National Cooperative Highway Research Program

NCHRP Synthesis 204

Portland Cement Concrete Resurfacing

A Synthesis of Highway Practice

Transportation Research Board
National Research Council

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Synthesis of Highway Practice 204

Portland Cement Concrete Resurfacing

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire highway community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation Research Board

This synthesis report will be of special interest to pavement designers, materials engineers, and others seeking information on portland cement concrete resurfacings (overlays) placed over both portland and asphalt cement concrete pavements. Information is presented on the various practices in use for the design, material selection, and construction techniques associated with each pavement type. Additional information is provided on resurfacing experience and performance, including an Appendix cataloging more than 700 existing resurfacing projects in North America.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

Transportation agencies in the United States are continuing to develop pavement management systems which take an objective and structured approach to life-cycle cost analysis requirements for pavement rehabilitation project analysis. This report of the

Transportation Research Board also discusses the considerations involved in the selection of technically feasible resurfacing alternatives. Based on the longitudinal experience of 375 resurfacing projects that were cataloged in 1982 and the more than 700 projects identified in 1993, much useful information on the performance characteristics of portland cement concrete resurfacing is presented.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Lawrence W. Cole, Vice President, Engineering & Research, American Concrete Pavement Association; Amir N. Hanna, Senior Program Officer, Transportation Research Board; Frederick D. Hejl, Engineer of Materials and Construction, Transportation Research Board; Walter P. Kilareski, Professor of Civil Engineering, Pennsylvania State University, Pennsylvania Transportation Institute; Sanford P. Lahue, Director of Engineering for Highways, American Concrete Pavement Association; Roger M. Larson, Development Team Leader, Federal Highway Administration; Brian R. McWaters, Pavement Engineer, Office of Road Design, Iowa Department of Transportation; M. Lee Powell, III, President, Ballenger Paving Company, Inc.; Earl R. Scyoc, West Virginia Department of Transportation (Retired), Roger W. Surdahl, Highway Engineer, Federal Highway Administration; and Jon P. Underwood, Engineer of Research and Development, Texas Department of Transportation.

The Principal Investigators responsible for the conduct of this synthesis were Sally D. Liff, Manager, Synthesis Studies, and Stephen F. Maher, Senior Program Officer. This synthesis was edited by Linda S. Mason.

Scott A. Sabol, Program Officer, National Cooperative Highway Research Program, provided valuable assistance to the Topic Panel and the 20-5 Staff.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance were most helpful.

The Transportation Research Board would like to acknowledge the participation of the American Concrete Pavement Association and the Portland Cement Association in the development of this synthesis.

PORTLAND CEMENT CONCRETE RESURFACING

SUMMARY

Use of portland cement concrete (PCC) to resurface existing pavements can be traced to as early as 1913. An earlier Synthesis of Practice (*1*) showed that a relatively low-maintenance service life of 20 years can be expected and that many resurfacings have provided 30 to 40 years of service. It was evident by the mid 1980s that many new PCC overlays were being constructed and that the technology was rapidly maturing into a standard practice in some agencies. These new applications and the accompanying improved technologies had not been examined in a single document. The present effort was undertaken to provide a state-of-the-practice review of where the technology now stands.

That PCC resurfacings have undergone an impressive growth is evident in the number of documented resurfaced highways in service (Appendix). Cataloged projects have increased from 375 in 1982 to more than 700 in 1993. This growth may be evidence that the overlays are a good investment for highway agencies seeking an additional rehabilitation alternative.

Many of the changes and improvements in the technology foreseen in the earlier synthesis have been realized as the highway community has cooperated in working for better design procedures, construction guidelines, and specifications for all types of PCC overlays. Among the major advances has been the better definition of how the existing pavement should be evaluated and prepared for a PCC overlay. Another has to do with improved methods of achieving and measuring the bond strength attained at the interface between a bonded overlay and the underlying pavement. Major research projects dealing with bonded and unbonded overlays of PCC pavements and whitetopping of existing asphalt pavements have been completed. These studies have provided a wealth of information on the design, construction, and performance of all classes of PCC resurfacings.

Not surprisingly, PCC resurfacings share at least one design requirement with on-grade PCC pavements: they require uniform support conditions if satisfactory performance is to be realized. Nearly all the documented cases of premature overlay failure can be traced to some violation of this single requirement, often a result of "picking the wrong project" to resurface. For this reason, construction guidelines and specifications dwell heavily on the preparation of the underlying pavement and interface layer to ensure that uniform support is provided. Also similar to on-grade PCC pavements, the performance of PCC overlays is enhanced by the use of positive drainage systems and load transfer devices.

Jointed plain and reinforced concrete overlays are in service throughout the country as bonded, unbonded, and partially bonded overlays of PCC pavements. Many plain and a few reinforced jointed overlays also are in service as whitetoppings of asphalt concrete pavements, especially in heavy trucking corridors. Similar uses are being made of continuously reinforced overlays. Fiber-reinforced concrete resurfacings remain in service, almost

exclusively as thinner sections. Few of the latter have been constructed over the past decade.

By far the most popular PCC resurfacing is jointed plain concrete placed, unbonded, on a pavement of similar design. Among recent projects, a close second is whitetopping, also using the jointed plain design. As the Appendix shows, this class of PCC resurfacing has experienced the largest growth over the past decade.

Thin-bonded resurfacings continue to have a place in the rehabilitation of PCC pavements suffering from surface distress or in instances where structural enhancement of a sound existing PCC pavement is desired. The monolithic nature of the overlay and the underlying pavement makes this the most efficient way of increasing the structural capacity of a structurally sound, existing PCC pavement. Reductions in the costs and improvements in the techniques of surface preparation, the construction of the interface, and the placement and curing of the overlay make this an increasingly useful alternative under the proper conditions. Thin-bonded PCC overlays should not be used on pavements that have any appreciable distress, as that distress will be reflected in the overlay.

Federal Highway Administration (FHWA) initiatives on pavement management and on the objective and structured selection of pavement rehabilitation alternatives portend continued growth in the use of various types of PCC resurfacings. Pavement management provides better databases to support design choices, while life-cycle cost analysis takes the decision-making process far beyond just the first cost and into a public investment concern.

CHAPTER ONE

INTRODUCTION

PROBLEM STATEMENT

The resurfacing of pavement with portland cement concrete (PCC) is a technology that has been evolving rapidly in the modern era of higher traffic volumes and axle loadings. Much new work has not been documented, though there has been an earlier synthesis (*1*) and a related bibliography (*2*). Concrete resurfacing is used principally to upgrade pavement structurally or to enhance ride quality (functional enhancement). One of the evolving uses of structural resurfacing involves stage construction, in which future bonded resurfacing may be planned at the time of original pavement design. Also rapidly emerging as a more popular technology is the resurfacing of asphalt concrete (AC) pavement with PCC, generally referred to as "whitetopping."

SCOPE OF SYNTHESIS

National Cooperative Highway Research Program (NCHRP) Synthesis of Highway Practice 99: Resurfacing With Portland Cement Concrete (1982) is the major source document for the present synthesis. The present effort emphasizes activities since the early 1980s, resulting in a true "state-of-the-practice" rather than a historical summary. However, the popular appendix to the earlier synthesis, containing some 375 PCC resurfacing projects, has been updated and expanded to more than 700 projects in this synthesis.

Following an overview of PCC resurfacing use, the synthesis provides information on latest design, materials, and construction techniques. In addition, the reported performance of PCC resurfacing is thoroughly examined. Prestressed concrete overlays, which received some mention in the previous synthesis, have not been constructed in the past decade and are not included in the present document. A review of some of the research in progress as well as suggestions for future research are included. A chapter in the earlier synthesis devoted to traffic delay assessment has been expanded to deal with the use of life-cycle cost analysis in the selection of resurfacing type. Finally, conclusions and recommendations are offered.

APPROACH TO SYNTHESIS DEVELOPMENT

A comprehensive literature search was carried out under the auspices of the Transportation Research Board (TRB) and using the Transportation Research Information Service database. This search, limited to North American resurfacing constructed after 1960, resulted in 122 items covering a wide variety of resurfacing projects. The majority of these documents are available through TRB, the FHWA, or through the various agencies. A questionnaire provided to all state highway or transportation administrations was used to elicit more recent information and to verify the performance of older projects. Of 54 questionnaires circulated to the United States and its possessions, 41 were completed and returned. Several of the highway agencies that did not respond have used little concrete pavement, so the response is considered to be very good. In addition, the American Concrete Pavement Association (ACPA), the Portland Cement Association (PCA), and the National Ready-Mix Concrete Association assisted in getting questionnaires to city street interests and provided most of the input to those entries in the Appendix. The civilian airfield data was provided by local airport authorities, and the military airfield information was provided by the United States Air Force. The latter two sources reported more than 40 projects constructed in the last 10 years. Additional input was provided from field surveys conducted in 1989 by the FHWA in cooperation with the ACPA and the PCA. Databases built around these surveys as well as historical records held by the above organizations also were used (*3*).

As far as possible, the descriptive terms used throughout the synthesis are generic and in common use in the late 1980s and early 1990s. Terms considered to be somewhat specific to PCC overlays are defined in the Glossary. Understandably, the various original terms do not share common meanings across the wide spectrum of users represented. For that reason, at times it was necessary to translate from the original wording to the most commonly used terminology, depending on the context in which the original term was used. Any errors resulting from this translation are regrettable, but hardly avoidable. A major deviation from the earlier synthesis is in the use of the terms "resurfacing" and "overlay." In Synthesis 99, the convention of using "resurfacing" throughout was adopted. Although that convention appeared workable then, the more recent literature makes heavy use of "overlay" in the same contexts. For this reason, the two terms are used interchangeably in the present document.

CHAPTER TWO

OVERVIEW OF CONCRETE RESURFACINGS

RESURFACING BACKGROUND

Synthesis 99 provides such an excellent history of concrete resurfacing (*1*) that only an overview is provided here. Many early pavements were constructed of thin layers of portland cement or AC. If designed at all, these pavements were designed for much lighter and less frequent loadings than have been experienced in more recent times. Some observers suggest that World War II was the turning point from an agrarian to an industrial society in North America, when the move to ever-increasing numbers and magnitudes of highway loads began. This change put an unexpected burden on the nation's highways, streets, and airfields. The result was pavement distress at unheard-of levels and a need for effective rehabilitation techniques.

Resurfacing with concrete was used as a means of extending pavement life as early as 1913 and has been used by some agencies almost continuously since then. The Michigan Department of Transportation (DOT), for example, placed 21 concrete resurfacings between 1932 and 1954, one of which was still in service after 35 years (*4*). Still, it was not until the post-war recovery (the 1940s) that the approach began to find widespread use for both roads and airfields (*1*). The majority of the work was on airfields until the mid 1960s.

At about that time, construction of the interstate highway system was underway. In some cases, highways were upgraded to interstate standards through the use of concrete resurfacing. By the mid 1970s, some older interstate pavement began to need rehabilitation or upgrading to accommodate heavier traffic. These projects, too, became candidates for concrete resurfacing. The need has continued to grow for alternative means of pavement rehabilitation, and concrete resurfacing remains one of those alternatives. While the earlier synthesis catalogued some 375 concrete resurfacing projects by 1981, current records show a tremendous growth in the technology during the 1980s: by 1993 at least 708 concrete resurfacing projects were known to exist, as catalogued in the Appendix. Iowa alone now has more than 150 PCC resurfacing projects in service.

The resurfacing of AC pavement with PCC overlays (whitetopping) was becoming fairly common at the time of the earlier synthesis. Noted in the literature as early as 1918, some 70 projects were identified in the earlier synthesis (*1*). As a later section will explain, during the early 1990s this became the major use of PCC resurfacing by some agencies. Nearly 100 new whitetopping projects reportedly have been built nationally in the 1980s and early 1990s, and are now a part of the revised Appendix.

Another recent advance in the technology is the use of the "fast-track" concept of PCC resurfacing. In this approach, which originated in Iowa in the mid 1980s, PCC resurfacing is planned and executed to expedite the return of the roadway to normal traffic use. In several instances where high-early-strength concretes were used, overlay construction from lane closure to reopening to traffic has taken place within 2 days (*5,6*). Proponents of the fast-track approach note that the reduced lane closure times make PCC resurfacing more economically competitive with other rehabilitation approaches, as well as more psychologically acceptable to the owners and users.

The Strategic Highway Research Program (SHRP), in its Long Term Pavement Performance (LTPP) program, has conducted two experiments in PCC resurfacing (*7,8*). The first of these (GPS-9) recognizes that a significant number of unbonded (no bond between the PCC resurfacing and the underlying pavement) resurfacing projects are in use and provide a ready range of test pavement (*7*). The other experiment (SPS-7) recognizes the relative absence of bonded (efforts are made to ensure a bond between the resurfacing and the underlying pavement) projects that lend themselves to research and establishes an experiment to construct and study such pavements (*8*).

TYPES AND USES OF CONCRETE RESURFACINGS

Nearly all early concrete resurfacing was of the plain, unreinforced type applied in relatively thick courses to unprepared surfaces. With experience, the technology has evolved and there is now a family of different types used for a variety of conditions, including PCC overlays of AC pavements or whitetopping. Underlying pavement condition, economics, the availability of materials, traffic handling requirements, constructability, and personal preference of the engineer are the major elements in a decision on which type of resurfacing to use. These factors are discussed below for each of the resurfacing types identified in the literature.

As discussed in detail later, the interface between the resurfacing and the underlying pavement is an important consideration for every resurfacing type. General interface classifications are unbonded, partially bonded, and bonded. Unbonded means that specific actions are taken to ensure that there is no bond between the concrete layers. Partially bonded means that bonding is not particularly addressed. Bonded means that special efforts are employed to enhance bonding between the layers.

Derived from data given in the Appendix, Figure 1 depicts total PCC overlay use across the United States. There is a wide variation in the use of this rehabilitation method from state to state. Rapid growth in the technology in the late 1980s and early 1990s is indicted by Figure 2, a graphical display of the number of PCC overlay projects by decade. Tables 1 through 3 provide numerical summaries of PCC resurfacing data extracted from the Appendix. An overview of use organized by type follows.

Jointed Plain Concrete Pavement (JPCP) Overlays

Unreinforced (plain) concrete has been and remains the most popular concrete resurfacing option. As shown in Table 2, nearly two-thirds of the reported resurfacing is of the JPCP type. To a

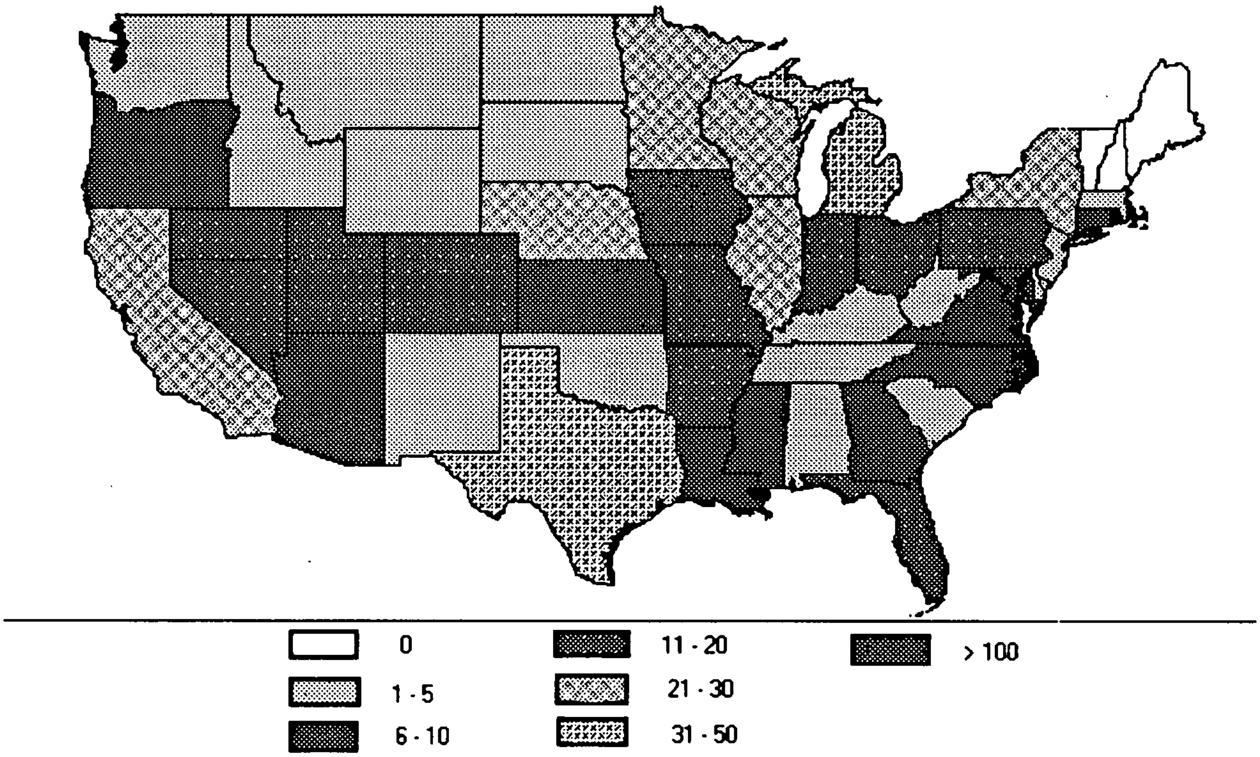

FIGURE 1 All PCC overlay use by state.

great extent this popularity results from the fact that much of the underlying concrete pavement also is unreinforced and constructed with short slab lengths.

Plain concrete resurfacing may be bonded, unbonded, or partially bonded (Table 3). Because of the tendency for cracks in the underlying pavement to be reflected in the resurfacing if it is bonded or partially bonded, such interfaces are most often used where the underlying pavement is in reasonably good condition. The major impetus for such resurfacing may be structural enhancement of the pavement.

On distressed pavement, plain, unbonded resurfacing normally is used so that the interface material will deter reflective cracking. Thus, it is not necessary that joints coincide with those in the underlying pavement. In fact, recent construction guidelines recommend substantial mismatching of unbonded overlay and original joints.

JPCP is also by far the most popular PCC type for whitetopping. As shown in Table 3, whitetopping accounts for about one-fourth of the JPCP overlays reported.

As with original pavement construction, plain concrete resurfacing may be used in the full range of thicknesses, up to about 0.6 m (2 ft) for heavy airport pavements. Thin layers are widely used to correct pavement surface distresses such as scaling (*9*). PCC overlays of less than 75 to 100 mm (3 to 4 in.) tend to be bonded to the underlying layer, though others may employ any interface.

Jointed Reinforced Concrete Overlays

Like reinforced concrete pavement, reinforced resurfacing employs distributed steel to control the movement of shrinkage cracks and to accommodate curling and warping stresses in long slabs. If used as a bonded surface, a reinforced layer's joints must coincide with joints in the underlying pavement. Otherwise, reflective cracking will result in an undesirable random cracking pattern. For partially bonded and unbonded resurfacing, the mismatching of joints is again recommended. Table 3 shows that most of the jointed reinforced concrete pavement (JRCP) overlay use has been unbonded or partially bonded.

Reinforced resurfacing layers are subject to one practical limitation not applicable to those without reinforcement: the need to provide a minimum cover on the reinforcing steel. Although there is no real consensus on what that minimum should be, many apply a criterion similar to that applied to reinforced concrete pavement and bridge decks, which suggests a 50-mm (2-in.) minimum cover. This criterion is recommended by the American Association of State Highway and Transportation Officials (AASHTO) in the 1990 publication *Guide Specifications for Concrete Overlays of Pavements and Bridge Decks* (*10*).

To allow room for the steel itself, a practical minimum thickness is about 90 mm (3.5 in.). Historically, few reinforced resurfacings of less than 125 mm (5 in.) have been used, as can be seen in the Appendix.

Continuously Reinforced Concrete Overlays

Continuously reinforced concrete (CRC) resurfacing has similar design requirements to CRC pavements. Steel reinforcement of approximately 0.6 percent of the concrete cross-sectional area is used in the longitudinal direction to control random shrinkage

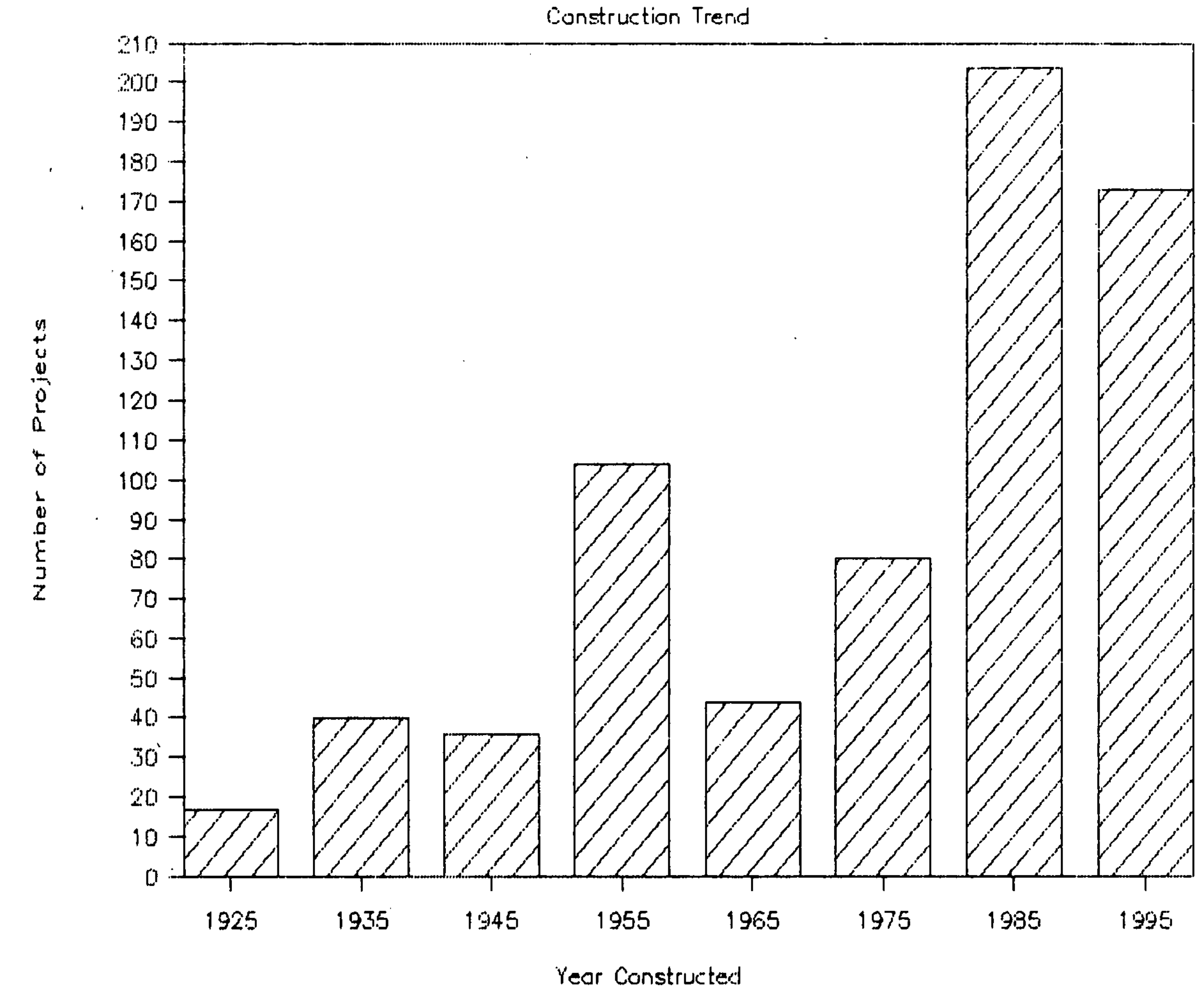

FIGURE 2 Construction trend, all PCC overlays.

TABLE 1
NUMBER OF CONCRETE RESURFACINGS BY TYPE AND USE

	USE(b)			
TYPE(a)	Highways	Streets	Airfields	Total
JPCP	319	38	119	476
JRCP	99	24	6	129
CRCP	57	1	9	67
FRC	6	8	18	32
PRC	2	-	2	4
Totals	483	71	154	708

(a) JPCP = jointed plain concrete
JRCP = jointed reinforced concrete
CRCP = continuously reinforced concrete
FRC = fiber reinforced concrete
PRC = prestressed concrete

(b) As classified by the reporting agency.

cracking. Transverse steel may be used. Little bonded or partially bonded CRC resurfacing has been reported (Table 3), and when used, it has not performed well. Unbonded CRC resurfacing has been used on all types of pavement, usually to restore ride quality in heavy traffic corridors and where it is not feasible to match the joints of underlying layers. Several CRC overlays are found as whitetopping applications (Table 2).

Fibrous Concrete

Fibrous concrete resurfacing employs fibers made of steel or other material randomly distributed throughout the mix. The fibers are purported to enhance flexural, compressive, and impact strengths and to reduce shrinkage cracking. Although most fibrous resurfacing uses steel fibers, some has also been successfully constructed using glass and polypropylene fibers (*11*). Fiber-reinforced resurfacing may be bonded, unbonded, or partially bonded. Because the fibers add significantly to the cost of the resurfacing, layers tend to be relatively thin. On highways, most have been applied as bonded layers to withstand curling stresses. However, because of the generally thick layers required, much of the fiber-

TABLE 2
NUMBER OF CONCRETE RESURFACINGS BY TYPE AND UNDERLYING PAVEMENT

	Underlying Pavement (a)					
TYPE(a)	JPCP	JRCP	CRCP	AC/F	OTHER	TOTALS
JPCP	220	44	25	175	12	476
JRCP	88	18	2	14	7	129
CRCP	22	26	2	17	-	67
FRC	10	2	4	14	2	32
PRC	2	-	1	1	-	4
Totals	342	90	34	221	21	708

(a) JPCP = jointed plain concrete
JRCP = jointed reinforced concrete
CRCP = continuously reinforced concrete
FRC = fiber reinforced concrete
PRC = prestressed concrete
AC/F = asphalt concrete or flexible

reinforced overlay work on airfields (Table 1) has been unbonded, some as whitetopping for flexible pavement.

Records show a good deal of fibrous concrete construction in the 1970s, then tapering off; except on airfields, very little has been used since about 1980 (Appendix). Only two recent highway projects have been constructed—a highway project in Louisiana (*11*), and an experimental road project in Louisville, Kentucky (*12*). A number of experimental sections of fibrous concrete overlays have been or will shortly be constructed in Georgia, Tennessee, Virginia, Iowa, and Kansas (personal communication from Roger Larson, April 1994).

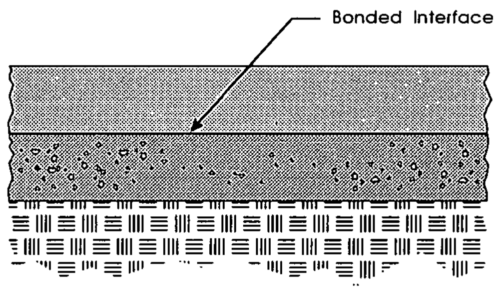

FIGURE 3 Bonded PCC overlay.

INTERFACES USED WITH CONCRETE RESURFACINGS

Over the years, two schools of thought have evolved concerning the nature of the interface between the underlying old pavement and the resurfacing itself. The first, generally held by highway engineers, is that resurfacing is either bonded (specific activities are directed at achieving near-monolithic bonding between the layers) or unbonded (specific activities are intended to ensure that there is no bond between the layers). The second, generally espoused by airfield engineers, takes the position that there is an additional, intermediate state in which the layers are partially bonded (*1*). In this case, construction procedures may include modest bond-enhancing activities, or the bonding issue simply may be ignored. Bonding is less of an issue with airfield pavement because of the generally thicker overlays employed. In this synthesis, both schools of thought will be addressed, though most of the discussion is restricted to the more common bonded and unbonded types.

TABLE 3
NUMBER OF CONCRETE RESURFACINGS BY TYPE AND INTERFACE

	Interface(b)			
TYPE(a)	Bonded	U/P Bonded	Whitetopping	Total
JPCP	105	218	151	474
JRCP	10	116	6	132
CRCP	3	50	13	66
FRC	8	16	8	32
PRC	-	4	-	4
Totals	126	404	178	708

(a) JPCP = jointed plain concrete pavement
JRCP = jointed reinforced concrete pavement
CRCP = continuously reinforced concrete pavement
FRC = fiber reinforced concrete
PRC = prestressed concrete pavements

(b) As classified by the reporting agency.

Bonded Interface

Pavement engineers and others have long recognized that bonding a resurfacing to the underlying pavement (Figure 3) to achieve monolithic behavior of the two layers is a very efficient means of structural enhancement. Early studies showed that bonding between the two layers is principally a mechanical process that depends primarily on the soundness and cleanliness of the underlying pavement (*13*). Later work (*14,15*) recognized a degree of chemical bonding between the overlay and the underlying pavement. Felt (*13*) went on to point out that "a slight degree of roughness is desirable, but an extremely rough surface is not required." In

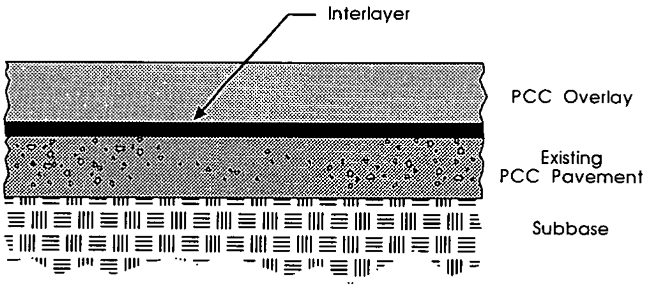

FIGURE 4 Unbonded PCC overlay.

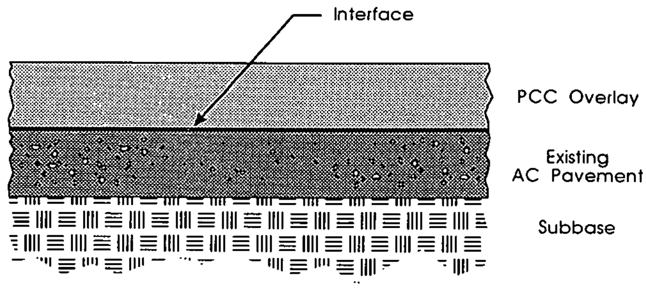

FIGURE 5 Whitetopping.

that and other work, shear bond strengths of up to 600 pounds per square inch (psi) have been reported. When properly constructed, the bond strength often exceeds the strength of even the strongest layer, so that bond test specimens fail in one of the layers rather than at the interface (*6*).

Cleaning and grinding procedures generally used to create the necessary surface conditions will be discussed in Chapter 5. Also discussed later is whether a portland cement and water grout is required to enhance bonding. In most instances of bonded resurfacing construction the specifications will provide for some means of bond testing.

Unbonded Interface

To achieve an unbonded interface, special care is taken to ensure that no significant bond develops in situations where cracking or other pavement characteristics may be reflected from the underlying pavement. Generally, a bond-breaking/separation layer that does not bond strongly to concrete is used (Figure 4). In many cases, the bond-breaking layer is underlain by a separation layer to prevent interlock between the overlay and joint faults or other irregularities in the underlying pavement surface. The separation layer often is composed of AC covered with membrane curing compound to impede bonding. With a few special considerations, the resurfacing may then be constructed as if the underlying pavement were a conventional subbase layer.

Partially Bonded Interface

If the issue of bonding between the resurfacing and the underlying pavement is of little importance, such as on thick airfield pavement, the partially bonded approach may be employed. Because no particular attention is paid to cleaning or grinding the base pavement, various degrees of bonding may occur, but will have little bearing on the performance of the resurfacing. Partially bonded overlays are sometimes referred to as direct overlays (*1*), implying simply that little or no surface preparation is done. In most of the recent literature, partially bonded overlays are considered special cases of the unbonded type, because the evidence shows that the performance is similar (*16*).

Other Interfaces

On occasion, the interface is not well defined because of variations in the underlying pavement. The old pavement may contain intermittent repairs of various materials, or it may consist of an old flexible pavement with or without leveling courses or other AC layers. In such cases (Figure 5), the resurfacing is similar to an unbonded layer but, due to uncertainties in design, is not technically considered as such. In these instances, engineering judgment is an especially important element of resurfacing design.

Finally, the resurfacing of AC pavement with PCC overlays (commonly known as whitetopping) is now a common practice in some agencies. In view of the increasing popularity of whitetopping over the past few years, Figure 6 provides an indication of its use by state, and Figure 7 indicates the rapid growth in applications in the 1980s and 1990s. All the whitetopping data in the Appendix were used to develop Figure 7. Nearly all whitetopping has been on highways.

CONCRETE RESURFACING PROJECTS

The Appendix includes 708 concrete resurfacing projects identified in the literature or through personal communication with various highway, street, and airfield agencies. Tables A-1 through A-3 are broken down by interface: Table A-1 lists all bonded overlays, Table A-2 all partial or unbonded overlays, and Table A-3 all others. Nearly all projects in Table A-3 are PCC overlays of asphalt pavement or whitetopping. Project numbering in all three tables is in order of project age, from oldest to newest.

Approximately 375 (through 1981) of the projects listed were also included in Synthesis 99. Special efforts have been made to provide updated information on these projects to describe what has happened to them since the earlier synthesis. The column "Status in 1992" of the tabulation includes any later information gathered on these older projects.

Projects included in the tabulation include highways, streets, airfields, parking lots, and special experimental sections. SHRP project types GPS-9(*7*) and SPS-7(*8*) also are included.

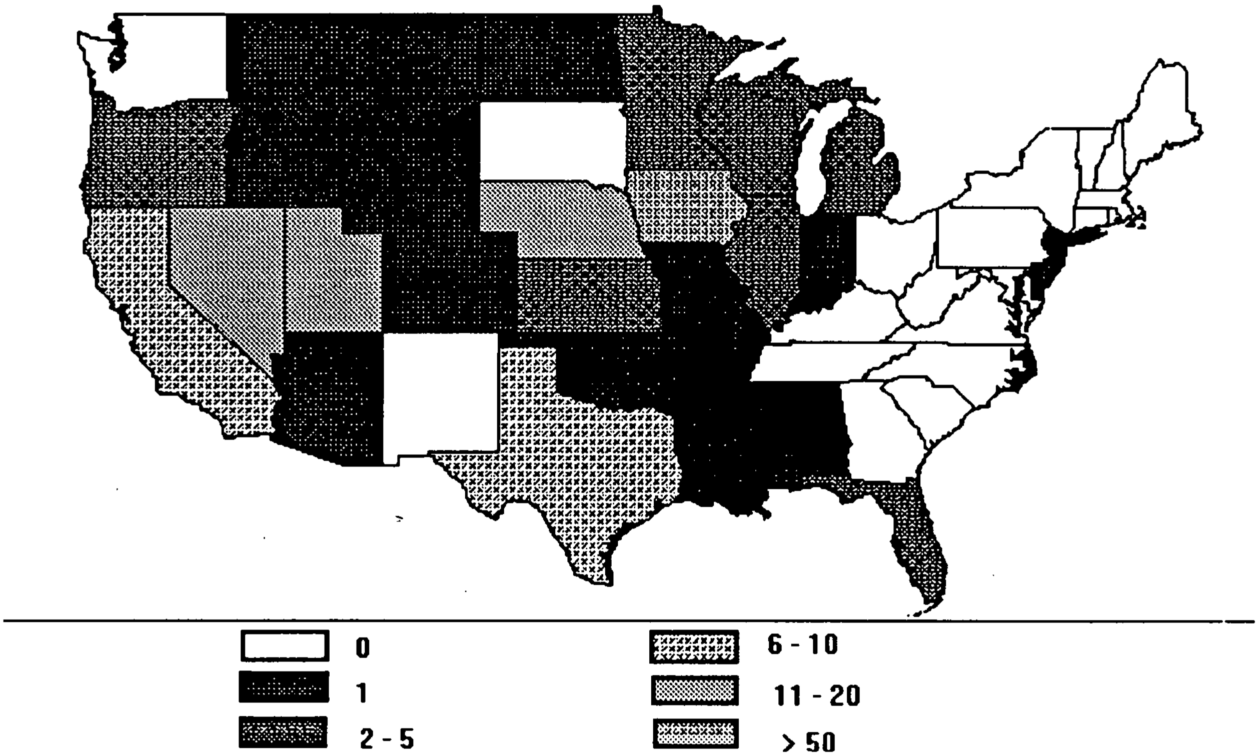

FIGURE 6 Whitetopping use by state.

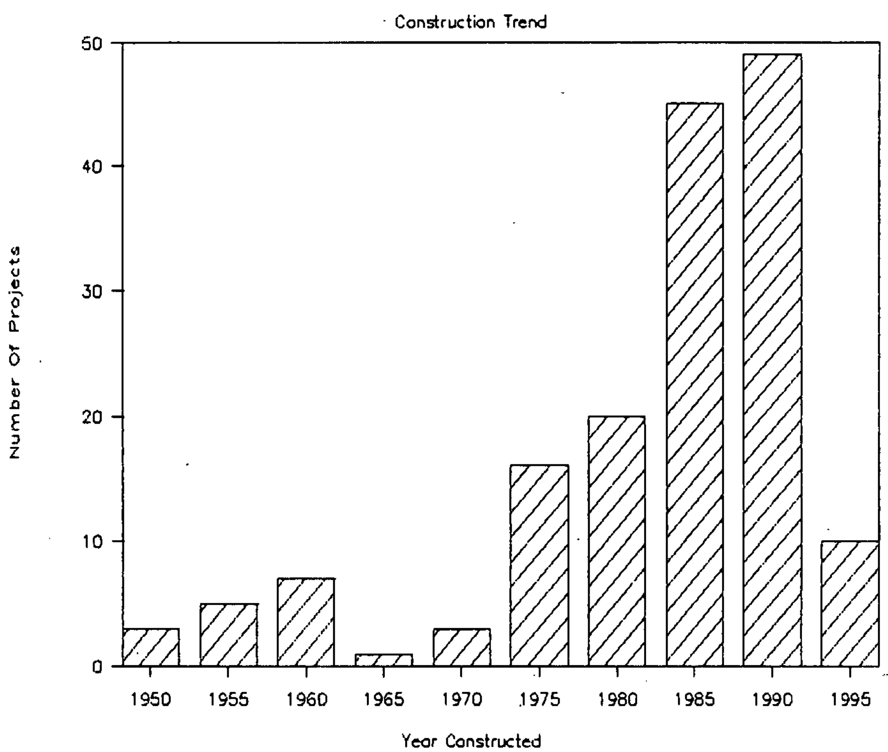

FIGURE 7 Construction trend, whitetopping.

CHAPTER THREE

CONCRETE RESURFACING DESIGN

This chapter summarizes concrete resurfacing design considerations, beginning with evaluation of the existing pavement and including determination of the required functional or structural resurfacing (thickness and other qualities). While all design questions may not be answered, the designer will be directed to appropriate references.

Significant progress has been made in the general resurfacing design area since the earlier synthesis. Of particular importance is the 1993 AASHTO *Guide for Design of Pavement Structures* (*17*). This is a single source for most of the important design considerations for all types of PCC resurfacing and will be frequently referenced in this chapter.

Before proceeding with the detailed discussion, it is worthwhile to repeat several concrete resurfacing design and construction requirements reported in the earlier synthesis(*1*) from work by Martin (*18*):

1. Thickness must be adequate for the anticipated service conditions.
2. Joints (longitudinal and transverse) and cracks must have the capacity to transfer applied loads without loss of surface smoothness. The joint and crack system should minimize the migration of moisture and fine solids through the resurfacing as well as between it and the underlying pavement.
3. Reinforcement must have adequate cover for the exposure conditions and should be of such size and spacing that all cracks are held tight.
4. The maximum size aggregate must be compatible with the resurfacing thickness and spacing of steel.
5. Sound, durable aggregate must be used; air entrainment must also be used if freezing and thawing or the use of de-icing salts might occur.
6. Shoulders should be of concrete, tied to the resurfacing, or another material stabilized for the full depth of the resurfacing to minimize infiltration of shoulder material between the underlying pavement and the resurfacing.

EVALUATION OF EXISTING PAVEMENT

An important consideration in resurfacing design is the condition of the existing pavement on which the resurfacing is proposed. The evaluation of existing pavement condition consists of three major elements: serviceability (functional condition) evaluation, distress surveys, and structural testing. The three are not mutually exclusive; any of the three separately or in combination can contribute to a decision to resurface. Barenberg (*19*) in 1981 put condition evaluation of the existing pavement in perspective as one of the most important resurfacing considerations:

> Evaluating the true condition of the existing pavement is one of the most critical factors in selecting the best overlay option. This evaluation should reflect how the existing pavement will affect the behavior and performance of the overlaid pavement. Such an evaluation should be based on structural or behavioral considerations rather than serviceability considerations.

While Barenberg's thesis still seems to be generally accepted, some advances in PCC resurfacing technology make the thin, functionally required resurfacing a more acceptable alternative than it was earlier.

FHWA initiatives to promote more formal pavement management processes in the state DOTs are leading to rapid change in the area of pavement condition evaluation (*20*). As a result, the National Research Council (NRC) is publishing a synthesis of the various practices in use (*21*). This effort will supplement a previous synthesis on the collection and use of pavement condition data (*22*). These two documents provide excellent resource materials for the evaluation of pavement to be considered for a PCC overlay; some of the major points are discussed below.

Functional Adequacy

Serviceability generally refers to user perception of pavement condition, usually reflected in ride quality. While panel ratings may be used for this evaluation, most agencies use objective measures of ride quality, such as response-type road roughness measurements (*23*). Correction of a low skid-resistance problem might also be a reason for a functional overlay (*24*). Generally, functional overlays are used when the pavement no longer meets one or more levels of service established as agency policy. When required for functional reasons, resurfacing will generally be of the minimum thickness required for construction expediency (*9,25*), or to restore the level of service to an acceptable level.

Distress Surveys

Distress surveys are used to determine the nature and extent of deterioration of the underlying pavement. Such data are extremely important in view of the impact on resurfacing performance that can be attributed to distress (e.g., reflection cracking). Such data also are useful in determining appropriate procedures to use in preparation for a PCC overlay of an existing pavement (Chapter 5).

While several procedures have been established to evaluate such distresses there seems to be little consensus on their use, although the FHWA is attempting standardization (*26*). Popular methods currently in use are the Concrete Pavement Evaluation System (COPES) (*27*) for concrete pavement, and the Pavement Condition Index (PCI) (*28*) for flexible pavement. A manual that had a good deal of use in the past is the *Highway Pavement Distress Identification Manual* (*29*). A more recent manual being tried by a number of agencies is the SHRP distress identification manual (*30*). While the details of distress evaluation procedures and the uses of the data are beyond the scope of the present synthesis, the succeeding chapters will show the need for following some formal procedure whenever a PCC resurfacing is considered.

Structural Adequacy

The preferred approach by far to determining the structural adequacy of an existing pavement is through nondestructive testing (NDT) to assess the pavement's response to applied loads. The nature of the response is directly related to the structural capacity. Methods useful on both PCC and AC pavement have been developed (*31,32*).

Another approach presented by the AASHTO (*17,33*) is termed the "remaining life." In this approach, the pavement is evaluated to determine the proportion of its original design life that has been consumed. Consumption may be based on time or on accumulated equivalent axle loadings. The 1993 version of the design guide (*17*) warns of serious limitations of this method of determining remaining life. These limitations are related to the poor predictive capability of the AASHO Road Test Equations; either unreasonably high or unreasonably low estimates of remaining life may result (*17*).

A third approach, also presented by the AASHTO (*17*), provides for an estimation of structural capacity through the analysis of distress surveys and existing pavement materials properties.

The revised AASHTO overlay design procedures provide for using any of the three approaches with a preference for the NDT, with a precaution that the analysis be performed by "knowledgeable, experienced personnel" (*17*).

The determination of overlay thickness based on both functional and structural considerations is discussed next.

RESURFACING THICKNESS REQUIREMENTS

As suggested above, two broadly defined pavement deficiencies can result in the application of an overlay: functional deficiency or structural deficiency. Many older pavements will suffer both deficiencies at the same time; in such cases special considerations apply, as discussed later. As pointed out by Kilareski (*34*), "the AASHTO Design Guide (*17*) does not adequately integrate functional and structural design needs for overlays." Functional overlay design remains primarily a matter of engineering judgment even in recent revisions to the AASHTO Guide (*17*).

Functional Design

Because a functional resurfacing needs to be only thick enough to restore ride quality or repair surface defects, it may be relatively thin. Typically, the capability of paving machines, the sizes of the aggregate particles, and geometric considerations (overpass elevations, guardrail heights, grades, etc.) will dictate how thick such resurfacing must be. On the other hand, reinforced sections may need to be a minimum of 75 to 100 mm (3 to 4 in.) thick to accommodate the reinforcing steel with sufficient cover to impede early corrosion. These limitations are discussed in detail in later chapters.

Structural Design

In general, structural deficiency will override functional deficiency because a thicker resurfacing is almost always required—that is, a resurfacing thick enough to satisfy structural requirements should be more than thick enough to correct any functional deficiency. While there are numerous approaches to resurfacing thickness design, all are conceptually similar and involve the determination of (1) the structural capacity required to carry the prevailing and projected traffic for the design life of the resurfacing, (2) the in-situ (effective) structural capacity, and (3) the difference between (1) and (2). Several overlay thickness design procedures used successfully in recent years include those developed by McCullough et al. (*35*), Trebig et al. (*36*), the U. S. Army Corps of Engineers (*37*), and the Minnesota DOT (*38*). In addition, Hall et al. recently examined various approaches to unbonded overlay design (*39*).

Even with numerous options available, as late as November of 1991, Forsyth (*40*) found that "most" agencies use no formal design procedure, but rely on engineering judgment and experience for PCC overlay designs of both rigid and flexible underlying pavements. He did find that a "few" agencies were making use of the 1986 AASHTO Design Guide (*33*) while it was undergoing revision (*17*). This revision (*17*) is now completed and constitutes the official AASHTO rehabilitation design document. For that reason, it is the basis for the following discussion of overlay thickness design.

Clearly at issue in determining overlay thickness is the nature of the interface. For example, bonding at the interface results in the resurfacing and the original pavement functioning as a monolithic unit. Thus, per unit of thickness and in the absence of other factors, the bonded resurfacing is the most efficient means of achieving structural enhancement.

AASHTO expresses the general overlay structural deficiency design concept as given in Figure 8 (*17*). In that figure, the structural capacity of a new pavement is given as SC_o while SC_{OL} refers to the structural capacity of an overlay applied after the pavement has carried N_P loads. The present cumulative loading (N_P) is assumed to be less than a terminal loading ($N_{1.5}$), which would apply at a terminal serviceability rating of 1.5. After the overlay is applied the future structural capacity is designated as SC_f, corresponding to a future load capacity of N_f.

Note that in the AASHTO terminology the structural capacity of an asphalt concrete pavement is the structural number (SN), while for a PCC pavement it is the slab thickness (D). If the pavement is a composite, the capacity is expressed as an equivalent slab thickness. The structural capacity declines with age and accumulated traffic such that by the time an overlay is considered, the effective structural capacity is SC_{eff} (D_{eff} for a PCC or composite pavement). Then, to provide a structural capacity (D_f) required to carry the future traffic for the chosen design period, Equation (1) provides an overlay with a structural capacity of D_{ol}.

$$D_{ol} = D_f - D_{eff} \qquad \text{Eq. 1}$$

Eq. (1) is the general overlay design relationship used throughout the revised design guide.

While conceptually very straightforward, overlay design is complicated by the uncertainties of evaluating the effective structural capacity. The AASHTO revised overlay design procedure outlines the three structural evaluation methods mentioned earlier and discusses the limitations of each (*17*).

The procedure (*17*) continues with recommended design meth-

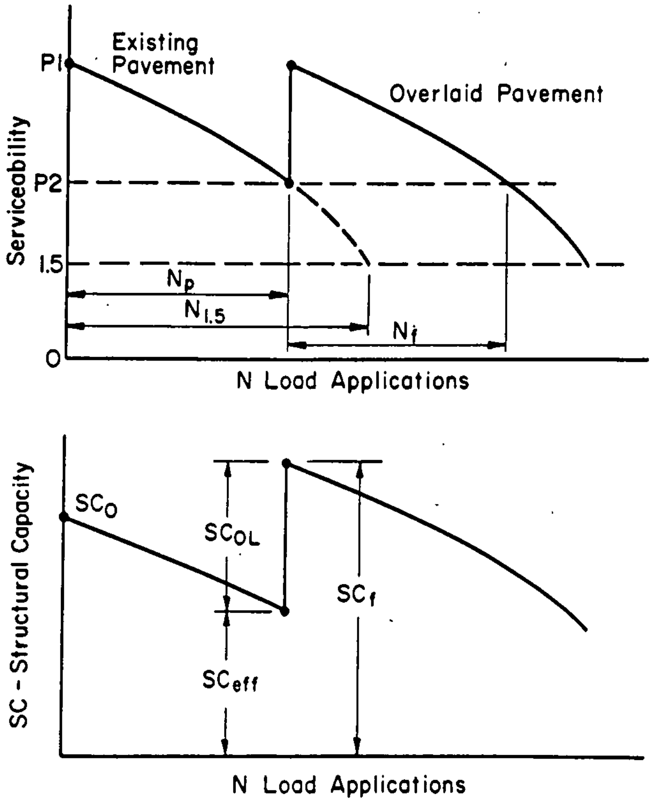

FIGURE 8 Structural capacity, loss over time and with traffic (*17*).

ods for all types of AC overlays of AC and PCC pavements and with JRCP, JPCP, and CRCP overlays of PCC and AC pavements. A National Highway Institute (NHI) training course on the revised 1993 AASHTO Overlay Design Procedures will be available upon request in the Fall of 1994. The details of these procedures are beyond the scope of the present effort, but the major points in the PCC methods are summarized below by interface type. Examples of various overlay designs are given in the Appendix to the revised procedures. Partially bonded resurfacing is not considered a usual alternative for highway pavement. Furthermore, modern airfield literature makes little reference to the partially bonded type of overlay. For design purposes, only the bonded, unbonded, and whitetopping types of overlays are considered.

AASHTO Design—Overlays of PCC and Composite Pavement

The design of either bonded or unbonded overlays applied to underlying concrete pavement begins with an evaluation of the existing pavement to determine thickness, type of load transfer, and type of shoulder.

Next, the accumulated 80kN (18-kip) equivalent single-axle loads (ESALs) in the design lane are determined if the remaining life approach will be used. In all cases, the projected 80kN (18-kip) ESALs in the design lane for the design period are determined.

A condition survey is used to determine the types and severities of distress present, while deflection tests are used to evaluate the effective k-value, slab elastic modulus, and joint load transfer.

Coring of the existing pavement is highly recommended where a bonded overlay is planned, or where the underlying pavement is of composite construction. Cores are used to determine the splitting tensile strength of the existing concrete and may be used to determine the asphaltic concrete modulus for composite pavement.

Part II of the 1993 AASHTO Design Guide (*17*) is used to determine the slab thickness (D_f) required for future traffic. The effective slab thickness (D_{eff}) for the existing pavement is determined through procedures given in the revised guide and involving the consideration of distresses, reactive aggregates or "D" cracking, and fatigue damage.

Finally, the required overlay thickness is determined:

(a) For bonded overlays Equation (1) applies directly and

$$D_{ol} = D_f - D_{eff}.$$

(b) For unbonded overlays, the layers do not function monolithically and

$$D_{ol} = \sqrt{D_f^2 - D_{eff}^2}.$$

AASHTO Design—PCC Overlays of AC Pavement (Whitetopping)

Again, the first step is to evaluate the existing pavement design to determine types and thicknesses of materials. Then, the projected 80kN (18-kip) ESALs in the design lane for the design period are determined.

Next, a general condition survey identifies distortions and stripping and quantifies the types and severities of the distresses present, while deflection tests are used to determine the effective dynamic k-value. Part II of the 1993 *AASHTO Design Guide* (*17*) is used to determine the slab thickness (D_f) required for future traffic. The overlay is effectively a new concrete pavement built on an old AC pavement, so the effective slab thickness (D_{eff}) is zero and

$$D_{ol} = D_f - D_{eff}.$$

While the latter equation is used in the AASHTO design procedure, recent research in several locations suggests that assigning an effective D = 0 for the existing pavement is an oversimplification. Iowa has constructed test sections where an effort was made to enhance the bond between the underlying AC pavement and the PCC overlay (*41*). The research showed that a bond was developed in every section such that the underlying AC pavement contributed to the composite structure and could be considered in the design thickness of the overlay. Similar results were found for a thin whitetopping of an AC pavement in Kentucky (*12,42,43*). These results suggest that some type of composite design approach may be justified for whitetopping. The whole area of whitetop bonding appears deserving of further research, some of which is underway (*44,45*).

OTHER RESURFACING REQUIREMENTS

While many factors other than thickness must be considered when designing a PCC overlay, several warrant special discussion. The succeeding discussion provides a design overview of these issues, and the construction details will be discussed later.

Interface

The interface between the underlying pavement and a PCC resurfacing is one of the most important design considerations. Specifically, the nature of the bond relates directly to the behavior of the resurfacing. The various stages of bonding are discussed in Chapter 2. Conceptually, if the bond is effective the underlying pavement and the resurfacing behave monolithically—an important design consideration. If bonding does not take place, the underlying pavement and the overlay are treated as two separate layers, as also seen in the above design discussion.

Drainage

Surface runoff drainage of PCC overlays is provided, as with new pavement, by the appropriate cross slope. In addition, many agencies now require PCC surfaces to be heavily textured to enhance skid resistance (*10*).

In many cases it is desirable to enhance the subsurface drainage of a pavement when a resurfacing is applied. *NCHRP Synthesis of Highway Practice 96: Pavement Subsurface Drainage Systems* (*46*) provides helpful guidelines on drainage features, and the AASHTO design guide makes provision for a drainage evaluation of existing pavements (*17*). The designer is advised to look for such signs of poor drainage as pumping, corner breaks, joint faulting, or other deterioration of PCC pavement, or stripping, early fatigue cracking, or potholing of AC pavement. If the existing pavement shows signs of moisture-related distress, the drainage system is inadequate and will need attention when the overlay is applied.

In the cases of unbonded overlays of PCC pavement and of whitetopping projects, recent studies show that open-graded drainage layers may be helpful as interface materials. Studies in California and Wyoming indicate that long-term joint faulting and pumping may be significantly reduced by the presence of the drainage layer (*47*). A recent Minnesota unbonded overlay design procedure calls for a permeable drainage layer to be used as the stress-relieving interface (*38*).

When drainage enhancement is required, it is likely that some form of edge or shoulder drain will be necessary as an alternative to removal and replacement of the existing pavement (in which case an overlay would not be required). Appendix AA, Volume 2 of the 1993 design guide provides subdrainage design information (*17*).

Reinforcement

Reinforcement in the form of distributed deformed steel is provided in JRCP and CRCP resurfacing to control various types of cracking. Such cracking is a function of joint spacing, principally due to shrinkage associated with the hydration of portland cement and with changes in the temperature profile and moisture content of the slab. Reinforcing design for overlays is identical to that for new pavement and has been fully addressed in the 1993 AASHTO design guide (*17*).

For jointed overlays, reinforcement design is a function of slab length. Reinforcing usually is not provided when the slabs are less than 4.6 m (15 ft) long. For longer slabs, the cross-sectional area of reinforcement required ranges from 0.05 to 0.20 percent of the cross-sectional area of the slab (*2, 17*).

In the case of CRC overlays, sufficient longitudinal steel is required to keep the transverse cracks tightly closed to provide for load transfer and to inhibit infiltration of water and deicing chemicals to the steel. The percentage of steel as a function of cross-sectional area is much higher than for jointed overlays (*1*). Generally, a minimum of 0.6 percent is required. Recent design charts provide for up to 0.9 percent under certain adverse conditions (*17*).

Jointing

Joints are constructed in PCC pavement and resurfacing to accommodate the movements associated with concrete volume changes caused by variations in temperature and moisture conditions. Most technologists agree that for jointed plain PCC pavement on grade, the slab length in feet should be no more than two times the thickness in inches (*17,48*). The length can be substantially increased when a properly designed distributed steel layout is used. As will be discussed in Chapter 6, the allowable slab length is somewhat reduced for plain PCC overlays as compared to "on grade" pavement (*17,25*).

For PCC resurfacing, the location of joints in the resurfacing is closely related to the type of interface used. Bonded resurfacing requires that joints in the resurfacing very closely coincide with those in the underlying pavement. Otherwise, uncontrolled reflective cracking will occur and result in reduced performance of the pavement. For unbonded interfaces, the situation is quite different. The consensus now is that transverse joints in the overlay must be mismatched by 0.6 to 0.9 m (2 to 3 ft) from those in the original pavement (*25*). Consideration should be given to matching joint orientation (skewed or square) in the underlying slab to avoid major stress concentrations. Achieving the proper overlay joint location will be discussed in detail in Chapter 5.

For whitetopping projects, joint design is again identical to that for new concrete pavement (*17*), though the underlying pavement will probably provide better than usual support conditions.

Load-transfer devices may be required less often for PCC resurfacing than for new pavement. On highway work, bonded overlays often will be thin and have slab lengths short enough to provide adequate aggregate interlock so that no mechanical devices are needed. In the case of unbonded resurfacing, the mismatching of joints in modern work provides some enhancement of load transfer (*25*). Nevertheless, FHWA performance reviews show that nearly all undowelled pavement faults significantly in 10 to 15 years (*49*). Therefore, load transfer designs applicable to new pavement are recommended. For unbonded overlays and whitetopping projects, mechanical load transfer devices may be designed according to AASHTO procedures for new pavement (*17*).

CHAPTER FOUR

MATERIALS USED IN RESURFACING WITH PCC

The materials used in PCC resurfacing include those used at the interface, those used in the resurfacing layer, those used for curing the resurfacing layer, and those used to seal joints and cracks in the resurfacing and its appurtenances.

INTERFACE MATERIALS

Interface materials serve one of two purposes: they either enhance the bond between the underlying pavement and the resurfacing, or they separate the overlay and the old pavement. In the first case the design concept is that the underlying pavement and the resurfacing perform monolithically. In the second case the converse is assumed—that there is little or no bond and the two layers function independently.

Bonded Resurfacing

The material most commonly used to achieve bonding at the interface is a PCC slurry or grout. The grout is generally produced in a mobile mixer from a mixture of portland cement and water. Typical specifications provide for a water-cement ratio of not more than 0.62 (*10*). However, several recent installations have omitted the grout and achieved successful bonding with the resurfacing material applied directly to a clean, dry underlying surface (*6,50*).

Much of the historical emphasis on grouted interfaces has resulted from work by Felt in 1956 (*13*). This work showed that bond strengths were significantly enhanced when the grout was applied to surfaces prepared by chemical etching. Later ungrouted work has been on mechanically (ground or shotblasted) prepared surfaces. Surface preparation is discussed under Chapter 5 on construction practices.

Unbonded Resurfacing

Because unbonded resurfacing is most often used where the underlying pavement is in such poor condition that a bonded resurfacing would be highly subject to reflective cracking and other distresses related to the underlying pavement, it is important to provide a positive separation layer at the interface. Numerous materials have been used in attempts to provide such a positive layer. The most common have been polyethylene, wax-based curing compounds, liquid asphalts, and asphalt-aggregate mixtures of various types. The early preference was liquid asphalt (*4*), followed by polyethylene sheeting. The sheeting was beset by construction and performance difficulties and has generally given way to the asphalt materials (*25*).

One compelling reason to avoid thin separation layers is if the existing pavement has joint, crack, or repair faults or other surface irregularities into which the overlay can mechanically "key" (Figure 9). Thin interlayers also permit the ready development of reflective cracking from the underlying pavement. Thicker interlayers, such as asphalt concretes, will prevent the keying action and inhibit the development of reflective distresses. When the keying action is not a concern and the pavement profile does not need to be altered, thin asphalt layers such as chip seals and slurry seals can serve as effective separation layers (*25*). AASHTO (*10*) provides the following guidelines:

1. Where joint and crack faulting is greater than 6 mm (0.25 in.), spalling is evident, and slabs are highly deteriorated, an asphalt concrete layer shall be constructed to a minimum thickness of 25 mm (1 in.).
2. Where faulting and deterioration are not as sévere, a thinner AC layer, 13-mm (0.5-in.) minimum, or a slurry seal material of 3-mm (0.125-in.) nominal thickness can be used. This layer must be able to cover the present deterioration and prevent it from reaching the overlay slab.
3. Where joint and crack faulting is nonexistent or insignificant, a slurry seal material of 3-mm (0.125-in.) nominal thickness or an asphalt with sand cover may be specified.

One school of thought holds that AC also is not really a bond breaker, as there are documented cases of bonding between PC concrete and that material (*25*). To guard against bonding, some specifications provide for a "whitewash" layer of lime slurry or

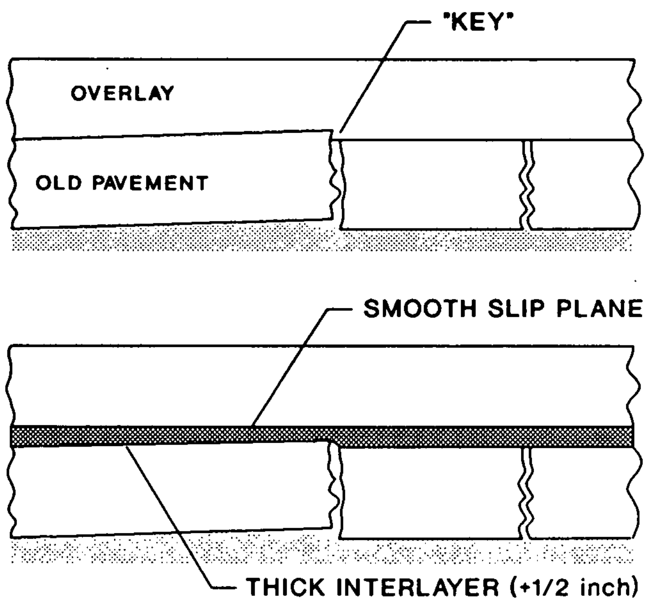

FIGURE 9 An inadequate interlayer thickness will not prevent keying of the overlay (*25*).

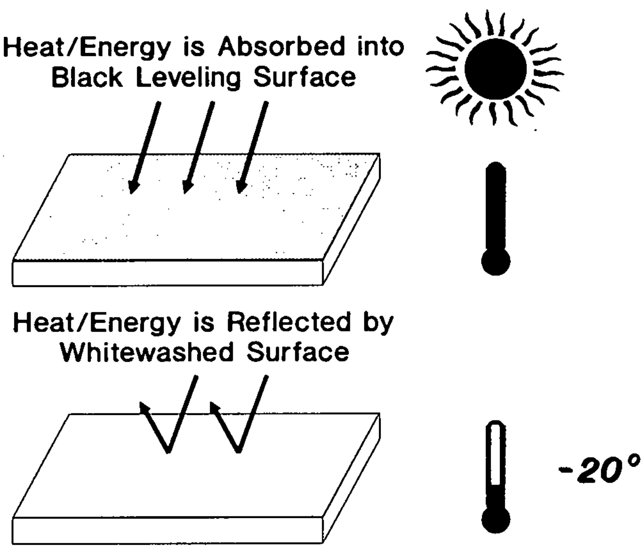

FIGURE 10 Effects of whitewashing AC surface (*25*).

pigmented curing compound (*10,25*) over the AC. In some cases bonding between the PCC and AC is ignored and the AC is assumed to provide a stress-relieving layer and achieve much the same purpose as a bond breaker. Some recent European construction has employed geotextiles as an interlayer between JPCP overlays and fractured underlying slabs (*51*), while the Minnesota DOT employs a drainable interlayer for unbonded overlays (*38*).

AASHTO (*10*) and ACPA (*25*) also recommend use of the whitewash layer when the surface temperature of the asphalt concrete separation layer is expected to exceed 43° C (110° F). The whitewash has the effect of reflecting heat from the AC surface to prevent overheating and the accompanying mixture instability and equipment handling problems (Figure 10).

RESURFACING WITH CONVENTIONAL PCC

Historically, the great majority of PCC resurfacings have contained conventional concrete mixtures, sometimes with a fairly high cement factor to promote rapid strength development. In recent years, many have also contained water-reducing or set-retarding admixtures, sometimes both. These are generally directed at achieving acceptable workability, particularly on projects placed with slipform pavers. Nearly all contain approximately 6 percent entrained air.

Concrete materials for resurfacing differ very little from materials used in new concrete pavement construction. Aggregates range from very high-quality crushed stones to river gravel and glacial deposits, as local conditions dictate. The maximum aggregate size used is a function of the thickness of the resurfacing and has ranged from fine aggregates up to 50 to 75 mm (2 to 3 in.) in diameter. Modern guidelines suggest a maximum size of 18 to 25 mm (0.75 to 1 in.) (*9*). Cements are most often Types I and II, though Type III has been used infrequently for "fast-track" work (*2,6*). For bonded resurfacing, water-cement ratios tend to be somewhat lower than for conventional paving concrete in order to minimize the effects of drying shrinkage on bond strength (*9*).

RESURFACING WITH SPECIALTY CONCRETES

Resurfacing technology has changed significantly over the past two decades. Much resurfacing now uses specialty concretes designed for better placement properties, higher early strength, greater durability, or for the enhancement of other properties. The most commonly used specialty concretes are discussed below.

Fiber-Reinforced Concrete

In the 1970s many agencies employed fiber-reinforced concretes, at least for experimental purposes. Synthesis 99 lists 28 projects where such materials were used (*1*). Most of these concretes contain a small percentage (by volume) of steel or polypropylene fibers, which are a few mils (microns) in diameter and from 13 to 64 mm (0.5 to 2.5 in.) long, randomly distributed throughout the mixture. Panarese (*52*) reports the use of nylon, polyester, polyethylene, aramid, carbon, and acrylic fibers in similar configurations. These materials may have tensile strength and moduli of elasticity much greater than conventional concrete (*52*). Because of the greater unit cost of concretes containing reinforcing fibers, they typically are used in layers 50 to 75 mm (2 to 3 in.) thick for highway work. However, several airfield projects have employed fiber-reinforced concretes up to 175 mm (7 in.) thick.

Some researchers have found that fiber-reinforced concretes must contain greater proportions of fine materials to be satisfactorily workable than conventional mixtures (*1*). This may be accomplished through the use of high cement factors (up to 560 kg/m^3 (10 bags per yd^3) is typical), or the addition of other pozzolanic materials such as fly ash. Air entraining, water-reducing superplasticizers, and set-retarding admixtures all have been used successfully with fiber-reinforced concretes (*2,12*).

Panarese (*52*) points out that limited use of fiber reinforcement reflects a lack of design and materials performance criteria. He goes on to note that "Fiber reinforcement bears a fundamental engineering inefficiency as many fibers are not positioned to resist tensile stresses from applied loads."

Modified Concretes

Concretes containing chemical modifiers have become increasingly popular for thin-bonded resurfacing work in the past few years. While much of the technology has been developed and applied to bridge deck rehabilitation, some agencies are beginning to make use of the approach for pavement work.

High-range water reducers (HRWR) are popular modifiers used to enhance ultimate strength by providing acceptable workability at a low water-cement ratio. Sprinkel (*53*) found that water-cement ratios as low as 0.33 to 0.37 were feasible using the HRWRs and that the mixtures could be placed with slip form pavers and would develop high strengths. He reported higher than normal variability of air content and other concrete properties for mixtures containing HRWRs.

After the work reported and other projects conducted in Europe and Japan, Iowa used the HRWRs on several thin-bonded plain concrete resurfacing projects (*1*). The Iowa designers, too, found excessive variability of mixture properties and reverted to conventional water reducers in much of their later work.

The HRWR mixtures have the advantage of being usable with most other concrete ingredients and materials handling procedures used with conventional concrete.

Polymer-modified concretes offer another option for thin-bonded resurfacing. Although most work has again been applied to bridge decks and would be expensive for other than thin overlays, the technology seems fully capable of transfer to pavement. Silicon-fume concrete might also be considered.

INCIDENTAL MATERIALS

Materials incidental to PCC resurfacing, such as curing and joint sealing materials, are usually identical to those employed in PCC paving. Typical curing materials are wet burlap, polyethylene, and wax-based compounds; joint sealants are hot- or cold-poured liquids and preformed sealants. However, the presence of the underlying layer and its tendency to create problems in the resurfacing lead to some differences in the way the materials are used. These differences will be discussed in the next chapter on construction practices.

CHAPTER FIVE

RESURFACING CONSTRUCTION PRACTICES

The construction technology and information exchange for all types of PCC resurfacing took a huge step forward in 1990 when AASHTO issued the *Guide Specifications for Concrete Overlays of Pavements and Bridge Decks* (*10*). This document, prepared as a cooperative effort of AASHTO, the Associated General Contractors (AGC), and the American Road & Transportation Builders Association (ARTBA), includes guide specifications for bonded and unbonded resurfacing of PCC pavement and for PCC resurfacing of AC pavement (whitetopping). Also in 1990, the ACPA issued two technical bulletins dealing with the construction of bonded and unbonded overlays (*9,25*). These were followed in 1991 by a technical bulletin on whitetopping (*54*). The ACPA publications expand on many of the issues covered in the guide specifications. The succeeding discussion draws heavily on these four documents, with additional information from agency experience and reports.

The wide use of whitetopping documented in recent literature dictates that existing pavement concerns must be extended to other than PCC. The following discussion recognizes that distinction.

PREPARATION OF EXISTING CONCRETE PAVEMENT

General Concerns

Preparation of an existing PCC pavement for PCC resurfacing varies widely with the condition of the pavement and the type of resurfacing proposed. The presence of an interface layer serves to separate an unbonded resurfacing from many of the effects of a distressed underlying pavement. Conversely, without special treatment, some defects in the original pavement will be reflected in a bonded resurfacing and could impair its performance. Thus, existing pavement in generally good condition may require little or no preparation, though pavement in poor condition may require extensive rehabilitation prior to the resurfacing. This is especially true if a bonded resurfacing, not normally recommended for pavement in poor condition, is planned. Bonded resurfacing is thin and depends on the existing pavement for its structural capacity (*9*).

Regardless of the type of PCC overlay envisioned it is necessary to ensure uniform support conditions. This requires the removal and replacement of shattered slabs (*53*) (Figure 11). Pumping slabs (Figure 12) or seriously deteriorated joints must also be replaced if they show significant deterioration. More importantly, the pumping condition must be eliminated.

Where patching or removal and replacement of underlying pavement failures are required it is now generally accepted that repairs should be made with like material—that is, PCC pavement should be repaired with PCC. Again, experience has shown that PCC resurfacing, like original PCC pavement, performs better when provided with uniform support conditions (*9*). Such uniformity of support will not be achieved when the underlying pavement is repaired with materials differing substantially in mechanical properties.

A special case of support loss is manifested in the form of punchouts of CRCP. An example of a punchout is shown in Figure 13. Punchouts occur when aggregate interlock is lost at one or more closely spaced cracks. Then the reinforcing steel is overstressed and shears under wheel loads, permitting the concrete to punch down into the subbase (*25*). Again, full-depth repair of the subbase and pavement may be required to restore uniform support in preparation for a PCC overlay.

Because some elements of existing pavement preparation depend a great deal on the type of overlay proposed, bonded and

FIGURE 11 Shattered slabs.

FIGURE 12 Pumping slabs.

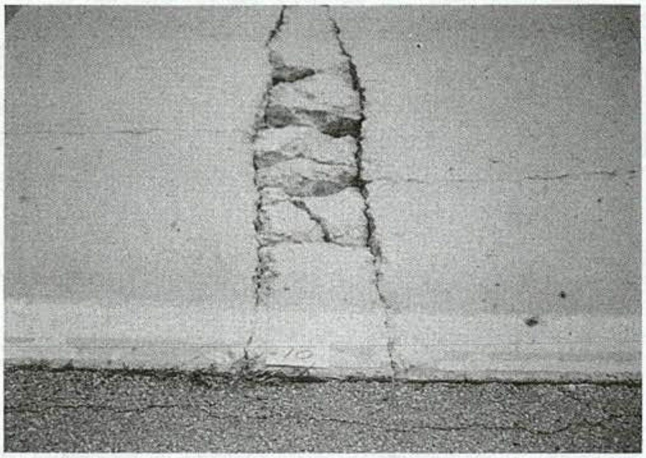

FIGURE 13 CRCP punchout.

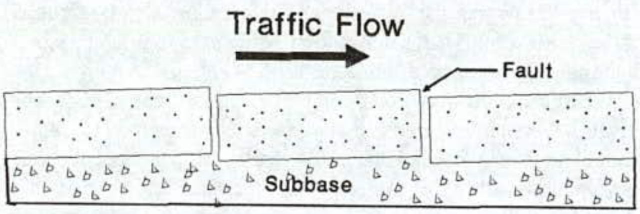

FIGURE 14 Joint faulting.

unbonded overlays are discussed separately below. For the purposes of this discussion, partially bonded is considered to be equivalent to unbonded.

Preparation for Bonded Overlays

One of the most important elements of pavement preparation for a bonded overlay is the attention given to any joints in the existing pavement. Lightly spalled joints, when subject to a bonded overlay, may be milled to sound concrete. The resulting depressed areas, less than 50 mm (2 in.) deep, can be filled with concrete during the overlay operation (*9*). Depressions more than 50 mm (2 in.) deep should be filled with concrete prior to the overlay to ensure adequate consolidation of the repair (*55*). Badly deteriorated joints with corner breaks, major spalls, inadequate load transfer, or blowups require full-depth repair including removal and replacement of load transfer devices. Wider cracks may be repaired by restoring load transfer using dowels or reinforcing bars in slots (*56*).

Faulted joints (Figure 14) in excess of about 5 mm (0.2 in.) are an indication of pumping and possible loss of foundation support; their presence should cause the designer to evaluate the pavement for voids beneath the slabs. Minor faulting, however, may be treated by grinding to an acceptable grade prior to the overlay (*9*).

Random transverse or longitudinal cracks, which can be accommodated by the interface material for unbonded overlays, require special attention in preparation for bonded resurfacing. Transverse cracks that are tight and do not move can be left untreated. Those in poor condition should be replaced to full depth. The intermediate

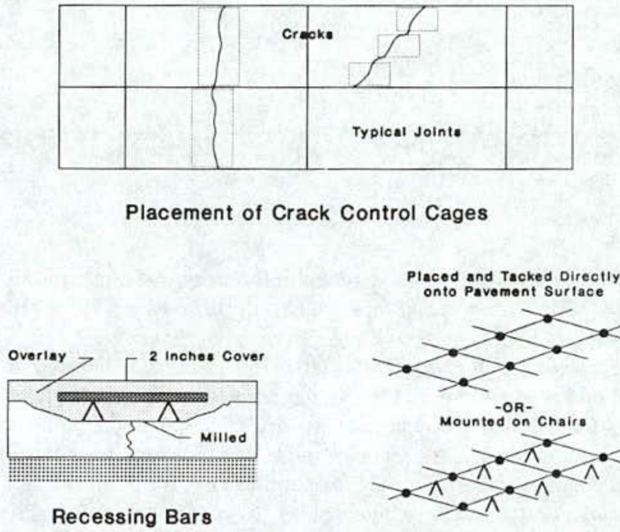

FIGURE 15 Details of "Random Crack Control" (*9*).

stage cracking (less than high-severity distress) can be addressed through the use of random crack control reinforcing steel (*9*), as indicated in Figure 15. This procedure requires milling the existing pavement to provide room for reinforcing steel, with adequate cover, to span the crack. A minimum 50 mm (2 in.) of cover is needed to protect the steel from corrosion (*10*). The recommended arrangement is No. 4 or 5 bars, 0.6 m (24 in.) long, spaced at 0.76 m (30 in.) centers, and centered at right angles to the crack (*9,10*).

The significance of longitudinal cracking in the existing pavement to bonded resurfacing performance depends upon the location of the cracking. Longitudinal cracks at mid-slab normally are not load related and, if not moving, require no special preparation (though reflective cracking should be expected). However, those in or near wheelpaths are load- or pavement-strength related and require slab replacement or major repair. One means of repair involves a "cross-stitching" arrangement, such as illustrated in Figure 16 (*9*). To construct the cross stitch, holes spaced 0.76 m

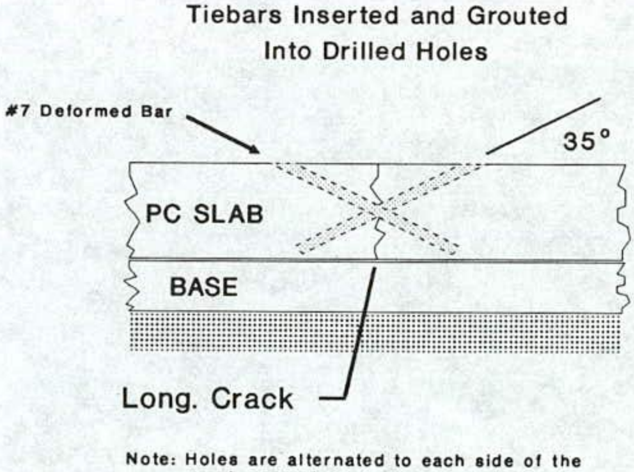

FIGURE 16 Profile of cross-stitching. Note that holes alternate from each side of the crack (*9*).

(30 in.) apart are drilled at a 35° angle to intersect the crack at mid-depth. Then, No. 7 deformed reinforcing bars are grouted into the holes. The cross-stitch pattern holds the crack together to prevent movement and preserve aggregate interlock. Cross stitching has been used predominately on new construction to address longitudinal cracking due to late sawing, so its effectiveness on rehabilitation has not been verified. However, the cross-stitch principle appears to merit at least some trials on rehabilitation work as the approach may be much more cost effective than removal and replacement of cracked slabs. Alternatively, the installation of retrofit load transfer devices might also be accomplished economically.

Preparation for Unbonded Overlays

Joints in existing pavements have been prepared in various ways for unbonded PCC resurfacing. Although such attention is not nearly as critical as for bonded resurfacing, badly deteriorated joints must be repaired or replaced. Generally, full-depth replacement is the most desirable approach to achieving the necessary uniformity of support. However, joints exhibiting strictly partial-depth deterioration may be repaired with partial-depth concrete repairs. In addition, slightly spalled joints may be cleaned and filled with the interface material (*25*).

Faulted joints also require attention, depending on the type of overlay proposed. Under unbonded overlays, joints faulted more than 6 mm (0.25 in.) require attention. If milling is not desirable, these joints can be accommodated by the interface layer if it is at least 25 mm (1 in.) thick (*10*). Joints faulted less than 6 mm (0.25 in.) can be accommodated by thin interface layers of chip or slurry seals. In all cases of faulting, the cause should be investigated and the need for slab stabilization and drainage improvements determined.

In addition to the proper treatment of punchouts discussed earlier, CRCPs have received other special treatment in preparation for unbonded resurfacing. Michigan, for example, has sawed CRCP into segments no longer than 30 m (100 ft) in preparation for an unbonded overlay (*4*).

For pavement in extremely poor condition due to shattered slabs or the presence of D-cracking, some agencies have begun to use a process called rubblizing to prepare for an unbonded overlay. The process turns the pavement into rubble using resonant pavement breakers or drop hammers (*25*). The broken slabs are then seated using up to 46-metric-ton (50-ton) rollers. Deflection or other tests are typically used to determine that reasonable uniformity of support results. As noted by the ACPA, although a uniform support condition will result from rubblizing, the pavement will be generally weakened and a thicker interface may be required (*25*). Depending upon the particular case, other preparation methods may be more cost effective.

PREPARATION OF EXISTING ASPHALT CONCRETE PAVEMENT

PCC overlays of existing asphalt concrete pavement are currently designed as unbonded. From a practical standpoint, there is nearly always some bonding between the overlay and asphalt concrete layer (*25*). This partial bonding may enhance overlay performance, but the issue really has not been resolved and needs additional study.

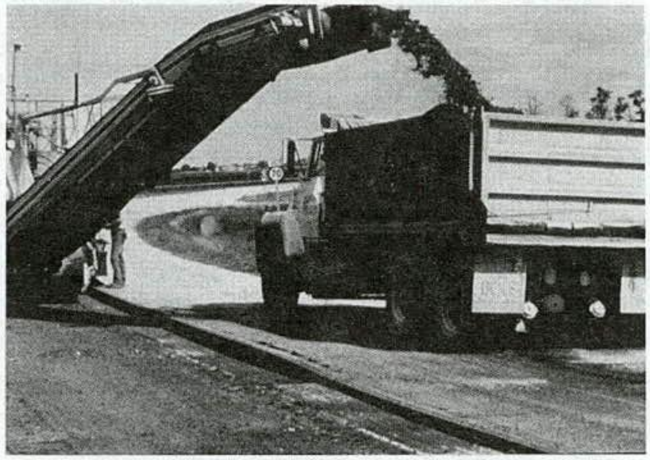

FIGURE 17 AC pavement milling to remove ruts.

A critical performance issue is the provision of uniform support for the resurfacing. Areas of subgrade or base failure must be removed and replaced with a stable material. Beyond that, only badly distressed areas such as severe rutting, potholes, or shoving need to be addressed from a performance standpoint (*54*). As with any overlay, it is important to evaluate the drainage capability of the existing pavement and provide any necessary enhancements before the overlay is applied.

The geometrics of the existing pavement require consideration from the point of view of construction expediency and estimation of material quantities. Distortions of existing asphalt concrete pavement surface have led to the application of at least three approaches to preparation (*1,57,58*). These are discussed below.

Direct Application

In this approach, the existing pavement is swept and the PCC resurfacing applied directly. This approach is recommended by the industry when rutting does not exceed 50 mm (2 in.) (*54*). Because the ruts will be filled with the resurfacing material, roadway cross sections by a survey crew or automated rut measuring equipment sometimes are used to estimate quantities needed. Direct application often is used on old crowned roadway sections as well. In Iowa, county roads often are built with thickened edge resurfacing sections (the edges of the overlay are thicker than the center line) to accommodate the crown. Three projects with 180-130-180-mm (7-5-7-in.) cross sections are reported in the Appendix. At least one Iowa engineer (Personal communication with Gordon Smith, Iowa Concrete Paving Association, July 30, 1992) reports that many local whitetopping projects have been built using the thickened edge approach.

Profile Milling

A second approach to preparing a pavement for whitetopping is the removal of surface distortion through profile milling (Figure 17). Experience has shown that 25 to 75 mm (1 to 3 in.) of material must be removed to produce a uniform profile (*54*). The trade-off is the cost of surveys, etc. for quantity determination vs. the cost of milling.

A special use of milling is to prepare for a PCC inlay where the grade cannot be raised. In such cases, only the driving lanes are milled, and the shoulders are left in place to be used as paver tracklines. It is important to note that when inlays are provided in individual lanes there is danger of constructing the inlay in a "bathtub." Such a condition should be avoided by the use of a positive drainage system. Dowelled joints are also essential for such inlays.

Leveling Course

As a third alternative, a leveling course can be used to produce a uniform surface for paving (*1,54*). Typically, 25 to 50 mm (1 to 2 in.) of asphalt concrete will be required. Because of the additional expense, this option usually is not considered when distortions exceed about 50 mm (2 in.). In such cases, milling may be less expensive.

INTERFACE CONSTRUCTION

As discussed earlier, the two major types of interface remain bonded and unbonded; airfield interests give some recognition to partial bonding. Because little attention is paid to the interface in partial bonding, the discussion here addresses only the bonded and unbonded cases. In both, proper attention to the interface is critical to satisfactory resurfacing performance.

Bonded Interfaces

After the steps to prepare the underlying pavement discussed above have been taken, the next step in construction of a bonded interface is to clean the existing pavement surface. Most agencies use mechanical methods to achieve a clean surface capable of bonding with the resurfacing. However, it is sometimes necessary to first remove contaminants from the surface. Many of these are petroleum based and may be removed chemically (now considered environmentally undesirable) or through scraping or wire brushing. Failure to remove such contaminants can inhibit later sandblasting or shotblasting, rendering them ineffective in providing the desired texture.

A number of mechanical preparation methods have been attempted. Much of the earlier work employed cold milling as a removal technique. However, some engineers contend that cold milling PCC may cause micro-cracking, which can have an adverse effect on bond strength (*59*). The approaches that now seem to have the widest acceptance are shotblasting, sandblasting, or some combination of the two.

The texture needed to achieve satisfactory bond strength between the resurfacing and the underlying pavement is not well defined. While some agencies conduct sand patch and other texture tests, there has been no general agreement on an objective measure. Texas recommends either specifying a minimum depth of surface removal or using a sand-patch test to determine average texture depth (*60*). Their suggested guidelines are 6 mm (0.25 in.) removal or 3 mm (0.125 in.) average texture depth. Others use more subjective measures. At least one state has described the acceptable texture as one in which the faces of coarse aggregate particles have been fractured to expose a fresh surface (*6*). Virginia achieved excellent results applying that criterion to a pavement; the major mode of cleaning was shotblasting, followed by sandblasting immediately in front of the paving train (Figures 18 and 19). The latter was primarily to remove any oil drippings or other contaminants related to construction operations.

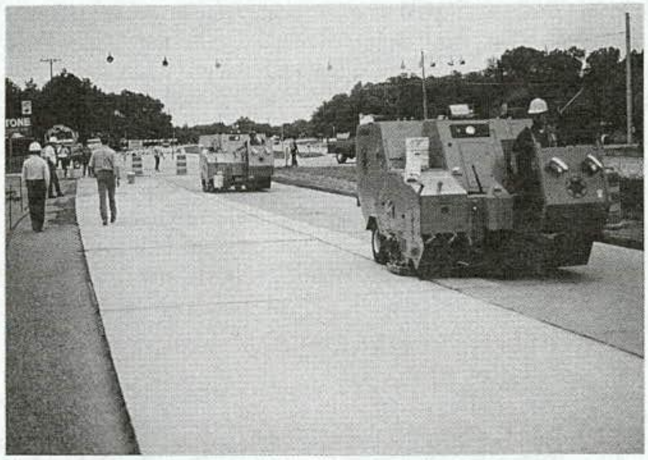

FIGURE 18 Shotblasting followed by sandblasting to expose a fresh surface.

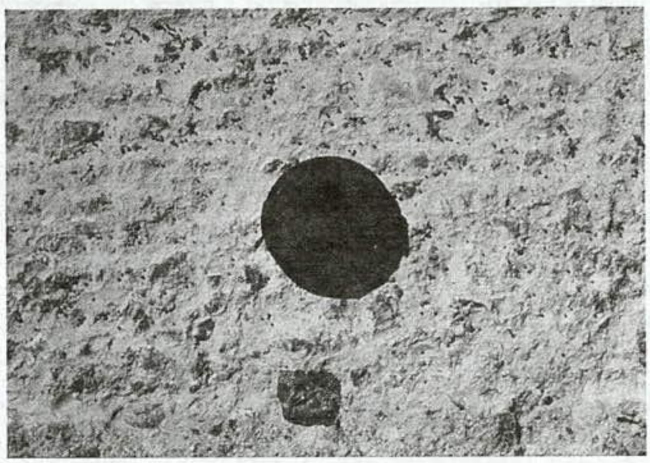

FIGURE 19 A textured surface improves bond strength.

Oil drippings from concrete trucks or other elements of the paving train can prevent proper bonding, and therefore are a serious concern in bonded resurfacing. Every effort is made to keep paving equipment off the prepared surface until the resurfacing is in place. If the prepared surface must be used by vehicular traffic, agencies have specified that trucks be diapered, or that plywood or other covering materials be used to protect the surface (*6*). These precautions tend to be unwieldy and are avoided wherever possible, but must be used when equipment is in poor repair and likely to drip oil and other contaminants.

When PC grout is used as a bonding material, a major construction concern is that the grout not dry or hydrate entirely before it

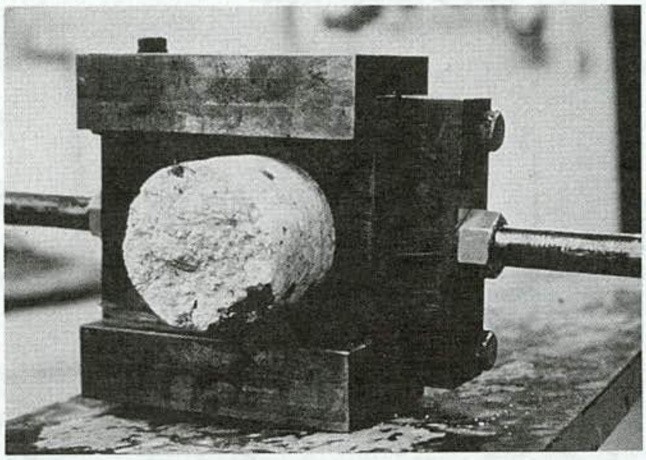

FIGURE 20 Shear testing device.

is covered with the resurfacing concrete. Dried-out grout has no bonding capability, and on several projects has been found to contribute to debonding (*9*). In at least one case, when concrete supply was slow, project personnel moved concrete from the paving machine "head" forward to cover exposed grout until additional concrete arrived on the job (*6*). Most agencies spray the grout into place, then use brooms to achieve uniform coverage. The ACPA (*9*) suggests a maximum 3-m (10-ft) margin of grout in front of the concrete spreader or paver to provide room for working the grout.

As an additional placing precaution, Felt (*13*) has noted the importance of good consolidation at the interface to good bond strength development. Interface bond strengths have been measured by several methods and by many agencies and researchers. Felt (*13*) probably did the first significant and comprehensive work in 1956. He used a direct shear device, similar to the one in Figure 20, to show that a variety of preparation methods would result in good bond strengths (up to 550 kPa (800 psi)) as long as a clean, sound surface was provided and adequate consolidation and curing methods employed. Iowa (*61*) uses a similar device and typically specifies a minimum shear strength of at least 138 kPa (200 psi) from cores taken from the pavement 14 days after placement. AASHTO recommends the same test method and minimum 138 kPa shear strength (*10*).

Some agencies use a "pull-off" test to measure the direct tensile strength at the interface (*62*). This involves epoxying a threaded cap to the new surface in the center of a partial-depth (through the overlay and interface) core, then pulling the cap and attached overlay off with a hydraulically operated pulling device.

Unbonded Interfaces

One reason unbonded resurfacing is the most popular is the relative ease with which the interface is constructed. As discussed earlier, the most popular interface materials now are asphalt—with chip or slurry seals used where a thin interlayer will suffice—and asphalt concretes used where a thick interlayer is needed. Application procedures are the same as for other applications of these materials; a mechanical sweeping of the existing pavement surface is the most important step.

Whitewashing, when required, should be applied at least 1 day before placing reinforcement or dowel baskets and 1 day before placing the overlay (*10*). This time is required to permit pavement cooling. If rain or construction traffic has faded the whitewash, a second coating may be required before paving. The ACPA cautions that slipform pavers may lose traction on hills where a wax-based whitewash is used (*25*). The result can be a poor surface profile.

CONCRETE PLACEMENT, FINISHING, AND CURING

Concrete placement and finishing operations for PCC resurfacing differ little from similar activities on new pavement construction. However, resurfacing operations are much more likely to take place under adverse traffic conditions; it is seldom that more than a lane or two can be closed at one time. For the same reasons, time constraints are likely to be more severe on resurfacing work than on new construction. With these limitations in mind, the industry has developed the fast-track approach to both resurfacing and new construction over the past few years (*62*).

With fast-track paving, rapid paving operations and rapid concrete strength development are important. The rapid setting characteristic of the high-early-strength concrete used for fast-track paving presents some constructability problems and requires good project planning. Especially important are the sequencing of operations and the ability to rapidly place concrete once it has been mixed. On some projects, efforts have been made to limit lane closures to a maximum of 48 hours from the beginning of surface preparation to opening the pavement to traffic. On a thin-bonded overlay project, Virginia was not successful in meeting the 48-hour time limit (56 hours were required), but reported that slight improvements in project logistics would permit that limit to be met if a similar future project was attempted (*6*).

Concrete placement (both conventional and fast track) for bonded overlays requires some special attention. Because there is no opportunity to make profile adjustments with the underlying layer, such adjustments must be made with the overlay. Therefore, deviations from planned thickness must increase rather than decrease the average overlay thickness (*9*). Extreme care must be taken to ensure that the old pavement surface is clean and free of contaminants. If good bonding is to be achieved, this precaution applies regardless of whether grout is to be used.

A recent innovation used on PCC resurfacing is the zero-clearance paver (*63*). The track is inside the formline on this paving machine. The track line allows paving directly against a vertical face, such as the paved shoulder remaining after an AC surface has been milled in preparation for an inlay. The new technology facilitates pavement construction where existing shoulders are left in place.

Most agencies require the same texture on PC resurfacing and on newly constructed pavement. Generally, the procedure is to apply a light burlap or artificial turf drag in the longitudinal direction, followed by transverse tining (*10*). There seems to be some consensus to use nominal 3-mm × 3-mm (0.125-in. × 0.125-in.) transverse striations at approximately 19-mm (0.75-in.) spacing (*64*). Exact tining configuration, however, is a local agency option. Recent FHWA guidelines suggest random spacing in the range of 13 to 26 mm (0.5 to 1 in.) and a depth of 3 to 5 mm (0.125 to 0.188 in.) (*65*). The same guidelines suggest omitting striations in the area where joints will be sawed. The omission of striations

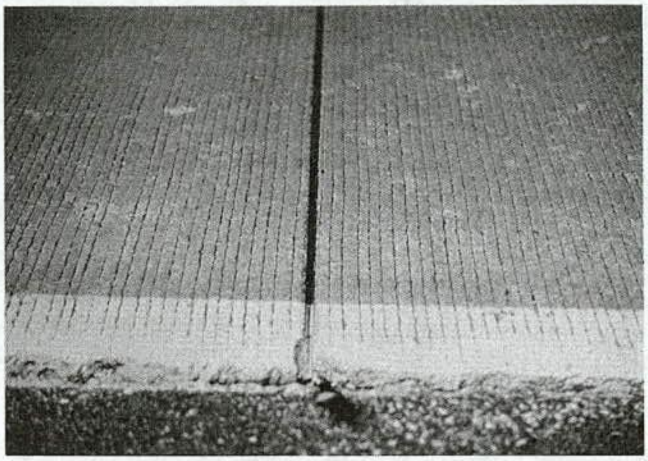

FIGURE 21 Tined texture.

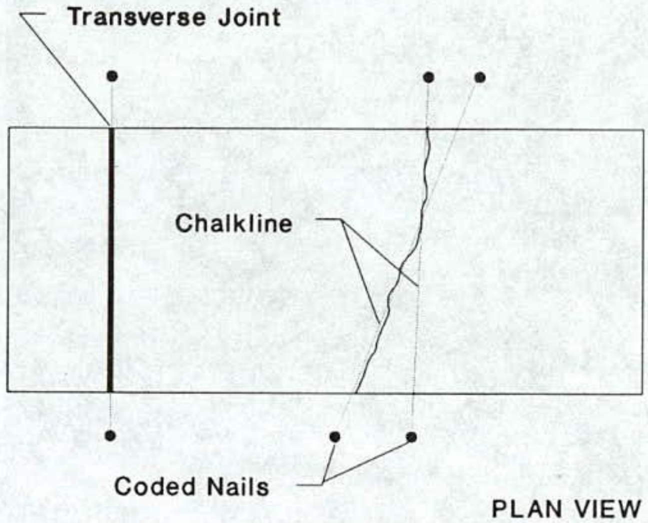

FIGURE 22 Two (or more) chalklines are used to mark joints that do not follow straight paths (*9*).

in those areas reduces joint spalling and enhances joint sealant performance. The striations are imparted by wire tines, either hand held or mounted on a texturing machine in the paving train. A typical tined texture is illustrated in Figure 21.

While curing operations differ little from new pavement construction for unbonded overlays and for whitetopping, special considerations apply to bonded overlays and to projects constructed in the fast-track mode.

In bonded resurfacing, proper curing is critical to adequate shear strength development. The ACPA (*9*) points out that bonded overlays are generally thin and have a high ratio of surface area to concrete volume. Therefore, they are more subject to moisture loss caused by bleeding and evaporation. During the early curing period just after finishing, these overlays are especially subject to shrinkage and curling caused by drying; this can result in shear stresses exceeding the bond strength (*66*). For this reason, curing procedures should begin as soon as possible after texturing is completed. Most agencies, in normal weather, apply pigmented curing compound at a rate of 2.5 square meters per liter (m^2/l) (100 ft^2 per gallon), or approximately 1.5 times the rate used for new pavement construction (*10*). In hot, dry conditions, more aggressive curing methods such as fog curing, polyethylene sheeting, or wet burlap may be warranted (*67*).

This curing compound rate also applies to fast-track paving, but additional measures are required to ensure the retention of hydration heat needed to maximize early strength development. Most specifications call for an insulated curing blanket to be placed as soon as possible after the curing compound (*6,9*). Typical blankets are made of polystyrene with a plastic protective coating on one side, and have a minimum R-value of 0.5. Temperature restrictions and/or nighttime paving might be necessary under adverse conditions, such as hot days and cold nights.

JOINTING

Bonded Overlays

Bonded PC resurfacing has special jointing considerations due to the necessity to match joints in the underlying pavement with joints in the overlay that are at least as wide as those in the original pavement. The location of joints in the underlying pavement must be marked before placement of the resurfacing. Methods used to accomplish this include staking, putting paint marks on shoulders or other appurtenances, and using precision survey instruments (*9*). These methods work reasonably well for straight transverse joints where a stringline between stakes or marks may be used to locate the joints in the resurfacing. For meandering joints or cracks, however, special marking procedures are employed as indicated in Figure 22 (*9*). Usual procedures employ color-coded markings or nails paired to delineate portions of the joint or crack. A chalkline snapped between the pairs outlines an approximate location on the overlay surface. A stringline may also be used to mark the plastic concrete in similar situations. For difficult to mark cracks, it is sometimes better to let the crack reflect through then to apply routing and sealing procedures.

Longitudinal joints in the overlay are easy to locate if those in the underlying pavement are a uniform distance from the pavement edge. Measurements are simply referenced to the edge of the overlay. Where longitudinal joints in the old pavement meander, location is somewhat more difficult on the resurfacing and may require numerous offset measurements to achieve adequate precision in location (*9*).

With bonded PC resurfacing, as with new pavement construction, the proper timing of early joint sawing allows control of joint location and to prevent random cracking. A narrow preliminary sawcut should be made as soon as the pavement surface will support the saw and personnel without suffering damage. On transverse joints, the preliminary sawcut on overlays less than 100 mm (4 in.) thick typically is through the full depth of the resurfacing and a short distance (often 13 mm (0.5 in.)) into the existing pavement joint (*10*). This type of cut prevents the buildup of possibly damaging compressive stresses in any lower, uncut portion of the overlay. It also prevents secondary cracking caused by readjustment of a crack initiating at any underlying joint prior to joint sawing, as depicted in Figure 23. Because parking areas and airfields consist of large expanses of concrete in either direction, and because of the danger of damaging compressive stresses being

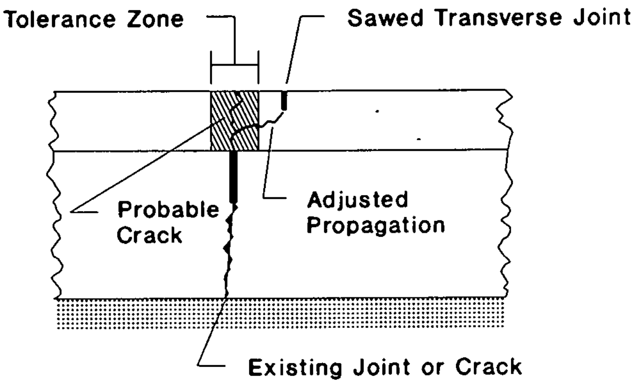

FIGURE 23 Crack adjustment in thin overlays (*9*).

TABLE 4
JOINT SAWING RECOMMENDATIONS, BONDED OVERLAYS (*9,10*)

Joint Type	Depth(1) <= 4"(2)	Depth > 4"
Transverse	D + 1/2"	1/3 D
Longitudinal	1/2 D	1/2 D
Expansion	D + 1/2"	D + 1/2"

(1) D = nominal overlay depth.
(2) 1" = 25.4 mm

built up, the industry recommends sawing all joints on these areas entirely through the overlay (*9*).

When highway overlays are greater than 100 mm (4 in.) thick, standard specifications provide for the initial transverse sawcut to be one-third the nominal overlay thickness (*10*). Experience shows that for thicker overlays neither secondary cracking nor the buildup of expansive stresses have been problems (*9*).

As mentioned earlier, longitudinal joints in the resurfacing may not be very precisely located if those in the underlying pavement are not a uniform distance from the pavement edge. Full resurfacing depth longitudinal sawcuts that miss the joint in the underlying pavement can create parallel center joints spaced very close together. When that happens, the resulting sliver of concrete is subject to early failure. For that reason, specifications provide for the longitudinal sawcut to be one-half the nominal overlay thickness (*10*). The rationale is that the uncut vertical section will provide room for some wander of the controlled shrinkage crack so a crack will not occur parallel to the joint.

Joint sawing recommendations for bonded resurfacing are summarized in Table 4.

Unbonded Overlays

For unbonded and partially bonded resurfacing, jointing considerations are not as critical as for the bonded case, but cannot be

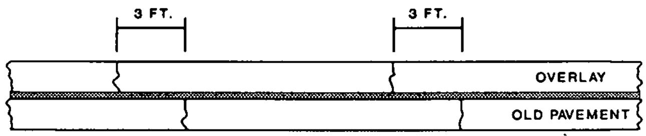

FIGURE 24 Overlay joint mismatched from existing joint to provide a sleeper-slab arrangement and improved load transfer (*25*).

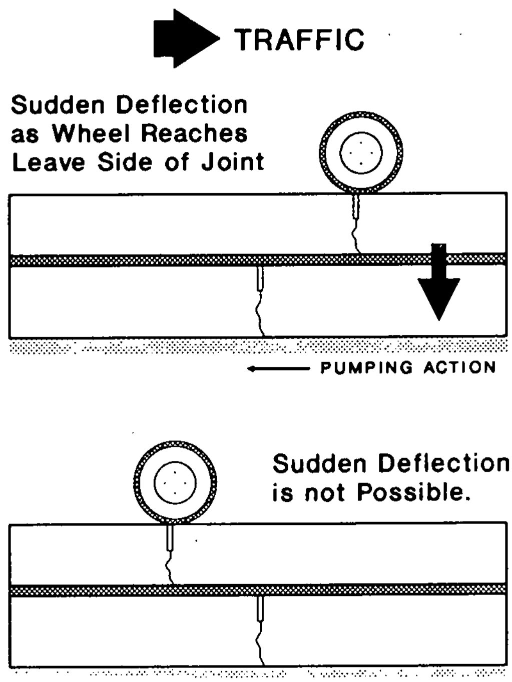

FIGURE 25 Placing the overlay joint on the approach side of the existing joint reduces sudden deflections through both the overlay and underlying slabs. This inhibits the typical pumping action as loads reach the leave side of the overlay joint (*25*).

ignored if optimum performance is to be achieved. Unlike the bonded case, matching the transverse joints in the resurfacing with those in the underlying pavement is not recommended for unbonded resurfacing. In fact, the AASHTO recommendation for transverse jointing of unbonded resurfacing is that "the placement of joints in the overlay should be mismatched from existing joints and working cracks by at least 0.9 m (3 ft) where possible" (*10*). Others have echoed this recommendation and noted that the mismatching provides for the "sleeper slab" effect illustrated in Figure 24. This arrangement no doubt improves load transfer of the overlay joints and reduces the tendency toward reflection cracking of the original joints. An additional recommendation is that the overlay joint be placed on the approach side of the existing pavement joint (*25*). Thus, the leave slab bridges the existing joint and reduces deflections and pumping action under the slab, as illustrated in the lower half of Figure 25.

Joint spacing is an important element of unbonded resurfacing

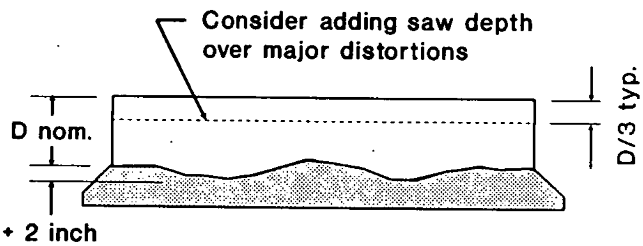

FIGURE 26 Consideration should be given to increasing the depth of sawing where distortions exceed 2 in. (*54*).

design and construction. As will be discussed in Chapter 6, unbonded overlays require a closer joint spacing than pavement built on softer materials such as asphalt concrete or granular subbase.

As with any concrete construction, joints must be sawed as soon as possible to ensure that the controlled shrinkage cracking will occur at the proper locations. To avoid random longitudinal cracking, it is a good practice to saw longitudinal joints as soon as possible after the transverse. The industry recommends both transverse and longitudinal sawcuts be made to at least one-third the nominal overlay thickness (*10,25*).

Whitetopping

Placing joints in whitetopping layers is similar to placement in conventional on-grade concrete pavement construction, with the exception of possible adjustment to sawcuts on overlays of distorted existing pavement (Figure 26). If distortions are excessive, it may be necessary to increase the sawcut depth to achieve the desired crack control (*54*). Some engineers caution that too much distortion may lead to random cracking, and that PCC overlays on rutted pavement should be restricted to low-volume roads.

Joint Sealing

The second sawcut, at the time of joint sealing, is not a function of overlay type. It should follow the guidelines employed for new pavement construction. That is, a shape factor appropriate to the anticipated movement and to the capability of sealing materials used should be employed. Within those guidelines, agencies use cold- and hot-poured sealants and preformed seals on resurfacing construction.

MISCELLANEOUS CONSTRUCTION ACTIVITIES

Clearances and Transitions

Among major miscellaneous activities requiring some attention in the construction of PC resurfacing are those concerning overhead and on-grade structures.

Clearances for overhead structures may make it necessary either to raise overhead structures (usually not an economical alternative unless benefits other than pavement enhancement will accrue), or to lower the grade. Most often the decision is made to remove the existing pavement under the structure and to provide adequate transitions on either side for a sufficient distance. Where overhead

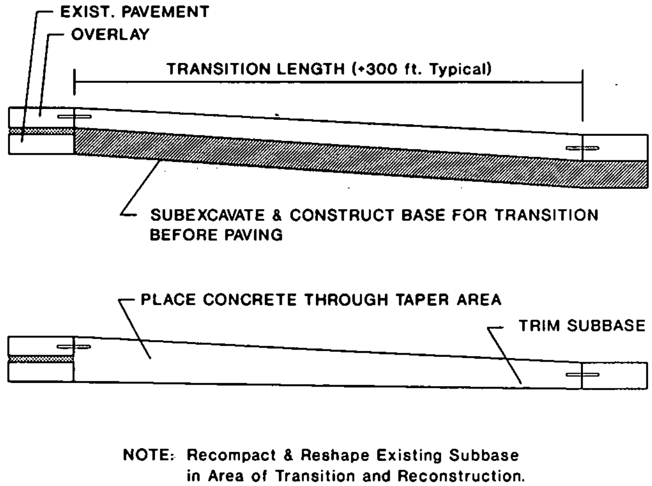

FIGURE 27 Typical transition tapers used to meet bridge approach slabs or maintain clearance under bridges (*25*).

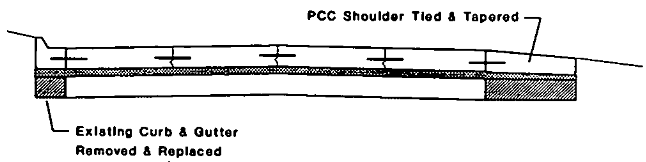

FIGURE 28 Curb and gutter and concrete shoulders should be tied to the mainline slabs; shoulders can be tapered (*25*).

clearances are reduced, signing to indicate the revised clearances is mandatory.

In the case of on-grade structures, it is usually necessary to remove the existing pavement so that the structure and pavement grades can be matched at the approach slab to the structure and to provide adequate transitions on either side for a sufficient distance.

A typical transition adaptable to either of these conditions is shown schematically in Figure 27. A minimum of 12 m (40 ft) of length per 25-mm (1-in.) change in grade is recommended for a smooth transition (*25*). The design of transition slabs is comparable to the design of overlay slabs. A special consideration is the location of dowels in the upper portion of transitions, where the slabs are tapered. The dowel is placed in the center of the overlay slab thickness and in the upper portion of the adjoining transition slab (Figure 27).

Tied Shoulders and Widened Lanes

Concrete shoulders tied to the mainline pavement have become increasingly popular as the benefits of improved performance and traffic handling have been realized (*59,67*). In many instances the shoulder is tapered about 50 mm (2 in.) to the outside edge, as illustrated in Figure 28. The taper provides the desirable shoulder cross-slope without special grading of the underlying layers. Some agencies choose to establish cross-slope in the subgrade and use shoulders with the full overlay thickness throughout. Tied shoulders apply only to unbonded overlays and to whitetopping, because

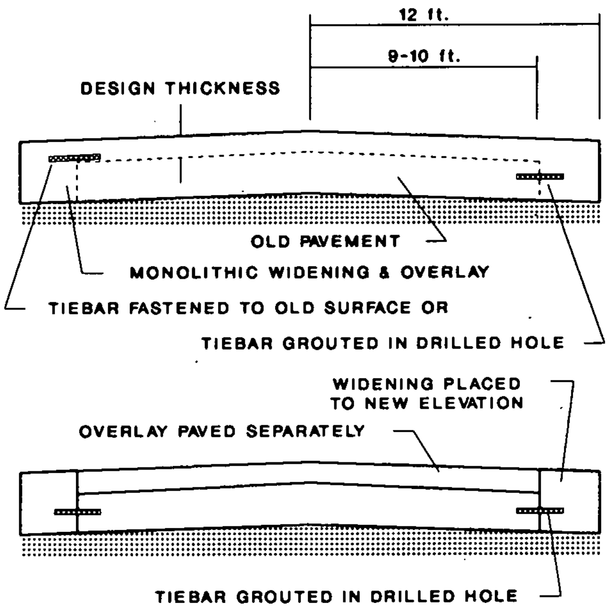

FIGURE 29 A pavement can be widened while paving a bonded concrete overlay or paved separately (*9*).

bonded resurfacing typically is too thin. However, an integral widening, indicated in Figure 29, may be used with a bonded overlay. As shown in that figure, the monolithic widening generally will result in longitudinal cracks directly above the edge of the underlying pavement. For that reason, the separate paving indicated in the lower portion of Figure 29 is most often used.

Similarly, widened lanes are used both with and without tied shoulders to further enhance the pavement's ability to sustain wheelloads. The design criteria for both tied shoulders and widened lanes used in conjunction with overlays are consistent with those for new pavement (*17*).

PAYMENT FOR PCC OVERLAYS

Because it is difficult to precisely estimate quantities for concrete resurfacing, the paving industry has taken the position that the overlay concrete should be furnished on a volume basis (m^3 or yd^3), and the placement should be on the basis of area (m^2 or yd^2). The position taken by the ACPA and generally accepted by AASHTO (*10*) is as follows (*9,25,54*):

> **Cubic Yard Payment**—The cost of materials used in the mix, mixing the concrete and transporting the concrete should be included in the unit price per cubic yard for supplying the concrete. To determine the volume of concrete used, it is recommended that each concrete batch quantity be recorded. The quantities should be recorded at the point of placement. The engineer and contractor can then agree on the actual volume of concrete placed by summing the volumes recorded on batch tickets for each batch delivered and placed.
>
> **Square Yard Payment**—The placement cost of the overlay would include concrete placing, finishing, curing, reinforcing, and sawing and sealing joints.

Iowa, on the other hand, takes the position that unbonded overlays with suitable interlayers and whitetopping placed on milled surfaces should be treated as new pavement, and paid for on a square-yard basis in place (personal communication from Brian McWaters, pavement engineer, Iowa Department of Transportation, March 5, 1993).

CHAPTER SIX

RESURFACING EXPERIENCE AND PERFORMANCE

The most commonly used resurfacing is jointed plain or reinforced concrete pavement applied over pavement of the same or similar design. Some CRC or fiber-reinforced resurfacing is used for special applications. The predominant interface by far is the unbonded, constructed of an AC-based material with or without an additional bond-breaking enhancement such as a wax-based curing compound.

Perhaps the two most noticeable changes in the technology since the earlier synthesis are the tendency toward thicker resurfacing, no doubt related to heavier traffic volumes and weights, and a move by several agencies to extensive use of whitetopping, apparently brought about by the susceptibility of AC pavement to rutting under increasingly heavier axle loads and volumes.

PCC resurfacing experience in the United Kingdom was recently reviewed (*68*), with the conclusion that concrete overlays and inlays are an economical method of strengthening and maintaining existing PCC concrete and asphalt concrete roads.

Almost all the relevant literature on PCC overlays is classified according to interface type, making that a convenient means of organizing a discussion of resurfacing experience and performance.

BONDED CONCRETE RESURFACING

The first bonded PCC resurfacing on record was applied to Warsaw Street in Toledo, Ohio, in 1913. The reported purpose was to correct construction deficiencies relating to a frozen pavement. This proved to be a typical application of the bonded resurfacing technology, where most of the use has been to correct construction deficiencies, to overcome surface problems relating to wear or loss of skid resistance, and to repair damage caused by chemical spills. In recent years, more consideration has been given to bonded resurfacing to improve load-carrying capability where it is not feasible to make significant changes in grades because of appurtenances or overhead clearances.

Early Performance Studies

The first major work on the evaluation of bonded overlay performance was reported by Gillette (*69*) in 1965. The study included 10 overlays placed between 1954 and 1963, ranging from 13 mm (0.5 in.) to 150 mm (6 in.) thick. Eight of the projects were located on airfields. The results documented some of the still-pertinent procedures used to ensure adequate bonding and emphasized that bonded overlays are highly subject to reflective cracking. Without really defining his terms, Gillette concluded in his report that: "The evidence gathered shows that adequate performance can be expected regardless of the thickness of the resurfacing and the type and frequency of traffic."

Special Performance Studies

Later, in 1980, Gausman reported on thin-bonded overlays located in seven states and built between 1973 and 1985. These are listed in Table A-1 as items 44, 58, 67, 69, 71, 80-84 and 97 (*70*). Generally, these studies showed that overlays can be effectively bonded to clean pavements in good condition, that for proper performance quality surface preparation is critical, and that early indications were that bond strength could be retained in the absence of a bonding grout.

Still later, Peshkin and Mueller (1990) reported on a performance study of 10 thin-bonded resurfacing projects constructed between 1976 and 1985 (*71*). These project locations are identified in Table A-1 as items 51, 52, 53, 55, 58, 67, 69, 71, 86-88, 90, and 97. The 10 locations incorporated 16 resurfacing designs and were located in six states. Resurfacing thickness ranged from 50 to 125 mm (2 to 5 in.). All were jointed resurfacing of jointed original pavement. The original transverse joint spacings ranged from a 3.7-4.0-5.8-5.5 m (12-13-19-18 ft) random configuration used on a JPCP in California to several at 23.3 m (76.5 ft) on JRCP projects in Iowa. The information considered included distress surveys, debonding surveys, roughness test results, panel ratings, deflection testing, and materials evaluation. In addition, historical traffic data were used to estimate accumulated ESALs before and after each resurfacing, and previous studies were used to characterize the preoverlay condition of each section. At the time of the study, some resurfacing had carried more traffic than the underlying pavement had before resurfacing.

Generally, the authors found "mixed success" with bonded resurfacing. Some projects were nearing failure in relatively few years while others had carried more than the anticipated traffic and still were performing well. On the low end of the performance scale, a New York project on I-81 near Syracuse (No. 71, Table A-1) showed extensive debonding accompanied by cracking and faulting after 6 years. In those 6 years, however, the roadway carried 70 percent as much traffic as it had in the previous 24 years. The authors attribute the less-than-desirable life expectancy to the condition of the underlying pavement. In their words, "It is very likely that there was too much deterioration present in the original pavement to warrant the construction of a bonded overlay" (*71*).

Demonstrating better performance were two Iowa projects (Nos. 55 and 58, Table A-1) that had performed well for more than 10 years even though both were resurfacing of D-cracked pavement. In both cases, severely distressed areas were repaired prior to resurfacing. No. 55, on SR 12 near Sioux City, had carried ESALs approximately equivalent to the original pavement and was still performing well. It did have excessive longitudinal cracking, which the authors (*71*) attributed to "insufficient depth of cut of the longitudinal joint." A third Iowa project (No. 51) was listed as in poor condition after 12 years. However, it was further noted that the original pavement was severely distressed by D-cracking, which was now appearing in the resurfacing. Under the prevailing conditions this project seems to have performed well, though bonded resurfacing might not have been the most desirable rehabilitation technique.

Of somewhat special interest is experimental bonded resurfacings (Nos. 52 and 53, Table A-1) built in Iowa to explore the effects of resurfacing thicknesses on performance. Thicknesses ranged from a 50-mm (2-in.) thick unreinforced section to 75-, 100-, and 125-mm (3-, 4-, and 5-in.) thick sections with No. 4 reinforcing bars placed at 750-mm (30-in.) centers. Unfortunately, the variations in thickness and reinforcing were so confounded by variations in the condition of the underlying pavement that the results of 10 years of service are not very conclusive. For example, the 50-mm (2-in.) thick section demonstrated the best overall performance, but project records show that it was placed on the least-distressed portion of the original pavement. The Peshkin and Mueller study (*71*) was unable to draw conclusions on the effects of the design variables on overlay performance.

The authors concluded that many of the projects described above were constructed for purposes other than those typically considered appropriate for bonded resurfacing, i.e., to correct a surface defect or to improve structural capacity. They also concluded that

> .... it is believed that with proper preoverlay repair, thorough cleaning and preparation of the surface, use of a good bonding agent, careful placement and curing of concrete, and proper joint sawing techniques, many years of benefit can be attained through the placement and use of bonded overlays.

Others have since placed less emphasis on the need for a bonding agent (*6,9,32*).

Iowa Field Measurements

Tayabji and Ball (*14*) conducted a field measurement program on four bonded resurfacings in Iowa (portions of Nos. 58, 89, and 93, Table A-1). Their purpose was to provide a partial database for verification of bonded resurfacing thickness design procedures. The data collected included condition surveys, materials characterization, load-related stress-strain measurements, and temperature-related curl measurements. The studies showed that reflective cracks from the underlying pavement were still tightly closed after up to 7 years, and that the overlays had high interface shear strength. These findings led the authors to conclude that ".... for properly constructed bonded overlays, pavement strengthening is achieved and that the overlaid pavement behaves monolithically as a full-depth concrete pavement."

Texas Bonded CRCP Overlay

Koesno and McCullough (*15*) evaluated the performance of a 1986 Texas experimental bonded resurfacing located on I-610 North in Houston (No. 107, Table A-1). The basic design was a 100-mm (4-in.) bonded resurfacing placed on a 200-mm (8-in.) CRCP. In addition to typical CRCP transverse cracking, the original pavement had extensive longitudinal cracking. The experiment was conducted in 10 sections — two with steel-fiber-reinforced bonded overlays, two with bonded CRC overlays containing limestone aggregate, and six with bonded CRC overlays containing siliceous aggregate. The aggregate variable was provided because earlier University of Texas research had shown a long-term performance advantage in favor of limestone coarse aggregate. The fiber-reinforced sections contained 50 kilograms (kg) of steel fibers per cubic meter of concrete (85 lb/yd^3). The construction of the reinforced sections was of special interest. First, the old pavement was scarified to a depth of 6 mm (0.25 in.); then the reinforcing steel (a 1.8- × 3.7-m (6- × 12-ft) fabric) was placed in the scarified area. Finally, a cement grout was placed over the fabric and the concrete slipformed into place.

The evaluation consisted of Dynaflect deflections, distress surveys, and profilometer measurements both before and after the overlays were placed. The studies showed that the resurfacing decreased deflections and added fatigue life to an existing pavement by stiffening the pavement structure, and that limestone coarse aggregate results in fewer transverse cracks. Early indications were also that existing pavement conditions do not affect bonded overlay performance as long as the distress is repaired before the overlay is placed.

The resurfacing is still undergoing evaluation. A later report (*72*) discussed a small amount (0.6 percent) of delamination at the interface on the I-610 project. The delamination seemed related to the use of river gravel in the concrete on sections constructed without grout. Despite the delamination, the researchers considered the project to be a success for several reasons:

1. It demonstrated that bonded concrete overlays could be constructed under Texas environmental conditions on CRC pavement.
2. The reduction in distress and the associated increase in remaining life of the facility were substantial. Estimates range from 6 to 16 years, with an average increase in facility life of 10 years.
3. The performance of this experimental section over the last 5 years has been excellent.

Other Iowa Studies

The number of projects in service have led the Iowa DOT to research bonded overlays extensively (*5,50,73,74,16*). This research has formed the basis for much of the AASHTO and ACPA material published on these overlays (*9,10*) and remains a major source of information for additional research, some of which was discussed above. Among the more general findings from these various projects are those quoted below:

1. Any reasonably competent concrete paving contractor would be able to construct a bonded concrete resurfacing project. In review and evaluation of the projects constructed to date, bonded PCC resurfacing is considered a viable alternative to bituminous resurfacing for concrete pavement rehabilitation and restoration (*74*).
2. The location of sawcuts over joints is critical to prevent the overlay from breaking parallel to the joint. It is recommended that the overlay be a minimum of 4-inches (100 mm) thick (*16*).
3. Adequate bond between the original slab and PCC overlay can be achieved both with and without grout (*50*).

Other States' Experience

Other states with some recent experience using bonded PCC resurfacing include Louisiana (*75*), Missouri (*76*), New York (*77*), Pennsylvania (*78*), Virginia (*6*), and Wisconsin (*79*). Louisiana experienced some debonding of their 1981 overlay (No. 69, Table A-1). They attributed some of the debonding to "upswings" in the entrained air content of the mix, and some to edge-curling stresses. As a result, specifications for a 1990 fiber-reinforced project called for an air content range of 3.5 ± 0.5 percent (as opposed to 5 ± 2 percent on the 1985 job) and for the edge reinforcement discussed earlier (*11*).

Missouri's 1990 project (No. 119, Table A-1) was a SHRP SPS-7 site and consisted of the various surface preparation, bonding, and thickness variables set forth by SHRP. While there has been little time to assess performance, some of the construction observations (*76*) were as follows:

1. Shotblasting alone (an alternate section not specified for SPS-7) may not provide a surface capable of adequate bonding, either with or without a grout.
2. A combination of milling and shotblasting is needed to promote adequate bonding.
3. Epoxy-coated deformed bars used in the overlay over working cracks did not prevent reflective cracking.

The New York project described by Obuchowski (*77*) (No. 71, Table A-1) was a 75-mm (3-in.) overlay of a 225-mm (9-in.) thick JRCP with a 13-m (43-ft) contraction joint spacing constructed in 1957 on I-81. When it was resurfaced in 1981, the pavement was badly deteriorated at both longitudinal and transverse joints as a result of freezing and thawing of a porous aggregate used in the original concrete. The overlay was unique in its treatment of the transverse joints. The existing pavement was milled to a depth just above the existing dowels (approximately 150 mm (6 in.) of the old pavement remained) to remove deteriorated concrete. Then, the 75-mm (3-in.) overlay was bonded to the surface with a cement-sand grout. After 2 years of service, the author reported that the thickened overlay was bridging the joint deterioration. He also reported the expected shrinkage and reflective cracking, but no performance problems.

The Pennsylvania project (No. 121, Table A-1) also has not been in service long enough for definitive performance information to develop. However, based on satisfactory early performance the Pennsylvania DOT (PennDot) author (*78*) noted that "There are numerous scenarios where a thinner concrete pavement section is more desirable than a bituminous overlay alternative." Of major interest was the ability of a bonded overlay to significantly improve the pavement structure without a substantial increase in thickness. In addition, the benefits resulting from not having to raise guardrails, structures, and other appurtenances were considered to be very important.

The Virginia project (No. 123, Table A-1), which is only 2 years old, is providing excellent early performance (*6*). Ironically, after the first year, two small areas of bond failure were found in a section where a grout had been applied. Bond failures were identified by chain drag and verified by coring. No surface distress was observed, and no failures were identified in the ungrouted test section. After the second year, these bond failures appear not to have progressed and no further indication of significant problems has been seen (personal communication with Will Cumming, Resident Engineer, August 1992).

The Wisconsin project (No. 114, Table A-1) was a nominal 75-mm (3-in.) thick bonded overlay of a 16-year-old CRCP. The old pavement had been given a "critical" distress rating prior to the overlays in 1988. State reports do not mention repairs to the underlying pavement in preparation for the overlay. Due to extensive debonding, the overlay had returned to a nearly critical level after only 2 years of service. At the end of 5 years, the DOT reported extensive surface cracking and apparent debonding, though the overlay had not begun to break up. On the basis of this project, the DOT recommended ". . . that 3-inch bonded concrete overlay should not be considered as a means of extending the service life of a CRCP structure" (*79*).

Fiber-Reinforced Concrete Overlays

Bonded resurfacings constructed with fiber-reinforced concrete deserve some discussion. Marks (*80*) issued a 15-year performance report in 1989 on fibrous overlays in Iowa. Of some 40 test sections, only seven, ranging from 50 to 100 mm (2 to 4 in.) in thickness, were intended to be bonded. While the technology to achieve and measure bonding was still evolving at the time the overlays were constructed, later tests showed no greater bonding on the "bonded" than on the unbonded sections. Yet the performance of all sections was at least up to Iowa expectations (the required maintenance at 15 years was average to less than average). These findings suggest that losing bond does not necessarily imply failure of a bonded overlay, an admonition used by ACPA (*9*) in discussing this technology. On the other hand, the presence of the fiber reinforcement in the Iowa projects may have contributed to better performance than would be observed for debonded conventional concrete.

The Louisiana fiber-reinforced project mentioned earlier is a 100-mm (4-in.) thick overlay bonded to a 16-year-old CRCP "which has carried twice its design load" (*11*). The overlay was intend to provide a slab thickness commensurate with an additional 20 years of design loading. The design variables intended to increase the probability of good long-term performance were the use of the steel fibers with a high cement factor, the use of a clean-textured bonding surface, the use of edge-bond reinforcement, and the use of tied shoulders. After 1 year of service, the researchers reported the expected reflection of transverse cracking. However, they noted that the cracks "are held tight by the steel fiber reinforcement."

FHWA Position on Bonded Overlays

Returning to a general discussion of bonded overlays, the FHWA "Pavement Notebook" (*59*) provides an overview and states that bonded resurfacing can be successfully constructed if certain precautions are observed. These precautions include the following:

1. Proper preliminary investigation of the existing pavement structure to ensure that adequate structural support exists. This rehabilitation technique should be applied only to add thickness and increase structural capacity or to repair some form of surface deterioration of an otherwise sound pavement.
2. This technique should not be used when the expected air temperature will exceed 90° F (32° C). High temperatures, both air and surface, will cause rapid moisture loss, thereby increasing the incidence of shrinkage cracks. This rapid mois-

ture loss can be caused by low humidity and warm dry conditions as well. In addition, inordinately high stresses between the overlay and the existing pavement can develop when fresh concrete is placed on a slab with an elevated surface temperature, thereby affecting the bond development.

3. Surface preparation and cleanliness are of great importance. All foreign material and substances (e.g., loose concrete, asphalt, oil, rubber, paint, etc.) must be removed from the surface. The value of roughening the existing surface for bonded overlays and the method to achieve such roughening are still being debated. It is thought by some that the bond strength between the overlay and the existing pavement is enhanced by roughening. However, cold milling existing concrete pavement may cause micro-cracking, adversely affecting the bond.
   Shotblasting and cold milling have generally been effective methods of cleaning and providing surface texture. The surface must be thoroughly cleaned of dust and loose contaminants just ahead of the overlay laydown operation as well.
4. All necessary repairs to the existing pavement to restore integrity to the existing pavement must be made prior to the overlay. These would include restoration of load transfer, full and partial depth joint repairs, joint and crack sealing, etc.
5. Several experimental projects have shown that adequate bond strengths can be achieved without the use of a bonding agent. This has not been universally accepted, therefore, careful investigation by the owner agency should be conducted to determine whether to use a bonding agent. Some research also suggests that overlays can be successfully placed on dry or damp surfaces without bonding agents. Placement of an overlay on a damp surface is not recommended without agency verification.

The reader should note that the material quoted above was prepared prior to the initiation of SHRP Experiment SPS-7 which will examine the bonding issue described in item 5. It should be further noted that Section 6005(e)(7) of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 provides for a 6-year, $15 million effort to evaluate thin-bonded overlays and surface laminants for highway pavement and bridges (*81*).

PARTIALLY BONDED RESURFACING

There is no record of a partially bonded resurfacing having been constructed on a highway project since the earlier synthesis (1981). Few had been constructed since the 1960s and those were predominantly on airfields. Even on airfield work, "partially bonded" seems to be a less-often-used designation. Again, the term really implies that the designers, builders, etc., give little or no attention to the interface, so the end result can be from no bonding to a significant bonding action. As discussed earlier, the distinction may or may not be important, depending on the condition of the underlying pavement. If the underlying pavement is in good condition prior to the resurfacing, the interface is of little consequence. Conversely, reflective cracking from a poor underlying pavement can severely impair performance when no positive separation layer is present.

In discussing the Greene County, Iowa, experimental pavement designed to include bonded, partially bonded, and unbonded overlays, Marks (*80*) made the observation that "Experience has shown that overlays are either bonded or unbonded, as a partial bond yields an unbonded overlay."

UNBONDED RESURFACING

In general, the preference for unbonded resurfacing is clear. Table 3 shows that of 708 reported resurfacing projects, 404 or 57 percent are classified as unbonded or partially bonded. As with the other interface types, the focus of this section is to present an overview of projects built since the earlier synthesis was completed. Where new information is available on projects reported in that synthesis, it will be discussed. Otherwise, the reader is referred to the other synthesis for details not given in the Appendix. The Appendix is complete to the extent possible, so little reference to the earlier work should be required in most instances.

Special Performance Studies

A special performance study of 14 unbonded resurfacings constructed in six states between 1975 and 1985 was reported by Voigt et al. in 1989 (*63*). Insofar as possible, the projects incorporated in that evaluation are referenced to Appendix item numbers. On these projects, resurfacing thicknesses ranged from 150 to 250 mm (6 to 10 in.) with joint spacing from 4.1R to 18.3 m (13.5R to 60 ft). (The "R" indicates a random joint spacing, in this case with a 4.1-m (13.5-ft) average.) Three of the projects were JRCP, the others JCPC. The interlayers used ranged from a white-pigmented curing compound in Georgia (No. 220-221, Table A-2) to hot-mix AC used by most agencies. Colorado, however, used a somewhat unusual combination of a 13-mm (0.5-in.) thick AC layer followed by a sand cover (No. 297, Table A-2). In all instances except the Georgia project, the resurfacing joints were mismatched with joints in the underlying pavement. Generally, the approach is to place resurfacing joints no closer than about 900 mm (3 ft) from the original pavement joints. This is intended to lessen the probability of reflective cracking, and the "sleeper-slab" effect created serves to transfer loads across the new joints. In Georgia, slabs in the old pavement were 9.2 m (30 ft) long. In one section, the resurfacing was built so that the new joints matched the old. In a second section, additional contraction joints were constructed at the midpoints for an effective slab length of 4.6 m (15 ft). It is important to note that the Georgia sections, with other experimental features, also were the thinnest (150 mm (6 in.)) resurfacings studied.

This study of 14 resurfacing projects yielded several important findings. Among the most important was that curing compound is not an adequate separation layer. This was reported earlier by Georgia DOT researchers (*82*). Bonding of the resurfacing and the old pavement occurred, as evidenced by the high frequency of transverse reflection cracking reported in both of the Georgia studies. However, after some 10 years, the pavement showed generally good performance and none of the cracks had deteriorated into working cracks. Voigt (*63*) recommends a minimum 25-mm (1-in.) asphalt concrete layer as a separation layer when there is any significant faulting of the existing pavement joints. He notes that a thin layer, such as a slurry seal, appears to be adequate if there is little or no faulting.

Longitudinal cracks also occurred frequently on the Georgia sections and were attributed to the failure of the curing compound to break the bond — reflection cracking again was the culprit

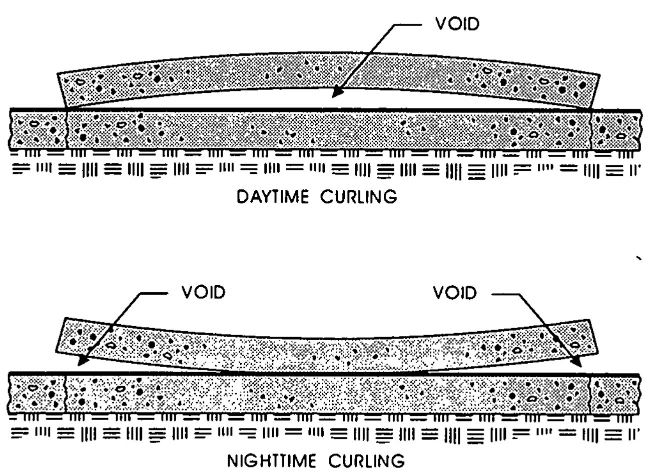

FIGURE 30 Development of void under unbonded concrete pavements from the differential curling phenomenon, Voigt et al. (*63*).

(*63,82*). Some longitudinal cracking found on an Illinois East-West Tollway section (No. 259, Table A-2) was attributed to late sawing of the longitudinal joints, as reported by project personnel.

The researchers (*63*) noted that special consideration needs to be given to cracking caused by curling stresses on unbonded resurfacing, in which the pavement temperature gradient from daytime heating to nighttime cooling is much more pronounced than is the case with a bonded resurfacing. They go on to point out that the usual new pavement procedure has been to limit the slab length (in feet) to less than twice the pavement thickness (in inches). This procedure, however, is inadequate when the pavement is placed on a stiff foundation such as an existing concrete pavement. This research was the foundation for the guidelines given in Chapter 5, in which the unbonded resurfacing slab length (in ft) is restricted to 1.75 times the thickness (in in.) (*25*). The mechanism for development of this type of distress is depicted in Figure 30. Either day or night curling can cause the resurface slab to lift from its foundation and create a void under the resurfacing. Such voids can lead to transverse cracking in the presence of traffic loadings on the stiff foundation.

Other conclusions from the Voigt et al. work are as follows:

1. Unbonded resurfacing without dowels faults far less than new undowelled pavement for the same number of ESALs. This finding seems related to the use of mismatched joints in the resurfacing, to the uniform support provided to the overlay, and to the thick pavement structure created by the old pavement and the resurfacing combined.
2. Longitudinal cracking is primarily attributable to late sawing or improper depth of the centerline joint. The researchers recommend that the joint be sawed to one-third the depth of the resurfacing slab as soon as possible after the concrete has been placed.
3. The greatly reduced deflections of unbonded slabs and the firm foundation provided by the underlying pavement greatly reduce the potential for pumping. (However, FHWA reviews have shown that positive load transfer and short slabs are needed if significant pumping and joint faulting are to be avoided after 10 to 15 years) (*47*).

Finally, a general conclusion from the study was:

> Unbonded concrete overlays have been used successfully to resurface existing pavement with extensive deterioration. The performance of practically all the 14 uniform sections of unbonded concrete overlays was very good, with no significant deterioration.

Hall et al. (*83*), in their nationwide study of pavement rehabilitation techniques, studied many of the same pavements and concluded that:

> Unbonded concrete overlays have given very good performance on practically all projects surveyed. They typically exhibit very little distress even after a large number of traffic loadings. The high initial cost of an unbonded overlay may be in many cases more than offset by the low-maintenance performance of this technique.

Georgia Experience

The 1975 Georgia DOT resurfacing experiment on I-85 included a 150-mm (6-in.) plain dowelled overlay and 75-mm (3-in.), 114-mm (4.5-in.), and 150-mm (6-in.) CRC overlays (*2,82*). All were placed on a 15-year-old JPCP with a 230-mm (9-in.) thick slab with undowelled joints spaced at 9 m (30 ft). All sections were constructed with 3-m (10-ft) wide tied concrete shoulders. The old pavement was in poor condition with broken slabs and faulting. The JPCP overlay was built in two sections: one with joints matching the old pavement and one with additional joints midway between those on the old pavement for an effective spacing of 4.6 m (15 ft). Joints matching those in the old pavement were dowelled. In an attempt to provide a separation layer, curing compound was applied to the old pavement prior to paving.

After 6 years, the JPCP section with 9-m (30-ft) long slabs was in poor condition and about 65 percent of the slabs had cracked. The cracking was attributed to failure to break the bond between the overlay and the existing pavement. The JPCP with 4.6-m (15-ft) long slabs was in better condition with approximately 30 percent of the slabs broken.

Also after 6 years of heavy interstate traffic, the 75-mm (3-in.) CRC section was in poor condition with excessive cracking, punchouts, and patching. The 114-mm (4.5-in.) section had fared somewhat better, though it had reflective cracking from all the old pavement joints. At the same time, the 150-mm (6-in.) section had shown good performance with little unusual cracking.

The Georgia researchers concluded that unbonded overlays can be successful if the underlying pavement is properly prepared, all slabs are stabilized, and a sufficient separation layer prohibits locking of the overlay to faulted joints in the old pavement. They also found that curing compound was an inadequate separation layer and that concrete shoulders should be used with concrete overlays. Finally, based on their experiences, they recommended that CRC overlays be no less than 150 mm (6 in.) thick where there are large volumes of truck traffic.

The JPCP sections of the Georgia project were included in the Voigt et al. study discussed earlier (*63*). At that time the project was 10 years old and showed significant cracking in both the 4.6-m (15-ft) and 9-m (30-ft) sections. However, the cracks had not deteriorated into working cracks. Average faulting was reported as "not significant" and no structural problems other than the cracking and faulting were evident. These researchers considered the performance of both sections to be good.

Iowa Unbonded Overlays

The Greene County, Iowa, research project discussed earlier contained a number of partially bonded and unbonded sections, all of which became unbonded with time (*80*) and are considered to be unbonded for the present discussion. The sections included JRC, CRC, and fiber-reinforced overlays placed on a 50-year-old unreinforced, unjointed pavement that had severe cracking and spalling. Because of the broad scope of this project, portions of the report summary (with emphasis added) are reproduced below:

> The Greene County, Iowa overlay project, completed in October 1973, was evaluated in October 1978 after five years, in October 1983 after ten years, and most recently in October 1988 after fifteen years of service.
>
> All experimental overlay sections had performed quite well in the period from five through 15 years, experiencing only limited additional deterioration. The 100 mm (4") thick nonfibrous mesh reinforced *CRC* overlay sections provided the best performance in this research project. Another nonfibrous 125 mm (5") thick bar reinforced *JRC* overlay section performed second best. The best performance of a *fibrous reinforced concrete* section was obtained with 160 pounds of fiber per cubic yard (95 kg/m^3).
>
> The use of 750 pounds of cement per cubic yard (442 kg/m^3) in the *fibrous concrete overlays* provided no benefit over the use of 600 pounds of cement per cubic yard (354 kg/m^3).
>
> The performance of the *fibrous overlays* was directly related to fiber content of the concrete mix. The 160 pounds per cubic yard (95 kg/m^3) provided the best performance with the poorest performance exhibited by the 60 pounds of fiber per cubic yard (35 kg/m^3). There is no significant difference in the performance of the 64 mm (2-½") long and 25 mm (1") long fibers.
>
> The 75 mm (3") thick *fibrous concrete overlays* yielded substantially better performance than the 50 mm (2") *fibrous overlays*.
>
> In general, the thicker, nonfibrous (JRC, JPC, and CRC) pavement overlay sections performed better than the *fibrous reinforced* concrete overlays. The additional cost of the *fibrous* concrete overlays cannot be justified based upon the comparative performance of the fibrous and thicker nonfibrous overlay sections.

McWaters (*84*) reported further on unbonded overlays in a 1990 FHWA Pavement Rehabilitation Workshop. He noted that Iowa's past unbonded overlays had generally experienced a recurrence of preoverlay conditions after 12 years. The reasons given were poor drainage and too-thin stress relief layers. McWaters continued that unbonded overlays perform well

> where there is uniform subgrade support including the stress relief layer that allows the stresses to be evenly distributed. This allows the new pavement to behave as an independent pavement and not subject to the direct influence of the existing pavement.

He further observed that, on low-volume roads, unbonded overlays have performed well even without a 25-mm (1-in.) or thicker stress relief layer. Finally, he acknowledged the amount of truck traffic to be the major determinant of unbonded overlay performance.

An unbonded overlay experiment by the Minnesota DOT in 1988 (No. 335, Table A-2) is beginning to yield some results. The experiment included several variables, such as dense- and open-graded asphalt interfaces, sections with and without dowels, sections with and without edge drains, and sections with joint sealant (preformed neoprene or poured silicone). An FHWA review of the experiment after 5 years' service found the overlays to be performing well (*85*). There were significant differences in joint faulting, with the higher faulting on sections without dowels and on those without positive drainage features.

Survival of Unbonded Overlays

Unlike bonded overlays and whitetopping projects, a number of unbonded or partially bonded projects have been removed from service. Project-specific information is given in the "Status in 1992" column of Table A-2, Appendix. It may be noted in Table A-2 that some projects have been reconstructed, some resurfaced with either PCC or AC, and others simply retired from service with no explanation. The total number of unbonded or partially bonded projects reported by the DOTs to no longer be in service in 1993 was 71.

The distribution of ages at which the projects were removed from service is shown graphically in Figure 31. It appears that the ages are approximately normally distributed. Statistically, the 71 projects were removed from service at an average age of 25.6 years, with a standard deviation of 10.7 years. These statistics permit the calculation of a form of survivor curve, as shown in Figure 32. While many inferences could be drawn from Figure 32, perhaps the most meaningful is that about two-thirds of the unbonded overlays no longer in service lasted for at least 20 years before they were removed from service. In the absence of other information, this finding may provide a good basis for economic analysis of rehabilitation alternatives.

The reader is cautioned that the data represented in Figures 31 and 32 are aggregations of numerous designs from across the country rather than from a controlled experimental database. The results could be confounded by many unidentified variables. Further, there may be projects in use that will last much longer than those already removed from service. Conversely, there may have been projects removed from service at very early ages that are not represented in the database. Projects of either type could skew the results. Therefore, persons using the survivor relationships given in Figure 32 should do so with a full understanding of the possible limitations.

WHITETOPPING

As noted earlier, whitetopping is an increasingly popular use of PCC resurfacing as a rehabilitation or structural strengthening alternative on AC pavement. Plain concrete, reinforced concrete, and continuously reinforced concrete all have been used successfully as whitetoppings. Again, the early work was well documented in the previous synthesis (*1*) and will not be repeated here except to the extent that up-to-date performance information is available.

Lokken (*86*) in 1981 provided some performance data on PCC resurfacing of AC pavement. In that work, eight plain undowelled overlays from 4 to 24 years old were evaluated and found to be in good to very good condition in 1977. The ACPA (*54*) followed up the Lokken work with 1989-1990 reviews of 18 projects, several of which were included in Lokken's database. One project reviewed in both studies is located on US-101 in Orange Co., California (No. 27, Table A-3). The resurfacing consists of a 200-mm (8-in.) plain concrete placed in 1966. When reviewed in 1989, the project had carried more than 10 million ESALs and was considered to be in excellent condition. A 150-mm (6-in.) overlay in Iowa has carried truck traffic to a grain elevator for some 20 years and was rated in fair condition with some mid-panel cracking of 12-m (40-ft) long slabs.

The Florida DOT reported on the recent (1988) construction of a concrete overlay of an existing flexible pavement (*87*) (Nos.

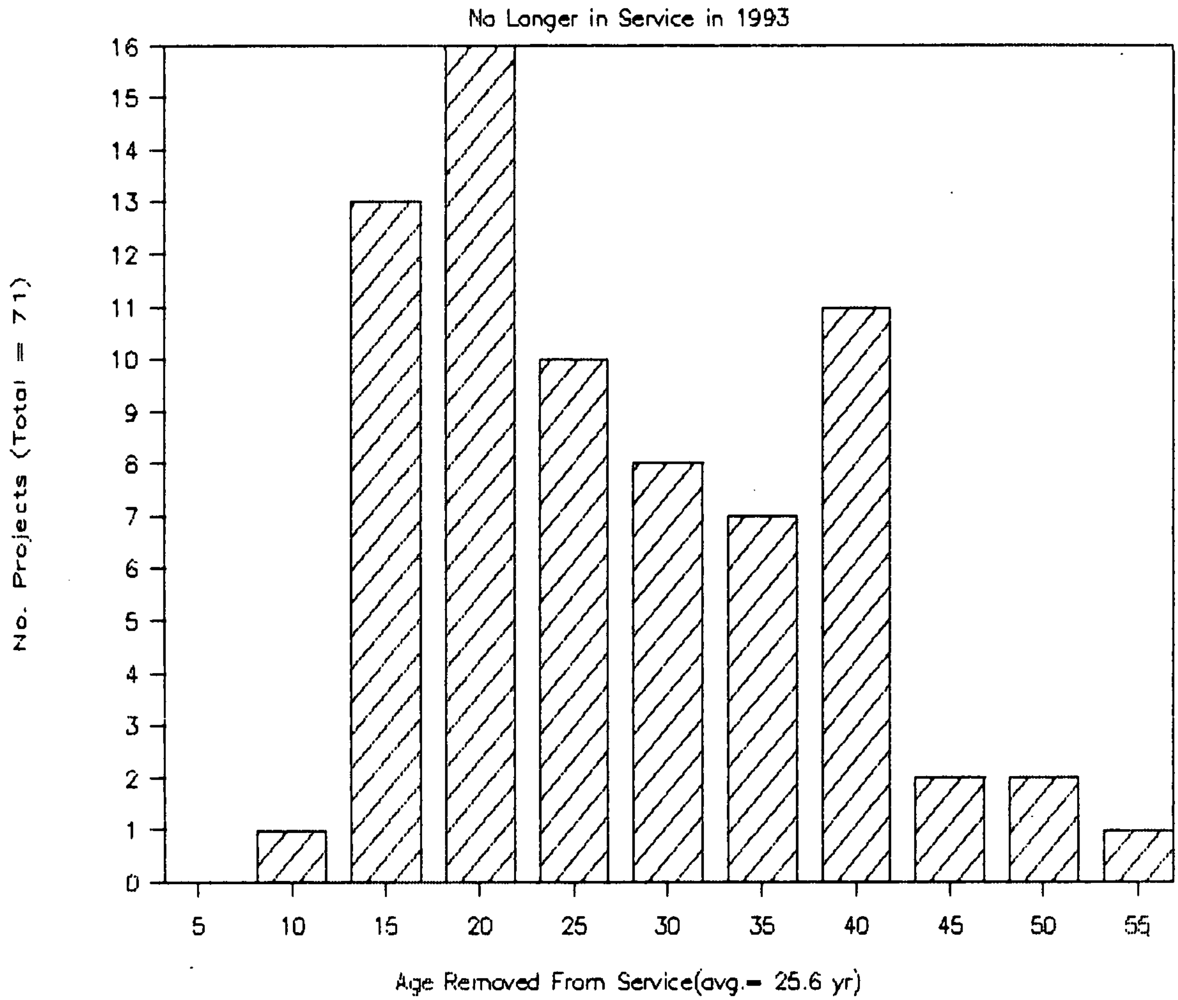

FIGURE 31 Ages at which unbonded and partially bonded overlays have been removed from service.

143-145, Table A-3). The project consists of 19 sections with slab thicknesses of 150, 175, and 200 mm (6, 7, and 8 in.). For each thickness, slab lengths were 3.7, 4.3, 4.9, 5.5, and 6.1 m (12, 14, 16, 18, and 20 ft). According to the designer (personal communication with W. N. Lofroos, Florida, DOT, July 30, 1992), the resurfacing was designed for a 10-year life. The 175-mm (7-in.) thickness then increased by 25 mm (1 in.) and decreased by 25 mm (1 in.) to form the experiment. The designers anticipate relatively early distress on the 150-mm (6-in.) thick sections. Some sections are doweled, and others rely on aggregate interlock for load transfer. Because of the poor condition of the existing pavement, a 25-mm (1-in.) leveling course of asphalt surface mix was placed immediately under the PCC overlay. After 3 years of service, all sections are reported to be in excellent condition (Lofroos, July 30, 1992) with no signs of the anticipated early distress in the thin sections.

Recent reports from the Wyoming DOT (*47*) show that whitetopping projects built without dowelled joints can be subject to significant faulting in a few years of interstate traffic. Similarly, undowelled whitetopping projects in Utah were found to fault significantly in fewer than 15 years, even with very low annual rainfall (*49*). Wyoming engineers expect to add dowels to the next whitetopping projects they build. They also see some benefits in using a drainable layer between the PCC overlay and the underlying AC pavement.

Cole (*12*) reported on a very thin experimental whitetopping project constructed in 1991 on a recycling center access road near Louisville, Kentucky (Nos. 179-180, Table A-3). The project consists of two 84-m (275-ft) long overlay sections. One section is 50-mm (2-in.) thick while the other is 90-mm (3.5-in.) thick. Features included in the experimental construction are "fast-track" paving, high-strength concrete, polypropylene fibers, and high-range water reducers. The existing asphalt concrete was milled to provide a foundation of uniform grade and a rough, exposed aggregate surface. Although project personnel initially were concerned over placement of the 50-mm (2-in.) section "... after a few minor adjustments at the start, the paving went very smoothly."

To evaluate the experiment, the PCA entered into a contract with the Civil Engineering Department at the University of Louisville. During construction, the various materials were characterized and strain gauges were installed at strategic locations in the resurfacing. Initial indications are that the pavement is performing better than design equations predicted. Some project personnel expected early cracking of the 150-mm (2-in.) thick section under the prevailing

FIGURE 32 Survivor Curve for bonded and unbonded overlays no longer in service in 1993.

heavy truck traffic. That the cracking did not occur as early as expected is attributed to bonding between the overlay and the underlying pavement—the existing asphalt takes a higher portion of the load than anticipated. The concrete paving industry urges "a deliberate and cautious approach to this new technology" through additional studies. With regard to the same project, Mack et al. (*42*) point out the need for research into the strain and deflection of AC layers under thin PCC overlays. They identify further research needs in the areas of slab interaction and size effects including moisture warping and temperature curling. Additional research in this area is now underway in Iowa where Cable has proposed a 5-year evaluation of a PCC overlay bonded to an existing asphalt concrete pavement. This project is to be constructed on Iowa Highway 21 in 1994 (*44*). This study will involve strain gauge instrumentation of the overlay to measure pavement reaction to changes in bond, pavement structure, and load transfer capability. The overall objective is to better define bonding characteristics, minimum overlay thicknesses, and optimum jointing patterns.

INLAYS

PCC inlays of both AC and PCC pavements have been used in situations where it is desirable to rehabilitate only a portion of a pavement's width or where vertical clearances or other geometric factors prohibit raising the grade with a conventional overlay. Instances of the first kind are most frequently observed on wide airfield pavement. As reported in the earlier synthesis (*1*), it is not uncommon to rehabilitate only the center third of 91.5-m (300-ft) wide runways where the loading intensity is greatest. An inlay is one way such rehabilitation has been accomplished. Federal Aviation Administration (FAA) engineers have reported that (*1*)

> This method of strengthening (resurfacing) has proven more economical than overlaying the entire width of the pavement and after 2 to 3 years of service, the pavements are entirely satisfactory.

It also is not unusual to see one lane (usually the most heavily traveled) of highway projects rehabilitated with an inlay, especially where asphalt layers have been subject to recurring rutting. Inlays also are used where vertical clearances are limited and where an inlay is more economical than raising guardrails and fill slopes, as would be required with an overlay (*54*). Still others have been used to restore pavement damaged by freezing or by chemical spills.

Price and Ardani (*88*) reported on a whitetopping inlay demonstration conducted in Colorado in June 1990. Two 91.5-m (300-

ft) overlay sections were placed at thicknesses of 90 and 125 mm (3.5 and 5 in.), respectively. These were joined by a 100-ft. (30.5 m) transition section. One short segment had proprietary polypropylene fibers added to the mix at a rate of 0.89 kg/m^3 (1.5 lb/y^3). Another unique feature was the jointing arrangement which resulted in very small slabs on the 90-mm (3.5-in.) section. Green concrete sawing began about 2 hours after concrete placement began and was configured to result in a 2-m × 2-m (6.5-ft × 6.5-ft) joint pattern. One Colorado engineer (personal communication with Denis E. Donnelly, July 30, 1992) reported that the small slabs were used to control shrinkage cracking on the thin section and that they seemed to have been very successful. An 3.8-m × 4-m (12.5 ft × 13-ft) joint pattern was used on the 125-mm (5-in.) thick section. All sawcuts were 3 mm (0.025 in.) wide and 19 mm (0.75 in.) deep. Some were sealed with a cold-poured emulsified asphalt sealer, though most were left unsealed. The pavement was reopened to traffic 24 hours after the start of construction.

Early evaluations showed some spalling at nearly every joint 3 weeks after the joints were sawed. Performance after two years in service is considered satisfactory (Donnelly, July 1992).

Inlays constructed on I-70 in Kansas in the mid 1980s (Nos. 97 and 113, Table A-3) have not been very successful. These projects were partial inlays; the top 100 mm (4 in.) of an existing 250-mm (10-in.) AC pavement were removed and the inlay placed in a "bathtub." In addition, the design depended on aggregate interlock rather than dowels for load transfer. After about 3 years the two projects exhibited joint faulting of more than 3 mm (0.025 in.), some uncontrolled longitudinal cracking, and a minor amount of pumping and corner breaking (personal communication with Roger Larson, FHWA Pavements Division, December 1993). The DOT concluded that the absence of dowels was a major contributor to poor performance under the interstate traffic carried by the projects.

Positive load transfer and positive drainage are also essential. In Oregon, 33-cm (13-in.) CRCP inlays in the truck lanes of I-5 have performed very well (personal communication with Roger Larsen, December 1993).

Wyoming has had similar experience with inlays constructed without dowels (*47*). Undowelled inlays constructed on HMAC, drainable bases, and dense-graded bases all showed measurable but not severe joint faulting in a few years. However, faulting trend lines that developed in the first few years suggest that the drainable bases will significantly improve long-term performance of inlays, even without dowelled joints.

In summary, to enhance the performance of inlay projects both positive load transfer and positive drainage features are essential (*49*).

CHAPTER SEVEN

THE SELECTION OF TECHNICALLY FEASIBLE RESURFACING ALTERNATIVES

There seems to be a consensus that the two major considerations in the selection of a technically feasible resurfacing alternative are traffic delays (lane closure times) and life-cycle costs. Although the two are directly related, they will be discussed initially as two separate issues. The first, although in many ways contributing to the total cost of a rehabilitation project, is more often perceived as important because of its aggravation to the public. The second has too often been ignored in favor of decisions based on simple first cost. Public transportation agencies historically have argued that funding restrictions preclude the long-term cost considerations (one of which is traffic delays or lane closures during maintenance activities) necessary to life-cycle cost analysis. It was not until recent years that the transportation community began to accept the necessity of recognizing pavement construction and rehabilitation as long-term investments wherein the time value of money must be an integral part of the rehabilitation analysis process.

The stage was set for routine consideration of life-cycle cost analysis with the publication in 1985 of *NCHRP Synthesis of Highway Practice 122: Life Cycle Cost Analysis of Pavements* (*89*). This document outlined the various components to be considered in the economic analysis of pavement and provides the framework for the procedures recommended for alternative selection in the present discussion. With the publication of FHPM 6-2-4-1 (*20*), the FHWA in 1989 provided major impetus to life-cycle cost analysis as a "way of life" for people involved in rehabilitation design. That policy set forth the following requirements for pavement rehabilitation project analysis:

1. Perform an engineering and economic analysis on candidate strategies. The engineering analysis should consider the traffic loads, climate, materials, construction practices, and expected performance. The economic analysis should consider service life, initial cost, maintenance costs, and future rehabilitation requirements, including maintenance of traffic costs.
2. Select the best rehabilitation alternative. Although the economic analysis results are important in selecting the preferred alternatives, budget constraints and engineering judgment should also be considered in selecting the best alternative for a particular project.

Although detailed consideration of every issue raised by the FHWA policy is beyond the scope of this synthesis, every effort has been made to address the major questions in the foregoing discussion. It should be noted that in life-cycle cost analysis the analysis period is defined as ". . . . the time period used for comparing design alternatives" (*89*). Although 25 to 40 years are typically used for the evaluation of new design alternatives, less than 25 years is common for rehabilitation design. Several years will pass between the original design and construction and the first rehabilitation, sometimes referred to as the initial performance period. During this period, traffic will typically increase significantly while other demands on the roadway may change such that total reconstruction would be warranted before another 25 years could pass. A typical performance curve is illustrated in Figure 33. In this example some routine maintenance was performed at time t_1, when the pavement's serviceability level improved slightly. The pavement continued in its first performance period to time t_2, when the first rehabilitation occurred and there was a major improvement in serviceability. It is possible to extend the analysis period indefinitely with periodic rehabilitation activities. However, it can be shown that, even if a 100-year analysis period was used, discounting causes some 80 percent of the total cost of the system to be accrued in the first 25 years (*89*).

The importance of life-cycle cost analysis is emphasized by the ISTEA of 1991 for both metropolitan and statewide planning processes (*81*) and the December 1, 1993 Federal Register on Management and Monitoring Systems (*20*).

LANE CLOSURE TIMES

Numerous factors influence the lane closure times for every rehabilitation alternative evaluated. While the initial traffic control scheme will be a major consideration in selecting the alternative, that initial scheme and the accompanying delays are only one consideration. Recalling that the analysis covers the life of the alternative, the times of concern are not just those incurred during initial construction of the alternative, but must include those times associated with routine maintenance and with other rehabilitation

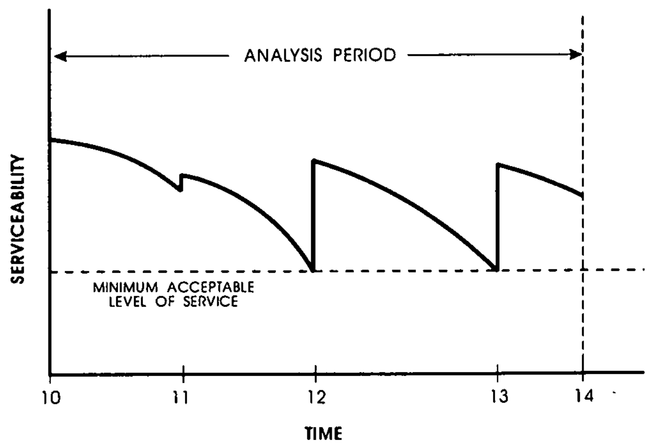

FIGURE 33 Performance curve illustrating rehabilitation and maintenance activities over the analysis period (*87*).

TABLE 5
FACTORS TO CONSIDER: PAVEMENT RESURFACING ECONOMIC ANALYSIS

Economic Factors	Project Factors (1)
Analysis Period	Alternatives
Discount Rate	Pre-overlay Repair Costs
Escalation Rate	Initial Resurfacing Costs
Analysis Method	Maintenance Costs (2)
	Future Rehabilitation Costs
	Salvage Value

(1)Each activity may contain traffic handling and/or user costs.
(2)May be repeated several times in an analysis period.

actions foreseen for the analysis period. Viewed in this manner, it may not be immediately obvious which alternative would be most acceptable to users. For example, some alternatives may cause large initial lane closure times, but little interference with traffic for the rest of the analysis period. Other alternatives may be initially accomplished with little traffic interference, but require other actions in a short period of time. Thus, only a long-range view permits the designer to determine the most desirable alternative in terms of traffic interference. Even then, the relative costs of the various alternatives may outweigh the traffic concerns. Some of the more important traffic handling issues are discussed next as a part of the life-cycle cost analysis.

LIFE-CYCLE COST ANALYSIS

Again, the treatment of all details of life-cycle cost analysis (often referred to as economic analysis) is beyond the scope of the present synthesis. The basic framework for such an analysis and the major issues identified in the present effort are discussed below. Numerous references have additional information on the approach (*17,19,42,90-93*). Most of the important issues relating to the analysis of a pavement resurfacing project are listed in Table 5. The factors are listed according to economic or project categories.

The Analysis Period

It is important that the analysis period used realistically account for the future plans for the roadway section under consideration. For example, if a pavement will be reconstructed in 10 years, a 20-year rehabilitation analysis is inappropriate. On the other hand, in the absence of long-term restrictions, a 25- to 40-year period may be totally acceptable. Like many others in the life-cycle cost analysis, this issue will be somewhat site dependent.

The Discount Rate

The discount rate is the factor used in economic analysis to bring the costs of various actions taking place over the analysis period to a common basis for comparison. Historically, it has been one of the most volatile issues in life-cycle cost analysis. There seems to be general agreement that a defensible rate is the difference between the market interest rate and the rate of inflation using constant dollars (*89*). However, there is still considerable disagreement on exactly what that definition means, because the market interest rate has become highly unpredictable in the past few years. Because they vary widely with time and other factors, the discount rate should be estimated at the time an analysis is undertaken and for the conditions prevailing at that time. Values most often noted in the literature range approximately from 1 to 10 percent (*89-91*).

Salvage Values

Among other controversial life-cycle cost analysis issues is the salvage value of the pavement or of the alternative at the end of the analysis period. Some economists have used the inherent (market) values of the materials in the pavement as the salvage value. Others have argued that salvage value is an issue so far into the future that discounting will diminish it and it may be ignored in most cases. A more common approach is to assume that the salvage value will not be significantly altered by the choice of alternative, and it will not contribute to the decision-making process.

Cost Analysis Methods

There are two generally accepted methods of conducting life-cycle cost analysis: the present worth and the uniform annual cost methods. Present worth involves using the discount rate to express the cost of future expenditures in terms of present dollars. When various alternatives are considered, an expenditure stream for each alternative must be estimated and the total present costs of those alternatives compared. Other factors being equal, the alternative with the lowest present worth would be the most desirable.

The uniform annual cost method involves expressing all expenditures in terms of uniform annual costs. Some analysts prefer this method for pavement because routine maintenance expenditures can be conveniently expressed as uniform annual costs without the need for a discounting process. However, one-time expenditures such as rehabilitation costs must be first converted to a present value, then to an annual cost.

Some economists have shown that the present worth and the annual cost methods, performed with the same discount rate on the same expenditure streams, will result in the same preferred alternative (*93*). Examples of both types of analysis are given in Synthesis 122 (*89*). Whichever approach is used, it is necessary to express all costs in similar units so they can be combined for the economic analysis. In the case of pavement alternatives, it is common to consider the costs in terms of length or area paved. Factors for use in discounting at various discount rates are given in Synthesis 122 for both the present worth and uniform annual cost methods.

Initial Resurfacing Costs

A major element in the life-cycle cost analysis of a pavement rehabilitation alternative is the initial cost of the rehabilitation, in this case a PCC resurfacing. A realistic assessment of that cost involves consideration of all the costs encountered. These will include at least the following:

- Engineering costs including design, inspection, materials testing, etc.
- Traffic control costs including the costs of constructing any necessary detours
- Any quantifiable user costs related to delays, etc.
- The costs of repair to the underlying pavement and for preparing the surface for the overlay
- The costs of furnishing, placing, finishing, texturing, curing, and jointing of the overlay (including bonding material or unbonding interlayers, etc.)
- The costs of final preparation such as rebuilding shoulders, installing drainage features, and other incidental costs.

When the present value approach to life-cycle cost analysis is applied, this initial rehabilitation cost (the sum of the six items listed above) is one of the major elements in the present value. If the uniform annual cost approach is chosen, it is necessary to spread the initial cost over the full analysis period.

It should be further noted that the analysis can be simplified whenever it can be established that a cost element is common, in all aspects, to all alternatives under consideration. An example might be the cost of providing detours where the same detours would apply to all alternatives for the same periods of time.

Existing Pavement Preparation Time and Cost

All PCC resurfacing alternatives will have some common existing pavement preparation requirements. Examples of these are the removal and repair of base failures, the repair of local pavement failures, the repair of badly deteriorated joints, and the rehabilitation or provision of adequate pavement drainage systems. Often, these repairs can be made with the closure of the lane where the work is taking place while traffic is maintained on adjacent lanes. On some projects, it has been convenient to use "slip" lanes to move traffic to opposing lanes even during this preliminary stage. Whatever the approach taken, all the costs of repairs and traffic control must be considered.

Routine Maintenance Costs

The costs of anticipated routine maintenance should be considered an integral part of the life-cycle cost analysis. However, the frequency and cost of many such activities have proven hard to define as most highway agencies do not capture the necessary data. Routine maintenance needs are very difficult to predict with any degree of confidence so the tendency is to use historical data. Again, NCHRP Synthesis 122 found that "Maintenance costs themselves are generally not gathered with the precision required for a life-cycle cost analysis" (*89*). That same synthesis identified several ongoing research studies and FHWA policy statements (*20,92*) that will encourage the development of better data on maintenance costs.

Depending on the specific alternative under consideration, examples of routine maintenance costs that may apply to PCC resurfacing are joint cleaning and resealing, spall and other surface repairs, local undersealing, and local base repairs. Agencies may be able to identify others depending on specific internal maintenance and level-of-service policies. Not every activity will apply to each alternative. CRC resurfacing, for example, may have little or no need for joint cleaning and resealing.

It is unlikely that all of the identifiable maintenance activities will be performed each year. However, for analysis purposes some may be assumed to occur each year while others are planned periodically. For example, a small outlay for surface repairs may be expected each year while joint cleaning and resealing is planned every 8th year. The frequencies of various activities also may be agency specific. For a realistic analysis, it is important to keep in mind that each maintenance activity may have secondary costs such as traffic control, mobilization, and user costs. These costs should also be included in the analysis, either directly or as "add-ons" to the cost of the activity. For example, the unit cost of joint resealing may include elements for traffic control, user costs, etc.

Voigt and Knutson (*90*) have published Iowa data on the cost of various routine maintenance activities. These may be of value to designers who do not have their own database of costs.

Future Rehabilitation Costs

Other major cost elements are associated with rehabilitation of the pavement at some future date. For each alternative it is necessary to estimate if and when, within the analysis period, the pavement will require major rehabilitation work. Then, the total costs of those rehabilitation actions must be estimated and either expressed as present value expenditures or pro-rated over the analysis period. Again, traffic control and other peripheral costs should not be ignored.

In some cases, two or more rehabilitation actions may be expected to occur during the analysis period. For example, over a 25-year analysis period it is not unreasonable to expect a jointed pavement to require joint grinding at some point and a slab replacement at some other time. Again, it may be necessary for the designer to use historical data to make the necessary time, action, and cost estimates. The Iowa data are available as a starting point for those who do not have their own (*90*).

Performing the Analysis

The principles of engineering economic analysis are explained in various textbooks (*93*), and pavement-specific examples are plentiful in Synthesis 122 and its references. In addition, the paving industries have published examples of analyses pertaining to pavement rehabilitation alternatives, some that incorporate PCC overlays (*90,91*). These examples offer excellent guidelines for conducting the life-cycle cost analysis, but must be considered in light of the economic and other conditions prevailing at the time the analysis is conducted.

CHOOSING THE ALTERNATIVE

Even after the life-cycle cost analysis has been completed, the appropriate alternative may not be immediately obvious. The FHWA (*20*) noted the need to apply engineering judgment and to consider the needs of the specific project in the decision-making process. The AASHTO design guide (*17*) provides nonmonetary considerations which may influence the selection even after the economic analysis has been completed, such as the expected service life, the duration of construction, traffic control problems, use of designs proven for a specific region, constructibility, and maintainability. The guide also offers a decision matrix containing costs and these factors with suggested weightings for each factor.

On a Kansas project, Gisi (*58*) found it advisable to employ a Value Engineering Committee, now used by nearly every DOT, to help in the decision-making process after the economic analysis had been completed. These committees examine issues not included in an economic analysis, such as constructability.

PCC RESURFACING IN STAGE CONSTRUCTION

PCC resurfacing is an alternative for use in stage-constructed pavement in which, for various reasons, the pavement is originally designed and constructed with less structural capacity than is required over the normal design life. According to AASHTO (*17*), experience in some states has shown that there may be a "practical maximum performance period" associated with some pavement in some traffic streams. To realistically consider analysis periods that are longer than this maximum period it is necessary to consider stage construction or "planned rehabilitation" early in the design process. The design guide (*17*) provides for use of rehabilitation design procedures in assessing the original pavement and the thickness of the second stage.

CHAPTER EIGHT

CONCLUSIONS AND RESEARCH NEEDS

This chapter identifies conclusions relating to changes in PCC resurfacing technology that have taken place since the previous synthesis. The fact that another synthesis was initiated only about 10 years after the first is evidence that the technology is rapidly changing. It also suggests that there has been a rapid increase in the number of PCC overlays in service. These changes have been described in the earlier chapters and are summarized below.

The Growth in PCC Resurfacing Use

The past decade has seen a substantial increase in the numbers of PCC resurfacing projects reported by the various states, cities, and airport authorities. From a total of 375 projects documented in 1982, there are now more than 700 known to be in use.

For highways and city streets, the greatest use has been and continues to be in the central part of the country, including the midwestern and western states. Iowa alone has more than 150 PCC resurfacing projects in service at this time. Michigan has also been a big user, along with Texas and California. In the East, the major user has been New York, joined in recent years by Pennsylvania. A new user is Colorado which, as discussed below, has become a major user of PCC overlays for both concrete and asphalt pavement. One apparent cause for the increased popularity of PCC overlays involves the increased volume and weights of truck traffic with the accompanying increase in 80kN (18-kip) equivalencies generated.

The Growth in Whitetopping

Perhaps the most dramatic change in PCC resurfacing is the rapid increase over the past decade in the use of whitetopping on highway pavement. Whitetopping is used either as an additional surface or as an inlay to an AC pavement. The literature suggests that much of this growth has taken place in response to increased rutting and other distresses on AC pavement in heavy truck corridors. Given the results of theoretical, laboratory, and field studies indicating that rigid layers would be more resistant to the effects of higher axle loads and tire pressures, some agencies have chosen to combat these distresses through the provision of a more rigid surface course.

The number of documented whitetopping projects has grown from approximately 70 in 1982 to more than 150 in 1993. Again, much of that growth has been in the states where rutting of asphalt concrete has been a recurring problem. Colorado, Nevada, and Nebraska combined have added more than 30 whitetopping projects in the past few years.

Fast-Track Paving

The efforts initiated in the mid 1980s to demonstrate the feasibility of constructing PCC resurfacing in a "fast track" mode have proven to be worthwhile and have resulted in another advancement to the technology. This advancement, coupled with the introduction of the zero-clearance paver, permits PCC overlay rehabilitation projects to be reopened to traffic within a day or two of the beginning of paving operations. This speed clearly enables fast-track PCC overlays to compete more readily with other resurfacing alternatives.

Improvements in Design and Construction Aids

The past decade has seen enormous improvement in the exchange of design and construction information relative to all types of PCC resurfacing. Major research projects have addressed bonded and unbonded overlays as well as whitetopping on a national basis. These studies have provided a wealth of new construction and design information that is the foundation for new construction manuals and revised design procedures. The most evident of these are new *AASHTO Guide Construction Specifications for Overlays* (*10*) and the 1993 *AASHTO Pavement Design Guide*. Finally, the concrete paving industry has issued well-written and highly understandable technical bulletins dealing with bonded and unbonded overlays, whitetopping, and fast-track paving.

All of these efforts have been supplemented and made more meaningful by FHWA initiatives concerning pavement management. These initiatives have encouraged an objective and structured approach to rehabilitation design, including the use of economic analysis.

Other Changes in Technology

Several other recent changes in the technology of PCC resurfacing deserve special mention.

The preparation of the old pavement surface to receive a bonded overlay has undergone some major changes in the last decade. The application of chemicals as the preferred cleaning method has given way to the use of mechanical devices. This change is due in part to environmental concerns about the use of some of those chemicals and in part to improvements in the equipment needed to do the job mechanically. Fast shotblasting machines that clean the surface without causing undue damage to the underlying concrete are now available.

Another change in bonded overlays is the attitude toward the use of grout at the interface. Several agencies have successfully constructed bonded resurfacing with excellent bond strength without using grout. As addressed in part by the SHRP SPS-7 experiment (*7*), further study of the benefit of grout appears warranted.

On unbonded overlays, the practice of matching joints in the overlay to those in the underlying pavement has completely given way to mismatching. Guide specifications now call for an offset of at least 0.9 m (3 ft) to provide for a sleeper slab effect, which provides improved load transfer and performance.

AC is no longer considered to be a bond breaker for unbonded overlays and whitetopping projects, though it is still useful as an interface layer. The AC tends to adhere to the PCC overlays, especially in hot weather. A "whitewash" film of membrane curing compound or lime-water is now used on the surface of the AC to inhibit overheating. The surface cooling both reduces the adhesion between layers and assists in avoiding some of the early curing problems associated with too much heat in the newly placed concrete overlay.

Another new development in interfaces for unbonded overlays is the use of drainage layers. The drainage layer serves the dual purposes of debonding and enhancing drainage. NCHRP Project 10-41 (*45*) will evaluate the performance of unbonded PCC overlays with special emphasis on the interlayer.

Performance Overview

One advantage of following a synthesis with a second effort a decade later is that more performance data are available. The obvious reason for this is that the first synthesis catalogued and made the earlier projects more readily available to academia, industry representatives, and agency personnel who might have an interest in following the results of projects. Another is the increased interest nationally in pavement management systems and the accompanying demands by managers for accountability in public investment. The result is greater documentation of both good and poor performance of pavement sections. The following performance overview makes use of that improved documentation and the research studies discussed earlier.

A factor found to contribute to the performance of all types of PCC overlays is the uniformity of support conditions. PCC overlays, like PCC pavement, are relatively brittle structures and cannot tolerate large variations in the support provided by the underlying layer.

Other factors especially important to PCC overlay performance are the use of positive load transfer devices and drainage features. Both are essential for routes that carry medium or heavy volumes of truck traffic if satisfactory long-term (more than 15 years) performance is to be obtained (*49*).

Finally, like on-grade pavement, where the geometrics permit, all types of PCC overlays seem to benefit from the use of widened lanes, tied shoulders, or both. Overlays are special classes of concrete pavement, and many of the features found to enhance the performance of PCC pavement are applicable. Reducing stresses imposed by edge loadings is one of those helpful features.

Bonded Overlays

Bonded overlays have experienced mixed success from a performance point of view. While some projects have performed well for more than 20 years, others have shown substantial distress within the first year or two. Almost every time, however, bonded overlays that have failed early were later deemed to have been used where the underlying pavement condition was too poor to accommodate the overlay. The mechanisms of failure generally are reflective cracking and slab breakup from nonuniform support conditions.

While it is undesirable for a bonded overlay to lose the bond with the underlying pavement, the loss of that bond does not in itself constitute failure of the overlay. Several studies have documented 15 or more years of good resurfacing service even though the bond may never have existed at the interface.

Although the majority of bonded overlays have been the jointed plain type, jointed reinforced also have given good performance when used under the proper circumstances. All types have also shown substantial distress when improperly used. Again, the recommended use is to repair surface deterioration or to structurally enhance an existing pavement by taking advantage of the monolithic slab behavior of the overlay and existing pavement combined.

Unbonded Overlays

Unbonded overlays have demonstrated good performance on a large number of projects—some for well over 30 years. Where failures have occurred, most have been traced to inadequate thickness of separator layer and unanticipated bonding at the interface, to nonuniform support conditions, to inadequate load transfer, or to inadequate drainage. The unexpected bonding permits deterioration in the underlying pavement to be reflected through the overlay and may cause its structural failure. The other factors contributing to poor performance are applicable to on-grade pavement as well as to unbonded overlays.

Random cracking of unbonded overlays has been related to the use of excessive slab lengths for unreinforced pavement and to late sawing of both transverse and longitudinal joints. Studies have shown that the slab length in feet should not exceed 1.75 times the slab thickness in inches if uncontrolled cracking is to be avoided. Thus, a 200-mm (8-in.) thick pavement should have a slab length of no more than 4.3 m (14 ft). This is somewhat more restrictive than the factor 2 used for on-grade plain pavement.

Again, plain, reinforced, and continuously reinforced unbonded overlays have provided good service when the above precautions have been observed. CRC pavement needs a minimum thickness to provide adequate steel cover and may need to be at least 150 mm (6 in.) thick in order to provide good performance.

A performance review of unbonded and partially bonded resurfacing reported as having been removed from service shows that approximately two-thirds of such overlays can be expected to last at least 20 years.

Whitetopping

While many whitetoppings are too new to provide performance data, most of those that have been in service for some years are providing good to excellent performance. The argument can be made that the underlying AC pavement provides an ideal subbase course for the PCC resurfacing layer. Generally, the asphalt concrete layer possesses the desired properties of strength and uniformity of support. There is reason to believe that whitetopping will continue to be a popular alternative.

Where performance problems have been identified they generally have been related to the failure to provide adequate drainage and to the absence of dowels in joints. If either condition exists, PCC overlays in service for 10 to 15 years can be expected to demonstrate significant joint faulting. Overlays without adequate drainage features may also be subject to pumping.

Inlays, a special class of whitetopping, also can provide good service, but must be designed with both positive drainage and positive load transfer features.

RESEARCH NEEDS

In the course of data collection, field reviews, and discussions with people in the business of specifying or constructing PCC overlays, the following issues have been identified as in need of additional research. Some were identified in Synthesis 99 and have yet to be adequately addressed.

A thorough understanding of the unbonding medium (separation layer) for unbonded overlays still needs development. There is evidence that asphalt concrete and most other materials often thought to serve as bond breakers do, in fact, bond to the overlay, at least to a modest degree. The magnitude of that bonding and its impact on design assumptions is yet to be analyzed. Many of these issues may be addressed in proposed NCHRP Project 10-41 (*45*) mentioned earlier and in NCHRP Project 1-30, *Support Under PCC Pavements* (*94*).

Similarly, the interface between whitetopping PCC layers and the underlying asphalt concrete pavement is not well understood. Recent field work and preliminary performance studies suggest that the overlay and the underlying pavement may function much more monolithically than earlier assumed. The result is that some thin overlays have performed significantly better than expected. The design assumptions used in this type of overlay also are in need of further study. Some work in this area is now underway (*44*).

Another interface issue still to be fully evaluated concerns the use of grout between bonded PCC overlays and the underlying pavement. Recent studies have shown mixed results; i.e., in some cases bond strengths are higher when the grout is used, though in others it is higher when the grout is omitted. Because there are clear economic advantages to omitting the grout, a study of the technical merits would be beneficial. This research will, in part, be addressed through the SHRP SPS-7 experiment.

While the data analyzed in this synthesis suggest excellent performance of many PCC overlays, the approach employed necessarily involved the aggregation of data that are far too global to support conclusions relating to variations in design features. Now that most overlays are incorporated in working pavement management systems, much of the detailed supporting data should become available over the next few years. There is a need for additional research, when it is possible, relating overlay performance to variations in underlying pavement condition, interface type, and overlay thickness as a function of interface type. The condition of underlying pavement prior to overlay is an especially important need.

There is a need for additional work in the area of materials to be used in the fast-track paving mode. While high cement factor Type I and Type III cements are frequently used, enough early cracking and other performance problems have been identified to suggest that further study would be warranted. Specialty concretes such as those modified with polymers may deserve additional consideration. In addition, improved guidelines for concrete mixture proportioning and early curing of fast-track projects may be needed.

There is a continuing need for research into techniques of rehabilitating existing pavement in preparation for resurfacing. One approach that seems to need validation on rehabilitation work is the "cross-stitch" (*9*) method of strengthening longitudinal cracks. The method has been used successfully to repair random cracking of new pavement and may be a cost-effective measure for rehabilitation work.

GLOSSARY

aggregate interlock A load transfer mechanism whereby the shear is carried by the aggregate-cement paste interface.

alternatives Different courses of action or systems that will satisfy objectives and goals (*89*).

analysis period The time period used for comparing design alternatives. An analysis period may contain several maintenance and rehabilitation activities during the life cycle of the pavement being evaluated (*89*).

blowup An upward eruption of a concrete pavement slab near a crack or joint (*95*).

bonded concrete overlay A portland cement concrete pavement layer used as a resurfacing for and bonded to an existing portland cement concrete pavement.

bridge protection expansion joints PCC pavement expansion joints designed to protect on-grade structures from forces exerted by growth or movement of the pavement toward the structure.

cement grout A slurry, usually consisting of portland cement and water, used to enhance the bond at the interface between a bonded concrete overlay and the underlying pavement.

construction joint A joint made necessary by a prolonged interruption in the placing of concrete (*18*).

continuously reinforced concrete pavement (CRCP) Portland cement concrete pavements with no transverse joints and with relatively heavy amounts of longitudinal steel to ensure holding the cracks tightly closed (*96*).

contraction joint A joint normally placed at recurrent intervals in a rigid slab to control transverse cracking (*18*).

curling Deformation of a pavement slab caused by a temperature gradient between the two surfaces of the slab.

deflections Vertical deformation of a pavement under an applied load.

design life The length of time (in years) for which a pavement facility is being designed, including programmed rehabilitation (*89*).

discount rate A value (in percentage) used as the means for comparing the alternative uses for funds by reducing the future expected costs or benefits to present-day terms. Discount rates are used to reduce various costs or benefits to their present worth or to uniform annual costs so that the economics of the different alternatives can be compared (*89*).

dowel A load transfer device consisting of a plain round steel bar in a rigid slab (*18*).

equivalent dollars Dollars, both present and future, expressed in a common baseline reflecting the time value of money and inflation (*89*).

expansion joint A joint located to provide for expansion of a rigid slab, without damage to itself, adjacent slabs, or structures (*18*).

faulting Elevation or depression of a slab in relation to an adjoining slab (*95*).

fiber-reinforced concrete (FRC) Portland cement concrete containing uniformly distributed steel or other fibers.

interlayer See separation layer.

jointed plain concrete pavement (JPCP) Jointed portland cement concrete pavement with or without joint load transfer devices and having no distributed steel reinforcement.

jointed reinforced concrete pavement (JRCP) Jointed portland cement concrete pavement having distributed steel reinforcement.

life-cycle costing An economic assessment of an item, area, system, or facility and competing design alternatives considering all significant costs of ownership over the economic life, expressed in terms of equivalent dollars (*89*).

load transfer device A mechanical means designed to carry loads across a joint in a rigid slab (*18*).

maintenance Work done to the pavement after original construction until complete reconstruction, excluding shoulders and bridges. It includes pavement rehabilitation and restoration (*97*).

pavement condition The present status or performance of a pavement (*97*).

pavement performance Measure of accumulated service provided by a facility; i.e., the adequacy with which it fulfills its purpose based on all indicators or measurement types (*97*).

plain concrete Portland cement concrete without reinforcing steel.

present worth method Economic method that requires conversion of all present and future expenditures to a baseline of today's costs (*89*).

pumping The ejection of foundation material, either wet or dry, through cracks or joints, or along edges of rigid slabs resulting from vertical movements of the slab under traffic (*18*).

reactive aggregates Portland cement concrete aggregates having the property of reacting chemically with components of the cement.

rehabilitation The act of restoring the pavement to a former condition so that it can fulfill its function (*97*).

rigid pavement A pavement structure which distributes loads to the subgrade, having as one course a portland cement concrete slab of relatively high bending resistance (*18*).

salvage value The value (positive if it has residual economic value and negative if it requires demolition) of competing alternatives at the end of the life cycle or analysis period (*89*).

separation layer An asphalt concrete or other stress-relieving layer used at the interface between an unbonded concrete overlay and the underlying concrete pavement.

subbase The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a base course (or in the case of rigid pavements, the portland cement concrete slab) (*18*).

tiebar A deformed steel bar or connector embedded across a joint in a rigid slab to prevent separation of abutting joints (*18*).

unbonded concrete overlay A portland cement concrete layer used as a resurfacing for an underlying portland cement concrete pavement, but separated from that underlying pavement by a separation layer.

user costs Those costs that are accumulated by the user of a facility. In a life-cycle cost analysis these could be in the form of delay costs or changes in vehicle operating costs (*89*).

warping Deformation of a pavement slab caused by a moisture gradient between the two surfaces of the slab.

whitetopping A portland cement concrete pavement layer used as a resurfacing for an underlying flexible pavement.

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APPENDIX
RESURFACING PROJECTS

TABLE A-1
BONDED PORTLAND CEMENT CONCRETE RESURFACING PROJECTS

Proj. No.	Location	State	Use	Resurfacing Year Built	Resurfacing Thick-ness(in.)	Resurfacing OL Type	Resurfacing Inter-face	Existing Pavement Year Built	Existing Pavement Thick-ness(in.)	Existing Pavement Type
1	Warsaw St., Toledo, Ohio	OH	S	1913	1-2	JRCP	B	1912	6	JPCP
2	Market St., Savannah, Mo.	MO	S	1914	1-2	JRCP	B	1913	5	JPCP
3	Wisconsin	WI	S	1917	3-1/2	JRCP	B	-	-	JPCP
4	Olive St., Pine Bluff, Ark.	AR	S	1921	4	JRCP	B	-	-	JPCP
5	Aberdeen, Wash.	WA	S	1921	1/4-1/2	Gunite	B	-	8	JPCP
6	Route 42A, Ill.	IL	H	1931	2-1/2 - 3	JRCP&JPCP	B	-	6	JPCP
7	Route 44, Providence, R. I.	RI	H	1936	2	JPCP	B	-	6	JPCP
8	Highway near Albany, N.Y.	NY	H	1938	2	JPCP	B	-	-	JPCP
9	US-322, Grampian, Pa.	PA	H	1938	2-9	JPCP	B	-	6-8-6	JPCP
10	SR-11, Tulsa	OK	H	1941	4	JRCP	B	-	6-1/4	JRCP
11	Meadowbrook Rd., Rochester, N.Y.	NY	H	1942	1-1/2	JPCP	B	-	6	JPCP
12	Main St., bus stop, Rochester, N.Y.	NY	S	1942	4	JPCP	B	-	6	JPCP
13	General Pulaski Skyway, N.J.	NJ	H	1946	4-3/4	JPCP	B	-	11-1/2	AC/JPCP
14	W. Seventh St., Hastings, Nebr.	NE	S	1948	4	JPCP	B	1911	3/4	AC/JPCP
15	W. First St., Hastings, Nebr.	NE	S	1948	4	JPCP	B	1913	3/3-1/2	AC/JPCP
16	South St., Hastings, Nebr.	NE	S	1949	4	JPCP	B	-	3/4	AC/JPCP
17	Llene Street, Detroit Mich.	MI	S	1950	1/2	(g)	B	-	-	JPCP
18	Martha Washington Dr., Wauwatosa	WI	S	1951	2	JRCP	B	1931	6	JPCP
19	Second Ave., N., Minneapolis, Minn.	MN	S	1952	1/2 - 2	JPCP	B	1939	6	JPCP
20	Tennant Co., driveway, Minneapolis	MN	S	1952	1	JPCP	B	-	7	JPCP
21	Runway, Laredo AFB, Tex.	TX	A	1952	2	JPCP	B	1943-44	6 & 7	JPCP
22	Apron, Little Rock AFB, Ark.	AR	A	1954	1-1/2 - 2	JPCP	B	1954-55	15	JPCP
23	Skokie, Ill.	IL	S	1954	1/4 - 2	JPCP	B	1929	6	JPCP
24	Pennsylvania Turnpike	PA	H	1954	2	JRCP	B	1940	9	JRCP
25	Pennsylvania Turnpike	PA	H	1954	1/2 - 1	JPCP	B	1940	9	JRCP
26	City Street, Burlington, (Old US-34)	IA	H	1955	1-3	JPCP	B	1921	-	JPCP
27	US-62, WBL, Lawton	OK	H	1955	4	JRCP	B	-	-	JPCP
28	Apron, Selfridge AFB, Mich.	MI	A	1956	1 - 1-1/2	JPCP	B	1929-42	6-10	JPCP
29	Hardstands, Campbell AFB, Ky.	KY	A	1957	2	JPCP	B	1957	15	JPCP
30	Apron, Grissom AFB, Ind.	IN	A	1959	3	JPCP	B	1942-43	10-8-10	JPCP
31	Runway 1-19, Standiford Fld, Louisville	KY	A	1959	4	JPCP	B	1944	6/9-6-6-9	AC/JPCP
32	Runway, Randolph AFB, Tex.	TX	A	1960	2-1/2	JPCP	B	1944	8	JPCP
33	Apron, Glenview NAS (Phase I), Ill.	IL	A	1961	5	JPCP	B	1941-42	6 & 7	JPCP
34	Runway, Andrews AFB, Md.	MD	A	1961	2-6	JPCP	B	1941	12-9-12	JPCP
35	Runway, apron, Otis AFB, Mass.	MA	A	1962	7	JPCP	B&P	1955	10	JPCP
36	Kellogg Field, Battle Creek, Mich.	MI	A	1962	2	JPCP	B	-	8	JPCP
37	Apron, Glenview NAS (Phase II), Ill.	IL	A	1963	5	JPCP	B	1941-42	9	JPCP
38	Apron, Detriot Municipal Airport	MI	A	1963	2	JPCP	B	1935-41	9	JPCP
39	Runway, Selfridge AFB, Mich.	MI	A	1963	3	JPCP	B	1954	12	JPCP
40	Runway, Grissom AFB, Ind.	IN	A	1965	2	JPCP	B	1954-55	14	JPCP
41	Apron, Rickenbacker AFB, Ohio	OH	A	1967	2	JPCP	B	1954	12	JPCP
42	Glenview NAS	IL	A	1971	6	CRCP	B	-	6	JPCP
43	Glenview NAS	IL	A	1971	5	CRCP	B	-	7	JPCP
44	Route E-33, Greene Co. Iowa	IA	H	1973	2 & 3	FRC	B,U,P	1921-22	8-1/2	JRCP
45	Snelling Ave., St. Paul, Minn.	MN	S	1974	2 & 3	FRC	B&P	-	-	JPCP
46	Snelling Ave., St. Paul, Minn.	MN	S	1974	3	FRC	B	-	-	JPCP
47	Apron, Reno Municipal Airport	NV	A	1975	4	FRC	B	1958-59	11	JPCP
48	Hammond Ave., Waterloo, Iowa	IA	S	1976	1-2	JPCP	B	1940	6	JRCP
49	FN-20-6(21), .284 mi.	IA	H	1976	2	JPCP	B	1958	-	JPCP
50	Prospect Blvd., Waterloo, Iowa	IA	S	1976	1-2	JPCP	B	1940	6	JRCP
51	US-20, Waterloo, Black Hawk Co.	IA	H	1976	2	JPCP	B	1958	10	JPCP
52	C-17, Clayton Co., Iowa	IA	H	1977	2	JPCP	B	1968	6	JPCP
53	C-17, Clayton Co., Iowa	IA	H	1977	3,4,5	JRCP	B	1968	6	JPCP
54	SR-12 (SBL), Sioux City	IA	H	1978	3	JPCP	B	-	9	JPCP
55	US-20, Sioux City, Iowa	IA	H	1978	3	JPCP	B	-	9	JPCP
56	Rnwy 4/22, Willard Aprt, Champaign	IL	A	1978	8	JPCP	B	1944	8	JPCP
57	I-35, Blaine, Minn.	MN	H	1978	2-3	JPCP	B	1969	8	CRCP
58	I-80, Pottawattamie Co., Iowa	IA	H	1979	3	JPCP	B	1966	8 & 10	CRCP&JRCP
59	Public Square, Indianola, Iowa	IA	S	1979	2	JPCP	B	1949	6	JRCP
60	Route 12, N. of Utica, (5 inlays)	NY	H	1979	2	JPCP	B	1970	9	JPCP
61	Vine Street, W. Des Moines, Iowa	IA	S	1980	2	JPCP	B	1950-60	5-6	JPCP
62	City Square, Indianola, 10,300 sy	IA	S	1980	2	JPCP	B	1949	-	JPCP
63	SW & NE Taxiway, Willard Aprt, Champ.	IL	A	1980	7	JPCP	B	1944	8&9	JPCP
64	Hangar Taxiway, Willard Aprt, Champ.	IL	A	1980	7	JPCP	B	1962	9	JPCP
65	Runway, Newark Int. Airport - RW 22R	NJ	A	1980	3	FRC	B	-	-	FC
66	New Utrecht Ave., N.Y. City, N.Y.	NY	S	1980	2	JPCP	B	-	-	JPCP
67	I-80, W. of Truckee Calif.	CA	H	1981	2.5,3,3.6	JPCP	B	-	8	JPCP
68	Great River Road, Clayton Co.	IA	H	1981	3	JPCP	B	1968	6	JPCP
69	US-61, Port Hudson, La.	LA	H	1981	3 - 4-3/4	JPCP	B	1960	-	JPCP
70	I-81, I-481 Int. to 3 mi. N. of S'cuse	NY	H	1981	3	JPCP	B	-	9	JPCP
71	I-81, Syracuse	NY	H	1981	3	JPCP	B	1957	9	JRCP
72	I-88, SB, Duanesburg, 700' (Inlay)	NY	H	1981	2	JPCP	B	1981	9	JPCP
73	W. Des Moines, 1982 #1	IA	S	1982	2	JPCP	B	1950	-	JPCP
74	Bloomington	IL	S	1982	2	JPCP	B	-	-	-
75	Rickenbacker Field, Colombus	OH	A	1982	6	JPCP	B	-	-	JPCP
76	IA 141, MP 134-138, Dallas Co.	IA	H	1983	3 to 4-1/2	JPCP	B	1941	10-7.5-10	JRCP
77	W. Wood Street, Bloomington	IL	S	1983	2	JPCP	B	-	-	-
78	US-160, Main Street, Parsons	KS	S	1983	3-1/2	JPCP	B	-	-	JPCP
79	I-70, Sherman Co., 0.28 mi., Inlay	KS	H	1983	1-1/2	JPCP	B	1983	10	JPCP
80	I-610, EBL, Houston	TX	H	1983	3	JPCP	B	1970	8	CRCP
81	I-610, EBL, Houston	TX	H	1983	2	FRC	B	1970	8	CRCP
82	I-610, EBL, Houston	TX	H	1983	2	JPCP	B	1970	8	CRCP
83	I-610, EBL, Houston	TX	H	1983	3	FRC	B	1970	8	CRCP
84	I-610, EBL, Houston	TX	H	1983	2	JPCP	B	1970	8	CRCP
85	US-10, Prescott	WI	H	1983	7	JPCP	B	1934	-	JRCP

Construction and Performance Remarks	Status in 1992	Proj. No.
Correct construction deficiency (frozen surface).	No new information.	1
Correct construction deficiency (roughness).	No new information.	2
-	Not enough information available for follow-up.	3
Surface deterioration of existing pavement.	No new information.	4
Correct construction defic. Gunite surface failed by peeling.	Failed earlier due to gunite peeling.	5
Previous AC surface failed and removed.	No new information.	6
Vacuum processed concrete used to patch existing surface.	No new information.	7
Correct surface distress.	Location too inexact for DOT to locate in 1992.	8
Vacuum processed PC used. Existing pavement structurally distr.	No new information.	9
No information on this item.	No new information.	10
Correct surface distress.	Location too inexact for DOT to locate in 1992.	11
Correct surface distress and strengthen existing pavement.	No new information.	12
Remove AC blocks. Resurface to correct surface defects.	No new information.	13
Distorted AC replaced with PC. Base pavement fair.	3" HMAC Overlay in 1988.	14
Distorted AC replaced with PC. Base pavement fair.	3" HMAC Overlay in 1988.	15
Distorted AC replaced with PC. Base pavement fair.	3" HMAC Overlay in 1988.	16
Correct raveling and scaling of surface.	No new information.	17
Correct surface distress. Existing pavement cracked.	Resurfaced with AC in 1987.	18
Severely scaled surface.	No new information.	19
Severely scaled surface.	No new information.	20
Surface deterioration and rough.	No new information.	21
Correct for frozen surface during construction.	No new information in 1992.	22
Resurface badly cracked and scaled pvmt.	No new information in 1992.	23
Surface scaled with some cracking.	No new information in 1992.	24
Surface scaled with some cracking.	No new information in 1992.	25
Deteriorated surface and cracking in existing PC.	AC Overlay in 1968.	26
No information on this item.	No new information.	27
Correct surface deterioration.	No new information.	28
Correct for surface irregularities during construction.	Good to excellent (PCI's of 58 - 87) (WES).	29
Correct for surface irregularities.	No new information.	30
Strengthen. Correct surface distress and improve grade.	Overlaid in 1972 with project described below, Airport Author.	31
Strengthen and correct surface distress.	Rebuilt in 1991 (USAF).	32
Strengthen and correct surface distress.	Replaced in 1990 (USN).	33
Correct roughness.	4" HMAC overlay in 1968 (USAF).	34
Strengthen and correct surface irregularities.	No new information.	35
Correct surface distress.	No record in 1992, DOT could not find (DOT).	36
Strengthen and correct surface distress.	Replaced in 1990 (USN).	37
Correct surface distress.	No new information.	38
Correct surface distress.	Has performed well w/some corner spalls, spot patching.	39
Correct surface distress.	Pavement replaced in 1985 (USAF).	40
Correct surface distress.	No new information.	41
No information on this item.	No new information.	42
No information on this item.	No new information.	43
Test resurfacings with integral widening. Existing pvmt. crk.	Average maintenance for 15 yrs., avg. perform. (Writer Observed).	44
Test with glass and steel fibers, epoxy and sand-cement bond.	No new information.	45
Test resurfacing of surface distressed area.	No new information.	46
Stengthen and resurface.	No new information.	47
Surface and joint distress, some cracking.	Overlayed in 1992 (Iowa Conc. Paving Assoc.).	48
No information on this item.	No new information.	49
Surface and joint distress, some cracking.	Major cracking and overlay separation (Iowa Conc. Pav. Assoc.).	50
Alleviate joint and surface distress, some cracking.	Joint breakup on 50-75% of jts. extends into old pavement.	51
Strengthen existing pavement for heavier traffic.	Reflective cracking, some joint breakup, perform. satisfactory.	52
Strengthen existing pavement for heavier traffic.	Reflective cracking, some patching, performance satisfactory.	53
No information on this item.	No new information.	54
Correct surface distress. Existing pavement cracked.	Several trans. & long. crks., few small patches at crks.	55
Strengthen existing pavement.	In service (IL Concrete Council).	56
Correct surface distress.	Overlayed in 1991.	57
Correct surface, joint, and crack distress.	1991, recycled, replaced w/ 12" PCC.	58
Correct surface distress.	In service, good condition (Consultant Visited Site).	59
Correct surface distress, deficient air entrainment.	Little wear w/isolated distress due to debonding, patched w/PCC.	60
Correct surface distress and structural deficiencies.	Considerable reflective cracking, needs rehab. (Iowa Conc. Pav).	61
Bonded overlay with grout.	Excellent, but carries little truck traffic (Writer Observed).	62
No information on this item.	In service (IL Concrete Council).	63
No information on this item.	In service (IL Concrete Council).	64
Resurface and raise grade of runway ends.	Good to excellent condition (Port Authority).	65
Correct surface distress.	No new information.	66
Correct surface distress.	No new information, Caltrans could not locate.	67
Strengthen existing pavement for heavier loadings.	Location unknown to DOT in 1992.	68
Correct surface distress and improve rideability.	1985, some corner diag. crk. due to debonding (grout dried).	69
Correct surface distress.	Some jt. faulting, 2 blowups, reflect. crks., punchouts.	70
No information on this item.	No additional information.	71
Current condition is good, little distress.	No additional information.	72
In service.	No additional information.	73
In service.	In service.	74
In service.	In service.	75
Patching and reflective cracking, contract underway for full depth patching and joint maint.	Generally excellent, some isolated patching (Writer Observed).	76
No information on this item.	In service.	77
No information on this item.	In service.	78
Section performing very well.	In service.	79
Details in TRB reports.	In service.	80
Details in TRB reports.	In service.	81
Details in TRB reports.	In service.	82
Details in TRB reports.	In service.	83
Details in TRB reports.	In service.	84
PRS = 3.3 in 1990, avg. fault = 0.11", 0.33 mill. ESAL's.	In service.	85

TABLE A-1
BONDED PORTLAND CEMENT CONCRETE RESURFACING PROJECTS

Proj. No.	Location	State	Use	Resurfacing: Year Built	Resurfacing: Thick-ness(in.)	Resurfacing: OL Type	Resurfacing: Inter-face	Existing Pavement: Year Built	Existing Pavement: Thick-ness(in.)	Existing Pavement: Type
86	I-25, SBL, #2 (20' jt., AC shld.)	WY	H	1983	3	JPCP	B	1968	9	JPCP
87	I-25, SBL, #1 (15.5' jt., AC shld.)	WY	H	1983	3	JPCP	B	1968	9	JPCP
88	I-25, SBL, #3 (20' jt., PC shld.)	WY	H	1983	3	JPCP	B	1968	9	JPCP
89	I-80 WB, Poweshiek Co., MP192.82-183.67	IA	H	1984	4	JPCP	B	1964	10	JRCP
90	I-80 (EBL), Grinnel	IA	H	1984	4	JPCP	B	1964	10	JRCP
91	I-40, Alberquerque	NM	H	1984	3	JPCP	B	-	-	-
92	I-90/I-94, Madison-Portage	WI	H	1984	2	JPCP	B	-	8	CRCP
93	T-61, Wapello Co., 137 to H-21	IA	H	1985	4	JPCP	B	1972	6	JPCP
94	T59, Monroe & Wapello Cos., 2.98 mi.	IA	H	1985	4	JPCP	B	1972	-	JPCP
95	Burlington Aprt, Des Moines Co.,10139sy	IA	A	1985	2	JPCP	B	-	-	JPCP
96	Fillmore Ave., St. Paul, Ramsey Co.	MN	S	1985	3	JPCP	B	-	9	JPCP
97	HWY 38A, N. Side Sioux Falls., 1.73 mi.	SD	H	1985	3	JPCP	B	1950	8	JPCP
98	I-90, Lake Delton-Madison Rd., Dane Co.	WI	H	1985	2-1/2	JPCP	B	-	8	CRCP
99	I-80, Cheyenne	WY	H	1985	3	JPCP	B	-	10	JPCP
100	I-25, Cheyenne	WY	H	1985	3	JPCP	B	-	10	JPCP
101	US 71, MP 177-184, Buena Vista Co.	IA	H	1986	4	JPCP	B	1937	7.5	JRCP
102	11th Ave. W., Oskaloosa, 0.65 mi. long	IA	S	1986	3	JPCP	B	1930	7	JPCP
103	S. Apron, Eppley Field, Omaha	NE	A	1986	-	JPCP	B	1940	12+	JPCP
104	SR-422, New Castle, Lawrence Co.	PA	H	1986	2	JPCP	B	-	9	JRCP
105	SR-380, Pittsburgh	PA	H	1986	2	JPCP	B	-	-	-
106	I-610, Houston	TX	H	1986	4	JPCP	B	-	8	CRCP
107	I-610 North, Houston, 10 Sections	TX	H	1986	4	CRCP/FC	B	-	8	CRCP
108	STH-13, STH-73 to Marshfield, Wood Co.	WI	H	1986	3-1/2	JPCP	B	-	8	JPCP
109	US-56, Barton Co.	KS	H	1987	4	JPCP	B	1955	9	JRCP
110	I-35, Waco	TX	H	1987	4	JPCP	B	-	-	CRCP
111	I-80, WB, (MP 35-39), Pottawattami Co.	IA	H	1988	6	JPCP	B	1966	8	CRCP
112	TR 422, Lawrence Co.	PA	H	1988	3	JPCP	B	-	-	-
113	SR3016, Aliquippa, Beaver Co.	PA	H	1988	2	JPCP	B	-	-	-
114	SH-41, Green Bay	WI	H	1988	3	JPCP	B	1972	-	CRCP
115	SR910, Allegheny County, 1.8 mi.	PA	H	1989	2	JPCP	B	1969	9	JRCP
116	I-280 E & WB, MP 0 - 8, Scott Co.	IA	H	1990	5	JPCP	B	1973	8	CRCP
117	I-435, Johnson Co. (Bonded inlay)	KS	H	1990	2	JPCP	B	1982	9	JRCP
118	I-10, Siegen Lane-Jct. LA 42, 4.36 mi.	LA	H	1990	4	FRC	Edge	1979	8	CRCP
119	Rte. 67, NBL, Jefferson Co., 7.52 mi.	MO	H	1990	4	JPCP	B	1955	8	JPCP
120	I-70, WBL, Cooper Co., 2.53 mi.	MO	H	1990	5	JPCP	B	1963	8	JRCP
121	SR48, Allegheny County, 4.3 mi.	PA	H	1990	2	JPCP	B	-	-	JPCP
122	TR 422, Lawrence Co., 1.1 mi.	PA	H	1990	2	JPCP	B	-	9	JPCP
123	Rte. 13, Northampton Co., SBL, 1.0 mi.	VA	H	1990	3-1/2	JPCP	B	1965	8	JPCP
124	C Ave. & Boyson Rd., Cedar Rapids	IA	S	1991	9	JPCP	B	-	-	JPCP
125	I-35 N.of Co. Rd. D41, Hamilton Co., 4 mi	IA	H	1991	5	JPCP	B	-	-	JPCP
126	Various locations, Eppley Field, Omaha	NE	A	1991	4+	JPCP/JRCP	B	-	-	JPCP
127	I-35, N & SB, MP 134-140, (SHRP SPS-7)	IA	H	1992	Varies	JPCP	B	1967	8	CRCP

S = street; H = highway; A = airfield.
JRCP = Jointed reinforced concrete pavement, JPCP = Joint Plain Concrete Pavement, CRCP = Continuously Reinforced Concrete Pavement,
FRC = Fiber Reinforced Concrete, PRCP = Prestressed Concrete Pavement
F = flexible; AC = asphalt concrete.
B = bonded; U = unbonded; P = partially bonded; W = Whitetopping.

Construction and Performance Remarks	Status in 1992	Proj. No.
No information on this item.	In service.	86
No information on this item.	In service.	87
No information on this item.	In service.	88
Old slabs "D" cracked, 76.5' long slabs.	Patching in 1991, some problems w/underlying patches.	89
No information on this item.	In service.	90
No information on this item.	In service.	91
No information on this item.	In service.	92
Little surface distress, some debonding of one section.	In service.	93
No information on this item.	In service.	94
No information on this item.	In service.	95
No information on this item.	In service.	96
Good condition w/ minor mid-panel cracking.	In service.	97
No information on this item.	In service.	98
No information on this item.	In service.	99
No information on this item.	In service.	100
Fast-Track resurf. w/integral 4' widening,good perform. @ 5 yrs.	In service.	101
Dowels in integral widening only. Project had no grout.	Excellent, (Writer Observed).	102
Have had to do some reconstruction in past year (1991).	In service.	103
No information on this item.	In service.	104
No information on this item.	In service.	105
No information on this item.	In service.	106
Two fiber, 8 CRCP sections, performance OK.	In service.	107
Bonded overlay of existing JPCP. No performance information.	In service.	108
Debonding,surface crk. in two 500' sections,1 blowup in 1990, good ride.	In service.	109
No information on this item.	In service.	110
Resurf. thickness varied from 6-12" to level out grade.	In service.	111
No information on this item.	In service.	112
No information on this item.	In service.	113
Nom. 3" o.lay applied to inplace CRCP, exten. debond. @ 2 yrs.	In service with extensive debonding and crit. distress level.	114
No information on this item.	In service.	115
EBL paved in 1989, some areas not bonded, patched. Good perf.	In service.	116
Midpanel crks. have reflected (as expected), Good perform.	In service.	117
Tied PCC should., steel fiber reinf., some trans. reflect. crks.	In service.	118
SPS-7 Site, Plastic shrink. crk. due to high early strength.	Good except for 1/3 pt. crking. maybe due to HES (Writer Observed	119
Cracking on entire proj., some full depth. Believed due to HES .	Early cracks have performed fairly well (Writer Observed).	120
No information on this item.	In service.	121
No information on this item.	In service.	122
Two 4sf areas of debonding in slurry section @ 18 mos. Good.	In service.	123
No information on this item.	In service.	124
No information on this item.	Some "Y" cracking has been repaired, fair perf. (Writer Observed).	125
Not 100% satisfied with results.	In service.	126
To be built in 1992, see SHRP SPS-7 Requirements.	New, excellent condition (Writer Observed).	127

Table A-2
UNBONDED AND PARTIALLY BONDED PORTLAND CEMENT CONCRETE RESURFACING PROJECTS

				Resurfacing				Existing Pavement		
Proj. No.	Location	State	Use	Year Built	Thick-ness(in.)	OL Type	Inter-face	Year Built	Thick-ness(in.)	Type
1	Grand River Rd., Wayne Co. (82121)	MI	H	1916	3	JRCP	U	1910	6-1/2	JPCP
2	East Brodge St., Oswego, N.Y.	NY	S	1919	4	JRCP	P	1906	4-1/2	AC/JPCP
3	Idaho-Pac. Highway, Old Rte. 30, Boise	ID	H	1920	3	JRCP	U	1912	6	JPCP
4	Highway 119, Taft to Bakersfield, Kern Co.	CA	H	1921	5	JPCP	U	1916	4	JPCP
5	3 Streets, Cape Girardeau, Mo.	MO	S	1922	4 & 5-1/2	JRCP	P	1910	4	JPCP
6	Wetmore Ave., Everett, Wash.	WA	S	1922	5	JPCP	P	-	5	JPCP
7	Route 1, Illinois	IL	H	1923	6	JRCP	P	-	4-1/2	JPCP
8	Water & Central Sts., Peekskill, N.Y.	NY	S	1923	5	JRCP	P	1901	-	AC/JPCP
9	67 Projects, Los Angeles, Calif.	CA	S	1924	5	JPCP	P	-	-	JPCP
10	Rte. 48, Fulton to Oswego, N.Y., 10 mi.	NY	H	1925	4-1/2	JRCP	P	1912	4-1/2	(e)
11	Test Road, Syracuse, N.Y.	NY	-	1925	2-3/4 - 4-1/2	JRCP	P	1914	(d)	JPCP
12	78 Miles of Highway, Calif.	CA	H	1926	5	JRCP	U	-	-	AC/JPCP
13	Main St., Ossining, N.Y.	NY	S	1926	5	JRCP	P	-	4	Brick/JPCP
14	Main Street, Ossining, Westchester Co.	NY	S	1926	5	JRCP	P	-	4	JPCP
15	Rte 96, Ovid to Romulus, N.Y., 5 mi.	NY	H	1926	4-1/2	JRCP	P	-	5	JPCP
16	Boston Rd., Milford to W. Haven	CT	H	1927	9, 6-7	JPCP	P	-	6-8-1/2-6	JRCP
17	Main St., Lexington, Ky.	KY	S	1927	5	JRCP	U	-	-	JPCP
18	US-23, Mt. Morris to M-8, (25052)	MI	H	1927	5	JRCP	U	-	-	JPCP
19	Several Streets, Battle Creek, Mich.	MI	S	1927	2-1/2-5-2-1/2	JRCP	P	-	-	AC/JPCP
20	US-25, Buncombe Co., N.C.	NC	H	1928	6	JPCP	U&P	1916	-	JPCP
21	Main St., Ada, Okla.	OK	S	1928	4-5	JRCP	P	-	-	JPCP
22	Halifax St., Petersburg, Va.	VA	S	1928	4-1/2 - 7-1/2	JRCP	P	-	4	JPCP
23	US-25, Piqua to Troy, Ohio	OH	H	1929	6	JRCP	P	1928	-	JPCP
24	National Old Trails Rd., Indianapolis, Ind.	IN	H	1930	5	JRCP	P	1922	6-8-6	JPCP
25	US-23, Michigan (25052)	MI	H	1930	6	JRCP	U	-	6-8-6	JRCP
26	US-70, Black Mountain, N.C.	NC	H	1930	6	JPCP	P	1914	-	JPCP
27	Richmond Terrace, Richmond, N.Y.	NY	S	1930	4	JRCP	P	1913	6	JPCP
28	4 Streets in Elgin, Ill.	IL	S	1931	7	JRCP	U	1905	5	JPCP
29	Streets in Indianapolis, Ind.	IN	S	1931	5	JRCP	P	-	-	JPCP
30	Route M-43, Mich.	MI	H	1931	6	JPCP	U	-	-	PC
31	US-23, Flint to Mt. Morris, (25052)	MI	H	1931	6	JPCP	U	-	-	JPCP
32	US-71, S. of Joplin, Mo.	MO	H	1931	4	JRCP	U&P	-	6-7-1/2-6	JPCP
33	Central Avenue, Superior, Nebr.	NE	S	1931	4	JRCP	P	1914	4-5	AC/JPCP
34	US-60, E. of Huntington, W. Va.	WV	H	1931	5	JRCP	U	-	-	JPCP
35	US-25, SE of Port Huron, (77031)	MI	H	1932	6	JRCP	U	-	-	JPCP
36	US-10, South of M-38, (73071)	MI	H	1932	6	JRCP	U	-	-	JPCP
37	NBL, US-25, New Haven, (50052)	MI	H	1932	6	JRCP	U	-	-	JPCP
38	US-40, Callaway Co. Mo.	MO	H	1932	4&6	JRCP	P	1924-25	9-6-9	JPCP
39	Lynnhaven Inlet to Cape Henry, Va.	VA	H	1932	4	JRCP	U&P	-	6	JPCP
40	US-42, Racine to Kenosha Co., Racine Co.	WI	H	1932	4	JRCP	U&P	1927	6-8-6	JPCP
41	US-18, W. of Mason City, Iowa	IA	H	1933	7	JRCP	P	1913	6-7-6	JPCP
42	US-66, Springfield, Mo.	MO	H	1934	4	JRCP	U	1913	5	JPCP
43	US-45, Champaign, Ill.	IL	H	1935	5	JRCP	P	-	7	JPCP
44	US-29, N. C.	NC	H	1935	5	JPCP	U	-	-	JPCP
45	Route 10, Chesire to Milldale, Conn.	CT	H	1936	7-5-7	JPCP	P	1916	6-8-6	AC/JPCP
46	US-40, Montgomery Co., Mo.	MO	H	1936	4,5&6	JRCP	P	1924-25	9-6-9	JPCP
47	US-1, Richmond to Petersburg, Va.	VA	H	1936	6-5-6	JPCP	P	1921	5-7-5	JPCP
48	Route 2, Elkhart to Goshen, Ind.	IN	H	1937	5	JRCP	U&P	-	-	JPCP & Brick
49	Street in Iron River, Mich.	MI	S	1937	4	JPCP	U	1916	6	AC/JPCP
50	Pike St. & 4th Ave., Seattle, Wash.	WA	S	1937	5-7	JPCP	P	-	5-9	JPCP
51	Genessee St., Mich.	MI	S	1938	4	JPCP	P	-	-	JPCP
52	Harrison St., Liberty, Mo.	MO	S	1939	3-4	JRCP	U	1913	1/4	AC/JPCP
53	Joy Blvd. E. of US-25, Mich.	MI	S	1941	4	JRCP	U	-	-	JPCP
54	Route 110, Mich.	MI	H	1941	4	JRCP	U	-	-	JPCP
55	US-71, Newton Co., Mo.	MO	H	1941	5	JRCP	U	1919	6-8-6	JPCP
56	US-52, Florence to Darlington, S.C.	SC	H	1941	8-5-8	JPCP	U	1925	2/5	AC/JPCP
57	US-52 & 401, S.C.	SC	H	1941	5	JRCP	U	-	-	AC/JPCP
58	Main St., Charles City, Iowa	IA	S	1942	4	JRCP	P	-	-	AC/JPCP
59	US-112, E. of Ypsilanti, Mich.	MI	H	1942	6	JRCP	U	-	-	JPCP
60	Route 20, Albany to Schenectady CL's	NY	H	1942	5&6	JRCP	P	1924	5	JPCP
61	Apron, England AFB, La.	LA	A	1943	6-1/2	JPCP	U	1943	6	JPCP
62	Route M-53, (50011)	MI	H	1943	5	JRCP	U	-	-	JPCP
63	US-60, S. of Charleston, W. Va.	WV	H	1943	6	JPCP	U	1934	-	JPCP
64	Apron, Hamilton AFB, Calif.	CA	A	1944	12	JPCP	U	1933	8-6-8	JPCP
65	Runway, Standiford Field, Louisville	KY	A	1944	6	JPCP	P	-	9-6-6-9	JPCP
66	Runway, Offutt AFB, Nebr.	NE	A	1944	9	JPCP	U	1941	9-7-9 & 9	JPCP
67	Runway, taxiway, Langley AFB, Va.	VA	A	1944	8 & 10	JPCP	U	1933	8-6-8	JPCP & JRCP
68	Apron, Davis-Monthan AFB, Ariz.	AZ	A	1945	12	JPCP	U	1941	9-6-9	JPCP
69	Apron, Davis-Monthan AFB, Ariz.	AZ	A	1945	10	JPCP	U	1941	9-6-9	JPCP
70	Route 91, Ill.	IL	H	1945	8	JRCP	U	1925	9-6-9	JRCP
71	Apron, Carswell AFB, Tex.	TX	A	1945	10 & 15	JPCP	U	1942-43	8-6-8	JPCP
72	Packard Test Track, Mich.	MI	-	1946	6	JRCP	U	1927	6	JPCP
73	15 Mile Road, Mich.	MI	H	1946	4-3/4	JRCP	P	-	-	JPCP
74	US-82, Lamar Co. Tex.	TX	H	1946	6	JPCP	P	-	-	JPCP
75	US-12, Augusta to Fall Creek, Eau Claire	WI	H	1946	5-6-5	JPCP	P	1929	9-6-1/2-9	JPCP
76	Route 21, Chatham Co., Ga.	GA	H	1947	5	JPCP	P	1920-21	5-1/2-6-5-1/2	JPCP
77	US-40, Baltimore to Aberdeen, Md.	MD	H	1947	7-1/2-7-1/2-5	JRCP	P	1939	9-7-9	JPCP
78	Rte 31, Cicero to Baldwinsville, 10 mi.	NY	H	1947	8	JPCP	U	1933	5	JPCP
79	Route 27, Suffolk Co., N.Y.	NY	H	1947	5	JRCP	P	1927	7	JPCP
80	US-30, W. of Westinghouse Bridge, Pa.	PA	H	1947	6	JRCP	P	-	8	JPCP
81	US-51 to Ill.-37, Cairo, Ill.	IL	H	1948	7-6-7	JRCP	U	-	5	JPCP
82	Route M-19, (US-25 Northeast). (50091)	MI	H	1948	5	JRCP	U	-	6	JPCP
83	SR-82, Cedar Co., Mo.	MO	H	1948	4	JRCP	U	1910	6	JPCP
84	US-6, Lancaster Co., MP 320.59-329.97	NE	H	1948	5 to 6	JRCP	U&P	-	9-6-9	JPCP
85	Rte 20,Morrisville to Cazenovia,10 mi.	NY	H	1948	8	JPCP	P	-	-	JPCP

Construction and Performance Remarks	Status in 1992	Proj. No.
Experimental project to correct structural distress.	Removed from service in 1923.	1
Replace distorted AC. Existing pavement fair.	No new information.	2
Structural distress and surface deterioration.	Overlayed with AC.	3
Existing pavement failed structurally.	Major Structural Problems 1977/78	4
Replacement for wood block surfacing.	No new information.	5
Previous AC surface failed. Existing PC structurally cracked.	No new information.	6
Previous AC surface failed.	No new information.	7
AC failed and was removed.	No new information.	8
Existing pavement structurally distressed.	No new information.	9
Existing pavement structurally distressed.	Now HMAC pavement, no record of when rebuilt.	10
Existing pavement structurally distressed.	No new information.	11
Replace distorted AC surfacing.	Unknown to Caltrans.	12
Replace uneven and rough brick. Base pavement good.	No new information.	13
No information on this item.	No information on this item.	14
Existing pavement structurally distressed.	Overlayed with AC in 1947. Other overlays later.	15
Structural strengthening. Existing pavement cracked.	No additional information.	16
-	No new information on this project was available.	17
Strengthen and correct structural distress.	Resurfaced in 1951.	18
Distorted AC replaced. Existing pavement generally fair.	No additional information.	19
Existing pavement structurally distressed.	Overlayed with 2-1/2" AC in 1958.	20
Previous AC surfacing failed and removed.	Now HMAC pavement, no record of when overlayed.	21
Wood block surfacing deteriorated and removed.	No additional information.	22
-	No additional information.	23
Structural strengthening. Existing pavement structurally distr.	Unknown to Indiana DOT in 1992.	24
Strengthen and correct structural distress.	Overlayed in 1968 after 38 years service.	25
Existing pavement structurally distressed.	Widened and overlayed with 2" AC in 1968.	26
Wood block surface deteriorated and removed.	No new information.	27
Brick surfacing failed and removed.	No new information.	28
Strengthen and correct structural distress.	No new information.	29
Strengthen and correct structural distress.	No information given in 1992 survey.	30
Strengthen and correct structural distress.	Overlayed in 1960-69.	31
Experimental resurfacings for strengthening.	Resurfaced with AC in 1977 & 1991.	32
Distorted AC removed and replaced. Base pavement fair.	No new information.	33
Strengthen and correct structural distress.	No new information.	34
Strengthen and correct structural distress.	Resurfaced in 1951.	35
Strengthen and correct structural distress.	Resurfaced in 1958.	36
Strengthen and correct structural distress.	Resurfaced in 1972.	37
Existing pavement structurally poor.	Resurfaced with AC in 1951, became I-70 outer rd. in 1965.	38
Correct for surface roughness.	Covered with HMAC for many years.	39
Upgrade with integral widening. Existing pavement fair.	Covered with HMAC prior to 1981.	40
Strengthen and upgrade existing pavement.	1971, Half Replaced w/PCC; 1977, 2" ACOL; 1991, 3" ACOL.	41
Strengthen and correct structural distress.	State has no current records on this project.	42
Strengthen and correct structural distress.	No new information.	43
Strengthen and correct structural distress.	Overlayed with 2" AC in 1946.	44
Distorted AC replaced. Existing pavement fair.	No new information.	45
Existing pavement in poor structural condition.	Resurfaced with AC in 1951. Became supplementary Rte. N in 1965.	46
Strengthen and correct structural distress.	Covered with HMAC for many years.	47
Widen and resurface to correct structural distress.	Totally reconstructed in 1972.	48
Replace stripped AC surfacing. Existing pavement fair.	No new information.	49
Existing pavement structurally distressed.	No new information.	50
-	No new information.	51
AC removed and replaced with PC. Base pavement cracked.	No new information.	52
Upgrade and strengthen. Correct structural distress.	No new information.	53
-	No information given in 1992 survey.	54
Upgrade with integral widening. Strengthen.	Resurfaced with AC in 1977 & 1991.	55
AC surface distorted but not removed. Widened and strengthened.	No new information.	56
AC surface distorted but not removed. Widened and strengthened.	No new information.	57
Replace distorted AC and correct structural distress.	HMAC Overlay in 1960 (Iowa Conc. Paving Assoc.).	58
Upgrade and strengthen. Correct structural distress.	No information given in 1992 survey.	59
Upgrade and strengthen.	Overlayed with 2-1/2" AC in 1965, others later.	60
Strengthen and correct structural distress.	No new information.	61
Upgrade and strengthen. Correct structural distress.	Resurfaced in 1974.	62
Upgrade and widen.	No new information.	63
Strengthening program.	No new information.	64
Strengthen and correct structural distress.	Airport Authority could not locate in 1992.	65
Strengthen for increased loadings.	Extended and reconstructed in 1958.	66
Strengthen for increased loadings.	Center portion reconstructed in 1989, edges still good (USAF).	67
Strengthening program.	No new information.	68
Strengthening program. Existing pavement fair.	No new information.	69
-	No new information.	70
Strengthening program.	No new information.	71
Correct roughness and structural distress.	No new information.	72
Upgrade and strengthen.	No information given in 1992 survey.	73
-	No new information.	74
Correct structural distress and uneveness.	Covered with HMAC prior to 1984.	75
Replace distorted AC. Existing PC good, some structural distr.	Resurfaced with AC in ?	76
Correct failed existing pavement.	No new information.	77
Widen and strengthen existing pavement.	4 mi. ACOL in 1966, 6 mi. in 1976.	78
Correct excessive faulting and cracking.	Location too inexact for DOT to locate in 1992.	79
Correct structural cracking and surface distress.	No new information.	80
Correct roughness due to settlement of unstable embankment.	No new information.	81
Upgrade and strengthen.	Resurfaced in 1979.	82
-	Resurfaced with bit. mix surface leveling course in 1979.	83
Upgrade and strengthen.	MP 320.70-326.41, ACOL in 1972; MP 326.41-329.97,ACOL in 1988.	84
Upgrade and strengthen.	2-1/2" ACOL placed in 1977, second in 1990.	85

Table A-2
UNBONDED AND PARTIALLY BONDED PORTLAND CEMENT CONCRETE RESURFACING PROJECTS

				Resurfacing				Existing Pavement		
Proj. No.	Location	State	Use	Year Built	Thick-ness(in.)	OL Type	Inter-face	Year Built	Thick-ness(in.)	Type
86	Montauk Highway, Long Island, N.Y.	NY	H	1948	5	JRCP	P	1927	7	JPCP
87	US-131, Mich.	MI	H	1949	5	JRCP	U	-	-	JPCP
88	Route M-50, Mich. (58032)	MI	H	1949	5	JRCP	U	-	-	JPCP
89	(c) HWY #91, MP 188.91-193.15	NE	H	1949	6	JRCP	U&B	-	9-6-9	JPCP
90	(a) HWY #6, MP 97.42-102.66	NE	H	1949	6	JRCP	U&B	-	9-6-9	JPCP
91	(b) HWY #275, MP 164.20-166.36	NE	H	1949	6	JRCP	U&B	-	9-6-9	JPCP
92	Runway, taxiway, Buckley ANG, Colo.	CO	A	1950	8	JRCP	U	1940	8-6-8	JPCP
93	(a)US-30, MP 204.4-205.4	IA	H	1950	6	JRCP	P	1927	10-7-10	JPCP
94	(b)US-30, MP 221-232.1	IA	H	1950	6	JRCP	P	1927	10-7-10	JPCP
95	(d)US-30, MP 242-243.5	IA	H	1950	6	JRCP	P	1927	10-7-10	JPCP
96	(c)US-30, MP 232-242	IA	H	1950	6	JRCP	P	1927	10-7-10	JPCP
97	5 Streets, Indianapolis, Ind.	IN	S	1950	7	JPCP	P	-	-	JPCP
98	Morris St., Indianapolis, Ind.	IN	S	1950	8	JPCP	P	-	8	JPCP
99	US-31, Oceana Co., N.of Hart to Monroe Rd.	MI	H	1950	5	JRCP	U	1922	-	JPCP
100	Elizabeth Lake Road, Mich.	MI	H	1950	5	JRCP	U	-	-	JPCP
101	US-40, Racine Co., Wis.	WI	H	1950	AC/7	AC/JPCP	U	1930	10-8-8-10	JRCP
102	US-6 & 30, Iowa (4 projects)	IA	H	1951	6	JRCP	P	-	-	JPCP
103	Delaware St., Indianapolis, Ind.	IN	S	1951	6	JPCP	P	-	8	JPCP
104	US-61, S. of New London, Mo.	MO	H	1951	5	JRCP	P	-	-	JPCP
105	US-6, Cass Co., MP 329.97-336.19	NE	H	1951	5 & 6	JRCP	U&P	1929	9-6-9	JPCP
106	Runway, Rickenbacker AFB, Ohio	OH	A	1951	6	JPCP	P	1942-44	-	JPCP
107	US-6, Poweshiek Co. Iowa, MP 184-186	IA	H	1952	6	JRCP	P	1927	-	JPCP
108	(a)Rte. 30, MP 117-119, MP 119-125	IA	H	1952	6	JRCP	P	-	-	JPCP
109	(a)Rte. 69, MP 126-129, MP 129-136	IA	H	1952	6	JRCP	P	-	-	JPCP
110	(b)Rte. 65, MP 59-69N, MP 59-69S	IA	H	1952	6	JRCP	P	-	-	JPCP
111	Taxiway, England AFB, LA.	LA	A	1952	9-13	JPCP	P	1943	8 & 9	JPCP
112	Route M-21, Mich. (77021)	MI	H	1952	6 & 8	JRCP	U	-	-	JPCP
113	Route M-59, Mich. (50022)	MI	H	1952	5	JRCP	U	-	-	JPCP
114	Route M-21, St.Clair Co., Capac to Emmett	MI	H	1952	5	JRCP	U	1924	-	JPCP
115	Route M-97, Mich., Mile 8 to mile 14.	MI	H	1952	5	JRCP	U	-	-	JPCP
116	Route M-97, Mich. (50031)	MI	H	1952	5	JRCP	U	-	-	JPCP
117	US-29, Lexington, N.C.	NC	H	1952	7	JPCP	P	-	-	AC/JPCP
118	Taxiway, Lincoln AFB, Nebr.	NE	A	1952	16-17	JPCP	P	1942	6	JPCP
119	Apron, Lincoln AFB, Nebr.	NE	A	1952	14	JPCP	P	1945	10	JPCP
120	Runway, travis AFB, Calif.	CA	A	1953	10,11,13	JPCP	P	1943	7,8,9,10	JPCP
121	Runway, Barksdale AFB, La.	LA	A	1953	8-12	JPCP	P	1940'S	6-11	JPCP
122	Beecher Rd., Mich.	MI	H	1953	8	JPCP	U	-	-	JPCP
123	US-131 to M-60, St. Joseph Co.,	MI	H	1953	6-8	JRCP	U	-	-	JPCP
124	SB, US-127, Ingham Co., Holt to Mason	MI	H	1953	6	JRCP	U	1926	9-7-9	JPCP
125	Route TH-12, Minn.	MN	H	1953	5	JRCP	P	1928	9-7-9	JPCP
126	Apron, taxiway, Whiteman AFB, Mo.	MO	A	1953	14	JPCP	P	1942	9-7-9	JPCP
127	Taxiway, apron, runway, Dover AFB	DE	A	1954	13 & 18	JPCP	P	1942-43	9-7-9	JPCP
128	US-34, Henry Co., MP 238-244	IA	H	1954	6	JRCP	P	-	10-7-10	JPCP
129	RTE 956 (Old US-61), Scott Co., Iowa	IA	H	1954	6	JRCP	P	1928	10-7-10	JPCP
130	Runway, taxiway, apron, Grissom AFB	IN	A	1954	12	JPCP	P	-	10-8-10	JPCP
131	Runway, Schilling AFB, Kans.	KS	A	1954	12 & 14	JPCP	P	1942	10-8-10	JPCP
132	Apron, taxiway, rnwy., Forbes AFB	KS	A	1954	14 & 15	JPCP	P	1942	7 & 8	JPCP
133	Taxiway, apron, Chennault AFB, La.	LA	A	1954	13	JPCP	P	1943	8-6-8	JPCP
134	Route M-29, Macon CL to Perch Rd.	MI	H	1954	6	JRCP	U	-	-	JPCP
135	US-71, Newton Co., Mo.	MO	H	1954	5	JRCP	P	-	-	JPCP
136	Apron, Whiteman AFB, Mo.	MO	A	1954	13,14,19	JPCP	P	1942	9-7-9	JPCP
137	US-70, Durham, N.C.	NC	H	1954	5	JPCP	U	-	-	JPCP
138	Runway, Tinker AFB, Okla.	OK	A	1954	11 & 14	JPCP	P	1942	9-7-9	JPCP
139	Calibration Platform, Ellsworth AFB	SD	A	1954	13	JPCP	P	1942-43	7	JPCP
140	Route 347, Tex.	TX	H	1954	7	JRCP	P	-	-	JPCP
141	Runway, taxiway, apron, Langley AFB	VA	A	1954	9	JPCP	U	1951	6	JPCP
142	Runway, taxiway, apron, Blytheville AFB	AR	A	1955	11 & 12	JPCP	P	1942	8-6-8	JPCP
143	Apron, Davis-Monthan AFB, Ariz.	AZ	A	1955	12	JPCP	P	1943	9-6-9	JPCP
144	Apron, Davis-Monthan AFB, Ariz.	AZ	A	1955	7	JPCP	P	1953	12	JPCP
145	Apron, Davis-Monthan AFB, Ariz.	AZ	A	1955	10	JPCP	U	1953	9-6-9	JPCP
146	Taxiway, runway, Palmdale AFB	CA	A	1955	8-14	CRCP	U	-	12 & 14	JPCP
147	Rnwy., taxiway, apron, Castle AFB	CA	A	1955	10	JPCP	U	1946	11	JPCP
148	Runway, Mather AFB, Calif.	CA	A	1955	12	JPCP	P	1943	10-1/2-7-10-1/2	JPCP
149	Taxiway, Travis AFB, Calif.	CA	A	1955	13	JPCP	P	1943	7 & 9	JPCP
150	Apron, Schilling AFB, Kans.	KS	A	1955	13 & 15	JPCP	P	1942	11-8-11	JPCP
151	Apron, Westover AFB, Mass.	MA	A	1955	11-12	JPCP	P	1942	9-6-9	JPCP
152	Route TH-12, Minn.	MN	H	1955	5	JPCP	P	-	-	JPCP
153	Feature A15B, Apron, Sey.-Johnson AFB	NC	A	1955	11	JPCP	P	1942	8-6-8	JPCP
154	Apron, Rickenbacker AFB, Ohio	OH	A	1955	7	JPCP	P	1942-44	10-8-10	JPCP
155	US-41, Smyrna to Nashville, Tenn.	TN	H	1955	6	JPCP	U	1943	8	JPCP
156	Taxiway, runway, England AFB, La.	LA	A	1956	9,10,11,13	JPCP	P	1943	8 & 9	JPCP
157	Taxiway, Selfridge AFB, Mich.	MI	A	1957	12	JPCP	P	1942-43	10-8-10	JPCP
158	SBL, I-69 Temporary, Lansing, (23012)	MI	H	1957	6	JRCP	U	1926	-	JPCP
159	Apron, Holloman AFB, N.M.	NM	A	1957	13	JPCP	P	1944-45	10	JPCP
160	Taxiway, Griffiss AFB, N.Y.	NY	A	1957	12 & 21	JPCP	P	1941	9-7-7-9	JPCP
161	Taxiway, K.I. Sawyer AFB, Mich.	MI	A	1958	8 & 16	JPCP	P	1955-57	16	JPCP
162	Runway, Kincheloe AFB, Mich.	MI	A	1958	12	JPCP	P	1957	9 & 10	JPCP
163	Runway, Kincheloe AFB, Mich.	MI	A	1958	14	JRCP	P	1942	8-6-8	JPCP
164	Runway, Selfridge AFB, Mich.	MI	A	1958	9	JPCP	P	1942-43	10-11-12	JPCP
165	US-29, Concord to Charlotte, 15 mi.	NC	H	1958	6	JPCP	U	-	-	AC/JPCP
166	US-99, Kern Co. Calif.	CA	H	1959	8	JPCP	U	-	-	AC/JPCP
167	US-99, Madera Co., Calif.	CA	H	1959	9	JPCP	U	1929	7 & 9	AC/JPCP
168	Apron, Selfridge AFB, Mich.	MI	A	1959	6	JRCP	P	1942-43	12-10-12	JPCP
169	Apron, San Antonio Int. Airport, Tex.	TX	A	1959	4	PRCP	U	-	6	JPCP
170	I-35, Falls & McLennan Cos., Tex.	TX	H	1959	7	CRCP	U	1934	3-1/2/9-6-9	AC/JPCP

Construction and Performance Remarks	Status in 1992	Proj. No.
Correct roughness due to heavy traffic and settlement in sand.	Location too inexact for DOT to locate in 1992.	86
Upgrade and strengthen.	No information given in 1992 survey.	87
Upgrade and strengthen.	Resurfaced in 1962.	88
Upgrade and strengthen.	Still in service.	89
Upgrade and strengthen.	AC overlay in 1990.	90
Upgrade and strengthen.	Still in service.	91
Strengthen and correct structural distress.	No new information.	92
Upgrade and strengthen.	1965, 3" ACOL; 1984, mill 3" then 6" ACOL.	93
Upgrade and strengthen.	1965, 3" ACOL; 1977, 3" ACOL; 1990, mill 1-1/2" then 3" ACOL.	94
Upgrade and strengthen.	1965, 3" ACOL; 1976, 3" ACOL; 1990, mill 1" then 5" ACOL.	95
Upgrade and strengthen.	1965, 3" ACOL; 1977, 3" ACOL; 1990, mill 1-1/2" then 3" ACOL.	96
Correct roughness and structural distress.	No new information.	97
Strengthen and correct roughness and structural distress.	No new information.	98
Upgrade and strengthen.	Resurfaced in 1980, most jts. deteriorated and patched.	99
-	No information given in 1992 survey.	100
AC/lean concrete resurfacing to correct structural distress.	Location unknown to WIS. DOT.	101
Upgrade and strengthen.	US #6, 3" ACOL in 1975, others not located in 1992.	102
Correct roughness and structural distress.	No new information.	103
Upgrade and widen. Correct structural distress.	Resurfaced with AC in 1988. Widened and add. surface 1990.	104
Upgrade and strengthen.	MP 329.97-331.22, ACOL in 1985; MP 331.21-336.19, ACOL in 1991.	105
Correct surface distress and strengthen.	No new information.	106
Upgrade and strengthen.	3" AC Overlay in 1975.	107
Upgrade and strengthen. Correct structural distress.	1967, 3" ACOL; 1983, mill 1" then 1-1/2" ACOL.	108
Upgrade and strengthen. Correct structural distress.	1971, 3" AC overlay.	109
Upgrade and strengthen. Correct structural distress.	1972, 3" ACOL; 1991, 4" ACOL	110
Strengthen for heavier load. Existing PC good.	No new information.	111
Strengthen and upgrade. Existing PC fair to good.	Partial resurface in 1970.	112
Strengthen and upgrade. Existing PC fair to good.	Resurfaced in 1971-76.	113
Upgrade and strengthen.	Resurfaced in 1970, most jts. patched, deteriorated, faulted.	114
Upgrade and strengthen. Correct structural distress.	Resurfaced in 1969-74.	115
Strengthen and upgrade. Existing PC fair to good.	Resurfaced in 1969-74.	116
Remove failed AC surface. Existing PC good.	Overlayed with 2-1/2" AC in 1983.	117
Strengthen for heavier load. Existing PC fair.	No new information.	118
Strengthen for heavier load. Existing PC very good.	No new information.	119
Strengthen for heavier load. Existing PC good.	No new information.	120
Upgrade for heavier load. Existing PC fair to very good.	Replaced in 1992 by project shown later w/same descrip. (USAF).	121
-	No information given in 1992 survey.	122
Upgrade and strengthen. Includes unbonding medium test sects.	Resurfaced in 1977.	123
Includes tests of bonding media. Existing PC fair with cracks.	Still in service as a county road. (Abandoned by state in 1967).	124
Upgrade with integral widening. Existing PC fair to good.	Minn. DOT had no information, suggests this listing is in error.	125
Strengthen for heavier load. Existing PC fair to good.	Still in service with repairs due to "D" cracking/popouts (COE).	126
Strengthening program.	No new information in 1992.	127
General upgrading and strengthening.	3" AC overlay in 1981.	128
General upgrading and strengthening.	30% has short or overlay patches, minor edge and CL faulting, cracking.	129
Strengthening program.	Pavement abandoned prior to 1992, joint spalls, corner breaks (USAF).	130
Strengthen for increased loadings.	No new information in 1992.	131
Strengthen and upgrade. Existing PC generally good.	No new information in 1992.	132
Strengthen and upgrade. Existing PC fair to good.	No new information in 1992.	133
General upgrading and strengthening.	Resurfaced in 1981.	134
Strengthen and integrally widen.	Resurfaced with AC in 1974.	135
Upgrade and strengthen. Existing PC fair to poor.	Still in service (COE).	136
Upgrade and correct structural distress.	Widened and overlayed with AC in 1967.	137
Upgrade and strengthen. Existing PC fair to poor.	No new information in 1992.	138
Upgrade. Existing PC fair to good.	Still fair to good condition, not used for aircraft since 1962.	139
Strengthen and correct structural distress.	No new information in 1992.	140
Upgrade. Existing PC poor to fair.	Poor condition, needs replacement (USAF).	141
Upgrade and strengthen. Existing PC poor to fair.	No new information in 1992.	142
Strengthening program. Existing PC poor to fair.	No new information in 1992.	143
Strengthen and resurface. Existing PC good.	No new information in 1992.	144
Strengthen and correct structural distress.	No new information in 1992.	145
Strengthening program. Existing PC good.	No new information in 1992.	146
Upgrade and strengthen. Existing PC fair.	No new information in 1992.	147
Strengthening program. Existing PC fair.	Still in service (USAF).	148
Strengthening program. Existing PC fair to good.	Reconstructed in 1991 (USAF).	149
Strengthening program. Existing PC fair.	No new information.	150
Strengthen and resurface. Existing PC badly cracked.	Generally Good condition in 1992 (USAF).	151
-	Minn. DOT had no information, suggests this listing is in error.	152
Strengthening program. Existing PC poor to fair.	In 1992, PCI = 79, Very Good Condition (USAF).	153
Strengthen and correct for surface deterioration.	No new information.	154
Upgrade and strengthen. Correct structural distress.	No new information.	155
Strengthening program. Existing PC fair to good.	No new information.	156
Strengthen and correct surface defects.	No new information.	157
Upgrade with integral widening. Existing PC fair to good.	Trans. jts. patched, deter., faulted. Trans. crks.	158
Strengthening program. Existing PC good.	Partially replaced in 1992 to build Hangars (USAF).	159
Strengthen and resurface. Existing PC poor.	No new information.	160
Upgrade and resurface.	Still in service w/routine maintenance required (USAF).	161
Strengthen and resurface. Existing PC fair to good.	No new information.	162
Strengthen and upgrade. Existing PC poor to fair.	No new information.	163
Upgrade and correct for surface distress.	No new information.	164
Correct distortion and roughness. Some structural distress.	Overlayed with 2-1/2 to 3" AC in 1971-72.	165
Upgrade and correct for surface distortion and roughness.	Major structural problems in 1982-85. PSR = 3.7 in 1990.	166
Upgrade and correct for surface distortion and roughness.	ACOL in 1986 due to major structural problems.	167
Strengthen and correct surface distress.	No new information.	168
Experimental strengthening. Existing PC fair to good.	No new information.	169
Strengthen and improve rideability.	No new information.	170

Table A-2
UNBONDED AND PARTIALLY BONDED PORTLAND CEMENT CONCRETE RESURFACING PROJECTS

Proj. No.	Location	State	Use	Resurfacing Year Built	Resurfacing Thick-ness(in.)	Resurfacing OL Type	Resurfacing Inter-face	Existing Pavement Year Built	Existing Pavement Thick-ness(in.)	Existing Pavement Type
171	Taxiway, Langley AFB, Va.	VA	A	1961	16	JPCP	P	1944	10	JPCP
172	Ashworth Rd., 2nd to 11th Sts., W. Des Mns.	IA	H	1963	5	JPCP	P	-	10-7-10	JPCP
173	US-6-34, Red Willow Co., MP 87.38-90.06	NE	H	1964	5	JRCP	U	-	8	JPCP
174	I-35, Guadalope Co., Tex.	TX	H	1965	6	CRCP	U	1934	2-1/4/9-6-9	AC/JPCP
175	I-35, Johnson Co., Tex.	TX	H	1965	6	CRCP	U	1936	3/9-6-9	AC/JPCP
176	I-5, Los Angeles Co., Calif.	CA	H	1966	8	JPCP	U	-	-	JPCP
177	I-5 (SBL), Gorman	CA	H	1967	8	JPCP	U	-	-	JPCP
178	I-70, Bond Co., Ill.	IL	H	1967	7	CRCP	U	-	10	JPCP
179	I-70, W. of Pocohontas, Ill.	IL	H	1967	6,7,8	CRCP	U	1939	10-8-10	AC/JPCP
180	Apron, Patuxent NAS, Md.	MD	A	1967	5	CRCP	P	-	9	JRCP
181	I-80, W. of Sacramento, Calif.	CA	H	1968	8	JPCP	U&P	-	-	JPCP
182	US-99, N. of Bakersfield, Calif.	CA	H	1968	8	JPCP	U	1914	12/4	AC/JPCP
183	I-8, E. of San Diego, Calif.	CA	H	1968	6	JPCP	U	1951	-	JPCP
184	I-55, near Springfield, Ill.	IL	H	1968	8	CRCP	U	-	10	JRCP
185	I-8, San Diego	CA	H	1969	6	JPCP	U	1951	-	JPCP
186	Route 163, San Diego Co., Calif.	CA	H	1970	6 & 8	JPCP	U	-	-	JPCP
187	I-69, N. of Indianapolis, Ind.	IN	H	1970	6	CRCP	P	1955	9	JRCP
188	US-99, Tulare Co., Calif.	CA	H	1971	7	JPCP	U	1915	-	AC/JPCP
189	I-75, Forsyth to Macon, Ga.	GA	H	1971	8	CRCP	P	1967	8,9,10	JPCP
190	I-75, Forsyth to Macon, Ga.	GA	H	1971	7	CRCP	P	1967	10	JPCP
191	I-75, N. of Macon, Ga.	GA	H	1971	7 & 8	CRCP	P	1954	9-8-10	JPCP
192	Manteno Road, Kankakee Co., Ill.	IL	H	1971	6	JPCP	P	-	6 & 7	JPCP & F
193	I-69, Indianapolis	IN	H	1971	6	CRCP	U	1955	9	JRCP
194	I-69, N. of Indianapolis, Ind.	IN	H	1971	6	CRCP	U	1955	9	JRCP
195	Apron, Patuxent NAS, Md.	MD	A	1971	5	CRCP	P	-	9	JRCP
196	I-70 W. of Baltimore, Md. (3 projects)	MD	H	1971	6	CRCP	U	-	9	JPCP & JRCP
197	Exp. overlay, WES, Vicksburg, Miss.	MS	TP	1971	4	FRC	P	1970	10	JPCP
198	I-20, Vicksburg, Miss.	MS	H	1971	6	CRCP	U	-	9	JRCP
199	I-40 @ West Memphis, 1.7 mi.	AR	H	1972	6	CRCP	U	-	9	JRCP
200	I-55, W. of Memphis, (Ark)	AR	H	1972	6	CRCP	U	1951	9	JRCP
201	Taxiway, Tampa Int. Airport, Fla.	FL	A	1972	4 & 6	FRC	P	-	12	JPCP
202	Danbury St., Cedar Rapids, Iowa	IA	S	1972	3	FRC	P	-	7	JRCP
203	Taxiway, Cedar Rapids Airport, Iowa	IA	A	1972	3	FRC	P	-	-	JPCP
204	Outer Carrier Apron, Capital Airport	IL	A	1972	6	JPCP	P	1947	8	JPCP
205	Runway 4/22 and taxiways, Capital Apt.	IL	A	1972	8-11	JPCP	P	1947-57	9&10	JPCP
206	Apron, Glenview NAS, Ill. (Phase II)	IL	A	1972	5 & 6	CRCP	P	-	6 & 7	JPCP
207	Runway 1-19, Standiford Field, Louis.	KY	A	1972	14	JPCP	U	1941-60	15	JPCP
208	M-102, 8 Mile Road, Detroit, Mich.	MI	H	1972	3	FRC	P	-	-	JPCP
209	I-29, Grand Forks, N.D.	ND	H	1972	6	CRCP	U	1958	8	JPCP
210	Route E-33, Greene Co. Iowa	IA	H	1973	4 & 5	JRCP	P	1921-22	8-1/2	JRCP
211	Route E-33, Greene Co. Iowa	IA	H	1973	3 & 4	CRCP	U	1921-22	8-1/2	JRCP
212	Route E-33, Greene Co. Iowa	IA	H	1973	5	JPCP	P	1921-22	8-1/2	JRCP
213	I-83, S. of Pa. border, Md.	MD	H	1973	6	CRCP	U	-	9	JRCP
214	I-10, Beaumont, Tex.	TX	H	1973	3 - 3-1/2	FRC	P	-	8	CRCP
215	US-16, Hartland-Pewaukee, Waukesha Co.	WI	H	1973	7	CRCP	U	1950'S	9	JPCP
216	Air Carrier Apron, Greater Peoria Aprt.	IL	A	1974	9	JPCP	U	1956	10	JPCP
217	I-29, Walsh Co., N.D.	ND	H	1974	6	CRCP	U	-	8	JPCP
218	Rnwy, JFK Int. Airport, New York, N.Y.	NY	A	1974	5	FRC	U	-	-	AC/JPCP
219	I-86, Near Mass. border, Conn.	CT	H	1975	6	CRCP	U	1948-54	8	JRCP
220	I-85, Gwinnett Co., Ga.	GA	H	1975	3, 4-1/2, 6	CRCP	U	1960	9	JPCP
221	I-85, Gwinnett Co., Ga.	GA	H	1975	6	JPCP	U	1960	9	JPCP
222	Runway 13/31, U. of IL. Willard Airport	IL	A	1975	8-12	JPCP	P	1944	8-9	JPCP
223	Runway 14/32, U. of IL. Willard Airport	IL	A	1975	11&12	JPCP	U	1944	8&9	JPCP
224	Apron, Portland Int. Airport, Ore.	OR	A	1975	3	FRC	U	-	4-1/2	JPCP
225	I-90, Near Erie, Pa.	PA	H	1975	7	CRCP	U	1957-61	10	JRCP
226	I-610, Houston,. Tex.	TX	H	1975	8	CRCP	U	-	-	JPCP
227	Columbus St., Anderson, Ind.	IN	S	1976	3 & 4	JPCP	U & P	1944	8	JRCP
228	US-84, Brookhaven, Miss. (Whitetopping)	MS	H	1976	6	PRCP	U	1976	4 AC/4 Granular	
229	I-45, Houston	TX	H	1976	6	CRCP	U	-	-	JPCP
230	I-45, Houston to Galveston, Tex.	TX	S	1976	6	CRCP	U	-	-	JPCP
231	Air Carrier Apron, Quincy Mun. Airport	IL	A	1977	8,9	JPCP	U	1941	9	JPCP
232	Old carrier apron, Willard Airport	IL	A	1977	10&12	JPCP	P	1944-59	9	JPCP
233	Aprons, Patuxent NAS, Md. (7 projects)	MD	A	1977	6	CRCP	U	-	8	JPCP
234	TH-71, Kandiyohi & Renville Cos.	MN	H	1977	5-1/2	JPCP	U	1947	9-7-9	JPCP
235	Apron, Norfolk NAS, Va.	VA	A	1977	5	FRC	U	1940	1-1/2 - 3/8	AC/JPCP
236	US-24, Shawnee Co., Kans.	KS	H	1978	6	JPCP	U	1956	9	JRCP
237	Runway 11-29, Standiford Field, Louis.	KY	A	1978	14-18	JPCP	U	1941-60	4	AC
238	Taxiway C, Standiford Field, Louisville	KY	A	1978	14	JPCP	U	-	3	JPCP
239	I-86, NE of Hartford, Conn.	CT	H	1979	6	CRCP	U	-	9	JRCP
240	Air carrier apron, Capital Airport	IL	A	1979	9	JPCP	U	1958	9	JPCP
241	Hines Dr., Wayne Co., Mich.	MI	S	1979	5	JPCP	U	1939	9	AC/JPCP
242	US-16, Oconomowoc	WI	H	1979	8	CRCP	U	1950	9	JPCP
243	US-16, Oconomowoc, Waukesha Co.	WI	H	1979	8	CRCP	U	1950	9	JPCP
244	I-55, W. of W. Memphis, Ark.	AR	H	1980	6	CRCP	U	-	-	JRCP
245	I-80, Tolland	CT	H	1980	3	CRCP	U	-	9	JRCP
246	I-80, Vernon	CT	H	1980	5	CRCP	U	-	-	-
247	Sec. Rd. @ NW Corner Sec.19-73-30, Union	IA	H	1980	7	JPCP	U	1969	6	JPCP
248	County Road, Adair Co.	IA	H	1980	7	JPCP	U	1968	6	-
249	Sec. Rd. P33, Adair Co., 2.99 mi.	IA	H	1980	7	JPCP	U	1968	6	JPCP
250	Runway, O'Hare Int. Airport, Chicago	IL	A	1980	8 & 9	PRCP	U	-	-	CRCP
251	Runway 12I-30R, Lambert Int. Airport	MO	A	1980	10	JPCP	U	1960,69	14	JPCP
252	Apron, Fallon NAS, Nev.	NV	A	1980	5	FRC	U	1943	9	JPCP
253	Runway, JFK Int. Airport, N.Y. City	NY	A	1980	4-7	FRC	U	-	-	AC/JPCP
254	I-94, Warrens & Millston	WI	H	1980	8	CRCP	U	1970	-	JRCP
255	Adair Co., Iowa	IA	H	1981	6	JPCP	U	-	-	JPCP

Construction and Performance Remarks	Status in 1992	Proj. No.
Strengthening program. Existing PC good.	Still in good condition (USAF).	171
Correct surface distress and structural cracking.	Approx. 6 trans. crks, no long. crks, PC patches,most jts. spalled.	172
Upgrade and strengthen.	Still in service.	173
Upgrade and improve serviceability.	No new information.	174
Upgrade and improve serviceability.	No new information.	175
-	PCC Slab Replacement and ACOL in 1991.	176
No information on this item.	No new information.	177
Upgrade and improve serviceability.	No new information.	178
Experimental sections. Improve rideability.	No new information.	179
Strengthen and resurface structurally distressed pavement.	No new information in 1992.	180
Upgrade. Experimental sections of bonding media.	No new information, Caltrans could not locate.	181
Improve serviceability due to distorted AC.	No new information, Caltrans could not locate.	182
Upgrade to Interstate standards.	No new information, Caltrans could not locate.	183
Upgrade to Interstate standards.	No new information.	184
No information on this item.	No new information.	185
-	No major problems or bad ride. In 1990, PSR=4.0, 2.7 M. ESAL.	186
Upgrade existing RC to Interstate standards.	6" ACOL applied in 1991 due to crack deter. & punchouts.	187
Upgrade and restore rideability.	Drainage work in 1987, ACOL due to structural problems.	188
Upgrade existing pavement to Interstate standards.	Good condition, construction dates corrected.	189
Upgrade existing pavement to Interstate standards.	Good condition, construction dates corrected.	190
Upgrade existing PC to Interstate standards.	Good condition. In 1990, PSR = 4.1, Some med sev. crk.	191
ACPA pave-in. Exist. PC cracked. Exist. F distort	No new information.	192
No information on this item.	No new information.	193
Upgrade existing pavement to Interstate standards.	6" ACOL applied in 1991 due to crack deter. & punchouts.	194
Strengthen and resurface cracked pavement.	Good condition w/ some spall repairs (USN).	195
Upgrade existing pavement to Interstate standards.	No new information.	196
Test resurfacing. Existing PC trafficked and cracked.	No new information.	197
Upgrade existing pavement to Interstate standards.	Still in service., no report on condition.	198
Generally good results.	No new information.	199
Upgrade existing pavement to Interstate standards.	Remarks still apply. PSR = 3.5 in 1990, Some med. sev. crk.	200
Test resurfacings. Existing PC cracked but in good condition.	No new information.	201
Resurface because of surface distress.	In service (Iowa Concrete Paving Assoc.).	202
Resurface distressed surface.	No new information.	203
No information on this item.	In service (IL Concrete Council).	204
No information on this item.	In service (IL Concrete Council).	205
Strengthen and resurface cracked pavement.	Fair condition w/popouts and extensive transverse cracking (USN).	206
Placed AC leveling course, paved.	Pavement in good shape (Airport Authority).	207
Experimental resurfacing of surface distressed pavement.	<State couldn't find - check TRB reports, etc.>	208
Upgrade existing pavement to Interstate standards.	No new information	209
Test resurfacings with integral widening. Existing pvmt. crack.	Minor maintenance for 15 yrs., good performance. (Writer Obs).	210
Test resurfacings with integral widening. Existing pvmt. crack.	4" good and 3" average performance for 15 yrs. (Writer Obs).	211
Test resurfacings with integral widening. Existing pvmt. crack.	Minor maintenance for 15 yrs., good performance. (Writer Obs).	212
Upgrade existing pavement to Interstate standards.	No new information.	213
Experimental resurfacing of distressed CRC.	No new information.	214
Upgrade and strengthen.	HMAC overlay in 1990 due to excessive long. cracking.	215
No information on this item.	In service (IL Concrete Council).	216
Upgrade existing pavement to Interstate standards.	No new information.	217
Remove distressed AC and resurface with FC.	No new information.	218
Upgrade existing pavement to Interstate standards.	In 1990, AC patch, poor drainage, med. sev. cracking.	219
Thickness test sections of distressed pavement.	3" removed in 1988, 4-1/2 & 6" in fair condition w/patching, all failures over old pavement joints.	220
Existing pavement distressed.	Fair perf. w/extensive long. cracking. In 1990 PSR=3.5, 26.5 M. ESAL's.	221
Cleaned of loose material, slipform paved.	Extensive "D" cracking evident (U. of Ill.).	222
No information on this item.	In service (IL Concrete Coucil).	223
Replace rutted asphaltic concrete in parking areas.	No new information.	224
Upgrade existing pavement to Interstate standards.	No new information.	225
Upgrade existing pavement to Interstate standards.	No new information.	226
Test resurfacings of distressed street.	No new information.	227
New PRC resurfacing of foundation simulating existing F Pvmt.	Still in service., no report on condition.	228
No information on this item.	No new information.	229
Upgrade existing pavement to Interstate standards.	No new information.	230
No information on this item.	In service (IL Concrete Council).	231
Clean old surface, slipform paved.	In service (IL Concrete Council). Some "D" cracking.	232
Strengthen existing distressed pavement.	Very good condition (USN).	233
-	1991, PQI = 3.1, 6% cracked panels, 3% broken panels,8% faulted joints.	234
Existing AC distorted and PC badly cracked.	Still in service, portions to be replaced in 1993 (USN).	235
Strengthen and improve rideability.	Some panels have mutiple cracks, ride quality is fair. PSR = 3.3 in 1990.	236
Mill to maintain min. 14" thickness, pave.	Pavement in good shape, some slab repairs (Airport Authority).	237
Cleaned existing pavement, overlaid old 3" AC surface.	Distress around exp. joints, several recent slab replacements.(APT. Auth.).	238
Upgrade existing pavement to Interstate standard.	In 1990, excellent condition, 1 to 2 mill. ESAL's carried.	239
No information on this item.	In service (IL concrete council).	240
Replace distorted AC. Existing PC cracked.	No new information.	241
PSR = 3.9 in 1990, 1.1 Mill. ESAL's carried, one patch.	No new information.	242
No information on this item.	No information on this item.	243
Strenghten and restore serviceability.	Old Data Corrected, original pavement was RC rather than PC.	244
No information on this item.	No new information.	245
No information on this item.	No new information.	246
No information on this item.	No new information.	247
No information on this item.	No new information.	248
No information on this item.	No new information.	249
Strengthen and correct structural deficiencies.	No new information.	250
Swept, slipformed, curing cmpd, overlay to strengthen.	In service (Airport Authority).	251
Strengthen and correct surface distress.	Good condition (USN).	252
Remove distorted AC and replace with FC.	No new information.	253
Strenghten and restore serviceability.	PSI of 4.0 to 4.8 in 1991.	254
Correct surface distress and structural cracking.	Performing well, very few cracks.	255

Table A-2
UNBONDED AND PARTIALLY BONDED PORTLAND CEMENT CONCRETE RESURFACING PROJECTS

				Resurfacing				Existing Pavement		
Proj. No.	Location	State	Use	Year Built	Thick-ness(in.)	OL Type	Inter-face	Year Built	Thick-ness(in.)	Type
256	Sec. Rd. G61, Madison Co., 5.33 mi.	IA	H	1981	5	JPCP	U	1968	6	JPCP
257	G-61, US-169, Madison Co., Iowa	IA	H	1981	5	JPCP	U	-	-	JPCP
258	G. A. Apron, Decatur Airport, Decatur	IL	A	1981	9	JPCP	U	1943	9	JPCP
259	E-W Tollway, Chicago, Ill.	IL	H	1981	8	JPCP	U	-	3-4/10	AC/JPCP
260	I-59, Ellisville to Moselle, Miss.	MS	H	1981	6	CRCP	U	-	8	CRCP
261	Apron, Fallon NAS, Nev.	NV	A	1981	5	FRC	U	1940	9	JPCP
262	Penn-Lincoln Pkwy., Pittsburgh, Pa.	PA	H	1981	8	JRCP	U	-	10	JRCP
263	I-45, La Margue, Galveston Co., Tex.	TX	H	1981	6	CRCP	U	1949-51	9 & 10	JPCP
264	Apron, Salt Lake City Airport, Utah	UT	A	1981	7	FRC	U	-	12	AC/JPCP
265	Apron, Norfolk NAS (3 projects), Va.	VA	A	1981	5	FRC	U	-	1-1/2 - 3/8	AC/JPCP
266	I-43, Green Bay to Sheboygan	WI	H	1981	6	CRCP	U	-	-	JPCP
267	I-77, N. of Princeton, W. Va.	WV	H	1981	8	JRCP	U&P	1978-79	10	JRCP
268	Sec.Rd. @ N.1/4Corner Sec.32-88-47, Wood	IA	H	1982	6	JPCP	U	1958	6	JPCP
269	G. A. Apron, Willard Airport, Savoy	IL	A	1982	8-9	JPCP	U	1944	8-9	JPCP
270	Student Ramp, U. of Il., Willard Aprt.	IL	A	1982	6	JPCP	U	1944-47	9	JPCP
271	Main Apron, Vermillion Co. Airport	IL	A	1982	6	JPCP	U	-	8	JPCP
272	Runway 12R-30L, Lambert Int. Airport	MO	A	1982	15	JPCP	U	1950-53	14	JPCP
273	Taxiway A, Lambert Int. Airport	MO	A	1982	15	JPCP	U	1950-53	14	JPCP
274	Rte. 33, Logan Co., MP 2.01, 3.72 mi.	OH	H	1982	7	JPCP	U	-	9	JRCP
275	I-376, Pittsburgh	PA	H	1982	8	JRCP	U	1946	10	JRCP
276	I-376, Pittsburg	PA	H	1982	8	JRCP	U	-	10	JRCP
277	SR-61, Fennimore-Boscobel	WI	H	1982	8	JPCP	U	-	-	JPCP
278	I-96, Portland	MI	H	1983	7	JRCP	U	-	-	-
279	Taxiway M, Lambert Int. Airport	MO	A	1983	10.5 - 14	JPCP	U	1950	9	JPCP
280	Taxiway C, Lambert Int. Airport	MO	A	1983	9	JPCP	U	1958	14	JPCP
281	Runway 6-24, Lambert Int. Airport	MO	A	1983	12-1/2	JPCP	U	1950-58	14 -16	JPCP
282	I-35, Waco	TX	H	1983	6	PRCP	U	-	-	JPCP
283	US-10, Prescott, Peirce Co.	WI	H	1983	7	JPCP	U	1934	-	JRCP
284	US-8, Prentice-Tomahawk	WI	H	1983	8	JPCP	U	-	-	-
285	I-77	WV	H	1983	8	JRCP	U	-	10	JRCP
286	I-25, SH 119 - North, MP 243-254.	CO	H	1984	7-3/4	JPCP	U	1961-62	8	JPCP
287	I-85, Banks & Franklin Cos.	GA	H	1984	8	CRCP	U	-	9	JPCP
288	Sec. Rd. H38, Des Moines, 2.59 mi.	IA	H	1984	5	JPCP	U	1968	7	JPCP
289	I-96, Ionia Co., 2.86 mi. E, 5.45 mi. W	MI	H	1984	7	JRCP	U	1958-59	9/8	JRCP/CRCP
290	US 23, Monroe Co., 7.8 mi.	MI	H	1984	7	JRCP	U	1959-61	9	JRCP
291	Rte. 70, Clark Co., MP 20.94, 4.19 mi.	OH	H	1984	9	JRCP	U	1969	9	JRCP
292	I-78, Lenhartsville	PA	H	1984	12	JPCP	U	-	7	CRCP
293	I-80, I-380, Poconos	PA	H	1984	11	JPCP	U	-	10	JRCP
294	I-376 Allegheny County, 2.2 mi.	PA	H	1984	8	JRCP	U	1950	10	JRCP
295	I-40 North Little Rock, 1.2 mi.	AR	H	1985	6	CRCP	U	-	10	JRCP
296	I-70, Burlington	CO	H	1985	6	JPCP	U	-	-	-
297	I-25, N. of SH 60, MP254-260.	CO	H	1985	8	JPCP	U	1963-65	8	JPCP
298	Sec. Rd. F32, Audubon Co., 5.43 mi.	IA	H	1985	5	JPCP	U	1968	6	JPCP
299	Sec. Rd. M66, Audubon Co., 3.84 mi.	IA	H	1985	5	JPCP	U	1970	6	JPCP
300	Sec. Rd. J5T, Appanoose Co., 0.97 mi.	IA	H	1985	6	JPCP	U	1970	6	JPCP
301	G.A. Apron, Quincy Municipal Aprt.	IL	A	1985	9	JPCP	U	1940's	9	JPCP
302	TH-212, Glencoe, WB lanes, 7.4 mi.	MN	H	1985	7	JPCP	U	1966	9	JPCP
303	Rte. 33, Athens Co., MP 13.31, 2.22 mi	OH	H	1985	8	JPCP	U	1971	7	CRCP
304	Rte. 70, Franklin Co., MP 0.02, 3.38 mi.	OH	H	1985	3AC/9PC	JPCP	U	1970	9	JRCP
305	Rte. 71, Clinton Co., MP 4.26, 3mi.	OH	H	1985	9	JRCP	U	1964	9	JRCP
306	I-45, Richland, Navarro Co.	TX	H	1985	10	JPCP	U	-	8	CRCP
307	I-610, EBL, Houston	TX	H	1985	4	JPCP	P	1970	8	CRCP
308	US-59, Houston	TX	H	1985	2	JPCP	U	-	-	-
309	US-59, Houston	TX	H	1985	3	JPCP	U	-	-	-
310	I-45, Richland	TX	H	1985	10	JPCP	U	-	-	CRCP
311	I-25, Co. Rd. 26 - North, MP 259-265	CO	H	1986	8-3/4	JPCP	U	1965	8	JPCP
312	Sec. Rd. F32, Audubon Co., 6.00 mi.	IA	H	1986	5	JPCP	U	1962	6	JPCP
313	Sec. Rd. F32, Guthrie Co., 0.98 mi.	IA	H	1986	5	JPCP	U	1963	6	JPCP
314	I-69, From SR 18 to 5.56 mi. N.	IN	H	1986	10	JPCP	U	1963	10	JPCP
315	Taxiway G, Standiford Field, Louisville	KY	A	1986	14	JPCP	U	1956-65	10	JPCP
316	TH-90, Adrian, 8.7 mi. (SP 5380-86)	MN	H	1986	8-1/2	JPCP	U	1968	8	CRCP
317	I-20, WBL, Vicksburg	MS	H	1986	10	JPCP	U	-	-	JRCP
318	I-20, WBL, Vicksburg	MS	H	1986	12	JPCP	U	-	-	JRCP
319	I-71, Wilmington	OH	H	1986	9	JRCP	U	-	9	-
320	I-30, Sulphur Springs	TX	H	1986	10	CRCP	U	-	-	-
321	I-94, WB, West CL to Hixton, Jackson Co.	WI	H	1986	10	CRCP	U	-	9	JRCP
322	I-25, S. of SH 68-North, MP 264.5-268.3	CO	H	1987	8	JPCP	U	1966	8	JPCP
323	Sec. Rd. G52, Washington Co., 2.94 mi.	IA	H	1987	7	JPCP	U	1968	6	JPCP
324	Sec. Rd. H38, Henry Co., 8.06 mi.	IA	H	1987	6	JPCP	U	1965	6	JPCP
325	Sec. Rd. @ SE Corner Sec. 25-84-26, Boone Co.	IA	H	1987	7	JPCP	U	1957	6	JPCP
326	Sec. Rd. G76, Warren Co., 7.19 mi.	IA	H	1987	6.5	JPCP	U	1963	6	JPCP
327	TH-35, Harris, 8.3 mi., (SP 1380-53)	MN	H	1987	8-1/2	JPCP	U	1969	9	JRCP
328	Rte. 270, Franklin Co., MP 31.70, 2.40 mi.	OH	H	1987	9	JPCP	U	1969	8	CRCP
329	I-90, Erie	PA	H	1987	13	JPCP	U	-	10	JRCP
330	I-94, WBL, Hixton	WI	H	1987	10	CRCP	U	-	-	JRCP
331	I-80, Donner Summit, Nevada Co.	CA	H	1988	8	JPCP	U	1962	8	JPCP
332	SBL I-25, Prospect Int. - North	CO	H	1988	8-1/4	JPCP	U	1966-67	8	JPCP
333	NBL I-25, Prospect Int. - North	CO	H	1988	10	JPCP	U	1966-67	8	JPCP
334	Sec. Rd. R57, Warren Co., 3.85 mi.	IA	H	1988	6.5	JPCP	U	1966	6	JPCP
335	TH-90, Luverne, 7.1 mi., (SP 6780-74)	MN	H	1988	8	JPCP	U	1966	9	JPCP
336	I-20, US-61 to Bovina, Warren Co.	MS	H	1988	10	JRCP	U	1960's	8	CRCP
337	HWY 281-Grand Island, MP 69.59-71.16	NE	H	1988	7 & 9	JPCP	U	1964	8	JRCP
338	Rte. 270, Franklin Co., MP 2.60, 7.55 mi.	OH	H	1988	9	JPCP	U	1967-68	9	JRCP
339	I-80, WBL, Clearfield County	PA	H	1988	10	JPCP	U	-	10	JRCP
340	I-80, St. Johns, Luzerne Co.	PA	H	1988	13	JPCP	U	-	10	JRCP

Construction and Performance Remarks	Status in 1992	Proj. No.
No information on this item.	No new information.	256
Correct surface distress and structural cracking. SS interlay.	Some crks. next to saw cuts that missed jts. in old pvmnt. Some corner breaks (Writer Observed	257
No information on this item.	In service (IL Concrete Council).	258
Replace AC resurfacing to strengthen and improve service.	In 1990, PSR = 2.9, avg. fault = 0.22", 9.5 mill. ESAL's.	259
Strengthen and restore serviceability.	Scheduled for AC overlay within 3 years.	260
Strengthen and correct surface distress.	In service, but loose fibers hazardous (USN).	261
Strengthen and restore serviceability.	No additional information.	262
Upgrade existing pavement to Interstate standard.	No additional information.	263
Apron reconstruction-strengthen and correct structural distr.	No additional information.	264
Strengthen and correct for surface distress.	Still in service, repairs due to corner breaks, good cond. (USN).	265
-	PSI of 3.1 to 4.7 in 1991.	266
Strengthen and correct for structural distress.	No additional information.	267
In service.	No additional information.	268
Removed loose material from old, paved.	No distresses evident (U. Of Ill.).	269
In service.	In service (IL Concrete Council).	270
In service.	In service (IL Concrete Council).	271
HMAC layer, slipformed, curing cmpd., overlaid to strengthen.	In service (Airport Authority).	272
HMAC layer, slipformed, curing cmpd., overlaid to strengthen.	In service (Airport Authority).	273
1000' failed early, poor consolidation; faulting corner breaks.	In service.	274
In service.	In service.	275
PSR = 3.7 in 1990,0.045" avg. faulting,8.8 mill. ESAL's carried.	In service.	276
In service.	In service.	277
No information on this item.	In service.	278
Old pavement swept, overlaid to strengthen, slip formed.	In service (Airport Authority).	279
Old pavement swept, overlaid to strengthen, slip formed.	In service (Airport Authority).	280
HMAC on part, part swept, overlay to strengthen, slipform.	In service (Airport Authority).	281
No information on this item.	In service.	282
No information on this item.	In service.	283
No information on this item.	In service.	284
No information on this item.	In service.	285
Project has tied PCC shoulders,.4% of slabs have some distress in 1990.	In service.	286
No information on this item.	In service.	287
No information on this item.	In service.	288
Overall performance is good.	In service.	289
Overall performance is good. Moderate crk. due to loads.	In service.	290
3 dowels per wheelpath,tied shoulders. Some trans crk. PSI=3.4.	In service.	291
No information on this item.	In service.	292
No information on this item.	In service.	293
No information on this item.	In service.	294
Generally good results, but isolated "pop outs".	In service.	295
No information on this item.	In service.	296
Project has tied PCC shoulders, .4% of slabs have some distr.	In service.	297
No information on this item.	In service.	298
No information on this item.	In service.	299
No information on this item.	In service.	300
No information on this item.	In service (IL Concrete Council).	301
1991, 1.2% cracked panels, PQI = 3.9.	In service.	302
Skewed, random jts., tied shoulders, PSI = 3.5 in 1991.	In service.	303
Skewed, random jts., tied shoulders, AC Surf. saw & seal, PSI=3.8	In service.	304
Skewed, doweled jts., tied shoulders, PSI = 3.3 in 1991.	In service.	305
No information on this item.	In service.	306
<see reports>	In service.	307
No information on this item.	In service.	308
No information on this item.	In service.	309
PSR = 4.3 in 1990, 0 faulting, 4.3 mill. ESAL's carried.	In service.	310
Project has tied PCC shoulders, .4% of slabs have some distr.	In service.	311
No information on this item.	In service.	312
No information on this item.	In service.	313
March 1992, excellent condition w/ minor jt. seal problems only.	Excellent (INDOT).	314
Slipformed, curing compound, joints match those below.	Good condition (Airport Authority).	315
PSR =4.2 in 1990,0.021" avg. faulting, 1.3 mill. ESAL's carried.	In service.	316
No information on this item.	In service.	317
No information on this item.	In service.	318
No information on this item.	In service.	319
No information on this item.	In service.	320
Unbonded CRCP overlay of existing JRCP. No perf. information.	In service.	321
Project has tied PCC shoulders, .4% of slabs have some distr.	In service.	322
No information on this item.	In service.	323
No information on this item.	In service.	324
No information on this item.	In service.	325
Old "d" crked. pavement, SS interlayer. Relief joints @ 1500'.	Generally excellent with isolated problems (Writer Observed).	326
1991, 0.7% Cracked panels, PQI = 3.9.	In service.	327
No information on this item.	In service.	328
No information on this item.	In service.	329
No information on this item.	In service.	330
No information on this item.	In service.	331
Project has tied PCC shoulders, .4% of slabs have some distr.	In service.	332
Project has tied PCC shoulders, .4% of slabs have some distr.	In service.	333
No information on this item.	In service.	334
Has 1/2 mi. test sections of various drainage layers, dowels.	In service. Avg. faulting of 0.14 (OGB section) to 0.24 in. (undowelled sec.).	335
No information on this item.	In service.	336
No information on this item.	In service.	337
Cracked and seated, NBL only.	In service.	338
No information on this item.	In service.	339
No information on this item.	In service.	340

Table A-2
UNBONDED AND PARTIALLY BONDED PORTLAND CEMENT CONCRETE RESURFACING PROJECTS

Proj. No.	Location	State	Use	Resurfacing Year Built	Resurfacing Thickness(in.)	OL Type	Interface	Existing Pavement Year Built	Existing Pavement Thickness(in.)	Type
341	I-25, Larimer Co. Rd. 56 - North	CO	H	1989	8	JPCP	U	1966-67	8	JPCP
342	Sec. Rd. N36, Audubon Co., 7.09 mi.	IA	H	1989	5	JPCP	U	1968	6	JPCP
343	Sec. Rd. R45, Warren Co., 7.05 mi.	IA	H	1989	6.5	JPCP	U	1965	6	JPCP
344	I-80, Venango County, 14.7 mi.	PA	H	1989	13	JPCP	U	-	10	JRCP
345	I-76, W. of Crook to Crook	CO	H	1990	8	JPCP	U	1966	8	JPCP
346	Sec. Rd. W47, Washington Co., 7.56 mi.	IA	H	1990	7	JPCP	U	1967	6	JPCP
347	Sec. Rd. C54, Wright Co., 2.11 mi.	IA	H	1990	5	JPCP	U	1956	6	JPCP
348	G. A. Apron, Capital Airport	IL	A	1990	9	JPCP	U	1948	9	JPCP
349	I-275, Boone Co., 2.986 mi. (Rubblized)	KY	H	1990	9	JRCP	U	1977	9	RUBB.CRCP
350	TH-90, Beaver Cr., WB lanes, 9.2 mi.	MN	H	1990	8	JPCP	U	1964	9	JRCP
351	WB US 10, Bay City to Midland, 12.2 mi.	MI	H	1990	7	JPCP	U	1958	9	JRCP
352	I-80, Jefferson County, 7.25 mi.	PA	H	1990	10	JPCP	U	1966	10	JRCP
353	I-80, Luzerne County, 1.5 mi.	PA	H	1990	13	JPCP	U	1966	10	JRCP
354	I-78, Lebanon County, 7.51 mi.	PA	H	1990	13	JPCP	U	1967	10	JRCP
355	I-76 E. of Roggen-East, MP 50.09-61.93	CO	H	1991	8-1/2	JPCP	U	1959	8	JPCP
356	Sec. Rd. fr. Kanawa to Britt, Hancock	IA	H	1991	5	JPCP	U	1931	10	JPCP
357	Sec. Rd. G38, Washington Co., 4.16 mi.	IA	H	1991	7	JPCP	U	1928	10	JPCP
358	Sec. Rd. F58, Audubon Co., 6.40 mi.	IA	H	1991	5	JPCP	U	1967	6	JPCP
359	Runway 18/36, Capital Airport	IL	A	1991	6	JPCP	U	1947	9	JPCP
360	I-96, Clinton Co., 6.76 mi.	MI	H	1991	7-1/2	JRCP	U	1962	9	JRCP
361	TH-90, Worthington, WB lanes, 10.3 mi.	MN	H	1991	8	JPCP	U	1969	8	CRCP
362	Rte. 70, Clark Co., MP 0.51, 6.25 mi.	OH	H	1991	3AC/6PC	JPCP	P	1957	9	JRCP
363	Bus loop, Alexander Graham Bell Sch.	OH	P	1991	4-5	JPCP	U	1958	3	AC
364	SR56, Somerset County, 5.8 mi.	PA	H	1991	9	JPCP	U	1960	9	JRCP
365	I-80, Clinton County, 9.88 mi.	PA	H	1991	12	JPCP	U	1969	10	JRCP
366	EBL I-30, Hwy 108 to Hwy 67, 5.62 mi.	AR	H	1992	6 & 10	CRCP	U	1967	10	JRCP
367	I-30, Texas Line to Hwy 296, 5.54 mi.	AR	H	1992	6 & 8	CRCP	U	1967	10	JRCP
368	WBL I-30, Hwy 108 to Hwy 67, 5.62 mi.	AR	H	1992	10	JRCP	U	1967	10	JRCP
369	I-76, Iliff, MP128.11-140.0	CO	H	1992	8-1/2	JPCP	U	1967	8	JPCP
370	I-495, Edgemoor Rd. to Phil. Pike	DE	H	1992	12	JPCP	U	-	9	CRCP
371	Sibley Municipal Airport	IA	A	1992	5	JPCP	U	1966	6	JPCP
372	Sec. Rd. R38, Wright Co., 3.84 mi.	IA	H	1992	5	JPCP	U	1956	6	JPCP
373	Spencer Municipal Airport	IA	A	1992	6	JPCP	U	-	-	F
374	Sec. Rd. R38, Wright Co., 4.01 mi.	IA	H	1992	5	JPCP	U	1956	6	JPCP
375	Sec. Rd. A52, Allamakee Co., 6.75 mi.	IA	H	1992	6	JPCP	U	-	-	JPCP
376	Midway Airport, Chicago	IL	A	1992	10.5	JPCP	U	1967	8	CRCP
377	Int. Rwys C & S, Standiford Field	KY	A	1992	17	JPCP	U	1978	14	JPCP
378	Runway, Barksdale AFB.	LA	A	1992	12-16	JPCP	U	1953	6-11	JPCP
379	Alpena Co. Regional Airport	MI	A	1992	7	JPCP	U	1944-45	7	JPCP
380	TH-52, Rochester, 6.0 mi. (SP 5507-47)	MN	H	1992	8	JPCP	U	1971-78	8	-
381	TH-90, Olmstead Co., EB lanes, 12.2 mi.	MN	H	1992	8 & 9	JPCP	U	1971	9	JRCP
382	TH-90, Adrian, WB lanes, 5.4 mi.	MN	H	1992	8	JPCP	U	1966	8	CRCP
383	TH-35, Mooselake, NB lanes, 10.1 mi.	MN	H	1992	10	JPCP	U	1970	9	JRCP
384	I-70, EBL, Callaway Co., 10.19 mi.	MO	H	1992	11	JRCP	U	1965	8	JRCP
385	I-20, Bovina to Big Black R.	MS	H	1992	10	JPCP	U	1960's	8 & 9	CRCP/JRCP
386	Bus loop, East Guernsey Schools	OH	P	1992	4-5	JPCP	U	-	3	Chipseal
387	I-80, Columbia County, 5.75 mi.	PA	H	1992	13	JPCP	U	1965	10	JPCP
388	I-81, Luzerne County, 12 mi.	PA	H	1992	13	JPCP	U	1967	10	JRCP
389	I-80, Mercer County, 15.7 mi.	PA	H	1992	13	JPCP	U	1964	10	JRCP
390	Naval Air Station, Norfolk, Va.	VA	A	1992	8-11	JPCP	U	1940	10	JPCP
391	Fort Pickett Airfield, Blackstone, Va.	VA	A	1992	16	JPCP	U	1940's	-	JPCP
392	SR300, Lancaster County	PA	H	1992	11	JPCP	U	1968	10	JRCP

S = street; H = highway; A = airfield.
JRCP = Jointed reinforced concrete pavement, JPCP = Joint Plain Concrete Pavement, CRCP = Continuously Reinforced Concrete Pavement,
FRC = Fiber Reinforced Concrete, PRCP = Prestressed Concrete Pavement
F = flexible; AC = asphalt concrete.
B = bonded; U = unbonded; P = partially bonded; W = Whitetopping.

Construction and Performance Remarks	Status in 1992	Proj. No.
Project has tied PCC shoulders, .4% of slabs have some distr.	In service.	341
No information on this item.	In service.	342
No information on this item.	In service.	343
No information on this item.	In service	344
Project has tied PCC shoulders, no distress noted in 1992.	In service	345
1" AC interlayer, 15' slabs, skewed joints.	Excellent condition and ride (Writer Observed).	346
No information on this item.	In service.	347
Old pavement cracked and seated prior to overlay.	In service (IL Concrete Council).	348
No information on this item.	In service.	349
1991, 0.6% cracked panels, PQI = 3.6.	In service.	350
Half on rubbilized, half on 1" AC interlayer.	In service.	351
No information on this item.	In service.	352
No information on this item.	In service.	353
No information on this item.	In service.	354
No distress noted in 1992. (Project has tied PCC shoulders).	In service.	355
No information on this item.	In service.	356
1" AC interlayer, 15' slabs, skewed joints.	Excellent condition and ride (Writer Observed).	357
No information on this item.	In service.	358
Old pavement cracked and seated prior to overlay.	In service (IL Concrete Council).	359
-	In service.	360
No information on this item.	In service.	361
New PCC base was bonded to milled AC surface, early cracking.	In service.	362
Donated by Ohio Ready Mixed Concrete Assoc.	In service.	363
No information on this item.	In service.	364
No information on this item.	In service.	365
6" CRCP Poor (excessive cracking), Change ordered to 10" CRC.	In service.	366
6" poor perf. due to excessive cracking, two mi. @ 8"	In service.	367
Change ordered from 6-in. CRCP due to excessive cracking.	In service.	368
Project has tied PCC shoulders, under construction in 1992.	In service.	369
Under construction in 1992.	In service.	370
Broomed old, filled cracks w/sand-cement-water, overlaid.	New (Iowa DOT).	371
No information on this item.	In service.	372
AC leveling course covered w/ curing compound, paved.	New (Iowa DOT).	373
No information on this item.	In service.	374
No information on this item.	In service.	375
Slip formed, curing compound, broom finish.	New (Airport Authority).	376
6 mil plastic between old pavement and overlay.	Under construction (Airport Authority).	377
Pyrament cement overlay of earlier (1953) overlay.	New (USAF).	378
HMAC overlay to correct grade, std. mix, slipformed.	New (Mich. DOT).	379
No information on this item.	In service.	380
No information on this item.	In service.	381
No information on this item.	In service.	382
No information on this item.	In service.	383
Slabs 61.5' typical, but shortened to stay 15' from old joints.	New (Writer Observed).	384
No information on this item.	In service.	385
Donated by Ohio Ready Mixed Concrete Assoc.	In service.	386
No information on this item.	In service.	387
No information on this item.	In service.	388
In service	In service.	389
Slip formed, membrane cure, 12.5' x 15' slabs.	New (USN).	390
To provide runway for shipment of heavy commodities.	New (ACPA).	391
No information on this item.	Under construction.	392

TABLE A-3
PORTLAND CEMENT CONCRETE OVERLAYS OF ASPHALT PAVEMENTS (WHITETOPPING PROJECTS)
·INCLUDES MISCELLANEOUS OVERLAYS OF BRICK, ETC.

				Resurfacing				Existing Pavement		
Proj.	Location	State	Use	Year Built	Thick-ness(in.)	OL Type	Inter-face	Year Built	Thick-ness(in.)	Type
1	South 7th St., Terre Haute, Ind. (WT)	IN	S	1918	3-4	JRCP	W	-	-	F
2	Cleveland to Berea, Ohio	OH	H	1926	6	JRCP	-	1901-04	-	Brick
3	Center Rd., Cleveland to Akron, Ohio	OH	H	1926	6	JRCP	-	-	-	Brick
4	W. Fourth St., Williamson, W. Va.	WV	S	1928	4	JRCP	-	1912	-	Brick
5	Fullerton St., Chicago, Ill.	IL	S	1931	5	JPCP	-	-	-	Base
6	South Chicago Ave., Chicago, Ill.	IL	S	1931	5	JPCP	-	-	-	Base
7	4th Ave., Portland, Ore.	OR	S	1935	3-1/2 - 10	JPCP	-	-	-	Base
8	Runway, Offutt AFB, Nebr. (White.)	NE	A	1944	7 & 9	JPCP	W	1941	-	F
9	Second Ave., Seattle, Wash.	WA	S	1944	6-1/2	JPCP	-	-	-	Brick
10	Apron, Davis-Monthan AFB, Ariz. (WT)	AZ	A	1945	12	JPCP	W	-	-	F
11	Dye Road, Miller Rd. to Corunna Rd., WT	MI	H	1953	8	JPCP	W	-	-	F
12	Craig AFB, Ala. (Whitetopping)	AL	A	1954	8	JPCP	W	-	11-1/2	F
13	Runway, Dover AFB, Del. (Whitetopping)	DE	A	1954	16	JPCP	W	1941-43	29	F
14	Baton Rouge Municipal Airport, WT	LA	A	1954	10	JPCP	W	-	10	F
15	Apron, taxiway, Castle AFB, WT	CA	A	1955	16 & 18	JPCP	W	1942	10	F
16	US-99, Hwy 119 to Hwy 65, Bakersfield, WT	CA	H	1956	8	JPCP	W	1936	-	F
17	US-99, Union Ave. off ramp, WT	CA	H	1956	8	JRCP	W	1938-48	9-1/2-11-1/2	F
18	Taxiway, Columbus AFB, Miss. (White.)	MS	A	1956	16	JPCP	W	-	17	F
19	Runway, O'Hare Int. Airport, WT	IL	A	1958	9 & 11	JPCP	W	-	24	F
20	Runway, Selfridge AFB, Mich. (White.)	MI	A	1958	13	JPCP	W	1951	34	F
21	Taxiway, Glasgow AFB, Mich. (White.)	MI	A	1958	15	JRCP	W	-	55	F
22	Runway, Kincheloe AFB, Mich. (White.)	MI	A	1958	12	JRCP	W	1942	9	F
23	I-5, Near Gorman, Calif. (White.)	CA	H	1959	8	JPCP	W	1949	-	F
24	Runway, Los Angeles Int. Airport, WT	CA	A	1960	10-1/2 & 15	JPCP	W	-	-	F
25	Woodbury Co., Iowa (Whitetopping).	IA	H	1960	6	JPCP	W	-	-	F
26	US-99, Kern Co. Calif. (Whitetopping)	CA	H	1964	7	JPCP	W	1922-48	9-1/2 - 13	F
27	US-101, Los Angeles Co., WT	CA	H	1966	7	JPCP	W	-	-	F
28	US-91, Orange Co., Calif. (White.)	CA	H	1966	8	JPCP	W	-	-	F
29	Midway Airport, Chicago, Ill. (White.)	IL	A	1967	8	CRCP	W	-	-	F
30	I-5, Project City, Calif.	CA	H	1968	6	JPCP	W	1950-54	8 & 12	AC/CTB
31	Storm Lake Airport, Iowa (White.)	IA	A	1971	5	JPCP	W	1963	2-4	F
32	Woodbury Co., Iowa (Whitetopping)	IA	H	1971	6	JPCP	W	-	-	F
33	I-5,S. of Portland,Ore.(4 WT projects)	OR	H	1971	7 & 9	CRCP	W	1950	-	F
34	I-80, Near Ladd, Ore. (Whitetopping)	OR	H	1971	7 & 9	CRCP	W	-	-	F
35	I-40, Potter Co., Tex. (Whitetopping)	TX	H	1971	8	CRCP	W	-	12-16	F
36	Fifth Ave., S.E., Cedar Rapids, Iowa	IA	S	1972	2-1/2	FRC	W	-	-	AC/Brick
37	I-205, E. of Portland, Ore.	OR	H	1972	7-9	CRCP	-	-	-	-
38	I-40, W. of Bushland Tex. (White.)	TX	H	1972	8	CRCP	W	1953	16+	F
39	I-30, Little Rock, Ark. (Whitetopping)	AR	H	1973	6	CRCP	W	-	-	F
40	I-5, Siskiyou Co., Calif. (White.)	CA	H	1973	8-1/2	JPCP	W	1971	5-1/2	F
41	I-29, Walsh Co., N.D. (Whitetopping)	ND	H	1973	6	CRCP	W	-	-	F
42	I-205 E. of Portland, Ore. (White.)	OR	H	1973	7 & 9	CRCP	W	1959	-	F
43	Taxiway, Moody AFB, Ga. (Whitetopping)	GA	A	1974	6	CRCP	W	-	-	F
44	Y 34, Clinton Co., Iowa (Whitetopping)	IA	H	1974	6	JPCP	W	-	-	F
45	Plank Rd., Peru, Ill. (Whitetopping)	IL	H	1974	5	JPCP	W	-	8	F
46	Tank Apron, Ft. Hood, Tex. (White.)	TX	S	1974	4	FRC	W	-	17-19	F
47	I-80, Ore. (Whitetopping)	OR	H	1975	7 & 9	CRCP	W	-	-	F
48	I-5, Ore. (Whitetopping)	OR	H	1975	-	CRCP	W	-	-	F
49	Newark Int. Airport, N.J. (White.)	NJ	A	1976	4	FRC	W	-	-	F
50	Apron, McCarran Field, Las Vegas, WT	NV	A	1976	6	FRC	W	-	18	F
51	I-84, Hansel Vally Jct., Snowville, WT	UT	H	1976	9	JPCP	W	1966	-	F
52	Route 163, San Diego, Calif. (White.)	CA	H	1977	9	JPCP	W	-	-	F
53	Dallas Co., Iowa (Whitetopping)	IA	H	1977	5	JPCP	W	1955	11	F
54	Z40 or X46, Clinton Co., Iowa (White.)	IA	H	1977	6	JPCP	W	-	-	F
55	R-18, from E-57 S. 3 mi., Boone Co.,WT	IA	H	1977	5	JPCP	W	1957	11	F
56	X-40, Cedar Co., Iowa (Whitetopping)	IA	H	1977	6	JPCP	W	1955	-	F
57	Washington Co., Iowa (Whitetopping)	IA	H	1977	5	JPCP	W	1958	12-1/2	F
58	Apron, La Guardia Int. Airport, WT	NY	A	1977	6	FRC	W	-	-	F
59	T-55, 175 S. 2.4 mi., Grundy Co., WT	IA	H	1978	5	JPCP	W	-	-	F
60	I-80, W. of Des Moines, one lane WB, WT	IA	H	1979	10	JPCP	W	1959-72	37	F
61	Centerville Airport, Iowa (White.)	IA	A	1979	5	JPCP	W	1966	2-1/2	F
62	Apron, McCarran Fld., Las Vegas, WT	NV	A	1979	7	JPCP	W	-	14	F
63	I-80, Wyo. Line to Wahsatch, WT	UT	H	1979	10	JPCP	W	1964	5-1/2	F
64	F-31 West from Granger, Dallas Co.,WT	IA	H	1980	4	JPCP	W	-	-	F
65	Clayton Co., Iowa (Whitetopping)	IA	H	1980	6	JPCP	W	-	-	F
66	I-84, SW of Boise, Ida., MP 70.2-82.3, WT	ID	H	1980	7	JPCP	W	-	14	F
67	I-80, Wahsatch to Castle Rock, WT	UT	H	1980	10	JPCP	W	1964	-	F
68	Apron, Stapleton Airport, Denver, Colo.	CO	A	1981	4-7	FRC	-	-	-	-
69	E-57, Luther East, Boone Co., WT	IA	H	1981	6	JPCP	W	-	-	F
70	J-20, Jct. 218, W to Salem, Henry Co., WT	IA	H	1981	7	JPCP	W	-	-	F
71	F-31, Dallas Co., Iowa (Whitetopping)	IA	H	1981	5	JPCP	W	-	-	F
72	Sec. Rd. G36, Washington Co., 2.0 mi.,WT	IA	H	1981	8	JPCP	W	-	-	F
73	Greene Co. Line, Greene Co., WT	IA	H	1981	6	JPCP	W	-	-	F
74	F-41, 1st. St. Long Grove E. to #61,WT	IA	H	1981	6	JPCP	W	-	-	F
75	IA-92 to Jct. 114, Washington Co., WT	IA	H	1981	7	JPCP	W	-	-	F
76	I-80, Adair, 1/2 width WBL MP 85-94, WT	IA	H	1981	10	JPCP	W	1959-72	37	F
77	IA-92 to Wellman, Washington Co., WT	IA	H	1981	8	JPCP	W	-	-	F
78	R-18, Boone Co., 1 mi. S-30 to E-57, WT	IA	H	1981	6	JPCP	W	-	-	F
79	C-38, Cherokee, Plymouth CL E. 3 mi, WT	IA	H	1981	6	JPCP	W	-	-	F
80	X-23, Henry Co., 28 N. 2 mi. (White.)	IA	H	1981	5	JPCP	W	-	-	F
81	Apron, Salt Lake City Airport, WT	UT	A	1981	8	FRC	W	-	-	F
82	I-80, Salt Air- WBL, W. of S.L.City, WT	UT	H	1981	11	JPCP	W	-	-	F
83	Sec. Rd. D15, Sac Co., 3.0 mi., WT	IA	H	1982	5	JPCP	W	-	-	F
84	Clarion Airport, 24,200 sy, WT	IA	A	1982	5	JPCP	W	1965	2	F

Construction and Performance Remarks	Status in 1992	Proj.
Strengthen and correct distortion and cracking.	No new information.	1
Correct for uneveness and roughness.	No additional information.	2
Rideability improvement.	No additional information.	3
Strengthen and correct roughness.	No additional information.	4
Wood block surfacing and brick failed and removed.	No new information.	5
Wood block surfacing and brick failed and removed.	No new information.	6
AC & wood block surface failed and removed.	No new information.	7
Correct structural distress.	Extended and reconstructed in 1958.	8
Correct roughness and unsatisfactory service from brick.	No new information.	9
Strengthening program. Existing pavement surface distr.	No new information.	10
Existing AC deteriorated.	No new information in 1992.	11
Strengthen and resurface deteriorated AC pavement.	No new information in 1992.	12
Strengthening program	No new information in 1992.	13
Strengthen and resurface deteriorated AC pavement.	No new information in 1992.	14
Upgrade and strengthen. Existing AC poor to fair.	No new information in 1992.	15
Correct surface distortion and strengthen.	Digout, 1977-78.	16
Correct distortion and surface roughness. Strengthen.	No new information (none kept on ramps).	17
Strengthening program. Existing AC good.	Still in service (USAF).	18
Strengthen and repair damaged pavement.	No new information.	19
Strengthening program. Existing AC fair.	No new information.	20
Strengthening program. Existing AC fair.	No new information.	21
Strengthen and upgrade. Existing AC fair.	No new information.	22
Upgrade and correct for surface distortion and roughness.	No new information, Caltrans could not locate.	23
Upgrade and correct surface distortion and cracking.	No new information.	24
Strengthen and improve rideability.	No report from IDOT in 1992.	25
Upgrade and improve serviceability.	No new information, Caltrans could not locate.	26
Upgrade and improve serviceability.	In 1990, PSR = 4.1, corner brks., avg. fault = .08", 9.5 mill. ESAL's.	27
Upgrade and improve serviceability.	Some struct. problems. PSR=4.0 in 1990, Avg. Fault = 0.11", 4.0 M. ESAL.	28
Strengthen and correct distorted existing pavement.	Overlaid in 1988 - 1992, see 1992 project below, Airport Auth.	29
Strengthen and improve rideability.	No new information.	30
Strengthen and correct surface distortion.	In service (Iowa Conc. Paving Assoc., DOT).	31
Strengthen and improve rideability.	No report from IDOT in 1992.	32
Upgrade existing F to Interstate standards.	No new information.	33
Upgrade existing pavement to Interstate standards.	No new information.	34
Upgrade existing pavement to Interstate standards.	No new information.	35
Resurface distorted surface.	In service (Iowa Concrete Paving Assoc.).	36
-	No new information.	37
Upgrade existing pavement to Interstate standards.	No new information.	38
Upgrade existing pavement to Interstate standards.	Old data in error and should be deleted.	39
Upgrade existing pavement to Interstate standards.	ACOL 1986-89 due to structural problems.	40
Upgrade existing pavement to Interstate standards.	No new information.	41
Upgrade existing pavement to Interstate standards.	No new information.	42
Strengthen and resurface deteriorated pavement.	No new information.	43
Strengthen and improve rideability.	Minimal long.&trans. crk., outside corner breaks, random crks.	44
Strengthen and improve rideability.	In 1990, PSR=3.7, avg. fault = 0.13", 0.7 mill. ESAL's.	45
Resurface distressed AC for tank parking.	No new information.	46
Upgrade existing pavement to Interstate standards.	No new information.	47
Upgrade existing pavement to Interstate standards.	No new information.	48
Remove existing distorted AC and resurface with FC.	Overlaid in 1980 by project shown below as RW 22R End.	49
Upgrade deteriorated pavement.	Half has been replaced, the rest is ready due to crk. (Auth.).	50
Strengthen and improve rideability.	2800 ADT, 25% trucks.	51
Improve serviceability.	No new information.	52
Strengthen and improve rideability.	No trans. crk., few corner breaks, 60' of long. crk., good.	53
Strengthen and improve rideability.	40' slabs, most have mid-slab trans crks., AC & PC patches.	54
Strengthen and improve rideability.	Looks good, min. 1/4 pt. crk., some mid-panel crk. ,40' slabs.	55
Strengthen and improve rideability.	Approx. 100' long. crk. per mi., minor corner break. & trans.	56
Some bonding between overlay and old AC noted.	40' long slabs, a few with mid-panel breaks, few crks, good.	57
Remove distorted AC and resurface with FC.	Removed from service or rebuilt prior to 1992 (Port Auth.).	58
Strengthen and improve rideability.	Looks good, minimal trans. crk, 1000-1500' of long. crk.	59
Correct AC distortion and cracking, 10"old pvmt removed.	No cracks or patching.	60
Strengthen and restore serviceability.	In service (Iowa Concrete Paving Assoc, DOT).	61
Strengthen and correct distortion and cracking.	No new information.	62
Strengthen and improve service. Shoving and rutting.	4500 ADT, 36% trucks.	63
Strengthen and correct surface distortion and cracking.	Minimal cracking, performing very well (Writer Observed).	64
Strengthen and correct surface distortion and cracking.	Location unknown to DOT in 1992.	65
To replace distorted and cracked AC.	Extensive longitudinal cracking.	66
Strengthen and restore service. Shoving and rutting.	4500 ADT, 36% trucks.	67
-	No new information.	68
Strengthen and improve rideability.	Looks very good, minimal cracking.	69
Strengthen and improve rideability.	Few trans. crks., About 500' long. crk. per mi., perf. OK.	70
Strengthen and improve rideability.	Minimal cracking, performing well (Writer Observed).	71
No information on this item.	No new information.	72
Strengthen and improve rideability.	Location unknown to DOT in 1992.	73
Strengthen and improve rideability.	Minimal cracking, performance very good.	74
Strengthen and improve rideability.	Minimal cracking, project performing well.	75
To replace distorted and cracked AC, 10" removed.	2 trans. crks., 9-2sq.ft. patches @ interior joint corners.	76
Strengthen and improve rideability.	Minimal long. & random cracking, performance very good.	77
Strengthen and improve rideability.	Looks very good, minimal cracking.	78
Strengthen and improve rideability.	19 Long. cracks, no patches.	79
Strengthen and improve rideability.	No cracks, performance very good.	80
Apron reconst. - strengthen and correct structural distr.	No additional information.	81
Strengthen and restore serviceability.	No additional information.	82
In service.	No additional information.	83
Clean and fill cracks with cement/sand/water grout,overlay.	In service (Iowa DOT).	84

TABLE A-3
PORTLAND CEMENT CONCRETE OVERLAYS OF ASPHALT PAVEMENTS (WHITETOPPING PROJECTS)
INCLUDES MISCELLANEOUS OVERLAYS OF BRICK, ETC.

				Resurfacing				Existing Pavement		
Proj.	Location	State	Use	Year Built	Thick-ness(in.)	OL Type	Inter-face	Year Built	Thick-ness(in.)	Type
85	Sec. Rd. @ SE Corner Sect. 5-86-36, WT	IA	H	1982	6	JPCP	W	-	-	F
86	Sec. Rd. E18, Boone Co., 5.8 mi., WT	IA	H	1982	7	JPCP	W	-	-	F
87	Sec. Rd. X52,Allamakee Co., 2.0 mi., WT	IA	H	1982	8	JPCP	W	-	-	F
88	Olmstead County, Olmstead, WT	MN	S	1982	6	JPCP	W	-	-	AC
89	CR-10, Chatfield, Olstead Co., WT	MN	H	1982	6	JPCP	W	-	-	ACP
90	Belvidere N. & S., MP 17.00-22.02, WT	NE	H	1982	9	JPCP	W	1972-75	8-12	HMAC
91	Sec. Rd. V18, Chickasaw Co., 8.7 mi., WT	IA	H	1983	6.5	JPCP	W	-	-	F
92	Sec. Rd. T38, Mitchell Co., 4.3 mi., WT	IA	H	1983	6,7	JPCP	W	-	-	F
93	County Road, Davenport Co.	IA	H	1983	7	JPCP	W	-	-	ACP
94		IA	H	1983	5	JPCP	W	-	-	F
95	Sec. Rd. L36, Cherokee Co., 4.0 mi., WT	IA	H	1983	6.5	JPCP	W	-	-	F
96	Waverly Airport, Bremer Co., WT	IA	A	1983	5	JPCP	W	-	-	F
97	I-70, Sherman Co., 10.24 mi., WT	KS	H	1983	8	JPCP	W	1969	10	HMAC
98	S. of David City & 4th St., WT	NE	H	1983	9	JPCP	W	1972	3	HMAC
99	I-215, Salt Lake City, WT	UT	H	1983	10	JPCP	W	-	-	ACP
100	USH-151, Min. Pt.-Dodgeville Rd., WT	WI	H	1983	8	JPCP	W	-	3	AC
101	Sec. Rd. V56 @ NW cor. sect 15-95-11, WT	IA	H	1984	6	JPCP	W	-	-	F
102	Sec. Rd. D55, Hardin Co., 6.9 mi., WT	IA	H	1984	4	JPCP	W	-	-	F
103	Sec. Rd. V56 to Jct. IA24,Chickasaw, WT	IA	H	1984	6	JPCP	W	-	-	F
104	Sec. Rd. A52, Allamakee Co., WT	IA	H	1984	5	JPCP	W	-	-	F
105	Sec. Rd. V56 Fr. Bremer CL,Chickasaw, WT	IA	H	1984	6	JPCP	W	-	-	F
106	Sec. Rd. X42, Allamakee Co., WT	IA	H	1984	5	JPCP	W	-	-	F
107	Sec. Rd. L51, Cherokee Co., 3.2 mi., WT	IA	H	1984	5	JPCP	W	-	-	F
108	York, North, MP 64.11-74.42, WT	NE	H	1984	9	JPCP	W	1974	3-1/2	HMAC
109	Sec. Rd. F31, Dallas Co., 2.5 mi., WT	IA	H	1985	6	JPCP	W	-	-	F
110	County Road, Hampton Co.	IA	H	1985	6	JPCP	W	-	-	ACP
111	Sec. Rd. G62, Louisa Co., 4.6 mi., WT	IA	H	1985	6	JPCP	W	-	-	F
112	Sec. Rd. X37, Louisa Co., 7.4 mi., WT	IA	H	1985	6	JPCP	W	-	-	F
113	I-70, Sherman Co., 17.047 mi., WT	KS	H	1985	8	JPCP	W	1970	10	HMAC
114	I-80, 3.50 mi., (Whitetopping)	NV	H	1985	8	JPCP	W	1953	2.5	HMAC
115	I-215, I-15 to 2200 N., 2.8 mi., WT	UT	H	1985	11	JPCP	W	1969	5-1/2	AC
116	Sec. Rd. N14, Dickinson Co., 8.6 mi., WT	IA	H	1986	6	JPCP	W	-	-	F
117	Sec. Rd. G62, Washington Co., WT	IA	H	1986	7	JPCP	W	-	-	F
118	I-55, SBL, Pemiscot Co., 7.96 mi., WT	MO	H	1986	9	JRCP	W	1953-1976	12	HMAC
119	Benedict - Osceola, MP 162.01-168.97, WT	NE	H	1986	9	JPCP	W	1962	3-1/2	HMAC
120	Stromburg, N. & S., MP 72.91-82.92, WT	NE	H	1986	9	JPCP	W	1974	4-3/4	HMAC
121	I-80, 12.5 mi., (Whitetopping)	NV	H	1986	8	JPCP	W	1972	9	HMAC
122	I-80, 15 mi., (Whitetopping)	NV	H	1986	8	JPCP	W	1956-59	3-1/2	HMAC
123	I-30, Royce City, (Whitetopping)	TX	H	1986	11	JPCP	W	-	-	AC
124	I-30, Royce City, Rockwall Co.	TX	H	1986	11	JPCP	W	-	-	ACP
125	I-80, Cole Point to Blackrock, WT	UT	H	1986	10	JPCP	W	1965	-	AC
126	I-15, N. Beaver to Wildcat, 8.8 mi.,WT	UT	H	1986	10	JPCP	W	1967	5-1/2	AC
127	I-80, Point of Rocks, 8.0 mi., (Inlay)	WY	H	1986	10	JPCP	W	-	-	F
128	Sec. Rd. G62, Louisa Co., 3.2 mi., WT	IA	H	1987	7-5-7	JPCP	W	-	-	F
129	Corning Airport, 0.5 mi., WT	IA	A	1987	5	JPCP	W	-	4	F
130	Sec. R18 near sect 23-83-27, Boone, WT	IA	H	1987	7	JPCP	W	-	-	F
131	Sec. R18 near sect 25-82-27, Boone, WT	IA	H	1987	7	JPCP	W	-	-	F
132	Sec. Rd. V18, Chickasaw Co., 2.3 mi.,WT	IA	H	1987	6	JPCP	W	-	-	F
133	Sec. Rd. W66, Louisa Co., 2.9 mi., WT	IA	H	1987	7-5-7	JPCP	W	-	-	F
134	Sec. Rd. X42 & X52, Allamakee Co., WT	IA	H	1987	6	JPCP	W	-	-	F
135	Sec. Rd. X37, Louisa Co., 5.8 mi.,WT	IA	H	1987	7-5-7	JPCP	W	-	-	F
136	Sec. Rd. A52, Winneshiek Co., 0.7 mi., WT	IA	H	1987	6	JPCP	W	-	-	F
137	Sec. Rd. G52, Louisa Co., 2.3 mi., WT	IA	H	1987	7-5-7	JPCP	W	-	-	F
138	I-80, 13 mi., (Whitetopping)	NV	H	1987	9	JPCP	W	1965-66	5	HMAC
139	I-80, 7 mi., (Whitetopping)	NV	H	1987	9	JPCP	W	1965	3-1/2	HMAC
140	I-35, Gainesville	TX	H	1987	10	CRCP	W	-	-	AC
141	I-35, Gainesville, Cooke Co.	TX	H	1987	10	CRCP	W	-	-	ACP
142	Dane Co. Airport	WI	A	1987	15	JRCP	W	-	-	ACP
143	US Rte.1, Bet.Titusville & Day. Beach, WT	FL	H	1988	8	JPCP	W	-	-	HMAC
144	US Rte.1, Bet.Titusville & Day. Beach, WT	FL	H	1988	7	JPCP	W	-	-	HMAC
145	US Rte.1, Bet.Titusville & Day. Beach, WT	FL	H	1988	6	JPCP	W	-	-	HMAC
146	Sec. Rd. P58, Dallas Co., 6.0 mi., WT	IA	H	1988	5	JPCP	W	-	-	F
147	Carroll Airport, 0.8 mi., WT	IA	A	1988	5	JPCP	W	1972	2	F
148	Sec. Rd. B25, Allamakee Co., 6.3 mi., WT	IA	H	1988	7	JPCP	W	-	-	F
149	I-80, Bigelow Bench, MP 22.7 - 28.0, WT	WY	H	1988	10.5	JPCP	W	-	-	F
150	I-80, Elk Mountain, EBL, (Inlay)	WY	H	1988	10	JPCP	W	-	-	F
151	Thayer-Fillmore CL., 7.5 mi., WT	NE	H	1988	9	JPCP	W	1975	3	HMAC
152	Sec. Rd. P46 @ NCL Redfield, Dallas, WT	IA	H	1989	5	JPCP	W	-	-	F
153	Sec. Rd. L-401, Dickinson Co., WT	IA	H	1989	6	JPCP	W	-	-	F
154	Sec. Rd. B60, Floyd Co., 2.5 mi., WT	IA	H	1989	5	JPCP	W	-	-	F
155	Sec. Rd. P46 @ IA44, Dallas, 10.1 mi., WT	IA	H	1989	5	JPCP	W	-	-	F
156	Sec. Rd. D15, Hardin Co., 6.8 mi., WT	IA	H	1989	4.5	JPCP	W	-	-	F
157	US-81, N-59 to N-84, MP 186.97-196.95, WT	NE	H	1989	9	JPCP	W	1989	11	HMAC
158	Taxiways R & D, Newark Int. Airport	NJ	A	1989	10	FRC	W	1968	4	HMAC
159	I-80, 8 mi., (Whitetopping)	NV	H	1989	9	JPCP	W	1968	4	HMAC
160	I-80, 7 mi., (Whitetopping)	NV	H	1989	10	JPCP	W	1969	3	HMAC
161	I-15, 10 mi., (Whitetopping)	NV	H	1989	10-1/2	JPCP	W	1960	4	HMAC
162	I-80, Elk Mtn., East, EBL, (Inlay)	WY	H	1989	10	JPCP	W	-	-	F
163	I-80, Elk Mtn., West, EBL, (Inlay)	WY	H	1989	10	JPCP	W	-	-	F
164	SH 68, Harmony Rd., (Whitetopping)	CO	H	1990	3.5 & 5	JPCP	W	-	4.75 - 7.25	AC
165	Sec. Rd. C54, Wright Co., 2.65 mi., WT	IA	H	1990	5	JPCP	W	-	-	F
166	Sec. Rd. B60, Clayton Co., 1.45 mi., WT	IA	H	1990	6	JPCP	W	-	-	F
167	HWY 281, Blue Hill N., WT	NE	H	1990	9	JPCP	W	1954/1975	3	HMAC
168	US-81, Rising City N., WT	NE	H	1990	9	JPCP	W	1970-1980	2-3	HMAC

Construction and Performance Remarks	Status in 1992	Proj.
In service.	No additional information.	85
In service.	No additional information.	86
In service.	No additional information.	87
PSR = 4.0 in 1990.	In service.	88
No information on this item.	In service.	89
No information on this item.	In service.	90
In service.	In service.	91
In service.	In service.	92
In service.	In service.	93
In service.	In service.	94
In service.	In service.	95
Scarified and compacted old sealcoats, slipform paving.	In service (Iowa DOT).	96
4" of ACC milled before PCC overlay was placed.	Some faulting, long. cracking, patching. Ride good to fair.	97
No information on this item.	In service.	98
No information on this item.	In service.	99
No information on this item.	In service.	100
No information on this item.	In service.	101
No information on this item.	In service.	102
No information on this item.	In service.	103
No information on this item.	In service.	104
No information on this item.	In service.	105
No information on this item.	In service.	106
No information on this item.	In service.	107
No information on this item.	In service.	108
No information on this item.	In service.	109
No information on this item.	In service.	110
No information on this item.	In service.	111
No information on this item.	In service.	112
4" of AC milled before PCC overlay was placed.	Some faulting, long. crk., patching. Ride good to fair. KS DOT.	113
Faulting, PSI = 2.5.	In service.	114
No information on this item.	In service.	115
No information on this item.	In service.	116
No information on this item.	In service.	117
Project has 61.5' long slabs. No reported problems.	In service.	118
No information on this item.	In service.	119
No information on this item.	In service.	120
Wide (2") long. joints, slab breakups.	In service.	121
Small corner breaks occured at 1 year.	In service.	122
PSR = 4.3 in 1990, 0 faulting, 3.7 mill. ESAL's carried.	In service.	123
No information on this item.	In service.	124
No information on this item.	In service.	125
No information on this item.	In service.	126
No information on this item.	In service, average 3.0 mm faulting.	127
No information on this item.	In service.	128
Granular layer used to correct grade, paved.	In service (Iowa DOT).	129
No information on this item.	In service.	130
No information on this item.	In service.	131
No information on this item.	In service.	132
No information on this item.	In service.	133
No information on this item.	In service.	134
No information on this item.	In service.	135
No information on this item.	In service.	136
No information on this item.	In service.	137
PSI = 3.5.	In service.	138
No information on this item.	In service.	139
PSR = 4.1 in 1990, 2.6 mill. ESAL's carried.	In service.	140
No information on this item.	In service.	141
No information on this item.	In service.	142
WT,16,18,& 20'slabs,two dowel layouts.Excellent 3 yr.perf.	In service.	143
WT,16,18,& 20'slabs,two dowel layouts.Excellent 3 yr.perf.	In service.	144
WT,16,18,& 20'slabs,two dowel layouts.Excellent 3 yr.perf.	In service.	145
No information on this item.	In service.	146
Standard slipform.	In service (Iowa DOT).	147
No information on this item.	In service.	148
No information on this item.	In service, average 1 mm faulting.	149
No information on this item.	In service, average 1.7 mm faulting.	150
No information on this item.	In service.	151
No information on this item.	In service.	152
No information on this item.	In service.	153
No information on this item.	In service.	154
No information on this item.	In service.	155
No information on this item.	In service.	156
No information on this item.	In service.	157
Slabs 26' x 50'.	Excellent condition.	158
Shrinkage cracking associated w/ cold weather placement.	In service.	159
Has about 30,000 popouts due to soft particles.	In service.	160
Some difficulty w/ placing tiebars.	In service.	161
No information on this item.	In service, average 2.3 mm faulting.	162
No information on this item.	In service, average 2.5 mm faulting.	163
300'sect. poly. fiber reinf.,very short slabs in 3.5" sect., good perf	In service.	164
No information on this item.	In service.	165
No information on this item.	In service.	166
No information on this item.	In service.	167
No information on this item.	In service.	168

TABLE A-3
PORTLAND CEMENT CONCRETE OVERLAYS OF ASPHALT PAVEMENTS (WHITETOPPING PROJECTS)
INCLUDES MISCELLANEOUS OVERLAYS OF BRICK, ETC.

				Resurfacing				Existing Pavement		
Proj.	Location	State	Use	Year Built	Thick-ness(in.)	OL Type	Inter-face	Year Built	Thick-ness(in.)	Type
169	HWY N-2, Litchfield - Hazard, WT	NE	H	1990	9	JPCP	W	1943-1975	2-3	HMAC
170	I-80, 7 mi., (Whitetopping)	NV	H	1990	11	JPCP	W	1955	2-1/2	HMAC
171	Randell St., Betwn. 3rd. & Walters, OKC, WT	OK	S	1990	6	JPCP/AC	W	1952	1-1/2	AC
172	I-80, Elk Mountain, WBL, (Inlay)	WY	H	1990	10	JPCP	W	-	-	F
173	I-80, Elk Mountain, MP 269.4-275.6	WY	H	1990	10	JPCP	W	-	-	F
174	Sec. Rd. D61, Jones Co., 1.65 mi., WT	IA	H	1991	7	JPCP	W	-	-	F
175	Sec. Rd. R16, Dallas Co., 4.5 mi., WT	IA	H	1991	5	JPCP	W	-	-	F
176	Sec. Rd. D61, Dubuque Co., 1.26 mi., WT	IA	H	1991	7	JPCP	W	-	-	F
177	Sec. Rd. A34,Dickinson Co., 8.25 mi., WT	IA	H	1991	6	JPCP	W	-	-	F
178	Fort Madison Municipal Airport	IA	A	1991	5	JPCP	W	1958	5	AC
179	Waste Management access road, Louis., WT	KY	S	1991	2	FRC	W	-	-	AC
180	Waste Management access road, Louis., WT	KY	S	1991	3-1/2	FRC	W	-	-	AC
181	US-81, US-20-N-59, MP 180.05-186.97, WT	NE	H	1991	9	JPCP	W	1972	3	HMAC
182	N-2, Ansley - Mason City, WT	NE	H	1991	9	JPCP	W	1979	4	HMAC
183	I-80, Redwood Rd. to I-15, 1.2 mi., WT	UT	H	1991	-	JPCP	W	1966	5-1/2	AC
184	I-80, Utah State Line, MP 0.0 - 2.9, WT	WY	H	1991	11.5	JPCP	W	-	-	AC
185	I-80, Evanston West, MP 17.7-22.7, WT	WY	H	1991	12.5	JPCP	W	-	-	AC
186	Sec. Rd. A52, Allamakee Co., 0.94 mi., WT	IA	H	1992	6	JPCP	W	-	-	F
187	Reloc. Rd. F31, Dallas Co., 4.39 mi., WT	IA	H	1992	7	JPCP	W	-	-	F
188	I-80, Burmester to 700 E. Int., WT	UT	H	1992	11&13	JPCP	W	-	-	AC
189	I-80, Evanston East, MP 6.9 - 12.3, WT	WY	H	1992	12	JPCP	W	-	-	AC

S = street; H = highway; A = airfield.
JRCP = Jointed reinforced concrete pavement, JPCP = Joint Plain Concrete Pavement, CRCP = Continuously Reinforced Concrete Pavement,
FRC = Fiber Reinforced Concrete, PRCP = Prestressed Concrete Pavement
F = flexible; AC = asphalt concrete.
B = bonded; U = unbonded; P = partially bonded; W = Whitetopping.

Construction and Performance Remarks	Status in 1992	Proj.
No information on this item.	In service.	169
Two pass construction, performing very well.	In service.	170
City well pleased with WT, another 1.5mi. scheduled .	In service.	171
No information on this item.	In service, Average 0.8 mm faulting.	172
No information on this item.	In service, average 1.2 mm faulting.	173
No information on this item.	In service.	174
No information on this item.	In service.	175
No information on this item.	In service.	176
No information on this item.	in service.	177
In service (Iowa DOT).	In service.	178
Fast Track whitetopping with polypropylene fibers.	Surprisingly good performance after first two years (PCA).	179
Fast Track whitetopping with polypropylene fibers.	In service.	180
No information on this item.	In service.	181
No information on this item.	In service.	182
No information on this item.	In service.	183
No information on this item.	In service, average 0.1 mm faulting.	184
No information on this item.	In service, average 0.5 mm faulting.	185
No information on this item.	In service.	186
No information on this item.	In service.	187
No information on this item.	In service.	188
No information on this item.	In service, average 0.2 mm faulting.	189

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