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EVALUATING BASE WIDENING METHODS

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Abstract:
The surface transportation system forms the biggest infrastructure investment in the United States of which the roadway pavement forms an integral part. Maintaining the roadways can involve rehabilitation in the form of widening; which require a longitudinal joint between the existing and new pavement sections to accommodate the wider travel lanes, additional travel lanes or modification to shoulder widths. Several methods are utilized for the joint construction between the existing and new pavement sections; vertical, tapered and stepped joints. The main purpose of this research is to develop a formal recommendation as to the preferred joint construction method that provides better pavement support in the State of Wyoming. Field data collection of Dynamic Cone Penetrometer (DCP), Falling Weight Deflectometer (FWD), base samples for gradation and moisture content were conducted on 28 existing and 4 newly constructed widening projects. Survey of practices and preferences of other states, and constructability issues were undertaken. Costs of each joint type were compared as well.

Results of the analysis indicate that the tapered joint technique showed relatively better pavement strength compared to the vertical joint type, and could be the preferred joint construction method. The vertical joint has an 18% increase in cost compared to the tapered joint. This research is intended to provide information and/or recommendation to state policy makers as to which of the base widening joint techniques (vertical, tapered, stepped) for flexible pavement provides better pavement performance.

Key Words Longitudinal Joints, Pavement Distress, DCP, FWD, Back calculated Moduli, Wyoming	Distribution Statement This document is available to the public.		
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Metric Conversion Table

SI* (MODERN METRIC) CONVERSION FACTORS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
t	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
t^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
1 oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
t^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
1	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	t
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	t^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	1 oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	t^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	1
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised March 2003)

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CHAPTER 1: INTRODUCTION

Background

The surface transportation system forms the biggest infrastructure investment in the United States - the roadway pavement forms an integral part of this system. The rehabilitation or reconstruction of these roadways is a great financial burden to most state agencies. A common type of road rehabilitation project is one that calls for the widening of the pavement surface to accommodate wider travel lanes or shoulders or to add additional travel lanes. These types of projects require a longitudinal widening joint between the existing and new pavement sections on one or both sides of the roadway. These widening joints are often susceptible to increased pavement distresses such as surfacing cracking and raveling along the joint line. The construction of the widening joint becomes more critical when the location of the joint is placed close to the vehicle wheel paths. Joint failure often occurs much faster than deterioration of the adjacent pavement surfaces.

When widening an existing asphalt roadway, there are several methods for constructing the joint between the existing and new asphalt surface sections, including vertical, tapered, and stepped joints. A vertical joint consists of a simple full depth-vertical cut of the pavement section. Figure 1 shows the cross-section of a vertical cut where the cut begins from the top layer (asphaltic concrete) to bottom of the base layer.

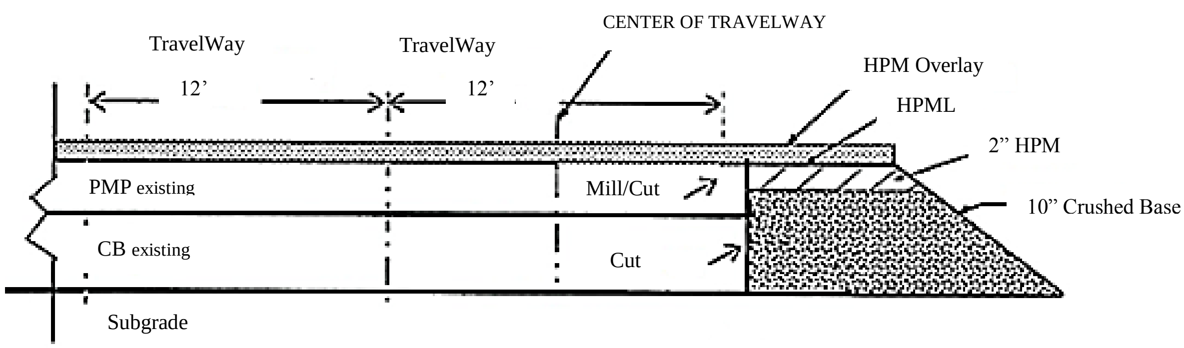


Figure 1: Diagram. Vertical Joint Type

The tapered joint type consists of a cut at an angle. Figure 2 shows a cross-section of a tapered cut where part of the pavement is milled or cut vertically and then the remaining pavement of the asphalt and base materials are cut in a semi-vertical line that is greater than the angle of repose of the base material and greater than the existing surface taper.

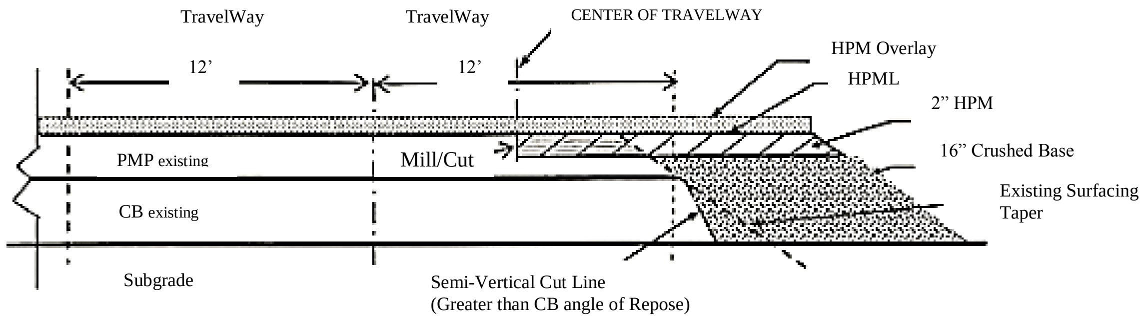


Figure 2: Diagram. Tapered Joint Type

A stepped or notched joint is where the existing asphalt layer is vertically cut for its full depth and the base material is also vertically cut full depth but the vertical cuts of the asphalt and base layers are offset by 1 foot. The stepped joint is usually used for existing pavement sections that have cement treated bases (CTB) but are also used for non-treated, crushed bases as well. Figure 3 shows the cross section of a stepped (or notched joint).

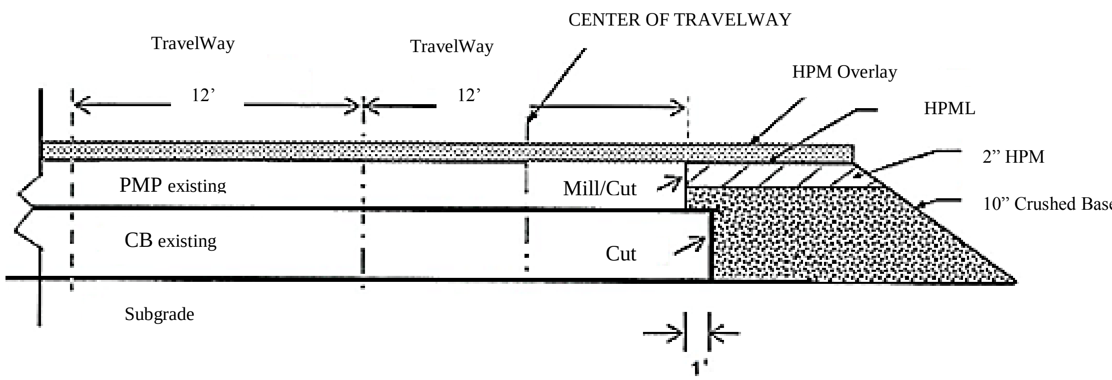


Figure 3: Diagram. Stepped or Notched Joint Type

The Wyoming Department of Transportation (WYDOT) currently uses all three methods of widening joint construction. The purpose of this research is to evaluate road widening projects to determine if there is a preferred joint construction method. Both the stepped and tapered joints offer cost savings as more of the existing pavement material is retained when compared to the vertical cut. A fourth method used for shoulder widening is to lay the asphalt directly over the existing base course taper. The major concerns regarding the selection of a construction method can be summarized as follows:

1. Sluffing of the base material that occurs before the new section is constructed since there is no method to re-compact the base material under the existing section if any material is lost.
2. Conservation of base materials in order to save haul and preserve virgin pit materials for future uses.

3. Constructability and cost effectiveness of the different methods.
4. Ability of the design software to estimate quantities effectively and accurately.

Project Objectives

The objective of this research is to develop formal recommendations for the Wyoming Department of Transportation on the preferred construction of longitudinal widening joints for asphalt road surfaces with the emphasis on the base course layer. The accomplishment of this objective will involve formal evaluation of constructed road widening projects as well as discussions with stakeholders including WYDOT District Construction Engineers and paving contractors.

To achieve this, the primary objectives will be divided into the following tasks:

- Conduct a comprehensive literature review and a survey of practices in similar states.
- Develop a design of experiments to determine the number of existing road widening projects that need to be evaluated.
- Identify road widening projects that were constructed during the summer of 2012.
- Evaluate the pavement distresses associated with the joints using video logs and site visits.
- Core pavements at the joint area and adjacent to the joint area.
- Determine the relative strength and density of the compacted base utilizing the Dynamic Cone Penetrometer at and adjacent to the joint area.
- Perform Falling Weight Deflectometer (FWD) testing on test sections to investigate any variations in deflection measurements due to differences in the construction techniques used for widening joints.
- Determine pavement layer moduli from the deflection data utilizing the back-calculation procedure at and adjacent to the joint area.
- Perform statistical analyses on the test data.
- Examine the constructability issues of the different joints types by conducting a survey of WYDOT District Construction Engineers and Wyoming paving contractors.
- Conduct cost comparisons among the widening joint alternatives by quantifying and analyzing the contract bid prices of each option.

Report Format

Chapter 1 of this report provides a brief description of the background and research objectives. Chapter 2 presents a literature review of previous pavement widening studies undertaken by WYDOT and common practices of other states. The Falling weight deflectometer (FWD) testing procedure and factors that affect FWD deflection data and the use of the back-calculation procedure to estimate the pavement layer moduli are also presented. Chapter 3 focuses on research approach, including an in-depth description of the selection of the project location, data collection methodology, the equipment used to collect data, laboratory evaluations of moisture content and base materials gradation and the data quality issues. Chapter 4 describes the data analysis methodology and results obtained. The results of a survey of constructability practices of Mountains and Plains States, Wyoming Department and Transportation (WYDOT) District Construction and Resident Engineers, and Wyoming Paving Contractors Association are presented in Chapter 5. Chapter 6 presents results of the economic analysis of each joint type. Chapter 7 summarizes the results, provides final conclusions and develops recommendation from this research effort.

CHAPTER 2: LITERATURE REVIEW

The pavement widening practices by WYDOT are introduced and previous studies by other agencies and/or researchers are presented in this chapter. The testing equipment, such as DCP and FWD, used for pavement evaluation and the use of the back-calculated procedure to determine pavement layer moduli from nondestructive deflection data are presented as well.

Pavement Widening Practices by WYDOT

A study was undertaken by WYDOT to 1) "determine the typical sections that have been used to widen existing highway segments in Wyoming", 2) determine the extent of longitudinal cracking occurring at the widening joint for each widening type, and 3) find out the typical widening sections that are used by surrounding states. (1) Sixteen projects, each about ten years old, were selected for the study. Of the 16 widening projects, eleven projects were widened by cutting the joints vertically (vertical joints), and the remaining five were widened at the existing taper (tapered joints). Projects using the notched type of joint were not included, and this may have been due to the fact that this type of widening is rarely implemented by WYDOT.

In determining the typical widening sections used by surrounding states, information was sought from the Federal Highway Administration (FHWA) on the practices of Montana and Utah. (1) Typical sections collected from Montana showed their preference for new crushed base was placed directly on the existing side slope. Utah preferred the stepped widening method because they believed that widening without stepping results in the formation of a slip plane.

Video logs of selected WYDOT projects were examined to determine the extent of longitudinal cracks, and the information gained from this exercise showed that four of the eleven projects (36%) for which plans indicated vertical joints had longitudinal cracks. Most of these cracks were isolated and slight with the exception of cracks on one project that were severe. Longitudinal cracking occurred at the widening joints of five projects (20%) for which plans indicated tapered joints but the cracking was isolated and slight. In conclusion, planned tapered widening joints were identified to have performed better than planned vertical widening joints. Thus the better performance and increased savings of existing material reported in the study made tapered joints an attractive option for widening projects.

However, it was admitted that widening joints are not always constructed as planned, and the actual method of construction may be changed or modified. The study recommended further study to interview resident engineers or sample field cores to determine the exact method of construction. It was also recommended that economic benefits be quantified by analyzing contract bid prices in future studies.

Previous Studies on Pavement Widening Joints

The bulk of the existing research in the area of longitudinal joints has been focused on the effects of joint construction on asphalt densities in the joint area. (2, 3, 4, and 5) Most previous studies were performed by the National Center for Asphalt Technologies in the 1990's and found an area of high air voids (low density) from the center of the longitudinal joint into the widening section about 6 – 8 inches. The higher air voids allow water to permeate the joint and thus increase the pavement's susceptibility to freeze-thaw issues. Earlier studies have shown that the in-place densities can be 1 to 2 percent lower at the joint location than the surrounding pavement. [6]

A study by Kandhal et al identified 10 joint construction techniques for traditional road paving projects. They noted that longitudinal joint between the paving lanes is particularly problematic especially for full width construction. [3] This was because of the difficulty in compacting the unconfined edge of the first pass ("cold lane") before moving to placement of the adjacent lane's ("hot lane") pavement surface (see Figure 4).

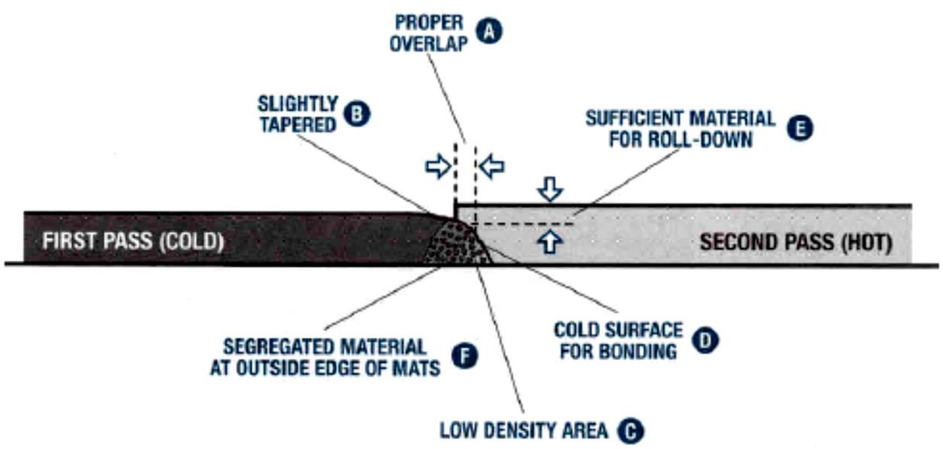


Figure 4: Diagram. Longitudinal Joint Construction for Full Width Construction. [2]

The techniques identified were:

1. Rolling from hot side.
2. Rolling from cold side.
3. Rolling from hot side 152 mm (6 inch) away from joint.
4. Use of notched wedge joint.
5. Use of tapered (3:1) joint with vertical 25 mm offset.
6. Use of edge restraining device.
7. Use of cutting wheel.
8. Use of joint maker.
9. Use of rubberized asphalt tack coat.
10. Use of NJ Wedge (3:1) and infrared heating.

From the study, the edge restraining device and the cutting wheel techniques produced the highest densities. [3]

Some Departments of Transportation (DOTs) such as Texas DOT (TxDOT) realized the need for setting up guidelines for pavement widening of existing sections. [7] TxDOT Guidelines for Design of Flexible Pavement Widening was developed "based upon the responses of multi-district survey within TxDOT". The guideline identified the types of joints based on how the existing section interfaces with the widening section. The tapered and the notched techniques were recommended to combat the problem of high air voids at the joint as identified by the NCAT studies.

Types of Deterioration on Road Pavement

The performance of pavements can be assessed by determining the severity of deterioration over a period of time. [8] The American Society for Testing and Materials (ASTM) standardized the Pavement Condition Index (PCI) as a means of evaluating deterioration of asphalt pavements by indicating the pavement condition on a scale of 0 to 100. [9] The steps used in the PCI process to quantify distresses involve:

a) Demarcating the pavement section into sample units.
b) Selecting a certain number of units to be tested based on the number of units in the total section.
c) Recording the type, extent and severity of pavement distress in each section using ASTM standard D5340.
d) Calculating the PCI of each sample unit using the distress quantities and densities for each tested unit.
e) Determining the PCI for the road section from calculations done in step d. [9]

In evaluating the cracks located at longitudinal joints in the previous WYDOT road widening study, definitions that stipulated the following were used: [1]

- Isolated cracking – cracks occurring over less than 5% of the project length.
- Slight cracking – crack width less than ¼ inch.
- Moderate cracking – crack width of ¼ to ½ inch.
- Severe cracking – crack width greater than ½ inch.

The main type of deterioration that occurs in longitudinal joints is longitudinal cracks. [10] Longitudinal cracks were therefore the primary focus during the pavement deterioration evaluation for this study.

Factors Affecting Durability of Pavement Widening Joints

In their study, Kandhal et al determined that the ability of a widened pavement to resist early deterioration along the widening joint is mainly influenced by the density gradient encountered across the joint created during construction. [3] A relatively low density at the unconfined edge of the first lane compared to the high density at the confined edge during paving of an adjacent lane creates a density gradient along the joint where cracks are more likely to occur than elsewhere.

Foster found similar results about the density gradient across longitudinal joints, but added that overlapped rolling produced the highest densities in semi-hot joint construction, and infrared heating improved density slightly in the initial lane although no improvement in tensile strength was recorded. [6] This study concluded that rolling a bituminous surface in a plastic state without edge confinement cannot produce the required density, and an area of low density and tensile strength is left extending from the joint to an unknown distance when the pavement in the initial lane cools before the adjoining lane is placed. It was suggested that some form of confinement, edge compaction, infrared heating, or a combination of these may be the solution.

The studies by the National Center for Asphalt Technology (NCAT) found an area of low density and high air voids over 6 to 8 inches from the center of the joint. (2) This area allowed water to enter the pavement and subsequent freezing would break up the asphalt leading to premature failure.

Estakhri et al assessed the density along the longitudinal construction joint of several Texas pavements to determine if a problem existed. (11) Their research consistently found an area of low density at the edge of the first paved lane. This area is shown in Figure 5, which is the mean density profile for one of the sections tested on Loop 323 in Tyler, Texas.

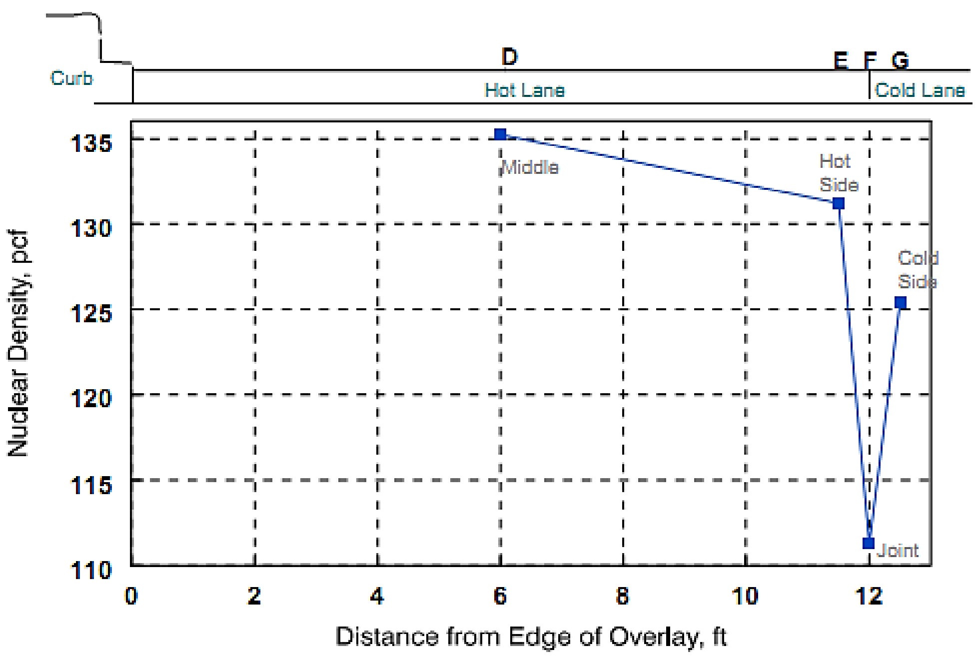


Figure 5: Diagram. Mean density profile for Loop 323 in Tyler, Texas (11)

Testing on cores taken near the unconfined edge of the pavements indicated that permeability was higher than those taken from the middle of the lane. (12) The case studies indicated that pavement failures were due to inadequate density at the longitudinal joints, which allowed water intrusion into the pavement structure.

In the studies mentioned above, conventional asphalt pavement construction techniques were considered, but in the situation where the cold lane is an existing base section, density gradients may still be applicable in the evaluation of widening joint techniques. Thus, longitudinal joint construction techniques which result in greater density variations near the widened joint section and the existing section are more likely to deteriorate.

Pavement Testing Equipment

Field and laboratory evaluations were undertaken in the study, and these tests required the use of specialized testing equipment. For field tests, the Falling Weight Deflectometer (FWD) and the Dynamic Cone Penetrometer (DCP) were used.

Dynamic Cone Penetrometer Test (DCPT)

The DCPT is an in-situ penetration test used for site investigation in support of analysis or design. [13] The DCPT equipment is used by dropping a hammer from a certain fall height and measuring the penetration depth per blow for each tested depth. The data obtained from the test is converted to the California Bearing Ratio (CBR) using equations or charts supplied by the manufacturer of the DCP equipment. The CBR values obtained are a reflection of the stiffness properties of the base.

Abu-Farsakh et al (2005) conducted a study to evaluate the use of the DCP testing device in quality control-quality assurance (QC-QA) procedures during pavement layer construction by undertaking laboratory and field tests such as the Plate Loading Test (PLT), Falling Weight Deflectometer (FWD) tests, and California Bearing Ratio (CBR) tests to compare with results obtained from the DCP tests. Laboratory tests were conducted on different materials prepared inside two test boxes measuring 1.5m x 0.9m (5ft x 3ft) located at the Louisiana Transportation Research Center (LTRC), and field tests were performed on highway sections selected from different projects in Louisiana. [14]

The data from DCP tests were correlated with the data from the three reference tests (PLT, FWD, and CBR) using regression analysis on the collected data, and the developed models yielded accurate predictions of the measured FWD moduli and CBR values, suggesting that the derived relationship could be used reliably to evaluate the stiffness and strength of pavement materials. [14] Figure 6 shows the dynamic cone penetrometer.

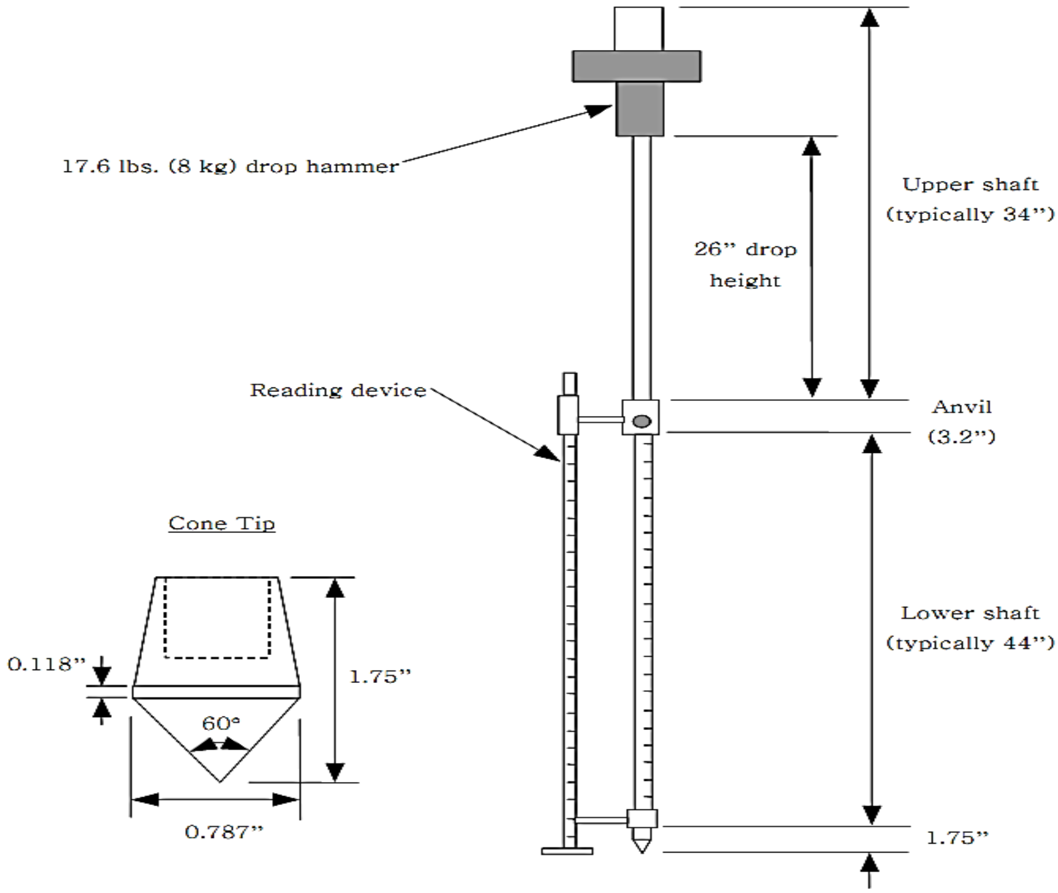


Figure 6: Diagram. Dynamic Cone Penetrometer [13]

Concerns about the reliability of DCP tests in predicting subgrade moduli have been allayed by other previous research. For instance, varying subgrade moduli obtained using DCP along project lengths in Minnesota using the existing relationship between the DCP test value and subgrade modulus motivated a study to develop a more accurate correlation between the DCP values and the more reliable FWD back-calculated subgrade moduli. [15] From the study, a significant correlation was found between the DCP values and the FWD-back-calculated subgrade moduli, and a model was developed for the relationship. The model yielded a coefficient of determination, R, ranging from 0.72 to 0.95. Based on the acceptable range of R, the use of DCP testing methods in combination with an appropriate conversion model was deemed to be fairly accurate.

In another study to predict the resilient modulus of cohesive subgrade soils using DCP test parameters, two statistical models were developed to predict resilient modulus. (16) Results from DCP tests were used to predict two sets of resilient modulus using the models and compared with actual laboratory-measured resilient moduli for verification. A good agreement was obtained between the measured and predicted values of one of the models as shown in Figure 7.

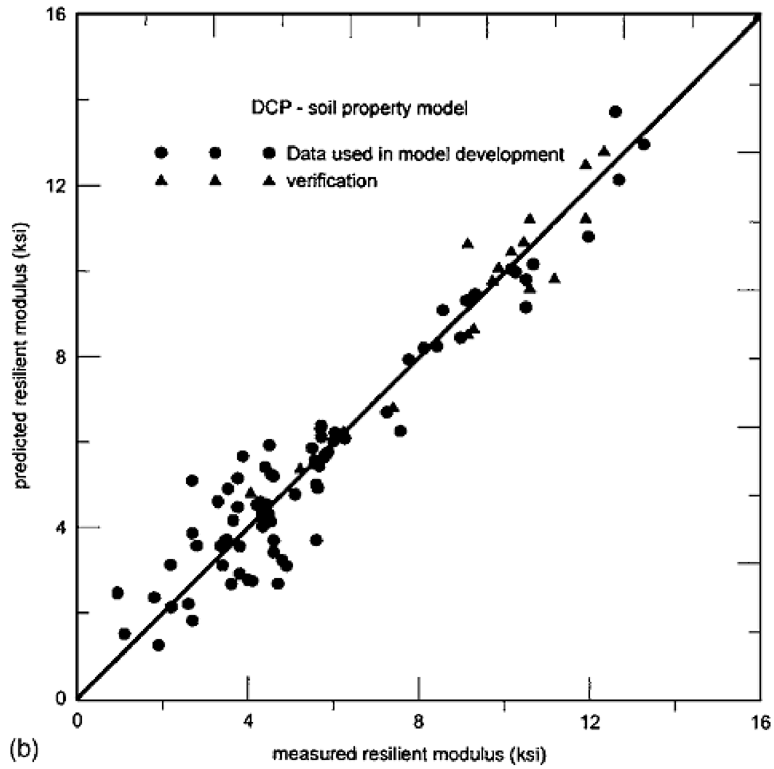


Figure 7: Graph. Predictions from a DCP-soil property model (16)

Falling Weight Deflectometer (FWD)

One of the most common tools to measure nondestructive surface deflection is the FWD, which is an impulse deflection device. (17) The FWD is a nondestructive testing (NDT) and non-intrusive device widely used in pavement engineering to evaluate pavement structural condition. The FWD plays a crucial role in selecting optimum pavement maintenance and rehabilitation strategies. The FWD is a tool to achieve rapid and repeatable in-situ characterization of the pavement layer stiffness. The FWD uses a mass falling onto a circular load plate. The FWD load pulse shape simulates traffic loads better than other deflection devices. (18) FWD transmits relatively heavy loads to the pavements compared with the other deflection testing devices. FWD testing has multiple advantages. First, it allows testing the in-situ condition of the pavement without damaging the pavement structure by trenching or coring. Secondly, it allows for the determination of the structural capacity of a pavement, which is critical for the determination of optimum overlay thicknesses and potentially identifies structural weaknesses in a pavement. (19)

The major components of the FWD system include: control system, loading weight and plate, hydraulic system, and geophones. Different types of FWD Equipment are widely used by State Highway Agencies in the country. Most of the FWD's are either towed by a vehicle or built into a vehicle's cargo area. The commonly used FWD's are KUAB, Dynatest, JILS, and Carl Bro.

KUAB

The KUAB FWD Equipment is marketed by the Engineering and Research International, Inc. based in Savoy, Illinois. The KUAB Equipment can be either trailer-mounted or vehicle-mounted. There are four different models of the KUAB Equipment, which supports up to seven deflection sensors. The Equipment has a 300mm (12in) load plate, automatic ambient temperature sensors, surface temperature sensor, distance measurers and a laptop. [20] Figure 8 shows the KUAB FWD Equipment.

Figure 8: Photo. KUAB FWD Equipment

Dynatest

The Dynatest FWD Equipment was manufactured by the Dynatest Group of Denmark, the United States, and the United Kingdom. The FWD equipment provides FHWA-compliant FWD calibrations. They are trailer-or vehicle-mounted. [20] The Dynatest model 8000E supports drop masses from 50 to 350 kg (110 to 770 lbs.). The resulting applied force ranges from 7 to 120kN (1,500 to 27,000 lbf). The Dynatest equipment supports loading plates of diameters 305mm (12in) and 450mm (18 in). The system supports from 7 to 15 deflection sensors. The Dynatest system's Pavement Deflection Data Exchange (PDDX) formatted FWD output is compatible with most of the back calculation software packages. Figure 9 shows a photo of Dynatest FWD Equipment.

Figure 9: Photo. Dynatest FWD Equipment

JILS

The JILS FWD is produced by Foundation Mechanics, Inc. in California. This type of FWD equipment has a 305mm (12in.) loading plate, distance measurer, video monitoring system, and temperature measurement hardware. The JILS FWD provides a separate gasoline engine for the hydraulic system which allows for independent vehicle and FWD operation. The system supports up to ten deflection sensors. The FWD data are output in raw data format, which can be converted to the PDDX format. [20]

TESTING PROCEDURE FOR THE FALLING WEIGHT DEFLECTOMETER (FWD)

General

The FWD testing procedure is a type of plate-bearing test. The load is a force pulse generated by a weight dropped on a buffer system and transmitted through a plate on the pavement surface. The equipment may be mounted in a vehicle or on a trailer towed by a vehicle. During testing, the vehicle mounted FWD testing equipment is brought to a stop with the loading plate positioned over the desired test location. The plate and deflections are lowered on to the pavement surface. The weight is raised to the desired height that, upon impact will impart the desired force to the pavement. [21]

The weight is dropped and the resulting vertical movement of deflection of the pavement surface is measured. The peak pavement deflections are measured at the center of the loading plate and at several radial positions by a series of deflection sensors. These deflections are recorded in micrometers, millimeters, mils, or inches. The peak force imparted by the falling weight is measured by a load cell and recorded as the force in kN or lbf or the mean stress (the load divided by the plate area) in kN/m^2 or psi. Usually, multiple tests at the same or different height drops are performed before the apparatus is then raised and moved to the next test site. [21] Figure 10 shows a schematic diagram of FWD testing.

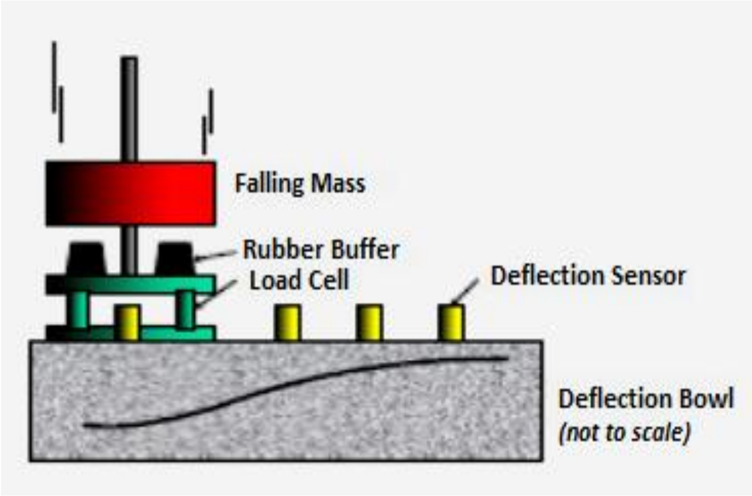


Figure 10: Diagram. Schematic Diagram of FWD in Operation. [22]

Load Levels Used for FWD Testing

Loading sequences for FWD testing differs by the type of pavement and the purpose of the study. For flexible pavement test studies, four drop heights are used with the target load and acceptable load range at each height. [23] The FWD loading sequence for flexible pavements can be found in Table 1.

Table 1: FWD Loading Sequence for Flexible Pavement Plan

Height	Target Load (kips)	Acceptable Range (kips)
1	6 (26.7kN)	5.4 to 6.6 (24.0kN to 29.4kN)
2	9 (40.0kN)	8.1 to 9.9 (36.0kN to 44.0kN)
3	12 (53.3kN)	10.8 to 13.2 (48.1kN to 58.7kN)
4	16 (71.1kN)	14.4 to 17.6 (64.1kN to78.3kN)

The impulse load induced and measured by the FWD is partially influenced by the pavement stiffness, and the loads measured from one pavement to another will vary even if the distance the weight falls is the same. Figure 11 shows a typical FWD loading plate.

Figure 11: Photo. FWD Loading Plate

The drop sequence consists of three seating drops from drop height 3 then repeated measurements at each of the specified drop heights. The data from the seating drops is not stored. The complete load-deflection time histories (60m-sec) shall be recorded for the last drop from each drop height. The LTPP FWD drop sequence test plans can be found in Table 2. (24)

Table 2: LTTP FWD Drop Sequence Test Plans

Flexible Pavement Testing Plans			**Rigid Pavement Testing Plans**		
No. Of Drops	**Drop Height**	**Data Stored**	**No. Of Drops**	**Drop Height**	**Data Stored**
3	3	No	3	3	No
4	1	Peaks	4	2	Peaks
4	2	Peaks	4	3	Peaks
4	3	Peaks	4	4	Peaks & History
4	4	Peaks & History			

FWD Deflection Sensor Spacing

The FWD has varying sensor spacing depending on the pavement surface being tested and the number of sensors on the FWD equipment. The deflection sensors are placed at radial offsets from the center of the load plate to define the shape of the deflection basin. (23) The deflection basin shape ranges significantly from steep basins for weak flexible pavements to shallow basins for stiff rigid pavements.

The deflection sensor is capable of measuring the maximum vertical movement of the pavement. It is usually mounted in a manner as to minimize the angular rotation with respect to its measuring plane at the maximum expected movement. Sensors may be of several types such as displacement transducers, velocity transducers or accelerators. [21] Figure 12 shows the deflection sensor of the geophone type.

Figure 12: Photo. Deflection Sensor of the Geophone Type

Sensor spacing depends on the pavement surface being tested and the number of sensors on the FWD equipment:

- 0, 203, 305, 457, 610, 914, 1,219, 1,524, and −305 mm (0, 8, 12, 18, 24, 36, 48, 60, and −12 in.) for nine-sensor FWDs.
- 0, 203, 305, 457, 610, 914, and 1,524 mm (0, 8, 12, 18, 24, 36, and 60 in.) for seven-sensor FWDs on flexible pavements.
- −305, 0, 305, 457, 610, 914, and 1,524 mm (−12, 0, 12, 18, 24, 36, and 60 in.) for seven-sensor FWDs on rigid pavements. [20]

Figure 13 below shows the schematic diagram of the sensor configuration for deflection testing.

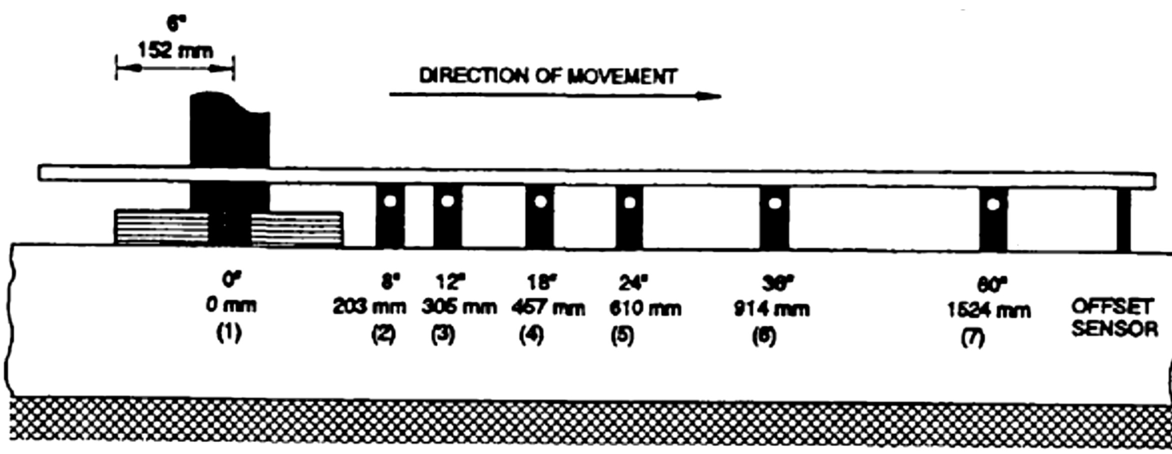


Figure 13: Diagram. Sensor Configuration for Deflection Basin Testing. Source: [23].

FWD Testing for Widening and New Construction Monitoring

FWD Testing for widening projects is usually carried out in the area of the widening rather than the existing wheel path. Tests are useful for determining the effectiveness of the existing pavement and then estimating the likely equilibrium values for the subgrade moduli beneath the new widening. According to a study by Tokin (1998) in New Zealand, new pavements show relatively low moduli for the base and sub base courses even though they may be thoroughly compacted. However, further densification with substantial improvement in base course moduli will occur in an unbound granular pavement during trafficking. [25]

FACTORS AFFECTING FWD DEFLECTION DATA

Background

FWD deflection data are affected by factors other than the normal variation in the pavement cross-section (layer thickness, layer material type, material quality, and subgrade support) that influence the deflection response of a pavement. Factors that affect the deflection data significantly are temperature and moisture conditions, pavement discontinuities, and variability in the pavement structure.

Environmental Factors

Deflection data is affected by both temperature and moisture on both flexible pavements (asphaltic concrete) and rigid pavements (Portland Cement Concrete). The stiffness (rigidity) of asphalt concrete is very sensitive to temperature changes which occur over long term (seasonal) and short term (hourly) periods. The magnitude of deflection from a given impulse load will increase as the pavement temperature increases. Therefore, deflections measured on a hot summer day will be larger than the deflections measured during a cooler period. Changes in temperature with depth (vertical temperature gradients) influence stresses in the asphaltic layer. The influence of vertical temperature gradients becomes more pronounced as the thickness of the asphaltic concrete increases. [23] The 1993 AASHTO Guide for Design of Pavement Structures gives a temperature correction protocol for FWD deflections. The AASHTO procedure uses an average air temperature for the previous day to predict pavement temperature at selected depths. [26]

Several researchers have developed models for temperature-deflection corrections for the hot-mix asphalt (HMA) layers since FWD measurements are strongly influenced by ambient and pavement temperatures. Park et al (2001) developed a new temperature prediction for HMA temperatures using six selected test sites in Michigan. They used temperature from the test sites and several other sites from the LTPP Seasonal Monitoring Program to validate the model. Results suggested that the model could be adapted to all seasons and other climatic and geographical regions. [27] Kim et al (1995) also developed a model using data from North Carolina sites and validated it using data from sites other than the test sites. The procedure they used was found to greatly improve the accuracy of temperature deflection correction procedures. [28]

Moisture in the pavement weakens the structure, which causes deflection to increase. These changes are long term and occur over an annual cycle. Pavement sections in areas with significant frost penetration can have extreme changes in deflection if significant moisture exists within the fine grain soil. The pavement structure thaws from the surface downwards during spring as moisture is trapped between the surface and subgrade material, making it weak and producing very high deflections. [(23)] According to a study by Irwin, changes in moisture also affect the base course and upper subgrade layers. [(29)]

Spatial Variation of Deflection Data

The structural capacity of a pavement is affected by the spatial variability of the measured deflections. Variability results from the equipment repeatability and spatial characteristics of the pavement structure and materials. Pavement thicknesses are seldom constant, with varying materials of different gradation, angularity, and compaction level along a section of road. The spatial variations are due to the heterogeneous nature of the pavement materials and non-uniform layer thicknesses.

A study by Irwin (2002) stated that there is usually a big difference between the deflection test results within and between the wheel paths. [(29)] The effect of minor variations in layer thickness during construction, if not accounted for, can result in major errors in back-calculated layer moduli. Load effects can compact and wear out pavement materials in the wheel path. The spatial variability of deflection measurements reflects the variability of the structural response of the existing pavement sections along the roadway. Irwin (2002) suggested a statistical procedure to deal with the high degree of variability of the moduli along the road by performing the back-calculation at all test points, then analyze the pavement at each point, and take the 85^{th} percentile result. [(29)] Richter et al concluded from their study that the spatial variation is properly accounted for by doing the analysis at each point, and afterward selecting the answer that is “right” 85 percent of the time, since each test point has a unique answer. [(30)]

Hossain et al performed a research study to estimate the variability of structural capacity of existing pavements from FWD data. They concluded that the variability of the deflection data is the same for all the sensors for pavement with granular and stabilized bases and that the stabilized bases may be responsible for the uniform response of the pavements to the applied FWD load. The authors noted that small variability in sensor data over a section of pavement result in high variability on calculated layer moduli. [(31)]

Pavement Discontinuities

Pavement discontinuities such as cracks and/or joints, and subsurface conditions such as voids underneath rigid pavements lead to higher deflection readings and lower moduli than a pavement section without such discontinuities. The magnitude of the deflection increase is dependent on the degree and severity of the cracks and joint spacing. [(24)] Although pavement discontinuities significantly affect measured deflections and back-calculated moduli, avoiding testing over cracked areas would introduce measurement bias into the analysis. The effective layer moduli would not be representative of the overall pavement condition. Deflection testing at cracked areas only would result in unrealistically low effective moduli. [32]

Calibration of the Falling Weight Deflectometer (FWD)

There are three main sources of errors in FWD data collection. These are seating errors, random errors, and systematic errors. Irwin et al (1989) showed that very small deflections errors, on the order of 2µm or less, can have a very large effect on the back-calculated moduli. Seating error occur due to the rough texture and loose debris on asphaltic concrete pavements. The seating error is eliminated by applying one or two drops at each new test point and discarding the data. The vibrations cause the deflection sensors to become seated. Random errors usually occur in the order of ±2µm. This error is associated with the analog-to-digital conversion of the deflections. [33] This type of error is reduced by taking multiple readings and averaging the result. This means that if four replicate FWD drops are averaged, the random error would be reduced by half.

The systematic errors can be reduced through calibration. The FWDs are specified to have accuracy up to ±2 percent of the load or ±2µm of the deflection readings, whichever is larger. This specification combines the systematic error and the random error. The Strategic Highway Research Program (SHRP) began efforts to calibrate FWDs in 1988. The calibration equipment and protocols were further refined. There are different types of calibration used for FWDs: relative and reference. The relative calibrations ascertain sensor functionality and relative accuracy. According to ASTM D4694-96, the systematic error is generally reduced to 0.3 percent or less for each individual sensor, including the load cell. The reference calibration ensures sensor accuracy according to defined benchmarks. [21]

HISTORY OF BACKCALCULATION

Road building has evolved in recent years toward preserving and rehabilitating existing roads, rather than building new ones. Pavement rehabilitation projects involve the retention of most, if not all, of the layers in the existing pavement. The pavement is tested in place, nondestructively, and the data is processed to determine the in situ layer moduli. This process involves back-calculation. Back calculation is popular today because of three important advances in the field of pavement engineering: [29]

- The discovery of a relationship between pavement deflection and pavement strength (1935 – 1960).
- Development of mechanistic theories that relate fundamental materials properties to the stresses, strains, and deflections in a layered system and computer programs (1940 – 1970).
- Development of deflection testing devices for measuring pavement deflections (1955 – 1980).

Back calculation is the procedure that determines Young’s modulus of elasticity for pavement materials using measured surface deflections by working the elastic layer theory “backwards”. Since most of the pavement rehabilitation projects involve keeping and re-using some, if not all, of the existing pavement layers, it is imperative to test the pavement in place, nondestructively, and to process the data to determine the in situ layer moduli. [29]

Hveem was one of the pioneers in relating pavement deflection to pavement strength. In a study by Hveem, he began measuring transient deflections of pavements in 1938, using linear variable differential transformers on 43 projects to measure deflections due to moving wheel loads. The measurements were correlated to surface deflections measured with the Benkelman Beam. He complemented the study by performing laboratory measurements of the resilient properties of the materials. [34, 35]

Hveem's study concluded that *"Undoubtedly, the results of future deflection investigations over a variety of pavement structural sections throughout the United States will enable highway engineers to assign safe levels of deflection with reasonable certainty that they will not be overly fatigued during their design life. These deflection levels will of necessity take into account local materials, weather, mixture design and construction practices".* [35]

Hveem et al (1962), realized that in the absence of a unifying theory to analyze and understand pavement deflections, it would be necessary to develop limiting deflection criteria for each different pavement structural section, for each material type, and for each environment. [35] In the 1940's, researchers started working on the development of elastic layer theory and computer programs for the automation of the backcalculation procedure. Several researchers contributed the mechanistically-based theoretical tools that would enable calculation of pavement deflections. One-layer elastic system theories had been published by Boussinesq in 1885 and by Westergaard in 1925 for an elastic plate on a dense, liquid subgrade (i.e. no shear coupling). [29] A study by Burmister (1962), provided the first theoretical solutions for a system of two or more elastic layers, predicated on the use of Bessel's functions. [36] A study by Schiffman (1962) built on Burmister's model to provide a general solution for an n-layer system of elastic layers. [37] Based on this solution, backcalculation computer programs were developed in the mid-1960s by the Chevron and Shell oil companies. [38]

BACKCALCULATION SOFTWARE PROGRAMS

Several computer programs have been developed for doing automated back-calculation. The most widely used programs are:

- ELMOD (Dynatest).
- EVERCALC (Washington State DOT).
- MODCOMP (Cornell University).
- MODULUS (Texas A&M University).
- PADAL (University of Nottingham).
- WESDEF (U. S. Army, Waterways Experiment Station).

All of these programs exist in various versions as improved and updated editions are periodically released. Most of these automated back-calculation programs rely on an elastic layer program with the exception of the ELMOD program. An iterative process is used where an initial set of layer moduli is assumed, the moduli are then used to compute surface deflections, and these are compared to the measured deflections. [29]

Attempts have been made by agencies to compare of several back-calculation programs in order to identify the "best" one. According to Irwin (2002), before such comparisons, the agency should first define its purpose (in doing back-calculation) and the evaluation criteria that it will use, as most of the programs were written for production purposes. They are intended to get to a solution reliably, and with minimum involvement of the program user. [29]

EVERCALC

The Evercalc program was developed by the Washington State Department of Transportation (WSDOT). It uses an iterative process to estimate the elastic moduli of pavement layers, and determine the stresses and strains at various locations. It uses the WESLEA program (a multi-layer computer program developed by the U.S. Army Corps of Engineers) as a subroutine to calculate theoretical deflections basin on layer moduli. It is capable of evaluating up to five pavement layers. [39] The program allows the user to define the deflection tolerance, moduli tolerance and the maximum number of iterations. The program terminates when one of the conditions is satisfied. [39]

ELMOD

The Elmod was developed by Dynatest International A/S. It is used to evaluate the pavement layer moduli and overlay design based on FWD deflection data. There are three back-calculation options available in the Elmod program: Linear Elastic Theory (LET), Method of Equivalent Thickness (MET) and Finite Element Method (FEM). These three options use different forward analysis methods in its computations. The LET uses the WESLEA as a forward calculation subroutine to compute deflections. The MET uses the method of equivalent thickness with improved adjustment factors, while the FEM uses the axial symmetric finite element program to calculate theoretical deflections. The FEM option treats all the pavement layers as non-linear elastic. The Elmod program reads directly FWD data from Dynatest FWD equipment. [40]

MODTAG/MODCOMP

The ModTag part of the software was developed by the Virginia Department of Transportation (VDOT) in cooperation with the University of Cornell. The MODCOMP back-calculation program was initially developed by Irwin and Speck for the U.S. Army Cold Regions Research and Engineering Laboratory, with version 3 developed by Irwin and Szebenyi. [41] The MODCOMP3 program uses the elastic layer theory, with the CHEVRON computer code, as the method of forward calculation within its iterative analysis approach. This program first evaluates the modulus of the deepest layer and then works upward to the surface layer; i.e., modulus of each layer at some depth is related to a deflection at some distance from the load. This program can evaluate from two to fifteen layers in a pavement system, including the bottom layer which is assumed to be a semi-infinite half space. [41]

No more than five layers, which have upper interfaces at depths up to approximately 3 to 4 feet, should be treated as unknown layers whose moduli are to be determined. This program can accept data for up to six different load levels, and it can accept up to ten surface deflections for each load level. The MODCOMP program back calculates the moduli for the unknown layers, assuming them to be either linearly elastic or non-linear. Some layers in the pavement system can have assumed known values assigned to them. These known layers can be either linearly elastic or stress dependent, in which case the appropriate constitutive model can be assigned as an input parameter. This program is notable for its extensive controls on the seed moduli and the range of acceptable moduli. [41]

MODULUS

This program was developed by the Texas Transportation Institute and utilizes a forward calculation scheme, WESLEA (layered elastic solution), to build a deflection basin database for a given pavement system. A pattern search technique is then used to determine the set of layer moduli that best fits the measured basin. The number of unknowns is limited to four in order to minimize the errors from the interpolation technique and to produce acceptable results. Other salient features of the program include: automatic calculation of a depth to a stiff layer which can be overridden by the user; automatic calculation of weighing factors for each deflection sensor; and detection of non-linearity in the subgrade and automatic selection of the optimum number of sensors used in the back-calculation process. Because the program does not use a forward calculation scheme in the iterative process, it is particularly suited for the analysis of large numbers of deflection basins measured on pavements with the same structure. [42]

WESDEF

This WESDEF program was developed by the U.S. Army Corps of Engineers to determine the set of modulus values that provide the best fit between a measured deflection basin and computed deflection basin when given seed moduli, a range of acceptable modulus values, and a set of measured deflections. The program is notable for its gradient search technique and it uses the WESLEA computer code as a forward calculation subroutine within an iterative process. WESLEA is a three-dimensional layered elastic solution that will handle up to five layers, although the maximum number of layers with unknown modulus values in WESDEF should be limited to three in the back-calculation process. The program incorporates a stiff layer (modulus of elasticity of 1,000,000 psi and infinite thickness) below the subgrade into the analysis. This stiff layer is located at a depth of 20 feet unless the user specifies otherwise based on soil profile or other data (i.e., presence of shallow rock). WESDEF is also capable of handling layers with varying interface conditions and multiple loads. [43, 44]

Backcalculation Software Programs Summary

A research study by SHRP (1993), noted that the selection of back-calculation programs should be based on the reasonableness, robustness and stability, goodness of fit, and general suitability for SHRP's purposes. [45] The purpose of the SHRP's study was the evaluation and selection of the best back-calculation software for use in the SHRP back-calculation. Six back-calculation programs were selected for further evaluation, two for rigid pavements and four for flexible pavements. The study concluded that on the basis of the correlation coefficient (R^2), the best agreement exists among the MODULUS, WESDEF and MODCOMP3 back-calculation programs. They further stated that the MODCOMP3 program tends to predict higher subgrade moduli but lower base and sub-base moduli, especially when compared to the WESDEF results. However, the modulus of the asphaltic concrete surface layer appears to be consistent among all three programs. Based on the analysis, it was concluded by the study that the MODULUS program was superior in terms of performance to the other programs. [(45)]

THE PAVEMENT MODEL

To perform a back-calculation, the pavement model has to be set up correctly. The term "pavement model" refers to the layer thicknesses and related parameters such as Poisson's ratio. The objective of setting up a pavement model is to try to achieve useful results.

Thin Layers

If the pavement layer is too thin, especially if the thickness of the asphaltic concrete (AC) layer is less than 3 inches, it will affect the back-calculated moduli of the top layer. Irwin (2002) suggested that it is always best to combine a thin pavement layer with the next layer of the same material properties. The 'sensitivity' of back calculating the moduli of thin layers becomes less. Thus, the deflection becomes insensitive to the layer moduli. [(29)]

Subgrade Layers

Modeling subgrade requires an assumption of homogeneity. Thus the gradation and plasticity are quite uniform throughout the layer. The entire depth would be classified as being one material. However, for back-calculation purposes the subgrade would need to be modeled as at least two layers; upper and lower subgrade layers. This is done to account for possible changes in subgrade modulus with depth due to such factors as the stress sensitivity of the subgrade soil, and varying moisture conditions. The moisture content has a big influence on modulus, particularly for cohesive materials. [(29)]

According to the SHRP report, if the total subgrade thickness is less than 72 inches due to the presence of rigid layer, a single subgrade layer is used. [(46)] Irwin (2002) noted that the upper portion of the subgrade near the sub base is most likely to be affected throughout the year by the weather, as it will undergo annual cycles of freezing and thawing, and wetting and drying. However, the lower subgrade is not so affected by the weather, but may be affected by a shallow water table which will cause the subgrade material to be saturated. The upper subgrade thickness may differ from one season to the next, and its depth will be arbitrary. [(29)]

Bedrock

The bedrock of the pavement structure is modeled separately. For shallow bedrocks, it is possible to back-calculate the moduli for the layer. However for deeper bedrocks, it will be necessary to assign a high, fixed value of modulus to the layer. [(29)]

TYPICAL INPUT FOR BACKCALCULATION

To accurately determine the moduli using the back-calculation procedure, necessary inputs are required. The typical inputs for back-calculation are Poisson's ratios and seed moduli for the different pavement layers.

Poisson's Ratio

The Poisson's ratio is a very important input to the back-calculation of pavement layers. Poisson's ratio is a function of the material type. SHRP (1993) recommends Poisson's ratio for different pavement materials. [46] Table 3 shows the Poisson's ratio for various material types.

Table 3: Poisson's Ratio as a Function of Material Type

Material Type	Poisson's Ratio
Asphalt Concrete	
E > 500ksi	0.30
E < 500ksi	0.35
Portland Cement Concrete	0.15
Stabilized Base/Subbase	
Lime	0.20
Cement	0.20
Asphalt	0.35
Other (Stabilized subgrade)	0.35
Other (Fractured PCC)	0.30
Granular Base/Subbase	0.35
Cohesive Subgrade	0.45
Cohesionless Subgrade	0.35

Layer Moduli Ranges

Seed or initial moduli values for each pavement layer are required to back-calculate the final moduli of each layer. The SHRP (1993) recommended the initial modulus and range of moduli for unbound base and subbase materials. [46] Table 4 shows the initial and moduli range.

Table 4: Initial Modulus and Moduli Range for Unbound Base and Subbase Materials

Material Type	Initial Modulus (ksi)	Moduli Range (ksi)
Crushed Stone, Gravel or Slag		
Bases	50	10.0 to 150.0
Subbases	30	10.0 to 100.0
Gravel or Soil-Agg. Mix, Coarse		
Bases	30	10.0 to 100.0
Subbases	20	5.0 to 80.0
Sand		
Bases	20	5.0 to 80.0
Subbases	15	5.0 to 60.0
Gravel or Soil-Agg. Mix, Fine		
Bases	20	5.0 to 80.0
Subbases	15	5.0 to 60.0

For stabilized base and subbase layers, estimates of the initial modulus and range of moduli are based on unconfined compressive strength data. SHRP (1993) recommended values according to the stabilizing agent used. [46] Table 5 indicates the recommended moduli ranges.

Table 5: Initial Modulus and Moduli Range for Stabilized Base and Subbase Materials

Material Type	Unconfined Comp. Strength (psi)	Initial Modulus (ksi)	Moduli Range (ksi)
Lime Stabilized	< 250	30	5.0 to 100.0
	250 -500	50	10.0 to 150.0
	> 500	70	15.0 to 200.0
Asphalt Stabilized	< 300	100	10.0 to 300.0
	300 - 800	150	25.0 to 800.0
	> 800	20	50.0 to 1500.0
Cement Stabilized	< 750	400	50.0 to 1500.0
	750 - 1250	1000	100.0 to 3000.0
	> 1250	1500	150.0 to 4000.0
Fractured PCC	-	500	100.0 to 3000.0
Others	-	50	10.0 to 150.0

BACKCALCULATION PROCESS

Back calculation is an iterative process by which pavement layer moduli or other stiffness properties are estimated from the Falling Weight Deflectometer (FWD) deflection data. The layer moduli are adjusted until the measured deflections match the calculated deflections within a specified tolerance. [47] The iteration process stops if one of the following occurs:

- The mean root-mean-square of the relative difference between measured and back calculated readings is less than a given value.

- The combined change of modulus for all layers from one iteration to the next is less than a given value.
- The maximum number of user-specified iterations has been reached.

The purpose of the back-calculation is primarily to find the in-situ elastic moduli (E) of the different pavement layers. In the process, the deflection values are calculated for assumed elastic moduli values, compared with the observed deflection values and the assumed moduli values are further adjusted for the next iteration. The iteration continues until the calculated and observed deflection values match closely.
An iterative process is required where an initial set of layer moduli are assumed. The moduli are then used to compute surface deflections, and these are compared to the measured deflections. The assumed moduli are adjusted, and the process is repeated until the calculated deflections match the measured deflections within some specified tolerance. [48] Figure 14 shows the flowchart for the back-calculation process.

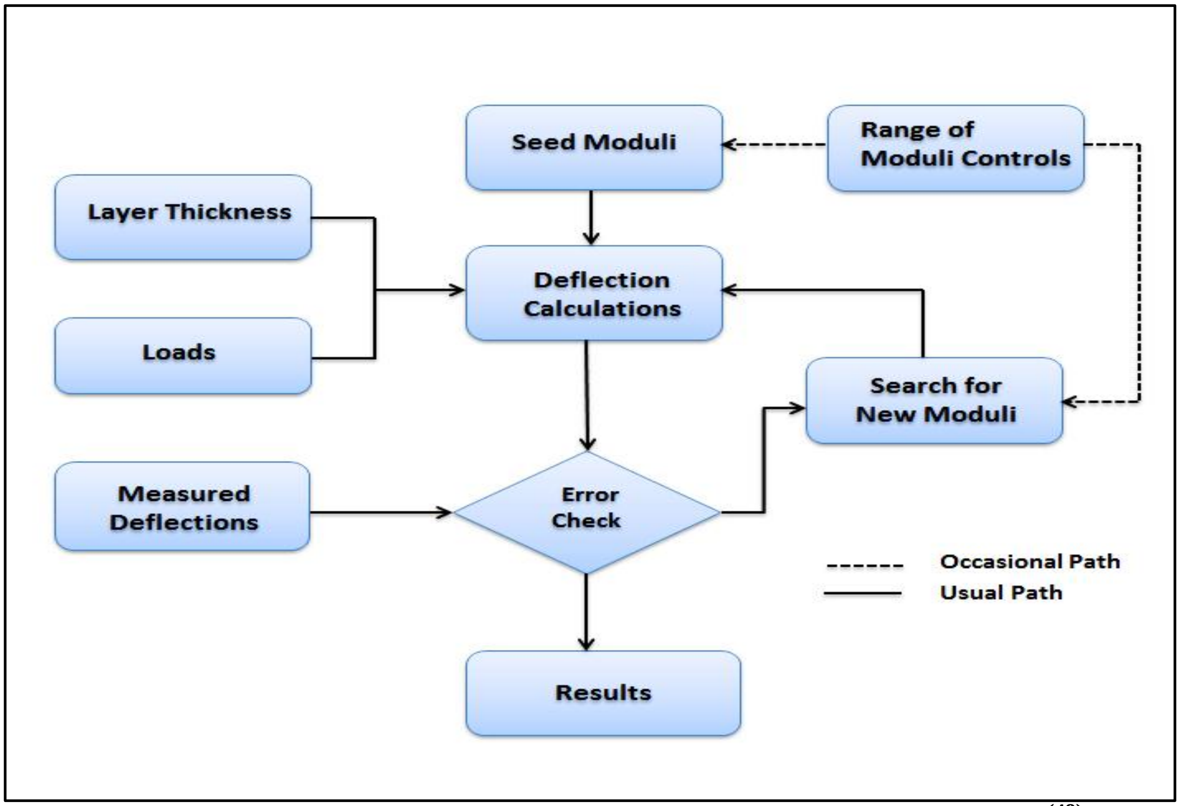


Figure 14: Chart. Flowchart of the Back-calculation Process. Source: [48]

The assumptions that constrain back-calculation are:
1. Surface load is uniformly distributed over a circular area.
2. All layers are homogeneous, isotropic, and linearly elastic.
3. Upper layers extend horizontally to infinity.
4. Bottom layer is a semi-infinite half-space.

When the pavement model matches the above assumptions, then the results of the back-calculation may be useful. [29] To assess the validity of the back-calculated moduli, a thorough knowledge of the pavement materials is needed, and the root-mean-square-error (RSME) statistic is also used for the overall match between the measured and the back-calculated deflection basins. A small RMS error (< one percent) is usually a good indication that the moduli are accurate provided that the pavement layer system is being modeled accurately. [29]

Several researchers have indicated that stiffness/strength determined through nondestructive testing is a fundamental method of determining effective layer moduli. [49, 50] Roque et al (2002) stated that since the use of deflection measurements to characterize pavement structural capacity and to determine the layer moduli of the separate layers has increased, it has become important to understand and refine the back-calculation process. [51]

BACK CALCULATION VS. FORWARD CALCULATION

Direct Computation or Forward calculation is used to generate the modulus or stiffness that is independent of the back-calculated values so they can be used for comparison to screen the back-calculated moduli. This approach for the direct computation is based on the premise that the two substantially different approaches to calculated layered elastic parameters from the same deflection data should produce at least somewhat similar moduli given that either approach is credible. [52] The forward calculations use certain portions of the FWD deflection basin to derive an apparent modulus or stiffness of the subgrade and/or the bound surface course using closed-form as opposed to the iterative solutions. The direct computation using the closed-form solutions for determining layered-elastic properties of pavement systems have been used extensively in the past. [52]

Based on the Boussinesq theory developed in 1884, a set of closed-form equations for a semi-infinite, linear elastic medium half-space, including the modulus of elasticity of the medium, based on a point load, forward calculation programs were developed. These are BISAR, ELSYM5, WESLEA, JULEA, NELAPAV and CIRCLY. [29] The forward calculation or direct computation utilizes the Hogg model to ascertain the approximate subgrade stiffness or elastic modulus under an imposed surface load. This model is based on a hypothetical two-layer system consisting of a thin plate on the elastic foundation. It uses the deflection at the center of the load and one of the offset deflections. Hogg showed that estimation bias is effectively removed where the deflection is approximately one-half of that under the center of the load plate. [53] Wiseman described the implementation of the Hogg model using three cases. One is for an infinite elastic foundation, and the other two are for a finite elastic layer with an effective thickness that is assumed to be approximately 10 times the characteristics length. [53]

The back-calculation and direct computation (forward calculation) approaches of layer properties and/or structural capacity have some similarities and differences. [52] Some of the differences are as follows:

1. The forward calculation provides a unique solution since the subgrade and bound surface course stiffnesses obtained are not dependent on the other moduli within the pavement system, as is the case with back-calculation.
2. Forward calculation is easy to understand and use, whereas back-calculation is presently more of an art than a science.
3. Back-calculation requires expert engineering judgment along with the art of running the iterative program of choice and evaluation of the reasonableness of the results and

selection of the model and other input parameters, whereas anyone can perform forward calculation.

4. The forward calculation techniques produce considerably less scatter in the data (for the same layer and test section) than do back-calculation techniques.

There are drawbacks to both the back-calculation and forward calculation (direct computation). In spite of the drawbacks, many of the moduli appear to be reasonable and rational based on common engineering sense and a working knowledge of pavement materials. [52]

QUALITY CONTROL OF BACKCALCULATED MODULI

To ensure that back-calculated moduli of pavement are accurate, it is important to access its validity and quality control. Irwin (2002) recommended that having thorough knowledge of the materials in the pavement helps to overcome some of the quality problems and assess the validity of the back-calculated moduli. Experience provides a basis to anticipate what moduli to expect. [29]

A study by Sivaneswaran et al (2001) noted that the root-mean-squared error is a common representation of the overall difference between the measured deflection basin and the layered-elastic predicted deflections. This term represents the overall percentage error between the calculated and measured deflections. Minimization of this error term is desirable to ensure reasonable back-calculated moduli. [54] Von Quintus et al (1998) utilized the practice of eliminating deflection basins with an RMS error term above a specific cut-off value. For their data set, this value was set at 2.5 percent. [19]

The Nevada DOT uses a maximum acceptable RMS of 2.5 percent for the FWD deflection basins. They noted that using this cut-off value is both practical and provides reasonable predictions of in-situ moduli values. [55] A study conducted at the WESTRACK pavement testing facility for FWD-based back calculation analysis used different RMS error values which were ranked on a relative scale, with RMS error less than 1 being considered ‘excellent’, values between 1 and 4 percent RMS error being ‘very good’, and values between 5 and 7 percent RMS error being ‘good’. The study concluded that very good overall matches were achieved for each section. [56] It is possible for back-calculation software to produce multiple combinations of pavement layer moduli from the same deflection basin. This non-unique solution dilemma therefore requires some interpretation of the most logical combination of layer moduli. According to Seed et al (2000), accurate pavement cross-section information (thicknesses and layer composition) is required to generate reasonable back-calculated results. [56]

COMPARISON OF LABORATORY AND BACKCALCULATED MODULUS VALUES

Past researchers have found that the resilient modulus of a pavement layer determined from the laboratory testing differs significantly from that determined from Nondestructive Testing (NDT) based back-calculation. Von Quintus et al. (1998) presented the results of a comparison between laboratory and in situ moduli from LTPP database. They could not establish a meaningful relationship between laboratory and back-calculated moduli. The authors recommend a correction for back-calculated moduli since the AASHTO Pavement Design Guide is based on laboratory determined moduli. [19] A study by Nazarian et al. (1998) showed results of a comparison between laboratory tests, back-calculated moduli, and moduli from the Seismic Pavement Analyzer (SPA) for base materials in Texas. The results indicated that the moduli from virgin and in-service materials from the same quarry are different. They concluded that the FWD and SPA moduli exhibited the same trend, with the SPA having 70 percent higher moduli than the FWD moduli. However, they could not identify a unique relationship between the moduli from laboratory and field tests. [57]

Zhou (2000) performed a comparison between the laboratory and back-calculated modulus values for asphalt concrete (AC) and granular base materials at two FWD testing sites in the state of Oregon. The study performed the comparisons between the laboratory and field modulus values by plotting the resilient modulus against the bulk stress for each testing site. The analyses showed that the back-calculated moduli for the asphalt concrete (AC) layer was generally lower than the laboratory measurements at the same temperature, generally by 20 to 30 percent. However for the granular base material, the back-calculated moduli were higher than the moduli measured in the laboratory. The authors concluded that the data showed reasonable agreement in the range of bulk stresses most commonly experienced in pavement base layers, between 40 and 140 kPa (5.8 and 20.3 psi). [58]

Ping et al. (2001) conducted a comparison study between the laboratory and FWD measured moduli for granular materials in Florida. Their study indicates that a reasonable correlation relationship exists between the FWD back-calculated moduli and the laboratory resilient moduli. They concluded that the back-calculated moduli were about 1.8 times higher than the laboratory resilient moduli for the granular materials compacted to in-situ moisture contents and densities. The authors noted that this finding was in general agreement with the AASHTO design guide, which states that FWD moduli are typically between 2 and 3 times higher than laboratory moduli. For this comparison, the 9,000 lb FWD loadings were used for the back-calculated moduli, and the layered-elastic simulated stress-states beneath this loading were entered into the laboratory generated constitutive equation. [59]

Studies conducted by Seeds et al (2000) compared base course resilient moduli determined from both laboratory testing and NDT-based back-calculation analysis at the WesTrack experiment. In order to perform the comparison, they calculated the laboratory moduli with the material-specific constitutive equation using typical stresses under a 40kN (9kip) FWD load. The comparison between the laboratory and FWD moduli for the base layer materials (using the average and standard deviation for FWD testing, which encompass the variability within each section) can be found in Figure 15. The figure below clearly indicates that the back-calculated moduli are two to three times the value of the laboratory-based resilient modulus. [56] They observed that because the base course is of high-quality, densely compacted material, it produced reasonable back-calculation results, while the laboratory–based procedure consistently underestimates the in-situ resilient modulus of the unbound base course material. Although the statistical analysis of two datasets showed a correlation coefficient of 0.1, the authors concluded that it may not be possible to develop a simple relationship between laboratory and back-calculated moduli because of differences in the sampling procedures, tests methods and analytical/simulation processes. [56]

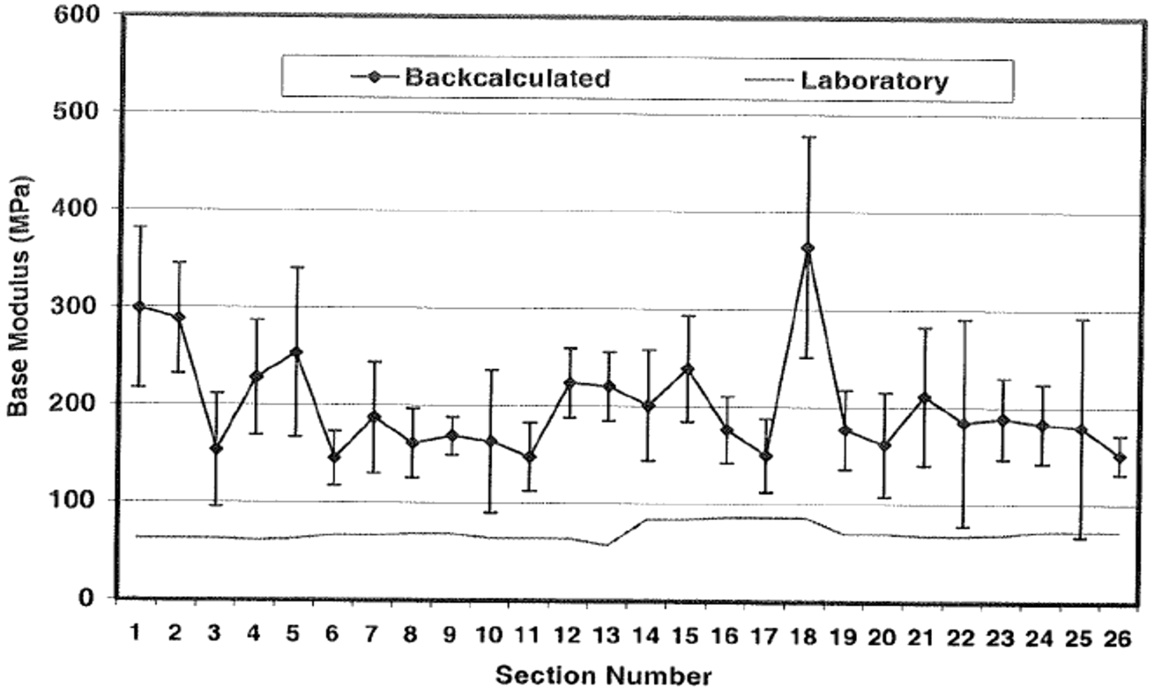


Figure 15: Graph. Comparison of Laboratory and FWD Moduli for Base Layer Materials at WESTRACK Experiment. Source: (56)

Chapter Summary

This chapter presents a literature review that provides a basis for the background of this study. An overview of previous studies on pavement widening projects by WYDOT and other agencies was presented. The testing equipment, such as DCP and FWD, used for pavement evaluation and the use of back-calculation procedures to determine pavement layer moduli from nondestructive deflection data are presented as well.

WYDOT's preliminary study on pavement widening projects determined typical widening sections and the extent of longitudinal cracking at the joint area for each joint type. According to a Montana DOT study, the use of crushed base placed directly on the existing side slope is preferred. Utah DOT preferred the stepped widening joint type. They believed widening sections without stepping (notched) often results in the formation of a slip plane.

Other studies have been focused on the effects of joint construction on asphalt densities in the joint area. The study by the National Center for Asphalt Technology (NCAT) found an area of low density and high air voids over 6 to 8 inches from the center of the joint. The higher air voids allow water to permeate the joint, and thus increase the pavement's susceptibility to freeze-thaw. The in-place densities can be 1 to 2 percent lower at the joint location than the surrounding pavement.

Paving longitudinal joints is particularly problematic because of the difficulty in the compaction of the unconfined edge of the first pass, the "cold lane" before placing the adjacent lane's pavement surface. However, overlapped rolling produced the highest densities in semi-hot joint construction, and infrared heating improved density slightly in the initial lane although no improvement in tensile strength was recorded. It was suggested that some form of confinement, edge compaction, infrared heating, or a combination of these may be the solution.

Pavement evaluations and testing are usually performed by the use of specialized testing equipment such as Falling Weight Deflectometer (FWD) and the Dynamic Cone Penetrometer (DCP). The DCP is an in-situ penetration test used for site investigation in support of analysis or design. The data obtained from the test is converted to the California Bearing Ratio (CBR) using equations or conversion charts supplied by the manufacturer of the DCP equipment. The CBR obtained is a reflection of the stiffness properties of the base layer. The FWD is a nondestructive (NDT) and non-intrusive testing device widely used in pavement engineering to evaluate pavement structural condition.

Back-calculation is an iterative process by which pavement layer moduli, or other stiffness properties, are estimated from the Falling Weight Deflectometer (FWD) deflection data. The in-situ elastic moduli (E) of the different pavement layers are determined from the deflection data. In the process, the deflection values calculated from an assumed elastic moduli value are compared with the observed deflection values, and the assumed moduli values are further adjusted for the next iteration. The iteration continues until the calculated and observed deflection values are closely matched.

CHAPTER 3: RESEARCH APPROACH

The evaluation of the pavement widening joints to determine which joint type provides better base support was performed through field and laboratory testing. This chapter presents the research methodology that was developed, the selection of test sections, the testing protocol used for the field data collection, and the laboratory processes.

Research Methodology

The methodology followed for this research project can be found in Figure 16. This strategy includes the identification and selection of projects with different widening projects, field and laboratory testing, a survey of practices across the mountain and plain states, and an evaluation of cost comparisons between the widening joint types. The survey of WYDOT District Construction and Resident Engineers and the Wyoming Paving Contractors Association on the evaluation of constructability issues was performed.

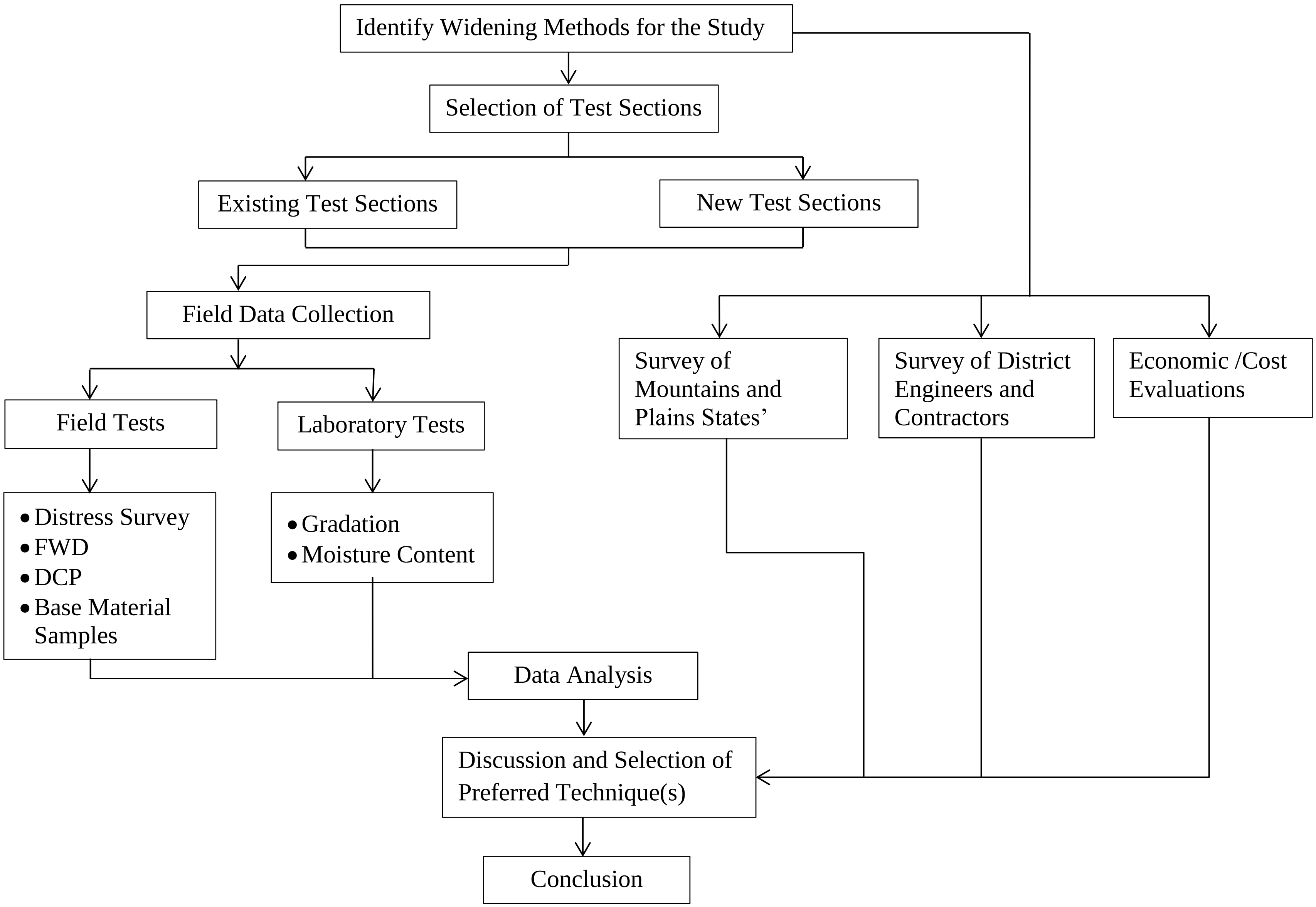


Figure 16: Chart. Strategy for Data Collection and Analysis

Selection of Test Sections

Existing Test Sections

Discussions were held with WYDOT Materials Program personnel about the road widening projects to be selected for the study, and it was concluded that projects undertaken from 2000 to 2010 within the state were to be used for the study. The decision to select 2000 to 2010 projects was to enable the rates of deterioration of the various widening projects over this period to be studied.

Hundred and five (105) road widening projects that had been implemented from 2000 to 2010 were retrieved from an inspection of WYDOT project plans. Out of the 105 widening projects identified, 88 have the vertical joint technique, 14 used the tapered joint technique and the notched joint technique has 3 projects. However, discussions with WYDOT determined that widening width of 3 ft. or less could not be included in the study because the FWD testing equipment required wider space to operate, and also the FWD tests could not produce accurate results when the data points were too close to the uneven road edge. Therefore, the available number of widening projects had to be reviewed to select projects that met this criterion.

After the review, 54 vertical widening and 6 tapered widening joint projects were selected for consideration for testing. Further discussions with WYDOT concluded that approximately 30 projects would be selected for the study due to budget and time constraints, and all 6 tapered projects should be included in the study with the remaining 24 vertical projects to be selected randomly across the state.

Thirty projects were selected based on discussions with WYDOT's Materials Program, and the list was presented to the WYDOT Materials Program for approval. However, WYDOT requested minor amendments to allow for testing on more projects within a week considering the limited summer testing period (May to July) and the limited budget allocated for the study. A final list of 28 projects, out of which 6 are tapered and 22 vertical projects was approved. The list of 28 selected projects for the study is as shown in Table 6 below which includes the year of construction and the joint type obtained from WYDOT construction plans.

Table 6: List of Existing Projects Selected for the Study

No.	Project #	Road Class	Joint Type	Const. Year
1	ACSTPS-0107-00(23)	Non Interstate	Tapered	2004
2	P114035	Non Interstate	Tapered	2008
3	STP-W113-00(002)	Non Interstate	Vertical	2001
4	NH-0N12-02(014)	Non Interstate	Vertical	2002
5	SCP-0P16-01(020)	Non Interstate	Vertical	2007
6	SIB-ACSTPS-1906-00(017)	Non Interstate	Vertical	2006
7	STPS-0202-00(013)	Non Interstate	Vertical	2000
8	ACNH-PO-0N21-02(100)	Non Interstate	Vertical	2006
9	MG-OP23-02-(037)	Non Interstate	Vertical	2002
10	SCP-030037	Non Interstate	Vertical	2007
11	SCP-SL081.55 0404010	Non Interstate	Vertical	2008
12	STPS-0600-00(19) & ARSCT	Non Interstate	Vertical	2006
13	STPS-0703-00(012)	Non Interstate	Vertical	2000
14	SCP-SL0812.89 1801020	Non Interstate	Vertical	2008
15	I025-02(137)	Interstate	Vertical	2006
16	ACIM-I025-04(138)	Interstate	Vertical	2007
17	SIB-ACIM-80-1(104)	Interstate	Vertical	2000
18	NHI-80-4(197)216	Interstate	Vertical	2000
19	ACIM-I080-05(130)	Interstate	Tapered	2005
20	IM-I080-06(139)	Interstate	Tapered	2000
21	SIB-ACIM-80-06(171)	Interstate	Tapered	2003
22	ACIM-I090-01(093) & (110)	Interstate	Vertical	2003
23	901102	Interstate	Vertical	2007
24	ACIM-I025-03(094)	Interstate	Tapered	2005
25	IM-1080-04(199)&(218)	Interstate	Vertical	2001
26	ACIM-1080-05(125)	Interstate	Vertical	2004
27	IM-90-3(87)118	Interstate	Vertical	2000
28	ACIM-I025-05(094)	Interstate	Vertical	2006

Figure 17 below shows the plot of the selected project locations for the field testing. The locations show geographical distribution across the state of Wyoming. The type of joint was further confirmed in the field by observing cores drilled at the joint locations.

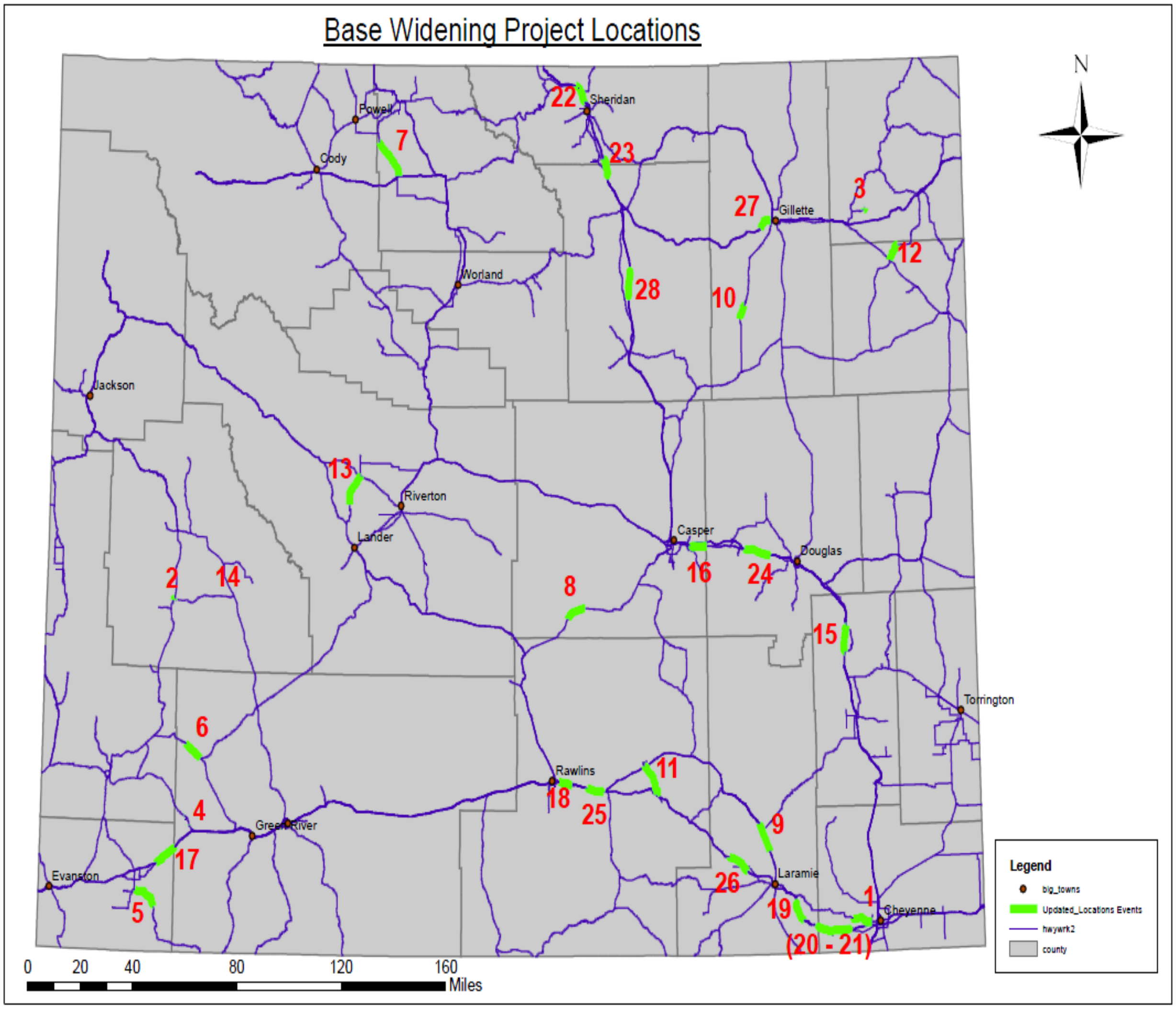


Figure 17: Diagram. Map of Selected Testing Locations

New Test Sections

Most of the newly constructed projects were awarded on contract in 2011. Construction for most of the projects started in early 2012 and was completed in late 2012. Table 7 shows the list of the newly constructed widening projects. All the newly constructed projects are on state highways. The research team proposed that 500 feet be reserved on each project so that both joint types (vertical and tapered) could be constructed. With the assistance of the Wyoming Department of Transportation (WYDOT), the contractors on two projects (WY 59 and US 16) agreed to this proposal. The research team visited the site during the various stages of construction to observe the cutting of the longitudinal joint type (vertical, tapered), and the placement and compaction of the base material (crushed rock or natural material). The team also performed Dynamic Cone Penetrometer (DCP) on the unbound base layer prior to paving with asphaltic concrete.

Table 7: List of Newly Constructed Widening Projects

Project	Highway	Class	County	MP Start	MP End	Letting	Location	Description	Planned Widening Type
N852001	US 85	Non-Int. NHS	Laramie	21.80	56.54	Mar 2012	Cheyenne - Torrington	Passing Lanes	Vertical
N132095	US 191	Non-Int. NHS	Sublette	89.90	91.70	Nov 2011	Pinedale South	Widen to 5 Lanes	Taper
P433035	WYO 59	Non-Int. NHS	Campbell	142.05	148.6	Nov 2011	Gillette-Montana/Weston	Widen & Overlay	Vertical
N361053	US 16	Non-Int. NHS	Washakie	1.52	4.87	2011	Worland - Ten Sleep	Reconstruction	Taper

Field Testing Procedure/Protocol

The UW research team and WYDOT discussed the procedure for carrying out the various tests. From these discussions, a testing protocol, described in Appendix A, was prepared by the research team and approved by WYDOT to meet the needs of the study.

In order to evaluate the pavements to determine the performance of the types of widening joints, it was necessary to assess the extent of longitudinal cracks along the joints as well as to carry out a measure of the properties that reflect the density gradient across the joint. This required field tests including DCP and FWD, and laboratory tests such as aggregate gradation and moisture content determination. The Testing Protocol contained a guideline about how to carry out the field tests. It outlined the field testing process including important safety measures, test naming conventions, sequences for carrying out the tests, test data and samples to be collected at each site, and how to fill holes created by core drilling during tests.

The sequence proposed by the testing protocol is outlined as follows:

1) Setting up a traffic control by WYDOT staff on selected road sections prior to each test.
2) Naming test locations and sampling points by following a system that uses the project number followed by a letter that denotes the direction of offset in relation to the joint line (J, R, L representing joint line, right side of the joint line, and left side of the joint line, respectively), then a number indicating the offset distance in feet from the joint line to the referenced point, and a final number that indicates the location. For example, labeling a core N09R23 indicates that the core sample was taken from location 3 of project number nine which is project MG-OP23-02-(037) as identified in Table 6.The sample point is located at a 2 feet offset to the right of the joint line. Figure 18 shows an example of the naming convention and a general layout of test locations for each project.
3) Marking points where various tests and sampling may be carried out using spray paint as shown in Figure 18.
4) Filling the forms for recording the presence of cracks and rumble strips (Appendix B) at the beginning of the tests.

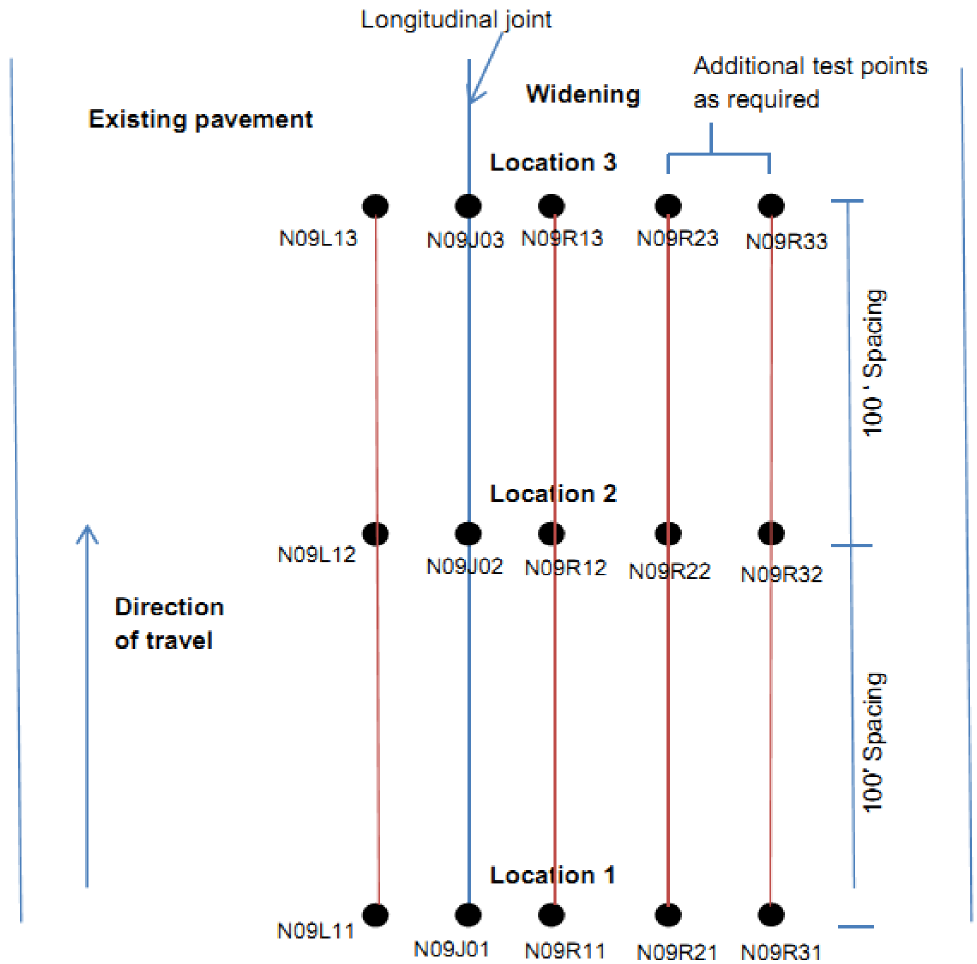
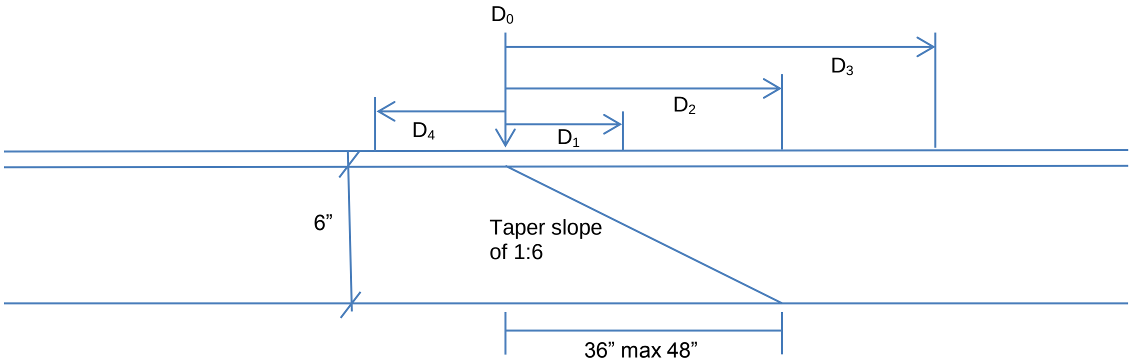


Figure 18: Diagram. Spacing and Number of Locations per Road Project

5) Carrying out FWD tests at each location as shown in Figure 19, as well as drops at additional locations beyond the marked locations.
6) Measuring and recording air and pavement temperatures as part of the FWD test.
7) Drilling a 6" core at each marked location after the FWD tests with a minimum of nine cores for each section, and ensuring no disturbance of the base layer by drilling to approximately ¾ of the estimated asphalt layer thickness and vacuuming excess water immediately from the core hole.



Proposed
$D_0 = 0$
$D_1 = 1'$
$D_2 = 3'$ (for tapered joints) if needed
$D_3 = 5'$ (for tapered joints) if needed
$D_4 = 1'$

Figure 19: Diagram. Test Section Showing Distances from the Joint for Sampling

8) Examining the hole and the core for any cracks or signs of raveling across the cross-section of the pavement.
9) Carrying out DCP tests after the FWD tests. The DCP tests are carried out with a 17.6 lb hammer, and involved recording the number of blows every 2" but discontinuing and moving the device to another test location when penetration recorded is less than 0.08 in after 5 blows.
10) Collecting base material samples for moisture content determination and gradation tests. All samples collected were tagged with the appropriate core names.
11) Closing all the holes created by coring activities by filling them with appropriate materials, and having the fill well compacted.
12) Loading the various samples into WYDOT trucks and transporting them to the materials laboratory for testing.

In the months of June and July 2012, the field tests were carried out on the existing selected projects as prescribed by the Testing Protocol, and the laboratory tests were completed in December 2012. Field testing continued the following summer in 2013 to collect data for the newly constructed projects.

Field and Laboratory Evaluations

The data collection for the field evaluation was achieved by identifying the extent of longitudinal crack deteriorations and the presence of raveling. In addition, DCP and FWD tests were performed. Laboratory test data in the form of gradation and moisture content test results were also collected. The field data collection was used for both the existing and new projects.

Examination of Extent of Deterioration and Raveling

In order to determine the extent and severity of deterioration for the selected test sections of the earmarked projects, the ASTMD 6433 procedure was employed. Ultimately, the procedure was used here to obtain the Corrected Deduct Value (CDV), which is a measure of the severity of deterioration (CDV values of 0 and 100 imply lowest and highest levels of pavement deterioration, respectively). Following the ASTMD 6433 procedure, each test section of 300 feet was divided into three sample units with the length of each segment being 100 ft. An illustration of the partitioning for a road section 32 ft. wide is found in Figure 20.

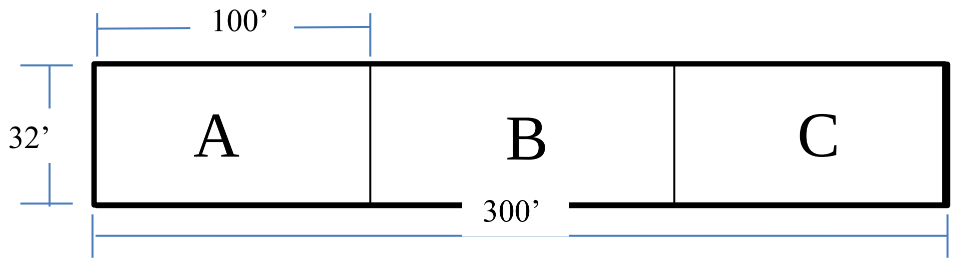


Figure 20: Diagram. Partitioning Road Test Section for a Condition Survey

A condition survey was carried out by measuring width, length, and location of longitudinal cracks relative to the location of the joint line. The cracks were then classified as being low (L) when the crack width was less than ½”, medium (M) when the crack width was from ½” to 2” and high (H) when the crack width was greater than 2”. Figure 21 shows visible longitudinal cracks in the vicinity of the pavement widening section.

Figure 21: Photo. Longitudinal Cracks on Pavements

The information gained from the condition survey was used to fill Table 8 below for sample units A, B, and C.

Table 8: Pavement Condition Longitudinal Cracks Survey Sheet

Distress Severity	Quantity			Total	Density	Deduct value
	A	B	C			
48L						
48M						
48H						

To determine the "Total" for distress type 48L (Longitudinal cracks of low severity) as shown in Table 8 above, the lengths of cracks recorded under A, B, and C were summed and recorded under the "Total" column. The densities for the distress types were also determined by dividing the "Total" by the area of the sample unit and multiplying the result by 100. The distress density in percentage was then used with the chart shown in Figure 23 to determine the individual deduct values.

If only one individual deduct value was greater than 2, that deduct value was recorded as the highest deduct value (HDV). But in the instance where there were two or more deduct values and the number of deduct values was greater than *m*, the number of deduct values was reduced to *m*. With *m* described by the equation in Figure 22 below:

$$m = 1 + \left(\frac{9}{98}\right)(100 - HDV)$$

Figure 22: Equation. Formula for Determining *m* for Pavement Condition Assessment

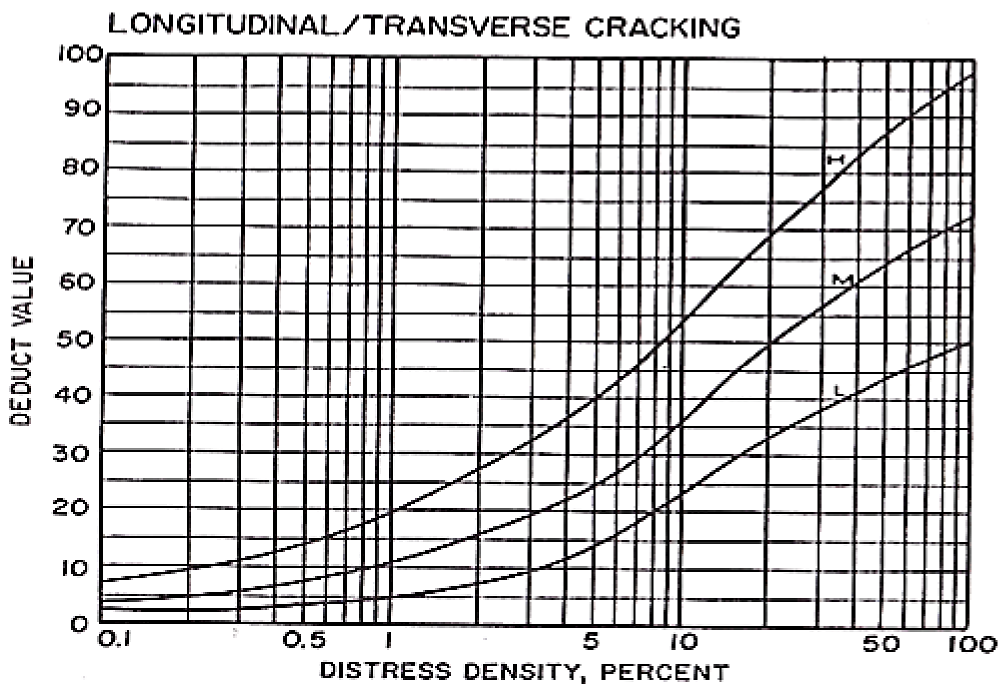


Figure 23: Chart. Determining Deduct Value from Distress Density Chart [60]

When the number of deduct values was less than m, then all the deduct values were summed to obtain the total deduct value (TDV). All individual deduct values greater than 2 were counted to obtain a value *q*. The TDV and q values were used with the chart shown in Figure 24 to determine the corrected deduct value (CDV). [60] The list of individual deduct values was inspected and the smallest deduct value greater than 2 was reduced to 2 and the process of determining another CDV was iterated till the value of q was equal to 1. The highest of the CDV values obtained from the iterations was selected as the CDV value of the project being evaluated. A copy of deterioration and raveling results from the field evaluations for the existing projects can be found in Appendix C.

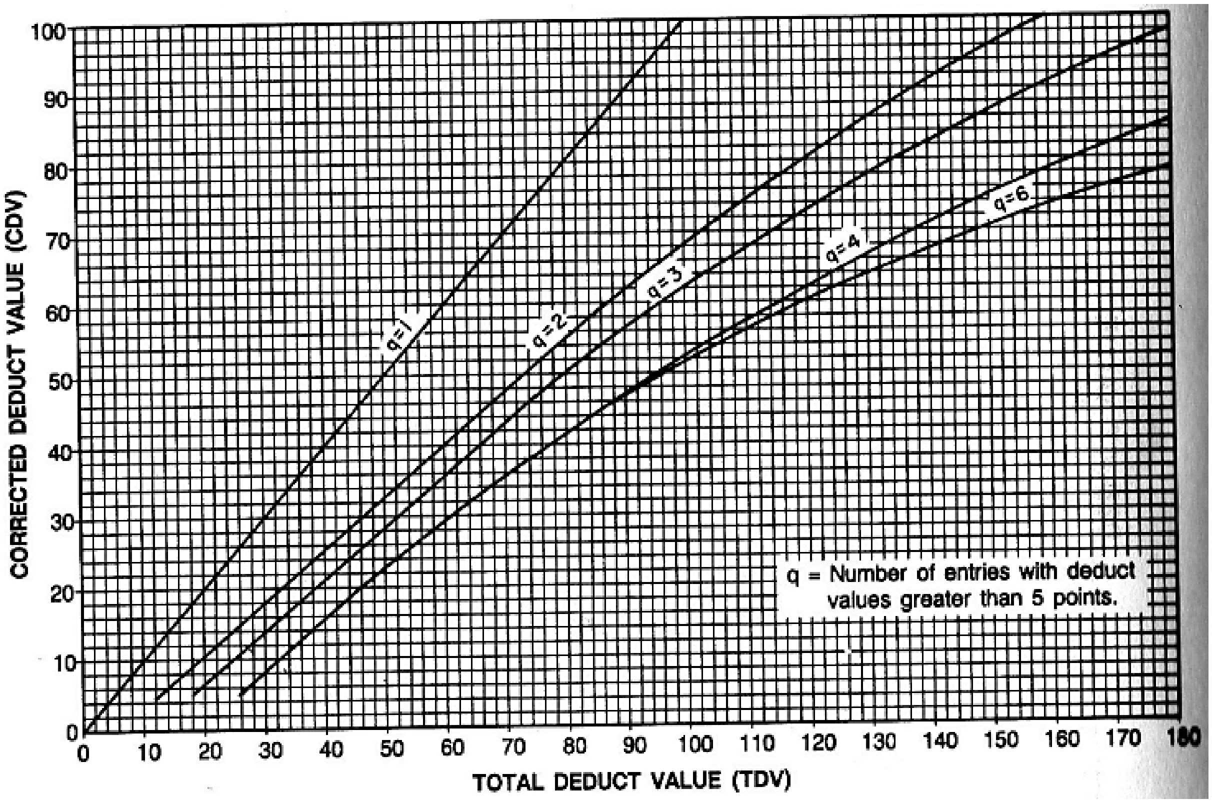


Figure 24: Chart. Corrected Deduct Values for Asphalt Pavements (60)

Falling Weight Deflectometer Tests

Falling Weight Deflectometer (FWD) tests were carried out using WYDOT's KUAB testing equipment. The testing equipment required wider space to operate and so only projects with widening widths of at least four feet or more could be considered for testing. The FWD testing procedure generally followed the LTPP methodology with Wyoming Department of Transportation (WYDOT) testing modification. The FWD testing methodology adopted for this project included three seating drops from drop height 3 (12,000lbs). The seating drops were performed to eliminate seating and random errors usually associated with FWD testing. After the seating drops, three data drops were performed at drop height 2 (9000lbs) to obtain the pavement deflection measurements for each test station. Unique deflection data for the fifteen test stations were obtained. The KUAB nondestructive FWD equipment was used for the testing with eight-sensors at varying distances 0, 8, 12, 18, 24, 36, 48, 60 inches (0, 203, 305, 457, 610, 914, 1219, 1524 mm) from the center of the loading plate of the KUAB FWD equipment. Figure 25 shows the KUAB FWD testing equipment in operation.

Figure 25: Photo. KUAB FWD Testing Equipment in Operation

Drilling and Inspection of Cores

In order to avoid the introduction of water into the base during the drilling process, an estimate of the thickness of the asphalt surfacing was determined from the project plans and ¾ of that depth was drilled. Water produced from the drilling activity was quickly vacuumed and the remaining asphalt layer was then chiseled to reveal the base. This operation can be seen in Figure 26. These precautions were taken to limit or reduce any disturbance from the drilling activity that may affect DCP tests on the base.

Figure 26: Photo. A WYDOT Technician Chiseling Remaining Asphalt After Cores to Expose Base Layer

The drilled cores were then inspected for signs of weakness, cracks or raveling and the results of the inspection were recorded in the field data sheet as can be found in Appendix C. The type of base material was also confirmed and recorded in the field data sheet. Figure 27 shows the cored asphaltic concrete (left) and the drilled hole showing the top of the base layer.

Figure 27: Photo. A core and a drilled hole being inspected

Dynamic Cone Penetrometer Tests

The DCP tests were carried out after the FWD tests, the drilling, and the inspection activities. In situations where the base material was determined to be a hard material, such as cement treated base, no DCP tests or sampling for moisture content or gradation tests were done. Five road projects were impenetrable and could not be tested using DCPT. The depth to which the DCP equipment was allowed to penetrate was generally 12 inches, but this mainly depended on the depth of the base layer as shown in the drawings of plans and cross sections, or the depth at which the device was determined to have penetrated the subbase. Figure 28 shows the field DCP testing on the base layer.

The DCP data was recorded on the field data sheet which can found in Appendix B. The DCP data obtained from the tests were used to determine the penetration per blow for the base material. Summary results of the tests can be found in Appendix D.

Figure 28: Photo. Carrying out a DCP test

Laboratory Testing

As per the Testing Protocol, samples were collected from the various test locations and transported to WYDOT and University of Wyoming laboratories for gradation and moisture content tests, respectively.

Moisture Content Determination

Base samples for moisture content tests were collected from each hole and stored in sealed moisture cans for transport back to the UW Materials Laboratory. Fifteen samples were taken for each project, and the moisture content was determined for each individual sample.

The moisture content test was carried out to determine the amount of moisture retained in the base material. The tests were carried out by drying the samples in an oven at a temperature of 230°C. The weights of the samples were recorded before putting them in the oven and re-weighed every 12 hours till a consistent weight was obtained for two subsequent readings. The moisture content for each of the fifteen samples was then obtained by the equation shown in Figure 29. The average moisture content for each project was determined. Results of the moisture content of the base materials are presented in Appendix C.

$$MC = \frac{W_{stock} - W_{SSD}}{W_{SSD}} \text{ x } 100$$

Where: *MC = Moisture content expressed as a percentage*
Wstock = Weight of Aggregate in Stockpile Condition (Wet Sample)
WSSD = Weight of Aggregate in Saturated Surface Dry Condition (Oven Dry Sample)

Figure 29: Equation. Moisture Content Determination Formula

Gradation

The gradation test is used to determine aggregate size particle distribution. [61] The process involves the use of a series of sieves to separate the aggregate sample into groups differentiated by size. Each group of separated aggregates is weighed and compared to the total weight. The results presented in graphical form are expressed as a percentage retained by weight on each sieve size.

The project plans specified grading W for bases as shown in Table 803.4.4-1 of the WYDOT 2010 Standard Specifications. Table 9 shows the WYDOT standard specification for gradation. This was confirmed by carrying out gradation tests at the WYDOT Materials laboratory for each project that utilized crush rock base or recycled asphalt materials. Cement treated bases and some recycled asphalt bases could not be sampled for testing because of the hardness of these materials. The results of the gradation tests are presented in Appendix C.

Table 9: WYDOT Standard Specification for Gradation Requirements

Table 803.4.4-1
Gradation Requirements: Subbase and Base

Sieve	Grading				
	J	GR	L	K	W
	% Passing				
2 in [50 mm]	100	–	–	–	–
1½ in [37.5mm]	90 to 100	–	100	100	100
1 in [25 mm]	–	100	90 to 100	90 to 100	90 to 100
¾ in [19 mm]	–	90 to 100	–	–	–
½ in [12.5 mm]	–	65 to 85	60 to 85	–	60 to 85
⅜ in [9.50 mm]	–	–	–	–	–
No. 4 [4.75 mm]	35 to 75	50 to 78	35 to 55	40 to 65	45 to 65
No. 8 [2.36 mm]	–	37 to 67	25 to 50	30 to 55	33 to 53
No. 30 [600 µm]	–	13 to 35	10 to 30	–	–
No. 200 [75 µm]	0 to 15	4 to 15	3 to 15	3 to 15	3 to 12

Data Quality Issues

Data collected for a project has quality issues associated with it, and this research project is no exception. Efforts were made to address data quality. To obtain accurate samples for moisture testing, the top layer of the base which may have some water due to the coring was scooped out until there was no water before sampling was taken for moisture testing. The sample was then put into covered cans with the lid sealed with masking tape to prevent the escape of moisture. For the DCP testing, efforts were made to ensure that the testing rod was straight and the drop weight was lifted to the base of the handle to achieve accurate data. For the FWD testing, efforts were made to assure that the testing location was level and free of debris to achieve accurate deflection data. The KUAB equipment gives inaccurate deflection if placed on an uneven platform. Seating drops were also performed to eliminate any seating errors. The FWD data obtained were also checked for suspect deflection data.

Chapter Summary

This chapter describes the methodology for this research effort. A flow chart was developed that includes the data collection and analysis, a survey of Mountains and Plains States, a survey of WYDOT District Construction and Resident Engineers and Wyoming Paving Contractors, and cost evaluations. The project selection process was also discussed. A total of 28 existing widening projects were approved out of which 6 are tapered joint and 22 are vertical joint types. The four newly constructed widening projects were also included in the study. The testing protocol for field data collection was presented. Identification of longitudinal cracks and raveling was performed. FWD and DCP testing, drilling of asphalt cores, and examinations of holes were carried out. Material samples for gradation and moisture content determination in the laboratory were obtained. The validation of data quality issues was also presented.

CHAPTER 4: DATA ANALYSIS

The data obtained from the field and laboratory tests on the existing and new projects were analyzed to produce statistically supported recommendations for a preferred base widening technique. The analyses involved descriptive and statistical analyses of the effects of joint widening types on longitudinal pavement cracking for the existing projects, and the effect on the strength of the base as predicted by the DCP test data, FWD deflection and the back-calculated moduli for both the existing and new (2012 constructed) projects.

ANALYSIS OF EXISTING PROJECTS

The analyses of joint widening type with respect to deterioration and raveling as estimated by the Corrected Deduct Value (CDV) were performed for the existing projects in this section Analyses on the gradation, base widening material (recycled asphalt or crushed based), and widening joint location with respect to wheel loads were also performed for the existing projects. The analyses of DCP, FWD and backcalculated moduli were performed as well.

Widening Joint Type and Corrected Deduct Value

A scatterplot of the two joint types was plotted over their periods of construction and compared to the CDV values. Figure 30 shows the plot of the longitudinal cracks in terms of its corrected deduct values (CDV) and the year of construction. The plot shows that the age of the pavement has no apparent effect on the severity or occurrence of deterioration for both vertical and tapered types of joints, since there is no increasing or decreasing trend for the CDV values at different construction years. The data points for widening projects that used the vertical methods show CDV values that are scattered over a range from 0 to 44, whereas values for tapered widening joint projects had CDV values range from 0 to 12. Due to the small sample size of the tapered joint widening type being only 6 compared to 22 vertical joint widening types, a conclusion cannot be confidently drawn that CDV values of vertical widening projects are marginally higher than those of tapered widening projects. Further statistical analysis is required to verify if the severity of damages for each widening joint type is significantly different from the other and thus conclude that severity of deterioration may be affected by the widening joint type.

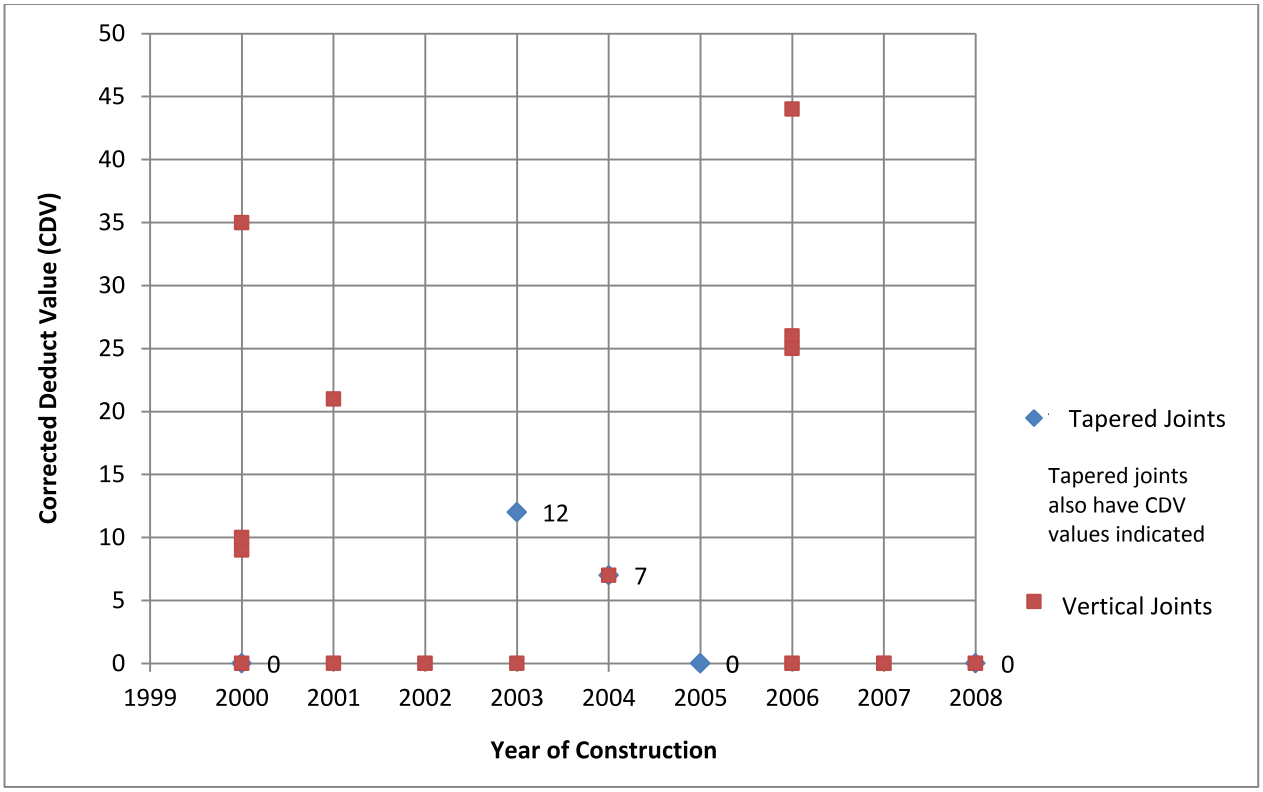


Figure 30: Graph. Scatterplot Comparing Joint Types and their Deterioration Level

Widening Joint Type Effects on Occurrence of Longitudinal Cracking

To test for a relationship between the type of joint widening and the occurrence of longitudinal cracks on the pavement, a simple Chi square 2x2 contingency table test was used, where the data was categorized into roads with longitudinal cracks and those without longitudinal cracks as can be seen in Table 10. The null hypothesis is that the type of pavement widening joint is not related to the number of pavements with longitudinal cracking. The alternative hypothesis is that the type of pavement widening joint is related to the number of pavements with longitudinal cracking.

Result shows a Chi square (X^2) of 3.39 with a p-value (0.065) was obtained. With a 90% confidence interval the null hypothesis was rejected. Therefore, the type of pavement widening joint is related to the occurrence of longitudinal cracks on pavements with less cracking occurring on tapered widening joints compared to vertical widening joints.

Table 10: Summary of Pavement Cracking by Joint Type

Joint Types	Cracks	Absence of Cracks
Vertical widening joint projects	13	9
Tapered widening joint projects	1	5

Widening Joint Type Effects on Severity of Deterioration

To determine the effects of widening joint type on severity of deterioration, the range of levels of deterioration was found to be 0 to 12 for the tapered joint widening projects and 0 to 44 for the vertical joint widening projects. To further explore the relationship between joint construction methods and future pavement deterioration, the CDV values were categorized with values of 0 as undamaged, 1 to 15 as lightly damaged, and values greater than 15 as heavily damaged. A graph was produced comparing the levels of deterioration for the two types of widening joints as shown in Figure 31. The graph clearly shows consistently higher frequency of occurrence for longitudinal cracks on vertical joint widening projects compared to tapered joint widening projects for each class of cracking severity.

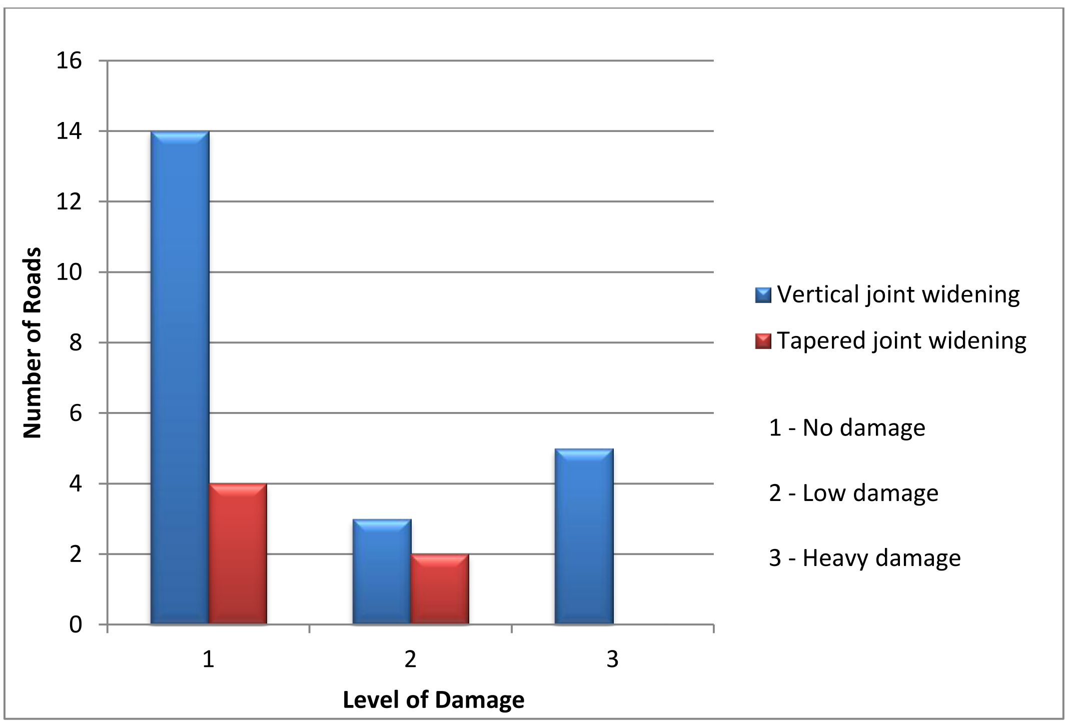


Figure 31: Graph. Plot Comparing Widening Joints and Severity of Damage

To determine if the difference in the levels of damage is indicative of a significant difference in the effects of the joint widening type, a Chi square test of independence was used to analyze the data and summarized in Table 11.

- H_0: The type of pavement widening joint is independent of the extent of damage.
- H_1: The type of pavement widening joint is related to the extent of damage experienced by the pavement.

Table 11: Summary of Pavement Damage Extent with Ranking by Type of Widening

Joint Type	No Damage	Low Damage	Heavy Damage
Vertical joint widening	14	3	5
Tapered joint widening	4	2	0

The expected values (E) obtained from the test can be found in Table 12.

Table 12: Table of Expected Values (E)

Joint Type	No Damage	Low Damage	Heavy Damage
Vertical joint widening	14.1	3.93	3.93
Tapered joint widening	3.86	1.07	1.07

Considering $\alpha = 0.05$

The calculated X^2 (Chi square) = 2.39, with 2 degrees of freedom but at a 95% confidence level ($\alpha = 0.05$, $X^2 = 5.991$) the null hypothesis is accepted indicating that the type of widening joint is independent of the extent of damage. This may be due to true lack of a relationship between the two or due to the small sample size of the tapered widening joint.

Gradation

The data shows that 100% of the projects were constructed with base aggregate of gradation W. This can be found in Appendix C. No analysis can therefore be carried out to examine the possibility of the difference in levels of deterioration being a result of differences in base aggregate gradation.

Moisture Content of Base

An R-value is a measure of a material's resistance to plastic deformation and this is influenced by the moisture content of the material. During the selection of base material by WYDOT, the material is selected such that the difference in R-Values at exudation pressures of 300 psi and 200 psi is less than or equal to 5. The selection of a material to satisfy this criterion ensures that normal variations in moisture content experienced on most roads in Wyoming do not significantly affect the strength of the base.

The data on moisture content for the projects under study as presented in Appendix C indicate a mean moisture content of 4.5% with a standard deviation of 0.01. The low standard deviation points to small variations in the moisture contents and thus it can be inferred that there was no significant change in R-Value for the tested projects from acceptable R-Values.

Base Widening Material

Thirteen of the projects utilized Recycled Asphalt Pavement (RAP) for base widening compared to 15 projects that used crushed base (CB). Of the projects that used RAP, 30.8% experienced some deterioration compared to 26.7% for CB. Since the two types of construction materials used for base widening recorded an approximately equal proportion of damaged roads in terms of the CDV values, an inference can be made that the type of base material used has no significant impact on the deterioration of the pavement.

Widening Joint Location

The location of the widening joint on the roadway was also considered as a possible factor that may affect the occurrence of deterioration since joints located in the travel lane may experience more traffic loads compared to joints located in the shoulder. Fourteen projects had their joints located in the shoulder and the remaining 14 had their joints in the travel lane.

Table 13: Data comparing longitudinal crack occurrence for two joint locations

Categories	Cracked	No Cracks
Shoulder	5	9
Travel Lane	9	5

An analysis of the data presented in Table 13 resulted in a chi square value of 2.29, a degree of freedom of 1 and a p-value of 0.131. Since the p value was greater than 0.1, there was no statistically significant difference in the occurrence of longitudinal cracks for projects with joints in the travel lane compared to those with longitudinal joints in the shoulder of the roadway.

However further analysis of widening joints located in the travel lane was performed. The widening joints located in the travel lane were separated into whether they were located in the wheel path or not. Of the 14 projects found in the travel lane, 8 were identified as having joints in the wheel path (2-4’ from outside edge of lane) and the remaining 6 were found to be outside the wheel path (non-wheel path). The plot of joints located in the travel lane (wheel path and non-wheel path) can be found in Figure 32, which shows that the widening joints located in the wheel path have higher longitudinal cracks (CDV values) compared to the joints in the non-wheel path.

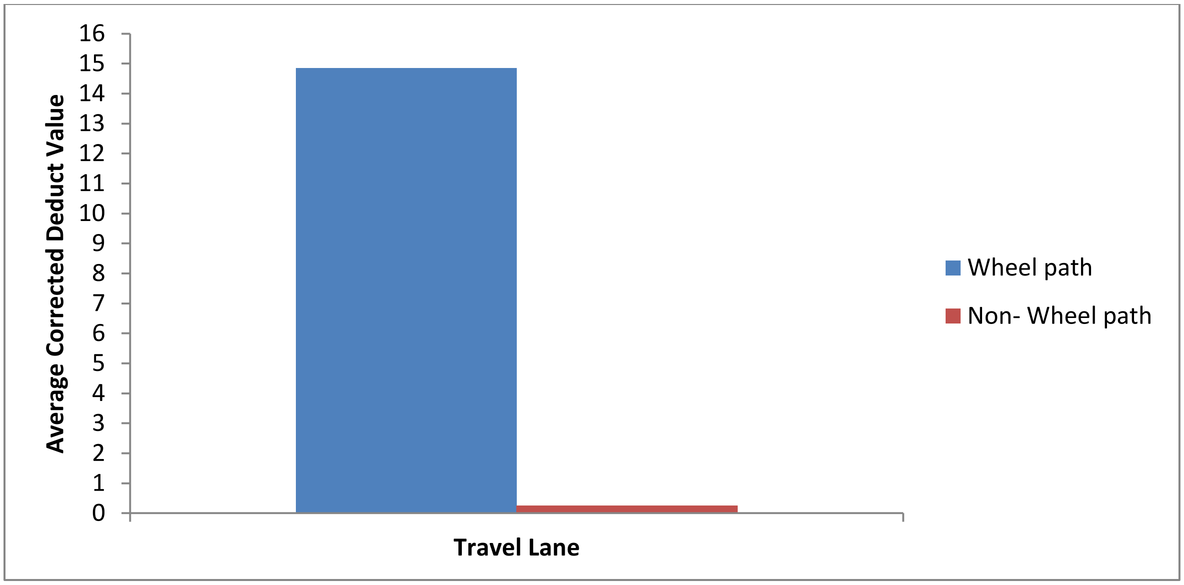


Figure 32: Graph. Plot of Joints Located in the Travel Lane (Wheel path and Non-wheel path)

Statistical analysis was performed to determine if there is a difference between joints located in the wheel path and others. Results indicate a p-value (0.0249) less than the alpha level of 0.1, which means there is a significant difference caused by whether the joint is located in the wheel path or not. Table 14 shows the analysis of variance (ANOVA) statistical results for the location of joints within the wheel path and away from the wheel path.

Table 14: Analysis of Variance between Joint Location (Wheel path and Non-Wheel path)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	730.209	730.209	6.56	0.025
Error	12	1334.992	111.249		
Corrected Total	13	2065.201			

The box plot found in Figure 33 also indicates that the observed variation of corrected deduct values (CDV) within the joints located in the wheel path (WP) is higher compared to the joints in the non-wheel path (NWP).

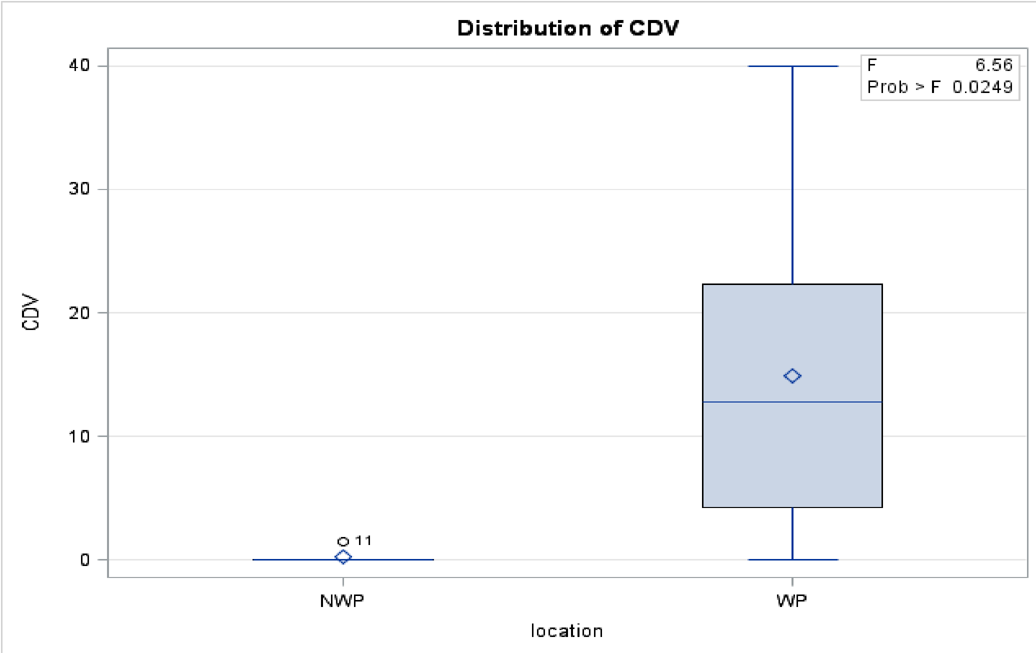


Figure 33: Graph. Boxplot of Joint Location (Wheel path and Non-Wheel path)

Analysis of Joint Type and DCP Test Data

An analysis of joint type effects on the stiffness of the base as inferred from DCPT test data was carried out using variance statistical analysis. The purpose of this test was to determine whether there is a statistically significant difference in the base stiffness of the vertical widening joints compared to tapered widening joints.

Based on the diagram for the field testing protocol found in Figure 18, the five points (L1, J, R1, R2, and R3) at the three locations of each road were considered as “Placement”, and the tapered and vertical widening joint types were described as “Treatment”. The analysis considered the depth from 0” to 6” (top layer) separate from the lower layer (6” to 12”). Results of the analysis are presented in Appendix E.

Plots of the mean values of penetration per blow (lower values of penetration per blow indicate better base performance) for the top and bottom layers of the base, considering the five locations across the joint are shown in Figures 34 and 35 respectively. The plots show similar trends for the top and bottom layers across the widening joints.

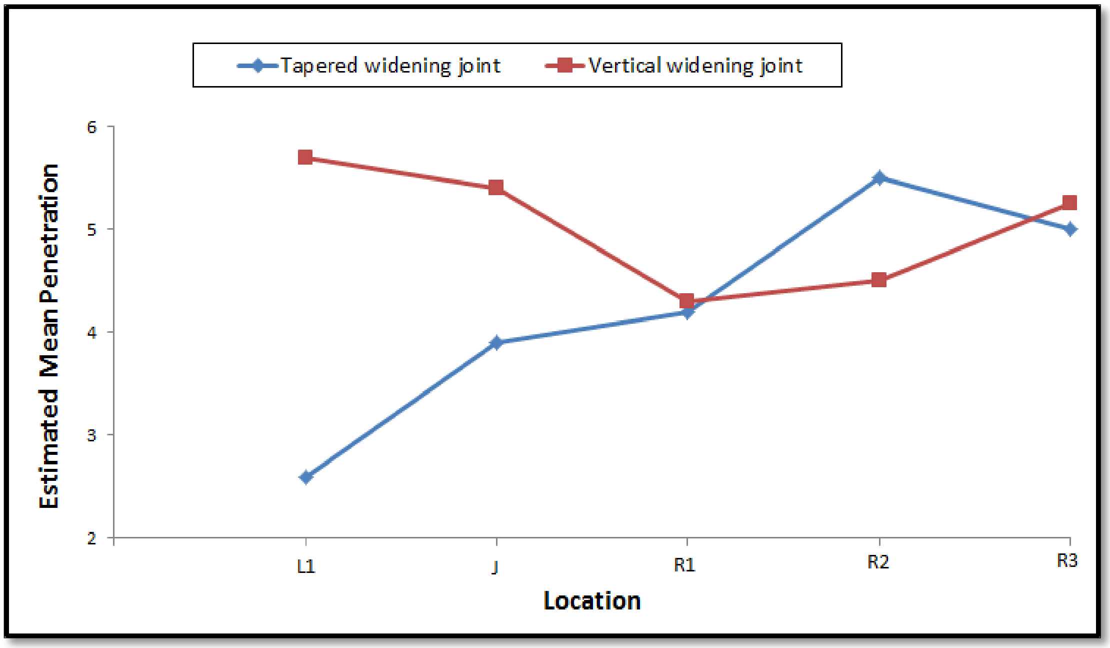


Figure 34: Graph. Plot of Mean Penetration per blow for Joint Types at Top Base Layer

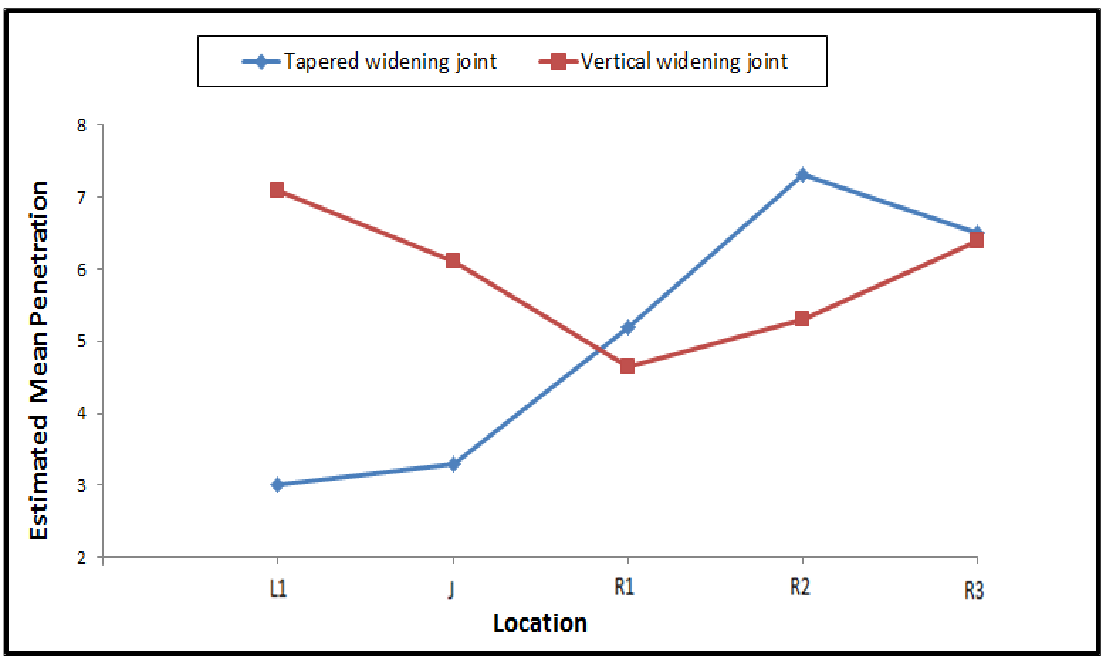


Figure 35: Graph. Plot of Mean Penetration per blow for Joint Types at Bottom Base Layer

The differences in penetration per blow for vertical widening joints compared to tapered widening joints were found to be statistically significant at a 95% confidence interval at some of the locations, which corresponds to a p-value of 0.05 or less. For the top layer of base, a significant value of 0.002 was recorded and a value of 0.007 was recorded for the bottom layer.

The results of the analysis indicate significantly better stiffness of the tapered base compared to the vertical base at the joint (J) and 1 feet offset from the joint on the existing section (L1). However at 1 feet from the joint on the widened base (R1), the stiffness of both joint types are approximately the same, and then the base of both joint types become less stiff at 2 feet offset from the joint (R2) but with the tapered joint type less stiff than the vertical joint type, and at 3 feet from the joint (R3), the base of both joint types show approximately equal stiffness/strength.

Analysis of Joint Type and Deflection Data

Data validation and quality checks were performed for the FWD deflection data using the MODTAG software. The shape of the deflection basin was evaluated to assess the pavement homogeneity and quality of the deflection data. The surface modulus was reviewed to assess the number of effective sensors and linearity of the pavement materials. This was important to check for any errors that may be associated with the deflection data.

The FWD deflection data for all the projects were corrected for temperature. The fifteen deflection data points for each test station were averaged and arranged according to their five locations as L1, J, R1, R2, R3, with 'J' denoting the joint location, 'L1' left of joint on the existing section, R1-3 denoting test stations right of joint on the widen section. This was done for the two different joint types, vertical and tapered. Since the base layer was the focus of this research project, sensor 4 (D4) located 18 inches from the center of the FWD loading plate was used to compute the average deflections for the joint types (vertical or tapered).

High deflection values means weak pavement sections whereas low deflection values indicate strong pavement sections. The mean deflection profile plot of the two joint types can be found in Figure 36. The plot indicates that the vertical joint has higher deflections than that of the tapered joint across the five locations.

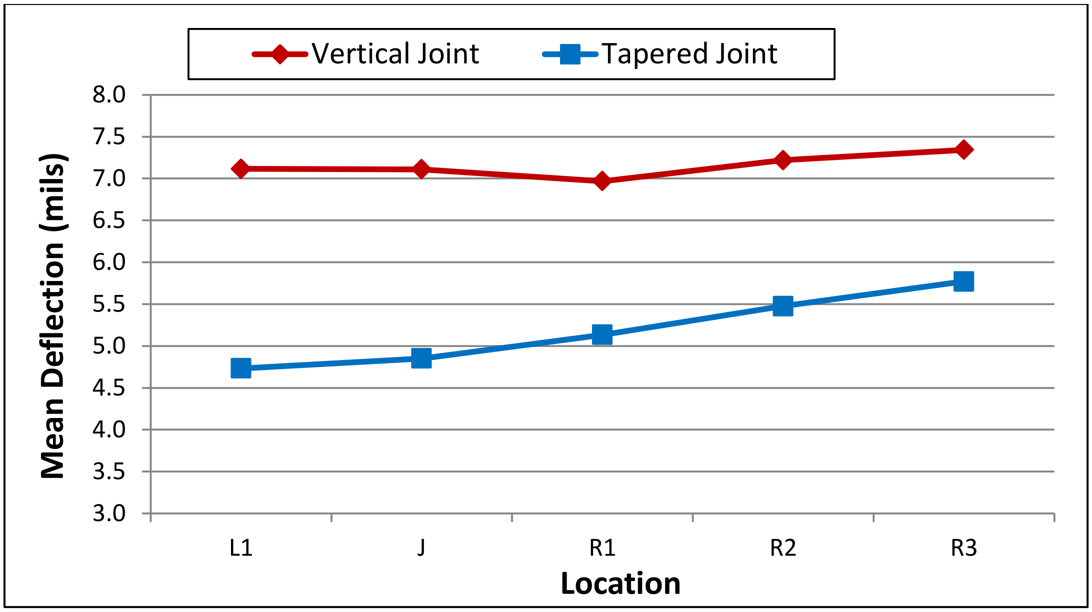


Figure 36: Graph. Mean Deflection Plot of the Two Joint Types

Statistical analysis of the deflection data was performed to establish which of the two joint types (vertical or tapered) provide better pavement support or performance. The statistical analysis was to determine whether or not the true mean deflection can be declared different between the vertical and tapered joints. The null hypothesis is that the true mean deflections are the same for vertical and tapered joints. The alternative hypothesis is that the true mean deflections are not the same for vertical and tapered joints. The null hypothesis will be rejected at an alpha level of 0.1 (90% significant level). The statistical analysis results can be found in Appendix E.

The results from the analysis for all 5 locations indicate that there are statistically significant differences between the mean deflection of the vertical and tapered joints. This means that the tapered joint types exhibit much better strength across the five stations compared to the vertical joint types.

Analysis of Joint Type and Back-Calculated Moduli

The FWD deflection data for existing pavement widening projects was checked for data quality issues before analysis was performed. The MODCOMP pavement analysis software was utilized to determine the pavement layer moduli through the process of back-calculation. There are three basic approaches to the back-calculation of pavement layer moduli: equivalent thickness optimization and iterative methods. [62] The MODCOMP software uses the iterative method that progressively adjusts the moduli to fit the deflection basin. The basic principle is to start off with "seed" moduli from which surface deflections are computed. The "seed" moduli establish the starting point from which the back-calculations begin. Only a small number of iterations will be required to achieve a solution if they are close to the correct parameters. Otherwise it will take more iterations to achieve a solution. Setting appropriate values for the seed moduli requires good information regarding the types of materials in the pavement layers, their age and their condition. The computed deflections are compared to the measured deflections and the seed moduli as a function of the magnitude of the difference in deflections. The MODCOMP gives a lot of control over the back-calculation process since it was written for use by researchers; however it requires some advanced knowledge.

The MODCOMP back-calculation procedure uses the mechanistic-empirical pavement design approach to calculate the moduli of the pavement layers from the surface deflection data. It can be used to perform linear and non-linear pavement analysis. It provides three levels of quality of deflection fit tolerance: ‘LOW’, ‘MEDIUM’ and ‘HIGH’. [62] Table 15 shows the Deflection Fit Tolerances. For this research effort, the high tolerance level (0.15) was used. The other tolerance criterion used is the modulus rate of convergence. This criterion provides some control on the precision of the moduli. A suitable rate of convergence of 1.0 percent was assigned. Each of the four layers was modeled as linear.

Table 15: Deflection Fit Tolerances for Linear and Nonlinear Pavement Systems

Deflection Fit Tolerance Level	Tolerances in Percent	
	Pavement System with All Linear Layers	One or More Nonlinear Layers
Low	0.5	1
Medium	0.3	0.6
High	0.15	0.3

The deflection data from the FWD field testing is imported into the MODTAG software after it had been converted into the PDDX format using the AASHTO PDDX. The software determines the number of drops per location during the import process and the data is aggregated. Once the deflection data has been averaged, the pavement structure is modeled. A consecutive cutoff RMSE value of 4% was selected for the back-calculated process. This is in agreement with several literature sources which recommend a range of 1% to 4%, with RMSE value of 2% providing an encouraging outcome. [56]

In order to perform the back-calculation, the pavement structure, which consists of a system of layers, with each layer having a modulus of elasticity, a Poisson’s ratio, and a thickness has to be modeled. If the modeled pavement accurately describes the actual pavement structure, then the moduli that are computed should yield a good match between the measured deflections and the deflections that are calculated using the MODCOMP software. Thus accurate pavement structure information is very important in the back-calculation process to determine accurate pavement layer moduli.

The pavement structure was modeled as five different layers of varying thicknesses for the back-calculation analysis: Asphaltic concrete, base layer, upper subgrade, lower subgrade and bedrock. The subgrade layer was modeled as two different layers; upper and lower subgrade because the moisture content in the subgrade is most likely not uniform. The upper portion of the subgrade, near the base or sub-base is subject to seasonal changes due to weather, which can significantly affect the modulus. Upper subgrade layer was assigned a thickness of 24 inches, considered a higher limit than what the Wyoming Department of Transportation (WYDOT) generally uses in the preparation of the top of the subgrade layer before placement of subsequent layer. The deeper (lower) subgrade layer is not so affected by the weather. The bedrock layer was not calculated for modulus, it was assigned a fixed modulus. This is because the bedrock is assumed to be semi-infinite in depth, with a constant elastic modulus. The other four pavement layers were calculated for modulus. Model of the pavement structure used for the analysis can be found in Figure 37.

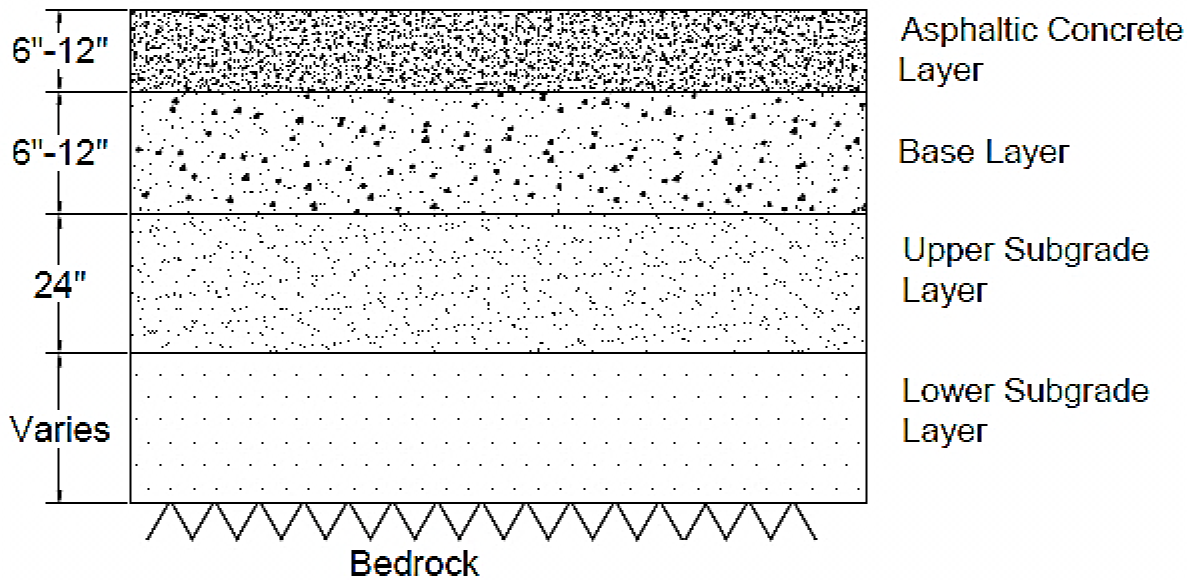


Figure 37: Diagram. Pavement Structure Model

The different pavement layers were each assigned a "seed" moduli, Poisson ratio depending of the material type, and a coefficient of elasticity. Back-calculation of the pavement layer moduli for the 28 existing widening projects was performed. The "seed" modulus was occasionally varied during the iterative back-calculation process to achieve accurate and reasonable pavement layer moduli that yielded a good match between the measured deflections and the calculated deflections. For each project, the pavement layer moduli were back-calculated at each of the fifteen test stations. The pavement layer moduli (E) for each of the fifteen stations and the Root Mean Square Error (RMSE) for WY 220 (existing project) with a vertical joint type can be found in Table 16. This project has a crushed rock base layer and Hot Plant Mix Bituminous (HPMB) for the Asphaltic Concrete layer. The Asphaltic concrete layer modulus is denoted as E1, the base modulus as E2, and the upper and lower subgrade as E3 and E4 respectively. The results show that all fifteen stations have RSME less than 3%. This indicates that there is good overall match between the measured and the calculated deflection basins for each of the test stations. The RSME values provide confidence in the back-calculated modulus for each pavement layer.

Table 16: Back-calculated Pavement Layer Moduli (WY 220)

Station	RMSE	E1	E2	E3	E4
1	2.08	870000	27100	10500	7390
2	1.41	1110000	15800	15400	7100
3	1.95	942000	27900	11500	7510
4	2.23	730000	32700	9980	7600
5	1.3	707000	21800	11800	7460
6	1.78	1190000	65300	20700	10100
7	1.27	982000	66700	21900	9830
8	1.35	964000	57500	21000	9820
9	2.13	886000	44800	18800	9890
10	2.07	821000	28100	21700	9460
11	2.36	1170000	23400	15900	10200
12	2.61	1250000	24800	14400	9910
13	2.42	1010000	29700	12700	9370
14	1.89	991000	18000	15100	8630
15	2.36	978000	17900	14500	8530

The back-calculated moduli for the fifteen test stations on all existing projects were then averaged to 5 locations: left of joint (L1), joint (J), one foot right of joint location (R1), two feet right of joint location (R2), and three feet right of joint location (R3). The pavement layer back-calculated moduli were plotted against the 5 locations (L1, J, R1, R2 and R3) for the base, upper and lower subgrade layers. This can be found in Figure 38. The figure indicates a higher modulus value at the left of joint (L1) for the base layer than the other locations (J, R1, R2, and R3). However, the joint location (J) has slightly lower modulus than the location R1 (one foot right of joint). Locations R2 and R3, 2 feet and 3 feet right of the joint location, respectively show lower modulus than R1. This means the vertical joint type for this particular project indicates relatively better pavement strength at the left (L1) and right (R1) of the joint location than R2 and R3 which are further away from the joint. The upper subgrade however, indicates a higher modulus value at the joint (J) than at locations L1 and R1, one foot to the left of the joint on the existing road and one foot right of the joint on the widened section.

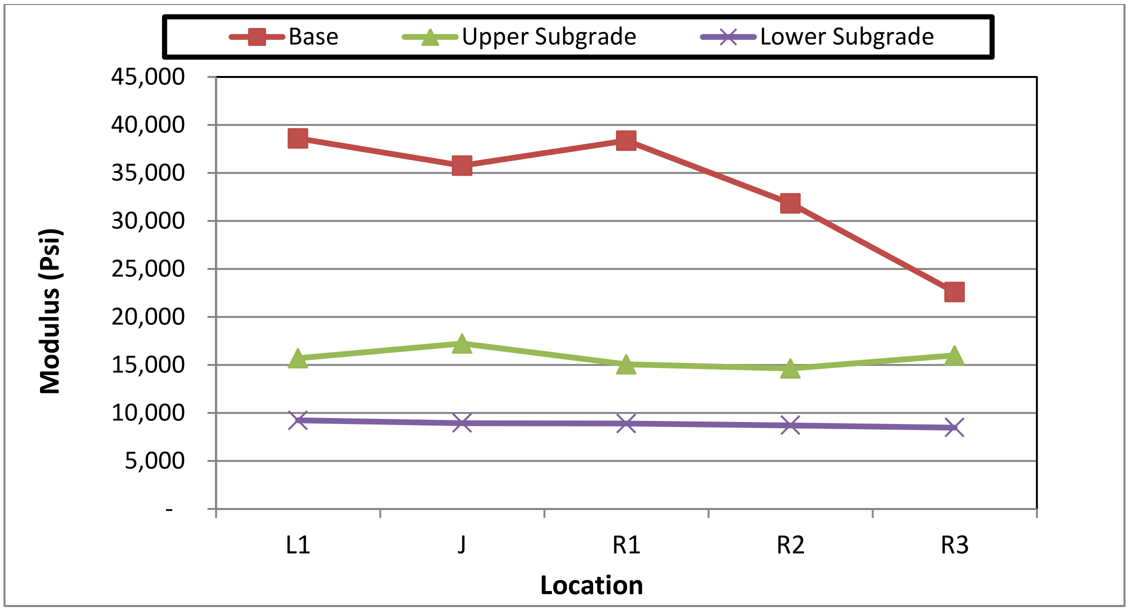


Figure 38: Graph. Average Pavement Layer Moduli for Each Layer (WY 220)

The back-calculated moduli for the base layer (E2) for the 22 vertical joint and 6 tapered joint types were averaged according to the 5 locations: L1, J, R1, R2 and R3. This was done to determine which joint type has higher moduli with respect to the five locations. The base layer modulus was used because this research effort seeks to determine which joint type provides better pavement support with regards to the base layer. Figure 39 shows the plot of the mean back-calculated moduli for the base layer across the five locations. The Figure indicates that the tapered joint type has higher modulus value to the left of the longitudinal joint than the vertical joint type at the same location. It can be inferred that tapered joint type shows slightly better pavement support left of the joint than the vertical joint type. However at the joint location, the vertical joint has almost the same value as the tapered joint. This can be attributed to several factors such as the time of exposure of the cut surface before subsequent works are performed or before the pavement is sealed to prevent water seepage especially into the base layer. Right of the joint location, R1, R2 and R3 has higher moduli for the vertical joints type than the tapered joints type. It can inferred that since vertical joint projects have equal depths across the widening section, while the tapered joint has varying depths across the test stations, the higher moduli for the vertical joints are expected. It means that the vertical joints exhibit relatively better pavement support on the widened sections (right side of the joint) compared to the tapered joint type.

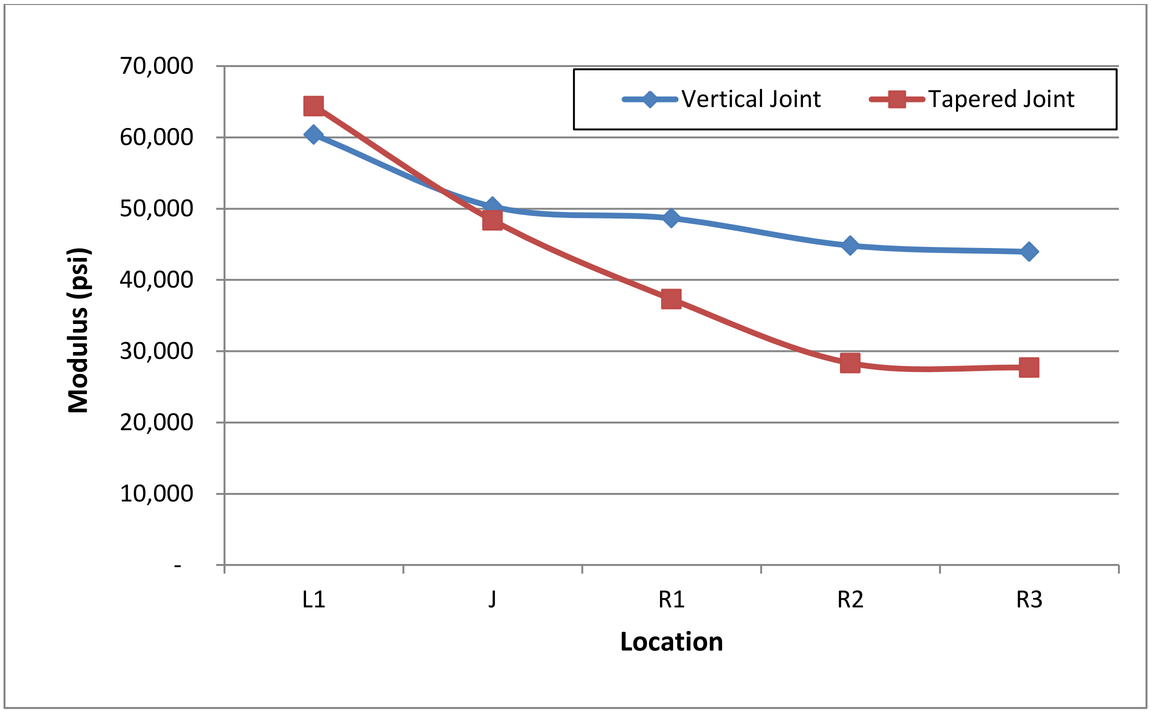


Figure 39: Graph. Averaged Back-calculated Base Layer Moduli for the Different Joint Types

Statistical analysis of the back-calculated moduli data was performed to establish if there are any significant differences between the base materials' layer moduli of the two joint types (vertical or tapered). The statistical analysis can be found in Appendix E. Results show there is no statistically significant difference between the back-calculated moduli for the two joint types with a p-value (0.6476) greater than the alpha level of 0.1.

ANALYSIS OF NEWLY CONSTRUCTED WIDENING PROJECTS

The four newly constructed widening projects were included to serve as a control for this research effort. Most of these projects were completed in late 2012. In order for the two joint types (vertical and tapered) to be constructed on one project, it was proposed that a test section of about 500 feet be reserved for that purpose. Of the four projects, two project locations (WY59 and US16) adopted the proposal to construct the two joint types. However the other two projects could not because they were well advanced with their construction when the proposal was agreed upon. The projects with the two joint types were used to evaluate the effect of the different joint types on the same project, with the same traffic and environmental conditions.

Analysis of Dynamic Cone Penetrometer (DCP) Test Data

As part of collecting field data for this project, the dynamic cone penetrometer (DCP) was used to collect information on the base layer by means of penetration per blow, also known as the penetration index. The penetration index is used to determine the strength of the base layer. The DCP test was taken for each test point. About ten to twelve inches of penetration was taken for each test point. The field penetration data on the base layer was divided into two layers; top base layer of 0” - 6” depth, and bottom base layer of 6”-12” depth. The penetration (mm) per blow obtained from the DCP test data for the top base layer for both the vertical and tapered joint types can be found in Figure 40. The plot indicates that the vertical joint has higher penetration (mm) per blow than the tapered joint. At location L1, the penetration per blow for the two joint types has the same values. Other locations have different penetration values for the two joint types.

Statistical analysis was performed on the top base layer to determine if there is any significant difference between the vertical and tapered joint types. The statistical analysis results can be found in Appendix F. The results indicate that at location R1, we fail to reject the null hypothesis due to a p-value (0.0695) using a 0.1 alpha level. This means that there is significant difference at that location between the tapered and vertical joints, and thus the tapered joint type shows relatively better base strength than the vertical. However there is no significant difference at the other locations (L1, J, R2 & R3) between the joint types.

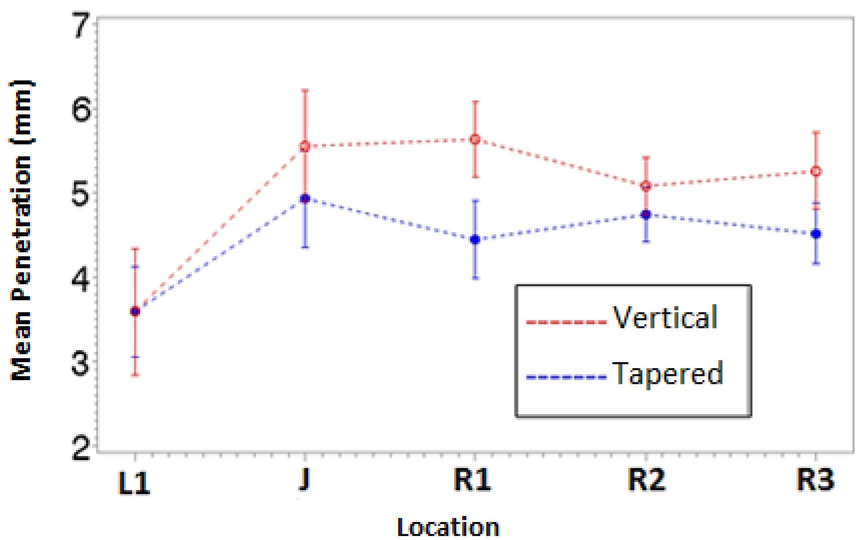


Figure 40: Graph. DCP Results for the Top Base Layer

The bottom part (6”-12”) of the base layer was analyzed as well and can be found in Figure 41. The plot indicates that the tapered joint type has lower penetration values generally for most of the locations (J, R1 & R3) compared to the vertical joint type. This shows that the tapered joint has better pavement support than the vertical joint type. This was confirmed from the statistical analysis, which shows statistical significance with a p-value less than the 0.1 alpha level at locations J and R1. This means that there is statistical difference between the tapered and vertical joint types. Results from the statistical analysis can be found in Appendix F.

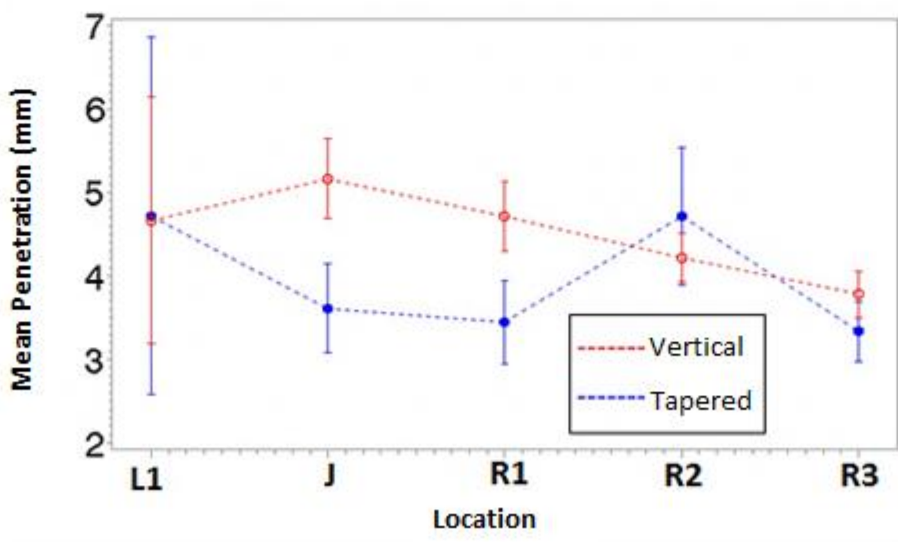


Figure 41: Graph. DCP Results for the Bottom Base Layer

DCP Analysis of Highway WY 59 (Gillette – Montana State Line)

The projects with the two joint types were used to evaluate the effect of the different joint types on the same project, with the same traffic and environmental conditions.

The penetration per blow for Highway WY 59 that has the two joint types was analyzed. The DCP data on the base was divided into two layers; top and bottom base layer. A lower penetration value indicates better base strength and less base strength shows higher penetration values. Figure 42 show the top base layer for highway WY 59. The plot indicates that the vertical joint type has higher penetration than the tapered joint type. This means that the tapered exhibit much better base support than the vertical joint. Statistical analysis was performed to determine if there are differences between the two joint types across the locations. Using an alpha level of 0.1, result shows that there is significant difference between the tapered and vertical joint types with a p-value of 0.0577. However, the univariate analysis of each location shows that L1 has significant difference between the tapered and vertical, but the other locations (J, R1, R2 and R3) do not show any statistical significant differences.

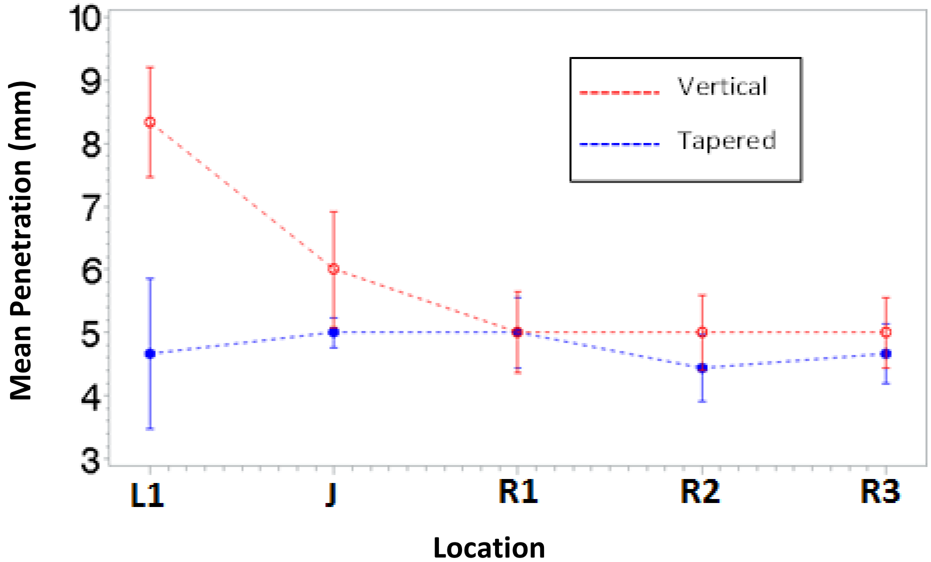


Figure 42: Graph. DCP Test Results for the Top Base Layer for WY 59

The bottom base layer for highway WY 59 can be found in Figure 43. The plot indicates that the vertical joint type has higher penetration than the tapered joint type. This means that the tapered exhibit much better base support than the vertical joint. Statistical analysis was performed to determine if there are differences between the two joint types across the locations. The results of the statistical analysis can be found in Appendix F. Using an alpha level of 0.1, result from the univariate analysis of each location shows that there is significant difference at locations J and R3 between the tapered and vertical. The other locations (L1, R1 and R2) do not show any statistically significant differences.

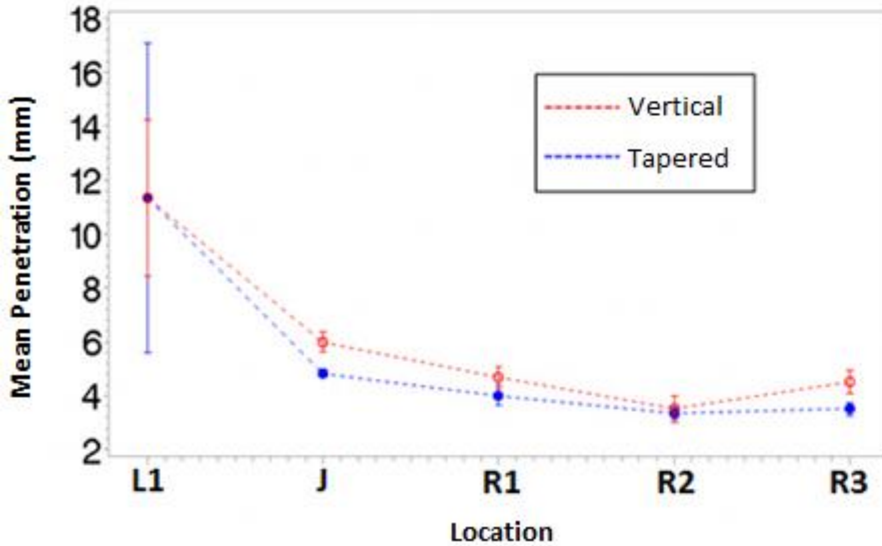


Figure 43: Graph. DCP Test Results for the Bottom Base Layer for WY 59

DCP Analysis of Highway US 16 (Worland – Ten Sleep)

The penetration per blow from the DCP test data for Highway US16 that has the two joint types was analyzed. The top (0-6") and bottom (6"-12") base layers were analyzed. Figure 44 show the top base layer for highway US 16. The plot indicates that generally the vertical joint type has higher penetration values than the tapered joint for most of the locations with the exception of the L1 location.

A statistical analysis was performed to determine if there are statistically significant differences between the joint types in terms of relative strength of the base using the penetration values. The statistical results can be found in Appendix F. Results from the univariate analysis of each location shows that there is significant difference at locations L1 and R1, with p-value less than 0.1 between the tapered and vertical. However the other locations (J, R2 and R3) do not show any statistically significant differences. Thus the tapered joint type shows relatively better base support to the right of the joint location compared to the vertical joint.

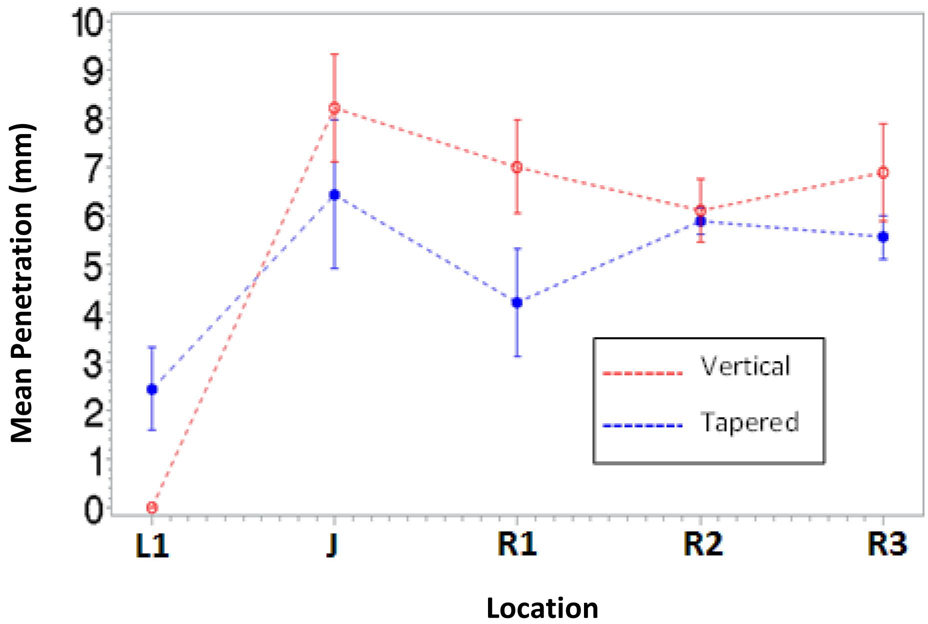


Figure 44: Graph. DCP Test Results for the Top Base Layer for US 16

The penetration values for the bottom base layer for highway US 16 can be found in Figure 45. The plot indicates that generally the vertical joint type has higher penetration values than the tapered joint for most of the locations with the exception of the L1 location where the tapered seem to have higher penetration value.

A statistical analysis was performed to determine if there are statistically significant differences between the joint types in terms of relative strength of the base using the penetration values. The statistical results for the bottom base layer for US 16 project can be found in Appendix F. Results from the univariate analysis of each location shows that there is significant difference at locations L1, J and R2, with p-value less than 0.1. This means that there are significant differences in relative base strength between the vertical joint and the tapered joint types across these locations. However the other locations (R1 and R3) do not show any statistically significant differences.

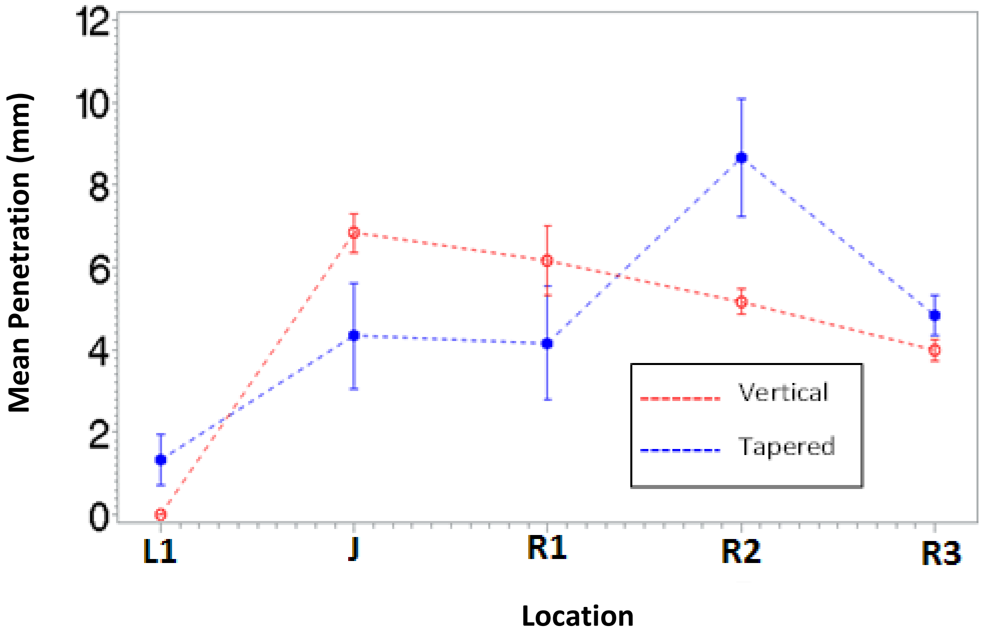


Figure 45: Graph. DCP Test Results for the Bottom Base Layer for US 16

Confined and Unconfined DCP Analysis

The research team performed DCP tests on the unconfined and confined base layer, before and after placement of asphaltic concrete, respectively. DCP testing on the confined base layer is performed after the asphaltic concrete has been placed and the project completed. Before the confined DCP testing is performed, pavement cores are taken at the locations to be tested. With respect to the unconfined DCP testing, the tests were performed on the base layer prior to the placement of asphaltic concrete. Figure 46 shows DCP testing on unconfined base layer prior to paving with asphaltic concrete. The testing on the unconfined base layer was performed at the joint location (J), and to the right of joint at R1, R2 and R3. The purpose is to investigate and compare the difference in in-situ base strength for the confined and unconfined base layer.

Figure 46: Photo. DCP Testing on Unconfined Base Layer

The mean penetration results for the confined and unconfined DCP testing on WY 59 for the different joint types can be found in Figure 47. The solid lines show the confined (or after asphaltic concrete placement) DCP test results and the dotted/broken lines (unconfined DCP) test results. Mean penetration result for the unconfined (before asphaltic concrete placement) indicates lower penetration values at locations J and R1 for the tapered joint than for the vertical joint. This means that the tapered joint has a better base strength at those locations compared to the vertical joint type. However at locations R2 and R3, two and three feet away from the joint respectively, the vertical joint seems to have better base strength. Results for the confined DCP tests indicate the vertical joint has a higher mean penetration (mm) per blow across four locations (J, R1, R2 and R3) than the tapered joint. This means the tapered joint exhibit a better base strength than the vertical joint. The confined base shows lower mean penetration values than the unconfined base, which indicates that the base layer provides better pavement support when confined than unconfined.

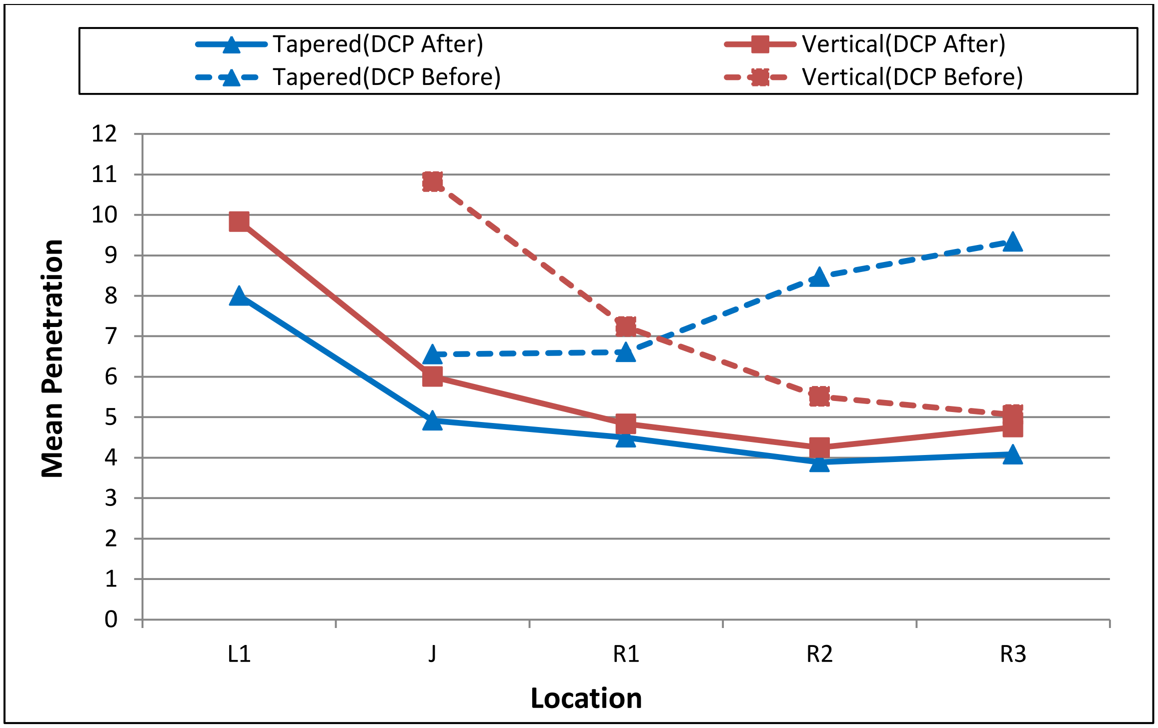


Figure 47: Photo. Confined and Unconfined DCP Test Results for WY 59

Figure 48 shows the mean penetration for the before and after DCP tests for US 16 project. The graph shows the mean penetrations for both vertical and tapered joints. The confined (DCP after paving) mean penetration shows that the tapered joints have lower values compared to the vertical joints especially at locations J and R1. The vertical joint has lower mean penetration values at location R2. It can be concluded that the tapered joint exhibit better joint strength at the J and R1 locations. The unconfined base (before asphaltic concrete placement) mean penetration shows tapered joint has lower values at location J and R1, but higher values at locations at R2 and R3 than for the vertical joint. Results indicate that the tapered joint provides better base strength compared to the vertical joint at the locations J and R1.

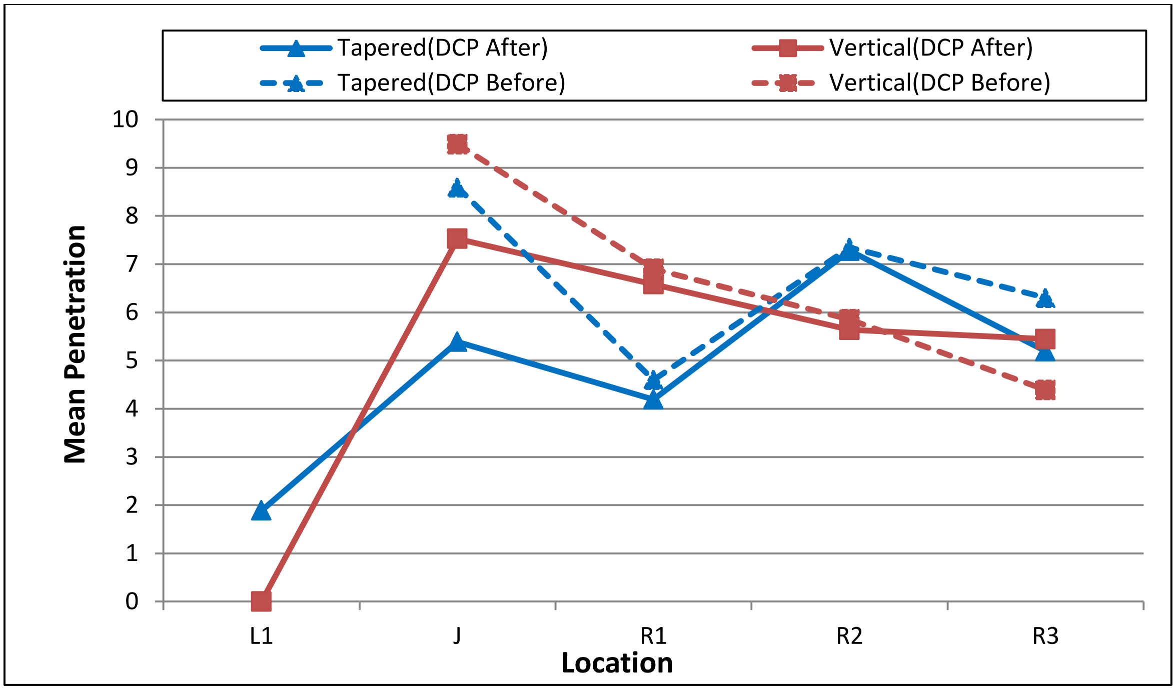


Figure 48: Photo. Confined and Unconfined DCP Test Results for US16

Analysis of Joint Type and Deflection Data

The non-destructive deflection data was analyzed to identify if there are any variations between the two joint types. The fifteen nondestructive deflection data were corrected for temperature and averaged along the five locations: left of joint (L1), joint (J), one foot right of joint (R1), two feet right of joint (R2), and three feet right of joint (R3). Since the base layer was the focus of this research project, sensor 4 (D4) which is located 18 inches from the center of the FWD loading plate was used to compute the average deflections for the joint types (vertical or tapered).

The deflection measurements for WY 59 showing both tapered and vertical joint types can be found in Figure 49. Although the figure shows that the tapered joint has higher deflection than the vertical joint for the WY 59 project, no statistical analysis could be performed to establish statistical difference between the two joint types for WY 59 project because of the small sample size.

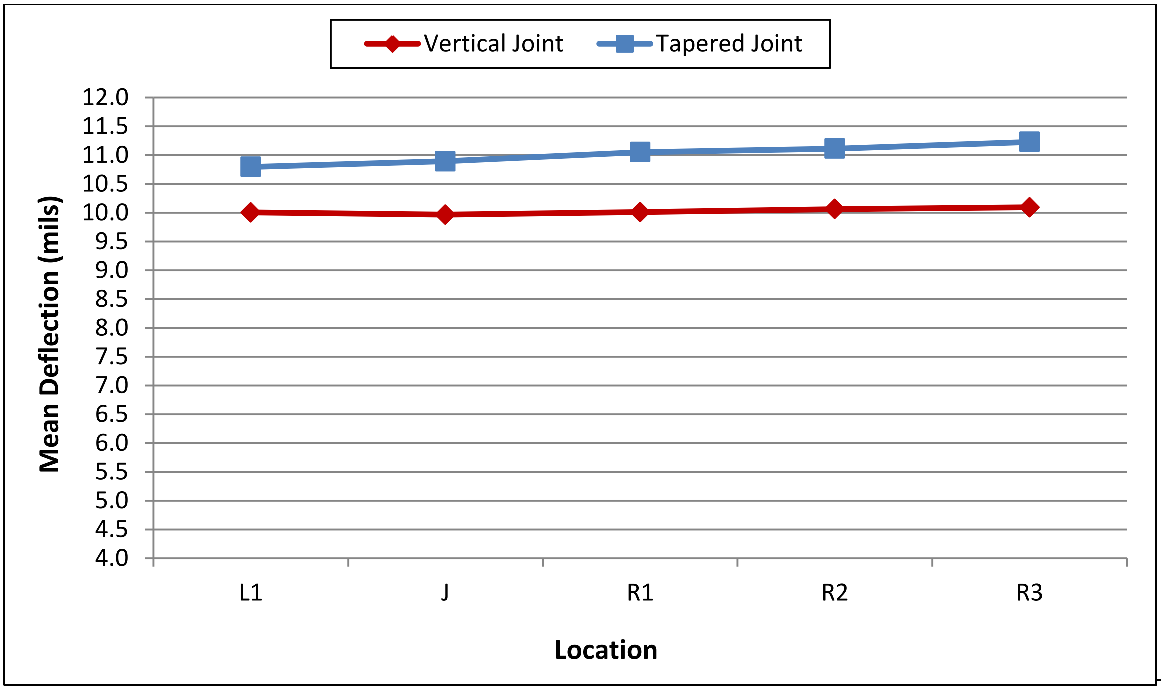


Figure 49: Graph. Mean Deflection Measurements for WY 59

Descriptive analysis of the mean deflection of the vertical and tapered joint types for US 16 was performed. Figure 50 shows the mean deflection measurements of both vertical and tapered joint types for US 16. The plot indicates the tapered joint has relatively higher deflections than the vertical joint across the five locations. No statistical analysis could be performed to establish statistical difference between the two joint types for US 16 project because of the small sample size.

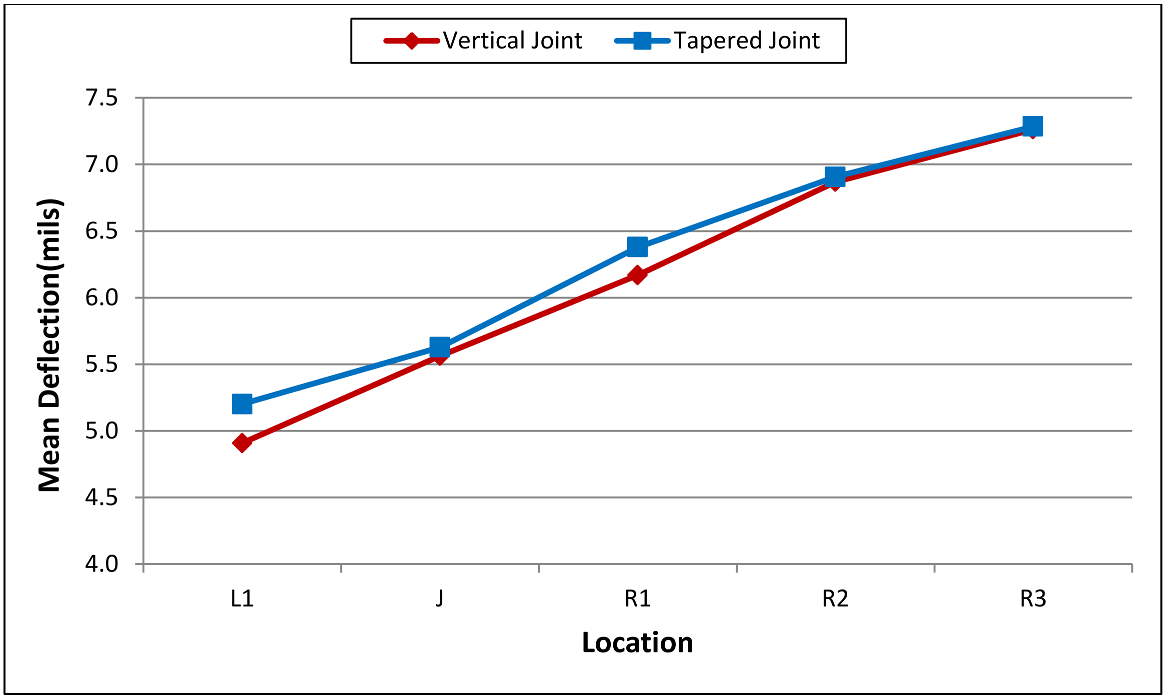


Figure 50: Graph. Mean Deflection Measurements for US 16

Deflection data for the other two new highway projects US 85 and US 191, and highway WY 59 and US 16 discussed in earlier sections were averaged to determine which joint type exhibit better base support across the different joint types (tapered and vertical). Figure 51 shows the mean deflections for all the projects. The Figure indicates that the vertical joint type has relatively higher deflection values than the tapered joint across the five locations. Statistical analysis was performed to determine if there is significant difference between the two joint types in terms of deflection measurement. The statistical results can be found in Appendix F. Results show a p-value of 0.9519, which indicate there is no significant difference between the two joints. This means we could not statistically conclude whether the tapered joints exhibit better strength for the base layer than the vertical joints. The reason could be due to few projects, and to the small dataset used for the analysis.

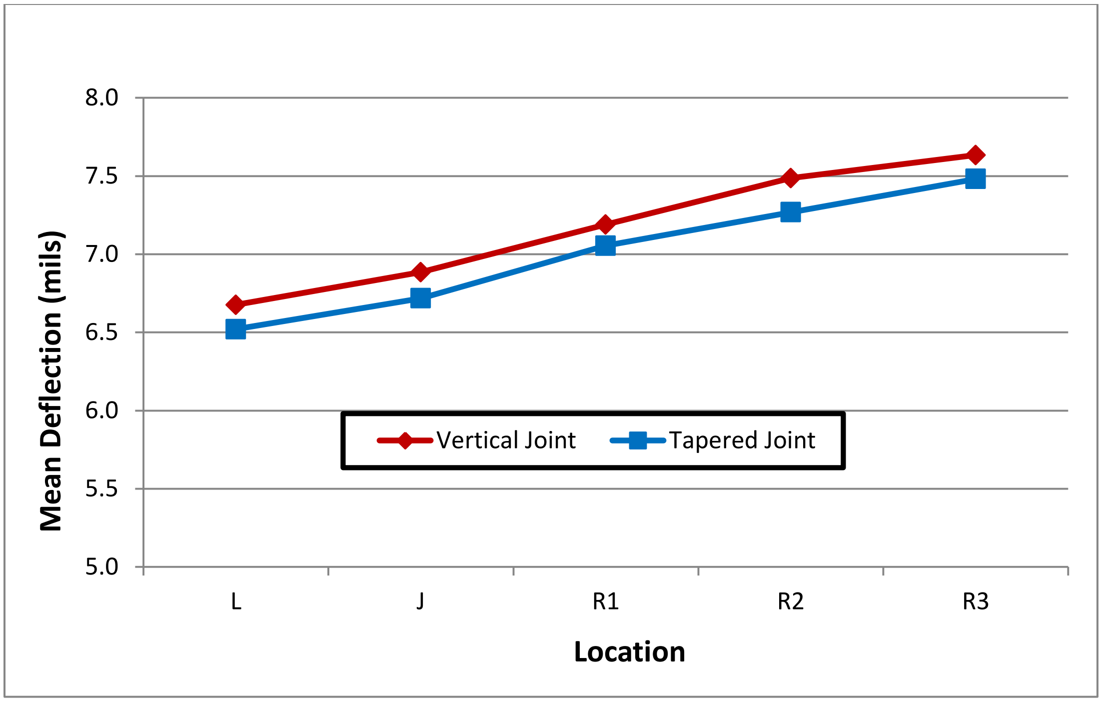


Figure 51: Graph. Mean Deflection Data

Analysis of Joint Type and Back-calculated Moduli

The back-calculated moduli for the projects that have the two joints constructed on them were compared and analyzed to determine which joint type performs better. The methods for the analysis of back-calculated moduli were discussed in the earlier section of this chapter. The moduli for both tapered and vertical joints on the WY 59 project can be found in Figure 52. The figure shows the tapered joint has higher moduli values at locations L1 and J than the vertical joint. This indicates the tapered joint has relatively better strength at locations L1 and J than the vertical. However, the vertical joint has better base strength to the right of joint than the tapered joint. No statistical analysis could be performed because of the small sample size to establish statistical difference between the two joint types for WY 59 project.

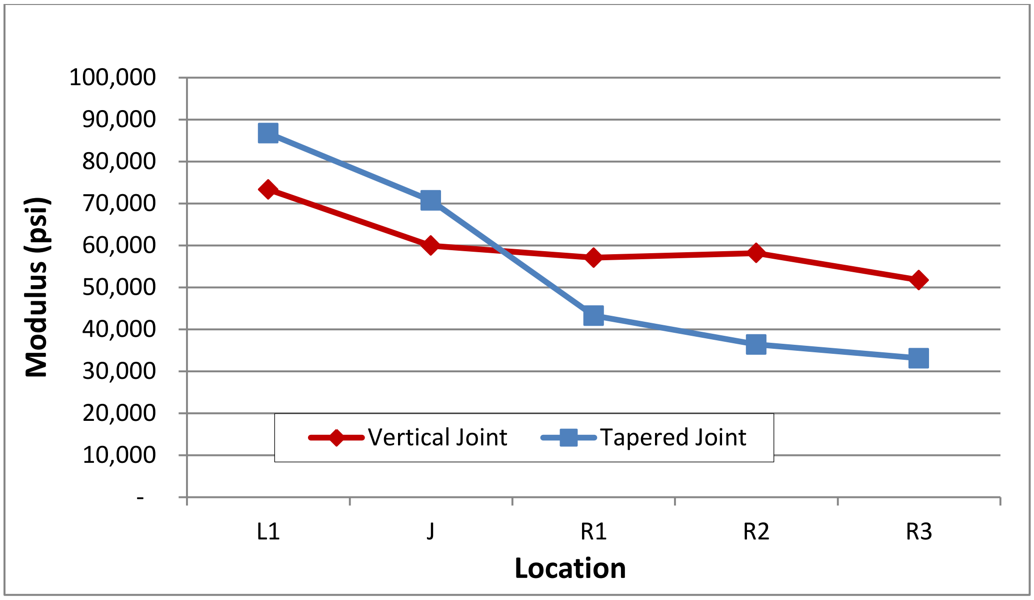


Figure 52: Graph. Moduli for Base Layer for Highway WY 59

The moduli for the tapered and vertical joints on US 16 can be in Figure 53. The graph shows the tapered joint has higher modulus at the location L1 and lower moduli value at the joint location than the vertical joint. The vertical joint has relatively higher moduli at locations R1, R2 and R3 than the tapered joint. This means that tapered joint has relatively higher strength at location L1 than vertical, but the other locations J, R1, R2 and R3 show vertical joints have better strength than the tapered joints. No statistical analysis could be performed because of the small sample size to establish statistical difference between the two joint types for US 16 project.

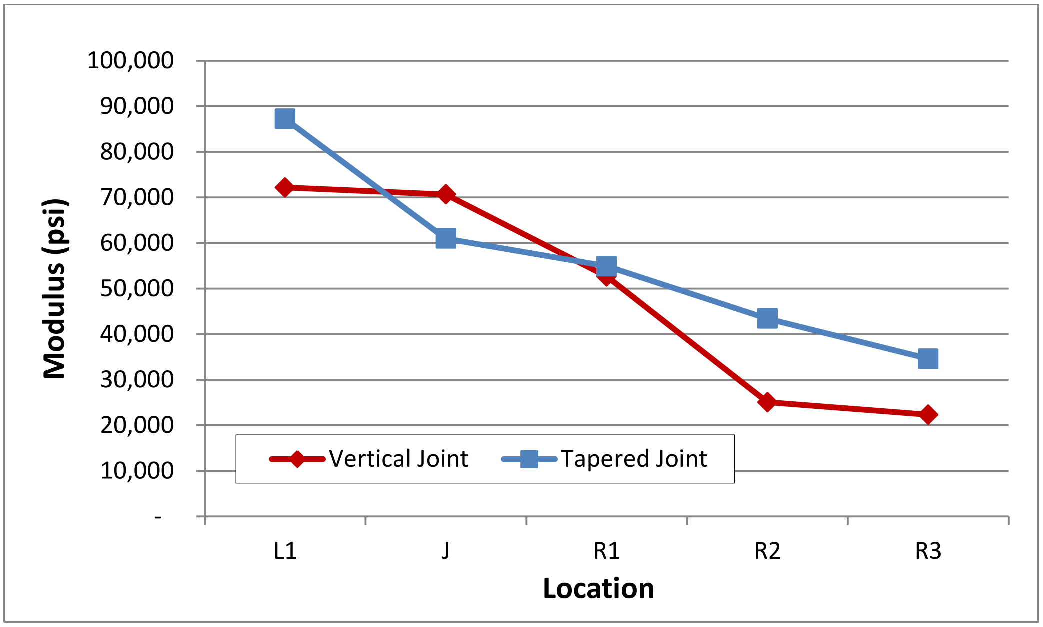


Figure 53: Graph. Moduli for Base Layer for Highway US 16

The moduli for the other two new highway projects US 85 and US 191, and highway WY 59 and US 16 discussed in this section were averaged across the different joint types (tapered and vertical). Figure 54 shows the mean moduli for the base layer. The graph indicates that the tapered joint has relatively higher modulus value at location L1 than the vertical joint. However at the joint J and R1 locations the vertical joint has a higher modulus value than the tapered joint. This means that the tapered joints exhibit relatively less strength to the right of joint. Statistical analysis was performed to determine if there is any significant difference between the joint types; vertical and tapered. Results from the statistical analysis can be found in Appendix F. The results show a p-value of 0.8463, which indicate there is no statistically significant difference between the tapered and vertical joint types in terms of the back-calculated moduli.

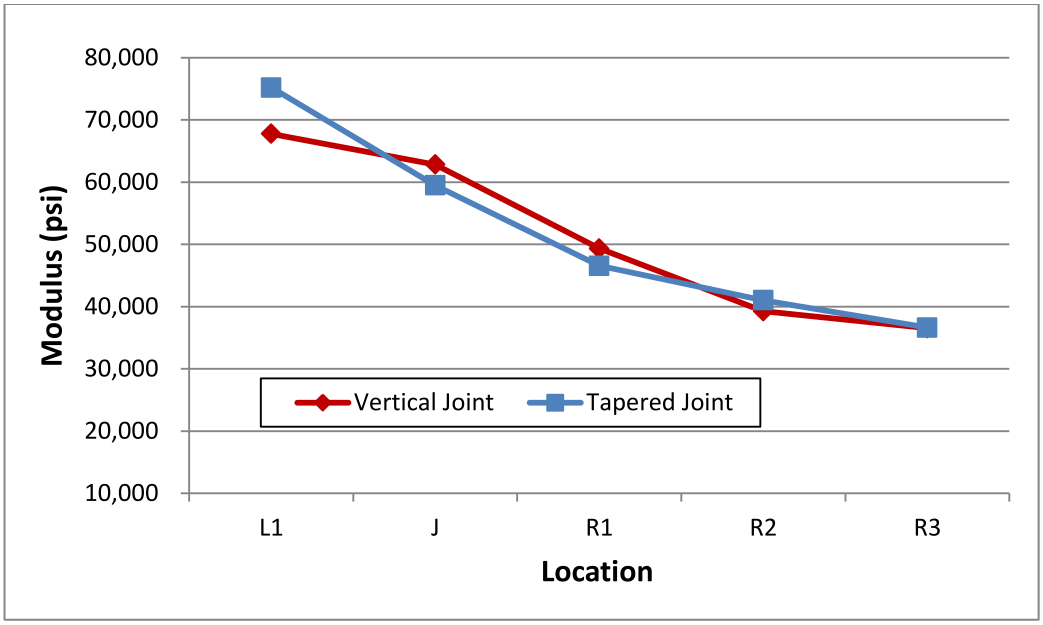


Figure 54: Graph. Mean Moduli for Base Layer for All Projects

Chapter Summary

This chapter describes the analysis undertaken of older (existing) and newly constructed widening projects. Analyses of widening joint type, age of pavement, aggregate gradation, base widening material, and widening joint location and how they relate to CDV values for the existing projects were performed. The purpose of the analysis was to identify any trends that may relate identified possible pavement deterioration factors to the deteriorations experienced in the selected projects. The analysis found that the age of the pavement, aggregate gradation, base widening material, and widening joint locations showed no apparent trend with respect to recorded CDV values. However, the range of CDV values for vertical widening joint was observed to be wider than those for tapered widening joints. Results show consistently higher frequency of occurrence for longitudinal cracks on vertical joint widening projects compared to tapered joint widening projects for each class of cracking severity.

The location of widening joints whether in the shoulder or travel lane (wheel path and outside the wheel path) was analyzed, since most of the deterioration occurs in the traveled lane. Statistical analysis to determine if there is any significant difference between joints located in the wheel path and non-wheel path was performed. Results show significant differences between joints in the wheel path and outside the wheel path. Joints located in wheel path showed high cracks based on CDV values along the joint lines compared to joints located outside the wheel paths.

The analysis indicated that the type of pavement widening was not related to the number of damaged pavements or the extent of damage. However, an analysis of the DCPT data for the existing projects showed a statistically significant difference in the penetration per blow (stiffness) recorded across the joint for tapered and vertical widening joint, with a better stiffness for the tapered joint compared to the vertical joint type at locations in the vicinity of the joint.

However, beyond a 2 ft. offset from the joint on the widened section, the base of the tapered joints has lower stiffness compared to the vertical joint base, and the two base widening types were found to be of approximately equal stiffness at 3 ft. from the joint.

Deflection data for the existing projects was analyzed to determine which of the joint types, tapered and vertical, exhibit better pavement support. High deflection values means weak pavement sections whereas low deflection values indicate strong pavement sections. Analysis of the existing 28 projects with 6 being tapered and the remaining 22 as vertical joints, show that the tapered joint type has relatively lower deflection values across the five locations compared to the vertical joints. It was proven there is a statistically significant difference in deflection between the tapered and vertical joints. This means that the base layer exhibits better pavement support for the tapered joint than for the vertical joint. However, deflection analysis for the new projects did not show any significant differences between the joint types. This could be due to small dataset for the new projects.

The penetration data obtained from the DCP testing for the new projects was analyzed both descriptively and statistically to determine if there is any significant difference between the two joint types. Results show there are statistically significant differences between the tapered and vertical joint types. The tapered joint exhibits relatively better strength and densities for the compacted base at the vicinity of the joint location compared to the vertical joint. Further analysis of the projects constructed with both joint types also indicates that there are significant differences between the tapered and vertical joints.

The pavement layer moduli obtained from the back-calculation process was used to determine if there is any difference between the two joint types, tapered and vertical. The fifteen moduli values for the base layers were averaged for the two joint types. It was observed that the tapered joint type has higher modulus values to the left of the joint compared to the vertical joint. However, the vertical joint has higher modulus at the other locations (J, R1, R2 and R3). Results from the statistical analysis shows there is no significant difference in the base materials' layer moduli for the two joint types.

CHAPTER 5: SURVEY EFFORTS

This chapter describes the surveys undertaken for this research effort. There were two types of surveys administered. The first survey was sent out to other transportation agencies in the Mountains and Plains states to document the practices and techniques they use in pavement widening projects. The other survey was sent out to the District Construction Engineers (DCE) and Resident Engineers (RE) of WYDOT, and the Wyoming Paving Contractors Association (WCA).

Survey of Mountains and Plains States

A survey of Mountains and Plains state Departments of Transportation was carried out in February 2012 to catalog the best practices and techniques for pavement widening. Seven states were selected for this survey because of similarities in climate, soil, and traffic patterns to Wyoming. The seven states were Colorado, Idaho, Montana, North Dakota, South Dakota, Nebraska, and Utah. Of the seven states, Utah was the only state that did not respond to the survey.

Discussion of Survey Contents

Survey questions were created by the research team and reviewed by the WYDOT materials program. The survey was directed to personnel responsible for pavement widening in the materials programs at the states departments of transportation. A sample of the questionnaire can be found in Appendix G.

The survey contained 10 questions asking respondents to list the type(s) of pavement joint construction technique(s) that are utilized by their agencies. Information was also sought about the respondents' preferences and opinions on the performance of the preferred technique(s). Some of the questions also sought to obtain information on the base materials commonly used for base widening construction and the availability of density test data for previously widened sections.

Responses from the Survey

Department of Transportation personnel from six out of the seven selected states who were experienced in road widening design and construction responded to the survey. Below is a breakdown of their responses.

Question: What joint construction technique is used in road widening projects in your agency?

Tapered method 1 and Tapered method 2 are variations of the tapered widening joint. Tapered method 1 has the base and asphalt of the widened section laid flush with the corresponding base and asphalt of the existing section. Figure 55 shows the tapered method 1. In the Tapered method 2, widening base material is laid flush with the asphalt of the existing section and both sections covered with an overlay. The differences between these two are also portrayed in Question 2 of Appendix G.

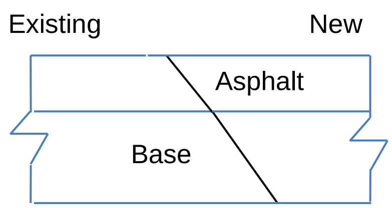


Figure 55: Diagram. Tapered Method 1

The preferred joint construction techniques by the transportation agencies in the Mountains and Plains states can be found in Table 17.

Table 17: Preferred Joint Construction Techniques by Respondent Agencies

Technique	Responding States					
	CDOT	**IDOT**	**MDOT**	**NDDOT**	**SDDOT**	**NEDOR**
Tapered Method 1	√	-	-	-	-	-
Tapered Method 2	-	-	√*[1]	-	-	-
Stepped Method	√	√	-	-	-	-
Vertical Method	√	-	-	√	√	√*[2]
Other Methods	-	-	-	-	-	√*[3]

The Montana DOT uses the tapered method 2 as their preferred joint construction technique. Figure 56 below shows the tapered method 2 used by Montana DOT.

[1] Montana State Department of Transportation (MDOT) uses "Tapered Method 2" but with a widening overlay placed flush with the existing pavement surface, and another overlay over the entire finished pavement surface as illustrated in Figure 57. The reason for this variation is that shoulders are designed with 20 years pavement life based on the ESALs within the travel lane.

[2] Nebraska State Department of Roads (NEDOR) uses a variation of the "Vertical Method", but widening is carried out using recycling of the mainline (either partial or full depth), and thereafter the entire pavement is covered with overlay.

[3] "Other Methods" states in Table 17 as utilized by NEDOR was a variation of the "Vertical Method" but involves widening HMA next to PCC or widening composite pavements with tied PCC.

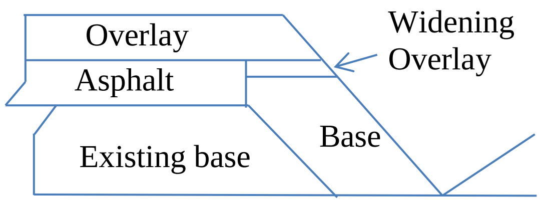


Figure 56: Diagram. Montana DOT Tapered Method 2 Variation

Question: For the joint widening techniques used by your agency, how would you rate the performance of each technique? Comment on the performance and indicate if the performance is based on experience, research or both.

The response provided by the agencies about the performance rating of the joint types can be found in Table 18.

Table 18: Performance Rating by Responding Agencies

Technique	**Responding States**					
	CDOT	IDOT	MDOT	NDDOT	SDDOT	NEDOR
Tapered Method 1	Good	-	-	-	-	Good
Tapered Method 2	-	-	Good	-	-	-
Stepped Method	Fair	Good	-	-	-	-
Vertical Method	Poor	-	-	Good	Good	Good
Other Methods	-	-	-	-	-	Good

Comments on Joint Techniques by Respondents

Tapered Method 1

Colorado DOT and Nebraska DOT felt "Tapered Method 1" performed well by being more durable as compared to other methods. CDOT suggested that this worked best when the method was used with the placement of a widening overlay.

Tapered Method 2

Montana DOT stated that this method consistently performed well but also confirmed that a few widening sections have deteriorated along the widening joint, and the deterioration may have been due to improper compaction along the joint and placement of joints in the wheel paths.

Stepped Method

Idaho DOT said the "Stepped Method" is specified for their projects and has worked well by preventing early deterioration. Satisfactory performance of this method was attributed to paving of widened sections to match the existing section and overlaying the full width with the step joint which kept the joint from reflecting a crack through the overlay quickly. Colorado DOT felt that the "Stepped Method" worked well for initial construction. However, the HMA needed to be crack sealed within three to five years because overlays experienced reflective cracks within 5 years after construction.

Vertical Method

Nebraska DOR used recycled material for widened sections and overlaid the entire pavement. NEDOR felt this method produced decent results but Colorado DOT was of the view that construction of this method tended to result in base settlement, and contractors had difficulty constructing this method.

Other Methods

Nebraska DOR utilized a method where a vertical joint was used in widening HMA next to PCC and widening composite pavements with tied PCC. NEDOR felt this method also produced excellent results.

Summary of Comments

The Vertical Method and Tapered Method 1 received the most favorable responses, although the Vertical Method received a "Poor" rating response. Tapered Method 2 and the Stepped Method received a "Good" rating each but the Stepped Method receiving an additional rating of "Fair". NEDOR also rated their Vertical method as "Good".

Question: What are the gradations and kinds of crushed base material typically used in road widening construction? Are there any internal documents, supplemental specifications or typical drawings on pavement base widening in your state?

Colorado DOT uses a nominal ¾ inch (CDOT class 6) material or RAP meeting CDOT class 6 gradations as prescribed in their specification (Appendix H). Idaho DOT also specifies using ¾ nominal maximum aggregate sizes for untreated aggregate (Appendix I). Montana DOT specifies using crushed base course consisting crushed gravel (Appendix J). North Dakota DOT specifies Salvaged Base Course or Class 5 (Appendix K). South Dakota uses base course meeting the requirement of South Dakota Standard Specification (Appendix L) and Nebraska DOR uses crushed concrete, millings, or sand and gravel if there is granular material under existing PCC pavement, and crushed base is used under HMA pavements using the Nebraska Standard Foundation Course Specifications.

Survey of District Construction & Resident Engineers

The research team undertook a series of surveys with stakeholders especially the District Construction Engineers (DCE), Resident Engineers (RE) and Wyoming Contractors Association (WCA) paving committee. The purpose of the survey was to document the best construction practices and techniques used in the construction of pavement widening joint types (vertical, tapered, stepped) in Wyoming, and evaluate the best performing joint type that could improve pavement performance and serviceability at reduced costs.

Survey Description

Two different surveys were designed for both District Construction Engineers (DCE) and Resident Engineers (RE), and the Wyoming Paving Contractors Association. The surveys can be found in Appendices M and N. The survey sent to the District Construction and Resident Engineers in Wyoming was looking for feedback on what type of widening joint types (vertical, tapered, stepped) they have been involved in. Some of the questions found in the survey include:

- What widening joint type construction project have you been involved with?
- How would you rate the performance of each widening joint technique, based on your experience?
- What best construction practices and techniques have you employed relative to widening joint type projects?

The survey also seeks to get feedback about the effectiveness of construction supervision by DCE's and RE's. Some of the survey questions include the following:

- Do you perform constructability issues review before actual construction?
- What are the quality control and quality assurance (QC/QA) practices enforced during construction?
- Have you encountered any changes to the original widening joints projects during the construction phase? What factors necessitated those changes?
- Have you had any issues with contractor's expertise, both in general and that of equipment operators?

The complete surveys for both District Construction Engineers and Resident Engineers in Wyoming can be found in the Appendix M.

The other survey sent to the Wyoming Contractors Association (WCA) Paving Committee contains similar questions sent to the DCEs on constructability but includes other questions on cost issues and their experience with widening projects. Some of the survey questions include:

- How long has your company been involved in road widening projects?
- How would you rate the constructability issues of each widening joint technique?
- How would you rate the performance of each widening joint technique?
- For a project bid perspective, how would you rate the cost of each widening joint technique?

Other survey questions that required feedback on the construction strategies used by the contractors include:

- Can you please state the various construction strategies that you employ for widening projects?
- Typically, how long do you expose the cut surface before the next procedure is performed?
- How do you perform compaction of the interface between the existing and new pavements?

The complete surveys sent to the Wyoming Contractors Association (WCA) Paving Committee can be found in Appendix N.

Survey Outreach

The research team contacted the District Construction Engineers (DCE) through emails to set up a convenient time for the survey. It was decided that the best time was during the quarterly meeting of DCEs in Wyoming. On June 12, 2013, the research team attended the quarterly meeting of the District Construction Engineers in Riverton. A presentation about the research effort and overview of the survey was made at the meeting. After the presentation, the survey questions were distributed to about 12 District Construction Engineers present at the meeting. It was suggested at the DCE meeting for the research team to extend its survey efforts to Resident Engineers in Wyoming. The Resident Engineers are directly in charge of construction sites for most of the widening projects. With that suggestion, the research team sent the survey via email to the Resident Engineers on June 13, 2013. In all, 29 Resident Engineers were contacted for the survey.

The research team contacted the Wyoming Contractors Association (WCA) Paving Committee through an email on June 26, 2013 in an effort to get information/feedback from contractors with experience in widening project. The survey was eventually sent out to the Wyoming Contractors Association (WCA) Paving Committee on August 8, 2013 through the association to be forwarded to the paving contractors and related suppliers in Wyoming. The research team followed up with a second round of surveys to the contractors in November since no response was received from the earlier survey sent to them.

Survey Results

Given the extensive outreach effort for the surveys, five and seven responses were received from the District Construction Engineers (DCE) and Resident Engineers (RE) respectively. The survey results will focus on only the responses from the District Construction Engineers and Resident Engineers. A 100% response was received from the DCEs; however that cannot be said of the survey responses from the REs, as we were not able to get responses from all of them. No responses have been received from the Wyoming paving contractors at the time of finalizing this report.

Survey Results for District Construction Engineers and Resident Engineers

From the responses, 45% of the District Construction Engineers (DCE) and Resident Engineers (RE) have experience with the vertical joint type widening projects. Fifteen percent of the respondents have experience in both stepped and tapered (Type I and II) joint types, and ten percent indicate that they have experience in other methods which is stepped at the top (asphalt level) with tapered at the base level. Figure 57 shows the experience of respondents with the different joint types.

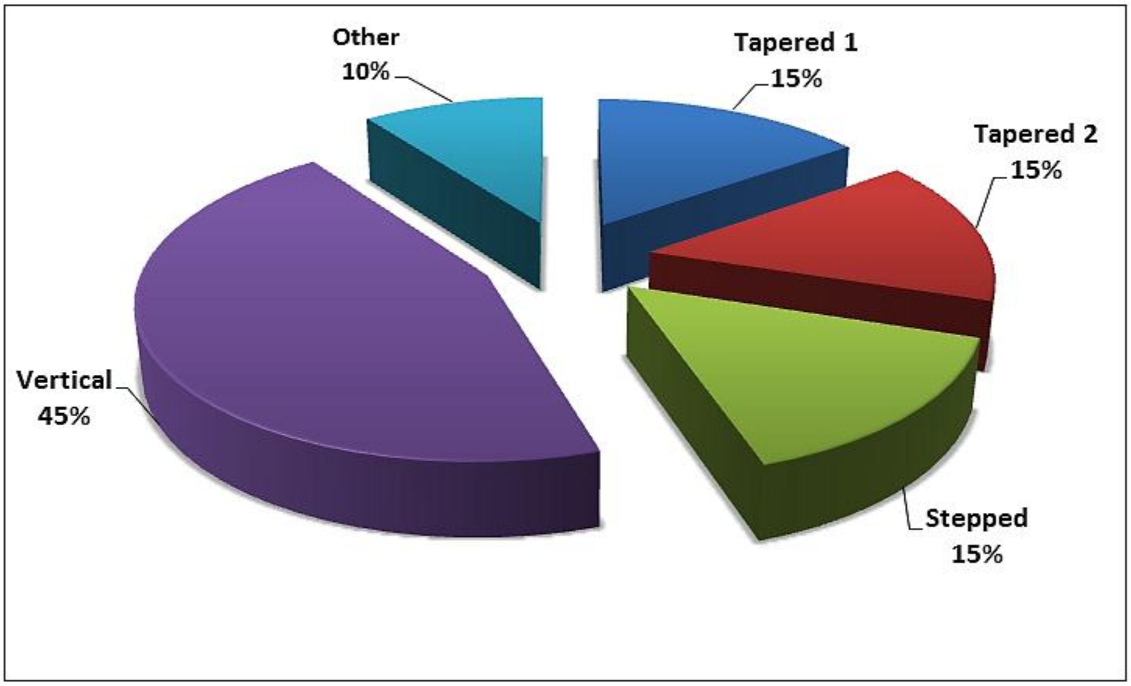


Figure 57: Pie Chart. Experience with Different Joint Widening Projects

With respect to rating the performance of each widening joint type, about 60% of the engineers rated the vertical joint type as “Good”. Twenty-one percent rated the tapered joint type 1 as “Good” and 11% rated the stepped joint type as “Good”. About 30% of respondents rated the Tapered joint (Type I and II) and the Stepped Joint as “Fair”, and 14% rated the other methods as “Fair”. Thirty-three percent of engineers have no experience with the stepped joint type. Figure 58 shows the performance rating for each widening joint technique. It must be noted that no performance rating for “poor” was obtained from the survey.

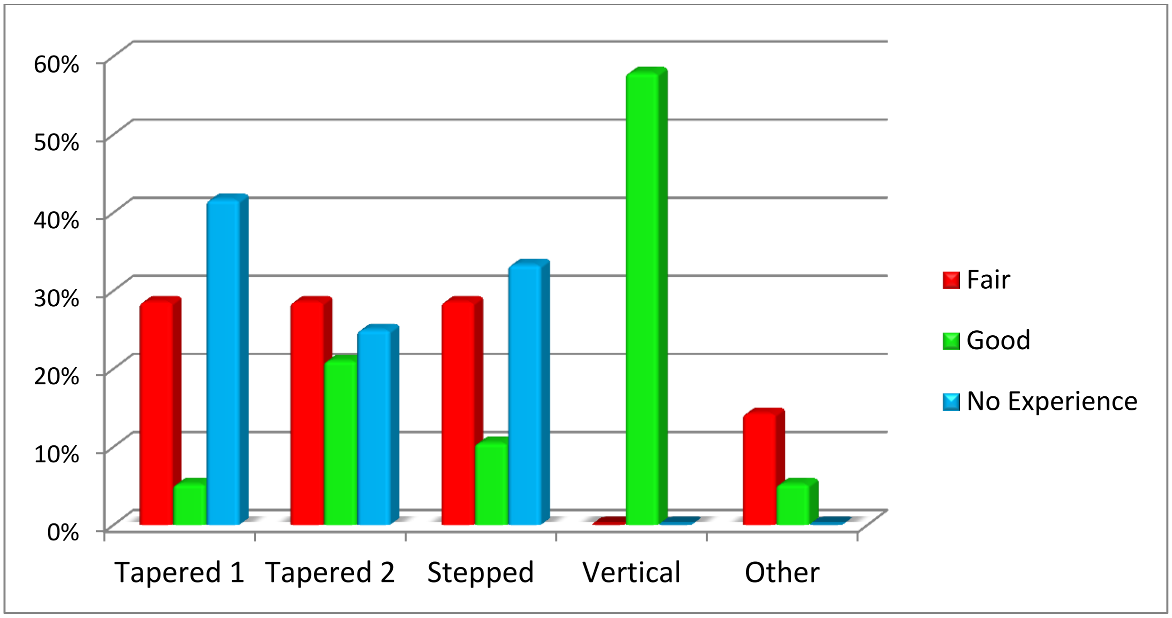


Figure 58: Graph. Performance Rating of Each Widening Joint Technique

Reviews of constructability issues during the design phase and before the actual construction period are important to anticipating problems and providing mitigation measures before construction. From the survey, 60% of the respondents (District Construction Engineers and Resident Engineers) say they perform constructability reviews before actual construction. They stated that most of the constructability reviews are informal, and that once a problem is identified, they discuss proposed methods which might fit into the contractor's operations to address it.

About 50% of respondents said they have encountered changes to the original widening joints designed for projects during the construction phase. Some of the factors that necessitate these changes focus on constructability. For instance, a respondent mentioned that the original design specified a '6" stepped joint type", which was changed because it was practically not feasible to achieve. Other respondents stated that original tapered joint type was changed to vertical joint type at the request of the contractor for ease of construction.

The expertise of contractors to deliver a high quality work affects how a specific joint type may perform. Against this backdrop the survey seeks to obtain feedback from district construction engineers and resident engineers, who usually supervise the work of contractors. Fifty percent of the respondents had issues with contractor's expertise, both with respect to their general work performance and their equipment operators. Some of the reasons they attributed to the poor expertise was that most of the contractors were new to widening road projects, and some of the contractor's workers especially equipment operators have little technical expertise even with the placement of material.

All the respondents stated that they enforce the standard quality control and quality assurance (QC/QA) for base and asphalt widening construction. They noted that checking the density of pavement material (crushed base), achieving adequate compaction at the joint area, proper drainage, and visual inspection of the joint location during construction are key to achieving a better performing pavement structure. The performance rating of contractors' work on widening project by the respondents (District Construction and Resident Engineers) can be found in Figure 59. Ninety-two percent of the respondents (engineers) rated the performance of contractors they have supervised on road widening projects as "Good", and 8% rate the contractors' performance as "Fair".

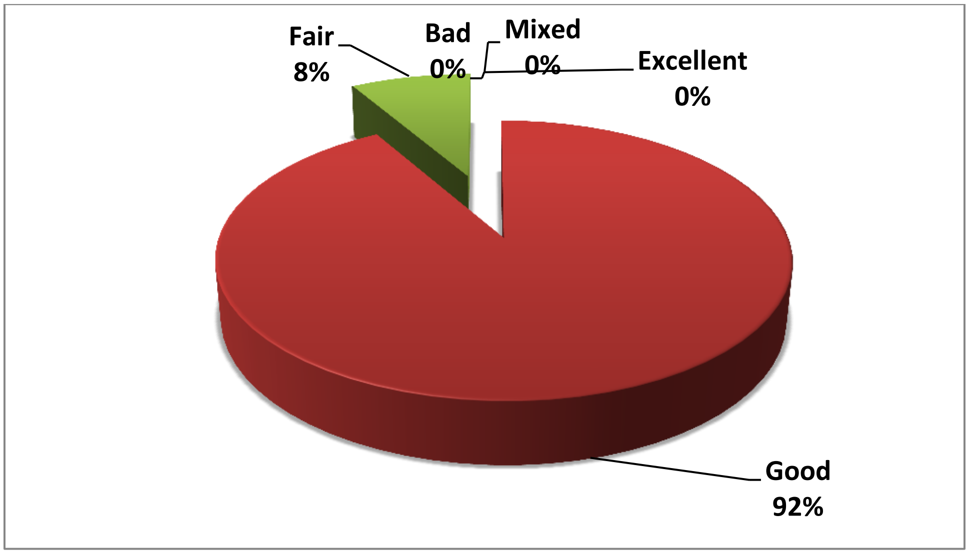


Figure 59: Pie Chart. Performance Rating of Contractors

Chapter Summary

From the survey of Mountains and Plains states, the base widening technique most widely preferred by neighboring states is the Vertical Method. This technique is used by four states with three of the states – North Dakota, South Dakota and Nebraska – determining that it performed satisfactorily, but Colorado DOT determined that this technique performs poorly due to settlement issues that are encountered with vertical joints for the base.

Tapered method 1 is preferred by both Colorado and Nebraska DOTs which rated this method as "Good". The Stepped method was rated by Idaho as "Good" and by Colorado as "Fair". Nebraska preferred a variation of the "Vertical Method" that involved widening joints for composite materials, PCC and HMA; this method by Nebraska was also rated as being "Good".

Tapered method 1 and the stepped method are each preferred by two states but tapered method 1 received more favorable ratings of "Good" from both Colorado and Nebraska, while the stepped method received "Good" ratings from Idaho but was rated by Colorado as "Fair". Tapered method 2 is used by only Montana DOT who rated it as being "Good". Nebraska preferred a variation of the vertical method that had composite materials, PCC and HMA and this method was also rated as being "Good".

Colorado DOT used almost all methods with the exception of the “Tapered Method 2” thereby providing an equal platform for comparing techniques. CDOT rated “Tapered Method 1” as the best technique, followed by the “Stepped Method” and finally the “Vertical Method”. However, the ratings by CDOT cannot be interpreted as the general trend since the various states had some variations in standards and methods of construction that may affect the performance ratings for each state.

Results from the survey of both District Construction Engineers (DCEs) and Resident Engineers (RE) indicate that 45% of the respondents have experience with the vertical joint type widening projects. Fifteen percent of the respondents have experience in both stepped and tapered (Type I and II) joint types, and ten percent indicate they have experience with another method, stepped at the top (asphalt level) with a taper at the base level.

About 60% of the engineers rated the vertical joint type as having “Good” performance. Twenty-one percent rated the tapered joint type 1 as “Good” and 11% rated the stepped joint type as “Good”. About 30% of respondents rated the tapered Joint (Type I and II) and the stepped Joint as “Fair”, with the remaining 14% of respondents rating the other methods as “Fair”. Thirty-three percent of engineers have no experience with the stepped joint type. It must be noted that no performance rating for “poor” was obtained from the survey.

Reviews of constructability issues during the design phase and before the actual construction period are important to anticipating problems and providing mitigation measures before construction. From the survey, 60% of the respondents (District Construction Engineers and Resident Engineers) perform constructability reviews before actual construction. They stated that most of the constructability reviews are informal, and that once a problem is identified, they discuss proposed methods which might fit into the contractors’ operations to address it. Changes to the original widening joints design projects during construction are inevitable. About 50% of respondents stated they do encounter changes to the original widening joints design projects during construction. Some of the factors that necessitate these changes are based on constructability issues.

The expertise of contractors to deliver high quality work affects how a specific joint type may perform. Against this backdrop the survey seeks to obtain feedback from district construction engineers and resident engineers, who usually supervise the work of contractors. Fifty percent of the respondents had issues with contractor’s expertise, both with respect to their general work performance and their equipment operators. Some of the reasons they attributed to the poor expertise was that most of the contractors were new to widening road projects, and some of the contractor’s workers especially equipment operators have little technical expertise even with the placement of material.

Since quality control and quality assurance (QC/QA) during construction is imperative to the performance of these widening projects, respondents said they enforce the highest standard of QC/QA during construction. They noted that checking the density of crushed base pavement materials, achieving adequate compaction at the joint area, proper drainage, and visual inspection of the joint location during construction are key to achieving a better performing pavement structure.

CHAPTER 6: ECONOMIC ANALYSIS

This chapter presents an economic analysis of the joint types by quantifying the differences in material quantities and the differences in costs using weighted average bid prices.

WYDOT CONTRACT BID PROCEDURE

The capital-intensive nature of infrastructural projects makes it imperative to have value for money for such projects. The economic benefits of infrastructural projects to the state cannot be over-emphasized. However, to quantify such benefits, economic analyses are important.

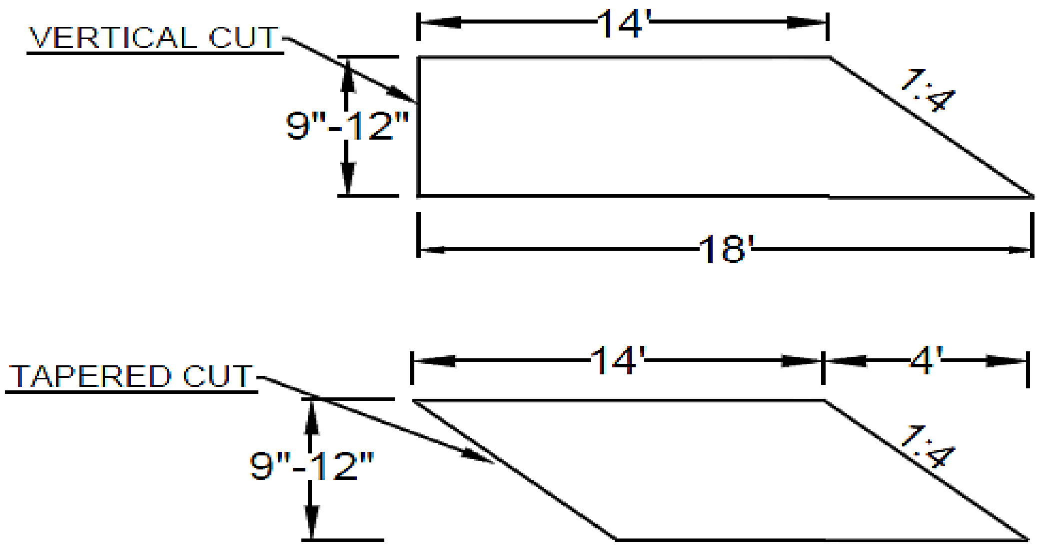
Bidding for highway and bridge construction or other federally funded projects are handled by the Wyoming Department of Transportation (WYDOT) Contracts and Estimates office. These projects may include fencing, crack seals, seal coats, guardrail, slope and slide repair, median barriers, bridge reconstruction or rehabilitation, highway reconstruction or widening, surfacing, grading and maintenance. For any contractor to bid on a WYDOT project, they have to be on WYDOTs list of bidders/vendors. For parties interested in bidding on WYDOT construction projects for highways and/or buildings, they must first be prequalified through WYDOT's State Construction Office. After the prequalification, contractors are invited to send in bids for listed projects through an advertisement from WYDOT. The received sealed bids from the contractors are evaluated and the successful bidder (contractor) is selected. A signed purchase order/contract is furnished to the successful bidder, resulting in a binding contract without further action by either party.

Bid prices are known to vary between projects and between contractors for a variety of reasons including the scale of the project, the workload of the contractor, and different contractor strategies regarding where the profit for particular projects are built into the bid. This variation makes analysis of bid prices challenging.

For this chapter, two categories of bid prices for base widening projects are used. The first analysis uses idealized typical sections for both vertical and tapered joints to determine differences in estimated bid item quantities. To put the differences in terms of cost, weighted average bid prices for 2012 from WYDOT were used. The second analysis looked at actual bid prices for the four new pavement widening projects analyzed in this study. Due to the small number of projects and the variation in bid prices in general, only a qualitative review of these prices could be performed to see if any trends in the data were noticeable.

COST ANALYSIS

In order to determine the cost estimates and to perform a comparison between the two joint types, certain simplifying assumptions were necessary. A typical cross section of each joint type was used to estimate the base material (see Figure 60). The cross sections were based on typical measurements of projects analyzed in this research study for the two joint types. Three cross section depth options (9, 10, and 12 inches) were evaluated for each joint type. In addition to the cross section, a distance of 1 mile for each option was considered to determine material quantities and cost estimates.



Not to scale

Figure 60: Diagram. Typical Cross Sections for Base Material Estimation of the two Joint Types

The analysis examined the base material and the preparation of joint surface costs. Two different base materials, crushed base and Recycled Asphalt Pavement (RAP), were used in the estimates since these were the commonly used base materials in the analyzed projects. For the vertical joint projects, bid items include the cost of cutting the bituminous pavement, which was not a bid item for tapered joint projects. The unclassified excavation for both joint types was included in the cost estimation as well. Using the 2012 WYDOT Weighted Averaged Bid Prices that can be found in Appendix O, the cost estimates of the base material, unclassified excavation, and bituminous pavement cutting were calculated for both tapered and vertical joint types. The base material estimates for the tapered and vertical joint types are shown in Tables 19 and 20 respectively. The bold items in both tables were used to estimate the material cost of the two different base materials.

Table 19: Base Material Estimation for the Tapered Joint Type

	Base Material Type	Width (ft)	Depth (in)	Length (ft)	Area (ft^2)	Volume (cf)	Unit Rate (lbs/cf)	Unit Weight (lbs)	Unit Rate (ton)	Unit	Average Bid Price	Amount
Option 1	Crushed Base	14	9	5,280	10	55,418	147	8,146,420	**4,073**	TON	**$12.78**	**$52,055.62**
Option 2	Crushed Base	14	10	5,280	12	61,575	147	9,051,578	**4,526**	TON	**$12.78**	**$57,839.58**
Option 3	Crushed Base	14	12	5,280	14	73,890	147	10,861,894	**5,431**	TON	**$12.78**	**$69,407.50**

	Base Material Type	Width (ft)	Depth (in)	Length (ft)	Area (ft^2)	Volume (cf)	Volume (cy)	Unit Weight (lbs/cf)	Unit Rate (lbs)	Unit	Ave. Bid Price	Amount
Option 1	RAP	14	9	5,280	10	55,418	**2,053**	150	8,312,674	CY	**$10.36**	**$21,264.02**
Option 2	RAP	14	10	5,280	12	61,575	**2,281**	150	9,236,304	CY	**$10.36**	**$23,626.69**
Option 3	RAP	14	12	5,280	14	73,890	**2,737**	150	11,083,565	CY	**$10.36**	**$28,352.03**

Table 20: Base Material Estimation for the Vertical Joint Type

	Base Material	Width (ft)	Depth (in)	Length (ft)	Area (ft^2)	Volume (cf)	Unit Weight (lbs/cf)	Unit Rate (lbs)	Unit Rate (ton)	Unit	Average Bid Price	Amount
Option 1	Crushed Base	14	9	5,280	12	63,335	147	9,310,194	**4,655**	TON	**$12.78**	**$59,492.14**
Option 2	Crushed Base	14	10	5,280	13	70,372	147	10,344,660	**5,172**	TON	**$12.78**	**$66,102.38**
Option 3	Crushed Base	14	12	5,280	16	84,446	147	12,413,593	**6,207**	TON	**$12.78**	**$79,322.86**

	Base Material Type	Width (ft)	Depth (in)	Length (ft)	Area (ft^2)	Volume (cf)	Volume (cy)	Unit Weight (lbs/cf)	Unit Rate (lbs)	Unit	Average Bid Price	Amount
Option 1	RAP	14	9	5,280	12	63,335	**2,346**	150	9,500,198	CY	**$10.36**	**$24,301.74**
Option 2	RAP	14	10	5,280	13	70,372	**2,606**	150	10,555,776	CY	**$10.36**	**$27,001.94**
Option 3	RAP	14	12	5,280	16	84,446	**3,128**	150	12,666,931	CY	**$10.36**	**$32,402.32**

The estimation of the unclassified excavation also used typical cross sections based on the drawings of the analyzed projects (see Figure 61).

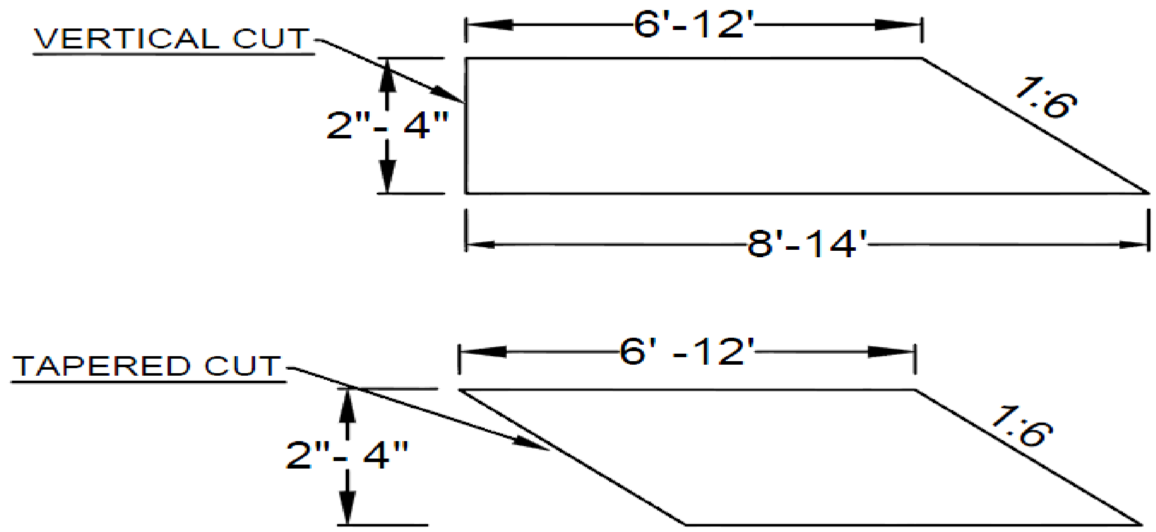


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Figure 61: Diagram. Typical Cross Section for Estimating Unclassified Excavation for the two joint types

It can be seen from the base material estimates that the vertical joint has higher material cost for all three options than the tapered joint type due to the materials savings associated with retaining the material in the taper area. The unclassified excavation was also calculated for both joint types, tapered and vertical. Table 21 and 22 show the estimates of the unclassified excavation for the tapered and vertical joint types.

Table 21: Unclassified Excavation Estimation for the Tapered Joint

	Width (ft)	Depth (in)	Length (ft)	Area (ft^2)	Volume (cf)	Volume (cy)	Units	Unit Price	Amount
Option 1	6	2	5,280	0.999	5,277.89	195.48	CY	$3.34	652.89
Option 2	10	3	5,280	2.499	13,194.72	488.69	CY	$3.34	1,632.23
Option 3	12	4	5,280	3.998	21,111.55	781.91	CY	$3.34	2,611.57

Table 22: Unclassified Excavation Estimation for the Vertical Joint

	Width (ft)	Depth (in)	Length (ft)	Area (ft^2)	Volume (cf)	Volume (cy)	Units	Unit Price	Amount
Option 1	6	2	5,280	1.17	6,157.54	228.06	CY	$3.34	$761.71
Option 2	10	3	5,280	2.75	14,514.19	537.56	CY	$3.34	$1,795.46
Option 3	12	4	5,280	4.33	22,870.85	847.07	CY	$3.34	$2,829.21

A percent difference in the unclassified excavation for the two joint types was performed (see Table 23). It can be inferred from the percent difference of the estimated unclassified excavated volumes that the vertical joint has higher quantities compared to the tapered joint for all three options.

Table 23: Percent Difference in Unclassified Excavation Volumes

	Tapered	Vertical	% Diff.
	Volume (CY)	Volume (CY)	
Option 1	195.477	228.057	14.3%
Option 2	488.693	537.562	9.1%
Option 3	781.909	847.068	7.7%

Since the vertical joint type projects have a bid item for the bituminous cutting, the cost of providing a vertical joint cut was estimated. Table 24 shows the cost estimates of the bituminous pavement cutting of vertical joint.

Table 24: Bituminous Pavement Cutting Estimation for the Vertical Joint

Length (ft)	Units	Unit Price	Amount
5,280.00	ft.	$0.72	$3,801.60

To determine the cost comparisons between the joint types, the estimates for the base materials, unclassified excavation, and the bituminous pavement cutting were totaled and the results are shown in Table 25 for the vertical and tapered joint types. The cost estimates between the two joint types shows that there is an 18% increase in cost of the vertical joint over the tapered joint.

Table 25: Cost Comparison between the Vertical and Tapered Joints

Joint Types	Base Material Estimation			Excavation			Joint Cutting		Total
	Volume (cf)	Unit Price	Amount	Volume (cy)	Unit Price	Amount	Unit Price	Amount	
Vertical	63,335	$12.78	$59,492	228	$3.34	$762	0.72	$3,802	$64,055
Tapered	55,418	$12.78	$52,056	196	$3.34	$653	-	-	$52,709

ACTUAL BID PRICES FOR WIDENING PROJECTS

Actual Contract bid prices for relevant bid items for both tapered and vertical joint type projects can be found in Table 26. The full bid tabs for the projects can be found in Appendix P. It can be seen that different contractors bid on each item differently due to factors such as the ease of construction, and maximization of profits and no apparent trend can be seen relative to the type of joint specified in the project.

Table 26: Actual Contract Bid Prices for the Four New Projects

			NH-N132095 (US191) - Tapered Joint Project		NH-N852001 (US85) -Vertical Joint Project		SCP-SL12-P433035 (WY59) -Vertical Joint Project		NH-N361053 (US16) - Tapered Joint Project	
Bid Item	Description	Unit	Engineer's Estimate	Bidder's Estimate	Engineer's Estimate	Bidder's Estimate	Engineer's Estimate	Bidder's Estimate	Engineer's Estimate	Bidder's Estimate
			Unit Price	Unit Price	Unit Price	Unit Price	Unit Price	Unit Price	Unit Price	Unit Price
106.05100	Field Laboratory	EA	7,000	5,000	7,000	4,000	8,500	17,734.31	10,500	10,000
106.05200	Contractor Testing	LS	28,000	40,000	22,400	22,000	50,000	53,926.42	17,000	60,000
109.08000	Mobilization	LS	269,000	205,000	280,000	70,000	775,000	7,486,994.58	725,000	832,500
202.03305	Milling Plant Mix	SY	1.25	0.82	2.25	3.00	2.00	2.13	2.50	1.60
202.03600	Cutting Bit Pvmt.	FT	-	-	0.75	0.48	0.75	0.62	6.00	9.50
203.02500	Unclassified Excavation	CY	6.25	5.70	3.05	3.35	3.15	2.06	5.15	5.25
207.03100	Topsoil Storing	CY	1.65	1.25	1.30	1.00	1.40	1.34	2.50	4.25
207.03200	Topsoil Placing	CY	1.95	1.50	1.50	1.10	1.65	1.64	3.00	4.25
217.01025	Geotextile, Material Separation (Non-Woven)	SY	-	-	2.20	1.60	2.20	1.91	3.00	4.00
301.01010	Pit Run Subbase	CY	-	-	21.00	20.00	-	-	-	-
301.01030	Crusher Run Subbase	CY	-	-	-	-	19.00	14.03	19.00	18.00
301.01080	Crushed Base	TON	15.75	9.00	25.00	15.05	-	-	22.50	18.00
302.00020	Blended Base	CY	-	-	-	-	30.00	41.20	-	-
401.02000	Hot Plant Mix	TON	29.00	23.00	35.00	34.11	41.00	49.72	29.50	33.00
401.02030	Hot Plant Mix Leveling	TON	29.00	24.00			42.00	45.90	-	-
401.02040	Test Strip	EA	7,500.00	5,000.00	7,500.00	7,800.00	7,500.00	7,800.00	8,000.00	12,000.00
401.02055	Hot Plant Mix Approaches	TON	58.00	48.00	75.00	55.00	75.00	55.00	70.00	115.00
401.03322	Asphalt Binder (PG64-28)	TON	-	-	-	-	710.00	779.49	686.00	640.00
401.03323	Asphalt Binder (PG64-22)	TON	585.00	574.50	620.00	618.00	-	-	-	-
407.01000	Tack Coat	TON	575.00	740.00	600.00	581.00	620.00	582.59	600.00	499.00

Chapter Summary

This chapter evaluated the costs associated with each of the joint types using typical cross section quantities and WYDOT's weighted average bid prices. The costs for the base material estimates, unclassified excavation, and the cutting bituminous pavement for both joint types were analyzed. The vertical joint cut projects have an 18% cost increase over the tapered joint projects. Actual contract bids for tapered and vertical joint projects indicate differences in bid items submitted by contractors on the same project (vertical joint). It was observed that contractors bid prices differ for similar projects they have worked on before due to several factors such as ease of construction and maximization of profit.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATION

This chapter summarizes the results from the evaluations of longitudinal cracks, widening joint location, and the relationship between DCP, deflection, back-calculated Moduli and joint type. Recommendations of the preferred joint type will be presented based on the analysis.

CONCLUSIONS

Longitudinal Cracks & Joint Location

Levels of pavement deterioration based on the corrected deduct values (CDV) and longitudinal crack data obtained from the field studies were analyzed. Widening joint type, age of pavement, aggregate gradation, base widening material, and widening joint location and how they relate to CDV values were also analyzed. The analysis found that the age of the pavement, aggregate gradation, base widening material, and widening joint locations showed no apparent trend with respect to recorded CDV values. However, the range of CDV values for vertical widening joints was observed to be greater than those for tapered widening joints. Results show consistently more longitudinal cracks on vertical joint widening projects compared to tapered joint widening projects for each level of cracking severity.

The location of the widening joint whether in the shoulder or travel lane (wheel path and outside wheel path) is assessed. Most of the deterioration occurs in the travel lane. Analysis of joints located in the travel lane (wheel path and outside wheel path) indicates significant differences between joints in and away from the wheel path. It was determined that joints located in the wheel path have more cracks along the joint lines compared to joints located away from the wheel paths.

Tests on gradation showed all the projects used WYDOT grading W aggregates for the base, so gradation was not considered as a cause for the differences in occurrence and severity of cracking. Moisture content was found to have no significant impact on the longitudinal cracking of the pavement because the base materials selected for construction were such that considerable variations in moisture did not affect the strength of the pavement.

Dynamic Cone Penetrometer (DCP) and Joint Types

The dynamic cone penetrometer (DCP) test data was analyzed to determine the penetration of the base layer. The test depth of 12 inches was divided into top base layer (0- 6 inches) and the bottom base layer (6-12 inches). The analysis considered the different base layers (top and bottom). Analysis of the mean penetration across the joint for the 28 existing projects indicate that the tapered widening joint shows relatively better strength at 1 foot offset from the joint on the existing section and at the joint location itself. At 1 foot offset from the joint onto the widening section, both joint types have approximately the same strength but at 2 feet offset from the joint on the widening section, the vertical widening method is relatively stronger than the tapered joint and the two joint types have equal strength at 3 feet from the joint.

The mean penetration data obtained from the DCP testing for the new projects was analyzed to determine if there is any significant difference between the two joint types. Results show there are statistically significant differences between the tapered and vertical joint types. The tapered joint exhibits relatively better strength for the compacted base near the joint location compared to the vertical joint. Further analysis of the two projects (WY59 and US16) with both joint types also indicates that there are significant differences between the tapered and vertical joints, with the tapered joint having relatively better base support than the vertical joint type.

Deflection Data and Joint Types

The FWD deflection data for all the projects were corrected for temperature after data quality checks had been performed. The fifteen deflection data points for each test station were averaged and arranged according to their five transverse locations as L1, J, R1, R2, R3, with 'J' denoting the joint location, 'L1' left of joint on the existing pavement, R1-3 denoting test stations right of joint on the widened section for both joint types, vertical and tapered. Since the base layer was the focus of this research project, sensor 4 (D4) which is located 18 inches from the center of the FWD loading plate was used to compute the average deflections for the two joint types. High deflection values indicate weaker pavement sections, while lower deflection values indicate stronger pavement sections. Results from the analysis for the 28 existing projects indicate that vertical joints have higher deflections than tapered joints across the five locations. The mean deflection of each joint type was different across all five locations. It can be concluded that tapered joints type have relatively greater strength across the five transverse locations when compared to vertical joints.

Results for the new projects indicate that the vertical joint type has relatively higher deflection values than the tapered joint across the five transverse locations. However, both joint types cannot be declared statistically different due to the small dataset for the new projects. The deflection analysis for the two projects (WY59 and US16) also indicates that the two joint types, vertical and tapered are not statistically different. This means we could not statistically conclude whether tapered joints exhibit better base strengths than vertical joints. This may be due to the small number of projects.

Back-Calculated Moduli and Joint Types

The MODCOMP pavement analysis software was used to determine the pavement layer moduli through back-calculation. The MODCOMP software uses an iterative method that progressively adjusts the moduli to fit the deflection basin. The MODCOMP gives a lot of control over the back-calculation process since it was written for use by researchers, though it requires some advanced knowledge. Accurate pavement structure information is very important in the back-calculation process to determine accurate pavement layer moduli. Five different layers of varying thicknesses for the back-calculation analysis were used.

The back-calculated moduli for the base layer (E2) were averaged for the 5 locations: L1, J, R1, R2 and R3. This was done to determine which joint type has higher moduli at the five locations. The base layer modulus was used because this research effort seeks to determine which joint type provides better support to the base layer. Results for the 28 existing projects indicate that the tapered joint type has higher modulus values to the left of the longitudinal joint on the existing pavement than the vertical joint type. However, at the joint location, the vertical joints have higher moduli than the tapered joints. Statistical analysis was performed to determine if significant differences between the joint types could be established. Results from the analysis indicate no significant differences between the two joint types with respect to their moduli, a property of the base material.

The results for the two projects (WY59 and US16) with the two joint types indicate there is no significant difference in base layer moduli between the two joint types for the two projects.

Survey of Rocky Mountains and Plains States

From the survey of Mountains and Plains states, the base widening technique most widely preferred by the neighboring states is the Vertical Method. This technique is used by four states, with three of the states – North Dakota, South Dakota and Nebraska – determining that it performed satisfactorily. Colorado DOT determined that the vertical joint type performs poorly due to base settlement issues encountered using vertical joints.

Tapered method 1 (see Figure 55) is preferred by both the Colorado DOT and Nebraska DOR which rated this method as “Good”. The Stepped method was rated by Idaho as “Good” and by Colorado as “Fair”. Nebraska preferred a variation of the “Vertical Method” that involves widening joints for composite materials, PCC and HMA; the vertical method was also rated as being “Good” by Nebraska.

Tapered method 1 and the stepped method are each preferred by two states but tapered method 1 received more favorable ratings of “Good” from both Colorado and Nebraska, while the stepped method received “Good” ratings from Idaho but was rated by Colorado as “Fair”. Tapered method 2 is used by only the Montana DOT which rated it as “Good”. Nebraska preferred a variation of the vertical method that had composite materials, PCC and HMA and this method was also rated as being “Good”.

Colorado DOT used almost all methods with the exception of the “Tapered Method 2”, thereby providing a more comprehensive comparison of techniques. CDOT rated “Tapered Method 1” as the best technique, followed by the “Stepped Method” and finally the “Vertical Method”. However, the ratings by CDOT cannot be interpreted as the general trend since the various states had some variations in standards and methods of construction that may affect the performance ratings for each state.

Survey of Constructability Issues

Two different surveys were designed for both District Construction Engineers and Resident Engineers, and the Wyoming Paving Contractors Association. The survey sent to the District Construction and Resident Engineers in Wyoming was looking for feedback on what type of widening joint types (vertical, tapered, stepped) they have been involved with.

Results from the survey of both District Construction Engineers (DCEs) and Resident Engineers (RE) indicate that 45 percent of the respondents have experience with vertical widening joint type projects. Fifteen percent of the respondents have experience with both stepped and tapered (Type I and II) joint types, while ten percent indicate that they have experience in other methods including stepped at the top (asphalt level) and tapered at the base level.

About 60 percent of the engineers rated the vertical joint type as having “Good” performance. Twenty-one percent rated the tapered joint type 1 as “Good” and 11 percent rated the stepped joint type as “Good”. About 30 percent of the respondents rated tapered Joint (Type I and II) and Stepped Joint as “Fair”, with the remaining 14 percent rating the other methods as “Fair”. Thirty-three percent of engineers have no experience with the stepped joint type. It must be noted that no performance rating for “poor” was obtained from the survey.

Reviews of constructability issues during the design phase and before actual construction are useful for anticipating problems and providing mitigation measures before construction. From the survey, 60 percent of the respondents (District Construction Engineers and Resident Engineers) perform constructability reviews before actual construction. They stated that most of the constructability reviews are informal, and that once a problem is identified, they discuss proposed methods which might fit into the contractors’ operations to address it. Changes during construction to the original widening joints designed for a project are inevitable. Fifty percent of the respondents stated that they encounter changes to the original widening joints designed for projects during construction. Some of the factors that necessitate these changes include constructability issues.

The expertise of contractors to deliver a high quality work affects how a specific joint type may perform. Against this backdrop, the survey seeks to obtain feedback from district construction engineers and resident engineers who usually supervise the work of contractors. Fifty percent of the respondents had issues with contractor’s expertise, both with respect to their general work performance and their equipment operators. Some of the reasons they attributed to the poor expertise were that most of the contractors were new to widening road projects, and some of the contractor’s workers, especially equipment operators, have less technical expertise with the placement of material.

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Economic Analysis

The economic analysis evaluated the cost analysis of each of the joint types using typical cross sectional quantities and WYDOT's weighted average bid prices. The costs for the base material estimates, unclassified excavation, and the cutting bituminous pavement for both joint types were analyzed. The vertical joint cut projects have an 18% cost increase over the tapered joint projects. Actual contract bids for tapered and vertical joint projects indicate differences in bid items costs submitted by contractors on a same project (vertical joint). It was observed that contractors bid prices differ even on the similar projects due to several factors such as ease of construction and profitability.

RECOMMENDATIONS

The main objective of this research is to develop a formal recommendation for the preferred longitudinal widening joint construction for asphalt road surfaces.
Based on the following conclusions obtained from the analysis, the tapered joint type is identified as the preferred widening joint due to better pavement base support than the vertical joint. Also, the tapered joint should be used based on site specific conditions:

- Occurrence and severity of longitudinal cracking depends on the location of the widening joint, either in the wheel path or not. It was determined that severe cracks occur on the joints located in the wheel path, especially for the vertical joint compared to the tapered joint.
- The penetration from the DCP data indicates that tapered joints exhibit relatively better base strength and support near the joint location than vertical joints.
- The deflection also indicates a relatively greater base strength for the tapered joint than for the vertical joint across the joint locations.
- A survey of Rocky Mountain States' transportation departments indicate that the vertical joint type is predominately used. Colorado DOT was the only state that uses all three joint types (tapered, vertical and stepped).They reported severe settlements associated with the vertical joint type.
- A survey of District Construction Engineers (DCEs) and Resident Engineers (RE) indicate that more of them have supervised vertical joint construction than tapered joints.
- The cost comparison between the two joint types indicates that vertical joint projects have an 18% increase in costs over the tapered joint projects.

REFERENCES

1. **Maillet, L.J.** *Roadway Widening Study*. s.l. : Materials Program, Wyoming Department of Transportation, 2009.

2. *Evaluation of Notched-Wedge Longitudinal Joint Construction.* **Buchanan, M.S.** 2000, Trasnportation Research Record 1712,, pp. pp 50-57.

3. **Kandhal, P.S. and Mallick, R.** *Longitudinal Joint Construction Techniques for Asphalt Pavements.* s.l. : NCAT Report No. 97-4 National Center for Asphalt Technology, 1997.

4. *Evaluation of Eight Longitudinal Joint Construction Techniques for Asphalt pavements in Pennsylvania.* **Kandhal, P.S., Ramirez, T. and Ingram, P.** 2002, Transportation Research Record 1813,9., pp. pp 87-94.

5. **Kandhal, P.S. and Rao, S.** *How to Evaluate Longitudinal Joint Construction Techniques.* s.l. : Better Roads, 1995.

6. *Constructing Longitudinal Joints in Hot Mix Asphalt Pavement.* **Foster, C.R., Hudson, S.B. and Nelson, R.S.** Washington, DC : s.n., 1964, Highway Research Record 51, TRB National Research Council.

7. **Texas Transportation Institute.** *Guidelines for Design of Flexible Pavement Widening.* s.l. : Texas Department of Transportation, 2006.

8. **Shahin, M.Y., et al., et al.** *Effect of sample unit size and number of surveyed distress types on pavement condition index for SHRP-P-338 (1993). Distress Identification Manual for the Long-Term Pavement Performance Project.* Washington, D.C. : Strategic Highway Research Program (SHRP), National Research Council, 1995. p. pp147.

9. **ASTM.** *Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys D6433.* West Conshohocken, PA : ASTM International, 2011.

10. *Fracture Mechanics Analysis of Cracking in Asphalt Pavement Widening.* **Zhang, J.** 2009. Proceddings of the 9th International Conference of Chinese Transportation Professionals. pp. pp. 2359 - 2365.

11. **Estakhri, C., Freeman, T.J. and Spiegelman, C.** *Density Evaluation of the Longitudinal Construction Joint of Hot-Mix Asphalt Pavements.* s.l. : Report 1757. Texas Transportation Institute, College Station, TX, 2001.

12. **Hilbirch, S. and Scullion, T.** *Design Considerations For Flexible Pavment Widening.* s.l. : FHWA/TX-07.0-5429-1 Texas Transportation Institute, 2007.

13. **Salgado, R and Yoon, S.** *Dynamic Cone Penetration Test (DCPT) for Subgrade Assessment.* West Lafayette, Indiana : Publication FHWA/IN/JTRP-2002/30. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, 2003.

14. *Application of Dynamic Cone Penetrometer in Pavement Construction Control.* **Abu-Farsakh, M.Y., et al., et al.** 2005, Transportation Research Record 1913, pp. pp. 53-61.

15. *Use of Falling Weight Deflectometer and Dynamic Cone Penetrometer in Pavement Evaluation.* **Chen, J.** 1999, Transportation Research Record 1655 1. (0361-1981), p. p145.

16. *Prediction of Resilient Modulus of Cohesive Subgrade Soils from Dynamic Cone Penetrometer Test Parameters.* **Mohammed, L., et al., et al.** 2007, J. Materials Civil Eng., 19(11), , pp. pp 986-992.

17. *Estimation of Paving Materials Design Moduli from Falling Weight Deflectometer Measurements.* **Frazier, P. Jr.** washington, DC : s.n., 1991, Transportation Research Record 1293, National Research Council, pp. pp. 42 -51.

18. **Ullidtz, P.** *Pavement Analysis.* Amsterdam, The Netherlands : Elseiver Science, 1987.

19. **Von Quintus, H. and Killingsworth, B.** *Analyses Relating to Pavement Material Characterizations and Their Effects on Pavement Performance.* Mclean, VA : Federal Highway Administration,, 1998. Publication No. FHWA-RD-97-085.

20. **Alavi, S., LeCates, J.F. and Tavares, M.P.** *Falling Weight Deflectometer Usage; A Synthesis of Highway Practice.* Washington, DC : Transportation Research Board, 2008. National Cooperative Highway Research Program, NCHRP Synthesis 381.

21. **ASTM.** *D 4694-96: Standard Test Method for Deflections with a Falling-Weight-Type Impulse Load Device.* . West Conshohocken, PA : ASTM International, 2003.

22. **Beuving, E.** *Final Report of the Action, COST Action 336.* Brussels, Belgium : European Cooperation in the Field of Scientific and Technical Research, European Commisison, 2000.

23. **SHRP.** *Manual for FWD Testing in the Long-Term Pavement Perfromance Program.* Washington, DC : Strategic Highway Research Program, National Academy of Sciences, 1993. Strategic Highway Research Program, SHRP-P-661.

24. **FHWA-LTPP.** *LTPP Manual for Falling Weight Deflectometer Measurements Operational Field Guidelines.* McLean, VA : U.S. Department of Transportation, Federal Highway Administration, 2000. HRDI-13, Version 3.1.

25. **Tonkin.** *Pavement Deflection Measurement & Interpretation for the Design of Rehabilitation Treatments.* Auckland, NZ : New Zealand Transport Agency, 1998. Transit New Zealand Research Report No.117.

26. **AASHTO.** *American Association of State Highway and Transportation Official Guide for Design of Pavement Structures.* Washington, DC : s.n., 1993.

27. *Effective Layer Temperature Prediction Model and Temperature Correction Via Falling Weight Deflectometer.* **Park, D., Buch, N. and Chatti, K.** Washington, DC : s.n., 2001, Transportation Research Record 1764, National Research Council, pp. pp 97 - 111.

28. *Temperature Correction of Deflections and Backcalculated Moduli.* **Kim, Y. R., Hibbs, B. O. and Lee, Y.C.** 1995, Transportation Research Record 1473, National Research Council, pp. pp 55-62.

29. *Backcalculation: An Overview and Perspective.* **Irwin, L. H.** 2002, Proceedings of the Pavement Evaluation Conference, Roanoke, Virginia, USA, pp. pp.1-22.

30. *Application of Deflection Testing to Overlay Design, A Case Study.* **Richter, C. and Irwin, L.H.** Washington, DC : National Research Council, Transporation Research Board, 1988, Transportation Research Record 1196, pp. pp. 193-200.

31. **Mustaque Hossian, A.S.M. and Zanlewski, J.P.** *Variability In Estimation of Structural Capacity of Existing Pavements From Falling Weight Deflectometer Data.* Phoenix, AZ : Arizona Department of Transportation, 1990. Final Report, AZ-SP-9001.

32. **Apea, A.K.** *Validation of FWD Testing Results at the Virginia Smart Road: Theoretically and by Instrument Responses.* Blacksburg, Virginia : s.n., 2003. PhD Dissertation.

33. *SHRP Prototype Procedures for Calibrating Falling Weight Deflectometer.* **Richter, C. and Irwin, L.H.** Hanover, NH : U.S. Army Cold Regions Research and Engineering Laboratory, 1989. Proc. International Symposiums of the State of the Art of Pavement Response Monitoring Systems for Roads and Airfield. pp. pp. 296-303.

34. *Pavement deflections and fatigue failures.* **Hveem, F.N,.** Washington, DC : National Research Council, Highway Research Board, 1955. Highway Research Bulletin 114. pp. 43-87.

35. *The effect of resilience-deflection relationship on the structural design of asphaltic pavements.* **Hveem, F.N., et al., et al.** Ann Arbor : University of Michigan, 1962, Proc. Intl. Conf. on Structural Design of Asphalt Pavements, pp. 649-666.

36. *Applications of layered system concepts and priciples to interpretations and evaluations of asphalt pavement performances and to design and construction.* **Burmister, D.M.** Ann Arbor : University of Michigan, 1962. Proc. Intl. Conf. on Structural Design of Asphalt Pavements. pp. 441-453.

37. *General analysis of stresses and displacements in layered elastic systems.* **Schiffman, R.L.** Ann Arbor, MI : University of Michigan, 1962. pp. 365-375.

38. *Analysis of stresses and displacements in a n-layered elastic system under a load uniformly distributed on a circular area.* **Michelow, J.** Richmond, CA : s.n., 1963. California Research Corporation. pp. 1-14.

39. **WSDOT.** *Everseries User's Guide, Pavement Analysis Computer Software and Case Studies.* Tumwater, WA : WSDOT Environmental and Engineering Programs, Materials Laboratory - Pavements Division, 2005.

40. **Dynatest.** *Elmod 6 Quick Start Manual.* Ventura, CA : s.n., 2009.

41. **Irwin, L. and Szebenyi, T.** *User's Guide to MODCOMP3, Version 3.2.* Ithaca, New York : CLRP Report Number 91-4, Cornell University Local Roads Program, 1991.

42. **Texas Transportation Institute, TTI.** *MODULUS: Preliminary User's Manual - Version 4.0.* College Station, Texas : Texas A&M University, 1990.

43. **Alexander, D.R.** *Nondestructive Testing Techniques and Evaluation Procedures for Airfield Pavements.* Philadephia, Pennsylvania : Bush and Baladi, Editors, 1989. ASTM STP 1026.

44. **Van Cauwelaert, F.J.** *Multilayer Elastic Program for Backcalculating Layer Moduli in Pavement Evaluation.* Philadelphia, Pennsylvania : Bush and Baladi, Editors, 1989. ASTM STP 1026.

45. *Layer Moduli Backcalculation Procedure: Software Selection.* **Strategic Highway Research Program, SHRP.** Washington, DC : Strategic Highway Research Program,SHRP-P-651, National Research Council, 1993.

46. **SHRP.** *SHRP's Layer Moduli Backcalculation Procedure.* Washington, DC : Strategic Highway Research Program, National Research Council, 1993. SHRP-P-655.

47. **Deusen, D.V.** *Selection of Flexible Backcalculation Software for the Minnesota Road Research.* Maplewood, MN : Report No. MN/PR-96/29, Minnesota Department of Transportation (MnDOT), 1996.

48. **Lytton, R. L.** *Backcalculation of pavement layer properties.* America Society for Testing and Materials. Philadelphia : In A.J. Bush III & G.Y. Baladi (eds.), Nondestructive testing of pavements and backcalculation of moduli, ASTM STP1026, 1989. pp. 7-38.

49. *Variability in Measured Deflections and Backcalculated Moduli for the Strategic Highway Research Program - Southern Region.* **Rauhut, B.J. and Jordahl, P.R.** Washington, D.C : s.n., 1992, Transportation Research Record 1377, Transportation Research Board.

50. *Layer Moduli from Deflection Measurements: Software Selection and Devleopment of Strategic Highway Research Program Procedure for Flexible Pavements.* **Rada, G.R., Richter, C.A. and Stephanos, P.J.** Washington, D.C. : s.n., 1992, Transportation Research Record 1377, Transportation Research Board.

51. *Prediction by Asphalt Pavement Structural Layer Moduli using Optimized FWD Configuration.* **Roque, R., et al., et al.** 1992, Association of Asphalt Paving Technology, 64, pp. pp.278-305.

52. **Stubstad, R.N., et al., et al.** *Review of the Long-Term Pavement Performance Backcalculation Results - Final report.* McLean,Virginia : Report No. FHWA-HRT-05-150,Federal Highway Adminstration (FHWA), 2006.

53. *Comparison of Methods of Determining Pavement Paramters from deflection Bowl Measurements.* **Wiesman, G. and Greenstein, J.** 1983, Proceedings of the 7th Asian Regional Conference on Soil Mechanics and Foundation Engineering, pp. 158-165.

54. **Sivaneswaran, N., Pierce, L.M. and Mahoney, J.P.** *EVERCALC Help File. EVERCALC Version 5.0.* s.l. : Washington State Department of Transportation Materials Labortory, 2001.

55. *Nevada's Approach to the Backcalculation Process.* **Sebally, P.E., Bemanian, S. and Lani, S.** West Conhohocken, PA : s.n., 2000, Nondestructive Testing and Backcalculation of Moduli: Third Volume. ASTM STP 1375. S.D. Tayabi and E.O. Lukanen, Eds., American Society of Testing and Materials.

56. *Evaluation of Labortory Determined and Nondestructive Test based Resilient Modulus Values from the WesTrack Experiment.* **Seeds, S. B., et al., et al.** West Conshohocken, PA : s.n., 2000, Nondestructive Testing and Backcalculation of Moduli: Third Volume. ASTM STP 137 . S.D.Tayabi and E.O. Lukanen, Eds., American Society of Testing and Materials.

57. *Relating Laboratory and Field Moduli of Texas Base Materials.* **Nazarian, S., et al., et al.** Washington, D.C. : Transportation Research Board of the National Academies, 1998, Transportation Research Record 1639, pp. pp 1-11.

58. *Comparison of Backcalculated and Laboratory Measured Moduli on AC and Granular Base Layer Materials.* **Zhou, H.** West Conshohocken, PA : American Society for Testing and Materials, 2000, Nondestructive Testing of Pavements and Backcalculation of Moduli: Third Volume, ASTM STP 1375, S.D. Tayabi and E.O. Lukanen, Eds., , pp. pp. 161-172.

59. *Measuring Resileint Modulus of Granular materials in Flexible Pavements.* **Ping, W.V., et al., et al.** Washington, DC : s.n., 2001, Transportation Research Record 1778, Vols. Paper No. 01-0398, pp. pp.81-90.

60. **Shahin, M.Y.** *Pavement Management for Airports, Roads and Parking Lots.* New York : Chapman and Hall, 1994.

61. **Pavement Interactive.** Gradation Test. [Online] 2011. [Cited: March 7, 2013.] http;//www.pavementinteractive.org/article/gradation-test.

62. **Irwin, L.H.** *Instructional Guide for Back-Calculation and the Use of MODCOMP3, Version 3.6.* Ithaca, New York : Cornell UNiversity Local Roads Program, 2004. CLRP Publication No. 94-10.

63. **VDOT and Cornell.** *MODTAG: The FWD Analysis Program.* Richmond, VA : VDOT and Cornell Local Roads Program, 2007. MODTAG Version 4.0.

64. **Huang, Y.H.** Pavement Analysis and Design. 2nd ed. New Jersey : Prentice Hall, 2004.

APPENDIX A: FIELD TESTING PROTOCOL

Evaluating Base Widening Methods

Testing Protocol

This section presents the testing protocol that was used for the field testing. The sequence as spelt out in the testing protocol was used for both the existing and new projects.

Sequence of Testing Existing Sections:

1. Traffic Control.
2. Test Location Naming Convention.
3. Mark locations.
4. Perform Falling Weight Deflectometer (FWD) testing.
5. Core the pavement surface at appropriate locations.
6. Perform Dynamic Cone Penetrometer (DCP) testing.
7. Obtain samples for determining moisture content of the base.
8. Obtain samples from the base to perform aggregate gradation.
9. Fill, compact and cover the hole.
10. Transport test samples to the UW and WYDOT laboratories for moisture content and gradation respectively.

1. Traffic Control

Considerations:

- WYDOT will set-up traffic control on the selected road sections prior to testing.
- The selected sections must be safe with adequate sight distance (preferably tangent sections).

2. Test Location Naming Convention

Naming of test locations will be as shown in Figure 62 using a system of six digits with the first three digits denoting the project as numbered in Tables 27 and 28. The fourth digit (a letter) denotes location of the test point where J is for the joint line, L is for the line left of the joint line and R is for the line right of the joint line as shown in Figure 62.The fifth digit is for offset distance from the joint line in feet, and the last digit is the location number. For example, labeling a core N09R23 indicates that the core sample was taken from location 3 of project number nine which is project MG-OP23-02-(037), the sample point is located at a 2 feet offset to the right of the joint line.

3. Marking Locations

The points on the pavement where various tests and sampling are to be carried out are marked as follows:

- A testing sheet for each project will be provided showing tests to be performed at each location at the beginning of each day.
- Note and record presence of rumble strips close to joints.
- A spotter with spray paint will mark locations.

- More locations to be marked for FWD and core locations.
- Generally, three locations will be selected for each road corridor at 100 ft. spacing as shown in Figure 63.

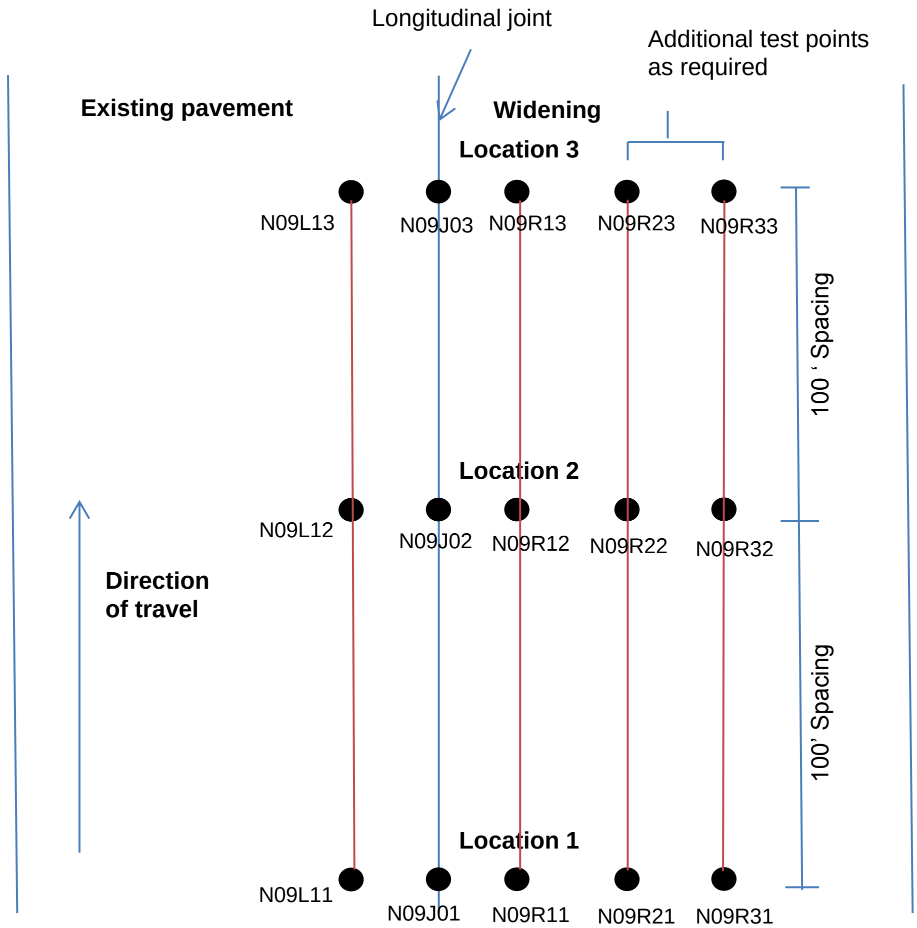
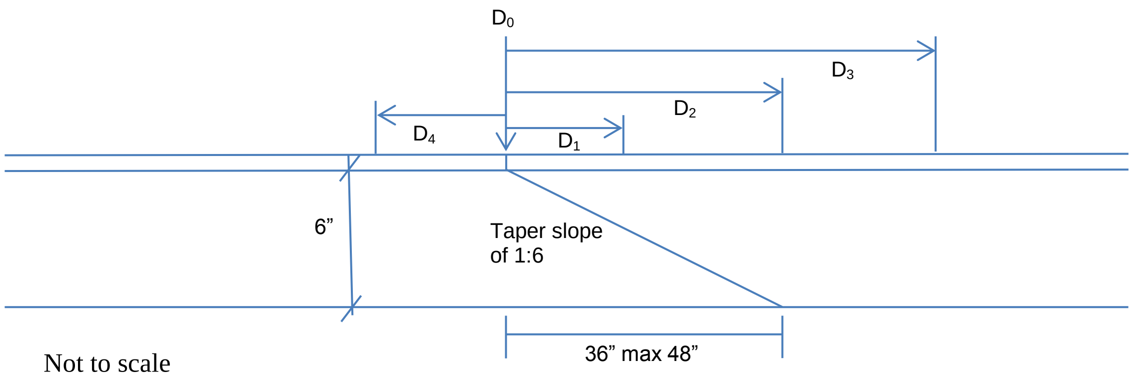


Figure 62: Diagram. Spacing and number of locations per road project



Proposed

$D_0 = 0$

$D_1 = 1'$

$D_2 = 3'$ (for tapered joints) if needed

$D_3 = 5'$ (for tapered joints) if needed

$D_4 = 1'$

Figure 63: Diagram. Cross Section of test location showing distances to be marked relative to the joint line

- In selecting transverse spacing across the test sections, a minimum of nine test points were selected for each location with the points located such that one is on the longitudinal joint, another at 1ft from the joint on the existing pavement and the final one on the widened pavement offset 1ft from the longitudinal joint (as illustrated in Figure 63). For tapered joints, additional points may be marked at increments of 2ft transversely from the closest test point on the widened pavement. The number of additional test points may be limited by the closeness of the road edge to the joint.
- Location of test points for FWD should be at least 2.5 ft from the wheel of the trailer and all wheels are required to be on pavement during testing.

4. Falling Weight Deflectometer

Considerations:

- FWD testing will be performed at the marked locations as shown in Figure 62.
- FWD datasets are named using project numbers in Table 27 and prefixed with UW.
- Air and pavement temperatures will be measured and recorded as part of the FWD testing.

5. Coring

Considerations:

- 6 inch or 8 inch diameter for coring.
- Fifteen cores for each project section will be performed (see Figure 62).
- To minimize water infiltration into base layers, core locations will be cored to ¾ of estimated asphalt layer thickness with the first core depth estimate will be provided based on information from plans.
- Excess water from coring will be immediately removed from the core hole with a vacuum.
- Examine cross-sections in each hole to determine base thicknesses as well as stripping and distresses.

6. DCP Testing

Considerations:

- Number of test points per section will be as marked for cores.
- Weight of hammer is 17.6 lb
- Record number of accumulated blows after every 2 inch penetration. If penetration is less than 0.08 in. (2 mm) after 5 blows or the handle deflected more than 3 in. (75 mm) from the vertical position, end the test.

7. Sampling for Moisture Content of Base

Considerations:

- Fifteen test points per section as marked for cores.
- Collect samples in sealed cylinder cans and tag with the appropriate core name.

8. Sampling of Base Material

Considerations:

- Fifteen test points per section as indicated for cores.
- The base material may be combined according to the locations (L1, J, R1, R2 and R3).
- Tag samples with appropriate project naming convention.

9. Filling and Covering the Hole

Considerations:

- Fill each hole with appropriate filling materials and compact as required.

10. Transportation of Test Samples and Testing

WYDOT personnel will be responsible for transporting the base material sample to the materials lab for gradation testing. The UW research team will transport the base sample in the sealed cans for moisture content testing at the UW laboratory.

Sequence for Testing New Sections:

The testing of new sections focus primarily on the following:

1. Test base before application of asphalt: DCP testing.
2. Test after asphalt is laid: FWD and DCP testing.

1. DCP Testing of Base before Applying Asphalt Mix

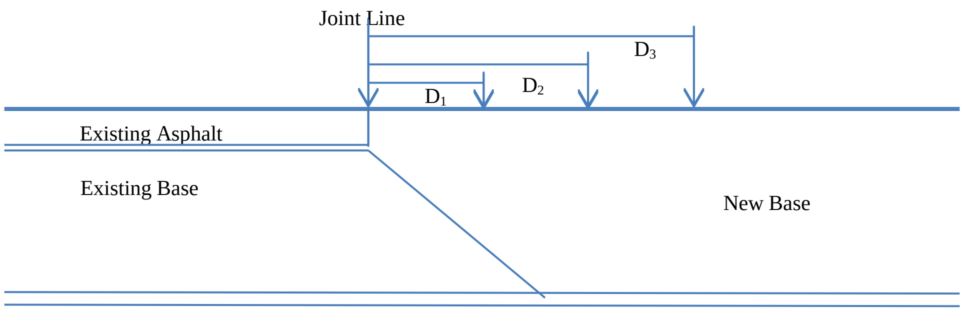


Figure 64: Diagram. New Widening using Tapered Longitudinal Joint

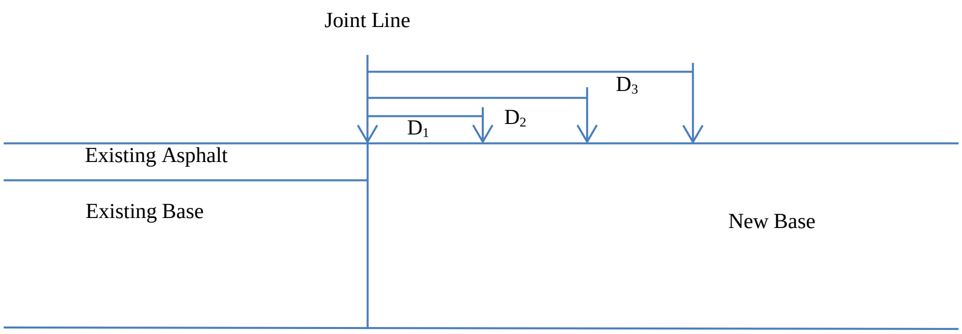


Figure 65: Diagram. New Widening using Vertical Longitudinal Joint

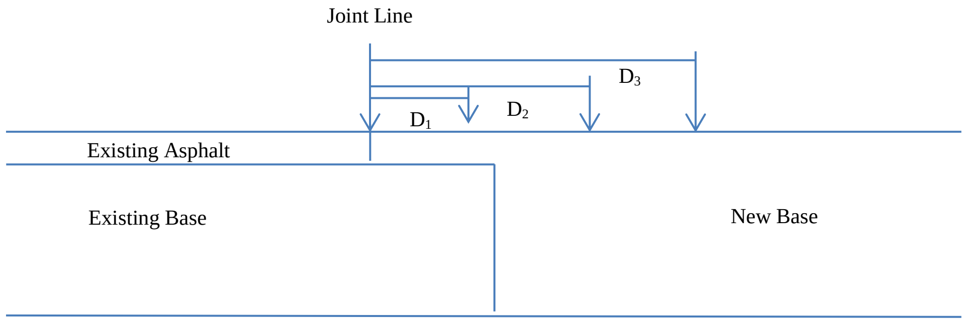


Figure 66: Diagram. New Widening using Notched Longitudinal Joint

Discussion points:

- D_1 = 1', D_2 = 2', D_3 = 3'.
- Number of locations on new base.
- Sampling of base for gradation and moisture.

2. Testing after Application of Asphalt

- FWD testing of new pavement at approximately same locations as base DCP testing.

Table 27: Project Located on Non-Interstate

No.	Route Main Line (ML)	Route Name	Project #	Location	Proposed Widening Type
N01	107	WY 210	ACSTPS-0107-00(23)	Laramie County (Happy Jack Road, Cheyenne West)	Tapered
N02	11	US 189	P114035	Sublette County (Big Piney Cutoff Road & Turn Lane, Big Piney - Daniel Jct.)	Tapered
N03	113	WY 113	STP-W113-00(002)	Crook County (Pine Haven Road, Wyo. 113 turn lane)	Vertical
N04	12	US 30	NH-0N12-02(014)	Sweetwater County	Vertical
N05	16	WY 414	SCP-0P16-01(020)	Uinta County (Mountain View - Lonetree)	Vertical
N06	1906	WY 372	SIB-ACSTPS-1906-00(017)	West Sweetwater (Green River - Fontenelle)	Vertical
N07	202	WY 32	STPS-0202-00(013)	Big Horn County (Lovell-Emblem, Whistle Creek South Section, Burlington - Main St.	Vertical
N08	21	WY 220	ACNH-PO-0N21-02(100)	Natrona County (Natrona Co. Line - Casper)	Vertical
N09	23	US 287	MG-0P23-2(037)	Albany County (Rock River - Laramie)	Vertical
N10	300	WY 50	SCP-030037	Campbell (Gillette - Pine Tree Jct.)	Vertical
N11	404	WY 72	SCP-SL081.55 0404010	Carbon County (Hanna - Elk Mountain)	Vertical
N12	600	WY 116	STPS-0600-00(19) & ARSCT	Weston County (Upton North Section, Sundance-Upton Rd)	Vertical
N13	703	WY 132	STPS-0703-00(012)	Fremont County (Ethete - Kinnear)	Vertical
N14	1801	WY 351	SCP-SL0812.89 1801020	Sublette County (Big Piney - Daniel Jct.)	Vertical

Table 28: Projects Located on Interstate

No.	Route Main Line (ML)	Route Name	Project #	Location	Proposed Widening Type
F21	25	I 25	I025-02(137)	Platte County (Wheatland - Glendo Road, Cassa North Section)	Vertical
F22	25	I 25	ACIM-I025-04(138)	Converse & Natrona Counties (Casper - Glenrock, County line west section)	Vertical
F23	80	I 80	SIB-ACIM-80-1(104)	Uinta County (Lyman - Granger, County Line West)	Vertical
F24	80	I 80	NHI-80-4(197)216	Carbon County (Rawlins - Walcott Jct., Rawlins East Section)	Vertical
F25	80	I 80	IM-I080-5(130)	Albany County (Vedauwoo West Section)	Tapered
F26	80	I 80	IM-I080-06(139)	Laramie County (Laramie - Cheyenne)	Vertical and Tapered (Crusher run subbase used for widening)
F27	80	I 80	SIB-ACIM-I080-06(171)	Laramie County (EBL, Laramie - Cheyenne)	Vertical/Tapered
F28	90	I 90	ACIM-I090-01(193) & (110)	Sheridan County (Ranchester - Sheridan)	Vertical
F29	90	I 90	ACIM 40.20 901102	Sheridan & Johnson Counties (Sheridan - Buffalo Road, County Line Section)	Vertical
F30	25	I 25	ACIM I025-03(094)	Converse County (Douglas-Glenrock road, Glenrock East Section)	Tapered
F31	80	I 80	IM-I080-04(199) & (218)	Carbon County (Rawlings-Walcott Jct., Ft. Steele Section)	Vertical
F32	80	I 80	ACIM-I080-05(125)	Albany County (Walcott Jct. - Laramie Road, Herrick Lane Section)	Vertical
F33	90	I 90	IM-90-3(87)118	Campbell County (Buffalo - Gillette, Gillette West Section)	Vertical
F34	25	I 25	ACIM-I025-05(094)	Johnson County (Kaycee - Buffalo, District Boundary No. Section)	Vertical

Table 29: 2012 Widening Projects included in the Study

Project	Highway	Class	Dist.	County	MP Start	MP End	Letting	Location	Description	Planned Widening Type	Contractor	Resident Engineer
N852001	US 85	Non-Int. NHS	1	Laramie	21.80	56.54	Mar 2012	Cheyenne - Torrington	Passing Lanes	Vertical	Knife River	Don Fuller
												777-4405
N132095	US 191	Non-Int. NHS	3	Sublette	89.90	91.70	Nov 2011	Pinedale South	Widen to 5 Lanes	Taper	LaGrand Johnson Construction	Peter Hallsten
												367-4488
P433035	WYO 59	Non-NHS	4	Campbell	142.05	148.6	Nov 2011	Gillette-Montana/Weston	Widen & Overlay	Vertical	Intermountain Constr. & Materials	Josh Jundt
												682-3550
N361053	US 16	Non-Int. NHS	5	Washakie	1.52	4.87	2011	Worland - Ten Sleep	Reconstruction	Taper	Hout Fencing of Wyoming	Dan McAfee
												347-2822

APPENDIX B: FIELD DATA SHEETS

ROAD INSPECTION

Highway: ______________________ Project name: ______________

Date: ______________ Personnel: ____________________

Location 1 (Approximate station): ______________

Location of joint: ________ Offset from centre line ________ Offset from edge of pavement

Condition of pavement: ________________________________

Presence of Longitudinal Cracks

☐ None

☐ Yes

Crack no.	1	2	3	4	5
Distance from crack to jnt (in.)					
Distance from crack to loc (in.)					
Width of crack (in.)					
Length of crack (in.)					

Presence of transverse cracks

☐ None

☐ Yes

Crack no.	1	2	3	4	5
Distance from crack to jnt (in.)					
Distance from crack to loc (in.)					
Width of crack (in.)					
Length of crack (in.)					

Location 2 (Approximate station): ______________

Location of joint: ________ Offset from centre line ________ Offset from edge of pavement

Condition of pavement: ________________________________

Presence of Longitudinal Cracks

☐ None

☐ Yes

Crack no.	1	2	3	4	5
Distance from crack to jnt (in.)					
Distance from crack to loc (in.)					
Width of crack (in.)					
Length of crack (in.)					

Presence of transverse cracks

☐ None

☐ Yes

Crack no.	1	2	3	4	5
Distance from crack to jnt (in.)					
Distance from crack to loc (in.)					
Width of crack (in.)					
Length of crack (in.)					

Location 3 (Approximate station): ______________

Location of joint: ________ Offset from centre line ________ Offset from edge of pavement

Condition of pavement: ________________________________

Presence of Longitudinal Cracks

☐ None

☐ Yes

Crack no.	1	2	3	4	5
Distance from crack to jnt (in.)					
Distance from crack to loc (in.)					
Width of crack (in.)					
Length of crack (in.)					

Presence of transverse cracks

☐ None

☐ Yes

Crack no.	1	2	3	4	5
Distance from crack to jnt (in.)					
Distance from crack to loc (in.)					
Width of crack (in.)					
Length of crack (in.)					

CORES

Location: Project name: Personnel:

Field ID	Test ID	Core thickness	Presence of cracks in core	Core Sample Picture	Hole Picture	NOTES (Presence of rumble strips)
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
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				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	
				Done ☐	Done ☐	

* FWD file name should be same as project number (as in Testing Protocol page 8 & 9) prefixed with UW

Gradation Samples:

Date: Personnel:

Location: Project name:

Sample ID	Locations of cores from which sample is drawn	Field ID	Notes on base materials and depth

DCPT DATA SHEET

Project: Date:

Location: Personnel:

Material classification: Hammer weight: 17.6lb

Pavement condition: Weather:

Mile Post	Field ID	Test ID	Cumulative Penetration (In.)	Number of blows	Notes
			2		
			4		
			6		
			8		
			10		
			12		
			14		
			16		
			2		
			4		
			6		
			8		
			10		
			12		
			14		
			16		
			2		
			4		
			6		
			8		
			10		
			12		
			14		
			16		
			2		
			4		
			6		
			8		
			10		
			12		
			14		
			16		
			2		
			4		
			6		
			8		
			10		
			12		
			14		
			16		

Moisture Content Samples

Sample ID	Locations of cores from which sample is drawn	Field ID	Notes on base materials and depth

APPENDIX C: SUMMARY OF FIELD AND LABORATORY DATA

No	Project #	Road Class	Joint Type	Widening Base Material	Existing Base Material	Longitudinal Crack Density	Cracks in Core	Rumble strips	Joint Loc.	Ave. Asphalt thickness	M.C. Average values	M.C. Standard deviation	Gradation
1	ACSTPS-0107-00(23)	Non Interstate	Tapered	CB	CB	0	No	No	shoulder	5"	5%	0.258	w
2	P114035	Non Interstate	Tapered	CB	CB	0	No	No	shoulder	6.5"	4%	0.778	w
3	STP-W113-00(002)	Non Interstate	Vertical	CB	CB	1	No	No	travel lane	4"	3%	0.315	w
4	NH-0N12-02(014)	Non Interstate	Vertical	CB	CB	6	No	Yes	travel lane	6"	5%	0.010	w
5	SCP-0P16-01(020)	Non Interstate	Vertical	CB	CB	2	No	Yes	travel lane	7"	5%	0.016	w
6	SIB-ACSTPS-1906-00(017)	Non Interstate	Vertical	CB	CB	0	No	Yes	travel lane	6"	4%	0.008	w
7	STPS-0202-00(013)	Non Interstate	Vertical	CB	CB	1	No	No	shoulder	5"	5%	0.664	w
8	ACNH-PO-0N21-02(100)	Non Interstate	Vertical	CB	CB	2	No	No	shoulder	5"	4%	0.500	w
9	MG-OP23-02-(037)	Non Interstate	Vertical	CB	CB	1	No	Yes	shoulder	5"	4%	0.557	w
10	SCP-030037	Non Interstate	Vertical	RAP	CTB	1	No	No	shoulder	5"	3%	0.528	w
11	SCP-SL081.55 0404010	Non Interstate	Vertical	CB	CTB	0	No	No	shoulder	5"	4%	0.549	w
12	STPS-0600-00(19) & ARSCT	Non Interstate	Vertical	CB	CB	0	No	No	travel lane	4"	3%	0.457	w
13	STPS-0703-00(012)	Non Interstate	Vertical	CB	CB	0	No	No	travel lane	5"	4%	0.418	w
14	SCP-SL0812.89 1801020	Non Interstate	Vertical	CB	CB	0	No	Yes	shoulder	6	-	-	-
15	I025-02(137)	Interstate	Vertical	CB	CB	9	No	No	travel lane	6"	4%	0.459	w
16	ACIM-I025-04(138)	Interstate	Vertical	RAP	CTB	0	No	No	shoulder	5"	5%	0.544	w
17	SIB-ACIM-80-1(104)	Interstate	Vertical	RAP	CTB	19.4	Yes	No	travel lane	7"	-	-	-
18	NHI-80-4(197)216	Interstate	Vertical	RAP	CTB	2.9	No	No	shoulder	9"	-	-	-
19	ACIM-I080-	Interstate	Tapered	RAP	CTB	0	No	No	travel	6"	-	-	-

No	Project #	Road Class	Joint Type	Widening Base Material	Existing Base Material	Longitudinal Crack Density	Cracks in Core	Rumble strips	Joint Loc.	Ave. Asphalt thickness	M.C. Average values	M.C. Standard deviation	Gradation
	05(130)								lane				
20	IM-I080-06(139)	Interstate	Tapered	RAP	CTB	0	No	No	shoulder	5"	5%	0.925	w
21	SIB-ACIM-80-06(171)	Interstate	Tapered	RAP	RAP	0	No	No	shoulder	12	-	-	-
22	ACIM-I090-01(093) & (110)	Interstate	Vertical	RAP	CB	1	No	Yes	shoulder	9"	5%	0.538	w
23	901102	Interstate	Vertical	RAP	CB	0	No	No	travel lane	6"	7%	1.466	w
24	ACIM-I025-03(094)	Interstate	Tapered	RAP	CTB	3	Yes	No	travel lane	6"	-	-	-
25	IM-1080-04(199)&(218)	Interstate	Vertical	RAP	CTB	4.4	No	No	travel lane	12"	-	-	-
26	ACIM-1080-05(125)	Interstate	Vertical	RAP	CTB	2.2	No	Yes	travel lane	9"	-	-	-
27	IM-90-3(87)118	Interstate	Vertical	RAP	CTB	0	No	No	shoulder	9"	-	-	-
28	ACIM-I025-05(094)	Interstate	Vertical	CB	CB	4	No	No	travel lane	12"	6%	0.560	w

APPENDIX D: FIELD DATA

DCP Test Results for Tapered Joint Widening Projects

ACSTPS-0107(023)	L	J	R1	R2	R3
Top Average	1.3	0.0	0.3	-0.1	-0.1
Bottom Average	1.2	0.0	0.1	-0.3	1.0

P114035	L	J	R1	R2	R3
Top Average	-1.1	0.0	-0.2	-0.6	-0.2
Bottom Average	-2.0	0.0	-2.0	0.2	-1.7

ACIM-I080-06(171)	L	J	R1	R2	R3
Top Average	-0.4	0.0	0.6	NA	
Bottom Average	2.0	0.0	4.3	NA	

ACIM-I025-03(094)	L	J	R1	R2	R3
Top Average	CTB	0.0	0.1	7.6	0.6
Bottom Average	CTB	0.0	5.8	13.7	9.3

ACIM-I080-05(130)	L	J	R1	R2	R3
Top Average	-0.2	0.0	0.3	-0.3	NA
Bottom Average	0.3	0.0	-0.3	-0.3	NA

IM-I080-06(139)	L	J	R1	R2	R3
Top Average	CTB	CTB	0.0	2.0	2.2
Bottom Average	CTB	CTB	0.0	-1.3	0.0

DCP Test Results for Vertical Joint Widening Projects

STP-W113(002)	L	J	R1	R2	R3
Top Average	2.8	0.0	-0.1	-0.3	0.1
Bottom Average	10.7	0.0	-8.7	-10.0	-7.6

NH-ON1202(014)	L	J	R1	R2	R3
Top Average	0.2	0.0	0.7	0.2	0.8
Bottom Average	-0.4	0.0	0.0	0.2	0.3

SCP-OP16-01(020)	L	J	R1	R2	R3
Top Average	-0.8	0.0	0.8	0.1	2.0
Bottom Average	0.4	0.0	0.8	2.3	2.8

SIB-ACSTPS-1906(017)	L	J	R1	R2	R3
Top Average	-0.4	0.0	-0.8	-1.2	-0.4
Bottom Average	0.7	0.0	-1.5	-1.3	3.8

STPS-0202(013)	L	J	R1	R2	R3
Top Average	-5.4	0.0	2.6	-0.1	NA
Bottom Average	0.8	0.0	-0.8	-2.1	NA

ACNH-PO-ON21-02(100)	L	J	R1	R2	R3
Top Average	0.0	0.0	-0.1	-0.4	0.2
Bottom Average	1.1	0.0	0.2	3.0	3.7

MG-OP23-2(037)	L	J	R1	R2	R3
Top Average	1.8	0.0	-2.6	-2.3	-1.0
Bottom Average	-0.4	0.0	-3.6	-3.4	-3.4

30037	L	J	R1	R2	R3
Top Average	CTB	CTB	0.0	-1.6	NA
Bottom Average	CTB	CTB	0.0	2.0	NA

SCP-SL 0404010	L	J	R1	R2	R3
Top Average	-1.1	0.0	-1.7	-1.3	-2.0
Bottom Average	0.9	0.0	-2.1	-1.9	-2.7

STPS-0600(019)	L	J	R1	R2	R3
Top Average	3.2	0.0	-6.0	-6.1	-6.3
Bottom Average	4.2	0.0	-6.1	-6.9	-8.0

STPS-0703(012)	L	J	R1	R2	R3
Top Average	1.2	0.0	0.7	1.3	2.2
Bottom Average	-0.3	0.0	-0.2	1.0	1.7

SCP SL 1801020	L	J	R1	R2	R3
Top Average	0.1	0.0	3.8	3.6	8.2
Bottom Average	0.5	0.0	-0.5	4.0	17.0

I025-02(137)	L	J	R1	R2	R3
Top Average	-0.2	0.0	-0.6	0.0	-0.1
Bottom Average	-0.1	0.0	0.3	-0.2	0.1

ACIM-I025-04(138)	L	J	R1	R2	R3
Top Average	-0.9	0.0	-0.1	-0.2	0.0
Bottom Average	0.8	0.0	0.9	0.8	1.3

I090-01(093)	L	J	R1	R2	R3
Top Average	-0.1	0.0	Hard Material		
Bottom Average	-1.3	0.0	Hard Material		

901102	L	J	R1	R2	R3
Top Average	-0.3	0.0	-0.3	NA	
Bottom Average	No penetration				

ACIM-I025-05(094)	L	J	R1	R2	R3
Top Average	1.4	0.0	-1.6	3.0	2.4
Bottom Average	-1.1	0.0	-0.8	2.4	1.7

APPENDIX E: STATISTICAL ANALYSIS OUTPUT (OLD PROJECTS)

- Generalized Linear Model (GLM) of Top Base Layer for DCP Results
- Generalized Linear Model (GLM) of Bottom Base Layer for DCP Results
- Generalized Linear Model (GLM) of FWD Deflection Results
- Generalized Linear Model (GLM) of Back-calculated Moduli Results

Generalized Linear Model (GLM) of Top Base Layer (0-6 inch depth) for DCP Results

Treatment	**Value Label**	**N**
1	Tapered	36
2	Vertical	135

Tests of Within-Subjects Effects

Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**
Placement	Pillai's Trace	.070	3.119a	4.000	166.000	.017
	Wilks' Lambda	.930	3.119a	4.000	166.000	.017
	Hotelling's Trace	.075	3.119a	4.000	166.000	.017
	Roy's Largest Root	.075	3.119a	4.000	166.000	.017
Placement * Treatment	Pillai's Trace	.096	4.417a	4.000	166.000	.002
	Wilks' Lambda	.904	4.417a	4.000	166.000	.002
	Hotelling's Trace	.106	4.417a	4.000	166.000	.002
	Roy's Largest Root	.106	4.417a	4.000	166.000	.002

Multivariate Tests

Source		**Type III sum of squares**	**df**	**Mean Square**	**F**	**Sig.**
Placement*Treatment	Sphericity Assumed	272.471	4	68.118	7.185	.000
	Greenhouse-Geisser	272.471	2.432	112.058	7.185	.000
	Huynh-Feldt	272.471	2.484	109.682	7.185	.000
	Lower-bound	272.471	1.000	272.471	7.185	.008
Error (Placement)	Sphericity Assumed	6408.652	676	9.480		
	Greenhouse-Geisser	6408.652	410.926	15.596		
	Huynh-Feldt	6408.652	419.830	15.265		
	Lower-bound	6408.652	169.000	37.921		

Generalized Linear Model (GLM) of Bottom Base Layer (6-12inch depth) for DCP Results

Treatment	Value Label	N
1	Tapered	26
2	Vertical	121

Tests of Within-Subjects Effects

Effect		Value	F	Hypothesis df	Error df	Sig.
Placement	Pillai's Trace	.097	3.802[a]	4.000	142.000	.006
	Wilks' Lambda	.903	3.802[a]	4.000	142.000	.006
	Hotelling's Trace	.107	3.802[a]	4.000	142.000	.006
	Roy's Largest Root	.107	3.802[a]	4.000	142.000	.006
Placement * Treatment	Pillai's Trace	.094	3.666[a]	4.000	142.000	.007
	Wilks' Lambda	.906	3.666[a]	4.000	142.000	.007
	Hotelling's Trace	.103	3.666[a]	4.000	142.000	.007
	Roy's Largest Root	.103	3.666[a]	4.000	142.000	.007

Multivariate Tests

Source		Type III sum of squares	df	Mean Square	F	Sig.
Placement	Sphericity Assumed	215.418	4	53.854	2.132	.075
	Greenhouse-Geisser	215.418	2.601	82.819	2.132	.105
	Huynh-Feldt	215.418	2.671	80.648	2.132	.103
	Lower-bound	215.418	1.000	215.418	2.132	.146
Placement*Treatment	Sphericity Assumed	533.366	4	133.342	5.279	.000
	Greenhouse-Geisser	533.366	2.601	205.056	5.279	.002
	Huynh-Feldt	533.366	2.671	199.682	5.279	.002
	Lower-bound	533.366	1.000	533.366	5.279	.023
Error (Placement)	Sphericity Assumed	14649.834	580	25.258		
	Greenhouse-Geisser	14649.834	377.156	38.843		
	Huynh-Feldt	14649.834	387.306	37.825		
	Lower-bound	14649.834	145.000	101.033		

Generalized Linear Model (GLM) of FWD Deflection Results

Number of Observations Read	28
Number of Observations Used	28

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Jtype	1	95.414	95.414	3.59	0.0694
Error	26	691.478	26.595		

Comparison of Mean Deflection between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	26.751	26.751	3.99	0.0564
Error	26	174.438	6.7099		
Corrected Total	27	201.189			

Comparison of Mean Deflection between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	24.028	24.028	4.15	0.0521
Error	26	150.713	5.797		
Corrected Total	27	174.7403			

Comparison of Mean Deflection between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	15.863	15.863	3.01	0.0944
Error	26	136.821	5.262		
Corrected Total	27	152.684			

Comparison of Mean Deflection between the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	14.309	14.309	2.65	0.1155
Error	26	140.333	5.397		
Corrected Total	27	154.642			

Comparison of Mean Deflection between the Joint Types at Location R3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	16.019	16.019	2.50	0.1259
Error	26	166.581	6.407		
Corrected Total	27	182.600			

Generalized Linear Model (GLM) of Back-calculated Moduli Results

Number of Observations Read	28
Number of Observations Used	28

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Jtype	1	0.342	0.342	0.21	0.6476
Error	26	41.592	1.600		

Comparison of Back-Calculated Moduli between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.002	0.002	0.00	0.9558
Error	26	13.598	0.523		
Corrected Total	27	13.600			

Comparison of Back-Calculated Moduli between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.001	0.001	0.00	0.9502
Error	26	8.771	0.337		
Corrected Total	27	8.772			

Comparison of Back-Calculated Moduli between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.080	0.080	0.21	0.6490
Error	26	9.851	0.379		
Corrected Total	27	9.931			

Comparison of Back-Calculated Moduli for the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.385	0.385	0.83	0.3720
Error	26	12.114	0.466		
Corrected Total	27	12.498			

Comparison of Back-Calculated Moduli between the Joint Types at Location R3

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	0.107	0.10713579	0.16	0.6941
Error	26	17.610	0.677		
Corrected Total	27	17.717			

APPENDIX F: STATISTICAL ANALYSIS OUTPUT (NEW PROJECTS)

- Generalized Linear Model (GLM) of Top Base Layer for DCP Results
- Generalized Linear Model (GLM) of Bottom Base Layer for DCP Results
- Generalized Linear Model (GLM) of FWD Deflection Results
- Generalized Linear Model (GLM) of Back-calculated Moduli Results

Generalized Linear Model (GLM) of Top Base Layer (0-6 inch depth) for DCP Results

Number of Observations Read	54
Number of Observations Used	54

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
JTypes	1	22.533	22.533	1.95	0.1683
Error	52	600.267	11.544		

Comparison of Mean Penetration between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.00	0.00	0.00	1.0000
Error	52	597.037	11.481		
Corrected Total	53	597.037			

Comparison of Mean Penetration between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5.352	5.352	0.52	0.4746
Error	52	536.519	10.318		
Corrected Total	53	541.870			

Comparison of Mean Penetration between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	18.963	18.963	3.44	0.0695
Error	52	286.963	5.519		
Corrected Total	53	305.926			

Comparison of Mean Penetration between the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.500	1.500	0.51	0.4785
Error	52	153.037	2.943		
Corrected Total	53	154.537			

Comparison of Mean Penetration between the Joint Types at Location R3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	7.407	7.407	1.66	0.2032
Error	52	231.926	4.460		
Corrected Total	53	239.333			

Generalized Linear Model (GLM) of Bottom Base Layer (6-12 inch depth) for DCP Results

Number of Observations Read	36
Number of Observations Used	36

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
JTypes	1	13.339	13.339	0.69	0.4103
Error	34	652.589	19.194		

Comparison of Mean Penetration between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.028	0.028	0.00	0.9831
Error	34	2071.611	60.930		
Corrected Total	35	2071.639			

Comparison of Mean Penetration between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	21.778	21.778	4.72	0.0368
Error	34	156.778	4.611		
Corrected Total	35	178.556			

Comparison of Mean Penetration between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	14.694	14.694	3.84	0.0582
Error	34	130.056	3.825		
Corrected Total	35	144.750			

Comparison of Mean Penetration n between the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.250	2.250	0.33	0.5702
Error	34	232.722	6.845		
Corrected Total	35	234.972			

Comparison of Mean Penetration between the Joint Types at Location R3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.778	1.778	0.96	0.3347
Error	34	63.111	1.856		
Corrected Total	35	64.889			

Generalized Linear Model (GLM) of Top Base Layer (0-6 inch depth) for DCP Results (WY 59)

Number of Observations Read	18
Number of Observations Used	18

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
JTypes	1	27.778	27.778	4.18	0.0577
Error	16	106.311	6.644		

Comparison of Mean Penetration between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	60.500	60.500	6.21	0.0241
Error	16	156.000	9.750		
Corrected Total	17	216.500			

Comparison of Mean Penetration between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.500	4.500	1.13	0.3046
Error	16	64.000	4.000		
Corrected Total	17	68.500			

Comparison of Mean Penetration between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.000	0.000	0.00	1.0000
Error	16	52.000	3.250		
Corrected Total	17	52.000			

Comparison of Mean Deflection for the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.389	1.389	0.48	0.4980
Error	16	46.222	2.889		
Corrected Total	17	47.611			

Comparison of Mean Penetration between the Joint Types at Location R3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.500	0.500	0.21	0.6525
Error	16	38.000	2.375		
Corrected Total	17	38.500			

Generalized Linear Model (GLM) of Bottom Base Layer (6-12 inch depth) for DCP Results (WY 59)

Number of Observations Read	12
Number of Observations Used	12

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
JTypes	1	5.400	5.400	0.18	0.6787
Error	10	296.800	29.680		

Comparison of Mean Penetration between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.000	0.000	0.00	1.0000
Error	10	1240.667	124.067		
Corrected Total	11	1240.667			

Comparison of Mean Penetration between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	4.083	4.083	8.45	0.0157
Error	10	4.833	0.483		
Corrected Total	11	8.917			

Comparison of Mean Penetration between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1.333	1.333	1.43	0.2596
Error	10	9.333	0.933		
Corrected Total	11	10.667			

Comparison of Mean Penetration between the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.083	0.083	0.09	0.7650
Error	10	8.833	0.883		
Corrected Total	11	8.917			

Comparison of Mean Penetration f between the Joint Types at Location R3

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	3.000	3.000	4.29	0.0653
Error	10	7.000	0.700		
Corrected Total	11	10.000			

Generalized Linear Model (GLM) of Top Base Layer (0 -6 inch depth) for DCP Results (US 16)

Number of Observations Read	18
Number of Observations Used	18

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
JTypes	1	12.100	12.100	1.12	0.3066
Error	16	173.556	10.847		

Comparison of Mean Penetration between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	26.889	26.889	8.24	0.0111
Error	16	52.222	3.264		
Corrected Total	17	79.111			

Comparison of Mean Penetration between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	14.222	14.222	0.89	0.3596
Error	16	255.778	15.986		
Corrected Total	17	270.000			

Comparison of Mean Penetration between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	34.722	34.722	3.62	0.0753
Error	16	153.556	9.597		
Corrected Total	17	188.278			

Comparison of Mean Penetration between the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.222	0.222	0.10	0.7567
Error	16	35.778	2.236		
Corrected Total	17	36.000			

Comparison of Mean Penetration between the Joint Types at Location R3

Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	8.000	8.000	1.47	0.2430
Error	16	87.111	5.444		
Corrected Total	17	95.111			

Generalized Linear Model (GLM) of Bottom Base Layer (6 -12 inch depth) for DCP Results (US 16)

Number of Observations Read	12
Number of Observations Used	12

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
JTypes	1	0.817	0.817	0.97	0.3483
Error	10	8.433	0.843		

Comparison of Mean Penetration between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5.333	5.333	4.71	0.0552
Error	10	11.333	1.133		
Corrected Total	11	16.667			

Comparison of Mean Penetration between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	18.750	18.750	3.34	0.0976
Error	10	56.167	5.617		
Corrected Total	11	74.917			

Comparison of Mean Penetration between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	12.000	12.000	1.55	0.2422
Error	10	77.667	7.767		
Corrected Total	11	89.667			

Comparison of Mean Penetration between the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	36.750	36.750	5.73	0.0378
Error	10	64.167	6.417		
Corrected Total	11	100.917			

Comparison of Mean Penetration between the Joint Types at Location R3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.083	2.083	2.36	0.1556
Error	10	8.833	0.883		
Corrected Total	11	10.917			

Generalized Linear Model (GLM) of FWD Deflection Results for All New Projects

Number of Observations Read	6
Number of Observations Used	6

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Jtype	1	0.205	0.205	0.00	0.9519
Error	4	199.526	49.882		

Comparison of Mean Deflection between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.036	0.036	0.00	0.9576
Error	4	45.407	11.352		
Corrected Total	5	45.443			

Comparison of Mean Deflection between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.042	0.042	0.00	0.9529
Error	4	42.467	10.617		
Corrected Total	5	42.509			

Comparison of Mean Deflection between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.027	0.027	0.00	0.9606
Error	4	39.729	9.932		
Corrected Total	5	39.757			

Comparison of Mean Deflection between the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.071	0.071	0.01	0.9352
Error	4	37.901	9.475		
Corrected Total	5	37.972			

Comparison of Mean Deflection between the Joint Types at Location R3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.035	0.035	0.00	0.9544
Error	4	37.284	9.321		
Corrected Total	5	37.318			

Generalized Linear Model (GLM) of Back-calculated Moduli Results for All New Projects

Number of Observations Read	6
Number of Observations Used	6

Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Jtype	1	0.004	0.004	0.04	0.8463
Error	4	0.416	0.104		

Comparison of Back-Calculated Moduli between the Joint Types at Location L1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.010	0.010	0.19	0.6889
Error	4	0.216	0.054		
Corrected Total	5	0.226			

Comparison of Back-Calculated Moduli between the Joint Types at Location J

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.006	0.006	0.23	0.6566
Error	4	0.110	0.027		
Corrected Total	5	0.116			

Comparison of Back-Calculated Moduli between the Joint Types at Location R1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.004	0.004	0.12	0.7497
Error	4	0.135	0.034		
Corrected Total	5	0.139			

Comparison of Back-Calculated Moduli between the Joint Types at Location R2

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.016	0.016	0.16	0.7062
Error	4	0.382	0.095		
Corrected Total	5	0.397			

Comparison of Back-Calculated Moduli between the Joint Types at Location R3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.004	0.004	0.05	0.8417
Error	4	0.387	0.097		
Corrected Total	5	0.392			

APPENDIX G: SURVEY OF ROCKY MOUNTAIN & PLAIN STATES

Evaluating Base Widening Methods

SURVEY OF ROCKY MOUNTAIN & PLAINS STATES

RESEARCH SPONSOR:

Robert Rothwell, P.E., Assistant State Materials Engineer

Email: Bob.Rothwell@wyo.gov

This questionnaire should be completed by someone responsible for designing or constructing pavement widening projects in your state.

Your name: ____

Agency name: ____

Title: ____

E-mail address: _________________________

Phone number: __________________________

Background Information

The Wyoming Department of Transportation (WYDOT) is sponsoring a study aimed at determining the best performing widening joint construction methods that lead to longer performing pavements and reduced costs.

This survey is being conducted to catalog the best practices and techniques of pavement widening in states with similar climate, soils and traffic patterns as Wyoming. The primary focus of the research is on the base layer construction methods.

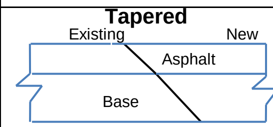
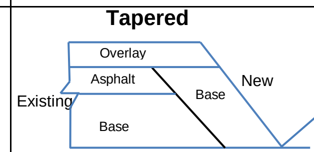
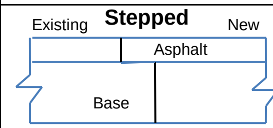
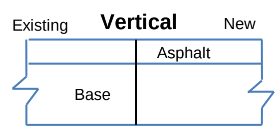
Survey Questions

1. Do you have experience in road widening design or construction?

   ☐ Yes ☐ No

If the answer above is **Yes,** continue to 2, if **No**, please forward this survey to the appropriate person(s) in your agency.

2. What joint construction technique is used in road widening projects in your agency?

Technique	**Tick (√) as appropriate**		**Description**
	Asphalt	**Base**	
Tapered widening joint construction method 1			
Tapered widening joint construction method 2			
Stepped widening joint construction method			
Vertical widening joint construction method			
Other methods:			

3. For the joint widening techniques used by your agency, how would you rate the performance of each technique? Comment on the performance and indicate if the performance is based on experience, research, or both.

Technique	**Performance**				**Comments**
	Poor	**Fair**	**Good**	**No Experience**	
Tapered widening joint construction method 1					

Technique	Performance				Comments
	Poor	Fair	Good	No Experience	
Tapered widening joint construction method 2					
Stepped widening joint construction method					
Vertical widening joint construction method					
Other methods:					

4. What kind of crushed base material is typically used in road widening construction? ____

____

5. Are there any internal documents, supplemental specifications or typical drawings on pavement base widening in your state?

☐ Yes ☐ No

6. Do you have specifications relating to the gradation of materials for the base?

☐ Yes ☐ No

Comment on gradation specification:

7. Has testing for in-place density of bases been performed on past road widening projects in your state?

☐ Yes ☐ No

8. Has non-destructive testing on widened pavements been performed on past road widening projects in your state?

☐ Yes ☐ No

If the answer to any of the questions from 5 to 8 above was **Yes**, please provide contact information of person who can provide the detailed information.

Name: ____

Title: ____

Email address: ______________________________________

Phone number: ______________________________________

9. Please indicate below if you want a summary of the findings of this survey to be sent to you when it is completed.

☐ Yes ☐ No

10. General Comments.

____

____

____

____

Thank you for completing this survey.

APPENDIX H: CDOT GRADATION SPECIFICATION FOR BASE WIDENING

CDOT GRADATION SPECIFICATION

703.03 Aggregate for Bases. Aggregates for bases shall be crushed stone, crushed slag, crushed gravel, natural gravel, or crushed reclaimed concrete or asphalt material which conforms to the quality requirements of AASHTO M 147 except that the requirements for the ratio of minus 75 µm (No. 200) sieve fraction to the minus No. 40 sieve fraction, stated in 2.2.2 of AASHTO M 147, shall not apply. The requirements for the Los Angeles wear test (AASHTO T 96) shall not apply to Class 1, 2, and 3. Aggregate for bases shall meet the grading requirements of Table 703-3 for the class specified for the project, unless otherwise specified.

The liquid limit shall be as shown in Table 703-3 and the plasticity index shall not exceed six when the aggregate is tested in accordance with AASHTO T89 and T 90 respectively.

Table 703-3
CLASSIFICATION FOR AGGREGATE BASE COURSE

Sieve Size	Mass Percent Passing Square Mesh Sieves						
	LL not greater than 35			LL not greater than 30			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class7
100 mm (4")		100					
75 mm (3")		95-100					
60 mm (2½")	100						
50 mm (2")	95-100			100			
37.5 mm (1½")				90-100	100		
25 mm (1")					95-100		100
19 mm (¾")				50-90		100	
4.75 mm (#4)	30-65			30-50	30-70	30-65	
2.36 mm (#8)						25-55	20-85
75 µm (#200)	3-15	3-15	20 max.	3-12	3-15	3-12	5-15
NOTE: Class 3 material shall consist of bank or pit run material.							

Source: Colorado DOT's 2005 Standard Specifications for Road and Bridge Construction

APPENDIX I: IDAHO STATE GRADATION SPECFICATION FOR BASE WIDENING

703.04 Aggregate for Untreated Base, Treated Base and Road Mix.
Aggregate shall conform to one of the following gradations as specified:

NOMINAL MAXIMUM SIZE

SIEVE SIZE	3/8 in. (9.5 mm)	1/2 in. (12.5 mm)	3/4 in. A (19 mm A)	3/4 in. B (19 mm B)	1 in. A (25 mm A)	1 in. B (25 mm B)	2 in. (50 mm)
PERCENT PASSING							
2 1/2 in. (63 mm)							100
2 in. (50 mm)						100	90-100
1 1/2 in. (37.5 mm)					100		
1 in. (25 mm)			100	100	90-100	90-100	55-83
3/4 in. (19 mm)		100	90-100	90-100			
1/2 in. (12.5 mm)	100	90-100			60-80	65-100	
3/8 in. (9.5 mm)	85-100						
No. 4 (4.75 mm)	55-75	50-70	30-60	40-65	35-60	40-80	30-60
No. 8 (2.36 mm)	40-60	35-55		30-50	25-50	30-60	
No. 30 (0.60 mm)	20-40	12-30	10-25		10-30	15-35	10-25
No. 200 (0.075 mm)	3-9	3-9	0-7	3-9	2-9	6-18	0-8

The sand equivalent shall not be less than 30 if 5 percent or more of the material passes the No. 200 (0.075 mm) sieve. Sand equivalent will not be required if less than 5 percent passes the No. 200 (0.075 mm) sieve, or for aggregate to be used for lime or cement treated base.

The aggregate shall not show a loss of more than 35 in the Los Angeles Abrasion Test. The material shall have a minimum R–value of 75 as measured by Idaho T-8. When tested in accordance with AASHTO T 182, aggregate for road mix shall have a retained asphalt film above 95 percent. Road mix aggregate not meeting this requirement may be used in combination with an anti-strip agent, provided the combination meets the 95 percent requirement.

The percentage of aggregate retained on the No. 4 (4.75 mm) sieve having at least one fractured face as determined by AASHTO TP-61, Method 1 shall be 60 percent for untreated base and 75 percent for treated base and road mix.

Idaho Standard Specification for Highway Construction – 2004

APPENDIX J: MONTANA DOT GRADATION SPECFICATION FOR BASE WIDENING

Base Course Specification:

301.03.4 Crushed Aggregate Course

When crushed aggregate course is a bid item, construct the aggregate surfacing section to the specified typical cross section and profile grade.

Select one of the following two options to construct the aggregate section:

1. Full depth crushed base course.

2. Top 0.15 ft (45 mm) crushed top surfacing, remaining depth crushed base course.

Indicate the selected option and the grade of crushed base course (Type "A" Grade 5 or Type "A" Grade 6) before beginning aggregate production. Only one grade of crushed base course will be permitted. If option 2 is selected use Type "A" Grade 2 crushed top surfacing.

Quality assurance lot sizes, test intervals and material tolerances will be based upon the materials selected.

701.02.4 Crushed Base Course Type "A"

Furnish crushed base course Type "A," including added binder or blending material, meeting Table 701-8 gradation requirements. Glass Cullet meeting Subsection 701.11 requirements may be used as blending material.

TABLE 701-8

TABLE OF GRADATIONS - CRUSHED BASE COURSE TYPE "A"
PERCENTAGE BY WEIGHT PASSING SQUARE MESH SIEVES

	Grade 5A		Grade 6A	
Sieve Size	**Job Mix Target Limits**	**Job Mix Tolerance**	**Job Mix Target Limits**	**Job Mix Tolerance**
2 inch (50 mm)	100		100	
1 1/2 inch (37.5 mm)	97		± 3	100
3/4 inch (19.0 mm)	78-80	± 8	82-88	± 8
3/8 inch (9.5 mm)	58-62	± 8	52-64	± 12
No. 4 (4.75 mm)	42-50	± 8	36-48	± 12
No. 40 (0.425)	14-22	± 8	16-24	± 10
No. 200 (0.075)	3-5	± 3	3-5	± 3

Meet the following requirements for crushed base course Type "A":

1. The maximum liquid limit and plasticity index for the material passing the No. 40 sieve is 25 and 6 respectively;

2. Dust ratio limitations do not apply;

3. A wear factor not exceeding 50 percent at 500 revolutions;

4. Furnish binder meeting Subsection 301.02.2 requirements; and

5. At least 35 percent by weight of the aggregate retained on the No. 4 sieve has at least one mechanically fractured face for Grade 5 and 25 percent for Grade 6.

APPENDIX K: NORTH DAKOTA DOT GRADATION SPECFICATION FOR BASE WIDENING

816.03 AGGREGATES FOR SURFACING, BASE, ASPHALT MIXES, BLOTTER, AND SEAL COATS.

A. General. The material shall consist of sound, durable particles of gravel or sand which may include limited quantities of fine soil particles as binding material. It shall be free of sod, roots, and other organic matter. The physical characteristics and quality of the materials shall be approved by the Engineer.

CLASS OF AGGREGATE AND SPECIFICATION LIMITS

B. **Specific Requirements.**

Table I: Aggregates for Subgrade Repair, Trench Backfill, Bases, and Surfacing

Sieve Size Percent Passing	Permeable Trench Backfill	Aggr. for Subgrade Repair[5]	Aggr. for Blended Base	Shldr. Aggr. Surface	Aggr. Base[5]	Permeable Base Aggr.	Temp. Traffic Surface Aggr.	Aggr. Surface
	2	3	3M	4	5	7	8	13
3"		100						
1-1/2"							100	
1-1/4"								
1"			100		100	100		100
3/4"	100	80-100	80-100	100	90-100	95-100		70-100
5/8"								
1/2"						85-100		
3/8"	50-95					60-90		
No. 4		35-85	35-85	35-85	35-70	15-25	35-80	38-75
No. 8						2-10		22-62
No. 10	0-15							
No. 16								
No. 30	0-4	20-50	20-50	10-50	16-40			12-45
No. 50								
No. 100								
No. 200		0-15	4-10	7-17	4-10	0-3		7-15
Shale[1]		12%	12%	15%	12%	8%	20%	12%
L. A. Abrasion[1]				50%	50%	40%		50%
Plasticity Index[2]								
Fractured Faces[3]				10%	10%	85%		10%

Footnotes for Tables I and II:

[1] Maximum Allowable Percentages.

[2] Maximum allowable unless range shown. N.P. = Non Plastic as per AASHTO T-90. Use material passing the No. 40 sieve (standard method). For Class 5 aggregate the maximum allowable Plasticity Index shall be determined from the following formula: Max. allowable PI for Class 5 = 10 - (% Passing No. 40 Sieve / 10)

[3] Minimum weight percentage allowable for the portion of the aggregate retained on a No. 4 sieve having at least 1 fractured face for Classes 4, 5, 13, 27, 29, 31, and 33, and at least 2 fractured faces for Class 7.

[4] Minimum percentage of material passing a No. 4 sieve that is composed of fractured material produced by a crushing process. The Contractor shall demonstrate that the crushing operation produces this result.

[5] Salvaged Base meeting the requirements of Section 302 and 817 may be substituted for Cl. 3 or Cl. 5 virgin aggregate, unless otherwise specified on the Plans.

816.03 B

APPENDIX L: SOUTH DAKOTA DOT GRADATION SPECFICATION FOR BASE WIDENING

AGGREGATES FOR GRANULAR BASES AND SURFACING 882

882.1 GENERAL REQUIREMENTS

The aggregate for granular bases and surfacing shall consist of sound durable particles of gravel and sand, may include limited amounts of fine soil particles, but shall be free of sod, roots, vegetation, wood, paper, metal, glass, and other foreign objectionable material. The physical characteristics and quality of the materials shall conform to the specifications for the particular material required by the contract.

882. 2 SPECIFIC REQUIREMENTS

Granular material of which 30% of the particles retained on the No. 4 sieve shall contain one or more fractured faces.

Aggregates for granular bases and surfacing shall conform to the requirements of Table 1.

TABLE 1

REQUIREMENT	Subbase	Gravel Cushion	Aggregate Base Course	Limestone Ledge Rock		Gravel Surfacing
				Base Course	Gravel Cushion	
SIEVE	PERCENT PASSING					
2" (50 mm)	100					
1" (25.0 mm)	70-100		100	100		
3/4" (19.0 mm)		100	80-100	80-100	100	100
½" (12.5 mm)			68-91	68-90		
No. 4 (4.75 mm)	30-70	50-75	46-70	42-70	46-70	50-78
No. 8 (2.36 mm)	22-62	38-64	34-58	29-53	29-53	37-67
No. 40 (425 µm)	10-35	15-35	13-35	10-28	10-28	13-35
No. 200 (75 µm)	0.0-15.0	3.0-12.0	3.0-12.0	3.0-12.0	3.0-12.0	4.0-15.0
Liquid Limit Max		25	25	25	25	
Plasticity Index	0-6	0-6	0-6	0-3	0-3	4-12
L.A. Abra. Loss, max.	50	40	40	40	40	40
Foot Notes		2	1,2			
Processing Required	crushed	crushed	crushed	crushed	crushed	crushed

APPENDIX M: SURVEY OF DISTRICT CONSTRUCTION AND RESIDENT ENGINEERS

Evaluating Base Widening Methods

SURVEY OF CONSTRUCTABILITY ISSUES FOR DISTRICT CONSTRUCTION ENGINEERS (DCE) & RESIDENT ENGINEERS

WYDOT Sponsor:
Robert Rothwell, P.E., Assistant State Materials Engineer
Email: Bob.Rothwell@wyo.gov

Principal Investigators:
Dr. Khaled Ksaibati, P.E.,
Professor

Dr. Rhonda Young, P.E.,
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Laramie, Wyoming 82071
Telephone: (307) 766-2184
Fax: (307) 766-2221
E-Mail: **Khaled@uwyo.edu**
rkyoung@uwyo.edu

Your name: ____

Work Location: ____

Job Title: ____

E-mail address: ____

Phone number: ____

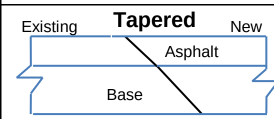
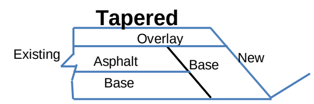
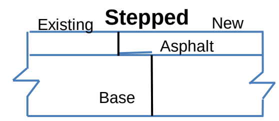
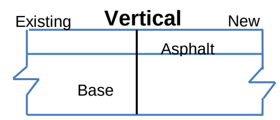
Background Information

The University of Wyoming (UW) and Wyoming Department of Transportation (WYDOT) are conducting a research study to evaluate the best performing widening joint construction methods (tapered, vertical, stepped) that could improve pavement performance and serviceability at reduced costs.

This survey is being conducted to catalog the best construction practices and techniques used in pavement widening joints types (tapered, vertical, stepped) in Wyoming. The research focus is mainly on the base layer construction methods.

Survey Questions

1. What widening joint type construction project have you been involved?

Technique	Tick (√) as appropriate		Description
	Asphalt	Base	
Tapered widening joint construction method 1			
Tapered widening joint construction method 2			
Stepped widening joint construction method			
Vertical widening joint construction method			
Other methods:			

2. How would you rate the performance of each widening joint technique? Please comment based on your experience with such construction technique or otherwise.

Technique	Performance				Comments
	Poor	Fair	Good	No Experience	
Tapered widening joint construction method 1					
Tapered widening joint construction method 2					
Stepped widening joint construction method					
Vertical widening joint construction method					
Other methods:					

3. What best construction practices and techniques have you employed relative to widening joint type projects?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

4. Do your district construction supervision teams perform constructability issues review before actual construction?

☐ Yes ☐ No

If answered yes, what are some of the constructability issues?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

5. What are the quality control and quality assurance protocols that you enforce during construction?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

6. Have you encountered any changes to the original widening joints design projects during the construction phase?

☐ Yes ☐ No

If answered yes, what factors necessitated those changes?

…………………………………………………………………………………………………
…………………………………………………………………………………………………

……………………………………………………………………………………………
……………………………………………………………………………………………

7. Have you had any issues with contractor's expertise, both in general and that of equipment operators?

   ☐ Yes ☐ No

   If yes, please provide comments?

   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………
   ……………………………………………………………………………………………

8. Have you encountered any poor condition of contractor's equipment working on a road widening project?

   ☐ Yes ☐ No

9. How do you rate contractors you have supervised working on road widening projects?

   ☐ Excellent ☐ Good ☐ Fair ☐ Bad ☐ Mixed

10. General Comments

    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………
    ……………………………………………………………………………………………

Thank you for completing this survey.

APPENDIX N: SURVEY OF WYOMING PAVING CONTRACTORS ASSOCIATION

Evaluating Base Widening Methods

SURVEY OF CONSTRUCTABILITY AND COST ISSUES WITH WYOMING CONTRACTORS ASSOCIATION (WCA) PAVING COMMITTEE

WYDOT Sponsor:
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Email: Bob.Rothwell@wyo.gov

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Your name: ____

Work Location: ____

Job Title: ____

E-mail address: ____

Phone number: ____

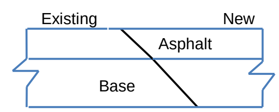
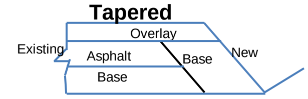
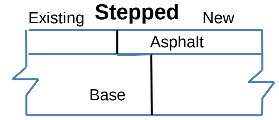
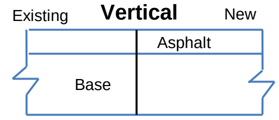
Background Information

The University of Wyoming (UW) and Wyoming Department of Transportation (WYDOT) are conducting a research study to evaluate the best performing widening joint construction methods (tapered, vertical, stepped) that could improve pavement performance and serviceability at reduced costs.

This survey is being conducted to catalog the best construction practices and techniques used in pavement widening joints types (tapered, vertical, stepped) in Wyoming. The research focus is mainly on the base layer construction methods.

Survey Questions

1. What widening joint type construction projects have you been involved?

Technique	**Tick (√) as appropriate**		**Description**
	Asphalt	**Base**	**Tapered**
Tapered widening joint construction method 1			
Tapered widening joint construction method 2			**Tapered** 
Stepped widening joint construction method			Existing **Stepped** New 
Vertical widening joint construction method			Existing **Vertical** New 
Other methods:			

2. How would you rate the **constructability** of each widening joint technique? Please provide comments to support your rating.

Technique	**Constructability**				**Comments**
	Poor	**Fair**	**Good**	**No Experience**	
Tapered widening joint construction method 1					
Tapered widening joint construction method 2					
Stepped widening joint construction method					
Vertical widening joint construction method					
Other methods:					

3. How would you rate the **performance** of each widening joint technique? Please provide comments to support your rating.

Technique	Performance				Comments
	Poor	Fair	Good	No Experience	
Tapered widening joint construction method 1					
Tapered widening joint construction method 2					
Stepped widening joint construction method					
Vertical widening joint construction method					
Other methods:					

4. For a project bid perspective, how would you rate the **cost** of each widening joint technique? Please provide comments to support your rating.

Technique	Cost				Comments
	Poor	Fair	Good	No Experience	
Tapered widening joint construction method 1					
Tapered widening joint construction method 2					
Stepped widening joint construction method					
Vertical widening joint construction method					
Other methods:					

5. How long has your company been involved in road widening projects?

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6. Can you please state the various construction strategies that you employ for the different widening joint type projects?

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7. Typically, how long do you expose the cut surface before the next procedure is performed?

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8. How do you perform compaction of the interface between the existing and new pavements?

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9. Do you review and critique the construction plans for road widening projects before actual construction?

☐ Yes ☐ No

If yes, please provide comments

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10. What are the quality control and quality assurance protocols that you put in place during construction?

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11. Have you encountered any changes to the original widening joints design projects during the construction phase?

☐ Yes ☐ No

If answered yes, what factors necessitated those changes?

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12. Do those changes go with additional construction costs?

☐ Yes ☐ No

If yes, how much is such additional costs?

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13. Have you had any issues with client's supervising engineers on road widening projects?

☐ Yes ☐ No

If yes, please provide comments?

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14. What challenges have you encountered during the construction of road widening projects?

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15. How do you rate your work performance on road widening projects?

☐ Excellent ☐ Good ☐ Fair ☐ Bad ☐ Mixed

16. General Comments

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Please send completed survey to: Jonathan Downing (jd@wyomingcontractors.org)

Thank you for completing this survey.

APPENDIX O: WYDOT AVERAGE WEIGHTED BID PRICES

2012
WEIGHTED AVERAGE
BID PRICES

Prepared by:

Contracts and Estimates Program

Wyoming Department of Transportation

5300 Bishop Blvd.

Cheyenne, Wyoming

2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
106.05100	FIELD LABORATORY	EA	57	56.00	$8,456.44
201.03201	CLEARING AND GRUBBING	ACRE	6	25.28	$5,343.41
201.03206	CLEARING TREES 6 IN	EA	11	271.00	$101.24
201.03210	CLEARING TREES 10 IN	EA	9	132.00	$119.68
201.03218	CLEARING TREES 18 IN	EA	9	116.00	$197.37
201.03230	CLEARING TREES 30 IN	EA	6	27.00	$680.77
201.03248	CLEARING TREES 48 IN	EA	2	12.00	$2,341.67
201.03260	CLEARING TREES 60 IN	EA	1	1.00	$4,000.00
202.03140	REMOVAL OF CATTLE GUARDS	EA	8	21.00	$1,127.03
202.03150	REMOVAL OF SNOW FENCE	FT	2	48,525.00	$3.18
202.03155	REMOVAL OF SNOW FENCE PANELS	EA	2	20.00	$72.90
202.03165	REMOVAL OF GUARDRAIL AND BARRIER	FT	30	90,590.00	$2.06
202.03205	REMOVAL OF FENCE	FT	48	1,135,512.00	$.39
202.03210	REMOVAL OF STEEL BRIDGES	EA	1	1.00	$20,434.00
202.03220	REMOVAL OF TIMBER BRIDGES	EA	1	1.00	$25,000.00
202.03230	REMOVAL OF CONCRETE BRIDGES	EA	1	1.00	$62,200.00
202.03251	REMOVAL OF BRIDGE RAIL	FT	4	3,220.00	$8.50
202.03252	REMOVAL OF PEDESTRIAN RAIL	FT	2	661.00	$10.32
202.03260	REMOVAL OF PIPE	FT	5	3,287.00	$22.34
202.03270	REMOVAL OF PIPE	EA	17	138.00	$940.64
202.03280	REMOVAL OF PIPE FE SECTION	EA	6	99.00	$131.78
202.03290	REMOVAL OF MANHOLES	EA	2	4.00	$1,226.25
202.03295	REMOVAL OF INLETS	EA	8	63.00	$422.55
202.03300	REMOVAL OF STORM SEWER	FT	1	731.00	$16.85
202.03305	MILLING PLANT MIX	SY	51	2,701,302.00	$1.25
202.03310	MILLING PLANT MIX	CY	5	132,700.00	$10.90
202.03317	MILLING CONCRETE	SY	2	980.00	$6.59
202.03318	MILLING CONCRETE	CY	2	45,210.00	$9.64
202.03320	PROFILE MILLING PLANT MIX	SY	8	205,220.00	$.89
202.03400	REMOVAL OF SURFACING	SY	21	52,749.00	$6.70
202.03405	REMOVAL OF SURFACING	CY	1	64,100.00	$5.00
202.03415	REMOVAL OF CONCRETE PAVEMENT	SY	4	21,695.00	$5.82
202.03425	REMOVAL OF CRUSHED BASE	SY	1	3,925.00	$5.20
202.03430	REMOVAL OF SIDEWALK	SY	9	6,504.00	$6.07
202.03435	REMOVAL OF BIT CURB	FT	1	8,500.00	$1.00
202.03445	REMOVAL OF CURB AND GUTTER	FT	13	10,103.00	$3.94
202.03455	REMOVAL OF DOUBLE GUTTER	SY	3	685.00	$8.16
202.03470	REMOVAL OF CONCRETE	SY	4	696.00	$5.33
202.03500	RESET MAILBOX (SINGLE)	EA	13	76.00	$385.44
202.03510	RESET MAILBOX (DOUBLE)	EA	6	19.00	$448.46
202.03520	RESET MAILBOX (MULTIPLE)	EA	7	29.00	$873.66
202.03600	CUTTING BIT PVMT	FT	36	281,944.00	$.72
202.03610	CUTTING CONCRETE	FT	10	4,059.00	$2.42
203.02000	BORROW SPECIAL EXCAVATION	CY	19	48,725.00	$18.37
203.02110	BORROW SPECIAL EXCAVATION	TON	1	42,430.00	$10.50
203.02200	ROCK EXCAVATION	CY	4	294,350.00	$4.63
203.02400	MUCK EXCAVATION	CY	1	120.00	$26.00
203.02500	UNCLASSIFIED EXCAVATION	CY	69	5,699,166.00	$3.34
204.03100	HAUL	CYMI	1	6,000.00	$9.00
206.03100	FLOWABLE BACKFILL	CY	13	2,163.00	$82.94
206.03200	TRENCH SUBEXCAVATION	CY	1	536.00	$7.20
206.03300	CULVERT SUBEXCAVATION	CY	14	2,705.00	$15.52

*** N = NUMBER OF CONTRACTS ON WHICH THIS ITEM WAS BID**

2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
207.03100	TOPSOIL STORING	CY	56	911,034.00	$1.73
207.03200	TOPSOIL PLACING	CY	55	899,903.00	$2.16
207.03300	TOPSOIL BORROW	CY	6	11,328.00	$12.04
209.01000	WATER	MG	93	316,371.00	$5.33
210.03200	BULLDOZER	HR	18	1,115.00	$131.07
210.03300	MOTOR GRADER	HR	83	5,157.00	$136.56
210.03420	ROLLER, TYPE II	HR	3	200.00	$123.94
210.03430	ROLLER, TYPE III	HR	2	110.00	$137.09
210.03500	SCRAPER	CYHR	2	2,020.00	$10.73
210.03600	TRUCK	CYHR	1	3,000.00	$7.00
210.03610	EXCAVATOR	HR	30	905.00	$152.49
210.03700	LOADER	HR	14	540.00	$134.20
210.03710	BACKHOE	HR	9	424.00	$96.29
211.03315	CULVERT CLEANING	EA	8	78.00	$2,333.09
212.02100	DRY EXCAVATION	CY	18	24,790.00	$14.72
212.02200	WET EXCAVATION	CY	4	920.00	$41.82
212.03900	PERVIOUS BACKFILL MATERIAL	CY	6	150.00	$56.97
213.03100	OVERBURDEN REMOVAL	CY	12	223,920.00	$.35
213.03110	OVERBURDEN PLACING	CY	19	329,450.00	$.38
215.03200	BURLAP BAG CURB	FT	1	4,450.00	$8.60
215.03300	SILT FENCE	FT	5	4,115.00	$4.20
215.03402	EXCELSIOR SEDIMENT LOG	FT	24	61,360.00	$4.99
215.03404	ROCK CHECK DIKES	FT	2	7,040.00	$5.69
215.03410	EROSION CONTROL AGENT	ACRE	1	61.00	$525.00
216.03100	SEEDING (PLS)	LB	65	30,980.00	$17.23
216.03105	SEEDING	SY	25	71,889.00	$.93
216.03120	FERTILIZER TYPE I	LB	58	50,242.00	$2.80
216.03130	FERTILIZER TYPE II	LB	2	234.00	$5.66
216.03180	FERTILIZER SPECIAL	LB	6	121,850.00	$.82
216.03600	HYDRAULIC MULCHING	TON	10	49.00	$1,320.88
216.03700	SODDING	SY	4	3,223.00	$6.11
216.03900	DRY MULCH	TON	57	2,564.40	$207.33
216.03910	EROSION CONTROL BLANKET	SY	33	596,785.00	$1.15
216.03920	EROSION CONTROL NETTING	SY	2	250.00	$4.22
216.03950	MULCH TACK TYPE MC	ACRE	11	446.85	$259.06
216.03952	MULCH TACK TYPE GU	ACRE	4	85.00	$665.29
216.03955	COCONUT FIBER DITCH LINING	SY	14	122,379.00	$1.70
216.03960	SYNTHETIC MATTING	SY	2	8,070.00	$4.55
217.01000	GEOTEXTILE, DRAINAGE AND FILTRATION	SY	2	1,664.00	$1.02
217.01010	GEOTEXTILE, EROSION CONTROL	SY	45	55,021.00	$2.81
217.01020	GEOTEXTILE, MATERIAL SEPARATION (WOVEN)	SY	1	1,690.00	$2.00
217.01025	GEOTEXTILE, MATERIAL SEPARATION (NON-WOVEN)	SY	24	102,371.00	$1.83
217.01030	GEOTEXTILE, EMB AND RETAINING WALL	SY	13	46,748.00	$1.84
217.01043	GEOTEXTILE, SUBGRADE REINFORCEMENT	SY	2	30,300.00	$2.51
217.01050	GEOCELL	SY	2	2,980.00	$16.25
217.01065	BIAXIAL GEOGRID	SY	13	330,710.00	$2.53
217.01069	BIAXIAL GEOGRID (STIFF)	SY	20	281,041.00	$2.06
217.01080	HIGH DENSITY POLYURETHANE FILL	LB	1	465.00	$5.68
218.01000	IMPERMEABLE PLASTIC MEMBRANE	SY	4	130,075.00	$2.59
221.01000	DUST CONTROL AGENT	TON	26	4,476.00	$140.72
299.02300	PRESPLITTING	FT	1	386.00	$12.00
299.03500	INSTALLING SETTLEMENT PLATFORM	EA	2	4.00	$3,737.50

* N = NUMBER OF CONTRACTS ON WHICH THIS ITEM WAS BID

2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
299.03600	CONTAMINATED EXCAVATION	CY	1	30.00	$100.00
299.03900	GEOTEXTILE BAG CURB	FT	3	6,340.00	$4.55
299.03910	REMOVE AND REPLACE TOPSOIL	MI	1	19.00	$336.84
301.01000	PIT RUN SUBBASE	TON	2	28,800.00	$8.82
301.01010	PIT RUN SUBBASE	CY	14	19,487.00	$14.36
301.01020	CRUSHER RUN SUBBASE	TON	3	110,780.00	$13.72
301.01030	CRUSHER RUN SUBBASE	CY	7	44,680.00	$20.10
301.01040	CRUSHED SUBBASE	TON	1	3,100.00	$11.50
301.01050	SUBBASE	TON	1	377.00	$1.00
301.01055	SUBBASE	CY	2	40,930.00	$13.61
301.01080	CRUSHED BASE	TON	29	666,917.00	$12.78
301.01085	CRUSHED BASE	CY	44	126,893.00	$25.78
302.00000	BLENDED BASE	TON	1	34,600.00	$6.47
302.00030	BLENDED SUBBASE	CY	1	2,320.00	$25.00
310.01030	STOCKPILED CRUSHED BASE	TON	1	6,200.00	$20.16
310.01035	STOCKPILED CHIP SEAL AGGREGATE	TON	1	9,000.00	$23.64
310.02000	MAINT STOCKPILE TYPE A 3/8 IN	TON	1	28,000.00	$9.72
310.02030	MAINT STOCKPILE TYPE B 3/8 IN (SALT MIXED)	TON	3	22,000.00	$22.94
310.02056	MAINT STOCKPILE TYPE B NO. 4 (SALT MIXED)	TON	1	12,000.00	$11.10
310.02063	MAINT STOCKPILE TYPE B NO. 4 MOD (SALT MIXED)	TON	3	30,000.00	$17.64
310.03800	SODIUM CHLORIDE	TON	7	5,123.00	$62.87
399.00021	FULL DEPTH RECLAMATION	SY	1	17,740.00	$1.40
399.00027	STREAM BED MATERIAL	CY	1	130.00	$21.90
399.00032	STOCKPILED RECLAMED ASPHALT PAVEMENT	CY	1	3,690.00	$7.50
401.02000	HOT PLANT MIX	TON	60	769,542.00	$38.54
401.02010	WARM PLANT MIX	TON	2	21,650.00	$43.95
401.02030	HOT PLANT MIX LEVELING	TON	25	206,950.00	$31.46
401.02040	TEST STRIP	EA	37	39.00	$7,844.41
401.02055	HOT PLANT MIX APPROACHES	TON	38	24,824.00	$69.23
401.02130	HOT PLANT MIX MAINT	TON	5	32,050.00	$66.38
401.02135	HOT PLANT MIX MAINT	SY	1	1,500.00	$36.35
401.03321	ASPHALT BINDER (PG 58-28)	TON	18	14,697.00	$613.54
401.03322	ASPHALT BINDER (PG 64-28)	TON	32	23,500.00	$697.89
401.03323	ASPHALT BINDER (PG 64-22)	TON	24	14,126.00	$607.60
401.03325	ASPHALT BINDER (PG 70-28)	TON	8	9,121.00	$779.38
401.03329	ASPHALT BINDER (PG 76-28)	TON	1	1,840.00	$820.00
403.05050	CRACK SEAL (PLANT MIX)	LB	6	1,725,400.00	$1.31
404.01000	PLANT MIX WEARING COURSE	TON	17	61,998.00	$42.62
404.01005	SEAL COAT	TON	14	482.00	$596.64
406.03005	PLANT MIX (COMMERCIAL)	TON	17	5,024.00	$140.08
407.01000	TACK COAT	TON	55	1,254.00	$592.35
408.01000	PRIME COAT	TON	10	358.00	$927.43
408.01200	BLOTTER	TON	3	130.00	$45.38
409.02100	FOG SEAL	TON	20	674.00	$645.93
409.03070	CHIP SEAL	SY	24	5,979,004.00	$.58
409.03075	CHIP SEAL (OVERSHOOT)	SY	3	2,419,200.00	$.59
409.03078	PLACING STOCKPILED CHIP SEAL AGGREGATE	SY	2	430,000.00	$.58
409.03080	EMULSIFIED ASPHALT	TON	5	2,106.00	$446.24
409.03085	EMULSIFIED ASPHALT MODIFIED	TON	20	12,884.00	$569.96
409.03090	EMULSIFIED ASPHALT OVERSHOOT	TON	4	700.00	$698.70
411.01010	GLASS FIBER REINFORCED PAVING FABRIC	SY	2	35,900.00	$6.17
411.01016	POLY-FIBER MATRIX PAVING FABRIC	SY	1	18,000.00	$4.25

*** N = NUMBER OF CONTRACTS ON WHICH THIS ITEM WAS BID**

2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
412.01000	CURB (PLANT MIX)	FT	4	2,630.00	$19.83
412.01040	BIKE PATH (PLANT MIX)	TON	2	3,290.00	$35.63
412.01070	MEDIAN PAVING (PLANT MIX)	SY	1	715.00	$5.25
413.01000	HYDRATED LIME	TON	63	11,273.00	$160.85
414.01031	CONCRETE PVMT (6 IN)	SY	1	240.00	$70.00
414.01035	CONCRETE PVMT (8 IN)	SY	2	810.00	$63.67
414.01040	CONCRETE PVMT (9 IN)	SY	4	95,260.00	$51.36
414.01050	CONCRETE PVMT (10 IN)	SY	2	13,205.00	$62.11
415.02010	CONC SLAB REPLACEMENT	SY	6	14,855.00	$116.56
415.02015	CONC PVMT SPALL REPAIR	SF	3	795.00	$91.37
415.02017	GRIND/TEXTURE CONC PVMT	SY	1	495,000.00	$1.81
415.02022	SLAB LIFTING AND UNDERSEALING	LB	2	21,400.00	$5.75
417.05000	SEALING CRACKS (CONC PVMT)	FT	1	455.00	$12.00
417.05010	SEALING JOINTS (CONC PVMT)	FT	6	805,625.00	$.70
417.06015	CRACK SEAL (PLANT MIX)	FT	3	260,100.00	$.49
418.01016	RUMBLE STRIPS (ASPHALT)	MI	1	809.00	$400.00
418.01020	RUMBLE STRIP SECTION	EA	2	7.00	$1,428.57
499.03040	REUSED SURFACING	CY	8	171,170.00	$10.36
499.03046	RECLAIMED ASPHALT PAVEMENT WIDENING	CY	10	27,405.00	$7.16
499.03358	RECLAIMED ASPHALT PAVEMENT	CY	2	1,610.00	$16.86
501.01005	STRUCTURAL STEEL	LB	17	3,434,100.00	$1.63
502.11212	PRECAST BOX CULVERTS 12 X 12 FT	FT	1	132.00	$1,223.65
502.12010	PRECAST BOX CULVERTS 20 X 10 FT	FT	1	84.00	$997.20
502.12012	PRECAST BOX CULVERTS 20 X 12 FT	FT	1	30.00	$3,600.00
503.01000	BRIDGE RAILING	FT	11	8,873.00	$91.40
503.01100	BRIDGE RAILING MODIFICATION	FT	9	2,682.00	$123.34
503.01310	RESET BRIDGE RAILING	FT	3	592.00	$59.10
503.01400	PEDESTRIAN RAILING	FT	3	1,962.00	$205.51
504.04000	PREDRILLED HOLES	FT	1	120.00	$25.00
504.04010	PILE SPLICES	EA	8	9.00	$409.32
504.11253	STEEL PILING HP 12 X 53	FT	5	7,697.00	$43.82
504.11473	STEEL PILING HP 14 X 73	FT	3	4,146.00	$65.50
504.11489	STEEL PILING HP 14 X 89	FT	3	2,184.00	$75.79
504.11616	STEEL SHEET PILING (SM 16.0)	SF	5	9,937.00	$26.78
504.11630	STEEL SHEET PILING (SM 30.0)	SF	1	1,428.00	$26.35
505.01000	BRIDGE BARRIER	FT	1	940.00	$55.55
506.01024	DRILLED SHAFT FOUNDATIONS 24 IN	FT	6	148.00	$175.52
506.01030	DRILLED SHAFT FOUNDATIONS 30 IN	FT	14	1,436.00	$172.23
506.01036	DRILLED SHAFT FOUNDATIONS 36 IN	FT	10	899.00	$300.78
506.01042	DRILLED SHAFT FOUNDATIONS 42 IN	FT	2	238.00	$439.54
506.01048	DRILLED SHAFT FOUNDATIONS 48 IN	FT	6	14,401.00	$366.11
507.01000	REINFORCED CONC APPROACH SLABS	SY	14	7,413.00	$136.55
507.01100	BRIDGE APPROACH BACKFILL	CY	13	13,160.00	$49.55
508.01000	REINFORCED CONC SLOPE PAVING	SY	3	4,730.00	$63.20
508.01101	SLOPE PAVING REPAIR/MODIFICATION	SY	3	848.00	$74.32
511.01000	GABIONS	CY	3	1,440.00	$128.68
511.02000	GABIONS	SY	5	2,812.00	$114.53
511.04000	FILTER AGGREGATE	CY	1	75.00	$80.30
511.05000	HAND-PLACED RIPRAP	CY	1	16.00	$105.35
511.06000	MACHINE-PLACED RIPRAP	CY	37	29,875.00	$72.40
511.07000	WIRE-ENCL RIPRAP	SY	2	290.00	$119.17
511.08000	GROUTED RIPRAP	CY	2	520.00	$139.12

*** N = NUMBER OF CONTRACTS ON WHICH THIS ITEM WAS BID**

2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
512.01012	EXPANSION JOINT (GLAND)	FT	5	675.00	$245.25
512.01040	COMPRESSED JOINT MATERIAL	FT	13	3,449.00	$40.49
512.01050	ELASTOMERIC COMP JOINT SEAL	FT	16	4,045.00	$55.72
513.00010	CLASS A CONCRETE	CY	25	3,361.20	$504.98
513.00020	CLASS B CONCRETE	CY	72	7,334.70	$435.01
513.00300	CLASS S CONCRETE	CY	1	1,307.00	$250.00
513.01510	GROUT	CY	2	623.20	$317.08
514.00010	MECHANICAL SPLICES	EA	8	1,922.00	$32.17
514.00020	REINFORCING STEEL	LB	45	935,676.00	$.93
514.00030	REINFORCING STEEL (COATED)	LB	33	985,700.00	$1.00
515.02710	BRIDGE DECK REPAIR CLASS I-A	SY	5	6,708.00	$23.85
515.02720	BRIDGE DECK REPAIR CLASS I-B	SY	7	16,406.00	$38.16
515.02730	BRIDGE DECK REPAIR CLASS II-A	SY	12	3,302.00	$166.97
515.02740	BRIDGE DECK REPAIR CLASS II-B	SY	13	600.00	$320.51
515.02800	SILICA FUME MODIFIED CONCRETE	CY	29	1,390.60	$1,167.25
516.42012	PAINT REPAIR-STRUCTURAL STEEL	SF	4	33,711.00	$4.27
516.42035	PAINT REPAIR-STEEL PILING	SF	1	872.00	$8.00
599.00002	PRECAST WALL COMPONENT SYSTEM	SF	4	47,726.00	$19.34
599.00032	BRIDGE DECK MEMBRANE	SY	5	7,309.00	$41.43
599.00036	BRIDGE DECK SEALER	SY	3	3,139.00	$28.35
599.00047	BRIDGE DECK OVERLAY (EPOXY)	SY	5	12,127.00	$41.64
599.00052	REPAIR - BOX CULVERT	SF	1	6.00	$400.00
599.00080	BRIDGE CONCRETE REPAIR	SF	11	622.00	$98.50
603.01012	PIPE 12 IN	FT	3	3,502.00	$27.65
603.01015	PIPE 15 IN	FT	1	24.00	$34.00
603.01018	PIPE 18 IN	FT	15	4,513.00	$38.25
603.01024	PIPE 24 IN	FT	11	6,618.00	$55.63
603.01030	PIPE 30 IN	FT	3	1,496.00	$59.12
603.01036	PIPE 36 IN	FT	6	1,520.00	$67.27
603.01042	PIPE 42 IN	FT	1	152.00	$105.35
603.01048	PIPE 48 IN	FT	1	100.00	$73.00
603.01054	PIPE 54 IN	FT	1	174.00	$166.63
603.01096	PIPE 96 IN	FT	1	144.00	$204.00
603.03012	PIPE FE SECT 12 IN	EA	1	4.00	$107.00
603.03015	PIPE FE SECT 15 IN	EA	1	1.00	$160.50
603.03018	PIPE FE SECT 18 IN	EA	15	142.00	$175.30
603.03024	PIPE FE SECT 24 IN	EA	11	128.00	$270.61
603.03030	PIPE FE SECT 30 IN	EA	3	18.00	$403.22
603.03036	PIPE FE SECT 36 IN	EA	6	28.00	$706.82
603.03042	PIPE FE SECT 42 IN	EA	1	2.00	$1,075.00
603.03048	PIPE FE SECT 48 IN	EA	1	2.00	$1,129.00
603.03054	PIPE FE SECT 54 IN	EA	1	2.00	$1,720.00
603.20012	RCP 12 IN	FT	1	90.00	$50.00
603.20018	RCP 18 IN	FT	13	5,526.00	$38.75
603.20024	RCP 24 IN	FT	17	8,239.00	$69.48
603.20030	RCP 30 IN	FT	9	2,008.00	$66.97
603.20036	RCP 36 IN	FT	8	7,258.00	$83.03
603.20042	RCP 42 IN	FT	3	824.00	$119.39
603.20048	RCP 48 IN	FT	5	1,984.00	$164.63
603.20054	RCP 54 IN	FT	1	8.00	$500.00
603.20060	RCP 60 IN	FT	1	52.00	$301.00
603.20072	RCP 72 IN	FT	1	54.00	$440.75

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2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
603.20084	RCP 84 IN	FT	2	366.00	$438.05
603.20090	RCP 90 IN	FT	1	300.00	$699.55
603.22018	RCP FE SECT 18 IN	EA	9	41.00	$594.36
603.22024	RCP FE SECT 24 IN	EA	14	67.00	$741.88
603.22030	RCP FE SECT 30 IN	EA	4	14.00	$923.95
603.22036	RCP FE SECT 36 IN	EA	6	17.00	$1,192.18
603.22042	RCP FE SECT 42 IN	EA	2	4.00	$1,316.38
603.22048	RCP FE SECT 48 IN	EA	4	14.00	$1,602.57
603.22060	RCP FE SECT 60 IN	EA	1	1.00	$2,030.00
603.22072	RCP FE SECT 72 IN	EA	1	2.00	$3,010.00
603.22084	RCP FE SECT 84 IN	EA	3	4.00	$5,635.25
603.22090	RCP FE SECT 90 IN	EA	1	2.00	$7,675.00
603.30036	RCP ARCH 36 X 23 IN	FT	1	160.00	$69.00
603.30044	RCP ARCH 44 X 27 IN	FT	2	1,258.00	$90.28
603.30051	RCP ARCH 51 X 31 IN	FT	1	24.00	$315.00
603.30059	RCP ARCH 59 X 36 IN	FT	1	42.00	$343.00
603.30073	RCP ARCH 73 X 45 IN	FT	1	106.00	$300.00
603.32044	RCP ARCH FE SECT 44 X 27 IN	EA	1	2.00	$2,949.75
603.32051	RCP ARCH FE SECT 51 X 31 IN	EA	1	4.00	$1,407.00
603.32059	RCP ARCH FE SECT 59 X 36 IN	EA	1	2.00	$1,940.00
603.32073	RCP ARCH FE SECT 73 X 45 IN	EA	1	1.00	$1,200.00
603.40023	RCP ELLIPTICAL 23 X 14 IN	FT	1	24.00	$184.35
603.40060	RCP ELLIPTICAL 60 X 38 IN	FT	1	58.00	$235.00
603.41060	RCP ELLIPTICAL FE SECT 60 X 38 IN	EA	1	4.00	$1,609.00
603.50012	CMP 12 IN	FT	1	12.00	$24.25
603.50018	CMP 18 IN	FT	7	1,016.00	$60.37
603.50024	CMP 24 IN	FT	19	1,800.00	$75.86
603.50030	CMP 30 IN	FT	8	638.00	$72.58
603.50036	CMP 36 IN	FT	7	704.00	$89.48
603.50042	CMP 42 IN	FT	3	372.00	$93.59
603.50048	CMP 48 IN	FT	4	554.00	$99.20
603.50054	CMP 54 IN	FT	1	70.00	$80.00
603.50060	CMP 60 IN	FT	3	260.00	$156.07
603.50066	CMP 66 IN	FT	1	54.00	$120.00
603.50072	CMP 72 IN	FT	3	254.00	$115.75
603.50078	CMP 78 IN	FT	1	216.00	$306.38
603.50084	CMP 84 IN	FT	2	108.00	$187.69
603.50096	CMP 96 IN	FT	2	450.00	$188.54
603.52018	CMP FE SECT 18 IN	EA	5	56.00	$248.44
603.52024	CMP FE SECT 24 IN	EA	17	72.00	$282.15
603.52030	CMP FE SECT 30 IN	EA	8	23.00	$444.93
603.52036	CMP FE SECT 36 IN	EA	7	24.00	$658.81
603.52042	CMP FE SECT 42 IN	EA	3	6.00	$1,185.87
603.52048	CMP FE SECT 48 IN	EA	4	13.00	$1,106.22
603.52054	CMP FE SECT 54 IN	EA	1	1.00	$1,500.00
603.52060	CMP FE SECT 60 IN	EA	2	8.00	$1,681.23
603.52066	CMP FE SECT 66 IN	EA	1	1.00	$3,400.00
603.52072	CMP FE SECT 72 IN	EA	1	2.00	$2,500.00
603.52084	CMP FE SECT 84 IN	EA	2	4.00	$2,730.45
603.55018	SME SECT 18 IN W/ GRATE	EA	1	2.00	$625.00
603.55024	SME SECT 24 IN W/ GRATE	EA	3	5.00	$864.40
603.60028	CMP ARCH 28 X 20 IN	FT	1	32.00	$55.00

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2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
603.60042	CMP ARCH 42 X 29 IN	FT	2	68.00	$75.06
603.60049	CMP ARCH 49 X 33 IN	FT	1	26.00	$95.00
603.60057	CMP ARCH 57 X 38 IN	FT	2	214.00	$106.06
603.60064	CMP ARCH 64 X 43 IN	FT	1	6.00	$500.00
603.62028	CMP ARCH FE SECT 28 X 20 IN	EA	1	2.00	$550.00
603.62042	CMP ARCH FE SECT 42 X 29 IN	EA	2	6.00	$574.67
603.62049	CMP ARCH FE SECT 49 X 33 IN	EA	1	2.00	$710.00
603.62057	CMP ARCH FE SECT 57 X 38 IN	EA	2	3.00	$1,075.00
603.62064	CMP ARCH FE SECT 64 X 43 IN	EA	1	1.00	$1,050.00
603.66024	HDPE LINER PIPE 24 IN.	FT	1	2,066.00	$120.00
603.66030	HDPE LINER PIPE 30 IN.	FT	1	966.00	$150.00
603.66042	HDPE LINER PIPE 42 IN.	FT	1	398.00	$210.00
603.66060	HDPE LINER PIPE 60 IN.	FT	1	1,514.00	$280.00
603.70010	RELAYING PIPE	FT	1	76.00	$70.00
603.71010	PIPE COLLARS	CY	19	192.60	$561.79
605.09000	GRAVEL FOR DRAINS	CY	6	2,536.00	$51.23
605.10004	UNDERDRAIN PIPE (PERF) 4 IN	FT	3	8,784.00	$6.24
605.10006	UNDERDRAIN PIPE (PERF) 6 IN	FT	14	3,329.00	$9.37
605.20004	UNDERDRAIN PIPE (NON-PERF) 4 IN	FT	7	1,312.00	$15.60
605.20006	UNDERDRAIN PIPE (NON-PERF) 6 IN	FT	14	1,072.00	$11.30
605.20008	UNDERDRAIN PIPE (NON-PERF) 8 IN	FT	1	737.00	$43.80
605.20010	UNDERDRAIN PIPE (NON-PERF) 10 IN	FT	2	1,001.00	$36.81
605.50010	EDGE DRAIN TYPE X	FT	3	23,695.00	$6.36
606.01000	CORR BEAM GUARDRAIL	FT	8	12,378.00	$21.94
606.01010	CORR BEAM GUARDRAIL SPECIAL	FT	1	4,096.00	$19.95
606.02000	CORR BEAM GUARDRAIL (SELF-OXIDIZING)	FT	1	488.00	$33.54
606.02020	CORR BEAM GUARDRAIL END ANCH TYPE A	EA	9	49.00	$2,053.57
606.02035	CORR BEAM GUARDRAIL END ANCH TYPE D	EA	2	2.00	$1,994.38
606.03000	CORR BEAM GUARDRAIL END ANCH TYPE A (SELF-OXIDIZING)	EA	3	5.00	$2,308.75
606.03015	CORR BEAM GUARDRAIL END ANCH TYPE D (SELF-OXIDIZING)	EA	1	1.00	$2,300.00
606.04300	RESET CORR BEAM GUARDRAIL	FT	8	4,062.00	$14.45
606.04305	UPGRADE CORR BEAM GUARDRAIL	FT	6	16,122.00	$19.02
606.05000	BOX BEAM GUARDRAIL	FT	17	43,722.00	$37.22
606.05005	BOX BEAM GUARDRAIL (SELF-OXIDIZING)	FT	2	9,756.00	$33.41
606.05010	BOX BEAM GUARDRAIL END ANCH TYPE I	EA	7	24.00	$1,523.63
606.05011	BOX BEAM GUARDRAIL END ANCH TYPE I (SELF OXIDIZING)	EA	1	36.00	$1,164.25
606.05013	BOX BEAM END TERM (WYBET)	EA	15	131.00	$4,309.15
606.05015	BOX BEAM END TERM (WYBET SELF-OXIDIZING)	EA	2	4.00	$6,490.00
606.05600	RESET BOX BEAM GUARDRAIL	FT	8	6,013.00	$17.96
606.06000	BOX BEAM MED BARRIER	FT	1	258.00	$45.75
606.06010	BOX BEAM MED BARRIER END ANCH TYPE I	EA	1	8.00	$1,750.00
606.06013	BOX BEAM MED BARRIER END TERM (WYBET)	EA	1	2.00	$4,690.00
606.06500	RESET BOX BEAM MED BARRIER	FT	1	218.00	$14.00
606.06700	UPGRADE BOX BEAM GUARDRAIL	FT	2	2,354.00	$22.99
606.06715	RESET BOX BEAM END TERM (WYBET)	EA	2	6.00	$2,201.20
606.06720	TEMPORARY GUARDRAIL	EA	1	10.00	$2,400.00
606.06725	CABLE MEDIAN BARRIER	FT	2	1,704.00	$24.56
606.06730	CABLE MEDIAN BARRIER GATING TERMINAL	EA	1	1.00	$2,500.00
607.10910	FENCE TYPE X	FT	7	40,650.00	$10.76
607.20100	FENCE TYPE A (WOOD POSTS)	FT	4	129,925.00	$2.11
607.20200	FENCE TYPE B (WOOD POSTS)	FT	11	237,565.00	$2.04
607.20300	FENCE TYPE C (WOOD POSTS)	FT	2	1,934.00	$2.67

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2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
607.20400	FENCE TYPE D (WOOD POSTS)	FT	4	126,445.00	$1.71
607.20500	FENCE TYPE E (WOOD POSTS)	FT	7	148,837.00	$1.79
607.20600	FENCE TYPE F (WOOD POSTS)	FT	8	181,211.00	$1.71
607.20700	FENCE TYPE G (WOOD POSTS)	FT	4	72,630.00	$1.36
607.20800	FENCE TYPE H (WOOD POSTS)	FT	3	36,501.00	$1.81
607.30100	FENCE TYPE A (METAL POSTS)	FT	1	1,500.00	$3.75
607.30200	FENCE TYPE B (METAL POSTS)	FT	2	45,200.00	$1.97
607.30300	FENCE TYPE C (METAL POSTS)	FT	1	33,000.00	$1.71
607.30500	FENCE TYPE E (METAL POSTS)	FT	1	47,850.00	$1.15
607.30600	FENCE TYPE F (METAL POSTS)	FT	2	2,920.00	$2.72
607.30700	FENCE TYPE G (METAL POSTS)	FT	4	74,740.00	$1.47
607.30800	FENCE TYPE H (METAL POSTS)	FT	2	50,300.00	$1.41
607.40200	FENCE INDUSTRIAL 48 IN	FT	2	193.00	$19.39
607.40300	FENCE INDUSTRIAL 60 IN	FT	1	140.00	$25.70
607.40700	FENCE INDUSTRIAL 72 IN (BW TOP)	FT	1	4,500.00	$12.90
607.40800	FENCE INDUSTRIAL 84 IN (BW TOP)	FT	1	250.00	$20.00
607.50100	FENCE DEER	FT	1	630.00	$12.00
607.50400	FENCE BARRIER	FT	1	5,000.00	$2.80
607.50900	FENCE-WING (WOOD POSTS)	FT	15	18,622.00	$3.43
607.51100	FENCE TEMPORARY	FT	23	228,061.00	$1.55
607.51200	RESET FENCE	FT	3	790.00	$10.14
607.60500	GATES INDUSTRIAL- SINGLE SWING 12 FT	EA	1	2.00	$679.40
607.61700	GATES INDUSTRIAL-ROLLING 20 FT	EA	1	2.00	$3,763.40
607.70000	RESET GATES	EA	5	76.00	$203.27
607.70100	GATES GALV STL 4 FT	EA	1	5.00	$150.00
607.71000	GATES RAIL 10 FT	EA	1	4.00	$175.00
607.71100	GATES RAIL 12 FT	EA	2	10.00	$263.93
607.71300	GATES RAIL 16 FT	EA	3	14.00	$301.71
607.71500	GATES RAIL 20 FT	EA	1	8.00	$605.00
607.72000	GATES DEER	EA	1	2.00	$900.00
607.72100	GATES SPECIAL	EA	1	1.00	$320.00
607.80100	BRACE PANELS	EA	29	2,714.00	$115.41
607.80400	BRACE PANELS (INDUSTRIAL)	EA	1	14.00	$268.81
607.90100	END PANELS	EA	42	3,257.00	$142.46
607.90400	END PANELS (INDUSTRIAL)	EA	4	23.00	$272.78
607.90500	END PANELS (DEER)	EA	1	19.00	$450.00
608.10100	CONCRETE	SY	2	875.00	$47.67
608.10200	SIDEWALK (CONC)	SY	18	29,558.00	$34.13
608.10205	SIDEWALK SPECIAL (CONC)	SY	1	70.00	$71.69
608.10300	BIKE PATH (CONC)	SY	1	1,777.00	$33.72
608.10400	MEDIAN PAVING (CONC)	SY	3	1,501.00	$48.53
608.10500	DITCH PAVING (CONC)	SY	2	966.00	$49.46
608.10700	DECORATIVE CONCRETE	SY	2	677.00	$78.75
609.10120	SPECIAL CURB TYPE X	FT	1	252.00	$37.00
609.10200	CURB AND GUTTER TYPE A	FT	20	60,138.00	$20.60
609.10400	CURB AND GUTTER TYPE C	FT	2	580.00	$20.85
609.10700	DOUBLE GUTTER	SY	14	9,253.00	$51.32
610.10100	METAL DRAIN INLET	EA	4	24.00	$2,120.08
610.10200	METAL DRAIN PIPE	FT	3	880.00	$56.17
611.10100	HIGHWAY MONUMENTS	EA	3	61.00	$270.80
614.01000	EROSION CONTROL CONCRETE	CY	22	878.00	$392.80
615.01012	CATTLE GUARD (HEAVY DUTY) 12 FT	EA	2	6.00	$6,417.83

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2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
615.01018	CATTLE GUARD (HEAVY DUTY) 18 FT	EA	5	26.00	$8,385.75
615.01024	CATTLE GUARD (HEAVY DUTY) 24 FT	EA	8	16.00	$11,566.96
615.01030	CATTLE GUARD (HEAVY DUTY) 30 FT	EA	5	5.00	$14,521.74
615.01036	CATTLE GUARD (HEAVY DUTY) 36 FT	EA	2	2.00	$13,666.80
615.02012	CATTLE GUARD (MEDIUM DUTY) 12 FT	EA	3	8.00	$5,678.73
615.02018	CATTLE GUARD (MEDIUM DUTY) 18 FT	EA	2	6.00	$6,708.67
615.02030	CATTLE GUARD (MEDIUM DUTY) 30 FT	EA	1	1.00	$12,000.00
615.06030	RESET CATTLE GUARD (HEAVY DUTY) 30 FT	EA	1	1.00	$1,728.00
616.09000	RESET SNOW FENCE	EA	1	11.00	$90.00
616.09010	SNOW FENCE (WOOD) 10 FT	EA	2	1,063.00	$179.50
616.09012	SNOW FENCE (WOOD) 12 FT	EA	1	202.00	$205.75
616.09108	SNOW FENCE (EMBEDDED POSTS) 8 FT	FT	1	945.00	$24.25
616.09110	SNOW FENCE (EMBEDDED POSTS) 10 FT	FT	1	2,120.00	$33.50
616.09112	SNOW FENCE (EMBEDDED POSTS) 12 FT	FT	2	56,275.00	$35.53
617.01000	CUT-OFF WALL (CONC)	CY	7	65.00	$786.42
617.01010	HEADWALL (CONC)	CY	5	82.20	$807.48
618.10707	RC STOCK PASS 91 X 91 IN	FT	1	144.00	$573.40
618.20707	RC STOCK PASS FE SECT 91 X 91 IN	EA	1	2.00	$8,000.00
619.01024	TRASH GUARD 24 IN	EA	1	1.00	$465.00
619.01048	TRASH GUARD 48 IN	EA	2	2.00	$777.50
619.02018	TRASH GUARD CMP 18 IN	EA	1	1.00	$435.00
619.04036	TRASH GUARD RCP 36 IN	EA	1	1.00	$1,000.00
620.0167C	BEND 45 DEGREE 8" DIP - MJ	EA	1	4.00	$1,500.00
620.0222B	6" DIP CAP - MJ	EA	1	6.00	$500.00
620.0238X	WET TAPS 2"	EA	1	6.00	$1,000.00
620.0238Y	WET TAPS 6"	EA	1	6.00	$1,600.00
620.0308Q	15" X 6" PVC SEWER TAP	EA	1	2.00	$500.00
620.07000	ADJUSTMENTS, FIRE HYDRANTS	EA	4	12.00	$1,974.89
620.07010	ADJUSTMENTS, VALVE BOXES	EA	11	86.00	$315.42
620.0709A	FIRE HYDRANT ASSEMBLY	EA	1	2.00	$7,500.00
620.0709C	REMOVE FIRE HYDRANT	EA	1	1.00	$1,000.00
622.10078	STRUCTURAL PLATE PIPE 78 IN	FT	1	50.00	$390.00
622.10090	STRUCTURAL PLATE PIPE 90 IN	FT	1	60.00	$637.00
622.10108	STRUCTURAL PLATE PIPE 108 IN	FT	1	70.00	$736.00
622.10180	STRUCTURAL PLATE PIPE 180 IN	FT	1	100.00	$790.00
622.20095	STRUCTURAL PLATE PIPE-ARCH 95 X 67 IN	FT	1	53.00	$800.00
622.20162	STRUCTURAL PLATE PIPE-ARCH 162 X 114 IN	FT	1	110.00	$980.00
622.30068	STRUCTURAL PLATE STOCK PASS 68 X 78 IN	FT	1	44.00	$830.00
625.10100	MANHOLE TYPE A	EA	3	22.00	$5,031.82
625.10300	MANHOLE TYPE C	EA	6	45.00	$4,528.09
625.10400	MANHOLE TYPE D	EA	1	2.00	$4,950.00
625.10700	MANHOLE TYPE X	EA	1	2.00	$5,430.00
625.12000	MANHOLE ADJUSTMENT	EA	13	77.00	$594.80
625.20100	INLET TYPE A	EA	11	147.00	$3,154.89
625.20300	INLET TYPE C	EA	1	3.00	$5,500.00
625.20501	INLET TYPE F	EA	1	2.00	$4,240.00
625.20505	INLET TYPE W	EA	1	1.00	$6,200.00
625.20600	INLET TYPE X	EA	4	24.00	$3,449.58
625.20700	INLET TYPE Y	EA	2	16.00	$4,906.25
625.20800	INLET TYPE Z	EA	2	5.00	$2,960.16
625.22000	INLET ADJUSTMENT	EA	2	3.00	$2,169.67
625.30100	INLET TYPE M1	EA	10	29.00	$4,083.11

*** N = NUMBER OF CONTRACTS ON WHICH THIS ITEM WAS BID**

2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
625.40100	DIVERSION BOX TYPE X	EA	1	1.00	$6,800.00
627.01005	EPOXY RESIN INJECTION	FT	2	272.00	$79.19
630.01010	POND LINER SYSTEM	SY	2	26,400.00	$13.96
631.01018	SLOTTED DRAIN 18 IN	FT	2	50.00	$141.00
699.01040	SCALE HOUSE	EA	1	1.00	$36,100.00
699.01061	COLORING AND TEXTURING CONCRETE SURFACES	SF	4	25,514.00	$2.36
699.02006	DUCTILE IRON WATER LINE 6 IN	FT	1	202.00	$60.00
699.02008	DUCTILE IRON WATER LINE 8 IN	FT	1	65.00	$60.00
699.03086	POLYVINYL CHLORIDE PRESSURE PIPE 16 IN	FT	1	738.00	$50.00
699.03090	POLYVINYL CHLORIDE PRESSURE PIPE 18 IN	FT	1	144.00	$59.00
699.04006	WATER VALVES 6 IN	EA	1	6.00	$1,000.00
699.06010	WATER SERVICE LINE	EA	1	6.00	$1,200.00
699.07004	SANITARY SEWER LINE 4 IN	FT	1	136.00	$25.00
699.07006	SANITARY SEWER LINE 6 IN	FT	1	50.00	$25.00
701.12300	CONDUIT BORING	FT	21	7,975.00	$25.22
701.17007	CONDUIT-RIGID STL 3/4 IN	FT	4	1,055.00	$10.37
701.17010	CONDUIT-RIGID STL 1 IN	FT	3	90.00	$10.76
701.17015	CONDUIT-RIGID STL 1 1/2 IN	FT	12	2,230.00	$15.41
701.17020	CONDUIT-RIGID STL 2 IN	FT	5	551.00	$15.23
701.17030	CONDUIT-RIGID STL 3 IN	FT	6	175.00	$24.52
701.1710G	CONDUIT-RIGID PVC 1/2 IN	FT	1	45.00	$12.50
701.17110	CONDUIT-RIGID PVC 1 IN	FT	14	4,718.00	$6.49
701.1711C	CONDUIT-RIGID PVC 1 1/4 IN	FT	1	190.00	$.01
701.1711F	CONDUIT-RIGID PVC 1 1/2 IN	FT	13	3,100.00	$6.42
701.17120	CONDUIT-RIGID PVC 2 IN	FT	38	28,366.00	$7.73
701.17130	CONDUIT-RIGID PVC 3 IN	FT	22	11,307.00	$9.08
701.17160	CONDUIT-RIGID PVC 6 IN	FT	2	412.00	$35.00
701.17168	CONDUIT-RIGID PVC 8 IN	FT	1	145.00	$20.00
701.17207	CONDUIT-FLEXIBLE METAL 3/4 IN	FT	4	1,350.00	$8.43
701.1750A	CONDUIT - PE DUCT	FT	2	8,100.00	$7.40
701.20100	PULL BOX TYPE A	EA	27	198.00	$476.65
701.20200	PULL BOX TYPE B	EA	27	126.00	$647.08
701.2025A	PULL BOX TYPE RB	EA	5	9.00	$1,803.65
701.20300	PULL BOX TYPE S	EA	6	63.00	$399.48
701.20600	REMOVE PULL BOX	EA	2	3.00	$187.95
701.21100	SERVICE POINT LIGHTING	EA	6	15.00	$4,819.32
701.21300	SERVICE POINT SIGNAL	EA	17	30.00	$3,830.26
701.2130B	SAFETY DISCONNECT	EA	1	1.00	$842.45
701.21310	SERVICE POINT PEDESTAL	EA	6	8.00	$6,301.70
701.21325	TYPE II SOLAR SERVICE POINT	EA	7	22.00	$13,049.41
701.2132A	REMOVE AND REINSTALL SOLAR SERVICE POINT	EA	1	1.00	$3,445.00
701.2133A	AC/DC SERVICE POINT	EA	1	1.00	$11,100.00
701.2133B	ROAD CLOSURE CABINET	EA	2	5.00	$15,016.00
701.2133C	SOLAR ARRAY	EA	1	11.00	$6,015.00
701.21600	REMOVE SERVICE POINT	EA	6	7.00	$608.14
701.21800	MODIFY SERVICE POINT	EA	5	11.00	$2,146.36
701.2180B	DISCONNECT SWITCH IN NEMA 3R ENCLOSURE	EA	6	32.00	$245.35
701.2180C	JUNCTION BOX NEMA	EA	9	128.00	$287.48
701.24010	STL POLE TYPE I	EA	4	16.00	$1,293.44
701.2401B	STL POLE 6"	EA	2	10.00	$2,143.53
701.24040	STL POLE TYPE IV	EA	1	1.00	$12,932.00
701.24050	STL POLE TYPE V	EA	4	9.00	$16,704.75

*** N = NUMBER OF CONTRACTS ON WHICH THIS ITEM WAS BID**

2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
701.24060	STL POLE TYPE VI	EA	7	33.00	$4,182.57
701.2406B	DECORATIVE LIGHT POLE	EA	2	26.00	$2,800.00
701.2406G	DECORATIVE LIGHTING UNIT	EA	1	22.00	$730.00
701.24070	STL POLE TYPE VII	EA	2	13.00	$4,647.69
701.2407A	STL POLE TYPE VIII	EA	5	12.00	$4,445.19
701.2407B	HIGH MAST LIGHTING STANDARD	EA	3	20.00	$24,231.97
701.2417A	FIBERGLASS POLE TYPE VII	EA	1	2.00	$2,434.00
701.24400	INSTALL LIGHTING POLE	EA	6	27.00	$1,450.86
701.24410	HIGHMAST LOWERING DEVICES	EA	3	20.00	$8,719.13
701.24420	HIGHMAST LIGHTING CONTROL CABINET	EA	3	20.00	$6,134.78
701.2442K	COMMERCIAL BASE METER SOCKET	EA	1	1.00	$1,700.00
701.24600	REMOVE LIGHTING POLE	EA	12	32.00	$305.29
701.24700	RESET LIGHTING POLE	EA	2	2.00	$1,418.50
701.25600	REMOVE POLE FOUNDATION	EA	12	32.00	$539.34
701.2570A	GFI OUTLET	EA	2	34.00	$86.18
701.2580C	CELLULAR MODEM	EA	2	5.00	$1,230.16
701.2800A	ROAD CLOSURE DROP GATE	EA	5	12.00	$5,524.35
701.2800B	ROAD CLOSURE SWING GATE	EA	1	2.00	$2,280.00
701.2810B	REMOVE ROAD CLOSURE SWING GATE	EA	1	1.00	$298.00
701.2810C	REMOVE ROAD CLOSURE DROP GATE	EA	3	4.00	$334.79
701.28990	SINGLE CONDUCTOR WIRE THWN #250 KCMIL	FT	1	1,721.00	$6.65
701.28995	SINGLE CONDUCTOR WIRE THWN #4/0 AWG	FT	2	2,660.00	$5.43
701.29000	SINGLE CONDUCTOR WIRE #3/0 AWG	FT	1	60.00	$5.40
701.29020	SINGLE CONDUCTOR WIRE #1/0 AWG	FT	3	10,250.00	$3.46
701.29030	SINGLE CONDUCTOR WIRE #1 AWG	FT	3	8,486.00	$2.83
701.29040	SINGLE CONDUCTOR WIRE #2 AWG	FT	3	12,084.00	$2.44
701.2904F	SINGLE CONDUCTOR WIRE #3 AWG	FT	2	4,600.00	$2.08
701.29050	SINGLE CONDUCTOR WIRE #4 AWG	FT	12	41,435.00	$1.66
701.29060	SINGLE CONDUCTOR WIRE #6 AWG	FT	19	46,918.00	$1.14
701.29070	SINGLE CONDUCTOR WIRE #8 AWG	FT	19	30,789.00	$.95
701.29080	SINGLE CONDUCTOR WIRE #10 AWG	FT	16	52,901.00	$.79
701.29090	SINGLE CONDUCTOR WIRE #12 AWG	FT	4	1,676.00	$.54
701.29150	SINGLE CONDUCTOR WIRE RHW #4 AWG	FT	1	1,400.00	$2.10
701.29175	SINGLE CONDUCTOR WIRE RHW #6 AWG	FT	1	4,450.00	$1.31
701.29200	SINGLE CONDUCTOR WIRE RHW #8 AWG	FT	4	11,125.00	$1.00
701.29225	SINGLE CONDUCTOR WIRE RHW #10 AWG	FT	2	3,400.00	$.92
701.29250	SINGLE CONDUCTOR WIRE RHW #12 AWG	FT	4	3,675.00	$.66
701.31010	SIGNAL CABLE 3 CONDUCTOR #14 AWG	FT	7	2,390.00	$1.03
701.31020	SIGNAL CABLE 5 CONDUCTOR #14 AWG	FT	10	13,370.00	$1.34
701.31030	SIGNAL CABLE 7 CONDUCTOR #14 AWG	FT	7	4,520.00	$1.65
701.3105C	SIGNAL CABLE 16 CONDUCTOR #14 AWG	FT	1	100.00	$3.50
701.3106E	SIGNAL CABLE 20 CONDUCTOR #14 AWG	FT	7	4,630.00	$4.09
701.31800	LIGHTING CABLE 3 CONDUCTOR #12 AWG	FT	14	8,490.00	$1.69
701.33000	LOOP DETECTOR SHIELDED LEAD-IN CABLE	FT	5	16,150.00	$.95
701.3300B	VIDEO DETECTOR SHIELDED LEAD-IN CABLE	FT	3	2,530.00	$1.23
701.36500	RADAR DETECTOR CABLE	FT	2	3,560.00	$3.54
701.3700A	COMMUNICATIONS CABLE	FT	13	6,610.00	$2.33
701.3700F	SERIAL CABLE	FT	4	1,150.00	$4.95
701.3700K	VIDEO CABLE	FT	5	900.00	$9.40
701.39000	SPLICING KIT	EA	1	168.00	$61.60
701.40100	CONNECTOR KIT - FUSED I	EA	21	204.00	$65.50
701.40300	CONNECTOR KIT - UNFUSED I	EA	14	105.00	$45.45

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2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
701.4610J	SIGNAL CONTROLLER CABINET FOOTING	EA	8	11.00	$1,088.85
701.4860C	SOLID STATE FLASHER UNIT	EA	3	7.00	$161.81
701.50010	SIGNAL INDICATION 12	EA	9	84.00	$353.04
701.50015	SIGNAL INDICATION 12 - SOLAR	EA	1	4.00	$3,660.00
701.50050	SIGNAL INDICATION 12-12-12	EA	7	98.00	$909.28
701.5005B	SIGNAL INDICATION 12-12-12-12	EA	3	18.00	$728.56
701.50060	SIGNAL INDICATION 12-12-12-12-12	EA	3	9.00	$931.78
701.50600	REMOVE SIGNAL INDICATION	EA	1	1.00	$140.00
701.50700	RESET SIGNAL INDICATION	EA	2	33.00	$146.97
701.51100	PED SIGNAL INDICATION	EA	7	54.00	$616.38
701.5220A	LOUVERED BACKPLATE	EA	8	67.00	$149.77
701.53100	MAST ARM FRAMEWORK	EA	9	75.00	$433.05
701.53200	POST TOP FRAMEWORK	EA	3	14.00	$244.71
701.53300	SIDE BRACKET FRAMEWORK	EA	9	36.00	$531.92
701.56000	PREFAB LOOP DETECTOR	EA	5	71.00	$990.01
701.57000	MICRO LOOP DETECTOR	EA	3	18.00	$963.11
701.5720A	AXLE SENSOR	EA	1	1.00	$16,412.64
701.58100	VIDEO DETECTOR	EA	3	11.00	$5,865.91
701.58200	RADAR PRESENCE DETECTOR	EA	2	8.00	$7,596.88
701.58205	RADAR MOUNTING BRACKET	EA	2	8.00	$888.71
701.5820A	2 CHANNEL CONTACT CLOSURE CARD	EA	2	7.00	$607.20
701.5820B	4 CHANNEL CONTACT CLOSURE CARD	EA	1	1.00	$633.85
701.58210	PREASSEMBLED BACKPLATE	EA	1	2.00	$2,695.20
701.58220	DIN RAIL 19" BENT	EA	1	2.00	$213.05
701.59100	PED DETECTOR	EA	6	35.00	$317.99
701.59300	COMMUNICATION ANTENNA	EA	3	4.00	$961.83
701.59400	REMOVE & REINSTALL COMMUNICATION ANTENNA	EA	3	6.00	$515.57
701.5950H	CLUSTER MANAGEMENT MODULE	EA	2	3.00	$1,708.67
701.5960A	POINT-TO-POINT (PTP) RADIO	EA	1	6.00	$6,443.00
701.5960B	POINT-TO-MULTIPOINT (PMP) ACCESS POINT	EA	4	14.00	$2,376.00
701.5960C	POINT-TO-MULTIPOINT (PMP) SUBSCRIBER MODULE	EA	6	43.00	$1,502.03
701.5980G	COMMUNICATION TOWER 40'	EA	6	25.00	$9,670.10
701.5981A	COMMUNICATION TOWER SECTION	EA	1	3.00	$1,300.00
701.62100	ROADWAY LUMINAIRE	EA	17	82.00	$940.45
701.6210B	DECORATIVE LUMINAIRE	EA	1	20.00	$2,305.00
701.6210C	HIGHMAST LUMINAIRE	EA	3	118.00	$556.04
701.62600	REMOVE ROADWAY LUMINAIRE	EA	3	5.00	$57.37
701.64100	OVERHEAD SIGN LUMINAIRE	EA	4	74.00	$1,113.52
701.6470B	MODIFY SIGN LIGHTING BRACKET	EA	1	30.00	$209.11
701.7070B	REMOVAL OF FLASHING BEACON SYSTEM	EA	1	8.00	$255.00
701.7090A	REMOVE AND REINSTALL VARIABLE MESSAGE SIGN	EA	1	1.00	$1,434.10
701.8110A	ITS CABINET	EA	5	7.00	$10,081.25
701.8110C	ITS CABINET FOOTING	EA	13	47.00	$1,018.71
701.8123A	REMOTE VIDEO CAMERA - PTZ	EA	5	11.00	$4,535.22
701.8126A	VIDEO SERVER / IP ENCODER	EA	5	12.00	$756.83
701.8145A	ETHERNET NETWORK SWITCH	EA	7	42.00	$1,222.12
701.8170A	ROAD WEATHER INFORMATION SYSTEM (RWIS)	EA	6	17.00	$18,837.18
701.8172B	COUNTER/SPEED SENSOR	EA	4	16.00	$9,432.49
701.8176A	PAVEMENT SURFACE SENSOR	EA	6	17.00	$3,731.83
701.8177A	SUBSURFACE SENSOR	EA	6	17.00	$1,654.77
701.8256A	WEIGH-IN-MOTION (WIM) SCALE	EA	1	2.00	$48,924.67
701.8256B	WEIGH-IN-MOTION (WIM) SCALE FRAME	EA	1	2.00	$26,190.74

*** N = NUMBER OF CONTRACTS ON WHICH THIS ITEM WAS BID**

2012 WEIGHTED AVERAGE BID PRICES

WYOMING DEPARTMENT OF TRANSPORTATION

AVERAGE UNIT BID PRICES FOR 2012 ENGLISH

ITEM	ITEM DESCRIPTION	UNITS	N	TOTAL QUANTITY	AVERAGE PRICE
701.84005	DYNAMIC MESSAGE SIGN - SIDE MOUNT	EA	3	9.00	$49,386.48
701.8450B	INSTALL DMS - SIDE MOUNT	EA	1	2.00	$47,800.74
701.85005	DYNAMIC MESSAGE SIGN - OVERHEAD	EA	3	5.00	$65,470.00
701.89500	DYNAMIC MESSAGE SIGN - VARIABLE SPEED LIMIT	EA	1	2.00	$3,670.00
701.89505	DYNAMIC MESSAGE SIGN - VARIABLE SPEED LIMIT (SOLAR)	EA	1	14.00	$3,670.00
701.8950C	VARIABLE SPEED LIMIT SIGN CABINET	EA	1	2.00	$16,235.00
702.09400	STL BREAK-AWAY SIGN SUPPORT W6 X 15	FT	5	370.00	$113.29
702.09500	STL BREAK-AWAY SIGN SUPPORT W8 X 21	FT	6	614.00	$123.55
702.09600	STL BREAK-AWAY SIGN SUPPORT W10 X 26	FT	3	530.00	$126.22
702.20100	REFERENCE MARKERS	EA	18	102.00	$57.83
702.20200	REFERENCE MARKER PANELS	EA	16	89.00	$45.97
702.30100	SIGN POSTS, WOOD 4 X 4 IN	FT	7	288.00	$9.67
702.30105	SIGN POSTS, WOOD 4 X 6 IN	FT	20	2,787.00	$10.42
702.30110	SIGN POSTS, WOOD 6 X 6 IN	FT	20	3,810.00	$13.53
702.30115	SIGN POSTS, WOOD 6 X 8 IN	FT	21	4,860.00	$17.52
702.30120	SIGN POSTS, WOOD 8 X 8 IN	FT	3	310.00	$16.98
702.30125	SIGN POSTS, WOOD 10 X 10 IN	FT	6	1,420.00	$39.00
702.30205	SIGN POST, RND TUBULAR STL	EA	10	82.00	$484.69
702.30300	SIGN POST, SQ TUBULAR STL	EA	19	364.00	$284.41
702.30310	INSTALL SIGN PANELS, PLYWOOD	SF	1	3,445.00	$10.00
702.30320	INSTALL SIGN PANELS, ALUMINUM	SF	1	25.00	$15.00
702.30400	SIGN PANELS, PLYWOOD	SF	21	6,387.00	$31.81
702.30500	SIGN PANELS, ALUMINUM	SF	43	8,930.04	$32.10
702.50100	DELINEATORS, TYPE I	EA	8	1,894.00	$30.75
702.50200	DELINEATORS, TYPE II	EA	43	2,170.00	$33.02
702.50300	DELINEATORS, TYPE III	EA	43	7,543.00	$34.55
702.50400	DELINEATORS, TYPE IV	EA	2	11.00	$39.93
702.50500	DELINEATORS, TYPE V	EA	3	11.00	$46.07
702.50600	DELINEATORS, TYPE VI	EA	3	13.00	$43.70
702.50650	DELINEATORS, TYPE VII	EA	2	250.00	$49.82
702.50655	DELINEATORS, TYPE VIII	EA	2	70.00	$50.00
703.01000	CATEGORY I TCD UNITS	EA	1	2,000.00	$.10
703.01002	CATEGORY II TCD UNITS	EA	1	4,400.00	$.10
703.01003	CATEGORY III TCD UNITS	EA	1	450.00	$2.00
703.03100	FLAGGING	HR	121	186,120.00	$21.50
703.03410	TEMPORARY CONCRETE BARRIER	FT	35	50,710.00	$22.52
703.03421	PLASTIC WATER BARRIER	FT	4	1,700.00	$30.11
703.10805	WC-3 BARRICADE SIGNS (ANCHORED)	EA	1	2.00	$2,000.00
799.70105	THERMOPLASTIC PAVEMENT MARKINGS	SF	2	1,164.00	$28.93
799.70118	THERMOPLASTIC PAVEMENT MARKINGS 18 IN	FT	3	2,191.00	$30.65
799.70124	THERMOPLASTIC PAVEMENT MARKINGS 24 IN	FT	1	50.00	$42.60
799.70200	PREFORMED PAVEMENT MARKINGS	SF	2	421.00	$29.27
799.70400	PREFORMED PAVEMENT LINE 4 IN	FT	2	31,221.00	$5.82
799.70600	PREFORMED PAVEMENT LINE 6 IN	FT	1	960.00	$6.75
799.70800	PREFORMED PAVEMENT LINE 8 IN	FT	3	5,062.00	$11.61
799.71200	PREFORMED PAVEMENT LINE 12 IN	FT	3	1,935.00	$17.96
799.71810	EPOXY PAVEMENT LINE 4 IN	FT	2	6,513,850.00	$.24
799.71815	EPOXY PAVEMENT LINE 8 IN	FT	2	227,500.00	$.53
799.74900	PAVEMENT MARKING REMOVAL	SF	1	1,750.00	$3.75

Total Number of Items: 673

*** N = NUMBER OF CONTRACTS ON WHICH THIS ITEM WAS BID**

APPENDIX P: BID CONTRACT FOR VERTICAL AND TAPERED JOINT TYPES

- Contract Bids for NH-N132095 (US191) – Tapered Joint Project
- Contract Bids for NH-N852001 (US85) – Vertical Joint Project
- Contract Bids for NH-N361053 (US16) – Tapered Joint Project
- Contract Bids for SCP-SL12-P433035 (WY59) – Vertical Joint Project

Contract Bids for NH-N132095 (US 191) – Tapered Joint Project

Wyoming Department of Transportation
Abstract of Bids

Project Number: NH-N132095, STP-E-N132092, ARSCT-N132A03
Bid Opening: 11/10/2011
Project Name: Rock Springs - Pinedale (Pinedale South)
Estimated Completion: 10/30/2012
County: Sublette
Detail Description: Grading, draining, placing crushed base and bituminous pavement surfacing, milling plant mix, signing, fencing, guardrail and miscellaneous work on 2.24 miles on US 191 beginning at RM 89.68 between Rock Springs and Pinedale.

Company	Bid	% of Low Bid
Engineer's Estimate:	**$3,958,663.00**	
LeGrand Johnson Construction Co. Logan, UT	$3,324,532.05	100.00 %
H-K Contractors, Inc. Idaho Falls, ID	$3,679,606.25	110.68 %
Oftedal Construction, Inc. Miles City, MT	$4,146,708.00	124.73 %
McMurry Ready-Mix Co. Casper, WY	$4,165,419.35	125.29 %
McGarvin-Moberly Construction Co. Worland, WY	$4,246,432.47	127.73 %
Knife River Northwest Boise, ID	$4,253,794.10	127.95 %
Lewis & Lewis, Inc. Rock Springs, WY	$4,860,152.58	146.19 %

Wyoming Department of Transportation
Abstract of Bids
Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

					Engineer's Estimate		Bidder: LeGrand Johnson Construction Co.		Bidder: H-K Contractors, Inc.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	5 - ROADWAY									
1	106.05100	FIELD LABORATORY	1.00	EA	7,000.00	7,000.00	5,000.00	5,000.00	12,000.00	12,000.00
2	106.05200	CONTRACTOR TESTING	1.00	LS	28,000.00	28,000.00	40,000.00	40,000.00	30,000.00	30,000.00
3	109.04000	FORCE ACCOUNT WORK	5,000.00	$$	1.00	5,000.00	1.00	5,000.00	1.00	5,000.00
4	109.08000	MOBILIZATION	1.00	LS	269,000.00	269,000.00	205,000.00	205,000.00	212,800.00	212,800.00
5	202.03140	REMOVAL OF CATTLE GUARDS	5.00	EA	650.00	3,250.00	1,000.00	5,000.00	600.00	3,000.00
6	202.03205	REMOVAL OF FENCE	23,800.00	FT	0.28	6,664.00	0.50	11,900.00	0.50	11,900.00
7	202.03270	REMOVAL OF PIPE	8.00	EA	700.00	5,600.00	1,000.00	8,000.00	330.00	2,640.00
8	202.03280	REMOVAL OF PIPE FE SECTION	2.00	EA	175.00	350.00	250.00	500.00	100.00	200.00
9	202.03305	MILLING PLANT MIX	24,400.00	SY	1.25	30,500.00	0.82	20,008.00	0.93	22,692.00
10	203.02500	UNCLASSIFIED EXCAVATION	41,600.00	CY	6.25	260,000.00	5.70	237,120.00	9.20	382,720.00
11	207.03100	TOPSOIL STORING	8,900.00	CY	1.65	14,685.00	1.25	11,125.00	0.01	89.00
12	207.03200	TOPSOIL PLACING	8,900.00	CY	1.95	17,355.00	1.50	13,350.00	0.01	89.00
13	209.01000	WATER	3,800.00	MG	15.00	57,000.00	19.50	74,100.00	11.00	41,800.00
14	210.03300	MOTOR GRADER	200.00	HR	135.00	27,000.00	135.00	27,000.00	125.00	25,000.00
15	213.03100	OVERBURDEN REMOVAL	3,000.00	CY	1.35	4,050.00	1.50	4,500.00	0.01	30.00
16	213.03110	OVERBURDEN PLACING	3,000.00	CY	1.65	4,950.00	1.50	4,500.00	0.01	30.00
17	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	3,000.00	3,000.00	9,750.00	9,750.00	9,300.00	9,300.00
18	215.01010	DEPARTMENT STORM WATER CONTROL	5,000.00	$$	1.00	5,000.00	1.00	5,000.00	1.00	5,000.00
19	216.03100	SEEDING (PLS)	670.00	LB	10.50	7,035.00	11.35	7,604.50	12.00	8,040.00
20	216.03120	FERTILIZER TYPE I	1,310.00	LB	2.00	2,620.00	3.70	4,847.00	3.80	4,978.00
21	216.03900	DRY MULCH	66.00	TON	165.00	10,890.00	163.00	10,758.00	165.00	10,890.00
22	216.03910	EROSION CONTROL BLANKET	640.00	SY	2.00	1,280.00	2.10	1,344.00	2.00	1,280.00
23	221.01000	DUST CONTROL AGENT	135.00	TON	160.00	21,600.00	104.00	14,040.00	170.00	22,950.00
24	301.01080	CRUSHED BASE	37,500.00	TON	15.75	590,625.00	9.00	337,500.00	12.00	450,000.00
25	401.02000	HOT PLANT MIX	17,300.00	TON	29.00	501,700.00	23.00	397,900.00	22.00	380,600.00
26	401.02030	HOT PLANT MIX LEVELING	4,860.00	TON	29.00	140,940.00	24.00	116,640.00	25.00	121,500.00
27	401.02040	TEST STRIP	1.00	EA	7,500.00	7,500.00	5,000.00	5,000.00	6,500.00	6,500.00
28	401.02055	HOT PLANT MIX APPROACHES	1,180.00	TON	58.00	68,440.00	48.00	56,640.00	62.00	73,160.00
29	401.03323	ASPHALT BINDER (PG 64-22)	1,280.00	TON	585.00	748,800.00	574.50	735,360.00	585.00	748,800.00
30	407.01000	TACK COAT	26.00	TON	575.00	14,950.00	740.00	19,240.00	550.00	14,300.00
31	413.01000	HYDRATED LIME	219.00	TON	205.00	44,895.00	215.00	47,085.00	215.00	47,085.00
32	603.20042	RCP 42 in	156.00	FT	158.00	24,648.00	200.00	31,200.00	135.00	21,060.00
33	603.22042	RCP FE SECT 42 in	2.00	EA	1,500.00	3,000.00	1,100.00	2,200.00	830.00	1,660.00
34	603.50018	CMP 18 in	12.00	FT	60.00	720.00	46.00	552.00	120.00	1,440.00
35	603.50024	CMP 24 in	306.00	FT	65.00	19,890.00	41.50	12,699.00	80.00	24,480.00
36	603.52018	CMP FE SECT 18 in	2.00	EA	210.00	420.00	180.00	360.00	68.00	136.00
37	603.52024	CMP FE SECT 24 in	12.00	EA	230.00	2,760.00	255.00	3,060.00	100.00	1,200.00
38	607.20500	FENCE TYPE E (WOOD POSTS)	15,600.00	FT	1.70	26,520.00	1.30	20,280.00	1.30	20,280.00

Wyoming Department of Transportation
Abstract of Bids
Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

					Engineer's Estimate		Bidder: LeGrand Johnson Construction Co.		Bidder: H-K Contractors, Inc.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
39	607.20600	FENCE TYPE F (WOOD POSTS)	9,200.00	FT	1.75	16,100.00	1.35	12,420.00	1.40	12,880.00
40	607.80100	BRACE PANELS	26.00	EA	125.00	3,250.00	90.00	2,340.00	93.00	2,418.00
41	607.90100	END PANELS	68.00	EA	175.00	11,900.00	100.00	6,800.00	100.00	6,800.00
42	615.01018	CATTLE GUARD (HEAVY DUTY) 18 FT	2.00	EA	9,000.00	18,000.00	7,625.00	15,250.00	8,500.00	17,000.00
43	615.01024	CATTLE GUARD (HEAVY DUTY) 24 FT	3.00	EA	10,500.00	31,500.00	9,800.00	29,400.00	10,900.00	32,700.00
44	615.01036	CATTLE GUARD (HEAVY DUTY) 36 FT	1.00	EA	13,700.00	13,700.00	14,300.00	14,300.00	15,400.00	15,400.00
45	702.30105	SIGN POSTS, WOOD 4 X 6 in	60.00	FT	11.00	660.00	8.40	504.00	8.50	510.00
46	702.30110	SIGN POSTS, WOOD 6 X 6 in	100.00	FT	13.00	1,300.00	12.60	1,260.00	12.75	1,275.00
47	702.30115	SIGN POSTS, WOOD 6 X 8 in	150.00	FT	16.00	2,400.00	14.70	2,205.00	14.90	2,235.00
48	702.30500	SIGN PANELS, ALUMINUM	211.00	SF	31.00	6,541.00	33.60	7,089.60	34.00	7,174.00
49	702.50200	DELINEATORS, TYPE II	42.00	EA	32.00	1,344.00	36.75	1,543.50	37.00	1,554.00
50	702.50300	DELINEATORS, TYPE III	115.00	EA	32.00	3,680.00	36.75	4,226.25	37.00	4,255.00
51	703.03100	FLAGGING	6,000.00	HR	32.00	192,000.00	31.50	189,000.00	30.00	180,000.00
52	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	140,000.00	140,000.00	81,250.00	81,250.00	132,960.00	132,960.00
		Subtotal				3,430,012.00		2,878,750.85		3,141,790.00
	5 - ROADWAY									
53	106.05200	CONTRACTOR TESTING	1.00	LS	5,500.00	5,500.00	9,900.00	9,900.00	10,600.00	10,600.00
54	109.04000	FORCE ACCOUNT WORK	1,000.00	$$	1.00	1,000.00	1.00	1,000.00	1.00	1,000.00
55	109.08000	MOBILIZATION	1.00	LS	25,000.00	25,000.00	10,500.00	10,500.00	54,500.00	54,500.00
56	209.01000	WATER	200.00	MG	15.00	3,000.00	25.00	5,000.00	12.00	2,400.00
57	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	135.00	13,500.00	125.00	12,500.00
58	210.03460	ROLLER, TYPE VI	50.00	HR	105.00	5,250.00	135.00	6,750.00	115.00	5,750.00
59	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	1,500.00	1,500.00	5,000.00	5,000.00	5,000.00	5,000.00
60	221.01000	DUST CONTROL AGENT	33.00	TON	160.00	5,280.00	131.00	4,323.00	170.00	5,610.00
61	301.01080	CRUSHED BASE	2,410.00	TON	25.00	60,250.00	14.00	33,740.00	20.00	48,200.00
62	401.03321	ASPHALT BINDER (PG 58-28)	81.00	TON	585.00	47,385.00	589.00	47,709.00	590.00	47,790.00
63	412.01040	BIKE PATH (PLANT MIX)	1,360.00	TON	52.00	70,720.00	45.75	62,220.00	37.00	50,320.00
64	413.01000	HYDRATED LIME	13.00	TON	205.00	2,665.00	215.00	2,795.00	215.00	2,795.00
65	702.30100	SIGN POSTS, WOOD 4 X 4 in	350.00	FT	9.00	3,150.00	6.30	2,205.00	6.40	2,240.00
66	702.30500	SIGN PANELS, ALUMINUM	97.00	SF	31.00	3,007.00	33.60	3,259.20	34.00	3,298.00
67	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	1,500.00	1,500.00	15,000.00	15,000.00	5,300.00	5,300.00
		Subtotal				248,707.00		222,901.20		257,303.00
	5 - ROADWAY									
68	106.05200	CONTRACTOR TESTING	1.00	LS	7,000.00	7,000.00	6,700.00	6,700.00	5,500.00	5,500.00
69	109.04000	FORCE ACCOUNT WORK	500.00	$$	1.00	500.00	1.00	500.00	1.00	500.00
70	109.08000	MOBILIZATION	1.00	LS	30,000.00	30,000.00	7,500.00	7,500.00	36,600.00	36,600.00
71	202.03305	MILLING PLANT MIX	5,900.00	SY	1.50	8,850.00	0.87	5,133.00	1.05	6,195.00
72	203.02500	UNCLASSIFIED EXCAVATION	1,000.00	CY	7.50	7,500.00	8.50	8,500.00	13.75	13,750.00
73	209.01000	WATER	117.00	MG	15.00	1,755.00	25.00	2,925.00	12.00	1,404.00

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

					Engineer's Estimate		Bidder: LeGrand Johnson Construction Co.		Bidder: H-K Contractors, Inc.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
74	210.03300	MOTOR GRADER	15.00	HR	135.00	2,025.00	135.00	2,025.00	125.00	1,875.00
75	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	2,500.00	2,500.00	1,000.00	1,000.00	1,800.00	1,800.00
76	216.03100	SEEDING (PLS)	19.00	LB	25.00	475.00	12.00	228.00	12.55	238.45
77	216.03120	FERTILIZER TYPE I	36.00	LB	5.00	180.00	4.20	151.20	4.30	154.80
78	216.03900	DRY MULCH	2.00	TON	185.00	370.00	210.00	420.00	215.00	430.00
79	221.01000	DUST CONTROL AGENT	6.00	TON	175.00	1,050.00	224.00	1,344.00	170.00	1,020.00
80	301.01080	CRUSHED BASE	1,400.00	TON	25.00	35,000.00	13.00	18,200.00	23.00	32,200.00
81	401.02000	HOT PLANT MIX	1,580.00	TON	45.00	71,100.00	33.00	52,140.00	32.00	50,560.00
82	401.02030	HOT PLANT MIX LEVELING	385.00	TON	46.00	17,710.00	38.50	14,822.50	54.00	20,790.00
83	401.02055	HOT PLANT MIX APPROACHES	89.00	TON	60.00	5,340.00	53.50	4,761.50	62.00	5,518.00
84	401.03323	ASPHALT BINDER (PG 64-22)	113.00	TON	585.00	66,105.00	574.50	64,918.50	585.00	66,105.00
85	407.01000	TACK COAT	2.00	TON	600.00	1,200.00	1,000.00	2,000.00	550.00	1,100.00
86	413.01000	HYDRATED LIME	20.00	TON	205.00	4,100.00	215.00	4,300.00	215.00	4,300.00
87	702.30105	SIGN POSTS, WOOD 4 X 6 in	50.00	FT	11.00	550.00	8.40	420.00	8.50	425.00
88	702.30500	SIGN PANELS, ALUMINUM	18.00	SF	31.00	558.00	33.60	604.80	34.00	612.00
89	702.50200	DELINEATORS, TYPE II	4.00	EA	32.00	128.00	36.75	147.00	37.00	148.00
90	702.50300	DELINEATORS, TYPE III	14.00	EA	32.00	448.00	36.75	514.50	37.00	518.00
91	703.03100	FLAGGING	250.00	HR	32.00	8,000.00	31.50	7,875.00	30.00	7,500.00
92	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	7,500.00	7,500.00	15,750.00	15,750.00	21,270.00	21,270.00
		Subtotal				279,944.00		222,880.00		280,513.25
				Total:		**3,958,663.00**		**3,324,532.05 AWARDED**		**3,679,606.25**

Wyoming Department of Transportation
Abstract of Bids
Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Oftedal Construction, Inc. Unit Price	Bidder: Oftedal Construction, Inc. Amount	Bidder: McMurry Ready-Mix Co. Unit Price	Bidder: McMurry Ready-Mix Co. Amount
	5 - ROADWAY									
1	106.05100	FIELD LABORATORY	1.00	EA	7,000.00	7,000.00	3,500.00	3,500.00	4,485.00	4,485.00
2	106.05200	CONTRACTOR TESTING	1.00	LS	28,000.00	28,000.00	25,000.00	25,000.00	64,040.00	64,040.00
3	109.04000	FORCE ACCOUNT WORK	5,000.00	$$	1.00	5,000.00	1.00	5,000.00	1.00	5,000.00
4	109.08000	MOBILIZATION	1.00	LS	269,000.00	269,000.00	408,500.00	408,500.00	372,550.00	372,550.00
5	202.03140	REMOVAL OF CATTLE GUARDS	5.00	EA	650.00	3,250.00	1,800.00	9,000.00	806.50	4,032.50
6	202.03205	REMOVAL OF FENCE	23,800.00	FT	0.28	6,664.00	0.47	11,186.00	0.50	11,900.00
7	202.03270	REMOVAL OF PIPE	8.00	EA	700.00	5,600.00	1,150.00	9,200.00	312.00	2,496.00
8	202.03280	REMOVAL OF PIPE FE SECTION	2.00	EA	175.00	350.00	240.00	480.00	82.00	164.00
9	202.03305	MILLING PLANT MIX	24,400.00	SY	1.25	30,500.00	1.20	29,280.00	0.57	13,908.00
10	203.02500	UNCLASSIFIED EXCAVATION	41,600.00	CY	6.25	260,000.00	9.50	395,200.00	7.90	328,640.00
11	207.03100	TOPSOIL STORING	8,900.00	CY	1.65	14,685.00	3.00	26,700.00	0.001	8.90
12	207.03200	TOPSOIL PLACING	8,900.00	CY	1.95	17,355.00	3.00	26,700.00	2.50	22,250.00
13	209.01000	WATER	3,800.00	MG	15.00	57,000.00	8.00	30,400.00	7.15	27,170.00
14	210.03300	MOTOR GRADER	200.00	HR	135.00	27,000.00	130.00	26,000.00	187.50	37,500.00
15	213.03100	OVERBURDEN REMOVAL	3,000.00	CY	1.35	4,050.00	2.00	6,000.00	0.002	6.00
16	213.03110	OVERBURDEN PLACING	3,000.00	CY	1.65	4,950.00	2.00	6,000.00	0.002	6.00
17	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	3,000.00	3,000.00	19,800.00	19,800.00	30,667.00	30,667.00
18	215.01010	DEPARTMENT STORM WATER CONTROL	5,000.00	$$	1.00	5,000.00	1.00	5,000.00	1.00	5,000.00
19	216.03100	SEEDING (PLS)	670.00	LB	10.50	7,035.00	15.00	10,050.00	11.50	7,705.00
20	216.03120	FERTILIZER TYPE I	1,310.00	LB	2.00	2,620.00	3.00	3,930.00	3.70	4,847.00
21	216.03900	DRY MULCH	66.00	TON	165.00	10,890.00	195.00	12,870.00	163.00	10,758.00
22	216.03910	EROSION CONTROL BLANKET	640.00	SY	2.00	1,280.00	3.00	1,920.00	2.10	1,344.00
23	221.01000	DUST CONTROL AGENT	135.00	TON	160.00	21,600.00	260.00	35,100.00	99.25	13,398.75
24	301.01080	CRUSHED BASE	37,500.00	TON	15.75	590,625.00	11.00	412,500.00	12.00	450,000.00
25	401.02000	HOT PLANT MIX	17,300.00	TON	29.00	501,700.00	41.00	709,300.00	39.75	687,675.00
26	401.02030	HOT PLANT MIX LEVELING	4,860.00	TON	29.00	140,940.00	29.00	140,940.00	27.50	133,650.00
27	401.02040	TEST STRIP	1.00	EA	7,500.00	7,500.00	10,100.00	10,100.00	8,526.00	8,526.00
28	401.02055	HOT PLANT MIX APPROACHES	1,180.00	TON	58.00	68,440.00	37.00	43,660.00	69.50	82,010.00
29	401.03323	ASPHALT BINDER (PG 64-22)	1,280.00	TON	585.00	748,800.00	530.00	678,400.00	549.50	703,360.00
30	407.01000	TACK COAT	26.00	TON	575.00	14,950.00	500.00	13,000.00	508.50	13,221.00
31	413.01000	HYDRATED LIME	219.00	TON	205.00	44,895.00	96.00	21,024.00	100.50	22,009.50
32	603.20042	RCP 42 in	156.00	FT	158.00	24,648.00	190.00	29,640.00	156.50	24,414.00
33	603.22042	RCP FE SECT 42 in	2.00	EA	1,500.00	3,000.00	1,900.00	3,800.00	1,634.00	3,268.00
34	603.50018	CMP 18 in	12.00	FT	60.00	720.00	168.00	2,016.00	66.25	795.00
35	603.50024	CMP 24 in	306.00	FT	65.00	19,890.00	71.00	21,726.00	46.25	14,152.50
36	603.52018	CMP FE SECT 18 in	2.00	EA	210.00	420.00	230.00	460.00	224.50	449.00
37	603.52024	CMP FE SECT 24 in	12.00	EA	230.00	2,760.00	310.00	3,720.00	311.00	3,732.00
38	607.20500	FENCE TYPE E (WOOD POSTS)	15,600.00	FT	1.70	26,520.00	1.58	24,648.00	1.30	20,280.00

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

					Engineer's Estimate		Bidder: Oftedal Construction, Inc.		Bidder: McMurry Ready-Mix Co.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
39	607.20600	FENCE TYPE F (WOOD POSTS)	9,200.00	FT	1.75	16,100.00	1.63	14,996.00	1.35	12,420.00
40	607.80100	BRACE PANELS	26.00	EA	125.00	3,250.00	142.09	3,694.34	89.25	2,320.50
41	607.90100	END PANELS	68.00	EA	175.00	11,900.00	163.15	11,094.20	99.75	6,783.00
42	615.01018	CATTLE GUARD (HEAVY DUTY) 18 FT	2.00	EA	9,000.00	18,000.00	9,700.00	19,400.00	8,309.00	16,618.00
43	615.01024	CATTLE GUARD (HEAVY DUTY) 24 FT	3.00	EA	10,500.00	31,500.00	12,700.00	38,100.00	10,903.00	32,709.00
44	615.01036	CATTLE GUARD (HEAVY DUTY) 36 FT	1.00	EA	13,700.00	13,700.00	21,800.00	21,800.00	16,984.00	16,984.00
45	702.30105	SIGN POSTS, WOOD 4 X 6 in	60.00	FT	11.00	660.00	8.42	505.20	8.40	504.00
46	702.30110	SIGN POSTS, WOOD 6 X 6 in	100.00	FT	13.00	1,300.00	12.63	1,263.00	12.50	1,250.00
47	702.30115	SIGN POSTS, WOOD 6 X 8 in	150.00	FT	16.00	2,400.00	14.74	2,211.00	14.75	2,212.50
48	702.30500	SIGN PANELS, ALUMINUM	211.00	SF	31.00	6,541.00	33.68	7,106.48	33.50	7,068.50
49	702.50200	DELINEATORS, TYPE II	42.00	EA	32.00	1,344.00	36.84	1,547.28	36.75	1,543.50
50	702.50300	DELINEATORS, TYPE III	115.00	EA	32.00	3,680.00	36.84	4,236.60	36.75	4,226.25
51	703.03100	FLAGGING	6,000.00	HR	32.00	192,000.00	32.00	192,000.00	31.50	189,000.00
52	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	140,000.00	140,000.00	147,000.00	147,000.00	119,700.00	119,700.00
		Subtotal				3,430,012.00		3,686,704.10		3,548,757.40
	5 - ROADWAY									
53	106.05200	CONTRACTOR TESTING	1.00	LS	5,500.00	5,500.00	2,828.73	2,828.73	11,797.00	11,797.00
54	109.04000	FORCE ACCOUNT WORK	1,000.00	$$	1.00	1,000.00	1.00	1,000.00	1.00	1,000.00
55	109.08000	MOBILIZATION	1.00	LS	25,000.00	25,000.00	11,000.00	11,000.00	66,712.00	66,712.00
56	209.01000	WATER	200.00	MG	15.00	3,000.00	8.00	1,600.00	20.75	4,150.00
57	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	130.00	13,000.00	187.50	18,750.00
58	210.03460	ROLLER, TYPE VI	50.00	HR	105.00	5,250.00	98.00	4,900.00	170.00	8,500.00
59	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	1,500.00	1,500.00	5,000.00	5,000.00	9,003.00	9,003.00
60	221.01000	DUST CONTROL AGENT	33.00	TON	160.00	5,280.00	260.00	8,580.00	114.00	3,762.00
61	301.01080	CRUSHED BASE	2,410.00	TON	25.00	60,250.00	21.00	50,610.00	17.25	41,572.50
62	401.03321	ASPHALT BINDER (PG 58-28)	81.00	TON	585.00	47,385.00	530.00	42,930.00	648.50	52,528.50
63	412.01040	BIKE PATH (PLANT MIX)	1,360.00	TON	52.00	70,720.00	31.00	42,160.00	59.75	81,260.00
64	413.01000	HYDRATED LIME	13.00	TON	205.00	2,665.00	96.00	1,248.00	213.00	2,769.00
65	702.30100	SIGN POSTS, WOOD 4 X 4 in	350.00	FT	9.00	3,150.00	6.32	2,212.00	6.30	2,205.00
66	702.30500	SIGN PANELS, ALUMINUM	97.00	SF	31.00	3,007.00	33.68	3,266.96	33.50	3,249.50
67	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	1,500.00	1,500.00	5,262.76	5,262.76	22,050.00	22,050.00
		Subtotal				248,707.00		195,598.45		329,308.50
	5 - ROADWAY									
68	106.05200	CONTRACTOR TESTING	1.00	LS	7,000.00	7,000.00	2,828.73	2,828.73	8,426.00	8,426.00
69	109.04000	FORCE ACCOUNT WORK	500.00	$$	1.00	500.00	1.00	500.00	1.00	500.00
70	109.08000	MOBILIZATION	1.00	LS	30,000.00	30,000.00	9,100.00	9,100.00	47,651.00	47,651.00
71	202.03305	MILLING PLANT MIX	5,900.00	SY	1.50	8,850.00	2.50	14,750.00	0.57	3,363.00
72	203.02500	UNCLASSIFIED EXCAVATION	1,000.00	CY	7.50	7,500.00	14.00	14,000.00	9.75	9,750.00
73	209.01000	WATER	117.00	MG	15.00	1,755.00	4.00	468.00	19.25	2,252.25

Wyoming Department of Transportation
Abstract of Bids
Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

					Engineer's Estimate		Bidder: Oftedal Construction, Inc.		Bidder: McMurry Ready-Mix Co.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
74	210.03300	MOTOR GRADER	15.00	HR	135.00	2,025.00	130.00	1,950.00	187.50	2,812.50
75	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	2,500.00	2,500.00	700.00	700.00	10,027.00	10,027.00
76	216.03100	SEEDING (PLS)	19.00	LB	25.00	475.00	15.26	289.94	12.00	228.00
77	216.03120	FERTILIZER TYPE I	36.00	LB	5.00	180.00	3.16	113.76	4.20	151.20
78	216.03900	DRY MULCH	2.00	TON	185.00	370.00	194.72	389.44	210.00	420.00
79	221.01000	DUST CONTROL AGENT	6.00	TON	175.00	1,050.00	260.00	1,560.00	114.00	684.00
80	301.01080	CRUSHED BASE	1,400.00	TON	25.00	35,000.00	12.00	16,800.00	12.25	17,150.00
81	401.02000	HOT PLANT MIX	1,580.00	TON	45.00	71,100.00	55.65	87,927.00	44.50	70,310.00
82	401.02030	HOT PLANT MIX LEVELING	385.00	TON	46.00	17,710.00	52.99	20,401.15	45.75	17,613.75
83	401.02055	HOT PLANT MIX APPROACHES	89.00	TON	60.00	5,340.00	39.77	3,539.53	62.75	5,584.75
84	401.03323	ASPHALT BINDER (PG 64-22)	113.00	TON	585.00	66,105.00	530.00	59,890.00	549.50	62,093.50
85	407.01000	TACK COAT	2.00	TON	600.00	1,200.00	500.00	1,000.00	508.50	1,017.00
86	413.01000	HYDRATED LIME	20.00	TON	205.00	4,100.00	96.00	1,920.00	100.50	2,010.00
87	702.30105	SIGN POSTS, WOOD 4 X 6 in	50.00	FT	11.00	550.00	8.42	421.00	8.40	420.00
88	702.30500	SIGN PANELS, ALUMINUM	18.00	SF	31.00	558.00	33.68	606.24	33.50	603.00
89	702.50200	DELINEATORS, TYPE II	4.00	EA	32.00	128.00	25.00	100.00	36.75	147.00
90	702.50300	DELINEATORS, TYPE III	14.00	EA	32.00	448.00	25.00	350.00	36.75	514.50
91	703.03100	FLAGGING	250.00	HR	32.00	8,000.00	32.00	8,000.00	31.50	7,875.00
92	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	7,500.00	7,500.00	16,800.66	16,800.66	15,750.00	15,750.00
		Subtotal				279,944.00		264,405.45		287,353.45
				Total:		**3,958,663.00**		**4,146,708.00**		**4,165,419.35**

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: McGarvin-Moberly Construction Co. Unit Price	Bidder: McGarvin-Moberly Construction Co. Amount	Bidder: Knife River Northwest Unit Price	Bidder: Knife River Northwest Amount
	5 - ROADWAY									
1	106.05100	FIELD LABORATORY	1.00	EA	7,000.00	7,000.00	8,250.00	8,250.00	7,000.00	7,000.00
2	106.05200	CONTRACTOR TESTING	1.00	LS	28,000.00	28,000.00	23,261.93	23,261.93	39,000.00	39,000.00
3	109.04000	FORCE ACCOUNT WORK	5,000.00	$$	1.00	5,000.00	1.00	5,000.00	1.00	5,000.00
4	109.08000	MOBILIZATION	1.00	LS	269,000.00	269,000.00	369,237.00	369,237.00	410,000.00	410,000.00
5	202.03140	REMOVAL OF CATTLE GUARDS	5.00	EA	650.00	3,250.00	9,675.00	48,375.00	950.00	4,750.00
6	202.03205	REMOVAL OF FENCE	23,800.00	FT	0.28	6,664.00	0.52	12,376.00	0.50	11,900.00
7	202.03270	REMOVAL OF PIPE	8.00	EA	700.00	5,600.00	1,236.25	9,890.00	700.00	5,600.00
8	202.03280	REMOVAL OF PIPE FE SECTION	2.00	EA	175.00	350.00	258.00	516.00	209.00	418.00
9	202.03305	MILLING PLANT MIX	24,400.00	SY	1.25	30,500.00	1.39	33,916.00	1.15	28,060.00
10	203.02500	UNCLASSIFIED EXCAVATION	41,600.00	CY	6.25	260,000.00	10.64	442,624.00	8.80	366,080.00
11	207.03100	TOPSOIL STORING	8,900.00	CY	1.65	14,685.00	3.30	29,370.00	1.60	14,240.00
12	207.03200	TOPSOIL PLACING	8,900.00	CY	1.95	17,355.00	3.39	30,171.00	1.80	16,020.00
13	209.01000	WATER	3,800.00	MG	15.00	57,000.00	0.01	38.00	16.00	60,800.00
14	210.03300	MOTOR GRADER	200.00	HR	135.00	27,000.00	143.00	28,600.00	130.00	26,000.00
15	213.03100	OVERBURDEN REMOVAL	3,000.00	CY	1.35	4,050.00	2.20	6,600.00	2.00	6,000.00
16	213.03110	OVERBURDEN PLACING	3,000.00	CY	1.65	4,950.00	3.39	10,170.00	2.30	6,900.00
17	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	3,000.00	3,000.00	21,285.00	21,285.00	10,000.00	10,000.00
18	215.01010	DEPARTMENT STORM WATER CONTROL	5,000.00	$$	1.00	5,000.00	1.00	5,000.00	1.00	5,000.00
19	216.03100	SEEDING (PLS)	670.00	LB	10.50	7,035.00	37.63	25,212.10	12.00	8,040.00
20	216.03120	FERTILIZER TYPE I	1,310.00	LB	2.00	2,620.00	5.38	7,047.80	4.00	5,240.00
21	216.03900	DRY MULCH	66.00	TON	165.00	10,890.00	215.00	14,190.00	170.00	11,220.00
22	216.03910	EROSION CONTROL BLANKET	640.00	SY	2.00	1,280.00	3.23	2,067.20	2.20	1,408.00
23	221.01000	DUST CONTROL AGENT	135.00	TON	160.00	21,600.00	237.69	32,088.15	175.00	23,625.00
24	301.01080	CRUSHED BASE	37,500.00	TON	15.75	590,625.00	11.62	435,750.00	15.00	562,500.00
25	401.02000	HOT PLANT MIX	17,300.00	TON	29.00	501,700.00	42.32	732,136.00	29.00	501,700.00
26	401.02030	HOT PLANT MIX LEVELING	4,860.00	TON	29.00	140,940.00	27.74	134,816.40	31.00	150,660.00
27	401.02040	TEST STRIP	1.00	EA	7,500.00	7,500.00	10,000.10	10,000.10	7,500.00	7,500.00
28	401.02055	HOT PLANT MIX APPROACHES	1,180.00	TON	58.00	68,440.00	36.43	42,987.40	61.80	72,924.00
29	401.03323	ASPHALT BINDER (PG 64-22)	1,280.00	TON	585.00	748,800.00	526.82	674,329.60	664.00	849,920.00
30	407.01000	TACK COAT	26.00	TON	575.00	14,950.00	487.60	12,677.60	640.00	16,640.00
31	413.01000	HYDRATED LIME	219.00	TON	205.00	44,895.00	94.48	20,691.12	212.00	46,428.00
32	603.20042	RCP 42 in	156.00	FT	158.00	24,648.00	204.25	31,863.00	140.00	21,840.00
33	603.22042	RCP FE SECT 42 in	2.00	EA	1,500.00	3,000.00	2,042.50	4,085.00	1,200.00	2,400.00
34	603.50018	CMP 18 in	12.00	FT	60.00	720.00	180.60	2,167.20	100.00	1,200.00
35	603.50024	CMP 24 in	306.00	FT	65.00	19,890.00	76.33	23,356.98	56.00	17,136.00
36	603.52018	CMP FE SECT 18 in	2.00	EA	210.00	420.00	247.25	494.50	340.00	680.00
37	603.52024	CMP FE SECT 24 in	12.00	EA	230.00	2,760.00	333.25	3,999.00	400.00	4,800.00
38	607.20500	FENCE TYPE E (WOOD POSTS)	15,600.00	FT	1.70	26,520.00	1.33	20,748.00	1.40	21,840.00

Wyoming Department of Transportation Abstract of Bids Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03 Project Name: Rock Springs - Pinedale (Pinedale South)					Engineer's Estimate		Bidder: McGarvin-Moberly Construction Co.		11/10/2011 Bidder: Knife River Northwest	Page 8 of 12
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
39	607.20600	FENCE TYPE F (WOOD POSTS)	9,200.00	FT	1.75	16,100.00	1.38	12,696.00	1.40	12,880.00
40	607.80100	BRACE PANELS	26.00	EA	125.00	3,250.00	91.38	2,375.88	95.00	2,470.00
41	607.90100	END PANELS	68.00	EA	175.00	11,900.00	102.13	6,944.84	105.00	7,140.00
42	615.01018	CATTLE GUARD (HEAVY DUTY) 18 FT	2.00	EA	9,000.00	18,000.00	10,427.50	20,855.00	9,000.00	18,000.00
43	615.01024	CATTLE GUARD (HEAVY DUTY) 24 FT	3.00	EA	10,500.00	31,500.00	13,652.50	40,957.50	11,000.00	33,000.00
44	615.01036	CATTLE GUARD (HEAVY DUTY) 36 FT	1.00	EA	13,700.00	13,700.00	23,435.00	23,435.00	15,800.00	15,800.00
45	702.30105	SIGN POSTS, WOOD 4 X 6 in	60.00	FT	11.00	660.00	8.60	516.00	8.90	534.00
46	702.30110	SIGN POSTS, WOOD 6 X 6 in	100.00	FT	13.00	1,300.00	12.90	1,290.00	13.30	1,330.00
47	702.30115	SIGN POSTS, WOOD 6 X 8 in	150.00	FT	16.00	2,400.00	15.05	2,257.50	15.50	2,325.00
48	702.30500	SIGN PANELS, ALUMINUM	211.00	SF	31.00	6,541.00	34.40	7,258.40	35.40	7,469.40
49	702.50200	DELINEATORS, TYPE II	42.00	EA	32.00	1,344.00	37.63	1,580.46	38.70	1,625.40
50	702.50300	DELINEATORS, TYPE III	115.00	EA	32.00	3,680.00	37.63	4,327.45	38.70	4,450.50
51	703.03100	FLAGGING	6,000.00	HR	32.00	192,000.00	32.25	193,500.00	30.00	180,000.00
52	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	140,000.00	140,000.00	107,500.00	107,500.00	111,000.00	111,000.00
		Subtotal				3,430,012.00		3,740,881.11		3,748,493.30
	5 - ROADWAY									
53	106.05200	CONTRACTOR TESTING	1.00	LS	5,500.00	5,500.00	2,687.50	2,687.50	5,600.00	5,600.00
54	109.04000	FORCE ACCOUNT WORK	1,000.00	$$	1.00	1,000.00	1.00	1,000.00	1.00	1,000.00
55	109.08000	MOBILIZATION	1.00	LS	25,000.00	25,000.00	20,526.00	20,526.00	2,000.00	2,000.00
56	209.01000	WATER	200.00	MG	15.00	3,000.00	0.01	2.00	16.00	3,200.00
57	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	143.00	14,300.00	130.00	13,000.00
58	210.03460	ROLLER, TYPE VI	50.00	HR	105.00	5,250.00	107.80	5,390.00	100.00	5,000.00
59	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	1,500.00	1,500.00	5,500.00	5,500.00	2,000.00	2,000.00
60	221.01000	DUST CONTROL AGENT	33.00	TON	160.00	5,280.00	267.97	8,843.01	180.00	5,940.00
61	301.01080	CRUSHED BASE	2,410.00	TON	25.00	60,250.00	26.24	63,238.40	23.00	55,430.00
62	401.03321	ASPHALT BINDER (PG 58-28)	81.00	TON	585.00	47,385.00	526.82	42,672.42	664.00	53,784.00
63	412.01040	BIKE PATH (PLANT MIX)	1,360.00	TON	52.00	70,720.00	30.03	40,840.80	38.00	51,680.00
64	413.01000	HYDRATED LIME	13.00	TON	205.00	2,665.00	94.48	1,228.24	212.00	2,756.00
65	702.30100	SIGN POSTS, WOOD 4 X 4 in	350.00	FT	9.00	3,150.00	6.45	2,257.50	6.60	2,310.00
66	702.30500	SIGN PANELS, ALUMINUM	97.00	SF	31.00	3,007.00	34.40	3,336.80	35.40	3,433.80
67	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	1,500.00	1,500.00	32,250.00	32,250.00	28,000.00	28,000.00
		Subtotal				248,707.00		244,072.67		235,133.80
	5 - ROADWAY									
68	106.05200	CONTRACTOR TESTING	1.00	LS	7,000.00	7,000.00	2,687.50	2,687.50	9,000.00	9,000.00
69	109.04000	FORCE ACCOUNT WORK	500.00	$$	1.00	500.00	1.00	500.00	1.00	500.00
70	109.08000	MOBILIZATION	1.00	LS	30,000.00	30,000.00	5,425.00	5,425.00	3,500.00	3,500.00
71	202.03305	MILLING PLANT MIX	5,900.00	SY	1.50	8,850.00	1.02	6,018.00	1.70	10,030.00
72	203.02500	UNCLASSIFIED EXCAVATION	1,000.00	CY	7.50	7,500.00	15.47	15,470.00	8.00	8,000.00
73	209.01000	WATER	117.00	MG	15.00	1,755.00	0.01	1.17	16.00	1,872.00

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: McGarvin-Moberly Construction Co. Unit Price	Bidder: McGarvin-Moberly Construction Co. Amount	Bidder: Knife River Northwest Unit Price	Bidder: Knife River Northwest Amount
74	210.03300	MOTOR GRADER	15.00	HR	135.00	2,025.00	143.00	2,145.00	130.00	1,950.00
75	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	2,500.00	2,500.00	770.00	770.00	1,500.00	1,500.00
76	216.03100	SEEDING (PLS)	19.00	LB	25.00	475.00	37.63	714.97	12.80	243.20
77	216.03120	FERTILIZER TYPE I	36.00	LB	5.00	180.00	5.38	193.68	4.40	158.40
78	216.03900	DRY MULCH	2.00	TON	185.00	370.00	215.00	430.00	221.00	442.00
79	221.01000	DUST CONTROL AGENT	6.00	TON	175.00	1,050.00	728.16	4,368.96	180.00	1,080.00
80	301.01080	CRUSHED BASE	1,400.00	TON	25.00	35,000.00	16.28	22,792.00	22.00	30,800.00
81	401.02000	HOT PLANT MIX	1,580.00	TON	45.00	71,100.00	52.87	83,534.60	38.00	60,040.00
82	401.02030	HOT PLANT MIX LEVELING	385.00	TON	46.00	17,710.00	50.34	19,380.90	46.00	17,710.00
83	401.02055	HOT PLANT MIX APPROACHES	89.00	TON	60.00	5,340.00	37.78	3,362.42	61.80	5,500.20
84	401.03323	ASPHALT BINDER (PG 64-22)	113.00	TON	585.00	66,105.00	526.82	59,530.66	664.00	75,032.00
85	407.01000	TACK COAT	2.00	TON	600.00	1,200.00	487.60	975.20	640.00	1,280.00
86	413.01000	HYDRATED LIME	20.00	TON	205.00	4,100.00	94.48	1,889.60	212.00	4,240.00
87	702.30105	SIGN POSTS, WOOD 4 X 6 in	50.00	FT	11.00	550.00	8.60	430.00	9.00	450.00
88	702.30500	SIGN PANELS, ALUMINUM	18.00	SF	31.00	558.00	34.40	619.20	35.40	637.20
89	702.50200	DELINEATORS, TYPE II	4.00	EA	32.00	128.00	37.63	150.52	39.00	156.00
90	702.50300	DELINEATORS, TYPE III	14.00	EA	32.00	448.00	37.63	526.82	39.00	546.00
91	703.03100	FLAGGING	250.00	HR	32.00	8,000.00	32.25	8,062.50	30.00	7,500.00
92	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	7,500.00	7,500.00	21,500.00	21,500.00	28,000.00	28,000.00
		Subtotal				279,944.00		261,478.70		270,167.00
				Total:		**3,958,663.00**		**4,246,432.48**		**4,253,794.10**

Wyoming Department of Transportation
Abstract of Bids
Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Lewis & Lewis, Inc. Unit Price	Bidder: Lewis & Lewis, Inc. Amount	Unit Price	Amount
	5 - ROADWAY									
1	106.05100	FIELD LABORATORY	1.00	EA	7,000.00	7,000.00	3,000.00	3,000.00		
2	106.05200	CONTRACTOR TESTING	1.00	LS	28,000.00	28,000.00	25,000.00	25,000.00		
3	109.04000	FORCE ACCOUNT WORK	5,000.00	$$	1.00	5,000.00	1.00	5,000.00		
4	109.08000	MOBILIZATION	1.00	LS	269,000.00	269,000.00	250,000.00	250,000.00		
5	202.03140	REMOVAL OF CATTLE GUARDS	5.00	EA	650.00	3,250.00	1,500.00	7,500.00		
6	202.03205	REMOVAL OF FENCE	23,800.00	FT	0.28	6,664.00	0.55	13,090.00		
7	202.03270	REMOVAL OF PIPE	8.00	EA	700.00	5,600.00	1,500.00	12,000.00		
8	202.03280	REMOVAL OF PIPE FE SECTION	2.00	EA	175.00	350.00	500.00	1,000.00		
9	202.03305	MILLING PLANT MIX	24,400.00	SY	1.25	30,500.00	1.78	43,432.00		
10	203.02500	UNCLASSIFIED EXCAVATION	41,600.00	CY	6.25	260,000.00	10.00	416,000.00		
11	207.03100	TOPSOIL STORING	8,900.00	CY	1.65	14,685.00	1.50	13,350.00		
12	207.03200	TOPSOIL PLACING	8,900.00	CY	1.95	17,355.00	2.00	17,800.00		
13	209.01000	WATER	3,800.00	MG	15.00	57,000.00	33.00	125,400.00		
14	210.03300	MOTOR GRADER	200.00	HR	135.00	27,000.00	135.00	27,000.00		
15	213.03100	OVERBURDEN REMOVAL	3,000.00	CY	1.35	4,050.00	1.00	3,000.00		
16	213.03110	OVERBURDEN PLACING	3,000.00	CY	1.65	4,950.00	1.00	3,000.00		
17	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	3,000.00	3,000.00	5,000.00	5,000.00		
18	215.01010	DEPARTMENT STORM WATER CONTROL	5,000.00	$$	1.00	5,000.00	1.00	5,000.00		
19	216.03100	SEEDING (PLS)	670.00	LB	10.50	7,035.00	14.45	9,681.50		
20	216.03120	FERTILIZER TYPE I	1,310.00	LB	2.00	2,620.00	1.43	1,873.30		
21	216.03900	DRY MULCH	66.00	TON	165.00	10,890.00	215.00	14,190.00		
22	216.03910	EROSION CONTROL BLANKET	640.00	SY	2.00	1,280.00	2.12	1,356.80		
23	221.01000	DUST CONTROL AGENT	135.00	TON	160.00	21,600.00	105.00	14,175.00		
24	301.01080	CRUSHED BASE	37,500.00	TON	15.75	590,625.00	15.00	562,500.00		
25	401.02000	HOT PLANT MIX	17,300.00	TON	29.00	501,700.00	55.00	951,500.00		
26	401.02030	HOT PLANT MIX LEVELING	4,860.00	TON	29.00	140,940.00	60.00	291,600.00		
27	401.02040	TEST STRIP	1.00	EA	7,500.00	7,500.00	7,500.00	7,500.00		
28	401.02055	HOT PLANT MIX APPROACHES	1,180.00	TON	58.00	68,440.00	80.00	94,400.00		
29	401.03323	ASPHALT BINDER (PG 64-22)	1,280.00	TON	585.00	748,800.00	570.00	729,600.00		
30	407.01000	TACK COAT	26.00	TON	575.00	14,950.00	600.00	15,600.00		
31	413.01000	HYDRATED LIME	219.00	TON	205.00	44,895.00	233.00	51,027.00		
32	603.20042	RCP 42 in	156.00	FT	158.00	24,648.00	140.00	21,840.00		
33	603.22042	RCP FE SECT 42 in	2.00	EA	1,500.00	3,000.00	1,500.00	3,000.00		
34	603.50018	CMP 18 in	12.00	FT	60.00	720.00	100.00	1,200.00		
35	603.50024	CMP 24 in	306.00	FT	65.00	19,890.00	65.00	19,890.00		
36	603.52018	CMP FE SECT 18 in	2.00	EA	210.00	420.00	300.00	600.00		
37	603.52024	CMP FE SECT 24 in	12.00	EA	230.00	2,760.00	300.00	3,600.00		
38	607.20500	FENCE TYPE E (WOOD POSTS)	15,600.00	FT	1.70	26,520.00	1.43	22,308.00		

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

					Engineer's Estimate		Bidder: Lewis & Lewis, Inc.			
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
39	607.20600	FENCE TYPE F (WOOD POSTS)	9,200.00	FT	1.75	16,100.00	1.50	13,800.00		
40	607.80100	BRACE PANELS	26.00	EA	125.00	3,250.00	98.00	2,548.00		
41	607.90100	END PANELS	68.00	EA	175.00	11,900.00	109.00	7,412.00		
42	615.01018	CATTLE GUARD (HEAVY DUTY) 18 FT	2.00	EA	9,000.00	18,000.00	8,000.00	16,000.00		
43	615.01024	CATTLE GUARD (HEAVY DUTY) 24 FT	3.00	EA	10,500.00	31,500.00	10,000.00	30,000.00		
44	615.01036	CATTLE GUARD (HEAVY DUTY) 36 FT	1.00	EA	13,700.00	13,700.00	14,000.00	14,000.00		
45	702.30105	SIGN POSTS, WOOD 4 X 6 in	60.00	FT	11.00	660.00	9.00	540.00		
46	702.30110	SIGN POSTS, WOOD 6 X 6 in	100.00	FT	13.00	1,300.00	14.00	1,400.00		
47	702.30115	SIGN POSTS, WOOD 6 X 8 in	150.00	FT	16.00	2,400.00	16.00	2,400.00		
48	702.30500	SIGN PANELS, ALUMINUM	211.00	SF	31.00	6,541.00	37.00	7,807.00		
49	702.50200	DELINEATORS, TYPE II	42.00	EA	32.00	1,344.00	40.00	1,680.00		
50	702.50300	DELINEATORS, TYPE III	115.00	EA	32.00	3,680.00	40.00	4,600.00		
51	703.03100	FLAGGING	6,000.00	HR	32.00	192,000.00	35.00	210,000.00		
52	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	140,000.00	140,000.00	170,000.00	170,000.00		
		Subtotal				3,430,012.00		4,275,200.60		
	5 - ROADWAY									
53	106.05200	CONTRACTOR TESTING	1.00	LS	5,500.00	5,500.00	5,000.00	5,000.00		
54	109.04000	FORCE ACCOUNT WORK	1,000.00	$$	1.00	1,000.00	1.00	1,000.00		
55	109.08000	MOBILIZATION	1.00	LS	25,000.00	25,000.00	5,000.00	5,000.00		
56	209.01000	WATER	200.00	MG	15.00	3,000.00	33.00	6,600.00		
57	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	135.00	13,500.00		
58	210.03460	ROLLER, TYPE VI	50.00	HR	105.00	5,250.00	120.00	6,000.00		
59	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	1,500.00	1,500.00	1,000.00	1,000.00		
60	221.01000	DUST CONTROL AGENT	33.00	TON	160.00	5,280.00	105.00	3,465.00		
61	301.01080	CRUSHED BASE	2,410.00	TON	25.00	60,250.00	20.00	48,200.00		
62	401.03321	ASPHALT BINDER (PG 58-28)	81.00	TON	585.00	47,385.00	570.00	46,170.00		
63	412.01040	BIKE PATH (PLANT MIX)	1,360.00	TON	52.00	70,720.00	80.00	108,800.00		
64	413.01000	HYDRATED LIME	13.00	TON	205.00	2,665.00	233.00	3,029.00		
65	702.30100	SIGN POSTS, WOOD 4 X 4 in	350.00	FT	9.00	3,150.00	7.00	2,450.00		
66	702.30500	SIGN PANELS, ALUMINUM	97.00	SF	31.00	3,007.00	37.00	3,589.00		
67	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	1,500.00	1,500.00	5,000.00	5,000.00		
		Subtotal				248,707.00		258,803.00		
	5 - ROADWAY									
68	106.05200	CONTRACTOR TESTING	1.00	LS	7,000.00	7,000.00	5,000.00	5,000.00		
69	109.04000	FORCE ACCOUNT WORK	500.00	$$	1.00	500.00	1.00	500.00		
70	109.08000	MOBILIZATION	1.00	LS	30,000.00	30,000.00	5,000.00	5,000.00		
71	202.03305	MILLING PLANT MIX	5,900.00	SY	1.50	8,850.00	3.00	17,700.00		
72	203.02500	UNCLASSIFIED EXCAVATION	1,000.00	CY	7.50	7,500.00	12.00	12,000.00		
73	209.01000	WATER	117.00	MG	15.00	1,755.00	33.00	3,861.00		

Wyoming Department of Transportation
Abstract of Bids
Project No: NH-N132095, STP-E-N132092, ARSCT-N132A03
Project Name: Rock Springs - Pinedale (Pinedale South)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Lewis & Lewis, Inc. Unit Price	Bidder: Lewis & Lewis, Inc. Amount	Unit Price	Amount
74	210.03300	MOTOR GRADER	15.00	HR	135.00	2,025.00	135.00	2,025.00		
75	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	2,500.00	2,500.00	500.00	500.00		
76	216.03100	SEEDING (PLS)	19.00	LB	25.00	475.00	14.50	275.50		
77	216.03120	FERTILIZER TYPE I	36.00	LB	5.00	180.00	1.43	51.48		
78	216.03900	DRY MULCH	2.00	TON	185.00	370.00	215.00	430.00		
79	221.01000	DUST CONTROL AGENT	6.00	TON	175.00	1,050.00	105.00	630.00		
80	301.01080	CRUSHED BASE	1,400.00	TON	25.00	35,000.00	20.00	28,000.00		
81	401.02000	HOT PLANT MIX	1,580.00	TON	45.00	71,100.00	80.00	126,400.00		
82	401.02030	HOT PLANT MIX LEVELING	385.00	TON	46.00	17,710.00	80.00	30,800.00		
83	401.02055	HOT PLANT MIX APPROACHES	89.00	TON	60.00	5,340.00	80.00	7,120.00		
84	401.03323	ASPHALT BINDER (PG 64-22)	113.00	TON	585.00	66,105.00	570.00	64,410.00		
85	407.01000	TACK COAT	2.00	TON	600.00	1,200.00	600.00	1,200.00		
86	413.01000	HYDRATED LIME	20.00	TON	205.00	4,100.00	233.00	4,660.00		
87	702.30105	SIGN POSTS, WOOD 4 X 6 in	50.00	FT	11.00	550.00	9.00	450.00		
88	702.30500	SIGN PANELS, ALUMINUM	18.00	SF	31.00	558.00	37.00	666.00		
89	702.50200	DELINEATORS, TYPE II	4.00	EA	32.00	128.00	40.00	160.00		
90	702.50300	DELINEATORS, TYPE III	14.00	EA	32.00	448.00	40.00	560.00		
91	703.03100	FLAGGING	250.00	HR	32.00	8,000.00	35.00	8,750.00		
92	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	7,500.00	7,500.00	5,000.00	5,000.00		
		Subtotal				279,944.00		326,148.98		
				Total:		**3,958,663.00**		**4,860,152.58**		

Contract Bids for NH-N852001 (US 85) – Vertical Joint Project

Wyoming Department of Transportation
Abstract of Bids

Project Number: NH-N852001
Bid Opening: 03/08/2012
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)
Estimated Completion: 10/31/2012
County: Laramie
Detail Description: Grading, draining, milling plant mix, placing crushed base and bituminous pavement surfacing, signing, fencing and miscellaneous work on 33.90 miles on US 85 beginning at RM 21.80 between Cheyenne and Torrington.

Company	Bid	% of Low Bid
Engineer's Estimate:	$3,137,928.00	
Knife River Cheyenne, WY	$2,521,104.88	100.00 %
Simon Contractors and Subsidiaries Cheyenne, WY	$2,587,892.00	102.65 %
Connell Resources, Inc. Fort Collins, CO	$2,999,722.25	118.98 %
McMurry Ready-Mix Co. Casper, WY	$3,296,070.50	130.74 %
Oftedal Construction, Inc. Miles City, MT	$3,437,717.00	136.36 %

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N852001
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Knife River Unit Price	Bidder: Knife River Amount	Bidder: Simon Contractors and Subsidiaries Unit Price	Bidder: Simon Contractors and Subsidiaries Amount
	5 - ROADWAY									
1	106.05100	FIELD LABORATORY	1.00	EA	7,000.00	7,000.00	4,000.00	4,000.00	4,000.00	4,000.00
2	106.05200	CONTRACTOR TESTING	1.00	LS	22,400.00	22,400.00	22,000.00	22,000.00	45,000.00	45,000.00
3	109.04000	FORCE ACCOUNT WORK	25,000.00	$$	1.00	25,000.00	1.00	25,000.00	1.00	25,000.00
4	109.08000	MOBILIZATION	1.00	LS	280,000.00	280,000.00	70,000.00	70,000.00	147,000.00	147,000.00
5	202.03120	REMOVAL OF SIGNS(Est. Lump Qty: 11 EA)	1.00	LS	2,200.00	2,200.00	1,127.07	1,127.07	1,100.00	1,100.00
6	202.03205	REMOVAL OF FENCE	13,200.00	FT	0.50	6,600.00	0.41	5,412.00	0.30	3,960.00
7	202.03270	REMOVAL OF PIPE	3.00	EA	1,100.00	3,300.00	500.00	1,500.00	440.00	1,320.00
8	202.03280	REMOVAL OF PIPE FE SECTION	13.00	EA	350.00	4,550.00	150.00	1,950.00	120.00	1,560.00
9	202.03305	MILLING PLANT MIX	4,230.00	SY	2.25	9,517.50	3.00	12,690.00	0.80	3,384.00
10	202.03500	RESET MAILBOX (SINGLE)	1.00	EA	350.00	350.00	512.31	512.31	200.00	200.00
11	202.03600	CUTTING BIT PVMT	28,000.00	FT	0.75	21,000.00	0.48	13,440.00	0.40	11,200.00
12	203.02500	UNCLASSIFIED EXCAVATION	65,000.00	CY	3.05	198,250.00	3.35	217,750.00	3.30	214,500.00
13	207.03100	TOPSOIL STORING	17,500.00	CY	1.30	22,750.00	1.00	17,500.00	1.55	27,125.00
14	207.03200	TOPSOIL PLACING	17,500.00	CY	1.50	26,250.00	1.10	19,250.00	1.70	29,750.00
15	209.01000	WATER	2,640.00	MG	15.00	39,600.00	0.01	26.40	13.00	34,320.00
16	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	115.00	11,500.00	125.00	12,500.00
17	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	8,500.00	8,500.00	11,000.00	11,000.00	25,000.00	25,000.00
18	216.03100	SEEDING (PLS)	565.00	LB	13.00	7,345.00	17.00	9,605.00	16.60	9,379.00
19	216.03120	FERTILIZER TYPE I	1,165.00	LB	1.90	2,213.50	3.50	4,077.50	3.40	3,961.00
20	216.03900	DRY MULCH	60.00	TON	180.00	10,800.00	128.00	7,680.00	125.00	7,500.00
21	216.03910	EROSION CONTROL BLANKET	6,300.00	SY	1.75	11,025.00	0.86	5,418.00	0.84	5,292.00
22	217.01025	GEOTEXTILE, MATERIAL SEPARATION (NON-WOVEN)	2,020.00	SY	2.20	4,444.00	1.60	3,232.00	1.60	3,232.00
23	217.01069	BIAXIAL GEOGRID (STIFF)	61,800.00	SY	2.20	135,960.00	1.70	105,060.00	1.70	105,060.00
24	301.01010	PIT RUN SUBBASE	760.00	CY	21.00	15,960.00	20.00	15,200.00	22.00	16,720.00
25	301.01080	CRUSHED BASE	32,600.00	TON	25.00	815,000.00	15.05	490,630.00	13.60	443,360.00
26	401.02000	HOT PLANT MIX	15,900.00	TON	35.00	556,500.00	34.11	542,349.00	33.50	532,650.00
27	401.02040	TEST STRIP	1.00	EA	7,500.00	7,500.00	7,800.00	7,800.00	8,000.00	8,000.00
28	401.02055	HOT PLANT MIX APPROACHES	100.00	TON	75.00	7,500.00	55.00	5,500.00	57.00	5,700.00
29	401.03323	ASPHALT BINDER (PG 64-22)	827.00	TON	620.00	512,740.00	618.00	511,086.00	595.00	492,065.00
30	407.01000	TACK COAT	14.00	TON	600.00	8,400.00	581.00	8,134.00	580.00	8,120.00
31	409.02100	FOG SEAL	13.00	TON	590.00	7,670.00	596.00	7,748.00	630.00	8,190.00
32	413.01000	HYDRATED LIME	230.00	TON	155.00	35,650.00	135.00	31,050.00	145.00	33,350.00
33	603.01018	PIPE 18 in	222.00	FT	40.00	8,880.00	39.00	8,658.00	35.00	7,770.00
34	603.01036	PIPE 36 in	110.00	FT	65.00	7,150.00	61.00	6,710.00	52.00	5,720.00
35	603.03018	PIPE FE SECT 18 in	6.00	EA	190.00	1,140.00	312.00	1,872.00	180.00	1,080.00
36	603.03036	PIPE FE SECT 36 in	2.00	EA	500.00	1,000.00	676.00	1,352.00	670.00	1,340.00
37	603.20018	RCP 18 in	48.00	FT	52.00	2,496.00	59.00	2,832.00	50.00	2,400.00

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N852001
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Knife River Unit Price	Bidder: Knife River Amount	Bidder: Simon Contractors and Subsidiaries Unit Price	Bidder: Simon Contractors and Subsidiaries Amount
38	603.20024	RCP 24 in	20.00	FT	75.00	1,500.00	81.60	1,632.00	81.00	1,620.00
39	603.20030	RCP 30 in	30.00	FT	110.00	3,300.00	101.00	3,030.00	80.00	2,400.00
40	603.20036	RCP 36 in	72.00	FT	140.00	10,080.00	113.00	8,136.00	36.00	2,592.00
41	603.22018	RCP FE SECT 18 in	1.00	EA	550.00	550.00	605.00	605.00	365.00	365.00
42	603.22024	RCP FE SECT 24 in	1.00	EA	650.00	650.00	751.00	751.00	456.00	456.00
43	603.22030	RCP FE SECT 30 in	1.00	EA	800.00	800.00	813.00	813.00	912.00	912.00
44	603.22036	RCP FE SECT 36 in	2.00	EA	1,000.00	2,000.00	1,302.00	2,604.00	650.00	1,300.00
45	603.50018	CMP 18 in	86.00	FT	43.00	3,698.00	39.00	3,354.00	45.00	3,870.00
46	603.50024	CMP 24 in	40.00	FT	55.00	2,200.00	52.00	2,080.00	76.00	3,040.00
47	603.50036	CMP 36 in	52.00	FT	72.00	3,744.00	65.00	3,380.00	60.00	3,120.00
48	603.52018	CMP FE SECT 18 in	2.00	EA	180.00	360.00	207.00	414.00	180.00	360.00
49	603.52024	CMP FE SECT 24 in	1.00	EA	220.00	220.00	471.00	471.00	235.00	235.00
50	603.52036	CMP FE SECT 36 in	1.00	EA	450.00	450.00	831.00	831.00	600.00	600.00
51	603.55018	SME SECT 18 in W/ GRATE	2.00	EA	850.00	1,700.00	625.00	1,250.00	530.00	1,060.00
52	603.55024	SME SECT 24 in W/ GRATE	2.00	EA	1,900.00	3,800.00	1,031.00	2,062.00	1,100.00	2,200.00
53	603.71010	PIPE COLLARS	5.00	CY	650.00	3,250.00	665.00	3,325.00	600.00	3,000.00
54	607.20300	FENCE TYPE C (WOOD POSTS)	1,610.00	FT	3.00	4,830.00	2.41	3,880.10	2.50	4,025.00
55	607.20600	FENCE TYPE F (WOOD POSTS)	11,600.00	FT	1.80	20,880.00	1.61	18,676.00	1.50	17,400.00
56	607.51100	FENCE TEMPORARY	14,400.00	FT	1.65	23,760.00	1.43	20,592.00	1.45	20,880.00
57	607.80100	BRACE PANELS	80.00	EA	115.00	9,200.00	66.60	5,328.00	110.00	8,800.00
58	607.90100	END PANELS	44.00	EA	145.00	6,380.00	97.34	4,282.96	136.00	5,984.00
59	702.20100	REFERENCE MARKERS	6.00	EA	40.00	240.00	66.60	399.60	65.00	390.00
60	702.20200	REFERENCE MARKER PANELS	6.00	EA	60.00	360.00	40.99	245.94	40.00	240.00
61	702.30105	SIGN POSTS, WOOD 4 X 6 in	100.00	FT	8.00	800.00	16.40	1,640.00	16.00	1,600.00
62	702.30110	SIGN POSTS, WOOD 6 X 6 in	440.00	FT	10.00	4,400.00	23.00	10,120.00	2.00	880.00
63	702.30115	SIGN POSTS, WOOD 6 X 8 in	500.00	FT	12.00	6,000.00	31.00	15,500.00	30.00	15,000.00
64	702.30400	SIGN PANELS, PLYWOOD	25.00	SF	34.00	850.00	46.00	1,150.00	45.00	1,125.00
65	702.30500	SIGN PANELS, ALUMINUM	780.00	SF	31.00	24,180.00	46.00	35,880.00	45.00	35,100.00
66	702.30600	RESET SIGNS(Est. Lump Qty: 1 EA)	1.00	LS	250.00	250.00	512.00	512.00	500.00	500.00
67	702.50200	DELINEATORS, TYPE II	4.00	EA	32.50	130.00	46.00	184.00	45.00	180.00
68	702.50300	DELINEATORS, TYPE III	130.00	EA	32.50	4,225.00	46.00	5,980.00	45.00	5,850.00
69	703.03100	FLAGGING	2,000.00	HR	34.00	68,000.00	36.00	72,000.00	35.00	70,000.00
70	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	75,000.00	75,000.00	79,345.00	79,345.00	85,000.00	85,000.00

Wyoming Department of Transportation Abstract of Bids Project No: NH-N852001 Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)					Engineer's Estimate		Bidder: Knife River		03/09/2012 Bidder: Simon Contractors and Subsidiaries	Page 3 of 9
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
		Subtotal				3,137,928.00		2,521,104.88		2,587,892.00
				Total:		**3,137,928.00**		**2,521,104.88** **AWARDED**		**2,587,892.00**

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N852001
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)

					Engineer's Estimate		Bidder: Connell Resources, Inc.		Bidder: McMurry Ready-Mix Co.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	5 - ROADWAY									
1	106.05100	FIELD LABORATORY	1.00	EA	7,000.00	7,000.00	4,100.00	4,100.00	4,600.00	4,600.00
2	106.05200	CONTRACTOR TESTING	1.00	LS	22,400.00	22,400.00	47,100.00	47,100.00	28,500.00	28,500.00
3	109.04000	FORCE ACCOUNT WORK	25,000.00	$$	1.00	25,000.00	1.00	25,000.00	1.00	25,000.00
4	109.08000	MOBILIZATION	1.00	LS	280,000.00	280,000.00	121,000.00	121,000.00	331,601.00	331,601.00
5	202.03120	REMOVAL OF SIGNS(Est. Lump Qty: 11 EA)	1.00	LS	2,200.00	2,200.00	15,700.00	15,700.00	12,600.00	12,600.00
6	202.03205	REMOVAL OF FENCE	13,200.00	FT	0.50	6,600.00	1.10	14,520.00	0.42	5,544.00
7	202.03270	REMOVAL OF PIPE	3.00	EA	1,100.00	3,300.00	900.00	2,700.00	157.50	472.50
8	202.03280	REMOVAL OF PIPE FE SECTION	13.00	EA	350.00	4,550.00	475.00	6,175.00	78.75	1,023.75
9	202.03305	MILLING PLANT MIX	4,230.00	SY	2.25	9,517.50	1.50	6,345.00	1.80	7,614.00
10	202.03500	RESET MAILBOX (SINGLE)	1.00	EA	350.00	350.00	400.00	400.00	853.50	853.50
11	202.03600	CUTTING BIT PVMT	28,000.00	FT	0.75	21,000.00	1.60	44,800.00	0.96	26,880.00
12	203.02500	UNCLASSIFIED EXCAVATION	65,000.00	CY	3.05	198,250.00	2.76	179,400.00	5.25	341,250.00
13	207.03100	TOPSOIL STORING	17,500.00	CY	1.30	22,750.00	2.38	41,650.00	1.80	31,500.00
14	207.03200	TOPSOIL PLACING	17,500.00	CY	1.50	26,250.00	2.68	46,900.00	2.30	40,250.00
15	209.01000	WATER	2,640.00	MG	15.00	39,600.00	5.00	13,200.00	3.20	8,448.00
16	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	125.00	12,500.00	197.50	19,750.00
17	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	8,500.00	8,500.00	15,000.00	15,000.00	26,585.00	26,585.00
18	216.03100	SEEDING (PLS)	565.00	LB	13.00	7,345.00	19.25	10,876.25	18.75	10,593.75
19	216.03120	FERTILIZER TYPE I	1,165.00	LB	1.90	2,213.50	4.00	4,660.00	3.25	3,786.25
20	216.03900	DRY MULCH	60.00	TON	180.00	10,800.00	145.00	8,700.00	252.00	15,120.00
21	216.03910	EROSION CONTROL BLANKET	6,300.00	SY	1.75	11,025.00	0.90	5,670.00	1.45	9,135.00
22	217.01025	GEOTEXTILE, MATERIAL SEPARATION (NON-WOVEN)	2,020.00	SY	2.20	4,444.00	1.50	3,030.00	3.80	7,676.00
23	217.01069	BIAXIAL GEOGRID (STIFF)	61,800.00	SY	2.20	135,960.00	1.50	92,700.00	1.80	111,240.00
24	301.01010	PIT RUN SUBBASE	760.00	CY	21.00	15,960.00	44.50	33,820.00	43.00	32,680.00
25	301.01080	CRUSHED BASE	32,600.00	TON	25.00	815,000.00	19.95	650,370.00	19.00	619,400.00
26	401.02000	HOT PLANT MIX	15,900.00	TON	35.00	556,500.00	41.15	654,285.00	40.35	641,565.00
27	401.02040	TEST STRIP	1.00	EA	7,500.00	7,500.00	6,000.00	6,000.00	11,000.00	11,000.00
28	401.02055	HOT PLANT MIX APPROACHES	100.00	TON	75.00	7,500.00	130.00	13,000.00	243.50	24,350.00
29	401.03323	ASPHALT BINDER (PG 64-22)	827.00	TON	620.00	512,740.00	625.00	516,875.00	625.50	517,288.50
30	407.01000	TACK COAT	14.00	TON	600.00	8,400.00	625.00	8,750.00	627.00	8,778.00
31	409.02100	FOG SEAL	13.00	TON	590.00	7,670.00	540.00	7,020.00	695.50	9,041.50
32	413.01000	HYDRATED LIME	230.00	TON	155.00	35,650.00	156.00	35,880.00	166.50	38,295.00
33	603.01018	PIPE 18 in	222.00	FT	40.00	8,880.00	65.00	14,430.00	30.50	6,771.00
34	603.01036	PIPE 36 in	110.00	FT	65.00	7,150.00	75.00	8,250.00	68.25	7,507.50
35	603.03018	PIPE FE SECT 18 in	6.00	EA	190.00	1,140.00	89.50	537.00	184.00	1,104.00
36	603.03036	PIPE FE SECT 36 in	2.00	EA	500.00	1,000.00	392.00	784.00	829.50	1,659.00
37	603.20018	RCP 18 in	48.00	FT	52.00	2,496.00	69.00	3,312.00	49.25	2,364.00

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N852001
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)

					Engineer's Estimate		Bidder: Connell Resources, Inc.		Bidder: McMurry Ready-Mix Co.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
38	603.20024	RCP 24 in	20.00	FT	75.00	1,500.00	87.00	1,740.00	66.25	1,325.00
39	603.20030	RCP 30 in	30.00	FT	110.00	3,300.00	79.00	2,370.00	82.25	2,467.50
40	603.20036	RCP 36 in	72.00	FT	140.00	10,080.00	85.00	6,120.00	107.00	7,704.00
41	603.22018	RCP FE SECT 18 in	1.00	EA	550.00	550.00	430.00	430.00	520.00	520.00
42	603.22024	RCP FE SECT 24 in	1.00	EA	650.00	650.00	500.00	500.00	709.00	709.00
43	603.22030	RCP FE SECT 30 in	1.00	EA	800.00	800.00	620.00	620.00	1,087.00	1,087.00
44	603.22036	RCP FE SECT 36 in	2.00	EA	1,000.00	2,000.00	1,000.00	2,000.00	1,351.00	2,702.00
45	603.50018	CMP 18 in	86.00	FT	43.00	3,698.00	55.00	4,730.00	30.50	2,623.00
46	603.50024	CMP 24 in	40.00	FT	55.00	2,200.00	61.00	2,440.00	42.00	1,680.00
47	603.50036	CMP 36 in	52.00	FT	72.00	3,744.00	65.00	3,380.00	68.25	3,549.00
48	603.52018	CMP FE SECT 18 in	2.00	EA	180.00	360.00	90.00	180.00	184.00	368.00
49	603.52024	CMP FE SECT 24 in	1.00	EA	220.00	220.00	135.00	135.00	278.50	278.50
50	603.52036	CMP FE SECT 36 in	1.00	EA	450.00	450.00	400.00	400.00	829.50	829.50
51	603.55018	SME SECT 18 in W/ GRATE	2.00	EA	850.00	1,700.00	632.00	1,264.00	840.00	1,680.00
52	603.55024	SME SECT 24 in W/ GRATE	2.00	EA	1,900.00	3,800.00	1,000.00	2,000.00	1,260.00	2,520.00
53	603.71010	PIPE COLLARS	5.00	CY	650.00	3,250.00	1,500.00	7,500.00	840.00	4,200.00
54	607.20300	FENCE TYPE C (WOOD POSTS)	1,610.00	FT	3.00	4,830.00	2.75	4,427.50	2.45	3,944.50
55	607.20600	FENCE TYPE F (WOOD POSTS)	11,600.00	FT	1.80	20,880.00	1.65	19,140.00	1.65	19,140.00
56	607.51100	FENCE TEMPORARY	14,400.00	FT	1.65	23,760.00	1.60	23,040.00	1.55	22,320.00
57	607.80100	BRACE PANELS	80.00	EA	115.00	9,200.00	121.00	9,680.00	68.25	5,460.00
58	607.90100	END PANELS	44.00	EA	145.00	6,380.00	150.00	6,600.00	99.75	4,389.00
59	702.20100	REFERENCE MARKERS	6.00	EA	40.00	240.00	60.00	360.00	52.50	315.00
60	702.20200	REFERENCE MARKER PANELS	6.00	EA	60.00	360.00	61.00	366.00	52.50	315.00
61	702.30105	SIGN POSTS, WOOD 4 X 6 in	100.00	FT	8.00	800.00	14.50	1,450.00	12.50	1,250.00
62	702.30110	SIGN POSTS, WOOD 6 X 6 in	440.00	FT	10.00	4,400.00	17.50	7,700.00	15.25	6,710.00
63	702.30115	SIGN POSTS, WOOD 6 X 8 in	500.00	FT	12.00	6,000.00	19.40	9,700.00	16.75	8,375.00
64	702.30400	SIGN PANELS, PLYWOOD	25.00	SF	34.00	850.00	42.50	1,062.50	36.75	918.75
65	702.30500	SIGN PANELS, ALUMINUM	780.00	SF	31.00	24,180.00	42.50	33,150.00	36.75	28,665.00
66	702.30600	RESET SIGNS(Est. Lump Qty: 1 EA)	1.00	LS	250.00	250.00	600.00	600.00	525.00	525.00
67	702.50200	DELINEATORS, TYPE II	4.00	EA	32.50	130.00	47.00	188.00	36.75	147.00
68	702.50300	DELINEATORS, TYPE III	130.00	EA	32.50	4,225.00	47.00	6,110.00	36.75	4,777.50
69	703.03100	FLAGGING	2,000.00	HR	34.00	68,000.00	37.00	74,000.00	36.75	73,500.00
70	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	75,000.00	75,000.00	90,900.00	90,900.00	89,250.00	89,250.00

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N852001
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)

					Engineer's Estimate		Bidder: Connell Resources, Inc.		Bidder: McMurry Ready-Mix Co.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
		Subtotal				3,137,928.00		2,999,722.25		3,296,070.50
				Total:		**3,137,928.00**		**2,999,722.25**		**3,296,070.50**

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N852001
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)

					Engineer's Estimate		Bidder: Oftedal Construction, Inc.			
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	5 - ROADWAY									
1	106.05100	FIELD LABORATORY	1.00	EA	7,000.00	7,000.00	6,000.00	6,000.00		
2	106.05200	CONTRACTOR TESTING	1.00	LS	22,400.00	22,400.00	30,000.00	30,000.00		
3	109.04000	FORCE ACCOUNT WORK	25,000.00	$$	1.00	25,000.00	1.00	25,000.00		
4	109.08000	MOBILIZATION	1.00	LS	280,000.00	280,000.00	323,030.00	323,030.00		
5	202.03120	REMOVAL OF SIGNS(Est. Lump Qty: 11 EA)	1.00	LS	2,200.00	2,200.00	12,400.00	12,400.00		
6	202.03205	REMOVAL OF FENCE	13,200.00	FT	0.50	6,600.00	0.30	3,960.00		
7	202.03270	REMOVAL OF PIPE	3.00	EA	1,100.00	3,300.00	2,114.33	6,342.99		
8	202.03280	REMOVAL OF PIPE FE SECTION	13.00	EA	350.00	4,550.00	420.00	5,460.00		
9	202.03305	MILLING PLANT MIX	4,230.00	SY	2.25	9,517.50	1.70	7,191.00		
10	202.03500	RESET MAILBOX (SINGLE)	1.00	EA	350.00	350.00	550.00	550.00		
11	202.03600	CUTTING BIT PVMT	28,000.00	FT	0.75	21,000.00	0.85	23,800.00		
12	203.02500	UNCLASSIFIED EXCAVATION	65,000.00	CY	3.05	198,250.00	5.05	328,250.00		
13	207.03100	TOPSOIL STORING	17,500.00	CY	1.30	22,750.00	1.66	29,050.00		
14	207.03200	TOPSOIL PLACING	17,500.00	CY	1.50	26,250.00	2.05	35,875.00		
15	209.01000	WATER	2,640.00	MG	15.00	39,600.00	7.50	19,800.00		
16	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	132.00	13,200.00		
17	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	8,500.00	8,500.00	30,125.00	30,125.00		
18	216.03100	SEEDING (PLS)	565.00	LB	13.00	7,345.00	17.64	9,966.60		
19	216.03120	FERTILIZER TYPE I	1,165.00	LB	1.90	2,213.50	3.60	4,194.00		
20	216.03900	DRY MULCH	60.00	TON	180.00	10,800.00	133.00	7,980.00		
21	216.03910	EROSION CONTROL BLANKET	6,300.00	SY	1.75	11,025.00	0.90	5,670.00		
22	217.01025	GEOTEXTILE, MATERIAL SEPARATION (NON-WOVEN)	2,020.00	SY	2.20	4,444.00	1.85	3,737.00		
23	217.01069	BIAXIAL GEOGRID (STIFF)	61,800.00	SY	2.20	135,960.00	2.25	139,050.00		
24	301.01010	PIT RUN SUBBASE	760.00	CY	21.00	15,960.00	21.30	16,188.00		
25	301.01080	CRUSHED BASE	32,600.00	TON	25.00	815,000.00	21.75	709,050.00		
26	401.02000	HOT PLANT MIX	15,900.00	TON	35.00	556,500.00	47.75	759,225.00		
27	401.02040	TEST STRIP	1.00	EA	7,500.00	7,500.00	11,690.00	11,690.00		
28	401.02055	HOT PLANT MIX APPROACHES	100.00	TON	75.00	7,500.00	150.49	15,049.00		
29	401.03323	ASPHALT BINDER (PG 64-22)	827.00	TON	620.00	512,740.00	580.00	479,660.00		
30	407.01000	TACK COAT	14.00	TON	600.00	8,400.00	538.00	7,532.00		
31	409.02100	FOG SEAL	13.00	TON	590.00	7,670.00	538.00	6,994.00		
32	413.01000	HYDRATED LIME	230.00	TON	155.00	35,650.00	108.00	24,840.00		
33	603.01018	PIPE 18 in	222.00	FT	40.00	8,880.00	27.30	6,060.60		
34	603.01036	PIPE 36 in	110.00	FT	65.00	7,150.00	42.95	4,724.50		
35	603.03018	PIPE FE SECT 18 in	6.00	EA	190.00	1,140.00	441.55	2,649.30		
36	603.03036	PIPE FE SECT 36 in	2.00	EA	500.00	1,000.00	935.20	1,870.40		
37	603.20018	RCP 18 in	48.00	FT	52.00	2,496.00	66.61	3,197.28		

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N852001
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)

					Engineer's Estimate		Bidder: Oftedal Construction, Inc.			
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
38	603.20024	RCP 24 in	20.00	FT	75.00	1,500.00	77.00	1,540.00		
39	603.20030	RCP 30 in	30.00	FT	110.00	3,300.00	95.50	2,865.00		
40	603.20036	RCP 36 in	72.00	FT	140.00	10,080.00	120.00	8,640.00		
41	603.22018	RCP FE SECT 18 in	1.00	EA	550.00	550.00	662.00	662.00		
42	603.22024	RCP FE SECT 24 in	1.00	EA	650.00	650.00	770.00	770.00		
43	603.22030	RCP FE SECT 30 in	1.00	EA	800.00	800.00	920.00	920.00		
44	603.22036	RCP FE SECT 36 in	2.00	EA	1,000.00	2,000.00	1,232.88	2,465.76		
45	603.50018	CMP 18 in	86.00	FT	43.00	3,698.00	27.30	2,347.80		
46	603.50024	CMP 24 in	40.00	FT	55.00	2,200.00	31.95	1,278.00		
47	603.50036	CMP 36 in	52.00	FT	72.00	3,744.00	42.95	2,233.40		
48	603.52018	CMP FE SECT 18 in	2.00	EA	180.00	360.00	441.55	883.10		
49	603.52024	CMP FE SECT 24 in	1.00	EA	220.00	220.00	509.09	509.09		
50	603.52036	CMP FE SECT 36 in	1.00	EA	450.00	450.00	935.20	935.20		
51	603.55018	SME SECT 18 in W/ GRATE	2.00	EA	850.00	1,700.00	764.00	1,528.00		
52	603.55024	SME SECT 24 in W/ GRATE	2.00	EA	1,900.00	3,800.00	1,254.61	2,509.22		
53	603.71010	PIPE COLLARS	5.00	CY	650.00	3,250.00	423.84	2,119.20		
54	607.20300	FENCE TYPE C (WOOD POSTS)	1,610.00	FT	3.00	4,830.00	2.25	3,622.50		
55	607.20600	FENCE TYPE F (WOOD POSTS)	11,600.00	FT	1.80	20,880.00	1.90	22,040.00		
56	607.51100	FENCE TEMPORARY	14,400.00	FT	1.65	23,760.00	1.60	23,040.00		
57	607.80100	BRACE PANELS	80.00	EA	115.00	9,200.00	160.00	12,800.00		
58	607.90100	END PANELS	44.00	EA	145.00	6,380.00	186.00	8,184.00		
59	702.20100	REFERENCE MARKERS	6.00	EA	40.00	240.00	53.13	318.78		
60	702.20200	REFERENCE MARKER PANELS	6.00	EA	60.00	360.00	53.13	318.78		
61	702.30105	SIGN POSTS, WOOD 4 X 6 in	100.00	FT	8.00	800.00	12.75	1,275.00		
62	702.30110	SIGN POSTS, WOOD 6 X 6 in	440.00	FT	10.00	4,400.00	15.40	6,776.00		
63	702.30115	SIGN POSTS, WOOD 6 X 8 in	500.00	FT	12.00	6,000.00	17.00	8,500.00		
64	702.30400	SIGN PANELS, PLYWOOD	25.00	SF	34.00	850.00	37.00	925.00		
65	702.30500	SIGN PANELS, ALUMINUM	780.00	SF	31.00	24,180.00	37.00	28,860.00		
66	702.30600	RESET SIGNS(Est. Lump Qty: 1 EA)	1.00	LS	250.00	250.00	531.50	531.50		
67	702.50200	DELINEATORS, TYPE II	4.00	EA	32.50	130.00	37.00	148.00		
68	702.50300	DELINEATORS, TYPE III	130.00	EA	32.50	4,225.00	37.00	4,810.00		
69	703.03100	FLAGGING	2,000.00	HR	34.00	68,000.00	37.00	74,000.00		
70	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	75,000.00	75,000.00	90,000.00	90,000.00		

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N852001
Project Name: Cheyenne - Torrington (Torrington Int - Laramie/Goshen County Line)

03/09/2012

					Engineer's Estimate		Bidder: Oftedal Construction, Inc.			
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
		Subtotal				3,137,928.00		3,437,717.00		
				Total:		**3,137,928.00**		**3,437,717.00**		

Contract Bids for NH-N361053 (US 16) – Tapered Joint Project

Wyoming Department of Transportation
Abstract of Bids

Project Number: NH-N361055
Bid Opening: 12/07/2011
Project Name: Ten Sleep - Buffalo (County Line West)
Estimated Completion: 06/30/2013
County: Washakie
Detail Description: Grading, draining, placing crushed base and bituminous pavement surfacing, chip seal, wetland construction, MSE retaining wall, removal and replacement of box culverts, signing, guardrail, fencing and miscellaneous work on 2.30 miles on US 16 beginning at RM 44.04 between Ten Sleep and Buffalo.

Company	Bid	% of Low Bid
Engineer's Estimate:	**$8,679,598.25**	
Oftedal Construction, Inc. Miles City, MT	$8,211,281.70	100.00 %
High Country Construction, Inc. Lander, WY	$8,392,191.88	102.20 %
Knife River (Montana) Billings, MT	$13,706,328.10	166.92 %

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N361055
Project Name: Ten Sleep - Buffalo (County Line West)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Oftedal Construction, Inc. Unit Price	Bidder: Oftedal Construction, Inc. Amount	Bidder: High Country Construction, Inc. Unit Price	Bidder: High Country Construction, Inc. Amount
	5 - ROADWAY									
1	105.09010	CONTRACTOR SURVEYING	1.00	LS	16,000.00	16,000.00	17,000.00	17,000.00	22,680.00	22,680.00
2	106.05100	FIELD LABORATORY	1.00	EA	10,500.00	10,500.00	10,000.00	10,000.00	15,120.00	15,120.00
3	106.05200	CONTRACTOR TESTING	1.00	LS	17,000.00	17,000.00	60,000.00	60,000.00	13,228.43	13,228.43
4	108.03000	CPM SCHEDULE	1.00	LS	12,000.00	12,000.00	7,500.00	7,500.00	32,559.93	32,559.93
5	109.04000	FORCE ACCOUNT WORK	25,000.00	$$	1.00	25,000.00	1.00	25,000.00	1.00	25,000.00
6	109.08000	MOBILIZATION	1.00	LS	725,000.00	725,000.00	832,500.00	832,500.00	756,000.00	756,000.00
7	201.03201	CLEARING AND GRUBBING	51.00	ACRE	5,000.00	255,000.00	6,200.00	316,200.00	6,388.08	325,792.08
8	202.03120	REMOVAL OF SIGNS	1.00	LS	250.00	250.00	1,000.00	1,000.00	428.82	428.82
9	202.03165	REMOVAL OF GUARDRAIL AND BARRIER	1,488.00	FT	1.50	2,232.00	3.00	4,464.00	10.80	16,070.40
10	202.03205	REMOVAL OF FENCE	3,980.00	FT	0.75	2,985.00	0.75	2,985.00	0.43	1,711.40
11	202.03250	REMOVAL OF RC BOX CULVERTS(Est. Lump Qty: 2 EA)	1.00	LS	8,000.00	8,000.00	20,000.00	20,000.00	15,352.83	15,352.83
12	202.03270	REMOVAL OF PIPE	22.00	EA	1,500.00	33,000.00	500.00	11,000.00	5,239.39	115,266.58
13	202.03305	MILLING PLANT MIX	32,500.00	SY	2.50	81,250.00	1.60	52,000.00	2.49	80,925.00
14	202.03600	CUTTING BIT PVMT	65.00	FT	6.00	390.00	9.50	617.50	4.26	276.90
15	203.02500	UNCLASSIFIED EXCAVATION	317,000.00	CY	5.15	1,632,550.00	5.25	1,664,250.00	5.41	1,714,970.00
16	206.03300	CULVERT SUBEXCAVATION	160.00	CY	14.00	2,240.00	17.00	2,720.00	14.37	2,299.20
17	207.03100	TOPSOIL STORING	22,000.00	CY	2.50	55,000.00	4.25	93,500.00	3.49	76,780.00
18	207.03200	TOPSOIL PLACING	22,800.00	CY	3.00	68,400.00	4.25	96,900.00	3.74	85,272.00
19	207.03300	TOPSOIL BORROW	13,212.00	CY	10.00	132,120.00	6.00	79,272.00	4.76	62,889.12
20	209.01000	WATER	10,700.00	MG	12.00	128,400.00	5.50	58,850.00	0.01	107.00
21	210.03200	BULLDOZER	200.00	HR	165.00	33,000.00	260.00	52,000.00	184.52	36,904.00
22	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	145.00	14,500.00	143.61	14,361.00
23	210.03610	EXCAVATOR	200.00	HR	145.00	29,000.00	155.00	31,000.00	157.50	31,500.00
24	215.01010	DEPARTMENT STORM WATER CONTROL	10,000.00	$$	1.00	10,000.00	1.00	10,000.00	1.00	10,000.00
25	215.03200	BURLAP BAG CURB	2,200.00	FT	11.00	24,200.00	6.00	13,200.00	4.04	8,888.00
26	215.03300	SILT FENCE	5,800.00	FT	5.00	29,000.00	4.50	26,100.00	4.72	27,376.00
27	215.03402	EXCELSIOR SEDIMENT LOG	1,220.00	FT	7.00	8,540.00	4.50	5,490.00	5.39	6,575.80
28	216.03100	SEEDING (PLS)	930.00	LB	20.00	18,600.00	30.00	27,900.00	27.00	25,110.00
29	216.03130	FERTILIZER TYPE II	350.00	LB	6.00	2,100.00	8.00	2,800.00	7.56	2,646.00
30	216.03180	FERTILIZER SPECIAL	30,900.00	LB	0.95	29,355.00	1.50	46,350.00	1.08	33,372.00
31	216.03600	HYDRAULIC MULCHING	41.00	TON	1,600.00	65,600.00	2,700.00	110,700.00	2,586.60	106,050.60
32	216.03900	DRY MULCH	27.00	TON	185.00	4,995.00	225.00	6,075.00	216.00	5,832.00
33	216.03910	EROSION CONTROL BLANKET	49,800.00	SY	1.65	82,170.00	2.40	119,520.00	1.94	96,612.00
34	216.03955	COCONUT FIBER DITCH LINING	15,000.00	SY	1.85	27,750.00	2.40	36,000.00	1.73	25,950.00
35	216.03973	WETLAND CONSTRUCTION	1.00	LS	70,000.00	70,000.00	20,000.00	20,000.00	12,960.00	12,960.00
36	217.01010	GEOTEXTILE, EROSION CONTROL	327.00	SY	3.00	981.00	4.00	1,308.00	9.62	3,145.74
37	219.01000	ROCKFALL MESH	54,500.00	SY	14.00	763,000.00	12.00	654,000.00	11.33	617,485.00

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N361055
Project Name: Ten Sleep - Buffalo (County Line West)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Oftedal Construction, Inc. Unit Price	Bidder: Oftedal Construction, Inc. Amount	Bidder: High Country Construction, Inc. Unit Price	Bidder: High Country Construction, Inc. Amount
38	219.02500	DRIVEN ANCHORS	320.00	EA	140.00	44,800.00	105.00	33,600.00	103.73	33,193.60
39	220.01010	SCALING (MANUAL)	40.00	CRWH	240.00	9,600.00	204.00	8,160.00	210.83	8,433.20
40	221.01000	DUST CONTROL AGENT	180.00	TON	170.00	30,600.00	212.50	38,250.00	189.00	34,020.00
41	299.02100	CONTROLLED BLASTING	20,000.00	FT	20.00	400,000.00	0.01	200.00	0.01	200.00
42	301.01030	CRUSHER RUN SUBBASE	17,290.00	CY	19.00	328,510.00	18.00	311,220.00	27.33	472,535.70
43	301.01085	CRUSHED BASE	10,300.00	CY	22.50	231,750.00	18.00	185,400.00	18.00	185,400.00
44	401.02000	HOT PLANT MIX	11,100.00	TON	29.50	327,450.00	33.00	366,300.00	40.49	449,439.00
45	401.02040	TEST STRIP	1.00	EA	8,000.00	8,000.00	12,000.00	12,000.00	11,340.00	11,340.00
46	401.02055	HOT PLANT MIX APPROACHES	126.00	TON	70.00	8,820.00	115.00	14,490.00	123.14	15,515.64
47	401.03322	ASPHALT BINDER (PG 64-28)	610.00	TON	686.00	418,460.00	640.00	390,400.00	681.16	415,507.60
48	407.01000	TACK COAT	7.00	TON	600.00	4,200.00	499.00	3,493.00	538.06	3,766.42
49	409.02100	FOG SEAL	6.00	TON	600.00	3,600.00	499.00	2,994.00	538.06	3,228.36
50	409.03070	CHIP SEAL	32,500.00	SY	0.90	29,250.00	1.00	32,500.00	0.55	17,875.00
51	409.03085	EMULSIFIED ASPHALT MODIFIED	54.00	TON	620.00	33,480.00	565.00	30,510.00	583.85	31,527.90
52	412.01000	CURB (PLANT MIX)	900.00	FT	18.00	16,200.00	14.25	12,825.00	14.48	13,032.00
53	413.01000	HYDRATED LIME	106.00	TON	170.00	18,020.00	105.00	11,130.00	104.87	11,116.22
54	499.03040	REUSED SURFACING	4,600.00	CY	7.50	34,500.00	8.00	36,800.00	7.80	35,880.00
55	506.01030	DRILLED SHAFT FOUNDATIONS 30 in	24.00	FT	200.00	4,800.00	72.00	1,728.00	70.20	1,684.80
56	511.06000	MACHINE-PLACED RIPRAP	113.00	CY	95.00	10,735.00	55.00	6,215.00	56.68	6,404.84
57	599.00002	PRECAST WALL COMPONENT SYSTEM	33,926.00	SF	21.00	712,446.00	19.75	670,038.50	19.53	662,574.78
58	603.01018	PIPE 18 in	202.00	FT	36.00	7,272.00	55.00	11,110.00	89.82	18,143.64
59	603.01024	PIPE 24 in	1,804.00	FT	53.00	95,612.00	57.50	103,730.00	95.49	172,263.96
60	603.01030	PIPE 30 in	82.00	FT	68.00	5,576.00	79.50	6,519.00	107.62	8,824.84
61	603.01036	PIPE 36 in	126.00	FT	72.00	9,072.00	85.75	10,804.50	139.84	17,619.84
62	603.01048	PIPE 48 in	400.00	FT	96.00	38,400.00	92.75	37,100.00	139.35	55,740.00
63	603.03018	PIPE FE SECT 18 in	4.00	EA	200.00	800.00	204.50	818.00	219.26	877.04
64	603.03024	PIPE FE SECT 24 in	25.00	EA	260.00	6,500.00	244.50	6,112.50	253.97	6,349.25
65	603.03030	PIPE FE SECT 30 in	2.00	EA	380.00	760.00	430.00	860.00	386.42	772.84
66	603.03036	PIPE FE SECT 36 in	2.00	EA	550.00	1,100.00	642.00	1,284.00	618.53	1,237.06
67	603.03048	PIPE FE SECT 48 in	6.00	EA	1,200.00	7,200.00	1,230.00	7,380.00	1,186.58	7,119.48
68	605.09000	GRAVEL FOR DRAINS	196.00	CY	40.00	7,840.00	64.50	12,642.00	89.89	17,618.44
69	605.10004	UNDERDRAIN PIPE (PERF) 4 in	2,626.00	FT	7.00	18,382.00	1.00	2,626.00	1.07	2,809.82
70	605.20004	UNDERDRAIN PIPE (NON-PERF) 4 in	463.00	FT	8.50	3,935.50	1.00	463.00	1.07	495.41
71	606.02000	CORR BEAM GUARDRAIL (SELF-OXIDIZING)	3,125.00	FT	17.50	54,687.50	12.00	37,500.00	11.88	37,125.00
72	606.03000	CORR BEAM GUARDRAIL END ANCH TYPE A (SELF-OXIDIZING)	6.00	EA	2,400.00	14,400.00	1,200.00	7,200.00	1,215.00	7,290.00
73	607.10910	FENCE TYPE X	6,600.00	FT	7.00	46,200.00	10.75	70,950.00	8.64	57,024.00
74	607.20500	FENCE TYPE E (WOOD POSTS)	6,890.00	FT	2.00	13,780.00	2.50	17,225.00	2.92	20,118.80
75	607.50900	FENCE-WING (WOOD POSTS)	410.00	FT	3.75	1,537.50	5.85	2,398.50	3.51	1,439.10

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N361055
Project Name: Ten Sleep - Buffalo (County Line West)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Oftedal Construction, Inc. Unit Price	Bidder: Oftedal Construction, Inc. Amount	Bidder: High Country Construction, Inc. Unit Price	Bidder: High Country Construction, Inc. Amount
76	607.51100	FENCE TEMPORARY	1,930.00	FT	2.10	4,053.00	2.50	4,825.00	2.11	4,072.30
77	607.80100	BRACE PANELS	13.00	EA	135.00	1,755.00	125.00	1,625.00	151.20	1,965.60
78	607.90100	END PANELS	34.00	EA	175.00	5,950.00	155.00	5,270.00	172.80	5,875.20
79	610.10100	METAL DRAIN INLET	2.00	EA	800.00	1,600.00	862.35	1,724.70	631.54	1,263.08
80	610.10200	METAL DRAIN PIPE	110.00	FT	30.00	3,300.00	64.75	7,122.50	37.77	4,154.70
81	625.30100	INLET TYPE M1	7.00	EA	3,500.00	24,500.00	3,000.00	21,000.00	2,671.45	18,700.15
82	702.09400	STL BREAK-AWAY SIGN SUPPORT W6 X 15	52.00	FT	125.00	6,500.00	200.00	10,400.00	178.20	9,266.40
83	702.30100	SIGN POSTS, WOOD 4 X 4 in	50.00	FT	10.00	500.00	13.00	650.00	12.42	621.00
84	702.30105	SIGN POSTS, WOOD 4 X 6 in	180.00	FT	11.00	1,980.00	13.50	2,430.00	13.50	2,430.00
85	702.30110	SIGN POSTS, WOOD 6 X 6 in	240.00	FT	13.00	3,120.00	14.00	3,360.00	13.88	3,331.20
86	702.30115	SIGN POSTS, WOOD 6 X 8 in	50.00	FT	15.00	750.00	16.75	837.50	16.74	837.00
87	702.30400	SIGN PANELS, PLYWOOD	60.00	SF	32.00	1,920.00	33.00	1,980.00	32.40	1,944.00
88	702.30500	SIGN PANELS, ALUMINUM	260.00	SF	32.00	8,320.00	33.00	8,580.00	32.40	8,424.00
89	702.30600	RESET SIGNS(Est. Lump Qty: 1 EA)	1.00	LS	300.00	300.00	1,500.00	1,500.00	1,080.00	1,080.00
90	702.50655	DELINEATORS, TYPE VIII	250.00	EA	68.00	17,000.00	75.00	18,750.00	64.80	16,200.00
91	703.03100	FLAGGING	4,000.00	HR	34.00	136,000.00	39.00	156,000.00	37.80	151,200.00
92	703.03205	PORTABLE VARIABLE MESSAGE SIGN(Est. Lump Qty: 2)	1.00	LS	25,000.00	25,000.00	15,000.00	15,000.00	12,960.00	12,960.00
93	703.03410	TEMPORARY CONCRETE BARRIER	3,000.00	FT	22.00	66,000.00	24.00	72,000.00	34.42	103,260.00
		Subtotal				7,735,931.50		7,370,732.20		7,620,626.04
	15 - STRUCTURES									
94	202.03250	REMOVAL OF RC BOX CULVERTS(Est. Lump Qty: 1 EA)	1.00	LS	10,000.00	10,000.00	26,900.00	26,900.00	22,398.30	22,398.30
95	206.03300	CULVERT SUBEXCAVATION	370.00	CY	13.75	5,087.50	18.00	6,660.00	20.83	7,707.10
96	301.01030	CRUSHER RUN SUBBASE	370.00	CY	20.00	7,400.00	55.00	20,350.00	17.27	6,389.90
97	502.11010	PRECAST BOX CULVERTS 10 X 10 ft	378.00	FT	1,280.00	483,840.00	1,300.00	491,400.00	1,124.28	424,977.84
98	699.01061	COLORING AND TEXTURING CONCRETE SURFACES	2,150.00	SF	2.75	5,912.50	5.00	10,750.00	16.20	34,830.00
99	900.60000	CONTRACTOR QUALITY CONTROL (CONCRETE)	1.00	LS	7,800.00	7,800.00	12,000.00	12,000.00	10,800.00	10,800.00
		Subtotal				520,040.00		568,060.00		507,103.14
	35 - 513.00015 - CLASS B CONCRETE									
100	513.00020	CLASS B CONCRETE	97.30	CY	560.00	54,488.00	850.00	82,705.00	810.00	78,813.00
		Subtotal				54,488.00		82,705.00		78,813.00
	45 - 514.00015 - REINFORCING STEEL									
101	514.00020	REINFORCING STEEL	8,210.00	LB	1.25	10,262.50	1.45	11,904.50	2.70	22,167.00
		Subtotal				10,262.50		11,904.50		22,167.00
	94 - 701.81700 - ROAD WEATHER INFORMATION SYSTEM									
102	701.17110	CONDUIT-RIGID PVC 1 in	50.00	FT	6.00	300.00	8.00	400.00	8.10	405.00

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N361055
Project Name: Ten Sleep - Buffalo (County Line West)

					Engineer's Estimate		Bidder: Oftedal Construction, Inc.		Bidder: High Country Construction, Inc.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
103	701.17120	CONDUIT-RIGID PVC 2 in	175.00	FT	6.50	1,137.50	8.00	1,400.00	8.10	1,417.50
104	701.17130	CONDUIT-RIGID PVC 3 in	60.00	FT	7.25	435.00	8.00	480.00	8.10	486.00
105	701.20100	PULL BOX TYPE A	1.00	EA	430.00	430.00	475.00	475.00	8.10	8.10
106	701.20200	PULL BOX TYPE B	1.00	EA	480.00	480.00	650.00	650.00	8.10	8.10
107	701.21300	SERVICE POINT SIGNAL	1.00	EA	3,200.00	3,200.00	4,500.00	4,500.00	4,320.00	4,320.00
108	701.29080	SINGLE CONDUCTOR WIRE #10 AWG	350.00	FT	1.50	525.00	4.00	1,400.00	3.24	1,134.00
109	701.3600A	TELEPHONE CABLE	125.00	FT	1.65	206.25	4.00	500.00	3.24	405.00
110	701.3700A	COMMUNICATIONS CABLE	50.00	FT	1.25	62.50	4.00	200.00	3.24	162.00
111	701.3700K	VIDEO CABLE	50.00	FT	15.00	750.00	4.00	200.00	3.24	162.00
112	701.5980G	COMMUNICATION TOWER 40'	1.00	EA	10,500.00	10,500.00	17,500.00	17,500.00	17,280.00	17,280.00
113	701.8110A	ITS CABINET	1.00	EA	12,500.00	12,500.00	20,000.00	20,000.00	19,440.00	19,440.00
114	701.8123A	REMOTE VIDEO CAMERA - PTZ	1.00	EA	4,750.00	4,750.00	6,000.00	6,000.00	5,400.00	5,400.00
115	701.8126A	VIDEO SERVER / IP ENCODER	1.00	EA	1,000.00	1,000.00	1,200.00	1,200.00	1,080.00	1,080.00
116	701.8170A	ROAD WEATHER INFORMATION SYSTEM (RWIS)	1.00	EA	17,500.00	17,500.00	45,000.00	45,000.00	40,500.00	40,500.00
117	701.8176A	PAVEMENT SURFACE SENSOR	1.00	EA	4,000.00	4,000.00	7,500.00	7,500.00	7,020.00	7,020.00
118	701.8177A	SUBSURFACE SENSOR	1.00	EA	1,100.00	1,100.00	3,800.00	3,800.00	3,240.00	3,240.00
		Subtotal				58,876.25		111,205.00		102,467.70
	(OPTION)									
119	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	300,000.00	300,000.00				
		Subtotal				300,000.00		0.00		0.00
	97 - TRAFFIC CONTROL Alt Group: 1 Alt: 2 TRAFFIC ITEMS (OPTION)									
120	703.01000	CATEGORY I TCD UNITS	30,000.00	EA	5.00	150,000.00	0.95	28,500.00	0.86	25,800.00
121	703.01002	CATEGORY II TCD UNITS	6,000.00	EA	5.00	30,000.00	0.60	3,600.00	0.54	3,240.00
122	703.01003	CATEGORY III TCD UNITS	5,000.00	EA	5.00	25,000.00	0.95	4,750.00	0.86	4,300.00
123	703.01004	CATEGORY IV TCD UNITS	8,500.00	EA	5.00	42,500.00	1.45	12,325.00	1.35	11,475.00
124	703.01005	CATEGORY V TCD UNITS	10,000.00	EA	5.25	52,500.00	1.75	17,500.00	1.62	16,200.00
		Subtotal				300,000.00		66,675.00		61,015.00
				Total:		**8,679,598.25**		**8,211,281.70 AWARDED**		**8,392,191.88**

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N361055
Project Name: Ten Sleep - Buffalo (County Line West)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Knife River (Montana) Unit Price	Bidder: Knife River (Montana) Amount	Unit Price	Amount
	5 - ROADWAY									
1	105.09010	CONTRACTOR SURVEYING	1.00	LS	16,000.00	16,000.00	22,200.00	22,200.00		
2	106.05100	FIELD LABORATORY	1.00	EA	10,500.00	10,500.00	9,220.00	9,220.00		
3	106.05200	CONTRACTOR TESTING	1.00	LS	17,000.00	17,000.00	13,000.00	13,000.00		
4	108.03000	CPM SCHEDULE	1.00	LS	12,000.00	12,000.00	2,880.00	2,880.00		
5	109.04000	FORCE ACCOUNT WORK	25,000.00	$$	1.00	25,000.00	1.00	25,000.00		
6	109.08000	MOBILIZATION	1.00	LS	725,000.00	725,000.00	1,680,600.00	1,680,600.00		
7	201.03201	CLEARING AND GRUBBING	51.00	ACRE	5,000.00	255,000.00	5,400.00	275,400.00		
8	202.03120	REMOVAL OF SIGNS	1.00	LS	250.00	250.00	2,120.00	2,120.00		
9	202.03165	REMOVAL OF GUARDRAIL AND BARRIER	1,488.00	FT	1.50	2,232.00	9.00	13,392.00		
10	202.03205	REMOVAL OF FENCE	3,980.00	FT	0.75	2,985.00	0.50	1,990.00		
11	202.03250	REMOVAL OF RC BOX CULVERTS(Est. Lump Qty: 2 EA)	1.00	LS	8,000.00	8,000.00	14,400.00	14,400.00		
12	202.03270	REMOVAL OF PIPE	22.00	EA	1,500.00	33,000.00	970.00	21,340.00		
13	202.03305	MILLING PLANT MIX	32,500.00	SY	2.50	81,250.00	1.80	58,500.00		
14	202.03600	CUTTING BIT PVMT	65.00	FT	6.00	390.00	9.00	585.00		
15	203.02500	UNCLASSIFIED EXCAVATION	317,000.00	CY	5.15	1,632,550.00	17.00	5,389,000.00		
16	206.03300	CULVERT SUBEXCAVATION	160.00	CY	14.00	2,240.00	16.00	2,560.00		
17	207.03100	TOPSOIL STORING	22,000.00	CY	2.50	55,000.00	3.60	79,200.00		
18	207.03200	TOPSOIL PLACING	22,800.00	CY	3.00	68,400.00	4.80	109,440.00		
19	207.03300	TOPSOIL BORROW	13,212.00	CY	10.00	132,120.00	4.60	60,775.20		
20	209.01000	WATER	10,700.00	MG	12.00	128,400.00	16.00	171,200.00		
21	210.03200	BULLDOZER	200.00	HR	165.00	33,000.00	270.00	54,000.00		
22	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	160.00	16,000.00		
23	210.03610	EXCAVATOR	200.00	HR	145.00	29,000.00	160.00	32,000.00		
24	215.01010	DEPARTMENT STORM WATER CONTROL	10,000.00	$$	1.00	10,000.00	1.00	10,000.00		
25	215.03200	BURLAP BAG CURB	2,200.00	FT	11.00	24,200.00	4.70	10,340.00		
26	215.03300	SILT FENCE	5,800.00	FT	5.00	29,000.00	2.40	13,920.00		
27	215.03402	EXCELSIOR SEDIMENT LOG	1,220.00	FT	7.00	8,540.00	3.80	4,636.00		
28	216.03100	SEEDING (PLS)	930.00	LB	20.00	18,600.00	26.00	24,180.00		
29	216.03130	FERTILIZER TYPE II	350.00	LB	6.00	2,100.00	7.00	2,450.00		
30	216.03180	FERTILIZER SPECIAL	30,900.00	LB	0.95	29,355.00	1.10	33,990.00		
31	216.03600	HYDRAULIC MULCHING	41.00	TON	1,600.00	65,600.00	2,530.00	103,730.00		
32	216.03900	DRY MULCH	27.00	TON	185.00	4,995.00	210.00	5,670.00		
33	216.03910	EROSION CONTROL BLANKET	49,800.00	SY	1.65	82,170.00	1.90	94,620.00		
34	216.03955	COCONUT FIBER DITCH LINING	15,000.00	SY	1.85	27,750.00	1.70	25,500.00		
35	216.03973	WETLAND CONSTRUCTION	1.00	LS	70,000.00	70,000.00	12,700.00	12,700.00		
36	217.01010	GEOTEXTILE, EROSION CONTROL	327.00	SY	3.00	981.00	3.00	981.00		
37	219.01000	ROCKFALL MESH	54,500.00	SY	14.00	763,000.00	11.00	599,500.00		

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N361055
Project Name: Ten Sleep - Buffalo (County Line West)

					Engineer's Estimate		Bidder: Knife River (Montana)			
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
38	219.02500	DRIVEN ANCHORS	320.00	EA	140.00	44,800.00	100.00	32,000.00		
39	220.01010	SCALING (MANUAL)	40.00	CRWH	240.00	9,600.00	210.00	8,400.00		
40	221.01000	DUST CONTROL AGENT	180.00	TON	170.00	30,600.00	110.00	19,800.00		
41	299.02100	CONTROLLED BLASTING	20,000.00	FT	20.00	400,000.00	30.00	600,000.00		
42	301.01030	CRUSHER RUN SUBBASE	17,290.00	CY	19.00	328,510.00	27.00	466,830.00		
43	301.01085	CRUSHED BASE	10,300.00	CY	22.50	231,750.00	22.00	226,600.00		
44	401.02000	HOT PLANT MIX	11,100.00	TON	29.50	327,450.00	49.00	543,900.00		
45	401.02040	TEST STRIP	1.00	EA	8,000.00	8,000.00	11,100.00	11,100.00		
46	401.02055	HOT PLANT MIX APPROACHES	126.00	TON	70.00	8,820.00	130.00	16,380.00		
47	401.03322	ASPHALT BINDER (PG 64-28)	610.00	TON	686.00	418,460.00	670.00	408,700.00		
48	407.01000	TACK COAT	7.00	TON	600.00	4,200.00	530.00	3,710.00		
49	409.02100	FOG SEAL	6.00	TON	600.00	3,600.00	530.00	3,180.00		
50	409.03070	CHIP SEAL	32,500.00	SY	0.90	29,250.00	1.20	39,000.00		
51	409.03085	EMULSIFIED ASPHALT MODIFIED	54.00	TON	620.00	33,480.00	570.00	30,780.00		
52	412.01000	CURB (PLANT MIX)	900.00	FT	18.00	16,200.00	17.00	15,300.00		
53	413.01000	HYDRATED LIME	106.00	TON	170.00	18,020.00	100.00	10,600.00		
54	499.03040	REUSED SURFACING	4,600.00	CY	7.50	34,500.00	6.00	27,600.00		
55	506.01030	DRILLED SHAFT FOUNDATIONS 30 in	24.00	FT	200.00	4,800.00	70.00	1,680.00		
56	511.06000	MACHINE-PLACED RIPRAP	113.00	CY	95.00	10,735.00	36.00	4,068.00		
57	599.00002	PRECAST WALL COMPONENT SYSTEM	33,926.00	SF	21.00	712,446.00	21.00	712,446.00		
58	603.01018	PIPE 18 in	202.00	FT	36.00	7,272.00	37.00	7,474.00		
59	603.01024	PIPE 24 in	1,804.00	FT	53.00	95,612.00	52.00	93,808.00		
60	603.01030	PIPE 30 in	82.00	FT	68.00	5,576.00	72.00	5,904.00		
61	603.01036	PIPE 36 in	126.00	FT	72.00	9,072.00	81.00	10,206.00		
62	603.01048	PIPE 48 in	400.00	FT	96.00	38,400.00	59.00	23,600.00		
63	603.03018	PIPE FE SECT 18 in	4.00	EA	200.00	800.00	300.00	1,200.00		
64	603.03024	PIPE FE SECT 24 in	25.00	EA	260.00	6,500.00	300.00	7,500.00		
65	603.03030	PIPE FE SECT 30 in	2.00	EA	380.00	760.00	410.00	820.00		
66	603.03036	PIPE FE SECT 36 in	2.00	EA	550.00	1,100.00	730.00	1,460.00		
67	603.03048	PIPE FE SECT 48 in	6.00	EA	1,200.00	7,200.00	1,040.00	6,240.00		
68	605.09000	GRAVEL FOR DRAINS	196.00	CY	40.00	7,840.00	59.00	11,564.00		
69	605.10004	UNDERDRAIN PIPE (PERF) 4 in	2,626.00	FT	7.00	18,382.00	1.10	2,888.60		
70	605.20004	UNDERDRAIN PIPE (NON-PERF) 4 in	463.00	FT	8.50	3,935.50	1.10	509.30		
71	606.02000	CORR BEAM GUARDRAIL (SELF-OXIDIZING)	3,125.00	FT	17.50	54,687.50	19.00	59,375.00		
72	606.03000	CORR BEAM GUARDRAIL END ANCH TYPE A (SELF-OXIDIZING)	6.00	EA	2,400.00	14,400.00	2,150.00	12,900.00		
73	607.10910	FENCE TYPE X	6,600.00	FT	7.00	46,200.00	11.00	72,600.00		
74	607.20500	FENCE TYPE E (WOOD POSTS)	6,890.00	FT	2.00	13,780.00	2.40	16,536.00		
75	607.50900	FENCE-WING (WOOD POSTS)	410.00	FT	3.75	1,537.50	5.00	2,050.00		

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N361055
Project Name: Ten Sleep - Buffalo (County Line West)

					Engineer's Estimate		Bidder: Knife River (Montana)			
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
76	607.51100	FENCE TEMPORARY	1,930.00	FT	2.10	4,053.00	2.20	4,246.00		
77	607.80100	BRACE PANELS	13.00	EA	135.00	1,755.00	120.00	1,560.00		
78	607.90100	END PANELS	34.00	EA	175.00	5,950.00	150.00	5,100.00		
79	610.10100	METAL DRAIN INLET	2.00	EA	800.00	1,600.00	770.00	1,540.00		
80	610.10200	METAL DRAIN PIPE	110.00	FT	30.00	3,300.00	790.00	86,900.00		
81	625.30100	INLET TYPE M1	7.00	EA	3,500.00	24,500.00	3,500.00	24,500.00		
82	702.09400	STL BREAK-AWAY SIGN SUPPORT W6 X 15	52.00	FT	125.00	6,500.00	180.00	9,360.00		
83	702.30100	SIGN POSTS, WOOD 4 X 4 in	50.00	FT	10.00	500.00	12.00	600.00		
84	702.30105	SIGN POSTS, WOOD 4 X 6 in	180.00	FT	11.00	1,980.00	14.00	2,520.00		
85	702.30110	SIGN POSTS, WOOD 6 X 6 in	240.00	FT	13.00	3,120.00	14.00	3,360.00		
86	702.30115	SIGN POSTS, WOOD 6 X 8 in	50.00	FT	15.00	750.00	17.00	850.00		
87	702.30400	SIGN PANELS, PLYWOOD	60.00	SF	32.00	1,920.00	32.00	1,920.00		
88	702.30500	SIGN PANELS, ALUMINUM	260.00	SF	32.00	8,320.00	32.00	8,320.00		
89	702.30600	RESET SIGNS(Est. Lump Qty: 1 EA)	1.00	LS	300.00	300.00	1,080.00	1,080.00		
90	702.50655	DELINEATORS, TYPE VIII	250.00	EA	68.00	17,000.00	65.00	16,250.00		
91	703.03100	FLAGGING	4,000.00	HR	34.00	136,000.00	38.00	152,000.00		
92	703.03205	PORTABLE VARIABLE MESSAGE SIGN(Est.	1.00	LS	25,000.00	25,000.00	13,000.00	13,000.00		
		Lump Qty: 2)								
93	703.03410	TEMPORARY CONCRETE BARRIER	3,000.00	FT	22.00	66,000.00	15.00	45,000.00		
		Subtotal				7,735,931.50		12,893,834.10		
	15 - STRUCTURES									
94	202.03250	REMOVAL OF RC BOX CULVERTS(Est. Lump	1.00	LS	10,000.00	10,000.00	24,600.00	24,600.00		
		Qty: 1 EA)								
95	206.03300	CULVERT SUBEXCAVATION	370.00	CY	13.75	5,087.50	17.00	6,290.00		
96	301.01030	CRUSHER RUN SUBBASE	370.00	CY	20.00	7,400.00	32.00	11,840.00		
97	502.11010	PRECAST BOX CULVERTS 10 X 10 ft	378.00	FT	1,280.00	483,840.00	1,220.00	461,160.00		
98	699.01061	COLORING AND TEXTURING CONCRETE	2,150.00	SF	2.75	5,912.50	4.80	10,320.00		
		SURFACES								
99	900.60000	CONTRACTOR QUALITY CONTROL	1.00	LS	7,800.00	7,800.00	6,940.00	6,940.00		
		(CONCRETE)								
		Subtotal				520,040.00		521,150.00		
	35 - 513.00015 - CLASS B CONCRETE									
100	513.00020	CLASS B CONCRETE	97.30	CY	560.00	54,488.00	1,170.00	113,841.00		
		Subtotal				54,488.00		113,841.00		
	45 - 514.00015 - REINFORCING STEEL									
101	514.00020	REINFORCING STEEL	8,210.00	LB	1.25	10,262.50	1.30	10,673.00		
		Subtotal				10,262.50		10,673.00		
	94 - 701.81700 - ROAD WEATHER INFORMATION SYSTEM									
102	701.17110	CONDUIT-RIGID PVC 1 in	50.00	FT	6.00	300.00	11.00	550.00		

Wyoming Department of Transportation
Abstract of Bids

Project No: NH-N361055
Project Name: Ten Sleep - Buffalo (County Line West)

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Knife River (Montana) Unit Price	Bidder: Knife River (Montana) Amount	Unit Price	Amount
103	701.17120	CONDUIT-RIGID PVC 2 in	175.00	FT	6.50	1,137.50	12.00	2,100.00		
104	701.17130	CONDUIT-RIGID PVC 3 in	60.00	FT	7.25	435.00	20.00	1,200.00		
105	701.20100	PULL BOX TYPE A	1.00	EA	430.00	430.00	490.00	490.00		
106	701.20200	PULL BOX TYPE B	1.00	EA	480.00	480.00	670.00	670.00		
107	701.21300	SERVICE POINT SIGNAL	1.00	EA	3,200.00	3,200.00	4,050.00	4,050.00		
108	701.29080	SINGLE CONDUCTOR WIRE #10 AWG	350.00	FT	1.50	525.00	0.80	280.00		
109	701.3600A	TELEPHONE CABLE	125.00	FT	1.65	206.25	2.00	250.00		
110	701.3700A	COMMUNICATIONS CABLE	50.00	FT	1.25	62.50	3.80	190.00		
111	701.3700K	VIDEO CABLE	50.00	FT	15.00	750.00	10.00	500.00		
112	701.5980G	COMMUNICATION TOWER 40'	1.00	EA	10,500.00	10,500.00	26,200.00	26,200.00		
113	701.8110A	ITS CABINET	1.00	EA	12,500.00	12,500.00	14,400.00	14,400.00		
114	701.8123A	REMOTE VIDEO CAMERA - PTZ	1.00	EA	4,750.00	4,750.00	7,430.00	7,430.00		
115	701.8126A	VIDEO SERVER / IP ENCODER	1.00	EA	1,000.00	1,000.00	1,730.00	1,730.00		
116	701.8170A	ROAD WEATHER INFORMATION SYSTEM	1.00	EA	17,500.00	17,500.00	31,100.00	31,100.00		
		(RWIS)								
117	701.8176A	PAVEMENT SURFACE SENSOR	1.00	EA	4,000.00	4,000.00	9,130.00	9,130.00		
118	701.8177A	SUBSURFACE SENSOR	1.00	EA	1,100.00	1,100.00	4,160.00	4,160.00		
		Subtotal				58,876.25		104,430.00		
	(OPTION)									
119	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	300,000.00	300,000.00				
		Subtotal				300,000.00		0.00		
	97 - TRAFFIC CONTROL Alt Group: 1 Alt: 2 TRAFFIC ITEMS (OPTION)									
120	703.01000	CATEGORY I TCD UNITS	30,000.00	EA	5.00	150,000.00	0.90	27,000.00		
121	703.01002	CATEGORY II TCD UNITS	6,000.00	EA	5.00	30,000.00	0.50	3,000.00		
122	703.01003	CATEGORY III TCD UNITS	5,000.00	EA	5.00	25,000.00	0.90	4,500.00		
123	703.01004	CATEGORY IV TCD UNITS	8,500.00	EA	5.00	42,500.00	1.40	11,900.00		
124	703.01005	CATEGORY V TCD UNITS	10,000.00	EA	5.25	52,500.00	1.60	16,000.00		
		Subtotal				300,000.00		62,400.00		
				Total:		**8,679,598.25**		**13,706,328.10**		

Contract Bids for SCP-SL12-P433035 (WY 59) – Vertical Joint Project

Wyoming Department of Transportation
Abstract of Bids

Project Number: SCP-SL12-P433035 **Bid Opening:** 11/10/2011

Project Name: GILLETTE - MONTANA STATE LINE **Estimated Completion:** 10/31/2012

County: Campbell

Detail Description: Recontstruction including grading, draining, placing bituminous pavement leveling and surfacing, structures, fencing and miscellaneous work on 6.55 miles of WYO59 beginning at reference marker 142.05 north of Gillette.

Company	Bid	% of Low Bid
Engineer's Estimate:	$9,088,750.25	
Intermountain Construction & Materials Gillette, WY	$8,609,561.40	100.00 %
Oftedal Construction, Inc. Miles City, MT	$8,781,206.40	101.99 %
McGarvin-Moberly Construction Co. Worland, WY	$9,221,122.07	107.10 %
McMurry Ready-Mix Co. Casper, WY	$9,256,382.13	107.51 %
Simon Contractors and Subsidiaries Cheyenne, WY	$9,463,781.37	109.92 %

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

					Engineer's Estimate		Bidder: Intermountain Construction & Materials		Bidder: Oftedal Construction, Inc.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	5 - ROADWAY									
1	105.09010	CONTRACTOR SURVEYING	1.00	LS	52,000.00	52,000.00	39,089.62	39,089.62	10,000.00	10,000.00
2	106.05100	FIELD LABORATORY	1.00	EA	8,500.00	8,500.00	17,734.31	17,734.31	20,000.00	20,000.00
3	106.05200	CONTRACTOR TESTING	1.00	LS	50,000.00	50,000.00	53,926.42	53,926.42	34,600.00	34,600.00
4	109.04000	FORCE ACCOUNT WORK	5,000.00	$$	1.00	5,000.00	1.00	5,000.00	1.00	5,000.00
5	109.08000	MOBILIZATION	1.00	LS	775,000.00	775,000.00	486,994.58	486,994.58	850,000.00	850,000.00
6	201.03206	CLEARING TREES 6 in	4.00	EA	150.00	600.00	87.55	350.20	289.00	1,156.00
7	201.03218	CLEARING TREES 18 in	8.00	EA	200.00	1,600.00	206.01	1,648.08	342.00	2,736.00
8	201.03230	CLEARING TREES 30 in	2.00	EA	350.00	700.00	309.01	618.02	395.00	790.00
9	201.03248	CLEARING TREES 48 in	5.00	EA	550.00	2,750.00	618.02	3,090.10	473.00	2,365.00
10	202.03100	REMOVAL OF STRUCTURES AND OBSTRUCTIONS(Est. Lump Qty: 1 EA)	1.00	LS	250.00	250.00	77.25	77.25	10,000.00	10,000.00
11	202.03140	REMOVAL OF CATTLE GUARDS	6.00	EA	900.00	5,400.00	618.02	3,708.12	1,230.00	7,380.00
12	202.03205	REMOVAL OF FENCE	69,130.00	FT	0.25	17,282.50	0.31	21,430.30	0.32	22,121.60
13	202.03250	REMOVAL OF RC BOX CULVERTS(Est. Lump Qty: 5 EA)	1.00	LS	60,000.00	60,000.00	40,500.77	40,500.77	84,500.00	84,500.00
14	202.03270	REMOVAL OF PIPE	8.00	EA	900.00	7,200.00	614.93	4,919.44	2,500.00	20,000.00
15	202.03280	REMOVAL OF PIPE FE SECTION	74.00	EA	150.00	11,100.00	83.43	6,173.82	280.00	20,720.00
16	202.03305	MILLING PLANT MIX	1,700.00	SY	2.00	3,400.00	2.13	3,621.00	2.10	3,570.00
17	202.03320	PROFILE MILLING PLANT MIX	96,100.00	SY	0.65	62,465.00	1.91	183,551.00	0.60	57,660.00
18	202.03500	RESET MAILBOX (SINGLE)	1.00	EA	250.00	250.00	221.46	221.46	615.00	615.00
19	202.03520	RESET MAILBOX (MULTIPLE)	1.00	EA	500.00	500.00	375.96	375.96	769.00	769.00
20	202.03600	CUTTING BIT PVMT	67,470.00	FT	0.75	50,602.50	0.62	41,831.40	0.35	23,614.50
21	203.02500	UNCLASSIFIED EXCAVATION	172,000.00	CY	3.15	541,800.00	2.06	354,320.00	2.50	430,000.00
22	206.03100	FLOWABLE BACKFILL	230.00	CY	150.00	34,500.00	155.53	35,771.90	113.00	25,990.00
23	206.03300	CULVERT SUBEXCAVATION	550.00	CY	12.50	6,875.00	10.30	5,665.00	19.00	10,450.00
24	207.03100	TOPSOIL STORING	57,100.00	CY	1.40	79,940.00	1.34	76,514.00	1.40	79,940.00
25	207.03200	TOPSOIL PLACING	57,100.00	CY	1.65	94,215.00	1.65	94,215.00	1.50	85,650.00
26	209.01000	WATER	11,500.00	MG	15.00	172,500.00	4.02	46,230.00	5.60	64,400.00
27	210.03200	BULLDOZER	300.00	HR	180.00	54,000.00	154.50	46,350.00	190.00	57,000.00
28	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	118.45	11,845.00	121.00	12,100.00
29	211.03315	CULVERT CLEANING	37.00	EA	1,050.00	38,850.00	1,931.31	71,458.47	1,540.00	56,980.00
30	212.02100	DRY EXCAVATION	510.00	CY	12.00	6,120.00	7.42	3,784.20	7.60	3,876.00
31	212.03900	PERVIOUS BACKFILL MATERIAL	90.00	CY	54.00	4,860.00	131.64	11,847.60	134.00	12,060.00
32	213.03100	OVERBURDEN REMOVAL	500.00	CY	1.40	700.00	0.01	5.00	3.20	1,600.00
33	213.03110	OVERBURDEN PLACING	500.00	CY	1.70	850.00	0.01	5.00	4.20	2,100.00
34	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	15,000.00	15,000.00	39,047.59	39,047.59	35,000.00	35,000.00
35	215.01010	DEPARTMENT STORM WATER CONTROL	1,000.00	$$	1.00	1,000.00	1.00	1,000.00	1.00	1,000.00
36	216.03100	SEEDING (PLS)	1,100.00	LB	15.00	16,500.00	12.82	14,102.00	13.00	14,300.00

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Intermountain Construction & Materials Unit Price	Bidder: Intermountain Construction & Materials Amount	Bidder: Oftedal Construction, Inc. Unit Price	Bidder: Oftedal Construction, Inc. Amount
37	216.03120	FERTILIZER TYPE I	2,930.00	LB	2.20	6,446.00	2.77	8,116.10	2.80	8,204.00
38	216.03900	DRY MULCH	110.00	TON	165.00	18,150.00	221.46	24,360.60	226.00	24,860.00
39	216.03910	EROSION CONTROL BLANKET	1,735.00	SY	2.00	3,470.00	2.33	4,042.55	2.40	4,164.00
40	217.01025	GEOTEXTILE, MATERIAL SEPARATION	787.00	SY	2.20	1,731.40	1.91	1,503.17	1.80	1,416.60
		(NON-WOVEN)								
41	217.01043	GEOTEXTILE, SUBGRADE REINFORCEMENT	110,736.00	SY	1.60	177,177.60	2.06	228,116.16	2.20	243,619.20
42	221.01000	DUST CONTROL AGENT	25.00	TON	160.00	4,000.00	171.29	4,282.25	176.00	4,400.00
43	301.01030	CRUSHER RUN SUBBASE	59,100.00	CY	19.00	1,122,900.00	14.03	829,173.00	12.00	709,200.00
44	302.00020	BLENDED BASE	10,610.00	CY	30.00	318,300.00	41.20	437,132.00	40.00	424,400.00
45	401.02000	HOT PLANT MIX	23,375.00	TON	41.00	958,375.00	49.72	1,162,205.00	56.00	1,309,000.00
46	401.02030	HOT PLANT MIX LEVELING	13,170.00	TON	42.00	553,140.00	45.90	604,503.00	41.50	546,555.00
47	401.02040	TEST STRIP	1.00	EA	8,000.00	8,000.00	10,432.33	10,432.33	10,500.00	10,500.00
48	401.02055	HOT PLANT MIX APPROACHES	280.00	TON	80.00	22,400.00	159.31	44,606.80	76.50	21,420.00
49	401.03321	ASPHALT BINDER (PG 58-28)	944.00	TON	610.00	575,840.00	662.74	625,626.56	554.00	522,976.00
50	401.03322	ASPHALT BINDER (PG 64-28)	1,041.00	TON	710.00	739,110.00	779.49	811,449.09	655.00	681,855.00
51	407.01000	TACK COAT	46.00	TON	620.00	28,520.00	582.59	26,799.14	521.00	23,966.00
52	408.01000	PRIME COAT	129.00	TON	770.00	99,330.00	887.34	114,466.86	842.00	108,618.00
53	413.01000	HYDRATED LIME	350.00	TON	135.00	47,250.00	137.52	48,132.00	101.00	35,350.00
54	502.01909	PRECAST BOX CULVERTS 9 X 9 ft	378.00	FT	925.00	349,650.00	818.87	309,532.86	883.00	333,774.00
55	511.06000	MACHINE-PLACED RIPRAP	50.00	CY	100.00	5,000.00	80.34	4,017.00	83.50	4,175.00
56	511.08000	GROUTED RIPRAP	150.00	CY	350.00	52,500.00	174.90	26,235.00	179.00	26,850.00
57	603.50018	CMP 18 in	1,110.00	FT	43.00	47,730.00	29.87	33,155.70	45.00	49,950.00
58	603.50024	CMP 24 in	164.00	FT	47.00	7,708.00	57.68	9,459.52	54.50	8,938.00
59	603.50030	CMP 30 in	266.00	FT	55.00	14,630.00	47.38	12,603.08	67.50	17,955.00
60	603.50036	CMP 36 in	472.00	FT	70.00	33,040.00	61.80	29,169.60	80.50	37,996.00
61	603.50042	CMP 42 in	70.00	FT	76.00	5,320.00	72.10	5,047.00	94.00	6,580.00
62	603.50048	CMP 48 in	186.00	FT	85.00	15,810.00	75.19	13,985.34	111.00	20,646.00
63	603.50108	CMP 108 in	420.00	FT	380.00	159,600.00	267.81	112,480.20	260.00	109,200.00
64	603.52018	CMP FE SECT 18 in	37.00	EA	180.00	6,660.00	159.65	5,907.05	170.00	6,290.00
65	603.52024	CMP FE SECT 24 in	5.00	EA	220.00	1,100.00	258.54	1,292.70	231.00	1,155.00
66	603.52030	CMP FE SECT 30 in	6.00	EA	480.00	2,880.00	446.00	2,676.00	378.00	2,268.00
67	603.52036	CMP FE SECT 36 in	18.00	EA	500.00	9,000.00	681.88	12,273.84	611.00	10,998.00
68	603.52042	CMP FE SECT 42 in	2.00	EA	900.00	1,800.00	1,365.82	2,731.64	1,240.00	2,480.00
69	603.55018	SME SECT 18 in W/ GRATE	12.00	EA	800.00	9,600.00	331.67	3,980.04	555.00	6,660.00
70	603.71010	PIPE COLLARS	35.00	CY	600.00	21,000.00	520.16	18,205.60	500.00	17,500.00
71	607.20500	FENCE TYPE E (WOOD POSTS)	31,660.00	FT	1.85	58,571.00	1.39	44,007.40	1.40	44,324.00
72	607.20700	FENCE TYPE G (WOOD POSTS)	23,100.00	FT	1.80	41,580.00	1.49	34,419.00	1.50	34,650.00
73	607.20800	FENCE TYPE H (WOOD POSTS)	14,375.00	FT	1.75	25,156.25	1.55	22,281.25	1.60	23,000.00
74	607.50900	FENCE-WING (WOOD POSTS)	1,810.00	FT	2.20	3,982.00	1.75	3,167.50	1.80	3,258.00

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Intermountain Construction & Materials Unit Price	Bidder: Intermountain Construction & Materials Amount	Bidder: Oftedal Construction, Inc. Unit Price	Bidder: Oftedal Construction, Inc. Amount
75	607.51100	FENCE TEMPORARY	12,660.00	FT	1.25	15,825.00	1.29	16,331.40	1.30	16,458.00
76	607.71300	GATES RAIL 16 FT	8.00	EA	185.00	1,480.00	319.31	2,554.48	326.00	2,608.00
77	607.80100	BRACE PANELS	109.00	EA	115.00	12,535.00	113.30	12,349.70	116.00	12,644.00
78	607.90100	END PANELS	140.00	EA	150.00	21,000.00	123.60	17,304.00	126.00	17,640.00
79	614.01000	EROSION CONTROL CONCRETE	25.00	CY	450.00	11,250.00	375.75	9,393.75	384.00	9,600.00
80	615.02018	CATTLE GUARD (MEDIUM DUTY) 18 FT	5.00	EA	8,000.00	40,000.00	9,213.62	46,068.10	8,710.00	43,550.00
81	615.02024	CATTLE GUARD (MEDIUM DUTY) 24 FT	2.00	EA	9,000.00	18,000.00	12,154.35	24,308.70	11,800.00	23,600.00
82	617.01010	HEADWALL (CONC)	60.00	CY	600.00	36,000.00	441.63	26,497.80	594.00	35,640.00
83	618.10707	RC STOCK PASS 91 X 91 in	86.00	FT	650.00	55,900.00	818.87	70,422.82	908.00	78,088.00
84	618.20707	RC STOCK PASS FE SECT 91 X 91 in	2.00	EA	6,200.00	12,400.00	8,099.13	16,198.26	6,440.00	12,880.00
85	640.00001	SPECIAL ITEM LS-A(Est. Lump Qty: 10000 CY)	1.00	LS	150,000.00	150,000.00	0.01	0.01	29,500.00	29,500.00
86	702.30105	SIGN POSTS, WOOD 4 X 6 in	100.00	FT	10.00	1,000.00	12.36	1,236.00	12.50	1,250.00
87	702.30110	SIGN POSTS, WOOD 6 X 6 in	20.00	FT	12.00	240.00	14.42	288.40	14.50	290.00
88	702.30500	SIGN PANELS, ALUMINUM	52.00	SF	32.00	1,664.00	30.90	1,606.80	31.50	1,638.00
89	702.50200	DELINEATORS, TYPE II	30.00	EA	32.00	960.00	30.90	927.00	31.50	945.00
90	702.50300	DELINEATORS, TYPE III	235.00	EA	32.00	7,520.00	30.90	7,261.50	31.50	7,402.50
91	703.03100	FLAGGING	6,000.00	HR	33.00	198,000.00	0.01	60.00	0.01	60.00
92	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	160,000.00	160,000.00	384,201.05	384,201.05	390,000.00	390,000.00
93	900.60000	CONTRACTOR QUALITY CONTROL (CONCRETE)	1.00	LS	5,000.00	5,000.00	8,240.24	8,240.24	10,000.00	10,000.00
		Subtotal				8,501,041.25		8,063,846.55		8,212,987.40
	15 - STRUCTURES									
94	206.03300	CULVERT SUBEXCAVATION	100.00	CY	20.00	2,000.00	21.46	2,146.00	22.00	2,200.00
95	212.03900	PERVIOUS BACKFILL MATERIAL	20.00	CY	60.00	1,200.00	131.64	2,632.80	134.00	2,680.00
96	217.01025	GEOTEXTILE, MATERIAL SEPARATION (NON-WOVEN)	143.00	SY	3.00	429.00	4.50	643.50	4.60	657.80
97	301.01030	CRUSHER RUN SUBBASE	100.00	CY	30.00	3,000.00	45.93	4,593.00	22.00	2,200.00
98	900.60000	CONTRACTOR QUALITY CONTROL (CONCRETE)	1.00	LS	28,000.00	28,000.00	10,300.30	10,300.30	10,500.00	10,500.00
		Subtotal				34,629.00		20,315.60		18,237.80
	35 - 513.00015 - CLASS B CONCRETE									
99	513.00020	CLASS B CONCRETE CODE 04 (STR) - MJI	75.40	CY	570.00	42,978.00	509.06	38,383.12	536.00	40,414.40
100	513.00020	CLASS B CONCRETE CODE 04 (STR) - MKY	75.40	CY	570.00	42,978.00	509.34	38,404.24	537.00	40,489.80
101	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLA	75.40	CY	570.00	42,978.00	509.73	38,433.64	537.00	40,489.80
102	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLB	75.40	CY	570.00	42,978.00	506.59	38,196.89	534.00	40,263.60
103	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLX	128.50	CY	550.00	70,675.00	546.53	70,229.11	568.00	72,988.00
104	513.00020	CLASS B CONCRETE CODE 14 (STR) - CHE	142.90	CY	550.00	78,595.00	541.73	77,413.22	584.00	83,453.60
105	513.00020	CLASS B CONCRETE CODE 14 (STR) - CHF	236.40	CY	540.00	127,656.00	509.46	120,436.34	545.00	128,838.00
		Subtotal				448,838.00		421,496.56		446,937.20

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

					Engineer's Estimate		Bidder: Intermountain Construction & Materials		Bidder: Oftedal Construction, Inc.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	45 - 514.00015 - REINFORCING STEEL									
106	514.00020	REINFORCING STEEL CODE 04 (STR) - MJI	5,990.00	LB	1.25	7,487.50	1.21	7,247.90	1.20	7,188.00
107	514.00020	REINFORCING STEEL CODE 04 (STR) - MKY	5,990.00	LB	1.25	7,487.50	1.21	7,247.90	1.20	7,188.00
108	514.00020	REINFORCING STEEL CODE 04 (STR) - MLA	5,990.00	LB	1.25	7,487.50	1.21	7,247.90	1.20	7,188.00
109	514.00020	REINFORCING STEEL CODE 04 (STR) - MLB	5,990.00	LB	1.25	7,487.50	1.21	7,247.90	1.20	7,188.00
110	514.00020	REINFORCING STEEL CODE 14 (STR) - CHE	15,080.00	LB	1.20	18,096.00	1.21	18,246.80	1.20	18,096.00
111	514.00020	REINFORCING STEEL CODE 14 (STR) - CHF	24,320.00	LB	1.20	29,184.00	1.21	29,427.20	1.20	29,184.00
112	514.00020	REINFORCING STEEL CODE O4 (STR) - MLX	22,510.00	LB	1.20	27,012.00	1.21	27,237.10	1.20	27,012.00
		Subtotal				104,242.00		103,902.70		103,044.00
				Total:		**9,088,750.25**		**8,609,561.41**		**8,781,206.40**
								AWARDED		

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: McGarvin-Moberly Construction Co. Unit Price	Bidder: McGarvin-Moberly Construction Co. Amount	Bidder: McMurry Ready-Mix Co. Unit Price	Bidder: McMurry Ready-Mix Co. Amount
		5 - ROADWAY								
1	105.09010	CONTRACTOR SURVEYING	1.00	LS	52,000.00	52,000.00	35,475.00	35,475.00	72,030.00	72,030.00
2	106.05100	FIELD LABORATORY	1.00	EA	8,500.00	8,500.00	8,250.00	8,250.00	7,947.00	7,947.00
3	106.05200	CONTRACTOR TESTING	1.00	LS	50,000.00	50,000.00	32,925.10	32,925.10	56,049.00	56,049.00
4	109.04000	FORCE ACCOUNT WORK	5,000.00	$$	1.00	5,000.00	1.00	5,000.00	1.00	5,000.00
5	109.08000	MOBILIZATION	1.00	LS	775,000.00	775,000.00	434,523.00	434,523.00	593,442.73	593,442.73
6	201.03206	CLEARING TREES 6 in	4.00	EA	150.00	600.00	91.38	365.52	359.00	1,436.00
7	201.03218	CLEARING TREES 18 in	8.00	EA	200.00	1,600.00	215.00	1,720.00	718.00	5,744.00
8	201.03230	CLEARING TREES 30 in	2.00	EA	350.00	700.00	322.50	645.00	1,439.00	2,878.00
9	201.03248	CLEARING TREES 48 in	5.00	EA	550.00	2,750.00	645.00	3,225.00	2,157.00	10,785.00
10	202.03100	REMOVAL OF STRUCTURES AND OBSTRUCTIONS(Est. Lump Qty: 1 EA)	1.00	LS	250.00	250.00	80.63	80.63	344.00	344.00
11	202.03140	REMOVAL OF CATTLE GUARDS	6.00	EA	900.00	5,400.00	645.00	3,870.00	1,733.00	10,398.00
12	202.03205	REMOVAL OF FENCE	69,130.00	FT	0.25	17,282.50	0.43	29,725.90	0.32	22,121.60
13	202.03250	REMOVAL OF RC BOX CULVERTS(Est. Lump Qty: 5 EA)	1.00	LS	60,000.00	60,000.00	42,269.00	42,269.00	120,932.00	120,932.00
14	202.03270	REMOVAL OF PIPE	8.00	EA	900.00	7,200.00	641.78	5,134.24	934.50	7,476.00
15	202.03280	REMOVAL OF PIPE FE SECTION	74.00	EA	150.00	11,100.00	87.08	6,443.92	104.00	7,696.00
16	202.03305	MILLING PLANT MIX	1,700.00	SY	2.00	3,400.00	1.00	1,700.00	1.45	2,465.00
17	202.03320	PROFILE MILLING PLANT MIX	96,100.00	SY	0.65	62,465.00	1.45	139,345.00	1.90	182,590.00
18	202.03500	RESET MAILBOX (SINGLE)	1.00	EA	250.00	250.00	231.13	231.13	275.50	275.50
19	202.03520	RESET MAILBOX (MULTIPLE)	1.00	EA	500.00	500.00	392.38	392.38	557.00	557.00
20	202.03600	CUTTING BIT PVMT	67,470.00	FT	0.75	50,602.50	0.65	43,855.50	0.52	35,084.40
21	203.02500	UNCLASSIFIED EXCAVATION	172,000.00	CY	3.15	541,800.00	2.31	397,320.00	3.80	653,600.00
22	206.03100	FLOWABLE BACKFILL	230.00	CY	150.00	34,500.00	162.33	37,335.90	99.75	22,942.50
23	206.03300	CULVERT SUBEXCAVATION	550.00	CY	12.50	6,875.00	10.75	5,912.50	14.50	7,975.00
24	207.03100	TOPSOIL STORING	57,100.00	CY	1.40	79,940.00	13.98	798,258.00	1.35	77,085.00
25	207.03200	TOPSOIL PLACING	57,100.00	CY	1.65	94,215.00	1.74	99,354.00	1.50	85,650.00
26	209.01000	WATER	11,500.00	MG	15.00	172,500.00	0.01	115.00	7.55	86,825.00
27	210.03200	BULLDOZER	300.00	HR	180.00	54,000.00	161.25	48,375.00	208.00	62,400.00
28	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	123.63	12,363.00	190.00	19,000.00
29	211.03315	CULVERT CLEANING	37.00	EA	1,050.00	38,850.00	1,075.00	39,775.00	1,335.00	49,395.00
30	212.02100	DRY EXCAVATION	510.00	CY	12.00	6,120.00	7.74	3,947.40	7.55	3,850.50
31	212.03900	PERVIOUS BACKFILL MATERIAL	90.00	CY	54.00	4,860.00	187.54	16,878.60	134.00	12,060.00
32	213.03100	OVERBURDEN REMOVAL	500.00	CY	1.40	700.00	0.01	5.00	0.001	0.50
33	213.03110	OVERBURDEN PLACING	500.00	CY	1.70	850.00	0.01	5.00	0.001	0.50
34	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	15,000.00	15,000.00	13,200.00	13,200.00	43,475.00	43,475.00
35	215.01010	DEPARTMENT STORM WATER CONTROL	1,000.00	$$	1.00	1,000.00	1.00	1,000.00	1.00	1,000.00
36	216.03100	SEEDING (PLS)	1,100.00	LB	15.00	16,500.00	12.36	13,596.00	12.00	13,200.00

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

					Engineer's Estimate		Bidder: McGarvin-Moberly Construction Co.		Bidder: McMurry Ready-Mix Co.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
37	216.03120	FERTILIZER TYPE I	2,930.00	LB	2.20	6,446.00	2.82	8,262.60	2.75	8,057.50
38	216.03900	DRY MULCH	110.00	TON	165.00	18,150.00	166.63	18,329.30	163.00	17,930.00
39	216.03910	EROSION CONTROL BLANKET	1,735.00	SY	2.00	3,470.00	1.96	3,400.60	1.90	3,296.50
40	217.01025	GEOTEXTILE, MATERIAL SEPARATION	787.00	SY	2.20	1,731.40	1.99	1,566.13	4.60	3,620.20
		(NON-WOVEN)								
41	217.01043	GEOTEXTILE, SUBGRADE REINFORCEMENT	110,736.00	SY	1.60	177,177.60	2.15	238,082.40	1.70	188,251.20
42	221.01000	DUST CONTROL AGENT	25.00	TON	160.00	4,000.00	196.92	4,923.00	156.00	3,900.00
43	301.01030	CRUSHER RUN SUBBASE	59,100.00	CY	19.00	1,122,900.00	17.24	1,018,884.00	16.50	975,150.00
44	302.00020	BLENDED BASE	10,610.00	CY	30.00	318,300.00	43.14	457,715.40	46.75	496,017.50
45	401.02000	HOT PLANT MIX	23,375.00	TON	41.00	958,375.00	56.06	1,310,402.50	56.25	1,314,843.75
46	401.02030	HOT PLANT MIX LEVELING	13,170.00	TON	42.00	553,140.00	39.80	524,166.00	44.75	589,357.50
47	401.02040	TEST STRIP	1.00	EA	8,000.00	8,000.00	10,000.10	10,000.10	8,633.00	8,633.00
48	401.02055	HOT PLANT MIX APPROACHES	280.00	TON	80.00	22,400.00	73.97	20,711.60	96.00	26,880.00
49	401.03321	ASPHALT BINDER (PG 58-28)	944.00	TON	610.00	575,840.00	524.70	495,316.80	542.00	511,648.00
50	401.03322	ASPHALT BINDER (PG 64-28)	1,041.00	TON	710.00	739,110.00	614.80	640,006.80	640.50	666,760.50
51	407.01000	TACK COAT	46.00	TON	620.00	28,520.00	495.02	22,770.92	509.50	23,437.00
52	408.01000	PRIME COAT	129.00	TON	770.00	99,330.00	894.00	115,326.00	914.00	117,906.00
53	413.01000	HYDRATED LIME	350.00	TON	135.00	47,250.00	96.30	33,705.00	99.00	34,650.00
54	502.01909	PRECAST BOX CULVERTS 9 X 9 ft	378.00	FT	925.00	349,650.00	854.63	323,050.14	778.00	294,084.00
55	511.06000	MACHINE-PLACED RIPRAP	50.00	CY	100.00	5,000.00	83.85	4,192.50	289.00	14,450.00
56	511.08000	GROUTED RIPRAP	150.00	CY	350.00	52,500.00	144.05	21,607.50	318.50	47,775.00
57	603.50018	CMP 18 in	1,110.00	FT	43.00	47,730.00	31.18	34,609.80	31.50	34,965.00
58	603.50024	CMP 24 in	164.00	FT	47.00	7,708.00	60.20	9,872.80	44.00	7,216.00
59	603.50030	CMP 30 in	266.00	FT	55.00	14,630.00	48.91	13,010.06	74.25	19,750.50
60	603.50036	CMP 36 in	472.00	FT	70.00	33,040.00	64.50	30,444.00	62.00	29,264.00
61	603.50042	CMP 42 in	70.00	FT	76.00	5,320.00	75.25	5,267.50	73.75	5,162.50
62	603.50048	CMP 48 in	186.00	FT	85.00	15,810.00	78.48	14,597.28	88.25	16,414.50
63	603.50108	CMP 108 in	420.00	FT	380.00	159,600.00	279.50	117,390.00	347.00	145,740.00
64	603.52018	CMP FE SECT 18 in	37.00	EA	180.00	6,660.00	166.63	6,165.31	315.00	11,655.00
65	603.52024	CMP FE SECT 24 in	5.00	EA	220.00	1,100.00	269.83	1,349.15	359.00	1,795.00
66	603.52030	CMP FE SECT 30 in	6.00	EA	480.00	2,880.00	465.48	2,792.88	585.00	3,510.00
67	603.52036	CMP FE SECT 36 in	18.00	EA	500.00	9,000.00	711.65	12,809.70	769.50	13,851.00
68	603.52042	CMP FE SECT 42 in	2.00	EA	900.00	1,800.00	1,425.45	2,850.90	1,274.00	2,548.00
69	603.55018	SME SECT 18 in W/ GRATE	12.00	EA	800.00	9,600.00	346.15	4,153.80	417.00	5,004.00
70	603.71010	PIPE COLLARS	35.00	CY	600.00	21,000.00	542.88	19,000.80	711.00	24,885.00
71	607.20500	FENCE TYPE E (WOOD POSTS)	31,660.00	FT	1.85	58,571.00	1.29	40,841.40	1.40	44,324.00
72	607.20700	FENCE TYPE G (WOOD POSTS)	23,100.00	FT	1.80	41,580.00	1.34	30,954.00	1.50	34,650.00
73	607.20800	FENCE TYPE H (WOOD POSTS)	14,375.00	FT	1.75	25,156.25	1.51	21,706.25	1.60	23,000.00
74	607.50900	FENCE-WING (WOOD POSTS)	1,810.00	FT	2.20	3,982.00	2.96	5,357.60	1.80	3,258.00

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

					Engineer's Estimate		Bidder: McGarvin-Moberly Construction Co.		Bidder: McMurry Ready-Mix Co.	
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
75	607.51100	FENCE TEMPORARY	12,660.00	FT	1.25	15,825.00	1.92	24,307.20	1.30	16,458.00
76	607.71300	GATES RAIL 16 FT	8.00	EA	185.00	1,480.00	345.08	2,760.64	325.50	2,604.00
77	607.80100	BRACE PANELS	109.00	EA	115.00	12,535.00	86.00	9,374.00	115.50	12,589.50
78	607.90100	END PANELS	140.00	EA	150.00	21,000.00	107.50	15,050.00	126.00	17,640.00
79	614.01000	EROSION CONTROL CONCRETE	25.00	CY	450.00	11,250.00	392.16	9,804.00	383.00	9,575.00
80	615.02018	CATTLE GUARD (MEDIUM DUTY) 18 FT	5.00	EA	8,000.00	40,000.00	9,615.88	48,079.40	7,350.00	36,750.00
81	615.02024	CATTLE GUARD (MEDIUM DUTY) 24 FT	2.00	EA	9,000.00	18,000.00	12,685.00	25,370.00	8,925.00	17,850.00
82	617.01010	HEADWALL (CONC)	60.00	CY	600.00	36,000.00	460.91	27,654.60	450.00	27,000.00
83	618.10707	RC STOCK PASS 91 X 91 in	86.00	FT	650.00	55,900.00	854.63	73,498.18	670.00	57,620.00
84	618.20707	RC STOCK PASS FE SECT 91 X 91 in	2.00	EA	6,200.00	12,400.00	8,452.73	16,905.46	5,366.00	10,732.00
85	640.00001	SPECIAL ITEM LS-A(Est. Lump Qty: 10000 CY)	1.00	LS	150,000.00	150,000.00	43,492.35	43,492.35	23,499.00	23,499.00
86	702.30105	SIGN POSTS, WOOD 4 X 6 in	100.00	FT	10.00	1,000.00	12.90	1,290.00	9.20	920.00
87	702.30110	SIGN POSTS, WOOD 6 X 6 in	20.00	FT	12.00	240.00	15.05	301.00	10.25	205.00
88	702.30500	SIGN PANELS, ALUMINUM	52.00	SF	32.00	1,664.00	32.25	1,677.00	57.75	3,003.00
89	702.50200	DELINEATORS, TYPE II	30.00	EA	32.00	960.00	32.25	967.50	26.25	787.50
90	702.50300	DELINEATORS, TYPE III	235.00	EA	32.00	7,520.00	32.25	7,578.75	26.25	6,168.75
91	703.03100	FLAGGING	6,000.00	HR	33.00	198,000.00	0.01	60.00	0.01	60.00
92	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	160,000.00	160,000.00	408,500.00	408,500.00	391,650.00	391,650.00
93	900.60000	CONTRACTOR QUALITY CONTROL (CONCRETE)	1.00	LS	5,000.00	5,000.00	8,600.00	8,600.00	8,400.00	8,400.00
		Subtotal				8,501,041.25		8,653,479.32		8,700,862.13
	15 - STRUCTURES									
94	206.03300	CULVERT SUBEXCAVATION	100.00	CY	20.00	2,000.00	22.39	2,239.00	21.75	2,175.00
95	212.03900	PERVIOUS BACKFILL MATERIAL	20.00	CY	60.00	1,200.00	207.87	4,157.40	134.00	2,680.00
96	217.01025	GEOTEXTILE, MATERIAL SEPARATION (NON-WOVEN)	143.00	SY	3.00	429.00	4.70	672.10	4.60	657.80
97	301.01030	CRUSHER RUN SUBBASE	100.00	CY	30.00	3,000.00	17.24	1,724.00	25.25	2,525.00
98	900.60000	CONTRACTOR QUALITY CONTROL (CONCRETE)	1.00	LS	28,000.00	28,000.00	10,750.00	10,750.00	10,500.00	10,500.00
		Subtotal				34,629.00		19,542.50		18,537.80
	35 - 513.00015 - CLASS B CONCRETE									
99	513.00020	CLASS B CONCRETE CODE 04 (STR) - MJI	75.40	CY	570.00	42,978.00	531.29	40,059.27	519.00	39,132.60
100	513.00020	CLASS B CONCRETE CODE 04 (STR) - MKY	75.40	CY	570.00	42,978.00	531.58	40,081.13	519.00	39,132.60
101	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLA	75.40	CY	570.00	42,978.00	531.99	40,112.05	519.50	39,170.30
102	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLB	75.40	CY	570.00	42,978.00	528.71	39,864.73	516.50	38,944.10
103	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLX	128.50	CY	550.00	70,675.00	570.40	73,296.40	557.00	71,574.50
104	513.00020	CLASS B CONCRETE CODE 14 (STR) - CHE	142.90	CY	550.00	78,595.00	565.39	80,794.23	552.00	78,880.80
105	513.00020	CLASS B CONCRETE CODE 14 (STR) - CHF	236.40	CY	540.00	127,656.00	531.71	125,696.24	519.50	122,809.80
		Subtotal				448,838.00		439,904.05		429,644.70

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: McGarvin-Moberly Construction Co. Unit Price	Bidder: McGarvin-Moberly Construction Co. Amount	Bidder: McMurry Ready-Mix Co. Unit Price	Bidder: McMurry Ready-Mix Co. Amount
	45 - 514.00015 - REINFORCING STEEL									
106	514.00020	REINFORCING STEEL CODE 04 (STR) - MJI	5,990.00	LB	1.25	7,487.50	1.26	7,547.40	1.25	7,487.50
107	514.00020	REINFORCING STEEL CODE 04 (STR) - MKY	5,990.00	LB	1.25	7,487.50	1.26	7,547.40	1.25	7,487.50
108	514.00020	REINFORCING STEEL CODE 04 (STR) - MLA	5,990.00	LB	1.25	7,487.50	1.26	7,547.40	1.25	7,487.50
109	514.00020	REINFORCING STEEL CODE 04 (STR) - MLB	5,990.00	LB	1.25	7,487.50	1.26	7,547.40	1.25	7,487.50
110	514.00020	REINFORCING STEEL CODE 14 (STR) - CHE	15,080.00	LB	1.20	18,096.00	1.26	19,000.80	1.25	18,850.00
111	514.00020	REINFORCING STEEL CODE 14 (STR) - CHF	24,320.00	LB	1.20	29,184.00	1.26	30,643.20	1.25	30,400.00
112	514.00020	REINFORCING STEEL CODE O4 (STR) - MLX	22,510.00	LB	1.20	27,012.00	1.26	28,362.60	1.25	28,137.50
		Subtotal				104,242.00		108,196.20		107,337.50
				Total:		**9,088,750.25**		**9,221,122.07**		**9,256,382.13**

Wyoming Department of Transportation Abstract of Bids Project No: SCP-SL12-P433035 Project Name: GILLETTE - MONTANA STATE LINE					Engineer's Estimate		Bidder: Simon Contractors and Subsidiaries		11/10/2011	Page 9 of 12
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	5 - ROADWAY									
1	105.09010	CONTRACTOR SURVEYING	1.00	LS	52,000.00	52,000.00	75,000.00	75,000.00		
2	106.05100	FIELD LABORATORY	1.00	EA	8,500.00	8,500.00	35,000.00	35,000.00		
3	106.05200	CONTRACTOR TESTING	1.00	LS	50,000.00	50,000.00	100,000.00	100,000.00		
4	109.04000	FORCE ACCOUNT WORK	5,000.00	$$	1.00	5,000.00	1.00	5,000.00		
5	109.08000	MOBILIZATION	1.00	LS	775,000.00	775,000.00	958,600.00	958,600.00		
6	201.03206	CLEARING TREES 6 in	4.00	EA	150.00	600.00	450.00	1,800.00		
7	201.03218	CLEARING TREES 18 in	8.00	EA	200.00	1,600.00	630.00	5,040.00		
8	201.03230	CLEARING TREES 30 in	2.00	EA	350.00	700.00	1,300.00	2,600.00		
9	201.03248	CLEARING TREES 48 in	5.00	EA	550.00	2,750.00	1,700.00	8,500.00		
10	202.03100	REMOVAL OF STRUCTURES AND	1.00	LS	250.00	250.00	800.00	800.00		
		OBSTRUCTIONS(Est. Lump Qty: 1 EA)								
11	202.03140	REMOVAL OF CATTLE GUARDS	6.00	EA	900.00	5,400.00	260.00	1,560.00		
12	202.03205	REMOVAL OF FENCE	69,130.00	FT	0.25	17,282.50	0.35	24,195.50		
13	202.03250	REMOVAL OF RC BOX CULVERTS(Est. Lump	1.00	LS	60,000.00	60,000.00	35,000.00	35,000.00		
		Qty: 5 EA)								
14	202.03270	REMOVAL OF PIPE	8.00	EA	900.00	7,200.00	580.00	4,640.00		
15	202.03280	REMOVAL OF PIPE FE SECTION	74.00	EA	150.00	11,100.00	75.00	5,550.00		
16	202.03305	MILLING PLANT MIX	1,700.00	SY	2.00	3,400.00	2.60	4,420.00		
17	202.03320	PROFILE MILLING PLANT MIX	96,100.00	SY	0.65	62,465.00	1.00	96,100.00		
18	202.03500	RESET MAILBOX (SINGLE)	1.00	EA	250.00	250.00	200.00	200.00		
19	202.03520	RESET MAILBOX (MULTIPLE)	1.00	EA	500.00	500.00	350.00	350.00		
20	202.03600	CUTTING BIT PVMT	67,470.00	FT	0.75	50,602.50	0.37	24,963.90		
21	203.02500	UNCLASSIFIED EXCAVATION	172,000.00	CY	3.15	541,800.00	3.78	650,160.00		
22	206.03100	FLOWABLE BACKFILL	230.00	CY	150.00	34,500.00	170.00	39,100.00		
23	206.03300	CULVERT SUBEXCAVATION	550.00	CY	12.50	6,875.00	70.00	38,500.00		
24	207.03100	TOPSOIL STORING	57,100.00	CY	1.40	79,940.00	1.45	82,795.00		
25	207.03200	TOPSOIL PLACING	57,100.00	CY	1.65	94,215.00	1.60	91,360.00		
26	209.01000	WATER	11,500.00	MG	15.00	172,500.00	10.00	115,000.00		
27	210.03200	BULLDOZER	300.00	HR	180.00	54,000.00	190.00	57,000.00		
28	210.03300	MOTOR GRADER	100.00	HR	135.00	13,500.00	140.00	14,000.00		
29	211.03315	CULVERT CLEANING	37.00	EA	1,050.00	38,850.00	500.00	18,500.00		
30	212.02100	DRY EXCAVATION	510.00	CY	12.00	6,120.00	9.00	4,590.00		
31	212.03900	PERVIOUS BACKFILL MATERIAL	90.00	CY	54.00	4,860.00	140.00	12,600.00		
32	213.03100	OVERBURDEN REMOVAL	500.00	CY	1.40	700.00	0.01	5.00		
33	213.03110	OVERBURDEN PLACING	500.00	CY	1.70	850.00	0.01	5.00		
34	215.01000	CONTRACTOR STORM WATER CONTROL	1.00	LS	15,000.00	15,000.00	25,000.00	25,000.00		
35	215.01010	DEPARTMENT STORM WATER CONTROL	1,000.00	$$	1.00	1,000.00	1.00	1,000.00		
36	216.03100	SEEDING (PLS)	1,100.00	LB	15.00	16,500.00	12.00	13,200.00		

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

					Engineer's Estimate		Bidder: Simon Contractors and Subsidiaries			
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
37	216.03120	FERTILIZER TYPE I	2,930.00	LB	2.20	6,446.00	2.70	7,911.00		
38	216.03900	DRY MULCH	110.00	TON	165.00	18,150.00	160.00	17,600.00		
39	216.03910	EROSION CONTROL BLANKET	1,735.00	SY	2.00	3,470.00	1.85	3,209.75		
40	217.01025	GEOTEXTILE, MATERIAL SEPARATION	787.00	SY	2.20	1,731.40	3.50	2,754.50		
		(NON-WOVEN)								
41	217.01043	GEOTEXTILE, SUBGRADE REINFORCEMENT	110,736.00	SY	1.60	177,177.60	1.40	155,030.40		
42	221.01000	DUST CONTROL AGENT	25.00	TON	160.00	4,000.00	170.00	4,250.00		
43	301.01030	CRUSHER RUN SUBBASE	59,100.00	CY	19.00	1,122,900.00	16.45	972,195.00		
44	302.00020	BLENDED BASE	10,610.00	CY	30.00	318,300.00	48.50	514,585.00		
45	401.02000	HOT PLANT MIX	23,375.00	TON	41.00	958,375.00	54.00	1,262,250.00		
46	401.02030	HOT PLANT MIX LEVELING	13,170.00	TON	42.00	553,140.00	44.00	579,480.00		
47	401.02040	TEST STRIP	1.00	EA	8,000.00	8,000.00	10,000.00	10,000.00		
48	401.02055	HOT PLANT MIX APPROACHES	280.00	TON	80.00	22,400.00	90.00	25,200.00		
49	401.03321	ASPHALT BINDER (PG 58-28)	944.00	TON	610.00	575,840.00	565.00	533,360.00		
50	401.03322	ASPHALT BINDER (PG 64-28)	1,041.00	TON	710.00	739,110.00	660.00	687,060.00		
51	407.01000	TACK COAT	46.00	TON	620.00	28,520.00	530.00	24,380.00		
52	408.01000	PRIME COAT	129.00	TON	770.00	99,330.00	850.00	109,650.00		
53	413.01000	HYDRATED LIME	350.00	TON	135.00	47,250.00	132.00	46,200.00		
54	502.01909	PRECAST BOX CULVERTS 9 X 9 ft	378.00	FT	925.00	349,650.00	600.00	226,800.00		
55	511.06000	MACHINE-PLACED RIPRAP	50.00	CY	100.00	5,000.00	135.00	6,750.00		
56	511.08000	GROUTED RIPRAP	150.00	CY	350.00	52,500.00	180.00	27,000.00		
57	603.50018	CMP 18 in	1,110.00	FT	43.00	47,730.00	44.00	48,840.00		
58	603.50024	CMP 24 in	164.00	FT	47.00	7,708.00	48.00	7,872.00		
59	603.50030	CMP 30 in	266.00	FT	55.00	14,630.00	72.00	19,152.00		
60	603.50036	CMP 36 in	472.00	FT	70.00	33,040.00	65.00	30,680.00		
61	603.50042	CMP 42 in	70.00	FT	76.00	5,320.00	75.00	5,250.00		
62	603.50048	CMP 48 in	186.00	FT	85.00	15,810.00	85.00	15,810.00		
63	603.50108	CMP 108 in	420.00	FT	380.00	159,600.00	350.00	147,000.00		
64	603.52018	CMP FE SECT 18 in	37.00	EA	180.00	6,660.00	200.00	7,400.00		
65	603.52024	CMP FE SECT 24 in	5.00	EA	220.00	1,100.00	240.00	1,200.00		
66	603.52030	CMP FE SECT 30 in	6.00	EA	480.00	2,880.00	490.00	2,940.00		
67	603.52036	CMP FE SECT 36 in	18.00	EA	500.00	9,000.00	650.00	11,700.00		
68	603.52042	CMP FE SECT 42 in	2.00	EA	900.00	1,800.00	1,300.00	2,600.00		
69	603.55018	SME SECT 18 in W/ GRATE	12.00	EA	800.00	9,600.00	600.00	7,200.00		
70	603.71010	PIPE COLLARS	35.00	CY	600.00	21,000.00	300.00	10,500.00		
71	607.20500	FENCE TYPE E (WOOD POSTS)	31,660.00	FT	1.85	58,571.00	1.50	47,490.00		
72	607.20700	FENCE TYPE G (WOOD POSTS)	23,100.00	FT	1.80	41,580.00	1.60	36,960.00		
73	607.20800	FENCE TYPE H (WOOD POSTS)	14,375.00	FT	1.75	25,156.25	1.60	23,000.00		
74	607.50900	FENCE-WING (WOOD POSTS)	1,810.00	FT	2.20	3,982.00	1.80	3,258.00		

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

					Engineer's Estimate		**Bidder:** Simon Contractors and Subsidiaries			
No.	Item No.	Description	Qty	Unit	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
75	607.51100	FENCE TEMPORARY	12,660.00	FT	1.25	15,825.00	1.40	17,724.00		
76	607.71300	GATES RAIL 16 FT	8.00	EA	185.00	1,480.00	300.00	2,400.00		
77	607.80100	BRACE PANELS	109.00	EA	115.00	12,535.00	120.00	13,080.00		
78	607.90100	END PANELS	140.00	EA	150.00	21,000.00	130.00	18,200.00		
79	614.01000	EROSION CONTROL CONCRETE	25.00	CY	450.00	11,250.00	400.00	10,000.00		
80	615.02018	CATTLE GUARD (MEDIUM DUTY) 18 FT	5.00	EA	8,000.00	40,000.00	8,500.00	42,500.00		
81	615.02024	CATTLE GUARD (MEDIUM DUTY) 24 FT	2.00	EA	9,000.00	18,000.00	10,000.00	20,000.00		
82	617.01010	HEADWALL (CONC)	60.00	CY	600.00	36,000.00	500.00	30,000.00		
83	618.10707	RC STOCK PASS 91 X 91 in	86.00	FT	650.00	55,900.00	1,100.00	94,600.00		
84	618.20707	RC STOCK PASS FE SECT 91 X 91 in	2.00	EA	6,200.00	12,400.00	6,750.00	13,500.00		
85	640.00001	SPECIAL ITEM LS-A(Est. Lump Qty: 10000 CY)	1.00	LS	150,000.00	150,000.00	30,000.00	30,000.00		
86	702.30105	SIGN POSTS, WOOD 4 X 6 in	100.00	FT	10.00	1,000.00	9.50	950.00		
87	702.30110	SIGN POSTS, WOOD 6 X 6 in	20.00	FT	12.00	240.00	10.50	210.00		
88	702.30500	SIGN PANELS, ALUMINUM	52.00	SF	32.00	1,664.00	60.00	3,120.00		
89	702.50200	DELINEATORS, TYPE II	30.00	EA	32.00	960.00	27.00	810.00		
90	702.50300	DELINEATORS, TYPE III	235.00	EA	32.00	7,520.00	27.00	6,345.00		
91	703.03100	FLAGGING	6,000.00	HR	33.00	198,000.00	0.01	60.00		
92	703.03110	TEMPORARY TRAFFIC CONTROL	1.00	LS	160,000.00	160,000.00	400,000.00	400,000.00		
93	900.60000	CONTRACTOR QUALITY CONTROL (CONCRETE)	1.00	LS	5,000.00	5,000.00	9,000.00	9,000.00		
		Subtotal				8,501,041.25		8,909,151.05		
	15 - STRUCTURES									
94	206.03300	CULVERT SUBEXCAVATION	100.00	CY	20.00	2,000.00	23.00	2,300.00		
95	212.03900	PERVIOUS BACKFILL MATERIAL	20.00	CY	60.00	1,200.00	140.00	2,800.00		
96	217.01025	GEOTEXTILE, MATERIAL SEPARATION (NON-WOVEN)	143.00	SY	3.00	429.00	4.74	677.82		
97	301.01030	CRUSHER RUN SUBBASE	100.00	CY	30.00	3,000.00	51.00	5,100.00		
98	900.60000	CONTRACTOR QUALITY CONTROL (CONCRETE)	1.00	LS	28,000.00	28,000.00	11,000.00	11,000.00		
		Subtotal				34,629.00		21,877.82		
	35 - 513.00015 - CLASS B CONCRETE									
99	513.00020	CLASS B CONCRETE CODE 04 (STR) - MJI	75.40	CY	570.00	42,978.00	500.00	37,700.00		
100	513.00020	CLASS B CONCRETE CODE 04 (STR) - MKY	75.40	CY	570.00	42,978.00	500.00	37,700.00		
101	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLA	75.40	CY	570.00	42,978.00	500.00	37,700.00		
102	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLB	75.40	CY	570.00	42,978.00	495.00	37,323.00		
103	513.00020	CLASS B CONCRETE CODE 04 (STR) - MLX	128.50	CY	550.00	70,675.00	535.00	68,747.50		
104	513.00020	CLASS B CONCRETE CODE 14 (STR) - CHE	142.90	CY	550.00	78,595.00	580.00	82,882.00		
105	513.00020	CLASS B CONCRETE CODE 14 (STR) - CHF	236.40	CY	540.00	127,656.00	540.00	127,656.00		
		Subtotal				448,838.00		429,708.50		

Wyoming Department of Transportation
Abstract of Bids

Project No: SCP-SL12-P433035
Project Name: GILLETTE - MONTANA STATE LINE

No.	Item No.	Description	Qty	Unit	Engineer's Estimate Unit Price	Engineer's Estimate Amount	Bidder: Simon Contractors and Subsidiaries Unit Price	Bidder: Simon Contractors and Subsidiaries Amount	Unit Price	Amount
	45 - 514.00015 - REINFORCING STEEL									
106	514.00020	REINFORCING STEEL CODE 04 (STR) - MJI	5,990.00	LB	1.25	7,487.50	1.20	7,188.00		
107	514.00020	REINFORCING STEEL CODE 04 (STR) - MKY	5,990.00	LB	1.25	7,487.50	1.20	7,188.00		
108	514.00020	REINFORCING STEEL CODE 04 (STR) - MLA	5,990.00	LB	1.25	7,487.50	1.20	7,188.00		
109	514.00020	REINFORCING STEEL CODE 04 (STR) - MLB	5,990.00	LB	1.25	7,487.50	1.20	7,188.00		
110	514.00020	REINFORCING STEEL CODE 14 (STR) - CHE	15,080.00	LB	1.20	18,096.00	1.20	18,096.00		
111	514.00020	REINFORCING STEEL CODE 14 (STR) - CHF	24,320.00	LB	1.20	29,184.00	1.20	29,184.00		
112	514.00020	REINFORCING STEEL CODE O4 (STR) - MLX	22,510.00	LB	1.20	27,012.00	1.20	27,012.00		
		Subtotal				104,242.00		103,044.00		
				Total:		**9,088,750.25**		**9,463,781.37**		

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