**Technical Report Documentation Page**

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| FHWA/TX-06/0-4687-1 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| RUBBLIZATION FOR REHABILITATION OF CONCRETE PAVEMENT IN TEXAS: PRELIMINARY GUIDELINES AND CASE STUDIES | November 2005<br>Resubmitted: February 2006 |
| | 6. Performing Organization Code |
| 7. Author(s)<br>Stephen Sebesta, Tom Scullion, and Christopher Von Holdt | 8. Performing Organization Report No.<br>Report 0-4687-1 |
| 9. Performing Organization Name and Address<br>Texas Transportation Institute<br>The Texas A&M University System<br>College Station, Texas  77843-3135 | 10. Work Unit No. (TRAIS)<br><br>11. Contract or Grant No.<br>Project 0-4687 |
| 12. Sponsoring Agency Name and Address<br>Texas Department of Transportation<br>Research and Technology Implementation Office<br>P. O. Box 5080<br>Austin, Texas 78763-5080 | 13. Type of Report and Period Covered<br>Technical Report:<br>September 2004-August 2005<br><br>14. Sponsoring Agency Code |

15. Supplementary Notes

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.
Project Title: Rubblization and Crack and Seat as Major Rehabilitation for Concrete Pavements
URL: http://tti.tamu.edu/documents/0-4687-1.pdf

16. Abstract

Rubblization is a unique means of rehabilitating concrete pavements by in-place conversion of the old concrete pavement into a useable base. Rubblization employs machinery that will break apart the concrete in place and leave pieces small enough that reflective cracking problems are significantly reduced or ideally eliminated. This report presents an overview of recommendations from other states that routinely use rubblization, and then focuses on preliminary guidelines and case studies for conducting rubblization in Texas. First, a plan for determining the suitability of a project for rubblization is presented. Next, two case studies illustrate how to evaluate a project to determine whether rubblization is a viable rehabilitation option. Finally, draft construction specifications for conducting rubblization in Texas are presented.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| Rubblization, Crack and Seat, Break and Seat | No restrictions. This document is available to the public through NTIS:<br>National Technical Information Service<br>Springfield, Virginia  22161<br>http://www.ntis.gov |

| 19. Security Classif.(of this report) | 20. Security Classif.(of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 56 | |

**Form DOT F 1700.7** **(8-72)** **Reproduction of completed page authorized**

# RUBBLIZATION FOR REHABILITATION OF CONCRETE PAVEMENT IN TEXAS: PRELIMINARY GUIDELINES AND CASE STUDIES

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Report 0-4687-1
Project 0-4687
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# ACKNOWLEDGMENTS

This project was made possible by the Texas Department of Transportation (TxDOT) in cooperation with the Federal Highway Administration. Special thanks must be extended to Darlene Goehl, P.E., for serving as the project director. Additionally, personnel in the Bryan, Beaumont, and Childress Districts of TxDOT are acknowledged for their participation in identifying field sites for use in this project. The authors also extend their thanks to the Project Monitoring Committee: Bill Willeford, P.E., Leo Betancourt, P.E., Susan Chu, P.E., and Andrew Wimsatt, P.E.

# TABLE OF CONTENTS

**Page**

# LIST OF FIGURES

# LIST OF TABLES

**Table** **Page**

# EXECUTIVE SUMMARY

Rehabilitation of concrete pavements is a major issue within TxDOT. The department has many miles of old jointed and continuously reinforced concrete pavement which are approaching the end of their service life. Black topping and white topping can be used to gain additional life, but these treatments are often impacted by reflection cracking. In many instances the existing concrete pavement is structurally deteriorated so that simple overlays will not provide adequate performance. TxDOT needs good alternatives for rehabilitating these pavements. In the last 20 years, slab fracturing techniques have become popular, such as: crack and seat, break and seat, and rubblization.

This report presents findings from the first year's work on a TxDOT-sponsored project investigating crack and seat and rubblization as rehabilitation options for concrete pavements. Chapter 1 presents an overview of concrete pavement rehabilitation options, along with summaries of other states' experiences. Chapter 2 presents a field forensic investigation plan for use in evaluating what rehabilitation options are feasible for a project, then presents analysis criteria for determining if rubblization is a viable option. Chapters 3 and 4 present case studies from two projects in the Childress District, and Chapter 5 presents a proposed rubblization construction specification for TxDOT's consideration. Based upon the literature review and work completed thus far, rubblization (when feasible) appears to be a better alternative for concrete pavement rehabilitation than crack and seat. Some issues that need better clarification for rubblization are:

- verifying the decision criteria for when rubblization is feasible,
- evaluating the performance of the two competing rubblizers,
- resolving issues with pavement structural design, and
- incorporating better-performing surface overlays.

Chapter 6 of this report further details the future work suggested for each of these topics.

# CHAPTER 1
# REVIEW OF LITERATURE

## SUMMARY

Reviews of other states' experience with rubblization indicate numerous factors are essential for rubblizing success. The thickness of the pavement structure, subgrade condition, and the presence of excessive moisture in the subgrade are key issues that must be considered when reviewing the suitability of a project for rubblization. Additional considerations such as the presence of shoulder additions are important because their presence may dictate installation of special drainage systems. To facilitate the efficient review of a project's suitability for rubblization, a forensic investigation of the project should include, as a minimum, review of historical plan sheets, a field visual assessment, field falling weight deflectometer (FWD) testing, and field dynamic cone penetrometer (DCP) testing. For a more complete view of the project, ground-penetrating radar (GPR) and rolling dynamic deflectometer (RDD) testing may be conducted. This chapter further details experiences of other agencies with rubblization, and a field forensic plan for evaluating the suitability of a project for rubblization.

## BACKGROUND TO CONCRETE PAVEMENT REHABILITATION TECHNIQUES

Rehabilitation of concrete pavements is a major issue within TxDOT. The department has many miles of old jointed and continuously reinforced concrete pavement which are approaching the end of their service life. Black topping and white topping can be used to gain additional life but these treatments are often impacted by reflection cracking. In many instances the existing Portland cement concrete (PCC) is structurally deteriorated so that simple overlays will not provide adequate performance. It is in these areas that slab fracturing techniques have become popular over the last 20 years. The first fracturing techniques developed were either break and seat or crack and seat which were used for either reinforced or plain jointed concrete pavements. These first techniques use either the guillotine or spring arm hammers. Figure 1.1 shows an example of the guillotine equipment.


**Figure 1.1. Guillotine Equipment Used to Break Existing Concrete Slabs.**

The term "crack and seat" is often applied to unreinforced concrete pavements where the objective is to develop closely spaced tight cracks which permit load transfer through aggregate interlock with little loss of structural value. Cracking through the entire layer is the goal. Break and seat is recommended for reinforced slab where the goal is to physically fracture the distributed steel or completely debond the steel from the concrete to reduce the effective slab length.

Rubblization is a relatively new process in which special equipment reduces the concrete (in place) to fragments having the same textural and gradation characteristics as large aggregate flexible base. In structural design, rubblization is thought to reduce the stiffness of the PCC pavement to that of a flexible base and therefore a thicker overlay may be required. Rubblization is the most expensive of the three slab-fracturing techniques, but it is gaining popularity among many departments of transportation (DOTs) as it is judged the most effective at developing uniform pavement support and at minimizing reflection cracking.

## RUBBLIZING TECHNIQUES

Two primary pieces of equipment are available for rubblization. The resonant breaker method used by Resonant Machines, Inc. (RMI) employs a high-frequency, low-amplitude tamper to fracture the pavement. Figure 1.2 shows this machine. More details of the equipment are available at the company's website (*1*). The other common rubblizing equipment is the multi-head breaker (MHB) used by Antigo Construction, shown in Figure 1.3. This equipment uses 12 drop hammers that impact the pavement to accomplish rubblization. More details of this equipment are available at Antigo's website (*2*).


**Figure 1.2. RMI Resonant Breaker (*1*).**


**Figure 1.3. Multi-Head Breaker (*2*).**

## EARLY RUBBLIZATION EXPERIENCES

The first nationwide performance comparison of the various methods of fracturing PCC slabs was conducted by Witczak and Rada (*3*) in the early 1990s. A comparison, shown in Figure 1.4, was developed showing the variation in backcalculated moduli values after each of the fracturing methods. This figure shows that the moduli for the break and seat and crack and seat techniques are substantially more variable than for rubblization. This variability may be associated with the problem of fracturing slabs containing reinforcing steel. In some of the earlier projects the steel may not be debonded from the concrete and it may still be acting as an intact slab.

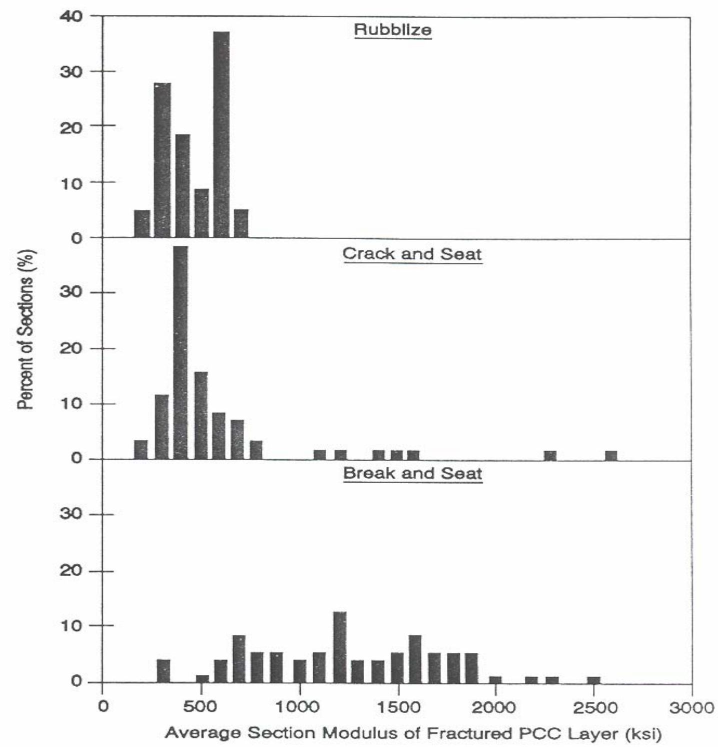


**Figure 1.4. Frequency Distribution of In-Site PCC Moduli Values after Treatment (*3*).**

The Strategic Highway Research Program (SHRP) Long Term Pavement Performance (LTPP) program also includes rubblization projects. In particular, performance and deflection results from rubblized sections constructed by the Oklahoma DOT in the early 1990s illustrate problems that can occur. The description of the sections is available from a project report prepared by Brent Rauhut Engineering (*4*), the condition data and deflection analyses were performed on data collected from the LTPP database. The performance of these sections was not good; the growth in alligator cracking is shown in Figure 1.5. The average backcalculated moduli values for the rubblized PCC slab in the two sections (400607 and 400608) were 90 ksi and 225 ksi sections, substantially below the average value of 412 ksi reported by Witczak and Rada.

In section 400607, substantial alligator cracking was found in the section after 5 years in service. This was the section with the lower PCC modulus. Both sections received substantial patching and maintenance in year 2001, 9 years after construction. The poor performance is attributed to the low base modulus resulting in a structurally inadequate section to carry the traffic loads. The cause of the low rubblized PCC modulus was not identified in this evaluation.

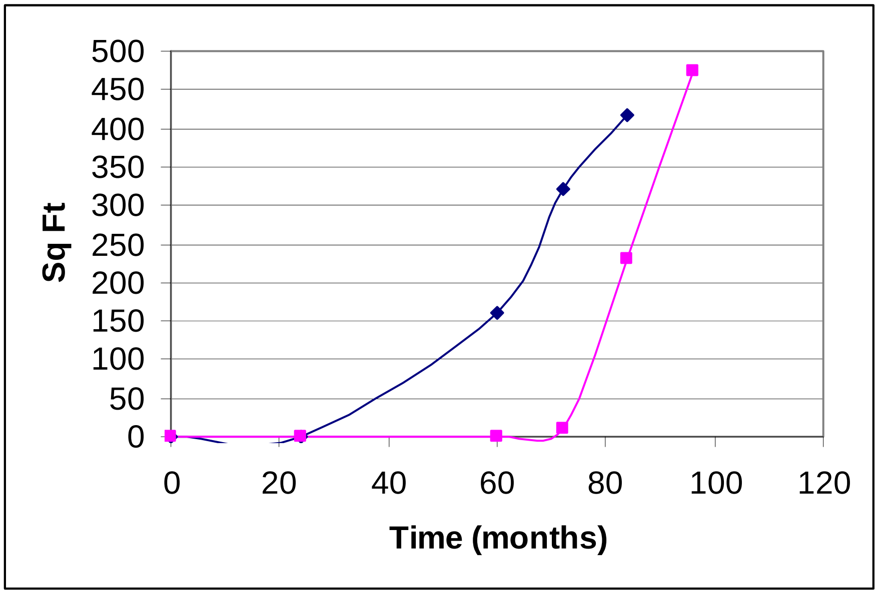


**Figure 1.5. Growth in Alligator Cracking from Rubblized Concrete Sections in Oklahoma.**

## RUBBLIZING RESULTS FROM TEXAS

Crack and seat has been widely used in West Texas but there has been little or no evaluation of the success or failure of this treatment. Most of the treatments have been reported to be working well; however, problems have been encountered when using this treatment on pavements with untreated subgrades. Crack and seat was the worst performing treatment on the US 59 experimental sections that were constructed just north of Corrigan in the Lufkin District. The condition of the section on US 59 is shown in Figure 1.6.

TxDOT does not have a lot of experience with rubblization and there are only three constructed projects identified from discussion with the TxDOT districts. The existing projects are on US 79 in the Bryan District, US 67 in the Atlanta District, and US 83 in the Childress District.

**Figure 1.6. Three-Year-Old Crack and Seat Experimental Section on US 59.**

## Bryan District Experience

On the US 79 project, the Bryan District reported problems with rubblizing. On about 20 percent of the project, the slabs would not break and had to be replaced with full depth hot mix, leading to an expensive field change. The district placed 7 inches of new flexible base and 3.5 inches of hot-mix asphalt (HMA) on top of the rubblized concrete. The rubblized section is now part of a major intersection. Most of the rubblized pavement is in the central turn lane. Performance to date has been good; the District reported one longitudinal crack in the area where they widened the existing slab with full depth hot mix. The section was constructed around 1998.

## Atlanta District Experience

The Atlanta section was constructed on US 67 by the Mount Pleasant Area Office. The process was not considered a success. It was reported by the district lab engineer that "the process was not effective over joint; big unbroken pieces remained which had to be replaced with full depth Asphalt Concrete Pavement (ACP). The rubblizer rutted the processed section and displaced the concrete. Upon coring it was found that water was seen in the rubblized concrete beneath the ACP." The average rubblized concrete moduli value was less than 50 ksi, which is less than would be anticipated for a Class 1 flexible base. This low value may be attributed to the fact that water may be trapped in the base. As with the Bryan District project, no edge drains were installed.

## Childress District Experience

The Childress District rubblized a section of US 83 in 2003. The Texas Transportation Institute (TTI) has evaluated a continuous section 0.9 miles long from FM 3256 northward. This section is still performing excellently. Figure 1.7 shows the pavement section. FWD data collected after rubblization, illustrated in Figure 1.8, show the variability in stiffness of the rubblized pavement is much less than the variability of crack and seat or break and seat projects illustrated previously in Figure 1.4.


**Figure 1.7. US 83 Rubblized Section Constructed in 2003.**

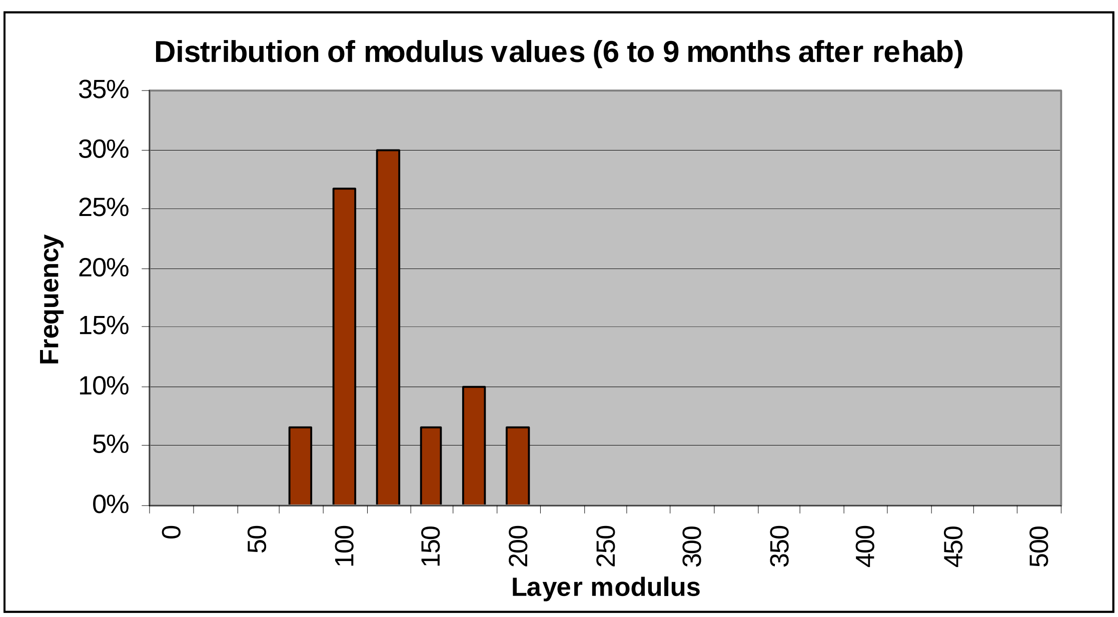


**Figure 1.8. Distribution of Rubblized Layer Modulus on US 83.**

## EXPERIENCE FROM ILLINOIS DOT

The Illinois DOT (IDOT) has more than 10 years' experience with rubblizing concrete pavements and has produced investigation and construction guidelines for the process. Their experience from 10 projects indicated overlaying rubblized pavement has performed better than simply patching and overlaying *(5)*. They have used both rubblization techniques, with three well-documented projects utilizing the resonant breaker and four projects using the MHB. From these projects they made the following observations *(5)*:

- In some cases the resonant breaker hinders traffic flow because the machine intrudes on the adjacent lane when rubblizing the centerline.
- Difficulties were encountered rubblizing where the subgrade California Bearing Ratio (CBR) was extremely low (around 3 to 5). Pieces of concrete larger than 12 inches in size remained on the top and had to be removed.
- On one project rubblized with the MHB, a tracked paver was used because the rubber-tired paver was excessively disturbing the surface of the rubblized layer.

Based on their experiences, IDOT developed comprehensive guidelines for rubblizing PCC pavements, and they also developed a special provision for use in controlling construction. IDOT's guidelines consist of two key steps before project review and approval: first a review of the existing pavement must be performed; next, design issues must be resolved *(5)*.

In reviewing the project, the first consideration is whether the rubblized pavement will protect the subgrade. An initial evaluation is made based on soils map data and personnel experience with the soils in the proposed project limits. If this analysis indicates the pavement can be rubblized, IDOT performs an extensive field analysis including, among other things, a review of the pavement structure, cone penetrometer testing, soil sampling, and a drainage survey. Their complete testing plan can be found in Heckel's report *(5)*. After conducting testing, IDOT plots the CBR of the top 12 inches of subgrade soil (divided into two 6-inch layers) on their Subgrade Rubblizing Guide, shown in Figure 1.9, to aid in deciding whether the structure can be rubblized without subgrade failure. The four methods identified for rubblization by IDOT are *(6)*:

- Method I: use the MHB.
- Method II: use the resonant breaker with high flotation tires with a tire pressure less than 60 psi.
- Method III: use the resonant breaker without restriction on tire pressure.
- Method IV: use either the MHB or the resonant breaker.

After determining the suitability for rubblization of the field test locations by using the rubblization selection chart, IDOT's guidelines state, "If it is found that several short or a few substantial segments of the project require omissions, or removal and replacement of the pavement; then other rehabilitation options should be considered" *(5)*.

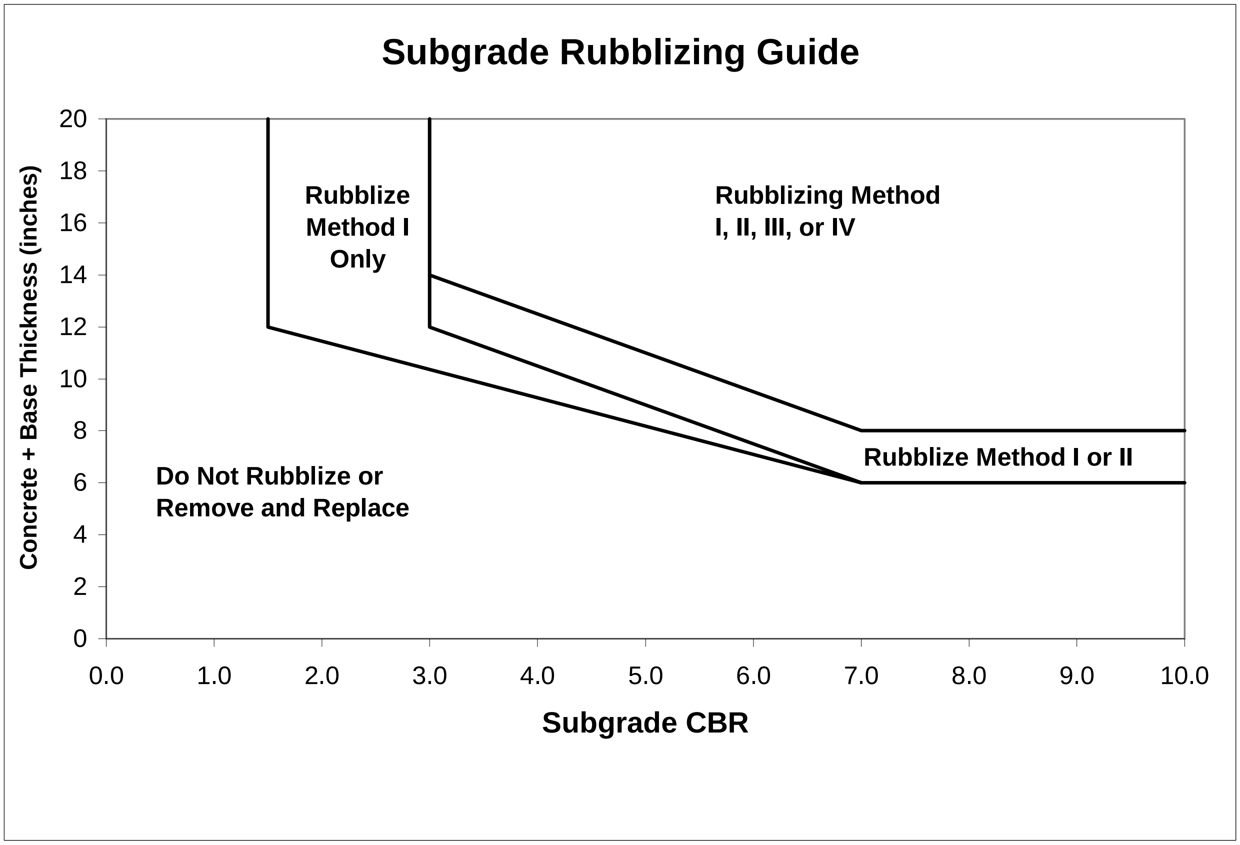


**Figure 1.9. IDOT Subgrade Rubblizing Guide (*5*).**

In Illinois, the typical construction sequence for rubblizing PCC pavements are (*7*):

- Install underdrains or French drains, as required.
- Remove any existing bituminous concrete overlay to the staged width.
- Remove and replace any existing unsound bituminous repair materials.
- Rubblize the pavement.
- Compact the broken pavement.
- Pave the binder lifts of the bituminous concrete overlay.

## Alabama DOT

The Highway Research Center at Auburn University evaluated the performance of nine rubblized pavements. They concluded rubblization was effective and efficient for rehabilitating PCC pavements. However, they noted that after approximately 5 years in service rubblized CRCP pavements had more distress than other PCC pavement types (*8*). They also observed distress levels increasing with increasing thickness of the rubblized PCC layer (*8*). They hypothesize these higher distress levels could be due to lack of debonding the reinforcing steel (in the case of CRCP), or failure to meet the specified particle size distribution (for thicker PCC pavements) (*8*).

## Pennsylvania DOT

In the fall of 1992, Pennsylvania constructed several test sections on jointed concrete pavement on I-80 as part of the SHRP SPS-6 project. Rehabilitation strategies employed included: overlay, overlay with sawcut and seal, crack/break and seat with overlay, and rubblize with overlay (*9*). Analysis of the functional and structural performance data after 10 years indicated rubblization with overlay provided the best performance of all the test sections (*9*). Additionally, personnel examining the data concluded that a pavement rehabilitation strategy should not be dictated by practice or policy; site-specific data should be used to develop a strategy for each project (*9*).

## Colorado DOT

In 1999 the Colorado DOT (CDOT) constructed approximately 80,000 square yards of rubblized JPCP on I-76 (*10*). Approximately half the project used the RMI, and the other half used the MHB to perform rubblization. The concrete had alkali-silica reactivity (ASR) problems. CDOT collected FWD data before and after rubblizing, and used the load transfer efficiency to gauge whether the slabs were fully fractured (*10*). Because of the experimental nature of the sections, CDOT is not pursuing any more rubblization projects until gaining at least 5 years of performance history from these first test sections (*10*).

## Michigan DOT

The Michigan DOT (MDOT) reports experience with rubblization since 1986 (*11*). In a comprehensive evaluation of rubblization projects, they made the following significant observations (*11*):

- Rubblization candidate projects should be investigated by examining history, distress, non-destructive test (NDT) data, coring, and soil boring data.
- Pavements with extensive discontinuities should not be rubblized.
- Concrete pavements on subbases with a resilient modulus less than 7 ksi should not be rubblized.
- If the subgrade soil has a resilient modulus under 3 ksi, rubblization should not be attempted.
- The rubblized layer consists of an upper layer of rubblized concrete and a lower layer of fractured concrete. Variations in thickness of these distinct layers result in variations in the pavement's response to loading. Therefore, the variation in deflection data may be a viable method of expressing the quality of the rubblization process.
- The average resilient modulus of rubblized layers from 18 projects was 207 ksi, with a minimum value of 46 ksi and a maximum of 1064 ksi. Moduli values of rubblized layers varied significantly both within projects and among different projects.
- Problems in performance on rubblization projects were caused by 1) inadequate performance of rubblizing, 2) poor construction of the asphalt mat, and 3) poor asphalt mix.

Based on their findings, MDOT recommended procedures for calibrating the rubblizing equipment to the concrete by testing the compressive strength, and recommendations were made to more adequately enforce the specifications and special provisions governing construction (*11*).

## UNRESOLVED ISSUES IN RUBBLIZATION

Although numerous states have some experience with rubblization, many unresolved issues remain. First, criteria and methodology for determining where rubblization is feasible are needed. From the review of literature, widespread experience shows that drainage and subslab support are crucial. Some states (*5, 11*) have recommended criteria on the bearing capacity or modulus of the beneath-slab layers to aid in evaluating whether rubblization is feasible. However, criteria need to be developed for Texas conditions.

Second, the constructibility and performance from the two main competing means of rubblization need further clarification. Conflicting reports of which device produces the better product exist. Some states seem to prefer one technique over the other (*5, 11*), and the manufacturers both point out areas where their equipment may have an advantage (*1, 2*). For example, the RMI claims to provide more interlock and achieve a more uniform thickness of the rubblized layer, while the MHB equipment has lower contact stress and therefore may be able to rubblize a project with weaker subgrades, and the MHB rubblizes in one pass. Likely, there are project conditions that in some cases may dictate which machine should be used. Ideally, Texas will have the opportunity to conduct rubblization projects with both devices to evaluate their performance on Texas roadways.

Finally, more guidance on the structural design of rubblized pavements is needed. Colorado obtained recommended overlay thicknesses of 2 to 6 inches, depending on design method (*10*). Illinois is in the process of evaluating the appropriateness of their overlay thickness design procedure (Winkleman, T., pers. comm.). Michigan reported widely varying backcalculated modulus values of rubblized layers, both within a single project and among different projects (*11*). The largest drawback is pointed out in the Federal Aviation Administration's (FAA's) documentation, "An evaluation of the rubblized material by a non-destructive testing procedure is the best approach; however this data cannot be made available up front in the design process" (*12*). There is a need for advance knowledge of the rubblized layers' modulus value. As this project continues, the research team will seek ways to relate the prerubblization modulus to the value after rubblization.

# CHAPTER 2
# FIELD INVESTIGATION PLAN AND DECISION CRITERIA

## FIELD INVESTIGATION PLAN

To efficiently collect data in the field for evaluating the suitability of a project for rubblization, TTI assembled a forensic investigation plan to obtain the needed information for making an informed decision on the suitability of a project for rubblization. The items investigated were determined by a review of other states' procedures in the literature search. This plan collects information on pavement structure, pavement condition (distress and structural properties), and subgrade condition (bearing capacity and moisture condition). TTI proposes TxDOT employ a tiered approach to evaluating projects. As a minimum, Tier 1 analysis consisting of reviews of plan sheets, a visual condition survey, FWD, and DCP testing should be performed on any potential rubblization candidate. For more complete information on pavement uniformity, subsurface condition, and subgrade moisture condition, GPR data should be collected to make a Tier 2 analysis. Finally, a Tier 3 analysis employs everything in Tiers 1 and 2, plus adds analysis through use of the RDD.

### Tier 1 Forensic Investigation

This analysis should be performed on any potential rubblization candidate. Review the project through the following means:

- *Plans*: Collect and review plan sheets from the project to identify the existing pavement structure. Identify important parameters such as: existence of any treated subgrade layers, presence and thickness of base (if any), thickness of concrete pavement, thickness of any overlays, and presence of any pavement widening with nonuniform construction.
- *Visual Condition Survey*: Review the project for the overall level of and type of distresses present. Examine if there appear to be any maintenance treatments where the structure may be different. Look for low-lying areas or areas with poor drainage where subgrade conditions may be poor.
- *FWD*: Collect FWD data on the project at 0.2 mile intervals, or at intervals sufficient to obtain at least 30 drops on the project, whichever is less. Collect the drops in the center of the concrete slabs. Randomly collect joint transfer tests between sensors 1 and 2 to aid in evaluating the joint transfer efficiency.
- *DCP*: From the FWD data identify the locations with the highest and lowest sensor 7 deflections. Perform DCP tests at these locations. Test a minimum of two locations of high sensor 7 deflection with the DCP, and one location with low sensor 7 deflection.

### Tier 2 Forensic Investigation

To perform a Tier 2 analysis, perform a GPR survey of the project in addition to all of the Tier 1 activities. Examine the GPR data for the following:

- pavement layer thickness,
- section breaks in pavement structure (nonuniform existing construction), and
- excessively wet subgrade beneath the concrete (evidenced by dielectric values above 15 for the layer beneath the concrete).

### Tier 3 Forensic Investigation

To perform a Tier 3 analysis, perform an analysis of the project with the RDD in addition to all the activities of Tier 1 and 2. The RDD essentially collects near-continuous deflection data across the entire project and may better be able to provide a complete picture of the variability of the project both in terms of joint transfer properties and suitability for rubblization.

## DECISION CRITERIA FOR SELECTING A PROJECT FOR RUBBLIZATION

After performing the forensic investigation, use the collected data to determine if the project is a candidate for rubblization. Other states' experience indicates the condition of the subgrade is most crucial for success in rubblization. In conditions of wet subgrades and/or soils with little bearing capacity, the concrete may not rubblize. Alternatively, if the subgrade condition is poor and the pavement does rubblize, the subgrade may not be able to support construction equipment. Therefore, the following conditions are necessary for a project to be considered for rubblization:

- Excessive moisture must not exist in the subgrade. GPR can be employed to investigate for excessive moisture beneath the concrete. Locations with a dielectric value above 15 are suspected of containing excessive moisture. Such locations should be investigated and considerations given to drainage improvements before attempting rubblization.
- Adequate drainage must exist. The visual survey in conjunction with a GPR survey can identify locations in need of drainage improvements. Any drainage improvement typically should be installed before initiation of rubblization operations.
- The subgrade bearing capacity and pavement thickness must be sufficient both for rubblization to satisfactorily occur and for supporting construction equipment after rubblization takes place. An FWD and DCP survey finalize the information needed to identify when a project is a candidate for rubblization.

After conducting the visual survey and reviewing the GPR survey (if conducted), analyze the FWD and DCP data to finalize the decision on whether a project is a candidate for rubblization by performing the following:

- Determine the CBR from 0 to 6 and from 6 to 12 inches in the subgrade at each DCP test location. Plot the pavement thickness (concrete + base; do not include the thickness of any overlay on top of the concrete) versus the determined subgrade CBR values on the rubblization selection chart from IDOT.

- If all data points fall in the zone identified as suitable for rubblization, the project is a candidate.
- If all the data points fall in the “Do Not Rubblize” zone of the chart, rubblization should not be attempted and other rehabilitation options should be pursued.
- If some, but not all, of the data points fall in the “Do Not Rubblize” zone, certain portions of the project may not be suitable for rubblization. More analysis, interpretation, and judgment is required:

    - Process the FWD data using Modulus 6.0 by inputting a dummy subbase layer of 12 inches. Fix the depth to bedrock at 240 inches. This procedure will isolate the stiffness of the top 12 inches of the subgrade.
    - Determine the composite CBR of the top 12 inches of subgrade from the DCP data.
    - From the IDOT rubblization selection chart, determine the minimum subgrade CBR necessary to support rubblization for the known pavement thickness at the project. Do this by starting on the Y-axis at the known pavement thickness, then project horizontally until intersecting the boundary where rubblization is feasible. At this intersection project down to the X-axis and read off the minimum subgrade CBR required.
    - Form a relationship between the subgrade modulus and CBR by graphing the modulus of the dummy 12-inch subgrade layer on the Y-axis versus the composite CBR of the top 12 inches of subgrade on the X-axis. Input the minimum subgrade CBR necessary into this relationship to determine the anticipated minimum subgrade modulus needed. From limited project experience, this minimum value is in the range of 10 to 15 ksi.
    - Graph the modulus of the dummy 12-inch subgrade layer with distance for the project. Where the modulus does not exceed the minimum subgrade modulus needed, a risk exists that the project may not rubblize. At this point the data must be reviewed on a case-by-case basis and a judgment made as to where, if at all, rubblization should be attempted.

# CHAPTER 3
# INVESTIGATION OF US 70 FOR RUBBLIZATION

## SUMMARY

The Childress District is currently in the process of rehabilitating their jointed concrete pavements and is considering rubblization as an option for approximately 15.4 miles of US 70 in Foard County from the Wilbarger County line (C/L) to the city of Crowell. Two projects exist in this section: first, from FM 267 to Crowell; second, from the Wilbarger C/L to FM 267. Based on existing recommendations for rubblization, testing revealed that the section from FM 267 to Crowell is a suitable candidate for rubblization. Within the second project limits, a majority of the project does not appear suitable for rubblization, and other rehabilitation options should be considered. Additionally, a few locations were identified with GPR where the signature varied significantly from the norm. Consideration should be given to coring within these sections to verify the pavement structure.

## RESULTS FROM FIELD INVESTIGATION

To evaluate if the US 70 project is suitable for rubblization, TTI performed a field analysis using GPR, FWD, and DCP testing. Figure 3.1 illustrates representative GPR data from the project between FM 267 and Crowell. An analysis of the GPR data indicated an average ACP thickness of 7.44 inches and an average jointed concrete pavement (JCP) thickness of 7.9 inches. These thicknesses match well with the plans provided by the Childress District, shown in Figure 3.2. Additionally, TTI reviewed the GPR data for signs of excessively wet subgrade, indicated by high layer 3 dielectric values, since a wet subgrade hinders the rubblization process. The GPR data did not indicate any locations of excessively wet subgrade soil. Typical subgrade dielectric values ranged from 5 to 8. In the GPR data, some instances existed of significant negative reflections in the ACP layer, which oftentimes indicate problems such as stripping in the ACP; however, if the JCP is to be rubblized the ACP must be removed, so these sites of potential ACP defects were not investigated further.

From the Wilbarger C/L to FM 267, a few instances exist where the GPR signature differs substantially from the norm. Figure 3.3 shows an example of the signature in these locations. In total, four of these sections exist. The limits of the sections, as distances west from the Wilbarger C/L, are:

- 4.56 to 4.68 miles
- 5.75 to 5.80 miles
- 6.49 to 6.53 miles
- 6.66 to 6.74 miles

The GPR survey on this section was conducted after FWD testing, and the intervals of the FWD tests did not fall within the limits of any of these sections. Therefore, no other additional information is currently available to verify the structure at these locations. Consideration should be given to coring within these locations to verify the pavement structure.

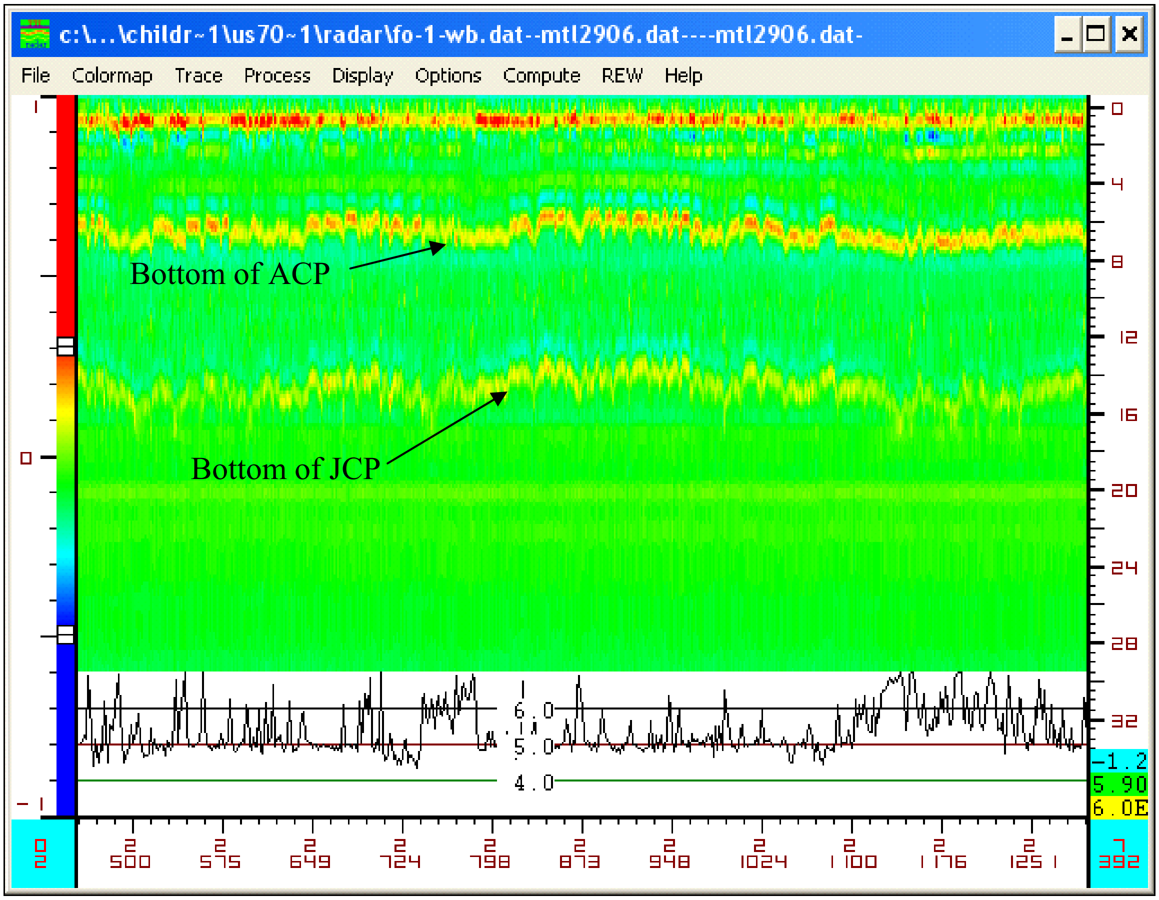


**Figure 3.1. Representative GPR Data on US 70 in Foard County.**

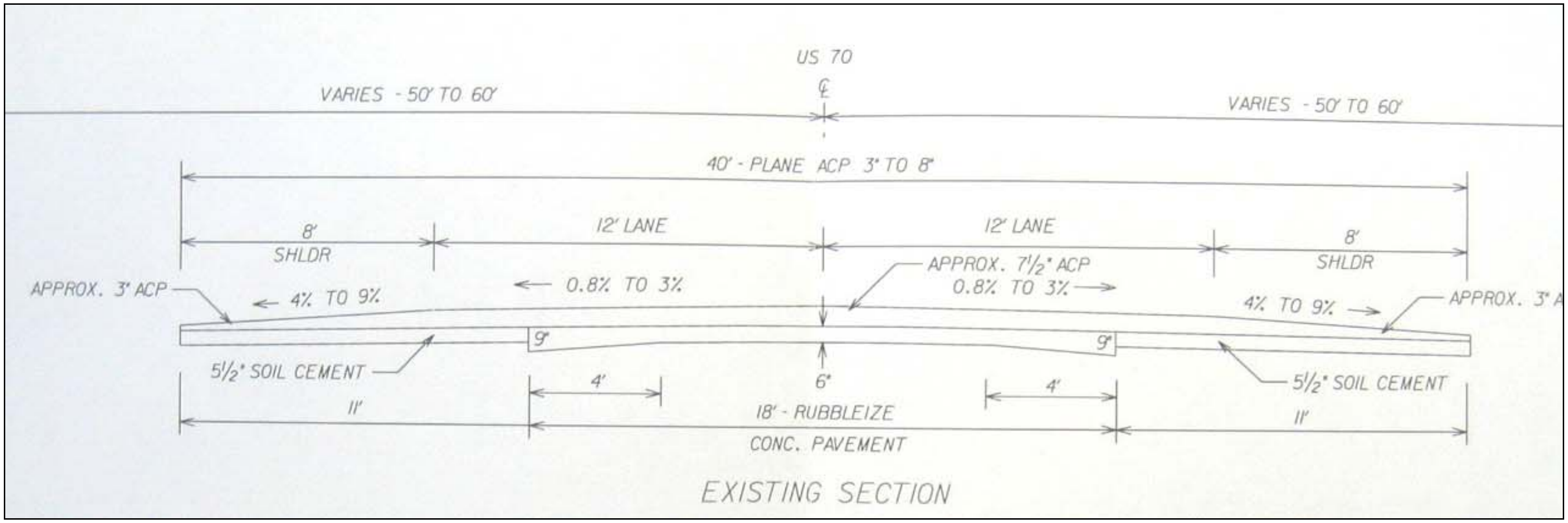


**Figure 3.2. Typical Existing Section on US 70 in Foard County.**

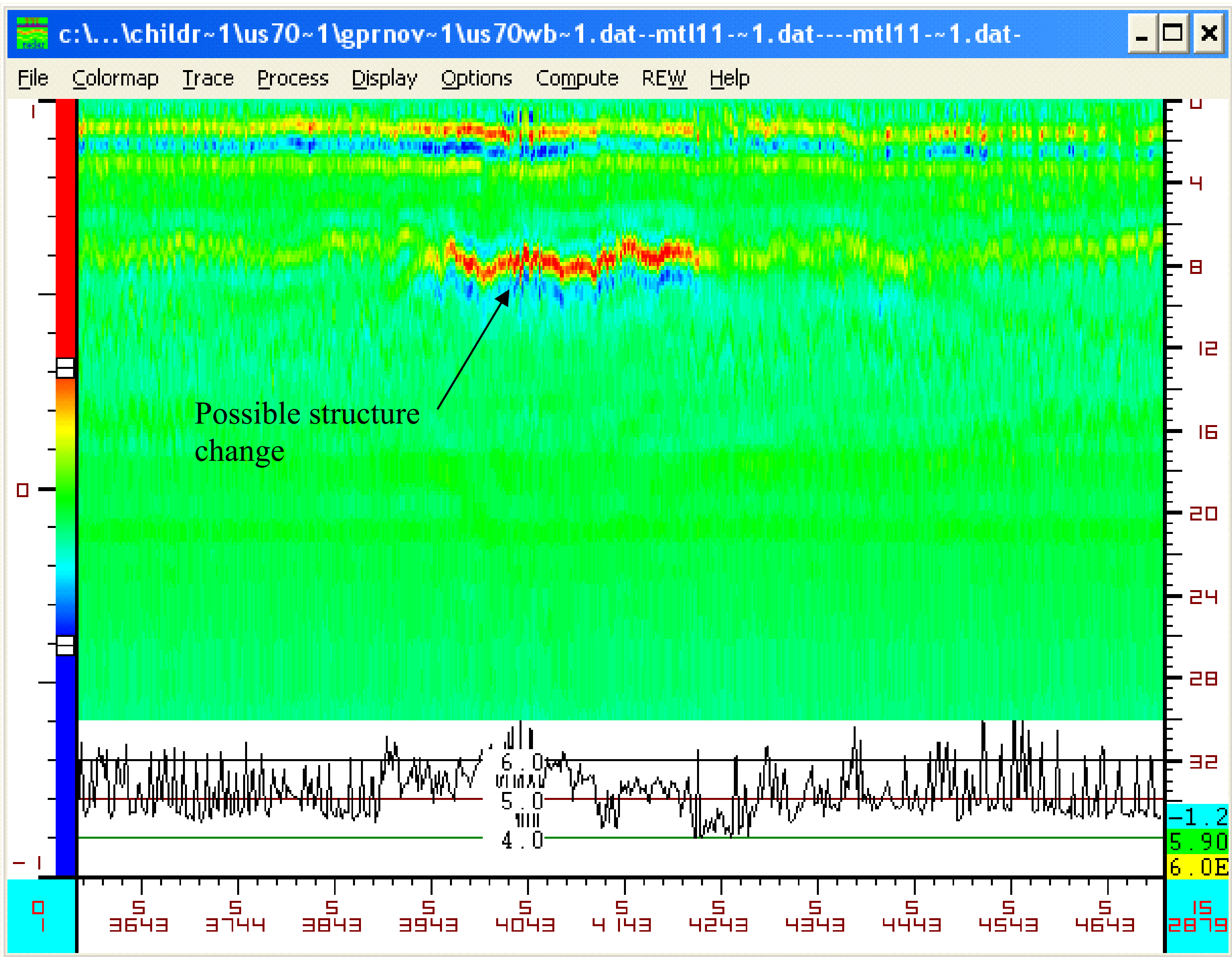


**Figure 3.3. Possible Structure Change between Wilbarger County Line and FM 267.**

**Results from FWD and DCP Testing**

Table 3.1 shows the FWD backcalculation results for US 70 from FM 267 to Crowell, and Table 3.2 shows the FWD results from the Wilbarger C/L to FM 267. Layer thicknesses of 7.5 inches were used for both the ACP and JCP based upon GPR and plan sheets. Additionally, since other states' experience indicates the top 12 inches of subgrade is most crucial for rubblizing success, a 12-inch dummy subbase layer was used, and a fixed depth to bedrock value of 240 inches was input into Modulus 6.0. After studying FWD results in the field, TTI selected several locations to perform DCP tests at the project site. These tests represented some of the softest and stiffest subgrade locations along the length of the project and are summarized in Table 3.3. Combined, the FWD and DCP data complete the information necessary to analyze the suitability of the project for rubblization.

For rubblization, two critical issues are drainage and support beneath the slab. The GPR data already indicated that trapped moisture was not a problem. From FM 267 to Crowell, all the DCP results (Holes 3 through 7) indicated subgrade support is suitable for rubblization. Figure 3.4 shows these data on IDOT's rubblization selection chart.

In the project from Wilbarger C/L to FM 267, results do not appear as favorable for rubblization. Figure 3.5 shows the DCP results on the IDOT rubblization chart. As indicated by Hole 2, areas of this project exist that likely cannot be rubblized. Based upon existing guidelines, for the thickness of pavement at this project a subgrade CBR of 6.5 or higher should exist in order to utilize rubblization. Figure 3.6 shows that for this CBR value, it is anticipated a subgrade modulus of 14 ksi or higher is needed. A majority of the project likely would not meet these criteria, as illustrated in Figure 3.7. Rubblizing would require splitting the project up into numerous small sections, which is not believed practical.

An additional observation on the section from the Wilbarger C/L to FM 267 is that some of the FWD sensor 1 deflections are very high, such as at 4.2 and 6.2 miles (34 and 29 mils, respectively). A GPR survey conducted over the project on November 2, 2005, did not reveal any unusual traces at these locations. Therefore, it is possible the FWD may have tested outside the limits of the concrete at these locations.

# Table 3.1. FWD Results for US 70 from FM 267 to Crowell.

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 6.0)

| | | | | | |
|---|---|---|---|---|---|
| District:25 | (Childress) | | MODULI RANGE (psi) | | Poisson Ratio Values |
| County: 97 | (FOARD) | Thickness(in) | Minimum | Maximum | |
| Highway/Road: us0070 | Pavement: | 7.5 | 60,000 | 800,000 | H1: v = 0.3 |
| | Base: | 7.5 | 100,000 | 10,000,000 | H2: v=0.2 |
| | Subbase: | 12 | 5,000 | 50,000 | H3: v=0.40 |
| | Subgrade: | 240.00 (user input) | 15,000 | | H4: v=0.4 |

| Station | Load (lbs) | R1 | R2 | R3 | R4 | R5 | R6 | R7 | SURF(E1) | BASE(E2) | SUBB(E3) | SUBG(E4) | Absolute ERR/Sens | Dpth to Bedrock | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Measured Deflection (mils) | | | | | | | Calculated Moduli Values (ksi) | | | | | | |
| 0.045 | 11,988 | 5.32 | 4.44 | 3.91 | 3.35 | 2.73 | 2.26 | 1.78 | 1052 | 3584.8 | 7.8 | 19.8 | 0.46 | 123.5 | |
| 0.101 | 11,094 | 10.28 | 6.3 | 5.77 | 4.89 | 3.87 | 3.13 | 2.43 | 167 | 5503.4 | 7.3 | 13.2 | 1.59 | 135.3 | |
| 0.201 | 11,523 | 8.97 | 5.64 | 4.89 | 3.99 | 3.14 | 2.56 | 1.98 | 203.6 | 4853.3 | 6.1 | 19 | 0.82 | 131.4 | |
| 0.214 | 11,293 | 9.55 | 5.72 | 5 | 4.12 | 3.24 | 2.62 | 2.04 | 170.4 | 5210.9 | 5.7 | 18 | 0.72 | 135.8 | |
| 0.302 | 10,951 | 9.48 | 5.37 | 4.76 | 3.94 | 3.09 | 2.48 | 1.88 | 153.8 | 4976.1 | 16.5 | 16 | 1.03 | 119 | |
| 0.4 | 10,864 | 8.97 | 5.22 | 4.52 | 3.74 | 2.98 | 2.28 | 1.8 | 168.2 | 4481.6 | 15.8 | 17.2 | 0.9 | 142.5 | |
| 0.5 | 10,824 | 8.16 | 5.78 | 5.15 | 4.33 | 3.48 | 2.84 | 2.19 | 296.2 | 3395.3 | 33.1 | 13.1 | 0.94 | 128.5 | |
| 0.6 | 11,392 | 9.25 | 5.3 | 4.56 | 3.8 | 3.06 | 2.57 | 1.98 | 163.1 | 4843.2 | 50 | 15.6 | 0.86 | 122.9 | * |
| 0.702 | 10,951 | 11.5 | 6.67 | 5.77 | 4.78 | 3.81 | 3.07 | 2.41 | 129.3 | 3953.2 | 13.1 | 13 | 0.38 | 148.5 | |
| 0.8 | 10,987 | 8.28 | 5.35 | 4.91 | 4.15 | 3.34 | 2.68 | 2.14 | 234.1 | 4756.2 | 46.1 | 13.7 | 1.69 | 152 | |
| 0.9 | 10,633 | 10.91 | 5.85 | 5.12 | 4.28 | 3.36 | 2.69 | 2.07 | 120.5 | 3740.9 | 42.5 | 13.7 | 0.99 | 128.5 | |
| 1 | 11,452 | 12.55 | 7.07 | 5.96 | 4.88 | 3.75 | 2.9 | 2.22 | 123.7 | 2184.3 | 33.4 | 13.9 | 0.82 | 131.4 | |
| 1.101 | 10,737 | 10.77 | 6.04 | 5.24 | 4.33 | 3.49 | 2.81 | 2.25 | 129.3 | 3730.1 | 38 | 13.3 | 0.27 | 165.2 | |
| 1.2 | 10,919 | 9.8 | 5.78 | 4.81 | 4.01 | 3.24 | 2.7 | 2.09 | 149.9 | 4821.1 | 16.2 | 15 | 1.6 | 128.3 | |
| 1.3 | 11,126 | 10.59 | 6.33 | 5.5 | 4.63 | 3.65 | 2.86 | 2.13 | 151.4 | 4592.5 | 5.7 | 15.6 | 0.61 | 112.1 | |
| 1.403 | 11,015 | 8.78 | 5.01 | 4.39 | 3.69 | 2.98 | 2.38 | 1.93 | 165.1 | 6214.4 | 16.8 | 16.5 | 0.41 | 162.6 | |
| 1.503 | 11,448 | 9.28 | 5.26 | 4.54 | 3.77 | 3.02 | 2.45 | 1.9 | 161.9 | 4542.3 | 46.2 | 16.2 | 0.34 | 127.1 | |
| 1.6 | 11,639 | 9.41 | 5 | 4.37 | 3.61 | 2.91 | 2.36 | 1.9 | 148.7 | 6104 | 34.2 | 17.7 | 0.39 | 156.3 | |
| 1.701 | 11,241 | 12.13 | 7.06 | 5.8 | 4.73 | 3.62 | 2.91 | 2.22 | 132.7 | 1571.2 | 47.2 | 13.5 | 0.79 | 129.1 | |
| 1.801 | 10,816 | 11.04 | 6.05 | 5.29 | 4.33 | 3.36 | 2.65 | 2.04 | 127 | 3028.3 | 37.7 | 14.3 | 1.21 | 133.5 | |
| 1.9 | 10,935 | 9.8 | 5.44 | 4.7 | 3.92 | 3.15 | 2.53 | 1.96 | 142.7 | 4291.5 | 43.7 | 15 | 0.25 | 128.6 | |
| 2 | 11,484 | 9.73 | 4.83 | 4.29 | 3.59 | 2.93 | 2.37 | 1.97 | 131.1 | 7235.2 | 43.6 | 17 | 0.46 | 196.7 | |
| 2 | 12,163 | 9.4 | 4.64 | 4.25 | 3.09 | 2.94 | 2.41 | 1.79 | 139.7 | 9670.7 | 38.6 | 18.4 | 3.88 | 300 | |
| 2 | 10,769 | 8.66 | 4.8 | 4.38 | 3.77 | 2.93 | 2.44 | 2.02 | 161.2 | 6195.6 | 48.8 | 14.9 | 1.83 | 300 | |
| 2.003 | 11,488 | 9.18 | 5.07 | 4.46 | 3.54 | 2.93 | 2.43 | 1.96 | 158 | 5064.2 | 49.8 | 16.8 | 1.34 | 171.8 | |
| 2.202 | 10,963 | 10.18 | 5.69 | 5.08 | 4.28 | 3.46 | 2.79 | 2.19 | 139.7 | 4970 | 40.3 | 13.3 | 0.85 | 139.1 | |
| 2.417 | 10,919 | 11.44 | 7.17 | 6.27 | 5.22 | 4.13 | 3.34 | 2.59 | 152.6 | 3542.6 | 11 | 12.1 | 0.63 | 141.7 | |
| 2.614 | 10,963 | 11.86 | 6 | 5.19 | 4.3 | 3.39 | 2.7 | 2.13 | 107 | 3512.1 | 50 | 14.4 | 0.68 | 147.6 | * |
| 2.802 | 10,403 | 10.43 | 6.79 | 5.97 | 4.98 | 3.94 | 3.17 | 2.46 | 175.3 | 3368.3 | 11.5 | 12 | 0.79 | 141.9 | |
| 3.003 | 12,306 | 11.02 | 6.75 | 6.12 | 5.14 | 4.11 | 3.07 | 2.5 | 177.5 | 4230.8 | 12.5 | 14.1 | 2.43 | 133.4 | |
| 3.207 | 11,158 | 8.33 | 5.2 | 4.7 | 3.84 | 3.09 | 2.43 | 1.87 | 214.6 | 5756.6 | 5.7 | 18.7 | 0.97 | 128.5 | |
| 3.401 | 11,730 | 9.1 | 5.42 | 4.78 | 4 | 3.06 | 2.4 | 1.84 | 188.5 | 5278.8 | 6.1 | 20.2 | 1.36 | 120.6 | * |
| 3.6 | 10,089 | 8.6 | 5 | 4.33 | 3.48 | 2.65 | 2.06 | 1.5 | 169.4 | 2792.3 | 29.5 | 17.3 | 1.36 | 106.5 | |
| 3.814 | 11,837 | 8.78 | 4.9 | 4.28 | 3.51 | 2.75 | 2.13 | 1.66 | 178.2 | 4983.9 | 22.6 | 20.2 | 0.97 | 129.3 | |
| 4.009 | 10,439 | 13.07 | 8.52 | 7.66 | 6.34 | 4.96 | 3.7 | 2.82 | 148.8 | 2327 | 5.1 | 10.7 | 2.24 | 142.4 | |
| 4.016 | 11,865 | 7.91 | 4.8 | 4.03 | 3.16 | 2.41 | 1.84 | 1.33 | 236.4 | 2945.4 | 20.7 | 23.8 | 0.58 | 100.7 | |
| 4.203 | 10,641 | 9.78 | 6.17 | 5.35 | 4.37 | 3.43 | 2.65 | 1.98 | 181.3 | 3072.3 | 11.8 | 14.9 | 0.82 | 118.6 | |
| 4.406 | 11,499 | 7.87 | 5.01 | 4.35 | 3.55 | 2.77 | 2.22 | 1.73 | 241.5 | 4962.6 | 7.3 | 21.6 | 0.74 | 131.8 | |
| 4.602 | 10,963 | 9.74 | 5.93 | 5.03 | 4.04 | 3.04 | 2.28 | 1.66 | 176.4 | 2951.2 | 6.1 | 20.2 | 0.95 | 107.9 | * |
| 4.804 | 10,403 | 8.56 | 7.44 | 6.26 | 5.05 | 3.93 | 3.08 | 2.27 | 1100 | 369.5 | 10.1 | 12 | 1.32 | 119.3 | * |
| 5.004 | 9,835 | 9.18 | 4.67 | 3.98 | 3.15 | 2.39 | 1.83 | 1.35 | 128.6 | 3076.4 | 30.7 | 19.8 | 1.04 | 110.9 | |
| 5.216 | 10,030 | 10.33 | 5.88 | 5.09 | 4.08 | 3.05 | 2.43 | 1.95 | 135 | 2604.8 | 19.1 | 15.2 | 1.4 | 180 | |
| 5.406 | 10,117 | 10.36 | 6.33 | 5.53 | 4.45 | 3.41 | 2.62 | 2.02 | 154.8 | 2571 | 10.5 | 14.4 | 1.34 | 142.6 | |
| 5.606 | 11,166 | 7.32 | 5.69 | 4.91 | 4.1 | 3.22 | 2.57 | 1.96 | 513.9 | 2340.3 | 5.4 | 17.8 | 0.59 | 120.4 | * |
| 5.806 | 10,955 | 9.53 | 6.75 | 6.13 | 5.11 | 4.07 | 3.28 | 2.51 | 262 | 3683.7 | 5.2 | 13.1 | 1.27 | 132.4 | |
| 5.984 | 10,657 | 7.1 | 4.99 | 4.42 | 3.62 | 2.82 | 2.23 | 1.7 | 338.4 | 3761.6 | 6 | 20 | 1.13 | 122 | * |
| Mean: | | 9.61 | 5.76 | 5.04 | 4.15 | 3.28 | 2.61 | 2.02 | 217.4 | 4166.2 | 23.3 | 16 | 1.04 | 132.3 | |
| Std. Dev: | | 1.47 | 0.87 | 0.76 | 0.65 | 0.5 | 0.38 | 0.3 | 197.4 | 1581.2 | 16.3 | 2.9 | 0.65 | 23.3 | |
| Var Coeff(%): | | 15.29 | 15.01 | 15 | 15.63 | 15.19 | 14.66 | 15.06 | 90.8 | 38 | 70.1 | 18.4 | 62.12 | 17.6 | |

# Table 3.2. FWD Results for US 70 from Wilbarger County Line to FM 267.

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 6.0)

| | | | | | | |
|---|---|---|---|---|---|---|
| District:25 | (Childress) | | MODULI RANGE (psi) | | | |
| County: 97 | (FOARD) | | Thickness(in) | Minimum | Maximum | Poisson Ratio Values |
| Highway/Road: us0070 | | Pavement: | 7.5 | 60,000 | 800,000 | H1: v = 0.3 |
| | | Base: | 7.5 | 500,000 | 10,000,000 | H2: v=0.2 |
| | | Subbase: | 12 | 5,000 | 50,000 | H3: v=0.40 |
| | | Subgrade: | 240.00 (user input) | | 15,000 | H4: v=0.4 |

| Station | Load (lbs) | R1 | R2 | R3 | Measured Deflection (mils) R4 | R5 | R6 | R7 | Calculated Moduli Values (ksi) SURF(E1) | BASE(E2) | SUBB(E3) | SUBG(E4) | Absolute ERR/Sens | Dpth to Bedrock | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.022 | 11,551 | 6.43 | 5.47 | 4.78 | 3.92 | 3.14 | 2.54 | 1.97 | 800 | 726.4 | 50 | 15.3 | 3.13 | 131.4 | * |
| 0.2 | 11,241 | 8.51 | 5.96 | 5.77 | 4.63 | 3.39 | 2.78 | 2.06 | 331.5 | 2997.3 | 5 | 16.7 | 3.76 | 206.7 | * |
| 0.4 | 10,594 | 9.96 | 5.65 | 4.83 | 3.93 | 3 | 2.32 | 1.76 | 147.6 | 2278.7 | 44 | 15.8 | 1.31 | 123 | |
| 0.6 | 10,792 | 11.53 | 8.73 | 7.48 | 6.2 | 4.88 | 3.88 | 2.94 | 279.9 | 1299.9 | 9.4 | 10 | 0.64 | 134.1 | |
| 0.8 | 11,245 | 10.81 | 7.61 | 6.07 | 5.05 | 3.8 | 3.04 | 2.13 | 281 | 464.7 | 48.4 | 12.6 | 1.1 | 96.3 | |
| 1 | 11,666 | 9.93 | 5.95 | 5.09 | 4.16 | 3.17 | 2.44 | 1.85 | 176 | 3279.1 | 12.7 | 17.9 | 1.01 | 120.6 | |
| 1.2 | 11,734 | 8.26 | 5.89 | 4.68 | 3.8 | 2.89 | 2.28 | 1.74 | 370.2 | 1047.5 | 30.8 | 18.6 | 0.91 | 120.7 | |
| 1.4 | 11,611 | 8.24 | 6.2 | 5.41 | 4.46 | 3.51 | 2.77 | 2.09 | 413 | 2168.3 | 12 | 15.3 | 1.04 | 119.4 | |
| 1.601 | 10,963 | 9.96 | 5.97 | 5.35 | 4.6 | 3.68 | 3.06 | 2.44 | 158.4 | 6435.4 | 10 | 13 | 0.88 | 149.2 | |
| 1.8 | 11,746 | 17.14 | 11.93 | 7.88 | 5.37 | 3.8 | 2.89 | 2.2 | 315.1 | 50 | 17.6 | 13.9 | 1.4 | 180.4 | * |
| 2 | 11,297 | 10.56 | 5.04 | 4.64 | 3.73 | 2.96 | 2.31 | 1.73 | 118 | 5249 | 43.4 | 17.3 | 1.84 | 116.6 | |
| 2.2 | 11,237 | 9.38 | 5.48 | 4.89 | 4.13 | 3.22 | 2.52 | 1.93 | 168.2 | 5785 | 5.6 | 18.1 | 1.37 | 120.7 | |
| 2.405 | 11,408 | 7.9 | 6.14 | 4.96 | 3.88 | 2.91 | 2.26 | 1.72 | 608.1 | 776.5 | 6.5 | 21.3 | 0.6 | 127.9 | |
| 2.6 | 11,774 | 9.63 | 8.15 | 6.91 | 5.64 | 4.33 | 3.32 | 2.54 | 800 | 562.6 | 6.2 | 13.1 | 1.63 | 136.5 | * |
| 2.801 | 10,765 | 10.12 | 8.01 | 6.58 | 5.32 | 4.19 | 3.13 | 2.32 | 484.1 | 626.9 | 6.1 | 13.1 | 0.8 | 121.3 | |
| 3 | 11,714 | 10.2 | 4.28 | 3.79 | 3.05 | 2.37 | 1.89 | 1.49 | 111.1 | 6439.1 | 42.6 | 23.1 | 1.1 | 136.5 | |
| 3.2 | 11,428 | 7.17 | 5.41 | 4.68 | 3.85 | 2.99 | 2.4 | 1.78 | 484 | 2048.4 | 16.8 | 17.2 | 1 | 108.7 | |
| 3.401 | 11,150 | 12.54 | 8.86 | 5.95 | 4.34 | 3.27 | 2.5 | 1.87 | 432 | 50 | 43.4 | 14.9 | 0.87 | 128.8 | * |
| 3.6 | 11,488 | 12.19 | 7.09 | 4.81 | 3.52 | 2.53 | 5.42 | 1.51 | 152.2 | 512 | 50 | 17.1 | 17.93 | 58.6 | * |
| 3.8 | 10,216 | 9.68 | 6.65 | 6.09 | 4.94 | 3.68 | 3 | 2.24 | 233.6 | 2360.4 | 8 | 13.1 | 2.51 | 261 | |
| 4 | 10,459 | 10.04 | 6.72 | 6.1 | 5.22 | 4.13 | 3.28 | 2.53 | 200.8 | 3710.3 | 14.8 | 11.1 | 1.74 | 133 | |
| 4.2 | 10,693 | 34.24 | 22.72 | 13.61 | 7.64 | 4.74 | 3.36 | 2.48 | 66.8 | 50 | 5 | 9.9 | 7.77 | 91.8 | * |
| 4.4 | 10,514 | 11.31 | 6.16 | 5.5 | 4.97 | 3.39 | 2.89 | 2.2 | 119.9 | 3663.7 | 27.8 | 12.8 | 3.53 | 99 | |
| 4.6 | 10,570 | 14.04 | 9.76 | 8 | 6.56 | 5.14 | 3.85 | 3 | 163.9 | 1222.1 | 6.5 | 10.5 | 0.92 | 157 | |
| 4.8 | 10,296 | 15.57 | 7 | 6.43 | 5.37 | 4.22 | 3.23 | 2.44 | 68.9 | 3290.5 | 46.8 | 10.9 | 2.48 | 129 | |
| 5 | 10,820 | 22.7 | 16.03 | 11.52 | 8.86 | 6.84 | 5.33 | 4.08 | 192.3 | 50 | 24.5 | 6.8 | 0.61 | 164.3 | * |
| 5.2 | 10,725 | 11.37 | 7.96 | 5.84 | 4.4 | 3.28 | 2.57 | 1.96 | 372.5 | 115 | 38.2 | 14.2 | 0.51 | 140.1 | |
| 5.402 | 10,347 | 11.29 | 8.94 | 7.76 | 6.41 | 5.01 | 3.92 | 2.93 | 380.2 | 849.2 | 5.4 | 9.7 | 1.2 | 130.3 | |
| 5.6 | 11,281 | 15.87 | 12.86 | 11.27 | 9.41 | 7.56 | 6.08 | 4.84 | 316.5 | 670.4 | 9 | 6.2 | 0.96 | 205.6 | |
| 5.8 | 10,765 | 13.94 | 9.3 | 8.04 | 6.78 | 5.5 | 4.61 | 3.46 | 144 | 1668 | 50 | 8 | 0.54 | 128.1 | * |
| 6.001 | 10,351 | 15 | 11.87 | 10.56 | 8.9 | 6.82 | 5.37 | 4.23 | 800 | 127.5 | 5 | 8 | 6.23 | 187.7 | * |
| 6.2 | 9,227 | 29.55 | 17.63 | 11.91 | 9.07 | 6.93 | 5.43 | 4.16 | 64.7 | 50 | 18.9 | 5.9 | 1.81 | 166.3 | * |
| 6.4 | 10,467 | 13.35 | 10.81 | 9.45 | 7.99 | 6.35 | 5.11 | 3.93 | 325 | 899.5 | 7.6 | 7 | 1.1 | 151.9 | |
| 6.6 | 10,463 | 18.85 | 12.06 | 9.96 | 8.17 | 6.52 | 5.07 | 3.92 | 93.2 | 1309.9 | 9.6 | 7.6 | 0.48 | 164.7 | |
| 6.8 | 10,153 | 14.07 | 8.64 | 7.42 | 6.16 | 4.88 | 3.91 | 2.97 | 110.2 | 2478.8 | 10.6 | 9.5 | 0.34 | 137.4 | |
| 7.001 | 11,317 | 10.7 | 8.08 | 7.36 | 6.31 | 5.01 | 4.24 | 3.3 | 289.5 | 3472.2 | 5 | 9.9 | 1.43 | 300 | * |
| 7.2 | 10,145 | 17.77 | 12.02 | 9.84 | 7.88 | 5.91 | 4.5 | 3.36 | 123.2 | 648.6 | 7.8 | 8.3 | 0.72 | 142.7 | |
| 7.4 | 10,788 | 10.51 | 7.57 | 6.85 | 5.84 | 4.72 | 3.75 | 2.89 | 245.1 | 2607.7 | 26.9 | 9.5 | 1.52 | 136.7 | |
| 7.6 | 10,824 | 13.13 | 7.69 | 6.96 | 5.91 | 4.7 | 3.79 | 2.76 | 116.1 | 4263.9 | 9.8 | 10.1 | 1.33 | 110.5 | |
| 7.8 | 9,914 | 8.99 | 7.1 | 6.67 | 5.39 | 4.19 | 3.34 | 2.71 | 453.3 | 1392.9 | 5 | 10.9 | 2.79 | 228 | * |
| 7.999 | 11,003 | 9.82 | 8.01 | 7.3 | 6.34 | 5.31 | 4.31 | 3.42 | 800 | 604.9 | 38.8 | 8 | 1.79 | 157.7 | * |
| 8.2 | 11,122 | 10.48 | 7.64 | 7.04 | 5.84 | 4.61 | 3.67 | 2.84 | 278.3 | 2409.5 | 11.3 | 10.6 | 2.06 | 147.3 | |
| 8.4 | 9,541 | 13.13 | 8.96 | 8.13 | 6.93 | 5.67 | 4.49 | 3.51 | 144.4 | 2811.1 | 10.3 | 7.3 | 1.38 | 163.5 | |
| 8.6 | 10,061 | 11.89 | 7.34 | 7.29 | 6.09 | 5.07 | 3.84 | 3.02 | 141.8 | 4179 | 25 | 8.3 | 3.94 | 172.2 | |
| 8.8 | 10,300 | 12.78 | 8.89 | 7.41 | 5.89 | 4.37 | 3.28 | 2.4 | 192.4 | 932.6 | 5.7 | 12.3 | 1.19 | 123.5 | |
| 9.001 | 10,288 | 19.74 | 11.51 | 9.41 | 7.99 | 6.56 | 5.3 | 4.19 | 69.4 | 1846.1 | 20.8 | 6.8 | 1.27 | 174.5 | |
| 9.201 | 10,359 | 16.13 | 10.83 | 9.02 | 7.61 | 5.62 | 4.31 | 3.18 | 128.4 | 1185.4 | 5.7 | 9.2 | 1.49 | 123.2 | |
| 9.4 | 11,738 | 15.91 | 6.44 | 5.88 | 4.89 | 4.02 | 3.06 | 2.42 | 69.4 | 5359.1 | 44.9 | 13.3 | 2.03 | 153.4 | |
| Mean: | | 12.96 | 8.65 | 7.15 | 5.78 | 4.47 | 3.6 | 2.7 | 277.8 | 2021.4 | 20.1 | 12.1 | 2.04 | 139.8 | |
| Std. Dev: | | 5.27 | 3.46 | 2.19 | 1.64 | 1.31 | 1.05 | 0.83 | 205.6 | 1785.2 | 16 | 4.1 | 2.73 | 39.9 | |
| Var Coeff(%): | | 40.62 | 39.99 | 30.64 | 28.42 | 29.33 | 29.32 | 30.73 | 74 | 88.3 | 79.8 | 34.2 | 133.9 | 28.5 | |

**Table 3.3. Summary DCP Results from US 70 in Foard County.**

| Hole | Subgrade CBR 0-6" | Subgrade CBR 6-12" | Subgrade Modulus from FWD (ksi) | Location |
|---|---|---|---|---|
| 1 | 34.0 | 23.3 | 43.4 | 2.0 miles west of Wilbarger C/L |
| 2 | 2.7 | 3.4 | 9.0 | 5.6 miles west of Wilbarger C/L |
| 3 | 9.1 | 9.8 | 7.3 | 0.101 miles west of FM 267 |
| 4 | 11.6 | 9.1 | 15.8 | 0.4 miles west of FM 267 |
| 5 | 8.5 | 5.2 | 11 | 2.417 miles west of FM 267 |
| 6 | 10.7 | 11.9 | 5.1 | 4.009 miles west of FM 267 |
| 7 | 12.8 | 12.6 | 30.7 | 5.004 miles west of FM 267 |

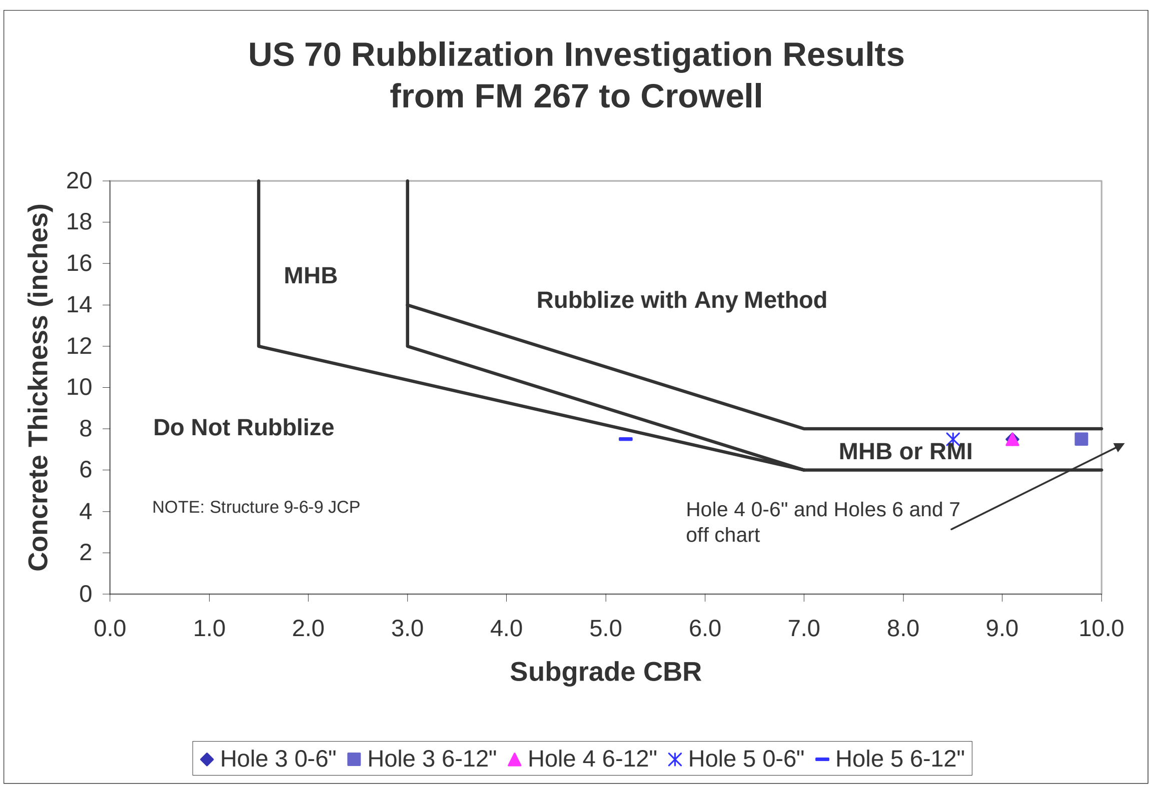


**Figure 3.4. DCP Results for US 70 from FM 267 to Crowell.**

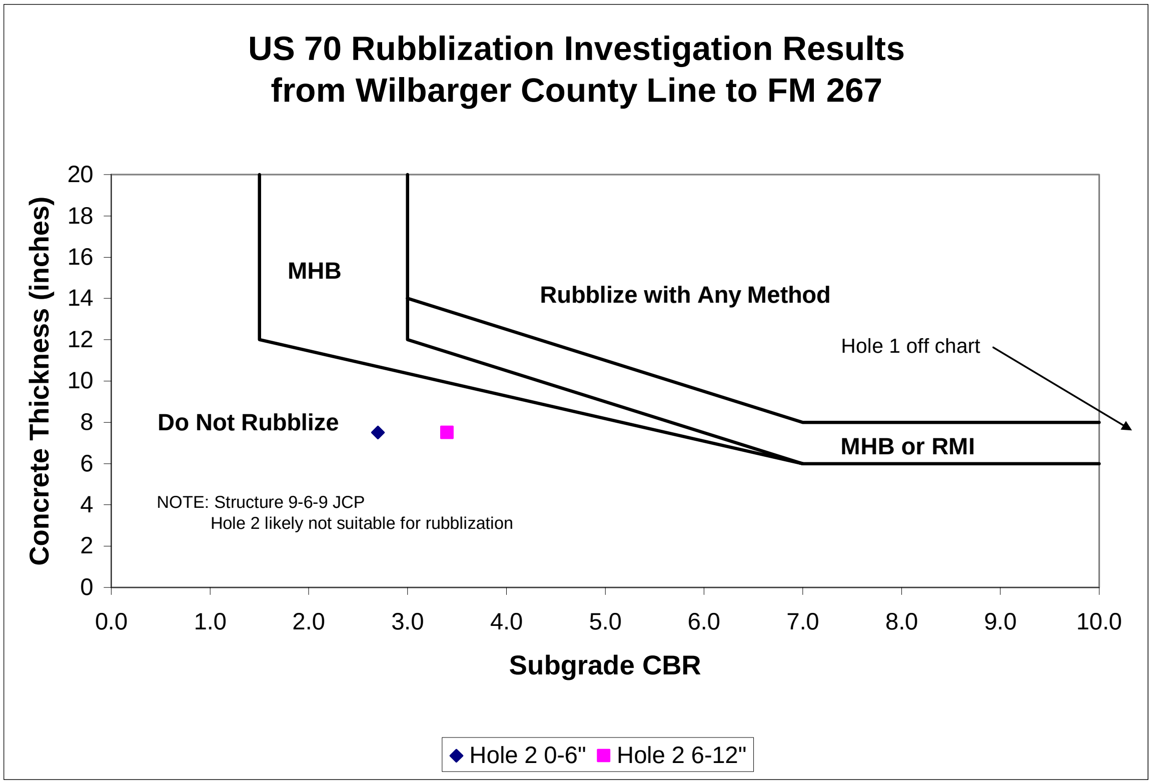


**Figure 3.5. DCP Results for US 70 from Wilbarger County Line to FM 267.**

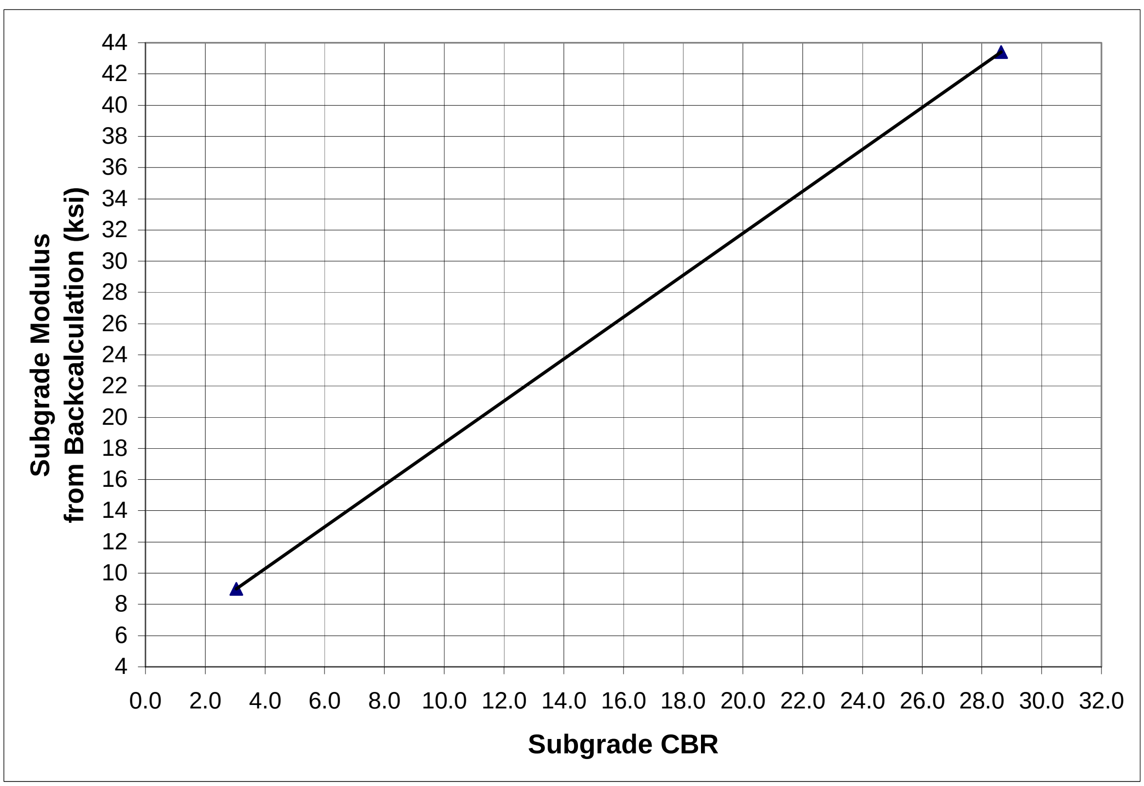


**Figure 3.6. Subgrade Modulus of Top 12 Inches versus CBR of Top 12 Inches from Wilbarger County Line to FM 267.**

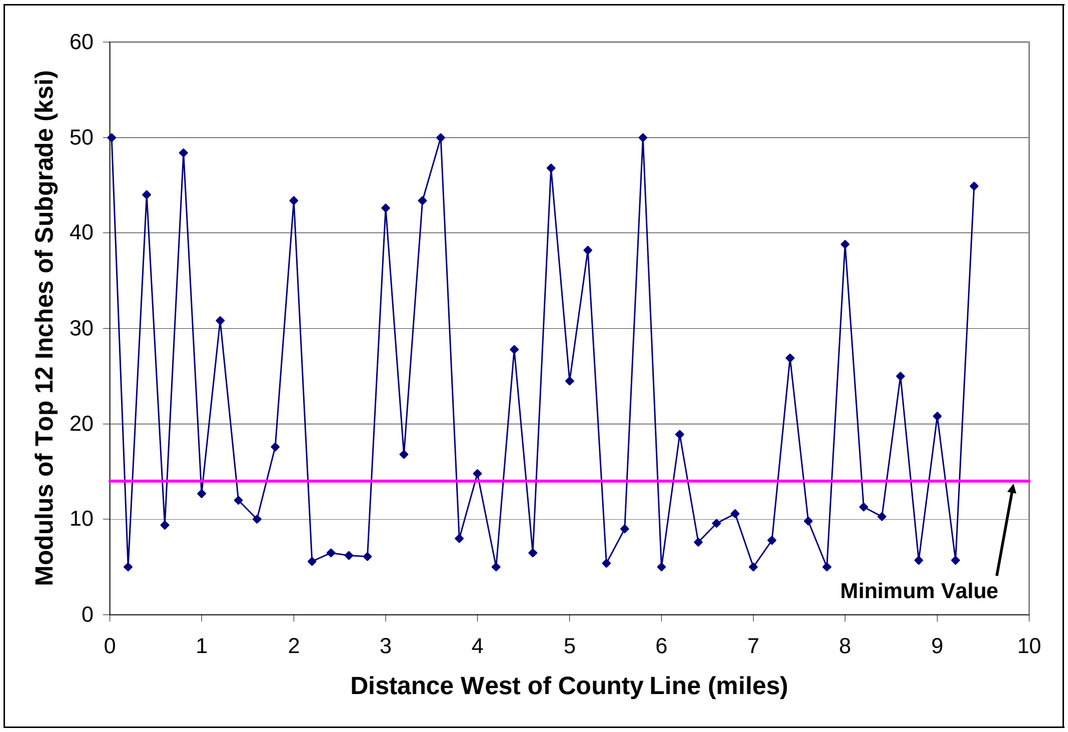


**Figure 3.7. Subgrade Modulus of Top 12 Inches from Wilbarger County Line to FM 267.**

## RECOMMENDATION

Based upon the results presented and discussed above, the rubblization recommendations on US 70 in Foard County are:

- From FM 267 to Crowell, data collected indicate the section is suitable for rubblization. However, the collected data were spot specific, so there is a chance some areas may exist between test locations where problems may be encountered. From experience, 10 to 20 percent of the project is normally estimated to require removal and replacement.
- Numerous sections of US 70 from the Wilbarger C/L to FM 267 are not suitable for rubblization. Utilizing rubblization would require numerous short sections of work. In particular, from 2.2 through 2.8 miles west of the Wilbarger C/L, from 3.8 through 4.6 miles west of the Wilbarger C/L, and from 5.4 miles west of the Wilbarger C/L to FM 267 are at high risk of not being suitable for rubblization.
- Due to the high subgrade variability on US 70 from the Wilbarger C/L to FM 267, options other than rubblization should be pursued.

# CHAPTER 4
# INVESTIGATION OF US 83 FOR RUBBLIZATION

## SUMMARY

The Childress District is currently in the process of rehabilitating its jointed concrete pavements and is considering rubblization as an option for approximately 6.57 miles of US 83 in Cottle County from the King/Cottle County lines to just south of County Road 240. Based upon collected DCP data, FWD data, and recommendations on rubblization from other states, numerous portions of the project are of questionable suitability for rubblization. Existing guidelines indicate the multi-head breaker would be the safest approach to rubblizing this project.

In light of these findings, TTI's investigation in conjunction with existing recommendations indicates a fair level of risk exists if the Childress District initiates rubblization on the US 83 project. Using a relationship between the subgrade CBR and backcalculated moduli values of the top 12 inches of subgrade, approximately 57 percent of the project may have subgrade too weak to support rubblization. However, the district may have prior experience on other similar projects that should also weigh into its decision on rehabilitation method. If the District does successfully rubblize this project, information gained from the US 83 project would be valuable input to modify existing rubblization guidelines to be more appropriate for Texas projects.

## RESULTS FROM FIELD INVESTIGATION

To evaluate if the US 83 project is suitable for rubblization, TTI performed a field analysis using GPR, FWD, and DCP testing. Figure 4.1 illustrates representative GPR data from the project. An analysis of the GPR data indicated an average ACP thickness of 3.5 inches and a typical JCP thickness of 8.6 inches. In portions of the project, the GPR data also showed what appears to be a fill layer of varying thickness beneath the slabs, ranging in thickness from 2 to 6 inches.

Since a wet subgrade hinders the rubblization process, TTI reviewed the GPR data for signs of excessively wet subgrade, indicated by high subgrade dielectric values. The GPR data did not indicate any locations of excessively wet subgrade soil. Typical subgrade dielectric values ranged from 4.4 to 5.6.

In the GPR data, two clear section breaks are evident. These sections of different structure are from 3.18 to 3.44 miles and from 4.22 to 4.82 miles north of the King/Cottle County line. Figure 4.2 shows an example of one of the section breaks.

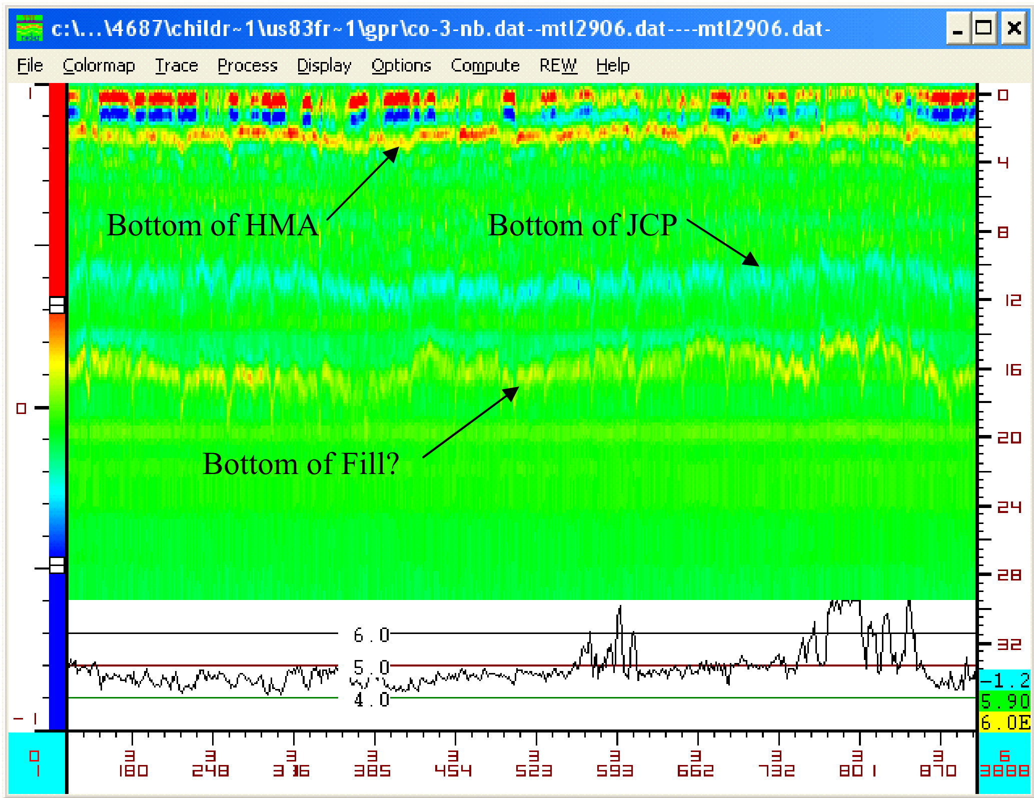


**Figure 4.1. Representative GPR Data on US 83 in Cottle County.**

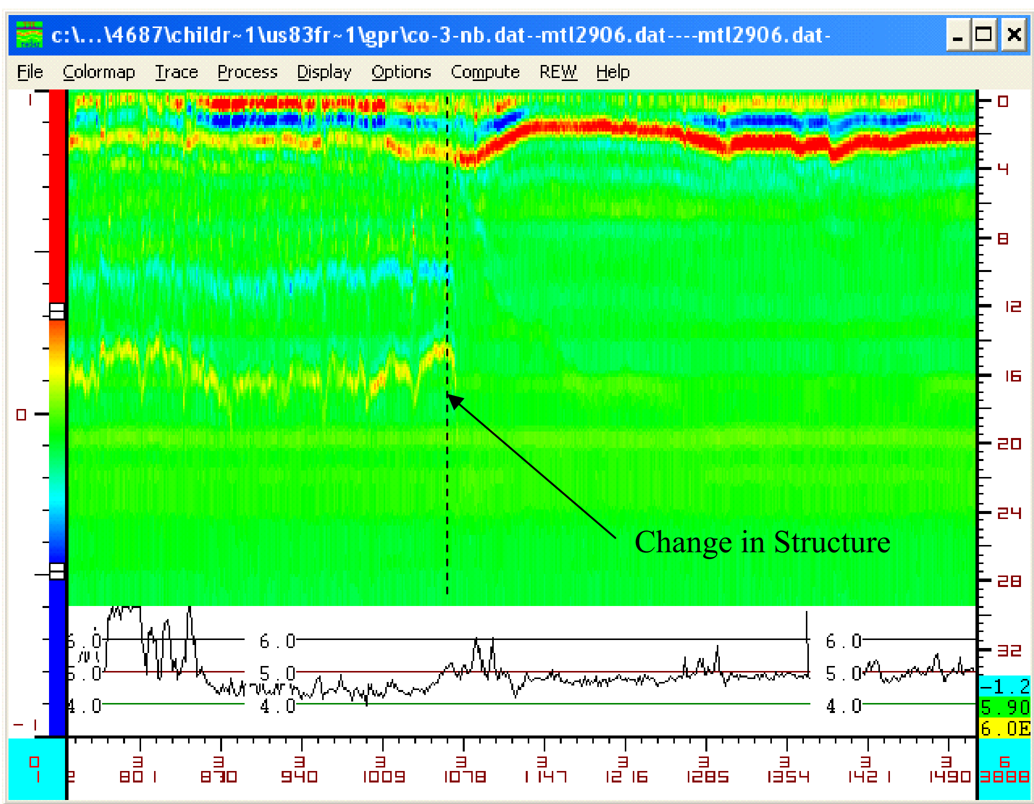


**Figure 4.2. Representative Section Break in GPR Data on US 83 Northbound.**

## Results from FWD and DCP Testing

Table 4.1 shows the FWD backcalculation results for US 83 from the King/Cottle County line to just south of County Road 240. Layer thicknesses of 3.5 inches were used for the ACP and 8.0 inches for the JCP. Additionally, since other states' experience indicates the top 12 inches of subgrade is most crucial for rubblizing success, a 12-inch dummy subbase layer was used, and a fixed depth to bedrock value of 240 inches was input into Modulus. After studying FWD results in the field, TTI selected several locations to perform DCP tests at the project site. Table 4.2 summarizes the DCP results for use in the IDOT rubblization selection chart. This chart uses the CBR of the top 12 inches of subgrade (divided into 6-inch layers) along with combined concrete and base thickness as an indicator of the project's suitability for rubblization. Combined, the FWD and DCP data complete the information necessary to analyze the suitability of the project for rubblization and show the following:

- The FWD data confirm the existence of different structures seen in the GPR data. Based on GPR, these sections are from 3.18 to 3.44 and 4.22 to 4.82 miles north of the King/Cottle County lines. In these sections, the FWD backcalculations have high errors per sensor, and the backcalculated base moduli are in the range of a flexible base as illustrated in Figure 4.3. In the GPR data, only the bottom of the surfacing could be seen in these sections, so other records or coring may be necessary to identify the structure of these sections.
- The DCP data when plotted on the IDOT rubblization selection chart indicate the project is of marginal suitability for rubblization. The data are plotted on the IDOT chart in Figure 4.4. These data show that the locations represented by Holes 1 and 3 are in the "gray area" of suitability. At Hole 1, the top 6 inches of subgrade are outside the rubblization zone, but the next 6 inches are in the suitability zone. Hole 3 shows the top 6 inches of subgrade are very good, but the next 6 inches of subgrade are poor. Problems rubblizing may occur at these locations and locations with similar soil properties.
- From the IDOT chart, assuming a concrete + base thickness of 8 inches for this project means the subgrade CBR value should be 6 or higher to have confidence in the feasibility of rubblizing the project with either the MHB or RMI. Figure 4.5 shows the relationship between the subgrade CBR and backcalculated subgrade modulus for the top 12 inches of soil for this project. From this relationship, the subgrade modulus should be 10 or higher to confidently pursue rubblization of the entire project with either rubblization method. A review of the FWD data reveals 57 percent of the observations for the first 12 inches of subgrade are below 10 ksi.

## Table 4.1. FWD Results for US 83.

TTI MODULUS ANALYSIS SYSTEM (SUMMARY REPORT) (Version 6.0)

District:25 (Childress)
County:
Highway/Road: us0083

MODULI RANGE (psi)

| | Thickness(in) | Minimum | Maximum | Poisson Ratio Values |
|---|---|---|---|---|
| Pavement: | 3.50 | 50,000 | 1,300,000 | H1: v = 0.3 |
| Base: | 8.00 | 50,000 | 5,000,000 | H2: v=0.2 |
| Subbase: | 12.00 | 5000 | 50000 | H3: v=0.40 |
| Subgrade: | 240.00 (User Input) | 15,000 | | H4: v=0.4 |

| Station | Load (lbs) | R1 | R2 | R3 | R4 | R5 | R6 | R7 | SURF(E1) | BASE(E2) | SUBB(E3) | SUBG(E4) | Absolute ERR/Sens | Dpth to Bedrock | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Measured Deflection (mils) | | | | | | | Calculated Moduli Values (ksi) | | | | | | |
| 0.016 | 10,387 | 8.18 | 6.35 | 5.54 | 4.62 | 3.68 | 3.03 | 2.38 | 219.5 | 3727.3 | 49.8 | 11.7 | 0.83 | 300 | |
| 0.201 | 10,308 | 6.33 | 5.64 | 4.93 | 3.94 | 3.04 | 2.44 | 1.97 | 1285.3 | 2662.9 | 5.6 | 17.4 | 1.25 | 300 | |
| 0.404 | 9,327 | 11.98 | 8.42 | 6.74 | 5.18 | 3.71 | 2.7 | 1.89 | 103.4 | 1463.2 | 8.1 | 13 | 0.81 | 210.7 | |
| 0.611 | 9,624 | 8.4 | 7.45 | 6.11 | 4.65 | 3.24 | 2.27 | 1.55 | 757.3 | 1044.5 | 5 | 16.4 | 4.01 | 193.2 | * |
| 0.803 | 9,803 | 6.84 | 6.31 | 5.47 | 4.54 | 3.59 | 2.94 | 2.39 | 1103 | 2903.9 | 7.6 | 12.4 | 1.46 | 300 | |
| 1.004 | 9,756 | 9.66 | 7.58 | 6.17 | 4.87 | 3.67 | 2.76 | 2.06 | 234 | 1736 | 13.2 | 12.9 | 0.32 | 297.9 | |
| 1.009 | 9,259 | 12.1 | 7.84 | 6.37 | 4.96 | 3.7 | 2.7 | 1.99 | 74.2 | 1837.3 | 11.6 | 12.5 | 0.44 | 273.3 | |
| 1.204 | 9,696 | 8.35 | 6.09 | 5 | 3.94 | 2.97 | 2.27 | 1.72 | 174.9 | 2038.2 | 34.5 | 14.9 | 0.53 | 300 | |
| 1.398 | 9,656 | 5.7 | 5.48 | 4.83 | 3.94 | 3.04 | 2.44 | 1.83 | 1300 | 3403 | 5.1 | 15.5 | 3.31 | 300 | * |
| 1.604 | 9,545 | 8.78 | 6.67 | 5.48 | 4.33 | 3.24 | 2.35 | 1.65 | 199.1 | 2271.4 | 7.4 | 15.8 | 0.89 | 214 | |
| 1.804 | 9,446 | 8.36 | 6.59 | 5.57 | 4.47 | 3.42 | 2.63 | 2.02 | 258.2 | 2189.3 | 23.4 | 12.6 | 0.81 | 300 | |
| 2.011 | 10,582 | 7.87 | 6.37 | 5.45 | 4.38 | 3.33 | 2.52 | 1.86 | 358.2 | 3177.1 | 5.4 | 17.6 | 1 | 277.3 | |
| 2.204 | 9,466 | 8.35 | 6.39 | 5.42 | 4.43 | 3.39 | 2.61 | 1.97 | 200.8 | 2717.9 | 21.3 | 12.8 | 0.81 | 300 | |
| 2.405 | 10,761 | 7.22 | 5.39 | 4.54 | 3.7 | 2.88 | 2.28 | 1.8 | 202.7 | 4943.5 | 7 | 19.7 | 0.39 | 300 | |
| 2.611 | 10,240 | 6.73 | 4.87 | 4.21 | 3.51 | 2.41 | 1.96 | 1.56 | 208.5 | 4432.6 | 6.8 | 22.5 | 2.53 | 300 | * |
| 2.8 | 10,526 | 5.96 | 4.89 | 4.11 | 3.36 | 2.64 | 2.03 | 1.6 | 501.2 | 3622.6 | 31 | 18.3 | 0.37 | 300 | |
| 3.006 | 10,431 | 6.68 | 5.88 | 5.04 | 4.09 | 3.17 | 2.49 | 1.94 | 1068.5 | 2707 | 5.2 | 17.4 | 0.74 | 300 | |
| 3.205 | 10,745 | 19.21 | 11.65 | 5.61 | 3.05 | 1.95 | 1.57 | 1.23 | 350.1 | 70.5 | 10.1 | 23.5 | 6.06 | 117.3 | * |
| 3.398 | 10,725 | 23.55 | 9.6 | 3.1 | 1.81 | 1.28 | 1.03 | 0.89 | 100.6 | 100.6 | 10.5 | 33.5 | 18.97 | 53 | * |
| 3.598 | 10,610 | 7.45 | 6.41 | 5.4 | 4.35 | 3.4 | 2.58 | 1.95 | 1272 | 1605 | 10 | 15.3 | 0.74 | 300 | |
| 3.798 | 10,200 | 7.25 | 6.4 | 5.76 | 4.36 | 3.3 | 2.52 | 1.92 | 1044.7 | 1928.5 | 5 | 16.4 | 2.63 | 300 | * |
| 3.998 | 9,696 | 10.44 | 9.95 | 6.3 | 4.93 | 3.83 | 2.96 | 2.3 | 1207.8 | 352.6 | 12.6 | 12.1 | 5.27 | 300 | * |
| 4.199 | 10,606 | 6.57 | 5.45 | 4.87 | 4.07 | 3.18 | 2.59 | 1.84 | 532.5 | 5000 | 5.2 | 17.1 | 1.38 | 226.1 | * |
| 4.404 | 10,034 | 26.87 | 13.66 | 5.92 | 3.7 | 2.49 | 1.93 | 1.51 | 79.3 | 54.4 | 11.3 | 18.1 | 5.91 | 140 | * |
| 4.604 | 10,133 | 26.59 | 11.6 | 4.8 | 3.04 | 2.23 | 1.79 | 1.44 | 64.3 | 50 | 24.1 | 16.7 | 18.24 | 103.9 | * |
| 4.802 | 9,593 | 31.85 | 15.05 | 4.33 | 2.38 | 1.78 | 1.59 | 1.33 | 50 | 50 | 11.8 | 16.7 | 33.64 | 47.9 | * |
| 4.999 | 11,070 | 6.75 | 5.24 | 4.55 | 3.63 | 2.54 | 2 | 1.65 | 379.8 | 3339.9 | 12.1 | 21.5 | 2.49 | 300 | |
| 5.204 | 10,018 | 6.85 | 5.82 | 5 | 4.09 | 3.2 | 2.54 | 1.94 | 637.1 | 2736.6 | 22.2 | 13.9 | 0.64 | 300 | |
| 5.405 | 9,994 | 6.91 | 6.18 | 5.27 | 4.26 | 3.29 | 2.59 | 2.02 | 1127.7 | 2195.1 | 6.2 | 15.3 | 1.18 | 300 | |
| 5.417 | 9,398 | 13.34 | 5.41 | 4.57 | 3.7 | 2.85 | 2.22 | 1.72 | 50 | 1200 | 50 | 16 | 7.33 | 300 | * |
| 5.606 | 9,672 | 8.33 | 6.23 | 5.03 | 3.9 | 2.94 | 2.29 | 1.77 | 234.1 | 1350 | 48.2 | 14.7 | 0.45 | 300 | |
| 5.806 | 10,483 | 11.26 | 6.67 | 5.3 | 4.07 | 3 | 2.28 | 1.73 | 70.4 | 2740.8 | 6.3 | 19.9 | 0.74 | 300 | |
| 6 | 9,549 | 9.84 | 7.57 | 6.24 | 4.89 | 3.58 | 2.73 | 2.11 | 203.6 | 1727.1 | 11.1 | 13 | 0.84 | 300 | |
| 6.2 | 9,700 | 7.35 | 6.38 | 5.37 | 4.32 | 3.24 | 2.59 | 1.99 | 1278.2 | 1446.7 | 6.7 | 14.9 | 1.16 | 300 | |
| 6.398 | 11,027 | 5.8 | 5.27 | 4.85 | 4.06 | 3.05 | 2.16 | 1.77 | 1300 | 3599.9 | 5.7 | 19.1 | 4.96 | 250.9 | * |
| 6.569 | 9,426 | 11.44 | 8.56 | 7.13 | 5.38 | 3.87 | 2.86 | 2.09 | 153.8 | 1519.1 | 5 | 13.3 | 1.21 | 259.6 | * |
| Mean: | | 10.7 | 7.26 | 5.29 | 4.08 | 3.06 | 2.37 | 1.82 | 510.7 | 2165.1 | 14.5 | 16.5 | 3.73 | 249.8 | |
| Std. | Dev: | 6.55 | 2.42 | 0.8 | 0.74 | 0.59 | 0.43 | 0.31 | 463.4 | 1352.3 | 13 | 4.2 | 6.69 | 200.3 | |
| Var | Coeff(%): | 61.25 | 33.4 | 15.05 | 18.02 | 19.22 | 18.01 | 16.91 | 90.7 | 62.5 | 89.7 | 25.3 | 179.23 | 80.2 | |

## Table 4.2. Summary DCP Results from US 83.

| Hole | Base+Concrete Thickness (inches, from GPR and DCP) | Subgrade CBR | | Subgrade Modulus from FWD (ksi, 12" dummy layer and 240" depth to bedrock) | Location |
|---|---|---|---|---|---|
| | | 0-6" | 6-12" | | |
| 1 | 9.4 | 3.1 | 5.0 | 7.6 | 0.803 mi N of County Line |
| 2 | 10.4 | 9.8 | 33.2 | 31.0 | 2.8 mi N of County Line |
| 3 | 6.9 | 10.4 | 3.9 | 11.1 | 6.00 mi N of County Line |

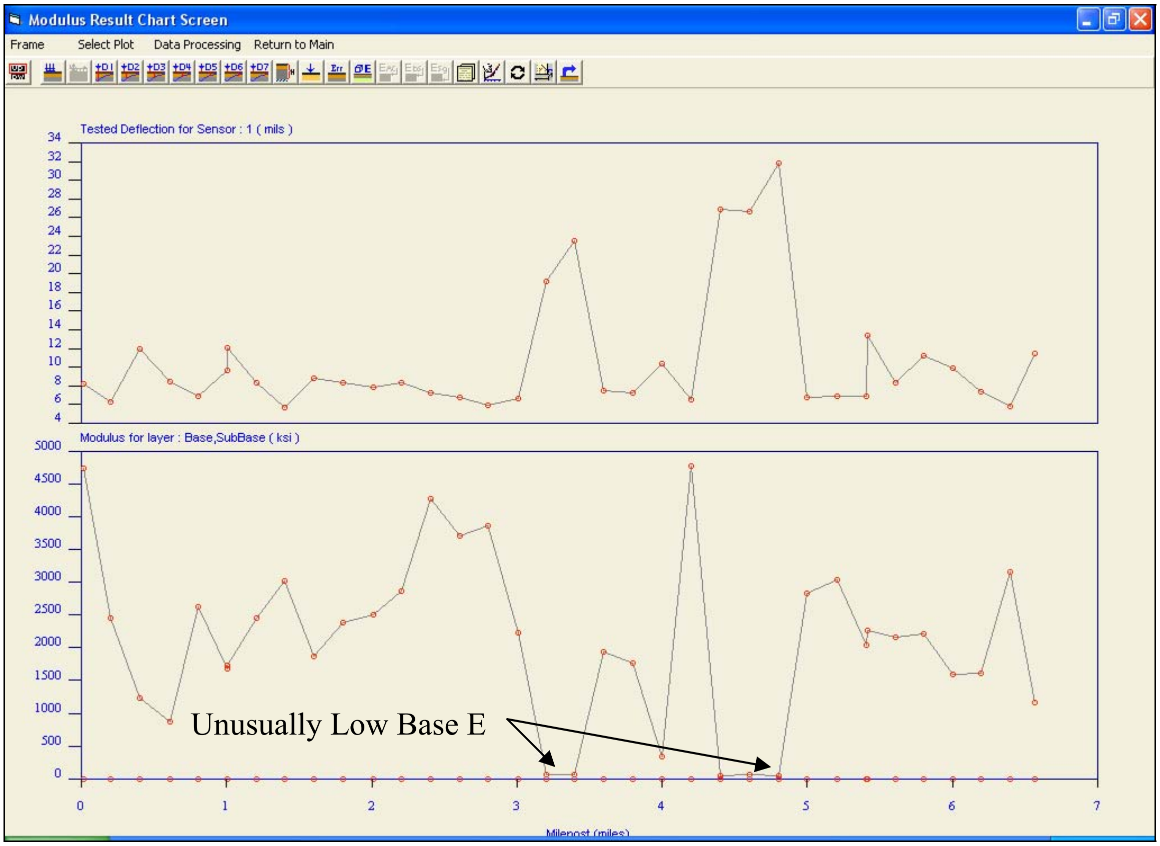

Figure 4.3. Base Modulus with Distance for US 83 Northbound.

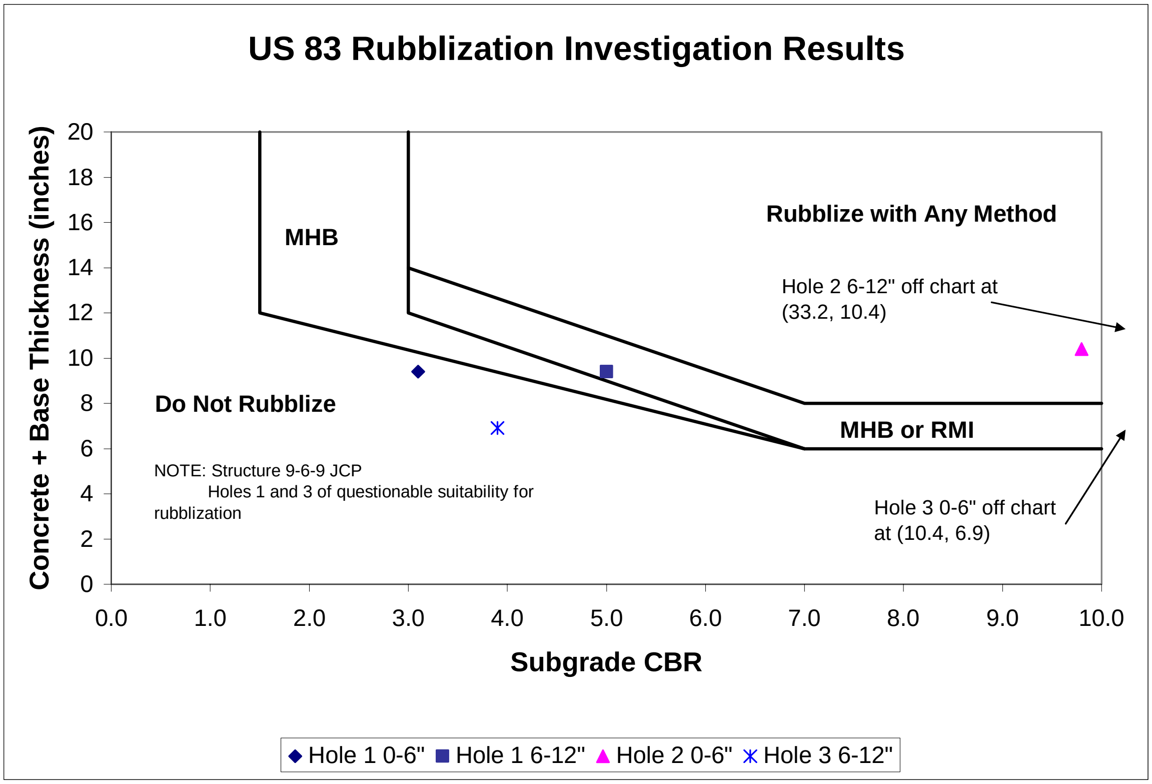


**Figure 4.4. DCP Results from US 83 on IDOT Rubblization Selection Chart.**

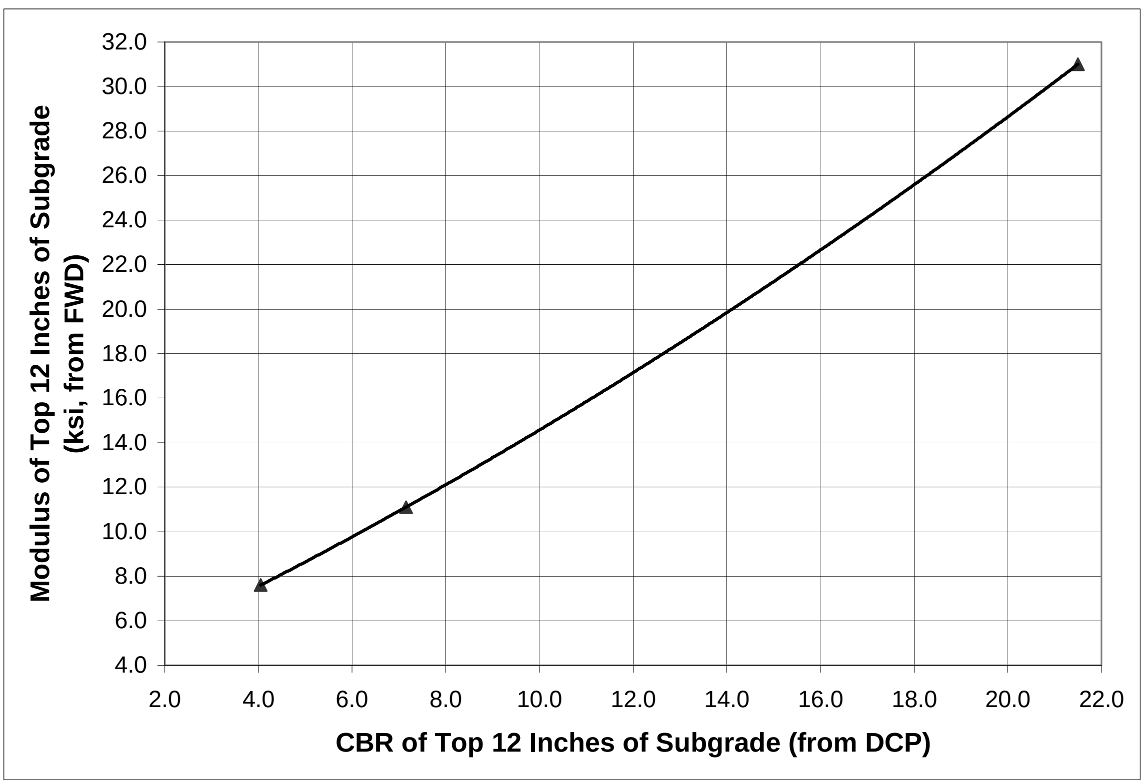


**Figure 4.5. Relationship between Subgrade Modulus and CBR on US 83.**

## RECOMMENDATION

Based upon the results presented and discussed above, the rubblization recommendations on US 83 in Cottle County are:

- Different structures exist from 3.18 to 3.44 and 4.22 to 4.82 miles north of the King/Cottle County lines. Records should be checked or coring performed at these locations to identify the structure. Field data suggest the concrete slabs have been removed.
- Based on existing rubblization guidelines and collected DCP and FWD, the majority of the project is of questionable suitability for rubblization. Prior work indicates the top 12 inches of subgrade are the most crucial. At this project, the condition of the top 12 inches of subgrade are highly variable. More than 50 percent of the project is of questionable suitability for rubblization.
- Based on existing guidelines, if rubblization is attempted the multi-head breaker would be the safest means to accomplish rubblization given the pavement thickness and subgrade conditions.

# CHAPTER 5
# RECOMMENDED SPECIFICATIONS FOR RUBBLIZATION

## SUMMARY

In the course of this project, work is in progress to assist TxDOT districts in the evaluation and construction monitoring of rubblization candidates. Therefore, construction specifications are needed for TxDOT to use. The current TxDOT special specification essentially was provided by one of the rubblization companies. This chapter first presents TxDOT's existing specification, then presents a proposed new construction specification for TxDOT's consideration. The research team drafted this specification based upon a review of rubblization literature from other agencies and their specifications. Numerous other states have specifications regarding rubblization, including: Iowa, Arkansas, Lousiana, Wisconsin, Indiana, Ohio, Oklahoma, Michingan, Pennsylvania, and Alabama. The research team proposes TxDOT adapt a new specification for rubblization that is not exclusive to a certain manufacturers' equipment.

## TXDOT EXISTING RUBBLIZATION SPECIFICATION

Figure 5.1 shows TxDOT's existing rubblization special specification.

2004 Specifications

**SPECIAL SPECIFICATION**

**2002**

**Rubblizing Existing Concrete Pavement**

1. **Description.** Rubblize and compact existing concrete pavement.

2. **Equipment.** Provide:

   - A self-contained, self-propelled, resonant frequency breaker capable of producing low amplitude 2000-lb. force blows at a rate of not less than 44 cycles per second.

   - A self-propelled steel wheel vibratory roller with a minimum static weight of 10 tons and at least 1 drum equipped to vibrate.

   - A medium pneumatic tire roller capable of providing a total uniform load of 12 to 25 tons and with tires capable of maintaining minimum ground contact pressure of 80 psi as directed.

3. **Construction.** Break material into pieces not larger than 6 in. Saw cut full depth at all joints where rubblizing abuts concrete pavement which is to remain in place. Operate resonant breaker at maximum amplitude of 1 in.

   At the beginning of rubblizing operations, excavate a 4 ft. by 4 ft. test pit in the middle of a lane as directed, to determine if material is being broken into the specified size. Additional test pits may be required as directed. Backfill and compact test pits with new flexible base as required in accordance with Item 247, "Flexible Base." Rubblized material can not be used as backfill.

   Begin at a free edge or previously broken edge and work toward the opposite shoulder or longitudinal centerline of the road. Where roadway must be overlaid one lane at a time, extend a minimum of 6 in. beyond the width of pavement to be overlaid. Reinforcement shall be debonded from the concrete and left in place. Cut and remove any exposed reinforcement.

   Unless otherwise shown on the plans, make a minimum of:

   One pass with vibratory steel wheel roller.

   One pass with medium pneumatic tire roller.

   Two passes with vibratory steel-wheel roller.

   A pass is defined as forward and backward in the same path. Rollers shall operate at a speed of 3 MPH.

1-2

2002
09-04

**Figure 5.1. TxDOT Existing Rubblization Special Specification.**

Place initial pavement course within 48 hours of rubblizing. In the event of rain, time limitation may be waived as directed, to allow pavement to dry. Remove material dislodged by construction traffic. Place initial pavement course prior to opening rubblized pavement to traffic.

Complete widening and shoulder work to elevation of existing pavement prior to rubblizing.

4. **Measurement.** This Item will be measured by the square yard of existing concrete pavement in its original position. Limits of measurement will be as shown on the plans.

5. **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement", will be paid for at the unit price bid for "Rubblizing Existing Concrete Pavement." This price is full compensation for rubblizing and compacting existing concrete pavement; and equipment, labor, tools and incidentals.

**Figure 5.1. TxDOT Existing Rubblization Special Specification (Continued).**

## PROPOSED NEW SPECIAL SPECIFICATION

The following three pages show the research team's proposed new special specification for TxDOT's consideration.

## PROPOSED SPECIAL SPECIFICATION

### Rubblizing Existing Concrete Pavement

1. **Description.** Rubblize and compact existing concrete pavement.

2. **Materials**

   A. **Aggregate.** Furnish aggregate of the type and grade shown on the plans and conforming to the requirements of Item 247, "FLEXIBLE BASE."
   B. **Hot-Mix Asphalt.** Furnish dense-graded hot-mix asphalt of the type shown on the plans and conforming to the requirements of Item 340, "DENSE-GRADED HOT-MIX ASPHALT (METHOD)."

3. **Equipment.** Provide either a Type I or Type II rubblizer, unless otherwise shown on the plans, and necessary rollers for compacting the rubblized pavement.

   A. **Type I Rubblizer.** A self-contained, self-propelled, resonant frequency breaker, capable of producing low-amplitude, 2000 lb blows, at a rate not less than 44 Hz.
   B. **Type II Rubblizer.** A self-contained, self-propelled, multiple-head breaker, with each hammer independently adjustable, and capable of rubblizing a width of up to 13 ft. in one pass.
   C. **Roller-Vibratory.** Drum (Type C), with a static weight ≥ 10 tons, meeting the requirements of Item 210.
   D. **Roller-Medium Pneumatic.** Conforming to the requirements of Item 210, "ROLLING."
   E. **Roller-Z Grid Vibratory.** When rubblizing with Type II equipment, provide a steel wheel, self-propelled vibratory roller, with a minimum weight of 10 tons, and a Z-pattern cladding bolted transversely to the surface of the drum.

4. **Construction.**

   A. **Preparatory Work.** Prior to initiating rubblization, the following work must be complete:
      - If required, construct pavement drainage systems at least two weeks prior to rubblization.
      - Any existing material overlaying the concrete pavement must be removed.
      - Adjustments or additions to the pavement adjacent to the existing concrete must be complete to the elevation of the concrete pavement to be rubblized.
      - Before rubblizing a section, cut full-depth saw cut joints at any locations shown on plans to protect facilities that will remain in place.

   B. **Rubblization and Compaction.** Operate equipment in a manner that will not damage the base, underground utilities, drainage structures, and other facilities on the project; in the event that damage to such features occurs, the Contractor shall be fully responsible for their repair.

Use a Type I or Type II rubblizer to completely debond any reinforcing steel and rubblize the existing concrete pavement. Other types of rubblizing equipment will only be used if shown on the plans or approved in writing. Above the reinforcing steel or upper one-half of the pavement (if unreinforced), the equipment shall produce at least 75 percent of broken pieces less than 3 inches in size. At the surface of the rubblized layer, all pieces shall be less than 6 inches. Below the reinforcing steel or in the lower half of the pavement, the maximum particle size shall be 9 inches. Any large concrete pieces that do not meet the size requirements previously specified shall be treated as follows:

i. If the affected area is less than 10 $ft^2$ the area may be patched with aggregate.
ii. Areas greater than 10 $ft^2$ that do not meet the specified particle size shall be repaired with hot-mix asphalt, unless otherwise approved by the Engineer.

Reinforcing steel exposed and projecting from the surface after rubblization or compaction shall be cut off below the surface and removed.

1. **Type I Rubblization.** Begin at a free edge or previously broken edge and work transversely toward the other edge. In the event the rubblizer causes excessive deformation of the pavement, the Engineer may require high flotation tires with tire pressures less than 60 psi. Any displaced areas shall be considered non-conforming and treated as described above.

   Compact by seating rubblized pavement with the following rolling pattern:
   i. one pass from a vibratory roller,
   ii. followed by at least one pass with the pneumatic roller,
   iii. followed by at least two more passes with the vibratory roller.

   The rolling pattern may be changed as directed.

2. **Type II Rubblization.** Unless otherwise directed, rubblize the entire lane width in one pass. Provide a screen to protect vehicles from flying particles as directed. Compact by seating the pavement with the following rolling pattern:
   i. a minimum of four passes with the Z-grid vibratory roller,
   ii. followed by four passes with a vibratory roller,
   iii. then at least two passes from a pneumatic roller.

   The rolling pattern may be changed as directed.

C. **Verification of Rubblization Process.** Before full production begins, the Engineer will select approximately 200 linear ft. of one lane width to verify the rubblization operation. The contractor shall rubblize the test section, using the section to adjust equipment. From within this test section, the Engineer and Contractor shall agree upon a test pit location. At the test pit, excavate a 4 ft. square test pit. The Engineer shall test the material to verify that the specified particle size distribution has been achieved through the entire depth of pavement. Additional test pits may be required during the project to confirm ongoing compliance with the particle size specification. Test pit areas shall be patched as directed either with aggregate or hot-mix asphalt.

If the rubblized material from the test pit does not meet specifications, another test strip shall be conducted and tested. Should this pit also fail, rubblization operations shall be suspended until the Contractor demonstrates to the satisfaction of the Engineer that specifications can be met, at which time the Engineer shall allow the Contractor to conduct another test strip.

**D.** **Trafficking.** Public traffic shall not be allowed on the rubblized pavement, except at Engineer-approved access points, and the Contractor shall avoid unnecessary trafficking of the rubblized pavement with construction equipment.

**E.** **Placement of Surfacing.** The Contractor shall coordinate construction activities so that the first overlay course is placed within 48 hours after completion of rubblization. If rain occurs after rubblization but before paving, paving shall not take place until the rubblized layer is dry and stable to the satisfaction of the Engineer.

**5.** **Measurement.** Rubblization shall be measured by the square yard of original concrete pavement. The limits of measurement will be as shown on plans.

**6.** **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit bid price for “Rubblizing Existing Concrete Pavement.” This price is full compensation for rubblizing and compacting existing concrete pavement, saw-cutting required locations, cutting and removing exposed reinforcing steel, repairing unstable or non-conforming locations, conducting required test pits, and equipment, labor, tools, and incidentals.

# CHAPTER 6
# RECOMMENDATIONS FOR FUTURE WORK

## SUMMARY

Based upon the literature review and work completed thus far, rubblization (when feasible) appears a better alternative for concrete pavement rehabilitation as opposed to crack and seat. Some issues that need better clarification for rubblization are: 1) verifying the decision criteria for when rubblization is feasible, 2) evaluating the performance of the two competing rubblizers, 3) resolving issues with pavement structural design, and 4) incorporation of better-performing surface overlays.

## RUBBLIZATION SELECTION CRITERIA

The research team has produced tentative selection criteria for evaluating whether rubblization is feasible. During the remainder of this project, work should focus on verifying these criteria. For example, TxDOT would like to avoid having to use the DCP; however, at this time results are mixed regarding whether or not the FWD can adequately serve to evaluate the project. Even with the FWD, further work is needed regarding the best way to process the data, and whether backcalculated values, or simply the outer sensor deflections, better correlate to the condition of the subgrade soil.

## EVALUATING THE MHB AND RMI

TxDOT should attempt to construct projects with both the MHB and RMI equipment to evaluate if either machine produces a better product in Texas conditions. Nationally, reports are mixed regarding which machine is better. TxDOT should consider some side-by-side evaluations of both machines on a few projects.

## STRUCTURAL DESIGN OF RUBBLIZED PAVEMENTS

While data indicate the modulus of rubblized pavement layers is substantially less variable than the crack and seat method, more work still needs completion in determining a reasonable value to use for design. As TxDOT constructs rubblization projects, the research team will monitor these projects and develop guidelines on values for the designer’s use. Ideally, the initial slab stiffness can be related to the modulus of the rubblized layer.

## OVERLAYS FOR RUBBLIZED PAVEMENTS

In several instances failures of rehabilitated concrete pavements have been attributed to poor overlay mixes and poor overlay construction (such as segregation). New mixes and new tests have recently been developed that may be able to contribute to better performance of the overlays placed on rubblized pavements. For example, in design the overlay tester combined with the Hamburg test can be used to develop a mix that is both rut and crack resistant, and in construction thermal imaging can help evaluate in real time whether segregation is a problem on the project.  TxDOT should consider incorporating such techniques into their rehabilitation strategy to increase the performance of the overlays on rubblized pavements.

# REFERENCES


1. Resonant Machines, Inc. (online). http://www.resonantmachines.com. Accessed October 14, 2005.
2. Antigo Construction, Inc. (online). http://www.antigoconstruction.com/. Accessed October 14, 2005.
3. Witczak, M. W., and G. R. Rada. Nationwide Evaluation Study of Asphalt Concrete Overlays Placed on Fractured PCC Pavements. In *Transportation Research Record, Journal of the Transportation Research Board,* No. 1374, TRB, National Research Council, Washington, D.C., 1992, pp. 19-26.
4. SPS 6 Project 4006 Rehabilitation of JCP IH 35, Southbound Kay County, OK, FHWA/LTPP Report, June, 1993, Brent Rauhut Engineering.
5. Heckel, L. B. Rubblizing with Bituminous Concrete Overlay – 10 Years' Experience in Illinois, Report IL-PRR-137, Illinois Department of Transportation, April 2002.
6. Special Provision for Rubblizing PCC Pavement, State of Illinois Department of Transportation.
7. Rubblizing PCC Pavement and Placing a Bituminous Concrete Overlay, Construction Memorandum No. 01-40, Illinois Department of Transportation, June 1, 2001.
8. Timm, D. D., and A. M. Warren. Performance of Rubblized Pavement Sections in Alabama. Highway Research Center, Report IR-04-02, Auburn University, Auburn, AL, May 2004.
9. Morian, D. A., L. Coleman, D. J. Frith, S. M. Stoffels, and D. Dawood. How Did It Work? Pennsylvania SPS-6 Performance at Ten Years-Strategy Evaluation of Concrete Pavement Rehabilitation. In *Transportation Research Record, Journal of the Transportation Research Board,* No. 1823, TRB, National Research Council, Washington, D.C., 2003, pp. 28-38.
10. Harmelink, D. S., W. Hutter, and J. Vickers. Interstate Asphalt Demonstration Project NH 0762-038 (Rubblization), Report CDOT-DTD-R-2000-4, Colorado Department of Transportation, Denver, CO, May 2000.
11. Baladi, G., and T. Svasdisant. Causes of Underperformance of Rubblized Pavements, Research Report RC-1416, Michigan State University, Lansing, MI, August 2002.
12. Engineering Brief No. 66 Rubblized Portland Cement Concrete Base Course, United States Department of Transportation, Federal Aviation Administration, February 13, 2004.