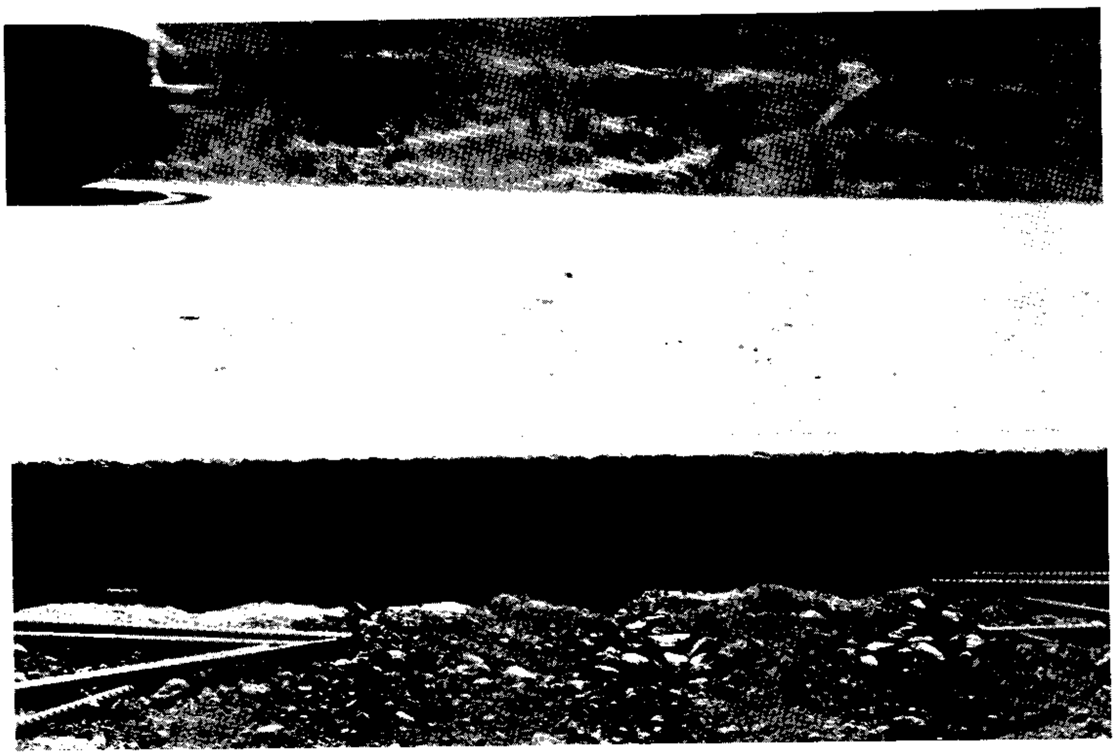


Picture 3. Joint faulting, looking east from end of job.

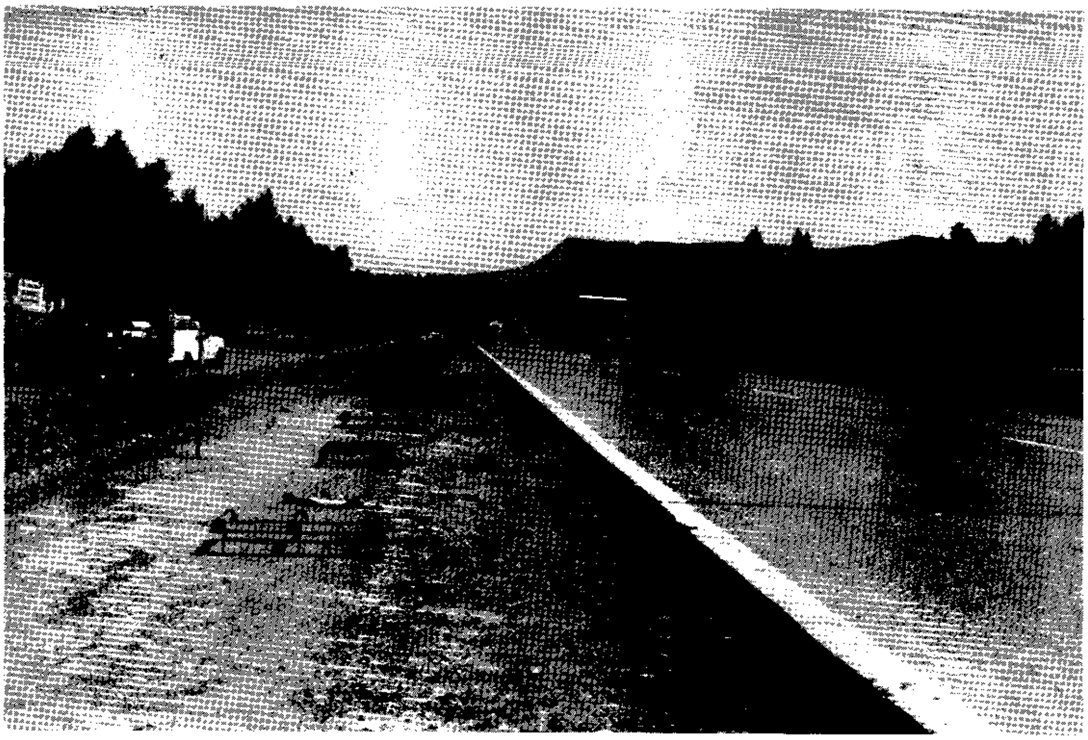


Picture 4. Typical joint faulting prior to rehabilitation.

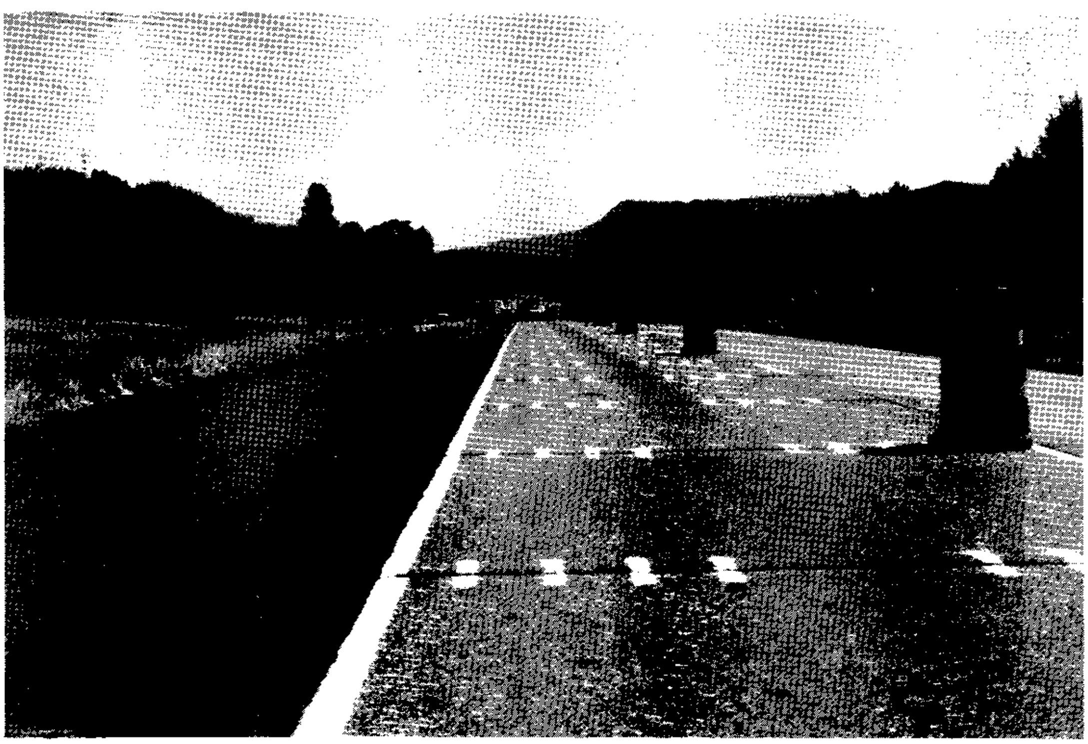
Picture 5. Hole drilling operation for tie bar placement.



Picture 6. Side view of tie bar holes.



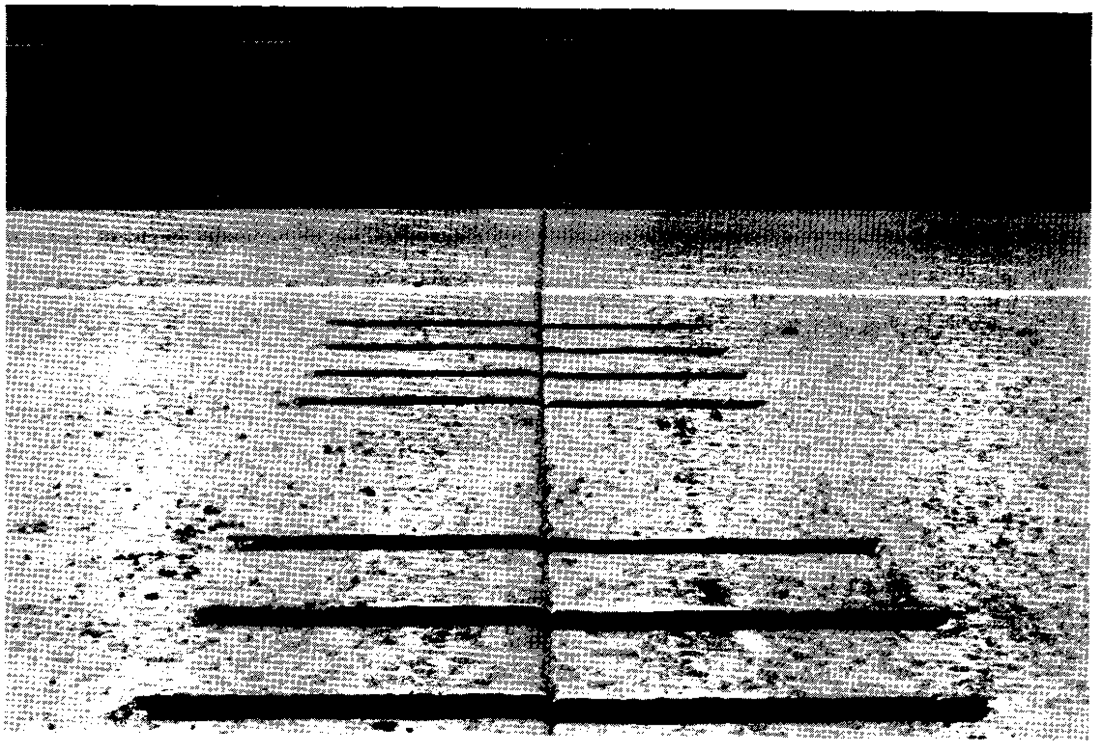
Picture 7. Concrete shoulder beam - tie bar and dowel basket placement.



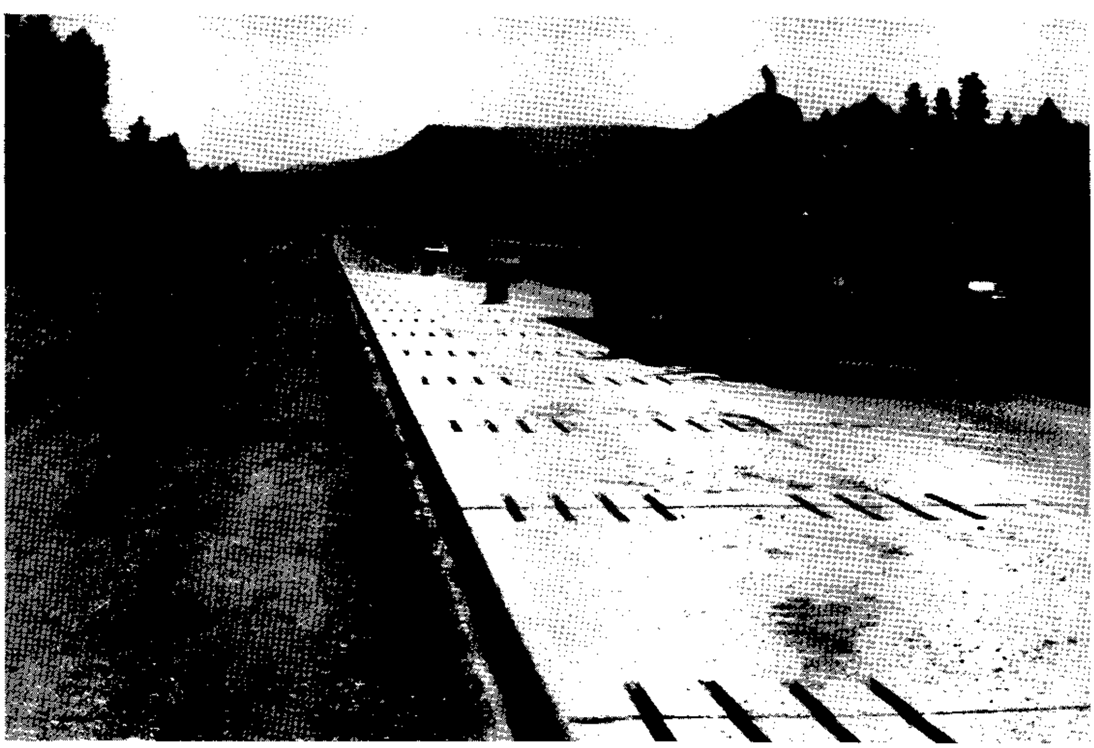
Picture 8. Pattern for dowel bar retrofit placement.

Picture 9. Sawing dowel bar slots.

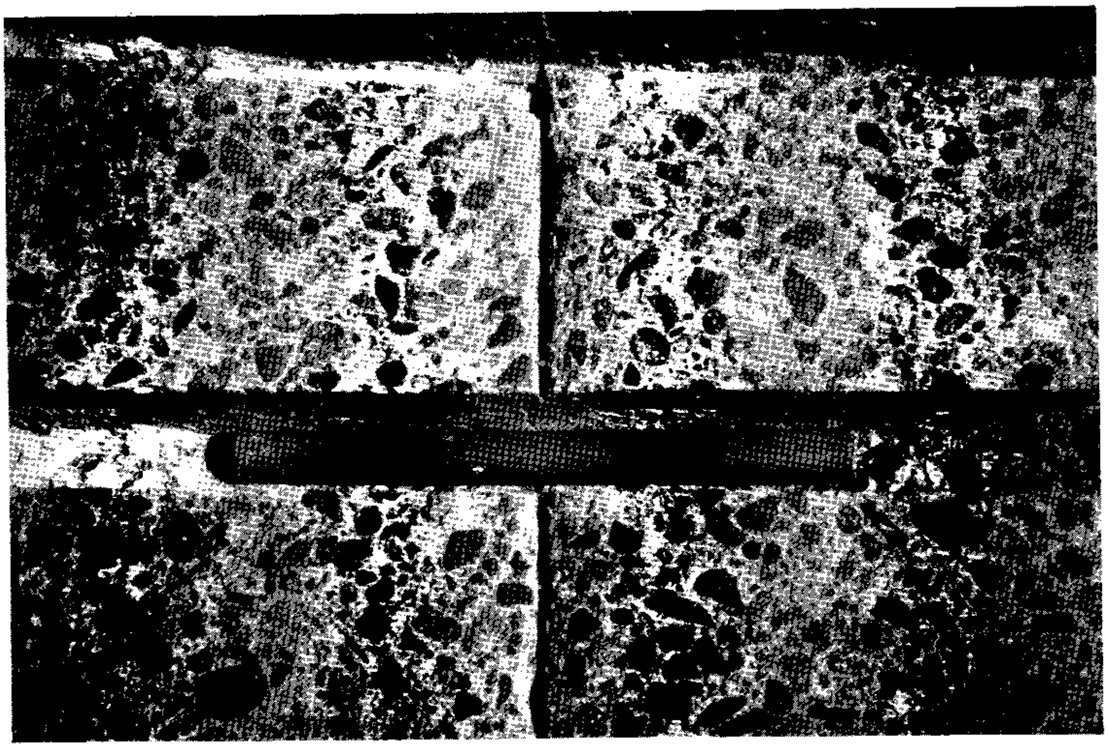
Picture 10. Removing concrete from dowel bar slots.



Picture 11. Dowel bar slots - 8 slots per transverse joint.

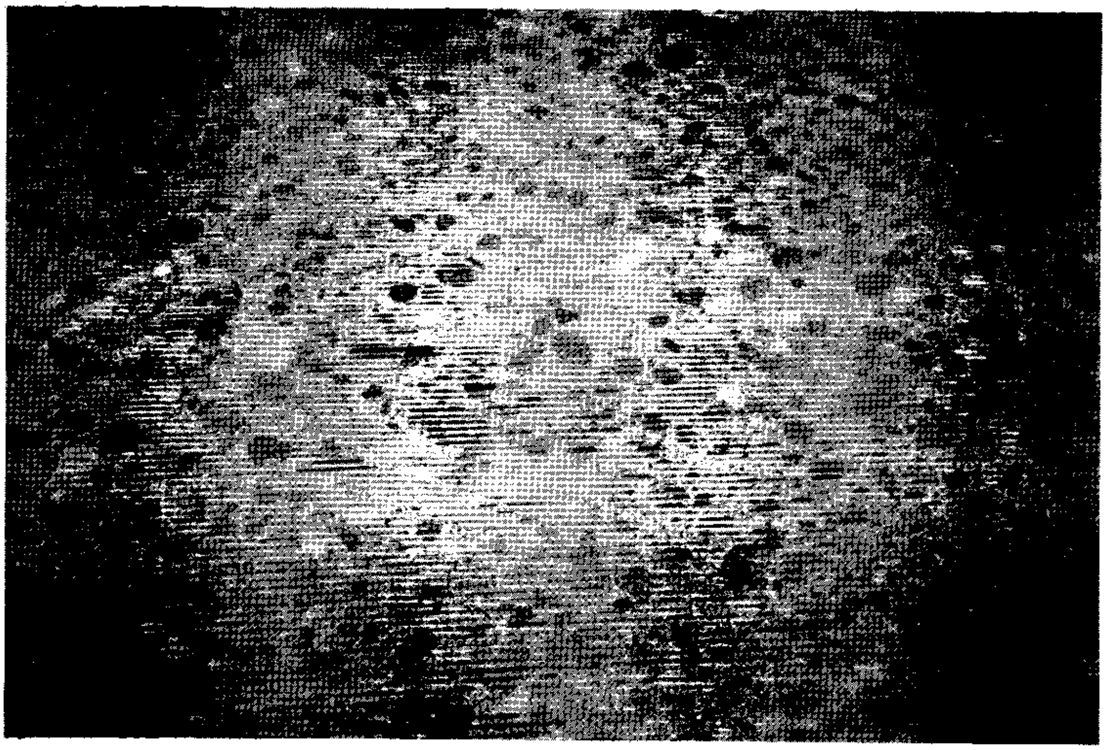


Picture 12. Dowel bar slots.



Picture 13. Dowel bar placement in slot. Not shown in picture are dowel bar chairs and mastic filler.

Picture 14. Diamond grinding operation.



Picture 15. PCC pavement texture immediately after grinding.

APPENDIX B - MATERIAL SPECIFICATIONS

Special Provisions are based on the most recent contract, Contract 4340, SR-90 Top of Easton Hill to Silver Creek, except as designated.

TRAFFIC CONTROL

Section 1-07.23 is supplemented by the following:

General

Existing SR-90 throughout the limits of this construction project is a fully controlled limited access highway and shall remain so throughout the life of this contract. No special ingress or egress will be provided to the Contractor other than normal legal movements unless permitted otherwise in a traffic control plan approved by the Engineer.

If the Engineer feels that the contract or standard traffic control precautions are inadequate, the Contractor shall supplement them with warning devices deemed necessary to protect the traveling public as ordered by the Engineer.

Interference or delay to the Contractors operations resulting from safeguarding traffic shall not be a basis for extra compensation.

The Contractor shall schedule work so that all lane restrictions and/or reductions are removed, all guardrail removed by the Contractor is reset, all excavation for the installation of underdrain pipe has been backfilled and the project area is returned to its original two lane configuration between the hours of 12:00 Friday and 11:00 p.m. Sunday.

One lane traffic sequences shall not be scheduled during the following major holidays and the Friday before the opening day of the general hunting season.

1. Memorial Day, defined as 1:00 a.m. Friday before Memorial Day and ending 11:00 p.m. Monday.
2. Fourth of July, defined as 1:00 a.m. Friday before July 4th and ending 11:00 p.m. Monday.
3. Labor Day, defined as 1:00 a.m. Friday before Labor Day and ending 11:00 p.m. Monday.
4. Thanksgiving defined as 1:00 a.m. Wednesday before Thanksgiving and ending 1:00 p.m. Sunday.

The Contractor shall maintain one lane of traffic in each direction at all times.

All Fridays except the one before the opening day of the general hunting season and the Fridays before the major holidays will be considered one working day.

If for any reason the Contractor cannot remove lane reduction or in anyway cannot return the project area to the original two lane configuration as stated above, the Contractor shall be subject to damages as described in the Special Provision **LIQUIDATED DAMAGES** and the Contracting Agency may without further notice to the Contractor, perform work to return the area to the original configuration and deduct the costs from any pavements due or coming due to the Contractor. If for any reason the above situation occurs, any effects shall not be a basis for extra compensation.

Delays to traffic shall be held to a maximum of 10 minutes. All traffic congestion shall be allowed to clear before traffic is delayed again. There shall be no delay to medical, fire, police, or other emergency vehicles with flashing lights or sirens. The Contractor shall alert all flaggers and personnel of this requirement.

LIQUIDATED DAMAGES

Description

Section 1-08.9 is supplemented by the following:

The Contractor shall schedule and conduct all operations in a manner to ensure that motorists traveling through the project will have two lanes open to traffic at times as described in the Special Provision **TRAFFIC CONTROL**.

If the Contractor fails to have the two lanes open as described in the Special Provision **TRAFFIC CONTROL**, the Contractor agrees to pay and authorizes and directs the Secretary to deduct liquidated damages in the amount of $7000 per day. This $7000 per working day will be in addition to the formula calculated liquidated damages for failure to physically complete the entire project within the allotted time.

This amount will be accessed for each day (or fraction there of) the public is required to travel on less than two lanes.

PANEL REMOVAL FOR SUBSURFACE INVESTIGATION

Description

This work shall consist of removing pavement panels for the purpose of investigating the cause of pavement faulting.

Construction Requirements

Prior to placing traffic control for the panel removal, the four foot asphalt concrete pavement shoulder shall be removed and replaced as detailed in these Plans.

The Contractor shall give five days written notice to the Engineer prior to conducting panel removal.

Prior to removing the cement concrete pavement panels, the panels adjacent to those that will be removed shall be ground according to the Special Provisions **PORTLAND CEMENT CONCRETE PAVEMENT GRINDING.** The existing cement concrete pavement panels and portions of the adjacent asphalt concrete pavement shoulders shall be removed where shown and as detailed in the Plans, and as described in this Special Provision.

In order not to disturb the underlying base material the use of water or any other medium that is used to cool the saw blade by flooding the blade and surrounding area will not be allowed.

Alternate methods of cooling the blade will be subject to the approval of the Engineer.

The cement concrete and asphalt pavement shall be removed in the following manner:

1. Saw cut full depth as shown in the Plans.

2. Remove a portion of the asphalt shoulder. Personnel from the Contracting Agency will then take samples of the base material. The Contractor shall allow time for this to be done. Base material shall then be removed to the depth of the concrete pavement.
3. Before lifting operations begin, cement concrete sections numbered 1 and 2 shall be fastened together, and cement concrete sections numbered 3 and 4 shall be fastened together, to prevent them from buckling while being lifted.
4. Lift and remove sections 1 and 2 simultaneously, then remove sections 3 and 4 simultaneously.
5. Equipment and procedures shall meet with the Engineer's approval prior to beginning work as specified above.

After the panels have been removed, personnel from the Contracting Agency will examine the conditions under the concrete panels. The Contractor shall provide a minimum of 2 daylight hours for this examination.

Care shall be taken during the panel removal operation to prevent damage to the adjacent panels or disturbance of the underlying material.

Any damage to any adjacent joints, subgrades or roadway surfaces due to the Contractor's operation shall be repaired by the Contractor at no cost to the Contracting Agency.

All material removed shall become the property of the Contractor and shall be disposed of outside the project limits.

The cement concrete pavement shall be replaced in accordance with the Special Provision **MODIFIED CONCRETE CLASS 4000 FOR PANEL REPLACEMENT**. After the replaced panel is open to traffic the Contractor shall move to the other removal location when designated by the Engineer.

Measurement

Measurement for panel removal for subsurface investigation shall be for each locations where the work is specified.

A removal area of approximately 14' x 30' x 9 inch (deep) will be considered a location.

Payment

The unit contract price per each "Panel Removal For Subsurface Investigation" shall be full pay for completing the work as specified, including but not limited to saw cutting the cement concrete and asphalt pavement and lifting and removing the pavement and base material.

REMOVING EXISTING SHOULDER PAVEMENT

Description

This work shall consist of removing asphalt concrete pavement and underlying materials from the shoulders.

Construction Requirements

The Contracting Agency estimates the existing pavement depth to be 0.15 foot. This depth is an approximation only.

The Contractor shall make a neat vertical cut to delineate the pavement to be removed. All asphalt to remain that is damaged due to the Contractor's operation shall be replaced by the Contractor at no cost to the Contracting Agency.

The removed asphalt concrete pavement and underlying material shall become the property of the Contractor and removed from the Project.

Measurement

Measurement for roadway excavation include. haul, will be in accordance with Section 2-03.4.

Payment

The unit contract price per cubic yard for "Roadway Excavation Include. Haul" shall be full pay to complete the work as specified.

CLEAN AND RESEAL EXISTING JOINTS

Description

This work shall consist of cleaning and resealing transverse and centerline longitudinal joints in the cement concrete pavement.

Material

Joint sealant filler shall be in accordance with Section 9-04.2.

Construction Requirements

The Contractor shall clean and reseal joints where shown in the Plans. The work shall be accomplished as follows:

1. Sealant Removal

   The old sealant and incompressibles shall be removed from the joint with a diamond blade saw.

   The joints shall be blown out with moisture and oil-free, compressed air to remove dust and incompressibles immediately prior to installation of sealant.

2. Sealant Installation

   The joints shall be completely dry when sealant installation begins. The sealant material shall be installed in conformance with the manufacturer's recommendations and in accordance with the requirements of Section 5-05-3(8)b immediately following the air blowing. The top surface of the sealant shall be at least 1/4 inch below the surface of the pavement.

Measurement

Cleaning and sealing will be measured by the linear foot of existing joint cleaned and resealed.

Payment

The unit contract price per linear foot for "Clean and Reseal Existing Joint" shall be full pay to complete the work as specified.

GROOVE AND SEAL EXISTING CONCRETE RANDOM CRACKS

Description

This work shall consist of grooving, sealing and extending random cracks across adjacent panel(s) where designated by the Engineer.

Materials

Joint sealant filler shall be in accordance with Section 9-04.2.

Construction Requirements

The Contractor shall groove, seal and extend existing concrete random cracks where shown in the Plans and as designated by the Engineer.

Random cracks shall be extended by saw cutting a 2-1/2 inch deep joint in accordance with Section 5-05.3(8)A paragraph 2.

Sealing the joints shall be done in accordance with the Special Provision **CLEAN AND RESEAL EXISTING JOINTS**.

Measurement

Grooving and sealing concrete random cracks will be measured by the linear foot of concrete random cracks grooved, extended and sealed.

Payment

The unit contract price per linear foot for "Groove and Seal Existing Conc. Random Cracks" shall be full pay to complete the work as specified.

PORTLAND CEMENT CONCRETE PAVEMENT GRINDING

Description

This work shall consist of grinding the existing cement concrete pavement and restoring the centerline paint stripe.

Materials

Materials for paint stripe shall be in accordance with the Special Provision **PAVEMENT MARKING**.

Construction Requirements

The pavement shall be ground where shown in the Plans or as designated by the Engineer to meet the following specifications:

1. A 1/8 inch minimum depth shall be removed from 95 percent of the surface area of the pavement by the grinding operation.
2. No high points deviation in excess of 0.3 inch.
3. A profile index of 0.7 inch in any 0.1 mile section.

The high points and profile index shall be determined by an electronic profilograph and procedures described in WSDOT Test Method 807.

During grinding of the right lane, the center line stripe will be removed due to the nature of this operation. The Contractor shall apply paint stripe on the centerline before moving the grinding operation and opening the right lane to traffic.

If for any reason the Contractor can not apply the paint stripe prior to returning the roadway to its original configuration as described in the Special Provision **TRAFFIC CONTROL**, the Contractor shall be subject to damages as described in the Special Provision **LIQUIDATED DAMAGES**.

The Contractor shall supply and operate an electronic profilograph as described in the Special Provision **PROFILOGRAPH**. All reports shall be produced with the profilograph in automatic mode.

The Contractor shall grind the existing cement concrete pavement where shown in the Plans to substantially eliminate joint faulting and to restore ride characteristics. This shall be done in accordance with the following:

1. After grinding, the surface shall not vary from a true plane enough to:

   Permit a 1/4 inch thick shim, three inches in width to pass under a ten foot straightedge laid on the surface parallel to centerline except at transverse joints.

   Permit a 1/8 inch thick shim, three inches in width to pass under a three foot straightedge laid on the surface with the straightedge centered on the transverse joint parallel to the centerline.

   Permit a 1/4 inch thick shim, three inches in width to pass under a ten foot straightedge laid on the surface perpendicular to the centerline.

2. After grinding, the surface shall:

   Be checked with two runs of a profilograph. The profilograph shall meet the requirements of the Special Provision **PROFILOGRAPH**. The runs shall be located 4 feet and 8 feet from center line. Grinding shall continue until the two profilograph runs show that all high points having deviations in excess of 0.3 inch are reduced to less than 0.3 inch and the profile index for each run shows 0.7 inch or less in 0.1 mile. In determination of the areas requiring reduction to produce the acceptable profile index, all high areas in excess of 0.1 inch shall be reduced to 0.0 inch prior to reducing any high points of 0.1 inch or less.

Reduction of the deviation areas shall be confirmed by reruns of the Contractor supplied and operated electronic profilograph. The profilograph generated reports of the reruns shall be supplied to the Engineer prior to payment for grinding.

The Contracting Agency may monitor the Contractors profilograph operation and may verify any readings with the Contracting Agency profilograph equipment. In the case of a discrepancy, the Engineer's decision as to which profilograph run is correct shall be final. The Contracting Agency profilograph equipment does not have to be of electronic or automated type.

Any reduction beyond that required by specification as described above shall be determined to be for the Contractor's benefit and shall be at the Contractor's cost. This includes all grinding, profilographing, and traffic control operations.

3. Bridge decks, approach slabs and bridge overlay insets shall not be ground, however the grinding operation shall feather the grinding to meet the bridge deck, approach slab or bridge insets as designed by the Engineer.

4. Removal of the grinding residue shall be done on a continuous basis. Residue shall not be allowed to drain across traffic lanes and shoulders. The Contractor shall dispose of the residue by one of the following methods:

   (a) The residue shall be collected and disposed of by the Contractor off the right of way.

   (b) The residue shall be disposed of by discharging the residue slurry onto the roadside slopes within the right of way in such a manner that none of the residue is allowed to enter any waterways or other areas designated by the Engineer.

   If for any reason the Contractor is not able to prohibit the slurry from entering a waterway or other areas designated by the Engineer, the residue shall immediately be collected and disposed of by the Contractor off the right of way.

5. The pavement shall be ground in a longitudinal direction that begins and ends at lines normal to the pavement centerline. However, this is not required at the end of each work shift. The minimum overlay between longitudinal passes shall be 2 inches.

6. No grinding shall be allowed from MP 69.50 to MP 70.84 between the hours of 10:00 p.m. and 5:00 a.m.

Equipment

The grinding equipment shall use diamond tipped saw blades mounted on a power driven, self-propelled machine that is specifically designed to smooth and texture PCC pavement. The equipment shall grind the pavement to the specified texture and smoothness tolerances. The equipment shall not damage the underlying surface of the pavement, cause excessive ravels, aggregate fractures, spall, or otherwise disturb the transverse or longitudinal joints.

Final Surface Finish

The surfaces that have been ground shall be uniform in appearances with longitudinal corduroy type texture. The grooves shall be between 0.10 and 0.15 inches wide. The land area between the grooves shall be between 0.065 and 0.100 inches. The peaks of the ridges shall be approximately 1/16 inch higher than the bottom of the grooves. Adjusting the blade spacing may be necessary to achieve the specified texture.

Measurement

Measurement for grinding will be by the square yard, based on the total lane width (12 feet) and the total lane length of the ground lane. Extra passes by the grinder to meet the above specifications, or overlaps by the grinder will not be considered for payment.

Measurement for centerline paint stripe after grinding will be in accordance with Section 8-22.4 for paint stripe.

Payment

The unit contract price per square yard for "Portland Cement Concrete Pavement Grinding" shall be full pay to complete the work as specified.

PROFILOGRAPH

Description

The Contractor shall provide and operate a 25 foot wheel base California-type profilograph meeting specifications as listed below or as approved by the Engineer. The profilograph shall be available for inspection and approval by the Engineer three days prior to beginning profilograph work as described in the Special Provisions titled **PORTLAND CEMENT CONCRETE PAVEMENT GRINDING**. The Contractor shall operate the equipment as approved by the Engineer and provide the Engineer with profilograph-generated pavement smoothness measurements as described in the Special Provisions titled **PORTLAND CEMENT CONCRETE PAVEMENT GRINDING**.

Localized low areas above existing culvert installations of other areas as determined by the Engineer will be exempt from Profilograph Readings.

After completion of the work, the profilograph will remain the property of the Contractor.

Instrumented California Profilograph Specification

General Description: The following specification is to describe a pavement surface roughness testing device. The device consists of a 25 foot wheel base California-type profilograph with instrumented data recording and printing capabilities. Instrumentation provides reduction of measured profile data and generates graphic report containing a scaled reproduction of the measured profile with stationing, deviation information and document points. Additional design descriptions, control parameters, and performance requirements as set forth herein are intended to clarify the specified versatility, performance, and durability of the equipment.

FRAME

CONSTRUCTION: The frame shall be all welded of light weight aluminum square tubing in three separate units of the same dimensions in width and within 6 inches in length of each other. Design shall be reinforced truss to withstand operational and handling stress without deformation.

LENGTH: The effective wheel base of the frame assembly shall be 25 feet. Overall length with multiple wheel assemblies attached shall not exceed 35 feet.

CONNECTIONS: Frame connections shall be indexed with steel locating pins or dowel to prevent misalignment of frame assembly. All frame connection points shall be secured with quick acting clamps rated at a minimum of 800 pounds each.

PARTS: Each of the three frame units shall be manufactured with a level of precision that allows for replacement of individual units.

WHEEL ASSEMBLIES

WHEEL SUPPORTS: Construction of wheel support assemblies shall be all-welded of light square aluminum tubing.

CONNECTIONS: All connection points between wheel assemblies and frame sections shall be secured with quick acting clamps.

WHEELS: All twelve support wheels shall have cast aluminum hubs with ball bearing supported steel axes and cushion rubber tires. Castor wheel assemblies shall also be ball bearing supported.

STEERING: Front wheels shall be steerable from the center of the machine. Rear wheels shall have a quick setting manual adjustment to allow for turning in short radius, moving laterally, and for trimming to avoid crabbing on super elevations.

RECORDING WHEEL

WHEEL: The recording wheel shall be light weight with a 26 inch diameter and heavy-duty spokes for maximum rigidity. Tire shall be pneumatic tube type with non-aggressive tread design.

FRAME: The recording wheel frame shall be all welded of light weight rectangular aluminum tubing. Frame pivot points and rotating shafts shall be supported by sealed ball bearings.

GENERAL MECHANICAL

CORROSION PROTECTION: All exposed steel components shall be anodized or nickel-plated to resist corrosion

INTERCHANGEABILITY OF PARTS: The profilograph shall be constructed to allow for interchangeability of parts from other similarly constructed profilographs and from manufacturer's stock.

EASE OF ASSEMBLY: The profilograph shall be constructed in such a manner as to allow complete assembly in less than 15 minutes with no tools.

EASE IF TRANSPORT: The profilograph shall break down into segments that can easily fit into the back of a standard pickup truck or van.

GENERATOR

The profilograph shall be equipped with a gasoline powered generator. The generator shall be used to provide electrical power to the electronic components and the printer. Electrical power shall be converted by solid state power converters prior to being supplied to electronic components. The generator shall be mounted on the rear frame section with appropriate vibration and shock mounted hardware.

SYSTEM CONTROLLER

CONTROLLER ELECTRONICS: The system shall be controlled by a dedicated computer and expansion boards. The computer board and system expansion boards must be replaceable and interchangeable with like items from manufacturer's stock to facilitate controller repairs. The components of the computer boards and expansion boards shall provide at least the minimum operation characteristics and functions as follows:

> Computer board must be compatible with Texas instruments TM990bus, 16 bit processor, and 3 Mhz System Clock; Multi-function board must contain 4K bytes CMOS RAM with on board nicad battery backup; 16 channel, 12 bit analog to digital interface; Low pass active filter for vertical transducer input; Precision power supplies and signal conditioning for temperature transducer; Interface electronics for front panel; Signal conditioning and interrupt latching for odometer; Reset and power relay driving logic; and Oscillator circuit for static simulation of odometer output.

TRANSDUCERS

All transducers shall be rated to withstand shock, vibration, dust, and moisture conditions. and shall be operational from minus 55 to 102 degrees F.

HEIGHT: The height transducer shall be capable of vertical resolution and accuracy to 0.005 inch.

TEMPERATURE: The temperature transducer shall consist of a two terminal integrated circuit sensor. Resolution to 1 degree F, and linear to 0.3 F over full range.

ODOMETER: The odometer shall be a contactless optical type with resolution of 0.39 inch.

PRINT PLOTTER

The print/plotter shall be compatible with computer and expansions board output. Data acceptance by the printer shall be adequate to fully register, plot, and/or print input data from a nominal 5 mph operation and operator keyed document points without excessive wait states. The printer/plotter shall provide at least four, 4 inch wide plots and reports.

OPERATOR CONTROL PANEL

The operator control panel shall be placed within easy access of the operator and in a location that does not hinder other operational functions or line of sight. The control panel shall contain operator actuated switches, observable indicators, and displays as described below.

Momentary switches for test control, data documentation, and input of test parameters; Bright light emitting diodes (LEDS) for switch annunciation's; Decimal encoded selector switches to multiply functions of momentary switches and aid in program mode selections; A switch to access hardware diagnostics function; A system power switch; A system reset switch; A memory lock key switch to lock in control and calibration parameters; and Large liquid crystal (LCD) display for monitoring test control, programming input, and test parameters.

TEST CONTROL SWITCHES: The control panel shall contain conveniently arranged momentary switches to control the test functions. LED annunciators shall indicate the "on" or "off" condition of the switches. The functions of the test control switches shall be as follows:

Increment of decrement pass number; Document roadway features; Clear display; Input numeric data to modify test control parameters and identification information; Update values within the system controller; Select an incrementing or decrementing odometer mode; Select automatic or manual start; and Select automatic or manually actuated print.

DISPLAY AND PROGRAMMING PARAMETERS: The run time parameters shall be switch selectable to program individual test runs. Parameters that are displayed, entered into controller, and printed are as follows:

Day's data; District, route and pavement in numeric code; pass number to discriminate between sequential passes over same surface; odometer display of odometer distance; begin test location to specify the down station end of pavement under test; end test location to specify end of test; vertical position of measuring wheel displayed; event numbering for documentation of roadway features, and; ambient temperature display.

FACTORS: The switch selectable profilograph calibration and scaling factors for display and operator modifications shall be as follows:

Odometers counts displayed in single units of distance (miles or kilometers); full scale value displayed for height transducer; segment length fro data reduction (0.1 mile or 528 feet); blanking band width (set of 0.2 inch); resolution of height measurement (0.05 inch); width of bum discrimination limits (25 feet); length over which each data point shall be averaged (1.00 to 2.00 feet); data filter (8000); and Null Band Filer (80).

Calibration and scaling factors shall be as described above or as agreed upon by the Engineer.

CONTROLLING THE RUN

MANUAL MODE: Manual mode shall be the simplest mode for using the profilograph. It is selected by assuring that the automatic printing mode is switched off. Profiles are measured by the following actions:

Key the correct station into the odometer; select incrementing or decrementing odometer with the direction modifier switch; select the data reduction method(s) by activating designated switches; activate start switch; push the profilograph over the desired report distance; activate the print switch whenever a segment is to be reported; and activate the print summary switch when a summary report is desired.

AUTOMATIC MODE: The profilograph shall be capable of being programmed to run in an automatic mode. In this mode, the controller triggers reports at programmed intervals. Operation in the automatic mode requires the following steps:

Key the correct station into the odometer; select incrementing and decrementing odometer with the direction modifier switch; assure the correct reduction length is programmed into controller; activate start switch.

In automatic mode, the controller shall generate reports at the programmed interval. There will be no output until the first segment is completed. The report will then be printed. The printing of the report shall not interfere with the accumulation of data for the next report.

When the start switch is activated, the starting station shall be transferred to the odometer and a header shall be printed. Data collection and reporting shall continue until the ending station is reached or the stop switch is activated. Once the run is completed, activation of the print summary switch shall cause a summary report to be printed.

The automatic start switch shall be used to automatically start measuring at an unmarked station. The following procedure should be used:

Position the profilograph at a marked station prior to the start of the measurement section; key this station into the odometer; set the starting odometer to the unmarked beginning station; and activate the automatic start and the automatic print switches.

As the profilograph passes the starting station, it shall automatically start. The automatic start indicator light will go out and normal automatic mode operation shall continue.

NULL BAND

There shall be two methods of determining the null band. The null band is normally centered upon a best fit line through all the points with in the section being reduced. This method does not work, however, when short vertical curves are present. In this case, a running average of points is used to establish the center of the null band on a point by point basis.

The type of null band computation shall be switch selectable at the start of the run. Changes during the run will be ignored. The length of the running average will affect the computation of the null band center. This length shall be established by the setup parameters, it shall be noted on the printed run header, and it may not be changed during a run.

REPORT FORMAT

Several reports shall be available. The header report shall be given whenever the start switch is activated. It shall list all the control and calibration parameters. These parameters may not be subsequently modified while running. A profile index report shall be written at the end of each measurement segment if this report is enabled by its designated switch. A summary report shall be available by activating the print summary switch.

Each profile Index report shall be preceded by an annotated profilograph of the measurement segment. The profilograph shall contain null band, station. magnitude and location of each recordable excursion, and the documentation number and station of document points.

The deviation information and documented points contained in the profilograph report shall consist of the following:

1. List milepost.
2. Show all high points and the amount in excess of 0.3 inch.
3. Show all areas and the amount requiring reduction to produce a profile index of 0.7 inch in 0.1 mile.

DOCUMENTATION

Documentation supplied with the profilograph system shall include but not be limited to the following:

Operator's Manual; Complete set of schematics, block diagrams and wiring diagrams covering electrical and electronic circuitry; Industry standard part number of name and model numbers for complete subsystem; and Manufacturer shall be documented on appropriate in-house production parts.

Payment

All costs associated with providing and operating the profilograph as described herein shall be included in the unit contract price per square yard for "Portland Cement Conc. Pavement Grinding".

MODIFIED CONCRETE CLASS 4000 FOR PANEL REPLACEMENT

Description

This work shall consist of replacing concrete panels with a one day design modified concrete Class 4000 pavement.

Materials

Crushed surfacing base course shall be in accordance with Section 9-03.9(3).

Asphalt concrete pavement shall be in accordance with Section 5-04.2.

The parting compound shall be a liquid membrane-forming compound that conforms to the requirements of AASHTO M 148 (ASTM C 309) type 1D or 2, Class A or B.

Epoxy-Coated dowel bars shall be in accordance with Section 9-07 except the first sentence of Section 9-07.5 is deleted and replaced by the following:

> Dowel bars shall be plain steel bars of the dimension shown in the Plans, and shall be epoxy-coated 100% on all surfaces including ends. Epoxy coating shall be in accordance with Section 9-07.3.

All tie bars shall be epoxy-coated in accordance with Section 9-07.3 and shall be epoxy-coated 100% on all surfaces including ends.

Grout shall be an epoxy resin in accordance with Section 9-26.

Materials for the Modified Concrete Class 4000 shall be in accordance with Section 6-02.2 except as modified herein.

Modified Concrete Class 4000

1 Day Mix Design Proportions are:

Cement (Type III)	705 lbs
Fine Agg (Class 1)	1100 lbs
Course Agg (No 2)	1930 lbs
Air	5% + 1 1/2%
Slump	3 in Max

Use of a water reducing agent is required. The amount used shall be within the manufacture's recommended dose range and as approved by the Engineer.

Water reducing and air entraining admixture shall conform to the requirements of Section 9-23.

Chairs for holding and supporting the dowel bars shall be completely epoxy-coated in accordance with Section 9-07.3, or made out of non-metallic materials. The Contractor shall submit to the Engineer for approval a sample of the chairs and obtain approval for them prior to use. The Contractor is advised that ordering of chairs prior to their approval by the Engineer is done at the Contractors risk and shall not be a basis for additional compensation.

Construction Requirements

Where the cement concrete panels are removed, the Contractor shall replace the pavement with the Modified Concrete Class 4000. The concrete shall be placed, cured, and finished in accordance with Section 5-05 except as follows:

1. The concrete pavement shall be placed against existing concrete pavement and stationary side forms, compacted to the specified density by suitable means, finished to the required surface smoothness by the hand-float method or other suitable means, and finally scored transversely with a comb. Concrete in the right lane need not be scored as it will be ground later.
2. After the surface has been finished as specified, the concrete shall be covered with wet burlap and an insulated curing blanket with a minimum resistance R value of 6 and shall be kept covered until the concrete has attained a minimum compressive strength of 2500 psi. Compression strength shall be determined by concrete cylinders which will be molded in accordance with WSDOT Test Method 809, from concrete last placed in the panel area and representing the quality of the concrete being placed. The cylinder will be cured in accordance with WSDOT Test Method 809, Method 2 and tested for compression strength in accordance with WSDOT Test Method 801.
3. The Contractor may use a hand pushed single blade saw for sawing joints.

All transverse contraction and construction joints shall be sawed and sealed with joint sealant filler conforming to the requirements of Section 9-04.2. The width of these joints shall be 3-16 inch minimum to 1/4 inch maximum and the depth shall be 5-16 of the concrete slab thickness.

All longitudinal construction joints shall be sawed and sealed with joint sealant filler conforming to the requirements of Section 9.04.2. The width of these joints shall be 1/8 inch minimum to 1/4 inch maximum and the depth shall be 1/3 of the concrete slab thickness.

4. Cores for depth checks and densities will not be taken.
5. Grade control shall be the responsibility of the Contractor.

The dowel bars to be placed at new transverse contraction joints shall be coated with parting compound on all sides before the bar is placed in a chair or approved device. They shall be placed parallel to the centerline and to the pavement surface mid-depth of the slab.

Where the new cement concrete pavement is to be placed against existing cement concrete pavement, installation of epoxy-coated dowel bars and epoxy-coated tie bars is required. The holes for the dowel and tie bars shall be drilled to the size and dimension as shown in the Plans.

The Contractor may use any method for drilling the holes provided the method selected does not damage the existing concrete. Any damage caused by the Contractor's operations shall be repaired by the Contractor at no cost to the Contracting Agency and the repair shall be to the satisfaction of the Engineer.

Epoxy-coated dowel and tie bars shall be grouted into the holes as noted in the Plans in the following manner:

The holes shall be blown clean with moisture and oil free, compressed air before grouting with epoxy. The bar shall be centered in the hole for the full length of embedment before grouting. The epoxy shall then be pumped into the hole around the bar in a manner that the back of the hole will be filled first. Blocking or shimming shall not impede the flow of the epoxy in the hole. Dams shall be placed at the front of the holes to confine the epoxy. The dams shall permit the escape of air without leaking epoxy and shall not be removed until the epoxy has cured in the hole.

Shoulder Replacement

The portion of the shoulder removed to allow for the forming of the panels shall be patched back with crushed surfacing base course and asphalt concrete pavement Class B as shown in the Plans. Compaction of asphalt concrete pavement and crushed surfacing base course shall be to the satisfaction of the Engineer.

For Test Section (Contract 4107)

The existing surfacing where the asphalt concrete shoulders were removed and the cement concrete shoulders are to be constructed shall be smoothed, shaped and compacted to the satisfaction of the Engineer. Dowel bars shall be installed as described in this Special Provision. Modified Concrete Class shall then be placed.

After the cement concrete shoulder has cured, the Contractor shall place the crushed surfacing base course and asphalt concrete pavement Class B in accordance with Sections 4-04 and 5-04.

All transverse and longitudinal construction joints shall be sawed or routed and sealed with joint sealant filler conforming to the requirements of Section 9-04.2. The width of these joints shall be 1/4 inch, the depth shall be in accordance with Standard Plan A-1 sheet 2 of 2.

Contraction joints shall be in accordance with Standard Plan A-1.

Opening to Traffic

Prior to opening any panel repair area to traffic, the modified concrete Class 4000 shall have a compression strength of 2500 psi as described elsewhere in this Special Provision.

If a panel repair area can be opened to traffic as required in the Special Provision **TRAFFIC CONTROL**, due to low strength, the Contractor shall be subject to liquidated damages in accordance with the Special Provision **LIQUIDATED DAMAGES** or the area will be opened to traffic and shall be replaced by the Contractor at no additional expense to the Contracting Agency, as determined by the Engineer.

Measurement

Crushed surfacing base course and asphalt concrete pavement will be measured in accordance with Sections 4-04.4 and 5-05.4.

Modified Concrete Class 4000 will be measured by the cubic yard to the neat lines shown in the Plans for the pavement completed and accepted.

Epoxy-coated #5 tie bars with drill hole, 1-1/2 inch x 18 inch epoxy-coated dowel bars with drill hole will be measured per each for the actual number of bars used in the completed work.

Payment

The unit contract prices per ton for "Crushed Surfacing Base Course" and "Asphalt Conc. Pavement Cl. B", per cubic yard for "Modified Concrete Class 4000", and per each for "Epoxy-Coated #5 Tie Bar With Drill Hole", "1-1/2 Inch x 18 Inch Epoxy-Coated Dowel Bar With Drill Hole", and "1-1/2 Inch x 18 Inch Epoxy-Coated Dowel Bar" shall be full pay to complete the work as specified.

1-1/2 INCH X 18 INCH EPOXY-COATED DOWEL BAR RETROFIT

Description

This work consists of installing 1-1/2 inch x 18 inch epoxy-coated dowel bars into existing cement concrete pavement.

Materials

The parting compound shall be a liquid membrane-forming compound that conforms to the requirements of AASHTO M 148 (ASTM C 309) Type 1 D or 2, Class A or B.

Epoxy-Coated dowel bars shall be in accordance with Section 9-07 except the first sentence of Section 9-07.5 is deleted and replaced by the following:

> Dowel bars shall be plain steel bars of the dimensions shown in the Plans, and shall be epoxy-coated 100% on all surfaces including the ends. Epoxy coating shall be in accordance with Section 9-07.3.

The dowel bars shall have tight fitting end caps made of non-metallic materials that allows for 1/4 inch movement of the bar at each end. The contractor shall submit to the Engineer sample end caps and obtain approval of them prior to use. The Contractor is advised that ordering of the end caps prior to there approval by the Engineer is at the Contractors risk and shall not be a basis for additional compensation.

Caulking filler shall be silicone sealant. The Contractor shall submit to the engineer a sample of the material and obtain approval prior to use.

A 1/2 inch thick foam core board filler material shall be a closed cell foam faced with poster board material on each side commonly referred to as foam core board by Office Suppliers. The Contractor shall submit to the Engineer a sample of the material and obtain approval prior to use.

Cement concrete pavement removed for the purpose of installing retrofitted dowel bars shall be replaced with Burke 928 Fast-Patch, Fosroc-Patch 10-60, or Five Star Highway Patch.

Chairs for supporting and holding the dowel bar in place shall be completely epoxy coated in accordance with Section 9-07.3, or made out of non-metallic materials. The Contractor shall submit to the Engineer for approval a sample of the chairs and obtain approval of them prior to use. The Contractor is advised that ordering of chairs prior to their approval by the Engineer is at the Contractors risk and shall not be a basis for additional compensation.

Construction Requirements

The Contractor shall install bars in the existing cement concrete pavement as shown in the Plans and in accordance with the following specifications:

1. Saw cut slots in the pavement as required to place the center of the dowel at mid-depth in the concrete slab. Multiple saw cuts parallel to the centerline may be required to properly remove material from the slot.
2. To prevent damage to the existing pavement designated to remain any jack hammers used to break loose the concrete shall have a weight less than 30 pounds.
3. All exposed surfaces and cracks in the slot shall be sand blasted and cleaned of saw slurry and any parting compound prior to installation of the dowel.

4. Dowel bars shall be lightly coated with a parting compound, and placed in a chair that will provide a minimum of 1/2 inch clearance between the bottom of the dowel and bottom of the slot. The dowel bars shall be placed to the depth as shown in the Plans, parallel to the centerline, and parallel to the pavement surface of the lower panel at the transverse joint, all to a tolerance of 1/4 inch.

   The chair design shall hold the dowel bar tight in place during placement of the grouting material. Any chair design that may allow movement of the bar during the placement of grout will be rejected by the Contracting Agency. If for any reason the above situation occurs, any effects shall not be a basis for extra compensation and it shall remain the Contractor's responsibility to open the roadway to traffic as required in the Special Provision **TRAFFIC CONTROL**.

5. Immediately prior to placement of the dowel bar and filler material, the Contractor shall caulk the existing transverse joint crack at the bottom and the sides of the slot as shown in the Plans. The caulking shall be placed to provide a smooth level surface and tight fit for the foam core board filler material to the bottom of the slot. The transverse joint crack shall be caulked sufficiently to satisfy the above requirements and to prevent any of the grouting material from entering the joint crack at the bottom or the sides of the slot.

6. A 1/2 inch thick foam core board filler material, as approved by the Engineer, shall be placed at the middle of the dowel to maintain the transverse joint as shown in the Plans. The filler material shall fit tight around the dowel and to the bottom and edges of the slot. The filler material shall be capable of remaining in a vertical position and tight to all edges during placement of the grout. If for any reason the filler material shifts during placement of the grout, the work shall be rejected and redone at the Contractor's expense. If for any reason the above situation occurs, any effect shall not be a basis for extra compensation and it shall remain the Contractor's responsibility to open the roadway to traffic as required in the Special Provision **TRAFFIC CONTROL**.

7. The joint shall be maintained by saw cutting the surface with a hand pushed single blade saw. The cut width shall be 1/4 inch and the depth shall be 2 inches deep. The joint shall be sawed within 24 hours after placement of the grout.

8. Any damage to the pavement due to the Contractor's operation shall be repaired by the Contractor at no cost to the Contracting Agency.

<u>Alternate Methods</u>

The Contractor may propose for the Engineer's evaluation an alternative method of cutting the retrofit slot and placing the dowel. The Contractor shall demonstrate on site the proposed alternate method. The Contractor is advised that the rejection of any proposed alternate method shall not be basis for additional compensation and/or contract time.

<u>Measurement</u>

Dowel bars will be measured per each dowel bar installed.

Payment

The unit contract price per each for "1-1/2 in x 18 in Epoxy-Coated Dowel Bar Retrofit" shall be full pay to complete the work as specified including chairs and end caps.

PAVEMENT MARKING

Materials

The following pavement marking materials have been tested and prequalified for meeting the requirements noted in Section 8-22, 8-23 and 9-21:

Paint Pavement Marking - Sprayed Applications

Baur Coating Division	White - 2143A9	Standard
Daniel Boone Paint Inc.	White - 7371	Standard
Norris Paints/TMT	White - BHW8W1-1	Standard
Norris Paints/TMT	White - BHW8W1-3	Standard
Norris Paints/TMT	White - BHWPW1-1	Premixed
Norris Paints/TMT	White - BHWPW1-2	Premixed
Baur Coating Division	Yellow - 2144A9	Standard
Daniel Boone Paint, Inc.	Yellow - 7372	Standard
Norris Paints/TMT	Yellow - BHW8Y2-2	Standard
Norris Paints/TMT	Yellow - BHW8Y2-3	Standard
Norris Paints/TMT	Yellow - BHWPY2-1	Premixed
Norris Paints/TMT	Yellow - BHWPY2-2	Premixed
Pervo Paint Company	Yellow - 5906	Standard

Plastic Pavement Marking - Preformed Tapes

Brite-Line Industries, Inc.	Series 1000 - 60 mil
Flint Trading Inc.	Premark - 125 mil
Linear Dynamics Inc.	Prismo Brand - 60 mil
Linear Dynamics Inc.	Prismo Brand - 90 mil
3M Company	Stamark 5730 - 60 mil
3M Company	Stamark 350 - 60 mil
3M Company	Stamark 380 - 60 mil

Preformed tapes are not allowed on bituminous surface treatment (BST) pavement.

Plastic Pavement Marking - Extruded Applications (Statewide)

Lafrentz Road Service Ltd.	Lafrentz Thermoplactic - 125 mil
Norris Paints/TMT	Dura-Stripe AC - 90 mil
Norris Paints/TMT	Norline Thermoplastic TP - 125 mil
Pave-Mark Corporation	Pave-Mark Alkyd - 125 mil
Pave-Mark Corporation	Pave-Mark Hydrocarbon - 125 mil

Plastic Pavement Marking - Extruded Applications (Western Washington Only)

Cataphote Inc.	Catatherm ABITOL - 125 mil
Lafrentz Road Service Ltd.	Lafrentz Thermoplastic - 125 mil

Norris Paints/TMT	Dura-Stripe AC - 90 mil
Norris Paints/TMT	Norline Thermoplastic TP - 125 mil
Pave-Mark Corporation	Pave-Mark Alkyd - 125 mil
Pave-Mark Corporation	Pave-Mark Hydrocarbon - 125 mil
Swedish A.B. Cheansol	Cleansol IT - 125 mil

Plastic Pavement Marking - Sprayed Applications

Norris Paints/TMT	Dura-Stripe AC - 40 mil

Raised Pavement Markers Type 1

Zumar	TM40W/Y

Raised Pavement Markers Type 2 (Permanent)

Pac-Tec, Inc.	Rau-O-Lite Model AA & Ray JR
Stimsonite	Stimsonite 88, 911, 948 & 953

Raised Pavement Markers Type 3

Engineered Plastics, Inc.	Guideline

Temporary Raised Pavement Markers Type 2 (Long Term)

Temporary pavement markers for long term (6 months or less). Raised pavement markers approved for permanent installations can also be used.

Astro-Optics Corp.	Model TPM
Davidson Plastics Co	RPM Standard Grade
Davidson Plastics Co	RPM Work Zone Grade
Flex-O-Lite	RCM
3M Company	Series 240
Stimsonite	Model 66
Stimsonite	Model 66GB

Temporary Raised Pavement Markers Type 2 (Short Term)

Temporary pavement markers for short term (14 days or less). Raised pavement markers approved for permanent and long term installation can also be used.

Astro-Optics	Model TPM
Davidson Plastics Co.	RPM Standard Grade
Davidson Plastics Co.	RPM Work Zone Grade
Davidson Plastics Co.	TOM
Flex-O-Lite	RCM
3M Company	Series 240
Stimsonite	Model 66
Stimsonite	Model 66GB

Temporary Raised Pavement Markers Type 2 (Short Term Seal Coat)

Davidson Plastics Co.	TRPM

Manufacturer's addresses and telephone numbers are as follows:

Astro-Optics Corp.
156 Williams Street
Carpentersville, IL 60110
(800) 444-4420

Bauer Coatings Division
Morton International
1021 North Mission Road
Los Angeles, CA 90033
(800) 338-7680

Brite-Lite Industries, Inc.
81 Hartwell Avenue
Lexington, MA 02173
(800) 231-8902

Cataphote, Inc.
PO Box 2369
Jackson, MS 39205
(800) 221-2574

Daniel Boone Paints, Inc.
15701 Nelson Place South
Tukwila, WA 98188
(206) 228-7767

Davidson Plastics Co
18726 East Valley Highway
Kent, WA 98031
(206) 251-8140

Engineered Plastics
1500A Copper Hill Parkway
Santa Rosa, CA 95403
(707) 579-1518

Pervo Paint Company
6624 Stanford Avenue
Los Angeles, CA 90001

Flex-O-Lite Division
Lukens Gen. Industries, Inc.
PO Box 4366
St Louis, MO 63123
(800) 325-9525

Flint Trading, Inc.
PO Box 160
Thomasville, NC 27360-0160
(919) 475-6600

Linear Dynamics, Inc.
300 Lanidex Plaza
Parisppany, NJ 07054
(201) 884-0300

3M Company
223-3N 3M Center
Saint Paul, MN 55015
(612) 733-8937

Norris Paints/TMT
Morton International
1675 Commercial Street NE
(800) 835-3357

Pac-Tec, Inc.
Box 877
Newark, OH 43058-0877
(800) 848-7025

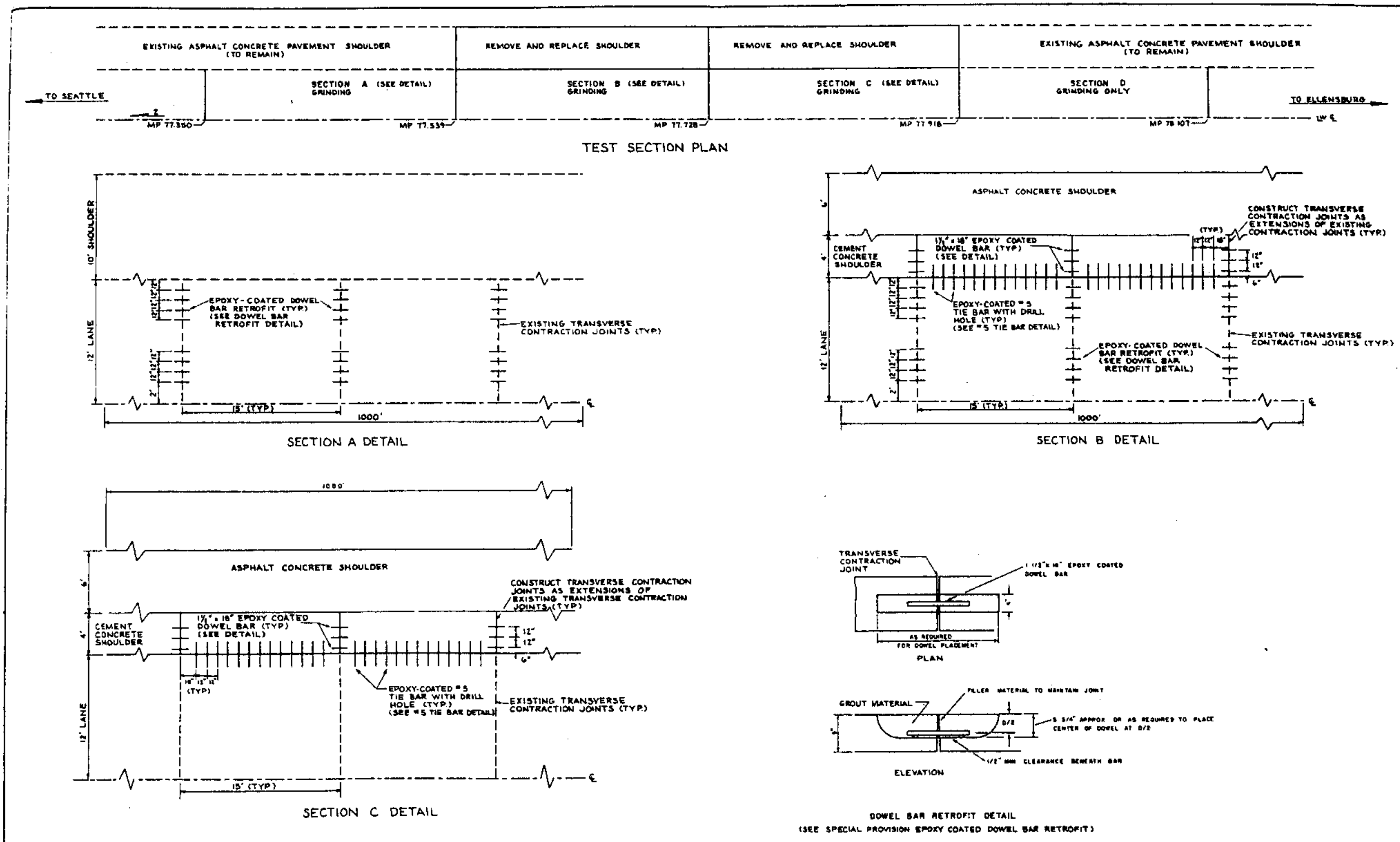
Pave-Mark Corp
PO Box 94108
1855 Plymouth Road NW
Atlanta, GA 30318
(404) 351-9780

Stimsonite Corporation
7542 North Natchez Avenue
Niles, IL 60648
(312) 647-7717

Swedish A.B. Cleansol
Kristianstad, Sweden

Zumar Industries, Inc.
PO Box 11305
Tacoma, WA 98411
(800) 562-7030

APPENDIX C - ROADWAY SECTIONS



DRAWN	K. W. HOLYOAK
CHECKED	R. C. BAKER
PROJ. ENGR.	K. G. LOCKWOOD
DIST. ADM.	R. L. LARSON

DATE | REVISION | BY | APP'D

REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
10	WASH	IR-90-2(167)		
JOB NUMBER 52E034				
CONTRACT NO.				

HIGHWAY DIVISION

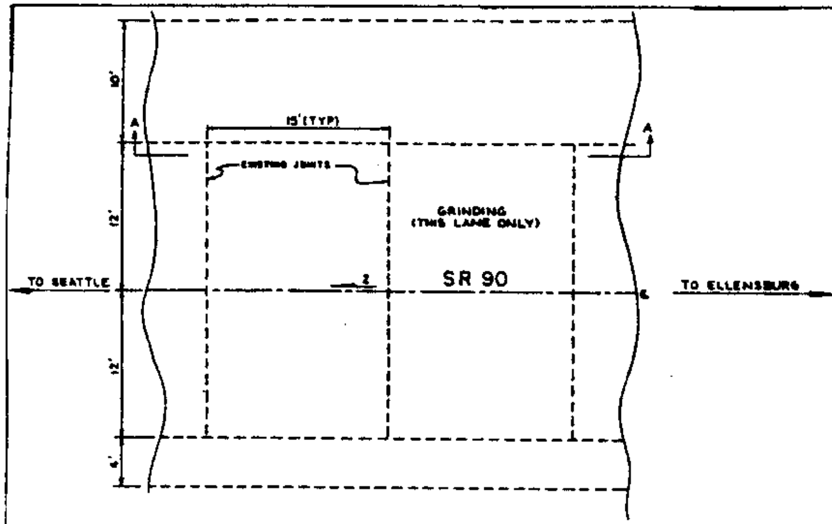
APPROVED

Washington State Department of Transportation

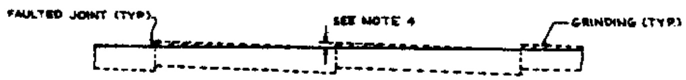
SR 90
KACHESS RIVER TO YAKIMA RIVER

TEST SECTIONS

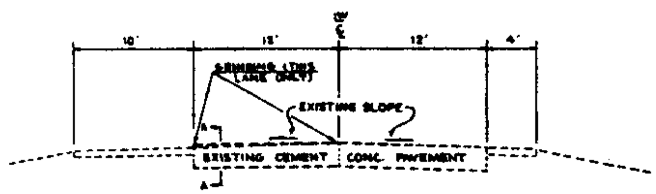
SHEET 5 OF 21 SHEETS



GRINDING PLAN



SECTION A-A



GRINDING SECTION (TYPICAL)

SECTION 1: MP 69.52 TO 79.36
SECTION 2: MP 80.85 TO 81.72
SECTION 3: MP 82.68 TO 101.55

NOTES

1.) ℄ LINE:

GUARDRAIL WORK WILL BE THE ONLY WORK ON THE EASTBOUND LANES OF THIS PROJECT

2.) BRIDGE DECKS:

NO GRINDING OR CRACK SEALING WILL BE DONE ON BRIDGE APPROACH SLABS AND BRIDGE DECKS.

3.) JOINTS AND CRACKS:

SECTION 1: MP 68.52 TO 79.36

SECTION 2: MP 80.85 TO 81.72

SECTION 3: MP 82.68 TO 102.49

CLEAN AND RESEAL ALL WESTBOUND (W) TRAVEL LANES

SEE SPECIAL PROVISION JOINT SEALING

4.) FAULTED JOINT DEPTH VARIES FROM 0 IN. TO 7/8 IN.

EQUATIONS
MP 71.21 (BK.) = MP 71.25 (AHD)

℄ BRIDGES AND APPROACHES NOT INCLUDED IN PROJECT			
BRIDGE NO.	MP	TO	MP
90/120N	71.255	TO	71.325
90/124N	74.045	TO	74.089
90/126N	75.355	TO	75.390
90/128N	76.595	TO	76.627
90/130N	78.055	TO	78.099
90/132N	78.805	TO	78.878
90/134N	80.785	TO	80.847
90/136N	83.525	TO	83.451
90/140N	86.195	TO	86.279
90/141N	86.625	TO	86.722
90/145N	90.635	TO	90.695
90/150N	97.265	TO	97.314
90/152N	100.545	TO	100.580

DRAWN	K. W. HOLYOAK			
CHECKED	R. C. BAKER			
PROJ. ENGR.	K. B. LOCKWOOD			
DIST. ADM.	R. L. LARSON			
		DATE	REVISION	BY / APP'D

REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
10	WASH	IR-90-2(167)		
JOB NUMBER 92E034				
CONTRACT NO.				

HIGHWAY DIVISION

APPROVED

Washington State Department of Transportation

SR 90

KACHESS RIVER TO YAKIMA RIVER

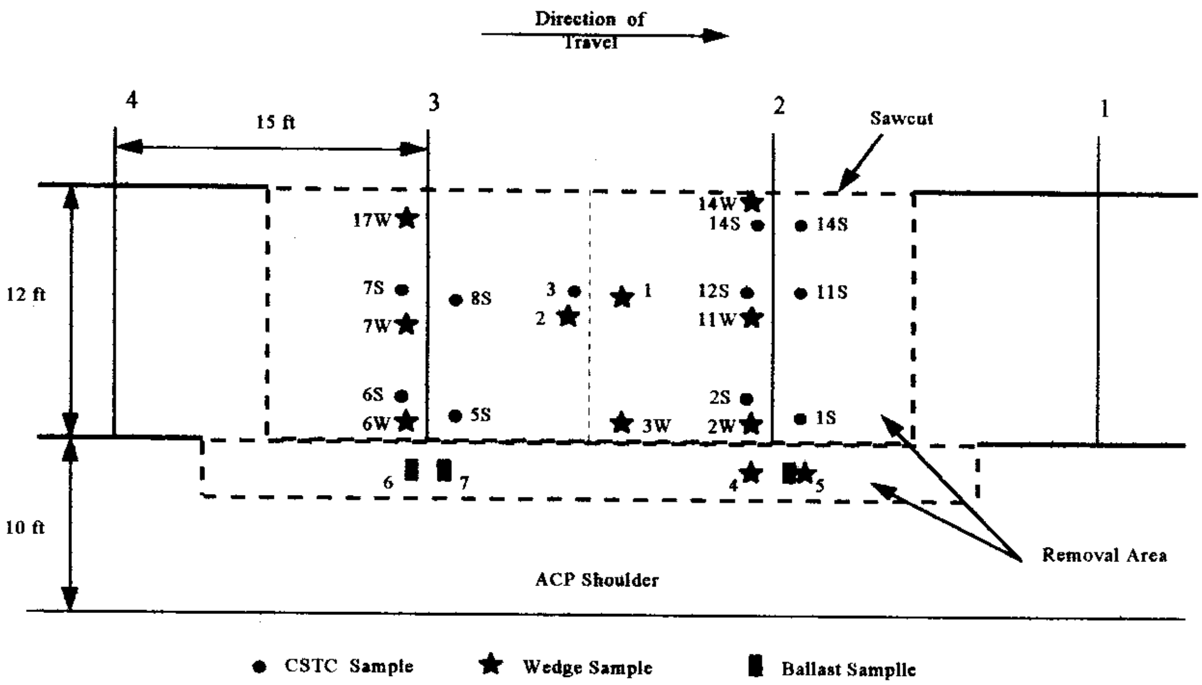
GRINDING DETAIL

GDI

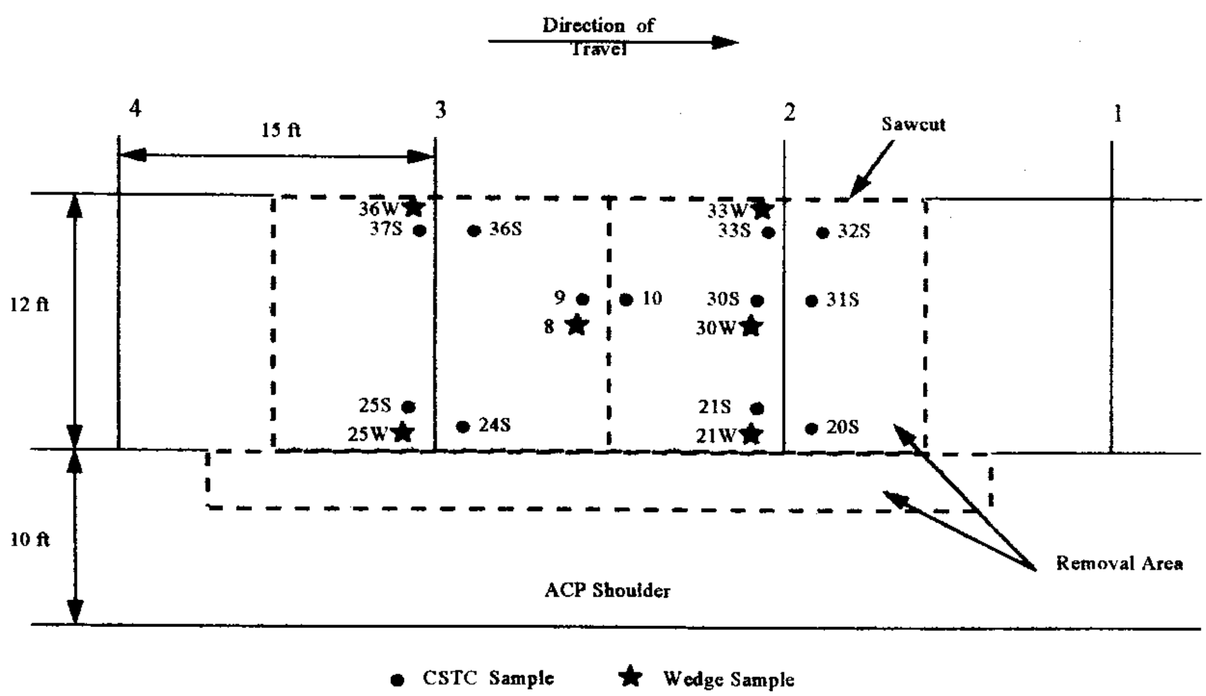
SHEET 3 OF 21 SHEETS

APPENDIX D - TEST REPORTS

Panel Removal and Sample Locations - MP 72.20



Panel Removal and Sample Locations - MP 98.70



CSTC Sample Gradations

WSDOT Gradation Specifications (1960 - 1967)

% Passing	CSTC Min	CSTC Max	Ballast Min	Ballast Max
2-1/2"				100
2"			65	100
1"			50	80
5/8"		100		
1/4"	50	65	30	50
#40	5	23		16
#200		10		9

	MP 72.20										Average	
	1S	2S	12S	11S	13S	14S	5S	6S	8S	7S	Ahead	Back
Percent Passing												
5/8"	96	99	99	98	97	96	97	94	100	99	98	97
3/8"	83	88	88	81	86	77	82	82	86	85	85	83
1/4"	71	73	73	71	72	61	70	70	75	73	74	70
#10	45	48	46	43	49	38	50	47	43	48	47	45
#40	30	29	27	24	32	24	34	28	25	29	29	27
#50	25	25	23	21	28	21	31	24	23	25	26	23
#80	22	21	20	18	24	19	27	20	20	21	23	20
#100	20	19	18	17	23	18	25	18	19	20	21	18
#200	15	14	14	14	17	14	19	14	16	15	16	14
Percent Fracture												
3/8"	71	83	92	90	76	80	85	80	70	74	79	81
1/4"	83	83	85	94	84	93	89	87	94	92	87	90
#10	89	94	89	92	90	88	85	78	85	94	88	89
Percent Moisture												
	5.6	5.0	5.3	4.9	6.3	5.0	6.0	5.7	4.7	5.3	5.6	5.2

	MP 98.70										Average	
	20S	21S	31S	30S	32S	33S	24S	25S	36S	37S	Ahead	Back
Percent Passing												
5/8"	99	100	96	98	94	97	96	100	94	95	96	98
3/8"	91	90	88	84	85	88	86	99	82	81	86	88
1/4"	78	81	77	67	74	73	72	80	67	69	73	74
#10	53	53	49	41	54	54	50	53	43	48	50	50
#40	37	33	31	21	39	33	34	32	29	28	34	29
#50	34	28	27	18	36	28	31	27	26	24	31	25
#80	30	23	24	14	32	22	28	22	23	19	27	20
#100	28	21	22	13	31	20	27	20	22	18	26	19
#200	22	16	18	10	23	15	22	15	15	14	20	14
Percent Fracture												
3/8"	81	96	73	75	66	51	66	69	77	86	73	75
1/4"	84	82	81	80	82	87	78	82	84	87	82	84
#10	87	88	90	88	84	87	95	91	92	87	90	88
Percent Moisture												
	6.4	5.1	5.1	4.2	6.5	5.5	7.0	5.9	5.7	4.3	6.1	5.0

Wedge and Ballast Sample Gradations

	MP 72.20							MP 98.70		
	1	2	3	4	5	6	7	8	9	10
Percent Passing										
5/8"	100	100	87	94	87	73	61	100	100	100
3/8"	90	93	75	73	65	55	48	98	90	97
1/4"	79	80	64	57	51	44	41	90	75	90
#10	35	38	40	32	29	28	27	58	48	58
#40	9	11	22	17	16	17	16	29	26	29
#50	7	8	19	14	13	14	13	23	22	24
#80	5	6	16	12	11	11	10	17	18	19
#100	4	5	15	11	10	10	9	16	17	17
#200	3	4	12	8	8	7	6	11	14	12
Percent Fracture										
3/8"	84	97						87	81	74
1/4"	96	96						90	83	83
#10	96	96						90	89	90
Sand Equivalency										
	69	62	35	55	65	47	54	52	60	42

Hydrometer Results for Wedge Samples

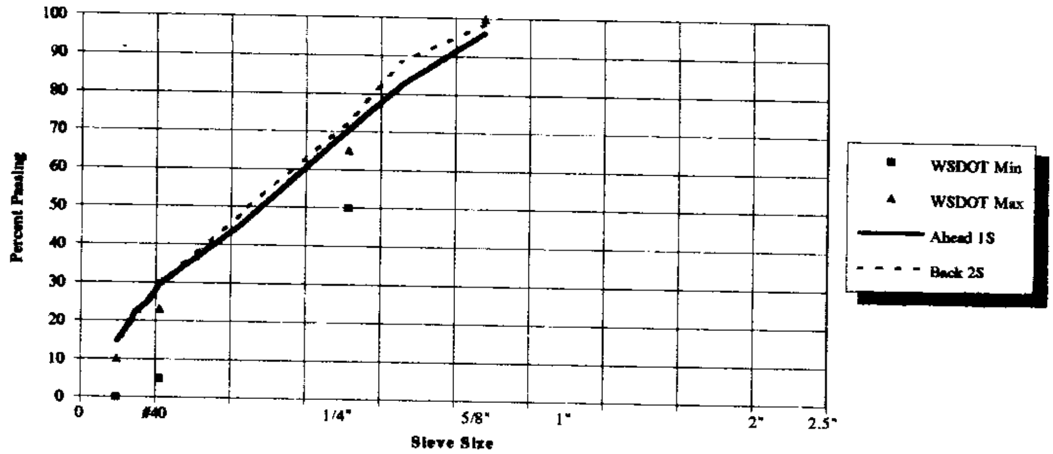
	MP 72.20							MP 98.70				
	2W	3W	6W	7W	11W	14W	17W	21W	25W	30W	33W	36W
Percent Passing												
#40	52	65	52	51	57		72	73	67	71	81	78
#200	17	36	18	16	21		32	34	27	35	34	28
0.020	7.6	24	8	6	7.9	16	14	18	8	19	18	8.7
0.002	1.5	6.0	1.5	0.5	1.8	1.5	2.4	3.8	1.5	6.2	4.3	1.4
0.001	0.5	1.5	0.5	0	0.3	0.2	0.1	0.3	0.2	2.5	1.2	0.9

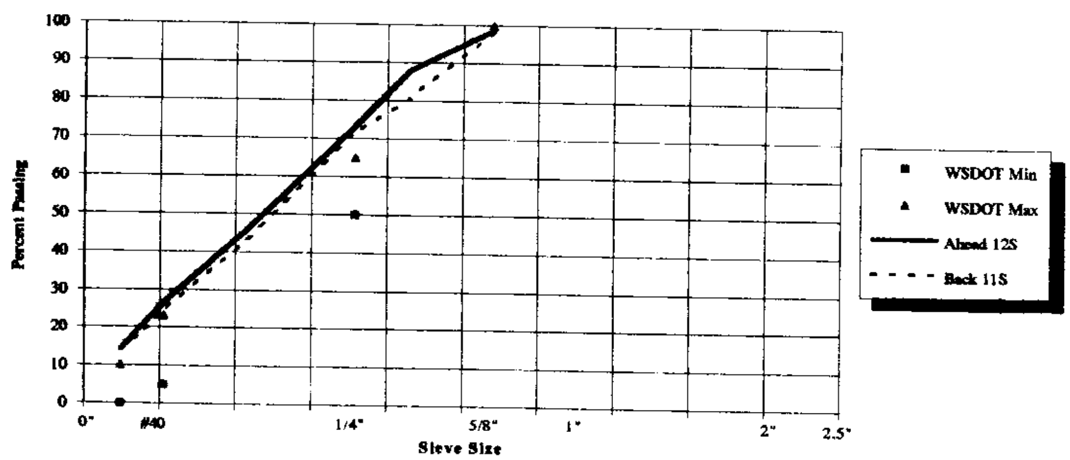
CSTC and Ballast Samples

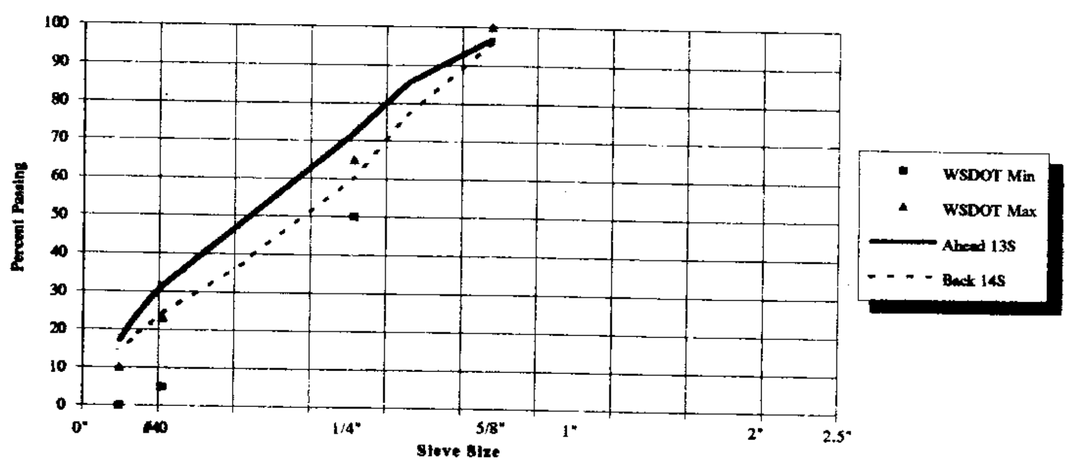
Sampled 2 ft from transverse joint and 4 ft from lane/shoulder joint.
Hole 1 is leave side of the joint, Hole 2 is approach side of the joint.

	MP 76.70				MP 98.70			
	Hole 1		Hole 2		Hole 1		Hole 2	
	CSTC	Ballast	CSTC	Ballast	CSTC	Ballast	CSTC	Ballast
Percent Passing								
2		100		100		100		100
1"		93		90		95		91
5/8"	100		99		100		99	
1/4"	78	56	69	51	74	60	75	56
#10					56		55	
#40	29	23	27	19	24	18	24	18
#200	23	12	15	8	13	9	13	8
Percent Fracture								
5/8"								
1/4"	89		57		84		82	
#10	86		87		83		91	
Percent Moisture								
	8.4	6.2			5.4	4.3	5.3	3.8
Sand Equivalency								
	25	21	30	27	32	38	33	37

MP 72.20 - Joint 2 Sample Gradations

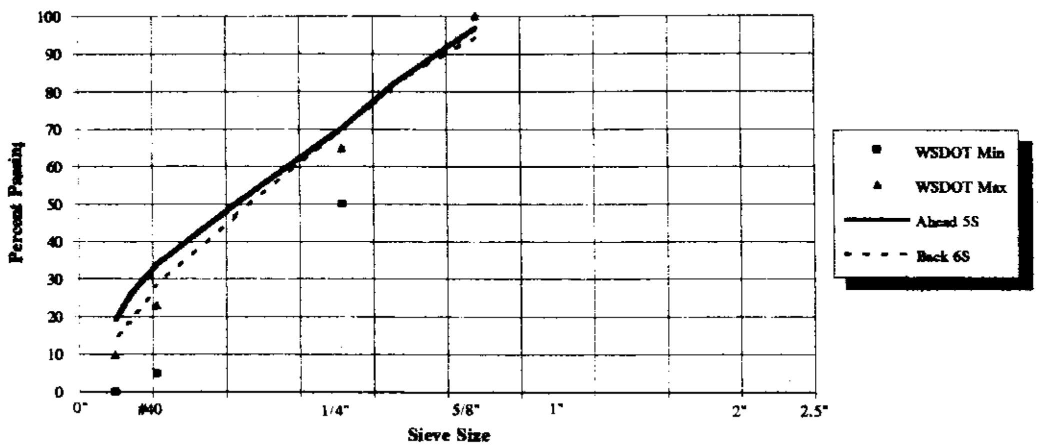


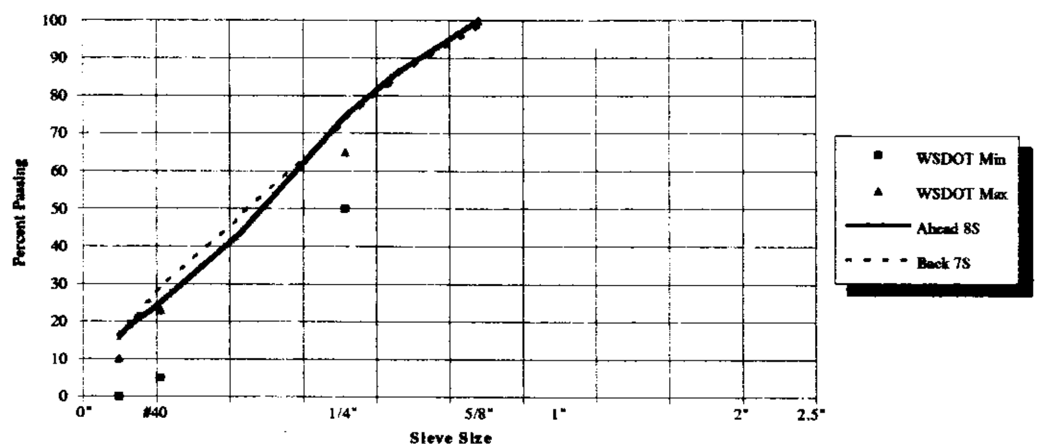




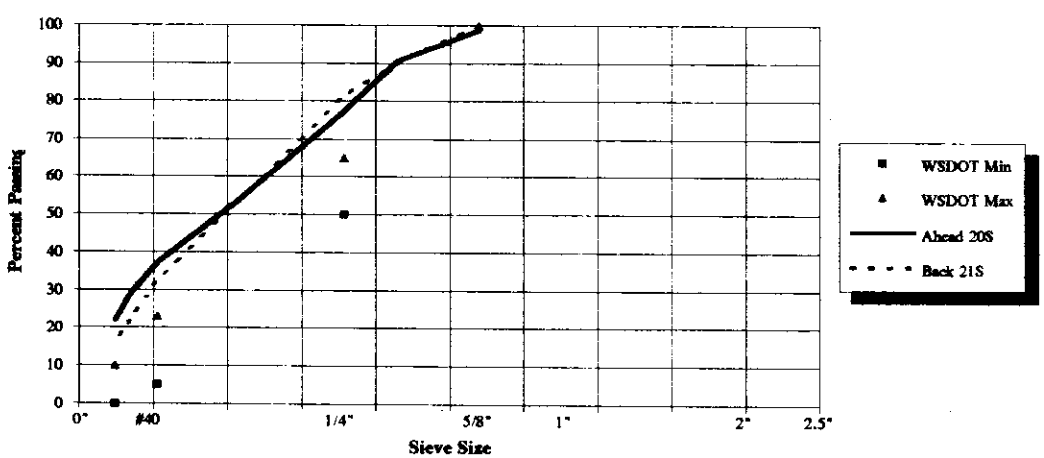
Sieve sizes raised to 0.45 power

MP 72.20 - Joint 3 Sample Gradations



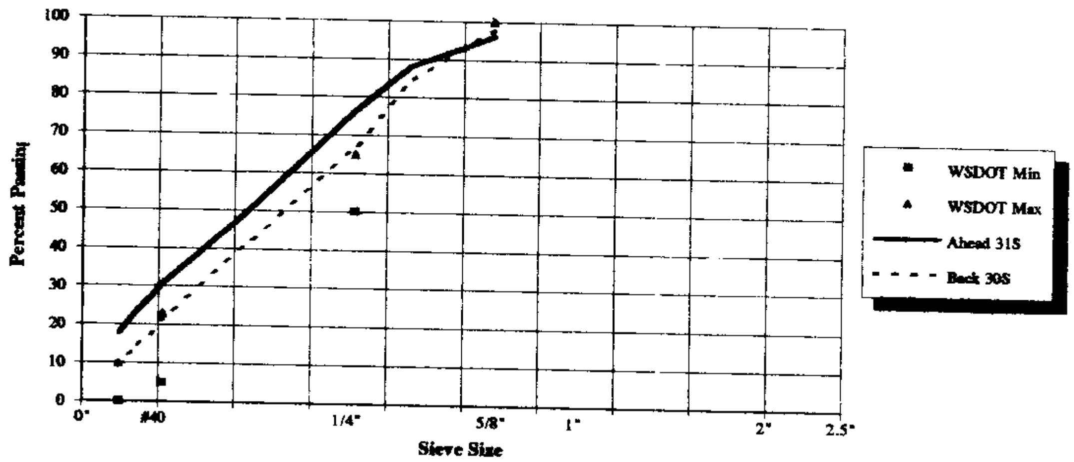


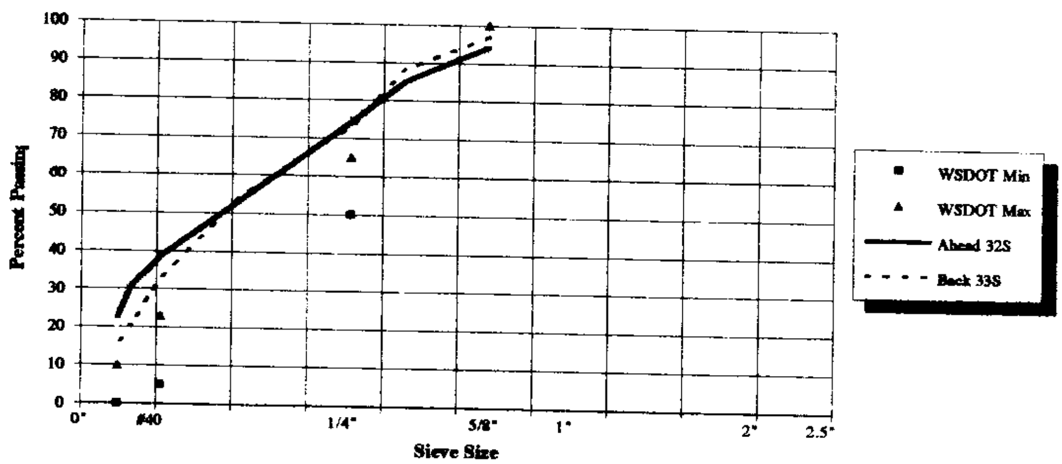
MP 98.70 - Joint 2 Sample Gradations



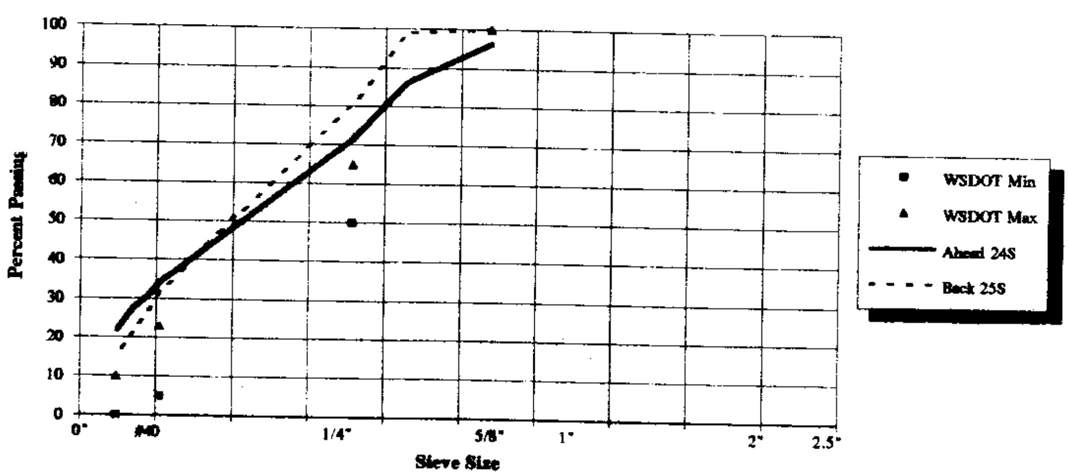
Sieve sizes raised to 0.45 power

MP 98.70 - Joint 2 Sample Gradations continued...



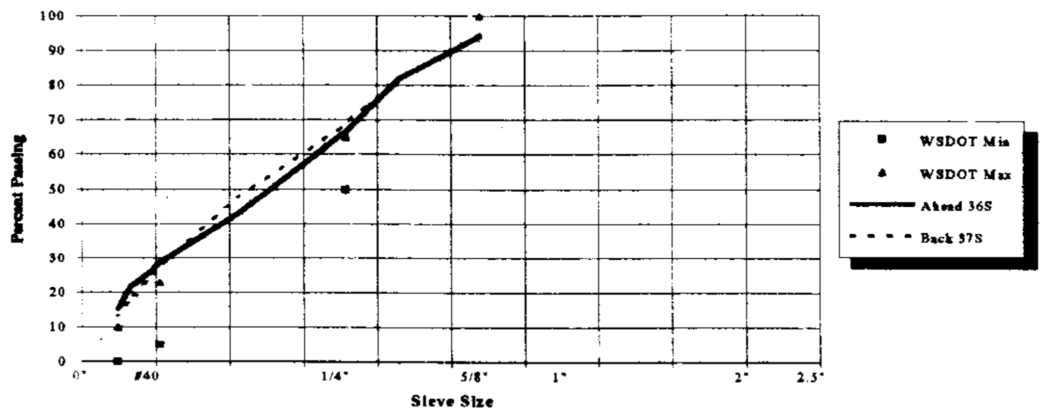


MP 98.70 - Joint 3 Sample Gradations

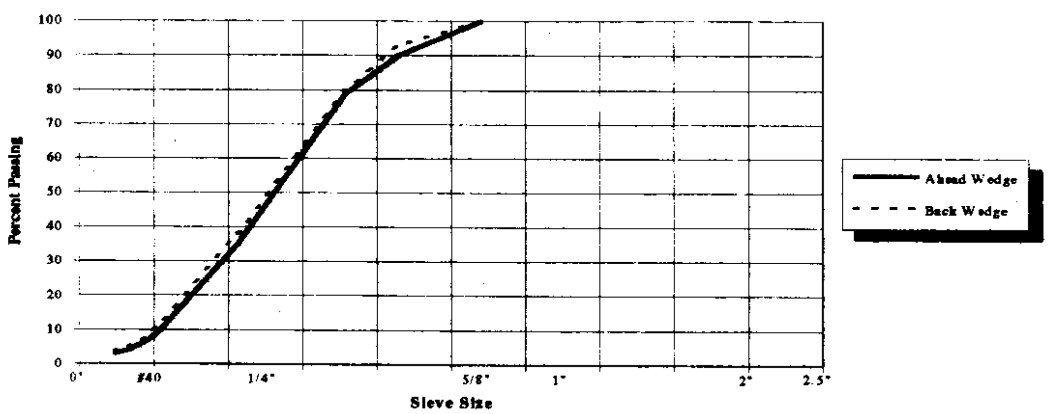


Sieve sizes raised to 0.45 power

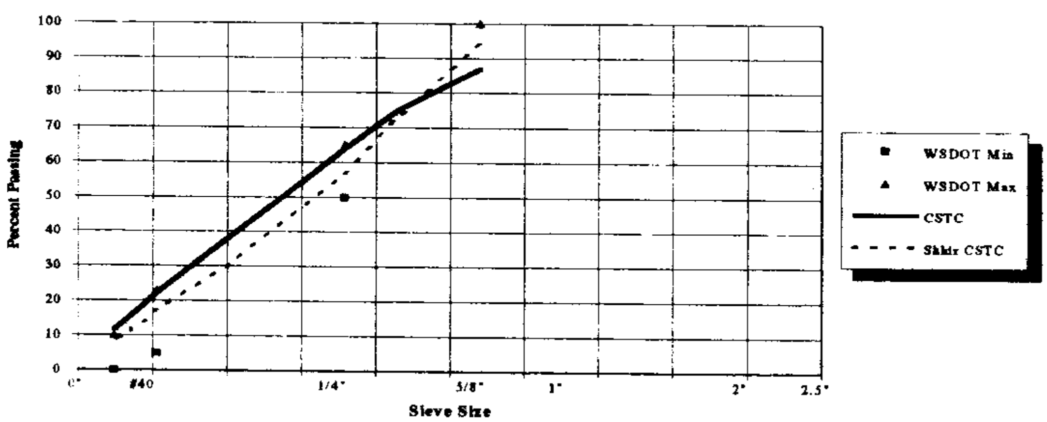
MP 98.70 - Joint 3 Sample Gradations continued...



MP 72.20 - Wedge Sample Gradation

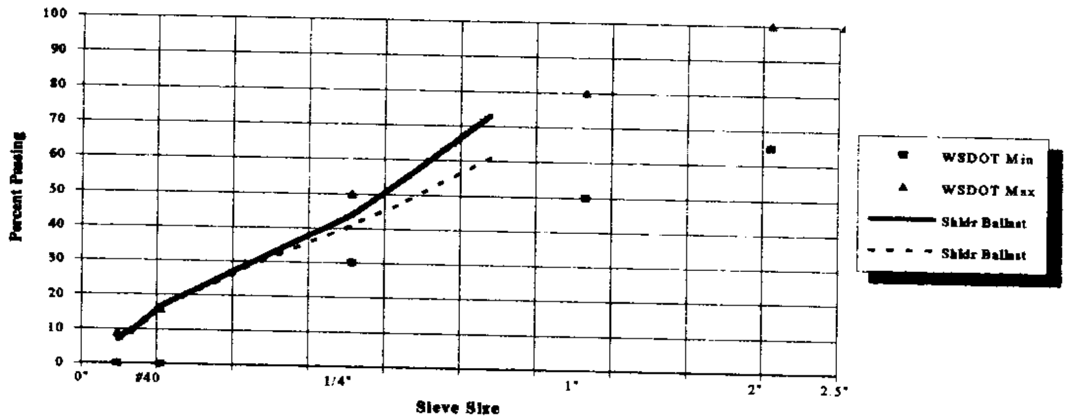


MP 72.20 - CSTC Sample Gradations

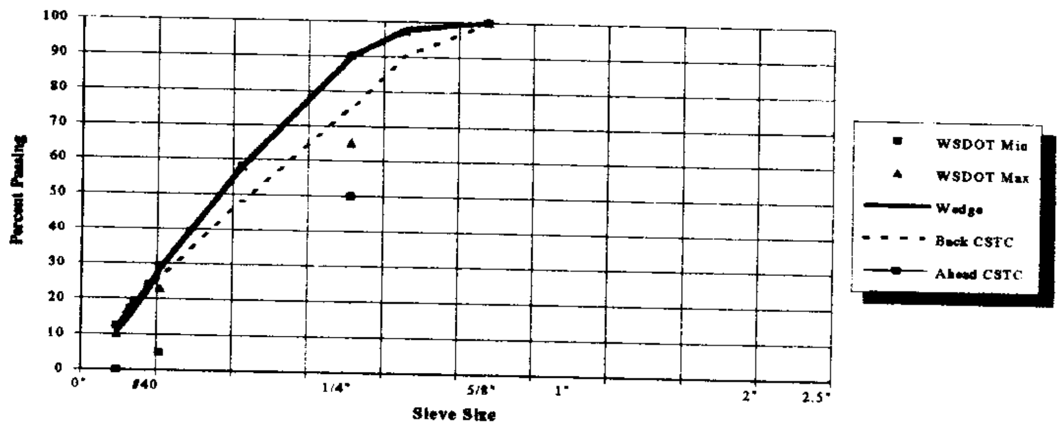


Sieve sizes raised to 0.45 power

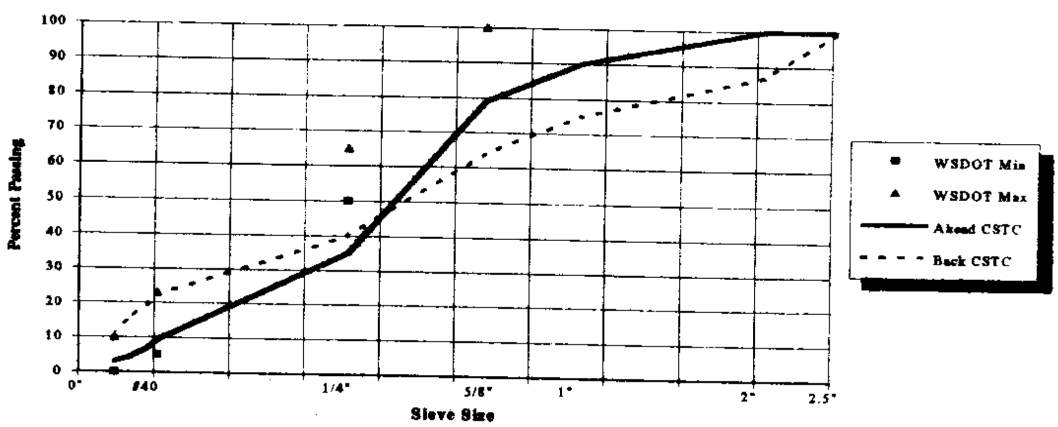
MP 72.20 - Joint 3 Shoulder Ballast Sample Gradations



MP 98.70 - Wedge and CSTC Sample Gradations

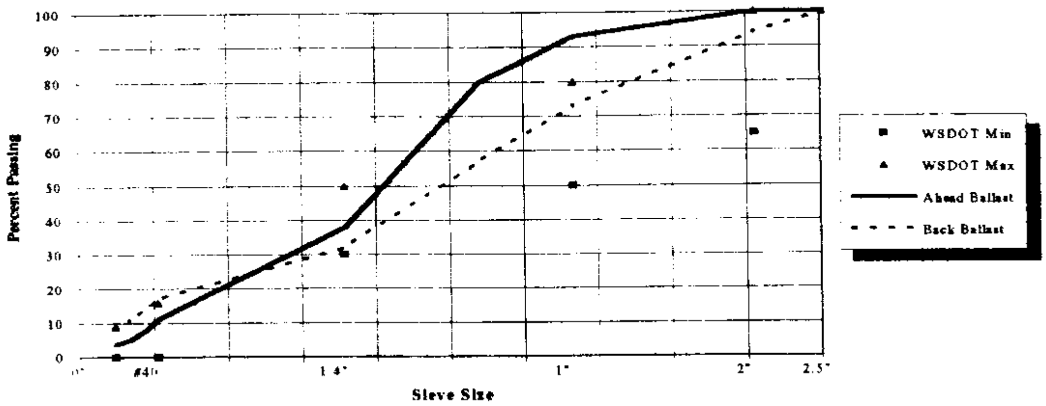


MP 98.70 - CSTC Sample Gradations



Sieve sizes raised to 0.45 power

MP 98.70 - Ballast Sample Gradations



Sieve sizes raised to 0.45 power