TECH SUMMARY
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Advancing Concrete Pavement Technology Solutions

CONCRETE OVERLAYS—THE VALUE PROPOSITION

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The paved roadway system in the United States consists of nearly 3 million miles of interconnected federal, state, and local networks. Given increasing traffic demands, aging infrastructure, and relentless constraints on available funding, most, if not all, jurisdictions struggle to keep the condition of their roads at levels of service expected by the public and commercial trucking industry.

The American Society of Civil Engineers' 2021 Report Card for America's Infrastructure has highlighted this challenge by assigning the nation's roads a grade of D. The assessment notes that currently 43% of US public roadways, the vast majority of which are on urban and rural collectors and non-Interstate highways, are in poor or mediocre condition. The report card recommends that agencies focus resources on preserving roads in a state of good repair because the nation will never be able to fully build its way out of congestion (ASCE 2021).

As public agencies struggle with this challenge, many have found that including concrete overlays in their "mix of fixes" has proven to be a valuable strategy for improving the overall condition of their roadway networks over time. Their experiences have inspired the title of this publication: *Concrete Overlays—The Value Proposition*.

Although concrete overlays have been built for over 100 years, the reader will find that the technology has advanced significantly in recent years due to the following:

- Development of performance-engineered concrete mixtures for materials optimization and increased mixture durability under harsh winter maintenance environments
- Advancements in overlay design procedures
- Innovations in separation layer materials
- Improvements in traffic management strategies and tools, including rapid opening to traffic based upon maturity concepts
- Advancements in construction technologies, including vibrator monitoring, real-time smoothness, and stringless paving
- Availability of scanning technologies to rapidly measure existing pavement geometry, making it easy to design profile improvements
- Documentation of practical experience, which has shown widespread and substantial benefits

A more in-depth technical overview of concrete overlays and how to effectively deploy them is offered in a companion document entitled *Concrete Overlays—A Proven Technology*. That document is intended to provide an introduction to concrete overlay selection, design, and construction practices for those with limited experience with concrete overlay technology, while this document focuses on the value proposition concrete overlays offer to agencies.

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Given the positive contribution of concrete overlays to an agency's "mix of fixes" strategy, the Federal Highway Administration (FHWA) has featured concrete overlays as a prominent element in the sixth round (2021–2022) of its Every Day Counts initiative (EDC-6), including the innovative Targeted Overlay Pavement Solutions (TOPS) program. Through this program, technical support and educational materials are provided to state highway agencies (SHAs) to give them firsthand experience with overlays and, more broadly, the benefits of a more robust pavement management strategy. The FHWA believes that an investment approach that includes concrete overlays will enable state and local agencies to improve the overall condition of their pavement assets over time.

While concrete overlays have proven to be very successful and cost-effective for many state and local agencies over decades of service, agencies with limited experience with the technology would also benefit from including concrete overlays in their approach to strategic pavement preservation and rehabilitation. This document provides an overview of the value proposition offered by concrete overlays, including the technology's excellent performance history and low lifetime costs, and offers advice for agencies seeking to introduce concrete overlays into their "mix of fixes." The title of this document summarizes the message that is being delivered to leaders and decision-makers in transportation agencies: concrete overlays offer a strong value proposition.

Testimonials from State and Local Agencies

Learning from each other and sharing best practices has always been of importance to transportation professionals. The following testimonials relate firsthand how several state and local agencies are developing robust pavement management strategies through the use of concrete overlays and describe the benefits accruing both to the agencies' pavement networks and the agencies themselves. Benefits cited include cost savings, improved construction procedures, positive changes in surface characteristics, improved durability, reduced maintenance, longer service life, and reduced complaints from the motoring public, including from motorists driving after sundown due to the natural albedo offered by concrete surfaces.

When reading the following statements, consider the fact that the underlying problem faced by agencies daily is the lack of sufficient funds to meet all the needs identified by the respective agencies for the public that they serve. By comparing the cost of reconstruction to the cost of a concrete overlay, many agencies find that selecting the overlay option allows more projects to be addressed while meeting the intended performance goals.

California

Michael Oreiro, P.E., Caltrans Project Engineer for District 11, highlights the low cost and environmental sustainability of concrete overlays:

> On our I-8 CRCP [continuously reinforced concrete pavement] overlay projects, one hundred percent of the old concrete pavement was reused and put back in the projects, and this led to significant cost savings. With the existing JPCP [jointed plain concrete pavement] functioning as a pavement base layer, there was zero waste and no processing required of the old concrete pavement. This resulted in the conservation of virgin aggregates, elimination of deposits at disposal sites, and reduction of the need to transport construction materials. These reductions led to decreases in greenhouse gas emissions and traffic congestion.

North Carolina

Clark Morrison, State Pavement Design Engineer for the North Carolina Department of Transportation (NCDOT), notes the cost-effectiveness and performance of concrete overlays:

> North Carolina has been using unbonded concrete overlays on existing concrete pavement for almost 25 years. It has been a cost-effective choice for Interstate rehabilitation for us and has performed very well over time.

Iowa

Many of Iowa's 99 counties have not only pioneered the development of modern concrete overlays but also routinely use them as a standard practice to maintain the 18,000 mi of paved roadways in Iowa's secondary road system. Since the 1970s through today, over 2,200 mi of concrete overlays have been constructed in 80 of Iowa's counties and have resulted in excellent long-term performance and value. Some SHAs that have responsibility for local roads may benefit from the experience of local agencies, such as those in Iowa.

Richard C. Brumm, P.E., Mitchell/Worth County Engineer, emphasizes the value of concrete overlays when maintenance budgets are limited:

> When Mitchell County and Worth County first chose to use concrete overlays, it was because the economy drove the price of other pavements to a point where a concrete overlay was affordable, specifically with the thinner overlay sections being designed. Our experiences have revealed that past full-depth concrete pavements have outlived other pavements placed at similar times. With ever-shrinking budgets, maintenance does not always get scheduled when it should, or even at all. In the event a concrete overlay needs repair, many times the county does not need special equipment and can use our own forces to perform the task. And while each type of pavement has its place, we continue to use concrete overlays because we feel that concrete gives us the best long-term value for our ever-shrinking tax dollar.

Jacob Thorius, P.E., Washington County Engineer, emphasizes the excellent performance of PCC pavements and overlays:

> When looking to improve or widen an existing road with an overlay, our first choice of pavements is PCC [portland cement concrete]. This is because we have experienced firsthand the success and longevity of PCC, with one of our initial pavements placed in 1962 and still serving the county strong before we determined we needed to widen the existing 20 ft road to 24 ft with 4 ft paved shoulders [using a concrete overlay]. Because of this success, continuing the use of PCC for our paved road overlays only makes sense.

Value Proposition for the Transportation Manager

It is essential for the transportation manager to understand the benefits to be derived from the use of concrete overlays. Equally important is his/her knowledge of the cost of concrete overlays versus reconstruction, not only in terms of dollars but also in terms of construction time and performance.

The demands on transportation networks have outpaced the available funding needed to maintain them at an acceptable level of service. Many agencies are choosing to use available resources to address their most heavily traveled roadways and are often then faced with disinvesting in a portion of their network due to inadequate funding.

Concrete overlays offer a strong value proposition in such scenarios. Many transportation managers have firsthand experience with the value of concrete overlays, while others may need to rely on cost and performance data from other agencies as they build a portfolio of projects that will confirm the experience of their peers.

A Strategy that Works

According to the American Concrete Pavement Association (ACPA), at least 46 states have built concrete overlays since concrete was first used to resurface an existing pavement in 1901, and concrete overlays currently represent approximately 12% of all concrete pavements built each year in the US. The engineering knowledge gained and lessons learned from over 15,000 lane-miles of concrete overlays constructed nationwide has advanced concrete overlay technology and enabled it to cost-effectively address most pavement conditions.

Many agencies now include concrete overlays as one of the strategies in their "mix of fixes" used to maintain safe and functional pavements. The strategic use of concrete overlays among the "mix of fixes" takes advantage of the versatility of concrete overlays and results in a more robust and sustainable pavement management approach for an agency.

The factors described below explain why concrete overlays have become such an attractive option for many agencies.

Excellent Performance

The excellent performance and low maintenance requirements of concrete overlays make them a go-to solution for many agencies. National Cooperative Highway Research Program (NCHRP) Synthesis 204 (McGhee 1994) reported a relatively low-maintenance service life of 20 years for concrete overlays, with many providing 30 to 40 years of service.

The Iowa Department of Transportation (Iowa DOT) recently sponsored a performance review of 348 concrete overlays on Iowa's roadways (Gross et al. 2017). Though restricted to Iowa, the long history of concrete overlay construction in the state coupled with the availability of a large amount of performance data presented the opportunity for a comprehensive, long-term performance study of concrete overlays in general. Most of the data was gathered from overlays on secondary roads. The study concluded that 89% of the concrete overlays in Iowa exhibited service life trends exceeding the expectations listed in NCHRP Synthesis 204 (McGhee 1994) and were on track to achieve a pavement condition index (PCI) rating of good or better (a rating of at least 60). Additionally, 93% of overlays had a ride quality rating (in terms of International Roughness Index [IRI]) of less than 170 in./mi during the first 35 years of service life.

A recent study sponsored by the Minnesota Department of Transportation (MnDOT) reviewed the performance of unbonded concrete overlays on the state's system and found a predicted service life in excess of 35 years (Izevbekhai et al. 2020).

The performance of concrete overlays is likely to improve in the future due to advancements in performance-engineered concrete mixtures that result in more workable and durable mixtures and due to construction technologies, such as stringless paving and real-time smoothness monitoring, that improve ride quality.

Versatility

Concrete overlays can be used on a wide range of pavements, from severely distressed pavements to those that are still structurally sound but need a renewed surface. They can be used on both existing asphalt and concrete pavements subjected to all types of loading conditions, from low-volume local streets to urban intersections to high-traffic primary and Interstate highways. Table 1 summarizes the versatility of concrete overlays.

Concrete overlays are also commonly used in military, commercial, and general aviation airports to renew runways, taxiways, and parking areas subject to very heavy wheel loads associated with aircraft weighing in excess of 500,000 lb.

Rapid Construction

Concrete overlay solutions can be very helpful in rapid or emergency response to natural disasters. Because of the efficiency that results from building on an existing pavement structure, overlay projects can usually be completed in approximately one-quarter of the time needed for a full reconstruction project.

Because concrete overlays typically involve the placement of a thinner concrete section than that needed for full reconstruction, sawcutting capacity rather than plant capacity controls overall progress. Production rates of more than a mile of overlay per day are not uncommon. Moreover, because the contractor is working on top of an existing pavement surface, overlay projects typically experience minimal weather impacts or delays.

Low Impact on Traffic during Construction

Concrete overlay construction can be planned to efficiently accommodate through traffic and local access. Because a concrete overlay is built over an existing pavement, a variety of maintenance of traffic scenarios is possible.

Table 1. Versatility of concrete overlays

Pavement condition and problems to address	Existing pavement type	Concrete overlay solution available
Minor to major distresses	Jointed plain concrete	Yes
Minor to major distresses	Continuously reinforced concrete	Yes
Minor to major distresses	Asphalt	Yes
Minor to major distresses	Composite	Yes
Additional structural capacity needed	All types	Yes
Rapid/Emergency response required	All types	Yes
Resiliency in flooding conditions	Asphalt	Yes

Additionally, due to the speed of overlay placement (with the full depth placed in one pass), traffic disruption can be significantly reduced compared to other paving alternatives.

Depending on traffic conditions over the entire length of the project or along designated segments, the following options can be used to manage through traffic and local access during concrete overlay construction:

- Through traffic
  - » If through traffic is maintained during construction, options include establishing contraflow or closing one lane at a time for four-lane divided highways or using a pilot car for two-lane highways.
  - » If acceptable detour routes are available, it is often beneficial to close the project to through traffic, thus allowing the contractor to accelerate the overall progress and restore through traffic sooner.
- Local access
  - » Local access needs vary by project, but efficient options are usually available to accommodate local access through temporary or adjacent means rather than through complex staging requirements.
  - » Communication with local residents and businesses before the project begins is important for fully understanding their access needs. Regular, even daily, updates go a long way in fostering good relationships.
  - » The contractor should be allowed flexibility. Many creative solutions are possible, such as accommodating local residents in a hotel for a day or two while access is restricted.
- Early opening to traffic
  - » The opening strength requirements for concrete overlays are lower than those for full-depth concrete pavements.
  - » It is highly recommended that arbitrarily selected curing times be avoided. When accelerated opening to traffic (construction and/or public) is desired, a project-specific minimum opening strength can be calculated based on the guidance in *Concrete Strength Required to Open to Traffic* (Freeseman et al. 2016).

Enhanced Safety for Road Workers and the Traveling Public

Working close to traffic is dangerous for contractor and agency employees. Even with advancements in traffic control technologies, the rate of injury in road construction and maintenance work zones is higher than for any other industry sector. Works zones can also pose a danger to the traveling public. In 2019, over 115,000 work zone crashes resulted in over 39,000 injuries and 842 fatalities (National Work Zone Safety Information Clearinghouse 2021).

Minimizing the need for regular maintenance and preservation activities, and thus minimizing the exposure of workers and the public to work zones, is a key factor for agencies to consider when deciding upon pavement repair and rehabilitation alternatives. Low maintenance requirements and long life are important benefits that concrete overlays offer.

Adaptability of the Concrete Paving Industry to Concrete Overlay Construction

Contractors familiar with concrete paving can easily adapt to building concrete overlays. The equipment needed for hauling, placing, texturing, and curing concrete for overlay construction is the same as that needed for conventional full-depth paving. For contractors that have never built a concrete overlay, extensive education and training resources are readily available regarding the differences between overlay construction and full-depth paving.

Rapid Planning and Development and Simplified Plan Sets

Concrete overlay projects can be planned and developed quickly, and the plan sets needed to build concrete overlays tend to be relatively simple. The following summarizes the advantages of concrete overlays in this regard:

- Concrete overlays can be placed successfully over existing pavements in a wide range of conditions, even pavements in poor condition (Figure 1). A clear process is used to determine whether a concrete overlay is a viable option for an existing pavement, and selection of the best overlay option for the existing pavement is straightforward.
- The plan set for concrete overlays can be quite simple. Some agencies, such as the Oklahoma Department of Transportation, have been successful with just a few pages: a typical section, tabs for any repairs, separation layer details (for unbonded overlay designs), a joint layout plan, and any special details. The National Concrete Pavement Technology Center (CP Tech Center) has developed two resources that offer more detail on developing plans for concrete overlays: *Guide for the Development of Concrete Overlay Construction Documents* (Gross and Harrington 2018) and *Guide Specifications for Concrete Overlays* (Fick and Harrington 2016). Both are available for free download from https://cptechcenter.org/concrete-overlays/.
- A concrete overlay design can easily incorporate profile improvements and address any geometric problems with the existing pavement.

Todd LaTorella, ACPA, MO/KS Chapter, used with permission

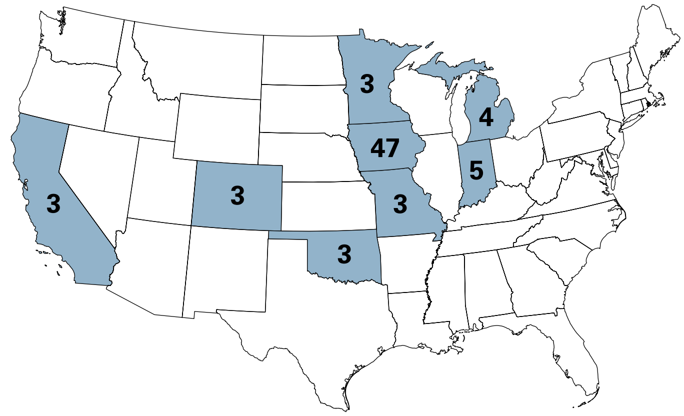
Figure 1. Missouri Route D (top, in 2007 before overlay construction; bottom, in 2020 after 12 years of service)

Cost Advantages

Many agencies consider concrete overlays a cost-effective and reliable part of their pavement maintenance, preservation, and rehabilitation programs. The key cost advantages of concrete overlays are described below.

Low Initial Construction Cost

Because contractors can build concrete overlays very efficiently, the initial construction cost is typically lower than that of other types of concrete pavement construction.



CP Tech Center

Figure 2. States providing concrete overlay cost data, with the number of overlay projects in each state indicated

Even in states that do not have a strong concrete paving contractor base, a properly packaged and advertised overlay project will normally attract competitive bidding and pricing.

In January 2021, the CP Tech Center contacted concrete paving associations affiliated with the ACPA in eight states (Figure 2) to gather cost data on concrete overlay projects constructed in the past five years (2016–2020).

Because each state has different concrete overlay needs, the emphasis for each state varied. For example, the data from Iowa emphasized concrete overlays on paved county roads, whereas the data from California emphasized unbonded overlays on the state's Interstate highways.

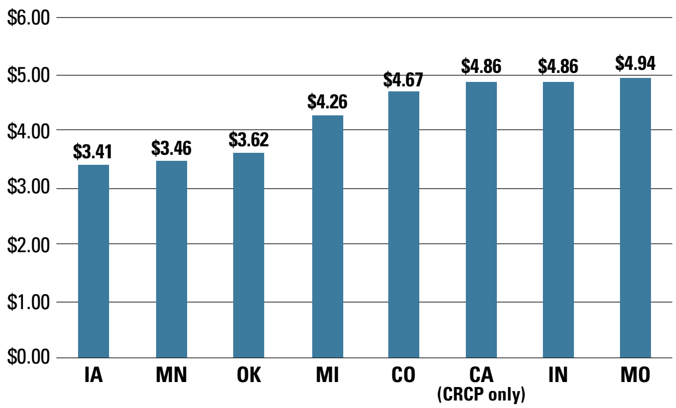
Table 2 summarizes the average cost per square yard per inch of overlay thickness by overlay type. The four main types include concrete on asphalt–unbonded (COA–U), concrete on asphalt–bonded (COA–B), concrete on concrete–unbonded (COC–U), and concrete on concrete–bonded (COC–B). The overlay costs summarize the cost of furnishing the concrete and placing the overlay, including the cost of placing dowel bars. They do not include the cost of traffic control. Note that representative cost data for COC–B overlays were not available for the analysis period.

Figure 3 further breaks down the cost of unbonded (both COA–U and COC–U) overlays by state.

Table 2. Summary of cost by overlay type

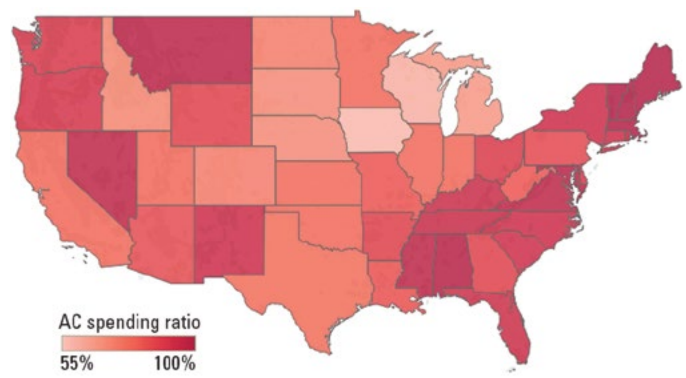
Overlay type	Number of projects	Average cost per square yard per inch of overlay thickness
COA–B	8	$4.57
COC–B	No data available	No data available
COA–U and COC–U *	63	$3.93
All	71	$4.22

* COC–U overlays include an additional cost for a separation layer.



CP Tech Center

Figure 3. Average costs per state for unbonded concrete overlays (in dollars per square yard per inch of overlay thickness)



CSHub 2020a

Figure 4. Share of spending on asphalt for state DOT projects in each state (except New Jersey) between 2005 and 2018

Low Annual Ownership Cost

Adequate funding for roadways is often very difficult to achieve, and most agencies routinely struggle to keep the condition of their pavements at an acceptable level. A common trap an agency can fall into is to focus on short-term solutions, primarily driven by initial cost, and not on long-term results.

Incorporating life-cycle cost analysis (LCCA) into the decision-making process for an agency's maintenance and resurfacing program, instead of focusing primarily on initial cost, can reduce overall annual ownership costs over time. Short-term solutions with low initial costs can result in higher overall costs when analyzed over a longer planning horizon.

A 1996 study examined three county highway networks in Iowa, one whose county invested primarily in full-depth concrete solutions, one whose county invested primarily in asphalt solutions, and one whose county used a combination of solutions to address the network's needs. The county that invested primarily in longer life concrete pavements and overlays had the lowest overall maintenance and construction costs over the 28-year analysis period (Cable 1996).

Increased Competition

Creating a competitive pricing environment for paving materials is a strategic policy decision for agencies to consider. Regularly including concrete overlays among the potential resurfacing and rehabilitation solutions, instead of relying solely on asphalt overlays, can help create a competitive pricing environment that will lower costs for both paving products.

The Massachusetts Institute of Technology (MIT) Concrete Sustainability Hub (CSHub) prepared an analysis demonstrating how competition would positively impact the construction prices of paving materials for the Missouri Department of Transportation (MoDOT) (CSHub 2020a). Key takeaways of the analysis include the following:

- Inter-industry competition is one of the most influential contributors to paving material unit costs. While SHA spending on concrete and asphalt paving materials varies greatly, all states spend most of their paving budgets on asphalt pavements (Figure 4).
- If concrete's market share in Missouri were to increase from 17% to 30%, the unit costs of concrete and asphalt materials could fall by around 17% and 4%, respectively.
- As a result, an additional 5% of paving material could be placed each year on a fixed budget.

Creating a stable volume of work through increased use of concrete overlays can also lower costs over time. Contractors would be able to efficiently size their companies to be competitive within their market area, and new businesses may be attracted to market areas where work is available. Significant fluctuation in the amount of work available each year makes it very difficult for a contractor to maintain a competitive workforce, thus leading to inefficiency and higher pricing.

Improved Pavement Asset Management

An agency can maintain the long-term performance of its pavement system at a lower annual cost by using a longer planning horizon and a "mix of fixes" strategy that includes preservation, rehabilitation, and reconstruction techniques. Part of this strategy would be to use long-life concrete overlays when applicable rather than relying solely on asphalt overlays. Routinely including concrete overlays as part of an agency's "mix of fixes" would enable the agency to optimize the condition and lower the overall cost of its pavement network.

Another study by the MIT CSHub focused on applying performance-based planning to pavements for the NCDOT. The study found that the state could save $50 million annually over 50 years by using a mix of paving materials (CSHub 2020b).

Life-Cycle Sustainability Benefits

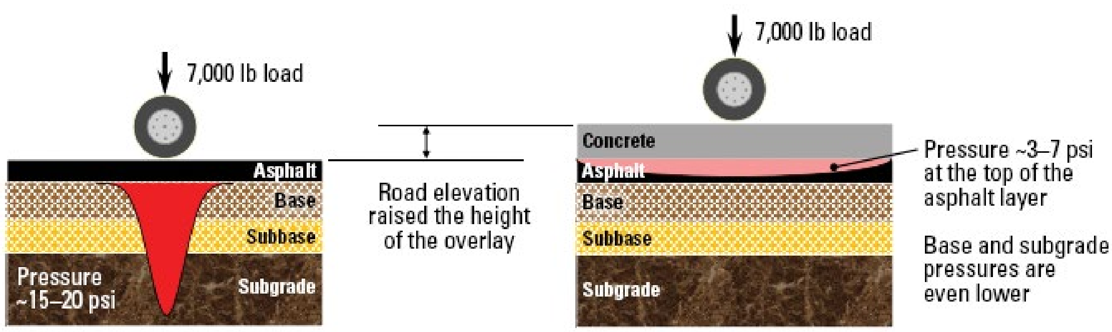
Sustainability is an important consideration for many agencies when selecting pavement alternatives. In 2015, the FHWA published, with broad stakeholder input, an excellent resource to assist SHAs in managing pavement assets in a more sustainable manner: *Towards Sustainable Pavement Systems: A Reference Document* (Van Dam et al. 2015). The use of concrete overlays is one of the specific strategies recommended for consideration due to their ability to significantly extend pavement life with minimal new material inputs. Renewing the condition of an existing pavement using a concrete overlay preserves the value of previous investments made in materials and greatly reduces the time, cost, and natural resources that would otherwise be needed for a new pavement.

The sustainability benefits of concrete overlays can be summarized as follows:

- The long lifespans and low maintenance requirements of concrete overlays minimize future environmental impacts.
- Fuel efficiency is higher on concrete surfaces than on flexible pavements due to lower rolling resistance, resulting in lower use-phase impacts.
- Concrete surfaces have a lower albedo than asphalt surfaces, lowering heat adsorption and reducing the heat island effect.
- Concrete is 100% recyclable and is, in fact, the most recycled material in the world.

Pavement Resiliency

Concrete overlays can reduce the damage caused by pavement flooding during extreme weather events. Roadway flooding saturates and weakens a pavement's underlying foundation, which significantly increases the stress experienced by the pavement. This is especially problematic for asphalt pavements. Concrete overlays of existing asphalt pavement prone to flooding offer added resiliency due to the stiffness of the concrete overlay, which lowers the stress at the top of the asphalt layer and reduces the amount of support needed from the foundation layer (Figure 5).



Jim Mack, used with permission

Figure 5. Pavement system hardened with a concrete overlay

A 2007 analysis conducted by the Louisiana Department of Transportation and Development after Hurricane Katrina (Gaspard et al. 2007) concluded that concrete pavements experienced little relative loss of strength due to being in a flooded condition when similar submerged and non-submerged concrete roadways were compared. Conversely, the analysis found that submerged asphalt pavement experienced a strength loss equal to 2 in. in thickness, resulting in the need for $50 million to rehabilitate the over 200 mi of submerged pavements.

Due to the stiffness they add to pavement systems, concrete overlays can be used to "harden" existing asphalt pavements in anticipation of extreme weather, which would enable rapid traffic restoration after flooding events while also minimizing potential long-term performance concerns (Gaspard et al. 2007).

Addressing Common Agency Barriers

The authors of this document reached out to five SHAs, two county/city engineers, and three ACPA state chapter executives to help identify the barriers agencies face when attempting to introduce concrete overlays into their "mix of fixes." The six most common barriers, along with recommendations on how to address them, are summarized in the sections below.

Lack of Inclusion of Concrete Overlays among Treatment Options

In many agencies, senior managers have come up through the organization without a technical background in or experience with concrete overlays and may not be familiar with the benefits of the technology. Lack of support for concrete overlays from upper management makes it difficult for technical program managers to incorporate concrete overlays into an agency's portfolio of treatment options.

Managers are encouraged to reach out to their counterparts in other agencies to discuss how concrete overlays are incorporated into pavement management decisions. Excellent forums are the American Association of State Highway and Transportation Officials (AASHTO) committee network and the National Concrete Consortium. The CP Tech Center and network of local ACPA chapters can also help identify agency representatives to contact.

A related barrier to the use of concrete overlays is that the pavement management systems for most agencies reflect the agencies' institutional experience with and practices regarding different treatment options. For an agency with limited or no experience with concrete overlays, concrete overlay solutions are often not even included among the alternatives analyzed.

Agencies are encouraged to compare the cost and performance information for the alternatives included in their pavement management systems to comparable information for concrete overlays, using national performance data for concrete overlays until local data can be obtained. Cost and performance information for concrete overlay options is readily available from peer agencies and national-level resources.

Lack of Technical Competency and Experience

A lack of technical competency and experience with concrete overlays among agency staff can be a barrier to introducing the technology. However, building technical competency in the use of concrete overlays is not difficult. It is recommended that agencies start with a few simple projects and build proficiency over time.

Numerous technical resources are available to help agencies become familiar with concrete overlays. A complete library of products is available for free download from the CP Tech Center's website at https://cptechcenter.org/concrete-overlays/. In addition, the FHWA has included concrete overlays in its TOPS program under the EDC-6 initiative, which presents opportunities for agencies to seek assistance with the technology. For information on the TOPS program, see https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/targeted_overlay_pavement.cfm.

A lack of concrete paving contractors with overlay experience may also appear to be a barrier to introducing concrete overlays. In reality, however, placing concrete overlays is very similar to placing full-depth pavement utilizing normal construction equipment and procedures.

Exclusive Focus on Surface Condition

At times, there may be pressure on an agency to maintain as much of the roadway network as possible with a singular focus on IRI. Many agencies have found this approach to be unsustainable because it consumes a disproportionate share of available resources on short-term fixes and seemingly deprioritizes longer term options such as concrete overlays. Further, short-term fixes entail traffic disruptions and safety issues.

Concrete overlays offer agencies an economically sustainable option for maintaining the surface condition of their road networks. Not only do concrete overlays provide excellent ride quality for many years, but if ride quality deteriorates over time, it can easily and cost-effectively be restored through diamond grinding. Diamond grinding is fast and can normally be accomplished with lane closures alone. For resources on diamond grinding, see the International Grooving and Grinding Association website, https://www.igga.net/.

Difficulty Identifying Candidate Projects

Concrete overlays are very versatile and can address a broad range of pavement conditions. However, some agencies indicate that finding candidate projects is difficult. Some of the technical concerns deterring agencies from considering concrete overlays may include whether overlays can adequately address existing asphalt pavements in poor condition and how to address the effects of raising the profile grade above the existing pavement.

Practical approaches are typically available for addressing concerns such as these. For example, if the condition of the existing asphalt is a concern, the agency can select an unbonded instead of a bonded overlay to mitigate problems such as reflective cracking. Unbonded concrete overlays over asphalt or concrete are the most commonly constructed type and are straightforward to design and build.

Raising of the profile grade can also be addressed quite easily on most projects. In lieu of using a thin asphalt overlay or a mill-and-fill approach on an existing asphalt pavement, for example, the existing asphalt can be milled to keep the new overlay profile at the required elevation. The millings can often be utilized on the project as shoulder material or recycled on another project. Clearance restrictions on overhead bridges can be easily addressed by completely replacing a short section of pavement.

Perceived Lack of Traffic Management/Detour Options

Concrete overlays are routinely built while through traffic is maintained on the project. Pilot cars work well on two-lane, two-way facilities. Concrete overlays can be efficiently built using all the normal traffic control options, including contra flow, detours, and a variety of local access options.

Communication with stakeholders along the length of the project is very important when selecting the best alternative for managing through traffic and providing local access. Additionally, allowing the contractor flexibility in addressing local access needs can be particularly beneficial and can yield creative solutions

Perceived Federal Funding Limitations

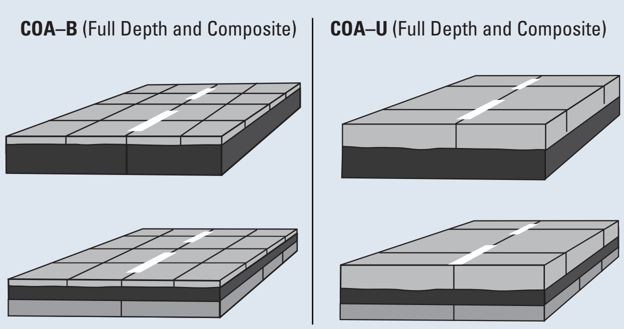
Over the years, requirements have changed on how federal funds can be used for preservation and maintenance needs. The latest guidance from the FHWA is contained in a memorandum dated February 25, 2016 from Walter C. Waidelich, Jr., Associate Administrator for Infrastructure, on the subject of "Guidance on Highway Preservation and Maintenance." The memo provides that concrete overlays can be considered preventative maintenance, qualifying them for the use of federal aid funds. As a result, federal aid funds are now routinely used on concrete overlay projects throughout the country. Agencies are encouraged to work with their local FHWA division office regarding any questions on current funding guidance.

Getting Started

The decision process for designing and building a concrete overlay is straightforward. The best way for an agency to get started is to identify the type of pavement to be overlaid. This will determine whether the overlay is concrete on asphalt (COA) or concrete on concrete (COC), as shown in Figure 6.

Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.



Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

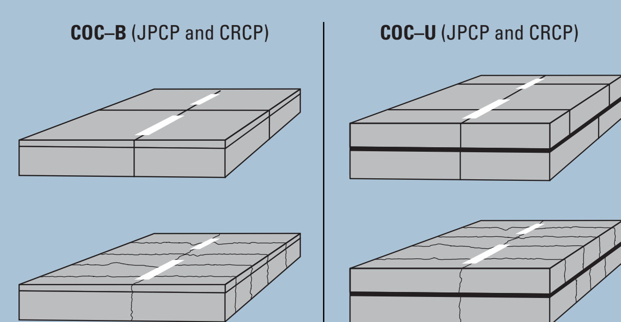


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Figure 6. Summary of concrete overlay types on existing asphalt and concrete pavements

After the existing pavement type is determined, the condition of the existing pavement, traffic projections, desired design life, and strategy for handling through traffic will drive the design details. Detailed engineering guidance on how to design and construct COA and COC overlays to address specific project conditions is provided in the *Guide to Concrete Overlays*, 4th Edition (Fick et al. 2021). The guide covers topics such as evaluation of the existing pavement, pre-overlay repairs, interlayer and bonding considerations, thickness design, development of plans and specifications, and construction requirements.

Concrete overlays are not difficult to build, but agencies just getting started should consider the approach to building technical proficiency outlined in the following sections.

Start with Simple Projects

During the interviews conducted to identify potential barriers to the use of concrete overlays, feedback from SHAs that routinely build concrete overlays suggested that agencies start with a simple project, one that does not have complicated staging, high traffic volumes, or tight completion requirements. An urban intersection or low-volume county or primary highway would be a recommended first project.

Evaluate Performance

A number of the SHA representatives that provided feedback recommended that agencies should simply get started with concrete overlay projects and allow the performance of the overlays to build confidence in the technology. Agencies should consider building a few projects per year and establish a process for annual field reviews and collection of performance data.

Build Technical Competency and Experience

Many resources are available to help agencies build technical competency with concrete overlays, including engineering guidance, technical manuals, and training materials on project selection, pre-overlay repairs, model specifications, plan development, and construction. Agencies are also encouraged to reach out to their peers and gain from their experience. The FHWA and the CP Tech Center are both available to help agencies identify resources and build technical competency within their organizations.

Integrate Concrete Overlays into the "Mix of Fixes" over Time

Agencies should incorporate concrete overlay solutions into their pavement management options and collect data to reflect local cost and performance experience. When getting started, however, agencies can consider using data from peer organizations and update that information with the agencies' own data over time. The CP Tech Center is available to facilitate this process.

Collaborate/Reach Out for Help when Needed

Many resources are available that provide technical support on concrete overlays. In addition to the FHWA and CP Tech Center, the ACPA offers numerous technical resources and has representatives at the local level. SHAs should also consider joining the Technology Transfer Concrete Consortium (TTCC), a technical peer exchange established under TPF-5(437) that meets twice per year and currently has 35 SHA members. The meetings are an excellent opportunity to learn from and network with other SHAs on a variety of concrete topics. The content of past meetings is available on the TTCC website at https://cptechcenter.org/national-concrete-consortium/.

Summary of Benefits

Concrete overlays provide an attractive solution to many pavement problems. The following is a partial list of benefits offered by concrete overlays:

- Concrete overlays consistently provide a cost-competitive alternative over competing treatments, especially from a life-cycle perspective. They are one of the most cost-effective, long-term pavement preservation or major rehabilitation options for existing pavements.
- In most cases, minimal pre-overlay repairs are necessary, reducing the cost and time of construction.
- The wide range of overlay thicknesses that can be used, combined with minimal required pre-overlay repair, means that concrete overlays provide a treatment option for almost any pavement type and condition, desired service life, and anticipated traffic loading.
- Concrete overlays can be constructed quickly and conveniently, and accelerated construction practices can be used to further expedite opening to traffic.
- The existing pavement is not removed but rather contributes to the load-carrying capacity of the overlaid pavement section. This reduces the need for new materials and minimizes the waste and fuel consumption associated with removal and transportation of the existing pavement, realizing broad environmental benefits.
- Concrete overlays are placed using conventional concrete pavement construction practices.
- Concrete overlays are relatively easy to maintain. Repairing concrete overlays, especially thin overlays, is usually much easier than repairing a section of conventional pavement.

Highlighted Projects

Numerous project case histories are available that show the performance of concrete overlay applications across the country. Additional examples are available from the following resources on the CP Tech Center's website, https://cptechcenter.org/:

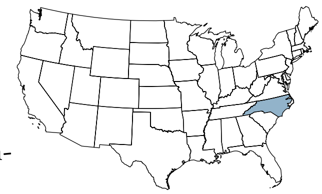
- EDC-6 TOPS examples for concrete overlays
- *Guide to Concrete Overlays, 4th Edition* (Fick et al. 2021)
- *History of Concrete Overlays in the United States* (Gross 2021)

Project highlights from five typical concrete overlay applications are summarized in Table 3 and described in greater detail in the following pages. Each highlighted project includes photos of the concrete overlay under construction or in service, a cross section of the concrete overlay and pavement structure, and information on cost and smoothness.

Table 3. List of highlighted projects

State/Route	Year constructed	Existing pavement and overlay type	Functional classification	Traffic volume	Maintenance of traffic strategy
North Carolina/I-77	2007–2008	COC–U on CRCP	Interstate	31,500 AADT with 25% trucks	Maintain two lanes each direction
Colorado/SH13	2016	COA–B on hot-mix asphalt (HMA)	Primary highway	1,400 AADT with 20% trucks	24-hour pilot car
Oklahoma/SH51	2016	COA–B on HMA	Primary highway	—	Closed to through traffic
Iowa/County Route S10/S14	2009	COA–U on HMA	County road	—	Closed to through traffic
Kansas/City of Salina	2012	COA–U on composite pavement	Urban intersection	32,000	Staged construction maintaining traffic

I-77 in Yadkin County, North Carolina, 2007–2008



Project highlights are as follows:

- The contract used the design-build delivery method.
- The contract required maintaining two lanes of traffic in both directions for all holidays, summer weekends, and NASCAR events in Charlotte, North Carolina.
- Ramps and bridge tie-ins at the US 421 interchange were restricted to an 11-day closure period. These sections were originally designed to be reconstructed with hot-mix asphalt; however, to accelerate construction of these critical milestones, the contractor proposed utilizing the same unbonded concrete overlay design as the mainline.

Robert Heibel, Jr., The Lane Construction Company, used with permission

Figure 7. Existing 8 in. CRCP with punchouts and ruptured steel, and faulting at cracks

ACPA, used with permission (The Lane Construction Corporation)

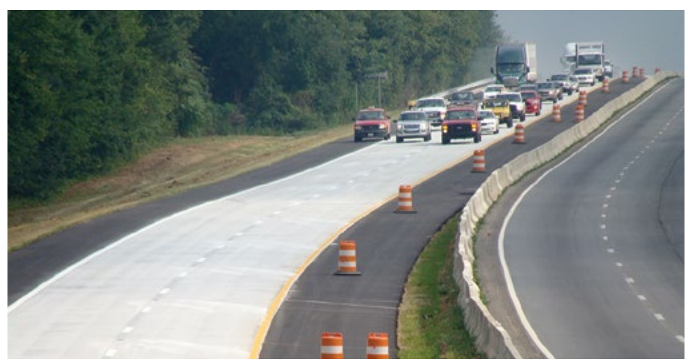
Figure 8. Two lanes of traffic maintained in each direction throughout the construction zone during times of peak demand

- Existing bridges were raised 13 in. to match the new elevation resulting from the combined thickness of the overlay and separation layer.
- The smoothness, noise, and texture of the concrete overlay were optimized by diamond grinding 100% of the traffic lanes.

Figures 7 through 10 show photos of the project, and Figure 11 shows a typical section of the overlay.

ACPA, used with permission (The Lane Construction Corporation)

Figure 9. Existing bridges reused and raised to match the elevation of the overlay, a cost-saving strategy that also eliminated the need for full-depth reconstruction transition sections on either side of the bridges



ACPA, used with permission (The Lane Construction Corporation)

Figure 10. Southbound lanes opened to traffic, showing a median detour that had been carrying southbound traffic during overlay construction

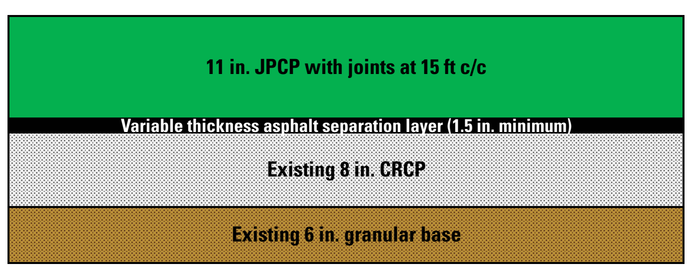


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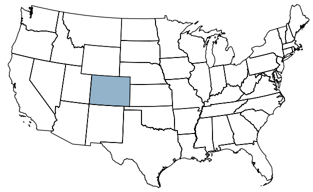
Figure 11. Unbonded concrete overlay typical section

SH-13 in Moffat County, Colorado, 2016



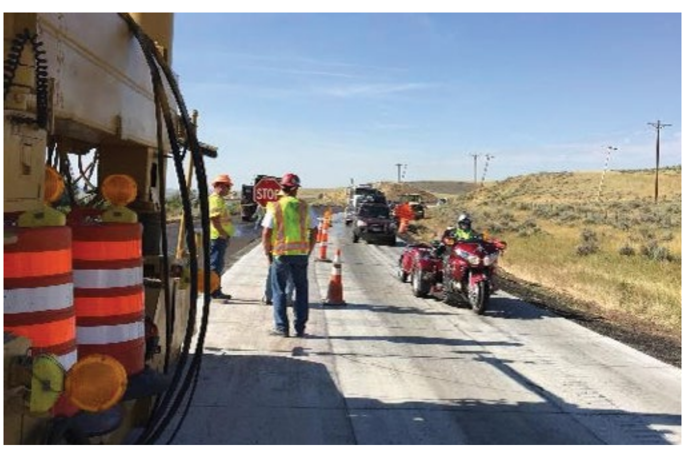
Project highlights:

- An alternate bid project, the 6 in. thick concrete overlay that was ultimately constructed came in as the lowest first cost compared to a 6 in. thick asphalt overlay on full-depth reclamation.
- Due to the remoteness of the project, detour routes were not an option. Two-way traffic was maintained through the 6 mi long project using a pilot car. Half-width paving allowed traffic to run adjacent to the construction operations.
- Construction was completed in 185 calendar days.
- Profile milling was utilized to optimize the volume of concrete needed as well as the smoothness of the final pavement.
- The average IRI for the entire project was 44 in./mi.

Figures 12 through 15 show photos of the project, and Figure 16 shows a typical section of the overlay.

Castle Rock Construction, provided by Angela Folkestad, ACPA, CO/WY Chapter, used with permission

Figure 12. Milled surface before placement of the concrete overlay



Angela Folkestad, ACPA, CO/WY Chapter, used with permission

Figure 13. Half-width paving (12 ft lanes and 7 ft shoulders) with pilot car traffic adjacent to the construction operations

Angela Folkestad, ACPA, CO/WY Chapter, used with permission

Figure 14. Half-width paving of the concrete overlay, with a rumble strip being placed using a roller mounted to the back of the paver

HDR, provided by Angela Folkestad, ACPA, CO/WY Chapter, used with permission

Figure 15. Completed concrete overlay

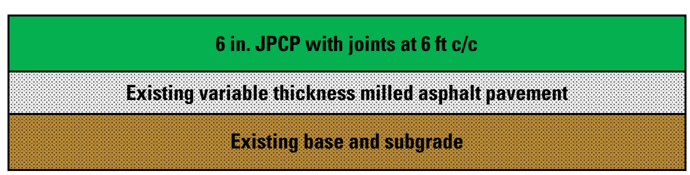


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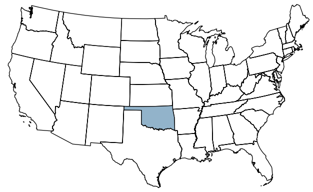
Figure 16. Concrete overlay typical section

SH-51 in Blaine County, Oklahoma, 2016



Project highlights:

- Originally designed as a 3 in. thick asphalt overlay, the Oklahoma Department of Transportation rejected bids twice due to budgetary limitations before redesigning this 5.5 mi long project as a 5 in. thick fiber-reinforced concrete overlay.
- Local access was maintained for property owners, while the roadway was constructed in discrete sections and closed to through traffic.
- The entire project was completed less than 90 days from the date that bids were opened, with the construction phase lasting 43 days.

Brent Burwell, ACPA, OK/AR Chapter, used with permission

Figure 17. Profile milling of the existing asphalt pavement

ACPA, used with permission (Duit Construction Company, Inc.)

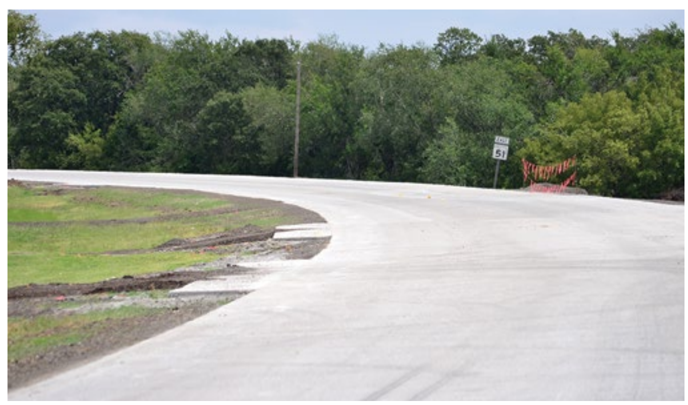
Figure 18. Roadway closed to through traffic during construction, allowing full-width paving of the concrete overlay and significantly reducing the construction duration

- The existing asphalt pavement width was variable throughout the length of the project. Excess asphalt millings were used to provide an adequate subbase and paver track line where the concrete overlay was wider than the existing pavement. Drainage structures were extended to accommodate the widened roadway.

Figures 17 through 20 show photos of the project, and Figure 21 shows a typical section of the overlay.

Brent Burwell, ACPA, OK/AR Chapter, used with permission

Figure 19. Span saw used to cut transverse contraction joints at 6 ft center on center



ACPA, used with permission (Duit Construction Company, Inc.)

Figure 20. Completed concrete overlay, with drainage structures extended to accommodate widening of the existing roadway

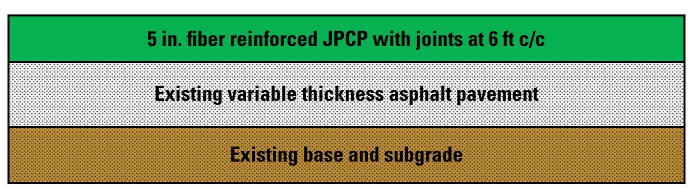


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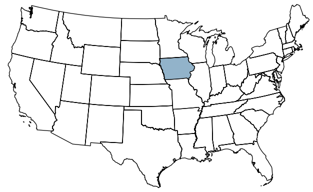
Figure 21. Concrete overlay typical section

County Highway S10/S14 in Worth County, Iowa, 2009



Project highlights:

- The construction of wind farms in north-central Iowa was taking a toll on the existing county road network. This 23 mi long project involved an alternate bid scenario. The asphalt alternative was a 3 in. thick overlay, while the concrete alternative was a 4 in. thick overlay. The lowest concrete bid came in approximately 9% higher than the asphalt alternative. The county engineer chose the concrete alternative based upon lower estimated life-cycle costs.
- The entire plan set for the project consisted of 10 sheets.
- No pre-overlay repairs were performed, with surface preparation prior to the overlay consisting of power sweeping.
- The road was closed to through traffic in sections as the paving progressed across the county. The contractor's project manager provided daily updates to every property owner that would be affected by that day's paving operations.
- The entire project was opened to unrestricted traffic in 110 calendar days.

Figures 22 through 25 show photos of the project, and Figure 26 shows a typical section of the overlay.

ACPA, used with permission (Cedar Valley Corp.)

Figure 22. Paving of the unbonded concrete overlay on the existing roadway, which was not milled before paving

ACPA, used with permission (Cedar Valley Corp.)

Figure 23. Transverse and longitudinal joints being sawed at a spacing of 6 ft center on center, with up to 54,000 lineal feet of joint sawing completed on high-production paving days

ACPA, used with permission (Cedar Valley Corp.)

Figure 24. Variable-depth concrete used to upgrade curves from a normal cross slope to a superelevated section

ACPA, used with permission (Cedar Valley Corp.)

Figure 25. Finished concrete overlay approximately one year after construction

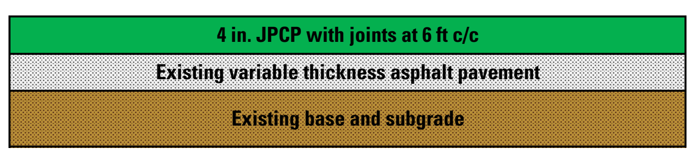


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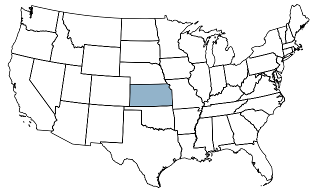
Figure 26. Concrete overlay typical section

Intersection of E. Crawford Street and S. Ohio Street in Salina, Kansas, 2012



Project highlights:

- At over 32,000 vehicles per day, the intersection where this overlay was placed is the busiest in Saline County, Kansas. Planned modifications of another intersection would involve routing a detour through this intersection, resulting in even more traffic.
- Though the project was scheduled for completion in 60 days, the contractor completed the project in 45 days, earning the maximum early completion incentive of $18,000.
- Staged construction of the concrete overlay kept the intersection open to traffic throughout the project.

ACPA, used with permission (Pavers Inc.)

Figure 27. Existing pavement condition prior to placement of the unbonded concrete overlay

ACPA, used with permission (Pavers Inc.)

Figure 28. Partial-depth milling of the existing asphalt overlay(s), with the asphalt remaining after milling utilized as a separation layer for the unbonded concrete overlay

- Total project cost was just over $425,000, with the concrete overlay costs representing approximately 30% of the contract amount.
- Approximately 20% of the project area included full reconstruction to provide transitions to match the existing profile grade and correct areas where the underlying pavement had failed.

Figures 27 through 30 show photos of the project, and Figure 31 shows a typical section of the overlay.

ACPA, used with permission (Pavers Inc.)

Figure 29. Traditional fixed-form methods being used to construct the unbonded concrete overlay

ACPA, used with permission (Pavers Inc.)

Figure 30. Finished project, including new curb and gutter system, inlets, and sidewalks

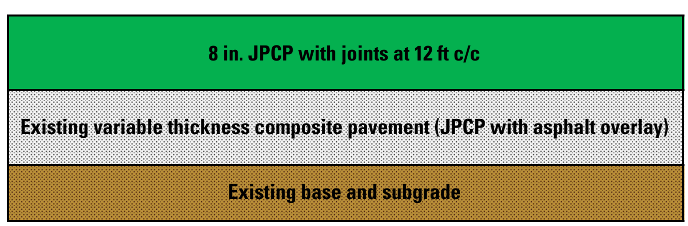


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Figure 31. Unbonded concrete overlay typical section

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