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16. Abstract
The Texas Department of Transportation (TxDOT) has experienced problems with construction quality and performance on narrow widening projects (i.e., projects that notch and widen pavement to increase lane width 2–8 ft or add a 2- to 5-ft shoulder). Texas has approximately 64,000 lane-miles of pavement with 9- to 11-ft wide lanes, which includes over 35,000 lane miles of FM roads (MapZapper 2011). In addition, approximately 20%, 26%, and 36% respectively of roadways with 9-, 10-, or 11-ft lanes have either no shoulder or a 1-ft shoulder. These roads are potential candidates for lane or shoulder widening to improve safety performance and increase capacity. However, due to constraints regarding construction equipment widths and other limitations, material selection options and compatibility, construction methods, and other issues, narrow widening projects can present construction and performance problems. These challenges include inadequate compaction of the subgrade, compaction of the base material at the notch-and-widen joint interface, drainage within the pavement and at the pavement surface, either high or depressed surface layer construction joints, and potential safety concerns. To effectively overcome these challenges, TxDOT has initiated this project to prepare a compendium of best practices and lessons learned regarding narrow widening projects.

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Flexible Pavement Narrow Widening Best Practices and Lessons Learned

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Products

0-6748-P1, *Narrow Pavement Widening Decision Support Tool and Master Document*, guides users in obtaining information needed to evaluate a proposed narrow widening project and summarizes the knowledge, best practices, and lessons learned gained during this study. This product is attached as a CD to the back of this bound report.

Also provided in this report is 0-6748-P3; Appendices D–F provide materials from the *Webinar Workshop*.

Preface

The Texas Department of Transportation (TxDOT) has experienced problems with construction quality and performance on narrow widening projects (i.e., projects that notch and widen pavement to increase lane width 2 to 8 ft or add a 2- to 5-ft shoulder). Texas has approximately 64,000 lane-miles of pavement with 9- to 11-ft wide lanes, which includes over 35,000 lane miles of Farm-to-Market roads (MapZapper 2011). In addition, approximately 20%, 26%, and 36% respectively of roadways with 9, 10, or 11 ft lanes have either no shoulder or a 1 ft shoulder (Machemehl 2006). These roads are potential candidates for lane or shoulder widening to improve safety performance and increase capacity. However, due to constraints regarding construction equipment widths and other limitations, material selection options and compatibility, construction methods, and other issues, narrow widening projects can present construction and performance problems. These challenges include inadequate compaction of the subgrade, compaction of the base material at the notch-and-widen joint interface, drainage within the pavement and at the pavement surface, either high or depressed surface layer construction joints, and potential safety concerns. To effectively overcome these challenges, TxDOT has initiated this project to prepare a compendium of best practices and lessons learned regarding narrow widening projects.

The primary goal of this project is to identify best practices for improving pavement performance on projects involving widening of narrow pavement structures. Following are the project objectives:

- review and document literature on current practices used by TxDOT districts, transportation agencies in other states and abroad, contractors and equipment developers (Chapter 1);
- conduct in-person and telephone interviews with experienced professionals and gain knowledge on their experiences and current practices (Chapter 2);
- conduct a webinar workshop with the attendance of experienced professionals to gain expert opinions on current practices (Chapter 3);
- seek to understand and assess alternatives on the mechanisms and actions that result in either poor or good pavement widening construction quality and pavement performance based on the literature, case studies, an expert panel Workshop and interviews (Chapter 4);
- develop a decision support tool to assist districts in making the most effective design decisions, develop appropriate design details, and manage and inspect the construction of widening projects (Chapter 5); and,
- conduct a training webinar workshop to present lessons learned and best practices to district personnel, while introducing and gaining feedback on the decision support tool (Chapter 6).

The decision support tool developed as a result of this project could be integrated with existing pavement management databases or additional features could be added as a future development. Chapter 7 of this report summarizes and concludes the project.

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Chapter 1. Introduction and Background

This chapter presents the comprehensive literature review conducted at the beginning of the project to investigate methods used for flexible pavement structure widening projects in Texas, the U.S., and abroad. This literature includes research reports, journal articles, department of transportation (DOT) technical reports, briefs, and guidance regarding widening projects; also surveyed was additional information obtained through contacts with other DOTs and transportation agencies, the construction industry, and construction equipment manufacturers and suppliers. The research team focused on pavement design details, construction methods and equipment, and strategies to improve widening project performance by preventing related problems. Special attention was given to design and construction challenges that may arise during or after narrow widening projects.

The literature review is composed of the following:

- **Introduction**: The introduction defines narrow widening and describes the reasons for narrow widening projects and the challenges that arise during narrow widening construction. It also introduces the references used to create this report.
- **Failures**: This section describes the different failures that can result from narrow widening projects.
- **Pre-design Assessment**: This section describes the different methods used to assess the existing condition of the roadway prior to design.
- **Materials**: The different types of materials used in narrow widening projects are discussed in this section.
- **Design**: This section discusses issues and solutions related to the design aspect of narrow widening projects.
- **Construction best practices**: This section shares best construction practices that work well for narrow widening projects.
- **Traffic management**: This section gives suggestions on how traffic can be managed during narrow widening construction.
- **Quality control**: This section discusses how narrow widening projects can enforce quality control.
- **Equipment**: This section discusses equipment that can be used for narrow widening projects.
- **Other reference material**: This section mentions other reference materials found that are related to narrow widening projects. In addition, Appendix A summarizes different equipment available from around the world.

1.1 Introduction

1.1.1 Reasons for Widening

Narrow pavement widening projects in Texas typically involve Farm-to-Market (FM) roads on other lower type facilities that were originally constructed in the 1940s, 1950s, or 1960s and have total paved widths of 18, 20, or 22 ft (lane widths, 9, 10, or 11 ft). Narrow widening typically involves adding lane width or a narrow shoulder, which results in widening each travel way by from 2 to 6 ft. The main reasons for roadway widening are typically to improve safety, increase capacity, or enhance pavement performance. In such cases, the existing roadway may exhibit edge drop-offs due to loadings by heavy trucks, rutting, cracking, or other issues.

Other states and countries have conducted research or developed agency documents that address narrow pavement widening problems and practices. The following sections document this information in order to capture lessons learned and best practices. With over 20 years' experience in conducting narrow widening, Virginia has recently started taking the initiative to narrow-widen from the edge of the pavement due to safety concerns with the shoulder, edge support, and bike lanes ("Pavement and Trench Widening Workshop," VDOT). In 2007, 2% of the total maintenance budget was invested in widening projects and the performance and cost-effective practices were gathered from project site visits.

1.1.2 Construction Challenges

Narrow widening projects introduce several construction challenges, such as the following:

- Narrow work areas in which full-sized construction equipment will not fit
- Variable subgrade conditions
- Surface and subsurface drainage
- Maintenance of traffic during construction
- The constraint of working within existing right-of-way (ROW) when additional ROW might be needed
- Challenges with lengthening or widening, small bridges, or cross and lateral drainage structures within available ROW or budgets
- Differences between the construction plan thicknesses and materials types compared to actual conditions
- Policy restrictions that require opening the lane to traffic at the end of each day

Challenges can also occur when trying to provide quality construction while keeping the time for each task short, as the road needs to be open for traffic. The equipment used for narrow widening can also pose a challenge, as equipment made solely for narrow widening may not be worth the expense because of the limited number of narrow widening projects.

It is important that the designer understands the policies associated with the various funding categories used for narrow widening projects. These policies involve required project letting schedules, allowable work types, and other factors that can potentially limit the category that can be used for a particular project. Narrow widening projects are funded through the following categories:

- Category 1, Pavement Preventative Maintenance and Rehabilitation (CAT-1),
- Category 8, Highway Safety Improvement Program (CAT-8),
- Strategy 144, Routine Maintenance Contracts (RMC), and
- Strategy 105, In House Maintenance Forces.

In addition, the Legislature may pass bills that provide additional funding through Safety Bonds (Proposition 14—Safety Bond program) or other sources to address safety, pavement conditions, narrow roadways, and heavy truck traffic in the shale development regions of Texas.

It is interesting to note that though some districts use all of the above funding categories for narrow pavement widening projects, other district may only use Strategy 105 or some sub-set of the available sources. This may be due to the policies associated with certain funding categories that might constrain the project design in relation to the work types the districts want to incorporate in the project.

Construction projects funded through CAT-1, safety-related projects funded by CAT-8, and routine maintenance projects funded by RMC are all performed by contractors who have a procedure for inspecting the quality of the materials used in the project. It is important to note, however, that many projects funded through CAT-1 or sources other than CAT-8 do enhance safety. TxDOT has emphasized the importance of safety through the CAT-8 funding category, which includes the High Risk Rural Roads (HRRR) and Hazard Elimination; narrow widening projects may be funded using HRRR funds which are allocated based on the project safety improvement index (SII), which is a form of benefit/cost (B/C) ratio.

In-house maintenance projects are performed by district maintenance forces that may be constrained by lack of detailed plans, different materials, or equipment, different inspection methods, and staffing levels, which can affect production rates.

Another challenge is that the in-house maintenance forces may not have the capability to do structure widening, which can result in the widened pavement lanes or shoulders being flush against a structure headwall, with no safety treatments for structures and close proximity of the pavement edges to steep ditch side slopes.

1.1.3 Guideline Reports

Globally, a number of guideline reports have been written to help guide engineers and contractors regarding best road widening practices. These guidelines provide tips on how to prevent certain problems from occurring, as well as different material and equipment options available for road widening. Information pertinent to narrow widening in Texas is summarized in this report.

U.K.

A report was prepared in the U.K. to give engineers guidance on repairing road edges while incorporating reusable materials (Potter, 1996). The guidance was based on three road trials on 22 test sections over a period of 2 years. The performance of reusable materials was compared to that of crushed rock (Type I) sub-base and bituminous road base control materials. The guide was intended for the repair of edges on roads carrying up to 10 million standard axles in one direction over a design life of 20 years. It can be beneficial to incorporate reusable materials in road edge repair, as recycling materials can be cost-effective and help conserve the environment. However, consideration should also be given to the possibility of environmental drawbacks and risk of early deterioration.

Virginia

The Virginia Department of Transportation (VDOT) conducted a workshop to gain information regarding how to improve the quality of pavement and trench widening projects ("Pavement and Trench Widening Workshop," VDOT). The workshop provides guidance on designing pavement widening projects and discusses the issues related to trench and pavement widening construction. The Virginia trench widening guidelines, revised in 2007, were written for trench widening 2–6 ft in width, asphalt mixes IM-19.0T or BM-25.0T (T=Trench), asphalt binders A or D, and trench depths at least 5 in. If the widening width is greater than 6 ft, the WP-2 standard can be used. Trench widening is not intended for travel lanes on high volume routes. The guidelines are not specifications and their purpose is to provide guidance to the field using special provision.

Northern Europe

The ROADEX Network has a report that provides information on the design, reasons for failures, and repair of widened roads (Varin & Saarenketo, 2012). This report was developed to provide cost-effective road widening guidelines that are tailored to the Northern Periphery (northern margins of Europe) conditions. The steps taken to develop this report involved a literature review on current practices and guidelines for road widening in the ROADEX countries (Greenland, Iceland, Norway, Sweden, Finland, Scotland, and Ireland), field surveys on widening test sites using various technologies, and collecting information that could be used in national guidelines for widening low volume roads. Existing guidelines on road widening for each of the ROADEX countries vary, and their differences and similarities were compared in the 2010 ROADEX report, *Road Widening: Literature Review and Questionnaire Responses*.

Texas

In 2006, the Texas Transportation Institute (TTI) prepared a design guide for the Texas Department of Transportation (TxDOT) on full lane-width flexible pavement widening (Hilbrich & Scullion, 2006). Information in the guide was taken from surveys within TxDOT, interviews with district personnel, field observations, and literature review on existing published guidelines on flexible pavement widening. The guide discusses recommended investigation procedures, subgrade and base stabilization, pavement drainage, equipment options, embankment widening, narrow bridge widening, longitudinal joint construction, and some construction alternatives for widening flexible pavements in good or poor condition.

1.1.4 Traffic Types

The amount of traffic that the roadway carries should be determined, as this will provide a basis for the structural design of the road edge repair. In the U.K. guide that incorporates reusable materials in edge repair, roads are categorized into "Road Type Categories" based on their traffic level (Table 1.1), and local traffic condition information can be assessed from the categories (Potter, 1996).

Table 1.1. Road type categories (Potter, 1996)

Road Type Category	Traffic Design Standard (Million standard axles)
1	More than 10 up to 30
2	More than 2.5 up to 10
3	More than 0.5 up to 2.5
4	Up to 0.5

1.1.5 Widening Types

The VDOT workshop discusses four types of trench widening ("Pavement and Trench Widening Workshop," VDOT). The first type of trench widening involves the shoulder(s) being widened at or outside the existing edge line, and the new edge line does not extend into the widened area (Figure 1.1). The second type of trench widening involves the shoulder(s) also being widened at or outside the existing edge line, but the new edge line extends into the widened area to increase the pavement width (Figure 1.2). The third type of trench widening involves the shoulder(s) being widened at or outside the existing edge line, while the new edge line extends into the widened area plus the new widened shoulder to increase lane width (Figure 1.3). The fourth type of trench widening involves the shoulder(s) being widened at or outside the existing edge line where width of widening exceeds 6 ft (Figure 1.4).

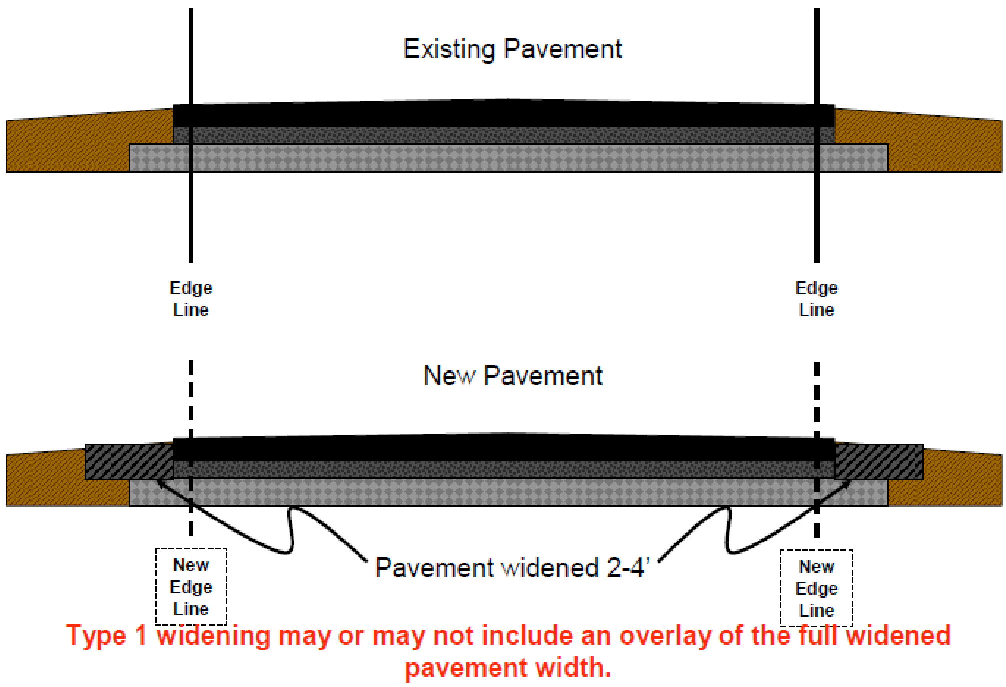


Figure 1.1. Type 1 trench widening where edge line doesn't extend to widened section ("Pavement and Trench Widening Workshop," VDOT)

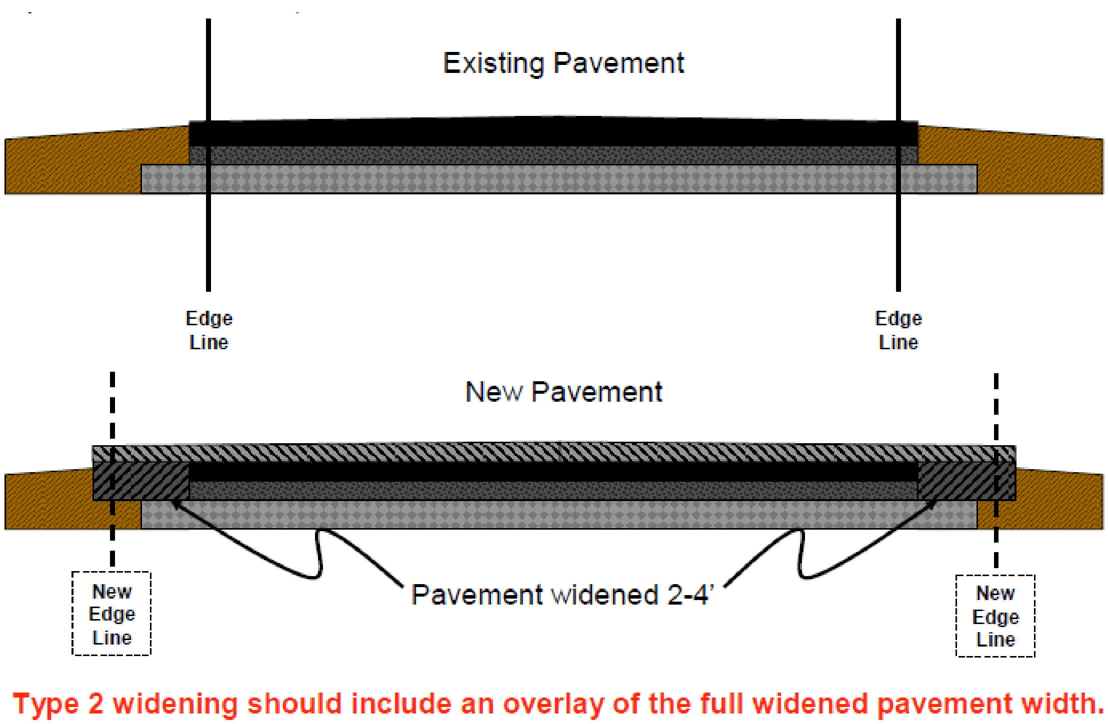


Figure 1.2. Type 2 trench widening to increase pavement width ("Pavement and Trench Widening Workshop," VDOT)

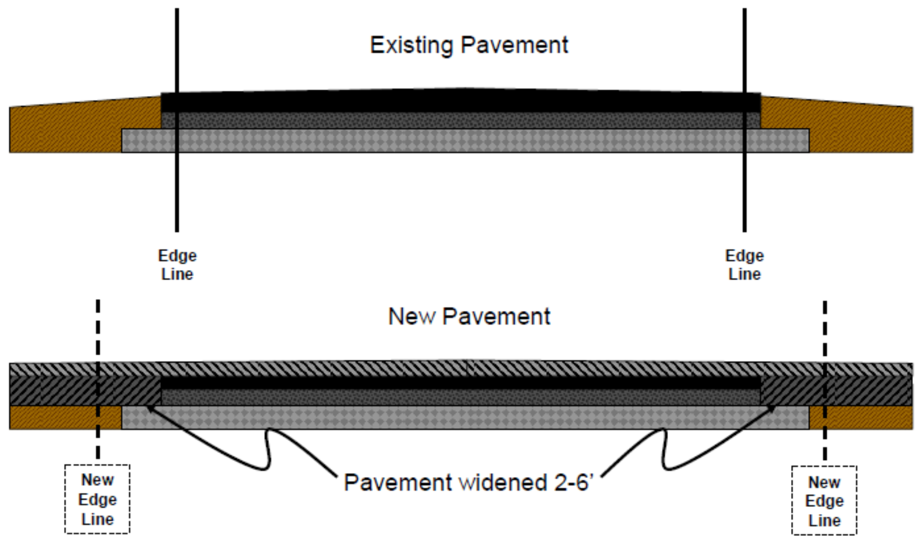


Figure 1.3. Type 3 trench widening to increase lane width ("Pavement and Trench Widening Workshop," VDOT)

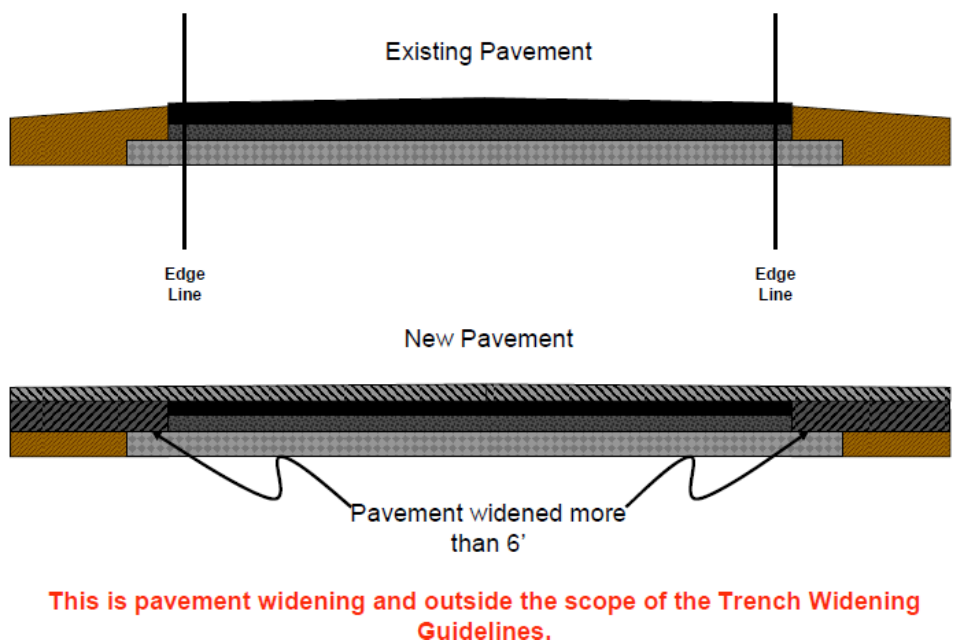


Figure 1.4. Type 4 trench widening where widening width exceeds 6 ft ("Pavement and Trench Widening Workshop," VDOT)

1.2 Failures

The Northern Europe guide on road widening discusses the failures that have been reported to occur when widening a road (Varin & Saarenketo, 2012). The failures are related to the difference between the old and new structure, joint construction, settlement, freeze-thaw cycles, drainage, slope stability, and curve crossfall. Prevention tips are discussed for each of these failures.

1.2.1 Old vs. New Structure

It is important to make the widening structure as similar as possible to the existing roadway with regards to the structural thickness, material properties, and degree of compaction. Differences between the old and new structure can result in differential frost heave, uneven settlements, reflection cracking, or different load bearing capacities for both structures.

1.2.2 Joint Construction and Location

When connecting the new pavement structure to the old pavement structure, the joint between them should not be placed under or near the wheel path, as traffic loading can cause reflection cracking to occur in that location.

1.2.3 Settlement

Enough time should be given for the new structure to settle and match the settlement of the old embankment before paving, as differential settlement could occur, especially on peat soils.

1.2.4 Freeze-Thaw Weakening

In cold climates, it is important to maintain the same thickness for the new and old structures, reduce use of frost-susceptible materials, and maintain proper drainage, as any of these could cause differential frost heave during the freezing period or decreased bearing capacity during the thawing period. Spring thaw weakening, in combination with Mode 2 rutting (rutting that takes place at the road structure/subgrade interface), could also cause soft subgrade to flow and result in unwanted widening from beneath the road.

1.2.5 Drainage

Sufficient drainage is important for preventing failure of the pavement. A road drainage system that is deteriorating will result in decreased bearing capacity along the thinner edges of the road, followed by edge deformation and ponding of water, which accelerates the deformation.

1.2.6 Slope Stability

It is important to ensure the stability of the side slopes (inner and outer), as slope stability problems can occur if the space for the road is limited. In a limited ROW space, the outer slope could be so steep that slope material could fill the ditches and raise the ground water level, causing edge deformation and frost heave problems. A steep inner slope could result in poor compaction of the widened road section, leading to shear failure and edge deformation.

1.2.7 Curve Crossfall

When reaching a curve in the pavement direction (horizontal curve), oftentimes the thickness of the inner curve is less than the centerline thickness. This can reduce bearing capacity of the widened structure and increase frost heave exposure if widening is made on the inner curve.

1.3 Pre-Design Assessment

The first step in a widening project is to assess the current condition of the site. Repair of a road edge involves identifying the damaged road edge(s), identifying the severity of the deterioration, and evaluating the structural designs and various materials available for the edge repair (Potter, 1996). Deteriorated edges can be identified through safety inspections, routine visual inspections, or deflection measurements. Sites should be identified based on location, length of deterioration, width of deterioration, type and severity of deterioration, condition of drainage, and condition of verge and adjacent carriageway.

Because of the subjectivity of a designer's opinion in a traditional site visit survey, it is recommended to take physical measurements as a pre-design survey (Varin & Saarenketo, 2012). This will provide more exact, more objective information on the existing condition of the roadway. Usually at least GPR measurements (discussed below), video recording, laser scanner measurement, and drainage analysis should always be done. Some other strategies for assessing the original pavement condition include a review of the construction records, soil borings, pavement cores, engineering properties of the base and subgrades, stabilization design of the base and subgrades, and testing the subgrades for sulfates and organics (Hilbrich & Scullion, 2006).

Districts have reported cracks at the longitudinal joint and moisture ingress, leading to rapid deterioration of the section, after flexible bases were widened with different base material, especially cement-treated base (Hilbrich & Scullion, 2006). This can be avoided by performing a thorough review of construction records and taking pavement cores to determine existing material properties, mix designs, and material thicknesses. More details are discussed on effective pre-design assessment procedures.

1.3.1 Temporary Works

Prior to the detailed investigation, emergency repairs should be carried out if the defective road edge poses a safety hazard (Potter, 1996).

1.3.2 GPR Surveys

Ground penetrating radar (GPR) data collection and analysis can help provide continuous information on the thicknesses and quality of the existing road structural layers (Varin & Saarenketo, 2012). It can also locate old structures that could be below or inside the existing road structure. GPR profiles taken longitudinally and transversely can provide information on differences in layer thicknesses or material properties. Failure causes could be identified from this information.

1.3.3 Visual Inspections

Visual signs of edge deterioration include rutting, cracking near the wheel path, and deterioration of the road between the wheel path and edge (Potter, 1996). Video recording can help identify the current condition and distresses in the pavement by providing a continuous record of the road, and it can aid in surveying the topography of the road and its surroundings (Varin &

Saarenketo, 2012). Video recording can be conducted at the same time as other measurements, such as GPR surveys, and all information can be linked together.

1.3.4 Deflection Surveys and Structural Strength Index

The falling weight deflectometer (FWD), an automated stationary impulse load method, can be used to measure deflections in the road surface, which can be used to determine the bearing capacity, reinforcement requirements, weak spots, road strengthening priorities, and the strength of layers during construction (Varin & Saarenketo, 2012).

The structural performance of reusable materials can be analyzed by comparing their Structural Strength Index (SSI), which can be obtained from deflection surveys (Potter, 1996). Obtaining the SSI allows for the option to reconstruct road edges, rather than carry out full overlays to extend the life of the road.

1.3.5 Laser Scanning

Mobile laser scanning (or Lidar) can be used to make accurate 3D surface images of the road and its surroundings and provide information such as the angle of side slopes, road width, ditch depth, and a map of the frost heave and deformation behavior of the road (Varin & Saarenketo, 2012). Data from laser scanner surveys can be used to compare conditions before and after widening or can be combined with other types of road survey data to determine reasons for failures in the existing road.

1.3.6 Profilometer Data Analysis

A laser profilometer can be used to measure the roughness and rutting on paved roads, collecting data such as the crossfall of the road, rut depth, rut increase rate, and the International Roughness Index values (Varin & Saarenketo, 2012). Information from the profilometer surveys can help identify problematic areas on the existing road; however, it does not provide information on the shoulders or side ditches.

1.3.7 Drainage

It is important to ensure proper drainage in the road and on its edges, as the sub-grade could soften and the pavement could deteriorate (Potter, 1996). The road drainage design should include controlling the water content in the sub-grade at formation level, reducing the ingress of water from the edges or through the roadway construction, and preventing water from being trapped in the barrier between the existing roadway and the new pavement edge. It is important to note that some materials are more susceptible to moisture-induced deterioration than others.

Because permanent deformation can be reduced by keeping the road free of excess water, it is profitable to maintain a good drainage system, which can be kept working with an effective monitoring system (Varin & Saarenketo, 2012). A drainage monitoring system, conducting drainage analysis surveys, can help identify road sections with inadequate drainage and define solutions for the problem sites in these sections.

1.3.8 Drilling, Sampling, and Laboratory Analysis

Properties of the existing road and subgrade can be determined from drill cores, sampling, and laboratory analyses (Varin & Saarenketo, 2012). If sampling and drilling and GPR measurements are both performed, structural layer thicknesses from the GPR data can be verified and calibrated with excavation test pits and drill cores. Laboratory analyses can determine material properties of the existing road layers and subgrade soils, such as grain size distribution, organic content, and water content. Also the soil type, moisture susceptibility, frost properties, and settlement properties can be determined. Knowing these properties is important for matching the new structure with the existing structure and is useful when designing repairs.

1.3.9 Trial Pit Investigation

The full depth of construction and any variations across the road should be examined with a trial pit, or if the pit is not possible, cores should be taken (Potter, 1996). From this, the condition of the granular layers and the sub-grade can be assessed through obtaining the California Bearing Ratio (CBR) of the subgrade to measure its strength, the drainage condition, the type of construction of the roadway, and layer thicknesses.

1.3.10 Subgrade and Base Stabilization

Testing should be performed to determine if the subgrade is highly plastic or weak and needs stabilization (Hilbrich & Scullion, 2006). If stabilizing with lime, a laboratory or a field test can be performed. The presence of soluble sulfates in the soil should be noted, as a high soluble sulfate content can lead to heaving when lime stabilizers are used. Sulfate presence can be determined from the lab, in the field, or there is a map that indicates counties in Texas with known sulfate presence in their soils. The presence of organics is also important to note, as organic material can block stabilization from occurring if using a lime stabilizer. Organic soils can be identified easily in the field. An appropriate stabilizer for subgrades, bases, and salvaged existing materials can be selected based on soil mineralogy, soil classification, goals of treatment, mechanisms of additives, desired engineering and material properties, design life, environmental conditions, and engineering economics. After a stabilizer is selected, a laboratory mix design should be conducted following TxDOT procedures. It is not recommended to use stabilized bases for widening projects if the existing structure has a flexible untreated base or if the subgrade soils have a PI>35 (longitudinal cracking will occur).

1.4 Materials

In order to determine the economic feasibility of incorporating reusable materials, the U.K. report describes how potential materials for the project should be compared based on availability, suitability, and cost (Potter, 1996). For Type 2, 3, and 4 roads (design life less than 10 million standard axles [msa]), defined in Table 1.1, careful consideration should be given when employing reusable, recycled, or alternative materials in the place of primary aggregates.

1.4.1 Environmental Considerations

Agenda 21, the list of objectives from the Earth Summit Conference in Rio de Janeiro in 1992, promotes sustainability through the encouragement of reducing of the use of finite resources, increasing energy efficiency, minimizing waste, and protecting the natural world (Potter, 1996). Highway authorities from around the world have been influenced by this message. In the U.K, the government aims to encourage more recycling of material by broadening specifications and increasing the technical scope of recycled materials through research on their performance and introducing a landfill levy from demolition or construction.

The U.K. Department of the Environment publication on Minerals Planning Guidance for Aggregate Provision (MPG6) has objectives for sustainability in minerals planning, which include conserving as much minerals as possible, minimizing waste, and encouraging efficient use of materials (Potter, 1996). The MPG6 encourages the use of secondary or recycled material for alternative aggregate sources. The use of higher grade material should be avoided if lower grade will suffice.

1.4.2 Waste Management

The U.K. Environment Protection Act of 1990 enforces restrictions on waste management activities and encourages recycling and minimization of waste (Potter, 1996). The Waste Management Licensing Regulations of 1994 extend and amend part of the Environmental Protection Act, and reference to these regulations can help determine which substances are considered waste. Exceptions to waste substances include waste soil or compost that is spread alongside the highway and results in ecological improvement, waste that is manufactured or treated and does not exceed the regulation limit, waste that is temporarily stored to be used in construction work, and waste that is stored and used for relevant work on a demolition and construction site. Certain mine and quarry wastes, such as quarry overburden, china clay waste, and slate waste, are not classified as controlled waste and are therefore not subject to the regulations.

1.4.3 Traditional Materials

For heavily trafficked Type 1 roads (design life between 10 and 30 msa), the U.K. report on reusable materials recommends that the materials comply with the TRL Report PA/SCR243 of 1994 (Potter, 1996). Materials recommended for road edge repair in the TRL Report and the CSS Report ENG/1/91 of 1991 are listed in Table 1.2.

Table 1.2. Materials for road edge repair recommended in PA/SCR243 and ENG1/91 (adapted from Potter, 1996)

GSB 1	Granular sub-base Type 1 as described in the Specification for Highway Works (MCHW 1) clause 803, but with moisture content controlled to within +1% to -2% of OMC.
GSB 1X	A granular material displaying a higher permeability than GSB 1.
GRAN	Any granular material which is physically and chemically stable, of adequate intrinsic strength and provides an equivalent modulus (bearing capacity) of at least 70 MPa after compaction. The moisture content requirement for GSB 1 may also be applicable to GRAN materials dependent upon the grain size distribution.
DBBC	20mm dense base course macadam BS4987: Part I: 1993 Clause 6.5, 100 Pen grade binder.
VDBBC	As DBBC material but coupled with end point compaction specification given in Appendix C4 of TRL Report SCR243.
HRABC	Rolled Asphalt Base course BS594: Pan I: 1992, Table 2 Column 2/3, 50 Pen binder.
HSCA	High Stone Content Asphalt incorporating 100 Pen binder BS594: Parts 1 and 2: 1992, Table 3 Col 3/4, 3/5 Table 4 Col 4/4, 4/5 or refer to PA/SCR243 Appendix C5 (1994).
DBWC(10)	10mm close-graded wearing course macadam BS4987: Part I: 1993 Clause 7.4, 100 Pen grade binder. Crushed rock or slag aggregate of PSV not less than 50.
DBWC(6)	6mm dense wearing course macadam BS4987: Part 1: 1993 Clause 7.5, 100 Pen grade binder. Crushed rock or slag aggregate of PSV not less than 50.
HRAWC(DM)	Rolled Asphalt wearing course BS594: Part 1: 1992, Table 3 Column 3/2, 50 Pen binder Table B1 Stability 5kN +/- 3kN. Crushed rock or slag coarse aggregate of PSV not less than 45 with coated chippings of appropriate PSV.
HRAWC	Rolled Asphalt wearing course BS594: Part I: 1992, Table 6 Column 6/4, 50 Pen binder crushed rock or slag coarse aggregate of PSV not less than 45 with coated chippings of appropriate PSV.

1.4.4 Reusable or Alternative Materials

Table 1.3 lists the reusable materials and processes that were included in road trials in the U.K. report, as they are placed into four different material categories: granular, granular-bituminous, bituminous-bound, and cement-bound (Potter, 1996). In the trials, reusable/alternative materials were compared to conventional unbound control materials with regards to structural equivalence.

Table 1.3. Categories of materials used in haunching trials (Potter, 1996)

Granular	Granular -Bituminous	Bituminous-bound	Cement-bound
Processed aggregates	Bituminous planings	Plant-recycled planings with foamed bitumen	No-fines concrete
Quarry waste	Granulated bituminous materials	Plant-rejuvenated planings	In-situ recycling with cement
Slate		In-situ recycling with foamed bitumen	In-situ cement-stabilised gravel
China clay Stent *		In-situ rejuvenated planings	
Crushed kerbstones			
As-dug sand and gravel			
Furnace bottom ash			

* Stent is the granite overburden that has to be extracted before mining of china clay sand.

Leachates

Leachates can be produced by the action of water on materials containing certain chemical compounds, and they can be hazardous for plants and wildlife that use the water systems (Potter, 1996). Possible production of leachates should be investigated before repairing a road edge.

Granular and Granular-Bituminous Materials

Previously used granular materials should be tested prior to use in road edge repair and comply with performance requirements, as these materials have more variable properties than freshly produced road aggregate material (Potter, 1996). Materials for structural course should achieve a minimum equivalent modulus of 100 MPa (Category A materials). Materials for the foundation platform can achieve lower minimum values (Category B with at least 70 MPa and Category C with at least 50 MPa), as the quality is balanced against the thickness of the layers.

Granular-bituminous materials include bituminous planings, bituminous materials rejected from construction sites, surplus or cooled production material, and the materials produced when mixing plants are first started up. These materials should be broken up and graded if they are adhering to each other from being stockpiled.

Appendix 3 in “Road Haunches: a guide to re-usable materials” (Potter, 1996) provides recommended requirements for granular and granular-bituminous materials and typical test values from the road edge repair trials.

Bituminous Hot In-Plant Recycling

For Type 1 roads, the U.K. report recommends the same maximum percentages of reclaimed bituminous materials as permitted by the DOT guidance on Maintenance of Bituminous Roads (up to 30% in hot rolled asphalt and coated macadam for base course and road base and up to 10% in hot rolled asphalt wearing course). For Type 2, 3, and 4 roads, the recommended maximum percentage of reclaimed material for the foundation platform or the structural course is to comply with the appropriate specification for new hot-mixed bituminous material.

Bituminous Cold In-Plant and Cold In-Situ Recycling

Cold in-plant recycling using foamed bitumen binder can be used for edge repair in the structural course and the foundation platform (Potter, 1996). For cold in-situ recycling using foamed bitumen binder, the structural course and foundation platform will be constructed together using specialized recycling machinery. Appendix 4 in "Road Haunches: A guide to re-usable materials" (Potter, 1996) provides recommended requirements for assessing the suitability of cold recycled materials for foundation platform and structural course. It is recommended to take samples from the full depth of the layer prior to compaction, as the material is difficult to core before it is fully cured.

Cement Cold In-Situ Recycling

Cold in-situ recycling using cementitious binders can be used for edge repair with the structural course and the foundation platform recycled as one layer (Potter, 1996). Recommended requirements for assessing the suitability of cold recycled materials using cementitious binders are shown in Appendix 4 of "Road Haunches: A guide to re-usable materials" (Potter, 1996).

No-Fines Concrete

No-fines concrete can be used for road edge repairs where there is a high water table or where it is important to have free drainage of the road foundation (Potter, 1996).

1.5 Design

In edge repair design, factors to consider are 1) the materials used in the foundation platform and structural course, which influence layer thickness; 2) the thickness of the foundation platform, which depends on the subgrade bearing capacity and materials used; and 3) the thickness of the structural and wearing courses, which depend on the traffic volume and materials used (Potter, 1996). Other important factors to consider are project location on pavement, traffic volume, truck volume, and overlay thickness ("Pavement and Trench Widening Workshop," VDOT). Various factors, as shown in Table 1.4, will determine the trench depth, asphalt mix, and asphalt binder.

Table 1.4. Various factors to determine trench depth, asphalt mix, and asphalt binder

Factor Matrix	Project Location on Pavement	Traffic Volume*	Truck Volume (%)	Trench Thickness	Trench Material
1	Outside the painted edge strip	< 5,000	< 10%	5"	IM-19.0A or BM-25.0A
2	Outside the painted edge strip	> 5,000	> 10%	8"	IM-19.0A or BM-25.0A
3	Inside the painted edge strip			8"	IM-19.0D or BM-25.0D

*In vehicles per day

If an overlay will be placed, the trench depth should be reduced to equal the overlay thickness. For example, a 2-in. overlay reduces an 8-in. trench to 6 in.

If the flexible pavement is in good condition, some important factors to consider for construction include placement and sealing of the joint, ensuring that the construction equipment can compact the narrow section, and matching sections to avoid trapping moisture in the existing base, as trapped moisture could cause the pavement to deteriorate in the long-term (Hilbrich & Scullion, 2006). If there is not enough time for curing in subgrade stabilization, using reclaimed asphalt pavement (RAP), placing flex base instead of subgrade stabilization, or using geotextiles can be considered to expedite construction. In dealing with edge drop-offs, cement-treated bases or asphalt-stabilized bases can be used rather than matching the existing section; however, a cost-effective approach involves tying the existing shoulder into the resurfaced roadway by installing a 45-degree asphalt fillet along the edge of the pavement.

If the flexible pavement is in poor condition, full depth recycling might be considered, though the amount of existing hot-mix asphalt surface to be reworked into the existing base should be less than 50% (Hilbrich & Scullion, 2006). When developing the pavement design for full depth recycling, a complete laboratory investigation should be conducted. Layer thicknesses of the pavement to be recycled can be verified through a GPR survey or coring of the pavement. The appropriate type and level of stabilization can be selected when conducting full depth reclamation.

If the subgrade is highly expansive with a Plasticity Index (PI) > 35, a Tensar Grid can be used to interpret refection cracks from the lower layers and minimize the longitudinal cracks that result from edge drying (Hilbrich & Scullion, 2006). A laboratory investigation should be conducted to determine the appropriate type and optimum amount of stabilizer.

If there are less than 1000 vehicles per day and the existing pavement is in poor condition, the existing base can be reworked and treated, and then a two-course surface treatment can be applied (Hilbrich & Scullion, 2006). A complete laboratory investigation should be conducted to develop the pavement design when the existing base is reworked.

1.5.1 Design of Foundation Platform

The use of a geosynthetic membrane should be considered where the CBR is 2–4%. If the CBR is less than 2%, a geosynthetic membrane is recommended to be laid at the bottom of the foundation platform (Potter, 1996). Recommended thicknesses for the foundation platform are shown in Table 1.5 for reusable materials and Figure 1.5 for traditional materials.

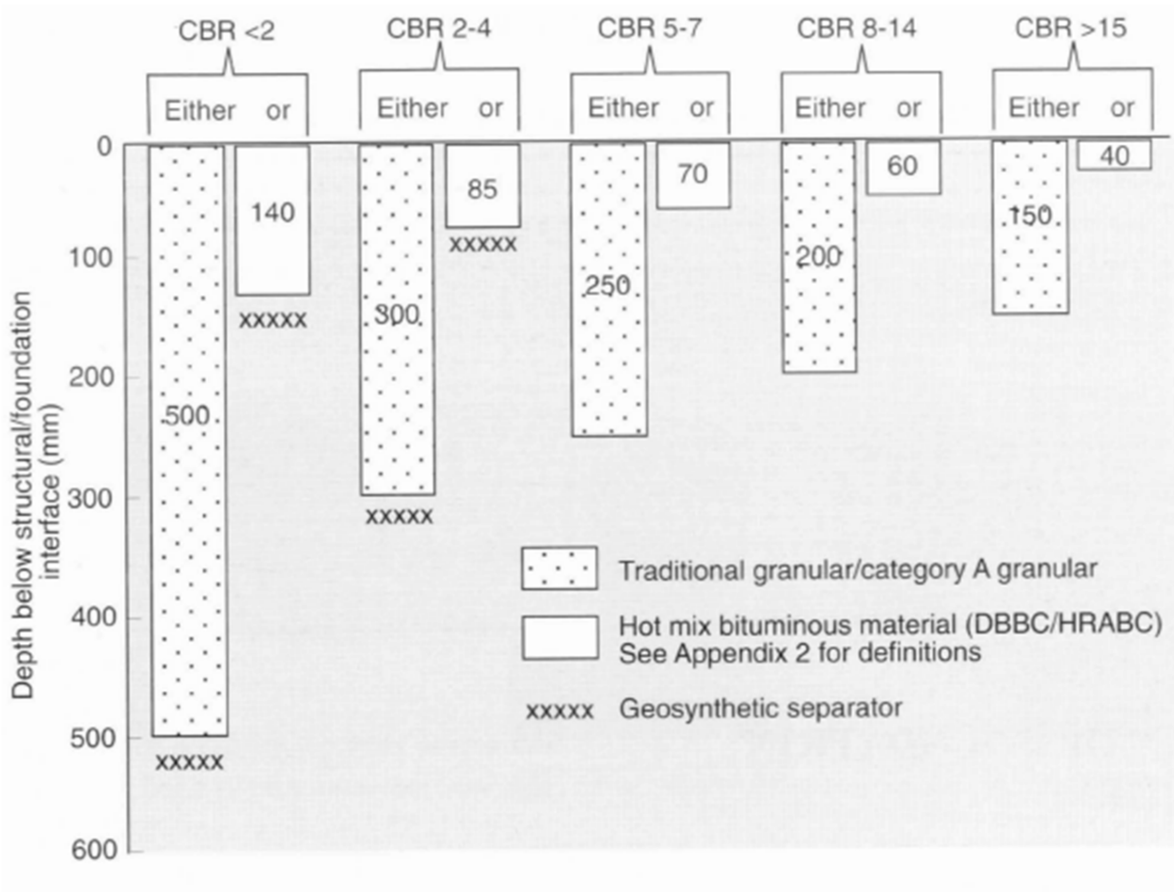


Figure 1.5. Thickness of foundation platform for traditional materials (Potter, 1996)

Table 1.5. Thickness of foundation platform for reusable materials (Potter, 1996)

Re-usable material	Recommended thickness of Foundation Platform (mm)				
	CBR <2*	CBR 2-4	CBR 5-7	CBR 8-14	CBR >15
Category A granular material (100MPa equivalent modulus Appendix 3, Table A3.2)	500	300	250	200	150
Category B granular material (70MPa equivalent modulus Appendix 3, Table A3.2)	625	375	315	250	190
Category C granular material (50MPa equivalent modulus. Appendix 3, Table A3.2). Type 4 roads only	750	450	375	300	225
Granulated bituminous materials complying with recommendations in Appendix 3	500	300	250	200	150
Bituminous planings complying with recommendations in Appendix 3	500	300	250	200	150
Cold in-plant recycled bituminous planings with foamed bitumen	200	120	70	60	40
Cold in-plant rejuvenated bituminous planings	460	280	235	185	140
No fines concrete (recommended for use on Type 4 roads only)	210	130	105	90	60

* Recommended to install geosynthetic separation layer

1.5.2 Assessment of Traffic

When the traffic flow is greater than 70 commercial vehicles per day, the cumulative traffic for a recommended 20-year design life will need to be calculated, enabling a full traffic assessment (Potter, 1996). Appendix 5 of “Road Haunches: A guide to re-usable materials” (Potter, 1996) shows the process for calculating the total design (cumulative) traffic. If a full traffic assessment is not used, Equation 1 can be used for traffic assessment.

$$msa = 9000 \times AADF \qquad \text{[Eq. 1]}$$

Where, msa is cumulative for 20-year life

1.5.3 Design of Structural Course and Surfacing Layers

Table 1.6 shows the recommended materials for the structural course depending on road type (Potter, 1996).

Table 1.6. Materials recommended per road type for the structural course

Road Type	Option	Material
1	1)	Conventional hot rolled asphalt or dense bitumen macadam
	2)	Recycled conventional hot-mix materials containing up to 30% reclaimed bituminous material
2	1)	The materials for road type 1
	2)	Cold in-plant recycled bituminous material using foamed bitumen binder
	3)	Cold in-situ recycling using cementitious or foamed bitumen binder
3	1)	The materials for road types 1 and 2
	2)	Cold in-plant rejuvenated planings using a proprietary rejuvenator
	3)	Category A unbound granular or granular-bituminous materials
4	1)	The materials for road types 1, 2, and 3
	2)	No fines concrete
	3)	Slate or furnace bottom ash

The thickness of the structural course and surfacing layers depends on the road type. The recommended thicknesses for traditional materials, reusable materials, cold-recycled in-plant bituminous materials, and cold-recycled in-situ materials are summarized in Figure 1.6, and Tables 1.7, 1.8, and 1.9 (Potter, 1996).

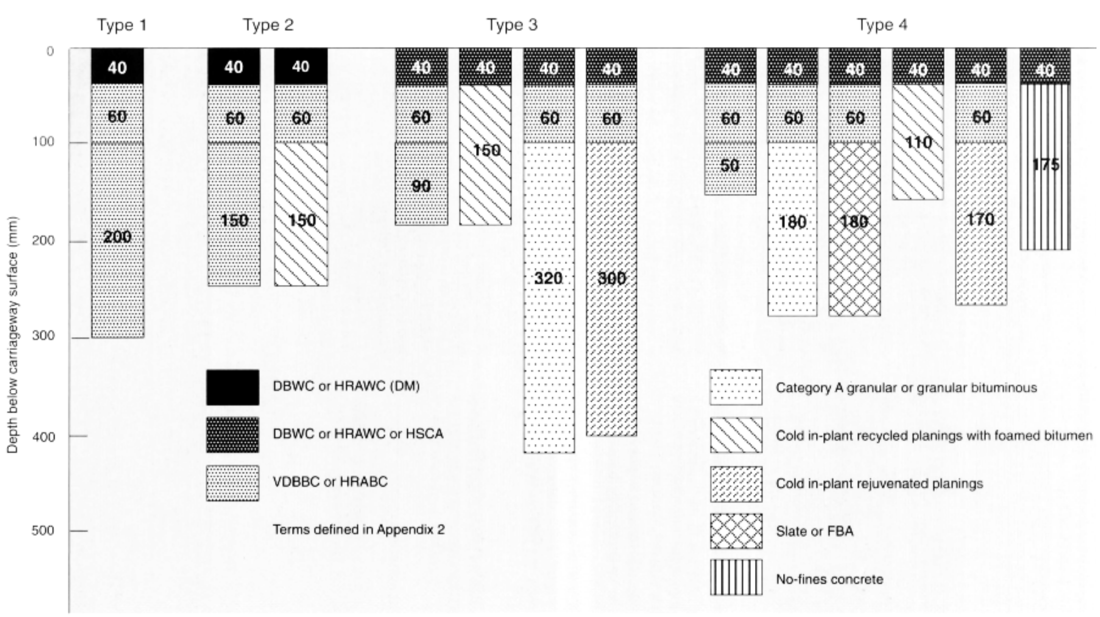


Figure 1.6. Thickness of structural course and surfacing layers per road type (Potter, 1996)

Table 1.7. Thickness of structural course for reusable granular and granular-bituminous materials (Potter, 1996)

Re-usable material	Recommended thickness of lower Structural Course (mm)	
	Type 3 road	Type 4 road
Category A granular or granular-bituminous material materials in trials: crushed quarry aggregates, china clay stent, crushed kerbstones, granulated bituminous materials, bituminous planings	320	180
Slate	not recommended at present	180
Furnace bottom ash	not recommended at present	180

Table 1.8. Thickness of structural course for cold recycled materials (Potter, 1996)

Re-usable material	Recommended thickness of Structural Course (mm)			
	Type 1 road	Type 2 road	Type 3 road	Type 4 road
Cold in-plant recycled bituminous planings with foamed bitumen	not permitted	150 *	150 #	110 #
Cold in-plant rejuvenated bituminous planings	not permitted	not suitable	300 *	170 *
Cold in-situ rejuvenated bituminous planings using diesel	not permitted	not suitable	not suitable	not suitable

* 100mm of dense bituminous surfacing layers required

\# 40mm of dense bituminous surfacing required

Table 1.9. Thickness of combined structural course and foundation platform for cold in-situ recycled materials (Potter, 1996)

Cold in-situ recycling	Depth of recycling (mm)					
	Type 2 road		Type 3 road		Type 4 road	
Thickness of surfacing layers	100mm	140mm	100mm	140mm	40mm	100mm
With foamed bitumen						
Subgrade CBR <2	n/r	n/r	n/r	n/r	n/r	n/r
2-4	n/r	280	250	200	280	195
5-7	n/r	260	230	170	260	185
8-14	300	240	215	160	245	160
>15	270	215	185	130	215	130
Thickness of surfacing layers	40mm	100mm	40mm	100mm	40mm	100mm
With cement						
Subgrade CBR <2	n/r	n/r	n/r	n/r	n/r	n/r
2-4	300	240	240	180	200	150
5-7	280	220	220	160	180	150
8-14	270	200	200	150	160	150
>15	250	200	200	150	150	150

n/r - not recommended unless the subgrade is stabilised before recycling

1.5.4 Limited Space and Slope Stability

If the road widening space is limited, this results in the side slopes being forced to be steeper in order to accommodate the wider road (Varin & Saarenketo, 2012). To improve the slope stability of these steeper side slopes, methods include use of geotextiles, geogrids, steel reinforcement, heavy rip-rap, retaining walls, stepped batters, and an appropriate drainage system. It is important to backfill the old ditch with material equal to the surrounding subgrade and to choose the most suitable type of drainage system for sites with limited space. If the road widening space not limited, trees can be felled to provide more space for gentler slopes.

1.5.5 Embankment Widening

When widening a pavement with steep side slopes, the existing fore slopes should be maintained if the fore slopes fall within American Association of State Highway and Transportation Officials (AASHTO) design recommendations (Hilbrich & Scullion, 2006). Fore slopes can be maintained by borrowing from the back slopes if needed. Guardrails may be needed if fore slopes are steeper than 1V:3H. Some recommendations for successful embankment widening construction include removing vegetation and organic top soil for an adequate construction joint, constructing benches in existing slopes for a good construction joint and compaction of lifts, compacting fills to a minimum dry density calculated from standard Proctor tests, compacting lifts wide enough to accommodate equipment, and considering permeability of existing embankment material and widening material to prevent reduction in shear strength or water from becoming trapped within the embankment. If there are clear zone issues, the road should be built up first and then widened.

During road widening construction, the existing embankment should be excavated parallel with the crossfall, to avoid excavating an insufficient amount of ground (Figure 1.7), which would result in a thinner structure thickness at the bottom side compared to the centerline (Varin & Saarenketo, 2012).

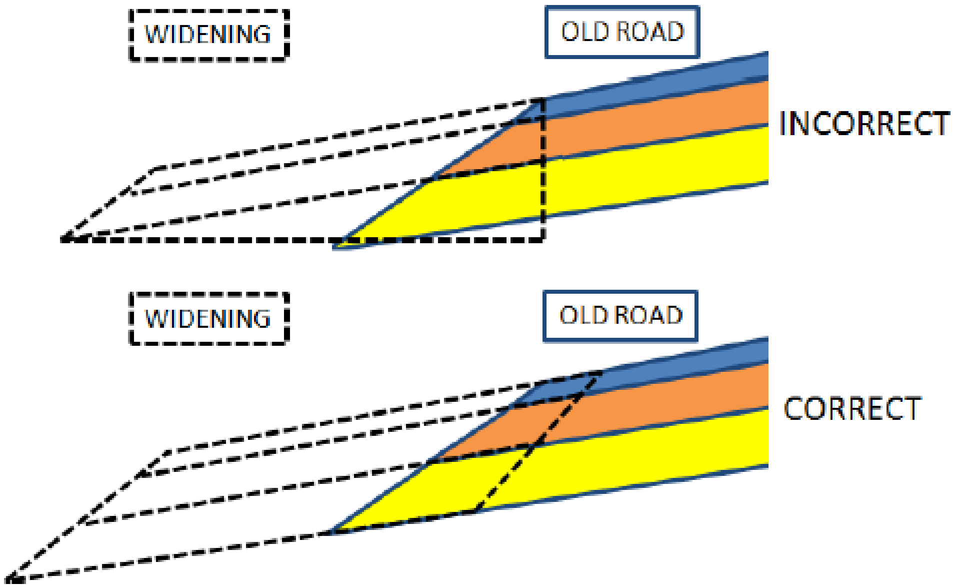
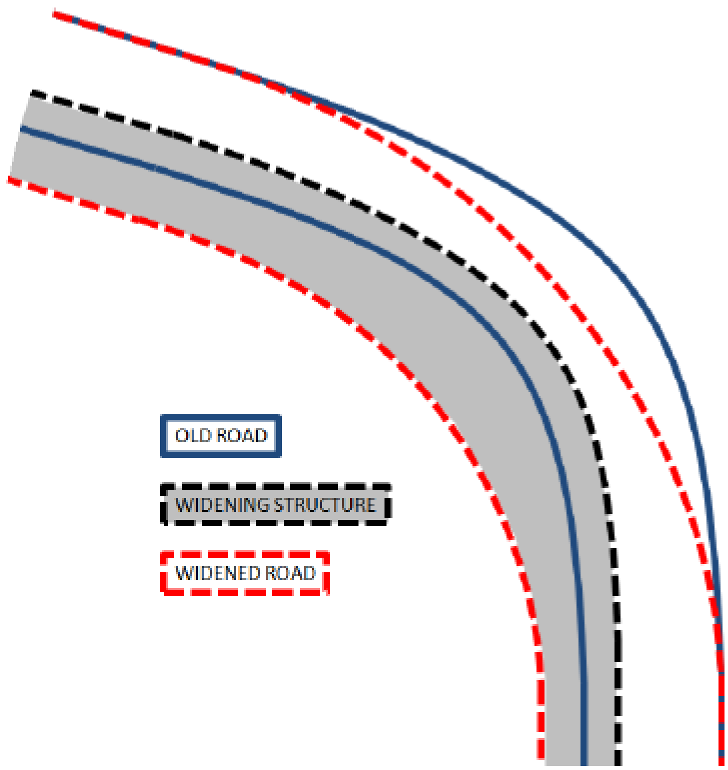


Figure 1.7. Crossfall consideration when excavating the existing embankment (Varin & Saarenketo, 2012)

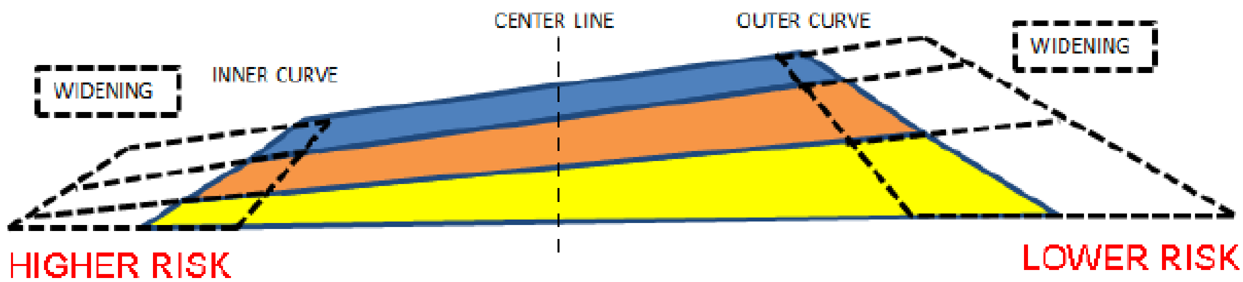
1.5.6 Horizontal Curves

Widening a road gives the opportunity to upgrade the horizontal geometry of the existing road (e.g., improving sharp curves), and in doing so, special attention should be given to the resulting diagonal joints between the new and old pavement (Varin & Saarenketo, 2012). The old road should also be improved at this time.

Because it is often general practice to dimension road structures based on the centerline thickness, this leads to the thickness of the inner curve to be less than the centerline and therefore, widening on the inner curve side of the road will result in higher risk for failures. It is recommended to widen in the inner curve side if the road geometry can be improved at the same time (Varin & Saarenketo, 2012). Figure 1.8 shows the problems associated with widening on a horizontal curve from the (a) plan view and (b) cross-section view.



(a)



(b)

Figure 1.8. Widening on a horizontal curve: a) plan view showing the diagonal joints connecting the new and old pavement, and b) cross-sectional view showing thickness of widening on the inner curve versus the outer curve (adapted from Varin & Saarenketo, 2012)

1.5.7 Old Road Structures

If there is an old structure within the existing pavement structure, its presence should be considered when widening the road (Varin & Saarenketo, 2012). For example, when the old structure below is a gravel road, the old road should also be part of the excavation of the existing embankment; otherwise it will cause the edges to be thinner than the center of the road. When the old structure below is bituminous pavement, the old structure should be removed or crushed and homogenized to prevent reflection cracking above the old pavement edge. Also, solutions that worked in the construction history of the existing road structure could work for the new widened structure.

1.5.8 Frost Action

Differential frost heave between the old road and widened structure can be minimized by including good consistent drainage, installing reinforcement (steel grids or geogrids 20–25 cm/7.9–9.8 in. inside the structure), and ensuring compatibility of the structures (structural thickness, material properties, and degree of compaction of the widening layers) (Varin & Saarenketo, 2012). The rule of thumb recommended in the Northern Europe widening report is this: if the maximum frost heave on the old road is less than 3.9 in. (10 cm), equal widening structures should be enough, and if it is 3.9 in. (10 cm) or greater, the old part of the road should be improved (Varin & Saarenketo, 2012).

1.5.9 Drainage

It is important to maintain a good working drainage system to improve the bearing capacity and prevent frost problems in the road. When widening a road, the drainage system should be continuous from the old to new structure, and roadside drainage should be far enough away so that it doesn't weaken the formation under the new road (at least 25–30 cm/9.8–11.8 in. below the road structure, as recommended by Northern European research) (Varin & Saarenketo, 2012). If space is limited for the road widening, the drainage system should be adjusted accordingly, as an example shows in Figure 1.9.

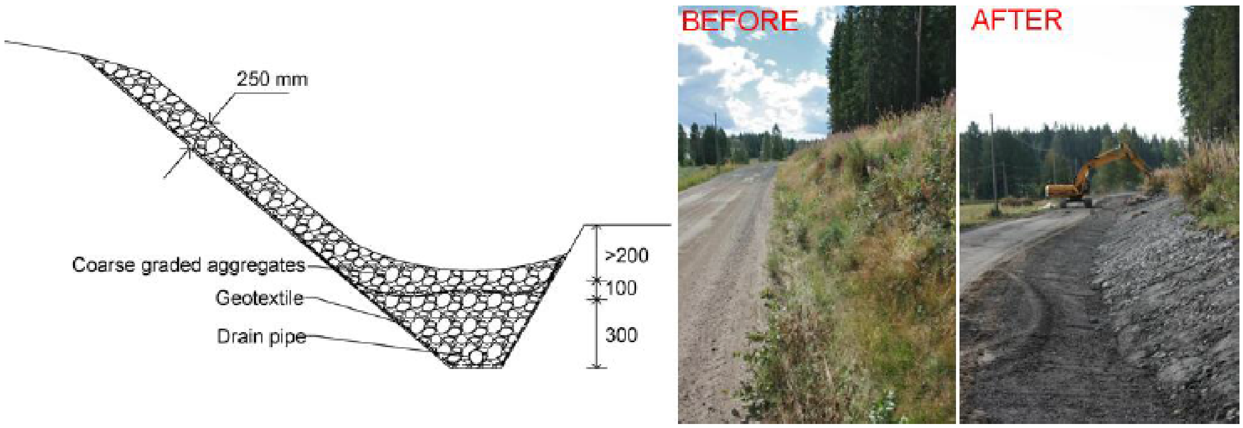


Figure 1.9. An "adjusted ROADEX solution" for a drainage system after road widening in a limited space (Varin & Saarenketo, 2012)

Edge drains should be considered, as moisture could get trapped from the widening operation or in the existing pavement (Hilbrich & Scullion, 2006). The use of edge drains could prolong pavement life and give better pavement performance by lowering the subgrade moisture at the shoulder, increasing the average subgrade moduli, and improving the ride index. For the drainage system to be effective, flow through the pavement layers should be unimpeded, or else the pavement system becomes permanently saturated from plugged subsurface drainage. A borescope or miniature pipeline camera can be used to check the edge drains and outlet pipe for sagging or coupling problems.

1.5.10 Settlement and Compressive Soils

If the road is widened on top of compressive soil, it is important to ensure that both the old and new part of the embankment settle uniformly to prevent uneven settlement and cracking (Varin & Saarenketo, 2012). Possible solutions to ensure uniform settlement on compressive soils include use of preload embankments, geogrids, steel reinforcement, soil replacement down to the hard base, piles, stabilization, and lightweight structures. For deep soft ground, new construction layers should be separated from the subgrade to prevent mitigation of materials that will lead to settlement; this can be done by using a separation fabric.

A cost-effective solution for widening roads over peat is preloading, and this procedure is described in Figure 1.10 (Varin & Saarenketo, 2012). Preloading involves excavating a new ditch, refilling the old ditch, placing a reinforcement geotextile in the widening area, preloading the widening area in increments, and removing the preloading material after the desired settlement is achieved. It is essential to design the settlement time for this process, which involves a geotechnical design engineer estimating the height and duration of the preloading required and the likely predicted settlement. Before the final paving of the finished widened road, the lateral settlement can be reduced by using a temporary pavement and waiting until the traffic has loaded and compacted the widening.

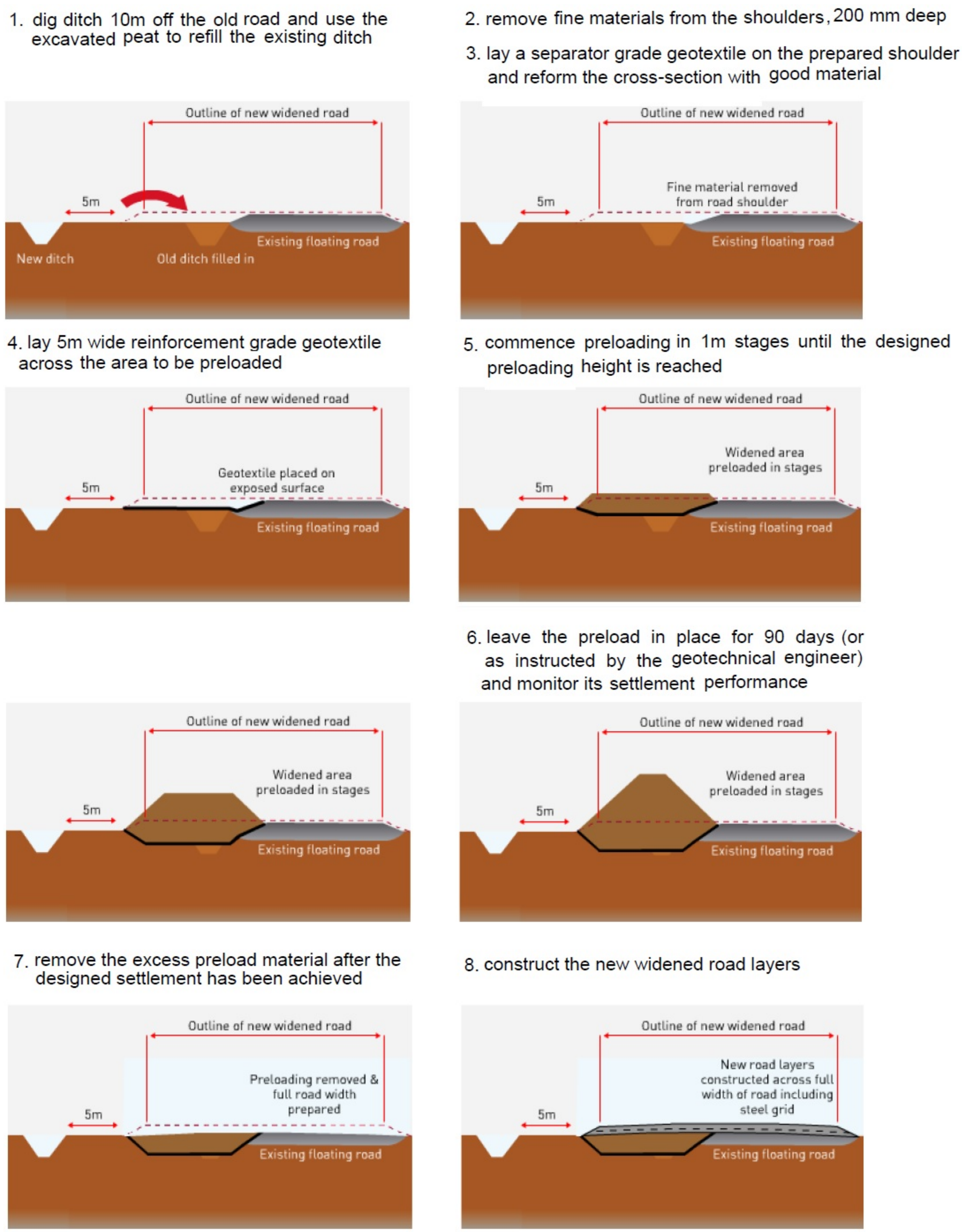


Figure 1.10. The construction sequence for widening by preloading (adapted from Varin & Saarenketo, 2012)

1.5.11 Bedrock

If there are tall masses of bedrock exposed adjacent to the road, the bedrock can be blasted and excavated to provide space for the road widening (Varin & Saarenketo, 2012). After the blasting, resulting aggregate that is of quality may be used for construction, and if exposed rock faces are unstable, rock netting can be used. Non-uniform settlements and frost action can result from the variable-surface of the bedrock. Some solutions to deal with road widening problems with bedrock involve surface reshaping to deal with improper surface water runoff, arranging proper drainage to maintain a low water table within the road, and reducing the width of side drain to reduce cutting of bedrock.

1.5.12 Cross Section Design

When widening a road, it is more beneficial to divide the widening to both sides of the road rather than widening only one side because dividing the work can reduce costs, constrain construction joint cracking and non-uniform settlement to only the shoulder areas, lessen the need for soil reinforcement or additional land, result in smaller deformation, and preserve the two-sided crossfall of the road (Varin & Saarenketo, 2012). Figure 1.11 shows how one-sided road widening could lead to a one-sided crossfall, increasing the chance of a crack forming on the old road centerline due to traffic loading.

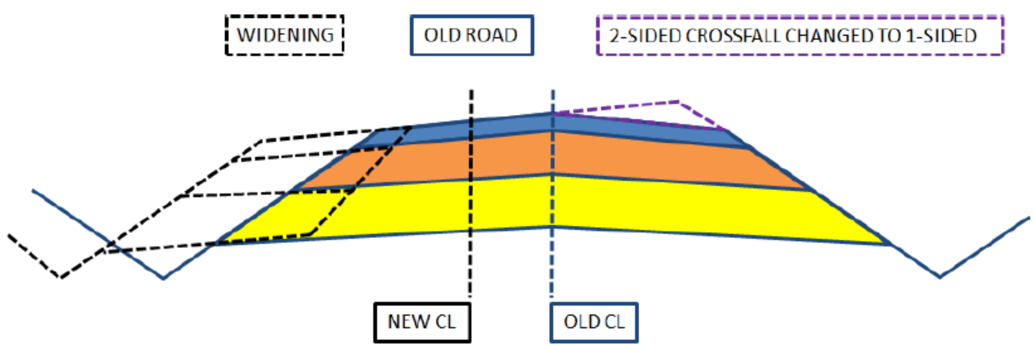


Figure 1.11. Two-sided crossfall changed to one-sided as a result of one-sided widening (Varin & Saarenketo, 2012)

1.5.13 Narrow Bridge Widening

Narrow bridges typically don't get widened unless there is funding available for it or the bridge poses a safety concern (Hilbrich & Scullion, 2006). The determining factors for widening a narrow bridge depend on where the funding is sourced (maintenance funds versus safety bond).

1.6 Construction Best Practices

During construction, it is important to prevent water from entering the structure reducing the bearing capacity of the sub-grade (Potter, 1996). Steps that can be taken to prevent ingress of moisture include pumping out any water from the excavation, rectifying any defects in the drainage system, taking care to avoid formation of a sump or water-trapping barrier against the new construction, using a geosynthetic separator to prevent clay migration from a soft subgrade, protecting materials from weather, and applying an adequate tack coat and edge sealant. The wearing course material of the new construction should match the existing surfacing, and the road markings may need to be updated after a road edge repair.

Figure 1.12 summarizes recommended practices to follow when widening a road (Varin & Saarenketo, 2012). The practices include descriptions of the manner in which the old road should be excavated and how the new and old ditches should be handled. It is recommended that the joint should be angled, stepped, and staggered, and geogrids or steel grids should be used and wrapped with unbound materials to firmly tie the new structure to the old one. The widening structure should not be built too strong, as it will behave differently from the rest of the road.

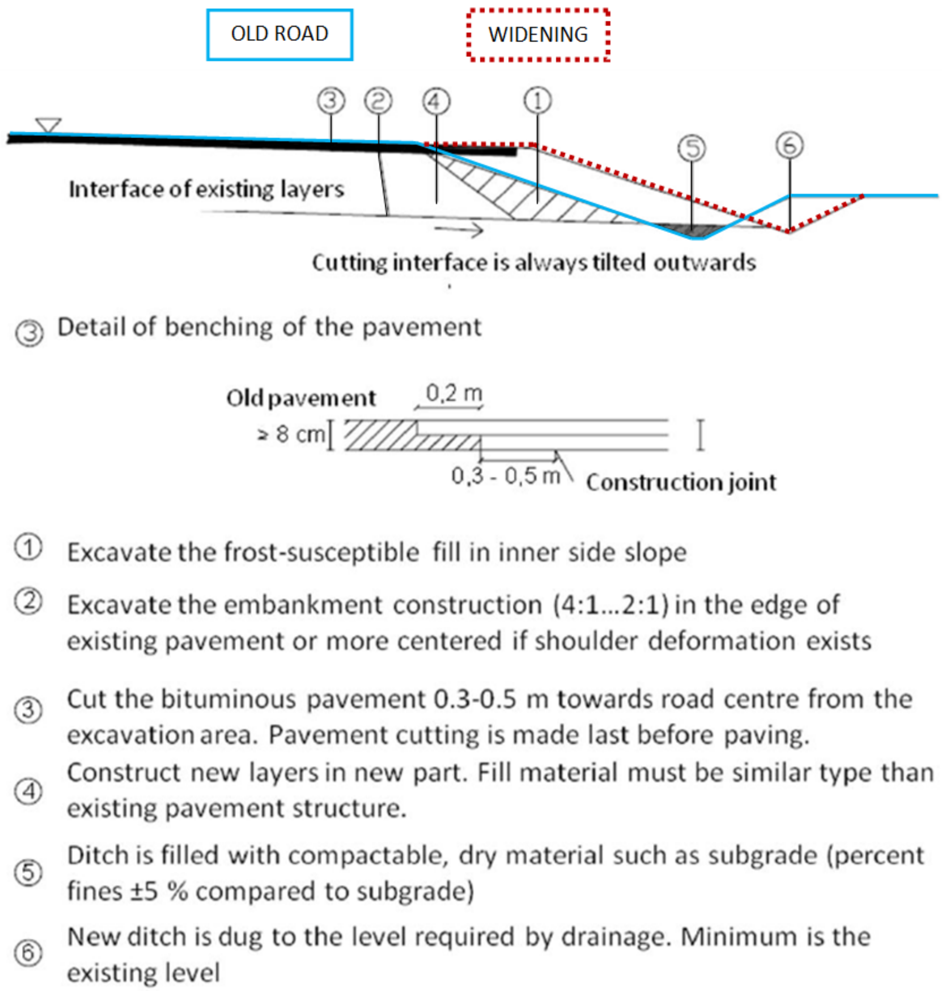


Figure 1.12. Recommended road widening practices for excavating the old road and handling of the old and new ditches (Modified from Varin & Saarenketo, 2012)

1.6.1 Supervision and Testing

Supervisors should ensure that, during road edge repair, materials are tested in accordance with recommended guidelines, compaction requirements are achieved, and the construction is within tolerance levels (Potter, 1996).

1.6.2 Compaction

It is important to have adequate compaction when road widening to prevent post-compaction from traffic loading, rutting, pavement cracking, and non-uniform settlements (Varin & Saarenketo, 2012). Compaction in road edge repair can be difficult due to working with a narrow width, so some steps to adequate compaction include using good quality materials, constructing the structure in several layers and applying a roller per layer, and to design the widening structure wide enough to fit the compaction equipment. Appropriate selection of the compaction equipment and the choice of materials for the structural course and foundation platform can assist the ease of compaction (Potter, 1996). For structural course with bituminous hot-mix material, hot rolled asphalt base course is easier to compact than dense macadam. In-plant recycled bituminous materials using foamed bituminous binder should be compacted in layers less than 200 mm.

Another way to make compaction easier is to cut the joint farther into the existing pavement (Figure 1.13). This way, there is more space to fit the compaction equipment and at the same time, the roadway is still being widened by the same amount. Note that the joint should not be placed under the wheel path to prevent cracking.

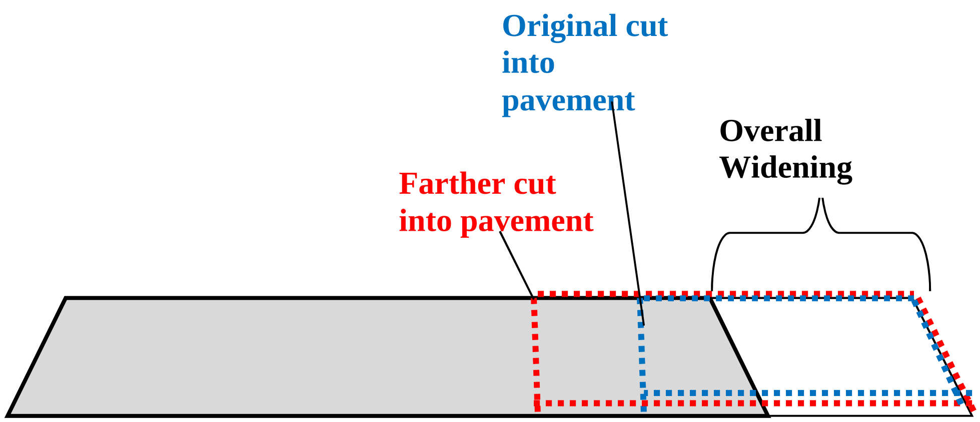


Figure 1.13. Joint position farther into the pavement to fit compaction equipment and get a better compaction result

1.6.3 Longitudinal Joint Construction

In order to minimize reflection cracking over the joint, the construction joint should not be placed under the wheel path, the joint should be stepped between pavement layers, the widening structure should be equal to the old structure, sufficient later transverse support (e.g., geogrids or steel reinforcement) should be ensured, and sufficient settlement time should be given before overlaying (Varin & Saarenketo, 2012).

Four tasks should be followed in order to properly construct a waterproof longitudinal joint (Hilbrich & Scullion, 2006). First, to avoid transverse movement and crack development at the edge, the unsupported edge of the first paved lane should be compacted in the proper position (about 6 in. over the edge of the first lane) and with a proper roller (steel wheel roller is known to be effective). Second, the mix of the second lane (newly placed material) should be overlapped over the top of the first lane (existing side of the joint) by about 1–1.5 in. Third, the mix should be raked off of the first lane and back onto the second lane if an excessive amount of mix is placed over the edge of the first lane. Fourth, the joint between the two lanes should be compacted with the roller on the second lane (newly placed, hot side) and the drum extended about 6 in. over the first lane (previously compacted, cold side). Some alternative construction techniques for joint construction include tapered joints and offsetting the construction joints.

1.6.4 Bituminous Planings

Bituminous planings exhibit some resistance to compaction, so when using them, better compaction can be achieved by compacting in layers less than 5.9 in. (150 mm), compacting when the planings are warm, and compacting at optimum moisture content (Potter, 1996).

1.6.5 Road Furniture and Utilities

Road furniture and utilities (e.g., road signs, guardrails, cables, and pipelines) should be mapped before widening to identify situations such as underground cables that need to be moved or new guardrails that are needed due to steepening the side slopes (Varin & Saarenketo, 2012).

1.7 Traffic Management

During road widening construction, traffic management will depend on the traffic volume of the road (Varin & Saarenketo, 2012). Low volume traffic roads will not need the whole road open during construction compared to high volume roads, which will need at least one lane open at all times or possibly a temporary bypass road built for traffic to use. To ensure the shortest working period possible in order to reduce inconvenience during rush hours involves carefully planned construction steps, selection of adequate resources, well-carried-out pre-design surveys and investigations that prevent unexpected surprises, and small, quickly filled excavations that are marked when sections are closed or open for traffic safety.

1.8 Quality Control

Properties such as structural thicknesses, bearing capacity, road width, and ditch depth can be monitored to verify that the road widening that was planned has been constructed satisfactorily (Varin & Saarenketo, 2012). GPR can be used to verify the final structural layer thicknesses after construction has been completed and compare them to the design thicknesses. The FWD can be used during construction to monitor the strength and compaction of the structural layers, and it can be used after construction to find the final bearing capacity of the widening portion. Video recording can be used to compare the road condition and surrounds before and after rehabilitation, provide documentation for future use, monitor drainage, detect freeze-thaw damages after construction, and collaborate with other surveys. Laser scanners can be used to compare the old road, the design, and the newly constructed road through parameters such as a continuous cross section profile of the road, the angle of the side slopes, the road width, and the ditch depth.

Article 3146.7 *Construction Methods* provides some specifications that can be used to evaluate longitudinal joint density (Hilbrich & Scullion, 2006). If a nuclear density gauge reading at 8 in. from the mat edge (which will become a longitudinal joint) is more than 3 lbs/ft^3 below the interior mat density reading, the evaluation fails. Two joint density evaluations need to pass after 2,000 linear ft of pavement has been placed. If they do not pass, the contractor needs to continue to make changes approved by the engineer until a placement of 2,000 linear ft of pavement passes the joint density evaluations.

1.9 Equipment

Some equipment or methods used during the construction of trench widening include using modified blades for trenching, using milling machines for trenches, compaction of trenches, tacking the vertical face of edges, and laying the trench mix ("Pavement and Trench Widening Workshop," VDOT).

When adding a narrow shoulder to an existing pavement, it is difficult to meet density requirements without the right equipment. Narrow rollers also result in difficulty with meeting density requirements because of their lighter weight, but one solution can be to reduce the lift thicknesses to 4 in. (Hilbrich & Scullion, 2006). Some rollers that are available in Texas to compact narrow shoulders are Hamm Model 2220 D, Hamm Model 2222 DS, Dynapac CC-122 Tandem Roller, Caterpillar CP-323C, and BOMAG BW124 Series. If the widening is around 2 ft, the rear tandem of a fully loaded 6-ton dump truck can be used to meet density requirements.

A study in Utah compared the bond strength between saw-cut joints and scarified joints in asphalt pavement patch repair (Woffinden et al., 2005). The scarified joints were created using a portable asphalt recycling machine that cuts and pulverizes the asphalt concrete, leaving a rough surface to the vertical cut. The saw-cut method leaves a smoothly sawn vertical face at the joint. After testing cores from patch joints before and after winter freeze-thaw cycling, the adjusted average strengths of the scarified cores were 20.8% and 25.1% higher than the corresponding strengths of the saw-cut cores before and after winter, respectively. The study found that a scarified face improved patch joint bond strength for all compaction densities, and the importance of proper compaction during construction increases as the joint ages. The quality of the interface between the existing pavement and the newly installed patch material has a significant impact on the performance and maintenance costs of the road, so it is important to ensure a strong interlock at the joint between the new and old material.

Some examples of possible equipment options are shown in Appendix A.

1.10 Other Reference Material

VDOT officially adopted a pavement widening standard (WP-2) in 2008 ("Pavement and Trench Widening Workshop," VDOT). Major features of the standard include constructability, clarity, flexibility to meet field conditions, applies to full lane additions, and uniform joint details regardless of existing pavement thickness. The standard notes that the pavement design for an asphalt widening should meet or exceed the depths and types of layers of the existing pavement. Subsurface drainage of the existing and proposed pavement should be addressed in the pavement design. At least three cores, spaced no more than 500 ft apart, should be taken along the center of the adjacent travel lane to determine the type and thickness of the existing pavement layers. It is recommended that the adjacent travel lane be milled to at least 1½ in. and replaced with an asphalt surface course to match the pavement asphalt surface course. The milling depth may be adjusted to achieve an acceptable pavement cross slope and effective surface drainage.

1.11 References

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Chapter 2. In-Person and Telephone Interviews

This chapter presents the interviews conducted by CTR personnel on narrow-widening of flexible pavement projects. The purpose of conducting the interviews was to learn about equipment, materials, methods, and best practices used for flexible pavement narrow-widening projects, and to gain insight into the interviewees' personal experiences in dealing with this type of project.

The interviewees fall into one of three main categories:

1. TxDOT personnel
2. Contractors
3. Equipment or material manufacturers or suppliers

Three different types of questionnaires were prepared, corresponding to the above-mentioned categories. However, those questionnaires served only as guidelines for the interviewers, as there was a wide variety and flexibility in the way the interviews were performed. Some were done on the phone, with several CTR researchers asking questions of TxDOT district staff members, contractors, or people related to the equipment industry. Other interviews took place during site visits in which the interviewees demonstrated projects or equipment to the researchers (Figure 2.1). The last type of interviews took the form of presentations made to the researchers by the equipment or material manufacturers at the CTR offices.

2.1 Interviewees

Following is the list of interviewees:

- TxDOT District Personnel
    - Austin – Mike Arellano, Lowell Choate, Cody Chambliss

      Conducted on February 13, 2013, at the Austin District Office by Mike Murphy, Andre Smit, and Manuel Trevino
    - Bryan – Terry Paholek

      Conducted on January 8, 2013, as a teleconference with Mike Murphy, Andre Smit, and Maria Burton
    - El Paso – Tomas Saenz

      Conducted on January 25, 2013, as a teleconference with Mike Murphy and Andre Smit
    - San Angelo – Tom Johnston, Donald Peterson, Lewis Nolan

      Conducted on January 30, 2013, as a teleconference with Mike Murphy, Andre Smit, and Maria Burton
    - Waco – John Jasek, Ali Bashi, Don Miller, Darren Poe, Jacob Chau

      Conducted on January 31, 2013, as a teleconference with Mike Murphy, Andre Smit, and Manuel Trevino

- Atlanta – Miles Garrison

  Conducted on May 2, 2013, as a teleconference with Andre Smit

- Contractors
  - MidState Equipment/ North Carolina Contractor – Sandy Grey

    Conducted on January 29, 2013, as a teleconference with Mike Murphy, Andre Smit, Maria Burton, and Manuel Trevino

  - Barrett Paving Ohio Contractor – Donald Cash, Mark Barnes, Elisa Holden

    Conducted on January 29, 2013, as a teleconference with Mike Murphy and Manuel Trevino

  - Allen Keller Company – Kory Keller

    Conducted on March 6, 2013, as a site visit to company offices in Fredericksburg and project sites in the San Angelo District, attended by Andre Smit, Maria Burton, and Manuel Trevino

- Equipment Manufacturers or Suppliers
  - Roadtec – David Zuehlke

    Presentation at CTR on February 1, 2013, attended by Jorge Prozzi, Mike Murphy, Maria Burton, and Manuel Trevino

  - HOLT Caterpillar – Dale Layne

    Conducted on December 19, 2012, as a site visit, attended by Mike Murphy, Maria Burton, and Manuel Trevino

  - Cooper Equipment Company – John Houston

    Conducted on November 20, 2012, as a site visit, attended by Mike Murphy, Maria Burton, and Manuel Trevino

  - Tencate Geosynthetics – Mike Samueloff, Brett Odgers, and Katie Strain

    Presentation at CTR on March 1, 2013, attended by Jorge Prozzi, Andre Smit, Maria Burton, and Manuel Trevino

Figure 2.1. CTR researchers during a site visit

2.2 Highlights

This section showcases some of the salient findings of the interviews, presentations, and site visits. These highlights represent important insights provided by the interviewees that can be applied to these types of projects. Full details of the interviews conducted are in Appendix B.

2.2.1 Bryan District

This district has implemented a policy to widen roadways by scarifying the existing roadbed, spreading out the material, placing and compacting new base material and then placing the surface. This method eliminates the joint line. Therefore, they perform full-depth reclamation (FDR) as opposed to narrow-widening projects because the district obtains a better quality road. This approach also enables the contractors to use full-size construction equipment, which makes their job easier as well. FDR costs are similar to those of a widening project. This type of construction does not increase the structural capacity of the roadway, but is intended to provide a higher quality, more uniform widened section of similar structural capacity to the original roadway.

When they did conduct narrow-widening projects, they tried out the Asphalt Zipper, but got better results by using a BOMAG scarifier, because the Zipper lacks self-propulsion.

When they used to do narrow widening, they found problems working within the narrow-widening section and would often need to widen the trench section out to 4 or 5 ft., attempting to get more space to work. They had also problems getting good compaction against the face of the existing pavement.

Another important issue is traffic control: the road remains open to traffic and the trench section must be filled with material by the end of the work day. This constrains the contractors in how much trench section can be opened in a day—they at least must have the un-compacted base placed in the trench by the end of the work day.

2.2.2 Austin District

When performing the cut in the existing pavement, a rough texture is better than a clean cut, as it provides better interlock. The depth of the cut is from 6 in. to 2 ft., depending on the job requirement, and it is done with a 1:1 slope, rather than vertical. This sloped cut is more stable than a vertical cut.

When using machines such as the MidState, they are concerned about getting the right compaction. Consolidation is a big issue.

The District uses geotextiles in those projects that have high PI clay (e.g., SH 21).

They want to create a stable subbase and stabilize it with the geogrid. The system is still flexible.

2.2.3 Waco District

On roadways that have structural problems and narrow ROW, they use flex base and cement-treat it. If it is too narrow to place and compact the flex base (4 ft. or narrower), they use hot mix.

2.2.4 Cooper Equipment

The most difficult challenge in this kind of project is trying to build a pavement that is only 4 ft. wide. Such a narrow structure is inherently weak. One way to get around it is to extend the widening to the inside, i.e., make it 4+4-ft wide, or if the money is available, repave the original lanes as well, at the same time.

Sometimes it is even advisable to construct the additional width (to the inside) for free, so as to minimize construction problems as well as to eliminate the weak joint.

2.2.5 Roadtec

Some contractors in the eastern part of Texas own road-widener devices (e.g., a Midland or a Weiler). The equipment does not get much use because TxDOT does not let a stable flow of widening projects. It is not very profitable for a contractor to buy a specialized piece of road-widening equipment without a stable flow of work. In the north and west part of the state, few companies own this type of equipment. Traditionally, there have been more widening projects east of IH 35.

2.2.6 Allen Keller Company

TxDOT gives the contractor typical sections, and gives them flexibility to make the decisions based on what is actually there on the road, which may not be represented accurately or entirely on the plans. This approach allows them to use their experience and their judgment to do a better job.

For some roads that are in bad shape, widening the edges is not advisable.

They use base material, rather than hot mix, because it is less expensive, can be constructed in all seasons, and can be mixed off-site. For them, this has represented savings of between $50,000 and $70,000 per mile on previous jobs.

When the existing subgrade is in failing condition, the better approach is to cut and replace it with extra base or cement-treated base.

They own a Roadtec machine for milling (Figure 2.2), which they have found extremely productive. In recent jobs in Real County, it helped them finish ahead of schedule. They found it more advantageous than both the Asphalt Zipper, with which the cross-slope cannot be controlled, and the Midland Road Widener, which spills the material.

Figure 2.2. Allen Keller's Roadtec milling machine

Their jobs don't require geotextiles, because Keller performs widening jobs only in an area (e.g., the San Angelo District) where the soil does not have too much moisture. The presence of heavy clays might warrant use of geotextiles.

2.2.7 Tencate Geosynthetics

They manufacture pavement interlayers that make use of fiberglass technology to alleviate longitudinal joint problems in this type of project. The geogrids also help stabilize the soil and eliminate differential settlements. Some of their products have wicking capabilities, so the water stays in the fabric rather than on the subgrade and base layers, and the fabric moves the moisture horizontally. An example of the use of these products is the test project on SH 21 between Old Potato Road and US 290 in the Austin District.

2.3 Final Remarks

By far, the most common problem that occurs in narrow-widening projects is the appearance of distresses at the longitudinal joint between the existing pavement and the newly widened structure. It happens frequently because the joint normally falls on the wheel path, where high stresses are present. One way that districts and contractors deal with this issue is by avoiding construction of narrow-widening projects altogether, performing FDR instead. The Bryan

District, for example, has chosen this approach; for them, the costs for both options are similar, but the quality of the product they get is much higher with the FDR.

Another way to avoid the appearance of distresses at the joint is by cutting more than just the width necessary to widen the road into the existing pavement. Besides moving the joint to a position where it is not subjected to the high stresses of the wheel path—and therefore, a position where it is not so critical—the contractors gain the advantage of having a little more room to maneuver, and they can even use larger equipment that will perform better. Sometimes the additional cost is absorbed by the contractors, who are willing to do so in order to avoid the subsequent appearance of failures at the joint.

The cuts into the existing pavement are made with a wide variety of equipment. There is no general consensus as to which type of equipment is better. It is a matter of preference by the contractors, which is generally based on their own experiences with certain brands, models, and machine designs.

The equipment industry has developed very specialized equipment specifically designed for narrow-widening projects. These machines are capable of performing the various narrow-widening tasks, offering optimal performance. A few contractors own such equipment—typically the contractors that frequently perform this type of job are able to afford acquiring specialized equipment, and they find it convenient and cost-effective. However, they appear to be a minority. Some other contractors that do narrow-widening jobs only occasionally do not necessarily have to own specialized equipment, and they can manage to do the work with whatever equipment they have available.

Among the district and contractor interviewees, the most frequently used traffic control method in narrow-widening projects is a pilot vehicle. This procedure seems to work well for rural roads with minimal traffic. For busier roads, such as state and US highways, more sophisticated methods of traffic control seem to be necessary. For all the districts and contractors interviewed, traffic control and safety are foremost priorities.

A critical aspect of narrow-widening projects is the need to bring the road surface to a drivable condition by the end of each working day so that traffic can use the road even if it is not completely finished. This timing constraint, as well as the speed and capacity of the equipment, limit the daily progress of construction.

A few innovative techniques and systems utilized elsewhere, mainly in Europe (e.g., flowable fill, precast blocks of pavement for the widened section), are unfamiliar to most of the interviewees, and for the most part, were deemed not feasible or practical for local projects due to their presumably higher costs.

Geotextiles can be conveniently used in widening projects for drainage and soil stabilization. Their use could be necessary where the soil conditions warrant it, such as for the wet soils and swelling clays of east Texas.
None of the districts interviewed had specifications that are consistently used for this type of project.

2.4 Interview Acknowledgements

The 0-6748 project staff wishes to acknowledge the invaluable contributions provided by everyone who generously shared their knowledge, experience, and time during these interviews for the benefit of this research.

Chapter 3. Webinar Workshop—Expert Opinions

This chapter presents a summary of the two half-day workshops/webinars that took place at CTR on July 2, 2013. The purpose of the workshops was to obtain expert opinions from TxDOT personnel, contractors, and construction equipment and materials manufacturers with experience in pavement widening projects. For logistical and practical reasons both workshops were conducted on the same day.

The workshop was conducted to facilitate face-to-face participation for those who could travel to Austin; the webinar component was added to increase the participation of those who could not attend due to limited travel budgets or time restrictions. The morning workshop focused on contractors and suppliers presenting their experience while the afternoon workshop focused on TxDOT experience. The details of the workshops and the workshop materials follow:

3.1 Workshop Webinar 1: Contractors and Suppliers Experience

The participants in the morning workshop included contractors, construction equipment and materials manufacturers and suppliers, and construction industry representatives. This workshop focused on construction methods and considerations; practical problems encountered during construction of narrow widening projects; modified or specialized equipment that has been successfully implemented; and suggested improvements to construction plan details, specifications, and standards. Discussion topics and points included the following:

a. It would be beneficial in terms of project costs and construction duration for TxDOT to standardize widening project designs to fit the sizes and widths of existing equipment and materials (geotextiles, geogrid, etc.). Improve preliminary project testing to ensure that information such as pavement thicknesses and material types are up to date.

b. Milling machines provide an excellent joint cut face that is clean and uniform. They also remove the scarified material from the cut trench and place the material into a dump truck using a conveyor system; and allow for adjustment of the cut width and depth depending on the machine type and size. In addition, milling machines can cut the trench along the entire length of the project as required by some districts or can stop the milling operation at drives or intersections, climb out of the trench, and cross to the road to begin the trench on the opposite side. Districts currently use both of these widening methods depending on circumstances.

c. TxDOT currently sets the maximum construction distance at 1 mile for widening projects. Some contractors might be able to successfully construct more than 1 mile per day. It is recommended that TxDOT consider allowing the contractor to demonstrate their equipment and capabilities to maximize construction efficiency.

d. TxDOT does not let a steady number of widening projects for statewide letting. For this reason, some contractors might be reluctant to invest in specialized equipment for constructing road widening projects, although the equipment could improve construction quality and efficiency.

e. TxDOT has successfully used geotextiles, fabrics, and grids to reinforce subgrade and base courses. However, placement of these materials varies from district to district. TxDOT may want to consider further studies to evaluate the best placement of these reinforcing materials within the pavement structure.

f. No guidance is provided regarding placement of geogrid or fabrics with regard to the vertical cut face of the widening section or overlap into the adjacent existing lane. It is suggested that further study address the benefits of wrapping the grid or fabric over the joint face and providing overlap within the lane to strengthen the joint and reduce the potential for reflective cracking.

g. When constructing the widened section using a Weiler or Midland road widener, it is unclear whether the contractor should set the widener screed at an elevation that places an additional thickness of material to allow for compaction and densification of the base layer. Further guidance is needed in this regard.

h. Manufacturers make narrow width steel wheel or pneumatic tired rollers that can fit in a narrow widening section to properly compact the subgrade and each subsequent pavement lift. Further study is needed to identify the appropriate type and weight of these smaller rollers, considering that the contractor will want to make use of this equipment for other applications.

i. Widening the pavement with asphalt-stabilized base (ASB) is preferred by many districts and contractors since this material is easy to place and compact and can be opened to traffic at the end of each day's construction. However, TxDOT design guidance warns that ASB should not be placed full-depth against a flexible base layer due to blockage of sub-surface drainage. A test site has been constructed on SH 21 in the Austin District to investigate the use of drainage layer fabric placed under a 3-in. stone base layer to accommodate drainage under the ASB base layer. Further study and monitoring of this and similar sites are recommended to determine the value of this installation.

j. The contractors and equipment suppliers requested additional information regarding the average widening amount on TxDOT projects, including the distribution of widening sections. This information would be helpful in determining equipment sizes during purchase.

k. Additional guidance is needed regarding the optimum moisture content of various base types for use in geogrid applications.

3.2 Workshop Webinar 2: TxDOT Experience

The participants in the afternoon workshop included personnel from TxDOT and other transportation agency and industry representatives. The afternoon workshop focused on design considerations, design details, standards and specifications, and construction problem areas and solutions. Discussion topics included the following:

a. Some districts have found that the cost of constructing a full-depth reclamation of the entire roadbed is from 15 to 22% higher than constructing a narrow widening section on each side of the roadway. Though slightly more expensive, full-depth reclamation results in total rehabilitation of the roadway and eliminates the widening joint lines and potential variability in material stiffness and moisture contents, which improves construction quality and pavement performance.

b. TxDOT funding guidelines for Category 8 (CAT-8) Highway Safety Improvement Program (HSIP) funding may restrict best practices for widening projects. There is some confusion and disagreement whether rehabilitation of the existing lanes can be performed using CAT-8 funding during a widening project. For this reason, deteriorated roadways might be selected as widening project candidates, although deteriorated roadways are better candidates for full-depth reclamation or rehabilitation (including lane widening). Further study is needed to clarify the selection criteria for HSIP criteria and funding.

c. Variations among districts regarding materials, climatic conditions, truck loading, and average daily traffic suggests that a more detailed study of recommended, standardized designs is needed to address these variations while providing consistency.

d. Variations from district to district occur regarding whether projects are constructed through statewide letting by contractors, through routine maintenance contracts or by state maintenance forces. Due to variations in available equipment, materials, personnel, and other factors, the resulting variability in construction quality and performance of widening projects may occur. Further study is needed to determine how resources can be made available to all districts to ensure the best quality and performance of widening projects.

e. Approximately 40,000 center line miles of FM roads exist on the state system. A large percentage of these roadways have narrow 9-, 10-, and 11-foot lanes and often do not have a paved shoulder. Districts in which oil and gas exploration is occurring are experiencing increased problems with pavement failures, rutting, edge-drop offs, cracking, and related distresses, raising concerns about safety and pavement structural capacity.

f. Pavement widening projects funded with CAT-8 money do not qualify for structure widening. This limits the ability of the district to provide the safest possible road cross section and clear zone widths in some cases. Further consideration should be given to the criteria and conditions established for HSIP funding for widening projects.

g. Some districts have purchased milling machines to construct narrow widening projects and to perform other functions in the district. Further consideration should be given to the value of purchasing self-propelled pavement widening equipment for maintenance sections to further expand in-house capabilities.

h. Further consideration should be given to the use of a water truck to control dust during construction. Often water trucks will spray the base material after placement in the trench, which might result in higher-than-optimum moisture content just prior to surface or prime placement. Higher-than-optimum moisture contents might result in later settlement, rutting, or dry land shrinkage cracking as the base dries out and/or moisture is drawn from the widened section into the existing pavement and subgrade layers.

i. Further study is needed to evaluate the use of dust palliatives during full-depth reclamation and narrow widening projects to hold down dust and enhance safety. Contractors use motorized brooms on certain projects to remove dust after base placement, causing dust clouds that obscure the roadway and may cause safety concerns for traffic and construction workers within the work zone.

j. Further work is needed to evaluate the specific mechanisms that cause cracking of the joint line within a narrow widening project. Failure of the joint line can occur due to poor joint construction, traffic loads, dry land shrinkage cracking, or a combination of these factors. Quite often extensive and continued maintenance activities are required to address joint failure problems.

k. The most common joint design is a vertical cut joint face at the pavement widening line. Further study is needed to determine if other designs that involve tapers or a stepped construction might improve joint density and reduce the potential for reflective cracking. However, the joint design should also address contractor equipment capabilities and construction efficiency.

3.3 Workshop Presentations and Materials

Six presentations were made in the morning workshop and another six presentations were given in the afternoon workshop. In addition, a recap discussion took place at the end of the afternoon workshop. To start the workshop, the first presentation was given to introduce the topic of narrow widening and explain the purpose of the workshop. Morning presentations included perspectives from RoadTec (equipment manufacturer), APAC (contractor), Allen Keller (contractor), and Tencate and Tensar (geosynthetic materials manufacturers). Presentations during the second workshop included perspectives from TxDOT's Austin, Waco, San Angelo, Bryan, and Atlanta Districts and an overview of pavement widening equipment. The final portions of the workshops were reserved to recap and further discuss important issues identified during the presentations.

3.4 Summary and Conclusions

The workshops were organized to obtain opinions and additional knowledge about narrow widening projects from experienced professionals involved in the construction, equipment, materials, and design aspects of these projects. Presenters came from different areas of Texas; some suppliers came from out of state.

During the workshops, knowledge was shared on the types of equipment available for narrow widening projects and the advantages and disadvantages of different equipment pieces. The size of the equipment used should match the work being done, and there are different options for the different types of work. For example, to cut the joint of the existing pavement, a milling machine or a road saw (attached to a skid steer or front end loader) could be used. To spread the base material, a road widener (self-propelled or non-self-propelled) or a belly dump could be used.

Geosynthetic manufacturers discussed the products they offer that could be used for narrow widening projects. In particular, they emphasized how geosynthetics could help provide reinforcement for the road and retard movement of cracks rising to the surface. Geosynthetics could also help with drainage issues. Participants noted the lack of standards for the use of pavement inter-layers, and indicated a study is needed.

Contractors and TxDOT representatives from District offices shared their current practices that work well, as well as lessons learned from experiences that did not provide acceptable results. Flex base was compared to ASB in multiple presentations: flex base is cheaper and allows better drainage, but ASB is faster (allowing the traffic to return to the road sooner) and reduces dust. A pilot car is usually needed for narrow widening projects, as the narrow width presents a safety issue. Some solutions for narrow widening issues depend on the source of funding (safety versus rehabilitation funds).

In summary, the workshop/webinar met the project objectives. According to the sign-in sheet and number of webinar logins, 17 individuals attended the workshop in person and an estimated 70–90 TxDOT personnel attended all or a part of the webinar through the TxDOT Webex system.

Chapter 4. Assessment of Alternatives

This chapter presents an assessment of widening options based on facts and information assembled from the literature review (Chapter 1), interviews (Chapter 2), and the webinar workshop on expert opinions (Chapter 3). Current best practices and case studies were analyzed and compared to help determine potential impacts of existing conditions when the widening project was designed and the widening project performance after completion. The following analyses were performed:

- Identify and apply factors to categorize widening projects based on criteria such as average daily traffic (ADT), number of trucks, current lane width, route type, structural condition, soil and base type, and other factors identified in Chapters 1, 2, and 3.
- For each of the different categories, identify potential widening options based on project existing conditions, historical widening project performance, and constructability. The historical performance factors include ride, fatigue cracking, longitudinal cracking at the joint, rutting, edge failures, bleeding, and other factors.
- Determination of the cost-effectiveness to achieve project goals (e.g., B/C ratio).

The Plans-On-Line archive was accessed to develop a broader perspective of the types of widening projects and challenges that have been experienced. The research team explored the types of widening projects and methods that have been implemented in relation to project performance. Recently constructed and projects that have been in service at least 5 to 10 years were included in this effort. Examples of typical sections for widening projects are shown in Appendix C.

Based on the case study comparison, widening options that are 'good performers' are identified for a given scenario. As a result of these assessments, best practices and a proposed draft specification and design details for various widening scenario were developed. Moreover, lessons learned from the case studies are summarized, detailing the potential for effectively preventing widening challenges.

4.1 ADT

4.1.1 Flex base vs. Black Base

Often the contractor does not have the option of choosing the base material; however, black base from a hot-mix plant is preferred by some contractors, as it is quicker, gives a better ride, and gets the public back on the road sooner (helpful for high ADT situations). For low ADT situations, flex base is often a better alternative, as it will save in material costs.

4.1.2 Traffic Management

During road widening construction in Northern Europe, traffic management will depend on the traffic volume of the road. Low volume traffic roads will not need the whole road open during construction compared to high volume roads, which will need at least one lane open at all times or possibly a temporary bypass road built. To ensure the shortest working period possible in order to reduce inconvenience during rush hours involves carefully planned construction steps, selection of adequate resources, carefully deployed pre-design surveys and investigations to prevent unexpected surprises, and small, quickly filled excavations that are marked when sections are closed or open for traffic safety.

On the FM roads in East Texas, traffic control can be difficult because of the narrowness of the existing roads. For sections where the road has curves and line-of-sight issues, a pilot car is used. For sections that are flat, only a flagger station is needed.

Figure 4.1 shows one of the traffic control setups for the FM 1414 project in East Texas when the ADT is less than 2000. R1-2 "YIELD" sign traffic control may be used on projects with approaches that have adequate sight distance. For projects in urban areas, work spaces should be no longer than one half city block. In rural areas on roadways with less than 2000 ADT, work spaces should be no longer than 400 ft.

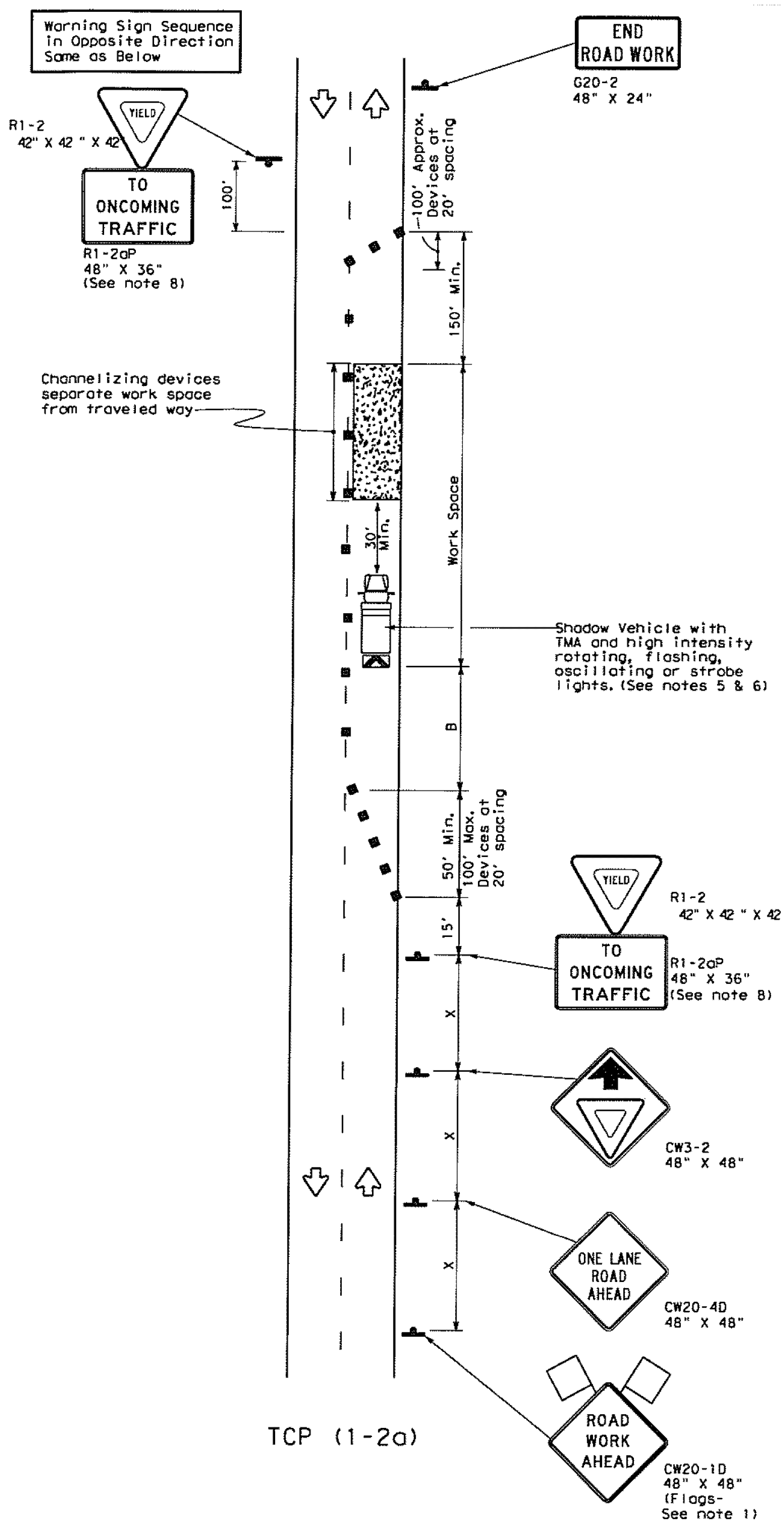


Figure 4.1. One-lane two-way control with yield signs for less than 2000 ADT (FM 1414 Project Traffic Control)

On roadways that are being widened using a full depth reclamation (FDR) approach, which involves re-working the pavement structure across the entire width, more extensive traffic control measures may be required. Figure 4.2 shows a narrow widening project being constructed using full-width FDR in the San Antonio District, Frio County, on FM 1582. Flaggers and a pilot car were used on this project. Note that due to extremely dry conditions and open base, the traffic can barely be seen in the opposing direction, as Figure 4.3 attests. The flaggers and pilot car driver must work closely to ensure heavy trucks and other traffic can pass safely through the construction zone without striking equipment, workers, or other vehicles.

Figure 4.2. Traffic waiting at the flagger position and ready to be led by the pilot car

Figure 4.3. As the vehicles pull forward, three heavy oil field trucks appear that were obscured by the dust

Narrow widening projects may intersect other roadways, which can introduce additional challenges for traffic control. The project depicted in Figure 4.4 on FM 535 in the Austin District is in fact a narrow widening project, but additional lane width has been provided as the roadway approaches an intersection. This project involves widening of the approaches and realignment of the intersection with FM 20. In this case, the contractor constructed a notch-and-widen section for the approaches, which were then filled with compacted base material. The driver is guided along the existing route by vertical caution panels placed along the paved edge adjoining the open base section.

Figure 4.4. Widening an approach for an intersection re-alignment.

Narrow widening projects may require notching and widening the existing pavement by a width greater than 8 ft in order to obtain sufficient existing base material to process and treat though the end product will only involve widening the pavement by 6 ft or less. Figure 4.5 shows a widening project on SH 16 in Bandera County, San Antonio District, in which the district elected to start the widening at a point roughly between the lane wheel paths. This decision was made when the contractor determined that the base thickness at the pavement edges was thinner than the plan thickness and was inferior materials. The widening joint was moved to a point between the wheel paths to provide higher quality existing materials to which was added new base. This material was processed with a Terex tiller attached to an emulsified asphalt tank truck (Figure 4.6). The Terex was equipped with a distributor system that applied emulsified asphalt to the base during tilling. This material was later re-worked with a grader and then rolled with a sheep's foot, steel wheel, and finally a pneumatic tired roller to achieve adequate compaction through the depth of the processed base. Due to the presence of several pieces of heavy construction equipment and construction workers, flaggers and a pilot car was used for traffic control on this project.

Figure 4.5. Terex tilling machine processing in place base on a narrow widening project

Figure 4.6. Mixing and re-working the emulsion-treated base with a grader

Figure 4.7 shows that multiple construction operations may leave limited room for movement of vehicles through the construction zone. Again, close coordination of the traffic control crew is needed to prevent collisions between vehicles and construction equipment or to prevent construction workers from being hit by passing vehicles.

Figure 4.7. Tilling, grader work, and multiple rolling operations on SH 16

Narrow widening or edge repair projects constructed by in house maintenance forces may involve less complex traffic control measures especially on very low volume FM roads. The narrow widening/edge repair notch-and-widen project shown in Figure 4.8 is being constructed with a grader with widening attachment and a cross-berm truck to place the new base material. Compaction of the base material is accomplished using the rear tires of a loaded dump truck. This type of narrow widening/edge repair project is commonly used to provide additional width on lower volume roads or to repair edges temporarily until a construction project can be funded.

Figure 4.9 shows the widening operation from the opposite direction compared to Figure 4.8 and shows the notch-and-widen attachment plowing the trench at the pavement edge and the dump trucks placing or waiting to place materials. Moving operations of this type will require maintenance workers to position flaggers well ahead of the operations to alert motorists to slow down as they approach the work area.

Figure 4.8. Dump truck with cross-berm conveyor placing RAP in trench

Figure 4.9. View from the opposite direction shows a dump truck waiting to place material

4.2 Number of Trucks

4.2.1 Oversize/Overweight (OS/OW) Trucks

When a large number of trucks use a road that is too narrow to safely accommodate them, the road becomes a good candidate for narrow widening. FM 1414 is a narrow road with several tight curves that runs through a forest, so the logging trucks that frequently use it were too long to negotiate some of the curves; see Figure 4.10 for an example. The road was widened and a slope was added in the curves. The following reasons explain why a road with a significant amount of large truck traffic would be a good candidate for widening:

1. Edge failures caused by truck tire loads at the pavement edges.
2. Trucks are wider than cars and take up more lane width—this provides less room between passing vehicles and might affect driver behavior of smaller vehicles traveling in the opposite direction.
3. Heavy truck trailers off-track to the outside in right-hand curves and to the inside on left-hand curves. Thus off-tracking can be a concern regarding edge loading conditions and encroachment of the trailer into the opposing lane.
4. OS/OW vehicles might be much wider than a single lane and much longer than a typical 18-wheeler, which can cause additional problems if a route is often used to accommodate OS/OW vehicles. This might be the case on lower volume FM roads that do not have cross-over bridges that restrict vehicle heights or are a more direct route to the final destination. In addition, certain divisible loads are not permitted to travel on the Interstate, although the Interstate section might provide the route geometrics and bridge heights to accommodate the load. Thus, OS/OW loads are often required to travel on that portion of the network that is least capable of accommodating the additional weight or dimensions.

Figure 4.10. East Texas logging truck

Narrow FM roads are also sustaining accelerated damage from heavy oil and gas exploration equipment including frac sand trucks, vacuum trucks, and heavy oil field equipment haulers.

Figures 4.11–4.12 show an FM route that is carrying both heavy oil and gas exploration trucks and aggregate haulers operating with belly dump trailers.

Figure 4.11. Oil field vacuum truck traveling on narrow FM road

Figure 4.12. Multiple heavy aggregate haulers operating along the same FM road as in Figure 4.11

The damage shown in Figure 4.13 will require extensive maintenance repairs unless a widening project can be funded. A narrow widening project can increase lane widths and add a narrow shoulder within available ROW as may exist in a rural residential community as shown in these photos. Lateral edge support will reduce the potential for edge failures and rutting which can lead to safety concerns and reoccurring maintenance expenses. During the design of the pavement widening it will be important to consider lateral sub-surface drainage and additional structural support necessary to handle multiple heavy truck loads. Inadequate thickness or inappropriate material selections that do not permit lateral drainage may result in a return of maintenance problems such as cracking at the widening joint, rutting of either the widened or existing pavement, settlement of the widened section or poor ride quality.

Figure 4.14 shows an extremely long super heavy load traveling along a ramp. This figure demonstrates the concept of trailer off-tracking as can be seen by the fact that the tractor is located to the extreme right of the pavement edge, which the trailer is tracking to the extreme left of the pavement edge. Under these conditions, and even when much shorter loads are involved, pavement edge damage can occur resulting in dangerous edge drop off conditions.

Figure 4.13. Severe rutting and shoving of the pavement due to repeated heavy loads on an unsupported pavement edge

Figure 4.14. Transporter with OS/OW load traversing a curved ramp

Figure 4.15 shows a heavy agricultural tractor pulling a heavy scraper along FM 696 in the Austin District. FM 696 has no paved shoulders and, therefore, no place for a vehicle traveling in the opposite direction to pull over to allow wide loads to pass. Note that the tractor extends into the opposing lane—a pilot vehicle with flashing lights is leading this OS/OW load to warn approaching motorists to take caution.

Figure 4.15. Heavy/wide agricultural tractor towing scraper on FM 696

Figure 4.16 is intended to provide a dramatic depiction of the damage that can occur due to heavy tire loads at the pavement edge. This particular load weighed in excess of 2,000,000 lbs and was required to travel on FM 796 in the Corpus Christi District to avoid low clearance bridges. The heavy tire loads caused rutting and severe edge failures during the move which had been predicted by TxDOT pavement engineers that evaluated the route prior to movement. Thin FM roads with unsupported pavement edges are least capable of carrying loads of this size and weight, but often must be used due to bridges, signs and other obstructions or routes with heavier pavement structures.

Figure 4.16. Super heavy load rutting pavement and damaging edges in real time

Coordination between the district and the Texas Motor Carrier Division—Motor Carrier Division, which issues OS/OW permits, can potentially help restrict movement of overweight loads along routes which cannot accommodate them. These situations can occur during construction work on main US or SH routes that normally would carry these loads, but are closed to OS/OW vehicles within the work zone. Thus, MCD must route the loads along available adjacent routes. The district can coordinate with MCD to select alternate routes which are best suited to accommodate the OS/OW loads during construction on the main route and potentially prevent damage to a narrow roadway that is incapable of carrying numbers of permitted OS/OW loads.

The large metal tank shown in Figure 4.17 was photographed at an intersection with 12 ft lane widths. However, loads of this size, and much larger, may find it difficult to make turns on narrow FM roads at intersections and driveways during transport and delivery. Routes that are often used as permitted OS/OW routes are potential narrow or full-width widening project candidates both in consideration of pavement damage and safety.

Figure 4.17. Large metal tank on transporter

Though not directly associated with narrow road widening, another aspect of lower volume roads that may need to be addressed during a narrow widening project is removal of bumps or dips at intersections or at grade rail road crossings. As discussed in the following sections, roadways built over 50 years ago were designed under different design standards, typically with lower design speeds, narrow ROW, and other conditions. Often routes that were designed and built in a rural setting in 1950 are now within suburban or city limits with higher posted speeds though the design standards might not have been upgraded. In addition, multiple surfaces placed over time, patches, the addition of ramps or drives and other features might result in locations in which a trailer with low clearance between the trailer and the pavement might result in potential safety concerns.

Figure 4.18 shows a super heavy load on a low boy transporter trailer with 6” or less under trailer clearance. Again, it is noted that the drive axles on the transporter dolly are almost directly on the pavement edges. Loads of this type can become stuck along the route, or at intersections, sometimes with disastrous results.

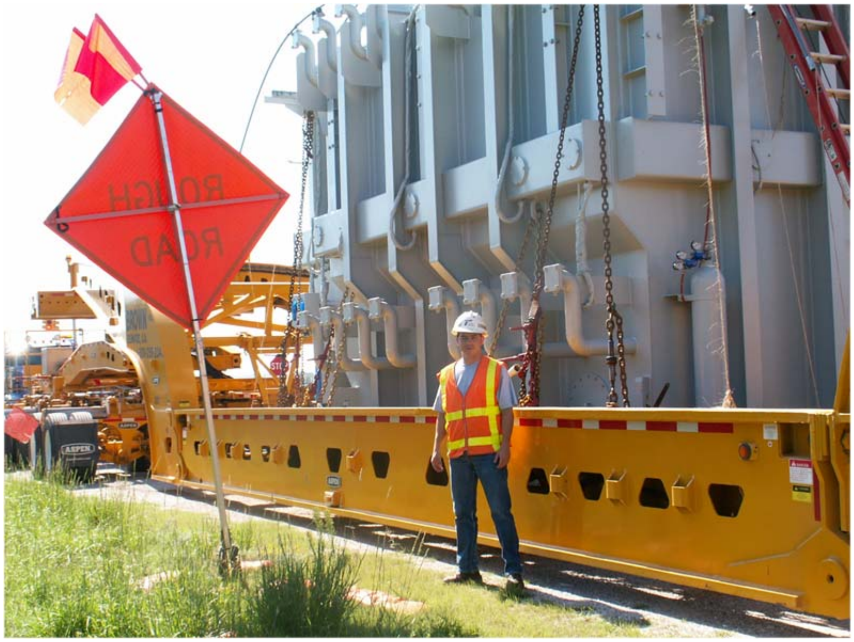


Figure 4.18. A super heavy and wide load on a low volume FM road

The following Figure 4.19 illustrates the consequences of low under trailer clearance at a rail road crossing in California. This load originated in Texas and had approximately 6" under trailer clearance. The load got off route near its destination, became stuck at a railroad crossing, and was struck by a train.

Figure 4.19. Super heavy load struck by train after becoming stuck at a high rail road crossing

Though the above crash occurred in an urban area, the same conditions can occur on low volume, narrow FM roads in Texas. Much smaller loads such as construction equipment on a low boy trailer have been hit by a train under similar circumstances. This points out that close control of pavement cross slopes and grades during narrow widening projects, especially at rail road crossings and intersections is critical to ensure similar results do not occur.

4.3 Current Lane Width

4.3.1 Tight Curves

In the case of the FM 1414 project (Figure 4.20), the reason for widening was to enhance safety and prevent collisions, as the current lane width and curves of the road were tight on traffic. The construction consisted of 4-ft. pavement widening, structure extension, seal coat, and restripe. The project length is approximately 5 miles. The proposed typical section is shown in Figure 4.21.

4.3.2 Overrunning Edges

The widening in West-Central Texas is typically done to improve safety and help alleviate the problem of vehicles overrunning the edges, as the current lane width is too narrow.

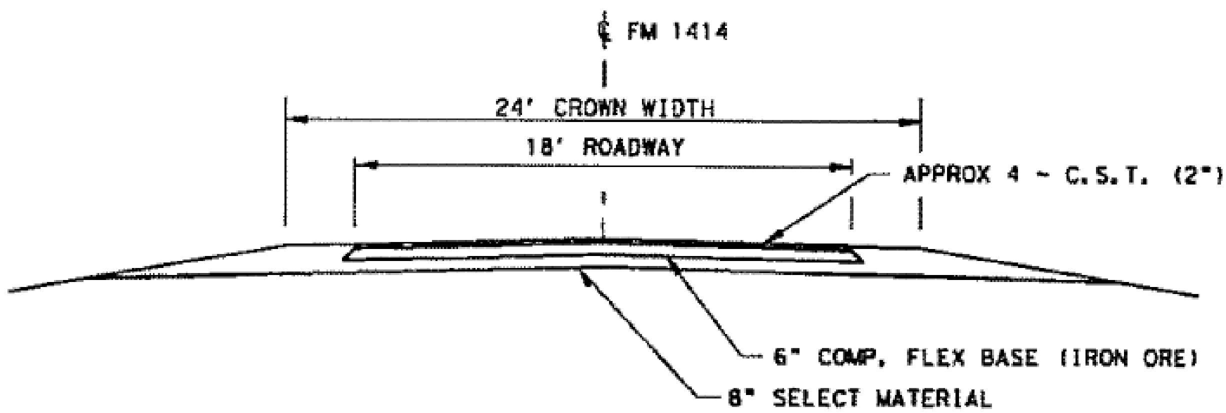


Figure 4.20. Existing typical section of narrow widening candidate (FM 1414 Project)

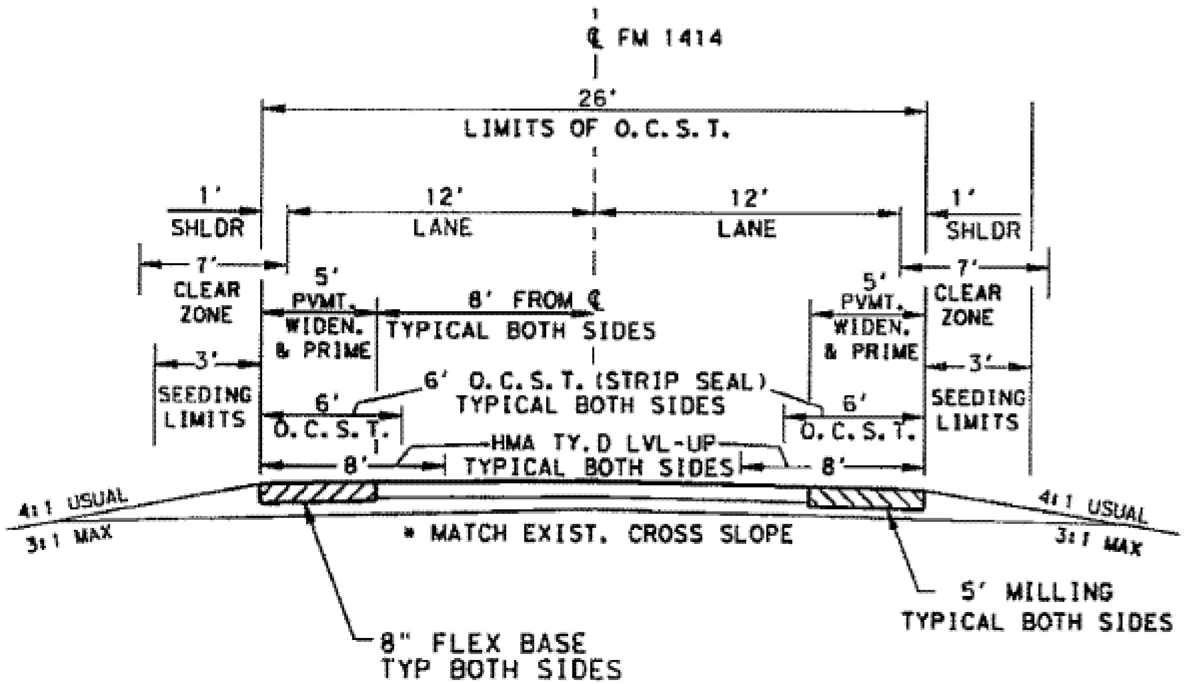


Figure 4.21. Proposed typical section of narrow widening (FM 1414 Project)

4.4 Route Type

4.4.1 FM and RM Roads

Typical narrow-widening projects in East Texas occur on FM roads. One of the main factors considered when selecting a widening project in this district is to provide safer access to mailboxes on the sides of the roads for mail carriers.

Common narrow-widening projects that are seen in West-Central Texas are on Ranch-to-Market (RM) and FM roads. The majority of widening is 6 ft or less, and many roads do not have a consistent slope. Details on some narrow widening sites follows:

- **RM 783**: A section of RM 783 showed the joint already visible on a recently widened road. This project was finished in October 2012. The total length was 8 miles, and the widening was 4 ft. Total cost was about $5 million.
- **US 83**: US 83, in Kerr County, starting at the Edwards County line, showcased a full-reconstruction project that required a 12-in. base, as it is a US highway. For this widening project, they took the money that was offered for it, and were able to do a full reconstruction, so there is no joint problem in this case. They placed two courses on the same day, with a fog seal on top.
- **RM 335, 336, 337**: Leakey, Texas, is the location of routes RM 335, RM 336, and RM 337, known as the “Three Sisters.” These widening jobs were necessary for safety reasons. These hilly and curvy roads are used frequently by motorcycle riders, and as such, are very prone to accidents. These jobs have not had joint failures.

- **FM 2093**: FM 2093 in Fredericksburg was a 1-mile project, started in the fall of 2012. There was a substantial amount of rain, which got the material wet. The subsoil is not very good—there is a 4- or 5-in. layer of caliche, with high PI—so the subgrade kept failing during construction. It was a hot-mix widening, about 500 ft. per day was done.
- **FM 535**: Sections of FM 535 in the Austin District are being widened using a phased approach in which structures are widened first to provide lateral clearance to the headwall and reshaping of the fore slopes and ditch line (Figure 4.22). This phase of work will be followed by narrow widening of the lanes.

Figure 4.22. Structure widening along FM 535

In this case, the contractor has widened the structure and also reshaped the pavement edges such that traffic cones or panels are not needed. Widening the structures during the first phase gives the contractor more space to operate equipment and allows continuous operations along the pavement edges without interruptions at each cross drain headwall.

4.4.2 Horizontal Curve and Curve Crossfall

Many Texas FM and RM routes were designed in the 1950s and 1960s and originally were posted at approximately 40 mph. However, in recent years, posted speeds have been increased to 60 or 65 mph on these narrow routes. Thus, the designer must consider opportunities to address pavement cross-slope (or crossfall) to address adequate surface drainage and safety with horizontal curves.

Higher slope rates exist in horizontal curves, and the challenge with shoulder widening within a horizontal curve is to avoid creating a trough due to the change in pavement and shoulder cross slope. This can occur at points along the curve as super-elevation rates change in relation to the shoulder cross slope rate.

In addition, within a horizontal curve that is super-elevated, the thickness of the pavement on the inside of the curve (in the direction of travel) may be less than the centerline or outer curve pavement thickness. This can reduce bearing capacity of the widened structure and increase frost heave exposure if widening is made on the inner curve. In contrast to the European countries, however, frost heave is likely of minimal concern in Texas.

Figure 4.23 shows an example of the curve interior widening detail for a project on FM 514 in Rains County. It is noted that the pavement marking edge line remain parallel to the roadway centerline. The edge line will not follow the pavement edge on the curve interior.

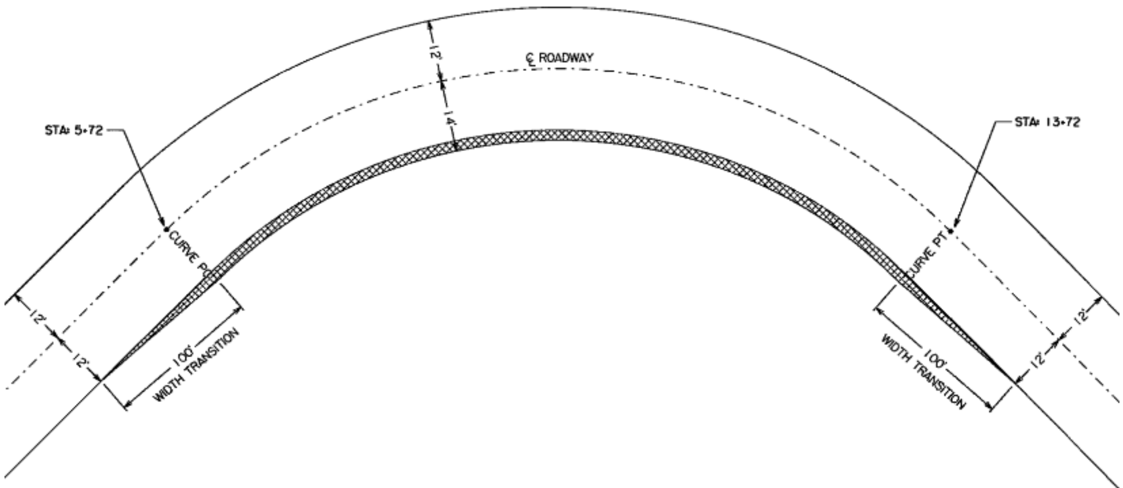


Figure 4.23. Curve interior widening detail (FM 514)

4.4.3 Vertical Curve Drainage

Vertical curve design requires considerations about both sight distance and drainage. Depending on the approach and departure grades on the route and whether the vertical curve is a crest or sag, the designer might have challenges providing proper drainage when the pavement is widened. At the lowest point of the sag, the cross slopes will need to be designed to ensure adequate drainage since surface water is draining toward the sage in both directions. At the crest of a vertical curve, a flat spot can occur, which may result in water ponding; the widening may be used to help mitigate or make matters worse.

4.4.4 Resident Access

Sometimes narrow widening projects can be on a route that interrupts residential access. The East Texas contractor will make sure residents along the road will have access to their driveways, and they will be notified ahead of time.

Typically for residential driveways in West-Central Texas, the contractor mills through the drive and then replaces the base material as quickly as possible, so the driveway is functional again. If there is a concrete driveway, the contractor will skip over it without milling.

Widening of FM 535 in Austin District involved working in both rural areas and small towns with businesses and residential areas. Figure 4.24 shows a horizontal curve in the FM 535 alignment through a small town, which will present challenges to the contractor in widening the right hand, lower edge of the curve, and the left hand upper edge of the curve while matching cross slope and providing sufficient pavement structural depth. This type of challenge can be addressed by considering the allowable design slope rates, drainage patterns, and features that control the grade along the curve line such as drives, intersections, and culverts. Again, traffic control in this type narrow-widening project will generally involve flaggers and a pilot car with additional signage on cross streets.

Figure 4.24. FM 535 within a horizontal curve passing through a small town

4.5 Structural Condition

4.5.1 Old vs. New Structure

It is important to make the widening structure as similar as possible to the existing roadway with regards to the structural thickness, material properties, and degree of compaction. Differences between the old and new structure with associated different load bearing capacities, can result in differential frost heave, uneven settlements, or reflection cracking. Recommended practices to follow when widening a road in Northern Europe include descriptions on the manner in which the old road should be excavated and how the new and old ditches should be handled. It is recommended that the joint should be angled, stepped, and staggered, and geogrids or steel grids should be used and wrapped with unbound materials to firmly tie the new structure to the old one. The widening structure should not be built too strong, as it will behave differently from the rest of the road.

4.5.2 Poor Existing Condition

A pavement structural condition and visual distress evaluation should be performed for a pavement widening candidate section. Pavements with low structural capacity or distresses such as fatigue cracking deep rutting, wide longitudinal cracking, or base failures may be more suited to a narrow widening project that involves FDR. In the case of an FDR project, the widening joints are eliminated and full size construction equipment can be used. This strategy is also sometimes employed to construct narrow widening projects that use a greater amount of the existing pavement width as will be discussed later.

4.5.3 Widening vs. Rehabilitation

When comparing labor, equipment, and project duration, the benefits and costs to widen versus rehabilitate a roadway are comparable. Major components of increase are cement, extra base, and second full width chip seal.

4.6 Soil/Subgrade

4.6.1 Slope Stability

It is important to ensure the stability of the side slopes when widening within a fill section, as slope stability problems can occur if the pavement widening results in fore- or back-slope rates that exceed ability of the soils to resist circular slip failure. The designer should consider soil properties including angle of repose, cohesive strength, and shear strength when wet; if these properties are insufficient, expensive repairs may be required after the pavement is constructed. The designer may need to consider stepped embankment construction and/or geo-synthetic reinforcement of the embankment layers.

If the ROW width is limited, the back slope rate could be so steep that slope material will erode and fill the ditches, thus raising the ditch water level. A steep fore slope could make the compaction process difficult, leading to a poorly compacted widened section and ultimately leading to shear failure and edge deformation.

4.6.2 Safety Slopes

Safety slopes in West-Central Texas can be a problem when it comes to narrow widening, as they cause quality control issues, expose risk to water infiltration, and are time consuming and counterproductive. To avoid the need for a safety slope, it is recommended that a single layer or “monolithic” approach should be considered. For example, place 6 or 8 in. of flex base in a single lift, or 4–8 in. of hot-mix asphalt (HMA) that fills to the final surface level of the existing pavement.

4.6.3 Settlement

Enough time should be given for the new structure to settle and match the settlement of the old embankment before paving, as differential settlement could occur, especially on peat soils.

4.6.4 Roughness

Increased pavement roughness can occur due to improper treatment of the subgrade soils during construction or if a drought period causing dry land cracking is followed by a period of heavy rainfall. The heavy clay soils that contributed to the dry land cracking will absorb the moisture and swell, causing roughness and unevenness of the paved surface. This condition can be made worse if sulfate bearing soils are present.

4.6.5 Drainage

Sufficient drainage is important for preventing failure of the pavement. A road drainage system that is deteriorating will result in decreased bearing capacity along the thinner edges of the road, followed by edge deformation and ponding of water, which accelerates the deformation. Uneven or improper pavement surface cross slopes need to be corrected and conform to TxDOT requirements both in tangent and curve sections.

During construction in the U.K., it is important to prevent water from entering the structure and reducing the bearing capacity of the sub-grade. Steps that can be taken to prevent ingress of moisture include pumping out any water from the excavation, rectifying any defects in the drainage system, taking care to avoid formation of a sump or water-trapping barrier against the new construction, using a geosynthetic separator to prevent clay migration from a soft subgrade, protecting materials from weather, and applying an adequate tack coat and edge sealant. The wearing course material of the new construction should match the existing surfacing, and the road markings may need to be updated after a road edge repair.

4.6.6 Obsolete Survey Data

Base failures can be caused when roots are discovered in the original material after milling. In a plan set, the existing road condition is needed, but some information is not always attainable. For example, it is a challenge to make a slope on something that is already there; however, the existing road condition information is based on surveys done years in advance. The road could have changed since those surveys (e.g., wheel ruts, etc.).

4.6.7 Geotextiles/Geosynthetics

Geosynthetics manufacturers produce pavement interlayers that make use of fiberglass technology to alleviate longitudinal joint problems in this type of project. The geogrids also help stabilize the soil and eliminate differential settlements. Some of their products have wicking capabilities, so the water stays in the fabric rather than on the subgrade and base layers, and the fabric moves the moisture horizontally out of the pavement. An example of the use of these products is the test project on SH 21 between Old Potato Road and US 290 in the Austin District.

Projects in West-Central Texas do not require geotextiles, because the soil does not have too much moisture. The presence of heavy clays might warrant use of geotextiles. The Austin District uses geotextiles in those projects that have high PI clay expansive subgrades (e.g., SH 21). They want to create a stable subbase and stabilize it with the geogrid. The system is still flexible.

4.7 Base Type

4.7.1 Flex Base vs. Hot Mix

In West-Central Texas, the contractor owns quarries in its area, allowing shorter hauling distances to their jobsites. In contrast to East Texas, West-Central Texas has no hot-mix plants, making flex base the preferred material, rather than hot mix, because it is less expensive. HMA is available only for large, interstate highway projects, which normally bring a portable plant to the jobsites. Flex base can be used in all seasons and can be mixed off-site. Using flex base rather than HMA created savings of between $50,000 and $70,000 per mile on previous jobs in this area.

On roadways in the Waco District that have structural problems and narrow ROW, they use flex base and cement-treat it. If it is too narrow to place and compact the flex base (4 ft. or narrower), they use hot mix.

Figure 4.25 shows a Midland Road Widener placing ASB in a milled trench section between a thick hot-mix pavement and a concrete gutter line. Though this photo was not taken on a TxDOT project, the photo is of interest in that it shows the Road Widener provides options for accurate placement of the ASB in terms of width, depth, and cross slope. The driver can control the cross slope of the screed to ensure that final grade matches the existing pavement. Placement of either flexible base or ASB in a narrow working area such as this might be difficult using a belly dump, which is often used on narrow-widening projects for base placement.

A belly dump truck provides less control over base placement which may require other processing operations to obtain the proper base thickness and widths. Road-widening machines provide more control for base placement and can be further equipped to provide a remote control to a construction worker walking alongside the widener so that the screed height and angle can be closely monitored and controlled.

Figure 4.25. Midland Road Widener placing ASB material (Midland 2012)

4.7.2 Aggregate Prime

For narrow widening projects in West-Central Texas, aggregate prime is key to logistics and quality. Benefits of aggregate prime include a quick and reliable protective cover, finished base under traffic, strong adherence to base course, low maintenance under traffic, protection of ride quality on finished base, ability for immediate traffic use, cheap base slope protection, and all-season application. The aggregate does not need to be of high quality, and the contractor can come back later and use quality summer asphalts for seal coats. Recommendations for aggregate prime are as follows:

- RC-250 with Grade 5 aggregate
    - 0.2–0.23 g/sv
    - Grade 5–Grade 6
        - → Dry screened
        - → Non-coated

4.7.3 Compaction

It is important to have adequate compaction when road widening in Northern Europe to prevent post-compaction from traffic loading, rutting, pavement cracking, and non-uniform settlements. Compaction in road edge repair can be difficult due to working with a narrow width, so some steps to adequate compaction include using good quality materials, constructing the structure in several layers and applying a roller per layer, and designing the widening structure wide enough to fit the compaction equipment. In the U.K., appropriate selection of the compaction equipment and the choice of materials for the structural course and foundation platform can assist the ease of compaction. For structural course with bituminous hot-mix material, hot rolled asphalt base course is easier to compact than dense asphalt base. In-plant recycled bituminous materials using foamed bituminous binder should be compacted in layers less than 200 mm.

4.7.4 Rutting

Rutting of the widened section can occur due to inadequate compaction and/or inadequate additional width that does not provide sufficient lateral support of the pavement edge. In addition, rutting may occur within the outer wheel path of the existing pavement if the widened section is very stiff and strong (e.g., ASB) but the existing pavement is relatively weak. Rutting in the existing outer wheel path may also occur if inadequate drainage of the existing pavement exists or if excessive moisture has been applied to the flexible base in the widened pavement section during construction. Under certain circumstances, water may be drawn from the wet, widened section into the drier existing pavement base material depending on climatic conditions and other factors.

4.7.5 Transverse Cracking

Transverse cracking of the widened area can occur if the base and/or subgrade are heavily stabilized. Transverse cracking may reflect through the pavement surface and increase the potential for water ingress. Although this widening strategy is not commonly used in Texas, it may be an option that is considered if the existing pavement is an old 9”-6”-9” jointed concrete pavement or the existing base is also cement or lime stabilized.

4.7.6 Drainage at Base

Drainage problems can occur from mismatching base materials without providing a drainage path, such as an ASB widening section with a crushed limestone existing pavement base. Widening with ASB expedites construction, but a drainage layer is required. ASB widening is favored by many TxDOT districts and contractors due to ease of opening to traffic at close of days operations.

4.7.7 Bathtub Effect

If widened shoulders are cement or asphalt stabilized without providing adequate drainage for the underlying layers in between, weakening of the pavement structure may occur though the build-up of moisture.

4.7.8 Dust

Sometimes dust can interfere with production, so a water truck will drive through to spray the site with water. Contractors prefer ASB, as opposed to flex base, as compaction can be achieved and dust control is not a problem.

4.8 Authorizations

4.8.1 Funding Source

It is important for the project to result in acceptable performance; however, this could be a challenge, depending on the category under which the project is funded. For example, funding for Texas roadway projects is categorized into four different funds (as discussed in Section 1.1.2): CAT-1, CAT-8, RMC, and In House. Construction projects funded by CAT-1, safety-related projects funded by CAT-8, and routine maintenance projects funded by RMC are all performed by contractors who have a procedure for inspecting the quality of the materials used in the project. In House maintenance projects are performed by the DOT itself, and they have different materials available that do not endure the same inspection, so the performance varies depending on the materials used. Another challenge is that In House projects do not have the capability to do structure widening, so only pavement widening is done through this funding source.

4.8.2 Project Operation

In West-Central Texas, TxDOT gives the contractor typical sections, and gives them flexibility to make the decisions based on what is actually there on the road, which may not be represented accurately or entirely on the plans. This varies from district to district. The contractor has access to the full construction plan set at least 3 months prior to letting and has the opportunity to attend a pre-proposal meeting and pre-construction meeting to ask questions and gain insights about what is known and what exists along the project. The approach allows contractors to use their experience and their judgment to do a better job. TxDOT inspects their jobs for safety, quality control, traffic control, and densities. The contractor normally can do 1 mile per day of subgrade and base widening. This limitation is in place because the new base material needs to be brought to the site. Typically, paving one mile at a time is specified by TxDOT because they need to get traffic back on by the end of the day; one mile at a time is the estimation of one day’s work.

4.8.3 Full Depth Reclamation (FDR)

The Bryan District has implemented a policy to widen roadways using FDR, which involves scarifying the existing roadbed, spreading out the material, placing a new base, compacting it, and then placing the surface. This method eliminates the joint line. This approach eliminates the widening joints and enables the contractors to use full-size construction equipment, which makes their job easier as well. Districts have reported FDR construction project costs from 15% to 22% higher than a narrow project costs; however, the life cycle costs may be similar due to reduced maintenance.

4.9 Climate

4.9.1 Freeze-Thaw Weakening

In cold climates, it is important to maintain the same thickness for the new and old structures, reduce the use of frost-susceptible materials, and maintain proper drainage, as any of these could cause differential frost heave during a freezing period or decreased bearing capacity during a thawing period. Spring thaw weakening, in combination with subgrade rutting, could also cause soft subgrades to shear and result in unwanted widening from beneath the road. In relation to Texas, freeze-thaw weakening might occur in northern districts, but it is not a prevalent problem as would be the case in the European countries.

4.9.2 Dry Land Cracking

Texas experiences periods of drought conditions during which severe damage can occur to pavements as water is drawn from under the pavement by vegetation within the ROW and/or trees outside the ROW. In addition, base and soil properties can contribute to the movement of moisture from wetter to drier areas under conditions of high temperatures, extended periods of intense sunlight, and low or no rainfall. Longitudinal cracking of the widened pavement and even the existing pavement may occur under these conditions unless the designer takes steps to stabilize and control the moisture levels under the pavement structure.

4.10 Equipment Considerations

4.10.1 Tighter Work Area

In narrow-widening projects, the work area is narrower than in full-width widening projects; therefore, it is difficult to use full size rollers, pavers, and other equipment. In these situations, specialized equipment specially designed for narrow widening may be used or full-size equipment that can be adjusted to meet the requirements may be employed. For example, the notch-and-widen section might be constructed using a milling machine, smaller sized rollers that can completely fit within the widened section rather than straddling the existing pavement and widened area, and other smaller equipment.

4.10.2 Option of Additional Width

The most difficult challenge in this kind of project is trying to build a pavement that is only 4 ft. wide. Such a narrow structure is inherently weak. One way to get around it is to extend the widening to the inside, i.e., make it 4+4-ft. wide, or if the money is available, repave the original lanes as well, at the same time.

Sometimes it is even advisable to construct the additional width (to the inside) at no cost, so as to minimize construction problems as well as to eliminate the weak joint. This will provide more space to fit equipment for compaction, and at the same time, the roadway is still being widened by the same amount as shown in Figure 4.26. Note that the joint should not be placed under the wheel path to prevent cracking.

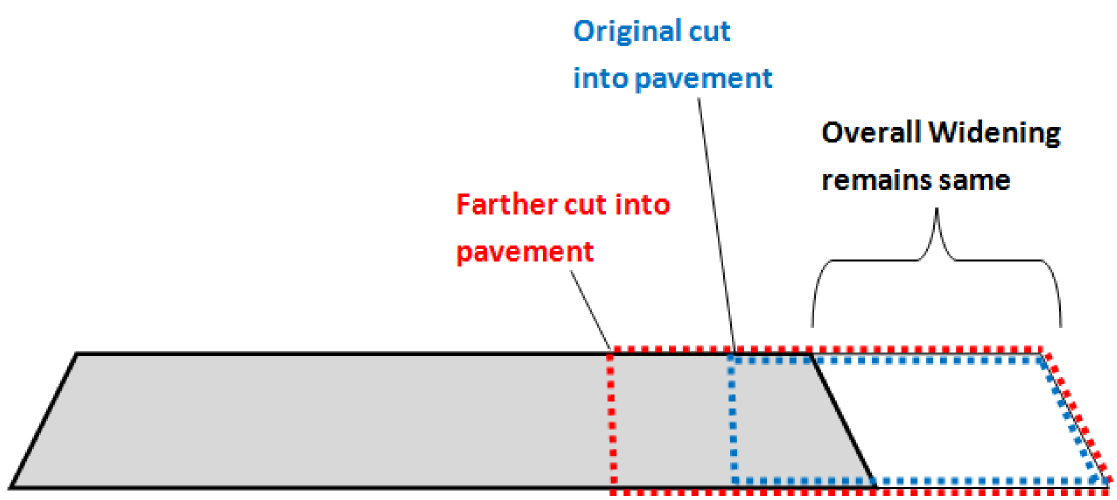


Figure 4.26. Joint position farther into the pavement to fit compaction equipment and get a better compaction result

4.10.3 Joint Construction and Location

When widening the existing pavement structure, the notched joint should not be placed under or near the wheel path, as heavy traffic loading can cause reflection cracking to occur at that location. Practice in Northern Europe suggests that in order to minimize reflection cracking over the joint, the construction joint should not be placed under the wheel path; the joint should be stepped between pavement layers; the widening structure should be equal to the old structure (structural thickness, material properties, and degree of compaction); sufficient later transverse support (e.g., geogrids or steel reinforcement) should be ensured; and sufficient settlement time should be given before overlaying.

4.10.4 Joint Face Construction

The joint face should be flush and neatly trimmed and not contain areas with base material that has sloughed into the widened section. If the joint face is uneven or contains void areas, when the new base is placed in the widened area, the rolling operation will have a difficult time properly compacting these areas. The performance problems resulting from poor compaction can include reflective cracking, water ingress, rutting, differential settlement, cracking, and related issues.

4.10.5 Scarified vs. Saw-Cut Joint

A study in Utah compared the bond strength between saw-cut joints and scarified joints in asphalt pavement patch repair. The scarified joints were created using a portable asphalt recycling machine that cuts and pulverizes the asphalt concrete, leaving a rough surface to the vertical cut. The saw-cut method leaves a smoothly sawn vertical face at the joint. After testing cores from patch joints before and after winter freeze-thaw cycling, the adjusted average strengths of the scarified cores were 20.8% and 25.1% higher than the corresponding strengths of the saw-cut cores before and after winter, respectively. The study found that a scarified face improved patch joint bond strength for all compaction densities, and the importance of proper compaction during construction increases as the joint ages. The quality of the interface between the existing pavement and the newly installed patch material has a significant impact on the performance and maintenance costs of the road, so it is important to ensure a strong interlock at the joint between the new and old material.

4.10.6 Current Practice Examples

East Texas Case Study
Equipment used for each part of the narrow widening process for the FM 1414 project in East Texas included the following:

- Sawing existing pavement: milling machine—used to cut notch and widened area, which provides a smooth vertical joint face
- Excavating or cutting trench: milling machine—width and depth of cut, etc.
- Compacting subgrade: double drum asphalt roller, 4-ft.
- Cleaning trench prior to base placement: maintainer with custom-made piece on the motor grader mouldboard

- Placing new base material: road widener/shoulder machine, self-propelled, spreads and levels material
- Compacting base: 12-ton roller
- Placing hot mix: asphalt paving machine
- Compacting hot mix: asphalt roller
- Other: backhoe to replace dropped material on existing roadway, broom to sweep excess material, water truck to spray dust, dozer for edges

West-Central Texas Case Study

For asphalt milling of the shoulder, the contractor in West-Central Texas uses a milling machine, the Roadtec RX-600e, which was new for the project performed in Real County. This machine has been advantageous because it allows them to finish the work ahead of schedule. The Roadtec matches the cross-slope, it is easier to operate and faster than other machines, and it saves them money. They found it more beneficial than both the Asphalt Zipper, with which the cross-slope cannot be controlled, and the Midland Road Widener, which spills the material.

The contractor uses the "sheep-foot" roller for compaction of subgrades only. For bases they use the flat-wheel, which is smooth. They use six to eight passes with the flat-wheel. Figure 4.27 shows the compaction process finishing the base on RM 335.

Figure 4.27 Finishing base on RM 335

Bryan District
When the contractor did conduct narrow-widening projects, they tried out the Asphalt Zipper, but got better results by using a BOMAG scarifier, because the Zipper lacks self-propulsion.

The contractor has performed trial sections on narrow widening projects, including use of a portable roto-mill attachment on a skid steer or front end loader and a full size scarifier/tiller. The results using the full sized tiller were better since the roto-mill attachment was more difficult to control and achieve uniform results.

In the past, when constructing narrow widening projects, they found problems working within the narrow-widening section and would often need to widen the trench section out to 4 or 5 ft, attempting to get more space to work. They also had problems getting good compaction against the face of the existing pavement.

Austin District
When performing the cut in the existing pavement, a rough texture is better than a clean cut, as it provides better interlock. The depth of the cut is from 6 in. to 2 ft, depending on the job requirement, and it is done with a 1:1 slope, rather than vertical. This sloped cut is more stable than a vertical cut.

When using machines such as the Midstate, the general concern is that lighter and especially non-self-propelled equipment that was advertised for pavement widening was more suited to edge repairs over short distances or construction of pavement patches. This equipment is considered too light and of inadequate capacity for a full length construction project.

Major Heavy Highway Construction Equipment Manufacturer
Some contractors in the eastern part of Texas own road-widener devices (e.g., a Midland or a Weiler). The equipment does not get much use because TxDOT does not let a stable flow of widening projects. It is not very profitable for a contractor to buy a specialized piece of road-widening equipment without a stable flow of work. In the north and west parts of the state, few companies own this type of equipment. Traditionally, there have been more widening projects in the eastern part of the state.

4.11 Summary and Conclusion

An array of widening options is available. The widening option that will perform well on a project will depend on parameters such as ADT, number of trucks, current lane width, route type, structural condition, soil/subgrade, base type, authorizations, climate, and equipment.

A high ADT may require at least one lane to be open at all times or possibly a temporary bypass road built for traffic to use. A section with a low ADT can use a pilot car (for curves and line of sight issues) or just a flagger station (if the section is flat). Black base from the hot-mix plant (as opposed to flex base) is a better alternative for getting the public back on the road sooner in high ADT situations. The type of construction taking place also affects the amount of traffic control needed. The FDR approach, which involves re-working the pavement structure across the entire width, may require more extensive traffic control measures.

The number of trucks that use the road can give more reason to perform a narrow widening, as the current lane width may not be able to accommodate heavy truck traffic in a safe manner. Widening the existing roadway by 1 to 8 ft is often necessary for roads with these trucks traveling on sharp curves and routes such as FM and RM roads.

The new widening structure should be built as similar as possible to the existing roadway with regards to the structural thickness, material properties, and degree of compaction. If the existing structure is in a heavily distressed condition, FDR may be more beneficial than widening.

It is important to ensure that the properties of the surrounding soil are enough to provide stable slopes, and the soil should not result in excessive settlement or insufficient drainage in the pavement structure. For soils with heavy clays, geosynthetic materials can be used to help stabilize the soil and eliminate differential settlements.

Depending on the type of base selected, different problems can be associated to activities such as compaction and drainage. For sections that are 4 ft or narrower, hot mix is easier to compact than flex base. A drainage layer is required if widening with ASB.

Widening results will vary depending on the authorizations enabled for the project. For example, different construction and inspection procedures are laid out for safety-related projects versus routine maintenance projects. In many cases, the specification is to pave one mile at a time, as this is the estimated time it takes to allow traffic back on by the end of the day.

Texas climate varies in different sections of the state, and this will affect decisions for widening. It is important to maintain proper drainage from freeze-thaw weakening in cold climates. In drought-susceptible climates, steps should be taken to stabilize and control the moisture levels under the pavement structure to prevent dry land cracking.

Because the width available to widen the road section is narrow, it is common to have problems with equipment size being too large for the job. Often there are not enough widening projects to justify buying specific widening equipment, so there are ways to accommodate the equipment that one already has, such as cutting the joint farther into the pavement to allow room for larger equipment. Wherever the joint is placed, it is recommended that it not be placed under or near the wheel path and that the joint face be flush and neatly trimmed.

Chapter 5. Development of the Decision Support Tool

This chapter describes the development of a decision support tool (DST) that will assist districts in making the most effective design decisions, develop appropriate design details, and manage and inspect the construction of widening projects. The tool will assist district personnel in evaluating a proposed widening project and to consider factors, such as design constraints, materials compatibility, constructability, and long term performance. This tool will provide a highly effective strategy within treatment options that have highest probability options. Factors implemented in the DST include the following:

1. **Reasons/Goals:**

   (Safety)

   a. History of crashes, injuries, fatalities
   b. Safety related to intersections
   c. Accommodate heavy vehicles more safely
   d. Other safety-related reason(s)

   (Increase Lane Width)

   e. To move traffic away from lane edges
   f. To accommodate mixed traffic, incl. wide, heavy trucks
   g. Due to truck low- or high-speed off-tracking
   h. Upgrading design standards for this route section
   i. Other lane width related reason(s)

   (Pavement Distresses)

   j. Repair and reduce edge failures
   k. Address rutting and alligator cracking
   l. Other distress-related reason(s)

   (Other Reasons)

   m. Reduce maintenance expenditures
   n. Greater width for oversize wide loads
   o. Greater traffic separation at centerline
   p. Add or increase shoulder widths
   q. Other reasons not listed

2. **Right-of-Way (ROW):**

   a. More ROW needed, but lack of funds
   b. More ROW needed, but time constraint
   c. Other ROW-related issue

3. **Priority for the Project:**
   a. Public
   b. County judge
   c. Local government
   d. MPO
   e. Legislature
   f. Other group not listed
4. **Performance Problems:**
   a. Notch and widen joint interface—cracking & deterioration
   b. Dry land cracking
   c. Longitudinal cracking
   d. Alligator cracking
   e. Transverse cracking
   f. Other types of cracking
   g. Rutting of the widened section
   h. Rutting of the adjacent pavement after widening section is added
   i. Settlement of the widened section
   j. Embankment failure/slope settlement after widening
   k. Maintenance issues not previously addressed
   l. Other problems not previously listed
5. **Construction Problems:**
   a. Obtaining a good joint cut and flush, vertical joint face
   b. Compaction of the subgrade
   c. Compaction of the base layer
   d. Problems w/ base placement, incl. loss of material or uneven thickness
   e. Problems with base segregation during placement
   f. Problems with ASB placement
   g. Differences between actual pavement thicknesses and quality & in the field compared to plan typical section
   h. Completion of base placement by end of day
   i. Problems with handling drainage and water runoff
   j. Difficulties with the 3:1 tapered safety slope
   k. Traffic control issues

l. Dust control during construction

m. Over watering subgrade or base to keep dust under control

n. Other construction problems not listed

6. **Equipment:**

(Contractor)

a. Self-Propelled Road Wideners

b. Non self-propelled Road Widener

c. Belly Dump for base placement

d. Motor Grader with blade attachment

e. Motor Grader to mix and work base

f. Milling Machine to cut joint face and excavate material

g. Saw attachment on grader, skid steer or front end loader to cut joint

h. BOMAG/reclaimer/tiller for full depth reclamation

i. Narrow width roller, pneumatic, steel wheeled or other type

j. Other equipment

(Maintenance)

k. Non-self-propelled Road Widener

l. Road Hog™ (roto-milling machine attachment for front end loader)

m. Asphalt Zipper™ (roto-milling machine attachment for skid steer)

n. Road Widener™ attachment for skid steer

o. Milling Machine

p. BOMAG/reclaimer/tiller

q. Motor Grader w/ blade attachment

r. Cross-berming machine on dump truck

s. Other equipment not listed

The DST program opens using Microsoft Excel. When the user first opens the Excel file, the user must first make sure macros are enabled and then click the "Tool Start" button to start the program (Figure 5.1).

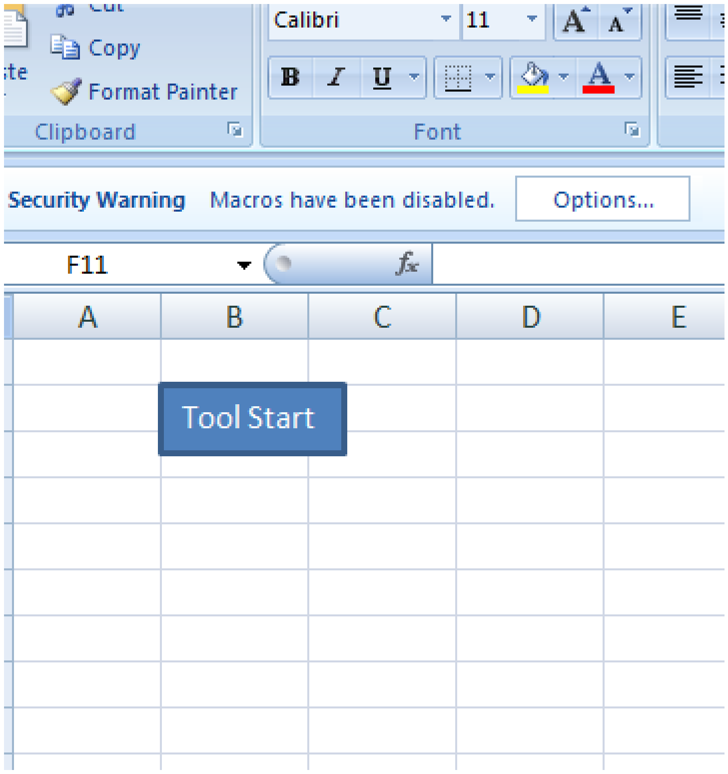


Figure 5.1. DST screen: "Tool Start" button

The decision support tool has the capability to save the project information that was typed in. This feature is helpful for districts to keep track of narrow pavement widening projects that have been considered, as well as keep a record of past narrow widening projects.

Note: The information entered into the file that the user works with is automatically saved to that filename. If the user wishes to work with a different project, they need to create a new Excel file (the tool gives the option to create a new file at the start of the program, as shown in Figure 5.2).

Figure 5.2. DST screen: Introduction screen when first opening the program

The first step of the program is to enter information about the project being considered, as shown in Figure 5.3. Information such as location, traffic, funding source, and letting date are included in this section to help the user keep the details of this project on file.

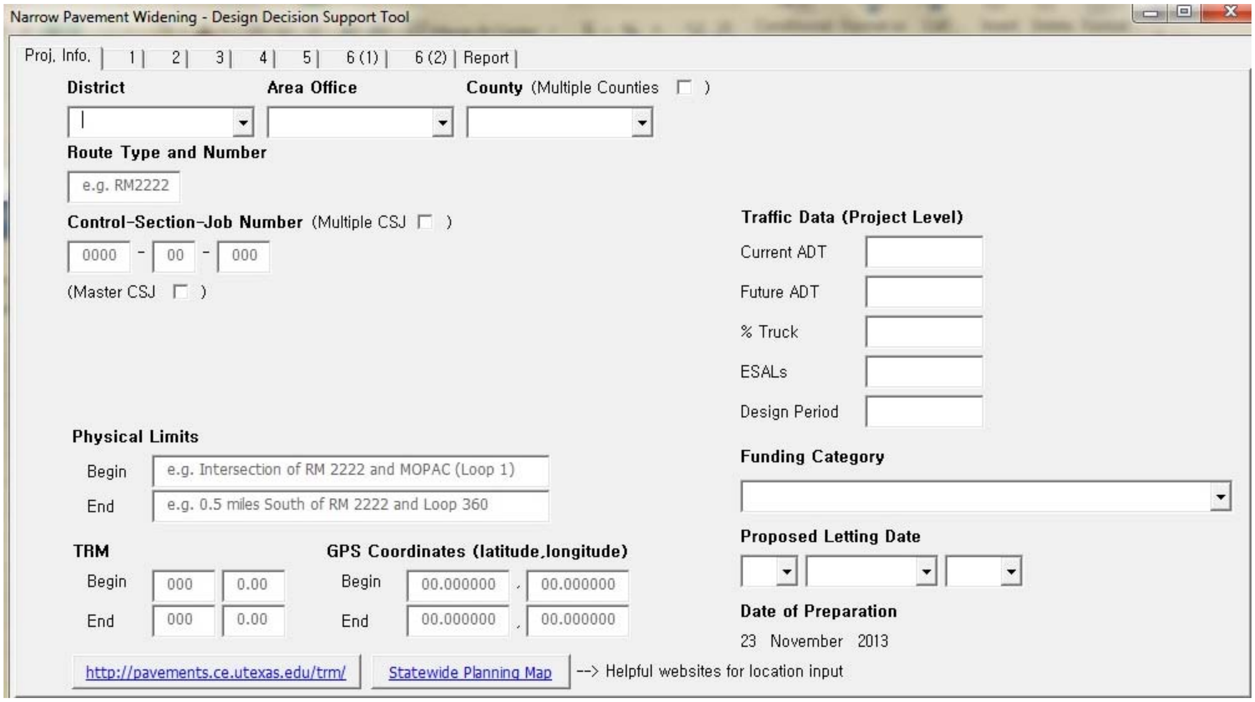


Figure 5.3. DST screen: enter project information

Tab 1, Question 1 of the program requests the user to select the reason(s) or goals for the proposed widening project (Figure 5.4). When the user selects an option, a blank box appears to the right side of screen where the user can enter more details regarding that option selected. Having this feature allows future users, who were not originally part of this project, to read the detailed descriptions and better understand the project.

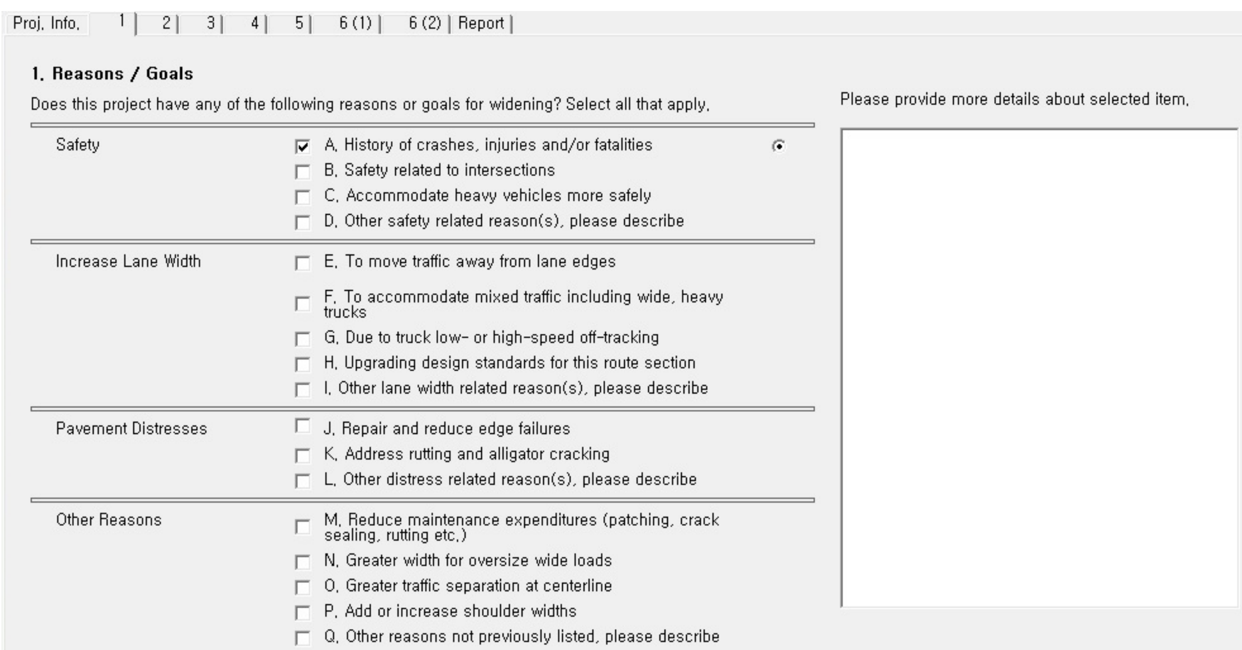


Figure 5.4. DST screen: enter reasons or goals

Tab 2, Question 2 asks for details on ROW issues (Figure 5.5). Tab 3, Question 3 asks who the project is a high priority for (Figure 5.6).

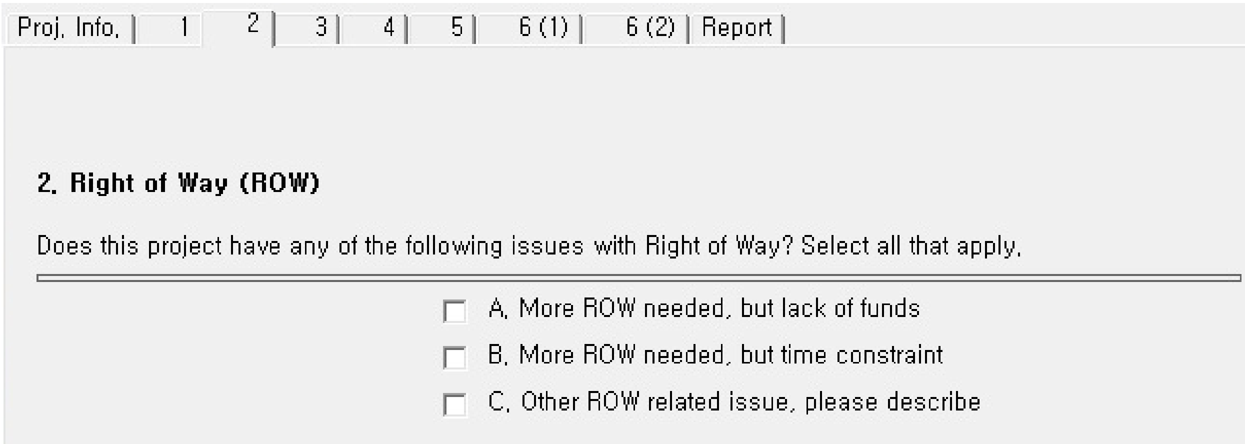


Figure 5.5. DST screen: enter ROW issues

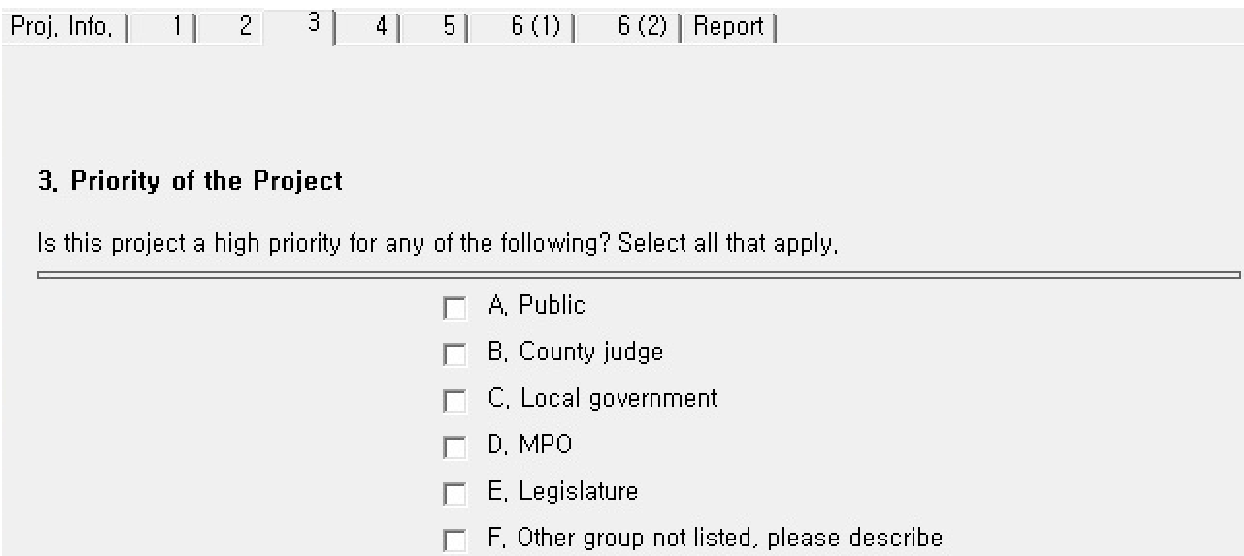


Figure 5.6. DST screen: enter who the project is a priority for

Tab 4, Question 4 asks if the district had experienced performance problems on widening projects before (Figure 5.7). There is a feature that asks for the number of projects that have had a specific problem. Knowing the number of projects shows how significant the problem is. By asking this question, it forces the district to find out more information about their past experiences and record it if it was not already recorded. It encourages the user to learn more and talk to people in the field doing the maintenance etc., so when they design they can consider these problems.

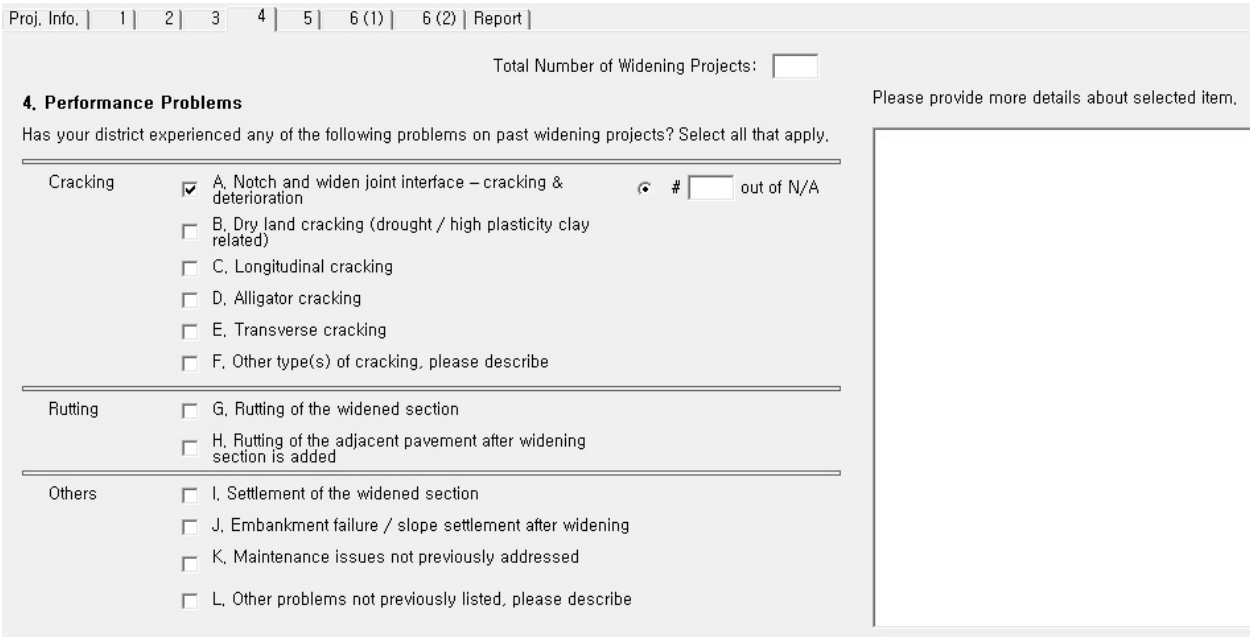


Figure 5.7. DST screen: enter past performance problems

Tab 5, Question 5 asks to list the construction problems encountered on past widening projects (Figure 5.8).

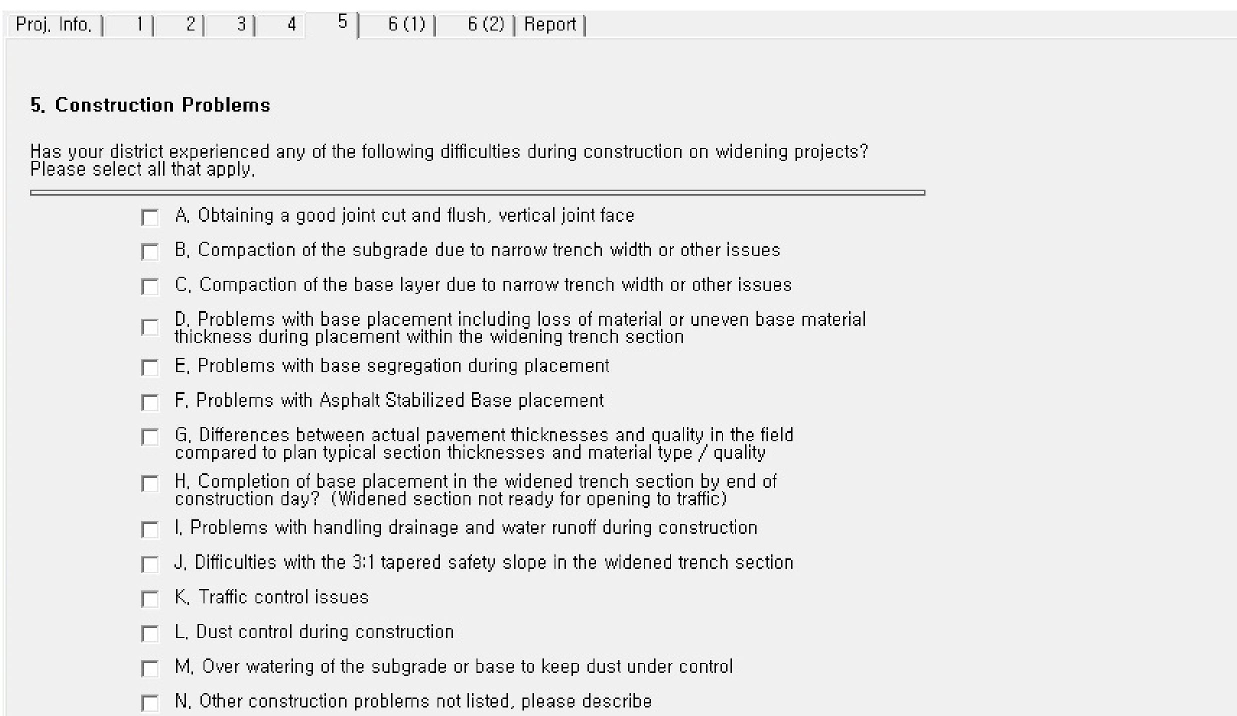


Figure 5.8. DST screen: enter past construction problems

Tab 6(1), Question 6–Part 1 asks the user to list the equipment used by contractors on past widening projects (Figure 5.9).

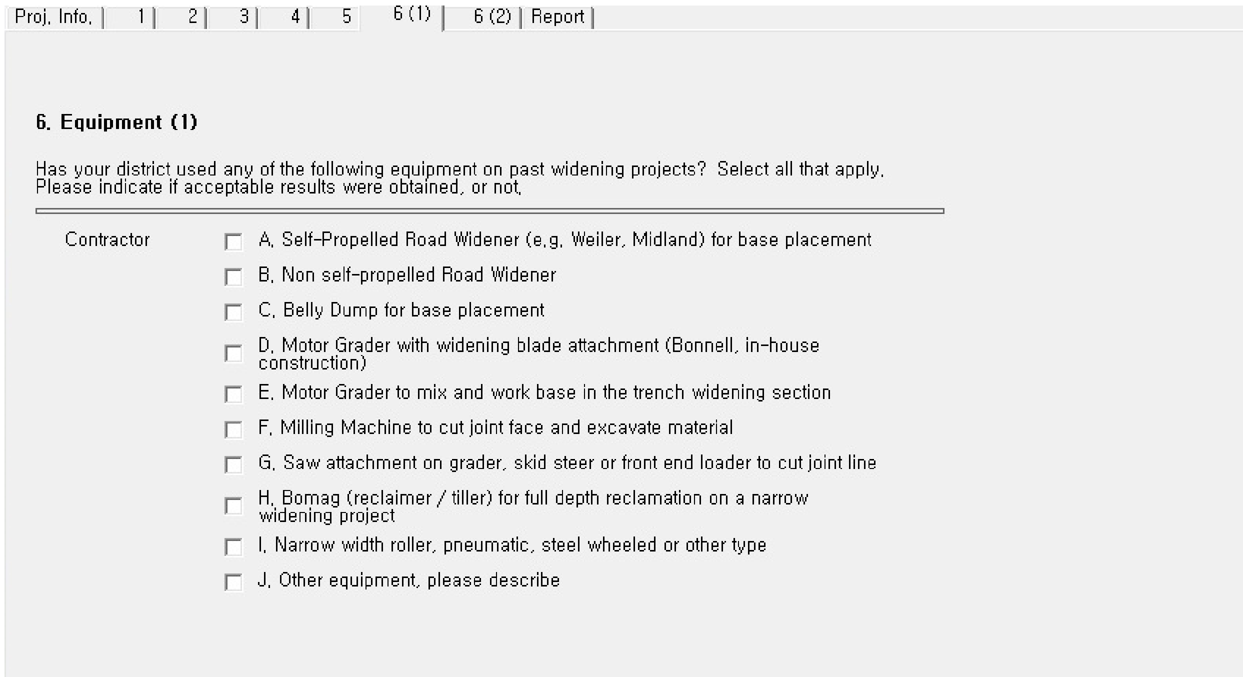


Figure 5.9. DST screen: enter contractor equipment used

Tab 6(2), Question 6–Part 2 asks to list the equipment used by maintenance on past widening projects (Figure 5.10).

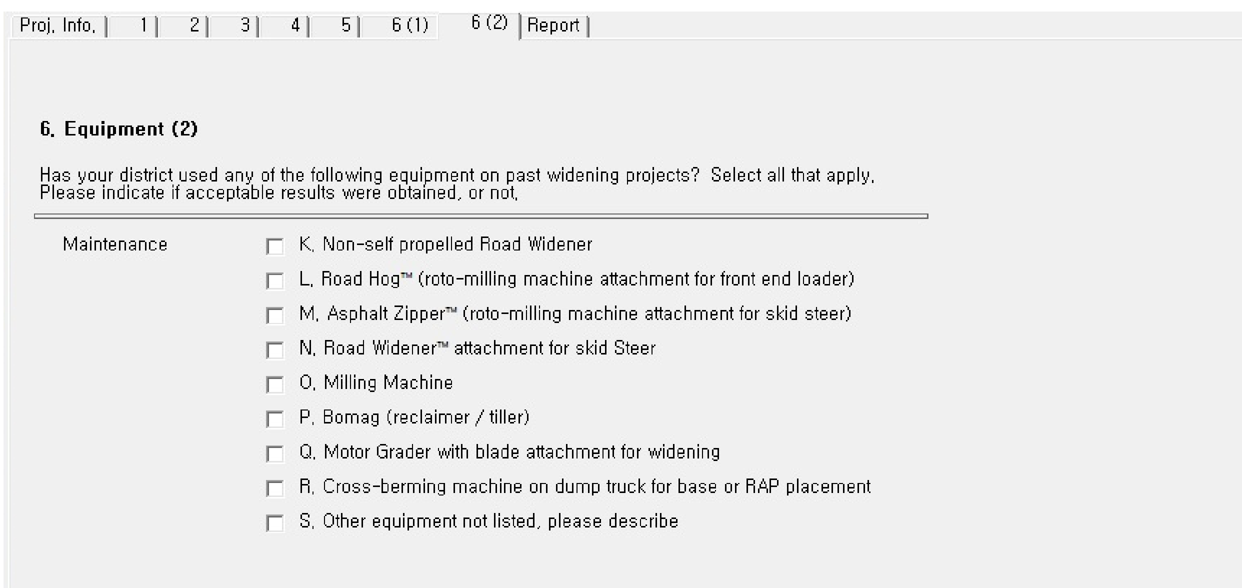


Figure 5.10. DST screen: enter maintenance equipment used

Once all the information has been entered for the proposed widening project, the user can view all of the items that have been selected in the final window and then click on the "Report" button in the Report Tab and a PDF (or Microsoft Word) document will be generated, customized according to the user inputs (Figure 5.11). The document provides experienced knowledge about what has worked and what has not worked for professionals in the field.

Note: The PDF document is created from a large "Master Document" and the items that the user does not select get deleted from the Master Document to create a shorter version that becomes the PDF document output. Because some of the questions are related to each other, some of the concepts may be repeated in the output document.

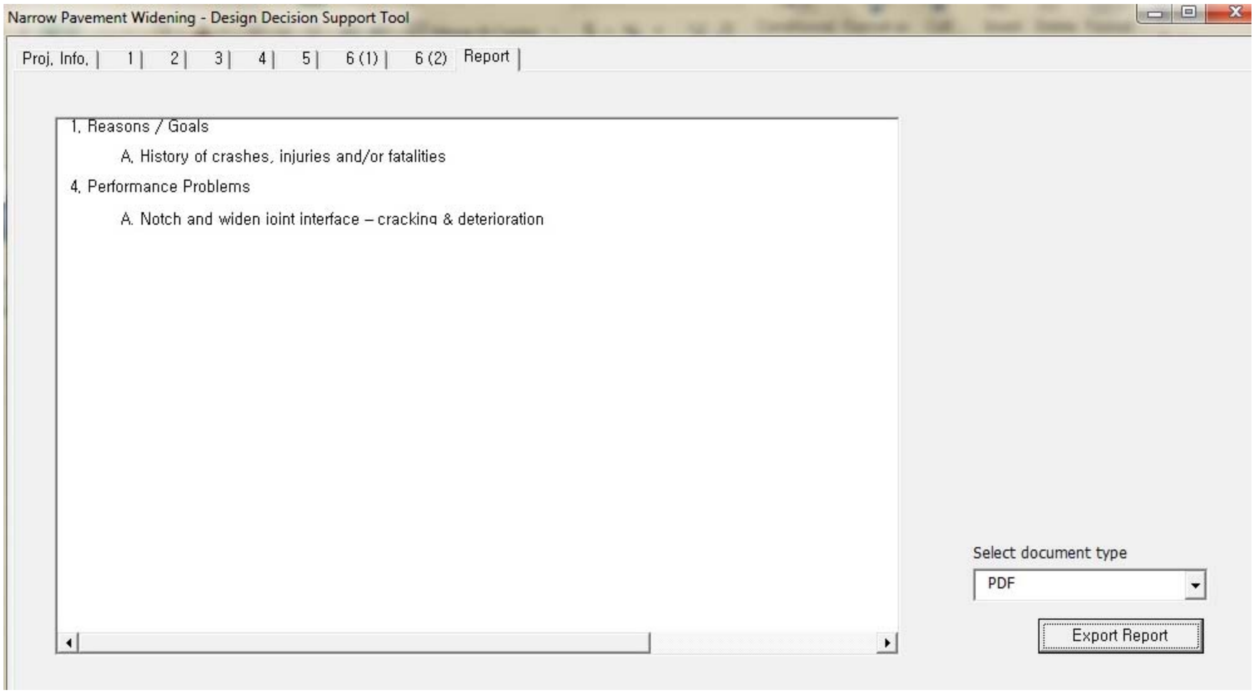


Figure 5.11. DST screen: final window with preview of selections and "Export Report" button

The decision support tool will help the designer identify treatment options that might result in constructability or future maintenance problems and those treatments that will provide good long-term performance. See Figure 5.12 for a schematic of the tool.

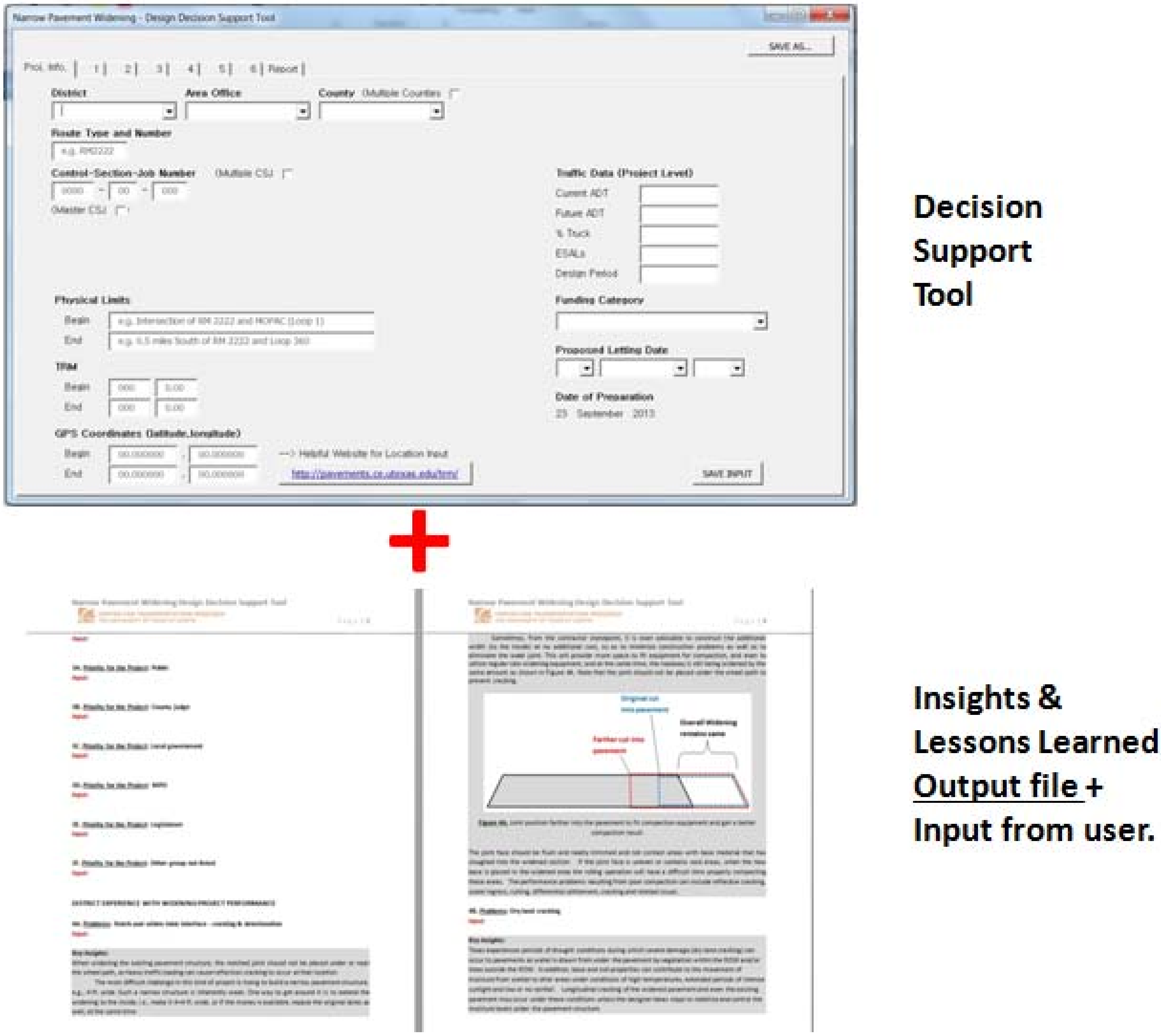


Figure 5.12. Schematic of DST

Chapter 6. Webinar Workshop—Decision Support Tool

This chapter presents a summary of the 3-hour training webinar workshop that took place at CTR on November 22, 2013. The purpose of the workshop was to present lessons learned and best practices to district pavement, laboratory, construction, and maintenance personnel, while introducing the decision support tool. The training workshop presented case studies showing problem areas and solutions that have been implemented. The researchers presented the decision support tool's process for evaluating candidate widening projects, considering on-site conditions, and identifying best treatment options for consideration.

The workshop was organized by first introducing the decision support tool concept and giving an overview of the software and its capabilities. Each function of the program was then demonstrated by different researchers that worked on the project. The final segment of the workshop was dedicated to the researchers describing the respective excerpts of knowledge suggested to the user that appear in the output document from the program. The PowerPoint presentation that supplemented the workshop is in Appendix F.

The participants in the workshop included contractors, construction equipment and materials manufacturers and suppliers, and construction industry representatives. The full agenda of the workshop is in Appendix D. A list of the attendees at the workshop is in Appendix E. Discussion topics and points included the following:

a. *Participant Question:* Does the tool provide a pavement design structure suggested for the user to use?
   Answer: There are too many options to have one correct answer, so the tool provides key insights to consider that help the user make decisions.

b. *Participant Comment:* Rehabilitation is better than narrow widening, as it will eliminate the joint.
   Answer: Rehabilitation is not always the option, as the funding source could enforce rules and restrictions for the project. Sometimes we want to get the most out of the existing pavement.

c. *Important point about equipment*: It is important to match the machine (size and capabilities) to the project to get the best quality.

d. *Question to Participants*: Has anyone seen the Road Widener machine used on projects?
   Answer: One participant has seen the Road Widener used, and the quality result was about the same.

e. *Question to Participants*: Is there a difference between having a 10-ft lane with a 3-ft shoulder vs. an 11-ft lane with a 2-ft shoulder? Sometimes maintaining a particular lane width is a requirement when widening.
   Answer: The lane width requirement depends on the type of traffic. Most widths are controlled by the design manual. A narrower lane might be safer than a wider

lane because it forces people to drive slower. The lane width requirement might sometimes be related to saving money, as it could be cheaper to keep the 10-ft lane and just add the 3-ft shoulder.

f. *Implementation of Tool*: The possibility has been discussed of making the decision support tool a web-based application. When it is web-based, users can use to most updated version of the tool. A web-based version of this tool would also be helpful because of the amount of computer storage space the reference document requires (the Master Document that issues the output PDF).

Conclusion

The decision support tool might be too detail-intense for some people to use, but most webinar participants agreed that connecting the tool with other databases would be helpful.

Chapter 7. Summary and Conclusions

This chapter summarizes and concludes the project. The purpose of this project was to prepare a compendium of best practices and lessons learned regarding narrow pavement widening projects in Texas. The steps involved in this project were divided into six chapters:

- Chapter 1: This chapter involved a comprehensive literature review conducted at the beginning of the project. The task required reviewing and documenting literature on current practices used by TxDOT districts, transportation agencies in other states and abroad, contractors, and equipment developers. This initial literature review cited most of its information from related guideline reports from the U.K., Virginia, Northern Europe, and Texas; however, many other related references are identified in Appendices B–G. The following topics were covered in this chapter:
    - *Introduction* on the reasons for narrow widening projects, and the challenges that arise during narrow widening construction.
    - *Failures* that can result from narrow widening projects.
    - *Pre-design assessment* methods for the existing condition of the roadway prior to design.
    - *Materials* used in narrow widening projects.
    - *Design* issues and solutions for narrow widening projects.
    - *Construction best practices* that work well for narrow widening projects.
    - *Traffic management* during narrow widening construction.
    - *Quality control* enforced on narrow widening projects.
    - *Equipment* that can be used for narrow widening projects.
- Chapter 2: This chapter involved conducting in-person and telephone interviews with experienced professionals and gain knowledge on their experiences and current practices. Different questionnaires were prepared depending on whether the interviewee was TxDOT personnel, a contractor, or an equipment or materials manufacturer or supplier. Some interviews were conducted on the phone. Other interviews were conducted in-person during a visit to a narrow-widening site, during a visit to an equipment supplier's office location, or when the interviewee conducted a presentation at the CTR office. The following interviewees were involved in this chapter:
    - TxDOT District Personnel
        - Austin, Bryan, El Paso, San Angelo, Waco, Atlanta
    - Contractors
        - MidState Equipment/North Carolina Contractor, Barrett Paving Ohio Contractor, Allen Keller Company

- Equipment Manufacturers or Suppliers
    - Roadtec, HOLT Caterpillar, Cooper Equipment Company, Tencate Geosynthetics

- Chapter 3: This chapter involved conducting a webinar workshop with the attendance of experienced professionals to gain expert opinions on current practices. The workshop was conducted to facilitate face-to-face participation for those who could travel to Austin; the webinar component was added to increase the participation of those who could not attend due to limited travel budgets or time restrictions. The morning workshop focused on contractors and suppliers presenting their experience while the afternoon workshop focused on TxDOT experience. The content of the workshops included the following presentations:
    - Morning Session:
        - Introductions and Purpose of the Workshop
        - RoadTec (equipment manufacturer)
        - APAC (site visit by CTR)
        - Allen Keller (contractor)
        - Tencate Geosynthetics (materials manufacturer)
        - Tensar (materials manufacturer)
    - Afternoon Session:
        - Austin District
        - Waco District
        - San Angelo District
        - Bryan District
        - Atlanta District (interview summary by CTR)
        - Pavement Widening Equipment (overview by CTR)
        - Recap of presentations Questions & Answers

- Chapter 4: This chapter assessed the mechanisms and actions that result in either poor or good pavement widening construction quality and pavement performance based on the literature, case studies, expert panel workshop, and interviews. The widening option that will perform well on a project will depend on parameters such as the following, which are discussed in this chapter:
    - *ADT*: High ADT can affect the traffic control needed and the speed of construction.
    - *Number of Trucks*: A high number of large trucks can justify greater road width.
    - *Current Lane Width*: Tight curves and overrunning edges could be a problem if the current lane width is too narrow.

- *Route Type*: Commonly, narrow widening projects are on FM or RM roads.
- *Structural Condition*: If the existing structure is heavily distressed, it might be more beneficial to conduct FDR rather than widening.
- *Soil/Subgrade*: The stability of the surrounding soil should be ensured to prevent excessive settlement or insufficient drainage.
- *Base Type*: Different drainage and compaction problems arise depending on the base type selected.
- *Authorizations*: Widening results will vary depending on the authorizations enabled for the project (e.g., a safety-related project vs. a routine maintenance project).
- *Climate*: Different climates have different problems that affect widening decisions (e.g., freeze-thaw weakening in cold climates vs. dry land cracking in drought-susceptible climates).
- *Equipment*: A variety of narrow-sized equipment is available, or there are construction methods to accommodate the currently available larger equipment.

- <u>Chapter 5</u>: This chapter involved developing a decision support tool to assist districts in making the most effective design decisions, developing appropriate design details, and managing and inspecting the construction of widening project. To use the tool, the following factors regarding the proposed widening project are entered into the program:
    - *Reasons/goals* for the project
    - *ROW* issues for the project
    - *Whose priority is it?* (Public, county judge, local government)
    - *Performance problems* with past projects (cracking, rutting, etc.)
    - *Construction problems* with past projects
    - *Equipment* used in projects

  Based on the results of the user input, a customized final document is generated that provides experienced knowledge about what has (and has not) worked for professionals in the field. The decision support tool will help the designer identify treatment options that might result in constructability or future maintenance problems and those treatments that will provide good long-term performance. The tool also helps serve as a database to store details about narrow widening projects.
- <u>Chapter 6</u>: This chapter involved conducting a training webinar workshop to present lessons learned and best practices to district personnel, while introducing and gaining feedback on the decision support tool. Participants agreed that a web-based application of the tool would be helpful to keep the tool updated and reduce using computer storage space.

The following items could be implemented or added as future developments regarding the decision support tool developed as a result of this project:

- The tool could be integrated with existing pavement management databases. For example, it could be integrated with PMIS (Pavement Management Information System) and extract the traffic inputs from there.
- A subdivision of this project in the development of this tool could account for ADT, crash data, geometry, trucks, drainage, presence of intersections, etc.
- The tool could include structural features such as bridges, and cross and parallel drains.
- The tool could include horizontal and vertical curves.
- It can consider TxDOT highway design manual policies regarding design and posted speeds.
- An option can be included to input crash data for each segment—used for SII and B/C ratio calculations
- An option can be included to perform Structural Condition Index (SCI) analysis and include PMIS distresses in structural evaluation
- The tool could become a web-based application and information could be updated on it when new information arrives.
- This decision support tool approach could be applied to provide a knowledge base for other TxDOT construction-related practices.

Appendix A – Equipment Options

Cold Planers/Millers

Caterpillar
PM-201 Cold Planer
Source: CAT PM 201 cold planer

RoadHog Cold Planers
(CP24 shown)
Source: hydraulic-skidsteer-cold-planer-RoadHog-literature 2

RoadHog RH Series
Self-Powered Cold Planers
Source: RH TLB literature Cat Nov 2011 b

Roadtec
RX-400e Cold Planer
Source: RoadTec RX 400e cold planer

Roadtec
RX-600e Half-Lane Cold Planer
Source: RoadTec RX 600 cold planer

Roadtec
RX-700 Cold Planer
Source: RoadTec RX 700 cold planer

Roadtec
RX-900 Cold Planer
Source: RoadTec RX 900 cold planer

Power Attachments – Zanetis
Cold Planers
Source: TDI-PowerAttachments - Zaneitis Cold Planers

Wirtgen
Cold Milling Machine W 150/W 150i
Source: Wirtgen cold milling machine DS_W150-W150i_EN_0912_LO

Soil Stabilizers & Stone Crushers

RSL
Rock shredder – Stone crusher – Soil stabilizer and Asphalt shredder
Source: Multi Tasking AU 11-2011

Broons - Stehr
Soil Stabilizers
Source: broons_stehr soil stabilizer

FAE
Road Soil Stabilizers
Source: FAE Road Soil Stabilizer AU 11-2011

FAE
Road Stone Crushers
Source: FAE Rock crusher Road AU 11-2011

Self-Propelled Road Wideners

Midland Machinery Co., Inc.
SPD-12 Self-Propelled Road Widener
Source: Midland Machinery Company SP-12 road widener

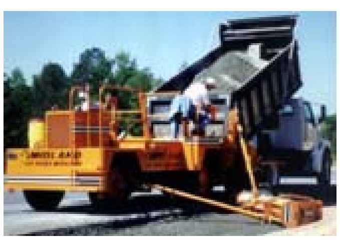
Blaw Knox
RW-195E Road Widener
Source: Blaw Knox Road Widener brochure W-195E

LB Performance
RW-35A Road Widener
Source: Blaw Knox RW-35A Full Brochure

Blaw Knox
RW-80A Road Widener
Source: Blaw Knox RW-80A Full Brochure

Blaw Knox
RW-100B Road Widener
Source: Blaw Knox RW-100B Full Brochure

Franex
Self-Propelled Road Widener EL1000
Source: EL_1000_ROAD_WIDENER_FRANEX_GB



Midland Machinery Co., Inc.
SP-8 Self Propelled Road Widener
Source: Midland Machinery Company SP-8 road widener

Midland Machinery Co., Inc.
SPD-10 Self Propelled Road Widener
Source: Midland Machinery Company SP-10 road widener

Midland Machinery Co., Inc.
SP-6 Self Propelled Road Widener
Source: sp6_broch2pgweb

Weiler
W430 Road Widener
Source: Weiler W430 -series Road Widener Brochure single page format

Weiler
W530 Road Widener
Source: Weiler W530 -series Road Widener Brochure single page format

More Road Wideners

BF 300 **Road Widener/Side paver**
Source: BF 300 Road widener side paver

Strassmayr
BF 290 Road Widener
Source: Roadwidener-STRASSMAYR-BF-290

STiM 2000
Road Widener
Source: STiM 2000 Road Widener Brochure

Weiler
W330 Road Widener
Source: Weiler W330 -series Road Widener Brochure single page format

Protec
BF 300 Road Widener
Source: Protec Roadwidener BF 300 1

PMD 130 Road Widener
Source: Road Widener PMD 130 1

Astec
BF 400 Side Paver - Road Widener
Source: Astec BF 400 side paver - road widener 3

Rollers

Mauldin Paving Products 4700 Pneumatic Roller
Source: Maudlin 4700 2 ton pneumatic

Hamm
CompactLine HD 8 – HD 14, The flexible all-rounder
Source: Hamm HD 14 TT compact pneumatic tire roller

Broons
BH-1300 Impact Roller
Source: Broons impact compactor BH 1300 used to proof roll road

Broons
Square Impact Rollers
Source: broons_square impact roller

Sakai SW/TW300-1 Series
Vibratory Asphalt Rollers
Source: Sakai 1507-124-SW_TW-300-1-brochure1

Sakai
Light Compaction Equipment
Source: SAKAI Lite Equip Broch

Sakai R2H-2 Series
Three-Wheel Static Roller
Source: Sakai R2H

Attachments & Tools

Flocon
Road Base Grader Attachment
Source: Flocon Road Base Grader Attachment

Road Widener
Skid Steer Attachment
Source: Bobcat-Road_Widener

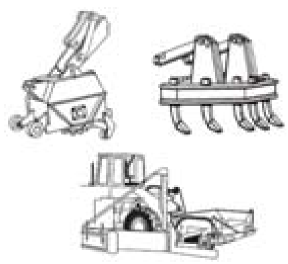
Bonnell Industries Inc.
Flow Gate
Source: Bonnell Flow Gate Brochure

Bonnell Industries Inc.
Road Widener
Source: Bonnell ROAD_WIDENER_MANUAL 2

Caterpillar – Ground Engaging Tools For Motor Graders
Source: Caterpillar Ground Engaging Tools for Moldboard

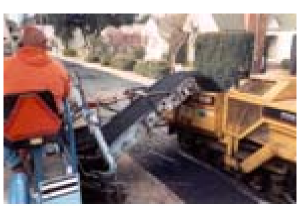
Maddock – RotoGrader Series II
RG72 Rotary Cutter Attachment
Source: Maddox Rotary mill for motor grader RG 72

Midland Machinery Co., Inc.
Widener Attachment
Source: Midland Machinery Company Widener Attachment Brochure



John Deere
Attachments & Custom Engineering
Source: John Deere Construction equipment custom_engineering

Maddock – BackhoeMill
Asphalt Milling Attachment for Backhoes
Source: Backhoe Mill Maddox



APCO Conveyor Tool
Source: APCO conveyor_tool_1

BG Pavers - C17
Source: Innovation in asphalt paving solutions

Construction Machinery Co., ltd.
(Sumitomo) Multi-Asphalt Paver
Source: Japanese dual layer paving technology

Twin layer paving
Source: Twin layer paving evolves

LeeBoy – 5000 Series Asphalt Pavers
5000 Path Master
Source: LeeBoy 5000 Path Master

LeeBoy – 7000 Series Asphalt Pavers
7000
Source: LeeBoy 7000 Paver

Mauldin Paving Products
550E Asphalt Paver
Source: Maudlin 550 narrow paver

Vogele
Tracked Paver – Super 700
Source: Vogele Super 700

Vogele
Tracked Paver – Super 800
Source: Vogele Super 800

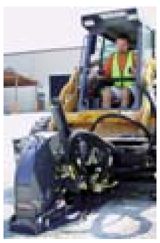
Vogele
Tracked Paver – Super 1100-2
Source: Vogele Super 1100-2

Pavement Maintainers, Road Saws/Cutters/Trimmers, Road Recyclers

LeeBoy
Asphalt Maintainer/Patcher 1200S
Source: LeeBoy Pavement Maintainer

Maddock
Model 48E Berm Cutter
Source: Maddox Model 48E berm cutter

Maddock
VersaTool VT325
Source: Maddox VersaToolCatSheet



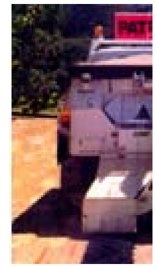
RoadHog
Road Saws
Source: RoadHog-road-saw-literature

Komatsu
Road Recycler GS500-1
Source: Komatsu GS 500-1 road recycler

Shoulder Machines/Wideners, Edge Maintenance

APCO Shoulder Machine
Source: APCO shoulder machine f

Strassmayr
BF 290 Shoulder Widener
Source: Strassmayr BF 290 shoulder widener 7



Flocon
Vehicle Off Road Edge Maintenance Unit
Source: Flocon Vehicle off road edge Maintenance unit - edge paver

SAS Shoulder Paver
Source: SAS shoulder paver 3

Inreco
Shoulder Widening Machine
Source: Inreco Shoulder widening machine 2

More/Other Equipment

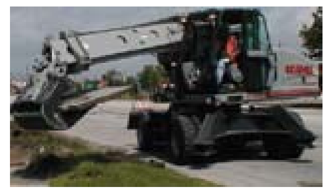
CAT Motor Grader Scarifier
Source: CAT motor grader scarifier

Concord Road Equipment
Berming Machine Undertailgate Cross Conveyor
Source: Concord Cross Berming Machine

Midland Europe
(SPR 6 shown)
Source: Midland Machinery - Europe Road widener brochure

CMI Reclaimer Mill Head
Source: CMI reclaimer mill head

Dynapac - Equipment
(Compact Planer – PL350T shown)
Source: dynapac_complete_range_brochure_en Sweden

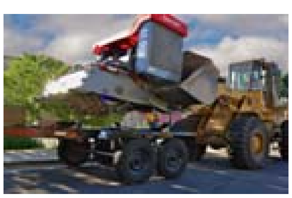


Gradall
Sidewalk Removal - XL 4300 II
Source: Gradall sidewalk removal for road widening

Sandvik
Mineral Ground Tools
Source: Sandvik Trenching_2008

Sharpe Brothers
Sidewinder
Source: Sharpe Brothers Road widening case study 3

Ullrich
Pavement Widening Machine
Source: Ullrich pavement widening machine 1



Asphalt Zipper
Source: asphalt zippe 4

UK Sidewinder
Widening Machine
Source: Sidewinder 24

Wilspread - Equipment
Source: wilspread-2

Appendix B – Interview Details

This section presents the detailed contents of each interview, presentation, and visit.

TxDOT Districts

Austin District

- Challenges with equipment and construction operations for narrow-widening?

  Examples of challenging situations:

  - FM 713, FM 786 in Caldwell County: problems with joint, rutting outside the wheelpath, settlement of widened part.
  - FM 3158: BOMAG project, 18-ft wide (very narrow), widened to 12-ft lanes, added flex base, added cement for binder.
  - FM 2984 in Caldwell County: a project that is coming up, currently being surveyed.
  - SH 21: going away from College Station, west of US 290, from US 290 to where it splits; very little ROW. Ongoing project, good candidate for visiting. Using geotextile. Double reinforcement, stair step, mechanical reinforcement, backfilled with high PI clay.
  - FM 812: edge widening from SH 21 to SH 20, it has been a disaster. In 1977 there was a drought and then there were 4 or 5 floods.
  - Using machines such as MidState, they have a concern about getting the right compaction. Consolidation is a big issue.
  - When the widened part is too stiff relative to the existing section, it causes rutting on the existing part.
- On which types of facilities (funding sources) has your district conducted narrow-widening projects (< 8 ft wide)?
  - US main lanes (e.g., US 183 South, between Luling and Lockhart. Cement stabilized, steep front slopes, narrow ROW)
  - SH main lanes
  - Farm-to-Market Road (FM) (Ranch-to-Market) (Ranch Road)
- Does your district have specifications/guidelines for narrow-widening projects—e.g., is there a particular design guide followed?

  No. They do 1,500 to 1,900 longitudinal ft per day.
- Does your district have standard sheets or details that are used for narrow-widening projects?

  Not yet. They are still learning the process of narrow-widening; they are only 4 or 5 years into it.

- Does your district conduct specific tests to determine how far to cut into the existing pavement to begin the widening section?

  No, nothing special.

- What do your construction inspectors look for to ensure that a good widening job is being constructed?

  That the project is leveled-up, that the edge is repaired; they look for the amount of material for the stabilized subbase, they take samples of the material (e.g., on SH 21 project, they reduced the percentage of cement, because the samples showed the material was better than expected). They monitor the water, and see where it is flowing.

- Does your district typically treat the subgrade prior to base placement (treatment types)?

  Yes. Cement stabilization, lime stabilization, sometimes geogrid (e.g., SH 21).

- How is traffic directed during narrow-widening construction? Does traffic control on narrow-widening projects constrain the types of treatments you use or otherwise have an impact on operations/equipment or material choices on projects of this type?

  Using a pilot car, automatic flagging devices, and a remote control.

- Do narrow-widening projects present greater problems in providing access to residents, businesses, or other property owners than full-width reconstruction or similar widening projects?

  Communicate with owners regarding the upcoming work and the use of their driveways. Keep them informed, and try to keep access for owners as much as possible.

- Willing to participate in a Webinar to discuss your experiences and the District's (counties') best practices and lessons learned regarding narrow-widening projects?

  Yes.

Bryan District

- Challenges with equipment and construction operations for narrow-widening?
  - Challenge trying to get even compaction to existing material. Will get a lot of settlement—outside wheel path "sunk" settled.
  - Do not have chance to get it right because traffic waiting to use road. It is a one-day operation.
  - Do not have great equipment.
  - Cost was about the same to do full-depth reclamation and got better product.
  - Variability in finished product (compaction): will use ordinary compaction instead of density control, which increases variation in densities.

- Types of facilities on which the district has conducted narrow-widening?
  - Have not done in-house maintenance—mostly contractors.
  - FM roads—construction projects, drop off repairs by in-house maintenance.
  - If doing road widening on higher type facilities (SH or US highways), would likely add full width lane and use regular construction processes.
- Common types of narrow-widening projects in district?
  - Do not have much good soil, clays. More like edge repair, not widening. Do not get compacted enough to support traffic.
  - When have failures on narrow roads, will BOMAG it and add more lateral support (widen 2 ft) and typically add cement when doing this.
  - Traffic always wearing out edges, so always trying to maintain edges.
- Common reasons for narrow-widening projects in district?
  - Safety enhancement: safety projects funded under the safety program. Add 3 ft on both sides.
  - Curve widening or widening at county road intersections for oil field traffic or other heavy trucks.
- Projects that performed well and lessons learned?

  7–10 ft widening with cement treating did well, but for narrow widening, sandy soils (as opposed to clay) performed better.
- Resulting distresses from projects that did not perform as planned?
  - Settlement of widened section
  - Rutting in the outside wheel path of existing pavement
  - Longitudinal cracking
  - Problems vary from project to project depending on soil type, have a lot of weak clays and some sandy soil
- How is existing pavement cut at widening joint?

  Cutting into an embankment: will cut material and roll it over onto the slope. Might have to do some blade work to create working platform.
- Types of equipment used by Contractors for narrow-widening projects?

  Contractors had in past: Knife River and A. L. Helmkemp. Knife River had an attachment placed on motor grader blade, would drive along road and create 2-in.-deep seam. A grader was used to cut the trench using the seam as a guide.
- Some names of equipment used for narrow-widening projects in district?
  - Asphalt Zipper: Do not have one. One for east region.
  - BOMAG scarifier: non-self-propelled, mount on front of front-end loader

- The Road Widener: an attachment for skid loader place base or hot mix
- Bobcat road widener: use to build safety edges, don't do widening road but edge repair. After placing material, roll it with dump truck tire.
- CAT road grader: used with road trenching or plow attachments

- District specifications/guidelines for narrow-widening projects?

  No specific guidance for these projects.

- Conditions to place RAP, cold mix, or ACP when existing has granular base course?

  Mainly use RAP for safety edges or treating drop offs.

- Is subgrade treated prior to base placement?
  - Typically do not use lime or cement to stabilize subgrade in widened section. If BOMAGing a road, will use cement as a stabilizer and cut into existing pavement a few feet rather than cut joint at edge.
  - Roll subgrade before base placement: drive a dump truck down the trench section to check for soft spots. If soft spots, will dump base material in trench and work over with motor grader.

- Traffic control challenges that may not exist on other types of widening projects?

  Traffic control problems: not like a big construction project, which can shut down a lane. Have to keep road open to traffic and have to fill trench with material by end of work day so don't have an open trench (have to at least have un-compacted base placed in trench by end of day).

- Projects that are not good for narrow-widening?

  Widening on edges of really old narrow roads will end up putting 2 ft on sides and nothing in between, so do not do that…

- Willing to participate in Webinar?

  Yes.

- Additional contacts?

  Mark Schafer, area engineer, Brenham Office, (979) 836-9359. Conducted negotiations with contractors. Good to call regarding types of equipment used by contractors.

- Additional comments?
  - Flowable fill in "bathtub" concept would get expensive compared to the cement/water/sand that we already use. Slow set times can also be a problem. Better to cement treat and place.
  - Putting precast shoulder slab blocks with rumble strips built in concept might be good for isolated areas, like a curve. Something in-house maintenance could do (because hard to pour concrete there) for when trucks tear up the radius. May not be good for long distance.

    - Hydrogenesis: moisture trapped inside. Could be reason for rutting on newly widened pavement from putting wet base down and material underneath pulling moisture in.

El Paso District

- Types of facilities on which the district has conducted narrow-widening?
    - Maintenance is not generally used for widening projects.
    - Past projects: FM 170 (flex base), FM 192 (on the US/Mexico border), and SH 118.
- Common types of narrow-widening projects in district?
    - Partial-lane widening
    - Add shoulder or partial shoulder widening
    - Widen or add turn lanes
    - SH 118 in Big Bend (popular tourist destination) against the mountain was widened to improve safety.
- Common reasons for narrow-widening projects in district?

  Safety enhancement.
- Types of equipment used by contractors for narrow-widening projects?

  The district owns typical construction equipment in terms of graders, loaders, rollers, trucks, etc.
- Some names of equipment used for narrow-widening projects in district?

  Asphalt Zipper: the district does not use one.
- District specifications/guidelines for narrow-widening projects?

  No.
- District standard sheets/details for narrow-widening projects?

  No.
- District standard sheets/details for narrow-widening projects?

  No.
- Tests conducted to determine where to cut for widening?

  No.
- Conditions to place RAP, Cold Mix, or ACP when existing has granular base course?

  SH 118 project: against mountain side and used cement stabilized RAP (cold mix) for the widening of the lane against the mountain with a seal coat across the entire roadway.

  RAP with cold mix placed to prevent water ingress.

- Is base material treated and what is done if different base materials?

  Base materials (crushed limestone) have high fines—cement stabilized to improve stability.

- Is subgrade treated prior to base placement?

  No.

- How is traffic directed and constraints from traffic control?

  Use of pilot vehicles.

- Projects that are not good for narrow-widening?

  Widening on RM 505 was a candidate but was rejected because "it would kill the scenic view."

San Angelo District

- Types of facilities on which the district has conducted narrow-widening?
  - Narrow-widening done in district maintenance, contract, and in-house, etc.
  - Adding shoulder to US highways
  - Mostly FM (e.g., the project FM 2011: 600 vehicles per day)
  - Areas with a lot of oilfield traffic
- Ongoing narrow-widening projects?
  - Ranch roads 335, 336, 337 in Real County: Roadtec Miller to mill and put material in dump truck and haul off, grade 3 flexible base, dump with belly dumps, prewetted speeds up production twice as estimated, priming asphalt with grade 5 rock, will sealcoat entire area, does not tack base because just using raw flexible base.
  - FM 2171, Runnels County: contractor using milling machine to mill edge where cut will go, sealing sections before doing milling again.
- Common types of narrow-widening projects in district?
  - Add shoulder or partial shoulder widening
  - Existing shoulder and adding pavement width
- Common reasons for narrow-widening projects in district?

  Safety bond widening: motorcycle tragedies from twisty/windy roads—need extra shoulder running room. (Ranch roads 335, 336, 337 in Real County, up to 700 vehicles per day).

- Projects that performed well and lessons learned?
  - So far all performed well, no failures
  - This is first time using Roadtec Miller

- Flexible base is put in trench with belly dump
- Truck material off rather than use it because not enough existing pavement
- Natural/subgrade material so not good material to be used back into base material
- Create a trench—best results when have “bathtub”

- Resulting distresses from projects that did not perform as planned?

  Problem where to put joint, start losing rock and joint exposed. Solution: 2-ft-wide strip seal to hold joint in place.

- How is existing pavement cut at widening joint?
  - Roadtec miller gives nice straight cut, does not disturb existing base.
  - Contractors saw-cut a straight edge. Two miles at a time. Remove existing material. Come back with new base material, compact it. Prime the base. Overlap with seal coat on existing pavement.
  - Use maintainer (blade)
  - Use milling machine to mill edge
- Some names of equipment used for narrow-widening projects in district?
  - First time using Roadtec Miller
  - Have not heard of Asphalt Zipper
- District specifications/guidelines for narrow-widening projects?
  - No guidelines/specifications for narrow widening
  - Will indicate to saw-cut edge but equipment used is not specified, let contractor propose the equipment to use
  - For cross-slope requirements: just match existing
- What is looked for to ensure quality of narrow-widening construction?
  - Compaction
  - Placement of base—proper depth
  - Materials being used
  - Density control
- Field/laboratory tests to ensure quality during/after construction?
  - Materials being used: samples tested in lab. Contractor submits where getting base from and they will test samples
  - Densities run as well for density control
- Is base material treated and what is done if different base materials?
  - Been using flexible base and black base, but have to come back and seal it or will lose it

- Does not tack base because using raw flexible base
- Remove existing material, come back with new base material, compact it, prime the base
- Black base so expensive so only use in repairs where safety hazard. It's dry in district so not a concern.
- Better quality of ditch, better the compaction. Black base doesn't have shelf life, but the fresher the better.

- Is subgrade treated prior to base placement?
  - Roller to compact subgrade and black base material
  - Important to have wider roller (will lease to do the work)
- How is traffic directed and constraints from traffic control?
  - Real County: traffic control used same—whole road or one side. Forced to use pilot car no matter what.
  - Lane closure with pilot car. Allow to leave safety slope at end of day.
- Problems with access to property owners?
  - Skip the driveway areas
  - Will go through driveway, will put ramp as soon as possible, but property owners do show sometimes. Do the best they can.
- Projects that are not good for narrow-widening?

  Condition of existing road, if needs rehabilitation is not good for this type of project.
- Willing to participate in a Webinar to discuss your experiences and the District's (counties') best practices and lessons-learned regarding narrow-widening projects?

  Yes.
- Additional comments?
  - Have not used geotextiles for sealcoats in widening
  - Safety bond money will not do rehabilitation, so had to do narrow widening—but rehabilitation gives better product because eliminates the joint between existing and new pavement. Could get better product for same cost if rehabilitating.
  - To use flowable fill for base material in widening—have to consider if it is stiffer
  - West Texas—do not have concrete back plant so costs go up to bring mobile plant
  - NC: put bigger aggregates to allow drainage. Did this in TX for full-width project and it worked well.
  - Manufactured blocks for widening—price is concern, concern with water getting between base and joint (joint sealed?). With hot mix, water blocked from getting out.

Waco District

- Types of facilities on which the district has conducted narrow-widening?

  Mostly FM roads.

- On-going narrow-widening projects?
  - FM 2113 McLennan County: was a notch down and cement treatment.
  - FM 1123 Bell County: was a notch down and cement rehab project (started November)
  - FM 39 Limestone County: a notch down widening project, but not rehab with cement (started 2 weeks ago)
  - SH 22 Hill County: a notch down and widening project
- Common reasons for narrow-widening projects in district?
  - Recently done full width reclamation projects. Depends on the limitations of the Hazard Elimination Program (HES) or now called Highway Safety Improvement Program (which funds to address safety issues but won't pay for rehabilitation).
  - For safety money, have to qualify through HES based on benefit cost analysis. Evaluated based on accidents—e.g., need to mitigate off the road crashes. Projects ranked by SSI score.
  - Widening projects done under Safety program and CAT-1. Safe Routes to School program just addresses sidewalks. Maintenance mainly spot repairs, base repairs, not widening except to add a shoulder at an intersection or turning lane.
- Projects that performed well and lessons learned?
  - Been doing narrow-widening projects at least 4 years
  - Methods depend on type of roadway and condition
  - To get paved width of 28 ft, adding 4 ft on either side
  - Notch down at edge of travel lane and typically use flex base for widening
  - If structural problems, notch down 10 in. and add flex base with cement treatment
  - If too narrow to work the base material (working area 5 ft or less), will use asphalt stabilized base
  - Notch down subgrade crown to the required width and depth or bring a BOMAG and scarify the entire width of the road about 6 in. deep. Spread the 6 in. of material out to edge of subgrade crown. Compact material and bring new base. Then prime entire road and place a 2-CST.
- Projects that did not perform as planned and lessons learned?
  - If widen with hot mix, may have a problem with a bathtub section that won't allow water to drain
  - FM 1860: notched and widened the base, but one side of the road had 6 in. of base and other side had 10 in. of base. Existing section thickness was matched with

widening, but the 6 in. section gave problems. Now will go to at least 10 in. deep when widening.

- Resulting distresses from projects that did not perform as planned?
  - FM 1860: had settlement mainly from truck traffic. Problem was subgrade failure, didn't stabilize the subgrade.
  - FM 1237 Bell County: longitudinal cracking at widening joint. Narrow-widening project was stabilized and included a 1-1/2 in. ACP level up. Entire roadway was BOMAGed.
- How is existing pavement cut at widening joint?
  - Typically notch the pavement using a blade (grader). If reclamation project, use a BOMAG or milling machine. In Hill County, use a blade to notch down to create widened area.
  - Milling used on FM 1858. Milling machine windrowed the material on the front slope, which that material was wasted. Then bring new material to place 10 in. of base in 4-ft widened area.
  - Do not tell contractor how to cut or what equipment to use
- Some names of equipment used for narrow-widening projects in district?
  - Have not seen contractors use a road widener (such as Midland or Weiler).
  - Usually base is placed using belly dumps and then base is processed with a blade.
- What is looked for to ensure quality of narrow-widening construction?
  - When using a BOMAG in full width reclamation with cement, will check densities if in a fill, but just proof roll the subgrade if in a cut
  - Inspectors check density on the subgrade and base material. Contractor has to meet density requirements in specifications.
- Is base material treated and what is done if different base materials?
  - Notch down at edge of travel lane and typically use flex base for widening
  - If structural problems, notch down 10 in. and add flex base with cement treatment
  - If too narrow to work the base material (working area 5 ft or less), will use asphalt stabilized base
  - Do not require contractor to tack the face of existing pavement before placing the widening material.
- How is traffic directed and constraints from traffic control?
  - Problem with handling traffic during construction and opening the roadway back up to traffic at the end of the work day. Can’t allow contractor to open more trench than he can pave in a day—must at least place the flex base so there's no drop-off. If placing hot mix in the widened section, you can turn traffic back onto the pavement that evening.

- Projects involve lane closure with pilot car. Contractor will get as much length in a day as possible. Can't leave open trench at end of day. Rule of thumb: can't pave over 2 miles in a day.

- Problems with access to property owners?
  - Contractors are required to maintain access to drives during construction. Contractor has to coordinate with residents to make sure they can get in/out of property.
  - Most projects are rural, so there are not many private drives.
- Additional contacts?
  - Contractors that have done district widening projects:
  - - Big Creek
  - - Stevenson-Martin
  - - APAC
- Additional comments?
  - Flowable fill could work, but could be problems to keep traffic off when curing. Also concern with cracking and flex base is $35/CY, while flowable fill is $100/CY.
  - They do not use fabrics on widening projects, but could be used. Used fabrics when placing overlay on existing base layer. One project used fabrics to prevent reflection cracking, but the cracks reflected anyway.

Atlanta District

Mr. Garrison indicated that most of the widening of roads in his district is completed—about 95%–98%—so very few projects are planned or ongoing, although there is one scheduled for July.

He indicated that widening in Texas will differ from district to district given varying materials and weather conditions. In his district it is particularly wet with very few HMA plants; hence, their widening projects differ significantly from their neighbor, Tyler, which uses a lot of HMA for widening.

- For which types of facilities (funding sources) has your district constructed narrow-widening projects (< 8 ft wide)?

  The majority of widening projects were funded through Safety bond funds. He did not know of any projects funded through the categories listed above. All widening projects are on rural FM roads with low traffic volume.

- What are the most common types of narrow-widening projects in your district?
  - Partial-lane widening
  - Add shoulder or partial shoulder widening

- Widening typically involves 10 inches of un-stabilized flex base, a level-up and seal coat covering the entire roadway. In some cases the subgrade is cement-stabilized in which case a 7-in. flex base is used. If the road is under the district wide seal coat program then the widening will receive a second surface treatment as well. Lots of attention to ensure adequate drainage—Atlanta is a wet district!

- What are the most common reasons for narrow-widening projects in your district?
  - Safety enhancement (traffic separation—crashes have occurred along route)
  - Usually decide to widen following wet weather accident reviews.

- Can you cite specific narrow-widening projects that resulted from public or political requests to widen the road?

  No.

- Can you cite specific projects which you think have performed well including specific reasons for the good performance? What lessons have you learned about narrow-widening projects that led to good performance?

  Most projects perform well, although some have shown settlement contributed to poor workmanship by contractors. These problems are addressed using a level-up.

- Regarding projects that did not perform as planned, what types of distresses occurred?

  Settlement, mainly with some longitudinal cracking at joint, although it has not been a major issue.

- Does the contractor (Contracted Maintenance – Routine Maintenance) use a saw or other device to cut the existing pavement at the widening joint? If not, how is the joint usually created (road grader, milling machine etc.)?

  Joints are cut using the blade from graders/maintainers.

- What types of equipment are used by Contractors for narrow-widening projects?

  Contractors do NOT use special equipment for widening projects.

- Does your district have specifications/guidelines for narrow-widening projects—e.g., is there a particular design guide followed?

  A design was previously emailed to Dr. Mike Murphy.

- Does your district have standard sheets or details that are used for narrow-widening projects?

  Some general notes for flexible base are used.

- What do your construction inspectors look for to ensure that a good widening job is being constructed?

  Few inspectors on these jobs—only when available.

- Does your district perform specific field or laboratory tests to ensure the quality of the widened sections during or after construction? What tests are performed?

  Density control on base, gradations, and plasticity index.

- Under what conditions would you place RAP, cold mix, or ACP in the widened section when the existing pavement has a granular base course?

  No ACP used for widening.

- Does your district typically treat the base material in the widened section?

  No.

- Does your district typically treat the subgrade prior to base placement (treatment types)?

  Yes, subgrade is treated sometimes. Reduce flex base thickness accordingly.

- How is drainage addressed during construction?

  Lots of attention given to drainage.

- How is traffic directed during narrow-widening construction?

  Use of pilot vehicles—ensure construction done by end of day.

- What types of traffic control challenges do narrow-widening projects present that may not exist if you were constructing a full-width scarify, re-compact, add base and new surface type project to widen a roadway?

  None.

- Do narrow-widening projects present greater problems in providing access to residents, businesses or other property owners than a full width reconstruction or similar widening project?

  No, mostly rural.

- Would you be willing to participate in a Webinar to discuss your experiences and the District's (counties') best practices and lessons learned regarding narrow-widening projects?

  Yes—although he did not think that districts could learn much from each other given differences in materials, weather conditions, etc.

Contractors

MidState Equipment Company in North Carolina

- Challenges with equipment and construction operations for narrow-widening?
  - Limited work zone area, which results in safety hazard issues
  - Limited equipment size: the WilSpread is the smallest among the road wideners at 102 in. wide. If no shoulders, traffic has to be directed while widening work takes place.
  - Rollers: contractors need to be careful about their safety, as they can turn over with ease.
- Projects that performed well and lessons learned?
  - With the milling machine, mill 1 ft of existing pavement
  - Compact the edge
  - Tack the edge with emulsion; otherwise there will be movement of material and cracks
  - When widening done, overlay the entire width of the road
  - The best way to compact is with the tire of the motor grader, if there is enough room for the wheel
- Districts/Area Offices with a good set of narrow-widening construction plans?

  No guidelines or specifications prepared by NC DOT or other state DOTs that know of. Engineer in charge of project makes the decisions using own experience rather than following guidelines.
- Some names of equipment that the company has purchased/used for narrow-widening projects?
  - Knows of Road Hog. It is more stable than Asphalt Zipper. It needs to stay at a consistent depth. It is good equipment.

Figure B.1. The Road Hog, a self-powered cold planer

  - Knows Asphalt Zipper. It is good equipment, but not as consistent as the Road Hog due to its design. Virginia DOT had one. Hasn't seen either of these doing milling, only localized patching.
  - Bobcat recommended with the milling machine attachment
  - MidState Equipment: Road Shoulder Machine
  - Wil Spread 318
  - Compact and self-propelled. Both are towable.

- Company practices for good narrow-widening results?

  To do the cut: use a bobcat with the attachment to saw, make a straight cut, keep the depth consistent, level up and compact.

- Training for employees on equipment use in narrow-widening projects?

  Yes, training is provided on equipment, on-site. Will go to a low-profile road to be widened, bring equipment, and go through operations and maintenance of equipment with crews. Will stay for entire day, go through starting and stopping to make sure operations understood.

- Treated (stabilized) the base material in the widened section?

  Sometimes place ABC stone and let it settle for a while.

- Treated (stabilized) the subgrade prior to base placement?

  Placing a binder course and then the surface course on top. Some counties in NC put ABC stone.

- How is drainage addressed?

  Hard to control the slope of the strike-off. But it can be done with company equipment, which is hydraulic and control is only visual. Larger equipment may have electronic slope control.

- How is traffic directed and constraints from traffic control?

  Too much traffic for narrow-widening depends on if being done day or night. Also if in urban setting, it might be too much. Another factor is whether there are shoulders or curb and gutter. Shoulders allow for some more room to redirect traffic.

- Problems with access to property owners?
  - If in urban area with housing developments, residents will complain about piling material over in ditches.
  - In rural setting, farmers don't normally care about the grader leaving material. Also it is better if materials are going to be reused.

- Projects that are not good for narrow-widening?

  Has not seen any particular project not good for widening. Projects that are not good for widening are those where the original pavement is severely rutted or cracked—in which case it is better to reclaim it. Most projects seen are good for in-house work. Longer/bigger projects need to be contracted.

- Willing to participate in Webinar?

  Yes. Also willing to participate in a pilot project.

- Additional contacts?

  Cousin works for a contractor in NC: Lane Construction.

- Additional comments?
  - No geotextile materials are used for drainage control but interviewee has seen it used as a moisture barrier on Interstate Highways.
  - Has not used flowable fill or honeycomb (used in Europe).

Barrett Paving Construction

- Challenges with equipment and construction operations for narrow-widening?

  Compaction is done with a vibratory roller. The smallest used is 36 in. wide. If something narrower, have to use something else, which is not as good.

- Types of facilities on which the company has conducted narrow-widening?
  - City streets
  - County roads
- Projects that performed well and lessons learned?
  - Projects with no less than 3 ft wide to ensure better compaction
  - Normally use 2 lifts of material to get better compaction, but it depends on the depth.
  - Use full-depth mix in the widened part.
  - Cross-slope: have controls to adjust the screed to strike-off the material. Have a hand-held control that allows to do that very well.
- Projects that did not perform as planned and lessons learned?

  None, oldest project is about 10 years old, and still in good condition. It carries a lot of agricultural vehicles and equipment, such as harvesters. It might have some cracking but not rutting. Rutting happens if compaction is not done properly.
- Types of information that would make narrow-widening job easier?

  Only follow what the owners (cities or municipalities) request or specify for their jobs. Normally place 9 in. of base, 1 1/2 in. of intermediate material, and the surface course.
- Districts/Area Offices with a good set of narrow-widening construction plans?

  Have not done work for the DOT.
- How is existing pavement cut at widening joint?

  Use cold-milling to cut the trench, which is normally 2 to 4 ft. Use the Wirtgen 1900. For the City of Fairfield, had a subcontractor doing the milling with Roadtec machines.
- Some names of equipment that the company has purchased/used for narrow-widening projects?
  - Have two Midland Wideners, used to place material back in the cut, and very happy with the equipment. Works well for 2- to 6-ft-wide trenches.

Figure B.2. Midland self-propelled road widener

- Used to have a Weiler Road Widener, but company likes the Midland better. Had an issue with Weiler: the tailgate of the dump truck hit the conveyor belt and ripped it.
- Know of the Road Hog and have used it, but prefer other equipment. Road Hog is hard to gauge and control because operator is far from the work area.
- Know of the Asphalt Zipper. Used a similar machine, the Road Hog.
- Dynapac Vibratory Roller is used.
- Know of the Hamm small compactor with pneumatic tires.

• Special training for employees on narrow-widening projects?

No extra training. These projects are done year-round so no need for additional training.

• What is looked for to ensure quality of narrow-widening construction?

- At least 3 ft wide
- Base course of good size rock
- Keep the edge clean
- Clean the edge before tacking it
- Sometimes use a joint fabric, to straddle the joint, which is a thick fabric; however, it may have workability problems and create bumps if not perfectly leveled

• How is traffic directed and constraints from traffic control?

Traffic control is an issue, especially in really narrow roads. Normally widen one side at a time.

- Problems with access to property owners?

  Typically in residential areas, will pass letters informing owners of driveway closures 2 days in advance. Normally residents leave vehicles out so can still leave without using driveway. Businesses with two driveways will shut down one at a time.

- Willing to participate in Webinar?

  Yes.

Allen Keller Company

The Allen Keller Company was founded after WWII. It is based in Fredericksburg. They do mostly work on rural roads. They own quarries in the area, which allows them to have shorter hauling distances to their jobsites. They own a Roadtec Milling machine, the Roadtec RX-600e, which was new for the job they performed in Real County. This machine has been advantageous because it allowed them to finish the job ahead of schedule.

The Roadtec matches the cross-slope, it is easier to operate and faster than other machines, and it saves them money.

TxDOT gives the contractor typical sections, and gives them flexibility to make the decisions based on what is actually there on the road, which may not be represented accurately or entirely on the plans. This allows them to use their experience and their judgment to do a better job.

TxDOT inspects their jobs for safety, quality control, traffic control, and densities.

They normally can do 1 mile per day of subgrade and base widening. This limitation is in place because the new base material needs to be brought to the site.

The visit to FM 783 showed the joint already visible on a recently widened road. This job was finished in October 2012. The total length is 8 miles, and the widening was 4 ft. Total cost was about $5 million.

Figure B.3. Joint reflecting on the wheelpath of the recently widened lane on FM 783

The visit to US 83, in Kerr County, starting at the Edwards County line, showcased a full-reconstruction project that required a 12-in. base, as it is a US highway. For this widening project, they took the money that was offered for it, and were able to do a full reconstruction, so there is no joint problem in this case. They placed two courses on the same day, with a fog seal on top.

Figure B.4. US 83: Full reconstruction instead of widening

The visit proceeded to Leakey, to see RM 335, RM 336, and RM 337, known as the "Three Sisters." These widening jobs were necessary for safety reasons. These are hilly and curvy roads that are used frequently by motorcycle riders, and as such, are very prone to accidents.

Figure B.5. Safety warning sign on RM 336 South

These jobs have not had joint failures. The Roadtec machine did the cutting, and they use a pneumatic roller for compaction.

Figure B.6. Construction work still taking place on RM 336

Figure B.7. Pilot car performing traffic control duties on RM 335

Figure B.8. Spreading the material with a blade attachment to a Caterpillar machine

Figure B.9. A pneumatic roller and a flat-wheel roller compact the material after it is spread

The last road visited was FM 2093 in Fredericksburg. It is a 1-mile project, started in the fall of 2012. There was a substantial amount of rain, which got the material wet. The subsoil is not very good—there is a 4 or 5 in. layer of caliche, with high PI—so the subgrade kept failing. It was a hot-mix widening, about 500 ft per day was done, and it did not turn out well. It has edges failures.

Figure B.10. FM 2093 in Fredericksburg, where the hot mix failed

- Some names of equipment that the company has purchased/used for narrow-widening projects?
  - They own a Roadtec machine, and have gotten great results with it.
  - They know of the Asphalt Zipper, and dislike the fact that the cross-slope cannot be controlled.
  - They know of the Midland Road Widener and they do not use it because it spills the material and is messy. They considered it, but decided against it in favor of the Roadtec.
- How is traffic directed and constraints from traffic control?

  Traffic control is conducted with a pilot car and flaggers. They normally can hold traffic for 15 minutes.
- Problems with access to property owners?

  Typically for residential driveways, they just mill straight through and try to place base material as quickly as possible, so the driveway is functional again. If there is a concrete driveway, they skip it without milling.
- Willing to participate in Webinar?

  Yes.
- Additional comments?
  - There is no need for using geotextiles on the jobs they perform, because they only perform widening jobs in an area (e.g., San Angelo District) where the soil does not have too much moisture. Places where heavy clays are prevalent might warrant use of geotextiles.
  - They do not use flowable fill: it would be too expensive.
  - They use the "sheep-foot" roller for compaction of subgrades only. For bases they use the flat-wheel, which is smooth. They use six to eight passes with the flat-wheel.
  - There are no hot-mix plants in the area where they perform their jobs, so they use base as opposed to hot mix. There is only hot mix available for large, interstate highway projects, which normally bring a portable plant to the jobsites.

Equipment or Material Manufacturers or Suppliers

Roadtec

Roadtec is an equipment manufacturing company that produces asphalt pavers, milling machines, and cold in-place recyclers. It is owned by Astec Industries. Astec owns several different companies and was started in 1972. Astec is a leader in manufacturing asphalt mix plants and probably have sold 60–70% of the plants in Texas. They own other companies such as Heatec and an aggregate and mining company called Telsmith. Roadtec was started in the mid-1990s in Chattanooga, Tennessee, and originally Astec owned Barber-Greene, but sold that company to Caterpillar.

Typically, for narrow-widening projects the RX-400e is one of their most popular pieces of equipment. The 400e was designed as a utility milling machine and can cut to a 12-in. depth (10–11 in.) nominal. If there is a severe front-slope adjacent to the milling machine, it might not be able to achieve 12 in.

The width of the cutting drum can be changed by installing different drums and using a blanking plate inside the milling enclosure. This is called the Variable Cutter System (VCS). The milling heads are 24 in., 36 in., and 48 in. wide. The blanking plate or false wall inside the milling head enclosure ensures that material does not build up inside the enclosure and that all milled material is forced forward so that the conveyor picks it up.

The 400e can be run with one person, but it is preferred to have 2 people—one running the machine, and the other walking along side acting as reconnaissance (looking for items such as storm sewer manhole covers or similar objects that could cause problems).

The 400e can easily mill either asphalt or soil, but has a hard time milling concrete. However, it can handle limestone rock in some cases. Another advantage of the 400e is that it is narrow enough to ride along-side the existing pavement in the trench area so there is minimal lane intrusion. Contractors who have bought this machine include the following:

- Smith & Company (Bryan, Houston, Lufkin and Beaumont)
- Big Creek Construction (Waco, Bryan)
- Gist Enterprises (Paris, Atlanta)
- Cutler Re-paving (Houston)

Contractors east of IH 35 tend to own one of the road widener devices, such as a Midland or a Weiler. However they are not used too often because TxDOT does not let a stable flow of widening projects. A district might let 40 or 50 miles of widening projects in one season and then none in the next season. In order to make it profitable for a contractor to buy a specialized piece of road widening equipment, there needs to be a stable flow of work. The road wideners that are owned by the companies in east Texas are likely at least 10 years old and really aren’t used that often. Companies that own road wideners include the following:

- Angel Brothers
- Smith & Green

- APAC

Not many companies in north or west Texas own a road widener.

Wirtgen is their competition and has sold about the same number of machines. The City of Houston has more milling machines than anyone else; this is because there is a shortage of good aggregate, and they have found it pays to mill off the old hot mix and reuse the RAP as aggregate.

The Rx 600e is an entry-level, half-lane width milling machine. One of these was bought by Allen Keller—this is the machine that is shown in the slides provided by the San Angelo District. Districts might specify a widening width that really does not match any of the standard milling drum widths. For example, a district might specify widening a roadway 2-1/2 ft, but no one has a milling drum that size. The most common half-lane milling heads are 6-ft 7-in. or 7-ft 2-in.; on the smaller machines the drums are usually 24, 36, or 48 in.

The three RM roads in the San Angelo district, RM 336, 337 and 338 are sometimes referred to as the “Three Sisters.” These three roads have a lot of twists and turns and are popular for motorcyclists. The widening project on which the Rx 600e was used by Allen Keller was a project to address motorcycle accidents.

For that project, Allen Keller set the cut depth to 6 in.—the district used a digital level every 25 ft to measure the pavement cross-slope that was written on the pavement. The milling machine operator used this information to set the cross-slope of the machine. This is done by raising or lowering the main support pistons attached to the tracks, which results in the entire machine being placed at an angle; the cutter drum inside the drum enclosure is fixed.

The Rx 600e can cut about 1 mile of trench in 4 hours—the milling operation usually moves faster than the paving crew; therefore, the milling machine operator needs to pay attention and not get too far ahead of the paving crew so that open trench is not left at the end of the day.

On this particular project in San Angelo, the millings were hauled further up the road and spread out on the fore slope of the ditch to make it easier for the milling machine to maintain an upright position. The maximum tilt that is feasible ranges from about 6 to 8 degrees; beyond that you are at risk of the milling machine rolling over.

The advantages of a milling machine over a motor grader are that the milling machine provides a nice, smooth, clean cut joint and both the cut depth and slope are accurate. If the contractor desires, the pavement can be milled in stages—the hot mix surface can be milled and stockpiled as RAP; then the base, and so forth. This way, the materials can be salvaged for use elsewhere on the project or on other projects (full recovery).

In terms of production speed, the milling machine can do 1 or 2 miles every day—distances that would take a week for the motor grader.

If you are cutting your trench with a road grader, you cannot remove the materials a layer at a time.

Regarding shoulder widening projects from a contractor’s perspective:

1. The biggest problem is inconsistency in work volume and timing of the projects. There must be a guaranteed threshold of work in order to make it worth the contractor’s investment to buy specialized equipment for widening projects. As mentioned, those contractors who have invested in widening machines have had them 10–20 years, and there is low utilization.

2. Inconsistency arises in the widening project specifications from one district to the other. As mentioned, one district specified a widening of 2-ft 6-in., when all of the drums are either 2, 3, or 4 ft wide—if districts were to pick a particular nominal widening width for statewide application, that would help improve widening projects and equipment utilization. The same is true for the wider projects that are over 4 ft: the drum sizes jump from 4 ft to 6-ft 7-in., followed by 7-ft 2-in. If the plans called for something in between 4 ft and 6-ft 7-in., the contractor will have problems using a milling machine.

3. An option that contractors have is to rent one of the variable drum width cutters for use on a specific project. Perhaps 15 milling machines are sold each year in Texas, and there are about 100 to 150 milling machines in the state. Contractors replace them about every 10 years. The 6-ft 7-in. drum head is the most common size—probably 9 or 10 of the 15 sold each year will be this size drum.

HOLT Caterpillar

- Is the narrow-widening construction equipment your company sells original to your company or did you purchase this device through acquisition of another company?

  They rent/sell Weiler equipment too. They used to rent/sell Road Hog machines as well, until recently. They do not do it anymore, because they did not do much business with the Road Hog equipment. CAT dealers do not work much with non-CAT products.

Figure B.11 Weiler road widener

- Is your equipment sold by other manufacturers of Roadway Construction Equipment?

  HOLT Caterpillar has dealerships in north, south, east, and central Texas, located in 118 counties with over 2,000 employees. Their main office is located in San Antonio and the corporate office is located in Peoria, Illinois. Caterpillar is a major construction equipment manufacturer that carries other brands of equipment as part of their inventory. They rent specialized equipment and their own equipment, especially if it is a new design—a contractor wants to ensure the equipment will meet their needs before they buy the equipment for their operations.

- Which agencies have purchased/use your company's equipment?
  - TxDOT
  - Travis County
  - Texas Forest Service: The Texas Forest Service (located in Bryan/College Station) has bought 25 dozers from them that were specially equipped for firefighting. These dozers have folding blades so they can be transported without a permit and also allow the operator more options during firefighting operations.

- How do you stay in active contact with customers that use your equipment to gain insights about how to improve or add features to your equipment?

  HOLT has an employee who provides support just to TxDOT regarding equipment issues. They are available to their customers to discuss operating, maintaining, and repairing equipment they sell.

- Are there specific equipment tradeshows or other conferences your company participates in?
  - TXAPA
  - Aggregate show in Las Vegas
  - NUCA: National Underground Contractors Association (Show in San Antonio)
  - ConExpo: Construction Exposition: Held in Las Vegas every third year
  - Texas Construction Aggregate Association

- Can you cite specific projects on which your company's equipment was used that did not perform as planned including specific reasons for the lower performance?

  The Weiler 330 was rented by a contractor (Ramming Paving) doing a job on an FM road in San Antonio (Blanco County). It was not successful. The machine was too light and the contractor tried to do too much with it. They got the cheapest, lightest equipment they could get. For chip seal it works fine, but not for hot mix. The machine was returned and now it is being repaired. One common problem is that contractors try to use a machine for heavier use than it is intended for. Likely, the contractor was operating the W330 at 150% above its capacity.

Figure B.12. Weiler's strike-off tool, shown in the dashed line, broke during construction of a widening section (Ramming Paving)

- Regarding projects that did not perform as planned, what types of distresses occurred?

  Longitudinal cracking along the joint line, which is very common on pavement widening projects.

- Can you name other narrow-pavement widening equipment companies you are familiar with?
  - Road Hog saw cutting machine. It is a good piece of equipment; they like it better than the Asphalt Zipper since the Road Hog milling device attaches directly to the skid loader boom rather than the bucket. The Zipper bolts to the side walls of a front-end loader bucket and does not last very long (in heavy construction applications) with that type of installation. The Zipper is much lighter than the Road Hog.
  - The Zipper was in Texas before Road Hog and a lot of cities and counties have bought a Zipper, but they think the Road Hog is better. Williamson County and Georgetown both bought a Zipper, but not Travis County. Road Hog decided that HOLT CAT was not selling enough pieces of their equipment and have gone to another construction equipment dealer as their representative in Texas. The Road Hog milling head can be attached to a CAT skid loader or a John Deere—likely, this is their Texas distributor now.
  - There are also a number of aftermarket companies (OEM = original equipment manufacturer) that will use the basic frame and engine from a CAT product and then customize it for a customer. For example, Travis County had a D3 Dozer specially modified with a narrow width blade and narrower tracks for use in cutting walking trials in rocky terrain. Mike Joyce is Travis County's fleet manager and can tell you more about this piece of equipment.

- Compactors (Rammax): Remote controlled compactor for narrow widths

- Do you provide training to purchasers of your company's equipment?

  Yes. They have training from the delivery. They provide an operations and a safety manual. If it is a high-profile job, they can bring a person from the manufacturer to provide training.

- Willing to participate in Webinar?

  Yes.

- Additional names and contact information:

  Dan Dooley (Daniel.dooley@holtcat.com).

Cooper Equipment

- Is the narrow-widening construction equipment your company sells original to your company or did you purchase this device through acquisition of another company?

  Cooper is the dealer for the Midland Road Widener (manufactured by Midland Machinery) and for the Wirtgen line of equipment (manufactured by Wirtgen, in Germany).

Figure B.13. Mr. John Houston, of Cooper Equipment, showing a paver

- If acquired, what is the original company's name?

  Midland Machinery Company, located in New York.

- Can you please name each application for which equipment manufactured by your company is used on narrow-widening projects?

- Excavating or cutting the trench/widened section with a road grader: The Wirtgen reclaimer does a good job of cutting the joint line and mixing/processing the materials. Asphalt or chemicals can be added during this process. They have sold the Champion road grader, but it is a light-duty machine; they have not done much in the way of sales with Champion, as it is becoming more difficult to get parts for Champion products.
- Treating the subgrade (lime, cement, etc.): The Wirtgen or CMI is used for this purpose.
- Compacting the subgrade: Their Hamm pneumatic tire compactors would probably work quite well in this application.
- Placing the new granular base material: This is likely the appropriate application for the Midland Machinery equipment.
- Treating the granular base with a stabilizer: Wirtgen or CMI sell equipment for this purpose.
- Other: They sell a tacking kettle that is basically a large tank for heating asphalt with a wand distributor. These are used to spray tack on the joint face prior to placement of the base and surface.
- They also sell an asphalt distributor with a variable width spray bar that is divided into two 8-ft lengths. The bars move laterally side-to-side and allow the operator to adjust the width of spray while traveling along the road—likely a good tool for use on variable width widening projects. They have sold several of these—they are quite popular.

Mr. John Houston has been involved in road widening projects for a number of years and provided direct support to TxDOT on projects involving full-depth reclamation of FM roads using a reclaimer with emulsified asphalt. They did several projects for the San Antonio District (e.g., SH 16 Bandera County in 2006). These projects involved the following steps:

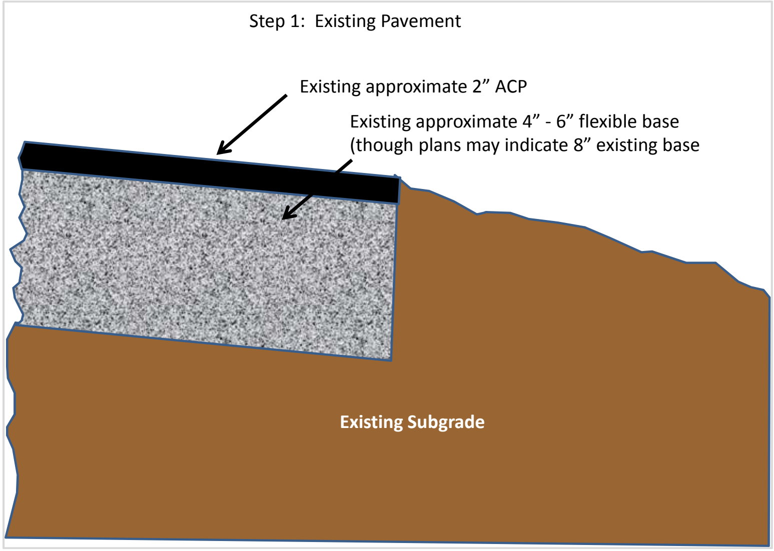


Figure B.14. Step 1: Full-depth reclamation

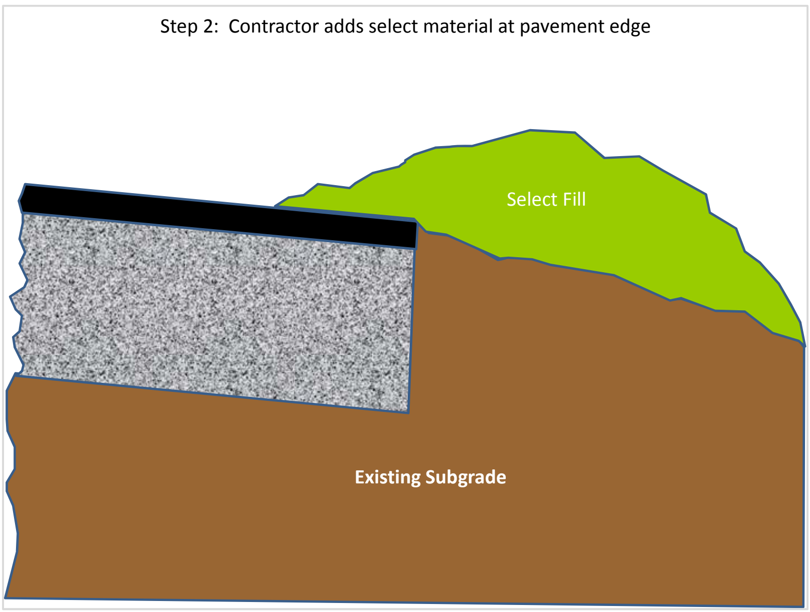


Figure B.15. Step 2: Full-depth reclamation

The contractor will place select fill material (low plasticity soils with good strength characteristics and low shrink-swell) on the pavement edge and then use a motor grader to begin mixing of the select material with a portion of the existing pavement and subgrade. This step prepares the in-place materials for the next step, which involves more thorough processes and mixing of the materials with a CMI reclaimer, and the addition of emulsified asphalt, which is a cement that binds the materials together to produce a more durable material with higher compressive and shear strength.

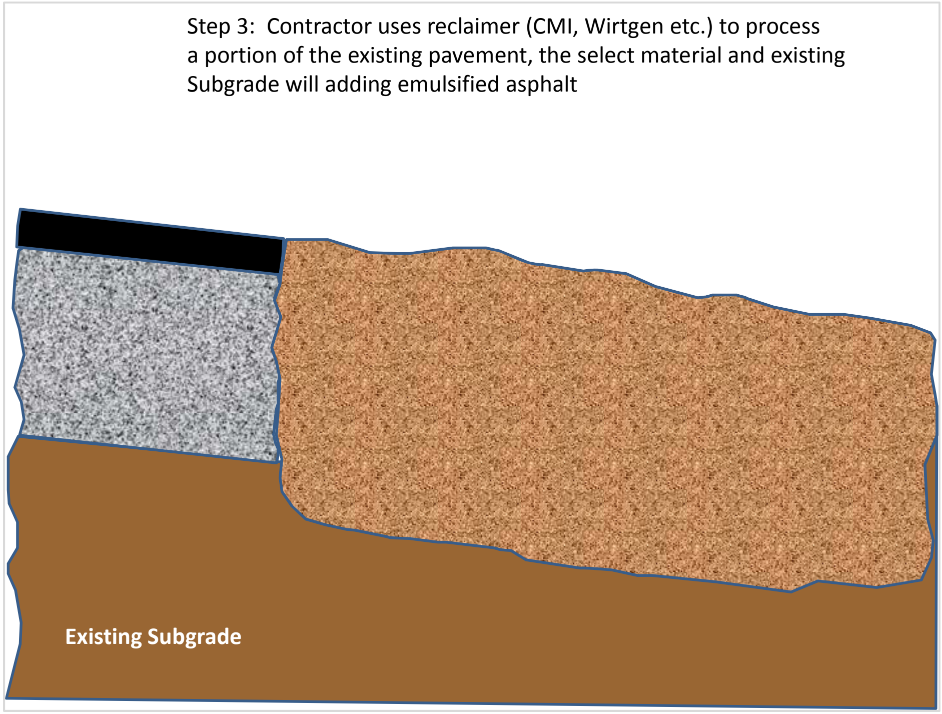


Figure B.16. Step 3: Full-depth reclamation

The contractor may actually construct the widened section by cutting into the existing pavement further than designated on the plans. This is to ensure that sufficient existing flexible base material and reclaimed asphalt hot mix is incorporated in the material that will be stabilized using emulsified asphalt. From the contractor's point of view, doing more work than the plans actually specify ensures that the final product will exhibit the properties required in the plans. This is due partially to the differences between the actual thickness of the existing flexible base material compared to the thickness shown in the plans and the condition of the asphalt concrete surface. There will be a weakened plane at the joint line between the existing pavement and the widened section; however, proper construction practices can help determine the quality of the joint and of course where the joint occurs within the pavement lane. (Note: The TxDOT Pavement Design Guide advises that a joint line should not be placed within the wheel paths of the pavement since wheel loads placed directly on the joint will lead to deterioration of the joint.)

Using a CMI to mix and process the material from the joint line helps ensure that the joint line will be properly mixed and help improve the joint quality. Using a CMI also ensures that the pavement joint line will be a straighter, more controlled cut than could be obtained by using a motor grader blade or similar process.

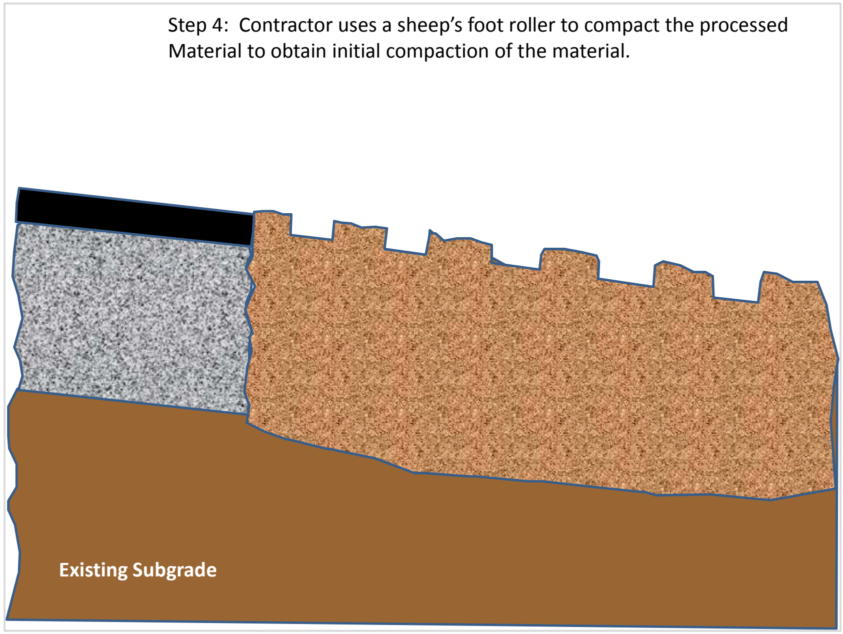


Figure B.17. Step 4: Full-depth reclamation

Initial compaction of the material after processing by the CMI is accomplished using a sheep's foot or pad foot roller. The sheep's foot roller drum is designed to apply higher pressure to the material being compacted since the load is transferred through the small protrusions on the face of the drum (sheep's foot or pads). This initial compaction obtains good densification of the material and ensures that the different materials and emulsified asphalt are compressed and brought into close contact to ensure good bonding.

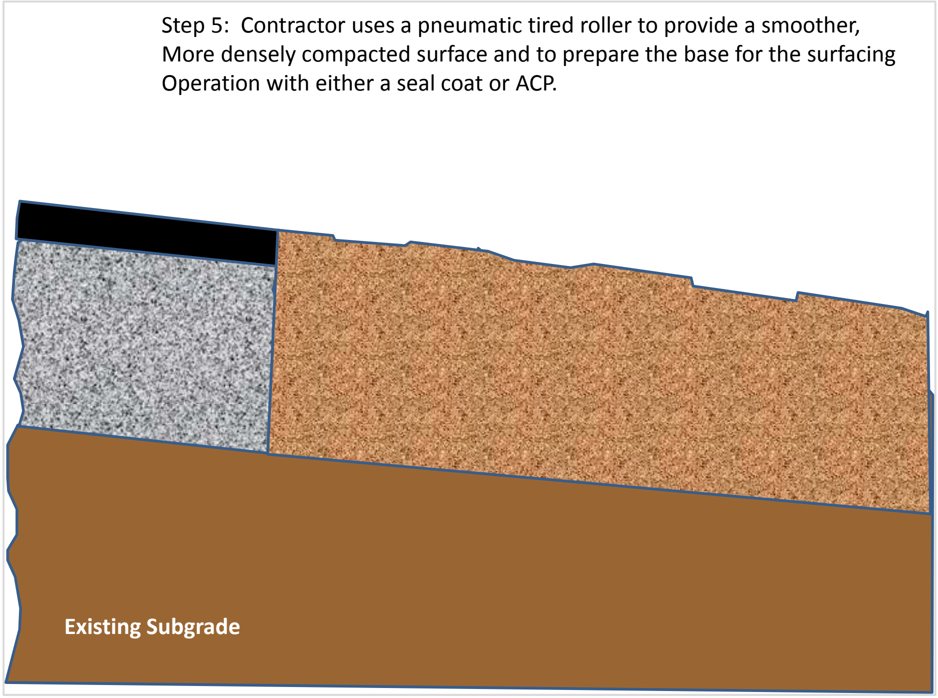


Figure B.18. Step 5: Full-depth reclamation

The high tire pressures associated with a pneumatic tired roller ensure high compaction of the surface and preparation of a smooth surface for later surfacing operations.

- What are the challenges that a narrow-widening project presents, compared to a full lane-widening, or a multi-lane-widening project in terms of equipment and construction operations?
    - Trying to build anything that is only 4 ft wide, or variable width (e.g., 3 to 9 ft widening) represents a big challenge. A 4-ft additional width is inherently weak.
    - In such narrow spaces, smaller pneumatic rollers are necessary (such as the Hamm, sold by Cooper).

Figure B.19. Hamm pneumatic roller for narrow spaces

- What lessons has your company learned about narrow-widening projects that you discuss with clients that purchase your equipment in order to obtain the best results?
  - One way to get around it is to extend the widening to the inside, i.e., make it 4+4-ft wide, or if the money is available, repave the original lanes as well, at the same time.
  - Sometimes it is even advisable to construct the additional width (to the inside) for free, so as to minimize construction problems as well as to eliminate the weak joint.
  - When a client buys one of their pieces of equipment—such as one of the large Wirtgen reclaimers that costs $750,000—they will get a couple of days training from a factory representative who will also provide training on an actual project to ensure the contractor is getting the results they want. The training is therefore tailored to the process the contractor is performing at the time the piece of equipment is purchased. The factory representative will explain all of the functions of the machine, including how to operate and maintain the equipment, and may also give some guidance on how to use the equipment to get best results. They are also there to provide knowledge about and insight into use of the equipment for the particular project the contractor is working on.
  - They were the company that sold the hot mix pavers to the contractor that built the F1 race track. In order to obtain the type of control needed on the surface, they had to link four pavers together to pave around curves and along the straightaway using processes that were special to that particular project. That contractor has finished the F1 track and is now using those same pavers on a project in Dallas paving IH 35—which is a completely different application. They will be there on site to help the operators use the equipment to get the results the contractor wants.

- Each type of project may have certain aspects, which are difficult for a contractor to handle with the equipment they have. For example, when building a narrow-widening project and the width of the widened portion never varies, it is a much simpler type of project to build that if the contractor has to widen from 4 ft to 9 ft along a route to tie into an intersection. The contractor has to think how to adjust the equipment during the operation to obtain the proper width at each point as the width transitions—some equipment is better suited to handling these types of problems than other types of equipment.

- On which types of facilities has your equipment been used for conducting narrow-widening projects (< 8 ft wide)?

  FMs and State Highways.

- Do you think the lighter equipment you sell that is designed for parking lot operations could be used by a Maintenance Section to construct 2-ft widening sections?

  No, that equipment is lighter duty and not intended to handle all of the types of heavier applications necessary on a highway paving project—even if it is just maintenance paving operations.

- Can you cite specific ongoing projects for which your company's equipment is currently being used?

  Several projects in San Antonio on FM roads and State Highways.

- How do you stay in active contact with customers that use your equipment to gain insights about how to improve or add features to your equipment?

  Remain in contact when the contractor needs help with specialized problems or projects. Each time a new piece of equipment is sold, they are usually involved in on-the-job training in use of the equipment

- Which agencies have purchased/use your company's equipment?

  Bexar County.

- Are there specific equipment tradeshows or other conferences your company participates in?

  World of Asphalt: premier show for road construction business (to be held in mid-March 2013, in San Antonio). Held every other year, alternating with Con Expo.

- Can you name other narrow-pavement widening equipment companies you are familiar with?
  - MidLand Road Widener: Self-propelled machines specifically for partial lane/shoulder widening, sold by Cooper. Mentioned that the road widener is not a very well-known machine in this part of the country, so it is not used to its full potential here. Bexar County owns one and they only use it for shoulder maintenance (for spreading millings on a shoulder, as a spreading device only), while it can be used for real structural improvement (as would be a road widening).
  - Asphalt Zipper: Attachment for front-end loader for milling the roadway or trench. Mentioned that the Zipper is a good machine, but not for long, continuous

processes. Also mentioned that the Zipper and the Road Hog might be the same equipment as the Zanetis.

Figure B.20. Zanetis attachment on a Road Hog

- Volvo road grader with road trenching or plow attachments—mentioned the Volvo, which is carried by Romco Equipment (in San Antonio)
- Champion road grader with road trenching or plow attachments—mentioned that it is only a compact motor grader

- Does your company have specifications/guidelines for constructing narrow-widening projects—e.g., is there a particular design guide followed for using your equipment?

  No, they do not exist.

- Does your company have a list of best practices or do’s and don’ts regarding narrow pavement widening?

  No, they do not exist. Educational resources follow the money. Road widening is low-volume, low-maintenance, not a big industry, so such materials are not available. Perhaps something can be found at Road Science (roadscience.net), a company spinoff of Coke Materials, that has created some support literature for asphalt-driven processes.

- Do you provide training to purchasers of your company’s equipment?

  Yes, training is provided as a combination of instruction from a Cooper’s technician and factory-trained people, over 1 or 2 days. There is training (about the specifics of the machine in question) and start-up, which is done by taking the equipment on the job.

Tencate Geosynthetics

Tencate Geosynthetics is a Dutch company; its U.S. headquarters are in Pendergrass, Georgia. They manufacture pavement interlayers, using fiberglass technology, aimed to alleviating the longitudinal joint problems that frequently occur in widening jobs.

Their geogrids are extruded, polyester geotextiles that are woven and are capable of stabilizing layers, eliminating differential settlements. These can be used for new pavements as well as for rehabilitation and widening jobs.

One of their products, the Mirafi H_2Ri, has wicking capabilities; it has a high modulus, high water flow, provides separation, and is color-coded for product identification. The water stays in the fabric and is moved horizontally.

Figure B.21. Sample of the H2Ri product, which provides separation, reinforcement, and drainage

This product is effective in drainage and non-drainage applications; it reduces differential settlements and improves general performance of pavements. An installation of this product took place in Alaska's Dalton Highway, a road with numerous potholes and accidents, where the adverse climatic conditions in the form of high moisture and low temperatures only contribute to worsen the road's situation. The distress mechanism is triggered by the weakening produced on the structure by the frost-heave and thawing cycles. The pressurized water flows upward to the road surface. This work was conducted in cooperation with the University of Alaska-Fairbanks. The sections were 18.5 m long, and temperature and moisture were monitored at 22 spots. The fabric performs as a syphon. The performance of the H_2Ri product is good, as it does not allow the water to come up to the pavement layer, and it rather deflects it to the shoulder, where it can drain properly.

Also, expansive soils are being investigated by The University of Texas at Austin's Professor Jorge Zornberg, who attended this presentation; this project built some experimental sections using Tencate's products. The experimental sections were placed on SH 21 near Bastrop, in the Austin District, between Old Potato Road and the US 290 highway. Distresses were present on the edge of the road, as is common on pavements. Such distresses had been addressed with the use of patches and level-ups, on the expansive subgrade. The original design of this project had a geotextile, but it was prescribed only for the purpose of separation between layers. The new design is testing four geosynthetics: the RS 580i, the H_2Ri, the HP 570, and the 140N, which is placed in the control sections. The objective is to try to eliminate differential settlements due to heaving. The eight sections are each 500 ft long. The cut was done vertically, with a reclaimer, to enable recycling of the material. Compaction was done with a pneumatic roller. The project is still ongoing.

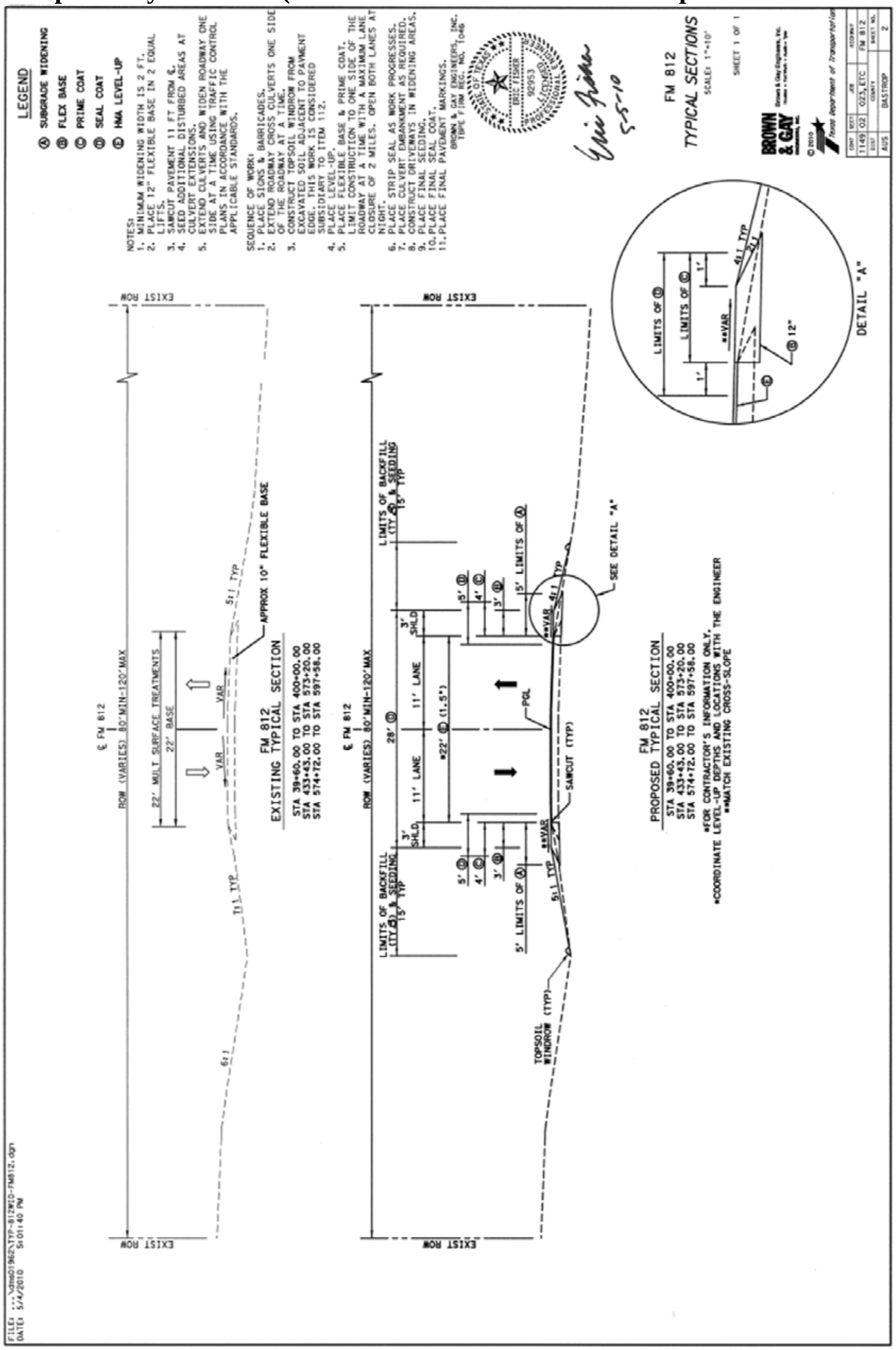
Tencate's products also aim to mitigate the problems that occur with the longitudinal joints. However, as with all products, they have their limitations, and they cannot solve all problems. For instance, the use of interlayers will not solve a binder issue. Also, interlayers prolong the life of the pavement to an extent, but they do not last forever. Interlayers that are properly placed and used can increase pavement life by about 5 years.

The use of tack coat is necessary for good pavement performance when placing the interlayers. It is important to place a good amount of tack coat between the existing pavement and the interlayer. If there is not enough tack coat, there will be delamination and slippage problems.

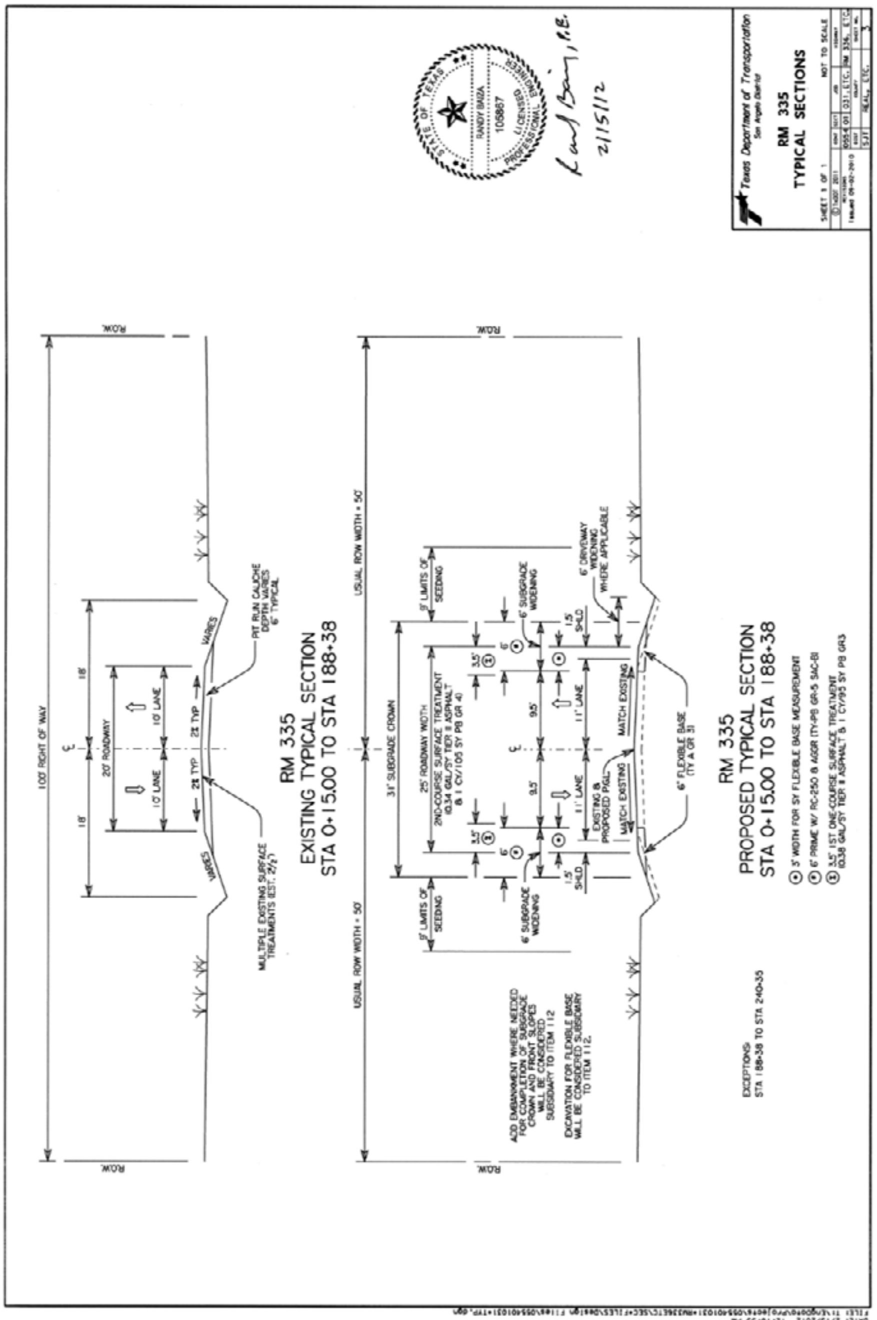
These interlayers can also be used as bond breakers for unbonded concrete overlays.

Appendix C – Examples of Typical Sections from TxDOT Plan Sets

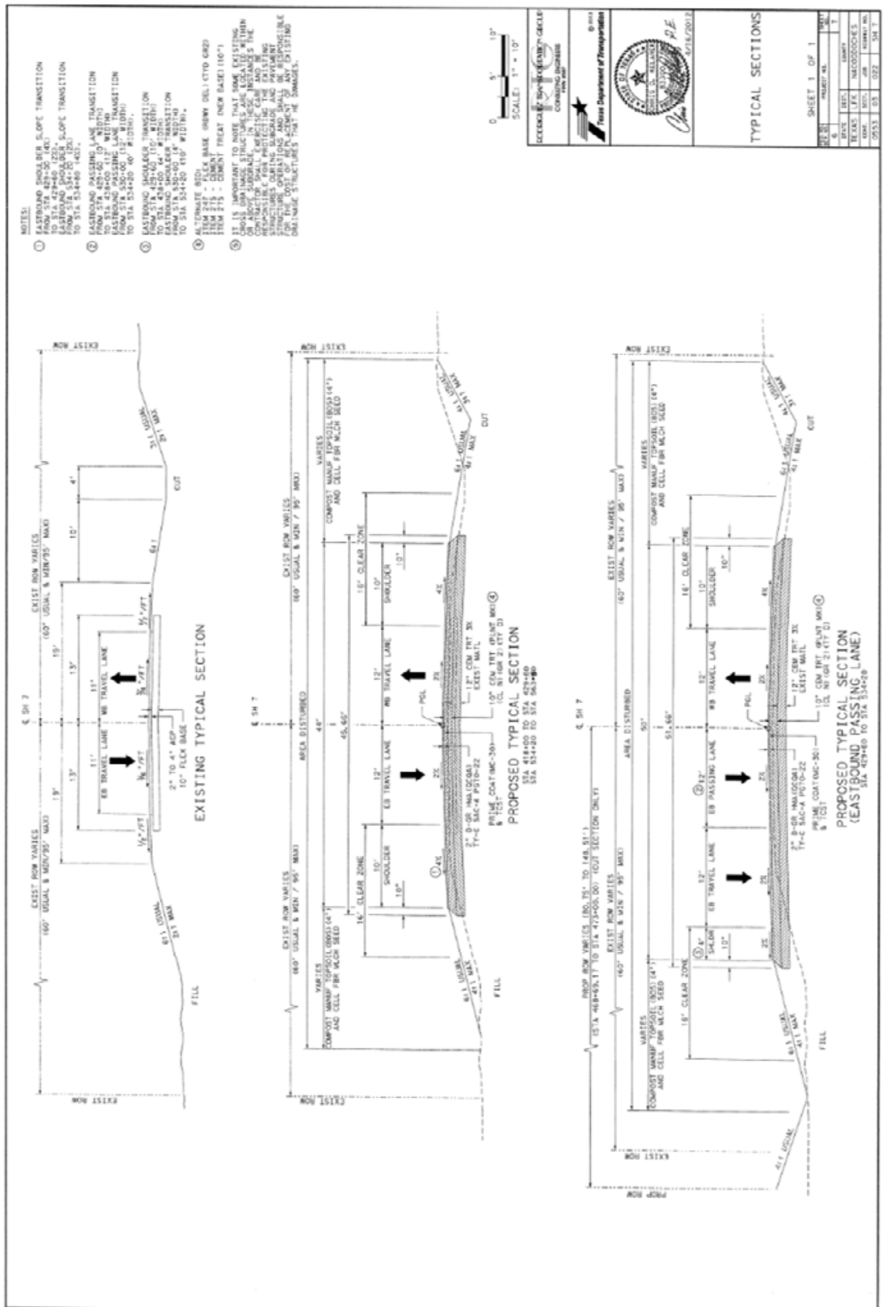
Bastrop County – FM 812 (For the construction of additional paved surface width)



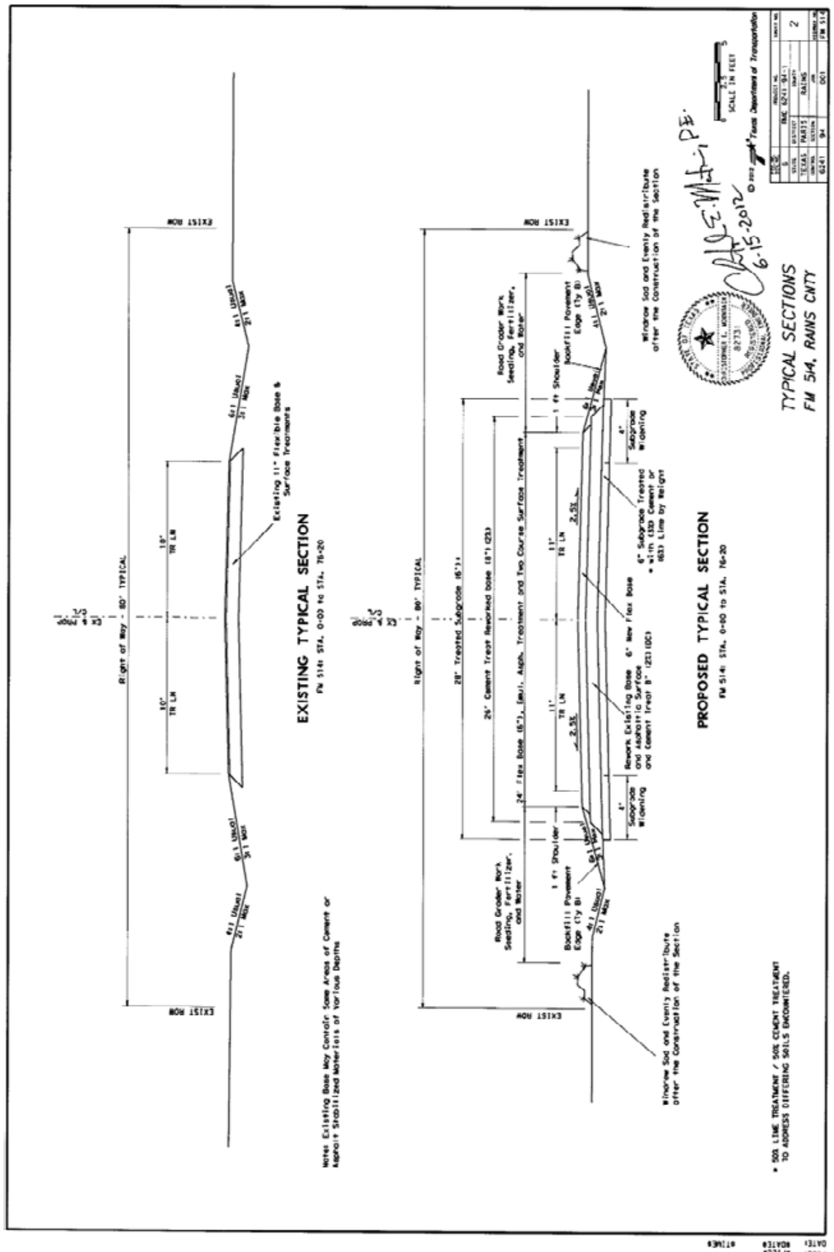
Real County – RM 335 (For hazard elimination and safety enhancement via widened roadways)



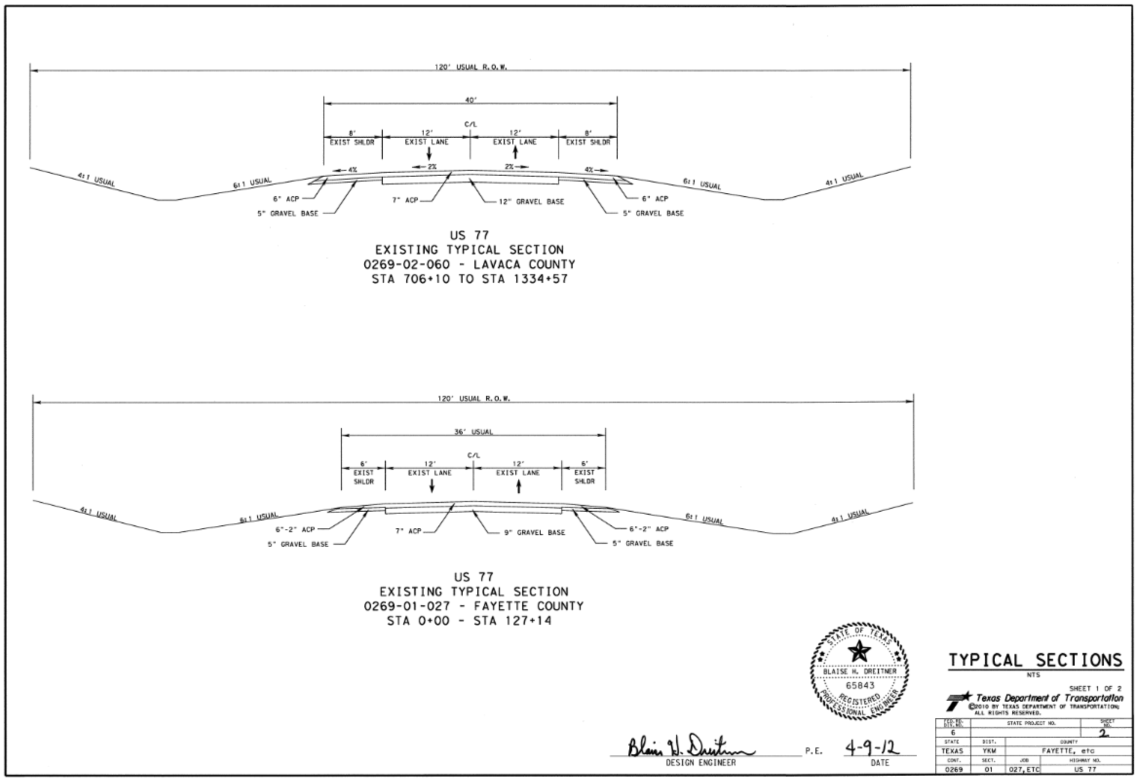
Nacogdoches County – SH 7 (For the construction and rehabilitation of existing road: rehabilitate existing roadway and add paved shoulders/passing lanes)



Rains County – FM 514 (Base restoration of existing roadway consisting of widening, adding lime- or cement-treated subgrade, reworking and cement-treating existing base, and adding new base and two-course surface treatment)



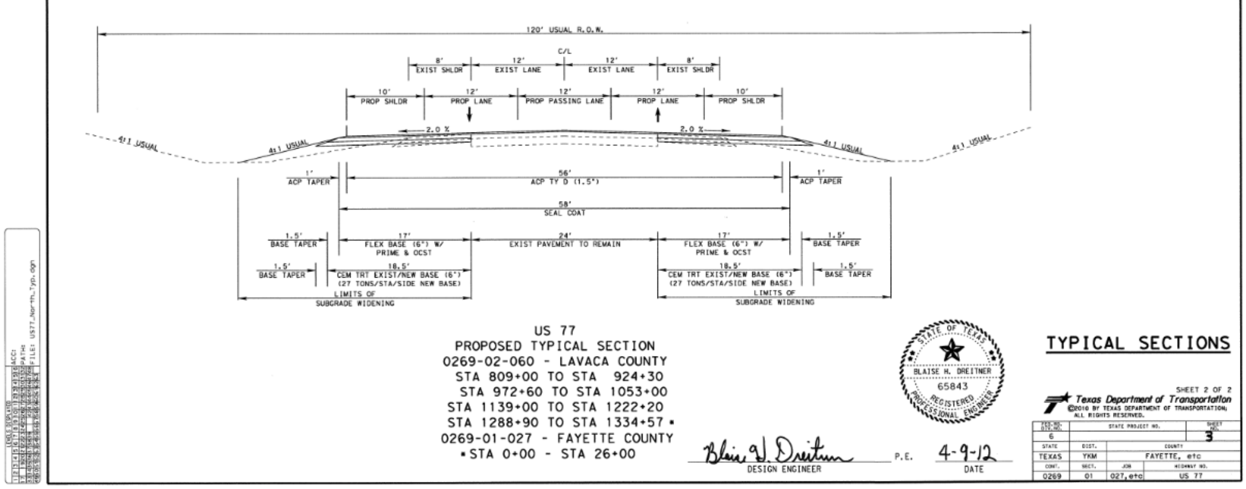
Fayette County – US 77 (For the construction or rehabilitation of existing roadway via auxiliary lanes)



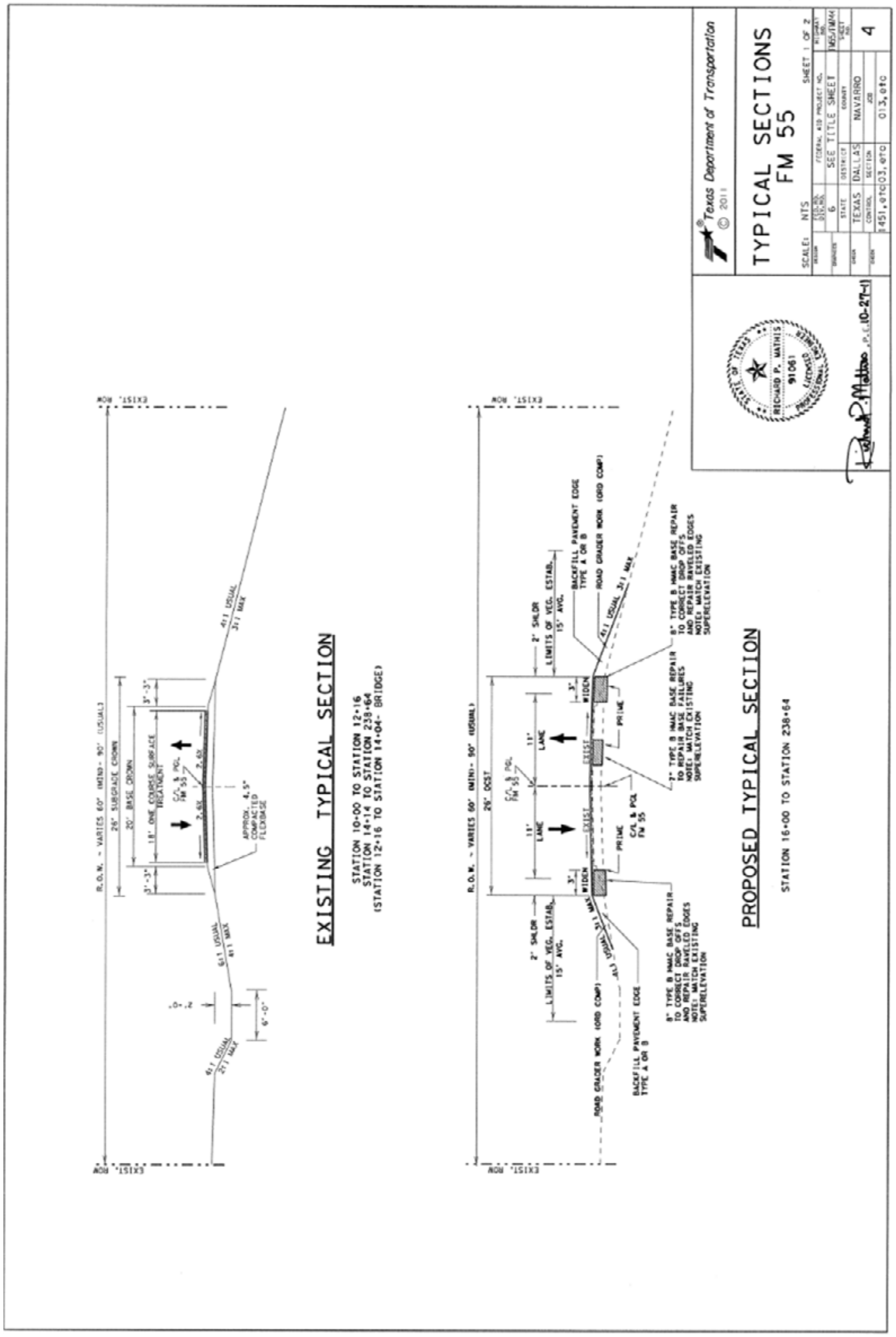
ROADWAY OVERVIEW

LIMITS	PROPOSED CONSTRUCTION
STA 706+10 TO STA 809+00	NO ROADWAY WORK
STA 809+00 TO STA 817+40	TAPER FROM EXISTING 2 LANE ROADWAY TO PROPOSED SUPER 2
STA 817+40 TO STA 915+90	PROPOSED SUPER 2 - SOUTHBOUND PASSING LANE
STA 915+90 TO STA 924+30	TAPER FROM PROPOSED SUPER 2 TO EXISTING 2 LANE ROADWAY
STA 924+30 TO STA 972+60	NO ROADWAY WORK
STA 972+60 TO STA 981+00	TAPER FROM EXISTING 2 LANE ROADWAY TO PROPOSED SUPER 2
STA 981+00 TO STA 1044+60	PROPOSED SUPER 2 - NORTHBOUND PASSING LANE
STA 1044+60 TO STA 1053+00	TAPER FROM PROPOSED SUPER 2 TO EXISTING 2 LANE ROADWAY
STA 1053+00 TO STA 1139+00	NO ROADWAY WORK
STA 1139+00 TO STA 1147+40	TAPER FROM EXISTING 2 LANE ROADWAY TO PROPOSED SUPER 2
STA 1147+40 TO STA 1213+80	PROPOSED SUPER 2 - SOUTHBOUND PASSING LANE
STA 1213+80 TO STA 1222+20	TAPER FROM PROPOSED SUPER 2 TO EXISTING 2 LANE ROADWAY
STA 1222+20 TO STA 1288+90	NO ROADWAY WORK
STA 1288+90 TO STA 1297+30	TAPER FROM EXISTING 2 LANE ROADWAY TO PROPOSED SUPER 2
STA 1297+30 TO STA 17+60 *	PROPOSED SUPER 2 - NORTHBOUND PASSING LANE
STA 17+60 TO STA 26+00	TAPER FROM EXISTING 2 LANE ROADWAY TO PROPOSED SUPER 2
STA 26+00 TO STA 127+14	NO ROADWAY WORK

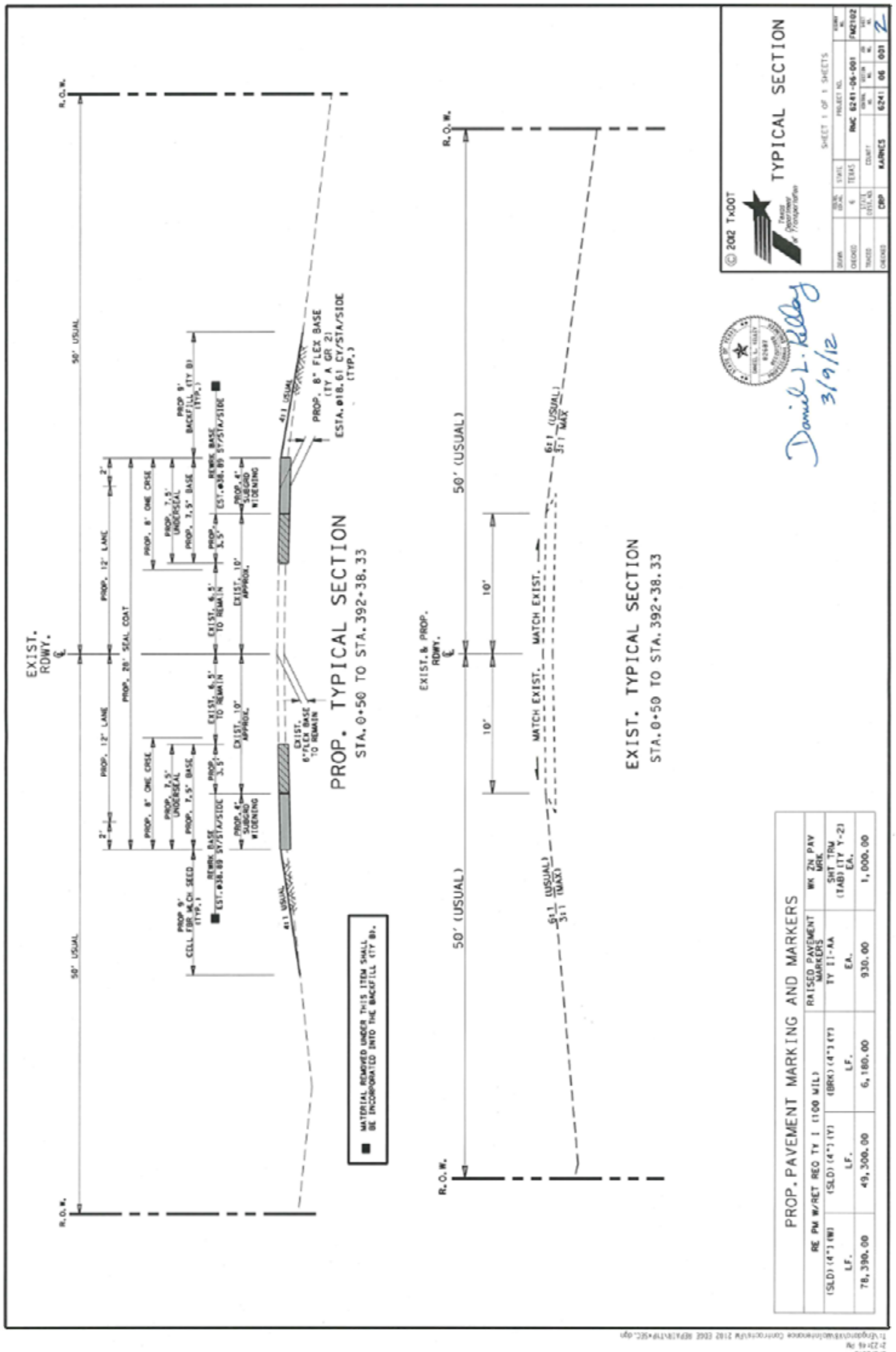
* STA 1334+57 = STA 0+00 @ LAVACA/FAYETTE C/L



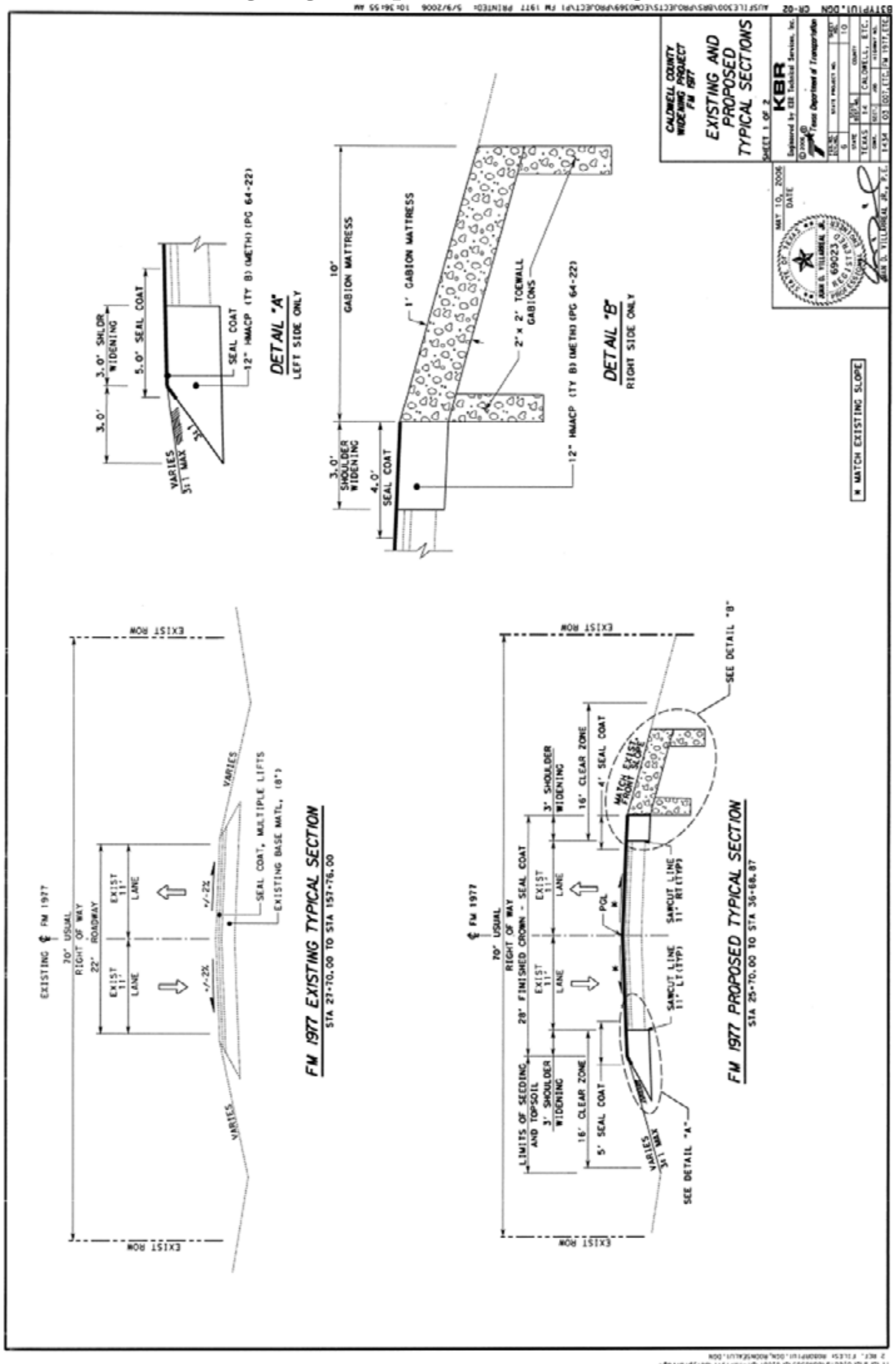
Navarro County – FM 55 (For the construction of additional paved surface width consisting of structure work, flexible pavement repair, surface treatment, and pavement markings)



Karnes County – FM 2102 (Construction of widening of an existing roadway consisting of flex base, seal coat and backfill, pavement markings, and markers)



Caldwell County - FM 1977 (For the construction of widening a non-freeway facility consisting of widening, grading, base, asphalt pavement, drainage structures, signing, and pavement markings)



Appendix D – Webinar Workshop: Agenda

AGENDA

0-6748 'Narrow Pavement Widening – Decision Support Tool – Training Workshop/Webinar'

University of Texas – Austin – Center for Transportation Research

Conference Room 4.518

November 22, 2013 9:00 AM – Noon

1. **Introduction and Welcome** – Darrin Jensen TxDOT RTI, Mike Murphy UT-CTR

2. **Project 0-6748 project objectives and Decision Support Tool Concepts** (ppt)
    a. Project Objectives – Mike Murphy
    b. Decision Support Tool Concepts – MooYeon Kim
        - DST software
        - Master Document Report

3. **Presentation of Decision Support Tool (Demonstration)**

a.	Project file(s) open / save	MooYeon
b.	Project Information Screen	MooYeon
c.	Project Reasons and Goals	Hui Wu
d.	ROW impacts	Mike Murphy
e.	Project Priority & Coordination	Mike Murphy
f.	Performance Problems	Maria Burton
g.	Construction Problems	Andre Smit
h.	Contractor construction equipment	Manuel Trevino
i.	Maintenance equipment	Manuel Trevino

4. **Presentation of Master Document (District input + best practices, lessons learned)**

a.	Project Information Screen	MooYeon
b.	Project Reasons and Goals	Hui Wu
c.	ROW impacts	Mike Murphy
d.	Project Priority & Coordination	Mike Murphy
e.	Performance Problems	Maria Burton
f.	Construction Problems	Andre Smit
g.	Contractor construction equipment	Manuel Trevino
h.	Maintenance equipment	Manuel Trevino

5. **Discuss potential for Web implementation** Andre Smit
6. **Present ideas for future development of the DST concept** Andre Smit
7. **Discussion Questions from Audience** – Next Steps CTR Group / Darren Jensen

The Webex information is listed below

Meeting information

Topic: 0-6748 - Workshop
Date: Friday, November 22, 2013
Time: 9:00 am, Central Standard Time (Chicago, GMT-06:00)
Meeting Number: 738 886 935
Meeting Password: 1234

To start or join the online meeting

Go to
https://txdot.webex.com/txdot/j.php?ED=261282032&UID=507150372&PW=NYjkxYTBjMWI1&RT=MiM3

Teleconference information

Provide your phone number when you join the meeting to receive a call back. Alternatively, you can call:
Call-in toll-free number: 1-866-637-1408 (US)
Call-in number: 1-660-422-5173 (US)
Conference Code: 909 406 3306

Appendix E – Webinar Workshop: List of Attendees

0-6748 Flexible Pavement Narrow Widening

Decision Support Tool Training Workshop

November 22, 2013 9:00 AM – Noon

UT-CTR Large Conference Room

Sign in Sheet

Name	District / Division / University	Email
1. Mike Murphy	UT-CTR	MURPHYMR @MAIL.UTEXAS. EDU
2. Andre' Smit	UT/CTR	ASMIT @ ''
3. ATLANTA D.		
4. BAILEY HEWES		
5. ANDY KISSIG		
6. BRIAN LAMB		
7. BRYAN D.		
8. CHARLES YURGANUS		
9. DEREK FELL		
10. FRANKLIN DESAI		
11. IFTEKHAR ALI		

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November 22, 2013 9:00 AM – Noon

UT-CTR Large Conference Room

Sign in Sheet

12. JOE LEIDY		
13. JOEY MIMS		
14. JOHN REAGAN		
15. REX MILLER		
16. JON LOVELL		
17. JUSTIN OBINNA		
18. KELLEY STEWART		
19. KEVIN DICKEY		
20. KORIN ADKINS		
21. Moo Yeon Kim	UT-CTR	mooyeon@utexas.edu
22. Hui Wu	UT-CTR	wuhui@mail.utexas.edu
23. Juan Porras-Alvarado	UT-CTR	
24. Maria Burton	UT	maria_christina.86@hotmail.com
25. Manuel Trevino	UT-CTR	manuel.trevino@mail.utexas.edu
26. Diniece Peters	UT-CTR	d.peters@utexas.edu
27. DARRIN JENSEN	TxDOT	djensen@txdot.gov

2

28. LFK

29. MARK MCDANIEL

30. MARSHALL

31. MT PLEASANT AO

32. OMAR DIXON

33. RANDY

34. RON BAKER

35. STEPHEN KASBERG

36. WEATHERFORD AO

37. ALLISON KURWITZ

38. ~~BAILEY~~ Hewes

39. DARRIAG CHEN

40. Kelley Stewart

41. MT PleASANT AO

42. LUFKIN

43. weatherford AO

44. Mike Arellano

45.

46.

3

Appendix F – Webinar Workshop: Workshop Presentation of Decision Support Tool

CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

0-6748 Best Practice for (Narrow) Flexible Pavement Structure Widening Projects

Darrin Jensen, RTI Project Manager

PMC Members

Henry Fojtik,	San Antonio – Contract Mgmt.
Brian Lamb,	Waco CPD
Justin Obinna,	MNT Division, Maint. Section
Carl Schroeder,	Bryan – Navasota Maintenance
Allen Warden,	Beaumont Jasper Area Office

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CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

0-6748 Best Practice for (Narrow) Flexible Pavement Structure Widening Projects

Research Team

Mike Murphy,	R.S.
Jorge Prozzi,	Faculty Researcher
Andre Smit,	Researcher
Maria Burton,	M.S. Student
MooYeon Kim,	Ph.D. Student
Hui Wu,	Research Fellow
Manuel Trevino	Researcher

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THE UNIVERSITY OF TEXAS AT AUSTIN

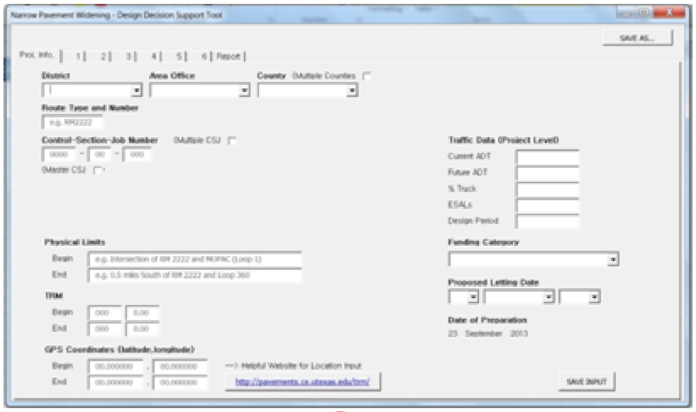
Project Goals & Objectives

1. Review current best practices regarding narrow pavement widening;
2. Seek to understand mechanisms that result in good and poor performing narrow widening projects;
3. Develop a compendium of narrow widening best practices
4. Conduct a Workshop to assist Districts in Making effective design decisions;
5. Prepare a comprehensive Report and supporting documents.

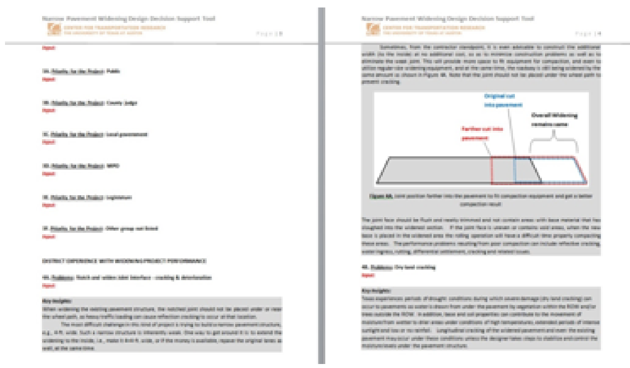
CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

1. Introduction and Welcome – **Darrin Jensen** TxDOT RTI, **Mike Murphy** UT-CTR
2. Project 0-6748 project objectives and Decision Support Tool Concepts (ppt)
   a. Project Objectives – **Mike Murphy**
   b. Decision Support Tool Concepts – **MooYeon Kim**
      > DST software
      > Master Document Report
3. Presentation of Decision Support Tool Demonstration – **(entire Team)**
4. Presentation of Master Document **(District input + best practices, lessons learned - Team)**
5. Discuss potential for Web implementation **Andre Smit**
6. Present ideas for future development of the DST concept **Andre Smit**
7. Discussion Questions from Audience – **Next Steps Jorge Prozzi / Darren Jensen**

Narrow Pavement Widening Decision Support Tool



Decision Support Tool



Master Insights & Lessons Learned Word file + Input from user.

Decision Support Tool

Demonstration

Master Document

Demonstration - Discussion

Implementation/Future Developments

- Integrate with existing TxDOT databases e.g. PMIS for traffic inputs, etc
- Subdivision of project to account for ADT, crash data, geometry, trucks, drainage, presence of intersections, etc
- Inclusion of structural features such as bridges, cross & parallel drains
- Inclusion of horizontal & vertical curves
- Consider TxDOT highway design manual policies regarding design & posted speeds

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Future Developments (Continued).

- Option to input Crash Data for each Segment – Used for SII and B/C Ratio Calculations
- Option perform SCI analysis and include PMIS distresses in structural evaluation
- Web-based application
- Apply this approach to provide a knowledge base for other TxDOT construction related practices

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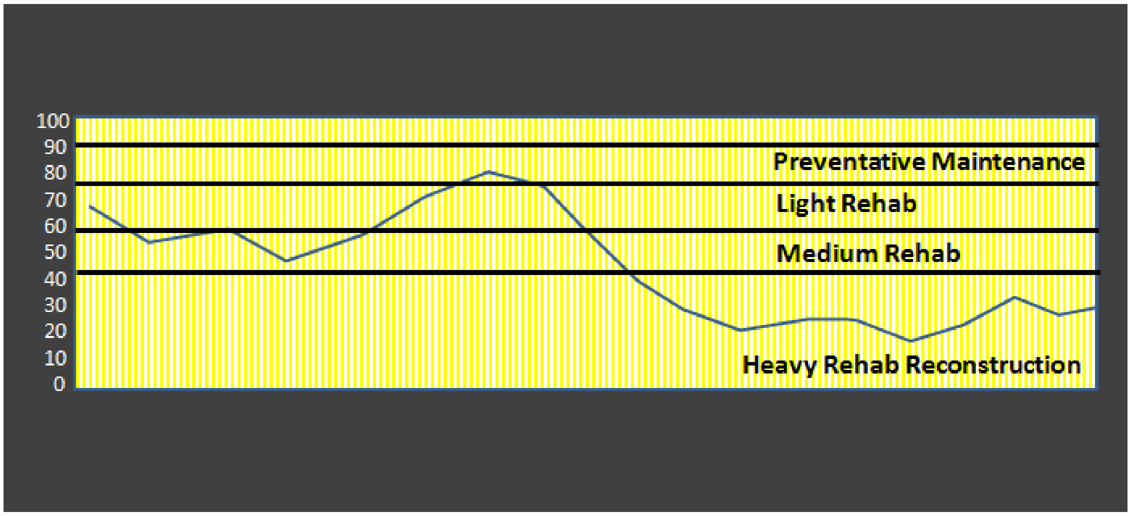
Structural evaluation of Candidate Pavement for Narrow Widening



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QUESTIONS – IDEAS - COMMENTS?

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