

Design, Construction, and Analysis of CRCP Patching Techniques

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<p>16. Abstract</p> <p>Continuously reinforced concrete pavements (CRCP) are difficult to patch, and patches often do not perform as well as expected. In an effort to improve patch performance, several alternative designs were constructed within five rehabilitation projects on FAI Routes 55 and 57 in Illinois. Alternatives included subdrainage of the patch, addition of steel fiber to the concrete, addition of transverse reinforcement, use of high early strength concrete, and the use of large (No. 11) rebars grouted into the adjacent pavement. In addition to these experimental patches, many "conventional" CRCP patches were constructed. The performance of 500 patches were monitored for 20 months. It was concluded that:</p> <ul style="list-style-type: none"> • The conventional CRCP patch provided relatively good performance. • Subdrainage of the patch caused other problems that resulted in early failures. • Patches with steel fibers performed only slightly better than the standard patch. • Addition of transverse reinforcement greatly reduced failures. <p>As a result of the study, Illinois has modified its patching standard to include transverse reinforcement bars at a nominal spacing of 12 inches.</p>			
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OF CRCP PATCHING TECHNIQUES IN ILLINOIS

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DISCLAIMER

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I. INTRODUCTION

There are approximately 500 centerline miles of bare Continuously Reinforced Concrete Pavement (CRCP) on the Interstate highway system in Illinois. A vast majority of this mileage is more than 15 years old and experiencing edge "punch outs" and areas of localized distress. Since these areas of distress are typically isolated, full depth CRCP patching is the most economical method of repair. However, the performance of CRCP patching has been highly variable. Some pavement repairs will last several years and perform well, while others will fail rapidly and require replacement within a year. In a few cases, repairs are needed at the same pavement location year after year. To address these problems, a two-year study was undertaken. The study was initiated to evaluate CRCP patching design details and to generate methods to improve CRCP patching performance from current levels.

This report documents the design and performance of the conventional patch design (in use since the early 1980s), plus the following 6 experimental patch designs: Class A CRCP Patch with PCC Subbase, Class A CRCP Patch with High-Early Strength Concrete, Drilled-Tied CRCP Patch, Transverse Rebar CRCP Patch, Steel Fiber Modified Concrete CRCP Patch, and Drainage Layer CRCP Patch. All patches referred to in this report were constructed between 1993 and 1994. Of the designs studied, the transverse rebar feature and the steel fiber modified concrete feature showed improved performance over the conventional patch. In 1995, additional patches using the transverse rebar and steel fiber designs were evaluated to confirm improved performance of these designs.

II. OBJECTIVES

The primary objective of this study was to examine factors affecting the durability and serviceable life of CRCP patches. To accomplish this task, several modified full depth CRCP patch designs were developed. The results are intended to produce revised guidelines and specifications. Major goals of the study included:

- Identify and evaluate causes of premature patch failure, including adjacent pavement-related failures.
- Develop a set of feasible patch design alternatives that address specific pavement problems.
- Construct alternative patch design methods in addition to the conventional Class A patch design in use.
- Evaluate contractor problems and ability to adhere to special provisions.
- Assess the effectiveness of pavement patching alternatives through performance monitoring of CRCP patch distresses.
- Determine the most cost-effective patch design method.
- Implement changes to CRCP patching standards and specifications if warranted.

III. PATCHED PAVEMENT EVALUATION SECTIONS

Five experimental site locations (Figure 1) were determined by incorporating CRCP patch designs into regular contract maintenance. These sites were randomly selected for the study by Districts 5 and 6. Sites 1-4 were located on Interstate Route 55 and Site 5 was located on Interstate Route 57. The experimental CRCP patch locations were as follows:

Site Number 1	Logan County	Interstate 55	MP 126-142 NB/SB
Site Number 2	Macoupin County	Interstate 55	MP 41-52 NB/SB
Site Number 3	Montgomery County	Interstate 55	MP 72-77 NB/SB
Site Number 4	Sangamon County	Interstate 55	MP 88-90.5 NB/SB
Site Number 5	Douglas County	Interstate 57	MP 205-212 NB/SB

Pavement sections consisted of 175, 200, and 225 mm (7-, 8-, and 9-inch) continuously reinforced concrete with 100 mm (4-inch) subbases. Over 500 conventional and modified CRCP patches were studied, beginning with patch construction. Each CRCP patch design attempted to address specific problems, such as poor load transfer, edge spalling, and longitudinal cracking. The soil predominantly encountered was a clayey silt with a California Bearing Ratio (CBR) range of 2 to 4. The pavement characteristics and major rehabilitations are summarized in Table 1.

IV. PAVEMENT REMOVAL PROCEDURES

Pavement removal procedures can greatly influence the performance of the new patch. Removal methods which greatly disturb the subbase or damage the adjacent pavement lead to shorter repair life or adjacent failures.

The most common pavement removal method on the projects studied involved breaking up the pavement to be removed with equipment-mounted jackhammers, followed by hand held jackhammers to remove the concrete around the steel. This procedure is known as a breakout method. This work can be performed carefully with minimal damage to the base and adjacent pavement.

A modification to the breakout method uses a skid steer loader mounted with a jackhammer as allowed in the attached Special Provision for Class A Patches (Skid-Steer Loader Equipped With a Hydraulic Hammer). The use of this equipment greatly speeds the operation. However, care must be taken not to damage the steel, undercut the pavement to remain in place, or allow the jackhammer to penetrate into the subbase. After pavement break up, the concrete is hand loaded into an end loader or backhoe, transferred to a truck and removed from the site.

Another pavement removal method uses a wheel saw to make the interior saw cuts of the CRCP patch. Refer to Special Provision for Class A Pavement Patching (transverse saw cuts). The remaining slab is then removed in large sections by use of the "lift out" method, using the exposed steel bars in the pavement. Another method in executing lift out is accomplished by drilling holes in the slab, inserting lifting pins and removing the pavement. When several saw cuts are made, a backhoe can lift one side of the slab segment for removal. This lift out is referred to as the "flip out" method.

Breakout methods are labor intensive and slow down production. In general, the lift out method reduces disturbance to the subbase is the preferred method. The use of the wheel saw needs to be carefully monitored to prevent "notching" the subbase by cutting deeper than needed. Typical photos of the removal procedures are shown in Photos 1 through 7.

V. PERFORMANCE OF CRCP PATCHING DESIGNS

Performance monitoring has shown that punch outs are found in many failed CRCP patches. The main structural distress in CRCP in Illinois is edge punch out. This was first identified in a 1979 study of "Behavior of Experimental CRC Pavements in Illinois" (Reference 1). A punch out is defined as the area enclosed by two closely spaced transverse cracks and a short longitudinal crack that is depressed.

Starting in the fall of 1993, seven detailed distress surveys were performed on the CRCP experimental patches. In performing these surveys, a number of failure

mechanisms that resulted from particular patch distresses were recorded. The failure rate of conventional Class A CRCP patches was determined to be the standard in which to measure alternative patch designs.

The survey data in Figure 2 presents the percentages of patch failures for each CRCP patch design throughout the study period. Only the Transverse Rebar and Steel Fiber Modified Concrete patch designs exhibited lower failure rates than the conventional Class A design. Data was also collected on distresses and categorized by percentages of low and medium, as well as higher failures for each patch design. A patch listed in the low distress category features minor spalls (less than 5) and corner breaks (less than 2). Tight, hairline transverse cracks are considered low severity and not counted as a distress. A patch in the medium distress category will have medium severity transverse and/or longitudinal cracks, plus any or all of the distresses listed in the low distress category. A patch in the high distress category will have high severity transverse and/or longitudinal cracks, plus spalls and/or punch outs. Failed patch distresses may include pumping of fines, adjacent pavement breakup, partial patch replacement, or have a combination of these factors. The extent of each distress is measured by the number of areas of distress at each severity level.

Conventional Class A CRCP Patch

This CRCP patch is referred to as the "conventional" Class A patch design and is detailed in the attached Standard 2425-5. The replacement steel reinforcement is lap-spliced a minimum distance of 400 mm (16 inches) for the 15 M (No. 5) bar size, as encountered at all patch locations. This dimension is acceptable, according to ACI Sections 12.16.3 concerning lap-splice lengths and detailed in Standard 2425-5. The design attempts to match, in kind, the original steel configuration of the pavement. During the study period, 80 conventional Class A patches were constructed and studied. These conventional patches were constructed at all sites, in addition to the various experimental patches.

Analysis of the distress data gathered over the two-year study period was used to represent the failure rate statewide for this conventional patch design. Patch

distress ranged from medium and high severity transverse cracking to pumping of fines and faulting, followed by patch failure. Seventeen percent of the conventional patches failed within 1 month, as shown in Figure 3. Many of these failures were severe in nature. It was evident that patch cracking resulted at existing steel junctions 1 month after construction when mechanical bar couplers were used instead of the lap-splice method. The data also showed a consistent deterioration rate with similar distress stages from patch to patch. However, the conventional Class A patch has a fair or moderate reliability if constructed according to standard policies and procedures.

Class A CRCP Patch with Portland Cement Concrete (PCC) Subbase

This CRCP patch design is the conventional Class A design as shown in Standard 2425-5, except that the subbase was removed and replaced with PCC. The procedure includes excavation, placing PCC to match the thickness of the subbase, and placing a bond breaker as outlined in the attached Special Provision for Subbase Replacement with Portland Cement Concrete.

This design is more costly and time consuming than the average rate for the conventional Class A patch. There were 13 patches constructed and studied using this procedure. These patches were located at Site 5 in Douglas County. This site consisted of a highly deteriorated 180 mm (7-inch) thick CRCP, as shown in Figure 4. Survey data analysis indicates a 92% patch failure rate after 2 years. Inconsistencies in subbase support is believed to be the cause of failures. Due to the low number of patches constructed, the performance of this design may not be representative of statewide experience. Typical failures are shown in Photos 8-10.

Class A CRCP Patch with High-Early Strength Concrete

This CRCP patch design is the conventional Class A design as shown in Standard 2425-5, except for the use of high-early strength concrete, plus accelerant. A calcium chloride mixture is added to the Type III (high-early strength cement)

portland cement concrete to achieve the required strength in a short time period. This method is often used when the roadway must be opened to traffic quickly. The attached Special Provision for High Opening Strength Portland Cement Concrete Patching Mixture allows a reduced flexural strength of 3800 KPa (550 psi) at opening to traffic due to the rapid strength gain. The high-early strength concrete mixture has a slight increase in cost over the standard patching concrete mixture. Between Site 4 in Sangamon County and Site 5 in Douglas County, 8 Class A CRCP patches with high-early strength concrete were constructed and studied.

Survey data analysis indicates an 80% patch failure rate after 2 years, as shown in Figure 5. Serious transverse cracks and spalling occurred at a higher rate than the standard concrete mixture. The surface of the concrete at Site 4 in Sangamon County appeared cracked or crazed (many fine cracks) soon after curing. The crack pattern produced pieces of concrete that eventually worked loose from the surface. It was noted that the recommended calcium chloride dose was exceeded. This may explain the surface crazing in the repair. Caution is needed in maintaining a maximum of 2% by weight of cement, and no more than 1% when the ambient temperature is above 80° F. This is to avoid a flash set and excessive heat of hydration. Further concerns on the use of calcium chloride include the corrosive properties imparted to the reinforcing bars. For further information, refer to the "Manual of Concrete Proportioning and Testing" issued January 1, 1988 (Reference 2).

Drilled-Tied CRCP Patch

This CRCP patch design replaces the existing rebars from the transverse patch face with 35 M (No. 11) deformed bars. The patch boundaries are sawed full depth, then 38 mm (1.5-inch) diameter holes are drilled between the existing rebars on the transverse face. The deformed bars are then anchored into the holes using a chemical adhesive, leaving 405 mm (16 inches) extended. Refer to Special Provision for Grouting of Reinforcing Bars. New longitudinal 15 M (No. 5) rebars are then tied to each of the deformed bars. The purpose of this design is to prolong adjacent pavement life by reducing the disturbance from

pavement removal. Between Site 2 in Macoupin County, Site 3 in Montgomery County, and Site 5 in Douglas County, 75 drilled-tied patches were constructed and studied. Survey data analysis indicates that 45% of the patches failed in the two-year study period (see Figure 6).

Patch distresses at all sites were remarkably similar and started at the drilled-tied ends in the old pavement (see Photo 11). Failures at the center of the patch were uncommon after the bars in the adjacent pavement became loose. The debonding of the existing concrete from the tie bars made them visible from the surface of the pavement. It was noted the shorter in length the patch was, the better the survival rate was. It was apparent that loading stresses were directly transferred to the patch joint that proved to be weaker than the patch concrete. This became the main mode of failure, which was repeated from patch to patch. Highly irregular transverse crack patterns of 0.15-4.5 m (0.5-15 feet) at Site 2 in Macoupin County caused an increase in patch distresses. Deeper tie-bar anchoring into the existing concrete has been used by others with limited success (see Reference 3).

Transverse Rebar CRCP Patch

This CRCP patch design consists of the conventional Class A design, with the addition of grade 60, 20M (No. 6) rebars tied to the longitudinal bars in the transverse direction as shown in the attached Standard 442001-01. Although not normally used, bar mats could also be used in place of the rebar grid, provided the area of steel in both directions is the same as shown in Standard 4421001-01. The intended purpose of transverse reinforcement is to deter longitudinal cracking and provide additional strength.

Between Site 1 in Logan County, Site 2 in Macoupin County, and Site 3 in Montgomery County, 132 transverse rebar patches of this design were constructed. Survey data analysis indicates that patch failures were few, with the majority having slight transverse cracking or none at all. No longitudinal cracking occurred in any of these patches.

Patch joints were sealed using ASTM D 3405 hot poured sealant for 90 of the 132 patches. Refer to Special Provision for Joint Sealing Continuously Reinforced Concrete Patches. Photos 12 through 14 illustrate the hot poured sealant procedure. The 90 sealed patches were able to withstand large impact forces resulting from traffic loadings at all sites, but most notably, Site 1 in Logan County. Figure 7 shows a very low percentage of patch failures (4.5% after 18 months). Unlike other experimental CRCP patch designs in this study, the transverse rebar design did not have a high failure rate immediately after construction (see Photo 15).

The development of longitudinal cracking has long been associated with the formation of "punch out" distress, along with poor subgrade support and short transverse crack spacing. Figure 8 illustrates the location of maximum bending stress CRCP experiences in the transverse direction. Stress concentration is the primary factor leading to a longitudinal crack approximately 760 mm (30 inches) from the pavement edge, as witnessed by the performance monitoring during this study.

Steel Fiber Modified Concrete CRCP Patch

This CRCP patch design is the conventional Class A design as shown in Standard 2425-5, except for the use of steel fibers in the concrete mixture for added reinforcement. Refer to Special Provision for Steel Fibers. The fibers measured 5.0 mm (2 inches) in length, and met the requirements of ASTM A820 Type 1. Mixing of the fibers was done in accordance with ASTM C94 (Standard Specifications for Ready-Mix Concrete Uniformity requirements). The steel fibers and required water were added after batching of the concrete materials. The intended purpose of this design was to deter spalling and cracking.

Between Site 2 in Macoupin County, Site 4 in Sangamon County, and Site 5 in Douglas County, 46 steel fiber modified patches were constructed and studied. Since a metal vibratory screed was used, these patches required an additional 5-10 minutes to finish. Fiber modified concrete used in CRCP patches at Site 2 in Macoupin County contained 59.3 kg/cu. meter (100 lb./cu. yd) of steel fibers. These

patches showed minimal distress at 2 months. Patches at Site 4 in Sangamon County contained only 44.5 Kg/cu. meter (75 lb/cu. yd) of steel fibers. These patches showed no improvement in performance over the conventional Class A patches. Patches of 7-inch CRCP at Site 5 in Douglas County contained 118.7 kg/cu. meter (200 lb/cu. yd) of steel fibers. These patches showed only marginal improvement (20% after 18 months) over the conventional Class A patches (see Figure 9). A reduced pavement thickness may have offset the strength gain of the steel fibers. The failure mode for the steel fiber modified concrete CRCP patch design was the formation of wide longitudinal and transverse cracks followed by punch outs, as depicted in Photo 16.

The addition of steel fibers to a concrete mixture does enhance the energy absorption properties of the concrete (higher material toughness). However, the benefits in using steel fibers were not significant enough to offset the higher cost of this design. The design would need to include an altered mixture design with a steel fiber content above 59.3 Kg/cu. meter (100 lb/cu. yd) or some combination of transverse rebar reinforcement. Additional work with steel fibers may prove useful for this application in the future.

Drainage Layer CRCP Patch

This CRCP patch design consists of the conventional Class A CRCP patch as shown in Standard 2425-5, except for the use of two types of drains placed directly under the patch. The first drainage procedure included excavation of the subbase and 200 mm (8 inches) of the subgrade. The excavation was then covered with filter fabric and backfilled with CA-16 that was compacted in two lifts. A lateral trench was cut, followed by the placement of drainage pipe. The second type of drain used CA-11 aggregate, which could not be compacted as well, resulting in an unreliable foundation. The drainage layer CRCP patch design is more time consuming and costly than the average conventional CRCP patch. Between Site 1 in Sangamon County, Site 3 in Montgomery County, and Site 5 in Douglas County, 101 drainage layer CRCP patches were constructed and studied. Slow draining subbases and

sediment-filled bituminous fiber pipe underdrains were encountered at Site 3 in Montgomery County as shown in Photos 17 and 18. The intended purpose of the design was to stop pumping of fines and drain unimpeded water from under the patch.

Survey data analysis indicates that over 75% of the patches failed completely in the two-year study period. Patch distresses ranged from spalling and longitudinal cracking to punch outs and pumping of fines. The design exhibited unexpected results with respect to the purpose of drainage. Figure 10 reveals an extremely high rate of patch failures. The fracture pattern of the majority of these patches showed that the excavation of the subbase between the rebar to be lap-spliced resulted in a loss of support between the rebar severed ends (see Photos 19-20). Drainage under the patch caused migration of subgrade fines, which washed through the underdrain network regardless of drain type. The drainage features actually allowed water to remain in the pavement, resulting in weakened subbase/subgrade support as indicated from CBR readings taken after the concrete was removed. It became evident that disturbance of the subbase/subgrade was responsible for the failures.

VI. SUMMARY AND CONCLUSIONS

Sufficient findings have been presented to recommend the Transverse Rebar CRCP patch design for implementation. The revised design has been approved by the department and Standard 2425-5 (now referred to as Standard 442001-01) has been revised to feature this design as the preferred method of pavement patching.

Early conclusions indicated that a wide range of CRCP patching performance existed throughout the state due to variable support and construction differences.

Although not part of this study, at some total level of CRCP patching, further patching alone is no longer cost effective. This is because a certain number of repairs will fail; thus, making other rehabilitation strategies more feasible. This study indicates that all

types of CRCP repairs have a failure rate ranging from 4.5% to 92% for an 18- to 24-month period. Patching CRCP without an overlay to levels above 2% should be reviewed due to the likely continued repair of new areas and previously failed patches.

Repairs which included removal of the existing subbase performed poorly. Failure rates of replaced subbase sections ranged from 25% to 92% within 2 years. For this reason, existing subbase material should be disturbed as little as possible.

There are numerous benefits to Standard 442001-01 (formerly Standard 2425-5). The transverse rebar design is easily understood, using familiar materials and installation procedures, in comparison to other design alternatives. The design increases patch life while adding only minimal material costs and labor incurred by the transverse steel. The additional steel reinforcement in this design contributes significantly to the structural capacity of the CRCP patch. This design also increases the bridging capacities of the patch over "soft" subgrade conditions.

Drainage in Illinois is poor and remains a major problem of saturated roadbed soils and subbases. All subbases have continuous exposure to moisture. This situation can create great hydrostatic pressure and freeze thaw conditions which can deteriorate subbase material. All test sections in this study had either a CAM I or BAM subbase. Subbases are susceptible to the migration of fines and pumping, resulting in pavement failure. One of the major factors that affects the serviceability of CRCP patching is the inconsistencies in the subbase/subgrade support. The importance of maintaining uniform support under CRCP cannot be over-emphasized. Even small differences in pavement removal and subbase repair procedures can be detrimental in terms of the repair life of the pavement and of the survivability of the adjacent pavement. It was noted, however, that the 225 mm and 250 mm (9- and 10-inch) patched CRCPs performed better than the 175 mm and 202 mm (7- and 8-inch) patched CRCPs.

A brief summary of the findings for each patch type is shown as follows:

Conventional Class A CRCP Patch: The conventional Class A CRCP patch is the standard patching design as shown in Standard 2425-5. This design has fair success if policy and procedures are followed.

Class A CRCP Patch with PCC Subbase: The purpose of the Class A CRCP patch with PCC subbase was to strengthen patch support to benefit patch performance. The design did not meet the requirement due to patch failures.

High-Early Strength Concrete: The purpose of the high-early strength concrete patch was to obtain strength quickly. Care must be exercised in the dosage levels of accelerator additives to make sure rates are within recommended limits.

Drilled-Tied: The purpose of the drilled-tied CRCP patch was to prolong adjacent pavement life. The design did not meet this requirement and failures were numerous.

Transverse Rebar CRCP Patch: The transverse rebar CRCP patch was to deter longitudinal cracking and provide additional strength. The design met the requirements and performed better than the conventional design. The survey indicated a 70% reduction in failure rate using this design.

Steel Fiber Modified Concrete CRCP Patch: The purpose of the steel fiber modified CRCP patch was to deter spalling and cracking. The design exhibited a partial success of these objectives, but not enough to be feasible.

Drainage Layer CRCP Patch: The drainage layer CRCP patch design was intended to stop the pumping of fines and drain water from under the patch. Failures of this design were extensive.

VII. RECOMMENDATIONS

Some precautions are recommended during construction of CRCP patching, including the following:

- Subbase materials should be disturbed as little as possible during pavement excavation.
- If subbase material is disturbed during pavement removal, or is unsound, replacement with bituminous material rather than PCC or aggregate is preferable.
- If a wheel saw is to be used to make the intermediate saw cuts, careful depth control is necessary. The cutting depth should be above the pavement subbase to prevent forming a keyway. This keyway is considered subbase disturbance.
- Skid steer loader mounted jackhammers can cause excessive damage (nicking or bending) to the rebar to be lap-spliced, as well as the adjacent pavement. The equipment can also cause corner breaks. If not being used with care, skid steer loader mounted jackhammers should be removed from the job. The use of a skid steer loader mounted jackhammer is currently allowed through the use of the Special Provision for Class A Patches (Skid Steer Loader Equipped with a Hydraulic Hammer) which is checkmarked to allow its use on most contracts.
- Caution should be exercised when patches are poured before noon in the hot summer months. High compressive forces which may occur on hot summer afternoons can damage new concrete during curing. More research is needed to quantify damage and temperature impacts before changes could be considered to existing specifications.

- Patches exhibiting spalls, or patches experiencing “rocking” or “pumping” action should be replaced as soon as practical before severe damage to the subgrade or adjacent pavement results.
- Individual drains along the side of the pavement, such as French drains, can be installed when patching continuously reinforced concrete pavements. Patch drains can be beneficial, especially if the existing underdrains are not functioning, such as the bituminous fiber pipe found in Logan County. Removal of the subbase and replacement with a drainage layer under the patch should not be allowed as this greatly increases the failure rate of the patch.
- The mechanical bar coupler used in place of the lap-splice method was not successful. Concrete showed evidence of cracking at the junction one month after installation. Use of the mechanical bar coupler should not be continued as an alternative to the lap-splice method in CRCP patching.

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10. "Evaluation of Mechanical Couplers in CRC Pavements," Pennsylvania Department of Transportation, Report No. 86-103, December 1993.
11. "Construction Handbook on PCC Pavement Rehabilitation," Construction and Maintenance, U.S. Department of Transportation, FHWA, January 1984.

Table 1. EXPERIMENTAL CRCP PATCH SITES

<u>EXPERIMENTAL SITES</u>	<u>contract #</u>	<u>Mile Post</u>	<u>season</u>	<u>ESALS/year</u> thousands*	<u>CRS</u> rating*	<u>pvmt. age</u> years	<u>number of prior rehabs.</u> using patching.
LOGAN COUNTY	92735	126-142	1993	720	6.0	17	3
SITE 1.	92859	126-142	1994	720			
MONTGOMERY CO.	92739	72-77	1993	934	5.7	22	3
SITE 2.	92855	72-77	1994				
MACOUPIN COUNTY	92855	41-52	1994	971	5.5	21	3
SITE 3.							
SANGAMON COUNTY	92738	88-90.5	1994	940	6.2	25	2
SITE 4.							
DOUGLAS COUNTY	90566	205-211	1993	884	5.2	25	4
SITE 5.							

* 1993 traffic data

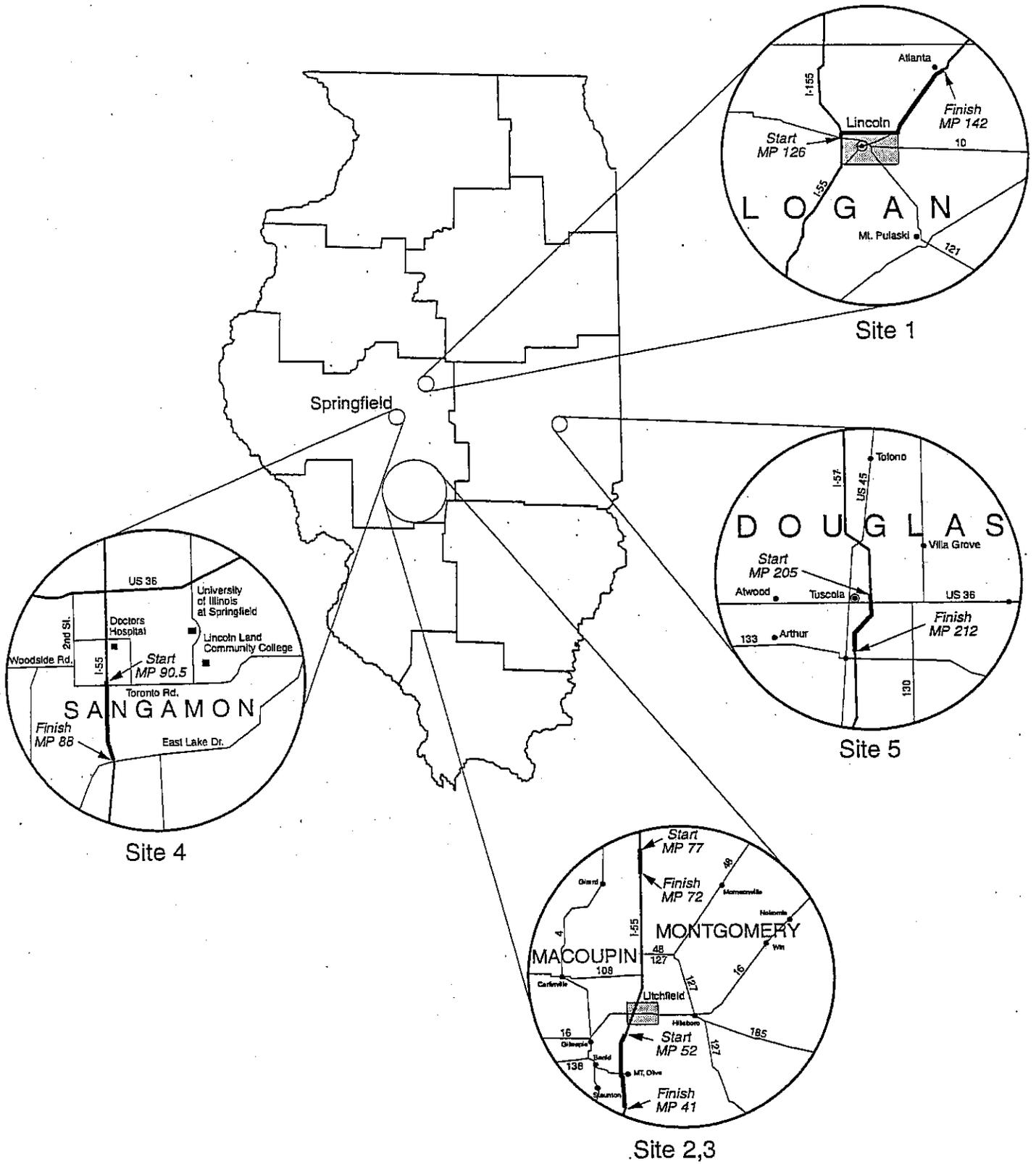


Figure 1.0 Experimental CRCP Patch Locations.

Age Versus Percent High Distress in CRCP Patches

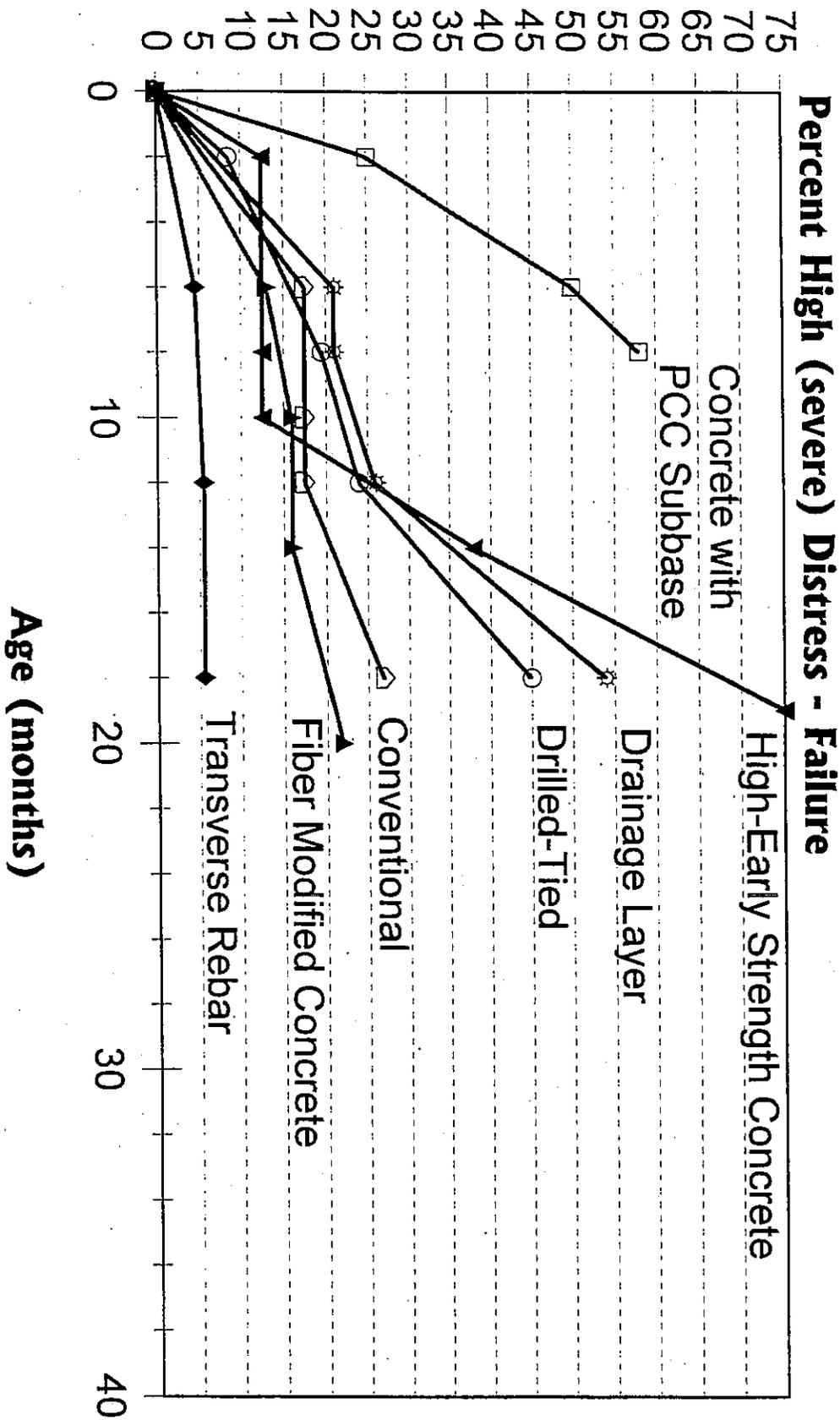


Figure 2. Comparison of CRCP Patch Performance

Age Versus Percent distress in CRCP Patches

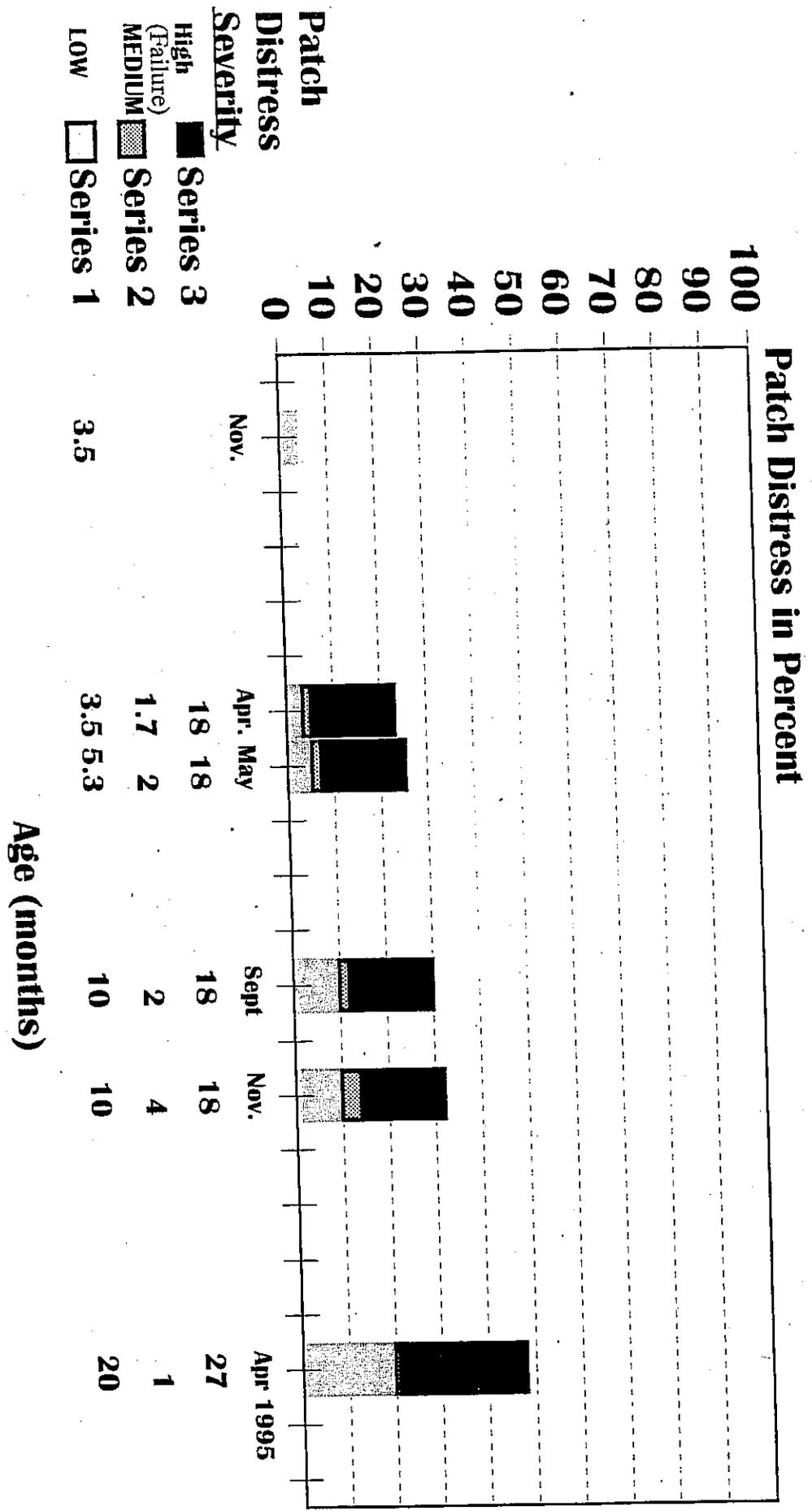
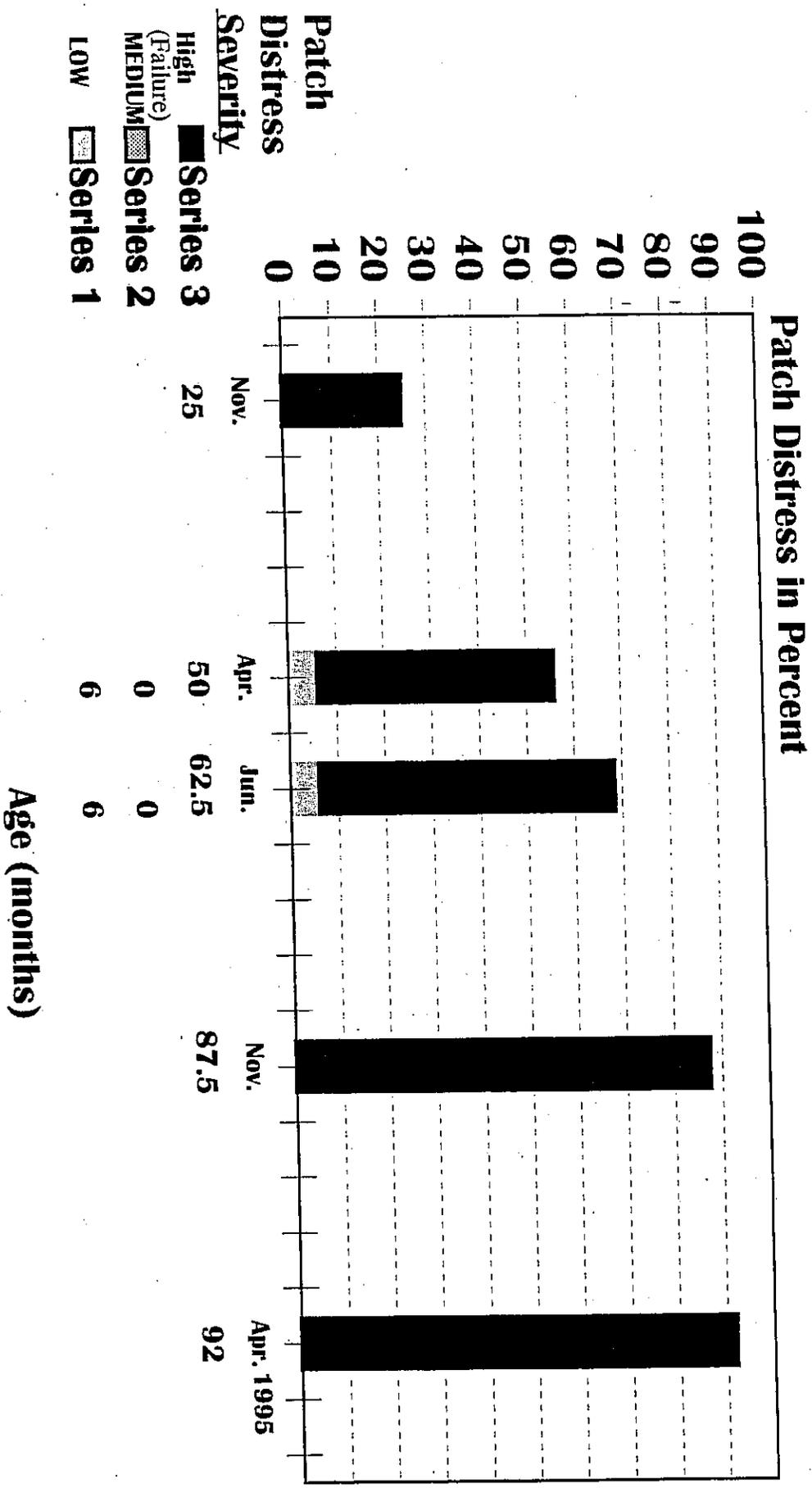


Figure 3. Conventional Class 'A' Patch Design

sample size = 80

Age Versus Percent distress in CRCP Patches



sample size = 13

Figure 4. Remove and Replace Subbase Patch Design

Age Versus Percent distress in CRCP Patches

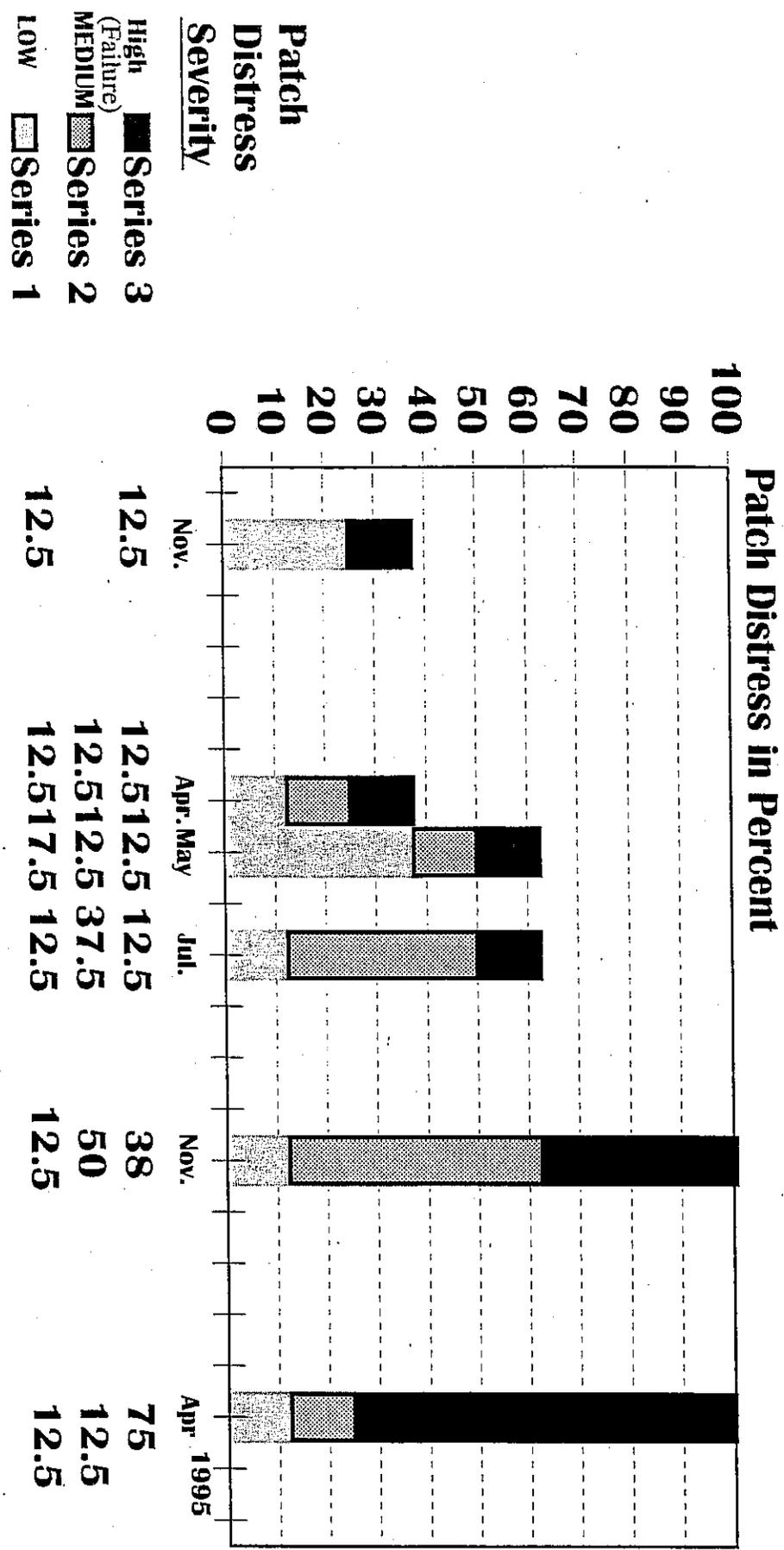


Figure 5. High-Early Strength Patch Design

sample size = 8

Age Versus Percent distress in CRCP Patches

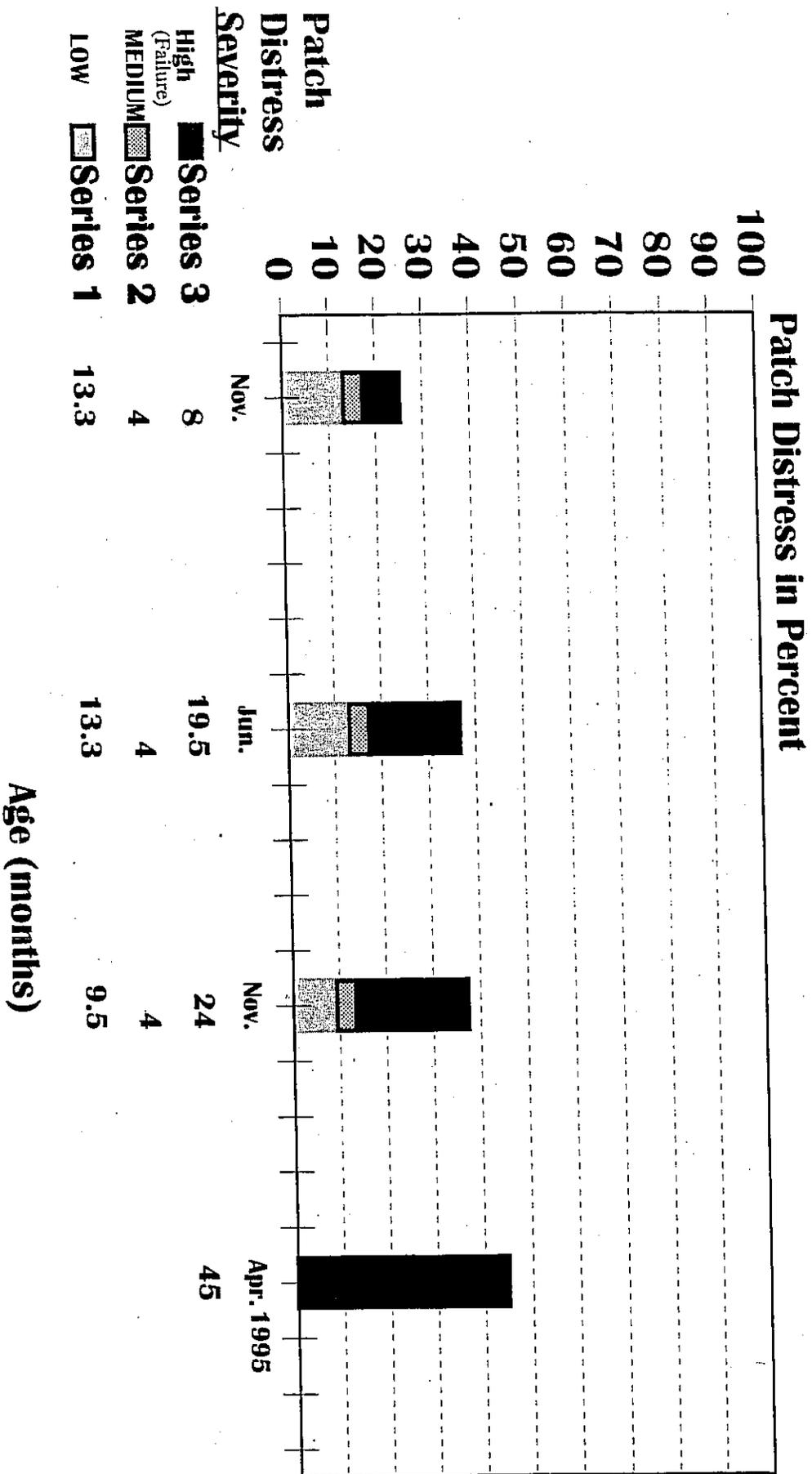


Figure 6. Drilled-Tied Patch Design

sample size = 75

Age Versus Percent distress in CRCP Patches

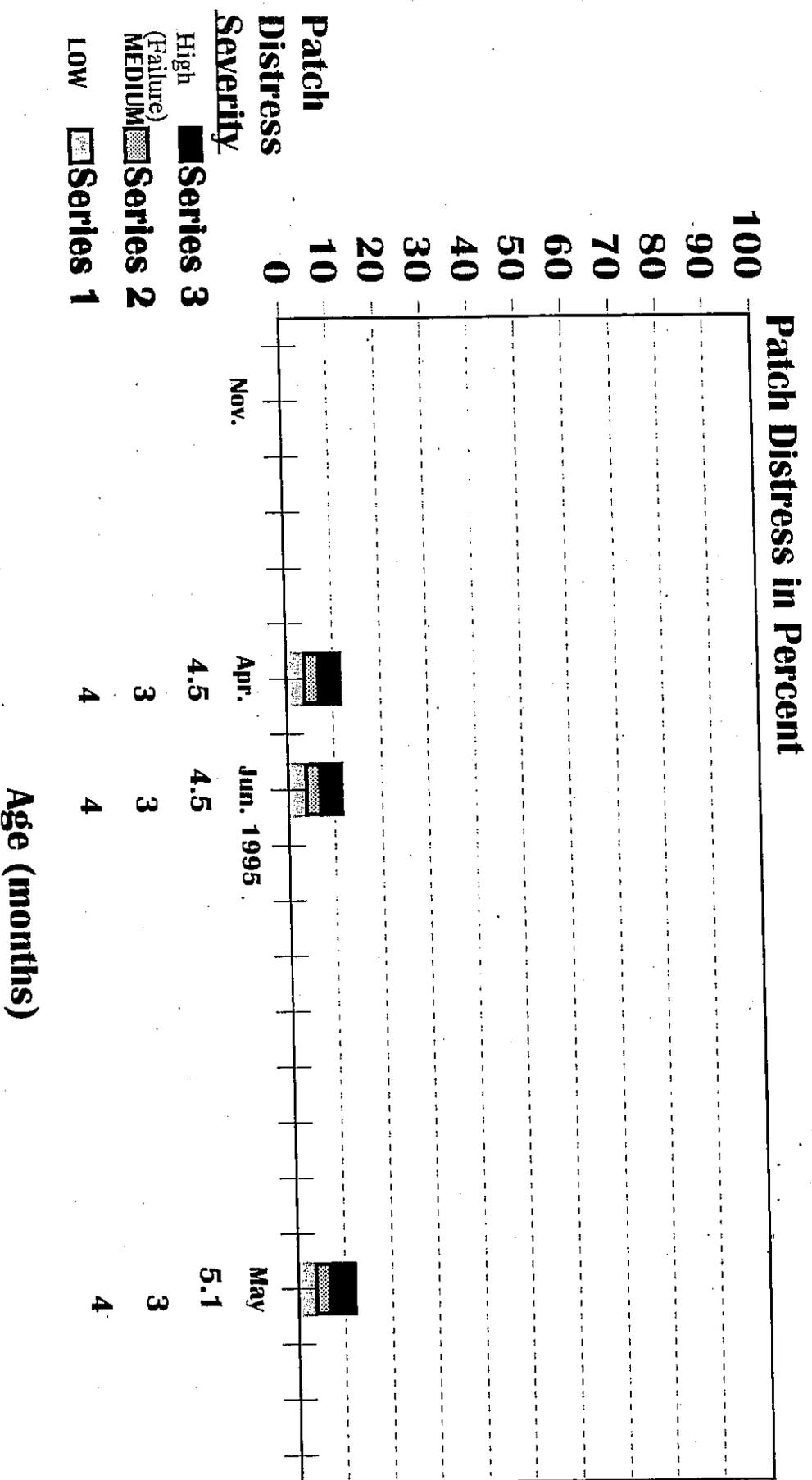


Figure 7. Transverse Rebar Patch Design

sample size = 132

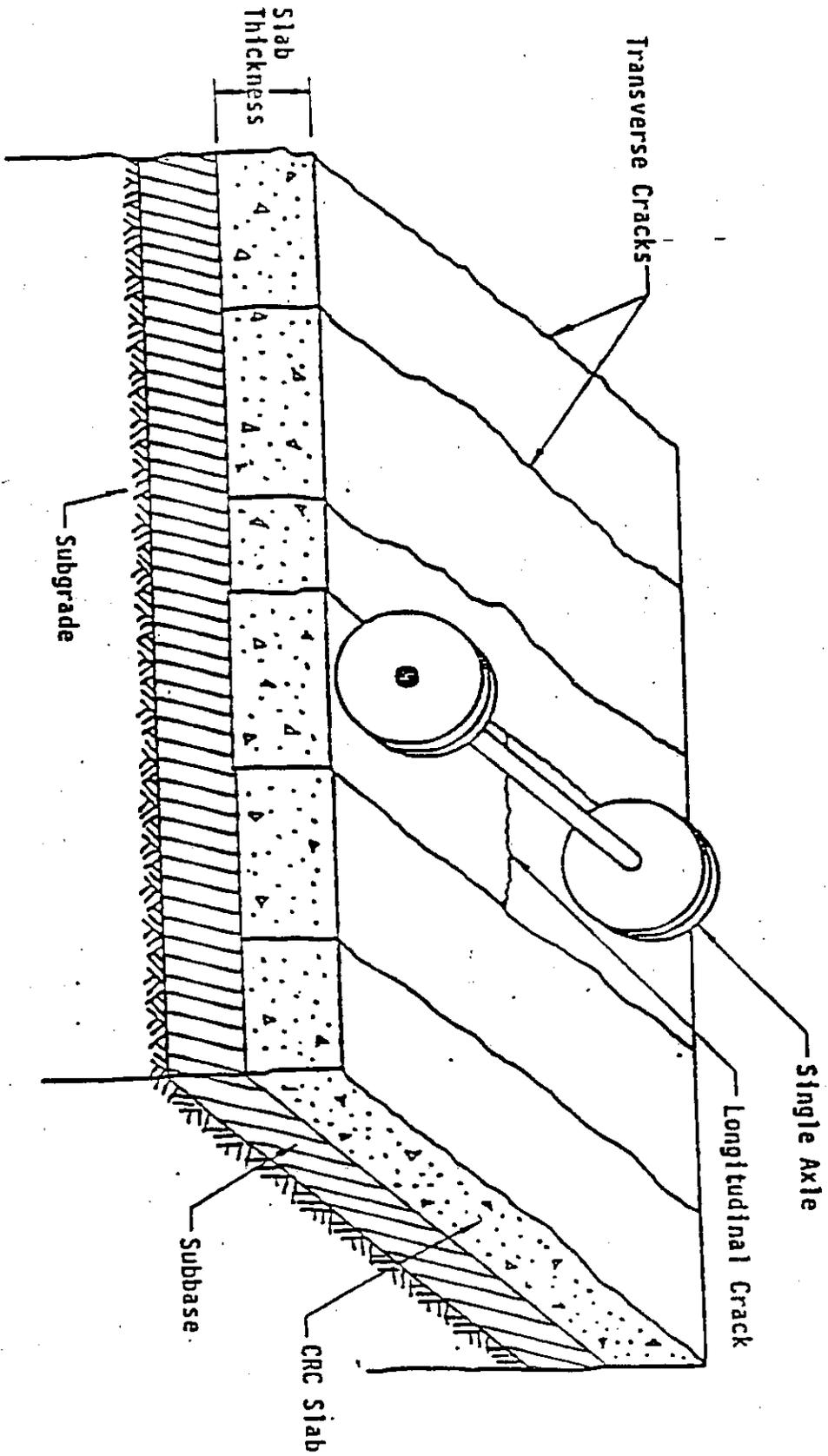
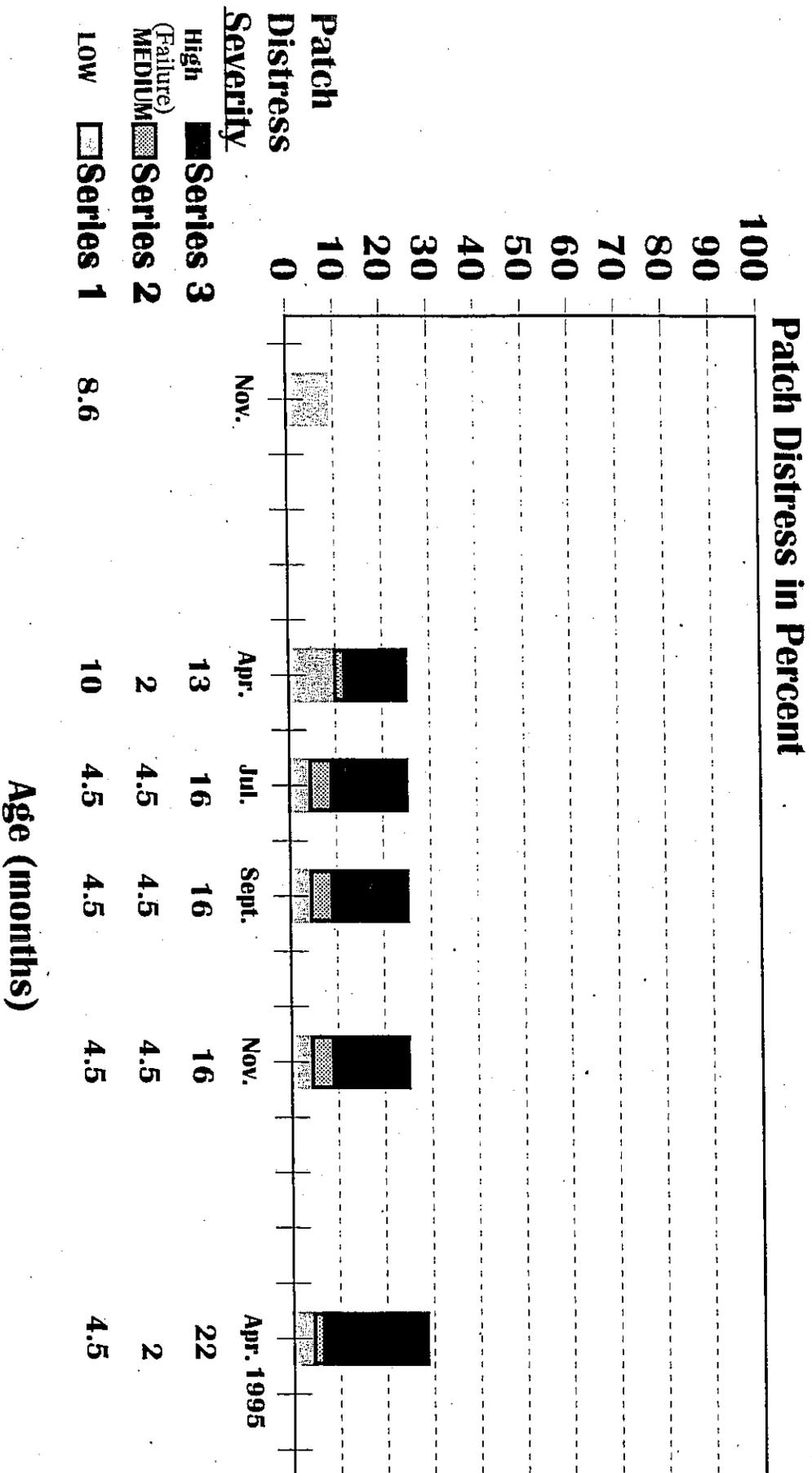


Figure 8. Formation of Longitudinal Crack Between Two Transverse Cracks - Intermediate State of Edge Punchout

Age Versus Percent distress in CRCP Patches



sample size = 46

Figure 9. Steel Fiber Modified Concrete Patch Design

Age Versus Percent distress in CRCP Patches

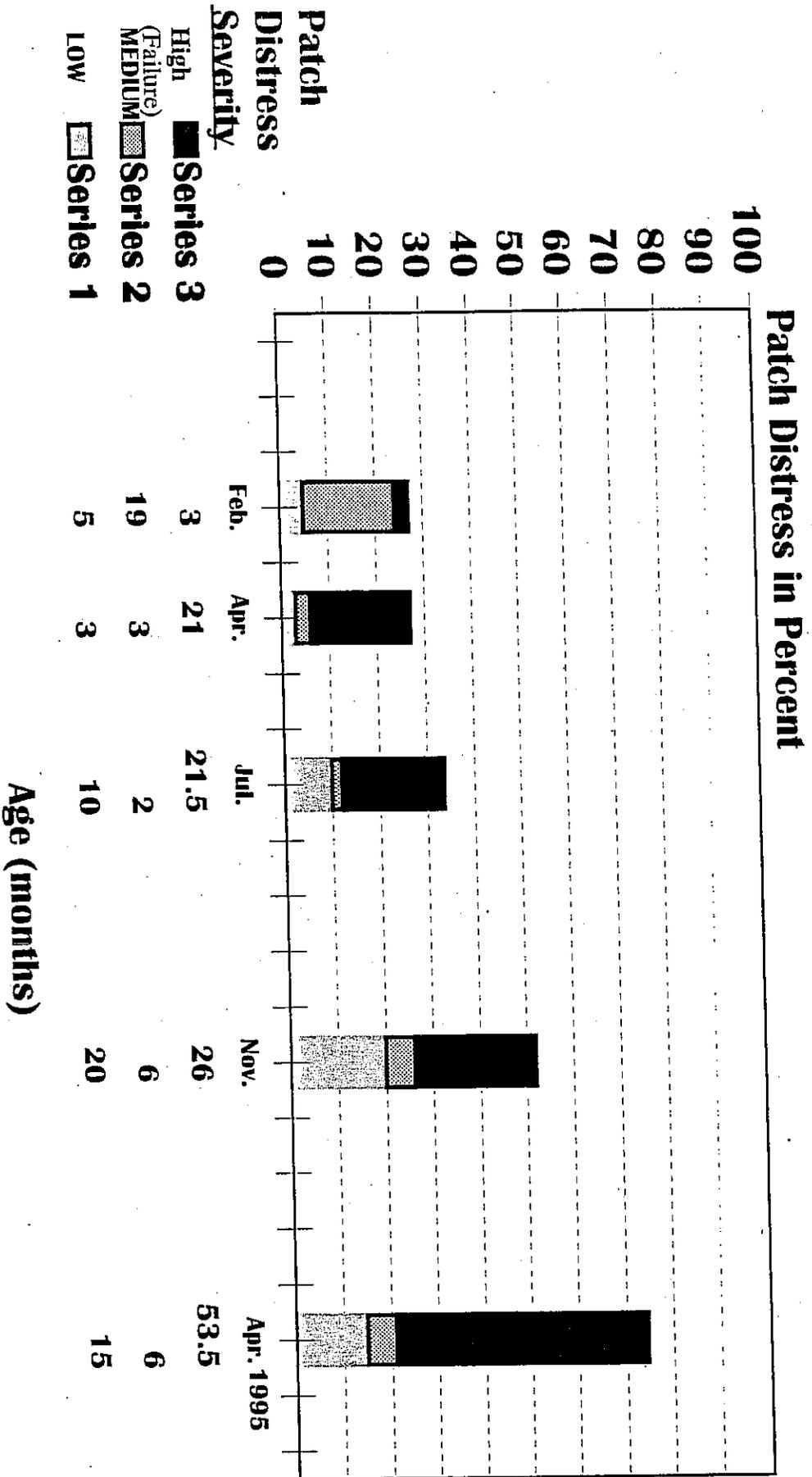


Figure 10. Drainage layer Patch Design

sample size = 101

State of Illinois
Department of Transportation

SPECIAL PROVISION
FOR
CLASS A PATCHES
Effective: August 1, 1994

Add the following to Article 442.03:

"(n) Skid Steer Loader Equipped with a Hydraulic Hammer
(Note 10)

Note 10. The skid steer loader shall be wheel mounted and hydraulically actuated, with a maximum horsepower rating of 45 kW (60 hp) and a maximum total machine mass (weight) of 3000 kg (6600 lbs.). The hydraulic hammer shall have a maximum impact energy of 410 J (300 ft-lbs.) and a maximum total mass (weight) of 215 kg (475 lbs.). The hydraulic hammer shall be attached to the skid steer loader in such a manner that the angle of attack of the hammer is fixed while breaking concrete."

Revise the 6th paragraph of Article 442.05(a) to read:

"The concrete in the splicing area, between the interior and outer saw cuts, shall be removed using hand held hammers and hand tools. The Contractor has the option to use a skid steer loader equipped with a hydraulic hammer to remove the concrete in the splicing area. Should the loader and hydraulic hammer damage the pavement and/or reinforcement which are to remain in place, the loader with a hydraulic hammer will no longer be allowed.

Care shall be taken to minimize underbreaking of the concrete to remain in place. To prevent underbreaking, the face of the concrete below the partial-depth saw cut shall be inclined slightly into the patch. The reinforcing steel in the splicing area shall not be bent to aid in removal of the concrete. If more than 10 percent of the reinforcing steel in the splice area is damaged due to the Contractor's operations, the patch shall be lengthened at his/her own expense to provide the required steel exposure for splicing. If less than 10 percent of the existing lap steel is damaged, it may be repaired by welding in lieu of lengthening the patch. No welding will be permitted on the splices between the existing steel and the new steel."

7625I

State of Illinois
Department of Transportation

SPECIAL PROVISION
FOR
CLASS A PAVEMENT PATCHING

Effective: August 1, 1993
Revised: February 1, 1994

Replace the first paragraph under Article 620.05(a) with the following:

- (a) "Class A. Patches. Two transverse saw cuts, shall be made perpendicular to the centerline at each end of the patch except that the saw cuts may be skewed slightly if necessary to maintain a minimum distance of 450 mm (18 inches) from the end of the patch to the nearest transverse crack in the pavement to remain in place when approved by the engineer. This minimum distance, however, may be reduced to 150 mm (6 inches) in areas of close crack spacing where the pavement otherwise appears to be sound. The saw cut located at the outside patch edge shall be to a depth which is just above the longitudinal reinforcement. The interior saw cut shall be made at the location that will provide the proper length of exposed existing steel as shown on the plans and shall be either full-depth or to a depth which will completely sever the longitudinal reinforcement. The longitudinal edges of the patch shall be formed by full-depth saw cuts. Patches less than half-lane in width will not be permitted. Saw cut extensions into pavement that is to remain in place will not be permitted. All outlining and interior saw cuts shall be made with an approved concrete saw. After the interior saw cuts have been made, an approved wheel saw may be used to make pressure relief cuts or intermediate cuts to reduce the pavement length to a size that accommodates removal and hauling operations, at the Contractor's expense. The wheel saw cutting operations shall be controlled to limit subbase penetration to a maximum of 15 mm (1/2 inch)."

Add the following paragraph after the last paragraph of Article 620.06(b)(1):

"When the existing reinforcement is fabric, the patches reinforcement bars shall be the same size and spacing as the existing longitudinal reinforcement.

Patches that are 9 m (30 ft.) or longer shall be tied to the adjacent lane of existing pavement with 20 mm (3/4 inch) diameter expansion anchor ties in accordance with Section 657, except that the cost of the anchors shall be considered as included in the contract unit price for the item of patching involved and no additional compensation will be allowed".

Special Provision for
Subbase Replacement with
Portland Cement Concrete

June 11, 1993

Description This work shall conform to Section 620 of the Standard Specifications and consist of removing the existing subbase and replacing it with concrete as follows:

Construction Requirements

The existing subbase shall be removed in such a manner as to minimize disturbance to the subgrade and pavement section to remain in place. All loose material shall be removed prior to concrete placement.

The subbase concrete shall be poured to the same elevation and line as the bottom of the adjacent pavement. The surface shall be troweled smooth.

The subbase concrete shall be allowed to cure a minimum of 30 minutes prior to patch placement and shall have gained enough strength to support reinforcement chairs if used. Curing shall be with two layers of polyethylene sheeting that are to remain in place as a bond breaker when the patch is poured.

27061/DLL/bb

Special Provision for
High Opening Strength
Portland Cement Concrete
Patching Mixture
Detail F

June 11, 1993

Description This mixture shall conform to Section 620 of the Standard Specifications and Special Provisions for Portland Cement Concrete Patching Mixture (Check Sheet #46 - Revised May 1, 1986) and the following additional requirements.

Opening to Traffic

The patch may be opened to traffic when beams cured with the patches achieve a flexural strength of 3800 kPa (550 psi) or a compression strength of 21,000 kPa (3000 psi) as determined by the Department's test method. The attached Table gives estimated time-to-opening for various initial ambient temperature, mixture and curing combinations. This Table is for the contractors information only.

Traffic control shall be provided until the patch has reached opening strength.

27071/DLL/bb

Special Provisions for
Grouting of Reinforcing Bars
Detail A & B

June 11, 1993

Grouting of Deformed Tie Bars and Dowel Bars

This work shall consist of drilling and grouting of tie bars and dowel bars into hardened concrete. An epoxy or polyester resin system shall be used.

The epoxy grout shall be a two-component, epoxy-resin bonding system conforming to the requirements of ASTM C 881, Type IV, Grade 2, Class B or C. The Class supplied shall be governed by the range of temperatures for which the material is to be used. The resin shall contain a white pigment and the hardener shall contain a black pigment in such proportions that the resulting mixture is concrete gray.

The polyester resin system shall consist of a two-part fast-setting polyester resin and filler/hardener meeting Grade 3 consistency when tested in accordance with ASTM C881, 11.1. The compressive strength of the polyester grout when tested in accordance with ASTM C 109 shall be a minimum of 35,000 kPa (5,000 psi) when cured for one hour at 15^o C (60^o F).

Packaging

The two-component, epoxy- or polyester-resin grout shall be furnished by the manufacturer in premeasured preassembled cartridges suitably designed for mixing and application of the grout to the rear of the drilled hole.

Installation

Holes shall be drilled as noted in plan details.

Prior to grouting, the holes shall be thoroughly cleaned of drilling debris by blowing with compressed air. The compressed air shall be oil free and filtered.

The grout shall be deposited near the rear of the hole. The tie/dowel bar shall be inserted in a rotating fashion to the rear of the hole with excess grout being extruded.

The exposed end of the dowel bars should be lightly coated with oil before pouring of the patch.

27081/DLL/bb

Special Provisions for
Joint Sealing Continuously Reinforced
Concrete Patches

June 11, 1993

Description This work shall conform to Section 620 of the Standard Specifications and the following requirements:

Materials

<u>Item</u>	<u>Article</u>
Hot poured joint sealer	716.04

Construction Requirements

This work shall consist of forming or sawing a sealant reservoir at the transverse and centerline patch boundaries. The reservoir shall conform to the dimensions detailed herein. If the reservoir is to be sawed, sawing shall not be performed until after the required curing period. The faces of the reservoir shall be thoroughly cleaned by sandblasting and then blown clean with compressed air having a pressure of at least 500kPa (90 psi) and a volume of 4 cubic meters per minute (150 cfm) of air at the nozzle.

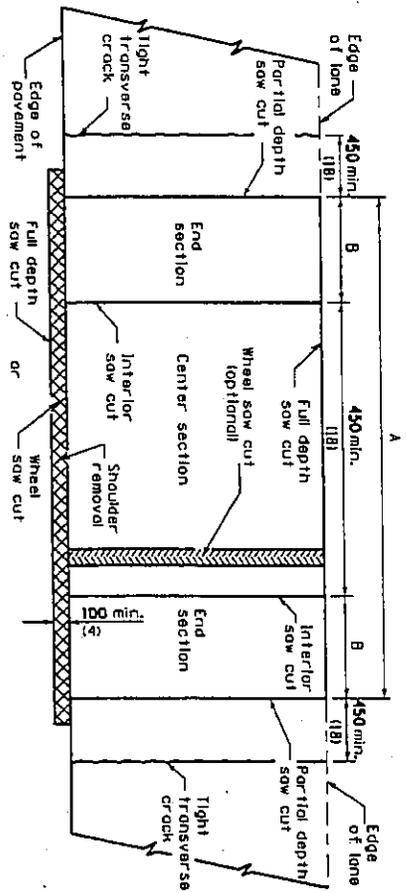
Sealing shall be done in one pour to fill the joint 3 mm (1/8 inch) below the adjacent pavement surface. Reheated or overheated material shall not be used.

27051/DLL/bb

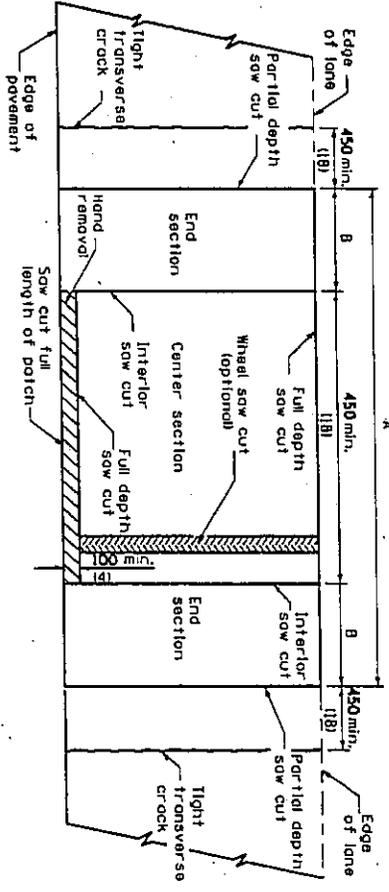
Special Provisions for
Steel Fibers
Detail D
June 11, 1993

Additional Pavement Reinforcement - Steel Fibers

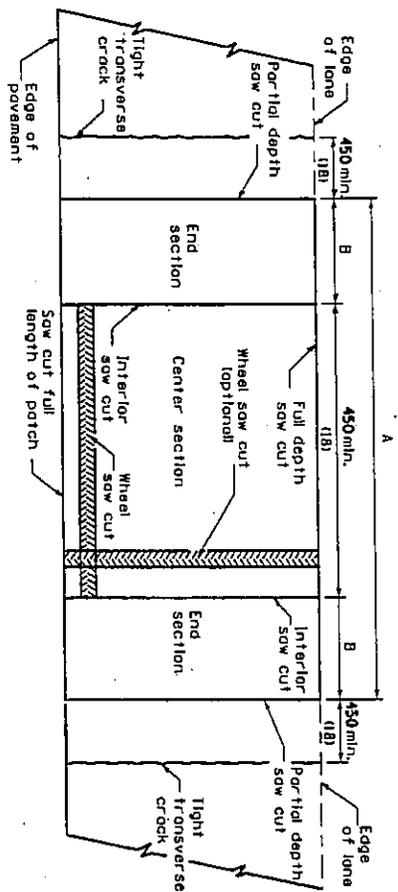
The patching should be performed as detailed in standard 2425-3 with the exception of adding steel fibers to the concrete mix. The fiber selected for this project is to meet all requirements of ASTM A820 Type 1. It shall be made from low carbon, cold drawn steel wire with an average ultimate tensile strength of 180 ksi. The fibers shall be 2" in length. Mixing of the steel fiber shall be at a rate of 200 pounds per cubic yard, shall conform to ASTM C94 standard specifications for ready-mixed concrete uniformity requirements, and may be added before, during, or after batching of the concrete materials.



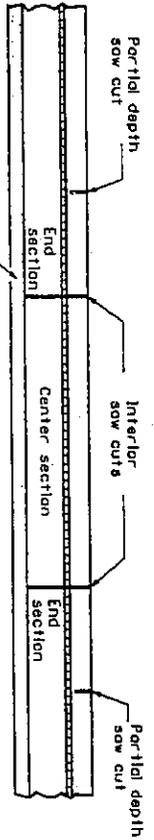
PAYEMENT SAWING DETAIL
(BITUMINOUS SHOULDER)



PAYEMENT SAWING DETAIL
(PCC SHOULDER)



ALTERNATE SAWING DETAIL
(PCC SHOULDER)



SAW CUT DETAIL

EXISTING REINFORCEMENT BARS	A (min.)	B (min.)	C (min.)
No. 15 (No. 5)	1.4 m (4'-6")	450 (18)	400 (16)
No. 20 (No. 6)	1.5 m (5'-0")	525 (21)	475 (19)
No. 25 (No. 7)	1.7 m (5'-6")	600 (24)	550 (22)
Fabric	1.5 m (5'-0")	525 (21)	450 (18)

GENERAL NOTES

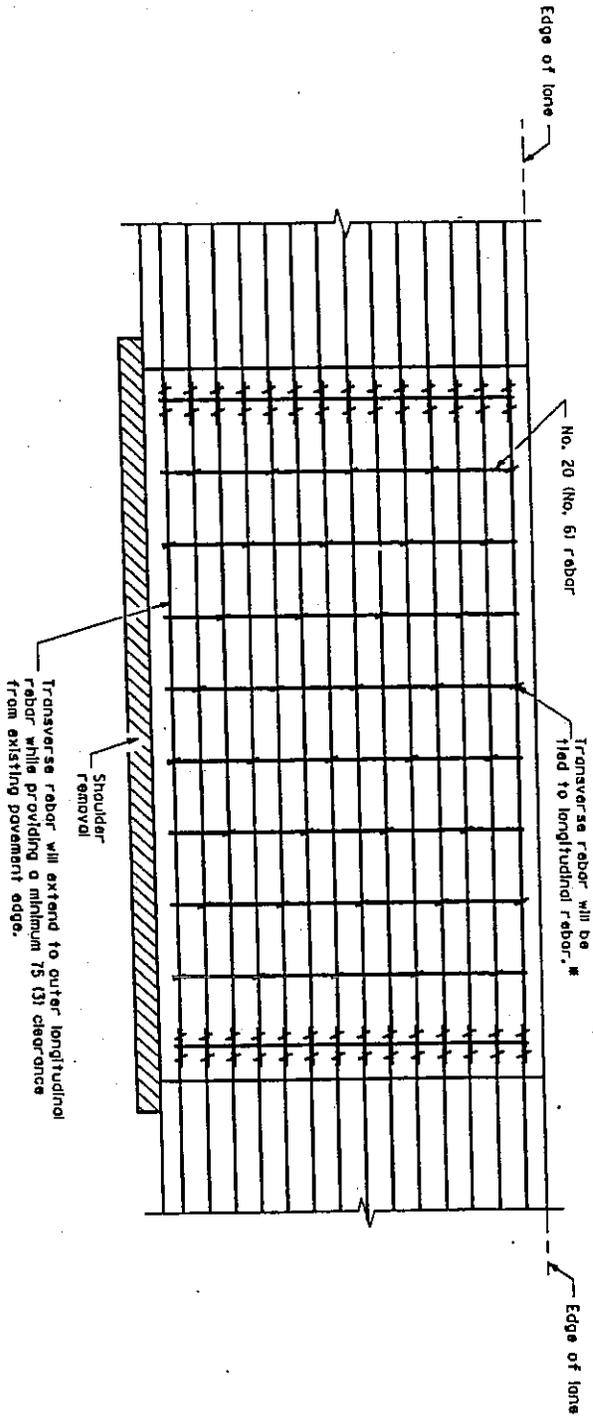
When patching two adjacent lanes in one operation, the length limit as detailed on Standard 442001 however, the groove shall be either performed or sanded. The bars shall only be included for patches 6.0 m (20') or longer.

All dimensions are in millimeters (inches) unless otherwise shown.

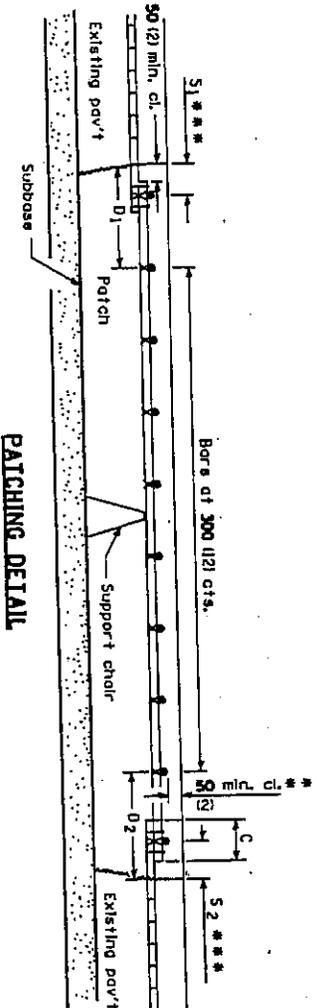
Length Department of Transportation
 PROJECT NO. 1-1-97
 DRAWING NO. 442001-01
 DATE 1-1-97

DATE	REVISIONS
1-1-98	Added PCC shoulder sawing details.
1-1-97	Revised Standard 4425-6.
	Rev. bar sizes.
	Rev. metric dim.

CLASS A PATCHES
 STANDARD 442001-01
 Sheet 1 of 21



PAVEMENT REINFORCEMENT DETAIL



PATCHING DETAIL

- * Every 3rd intersection must be tied.
- ** When the minimum clearance cannot be obtained with the transverse bar on top than the transverse rebar shall be tied to the bottom of the longitudinal rebar.
- *** Variables Where S1 and S2 are 65 (2 1/2) min. and 300 (12) max. D1 = 2(S1) and D2 = 2(S2).

PASSED _____ 1986
 PROJECT _____
 DESIGNER _____
 APPROVED _____
 DATE _____
 1-1-77

All dimensions are in millimeters (inches)
 unless otherwise shown.
CLASS A PATCHES
 STANDARD 442001-01
 (Sheet 2 of 2)



Photo 1. Skid-steer loader using mounted jackhammer to remove concrete.

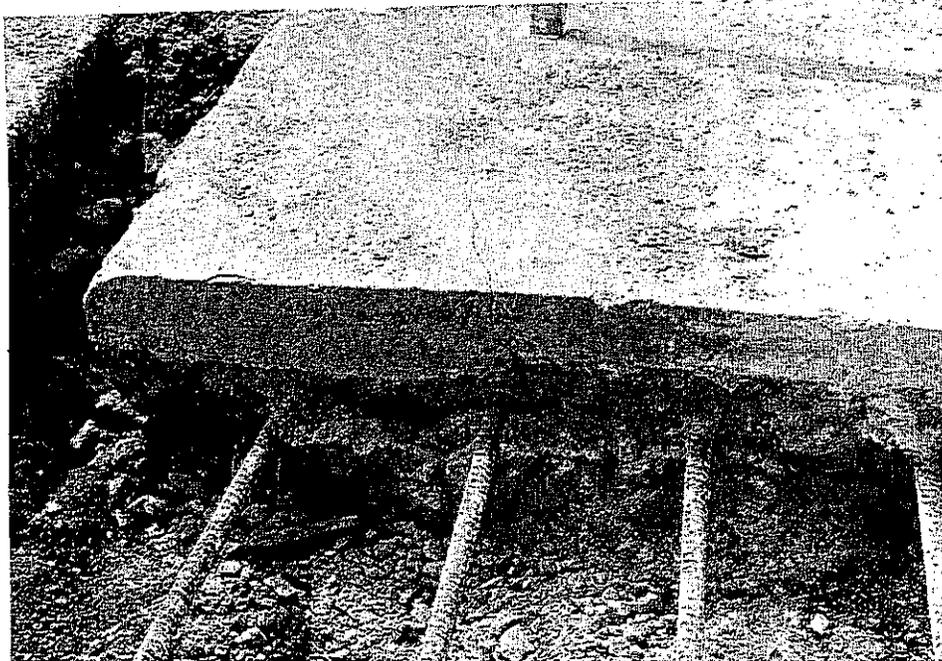


Photo 2. Corner break and undercutting from use of Skid-steer loader mounted jackhammer.



Photo 3. Interior saw cuts made by wheel saw, as shown, are too deep.



Photo 4. Backhoe bucket for concrete removal is not permitted. Procedure causes damage to adjacent pavement.

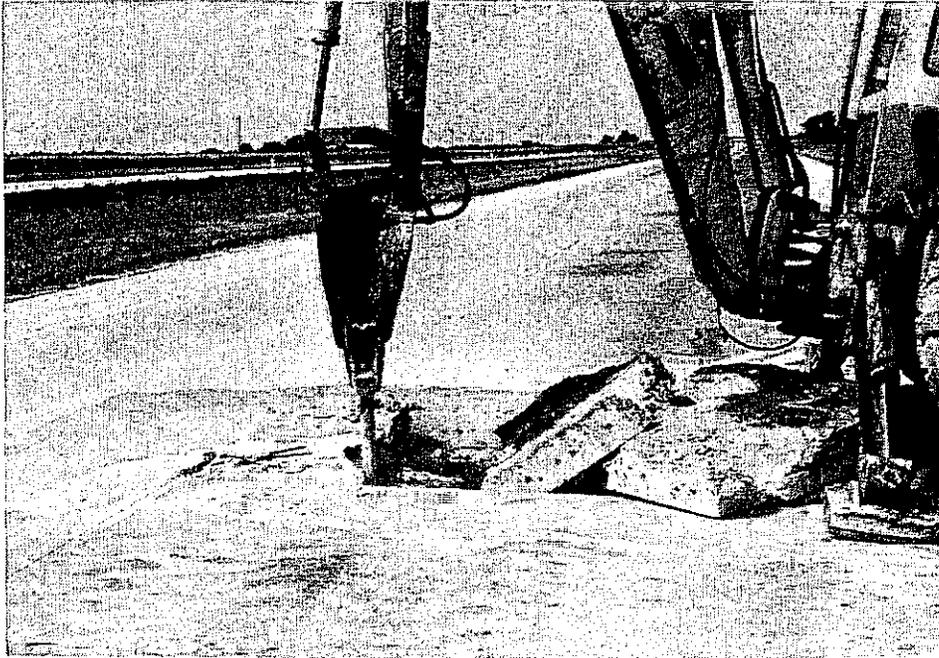


Photo 5. Backhoe mounted jackhammer is not permitted.
Causes damage to adjacent pavement and subbase.

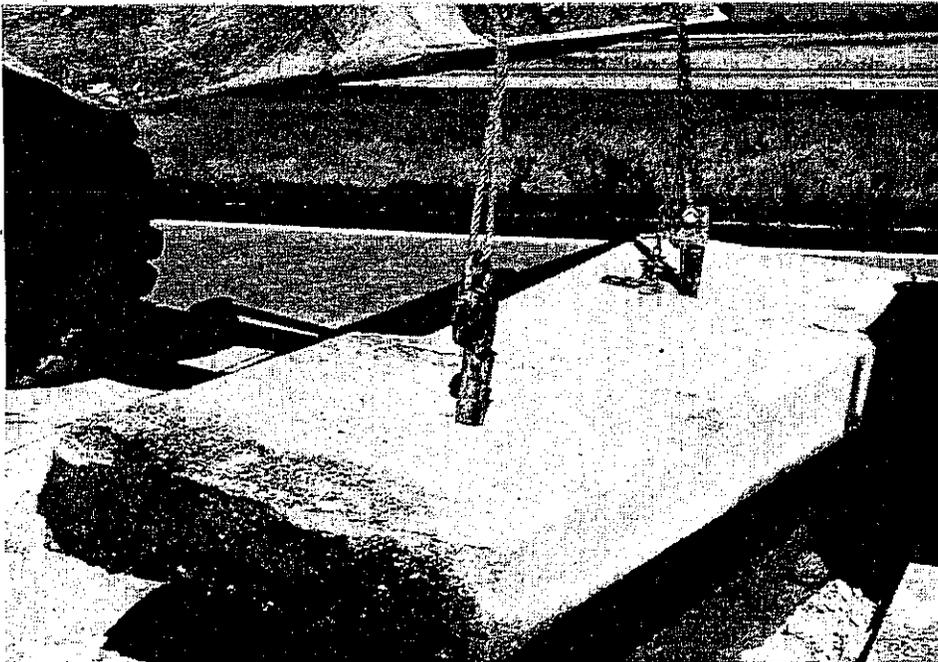


Photo 6. Slab lift-out method by the use of pins.

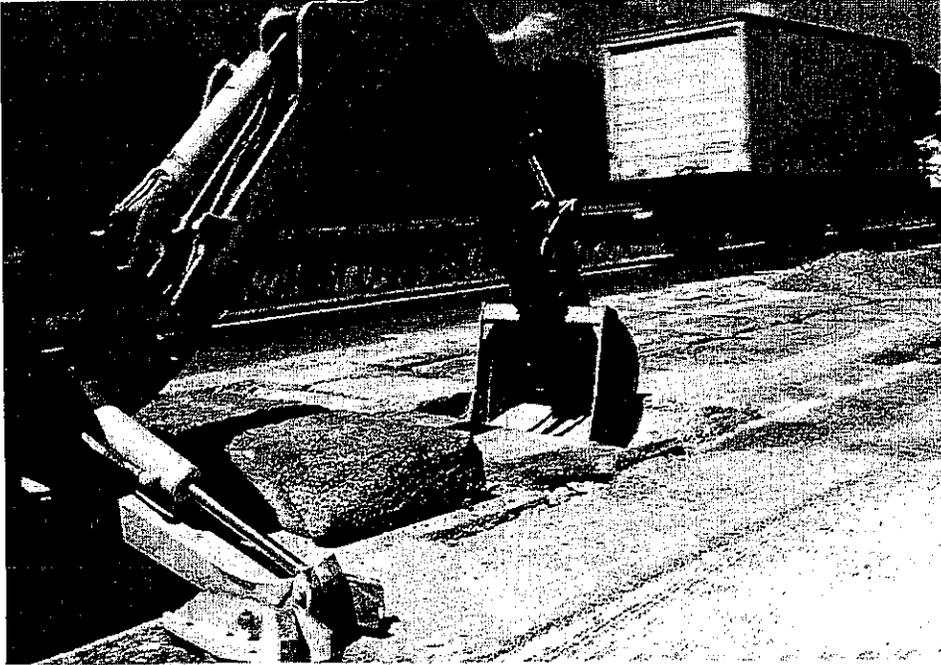


Photo 7. Removal of concrete by backhoe in segments.

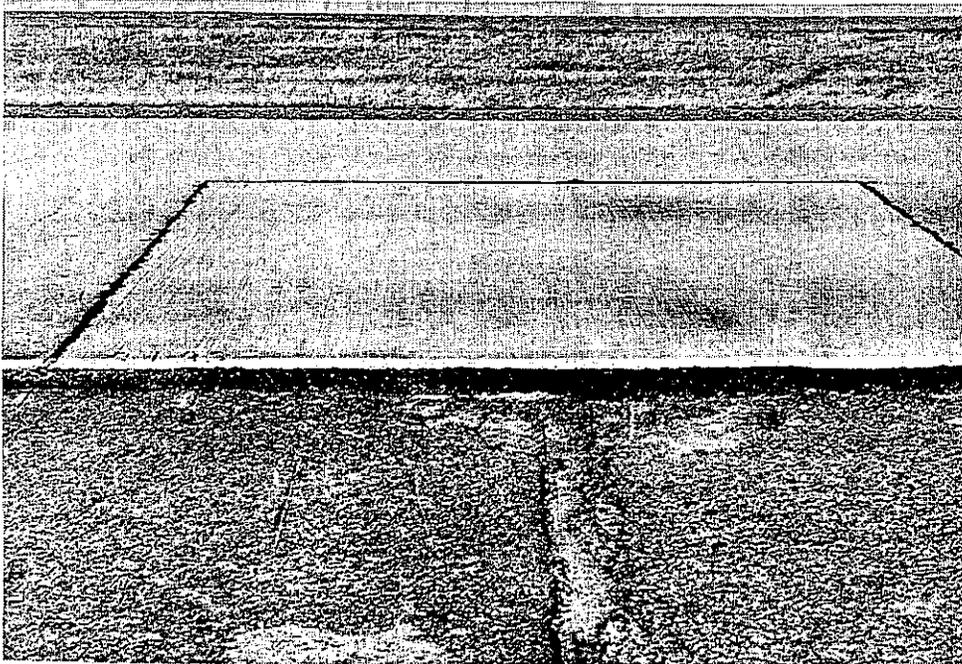


Photo 8. Remove and replace subbase with 4 inches of PCC.
Age: 1 month



Photo 9. Remove and replace subbase with 4 inches of PCC.
Age: 4 months.

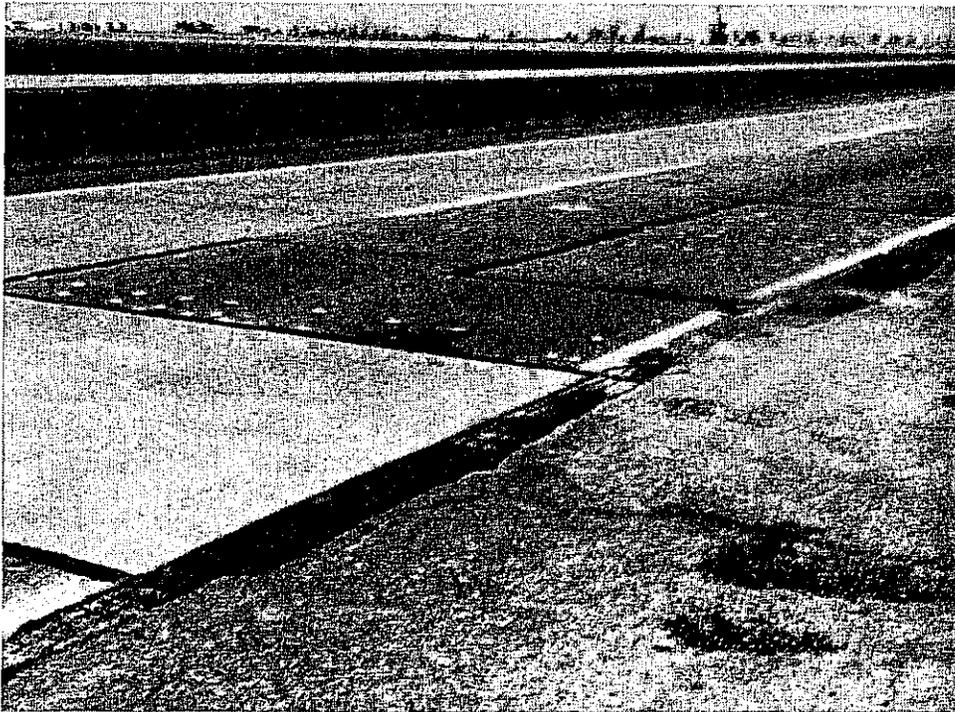


Photo 10. Remove and replace subbase with 4 inches of PCC.
Age: 1 year.



Photo 11. Drilled-tied experimental design. Age: 4 months.

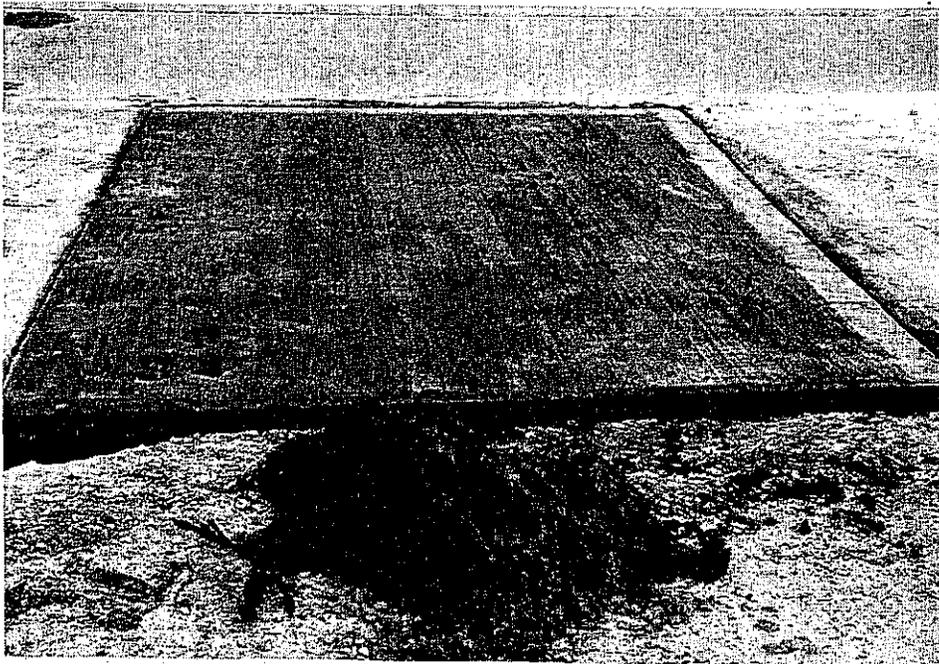


Photo 12. Edging of the patch perimeter to form sealant reservoir.



Photo 13. Pouring of joint sealant using ASTM D 3405.



Photo 14. An example of a completed patch with joint sealing.

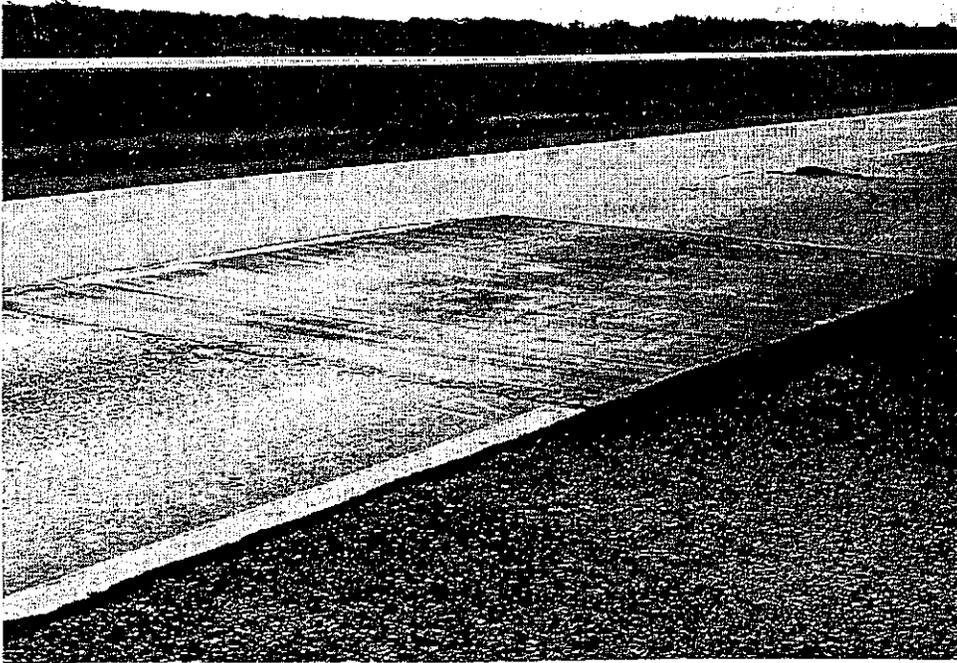


Photo 15. Transverse rebar experimental design.
Age: 6 months.

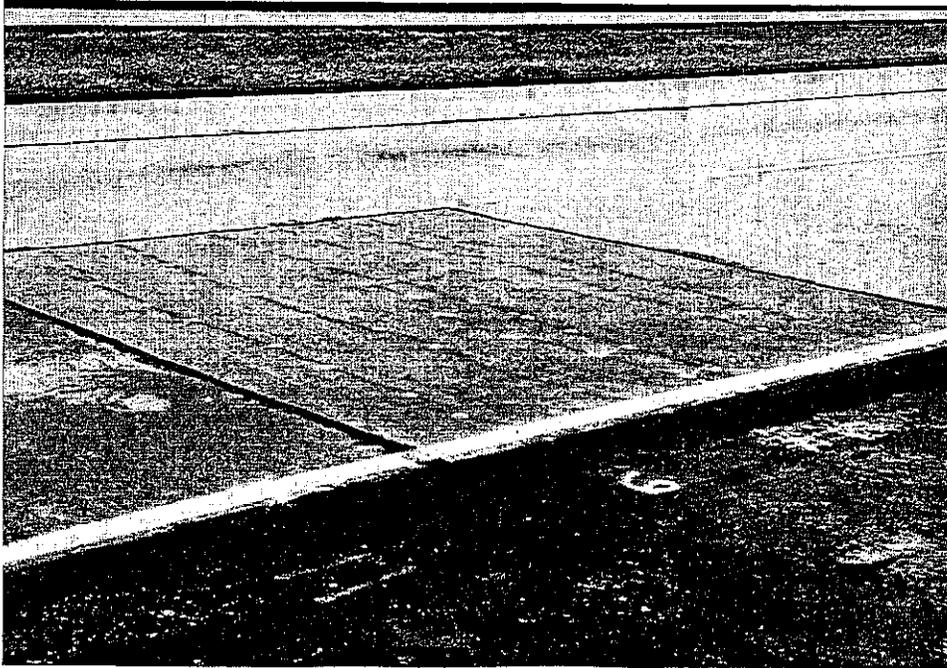


Photo 16. Steel fiber modified concrete experimental design.
Age: 6 months.

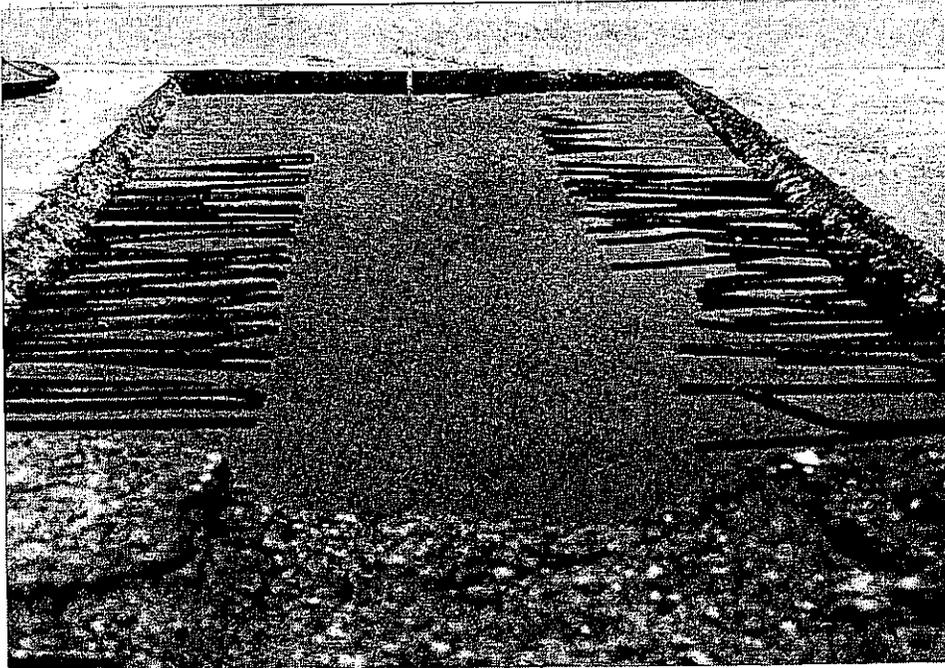


Photo 17. A weakened subgrade resulted from a saturated condition.



Photo 18. Deteriorated bituminous underdrain recovered during construction.



Photo 19. Drainage layer experimental design.
Age: 6 months



Photo 20. Drainage layer experimental design.
Age: 8 months