SUBSTANTIAL MAINTENANCE PRACTICE FOR BRIDGES ON THE KANSAS STATE HIGHWAY SYSTEM

By

Mark Hurt, P.E., S.E.

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Chairperson Steven D. Schrock, Ph.D., P.E.

____

Thomas E. Mulinazzi, Ph.D., P.E., L.S.

____

Caroline Bennett, Ph.D., P.E.

____

Oswald Chong, Ph.D., P.E.

____

Bonnie J. Johnson, Ph.D., AICP

____

Charles Miller, Ph.D., P.E., PTOE

Date Defended: January 10, 2013

The Dissertation Committee for Mark Hurt, P.E., S.E.

certifies that this is the approved version of the following dissertation:

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Chairperson Steven D. Schrock, Ph.D., P.E.

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Abstract

The Kansas Department of Transportation is currently facing the contradictory requirements of providing equivalent or improved operations to facilitate economic growth and reductions in funding. This will require the agency to maintain and operate its existing infrastructure as efficiently as possible. This is particularly true in regard to its inventory of bridges. This project examines KDOT's practices for substantial maintenance of bridges in its inventory and, specifically, the work of the Bridge Maintenance Plans (BMP) squad.

The efficiency and effectiveness of the delivery of plans and of engineering support by the BMP squad is reviewed by an analysis of Preliminary Engineering and Construction Engineering costs for substantial maintenance during the period of FY 1993 to FY 2010. The practices of surrounding states are discussed. The cost of current maintenance practices as opposed to more minimal investment in substantial maintenance for bridges is examined by review of the projects in the FY 2003 Bridge Substantial Maintenance program. The findings for agency cost as determined by Bridge Life Cycle Cost analysis are discussed. The findings for user cost as determined by an analysis of user delay at work zones and closures are discussed. The economic impact of allowing bridges at one site in the FY 2003 to deteriorate to restricted status for two years is reviewed.

Acknowledgments

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Much appreciation goes to those individuals at KDOT who have contributed materially to this report: Andrew Jenkins, David Schwartz, Mike Thompson and Dan Wadley.

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Chapter 1—Introduction and Problem Statement

1.1 Introduction

On June 1, 2012, the Governor of the State of Kansas signed into law a $14 billion State budget for the Fiscal Year (FY) 2013, which began on July 1, 2012 (1). This budget represented a relatively modest reduction in State spending of approximately $400 million; however, the Governor and the 2012 Legislature also passed large cuts in income taxes for individuals and corporations set to begin on January 1, 2013 (2). Combined with a reduction in sales taxes, the cuts are projected to result in a $231 million reduction in collections for FY 2013, which is expected to grow to an annual reduction of $934 million after six years. Projections by Kansas Legislative Research Department predict that a budget shortfall will begin in July 2014 which will result in cumulative shortfalls over five years exceeding $2.5 billion.

State agencies, including the Kansas Department of Transportation (KDOT), were instructed by the Governor's office to prepare budgets anticipating a 10 percent reduction in funding. As the entire State budget is squeezed, the ability of KDOT to pursue its mission of providing and maintaining transportation facilities for Kansas may be further impacted as the Legislature is tempted to borrow funds from the State Highway Fund to finance shortfalls in the operation of other agencies.

The stated intent of the Governor and the Legislators in passing tax cuts has been to stimulate and grow the Kansas economy (2). It is hoped that the predicted shortfalls will not come to pass in the long term as taxable income grows.

This presents a double edged challenge to KDOT in the coming years. There will be pressure to provide and maintain transportation facilities with less funding than in the past; while the same facilities are required to facilitate economic growth and development in the State. Early in its history and in the history of the automobile, Kansas was the epicenter for the Good Roads movement (3). This movement championed the development of routes through Kansas that would allow greater volumes of automobile traffic on roads transversable in all weather for the purpose of encouraging economic growth.

The tie between roads and economic activity continues to this day, and not simply as an abstract concept. In late 2012, KDOT concluded a study for rehabilitation (involving the author as the bridge squad leader) of the Lewis and Clark Viaduct in Kansas City (4); where a series of bridges carry I-70 and connect downtown Kansas City, MO, downtown Kansas City, KS and the industrial areas of the West Bottoms and Fairfax. Initially, the favored layouts for reconstruction involved consolidating access on the Kansas side to an at-grade intersection, eliminating three of the current bridges. However, the Fairfax industrial community reacted strongly against this proposal. The proposed layout would have eliminated the direct access of truck traffic to Fairfax and have forced trucks through either a signalized intersection or a roundabout. The current situation allows for not only direct access to Fairfax from I-70; but also for redundant access. Several of the business indicated that access to freight movement by truck was vital to their operation, and had implemented just-in-time inventorying requiring constant access for their operations.

Kansas is recognized as having one of the best highway systems in the nation (5). This is the result of consecutive multi-year transportation investment programs, beginning with the Comprehensive Highway Program (CHP) from the late 1980's. The current multi-year transportation program in Kansas is the 10 year, $8 billion T-WORKS program. Two of the stated goals for the program are the promotion of economic development and preservation of the existing highway system (6). Compared to the needs of the transportation networks of Kansas, the $8 billion in funding is very tight. To maximize utility of funding, an emphasis has been placed on maintenance and preservation, in line with the commonly held proposition that it is cheaper to maintain infrastructure than to replace it.

To meet the contradictory requirements of providing equivalent or improved operations to facilitate economic growth, while facing reductions in funding, KDOT is required to operate as efficiently as possible. This is particularly true in regard to its inventory of bridges. Bridges cost significant sums more to construct per area of travel way than to do roads, and so represent a significant investment. The failure of bridge facilities can also be catastrophic in terms of causalities, in impact to system operation and to KDOT's credibility. Almost any bridge closure results in the closure of a section of a route to through traffic. Even reductions in capacity of bridges, such as when load restrictions are posted, can have a significant economic impact by affecting commercial truck and agricultural traffic. Though smaller than the $13.3 billion 10 year Comprehensive Transportation Plan (CTP) which preceded it, T-WORKS maintains the same budget for state funded bridge substantial maintenance and rehabilitation.

1.2 Project Scope

This project examines KDOT's practices for substantial maintenance of bridges in its inventory and, specifically, the work of the Bridge Maintenance Plans (BMP) squad. This squad was developed in the Bureau of Design in 1999 during the CTP (and initially headed by the author) to provide engineering support and project management for programs administered by the Bridge Management Engineer (BME)—Bridge Substantial Maintenance, Bridge Redeck, Culvert Replacement—and to support bridge operations by handling emergency work and advising field personnel.

This squad differed from previous practice by integrating the processes of review and selection of candidates for work, scoping of work, plan production and engineering support of construction efforts for the entire Bridge Substantial Maintenance program under the purview and direction of a single squad leader. Furthermore, the squad leader was an experienced bridge designer, rather than personnel experienced mostly in inspection; with this it was expected that engineering challenges would be identified and addressed early in the programming and scoping process. It was expected that lessons learned during repair and rehabilitation projects would be remembered and applied consistently to future projects, and that design expertise could be brought into the management process more quickly and more often.

Having a single squad responsible for, and dedicated to, Bridge Substantial Maintenance work allowed for the development of expertise in the specific work of bridge rehabilitation, repair and maintenance in its members. Locating the duties of program selection and administration with this squad allowed for engineering expertise to directly inform the activity of administration. The intended outcomes of instituting the BMP squad were:

- The more efficient production of bridge repair and rehabilitation plans;
- More consistent practices and designs for repair and rehabilitation;
- The quicker inclusion of best practices and details;
- The development of designers with a greater understanding of, and competence in dealing with, repair and rehabilitation issues; and
- Quicker inclusion of designers in emergency events, such as vehicular impacts with bridges.

Prior to instituting the BMP squad, maintenance and rehabilitation work was dealt with by inspection staff and, if it was determined that bridge design effort would be required, it was assigned to one of five in-house KDOT Bridge Design Squads. It was expected that consolidating responsibility to one squad that worked directly with the Bridge Management group would bring efficiencies and consistency to the work.

This report examines whether such efficiencies were obtained and if the resulting maintenance work was of a net benefit to the State.

1.3 Approaches to Research and Review

The work tasks for the report were as follows:

Task 1—Defining the current practice at KDOT and defining the historical and organizational contexts for the work.

This consisted of documenting the history of bridge maintenance work at KDOT, and its predecessor, the Kansas State Highway Commission through its evolution to the current bridge management paradigm and the formation of the BMP squad. Key events, such as the Federal mandates for bridge inspection and load rating, are discussed in Chapter Two of this report.

Task 2—Examining efficiencies from maintaining a dedicated Bridge Maintenance Plans squad for this work.

Repair and rehabilitation work utilizes a different approach to engineering design than does work for new construction. The approach has similarities to the Practical Design methodology currently coming into use by KDOT (7). In Chapter Three of this report, the typical scope and methods of bridge substantial maintenance work is discussed. Case studies of key projects were used to illustrate the work of the squad. In Chapter Four the organization and operation of the BMP squad was examined, from its initial development, to its current organization and management.

Efficiency, in the activity of engineering design, is typically measured in terms of man-hours required to produce plans. In this task, efficiency obtained from consolidating such work in a dedicated squad was examined by looking at the costs resulting from hours for Preliminary Engineering (PE) for Bridge Substantial Maintenance projects done by the BMP squad and compared to projects completed by design squads and consulting engineers before the inception of the BMP squad.

The concept of efficiency has been further explored beyond the usual measure of plan production hours to look at savings in cost and time for delivery of the repair and/or rehabilitation of facilities in terms of construction costs by reviewing Construction Engineering (CE) costs for Bridge Substantial Maintenance projects. Data was obtained from KDOT's Construction Project Management System (CPMS) database.

Task 3—Examining best practices in other states' departments of transportation.

Other states' departments of transportation also dedicate resources specific to bridge maintenance and rehabilitation, but to varying degrees. The practices of surrounding Midwestern states (Illinois, Iowa, Missouri and Nebraska) in regard to programming and designing plans for bridge substantial maintenance work have been examined in Chapter Five. Data were obtained by interviews with engineers in those departments and by review of the literature.

Task 4—Comparing life cycle cost from maintenance projects to date to a paradigm of minimal maintenance and replacement.

The highway facilities maintained by KDOT provide access and facilitate economic and social activities in the state; doing such requires that the bridges on those highways remain open and be capable of carrying the freight loads allowed by law. In Chapter Six it was examined whether there have been the savings from maintaining operations by a paradigm of more aggressive maintenance and rehabilitation versus a more minimal approach to contract maintenance by calculating life cycle costs for Bridge Substantial Maintenance projects let by KDOT for FY 2003. This year represented a sample year of work by the BMP squad after a degree of proficiency had been obtained, and allowed for review of bridge performance in the approximately ten years of service after the repair work.

The review followed the methodology in the National Cooperative Highway Research Program (NCHRP) Report 483, *Bridge Life-Cycle Cost Analysis* (8), and further discussed in NCHRP Report 590, *Multi-Objective Optimization for Bridge Management* Systems (9). Data on construction costs, letting dates and scope have been obtained from KDOT's CPMS database and notes by the BMP engineer taken during project selection. Bridge data were obtained from KDOT's Bridge Inspection database. Data on projected deterioration rates were obtained from KDOT's Bridge Management section and from a review of literature.

Task 5—Comparing the user costs of maintenance projects to a paradigm of minimal maintenance and replacement.

The Federal Highway Administration's (FHWA) report on *Work Zone Road User Costs, Concepts and Application* (10) identifies costs other than the traditional construction cost for road construction projects. Bridge construction projects may result in costs to highway users resulting from increases in travel time. In Chapter Seven, user delay costs have been examined by applying procedures for calculating delay from the 2010 Highway Capacity Manual (HCM) (11) to the FY 2003 projects with the most common scope of Bridge Substantial Maintenance work- bridge deck repair and overlay- in order to quantify such costs.

Data were obtained from project plans, KDOT's CPMS and Bridge Inspection databases; as well as having obtained Annual Average Daily Traffic (AADT), truck volume and length of detour on state routes for each bridge sites from the CANSYS II database.

Crash costs have been discussed in general terms only, due to considerations in defining the impacts of work zones on crash rates.

The economic impact of Bridge Substantial Maintenance work in maintaining bridge capacity was examined through an economic impact analysis of a presumed posting of bridges on K-10 from the FY 2003 Bridge Substantial Maintenance program. The analysis was conducted by engineers in KDOT's Bureau of Transportation Planning.

In the conclusion in Chapter Eight, the three goals of the report are discussed, including:

- Quantify and report the savings of a strategy of bridge maintenance and rehabilitation in Kansas, in terms of construction and user costs;
- Quantify and report savings of maintaining a dedicated Bridge Maintenance Plans squad; and
- Identify any best practices that might be adopted here in Kansas.

Figure 1.1 illustrates the execution of these five tasks to develop this report.

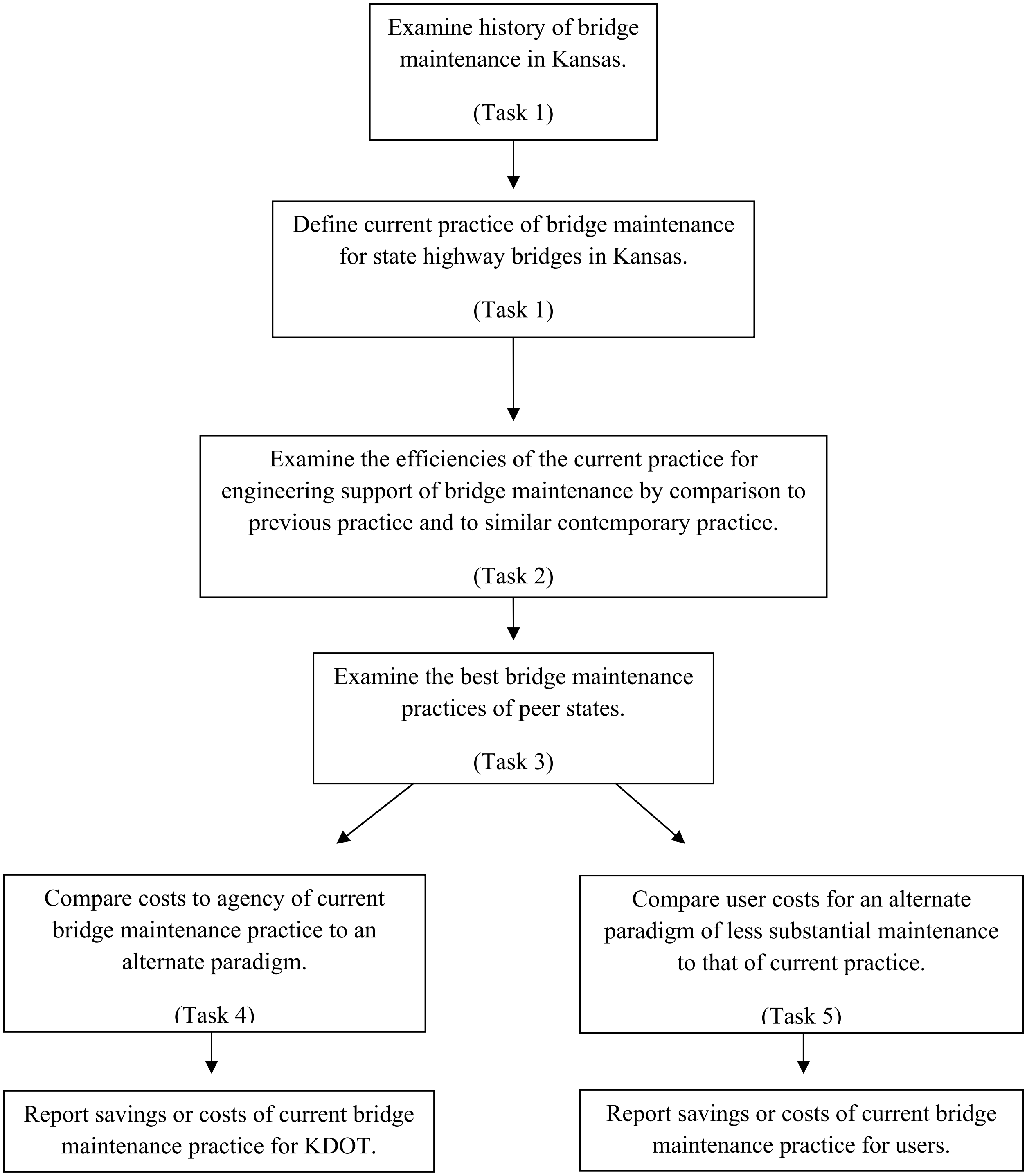


Figure 2.1—Flowchart of report tasks.

Chapter 2—History of Bridge Maintenance in the State of Kansas

In this chapter, the history of bridge maintenance in the state of Kansas is reviewed from the beginning of the state to the current day, with the formation of the Bridge Maintenance Plans squad. This history reveals challenges that have confronted those responsible for providing such maintenance, such as the size of the inventory of roads and bridges, federal mandates, and the relatively scarcity of funding. It also discusses the response of state engineers to those challenges.

2.1 Overview

Like organisms, organizations are shaped by forces in their environment. An understanding of the challenges which an organization has confronted in its history can help one understand its current form and can lead to insight as to how it may respond to current and future challenges. KDOT is charged, as were its predecessors, with the maintenance and operation of a system of highways and bridges in Kansas that is proportionally large compared to its population and resources[1]. These facilities are necessary for the state's economy. All the while, the agency and its predecessors have operated in a political climate characterized by a reflexive mistrust of central government, yet conversely, a dependence on federal funds for infrastructure.

2.2 From Statehood to the Automobile

Even at the inception of the state, Kansas politics have had a conservative inclination. The Wyandotte Constitution ratified in October 1859, under which the State was admitted to the Union on January 29, 1861, contained a provision that "the state shall never be a party of carrying on any works of internal improvements." Had that section not been amended in 1928 with the proviso "except that"… "It may adopt, construct, reconstruct and maintain a state system of highways, but no general property tax shall ever be laid nor general obligation bonds issued by the state for such highways" there would be no state highway agency. The reason for the original prohibition was that after the success of the Erie Canal in spurring the economy of New York in the early 1800's many states financed a number of infrastructure projects (roads, canals, railroads, etc) with land grants and cash. Many of these projects went bankrupt or were never constructed, with profound negative economic effects on the states in some cases (12).

It was believed that roads were a purely local matter. Roads were constructed only after 12 households within a given vicinity petitioned the county commissioners to have one. Nothing could be done without such a petition, and to prevent nuisance requests, a bond was required from one of the petitioners to pay the costs of the proceedings if the request was not approved.

[1] The size of the current Kansas road and bridge inventory is discussed in Section 2.5 of the report.

Prior to the advent of automotive traffic, load capacity requirements for bridges on public roads were relatively light; however, the general condition of the infrastructure was wanting even for the demands of the time. The first speed limit passed by legislature in 1869 posed a $5 fine for crossing a bridge at a speed above a walk. As written by a historian, “The state’s bridges simply could not take the stress of trot or canter” (12).

At this time, maintenance of the bridges carrying public roads was done by the same local landowners and farmers who were maintaining the public roads. The first comprehensive road law in Kansas was passed by the territorial legislature in January 1860, after the ratification of the constitution and prior to admission to the Union. It contained provisions requiring the counties to levy a poll-tax to fund maintaining highways (13). This was often paid in labor by farmers working out their obligation at the rate of $1.50 per day (12).

Until the automobile, most movement of freight and passengers between cities in Kansas was by rail. Even in 1908, there was no highway which crossed the state from border to border and very few roads extended 20 miles. However, the size of the Kansas road system was one of the largest in the country, its excess of 111,000 miles in 1917 ranked it as second only to Texas (13). At the turn of the twentieth century, there was impetus from several directions to improve the system. Within three years after the advent of free rural postal delivery in 1896, the US Post Office determined that it would not deliver on unserviceable roads. In 1890, a Kansas division of the League of American Wheelman (cyclists) formed to press for improvement in roads (12).

By 1900, automobiles began to appear on Kansas roads. In 1900, Kansas was tenth in the nation for automobile ownership with 220 cars. By 1910, there were 10,490 cars and by 1912 there were 30,000 cars.

The result was the development of the Good Roads Movement in Kansas, which had an official start with the state road convention held in Topeka in September 1900; complete with 500 delegates, 10,000 visitors and national press coverage for the four day event. Afterwards, the Good Roads Association was formed, and worked with the other interests to petition the legislature for a new road act, passed in 1901 (12). This made road and bridge maintenance the responsibility of the counties rather than the townships and the adjacent landowners; however, it did not forbid the payment of tax by labor. Most bridge maintenance on public roads was still performed by the public, itself.

2.3 Kansas State Highway Commission

In 1909, the Extension Department of the State Agricultural College (now, Kansas State University) began to assist various counties in the engineering of roads and bridges. The road law passed by the 1911 legislature authorized a state engineer connected with the Extension Department to advise and assist counties with road and bridge work at no expense to the counties. This move toward centralizing responsibility for roads and bridges in the State, and the need to have a state level organization for roads and bridges to accept the offer of Federal aid for highways extended by Congress in 1916, culminated in the general highway law of 1917. This law established the Kansas State Highway Commission (KHC). Its power included: apportioning Federal aid to the counties, approving the appointment of county engineers (with the power to remove for incompetency), approving plans for bridges with construction costs exceeding $2,000; devising, adopting and furnishing standard plans and specifications for road and bridge construction; and approving private bridge contracts (13).

The KHC also gathered information concerning public roads and bridges throughout the state. The first biennial report of the KHC discussed the initiation of a system of county bridge files. These files contain all correspondence and contract plans and documents for state bridges and are in use by KDOT to this day. The report also documented bridge failures in the state for the years 1917 and 1918, see Figure 2.1 below. Bridge failures were not uncommon. There were 42 reported failures in 1917 and 81 in 1918. Several of these were due to deteriorated wooden decks, an issue that could have been addressed with regular bridge maintenance.

TABLE No. 15.—BRIDGE FAILURES DURING 1917.

COUNTIES.	Location.	Date.	Type of structures.	Detailed statement of failures of structures.	Amount of damage paid.
Anderson	Ozark Township		Culvert	Horse went through culvert, breaking leg	$100.00
Anderson	Reeder Township		Culvert	Horse stepped through broken plank in wooden culvert and injured leg	
Brown	Sec. 26, T. 1, R. 16		Pile bridge	Engine went through 16-ft. pile bridge on south line of section; no one hurt.	
Brown	Mission Township		Bridge	Horse stepped through hole in bridge	51.00
Brown	Sec. 3, T. 3, R. 17	June, 1917	Concrete bridge	County bridge on township road; 8-ft. concrete arch; 14-ft. roadway; water cut under foundation during flood; county moved 30-ft steel bridge to this location	
Brown	Sec. 7, T. 3, R. 17		Corrugated iron pipe culvert	Corrugated iron pipe culvert, 4 in. in diameter, rebuilt with 6x7 ft. concrete box culvert	
Butler	Plum Grove Township		Culvert	One culvert washed out	
Butler	Plum Grove Township		Culvert	Culvert mashed in by a truck	
Butler	Sec. 10-15, T. 25, R. 5		Stone arch bridge	34-ft. span bridge; keystones dropped out: caused by becoming uncovered under heavy traffic; improperly cut stones flattened at haunches; condemned and blown down with dynamite by county commissioners and county engineer; replaced by 30-ft. T girder concrete bridge	
Cherokee	Salmanca Township		Culvert	Road overseer's horse fell through or off plank culvert that had been condemned, while on inspection of culvert. He thoughtlessly or carelessly drove on culvert	
Cherokee	Ryan Bridge	1916	150-ft steel bridge	Ryan Bridge over Spring River taken out by tornado in 1916; rebuilt in 1917.	
Coffey	Pottawatomie		Culvert	Horse valued at $150.00 got leg broken by stepping through hole in culvert	
Cowley			Concrete slab bridge	Bridge on sand foundation washed out by 10-inch rain or waterspout; the approach was out and one abutment undermined causing total collapse.	
Decatur	Sec. 28-29, T. 1, R. 26		Wall	Wall washed out before the fill was put in	
Decatur	Sappa Township		Walls	Two cement walls washed out	
Dickinson	Culvert No. 4		Concrete slab culvert	4-ft. span culvert built by a township trustee with only a 6-inch slab and no reinforcement or crushed rock was crushed through by a 10-ton tractor in two places about 18 inches in diameter. The holes were covered with brush by the driver; county engineer hit one of the holes; damaged car to the amount of $60.00	
Dickinson	Bridge No. .013			Stone abutment 10 feet high fell and was replaced by concrete	
Dickinson	Bridge No. 39		Culvert	Steel bent set on old boiler tubes; was incased in concrete	
Dickinson	Bridge No. 47			Condemned for some time and completely overhauled; wingwalls had to be tied together	
Finney	Bridge at Holcomb		Pile bridge	96 feet washed out replaced with 3 concrete piles to each bent. Two complete bents built with concrete cap and 32-ft. span, using 6 12-inch T beams and 2 12-inch channel for each span	
Geary	South Milford Road		Culvert	$25.00 paid for skinning up mule which fell through culvert	25.00
Harper	Chicaskia Township		Bridges	Three small bridges in north part of township which are badly decayed need new floors	
Harper	Chicaskia Township			New floor needed on county bridge between Sec. 31-32; several holes rotted through	

Figure 2.1—Partial list of bridge failures from the first report of the KHC.

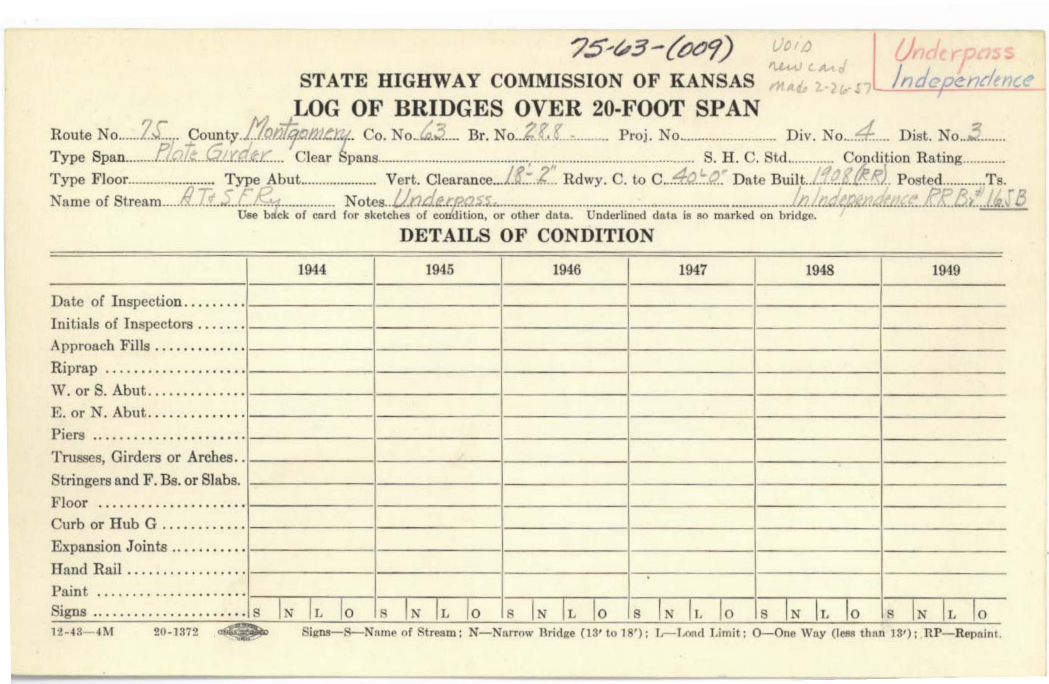
At its inception, the KHC worked through supporting the work of the counties. By the 1917 law, bridge inspections and responsibility for maintenance still lay with the county engineer; bridge work under $1,000 could still be performed with what was termed, lay-labor (i.e. farmers working off tax obligations) (13). Though a state system of routes was established in 1918, this was only the designation of routes which traverse the state and would be eligible for federal aid. Construction projects were let and maintenance was performed by the counties.

By 1925, the Agriculture Department (the department containing the US Bureau of Public Roads) had stopped approving all new Federal funds for work in Kansas due to their dissatisfaction with the output of projects. The state matching appropriations fell far short of what was needed and the situation was compounded by the inadequate staffing and inefficient organization of the commission. The loss of federal funding forced a reorganization and enlarging of the commission. Also, in 1925, the state passed a tax on gasoline for the purposes of funding roads. The number of divisions in the state was increased to six (corresponding to the current six KDOT districts) and the headquarters staff was increased and reorganized into four departments: design, construction, maintenance, and equipment. This was the start of viewing maintenance for public roads as a responsibility of the state, rather than the local units of government.

Further reorganization in 1929 resulted in the formation of nine design squads in the design department, the addition of resident engineers in the field to oversee construction and the addition of a maintenance engineer to each of the six divisions to oversee maintenance activities. For the first time, there was an engineer assigned specifically to be responsible for maintenance work, rather than leaving the activity to the responsibility of a field superintendent with some guidance by the county engineer.

With engineers responsible for maintaining the existing inventory, it was inevitable that specific concerns would make their way back to the design staff. The state's bridge design staff led the nation in implementing continuous girder and truss bridge design, eliminating deck joints that allow drainage to deteriorate bearings and substructure (14). In 1936 the US-77 highway bridge over the Smoky Hill River constructed at Junction City featured the longest continuous truss superstructure in the United States at 960 feet in length. A 940 foot, five span continuous girder unit of the 4,400 foot long bridge over the Kansas River at Topeka was an achievement of similar magnitude when completed in the same year.

From the 1930's onward there was the position of Bridge Maintenance Engineer within the Maintenance Department. This engineer was tasked with inspecting the bridge inventory and assisting maintenance forces in repair, and if necessary, replacement by KHC forces (15). Through the history of the KHC, there were only five engineers who held this position, the last of whom was Roger Alexander; who is currently associated with the Kansas University Transportation Center.



75-63-(009)

VOID new card made 2-26-57

Underpass Independence

STATE HIGHWAY COMMISSION OF KANSAS

LOG OF BRIDGES OVER 20-FOOT SPAN

Route No. 75 County Montgomery Co. No. 63 Br. No. 28.8 Proj. No. Div. No. 4 Dist. No. 3

Type Span Plate Girder Clear Spans S. H. C. Std. Condition Rating

Type Floor Type Abut. Vert. Clearance 18'-2" Rdwy. C. to C. 40'-0" Date Built 1908 (RR) Posted Ts.

Name of Stream AT&SF Ry Notes Underpass. In Independence RR Br# 165B

Use back of card for sketches of condition, or other data. Underlined data is so marked on bridge.

DETAILS OF CONDITION

	1944	1945	1946	1947	1948	1949
Date of Inspection						
Initials of Inspectors						
Approach Fills						
Riprap						
W. or S. Abut.						
E. or N. Abut.						
Piers						
Trusses, Girders or Arches						
Stringers and F. Bs. or Slabs						
Floor						
Curb or Hub G						
Expansion Joints						
Hand Rail						
Paint						
Signs	S N L O	S N L O	S N L O	S N L O	S N L O	S N L O

12-43—4M 20-1372 Signs—S—Name of Stream; N—Narrow Bridge (13' to 18'); L—Load Limit; O—One Way (less than 13'); RP—Repaint.

Figure 2.2—Bridge inspection card typical of old record format.

The inspections by the KHC Bridge Maintenance Engineer preceded the current paradigm of federally mandated inspections. The availability of such bridge records (and records for roads) allowed the KHC to be the first highway department in the nation to calculate the total dollar investment in its highway system ($145 million) in 1940 for the Bureau of Public Roads (12).

2.4 National Bridge Initiatives and the Kansas Department of Transportation

In 1967 the Silver Bridge, at Point Pleasant, West Virginia, collapsed into the Ohio River on December 15, 1967 killing 46 people. In response, Congress in 1968 directed the FHWA to develop National Bridge Inspection Standards (NBIS). In 1971 FHWA published these standards for all bridges on Federal Aid highways. It required that all bridges with 20 foot or greater spans to have a Structural Inventory and Appraisal report submitted to FHWA by 1972. Thereafter, these bridges were to be inspected on at least a biennial basis by personnel meeting FHWA requirements for training and experience. In 1978, this requirement was extended to all bridges on public roads (16).

In the 1970s, after reviewing failures of culvert structures on the Interstate in the Topeka area, the KHC began inspecting span and culvert structure less than 20 ft. but more than 10 ft. in length on a four year interval, which KDOT continues to this day (15). The FHWA Culvert Inspection Manual was not published until 1986 (16).

In 1975, the KHC was reorganized into the Kansas Department of Transportation, a cabinet level organization with a Secretary appointed by the Governor. With the reorganization, the departments of construction and maintenance were combined into the division of operations. The Bridge Maintenance Engineer position and its accompanying staff of two engineers went into the Division of Operations. In 1984 the Bridge Maintenance Engineer position was moved to the Bridge Office in the Bureau of Design.

Federal mandates concerning bridge inspections would increase in scope twice more in the next few years. The 1983 Here-Mianus River bridge collapse in Connecticut left three dead. This led to the mandate for fracture critical inspections in 1986. Then, in 1987 with the collapse of New York's I-90 Bridge over Schoharie Creek and the deaths of ten people, national attention turned to underwater inspections. This structure had failed due to scouring of the center pier. The 1987 Surface Transportation and Uniform Relocation Assistance Act required underwater inspections, at a 60-month minimum interval of scour critical bridges (16).

Federal mandates concerning bridges were not limited to inspection requirements. In 1971, FHWA began to require load ratings to be submitted for each bridge in its inventory. For Kansas, this required a squad in the Bridge Design section to be tasked with rating every bridge on the state system. Unfortunately, this first round resulted in the load posting of approximately 200 bridges. Many of these bridges carried the only state routes into some small towns. The load posting of these bridges effectively cut the towns off from truck and freight traffic (15).

To meet the need of maintaining freight access, the Bridge Maintenance Engineer was charged with developing bridge designs, assuming a ten-year life, to be built by state maintenance crews. These utilized, where possible, materials that the field office might have on hand, such as steel beams recycled from previous construction. Typically, these structures were 20-50 ft. long bridges on state highway "K" routes. The first round of bridge designs utilized timber stringers and decks; the next round of design utilized steel beams and timber decks. The last designs utilized steel beams and corrugated deck, and in at least one instance prestressed concrete panels for the deck (15).

2.5 Current Size

Kansas still has a large system of roads and bridge for its population. It ranks third in the nation with over 140,000 miles of public road, behind only Texas and California. According FHWA, as of 2009 Kansas ranked fourth in number of bridges (behind Texas, California and Illinois) and seventh in the nation in the number of bridges rated Structurally Deficient (17). When compared to population numbers from the 2010 US Census, Kansas ranks first in bridges per capita at 9.334.

2.6 Formation of the Bridge Maintenance Plans Squad

Currently, Kansas has a reputation for having a highway system in good condition; this was not the case in the 1980s. In the 1980s, the budget for transportation was insufficient compared to the needs of the State Highway System. It was not uncommon for the KDOT Bridge Office to produce replacement bridge plans utilizing salvaged bridge girders. This need led the administration of Governor Mike Hayden to push for a multi-year highway bill funded by bonding to improve the condition of the system. In 1989, House Bill 2014 enacted the eight-year CHP (18).

Major projects were selected at the beginning of the program. Funds were set aside at the beginning of the program to be assigned annually for maintenance projects, including substantial maintenance for bridges. Coincident with the CHP, came a new mandate from FHWA. The 1991 Intermodal Surface Transportation Act (ISTEA) required each state to adopt a bridge management system to track the condition and performance of its bridges. In response, KDOT created the position of BME in 1990, to oversee bridge inspections and evaluations. This position also was assigned to be the program manager for Bridge Substantial Maintenance funds.

The success of the CHP led to passage of a ten-year CTP in 1999. This program, too, included funds set aside for Bridge Substantial Maintenance. Colloquially, Bridge Substantial Maintenance projects are still referred to as “set-aside” projects to this day. Funding was increased for Bridge Substantial Maintenance with the CTP, from an annual average of $7.4 million during 1990-1997 for the CHP, to $14.9 million during 2000-2009 for the CTP (note, these dollars are not adjusted for inflation). With the CTP, two new funds under the authority of the BME were established for bridge rehabilitation: Bridge Redeck and Priority Bridge Culvert replacement. Together the two new funds averaged $5.3 million annually.

To assist the BME in the administration of the increased funding under the CTP, the BMP squad was created in 1999. The squad initially consisted of an engineer and a technician. The duties of the engineer were to assist the BME in selection of projects and to act as the bridge design squad leader for those projects requiring either structural or hydraulic engineering analysis. Plan production for those projects with a limited scope which did not require such analysis, i.e. bridge deck and overlay without associated work, was handled by the districts. The technician assisted the BMP Engineer with in-house plan production.

An additional impetus to the formation of the squad was the desire to place the design function for the multiple substantial maintenance projects ongoing at any one time under the control of the BME. Through the CHP to the CTP, any substantial maintenance work which would require structural or hydraulic analysis, such as replacing expansion joints or replacing a culvert, was assigned to one of the five bridge design squads. The design approach and assumptions used on repair work were not always consistent among the squads, leading to variations in the plans. Additionally, the bridge design squads were under increased workloads with the major highway projects and bridge replacement projects contained in CTP. Fitting in new maintenance work annually into a squad with a multi-year schedule was disruptive. It was decided that a separate squad dedicated to substantial maintenance and rehabilitation work would have a consistent approach and would be scheduled with the expectation of quicker response to program and project needs.

2.7 Chapter Summary

- Although, Kansans have been inclined to be fiscally conservative regarding state government expenditures since the inception of the state, they have also demanded a good highway system.
- Bridges have historically required more consideration and attention than many other elements of the public road system.
- State efforts to provide and maintain bridges have historically been shaped by federal money and mandates.
- In 1989, Kansas began to increase its investment in the State Highway System with the CHP.
- In 1999, the BMP squad was formed to facilitate bridge maintenance efforts for bridges on the State Highway System.

Chapter 3—Bridge Substantial Maintenance

The work of the Bridge Maintenance Plans squad is discussed in this chapter. The work in the primary funding category for the squad, Bridge Substantial Maintenance, is described. A typical Bridge Substantial Maintenance project is reviewed, as are projects for emergency repair and to support a repair by KDOT field forces. Engineering costs for these example projects are discussed.

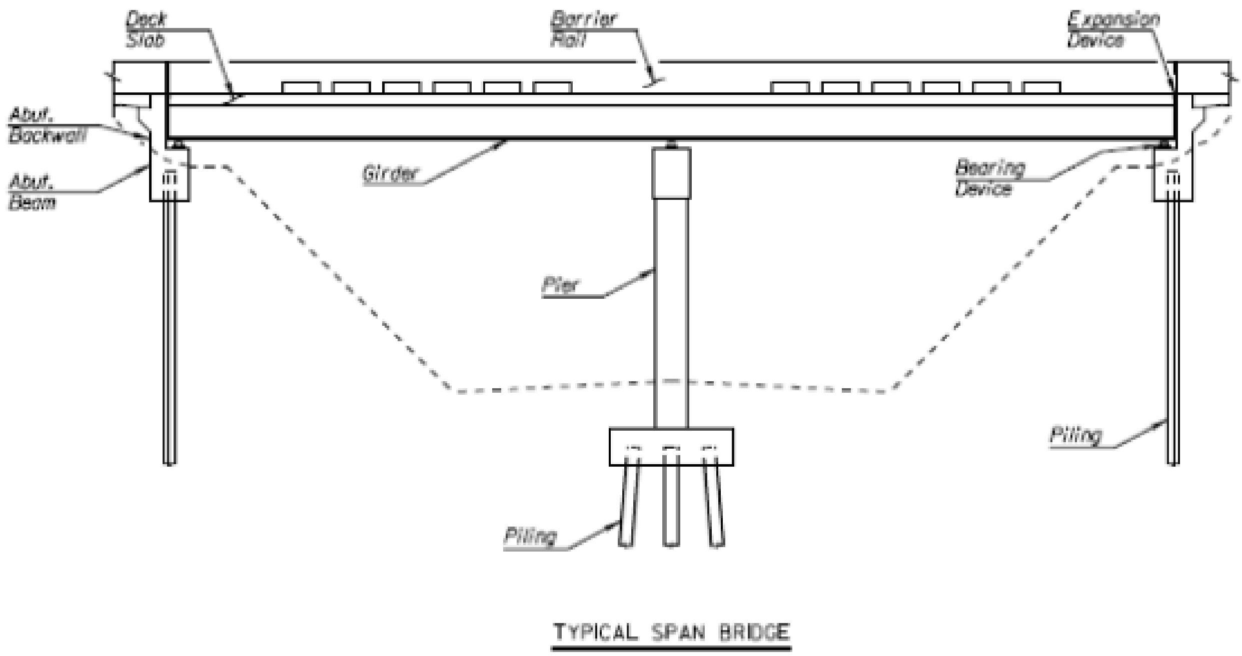
3.1 Typical Work

The Bridge Maintenance Plans Squad came to handle four distinct categories of projects: substantial maintenance, emergency repair, rehabilitation, and the ubiquitous—other duties as assigned.

Rehabilitation work consists of replacement of an entire element of the bridge, such as the deck or the superstructure (see Figure 3.1 for typical bridge and culvert elements). These were the projects programmed in the Bridge Redeck and Priority Bridge Culvert funds. This work is often, but not always, more engineering design intensive than substantial maintenance work. The process of work (schedules, types of analysis, etc.) is the same as it is for more standard bridge design and is not reviewed in this report.

Substantial maintenance work consists of repair work that is performed by a highway contractor due to its scope or magnitude. The most common of such work is the repair of bridge decks requiring removing the top of the wearing surface by milling, removing and patching damaged concrete that remains, then overlaying a new wearing surface onto the deck. The overlay material is typically concrete modified to reduce its permeability to water. For bridge decks water infiltrating into the concrete deck leads to deterioration primarily by corrosion of the reinforcing steel. The chloride ions from the salts used for snow and ice removal facilitate the creation of corrosion products (i.e. rust) from the water combining with the iron in the reinforcing steel. In Kansas, the overlay material is usually concrete modified with silica fume. Less common is concrete modified with latex. The newest concrete overlay material is a mix called a ternary mix, that is, it has three modifiers (usually one of which is silica fume) to reduce permeability.

Deck overlays that do not involve milling the top layer of the wearing surface prior to placement include polymer concrete overlays and bituminous overlays. The polymer concrete overlay is an epoxy which seals deck crack and bonds small aggregate to the deck for wearing. It can be applied on a deck that is cracked but has few spalls. Another application is to apply it over a previous rigid concrete overlay that has debonded from the subdeck beneath, but hasn’t yet spalled. This is done to seal it and prevent penetration of water under the rigid overlay.



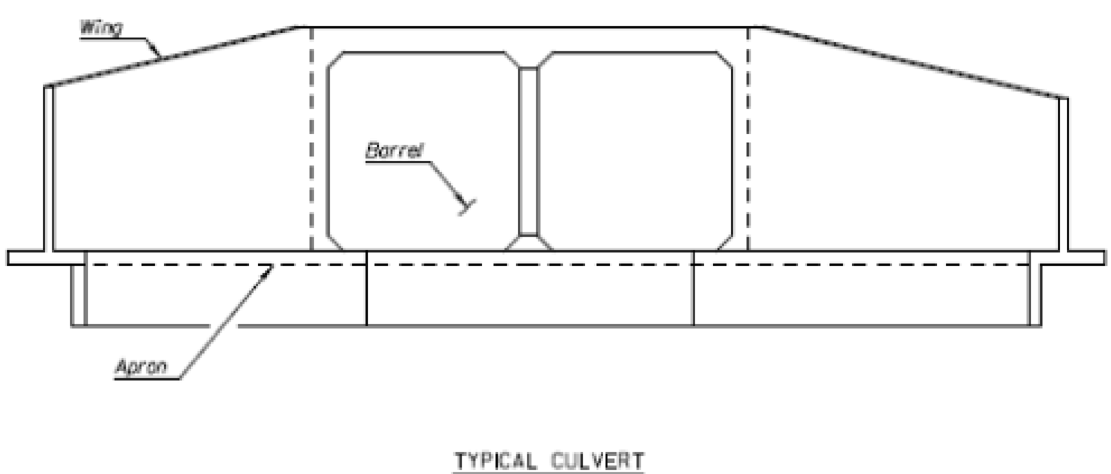


Figure 3.1—Elements of typical span bridges and culverts.

Bituminous overlays are applied as a last measure to decks in Kansas, for the most part. Bituminous material are porous to water, therefore the effectiveness of the overlay is sealing the underlying deck from water is a function of the waterproofing membrane placed between the deck and the overlay. This membrane is similar to tar paper and may easily be torn during application. KDOT's past experience with these systems has not encouraged confidence in their use for a service life of more than five years. They are used in other states as a long-term overlay, however.

The next most common scope for a span bridge is replacement of the deck expansion joints. All bridges are subject to thermal expansion and contraction. A bridge with a steel girder superstructure will expand approximately 0.08 in. per 100 ft. of girder per 10° F increase in temperature. A 400 ft. bridge will expand 1.27 in. at each end with a change in temperature of 60° to 100° F. It will contract 3.18 in. at each end in the drop from 100° to 0° F. This movement is accommodated with joints in the deck. For relatively large movements as described, a finger joint, as shown in Figure 3.2, is used. For smaller movements, where the largest gap at -30° F will not result in a gap larger than 4 in., a strip seal, as shown in Figure 3.3 is used. A strip seal consist of a neoprene gland held into place by two cast steel extrusions which clamp the gland. Joints have the shortest life of any element on the bridge because they see impact from traffic wheel loads (and the occasional snow plow) and drainage and debris washing off the wearing surface of the bridge deck.

Figure 3.2—Typical finger joint expansion device.

Figure 3.3—Strip seal expansion device on Br. 10-46-176.

When reviewing a bridge to replace the expansion joints, consideration is given to eliminating the joint by encasing the ends of the girders and deck in the backwall of the abutment. Note that the thermal movement is not eliminated; the entire abutment backwall will move, causing translation and rotation of the piling on which is sits. Whether or not the joints may be eliminated is dependent on the amount of thermal movement that would have to be accommodated and the capacity of the piling.

Culvert repair is another common scope of substantial maintenance work. The work may consist of replacing tipped wings, repairing cracked area in the barrel, or if the deterioration is extensive—replacement of the entire culvert. Though the scope may be replacing an entire culvert, the work is often considered as substantial maintenance since neither deep foundations nor heavy equipment (such as cranes) are required for construction.

There are other numerous scopes of work included in substantial maintenance, but the four most common are bearing replacement, girder repair or retrofit, and rail replacement. Table 3.1 shows the distribution of project scopes in the Bridge Substantial Maintenance program. On projects which include deck patching and overlay in the scope, those bid item almost always predominate the project cost. The bridge painting scope shown below is for those projects that are only painting. Bridge painting is included in some of the projects with deck work, but bridge painting as a bid item still does not make up a large percentage of any year's expenditures. The project scopes include in "Other" include scour repairs, concrete approach pavement replacements, pier repair with polymer fiber wraps, steel fatigue repairs and other miscellaneous work that can vary greatly from year to year. For example, the large percentage of "Other" in the FY 2005 substantial maintenance program included a $1.7 million project for fatigue repairs of a long steel girder bridge.

	Fiscal Year						
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Scope includes deck work	93.6%	84.5%	78.2%	80.9%	86.2%	51.0%	87.8%
Joint replacement only	0.0%	3.5%	6.8%	5.3%	1.0%	10.6%	0.9%
Culvert wing replacement or culvert extension	1.6%	1.8%	2.8%	1.3%	2.4%	1.4%	6.1%
Culvert replacement	2.4%	3.8%	7.9%	4.8%	0.9%	1.6%	0.0%
Painting only	0.0%	5.8%	0.0%	0.0%	0.4%	1.8%	0.0%
Other	2.4%	0.6%	4.3%	7.7%	9.1%	33.6%	5.2%

Table 3.1—Distribution of project scopes in Bridge Substantial Maintenance.

Projects which require structural analysis or require significant detailing of structural items have their plans produced by the BMP squad. Over half of the projects which include deck work typically also include joint replacement, concrete repair or other items requiring structural analysis, and so will have plans produced by the squad. However, this still leaves a significant number of projects for which plan production may be handled by district personnel. For this, and to facilitate continuity of design among projects, standard plans were developed for the most common substantial maintenance work. There are 31 standard sheets, most detail deck patching and overlay work on common bridge superstructure sheets, others detail bridge approaches, and some detail heat straightening procedures to be used to repair impact damage to steel girder bridges. These standards are included in Appendix A of this report.

The next sections of this chapter illustrate the typical process and scope of work for three of the categories of work handled by the squad. First, in Section 3.2, is Bridge Substantial Maintenance project K-8376-01. This was a FY 2003 project consisting of deck and approach work, joint replacement and bridge painting on two sets of twin steel girders bridges carrying eastbound and westbound K-10 highway over the ATSF Railroad and over Kill Creek near DeSoto in Johnson County. This project is part of the FY 2003 program analyzed in Chapter Five on bridge life cycle cost analysis. The K-10 bridges are also the subject of an economic impact on overweight freight traffic utilizing a Transportation Economic Development Impact System (TREDIS) model in Chapter Seven on user costs.

The BMP squad's initial location in Bridge Management and close work with bridge inspection made it the logical choice to handle emergency bridge repairs. One of the first emergency repairs handled by the squad happened within six months of its establishment. Section 3.3 of this report examines project K-8037-01, the repair of a truck impact of a concrete box girder structure carrying I-135 in Wichita.

The squad's involvement in Bridge Management resulted in it having a greater degree of involvement in operational matters at KDOT than did other design squads. Much as Roger Alexander's unit in the Maintenance Department in the KHC, the BMP squad became the default squad to support KDOT field personnel in repair and in unusual situations, such as the removal of bridges from service. Section 3.4 of this report examines the squad's work in providing bridge repair details from FY 2001 that allowed district bridge repair crew to repair the US-75 bridge over the Neosho River near Burlington sufficiently well to allow the removal of the load posting from the bridge.

3.2 K-10 over the BNSF Railway and over Kill Creek near DeSoto

From the inception of the squad to the current time, Bridge Substantial Maintenance projects are selected on an annual basis. KDOT bridge inspectors maintain an "A list" of structures programmed for substantial maintenance work or replacement, or which are recommended for it (see Figure 3.4). In the fall, this list is reviewed and the districts are solicited to send their top picks for candidates for work. In November and December, the BMP Engineer and the BME develop a list of candidates for field review that they visit with district personnel.

12/10/2012

SPECIAL SUMMARY LIST

District 1 Area 3

A) Structures Programmed or Recommended for Contract Repair or Replacement:

	Bridge No.	Condition	Avg III	Suff. Rating	Fed Fund	P.O. No.	Status
5 -	105 - 1.35 - (193)	SWGC-Deck-bottom side showing 17% bottom side deter. Polymer peeling up in places. Super corrosion on bearings at abuts. Sub Large spalls with exposed re-bar on Pier #3-Column C.	91.5	97.0	NE	1279	Repair P3, Col C - wrap all center cols Sandblast, paint bearings abuts
5 -	105 - 1.79 - (191)	RCSC-deck-spalled, delams. And patched areas. 25% top side deter. Super-some saturation on bottom. Sub-a few delams and scrapes.	70.6	84.9	NE	4056	OL Candidate
5 -	105 - 2.00 - (190)	RBGC-Deck has t-cracks with map cracking up to 1.00mm. Super-minor shear cracks at abuts. Sub-minor cracking.	91.0	98.0	NE	957	Polymer Candidate
7 -	105 - 164.93 - (258)	SWCH-Deck – good. Superstructure – good. Substructure – good. .	98.9	94.2	BH	126	KA-2230-01 Overlay-Paint
7 -	105 - 164.94 - (077)	SWCH-Deck-finger joints installed-polymer not on yet. Super-history of cracking with some cracks retrofitted. Bearing problems at piers #8 and #9. Bearing tabs gone and girders have shifted. Sub-fire damage to river pier.	89.2	96.2	NE	2574	Repair the scaling from fire damage on North face of P:5. Re-Align the bearings at P8 and P9.
32 -	105 - 28.60 - (105)	RBGC Deck- spalls w/exp rebar at, spalls w/scaling, mapping w/long and t-cracks 1-1.5mm, 5% delams. Super-splitting cracks at piers, impact damage, spalls & delams w/exp rebar, 1mm flexure cracks, 10% deter. Sub-spalls w/exp rebar in cols & abuts	74.0	78.0	BH	3291	Polymer candidate
32 -	105 - 31.99 - (277)	SWCH-Deck = good. Superstructure = good. Substructure = good. Routine Snooper 2011	96.7	76.5	NE	521	Future Polymer O.L Candidate
40 -	105 - 418.56 - (159)	SBMC-Deck=1.50 mm map cracks, w/long. and t-cracks, 10% top deter, apprs. settled, btm. showing full depth patches w/map cracks and t-cracks w/effl, 10% btm deter.	91.0	89.4	BH		Polymer or OL candidate

Figure 3.4—Example section of KDOT Bridge Inspection A-list.

Bridges[2] 46-176 and 46-177, carrying K-10 over lines of the BNSF Railway and bridges 46-178 and 46-179, carrying K-10 over Kill Creek near DeSoto, were field checked on November 26, 2011 by the District Engineer, District Construction Engineer, BME, and the author as the BMP Engineer. These four bridges were District One's top priority on their candidate list and all, but bridge, 46-176 were on the bridge inspection A-list at the time and recommended for maintenance work. Photos taken at the time documented the spalled condition of the deck and corrosion at the bearings caused by drainage through the sliding plate expansion device in the deck. Spalling and deterioration of the deck concrete on two of the bridges are shown in Figures 3.5 and 3.7. Figure 3.6 shows the excessive tip of the rockers at the west abutment on bridge 46-177.

Figure 3.5—East sliding plate expansion joint and deteriorated deck concrete on Br. 10-46-176.

[2] Note that KDOT bridges are identified by a bridge number. This number consists of the county number (counties are numbered by alphabetic ranking) follow the serial number of the bridge within that county. Sometimes a three number form is used where the route number precedes the county-serial numbers.

Figure 3.6—Rocker bearing tipped at west abutment of Br. 10-46-177.

Figure 3.7—Deteriorated deck concrete on Br. 10-46-179.

The abutment backwalls were reviewed and found to be in good condition. Cracks in the steel abutment diaphragms were examined and determined to be stable, the result of corrosion rather than fatigue. Consideration was given to eliminating the expansion device by encasing the girder ends in the abutment backwall, but the 386' length of bridges 46-176 and 46-177 meant that each end of each bridge would be expected to see a range of movement of approximately 4.6 in. over a temperature range of -30° to 120° F. This would have been too great for the existing abutment piling.

The bridges were programmed for joint replacement, deck patching and overlay, replacement of the approach slabs, and for bridges 46-176 and 46-177 it was decided on site to add bridge painting to the scope. The plans prepared for letting by the Bridge Maintenance Plans squad for this project are in Appendix B of this report.

The initial estimate for work in the district submittal was $1,211,744. After field check, the programmed estimate for this project was $1,650,000 for FY 2003. It was let in the intended fiscal year for $1,548,303.65.

Preliminary Engineering (PE) costs, i.e. design costs, for the project were $13,645.62, less than 1 percent of construction costs for the project. The in-house hourly designer rate with overhead was $33.72 in FY 2003. The hourly rate for the technician was $26.41. Assuming a split of 1 to 3 (engineer: technician) for engineering design and plan production, the plans were prepared in approximately 480 hours.

For comparison, two similar projects let in FY 2000 and three similar projects let in FY 2001 designed by consulting engineers were examined and are shown in Table 3.2. The PE costs for comparable consultant jobs were considerably higher, at a minimum of 5 percent of project construction costs.

Project	Scope	No. of Br.	PE/Const Cost	CE/Const Cost
K-7650-01	Bridge Deck Overlay, Expansion Joints, Backwall Repair	1	7.8%	14.7%
K-7653-01	Bridge Deck Overlay, Expansion Joints, Paint	1	6.3%	6.1%
K-7964-01	Bridge Overlay, Encase Abutments, Paint	2	7.9%	15.7%
K-7978-01	Bridge Overlay, Approach Pavement, Encase Abutments	2	6.7%	19.2%
K-7974-01	Bridge Overlay, Approach Pavement, Parapet Repair, Encase Abut., Paint	5	5.0%	9.4%

Table 3.2—Consultant designed projects from FY 2000 and 2001.

Construction Engineering (CE) cost for the in-house designed project was 8.4 percent of total and compares favorably with the consultant designed projects. CE costs reflect the cost to inspect and administer the project in the field and may be affected by the length of construction, complexity and any charge orders required.

3.3 I-135 in Wichita

On March 23, 2000, a container delivery truck was driving on 17th Street in Wichita with (unbeknownst to the driver) its hydraulic hoist upright. The hoist struck the bottom of a multi-cell concrete box girder bridge at speed. The floor of the east exterior cell was struck and damaged, resulting in a 3 ft. 6 in. x 6 ft. hole and a total damaged area of concrete measuring 6 ft. x 20 ft. (see Figures 3.8 and 3.9).

Figure 3.8—Truck on 17th St. impacting I-135 bridge in Wichita.

Figure 3.9—Impact damage on Br. 135-87-290.

The damage resulted in closing the outside lane of southbound I-135 above, affecting approximately 40,000 vehicles a day at that time.

On Friday, March 24, 2000 KDOT bridge inspectors visited the site and conducted an inspection of the structure. The report was transmitted to the BMP squad and work began immediately on repair plans. Repair plans were complete four business days later on March 30 for review and negotiations with the contractor chosen to complete the repair work. Plans may be found in Appendix C of this report. The scope of work consisted of removing damaged concrete and reinforcing steel, splicing in new reinforcing at replacing the concrete to the original lines.

A price of $78,500 was negotiated with a local contractor in Wichita. Work began on April 3, 2000 and was completed by April 26, 2000.

In-house plan production took 44 hours at a cost of $1,308.27; representing a cost of PE of 2 percent of construction costs.

3.4 US-75 over the Neosho River near Burlington

On March 1, 2001 the Bridge Office recommended to the State Signing Engineer that the truss carrying US-75 over the Neosho River north of Burlington (Br. 75-16-21) be posted to 25-35-40 tons[3] (see Figure 3.10). The cause for reduction in rated load capacity was a section of significant deterioration through the bottom chord on the east truss. Deterioration through over half the height of the channels forming the webs of the chord occurred at the batten plates[4] south of pier #2. The posting led to a letter dated March 20, 2000 from the Coffey County Commission to the Secretary of Transportation asking that a bridge replacement project at the site, scheduled for completion in October 2005, be accelerated out of concerns for truck traffic through the city of Burlington. On April 13, the Secretary responded to the county commission in writing; repair options that would allow the posting to be removed began to be evaluated.

Figure 3.10—Repaired chord of US-75 bridge over the Neosho River.

[3] Load posting designations are explained in Section 6.3 of this report. The load posting above restricts the bridges to trucks of a maximum gross weight of 25 tons, truck-semi trailer combinations of 35 tons, and truck-semi trailer-trailer combinations of 45 tons.
[4] Batten plates are the horizontal plates in the plane of the lacing between the channels forming the built-up chord section.

Figure 3.11—Close up of the repaired chord.

Later in the month, the BMP Engineer visited the site to obtain further information and to further define the defect. By late May, a repair plan was developed and presented to district personnel. District personnel affected a structural steel repair bridging the defect with steel plates. District forces conducted the repair in June 2001, and removed the posting by the end of the month (see Figure 3.11).

Plan production hours were approximately 60 hours at a cost of approximately $1,780 in FY 2000. The correspondence, inspection and repair plans for this project are in Appendix D of this report.

3.5 Chapter Summary

- Substantial maintenance work on bridges is repair work of a scope that requires a highway contractor to perform.
- For span bridges, the most common scope of substantial maintenance work is deck repair. The second most common is replacement of the expansion joints.
- Repairs to culverts are a regular, but small portion of the annual substantial maintenance budget.
- As illustrated in the example projects, the BMP squad was able to provide engineering services for substantial maintenance, emergency repair, and in-house maintenance projects quickly and at low cost.

Chapter 4—Management of the Bridge Maintenance Plans Squad

The management and organization of the Bridge Maintenance Plans squad is examined in this chapter. The history and structure of the squad as initially formed and as reorganized in 2006 is reviewed. The efficiency of the squad in providing engineering services for Bridge Substantial Maintenance projects is examined by reviewing Preliminary Engineering costs. The effectiveness of the squad in providing appropriate and complete project plans and support for these projects is examined by reviewing Construction Engineering costs. The reliability of the squad is examined by means of an organizational survey.

4.1 Squad Management from 2000-2005

The Bridge Maintenance Plans squad was constituted in 1999 as a unit in the Bridge Management Section of the State Bridge Office. It was charged with design and project administration duties for bridge substantial maintenance and rehabilitation projects annually selected by the Bridge Management Engineer. Bridge substantial maintenance projects were funded by one of three program funds: Bridge Repair, Culvert Repair or Bridge Painting. Bridge rehabilitation projects, projects which are larger in scope and involved complete replacement of culverts or of entire bridge elements (such as the deck), were funded through either the Priority Bridge Culvert or Bridge Redeck programs.

The original staffing for the squad consisted of the BMP Engineer and an engineering technician. The technician's sole focus was plan production for in-house projects. With the start of the squad occurring late in calendar year 1999 (middle of FY 2000), the first complete fiscal year of projects for the squad was 2001. Twenty three bridges were programmed for work which required non-standard bridge repair sheets. Additionally, three structures were programmed for emergency work that fiscal year. It was recognized early that the number of bridge repair plans would be daunting, especially for staff new to their positions. Nine of the bridges were let out in three projects to consulting engineering firms to develop bridge repair plans. This resulted in a spike in cost for PE. PE costs had traditionally run about 3 percent of the construction cost for this type of work, but increased to 4.6 percent for FY 2001.

In order to reduce these costs, it was decided to increase the in-house plan production capability. Two Engineering Associate positions were split in duties between plan production in the BMP squad and Bridge Inspection. This sharing of engineers between design and inspection duties would prove to be successful. Bridge Inspection was able to draw from a larger pool of inspectors for the inspection of large urban areas, where it was desired to minimize traffic impact by having as many inspections go on simultaneously as possible; and the design of repairs was improved by having designers familiar with the actual performance of bridges and bridge elements. Figure 4.1 shows the Bridge Office organization chart from that time.

For FY 2002, 28 bridges were programmed for in-house design of the repairs, one emergency bridge repair required plans; and a complete span bridge replacement was done by the squad. The complete replacement was for a 3-span steel girder structure carrying US-59 over Stranger Creek in Atchison County. The previous concrete girder bridge experienced a sudden and rapid deterioration at the south bearing and, it was determined that replacement would be cheaper than the initially scoped rehabilitation. Though fewer funds were programmed, more of the work consisted of joint replacements and concrete element repair, resulting in the greater number of bridges requiring non-standard bridge plans. Even with this increase in plan production needs, PE as a percentage of construction dropped significantly—to 1.6 percent.

In-house designers were significantly cheaper than consultant designers. In-house designers had immediate access to records and existing plans, and to load-rating analysis models of the structures. Additionally, by sharing the designers with inspection, there was less down time and overall overhead for the Bridge Office was reduced.

Though one of the engineers did leave KDOT in 2004 for work at a consulting firm, turnover was minimal in this period. The spot was filled with an internal candidate and work in the squad continued apace with 36 in-house bridge repair designs programmed for each of FY 2003 and 2004, without any consultant repair work programmed (though one emergency project did go to a consultant in FY 2004). PE continued to remain low at 1.3 percent and 0.8 percent of their respective FY construction cost.

For FY 2005, 34 in-house bridge repairs were programmed and one emergency project was done in-house. A bridge repair project in Wichita was given to a consultant as were two emergency repairs. PE that year went up to 2.7 percent of construction cost. In August of 2005, the author was promoted to a senior squad leader position in Bridge Design. The BMP Engineer position was filled and work continued on apace for FY 2006.

Two large bridge repair projects with two bridges each went out to consultants in FY 2006, this with the disruption inherent with supervisory changes (the BME and the Bridge Inspection Engineer positions also had changes in personnel that summer) saw some minor disruption in the smooth operation of the squad. PE costs for FY 2006 increased to 3.15 percent of construction costs.

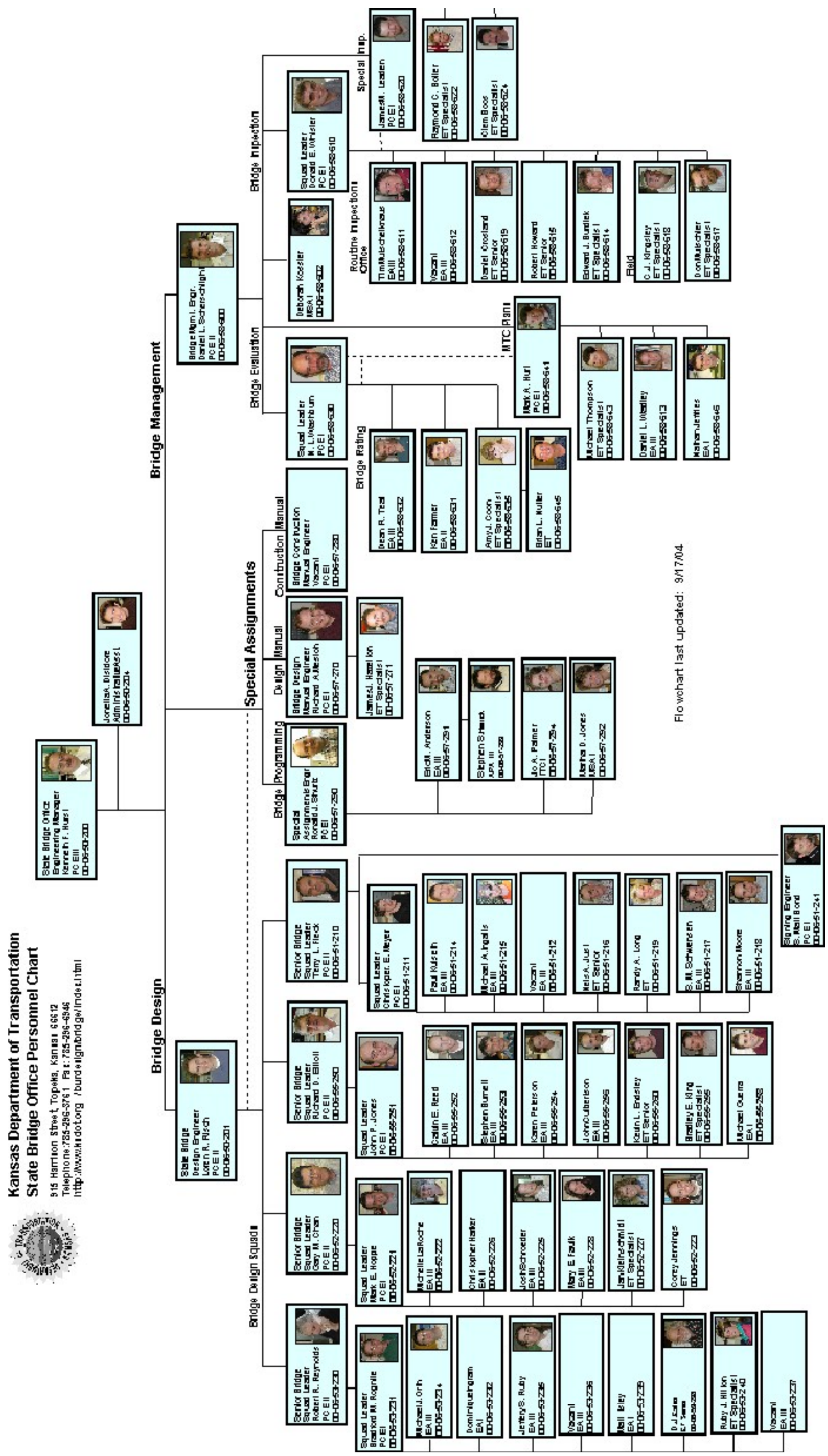


Figure 4.1—Bridge Office organizational chart from 2004.

4.2 Squad Management from 2006-present

In the summer of 2006, the BMP Engineer accepted a squad leader position in Bridge Design, leaving the position open. Just prior to this, one of the engineering associates took a field position in a construction office. Without any suitable internal or external candidates, the BMP Engineer position remained open for several weeks. As a remedy, the BMP squad was moved out of the Bridge Management section into the Bridge Design section under the author's supervision.

The move was intended to not only fill in the vacancy in supervision, but to allow for the resources of personnel and experience found in the author's Bridge Design squad to be available to the BMP squad. In the fall of 2006, the BMP Engineer position was filled by a bridge designer who had wished to return to the Bridge Office after a hiatus in the private sector with a consulting engineering firm.

In 2007, an engineering associate transferred into the BMP squad. Unlike prior engineering associates in the squad, he spent much less time with inspection duties. In 2009 he left for a consultant. The engineering associate who replaced him had a mix of inspection and design duties similar to previous engineers in the position.

During this period, the amount of PE charged as a percentage of construction did not return to the rate of 2 percent and less, but went up to 3 percent in FY 2008. For the next three fiscal years the PE percentages for Bridge Substantial Maintenance work (in terms of construction costs) were 3.2 percent in FY 2009, 2.9 percent in FY 2010 and 2.7 percent in FY 2011.

In winter of 2009, the BMP Engineer was promoted to a new position created to track performance measures. Within a few months, reorganizations occurred that transformed that position into the BME. A new BMP Engineer was hired internally. In 2011, one of the engineering associates was promoted to a position in Bridge Inspection. In 2012, the remaining engineering associate transferred to Bridge Design. Hiring freezes have prevented either of the positions from being filled to date. The current structure of the squad is back to the BMP Engineer and an engineering technician, both directly supervised by the author within his Bridge Design squad. The latest organizational chart is shown in Figure 4.2, note that the engineering associate shown in the BMP squad has moved to the Bridge Design portion of the author's work unit.

Though the staff has been reduced, the amount of work handled by the squad has not. For each year, other than FY 2010, the amount of work programmed for Bridge Substantial Maintenance has been approximately $15 million. For FY 2010, substantial maintenance accounts were zeroed out due to the budgetary constraints. Work programmed in previous fiscal years was delayed to FY 2010, and some substantial maintenance work was funded through the American Recovery and Reinvestment Act of 2009 (ARRA). With the reduction in staff and the loss of experience, more of the work recently has had to be let out to consulting engineering firms. For FY 2013, 16 projects will have plan sheets produced by the BMP squad and six will be let to consultants.

Figure 4.2—Bridge Office organizational chart from 2012.

4.3 Efficiency

Engineering costs for the review, design and plan production for a project are tracked as PE. PE costs are typically estimated when programming a new project as a percentage of the estimated construction costs. Different types of projects have differing average PE rates. For example, the rate for major modification highway projects for KDOT typically averages around 8 percent.

To determine whether the engineering design and plan production for bridge substantial maintenance projects have become more efficient with the implementation of the BMP squad, the costs of Preliminary Engineering as a percent of construction cost were obtained for these projects from 1993 to 2010 (see Table 4.1). Reviewing engineering costs as a percentage of construction cost has the benefit of inherently accounting for inflation costs. However, improvements in software and bridge design practices might also be expected to reduce, or possibly increase, engineering costs across the board over time. To allow a comparison of changes in Bridge Substantial Maintenance PE rates against changes in PE rates due to changes in design practice, the PE rates for bridge replacement projects were also obtained. The bridge replacement projects were project funded through the program category formally known as Priority Bridge Replacement. The scopes of these projects are predominantly bridge work, as opposed to a major modification project with might have several miles of grading and pavement reconstruction and some bridge work.

	Bridge Substantial Maintenance			Bridge Replacement (Priority Bridge Funds)		
FY	***PE***	***CE***	***Const***	***PE***	***CE***	***Const***
1993	3.10%	14.90%	$4,491,929	14.10%	11.30%	$12,684,002
1994	2.80%	11.90%	$5,963,432	14.50%	7.90%	$36,087,095
1995	2.40%	10.40%	$7,134,911	14.60%	10.10%	$10,382,413
1996	4.60%	11.60%	$6,954,204	15.40%	9.20%	$10,075,906
1997	2.90%	11.20%	$9,569,337	18.60%	8.00%	$16,037,271
1998	3.10%	13.50%	$11,273,198	10.20%	6.50%	$19,338,889
1999	3.10%	9.40%	$11,769,993	9.80%	9.30%	$28,872,848
2000	2.60%	11.30%	$11,915,820	7.30%	5.80%	$51,980,668
2001	4.30%	12.70%	$8,163,840	16.30%	7.60%	$35,902,551
2002	1.60%	13.90%	$4,246,440	11.40%	8.20%	$40,864,330
2003	1.30%	11.00%	$9,671,923	12.90%	8.70%	$48,250,753
2004	0.80%	10.90%	$13,278,708	17.60%	8.60%	$40,199,339
2005	2.70%	8.00%	$20,856,790	12.90%	10.30%	$38,248,403
2006	3.20%	9.70%	$11,437,888	11.90%	6.10%	$22,531,036
2007	1.30%	5.10%	$22,529,717	13.60%	8.80%	$19,730,180
2008	3.00%	9.50%	$11,184,962	14.60%	7.30%	$1,808,571
2009	3.20%	10.20%	$9,351,850	No projects let this FY		
2010	2.90%	9.00%	$5,933,929	19.30%	7.00%	$3,998,825

Table 4.1—Preliminary and Construction Engineering as a percentage of construction costs.

Plotting the PE percentages, although there is considerable scatter, a slight upward trend is noted for bridge replacement projects, while a slight downward trend is noticed for Bridge Substantial Maintenance projects .

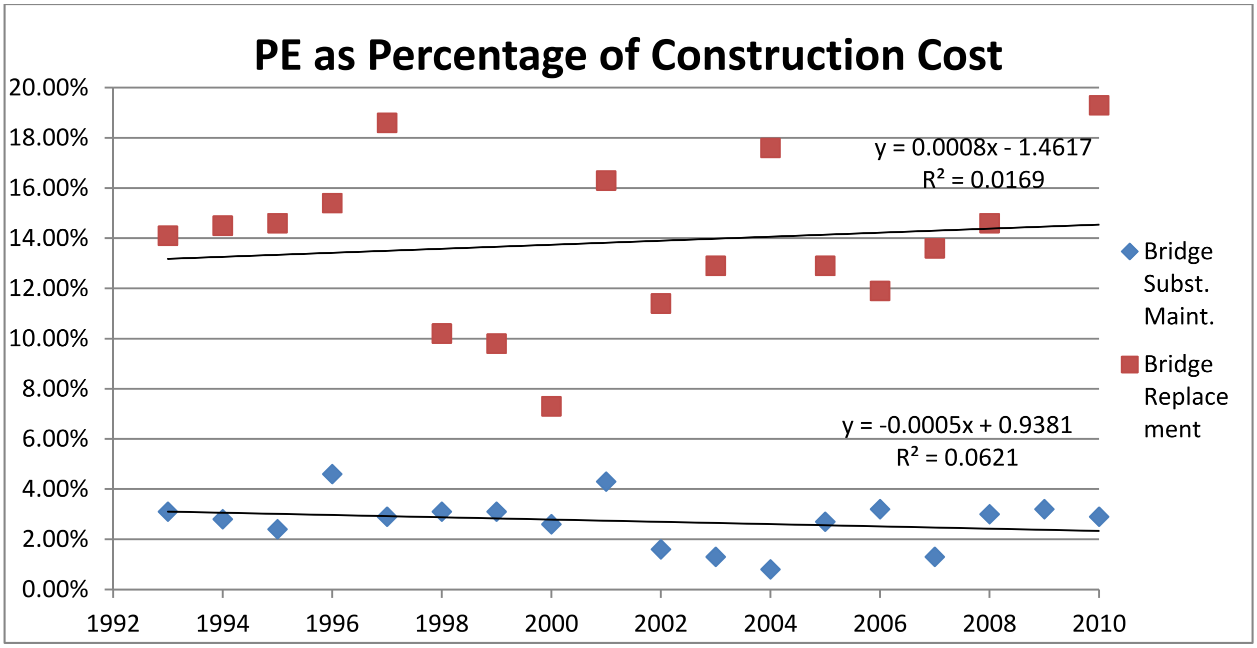


Figure 4.3—Preliminary Engineering as a percent of construction for FY 1993 – 2010.

Much of the scatter in the annual numbers for bridge replacements projects is due to the length of design time required for replacement projects. Bridge replacements designs will take several months and may be substantially complete months before the project is let. When the amount of bridge construction remains relatively constant from year to year, the delay between design and letting even out in the analysis. But as seen in the Figure 4.3, at the end of the CHP, design work for new project slows while bridges designed in the previous FYs were being let. This lag results in a low coefficient of determination, R^2, however the plot of PE for bridge replacement projects is still useful to show that values remain around 14 percent as an average over the long term.

To test for serial correlation errors common to time series data, Durbin-Watson statistics were calculated for PE over the FY 1993-2010 periods reviewed. For PE for Bridge Substantial Maintenance projects d = 1.90, while for bridge replacement projects d = 1.97, given that the statistic was very near 2.0 serial correlation of the residuals is not an issue for these data.

The plot of the PE for the substantial maintenance work is tighter. Projects are on a shorter schedule and PE usually occurs in the same year as the project is let. Though a simple linear regression shows a downward trend, reviewing the values at the beginning and end appear to average a similar 3percent. What appear to pull the trendline down are the low PE rates in FY 2002 – 2004. The PE percentage went back to approximately 3 percent as disruption in the BMP squad required the greater use of consultants.

To understand why the use of consultants would be more expensive than in-house engineer (beyond inherent efficiencies such as access to existing bridge information) the compensation mechanism for consulting engineer should be understood. Proposals for engineering services for state highway agencies are typically evaluated in terms of hours. Currently, the KDOT Bridge Office would expect bridge design and plan production for a fairly common three-to four-span steel rolled beam bridge to take approximately 1,400 man-hours. For projects involving federal aid money state departments of transportations are required by the Brooks Act (40 USC 11) to make rankings for the award of engineering contract during the bidding process on the basis of qualification. A fair and reasonable price consistent with market rates may be negotiated, but selection may not be made on the basis of price quotation.

With limited downward pressure on the market for engineering design services for DOT's, consultant costs have grown faster than the rate of inflation during the life of the Bridge Maintenance Plans squad. At the beginning of the squad in 1999 (FY 2000), the contract rate for an experienced design project manager at a consulting firm might be expected to be $31 per hour, with an overhead at an added 150 percent and a profit of 15 percent. An hour of the project manager's time would be: [$31 + (1.5 x $31)] x 1.15 = $89.13. Currently, in FY 2013, a design project manager rate would more typically be $45 per hour and the added overhead for the larger firms is approximately 190 percent, resulting in a rate to the state of $150.08. This resulted in an increase of 68 percent over the same 13 year period that inflation for construction materials has been assumed by KDOT to increase 58 percent. The same number of hours for a consultant on the same scope of construction will cost more.

A review of the project scopes through the fiscal years of the CTP show a similar mix for each year's program. The low PE cost (compared to construction dollars let) of the FY 2002 -2004 period occurred during a period of full staffing and minimal consultant usage. Staffing was typically by four positions: a supervisory engineer and technician dedicated full time to the squad's work, and two engineers who shared duties with inspection. One other characteristic distinguished the organization of the squad in this period from its organization subsequently, the location of the squad in Bridge Management under the fund manager for the program.

Part of the impetus for the formation of the squad in 1999 was to bring the design function under the supervision of the fund manager, the BME, to provide for consistency in designs and scope across the project in the program. Within a couple of program cycles, it became apparent that having design expertise working directly with program administration allowed for the better scoping of projects. The ongoing experience with repair methods being let provided feedback as to what was working to the decision maker in the project programming process.

The only reason the organization of the squad within the larger office was changed was to compensate for the scarcity of engineering expertise. The scarcity led (and still leads) to competent engineers moving through positions quickly, leaving important design production positions filled with relatively inexperienced engineers.

4.4 Effectiveness

Though PE can run into the tens of thousands of dollars for a bridge substantial maintenance project, it is still a small percentage of total project cost. More savings might potentially be found in ensuring that projects are designed appropriately and that plans are complete and clearly communicate intent.

A number of measures were investigated to determine if a tracked measure might indicate whether plans were being provided that effectively supported construction. It would be expected that projects with quality plans and details would have few change orders and few overruns. However, it was found that the reasons for change orders vary greatly and that the predominate cause was the preference of either the field engineer or the contractor as to a construction means or method, rather than a deficiency in the plan details or original scope. Often overruns on bridge maintenance projects were often due to changes to accommodate updating signing or other roadside appurtenances while there was a contractor at the location.

It was determined that the most reliable available measure of how well a project went which was common to all projects was the CE cost. CE includes the activities of inspection and contract administration for a project from the time after it is let until it is accepted and closed out. Change orders, disagreement between the contractor and the field engineer as regard to scope or the meaning of plan details, plan quantity errors—all of these result in more time spent in the Construction Engineering process.

Similar to PE, the average CE percentage, in respect to construction cost, varies per type of project. The CE percentages for KDOT major modification projects have averaged around 7.5 percent over the years.

As with the review of PE costs in the previous section, CE costs as a percentage of construction costs were obtained over the years 1993 through 2010 for Bridge Substantial Maintenance projects and, as a comparison, for bridge replacement projects. The fiscal year averages may be found in Table 4.1 with the Preliminary Engineering percentages. Plotting the years 1993 through 2010 in Figure 4.4 shows that CE percentages have decrease over the years for both types of projects.

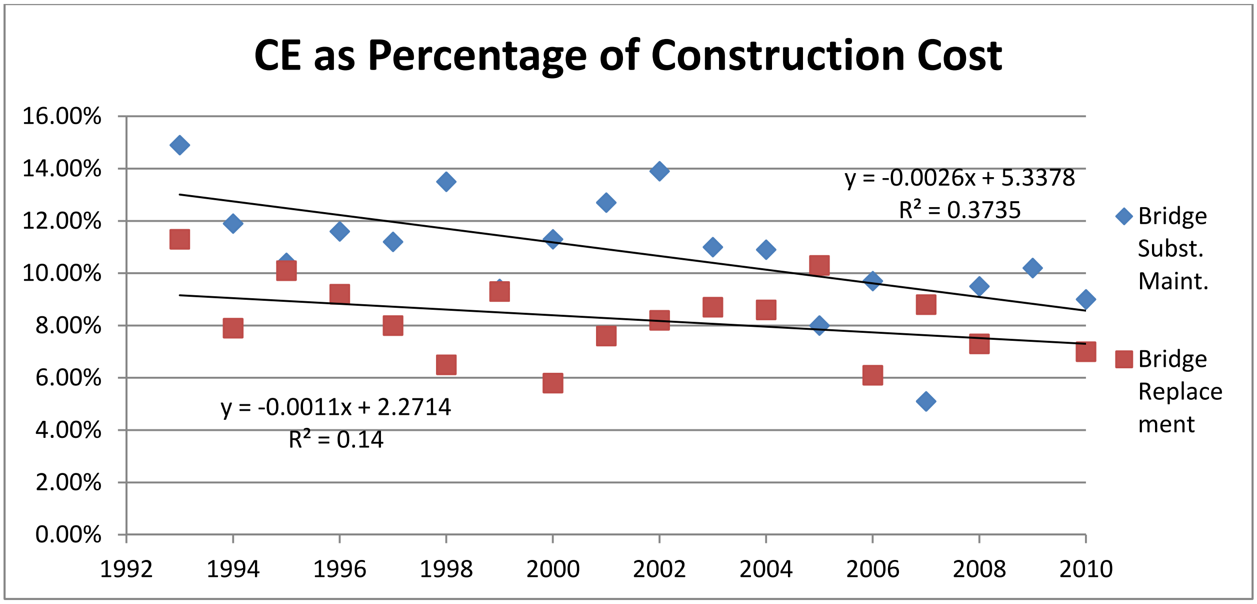


Figure 4.4—Construction Engineering as a percent of construction for FY 1993 – 2010.

Bridge repair projects have traditionally had higher CE percentages due to the complexity of details and the need for inspection inherent in accommodating existing structure details and conditions. The old adage that it is easier to build something new than to work on something old is founded in truth. But the trend has been, particularly since FY 2002, for the Construction Engineering on repair projects to converge with that for replacement projects. Looking at the percentage since the inception of the CTP, and the squad, highlights that drop.

To test for serial correlation errors common to time series data, Durbin-Watson statistics were calculated for CE over the FY 1993-2010 periods reviewed. For CE for Bridge Substantial Maintenance projects d = 1.57, while for bridge replacement projects d = 2.19, given that the statistic was near 2.0 serial correlation of the residuals is not an issue for these data.

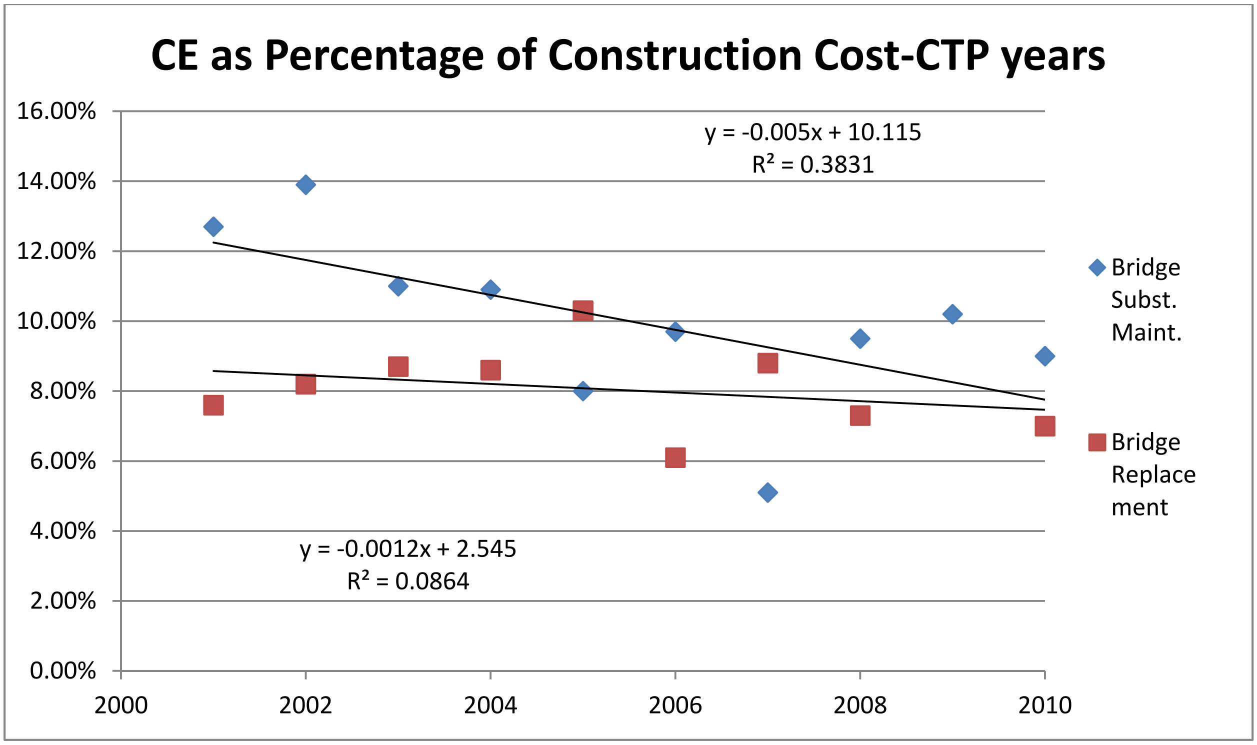


Figure 4.5—Construction Engineering as a percent of construction for FY 2001 – 2010.

Since the percentage of CE for typical bridge replacements has remained relatively steady through this time period and that inspection and administration practices have remained consistent overall, it is reasonable to speculate that drop in CE may be tied to the institution of the BMP squad. Throughout its tenure the squad has standardized and refined (due to construction feedback) common substantial maintenance scopes. Consistent details and design approaches have also led to consistent expectations by highway contractors bidding on the work.

A drop in average CE cost as a percentage of construction from 13 percent to 8 percent leads to a savings of $750,000 a year for an average annual letting of $15 million for bridge substantial maintenance construction.

4.5 Organizational Analysis-Reliability

Efficiency in operation and effectiveness in results are important to any organization. But given the severity of the consequence of failure, or even mismanagement, of the operation of a state's highway bridge inventory, a reviewer should also be concerned as to whether the organization charged with that operation is reliable. Does the organization minimize failure, while dealing with challenges to its operation?

In 2001, Karl Weick and Kathleen Sutcliffe published a study, *Managing the Unexpected*, of what they termed to be High Reliability Organizations (HRO) (19). They studied the organization of, and processes employed by air traffic controllers, nuclear aircraft carriers, nuclear power plants, hospital emergency rooms and others to determine how they operate under difficult circumstances with a minimum of accidents and failures. It was determined that HRO's share five characteristics:

- Preoccupation with failure;
- Reluctance to simplify interpretations;
- Sensitivity to operations;
- Commitment to resilience; and
- Deference to expertise.

HROs do not deny or minimize failures, especially the small ones. The history of modern bridge inspection in the United States is defined by the study of, and responses to bridge failures. Within KDOT, the notes and specifications that are a part of any plan set are a miniature history of construction issues and troubles in that they were written in large part to prevent a second occurrence of problems. In the BMP squad, part of the continual improvement of the plan process that contributed to the reduction in CE over the years has been a review of how repairs have held up over the years and how well the construction project went.

A reluctance to simplify infers that an organization appreciates complete and nuanced pictures of the situations that they encounter. A sensitivity to operations implies that an organization pays attention to what happens on its front lines. To be committed to resilience is to recover from failure. The work of the BMP squad with bridge inspectors has meant that its designers are keenly aware of the conditions faced on bridges and the KDOT forces that have to maintain them. They have seen firsthand how repairs have held up over seasons. When less than desired outcomes have been discovered, the issues have been noted and the subsequent designs or the ways of doing business have been adjusted.

A common mistake in organizations is to locate decision making authority for operational matters without regard to expertise. With the location of BMP squad near the Bridge Substantial Maintenance fund manager, decisions as to project matters and program choices could be informed by the ongoing experience of the BME.

In 2004, the author performed an audit of the BMP squad using nine sets of questions found in the Weick and Sutcliffe text (19) (these questions are reproduced in Appendix E of this report). Among the squad members and associates interviewed, the survey results were similar and consistent. The average scores are shown below. The possible range of scores and their suggested interpretation are discussed in Appendix E.

Exhibit	Subject	Score	Comment
4.1	Starting Point—Mindfulness Infrastructure	16	Currently building a Mindful Infrastructure.
4.2	Vulnerability to Mindlessness	20	Moderate Potential for Mindlessness.
4.3	Tendency for Doubt and Inquiring	7:2 (disagree:agree)	Greater tendency to doubt and inquire.
4.4	Requirement for Mindfulness	5:4 (disagree:agree)	Slight tendency to be complex and coupled.
4.5	Preoccupation with Failure	21	Healthy preoccupation with failure.
4.6	Reluctance to Simplify	27	Strong potential to avoid simplification.
4.7	Sensitivity to Operations	3:5 (disagree:agree)	Greater capacity to be sensitive to operations.
4.8	Commitment to Resilience	27	Strong commitment to resilience.
4.9	Deference to Expertise	21	Strong deference to expertise.

Table 4.2—Scores from Weick and Sutcliffe audit.

The scores indicated that the squad was operating in good shape as a reliable and resilient organization. This is something that the BMP squad has held out over the past few years.

The squad has been presented with significant emergency situations, including bearing replacements on the two girder units of the Lewis and Clark Viaduct conducted while I-70 eastbound traffic in Kansas City was being carried. Failure costs for that project would have been severe.

It has had to administer scopes of work that have fallen outside of the typical work of other units, including pedestrian bridges and bridge removal, demonstrating the ability to focus on the mission rather than remaining with what is comfortable as an organization. And it has had to deal with loss of personnel and experience, even changing its place in the organization structure to adapt.

4.6 Discussion

While PE costs (as a percentage of construction costs) for bridge replacement projects has been scattered over the past couple of decades, the mean has been a steady 14 percent. For Bridge Substantial Maintenance projects, the scatter has been less but has also remained around a steady mean of three percent, however for a three year period corresponding to the initial organization of the BMP squad, PE dropped to approximately one percent of construction costs for Bridge Substantial Maintenance projects. After reorganization into a larger Bridge Design squad, the PE costs returned to their historic levels of around 3 percent.

CE has a percentage of construction costs has dropped over the past couple of decades for all bridge projects, but more so for Bridge Substantial Maintenance projects. The drop has been particularly pronounced since the formation of the BMP squad, in this period dropping from 12 percent to 8 percent to nearly match the CE cost for bridge replacement projects.

As an engineering design group, the BMP squad appears to be as at least as efficient as the previous practice of assigning a Bridge Design squad and/or a consulting engineer to produce plans. When operating in close cooperation with the BME and Bridge Inspection, as was the original organization, it appears to have been more efficient. Even when changes to the larger organization due to loss of engineering experience forced a reorganization of the BMP squad, the effectiveness of providing complete and appropriate design plans and engineering support appeared to have been maintained as evidenced by the continuing drop in CE cost corresponding to the operation of the BMP squad.

The ability of the BMP to maintain progress in increasing the effectiveness of its plan production and engineering support has shown it to be a resilient organization. Concurrence for this has been provided through an organizational audit of squad members and associates.

4.7 Chapter Summary

- In the initial six year period after the institution of the BMP squad, PE costs measured as a percentage of construction costs for Bridge Substantial Maintenance projects dropped from its historic 3 percent to 1.5 percent.
- Throughout the life of the BMP squad, CE costs measured as a percentage of construction costs for Bridge Substantial Maintenance projects dropped steadily and faster than for bridge replacement projects.
- As an organization, the BMP squad has been resilient has measured by an organization survey and as demonstrated by functioning through reorganization due to external forces.

Chapter 5—Bridge Maintenance Practices in Other States

The bridge maintenance practices of four peer states are reviewed in this chapter, including that of a significantly more populous state, Illinois. The annual spending of each state on bridge maintenance is compared. Characteristics of each state's operation are discussed.

5.1 Introduction

All states face the challenge of maintaining an inventory of bridges on their state's highway system with limited resources. In order to examine how neighboring states do this, interviews were conducted with engineers from four states. These took place in the form of email correspondence and telephone conversations throughout the months of August and September 2012 and by interviews at the Midwest Bridge Preservation Partnership 2012 annual meeting in Council Bluffs, Iowa on Oct 16, 2012. The partnership is a forum of local, state and federal agencies, academia, contractors and the American Association of State Highway and Transportation Officials (AASHTO), which convenes annually to discuss bridge preservation, maintenance and management strategies.

5.2 Iowa

The contact for discussions with the Iowa Department of Transportation was Gary Novey, P.E. Assistant Bridge Engineer.

The Iowa DOT is responsible for inspection and maintenance of bridges on their state system, referred to as the Primary Highway system (Interstate, US and State highways). The inventory consists of 4,092 bridges.

Funding for construction and maintenance projects is currently administered through a five-year Transportation Improvement Program. Bridge replacements are funded out of a Bridge Reserve fund of $40 million. In FY 2012 this included $5.8 million for large bridge deck overlay projects. Smaller projects are selected out of Maintenance Bridge funds which were $2.3 million in 2012. These funds are set to be increased to $5.5 million in FY 2013 and to $9 million in FY 2014.

The Bridge office is divided into two sections: Design and Maintenance & Inspection. There are 36 positions in the Maintenance & Inspection (BMI) section under the direction of the Maintenance Bridge Engineer. The section's organizational chart is shown below. The BMI section inspects and load rates bridges on the Primary Highway system and is responsible of oversight of these activities by other agencies on the local highway system. The section is responsible for coordinating with the six districts in Iowa in the selection of bridge repair and rehabilitation projects.

There is no dedicated squad to design and administer bridge substantial maintenance; however, the Bridge Preservation Engineer is the person responsible for working with the districts to identify bridge repair, rehabilitation and replacement candidates. This position (added in 2009) also develops concepts and procedures for fatigue repair, joint repair and other bridge maintenance specific design work. The Bridge Preservation Engineer develops plans for in-house district repair crews. The position is involved in bridge inspections, both conducting inspections and reviewing inspections.

The Bridge Preservation Engineer has many similarities to the BMP Engineer position at KDOT. The position assists in selection of bridge maintenance project and is responsible for being the engineering expert in that type of work; however, it does not develop or administer contract repair plans.

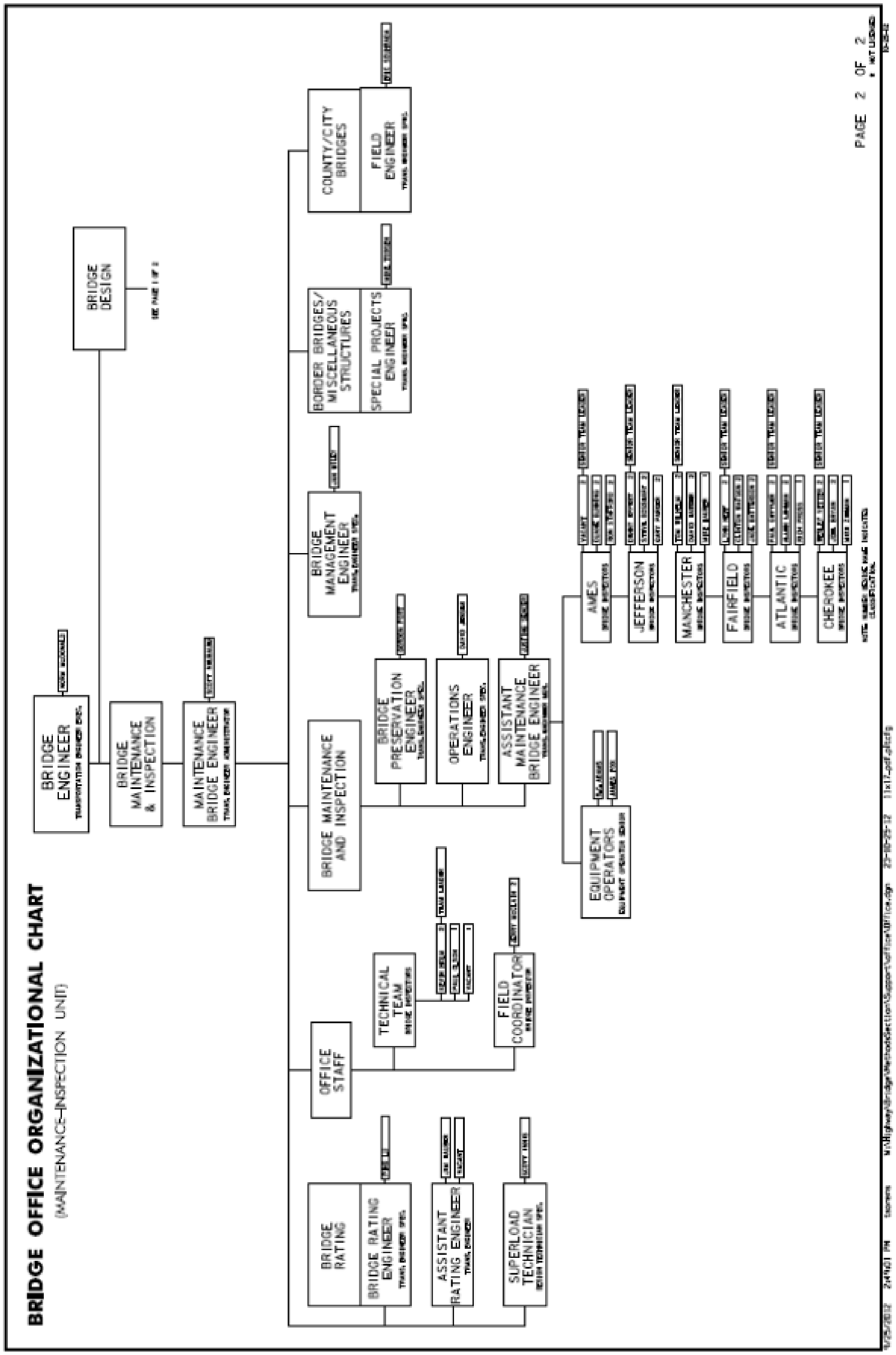


Figure 5.1—Iowa DOT bridge maintenance and inspection organization chart 2012.

5.3 Missouri

The contact for discussions with the Missouri Department of Transportation (MoDOT) was Scott Stotlemeyer, P.E. Assistant State Bridge Engineer.

MoDOT is responsible for the inspection and maintenance of bridges on the state system; however, a larger percentage of the total inventory of public roads in Missouri is under the state system than in Kansas. Approximately 33,600 of the total 130,300 miles of public roads are on Missouri's state highway system as opposed to 9,500 of the total 145,700 highway miles in Kansas. Approximately 25,600 miles of Missouri's system is classified as Supplementary as opposed to Interstate or Primary (18). There are 7,255 span bridges on Missouri's state system.

Budgeting for construction and maintenance projects is administered through its five-year State Transportation Improvement Program (STIP). The STIP is updated annually. There is no dedicated budget fund specifically for bridge maintenance, or even solely for new bridge projects

In FY 2011 MoDOT spent $7.7 million on bridge maintenance, including substantial maintenance and $3.6 million on bridge preservation. Bridge maintenance and construction projects are selected at the district level for consideration in the STIP. The headquarters bridge design staff in Jefferson City is responsible for all structural design.

Four years ago, the position of Bridge Maintenance Engineer was decommissioned with the retirement of Carl Calahan. Unlike positions of similar titles at KDOT and the other DOT's interviewed, this position had a significant in-house bridge repair crew which handled repairs throughout the state, mostly on the Supplementary (secondary road) system. The crew was capable of work including structural steel repairs, concrete repairs and overcoat painting.

There is a District Bridge Engineer in each of the districts who is responsible in coordinating bridge matters such as routine maintenance. Bridge inspections are conducted by headquarters staff. Bridge designers do not have an administrative role in bridge maintenance work at MoDOT.

5.4 Nebraska

The contact for discussions with the Nebraska Department of Roads (NDOR) was Chad Packard, P.E. Assistant Bridge Engineer for Bridge Design and Special Projects.

NDOR is responsible for inspection and maintenance of the 3,500 bridges on its state system. It has an annual bridge budget of $30 million, from which bridge maintenance is drawn.

Substantial maintenance projects for bridges are selected annually by headquarters bridge staff with input from the districts. There is no Bridge Maintenance Engineer position. These tasks are divided throughout the bridge office staff. Bridge design staff prepares any plans with structural work.

Although there is no particular group charged solely with bridge repair and rehabilitation work, the current focus of the organization has been for the last three years to emphasize rehabilitation over replacement.

5.5 Illinois

The contact for discussions with the Illinois Department of Transportation (IDOT) was Tim Armbrecht, P.E., S.E. Acting Engineer of Structural Services

IDOT is responsible for inspection and maintenance of the approximately 8,000 bridges on its state system. Construction projects are selected by the districts, with larger projects as part of a six year planning cycle, while small ones are selected annually.

Last year, the state's contract bridge maintenance budget was approximately $12 million and the budget for day labor projects was $3.5 million.

Districts have their own maintenance funds for all general maintenance, including bridges, if necessary. Although administration of bridge maintenance projects occurs primarily at the field level, with project selection by district maintenance engineers, the engineering is centralized at headquarters.

For the past 25 years, there has been a Repair Unit, currently headed by Victor Veliz, S.E. The unit prepares bridge repair and substantial maintenance plans. It consists of six engineers and three technicians. District staff may handle plan production for more routine bridge maintenance, such as overlay only, which may be dealt with by standard plans; however, the Repair Unit reviews all bridge repair plans before letting. There are approximately 200 to 300 plans per year. The unit may distribute some work to consulting firms, depending on work load.

Bridge rehabilitation projects (i.e. deck or superstructure replacements) are dealt with separately from substantial maintenance and are handled by a separate group in the bridge design office.

Due to the system of contract state work in Illinois, to let a bridge repair projects may take six months of lead time. When quicker action is needed, sometimes sealed bids from solicited contractor are taken. There is a similar process in Kansas, which may be reviewed by the Department of Administration; however, in Illinois, this process requires special permission. The more common procedure for quick response projects is the use of day labor. Day labor jobs have an IDOT foreman and assistant, who bring IDOT equipment to a bridge site and contract for laborer and tradesmen from the local union hall. Day labor is a form of project delivery mentioned in the earliest biennial Kansas Highway Commission reports, but was unfamiliar to any KDOT personnel interviewed by the author.

5.6 Findings

Although Kansas has the fourth largest number of bridges on public roads of the states in the United States (Illinois, interviewed for this report is the third largest); it is in the middle of neighboring states interviewed in regard to the number of bridges on its state highway system. Its approximately 5,000 bridges put it between Iowa's 4,100 and Missouri's over 7,000. This is a legacy from the founding of the state of Kansas when the numbers of state system highway miles were limited to 6,000 out of 111,000 public road miles. Kansas Statute 68-406 currently limits the number of state highway miles to 10,000.

However, Kansas spends the most on bridge maintenance, having programmed $21 million in substantial maintenance work for its state bridges in FY 2011 as compared to next largest spender, Illinois, at $15.5 million. State spending on bridge maintenance (as reported by the interviewees) and bridge inventory sizes are shown in Table 5.1.

	Illinois	**Iowa**	**Kansas**	**Missouri**	**Nebraska**
Approximate Number of State Maintained Bridges	8,000	4,100	5,000	7.300	3,500
Annual Spending on Bridge Maintenance (in millions for FY 2011 or 2012)	$15.5	$8.1	$21	$10.6	Not defined
Is there a dedicated group for the design of bridge maintenance plans?	Yes	No	Yes	No	No
Is there a dedicated group or individual position for the administration of bridge maintenance work?	No	Yes	Yes	No	No

Table 5.1—Spending on bridge maintenance and inventory size.

All of the states interviewed value substantial maintenance efforts as a cost effective means to maintain bridge operations. Nationally, there has been a push by the FHWA to promote bridge preservation as part of an overall asset management initiative. The *2008 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) Technical Corrections Act*, placed a greater emphasis on the importance of proper, timely bridge preservation. Funding rules changed to allow Highway Bridge Program funds to be used for replacement, rehabilitation, and preventive maintenance highway bridge projects (21). The addition of the Bridge Preservation Engineer position in Iowa in 2009 and the refocusing of Nebraska's bridge efforts onto rehabilitation, reflect this national trend.

Consolidation of bridge maintenance plan production into a specialized squad in Illinois is similar in practice to Kansas, although the same squad in Kansas has traditionally produced rehabilitation plans, as well. The other three states maintain plan production responsibilities in their bridge design sections.

Iowa's Bridge Preservation Engineer position joins substantial maintenance project selection responsibilities with expertise in the design of bridge maintenance work into a single point of contact, similar to Kansas. Nebraska selects substantial maintenance projects in its bridge office. Missouri and Illinois select maintenance projects in the district offices.

Although each of the states interviewed recognized the importance of substantial maintenance in maintaining the operation of their bridge inventories, none had placed the emphasis on these projects that Kansas has for the past several years.

5.7 Chapter Summary

- Kansas has placed more resources into bridge maintenance than have surrounding states.
- The combination of administrative and engineering support for bridge maintenance activities into a central engineering squad is unique in the region to Kansas.
- Illinois has maintained an engineering squad for centralized design of bridge maintenance projects for 25 years.
- Within the past four years, Iowa has added the position of Bridge Preservation Engineer to help centrally select and scope bridge repair projects.

Chapter 6—Bridge Life Cycle Costing of FY 2003 Bridge Substantial Maintenance Projects

The costs to KDOT of maintaining bridges in operation is reviewed by conducting a Bridge Life Cycle Cost analysis on bridges which had maintenance projects in FY 2003. The significant costs of Bridge Substantial Maintenance work is noted by reviewing the cost of $1,000,000+ projects in this funding category for FY 2011 and FY 2012. The methodology of Bridge Life Cycle Cost analysis is explained. This analysis requires establishing an alternate paradigm of work for comparison that provides the same minimal benefit. For the analysis, an alternate maintenance paradigm of minimum maintenance is defined as maintaining bridges with KDOT forces sufficiently to prevent closing access to Overweight truck traffic.

Deterioration rates for bridge elements are determined from a review of the literature and comparison to KDOT's experience. Maintenance activities and costs are determined by review of the 10-year history since the FY 2003 maintenance projects for these bridges and by interviews with KDOT Metro Engineers as to their standard field maintenance practices. A 20-year review period is chosen to capture a round of major maintenance work for each bridge in the review. The sensitivity of the analysis to discount rates for the future 10-years in the review period is examined by conducting the analysis for three different rates.

6.1 Impetus

As discussed throughout this report, the operation of bridges imposes significant costs on the agency responsible for the inventory. The initial project costs for constructing new bridges run from hundreds of thousands into tens of millions of dollars. Traffic is impacted by initial construction for periods of time extending from a minimum of a few months to years. Once constructed, every bridge will require routine and substantial maintenance to fulfill its service life.

Though usually less than initial construction, costs for the substantial maintenance bridge projects can be significant. Such costs routinely run from the tens of thousands into the millions of dollars. In Table 6.1 below, the range and magnitude of substantial maintenance expenditures is illustrated by showing the construction bid item cost of the least expensive project and of projects over $1 million, let in FY 2011 and FY 2012 by KDOT for work on the State Highway System. Because of this range of project costs, significant savings on a few larger projects can be used to fund multiple smaller projects.

FY 2011 Least Cost	*County*	*Location/Description*	*Scope*	*Cost*
KA-1311-01	Osborne	US-24, Bridge #45, 0.5 Mi N of North Fork Solomon River	Deck patching and Polymer Concrete Overlay	$31,675.50
FY2011 Over $1,000,000				
KA-1621-01	Sedgwick	Bridge #006, 007, 015 and 016 on I-135	Deck patching and Polymer concrete overlay, Repair expansion joints	$1,669,605.76
KA-1625-01	Sedgwick	Bridge #317 located 0.25 Miles East of Topeka Avenue	Deck patching, Silica Fume Overlay, Abutment repairs	$1,731,858.73
KA-1294-01	Wyandotte	Bridges #243 & #244	Expansion device replacement	$3,206,374.33
KA-1507-01	Leavenworth	Bridge #26, K-92 over the Missouri River	Pier and bearing repair, Deck drainage	$3,257,256.71
FY 2012 Least Cost				
KA-2228-01	Osage	Bridge #36	Expansion joint repair	$16,700.00
FY2012 Over $1,000,000				
KA-2232-01	Wyandotte	Bridge #234	Deck patching and Silica overlay, Expansion joint replacement, Painting	$1,078,513.97
KA-2256-01	Wyandotte	Bridges #238 and #239, I-70	Deck patching and Silica overlay, Expansion joint replacement, Painting	$1,110,386.56
KA-2231-01	Wyandotte	Bridges #198 and #199	Deck patching and Silica overlay, Expansion joint replacement	$1,112,551.91
KA-2726-01	Shawnee	Bridge #233, K-4	Deck patching and Polymer concrete overlay	$1,527,639.30
KA-1555-01	Wyandotte	Bridge #166, I-635 over the Missouri River	Deck repair—Funds provided to MoDOT	$1,599,999.87
KA-2258-01	Johnson	Bridge #230 on I-435	Abutment repair, Deck patching and Silica fume overlay	$1,667,129.03
KA-2230-01	Wyandotte	Bridge #258	Structural steel repair, Expansion joints, Deck patching and Polymer concrete overlay	$1,978,901.73

Table 6.1—Low and high cost substantial maintenance bridge projects in FY 2011 and 2012.

Bridge construction and substantial maintenance represent a significant portion of the each year's budget of state transportation agencies. For KDOT, projects for new or replacement bridges constituted $35.7 million out of the $320 million core T-Works programs for FY 2011 and $53.0 million out of the $266 million for FY 2012. Substantial maintenance projects were programmed for 71 bridges in FY 2011 at a cost of $22.6 million and for 89 bridges in FY 2012 at a cost of $23.1 million.

Declining budgets, increasing demand on highway infrastructure due to rising traffic counts and trucks weights, and the importance of a viable highway network to the Kansas economy requires KDOT to make the most efficient use of funds. For the inventory of bridges, since costs are incurred throughout the life of a bridge, maximizing the value of dollars spent on bridges requires more than minimizing their initial construction cost. To make efficient use of funds, an agency needs to both consider expenditures made throughout the life of a structure and to make decisions about what level of service in terms of load carrying and traffic volume capacities are required for bridges to fulfill their function.

This report focuses specifically on the work of KDOT's BMP squad, whose primary mission is to provide engineering and administrative support for Bridge Substantial Maintenance activities on the State Highway System of Kansas. Determining whether the work of the squad has been contributed to an efficient use of funds requires examining the impact of its expenditures over a period of time. A life cycle cost analysis examines funds expended in construction and reviews the actions done and funds spend later as a result of the initial projects. The methodology used in this report follows the guidance provided in NCHRP 12-43, *Bridge Life-Cycle Cost Analysis Guidance Manual* (8).

6.2 Bridge Life Cycle Costing Methodology

Life cycle cost analysis is a technique that allows comparisons between alternate scenarios that fulfill a given function and involves financial expenditures over a determined time period. Economic principles concerning the time value of money are used to compare cash flows made over a period of time in terms of equivalent base year dollars. Anticipated future expenditures are discounted to base year dollars on the basis of a presumed minimum rate of return. The equivalent base year dollars spent (or gained, though that is not the case typically in the analysis of expenditures on bridges) are summed over the study period and alternatives are compared.

This can be illustrated in a cash flow diagram as shown in Figure 6.1. The vertical lines represent expenditures whose magnitude (in base year dollars) is indicated by the y-axis scale. These expenditures take place at discrete times indicated by their location on the x-axis.

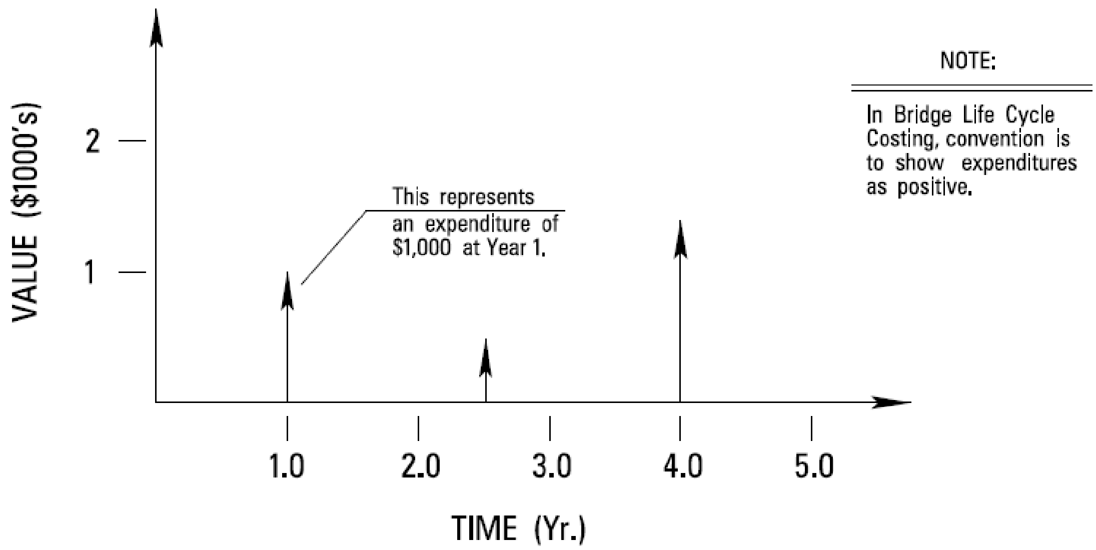


Figure 6.1—Example cash flow diagram.

In the National Council of Highway Research Projects Report 427 on *Bridge Life Cycle Cost Analysis*, such an analysis is characterized as a, "technique for considering the economic efficiency of expenditures." The report elaborates with "Given a certain set of requirements that a bridge must meet–e.g., traffic volumes to be carried, maximum vehicle loads, geotechnical and climate conditions–the lowest-cost set of actions meeting those requirements is preferable to other sets of actions" (8). The bridge life cycle scenario which provides required functionality for the least total base year dollars is the most efficient use of funds in this analysis.

Two key concepts to Bridge Life Cycle Cost Analysis (BLCCA) are *service life* and *life cycle*. The service life of a bridge is the period of time over which the bridge fulfills its function of carrying traffic. Service life extends from its opening soon after construction to the time that it is closed to traffic due to deterioration, obsolescence or relocation of the traffic route which it carries. A bridge may be considered obsolete when its original design is insufficient for current demands. The demands may be in regard to function, i.e. traffic volume, which has increased on most highways in the United States over time; or in regard to the structure, i.e. more load demand from heavier trucks.

The AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specification (22) presume a 75 year life for bridges, which is consistent with the literature on the deterioration rates of bridge elements discussed in Section 6.3 of this report. Not all of the elements of the bridge typically perform for the entire service life of the bridge without repair or rehabilitation. Various sources described in Section 6.3 place the expected service life of a concrete deck with uncoated, i.e. “black”, reinforcing steel at 38 to 45 years. Bridges require repair and rehabilitation to deteriorated elements in order to reach their full service life, which may be over the presumed 75 years. These activities of maintenance and repair over the service life constitute the life cycle of a bridge.

Figure 6.2 below illustrates the typical change in condition of elements (or of the entire bridge) over time. Elements start at an initial time in good condition, and then deteriorate to some level of condition that is not acceptable. The service life is the time it takes to reach an unacceptable condition.

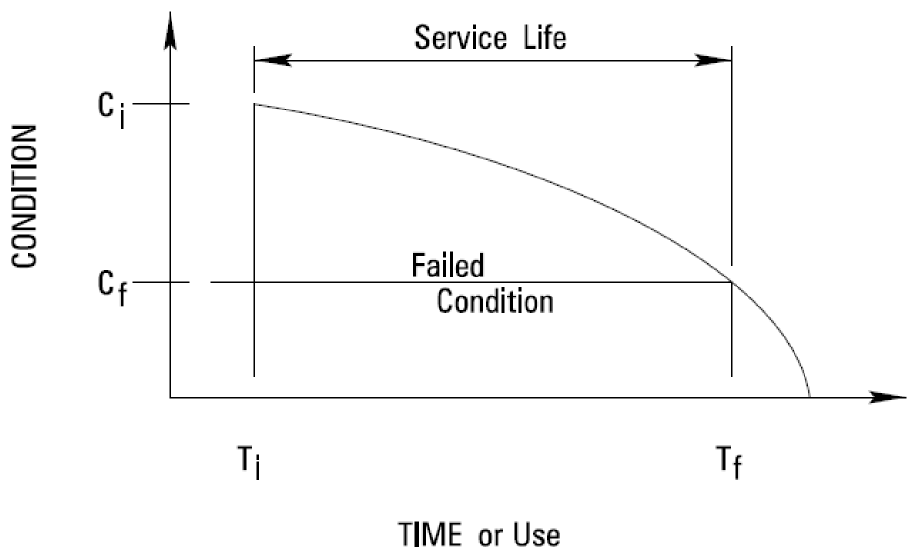


Figure 6.2—Element condition vs. time.

Activities to repair or rehabilitate deficient elements restore the element (and the bridge) to a higher condition level. The relation between these activities and expenditures over time can be illustrated as shown below in Figure 6.3.

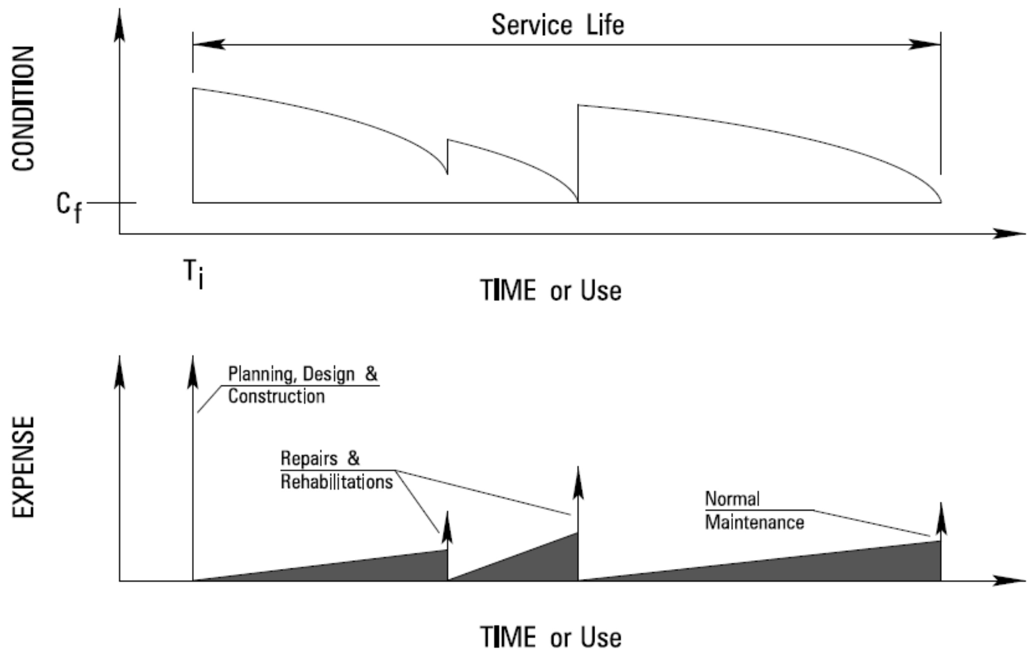


Figure 6.3- Condition and cash flow diagram over service life.

When using BLCCA to compare options for the construction of a new bridge, such as examining the lifetime cost of a bridge with a steel superstructure compared to an alternate prestressed concrete superstructure, it is typical to use the entire presumed service life of the bridge as the time period of the analysis. The analysis period does not have to be the entire life of the structure, though.

When performing an analysis for a group of bridges, which may not be all of the same age, or when the review assumes that service will be provided at a particular location and the cost of replacement may enter into the analysis; an analysis period is selected. For this report, a group of bridges which had Bridge Substantial Maintenance activities programmed in FY 2003, an analysis period extending ten years (from FY 2013 to FY 2023) was chosen and is discussed in Section 6.5 below.

6.3 Minimum Condition

A life cycle cost analysis is typically used as a tool to compare alternatives for current and future expenditures. The alternative scenarios are compared in the same base year dollars over the same analysis period. To keep comparison to that of costs only, each scenario must provide the same base line benefit. If different alternative scenarios provide significant different levels of benefit, then a benefit-cost analysis is the analysis that must properly be performed. To examine whether the bridge substantial maintenance program provides a benefit with an efficient use of funds, the minimum acceptable benefit must be defined.

The benefit that bridges provide is to allow traffic to travel over an obstacle. The minimum benefit that a bridge may provide and be considered to be fulfilling its function is defined by the minimum traffic handling capacity that is considered acceptable. Though the number of Functionally Obsolete bridges on the Kansas State Highway System is 442 as of November 2008 (23), few of those are actually the critical constriction point for traffic flow. The far more common concern is that the elements of a bridge deteriorate over time, whether by exposure or use, to a point that compromises the load carrying capacity of the structure. The deterioration may be rapid, but it is rarely sudden. The first milestone in deterioration that a bridge will reach is posting for load capacity.

When it has been determined by bridge inspectors that a bridge element has reached a critical condition, it is reviewed by engineers responsible for structurally evaluating the bridge. If the structural capacity is determined to be insufficient to carry legal truck loads as regular traffic, the bridge will be signed with a load restriction sign, an example of which is shown in Figure 6.4.

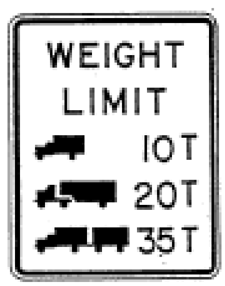


Figure 6.4—Typical Type R12-5 load posting sign.

Typically, the first posting is to restrict the bridge to legal truck weight only. For the Type R12-5 sign shown, this would have limits of 25 tons for the single vehicle, 43 tons for semi-trailer and 43 tons for the truck-trailer. The legal truck load combinations are shown in Figure 6.5 reproduced from the October 2012 KDOT Bridge Restrictions map (24). The purpose of this signing is to prevent the issuance of Oversize-Overweight permits for the structure by the Kansas Department of Revenue (KDOR).

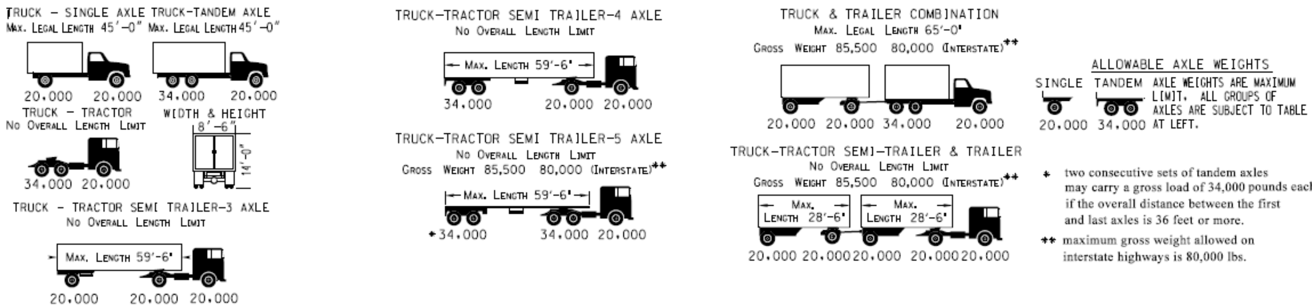


Figure 6.5—Legal loads for unpermitted trucks in Kansas.

The maximum gross weight of an unpermitted vehicle on Kansas highways is 80,000 lbs on the Interstate system and 85,500 lbs on non-Interstate highways (25). For vehicles with a gross weight of 150,000 lbs or more, a Superload permit must be issued by KDOT. The process of issuing that permit entails structural analysis of each bridge on the proposed route for the particular axle weights and configuration of the particular vehicle. Vehicles over the legal limit but under the Superload designation are considered overweight. The permit for such is issued by KDOR and is done without a structural analysis.

A bridge must be posted to allow no more than its operating load capacity. The operating load capacity is defined as the load which a bridge may carry on occasion without experiencing significant distress (this is in contrast to the lower load limit which a bridge may be subject to frequently without distress, the inventory limit). For a steel bridge, the operating limit is 75 percent of yield. The design trucks used in load rating analysis utilize 16-ton single loaded axles, as opposed to the legal 10 ton axle. For most common axle configurations, a vehicle up to the 150,000 lbs limit (with legal axles) will result in stresses less than yield.

However, subjecting a deteriorated bridge element to loading near yield may significantly and dangerously accelerate that deterioration; therefore, KDOR is not allowed to route any overweight trucks over posted bridges—even if the bridge is posted for legal truck loads.

Table 6.2 shows the number of Oversize-Overweight permits issued by KDOR from January 1, 2009 to the end of October 2012, and number of Superload permits from KDOT in the same period. The small number of agricultural and governmental Oversize-Overweight permits issued has been left out. Make note that KDOR issues standard and annual Oversize-Overweight permits. The annual permits allow a vehicle (with a maximum gross weight of 120,000 lbs) to make an unlimited number of trips over the year on the State Highway System, except at posted and restricted bridges.

	2009	**2010**	**2011**	**2012 (to Oct)**
Regular Oversize/Overweight Permits	47,941	50,109	56,625	56,087
Annual Oversize/Overweight Permits	3,621	4,034	4,566	4,867
Superload Permits	3,156	4,565	5,380	7,915
from the Kansas Department of Revenue, Motor Carrier Central Permit Office, November 25, 2012				

Table 6.2—Extra legal load permits in Kansas by year.

Freight movement is an ever increasingly important part of the traffic carried on Kansas highways. Given the importance of such to the Kansas economy now, and as discussed in Chapter Two in the past; the minimum condition for bridges used in the BLCCA is just above posting.

6.4 Deterioration Rates of Bridge Elements

In mid-1990s KDOT began its use of the Pontis bridge management system and doing element level inspection of bridges concurrently with National Bridge Inventory (NBI) inspections. KDOT has conducted NBI inspections since the early 1970's, as discussed in Chapter Two of this report. Pontis is a bridge management system, developed in 1992 under FHWA sponsorship, which defines each bridge as a collection of CoRE (Commonly Recognized Elements) elements and tracks their condition ratings, with ratings of 1 (best) to 5 (unacceptable) (26). Part of the impetus in the creation of the Pontis was to gain element level data to determine deterioration rates of those elements, which would in turn allow a bridge management system to predict future conditions and needs for a bridge inventory.

As Pontis becomes more widely adapted by state departments of transportation (39 states are licensees as of 11/2012) (27) interest in utilizing historic data to determine bridge element deterioration rates grows. As a result there is a growing body of literature on the subject, which has been utilized for this report.

One of the most comprehensive of these was the March 2009 report, Bridge Element Deterioration Rates for the New York State Department of Transportation (NYSDOT) (28). New York State has maintained a bridge inspection program for over 17,000 bridges in the state since 1981 utilizing a condition rating system for bridge elements. The condition ratings, shown in Table 6.3 below (adapted from the report) look very similar to those utilized by FHWA in the NBI inspections, shown in Table 6.4, but aren't an exact match (29).

Rating	Description
9	Condition and/or Existing Unknown
8	Not Applicable
7	New Condition, No deterioration
6	Used to shade between ratings of 5 and 7
5	Minor deterioration, but functioning as originally designed
4	Used to shade between ratings of 3 and 5
3	Serious deterioration, or not functioning as originally designed
2	Used to shade between ratings of 1 and 3
1	Totally deteriorated, or in failed condition

Table 6.3—NY State DOT condition ratings for bridge elements.

Code	Description
N	NOT APPLICABLE
9	EXCELLENT CONDITION
8	VERY GOOD CONDITION - no problems noted.
7	GOOD CONDITION - some minor problems.
6	SATISFACTORY CONDITION - structural elements show some minor deterioration.
5	FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
4	POOR CONDITION - advanced section loss, deterioration, spalling or scour.
3	SERIOUS CONDITION - loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	"IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.
0	FAILED CONDITION - out of service - beyond corrective action

Table 6.4—NBI element condition ratings.

The elements defined in NYSDOT inspections are much more numerous and specific than the more general five NBI elements of deck, superstructure, substructure, channel (for water crossing) and approach for span structures. NYSDOT elements include joints, bearings, pier caps, pier columns, etc. in addition to the general NBI elements—up to 47 distinct elements of a bridge.

Those researchers took the over-25 years of bridge inspection data and analyzed it with the aim of determining the probability that a given element would drop a condition level from one inspection to the next. There are two approaches to determining bridge element deterioration rates: deterministic and stochastic. Deterministic analysis employs techniques of regression analysis to determine the relation between explanatory variables and the progress of deterioration. This approach, though, ignores the effect of unobserved, and therefore unaccounted for, explanatory variables in the process. It also fails to account for the random nature of demands (i.e. traffic loadings) and environmental factors. Stochastic analysis treats deterioration in condition as subject to one or more random variables. The authors of the report for NYSDOT model the deterioration process through both a Markov chain approach and a Weibull-distribution approach (30).

The result of the Markov chain analysis is a transition matrix of probabilities that an element will deteriorate from one condition level to the next between inspections. An often cited weakness of this approach is that the probability of transition from one level to the next is the same regardless of the time that a particular element has been at a condition level. As an example, a deck rated at a condition level of 6 for four previous inspection cycles has the same probability of dropping to a 5 as a deck that changed to a 6 in just the last cycle. This can lead to underestimation of deterioration rates, particularly at the lower condition ratings.

The Weibull-distribution approach models the condition rating as a random variable with the probability that the time an element has been in a particular condition defined by a survival function. Data are analyzed with an end of determining the shape and scale parameters in the survival function which leads to a determination of the failure rate. The failure rate may increase or decrease with the length of time that an element has been in a particular condition rate.

For structural decks with uncoated reinforcing, the researchers reported that the time for a drop in condition rating from 7 to 4 was 49 years according to a Markov chain analysis and 43 years with a Weibull-distribution analysis. For structural decks with epoxy-coated reinforcing, the numbers were 62 and 60 years, respectively. One item of interest noted by this author in the review of the various deterioration rates was how linear the rates of deterioration were with respect to time, as seen in Figure 6.6, which was Figure 4-21 in the NYSDOT report.

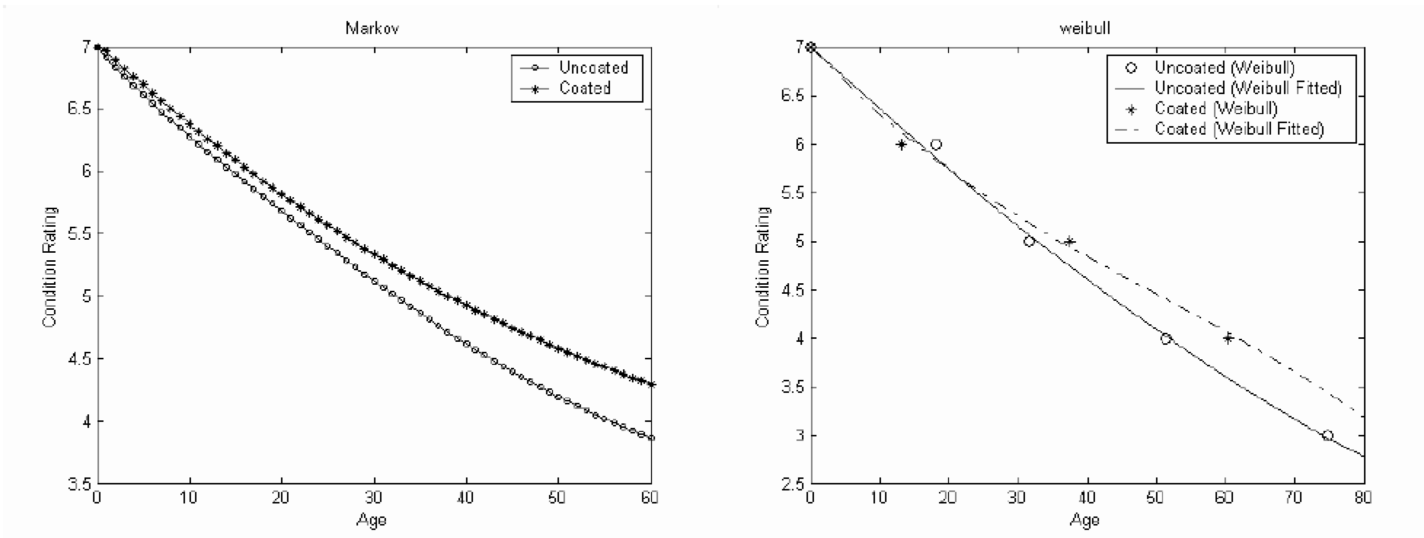


Figure 6.6—Deterioration plots for structural decks owned by NYSDOT.

In reviewing the NYSDOT data, it was apparent a condition rating 4 was the level where significant repairs and construction actions were expected to be required. Deterioration equations derived using the Weibull-distribution analyses were provided for most elements. Equations for the elements, which are also in common use in Kansas, were solved to find the time to drop from 7 to 4 in condition ratings. The results are shown in Table 6.5.

	Time for drop in NYSDOT condition rating from 7 to 4	
	Element	**Years**
Bearings	Steel Pier Bearing	43
	Steel Abutment Bearing	45
	Elastomeric Pier Bearing	51
	Elastomeric Abutment Bearing	59
Joints	Strip Seal Pier Joint	20
	Preformed Joint at Abutment	24
	Sliding Plate Pier Joint	25
	Modular Pier Joint	28
	Sliding Plate Joint at Abutment	34
Abutment	Abutment Pedestal	55
	Abutment Backwall	57
	Abutment Stem	58
	Abutment Wingwall	58
Pier	Concrete Pier Cap	55
	Concrete Pier Pedestal	56
	Concrete Pier Column	57
	Pier Stem	60
	Pier Footing	62
Superstr.	Slab or Box Primary Member	47
	T or I-Beam Primary Member	55
	Rolled Beam Primary Member	56
	Plate Girder Primary Member	60
	Box Culvert	56

Table 6.5—Time to condition level 4 for bridge elements of NY bridges.

Note, for concrete box girder bridges and slab bridges, the deck slab is the primary superstructure member. A review of the NYSDOT data shows that the deck (for deck slabs with uncoated reinforcing steel) is the first major structural element liable to need repair/substantial maintenance. Abutments, piers and girder superstructures all have a life cycle period of 55 or more years before major work is needed, as opposed to 42 year for bridge decks with black steel.

The author's own experience concurs that the deck and the deck joints are the first elements to require substantial maintenance on most bridges. These are the elements directly subjected to traffic and to road salts. Any life cycle study focused on a period less than the entire presumed 75 year service life of a bridge will need to pay special attention to deck work.

When making correlations with Kansas bridges, note that epoxy coated reinforcing was not adapted widely until the 1980s. Any bridge over 30 years old in Kansas will have uncoated reinforcing steel in its deck.

Other states and researchers have conducted research on deterioration rates of bridge elements, and of decks in particular. Their studies and results regarding the deterioration rates of bridge elements are discussed below, in brief.

Development of Agency Maintenance, Repair & Rehabilitation (MR&R) Cost Data for Florida's Bridge Management System, FDOT Contract BB-879, July 2001: This was the first large scale review of inspection and construction cost data to include element level inspection data in the development of MM&R cost data for the Pontis Bridge Management System. A deterioration model of bridge elements was developed by soliciting expert opinion from FDOT personnel experienced in bridge maintenance. The service life of concrete bridge decks was determined to be 50 years. The service life of superstructures was 59 years and of substructures 52 years. Joints and bearings had services lives of 21 and 50 years, respectively. Considering that Florida has a fairly aggressive environment for corrosion due to the humidity and the salt spray near the coasts on three sides of the state, the service lives for super and substructures may represent a lower bound for those elements (31).

Bridge Deck Service Life Prediction and Cost, Virginia Transportation Research Council Report VTRC 08-CR4, December 2007: Service life estimates of concrete bridge decks and costs for maintain decks for 100 years were developed. Service life estimates for decks were based on presumed rates of chloride diffusion, which were validated on 10 test decks in the field. The time to reach a deterioration level of 2 percent for decks with a water/cement ratio of 0.47 was 37 years on average for black steel decks. The time for progression of deterioration from 2 percent to 12 percent (assumed as the end of service life) was 16 years, establishing a typical service life of 53 years. Concrete overlays were found to have lives of 20-26 years and the life was relatively independent of ADT. Polymer concrete overlays lives, however, were highly dependent on ADT, with a range of 10 (ADT over 50,000) to 25 (ADT under 5,000) (32).

Developing Deterioration Models for Nebraska Bridges, NDOR Project No. SPR-P1(11)M302, July 2011: Deterioration models for Nebraska bridges were developed from NBI condition ratings from a period of bridge inspections extending from 1998 to 2010. Analysis was performed using Markov chains. Nebraska bridge inspection practice differs from Kansas in that a rating of 9 is assigned to new bridge elements and 5 is the minimal acceptable condition before assigning substantial maintenance. Bridge decks with black rebar were found to have an average service life to condition 5 of 40 years, for those with epoxy coated reinforcing it was 68 years. ADT was found to not have a pronounced effect except at very low, >100 counts (33).

Steel and prestressed concrete superstructures and concrete substructures were all found to have service lives to condition 5 of 80 years of more. Interestingly, according to the Nebraska paper's authors, the previous approach utilized to predict bridge element deterioration in Nebraska was to drop the deck condition one level every eight years, and the superstructure and substructure condition levels once every ten years. An approach it was claimed based on national deterioration rates.

Analysis of Life Cycle Maintenance Strategies for Concrete Bridge Decks, Journal of Bridge Engineering, ASCE, May/June 2004: Deck substantial maintenance strategies were evaluated using a mechanistic model of concrete deterioration and eight years of element level inspection data. Concrete overlays were estimated to provide a service life of 15-20 years; bituminous overlays over waterproofing membrane were estimated to provide a service life of 7 years and bituminous overlay without an underlying membrane to provide a service life of 2-3 years (34).

Guidelines for Selection of Bridge Deck Overlays, Sealers and Treatment, part of NCHRP Project 20-07 Task 234, Wiss, Janney, Elstner Associates, May 2009: Information regarding practice and service life for bridge decks and maintenance treatments was obtained from surveying state DOT's and review of the literature. The surveyed estimate of the service life of low slump concrete overlays had a mean of 16-32 years. For latex-modified concrete overlays the mean of the estimated service life was 14-29 yrs. Bituminous overlays with an underlying waterproofing membrane had a mean estimated service life of 12-19 yrs. For a polymer concrete overlay the mean was 9-18 years (35).

Bridge Preservation Guide, FHWA Publication No. FHWA-HIF-11042, August 2011: This primer on the framework and definitions for bridge preservation activities provided commonly used frequencies of 10-15 years for applying polymer concrete overlays, 10-15 years for applying bituminous overlays with waterproofing membranes and 20 to 25 years for concrete overlays (including silica fume and latex-modified) (36). These several research results are summarized in Table 6.6.

	Service Life in Years						
Element	*Florida*	*New York*	*Virgina*	*Nebraska*	*Wisconsin*	*WJSE Survey*	*FHWA*
Concrete Deck- Black Reinforcing	50	49	53	40			
Concrete Deck- Epoxy Reinforcing		60		68			
Concrete Overlay		25	22-26		15-20	16-32	20-25
Bituminous Overlay w/ Membrane					7	12-19	10-15
Polymer Concrete Overlay			10-25			9-18	10-15
Superstructure	59	Ave. 57		80			
Substructure	52	Ave. 58		80			

Table 6.6—Element service lives from the literature.

From a review of the available literature, and from discussions with personnel within KDOT and at agencies described in Chapter Five, the order in which elements will need to be addressed by maintenance over the life cycle of a bridge is: deck joints, decks, bearings, superstructure (beams, girders and secondary framing) and substructure. Deck joints and decks are subject to weather, traffic impacts and, in Kansas as well as most states, road salts and other deicing chemicals. As long as joints remain intact, bearings are not directly exposed to water or salt; but may be for prolonged periods after failure of deck joint glands or troughs. Superstructures and substructure are also rarely exposed except at grade separations with minimal horizontal and/or vertical clearances to traffic below.

Currently, KDOT has not developed a deterioration model for individual bridge elements, a deterioration matrix based off of the Bridge Health Index (BHI) measure has been developed by the KDOT Bridge Management Engineer to support the use of performance measurements in determining needs at the agency program level. The BHI represents the ratio of the sum of the current condition value of each element to the sum of the total condition value of each element, expressed as a score from 0 to 100. Zero would indicate that all of a particular bridge's elements are in the worst condition. A bridge health index of 88 or better would indicate that the condition of a system of bridges to be good; 75 percent indicated deteriorated condition. Currently, 88 percent of KDOT's bridges are in good condition.

For Span Bridges

		To				
		$Good_1$	$Good_2$	Fair	$Poor_2$	$Poor_1$
From	$Good_1$	97.00%	2.50%	0.50%	0.00%	0.00%
	$Good_2$		94.00%	5.50%	0.50%	0.00%
	Fair			96.00%	3.50%	0.50%
	$Poor_2$				96.00%	4.00%
	$Poor_1$					100.00%

Figure 6.7—Deterioration matrix for span bridges on the Kansas State Highway System.

For Underfill Bridges

		To				
		$Good_1$	$Good_2$	Fair	$Poor_2$	$Poor_1$
From	$Good_1$	97.00%	2.50%	0.50%	0.00%	0.00%
	$Good_2$		98.00%	1.50%	0.50%	0.00%
	Fair			97.00%	2.50%	0.50%
	$Poor_2$				96.50%	3.50%
	$Poor_1$					100.00%

Figure 6.8—Deterioration matrix for underfill bridges on the Kansas State Highway System.

The percentages in each cell of the deterioration matrix in Figures 6.7 and 6.8 are the probabilities of a structure remaining in that condition for the next year or transitioning downward. Using a technique from MnDOT for calculating an estimate of the deterioration curve from a transition probability matrix, the average transition time for of a span bridge from $good_1$ condition to $poor_1$ is 68 years (37). From this estimate, a 75 year service life is a reasonable estimate for Kansas state highway bridges.

6.5 Review Period and Activity Timing

The service life estimates found in the literature for superstructure and substructure elements are in agreement with the experience of KDOT Bridge Management personnel in a key respect. With a bridge service life of approximately 75 years and expected service lives for superstructure and substructure elements of 60 to 80 years; it may be reasonably expected that any particular bridge would only see one, if any, substantial maintenance project to repair either of those items. This compares to an expectation that a bridge would need to be overlaid once, twice or maybe three times depending on the expected life of the overlay material used and the amount of deck deterioration the agency would be willing to accept prior to programming a repair. Any life cycle analysis that compares current practice to an alternative would have to focus on bridge deck repairs.

Assuming a 75 year life for a bridge and a 40-50 year service life for a bridge deck (see values from Table 6.6), after its first concrete overlay a bridge has 25 to 35 years to carry traffic. If an agency is willing to have a number of bridges in its inventory in operation with their wearing surfaces in relatively poor condition, the agency may reduce the number of substantial maintenance projects let for bid.

Table 6.7 shows guidelines for deck condition ratings (NBI) from the KDOT Bridge Inspection Manual. Unlike Nebraska, the 9 rating is not used on active bridges, but the generalized NBI guidelines are followed. At a rating of 5, repair by contract, i.e. substantial maintenance is expected. At a rating of 4, a bridge is considered Structurally Deficient and is liable to be posted. A bridge may, typically, be posted for legal trucks, to preclude the running of permitted overweight truck, as discussed previously in section 5.4. As will be discussed later, the current practice of KDOT is to program deck repairs just before or after the deck rating will slip or has slipped to 5. This is before, what might be considered the full service life of the wearing surface is up. As discussed previously, a minimum maintenance regimen might consider postponing repairs until the deck rating is about to, or just has, slipped to 4.

Deck Condition Rating-KDOT		
Rating	***Description***	***Defects***
10	Not Applicable	
9	New Structure- Not open to traffic	
8	Good Condition-No repairs needed	
7	Generally Good Condition- Repairable by Area	Cracks up to 1.0mm, >10% Deck stained &/or deteriorated
6	Fair Condition- Repairable by District	2% or less of deck spalled, 10%-20% Deck stained &/or deteriorated
5	Generally Fair Condition- Requires Contract repair	2%-5% of deck spalled, 20%-40% Deck stained &/or deteriorated
4	Poor Condition- Warrants Posting more than 20 tons	>5% deck spalls, 40%-60% Deck stained &/or deteriorated
3	Serious Condition- Warrants Posting 10 to 20 tons	>60% Deck stained &/or deteriorated
2	Critical Condition- Facility Should be Closed until Repaired	Extreme case, i.e. collision
1	Critical Condition- Closed	
0	Critical Condition- Closed and Beyond Repair	

Table 6.7—KDOT deck condition ratings.

A review of bridge substantial maintenance projects shows that 36 out of 44 FY 2011 projects and 49 out of 54 FY 2012 projects had deck patching and overlay as a major part of their scope. The construction costs for those projects constituted 65 percent and 92 percent of the funds programmed for their respective years. Removing projects KA-2258-01 and KA-2230-01 (listed in Table 6.1 at the beginning of the chapter) from the FY 2011 review, projects with deck work constituted 91 percent of the remaining total for that year. A review of bridge life cycle costs focused on deck work will capture the bulk of the economic impact of bridge substantial maintenance work, and thereby the work of the BMP squad.

To determine activity phasing, deterioration rates to use in the analysis must be determined. Consistent with the surveyed literature and with KDOT practices the element service lives and deterioration rates in the Table 6.8 are assumed. The linear deterioration rate of the deck is consistent with the deterioration rates derived in the literature. Note, a linear rate in deck deterioration in regards to NBI ratings is not the same as a linear rating in terms of deck area. To go from an NBI deck rating of 6 to 3 is to step from 10 percent deterioration at 6, to 20 percent at 5, to 40 percent at 4, then to 60 percent at 3. The lower the rating, the greater the increase in area deteriorated between rating levels. The rate of deterioration increases in real terms over time, just as observed in bridge inspections.

Bridge Element Service Life and Deterioration Rate Assumed for Bridge Life Cycle Cost Analysis Model		
Element	*Service Life*[1]	*Years between NBI ratings*[2]
Concrete Deck with Black Reinforcing	45	11
Rigid Concrete (Silica Fume or Latex-Modified) Overlay	25	6
Polymer Concrete Overlay	15	4
Sliding Plate or Finger Joints	45	N/A
Strip Seal or Jeene™ Joints	15	N/A

1. Service Life is defined as meeting NBI ratings 8 through 4.
2. A linear deterioration is assumed. The numbers of years per incremental drop are rounded and may be adjusted in the analysis depending on individual bridge condition.

Table 6.8—Model element deterioration rates.

When performing a life cycle cost analysis on a particular structure to compare scopes for that structure alone, it is common to use the entire presumed service life of the structure as a study period and to include salvage value as a cash flow at the end of the period for any residual value remaining in any of the options. Reviewing an inventory of structures requires a different tact. The underlying assumption in this analysis is that the agency will maintain access on the routes that these bridges carry. Maintaining the wearing surface and the deck expansion joints in good condition may improve the functioning of the facility and may reduce the amount of agency resources required to maintain the facility. But, it will not necessarily prolong the final life of the superstructure or substructure elements. It may reduce maintenance requirement on them as that girder ends, bearing devices and the caps of abutments and piers may be damaged by drainage from leaky decks and joints; but those defects are repairable by their own maintenance actions. They will not require replacement, thereby shortening the bridge's overall service life. A bridge's ultimate service life is often determined by fatigue or obsolescence.

For this analysis, it is assumed that the bridges' ultimate service lives will be the same in either scenario- a minimum maintenance paradigm, or the current practice of more aggressive substantial maintenance. For purposes of comparison, then, salvage value is not a consideration and is not included.

A minimum maintenance paradigm is defined as allowing a deck to deteriorate until just above a rating of 4. A bare deck is presumed to remain at its inspected NBI rating for 11 years until it changes. A rigid overlay is presumed to have a life of 25 years. Under the current maintenance paradigm, an overlay would remain until it dropped from its initial 8 to a 5 rating, approximately 19 years for an even linear deterioration rate, but rounded to 20 years for the analysis. Given this, looking at a 20 year period in the life of the bridge would allow a review of a full cycle of overlay through deterioration for the current paradigm and, typically, capture an overlay for the minimum maintenance paradigm.

A 20-year review period also allows for a unique opportunity. With the inception of the Bridge Maintenance Plans squad in FY 2000 it is possible to review projects programmed in FY 2003. By this time the squad was fully operational and had some experience. Reviewing the maintenance and inspection history of the past ten years allows for review of life cycle assumptions. The 20 year period allows for projection as to what the impacts of that work will be on the next 10 years.

6.6 Discount Rate

With the establishment of alternate paradigms for comparison, activity scopes and timing, and the length of the review period; the only major item to be defined for a bridge life cycle analysis is the impact of time on the value of money. Given that the 20 year review period extends ten years into the past and ten years into the future, two distinct adjustments are needed to convert cash flows at various times into study year (2013) dollars.

Past dollars spent are adjusted into study year dollars by inflation factors. Inflation factors account for loss in purchasing power of each dollar as the costs for goods and services increases through time. Dollars spent in the past are inflated to today dollars. KDOT produces an inflation rate table (see Table 6.9) based on cost changes specific to highway construction, such as changes in fuel oil prices. For the past several years, the annual inflation rate for these items has been over 3 percent for most years. The KDOT factors are used to convert past costs into FY 2013 dollars. The KDOT table is included in Appendix F.

From Year	Inflation Factor
2003	1.430
2004	1.383
2005	1.336
2006	1.288
2007	1.242
2008	1.197
2009	1.152
2010	1.109
2011	1.071
2012	1.035

Table 6.9—KDOT inflation factors to convert to FY 2013 dollars.

Future expenditures must also be adjusted to study year dollars to allow for an equal comparison of expenditures. The discount rate represents the opportunity cost of money. It is presumed that funds be used for a productive purpose. KDOT has traditionally based its discount rate for pavement management life cycle costing on the difference between bond returns and inflation. As of December 6, 2013; the US Treasury 30-year bond rate is 2.75 percent and the 10-year rate is 1.6 percent, while the inflation rate based on the Consumer Price Index by the US Bureau of Labor Statistics is 2.2 percent. Projects and cost analysis for the Federal Government are required to use the discount rate established annually in the Office of Management and Budget's Circular A-94, Appendix C. For calendar year 2012, the rates are shown in Table 6.10.

Real Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)					
3 Year	*5 Year*	*7 Year*	*10 Year*	*20 Year*	*30 Year*
0.0	0.4	0.7	1.1	1.7	2.0

Table 6.10—Discount rate on real flows per OMB A-94, Appendix C for 2012.

By any measure the discount rate is low. Whereas in the 1990s a four percent discount rate was not uncommon in life cycle cost analysis, currently a short term cost analysis should use a one percent or less discount rate.

A zero discount rate would imply that the timing of activities and their associated cash flows were irrelevant in an analysis. Large discount rates prejudice against future expenditures. One method to quantify the magnitude of the effect of discount rate on an analysis, while allowing decisions to be made on a realistic range of possible discount rates, is to run the analysis with multiple rates.

The analysis for this project was conducted utilizing discount rates of 1 percent, 2 percent and 4 percent. One percent represents the probable correct discount rate for a 10-year future study period. Two percent represents a more moderate value that is conservative for decision makers who might be inclined to defer expenditures into the future. The four percent rate is, in today's market, an outlier which establishes the values for a profoundly optimistic view of the future value of money. If investing funds in maintenance today were shown to be more cost effective, this discount rate would show that it is not due to an assumption of low economic growth in the model.

The present worth factors to apply in discounting cash flows for each discount rate are shown in Table 6.11. They were calculated with the equation:

$$PWF = 1/(1+i)^n \text{ where } i = \text{discount rate and } n = \text{year}$$

Present Worth Factor				
n	***Year***	***i=1%***	***i=2%***	***i=4%***
1	2014	0.990	0.980	0.962
2	2015	0.980	0.961	0.925
3	2016	0.971	0.942	0.889
4	2017	0.961	0.924	0.855
5	2018	0.951	0.906	0.822
6	2019	0.942	0.888	0.790
7	2020	0.933	0.871	0.760
8	2021	0.923	0.853	0.731
9	2022	0.914	0.837	0.703
10	2023	0.905	0.820	0.676

Table 6.11—Present Worth Factors.

6.7 Fiscal Year 2003 Bridge Substantial Maintenance Projects

The FY 2003 program was the author's third year managing the squad and was the third year of set-aside program for Bridge Substantial Maintenance in the CTP. As such, all processes for selection and engineering were running without issue as regards to inexperience or novel conditions. The projects let for FY 2003 are shown in Table 6.12.

Bridge Set Aside-- FY 2003 Program Costs						
Route	**County**	**Bridgs**	**Project No.**	**Scope**	**Letting Date**	**Let Construction Cost**
5	105	185	K-8694-01	Limited Patching and Petromat	July-02	$137,019
7	3	27	K-8695-01	Patch & OL	March-03	$119,738
10	46	176	K-8376-01	Patch & OL, Curb, Appr, Bearing, Joint, Paint	March-03	$498,886
		177		Patch & OL, Curb, Appr, Bearing, Joint, Paint		$550,235
		178		Patch & OL, Curb, 4m Conc.Appr, Joint		$239,953
		179		Patch & OL, Curb, 4m Conc.Appr, Joint		$225,393
10	46	199	K-8696-01	Patch & OL, Curb, Strip Drain, Conc Appr	March-03	$185,423
10	46	184	K-8703-01	Patch & OL	March-03	$191,067
		189		Patch & OL, Curb, Drain Cells		$127,383
		190		Patch & OL, Curb, Drain Cells		$155,969
24	44	10	K-8705-01	Patch & OL, Curb Repair	April-03	$99,384
24	89	104	K-8706-01	Patch & OL, Joint, Concr Repair	January-03	$87,901
		105		Patch & OL, Joint, Concr Repair		$96,827
32	105	277	K-8707-01	Repair joints	August-02	$143,069
62	43	16	K-8708-01	Patch & OL	August-02	$85,686
70	105	211	K-9025-01	Stripseal repair	September-02	$43,228
99	56	534	K-8710-01	Replace (4) wings	April-03	$68,646
435	105	200	K-8712-01	Patch & OL, Strip Drain, 4m Conc. Appr.	June-03	$142,246
		201		Patch & OL, Strip Drain, 4m Conc. Appr.		$142,246
		202		Patch & OL, Strip Drain, 4m Conc. Appr.		$138,748
4	21	xxx	K-8713-01	Replace Culvert	June-03	$63,115
4	85	108	K-8714-01	Patch & OL, Curb repair, Rebar Insertion	Mar-03	$183,683
14	62	xxx	K-8715-01	Replace Culvert	June-03	$49,805
57	31	504	K-8718-01	Replace Culvert	March-03	$73,493
		505		Replace Culvert		$73,493
		xxx		Replace Culvert		$73,493
148	79	41	K-8719-01	Paint the bridge.	July-02	
153	59	105	K-8720-01	Patch & OL, Curb, Abut repair, Post repair	Apr-03	$178,954
181	53	29	K-8721-01	Overlay & Edge of Slab Repair	Apr-03	$135,496
181	53	30		Overlay & Edge of Slab Repair		$151,709
31	54	516	K-8723-01	Replace with pipe	May-03	$76,722
54	104	11	K-8729-01	Replace 4 wings	May-03	$49,422
59	67	4	K-8730-01	Patch & OL, Curb, Rail repair	Mar-03	$279,901
59	67	6	K-8731-01	Joint, Clean & Paint Rockers	Aug-02	$89,268
68	61	42	K-9158-01	Joint repair	May-03	$62,192
99	37	36	K-8732-01	Patch & OL	Jul-02	$114,634
166	63	34	K-8733-01	Patch & OL, Remove Median	Mar-03	$159,976

46	80	xxx	K-8709-01	Replace with pipe.	Mar-03	$36,756
49	96	101	K-8734-01	Patch & OL	Mar-03	$129,264
54	8	5	K-8735-01	Joints and Poly OL	May-03	$107,365
		6		Joints and Poly OL		$116,365
54	8	16	K-8736-01	Patch & OL, Curb repair	Jul-02	$196,393
54	87	303	K-8737-01	Patch & Latex OL, one appr, post rep.	Jul-02	$316,530
61	78	46	K-8738-01	Patch & OL, Curb, 4m Conc Appr	Mar-03	$160,513
		47		Patch & OL, Curb, 4m Conc Appr		$168,099
81	96	48	K-8739-01	Joint and reset backwalls	Jul-02	$150,746
96	5	48	K-8740-01	Patch & OL, Girder Ends, Shotcrete	Mar-03	$311,006
96	78	64	K-6879-02	Girder Repair in Hutchinson	Dec-02	$714,889
135	40	9	K-8741-01	Patch & OL, Joints	Apr-03	$270,889
		13		Patch & OL, Joints, 4m Conc Appr.		$343,854
135	87	47	K-9168-01	Patch & OL	May-03	$153,283
		48		Patch & OL		$200,166
160	18	21	K-8742-01	Petromat	Jul-02	$57,835
177	8	123	K-8743-01	Patch & OL, Joints	Jul-02	$201,624
		125		Patch & OL, Joints		$145,849
235	87	83	K-8744-01	Patch & OL, 10m Conc Appr, NE wing rep.	Jul-02	$161,460
					total as let	$9,237,290

Table 6.12—Fiscal Year 2003 Bridge Substantial Maintenance projects by district.

It should be noted for the reader reviewing the scope of work in the table that there was a period at KDOT when plans where produced and let with the SI system of measurement. The term 4m above refers to 4 meters for the length of the concrete approach slab.

There was $9.24 million worth of projects let in that fiscal year. However, for reasons previously discussed, only projects with bridge deck work as a major part of the scope are used in the analysis. A breakdown of the program by project scope and construction cost percentage is in Table 6.13.

Total FY 2003 Bridge Substantial Maintenance Let	***$9,237,290.14***	
Projects with deck work	$7,468,953	80.9%
Projects with joint work (but no deck work)	$488,503	5.3%
Culvert or small span replacement	$446,878	4.8%
Culvert Wing Replacement	$118,068	1.3%
Paint only	$0	0.0%
Miscellaneous- Steel Fatigue Repairs in Hutchinson	$714,889	7.7%

Table 6.13—Breakdown of fiscal year 2003 program by scope.

The fatigue repair and retrofit of the K-96 bridge in Hutchinson was required to turn the bridge back to the responsibility of the local government. There was no alternative to the repair except replacement prior to turnback, so it is not considered in a life cycle cost review of this year's work. Bridge work to replace joints is typically programmed when the joints have become intolerable for traffic or for the demand on local KDOT personnel and resources to maintain. There would be no minimum alternative to the scoped work, so they are not considered in the life cycle cost review. The same is true for culvert replacement, which is often replacements of structures at the very end of their service life; so they are not considered in the life cycle cost review. Replacement of culvert wings is a very small percentage of the programmed work, and the proper alterative to compare this work to, is replacement by maintenance forces rather than a delay of contract work. It is not considered in the life cycle cost analysis of FY 2003 work.

The final group of projects utilized in the life cycle costing was pared by removing two other projects, both of the bituminous overlays over waterproofing membrane, often referred to by the trade name of a common waterproofing membrane, Petromat™. Bridge serial number 185 in Wyandotte County was removed from service in 2008, before the end of the study period. Bridge serial number 21 carrying US-160 in Cowley County was also removed from service before the end of the study period. This type of overlay is typically applied in Kansas as a last treatment before a structure is scheduled for replacement.

The list of 38 bridges included in the bridge life cycle cost analysis is shown in Table 6.14.

	Route	**County**	**Bridges**
District 1	7	3	27
	10	46	176
	10	46	177
	10	46	178
	10	46	179
	10	46	184
	10	46	189
	10	46	190
	10	46	199
	24	44	10
	24	89	104
	24	89	105
	62	43	16
	435	105	200
	435	105	201
	435	105	202
Dist 2	4	85	108
	153	59	105
	181	53	29
	181	53	30
Dist 3	59	67	4
	99	37	36
	166	63	34
District 4	49	96	101
	54	8	5
	54	8	6
	54	8	16
	54	87	303
	61	78	46
	61	78	47
	96	5	48
	135	40	9
	135	40	13
	135	87	47
	135	87	48
	177	8	123
	177	8	125
	235	87	83

Table 6.14—Bridges in life cycle cost analysis, sorted by district.

With the selection of the data set to use in the analysis, it is possible to validate some of the assumptions planned for the analysis. First, with 10 years of inspection since the overlays were placed, the assumed deterioration rate of a drop in NBI deck rating by one level every six years can be examined. Out of the 20 bridges, 14 are currently at a NBI deck rating of 7. The two bridges which received polymer concrete overlays have remained at a 6. The polymer concrete overlays were placed on those bridges to seal and preserve debonded silica fume concrete overlays. The debonded areas, though stable, still chain as hollow and are, therefore still rated at 6. Given that slightly over half of the bridges are at the predicted NBI rating or better, the deterioration rate presumed for the overlays can be assumed acceptable.

As a check on the assumed 45-year service life for bridge decks, the average age of the bridge decks was calculated for these projects and was found to be 37 years, though there is a significant spread. Assuming that KDOT is programming bridge decks when they reach an NBI deck rating of 5, a linear deterioration in regard to NBI rating from 8 to 4 over 45 years would have a deck turn 5 at 34 years. The assumed deterioration rate would seem to be acceptable.

With a program year selected, it is also possible to calibrate the increased costs of repairs based on real construction data. A minimal maintenance scenario does not eliminate the need for contracted deck work to patch and overlay, it simply defers it until the condition of the deck is worse. With a worse condition, there is a higher patching quantity needed and more working days required, requiring higher traffic control cost. To project the cost of a deferred patching and overlay job, construction bid tabs for the FY 2003 overlay project were obtained and the patching as a percentage of deck area was determined for each bridge. For each bridge, the percentage of deck patching costs in regard to total construction costs was also calculated. The bridges were then grouped by NBI deck rating prior to the repair. The percent of deck patching vs. NBI deck rating is shown in Figure 6.9.

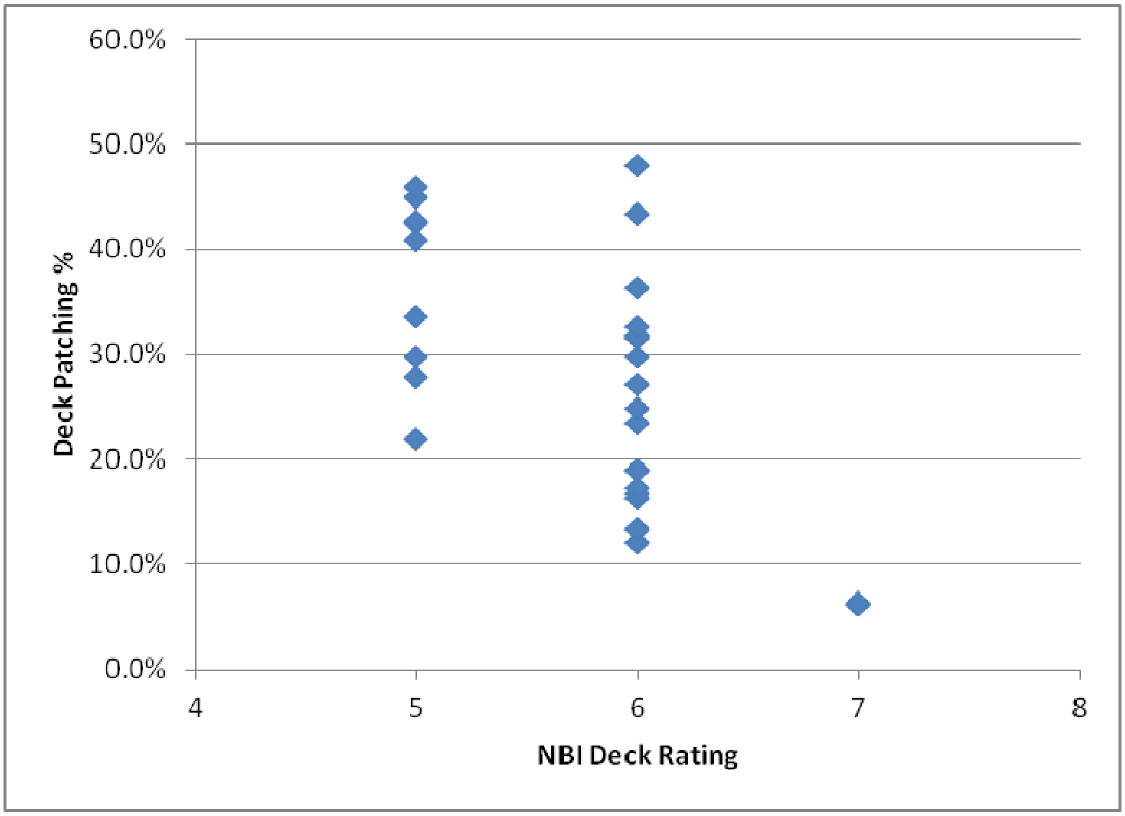


Figure 6.9—Percent of deck area patched vs. NBI deck rating for FY 2003 deck repairs.

NBI Deck Rating	7	6	5	4
Average Patching	6.30%	26.10%	36.70%	--
Average Patching Cost/Total Construction Cost	19.10%	33.10%	40.50%	--
Expected Deck Deterioration per NBI Rating Guide	>10%	10%-20%	20%-40%	40%-60%

Table 6.15—Average patching percent and ratio to construction cost for FY 2003 deck repair projects.

In the life cycle cost analysis, to adjust the cost from a 2003 deck patching project to a future project which would be programmed when the deck was about to turn to a 4, it is assumed that the future deck patching quantity would be 45 percent of the area of the deck.

The average patching quantity of the 2003 jobs with an NBI deck rating of 6 was 26.1 percent (see Table 6.15), which was 33.1 percent of the cost of the project. So, the 2003 project costs should be increased by:

$$[(0.45/0.261) \times 0.331] - 0.331 = 0.2397$$

Repeating for projects with had NBI rating of 5, their 2003 project costs should be increased by:

$$[(0.45/0.367) \times 0.367] - 0.367 = 0.083$$

For the analysis, rounded factors of 20 percent and 10 percent were used. Note, though the project costs are in 2003 dollars, the analysis is in 2013 dollars. The project costs will have to be inflated before applying the factors above.

6.8 Maintenance cost

When KDOT selects decks that are about to or are at a NBI deck rating of 5, the agency is selecting to provide wearing surfaces with no more than 2 percent of the surface spalled. The colloquial term is, of course, potholed. At a minimum potholes in the deck cause driver discomfort and may cause drivers to slow or to change lanes. Maintaining operation on a deck until it rates a 4 means maintaining the deck in operation with 5 percent or more spalled. The practical consequence is that KDOT crews will have to apply temporary deck patches during these years. The KDOT Johnson County and Topeka Metro Engineers were contacted as to the practices, procedures and materials their forces use for deck patching. The engineers gave similar responses.

KDOT crews operate for 6 hours at a site to minimize traffic impact. Patches are temporary in nature. Unlike contract patching where heavy equipment is mobilized, only spalled or areas imminent to spall are addressed by KDOT crews. In contrast, a Bridge Substantial Maintenance deck patching and overlay project involves removing all deteriorated areas, a process helped by the use of a milling machine to remove the top ¾ in. of the existing deck surface, which is often saturated with road salts. KDOT crews are only addressing current spalls and, therefore, are not stopping the deterioration process across the deck. Properly cleaned, prepped and dressed bituminous patches may last up to two years (note this is not, as referred to by field forces, “throw and go” bituminous patching). Concrete patching may last, in lower ADT areas, 4 years.

For the analysis, in urban areas with higher ADT’s, bituminous patching every two years is assumed as a maintenance activity in the cash flow analysis. This is the practice of the Metro areas and is chosen for its minimal traffic impact. In actual practice, patching is more frequent. More readily applied cold mix is used and maintenance to the deck often occurs, and is not tracked, as crews maintain a segment of highway. In order to avoid prejudicing this analysis in favor of current practice, conservative assumptions are made to minimize district maintenance cost in the analysis. Another minimizing assumption is to assume up to half of the spalls are occurring outside of the travelway, probably along the curb.

Treatments there should last much longer. The life cycle cost analysis assumes that only half the spalls expected from the NBI guide are being address by the KDOT crew.

Rapid set concrete patching is assumed elsewhere. The cost of labor and materials is higher, but the trade off is a longer lasting patch. Note, though, that for this and the other patching option, deck deterioration proceeds apace.

An additional activity that is applied in a hit and miss manner across the state, but should be standard practice, is sealing the deck. Applying an epoxy, or other approved, sealant to 1 mm cracks that appear when a deck reaches a rating of 6 can help prolong deck life. The derivation for maintenance activity costs are found in Appendix G of this report.

6.9 Example Bridge Life Cycle Cost Analysis

Life cycle analysis (for the 2 percent discount rate) for each of the 38 reviewed bridges can be found in Appendix H of this report. One analysis is presented here as an example.

Bridge 10-46-176 carries westbound K-10 over Kill Creek near DeSoto on a 40 ft. roadway. It is a twin to the eastbound structure. Both bridges have haunched and continuous steel girder superstructures, were constructed in 1975 and have sliding plate deck expansion devices. The AADT on the bridge is currently (2013) 13,700 with 5 percent truck traffic.

At the time of the 2002 biannual bridge inspection, the deck had an NBI rating of 6, a superstructure rating of 5 and a substructure rating of 7. The deck deterioration had closely followed the deterioration rate predicted from a 45 year service life for black reinforcing concrete decks. The lower superstructure rating was due to cracks in the abutment diaphragm which were found to be stable. Leakage through the sliding plate joint above was contributing to deterioration at the diaphragm.

Though this structure might be expected to last a few more years until deck work would be required, the twin bridge was showing signs of deck distress, having dropped to a NBI deck rating of 5, five years prior in 1998 and was showing 10 percent full depth-deterioration in the deck.

The work scoped in 2003 was to patch and overlay the deck with a silica fume concrete overlay, replace the sliding plate device with a new strip seal (which will stop the leaking onto the ends of the beams), repair the curbs and replacing the concrete approach slabs. The project was let at a cost of $239,953. A review of KDOT Maintenance Management System (MMS) shows that the area crew patched the deck and conducted miscellaneous repairs in 2011 at a cost of $3,152.

Assuming a 25-year life for the overlay placed in 2004, the overlay is expected to degrade to a 6 in 2017. Note that the overlay rated a 7 from its first day. This is due to cracking, probably due to movement of the bridge under traffic from phased construction of the repair. The condition has been stable and addressed with some sealing by the area crew. In 2017, assume that a deck sealing operation will take place, performed by KDOT crews. With a deck area of 11,588 square feet, it may take more than one day, so presume a cost of $1,200. By 2019, the strip seal will reach the end of its life necessitating a replacement project at $40,000. At 2023, the overlay will be 20 years old. A review of KDOT MMS records show that it is common that the district crew will have to conduct a patching operation prior to programming the bridge for a new overlay or other work. Assume that the crew patches 1 percent of the deck with bituminous patching (due to the ADT).

The cost to date and project are shown in Table 6.16 (assuming a 2 percent discount rate).

BLCCA with work as let:				
Year	***Item***	***Cost***	***Inflation Factor***	***Cost (2013)***
2003	Contract Repair	$239,953	1.43	$343,133
2011	Patch and Misc	$3,152	1.071	$3,376
	Maintenance Cost to date (cost above are in $ of year incurred)			$346,509
Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$1,200	0.924	$1,109
2019	Replace joint	$40,000	0.888	$35,520
2023	Patch deck	$4,056	0.820	$3,327
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$39,956
Sum of inflated cost to date and discounted cost expected from 2003-2023				$386,464

Table 6.16—Construction item costs for FY 2003 to FY 2023- current paradigm.

If the Department chose to follow a minimal approach to substantial maintenance, this bridge could have been left alone until about 2008, when the deck would have dropped to a 5 (within 2 percent of the deck area spalled). KDOT crews would then start patching the deck with hot mix bituminous material every couple of years on average. For purposes of this analysis, other work which would probably come in between heavier patching operations is ignored. Since the temporary patching does not address the rate of ongoing deck deterioration, the quantity of patching will increase each interval.

Though the leakage through the sliding plate will continue, the results can be dealt with by KDOT crews on an ongoing basis. By 2019, the deck will have deteriorated to such a point that a contract patching and overlay job would be required. Other items which were addressed in the 2003 project would have to be addressed then. Assume the 2019 project will cost 20 percent more than the 2003 project in 2013 dollars.

The assumed cost to date and projected costs are shown in Table 6.17.

BLCCA with minimum maintenance:				
Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2008	1% Bit patching	\$3,388	1.197	\$4,056
2010	1.25% Bit patch	\$4,571	1.109	\$5,070
2012	1.5% Bit patch	\$5,878	1.035	\$6,084
	Maintenance Cost to date (cost above are in \$ of year incurred)			\$15,209
Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	1.75% Bit patch	\$7,098	0.980	\$6,959
2016	2% Bit patching	\$8,112	0.942	\$7,644
2019	Contract overlay	\$411,759	0.888	\$365,642
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year \$)			\$380,244
Sum of inflated cost to date and discounted cost expected from 2003-2023				\$395,454

Table 6.17—Construction item costs for FY 2003 to FY 2023- Minimum Maintenance paradigm.

6.10 Results and Discussion

The results in the previous example are typical of those of the other 38 bridges taken in the aggregate. Had a scheme of minimal maintenance been pursued in 2003, the cost to date would have been less, but would have been more than made up for by the increase in need in the next ten years.

This analysis is conservative in favor of deferring cost. Not all maintenance activities have been accounted for, and those that have been, they have been assigned minimal scopes. The aggregate results of the analysis of all of the bridges are shown in Tables 6.18 and 6.19.

	From 2003 to 2013	From 2013 to 2023 in 2013 Dollars Discounted:		
	Inflated to 2013 $	1%	2%	4%
Substantial Maintenance as let in FY2003	$10,621,092	$671,546	$628,723	$552,121
Minimum Contract Substantial Maintenance	$4,950,840	$8,256,991	$7,840,983	$7,080,247

Table 6.18—Bridge maintenance cost for study period, separate into past and future.

	Total 2013 Dollars spent 2003-2023		
	1%	2%	4%
Substantial Maintenance as let in FY2003	$11,292,638	$11,249,815	$11,173,213
Minimum Contract Sub. Maintenance	$13,207,831	$12,791,823	$12,031,087
Ratio:	85%	88%	93%

A 1% Discount rate reflects the current likely rate of return vs. inflation.

A 2% Discount rate is conservative in support of deferring expenditures to the future.

A 4% Discount rate is currently unlikely, but had been widely used in the recent past

Table 6.19—Bridge maintenance cost for study period total for each discount rate.

Even with the most optimistic assumed discount rate, the life cycle analysis still finds the current paradigm of substantial maintenance to be more cost effective over the length of the study period in terms of agency expenditures for construction and heavy maintenance alone.

6.11 Chapter Summary

- Bridge Life Cycle Cost Analysis can be used to compare operation costs of alternate maintenance paradigms providing at least a minimum level of service in terms of base year dollars over a period of time.
- A fully operational bridge is capable of carrying all legal loads. The heaviest legal loads that a bridge is expected to carry are permitted Overweight trucks.
- Comparing the service life of bridge elements, the element which deteriorates most rapidly is the deck.
- A BLCCA of bridge deck repair projects from the FY 2003 program year shows that substantial maintenance as performed costs KDOT 12 percent less over a 20 year review period than a paradigm of minimum maintenance would.

Chapter 7—User Costs

The cost to highway users of bridge maintenance work is examined in this chapter. The concepts of user costs due to the delay incurred at work zones are introduced. User delay costs due to work zones and closures are calculated for the projects in the FY 2003 Bridge Substantial Maintenance program. Crash costs are discussed. The economic impact of bridge maintenance work is examined by conducting an economic analysis assuming bridges at one location in the FY 2003 program were restricted from allowing Overweight truck to pass.

7.1 Definition of User Costs and Project Scope

An inconvenient by-product of the past two-and-half decades of programmed highway work in Kansas is the familiarity of motorist with orange barrels. Work to repair or rehabilitate existing facilities means that traffic will be impacted. Traffic has to be diverted from the construction area, also known as the work zone. Sometimes traffic is diverted onto detour routes or on-site detours, known in Kansas as shooflies. Other times opposing directions of traffic will have to alternate use of a lane adjacent to construction by the use of flaggers, temporary signals, or any of a number of other strategies to maintain through traffic. What is common to any of these strategies is that the trip will take longer while construction is ongoing than it did before or will after completion of the work.

The FHWA defines work zone user cost as, "The additional costs borne by motorists and the community at-large as a result of work zone activity" (38). These costs include those associated with:

- the increased time of travel through a work zone; and
- the increase in crash rates inherent with the impositions placed on traffic through work zones.

The increase in travel time results in cost associated with user delay, vehicle operation and increased emissions. These costs are typically directly proportional to the additional time needed to travel through the work zone, the delay time.

Costs due to increased emissions from delays in work zones are not examined in this report. The delay time incurred at discrete bridge locations is small enough that the increase in emissions is negligible. These costs are included in the economic analysis discussed later because the economic impact of posting bridges results in a significant increase in miles travel for some vehicles.

Crash costs are functions of the characteristics of the site and ADT. Although improving work zone safety has been a major focus of FHWA and KDOT in recent years research has focused on improving crash rates and severities in work zones, not on quantifying any increase in crash rates due to the presence of work zones. A general discussion of crash costs at work zones and at bridges follows in a later section of the chapter.

When reviewing the cost effectiveness of maintenance work, the crux is how much does maintenance costs as opposed to the results of no, or reduced, maintenance? Deteriorated bridges also cause users to incur costs. The NCHRP report on bridge life cycle cost analysis discusses the delay associated with poor riding bridge decks (8). Such delay calculations are common with the life cycle costing of pavement facilities, however, very few bridges in Kansas are long enough that the delay caused by slowing traffic 10 mph for the length of the bridge will have a significant impact on overall user costs. These effects will be ignored in this report. The primary user impact of deteriorated bridges comes from the disruption in traffic due to closing bridges or restricting their traffic loads. Even if the load limitation on a bridge is no more than to restrict it to legal, i.e. unpermitted, loads; the growing amount of permitted overweight vehicles means that the impact to freight traffic can be considerable.

This chapter reviews the work zone user cost from the bridge deck repair projects on the State Highway System let in FY 2003. These are the same bridges reviewed in the bridge life cycle cost analysis in Chapter Three. To contrast these user costs to those incurred from a program of minimal bridge maintenance, the economic impact of posting program year FY 2003 bridges on K-10 near DeSoto for two years is discussed. The review is restricted to only bridge deck work, as those scopes of work such as bearing repair or concrete surface repair occur under the bridge deck and do not significantly affect the traffic operations above for long periods. Other maintenance work that does occur on the deck, such as joint replacement, may be phased to minimize impacts on traffic. Bridge deck repairs, by their nature, require lane closures that run the length of the span.

Culvert replacements may be programmed through substantial maintenance to address structural issues while limiting the scope of roadside work that would be required if the project was part of a different funding program. Regardless of the scope of roadside work, culvert replacements require removal of the existing culvert and, therefore, have the same impact on traffic as such work otherwise funded. Therefore, traffic impacts from culvert replacements aren't relevant for a comparison specifically involving substantial maintenance work against alternates.

All user costs calculated are based on current FY 2013 traffic counts and traffic standard plans. The intent of this review of user costs is not to examine the specific costs incurred by the public from the work in FY 2003, but to use that set of projects as representative of a typical year's bridge substantial maintenance program.

7.2 Work Zone Delay

Work zone delay is a function of method and layout of work zone traffic control specific to each job site. The 38 bridges that had bridge deck work in the FY 2003 Bridge Substantial Maintenance program were reviewed in regard to traffic control planned. All but three of the bridges carried traffic during construction of the repair work. Those three bridges included twin bridges over US-24 in Topeka and the ramp bridge carrying northbound I-235 to US-54 eastbound movements in Wichita. The bridges over US-24 carried local traffic which was detoured on the local road system. The focus of this review is on the impacts to State Highway System users. Impacts to users on the local road are not a part of this review, so these bridges have been excluded from this review. User cost from the work on the I-235 to US-54 ramp is discussed later.

The traffic control on the remaining 35 bridges was provided by one of two methods. For highway bridges carrying one-way traffic with two or more lanes, one lane at time was dropped and traffic carried through the phased construction on the remaining lane(s). Twenty one bridges had this traffic control. The other 14 bridges utilized temporary signals to carry traffic on one half of the bridge while construction occurred on the other half.

AADT for each of the bridges in the analysis was obtained from the bridge's current KDOT Bridge Inspection Form, which reads the value from the central CANSYS II database. To determine hourly volumes, the hourly variation factors were obtained from KDOT's Bureau of Transportation Planning. The factors are shown in Table 7.1 and Figure 7.1.

2011 Variations By Hour from KDOT Bureau of Transportation Planning for Weekday Traffic		
Hour	***for Urban Highways***	***for Rural Highways Statewide***
12 - 1 am	0.75	0.79
1 - 2 am	0.44	0.57
2 - 3 am	0.38	0.51
3 - 4 am	0.38	0.52
4 - 5 am	0.83	0.83
5 - 6 am	2.14	1.86
6 - 7 am	4.98	3.98
7 - 8 am	8.22	6.46
8 - 9 am	6.17	5.61
9 - 10 am	4.71	5.35
10 - 11 am	4.60	5.46
11 - 12 am	5.12	5.66
12 - 1 pm	5.45	5.84
1 - 2 pm	5.53	6.08
2 - 3 pm	6.16	6.49
3 - 4 pm	7.55	7.42
4 - 5 pm	8.63	8.18
5 - 6 pm	8.98	8.35
6 - 7 pm	5.74	6.05
7 - 8 pm	3.87	4.23
8 - 9 pm	3.23	3.45
9 - 10 pm	2.80	2.87
10 - 11 pm	2.01	2.07
11 - 12 pm	1.35	1.38
Factors shown are percent of AADT.		

Table 7.1—Hourly traffic variation factors.

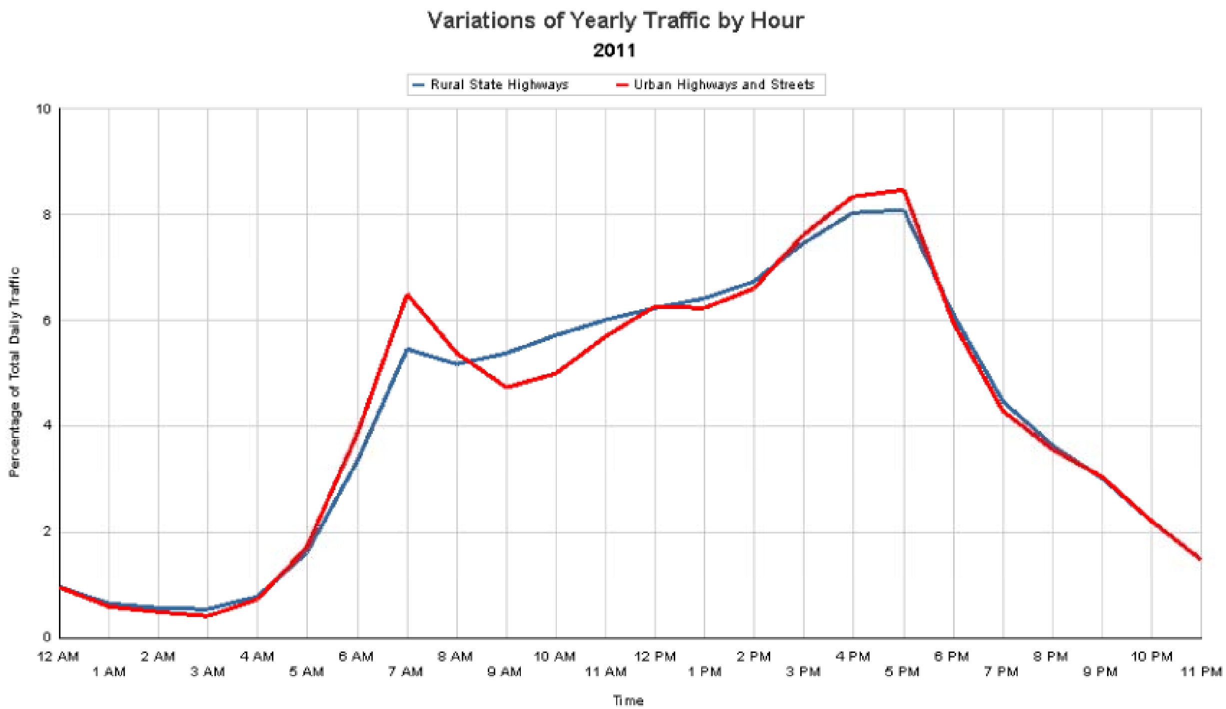


Figure 7.1—Plot of hourly traffic variations.

The capacity of the lanes carrying traffic through construction was determined using the methodology in the section, *Capacity Reductions due to Construction and Major Maintenance Operations* of the 2010 HCM (11). Exhibit 10-14 of the 2010 HCM provides values for lane capacities of long term construction zones. For a reduction of two lanes to one, the single lane has a default capacity of 1,400 vehicles per hour. For reductions of three lanes to two, each remaining lane has a default capacity of 1,450 vehicles per hour.

There are three adjustments provided for the base lane capacity values. The first is for the effect of heavy vehicles in the traffic stream. A heavy-vehicle adjustment factor is provided that is a function of the proportion of trucks and of recreational vehicles in the traffic stream. For the analysis in this report, rather than adjust the lane capacity, the peak hourly volume was adjusted to reflect the passenger car equivalent for trucks (a factor of 1.5).

The second adjustment is for the presence of ramps. KDOT Field personnel are aware of the impacts that traffic entering or existing near the work can have of operations and will mitigate for this in the individual traffic control plans.

The third adjustment is for lane widths. Twelve foot lanes were provided in all of the bridge work in this review.

For bridges that carried one-way traffic with a lane drop, the capacity of the work zone lane was compared to peak hour volumes adjusted for truck volumes by adding passenger car equivalents to the count (Table 7.2). Demand exceeded lane capacity on only four of the bridges. Capacity was exceeded by only 3 percent - 4 percent on three of the K-10 bridges. Demand did significantly exceed capacity on the US-54 ramp bridge in Wichita.

District	route	county	serial	directional	roadway	directional lanes	AADT	% Trucks	Peak Hr	Peak Hr Passenger Car Equivalents	HCM 2010 WZ Capacity	v/c	Queue at Peak Hour Volume?	Max. Delay (minutes)	Ave. Delay (minutes)	Delay Cost per day	Project Working Days	Total Delay Cost over Project
District One	10	46	176	WB	48	2	14100	5	1254.9	1286.3	1400	0.92	N	0	0	0	114	0
	10	46	177	EB	48	2	14100	5	1254.9	1286.3	1400	0.92	N	0	0	0	114	0
	10	46	178	WB	40	2	13700	5	1219.3	1249.8	1400	0.89	N	0	0	0	114	0
	10	46	179	EB	40	2	13700	5	1219.3	1249.8	1400	0.89	N	0	0	0	114	0
	10	46	199	WB	40	2	14100	5	1254.9	1286.3	1400	0.92	N	0	0	0	102	0
	10	46	184	WB	40	2	15850	5	1410.7	1445.9	1400	1.03	Y	2.61	0.23	$47.73	104	$2,147.85
	10	46	189	WB	40	2	16000	5	1424.0	1459.6	1400	1.04	Y	3.77	0.38	$102.59	104	$4,616.55
	10	46	190	EB	40	2	15850	5	1410.7	1445.9	1400	1.03	Y	2.61	0.23	$47.71	104	$2,146.95
	435	105	200	NB	56	3	27000	10	2403.0	2523.2	2860	0.88	N	0	0	0	0	0
	435	105	201	SB	56	3	27000	10	2403.0	2523.2	2860	0.88	N	0	0	0	0	0
	435	105	202	NB	56	3	27000	10	2403.0	2523.2	2860	0.88	N	0	0	0	0	0
District Five	54	8	5	WB	28	2	8350	10	743.2	780.3	1400	0.56	N	0	0	0	55	0
	54	8	6	EB	28	2	8350	10	743.2	780.3	1400	0.56	N	0	0	0	55	0
	54	8	16	SB	40	2	1165	21	103.7	114.6	1400	0.08	N	0	0	0	52	0
	54	87	303	Ramp	36	2	52000	4	1820.0	1856.4	1400	1.33	Y[1]	-	-	$59,968.82	1	$59,968.82
	61	78	46	SB	40	2	3815	11	339.5	358.2	1400	0.26	N	0	0	0	60	0
	61	78	47	NB	40	2	3815	11	339.5	358.2	1400	0.26	N	0	0	0	60	0
	135	87	47	SB	40	2	13100	17	1165.9	1265.0	1400	0.90	N	0	0	0	46	0
	135	87	48	NB	48	2	13100	17	1165.9	1265.0	1400	0.90	N	0	0	0	46	0
	177	8	123	-	44	2	365	11	32.5	34.3	1400	0.02	N	0	0	0	62	0
	177	8	125	-	44	2	365	11	32.5	34.3	1400	0.02	N	0	0	0	62	0
	235	87	83	Ramp	20	1	21100	9	1877.9	1962.4	-	-	detour[2]	-	-	$32,657.53	2.5	$81,643.83
																		$150,524.00

Notes:

1. Patching on the US-54 ramp bridge in Wichita was done with a very-rapid set latex-modified concrete.
The lane closures were completed from 7pm Sunday to 7am Monday. Excess traffic is assumed to have proceeded to next ramp.
2. Patching on the I-235 to US-54 bridge was done similarly to bridge 87-303, but using a silica fume mix closed Friday night to Monday morning.
The lane closures were completed from 7pm Sunday to 7am Monday. Excess traffic is assumed to have proceeded to next ramp.
1.,2. The Project Working Days for the short closure projects represent the length of time for deck overlays, not all project work.

User Cost per Hour	
Semi-Trailer Trucks	$31.95
Passenger Cars	$17.25

Table 7.2--Capacity and delay for bridges with open lanes through work zone.

The US-54 ramp bridge (Br. No. 54-87-303) carries 52,000 vehicles per day (see Table 7.3). To mitigate the traffic impact of closing the southbound I-135 to westbound US-54 movement, a rapid-set latex-modified concrete overlay was used. Milling of the deck and patching with high-early strength concrete occurred prior to placing the overlay in short duration operations performed in off peak hours. The overlay was placed half at a time on the bridge on Sunday night, maintaining one lane of traffic through. Even at the off-peak weekend time, the capacity of the single lane was exceeded. For the calculation of user cost from delay it was assumed that traffic in excess of the lane capacity continue south one mile to the next exit, travelled 1.5 miles west on Lincoln Street, then returned north one mile on Washington Street; for a total adverse travel distance of 3.5 miles over ten minutes.

Br. No. 54-87-303

Total Number of Lanes	2	**Number of Lanes Open**	1
Truck Percentage	4	**Open Lane Capacity**	1400
Total Capacity of Workzone	1274		

Hourly User Cost			
Semi-Trailer Truck	$31.95	$1.18	**mile**
Passenger Car	$17.25	$0.62	**mile**

Time	Demand	Capacity	Arrivals	Departures	Vehicles
19:00	2017.6	1274	2017.6	1274	744
20:00	2000	1274	4017.6	2548	1470
21:00	1846	1274	5863.6	3822	2042
22:00	1580.8	1274	7444.4	5096	2348
23:00	1149.2	1274	8593.6	6370	2224
0:00	769.6	1274	9363.2	7644	1719
1:00	494	1274	9857.2	8918	939
2:00	312	1274	10169.2	10169.2	0
3:00	249.6	1274	10418.8	10418.8	0
4:00	213.2	1274	10632	10632	0
5:00	374.4	1274	11006.4	11006.4	0
6:00	894.4	1274	11900.8	11900.8	0

			Total Excess	11485
Detour time	10	**min**		
Detour length	3.5	**miles**	**Excess Cars**	11026
			Excess Trucks	459
			Total Cost	$59,968.82

Note: Hourly traffic volumes above are adjusted for equivalent trucks.

Table 7.3—Overflow traffic at Br. 54-87-303.

For the K-10 bridges delay was determined by summing comparing demand to capacity for each hourly traffic volume, arrivals in excess of capacity are queued and discharged at the lane capacity as arrivals taper. The calculated delays are shown in Tables 7.4 and 7.5 below.

Br. No. 10-46-184 and 10-46-190

Total Number of Lanes	2	**Number of Lanes Open**	1
Truck Percentage	5	**Open Lane Capacity**	1600
Total Capacity of Workzone	1400		

Hourly User Cost

Semi-Trailer Trucks	$31.95
Passenger Cars	$17.25

Time	Demand	Capacity	Total Arrivals	Total Departures	Queued Vehicles	Queue Length	Delay (minutes)
0:00	122	1400	122	122	0	0.00	0.00
1:00	71	1400	193	193	0	0.00	0.00
2:00	62	1400	255	255	0	0.00	0.00
3:00	62	1400	317	317	0	0.00	0.00
4:00	135	1400	452	452	0	0.00	0.00
5:00	348	1400	799	799	0	0.00	0.00
6:00	809	1400	1608	1608	0	0.00	0.00
7:00	1335	1400	2944	2944	0	0.00	0.00
8:00	1002	1400	3946	3946	0	0.00	0.00
9:00	765	1400	4711	4711	0	0.00	0.00
10:00	747	1400	5459	5459	0	0.00	0.00
11:00	832	1400	6290	6290	0	0.00	0.00
12:00	885	1400	7176	7176	0	0.00	0.00
13:00	898	1400	8074	8074	0	0.00	0.00
14:00	1001	1400	9075	9075	0	0.00	0.00
15:00	1227	1400	10302	10302	0	0.00	0.00
16:00	1402	1400	11704	11702	2	0.01	0.09
17:00	1459	1400	13163	13102	61	0.15	2.61
18:00	933	1400	14095	14095	0	0.00	0.00
19:00	629	1400	14724	14724	0	0.00	0.00
20:00	525	1400	15248	15248	0	0.00	0.00
21:00	455	1400	15703	15703	0	0.00	0.00
22:00	327	1400	16030	16030	0	0.00	0.00
23:00	219	1400	16249	16249	0	0.00	0.00

2.61	***Max Delay (minutes)***
0.23	***Average Delay (min)***
$47.73	***User Cost***
0.15	***Max Queue Length (miles)***

Note: Hourly traffic volumes above are adjusted for equivalent trucks.

Table 7.4—Queue and delay for Br. 10-46-184 and 10-46-190.

Br. No. 10-46-189

Total Number of Lanes	2	**Number of Lanes Open**	1
Truck Percentage	5	**Open Lane Capacity**	1600
Total Capacity of Workzone	1400		

Hourly User Cost

Semi-Trailer Trucks	$31.95
Passenger Cars	$17.25

Time	Demand	Capacity	Total Arrivals	Total Departures	Queued Vehicles	Queue Length	Delay (minutes)
0:00	123	1400	123	123	0	0.00	0.00
1:00	72	1400	195	195	0	0.00	0.00
2:00	62	1400	257	257	0	0.00	0.00
3:00	62	1400	320	320	0	0.00	0.00
4:00	136	1400	456	456	0	0.00	0.00
5:00	351	1400	807	807	0	0.00	0.00
6:00	817	1400	1624	1624	0	0.00	0.00
7:00	1348	1400	2972	2972	0	0.00	0.00
8:00	1012	1400	3984	3984	0	0.00	0.00
9:00	772	1400	4756	4756	0	0.00	0.00
10:00	754	1400	5510	5510	0	0.00	0.00
11:00	840	1400	6350	6350	0	0.00	0.00
12:00	894	1400	7244	7244	0	0.00	0.00
13:00	907	1400	8151	8151	0	0.00	0.00
14:00	1010	1400	9161	9161	0	0.00	0.00
15:00	1238	1400	10399	10399	0	0.00	0.00
16:00	1415	1400	11815	11799	15	0.04	0.66
17:00	1473	1400	13287	13199	88	0.22	3.77
18:00	941	1400	14229	14229	0	0.00	0.00
19:00	635	1400	14863	14863	0	0.00	0.00
20:00	530	1400	15393	15393	0	0.00	0.00
21:00	459	1400	15852	15852	0	0.00	0.00
22:00	330	1400	16182	16182	0	0.00	0.00
23:00	221	1400	16403	16403	0	0.00	0.00

3.77	***Max Delay (minutes)***
0.38	***Average Delay (min)***
$102.59	***User Cost***
0.22	***Max Queue Length (miles)***

Note: Hourly traffic volumes above are adjusted for equivalent trucks.

Table 7.5—Queue and delay for Br. 10-46-189.

Work on the northbound I-235 to eastbound US-54 ramp required closing the bridge to place the overlay. The traffic impact was minimized by limiting the closure time to a two and a half day weekend. A special high early strength silica fume overlay was placed. User costs were calculated on the basis of routing 2.5 days of ramp traffic off early at the K-42 exit south of the I-235 interchange, proceeding east than exiting onto northbound West Street. The adverse travel was minimal, but five minutes would have been lost due to the slower speed on city streets. The total user cost was calculated as $81,643.83.

7.3 User Delay Costs

Consistent with the methodology in the FHWA's Work Zone Road User's manual, the user delay cost for passenger car trip for this analysis consist of the value of time for vehicle occupants and vehicle operation costs (38). These costs are also incurred by truck trips, which additionally incur cost from the time value of freight. Cost specific to Kansas highway were obtained from Appendix B of the KDOT report, *Transportation Infrastructure Investment and the Kansas Economy* (39).

Passenger Car Costs per Hour				
Trip Purpose	***Business***	***Commute***	***Personal***	
Distribution	6%	27%	67%	
Value of Time	$17.45	$10.47	$10.47	
Occupancy	1.27	1.14	1.81	
Averaged Cost per Hour			**$17.25**	
Vehicle Operating Cost per Hr			**$0.58**	per mile
Truck Costs per Hour				
Value of Time	$25.18			
Occupancy	1.12			
Inventory per Truck	15	tons		
Time Value of Invent	$0.25	per ton		
Averaged Cost per Hour			**$31.95**	
Vehicle Operating Cost per Hr			**$1.18**	per mile

Table 7.6—User costs for passenger car and truck trips.

Total project user delay costs for the bridges with lanes open to traffic adjacent to the work zone have been calculated and shown in Table 7.2 as the product of the delay costs per day times the number of days the traffic control was presumed to be in place. On the projects in Wichita involving short closures, this is known. For the K-10 projects, this was estimated as half of the project working days (the contractor would work on the eastbound bridges or the westbound bridges, not both simultaneously), less seven days to mobilize and demobilize.

7.4 Signalized Work Zone User Delay

To calculate the delay at signalized work zones, it is necessary to determine whether the hourly demand at the site would exceed the capacity of the signalized entrance. Consistent with the methodology in the Roess and Prassas text, the peak hour traffic volume (adjusted for trucks by passenger car equivalents) was compared to half of the hourly lane capacity (40). By this measure, the signalized lanes were running well under capacity, with the largest ratio at 0.59. At this low ratio, it is presumed that delays from overflow and random arrivals are minimal and that the delay from the controller can be modeled as uniform delay.

Delay through the signalized work zones in this analysis has been assumed to consist of uniform delay from the controller and the delay from travel through the work zone. Delay for a typical bridge deck repair work zone has been calculated in Appendix I, assuming a bridge length of 300 ft. Only one bridge in the analysis was longer, Br. No. 59-67-4 at 832 ft. The standard average delay for passenger cars was calculated as 44.6 seconds. For trucks, the standard average delay was calculated as 59.5 seconds. Delay costs per day were calculated as sums of the products of the hourly user cost and the cumulative daily delay for each passenger cars and trucks. The project delay cost was calculated as the product of the daily delay and the working days charged to the project less seven days for mobilization and demobilization. For Br. No. 59-67-4, 13 seconds was added to the standard average delays to account for traveling (832 ft.-300 ft. =) 532 ft. at (65 mph – 45 mph =) 20 mph. Delays and costs are shown in the Table 7.7

	route	county	serial	roadway	AADT	% Trucks	Peak Hr	Peak Hr Passenger Car Equivalents	Signalized Capacity	v/c	Culmative Daily Delay for Passenger Cars (hours)	Culmative Daily Delay of Truck (hours)	Delay Cost per day	Project Working Days	Total Delay Cost over Project
Dist 1	7	3	27	44	1560	12	138.8	147.2	700	0.21	17.01	3.09	$392.23	39	$12,551.43
	24	44	10	28.9	4420	11	393.4	415.0	700	0.59	48.74	8.04	$1,097.43	37	$32,922.89
	62	43	16	28	255	12	22.7	24.1	700	0.03	2.78	0.51	$64.11	26	$1,218.18
Dist 2	4	85	108	28	1450	8	129.1	134.2	700	0.19	16.53	1.92	$346.34	102	$32,902.51
	153	59	105	26	2010	13	178.9	190.5	700	0.27	21.66	4.32	$511.69	43	$18,421.00
	181	53	29	28	315	10	28.0	29.4	700	0.04	3.51	0.52	$77.22	66	$4,556.00
	181	53	30	28	485	10	43.2	45.3	700	0.06	5.41	0.80	$118.89	66	$7,014.79
Dist 4	59	67	4	28	3190	18	283.9	309.5	700	0.44	41.85	11.56	$1,091.42	65	$63,302.51
	99	37	36	28	890	11	79.2	83.6	700	0.12	9.81	1.62	$220.98	26	$4,198.54
	166	63	34	36	2530	16	225.2	243.2	700	0.35	26.33	6.69	$667.93	30	$15,362.45
Dist 5	49	96	101	44	1940	7	172.7	178.7	700	0.26	22.35	2.24	$457.28	31	$10,974.80
	96	5	48	44	1950	16	173.6	187.4	700	0.27	20.29	5.16	$514.81	70	$32,433.01
	135	40	9	28	155	3	13.8	14.0	700	0.02	1.86	0.08	$34.59	94	$3,009.03
	135	40	13	28	1630	7	145.1	150.1	700	0.21	18.78	1.89	$384.21	94	$33,426.48
															$272,293.62

User Cost per Hour	
Semi-Trailer Trucks	$31.95
Passenger Cars	$17.25

* Due to length of Br. 59-67-4 at 832', 13 seconds has been added to the standard assumed delay for that bridge.

Table 7.7—Delay and user cost for bridges with signalized work zones.

7.5 Crash Costs

Cost incurred by the users of road and bridge facilities from delay caused by bridge substantial maintenance projects can be compared with delays incurred under other operational paradigms, such as minimal maintenance. However, it is difficult to compare crash costs incurred from operations requiring work zones to a minimal maintenance operation. This would require quantifying the increase in crash rates that might be expected from the presence of a work zone. Agencies, which must employ work zones in their day-to-day operation (such as the one sponsoring this report), are loathe doing so because of the liability implications in future litigation. As stated by Dr. Bai in a report on causes of work zone crashes for KDOT, “Work zone crash rates by work zone travel mileage are not precisely known” (41).

An item to note from Dr. Bai’s report is that only 5 percent of work zone crashes occurred at bridge sites. Bridge projects tend to be fairly short in comparison to other maintenance projects involving pavement rehabilitation or shoulder reconstruction. Travelers are exposed for a relatively limited time at sites involving bridge construction.

The benefit in the reduction of crash rates due to substantial maintenance work on bridges has been quantified. In a report for the Florida DOT, Gan and Shen researched Crash Reduction Factors calculated and used by state DOT’s across the United States (42). They report that three states, Indiana, Kentucky and Missouri, had calculated Crash Reduction Factors for the repair of bridge decks. Each found crash reductions (no distinctions made between fatal, injury or property damage only crashes) of 13 percent, 14 percent and 15 percent. This work was also cited by FHWA in their 2008 reference work for Crash Reduction Factors (43).

This concurs with research on crashes at bridges in Kansas done by the author for the 2009 Mid-Continent Transportation Research Symposium at Iowa State University (44). A regression analysis of characteristics of bridges at which crashes had occurred in the period of 2005-2007 showed a strong negative correlation between the presence of a bridge deck overlay and crashes.

7.6 Economic Costs

A bridge failure effectively closes a road, impeding access to and from property and interrupting through traffic. Restricting the load that a bridge may carry due to deteriorated condition denies access and free movement to heavy trucks and equipment. As discussed in Chapter Two, the Federal requirement in 1971 to load rate all bridges in the National Bridge Inventory resulted in the posting of approximately 200 Kansas bridges, with significant impacts to the communities to whom those bridges provided access.

As part of the planning process that took place in the formation of the current T-Works funding program, KDOT commissioned a report, *Transportation Infrastructure Investment and the Kansas Economy*, on the economic impact of transportation investment (39). From page 10 of that report:

> KDOT has calculated the impact of reducing maintenance funding by 60 percent from $385 million per year to $154 million per year (in constant 2008 dollars) over the period from 2009 to 2020. By 2020, this scenario is predicted by KDOT to cause a 30 percent decrease in the share of state highway miles in good condition and an additional 100 bridges that would require weight restrictions or detours.
>
> Economic modeling of the consequences associated with a 60 percent decrease in maintenance funding suggests that by 2020 the Kansas economy would lose 12,000 jobs and $670 million per year in gross state product, including $460 million per year less labor income than would occur if preservation funding were to continue at its current level.

The condition data for the economic impact analysis performed for that report came from planning models showing the increase in travel time and in vehicle operating costs due to deteriorating pavement conditions and the increase in travel time and costs due to load restrictions on bridges. Bridge conditions were predicted based on the current bridge management database and the deterioration model shown in Chapter Five of this report.

FHWA defines economic impact analysis as “The study of the way in which the direct benefits and costs of a highway project (such as travel time saving) affect the local, regional, or national economy” (44). It differs from benefit/cost analysis in that the subjects of benefit/cost analysis are the direct benefits and costs that a project has for highway owners and users; and concerning externalities, nonusers affected by the project. Economic impact analysis attempts to measure how these direct benefits and costs are converted into indirect effects in the economy.

The economic impact analysis for the KDOT report was performed using the web based Transportation Economic Development Impact System (TREDIS). TREDIS consists of a series of modules maintained by the TREDIS Software Group a division of the Economic Development Research Group, Inc. of Massachusetts (45). The system is used by approximately 20 states and provinces and assorted municipalities and federal agencies to conduct benefit/cost analysis and economic impact analysis for projects across multiple transportation modes.

The system can be used to assess user benefits based on transportation forecasting results and to calculate wider economic benefits based on the estimated impacts to jobs, income, gross regional product and business output. What makes the system particularly attractive is the large pool of contemporary economic data that supporters use for their economic and transportation models.

To provide some measure of the impact of deferring maintenance on bridges specific to the scope of this report, a TREDIS analysis was conducted on a scenario that assumes a set of the bridges from the FY 2003 substantial maintenance bridge program was allowed to deteriorate to a posted condition for a two-year period. The analysis was conducted by David Schwartz, P.E. and Andrew Jenkins, P.E. of the KDOT Planning section.

The most minimal posting is one that restricts the bridge to only "legal" loads, those that do not require an Overweight permit issued by KDOR. As discussed in Chapter Five of this report, this would limit a non-Interstate highway bridge to trucks with a gross weight less than 85,500 lbs. The annual Overweight permit issued by KDOR for $150 would allow a truck of up to 120,000 lbs to travel on any unrestricted bridges in the State at will.

For this analysis, it was chosen to assume that at least one eastbound and one westbound bridge of the group of bridges repaired on K-10 near DeSoto were posted "legal" for the years 2014 and 2015.

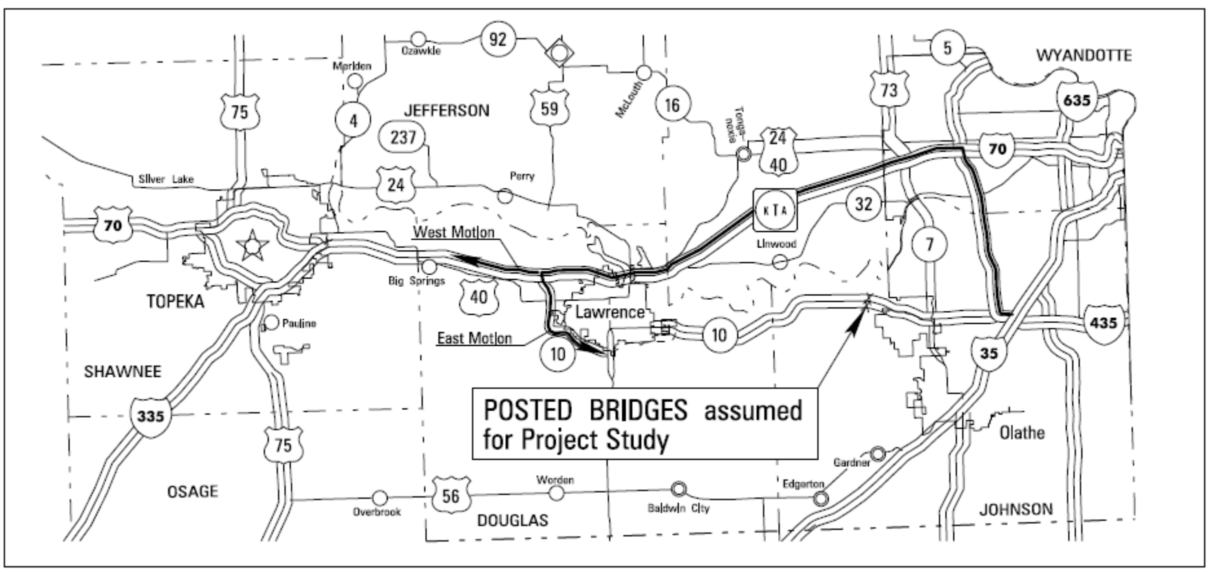


Figure 7.2—Detour overweight truck route for K-10 posting.

It was assumed that trips with destinations west of Lawrence would detour on K-7 to I-70. For trips with destinations inside of Lawrence the detour was assumed to be K-7 to I-70 to K-10 around the west side of Lawrence. This was assumed since the two turnpike entrances to Lawrence have size restrictions that would prevent oversized trucks from using these routes. It was assumed for this study that only trips wanting to go to Lawrence and trips wanting to go west on I-70 via K-10 as a shorter route than K-7 would use K-10. Trips going south to Ottawa and beyond would use I-35 as a direct route and trips going north of KC would take routes other than K-10 as they would be more direct, as well.

The volume of overweight trucks was determined from KDOT Weight and Motion studies averaged for all like roads to K-10 in the period 2003-2011. Superload (trucks over 150,000 lbs) permit data specifically for the K-10 bridges was averaged over years 2000-2006 and added in addition to the overweight vehicles.

Fifteen percent of overweight trucks and five percent of Superloads were assumed to have origins-destinations in Lawrence with the rest going west on I-70. Tolls were taken into account to the Lecompton exit on I-70 for the detour routes.

Trips, VMT and VHT were calculated by Andrew Jenkins and inputted into TREDIS along with other parameters. An analysis concerning overweight freight traffic only was conducted to determine the costs related to maintaining the detour for calendar years 2014 and 2015. The results are shown in Tables 7.8 and 7.9.

Increases in:	Truck Freight
Gross Vehicle Trips	0
Gross VMT	535,297
Gross VHT	5,406
Gross Buffer Time (hrs)	135
Freight Ton Miles	37,474,318
Fatalities	0
Personal Injuries	0.05
Property Damage	0.89
Local Portion of Trip Ends	7%
Total Value of Travel Impacts:	
Passenger Cost - Net Total	0
Crew Cost - Net Total	155,058
Freight Cost - Net Total	456,844
Reliability Cost - Net Total	8,427
Veh Oper Cost - Net Total	656,272
Toll Cost - Net Total	318,952
Safety Cost - Net Total	17,816
Environmental Cost - Net Total	28,371
Induced Benefit - Total	0
Total Value of Travel Impacts:	**1,641,740**
© 2012 Economic Development Research Group, Inc	
Operation Period:	
Start Year: 2014 End Year: 2015 Analysis Year: 2015 Travel Growth Rate: 1.5% Constant Dollar Year: 2012	

Table 7.8—Travel impacts to oversized freight traffic.

TREDIS REPORT 4b: TOTAL ECONOMIC IMPACTS - BY YEAR					
Count	**Year**	**Business Output ($ mil.)**	**Value Added ($ mil.)**	**Jobs**	**Wage Income ($ mil.)**
1	2014	-0.136	-0.063	0	-0.043
2	2015	-0.138	-0.064	0	-0.044
	Sum of Impact for all Years	-0.274	-0.127		-0.087

Table 7.9—Economic impact related to oversized freight traffic.

The manner in which the TREDIS analysis was conducted was to assume that the baseline condition for overweight freight traffic was the detour routes, then to determine the cost impacts from constructing the existing K-10 alignment as “new” construction. That should have provided a correct measure for adverse travel utilized for the user costs calculations shown in Table 6.8. The economic impact due to increased user costs on overweight freight traffic from posting K-10 near DeSoto was estimated to be $1.6 million in FY 2012 dollars.

In regard to the total economic impact to the study area as report by TREDIS Report 4b and shown in Table 6.9, it is not as clear that an economic benefit resulting from a transportation network improvement is the same value as the economic costs resulting from a degradation of the transportation network. However the results are useful to compare the magnitude of total economic impact to those of user impacts. The loss of wages and output to the economy is nominally $488,000 for the two-year period, as compared to $1.6 million in user costs, for impacts on overweight freight movements.

7.7 Chapter Summary

- Substantial maintenance work on bridge results in users incurring cost from delays through work zones and adverse travel.
- User delay cost resulting from bridge deck repairs in the FY 2003 project year would amount to approximately $423,000 estimated using current traffic volumes.
- Had bridges in one location repaired during the FY 2003 project year, K-10 near DeSoto, been allowed to deteriorate such that Overweight truck traffic would have been restricted for two years (2014 and 2015), the cost to those users would have been $1.6 million. The impact to the economy would have been approximately $488,000.

Chapter 8—Findings

The findings from the report are discussed in this chapter. The efficiency and effectiveness of the organization of the BMP squad is reviewed by the analysis of PE and CE cost for projects over the period of FY 1993 to FY 2010. The practices of surrounding states are discussed. The cost of current maintenance practices as opposed to more minimal investment in substantial maintenance for bridges is examined by review of the projects in the FY 2003 Bridge Substantial Maintenance program. The findings for agency cost as determined by a Bridge Life Cycle Cost analysis are discussed. The findings for user cost as determined by an analysis of user delays at work zones and closures are discussed. The economic impact of allowing bridges at one site in the FY 2003 to deteriorate to restricted status for two years is reviewed.

8.1 Initial Goals of Report

The impetus for this report was to see if the way KDOT was doing business in regards to bridge maintenance was a good way or not. Comparison of spending levels on bridge maintenance between Kansas and its neighboring states shows that Kansas has put more resources into maintaining its inventory than its neighbors. The result has been an inventory in enviably good condition. As reported by Calvin Reed, P.E., Bridge Management Engineer, as of August 2012:

- 88 percent of the state owned bridges are in Good condition (Bridge Health Index > 88)
- 9 percent are in Fair condition (BHI between 88 to 75)
- 3 percent are in Deteriorated condition (BHI < 75)

Only one percent of the bridges on the state system are Structurally Deficient, as defined by FHWA.

With a bridge inventory in good shape, and with budgets tightening for all state agencies and obligations, a question may be asked as to whether bridge maintenance funding may be cut back. History has shown us that this is not a question to take lightly. Kansas has, compared to other states, a low population compared to the size of its road network. However, this low density has enhanced the need for connectivity in the State. The economic activity of Kansas depends on it. Bridges are a critical link in that network and, as seen in the early 1970s after federal load rating requirements forced the posting of approximately 200 bridges, their deterioration can have a significant impact on the state.

8.2 Savings from Current Substantial Maintenance Practice

The approach taken in this report has been to review the results that have been achieved by the current practice of bridge maintenance and to compare it to the "what if" scenario of spending less on maintenance. One year's (FY 2003) Bridge Substantial Maintenance projects were examined, and the maintenance records for those bridges in the intervening 10 years have been examined, to provide the basis for an analysis with the most concrete data available. Life cycle costs were complied for 20 year periods (ten years in the past and ten years in the future) for two scenarios:

- current Bridge Substantial Maintenance practice; and
- a regime of minimal maintenance where poorer bridge conditions are tolerated and more work is done with state forces.

To do this with the least possible bias toward finding in favor of current practice, any extension in overall bridge service life has been ignored. Also, only projects whose deferral would result only in impediments to function rather than shortening structure life; i.e. bridge deck repair projects, have been examined.

The result is, for the bridges that had decks repaired in FY 2003, KDOT has spent $10.6 million (2013 dollars) in the intervening years. If a minimal maintenance policy had been pursued, this would have only been $4.95 million. However, to keep those bridges open to all traffic in the next 10 years, KDOT will only need to spend approximately $670 thousand (2013 dollars) at the current Federal 10 year discount rate of 1 percent. If a minimal maintenance policy had been pursued, KDOT would need to spend $8.3 million over the next 10 years.

Comparing the cost in equivalent dollars over the FY 2003 to 2012 period, it cost KDOT 12 percent less to keep bridge decks in good repair. This is not counting the additional staffing with field personnel that might be required to minimally maintain bridges with poorer decks for several years. By maintaining the current practice, KDOT gets better riding bridge decks for less money. But it requires a long-term perspective to realize that the cost is less.

8.3 Savings from the Bridge Maintenance Plans Squad

Defining and comparing alternate scenarios based on the physical results of a process is a more straightforward task than reviewing the organization behind the process. To review the performance of the BMP squad in providing design engineering services, the percentage of the cost of PE for bridge repair projects compared to construction cost of those projects has been plotted over a 17 year period. The period encompassed years before and after the formation of the squad. To provide a baseline for comparison, the same ratio was plotted for bridge replacement projects.

The overall result was that PE costs, as a percentage of construction for both scopes of projects, have remained the same over the 17 year period. ***But what is noticeable, is that for a three year period after***

the initial formation of the squad, when the squad was functioning as originally conceived, the PE costs dropped significantly. The average percentage of PE costs to construction costs has been 3.5 percent for the study period. During that three year period the percentage for the Bridge Maintenance Plans squad was one percent. Also during that period, the squad was dealing with emergency repair work and engineering support for field maintenance efforts with similar efficiency in PE costs.

Unfortunately, personnel and organizational changes let to reorganization of the squad in later years and a greater dependence on consulting engineer firms for PE services for bridge repair project. The PE percentage returned to its historic level around 3 percent; however, savings were still realized from a reduction in CE costs for bridge repair project as they let. ***In the years since the formation of the squad, CE as a percentage of construction costs for bridge replacement projects has remained steady around 8 percent, but same percentage for bridge repair projects went from over 13 percent to under 8 percent.*** CE represents the effort that the agency expends in inspecting and administrating let projects. It drops when less effort is required in inspection, in length of time to build a project, and in any change orders that might occur. The reduction in CE is consistent with an improvement in repair procedures in shaping contractor expectations through consistency in methods.

Although personnel turnover and loss of experience has led to changes in the organization of the BMP squad from the originally envisioned form its formation has led to savings for the agency and can be considered a better way of doing business than was done previously.

8.4 State of Practice

Continual improvement is a laudable goal for any organization. It was hoped that a review of other states facing conditions similar to Kansas would reveal practices to be adapted here. Instead, confirmation for our model of doing business was found. Iowa's 2009 addition of the Bridge Preservation Engineer to its Bridge Maintenance and Inspection section echoes many of the same considerations that led to formation of the Bridge Maintenance Plans squad in Kansas: working with the field to identify bridge maintenance issues and developing expertise in addressing those issues. Illinois has found maintaining a separate design squad for bridge repair work to be valuable enough to have retained it for 25 years and to require all such plans for the agency to go through the squad.

8.5 Impact to the Highway User

KDOT receives money from the citizens of Kansas and highway users to provide a benefit for them. Bridge maintenance work is necessary to keep facilities open, but the work itself causes lane closures and results in delay to those users. ***The bridge deck repair work in FY 2003 resulted in approximately***

$423,000 in delay costs to highway users. Just over 64 percent of that cost was borne by users at the signalized work zones common to work on two-lane rural highways. ***The average delay to those drivers, however, was less than one minute.***

The cost of this work is offset by its economic benefit. A review of the impacts for two years on one segment of users, Overweight trucks, from restricting the bridges at one location in the FY 2003 program, K-10 near DeSoto—showed that freight traffic suffered $1.64 million in user cost impacts over the period. The economic impact to the surrounding study area was estimated to have been just under $500,000 in the two year period.

The State of Kansas faces many decisions on how to spend the shrinking pool of tax money on the multiple and significant needs and wants facing it in the coming legislative session and years to follow. It must be remembered that the consequences of the decisions continue for years. Maintaining a highway network is a significant cost to the state, but it provides vital benefits that include support of the economy needed to derive those same taxes.

This report has examined the impact of decisions made for bridge maintenance ten years ago. The aggressive maintenance work done then has provided for bridges that have and will function well for less cost over the period of time since then and into the next ten years. Maintaining this function has avoided economic impacts more significant than any user impacts from doing the work. Money saved from deferring bridge maintenance work is lost within only a few years.

8.6 Future Work

There are opportunities to extend the work in this report into greater depth in future reviews of bridge maintenance practice. They include expanding the review of substantial maintenance practices for bridges to a national, rather than regional, scope. User cost might be better estimated by the use of microsimulation to model traffic behavior rather than estimates of uniform behavior. As more consistent in-house maintenance costs become available at KDOT with better computerized timesheet and equipment log histories, long term maintenance costs at bridges might be examined. Most ambitiously, unlike the BLCCA conducted which must be predicated on alternate paradigms providing the same base outcome, a benefit-user economic analysis might be conducted which would take advantage of the expected increase in service life provided by regular maintenance of bridge elements.

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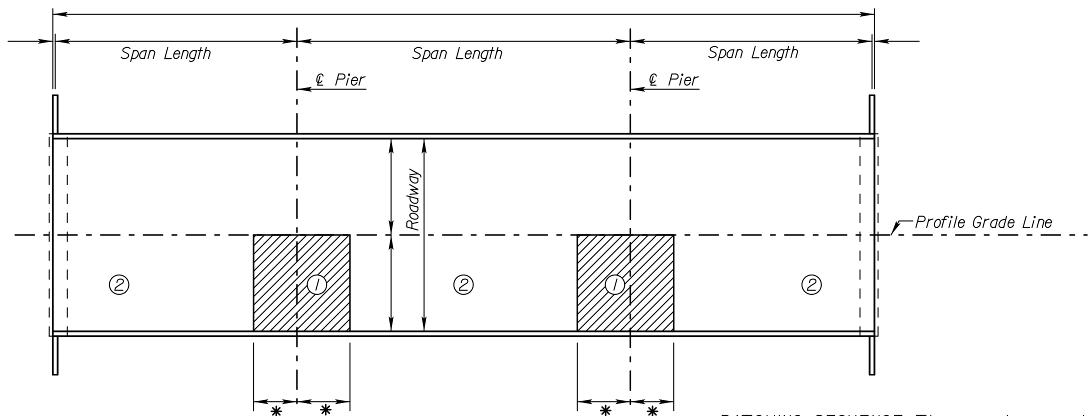
Appendix A Bridge Maintenance Standard Plans



DECK PATCHING SEQUENCE

(Showing sequence for one lane only, other lane similar)

* Span Length /4 or as directed by the Engineer.

PATCHING SEQUENCE: The concrete removal shall be completed in stages, beginning with removal of deteriorated concrete in Area ①. If more than 15 longitudinal bars in Area ① are debonded for a distance of greater than 4 ft. along the bars, the concrete removal shall stop and the patch area filled with Concrete Grade 4.0 (AE). The patch shall cure a minimum of 3 days before concrete removal resumes in that area. Following the completion of work in Area ①, concrete removal may begin in Area ②. Concrete removal shall not begin in Area ② until the patching concrete in adjacent Area ① has cured a minimum of 3 days. The maximum size of any full depth patch shall be limited to 4 ft. x 8 ft. in any direction. Fully debonded bars in Area ① shall be limited to the same 4 ft. x 8 ft. maximum patch size. All patching and BDWS concrete shall cure according to the Specifications prior to allowing traffic on that lane.

SUMMARY OF QUANTITIES

ITEM	UNITS	QUANTITY		
† Machine Preparation ( )	Sq. Yds.			
† Area Prepared for Patching	Sq. Yds.			
Area Prepared for Patching (Full Depth)	Sq. Yds.			
Silica Fume Overlay (1 ½")	Sq. Yds.			
Reinforcing Steel (Repair) (Grade 60) (Epoxy Coated) (Set Price)	Lbs.			
† Material for Silica Fume Overlay (Set Price)	Cu. Yds.			
HMA-Commercial Grade (Class A)	Tons			

† See KDOT Specifications when hydroblasting is used for machine preparation.

◪ MINIMUM REBAR SPLICE LENGTHS

Existing Bar Size	Minimum Splice Lengths (inches)	
	Existing Gr. 40 ksi Bars	Existing Gr. 60 ksi Bars
#4	12"	16"
#5	13"	20"
#6	16"	24"
#7	20"	30"
#8	26"	39"
#9	33"	49"
#10	42"	62"
#11	51"	77"

Note: If splicing epoxy coated reinforcing steel, increase the above splice lengths by 20%.

◪ Lap lengths are based on a Class B splice. Use the minimum splice length corresponding to the grade of the existing reinforcing in the deck.

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DECK PATCHING SEQUENCE (SLAB, BOX & T-GIRDER)

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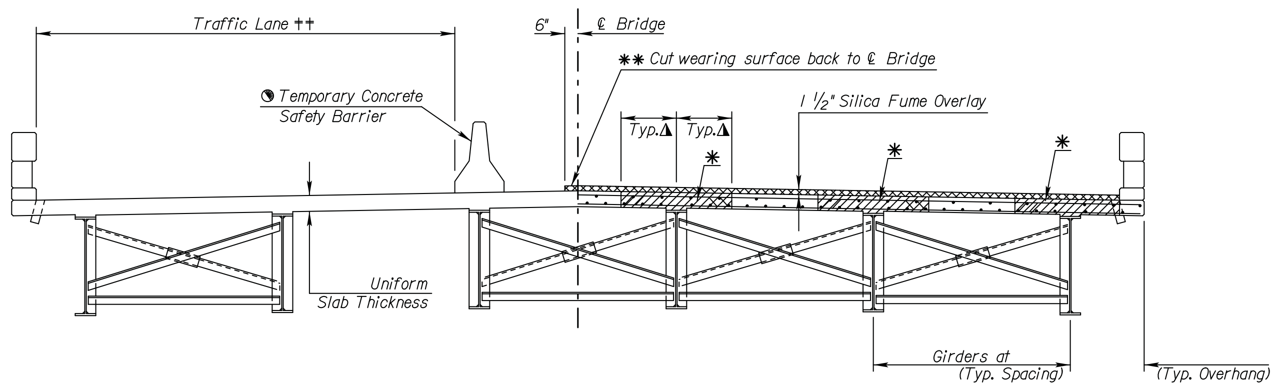
BRIDGE NO.

KANSAS DEPARTMENT OF TRANSPORTATION

Co. | PAGE



◔ The type of traffic delineator to be used is found in the traffic control sheets.

†† See "Construction Staging" sheet for traffic lane and roadway widths.

Δ Girder Spacing /4 or as directed by the Engineer.

✱✱ Note: Cutting the wearing surface back to ℄ Bridge, concrete removal, all material, equipment, and labor necessary for this item shall be <u>Subsidiary</u> to other items.

✳ PATCHING SEQUENCE: When large areas of full depth patches are needed in this area, they shall be patched in segments. The segments of full depth patch shall be a maximum of 8'-0" in length parallel to the centerline of bridge with a minimum of 8'-0" between segments. After the patches in the initial segments have cured, the areas between the segments shall be patched. The segmental patching will not be required if adequate shoring is provided to support the deck and curbs.

SUMMARY OF QUANTITIES				
ITEM	UNITS	QUANTITY		
† Machine Preparation ( )	Sq. Yds.			
† Area Prepared for Patching	Sq. Yds.			
Area Prepared for Patching (Full Depth)	Sq. Yds.			
Silica Fume Overlay (1 1/2")	Sq. Yds.			
Reinforcing Steel (Repair) (Grade 60) (Epoxy Coated) (Set Price)	Lbs.			
† Material for Silica Fume Overlay (Set Price)	Cu. Yds.			
HMA-Commercial Grade (Class A)	Tons			

† See KDOT Specifications when hydroblasting is used for machine preparation.

◪ MINIMUM REBAR SPLICE LENGTHS		
Existing Bar Size	Minimum Splice Lengths (inches)	
	Existing Gr. 40 ksi Bars	Existing Gr. 60 ksi Bars
#4	12"	16"
#5	13"	20"
#6	16"	24"
#7	20"	30"
#8	26"	39"
#9	33"	49"
#10	42"	62"
#11	51"	77"

Note: If splicing epoxy coated reinforcing steel, increase the above splice lengths by 20%.

◪ Lap lengths are based on a Class B splice. Use the minimum splice length corresponding to the grade of the existing reinforcing in the deck.

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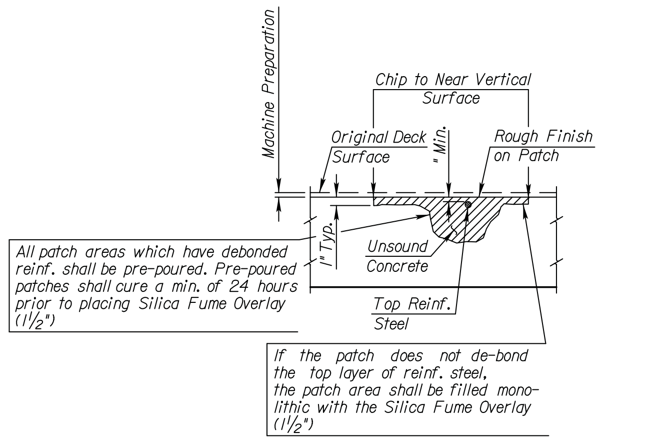
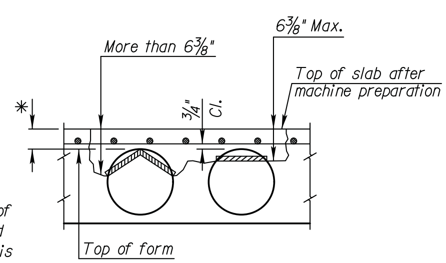
DECK PATCHING SEQUENCE (STEEL GIRDER)	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
	BRIDGE NO.	Co. PAGE





* The top of form shall be a Min. of ¾" Cl. from Reinforcing steel and a Min. of 4" from top of slab. This is typical for either form.

HOLLOW TUBE FORMING

DECK PATCHING DETAILS

MACHINE PREPARATION ( ): This item shall consist of preparing the deck for a SFO by removing concrete from the roadway surface of the bridge deck to a depth of inches. See KDOT Specifications.

AREA PREPARED FOR PATCHING: This item shall consist of removing unsound concrete and bituminous patches from the bridge deck, cleaning reinforcing bars, filling the removed patched areas with concrete and preparing the entire area of the deck for SFO. Quantity shown is an estimate of the areas involved. The exact areas shall be determined by tapping, before, during and after chipping operation to ensure that all unsound concrete has been removed. See KDOT Specifications.

FULL DEPTH PATCHING: Forms shall be provided to enable placement of concrete in areas of full depth removal of bridge slab. The forms may be suspended from existing reinforcing bars by wire ties or a method approved by the Engineer may be used. See KDOT Specifications for method of measurement and basis of payment.

REINFORCING IN BRIDGE DECK: Care should be exercised to prevent cutting, stretching or damaging exposed reinforcing steel. Extreme care should be exercised to avoid breaking the bond between the reinforcing steel and concrete where bars are partially exposed yet remain anchored in sound concrete. Reinforcing steel damaged, cut or deteriorated shall be replaced as directed by the Engineer. See table for replacement bar size and minimum splice length required. Replacement of bars damaged by the Contractor shall be subsidiary to "Area Prepared for Patching".

SILICA FUME OVERLAY: This item shall consist of cleaning the concrete surface and placing the 1½inch SFO. See KDOT Specifications.

SILICA FUME OVERLAY CONSTRUCTION JOINTS: All vertical construction joints in the overlay and the vertical joint between the overlay and the curbs shall be cleaned by sandblasting, and then painting the joints with an approved Concrete Masonry Coating 72 hours after placement of the Silica Fume Overlay.

REPAIR OF EPOXY COATED REINFORCING STEEL: Replace any epoxy coating that is removed from the reinforcing steel during the concrete removal process. Thoroughly clean damaged areas with a stiff wire brush to remove dirt and damaged coating. Apply an approved patching material in accordance with manufacturer's recommendations. Avoid dripping any patching material onto existing concrete that will have new concrete placed against it. See KDOT Specifications.

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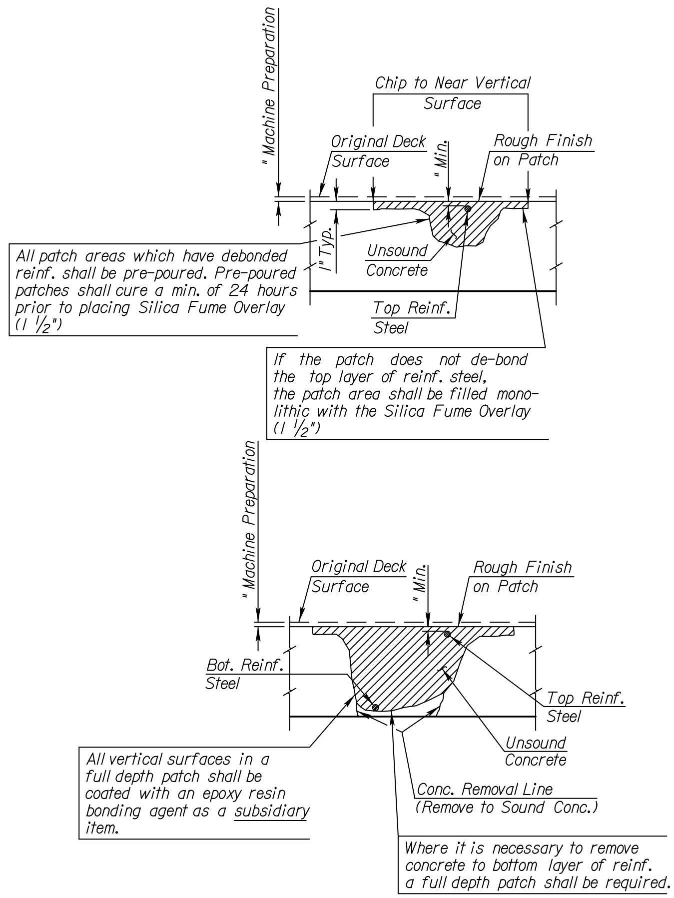
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn		
DECK PATCHING DETAILS (VOIDED SLAB)	BRIDGE NO.	Co. PAGE



DECK PATCHING DETAILS

MACHINE PREPARATION ( ): This item shall consist of preparing the deck for a SFO by removing concrete from the roadway surface of the bridge deck to a depth of inches. See KDOT Specifications.

AREA PREPARED FOR PATCHING: This item shall consist of removing unsound concrete and bituminous patches from the bridge deck, cleaning reinforcing bars, filling the removed patched areas with concrete and preparing the entire area of the deck for SFO. Quantity shown is an estimate of the areas involved. The exact areas shall be determined by tapping, before, during and after chipping operation to ensure that all unsound concrete has been removed. See KDOT Specifications.

FULL DEPTH PATCHING: Forms shall be provided to enable placement of concrete in areas of full depth removal of bridge slab. The forms may be suspended from existing reinforcing bars by wire ties or a method approved by the Engineer may be used. See KDOT Specifications for method of measurement and basis of payment.

REINFORCING IN BRIDGE DECK: Care should be exercised to prevent cutting, stretching or damaging exposed reinforcing steel. Extreme care should be exercised to avoid breaking the bond between the reinforcing steel and concrete where bars are partially exposed yet remain anchored in sound concrete. Reinforcing steel damaged, cut or deteriorated shall be replaced as directed by the Engineer. See table for replacement bar size and minimum splice length required. Replacement of bars damaged by the Contractor shall be subsidiary to "Area Prepared for Patching".

SILICA FUME OVERLAY: This item shall consist of cleaning the concrete surface and placing the $1\frac{1}{2}$inch SFO. See KDOT Specifications.

SILICA FUME OVERLAY CONSTRUCTION JOINTS: All vertical construction joints in the overlay and the vertical joint between the overlay and the curbs shall be cleaned by sandblasting, and then painting the joints with an approved Concrete Masonry Coating 72 hours after placement of the Silica Fume Overlay.

REPAIR OF EPOXY COATED REINFORCING STEEL: Replace any epoxy coating that is removed from the reinforcing steel during the concrete removal process. Thoroughly clean damaged areas with a stiff wire brush to remove dirt and damaged coating. Apply an approved patching material in accordance with manufacturer's recommendations. Avoid dripping any patching material onto existing concrete that will have new concrete placed against it. See KDOT Specifications.

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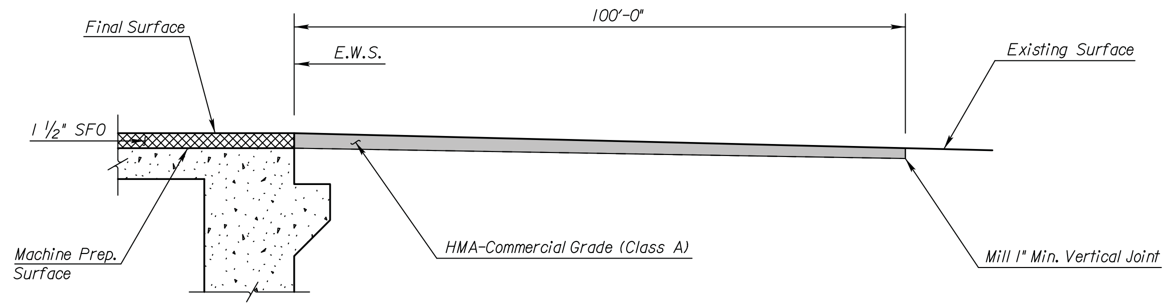
DECK PATCHING DETAILS	BRIDGE NO.	Co. / PAGE

HMA APPROACH OVERLAY: The approach and exit overlays shall be HMA-Commercial Grade (Class A) paid by the bid item designated. The overlay shall taper from the new Silica Fume Overlay in a manner that will provide a smooth transition in grade as shown. Contract quantity includes 10% for contingencies. Additional material may be required due to soft or unstable areas in the existing surface. These areas shall be repaired as needed and as directed by the Engineer. Milled material shall be disposed of in a manner and at a location approved by the Engineer.



TRANSITION AT BRIDGE ENDS

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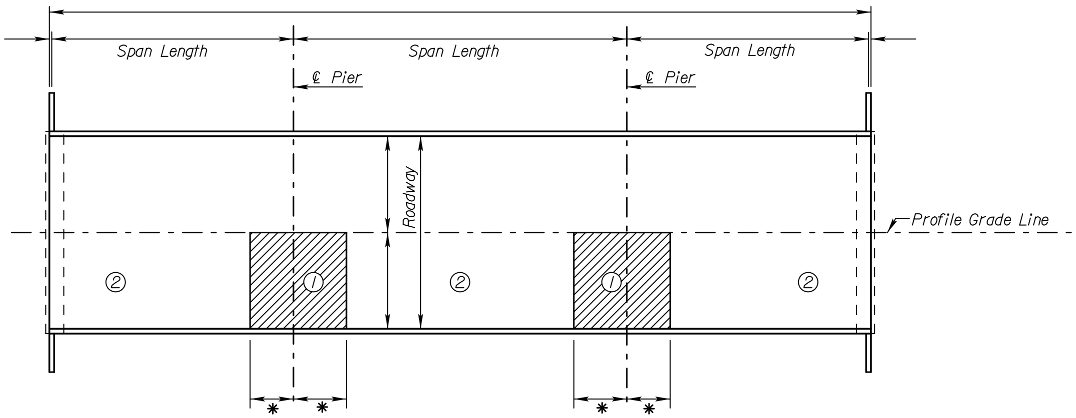
HMA APPROACH OVERLAY	BRIDGE NO.	Co. PAGE



DECK PATCHING SEQUENCE
(Showing sequence for one lane only, other lane similar)

* Span Length /4 or as directed by the Engineer.

PATCHING SEQUENCE: The concrete removal shall be completed in stages, beginning with removal of deteriorated concrete in Area ①. If more than 15 longitudinal bars in Area ① are debonded for a distance of greater than 4 ft. along the bars, the concrete removal shall stop and the patch area filled with Concrete Grade 4.0 (AE). The patch shall cure a minimum of 3 days before concrete removal resumes in that area. Following the completion of work in Area ①, concrete removal may begin in Area ②. Concrete removal shall not begin in Area ② until the patching concrete in adjacent Area ① has cured a minimum of 3 days. The maximum size of any full depth patch shall be limited to 4 ft. x 8 ft. in any direction. Fully debonded bars in Area ① shall be limited to the same 4 ft. x 8 ft. maximum patch size. All patching and BDWS concrete shall cure according to the Specifications prior to allowing traffic on that lane.

Note: Patching for this project is to be limited to the spalled surfaces of the deck or impending spalls, as determined by the Engineer. A significant portion of the existing concrete overlay may be debonded or cracked, but it is not to be removed unless spalling is imminent. No Full Depth patching is expected, but a set quantity price is to be provided in the contract.

SUMMARY OF QUANTITIES

ITEM	UNITS	QUANTITY		
Area Prepared for Patching	Sq. Yds.	10		
Area Prepared for Patching (Full Depth)	Sq. Yds.	5		
Multi-Layer Polymer Concrete Overlay	Sq. Yds.			
Reinforcing Steel (Repair) (Grade 60) (Epoxy Coated) (Set Price)	Lbs.	1		

◪ MINIMUM REBAR SPLICE LENGTHS

Existing Bar Size	Minimum Splice Lengths (inches)	
	Existing Gr. 40 ksi Bars	Existing Gr. 60 ksi Bars
#4	12"	16"
#5	13"	20"
#6	16"	24"
#7	20"	30"
#8	26"	39"
#9	33"	49"
#10	42"	62"
#11	51"	77"

Note: If splicing epoxy coated reinforcing steel, increase the above splice lengths by 20%.

◪ Lap lengths are based on a Class B splice. Use the minimum splice length corresponding to the grade of the existing reinforcing in the deck.

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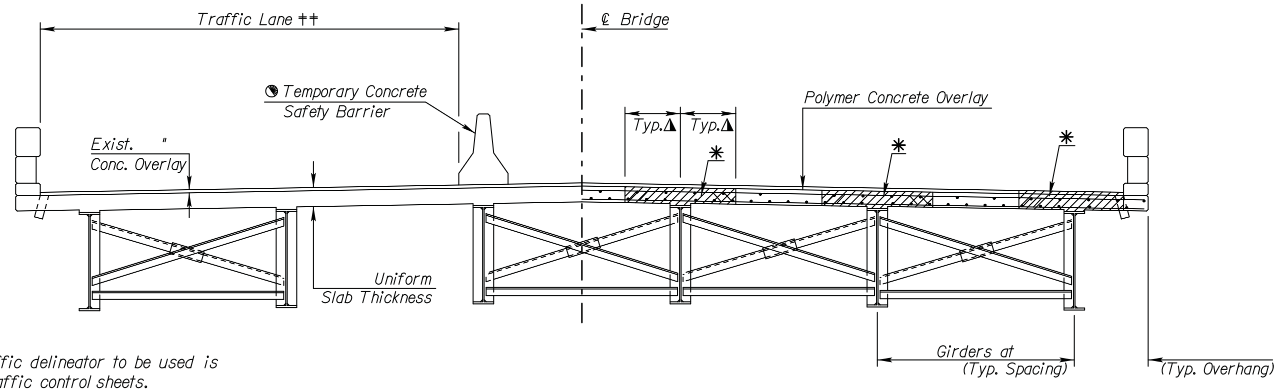
DECK PATCHING SEQUENCE (POLYMER CONCRETE OVERLAY)		BRIDGE NO.

KANSAS DEPARTMENT OF TRANSPORTATION

Co. | PAGE



◔ The type of traffic delineator to be used is found in the traffic control sheets.

†† See "Construction Staging" sheet for traffic lane and roadway widths.

Δ Girder Spacing /4 or as directed by the Engineer.

✱ PATCHING SEQUENCE: When large areas of full depth patches are needed in this area, they shall be patched in segments. The segments of full depth patch shall be a maximum of 8'-0" in length parallel to the centerline of bridge with a minimum of 8'-0" between segments. After the patches in the initial segments have cured, the areas between the segments shall be patched. The segmental patching will not be required if adequate shoring is provided to support the deck and curbs.

Note: Patching for this project is to be limited to the spalled surfaces of the deck or impending spalls, as determined by the Engineer. A significant portion of the existing concrete overlay may be debonded or cracked, but it is not to be removed unless spalling is imminent. No Full Depth patching is expected, but a set quantity price is to be provided in the contract.

SUMMARY OF QUANTITIES				
ITEM	UNITS	QUANTITY		
Area Prepared for Patching	Sq. Yds.	10		
Area Prepared for Patching (Full Depth)	Sq. Yds.	5		
Multi-Layer Polymer Concrete Overlay	Sq. Yds.			
Reinforcing Steel (Repair) (Grade 60) (Epoxy Coated) (Set Price)	Lbs.	1		

◪ MINIMUM REBAR SPLICE LENGTHS		
Existing Bar Size	Minimum Splice Lengths (inches)	
	Existing Gr. 40 ksi Bars	Existing Gr. 60 ksi Bars
#4	12"	16"
#5	13"	20"
#6	16"	24"
#7	20"	30"
#8	26"	39"
#9	33"	49"
#10	42"	62"
#11	51"	77"

Note: If splicing epoxy coated reinforcing steel, increase the above splice lengths by 20%.

◪ Lap lengths are based on a Class B splice. Use the minimum splice length corresponding to the grade of the existing reinforcing in the deck.

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DECK PATCHING SEQUENCE (POLYMER CONCRETE OVERLAY)

PROJ. NO.

BRIDGE NO.

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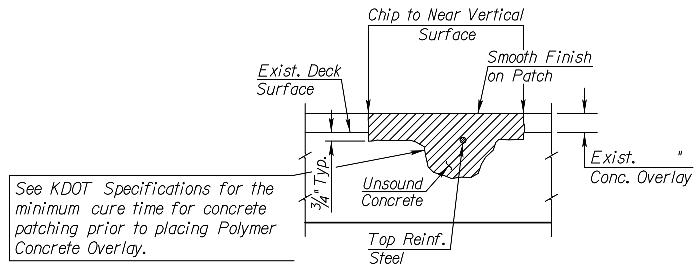
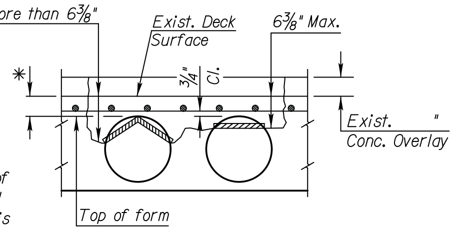
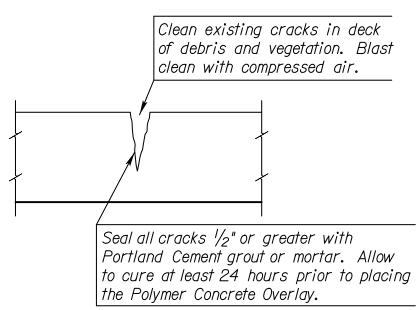




* The top of form shall be a Min. of ¾" Cl. from Reinforcing steel and a Min. of 4" from top of slab. This is typical for either form.

HOLLOW TUBE FORMING

DECK PATCHING DETAILS



CRACK SEALING DETAIL

AREA PREPARED FOR PATCHING: This item shall consist of removing unsound concrete and bituminous patches from the bridge deck, cleaning reinforcing bars, filling the removed patched areas with concrete and preparing the entire area of the deck for Polymer Concrete Overlay. Quantity shown is an estimate of the areas involved. The exact area shall be determined by tapping, before, during and after chipping operation to ensure that all unsound concrete has been removed. See KDOT Specifications. Areas to be patched will be determined by the Engineer.

FULL DEPTH PATCHING: Forms shall be provided to enable placement of concrete in areas of full depth removal of bridge slab. The forms may be suspended from existing reinforcing bars by wire ties or a method approved by the Engineer may be used. See KDOT Specifications for method of measurement and basis of payment.

REINFORCING IN BRIDGE DECK: Care should be exercised to prevent cutting, stretching or damaging exposed reinforcing steel. Extreme care should be exercised to avoid breaking the bond between the reinforcing steel and concrete where bars are partially exposed yet remain anchored in sound concrete. Reinforcing steel damaged, cut or deteriorated shall be replaced as directed by the Engineer. See table for replacement bar size and minimum splice length required. Replacement of bars damaged by the Contractor shall be subsidiary to "Area Prepared for Patching".

MULTI-LAYER POLYMER CONCRETE OVERLAY: Prepare and overlay the bridge roadway surface using a Polymer Concrete Overlay (Two-Coat Broom and Seed).
On bridges with corral rail, apply epoxy to the traffic face on interior post(s) to the bottom of the top rail and the two adjacent surfaces.
On bridges with corral rail without curb, apply a Polymer Concrete Overlay (Two-Coat Broom and Seed) to the outer edge of the bridge deck between the posts.
On bridges with corral rail with curb, apply the epoxy on the face of curbs to the top of the curb.
On bridges with continuous concrete barrier rails, apply the epoxy to the first break in the geometry of the barrier to a minimum height of 6 inches above the deck. Apply epoxy to the curb, barrier or post(s) as each of the overlay applications are performed.
All work related to applying epoxy to additional areas beyond the bridge roadway surface width shall be subsidiary to the bid item Multi-Layer Polymer Concrete Overlay.

REPAIR OF EPOXY COATED REINFORCING STEEL: Replace any epoxy coating that is removed from the reinforcing steel during the concrete removal process. Thoroughly clean damaged areas with a stiff wire brush to remove dirt and damaged coating. Apply an approved patching material in accordance with manufacturer's recommendations. Avoid dripping any patching material onto existing concrete that will have new concrete placed against it. See KDOT Specifications.

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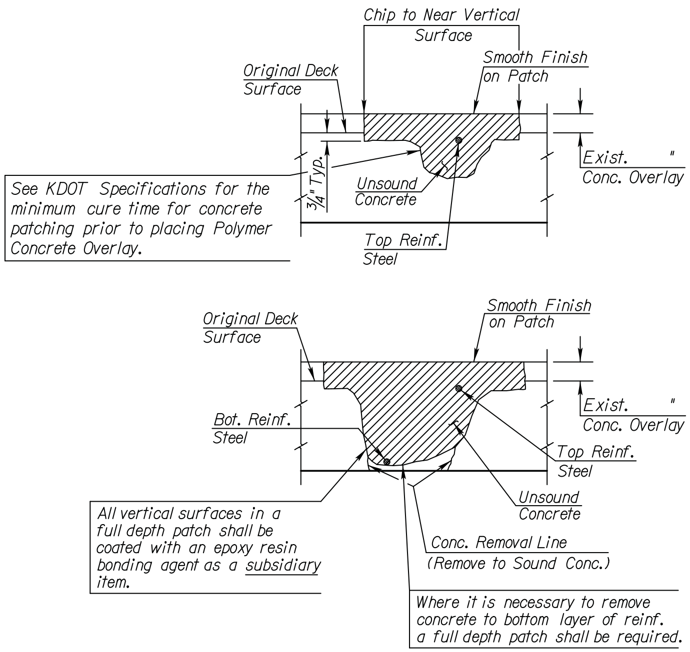
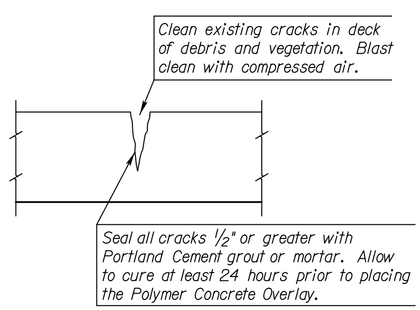
DECK PATCHING DETAILS (POLYMER CONCRETE OVERLAY)	BRIDGE NO.	Co. | PAGE



DECK PATCHING DETAILS



CRACK SEALING DETAIL

AREA PREPARED FOR PATCHING: This item shall consist of removing unsound concrete and bituminous patches from the bridge deck, cleaning reinforcing bars, filling the removed patched areas with concrete and preparing the entire area of the deck for Polymer Concrete Overlay. Quantity shown is an estimate of the areas involved. The exact area shall be determined by tapping, before, during and after chipping operation to ensure that all unsound concrete has been removed. See KDOT Specifications. Areas to be patched will be determined by the Engineer.

FULL DEPTH PATCHING: Forms shall be provided to enable placement of concrete in areas of full depth removal of bridge slab. The forms may be suspended from existing reinforcing bars by wire ties or a method approved by the Engineer may be used. See KDOT Specifications for method of measurement and basis of payment.

REINFORCING IN BRIDGE DECK: Care should be exercised to prevent cutting, stretching or damaging exposed reinforcing steel. Extreme care should be exercised to avoid breaking the bond between the reinforcing steel and concrete where bars are partially exposed yet remain anchored in sound concrete. Reinforcing steel damaged, cut or deteriorated shall be replaced as directed by the Engineer. See table for replacement bar size and minimum splice length required. Replacement of bars damaged by the Contractor shall be subsidiary to "Area Prepared for Patching".

MULTI-LAYER POLYMER CONCRETE OVERLAY: Prepare and overlay the bridge roadway surface using a Polymer Concrete Overlay (Two-Coat Broom and Seed).
On bridges with corral rail, apply epoxy to the traffic face on interior post(s) to the bottom of the top rail and the two adjacent surfaces.
On bridges with corral rail without curb, apply a Polymer Concrete Overlay (Two-Coat Broom and Seed) to the outer edge of the bridge deck between the posts.
On bridges with corral rail with curb, apply the epoxy on the face of curbs to the top of the curb.
On bridges with continuous concrete barrier rails, apply the epoxy to the first break in the geometry of the barrier to a minimum height of 6 inches above the deck.
Apply epoxy to the curb, barrier or post(s) as each of the overlay applications are performed.
All work related to applying epoxy to additional areas beyond the bridge roadway surface width shall be subsidiary to the bid item Multi-Layer Polymer Concrete Overlay.

REPAIR OF EPOXY COATED REINFORCING STEEL: Replace any epoxy coating that is removed from the reinforcing steel during the concrete removal process. Thoroughly clean damaged areas with a stiff wire brush to remove dirt and damaged coating. Apply an approved patching material in accordance with manufacturer's recommendations. Avoid dripping any patching material onto existing concrete that will have new concrete placed against it. See KDOT Specifications.

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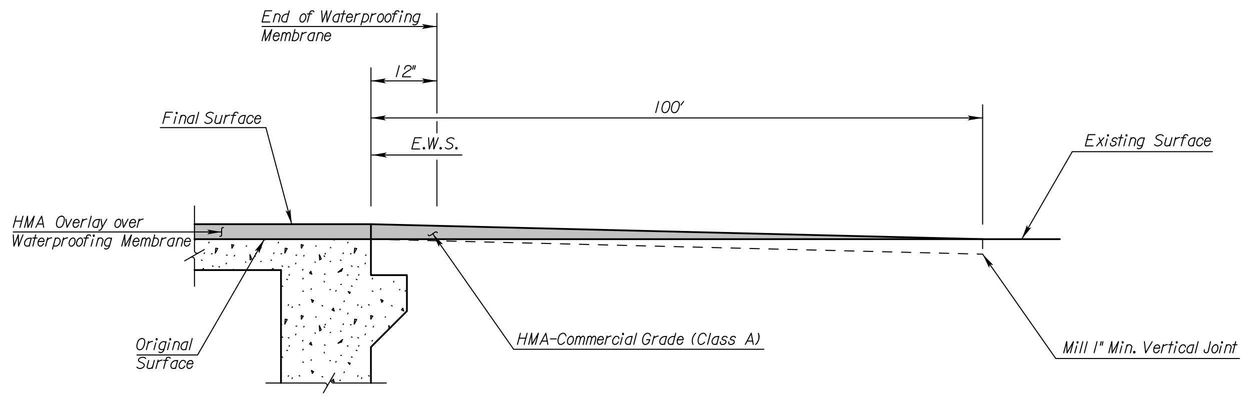
DECK PATCHING DETAILS (POLYMER CONCRETE OVERLAY)	BRIDGE NO.	Co. / PAGE

HMA APPROACH OVERLAY: The overlay shall taper from the new HMA Overlay in a manner that will provide a smooth transition in grade as shown. Additional material may be required due to soft or unstable areas in the existing surface. These areas shall be repaired as needed and as directed by the Engineer. Milled material shall be disposed of in a manner and at a location approved by the Engineer.



TRANSITION AT BRIDGE ENDS

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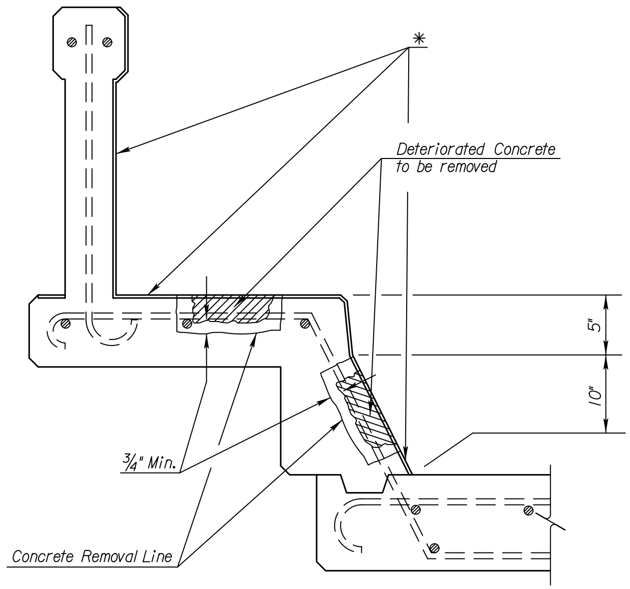
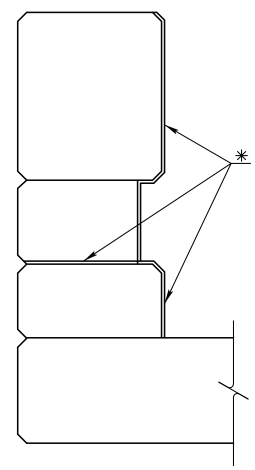
HMA APPROACH OVERLAY FOR BRIDGE DECK WATERPROOFING	BRIDGE NO.	Co. | PAGE



TYPICAL CURB REPAIR



CURB REPAIR: The Contractor shall remove all deteriorated concrete delineated by the Engineer. Additional concrete shall be removed to create minimum thickness of the new concrete of 1 inch. The concrete, at repair locations, shall be removed from around the reinforcing steel near the face of the curb to allow a positive bond of new concrete to the existing structure. Concrete Grade 4.0 (AE) or an approved Shotcrete shall be used. Prior to its placement, an epoxy resin, for bonding new concrete to existing concrete, shall be used. The removal of deteriorated concrete, placement of new concrete, and all labor, materials, equipment, and incidentals necessary to complete the repairs of the curbs, shall be paid for as "Bridge Curb Repair" (Lin. Ft.).

* These areas to be sandblasted to remove loose disintegrated concrete, dirt, oil, and any foreign material along the entire length of the curb and rail. Apply an approved Concrete Masonry Coating to the top of the curb and the traffic face of the curb and rail along the entire length of the curb and rail. This work shall conform to KDOT specifications. This shall all be Subsidiary "Bridge Curb Repair".

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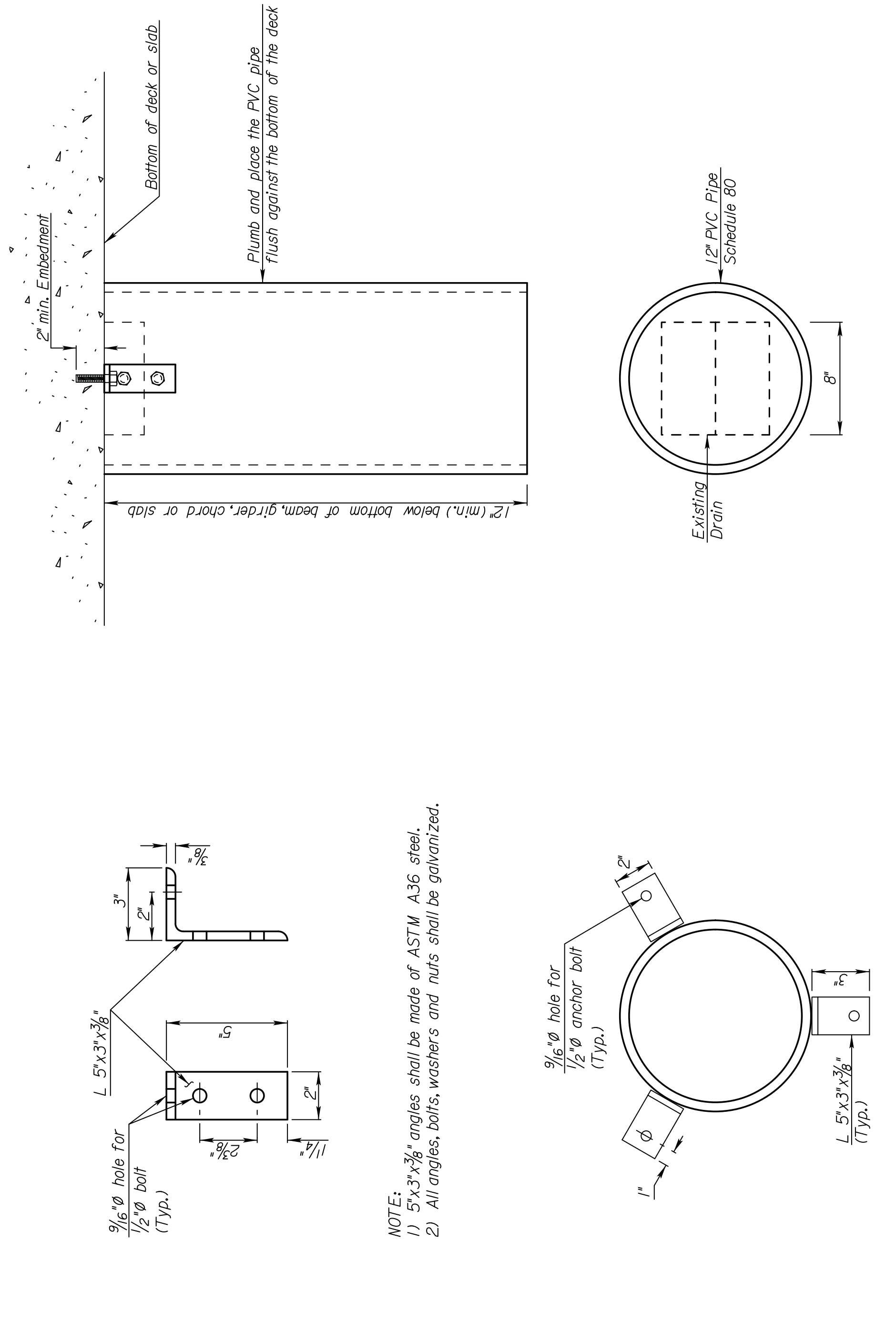
CURB REPAIR	BRIDGE NO.	Co. / PAGE



NOTE:
1) 5"x3"x3/8" angles shall be made of ASTM A36 steel.
2) All angles, bolts, washers and nuts shall be galvanized.

PVC DRAIN PIPE AND ATTACHMENT DETAIL

—— Required per Bid Item "Bridge Deck Drain Extension" (See KDOT Specifications)

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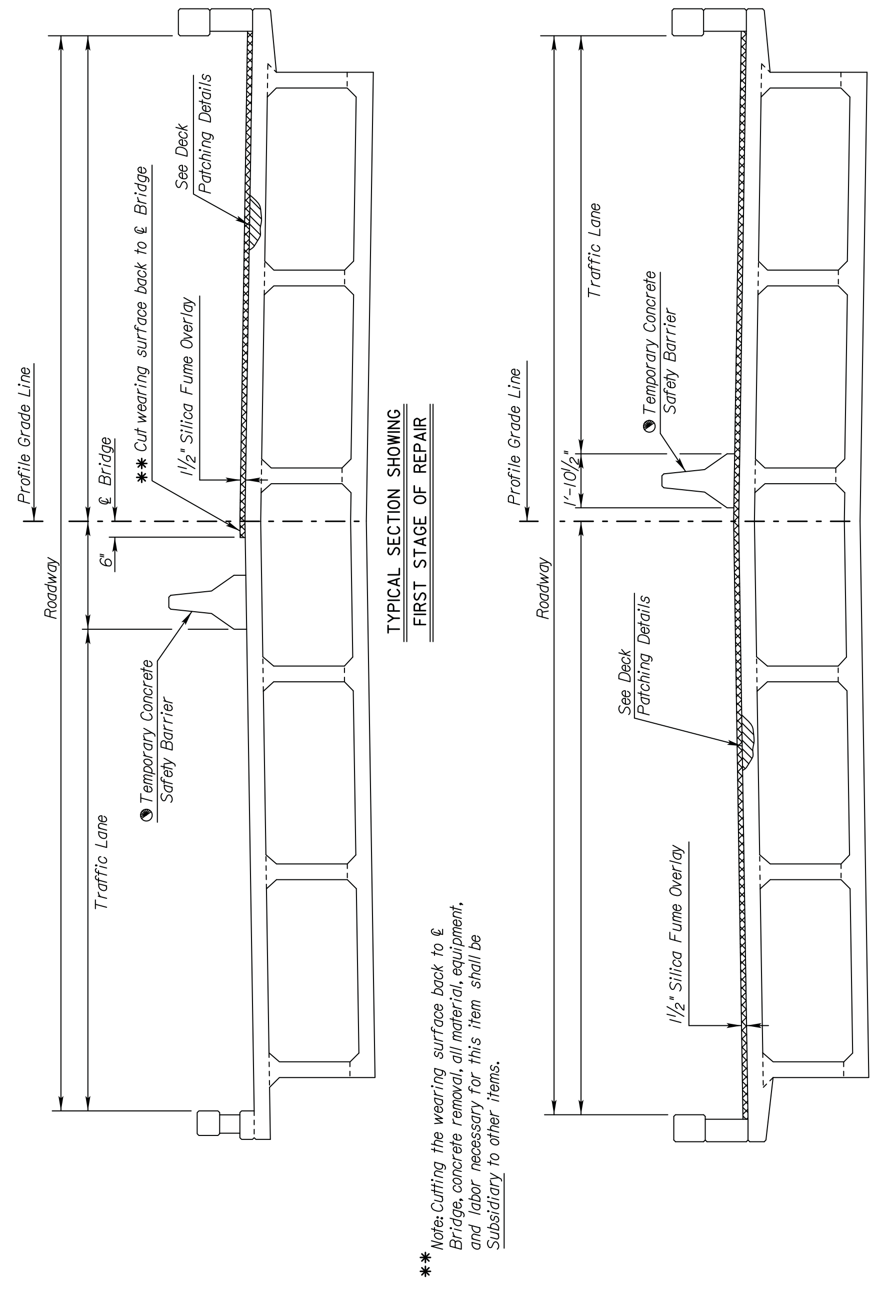
PVC DRAIN PIPE AND ATTACHMENT	BRIDGE NO.	Co. PAGE



TYPICAL SECTION SHOWING
FIRST STAGE OF REPAIR

TYPICAL SECTION SHOWING
SECOND STAGE OF REPAIR

✱✱ Note: Cutting the wearing surface back to ℄ Bridge, concrete removal, all material, equipment, and labor necessary for this item shall be Subsidiary to other items.

◔ The type of traffic delineator to be used is found in the traffic control sheets.

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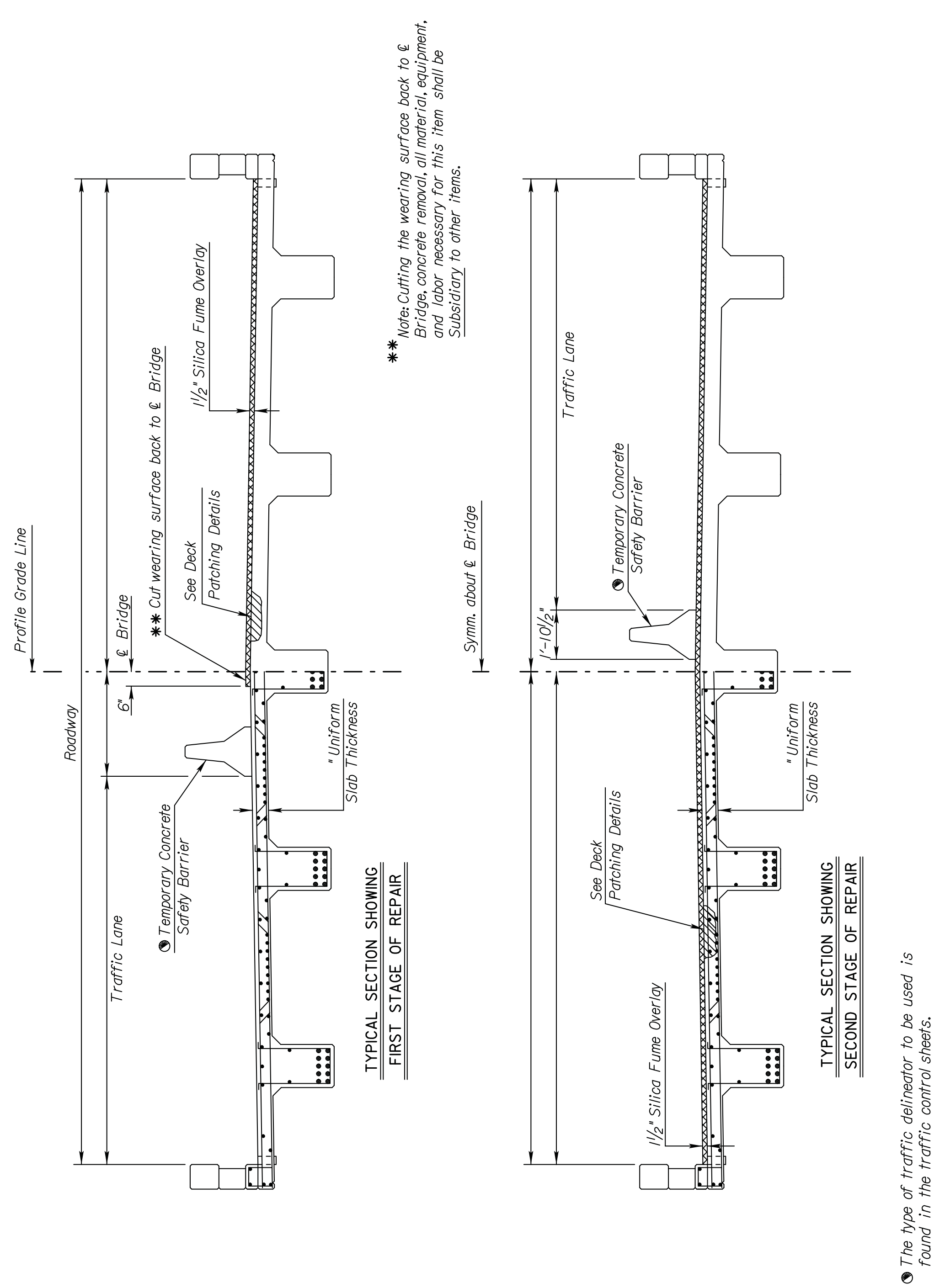
CONSTRUCTION STAGING (BOX GIRDER)		BRIDGE NO.	Co. PAGE



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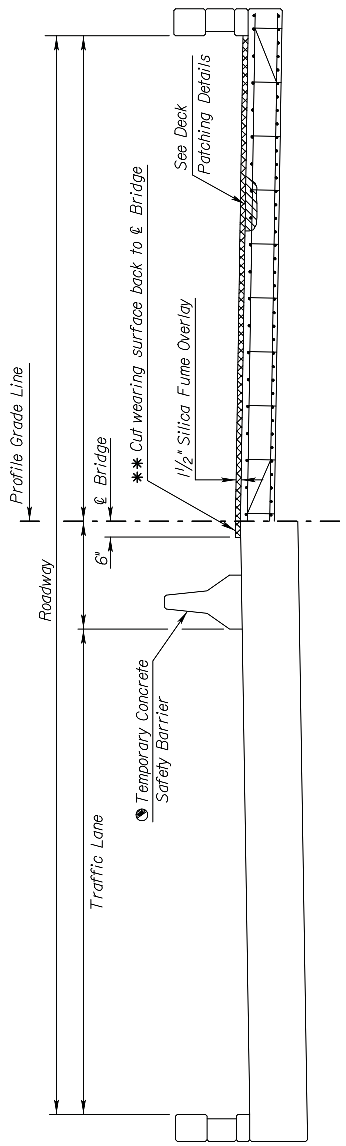
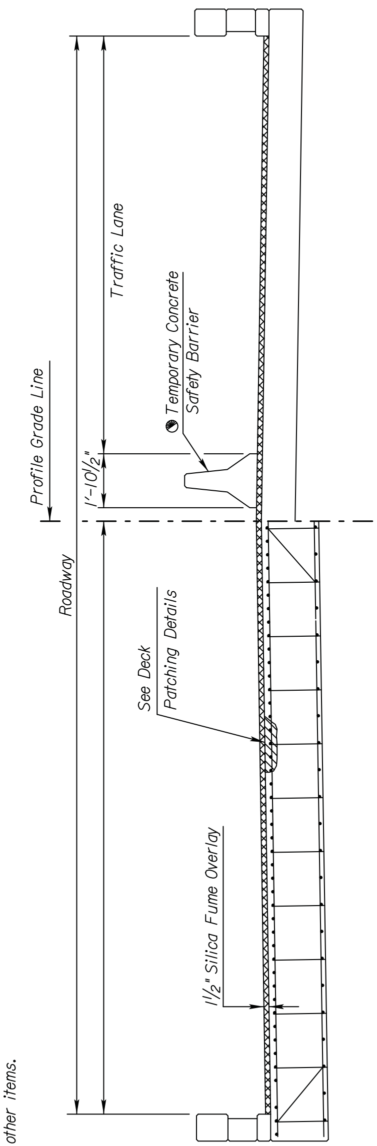
CONSTRUCTION STAGING (T-GIRDER)	BRIDGE NO.	Co.	PAGE



TYPICAL SECTION SHOWING
FIRST STAGE OF REPAIR

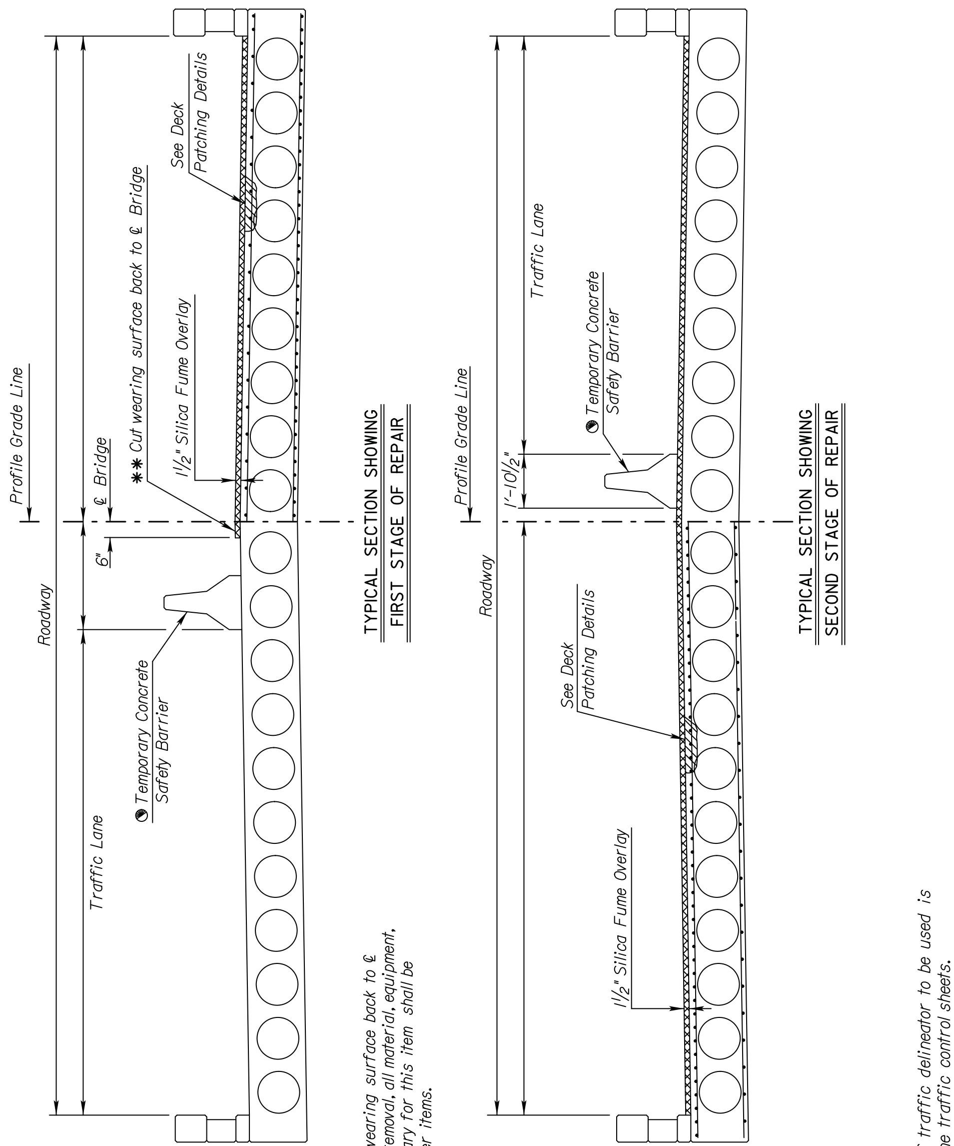


TYPICAL SECTION SHOWING
SECOND STAGE OF REPAIR

✱✱ Note: Cutting the wearing surface back to ℄ Bridge, concrete removal, all material, equipment, and labor necessary for this item shall be Subsidiary to other items.

◔ The type of traffic delineator to be used is found in the traffic control sheets.

Plot Date : 22-MAR-2012 16:03	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
CONSTRUCTION STAGING (HAUNCHED SLAB)		BRIDGE NO.	Co. PAGE



TYPICAL SECTION SHOWING
FIRST STAGE OF REPAIR

TYPICAL SECTION SHOWING
SECOND STAGE OF REPAIR

✱✱ Note: Cutting the wearing surface back to ℄ Bridge, concrete removal, all material, equipment, and labor necessary for this item shall be Subsidiary to other items.

◔ The type of traffic delineator to be used is found in the traffic control sheets.

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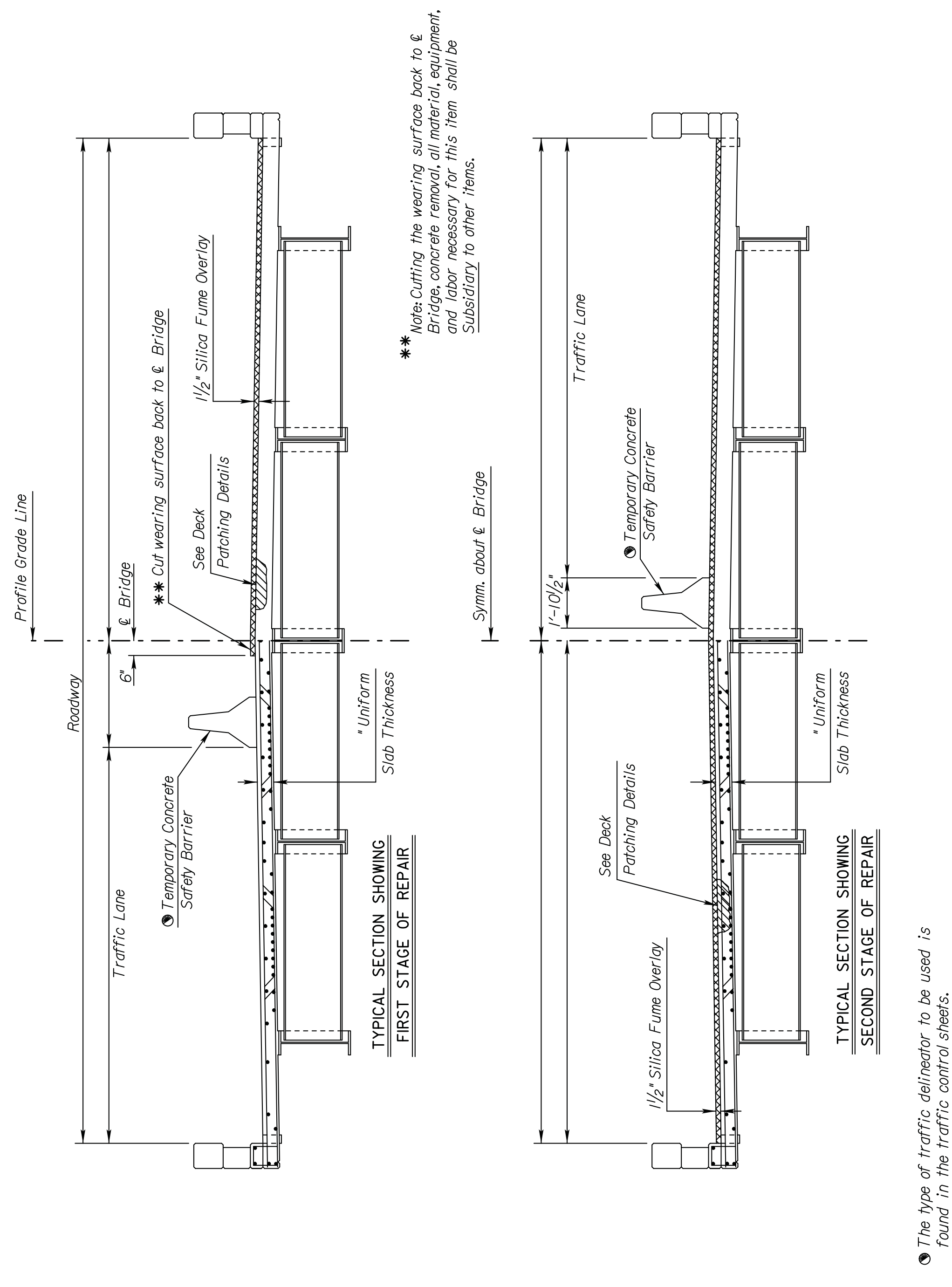
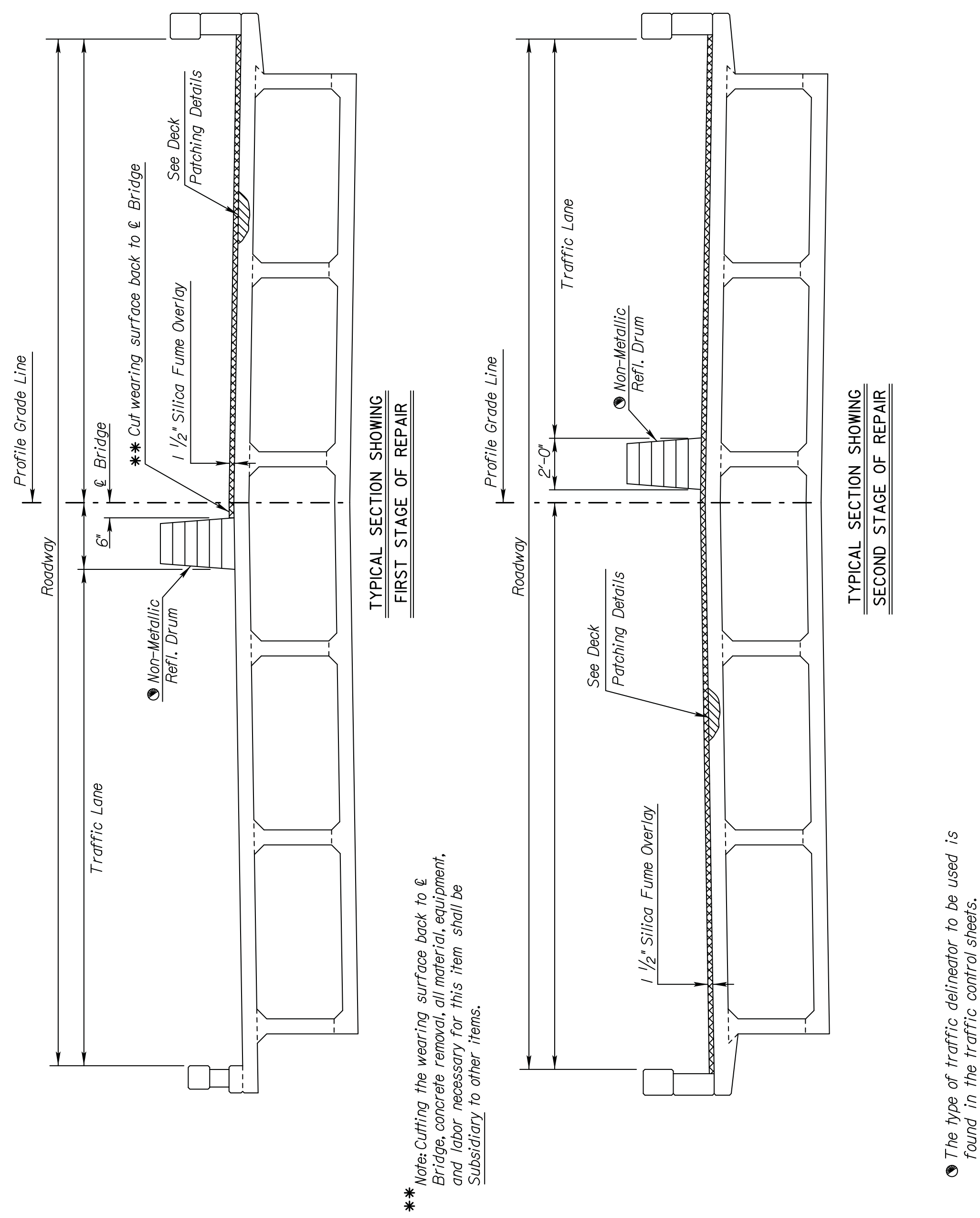
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn				
CONSTRUCTION STAGING (VOIDED SLAB)		BRIDGE NO.	Co.	PAGE



Plot Date : 22-MAR-2012 16:03 — Squad: BR. MAINT. STD. Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
CONSTRUCTION STAGING (STEEL GIRDER)	BRIDGE NO.	Co. | PAGE



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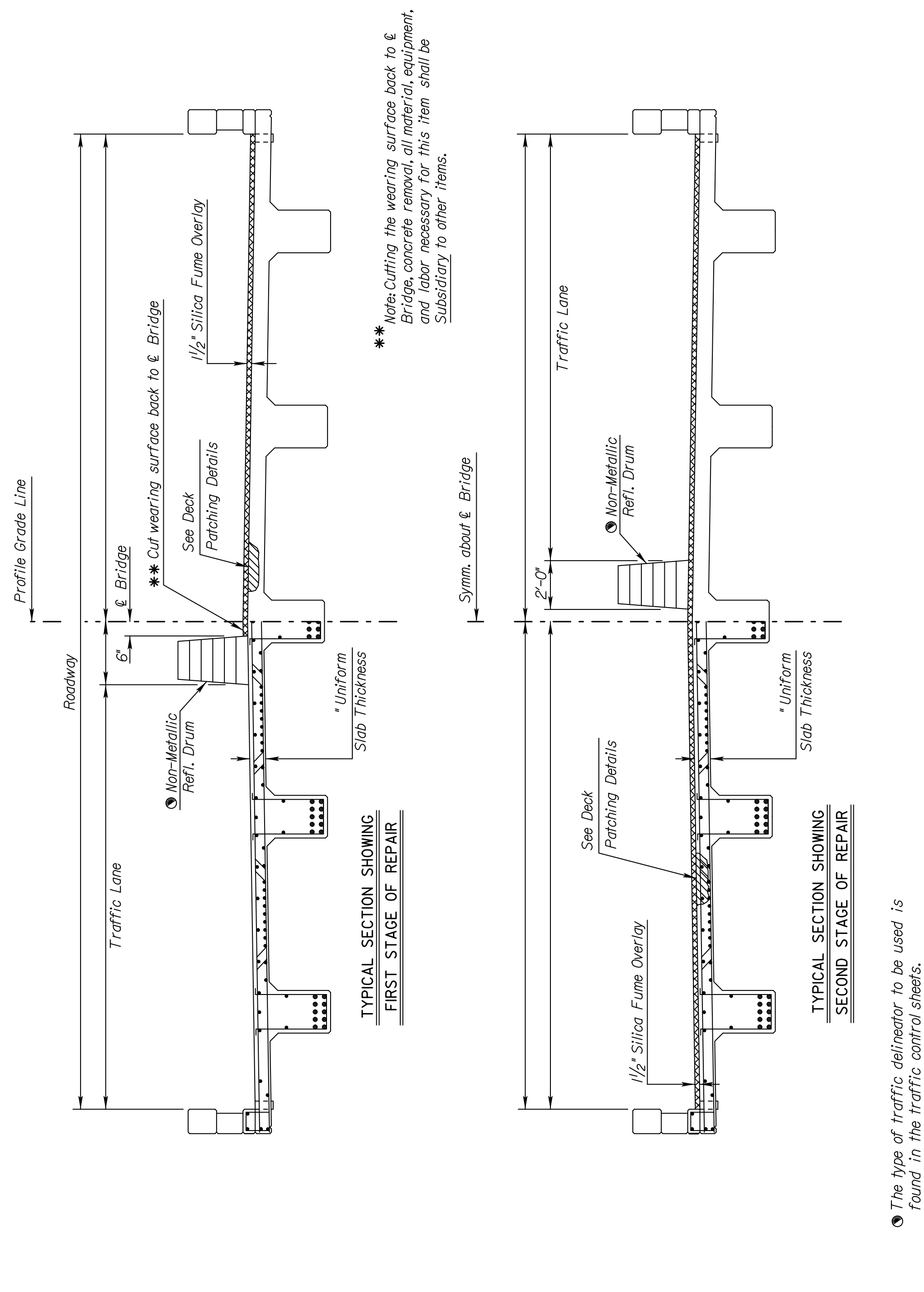
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
CONSTRUCTION STAGING (BOX GIRDER) (Non Interstate)		BRIDGE NO.	Co. PAGE



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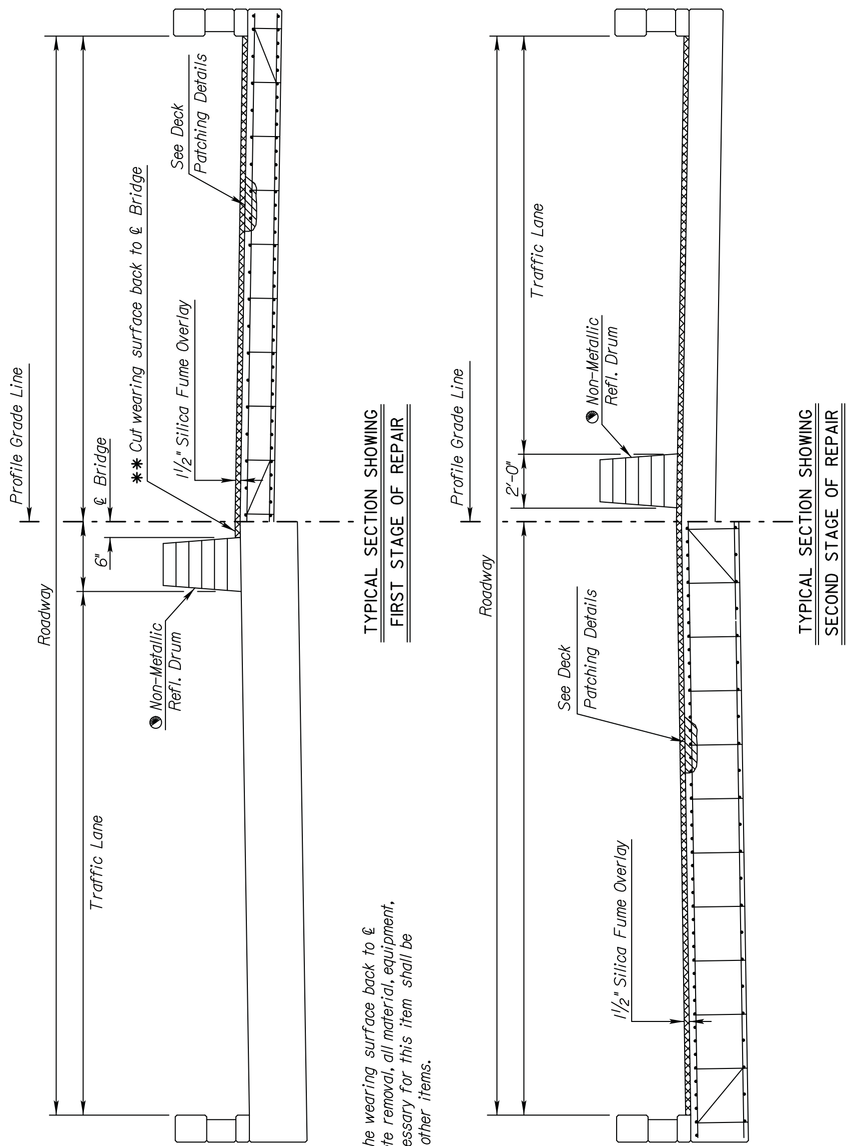
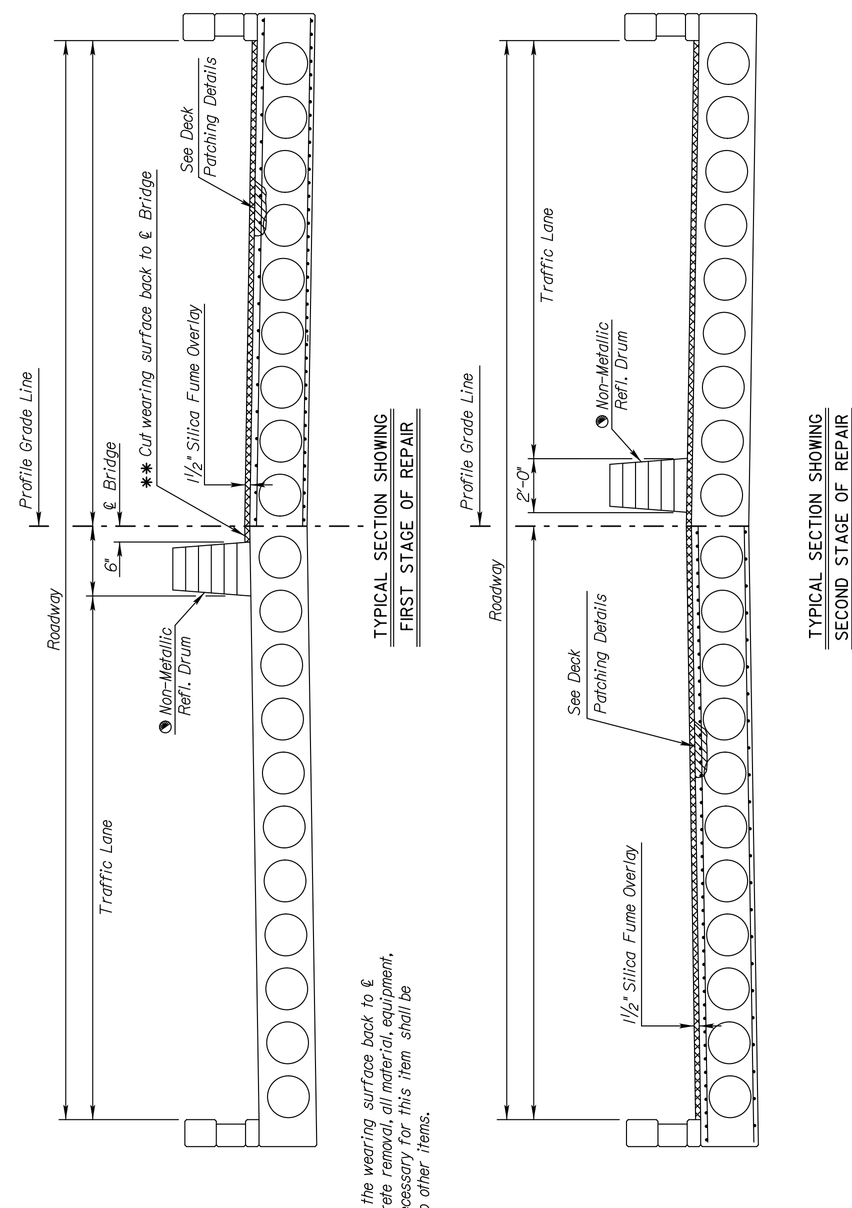
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
CONSTRUCTION STAGING (T-GIRDER) (Non Interstate)		BRIDGE NO.	Co. PAGE



✱✱ Note: Cutting the wearing surface back to ℄ Bridge, concrete removal, all material, equipment, and labor necessary for this item shall be Subsidiary to other items.

◔ The type of traffic delineator to be used is found in the traffic control sheets.

Plot Date : 22-MAR-2012 16:04 / Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
CONSTRUCTION STAGING (HAUNCHED SLAB) (Non Interstate)		BRIDGE NO.	Co. / PAGE



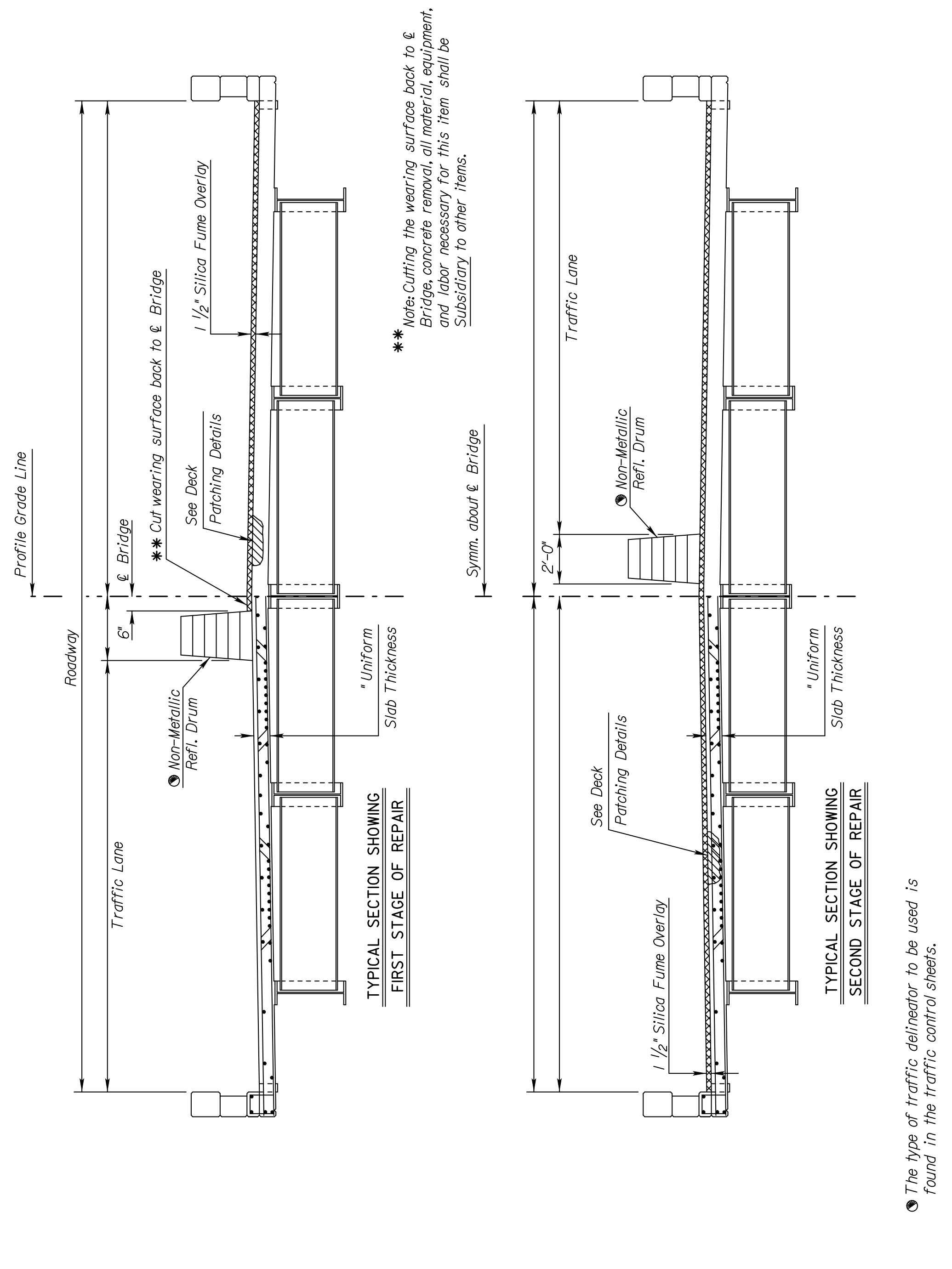
TYPICAL SECTION SHOWING FIRST STAGE OF REPAIR

TYPICAL SECTION SHOWING SECOND STAGE OF REPAIR

** Note: Cutting the wearing surface back to ℄ Bridge, concrete removal, all material, equipment, and labor necessary for this item shall be Subsidiary to other items.

◔ The type of traffic delineator to be used is found in the traffic control sheets.

Plot Date : 22-MAR-2012 16:04 / Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
CONSTRUCTION STAGING (VOIDED SLAB) (Non Interstate)		BRIDGE NO.	Co. PAGE



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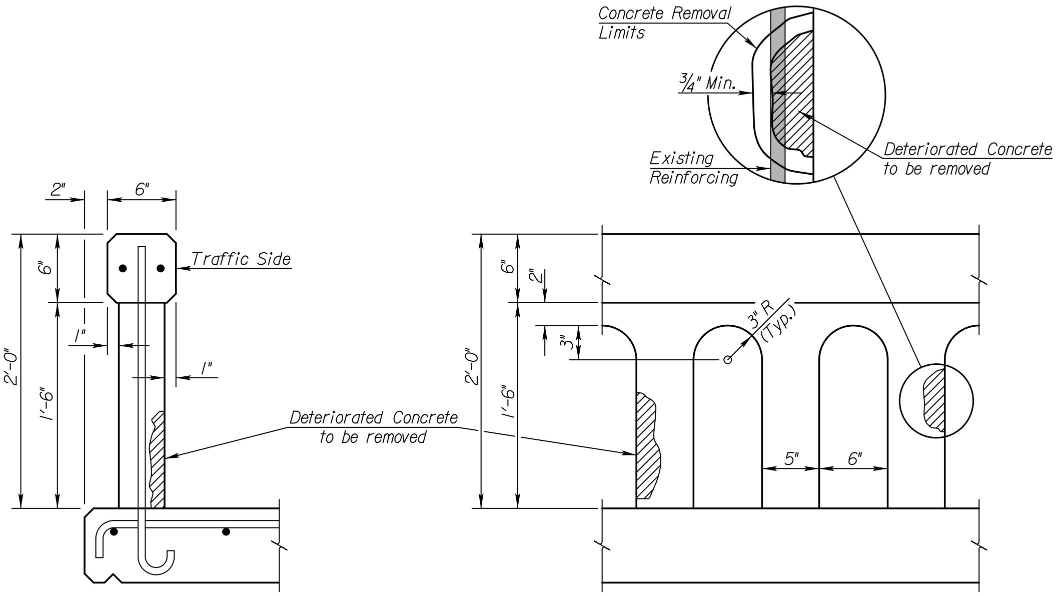
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
CONSTRUCTION STAGING (STEEL GIRDER) (Non Interstate)		BRIDGE NO.	Co. PAGE



SECTION

ELEVATION

EXISTING RAIL AND POST DETAILS

RAIL AND POST REPAIR: The Contractor shall remove all deteriorated concrete delineated by the Engineer. Additional concrete shall be removed to create minimum thickness of new concrete of 1 inch. The concrete, at repair locations, shall be removed from around the reinforcing steel near the surface of the post to allow a positive bond of new concrete to the existing structure. Concrete Grade 4.0 (AE) shall be used. Prior to its placement, an epoxy resin, for bonding new concrete to existing concrete, shall be used. The removal of deteriorated concrete, placement of new concrete, and all labor, materials, equipment, and incidentals necessary to complete the repairs shall be paid for as "Rail and Post Repair" (Lin. Ft.).

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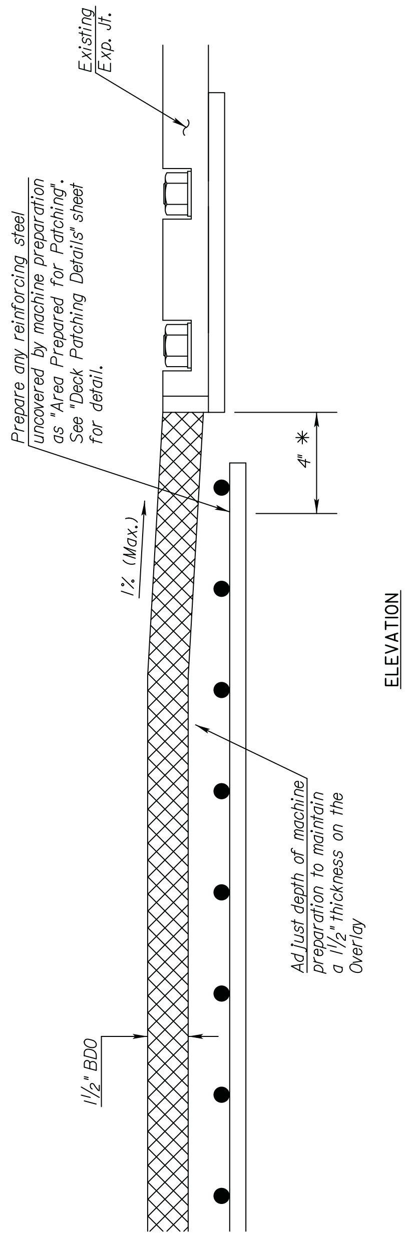
TYPICAL RAIL AND POST REPAIR DETAILS		BRIDGE NO.	Co. PAGE



* Note: Prepare the deck immediately adjacent to existing Joint armor by hand work. Use a maximum of a 25# air hammer. This work is subsidiary to the bid item "Machine Preparation".

Note: This detail is only valid for existing finger plate or armored bridge expansion joints. Do not debond any existing elastomeric concrete block-outs.

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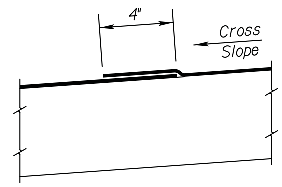
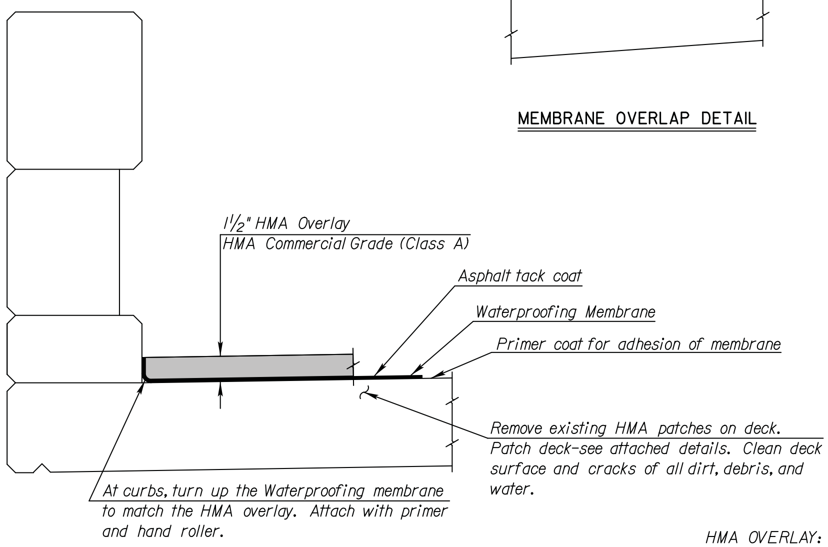
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
BRIDGE DECK OVERLAY AT EXISTING EXPANSION JOINTS		BRIDGE NO.	Co. PAGE

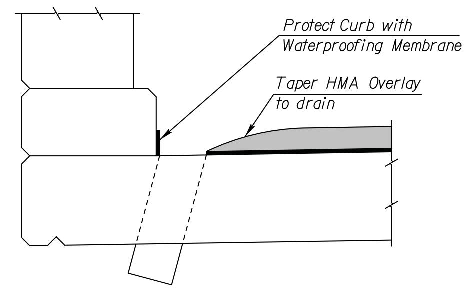


MEMBRANE OVERLAP DETAIL

BRIDGE INFORMATION	
Bridge	
Structure Type	
Spans	
Bridge Length	
Roadway	
Curb Length (one side)	
Skew	
Curvature	
Number of Deck Drains	



BRIDGE DECK WATERPROOFING



DETAIL AT DECK DRAINS

HMA OVERLAY: Place a 1½" overlay of HMA Commercial Grade (Class A) over the Pavement Waterproofing Membrane as shown. Use a tack coat compatible with the HMA Commercial Grade (Class A) surfacing and the Pavement Waterproofing Membrane. The tack coat is <u>subsidiary</u> to other bid items. Contract quantities include 10% for contingencies.

BRIDGE DECK WATERPROOFING: This work consist of cleaning the bridge deck surface, applying a primer, and placing a Pavement Waterproofing Membrane. Place the membrane 12" past the EWS onto the approach at each end of the bridge and from curb to curb or edge of deck to edge of deck. Lay the membrane parallel to the longitudinal ℄ of the bridge. Place membrane panels starting at the low side of the deck. Overlap in the direction of water runoff. See KDOT Specifications.

LIMIT DECK PATCHING: Take care to limit concrete patching to only that required for the structural integrity of the deck. Use a maximum of a 15 lb. air hammer for concrete removal unless given written authorization otherwise by the Engineer. The Engineer will designate all areas for concrete removal. Take care to limit full depth patching to areas with significant, existing full depth deterioration of the deck concrete.

PAY QUANTITIES: The pay quantity for "Pavement Waterproofing Membrane" is based on 36" rolls overlapping as detailed.

SUMMARY OF QUANTITIES				
ITEM	UNITS	QUANTITY		
Pavement Waterproofing Membrane (36")	ft.			
Area Prepared for Patching	sq. yds.			
Area Prep. for Patching (Full Depth)	sq. yds.			
Reinforcing Steel (Gr. 60) (Set)	lbs.			
Concrete Grade 4.0 (Set)	cu. yds.			
HMA Commercial Grade (Class A)	tons			

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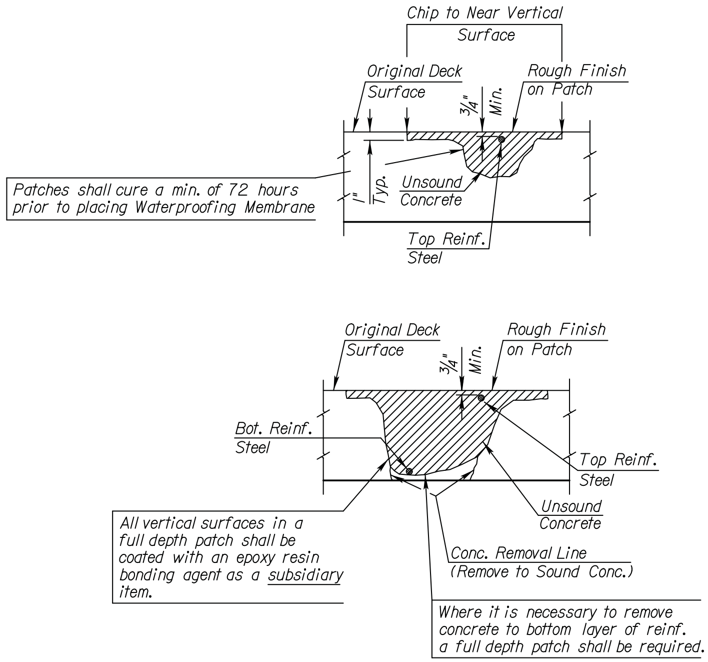
BRIDGE DECK WATERPROOFING

PROJ. NO.

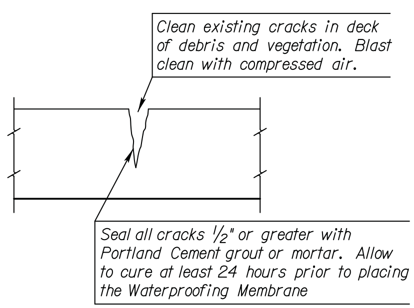
BRIDGE NO.

KANSAS DEPARTMENT OF TRANSPORTATION

Co. PAGE



DECK PATCHING DETAILS



CRACK SEALING DETAIL

AREA PREPARED FOR PATCHING: This item shall consist of removing unsound concrete and bituminous patches from the bridge deck, cleaning reinforcing bars, filling the removed patched areas and cracks ($\frac{1}{2}$" or greater) with concrete, and preparing the entire area of the deck for Waterproofing Membrane. Quantity shown is an estimate of the areas involved. The exact areas shall be determined by tapping. See KDOT Specifications.

FULL DEPTH PATCHING: Forms shall be provided to enable placement of concrete in areas of full depth removal of bridge slab. The forms may be suspended from existing reinforcing bars by wire ties or a method approved by the Engineer may be used. See KDOT Specifications for method of measurement and basis of payment.

REINFORCING IN BRIDGE DECK: Care should be exercised to prevent cutting, stretching or damaging exposed reinforcing steel. Extreme care should be exercised to avoid breaking the bond between the reinforcing steel and concrete where bars are partially exposed yet remain anchored in sound concrete. Reinforcing steel damaged, cut or deteriorated shall be replaced as directed by the Engineer. See table for replacement bar size and minimum splice length required. Replacement of bars damaged by the Contractor shall be subsidiary to "Area Prepared for Patching".

REPAIR OF EPOXY COATED REINFORCING STEEL: Replace any epoxy coating that is removed from the reinforcing steel during the concrete removal process. Thoroughly clean damaged areas with a stiff wire brush to remove dirt and damaged coating. Apply an approved patching material in accordance with manufacturer's recommendations. Avoid dripping any patching material onto existing concrete that will have new concrete placed against it. See KDOT Specifications.

◪ MINIMUM REBAR SPLICE LENGTHS

Existing Bar Size	Minimum Splice Lengths (inches)	
	Existing Gr. 40 ksi Bars	Existing Gr. 60 ksi Bars
#4	12"	16"
#5	13"	20"
#6	16"	24"
#7	20"	30"
#8	26"	39"
#9	33"	49"
#10	42"	62"
#11	51"	77"

Note: If splicing epoxy coated reinforcing steel, increase the above splice lengths by 20%.

◪ Lap lengths are based on a Class B splice. Use the minimum splice length corresponding to the grade of the existing reinforcing in the deck.

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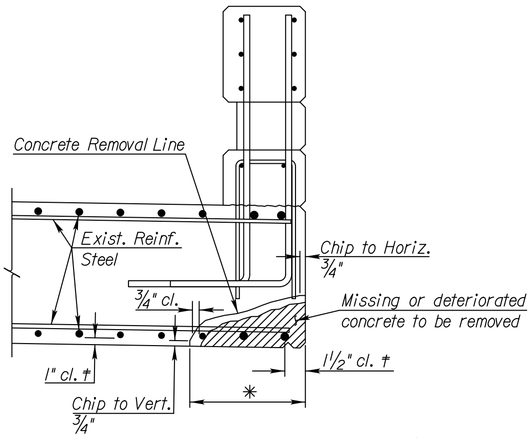
DECK PATCHING DETAILS (BRIDGE DECK WATERPROOFING)		BRIDGE NO.	Co. PAGE



TYPICAL DRIP LINE REPAIR

* Pay area for Concrete Surface Repair is this width times the length of the repair.

† Clearances typical of existing construction are shown. The bridge may differ slightly.

CONCRETE SURFACE REPAIR: Remove loose, cracked and delaminated concrete as directed by the Engineer. Repair as outlined in KDOT Specifications. Apply an Epoxy Bonding Agent prior to using Grade 4.0 (AE) Concrete. Sandblast and prepare areas to be repaired prior to placing shotcrete or Grade 4.0 (AE) Concrete. Repair or replace deteriorated reinforcing steel at the direction of the Engineer. Replacement of deteriorated reinforcing steel shall be paid for by the bid item "Reinforcing Steel (Repair) (Grade 60) (Set Price). Place shotcrete or Grade 4.0 (AE) Concrete to match existing surfaces. On overhead surfaces provide a minimum of 1 inch cover over the reinforcing steel.

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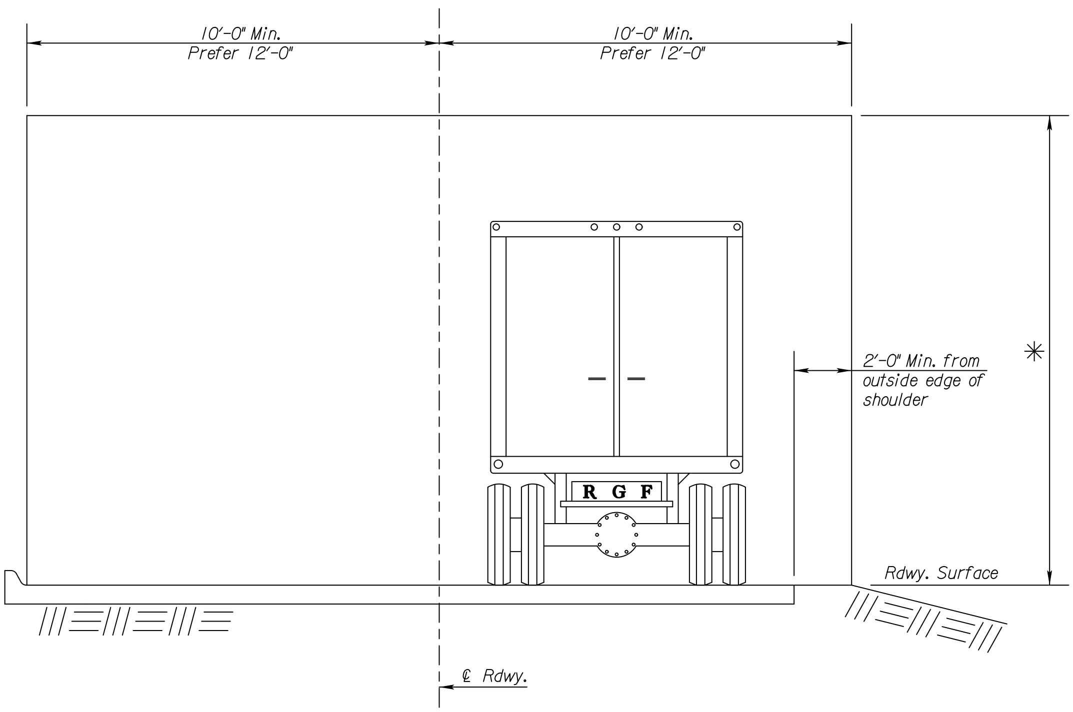
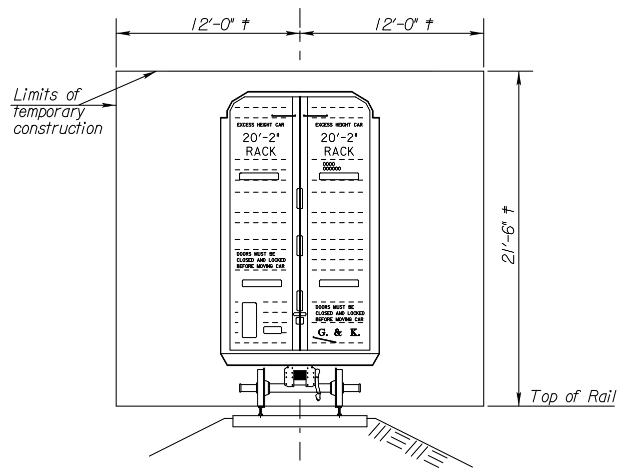
TYPICAL DRIP LINE REPAIR		BRIDGE NO.	Co. | PAGE



✳ As required by construction:
Preferable is 16'-0".
Advanced signing required for clearances of 15'-6" and less.

CONSTRUCTION CLEARANCE DETAILS

Plot Date : 22-MAR-2012 16:04 Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
CONSTRUCTION CLEARANCE DETAILS		BRIDGE NO.	Co. PAGE



CONSTRUCTION CLEARANCE DETAILS

† Note: Minimum Clearance Dimensions are shown. Clearance less than shown require advanced approval by the Railroad and KDOT.

RAILROAD PROTECTION: If removal of concrete is required through the full thickness of the deck (i.e. full depth patching, edge of slab removal, or complete deck replacement), then the Contractor shall execute the work in such a manner and take any precautions necessary to prohibit broken concrete and other debris from falling on and damaging the rails, ties, ballast or other railroad property. As much as possible, do the work so as not to interfere with the normal use of the tracks. The Railroad and the Engineer shall approve the methods of protection proposed by the Contractor before any work begins.

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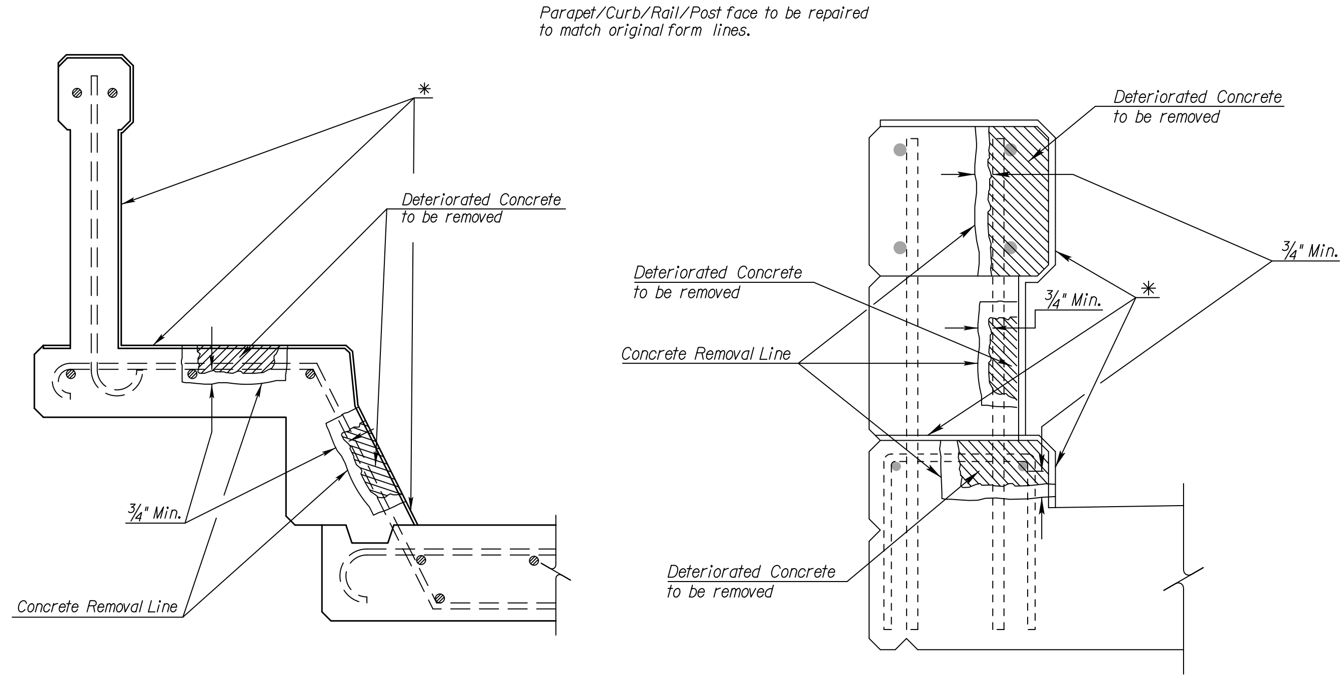
RAILROAD PROTECTION		BRIDGE NO.	Co.	PAGE



TYPICAL CURB, POST, or RAIL REPAIR

CURB REPAIR: The Contractor shall remove all deteriorated concrete delineated by the Engineer. Additional concrete shall be removed to create minimum thickness of the new concrete of 1 inch. The concrete, at repair locations, shall be removed from around the reinforcing steel near the face of the curb, rail or posts to allow a positive bond of new concrete to the existing structure. Concrete Grade 4.0 (AE) or an approved Shotcrete shall be used. Prior to its placement, an epoxy resin, for bonding new concrete to existing concrete, shall be used. The removal of deteriorated concrete, placement of new concrete, and all labor, materials, equipment, and incidentals necessary to complete the repairs of the curb, rail or posts shall be paid for as "Bridge Curb Repair" (Lin. Ft.).

* These areas to be sandblasted to remove loose disintegrated concrete, dirt, oil, and any foreign material along the entire length of the curb, rail and posts. Apply an approved Concrete Masonry Coating to the top of the curb and rail and the traffic face of the curb, rail and posts along the entire length of the bridge. This work shall conform to KDOT specifications. This shall all be Subsidiary to "Bridge Curb Repair".

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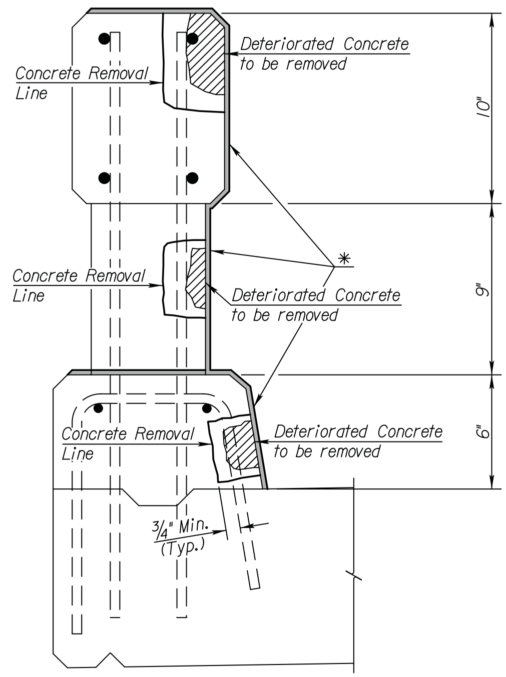
CURB, POST or RAIL REPAIR	BRIDGE NO.	Co. PAGE



Curb, rail and posts to be repaired to match original form lines.

TYPICAL CURB REPAIR

CURB REPAIR: The Contractor shall remove all deteriorated concrete delineated by the Engineer. Additional concrete shall be removed to create minimum thickness of the new concrete of 1 inch. The concrete, at repair locations, shall be removed from around the reinforcing steel near the face of the curb, rail or posts to allow a positive bond of new concrete to the existing structure. Concrete Grade 4.0 (AE) or an approved Shotcrete shall be used. Prior to its placement, an epoxy resin, for bonding new concrete to existing concrete, shall be used. The removal of deteriorated concrete, placement of new concrete, and all labor, materials, equipment, and incidentals necessary to complete the repairs of the curb, rail or posts shall be paid for as "Bridge Curb Repair" (Lin. Ft.).

* These areas to be sandblasted to remove loose disintegrated concrete, dirt, oil, and any foreign material along the entire length of the curb, rail and posts. Apply an approved Concrete Masonry Coating to the top of the curb and rail and the traffic face of the curb, rail and posts along the entire length of the bridge. This work shall conform to KDOT specifications. This shall all be Subsidiary to "Bridge Curb Repair".

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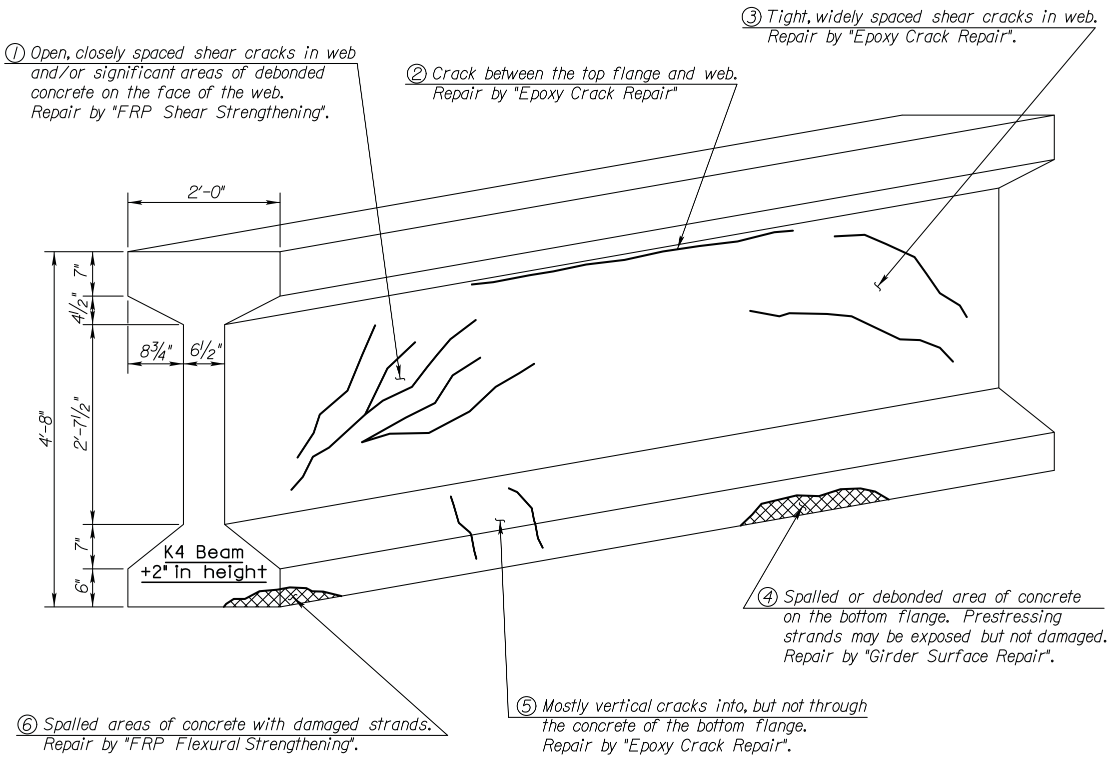
CURB REPAIR	BRIDGE NO.	Co. PAGE



TYPICAL PRESTRESSED CONCRETE GIRDER IMPACT DAMAGE

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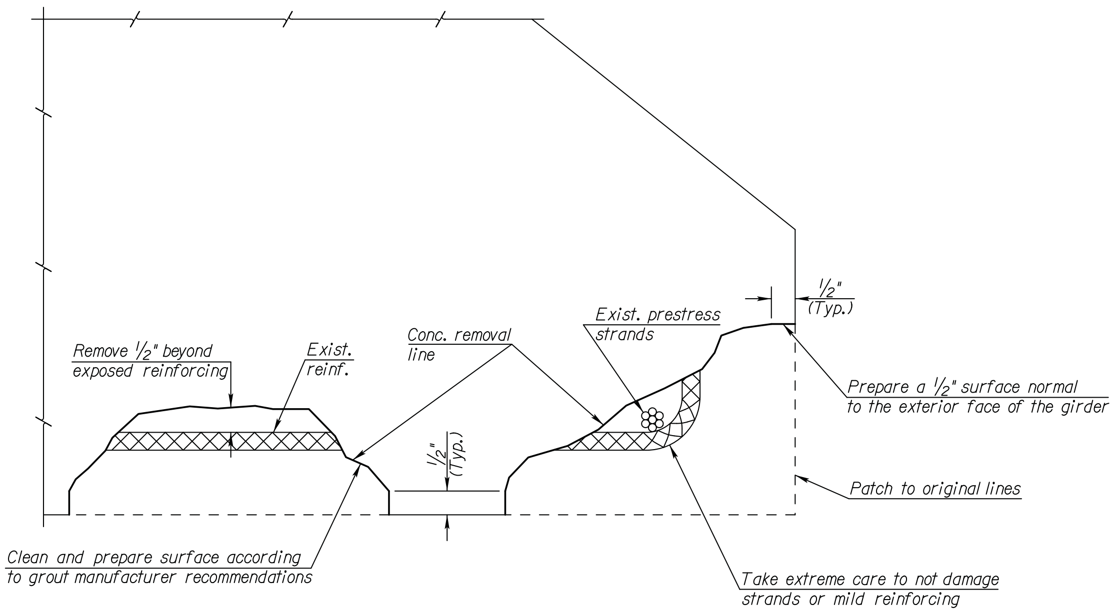
TYPICAL PRESTRESSED CONCRETE GIRDER IMPACT DAMAGE		BRIDGE NO.	Co.	PAGE



TYPICAL GIRDER SURFACE REPAIR

GIRDER SURFACE REPAIR: In areas of spalled concrete, or debonded concrete where directed by the Engineer, replace damaged concrete to original lines with "Emaco S88 CI". Clean and remove all loose concrete and debris. Prepare surface to grout manufacturers recommendations. Do not damage existing strands or reinforcing.

EPOXY CRACK REPAIR: For cracks approximately 1.0 mm in width or less in areas without significant debonding of underlying or adjacent concrete, or where directed by the Engineer, seal cracks with an approved epoxy. See KDOT Special Provision.

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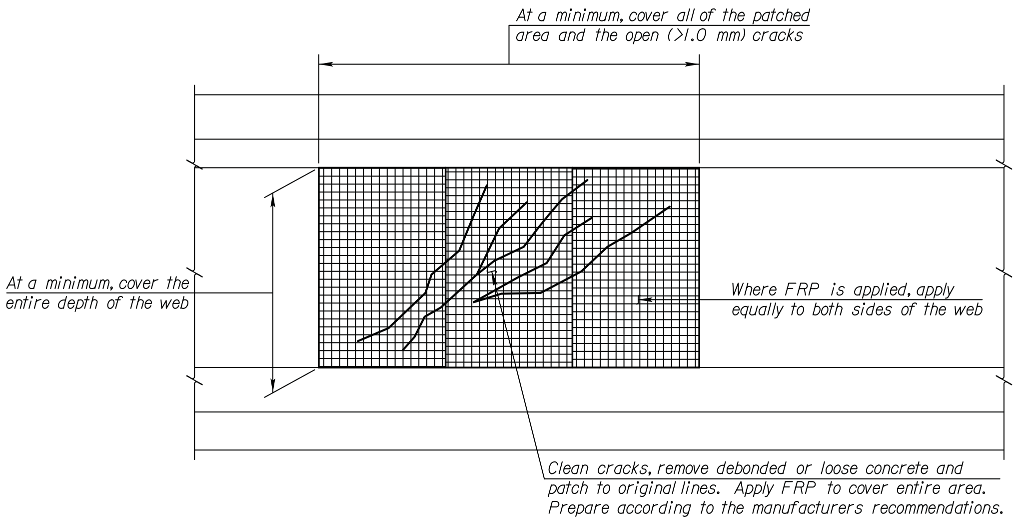
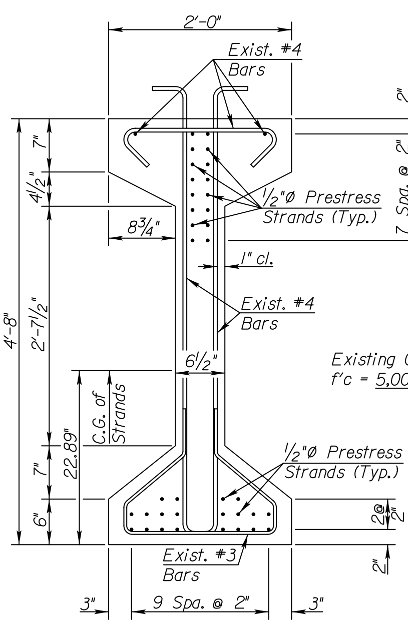
TYPICAL PRESTRESSED CONCRETE GIRDER REPAIRS		BRIDGE NO.	Co. PAGE



TYPICAL FRP SHEAR STRENGTHENING OF PRESTRESSED CONCRETE GIRDERS

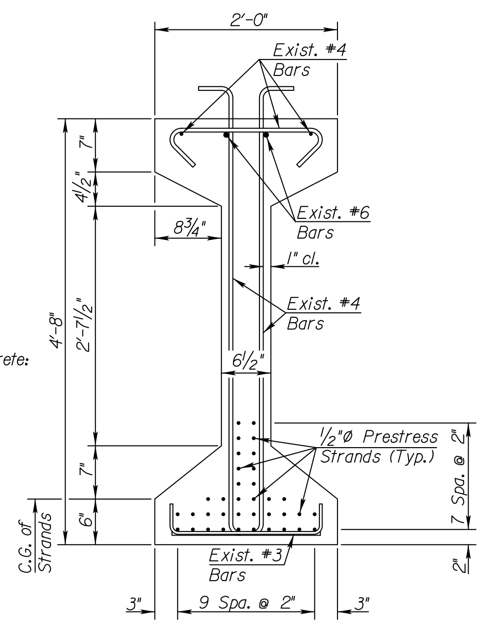
FRP SHEAR STRENGTHENING: Restore the shear capacity of the girder in areas where the concrete is severely cracked or delaminated by applying an approved FRP system to both sides of the web. Prepare the area in accordance with the manufacturers directions. Check the compatibility of the patching material prior to patching. Submit calculations to the Engineer showing that the FRP system will provide the required shear capacity.

Required Shear Capacity from FRP = 55 kips



TYPICAL PRESTRESSED BEAM SECTION AT BEARING

Existing Girder Concrete: f'c = 5,000 p.s.i.



TYPICAL PRESTRESSED BEAM SECTION AT CENTER OF SPAN

Plot Date : 22-MAR-2012 16:04	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
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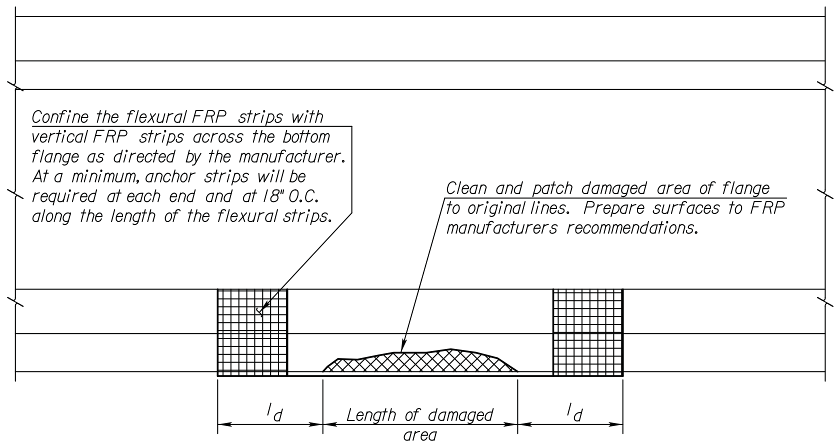
SHEAR STRENGTHENING OF PRESTRESSED CONCRETE GIRDERS		BRIDGE NO.	Co. PAGE

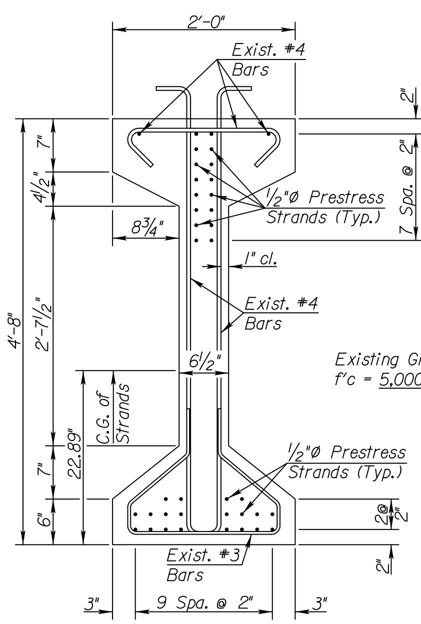


TYPICAL FRP FLEXURAL STRENGTHENING OF PRESTRESSED CONCRETE GIRDERS

FRP FLEXURAL STRENGTHENING: Restore the flexural capacity of the girder in areas with broken or damaged strands by applying an approved FRP system at the bottom flange. Prepare the area in accordance with the manufacturers directions. Check the compatibility of the patching material prior to patching. Submit calculations to the Engineer showing that the FRP system will provide the required flexural capacity.

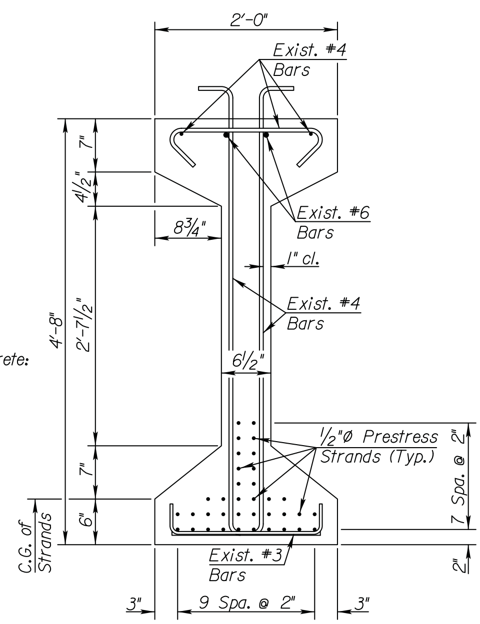
l_d = Development length of FRP as directed by the manufacturer. A minimum of 6" is required.

Required Flexural Capacity from FRP = 250 k-ft.



TYPICAL PRESTRESSED BEAM SECTION AT BEARING

Existing Girder Concrete: f'c = 5,000 p.s.i.



TYPICAL PRESTRESSED BEAM SECTION AT CENTER OF SPAN

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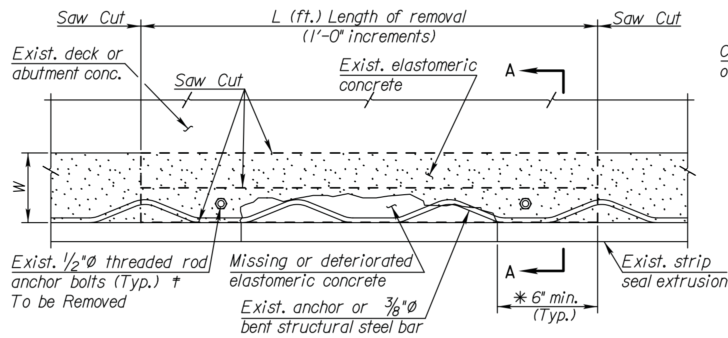
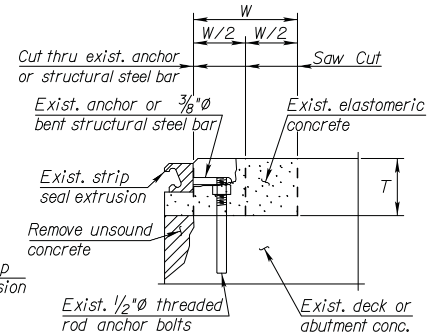
FLEXURAL STRENGTHENING OF PRESTRESSED CONCRETE GIRDERS	BRIDGE NO.	Co.	PAGE



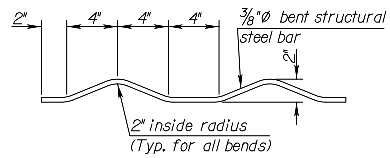
EXISTING PLAN



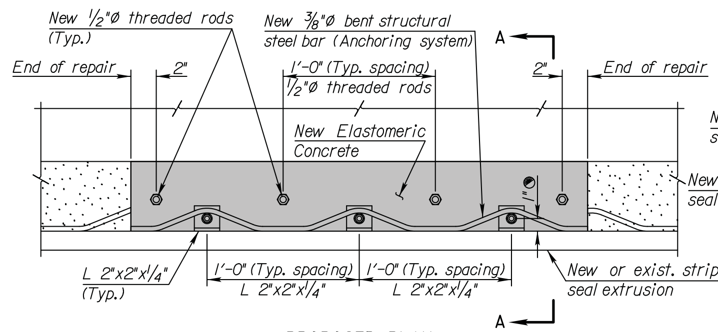
SECTION A-A

✱ Remove a minimum of 6" beyond missing or deteriorated elastomeric concrete and missing extrusion.

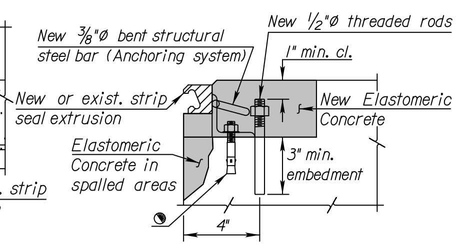
† Cut existing ½"Ø threaded rods flush with the bottom of the existing elastomeric concrete removal, then drill and grout new ½"Ø threaded rods at 1'-0" spacing or as shown in the details. Locate each hole with the aid of a pachometer to miss any existing reinforcing steel.



STRUCTURAL STEEL BAR

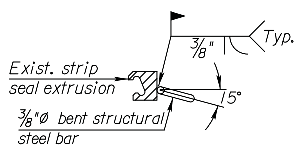


PROPOSED PLAN

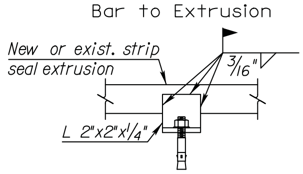


SECTION A-A

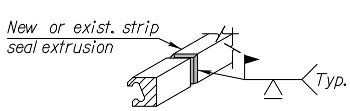
◔ ⅜"Ø Concrete wedge anchor or drill and grout ⅜"Ø threaded rod.



Bar to Extrusion



Clip Angle to Extrusion



Extrusion Field Splice

WELDING

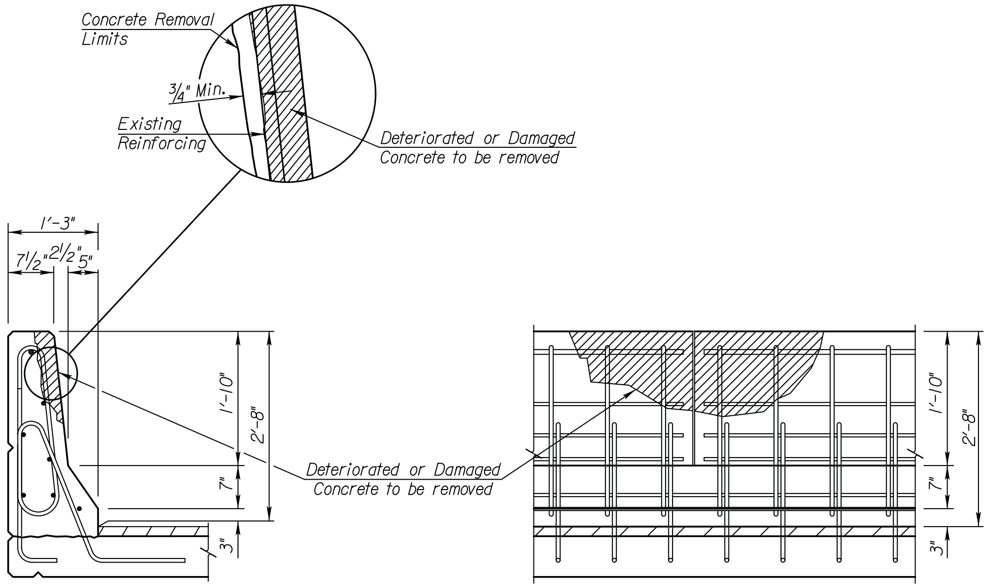
Note: The drawings and procedure shown on this sheet are intended to be a guideline for a typical repair on a strip seal assembly. Variations of these procedures may apply with the approval of the Engineer.

DIMENSION	LENGTH	
	Slab	Abutment
L		
W		
T		

REPAIR PROCEDURE

1) Remove existing gland.
2) Saw cut through existing elastomeric concrete to concrete sub-strate.
3) Remove existing elastomeric concrete.
4) Install new section of extrusion. Attach clip angles, anchoring system and install ½"Ø threaded rods.
5) Sandblast steel shapes and exposed concrete. Blow out with compressed air.
6) Place new elastomeric concrete.
7) Install new gland.

Plot Date : 22-MAR-2012 16:04	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
STRIP SEAL ASSEMBLY REPAIR		BRIDGE NO.	Co. PAGE



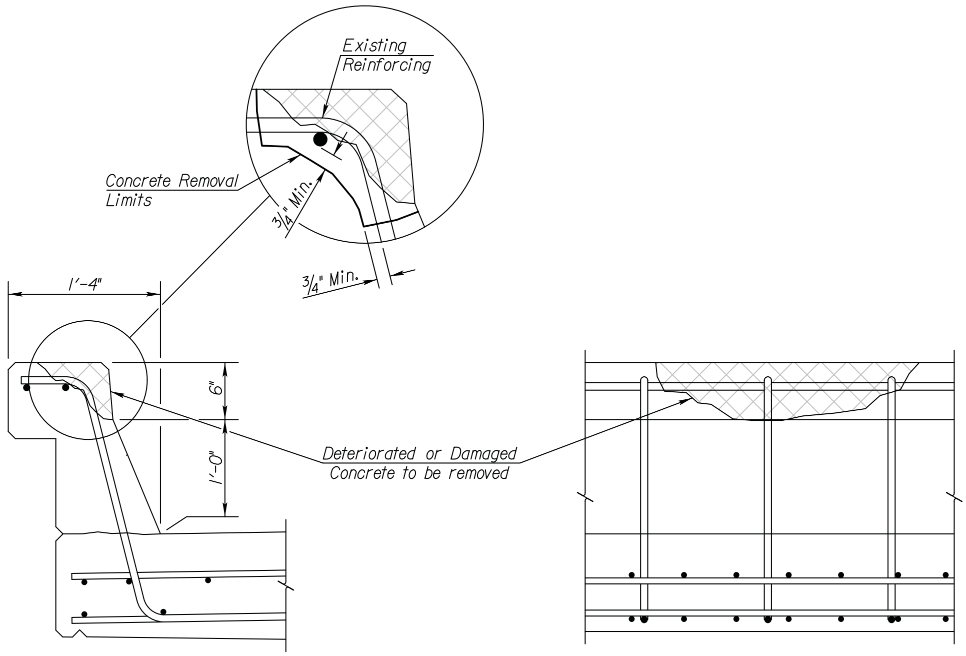
SECTION ELEVATION

EXISTING BARRIER RAIL DETAILS

Note: At some locations, portions of the rail may be missing entirely. Follow procedures as written below and recast to original lines.

RAIL REPAIR: The Contractor shall remove all deteriorated or damaged concrete delineated by the Engineer. Additional concrete shall be removed to create minimum thickness of new concrete of 1 inch. The concrete, at repair locations, shall be removed from around the reinforcing steel near the surface of the rail to allow a positive bond of new concrete to the existing structure. Concrete Grade 4.0 (AE) shall be used. Prior to its placement, an epoxy resin, for bonding new concrete to existing concrete shall be used. The removal of deteriorated or damaged concrete, placement of new concrete, and all labor, materials, equipment, and incidentals necessary to complete the repairs shall be paid for as "Bridge Repair" (Lump Sum).

Plot Date : 22-MAR-2012 16:04	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION	
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn				
TYPICAL BARRIER RAIL REPAIR DETAILS		BRIDGE NO.	Co.	PAGE

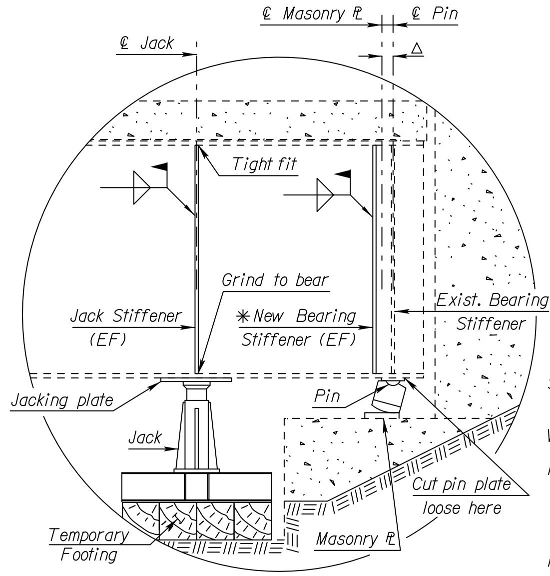


EXISTING RAIL DETAILS

Note: At some locations, portions of the rail may be missing entirely.
Follow procedures as written below and recast to original lines.

RAIL REPAIR: The Contractor shall remove all deteriorated or damaged concrete delineated by the Engineer. Additional concrete shall be removed to create minimum thickness of new concrete of 1 inch. The concrete, at repair locations, shall be removed from around the reinforcing steel near the surface of the rail to allow a positive bond of new concrete to the existing structure. Concrete Grade 4.0 (AE) shall be used. Prior to its placement, an epoxy resin, for bonding new concrete to existing concrete shall be used. The removal of deteriorated or damaged concrete, placement of new concrete, and all labor, materials, equipment, and incidentals necessary to complete the repairs shall be paid for as "Bridge Repair" (Lump Sum).

Plot Date : 22-MAR-2012 16:04	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
TYPICAL RAIL REPAIR DETAILS		BRIDGE NO.	Co. PAGE

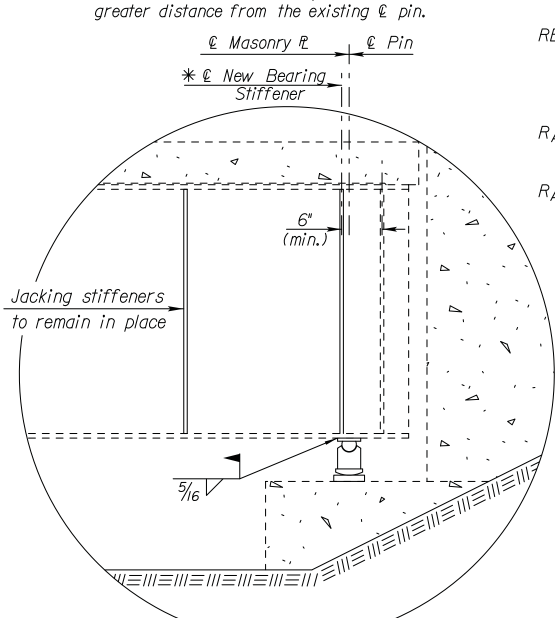


DETAIL A

(Showing Preparatory Work)

NOTE: New bearing stiffeners and jacking stiffeners shall have the same dimensions as existing bearing stiffeners. Welds shall be the same size as those connecting existing bearing stiffeners to web.

✳ NOTE: New bearing stiffeners will not be required if Δ is less than $12t_w$. If required, weld new bearing stiffener 6 inches from the center of the existing stiffener or on the new ℄ pin, whichever is the greater distance from the existing ℄ pin.



DETAIL A

(Showing Completed Work)

NOTE: Placement of jack is typical only. Jack may be placed on bridge seat, or as shown, or as otherwise approved by the Engineer. Jacking plate and Jacking Stiffeners must be provided.

NOTE: Any excavation required in placement of temporary footings for jacks shall be backfilled to its original condition, and any existing rip-rap shall be repaired.

SUMMARY OF QUANTITIES	
Reset Existing Bearing	Each

GENERAL NOTES

STRUCTURAL STEEL: Structural steel in stiffeners shall conform to ASTM A709M Grade 36 unless otherwise noted.

WELDING: Material and construction shall conform to KDOT Specifications.

PROCEDURE: Bearing Devices shall be made vertical (for a reference temp. of 60°F) one at a time by supporting the girder with the jack and moving the pin as shown below or as approved by the Engineer. See the detail in these plans for temperature corrections.

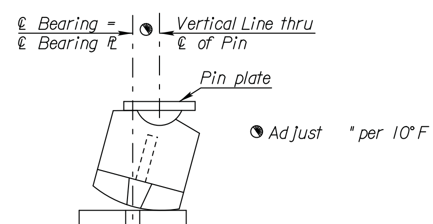
PAINTING: Prepare and paint areas of damaged paint with either an approved organic zinc primer with a waterborne acrylic finish coat or approved Calcium Sulfonate paint system. (The finish coat will match the existing paint). Painting shall be subsidiary to the bid item "Reset Existing Bearing".

RESET BEARING DEVICES: The bid item "Reset Existing Bearing (Each)" shall include all labor and materials necessary to temporarily support the girder, remove the existing bearing stiffener, to remove the bearing pin, to cut the existing girder ends to the required dimensions and to reset the bearing pin and reweld it to the existing girder. Only air carbon arc cutting will be allowed to remove existing welds. Care shall be taken not to damage the existing bearing pins and girders during removal.

REACTION: In lieu of a more exact analysis, the abutment reaction per girder (R_A) may be estimated as the smallest value obtained from the following formulas. (For existing stiffeners fabricated out of Grade 36 or Grade 33 ksi steel)

R_A(Kips) = $19A_G$, where A_G equals the gross cross-sectional area of the existing abutment bearing stiffeners (Sq. In.)

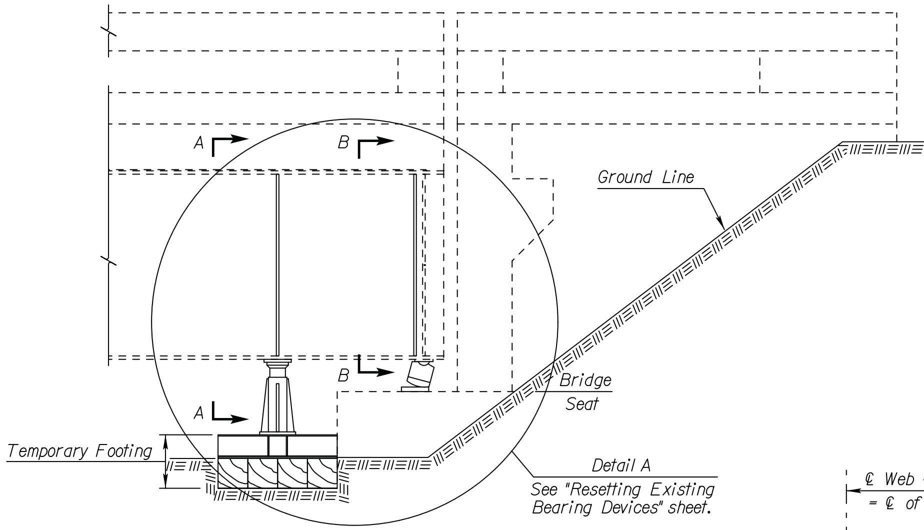
R_A(Kips) = $29A_C$, where A_C equals the cross-sectional area of the existing abutment bearing stiffeners in contact with the bottom flange of the girder (Sq. In.)



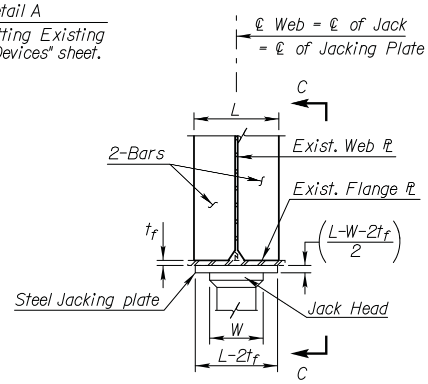
TEMPERATURE CORRECTION DETAIL

NOTE: For a temperature greater than 60°F the rocker should be adjusted (rocked) toward the nearest abutment. For a temperature less than 60°F the rocker should be adjusted (rocked) toward the center of the bridge. Adjust based on the ambient air temperature during the previous 24 hours.

Plot Date : 22-MAR-2012 16:04	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
RESETTING EXISTING BEARING DEVICES		BRIDGE NO.	Co. PAGE

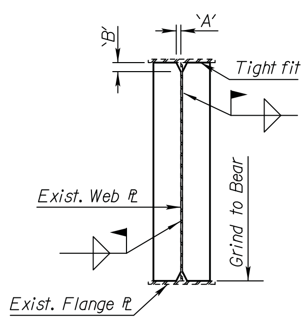


END ELEVATION OF ABUTMENT NO.1

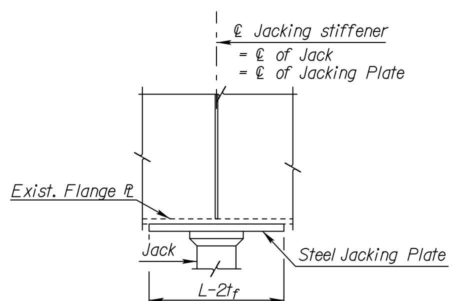


PARTIAL SECTION A-A

Showing Minimum Dimensions of Jacking Pad.
The length can be longer than its width.



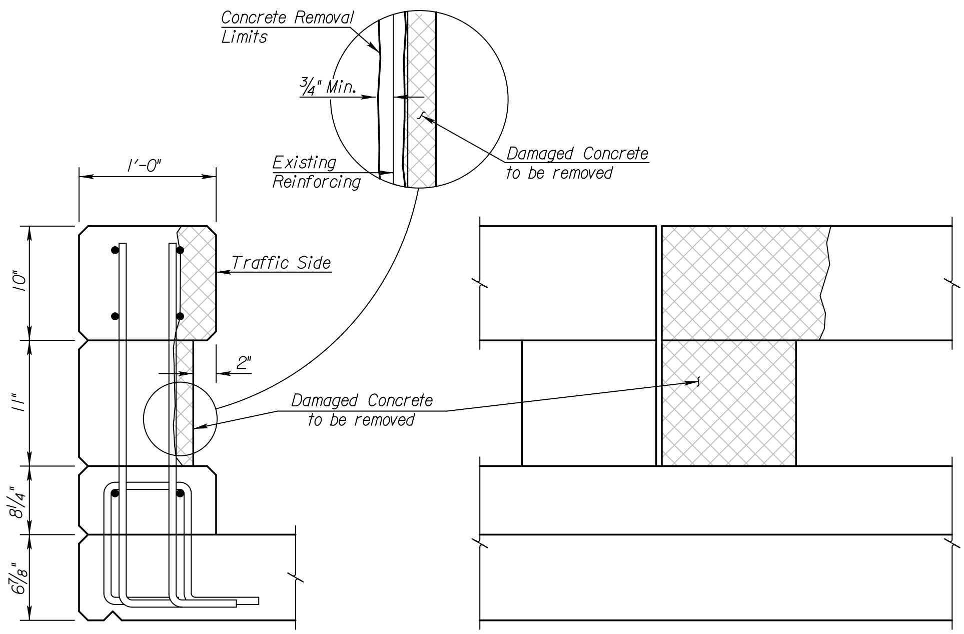
SECTION A-A or SECTION B-B



SECTION C-C

DIMENSIONS FROM EXISTING PLANS	
Bottom flange thickness (t_f)	
Web thickness (t_w)	
Bearing stiffener thickness	
Bearing stiffener width	
Clip-Dimension `A'	
Clip-Dimension `B'	

Plot Date : 22-MAR-2012 16:04	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
RESETTING EXISTING BEARING DEVICES AND STRUCTURAL STEEL		BRIDGE NO.	Co. PAGE



SECTION

ELEVATION

Note: At some locations, portions of the rail may be missing entirely. Follow procedures as written below and recast to original lines.

RAIL REPAIR: The Contractor shall remove all deteriorated or damaged concrete delineated by the Engineer. Additional concrete shall be removed to create minimum thickness of new concrete of 1 inch. The concrete, at repair locations, shall be removed from around the reinforcing steel near the surface of the rail to allow a positive bond of new concrete to the existing structure. Concrete Grade 4.0 (AE) shall be used. Prior to its placement, an epoxy resin, for bonding new concrete to existing concrete shall be used. The removal of deteriorated or damaged concrete, placement of new concrete, and all labor, materials, equipment, and incidentals necessary to complete the repairs shall be paid for as "Bridge Repair" (Lump Sum).

Plot Date : 22-MAR-2012 16:04	Squad: BR. MAINT. STD.	PROJ. NO.	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\engineering\Bridge Maint Projects\Standards\us\Bridge Maintenance Standards.dgn			
TYPICAL RAIL REPAIR DETAILS		BRIDGE NO.	Co. PAGE

Appendix B Bridge Repair Plans for Project 10-46 K-8376-01

K-10 over ATSF RR: Br. No. 10-46-176WB AND 177 EB

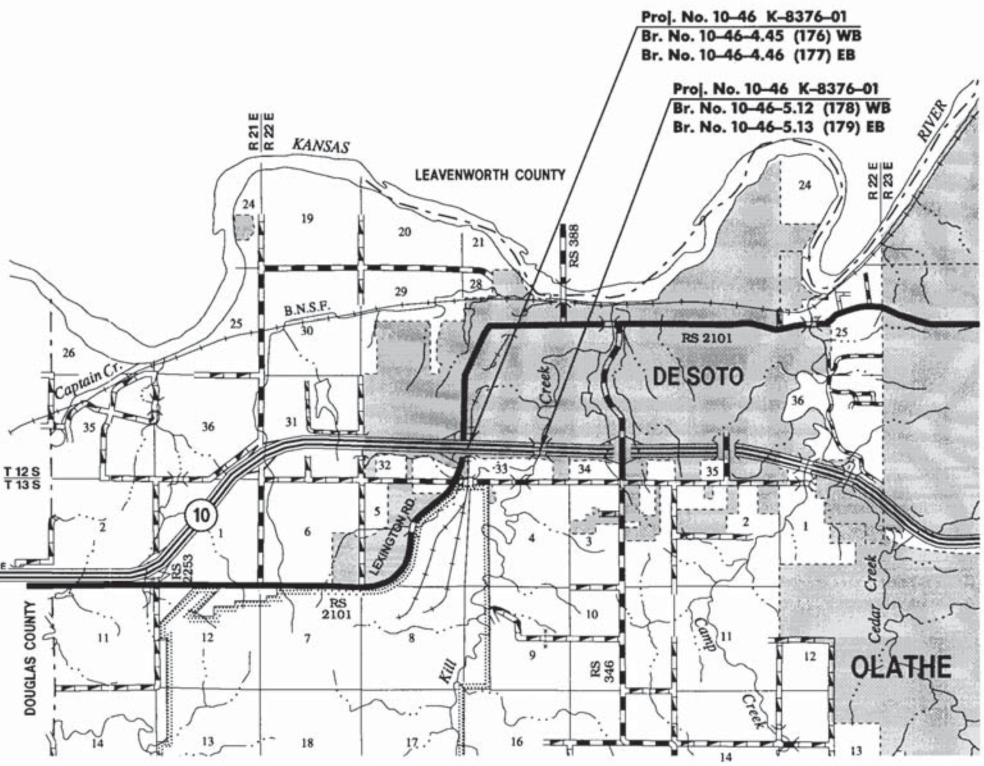
K-10 over Kill Creek: Br. No. 10-46-178WB AND 179EB

STATE OF KANSAS

DEPARTMENT OF TRANSPORTATION

BRIDGE REPAIR

KANSAS PROJECT
JOHNSON COUNTY
K–10
PROJ. NO. 10–46 K–8376–01



Plot Date : 07-OCT-2002 11:03	Server: dt06ft05	Squad: HURT	PROJ. NO. 10+46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\83760Ia.dgn				
TITLE SHEET	View= PLOT1		BRIDGE NO. 10-46 (176-179)	JOHNSON Co. PAGE 1

SUMMARY OF QUANTITIES

Location \ Item	Machine Preparation 20 mm m^2	Area Prepared for Patching m^2	Area Prep. for Patching (Full Depth) m^2	Silica Fume Overlay 40 mm m^2	Reinforcing Steel (Gr. 420) (Set) kg	Material for Silica Fume Overlay (Set) m^3	Plant Mix Bit. Mixture Comm. Gr. t	Reset Exist. Bearing Devices Each	Strip Seal Assembly (Type I) m	Curb Repair m	Bridge Painting Lump Sum	Environmental Protection Lump Sum
BR. No. 176	1 719.7	499	15	1 719.7	1	1	74	7	30.9	25	Lump Sum	Lump Sum
BR. No. 177	1 719.7	705	28	1 719.7	1	1	74	7	30.9	25	Lump Sum	Lump Sum
TOTAL	3 439.4	1 204	43	3 439.4			148	14	61.8	50		
BR. No. 178	1 061.7	372	15	1 061.7	1	1	62	-	26.0	19	-	-
BR. No. 179	1 061.7	308	9	1 061.7	1	1	62	-	26.0	19	-	-
TOTAL	2 123.4	680	24	2 123.4			124		52.0	38		
GRAND TOTAL	5 562.8	1 884	67	5 562.8	1	1	272	14	113.8	88	Lump Sum	Lump Sum

INDEX TO DRAWINGS

Sheet No.	Drawing
1	Title
2	General Notes and Quantities
3-5	Construction Layouts
6-7	Construction Staging
8-9	Deck Patching Sequences
10	Deck Patching Details
11	Curb Repair
12-13	Resetting Existing Bearing Devices (Br. 176 & 177)
14-15	Expansion Device Details (Limits of Removal)
16-19	Expansion Device Details (Proposed Construction)
20	Bituminous Approach Overlay
21	Construction Clearance Details
22	Railroad Protection

GENERAL NOTES

EXISTING STRUCTURE: Plans of the existing structure are on file and available for inspection by qualified bidders at the State Bridge Office, KDOT, Docking State Office Building, Topeka, KS.

REMOVAL OF EXISTING CONCRETE: All existing concrete removed from the project shall be wasted on a site provided by the contractor and approved by the engineer.

BRIDGE DECK REPORT: The bridge condition report is on file and available for inspection by qualified bidders at the State Bridge Office, KDOT, Docking State Office Building, Topeka, KS.

DIMENSIONS: All dimensions shown on the design plans are horizontal dimensions unless otherwise noted. Make necessary allowances for roadway grade and cross slope.

TEMPERATURE: The design temperature for all dimensions is 15 °C.

EPOXY BONDING AGENT: Prepare all existing concrete surfaces which will be in contact with new concrete with an approved Epoxy Bonding Agent in accordance with the manufacturer's recommendations. This is <u>subsidiary</u> to the bid item "Concrete-Grade 28 (AE)".

CONCRETE: All concrete used shall be Class 28 (AE). Bevel all exposed edges of concrete with a 20 mm triangular molding, except as otherwise noted on the plans.

ELASTOMERIC CONCRETE: Use one of the following products or an approved equal:

DELCRETE manufactured by The D.S. Brown Company
WABOCRETE manufactured by Watson Bowman Associates Inc.
SILSPEC 900 PNS manufactured by SSI Inc.

Place the elastomeric concrete at locations shown on the plans and in the manner prescribed in the application procedures published by the manufacturer of the binder. Arrange for a technical service representative of the binder manufacturer to be present on the project during the placement of the elastomeric concrete. The elastomeric concrete shall be <u>subsidiary</u> to the bid item "Strip Seal Assembly (Type I)" and will not be measured for payment.

QUANTITIES: Items not listed separately in the Summary of Quantities are <u>subsidiary</u> to other items in the proposal.

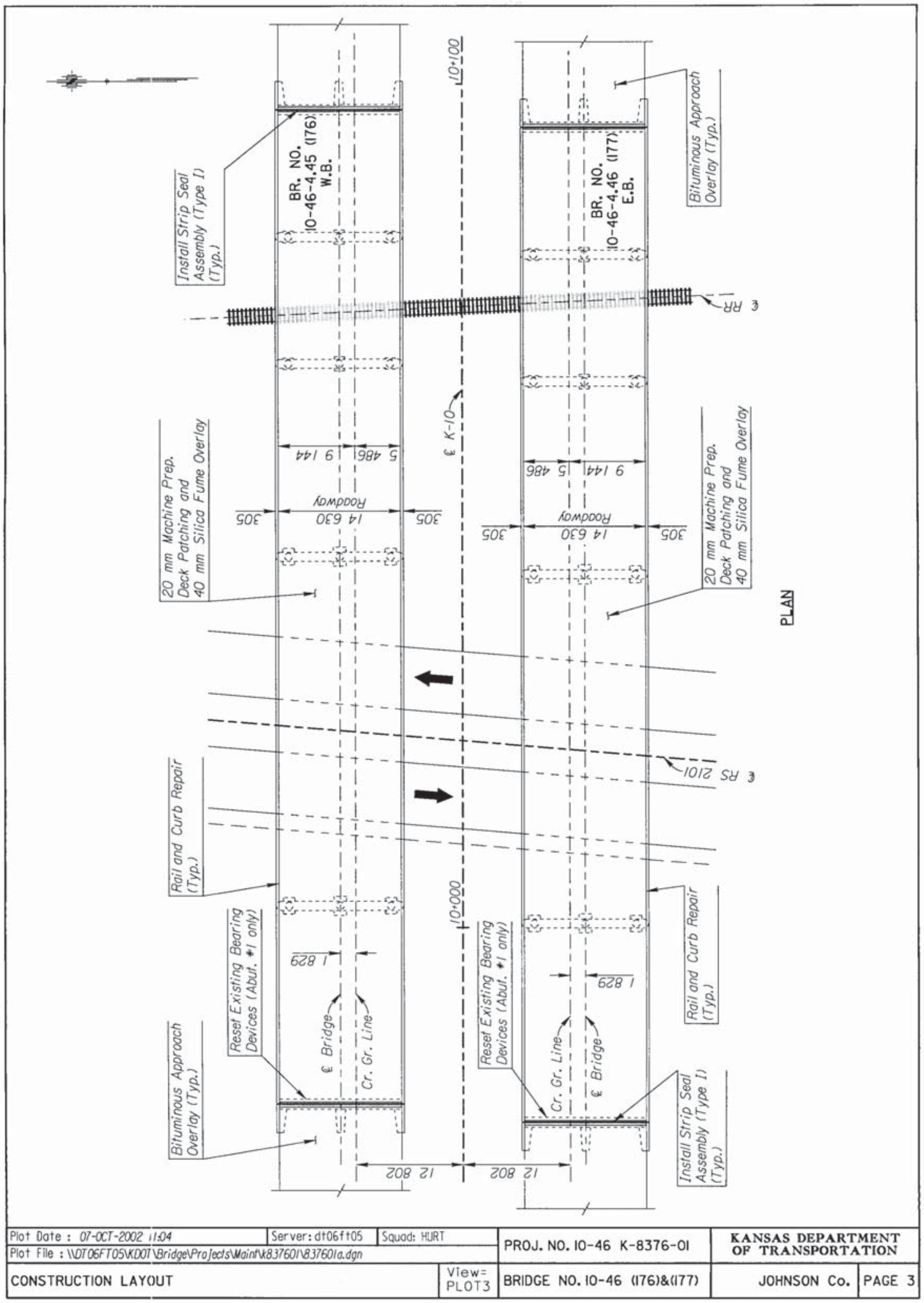
BRIDGE NUMBERS (176) & (177) ONLY

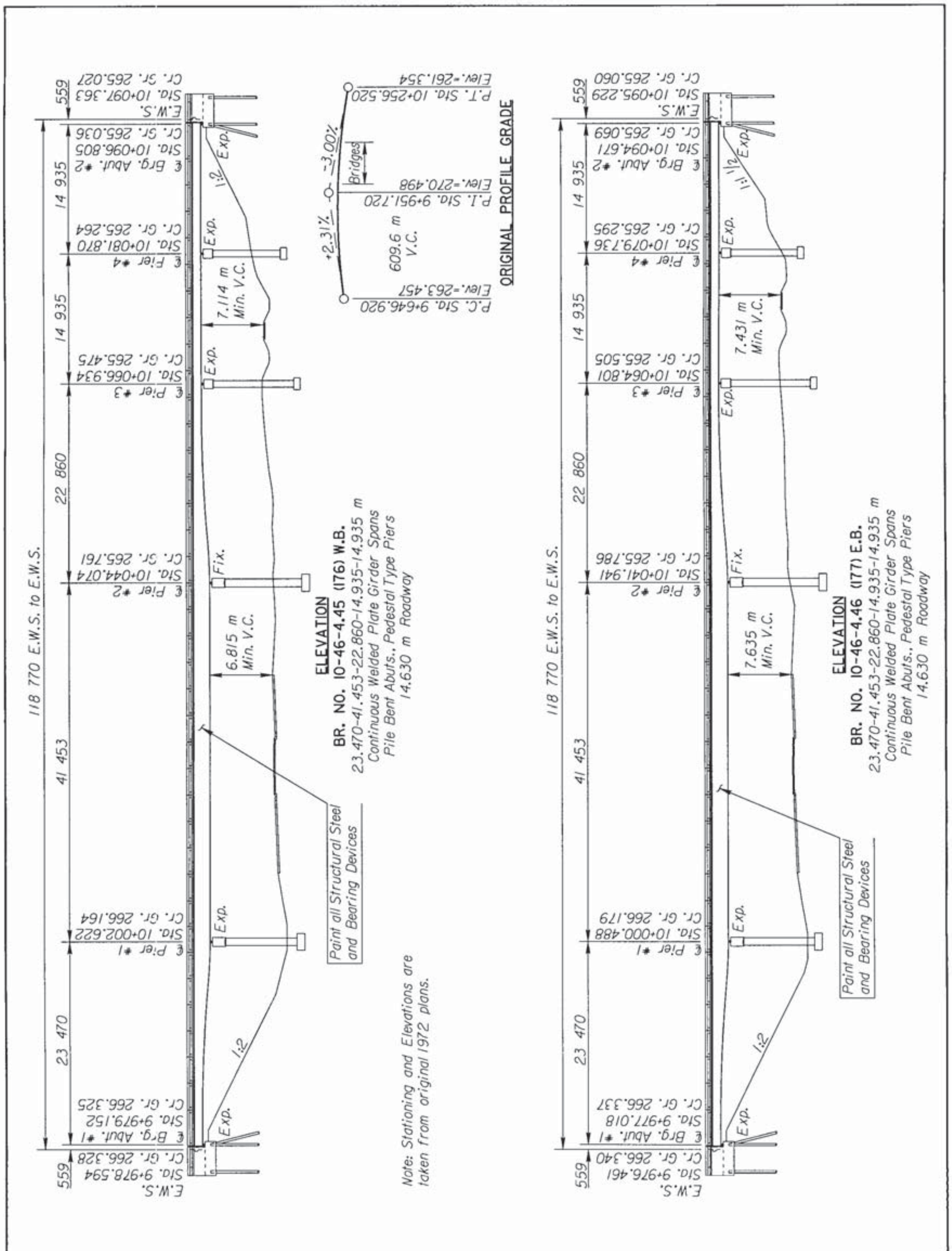
PAINTING: The surfaces to be painted shall be cleaned to meet Steel Structures Painting Council Specifications SSPC-SP6. The field coats applied shall conform to an inorganic zinc primer with a waterborne acrylic finish coat. The finish coat will be Kansas dark green, the color shall match Carboline #3359.

EXISTING BRIDGE PAINTING: Paint all structural steel and bearing devices in the existing structure in conformance with the KDOT Specifications. The existing paint system is a Basic Lead Silica Chromate system. The mass of existing bridge steel is 191,416 kg per bridge.

ENVIRONMENTAL PROTECTION: Use protection as shown in the KDOT Specifications. The Environmental Protection Structure Classification is Class .

Plot Date : 07-OCT-2002 11:03	Server: dt06ft05	Squad: HJRT	PROJ. NO. 10-46 K-8376-01
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Main\k83760\83760la.dgn			KANSAS DEPARTMENT OF TRANSPORTATION
GENERAL NOTES AND QUANTITIES	View= PLOT2	BRIDGE NO. 10-46 (176-179)	JOHNSON Co. PAGE 2


BR. NO. 10-46-4.45 (176) W.B.
BR. NO. 10-46-4.46 (177) E.B.
Install Strip Seal Assembly (Type I) (Typ.)
Bituminous Approach Overlay (Typ.)
20 mm Machine Prep. Deck Patching and 40 mm Silica Fume Overlay
Rail and Curb Repair (Typ.)
Reset Existing Bearing Devices (Abut. #1 only)
℄ RR
℄ K-10
℄ RS 2101
℄ Bridge
Cr. Gr. Line
10+100
10+000
14 630 Roadway
305
9 144
5 486
1 829
12 802
PLAN
Plot Date : 07-OCT-2002 11:04
Server: dt06ft05
Squad: HURT
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k837601\837601a.dgn
PROJ. NO. 10-46 K-8376-01
KANSAS DEPARTMENT OF TRANSPORTATION
CONSTRUCTION LAYOUT
View= PLOT3
BRIDGE NO. 10-46 (176)&(177)
JOHNSON Co.
PAGE 3



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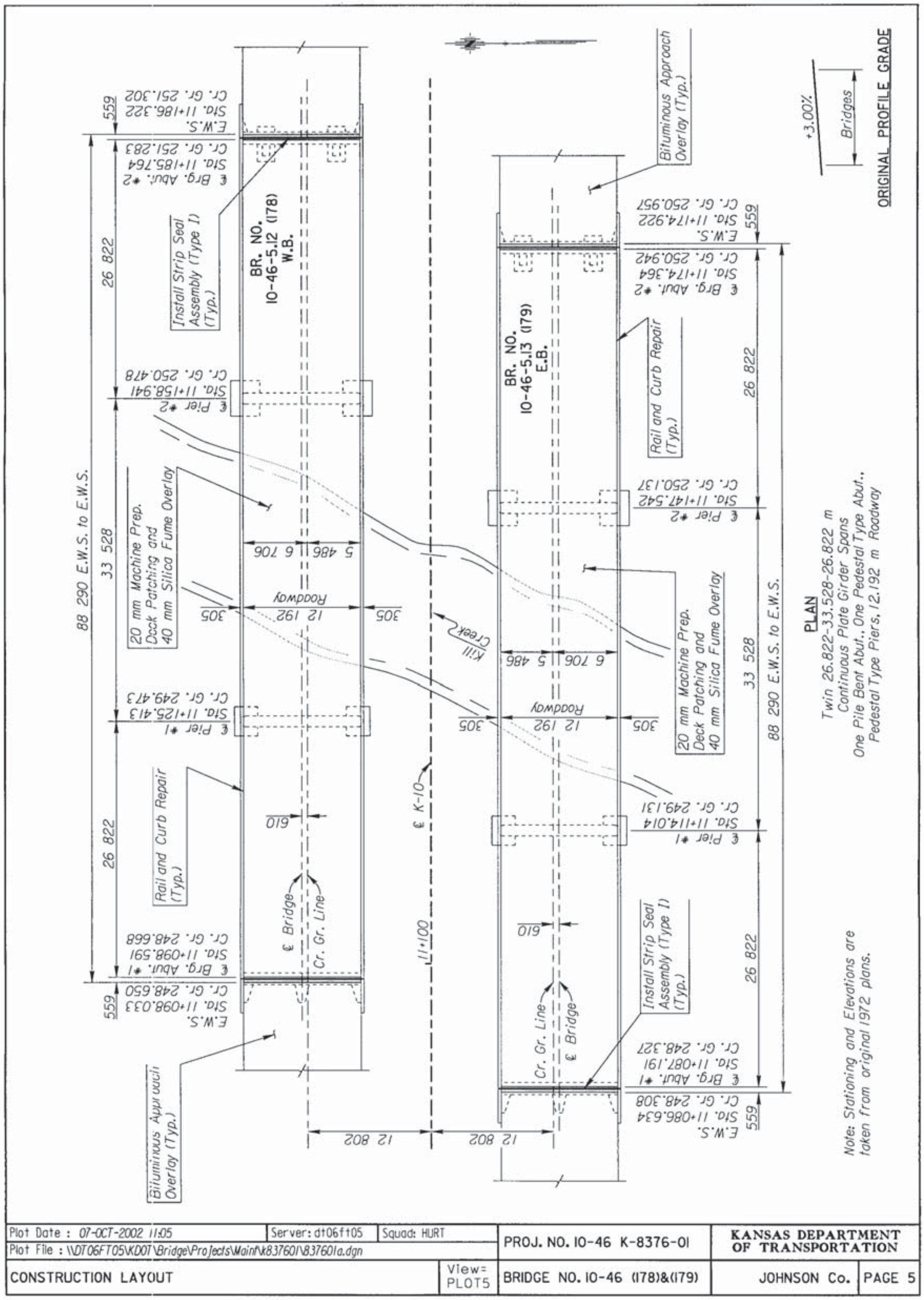
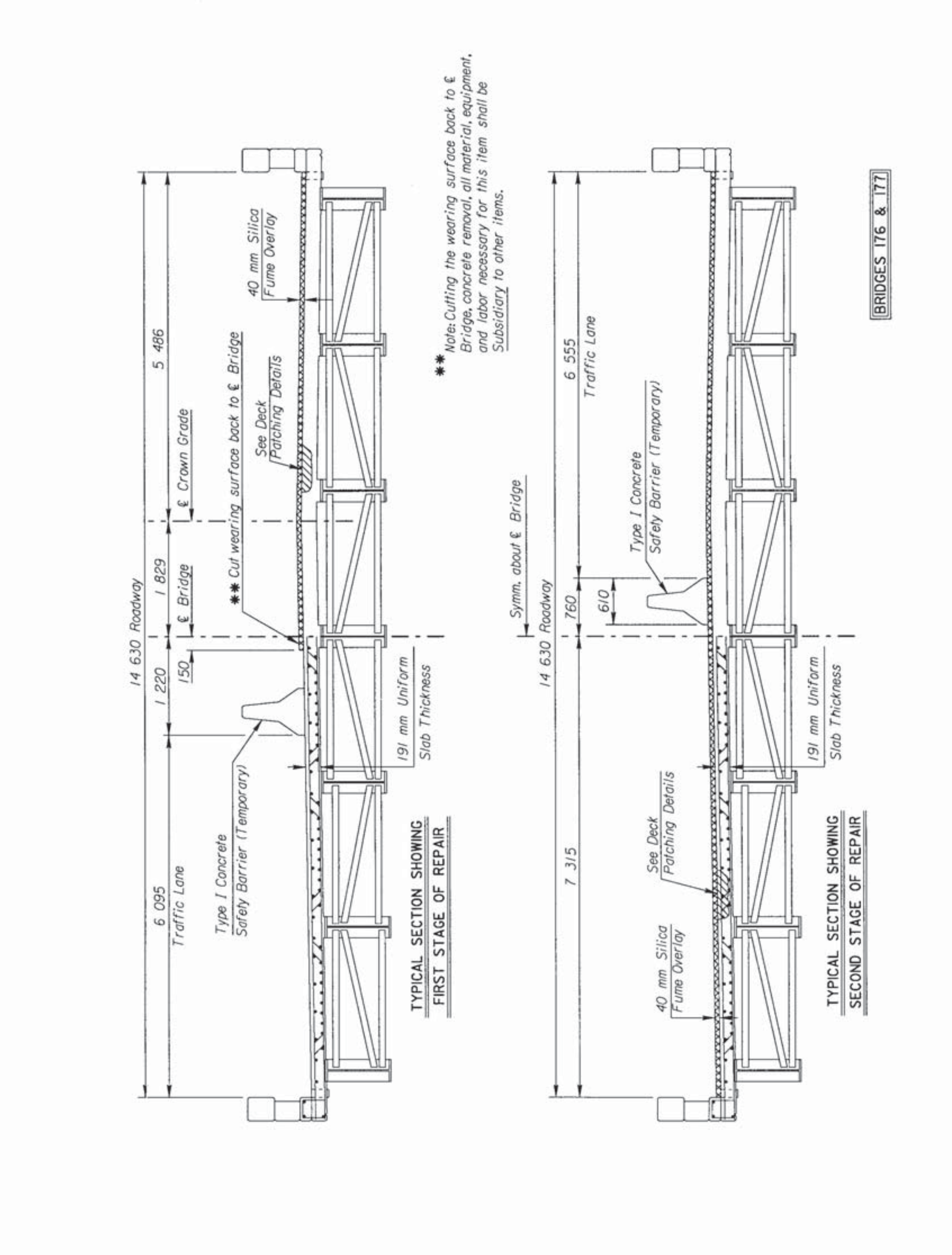
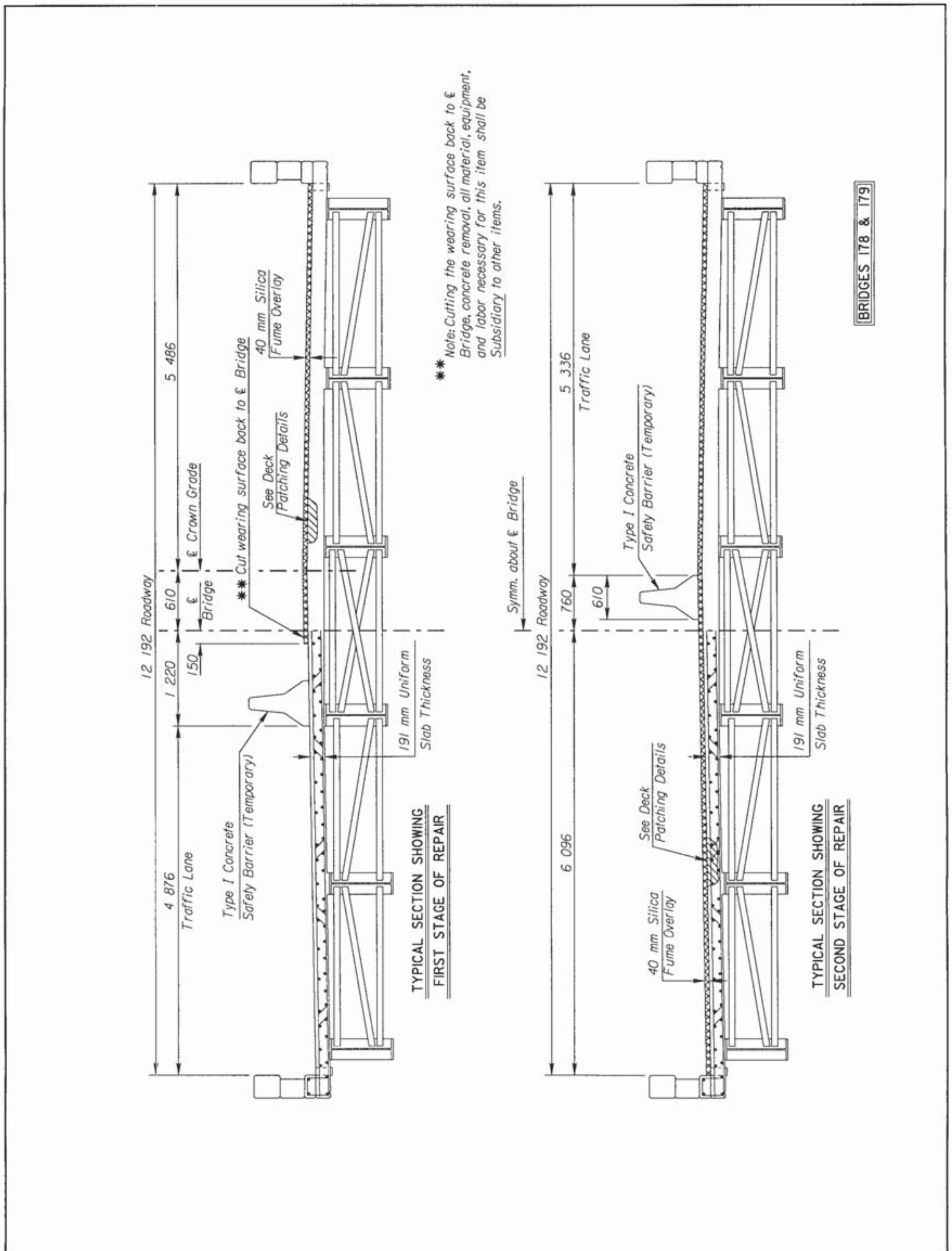
CONSTRUCTION LAYOUT		View= PLOT4	BRIDGE NO. 10-46 (I76)&(I77)	JOHNSON Co. — PAGE 4


PLAN
Twin 26.822-33.528-26.822 m
Continuous Plate Girder Spans
One Pile Bent Abut., One Pedestal Type Abut.,
Pedestal Type Piers, 12.192 m Roadway
ORIGINAL PROFILE GRADE
+3.00%
Bridges
Note: Stationing and Elevations are taken from original 1972 plans.
BR. NO. 10-46-5.12 (178) W.B.
BR. NO. 10-46-5.13 (179) E.B.
88 290 E.W.S. to E.W.S.
26 822
33 528
20 mm Machine Prep. Deck Patching and 40 mm Silica Fume Overlay
Install Strip Seal Assembly (Type 1) (Typ.)
Rail and Curb Repair (Typ.)
Bituminous Approach Overlay (Typ.)
Kill Creek
Roadway
12 192
305
℄ K-10
11+100
12 802
℄ Bridge
Cr. Gr. Line
Plot Date : 07-OCT-2002 11:05
Server: dt06ft05
Squad: HURT
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k837601\837601a.dgn
PROJ. NO. 10-46 K-8376-01
KANSAS DEPARTMENT OF TRANSPORTATION
CONSTRUCTION LAYOUT
View= PLOT5
BRIDGE NO. 10-46 (178)&(179)
JOHNSON Co.
PAGE 5



Plot Date : 07-OCT-2002 11:06 — Server: dt06ft05 — Squad: HURT Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\83760Ia.dgn		PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION	
CONSTRUCTION STAGING (STEEL GIRDER)	View= PLOT6	BRIDGE NO. 10-46 (I76)&(I77)	JOHNSON Co.	PAGE 6



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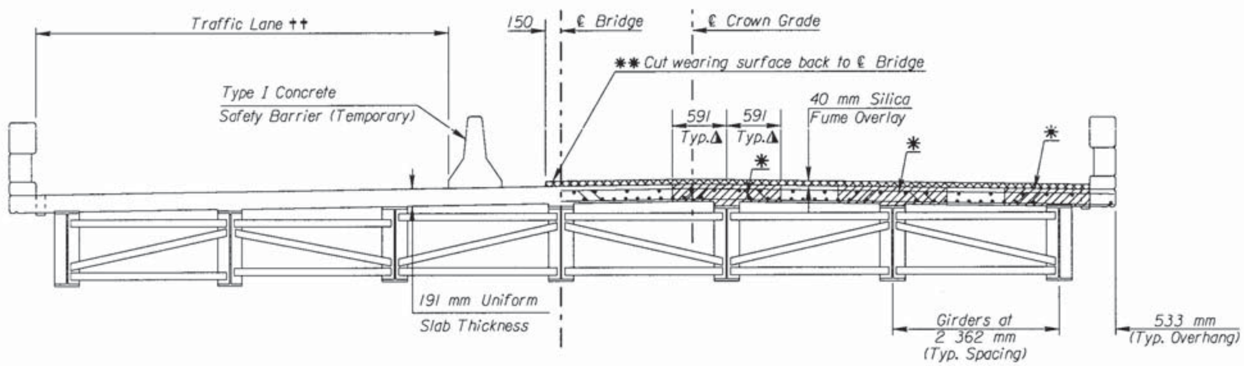
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\837601a.dgn				
CONSTRUCTION STAGING (STEEL GIRDER)		View= PLOT7	BRIDGE NO. 10-46 (178)&(179)	JOHNSON Co. — PAGE 7



†† See "Construction Staging" sheets for traffic lane and roadway widths.

Δ Girder Spacing /4 or as directed by the Engineer.

✱✱ Note: Cutting the wearing surface back to ℄ Bridge, concrete removal, all material, equipment, and labor necessary for this item shall be Subsidiary to other items.

✱ PATCHING SEQUENCE: When large areas of full depth patches are needed in this area, they shall be patched in segments. The segments of full depth patch shall be a maximum of 2.50 m in length parallel to the centerline of bridge with a minimum of 2.50 m between segments. After the patches in the initial segments have cured, the areas between the segments shall be patched.
The segmental patching will not be required if adequate shoring is provided to support the deck and curbs.

SUMMARY OF QUANTITIES				
ITEM	UNITS	QUANTITY		
		BR. 176	BR. 177	
† Machine Preparation (20 mm)	m^2	1 719.7	1 719.7	
† Area Prepared for Patching	m^2	499	705	
Area Prep. for Patching (Full Depth)	m^2	15	25	
Silica Fume Overlay (40 mm)	m^2	1 719.7	1 719.7	
Reinforcing Steel (Gr. 420) (Set)	kg	1	1	
† Material for Silica Fume Overlay (Set)	m^3	1	1	
Plant Mix Bit. Mix Comm. Gr.	t	74	74	

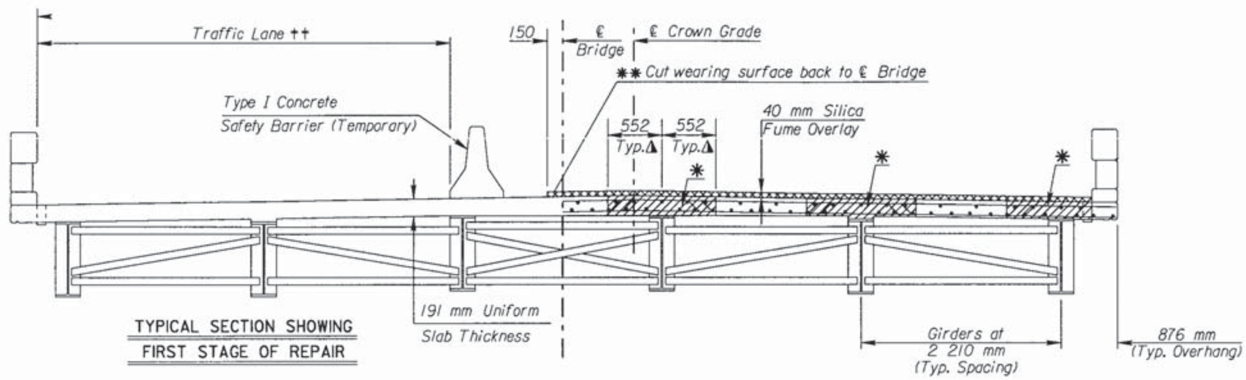
† See Special Provision when hydroblasting is used for machine preparation.

◪ MINIMUM REBAR SPLICE LENGTHS			
Existing Bar Size	Equivalent SI Bar	Minimum Splice Lengths (mm)	
		Existing Gr. 40 ksi Bars	Existing Gr. 60 ksi Bars
#4	13	300	405
#5	16	330	505
#6	19	400	605
#7	22	510	[illegible]
#8	25	660	965
#9	29	840	1 220
#10	32	1 070	1 550
#11	36	1 320	1 905

Note: If splicing epoxy coated reinforcing steel, increase the above splice lengths by 15%.

◪ Lap lengths are based on a Class B splice. Use the minimum splice length corresponding to the grade of the existing reinforcing in the deck.

Plot Date : 07-OCT-2002 11:07	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760\83760la.dgn			KANSAS DEPARTMENT OF TRANSPORTATION
DECK PATCHING SEQUENCE (STEEL GIRDER BRIDGE)	View= PLOT8	BRIDGE NO. 10-46 (176)&(177)	JOHNSON Co. PAGE 8



TYPICAL SECTION SHOWING
FIRST STAGE OF REPAIR

++ See "Construction Staging" sheets for traffic lane and roadway widths.

Δ Girder Spacing /4 or as directed by the Engineer.

** Note: Cutting the wearing surface back to ℄ Bridge, concrete removal, all material, equipment, and labor necessary for this item shall be Subsidiary to other items.

* PATCHING SEQUENCE: When large areas of full depth patches are needed in this area, they shall be patched in segments. The segments of full depth patch shall be a maximum of 2.50 m in length parallel to the centerline of bridge with a minimum of 2.50 m between segments. After the patches in the initial segments have cured, the areas between the segments shall be patched.
The segmental patching will not be required if adequate shoring is provided to support the deck and curbs.

SUMMARY OF QUANTITIES

ITEM	UNITS	QUANTITY		
		BR. 178	BR. 179	
† Machine Preparation (20 mm)	m^2	1 061.7	1 061.7	
† Area Prepared for Patching	m^2	372	308	
Area Prep. for Patching (Full Depth)	m^2	15	9	
Silica Fume Overlay (40 mm)	m^2	1 061.7	1 061.7	
Reinforcing Steel (Gr. 420) (Set)	kg	1	1	
† Material for Silica Fume Overlay (Set)	m^3	1	1	
Plant Mix Bit. Mix Comm. Gr.	t	62	62	

† See Special Provision when hydroblasting is used for machine preparation.

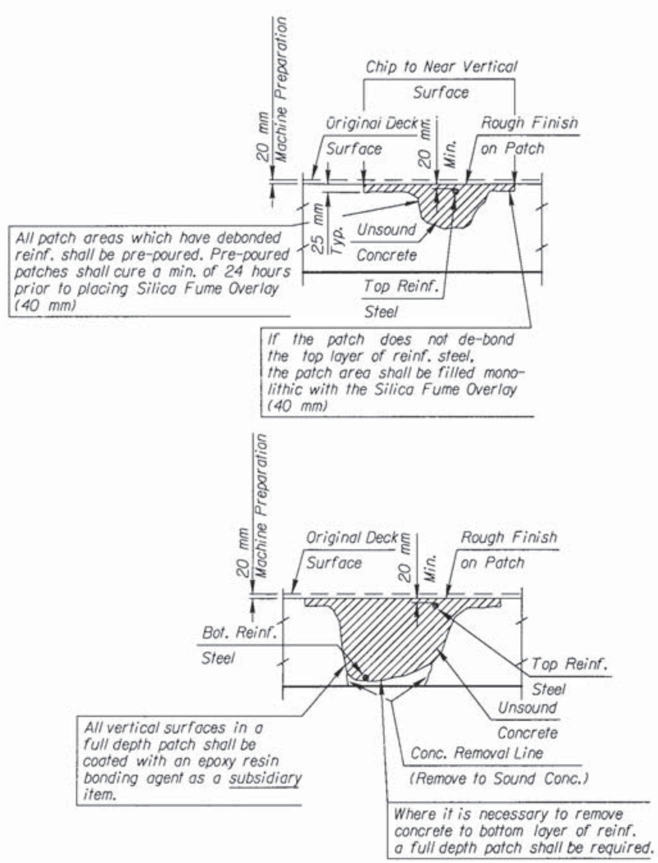
◪ MINIMUM REBAR SPLICE LENGTHS

Existing Bar Size	Equivalent SI Bar	Minimum Splice Lengths (mm)	
		Existing Gr. 40 ksi Bars	Existing Gr. 60 ksi Bars
#4	13	300	~~405~~
#5	16	330	~~505~~
#6	19	400	~~605~~
#7	22	510	~~725~~
#8	25	660	~~965~~
#9	29	840	~~1 220~~
#10	32	1 070	~~1 550~~
#11	36	1 320	~~1 905~~

Note: If splicing epoxy coated reinforcing steel, increase the above splice lengths by 15%.

◪ Lap lengths are based on a Class B splice. Use the minimum splice length corresponding to the grade of the existing reinforcing in the deck.

Plot Date : 07-OCT-2002 11:07	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\83760Ia.dgn				
DECK PATCHING SEQUENCE (STEEL GIRDER BRIDGE)	View= PLOT9		BRIDGE NO. 10-46 (178)&(179)	JOHNSON Co. PAGE 9



DECK PATCHING DETAILS

MACHINE PREPARATION (20 mm): This item shall consist of preparing the deck for a SFO by removing concrete from the roadway surface of the bridge deck to a depth of 20 mm. See KDOT Specifications.

AREA PREPARED FOR PATCHING: This item shall consist of removing unsound concrete and bituminous patches from the bridge deck, cleaning reinforcing bars, filling the removed patched areas with concrete and preparing the entire area of the deck for SFO. Quantity shown is an estimate of the areas involved. The exact areas shall be determined by tapping, before, during and after chipping operation to assure that all unsound concrete has been removed. See KDOT Specifications.

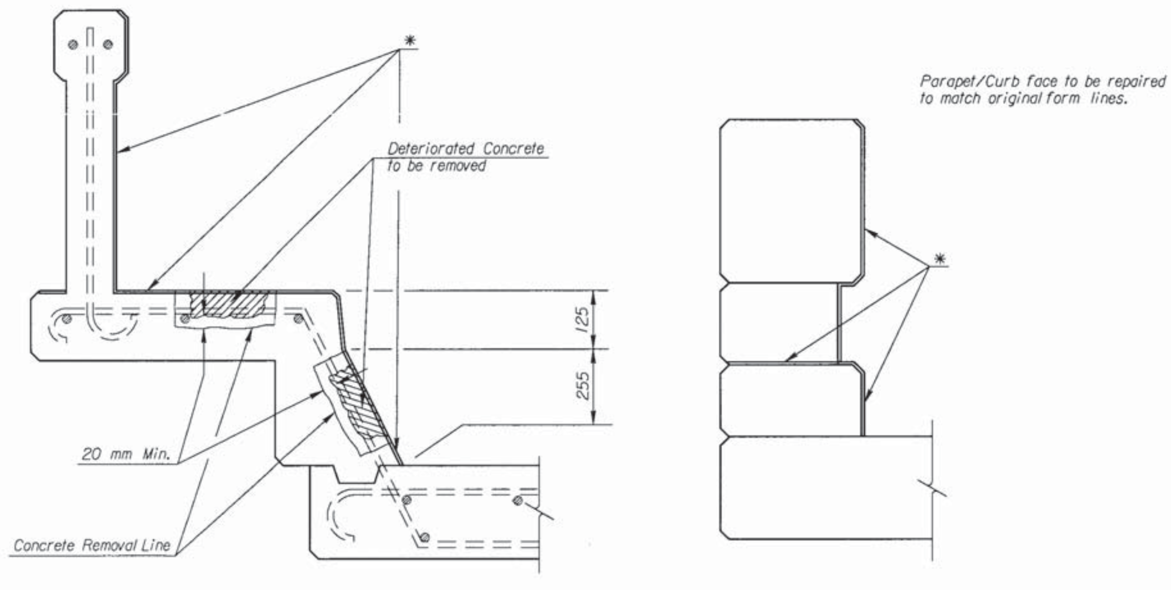
FULL DEPTH PATCHING: Forms shall be provided to enable placement of concrete in areas of full depth removal of bridge slab. The forms may be suspended from existing reinforcing bars by wire ties or a method approved by the Engineer may be used. See KDOT Specifications for method of measurement and basis of payment.

REINFORCING IN BRIDGE DECK: Care should be exercised to prevent cutting, stretching or damaging exposed reinforcing steel. Extreme care should be exercised to avoid breaking the bond between the reinforcing steel and concrete where bars are partially exposed yet remain anchored in sound concrete. Reinforcing steel damaged, cut or deteriorated shall be replaced as directed by the Engineer. See table for replacement bar size and minimum splice length required. Replacement of bars damaged by the Contractor shall be subsidiary to "Area Prepared for Patching".

SILICA FUME OVERLAY: This item shall consist of cleaning the concrete surface, application of grout and finishing and placing the 40 mm SFO. See KDOT Specifications.

SILICA FUME OVERLAY CONSTRUCTION JOINTS: All vertical construction joints in the overlay and the vertical joint between the overlay and the curbs shall be cleaned by sandblasting, and then painting the joints with an approved Concrete Masonry Coating 72 hours after placement of the Silica Fume Overlay.

Plot Date : 07-OCT-2002 11:08	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\83760Ia.dgn				
DECK PATCHING DETAILS		View= PLOT10	BRIDGE NO. 10-16 (176-179)	JOHNSON Co. PAGE10

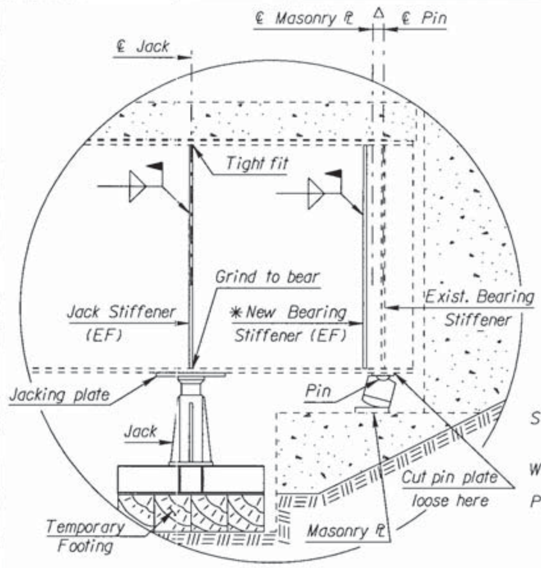


TYPICAL CURB REPAIR

CURB REPAIR: The Contractor shall remove all deteriorated concrete delineated by the Engineer. Additional concrete shall be removed to create minimum thickness of the new concrete of 25 mm. The concrete, at repair locations, shall be removed from around the reinforcing steel near the face of the curb to allow a positive bond of new concrete to the existing structure. Concrete Grade 28 (AE) shall be used. Prior to its placement, an epoxy resin, for bonding new concrete to existing concrete, shall be used. The removal of deteriorated concrete, placement of new concrete, and all labor, materials, equipment, and incidentals necessary to complete the repairs of the curbs, shall be paid for as "Curb Repair" (meter).

* These areas to be sandblasted to remove loose disintegrated concrete, dirt, oil, and any foreign material along the entire length of the curb and rail. Apply an approved Concrete Masonry Coating to the top of the curb and the traffic face of the curb and rail along the entire length of the curb and rail. This work shall conform to KDOT specifications. This shall all be Subsidiary to the Contract.

Plot Date : 07-OCT-2002 1:09	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION	
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Main\k83760I\83760Ia.dgn					
CURB REPAIR		View= PLOTII	BRIDGE NO. 10-46 (176-179)	JOHNSON Co.	PAGEII

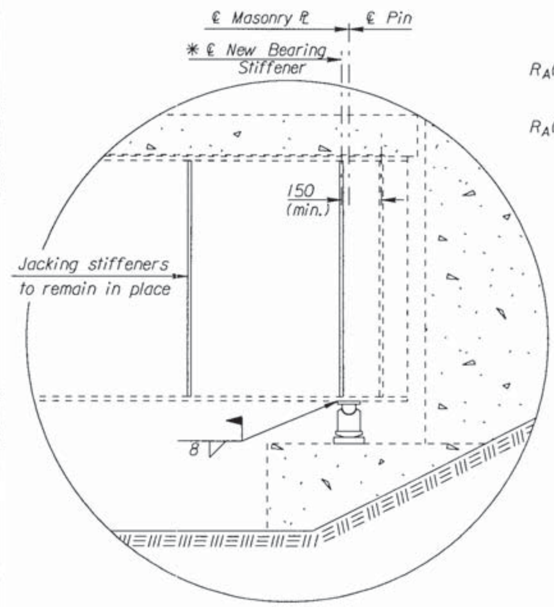


DETAIL A

(Showing Preparatory Work)

NOTE: New bearing stiffeners and jacking stiffeners shall have the same dimensions as existing bearing stiffeners. Welds shall be the same size as those connecting existing bearing stiffeners to web.

✻ NOTE: New bearing stiffeners will <u>not</u> be required if Δ is less than $12t_w$. If required, weld new bearing stiffener 150 mm from the center of the existing stiffener or on the new ℄ pin, whichever is the greater distance from the existing ℄ pin.



DETAIL A

(Showing Completed Work)

NOTE: Placement of Jack is typical only. Jack may be placed on bridge seat, or as shown, or as otherwise approved by the Engineer. Jacking plate and Jacking Stiffeners must be provided.

NOTE: Any excavation required in placement of temporary footings for Jacks shall be backfilled to its original condition, and any existing rip-rap shall be repaired.

SUMMARY OF QUANTITIES ◘			
ITEM	UNITS	QUANTITY	
		BR. 176	BR. 177
Reset Existing Bearing Devices	Each	7	7

◘ Abutment No. 1 only.

GENERAL NOTES

STRUCTURAL STEEL: Structural steel in stiffeners shall conform to ASTM A709M Gr. 250 unless otherwise noted.

WELDING: Material and construction shall conform to KDOT Specifications.

PROCEDURE: Bearing Devices shall be made vertical (for a reference temp. of 15°C) one at a time by supporting the girder with the jack and moving the pin as shown above or as approved by the Engineer. See the detail in these plans for temperature corrections.

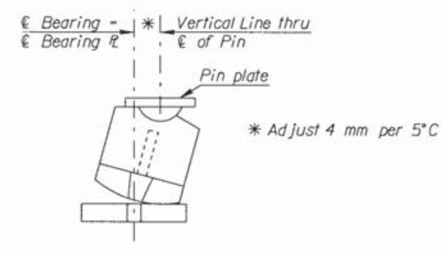
PAINTING: Reset existing bearing devices before painting the bridge.

RESET BEARING DEVICES: The bid item "Reset Existing Bearing Devices (Each)" shall include all labor and materials necessary to temporarily support the girder, remove the existing bearing stiffiner, to remove the bearing pin, to cut the existing girder ends to the required dimensions and to reset the ~~new~~ bearing pin and reweld it to the existing girder. Only air carbon arc cutting will be allowed to remove existing welds. Care shall be taken not to damage the existing bearing pins and girders during removal.

REACTION: In lieu of a more exact analysis, the abutment reaction per girder (R_A) may be estimated as the smallest value obtained from the following formulas. (For existing stiffeners fabricated out of Gr. 36 or Gr. 33 ksi steel)

R_A(Kips) = $19A_G$, where A_G equals the gross cross-sectional area of the existing abutment bearing stiffeners (Sq. In.)

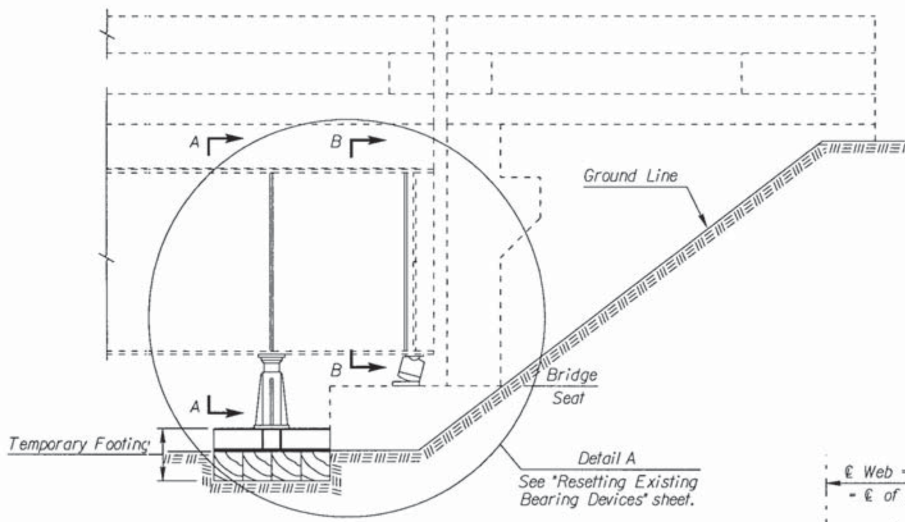
R_A(Kips) = $29A_C$, where A_C equals the cross-sectional area of the existing abutment bearing stiffeners in contact with the bottom flange of the girder (Sq. In.)



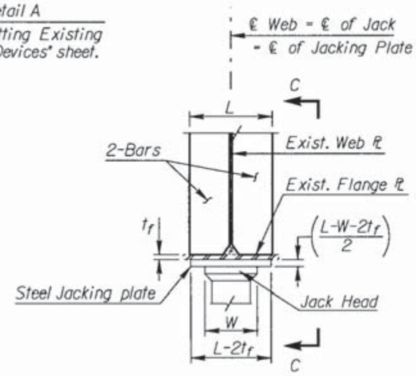
TEMPERATURE CORRECTION DETAIL

NOTE: For a temperature greater than 15°C the rocker should be adjusted (rocked) toward the nearest abutment. For a temperature less than 15°C the rocker should be adjusted (rocked) toward the center of the bridge. Adjust based on the ambient air temperature during the previous 24 hours.

Plot Date : 07-OCT-2002 11:09 Server: dt06ft05 Squad: HURT		PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760\83760la.dgn			
RESETTING EXISTING BEARING DEVICES	View= PLOT12	BRIDGE NO. 10-46 (176)&(177)	JOHNSON Co. PAGE12

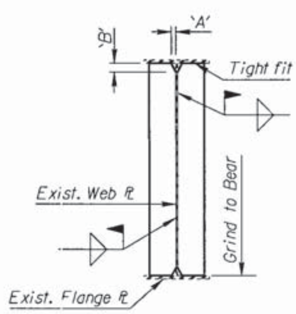


END ELEVATION OF ABUTMENT NO. 1

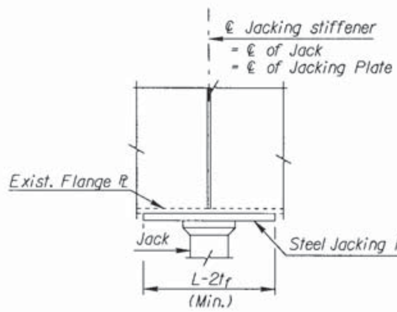


PARTIAL SECTION A-A

Showing *Minimum* Dimensions of Jacking Pad.
The length can be longer than its width.



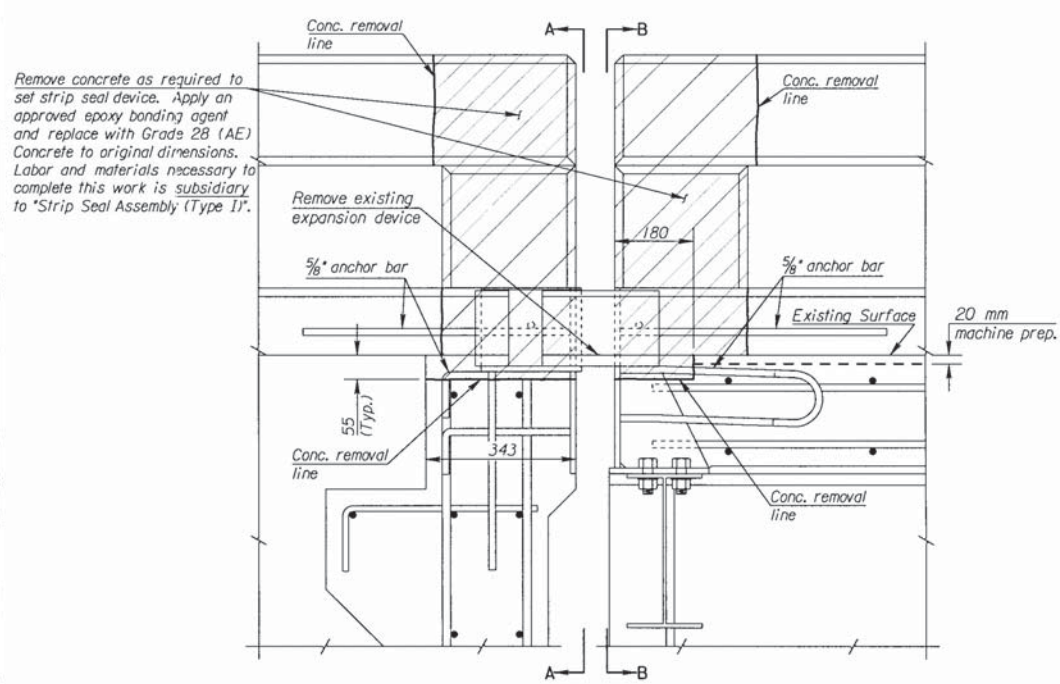
SECTION A-A or SECTION B-B



SECTION C-C

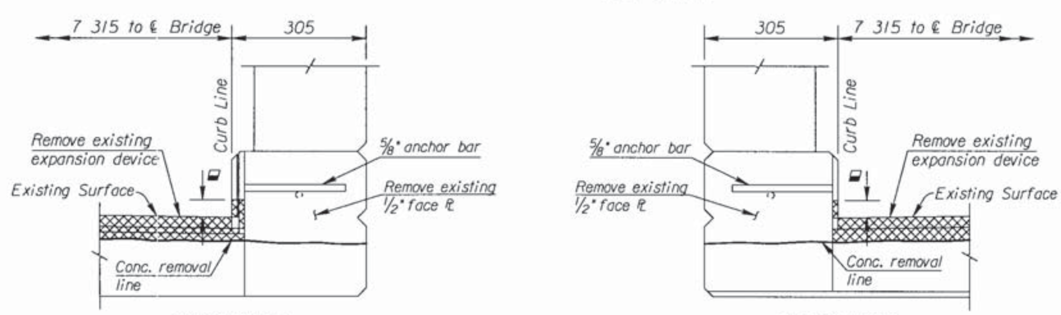
DIMENSIONS FROM EXISTING PLANS		
	English	SI equiv.
Bottom flange thickness (t_f)	1"	25 mm
Web thickness (t_w)	5/16"	8 mm
Bearing stiffener thickness	1/2"	13 mm
Bearing stiffener width	5 3/4"	146 mm
Clip-Dimension 'A'	1"	25 mm
Clip-Dimension 'B'	1"	25 mm

Plot Date : 07-OCT-2002 11:10	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\83760Ia.dgn				
RESETTING EXIST. BEARING DEVICES & STRUCTURAL STEEL	View= PLOT13		BRIDGE NO. 10-46 (176)&(177)	JOHNSON Co. PAGE13



ELEVATION

REMOVAL OF EXISTING EXPANSION DEVICE:
Remove the existing sliding plates and a portion of the armoring from the deck, backwall and curb. Leave and clean any bars or reinforcing protruding into the area of concrete removal for bond to all new concrete. Reinstall the curb sliding plate after installation of the new joint. Cut the bottom of the curb plate to provide 20 mm clearance to the top of the Silica Fume Overlay. Grind smooth.

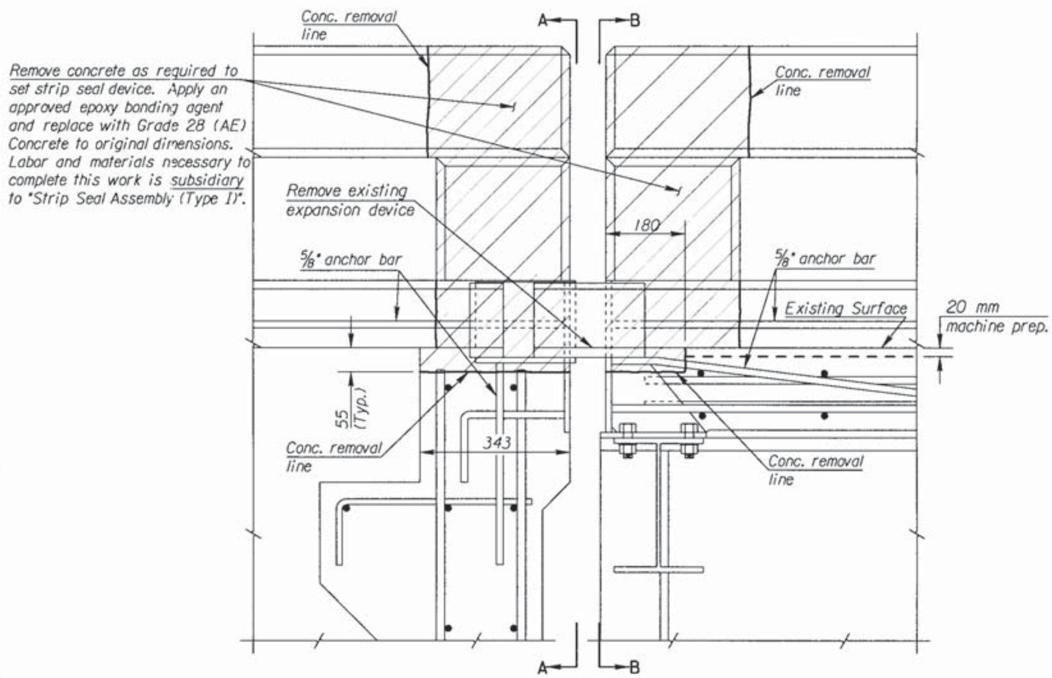


SECTION A-A

SECTION B-B

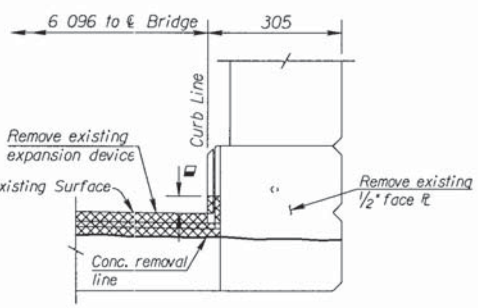
▬ Cut and grind curb plates smooth to clear existing surface by 40 mm.

Plot Date : 07-OCT-2002 11:11 / Server: dt06ft05 / Squad: HURT		PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760\83760la.dgn			
EXPANSION DEVICE DETAILS (LIMITS OF REMOVAL)	View= PLOT14	BRIDGE NO. 10-46 (176)&(177)	JOHNSON Co. PAGE14

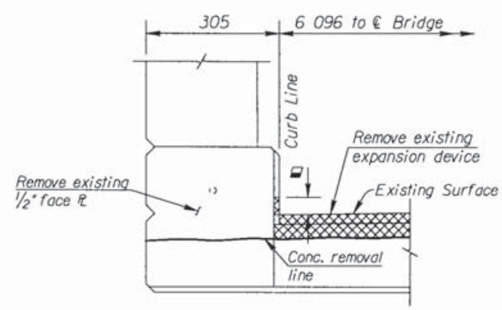


ELEVATION

REMOVAL OF EXISTING EXPANSION DEVICE:
Remove the existing sliding plates and a portion of the armoring from the deck, backwall and curb. Leave and clean any bars or reinforcing protruding into the area of concrete removal for bond to all new concrete. Reinstall the curb sliding plate after installation of the new Joint. Cut the bottom of the curb plate to provide 20 mm clearance to the top of the Silica Fume Overlay. Grind smooth.



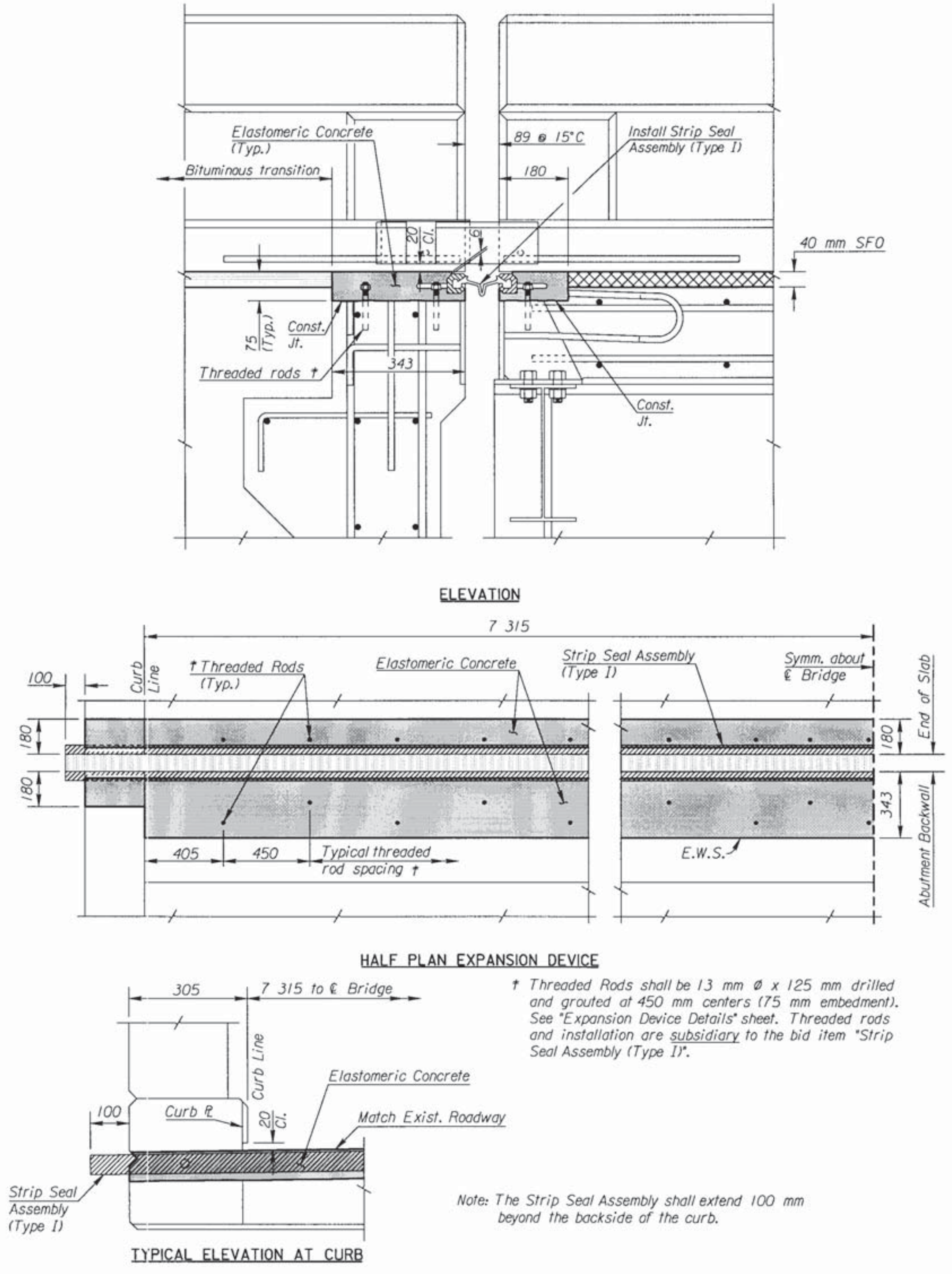
SECTION A-A



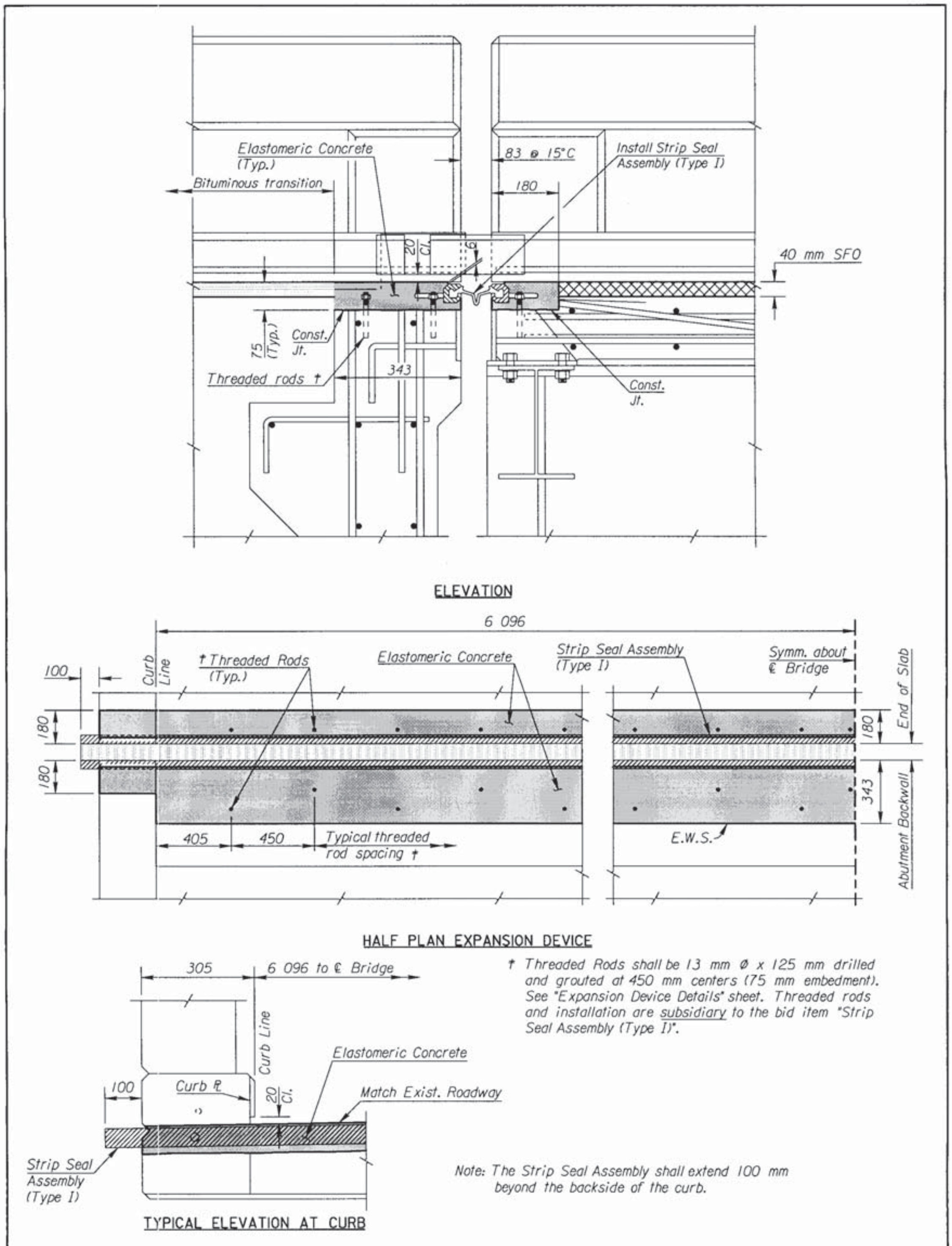
SECTION B-B

▭ Cut and grind curb plates smooth to clear existing surface by 40 mm.

Plot Date : 07-OCT-2002 11:11 · Server: dt06ft05 · Squad: HURT · Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\83760Ia.dgn		PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION	
EXPANSION DEVICE DETAILS (LIMITS OF REMOVAL)	View= PLOT15	BRIDGE NO. 10-46 (178)&(179)	JOHNSON Co.	PAGE15

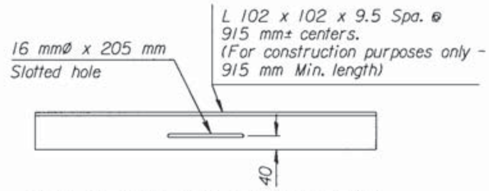


Plot Date : 07-OCT-2002 11:12	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k837601\837601a.dgn				
EXPANSION DEVICE DETAILS (PROPOSED CONSTRUCTION)	View= PLOT16		BRIDGE NO. 10-46 (176)&(177)	JOHNSON Co. PAGE16

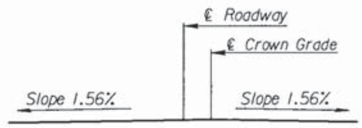


Plot Date : 07-OCT-2002 11:12	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION	
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\83760Ia.dgn					
EXPANSION DEVICE DETAILS (PROPOSED CONSTRUCTION)	View= PLOT17		BRIDGE NO. 10-46 (178)&(179)	JOHNSON Co.	PAGE17

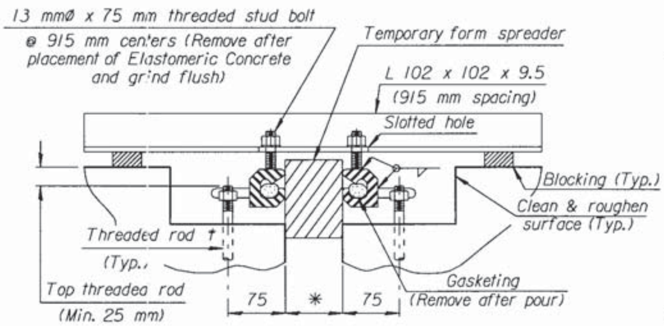
TEMPERATURE GAP CORRECTIONS (Measured along ℄ Project)	
TEMP. °C	* GAP DIMENSION
0	101 mm
5	97 mm
10	93 mm
15	89 mm
20	85 mm
25	81 mm
30	77 mm
35	73 mm



PLAN OF STRIP SEAL ERECTION ANGLE

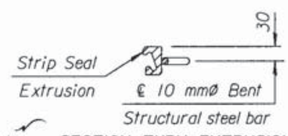


SLOPE OF STRIP SEAL

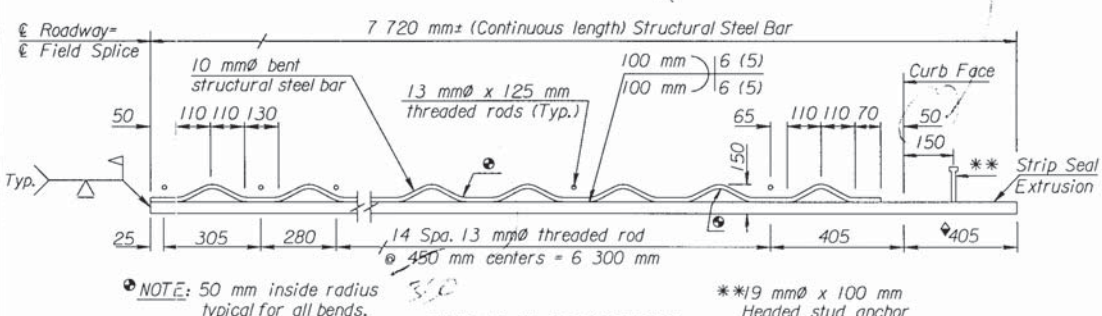


TYPICAL SECTION SHOWING ERECTION ANGLE

†Threaded Rods shall be 13 mmØ x 125 mm preset in early strength concrete at 450 mm centers (75 mm embedment).



SECTION THRU EXTRUSION



NOTE: 50 mm inside radius typical for all bends.

**19 mmØ x 100 mm Headed stud anchor

HALF PLAN OF EXTRUSION

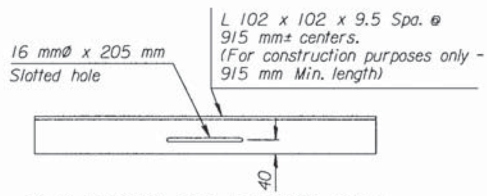
NOTE:
Immediately prior to placing the elastomeric concrete around the Strip Seal Assembly, the concrete surface shall be cleaned and roughened as per the elastomeric concrete manufacturer's recommendations. The erection angles shall be securely bolted to the extrusions. The extrusions shall be in the same plane and recessed 6 mm below the top of the roadway. The erection angles shall be removed as soon as the elastomeric concrete will support the assembly without allowing any settlement or tilting. Following the removal of the erection angles, remove the stud bolts on the extrusions and grind flush. The stud bolts, nuts and washers, and erection angles, labor and materials used to install and remove the erection angles shall be subsidiary to the bid item "Strip Seal Assembly (Type I)".

NOTE:
Extrusion and gland to extend approximately 405 mm beyond curb face.

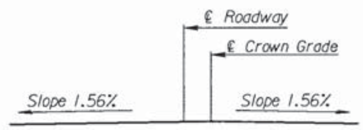
NOTE:
The Contractor may select an alternate steel extrusion shape. Details for the proposed alternate shall be submitted to the Engineer for approval prior to fabrication. All items shown on this sheet are included in the bid item "Strip Seal Assembly (Type I)". All welds on the expansion device shall be 6 mm continuous fillet welds, unless otherwise noted.

Plot Date : 07-OCT-2002 11:13	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION	
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760\83760la.dgn					
EXPANSION DEVICE DETAILS	View= PLOT18		BRIDGE NO. 10-46 (176)&(177)	JOHNSON Co.	PAGE18

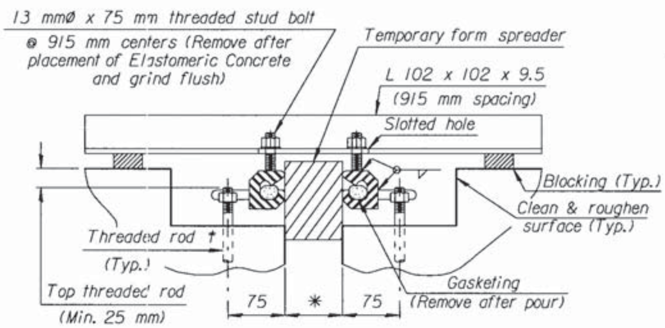
TEMPERATURE GAP CORRECTIONS (Measured along ℄ Project)	
TEMP. °C	* GAP DIMENSION
0	92 mm
5	89 mm
10	86 mm
15	83 mm
20	80 mm
25	77 mm
30	74 mm
35	71 mm



PLAN OF STRIP SEAL ERECTION ANGLE

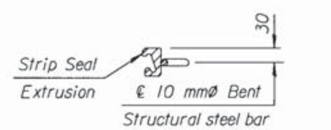


SLOPE OF STRIP SEAL

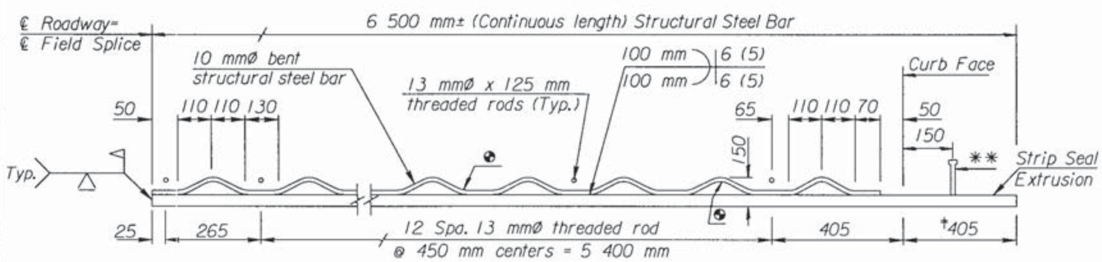


TYPICAL SECTION SHOWING ERECTION ANGLE

†Threaded Rods shall be 13 mmØ x 125 mm preset in early strength concrete at 450 mm centers (75 mm embedment).



SECTION THRU EXTRUSION



NOTE: 50 mm inside radius typical for all bends.

**19 mmØ x 100 mm Headed stud anchor

HALF PLAN OF EXTRUSION

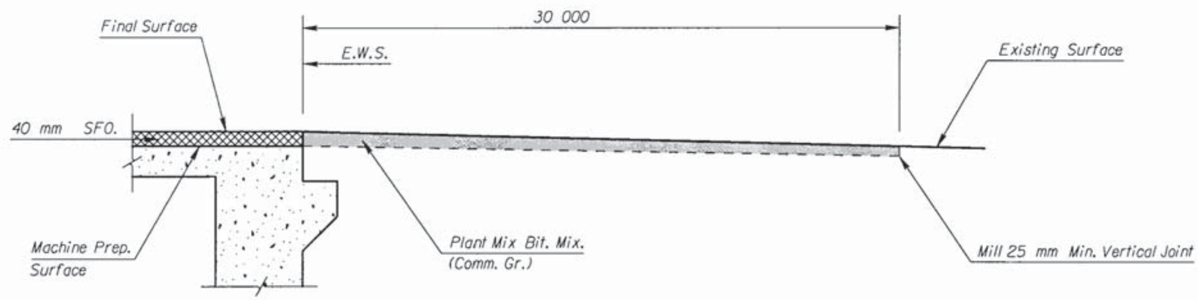
NOTE:
Immediately prior to placing the elastomeric concrete around the Strip Seal Assembly, the concrete surface shall be cleaned and roughened as per the elastomeric concrete manufacturer's recommendations. The erection angles shall be securely bolted to the extrusions. The extrusions shall be in the same plane and recessed 6 mm below the top of the roadway. The erection angles shall be removed as soon as the elastomeric concrete will support the assembly without allowing any settlement or tilting. Following the removal of the erection angles, remove the stud bolts on the extrusions and grind flush. The stud bolts, nuts and washers, and erection angles, labor and materials used to install and remove the erection angles shall be subsidiary to the bid item "Strip Seal Assembly (Type I)".

†NOTE:
Extrusion and gland to extend approximately 405 mm beyond curb face.

NOTE:
The Contractor may select an alternate steel extrusion shape. Details for the proposed alternate shall be submitted to the Engineer for approval prior to fabrication. All items shown on this sheet are included in the bid item "Strip Seal Assembly (Type I)". All welds on the expansion device shall be 6 mm continuous fillet welds, unless otherwise noted.

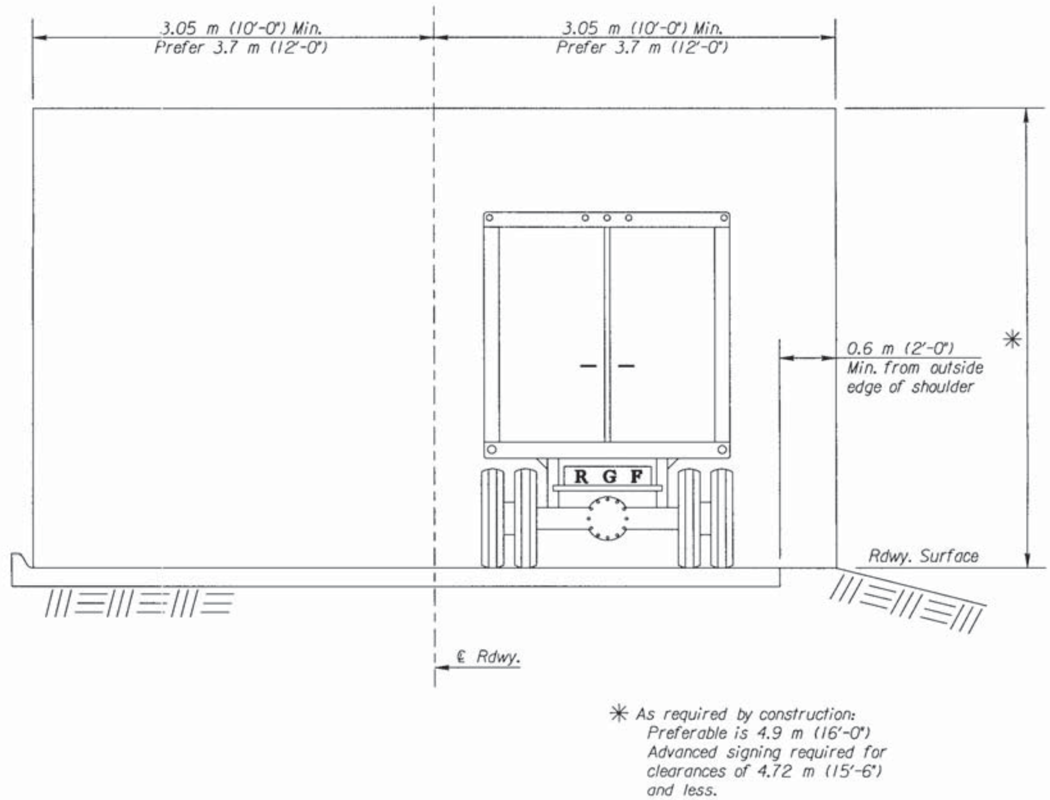
Plot Date : 07-OCT-2002 11:14	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760\83760la.dgn				
EXPANSION DEVICE DETAILS	View= PLOT19		BRIDGE NO. 10-46 (178)&(179)	JOHNSON Co. PAGE19

BITUMINOUS APPROACH OVERLAY: The approach and exit overlays shall be Plant Mix Bituminous Mixture (Commercial Grade) paid by the bid item designated. The overlay shall taper from the new Silica Fume Overlay in a manner that will provide a smooth transition in grade as shown. Contract quantity includes 10% for contingencies. Additional material may be required due to soft or unstable areas in the existing surface. These areas shall be repaired as needed and as directed by the Engineer. Milled material shall be disposed of in a manner and at a location approved by the Engineer.



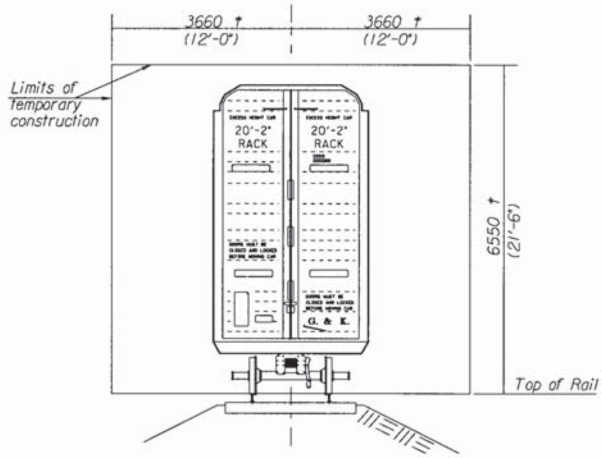
TRANSITION AT BRIDGE ENDS

Plot Date : 07-OCT-2002 11:14	Server: dt06ft05	Squad:	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k83760I\83760Ia.dgn				
BITUMINOUS APPROACH OVERLAY		View= PLOT20	BRIDGE NO. 10-46 (176-179)	JOHNSON Co. PAGE20



CONSTRUCTION CLEARANCE DETAILS

Plot Date : 07-OCT-2002 11:15	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION	
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Main\k837601\837601a.dgn					
CONSTRUCTION CLEARANCE DETAILS		View= PLOT21	BRIDGE NO. 10-46 (176)&(177)	JOHNSON Co.	PAGE21



CONSTRUCTION CLEARANCE DETAILS

† Note: Minimum Clearance Dimensions are shown. Clearance less than shown require advanced approval by the Railroad and KDOT.

RAILROAD PROTECTION: If removal of concrete is required through the full thickness of the deck (i.e. full depth patching, edge of slab removal, or complete deck replacement), then the Contractor shall execute the work in such a manner and take any precautions necessary to prohibit broken concrete and other debris from falling on and damaging the rails, ties, ballast or other railroad property. As much as possible, do the work so as not to interfere with the normal use of the tracks. The Railroad and the Engineer shall approve the methods of protection proposed by the Contractor before any work begins.

Server File :	Server: dt06ft05	Squad: HURT	PROJ. NO. 10-46 K-8376-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : \\DT06FT05\KDOT\Bridge\Projects\Maint\k837601\837601.dgn	Date : 01-OCT-2002 11:15			
RAILROAD PROTECTION		View= PLOT22	BRIDGE NO. 10-46 (176)&(177)	JOHNSON Co. PAGE22

Appendix C Emergency Bridge Repair Plans for Bridge Hit of I-35 over 17th St in Wichita

Br. No. 135-87-290

GENERAL NOTES

SLAB REPAIR: Repair the damaged section of the slab per these plans and in comformity to KDOT Standard Provision and applicable Special Provisions. All labor, material, equipment, and incidentals necessary to complete the work are subsidiary to the bid item "Slab Repair (m^2)". See KDOT Special Provisions.

TRAFFIC CONTROL: Remove traffic from the lane above the repair and keep the lane closed until the concrete has cured a minimum of 7 days. Protect traffic on 17th Street from broken concrete and other debris.

CONCRETE REMOVAL: Remove all damaged and/or debonded concrete. Remove addition concrete if and only as required to expose undamaged existing reinforcing steel for splicing to new reinforcing, and to form neat lines for concrete placement. Removed concrete is property of the Contractor.

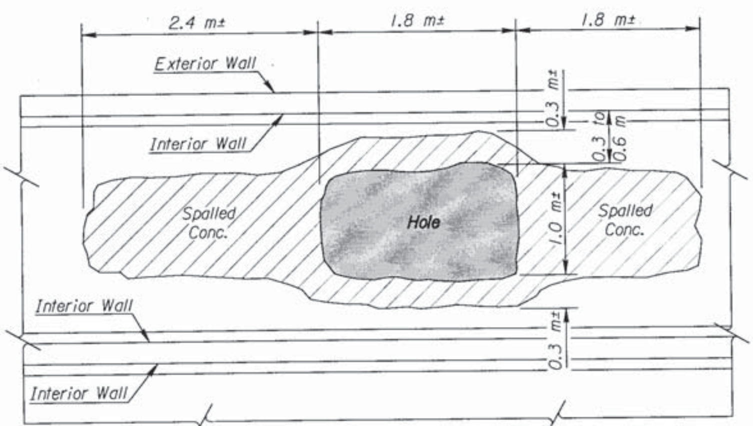
CONCRETE: Provide Gr. 28 (AE) Concrete that conforms to KDOT Standard Provisions. This item is subsidiary to the bid item "Slab Repair".

REINFORCING STEEL: Provide reinforcing steel that conforms to the requirements of ASTM A615M-96, Grade 420. This item is subsidiary to the bid item "Slab Repair". Existing Reinforcing Steel is referred to by US bar designations. New Reinforcing Steel is referred to by SI bar designations.

REINFORCING STEEL SPLICE: Splice new reinforcing steel to existing reinforcing steel with mechanical or thermomechanical reinforcing steel splices that conform to Special Provision 90M-166. A list of Prequalified splices is available from the Bureau of Materials and Research.

EPOXY RESIN CRACK REPAIR: Repair the horizontal crack at the inside face of the exterior girder web per these plans and in comformity to KDOT Standard Provision and applicable Special Provisions. All labor, material, equipment, and incidentals necessary to complete the work is subsidiary to the bid item "Epoxy Resin Crack Repair (m)". See KDOT Special Provisions.

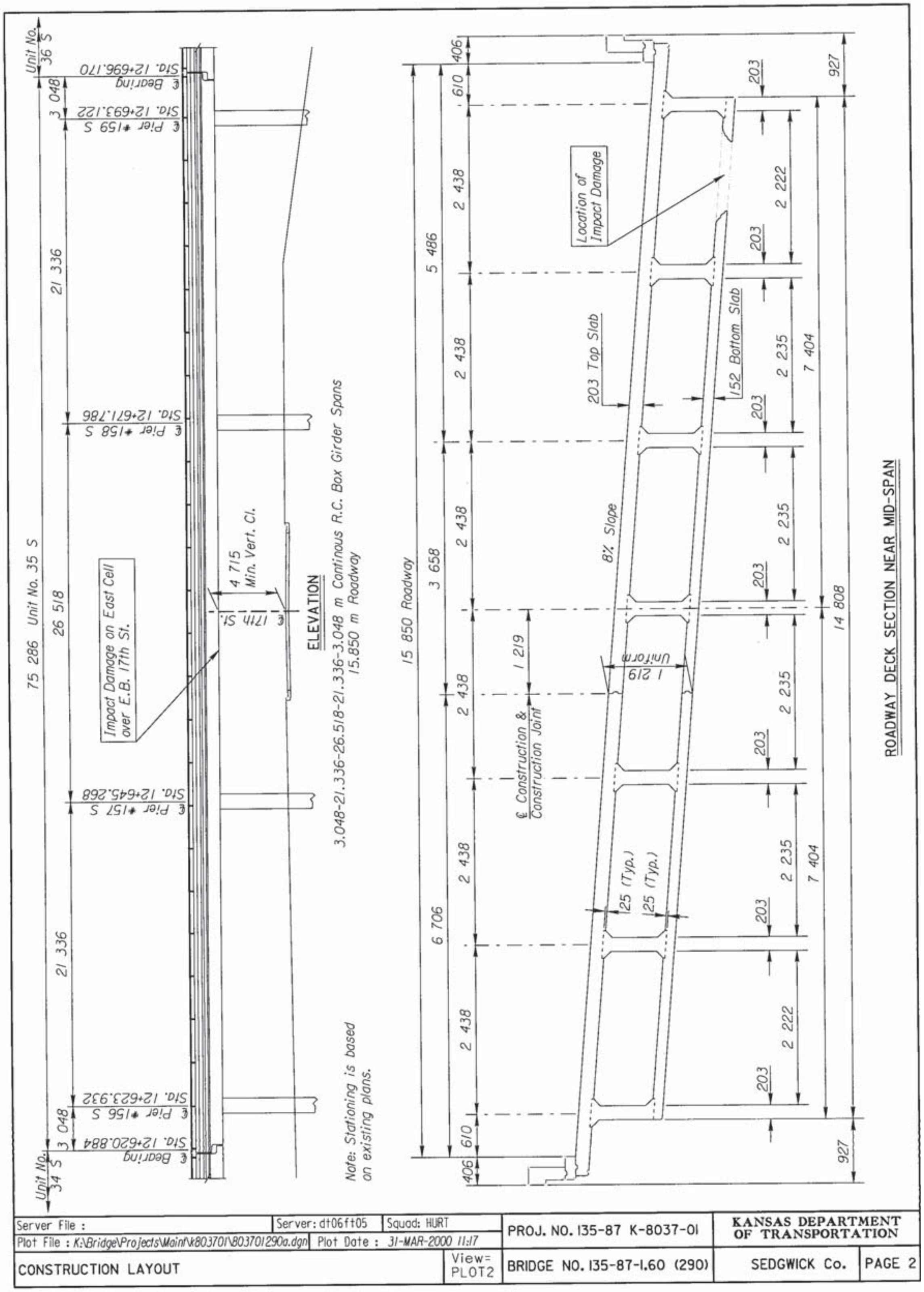
SUMMARY OF QUANTITIES		
Item	Quantity	Unit
Slab Repair	7.6	m^2
Epoxy Resin Crack Repair	11.0	m
Mobilization	Lump Sum	Lump Sum

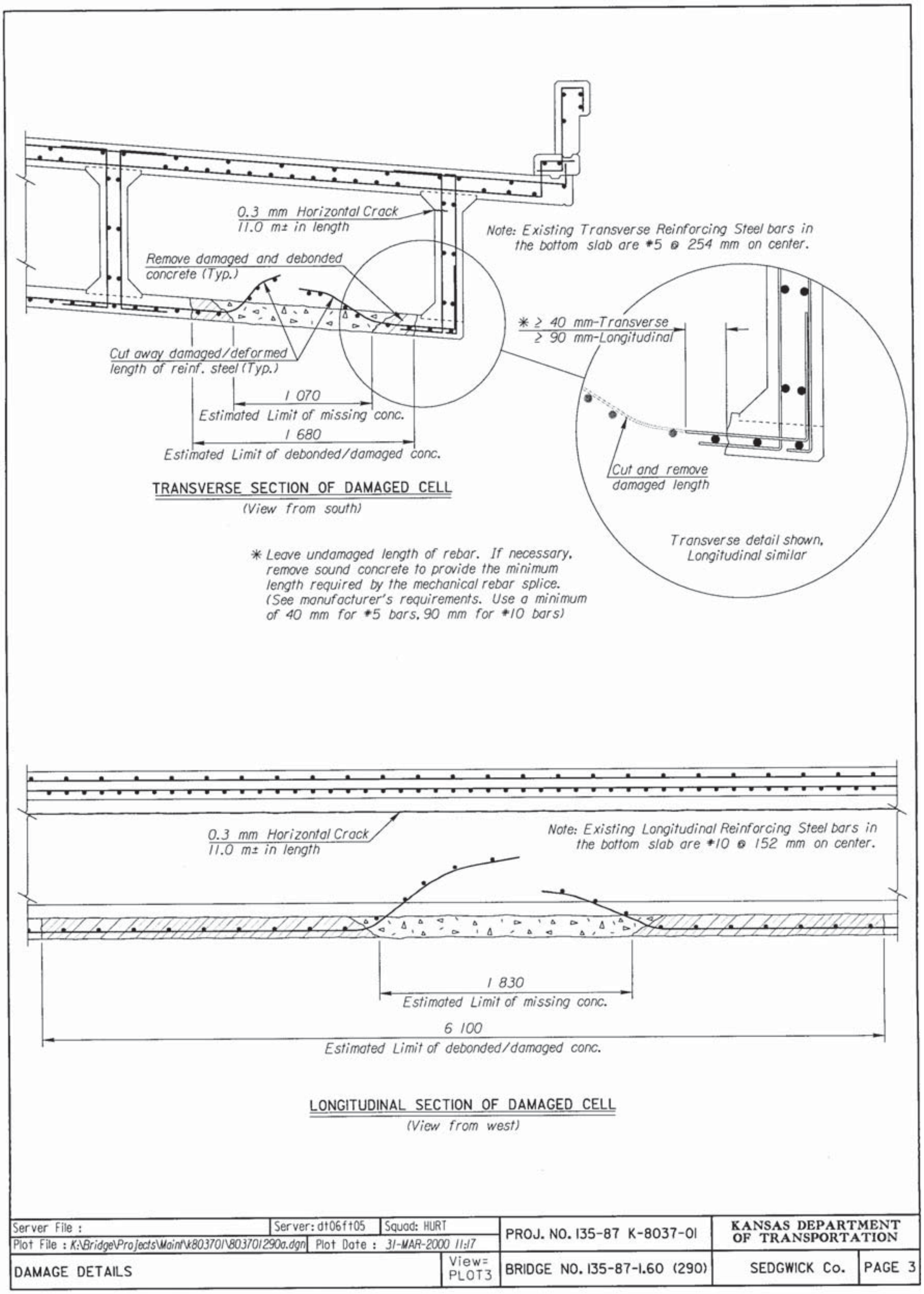


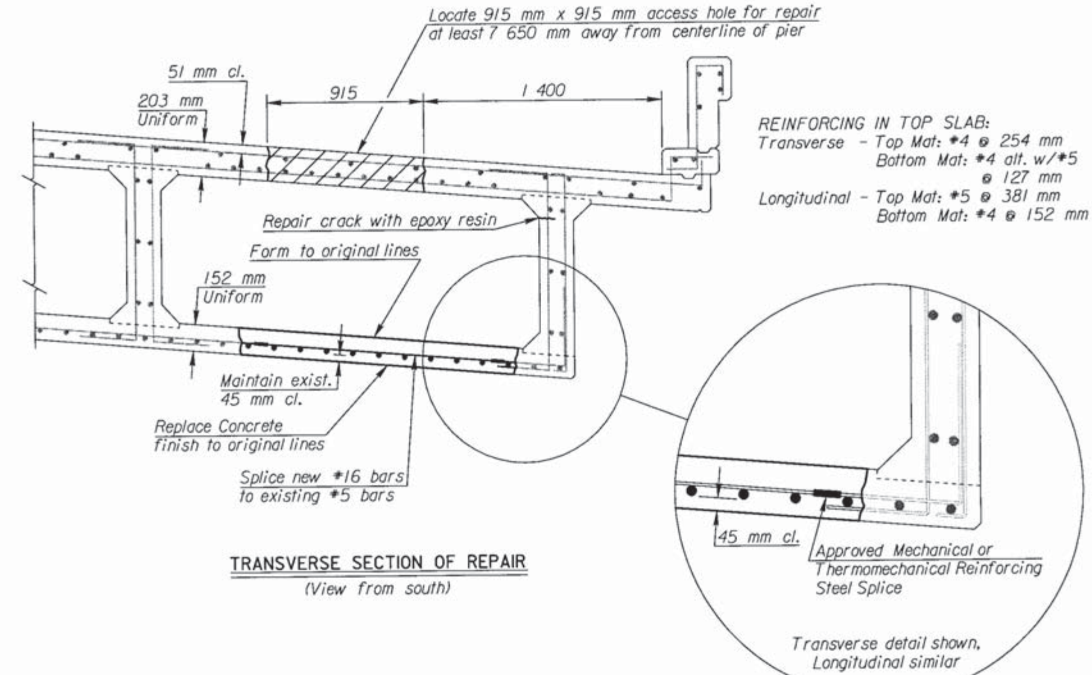
IMPACT DETAIL

(View from inside of cell, looking down)

Server File :	Server: dt06ft05	Squad: HURT	PROJ. NO. 135-87 K-8037-01	KANSAS DEPARTMENT OF TRANSPORTATION
Plot File : K:\Bridge\Projects\Maint\k803701\803701290a.dgn	Plot Date : 31-MAR-2000 11:13			
GENERAL NOTES AND SUMMARY OF QUANTITIES	View= PLOT1		BRIDGE NO. 135-87-1.60 (290)	SEDGWICK Co. PAGE 1


ELEVATION
3.048-21.336-26.518-21.336-3.048 m Continous R.C. Box Girder Spans
15.850 m Roadway
75 286 Unit No. 35 S
Unit No. 36 S
Unit No. 34 S
Impact Damage on East Cell over E.B. 17th St.
4 715 Min. Vert. Cl.
℄ 17th St.
℄ Bearing Sta. 12+696.170
℄ Pier #159 S Sta. 12+693.122
℄ Pier #158 S Sta. 12+671.786
℄ Pier #157 S Sta. 12+645.268
℄ Pier #156 S Sta. 12+623.932
℄ Bearing Sta. 12+620.884
Note: Stationing is based on existing plans.
ROADWAY DECK SECTION NEAR MID-SPAN
15 850 Roadway
Location of Impact Damage
203 Top Slab
152 Bottom Slab
8% Slope
Uniform
1 219
℄ Construction & Construction Joint
25 (Typ.)
14 808
7 404
927
Server File :
Server: dt06ft05
Squad: HURT
Plot File : K:\Bridge\Projects\Maint\k803701\803701290a.dgn
Plot Date : 31-MAR-2000 11:17
PROJ. NO. 135-87 K-8037-01
KANSAS DEPARTMENT OF TRANSPORTATION
CONSTRUCTION LAYOUT
View= PLOT2
BRIDGE NO. 135-87-1.60 (290)
SEDGWICK Co.
PAGE 2

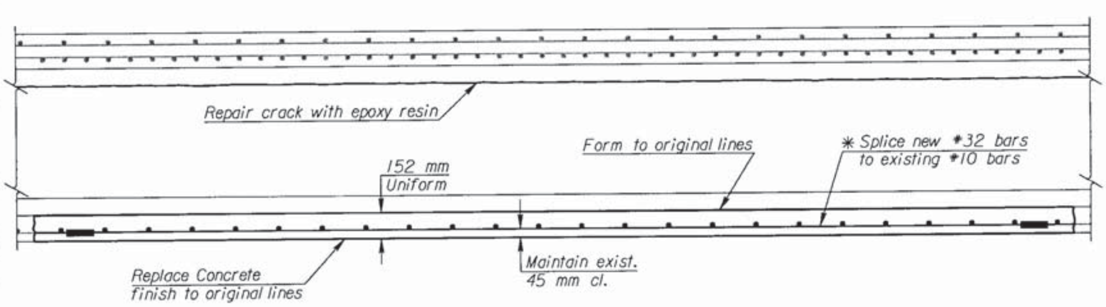

0.3 mm Horizontal Crack
11.0 m± in length
Remove damaged and debonded concrete (Typ.)
Note: Existing Transverse Reinforcing Steel bars in the bottom slab are #5 @ 254 mm on center.
✳ ≥ 40 mm-Transverse
≥ 90 mm-Longitudinal
Cut away damaged/deformed length of reinf. steel (Typ.)
1 070
Estimated Limit of missing conc.
1 680
Estimated Limit of debonded/damaged conc.
Cut and remove damaged length
TRANSVERSE SECTION OF DAMAGED CELL
(View from south)
Transverse detail shown, Longitudinal similar
✳ Leave undamaged length of rebar. If necessary, remove sound concrete to provide the minimum length required by the mechanical rebar splice. (See manufacturer's requirements. Use a minimum of 40 mm for #5 bars, 90 mm for #10 bars)
0.3 mm Horizontal Crack
11.0 m± in length
Note: Existing Longitudinal Reinforcing Steel bars in the bottom slab are #10 @ 152 mm on center.
1 830
Estimated Limit of missing conc.
6 100
Estimated Limit of debonded/damaged conc.
LONGITUDINAL SECTION OF DAMAGED CELL
(View from west)
Server File :
Server: dt06ft05
Squad: HURT
Plot File : K:\Bridge\Projects\Maint\k80370I\80370I290a.dgn
Plot Date : 31-MAR-2000 11:17
PROJ. NO. 135-87 K-8037-01
KANSAS DEPARTMENT OF TRANSPORTATION
DAMAGE DETAILS
View= PLOT3
BRIDGE NO. 135-87-1.60 (290)
SEDGWICK Co.
PAGE 3



TRANSVERSE SECTION OF REPAIR

(View from south)

ACCESS HOLE: Excavate a 915 mm x 915 mm hole in the top slab to provide access for pouring new concrete. Take care to minimize damage to the surrounding concrete and reinforcing steel. Immediately after repairs to the bottom slab are complete, the access hole is to be repaired in a similar manner. Labor, materials, and equipment required to excavate and repair the access hole are subsidiary to the bid item "Slab Repair".



LONGITUDINAL SECTION OF REPAIR

(View from west)

* Note: If an end of a longitudinal bar is completly debonded, provide a replacement bar with a length sufficient to reach the original end of the existing bar. The shortest existing bars are 10 972 mm in length, centered at midspan.

Server File :	Server: dt06ft05	Squad: HURT	PROJ. NO. 135-87 K-8037-01	KANSAS DEPARTMENT OF TRANSPORTATION	
Plot File : K:\Bridge\Projects\Maint\k80370l\80370l290a.dgn	Plot Date : 31-MAR-2000 11:12				
REPAIR DETAILS		View= PLOT4	BRIDGE NO. 135-87-1.60 (290)	SEDGWICK Co.	PAGE4

Appendix D Bridge Repair Plans for KDOT Forces for Bottom Chord of Neosho River Truss

Br. No. 75-16-21

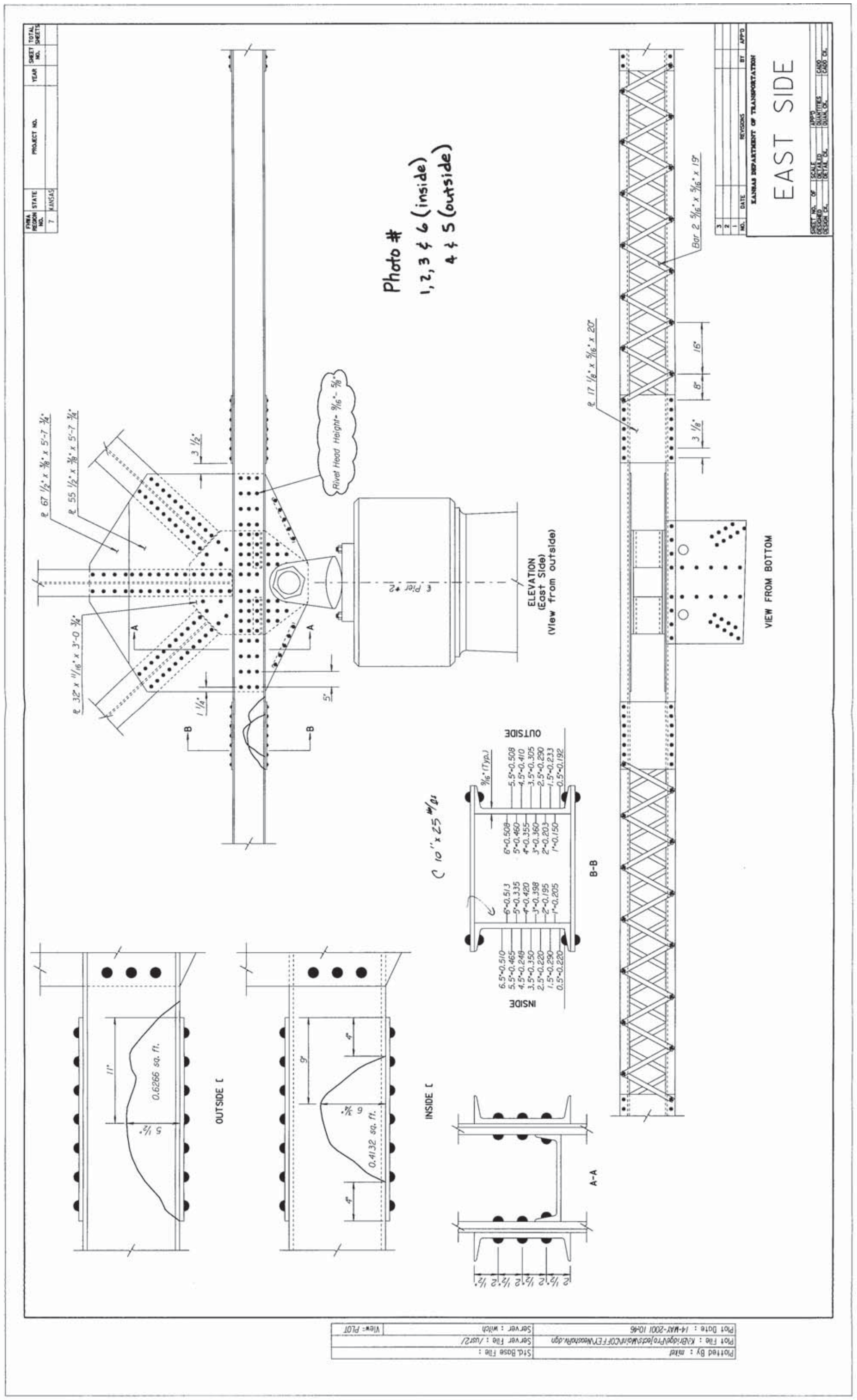
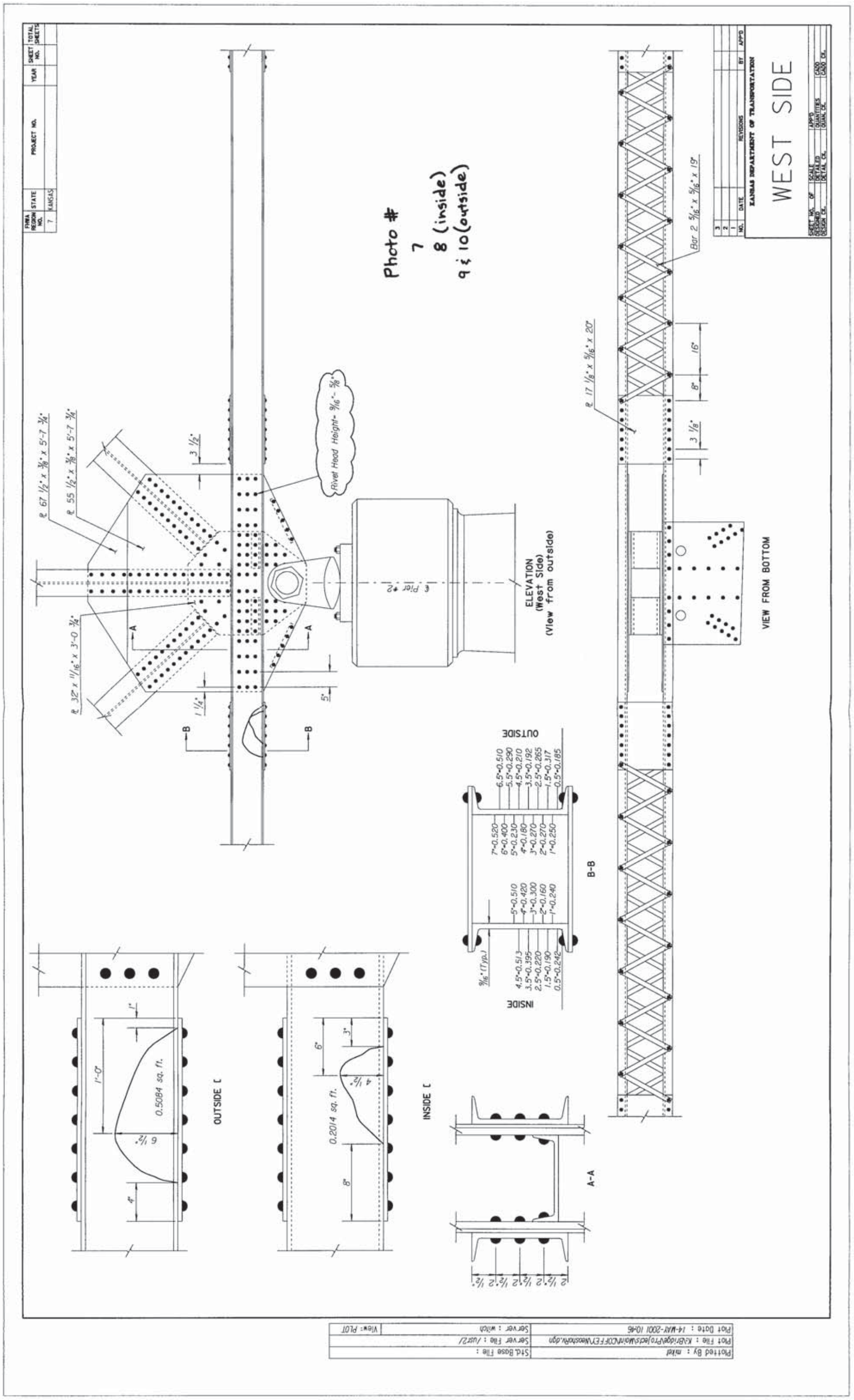
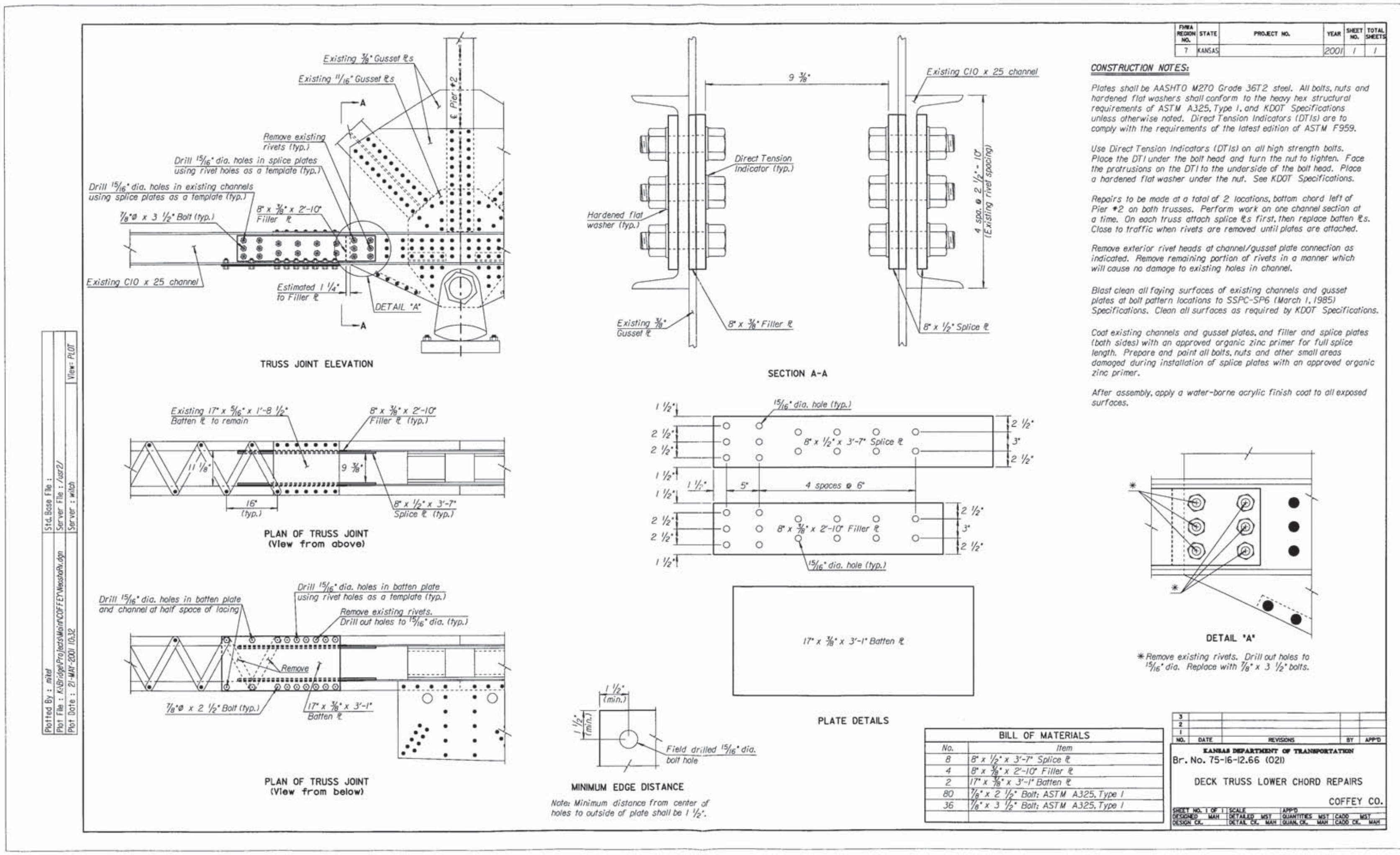


Photo #
1, 2, 3 & 6 (inside)
4 & 5 (outside)
ELEVATION
(East Side)
(View from outside)
VIEW FROM BOTTOM
OUTSIDE [
INSIDE [
A-A
B-B
INSIDE
OUTSIDE
KANSAS DEPARTMENT OF TRANSPORTATION
EAST SIDE


KANSAS DEPARTMENT OF TRANSPORTATION
WEST SIDE
Photo #
7
8 (inside)
9 & 10 (outside)
ELEVATION
(West Side)
(View from outside)
VIEW FROM BOTTOM
OUTSIDE
INSIDE
A-A
B-B



FHWA REGION NO. | STATE | PROJECT NO. | YEAR | SHEET NO. | TOTAL SHEETS
7 | KANSAS | | 2001 | 1 | 1
Existing 3/8" Gusset ℄s
Existing 11/16" Gusset ℄s
℄ Pier #2
Remove existing rivets (typ.)
Drill 15/16" dia. holes in splice plates using rivet holes as a template (typ.)
Drill 15/16" dia. holes in existing channels using splice plates as a template (typ.)
7/8"ø x 3 1/2" Bolt (typ.)
8" x 3/8" x 2'-10" Filler ℄
Existing C10 x 25 channel
Estimated 1 1/4" to Filler ℄
DETAIL "A"
TRUSS JOINT ELEVATION
9 3/8"
Existing C10 x 25 channel
Direct Tension Indicator (typ.)
Hardened flat washer (typ.)
4 spa. @ 2 1/2" = 10" (Existing rivet spacing)
Existing 3/8" Gusset ℄
8" x 3/8" Filler ℄
8" x 1/2" Splice ℄
SECTION A-A
Existing 17" x 5/16" x 1'-8 1/2" Batten ℄ to remain
8" x 3/8" x 2'-10" Filler ℄ (typ.)
11 1/8"
16" (typ.)
8" x 1/2" x 3'-7" Splice ℄ (typ.)
PLAN OF TRUSS JOINT (View from above)
Drill 15/16" dia. holes in batten plate and channel at half space of lacing
Drill 15/16" dia. holes in batten plate using rivet holes as a template (typ.)
Remove existing rivets. Drill out holes to 15/16" dia. (typ.)
Remove
7/8"ø x 2 1/2" Bolt (typ.)
17" x 3/8" x 3'-1" Batten ℄
PLAN OF TRUSS JOINT (View from below)
15/16" dia. hole (typ.)
8" x 1/2" x 3'-7" Splice ℄
1 1/2" 5" 4 spaces @ 6"
2 1/2" 3" 2 1/2"
8" x 3/8" x 2'-10" Filler ℄
17" x 3/8" x 3'-1" Batten ℄
PLATE DETAILS
1 1/2" (min.)
Field drilled 15/16" dia. bolt hole
MINIMUM EDGE DISTANCE
Note: Minimum distance from center of holes to outside of plate shall be 1 1/2".
CONSTRUCTION NOTES:
Plates shall be AASHTO M270 Grade 36T2 steel. All bolts, nuts and hardened flat washers shall conform to the heavy hex structural requirements of ASTM A325, Type I, and KDOT Specifications unless otherwise noted. Direct Tension Indicators (DTIs) are to comply with the requirements of the latest edition of ASTM F959.
Use Direct Tension Indicators (DTIs) on all high strength bolts. Place the DTI under the bolt head and turn the nut to tighten. Face the protrusions on the DTI to the underside of the bolt head. Place a hardened flat washer under the nut. See KDOT Specifications.
Repairs to be made at a total of 2 locations, bottom chord left of Pier #2 on both trusses. Perform work on one channel section at a time. On each truss attach splice ℄s first, then replace batten ℄s. Close to traffic when rivets are removed until plates are attached.
Remove exterior rivet heads at channel/gusset plate connection as indicated. Remove remaining portion of rivets in a manner which will cause no damage to existing holes in channel.
Blast clean all faying surfaces of existing channels and gusset plates at bolt pattern locations to SSPC-SP6 (March 1, 1985) Specifications. Clean all surfaces as required by KDOT Specifications.
Coat existing channels and gusset plates, and filler and splice plates (both sides) with an approved organic zinc primer for full splice length. Prepare and paint all bolts, nuts and other small areas damaged during installation of splice plates with an approved organic zinc primer.
After assembly, apply a water-borne acrylic finish coat to all exposed surfaces.
DETAIL "A"
* Remove existing rivets. Drill out holes to 15/16" dia. Replace with 7/8" x 3 1/2" bolts.
BILL OF MATERIALS
No. | Item
8 | 8" x 1/2" x 3'-7" Splice ℄
4 | 8" x 3/8" x 2'-10" Filler ℄
2 | 17" x 3/8" x 3'-1" Batten ℄
80 | 7/8" x 2 1/2" Bolt; ASTM A325, Type I
36 | 7/8" x 3 1/2" Bolt; ASTM A325, Type I
NO. | DATE | REVISIONS | BY | APP'D
KANSAS DEPARTMENT OF TRANSPORTATION
Br. No. 75-16-12.66 (021)
DECK TRUSS LOWER CHORD REPAIRS
COFFEY CO.
Plotted By : mikel
Plot File : K:\Bridge\Projects\Wsim\COFFEY\Newsheet.dgn
Plot Date : 21-MAY-2001 10:32
Std. Base File :
Server File : /usr2/
Server : witch
View: PLOT

File: 1505A

MEMO TO:	Mike Crow, P.E., Chief Bureau of Traffic Engineering
ATTENTION:	Lee Roadifer, P.E. State Traffic Signing Engineer
FROM:	G. David Comstock, P.E. Chief, Bureau of Design
BY:	Donald E. Whisler, P.E. Bridge Inspection Engineer Bridge Management Section
DATE:	March 1, 2001
REFERENCE:	Bridge Posting
SUBJECT:	KDOT Bridge No. 75-16-98.19 (021) 8.49 Miles North of K-57 N Jct. US-75 Over Neosho River Coffey County

Due to the deterioration of the superstructure (bottom chord section loss) the Bridge Office has re-evaluated the load carrying capacity of the above referenced bridge. It was concluded that the structure's load carrying capacity be restricted. We recommend a Load Posting of 25-35-40 Tons be installed on Type I signs.

Feel free to contact this office if you have any questions concerning this memorandum.

c: John Hrenak, District Four Maintenance Engineer
Michael Stringer, Area Engineer
Jeffery Smith, Bridge Engineer, FHWA
Dennis Gamble, Program Management Engineer, Bureau of Program Management
Lynn Washburn, Bridge Evaluation-Squad Leader

KANSAS DEPARTMENT OF TRANSPORTATION
OFFICE OF THE SECRETARY OF TRANSPORTATION
Docking State Office Building
915 SW Harrison Street, Rm.730
Topeka, Kansas 66612-1568
Ph. (785) 296-3461 FAX (785) 296-1095
TTY (785) 296-3585

E. Dean Carlson
Secretary of Transportation

Bill Graves
Governor

April 10, 2001

Mr. Gene L. Merry, Chairman
Board of County Commissioners
Coffey County
Courthouse
Burlington, Kansas 66839

Dear Commissioner Merry:

Thank you for the March 20, 2001 letter written on behalf of the Coffey County Commission regarding prioritizing for early replacement and establishment of appropriate detour routes for the US-75 Highway Bridge over the Neosho River which was recently signed for posted weight limits.

The Kansas Department of Transportation (KDOT) has recognized the importance of this bridge in the movement of commercial freight for many years. On December 7, 1998 KDOT initiated Project Number 75-16 K 7389-01 to replace Bridge No. 16-(021) on US-75 over the Neosho River north of Burlington. This bridge replacement project is on schedule with a letting date of September 2004 and estimated completion date of October 2005.

For several years KDOT has been routing overweight permitted loads around this bridge effectively limiting truck weights to the legal load of 85,500 pounds. The load limit for the heaviest of truck's will now be 80,000 pounds. This is a reduction of 5,500 pounds or six percent of a trucks total legal weight. The current weight limit on I-35 north of Burlington is the same 80,000 pounds. Nearly one half of the truck traffic using US-75 north of Burlington exits US-75 at I-35. We have informed the trucking firms and the Kansas Motor Carriers Association of the load postings on the bridge. We expect the haulers of commercial freight to adjust their truck routes using state highways or slightly reduce their loads during the duration of this load restriction. These are adjustments routinely made by commercial trucking operations for their normal operations based on economics.

Mr. Gene L. Merry
Page 2
April 13, 2001

The load posting of this bridge is necessary to protect the safety of all motorists until a new bridge can be constructed. I do understand your concerns about trucks adjusting their traffic patterns to adjust to the bridge posting.

I hope that my response has helped to address your concerns. If you have additional questions, please contact District Engineer, Roger Alexander, at (620) 431-1000.

Sincerely,

E. Dean Carlson
Secretary of Transportation

EDC:RBA:md

cc: Senator James Barnett
Senator Derek Schmidt
Representative Mary Compton
Representative Stanley Dreher

bc: Warren Sick#7017
SteveWoolington, Director of Operations
Dan Scherschligt, Bureau of Design
Nancy Bogina, Special Assistant to the Secretary/Division of Public Affairs

Appendix E Survey for the Organizational Audit for Reliability from Weick and Sutcliffe, *Managing the Unexpected*

Exhibit 4.1. A Starting Point for Your Firm's Mindfulness.

How well do each of the following statements characterize your organization? Enter next to each item below the number that corresponds with your conclusion: 1 = not at all, 2 = to some extent, 3 = a great deal.

1. There is an organizationwide sense of susceptibility to the unexpected.

2. Everyone feels accountable for reliability.

3. Leaders pay as much attention to managing unexpected events as they do to achieving formal organizational goals.

4. People at all levels of our organization value quality.

5. We spend time identifying how our activities could potentially harm our organization, employees, our customers, other interested parties, and the environment at large.

6. We pay attention to when and why our employees, our customers, or other interested parties might feel peeved or disenfranchised from our organization.

7. There is widespread agreement among the firm's members on what we don't want to go wrong.

8. There is widespread agreement among the firm's members about how things could go wrong.

Scoring: Add the numbers. If you score higher than sixteen, the *mindful infrastructure* in your firm is exemplary. If you score between ten and sixteen, your firm is on its way to building a mindful infrastructure. Scores lower than ten suggest that you should actively be considering how you can immediately improve your firm's capacity for mindfulness.

Exhibit 4.2. Assessing Your Firm's Vulnerability to Mindlessness.

How well do each of the following statements describe your work unit, department, or organization? Enter next to each item below the number that corresponds with your conclusion: 1 = not at all, 2 = to some extent, 3 = a great deal.

1. During a normal week, exceptions rarely arise in our work.

2. The situations, problems, or issues we encounter are similar from day to day.

3. People in this organization have trouble getting all the information they need to do their work.

4. People are expected to perform their jobs in a particular way without deviations.

5. People often work under severe production pressures (that is, time, costs, growth, or profits).

6. Pressures often lead people to cut corners.

7. There are incentives in the work environment to hide mistakes.

8. People have little discretion to take actions to resolve unexpected problems as they arise.

9. Many people lack the skills and expertise they need to act on the unexpected problems that arise.

10. People rarely speak up to test assumptions about issues under discussion.

11. If you make a mistake, it is often held against you.

12. It is difficult to ask others for help.

Scoring: Add the numbers. If you score higher than twenty-four, the current potential for *mindlessness* is high and you should be actively considering how you can immediately improve the capability for mindfulness. If you score between fourteen and twenty-four, the potential for *mindlessness* is moderate. Scores lower than fourteen suggest a strong capacity for mindfulness.

Exhibit 4.3. Assessing Your Firm's Tendency Toward Doubt, Inquiry, and Updating.

Respond *agree* or *disagree* with the following statements about your work unit, department, or organization.

Doubt

1. People around here are quick to deny problems when they show up.

2. When someone voices a doubt or concern, people are quick to dismiss it.

3. When something unexpected occurs, we rarely try to figure out why things didn't go as we expected.

Inquiry

1. When something unexpected happens, the information is not widely shared.

2. When unexpected problems arise, those involved rarely spend time to debrief what they saw and heard prior to the incident.

3. When things don't go as expected, people rarely try to uncover what they assumed in the first place.

4. It is uncommon to check our assumptions against reality.

Updating

l. If things don't go as we expected, it is uncommon for people to update their original assumptions.

2. It is uncommon to revise our practices and procedures to incorporate revised assumptions and understandings.

Scoring: Count the number of *agree* and *disagree* responses. The greater the number of *agree* responses, the less the tendency to doubt, inquire, or update; hence, a greater potential for *mindlessness.* Use these questions to begin thinking of ways to improve your capacity for mindfulness.

Exhibit 4.4. Assessing Where Mindfulness Is Most Required.

Respond *agree* or *disagree* with the following statements about your work unit, department, or organization.

1. Work is accomplished through a number of sequential steps carried out in a linear fashion.

2. Feedback and information on what is happening is direct and simply verified.

3. The work process is relatively well understood and easily comprehensible.

4. The work process *does not require* coordinated action by numerous mechanical components and operators.

5. We can directly observe all the components in our "production" process.

6. Our work process is such that it is possible to put the system on a stand-by mode, and delays are possible because unfinished products or services can sit for a while or be stored without damage.

7. There are many ways to produce our product or service, items can be rerouted, schedules changed, and parts can be added later if delays or shortages occur.

8. There is a lot of slack in our work process and it does not require much precision; things don't have to be done right the first time because they can always be repeated.

9. There is a lot of opportunity to improvise when things go wrong.

Scoring: Count the number of *agree* and *disagree* responses. The greater the number of *disagree* responses, the more your system is interactively complex and tightly coupled, and therefore the more important it is be mindful. Use these questions to begin thinking of ways to improve your capacity for mindfulness.

Exhibit 4.5. Assessing Your Firm's Preoccupation with Failure.

How well do each of the following statements describe your work unit, department, or organization? Enter next to each item below the number that corresponds with your conclusion: 1 = not at all, 2 = to some extent, 3 = a great deal.

1. We focus more on our failures than our successes.

2. We regard close calls and near misses as a kind of failure that reveals potential danger rather than as evidence of our success and ability to avoid disaster.

3. We treat near misses and errors as information about the health of our system and try to learn from them.

4. We often update our procedures after experiencing a close call or near miss to incorporate our new experience and enriched understanding.

5. We make it hard for people to hide mistakes of any kind.

6. People are inclined to report mistakes that have significant consequences even if nobody notices.

7. Managers seek out and encourage bad news.

8. People feel free to talk to superiors about problems.

9. People are rewarded if they spot problems, mistakes, errors, or failures.

Scoring: Add the numbers. If you score lower than eleven, you are preoccupied with success and should be actively considering how you can immediately improve your focus on *failure*. If you score between eleven and eighteen, you have a moderate preoccupation with success rather than a fully mindful preoccupation with failure. Scores higher than eighteen suggest a healthy preoccupation with failure and a strong capacity for mindfulness.

Exhibit 4.6. Assessing Your Firm's Reluctance to Simplify.

How well do each of the following statements describe your work unit, department, or organization? Enter next to each item below the number that corresponds with your conclusion: 1 = not at all, 2 = to some extent, 3 = a great deal.

1. People around here take nothing for granted.

2. Questioning is encouraged.

3. We strive to challenge the status quo.

4. People in this organization feel free to bring up problems and tough issues.

5. People generally prolong their analysis to better grasp the nature of the problems that come up.

6. People are encouraged to express different views of the world.

7. People listen carefully; it is rare that anyone's view is dismissed.

8. People are not shot down for surfacing information that could interrupt operations.

9. When something unexpected happens, people are more concerned with listening and conducting a complete analysis of the situation than with advocating for their view.

10. We appreciate skeptics.

11. People demonstrate trust for each other.

12. People show a great deal of mutual respect for each other.

Scoring: Add the numbers. If you score higher than twenty-four, the potential to *avoid simplification* is strong. If you score between fourteen and twenty-four, the potential to avoid simplification is moderate. Scores lower than fourteen suggest that you should actively be considering how you can immediately improve your capabilities to prevent simplification in order to improve your firm's capacity for mindfulness.

Exhibit 4.7. Assessing Your Firm's Sensitivity to Operations.

Respond *agree* or *disagree* with the following statements about your organization.

1. On a day-to-day basis, there is an ongoing presence of someone who is paying attention to what is happening and is readily available for consultation if something unexpected arises.

2. Should problems occur, someone with the authority to act is always accessible and available, especially to people on the front lines.

3. Supervisors readily pitch in whenever necessary.

4. During an average day, people come into enough contact with each other to build a clear picture of the current situation.

5. People are always looking for feedback about things that aren't going right.

6. People are familiar with operations beyond one's own job.

7. We have access to resources if unexpected surprises crop up.

8. Managers constantly monitor workloads and are able to obtain additional resources if the workload starts to become excessive.

Scoring: Count the number of *agree* and *disagree* responses. The greater the number of *disagree* responses, the less the *sensitivity to operations.* Use these questions to begin thinking of ways to improve your sensitivity to operations and capacity for mindfulness.

Exhibit 4.8. Assessing Your Firm's Commitment to Resilience.

How well do each of the following statements describe your work unit, department, or organization? Enter next to each item below the number that corresponds with your conclusion: 1 = not at all, 2 = to some extent, 3 = a great deal.

1. Forecasting and predicting the future is not that important here.

2. Resources are continually devoted to training and retraining people on the properties of the technical system.

3. People have more than enough training and experience for the kind of work they have to do.

4. This organization is actively concerned with developing people's skills and knowledge.

5. This organization encourages challenging stretch assignments.

6. People around here are known for their ability to use their knowledge in novel ways.

7. There is a concern with building people's competence and response repertoires.

8. People have a number of informal contacts that they sometimes use to solve problems.

9. People learn from their mistakes.

10. People are able to rely on others.

Scoring: Add the numbers. If you score higher than twenty, the *commitment to resilience* is strong. If you score between twelve and twenty, the commitment to resilience is moderate. Scores lower than twelve suggest that you should actively consider how you can immediately begin building resilience and the capacity for mindfulness.

Exhibit 4.9. Assessing the Deference to Expertise In Your Firm.

How well do each of the following statements describe your work unit, depart ment, or organization? Enter next to each item below the number that corresponds with your conclusion: 1 = not at all, 2 = to some extent, 3 = a great deal.

1. People are committed to doing their job well.

2. People respect the nature of one another's job activities.

3. If something out of the ordinary happens, people know who has the expertise to respond.

4. People in this organization value expertise and experience over hierarchical rank.

5. In this organization, the people most qualified to make decisions make them.

6. If something unexpected occurs, the most highly qualified people, regardless of rank, make the decisions.

7. People typically "own" a problem until it is resolved.

8. It is generally easy for us to obtain expert assistance when something comes up that we don't know how to handle.

Scoring: Add the numbers. If you score higher than sixteen, the *deference to* ex*pertise* is strong. If you score between ten and sixteen, the deference to expertise is moderate. Scores lower than ten suggest that you should actively think of ways to improve the deference to expertise and capacity for mindfulness.

Appendix F KDOT Inflation Rate Table

KANSAS
DEPARTMENT OF TRANSPORTATION
Responsible & Responsive

Bureau of Program and Project Managment 5.24.2010

Revised Inflation Rates for Construction Costs - May 2010

From FY	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1999	3.8%	7.6%	11.4%	15.1%	19.0%	23.2%	27.7%	32.4%	37.5%	42.8%	48.4%	53.6%	59.0%	64.5%	70.3%	76.3%	84.2%	92.5%	101.1%	110.2%	119.7%
2000		3.7%	7.3%	10.9%	14.6%	18.7%	23.0%	27.6%	32.4%	37.6%	43.0%	48.0%	53.2%	58.5%	64.1%	69.8%	77.5%	85.4%	93.8%	102.5%	111.6%
2001			3.5%	6.9%	10.6%	14.4%	18.7%	23.0%	27.7%	32.7%	37.9%	42.7%	47.7%	52.9%	58.2%	63.8%	71.1%	78.8%	86.9%	95.3%	104.1%
2002				3.3%	6.8%	10.6%	14.6%	18.9%	23.4%	28.2%	33.2%	37.9%	42.7%	47.7%	52.9%	58.2%	65.3%	72.8%	80.6%	88.7%	97.2%
2003					3.4%	7.0%	11.0%	15.1%	19.5%	24.1%	29.0%	33.5%	38.1%	43.0%	48.0%	53.2%	60.1%	67.3%	74.8%	82.6%	90.9%
2004						3.5%	7.3%	11.3%	15.5%	20.0%	24.7%	29.1%	33.6%	38.3%	43.1%	48.1%	54.8%	61.8%	69.0%	76.6%	84.6%
2005							3.7%	7.5%	11.6%	16.0%	20.5%	24.7%	29.1%	33.6%	38.3%	43.1%	49.6%	56.3%	63.3%	70.7%	78.3%
2006								3.7%	7.6%	11.8%	16.2%	20.3%	24.5%	28.8%	33.3%	38.0%	44.2%	50.7%	57.5%	64.6%	72.0%
2007									3.8%	7.8%	12.1%	16.0%	20.0%	24.2%	28.6%	33.1%	39.1%	45.3%	51.9%	58.7%	65.8%
2008										3.9%	8.0%	11.7%	15.6%	19.7%	23.9%	28.2%	34.0%	40.0%	46.3%	52.9%	59.8%
2009											3.9%	7.5%	11.3%	15.2%	19.2%	23.4%	29.0%	34.8%	40.8%	47.2%	53.8%
2010												3.5%	7.1%	10.9%	14.8%	18.8%	24.1%	29.7%	35.5%	41.6%	48.0%
2011													3.5%	7.1%	10.9%	14.8%	19.9%	25.3%	31.0%	36.8%	43.0%
2012														3.5%	7.1%	10.9%	15.9%	21.1%	26.5%	32.2%	38.2%
2013															3.5%	7.1%	11.9%	17.0%	22.2%	27.7%	33.5%
2014																3.5%	8.2%	13.0%	18.1%	23.4%	29.0%
2015																	4.5%	9.2%	14.1%	19.3%	24.6%
2016																		4.5%	9.2%	14.1%	19.3%
2017																			4.5%	9.2%	14.1%
2018																				4.5%	9.2%
2019																					4.5%

Appendix G Cost and Timing Calculations for Bridge Maintenance by KDOT Forces

APPENDIX G—KDOT Maintenance Activity Costs

Deck Sealing 8000 sf (200'x40' bridge deck) per day

Equipment	*qty*	*rate*	*per*	*unit*	
Pickup Truck	1	45	1	day	45
Dump Truck	0	190	1	day	0
Deck Sealer	1	172	1	day	172
Material					
Material cost negligible					
Labor					
Supervisor	0	31.5	8	hour	0
2-EO Seniors	2	25.5	8	hour	408
				total	625

use $300 per 4000 sf of bridge deck, incrementally.

Metro Patching estimate (small crew) 5 square yards (45 sf) of patching per day

Equipment	*qty*	*rate*	*per*	*unit*		
Pickup Truck	1	45	1	day	45	
Dump Truck	1	190	1	day	190	
Cold Mix Equipment	1	318	1	day	318	
Material						
Cold Mix	45	6	1	sf	270	
Labor						
Supervisor	1	31.5	8	hour	252	
3-EO Seniors	3	25.5	8	hour	612	
				total	1687	=$37.5 per sf
						use $35/sf

Concrete Patching estimate (small crew) 3 square yards (27 sf) of patching per day

Equipment	*qty*	*rate*	*per*	*unit*	
Pickup Truck	2	45	1	day	90
Dump Truck	1	190	1	day	190
Hammers & Vibrators	1	292	1	day	292
Material					
Rapid Set Concrete	27	6	1	sf	162
Labor					

Supervisor	1	31.5	8	hour	252	
5-EO Seniors	5	25.5	8	hour	1020	
				total	2006	=$74.3 per sf
						use $75/sf

The material and labor costs used above follow:

From KDOT Civil Service Classification and Salary Information:

Mid range EO Senior Salary = $17/hour, Pay Grade 19 *(assume a 1.5 multiplier to convert employee pay to payroll cost)*

Mid range Public Service Administrator= $21/hour, Pay Grade 24

From KDOT CM-5 Rental Rates, Bureau of Construction and Maintenance:

Crack Seal Machine, $28.70/hr

Mud Jacking Equipment, $87.03/hr

Loader, Skid Steer, $39.27/hr

Pot Hole Patcher, Air Blown, $52.99/hr

Roller, Vibratory, Self Propelled, $18.27/hr

Pickup, 1/2 ton, 3 Passenger, $0.47/mile --> Assuming 90 miles per day with multiple trips to site = $42.3 ~ $45 per day

Dump Truck, $6.29/mile --> Assuming 30 miles per day = $188.7 ~ $190 per day

From KDOT Bid Tabs:

Asphalt, $150 per ton (material only), At 145 pcf = $10.875.cf, for 6" deep patches ~ $6/sf

Concrete, $300 per cy (material only), for 6" deep patches ~ $6/sf

Application rate:

From interviews with Johnson County and Topeka Metro Engineers:

For asphalt patching, 4 men with equipment = 5 sy per day.

For concrete patching, 6 men with equipment = 3 sy per day.

Life of patch:

From interviews with Johnson County and Topeka Metro Engineers:

For asphalt patching, if the patches are properly cleaned and prepped and compacted- up to 2 years.

For concrete patching, if traffic volumes aren't high, up to 4 years.

The timing of the maintenance activities are:

From KDOT Interviews and calibrated with observed deck patch costs:

Patching bituminous on original deck with no epoxy coating.

Assuming 11 years from NBI 5 to 4 --> begin with 2% spalls, end with 5% spalls.
Assuming patches last 2 years.

Assuming only half of the spalls are in the travel lanes --> patch 1% of deck at beginning to 2.5% at end of 11 years.

year	0	1	2	3	4	5	6	7	8	9	10	11
%spall	2.00	2.27	2.55	2.82	3.09	3.36	3.64	3.91	4.18	4.45	4.73	5.00
half of spalled:	1.00	1.14	1.27	1.41	1.55	1.68	1.82	1.95	2.09	2.23	2.36	2.50
for estimating use:	1%		1.25%		1.50%		1.75%		2.00%			let contract

Patching rapid set concrete on original deck with no epoxy coating.

Assuming 11 years from NBI 5 to 4 --> begin with 2% spalls, end with 5% spalls.
Assuming patches last 4 years.

Assuming only half of the spalls are in the travel lanes --> patch 1% of deck at beginning to 2.5% at end of 11 years.

year	0	1	2	3	4	5	6	7	8	9	10	11
%spall	2.00	2.27	2.55	2.82	3.09	3.36	3.64	3.91	4.18	4.45	4.73	5.00
half of spalled:	1.00	1.14	1.27	1.41	1.55	1.68	1.82	1.95	2.09	2.23	2.36	2.50
for estimating use:	1%				1.50%				2.00%		let contract	

Appendix H Bridge Life Cycle Cost Analysis for FY 2003 Bridge Substantial Maintenance Projects, 2%Discount Rate

Project Number:	K-8685-01				**Fiscal Yr:**	2003
Bridge Number:	7	3	27		**County:**	Atchison
	(route)	*(county)*	*(serial)*			
Feature Carried:	K-7	**Feature Crossed:**		Independence Creek		

# of Units:	1		
Unit 1 Description:	RDGH-5	**Spans (ft):**	60-84-60
Year Built:	1964	**AADT:**	1,560
Previous Subst Maint:	none	**% Trucks:**	12
	Length of State Route Detour (mi):		1
Bridge Length (ft):	206.5	**Roadway Width (ft):**	44
Area of Deck (sf):	9086		
Expansion Joints (2003):	none	**Length of Joints (ft):**	70

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1995	7	8	7	5.2
1997	7	8	6	5.0
1999	6	8	6	4.8
2001	6	8	6	4.6
2003	6	7	6	4.5
2005	8	7	6	4.3
2007	8	7	6	4.1
2009	8	7	6	3.9
2011	7	7	7	3.7

FY 2003 Scope of Work as Let: **Let Price:** $119,738

Patch deck, Place silica fume overlay,

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface currently all Condition 1

Min. deterioration top and bottom.

Scour repair by KDOT Forces in 2010.

Was patched annually by KDOT Forces at 1997-2002.

Past bridge inspections show the deck Pontis condition at 3 in 2003.

Bridge Life Cycle Cost Analysis

Bridge: 7-3-27 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2039

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$119,738	1.43	$171,225
2007	Clean joints	$264	1.242	$ 328
2009	Clean joints	$209	1.152	$ 240
	Maintenance Cost to date (cost above are in $ of year incurred)			$171,794

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$ 554
2023	Patch deck	$6,815	0.820	$ 5,590
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$ 6,144

Sum of inflated cost to date and discounted cost expected from 2003-2023 $177,938

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2005	1% deck patch	$5,101	1.336	$6,815
2009	1.5% deck patch	$8,873	1.152	$10,222
2013	2% deck patch	$13,629	1.000	$13,629
	Maintenance Cost to date (cost above are in $ of year incurred)			$ 30,665

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2016	Contract Patch	$205,470	0.942	$193,615
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$193,615

Sum of inflated cost to date and discounted cost expected from 2003-2023 $224,280

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Based on element level inspection history, assume deck is about to change rating in 2003.
Assume that deck NBI dropped to 5 in 2005, drops to 4 in 2016.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2025.
No deck expansion joints to maintain.

Project Number:	K-8740-01				**Fiscal Yr:**	2003
Bridge Number:	96	5	48		**County:**	Barton
	(route)	*(county)*	*(serial)*			
Feature Carried:	K-96	**Feature Crossed:**		Walnut Creek Drainage		
# of Units:	1					
Unit 1 Description:	RDGS-9	**Spans (ft):**		3@35		
Year Built:	1941	**AADT:**		1,950		
Previous Subst Maint:	1964-Widen, 1993-Joint	**% Trucks:**		16		
	Length of State Route Detour (mi):			3		
Bridge Length (ft):	112.5	**Roadway Width (ft):**		44		
Area of Deck (sf):	4950					
Expansion Joints (2003):	Compression Seal	**Length of Joints (ft):**		88		

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	6	7	5.27
1997	7	6	7	5.00
1998	6	6	6	4.91
2000	6	6	6	4.73
2002	5	6	6	4.55
2004	8	7	7	4.36
2006	8	7	7	4.18
2008	8	7	7	4.00
2010	8	7	7	3.82

FY 2003 Scope of Work as Let: **Let Price:** $311,006

Patch deck, Place silica fume overlay, Repair concrete girder ends.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023
Assume 15 yr life for compression seal, to 2019.

Review Notes:
Wearing surface is all condition 1.
1% deterioration noted top and bottom of deck.
Expansion joint replaced in 1993 with K-4594-01.
KDOT Forces patched deck in 1999 and 2001.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 96-5-48 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2016

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$311,006	1.43	$444,739
	Maintenance Cost to date from 2003 (2013 dollars)			$444,739

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.924	$277
2019	Compression seal	$26,400	0.888	$23,443
2023	Patch deck	$3,713	0.820	$3,045
	Expected Discounted Maintenance Costs until 2023			$26,766
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $471,504

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1% deck patch	$3,713	1.430	$5,309
2006	1.5% deck patch	$5,569	1.288	$7,173
2010	2% deck patch	$7,425	1.109	$8,234
2013	Contract patch and	$489,212	1.000	$489,212
	Maintenance Cost to date from 2003 (2013 dollars)			$509,928

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
	None until 2024			
	Expected Discounted Maintenance Costs until 2023			
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $509,928

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 5 in 2002. Assume drop to 4 in 2013.
Contract overlay and patch in 2013, expect deck NBI to drop to 6 in 2024.
Replace compression seals with 2013 contract patch.

Project Number:	K-8735-01			**Fiscal Yr:**	2003
Bridge Number:	54 *(route)*	8 *(county)*	5 *(serial)*	**County:**	Butler
Feature Carried:	US-54 WB	**Feature Crossed:**	Whitewater River		
# of Units:	1				
Unit 1 Description:	SWGH-4	**Spans (ft):**	105-3@133-105		
Year Built:	1955	**AADT:**	8,350		
Previous Subst Maint:	1987-OL,1986-Paint	**% Trucks:**	10		
	Length of State Route Detour (mi):		1		
Bridge Length (ft):	612	**Roadway Width (ft):**	28		
Area of Deck (sf):	17136				
Expansion Joints (2003):	Strip Seal	**Length of Joints (ft):**	56		

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1996	7	8	7	6.71
1998	7	8	7	6.43
2000	7	6	7	6.14
2002	6	6	7	5.86
2004	6	6	7	5.57
2006	6	6	7	5.29
2008	6	6	7	5.00
2010	6	6	7	4.71

FY 2003 Scope of Work as Let: **Let Price:** $107,365

Patch deck, Place polymer overlay, Replace expansion joints.

Polymer has lasted well. Expect 15 year life. Reapply in 2019.
Strip seals being replaced in 2013 with project KA-1584-01. Assume 15 yr life to 2027.

Review Notes:
Wearing surface is all condition 1.
0% deterioration noted top and 10% bottom of deck.
2.25" Concrete overlay placed in 1987 with M-0535-01.
Expansion joint replacement scheduled this year (2013) with KA-1584-01.
KDOT Forces repaired expansion joints in 2000 and 2001.

**Projected Deck NBI presumes a <u>25 year overlay service life</u> with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 54-8-5 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Li 2030

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$107,365	1.430	$153,532
2004	Misc repairs	$2,927	1.383	$4,048
2009	Deck patch	$1,213	1.152	$1,398
2013	Replace joints	$28,000	1.000	$28,000
	Maintenance Cost to date (cost above are in $ of year incurred)			$186,978

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2019	Patch deck, Poly OL	$125,532	0.888	$111,472
	Expected Discounted Maintenance Costs until 2023			$111,472
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $298,450

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2004	Replace joints	$20,200	1.383	$27,937
2009	1% deck patch	$11,156	1.152	$12,852
2013	2% deck patch	$25,704	1.000	$25,704
	Maintenance Cost to date (cost above are in $ of year incurred)			$66,493

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2016	Contract overlay	$428,400	0.942	$403,681
2019	Replace joints	$28,000	0.888	$24,864
	Expected Discounted Maintenance Costs until 2023			$428,545
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $495,038

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 in 2002. Assume it dropped to 5 in 2009, then to 4 in 2016.
Contract overlay and patch in 2016. Note, cannot use Poly OL on a deteriorated deck.
Joints failing in 2003. Replace expansion joints under contract in 2004, and again in 2019.

Project Number:	K-8735-01			**Fiscal Yr:**	2003
Bridge Number:	54	8	6	**County:**	Butler
	(route)	*(county)*	*(serial)*		
Feature Carried:	US-54 EB	**Feature Crossed:**	Whitewater River		

# of Units:	1		
Unit 1 Description:	SWGH-4	**Spans (ft):**	105-3@133-105

Year Built:	1957	**AADT:**	8,350
Previous Subst Maint:	1989-OL, 1986-Paint	**% Trucks:**	10
	Length of State Route Detour (mi):		1

Bridge Length (ft):	612	**Roadway Width (ft):**	28
Area of Deck (sf):	17136		
Expansion Joints (2003):	Strip Seal	**Length of Joints (ft):**	56

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1996	7	8	8	7.00
1998	7	8	8	6.71
2000	7	6	8	6.43
2002	7	6	8	6.14
2004	7	6	8	5.86
2006	7	6	7	5.57
2008	7	6	7	5.29
2010	7	6	7	5.00

FY 2003 Scope of Work as Let: **Let Price:** $116,365

Patch deck, Place polymer overlay, Replace expansion joints.

Polymer has lasted well. Expect 15 year life. Reapply in 2019.
Strip seals being replaced in 2012 with project KA-1584-01. Assume 15 yr life to 2027.

Review Notes:
Wearing surface is all condition 1.
1% deterioration noted top and 10% bottom of deck.
2.25" Concrete overlay placed in 1989 with K-1739-01.
Expansion joint replacement this year with KA-1584-01.

**Projected Deck NBI presumes a* *__25 year overlay service life__* *with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 54-8-6 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2032

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract repair	$116,365	1.430	$166,402
2009	Misc repairs	$592	1.152	$682
2013	Replace joints	$28,000	1.000	$28,000
	Maintenance Cost to date (cost above are in $ of year incurred)			$195,084

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2019	Patch deck, Poly OL	$138,402	0.888	$122,901
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$122,901

Sum of inflated cost to date and discounted cost expected from 2003-2023 $317,985

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2004	Replace joints	$20,200	1.383	$27,937
2010	1% deck patch	$12,852	1.109	$14,253
2013	2% deck patch	$25,704	1.000	$25,704
	Maintenance Cost to date (cost above are in $ of year incurred)			$67,893

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2016	Contract patch	$428,400	0.942	$403,681
2019	Replace joints	$28,000	0.888	$24,864
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$428,545

Sum of inflated cost to date and discounted cost expected from 2003-2023 $496,439

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Assume that deck NBI dropped to 6 in 2004, 5 in 2011, then to 4 in 2018.
Contract overlay and patch in 2016, expect deck NBI to drop to 6 in 2029.
Joints failing in 2003. Replace expansion joints under contract in 2004, and again in 2019.

Project Number:	K-8736-01			**Fiscal Yr:**	2003
Bridge Number:	54	8	16	**County:**	Butler
	(route)	*(county)*	*(serial)*		
Feature Carried:	US-54 SB	**Feature Crossed:**	Turkey Creek		

# of Units:	1		
Unit 1 Description:	RCSH	**Spans (ft):**	39-52-52-39

Year Built:	1971	**AADT:**	1,165
Previous Subst Maint:	None	**% Trucks:**	21
	Length of State Route Detour (mi):		1

Bridge Length (ft):	184.5	**Roadway Width (ft):**	40
Area of Deck (sf):	7380		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1996	6	7	8	5.73
1998	6	7	8	5.55
2000	5	7	8	5.36
2002	5	7	8	5.18
2003	8	7	8	5.09
2004	8	7	8	5.00
2006	8	7	8	4.82
2008	8	7	8	4.64
2010	8	7	8	4.45

FY 2003 Scope of Work as Let: **Let Price:** $196,393

Patch deck, Place silica fume overlay.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
1% deterioration noted top and bottom of deck.
KDOT Forces patched deck in 2001.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 54-8-16 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2046

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$196,393	1.43	$280,842
	Maintenance Cost to date (cost above are in $ of year incurred)			$280,842

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$5,535	0.820	$4,540
	Expected Discounted Maintenance Costs until 2023			$5,095
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $285,937

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1.5% deck patch	$8,303	1.430	$11,873
2007	2% deck patch	$11,070	1.242	$13,749
2010	Contract patch	$278,563	1.109	$308,926
	Maintenance Cost to date (cost above are in $ of year incurred)			$334,548

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2023	Seal deck	$600	0.854	$512
	Expected Discounted Maintenance Costs until 2023			$512
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $335,060

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Assume that deck NBI dropped to 4 in 2010.
Contract overlay and patch in 2010, expect deck NBI to drop to 6 in 2023.
No deck expansion joints to maintain.

Project Number:	K-8743-01			**Fiscal Yr:**	2003
Bridge Number:	177 *(route)*	8 *(county)*	123 *(serial)*	**County:**	Butler
Feature Carried:	K-177	**Feature Crossed:**		ElDorado Lake	

# of Units:	1		
Unit 1 Description:	PBMC-6	**Spans (ft):**	4@100
Year Built:	1979	**AADT:**	365
Previous Subst Maint:	none	**% Trucks:**	11
	Length of State Route Detour (mi):		0
Bridge Length (ft):	403.5	**Roadway Width (ft):**	44
Area of Deck (sf):	17754		
Expansion Joints (2003):	Transflex	**Length of Joints (ft):**	88

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1996	8	8	7	6.45
1998	8	8	7	6.27
2000	5	8	7	6.09
2002	5	8	7	5.91
2004	8	8	7	5.73
2006	8	8	7	5.55
2008	8	8	7	5.36
2010	7	8	7	5.18

FY 2003 Scope of Work as Let: **Let Price:** $201,624

Patch deck, Place silica fume overlay, Replace Transflex joint with Jeene.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023.
Assume 15 year life for Jeene.

Review Notes:
Wearing surface is all condition 2. Long run of debonded overlay.
2% deterioration noted top of deck.
KDOT Forces patched deck in 1998 and 2001.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 177-8-123 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2054

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$201,624	1.43	$288,322
	Maintenance Cost to date from 2003 (2013 dollars)			$288,322

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$1,200	0.924	$1,109
2023	Patch deck	$13,316	0.820	$10,923
	Expected Discounted Maintenance Costs until 2023			$12,031
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $300,354

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1.5% deck patch	$19,973	1.430	$28,562
2007	2% deck patch	$26,631	1.242	$33,076
2011	Contract patch	$296,129	1.071	$317,155
	Maintenance Cost to date (cost above are in $ of year incurred)			$378,792

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2023	Seal deck	$1,200	0.820	$984
	Expected Discounted Maintenance Costs until 2023			$984
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $379,776

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 5 in 2000. Assume drop to 4 in 2011.
Contract overlay and patch in 2011, expect deck NBI to drop to 6 in 2023.
Replace Transflex with 2011 contract patch.

Project Number:	K-8743-01			**Fiscal Yr:**	2003
Bridge Number:	177 *(route)*	8 *(county)*	125 *(serial)*	**County:**	Butler
Feature Carried:	K-177	**Feature Crossed:**		Durechen Creek	

# of Units:	1		
Unit 1 Description:	PBMC-6	**Spans (ft):**	80-90-80
Year Built:	1979	**AADT:**	365
Previous Subst Maint:	none	**% Trucks:**	11
	Length of State Route Detour (mi):		0

Bridge Length (ft):	253.5	**Roadway Width (ft):**	44
Area of Deck (sf):	11154		
Expansion Joints (2003):	Transflex	**Length of Joints (ft):**	88

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1996	8	7	7	6.45
1998	8	7	7	6.27
2000	6	7	7	6.09
2002	6	7	7	5.91
2004	8	7	7	5.73
2006	8	7	7	5.55
2008	8	7	7	5.36
2010	8	7	7	5.18

FY 2003 Scope of Work as Let: **Let Price:** $145,849

Patch deck, Place silica fume overlay, Replace Transflex joint with Jeene.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023.
Assume 15 year life for Jeene.

Review Notes:
Wearing surface is all condition 1.
0% deterioration noted top and bottom of deck.
KDOT Forces patched deck in 2001.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge:	177-8-125	**Review Period:**	2003-2023	**Discount Rate:**	2%
		End of 75 yr Expected Life:		2054	

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$145,849	1.43	$208,564
	Maintenance Cost to date from 2003 (2013 dollars)			$208,564

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$900	0.924	$831
2023	Patch deck	$8,366	0.820	$6,862
	Expected Discounted Maintenance Costs until 2023			$7,694
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $216,258

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2009	Jeene Joint	$26,400	1.152	$30,413
2011	1% deck patch	$8,366	1.071	$8,959
	Maintenance Cost to date (cost above are in $ of year incurred)			$39,372

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	1.5% deck patch	$12,548	0.961	$12,061
2019	2% deck patch	$16,731	0.888	$14,857
2022	Contract patch	$218,597	0.837	$182,922
	Expected Discounted Maintenance Costs until 2023			$209,840
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $249,213

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 in 2000. Assume drop to 5 in 2011, then to 4 in 2022.
Contract overlay and patch in 2022 without joint work.
Assume 30 yr life for Transflex, replace in 2009 with Jeene.

Project Number:	K-8732-01			**Fiscal Yr:**	2003
Bridge Number:	99	37	36	**County:**	Greenwood
	(route)	*(county)*	*(serial)*		
Feature Carried:	K-99	**Feature Crossed:**	Bernard Creek		

# of Units:	1		
Unit 1 Description:	SBMC-5	**Spans (ft):**	4@32
Year Built:	1931	**AADT:**	890
Previous Subst Maint:	1976-New Superstr.	**% Trucks:**	11
	Length of State Route Detour (mi):		3
Bridge Length (ft):	130	**Roadway Width (ft):**	28
Area of Deck (sf):	3640		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	7	8	7	6.45
1997	7	8	7	6.09
1999	7	8	7	5.91
2001	6	8	7	5.73
2003	8	8	8	5.55
2005	7	8	7	5.36
2007	7	8	7	5.18
2009	7	7	7	5.00
2011	7	7	7	4.82

FY 2003 Scope of Work as Let: **Let Price:** $114,634

Patch deck, Place silica fume overlay.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
0% deterioration noted top and 2% bottom of deck.
New superstructure built in 1976.

**Projected Deck NBI presumes a 45 year service life for new superstructure with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 99-37-36 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2026* Assume 50 yr after superstructure replacement.

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$114,634	$1.430	$163,927
	Maintenance Cost to date from 2003 (2013 dollars)			$163,927

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.933	$280
2023	Patch deck	$2,730	0.820	$2,239
	Expected Discounted Maintenance Costs until 2023			$2,519
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $166,446

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2012	1% deck patch	$2,730	1.430	$3,904
	Maintenance Cost to date from 2003 (2013 dollars)			$3,904

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2016	1.5% deck patch	$4,095	0.942	$3,859
2020	2% deck patch	$5,460	0.871	$4,753
2023	Contract patch	$196,712	0.820	$161,363
	Expected Discounted Maintenance Costs until 2023			$169,975
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $173,879

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 in 2001. Assume drop to 5 in 2012, then to 4 in 2023.
Contract overlay and patch in 2023.
No deck expansion joints to maintain.

Project Number:	K-8741-01			**Fiscal Yr:**	2003
Bridge Number:	135 *(route)*	40 *(county)*	13 *(serial)*	**County:**	Harvey
Feature Carried:	Local Road	**Feature Crossed:**	I-135		
# of Units:	1				
Unit 1 Description:	SWGH-4	**Spans (ft):**	43-92-92-43		
Year Built:	1969	**AADT:**	1,630		
Previous Subst Maint:	none	**% Trucks:**	7		
		Length of State Route Detour (mi):	3		
Bridge Length (ft):	273.3	**Roadway Width (ft):**	28		
Area of Deck (sf):	7652.4				
Expansion Joints (2003):	Sliding Plate	**Length of Joints (ft):**	56		

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1996	6	7	8	5.55
1998	6	7	8	5.36
2000	5	6	8	5.18
2002	5	6	8	5.00
2003	5	6	8	4.91
2004	8	8	8	4.82
2006	8	8	8	4.64
2008	8	8	8	4.45
2010	7	8	8	4.27

FY 2003 Scope of Work as Let: **Let Price:** $343,854

Patch deck, Place silica fume overlay, Replace sliding plate with Jeene.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023
Assume 15 yr life for Jeene, to 2019.

Review Notes:
Wearing surface is all condition 1.
1% deterioration noted top and 2% bottom of deck.
KDOT Forces patched deck in 1998, 2000,2001, 2002 and 2003.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 135-40-13	**Review Period:** 2003-2023	**Discount Rate:** 2%	
End of 75 yr Expected Life: 2044			

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$343,854	$1.430	$491,711
2011	Seal deck	$1,947	$1.071	$2,086
	Maintenance Cost to date from 2003 (2013 dollars)			$493,797

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2019	Jeene joint	$16,800	0.888	$14,918
2023	Patch deck	$5,739	0.820	$4,708
	Expected Discounted Maintenance Costs until 2023			$20,181
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $513,978

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1.5% deck patch	$8,609	1.430	$12,311
2007	2% deck patch	$11,479	1.242	$14,256
2011	Contract patch and	$540,882	1.071	$579,285
	Maintenance Cost to date from 2003 (2013 dollars)			$605,852

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2023	Seal deck	$600	0.820	$492
	Expected Discounted Maintenance Costs until 2023			$492
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $606,344

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 5 in 2000. Assume drop to 4 in 2011.
Contract overlay and patch in 2011, expect deck NBI to drop to 6 in 2023.
Replace sliding plate joint (w/in 3 years of life = 45yrs) with 2011 contract patch.

Project Number:	K-8741-01			**Fiscal Yr:**	2003
Bridge Number:	135 *(route)*	40 *(county)*	9 *(serial)*	**County:**	Harvey
Feature Carried:	Local Road	**Feature Crossed:**	I-135		

# of Units:	1		
Unit 1 Description:	SWGH-4	**Spans (ft):**	43-92-92-43

Year Built:	1969	**AADT:**	155
Previous Subst Maint:	none	**% Trucks:**	3
	Length of State Route Detour (mi):		4

Bridge Length (ft):	273.3	**Roadway Width (ft):**	28
Area of Deck (sf):	7652.4		
Expansion Joints (2003):	Sliding Plate	**Length of Joints (ft):**	56

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1996	6	7	7	5.55
1998	6	7	7	5.36
2000	5	7	7	5.18
2002	5	7	7	5.00
2003	5	7	7	4.91
2004	8	7	7	4.82
2006	7	7	7	4.64
2008	7	7	7	4.45
2010	7	7	7	4.27

FY 2003 Scope of Work as Let: **Let Price:** $270,889

Patch deck, Place silica fume overlay. Replace joint with Jeene.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023
Assume 15 yr life for Jeene, to 2019.

Review Notes:
Wearing surface is all condition 1.
0% deterioration noted top and 3% bottom of deck.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 135-40-9 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2044

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$270,889	1.430	$387,371
2011	Seal deck	$1,947	1.071	$2,086
	Maintenance Cost to date from 2003 (2013 dollars)			$389,457

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2019	Jeene joint	$16,800	0.888	$14,918
2023	Patch deck	$5,739	0.820	$4,708
	Expected Discounted Maintenance Costs until 2023			$20,181
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $409,638

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1.5% deck patch	$8,609	1.430	$12,311
2007	2% deck patch	$11,479	1.242	$14,256
2011	Contract patch and joint	$426,108	1.071	$456,362
	Maintenance Cost to date from 2003 (2013 dollars)			$482,929

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2023	Seal deck	$600	0.820	$492
	Expected Discounted Maintenance Costs until 2023			$492
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $483,421

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 5 in 2000. Assume drop to 4 in 2011.
Contract overlay and patch in 2011, expect deck NBI to drop to 6 in 2023.
Replace sliding plate joint (w/in 3 years of life = 45yrs) with 2011 contract patch.

Project Number:	K-8708-01			**Fiscal Yr:**	2003
Bridge Number:	62	43	16	**County:**	Jackson
	(route)	*(county)*	*(serial)*		
Feature Carried:	K-62	**Feature Crossed:**	Soldier Creek		

# of Units: 1
Unit 1 Description: RDGH-2 **Spans (ft):** 40-50-40

Year Built: 1971 **AADT:**
Previous Subst Maint: **% Trucks:**
Length of State Route Detour (mi): 20

Bridge Length (ft): 132.5 **Roadway Width (ft):** 28
Area of Deck (sf): 3710
Expansion Joints (2003): none **Length of Joints (ft):** 0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	6	7	7	5.9
1996	6	7	6	5.7
1998	6	7	7	5.5
2000	6	7	6	5.4
2002	5	7	6	5.2
2004	8	7	6	5.0
2006	8	7	6	4.8
2008	8	7	6	4.6
2010	7	7	7	4.5
2012	7	7	7	4.3

FY 2003 Scope of Work as Let: **Let Price:** $85,686
Patch deck, Place silica fume overlay.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Minimum Maintenance Scope:
KDOT forces to maintain deck until rating of 4.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-176 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2046

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$85,686	1.430	$122,531
	Maintenance Cost to date (cost above are in $ of year incurred)			$122,531

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.924	$277
2023	Patch deck	$2,783	0.820	$2,282
	Expected Discounted Maintenance Costs until 2023			$2,560
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $125,091

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1% deck patch	$1,946	1.430	$2,783
2006	1.5% deck patch	$3,240	1.288	$4,174
2010	2% deck patch	$5,018	1.109	$5,565
2013	Contract patch	$134,784	1.000	$134,784
	Maintenance Cost to date (cost above are in $ of year incurred)			$147,305

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
	No work expected in review period			
	Expected Discounted Maintenance Costs until 2023			
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $147,305

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Observed NBI deck ratings slightly worse than assumed deterioration based on 45 yr service life.
Assume that deck NBI dropped to 4 in 2013.
Contract overlay and patch in 2013.
Assuming 25 yr life on overlay, expect deck NBI to drop to 6 in 2026 (after review period).

Project Number:	K-8705-01			**Fiscal Yr:**	2003
Bridge Number:	24	44	10	**County:**	Jefferson
	(route)	*(county)*	*(serial)*		
Feature Carried:	US-24	**Feature Crossed:**	Stone House Creek		

# of Units: 1
Unit 1 Description: RISC **Spans (ft):** 36-45-45-36

Year Built: 1952 **AADT:** 4,820
Previous Subst Maint: 1976-OL **% Trucks:** 11
Length of State Route Detour (mi): 0

Bridge Length (ft): 164.8 **Roadway Width (ft):** 28.9
Area of Deck (sf): 4762.72
Expansion Joints (2003): none **Length of Joints (ft):** 0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	8	7	5.4
1996	7	8	7	5.1
1998	6	7	7	4.9
2000	6	7	7	4.6
2002	6	7	7	4.3
2004	8	7	7	4.0
2006	8	7	7	3.7
2008	8	7	7	3.4
2010	7	7	7	3.1
2012	7	7	7	2.9

FY 2003 Scope of Work as Let: **Let Price:** $99,364
Patch deck, Place silica fume overlay, Repair curb.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:
Wearing surface is all element condition 1.
1% deterioration noted top and bottom of deck.
KDOT Forces patched deck in 1997. Had been overlaid in 1976.
KDOT Forces repaired rail in 2009.

**Projected Deck NBI presumes a 25 year overlay service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-176 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2027

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$99,364	1.430	$142,091
2009	Patch deck	$1,656	1.152	$1,908
	Maintenance Cost to date (cost above are in $ of year incurred)			$143,998

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.924	$277
2023	Patch deck	$3,572	0.820	$2,930
	Expected Discounted Maintenance Costs until 2023			$3,207
	(costs above are in base year $)			

164 $147,205

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2004	1% deck patch	$2,583	1.383	$3,572
2007	2% deck patch	$3,572	1.242	$4,436
2010	Contract patch	$140,937	1.109	$156,300
	Maintenance Cost to date (cost above are in $ of year incurred)			$164,308

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2023	Deck seal	$300	0.820	$246
	Expected Discounted Maintenance Costs until 2023			$246
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $164,554

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Assume that deck NBI dropped to 5 in 2004, to 4 in 2010.
Contract overlay and patch in 2010, expect deck NBI to drop to 6 in 2023.
No deck expansion joints to maintain.

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Project Number:	K-8376-01				**Fiscal Yr:**	2003
Bridge Number:	10	46	176		**County:**	Johnson
	(route)	*(county)*	*(serial)*			
Feature Carried:	K-10 WB	**Feature Crossed:**		Lexington Ave, ATSF RR		

# of Units:	1		
Unit 1 Description:	SWGH-7	**Spans (ft):**	77-136-75-49-49
Year Built:	1976	**AADT:**	14,100
Previous Subst Maint:	none	**% Trucks:**	5
	Length of State Route Detour (mi):		1
Bridge Length (ft):	389.7	**Roadway Width (ft):**	48
Area of Deck (sf):	18705.6		
Expansion Joints (2003):	Sliding Plate	**Length of Joints (ft):**	96

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	7	7	6.4
1996	7	7	7	6.2
1998	6	7	7	6.0
2000	6	7	7	5.8
2002	6	7	7	5.6
2004	7	7	7	5.5
2006	7	7	7	5.3
2008	7	7	7	5.1
2010	7	7	7	4.9
2012	7	7	7	4.7

FY 2003 Scope of Work as Let: **Let Price:** $498,886

Patch deck, Place silica fume overlay, Repair curb, Replace concrete approach slabs, Repair steel bearings and seat, Replace exp joints with strip seals, paint structural steel.

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023
Expect to replace new strip seal after 15 years in 2019.

Review Notes:

Wearing surface currently all Condition 1.
Inspection notes area of poor consolidation in silica fume wearing surface.
7% bottom of deck deterioration noted.
KDOT Forces patched deck in 2002.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-176 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2051

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*		*Cost (2013)*
2003	Contract Repair*	$498,886	1.43	(*less paint cost)	$713,407
	Maintenance Cost to date (cost above are in $ of year incurred)				$713,407

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$1,200	0.924	$1,109
2019	Replace joint	$48,000	0.888	$42,624
2023	Patch deck	$6,547	0.820	$5,370
	Expected Discounted Maintenance Costs until 2023			$49,103
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $762,510

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2008	1% Bit patching	$5,469	1.197	$6,547
2010	1.25% Bit patch	$7,379	1.109	$8,184
2012	1.5% Bit patch	$9,488	1.035	$9,820
	Maintenance Cost to date (cost above are in $ of year incurred)			$24,551

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	1.75% Bit patch	$11,457	0.980	$11,233
2016	2% Bit patching	$13,094	0.942	$12,338
2019	Contract overlay	$856,088	0.888	$760,206
	Expected Discounted Maintenance Costs until 2023			$783,777
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $808,329

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Observed NBI deck ratings nearly match assumed deterioration based on 45 yr service life.
Assume that deck NBI dropped to 5 in 2008, to 4 in 2019.
Contract overlay and patch in 2019.
Assuming 25 yr life on overlay, expect deck NBI to drop to 6 in 2032 (after review period).
Replace expansion joint with contract overlay in 2019, near end of 45 yr service life.

Project Number:	K-8376-01			**Fiscal Yr:**	2003
Bridge Number:	10 *(route)*	46 *(county)*	177 *(serial)*	**County:**	Johnson
Feature Carried:	K-10 EB	**Feature Crossed:**	Lexington Ave, ATSF RR		

# of Units:	1		
Unit 1 Description:	SWGH-7	**Spans (ft):**	77-136-75-49-49
Year Built:	1975	**AADT:**	14,100
Previous Subst Maint:	none	**% Trucks:**	5
	Length of State Route Detour (mi):		1
Bridge Length (ft):	389.7	**Roadway Width (ft):**	48
Area of Deck (sf):	18705.6		
Expansion Joints (2003):	Sliding Plate	**Length of Joints (ft):**	96

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	7	7	6.3
1996	6	7	7	6.1
1998	6	7	7	5.9
2000	6	7	7	5.7
2002	5	7	7	5.5
2004	5	7	7	5.4
2006	7	7	7	5.2
2008	7	7	7	5.0
2010	7	7	7	4.8
2012	7	6	7	4.6

FY 2003 Scope of Work as Let: **Let Price:** $550,235

Patch deck, Place silica fume overlay, Repair curb, Replace concrete approach slabs,
Repair steel bearings and seat, Replace exp joints with strip seals, paint structural steel.

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023
Expect to replace new strip seal after 15 years in 2019.

Review Notes:
Wearing surface is all condition 1.
1% deterioration noted top and bottom of deck.
Superstructure dropped to 6 this inspection due to cracking of diaphragms at bearing.
KDOT Forces patched and sealed deck ($8600) in 2002.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-177 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2050

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*		*Cost (2013)*
2004	Contract Repair*	$550,235	1.38	(*less paint cost)	$759,324
	Maintenance Cost to date (cost above are in $ of year incurred)				$759,324

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$1,200	0.924	$1,109
2019	Replace joint	$48,000	0.888	$42,624
2023	Patch deck	$6,547	0.820	$5,370
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$49,103

Sum of inflated cost to date and discounted cost expected from 2003-2023 $808,427

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1.75% Bit patch	$8,012	1.430	$11,457
2005	2% Bit patching	$9,801	1.336	$13,094
2008	Contract patch	$697,792	1.197	$835,257
	Maintenance Cost to date (cost above are in $ of year incurred)			$859,808

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2021	Seal Deck	$1,200	0.854	$1,024
2023	Strip Seal	$48,000	0.820	$39,374
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$40,399

Sum of inflated cost to date and discounted cost expected from 2003-2023 $900,206

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Deck NBI dropped to 5 in 2002. Deterioration faster than projected.
Assume that the deck will remain at 5 as long as it had at 6--6 years.
Contract overlay and patch in 2008.
Assuming 25 year service life on overlay, expect deck NBI to drop to 6 in 2021
Replace expansion joint with contract overlay in 2008.
Expect to replace new strip seal after 15 years in 2023.

Project Number:	K-8376-01			**Fiscal Yr:**	2003
Bridge Number:	10 (route)	46 (county)	178 (serial)	**County:**	Johnson
Feature Carried:	K-10 WB	**Feature Crossed:**	Kill Creek		

# of Units:	1		
Unit 1 Description:	SWGH-6	**Spans (ft):**	88-110-88
Year Built:	1975	**AADT:**	13,700
Previous Subst Maint:	none	**% Trucks:**	5
	Length of State Route Detour (mi):		7
Bridge Length (ft):	289.7	**Roadway Width (ft):**	40
Area of Deck (sf):	11588		
Expansion Joints (2003):	Sliding Plate	**Length of Joints (ft):**	80

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	7	7	6.3
1996	7	7	7	6.1
1998	6	7	7	5.9
2000	6	5	7	5.7
2002	6	5	7	5.5
2004	7	5	7	5.4
2006	7	5	7	5.2
2008	7	5	7	5.0
2010	7	5	7	4.8
2012	7	5	7	4.6

FY 2003 Scope of Work as Let: **Let Price:** $239,953

Patch deck, Place silica fume overlay, Repair curb, Replace concrete approach slabs, Replace exp joints with strip seals.

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023
Expect to replace new strip seal after 15 years in 2019.

Review Notes:
Wearing surface is all condition 1.
2% deterioration noted top and 5% bottom of deck.
Superstructure at 5 due to cracking of diaphragms at abutment bearing.
KDOT Forces patched deck in 2002, sealed deck in 1998.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-178 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2050

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$239,953	1.43	$343,133
2011	Patch and Misc	$3,152	1.071	$3,376
	Maintenance Cost to date (cost above are in $ of year incurred)			$346,509

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$1,200	0.924	$1,109
2019	Replace joint	$40,000	0.888	$35,520
2023	Patch deck	$4,056	0.820	$3,327
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$39,956

Sum of inflated cost to date and discounted cost expected from 2003-2023 $386,464

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2008	1% Bit patching	$3,388	1.197	$4,056
2010	1.25% Bit patch	$4,571	1.109	$5,070
2012	1.5% Bit patch	$5,878	1.035	$6,084
	Maintenance Cost to date (cost above are in $ of year incurred)			$15,209

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	1.75% Bit patch	$7,098	0.980	$6,959
2016	2% Bit patching	$8,112	0.942	$7,644
2019	Contract overlay	$411,759	0.888	$365,642
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$380,244

Sum of inflated cost to date and discounted cost expected from 2003-2023 $395,454

Minimum Maintenance Scope:

KDOT forces to maintain deck with bituminous patches until rating of 4.
Observed NBI deck ratings nearly match assumed deterioration based on 45 yr service life.
Assume that deck NBI dropped to 5 in 2008, to 4 in 2019.
Contract overlay and patch in 2019.
Assuming 25 yr life on overlay, expect deck NBI to drop to 6 in 2032 (after review period).
Replace expansion joint with contract overlay in 2019, near end of 45 yr service life.

Project Number:	K-8376-01			**Fiscal Yr:**	2003
Bridge Number:	10 *(route)*	46 *(county)*	179 *(serial)*	**County:**	Johnson
Feature Carried:	K-10 EB	**Feature Crossed:**	Kill Creek		

# of Units:	1		
Unit 1 Description:	SWGH-6	**Spans (ft):**	88-110-88
Year Built:	1976	**AADT:**	13,700
Previous Subst Maint:	none	**% Trucks:**	5
		Length of State Route Detour (mi):	7
Bridge Length (ft):	289.7	**Roadway Width (ft):**	40
Area of Deck (sf):	11588		
Expansion Joints (2003):	Sliding Plate	**Length of Joints (ft):**	80

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	7	7	6.4
1996	7	7	7	6.2
1998	5	7	7	6.0
2000	5	7	7	5.8
2002	5	5	7	5.6
2004	7	5	7	5.5
2006	7	5	7	5.3
2008	7	5	7	5.1
2010	7	5	7	4.9
2012	7	5	7	4.7

FY 2003 Scope of Work as Let: **Let Price:** $225,393

Patch deck, Place silica fume overlay, Repair curb, Replace concrete approach slabs, Replace exp joints with strip seals.

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023
Expect to replace new strip seal after 15 years in 2019.

Review Notes:
Wearing surface is all condition 1.
2% deterioration noted top and 10% bottom of deck.
Superstructure at 5 due to cracking of diaphragms at abutment bearing.
KDOT Forces patched deck in 2002.
Field review for maintenance project in 2003 showed multiple bituminous patches.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-179 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2051

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2003)*
2003	Contract Repair	$225,393	1.43	$322,312
	Maintenance Cost to date (cost above are in $ of year incurred)			$322,312

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2003)*
2017	Seal deck	$1,200	0.924	$1,109
2019	Replace joint	$40,000	0.888	$35,520
2023	Patch deck	$4,056	0.820	$3,327
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$39,956

Sum of inflated cost to date and discounted cost expected from 2003-2023 $362,268

BLCCA with minimum maintenance:

Same as scope as let.

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Deck NBI dropped to 5 in 1998. Sudden deterioration.
Field notes from 2003 show the entire deck in Pontis condition 5.
With an NBI deck rating of 4 as a trigger for contract, this had to be done in 2003 or 2004.

Project Number:	K-8703-01			**Fiscal Yr:**	2003
Bridge Number:	10	46	184	**County:**	Johnson
	(route)	*(county)*	*(serial)*		
Feature Carried:	K-10 WB	**Feature Crossed:**	Cedar Creek		
# of Units:	1				
Unit 1 Description:	RCSH	**Spans (ft):**	39-3@52-39		
Year Built:	1975	**AADT:**	15,850		
Previous Subst Maint:	none	**% Trucks:**	5		
	Length of State Route Detour (mi):		10		
Bridge Length (ft):	236.5	**Roadway Width (ft):**	40		
Area of Deck (sf):	9460				
Expansion Joints (2003):	none	**Length of Joints (ft):**	0		

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	8	8	6.3
1996	7	8	8	6.1
1998	6	8	7	5.9
2000	6	8	7	5.7
2002	5	7	7	5.5
2004	8	7	7	5.4
2006	8	7	7	5.2
2008	8	7	7	5.0
2010	8	7	7	4.8
2012	7	7	7	4.6

FY 2003 Scope of Work as Let: **Let Price:** $191,067

Patch deck, Place silica fume overlay.

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
1% deterioration noted top and bottom of deck.
KDOT Forces patched deck in 1999 and 2002; sealed deck in 1998.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-184 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2050

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$191,067	1.430	$273,226
	Maintenance Cost to date (cost above are in $ of year incurred)			$273,226

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$3,311	0.820	$2,716
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$3,270

Sum of inflated cost to date and discounted cost expected from 2003-2023 $276,496

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1.25% Bit patch	$2,894	1.43	$4,139
2005	1.5% Bit patch	$3,717	1.336	$4,967
2007	2% Bit patching	$5,332	1.242	$6,622
2010	Contract overlay	$271,008	1.109	$300,548
	Maintenance Cost to date (cost above are in $ of year incurred)			$316,276

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2023	Seal Deck	$600	0.820	$492
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$492

Sum of inflated cost to date and discounted cost expected from 2003-2023 $316,768

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Deck NBI dropped to 5 in 2002. Deterioration faster than projected.
Assume that the deck will remain at 5 for 8 years rather than 11.
Contract overlay and patch in 2010.
Assuming 25 year service life on overlay, expect deck NBI to drop to 6 in 2023.
No expansion joints.

Project Number:	K-8703-01			**Fiscal Yr:**	2003
Bridge Number:	10	46	189	**County:**	Johnson
	(route)	*(county)*	*(serial)*		
Feature Carried:	K-10 WB	**Feature Crossed:**		Cedar Creek Parkway	

# of Units:	1		
Unit 1 Description:	RBGC-6	**Spans (ft):**	51-68-51
Year Built:	1974	**AADT:**	16,000
Previous Subst Maint:	none	**% Trucks:**	5
	Length of State Route Detour (mi):		6
Bridge Length (ft):	172.4	**Roadway Width (ft):**	40
Area of Deck (sf):	6896		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	7	6	6.2
1996	7	7	6	6.0
1998	7	7	6	5.8
2000	7	7	6	5.6
2002	6	7	6	5.5
2004	8	6	6	5.3
2006	8	6	6	5.1
2008	8	6	6	4.9
2010	8	6	6	4.7
2012	8	6	6	4.5

FY 2003 Scope of Work as Let: **Let Price:** $127,383

Patch deck, Place silica fume overlay, Repair curb.

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
No deterioration noted top of deck, 10% noted on bottom of box girder.
KDOT Forces patched deck in 2002.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge:	10-46-189	**Review Period:**	2003-2023	**Discount Rate:**	2%
		End of 75 yr Expected Li	2049		

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$127,383	1.43	$182,158
	Maintenance Cost to date (cost above are in $ of year incurred)			$182,158

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$2,414	0.820	$1,980
	Expected Discounted Maintenance Costs until 2023			$2,534
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $184,692

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2012	1% Bit patching	$2,332	1.035	$2,414
	Maintenance Cost to date (cost above are in $ of year incurred)			$2,414

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	1.25% Bit patch	$3,017	0.980	$2,958
2016	1.5% Bit patch	$3,620	0.942	$3,412
2018	1.75% Bit patch	$4,224	0.906	$3,825
2020	2% Bit patching	$4,827	0.871	$4,203
2023	Contract overlay	$218,589	0.820	$179,309
	Expected Discounted Maintenance Costs until 2023			$193,706
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $196,120

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Observed NBI deck ratings slightly better than assumed deterioration based on 45 yr service life.
Assume that deck NBI dropped to 5 in 2012 (6 years later than projected), then to 4 in 2023.
Contract overlay and patch in 2023.
No expansion joints.

Project Number:	K-8703-01			**Fiscal Yr:**	2003
Bridge Number:	10 *(route)*	46 *(county)*	190 *(serial)*	**County:**	Johnson
Feature Carried:	K-10 EB		**Feature Crossed:**		Cedar Creek Parkway

# of Units:	1		
Unit 1 Description:	RBGC-8	**Spans (ft):**	51-68-51
Year Built:	1974	**AADT:**	15,850
Previous Subst Maint:	none	**% Trucks:**	5
		Length of State Route Detour (mi):	6
Bridge Length (ft):	172.5	**Roadway Width (ft):**	40
Area of Deck (sf):	6900		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	6	7	6	6.2
1996	6	7	6	6.0
1998	6	6	6	5.8
2000	6	6	6	5.6
2002	6	6	6	5.5
2004	8	6	6	5.3
2006	8	6	6	5.1
2008	8	6	6	4.9
2010	8	6	6	4.7
2012	8	6	6	4.5

FY 2003 Scope of Work as Let: **Let Price:** $155,969

Patch deck, Place silica fume overlay, Repair curb.

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
1% deterioration noted top of deck.
KDOT Forces patched deck in 2002.
Past bridge inspections show the deck dropped from Pontis condition 2 to 3 in 1998.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-190 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Li 2049

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$155,969	1.430	$223,036
	Maintenance Cost to date (cost above are in $ of year incurred)			$223,036

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$2,415	0.820	$1,981
	Expected Discounted Maintenance Costs until 2023			$2,535
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $225,571

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1% Bit patching	$1,689	1.430	$2,415
2005	1.25% Bit patch	$2,260	1.336	$3,019
2007	1.5% Bit patch	$2,917	1.242	$3,623
2009	1.75% Bit patch	$3,669	1.152	$4,226
2011	2% Bit patching	$4,510	1.071	$4,830
	Maintenance Cost to date (cost above are in $ of year incurred)			$18,113

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	Contract overlay	$267,643	0.980	$262,397
	Expected Discounted Maintenance Costs until 2023			$262,397
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $280,510

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Based on element level inspection history, assume deck is about to change rating in 2003.
Assume that deck NBI dropped to 5 in 2003, drops to 4 in 2014.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2025.
No deck expansion joints to maintain.

Project Number:	K-8696-01			**Fiscal Yr:**	2003
Bridge Number:	10	46	199	**County:**	Johnson
	(route)	*(county)*	*(serial)*		
Feature Carried:	K-10 WB	**Feature Crossed:**	Local Road		

# of Units:	1		
Unit 1 Description:	PBMC-5	**Spans (ft):**	45-55-45-55
Year Built:	1976	**AADT:**	14,100
Previous Subst Maint:	none	**% Trucks:**	5
	Length of State Route Detour (mi):		1
Bridge Length (ft):	202.6	**Roadway Width (ft):**	40
Area of Deck (sf):	8104		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	8	7	6.4
1996	7	8	7	6.2
1998	7	8	7	6.0
2000	7	8	7	5.8
2002	6	7	7	5.6
2004	8	7	7	5.5
2006	8	7	7	5.3
2008	8	7	7	5.1
2010	7	7	7	4.9
2012	7	7	7	4.7

FY 2003 Scope of Work as Let: **Let Price:** $185,423

Patch deck, Place silica fume overlay, Repair curb, Replace concrete approach slabs,

Expect to drop Deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface currently all Condition 1

No deterioration noted top or bottom.

KDOT Forces patched deck in 2002.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-199 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2051

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$185,423	1.430	$265,155
2012	Misc Repair	$312	1.035	$323
	Maintenance Cost to date (cost above are in $ of year incurred)			$265,478

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$2,836	0.820	$2,327
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$2,881

Sum of inflated cost to date and discounted cost expected from 2003-2023 $268,359

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2012	1% Bit patching	$2,740	1.035	$ 2,836
	Maintenance Cost to date (cost above are in $ of year incurred)			$ 2,836

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	1.25% Bit patch	$3,546	0.980	$3,476
2016	1.5% Bit patch	$4,255	0.942	$4,009
2018	1.75% Bit patch	$4,964	0.906	$4,496
2020	2% Bit patching	$5,673	0.871	$4,939
2023	Contract overlay	$318,186	0.820	$261,008
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$277,927

Sum of inflated cost to date and discounted cost expected from 2003-2023 $ 280,764

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Observed NBI deck ratings slightly better than assumed deterioration based on 45 yr service life.
Assume that deck NBI dropped to 5 in 2012 (4 years later than projected), then to 4 in 2023.
Contract overlay and patch in 2023.
No expansion joints.

Project Number:	K-8721-01			**Fiscal Yr:**	2003
Bridge Number:	181 *(route)*	53 *(county)*	29 *(serial)*	**County:**	Lincoln
Feature Carried:	K-181	**Feature Crossed:**	West Twin Creek		

# of Units:	1		
Unit 1 Description:	RCSH	**Spans (ft):**	30-40-30
Year Built:	1970	**AADT:**	315
Previous Subst Maint:	none	**% Trucks:**	10
	Length of State Route Detour (mi):		2
Bridge Length (ft):	102.5	**Roadway Width (ft):**	28
Area of Deck (sf):	2870		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	6	6	7	5.82
1996	6	6	7	5.64
1998	6	6	7	5.45
2000	6	6	7	5.27
2002	6	6	7	5.09
2004	8	8	7	4.91
2006	8	8	7	4.73
2008	8	8	7	4.55
2010	7	8	7	4.36

FY 2003 Scope of Work as Let: **Let Price:** $135,496

Patch deck, Place silica fume overlay, Repair edge of slab.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.

1% deterioration noted top of deck.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge:	181-53-29	**Review Period:**	2003-2023	**Discount Rate:**	2%
End of 75 yr Expected Life:	2045				

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$135,496	$1.430	$193,759
	Maintenance Cost to date from 2003 (2013 dollars)			$193,759

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.933	$280
2023	Patch deck	$2,153	0.820	$1,766
	Expected Discounted Maintenance Costs until 2023			$2,046
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $195,805

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1% deck patch	$2,153	1.430	$3,078
2007	1.5% deck patch	$3,229	1.242	$4,010
2011	2% deck patch	$4,305	1.071	$4,611
	Maintenance Cost to date from 2003 (2013 dollars)			$11,699

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	Contract patch	$232,511	0.980	$227,954
	Expected Discounted Maintenance Costs until 2023			$227,954
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $239,653

Minimum Maintenance Scope:

KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 prior to 1994. Assume drop to 5 in 2003, then to 4 in 2014.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2027.
No deck expansion joints to maintain.

Project Number:	K-8721-01			**Fiscal Yr:**	2003
Bridge Number:	181	53	30	**County:**	Lincoln
	(route)	*(county)*	*(serial)*		
Feature Carried:	K-181	**Feature Crossed:**	West Twin Creek		

# of Units:	1		
Unit 1 Description:	RCSH	**Spans (ft):**	33-44-33
Year Built:	1971	**AADT:**	485
Previous Subst Maint:	none	**% Trucks:**	10
	Length of State Route Detour (mi):		3
Bridge Length (ft):	112.5	**Roadway Width (ft):**	28
Area of Deck (sf):	3150		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	6	6	7	5.91
1996	6	6	7	5.73
1998	6	6	7	5.55
2000	6	6	7	5.36
2002	6	6	7	5.18
2004	8	8	7	5.00
2006	8	8	7	4.82
2008	8	8	7	4.64
2010	8	8	7	4.45

FY 2003 Scope of Work as Let: **Let Price:** $151,709

Patch deck, Place silica fume overlay, Repair curb, Repair edge of slab.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.

2% deterioration noted top and 1% bottom of deck.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 181-53-30 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2046

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$151,709	$1.430	$216,944
	Maintenance Cost to date from 2003 (2013 dollars)			$216,944

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.933	$280
2023	Patch deck	$2,363	0.820	$1,938
	Expected Discounted Maintenance Costs until 2023			$2,218
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $219,162

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1% deck patch	$2,363	1.430	$3,378
2007	1.5% deck patch	$3,544	1.242	$4,401
2011	2% deck patch	$4,725	1.071	$5,060
	Maintenance Cost to date from 2003 (2013 dollars)			$12,840

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	Contract patch	$260,333	0.980	$255,230
	Expected Discounted Maintenance Costs until 2023			$255,230
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $268,070

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 prior to 1994. Assume drop to 5 in 2003, then to 4 in 2014.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2027.
No deck expansion joints to maintain.

Project Number:	K-8720-01			**Fiscal Yr:**	2003
Bridge Number:	153 *(route)*	59 *(county)*	105 *(serial)*	**County:**	McPherson
Feature Carried:	K-153 Spur	**Feature Crossed:**	K-153 and Railroad		

# of Units:	1		
Unit 1 Description:	RISC	**Spans (ft):**	30-35-4@40-35-30
Year Built:	1948	**AADT:**	2,010
Previous Subst Maint:	1981-Deck repair	**% Trucks:**	13
	Length of State Route Detour (mi):		5
Bridge Length (ft):	294	**Roadway Width (ft):**	26
Area of Deck (sf):	7644		
Expansion Joints (2003):	Compression Seal	**Length of Joints (ft):**	52

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	7	7	7	3.91
1997	6	7	6	3.55
1999	6	7	6	3.36
2001	6	7	6	3.18
2003	6	7	6	3.00
2004	8	7	7	2.91
2005	8	7	7	2.82
2007	8	7	7	2.64
2009	8	7	7	2.45
2011	7	7	7	2.27

FY 2003 Scope of Work as Let: **Let Price:** $178,954

Patch deck, Place silica fume overlay, Repair curb, Repair abutments.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 2, longitudinal cracks in deck and cracking at joint.
1% deterioration noted top and 2% bottom of deck.
KDOT Forces patched deck in 2000.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 153-59-105 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2023

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$178,954	$1.430	$255,904
	Maintenance Cost to date from 2003 (2013 dollars)			$255,904

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.933	$560
2023	Patch deck	$5,733	0.820	$4,703
	Expected Discounted Maintenance Costs until 2023			$5,262
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $261,167

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2008	1% deck patch	$5,733	1.197	$6,862
2012	1.5% deck patch	$8,600	1.035	$8,900
	Maintenance Cost to date from 2003 (2013 dollars)			$15,763

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2016	2% deck patch	$11,466	0.942	$10,804
2019	Contract patch	$307,085	0.888	$272,692
	Expected Discounted Maintenance Costs until 2023			$283,496
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $299,259

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 in 1997. Assume drop to 5 in 2008, then to 4 in 2019.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2027.
No deck expansion joints to maintain.

Project Number:	K-8733-01			**Fiscal Yr:**	2003
Bridge Number:	166 *(route)*	63 *(county)*	34 *(serial)*	**County:**	Montgomery
Feature Carried:	US-166	**Feature Crossed:**	US-75		
# of Units:	1				
Unit 1 Description:	RVSC	**Spans (ft):**	43-59-43		
Year Built:	1959	**AADT:**	2,530		
Previous Subst Maint:	none	**% Trucks:**	16		
	Length of State Route Detour (mi):		3		
Bridge Length (ft):	147.6	**Roadway Width (ft):**	36		
Area of Deck (sf):	5313.6				
Expansion Joints (2003):	none	**Length of Joints (ft):**	0		

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	8	8	8	4.91
1997	7	7	7	4.55
1999	7	7	7	4.36
2001	7	7	7	4.18
2003	6	7	7	4.00
2005	8	7	7	3.82
2007	8	7	7	3.64
2009	7	7	7	3.45
2011	7	7	7	3.27

FY 2003 Scope of Work as Let: **Let Price:** $159,976

Patch deck, Place silica fume overlay, Remove median.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 2. Map and longitudinal cracks.
2% deterioration noted top and bottom of deck.

Bridge Life Cycle Cost Analysis

/

Bridge: 166-63-34 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2034

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$159,976	1.430	$228,766
	Maintenance Cost to date from 2003 (2013 dollars)			$228,766

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.933	$280
2023	Patch deck	$3,985	0.820	$3,269
	Expected Discounted Maintenance Costs until 2023			$3,549
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $232,315

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2009	1% deck patch	$3,985	1.336	$5,324
2012	2% deck patch	$7,970	1.071	$8,536
	Maintenance Cost to date from 2003 (2013 dollars)			$13,861

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	Contract patch	$274,519	0.961	$263,867
	Expected Discounted Maintenance Costs until 2023			$263,867
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $277,728

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 in 2003.
However, in 2003 field inspection, all of deck was condition 3 and corrosion appeared to be accelerated.
Assume drop to 5 in 2009, then to 4 in 2015. (Six years between states, same as overlay)
Contract overlay and patch in 2015.
No deck expansion joints to maintain.

Project Number:	K-8730-01			**Fiscal Yr:**	2003
Bridge Number:	59	67	4	**County:**	Neosho
	(route)	*(county)*	*(serial)*		
Feature Carried:	US-59	**Feature Crossed:**	Neosho River		

# of Units:	1		
Unit 1 Description:	SWGH-2	**Spans (ft):**	138-3@184-138

Year Built:	1959	**AADT:**	3190
Previous Subst Maint:	-Paint, 1988-Steel	**% Trucks:**	18
	Length of State Route Detour (mi):		10

Bridge Length (ft):	831.9	**Roadway Width (ft):**	28
Area of Deck (sf):	23293.2		
Expansion Joints (2003):	Strip Seal	**Length of Joints (ft):**	56

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1998	6	6	6	4.45
2000	6	6	6	4.27
2001	6	6	6	4.18
2002	6	6	6	4.09
2003	6	6	6	4.00
2004	7	6	7	3.91
2005	7	6	7	3.82
2006	7	6	7	3.73
2007	7	6	7	3.64
2008	7	6	7	3.55
2009	7	6	7	3.45
2010	7	6	7	3.36
2011	7	6	7	3.27
2012	7	6	7	3.18

FY 2003 Scope of Work as Let: **Let Price:** $279,901

Patch deck, Place silica fume overlay, Repair rail.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023
Assume 15 year life for strip seal.

Review Notes:

Wearing surface is all condition 2,transverse cracks in deck and cracking at joint.
5% deterioration noted top and 2% bottom of deck.
KDOT Forces patched deck in 2000, 2001, 2002 and 2004; repaired joint in 1998.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 59-67-4 **Review Period:** 2003-2023 **Discount Rate:** 2%

End of 75 yr Expected Life: 2034

BLCCA with work as let:

Year	Item	Cost	Inflation Factor	Cost (2013)
2003	Contract Repair	$279,901	1.430	$400,258
2008	Superstr Repair	$3,843	1.197	$4,600
2012	Repair Joints	$4,033	1.035	$4,174
	Maintenance Cost to date from 2003 (2013 dollars)			$409,032

Year	Item	Cost	Present Worth Factor	Cost (2013)
2017	Seal deck	$300	0.933	$280
2023	Patch deck	$17,470	0.820	$14,331
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$14,610

Sum of inflated cost to date and discounted cost expected from 2003-2023 $423,643

BLCCA with minimum maintenance:

Year	Item	Cost	Inflation Factor	Cost (2013)
2003	1% deck patch	$17,470	1.430	$24,982
2007	1.5% deck patch	$26,205	1.242	$32,546
2011	2% deck patch	$34,940	1.071	$37,421
2013	Strip Seal	$28,000	1.000	$28,000
	Maintenance Cost to date from 2003 (2013 dollars)			$122,949

Year	Item	Cost	Present Worth Factor	Cost (2013)
2014	Contract patch	$480,310	0.980	$470,896
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$470,896

Sum of inflated cost to date and discounted cost expected from 2003-2023 $593,845

Minimum Maintenance Scope:

KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 prior to 1998. Assume drop to 5 in 2003, then to 4 in 2014.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2027.
Replace strip seal in 2013.

Project Number:	K-8738-01			**Fiscal Yr:**	2003
Bridge Number:	61	78	46	**County:**	Reno
	(route)	*(county)*	*(serial)*		
Feature Carried:	K-61 SB	**Feature Crossed:**	Cow Creek		

# of Units:	1		
Unit 1 Description:	RCSH	**Spans (ft):**	33-44-44-33
Year Built:	1963	**AADT:**	3,815
Previous Subst Maint:	none	**% Trucks:**	11
	Length of State Route Detour (mi):		3
Bridge Length (ft):	155.5	**Roadway Width (ft):**	40
Area of Deck (sf):	6220		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	7	8	7	5.27
1997	7	8	7	4.91
1998	7	8	7	4.82
2000	6	7	7	4.64
2002	6	7	7	4.45
2004	8	7	7	4.27
2006	8	7	7	4.09
2008	8	7	7	3.91
2010	7	7	7	3.73

FY 2003 Scope of Work as Let: **Let Price:** $160,513

Patch deck, Place silica fume overlay, Repair curb, Repair concrete approach slab.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
0% deterioration noted top and 10% bottom of deck.
KDOT Forces repaired deck in 2002.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 61-78-46 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2038

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$160,513	1.43	$229,534
	Maintenance Cost to date (cost above are in $ of year incurred)			$229,534

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	600	0.924	$554
2023	Patch deck	4665	0.820	$3,827
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$4,381

Sum of inflated cost to date and discounted cost expected from 2003-2023 $233,915

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2011	1% deck patch	$4,665	1.071	$4,996
	Maintenance Cost to date (cost above are in $ of year incurred)			$4,996

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	1.5% deck patch	$6,998	0.9612	$6,726
2019	2% deck patch	$9,330	0.888	$8,285
2022	Contract patch	$275,440	0.8368	$230,488
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$245,499

Sum of inflated cost to date and discounted cost expected from 2003-2023 $250,496

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 in 2000. Assume drop to 5 in 2011, then to 4 in 2022.
Contract overlay and patch in 2022, expect deck NBI to drop to 6 in 2035.
No deck expansion joints to maintain.

Project Number:	K-8738-01			**Fiscal Yr:**	2003
Bridge Number:	61 *(route)*	78 *(county)*	47 *(serial)*	**County:**	Reno
Feature Carried:	K-61 NB	**Feature Crossed:**	Cow Creek		

# of Units:	1		
Unit 1 Description:	RCSH	**Spans (ft):**	33-44-44-33
Year Built:	1963	**AADT:**	3,815
Previous Subst Maint:	none	**% Trucks:**	11
	Length of State Route Detour (mi):		3
Bridge Length (ft):	155.5	**Roadway Width (ft):**	40
Area of Deck (sf):	6220		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	7	8	7	6.00
1997	7	8	7	5.73
1998	7	8	7	5.67
2000	6	7	7	5.53
2002	6	7	7	5.40
2004	8	7	7	5.27
2006	8	7	7	5.13
2008	8	7	7	5.00
2010	7	7	7	4.87

FY 2003 Scope of Work as Let: **Let Price:** $168,099

Patch deck, Place silica fume overlay, Repair curb, Repair concrete approach slab.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
1% deterioration noted top and bottom of deck.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 61-78-47	**Review Period:** 2003-2023	**Discount Rate:** 2%	
End of 75 yr Expected Life: 2038			

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$168,099	1.43	$240,382
	Maintenance Cost to date from 2003 (2013 dollars)			$240,382

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	600	0.924	$554
2023	Patch deck	4665	0.820	$3,827
	Expected Discounted Maintenance Costs until 2023			$4,381
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $244,763

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2011	1% deck patch	$4,665	1.071	$4,996
	Maintenance Cost to date (cost above are in $ of year incurred)			$4,996

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	1.5% deck patch	$6,998	0.9612	$6,726
2019	2% deck patch	$9,330	0.888	$8,285
2022	Contract overlay	$288,458	0.8368	$241,382
	Expected Discounted Maintenance Costs until 2023			$256,393
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $261,389

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 in 2000. Assume drop to 5 in 2011, then to 4 in 2022.
Contract overlay and patch in 2022, expect deck NBI to drop to 6 in 2035.
No deck expansion joints to maintain.

Project Number:	K-8714-01			**Fiscal Yr:**	2003
Bridge Number:	4	85	108	**County:**	Saline
	(route)	*(county)*	*(serial)*		
Feature Carried:	K-4	**Feature Crossed:**		Dry Creek	

# of Units:	1		
Unit 1 Description:	RDGH-4	**Spans (ft):**	45-63-45

Year Built:	1958	**AADT:**	1,450
Previous Subst Maint:	none	**% Trucks:**	8
	Length of State Route Detour (mi):		3

Bridge Length (ft):	155.5	**Roadway Width (ft):**	28
Area of Deck (sf):	4354		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	6	6	7	4.73
1996	6	6	7	4.55
1998	6	6	7	4.36
2000	6	6	7	4.18
2002	6	6	7	4.00
2004	8	7	7	3.82
2006	8	7	7	3.64
2008	7	7	7	3.45
2010	7	7	7	3.27

FY 2003 Scope of Work as Let: **Let Price:** $279,901

Patch deck, Place silica fume overlay, Repair curb, Rebar insertion.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 2, longitudinal cracks in deck.
2% deterioration noted top and bottom of deck.
KDOT Forces patched deck in 1998 and 2000.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 4-85-108 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2033

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$279,901	$1.430	$400,258
	Maintenance Cost to date from 2003 (2013 dollars)			$400,258

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.933	$280
2023	Patch deck	$3,266	0.820	$2,679
	Expected Discounted Maintenance Costs until 2023			$2,959
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $403,217

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1% deck patch	$3,266	1.430	$4,670
2007	1.5% deck patch	$4,898	1.242	$6,084
2011	2% deck patch	$6,531	1.071	$6,995
	Maintenance Cost to date from 2003 (2013 dollars)			$17,748

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	Contract patch	$480,310	0.980	$470,896
	Expected Discounted Maintenance Costs until 2023			$470,896
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $488,644

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Deck NBI dropped to 6 prior to 1994. Assume drop to 5 in 2003, then to 4 in 2014.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2027.
No deck expansion joints to maintain.

Project Number:	K-8706-01				**Fiscal Yr:**	2003
Bridge Number:	54	87	303		**County:**	Sedgwick
	(route)	*(county)*	*(serial)*			
Feature Carried:	US-54 Ramp	**Feature Crossed:**		Hydraulic Ave		

# of Units:	1		
Unit 1 Description:	RBGC-5	**Spans (ft):**	37-74-50
Year Built:	1976	**AADT:**	52,000
Previous Subst Maint:	none	**% Trucks:**	4
	Length of State Route Detour (mi):		0
Bridge Length (ft):	163	**Roadway Width (ft):**	36
Area of Deck (sf):	5868		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	8	8	6.36
1996	7	8	8	6.18
1998	7	8	8	6.00
2000	6	7	8	5.82
2002	6	7	8	5.64
2004	8	7	8	5.45
2006	8	7	8	5.27
2008	8	7	8	5.09
2010	8	7	8	4.91

FY 2003 Scope of Work as Let: **Let Price:** $316,530

Patch deck, Place rapid set latex overlay.
Polymer overlay placed in 2010 under I-135/US-54 reconstruction project K-7332-01.
Expect to patch and place new poly OL in 15 years, 2025.

Review Notes:

Wearing surface is all condition 1.
0% deterioration noted top and bottom of deck.
KDOT Forces patched deck in 1997 and 2000.
Polymer overlay placed under project K-7332-01 (I-135 and US-54 reconstruction) to preserve Latex OL.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 54-87-303 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2051

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*		*Cost (2013)*
2003	Contract Repair	$316,530	1.430		$452,638
2008	Deck and parapet	$4,927	1.197		$5,898
2010	Poly OL	$9,780	1.109	(bid price from K-7332-01)	$10,846
	Maintenance Cost to date (cost above are in $ of year incurred)				$469,382

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
	None until 2025			
	Expected Discounted Maintenance Costs until 2023			
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $469,382

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2011	1% Bit patch	$2,054	1.071	$2,200
2013	1.25% Bit patch	$2,567	1.000	$2,567
	Maintenance Cost to date (cost above are in $ of year incurred)			$4,767

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	1.5% Bit patch	$3,081	0.961	$2,961
2017	1.75% Bit patch	$3,594	0.924	$3,320
2019	2% Bit patch	$4,108	0.888	$3,648
2022	Contract patch	$543,165	0.837	$454,521
	Expected Discounted Maintenance Costs until 2023			$464,450
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $469,217

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patching until rating of 4.
Deck NBI dropped to 6 in 2000. Assume drop to 5 in 2011, then to 4 in 2022.
Contract overlay and patch in 2022, expect deck NBI to drop to 6 in 2035.
No deck expansion joints to maintain.

Project Number:	K-9168-01				**Fiscal Yr:**	2003
Bridge Number:	135	87	47		**County:**	Sedgwick
	(route)	*(county)*	*(serial)*			
Feature Carried:	I-135 SB	**Feature Crossed:**		85th Street		

# of Units:	1		
Unit 1 Description:	RCSH	**Spans (ft):**	43-57-57-43
Year Built:	1969	**AADT:**	13,100
Previous Subst Maint:	none	**% Trucks:**	17
	Length of State Route Detour (mi):		1
Bridge Length (ft):	202.5	**Roadway Width (ft):**	40
Area of Deck (sf):	8100		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	8	8	5.73
1996	7	8	8	5.55
1998	7	8	8	5.36
2000	7	8	8	5.18
2002	7	8	8	5.00
2004	7	8	7	4.82
2006	8	8	7	4.64
2008	8	8	7	4.45
2010	8	8	7	4.27

FY 2003 Scope of Work as Let: **Let Price:** $153,283

Patch deck, Place silica fume overlay.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 135-87-47 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2044

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$153,283	1.430	$219,195
2011	Misc Repairs	$220	1.071	$236
	Maintenance Cost to date from 2003 (2013 dollars)			$219,431

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$6,075	0.820	$4,983
	Expected Discounted Maintenance Costs until 2023			$5,538
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $224,968

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
	No work required i	$3,544	1.000	
	Maintenance Cost to date (cost above are in $ of year incurred)			

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	1% Bit patch	$2,835	0.961	$2,725
2017	1.25% Bit patch	$3,544	0.924	$3,274
2019	1.5% Bit patch	$4,253	0.888	$3,776
2021	1.75% Bit patch	$4,961	0.854	$4,234
2023	2% Bit patch	$5,670	0.888	$5,035
	Expected Discounted Maintenance Costs until 2023			$19,044
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $19,044

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patching until rating of 4.
Assume that deck NBI dropped to 6 in 2004, to 5 in 2015, then to 4 in 2026.
Contract overlay and patch not until after study period.
No deck expansion joints to maintain.

Project Number:	K-9168-01			**Fiscal Yr:**	2003
Bridge Number:	135	87	48	**County:**	Sedgwick
	(route)	*(county)*	*(serial)*		
Feature Carried:	I-135 NB	**Feature Crossed:**	85th Street		

# of Units:	1		
Unit 1 Description:	RCSH	**Spans (ft):**	43-57-57-43
Year Built:	1969	**AADT:**	13,100
Previous Subst Maint:	none	**% Trucks:**	17
		Length of State Route Detour (mi):	1
Bridge Length (ft):	202.5	**Roadway Width (ft):**	48
Area of Deck (sf):	9720		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	6	7	7	5.73
1996	6	7	7	5.55
1998	6	7	7	5.36
2000	6	7	7	5.18
2002	6	7	7	5.00
2004	8	7	8	4.82
2006	8	7	8	4.64
2008	8	7	8	4.45
2010	8	7	8	4.27

FY 2003 Scope of Work as Let: **Let Price:** $200,166

Patch deck, Place silica fume overlay.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
1% deterioration noted top and bottom of deck.
KDOT Forces patched deck in 1996, 1998, 2001 and 2002.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 135-87-48 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2044

BLCCA with work as let:

Year	Item	Cost	Present Worth Factor	Cost (2013)
2003	Contract Repair	$200,166	1.43	$286,237
	Maintenance Cost to date from 2003 (2013 dollars)			$286,237

Year	Item	Cost	Present Worth Factor	Cost (2013)
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$7,290	0.820	$5,980
	Expected Discounted Maintenance Costs until 2023			$6,534
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $292,772

BLCCA with minimum maintenance:

Year	Item	Cost	Inflation Factor	Cost (2013)
2003	1% Bit patch	$3,402	1.430	$4,865
2005	1.25% Bit patch	$4,253	1.336	$5,681
2007	1.5% Bit patch	$5,103	1.242	$6,338
2009	1.75% Bit patch	$5,954	1.152	$6,858
2011	2% Bit patch	$6,804	1.071	$7,287
	Maintenance Cost to date (cost above are in $ of year incurred)			$31,030

Year	Item	Cost	Present Worth Factor	Cost (2013)
2015	Contract overlay	$343,485	0.961	$330,158
	Expected Discounted Maintenance Costs until 2023			$330,158
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $361,187

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patching until rating of 4.
Deck NBI dropped to 6 in 1994, assume drop to 5 in 2003, then to 4 in 2014.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2027.
No deck expansion joints to maintain.

Project Number:	K-8744-01			**Fiscal Yr:**	2003
Bridge Number:	235	87	83	**County:**	Sedgwick
	(route)	*(county)*	*(serial)*		
Feature Carried:	I235 Ramp	**Feature Crossed:**	Abandoned ATSF RR		

# of Units:	1		
Unit 1 Description:	RCSC	**Spans (ft):**	30-3@42-30
Year Built:	1961	**AADT:**	21,100
Previous Subst Maint:		**% Trucks:**	9
	Length of State Route Detour (mi):		20
Bridge Length (ft):	189.5	**Roadway Width (ft):**	20
Area of Deck (sf):	3790		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	6	7	6	5.00
1996	6	7	6	4.82
1998	6	7	6	4.64
2000	6	7	6	4.45
2002	6	7	6	4.27
2003	8	7	6	4.18
2004	8	7	7	4.09
2006	8	7	7	3.91
2008	8	7	7	3.73
2010	8	7	7	3.55

FY 2003 Scope of Work as Let: **Let Price:** $161,460

Patch deck, Place silica fume overlay, Repair concrete approach slab, Repair NE wing.

Minimum Maintenance Scope:

KDOT forces to maintain deck until rating of 4.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.

0% deterioration noted top and 1% bottom of deck.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 235-87-83 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2036

BLCCA with work as let:

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2003	Contract Repair	$161,460	1.43	$230,888
	Maintenance Cost to date from 2003 (2013 dollars)			$230,888

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$300	0.924	$277
2023	Patch deck	$2,843	0.820	$2,332
	Expected Discounted Maintenance Costs until 2023			$2,609
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $233,497

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	1% Bit patch	$1,327	1.430	$1,897
2005	1.25% Bit patch	$1,658	1.336	$2,215
2007	1.5% Bit patch	$1,990	1.242	$2,471
2009	1.75% Bit patch	$2,321	1.152	$2,674
2011	2% Bit patch	$2,653	1.071	$2,841
	Maintenance Cost to date (cost above are in $ of year incurred)			$12,099

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	Contract overlay	$277,065	0.961	$266,315
	Expected Discounted Maintenance Costs until 2023			$266,315
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $278,414

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patching until rating of 4.
Deck NBI dropped to 6 in 1994, assume drop to 5 in 2003, then to 4 in 2014.
Contract overlay and patch in 2014, expect deck NBI to drop to 6 in 2027.
No deck expansion joints to maintain.

Project Number:	K-8706-01			**Fiscal Yr:**	2003
Bridge Number:	24 *(route)*	89 *(county)*	104 *(serial)*	**County:**	Shawnee
Feature Carried:	Old US-75 SB	**Feature Crossed:**	US-24		

# of Units:	1		
Unit 1 Description:	SWGC-2	**Spans (ft):**	44-66-59-44
Year Built:	1963	**AADT:**	2,870
Previous Subst Maint:	1990-Paint	**% Trucks:**	2
	Length of State Route Detour (mi):		0
Bridge Length (ft):	216	**Roadway Width (ft):**	22
Area of Deck (sf):	4752		
Expansion Joints (2003):	Sliding Plate	**Length of Joints (ft):**	44

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	7	7	7	5.2
1996	6	7	6	5.0
1998	6	6	6	4.8
2000	6	6	5	4.6
2001	6	6	5	4.5
2002	5	6	5	4.5
2003	5	6	5	4.4
2004	7	6	7	4.3
2005	7	6	7	4.2
2006	7	6	7	4.1
2007	7	6	7	4.0
2008	7	6	7	3.9
2009	7	6	7	3.8
2010	7	6	7	3.7
2011	7	6	7	3.6
2012	7	6	6	3.5

FY 2003 Scope of Work as Let: **Let Price:** $87,901

Patch deck, Place silica fume overlay, Replace sliding plate with Jeene.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023
Expect to replace Jeene in 2018.

Review Notes:

Wearing surface is all condition 1.
1% deterioration noted top and 10% bottom of deck.
Superstructure dropped to 6 this inspection due to condition of rockers at abutments
KDOT Forces patched deck in 2001 and repaired joints in 1998.

Bridge Life Cycle Cost Analysis

Bridge: 10-46-176 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2038

BLCCA with work as let:

Year	Item	Cost	Inflation Factor	Cost (2013)
2003	Contract Repair	$87,901	1.430	$125,698
2005	Misc repairs	$539	1.336	$720
2007	Repair joints	$197	1.242	$245
2009	Seal deck	$112	1.152	$129
	Maintenance Cost to date (cost above are in $ of year incurred)			$126,792

Year	Item	Cost	Present Worth Factor	Cost (2013)
2017	Seal deck	$300	0.924	$277
2018	Replace joint	$13,200	0.906	$11,955
2023	Patch deck	$3,564	0.820	$2,924
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$15,156

Sum of inflated cost to date and discounted cost expected from 2003-2023 $141,948

BLCCA with minimum maintenance:

Year	Item	Cost	Inflation Factor	Cost (2013)
2003	1% deck patch	$1,163	1.430	$1,663
2006	2% deck patch	$2,583	1.288	$3,326
2010	Contract patch	$124,678	1.109	$138,268
	Maintenance Cost to date (cost above are in $ of year incurred)			$143,258

Year	Item	Cost	Present Worth Factor	Cost (2013)
2023	Deck seal	$300	0.820	$246
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$246

Sum of inflated cost to date and discounted cost expected from 2003-2023 $143,504

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Assume that deck NBI dropped to 4 in 2010. (Stayed at 6 for 8 years)
Contract overlay and patch in 2010, expect deck NBI to drop to 6 in 2023.
Replace joint with contract patch project.
Replace joint in 2018 with Jeene.

Project Number: K-8706-01 **Fiscal Yr:** 2003
Bridge Number: 24 *(route)* 89 *(county)* 105 *(serial)* **County:** Shawnee
Feature Carried: Old US-75 NB **Feature Crossed:** US-24

# of Units: 1
Unit 1 Description: SWGC-2 **Spans (ft):** 44-66-59-44

Year Built: 1963 **AADT:** 2,870
Previous Subst Maint: 1990-Paint **% Trucks:** 2
Length of State Route Detour (mi): 0

Bridge Length (ft): 216 **Roadway Width (ft):** 22
Area of Deck (sf): 4752
Expansion Joints (2003): Sliding Plate **Length of Joints (ft):** 44

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1994	6	7	6	5.2
1996	6	7	6	5.0
1998	5	7	6	4.8
2000	5	7	6	4.6
2001	5	7	6	4.5
2002	5	7	6	4.5
2003	5	7	6	4.4
2004	8	7	8	4.3
2005	7	7	8	4.2
2006	7	7	6	4.1
2007	7	7	6	4.0
2008	7	6	6	3.9
2009	7	6	6	3.8
2010	7	6	6	3.7
2011	7	6	6	3.6
2012	7	6	6	3.5

FY 2003 Scope of Work as Let: **Let Price:** $96,827
Patch deck, Place silica fume overlay, Replace sliding plate with Jeene.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023
Expect to replace Jeene in 2014.

Review Notes:
Wearing surface is all condition 1.
2% deterioration noted top and 10% bottom of deck.
KDOT Forces patched deck in 2001.
Joints need to be replaced now.

Bridge Life Cycle Cost Analysis

Bridge:	10-46-176	**Review Period:**	2003-2023	**Discount Rate:**	2%
		End of 75 yr Expected L	2038		

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$96,827	1.430	$138,463
2007	Repair Exp Joints	$970	1.242	$1,205
2009	Seal Deck	$341	1.152	$393
2010	Seal Deck	$3,470	1.109	$3,849
	Maintenance Cost to date (cost above are in $ of year incurred)			$143,909

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2014	Replace joint	$13,200	0.980	$12,941
2017	Seal deck	$300	0.924	$277
2023	Patch deck	$3,564	0.820	$2,924
	Expected Discounted Maintenance Costs until 2023			$16,142
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $160,051

BLCCA with minimum maintenance:

Same as scope as let.

Minimum Maintenance Scope:

KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Assume deterioration rate result in deck NBI dropping to 4 in 2004.
During the review period selected, the min. maint. scope is equal to project let.

Project Number:	K-8734-01			**Fiscal Yr:**	2003
Bridge Number:	49 *(route)*	96 *(county)*	101 *(serial)*	**County:**	Sumner
Feature Carried:	K-49	**Feature Crossed:**	N. Branch Slate Creek		

# of Units:	1		
Unit 1 Description:	RDGH-5	**Spans (ft):**	50-70-70-50

Year Built:	1964	**AADT:**	1,940
Previous Subst Maint:	none	**% Trucks:**	7
	Length of State Route Detour (mi):		13

Bridge Length (ft):	242.5	**Roadway Width (ft):**	44
Area of Deck (sf):	10670		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	8	8	8	5.36
1997	7	7	7	5.00
1999	7	7	7	4.82
2001	7	7	7	4.64
2003	8	7	7	4.45
2005	8	7	7	4.27
2007	8	7	7	4.09
2009	8	7	7	3.91
2011	8	7	7	3.73

FY 2003 Scope of Work as Let: **Let Price:** $129,264

Patch deck, Place silica fume overlay.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.

1% deterioration noted top and bottom of deck.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge:	49-96-101	**Review Period:**	2003-2023	**Discount Rate:**	2%
End of 75 yr Expected Life:	2039				

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract repair	$129,264	1.430	$184,848
	Maintenance Cost to date (cost above are in $ of year incurred)			$184,848

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$3,735	0.820	$3,063
	Expected Discounted Maintenance Costs until 2023			$3,618
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $188,465

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2013	1% deck patch	$8,003	1.000	$8,003
	Maintenance Cost to date (cost above are in $ of year incurred)			$8,003

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2016	1.5% deck patch	$12,004	0.942	$11,311
2020	2% deck patch	$16,005	0.871	$13,934
2023	Contract patch	$221,817	0.820	$181,957
	Expected Discounted Maintenance Costs until 2023			$207,202
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $215,204

Minimum Maintenance Scope:
KDOT forces to maintain deck with rapid set concrete patching until rating of 4.
Pontis inspection in 2003 showed deck in condition 2, indicating drop to NBI 6.
Assume that deck NBI dropped to 6 in 2002, to 5 in 2013, then to 4 in 2023.
Contract overlay and patch in 2023.
No deck expansion joints to maintain.

Project Number:	K-8712-01			**Fiscal Yr:**	2003
Bridge Number:	435 *(route)*	105 *(county)*	200 *(serial)*	**County:**	Wyandotte
Feature Carried:	I-435 NB	**Feature Crossed:**	Metropolitan Ave		

# of Units:	1		
Unit 1 Description:	SWGC-7	**Spans (ft):**	39-82-40
Year Built:	1979	**AADT:**	27,000
Previous Subst Maint:	none	**% Trucks:**	10
	Length of State Route Detour (mi):		1
Bridge Length (ft):	163.6	**Roadway Width (ft):**	56
Area of Deck (sf):	9161.6		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	7	8	8	6.7
1997	7	8	7	6.4
1999	7	8	7	6.2
2001	7	7	7	6.0
2003	7	7	7	5.8
2005	7	7	7	5.6
2007	7	7	7	5.5
2009	7	7	7	5.3
2011	7	7	7	5.1

FY 2003 Scope of Work as Let: **Let Price:** $142,246

Patch deck, Place silica fume overlay, Repair concrete approach slab.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
2% deterioration noted top and 3% bottom of deck.
KDOT Forces sealed deck in 1998.
Past bridge inspections show the deck in Pontis condition 3 in 2003.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge: 10-46-176 **Review Period:** 2003-2023 **Discount Rate:** 2%
End of 75 yr Expected Life: 2054

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$142,246	1.430	$203,412
2008	Parapet and Seal De	$3,224	1.197	$3,859
	Maintenance Cost to date (cost above are in $ of year incurred)			$207,271

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$3,207	0.820	$2,630
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$3,185

Sum of inflated cost to date and discounted cost expected from 2003-2023 $207,271

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2013	1% Bit patching	$3,207	1.000	$3,207
	Maintenance Cost to date (cost above are in $ of year incurred)			$3,207

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	1.25% Bit patch	$4,008	0.961	$3,853
2017	1.5% Bit patch	$4,810	0.924	$4,443
2019	1.75% Bit patch	$5,611	0.888	$4,983
2021	2% Bit patch	$6,413	0.854	$5,474
2023	Contract patch	$244,094	0.820	$200,230
	Expected Discounted Maintenance Costs until 2023 (costs above are in base year $)			$218,983

Sum of inflated cost to date and discounted cost expected from 2003-2023 $222,190

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Based on Pontis condition, assume that deck NBI dropped to 6 in 2003, to 5 in 2013, then drops to 4 in 2023.
Contract overlay and patch in 2023.
No deck expansion joints to maintain.

Project Number:	K-8712-01			**Fiscal Yr:**	2003
Bridge Number:	435 *(route)*	105 *(county)*	201 *(serial)*	**County:**	Wyandotte
Feature Carried:	I-435 SB	**Feature Crossed:**		Metropolitan Ave	

# of Units:	1		
Unit 1 Description:	SWGC-7	**Spans (ft):**	39-82-40
Year Built:	1979	**AADT:**	27,000
Previous Subst Maint:	none	**% Trucks:**	10
	Length of State Route Detour (mi):		1
Bridge Length (ft):	163.6	**Roadway Width (ft):**	56
Area of Deck (sf):	9161.6		
Expansion Joints (2003):	none	**Length of Joints (ft):**	1

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	7	7	7	6.7
1997	7	7	7	6.4
1999	7	7	7	6.2
2001	7	7	7	6.0
2003	6	7	7	5.8
2005	6	7	7	5.6
2007	7	7	7	5.5
2009	7	7	7	5.3
2011	7	7	7	5.1

FY 2003 Scope of Work as Let: **Let Price:** $142,246

Patch deck, Place silica fume overlay, Repair concrete approach slab.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 1.
1% deterioration noted top and 5% bottom of deck.
KDOT Forces patched deck in 1997 and sealed deck in 1998.
Past bridge inspections show the deck in Pontis condition 2 in 2003.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge:	10-46-176	**Review Period:**	2003-2023	**Discount Rate:**	2%
		End of 75 yr Expected Li	2054		

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$142,246	1.430	$203,412
	Maintenance Cost to date (cost above are in $ of year incurred)			$203,412

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$3,207	0.820	$2,630
	Expected Discounted Maintenance Costs until 2023			$3,185
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $206,596

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2013	1% Bit patch	$3,207	1.000	$3,207
	Maintenance Cost to date (cost above are in $ of year incurred)			$3,207

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	1.25% Bit patch	$4,008	0.961	$3,853
2017	1.5% Bit patch	$4,810	0.924	$4,443
2019	1.75% Bit patch	$5,611	0.888	$4,983
2021	2% Bit patch	$6,413	0.854	$5,474
2023	Contract patch	$244,094	0.820	$200,230
	Expected Discounted Maintenance Costs until 2023			$218,983
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $222,190

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Deck NBI dropped to 6 in 2003. Assume drops to 5 in 2013, then drops to 4 in 2023.
Contract overlay and patch in 2023.
No deck expansion joints to maintain.

Project Number:	K-8712-01			**Fiscal Yr:**	2003
Bridge Number:	435	105	202	**County:**	Wyandotte
	(route)	*(county)*	*(serial)*		
Feature Carried:	I-435 NB		**Feature Crossed:**	Swartz Road	

# of Units:	1		
Unit 1 Description:	SWGC-7	**Spans (ft):**	34-82-37
Year Built:	1979	**AADT:**	27,000
Previous Subst Maint:	none	**% Trucks:**	10
	Length of State Route Detour (mi):		1
Bridge Length (ft):	155.1	**Roadway Width (ft):**	56
Area of Deck (sf):	8685.6		
Expansion Joints (2003):	none	**Length of Joints (ft):**	0

NBI Ratings

Year	Deck	Super	Sub	Projected Deck*
1993	7	8	7	6.7
1997	7	7	7	6.4
1999	7	7	7	6.2
2001	7	7	7	6.0
2003	7	7	7	5.8
2005	7	7	7	5.6
2007	7	8	7	5.5
2009	7	8	7	5.3
2011	7	7	7	5.1

FY 2003 Scope of Work as Let: **Let Price:** $138,748

Patch deck, Place silica fume overlay, Repair concrete approach slab.

Expect to drop deck NBI to 6 in 2017, to 5 in 2023

Review Notes:

Wearing surface is all condition 2.
2% deterioration noted top bottom of deck. Numerous asphalt patches.
KDOT Forces sealed deck in 1998.
Work to place bituminous patches not reported.
Past bridge inspections show the deck in Pontis condition 3 in 2003.

**Projected Deck NBI presumes a 45 year service life with a linear deterioration rate.*

Bridge Life Cycle Cost Analysis

Bridge:	10-46-176	**Review Period:**	2003-2023	**Discount Rate:**	2%
		End of 75 yr Expected L	2054		

BLCCA with work as let:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2003	Contract Repair	$138,748	1.430	$198,410
	Maintenance Cost to date (cost above are in $ of year incurred)			$198,410

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2017	Seal deck	$600	0.924	$554
2023	Patch deck	$3,040	0.820	$2,494
	Expected Discounted Maintenance Costs until 2023			$3,048
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $201,458

BLCCA with minimum maintenance:

Year	*Item*	*Cost*	*Inflation Factor*	*Cost (2013)*
2013	1% Bit patch	$3,040	1.000	$3,040
	Maintenance Cost to date (cost above are in $ of year incurred)			$3,040

Year	*Item*	*Cost*	*Present Worth Factor*	*Cost (2013)*
2015	1.25% Bit patch	$3,800	0.961	$3,653
2017	1.5% Bit patch	$4,560	0.924	$4,212
2019	1.75% Bit patch	$5,320	0.888	$4,724
2021	2% Bit patch	$6,080	0.854	$5,189
2023	Contract patch	$238,092	0.820	$195,307
	Expected Discounted Maintenance Costs until 2023			$213,085
	(costs above are in base year $)			

Sum of inflated cost to date and discounted cost expected from 2003-2023 $216,125

Minimum Maintenance Scope:
KDOT forces to maintain deck with bituminous patches until rating of 4.
Based on Pontis condition, assume that deck NBI dropped to 6 in 2003, to 5 in 2013, then drops to 4 in 2023.
Contract overlay and patch in 2023.
No deck expansion joints to maintain.

Appendix I Delay through Bridge Work Zone Calculations

Appendix I

Delay Calculation for Undercapacity Flow at a Typical Signalized Work Zone for Bridge Deck Repair Work

Capacity has been estimated for the signalized lanes of the work zones of the FY 2003 bridge deck repairs as ½ of 1,400 vph, the capacity of a lane through a work zone specified in the 2010 Highway Capacity Manual. With that assumption, the v/c ratio for the peak hour volumes is less than 0.6 for any of the projects with signalized work zones.

Delay will be calculated for a typical work site and the delay time will be applied to all the signalized bridges in this review. Delay will be assumed to consist of an average delay of the controller plus delay from the vehicle travelling the work zone at reduced speed.

The purpose of this review is to determine a conservative value for work zone delay to review the bridges from the FY 2003 program. Signals at KDOT work zones are actuated, but reasonable signal timing will be estimated to conservatively determine delay.

Since the lanes are well under capacity at peak hours, assume uniform delay to estimate delay from the controller.

The work zone traffic control is assumed to follow KDOT Traffic Engineering Standard TE732 for Temporary Signalized Work Zones.

Step 1- Determine typical layout of work zone.

Step 2- Determine typical signal timing.

Step 3- Calculate an average uniform delay from the signal controller.

Step 4- Calculate the delay in traveling through the work zone for four cases:

1. Passenger car with no stop.
2. Semi-trailer truck with no stop.
3. Passenger car with stop.
4. Semi-trailer truck with stop.

Step 5- Calculate total average delay for each passenger cars and for semi-trailers

Step 1

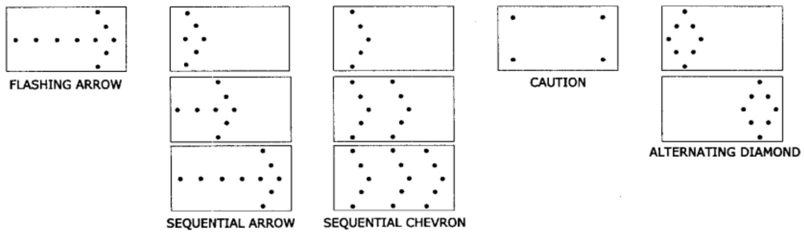
Referring to Standard TE732 for layout.

Values for dimensions A, B and C, from TE710 for Rural Highways: A = 750 feet, B = 750 feet, C = 750 feet.

Buffer = 165 feet for original site speeds > or = 60 mph.

STATE	PROJECT NO.	YEAR	SHEET NO.	TOTAL SHEETS
KANSAS				

ARROW DISPLAYS



ARROW DISPLAY ELEMENTS SHALL BE CAPABLE OF A MINIMUM 50 PERCENT DIMMING FROM THEIR FULL-RATED LAMP VOLTAGE. FULL LAMP VOLTAGE SHOULD BE USED DURING THE DAY AND DIMMED MODE SHALL BE USED AT NIGHT. FOR SHOULDER WORK, ROADSIDE WORK NEAR THE SHOULDER, BLOCKING THE SHOULDER, OR FOR TEMPORARY CLOSING ONE LANE ON A TWO-LANE, TWO-WAY ROADWAY, AN ARROW PANEL SHALL BE USED ONLY IN THE CAUTION MODE.

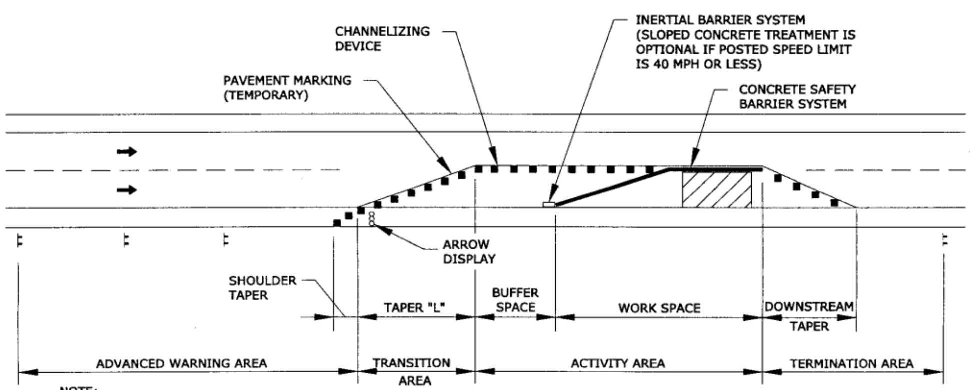
BUFFER SPACE

SPEED (MPH) ✳	*20*	*25*	*30*	*35*	*40*	*45*	*50*	*55*	*60*	*65*	*70*	*75*
LENGTH (ft)	*115*	*155*	*200*	*250*	*305*	*360*	*425*	*495*	*570*	*645*	*730*	*820*

✳ POSTED SPEED PRIOR TO WORK STARTING

NEITHER WORK ACTIVITY NOR STORAGE OF EQUIPMENT, VEHICLES, OR MATERIAL SHOULD OCCUR IN THE BUFFER SPACE. WHEN A PROTECTION VEHICLE IS PLACED IN ADVANCE OF THE WORK SPACE, ONLY THE SPACE UPSTREAM OF THE VEHICLE CONSTITUTES THE BUFFER SPACE.

IF TEMPORARY CONCRETE SAFETY BARRIER SYSTEM IS USED TO SEPARATE APPROACHING TRAFFIC FROM THE WORK SPACE, THE BARRIER SYSTEM SHALL BE CONSIDERED PART OF THE ACTIVITY AREA. A FULL LANE WIDTH SHOULD BE AVAILABLE THROUGHOUT THE LENGTH OF THE BUFFER SPACE. SEE TYPICAL WORK ZONE COMPONENTS.



NOTE:
REFER TO STD. TE702 FOR TAPER "L" FORMULA.

TYPICAL WORK ZONE COMPONENTS

NO.	DATE	REVISIONS	BY	APP'D
3	10/16/12	Removed Note 13. Added Alternating Diamonds	J.A.M.	K.P.
2	10/4/11	Modified Notes 9,12 & 14. Added Note 15	J.A.M.	K.P.
1	9/30/09	Added Note 14	J.A.M.	A.A.A.

KANSAS DEPARTMENT OF TRANSPORTATION

GENERAL TRAFFIC CONTROL

TE700 SHEET 3 OF 3

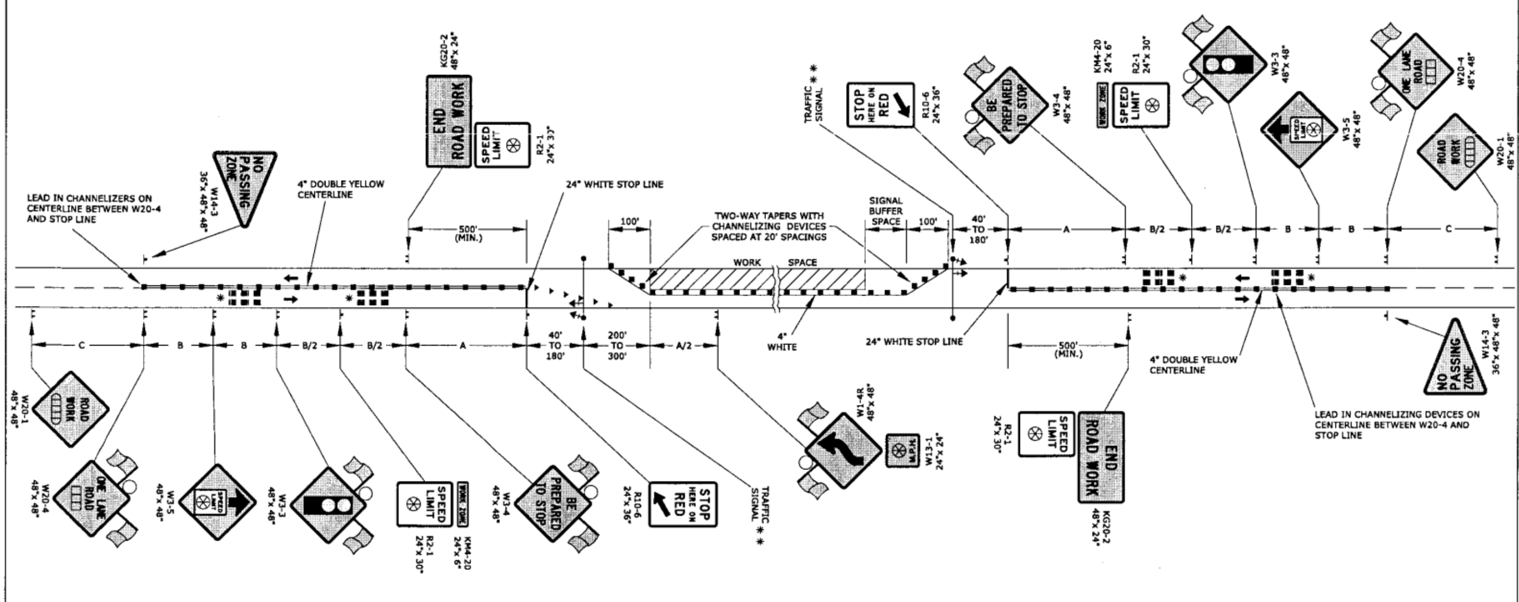
FHWA APPROVAL 10/16/12		APP'D Kristina Pyle	
DESIGNED B.A.H.	DETAILED B.A.H.	QUANTITIES	TRACED
DESIGN CK.	DETAIL CK.	QUAN. CK.	TRACE CK.

Plotted : 14-NOV-2012 11:29
Traffic

Drawn By : jmadrid
File : TE700_3.dgn

Drawn By : jmadrid Plotted : 14-NOV-2012 11:30
File : TE732_1.dgn Traffic

REFER TO STD. TE710 FOR ADDITIONAL INFORMATION ON TEMPORARY TRAFFIC CONTROL SIGNS AND SIGN SPACING. REFER TO STD. TE702 FOR INFORMATION ON TAPERS AND CHANNELIZING DEVICES.



SIGNAL BUFFER SPACE

SPEED (MPH) ▲	20	25	30	35	40	45	50	55	60	65	70
LENGTH (FT)	35	50	65	85	100	115	130	150	165	165	165

NEITHER WORK ACTIVITY NOR STORAGE OF EQUIPMENT, VEHICLES, OR MATERIAL SHOULD OCCUR IN THE BUFFER SPACE. WHEN A PROTECTION VEHICLE IS PLACED IN ADVANCE OF THE WORK SPACE, ONLY THE SPACE UPSTREAM OF THE VEHICLE CONSTITUTES THE BUFFER SPACE.

▲ POSTED SPEED PRIOR TO WORK STARTING

* TWO SETS OF RUMBLE STRIPS SHALL BE PLACED: ONE SET BETWEEN SIGNS W3-4 AND R2-1, AND ONE SET BETWEEN SIGNS W3-3 AND W3-5. MATERIALS, TEMPLATE, HAULING, INSTALLATION AND REMOVAL OF THE RUMBLE STRIPS ARE TO BE BY THE CONTRACTOR. PAYMENT SHALL BE SUBSIDIARY TO THE TEMPORARY TRAFFIC SIGNALS. SEE TE700, NOTE 14 FOR OTHER TEMPORARY RUMBLE STRIP OPTIONS.

** REFER TO TE733 AND TE734 FOR ADDITIONAL TEMPORARY TRAFFIC SIGNAL DETAILS.

- ▸ UNI-DIRECTIONAL YELLOW TEMPORARY RAISED PAVEMENT MARKER (TYPE 1) (FACING RIGHT)
- ■ CHANNELIZING DEVICE
- AHEAD, 1500 FT, OR 1 MILE
- AHEAD, 1000 FT, 1500 FT, OR ½ MILE
- ⊗ SPEED TO BE DETERMINED BY THE ENGINEER
- SPAN WIRE AND SIGNAL HEAD WITH BACK PLATE
- ● TEMPORARY SIGNAL POLE
- ○ TYPE "A" LOW INTENSITY WARNING LIGHT

STATE	PROJECT NO.	YEAR	SHEET NO.	TOTAL SHEETS
KANSAS				

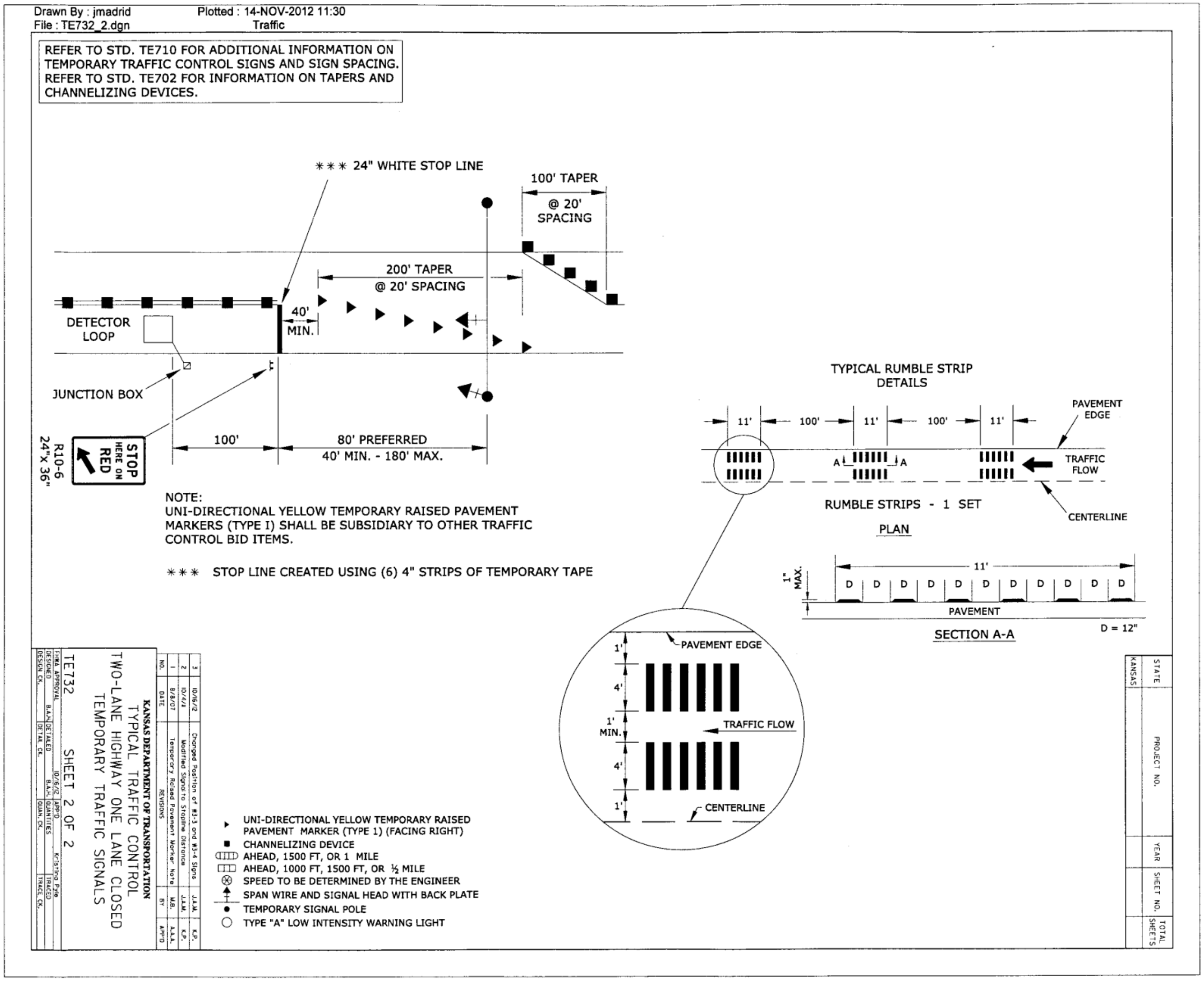
NO.	DATE	REVISIONS	BY	APP'D
3	10/16/12	Changed Position of W3-3 and W3-4 Signs	J.A.M.	K.P.
2	10/4/11	Modified Signal to Stopline Distance	J.A.M.	K.P.
1	8/8/07	Temporary Raised Pavement Marker Note	M.B.	A.A.A.

KANSAS DEPARTMENT OF TRANSPORTATION

TYPICAL TRAFFIC CONTROL
TWO-LANE HIGHWAY ONE LANE CLOSED
TEMPORARY TRAFFIC SIGNALS

TE732 SHEET 1 OF 2

FHWA APPROVAL		10/16/12	APP'D	Kristina Pyle	
DESIGNED	B.A.H.	DETAILED	B.A.H.	QUANTITIES	TRACED
DESIGN CK.		DETAIL CK.		QUAN. CK.	TRACE CK.


Drawn By : jmadrid
Plotted : 14-NOV-2012 11:30
File : TE732_2.dgn
Traffic
REFER TO STD. TE710 FOR ADDITIONAL INFORMATION ON TEMPORARY TRAFFIC CONTROL SIGNS AND SIGN SPACING. REFER TO STD. TE702 FOR INFORMATION ON TAPERS AND CHANNELIZING DEVICES.
∗∗∗ 24" WHITE STOP LINE
100' TAPER
@ 20' SPACING
200' TAPER
@ 20' SPACING
40' MIN.
DETECTOR LOOP
JUNCTION BOX
STOP HERE ON RED
R10-6
24"x 36"
100'
80' PREFERRED
40' MIN. - 180' MAX.
NOTE:
UNI-DIRECTIONAL YELLOW TEMPORARY RAISED PAVEMENT MARKERS (TYPE I) SHALL BE SUBSIDIARY TO OTHER TRAFFIC CONTROL BID ITEMS.
∗∗∗ STOP LINE CREATED USING (6) 4" STRIPS OF TEMPORARY TAPE
TYPICAL RUMBLE STRIP DETAILS
11'
100'
11'
100'
11'
PAVEMENT EDGE
TRAFFIC FLOW
CENTERLINE
A
A
RUMBLE STRIPS - 1 SET
PLAN
11'
1" MAX.
D D D D D D D D D D
PAVEMENT
SECTION A-A
D = 12"
PAVEMENT EDGE
1'
4'
1' MIN.
4'
1'
TRAFFIC FLOW
CENTERLINE
UNI-DIRECTIONAL YELLOW TEMPORARY RAISED PAVEMENT MARKER (TYPE 1) (FACING RIGHT)
CHANNELIZING DEVICE
AHEAD, 1500 FT, OR 1 MILE
AHEAD, 1000 FT, 1500 FT, OR ½ MILE
SPEED TO BE DETERMINED BY THE ENGINEER
SPAN WIRE AND SIGNAL HEAD WITH BACK PLATE
TEMPORARY SIGNAL POLE
TYPE "A" LOW INTENSITY WARNING LIGHT
3 10/16/12 Changed Position of W3-3 and W3-4 Signs J.A.M. K.P.
2 10/4/4 Modified Signal to Stopline Distance J.A.M. K.P.
1 8/8/07 Temporary Raised Pavement Marker Note M.B. A.A.A.
NO. DATE REVISIONS BY APP'D
KANSAS DEPARTMENT OF TRANSPORTATION
TYPICAL TRAFFIC CONTROL
TWO-LANE HIGHWAY ONE LANE CLOSED
TEMPORARY TRAFFIC SIGNALS
TE732 SHEET 2 OF 2
FHWA APPROVAL 10/16/12 APP'D Kristina Pyle
DESIGNED B.A.H. DETAILED B.A.H. QUANTITIES TRACED
DESIGN CK. DETAIL CK. QUAN. CK. TRACE CK.
STATE PROJECT NO. YEAR SHEET NO. TOTAL SHEETS
KANSAS

Work Space = 500 feet, assuming a 300 foot span bridge with 2-33' approaches and staging areas either side.

The stop bar to stop bar maximum distance is: 180' + 100' + 165' + 500' + 100' + 200' + 180' = 1,425'

Assume the highway speed limit is 65 mph and the work zone speed limit is 45 mph.

Step 2

Check minimum time necessary for a semi-trailer to accelerate from a stop and to clear the work zone.

From Figure 3-6, p. 65 of the 5^{th} Edition of the ITE Traffic Engineering Handbook, the acceleration for a semi-trailer to 45 mph is 1.1 ft/sec^2.

For uniform acceleration from an initial velocity of zero (where l = length):

$$t = \sqrt{2al}\,/a = \frac{\sqrt{2 * \frac{1.1\text{ft}}{\text{sec}^2} * 1425ft}}{1.1\text{ft/sec}^2} = 51 \text{ seconds.}$$

Assume a signal timing of 75 seconds, this would allow a truck to clear and allow 8 other vehicle in a queue, assuming 2.5 sec headways.

In conversation with Kristine Pyle, P.E. KDOT Work Zone Traffic Engineer, it was related that a signal timing of 60 sec is usually used initially; but is adjusted by the field to meet local conditions.

Step 3

Assuming that the signalized lane is being utilitized under its capacity, assume a uniform delay and an effective green time of half the cycle.

$$d_c = \frac{1}{2}C\frac{\left(1-\frac{g}{C}\right)^2}{\left(1-\frac{v}{s}\right)} = \frac{75}{2} * \frac{\left(1-\frac{1}{2}\right)^2}{\left(1-\frac{393}{1400}\right)} = 13.0\ sec$$

The value 393 for v is the largest peak hourly volume for the signalized bridge projects in FY 2003. A value of 200 for v results in a uniform delay of 11.2 sec.

Use 13 sec as the uniform controller delay for the analysis.

Step 4

Referring to the work zone layout in TE732, calculate the following travel times through the work zone for the four cases outlined. Assume the posted speed in the work zone is 45 mph and the highway speed is 65 mph.

(Note: 65 mph = 95.33 fps and 45 mph = 66.0 fps)

Case 1—Passenger Car Travels through with No Stop

1. Assume uniform deceleration from the initial warning sign to the speed sign, just past the first rumble strips:

   Distance = C + 2 ½ B = 750’ + 2 ½ * 750’ = 2,625’

   Time = $\frac{2*l}{v+v_0} = \frac{2*2{,}265\ ft}{95.3\ fps+66\ fps}$ = 32.5 sec.

2. Travel at 45 mph from the speed sign to the far stop bar:

   Distance = A + B/2 + 1,425’ = 750’ + 750’/2 + 1,425’ = 2,550’

   Time = l/v = 2,550’ / 66 fps = 38.6 sec.

3. Assume uniform acceleration from 45 mph to 65 mph:

   Distance = $\frac{v^2-v_0^2}{2a} = \frac{(95.33\ fps)^2-(66\ fps)^2}{2*3.5\frac{ft}{s^2}}$ = 676.1’ where from Fig. 3-7, p.66, ITE Traffic Engineering Handbook, 5th Ed 3.5 ft/s^2 is the typical rate of acceleration for a passenger car to 45 mph.

   Time= $\frac{v-v_0}{a} = \frac{95.33\ fps-66\ fps}{3.5\frac{ft}{s^2}}$ = 8.4 sec.

4. Calculate delay with respect to through travel at 65 mph:

   ∑distance = 2,625’ + 2,550’ + 676.1’ = 5,851.1’

   ∑time = 32.5 s + 38.6 s + 8.4 s = 79.5 sec.

   Time through at 65 mph = 5,851’/ 95.33 fps = 61.4 sec.

   Delay = 79.5 s – 62.4 s = 18.4 sec.

Case 2—Semi-Trailer Travels through with No Stop

1. Assume uniform deceleration from the initial warning sign to the speed sign, just past the first rumble strips:

   Distance = C + 2 ½ B = 750’ + 2 ½ * 750’ = 2,625’

   Time = $\frac{2*l}{v+v_0} = \frac{2*2{,}265\ ft}{95.3\ fps+66\ fps}$ = 32.5 sec.

2. Travel at 45 mph from the speed sign to the far stop bar:

   Distance = A + B/2 + 1,425’ = 750’ + 750’/2 + 1,425’ = 2,550’

   Time = l/v = 2,550’ / 66 fps = 38.6 sec.

3. Assume uniform acceleration from 45 mph to 65 mph:

   Distance = $\frac{v^2-v_0^2}{2a} = \frac{(95.33\ fps)^2-(66\ fps)^2}{2*1.1\frac{ft}{s^2}}$ = 2,151.1’

Time= $\frac{v-v_0}{a} = \frac{95.33\ fps - 66\ fps}{1.1\ \frac{ft}{s^2}}$ = 26.7 sec.

4. Calculate delay with respect to through travel at 65 mph:
   ∑distance = 2,625' + 2,550' + 2,151.1' = 7,326.1'
   ∑time = 32.5 s + 38.6 s + 26.7 s = 97.8 sec.

   Time through at 65 mph = 7,326.1'/ 95.33 fps = 76.8 sec.
   Delay = 97.8 s – 76.8 s = 21.0 sec.

Case 3—Passenger Car with Stop

1. Assume uniform deceleration from the initial warning sign to the speed sign, just past the first rumble strips:
   Distance = C + 2 ½ B = 750' + 2 ½ * 750' = 2,625'
   Time = $\frac{2*l}{v+v_0} = \frac{2*2{,}265\ ft}{95.3\ fps + 66\ fps}$ = 32.5 sec.

2. Assume uniform deceleration from the speed sign at 45 mph to the near stop bar:
   Distance = A + B/2 = 750' + 750'/2 = 1,125'
   Time = $\frac{2*l}{v+v_0} = \frac{2*1{,}125\ ft}{66\ fps + 0\ fps}$ = 34.1 sec.

3. Assume uniform acceleration from 0 mph to 45 mph:
   Distance = $\frac{v^2-v_0^2}{2a} = \frac{(66\ fps)^2 - (0\ fps)^2}{2*3.5\ \frac{ft}{s^2}}$ = 622.3'
   Time= $\frac{v-v_0}{a} = \frac{66\ fps - 0\ fps}{3.5\ \frac{ft}{s^2}}$ = 18.9 sec.

4. Travel at 45 mph to the far stop bar:
   Distance 1,425' – 622.3' = 1,425' – 622.3' = 802.7'
   Time = l/v = 802.7' / 66 fps = 12.2 sec.

5. Assume uniform acceleration from 45 mph to 65 mph:
   Distance = $\frac{v^2-v_0^2}{2a} = \frac{(95.33\ fps)^2 - (66\ fps)^2}{2*3.5\ \frac{ft}{s^2}}$ = 676.1'
   Time= $\frac{v-v_0}{a} = \frac{95.33\ fps - 66\ fps}{3.5\ \frac{ft}{s^2}}$ = 8.4 sec.

6. Calculate delay with respect to through travel at 65 mph:
   ∑distance = 2,625' + 1,125' + 622.3' + 802.7' + 676.1' = 5,851.1'
   ∑time = 32.5 s + 34.1 s + 18.9 s + 12.2 s + 8.4 s = 106.1 sec.

   Time through at 65 mph = 5,851'/ 95.33 fps = 61.4 sec.
   Delay = 106.1 s – 61.4 s = 44.7 sec.

Case 4—Semi-Trailer with Stop

1. Assume uniform deceleration from the initial warning sign to the speed sign, just past the first rumble strips:

   Distance = C + 2 ½ B = 750' + 2 ½ * 750' = 2,625'

   Time = $\frac{2*l}{v+v_0} = \frac{2*2{,}265\ ft}{95.3\ fps+66\ fps}$ = 32.5 sec.

2. Assume uniform deceleration from the speed sign at 45 mph to the near stop bar:

   Distance = A + B/2 = 750' + 750'/2 = 1,125'

   Time = $\frac{2*l}{v+v_0} = \frac{2*1{,}125\ ft}{66\ fps+0\ fps}$ = 34.1 sec.

3. Assume uniform acceleration from 0 mph to 45 mph:

   Distance = $\frac{v^2-v_0^2}{2a} = \frac{(66\ fps)^2-(0\ fps)^2}{2*1.1\frac{ft}{s^2}}$ = 1,980'

   Time= $\frac{v-v_0}{a} = \frac{66\ fps-0\ fps}{1.1\frac{ft}{s^2}}$ = 60.0 sec.

4. This is past the stop bar, so continue uniform acceleration from 45 mph to 65 mph:

   Distance = $\frac{v^2-v_0^2}{2a} = \frac{(95.33\ fps)^2-(66\ fps)^2}{2*1.1\frac{ft}{s^2}}$ = 2,151.1'

   Time= $\frac{v-v_0}{a} = \frac{95.33\ fps-66\ fps}{1.1\frac{ft}{s^2}}$ = 26.7 sec.

5. Calculate delay with respect to through travel at 65 mph:

   ∑distance = 2,625' + 1,125' + 1,980' + 2,151.1' = 7,881.1'

   ∑time = 32.5 s + 34.1 s + 60.0 s + 29.7 s = 153.3 sec.

   Time through at 65 mph = 5,851'/ 95.33 fps = 82.7 sec.

   Delay = 153.3 s – 82.7 s = 70.6 sec.

<u>Step 5</u>

Due to low v/c for the study bridges, ignore overflow and random delays. Assume half of arrivals arrive at green and half at red.

Average Delay = $\text{Delay}_{\text{controller}}$ + $\text{Delay}_{\text{travel}}$ = $\text{Delay}_{\text{controller}}$ + ½ $\text{Delay}_{\text{travel-no stop}}$ + ½ $\text{Delay}_{\text{travel-stop}}$

- For passenger cars: average delay = 13.7 s + 0.5*17.1 s + 0.5*44.6 s = <u>44.6 sec</u>.
- For semi-trailers: average delay = 13.7 s + 0.5*20.9 s + 0.5*70.6 s = <u>59.5 sec</u>.