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# ROCK NAIL DESIGN GUIDELINES FOR ROADWAY CUTS IN CENTRAL TEXAS

Robert B. Gilbert, Priscilla P. Nelson, Colin J. Young, Barry E. Moses, and Yousof Abd Al-Jalil

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# ROCK NAIL DESIGN GUIDELINES FOR ROADWAY CUTS IN CENTRAL TEXAS

by

Robert B. Gilbert Priscilla P. Nelson Colin J. Young Barry Moses and Yousof Abd Al-Jalil

Research Report 0-1407-1F

Research Project 0-1407 Rock Nail Anchor Retaining Wall Design Criteria

conducted for the

#### **Texas Department of Transportation**

in cooperation with the

# U.S. Department of Transportation – Federal Highway Administration

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## IMPLEMENTATION STATEMENT

The potential for reduced construction time and enhanced stability with "top down" construction is a distinct advantage of nailed retention systems in rock cuts. However, there is a lack of rational design procedures for these systems, and conservative design approaches that treat the rock as a soil have been used. The objective of this project is to formulate a design procedure for nailed rock excavations, which is linked integrally to the characteristics of the rock formations typically encountered in central Texas. Design recommendations are developed based on a systematic program of observation, documentation, and analysis of existing rock cuts. These recommendations include guidance on how to investigate a rock-cut site, when to use nails versus other forms of slope protection and support, and how to design nailed slopes.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

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#### SUMMARY

The objective of this project was to develop a rational design procedure for road cuts in the soft rocks of central Texas. Design recommendations were developed based on a systematic program of observation, documentation and analysis of 53 existing rock cuts. A comprehensive field reconnaissance was conducted, and the behavior and characteristics of the rocks in natural and man-made exposures were observed and documented. The rock units in this study included primarily the Cretaceous-age sedimentary rocks that outcrop in a broad band from west of San Antonio through Austin, Waco and Dallas. The lithologies ranged from limestones and dolostones of varying purity, through clay-rich marls and clay shales.

Observations included exposure geometry, rock mass quality, impact of weathering, and potential failure modes. Rock cores were also obtained and laboratory tests were conducted on core samples and grab samples from exposures. In addition, the performance of existing excavations and design procedures was evaluated. Performance information that was collected and analyzed included qualitative descriptions of stability, quantitative information on maintenance frequency and effort, and quantitative information on catchment adequacy.

The performance data were analyzed to identify the most important factors affecting the performance of the studied rock cuts. The dominant mode of failure was localized raveling and differential erosion. This failure mechanism was particularly dominant in the Glen Rose Formation and the Austin Chalk. Raveling of loose blocks was also observed in the Edwards Formation where paleokarst and recent (in geologic time) solutioning has created cavities and fractures. The block sizes in both instances tended to be comparable in dimension to the bedding thickness, on the order of 0.5 m. Increased weathering and block fallout were associated with groundwater seepage from the cut or overland run-off flowing down the cut surface. Large-scale planar or wedge failures due to continuous, steeply dipping discontinuities were observed in only 3 of the 53 road cuts studied. In all cases, these failures were associated with faulted zones within the Glen Rose Formation, although similar conditions exist within the Austin Chalk and to a lesser extent within the Edwards Formation.

Conventional information from borings provided limited information in predicting the performance of studied rock cuts. The quality of the rock core (i.e., the rock quality designation, RQD) did not correlate well with stability. While high RQD values are generally associated with good performance, low RQD values are not necessarily associated with poor performance. For example, the Edwards Formation generally had the lowest core quality, yet the slopes performed the best because the rock matrix in solution collapse zones fractured readily when cored but was cemented in situ. Stratigraphic information from borings, such as the presence of thick marly layers, was the most valuable type of information. It was found that differences in slake durability of greater than 20 to 30 percent between individual layers within a slope indicated a high potential for differential erosion. However, the absolute magnitude of slake durability, or other related properties such as unconfined compressive strength, were not effective indicators of this failure mode.

Maintenance requirements tended to be greater for cuts susceptible to raveling and differential erosion, cuts with groundwater seepage, and taller cuts. Benches were effective at reducing the slope height and, therefore, reducing the maintenance requirements. However, benches were only effective if they were wide enough to catch rock fall from the slope above and cleaned frequently. Several of the studied slopes had benches that were filled with debris and could not be accessed for cleaning. Flat catchments to collect rock fall were effective if the width was greater than one-half the slope height. Water seepage and pressures promoted rock mass deterioration. The few rock cuts containing rock nails have all performed well to date. The nails and facing materials have prevented raveling and erosion that has occurred in other cuts at the same sites.

Design guidelines are provided for rock cuts in central Texas based on this study. A site investigation program consisting of a review of published geologic maps and literature, local experience, the data included in this report, and a field reconnaissance of the site and vicinity will be adequate in most instances. Additional investigation work, such as borings and laboratory testing, are recommended only when potentially continuous discontinuities trend nearly parallel to the slope face and dip toward the slope; if the slope is to be left unsupported with a narrow catchment area (less than 0.5 times the slope height); and when the slope is to be supported with rock nails.

In most instances, near-vertical, 10 to 30-m high rock slopes or cuts in the formations common to central Texas can be left unprotected and unsupported if an adequate catchment area (of at least 0.5 times the slope height) is provided at the toe to prevent rockfall from entering the roadway.

In areas where adequate catchment cannot be provided due to right-of-way or other geometrical constraints, the slope should be protected from raveling and differential erosion with a thin layer of fiber reinforced shotcrete at the slope face. Spot nailing is recommended for supporting larger blocks (on the order of several meters in size) that may be unstable. Seepage and surface water control will also be helpful in minimizing raveling and erosion. In areas where external loads are to be supported near the crest of the rock cut, a pattern of short rock nails is recommended in addition to the shotcrete. Additional, longer rock nails should be installed near the slope crest if the external loads are large (e.g., a bridge abutment foundation).

If continuous, steeply dipping discontinuities will daylight at the cut face, then rock nails should be installed across the discontinuity to support the potentially unstable wedge. This recommendation is intended for both slopes with and without external loads if a large-scale planar or wedge failure is possible. A design equation and design charts are presented to estimate the required nail loads. Again, fiber reinforced shotcrete should be applied at the cut face to prevent localized raveling and differential erosion. Drainage should be provided behind the shotcrete and within the slope to prevent build up of water pressures. [This page replaces an intentionally blank page in the original document. --CTR Library digitization project]

## CHAPTER 1. INTRODUCTION

## 1.1 Objective

The Texas Department of Transportation (TxDOT) has designed and constructed a number of excavations and nailed walls in both soil and rock. The possibility for reduced construction time and enhanced stability with "top down" construction is a distinct advantage for nailed retention systems. However, because of a lack of design procedures and data for the relatively soft rocks in Texas, designs have been developed using a conservative approach similar to that used for soil excavation support with nails.

The response of reinforced rock slopes is distinctly different from nailed soil slopes due to differences between rocks and soils. With soils, deformation occurs as a result of strains throughout the soil mass and the mass behaves essentially as a continuum. In contrast, rock response is controlled by deformations along discontinuities such as fissures, cracks, joints and faults. Accordingly, different design approaches are required for the design of nailed slopes in rock and soil.

The objective of this project is to formulate a rational design procedure for nailed rock excavations, which is linked integrally to the characteristics of rock formations typically encountered in central Texas. The design recommendations will include guidance on how to investigate a site, when to use nails versus other forms of slope protection and support, and how to design nailed slopes.

#### 1.2 Approach

The design recommendations have been developed based on a systematic program of observation, documentation and analysis of existing rock cuts in central Texas. The primary study districts are shown on Fig. 1.1; several rock cuts in other TxDOT districts were included as well. A comprehensive field reconnaissance has been conducted at fifty-three sites, and the behavior and characteristics of the rocks in natural and man-made exposures have been systematically observed and documented. The rock units in this study have included primarily the Cretaceous-age sedimentary rocks that outcrop in a broad band from west of San Antonio through Austin, Waco and Dallas. The lithologies range from limestones and dolostones of varying purity, through clayrich marls and clay shales.

Observations have included exposure geometry, rock mass quality, impact of weathering, and potential failure modes. Rock cores have also been obtained and laboratory tests have been conducted on core samples and grab samples from exposures. In addition, the performance of existing excavations and design procedures has also been evaluated. Performance information that was collected and analyzed included qualitative descriptions of stability, quantitative information on maintenance frequency and effort, and quantitative information on catchment adequacy. Finally, theoretical and numerical analyses have been performed to gain insight into the behavior of nailed cuts in rock. While the design recommendations are specifically for central Texas, the methodology developed for this project can be applied to other geologic formations encountered in TxDOT construction.

#### 1.3 Report Organization

This report is organized into nine chapters and five appendices containing supporting materials.

Chapter 2 provides a brief overview of the regional geology encountered in exposures in central Texas.

Chapter 3 contains a description of rock nailing technology.

Chapter 4 provides a detailed description of the implemented program of field reconnaissance, data collection, site investigation, and laboratory testing. Appendices A, B, C and D contain the field data forms, maintenance data, boring logs and laboratory test results, respectively.

In Chapter 5, the field performance data are summarized by district. The geologic formation, slope height and length, method of support, and observed failure modes are tabulated for each site. In addition, rating schemes are developed and implemented to quantify the stability of different cuts based on visual observations, maintenance requirements based on documented maintenance information from TxDOT, and the adequacy of catchment areas to prevent rockfall from entering the roadway.

The performance data are analyzed in Chapter 6. Comparisons are made between observed performance and that predicted by conventional rock mass classification schemes. Additional factors that affect the performance of these cuts in central Texas but are not necessarily included in conventional schemes are also identified. Catchment design procedures are also evaluated within the context of observed catchment performance. The detailed graphical and statistical analyses that support the work summarized in Chapter 6 are contained in Appendix E.

Chapter 7 addresses the design of rock nails. The tensile capacities are estimated for grouted nails in the rock formations common to central Texas. Two design approaches are proposed for different rock types and conditions. The first approach treats the nails as structural members that support the rock and stabilize the rock mass, and is appropriate for sites in faulted areas where steeply dipping, continuous discontinuities that daylight into the rock face may be present. The second approach treats the nails as low-capacity reinforcing members that bind the rock mass together and prevent localized raveling and degradation. Design charts and guidelines are provided for estimating nail loads and determining required nail spacings and lengths. Guidelines are also included for facing material at the rock surface.

Chapter 8 identifies and discusses the advantages and disadvantages of alternative control measures that can be used in combination with nails or in place of nails.

Chapter 9 provides the major conclusions from this project and a set of design guidelines for rock cut designs in central Texas.



Fig. 1.1 Boundary Map of the Primary Study Districts in Texas.

#### CHAPTER 2. SUMMARY OF REGIONAL GEOLOGY

#### 2.1 Introduction

The research conducted for this project was concentrated in the Dallas, Fort Worth, Austin, and San Antonio Districts of TxDOT (Fig. 1.1). The rock cuts in these districts are primarily within Cretaceous-age (66 million years ago to 144 million years) formations, including the Austin Group, the Edwards Formation and the Glen Rose Formation. Exposures of the Walnut, Comanche Peak, Winchell, and Wolf Mountain Formations were also encountered at a few locations. A summary of the regional geology in central Texas is presented in this chapter based on published literature as well as observations and experiences of the authors.

#### 2.2 Dallas District

The Austin Group is the most predominant "soft rock" formation exposed in the Dallas area. The Austin Group, commonly referred to as the Austin Chalk, was deposited during the Cretaceous Period and outcrops in a northeast-southwest band that includes a significant portion of Dallas and surrounding areas to the north and south of the metropolitan area. The Austin Chalk has been subdivided into three separate members in the Dallas area based on lithology. The lower member is 61 m thick and consists of 0.6 to 1.5-m thick beds of chalk (soft limestone) interbedded with 0.3 to 0.6-m thick beds of marl (Allen and Flanigan, 1986). Marl is a hard calcareous clay or compact, impure limestone. The middle member is approximately 67 m thick and consists of 0.6 to 1.5-m thick chalky limestone beds. The upper member is similar in lithology to the lower member and averages 49 m in thickness. The Austin Chalk has a maximum thickness of about 206 m in Dallas County (Allen and Flanigan, 1986). The unweathered rock is light gray and weathers to a dull tan color. The Chalk also contains searas and beds of bentonitic material. Beds dip gently to the southeast at an approximate angle of 3 degrees toward the East Texas Embayment, a large broad basin marking the inland edge of the Gulf Coastal Plain.

Major fault zones in the Dallas District are associated with the Balcones Fault Zone to the west of the Dallas area. Blakemore (1939) studied the area faults and found them to be dip-slip normal faults generally striking N 10° W and with vertical displacements usually less than 4.5 m. Woodruff (1980) put the age of the faulting at early Cretaceous to Miocene. Joint systems were also studied by Blakemore (1939) and were found to be related to the faults. A major joint set strikes N 65° E and controls drainage patterns of small tributaries in the area.

The Austin Chalk is underlain by the Eagle Ford Formation and overlain by the Ozan Formation in the Dallas area. These two formations are composed of montmorillonitic clay/shale and marl, respectively. Neither of these formations was studied as part of this project. However, the Eagle Ford Formation controls the stability of cuts where its contact with the overlying Austin Chalk is exposed (i.e., White Rock Escarpment). The Eagle Ford is highly susceptible to erosion and typically erodes out from under ledges of Austin Chalk creating cantilevered beds which then break due to lack of support. A geologic profile of Dallas County is shown in Figure 2.1.

# 2.3 Fort Worth District

One exposure in the Fort Worth District was located at the contact between the Winchell Limestone and the Wolf Mountain Shale. These two formations are Pennsylvanian in age and are the only non-Cretaceous formations studied as part of this project. Another site was located at an outcrop of the Comanche Peak Limestone. Brief descriptions of each formation follow.

Winchell Limestone and Wolf Mountain Shale: The Winchell consists of interbedded limestone and shale. The limestone is fine-grained and thin to thick bedded. Shale is only present in the upper part of the formation, and is about 1 to 5 m thick. Total thickness of the Winchell near the site observed by Galvan (1994) is about 63 m. The Wolf Mountain Shale directly underlies the Winchell and consists of 30 to 90 m of gray shale with thin lignite and sandstone interbeds (BEG, 1972).

Comanche Peak Limestone: The Comanche Peak is a fine grained, clayey, nodular, burrowed limestone about 5 to 7 m thick (BEG, 1972). Burrows are tubular holes created by marine organisms during deposition of the material. Generally, the burrows are filled with calcareous material that is typically slightly different in color and texture than the surrounding rock.

# 2.4 Austin and San Antonio Districts

The Glen Rose and Edwards Formations are the predominant rock formations exposed in roadway cuts in the western portions of the Austin and San Antonio Districts. The Edwards is the younger of the two and thus overlies the Glen Rose, except in parts of the Austin District where the two are separated by the Walnut Formation. Descriptions of each of these formations are given in the following sections. A geologic profile of the Cretaceous rocks is shown in Figure 2.2.

# 2.4.1 Glen Rose Formation

The Glen Rose Formation is the oldest and most extensive rock formation that outcrops in the two districts. It outcrops in major portions of Travis, Hays, Burnet, Blanco, and Gillespie

Counties in the Austin District and Kerr, Kendall, Bexar, Medina, Bandera, and Comal Counties in the San Antonio District. Generally, the formation is subdivided into two distinguished members (Upper and Lower Glen Rose) separated by a Corbula (fossil) bed. However, in the Austin metropolitan area, the Glen Rose has been subdivided into five members (Rhodda, 1970). The oldest member, Member 1 consists of gray to tan, thin bedded, nodular limestone, marly limestone, and marl. A large portion of this member is also burrowed. The thickness of Member 1 is about 75 to 90 m in the Austin area to 150 m in the San Antonio District. Member 2 directly overlies the Corbula bed and consists of thin to thick bedded, gray to tan interbedded limestone and marl (Rhodda, 1970). The harder, thick limestone beds form resistive ledges which are visible along natural slopes. The thickness of Member 2 is approximately 36 m. Member 3 consists of about 21 m of thin to medium bedded interbedded gray-brown dolomite, dolomitic limestore, and gray and tan limestone, marly limestone, and marl. The dolomitic beds are more common in the lower 9 m. Member 4 is about 36 m thick and generally resembles Member 2. This member forms steep slopes and the harder limestone beds form resistive ledges. The upper-most member, Member 5, consists of about 30 to 35 m of thin bedded, gray-brown, porous dolomite and dolomitic limestone (Rhodda, 1970). Outside of the immediate Austin vicinity, Members 2 through 5 are not mapped separately but are grouped together as the Upper Glen Rose. Member 1 is thus referred to as the Lower Glen Rose. The total thickness of the Glen Rose in the region of study varies from 150 m in the northern part of the Austin District (Garner, 1976) to 270 m in the San Antonio District (BEG, 1983).

The marly beds, and to some extent the more dolomitic beds, are less resistant to erosion than the harder limestone beds, and thus help create a stair-step topography in the Glen Rose. This is a distinctive feature that can be seen on many of the hillsides in west Austin and the Texas Hill Country to the west and southwest. The Glen Rose is exposed along numerous road cuts in Austin and in the counties west and southwest of Austin. High, near vertical exposures of the Glen Rose can also be seen along the Colorado and San Gabriel Rivers in the Austin District, and the Medina, Frio, Guadalupe, and Sabinal Rivers in the San Antonio District, as well as the numerous tributaries that dissect the region.

## 2.4.2 Walnut Formation

The Walnut lies stratigraphically between the Glen Rose and Edwards and consists of two members each about 10 m in thickness. The lower member, known as the Bull Creek Member is a medium grained, burrowed, resistant limestone. The upper Bee Cave Member is described as an extensively burrowed, nodular, fossiliferous, limestone, marly limestone, and marl (Rhodda, 1970).

# 2.4.3 Edwards Formation

Like the Glen Rose, the Edwards is also a Cretaceous-age limestone and dolomite formation. Stratigraphically, the Edwards directly overlies the Glen Rose except in the Austin area where the two are separated by the Walnut Formation. The Edwards outcrops extensively in western Williamson and southwestern Travis County (west of the Balcones Fault Zone) in the Austin District. In the San Antonio District, the Edwards outcrops-west of IH-35 in Comal and northwest Bexar Counties, and also outcrops extensively in Kendall, Kerr, Medina, and Bandera Counties.

The Edwards in the Austin area has been subdivided into four members by Rhodda (1970), although these members not mapped separately. Member 1, the lowest member, consists of porous dolomite, dolomitic limestone, and hard crystalline limestone. Chert is abundant in Member 1, and the top of this member is marked by a 6-m thick solution collapse zone which is a result of groundwater circulation and dissolutioning of gypsum-anhydrite within the rock unit (Rhodda, 1970). This zone is typified by caves, solution collapse breccia, red clay, and large calcite crystals. The collapse zones typically are filled with rock fragments and soil (breccia). The collapse occurred during or shortly after deposition (Rhodda, 1970), and the collapse zones are often reconsolidated or cemented The total thickness of Member 1 is about 60 m, although the entire member is not exposed in Austin. Member 2 is about 13 m thick and is composed of fine to medium grained, hard, porcelaneous limestone. The lower beds are folded and fractured due to the collapse in Member 1 (Garner, 1976). Member 3 is 3 to 4.5 m thick and consists of softer nodular, marly limestone interbedded with flaggy limestone. Finally, Member 4 resembles Member 2 in lithology and thickness, although it contains a thin solution collapse zone in the middle.

In the San Antonio area and along the Balcones Fault Zone, the Edwards is mapped as a single unit presumably because of complex structural geology as a result of faulting. The thickness of this undifferentiated Edwards is about 90 to 150 m. North and west of the fault zone, the Edwards is divided into two separate mappable units. The lower member is known as the Fort Terret Member which consists of three different lithologic zones. The basal third is described as nodular limestone with a thin, yellow, fossiliferous clay bed at the base (BEG, 1983). This clay bed serves as a marker between the Fort Terret and the underlying Glen Rose. The middle third is cherty, fossiliferous limestone and dolomite, and the upper third of the member consists of

porcelaneous, aphanitic limestone, collapse breccia, chert and recrystallized limestone. Total thickness of the Fort Terret is about 7D to 90 m.

Overlying the Fort Terret is the Segovia Member which is a cherty, fossiliferous limestone at the top, followed by porous, massive to thin bedded dolomite with collapse breccia in the middle third, and marly limestone and marl at the base (BEG, 1983). The thickness of the Segovia is 90 to 115 m.

#### 2.5 Structural Geology

The basic geologic structure of the Austin-San Antonio area is a gently dipping homocline broken up by faulting in the area known as the Balcones Fault Zone, which consists of one major normal fault and numerous other smaller normal and drag faults. The broad regional dip of bedding is to the southeast at less than 3 degrees. On the small scale of individual slopes, dips can be approximated as horizontal. In the Austin area, however, the beds of the basal Cretaceous rocks (i.e., Glen Rose, Walnut, Edwards) dip gently to the northeast into the Round Rock syncline (Tucker, 1962). Within the Balcones Fault Zone, dips are less predictable and vary considerably.

The Balcones Fault system is a belt of northeast trending dip-slip normal faults which strike at about N40°E (Rhodda, 1970). Displacements vary from less than a meter to 180 m, but most mapped fault displacements are less than 15 m. Faults with displacements less than about 3 m are generally not mappable outside of road and stream cut exposures. Dips of the faults typically range from 55 to 75 degrees. Some minor localized folding and faulting is present in and above solution collapse zones in the Edwards.

According to Rhodda (1970), two major pairs of joint sets are common in the Austin area. One joint pair strikes at N40°E and N45°W and the other at N10°W and N80°E. No information was found on jointing in the San Antonio District.



Fig. 2.1. Geologic Profile of Dallas County (Allen and Flanigan, 1986).





# CHAPTER 3. ROCK NAIL WALLS

# 3.1 Introduction

Highways in central Texas are often constructed with vertical cuts or slopes excavated into the rock units described in Chapter 2. These cut slopes range in height from less than 3 m to greater than 30 m, and a variety of retention systems have been used to stabilize these excavations. Rock nail anchor retaining walls are one type of retention system that has been used recently. This chapter provides background on the principles behind rock nailing and the materials used in the construction of rock nail walls.

# 3.2 Rock Nail Retaining Structures

Nailed walls (Fig 3.1a) are constructed using a "top-down" construction procedure. In a "top-down" procedure the reinforcement is installed as the excavation progresses. This is in contrast to "bottom-up" procedures, in which the excavation is completed to full depth before a wall is built. "Bottom-up" procedures are used to construct, for example, conventional retaining walls and mechanically stabilized earth walls (Fig 3.1b). A drawback to "bottom-up" construction is that the full excavation is made before the wall is constructed. This requires the use of right-of-way behind the excavation which may not be available. It also requires the replacement of the natural material with select granular fill. In contrast, a rock-anchored wall generally refers to a conventional reinforced-concrete wall, where loads at the surface of the wall are transferred to a stable zone behind the retained mass through tie-backs (Fig. 3.1c). Alternatively, an anchored wall can be an element wall, a wall made up of several individual components, each anchored with a tie-back (Fig. 3.1d). A cantilevered retaining wall with vertical anchors acting through the footing and providing resistance to overturning can also be considered to be a type of rock-anchored wall.

# 3.3 Principles of Rock Nailing

Rock nailing refers to a procedure of installing reinforcing elements into a rock mass exposed by an excavation in order to form an internally supported structure. Rock nailing by TxDOT is generally applied as an extension of soil nailing techniques to the support of rock excavations. In soil nailing construction, reinforcement elements are installed in a systematic pattern as the excavation progresses, with each row of elements being installed into natural material before the next increment of excavation (Fig. 3.2). The elements are placed in a drilled hole, typically angled about 10° to 15° below horizontal, and secured with grout. Pneumatically-applied concrete (shotcrete) is used to give additional face-support to the retained mass, bridging between the nails. In addition, for permanent nailed structures, reinforced concrete facing panels are added to the face of the nailed wall.

Soil nail patterns and lengths are often chosen from experience, but some theoretical design procedures have been developed (Elias and Juran, 1991). Stocker and Riedinger (1990) report that German experiments have found that a spacing of less than 1.5 m is appropriate for soil. Mitchell and Villet (1987) report on designs used on various nailed walls in France. The spacings on these projects varied from 1.0 to 2.0 m vertically and 1.0 to 3.0 m horizontally.

A rock mechanics approach to nailing is typically focused on the behavior of discontinuities within the rock mass. Douglas and Arthur (1983) described the action of rock reinforcement as (1) preventing the detachment of loose blocks, (2) increasing the shear resistance along discontinuities, and (3) increasing the interlocking of rock blocks. Therefore, in rock, untensioned reinforcement is perceived to perform more of a knitting function, where reinforcement reactions are concentrated at discontinuities present in the rock mass.

#### 3.4 Grouted Anchorage Materials

Although many types of reinforcing elements have been developed in the mining and civil construction industries, the most common type of reinforcement used for rock slope reinforcement is the fully grouted type. Other types of reinforcement are discussed by Whitt (1995).

#### 3.4.1 Grout

Grouted anchorages transfer tensile and shear loads through cement or resin grout placed in the annulus of the borehole around the element. The grout transfers the applied load to the rock primarily through mechanical interlock. However, chemical bond and friction are also involved in load transfer.

The grout used for grouted anchorages is usually either Portland cement or resin. Cement grout is usually pumped or poured in a liquid state, although cartridges are also available so the materials can be mixed in place (Douglas and Arthur, 1983). Resin grouts are generally either polyester or epoxy. Polyester resin grouts are quicker setting and often less expensive, while epoxy resins are stronger and more versatile. Resin grout can be pumped in liquid form as with cement grout, but because of safety concerns and convenience it is usually placed in cartridges. Resin ingredients, especially in cartridge form, have a limited shelf life, because some of the ingredients break down over time.

Cartridges for resin and cement grouts allow the material to be placed in the borehcle in a dry form because the cartridges keep the active ingredients separated. Grout cartridges are placed in a borehole before installation of the reinforcing element. When the element is installed, it is rotated, shredding the plastic or glass cartridge casing and mixing the grout ingredients.

Grouted anchorages are the most appropriate anchorage type for rock slope reinforcement applications and the most commonly used. Therefore, grouted anchorages will be the anchor type most extensively discussed in this report.

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#### 3.4.2 Reinforcing Element Materials

The materials used for reinforcing elements are wires, cables, and bars. Wires and cables (also called strands - a member made up of bundled wires) are made from steel and are generally used in rock reinforcement only where very high capacity anchors are required. Bars are usually made from mild steel or high-carbon steel, although stainless steel and other alloys (like chromenickel steel for salt water and acid resistance) have been used. The bars can be smooth, deformed (rebar), or threaded. Deformed bars are the same as those used to reinforce concrete. Threaded bars have a thread pattern cold-rolled on the surface either over the full length of the bar (continuously threaded) or at one or both ends. Continuously threaded bars are useful on projects where different length bars are used because they can be cut to any length, while bars threaded only on the end must be specially ordered. Properties of continuously-threaded bars supplied by two sources, Dywidag-Systems International and Williams Form Engineering Corp., are presented in Table 3.1.

Bars are normally solid but, for easier grouting, hollow bars have been developed which permit grout to be injected through the hollow center of the bar. Williams Form Engineering Corp. (1992) advertises a 30 mm external diameter hollow core continuously-threaded bar with an 8.3 mm inside diameter core hole. The manufacturer states that this has an advantage over the use of grout tubes and solid bars, because grout tubes may not always reach the bottom of the borehole or they can be damaged during installation, both of which would prevent full grouting.

Fiberglass bars have been developed as an alternative to steel. Fiberglass bars have a similar capacity to steel bars of equivalent size, but are much more flexible (Douglas and Arthur, 1983). Dywidag-Systems International manufactures fiberglass bars (called Dywidur bars) with nominal diameters of 22 and 25 mm, a tensile strength of 950 MPa and a Young's modulus of 50,000 MPa (Dywidag, 1993b).

Some advantages of fiberglass reinforcing bars include:

- 1. The low stiffness allows them to be installed where space is confined;
- Fiberglass bars are lightweight and therefore easier to transport and handle than steel bars;

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- Unlike steel, fiberglass is resistant to corrosion and does not conduct electricity;
- Fiberglass bars are useful in corrosive environments;
- Fiberglass bars do not disrupt electro-magnetic fields near sensitive electromagnetic equipment; and
- Fiberglass bars can be more easily cut through than steel bars where re-excavation may be necessary;

Disadvantages of fiberglass bars include:

- 1. Fiberglass bars typically cost more than steel bars; and
- Fiberglass bars allow more deformation than similarly dimensioned steel bars because the Young's modulus of fiberglass is about one-fourth that for steel.

#### 3.4.3 Element Heads

The element head is the part of the reinforcing element where loads are transferred from the element to the rock at the face of the excavation, as well as to any surface support system that may be used, such as shotcrete and wire mesh. This transfer of load allows the surface rock and support system to be integrated with the rock mass, so that smaller loose blocks cannot fall cut and surface deformations are controlled.

Where the reinforcing elements used are bars, the most common design at the element head is a nut, washers and a face plate. A nut is screwed onto the threaded end of the element and bears on a face plate, which distributes the load to the rock surface. Washers are used between the nut and plate to provide more efficient load transfer. Douglas and Arthur (1983) recommend using two beveled washers, or a hemispherical washer in a shaped setting on the plate, to insure uniform load transfer. The washer immediately under the nut should be made of hardened steel to prevent damage to the washer during tensioning.

There are several types of face plates that have been used. Flat plates are often used and can be square, circular or triangular in shape. Table 3.2 includes typical plate sizes (diameter or length of a side) and thickness for different working element loads. In order to prevent deformations of the plate under high element loads, either the thickness of the plate can be increased or two plates can be used.

The disadvantage of a flat plate is that it bears on the rock at only a few points near the center of the plate. If element loads are high, the rock can be crushed at these points. As an alternative where loads or deformations are expected to be high, a deformed plate can be used. Figure 3.4 illustrates two commonly used deformed plates, the domed and triangular bell-shaped plates. Deformed plates contact the rock surface closer to the edges of the plate, reducing point

loads on the rock. Also, the plate deforms when load is applied giving a positive visual verification of tensioning.

#### 3.4.4 Corrosion Protection

Corrosion protection is an important part of choosing the proper reinforcing element materials. The most important parameters of the reinforced material (rock or soil) influencing corrosion are the content of dissolved salts, pH, porosity, and degree of saturation. Environmental conditions that cause the highest corrosion rates are a high content of total dissolved salts, high chloride concentration (> 200 ppm), high sulfate content (> 1000 ppm), and acidic or alkaline pH conditions (Mitchell and Villet, 1987).

For grouted reinforcing elements, the grout itself (primary and secondary) provides a measure of protection. However, since the grout often cracks, possibly allowing water to reach the member and cause corrosion, additional protection is needed. Common protection methods include epoxy coatings (limited to deformed bars for adequate bonding) and galvanized or plated bars (Douglas and Arthur, 1983). A minimum grout thickness of 37 mm and deformed reinforcing bars with electrostatically applied epoxy to a minimum thickness of 3.5 mm are recommended by Elias and Juran (1990).

Manufacturer	Yield Stress MPa	Ultimate Stress MPa	Available No	ominal Diam. Im
Dywidag	414	620	19.1, 25.4, 37.8, 44.5,	22.2, 28.6, 34.9, 57.2.
	517	689	22.2, 44.5, 63.5.	25.4, 57.2,
	881	1034	26.0, 36.0,	32.0,
	937	1103	26.0, 36.0.	32.0,
Williams	881	1034	26.0, 36.0,	32.0, 45.0.

Table 3.1. Properties of Continuously Threaded Bars (after Dywidag, 1993a and b; Williams, 1992).

# Table 3.2. Typical Faceplate Dimensions (after Douglas and Arthur, 1983).

Workina kN	Surface Area	Thickness
80	125 to 150	7
150	150 to 200	10
300	200 to 250	12



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Figure 3.1. Contrasting Retaining Systems (after Stocker and Riedinger, 1990).



Figure 3.2. Soil-Nailing Construction Process (from Mitchell and Villet, 1987).


Fig. 3.3. Reinforcement Behavior at a Discontinuity (from Douglas and Arthur, 1983).



Fig. 3.4. Common Deformed Shapes of Bearing Plates (from Stillborg, 1986).

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# CHAPTER 4. FIELD AND LABORATORY TESTING PROGRAM

### 4.1 Introduction

This chapter describes the field and laboratory testing program that was implemented to evaluate the properties and performance of existing road-cut exposures in Texas. All TxDOT districts with rock slopes were sent a questionnaire developed by the project team (Galvan, 1995) to identify areas and sites where rock cut slope stability was an important issue. Based on the responses, 53 sites were selected for investigation. Table 4.1 summarizes the sites by district and geologic formation.

A field reconnaissance study was conducted at each of the 53 sites. Based on these results, three case-study sites with rock-nail supported slopes were selected for further investigation. These sites were respectively located in the three major geologic formations studied, the Austin Group, Edwards Formation and Glen Rose Formation. Two rock-core borings were drilled at each of the case-study sites. Finally, laboratory tests were conducted on grab samples obtained from various sites and on core samples obtained from the case-study sites. Details for the field and laboratory testing program are presented in this chapter, and the results are summarized in Appendices A (field reconnaissance), B (maintenance information), C (boring logs) and D (laboratory test results). The results will be analyzed in Chapters 5 through 7.

### 4.2 Field Reconnaissance

#### 4.2.1 Introduction

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Field reconnaissance studies of particular road-cut exposures were made in the Dallas, Fort Worth, Austin, San Antonio, and El Paso Districts of TxDOT. Each of these districts responded to a questionnaire developed by the project team (Galvan, 1995) to identify areas where rock cut slope stability was an important issue to TxDOT. During the period from March 1994 to July 1995, a total of 53 detailed field reconnaissance studies were made on cut slopes in these districts.

### 4.2.2 Data Collection Forms

Four forms were developed for data collection at each field exposure. The first form (Fig. 4.1) contains basic information about the site. The second form summarizes the engineering geologic parameters (Fig. 4.2). The third form (Fig 4.3) allows the investigator to quantify the effect of discontinuities by conducting horizontal scanlines over a known distance and describing in detail each discontinuity encountered. The strike and dip relative to the cut face is recorded

along with the joint condition and persistence. A space is provided at the bottom of this page for the "apparent spacing" between joints of a given joint set and also the "true spacing" which is the number used in the empirical classification schemes. The apparent spacing is the distance between joint traces along the scanline, whereas the true spacing is the perpendicular distance between joints and is calculated by multiplying the apparent spacing by the sine of the angle between the strikes of the cut face and the joint. The final form (Fig. 4.4) is for vertical scanlines, RQD determination, and fracture frequency. A quick reference sketch is also provided to help the investigator determine the approximate slope height or height to any point on the slope if direct measurement is not feasible.

### 4.2.3 Site Descriptions

Sites in the Austin, Dallas, Fort Worth, and San Antonio districts were studied in detail using the developed data collection forms. Table 4.1 summarizes the 53 sites by district, geologic formation, and primary investigator. Locations and general information about the sites are presented in Tables 4.2 through 4.4, and the complete data collection forms for each site are included in Appendix A.

#### 4.2.4 Maintenance Information

Maintenance information, which provides an indication of historical performance of the cut slopes, was also collected. The TxDOT maintenance foreman of each section where cuts were studied was contacted to gather pertinent maintenance information. Standard information was requested for each site including the following:

- · Age of cut;
- Method of excavation;
- · Frequency and type of repair or cleanup;
- · Type and size range of debris;
- · Frequency of and amount of debris entering roadway; and
- · Any pertinent additional comments.

It was possible to obtain the above information for all but one site, the Lake Georgetown Spillway in Williamson County, which is under jurisdiction of the Army Corps of Engineers. The results of the maintenance surveys are presented in Appendix B.

### 4.3 Subsurface Exploration

#### 4.3.1 Background

Geotechnical core borings were drilled at three of the sites selected during the field reconnaissance phase of the project. The objective was to supplement field observations with data from core such as RQD, uniaxial compressive strength, bed thickness and discontinuity information, and to retrieve samples for laboratory testing. Drilling operations were conducted in accordance with standard practice in Texas. Hence, the core quality was comparable to that expected if TxDOT conducted the work or contracted out to local private firms. Currently, the Austin District contracts their core drilling work to local consultants, while the San Antonio District possesses its own drilling equipment and crews. In accordance with accepted practices, drilling was performed with a double-tube core barrel equipped with an NX-size (50 mm) diamond insert cutting bit for the Glen Rose and Edwards Formations, or a tungsten-carbide bit for Austin Chalk. The same crew, equipment, and rig was used for all coring to attempt to minimize the variability in core quality that can occur with different crews and equipment. The care of the driller is particularly important for softer rocks like the ones studied for this project.

#### 4.3.2 Case-Study Sites with Rock-Nailed Slopes

Three sites located in the three main geologic formations studied (Austin, Glen Rose, and Edwards) were selected for core drilling (Tables 4.2, 4.3 and 4.4). Two borings were drilled at each site to a depth of approximately 12 m. All three sites have near vertical cuts. At each site, a portion of the rock slope is supported by rock nails (e.g., at a bridge abutment) while the remainder is not supported. An attempt was made to locate the borings as close to the edge of the slope crest as possible. The field boring logs are included in Appendix C. A summary of pertinent site features is presented in Table 4.5, and plan and cross-section views of the sites are shown on Figs. 4.5 to 4.7.

Site 1: The first case-study site is a 10.5-m high cut in the Glen Rose Formation along RM 620 near Mansfield Dam (Lake Travis), west of Austin (Fig. 4.5). The cut on the west side of the road is unsupported, while that on the east side is supported with rock nails. One boring was drilled above the unsupported cut and one above the rock-nail wall. Below the top 2 to 3 m of weathered rock, core recovery was 100% and RQD's ranged from 65 to 100 with an average of 84.

Site 2: The second case-study site is a 6-m high cut along the westbound frontage road of IH-30 at Hampton Road in Dallas (Fig. 4.6). The Austin Chalk outcrops at this site, however the Eagle Ford Formation (shale) was encountered in the borings below the depth of the cut. The cut is supported with rock nails beneath a bridge abutment and unsupported elsewhere. Core recovery varied from 79 to 100% and RQD's ranged from 8 to 100. Boring No. 1 was started with a carbide bit and RQD's of consecutive core runs were 0, 85, 10, and 8. At a depth of 6 m, the bit was changed to a diamond bit and RQD's then ranged from 56 to 100. The average RQD for the two borings, neglecting the portion drilled with the carbide bit, was 87.5.

Site 3 The third case-study site is a 5.5 to 8-m high cut located along Loop 1604 at the Bitters Road underpass in San Antonio (Fig. 4.7). Vertical cuts were made along Loop 1604 to depress the road below Bitters Road. Rock nailed walls were installed under both bridge abutments. Outside of the bridge area, the cuts are left unprotected. One boring was drilled on either side of Loop 1604 above the cut, west of the bridge. This site is located in an extensively solutioned portion of the Edwards Formation. Drilling at this site was complicated due to the very blocky nature of the rock. Core recovery ranged from 20 to 100% and RQD's ranged from 0 to 42 with an average of less than 15.

### 4.4 Laboratory Testing

Laboratory tests were performed on samples from the road-cut sites. The objectives of the testing program were (1) to quantify and compare rock properties from different formations, sites, and layers at a site and (2) to correlate laboratory-measured properties with observed performance. Two types of samples were collected: grab samples taken from the face of the slope and core samples from the case study sites. The following tests were performed: water content (ASTM D2216-90), calcium carbonate content (ASTM D4373-84), slake durability (ASTM D 4644-87), splitting tensile (Brazilian) strength (ASTM D 3967-92), unconfined (uniaxial) compressive strength (ASTM D 2938-86), moduli of elasticity in uniaxial compression (ASTM D 3148-93), ultrasonic determination of elastic constants (ASTM D 2845-90), and Moh's hardness (Institution of Civil Engineers, 1976). The laboratory test results are presented in Appendix D.

TxDet District	Geologic Formation and Number of Sites	Field Investigator
Austin	Glen Rose: 12 sites Edwards: 2 sites	Young, Galvan
Dallas	Austin Chalk: 5 sites	Galvan
Ft. Worth	Winchell/Wolf: 1 site Comanche Peak: 1 site	Galvan
San Antonio	Glen Rose: 19 sites Edwards: 21 sites	Young

Table 4.1. Breakdown of Roadway-Cut Sites Observed

Table 4.2. Austin District Sites

Site Code	Location	County	Geologic Formation	H (m)	L (m)	Layback Angle (*)	Method of Support
360-1	Loop 360, N. of RM 2222	Travis	Kgr	22.5"	300	10	None
360-2	Loop 360 nt RM 2244	Travis	Ked, Kwa, Kgr	24.3*	390	10-12	None
360-3	Loop 360, 1.6 km N. of Wild Basin Road	Travis	Kgr	6.6	117	3	None
620-1*	RM 620 at Mansfield Dam	Travis	Kgr	10.5	279	12-15	Rock Nails/ None
620-2	RM 620 So. of Lakeway	Travis	Kgr	9 <sup>8</sup>	228	18-20	None
2244-1	RM 2244 at Crystal Creek Road	Travis	Kgr	6.6	111	12	None
2244-2	RM 2244 at Addie Roy Road	Travis	Kgr	5.4	165	15	None
SWP-1	Southwest Parkway, east of US 71	Travis	Ker	7.5	330	12	None
SRR-1	Steiner Ranch Road at Quinlan Park Road	Travis	Kgr	9	168	8-10	None
Au-1	RM 2222 hetween Loop 360 and Monac	Travis	Kgr	15	>1 km	<15	None
Au-2	RM 2222 at Loop 360 drainage channel	Travis	Kgr	7.5	45	3	None
Au-3	Lake Georgetown spillway	Williamson	Ked	14	1.6 km	30	None
An-d	US 87 north of Mason	Mason	Ked	12	110	10-15	None

Notes: \* indicates case study site, <sup>b</sup> indicates benched cut, Kgr = Glen Rose Fm., Ked = Edwards Fm., Kwa = Walnut Fm., H = maximum height, L = total length of slope

Site Code	Location	District	County	Geologic Formation	H (m)	L (m)	Layback Angle (*)	Method of Support
D-1	Loop 303 et of Loop 12	Dallas	Dallas	Austin Chalk	4.5	61	0 to 40	None
D-2*	IH 30 at Hampton Road	Dallas	Dallas	Austin Chalk	6	120	varies	Rock Nails (Abutment)
D.3	1H 30 at 1 non 12	Dallas	Dallas	Austin Chalk	11	150	40	None
D-4	FM 1382 Cedar Hill	Dallas	Dallas	Austin Chalk	11	60	15	None
D-5	New Clark Rd. at FM	Dallas	Dallas	Austin Chalk	12	73	12	Noos 1: T
FW-I	US 377 between Granbury and Cresson	FL Worth	Hood	Comanche Peak	5.5	156	13	None
FW-1	SH 16 west of SH 337	Ft Worth	Palo Pinto	Winchell, Wolf Mt.	20	500	15	None

Table 4.3. Dallas and Fort Worth District Sites

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Notes: \* indicates case study site, \* indicates benched cut, Kgr = Glen Rose Fm., Ked = Edwards Fm., Kwa = Walnut Fm., H = maximum height, L = total length of slope

Site Code	Location	County	Geologic Formation	H (m)	L (m)	Layback Angle (°)	Method of Support
281-1	US 281, S. of Cibolo Creek	Comal	Kgr	6	276	12	None
281-2	US 281 at Belverde Estates	Comal	Kgr	7.5	156	15	Nane
281-3	US 281 just S. of SH 46	Comal	Ker	10.5	375	15	None
281-4	US 281, 7.9 km S. of Guadalupe River	Comal	Kgr	4.5	189	12	None
281-5	US 281 just N. of 281-2	Comal	Ker	9	330	12	None
1376-1	FM 1376 N. of Boerne	Kendall	Kur	13.5	138	10-15	None
1376-2	FM 1376 S. of FM 473	Kendall	Ker	9	317	20-25	None
1-10-5	IH-10 near FM 289	Kendall	Ker	7.5	137	0	None
2722-1	FM 2722 btwn. FM 2673 and SH 46	Comal	Kgr	18.3	108	0	None
2673-1	FM 2673 at FM 2722	Comal	Ker	7.5	180	0 to 20	None
3159-1	FM 3159 N. of SH 46	Comal	Ked	6	360	5	None
1-10-1	0.8 km E. of SH 16	Кеп	Ked/Kgr	225	300	10	Nose
1-10-2	2.4 km E. of SH 16	Кеп	Ked	7.5	216	12	None
I-10-3	IH 10 at Cypress Creek	Kerr	Ked/Ker	213	360	Varies	None
1-10-4	IH 10 just west of Cypress Creek	Kerr	Ked/Kgr	16.5	300	10-12	None
1-10-6	IH 10, 1.6 km W. of SH 16	Kerr	Ked	21*	105	6	None
1-10-7	IH 10, 1.6 km W, of FM 783	Kerr	Ked	5.5	180	5	None
1-10-8	IH 10 just E. of FM 1338	Kerr	Ked/Kgr	24	308	10	None
1-10-9	IH 10 in Gillespie Co.	Gillespie	Ked	7.5	360	0	None
41-1	SH 41 at SH 27	Kerr	Ked	10.5	300	0	Nont
187-1	FM 187 N. of Lost Maples State Park	Bandera	Ked	15	780	15	None
337-1	FM 337 at Mill Creek	Bandera	Ked/Kgr	18	195	15	None
337-2	FM 337, top of Mill Creek Pass	Bandera	Ked	7.5	190	15-20	None
470-1	FM 470, Tarpley Pass	Banders	Kgr	16.5	293	30+	None
211-1	SH 211N. of FM 471	Medina	Ked	10*	300	16	None
211-2	SH 211 N., of Bexar Co. line.	Bexar	Ked	17'	550	15	None
211-3	SH 211 S. of SH 16	Bexar	Ked	30*	420	10-15	None
1283-1	FM 1283 at CR 270	Medina	Kgr	15	225	12	None
1283-2	FM 1283, 1.4 km S. of Park Road 37	Medina	Ked	10.5	170	10-12	None
173-1	FM 173 S. of Bandera- Medina Co. line	Medina	Ked	15	330	10-20	None
S-1*	Loop 1604 at Bitters Road	Bexar	Kad	8	>2 km	15	Rock Nails (Abutment)
S-2*	Loop 1604 at Gold Canyon Road	Bexar	Ked	5.5	400	15	Rock Nails (Aburment)

Table 4.4. San Antonio District Sites

Notes: \* indicates case study site, <sup>b</sup> indicates benched cut, Kgr = Glen Rose Fm., Ked = Edwards Fm., Kwa = Walnut Fm., H = maximum height, L = total length of slope

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Site	R.M. 620 West of Mansfield Dam	I.H. 30 and Hampton Rd,	Loop 1604 and Bitters Rd.
Geologic Formation	Glen Rose Limestone	Austin Chalk	Edwards Limestone
Age of Wall	6 mo	5 years	5 years
Method of Excavation	Ripping	Not Available	Blasting, Pre-Split
Height (m)	10	6.1	7 1
Face Strike	N 85° E	N 90°E	N 42°E
Layback	0°	Varies from 0° to 15°	15°
Nail Type	Grade 60 Dywidag threadbar, epoxy coated	Grade 60 Dywidag threadbar, epoxy coated	Grade 60 Dywidag threadbar, epoxy coated
Nail Spacing (m)	1.5 H, 1.5 V	1.5 H, 1.5-V	1.5 H, 1.5 V
Nail Length (m)	7	4.5	6
Facing Type	100-mm gunite with 6x6 No. 6 WW mesh	100-mm gunite with 6x6 No. 6 WW mesh	100-mm gunite with 6x6 No. 6 WW mesh
Drainage	300-mm wide mat at 3 m on center	300-mm wide mat at 3 m on center	300-mm wide mat at 3 m on center
External Loads	2H:1V Backfill	Bridge Traffic	Bridge Traffic

Table 4.5 Summa	ry of Case-Stud	y Sites with	Rock-Nailed Slop	es

Code: Date:
Pageof
Location:
~
Plan Sketch
egetation Effects:
i.
ion (ft) looking

Fig. 4.1. Field Form for General Exposure Description.

INDOI	Rock Mass Fiel	d Descr Summ	iption ary of En	gineering Ge	ologic Data	Page: Code::	nf
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Set #	Strike	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarks
Other 8	Structural						
<sup>7</sup> eature	Strike	Dip	Condition	Persistence		Remarks	
oints? Sedding Weather	Description:						
Form of	Slope Failure/Degrad	lation:					
Debris:							
Maintena	ince Record:						
Vailable Data:	Geotechnical						

Fig. 4.2. Field Form for Summary of Engineering Geologic Data.

TxDO	OT Rock	Mass Field I	Descripti	on							Date: Code:	_
			S	canlin	e Des	cript	ions					S - 32
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-	-				-	+	-	-		-		
-	-	-	-	-	-	-	-	-		-	-	-
-		-	-	-		-	-	-	_	+		-
6	+		+	-	-	-	-			+		
7	+		+	-		+	-	-		1		-
8	-		-			+	-	-		-		-
9			-	-	-	-		1		1		-
10	1	_				-		-		1		
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Fig. 4.3 Field Form for Scanline Descriptions.

TxDOT	Rock	Mass	Field	Descrit	ntion Sc	anline	D	escrip	tions				Dote: Code: Page:		
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Scanline	Info	rmatio	on:												
nbs#	S	IR.	Set	Strik	e w/r to 20-45	exposure 45-90	RAL.	Di +/-20	p w/r to 20-45	exposure 145-90	I R/L	Persist	C	ond'n	
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2															
4							_	-		-					
5								-			-				
6															
7						_									
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Fig. 4.4 Field Form for Vertical Scanlines and RQD Estimate.



Fig. 4.5 Plan and Cross-Section View of Case-Study Site 1 (RM 620 at Mansfield Dam)



Fig. 4.6 Plan and Cross-Section View of Case-Study Site 2 (IH 30 at Hampton Road)



Fig. 4.7 Plan and Cross-Section View of Case-Study Site 3 (Loop 1604 at Bitters Road)

### CHAPTER 5. PERFORMANCE OBSERVATIONS

### 5.1 Introduction

Performance of the study sites was based on visual observations by the authors as well as the maintenance history of the slopes as reported by TxDOT maintenance personnel. This chapter presents the results of the field observations and available maintenance information for each site, along with a discussion of rockfail potential and catchment adequacy. Several quantitative rating schemes are developed and applied to characterize slope performance: a stability rating, a maintenance rating, and a catchment adequacy rating.

#### 5.2 Modes of Failure in Rock Slopes

A brief discussion of the modes of failure in rock slopes is necessary before describing the field observations which included the predominant observed failure or potential failure modes. The term "failure" is used in a broad sense to include all forms of degradation.

**Planar:** This mode of failure occurs in soft and hard rock when a through-going discontinuity or weak plane strikes at an acute angle to the slope face and daylights into the face. Failure occurs when the angle of inclination (dip) exceeds the shear strength along the plane. An example of planar failure is shown in Fig. 5.1.

**Circular:** Circular failures occur in soft or highly weathered rock along a circular surface. This mode of failure is identical to slope failures in cohesive soil.

*Wedge:* Wedge failures occur when two discontinuities, dipping toward the slope face, intersect. The scale of the failure is determined by the discontinuity spacing. An example of a wedge type failure is given in Fig. 5.2.

**Block:** Block failure occurs where relatively flat lying, low strength discontinuities are present. Excavation relieves lateral stress, and where layers of different stiffness are in contact, differential strains occur at the contact and the shear strength along this surface is reduced. Lateral movements that occur as a result of stress relief tend to open joints or create steep tension cracks behind the slope face (Brawner, 1994). The resulting opening is now susceptible to increased pressure from build-up of precipitation which can create forces large enough to move the block.

**Toppling:** Toppling failure is not very common in flat lying sedimentary rocks, like those studied for this project. It occurs when there are closely spaced, steep discontinuities oriented in the same direction as the slope face. Therefore, this type of failure is most common in steeply dipping sedimentary and metamorphic rocks such as slates, shales, and siltstones.

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Toppling is possible in flat lying rock if there are other closely spaced, steeply dipping discontinuites that are oriented in the same direction as the slope face.

**Raveling:** Raveling can be thought of as similar to spalling of concrete where fragments fall from the face. Raveling can be caused by hydrostatic pressure in joints and cracks, ice-wedging, differential weathering or erosion along faults or shear zones, weakening of the rock due to climatic variations, and root wedging (Brawner, 1994). The presence of closely spaced, bed-confined joints increases the likelihood of raveling, although their mere presence does not cause the failure. Raveling was the most common type of failure observed during this project and at least some degree of raveling was present on almost every slope observed. An example of raveling is shown on Fig. 5.3.

Differential Erosion: A specific type of raveling occurs due to differential erosion, in which softer, more erodible layers weather to leave cantilevers of more resistant layers. The loss of support causes the overlying resistive layer to fail in tension after the tensile capacity of the rock is exceeded. An example of this type of failure is shown in Fig. 5.4.

### 5.3 Field Observations

One of the primary objectives of the field reconnaissance was to evaluate, as least qualitatively, the performance of the slope, by noting information such as: type of slope failure or degradation, type and size of debris, catchment description, and presence and effect of vegetation. The field data sheets are contained in Appendix A. The type of failure and relative scale (local/global) for each of the sites are given in Tables 5.1 through 5.3. The distinction between "local" and "global" in the context of this report is that local failure is considered anything less than the full slope or bench height (in the case of benched cuts), and global denotes a failure that extends the full height of the slope or bench.

### 5.4 Visual Stability Rating

During the field observations, a subjective visual assessment of stability was quantified using a the Visual Stability Rating (VSR). This rating was evaluated by estimating the percentage of the original, excavated slope face remaining at the time of the field reconnaissance. The categorization scheme for VSR is presented in Table 5.4. The maximum VSR value of 4 corresponds to the best performance, while the minimum value of 0 corresponds to the poorest performance. Identification of the original face was straightforward in most instances because the majority of cuts were excavated by pre-splitting. This procedure leaves half-casts as evidence of the shot holes used for explosives along the excavated face. In the small number of cases where the cut was not presplit or where there was no evidence of pre-splitting, a subjective estimate of the original slope face was made. Sites in the Edwards and Glen Rose Formations were assigned VSR values (Tables 5.1 and 5.3); insufficient information precluded the use of this measure for sites in the Austin Chalk.

# 5.5 Maintenance Information

The TxDOT maintenance foreman for each maintenance section in which cuts were studied was contacted to gather historical performance information and maintenance requirements of each site. This information allows a comparison between sites with different conditions and possibly some general characterizations that will help predict the performance of future cut slopes. The results of the maintenance surveys are given in Appendix B. One performance measure used to compare different slopes was based on maintenance frequency. The classification scheme given in Table 5.5 was used to summarize the maintenance data based on frequency. The maximum MR value of 3 corresponds to the best performance (i.e., minimal maintenance required), while the minimum value of 0 corresponds to the poorest performance. This rating scheme was developed to characterize performance of slopes experiencing "local" failures or degradation (e.g., raveling, differential erosion, and some wedge failures), and is based on the maintenance frequency. It is not applicable to overall, global type failures. The Maintenance Ratings are summarized in Tables 5.1 through 5.3.

# 5.6 Characteristics of Each Formation

Only the Edwards, Glen Rose, and Austin Chalk were observed at a sufficient number of sites to characterize the performance of the formation. Therefore, only those three are discussed here.

### 5.6.1 Glen Rose Formation

Based on the sites observed, the Glen Rose is massive, with widely spaced joints and the performance is generally not controlled by kinematic behavior along joints. A total of 28 sites in the Glen Rose were studied. Raveling, to varying degrees, was present on every slope observed. Differential erosion resulting in cantilevered block fallout was observed on 15 of the 28 slopes (54%) and depended on whether softer, marly beds were present in the slope stratigraphy. Wedge failure along intersecting discontinuities was only observed at 3 of the 28 sites (11%) and planar failure only observed at 2 sites (7%). The planar failures occurred along faults that happened to strike at about 20 degrees from the slope face at two sites in an area of Comal County where faults

are mapped (BEG, 1983). Toppling failure was observed at one site (1376-2) in Kendall County. This was the only site observed in the Glen Rose with closely spaced, near vertical joints, and at this site the joint strike was within 15 degrees of the strike of the slope face.

#### 5.6.2 Austin Chalk

Five sites were observed in detail in the Austin Chalk Formation. All 5 sites exhibited raveling to some degree and 3 of the 5 (60%) exhibited block fall raveling due to differential erosion. Based on the very limited number of sites, a reasonable conclusion would be that the Austin Chalk, like the Glen Rose, exhibits local type raveling failure and is not controlled by persistent discontinuities which may produce wedge, planar, or block failure. Allen and Flanigan (1986) noted that small gravity or normal faults are common in the Austin Chalk. Certainly if such discontinuities were present at the site of a cut slope they could quite possibly trigger large scale planar or wedge failures depending primarily on their orientations and dip angle. More sites would need to be observed to enable characterization of cut slopes in the Austin Chalk.

### 5.6.3 Edwards Formation

Like the Glen Rose, the Edwards is generally massive with infrequent, widely spaced discontinuities. A total of 23 sites in the Edwards Formation were studied and all but one site exhibited at least minor raveling. Differential erosion was only observed at six of the 23 sites (26%). At four of these sites, the differential erosion occurred at the contact between the Ft. Terret member of the Edwards Formation and the Glen Rose Formation. The Glen Rose is softer than the Edwards and is more susceptible to erosion. When the softer Glen Rose erodes back from the slope face, a cantilevered situation occurs and blocks of the massive Ft. Terret fail in tension. Minor, local wedge failures were only observed at one site. Large scale, global toppling was observed at one site (337-1) in Bandera County along FM 337. Persistent joints striking at an acute angle to the slope face and dipping slightly toward the face opened gradually over time, and scale blasting was conducted to remove the large blocks prior to seemingly imminent failure. Since the blasting operations, more joints have opened (as much as 0.3 m aperture) to the point where blasting is again being considered by TxDOT to remove the large blocks before they break free and impact the roadway. This particular site has no catchment. In summary, the performance of the Edwards is predominantly controlled by minor raveling except at the contact of the Glen Rose and in isolated cases where persistent joints are oriented in an unfavorable direction.

# 5.7 Catchment Adequacy

The adequacy of a slope's catchment area is determined by whether or not debris falling from the slope face reaches the roadway, and how often. Catchments for the sites observed consisted of many different configurations including flat, vegetated and unvegetated easements, gentle and steep natural ditches, concrete ditches and asphalt paving extending to the toe of the slope. For this project the catchment adequacy was rated from 0 (worst) to 3 (best) according to the frequency of debris reaching the roadway (Table 5.6). The catchment descriptions noted during the field observations along with the assigned catchment adequacy, based on maintenance information, are presented in Tables 5.7 and 5.8. It should be noted that the catchment adequacy is a function of not only the slope and catchment geometries but also on the performance of the slope itself. A completely stable slope with no form of local failure may have a 1-m wide ditch that is completely adequate for the particular slope. Conversely, if the same slope is susceptible to severe raveling, debris could quite possibly enter the roadway.

Site Code	Location	Geologic Formtn. <sup>1</sup>	H (m)	L (m)	Type of Failure <sup>2</sup>	Scale	VSR <sup>3</sup>	MR <sup>4</sup>
360-1	Loop 360, N. of RM 2222	Kgr	22.5 <sup>b</sup>	300	R,W,DE	local	1	2
360-2	Loop 360 at RM 2244	Ked, Kwa, Kgr	24.3	390	R	local	N/A	0-1
360-3	Loop 360, 1.6 km N. of Wild Basin Road	Kgr	6.6	117	R	local	3.5	3
620-1	RM 620 at Mansfield Dam	Kgr	10.5	279	R, possible DE	local	4	New Cut
620-2	RM 620 So. of Lakeway	Kgr	9 <sup>b</sup>	228	R	local	3	3
2244-1	RM 2244 at Crystal Creek Road	Kġr	6.6	111	R	local	3	3
2244-2	RM 2244 at Addic Roy Road	Kgr	5.4	165	R,DE	local	2	3
SWP-1	Southwest Parkway, east of US 71	Kgr	7.5	330	R,DE	local	3	3
SRR-1	Steiner Ranch Road at Quinlan Park Road	Kgr	9	168	R,DE	local	2.5	0
Au-1	RM 2222 between Loop 360 and Mopac	Kgr	>15	>1 km	R,DE	local	2	0
Au-2	RM 2222 at Loop 360 drainage channel	Kgr	7.5	45	R,DE	local	1	0-1
Au-3	Lake Georgetown spillway	Ked	14	1.6 km	R	local	N/A	N/A
Au-4	US 87 north of Mason	Ked	12	110	R,DE	local	N/A	3

Table 5.1. Performance Observations of Austin District Sites.

Notes:1 Kgr=Glen Rose Formation, Ked=Edwards Formation, Kwa= Walnut Formation

<sup>2</sup> R=raveling, DE=differential erosion, W=wedge

<sup>3</sup>Visual Stability Rating (Table 5.4)

<sup>4</sup> Maintenance Rating (Table 5.5)

<sup>b</sup> indicates benched cut

N/A = Not Available

Table 5.2.	Performance	Observations	of Dallas	and Ft.	Worth	District Sites.
THE REPORT OF THE PARTY	THE WAY A WARRANT PARTY OF	ALC: N. P. A. Y. ALCORDING PROPERTY.	Par as their transition to their	ALP 1 20	E T. F. Tartas field	and also on a set of a control of

Site Code	Location	Geologic Formation	H (m)	L (m)	Type of Failure <sup>1</sup>	Scale	MR <sup>2</sup>
D-1	Loop 303 ea. of Loop 12	Austin Chalk, Eagle Ford Shale	4.5	61	R,DE	local	2
D-2	IH 30 at Hampton Road	Austin Chalk	б	120	R	local	3
D-3	IH 30 at Loop 12	Austin Chalk, Eagle Ford Shale	11	150	C,R,DE	local	2
D-4	FM 1382, Cedar Hill	Austin Chalk	11	60	R	local	
D-5	New Clark Rd. at FM 1382	Austin Chalk	12	73	R,DE	local	3
FW-1	US 377 between Granbury and Cresson	Comanche Peak	5.5	156	B,R	R-local B-global	2
FW-2	SH 16 west of SH 337	Winchell, Wolf Mt.	20	500	R,DE	local	0

Notes: <sup>1</sup> R=raveling, DE=differential erosion, C=circular, B=block failure

<sup>2</sup> Maintenance Rating (Table 5.4)

Site	Location	Geologic	H	L	Type of	Scale/	VSR <sup>3</sup>	MR <sup>4</sup>
Code		Formtn.1	(m)	(m)	Failure <sup>2</sup>	· · · · · ·		
281-1	US 281, S. of Cibolo Creek	Kgr	6	276	R,DE	local	1	2
281-2	US 281 at Belverde Estates	Kgr	7.5	156	R,W	local	2	3
281-3	US 281 just S. of SH 46	Kgr	10.5	375	R,DE	local	2	0-1
281-4	US 281, 7.9 km S. of	Kgr	4.5	189	P,R	R-local	2	1
	Guadalupe River					P-global	-	
281-5	US 281 just N. of 281-2	Kgr	9	330	P,R	R-local	3	$1_{ I }$
1376-1	FM 1376 N. of Boerne	Ker	13.5	138	R	P-gtobal	0.5	0.1
1376-2	FM 1376 S of FM 473	Kgr	9	317	TR	local	0.5	0
1-10-5	TH-10 pear FM 289	Kar	75	137	RDE	Incal	1	3
2722-1	FM 2722	Kar	18 35	108	R potential	Relocal	4	2
	5 PL 67 66	лə	10.5	100	P	P-global	-	-
2673-1	FM 2673 at FM 2722	Ker	7.5	180	R.DE	local	0.5	2
3159-1	FM 3159 N. of SH 46	Ked	6	360	R	local	4	2-3
I-10-1	0.8 km E. of SH 16	Ked/Kgr	226	300	R,	local	4	2
		-			DE(Kgr)			
I-10-2	2.4 km E. of SH 16	Ked	7.5	216	R	local	3	2
I-10-3	IH 10 at Cypress Creek	Ked/Kgr	21 <sup>b</sup>	360	R,(C,DE-	local	1	3
					Kgr)			
I-10-4	IH 10 W of Cypress Cr.	Ked/Kgr	16.5	300	R	local		2
I-10-6	IH 10, 1.6 km W. of SH 16	Ked	21	105	R	local	4	2
I-10-7	IH 10, 1.6 km W. of FM 783	Ked	5.5	180	none	N/A	4	3
I-10-8	IH 10 just E. of FM 1338	Ked/Kgr	24	308	R.W.DE	local	3	1
I-10-9	IH 10 in Gillespie Co.	Ked	7.5	360	R	local	3	3
41-1	SH 41 at SH 27	Ked	10.5	300	R	local	2	2
187-1	FM 187 N. of Lost Maples	Ked	15	780	R	local	3.5	3
337-1	FM 337 at Mill Creek	Ked/Kgr	18	195	R,T(Ked)	R-local	1.5	0
					DE(Kgr)	T-global		
337-2	FM 337, Mill Creek Pass	Ked	7.5	190	R	local	3	1
470-1	FM 470, Tarpley Pass	Ked/Kgr	16.5	293	R, (DE-Kgr)	local	0.5	2
211-1	SH 211N. of FM 471	Ked	10 <sup>b</sup>	300	R	local	2	3
211-2	SH 211 N., of Bexar Co. line	Ked	17 <sup>b</sup>	550	R	local	2.5	3
211-3	SH 211 S. of SH 16	Ked	30 <sup>b</sup>	420	R	local	2.5	2
1283-1	FM 1283 at CR 270	Kgr	15	225	R	local	3	3
1283-2	FM 1283 1.4 km S of PR 37	Ked	10.5	170	R	local	3	2
173-1	FM 173 S of Bandera-	Ked	15	330	R	local	3.5	3
	Medina Co. line							
S-1	Loop 1604 at Bitters Road	Ked	8	>2 km	R	local	3.5	2
S-2	Loop 1604 at Gold Canyon	Ked	5.5	400	R	local	4	3

Table 5.3. Performance Observations of San Antonio District Sites.

Notes: 1 Kgr=Glen Rose Formation, Ked=Edwards Formation

<sup>2</sup>R=raveling, W=wedge, DE=differential erosion, T= toppling, P= planar, C=circular

<sup>3</sup> Visual Stability Rating (Table 5.4) <sup>4</sup> Maintenance Rating (Table 5.5) <sup>b</sup> indicates benched cut

Visual Stability Rating (VSR)	Percentage of Original Excavated Face Remaining
0	less than 25%
1	25 to 50%
2	50 to 75%
3	75 to 90%
4	greater than 90%

Table 5.4. Visual Stability Rating Scheme Based on Remaining Percentage of Excavated Face

Table 5.5.	Maintenance	Rating Scheme	Based on	Maintenance	Frequency.
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Degree of Local Stability	Maintenance Rating (MR)	Maintenance Frequency
Unstable; frequent maintenance, widespread degradation or localized failures	0	> 4 times per yr
Partially Stable; regular maintenance required	1	2 to 4 times per yr
Stable; some debris, regular but infrequent maintenance	2	1 time per 2yr to 2 times per yr
Completely Stable; little if any degradation, little maintenance	3	< 1 time per 2yr

Table 5.6. Catchment Adequacy Rating Based on Frequency of Debris in Roadway.

Catchment Adequacy	Frequency of Debris Reaching Roadway
0	>4 times per year
1	1 to 4 times per year
2	1 time in 10 years to 1 time per year
3	None to 1 time in 10 years

Site Code	Slope Height (m)	Horizontal Distance from Toe to Pavement (m)	Catchment Description <sup>1</sup>	Catchment Adequacy Rating <sup>2</sup>	W,/H,3
360-1	22.5 <sup>b</sup>	4.5	gentle ditch	2	0.20
360-2	24.3*	7.5	gentle ditch	0, 3	0.31
360-3	6.6	7.5	flat, grassy easement	3	1.14
620-1	10.5	7.5	gentle ditch	3	0.7
620-2	9%	6	flat, grassy easement	3	1.0
2244-1	6.6	3	flat, grassy easement	3	0.45
2244-2	5.4	4.5	gentle, grassy ditch	3	0.82
SWP-1	7.5	3	shallow rip-rap lined ditch	3	0.40
SRR-1	9	1.8	grassy easement slopes toward roadway	0	0.20
Au-1	15	1.8 to 3	varies from gentle to steep ditch	0	0.12-0.20
Au-2	7.5	N/A, slope is in drainage channel	N/A	N/A	N/A
Au-3	14	>15	flat easement	3	>1.10
Au-4	12	1.2	steep, grassy ditch	3	0.1
D-1	4.5	1.8	flat, grassy easement	1.3	0.40
D-2	6	4.5	flat, grassy easement	3	0.75
D-3	11	no information	no information	3	-
D-4	11	4.5	flat, grassy easement	No information	-
D-5	12	4.5	flat, grassy easement	3	0.38
FW-1	5.5	9	gentle, grassy ditch	3	1.63
FW-2	20	3 (prior to re- excavation), 45 (after)	flat easement	0, 3	0.15

Table 5.7. Catchment Information for Austin, Dallas and Ft. Worth District Sites.

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Notes: <sup>1</sup>Catchment Description: gentle = ditch slope flatter than 4H:1V, steep = ditch slope steeper than 4H:1V

<sup>2</sup> Catchment Adequacy Rating (Table 5.6)

<sup>2</sup> Ratio of catchment width to slope height (or height of lowest bench)

<sup>b</sup> Indicates benched cut

\* Catchment adequacy prior to corrective maintenance to catchment or slope (e.g., benching, guard rail, re-excavation)

Site Code	Slope Height (m)	Horizontal Distance from Toe to Payement (m)	Catchment Description <sup>1</sup>	Catchment Adequacy Rating <sup>2</sup>	W./H,3
281-1	6	6	gentle, grassy ditch	3	1.00
281-2	7.5	6	gentle, grassy ditch	3	0.80
281-3	10.5	6	gentle, grassy ditch	3	0.57
281-4	4.5	6.6	gentle ditch	3	1.47
281-5	9	7.5	flat easement	3	0.83
1376-1	13.5	3	flat easement	1	0.22
1376-2	9	0	pavement extends to slope	0	0
I-10-5	7.5	17	flat, grassy easement	3	2.27
2722-1	18.3 <sup>b</sup>	9	flat easement	1,3	0.49
2673-1	7,5	3	gentle ditch	1	0.40
3159-1	6	7.5	flat, grassy easement	3	1.25
I-10-1	6.6°	7.5	gentle, grassy ditch	3	1.14
I-10-2	7.5	4.8	gentle ditch	3	0.64
I-10-3	5.4 <sup>b</sup>	7.5	gentle concrete ditch	3	1.39
I-10-4	16.5	6	gentle, grassy ditch	3	0.36
I-10-6	21	6	flat easement	3	0.29
I-10-7	5.5	7.5	gentle ditch	3	1.36
I-10-8	24	12	gentle ditch	3	0.50
I-10-9	7.5	7.5	flat casement	3	1.00
41-1	10.5	9	flat, grassy easement	3	0.86
187-1	15	0	pavement extends to slope	1	0
337-1	18	0	pavement extends to slope	0	0
337-2	7.5	3	gentle ditch	3	0.40
470-1	16.5	0	pavement extends to slope	1,3	0
211-1	6 <sup>b</sup>	3.9	gentle concrete ditch	3	0.65
211-2	б <sup>ь</sup>	6	steep ditch	3	1.00
211-3	5.1*	7.5	gentle concrete ditch	3	1.47
1283-1	15	7.5	flat easement	3	0.50
1283-2	10.5	6	gentle ditch	3	0
173-1	15	0	pavement extends to slope (sloping toward slope)	3	0.56
S-1	8	4.5	gentle, grassy ditch	3	-
S-2	5.5	no information	no information	3	1

Table 5.8. Catchment Information for San Antonio District Sites.

Notes: 'Catchment Description: gentle = ditch slope flatter than 4H:1V, steep = ditch slope steeper than 4H:1V

<sup>3</sup> Catchment Adequacy Rating (Table 5.6)

<sup>3</sup> Ratio of catchment width to slope height (or height of lowest bench)

<sup>b</sup> Indicates benched cut

\* Catchment adequacy prior to corrective maintenance to catchment or slope (e.g., benching, guard rail, re-excavation)



Fig. 5.1. Example of Planar Failure in Glen Rose (Site 281-4)



Fig. 5.2. Example of Wedge Failure in Glen Rose (Site 281-2)



Fig. 5.3. Example of Raveling in Edwards (Site I-10-1)



Fig. 5.4. Example of Differential Erosion in Glen Rose (Au-2)

### 6. PERFORMANCE ANALYSIS

## 6.1 Introduction

The performance the 53 rock-cut slopes described in Chapter 4 and quantified in Chapter 5 is analyzed in this chapter. Comparisons are made between the observed performance and that predicted by conventional rock mass classification schemes. The weights applied to different parameters in the classification schemes are examined. Additional parameters that may affect performance but are not included in the conventional classification schemes are also identified. Details of the graphical and statistical analyses that support this chapter are presented in Appendix E.

### 6.2 Factors Affecting Performance

The percentage of total sites within a given geologic formation exhibiting the various modes of failure or degradation is shown on Fig. 6.1. It should be noted that many of the slopes exhibited more than one failure mode. The predominant mode of failure for all three formations is raveling. The two formations containing interbedded softer marl layers (Austin, Glen Rose) contained a significant amount of slopes exhibiting differential erosion which produces cantilevered situations where resistant layers overlying erodible material are undermined and break off due to loss of support. Less than 15 percent of the sites in each formation exhibited the classic kinematic modes of failure such as planar, wedge, and toppling.

The possible factors affecting performance were chosen with the predominant modes of failure as a basis. The potential geologic, geometric, and environmental factors are summarized in Table 6.2. The Rock Quality Designation (RQD) is defined as the percentage of the core run length that is in pieces 100 mm or greater in length. The Degree of Differential Erosion (DDE) is a measure of the erodibility of certain layers. It is defined by the distance back from the face that erodible layers have retreated. The degree of erosion was categorized and assigned a rating according to Table 6.2. The vast majority of slopes were excavated by pre-splitting. Half-cast impressions from the drill holes indicate the original excavated face, making estimation of erosion from the original face fairly simple. In the few cases where half-casts could not be observed, a subjective estimate of the original face was made. DDE is dependent on the relative bed thickness of the rock layers. Thicker layers (both erodible and resistant) generally exhibit greater differential erosion because very thin layers will break or ravel before a large "overhang" is developed. Insufficient data was obtained to fully address this issue of bed thickness. Future data collection in this area may be beneficial.

#### 6.2.1 Geologic Factors

Several of the geologic factors are used in the empirical rock mass classification schemes utilized for characterization of the sites. Bieniawski (1973) developed the Rock Mass Rating (RMR) system which characterizes the rock mass based on six factors including: uniaxial compressive strength, RQD, joint spacing, joint condition, water, and orientation of discontinuities. Weighting factors are assigned for each category and then added to comprise the RMR. Romana (1993) revised the RMR to be more applicable to rock slopes by including factors for joint dip and strike relative to the slope face, and damage due to method of excavation. This revised rating system is called the Slope Mass Rating (SMR) system. Galvan (1995) provides a comprehensive synopsis of these classification systems. The tables used for the classification procedures are presented in Appendix E.

Average RQD values for the sites were estimated visually in the field or calculated from the results of borings for the case-study sites (Appendix C). The RQD values are listed in Tables 6.3 through 6.5 for the Glen Rose and Edwards sites and were also used in the empirical rock mass classification schemes. Local data from a geotechnical consultant (TETCO, 1985-1995) was also gathered for RQD values in the Glen Rose and Edwards Formations in the Austin area. These data, which are shown in Appendix E, are comparable to the RQD values in the borings at the case-study sites and to the field-estimated values. Uniaxial compressive strength (UCS) was used in the rock mass classification schemes and was estimated based on local UCS data (TETCO, 1985-1995). These data are also shown in Appendix E,

Slake durability tests were conducted on core retrieved from one of the case history sites in the Glen Rose (site 620-1) and numerous grab samples taken from both exposed and fresh samples from other sites in the Glen Rose. As described earlier, the Glen Rose contains interbedded marly layers which are more susceptible to erosion than the harder limestone and dolomite layers. By conducting tests on both types of material, it was possible to determine the difference in slake durability between visually erodible and resistant layers. This difference is reported in Tables 6.3 and 6.5 for the sites exhibiting the differential erosion failure mode.

#### 6.2.2 Geometric Factors

Slope height, orientation, angle, and degree of differential erosion were evaluated in the field. The observations, except for slope angle, are shown in Tables 6.3 through 6.5. The slope angles generally ranged from vertical to 15 degrees from vertical.

#### **6.2.3 Environmental Factors**

Slope age was determined from construction plans or interviews with maintenance personnel from the respective maintenance sections. The presence of seepage was noted during the field reconnaissance. These two factors are noted in Tables 6.3 through 6.5. Climatic data was gathered from the National Weather Service, however, this information was not used because the weather among the areas studied was very similar in temperature and precipitation. Slope orientation is expressed as clockwise from north. The orientation is determined by turning a circle from 0 degrees (map north) clockwise until the open face of the slope is encountered (Fig. 6.2). For example if a slope strikes N45E and the slope faces the northwest, the orientation would be 45 degrees. If a slope trending in the same direction faced open to the southeast, the orientation would be expressed as 225 degrees. See Figure 6.2. With this definition of orientation, slopes with orientations between 0 and 180 degrees face NW, E, and NE and slopes with orientations between 180 and 360 degrees face SE, W, and SW. The potential effects of orientation are related to sun exposure (e.g., hydro-thermal alteration processes) and wind exposure (e.g., erosion).

### 6.3 <u>Performance of Formations</u>

# 6.3.1 Glen Rose

Relationships between slope performance (measured by the Maintenance and Visual Stability Ratings) and the different performance factors (Table 6.3) were investigated. In addition, relationships between MR and VSR were investigated. Results of these analyses are presented in Appendix E and summarized here. As shown in Fig. 6.3, no relationship between RQD and maintenance rating (MR) was observed. The difference in slake durability between non-erodible and erodible layers showed a pronounced relationship with VSR (Fig. 6.4) and DDE. In general, slake durability differences of more than 20 to 30 percentage points indicate large degrees of differential erosion (DDE = 2) and poor performance according to VSR (VSR < 2). The presence of scepage tends to increase the degree of differential erosion (Fig. 6.5). Possible relationships between the rock mass factors (RMR, SMR) and the Maintenance and Visual Stability Ratings were also observed although they are not definitive and there is much scatter. The RMR and SMR include several different factors such as uniaxial compressive strength, RQD, joint spacing/condition, water, etc. and would be expected to show a more conclusive relationship than any of the single variables alone; however, they do not. Finally, the presence of scepage had a significant effect on the Maintenance and Visual Stability Ratings (Figs. 6.6 and 6.7).

#### 6.3.2 Edwards

No relationships were found between the performance factors and the performance measures for the sites in the Edwards Formation. None of the factors or combinations of factors used to assess performance appear to control the actual performance in the field. Minor raveling was the predominant mode of degradation observed. In the field, the raveling appeared to come from layers that possessed closely spaced bed-confined joints that produced small blocks. The presence of these discontinuous joints is suspected to control the performance of the slopes exhibiting raveling. The rock mass classification schemes are not sensitive to the presence of bed-confined discontinuities. Graphs of all factors, including the RMR and SMR classifications, are contained in Appendix E.

### 6.3.3 Austin Chalk Sites

Since only five sites were observed in the Austin Chalk geologic formation, insufficient data were available for analysis. However, the Austin Chalk has a similar lithologic character to that of the Glen Rose (alternating hard and soft layers) and the sites observed exhibited raveling and four of the five exhibited differential erosion. Based on this limited information, the Austin Chalk sites are expected to behave similarly to rock cut slopes in the Glen Rose Formation.

#### 6.3.4 Comparison Between Formations

The performance factors and the performance measures (MR and VSR) for the Glen Rose and Edwards sites, as well as the sites where the Edwards was exposed on top of the Glen Rose Formation, were compared. With the exception of RQD, all performance *factors* were higher or more favorable for the Edwards Formation. The performance *measures* (MR and VSR) were also higher or more favorable in the Edwards versus the Glen Rose. Table 6.6 summarizes the average values of the pertinent factors and performance measures for the three groups of sites.

# 6.4 Catchment Analysis

The adequacy of the catchment areas was evaluated using a catchment adequacy rating factor based on the frequency of rockfall reaching the roadway (Table 5.6). The catchment adequacy as a function of catchment (or ditch) width,  $W_e$ , in relation to the slope height,  $H_s$  is shown on Fig. 6.8. The adequacy generally increases with increasing  $W_e/H_s$ . However, there is a fair amount of scatter due to the variance in slope performance (e.g., certain slopes produce more rockfall than others, some do not produce any) and the variability in catchment *shape*. The solid

points represent the average W<sub>c</sub>/H<sub>s</sub> ratio at each adequacy category. The curve does not go through the point at an adequacy rating of 2 because there is only one data point. While there is scatter in the data, a reasonable conclusion would be that a catchment width of at least 0.5H, where H is the slope height, would be necessary to achieve the best catchment adequacy rating of 3 (corresponding to 0 or 1 events of debris reaching the roadway in 10 years).

Previous work in the area of rockfall prediction and control has been done to address the design of catchments. Ritchie (1963) conducted field tests by rolling hard, basaltic rocks down slopes of different geometries and produced design charts for catch ditches with varying widths and depths as a function of slope height and angle. Of more relevance to the slopes in Texas, the Oregon Dept. of Transportation (ODOT) funded research on catchment geometry for slopes with angles of 0.25H:1V (Pierson, et. al., 1994). Rocks were rolled off the top of three different slopes (12 m, 18m, and 24m) all having an angle of 0.25H:1V. Catch ditch configurations varied from flat to 6H:1V and 4H:1V (sloping back toward the toe slope). Impact distance and roll-out distance were tabulated and design charts of ditch width vs. slope height were developed for various degrees of retention. Charts for retention rates varying from 30% to 100% are provided (Pierson et al., 1994); Fig. 6.9 is the design chart for retaining 90% of the rockfall. The 90% retention rate design chart is shown because Pierson concluded that a catchment designed to retain 100 percent of the rockfall is uneconomical and recommended a 90% retention rate for design. He implies that a 90 to 95 percent retention rate is probably most appropriate. For example, consider a an 18-m high slope with a ditch width of 7.2 m and a 6H:1V ditch slope, which corresponds to W/H = 0.4. The catchment would theoretically be sufficient to catch 90% of rockfall (Fig. 6.9). However, if 100% retention was desired, the ditch width would have to be increased to 14.7 m. requiring an additional excavation of 135 cubic meters per meter of slope length. The majority of the catchments observed for this project in Texas were either flat easements or gently sloping ditches (4H:1V or flatter).

A comparison of the design values from Fig. 6.9 with the actual catchment widths was made to assess the applicability of this design method in Texas. The results are tabulated in Table 6.7. The minimum slope height in the design charts is 12 m and unfortunately, only 12 slopes met that criteria. The 4H:1V design curve was used for both "steep ditches" and "gentle ditches." This approach is conservative for steep ditches. With only one exception, slopes with catchment adequacy ratings less than 3 have catchment widths less than the recommended design values. Hence, this proposed design approach seems to be appropriate for Texas rock cuts. Note slopes with catchment adequacy ratings of 3 have ditch widths that are both greater and less than the design width. This result illustrates the influence of slope performance on catchment adequacy.

Smaller ditch widths may be adequate for slopes that do not ravel or display differential erosion. While the initial results of the ODOT design procedures seem to compare well with observed conditions for slopes with rockfall potential, much more data is needed to access the applicability of the ODOT procedures.

### 6.5 Performance of Nailed Slopes

In the short times that the three case-study slopes with rock nails (Table 4.5) have been in place, they have performed well. There were no signs of distress or degradation in the nailed slopes at the time of the field reconnaissance. It is also of interest to compare the performance of the nailed slopes with unsupported slopes at the same site. At Case-Study site 1 (RM 620 west of Mansfield Dam), the unsupported slope has exhibited minor raveling and differential erosion, although its Visual Stability Rating is 3 (the maximum rating is 4). The unsupported slopes near the nailed bridge abutment at Case-Study site 2 (IH 30 at Hampton Road) have also localized degradation with raveling, differential erosion and circular failures in weathered rock. There is also evidence of erosion around the bridge abutment. At Case-Study site 3 (Loop 1604 at Bitters Road), unsupported slopes have exhibited raveling with a Visual Stability Rating of 3.5 (out of 4) and a Maintenance Rating of 2 (out of 3). In all cases, the successful performance of the nailed slopes versus the unsupported slopes at the same location could be attributed primarily to the facing panels that limit weathering and erosion.

### 6.6 Conclusions

In the Glen Rose Formation, relationships appear to exist between performance and 1) the presence of seepage, 2) the presence of erodible marl layers adjacent to harder resistant layers in the slope stratigraphy, 3) RQD, and 4) the RMR and SMR rock mass classification ratings. However, the relationships with the latter two factors are not very strong. There appeared to be no relationship between age and performance of the slopes as a whole. This does not mean that a particular slope does not degrade over time because most slopes do. However, when the Visual Stability or Maintenance Ratings are plotted versus the age of the slopes (Appendix E), there does not appear to be a relationship. This result implies that there is significant variability in the stratigraphy and/or other geologic factors such as RQD, joint spacing, joint conditions, water presence, etc. between sites. The predominant failure modes are raveling and raveling/block fall due to differential erosion. A very limited number of sites exhibited classical kinematic type rock slope failures such as toppling, planar, wedge modes. These failures or potential failures, and these

sites are located in areas of the districts where faults are mapped. The one site exhibiting the toppling mode of failure contains very closely spaced (less than 1m) vertical joints oriented nearly parallel to the slope face. The site exhibiting a classical soil-like circular slump failure was located in the San Antonio District (site I-10-3). This particular slope contains several benches and the layers within a mid-slope bench contained softer material that had weathered to a soil-like consistency and was not stable at the original excavated slope (about 20 degrees from vertical).

The performance of the Edwards Formation sites was not predicted by any of the data collected. Like the Glen Rose, the most predominant failure mode is raveling, although the Edwards sites have performed better than the Glen Rose as a whole. One site exhibited wedge failure, and one site had toppling failure. Most of the factors used to evaluate the performance were more favorable for the Edwards sites. The performance characteristics of the Edwards Formation, based on the number of sites observed, are minor raveling, with possible localized differential erosion of solution collapse features (although many of these are well cemented and very stable), and occasional local or global wedge or toppling failures depending on the orientation of joints/faults relative to the slope face. The toppling on site 337-1 in Bandera County extended the full height of the slope. Massive planar type failures were not observed. However, failures of this nature are certainly possible in areas where faults are present, depending on the orientation and dip of the discontinuity relative to the slope face.

Insufficient data were collected on the Austin Chalk and characterization of the formation is not possible with the limited information. However, of the five sites observed, all exhibited raveling and four of the five exhibited differential erosion. Further study of the Austin Chalk is necessary in order to characterize the performance of the formation.
Type of Factor	Factor	Source of Information
Geologic	Geologic formation	field reconnaissance, maps
-	Average RQD	core drilling, consultant's literature
	Joint spacing and condition	field reconnaissance
	Rock strength	lab tests on core, consultant's literature
	Slake durability	lab tests on core and grab samples
Geometric	Slope orientation	field reconnaissance
	Slope Angle	field reconnaissance
	Slope Height	field reconnaissance
	Degree of Differential Erosion	field reconnaissance
Environmental	Slope Age	interviews, construction documents
	Rainfall, temp. variations, and freeze occurrences	National Weather Service
	Seepage	field reconnaissance

Table 6.1. Summary of Potential Factors Affecting Performance.

Table 6.2. Degree of Differential Erosion.

Degree of Differential Erosion (DDE)	Magnitude of Erosion From Slope Face					
0	less than 0.3 m					
1	0.3 to 0.6 m					
2	0.6 m or greater					

Site	H (m)	Age (yr)	∆ Slake <sup>1</sup>	Seepage	Slope Orient. <sup>2</sup>	DDE3	Avg. RQD <sup>4</sup>	VSR	MR <sup>6</sup>	Avg. RMR <sup>7</sup>	Avg. SMR <sup>8</sup>
360-1	22.5	10	12%	YES	180°	2	70	1	2	69.5	75
360-3	6.6	18		NO	235°	0	80	3.5	3	66	74.5
620-1	10.5	1	22%	YES	270°	0	84	4	3	75	67.2
620-2	93	7		NO	155°	0	70	3	3	71	71
2244-1	6.6	7	3%	NO	240°	0	67.5	3	3	62	72
2244-2	5.4	7	5%	YES	250°	1	82.5	2	3	71	77.6
SWP-1	7.5	8	8%	NO	180°	0.5	77.5	3	3	71	81
SRR-1	9	6.5	()	YES	265°	2	62.5	2.5	0	58.5	54.5
AU-1	>15	22.5		NO		1		2	0		
AU-2	7.5	5.5	56%	YES	50°	2	67.5	1	0		
281-1	6	32		YES	165°	2	62.5	1	2	58	58
281-2	7.5	32		NO	0°	0	63	2	3	68	65
281-3	10.5	32	29%	YES	190°	2	70	2	0.5	60	69
281-4	4.5	32	48%	NO	180 <sup>a</sup>	0	65	2	1	65	49
281-5	9	32		NO	200°	0	95	3	1	67	57
1376-1	13.5	40		YES	0°	0	50	0.5	0.5	46	44
1376-2	9	40		NO	355°	0	70	0.5	0	67	50
I-10-5	7.5	25	32%	NO	160 <sup>n</sup>	2	62.5	1	3	67	66
2722-1	10.5 <sup>h</sup>	15		NO	168°	0	62.5	4	2	62	12
2673-1	7.5	25		NO	90°	1	62.5	0.5	2	56	56
1283-1	15	19		NO	195°	0	65	3 1	3	72	73
Mean	9.2	20				0.7	70	2.1	1.8	65	62
std. dev.	4.5	13				0.9	10	1.1	1.2	7.0	16

Table 6.3. Performance Analysis for Glen Rose Sites.

Notes: <sup>1</sup>Difference in Slake Durability between Erodible and Non-Erodible Layers <sup>2</sup>Slope Orientation (Fig. 6.2)

Degree of Differential Erosion (Table 6.2)

\*Rock Quality Designation

Visual Stability Rating (Table 5.4)

Maintenance Rating (Table 5.5)

7Rock Mass Rating (Biennwski, 1973)

Slope Mass Rating (Romana, 1993)

"Indicates benched cut

Site	H (m)	Age (yr)	Seepage	Slope Orient. <sup>1</sup>	DDE1	Avg. RQD <sup>3</sup>	VSR <sup>4</sup>	MR⁵	Avg. RMR <sup>6</sup>	Avg. SMR <sup>7</sup>
AU-3	14	22	NO		0	57.5			61	53
AU-4	12	42.5	NO	145°	0	70		3	68	68
3159-1	6	17.5	NO	225°	0	90	4	2.5	76	66
1-10-2	7.5	25	NO	100°	0	80	3	2	66	69
I-10-6	21	25	NO	270°	0	85	4	3	76	77
I-10-7	5.5	25	NO	120°	0	80	4	3	76	84
I-10-9	7.5	25	NO	285°	0	20	3	3	55	65
41-1	10.5	27.5	NO	255°	0	70	2	2	65	63
187-1	15	30	NO	40°	0	92.5	3.5	3	88	98
337-2	7.5	20	NO	90°	0	77.5.	3	1	76	75
211-1	6*	3	NO	250	0	30	2	3	62	70
211-2	6*	3	NO	235°	0	40.5	2.5	3	65	74
211-3	5.1 %	3	YES	140°	0	60	2.5	2	73	74
1283-2	10.5	19	NO	or	0	75	3	2	72	75
173-1	15	30	NO	350°	0	75	3.5	3	74	74
S-1	8	10	NO	222°	0	25	3.5	2	68	68
S-2	5.5	1	NO		0	60	4	3	62	62
Mean	9.6	19				64	3.2	2.5	69	71
stđ. dev.	4.5	12				23	0.7	0.6	7.9	9.8

Table 6.4. Performance Analysis for Edwards Sites.

Notes: Slope Orientation (Fig. 6.2)

<sup>2</sup>Degree of Differential Erosion (Table 6.2)

<sup>3</sup>Rock Quality Designation

<sup>4</sup>Visual Stability Rating (Table 5.4)

<sup>9</sup>Maintenance Rating (Table 5.5)

Rock Mass Rating (Bienawski, 1973)

7Slope Mass Rating (Romana, 1993)

Indicates benched cut

Site	H (m)	Age (yr)	∆ Slake <sup>t</sup>	Scepage	Slope Orient. <sup>2</sup>	DDE3	Avg. RQD4	VSR <sup>5</sup>	MR <sup>4</sup>	Avg. RMR <sup>7</sup>	Avg. SMR <sup>8</sup>
I-10-1	6.6 <sup>±</sup>	25	5%	yes	180°	2	82.5	4	2	77'	85
I-10-3	5.4 3	25	63%	yes	90 <sup>a</sup>	2	37.5	1	2	66	65
I-10-4	16.5	25	22%	80	270°	1	82.5	3	2	80	89
I-10-8	24	25		yes	280°	2	95	3	1	82	67
337-1	18	20		yes	90°	1	80	1.5	0	68	70
470-1	16.5	30	42%	yes	240°	2	46.5	0.5	2	56	56
Mean	15	25				1.7	71	2.2	1.5	71	72
std. dev.	7.2	3.2				0.5	23	1,4	0.8	10	13

Table 6.5. Performance Analysis Sites with Edwards Exposed over Glen Rose.

Notes: Difference in Slake Durability between Erodible and Non-Erodible Layers

<sup>2</sup>Slope Orientation (Fig. 6.2)

<sup>3</sup>Degree of Differential Erosion (Table 6.2)

<sup>4</sup>Rock Quality Designation

Visual Stability Rating (Table 5.4)

Maintenance Rating (Table 5.5)

Rock Mass Rating (Bienawski, 1973)

Slope Mass Rating (Romana, 1993)

<sup>9</sup>Indicates benched cut

Table 6.6. Comparison of Average Performance Factors and Measures.

Formation	Avg. RQD <sup>1</sup>	Avg. DDE <sup>2</sup>	Avg. RMR <sup>3</sup>	Avg. SMR <sup>4</sup>	Avg. VSR <sup>5</sup>	Avg. MR <sup>6</sup>
Glen Rose	69.5	0.7	64.8	61.7	2.1	1.8
Edwards	64.0	0	69.4	71.3	3.2	2.5
Edwards/Glen Rose	70.7	1.7	71.3	71.6	2.2	1.5

Notes: Rock Quality Designation

<sup>3</sup>Degree of Differential Emsion (Table 6.2)

3Rock Mass Rating (Biennwski, 1973)

<sup>4</sup>Slope Mass Rating (Romana, 1993)

<sup>5</sup>Visual Stability Rating (Table 5.4)

<sup>6</sup>Maintenance Rating (Table 5.5)

Site	H <sup>1</sup> (m)	Catchment Shape	Actual W <sub>c</sub> (m)	Design We <sup>2</sup> (m)	Catchment Adequacy Rating <sup>3</sup>
360-1	22.5 <sup>*</sup>	gentle ditch	4.5	6.5	2
360-2	24.3	gentle ditch	7.5	6.8	0
Au-1	15	gentle to steep ditch	1.8	3.7	0
Au-3	14	flat	>15	8	3
Au-4	12	steep ditch	1.2	2.7	3
D-5	12	flat	4.5	4.7	3
FW-2	20	flat	3	14	0
1376-1	13.5	flat	3	7.5	1
I-10-4	16.5	gentle slope	6	4.3	3
I-10-6	21	flat	6	14.5	3
I-10-8	24	gentle slope	12	7	3
1283-1	15	flat	7.5	9	3

Table 6.7. Comparison of Catchment Widths to Recommended Design Widths.

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Notes: <sup>1</sup>Height of Slope or Lowest Bench <sup>2</sup>Design Ditch Width (Fig. 6.9) <sup>3</sup>Catchment Adequacy Rating (Table 5.6)



Fig. 6.1. Modes of Failure Observed versus Formation Type.



Fig. 6.2. Definition of Slope Orientation.



Fig. 6.3. Maintenance Rating versus Rock Quality Designation for Glen Rose Sites.



Fig. 6.4. Visual Stability Rating versus Difference in Slake Durability for Glen Rose and Edwards over Glen Rose Sites.



Fig. 6.5. Effect of Seepage on Average Degree of Differential Erosion for Glen Rose Sites.



Fig. 6.6. Effect of Seepage on Average Maintenance Rating.



Fig. 6.7. Effect of Seepage on Average Visual Stability Rating.



Fig. 6.8. Catchment Adequacy versus Ratio of Ditch Width to Slope Height.



Fig. 6.9. Fallout Design Curves for 90-Percent Retention Rate (Pierson et.al., 1994).

## CHAPTER 7. DESIGN OF ROCK NAILS

### 7.1 Introduction

Rock nails are intended to stabilize rock masses and improve their properties (e.g., stiffness). This chapter presents a design methodology for rock nails based on analysis and experience. Two design approaches are suggested depending on the rock type and condition. The first approach treats the nails as structural members that support and stabilize the rock mass. The second approach treats the nails as low-capacity reinforcing elements that bind (or knit) the rock mass together and prevent localized raveling and degradation. Both approaches have relevance to highway cuts in Texas, although rock nails are not recommended necessarily for every cut.

## 7.2 Tensile Capacity of Grouted Nails

#### 7.2.1 Introduction

Nails stiffen and strengthen a rock mass by resisting tensile (along the nail), shear (across the nail), and bending (about the nail) stresses. They are considered passive elements in that they will only develop resistance in response to movements within the rock. The relative contributions of tensile, shear and bending resistances depend on the orientation of the nail with respect to movements in the rock, the stiffness of the nail and grout, and the stiffness of the rock and the magnitude of deformations in the rock (Spang and Egger 1990). In typical applications where the cut is near vertical and the bolts are oriented near horizontal, the tensile resistance will be dominant and shear and bending resistances are secondary.

Tensile capacities of grouted nails are typically expressed using the unit ultimate pullout resistance ( $\tau_{ult}$ ). The unit ultimate pullout resistance is an average shear stress acting over the contact surface area between the anchorage and the rock, and is calculated as follows

$$\tau_{ult} = \frac{T}{\pi dL}$$
(7.1)

where T is the maximum tensile load, d is the diameter of the anchorage and L is the length of anchorage. Unit ultimate pullout resistance can be estimated from pullout tests by dividing the load at yielding by the surface area of the anchorage (calculated using the nominal diameter of the borehole).

It is important to point out that the unit ultimate pullout resistance should be considered an index value and not an actual resistance encountered along the full length of the nail. The actual distribution of stress along the anchorage zone may be highly non-uniform, particularly when the bond between the grout and the rock remains intact and before relative displacements occur. Figure 7.1 shows results from a theoretical analysis reported by Coates and Yu (1970), as presented by Littlejohn (1993). Coates and Yu determined that most of the load transfer between grout and rock (as shown by the fastest rate of change in the mobilized load) occurs near the front of the anchorage zone. Their study indicates that the stress distribution depends on relative stiffness (in terms of Young's modulus, E) of the grout and the rock. A uniform distribution is not expected unless the grout is very stiff compared with the rock, which is true only for soils and very weak rocks.

## 7.2.2 Tensile Resistance versus Rock Type

Results of field and laboratory tests reported in the literature were compiled in order to identify typical values of unit ultimate pullout resistance encountered for grouted anchorages in various rock units worldwide. Table 7.1 presents a summary of the results of 43 pullout tests on cement-grouted anchors and 131 load tests on drilled piers (where the tests were carried out to failure). Table 7.2 presents a similar summary for 17 pullout tests on resin-grouted reinforcing elements. The sources and data for these tests are summarized by Whitt (1995).

Information taken only from tests carried out to failure is often biased toward lower strength rocks because, in very strong rocks, testing equipment may not be able to reach the ultimate capacity of the element. A design capacity is more easily achieved using field testing equipment than an ultimate capacity, and proof testing is all that is usually required by contract. Most of the data in Tables 7.1 and 7.2 are from sedimentary rock units, particularly arenaceous (sand-rich) and argillaceous (clay-rich) rocks. Generally higher capacities are found in arenaceous rocks (e.g., sandstones) and limestones. Lower capacities are found for argillaceous rocks (e.g., shales and mudstones) and chalks. Cement and resin grouts display similar values of pullout resistance.

The large values of standard deviation in Tables 7.1 and 7.2 indicate a substantial variability in pullout resistance, even within the same basic rock type. In part, this variability is due to the following factors:

1. Variations in intact rock strengths and rock mass properties;

- Differences in installation, such as borehole roughness and quality control during grouting;
- 3. Progressive failure; and
- The non-uniformities in stress distribution mentioned earlier, which lead to variations in unit ultimate pullout resistance for anchors of different diameters and lengths.

Therefore, these lists are only offered to present an idea of typical  $\tau_{ut}$  values, and are not a substitute for testing the rocks encountered at a particular project.

### 7.2.3 Tensile Resistance versus Intact Rock Strength

The strength of the intact rock is a major contribution to the unit ultimate pullout resistance of a grouted element. Many different correlations for estimating  $\tau_{ult}$  have been developed based on the uniaxial compressive strength (UCS) of the rock, as measured in ASTM D2938. For example, Littlejohn (1993) presents the following correlation between  $\tau_{ult}$  and UCS for massive rocks (rocks with widely spaced discontinuities)

$$\tau_{ub} = 0.1UCS$$
 (7.2)

This equation tends to underpredict  $\tau_{ult}$  for weaker rocks, particularly weathered clastic sedimentary rocks. The ratio of  $\tau_{ult}$  to UCS can be as large as 0.3 to 0.4 for weak rocks (Littlejohn 1993). Horvath et al. (1980) report another correlation between  $\tau_{ult}$  and UCS that takes the concrete strength into account

$$\tau_{\rm uh} = \mathbf{b} \cdot \mathbf{f'_w}^{\frac{1}{2}} \tag{7.3}$$

where  $f'_w$  is the controlling uniaxial compressive strength (the lower of the concrete and rock strengths) and b is an empirical factor that varies from 0.2 to 0.25 if  $\tau_w$  and  $f'_w$  are in MPa.

In order to evaluate the applicability of different correlations between  $\tau_{ab}$  and UCS, the  $\tau_{ab}$  test data in Table 7.1 are plotted versus UCS on Fig. 7.2. These plots include only test data in which rock strength information was also available. In cases where several tests were performed

at one site in the same rock unit, vertical bars on Fig. 7.2 show the mean pullout resistance +/- one standard deviation. Horizontal bars show the range in UCS values for each site.

The ultimate pullout resistance tends to increase with increasing rock strength, although there is substantial scatter in the data. The correlation proposed by Littlejohn (1993), Equation 7.2, provides a lower bound on pullout resistance for UCS values less than about 10 MPa (Fig. 7.2). However, this correlation is less conservative for higher strength rocks where the compressive strength of the grout ( $f'_{e'}$ ) becomes the controlling factor. The Horvath et al. (1980) correlation in Equation 7.3, which accounts for  $f'_{e'}$ , provides a more conservative fit of the data than Equation 7.2 for higher strength rocks (Fig. 7.2b). A similar analysis was not done for resin grouted anchorages because UCS values were only available for a few tests.

#### 7.2.4 Estimated Tensile Capacities for Rock Nails in Texas

The measured UCS values from the samples obtained during this project are presented in Appendix D and summarized in Table 7.3. Based on these values as well as experience with rock bolting for underground openings and tunnels in these formations, a typical  $\tau_{ult}$  value for each formation studied in this project is provided for use in design as well as a probable range of  $\tau_{ult}$ values.

## 7.3 Rock Nail Design Approaches

#### 7.3.1 Introduction

The design of rock nails depends on their intended function. There are two potential modes of failure in Texas slopes that can be controlled and prevented using rock nails: (1) global planar and wedge failures and (2) localized raveling and degradation. A design approach for each of these functions is described in the following sections.

#### 7.3.2 Design for Global Planar and Wedge Failures

Large-scale planar and wedge failures were not common in the 53 slopes that were studied. Global failures were observed in three of the rock cuts that were studied (i.e., Sites 281-4, 281-5 and 2722-1), and all of these failures were in the Glen Rose Formation. However, global failures are possible in cuts where there is a continuous, steeply dipping joint (typically greater than 30<sup>o</sup> dip) that is oriented near parallel to the cut face and daylights into the cut face (Fig. 7.3). Further, the consequences of a global failure can be severe. Therefore, although global failures are not likely in Texas road cuts, it is of interest to develop a design approach for those instances where they are possible.

## 7.3.2.1 Total Nail Load

Rock nails provide a lateral force to support an unstable wedge, as shown on Fig. 7.3. The required nail loads can be estimated from force equilibrium, as shown on Fig. 7.4 where the variables are defined as follows:

- P = total nail load (per unit width) required;
- W = weight of wedge (per unit width);
- N = normal force acting on joint (per unit width);
- q = contact pressure due to external loads;
- u = water pressure acting on joint;
- γ = unit weight of rock;
- H = slope height;
- α = dip of joint (measured from horizontal);
- β = orientation of total nail load (measured from horizontal);
- $N_q =$  non-dimensional factor representing external loads, where  $q = N_q \gamma H$ ; and

 $N_w =$  non-dimensional factor representing water pressure, where  $u = N_w \gamma H$ For this condition, the required total nail load, P, is obtained from the following expression

$$P = \left\{ \frac{(0.5 + N_q) \tan(90^\circ - \alpha) + 0.5 N_w \left[ \frac{F \tan(\alpha_{joint}) - 1}{\tan(\alpha)} \right]}{\cos(\beta)F - \sin(\beta)} \right\} \gamma H^2$$
(7.4)

where

$$F = \frac{\cos(\alpha) + \tan(\phi_{joint})\sin(\alpha)}{\sin(\alpha) - \tan(\phi_{joint})\cos(\alpha)}$$
(7.5)

The design implications of this equation are discussed in the following paragraphs.

Dip and Strength of Joint: The total nail load per unit width, normalized by γH2, is shown on Fig. 7.5 as a function of the joint dip,  $\alpha$ , and joint strength,  $\phi_{joint}$ . The required nail load is zero for  $\alpha < \phi_{\text{joint}}$ , and the maximum nail load occurs at a joint dip of  $\alpha = 45^{\circ} + \phi_{\text{joint}}/2$ . Typical joints observed in the studied road cuts were reasonably rough with little to no infilling, and are expected to have \$\phi\_loint\$ values between 30° and 40°. Most of the discontinuitites were oriented horizontally as bedding planes, which explains why global, planar failures are not very common in these formations. However, there were also joints observed that dipped at between 50° and 70° to the horizontal. These joints, which were associated with fault zones, are especially prominent in the Glen Rose Formation and the Austin Chalk; although they are also present to a lesser extent in the Edwards Formation as well. In general, these steeply dipping joints were not spaced closely enough to cause problems (i.e., they did not daylight in the 10 to 20 m high rock cuts that are typical in Texas), or they were not oriented parallel to the cut face so that the effective dip into the cut was fairly shallow. Also, it is important to point out that Equation 7.4 (and the associated design chart on Fig. 7.5) are only appropriate for planar type failures. If the unstable wedge is bounded by two discontinuities (i.e., a three dimensional sliding surface), then the required nail load obtained from Equation 7.4 will be conservative. References such as Hoek and Bray (1977) provide design charts for three-dimensional sliding surfaces.

External Loads: The effect of external loads is to increase the required nail load, as shown on Fig. 7.6. For traffic loads, a surcharge of approximately 0.6 m of soil is typically assumed for design in accordance with AASHTO Standard Specifications for Highway Bridges (1991). For a typical road cut between 5 and 25 m in height, traffic loads correspond to  $N_q$  values ranging from 0.02 to 0.1; therefore, external loads due to traffic are not expected to increase the total required nail load by more than 20 percent (Fig. 7.5). If a bridge abutment were founded at the crest of a rock cut (i.e., not founded on drilled piers that transmit the structural loads down through the rock), then  $N_q$  values could be as large as 0.5 and the total required nail load would be doubled. However, this type of a design is rarely implemented in Texas.

<u>Water Pressure:</u> Water pressure along the discountinuity also increases the required nail load, as shown on Fig. 7.7. Water pressure has two effects on the required nail load: it adds a horizontal compact of driving force to the wedge and it reduces the shear resistance along the discontinuity by reducing the normal load. A worst-case condition for water pressure would be that the water table rises to the crest of the slope (i.e., a hydrostatic water pressure of  $\gamma_w$  times the depth below the slope crest). This condition corresponds to an N<sub>w</sub> value of approximately 0.5, and a required nail force that is increased by more than a factor of 2 (Fig. 7.7). Also, since the water pressure reduces the normal load on the discontinuity, the discontinuity strength ( $\phi_{joint}$ ) becomes less important and the required nail load becomes less dependent on  $\phi_{joint}$  (Fig. 7.7). Therefore, water pressure can lead to large nail loads and the provision of adequate drainage within the slope is an important design consideration.

<u>Nail Orientation</u>: The nail orientations are typically not horizontal due to construction considerations; they are typically oriented at 10° to 15° to the horizontal. The effect of nail orientation on the required nail load is shown on Fig. 7.8. Since the horizontal component of the required stabilizing force is most important due to kinematical constraints (i.e., the wedge movement is horizontal, as shown on Fig. 7.3), the required nail load increases as the dip of the nails increases. Although the most effective nail orientation is horizontal, the difference between horizontal and orientations as large as 20° is not substantial (Fig. 7.8). Also, it is important to note that the nails have been assumed to provide resistance only through tension (i.e., bending and shear resistances are neglected). These other components of nail resistance may become more important as the nail orientation becomes oriented near perpendicular to the joint, and the increase in required nail load with increasing inclination may actually be less than that shown on Fig. 7.8. Therefore, the ease of construction associated with slightly dipping nails probably outweighs any benefit associated with horizontally oriented nails.

<u>Comparison with Apparent Earth Pressure Approach</u>: A common design approach in Texas slopes containing nails (both soil and rock slopes), is to use the apparent earth pressure envelopes developed by Terzaghi and Peck (e.g., Peck, 1969) for braced excavations in stiff clays. The typical envelope being used currently is shown on Fig. 7.9. The equivalent, total nail load associated with this envelope is obtained as follows

$$P = \frac{1}{2}(H + 0.6H)(0.4\gamma H) = 0.32\gamma H^2$$
(7.6)

This total load is shown on Fig. 7.5 together with the curves obtained from Equation 7.4. For typical conditions (i.e.,  $\phi_{qavet} = 30^{\circ}$ ,  $\alpha = 60^{\circ}$ ,  $\beta \approx 0^{\circ}$ ,  $N_q \approx 0$  and  $N_w = 0$ ), the total nail load estimated from the apparent earth pressure diagram is very conservative with a calculated nail load from apparent earth pressures that is about twice that obtained from Equation 7.4 (Fig. 7.5).

## 7.3.2.2 Distribution of Nail Loads

The force equilibrium approach described in the previous section provides an estimate for the total nail load required, but does not indicate the loads required in individual nails. In fact, there is an unlimited number of nail load combinations that would satisfy the total nail load requirement. However, there are other considerations in how the total load is distributed to individual nails:

- more lightly loaded nails will generally provide a more redundant system than fewer heavily loaded nails;
- uniformly distributed nail loads will generally be more effective at minimizing deformations during excavation; and
- nails near the top of the cut may improve both local (i.e., smaller wedges) and global stability.

Numerical analyses were performed to investigate how the rock stiffness and construction sequence affected the distribution of nail loads in a rock cut with a planar feature (Fig. 7.3). The Universal Discrete Element Code, UDEC (Itasca 1993), was used to model a rock cut with nails. The studied rock cut was 10 m in height with a planar feature dipping at  $60^{\circ}$  and daylighting at the toe of the cut. The strength of the discontinuity was assumed to be  $\phi_{joint} = 30^{\circ}$ . Six rows of nails were included, and the nails were modeled as tension members with no shear and bending stiffness.

For rock stiffnesses representative of the rocks in the studied slopes (i.e., between 1,000 and 5,000 MPa based on the laboratory testing results in Appendix D), the mobilized nail loads were uniform regardless of the construction sequence. Therefore, it is reasonable to assume that the total nail loads is divided uniformly among the individual nails for typical rock cut designs. For stiffnesses below 50 MPa, which is more typical of a soil, the nails near the middle of the slope mobilized larger loads than those near the top and bottom (similar to the assumed distribution shape shown on Fig. 7.9). Also, for soil-like materials, the top-down construction sequence affected the distribution and magnitude of nail loads.

### 7.3.2.3 Facing Design

For the planar failure mode, the wall facing is theoretically not necessary. The only requirement is that the nails be secured at the wall face so that they can transfer their full load to the unstable wedge. For fully grouted nails, this consideration is only relevant for the nails near the toe where the nail length within the wedge is short (Fig. 7.3). Even then, most typical element

head connections (as described in Chapter 3) will be sufficient to transfer the nail load to the rock wedge.

However, the facing plays an integral role in minimizing local raveling and degradation. Since these failure modes are by far the most common failure modes in the studied slopes and were present even in the slopes exhibiting global failures, some nominal facing support should be provided in all nailed slopes. This facing will serve two functions: it will provide confinement at the wall face to prevent local raveling and it will protect the fresh rock from weathering and erosion.

The facing could range from wire mesh to cast-in-place concrete panels. The pressure on the facing should be minimal because most of the local raveling is related to degradation of the slope; if the degradation is prevented, then the raveling will not occur. Therefore, a 100-mm thick, wire mesh or fiber reinfoced shotcrete facing should be sufficient in most instances. In critical areas, a conservative design approach is to assume that the facing must support an unstable wedge of rock that is defined in size by the nail spacing. These facing loads can then be estimated using the design chart on Fig. 7.5, where the wedge height H is the vertical distance between nail rows.

Drainage is an important consideration in the facing design. If adequate drainage is not provided, water pressure will build up behind the wall and increase the facing loads. Further, water pressure may build up within the slope along discontinuities and increase the required nail loads. Therefore, a drainage material should be placed between the facing and the rock slope and drainage outlets should be included in the facing. In addition, the drain outlets should be periodically monitored for flow during rainy periods to confirm that they remain open over the life of the wall.

#### 7.3.2.4 Design Example

In order to demonstrate the proposed rock-nail design approach for global stability, consider a 10-m high rock cut in a faulted zone of the Glen Rose. Based on field reconnaissance and local experience, the potential exists that a steeply dipping joint may daylight into the excavation. The discontinuity will be assumed conservatively to have a  $\phi_{joint}$  of 30° and dip into the face at 60°. The rock unit weight is assumed to be 23 kN/m<sup>3</sup>. A road will be located near the slope crest; a surcharge pressure 10 kPa will be used to represent this external load. Therefore, N<sub>q</sub> is equal to 10 kPa/(23 kN/m<sup>3</sup> x 10 m) = 0.043. The nails will be oriented at 15° to the horizontal. Two design cases will be analyzed: N<sub>w</sub> equal to 0 (no water pressure) and N<sub>w</sub> equal to 0.5 (a worst-case water pressure condition).

Nail Spacing: The total required nail loads are determined from Equation 7.4:

$$P = 0.222(23 \text{ kN/m}^3)(10 \text{ m})^2 = 511 \text{ kN/m for } N_w = 0.0; \text{ and}$$

$$P = 0.426(23 \text{ kN/m}^3)(10 \text{ m})^2 = 980 \text{ kN/m for } N_w = 0.5.$$

If reinforcing bars with a diameter of 25 mm ( $A_{suet} = 491 \text{ mm}^2$ ) with  $f_y = 420 \text{ MPa}$  are used in the rock nails, then the maximum load per nail is 206 kN. For a typical safety factor against steel yielding of 1.5, the allowable load per nail is 137 kN. If it is assumed that the nails are spaced uniformly horizontally and vertically at a distance of s, then the required nail spacings for the two design cases are calculated as follows:

$$s = \sqrt{\frac{(10 \text{ m})(137 \text{ kN per nail})}{511 \text{ kN/m}}} = 1.6 \text{ m for } N_w = 0.0; \text{ and}$$
  
 $s = \sqrt{\frac{(10 \text{ m})(137 \text{ kN per nail})}{980 \text{ kN/m}}} = 1.2 \text{ m for } N_w = 0.5.$ 

If water pressures are not anticipated in the slope, then the 1.6 m spacing would be sufficient. If water pressures are possible, then the costs of installing a drainage system within the slope versus installing nails spaced at 0.9 m should be compared to determine the optimal design.

<u>Nail Length</u>: The nail lengths are determined from their estimated tensile capacity. Each nail is required to develop a load of 137 kN. From Table 7.3, a unit ultimate pullout resistance of 1.0 MPa is assumed for the Glen Rose Formation. A safety factor of 2.0 against pullout is typically used in soil. Since there are no measured pullout resistances for these types of nails in the Glen Rose Formation at present, a larger safety factor of 3.0 is recommended. This safety factor could be reduced with pullout measurements, especially if they are performed at the particular project site. If a safety factor for pullout of 3.0 is used, then the unit allowable pullout resistance is 333 kPa. For a grouted annulus of 75 mm, the required anchorage length is obtained as follows:

 $L_a = \frac{137 \text{ kN}}{\pi (0.075 \text{ m})333 \text{ kPa}} = 1.7 \text{ m}$ 

where L<sub>a</sub> is the required anchorage length. Therefore, the nails should be anchored at least 1.7 m behind the discontinuity.

<u>Facing Pressure:</u> If adequate drainage is provided within the slope and behind the facing, then the facing pressure can be conservatively estimated from an unstable rock wedge that is bounded by the nails at the wall face (i.e., it is 1.6 m high by 1.6 m wide at the wall face). If it is assumed that the wedge is associated with the joint set that is dipping at 60°, then the design pressure is obtained from Equation 7.4 as follows:

 $w = 0.222(23 \text{ kN/m}^3)(1.6 \text{ m})^2/(1.6 \text{ m}) = 8.2 \text{ kPa}$ 

where w is the design facing pressure. This pressure could easily be accomodated by a 100-mm thick layer of shotcrete reinforced with wire mesh or fibers.

#### 7.3.3 Design for Localized Raveling and Degradation

Localized raveling and degradation was by far the most common mode of failure observed in the studied rock cuts. These localized features are typically controlled by bedding planes that are spaced 0.5 to 1.5 m apart and near vertical joints (or tension cracks) that are spaced as close as 0.3 m apart back into the cut face. Rock nails can help support these localized features and stabilize raveling. The nails create a reinforced mass of rock at the face of the cut that acts essentially as a gravity retaining wall.

The following design is recommended for using rock nails to stabilize localized instabilities at the rock cut face: 25-mm diameter steel bolts ( $f_y = 420$  MPa) grouted in 75-mm diameter holes, spaced at approximately 1.5 m horizontally and vertically, with a length of 3 m. This design is intended only for the Cretaceous-age sedimentary rocks in central Texas and for rock cuts that are 5 to 30 m in height.

The recommended design is based on the following rationale. First, empirical design procedures for using rock bolts to support cavern walls in underground construction indicate that the bolt length should be about 0.2 to 0.3 times the wall height and spaced at about 0.5 times the bolt length. Second, a simplistic and conservative analysis that treats the reinforced rock as a gravity retaining wall indicates that the wall width needs to be about 3.0 m to prevent overturning when external loads act at the wall crest. Third, the nails need to be spaced at about the same spacing as the bedding features that control the localized raveling. Fourth, an analysis of local instabilities (using Equation 7.4) with a wedge height of 1.5 m (the bedding thickness) indicates

that the nail force from a 3.0 m long nail will be sufficient to stabilize the wedge. Finally, a similar design approach was used successfully by Hall et al. (1994) to stabilize vertical cuts in the Edwards and Glen Rose Formations at an amusement park near San Antonio.

In cases where a large external load (e.g., a bridge abutment foundation) is to be applied near the slope crest, additional nails that are 6 to 9 m in length (or at least 3 times the foundation width) and spaced at about 3 m should be installed at the crest to prevent a local failure just below the foundation. These nails should be oriented at about 60° to the horizontal to intersect both near vertical joints and near horizontal becding plane features. Fig. 7.10 shows a schematic of this proposed design approach.

It is important to recognize that nails are not necessarily the best approach to stabilize localized raveling and degradation. In fact, nails will not be sufficient to prevent localized failures alone because the rock around the bolts will be susceptible to weathering and erosion. Therefore, some form of confinement at the wall face, such as shotcrete or wire mesh, should be used in addition to the nails. In cases where the rock mass is not heavily jointed, it should be possible to rely solely on face confinement with no nails (or nails that only serve to support the facing material) to create a stable rock cut that can support external loads. Nails could also be used only in areas of the rock face that are jointed and potentially unstable (i.e., spot bolting).

# 7.4 Corrosion Protection

Corrosion protection is an important design consideration for rock nails in roadway cuts. The nails will typically be used in critical, permanent structures (e.g., bridge abutments), and some of the rock formations (specifcally the Glen Rose) are aggressive concerning corrosion. When the nails are used for global stability, fully encapsulated nails should be used in accordance with FHWA guidelines for nail corrosion protection on U.S. Federal-aid Highway projects (FHWA, 1993). The nail should be grouted inside a corrugated plastic sheath using a neat cement grout. The minimum grout cover between the tube and the borehole wall should be 12 mm. When the nails are used for local stability, full encapsulation is not necessary. In these applications, a minimum grout cover of 37 mm should surround the nails and centralizers should be used to ensure grout cover along the entire nail length.

# 7.5 Summary

In summary, rock nails can be used to improve both global and local stability. In road cuts with continuous, steeply dipping discontinuities that are spaced closely enough to daylight at the cut face, nails should be anchored across the discontinuity. A design equation and design charts are provided to estimate the required nail loads. Conventional tiebacks could also be used in place of rock nails to stabilize these slopes effectively, and a cost comparison between the two should be conducted to determine the optimal design. Nominal facing support should be provided in either case to prevent localized raveling and degradation. While global planar failures are possible in Texas road cuts, they are not common.

The most common failure mode in Texas road cuts is localized raveling and degradation. If the rock mass is heavily jointed and fractured, closely spaced, lightly loaded rock nails can be used to provide support to local instabilities. Rock nails are specifically recommended in these rock conditions when a large external load (e.g., a bridge abutment foundation) will be applied near the slope crest. However, in many instances, rock nails are not necessary and confinement at the face (e.g., wire mesh or shotcrete) will serve the same purpose more effectively and less expensively. Altnemative control measures for local instabilities are described in the next chapter.

		Unit Ultimate Pullout Resistance, Tut (MPa)					
Rock Type	Number of Tests	Range	Mean	Standard Deviation			
Igneous	7	0.12-6.37	2.13	2.37			
Metamorphic	3	1.60-5.57	2.99	2.23			
Sedimentary			1. 1228-1220 1. 1228-1220	1.0000000			
Arenaceous	83	0.12-9.55	2.05	1.67			
Argillaceous	57	0.05-2.50	0.56	0.46			
Mari	13	0.10-1.03	0.38	0.31			
Mudstone	15	0.12-1.05	0.57	0.26			
Shale	24	0.05-2.50	0.63	0.61			
Calcareous	18	0.09-4.80	1.27	1.45			
Limestone	10	0.09-4.80	1.91	1.69			
Chalk	7	0.14-1.07	0.39	0.35			

Table 7.1. Unit Ultimate Pullout Resistance for Different Rock Types (Cement Grouted Anchorages).

Table 7.2. Unit Ultimate Pullout Resistance for Different Rock Types (Resin Grouted Anchorages).

		Unit Ultimate Pullout Resistance, Tat (MPa)					
Rock Type	Number of Tests	Range	Mean	Standard Deviation			
Igneous	6	1.22-2.29	1.73	0.45			
Metamorphic	0						
Sedimentary	11						
Arenaceous	0			6			
Argillaceous	3						
Shale	3	0.75-3.38	2.29	1.38			
Calcareous	8	0.72-3.32	2.27	0.73			
Limestone	7	0.72-3.32	2.27	0.79			

Table 7.3. Recommended Unit Ultimate Pullout Resistances for Texas Formations.

	Me	easured UCS	Recommended Tuk (MPa)		
Rock Formation	Mean	Range	Standard Deviation	Typical	Range
Glen Rose	12	5 - 30	7	1.0	0.5 - 2.0
Edwards	29	14 - 56	16	2.0	1.0 - 4.0
Austin Chalk	9	2 - 18	5	1.0	0.5 - 1.5



Fig. 7.1. Distribution of Pullout Resistance along a Grouted Reinforcing Element (after Littlejohn, 1993).



b. Cement grouted elements, average UCS > 3.0 MPa.

Fig. 7.2. Unit Ultimate Pullout Resistance vs. UCS.



Fig. 7.3. Rock Nails Stabilizing a Global Failure.



Fig. 7.4. Equilibrium of Unstable Wedge for Nail Design.



Fig. 7.5. Design Chart for Total Nail Load versus Joint Orientation.



Fig. 7.6. Effect of External Loads on Total Nail Load.



Fig. 7.7. Effect of Water Pressure on Total Nail Load.



Fig. 7.8. Effect of Nail Orientation on Total Nail Load.



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Fig. 7.10. Conceptual Nail Pattern for Local Stability of Rock Cuts Supporting External Loads (Figure Adapted from Hall et al., 1994).

## CHAPTER 8. ALTERNATIVE CONTROL MEASURES FOR ROCK SLOPES

# 8.1 Introduction

Rock nailing is only one of many measures that are available to control the performance of rock slopes. In this chapter, alternative measures of control, which can be used alone or in combination with other measures, are described. Table 8.1 provides a list of various control measures and a summary of their respective advantages and disadvantages.

### 8.2 Catchment Ditches

Catchment ditches are intended to catch rockfall and prevent it from entering the roadway. Ritchie (1963), Castaneda (1976), Pfeiffer et al. (1993) and Pierson et al. (1994) all provide design guidelines for catchments. Several interesting features of these design guidelines are that (1) angled slopes require larger catchments than vertical slopes because rolling rocks develop greater momentum than falling rocks, (2) slopes with benches and ledges also may require larger catchments because falling rocks may get launched over the ditch and (3) softer rocks (i.e., UCS less than 25 MPa) require smaller catchments because softer rocks do not bounce as high. Ritchie's design catchments tend to be narrow and deep. Due to safety concerns for motorists, more recent design guidelines (e.g., Pierson et al. 1994) provide for flatter ditches, such as those typically used in Texas.

Based on the data compiled in this project (Chapter 6), a preliminary design guideline for Texas slopes with rockfall potential is that the catchment width should be approximately 0.5 times the slope height. If the catchment is sloped, than this width can be reduced. The design chart shown on Fig. 6.9, which gives required catchment width as a function of the slope height and ditch slope, provides useful guidance for typical slopes in Texas.

### 8.3 Catch Fences. Nets and Barriers

Rockfall catch fences and nets can be constructed at the toe of the slope to catch rolling, bouncing, or falling rocks. Fences are systems using chain link or double-twist hexagonal gabion mesh, while nets use wire rope mesh. Because they are flexible, fences and nets are able to absorb and dissipate rockfall energy without sustaining damage. They can be installed at the outside edge of the ditch or on top of barrier walls. Flexible-post and suspended-fences can also be used in the middle of longer slopes to slow rolling and bouncing rocks. The fence and net should be constructed on the outside of their supporting posts to allow easier cleaning and repair, as illustrated in Fig. 8.1. Hearn et al. (1992) provide information regarding field tests and capacity analyses on flexible-post fences. Smith and Duffy (1990) give the results of field tests on rockfall catch nets, and Duffy (1992) discusses catch-net design. Brawner (1994) gives relevant construction specifications for catch fences and nets.

Barriers are rigid structures which prevent rocks from reaching the roadway. Barriers can be built on the outside edge of the ditch to effectively increase catchment depths. The most commonly used barriers are standard Jersey barriers (concrete barriers usually used as traffic barriers). However, these are only sufficient for stopping smaller blocks (Brawner, 1994). Gabion barriers (wire mesh boxes filled with cobbles), bin walls (metal, concrete or timber bins filled with freely-draining backfill), and debris mounds have also been used effectively.

# 8.4 Draped or Bolted Wire Mesh

Wire mesh can be placed on the slope to prevent raveling of loose rocks and to control rock fall. Mesh can be draped over the slope to direct falling rocks to the catchment ditch. The mesh can also be attached to the rock face with small diameter rock bolts to hold loose rocks in place. Brawner (1994) recommends that these bolts should have a minimum diameter of 19.1 mm and be resin-grouted for faster installation. Also, wire mesh should be double-twisted gabion wire rather than chain-link because the latter has a tendency to unravel if one strand is broken.

# 8.5 Cable Lashing and Anchored Cable Nets

Cable lashing and anchored cable nets are rockfall prevention techniques used to hold unstable rock blocks or slabs in place. Cable lashing involves using large diameter, high capacity steel cables to tie down large blocks or slabs. The post-tensioned cables are attached to rock anchors outside the unstable zone. Nets of steel cable can be used to hold groups of smaller blocks in place. The net is tied to supporting cables, which are attached and tensioned as in cable lashing. Anchored cable nets can be used for blocks with diameters as large as 2.5 m.

## 8.6 Spot Bolting and Dowels

Spot bolting involves using bolts to support localized areas of an instability in a slope. Design loads are dependent on the forces needed to achieve equilibrium of the area being supported. The discussion on nail design presented in Chapter 7 is applicable to the design of spot bolting. In addition to their use in rock reinforcement, dowels can also be used as shear keys installed below potential sliding blocks. A common situation is shown in Fig. 8.2, where a potentially sliding block exists on a slope. As the block attempts to move, the dowel resists the movement. The dowel is packed in concrete to assure that the applied stress is in shear rather than in bending. Design loads are determined from an equilibrium analysis of the block being supported.

### 8.7 Shotcrete and Dental Masonry

Many of the failures in the rock slopes studied in this project are related to differential weathering and erosion. Application of shotcrete to the freshly exposed surface of the weaker layer can be used to prevent these processes. There have been some objections to the use of shotcrete on aesthetic grounds, although shotcretes with a natural appearance have been developed. In locations where aesthetics are important, reinforced masonry provides an alternative to shotcrete. While more expensive, masonry can blend in well with the surrounding rock, especially if native material is used. Reinforced masonry was used in some areas of the Fiesta Texas Theme Park, north of San Antonio (Hall et al., 1994).

## 8.8 Differential Erosion Buttresses

Buttresses are structures designed to support the weight of an overhanging rock block or slab that has formed from differential erosion. They are often constructed of reinforced concrete or masonry. A typical application is illustrated in Fig. 8.3. Differential erosion of marl can occur below a more resistant limestone. If a vertical joint exists or is initiated in the limestone, the weight of the undercut section can cause this crack to propagate through the entire layer, leading to a situation of block toppling. A buttress can be used to support the weight of the limestone block and, therefore, prevent toppling (Fig. 8.3).

## 8.9 Slope Flattening

A common means of stabilizing unstable slopes in Texas has been to flatten the slope grade. A horizontal-to-vertical slope ratio of 1H:4V is a rule of thumb used by many highway departments to determine a safe slope angle in rock (Brawner, 1994). For example, slopes of 1H:4V were excavated along RM 2222 east of Loop 360 in Austin (TxDOT, 1972). While such rules of thumb may be appropriate in some local areas for massive rocks with few discontinuities, slope instability is more often controlled by the orientation of joints within a rock mass. Additionally, rock strength and weathering characteristics are very important in the lay-back decision. Some rock units are inherently unstable on the common 1:4 slope. For example, the Eagle Ford Shale in Texas is only marginally stable at a 5H:1V slope (Allen and Flanigan, 1986). Due to weathering characteristics, other rock units may actually be more stable at steeper slopes.
The Glen Rose Limestone, for example, appears to weather faster if laid back. Fig. 8.4 shows a photograph of a slope on Spur 534 in Kerrville (1.1 km east of SH 16) at the contact between the upper Glen Rose and the Fort Terrett member of the Edwards Formation. This slope exhibits extensive erosion furrowing and slumping of the weathered material, and has not supported vegetation. At the intersection with FM 1341, about 0.32 km farther east, a retaining wall supported by 0.6 m diameter drilled shafts was constructed to retain the slumping material on a similar slope (TxDOT, 1988).

## 8.10 Slope Benching

Excavation of horizontal benches on slopes is another traditional method of remediating unstable slopes. Benching can improve performance in two ways. First, reducing the height of slope between benches can prevent global stability problems. The required bench height and width will be related to the rock strength and, more importantly, the orientation and location of discontinuities. Second, benches act as a mid-slope catchment for rocks which dislodge from the slope (Fookes & Sweeney, 1976) and reduce erosion by dissipating the energy of surface runoff (Piteau and Peckover, 1978).

An important consideration in designing a benched slope is that benches must be regularly inspected for accumulation of debris (usually after large rainfall or freezing events, and on a regular basis as found necessary for the particular site) and must be accessible for maintenance equipment to remove the accumulated debris. In practice, benches are often either not accessible for clearing or not cleared frequently enough. As illustrated in Fig. 8.5, filled benches can act as ramps, launching falling rocks onto the roadway. For this reason, the Federal Highway Administration has recommended that benches <u>not</u> be used as a form of rock slope remediation or design, and recommends their use only at the contact between rock and overburden (Brawner, 1994).

### 8.11 Scaling, Chemical Expanders and Trim Blasting

Periodic removal of loose, unstable or overhanging blocks from the slope through scaling, application of chemical expanders, and trim blasting can minimize rockfall potential. Scaling is the removal of smaller, usually loose, blocks on the slope. Scaling is usually done by workers on ropes using prybars, bydraulic splitters, or jacks. On some slopes, mechanical equipment like backhoes and rock breakers can be used. No studies have been done in Texas to determine how often scaling must be performed on a given rock cut. Brawner (1994) reports that, in general, scaling is usually required every 8 to 10 years where freeze-thaw is common, and every 12 to 15

years in warm, dry climates. None of the TxDOT maintenance districts contacted for this project have indicated a regular program of scaling.

Where scaling methods are not feasible, chemical expanders and trim blasting can be used. Chemical expanders are chemicals, usually inorganic line compounds, that undergo volumetric expansion when they react. When these chemicals are placed in drill holes, the chemically-induced expansion breaks rock slowly, eliminating the rock mass damage and vibrations associated with blasting. Trim blasting is the use of small-scale explosives to remove larger blocks that are unstable or overhanging. The effectiveness of scaling, chemical expanders, and trim blasting is dependent on the quality of work. Inexperienced personnel can often cause more damage than is repaired. Brawner (1994) provides a set of sample specifications for scaling, chemical expanders and trim blasting.

### 8.12 Drain Holes and Surface Drainage

Slope failures are often driven by water pressures within the rock mass. Water can also cause damage through freeze-thaw (material degradation or block loosening from ice lenses) and erosion. Patterns of horizontal or inclined drain holes can be used to reduce the water table level behind a slope or to drain water-bearing discontinuities. Reduction in water pressures will help stabilize the slope and removal of water will reduce the potential for freeze-thaw damage. It is also important to control water at the surface. Piteau and Peckover (1978) recommend that ponds and water-filled depressions above the slope be drained, that the surface of the slope be reshaped to control drainage, that any cracks or permeable areas that would allow water to infiltrate the slope be sealed, and that surface drainage away from the slope be controlled by ditches and culverts. Establishing and protecting existing vegetation also reduces erosion. However, trees and large bushes should be removed from the slope and crest because they can loosen blocks through root wedging.

Control Measure	Advantages	Disadvantages
Rock Nails	<ul> <li>Support External Loads</li> <li>Improve Global Stability</li> <li>Minimize Ravelinglling</li> <li>Facing Can Prevent Weathering</li> </ul>	<ul> <li>May be Expensive</li> <li>Facing May Have Unnatural Appearance</li> </ul>
Catchment Ditches	<ul> <li>Minimize Rockfall from Entering Roadway</li> <li>Natural Appearance</li> </ul>	<ul> <li>Wide Right-of-Way May Be Necessary</li> <li>Ditch Maintenance Required</li> <li>Slope Degradation from Ravelinglling and Weathering not Prevented</li> </ul>
Catch Fences, Nets and Barriers	<ul> <li>Minimize Rockfall from Entering Roadway</li> <li>Can Be Installed Where and When Problems Arise</li> </ul>	<ul> <li>Unnatural Appearance</li> <li>Slope Degradation from Ravelinglling and Weathering not Prevented</li> <li>Maintenance Necessary</li> </ul>
Draped or Bolted Wire Mesh	<ul> <li>Minimize Ravelinglling</li> <li>Can Be Installed Where and When Problems Arise</li> </ul>	<ul> <li>Unnatural Appearance</li> <li>Mesh Can Corrode</li> <li>Limited to Small Block Sizes (less than 1 m)</li> <li>Slope Degradation from Weathering not Prevented</li> </ul>
Cable Lashing and Anchored Cable Nets	<ul> <li>Minimize Ravelinglling</li> <li>Block Sizes up to 2.5 m Can Be Stabilized</li> <li>Can Be Installed Where and When Problems Arise</li> </ul>	<ul> <li>Unnatural Appearance</li> <li>May Be Expensive</li> <li>Slope Degradation from Weathering not Prevented</li> </ul>
Spot Bolting and Dowels	<ul> <li>Minimize Ravelinglling of Small and Large Block Sizes</li> <li>Can Be Installed Where and When Problems Arise</li> </ul>	<ul> <li>May Be Expensive</li> <li>Slope Degradation from Weathering and Erosion May Still Occur</li> </ul>
Shotcrete and Dental Masonry	<ul> <li>Slope Degradation by Weathering and Erosion Minimized</li> <li>Ravelinglling May Be Minimized</li> </ul>	<ul> <li>May Have Unnatural Appearance</li> <li>Drainage Behind Shotcrete Can Be Problematic</li> </ul>
Differential Erosion Buttresses	<ul> <li>Minimize Ravelinglling from Differential Erosion</li> <li>Can Be Installed Where and When Problems Arise</li> </ul>	<ul> <li>May Have Unnatural Appearance</li> </ul>
Slope Flattening	<ul> <li>Prevent Global Stability Problems</li> </ul>	<ul> <li>Wide Right-of-Way Necessary</li> <li>Weathering and Erosion of Rock maybe Accelerated</li> </ul>
Slope Benching	<ul> <li>May Improve Global Stability</li> <li>May Reduce Erosion</li> <li>May Act as a Mid-Slope Catchment</li> <li>Can Be Installed Where and When Problems Arise</li> </ul>	<ul> <li>Maintenance Required</li> <li>May Launch Falling Rocks onto Roadway</li> </ul>
Scaling, Chemical Expanders and Trim Blasting	<ul> <li>Minimize Rockfall due to Ravelinglling</li> <li>Can Be Implemented Where and When Problems Arise</li> </ul>	<ul> <li>Slope Degradation from Weathering not Prevented</li> <li>May Damage Slope</li> </ul>
Drain Holes and Surface Drainage	<ul> <li>Reduce Slope Degradation from Weathering and Erosion</li> <li>Minimize Ravelinglling from Water Pressure and Freeze/Thaw</li> <li>May Improve Global Stability</li> </ul>	<ul> <li>Long-Term Maintenance and Inspection Necessary</li> </ul>

Table 8.1. Advantages and Disadvantages of Available Control Measures for Rock Slopes



Fig. 8.1. Rockfall Catch Fence Construction.









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Fig. 8.4. Spur 534 Slope in Kerrville.



Fig. 8.5. Debris-Filled Benches as Launching Ramps.

## **CHAPTER 9. CONCLUSIONS AND DESIGN RECOMMENDATIONS**

### 9.1 Summary

The objective of this project was to develop a rational design procedure for road cuts in the soft rocks of central Texas. A comprehensive field reconnaissance was conducted, and the behavior and characteristics of the rocks in natural and man-made exposures were systematically observed and documented. The rock units in this study have included primarily the Cretaceous-age sedimentary rocks that outcrop in a broad band from west of San Antonio through Austin, Waco and Dallas. The lithologies include limestones and dolostones of varying purity, through clay-rich marls and clay shales.

Observations have included exposure geometry, rock mass quality, impact of weathering, and potential failure modes. Rock cores were also obtained and laboratory tests were conducted on core samples and grab samples from exposures. In addition, the performance of existing excavations and design procedures was also evaluated. Performance information that was collected and analyzed included qualitative descriptions of stability, quantitative information on maintenance frequency and effort, and quantitative information on catchment adequacy. The major conclusions from this work are summarized in the following section, and design recommendations are provided in the final section of this chapter. The methodology developed here can be applied to other geologic formations encountered in TxDOT construction.

## 9.2 Major Conclusions

<u>Failure Modes</u>: The most common mode of failure in road cut exposures has been localized raveling and differential erosion. The Cretaceous-age rocks in central Texas contain varying amounts of clay, making them susceptible to disaggregation under the wet/dry cycling that is characteristic of the central Texas climate. Units that contain clay-rich rocks weather and erode very rapidly on exposure. As weathering proceeds, the more resistant units are left as tables or cantilevered overhangs that eventually break off. This failure mechanism is particularly dominant in the Glen Rose Formation and the Austin Chalk. Raveling of loose blocks is associated with the Edwards Formation where paleokarst and recent (in geologic time) solutioning has created cavities and fractures. The block sizes in both instances tend to be comparable in dimension to the bedding thickness, on the order of 0.5 m. Increased weathering and block fallout are associated with groundwater seepage from the cut or overland run-off flowing down the cut surface. For

excavations in uniform, layered rock, differential weathering is less of a problem because the rock face weathers uniformly.

Large-scale planar or wedge failures due to continuous, steeply dipping discontinuities are not common in central Texas road cuts. This failure mode was observed in only 3 of the 53 road cuts studied. In all cases, these failures were associated with faulted zones within the Glen Rose Formation. While localized raveling and differential erosion could eventually lead to larger-scale failures, this type of failure was not observed in any of the road cuts; hence, the time required to achieve such a failure is probably greater than 50 years.

<u>Performance versus Formation</u>: Cuts in the Edwards Formation are generally more stable than those in the Glen Rose or Austin Chalk. For the Glen Rose, the upper 10 to 15 m can have highly variable properties and low strengths due to weathering and the presence of marls. Shallow cuts that are laid back can actually weather into soil-like materials that eventually exhibit slumping. Weathering of the Edwards is much less pronounced than for the Glen Rose or Austin Chalk. The main source of variability in the Edwards is related to solutioning and collapse zones; these zones tend to ravel more readily and require greater maintenance than unsolutioned zones.

<u>Predicting. Performance:</u> Conventional information from borings provides limited information in predicting the performance of rock cuts in central Texas. The quality of the rock core (i.e., the rock quality designation, RQD) does not correlate well with stability. While high RQD values are generally associated with good performance, low RQD values are not necessarily associated with poor performance. For example, the Edwards Formation generally had the lowest core quality, yet the slopes are performing the best because rock matrix in solution collapse zones fractures readily when cored but is cemented in situ. It is especially important in these rocks to use high-quality coring techniques to minimize damage to the core sample during drilling. Borings may be useful in detecting marl layers in the Glen Rose. These layers can lead to significant problems from weathering and differential erosion.

In general, existing rock mass classification schemes such as the Rock Mass Rating (RMR) and the Slope Mass Rating (SMR), are not effective at predicting the performance of the soft rocks in central Texas. These schemes, which were developed over the past 20 years by correlating performance with rock properties and conditions, are most appropriate for rock masses where failure modes are driven by discontinuities and joints. Since the most common failure mode for the central Texas rock cuts is localized raveling and degradation, these conventional schemes are not appropriate.

Raveling and differential erosion are characterized by layered rock units with large differences in weathering resistance. It was found that differences in slake durability of greater than 20 to 30 percent between individual layers within a slope indicate a high potential for differential erosion. However, the absolute magnitude of slake durability, or other related properties such as unconfined compressive strength, are not effective indicators of this failure mode.

<u>Maintenance Requirements:</u> Maintenance requirements tend to be greater for cuts susceptible to raveling and differential erosion, cuts with groundwater seepage, and taller cuts. Benches can be effective at reducing the slope height and, therefore, reducing the maintenance requirements. However, benches are only effective if they are wide enough to catch rock fall from the slope above and are cleaned frequently. Several of the studied slopes, specifically along Loop 360 in Austin, have benches that are filled with debris and cannot be accessed for cleaning. Filled benches are problematic because subsequent rock fall will not be caught, and blocks may be projected out further from the slope toe and closer to the road.

<u>Catchment Adequacy</u>: Flat catchments to collect rock fall are effective if the width is greater than one-half the slope height. Increasing the grade of the catchment toward the slope can provide an effective catchment at narrower widths. Also, cuts that are not susceptible to raveling and differential erosion perform well even with narrow catchment areas because rock fall is not a problem.

Drainage: Water seepage and pressures can lead to rock mass deterioration. It is therefore important to maintain open drainage behind facing or walls.

<u>Rock Nail Performance</u>: The few rock cuts containing rock nails have all performed well to date. The nails and facing materials have prevented raveling and erosion that has occurred in other cuts at the same sites.

## 9.3 Design Recommendations

Design recommendations for road cuts in rock are provided in the following sections. These recommendations pertain specifically to the soft rocks of central Texas that were studied in this project.

## 9.3.1 Site Investigation

Site investigation is an important step in developing a design for a cut slope in rock. The following preliminary information should be obtained at a minimum from the investigation:

- stratigraphic information, including formation type;
- bedding thickness;
- · presence of voids or soft, weathered zones; and

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presence, dip and orientation of joints or other discontinuities.

In general, this information can be obtained from published geologic maps and literature, local experience, the data included in this report, and a field reconnaissance of the site and vicinity.

On the basis of this preliminary information, further investigation is recommended in the following instances:

- 1. If a potentially continuous discontinuity trends nearly parallel to the slope face and dips toward the cut, the orientation, dip and roughness of the discontinuity should be investigated. Borings are one possible approach, although they will only detect discontinuities with dips less than about 70° unless the borings are inclined. Shallow geophysical techniques might also be used to locate and orient these features. At a minimum, a more detailed field reconnaissance is warranted to identify the possible orientation and dip of these features. If continuous discontinuities are expected, site inspection by qualified geologists or geotechnical engineers should be planned during construction.
- 2. If a slope in the Glen Rose or Austin Chalk is to be unsupported and the catchment area will be less than 0.5 times the slope height, then the potential for differential weathering and erosion should be investigated. Borings should be drilled to identify if thick (greater than 0.3 m) marl layers are present. Also, slake durability tests should be conducted on core samples to determine the difference in slake durability between individual layers in the proposed cut. If thick marl layers are present or the difference in slake durability exceeds 20 percent, then some form of face support is recommended.
- 3. If a slope is to be supported with rock nails, then borings are recommended to estimate the thickness of beds and to identify anomalies, such as collapse features or soft, erodible layers of rock. Unconfined compression tests are also recommended on core samples to provide information on nail capacity.

Borings that are drilled should be drilled with double or triple tube core barrels using a diamond insert cutting bit. Percent recovery and RQD should be documented for each core run. Percent recovery is useful in identifying collapse features, fault zones and soft, erodible layers.

### 9.3.2 Rock Cut Design Recommendations

In most instances, near-vertical, 10 to 30-m high rock slopes or cuts in these formations can be left unprotected and unsupported if an adequate catchment area at the toe is provided to prevent rockfall from entering the roadway. A flat catchment area should be at least 0.5 times the slope height in width; catchments graded back toward the slope can be narrower, and the design chart included in Fig. 6.9 of this report is recommended for their design. Benching to decrease the effective slope height is not recommended unless the benches are made wide enough to catch falling debris (again, a bench width on the order of 0.5 times the bench height is recommended) and can be accessed for clean out. Cuts that are flatter than near-vertical (i.e., less than 70° from horizontal) are not recommended, because the reduction in drainage efficiency tends to promote weathering, especially in the Glen Rose Formation.

In areas where adequate catchment cannot be provided due to right-of-way or other geometrical constraints, the slope should be protected from raveling and differential erosion. The preferred approach for protection is a 100-mm thick layer of fiber reinforced shotcrete. Adequate drainage should be provided behind the shotcrete. Draped or bolted wire mesh is an alternative approach that may be less expensive and more pleasing visually; however, it will probably not be as effective as shotcrete at minimizing differential erosion. Spot bolting (or nailing) is recommended for supporting larger blocks (on the order of several meters in size) that may be unstable. Seepage and surface water control will also be helpful in minimizing raveling and erosion.

In areas where external loads are to be supported near the crest of the rock cut, rock nails are recommended in addition to the shotcrete. The rock nails in the face should be 25-mm diameter steel bolts ( $f_y = 420$  MPa) grouted in 75-mm diameter boreholes, oriented near horizontal, spaced at 1.5 m horizontally and vertically, and 3-m in length. Additional rock nails should be installed near the slope crest if the external loads are large (e.g., a bridge abutment foundation). These nails should be oriented at about 60° to the horizontal and at least 3 times the foundation width in length.

If continuous, steeply dipping discontinuities will daylight at the cut face, then rock nails (or tiebacks) should be installed across the discontinuity to support the potentially unstable wedge. This recommendation is intended for both slopes with and without external loads if a large-scale planar or wedge failure is possible. A design equation and design charts are presented in Chapter 7 to estimate the required nail loads. The nails should be similar to those described above, except that they should be fully encapsulated in a plastic sheath to minimize corrosion. Again, fiber reinforced shotcrete should be applied at the cut face to prevent localized raveling and differential erosion. Drainage should be provided behind the shotcrete and within the slope to prevent build up of water pressures.

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# APPENDIX A

Field Data Forms

## List of Field Reconnaissance Data F

Site Code	Location	No. of Pages
360-1	Loop 360, N. of RM 2222	4
360-2	Loop 360, at RM 2244	4
360-3	Loop 360, 1.6 km N. of Wild Basin Road	4
620-1	RM 620 at Mansfield Dam	7
620-2	RM620 S. of Lakeway	3
2244-1	RM 2244 at Crystal Creek Road	4
2244-2	RM 2244 at Addie Roy Road	4
SWP-1	Southwest Parkway, E. of US 71	4
SRR-1	Steiner Ranch Road at Quinlan Park Road	4
Au-1	RM 2222 between Loop 360 and Mopac	4
Au-2	Rm 2222 at Loop 360 drainage channel	4
Au-3	Lake Georgetown Spillway	4
Au-4	US 87, N. of Mason	4
D-1	Loop 303, E. of Loop 12	4
D-2	IH 30 at Hampton Road	4
D-4	FM 1382, Cedar Hill	4
D-5	New Clark Rd, at FM 1382	4
FW-1	US 377 between Granbury and Cresson	2
FW-1	SH 16, W. of SH 337	3
281-1	US 281, S. of Cibolo Creek	4
281-2	US 281 at Belverde Estates	4
281-3	US 281, just S. of SH 46	4
281-4	US 281, 7.9 km S. of Guadalupe	4
281-5	US 281, just N. of 281-2	4
1376-1	FM 1376, N. of Boerne	4
1376-2	FM 1376, S. of FM 473	4
I-10-5	IH-10 near FM 289	4
2722-1	FM 2722 between FM 2673 and SH 46	4
2673-1	FM 2673 at FM 2722	4
3159-1	FM3159 N. of SH 46	4
I-10-1	0.8 km E. of SH 16	4
I-10-2	2.4 km E. of SH 16	4
I-10-3	IH 10 at Cypress Creek	4
1-10-4	IH 10, just W. of Cypress Creek	4
1-10-6	IH 10, 1.6 km W. of Sh 16	4
1-10-7	H 10, 1.0 Km W. 01 FM /83	4
1-10-8	IH TO JUST E. OF PM 1558	4
1-10-9	In 10 in Gillespie Co.	4
41-1	DH 41 at DH 2/	4
18/-1	DM 227 at Mill Crack	4
337-1	FM 227 top of Mill Creak Page	4
337-2	EM 470 Torolov Pass	
470-1	SU 211 N of EM 471	0
211-1	SH 211, N. OF Payar Co. Line	4
211-2	CH 211 C of CH 16	4
211-5	EN 1292 et CP 270	1
1203-1	EM 1283 14 km S of Park Doad 27	4
1263-2	EM 172 S of Bandars Madina Co. Line	4
1/5-1	Loop 1604 at Bitters Road	4
5-1	Loop 1604 at Gold Canvon Road	4

Code <u>Av-4</u> Page 1 of 4



Dimensions and Orientation

Total beight (ft) <u>IS'Minit IS'EAST</u> Lateral Extent (ft): <u>rss</u> Benches: number of levels: <u>O</u> beight (ft): \_\_\_\_\_width (ft) \_\_\_\_\_ Face orientation: suikerdip <u>N MS' w</u> Catchment Description <u>IS'er Free H'er war hereny diff</u> Support Installed: <u>Name</u> Method of Excavation (if blasted, describe blast effects) <u>Black J recercies and receive</u> hash, Master d' <u>Stande</u>

Age of Exposure 20- 43-000000

Vegetation Effects Nrue



- Elevation Sketch of Exposure (ft) (add scale)

Page 2 of 4 Code 360-1

#### TxDOT Rock Mass Field Description Glen Rose Formation

#### Joint Description Summary Dip Seperation/ Persistence Weethering Set# Strike Roughness Remarks Filling L \* 90' P.R. TITL MATCHP NEST-NW 14 S. Dans -F.P. 8. C. TITL 2 N 75E 14 1.02 N₽ 5 \* COM ALY : LAT (40%) NGOW P.A. NP 7 80 TITL 15 Other Structural Features Feature Strike Dip Condition Persistence Remarks YES BC Occasional Random Joints? GENERALY MASSIVE M/ OCC. SEDS CI' THER Badding Description: RED 3' THICK 6' ABOVE BASE SEVENS MALLY Weathering/Erosion: R. ASION) Form of Slope Failure/Degradation: GLOCK / N.B.D.M. EARCOLL GUISOULY ADOUT PUBLI LAYOR RATE LINE I WEARL MONT RENCE MATSIVE AND OF DEBLIS ON BENCH (SILT TO 2' BOULDEL SING NOT MUCH DEBLOS IN ONTENDENT CONSI LIVE OF SELNICERATED SILT TO 1' BOULDUL SIDE Debris: Maintenance Record: 7 Available Geotechnical Data:

#### Summary of Engineering Geologic Data

## Page 3 of 4 Code 340-1

## **TxDOT Rock Mass Field Description**

Gien Rose Formation

#### Scanline Descriptions

1+00 0+00 0+50

Scaniine Sketch (include seepage locations)

Debris Description

obs #	Sta.	Set	Strik	e wir b	0 0000	SLITE	Dipv	NT to C	xposu	re	Persist.	Condition
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2					1							
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11		_										
12												
13	1			1	1							
14												
15	1				-							
16												
17												
18					1							
19												
20	1		1			-			1	1		

Set	Apparent spacing (#/scan length)	True Spacing (Mscan length)
1	25'	11'
2	200'	180
3	56'	53
4		
5		

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Page

#### TxDOT Rock Mass Field Description Glen Rose Formation

Scanline Descriptions



#### Scanline Information:

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		1	++-20	20-65	4540	RA	+/-20	20-6	45-60	RA.		
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2		1										
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4				1								
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8	-											
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961 8	Strike	Dip	Roughness	Separation/ Fitting	Persistence	Weathering	Re	HTUBIKS
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177	N45'N	15'35	55/P	TITE	P	-II-	HAY.	
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<u></u>	PA. HAST	194*	WR/U	TITE	P	14	Dey	THU /
					<u> </u>			HULT
		-						
ther Str	uctural Feat	ures						
eature	Strike	Dip	Condition	Pensistence		Rem	aries	
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Bedding D Aleatherin	escription: g/Erosion:	Tap: Ho MIDOLT Botton Tap: reiopci	NORT KEY, i soorge Li ni Kan; (um Nort- i madde	3'-8', 11099 6, mal (0,511 4 23) at 1'-3 NO M	iy oc 13. Lifesius) "Naturalis An Adl 9525	Void 2°± 3'-6' 133 Non. Koteme	25°) 55 (**	ettr sday : -2 <sup>4</sup> palamer
Bedding D Aleatherin	escription: g/Erosion:	Tap: HA A-10043 BATTA Tap: Tap: Tap: Batta	NONE MONE MANDE	3'-9', VU3) 6, mac (Assu A 3) = 1'-3 NO M	14. 000 /g. (195453114) (195253) Mal 9523	void 2'± 3'-6' 113 non. Kritisme	<u>25'y ec.</u> 25'ys c'-	-2 ' \$45
Bedding D Alsatherin Form of Si	escription: g/Erosion: lope Failure/	Taf: M MIDX3 Botton Taf: r410pi3 Botton Degrada	NONE KEY, i S SOFTER LI NONE MONE	3'-8', 1/099 E, mull (0,511 A 25) NO M NO M NO M I MATCH SAM	HING IT A	Void 2't 3'-6' 13 001. Kotone 1017-030 1016 PE K	25' 05 1"-	-2' paisment
Bedding D Aleatherin Form of Si Debris:	escription: g/Erosion: lope Failure/ <u>ToP 8 Tack</u>	Tap: Ma Milloux Button Taf: Suttons Taf: Suttons Degrada MS V.L H I L	HOD KEY, i S SOFTER LI S KAN; (LAPA NONE MADDE S HONE MIDDE MIDDE DOTTIN TTEL, SMA G. ANDUST OF	3'-8', 11099 E, MURL (ASSI A 23) H 1'-3 NO M NO M I MARD . SAN I BLOCK FA I BLOCK FA IL < C" E DIRLIS : FAL	W. ACC 13. LIFEGUNY) "MOREALIS AN MEL 9523 MELING AT A HELING ANS HELING	Void 2'± 3'-6' AI Mar. Koteme Mar. Koteme Lance of E Mar. The Co Mar. The Co M	25" 05 1"-	7.001 2' Paison 7.001 20 AT 50 5' 9 Lock
Bedding D Aleatherin Form of Si Debris:	lescription: g/Erosion: lope Failure/ <u>ToP 8 Two</u> <u>Mr 0 DER</u>	Тар: на Англост Ватта- Тар: Тагоріз Ватта- Degradas	HONE TOP 2' 80	3'-8', 11039 6, mar (6551 A 23) # 1'-3 NO M NO M I MAR (654 I MAR (64 I MAR (64) I MAR (	HING P D	Void 2'± 3'-6' 13 3'-6' 13 00. Kome 00. Kome	25' 55 1"-	7.00 2' Paison 7.00 10 AT 50 2' 9 Lock 10 Mg
Bedding D Alsatherin Form of Si Debris: Haintenan	lope Failure/ <u>TOP 8 Two</u> <u>Mr 00425</u> ice Record:	The?: Ho Antibolity Bort To- Traf: Tritopist Bort To- Traf: Degradas Degradas Degradas Degradas	HONE HONE	3'-8', 11039 6, mar (assu A 23) # 1'-5 NO M 1 MAR (ASPA 1 MAR (ASP	HING P D	Void 2'± 3'-6' 133 Non. Korene Martine 630 Lade 15 K State 15 K St	25' 55 1"-	11 5017 ) -2' Paismon 7ml 45 AT \$1 5' 9 Lock Abdy
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Bedding D Aleatherin Form of Si Debris: Asintenan	lescription: g/Erosion: hope Failure/ <u>T-2P 8-746</u> <u>M-(-2845</u> B+777m, ; los Record;	Tap: Ho           Δ           BortTon           Tap:           Degradation           String:           V.L           CodSec:	HOD KEY, i SCOTTE LS Key (1994 NONE MO	8'-8', 11099 5, MAL (ASSI A 23) H 1'-3 NO M 1 MAL . SAM 1 MAL . S	HING P D	Void 2'± 3'-6' AI 200. Kozene 2006 NE K 2006 NE K 2006 NE K 2007 NE	25' 05 1"- 25' 05 1"- 25' 05 1"- 50' 0 10 50' 0 10 50' 10	127 5017 ) -2' Paismon 7001 127 AT 50 5' 9 Lock Rada

## Summary of Engineering Geologic Data

## Page 3 of 4 Code 340-3

## **TxDOT Rock Mass Field Description**

## **Scaniine Descriptions**

Hortzontal Scantine Number: \_\_\_\_\_ Hortzontal Location (locate on sketch): \_ Height above base of cut (II): If with one layer, layer thickness: 

0+50 1+00

0+00

5

Scanline Sketch (Include seepage locations)

#### Debris Description

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7				1			_	1				
8	-	_			_		-	1	-	-	_	
9		-	1		1	1		1		1		
10	_	_	_				-	_				
_11	-	-		1	1	-	_	-	_			
12			-				-	1				
13					1					-		
14	_	-	-		-	1	-	_	_			
15		_	1		_		_		_	_		
16		_	_	-	_	_	_	-	_	-		
17		-	_		-	-	_	1	_	-		
18	_	_	_		-	_	_		-	-		
19	-	-	_		-	_		4	_			
20	1	-	-		1	1	_	1	-	1		
21		-			_	-		1		-		
22		-	-		-			-	1	1		

#### Set Apparent spacing True Spacing

	(#hican length)	(Wacan length)
1		
2		V 25-200
3		
4		
5		1

Page 4 or 4 Code 34-2



#### Scanline Descriptions



Page \_\_\_\_ of \_\_\_\_\_ Code \_\_\_\_\_\_

## **TxDOT Rock Mass Field Description**

Set #	Strike	Dip	Roughness	Separation/ Filling	Persistance	Weathering	Remarks
1	NISIE	90	V. GodGt	VAC-IES	P	파~파	STE SCHILINE
2	DUNE BASY	BS'N	y. Ander	Tin - Win	P	T	This sound LINE
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_		_					
	+						
		_					
		-					
-	1	-					
ther Str	Istrike	Din	Condition	Persistence		Remo	-
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ocasion Idding (	ai Random Jo Peacription:	11157 2072 11 74" - NOA	2' MARD THE 100-	NODUAL 150° 50 M	FOSSIL 1 PS HIGHES	FRACTURE	UPPLEIL' IS 2'- BIDS BIDS IN COME
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edding C /eatherir	ni Random Jo Description:	11157 austa 15 44" - NO 1 NO 1 NO 1	2' MARA TH- 100- MARLY 822	Noburt 150° <del>or</del> H	FOSSIL I PS HIGHOJ	FRACTURE	UPPLEIL' IS 2'- BIDS BIDS IN LOWIE
edding ( Veatherir	ai Random Jo Description: ( ng/Erosion:	NOA: NOA: NOA:	2' NARD TH+ 100- MARLY B23	NODUAL 150° 55 M	FOSSIL I PS HIGHOI	FRIQUS FRIETURA	UPPERIL' IS 2'- BIDS IN CONVE
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edding C Veatherir Ionm of S Vebris:	ai Random Jo Description: ( ng/Erosion: ) Nope Failure/C V. L/ 77	11157 0152 11 <u>74" - 1000</u> NO 1 NO 1	2' MARD TH- 100- TH- 100	NODUAL 150° & M 05 MA SPAL	FOSSIL ! PS +16mod	FRIQUS FRACTURE	CAPTERIL' IS 2'- BIDS IN COME BIDS IN COME
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ectasion edding C /eathenir onm of 6 ebnis:	ai Random Jo Description: ( ng/Erosion: ) Nope Failure/C  Nope Record: ,	11157 av32 14 <u>44" - 14 NO 11 NO 11 NO 11 NO 11 NO 11 NO 11 NO 11</u>	2' MARD TH- 100- MARLY 823 E Hon: Y. M. 11 208BLZ 5	NODUAL 150' # H DS NA SPAN	Fossil 1 PS 2+16 mod	FRIQUS FRACTURE	UPPLEIL' IS 2'- BIDS IN COME
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edding C Veatherif onm of S ebris: Wintenal	el Random Jo Description: ( Ng/Erosion: . Nope Failure/C 	11857 0052 14 94" - NON NON NON NON NON NON NON NO	2' MARD TH- 100- MARDY 822 2- Hon: Y. M. 11 208BLZ 5	NODUAL 150° STAN DS MA SPAN	Fossil 1 PS HIGHON	FRACTURE	UPPERIL' IS 2'- BIDS IN CONE & Q N. END

## Summary of Engineering Geologic Data

#### Page \_\_\_\_ of \_\_\_\_ Code \_\_\_\_\_

1+00

## **TxDOT Rock Mass Field Description**

#### Scanline Descriptions

Horizontal Scanline Number: / Horizontal Location (locate on sketch): <u>LANOUS\_ CUT</u> Height above base of cut (ft): <u>N/F</u> If win one layer, layer thickness: Length of scanline (ff): <u>390</u>/ Strike of scanline (if different from face): <u>SAMS</u>\_\_\_\_

0+00

0+50 Scanline Sketch (include seepage locations)

#### Debris Description

obs #	600 -	Set	Strik	e wit t		sure	Dipv	wir to	sxpos.	re	Persist	Condition	
1	PHEES/FT		+1-20	20-6	46-60	RL	+420	20-6	45-00	A.L		8 1	
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2	13	1		1×		L	X			404	11	VR/Ultm to par / IID	EY
3	21	11	1	X		L	14				Rettings #	Vele/TITE/Ja/ DAY	1
4	SE	1	1	IV.		17	X			N/A	Top 10'	VE/V/TOTI/IL) DEY	
5	33	$\Gamma C$		X		12	1×		L	11/8	FP	Velutrin > Vain 12/04	YFALL
6	43	17	1	X		TL	X			NA	P	142/0/ TIT 3/000 / 12/04	1. FiL
7	53	1	1	1×		14	1 X			14/1	+ 1	VEIU/TITE/II/DRY	·
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9	175	2		X		R	X			11/3	P	VE JULTER HOME LELAS FIEL	100
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19										-	1		
20										1			
21													
22			1	1	1								

#### Set Apparent spacing True Spacing

	(Wscan length)	(Wscan length)
1	40/	20'
2	A.MOPA	1/51092
3		1 /
4		
5		

#### Page 4 of 4 Code 340-3

## **TxDOT Rock Mass Field Description**

## Vertical Scanline Number: Scantine Location (show on sketch): Height of Scantine (ft): Length of Scanine(fl): 5 Photo Listing Description No LKG Sul PAN 775 Life NW ITS LKA N 19 Scanline Sketch NONZ Samples Taken: BST. RAD. 90'-100' UP MAR 12! Longe 10' 60'-70'

## Scanline Descriptions

Scanline Information:

obs #	Sta.	Set	Strik	Strike wir to expo		SUR	Dip	wir to	expos	ure	Persist.	Condin
	10.00		+20	20-6	640	RA.	++20	30-6	45-90	AL.		A SECOND SECTION
1												
2												
3												
4												
5	2											
6												
7								1				
8								1				
9												
10		1										

Code Av-4 Page 2 of 4

#### Summary Geologic Description

Bedding Description: Strike/dip:

Educido	New State		1
	T		
	12		
	2.		
5	1 <sup>41</sup>		
	5	- 5.	

#### Joint Description Summary

Jaint Set	Strike	Dip	Condition	Persistence
				-

Major Structural Features

Feature	Suike	Dip	Condition	Persistence	Remarks .
	-				*

Differential Weathering: of Mark bels scienting in 1' continues.

Active Erosion: M/A

Geotechnical Data (core available, site investigation report?): Mare

Form of Slope Degradation: Kaseling , differentia, Marthering

TXDOT Contact: \_

Win E. G. J

TxDOT Record of Maintenance: \_\_\_\_

Code <u>Av-4</u> Page <u>3 of 4</u>

## Scanline Descriptions

Horizontal Scanline Number: \_\_\_\_

Horizontal Location (key into profile sketch and elevation sketch):

Height above base of cut (ft): \_\_\_\_

If within one layer, layer thickness (ft): \_\_\_\_\_

Length of scanline (ft):

Strike of scanline:



Scanline Sketch (stationing in ft, include seepage locations)

Small bloks, mable

Debris Description

Scanline Information:

Obsn	Station	Set	Suike	twir to	exposi	ire)	Dip (	wir to e	xposure	)	Persist	Cond'n	Remarks
			±20"	20-45	#5-90°	R/L	20"	20-45	45-90	R/L			
1					1	1							
2.		-				1		1			•		
3							1						
4													
5												1	
ő		1									F.		

#### Description Keys:

Strike or D	ip: R = into L = into	slope to the right the slope to the left	Persisten	ice exposed length (ft) continuous through outcrop
Condition:	Closed	rough undulating planar slickensided		bed-confined termination index: T S
	Filled	sandy clayey gouge filling thickness	Debris:	R Estimated block size (ft) Joint or blast formation Differential Weathering

Code Av - 4 Page 4 of 4

## Scanline Descriptions

Vertical Scanline Number:

Scanline Location (key into profile sketch and elevation sketch):

Height of scanline (ft): \_\_\_\_\_ Length of scanline: \_\_\_\_\_



Scanline Sketch

Scanline Information:

Obsn	Station	n Set Strike (wir to exposure)						wir to e	xposture	)	Persist	Condin	Remarks
		-	±20"	20-45	45-90*	R/L	±20*	20-45	15-90	R/L			
1													
2						1		-		1			
3			1	1				1	1				
4													
5										-		1	
6													

Fracture Frequency (disc/ft):

Estimated RQD: 62-52



Elevation Sketch of Exposure (ft) (add scale)

Code Au-3 Page 2 of 4

#### Summary Geologic Description

## Bedding Description: Strike/dip:

Layer	Thickness	Geologic Formation	Physical Properties	Remarks	Samples Taken
			-		
_					
1					

#### Joint Description Summary

Joint Set	Strike	Dip	Condition	Persistence

#### Major Structural Features

Feature	Strike	Dip	Condition	Persistence	Remarks
		S			

Differential Weathering:

Active Erosion:

Geotechnical Data (core available, site investigation report?):

Form of Slope Degradation:

TxDOT Record of Maintenance:

BRAZOS BA. WENDT LAGRONE 2553567 (AUS) SG3 3016 (Gr) GOE HILL (HYDROLOGIST)

Code Av-3 Page 3 of 4

#### Scanline Descriptions

Horizontal Scanline Number: (1) Horizontal Location (key into profile sketch and elevation sketch): Height above base of cut (ft): \_\_\_\_ (BOTTO MLAYER If within one layer, layer thickness (ft): Length of scanline (ft): 105 CUTOFF 452 5:57 Strike of scanline: # 50 W WALL b Ł 0+50 0+00 1+00 Scanline Sketch (stationing in ft, include seepage locations) 15 11 新したう West for Debris Description 500 m

Scanline Information:

Obsu	Obs <sup>n</sup> Station Set			: (wir to	exposi	Dip (	w/r to e	xposure	)	Persist	Cond'n	Remarks	
		-	±20"	20-45	45-90	RIL	+20*	20-45	45-90	R/L			1
1	14:00				X		X			2	BED	TIGHT	PADSYALE
2	17400		1		X		X			K	Ł	45	n
3	:340				X		X			R	11	SIME	- 11
4					1								
5			-										
6						1							

#### Description Keys:

Strike or Dip: R = into slope to the rightL = into the slope to the left Persistence exposed length (ft) continuous through outcrop Condition: bed-confined Closed rough undulating termination index: planar Tt ENDS IN BEN slickensided s TERA. IN BEE Filled sandy R (: e Estimated block size (ft) TASER IHRU clayey Debris: Joint or blast formation gouge filling thickness FORM Differential Weathering NIT

Code Av-3 Page 4 of 4



Obs¤	Station	Set	Strike	e (w/r to	expose	Dip (	wit to e	xposure	)	Persist	Cond'n	Remarks	
			±20"	20-45	45-90	R/L	+20"	20-45	45-90"	R/L		-	
1													
2						1		T					
3						1							
4										-			
5						1				1			
6	,				1		1						1

Fracture Frequency (disc/ft):

Estimated RQD: 25-35 Solutiones 50-65 Non Scholare."



Elevation Sketch of Exposure (ft) (add scale)

.
Code Av-2 Page 2 of 4

## Scanline Descriptions

Horizontal Scanline Number: 1

Horizontal Location (key into profile sketch and elevation sketch):

Height above base of cut (ft):

If within one layer, layer thickness (ft): \_2'

Length of scaline (ft): \_100'

Strike of scanline: 555°

Scanline Sketch (stationing in ft, include seepage locations)

#### Scanline Information:

Obsa	Station	Set	Strike	e (wir te	o expos	ure)	Dip (	(wir to e	xposure	1)	Persist	Cond'n	Remarks
		-	±20*	20-45	45-90	R/L	±20"	20-45	45-90	RAL			
1		1			V	11	1	1	14	11	ind ine	S. AL	1
2.		2	1		11	TI					-		5-0 11-4 0-4+++5
3						1					l		
4			1			1				T			
5							1			1			
6								1		1			1

#### Description Keys:

Strike or D	ip: R = into L = into	slope to the right the slope to the left	Persistep	ce exposed length (ft) continuous through outcrop
Condition:	Closed	rough undulating planæ slickensided		bed-confined termination index: T S
	Filled	sandy clayey gouge filling thickness	Debris:	R Estimated block size (ff) Joint or blast formation Differential Weathering

Code AU-Z Page 3 of 4

Scauline Descriptions

Vertical Scanline Number: \_\_\_\_\_ Scanline Location (key into profile sketch and elevation sketch): \_\_\_\_\_ Height of scanline:  $\frac{q^2}{12}$ Length of scanline:  $\frac{12}{12}$ 



Scanline Sketch

Scanline Information:

Obsa	Station	Set	Strik	e (w/r to	exposi	ne)	Dip (	w/r to e	xposure	)	Persist	Cond'n	Remarks
-	-	-	20	20-45	45-90	R/L	+20*	20-45	45-90	R/L		-	
1			1	T									
2		1		1									
3		1	1	1									
4		1	1	1		1						1	1
5		1	1	1		T							
6				1			1	T					

Fracture Frequency (disc/ft):

Estimated RQD: 62-74

Code Au-2 Page 4 of 4

### Summary Geologic Description

Bedding Description: Strike/dip:

Layer	Thickness	Geologia Formation	Physical Properties	Rentarks	Samples   Taken
1	412	Gha Ruse (GA)	How & Fate A house & Sounday		1
\$			Silly File Harding		1
3		6,4	Max a Life Land		
*		hil	Same land have been the		
5		60	Hick had sandy		
6		62	Are the enter some		
7		68	Veren dank sie'nd		

Joint Description Summary

Joint Set	Strike	Dip	Condition	Persistence
			All toirs on bod	
			Lenrinist.	
			1	

Major Structural Features

Differential Weathering: Ver & Lewis 2. 4 Arth

Active Erosion: Nore

Geotechnical Data (core available, site investigation report?):

Form of Slope Degradation: defferential worthering Rear Hing in black fs/1.

TXDOT Contact:

Vies Surfeed

TxDOT Record of Maintenance: \_\_\_\_\_

More



#### TxDOT Rock Mass Field Description Glen Rose Formation



84

Elevation (ft) looking Sast

Page 2 of 4 Code 28/-2

# TxDOT Rock Mass Field Description Glen Rose Formation

Sel	Strike	Dip	Recentres	Separation/ Filling	Persistence	Weathering	Remarks
	H 45 W	90	IRAP	7772	P	I	
2	N302	2 55	15/55	7775	P	T	
3	N 305	45°NW	RIP	TITE	P	11/24	
4							
	1					-	
	344						
	-				1	-	
ther Str	Strike	Dip	Condition	Persistence	Ren	wartes 1	
PHUT I	N 60*5	6 NW	5/0/#	P	4"OFF	587	E- INTI MEL
FALT 2	N Je'E	SSESL	Ristone Ho-1	ALL P	1-1.1' 04		A PUT IT PARE
HAT'S	N 45'E	45044	S/PWW/	ALLON PTA HU	1 Tr. P 4	Mintanel Mitter	
eclasions adding D	al Random Jo Rescription:	South	of FAULT	BONE TYPE	chi MITILA 6 Mil may	iAtinic ma	to kort BLOS
edding D Veatherin	al Random Jo Description: ng/Erosion:	South Nesth Ar THIN	of there t of const wid HEIN mall hi	BONE TYPE	CAL METILA Conta monta BLANCE / 1	ATING MA Int. MIDLIA 2	the winder
ecational edding D Veatherin	il Random Jo Rescription: ng/Erosion:	South North Ar THIN	The Frank	BONE TYPE BONE H AT BOS HAWE T	CAL ACTILA	cating was in non-cating 2'	the winner
ectational edding D Veatherin form of S	al Random Jo Description: ng/Enosion: kope Failure/	South Nest Ar THIN Degradat	The FRANT + of Eant + of Eant + of Hard - made hi - made hi	ENTE TYPE	0 JT -	CATING MA Im. MEDICA 2' SAULT II	tokost BLOS the w/marks
leading D Veatherin	al Random Jo Description: Ig/Erosion: Iope Failure/	South Nesth Ar THIN Degradat	The FAULT	ENTE TYPE NT 2015 HAWE I K. LINEDGE DATILINE	0 JT:	ATING MA IM. MEDICA 2' FAULT II	tokorr BLOS the w/mark
edding D Veatherin orm of S ebris:	il Random Jo Description: ng/Erosion: liope Failure/	South Nesth Ar THIN Degradat	TAS of THULT of Gent will Held madel Ho minal S AT M	ENTE TYPE	0 JT:	ATING MA Im. MEDICA 2' FAULT II	tokorr BLOS the w/mark
leading D Veatherin Iomn of S Jebris:	il Random Jo Description: ng/Erosion: liope Failure/	South Nesth Ar THIN Degradat	TAS of FAULT + of Gent will Held Mall Hi minel S AT M	ENTE TYPE NT 203 HAVE 1 K. LARDSE DATILGASE CATLICASE	0 JT:	ATING MA Im. MEDILUM 2' CAULT II	tokorr BLOS the w/mark
leading D Veatherin form of S Vebris:	il Random Jo Description: ng/Erosion: liope Failure/	South Nesth Ar THIN Degradat	TAS of FAULT + of Const mild High mild hi mild hi m	ENTE TYPE	Q JT:	Ating wa m. Medica 2' SAULT II	tokost BLOS the w/mark
edding D Veatherin Iomn of S Jebris:	i Random Jo Description: ng/Erosion: liope Failure/	South Nesth Ar THIN Degradat	TAS of FAULT + of Const mild High mild hi mild hi m	ENTE TYPE	Q JT:	Ating wa m. Meduca 2' SAULT II	tokost BLOS the w/mmes these states
ecialisional ediding () /eatherin orm of S ebris: admienan	i Random Jo Description: ng/Erosion: liope Failure/  nce Record:	South Marth Ar THIN Degrada	TAS of FAULT + of Const will HEIG MALL M MALL M S AT M	ENTE TYPE	0 JT.	ATING MA Im. MODECH 2' SAULT II	tokost Beas the w/mmes these states
leading () Veatherin Iomn of S Jebris: Leantenen	al Random Jo Rescription: ng/Enosion: liope Failure/  nce Record:	South Marsta Ar THIN Degrada	TAS of FAIRT + of Gant will HEIG MARL M MARL M MARL M MARL M MARL M MARL M MARL M	BONE TYPE	0 JT:	Ating wa m. modech 2' part in	tokost Acas
leading () Veatherin Iomn of S Vebris:	al Random Jo Rescription: ng/Enosion: liope Failure/  nce Record:	South Marsta Ar THIN Degrada	TAS of FAIRT + of Gant will HEIG MARL M MARL M MARL M MARL M MARL M MARL M MARL M	ENTE TYPE	0 JT:	Ating MA Im. Mobile 2' FAULT II	tokost Acas
ecisional ledding () Veatherin form of S lebris: taintenan	il Random Jo Description: ng/Erosion: iope Failure/  ice Record:	South Marsta Ar THIN Degradat	TAS OF FAILT + OF GART + O HERE MARL M MARL M SON: BLOCK MINER S AT M	BONE TYPE	0 JT:	Ating MA Im. Mobile 2' FAULT II	tokost Acas
ecisional ledding () Veatherin ionn of S lebris: taintenan vailable (	il Random Jo Description: ng/Erosion: iope Failure/  ice Record: Geolechnical	Souther Marsta Ar THIN Degradat	TAS OF FAILT + OF GART HILL AT MARL AT SON: BLOCK MINER S AT M	BONE TYPE	0 JT:	Ating MA Im. Mobile 2' FAULT II	tokost Acas

Page 3 Code 23

Partice .

#### TxDOT Rock Mass Field Description Glen Rose Formation

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### Scanline Descriptions

Horizontal Scanline Number: 1Horizontal Location (locate on sketch): <u>score</u>  $0 \in 3$  <u>Geo</u> Sever (244')Height above base of cut (R): <u>4'</u> If with one layer, layer thickness: Length of scanline (R): <u>244'</u> Stilke of scanline (If different from face):

0+00	0+50	1+00

abs #	Sta.	Set	Strike	e wat to	o expo	5150	Dip w	et to e	NTROSE,		Parsist.	Condition
	PHU /ST		+30	20-6	45-00	RA.	+20	20-6	45-80	RL		
1	0 0	F3		X		14			X	L	2	SWATE 2" T" PALIAL / 2 - D
2	010	51			LX.	R	0			14%	*	RIP/TITE/IL/DRY
3	5/22	03		LX.		14	_		X	R	NP(BC)	RIVITIII DRY
4	12/52	F2.		X		1			12	14	P	3/P/ TAL TO W-1/5/04)
5	12/52	73		X		4			X	12	P	W/TIM/# / DRS
6	16/70	FI			X	4		X	_	TR.	P	SIN/TITE/ DRY
7	18/78	41			1×	A	¥			44	P	R/P/T/II/DRY
8	19/23	11			X	1R	X			INGR-	P	RIPTON / 1085
9	21/91	Red	1		$1 \times$	1B		X		R	P	RIU/TAL/SIDG
10	25/109	51	L		X	9	X			N/A	P	0/P/TTT/JE/DEV
11	26/113	31		-	X	R.	X			1/1	r	1. 11 1. 11
12	22/122	51			LX.	2	X			N/A	P	N 11 11 1
13	35/152	51			I Y	R	¥			14	P	
14	42/ 63	32		X	1	16	1	X.		A	P	K/U/TITZ/Z/XY
15	42/183	33		X		17			X	R	1	e/u/ 1/2" FILLINE/DEY
16	45/196	32		X		L	-	X		0	P	VL/U/TIT/I/DAY
17	45/ MG	21			X	R	¥			111/4	P	eleinteiz ber
18	47/20	31			X_	R	X			14/1	P	
19	40/218	93		X		14	_		X	R	P	S/U/7172/2/021
20	1 44 14	33		1X		L			1	A	P	n'n 11.
-	52/226	503	-	××	X	ルビ	×	×	ž	HIA R	4 4	S/U/TITI/Z/MY S/U/TITI/Z/MY

11#

8/4

3

Page 4 of 4 Code 2/8-2

#### TxDOT Rock Mass Field Description Glen Rose Formation



# Scanline Information:

obs#	Sta	Set	Strik	e wit to	o expo	-	Dip	wir to	expos	ure	Persist.	Condin
			+4-20	20-6	6.00	RA	+/-30	20-65	640	RAL		
1												
2												
3												
4								-				
5						1						
6				1								
7												
8		T										
9												
10		T										
11												
12												
13					1							
14												
15												

Date: Code\_337-/

#### **TxDOT Rock Mass Field Description** Formation: Ker Ikan Location: FM 337 TUST EAST OF MALL CALLER RAD TxDOT District: SAN ANTONIO Rm442 Elev.(II) 6 Fm.517 110 R1C 15542. BURNE CONSTR. A. 7 BLOTREAL FITTER) No SMY MILS MEAL Ker 1 Kont Profile Sketch Plan Sketch **General Exposure Description Dimensions and Orientation:** Total Height (ft): 60 154 H 15 = 650 Lateral Extent (ft): Benches-Height L1 12 13 Pace Orientation: Strke/dip: DUE WEST 75 Catchment Description: NENS CORE OF Th PUMT Artificial Support: NONS BLAGT Method of Excavation (incl. effects): Age of Exposure: Vegetation Effects: OC 39. WEED IN GLW RISE u Elev. (II)

Elevation (ft) looking 3007el

337

Page 2 of 4 Code 337-1

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# **TxDOT Rock Mass Field Description**

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# Summary of Engineering Geologic Data

Set #	Strike	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarks
1	N 65 %	18.	V. 4050/000	Inte les	Tourses and	T	FULSO IN SOME PLACE MI
	T	T	T	TIR FTIP			
				- 33mld			
2-	N YOW	900	V. Anto / 1000	77 707"	TRIACH CHES	л	SUT DAMAL WHELE OPEN
	-						
	1-	=					
Other Str	uctural Fea	tures				1	
eature	Shike	Dip	Condition	Persistence		Rema	aries
ledding D	Description:	-https://ke	IVS. NODUUA	UNCEY 1	N KET,	2'-4' #2	TULNATING BLOS IN
ledding D Veatherin	Description: ng/Erosion:	Antes Ke Start	IVE , NODULA 2 2 QADANNI , FRESH TA	IELLEMAN, MISACKE	N KET,	2'-4' AL DISCOLOT	THENATING BLOS IN LATION IN KET RATELLING / MUNUC
Bedding D Weatherin	Description: ng/Erosion:	Squal Space	NS , NODUA R E RLOGHN , FRISH TA CARENL (2'-3	1 JULEY I ISLL-MAL M SACKS BLOCKS	N KAR	2'-4' AL DISCOLOT	TULNATING BLOS IN 247,001 IN KAT RATELLING I MUNICH
Bedding D Aleatherin Form of Si	Description: ng/Erosion: Jope Failure	Antes Ke Space Degrada	INS , NODULA R FRISH TA CASH TA CAS	1 JUGEY 1 1 SURCHES M SURCHES MOR RAMUS NOR RAMUS NOR RAMUS	N KAT	2-4 AL DISCOLOT SPORTAN	TULNATING BLOS IN 247,001 IN KAT CRATELLING, JAUNISL RE RAUBELING, ELECK MUNCLIN KATOR IT ST
Bedding D Weatherin Form of Si Xebris:	Description: ng/Encelon: lope Failure	Antes Ke Spira Degrada	AL AL AL AL AL AL AL AL AL AL	V , VINGEY I ISLCHARD, M SURCESS SURCESS SURCESS NOT RANGE NOT RANGE N	N KAT	2-4 AL DISCOLOT SPORMA SPORMA ST. SEVE	THENATING BLOS IN THENATING BLOS IN RATELLING, IMINISH RE RAVELLING, SLEEK MLAC IN KAT B 37 357
Bedding D Weatherin Form of Si Debris:	Description: ng/Encelon: lope Failure	Degrada	NS NODUA R FRISH TH REAL(2'-3 MANS 2' BOILD	V JUGEY I ISLEMANDO M SURCHES MOR RAME Kee Po 7 265	N KAT, IN KAR. S INDICATI UNC IN K	2-4 AL DISCOLOT SPORTAR	THENATING BLOS IN THENATING BLOS IN RAYSLLING, MINIG RE RAYSLLING, SLOCK MENC IN KATOR 37 357
Bedding C Weatherin Form of Si Debris: Asintenan	Description: ng/Encelon: lope Failure  non Record:	Mitis Ke Speci Digrada	US NODUA 2 Eatonnal / Eaton Th Eaton Th Manual (2'-3 Manual (2'-3 Manual (2'-3) Manual (2'-3) Manual (2'-3) Manual (2'-3) 2' 30120	9 , HUGEY I 151 Landrado M SLACASE MARCHES M	N KET, IN KER. S INDICATS	2-4 AL DISCOLOT SPORMA	THENATING BLOS IN 2471001 IN KET CRAYLLING, JAUNIA RE RAYLLING, SLOCK PLAC IN KET (0, 37 3)
Bedding C Aveatherin Form of Si Debris: Waintenan	Description: ng/Encelon: lope Failure  non Record: Geotechnica	Mittis Ke Speci Degrada	US NODUA 2 ERISH TA CARENCIA - 3 CARENCIA - 3 CARENCIA - 3 MINIS 2' BOILD	9 JULEY I Islando M SLACKS MARCHS	N KET, IN KER. S INDICATS	2-4 AL DISCOLOT SPORMA	THENATING BLOS IN 2471001 IN KET CRAYLLING, JAUNIA RE RAYLLING, SLOCK PLAC IN KET (0, 37 3)7

#### Page 3 of 4 Code 957-/

# **TxDOT Rock Mass Field Description**



Debris Description

obs#	Sta.	Set	Strik	e ver s	D EXPO	SUTE	Dip	wir to a	expess	a't	Persist.	Condition	1
	1.00	100	+1-20	20-6	45-60	RA	+520	20-46	45-80	RA	1999	100	
1		11	1	X		TL	X		1	R	P	VR/manda i'm am hay I'm	LOGIA
2		12		X		R	X			1004	P	VE/WHO/THE TO A" /DAY/A	10-C3
3													
4		1					1	1					
5													
6						1			1				
7			1	1			1.0		1				
8													
9													]
10									1				
11									1				1
12					1				-				
13													
14													
15									1				
16	1	1		12 - 12				1	1				
17										1			
18			1	10.10	1					1			
19		1		1									
20	1												
21											1		
22	1	1	1			1		1	1				1

Set	Apparent spacing (#/scan length)	True Spacing (#/scan length)	
1	72-	41	THE ITT
2	130	113"	1644
3			
- 4			
5			

1

Page 4 of 4 Code 337-/

## **TxDOT Rock Mass Field Description**



## Scanline Descriptions

#### Scanline Information:

obs#	Sta	Set	Strik	e wir t	o expo	ISUT	Dip	white	expos	ane	Persist.	Condin
			+/-20	20-6	45-60	RA	+/-20	2046	45-60	RA.		
1												5 C20
2		1								1		
3					1	1		1		1		
4								1				
5		1			1							
6								1				
7												
8					1							
9												
10		1										

Dale: 6/3 AC 0

#### **TxDOT Rock Mass Field Description** Formation: FT. TLANER ( 2.DUINEDS



**Profile Sketch** 

**General Exposure Description** 



Elevation (ft) looking N

Page Zot 7

# Summary of Engineering Geologic Data

Set#	Strike	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarks
1.	NESW	400	T. Cardat	7.71	4	T	UNDILATING TO FLOOR
2	NSa'2	60"NB	V. MOSSE	7772 To San	P	T	WARDSTATING
3	NAMORE.	6ree	BOUGH	Tirt + 7 ma	P	IL	LADULATING
4							
		-		-			
		-					
	-						
				1			
ther Str.	sctural Feat						
abure	Strike	Dip	Condition	Persistence		Rema	arks
					1		
ocasiona Idding D	l Random Jo escription:	MASHVI	2-4 01	Elcapt Fr	A KOPE	The m	all 13735 M
ecasiona adding D	i Random Ja escription: g/Encsion:	MISAN THAN	8305 2-4 01	ELCRAT FR	A SLOPE	The p	REL BADS MO
ccasiona rdding D teathering	i Random Jt escription: g/Erosion:	MASAN THAN Drscal	REDS 2-4 01 CRAPCI I BIT OF R	ELCRAT FR DI on Conce NG EACE. 376547_P	a stars 2 stors 2 losion s 200 she	The p	REL BADS AND Radis Annual
ccasiona adding D leathering rm of Sk	i Random Jo escription: g/Erosion: ope Failum/	MISAN THEAD	CRAPCU CRAPCU	ELCRAT FR DI al Caus AF FACE, STREAT P	A SLOPE	The post	ALL BADS MU Babs Annuas
ccasiona edding D leathering ami of Sk	l Random Jo escription: g/Erosion: ope Failure/	MISAN THRA DISCOL DISCOL	2-4 02 2-4 02 Bot of a	ELCEPT Fr DI of Course STARAT P STALLING	A WOPE	The product	REL 13705 AND
ectasional edding D Asuthering orm of Sa	i Random Jo escription: g/Erosion: ope Failure/ 	Missing Thran Drscal Degradati	2-4 01 2-4 01 617 05 0 617 05 0 01: MAXA	ELCRAT FOR DI ON CONC AF EACE. STAFT P STALLING C STALLING C STALLING	A WORE BLOSION & Com Pro Ilom	The m E marks E F yante	REL BADS MU Radis Annuals C CONTINGUE
eclasional edding D Neuthering arm of Sk ebris:	I Random Jo escription: g/Erosion:  ope Pailure/    ce Record;	Degradation	CRAPEJ A	ELCRAT FOR DI and Conse STERAT P STARAT P STALLING R STALLING R STALLING	A YOPS	The ment	REL BADS AND BADS ANNUBS L COTTINISME
edding D Authoring orm of Sk ebris:	i Random Jo escription: g/Erosion:  ope Failure/    ce Record;	Degradation	REDS 2-4'01 BIT OF R BIT OF R DI HARM	ELCRAT FOR DI ON CONS ME EACL 3785AT P STASAT P STASAT P STASAT P STASAT P STASAT P	A SLOTE	The market	REL BADS ANU REDS ANNURS REDS ANNURS L COTT MONT
edding D Jeathering ann of Sk ebris:	i Random Jo escription: g/Erosion: 	Degradati	2-4 01 2-4 01 617 05 0 617 05 0 91 ANNA	ELCRAT Fr DI on Conc AF EACE. 3785AT P STALLING C STALLING C STALLING	A YOTS	The product	REL 13705 M



#### Debris Description

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obs #	Sta.	Set	Strike	e wit is		sure	(Dig 1	AT ID C	XDOS.	re	Peraist.	Condition
	Ma/T	-	-4-30	20-6	4540	Rt.	++30	20-6	640	TRA.		
1	0/0	3			X	L		X		A	-	TH ragen 19. U/D/JE HO PACE
2	2/	11			X	R	X	1		NA	4 **	THEIR VIE INS FRIMP
3	6/	11			x	R	X			NB		S-IOMA / R. W/ TT / TILTELY FILL
4	11/	11			¥	1	X			11/1		T.T. I/A. WITE / Nº FILLING
5	137	3			X	12		X		R	H 44	TITE TO 3mm / R. U/ El MANNY
5	167	3			X	4		X		R	11 11	N 10 10 10 10 10
7	15/	11			X	a	X			MIX		TITA / R. W/ =/per/N. =
8	27/	11			x	2	×			ALA	1. 14	1. 1. 1. 1. 1.
9	30/	11			X	12	Y			WIL	7 11	Ph 10 Ph 1 Ar
10	34/9	3		-	X	L		Y		R		TITE/R, U/Ta/ DAT/MIN
11	36/1	11			Y	R	Y			414	- 1-	TITILR. alIal Day / No. MIL
12	391	13			Y	4	_	X		R	11 11	TIT 1 7 /R. 1/= /057/ Mar
13	431	11	-	_	Y	0	Y			11/4	1 11	T/R. 0/ Jb / DAY / NO EAL
14	48/	1	-	_	Y	2	Y			Nº /4	ir H	" "/Jal Der / No Ent
15	52/	2		X.		12	_	X		4	1	T/R. V/II/DAY/HO MIL
16	52/	11			Y	R	Y		-	NIA	17 11	The ultal Day, No mil
17	601	12		2		the		X		4	11	TIL, I II-10 (NO PHU
18	611	11			X	R	X			All A	1.11	T/2, -1 3/0/ks FILL
19	63/	1			X	IL	X	1	-	14/2	1. 1.	11 11 1. 1. 11
20	00/	11	-	_	Y	K	X		_	114	** **	SAM / R. U/ IE/BAD SIGTS
21							_	-				
22				1	1	1		1	1	1		

Set	Apparent spacing (Wscan length)	True Specing (W/scan length)
1	27'	11'
2	175'	1121
3	70'	\$41
4		
5		

Page 4 of 4 Code 2 - / - - 6

th of Scantine(R):		
4. 1		
1		
- 1	Test	- Hite
]		
- 1		
	Photo Listina	
	No. Des	cription
	8 PANEANIE LKG	RAST
	9 11 11	+
	10 Portinants Lille	s pr
	11	NNW
3 1		
12-14-14-14-14-14-14-14-14-14-14-14-14-14-		
Republica Skalch	전 것 요즘 가장을 가장을 안	
SCOTTO CHARGE		

# Scanilne Descriptions

## Scanline Information:

ODS #	538.	Set	Strike	s wir t	O (TXIX)	THUR T	Dip	WIT to	63000	anu l	Persist	Condin
28.00	-16991	1000	+430	20-6	45-00	RL	++20	20-6	4540	RAL.	10.03 mil.	
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3												
4				1								
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8	1000	1										
7			1		-			L				
8					1	1					12	
9												
10					1			1		1		





Code \_ 620 - 1 Page 2 of 3

#### Summary Geologic Description

Bedding Description: Strike/dip:

Layer :;	Thickness	Form	ogic	Physical Properties	Remarks	Samples Taken
		2	÷			+
_		1	1			1
						1

Joint Description Summary

Joint Set	Strike	Dip	Condition	Persistence
1	A44 8	730	THE RANCH	BC. 8'
2	NHE	550	WARTS (P. U. R.S)	most mense course
	loint Set	I Autoria - Nigo E.	Ioint Set Strike Dip 1 64474 730 2 NAME 550	Idinit Set     Strike     Dip     Condition       1     Annal     73.0     There     RANAL       2     NAME     55°     Westis(1, U, R)

Major Structural Features

Feature	Strike	Dip;"	Condition	Pensistence	Remarks
+	- ÷				
		8	-		

Differential Weathering: 15

Active Erosion: N/A-

Geotechnical Data (core available, sile investigation report?): \_?

Form of Slope Degradation: N/A-

TxDOT Contact

TxDOT Record of Maintenance:

LL.

Ja

Code <u>620=/</u> Page <u>9 of 3</u>

#### Scanline Descriptions

Horizontal Scanline Number: Horizontal Location (key into profile sketch and elevation sketch): Height above base of cut (ft): 5-1 If within one layer, layer thickness (ft): 2 LAYELS (10'1) Length of scanline (ft): 100 Strike of scattine Shatt 45 SLAPL ٩, 0+00 1+00 0+50 Scanline Sketch (stationing in ft, include seepage locations) - Sabran - 6.67 Debris Description Scanline Information: Cond'n Remarks Obse Station Set Strike (wir to exposure) Dip (wir to exposure) Persist +20" 20-45" 45-90" R/L #20" 20-45" 45-90" R/L 1 15/100' Z, 2 9/500 ARCEST з 14 aster 4 5 6 Description Keys: Strike or Dip: R = into slope to the right Persistence exposed length (ft)

L = into the slope to the left continuous through outcrop Condition bed-confined Closed. rough undulating termination index: planar т slickennided S Filled sandy R clayey Debris Estimated block size (ft) Joint or blast formation gouge filling thickness Differential Weathering



#### TxDOT Rock Mass Field Description Glen Rose Formation



Page 2 of 3 Code 618-2-

# TxDOT Rock Mass Field Description Glen Rose Formation

# Summary of Engineering Geologic Data

Set#	Strike	Dip	Roughness	Separation/	Persistence	Weathering	Remunda
							-
_	2						
	1.000	-	10		122		
_	TELMISE	465 5	ASR CAN D	TIMEN D	505		
	-						
	-	-	+			-	
	-	-					
1.1.1.1		-					
(18there)	11.00.00	10000					245-2-53 - 25- L - 23
ther Str	uctural Fea	tures					
enture	Strike	Dip	Condition	Persistence	Ren	lanka	
_			-				
-	-	-					
leatherin	g:	Alm	DET PANT	AL WT	IS TH	als, w	DLS. MILY BOTTO
Weatherin Weilable ( Weilable (	g: sian: Geolechnic: Iope Failure	Alor 3'A accisi al Data: /Degrad	alion: Anno	AL RATU	IS THE	н. лето лето Вста	THE CALOMPINE
Weatherin Luctive Erc Luctive	g: sion: Geolechnic lope Failure <u>64449</u>	Alpr 3 a acrisi a Data: /Degrad	est Bulti 10. Universite 10. Martin 10. Mart	A RAPUL	UNG SOME	4-15, W	THE CHALOMEINE
Veatherin wailable ( iorm of Si iebris: laintenan	g: sion: Geolechnic: lope Failure <u>64445</u> ce Record:	ALSA 3'A gcAsi a Data: Degnadi	est Belti and United	A RATUL	UNG SOUTH	ель, ш летр : с в/тех з	THE ENCOMPINE
Veatherin Volte Ero Voltable ( Voltable ) Voltable Nebris: Naintenan	g: sion: Geolechnic lope Failure <u>64445</u> ce Record:	Alpr 3 a gcAs, a Data: /Degrad	est Bulti 6. United entel 724	A RAPUL	IS THE	н. лето лето Вста	THE CALOMPINE
Veatherin Veatherin Veathable ( Iorm of Si Nebris: Asintenan Nescription	g: sion: Geolechnic iope Failure <u>64449</u> ce Record: n Køy:	Actor 3 a accisi a Data: Degrad	est Bulti and United	A RATUL	IS TAN NAY. SEARS MO LING/SOURC	4-1.5. W	N.S. MILY BOTTO
Veatherin uctive Ere weikable ( com of Si ebris: laintenan escription	g: sion: Geolechnic lope Failure <u>64445</u> ce Record: n Key:	Alpr 3 A accisi a Data: Degrad	est Bulti and United	A RATUL	IS TAN NAY. SEARS PO LING/SOURC	4-1.5. W	N.S. MILY BOTTO THE ENGOMETRY

# TxDOT Rock Mass Field Description Gien Rose Formation

Page 3 of 3 Code 124-2

# Scanline Descriptions

Horizontal Scanline Number:	
Horizontal Location (locate on skatch)	k
Height above base of cut (ft): /8"	
If with one layer, layer thickness:	2'
Length of scanine (ft):	7'
Strike of scanline (if different from fac	a): SAME



Scanline Sketch (include seepage locations)

GRAVEL.	70	1" 5124	us,	LOUS	FRAGS
			Debris	Description	20

00s#	Şta.	Set	Strike	e wr t	o expo	sure	Dip	white a	xpos.		Persist	Condin	Remarks	
19	(FELT)		+1-30	20-6	<b>4</b> -30	RL	++-30	20-65	45-20	RA	1			
1	0406				X	K	X			-	Ning BC.	1-3	TA FILL UNDIN.	love
2	0+16			X		R	-	X	1		HA /H	THAT	LAND / ROLGH	200
3	0+ 23				X	A	· ·	X	-		THEN. SHE	THAT	HAD/Y. LOCKE	
4	0+24				X	R		X			Nord/AC	TIGHT	WOLV ROUT	
5	0+32				1×	R	X				May 6c	TUNT	L'MD LARGE OF	
6	0+34		Γ.		X	K		X	-		MAN/BC	TILLT	WHO / Y. BOUGH	
7	0+49			TX.	+	R		X			7HL JASDI	Wy w/main	TTL AND FAMEL LAN	1.4
8	0156		1.1.2		LX.	IR.		X			2-5125(1)	3- cuto	NEN/ LAND, Y AREE	
0	0+61		X		-	IA		X		1	NM /AC	2mm GL	/ UND SMOTT	
10	0+67				X	IA.		X			25305	Smm ene	+ CLARE / UND. K	were l
11	0+75				1	144		X			MMARC	Zon Like	/ UNIB WROUT	
12	0+77	1		X	1	TL.		X			HALLEC	77647	UND ROUGH	
13													111000000000000	
14								1 de 1		1.				
15														
16											12			
17													C	
18														
19														
20		_	-			-				-				

Set	Apparent specing (Macan length)	True Splicing (Wacan length)
1		
2		· (
3		
4		
5	12-12-12-12-12-12-12-12-12-12-12-12-12-1	



Page \_\_\_\_\_ of \_\_\_\_\_ Code \_\_\_\_\_\_

# TxDOT Rock Mass Field Description

**Gien Rose Formation** 

Joint Description Summary Set # Strike Dip Roughness Separation/ Persistence Weathering Remarks Filling N10 W 8Pm UR Smallen 1" P m W/mak.th Other Structural Features Feature Strike Dip Condition Persistence Remarks Occasional Random Joints? YES ALAGE 2244 SIDE - ONLY Z, LUSAL TO VELIVAL, TIGAT, L TO CUT Bodding Description: 4 45 5 - 6"- 1" thank bels @ hollow when 12-15" MISCUL 910, 742 1-2" dep 5 Weathering Erosion: not END AT ALL as I MARELY LAYAL 5-0' Phon THA (1' THICK) Form of Slope Failure/Degradation: BLOCK FALL - MASTLY IN WHAL THRANKL THEOS & THE OF SLOPE, SOME MANNER RAVELING 1.5'- 2' BLOCKS , SMIL SMALL PERRE-CONSUL SIZE DERLIS Debris: Maintenance Record: Available Geotechnical Data:

#### Summary of Engineering Geologic Data

WER BIDS WARE BEEN, DISPLACED TO THE SOUTH IN THE ABOR THANK WARE WARE THE CUT (P-12)

Gien Rose Formation

Page \_\_ of \_\_\_ Code \_\_\_\_\_

#### Scanline Descriptions



St- 3' tanates)

#### Debris Description

obs #	Sta.	Set	Strik	a wit to	o expo	SU/D	Dip	Afr to e	sposu	10	Persist.	Condition
2.5	- 12	100	++-30	20-65	45-60	BIL.	++20	20-6	640	RA.		
1	Otos	1	X		IX	14	X		1		P	UR, DRY, 0119 DAW 1"
2	2400	11	1 x		X	17	X				P	U.S. DAY TITE TO W. CID
3	15000		X		X	L	18				P	11, R. DAY, FALLES/W-4-) CLAY-+
4	47+10	1	×.		X	L	X				1	U.R. per, man Tite, ia)
5	66+00		1 10		1 Y	4	X				P	U.A. TITE TO W. Is , DAY
6	104100	1	X		X	12	X				P	U.B. pro N. DAY
7	186+00	1	X		X	T	X				P	
8	130+00	1	X		Y	L	X				17	
9	138+00	$\Box T$	ГΥ		X	14	X				P	
10	146+00	17	X		ΙX	4	X		E		1	
11		1.1			T		1				200	
12			1									
13			1								N	
14												
15	2											
16		-									1	
17			·					1.1.1			2	
18					1.1							
19											2	
20							-					

Set	Apparent specing (Wecan length)	True Specing (Wscan length)
1	5'	14'
2		
3		
4		S
5		

1.1

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#### TxDOT Rock Mass Field Description Glen Rose Formation

Scanline Descriptions



Scanline Information:

obs#	Sta.	Set	Strik	e wir b	o expx	SUR	Dip	white	expos	ure	Peraist	Condin
100000	G HERRER H		++20	2-6	4640	RL	+20	20-45	-6-60	R.L		5995 CF644
1	1100											
2												
3												
4												
5								T				
6												
7	Sec. 19.3										*	
8												
9		1										
10												
11												
12												
13												
14												
15												



Elevation (it) looking NW

Page Zat 4 Code 2244-2

# TxDOT Rock Mass Field Description Glen Rose Formation

# Summary of Engineering Geologic Data

Weathering/Erosion: Soft Andre Structures   Soccasional Random Joints? N 65" M   Noccasional Random Joints? N 65"	Set #	Strike	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarks
walable Geotechnical Data:		-	-					
where Structural Fastures     sature     Stike     Dip     Condition     Persistence     Remarks     sature     Stike     Dip     Condition     Persistence     Remarks     sature     Stike     Dip     Condition     Persistence     Remarks     sature     Structural Fastures     sature     Structural Fastures     Structural Fastures  <			-					
Wher Structural Fastures     Issture     Issture <			-					
Weathening/Erosion:   SOPT President (AMULL BEING PERIOD)     Veathening/Erosion:   SOPT President (AMULL BEING PLANDED)     Veathening/Erosion:   Soft (AMULL BEING PLANDED)     Veatholiciti			-					
Other Structural Features     stature     Strike   Dip     Condition   Persistance     Remarks     Accessional Random Joints?   N 65" 60     Nocassional Random Joints?   N 66" 60     Nocassional Random Joints?   N 66" 60     Nocassional Random Joints?   N 66" 60     National Random Joints?   Spectral LAMPS     Nation Random Joints?   Spectral LAMPS								
Other Structural Fastures     Fasture     Strike   Dip     Condition   Persistance     Remarks     Scassional Random Joints?   N 66" 60     Nocassional Random Joints?   N 66" 60     Nocassional Random Joints?   N 66" 60     Nacassional Random Joints?   Sept matu LAMILL BE 80     Nacassional Random Signe Failure/Degradation:   Sept Linkt / Reference 3500 nutre     Nather Lawere Record:   Nacassional Random Signe Acond<		_						
Other Structural Features     Structural Features     Structural Features     Structural Features     Dip   Condition   Persistence   Remarks     To   THEAL 1     Accassional Random Joints?   N 66" M   N 35" S.   BED   Carl FHILD   TTTE   But     Accassional Random Joints?   N 66" M   N 35" S.   BED   Carl FHILD   TTTE   But     Accassional Random Joints?   N 66" M   N 35" S.   BED   Carl FHILD   TTTE   But     Accassional Random Joints?   N 66" M   N 35" S.   BED   Carl FHILD   TTTE   But     Academic Description:   ALT WARTING HAM   Man.D /Same TL   Lartels   1.5" - 4"   B3D5     Weathering/Enosion:   SpPT match   LAYBER BE.   Carl Concentral , Taine TS     Corn of Slope Failure/Degradation:   Spettent/Corn Concentral , Taine TS     Corn of Slope Failure/Degradation:   Spettent/Corn Corn Corn Corn Corn Corn Corn Corn		-	-					
Other Structural Features     Isature   Strike   Dip   Condition   Persistence   Remarks     Vocasional Random Joints?   N 46" 60   N 35" 4. 35 D ConFFINED, TITE BUT     Vocasional Random Joints?   N 46" 60   N 35" 4. 35 D ConFFINED, TITE BUT     Vocasional Random Joints?   N 46" 60   N 35" 4. 35 D ConFFINED, TITE BUT     Vecasional Random Joints?   N 46" 60   N 35" 4. 35 D ConFFINED, TITE BUT     Vecasional Random Joints?   N 46" 60   N 35" 4. 35 D ConFFINED, TITE BUT     Vecasional Random Joints?   N 46" 60   N 35" 4. 35 D ConFFINED, TITE BUT     Vecasional Random Joints?   AttTENATION Ann.D /Saptitude States   1.5 '- 4' 33 DS     Vecasional Random Joints?   Saptitude States   Remarks   1.5 '- 4' 33 DS     Vecasional Random Joints?   Saptitude States   Remarks   1.5 '- 4' 33 DS     Vecasional Random Joints?   Saptitude States   Remarks   1.5 '- 4' 33 DS     Vecasional Random Joints?   Saptitude States   Remarks   1.5 '- 4' 33 DS     Vecasional Random Joints?   Saptitude States   Remarks   1.5 '- 4' 33 DS     Vecasional Random Joints?   Saptitude States   Remarks   1.5 '- 4' 33 DS			-					
Structural Features     Bature   Dip   Condition   Persistence   Remarks     Isature   Isature   Isature   Isature   Isature   Isature     Docasional Random Jaints?   N 66* W   N 35* 4   BED CantFinito   Isature     Docasional Random Jaints?   N 66* W   N 35* 4   BED CantFinito   Isature     Isadding Description:   ALTBENATIONS MAND/Sapping Tu   LAMBLS   1.5 '- 4'   BLOS     Isadding Description:   ALTBENATIONS MAND/Sapping Tu   LAMBLS   1.5 '- 4'   BLOS     Weathering/Erosion:   Sapping Feature   LAMBLS BEING PLANSE, To '- 4'   BLOS     Orm of Skope Failure/Degradation:   Sapping Feature   Remarks   Feature     Isates:   Sa/L   SIAMS   PLANSE, To '- 4'   BLANS     Isates:   Sa/L   SIAMS   PLANSE   LAMBLE     Isates:   Sa/L   SIAMS   PLANSE		_						
Bature   Strike   Dip   Condition   Persistence   Remarks     Antiple   Antiple   Antiple   Antiple   Antiple   Antiple     Antiple   Antiple   Antiple   Antiple   Antiple   Antiple   Antiple     Antiple   Antiple   Antiple   Antiple   Antiple   Antiple   Antiple   Antiple     Antiple   Anti	ther Str	uctural Feat	tures.					
To THICK I     Decassional Random Joints?     H 66" W     N 35" S. 35D CartFin1D, TITE BUT     Headling Description:     ALTERNATION MAND/SEPTUL LATERS     Headling Description:     Sept make     LATS off Sectors     LATS off Sectors     LATS off Sectors     LATS off Sectors     Corrections     LATS off Sectors     LATS off Sectors     LATS off Sectors     Corrections     LATS off Sectors     Corrections     Corrections     Corrections     Stope Failure/Degradation:     Sectors     Corrections     Corrections     Attract Sectors     Initiantenance Record:     Initiantenance Record:	eature	Strike	Dip	Condition	Persistence	Ren	varies	
Consistence   N 66" M   N 35" B   25D   Canifinition, Title But     Needeling Description:   ALTRUMATING MAND/SEPTUL LATERS   1.5 '- 4'   32DS     Needeling Description:   SEPT make   LATER BEING Another D     Vesithering/Erosion:   SEPT make   LATER BEING Another D     Comm of Slope Failure/Degradation:   SPELLING-// PAVELLONG AF SEPTER LS LA     Comm of Slope Failure/Degradation:   SPELLING-// PAVELLONG AF SEPTER LS LA     Metrix:   Self 5125, 70   2'     Neithering   Self 5125, 70   2'     Name   Self 5125, 70   100								
Accassional Random Joints?   N 66" W   N 35" A. 35D CANFINED, TITE BUT     adding Description:   ALTSCHATING HAMD/STATUL LANKES   1.5 '-4' 33DS     adding Description:   SATT MALL LANGE BEING BLING I.S '-4' 33DS     Heathering/Enosion:   SATT MALL LANGE BEING BLING HADDED     LATS OF SATHUR FROM BSDDING PLANSS, Jain 15     orm of Slope Failure/Degradation:   SPELLING-/ NAVELLING AF SAFTIL LS LA     AMAL SAD   Concheidel BRAS     aintenance Record:								A COLUMNS WAS
ebris: <u>Self SIAG. 70 2' BoxBQQ</u>	adding D	)escription:	ALT	senating a	4m.D./5=P7U	LAMALS	1.5 '-	4' 1305
Azintenance Record:	Bedding C Weatherin Form of Si	Description: g/Erosion: lope Failure/	ALT Sel La	tion: SPH	AND /SOP TU (AVILLE BE.I) SHOUL MEA (ING-) (M	LATELS	D HIC- PLANSI AF- SAFTS	4' BEDS
Azintenance Record:	Beckding C Weatherin Form of Si	Description: ng/Erosion: lope Failure	ALT Sel	tion: Spatia	AND /SEPTU (AVIAL BEN STORE PLA LING-/ PA	LATERS LG ALODE 35001 WELLING CONCHON	I.S - D HU- PLANSI AC SUST DAL BREAK	4' BEDS JEIN TS IN LS LAT
Vainienance Record:	Backting C Nealtherin Form of Si Xebris:	Description: ng/Erosion: lope Failure <u>\$1/4</u>	ALT Sel	tion: SPAL To 2'	MD /SOPTU (ANSLE BEN STORE PLA CINC- / MA MAL BED BANDAR	LATERS LG ALODE 35001 WELLONG CONCHON	I.S -	4' BLOS , JOINTS U. L.S. LATT
Valiable Geolechnical Data:	Beckting C Aleadherin Form of Si Xebris:	Description: ng/Erosion: lope Failure 	ALT Sel	tion: SPAL To 2'	MD/SOPTU (ANSLE BEN STORE PLA CINC-/ MA MAL BED BALDER	LATERS LG ALODE 35001 WELLONG CONCHON	I.S -	4' BLDS JUNTS ULS LAM
vailable Geolechnical Data:	Beckting C Weatherin Form of Si Debris:	Description: ng/Erosion: liops Failure <u>\$1/4</u>	ALT Sel	tion: SPAL TO 2'	MD /SOPTU ANGLE BEN STAR PLA CING-/ MA MAL BED Bandal	LATERS	D HIT- PLANSI AC SAFT DAL BRAAM	4' BLOS JEIN TS IN LS LATE
vailable Geolechnical Data:	Beckting E Weatherin Form of Si Debris: Waintenan	Vescription: ng/Erosion: Hope Failures  hoe Record:	ALT Sel	tion: SPAL 70 2'	AND /SOPTU (ANGLE BEIN STARE PLA CING-/ MA MAL BED Bandal	LATERS La Prope 35001 WELLONG Conchon	I.S -	4' BLOS , JOINTS IN LS LAM
vailable Geotechnical Data:	Bodding C Weatherin Form of Si Debris: Waintenan	Description: ng/Erosion: hope Failures  nce Record:	ALT Sel	tion: SPAL 70 2'	AND /SOPTU (ANGE BEIN STAR PEG (ING-/ MA MAL BED Bandal	LATERS Le Prope BEDDI WELLING Conchen	I.S -	4' BLOS , JOINTS IN LS LAM
	Beckling C Weatherin Form of S Debris: Vlaintenan	Description: ng/Erosion: lope Failure     nce Record:	ALT Sel	tion: SPAL 70 2'	AND /SOPTU ANGE BEN STORE PER LING-/ MA BALDER BALDER	LATERS LG ALODE 35001 WELLING Conchon	I.S - D HIT- PLANSI OF SOFT	4' BLOS JEIN TS IN LS LAY
	Bedding C Weatherin Form of S Debris: Waintenan	Description: ng/Erosion: lope Failure/  nce Record:	ALT	1001: 5044 70 2'	MD/SOPTU ANILL BEN SHOW ME CINC-/ M MAL BED BANDER	LATERS LG ALODE 35001 WELLING Conchen	I.S -	4' BEDS
	Beckling E Weatherin Form of Si Debris: Waintenan	Description: ng/Erosion: lope Failure/  nce Record: Geotechnica	ALT Sel Cograda SIAS-	1001: 5044 70 2'	AND /SEP TU ANGLE BEN SHER PLA CINC- / MA BANDAR	LATERS	I.S -	4' BEDS

Page 3 or 4 Code 22/4-2

### Scanline Descriptions

Horizontal Scantine Number: \_\_\_\_\_\_ Horizontal Location (locate on sketch): \_\_\_\_\_\_ Height above base of out (ft): \_\_\_\_\_\_ If win one layer, layer thickness: \_\_\_\_\_\_ Length of scanline (ft): \_\_\_\_\_\_ Strike of scanline (if different from face): \_\_\_\_\_\_

Glen Rose Formation

0+00 0+50 1+00

Scanline Statch (include seepage locations)

### Debris Description

oios#	s# Sta. Set	Set	Strik	e wr b		SUPP	Dip	NIT to e	suposu	10	Persist.	Condition
1.11	1.1	_	+/-20	20-6	640	RA.	++-30	20-6	640	BL		1979-1984 
1			1					1	1	-		
2		_										
3												
4												
5		1	1	1	1			-		1		
6		1.1						-				
7						T		-				
8		_										
9					1			1	-			
10								-		1		
11												
12	1					1		-	-			
13												
14												
15						-		-	-			
18				-								
17			1					-	-	-		
18	1.				-	-		-	-	-		
19						-		-	_	-		
20				-	_		-	-	-	-		

Set	Apparent spacing (#/scan length)	True Spacing (Miscan length)
1		
2		100
3		1
4		6
5		0

Page 4 of 4 Code 2247-2

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# **TxDOT Rock Mass Field Description**

Glen Rose Formation

Vertical Scanline Number: MID LINGTH Scanline Location (show on sketch): Height of Scanline (ft): 14' Lrength of Scanline(fi): 10 181 HALD. INT HALD meng MAGD at summy 507 5-D 13-2 mal Fracture frequency Est. ROD: o'

Scanline Descriptions

Scanline Sketch

#### Scanline Information:

obs #	Sta.	Set	Strike	e wer te		SUL	Dip	wir to	expos		Persist.	Contra
	0202	10000	+420	20-6	45-00	RA.	+4-20	20-6	640	RL		
1								-				
2					-				-			
3				-								
4								-				
5								-				
6			1	-				1				
7												
8												
9												
10												
11		1				1			1			
12												
13												
14												
15												



Page 2 of 4 Code sul-1

## TxDOT Rock Mass Field Description Glen Rose Formation

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Summary of Engineering Geologic Data

_	10474-045	- Unip		Filing	Persistence	Weathening	16m <sup>-</sup> 15
		-	-	-			
		-					
		-		-			
		-			<u> </u>		
		-					
				+			
		-		-			
her Stru	chural East	1					
	Strike	Dip	Condition	Persistence	Ren	varika	
		100		1 11000			
	-	-			-		
		-					
differ De		1- 7'	VIATAN J	Serve 16	ants a	THAN / LA D	Vice
edding De	escription:	1- Z'	THICK (2	5502-65 '-y')mmu	ante 7 BEDS (S	24N (68 12 -	VIHARY BED
edding De leathering	escription: p/Erosion:	1- 2' 2. Yom	the test of the cut ,	SAVE LS	ante mante ante 7 1 BEDS (S V 15 SC/1	HAN (68 12. 	NETRORACLE
edding De Vealthering	escription: VErosion:	1- 2' 2 Yom ALA	Harmer J To MA THICK (2 (4 CUT , NO MAC	SOVE LS 	anic 7 anic 7 1 BEDS (S V 15 SL14	HN (68 12)	NETRORALL
ledding De Vealthering corm of Sik	escription: VErosion: ope Failure	<u>/- Z'</u> <u>Z</u> <u>Y</u> @MA	Harrier J To MA THICK (2 G CUT , NO MALL Smith Chin	ALOSIO ALOSIO ALOSIO ALOSIO ALATZES ALATZES ALATZES ALATZES	ONIC T ONIC T OBEDS (S U IS SLIN L LAYERS ROM OFWITH	ALL ONE MALL	NETRORALY BED A NETRORADUL
lediding De Vealthering arm of Sic	escription: VErosion: ope Failure	<u>/- 2'</u> <u>2</u> <u>V</u> gM	Harrier J To MA THICK (2 (6) CUT , No MAC	ALDSID MADEL LS 	ONIC T ONIC T BEDS (S J JS SLIN L LAYERS ROM DANTI	ALL ONE MALL	NETRORASUL NETRORASUL NETRORASUL NETRORASUL
edding De leathering ann of Sic	escription: VErosion: ope Failure 2 <sup>7</sup> - <del>1</del> 14	<u>/- 2'</u> <u>2</u> <u>y</u> gyw <u>PL</u> Degrada	Harmer J To MA THICK (2 (6) CUT , No MAL Mo MALL Small Com Some AA Ban Dids	ALDSID ALDSID	ONIC T ONIC T BEDS (S J JS SLIN L LAYERS ROM DANTIN	ALL ONE MALL	NETRORASUL NETRORASUL NETRORASUL NETRORASUL

# Page 3 of

#### TxDOT Rock Mass Field Description Glen Rose Formation

## Scanline Descriptions

Horizontal Scanline Number: \_\_\_\_\_\_ Horizontal Location (locate on sketch): \_\_\_\_\_\_ Height above base of cut (fi): \_\_\_\_\_\_ If win one layer, layer thickness; \_\_\_\_\_\_ Length of scanline (fi): \_\_\_\_\_\_ Strike of scanline (if different from face): \_\_\_\_\_\_

0+00 0+50 1+00

Scanline Sketch (Include seepage locations)

#### Debris Description

obs #	Sta	Set	Strik	e wr l	o expo	oure	Dip	wit to a	toposu	re	Peraist	Condition
			++-30	20-65	640	RAL	+/-20	20-6	640	RL		
.1			-					-				
2												
3												
4			-	1		1						
5												
8												
7			1	· ·					_			
8												
9							<u> </u>					
10	1				1		-					
11									1.0			
12			<b>—</b>				-					
13			-	-			1.1					
14										L		
15	-		T						1	1		
16												
17			_									
18												
19					1.1							
20		1										

Set	Apparent spacing (Macan length)	True Spacing (Wacan length)
1		
2		
3		
4		
5		

Page 4 of 4 Code Sect -1

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# TxDOT Rock Mass Field Description Glen Rose Formation

Scanline Descriptions

Literation of Scanline(11):	PHOTOS P-2 ELEST DEMACIL P-3 CONCREDUTE FACE , CONTRIDUCE P-4 MARLY BED; SCARDE (3-1)
-	P-5 LKG SE ARMING/ALMAN
=	P-6 - mark \$20 (5-2)
	P-D Postacherin Limited Sent 1-8 - 50072
	1 mar 2000 - 2000 - 11. 1 mar 2000 - 2000 - 11. 1 mar 2000 - 2000 - 11.
	Fracture frequency:

### Scanline Information:

obs #	Sta.	Set	Strike wir to exposure Dip wir to exposure							Persist.	Condin	
			+4-20	20-6	45-80	RA	++ 30	20-6	4640	RL	Summer of the	an and the second
1				1					T			
2				1								
3												
4									Γ.		S	
5							-					
8				1								
7												
8	80 C								· · ·			÷
9								100				
10			1							1		
11	1.1						T		1			
12	_							1.1	1		-	
13	1.00											
14	1611			1				1		L		
15		1										



TxDOT Rock Mass Field Description Gien Rose Formation



Elevation (ft) looking N

Page 1\_ of \_\_\_\_\_

Glen Rose Formation

Joint Description Summary Roughness Separation/ Persistance (Weathering Remarks Dip Set # Strike Filling 100 SELACAN RASS/UND 18" MAS-NON And 75° ROMETUND MALMERIA NON PO' ROMETUND THEFT NON MI SUN 2 NROW N 70 R. 80" new 983 SCAN PHET I SITS MANASCZ BUT NUMBERUS REA-LANFICKS PACS. Other Structural Features Remarks Feature Strike Dip Condition Persistence Bedding Description: A FOW THIN BEDS NEAR TOP(26"), BUT MET AND STAL 12" 1 3 FT. Weathering: WALL LAVER L'MOR BASE IS SLOTE OT. THE UPAL PARASOUT AT ABOUT MID EZALOR OF SLOPE DAL TO SAMEZ OF ROMD. WIPER 3-3' PEST IS LEARTHING TO TAN COLOR. FROM TOP OF SLOPE DRIPPING FROM SOME BIDS AND Active Erosion: Available Geotechnical Data: . Form of Slope Failure/Degradation: Smell Alocks Alock Joint INTELSCTIONS UNDSLIMINING AT ATRI LAYER, SOUSTBURNT NEEL FALL Debris: GRAVIL TO 2-3 GIER LS ENDEMENTS Maintenance Record: 7 CHARLES WAR N SSIGERO Description Key: ot col si 13.5 E.Se 1

#### Summary of Engineering Geologic Data
Glen Rose Formation



#### **Debris Description**

obs #	Sta.	Set	Strik	a wir b		ŝ	Dip	NO TO P	S(DOSL)	re	Persist.	Condin	Remarks
32.2	12.		+420	20-6	640	FOL.	+4-20	20-65	45-00	RA	0.050.000	Carrier Co.	
1	0410	11			X	14	X			-	NN	Therefallers	dan
2	1137	2		1	X.	14	X			-	Not	ALATASAS	
3	0+12	11			X	16	X			-	Nm	W Reet Selan	
4	1452	3		X		16	X	-		-	NH	THEY THIS	+7N.
5	8+54	1		<u> </u>	X	14	X			-	Ner	atty weat	VANE ALACE
8	0465	12		×.	X	14	X		1	-	Net	and when	Y / loss retag
7	0+70	1			X	12	X	-		=	Net	TTUT 7	Vat No FILL
8	0+80	12		_	X	L	X		L	-	(Yep)	10001 (4ni-	WA WE FULL FISTER
	0+86	1			X	12	X			-	Mal	TIMETE	MAS + ( AND FULL LARAD
10	0+98	12	-		X	12	Y	_			Ness	APLA TOPE	No PHL , MAN
11	10.00		_		-			_					
12	-	-		-		-	-						
13	-	1	-	-				-					
14				_	-	-							
15						100					2		
16		-		_	-	L.		-	-		2		
17		-									2.1.2.3	-	_
18													
19		1		-		1	1.1						
20		1			11-11								

Set	Apparent specing (Wecan length)	True Specing (Wacan length)
1	20'	10'
2	25	16'
3	194	641
4		
5	5	

Page 3 of 4 Code 524-1

Page 4 of 4 Code 5/2-1

Glen Rose Formation

Scanline Descriptions



Scanline Sketch

#### Scanline Information:

obs#	Sta.	Set	Strik	e wir b	o expo	SUT	Dip	wit to	expos		Persist.	Condin	Remarks
		1.000	+4-20	20-6	4540	RA.	++20	20-6	640	RA.	Services		and the second participants
1	1 3		-								199		÷
2													
3								<u> </u>					1
4	1.00					1							
5	5-1-1-1	1									5		
6	1.1.1												
7				L.									
8													
9	(1												
10				-							1.		
11	1.1.5												S
12		1	·								3		
13	()												
14		1	T									() () () () () () () () () () () () () (	2
15	1												1



Elevation (it) looking

Page 1 of 4

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## TxDOT Rock Mass Field Description Gien Rose Formation

# Summary of Engineering Geologic Data

L Dither Sirus	n ≱o ∟ tural Feat		Ros 4/D(DAM	D172-	86.		Brs Constructio 7 Stas Adart - Specialor Support Fileren 41-12
Nher Strus Sature	tural Feat						SLA ABORT - SPACING- STORE Filem 4-12
Other Strus	stural Feet						Filen Y-12
Other Struc	tural Feat						Film 7-12
Other Struc	tural Feat						
ther Struc Bature	tural Feet Strike						
Other Strus	tural Feat						
other Struc sature	tural Feat Strike					-	
Other Struc Babure	tural Feet Strike			-			
Other Struc Robure	tural Feat Strike			-			
Other Struc Sature	tural Feat Strike					1	
Rher Struc Rature	tural Feat Strike		24-C			1	
8ature	Strike					C.C.C.C.C.C.	
		Dip	Condition	Persistence	Ren	narks	1
	_						1
							1
Veathering	Erosion: pe Failum/	En.c	5/201 07 n 5 /23-776-545	5 PALL	2. PROF	E BLD IN EACE	missis if the
1.1.1.1.1.1.1.1.1	60 E 107 C.		520 Ma	2 mm/ -	song aces	K SALE IE I	AL ANG OT /FACL I
Debris: -	Small	70	Los PILL	1000. 1	1'- 5' B4	The	
Maintenanc	Record:						
			_		_		

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Page 3 of 4 Code 281-1

Glen Rose Formation

#### Scanline Descriptions

Horizontal Scanline Number: \_\_\_\_\_\_ Horizontal Location (locate on sketch): \_\_\_\_\_\_ Height above blos of cut (ft): \_\_\_\_\_\_ If who one layer, layer thickness: \_\_\_\_\_\_ Length of scanline (ft): \_\_\_\_\_\_ Strike of scanline (if different from face): \_\_\_\_\_\_

0+50 1+00 0+00

Scanline Sketch (include seepage locations)

obs#	Sta.	Set	Strik	e wit t	o expo	oure	Dipv	to e	uposu		Persist.	Condition
			++20	20-6	45-00	RL	+20	20-6	45-00	IRA.		
1	-							-				
2												
3												
4	-											
5												•
6								1				
7												
8												
9	-	1			1							
10							<b>—</b>			Γ.		
11												
12	-	_								Γ.		
13						L.,	-					
14			_									
15												
16												
17												
18	-											
19												
20												

Set	Apparent spacing (#/scan length)	True Spacing (#/scan length)
1	4-12	2'=
2		
3		
4		
5		

Page 4 of 4 Code 28/-1

Glen Rose Formation

Vertical Scantine Number: Scantine Location (show on sketch): Height of Scantine (ft): Lrength of Scantine(ft): B-20 P-2/ P-27 P-27 P-27 P-27 Scantine Sketch

Scanline Information:

obs#	Sta.	Set	Strik	e wir t	o expo	sure	Dip	with to	expos	ure	Persist.	Condin
			+20	2-6	640	R.	4420	20-6	45-60	RA		period and a second
1		_				1			1			
2												
3												
4												
5												
6	0											
7	1											
8												
9												
10												
11										T		
12												
13												
14												
15												

.

Scanline Descriptions



Elevation (ft) looking #

Page 2-of 4 Code \_\_\_\_\_\_\_

Set#	Strike	CNp	Rougnness	Separation/	Peraistence	Weathering	Remarks
1	11 400 6-	85032	RANGH	7/172	P	TE	BEC, WET
2	N 70"N	50°42	Berther	TIFE	P	F	OCC. WET
2	NOG	010	ROUGH	TITS	P	T	ME. HAT
1	Q. 1520-144		1.200				
_		_					
_	-	_		-			
100							
other Stri nature	uctural Feet	Dio	Condition	Persistence	-	Rem	arks
				1			
ladding D	escription:	<u> 7→5</u> _2'#	: 5' 5+(s HED 320, 0			ss Hondel OS 1 (+2*), 2	6, 3'HMG, 1'MME -2'HMG 3105, 6"
Sadding D Veatherlin	escription:	T -B -2'M 2'M DW=F MID	: 5' SH(S MLD BZA, C MB, 6 * MAR BLANTINE Store He		144413 873 144413 873 144513 875 144513 8755 144513 8755 144513 8755 14451555 14451555555555555	HIMALL DS I (~2"), 2 SEVS FLA ML BED CACL.	6, 3'HARD, 1' MARC 
Bedding D Weatherin Form of S	escription: g/Erosion: lope Failure/	7-33 2'#1 2'#1 010= = =	: S' SH(S MD 32h, C MD, S*MAR BLOWTIN SLOP2 HO SLOP2 HO DOC M MS. FRO		ALL	HIMAL OS I (-2"), 2 SEUS FLA MIL BED CACL DINTS RU DINTS RU	6. 3'HARD, 1' MARL 
Badding D Weatherin Form of S	escription: g/Erosion: lope Failure/	7-36 -2'#i 2'#i 0;#= F 	: 5' 54(5 MD 324, C MD, 5 * 142 Stor2 He Stor2 He MS FRO 10' of St	CANTURE ) 214 1 - 1000 214 1 - 10000 214 1 - 10000 214 1 - 1000 214 1 - 1000 214	ALANG J	B) Hondel OS I (-2"), 2 SIVS FLO MLL BID CACL. DINTS RU TIM: ACM	6. 3'нно, 1' пина 
Sadding D Weathenin Sorm of S Jebris:	escription: g/Erosion: iope Failure/ 	7-36 -2'44 2'44 010=5 	: 5' 54(5 MD 32), 6 MD, 5 "MAD MD, 5 "MAD Stor2 HA Stor2 HA Stor2 HA MD, FRO MD, FRO MD, FRO MD, FRO MD, FRO		HAND STD. HAND STD. FARE. 201 FARE. 21 FARE. 21 FARE. 21 FARE. Alerig J CI SITUR	B) Hondel OS STUS Floo ML BED CACL. DINTS RU HON: Plan	6. 3'нно, 1' пине 
Sedding D Weathenin Form of S Debris:	escription: genesion: lope Failure/	7-36 2'44 2'44 011=5 MID Degradat	: 5' 54(5 MD 32), 6 MD, 6 * 1000 BL3N774 SLOP2 HA SLOP2 HA SLOP2 HA MS FRO 10' 0F 54 10' 0F 54 KKS , 5''	21-1112)214 1,24 AARD. 1,24	ALANG J	s) I'mtel OS SIVS Flor ML BED CACL. DUATS BUT TIM: ACM	6. 3'ннад, 1' пира - 2' набр 2105, 6*1 - масс 5223 (ол. нин 5. масс 5223 (ол. нин 6. масс 5223 (ол. нин 5. масс 5223 (ол. нин 6. масс 5223 (ол. нин 5. масс 5223 (ол. нин 6. масс 523 (ол. нин 5. масс 523 (ол. н
Bedding D Weatherin Form of S Debris: Waintenan	escription: g/Erosion: iope Failure/   nce Recont:	7-33 2'44 2'44 011= 5 011= 5 011= 5	: 5' 54(5 MLD 375, C MLD 375, C MLS 37, ML SLOP 2 Ho SLOP 2 Ho MLS FRO 10' of SL MLS , 5''	CANTURE		en Hondel Oss Stus Flor ML BED CACL. DINTS RU TION: Alor	6, 3'ннад, 1'лина 
Bedding D Westherin Form of S Debris: Maintenan Available	Description: g/Erosion: iope Failure/ <u></u>	7-36 2'# 2'# 01/2 = 1 01/2 = 1 00000000000000000000000000000000000	: 5' SH(s MD 320, 0 MD, 6 "MAR BLOWTH SLOP 2 HA SLOP 2 HA MCS FRO 10' OF 54 MCS , 5''	21-11-11-21-21-21-21-21-21-21-21-21-21-2	ALANG J	s) I'mtel OS SIVS Flor ML BID CACL. DINTS RU	6. 3'ннад, 1' пира - 3'ннад 0105, 6*1 - масс 5203 (ол. Ми 5. масс 5203 (ол. Ми 5. масс 520 (О 7 мост <u>Верскя</u> 6 тр <u>е</u> вотура.

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#### Page 3 of 44 Code 257-3

## **TxDOT Rock Mass Field Description**

#### Scanline Descriptions

III 0+50 0+00 1+00

Scanline Sketch (include seepage locations)

obs#	Sta	Set	Strik	e wir t	o expo	SLITE	Dip	to a	ixpos.	re	Persist	Condition
	·		++20	20-6	6-20	RA.	++30	20-6	640	RA.	1	
1		2			X	L		X		R	WFPER 20'	RIU/TITE IT INA FULLISE
2	1	3			X	A	X		1.5	MU	P	RIF/TITE JEIND FUL / DAY
3		3			X	R	×			AUA	P	1" " -/Eal HE ENLIPS
4		2	<b></b>		X	L	1.	X		A	WP42 20'	
5		11		X		R	X			14	P	VR/U/TITL/I DA FILLIDAY
6		3			Y	R	Y			NIA	P	RIP/TITZ/TAIN'S FILLIDAY
7		3		_	14	TR	X			MA	1 8	L/U/TITE / I TINO FAL/DAY
8		2			X	14		X		a	P	RIPITT /EL INA FAL IPE
9		2			1.4	L	_	X		R	P	** * * * * **
10				Y	1	A	¥			4	P	VR/ U/TITZ /IZE INO FOR MA
11		2			Y	16		Y		A	WHILL SO'	RIP/TITE/TEN/NE/DAY
12		L			۱Y	14		¥		12	-	1 /ILINE/DAY
13		2			¥	14	_	X		R	P	II . FITINE IDLY
14		T		X		16	X			4	P	A/U/TITE /SE/NE/DAILIN
15			_							Γ.		
16				1					1			
17												
18												
19												
20												
21												
22				1		1						

SM	Apparent spacing (#/scan length)	True Specing (Wacan length)
1	47'	34'
2	29	291
3	60'	47'
4		
5		



#### Scanline information:

obs #	Sta.	Set	Strik	a wirt	о екра	Sun	Dip	wirto	topos	ure	Persist.	Condin
		1	+4-30	20-6	4640	RA.	++-30	20-6	4640	RA.		
1												1
2		1	1									
3		1										
4												
5												
8		1	T				1					
7												
8	_		1									
8			1		Γ.	T	1			T		
10						1						

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Page 2 of 7 Code 26/-Y

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## **TxDOT Rock Mass Field Description**

$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	HUCT #	Strike	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarka
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	FI	NHSW	80°5W	VE/U	WTD I"	P	再	Seil Rac ath Palin
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	F2-	N 45" 5	445° MW	VEIN	777. 7. 7"	P	ヨーヨ	MALL DEC. MAR CHL
F3       N20*E       S3*SE       R/U       TTE       P       TE       CAUE SUME (COMPARENT)         T2       N12*W       S0*NE       R/U       TTE       P       TE       Y0* with a prime         F4       NGS*E       S1*SE       R/P       TE       Y0* with a prime       P       TE       Y0* with a prime         Image: Structural Features       AL       Dip       Condition       Persistence       Remarks         Image: Structural Features       AL       Condition       Persistence       Remarks         State       Dip       Condition       Persistence       Remarks         State       Structure       Condition       Persistence       Remarks         State       Dip       Condition       Persistence       Remarks         State       Structure       Gont#       State       State       Mark Netwerk         State       State       State       State       Mark Netwerk       State       Mark Netwerk         State       Test       Discol@RATIAL       No       Soft       Mark Netwerk       State         Mark Netwerk       Discol@RATIAL       No       Soft       Mark Netwerk       State       State       Netwerk	31	N40A	99 m	55/0	TITL	P	T	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	F3	NZD'E	53'54	RIU	TITE	P	H T	LAUS BLEE IS MILLI
E4       NGS-E       SST52       R/P       TER = N2       P       II.       Some And Status         Imposition       Features       ALL DAY       ALL DAY         Imposition       Dip       Condition       Persistence       Remarks         Imposition       Dip       Condition       Persistence       Remarks         Imposition       Dip       Condition       Persistence       Remarks         Imposition       A CIRCUME OT, NEM_TOP OF CUT LEFT OF F3 II       Status       Status       Status         Imposition       A CIRCUME OT, NEM_TOP OF CUT LEFT OF F3 II       Status       Status       Status       Status         Imposition:       Table 5 S' OF 1'-2' INTO EXC. Status       Mart Mark Notation       Status	12	N 78°W	50'N2	RIU	TTE	P	T	40' WIDL, HENEY
AL DAY AL DAY AL DAY AL DAY AL DAY AL DAY AL DAY AL DAY Condition Persistence Remarks Condition Persistence Remarks (Sourt Condition Persistence (Sourt Condition Persistence (Sourt (Sourt Condition Persistence	F4	N65-4	55152	RIP	TITLAK	ρ	<u>п</u>	Schut FINE 68. Soll
MIL DRY         MIL DRY         A CIRCUME OT, NEAL TOP OF CUT LEFT OF F3 IS         Condition Persistence         Remarks         Condition Persistence         Condition Provide Piece P		h						
AL DAY         AL DAY         Condition Persistence         Remarks         Condition Persistence         Condition         Condition Persistence         Remarks         Condition Persistence         Condition Persistence         Condition Persistence         Condition Persistence         Condition Persistence         Condition Persistence         Condition         Condition         Condition         Condition         Condition         Condition         Condition         Condition         Persistence         Condition         Condition         Persint Conditi	1	U U						
AL DRY alure Strike Dip Condition Persistence Remarks casional Random Joints? <u>A CURCLEME JT. NEARL TOP OF CUT LEFT OF F3 H</u> (soft Unificate Go <sup>2</sup> A <sup>2</sup> INTO EVEL Stocks Alert, Mile F3 H Unificate Go <sup>2</sup> A <sup>2</sup> INTO EVEL Stocks Alert, Mile F4146,0 dding Description: <u>THESS 5' OF 1'-2' WARD OSDS</u> , & 4' NORMAL 5208, 6' AMALE NORMAL sathering/Ension: <u>TUST DISCOLORATION</u> , No SOFT MOLED AS CO BADS BECRET LAMOR, MCLET OF MRALY SUIL LIKE MILE AND AN EXC Element t ENCL. LIKE SLOPE, PAIL UKE MICH Stope Failure/Degradation: MINIM DIGK / LIKES SLOPE, PAIL UKE Soms, Looss, BLOCKS ARE ONLY OF CUT bris: <u>5 of G</u> , 1'-2' BLOCKS ARE ONLY OF ALL ALARE SNITHER CUT	+							
Strike     Dip     Condition     Persistence     Remarks       castonal Random Joints?     A CIRCLURE OT: NEAR TOP OF CUT LEFT OF F3 II     (south       Strike     South     Strike     Strike       strike     Joints?     A CIRCLURE OT: NEAR TOP OF CUT LEFT OF F3 II       Strike     Strike     Strike     Strike	-	Colored East			2.25		5	(ALL DRY)
Satistical Contraction: Minim Discr / WEDDE CONT CONTRACTOR OF CONT CONTRACTOR OF CONT CONTRACTOR FOR FOR THE CONTRACT OF THE	ature	Strike	Dia	Condition	Persistence		Rem	ants
Cassional Random Joints? <u>A CIRCUM JT. NEAL TOP OF CUT LEFT OF F3 IS</u> UITING 60° AS" INTI EXC. SLOCKS ABOR M3. KEINED Idding Description: <u>TWB 5 5' OF 1'-2' WARD BEDS</u> , #4' NOOWAR 5205, 6' MARA NOOUL sathering/Erosion: <u>TUST DISCOURTATIN</u> , NO SOFT MERD AB 62 8325 BECRAT LANON, MC 2012 OF MARLY SUIL LIKE MATE AND UN EROSIMALT ENL. LIKS GLORE FAILURE I'-2' BLOCK ARE CALLY OF MARLY OF CUT Intis: <u>5 or 6</u> , 1'-2' BLOCKS ARE ONLY OF ALL MARE SNITLE CUT					1		+	
Cassional Random Joints? <u>A CIRCUME JT: NEAR TOP OF CUT LEFT OF F3 it</u> UITTING 60° AT INTO EXC. SLOCKS AMORE AND READ doing Description: <u>TOBS S' OF 1'-2' WARD DEDS</u> , & 4' NOOLUM DEDS, b' MALA NODUL sathering/Erosion: <u>TUST DISCOURTATIN</u> , No SOFT MELADIBLE BEDS BSCRFT LANSE, heizer of MARLY-SIN LIKE ANTER AND DE EROSMANT T SUL LIKE GLORE FAILURE In of Slope Failure/Degradation: M INTO DLOCK / LADIE ALLORE Martin Stope Failure/Degradation: M INTO DLOCK / LADIE ALLORE DISC S OK 6, 1'-2' BLOCKS ARE ONLY DEALE ALME SNTLLE CUT	_					-	_	
EROSANI + SOL LIKS GLOPS FAILURE m of Slope Failure Degradation: M WM OLOUX / WEDDE MLANKR Sound Loose BLOCKS APR ONLY OF OUT bis: 5 on 6 1'-2' BLOCKS APR ONLY OF OLU ALONE SNTILL CUT	cationa Sding D	f Random J escription:	oints? 	A CIRCUL SUITING	AL OT NE 60-05- 10 -21 MALD 0	ML TOP OF TO EXC. So SDS., & 4'	e cut 13 acus Mars Noouse 53	(SOUTH EFT OF F3 IS M3 REINED LOS, 6' AMER NOOL
nn of Stope Failure/Degradation: m with olion / whole MLANAR Some Loose Blocks When 2' OF CUT Ionis: 5 on 6, 1"-2" BLOCKS ARE ONLY DEBLIE ALONE SNTILLE CUT	scationa siding D satherin	l Random J escription: g/Erosion:	7.008	A CIRCU SUITING S S' OF I DISCULO	AL OT NE 60" 43" IN "2" MALD O RATIAL I	ML TOP OF TO EXC. SH SDS., NO SOFT OF MARL	NOOLLAN 53	COUTF EFT OF F3 IS M3 ACCINED LOS, 6' AMAGE NODUL LOS, 6' AMAGE NODUL LOS, 6' AMAGE NODUL LOS B3205 JAL MITL & M. 200
toris: 5 or 6, 1"-2" BLOURS ARE ONLY DEALLS ALONE SN'THE CUT	scasiona sidding D satherin	l Random J escription: g/Ension:	7.051	A CIRCU WILLIAN S S' OF I DISCOLO RET LALLA OSIMAL T S	ML OT NE 60 03 10 "2' WALD O RATIAL I heret ML LIAS 6	ML TOP OF TO EXC. SU KDS., O.Y. KDS., O.Y. KOS SOFT OF MR.922 KOK, FAI	NOOLAN DE MORE DA	(SOUTH EFT OF F3 IS M3 ACCINED LDS, 6' AMALA NODUL LDS, 6' AMALA NODUL LDS, 6' AMALA NODUL LDS, 6' AMALA NODUL LDS, 6' AMALA NODUL
tona: 5 ort 6 1 - 2 rectors not over beauty state so they cut	ecesiona edding D leadherin orm of S	l Random J escription: g/Erosion: ope Failure	Tes Tes Tust St Degnida	A CIRCLA WHINK S S' OF I DISCOLD RET LAKER OSMAN + S	ML OT. NZ 60° 43° IN 1-21 MALD 0 1-21 MAL	ML TOP OF TO EYC. SH KOS , & 4' NO SOFT OF MANY COPE FAIL EDIF	NOOMAL DO MOOMAL DO MOOMAL DO MORE DIA Y SAIL L CURE PLANAR	(SOUTH EFT OF F3 IS M3 ALENED LOS, 6' AMALA NODUL LOS, 6' AMALA NODUL LOS, 52.05 JEL MITL F. H. EX
	ecasiona edding D eatherin orm of S	l Random J escription: g/Ension: ope Failurs	TeB 7057 5/0 0 0 0 0 0 0 0 0 0 0 0	A CIRCLA SUITING S S' OF I DISCOLD RFT LALON OSIMPI + S Some + INF	M. JT. NE 60 AS - IN "-2" MALD O RATIAL, I heret N. LAS G LOOSE BLO LOOSE BLO	ML TOP OF TO EXC. SU KDS., MY' KDS., MY' KDS., MY' KDS., MY' KDS., FAI KDS., FAI KDS., CAP KDS., CAP	NOOLAN DE MOOLAN DE MOOLAND DE	(SOUT EFT OF F3 IS M3 ACCINED LDE, 6' AMALE NODUL LDE, 6' AMALE NODU
	ecasiona edding D eatherin erm of S ebria:	I Random J escription: g/Erusion: ope Failurei	Tes Tes Tust St Degrada	A CIRCLA WHINK S S' OF I DISCOLO RET LALON OSIMN + S MON M MAN Soms 1'-2' 0	AL OT. NE 60° 43° IN 1-21 MALD O 1-21 MAL	ALTOP OF TO EYE, SH SOS, OFT OF MANY COPE FAI COPE	NOOULAR 63 NOOULAR 63 NOOULAR 63 NOOULAR 63 NO 21 07 REANTR NO 31 07 EUS ALANE	(SOUTH EFT OF F3 IS M3 ACCINED LOS, 6' AMALA NODUL LOS, 6' AMALA NODUL
aintenance Record:	ecasiona edding D eatherin orm of S ebris: aintenan	r Random J escription: g/Erosion: ope Failure <u>5 er</u> ce Record:	Tees Tees Tust St Degrada	A CIRCLA WHINK S S' OF I DISCOLO RET LALON OSIMN + S MON: M MAN Soms 1'-2' 0	AL OT NE 60° 43° IN 1-21 MALD O 1-21 MALD	ALTOP OF TO EYE, SH SOS, OFT OF MANY COPE FAI COPE	NOOULAL 63 NOOULAL 63 NOOULAL 63 NOOULAL 63 NOCE 918 Y-SAIL L CURR PLANAR NO 31 OF LIS ALONE	(SOUT EFT OF F3 IS M3 AGENED LOS, 6' AMALA NODUS LOS, 6' AMALA NODUS

Page 3 of 7 Code 281-4

#### Scanline Descriptions

Horizontal Scanline Number: \_/ Horizontal Location (locate on sketch): <u>E ST: AT JI And</u> Go serTH 2:20 ' Height above base of cut (fi): <u>G'</u> If win one layer, layer thickness: Length of scanline (fi): <u>220'</u> Strike of scanline (if different from tace): <u>Shrvit</u>

0+50 0+00 1+00

Scanline Sketch (include seepage locations)

obs#	Sta	Set	Strik	B WAT D	o expo	SULT	Dip	AT ID	orposu	10	Persist.	Condition
			+20	20-6	65-80	RL	420	20-6	45-90	RA.	1000000000	
1		IF3	IX			R		X		IL	P	SIL AZ
2	42	JI		X		14		X		L	P	THE /RU/IL/MERIL/M
3	HA	132	1	1	X	4		X		TR	6	TITE AUT IN FINE /OA
4		FH		1	X	IR.	-	X		14	P	S11 P. Z.
5												
6												
7												
В												
9												
10												
11												
12		1										
13		1										
14		1		-	-							
15												
16		-	-		-					-		
17		1			-							
18		T								-		
19		-				-		-	-			
20		1	-	-								
21		1	-	-	-	-		-	-	-		
22		-	-	-	-	-	-	-		-		

Set	Apparent spacing (W/scan length)	True Spacing (#/scan length)	1
11	20'	/3'	THANK
J2	38'	261	MALIN
3			
4			
5			

Page 4 of 4 Code 24/-4



## Scanline Descriptions

Scanline Information:

obs # Sta.	Set	Strike	e wr t		SLIT	Dip	wir to	Persist.	Contin			
			+420	20-6	6.00	RA	+420	20-6	-6-20	RL.		
1								1				
2												
3												
4												
5												
6												
7 1		1			1	1	1		1			
8												
9												
10		1										



Page 1 off

8

Set#	Sanke	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remains	
77	N85"5-	55'NW	V2/U	TITL	A	I		THE
52	HID W	70'80	VUU	TITZ	I P	Te-Th		154 11
FI	NUGE	55 36	55/0	1"-1" oftal	P	37.	NE FILLNE SNAFLA	
13	N65W	90	WRIV	7/11 7.2.	P	I	Sent PALLINA FILLINA	1441
F7.	N SS'L	55° NW	45/11	7172	P	I	No FAL	
F3	NSO F	SS" HU	Wss/u	TTL	P	T	No FRL	-
F4:	N'TS' C	59.58	RKS/U	TITL	P	-E	NO FILL	
	.~							
M	-							
ther Stru	ctural Fea	turee						
enture	Strike	Dip	Condition	Persistence		Rem	arius	
			12					1
edding D	i Random J escription:	T-B	1 TOP 6'	15 3-2'D	105, Foll	~~~~ Bý	- K' 320 and 1	195.D
edding D Authering	i Random J escription: g/Ercsion:	<u>T-3</u> <u>New</u>	725, NE	15 3-2'D	105, Foll	<u>y 1 +5 cu</u> n-10 Bỳ (	L K' 320 -1 1	్రశ్ర - -
edding D Autherin	i Random J escription: g/Erosion:	<u>T-3</u> <u>Kew</u>	715, ML		1.05, Fall	<u>y</u> <u>+</u> + 5 €	- K' 320 - / 1	- - - - - - -
edding D Veathering orm of Si	i Random J escription: g/Erosion: ope Failure	<u>T-3</u> <u>New</u>	725, M2 : TOP L' E- Son: 2. M	45 3-2'0	LDS, Follow LDS, Follow L FA/L M2	ц. <u>Ү.</u> т.	L IS' BED and 1	- - - - - - - - -
ectasional edding D /eatherin orm of Si ebris:	i Random J escription: g/Erosion: ope Failurs	<u>T-3</u> <u>News</u> Degrada	725, 172	42 540273	LBS FOUL	цір дў 1 1.5. Ч. на	L IS' BED and 1	ුං හා - - - - - - - - - - - - -
ecasiona edding D Aeathering orm of Sa ebria:	i Random J escription: g/Erosion: ope Failure	<u>T-3</u> <u>New</u> Degrada	725, 172	42 540173	LDS Follow	ц. <u>ү.</u>	L IS' BED and 1	- - - - - - - - -
ecasiona edding D /eatherin orm of Si ebris: alnienan	i Random J escription: g/Erosion: ope Failure	<u>T-3</u> <u>News</u> Degrada	715, ML : TH 6' : TH 6' : TH 6' : TH 6'	42 540273	LDS, Follow LDS, Follow K FAIL M	<u>у 4 то со</u> еліо ду с	NOR SAALLING	- - - - - - - - - -
ecasiona edding D /eatherin arm of Si ebris: alnienan	i Random J escription: g/Erosion: ope Failure <u>k</u> ce Record:	<u>T-3</u> <u>New</u> Degrada	725, 172	42 540173	LDS, Follow	<u>х то аў</u> п. то аў н	NOR SPALLING	- - - - - - - - - - - - - - - - - - -

Page-2 Code,

## Scanline Descriptions

Horizontal Scanline Number: // Horizontal Location (locate on sketch): <u>Belt7143\_CUT</u> Height above base of cut (ft): <u>101</u> If with one layer, tayer thickness: Length of scanline (ft): <u>1100'</u> Strike of scanline (if different from face):

**TxDOT Rock Mass Field Description** 

0+00 0+50 1+00

Scantine Sketch (include seepage locations)

obs#	Sta	Set	Strik	a with	o expo	sura	Dip	white is	INCOME.		Persist	Condition
	1.1	-	+420	20-6	45-60	RI.	+420	20-6	4540	RA		
1	_	JI	_		X	R		X		R	P	THE IN ALTONIE INSEAL
2		1r		X		12	X			L	P	The / D / Stray / T TilmEN
3		33			X	TL	X			A1/4	P	Tant - law in the hiller he
4		E)	1. 7	X		R		X		12	P	1"-6"/SS/U/ to INO FILL /DEV
5	1000	E.	1	V I		R		X	1	1A	P	TITE ISS IN ITT   NO FILL JOA
8		IF3	100	18		R		TY		R	P	The less hill T I the But Inc
7		1 FH			LX.	12		X		17	P	ma 12-61/11/2/we Par Jack
8	-									1		1
9					1				1			
10		_			1				1			
11												
12		1			1 million - 1							
13					1				1			
14												
15												
16												
17				-				-		-	-	
18				-		-		-	-			
19				-	-			-	-			
20					-		-	-	-			
21				-	_	-	-	-	-			
22					-			-		-		

Set	Apparent specing (Wscan length)	True Spacing (#'scan length)
-11	220'	SHO '
12	123.	611
33	/38/	137
4		
5	Contraction of the	

Page 4 of 4 Code 28/5

1		
	Tania Bingan Hangki - <u>(K) alma - Andi</u> + N.L. Bingan-Bi	
-		
-	Photo Listing	
-	No. Description	
-	22 WR043 (NOTO)	
-	2.3 LARGE ( SOUTH)	
	1 49062 No	
	2 Periodemic LEG SW	
	3 amoses.	
_	4 DANSMANN LAG N	
_		
_		
_	J	
Scanline Sket		1
occarine ones	Samples Taken: AUNI	
EST ROL	)	
- 100		
		_

## Scanline Descriptions

obs#	obs# Sta.	Set	Set Strike wir to exposure Dip wir to exposure							Persist.	Contin	
			+420	20-6	4540	RL	+20	20-65	640	RUL.		
1												
2					-		-				-	
3												
4			1									
5												
6												
7												
8								1				
9												
10		-										



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Page 2-of 4 Code 1371-7

1000

# **TxDOT Rock Mass Field Description**

001#	Series	Dip	Roughness	Separation/	Persistence	Weathering	Remarks
1	H 20'E	80 1	LIP-U	Trin "A"	1 8	T	
2	N 50"W	70	R/P-U	7/3 7. 141	GWWWWY P	T	
3	N-10"1	45052	RIU	TITLT. IN	P	TE	
4	STODING	-					
_							
		-		1			
ther Str	uctural Featu						1
eature	Strike	Dip	Condition	Persistence		Remark	5
ledding C	Description:	U79	32 25'1 LY & JOSC 1 BLOCKY	5 1'- 4' 1	SLOS / most	ALSISTINE	), LOWER 10' A ATUSTICE LATE
ledding D Veatherin	Description:	UTP 10141 744 744 744	32 25' 1 LY 0 305( BLOCKY BLOCKY HCAL DIF TESAT BRA	5 1'- 4' 1 1-3') w FH JT 5273 1, F. ELISION PER FAC.	ALDS (most	Alsistive	), LOWEL 15' 6 ANSTRYE LATE D DI, NO DECUTY BUT WEST DO
ledding E Veatherin	Description:	UTP MARKA	22 25' 1 LY 0 3 DSC I BLOCKY I CAL DIF TELAT BLO S NOT BLO	5 1'- 4' 1 1-3') write JT 5173 1, F. ELECON PER FRE. VIE ATEN	ALDS / making	ALSISTINE	), LOWIL 10' W ATUSTIC LATE D DJ. NO DECENT BUT WEST DIX AT 32 SEASON
Bedding E Veatherin	Description:	UTP WE YE TY/ R3	32 25' 1 14 0 3 DSC 1 BLOCKY 1 BLOCKY 1 BLOCKY 1 CAL DIF 122MT BLO S NUT AN SHIML C	5 1'- +' 1 5-3') write JT 5373 1, F. ELOSION F. EL	ALOS / most	ALSISTINE	), LOWIL 10' W ANSTAL CONTL D D J. NO DECONT DUT WEST DAY AT 32 SEASONAL
Sedding C Veatherin	Description: ng/Erosion: iope Feiture/	UTP MAR VIA TY/ R3	32 25'1 LY 0 3 DOS () I BLOCKY I BLOCKY ICAL DIF TELAT BLO S MIT AND SHIPPIL C KON: FAV2	5 1'- 4' 1 5-3') write JT 5373 1, F. ELOSION PER SIGN NOR SIGN MINGGE SI	ALDS/ master ALDS/ master 2 valy C at when No CLUA M CLUA	ALSISTINE	), LOWIL 10' A ATUSTIC CONTL A BUT WEST DAS AT 34 SEASONAL E Sometic B
Bedding D Veatherin Form of S Debris:	Nescription: ng/Erosion: Nope Failure/C	UTP MAR VIA TY/ RS Degradat	20 25' 1 LY 0 3 DS ( ) BLOCKY ) BLOCKY ) DIF DIF DIF SHIP SHIP SHIP SHIP SHIP SHIP SHIP SHIP	5 1'- 4' 1 1-3') M TH JT 5173 1, F. ELOGION PER- PAE. VIELATOR MINGOT SI HING-; LAN AT ELOSZ	ALDS (most ALDS) (most ALDS) A Z VOLY C OF MACY NI CLUA MI CLU	ALSISTIC	Lowel 10' b 1115 THE LATE D 31, NO DECONT BUT WEST DAS AT 32 SEASONAL E 1 South B
Bedding D Veatherin Form of S Debris:	Description: ng/Erosion: kope Failure/C	UTP MAR VIL TY/ RS Degradat	20 25' 1 LY 0 305( ) BLOCKY ) BLOCKY ) CAL DIF TELAT BLOCK S MIT BLOCK S MIT BLOCK SHIPPEL C KOT: RAVE C TALUS DITENE MAK	5 1'- 4' 1 1-3') W THE JT 5173 1, F. ELOGION F. ELOGION F. ELOGION MACHINE OF SI LING-; LAN AT ELOSZ BIEN COM	ALDS/ MARY ALDS/ MARY 2 VOLY C AL SLOA MI SL	ALSISTIC	Lowel 10' 10 ANUSTRIE CONTE D DIT WEST DAY AT 32 SEASONAL E 1 Somatic Bu Laces Looks
Sedding D Veatherin Form of S Debris:	Description: ng/Erosion: kope Failure/C	UTP MAR VIL TY/ RS Degradat	20 25' 1 14 0 305( 1 Blocky 1 Blocky 1 CAL DIF TELAT BRAN S MIT BRAN S	5 1'- 4' 1 1-3') W TH JT 5173 1, F. ELOGION F. ELOGION F. ELOGION MACHINE AT MING-; LAN AT ELOSZ BZW COM	ALDS (most ALDS) (most ALDS) ( 2 VOLY C OF MACY NI CLEAN CONTRACTOR MI CLEAN CONTRACTOR MI CLEAN MI CLEAN MI CLEAN MI CLEAN	ALSISTIC	Lowel 10' W AND STATE CLARE D 35, NO DECOMPT BUT WEST DAS AT 32 SEASONAL E 1 South B
Sedding D Veatherin Form of S Debris:	Description:	UTP MAR VIII TY/ RS Degradat	AL 25' 1 LY 6 3 DSC BLOCKY I BLOCKY I BLOCKY I CAL DIF TELAT BLO S MIT BLO SHIPPE LAN SHIPPE	5 1'- 4' 1 1-3') W TH JT 5173 1, F. ELOSION F. ELOSION F. ELOSION MINGGE SI LINGGE: LAN AT ELOSI BIEN COM	ALDS / master ALDS / master 2 valy C at waly C AL SIGA MI SIGA MI SIGA MI SIGA AL TALAS + BCC MID RECTAN	ALSISTIC	Lowel 10' 6 ANSTAL CARE D BUT WEST DA AT 32 SEASONAL E 1 Somatic B Gert, Cooks
Sedding D Veatherin Form of S Debris: Asintenar	ng/Erosion:	UTP MAR VIII TY/ RS Degradat	AL 25' 1 LY 6 3 DSC BLOCKY I BLOCKY I BLOCKY I CAL DIF TELAT BLO S MIT BLO SHIPPE LAN SHIPPE	5 1'- 4' 1 1-3') W TH JT 5173 1, F. ELOSION F. ELOSION F. ELOSION MINGOT SI MINGOT SI MINGO	ALDS (mosting ALDS (mosting ALDS) AL AL YOLY C AL Y	ALSISTIC	Lowel 10' W 1915 THE LATE D 35, NO DECOMPT BUT WEST DAS AT 32 SEASONAL E 1 South B
Sedding D Veatherin Form of S Debris: Asintenar	ng/Erosion:	UTP MAR VIII TY/ RS Degradat	AL 25' 1 LY 6 3 DSC BLOCKY I BLOCKY I BLOCKY I CAL DIF TELAT BLO S MIT S M	5 1'- 4' 1 1-3') write JT 5273 1, F. ELOSION Pro- 545. North OF 51 Mint	ALDS (mosting ALDS (mosting ALDS) AL AL YOLY C AL Y	ALSISTIC	Lowel 11 4 11/2 11/2 11/2 10
Sedding D Veatherin Form of S Debris: Asintenar	ng/Erosion:	UTP MAR VIL TY/ RS Degradat	AL 25'1 LY 0 3 DSC 1 BLOCKY 1 BLOCKY 1 BLOCKY 1 DIF 1 BLOCKY 1 DIF 1 BLOCKY 1	5 1'- 4' 1 5-3') write JT 5373 1, F. ELOSION F. ELOSION F. ELOSION MING-: LA AT ELOSI BZW COM	ALDS (mosting ALDS (mosting ALDS) AL CONTRACTOR AL STOCK	ALSISTIC	Lowel 10 b anstric conte 0 31, No Decontr BUT WEST Dro at 32 setsorial E 1 South B Locks Looks
Sedding D Veatherin Form of S Debris: Asintenar	Description: ng/Erosion: iope Failure/  nce Record:	UTP MAR VIA TY/ RS Degradat	AL 25'1 LY 0 3DSC 1 BLOCKY 1 BLOCKY 1 BLOCKY 1 CAL DIF 1 BLOCKY SHITCH 1 TALUS DITENT MAK	5 1'- 4' 1 5- 3') IN THE JT 5273 1, F. ELOSION - PER SEC - PE	ALDS (mosting ALDS (mosting ALDS) AL CONTRACTOR AL SIGNA AL SIGNA AL SIGNA AL TALAS AL DOC ALDO RECTOR	ALSISTIC	Lowel 10 6 11/2 1/2 6 11/2 1/2 1/2 10/2 1/2 1/2 10/2 1/2 1/2 10/2 1/2

Page 3 of 4 Code 1576-7

## Scanline Descriptions

Norizontal Scanline Number: (Horizontal Location (locate on sketch): BATTL2 CUT (BAST FACE)Height above base of cut (ii): 25'If with one layer, layer thickness: Length of scanline (ii):  $B_{H}(T)PE cuT (460')$ Strike of scanline (if different from face):

1

.

0+00 0+50 1+00 Scanime Sketch (include skepage locations) 1

obs #	Sta.	Set	Strik	e wr te	D EXCO	<b>SUIT</b>	Dipy	NOT TO O	LXPO3U		Peraist	Condition
-			++-30	20-6	6.00	RA	++20	20-6	640	RL	1.555	
1		11		X		TR	X			L	P	100 TO 10 TO 10 TO 100
2		2		· ·	X	12	X			416	7	
3		3		X		R		X	_	R	P	TITLE VO"/ & JU/IT DAY
4		_	_	-				· ·				T
5		-	_	-		1					-	
6		_							-			
7			-		1							
8			5.22									+
9				1								
10												
11												
12									-			
13												
14			00									
15												
16			1 8								1000	
17											-	
18												
19												
20												
21											-	
22			1.1.1		-			-	-			

Set	Apparent specing (#/scan length)	True Specing (Whican length)	
1		11-51	WALE!
2		1'-3'	Wat is
3	66'	42'	7/cv
4	2-2020-02-02		1.70
5	9 - C - C - C - C - C - C - C - C - C -		1

#### Page 4 of 4 Code \_\_\_\_\_\_

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## **TxDOT Rock Mass Field Description**



obs#	Sta.	Set	Strik	a wir b	o expo	sure	Dip	wit to	expos	ure	Persist.	Condin
			+4-20	20-6	4540	PUL.	4-30	20-6	640	RL		
1	-											
2				12.1								
3								1				
4		1	1					1.1				
5				0.00					1.1			
6												
7												
	1.1.1.1.1		· .									
9	-			12.1								
10					1			1				



Elevation (ft) looking \_\_\_\_

Page Lot 4 Code 1376-2

## Joint Description Summary Separation/ Persistence (Weathering Dip Roughness Remarks Strike Set Filling 200 NISW SL. ROUGE TITL -Ť N 40" E. 900 BC II-II BID CONFINED / RANDON TITLES ROUGH Other Structural Features Dip Feature Strike Persistence Remarka Condition Occasional Random Joints? MANY FILACTURE ALMAND TREE BASES Bedding Description: 2'-5' HARD & NODULAR BEDS W/OCC. THIN WARLY SEAS (25"). BLACKY APPENDANCE Weathering/Erosion: V. LITTLZ, MARLY STATUS NAWE ARE DED SCIENTLY. Form of Slope Failure/Degradation: 8.Lacit to Tofflints Alact JT SET SE! Debris: V. LITTLE 3" - 8" SIER ROCES Maintenance Record: Available Geotechnical Data:

Page 1 of 9 Code 1376-2

1+00

#### **TxDOT Rock Mass Field Description**

#### Scanline Descriptions

0+00

0+50

Scantine Sketch (include seepage locations)

obs #	Sta.	Set	Strik	e wit t	o expo	SUITE	Dip	AT ID	xpos.	re	Persist.	Condition
			+420	20-65	45-60	RA	+20	20-6	4540	RL	1	
1		11	X			L	X			144	P	S. CALU /P-U/TITL IT/DO
2	1	2		X		IR	X			NA	AL.	Roude /U/mm + Smi/2 /04
3								T		T		
4												
5										1		
6								T_				
7						1	1	1				
8												
9												
10			T					T				
11												
12									1	T		
13												
14												
15				1						T		
16				1						T		
17												
18				1								
19												
20												
21												
22												

Set	Apparent specing (#/scan length)	True Specing (Miscan length)	]		
1		2-4	MACIES,	MEASCALD	W/M/E
2	RANDOM				
3			]		
4			1		
5			1		

## Page 4 of 4 Code 1376-2

## **TxDOT Rock Mass Field Description**



## Scanline Descriptions

Scanline Information:

obs #	Sta	Set	Strik	Strike wit to exposure Dip wit to exposure					Persist.	Condin		
			+4-300	20-65	45-80	RA.	+4-20	20-6	640	HL.		
1				1								
2	-											
3												
4				1				1				
5				1								
6				1								
7				1	1	1	1	1	1	1		
8						1						
9						1						-
10						1						



Bevation (ft) looking 5"

Page 2 d 4 10-5

#### **TxDOT Rock Mass Field Description** Glen Rose Formation

Joint Description Summary Strike Dip Roughness Separation/ Persistence Weathering Remarks Set # Filing N6010 85° AN R/P ΕC ILDRY CREATA TO LORD LAYSE TITL 2 NIS'E SOM RIP TITL 20 DODAY FISHE MARL JI SHEINE 1/3' T2 SPACINE 1/4' Other Structural Features Feature Strike Dip Condition Persistence Remarks Occasional Random Joints? YES / BC Bedding Description: & MAY AT: 3'MH 620, 4'MALLY, 3'MH, 6"MALLY, 3" HARD WITT, "" MALLY, 3'MH, 3' MH Weathering Erosion: WOAL BED HAS ENCORED UP TO 3.5 PEBOC FROM FACE Form of Slope Failure/Degradation: BLOCK FALL IN ARD B320 ABOVE MART DUG TO TENTRE FAILURE, JUNTS DON'T SIL TO CONTROL. SA TYPICAL FINT TALLS MOUND OR. 1'-3' BLACKS; HAR PALLEN I TO Debris: 12 PEON Fresh Maintenance Record: Available Geotechnical Data:

# Page 3 df

## TxDOT Rock Mass Field Description Glen Rose Formation

## Scanline Descriptions

Horizontal Scanline Humber: \_\_\_\_\_ Horizontal Location (locate on sketch): \_\_\_\_\_\_ Height above base of cut (ft): \_\_\_\_\_\_ If with one layer, layer thickness: \_\_\_\_\_\_ Longth of scanline (ft): \_\_\_\_\_\_ Strike of scanline (if different from face): \_\_\_\_\_\_



Scanline Sketch (include seepage locations)

obs #	Sta	Set	Strik	e wir t	o expo	SUIT	Dip	of to a	OCDORE.		Persist.	Condition
1002080			+4-20	20-65	45-50	IRA.	++20	20-6	640	DRU.		
1					1	T	-		-			
2												
3												
4												
5												
6												
7	1											
B												
9	-				1							
10	1											
11												
12	-	_										
13	1		1									
14	-											
15	1		1					-				
16												
17												
18			1									
19										T		
20					-	-						

Set	Apparent spacing (#/scan (ength)	True Specing (#/scan length)
1		
2		
3		
4		
5		

Page 4 of 4 Code 2 10-5

3

#### TxDOT Rock Mass Field Description Glen Rose Formation



#### Scanline Information:

obs#	Sta.	Set	Strik	e wir b	o expo	SUR	Dip	wir to	expos	une	Persist.	Condin
			++20	20-6	45400	RL.	+20	20-65	6-00	RL		
1								-				
2	1	T										
3												
4												
5												
8												
7												
8												
9												
10												
11												
12												
13												
14												
15	-				1							



Page 2 of 4 Code 2722-1

	Sanka	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarks
1 OTGD	OWE HATT	55" E.	55/1	TITL	9	I	DRY
IJTA	DN 12-W	SON	55/0	TITZ	A	Ŧ	DEY
FAST	Nº45 %	CON	1	1 2	P	VI	RILLY & FARET IS ALL SOUL LI
							(SWLS); BALS PAME IN A
-		+					CLAY MATRIX
-				-	-		
		-		1			
ther Stru	ctural Feat						
esture	Strike	Dip	Condition	Persistence		Rem	arks
ocasione stding D	i Random Jo escription:	No moto	JE COTE JZ UND	WATES 2	BOLEH AND - U' PSOVS	0VT TOP 0 3451	- 51104
Occasione ledding D	l Random Jo escription:	No me	JE COTE JZ UNO LY BYDS ON MILLY EL	WE THESE Z'	BOLH AND - U' FOUS - DF FAULT. DF FAULT.	2'-5' 1 2'-5' 1 2'-5' 1 50() 52	CLAY WI RACE MUTES
Occasione ledding D	i Random Jo escription: a/Erosion:	No miles	JE COTE JZ UNO LY BYDS ON MULTING	WE THENCH WATES Z'	BORH AND - U' FRONS - DE FAULT. D AKE (LIE A- N. OF )	2'-5' 1 2'-5' 1 2'-5' 1 SOIL) 52	CLAY WI RACE ANTES
ledding D Veatherin	l Random Jo escription: g/Erosion:	No mintes? of	JE COTE JZ UNO LY BIDS ON MUNTASIL MULLY EL MULLY EL MULLY EL MULLY EL	LETTES 2"	BOLEH AND - U' FRONS - DE FAULT D AKE (LIE A- N. DE ) IN THE D	2'-5' 1 2'-5' 1 2'-5' 1 SOIL) 52 HILT 10	CLAY WI RACE ALTES L P-10 MI (141 Kon MNO SCHIL THE
ledding D Veatherin	l Random Jo escription: g/Erosion:	No made	JE COTE JZ UNO LY BIDS ON MUNTASIL MULLY EL MULLY EL MULLY EL MULL FT	LETTES 2"	BOLEH AND - U' FROVE DE FAULT DAKE (LIE A-N. DE I IM THE CO STANDING	2'-5' 1 2'-5' 1 2'-5' 1 501() 52 HILD ALD 1 501() 52 HILD ALD 1 501() 52 1 501() 5	CLAY WI RACE ALTES CLAY WI RACE ALTES IL P-10 MIS (141 Kon NO 3:483 THL ILAN SLOPE
occasione ledding D Weatherin	l Random Jo escription: g/Erosion:	No more the test	JE COTE JZ UND LY BODS ON MALLY EL MALLY EL MALLY EL MALL & TH LUNEL AT	LETTES 2' FLEND, LID BEDDING M NOTE 44 MARK MARE 44 MARK LIN ARE LIN ARE LIN ARE LIN ARE LIN ARE LIN ARE LIN ARE LIN ARE LIN ARE LIN ARE	BENEH AND - U' PEOVE DE FAULT OF FAULT OF ALL (LIK A- N. DE I J.M. THE CL STANDING	21-51 HALD ALD I SOIL) SE FALLY LO WELL AL	CLAY WI ARCH ALTES SL P-10 MO 31APE THE END 31APE THE END 31APE THE
edding D /eacherin orm of Si	i Random Jo escription: g/Erosion: ope Failure/	No more than the test of test	JE COTE JZ UND LY BIDS ON MINTASUL ANLY EL ANLY EL AUST ATTA	MANULLING	BENEH AND - U' FRONS OF FAULT D AKE (LIKE A- N. OF ) ' IN THE CL STANDING AT BLOCK	ANT THE O - BASE - B	CLAY WI AACK ALTES CLAY WI AACK ALTES CLAY WI AACK ALTES CLAY WI AACK ALTES CLAY WI AACK ALTE CLAY WI AACK ALTE CLAY WI AACK ALTE CLAY WI AACK ALTES CLAY ALTES C
Occasione ledding D Weatherin form of Si	l Random Jo escription: g/Erosion: ope Failure/	No more No more Com BBC FAI	JE COTE JZ UND LY BODS ON MINTAGOL ANNLY EL MUST ATTO LOSE & TH LUNEL ATTO LOSE & TH LUNEL ATTO	ANULLLING	BENEH AND - U' FRONS - DE FANLT - DE FA	21-51 MAD ALD I SOIL) SZ MILO ALD MILO ALD MILO AL MILO AL	CLAY WI ARCH ALTES SL P-10 MET CLASS FUR INO SLAPS FUR INO SLAPS
Occasione ledding D Weatherin Torm of Si	i Random Jo escription: g/Erosion: ope Failure/	No more the test	JE COTE JZ UND LY BODS ON MALLY EL MALLY EL MALLY EL MALLY EL MALLY EL MALLY EL MALL ATTO MALL ATTO MALL AL MALL ALL MALL ALL MALL ALL MALL ALL MALL M	ANULLING	BENEH AND - U' PROVE DE PAVET OF PAVET OF PAVET OF PAVET A N. OF I IM THE C STANDING ET BIELE E BIELE SU	21-51 MAD ALD I SOIL) SZ HILD ALD MILL AL MILL	CLAY WI ARCH ALTES SL P-10 KS LINE KAN WO SLAPS THE INT CAL SLAPS T BARS WHEN THE ALSE AT BARS WHEN PROF ALSE
edding D Vescherin edding C Vescherin	i Random Jo escription: g/Erosion: ope Failure/ <u>3 Statet 1</u>	No more the test	JE COTE JZ UND LY BODS ON MINTAGE MALLY ES MALLY ES MUSE of TH LUNE ATS LASE GLASS LASE GLASS LASE GLASS LASE GLASS LASE GLASS	ANULLING AND	BENEH AND - U' FROVE DE FANLET DE FANLET DE FANLET IN THE DI STANDING E BOTH SU CODDUC	21-51 MAD ALD I SOIL) SE MILL AL MILL	CLAY WI ARCH ALTES CLAY WI ARCH ALTES IL P-10 MIS CLASS THE IL P-10 MIS CLASS THE MIS THE MIS CLASS THE MIS THE
edding D Veatherin orm of Si rebris:	i Random Jo escription: g/Erosion: ope Failure/ <u>352.4/cit</u> :	No more care care care care care care care ca	JE COTE JZ UND LY BYDS ON MALLY EL MALLY EL MALLY EL MALLY EL MALLY EL MALL ATT MALL	MERCEL TO	BENEH AND - U' PEOVE DE FAULT OF FAULT OF FAULT OF FAULT OF FAULT IN THE CL CIE AT BLOCK F BUTH SLA CODDUCE	21-51 1 21-51 1 21-51 1 21-51 1 501() 52 FALL-T LO 1 501() 52 1	CLAY WI LACK MUTAS CLAY WI LACK MUTAS IL P-10 MIS SLAPE THE IL P-10 MIS SLAPE THE IL P-10 MIS SLAPE THE IL P-10 MIS SLAPE THE IL P-10 MIS SLAPE IL P-10 MIS SLAPE MIS SLAPE IL P-10 MIS SLAPE MIS SLAPE MI
edding D /eacherin orm of Si ebris: laintenen	I Random Jo escription: g/Erosion: 	No more the test of test o	JE COTE JZ UND LY BODS ON MALLY ESA AMILY ESA	ANULLING	BENEH AND - U' PROVE DE PAULT DE PAULT DE PAULT AN. DE I IM THE D STANDING E BETH SU CODDUC	21-51 MAD ALD I SOIL) SZ HALT LO MEL ALT I MEL	CLAY W/ Acce Mittes SL P-10 WES LIKE Ken WAS SLORE THE INT CAL SLORE T EARS WHEE ROCKS MEL
ccasione edding D /eatherin ann of Si ebris: aintenan	I Random Jo escription: g/Erosion: 	No more the test of test o	JE COTE JZ UND LY BYDS ON MALLY EL ANLY EL ANY EL A	ANULL TO	BERTHAND - U' PEOVE DE FAULT. DE FAULT. DE FAULT. DE FAULT. DE FAULT. DE FAULT. DE FAULT. DE FAULT. DE FAULT. ET BLOCK E BETH-SLO CODDLE	21-51 1 21-51 1 21-51 1 21-51 1 5012) 52 FALL T 10 1 5012) 52 1 5012 1 5012) 52 1 5012 1	CLAY WI RACE ANTES CLAY WI RACE ANTES IL P-10 WES CLASS KAR END SCARE THE IL FOR WHEE THE ME AT RAIS WHEE EDGES MELL

Page 3 of 1

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## **TxDOT Rock Mass Field Description**

#### Scanline Descriptions

Horizontal Scanline Number: \_\_\_\_\_
Horizontal Locate on sketch): \_\_\_\_\_
Height above base of cut (it): \_\_\_\_\_
If win one layer, layer thickness: \_\_\_\_\_
Length of scanline (if): \_\_\_\_\_
Strike of scanline (if different from fpce): \_\_\_\_\_

0+00

0+50 Scanline Sketch (include seepage locations)

obs#	Sta.	Set	Strik	e wir ti	o expo	SUITE	Dipv	AT ID .	topos.	re	Persist.	Condition
			+4-20	20-46	45-00	1914	+20	20-6	45-00	IRA.	1	
1		11	X		1	R		+	X	1P	L P	
2		12	X		1	#1A		1	X	1444	P	
3										-		
4		-		-						1		
5						T						
5			1			T						
7				1						1		
8												
9												1
10												
11												
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13										T		
14												
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17												
18												
19						1		1				
20												
21												
22		-				-		1		_		

Set	Apperent specing (Wecan length)	True Specing (#/scan length)
1		
2		
3		
4		
5		

Page 2 of 4 Code 3154-1

## **TxDOT Rock Mass Field Description**

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Set	Strike	Dip	Roughness	Filling	Persistence	Weathering	Remarks
P4tallam	NUP	90		TTL	P	II	
1	N 30+6	60.52	R/16 - 0000	TITL	P	#	
2	H 30' 2	60 KM	Riv	mm	\$	T	
				-			
		-					
ther Stru	ctural Feat						
esture	Strike	Dip	Condition	Persistence		Remark	5
ocasiona Idding D	l Random Jo etcription:	ints? <u>T+→B</u> <u>550</u>	2'50K	JT N 4 3' VORCY B, 7'HANG	6°ω, 90° 320, 2'= 510, 1'= 4	R/U TITL, I, I	DEY
Occasional ledding D Veathering	l Random Jo escription: y/Erosion: ope Failure/	ints? <u>T+→G</u> <u>Apri</u>	УБ   2'50К   6" мася А 10-11 Т. 10-11 Т.	JT N 4 3' VOREY . B, 7'HAMO BAL FROM I	20° ω 90° 310, 2' μα 310, 1' μ 2 LATEY BE LINE, 0C	R/U TITL, I, I MIASA/MA B MEAL TO C. LOOSL BI	D. D.L.Y nirson locetrs, 5 OF SLOPE Norr Dre Ferm 708
Cocasiona Jedding D Veathering form of Si Jebris;	I Random Jo escription: (/Erosion: ope Failure/	ints? T++)(5 675) Aar Degmetat	УБ <u>р</u>   2'50к, 6"месь А 12. 521 130/N3.	ST N 4 3' VURLY B, 7'HAMO HA FROM 1 INTR. SAR	(0° ω, 90° <u>310, 2' πο</u> <u>310, 1' π</u> <u>310, 1' π</u> <u>310, 1' π</u> <u>310, 1' π</u>	R/U TITL, II, I MINES ~/~~ W4 AZA D. NEAL TOU C. LOOSL BU	DEY nirsen lacers, s OF SLOPE Nave Dre Ferm 708
Coasiona Jedding D Veathering form of Si Jebris:	I Random Jo escription: (/Erosion: ope Failure/	inta? <u>T++6</u> <u>April</u> Degradat	УБ <u>р</u>   2'50к, 6"месь а 12. 521 10/1/3.	JT N 4 3' VURLY B, 7'HAMO Her FRom 1 INTR SAR	0° ω, 90° 320, 2' μα 320, 1' + μ 244724 ΒΙ	R/U TITL, II, I MILL, I MI	DEY nirsen lactors, S OF SLOPE Nove Der From 700



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### **TxDOT Rock Mass Field Description**



obs #	Sta	Set	Strik	e wir t		sure	Dip	AT ID C	UCDOBL	re	Persist.	Condition
			++20	20-45	-65-60	RA.	+420	20-6	45-00	RA.	1	
1	1	1		X		L	4			14	11	TITL/RAS/LOND/DRY/IT/Nº F
2		12		X	1	TL	X			R	P	TITLE IV /DAY/SINA ANL
3												
4												
5					-	1		1				
6												
7												
8						L			-	1		
9						T						
10					1					T		
11						T						
12										Т		
13				1	1		1	1		Γ.		
14										T		
15										L		
16						1	1	1		r.		
17										T		
18												
19			1									
20												
21						1						
22			1		1		1	1	1	1	1	

Set	Apparent specing (#/scan length)	True Specing (Miscan length)
1	1200 15 = 158'	63'
2	1200/ 4 = 300'	127'
3		
4		
5		

Page 4 of Code 3,6



## Scanline Descriptions

Scanline Information:

obs #	Sta.	Set	Strike wit to exposure Dip wit to exposure								Persist.	Condin
			+4-20	20-65	6-00	RA.	+430	20-65	4540	RL		Concerns and the second s
1												
2								1				
3						1						
4						T						
5						1						
6		1				1	1		1			
7	-											
8		1				L						
9			1			T		1				
10		1		1						100		


Page 2 of 4 Code 2 - /+- /

### TxDOT Rock Mass Field Description Glen Rose Formation

Summary of Engineering Geologic Data

	oune	Dip	Roughness	Separation/	Persistence	Weathering	Remarka
1	NGGW	90'	MANCAJERNE	tite to 2"	P	71	Amil TO LAST
2	N 20° W	90'	Route	サイナシュ	P	Th	NY
		-					
	_						
_		-					
-		-					~ ~~
	_						
r Stru	ctural Fea	tures					
ture	Şirike	Dip	Condition	Persistence	Ren	Critics	
-		-					
ng De	acciption:	LIPP	BENEH, 146	n. JOINT N	Y WTEESTE	ICE NW WE	T, TITL I, TAIN (1"- 4"
kling De	veription: Verosion:	1 34 7200		5. 70147 1 14 00015000 14 0 DABON 14 0 DABON 10 0 000 10 0 000 10 0000 10 000 10 0000 10 0000 10 0000 10 00	I SE'E, OF 4	DE NIN WE DED BRATE ROW THIN & BASE. MOSS 15 17-15' T	T, TITL 11, TANA (1" - 4" 1005, M10012 11 10 820 M15 Some 10 800 M15 S
King De	actiption: VErosian:	MPP TAGE 130 THE SAEP	Brach, 116 R. SLOPE, 11'- R. RADE (2'- INZ AND W/ LOS COMPRESS V 2-1' model LY SE D (C) CO LS/model	n. 701NT 1 N CONTENT N CONTENT	Y MISSE, OF 4	10° NIW WE DED BATTE RET THIN & BASE. HVES 1 'S 17-15' T ED BACK 15'-11')	T, TITL 11, TANA (1" - 4" 12, TANA (1" - 4") 12, TANA (1" - 4" 12, TANA (1" - 4") 12, TANA (1" - 4") 13, TANA (1" - 4") 14, TANA (1
dding De athening m of Sio	acription: (Erosion: ope Failure)	UPP 7mc 1 34 779 6459 Degrada	BENEH. 1 LE ER SLOWE INT. AND MY LES COMPANY LY BE P (B CO LS/2006) LY BE P (B CO LS/2006) HOTE SPALLING MOTE SPALLING	A. JOINT A	ANTERSIE ANTERSIE CONTELLE LY ALD OF LY ALD OF CONTELLE LY ALD OF LY A	LITTEL BLOC	T, TITL 13. TANK (1"- 4" 13. TANK (1"- 4" 14. BED MES SAME 14. BED MES SAME 14. BED MES SAME 2' EAT K 2' EAT K E FAILLE, ELONG MEDICAT PO
toting De athening mu of Sio	Verasion: Verasion: Ope Feilum	UPP TAGE 1334 1790 Martin 5450 Degrada	BEREH. 1 16 The Score 1 M RADS (2'- M	A. JOINT A M. CONTENT M. DABAN M. DABAN AD DAST H MILLING MILLING MILLING MILLING C. ANDRE C. ANDRE C. ANDRE	A ST SET	ID NIN WE DED BRITE ROW THIN & BASE. MASS 15 17-15' T CD BACK 15-11' COTTEL BLOC AND SLOPE MASS SALLS	T, TITL 11, TANK (1" - 4" 12, TANK (1" - 4" 12, TANK (1" - 4" 12, TANK (1" - 4" 12, TANK (1000) 12, TANK 2' EATK 2' EATK 
ding De athering n of Sia ria: _	Percesion: VErcesion: Ope Failure LANSA &	UPP The The The Sales Degrada Faich : L	BEREH. 1 16 The Score 1 The Score 1 The AND w/ 103 Company 11 BE D W/ 12 -1 12 BE D W/ 14 BE D	h. TOINT A M CARITICAL M DABAN M DABAN M DABAN M DABAN M DABAN M DABAN M CANNER M DABAN M CANNER M DABAN M CANNER M DABAN M CANNER M CANNER	A STE OFF	ID NIN WE BATTA BATL. MASS ASL. MASL. MASS ASL. MASL. MASS ASL. MASS ASL. MASL. MASS ASL. MASS ASL. MASS ASL. MA	T, TITL II, TANK (1" - 4" CDS, MIDDLE 11 WE BED MAS SOME WE BED MAS SOME WE BED MAS SOME PICKED STATE CALLED FOR MANA CALLED FOR MANA
iding De athening m of Sio ria:	De Failure LANSA A To South	UPP 780G 7740 134 774 5459 Degrada Filost : L (1') 5	BENEH. 1 16 E. SLOWE N. ALD W/ 103 Company N. I. I' model N. I. I' model N. I. I' model N. I. I' model N. I. I' model I' J. I' M. J.	A TOINT A A CARTER AND A TO A AND A TO A AND A TO A AND A AND AND A AND A AND A AND	A MILL COSS	ID NIN WE DED BATTE DED THIN & BASE. MASS IS IT-IS'T CONTEL BLOW I AND SCOPE MED SCOPE MED SCOPE TOPE BUD IS STREE	T, TITL II, TANK (1" - 4" CDS. MIDDLE IN WE BED MAS SAME WE BED MAS SAME WE BED MAS SAME WE BED MAS SAME 2' EACH CASE PERMISSION CASE OF STANDAR CASE
kting De athering m of Sio xis: ntenanc	ecription: /Erosion: pe Failure <u>LAPEL A</u> <u>To Scott</u>	UPP Those The The Martin Sales Degrada Filet : L (1') S	BENEH. 1 16 The Score 1 16 ADS (2'- INT ADD W) INT ADD W) INT ADD W) INT ADD W) INT ADD W) INT AT MAL INT SPALLAN AT MAL INT SPALLAN AT JOL LAN	A TOINT A	ANTESSIE ANTESSIE CONTELLE LY ALD OF LY	LITTLE SLOOP	T, TITL II, THING (1"- 4" CDS. MIDDLE IN NE BED MESSING NE BUT AND NET 7' ENTR 2' ENTR 2' ENTR C FAILLE, ELONG CALL IS STIMMER CHART LITTLE C USUS
King De athering m of Sko xis: - -	ecription: (Erosion: pe Failura <u>LAPSA A Ya Santi</u> za Record:	UPP Those The Degrada The Degrada The Logical	BENEH. 1 16 ER SCORE 1 18 9205/2'- INT ALD W/ LOS COMPANE V 2-1' MORE 101 890/11/1 LOTE SPOYLOW MALE NO MALE NO	A TOINT A	ANTERSIE CONSI F LY ALD OF LY	10° NIN WE DED BATTE BATE. MARS AATE. MARS AATE. MARS ATTEL MARS ATTEL MARS ATTEL MARS ATTEL MARS ATTEL MARS ATTOP L ATTEL ATTOP L ATTOR ATTOL	T, TITL I, TITL I, TONE (1"- 4" CDS, MIDDLE 11 NE BED MASSIME NE BED MASSIME NE BED MASSIME PARTA P

Page 3 of 4 Code 2-10-1

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Gien Rose Formation

#### Scanline Descriptions

Height above base of cut (II): 5" 121 - 135 /PACE If win one layer, layer thickness: Length of scanline (ft): 313' Strike of scanline (if different from face):



#### **Debris Description**

obs #	Standla	Set	Strik	e wit to		sure	Dip	ID ID	uposu		Persist.	Condition
	(anive th)		+30	20-6	45-80	RA.	+20	20-6	4540	AL		
1	0/	5		X		L	LX			IR	P	RANK/RENE-/ ART/31. TITE
2	10/-125	5		X		6	X			R	P	
3	13/ 62.	32			×	L	X			4	P	
4	15/77	5)		Y		L	X			2	P	48 TE 42 TE
5	28/ 122	32			X	L	x			A	11	
6	33/ 131	31		X		TL	X			R	P	
7	39/14	51		¥		L	X			A	P	
B	37/161	32	1	1	4	TZ	Y			1	P	
Ð	461 200	JI		×	X	TL	X			e	1	"/"/ and rel Vincen
10	41/2/3	132		1	4	L	X			R	P	Pla/ MAY/ S. TIT
11	53/24	22			4	11	Y			R	P	1. F
12	58/ 232	52			Y	16	X			K	P	HI
13	67/291	ari.		X	3	14	X			R	P	PIRIPRY/MARY 6" Soll
14	172/13	32	-		X	TL	X			1A	A	MELD/=XTM
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16		1										
17												
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19				-			-					
20		-	-	-	-	-						

Set	Apparent spacing (#acan length)	True Spacing (Mscan length)	
1	AV6. 47	-vc. 43'	NGSW
2	A16. 44	A46. 41	NZOW
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62 39 20

Page / of f

### TxDOT Rock Mass Field Description Glen Rose Formation

#### Scanline Descriptions



obs#	Sta	Set	Strike	a wat to	o expo	sun	Dip	wh to	expos	ure	Persist	Contra
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2												
3		-	1	-		1	-	1				
4		-	1	-	1		-	-	-			
5				-								
6												
7		-	1									
8				-				1				
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11												
12										17		
13							-					
14												
15	-	-	1									



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### TxDOT Rock Mass Field Description Glen Rose Formation

## Summary of Engineering Geologic Data

Set	Strike	Dip	Roughness	Separation/	Persistence	Weathering	Remarks
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ther Stru	ctural Feat						
auture	Strike	Dip	Condition	Persistence	Ren	varits	
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edding D	escription:		THUNG O	E- C IETA	2.800	in Lee	
edding Di Veathering	sscription: yErosion:	HAR	THELLAG OF	F- 51FTM	348	IN Lee	
ledding Di Vesthering Form of Sk	escription: yErosion: ope Failure/	µ∰.A	ntiteuris of	e sifta will of	CLASSA	IN Kee	YP2 54
ledding Di Vesthering form of Sil	escription: yErosion: ope Failure/	<u>µ</u> ¶,A† Degrada	ntiturile of tion: A Co Parlants	e steta NHZ de N Sen	CLASSA GLASSA	IN Kee	YPE 54
edding Di Vesthering orm of Si	escription: p/Erosion: ope Failure/	<u>µ</u> ą,k Degrada	THELL NG OF	E-STETZA NELZ BE I AN SENI IZ RAVILLI	CLASSIN CLASSIN WILL OF	IN Lee IL SAIL T SAFTED MA	YPE SLA
ledding Di Vesthering form of Sk	escription: yErosion: ope Failure/	<u>µ</u> g,A <u>1</u> Degrada	Minu NG OT BOT A CO PATLATES THERM	E STETZA MEZ DE I NI BENI IZ RATILLI	CLASSIN CLASSIN MILL OF No, MILL	IN Kee ML SAIL T SAFTED MA	YPZ 5 L
ledding Di Vesthering Form of Sil	escription: p/Erosion: ope Failure/	<u>µ</u> ∰,Ar	THRUNG OF	E-STETZA NELZ BE I IN SENI IZ RAVILLI	CLASSIN CLASSIN WILL OF NG, MATTL	IN Kee The Sath T SAFTED MA	YPZ 54
Nedding Di Vesthering Form of Si	veription: verosion: ope Failure/	µي موس Degrada	HRUNG OT	E-SIFTZO WIZ OF I NI BEN IZ RAVILLI	CLASSIN GALC OF No, MATL	IN Kee the South T Sept The South	YPZ SLA
ledding Di Vesthering Form of Sk Jebris:	escription: yErosion: ope Failure/ ce Record:	Degrada	tion: & Co Parlona Thesam	efiz de N Sen I AN Sen I Z RAYSLLIN	CLASSIN CLASSIN MILL OF NB, MITL	IN Kee the soil T soff to ma	YPE 5 LA
Sedding Di Vesthering Form of Sik Setris:	escription: y/Erosion: ope Failure/	Degrada	Minu AG OT	E STETZA MIZ OF I NI SENI TZ RAYSLLI	CLASSIN CLASSIN MILL OF No, MITL	IN Kee ML SAIL T ESETED MA	YPE 54
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edding Di Jesthering orm of Si ebris: aintenan vailable (	escription: yErosion: ope Failure/ ce Record: Seotechnica	Degrada	NARUNG OF	E STETZA WHZ OF M SEN TZ RAYLLIN	CLASSIN CLASSIN MIC OF No, MITL	IN Kee IL Soil T ESETED MA	YPE 50

3 44 .m. I-10-3 ..... 411----100.0 日間 2 1 1 Bres-#3 P-5: 54 Hacen 掋 T.Imit. P-S: SCARP AS SLIPE FOR P-G: DEGUS N 6 P-7: BURK FALL LA P-8 PAN LEG SW i. . . 50 2 ÷ ļ Derry ł 70' i i. · · --÷. 4 Ì -----. -÷ 静 11 -\* • --ł 7 . 41 -., k ķ ŀ 6 . . £, ĥ tin lite 1000 1 1 + -- C

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THE SLOPE SLOPE HAS ME Z' PRESSAN HAND NOT BED -RENT OF SLOPE IS WATHER AD TO & ONAVEL/COSSES, BEACH ... HAS MINDE GRAVEL - COME OTER DEBUS ECONANT DEPASSION WERD & MINAL CLUMPS OF GREAS, DUE SLOPE PAILONE B3+ SLAPE: HOOD YVERY BED & LAST END W/YINTIGHY LITTLE DIMENTIN SOFTER MALLY LAYERS OUTCON BELOW THIS TO THE EAST AND MAL RANNO BUT ROOK STRUCTURE IS STILL VISIBLE B TH OF SLOPT. CHANL / CHALL SLOPE (151) RELAN THESE BEDE. BENCH DEBRIS K. GRAYEL TO DECREMAL 2' Soulder Lots on TRANSMY LODD, GARE BELOW HARL LAYER TO MEST IS HARDING RAD WISHEL FALL 2-4' bitson : INTERBOOD MED/ANT, MAR WAR AND IL'-3', ALMORATE VSG. BSTELOR ! MAJOR ALION IN SLOPE, ROTETIMEL W/2'SCARP O' WIDE, BENEW HILHILY VILLANTE LOUND BLOKS IN TO H (R-1) BE HERE: BLOCK FAR, MANSLUME (BLOCKS 1'-3'), HENVILY PERSONAL BEAL IS VALY WET MAN BAMA APPEALS TO THEY WET LOURE SLOPE : LOURE SLOPE IS INTERBOOD LIKE OTHER MY BLACK FILLS HAVE MALLY LATERS, LOTS OF VELETATION of THIS SLOPE, AND IS WANTIFUSD TO LOOK LIKE CLAYEY GLAVEL / COULES WITH DEC. PRESIGNANT BEDE LETAINING ROCK STUDETEDE , TRAVEL TO Z' Barine NOT USEY MUCH THOUGH



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### TxDOT Rock Mass Field Description Glen Rose Formation

### Summary of Engineering Geologic Data

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ther Stru	chural Fast	turnes.					
ature 1	Strike	(Dip	Condition	Persistence	Ren	aurice .	
		-	T				
_		-					
athering	VErasion:	TWIT	JULAND P	65 41.0023 16001-0077-00	1 70 ;	2' Flom F	HER OTHER WIS
form of Sik	ope Failum	Degrada	MAS OCCU	MININ A	AVELLING	Acrt LI with	SPOL REAK A
Vetaria:	ACC. 6	- 14	Black 07	HULAN J	VET TYPE	16 small -	TALUS AT BUS
					-		
laintenand	C PODCIETU						
Agintenano	ie Record:	-		_	-	_	

### TxDOT Rock Mass Field Description Glen Rose Formation

Page 3 of

Scanline Descriptions

0+00 0+50 1+00 Scanline Sketch (incluse seepage locations)

### Debris Description

obs #	Sta.	Set	Strik	e wit t	o expo	OUT 0	Dip	NT to a	xpodu		Persist.	Condition
			++20	20.45	600	RA.	+420	20-6	1640	RA	1 1	
1					1					T		
2	1											
3	T									1		
4												
5	1	_										
8					1					1		
7	-	1										
8	<b></b>			1								
9	1	1			1							
10		.1		1	1	1						
11						1	[					
12						1			1	1		
13					1			1	1			
14					1	1			1			
15								1				
16		_					1					
17		-		1	1							
18												
19						1.						
20						1			1			

Set	Apparent specing (Wiscan length)	True Spacing (Miscan length)
1		
2		
3		
4		
5		

Page 4 of 4 Code 7-10-4 Code

### TxDOT Rock Mass Field Description Glen Rose Formation

#### Scanline Descriptions



ODS #	Sta.	Set	Strike	e wit to	o expo	SUR	Dip	wit to	expos	ure :	Persist	Condin
			++20	20-6	6.40	RA	+420	20-6	45-00	RA		
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11	-											
12												
13												
14												
15				1		1				I		



Elevation (ft) looking 514

Page 2	20	4	Ł
Code	2-	10	-7

	91
	7
ic Data	

## Summary of Engineering Geologic Data

Set #	Strike	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarks
1	N 70'W	90	RIVEL IPLANSE	TIT A/Dam	P	IT - TT	CHAISILY FALME
2	N 20'W	90	RIV	1070-2"	P	In-Ib	NO BILLING
Wher Str	uctural Feat	ures	10-00			Dest	
eature	STIKE	CAID	Condition	Persistence		Rema	a KS
		-					
ecasion	al Random Jo	ints?	DIR +	STAINE T	2 2457 5	There in the	W CONT I
Decasion Sedding E Veatherir	al Random Jo Description: ng/Erosion:	1/4-13 63-0 87 0/500	THA CHAN - THA CHAN - THA CHAN - T' THAN - T' T' THAN - T' T' THAN - T' T' THAN - T'	ME BED STANKE T ME BED NORD BED NORD BED NORD BED NORD BED	E BAST S SLOPE S. (1'-2' ONS MITOP B ROSION SERT	THICK LAND	4 0' == cut 1 1 201 (1=12") - AL 14 BEDS NOR
Decasion Bedding E Weatherin - -	al Random Jo Description: ng/Erosion: Rope Failure/	hints? <u>Hiero</u> <u>Brsco</u> <u>Zef</u> Degrade	755 3 DIP + DIP + - THA CLAN - THA CLAN - THA CLAN - THAN CLAN - THAN - TH	JTE NEA STANKE - ME BED: MAD BED MAD BED MAD BED MAD BED MAD BED	2 5457 5 7 54082 3. (1'-2' 015 M1768 6 1203101 6 1203101 15 PT	THICK LAND	4 0' + 20+ 1 1 201 (6= 12+) - Bu
Docessions Bedding E Weathenin Tomn of S Xebris:	al Random Jo Description: ng/Erosion: iope Failure/	HALL B3D SY Disce Tak Degrada	755 3 DIP + DIP + DIP + DIP + TOTAL STATION DOT TOTAL DORATION OF CUT SI	775 N.84 574 WE 9 ME 8 80: NAME 880 NAME 880 NAME 880 NAME 880	2 2057 5 7 5608 5. (1'-2' 5. (1'-2') 5. (1'-2' 5. (1'-2' 5. (1'-2') 5. (1'-2') 5	THICK (and THICK (and IN / Hans A OF CLAM	LY GO
Decasion Bedding E Weathenin Form of S Debris: Maintenar	al Random Jo Description: ng/Enosion: lope Failure/ 	HALL 630 57 74E Degrade	1984 3 DIP +	775 N.84 574 WE 9 MJE 8 80: Y 575 A8 MARD 870 MARD 870 MARD 870	2 5457 5 7 54082 3. (1'-2' 015 M1768 6 1203101 15 PT	THICK LAND	LY CO

Page 3 of 4.

#### Scanline Descriptions

Horizontal Scanline Number: <u>[</u> Horizontal Location (locate on sketch); <u>Wep11</u> GUT Height above base of cut (R); <u>6'</u> If with one layer, layer thickness: Length of scanline (R); <u>647:43</u> GUT (6.0°) Strike of scanline (I) different from face);

0+00 0+50 1+00 Scanline Sketch (Include seepage locations)

Debris Description

obs #	Sta.	Set	Strik	a wir t	o expo	SURE	Dip	Sp wit to exposure Persist. Condit		Condition			
1999 - 1999 -		1.1	+20	2-6	640	RA	++20	20-45	4540	RL	1.000		
1		1	X			L	X			MA	P	TETR T. 2"/R. U/Z TE IN. A.	11
2		2	IX			0	X			74	P	TIT TOIMA IR IPIMM IS-ILAC	LACE
3										1		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	1
4													PICH
5			1		1								
6													
7					1								
8		_			1								
9													
10						1							
11													
12		_											
13						1							
14													
15													
16													
17													
18													
19													
20													
21								1					
22					1	1							

Set	Apparent specing (#/scan length)	True Specing (#/scan length)
1	9/60'=67'	12'
2	12/40/=51	38
3		
4		
5		

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#### **TxDOT Rock Mass Field Description**

Vertical Scanline Number: Scanline Location (show on sketch): Height of Scanline (ft): Length of Scanline(ft): 1111111111111111111 Photo Listing Description NO JUM 75 2 TOINTS 13 BANTRAMIC LAC SE. Scanline Sketch Samples Taken: NMV2\_ 357 490 75-85

### **Scanline Descriptions**

obs #	# Sta. Se		Strike	e wr	o expo	JOUR	Dip	wit to	Persist.	Condin		
			+20	20-6	-6-00	RIL	++-20	20-6	640	R.A.		×
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2				1		T						
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5		1										
6						T						
7												
8		T										
9												
10		T										

Date: 6/3/15 Page 1 of 4 Code 1-10-9

**TxDOT Rock Mass Field Description** Formation: FT. TREAST OVAL GLAN ROSE Location: I-10 JUST RAST OF FM 1338 TxDOT District: N. WAST OF & REALVILLE SAN MATONIO d BLAS Elev.(III) -10 N **Profile Sketch** Plan Sketch **General Exposure Description Dimensions and Orientation:** Total Height (ft): 80 236 = 4,35 = 1025' Width Lateral Extent (ft): Binches Height L1 12 13 Face Orientation: Strike/dip: KIN WOL TO ASI 180 A. SET BACK FRAN ER **Catchment Description:** SHALLAW DITCH 40 FT. Artificial Support: NONE Method of Excavation (incl. effects): BLAST, NONE Age of Exposure: Vegetation Effects: NONE Elev. (II) Elevation (ft) looking NH

Page \_2 of 4 Code \_\_\_\_\_8

# DOT Rock Mass Field Description

		Incough mess	Secaration	Persistence	Weathening	Romancs	
			Filling				
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NII'W	900	R / PLANINE	TITL	BC.	IA-Ib	CONFINISO TO MATERIE K	72
N 50 E.	60"1	RIUND	TITL	AR	ta-Ib	a • #	14
N 20 8	70	RIP	TITL	BC	In-Th	1° 11 #	1
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ctural Feat	ures		-				,
Strike	Dip	Condition	Peraistence		Rem	ins .	
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	0545			12 143-07 44	too care, you	THE PLACE THE PARTY	6Y 2'
Erosion:	Lowel	MOULAL LOY	in a Key	+ Uther	marcy K	HE HAVE RETREAT	167 Z'
Ærosion:	LOWEL UP 7	- MERVILAE LAY TO 6' SEMA	NO DECE.	+ UNICE	MARCH K	HE HAVE RETREET	7 67 2'
Ærosion:	Lowel UP 7	NORDELAL LOY TO 6' 55.44	ND FORE.	+ UNIL	MARCY K	HAN RETHER	τ <sup>ν</sup> 6γ <sub>.2</sub> , Έρ
Ærosion:	Lowel UP 7	newcae lay to 6' 35.M.	ND FORE.	+ UNIL JUT PISCOL	MARLY K	H HAN RETLER	το Το
/Erosion:	Lowel UP 7	- MEDILAL LAY 10 6' 55.M	ND FORE.	t Utile	MARCY K	H HAN RETLER	τ <sup>ο</sup> 6γ <sub>. Ζ</sub> ,
/Erosion: pe Failure/	Lowell UP 7	natural Lay To 6' 54.M.	NO FORE.	T UNEL	WARLY K MARIN OT	HE HAN RETRENT	т бу <sub>2</sub> , Та 2,47
/Erosion: pe Failure/	Lowell VP 7	nervick Ley To 6' 56.M. Ion: Ravilla Nooucht 1	NO FORE.	T UNEL JUT DISCOU	MARCY K MARCY K MARCY K MARCH OT IN 6420 ET. LARCE	HE HAVE RETHERT HELWISSE RALE AND IST G	т бу <sub>2</sub> , Ть 2,4/ 7 Г.40
/Erosion: pe Failure/	Lower UP 7	MONIAL LOY TO 6' 34 M. MONIAL S MT TURN	IND FORE.	+ UNEL JUT PIECOU K PPLI T. TEAA	MARCY K MARCY K MARCY K MARCH	HE HAVE RETHERT HERWISSE ROCE AND IST G CAILURE O LES BLOCK/WARE IN M	RAY ZY RA RAY T RAD KINC KF
/Erosion: ope Failure/ 	UP 7	MONIAL LOY TO 6' 34 MA	IND FORCE.	+ UNE JUT PIECOU K PPLI T. TEAA , SETTER, I	MARCY K MARCY K MARCY K MARCH CON IN GLEN ET. LABOR MOTOS). OCI	HE HAVE RETREAT	RAY ZY To SAY T FLAD KINC KE
	cturiil Peet Strike Random Jo	ctural Peetures Strike Dip Random Joints?	Churriel Features Strike Dip Condition Random Joints? <u>JT, etc. Char</u> <u>Strike </u>	Charles Persistence Strike Dip Condition Persistence Random Joints? JT. PT. CARCE 4552017 Strained To TTR. 10' 6 Scription: 9-16 * TWICH Kee. (z'-1' act)	Churrie Peetures Strike Dip Condition Persistence  Turk/LE Random Joints? JT, PT CAPCK 455 2017 AL Inductor Strike To TITE, 10' 624ad  Scription: 97-16 Y TINCHL Kee, /21-31 PET, MARD/MAN	Chisfiel Peeturee Strike Dip Condition Persistence Remu Turk/LÉ Random Joints? JT, pt CAACK EssanTurk Industrial To Cult Strike Dip Condition Persistence Remu Turk/LÉ Strike Strike Strike Strike Industrial To Cult Strike Dip Condition Persistence Remu Turk/LÉ Strike Strike Strike Strike Industrial To Cult Strike Strike	Chartel Peeturee Strike Dip Condition Persistence Remarks Twiki E Random Joints? JT. PT. CARCE ESSENTIAL INANTIEL TO CAT BEAR FACE OPUL Strategy To TTR. IN' BLOW From

Page_	1 0	4
Code_	2-1	I-E

### Scanline Descriptions

1 Horizontal Scanline Number: Horizontal Location (locate on sketch): W. SHP STATTAL & GUID IN CUT Gome EAST Height above base of cut (fi): 25' - 25' Length of scanline (ft): 235 Strike of scanline (if different from face): \_\_\_\_\_\_

0+00 D+50 1+00

Scanline Sketch (include seepage locations)

Debris Description

obs #	Sta.	Set	Strik	e wit b	o expo	sure	Dip	NT to e	NDOS.		Persist		Condition		٦					
			+4-30	20-6	45-00	RE	4420	20-65	640	RL										
1	-	1	X			R	X			TL	PINKET	TOTE	te la	-/	RIU	TE	-31	DRY	A,	2
2	-	2			X	L	X			N/A-	80	7773	IR.	ŧ/	7.	I6/1	14	Into 1	AL	
3	-	3			X	TL	X			4.04	84			1				+ + +		
4	-	4	1		X	R	X			a star	BC						- 3		•	
5												1								
6						T			1	T							1			
7												1								
8																		_		
9																				
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11		1		1		1	1													
12				1																
13						1						1								
14				T											-					
15																				
16					1															
17		1		1					1										٦.	
18		1				1											-		٦	
19		-		1	1	-	-	-		1		-						_	1	
20		-	-							1				-					٦	
21		1		-		1		-						-					1	
22		-	-	-	-	1	-					1	-	-					1	

Set	Apparent spacing (#/scan length)	True Spacing (Wscan length)	
1	37"	7'	T
2	1481	142'	11
3	59 *	45'	11
4	235	230'	1
5			

### Page 4 of 4 Code 1-10-8

### **TxDOT Rock Mass Field Description**



#### Scanline Descriptions

obs#	Sta.	Set	Strike	e wirt	o expo	oure	Dip	white	expos	une	Persist.	Candin
			+420	20-6	45-20	RA.	++-20	20-65	45-60	RL		
1	2											
2	9											
3	8											
4												
5	1											
6	S										2	
7	1.00	1							-			
8	3											
9	0											
10	S											



Indom Joints	Condition	Persistence		Remark	3
Indom Joints'	Condition	Persistence		Remark	3 3 15 CALLANTL
nal Features ike Dip NDS IN F Indom Joints'	Condition	Persistence		Remark	5
nal Featuree ike Dip NDS IN F Indom Joints'	Condition	Persistence		Remark	5
Indom Joints	Condition	Persistence		Remark	5 5 CALL#TL
ndom Joints'	ACE N/A	BLANCE OF BT	Fab. st. R.		S CALLANT
_ [	A Strik Land		CDDINE (B)	mer corre	
osion: _A	OR AS AN ALLA	ARE LIKE LS. ON HARD CLYSTA AREKETS AF U AREKETS AF U	ALCAREAS	(25 h) soft SRT u/Sm E 005. Sof	LS FRAGS
Failure/Degr	adation: John	NOR SPALLING			
ý ý	LITTLE	seaved to	1' Barba	L SIZE)	
lecord:					
technical Dat	ac				
	Failure/Degr	CEC #5.444 colon: <u>NOV2_ EX C3</u> Failure/Degradation: <u>M //</u> Failure/Degradation: <u>M //</u> ECOTI: ECOTI: Econical Data:	Contraction: MINTE CLYSTA CEC 451441 ACLASS AF C calon: <u>NON'2 2X CEPT For A</u> Failure/Degradation: <u>MINTE SPALLING</u> Failure/Degradation: <u>MINTE SPALLING</u> Failure/Degradation: <u>MINTE SPALLING</u> schnical Data:	CEC ASIMIAL ACLARTS OF CALCARAGES CONT. NONZ EXCRPT For MULDSIPH OF Failure/Degradation: MUNOR SAILLING Failure/Degradation: MUNOR SAILLING ECONT: ECONT: ECONT: ECONT: ECONT:	GERELALLY MAND CLYSTALLING PICES LY SAFT GEC ASIMIAL ACLAITS OF CALCAREADS SALT W/SAM Desion: <u>NON'L EXCEPT For MLOSIEN DE DEC. SA</u> Failure/Degradation: <u>MINOR SAALLING</u> Failure/Degradation: <u>MINOR SAALLING</u> Failure/Degradation: <u>MINOR SAALLING</u> Hecord:

### Summary of Engineering Geologic Data

Page 2 of 4 Code \_ \_ \_ \_ \_ 9

1+00

### **TxDOT Rock Mass Field Description**

0+00

#### Scanline Descriptions

Horizontal Scanline Number: \_\_\_\_\_\_ Horizontal Location (locate on sketch): \_\_\_\_\_\_ Height above base of out (fi): \_\_\_\_\_\_ If with one tayer, tayer thickness: \_\_\_\_\_\_ Length of scanline (fi): \_\_\_\_\_\_ Strike of scanline (if different from face): \_\_\_\_\_\_

0+50

Scanline Sketch (include seepage locations)

Debris Description

obs#	xbs # Sta.		Strik	o wat t	o expo	sure	Dip	NT ID C	1005	ne .	e Persist	Condition
			++20	20-6	45-60	RM.	++30	20-6	45-60	RL		and the second se
1										1		
2												
3												
4												
5												
8												
7												
8	1					1						
9						T						
10												
11												
12												
13							1					
14												
15												
16												
17												
18												
19					1							
20					1							
21												
22					1				1			

#### Set Apparent spacing True Spacing

	(Miscan length)	(Wscan length)
1		
2		
3		
4		0
5		

### Page 4 of 4 Code 70-9

### **TxDOT Rock Mass Field Description**



obs#	Sta.	Sta. Set		Strike wir to exposure Dip wir to exposure								Condin
			+4-20	20-6	45-00	RAL.	+420	20-6	45-00	RA		
1			1									
2												
3												
4								-				
5												
6												-
7												
8					1							
9							( ) ( )					
10												



Elevation (fl) looking N

		Filing		AAstronomical	Remains
		++			
		+			
	_	1			
		+			
_					
er Structural Features	10 and 10 and	Descision I		0	1-
aure series Dip	Conation	Persistence	_	Rema	105
	-+	++			
ing Description: <u>Abu</u>	L Mp RCEV.	VULGY BUD SKETCH	n Duto	I' TO S' AT	sylowed and u Her 2-7'
dding Description: <u>Alec</u> 5. sathering/Erosion: <u>54</u> 26	HO CAYS, CS, L. MO RCEV.	Emes VUGGY BID SKEPEN SKEPEN SKEPEN SKEPEN	ns, Dolla nuclass ns ana S	MITE AS	sylamont an u the 2-7'
eathering/Erosion: <u>//er.</u>	L. M. REASING	Emes VUGGY BID SKETEH, J OF YIMEY Pon	ns, Dolla DocuMASS Na Ana S	MITE AS	sylowal an v ele 2-7' ( Mare soci
realition Description: <u>Alex</u> lealthering/Encelon: <u>St.</u> 	HO CAYS, CS. L. MO RCEV. 15 MT BROSING . HLAPE.	20165 VU664 830 SKETER, 3 OF VUMEY 2011	ns. Dutto Thermass ns and s nf collat	MITE AS	Solower and a set 2-7'
eathering/Erosion: <u>//ec</u> eathering/Erosion: <u>%</u> 	HO CAYS, LS, L. MO REEV.	Emes VUSGY BID SKETCH, J OF VINEY PON CAN ANT OF COM ANT OF	ns. Dutto Threemass ns and s nf could and those	MITE AS	Show of an u the 2-7' Mary sold Mary sold Mary sold Mary sold Mary sold Black Street
tking Description: <u>//// sthering/Erosion: <u>%</u> </u>	HO CAYS, LS, L. MO REEV. 16 MT BRANN 16 MT BRANN 16 MT BRANN 16 MT BRANN 16 MT BRANN RUBER AN TO P" AND	SAE TER STO SAE TER STO OF VIEWY FOR ALANT A	ns. Dutto Threenass ns and s nf collat and 9705, t fam in	MITE AS I' TO B' AS SET BOLOW 71 SET VOID SENT LOVIE ENV 7. 2'	Show of an u the 2-7' ( Adams sold Markewitz S. Blacks asso (Ada 1').
kting Description: <u>/////</u> athering/Erosion: <u>St.</u>   m of Slope Failure/Degr ris: <u>occcav14.c.</u>	HO CAYS, LS, L. MO REEV. 16 MT BRASING 44.478. Tables REPORT OF REPORT OF REPORT OF REPORT OF REPORT OF REPORT OF RECORD	LONES VULGY BUD SKETCH, J OF VULLY PON OF VULLY PON	ns. Dutho Threenass ns and s nf collat and stos, t fam in	MITE AS I'TOB' AS SET BOLOW 71 SET VOID SENS LOVIE ENV 7: 2'(	Show of an u the 2-7' ( Adams sold Markew St. 5. Blacks also (All 1').
dding Description: <u>Alex</u> sathering/Erosion: <u>Sk</u> 	HO CAYS, CS, L. MO REEV. 16 MT BRASING 44.472 Tableton: FALL O REPORT MA TO 8" Rock	SAR TEN	ns. Dutho Threenass ns and s ns collar and stos, * Fam in	MITE AS I'TOB' AS SET BOLOW 71 SET VOID SET LOUSE ENV 7: 2'(	Show of an u the 2-7' More sold Marken of 5. Blacks of 5. (And 11).
kting Description: <u>Alex</u> athering/Enssion: <u>Sk</u> <u>46</u> m of Slope Failure/Degr m s: <u>e00. cavidus</u>	HO CAYS, LS, L. MO REEV. 16 MT BROWN 44472 Tableson FALL O REDCKS M REDCKS M TO 8" Rock	LONES VULLEY BUD SKETCH, J OF VULLY PON OF VULLY PON	ns Dutho Threenass ns and S ns and S s f collat and Stos, s f r m n	MITE AS I'TO B' AN TO B'	Solowith and U the 2-7' ( Addres sold MONE sold ( Addres sold ( Addres sold ( Addres sold) ( Addres 1 ).
tkiing Description: <u>Abc</u> samering/Erosion: <u>St.</u> <u></u>	HO CAYS, LS, L. MO REEV. 16 HT BROWN 16 HT BROWN 16 HT BROWN 16 HT BROWN REDCKS M REDCKS M TO 8" Rock	LONES VULGY BUD SKETCH, S OF VULLY PON	n Dutlo Threenass ns and s the collar and stos, * from th	MITE AS 1' TO B' AS SET BOLOW 71 SE VOID SENT 2015 ENT 7: 2'(	Solowith and V the 2-7' ( Addres sold Addres sold Addres sold ( Addres sold ( Addres 17),
dding Description: <u>Alex</u> sathering/Erosion: <u>S4</u> <u>46</u> mm of Slope Failure/Degr bris: <u>e02- cavidus</u> intenance Record:	HO CAYS, LS, L. MO REEV. 16 HT BROWN HAT BROWN HATSE REACKS I REACKS I REACKS I REACKS I REACKS I REACKS I	LONES VULGY BID SKETCH, S OF VILLEY PON	15. 20120 Three Miss 115 Ann 5 115 Ann 5 115 Ann 11 115 Ann 11	MITE AS	Sylow of an u see 2-7' ( Adave soci MONELWOISE SI (Alle 1').
dding Description: <u>Alex</u> sathering/Erosion: <u>S4</u> <u>46</u> m of Slope Failure/Degr bris: <u>eQC- carl 46</u> intenance Record:	HO CAYS, LS, L. MO REEV. 16 HT BROWN HAT BROWN HATS REACKS REACKS TO P" Rock	LONES VUGGY BID SKETCH, J OF VINGY PON OF VINGY PON	15. 20120 Three Miss 115 Ann S 115 Ann S 115 Ann Ann 115 Ann Ann	MITE AS . I' TO B' AT TET BOLOW 71 SE VOID SENT 2015 EMU 71 2' (	Sylowood and a ser 2-7' ( Maave sold MONELLUND E S. BLOCAS 085' (ANG 1').

Page 3 of 4 Code 4/-/

1+00

### **TxDOT Rock Mass Field Description**

### Scanline Descriptions

NONI CONDUCTED

Hortzontal Scanline Humber:	1.		-	-
Horizontal Location (locate on skutch):	 			
Height above base of out (ft):		1.1		
If whin one layer, layer thickness:				
Length of scanine (ft):				
Strike of scanline (if different from face):				

0+00

0+50 Scanline Sketch (include seepage locations)

#### Debris Description

obs#	Sta.	Set	Strik	e wir b	o expo	SULLE	(Dip v	WT to a	UCDONE.	re	Persist	Condition
			+20	20-6	640	RAL	++-30	20-6	1-6-60	194	1	
1			-			-		-	-	-		
2			1	-	1	-			-	-		
3			-	-	1	-	-	-	-			
4	1		-	-	-	-	-	-	-			
5				-	1	-	-	-	-	-		
6				-		-			-	-		
7										1		
8									-			
9												
10												
11												
12												1
13												
14				1								
15												
16					-							
17												
18					1							
19					1							
20												
21					1							
22					1							

Set	Apparent specing (Wscan length)	True Spacing (Mecan length)
1		
2		
3		
4		
5		

Page 4 of Code



obs#	Sta.	Set	Strik	e wit t	o eutro	tour t	Dip	wit to	expos	UTR	Persist.	Condin
			+/-20	20-6	45-90	RA	+4-20	20-6	4540	RI.		10000000000000000000000000000000000000
1												
2			1									
3												
4	_											
5												
6							[	1	(			
7												
8		1										
9									-			
10												









Set #	Strike	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarks
JOINT	4						
_				-			
	-	+					
	-	-					
				-			
	-	-					
other Str eature	Strike	IDip	Condition	Persistence		Remark	ks
edding (	Description:	MB2 Vel	SIVZ, Here of Com2.	D CAYST	ALLING. 3-2'	W/CHECT	NODULISS
ledding ( Veatherir	Description: ng/Erosion:	100	SIVE Here SIVE Here Hos Drsco	D. CAYST	AUINE. 3-2'	W/CHART REDS INTER	- NODULIS GLIDED HAT
Jedding D Veatherir	Description: ng/Erosion:	1005- 162 154	SIVZ, Here Si (com 2 195 DISCO	DI CAYST	BUINS. 3-2	W/CULCT Rebs MTLA	NODULISS GLIDED MIT
Bodding ( Weatherin Form of S	Description: ng/Encelon: llope Failure	jmőy kv vy	5122. 14th 15 (bom2 195 195 195 195 195 195 195 195 195 195	Di CAYST	ALLING 3-2'	W/CHACT REDS INTER CLAYG	- NODULIS BLIDED KAT
Bodding ( Weatheri Form of S	Description: ng/Erosion: Nope Failure	jentičy kol vije vije vije vije vije vije vije vije	51 v2, 14th 13 (5m2) 105 105 107 SCO 107 SC	DI CAYST	ALLING 3-2'	W/CURCT REDS INTER	NODULES GLIDED MIT
Bodding ( Wealtherin Form of S Debris:	Description: ng/Encaion: liope Failure	<u>indí</u> <u>izi</u> isi Moegrada	51 v2. 14th 15 (bm.2. 105 105 105 105 105 105 105 105	Di CAYST Gail Fills LORATINI VERY MI	BULING 3-2'	W/CULCT RRDS IN THE CLIVE	- HODULII SIDID KAT
Bedding ( Weatherir Form of S Debris:	Vescription: ng/Erosion: liope Failure		51 v2, 14th 15 (cm2) 105 107 SCO 1001: V147 14" 45	DI CAYST Gail FILLS LORATIN VERY M	BUING 3-2	W/CURCT REDS INTER	NODULIS GLIDED MIT
Sedding ( Wealtherin Form of S Debris: Maintenar	Description: ng/Erosion: liope Failure	<u><u>indér</u> <u>is</u> <u>is</u> Moegrada <u>c</u> 2"-</u>	51 v2. 14tu 13 (6m2 195 195 195 195 197 SCO 197 SCO 19	Di CAYST Gail Fills LORATIN VERY M	BULING. 3-2'	W/CURCT RRDS INTER	- HODULIS BLOED HAT
Bedding ( Weatherir Form of S Debris: Maintenar	Vescription: ng/Erosion: liope Failure	<u>ind5;</u> <u>viz</u> j vDegrada c 2"-	51 v2, 14th 15 (6m2 135 135 135 135 135 135 135 135	DI CAYST Gail FILLE LORATIN VERY M	BUING 3-2	W/CULCT REDS INTER	NODULIS GLIDED MIT
Bodding ( Weatherin Form of S Debris: Maintenar	Description: ng/Erosion: liope Failure (2) nce Record:	<u>indí</u> <u>i</u> u i vDegrada <u>c</u> 2"-	51 v2. 1400. 13 (im.2.) 135 135 135 135 135 135 135 135	Di CAYST Sail Fills LORATIN VERY MI	BULING 3-2'	W/CULLT	HODULIS SIDED KAT
Bedding ( Weatherir Form of S Debris: Maintenar Available	Description: ng/Erosion: liope Failure 22 nos Record: Geotechnic	<u>intersec</u> <u>intersec</u> <u>intersec</u> Moegrada <u>c</u> 2"-	51 v2, 1480. 15 (cm.2) 135 135 135 135 137 137 137 137 137 137 137 137	DI CAYST Gail FILLS LORATIN VERY M	BUING 3-2	W/CURCT REDS INTER	ANDED HAT

### Summary of Engineering Geologic Data

Page \_\_\_\_\_\_ or 4/\_\_\_\_\_ Code \_\_\_\_\_\_\_727-1/\_\_\_\_\_

	Scanline Descriptions	
Horizontal Scanline Number: Horizontal Location (locate on sketch): _ Height above base of out (ff): If win one layer, layer thickness: Length of scanline (ft): Strike of scanline (if different from face	NOT PELFORMED	
	0.40	
0+00	0+50	1+00

Scanline Sketch (include seepage locations)

## Debris Description

obs#	Sta.	Set	Strik	e wir b	0 expo	sure	Dip	AT to a	nipos.	re	Persist.	Condition
			+4-20	20-6	640	TH.	++20	30-6	45-60	RA	1 1	
1										1		
2												
3												
4												
5					1							
6	1									T		
7												
8												
9												
10						1		1				
11				1								
12												
13												
14				1								
15						1						
16									1			
17												
18								1.1				
19												
20												
21												
22												

Set	Apparent specing (Wacan length)	True Specing (Miscan length)
1		S
2		
3		
4		
5		

Page 4 of 4 Code 187-7

Vertical Scanline Number: Scanline Location (show on sketch): Height of Scanline (II): Length of Scanline(II): 1111111111111111 Photo Listing Description No. 14 PAN 186 1 DAH 15 1.16 1.44 16 PAT 2 Scanline Sketch 857 Rad 85-100 Samples Taken:

#### Scanline Descriptions

obs#	Sta	Set	Strik	e wir i	0 8000	SUF	Dip	wir to	expos	ure	Persist.	Condin
			++-20	20-6	640	R.L.	+/-20	20-6	45-00	RIL		
1					1							
2												
3												
4					-							
5				1								
6												
7												
8			-									
9												
10												



Page 2 of 4 Code 337-/

### **TxDOT Rock Mass Field Description**

/         MES*E         75°         V. Anter/wep (arte 1st., Tenants and II, FillSo III Some A)           72         N 40°W         90°         V. Anter/Wep         771 70 2'         780464 and II         311 7 8 anter. winter           72         N 40°W         90°         V. Anter/Wep         771 70 2'         780464 and II         311 7 8 anter. winter           72         N 40°W         90°         V. Anter/Wep         771 70 2'         780464 and II         311 7 8 anter. winter           74         90°         V. Anter/Wep         771 70 2'         780464 and II         311 7 8 anter. winter           74         90°         V. Anter/Wep         771 70 2'         780464 and II         311 7 8 anter. winter           75         N 40°W         90°         V. Anter/Wep         771 70 2'         780464 and II           76         90°         V. Anter/Wep         771 70 2'         780464 and II         910 anter           90°         Condition         Persistence         Remarks         100         100           000         Disponsionts         YES         YES VILTERAL         8C FRANCTINES / JOINTS // KE         Ket
Image: Strike     Dip     Condition     Persistence       Image: Strike     Dip     Condition     Persistence     Remarks
Image: State         Image: State<
Z_         N 40°W         90°         V. Anter/UKD         Tirt To 2'         TELEBRATION         JL         Starde model         Wave           A
Inter Structural Features     Inter Structural Features       inture     Strike     Dip     Condition     Persistence     Remarks       inture     Strike     Dip     Condition     Remarks     Remarks       inture     Vision     Remarks     Strike     Strike     Remarks       inture     Vision     Remarks     Strike     Strike     Strike       inture     Vision     Remarks     Strike     Strike     Strike       inture     Mathematical Strike     Strike     Strike     Strike     Strike
Image: Structural Features       ature     Structural Features       ature     Strike     Dip     Condition     Persistence       Remarks       Image: Strike     Dip     Condition     Persistence     Remarks       Image: Strike     Dip     Condition     Persistence     Remarks       Image: Strike     Dip     Condition     Persistence     Remarks       Image: Strike     Dip     Condition     Persistence     Remarks       Image: Strike     Dip     Condition     Persistence     Remarks       Image: Strike     Dip     Condition     Persistence     Remarks       Image: Strike     Dip     Condition     Persistence     Remarks       Image: Strike     Dip     Condition     Persistence     Remarks       Image: Strike     Mage: Strike     Strike     Strike       Image: Strike     Strike     Strike     Strike
Image: Structural Features     Image: Structural Features       ature     Strike     Dip     Condition     Persistence     Remarks       casional Random Joints?     YES     VISTRAL     BC     FARETURES     /JOATS     IN     Kcc       dding Description:     Image: Image
Inter Structural Features     Inter Structural Features       ature     Strike     Dip     Condition     Persistence     Remarks       casional Random Joints?     YES     YES     VIETRAL     BC     FAMETIMES / JOATS IN Kee       doing Description:     Interstyle     Interstyle     Interstyle     Interstyle       doing Description:     Interstyle     Interstyle     Interstyle     Interstyle       sathering/Erosion:     454444     Encoded     /sturning     Interstyle
Inter Structural Restures     Dip     Condition     Persistence     Remarks       sture     Strike     Dip     Condition     Persistence     Remarks       casional Random Joints?     YES     VILTURAL BC     Particular IN     Ket       doing Description:     Intersity Intersity     Intersity Intersity     Intersity       sathering/Erosion:     454442     Excerct / Sturrenkee Intersity     Ket
Inter Structural Features     Dip     Condition     Persistence     Remarks       atture     Strike     Dip     Condition     Remarks       attack     V3.5 V3.7x4L     BC     FARETIMES / 30 #75 /N     KgL       attack     MAKS/V1NoDUAL     W64Y     W Ker, 2'-4' ALTURATING BLOS       attack     Kar     Nobust     Nobust     N Ker
And Structural Features     Advantage     Remarks       ature     Strike     Dip     Condition     Persistence     Remarks       cassional Random Joints?     YES     YES     VILTURAL BC     FAMETIMES     /JOATS IN Ket       doing Description:     MAKSIVE     MODURE     WERY IN Ket     2'-4' ALTURATING BLOS       sathering/Erosion:     454442     Excharged /struments in Ket     Disconsidential IN Ket
And Structural Features         ature       Strike       Dip       Condition       Persistence       Remarks         ature       Strike       Dip       Condition       Persistence       Remarks         casional Random Joints?       YES       YES       Mathematical       BC       Forfermes       Joints       No         doing Description:       Mathematical       No       No       No       Ker       Z'-4'       ALTURATING_8105         sathering/Erosion:       Asural Encoded       Isturation       Ker       Disconstruct       N Ker
Strike     Dip     Condition     Persistence     Remarks       casional Random Jaints? <u>YES VILTEAL BC FARETURES /JOATS IN KEL</u> sating Description: <u>MASIVE NODURE NUMPY IN KET, 2'-4' ALTURATING BLOS</u> sathering/Erosion:     454462
casional Random Joints? <u>YES VILTERAL BC PARTERS /JOATS IN KE</u> dding Description: <u>MAKSIVE NODURE NUGLY IN KET, 2'-4' ALTURIATING BLOS</u> KAR sathering/Erosion: SEURAL EROSAN /SELEMANCE IN KER, DISCONDRATION IN KET
cassional Random Joints? <u>VES VILTEAL BC FARETIRES /JOATS IN KER</u> doing Description: <u>MARSIVE NODURE NUGLY IN KET 2'-4' ALTURIATION BLOS</u> KER sthering/Erosion: 45/262 EROSAR /SLUMMAR IN KER. DISCONDRATION IN KET
casional Random Joints? <u>YES VICTORE BC FRANCTURES /JOANS IN KER</u> doing Description: <u>MARSIVE NODURE VICEY IN KET, 2'-4' ALTURIATION BLOS</u> KER sathering/Erosion: 45/262 EROSION /SCUMPTING IN KER, DISCONDRATION IN KET
Sours FRESH THIS SUCCESS INDICATE SPORADE RAVELLING/M. BLOCKFALL/2'-3' BLOCKS)
The IN Kar SETTER AND AND IN KET SETTER ANTELING IN KET SETTER AAVELING, O PALL IN Kar Po TENTIAL FOR LARGE TOPPLAL IN KET B T MILES
ana: some 70 2 some as

### Summary of Engineering Geologic Data





#### Debris Description

ibs #	Sta.	Set	Strik	e wir b	o expo	sure	Dip	NIT TO O	DODOSL		Persist.	Condition
			+420	20-6	6-00	RL	+420	20-6	45-80	AL.	1	100
1		1		X		TL	X			R	P	VR/mattor i'm some lasy/I
2		2		X		R	X			100	P	VE/WAD/THE += 2"/DEY/S
3										1		
4				_								
5						1						
6												
7									1			
8									1			
9												
10					1							
11						1						
12										Ľ.,		
13		_		-								
14												
15												
16												
17								1				
18												
19												
20										1		
21												
22									1			

Set	Apparent spacing (#/scan length)	True Specing (#/scan length)	
1	72-	41	THE INI
2	130	113'	154
3			1
4			1
5			1

Page 4 of 4 Code 337-/



#### Scanline Descriptions

obs#	Sta.	Set	Strike wir to exposure Dip wir to exposure							Persist	Condin	
			++30	20-6	640	RL.	+20	20-6	640	RA.		
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												


Page 2 of 4 Code 337-2

# **TxDOT Rock Mass Field Description**

Set #	Strike	Dip	Roughness	Separation/ Filling	Persistence	Weathering	Remarks
		-					
other Str	uctural Fea	Lares.		-			
eature	Strike	Dip	Condition	Persistence		Rema	rks
		-					
xidding D	escription:	<u>B-27</u> <u>10' N</u> INT	<u>VIS ONFIN 1 5 ANTIA</u> 19: 8'HALB 19: 8'HALB 19: 2'	NO TO LANG A LANDTO & C MARINE OND, MAL 31.D. OLICES.	а 8' тна ат (27 З'тацу тересь н	NODERAL A	(ME BO, NO'E) (ACITA) (50, 4-6"-2" BI ACE MARKY PRACT
ledding D Veatherin	il Random J lescription: g/Erosion;	<u>B-77</u> <u>18' N</u> INT <u>P150</u>	YIS ONFIN . 5 BATTION . 8' MALLO . 8' MALLO . 8' MALLO . 8' MALLO . 8' MALLO 	AD TO LAND A DEFINE OD, NOL BED. OLICES. CLIENT RAN	2 8' 7400 127	K CRYSTAL TANI S NODHAL G MAD ALOS	LAL BO, NETE ; 4 ACTAL) 550, 4-6"-2" SI ACE MANY MERCY
ledding D Veatherin	escription: g/Erosion;	<u>B-97</u> <u>10' A</u> 1NT <u>P/50</u>	YIS CARFA 2 5 BATTA 19: 8'HALLE 1944 MALLE 1944 MA	AND TO LAND A LAND AT A LAND A LAND A LAND ALACESS	<u>и. 8' тине</u> Эт (27 З'ресенцу не ирека на спол не ман	K CRYSTAL TAWE S NODUAL A WED ALOS	(ME 80, NEVE) (ACTAL) (SD. 4-6"-2" BI ACE MARKY PACACI
Sedding D Veatherin	escription: G/Erosion: Ope Failure	<u>8 - 2 - 7</u> <u>10' n</u> 1NT <u>1/50</u> Degrada	VIS ONFM 3 5 BNTIA 100000 MALS 100000 MALS 1000000 MALS 10000000 MALS 100000000 MALS 100000000 MALS 100000000 MALS 100000000 MALS 100000000 MALS 100000000 MALS 1000000000 MALS 1000000000000000000000000000000000000	AND TO LAND A DEFINE OUD, INC. BED. OLICES. (LIGHT SLAN FALL FROM	A B' THE	K CAYSTAL TAWL 3 , NODUAL 4 (MD ALOS (MY 510 (MAD SID)	LACTOR BO, NET SI VACIONAL SED. 4-6"-2" SI DEE MARKY PROCE
Seciding D Weatherin	il Random J lescription: g/Erosion; lope Failure	<u>B - 77</u> <u>10' A</u> 1NT <u>0160</u> Degrada	YIS ONFIN 2 5 BNP14 19: 8'HALLE 1940 MALLE 1940 MA	AND TO LAND A LAND TO LAND A LAND TO LAND ALANCESS CLIGHT SLA FALL FREE M. BLOCKS (	A B' THE AT (27 3' promety) HIPPLS H HIPPLS H HIPPLS H HIPPLS HIPLS HIPLS HIPLS HIPLS HIPLS HIPLS HIPLS	K CRYSTAL TAWE 3 NODUCAL 4 MOD ALOS WY 53.0 HALD BZD. COLL MATH	(1) (1) (10) (10) (10) (10) (10) (10) (1
Sedding D WeatherIn Form of S Debris:	il Random J escription: g/Erosion; lope Failure	B-27 - 10' A - 10'	YIS ONFIN 3 5 BNTIA 100 8' MALE 100 00 10 2' 0100047111', 10000047111', 10000047111', 11' BALDIA 11' BALDIA	AND TO LAND A HOLDE OND, AND JUD. OLICES. CLISHY SLA FALL FRE M. BLOKS I SIZE TI	2 8' THE 2 (27 3' MARLY 3' MARLY MIPPLS 4 1000LE (1) MAR MLS JULIA	K CATSTAL TAWE SED WED ALOS KNED BED GAR MATHER	LME BO, NETES
Sedding D Weatherin Form of S Debris:	escription: g/Erosion: ope Failure <u>6-0-943</u>	B	VIS ONFM B S BATTA P: 8'MALD VOLATION BOUCH MESS 0.00047100 D.00047100 D.00047100 D.00047100 D.00047100 D.00047100 D.00047100 D.00047100 D.00047100	AND TO LAND A MAINT & C AMAINT & C AMAINT & A AMAINT & A CALLERT & A MALE FROM MALE FROM MA	A S' THE at (27 3' mater 3' mater at BELL at BELL a	ALATING	(ME BD, NET 2 ) + 20146) 550, 4-6"-2" - 31 550, 4-6"-2" - 31 550, 4-6"-2" - 31 550, 4-6"-2" - 31 550, 4-6"-2" - 31 50, 4-6" - 2" - 31 50, 4-7 50, 4-7 50
Seciding D Weatherin Form of S Debris:	escription: g/Eroaion; <u>g/Eroaion;</u> <u>g/Eroaion;</u>	B-27 10' A 10'	YIS ONFIN 2 5 BNT 14 10 21 BLACK 10 21 - 7 2' 01 01247114 10 01247114 10 01247114 10 01247114 11 6012 012471	AND TO LAND A HALITY & C AND TO LAND ALIENT & LAN ALIENT & LAN FALL FALL M. BLOCKS I SIZE TH SO ESCENT	A B' THE AT (27 3' promotion The PRIS A AT (27 AT (27) AT (2	K CAYSTAL TAWE STO NODUCAL A WED ALOS WY STO WY STO ALAN D SED COLAR MATT	(ME BD, NEP'E) # ACATAL) BED. 4 - 6"-2" BI ASE MARKY PRACT ASE MARKY PRACT I MINDE RAPELING ML 1350 TOL. ATTEMES
Sedding D Weatherin Form of S Debris: Maintenan	I Random J Iescription: g/Erosion; lope Failure 	B -97 10' A 10' A 10	VIS ONFIN B S BNPIA P) B'MALE POLAL MESS POLAL MES	HO TO LAND A LAND TO LAND A LAND TO LAND A LAND TO LAND ALANCESS CLISHY REA FALL FRE M. BLOCKS SIZE TI SO RECENT	N. 8' THE DT (27 3'money misses H similat Anton misses Time misses Miss Jusin 24	K CAYSTAL TAWE SED NODUCAL A KOLD ALOS KY SED KHALD BED COLL MATH	LACE BED, NED'E ; ACTAL SED, 4-6"-2" BI ACE MANY PRACE S. MINOR RAPILLONG ML 1360 TOL. ATTEMES
Sedding D Weatherin Form of S Debris: Maintenan	escription: Q/Erosion: Q/Ero	B - 27 10' A 10' A 1	VIS ONFIN B S BATTA P: 8'MALE VELL MES VELL MES VELL MES VELL VELL I' CALDIA I' CALDIA I' CALDIA	AND TO LAND A DEFINE OUD, INC. BED. OLICES. CLIENT REN M. BLOCKS I SIZE TI SO ESCENT	A S' THE at (27 3' material at BELL H at BELL H at BELL H at BELL (1') Man ALS JUSH	K CRYSTAL TANE S NODUAL A WED ALOS WILD ALOS WILD ALOS WILD BED GOAL WAT	(1) 190, NOVE ; 4 20146) 550, 4 - 6"-2" 51 550, 4 - 6"-2" 51 550, 4 - 6"-2" 51 550, 4 - 6"-2" 51 550, 4 - 6"-2" 51 50, 4 - 6"-2" 51 50, 4 - 6" - 2" 51 50, 50, 50, 50 50, 50 50
Seciding D Aveatherin Form of S Debris: Maintenan	i Random J escription: g/Erosion; iope Failure <u>6-6-8+4a</u> 79 A ce Record: Geotechnica	B - 27 	YIS ONFIN 1 5 BATTA 10 8 MALE 10 LOLL MESS 10 DOLL MESS 10 DOLL MESS 10 DOLL MESS 10 DOLL MESS 10 DOLL MESS 11 BALDER 10 CLEAR	AND TO LAND A HALITY & C AND TO LAND ALIENT REA CLIENT REA FALL FALS M. BLOCKS I SIZE TH SIZE TH	A B' THE AT (27 3' promotion The Part of the Part o	K CAYSTAL TAWE STO NODUCAL A WED ALOS WY STO WY STO COM MATH	LATE BO, NEVE ; # RCATE) ED. 4 - 6"-2" BI ASE MARKY PRACE E. MINDE RAPELING ML 1350 Tol. ATTEACS
Sedding D Weatherin Form of S Debris: Maintenan	I Random J Iescription: g/Erosion; iope Failure <u>6-0-Rvs</u> ce Record; Geotechnica	B -97 10' A 10' A 10	VIS ONFIN B S BNPIA P): 8'MALE POLAL MESS POLAL ME	AND TO LAW A LAND TO LAW A LAND OD, AND JED. OLICES. CLISHT REA M. BLOCKS I SIZE TI SO RECENT	N. 8' THE DT (27 3'money missels H signal of Andre missels Miss Jusin 27	K CAYSTAL TAWE SED	LACE BO, NEVE ; ACTAL SED. 4-6"-2" BI ACE MANY PRACE S. MINOR CARLING ML 1360 TOL. ATTEMES
Sedding D Weatherin Form of S Debris: Maintenam	I Random J Iescription: g/Erosion: lope Failure 	B -97 10' A 10' A 10	VIS ONFM 1 5 BNP14 1 5 BNP14 10040 Mts 20040 Mts 200000714, 100000714, 100000714, 100000714, 100000714, 1000000714, 10000000000000000000000000000000000	AND TO LAW A DECEMBER OF LAW A	12 B' THE DT (27 3' MATIN 3' MATIN 3' MATIN 3' MATIN 10015 1010	K CAYSTAL TAWE 3 NODUCAL 6 INSDUCAL 6 INSDUCAL 6 INSDUCAL 6 INSDUCAL 6 INSDUCAL 6 INST	LNE BO, NEVE, ACTOR SED, 4-6"-2" BI ACE MARKY PRAC S. MINDE RAPEING TOL. MIRKS

Page	3	of	4
Code,	33	7-	2

#### Scanline Descriptions

Hortzontal Scanline Numb	NO SCHALINE. NO MAJOR JOHN	NTS HOWEVER,
Height above base of cut (ft	): /// // /// /// /////////////////	MALD ALLS ME
If with one layer, layer thicks	ness:	PRACTURED (LANGE ROLD)
Strike of scanline (if differen	t from face):	
0+00	0+50	1+00
	Scientine Sketch (include seemine incutions)	

#### Debris Description

obs #	Sta.	Set	Strike wit to exposure				Dip	NT to a	oposi	re	Persist.	Condition
			++-20	20-65	45-80	IRA.	++20	20-6	6.00	RA		
1								1		1		
2												
3				1					1			
4										1		
5					1							
6								1		T		
7												
8					1	1						
9												
10												
11							· · ·					
12												
13												
14								1				
15												
16												
17												
18												
19												
20												
21												
22												

#### Set Apparent spacing True Spacing

	(Wacan length)	(Wscan length)
1		
2		
3		
4	5. Sec. 1997	
5		

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#### Scanline Descriptions

obs #	Sta	Set	Strik	e with		SUIT	Dip	wit to	Persist	Condin		
			+/-20	20-6	45-50	RA	+20	20-6	45-00	RL		
1				1				1				
2		1										
3												
4												
5			1									
6												
7												
8												
9		1										
10		1										



Page Zot 4 Code 470-1

# Summary of Engineering Geologic Data Joint Description Summary Set # Strike Dip Separation/ Persistence (Weathering Set # Dip Remarks Roughness Filling DESTRUCTO NOWS Other Structural Features Dip Feature Strike Persistence Remarks Condition MONE DESCURE IN GERN RESE. BC TOMITS (UN TOK L' SHOPL, THE "C I' WENNE RESERVE IN KET (SEE PATTO II) Occasional Random Joints? 170 Bedding Description: INTERSORD MORES/SOFTER MARLY LAYELS IN GERN ASSI. LOUGH. 20' THEOREM & 6"-1. CONTY TELL IN THIS MARLY BANE DUE TO GLOGINI, THEN 2'-Y" TO KEY WHEN LOES TO 35 MASTINE. Weathering Erosion: STYPALE ALOUND OF WHELY BANG AT MAP SLOPE. MINGL FRESSOT LONGA 20' MARCY BANG HAS BUSSION GULISUS AND APPERESSOL LIKE (IN:IV) Form of Slope Failure/Degradation: BLOCK FALL I & 28 Aus SLIDES JUR TO BADSIM TE MALLY BATE. RAMULING IN LOWAR BO' LALOS TALES ALLS (CLAY - & SAMOLA). STAR BLOCKS DESTLUND 6- -3' - Debris: Maintenance Record: Available Geotechnical Data:

Page	2.0	4
Code	-4	70-1

	Scanline Descri	ptions
Horizontal Scanil Horizontal Locatio Height above base If win one layer, is Length of scanline Strike of scanline	ne Number: n (locale on sketch): of cut (ft): yer thickness: (ft): (ft): if different from lace):	NOT PERFORMED NO TOINTS OBSERVED IN KGR ONLY IN OVIEWING KFT
0+00	0+50 Scanline Sketch (include see	page locations)

Debris	Descrip	noite

1

obs #	Sta.	Set	Strik	o wir b	o expo	Dipv	wir to a	Incosu	-	Persist	Condition	
_			++-20	20-6	4540	RL	++20	20-6	6.00	RA		
1				1								
2									1			
3												
4			1.		1							
5												
6					1							
7		_			1			1				
8		_										
9												
10			1									
11		_										
12												
13		_	-									
14												
15										1		
16												
17												
18												
19					1							
20												
21												
22								1				

Set	Apparent spacing (#/scan length)	True Spacing (#/acan length
1		
2		
3		
4		
5		

Page 4 of 4 Code





obs#	Sta.	Set	Strik	e wir b	o expe	SUIT	Dip	wit to	Persist.	Candh		
			++-20	20-65	45-90	RA.	+4-20	20-6	640	RA		
1												
2												
3												
4												
5												
6										í I		
7												
8												
9												
10				1								



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# Summary of Engineering Geologic Data

Set #	Strike	Dip	Roughness	Separation/ Filting	Persistence	Weathering	Remarks
_			173				
	NO	30					
_							
		_					

# Other Structural Features Feature Strike Dip Condition Persistence Remarks

Occasional Random Joint	87 NO JOINT'S OTHER THAN BED FUNCTIONS
Bodding Description:	HALD CRUSTOLLING / POSSILIFICOUS BEDS, ALTELANTING W/YUGGY BEDS WELAY FILLING (SOME SOLUTION (UTAL) VOIDS (2")
Weathering/Erosion:	1932 5' BZO OF SUPE IS WEATHING W/SOME COIL MEANNIE
Form of Skope Failure/Dep	BED CAREMED FRACTICANCE
Debris: <u>G-RAVAL</u> MAD RA +shi	-> 2' LS. BLOCKS, TODGING FROM SLOPE BLOCK SIDE HEG. FROM CINTO 3' ; WILLIESLY TO HAVE BLOCKS LORDE THAN S OUT TO MIGH FEEL, PRACTICING '!
Maintenance Record:	ENCIPIED AFTER CONSTRUCTION DUE TO BLOCK FALL (RAMILING). HAVE TO CLEME DITCH / READ - ITIME / VEAR
Available Gentechnical D	

#### Page <u>3</u> of <u>4</u> Code <u>2/1~1</u>

1+00

#### **TxDOT Rock Mass Field Description**

#### Scanline Descriptions

Horizontal Scanline Number: \_\_\_\_\_ Horizontal Location (locate on sketch): \_\_\_\_\_ Height above base of cut (ft): \_\_\_\_\_ If win one layer, layer thickness: \_\_\_\_\_ Length of scanline (if): \_\_\_\_\_ Strike of scanline (if different from face): \_\_\_\_\_

0+00

0+50

Scanline Sketch (include seepage locations)

#### Debris Description

obs#	Sta.	Set	Strik	e wir ti	o expo	sure	Dipv	wit to e	posu	10	Persist	Condition
			++-30	20-6	46-60	RA	+4-20	20-6	6.00	RA		
1			10.1						1			
2												
3										1		
4			1									
5								[				
6												
7		1				1.1						
8												
9						1						
10												
11				-		1						
12												
13												
14												
15												
16												
17					1							
18												
19												
20												
21												
22												

#### Set Apparent spacing True Spacing

	(Widecan length)	(Wacan length)
1		
2		
3		
4		
5		

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obs#	Sta. Sta	Set	Strik	e wit b	o expo	SUIT	Dip	WT ID	600005	ure	Persist.	Condin
			++20	20-65	45-00	RI.	++20	20-65	45-80	R.L.		
1		1		1				T				
2		1										
3												
4												
5												
6							1					
7												
8			T			1	1					
9												
10		T										



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Set	Strike	Dip	Roughness	Separation	Persistence	Weathering	Remarks
				Filling			
		-					
				-			
her Structu	stal Feat	UPOS	Constant Second	10		Barris	4
ame ou	1160	UND	Condition	Persistence		Poentisa	15
asional Ra Iding Desci	indom Jo ription: ]	unts?	51.092 1: 3' CM	Lack NITH FIL MC VU664 LA	and BY 13' I	15 555762 WR	MINULA LS WICHLO ALLANSE FILL
Docesional Ra Jedding Desci Veathering/Er	ndom Ja niption: ] rosion: /	FRUA FRUA MIORIT	Scorel: 3'can to 50 2'm scorel: mete scorel: 0300 mete score m	LACK NITH FILL MLF VUGGY LO CLYSTALL AL LIT-3 THAC BLATTELLA	and BY 13' 1 BLOC, SLAP [Lange] LAC	AF SAFTUL WI BY ANY MESS C FLY WARY OC T. HING CRYST SELL THETES	ATTALLO LS WICHLO OLLANSE FILL - 1'-2' WOR. ATTARE ALLINE OLLOS AND BODS WICHT FILL BODS WICHT FILL
edding Desci Veathering/Ed	ndom Je ription: ] rosion: (	Ants?	Store: 3' cap to 50 2' m stare: made stare: made stare: stare: Times: to a	LACK MITH FILL MED VUGGY LO CLYSTALLAIL I 1 - 3 THAC ALTICILO 254-04/2 MICH	and BY 13' 1 BLOC, SLAND [Land] SHAD	AF SEFTUL WI BY ANY MESS C TEY WARY OC T. HING COYEN SELLITIONES SELLITIONES SELLITIONES SELLITIONES SELLITIONES	ATTALLED LS WICHLO CLARSE FILL LI-2 / WOID, ATTANK ALLINE BEDS, AND BEDS WICHAY FIL THIS AREA IS FORMET FILLAT FIL FORMET FILLAT FILLAT
ccasional Ra edding Desc feathering/Ed	ndom Ju niption: ] rosion: (	ints? Fala Fala Moret Ner?	SLOPE: 3'CAN TO GY 2'M SLOPE: WED BED SLOPE: WED BED STH BED OTH BED SLOPE: TO E	Lack NITH FILL ALF VUGGY LO OLYSTALLAIL II-3 THAC ALFREILA 354-442 CONT	and BY 13' 1 BLOC, SLAP [Land] SHAP	AF SAFTUL WI AT ANY MEL C TEY WARY OC T. HING COYEN SELL THETEH STM2 OF TO THE L/J/2	ATTALLED LS WICHLO OLLANSE SILL - 12-2 / WOID, ATTANE ALLINE BEDS WICHAY SIL BEDS WICHAY SIL FOINT THAT I FOUNT THAT I
ccasional Ra edding Desc feathering/Ed	ndom Ja niption: ] rosion: (	ints? Follow Moret Here	SLOPE: 3'CAN TO GY 2' M SLOPE: MED BED SLOPE: MED BED STH BED STH BED SLOPE: TO L DTH BED SLOPE: TO L	Lack MITH FILL MLF VUGGY LO OLYSTALLAIL I 1-3 THAC MATTRILA 354-442 CONT	and BY 13' 1 BLOC, SLAP [Earth Link]	AF SEFTUL WI AT ANY MELS C TEY WARY OC T. HING COYEN SELL THETER STM2 OF TO THE L/K2 TRUCCO	ATTALLED LS WICHLO CLAMES FILL 12-21 WOLD, ATTANK ALLINE BEDS, AND REDS WICHAY FIL POINT THAT IT FOINT THAT IT MESS RANGES 6 <sup>20</sup> -4
ccasional Ra edding Desc feathering/Ed	ndom Ja niption: ] rosion: ( h Failune/	ints? Follow Mycgat Salwijer Nova	52092: 3' CAN 30 57 2' M 52092: MALD 3205 M TIMES TO & 0774 BROMS 0774 BROMS 0774 BROMS	LOCK MITH FILL MED VUGGY LO I CLYSTALLAIL I 1-3 THAC ALTINIZA I RALL SAM	and BY 13' 1 BLOC, SLAND [Land] SALAN SAL Z SLAND	AF SEFTUL WIL AT ANY MEL C TEY WARY OC T. HING COYEN SELL THETER STM2 OF TO THE L/K2 TRUCK MARY TS.	ATTALLED LS WICHLO CLAMES FILL 12-21 WOID, ATTANK ALLINE BEDS, AND ADDS WICHAY FIL THIS AREA IS FOINT THAT IS FOINT THAT IS THE LINES OF Y FOLLOWED OF Y
ccasional Ra edding Desc /eathering/Ed	ndom Ja niption: ] rosion: ( + Failure/	Saturier Saturier Degrada	51092: 3' CAN 30 57 2' M 51092: WED 3205 W 710 8205 W 7714 BLANKS 0714 BLANKS MINOR	LOCK NITH FILL MED VUGGY LO I CLYSTALLAIL I J - 3' THAC BLATTELLA JSTANGLI MAL RALL UPPI BLOCK PALL	and BY 13' 1 BLOC, SLAND [Land] SLAC MARE SULT MARE SULT ANIO SLATS	AF SOFTIL WIL AT ANY YEL C TEY WARY OC T. HING CLYST SELL THETER STM2 OF TO THE TO THE THE THE THE S. THE THE S. THE THE S. THE THE S. S. THE S. THE S. S. THE S. S. THE S. S. THE S. S. THE S. S. THE S. S. THE S. S. THE S. S. THE S. S. THE S. S. THE S. S. THE S. S. S. S. S. S. S. S. S. S. S. S. S.	ATTALLAD LS WICHLO CLAMES FILL 12-21 WOLD, ATTANK ALLINE BEDS AND ADDS WICHAY FIL THIS AREA IS B FOLLOWED ALT UN MESS RANGES 6 <sup>10</sup> - 4 FOLLOWED 6 <sup>10</sup> - 4 FOLLOWED 10 <sup>10</sup>
ccasional Ra edding Desc feathering/Ed	ndom J niption: ] rosion: Failure/	Saturier Follow Saturier New?	51092: 3' CAN 30 57 2' M 51092: WED 3205 W TIMES TO E 0774 BELINKS 0774 BELINKS MINOR	LOCK NITH FILL ME VUGGY LO OLYSTALLAIL I J 3' THAC ALT - 3' THAC BLACK PALL BLOCK PALL	SAL Z SLAN AND SUSS	AF SOFTIL WIL AT ANY YEL C TEY WARY OC T. HING CAYEN SELL THETER STM2 OF TO THE TO THE THE THE THE S. THE THE S. THE THE S. THE THE S. THE S. THE S. THE S. THE S. THE S. THE S. THE S. THE S. THE S. THE S. S. S. S. S. S. S. S. S. S.	ATTALLED LS WICHLO CLARSE FILL 12-21 WOID, ATTANK ALLINE BEDG AND ADDS WICHAY FIL THIS AREA IS FOINT THAT IS FOUNT THAT IS THE LINES CRISS STATION THE OF SATTON
ocessional Ra edding Desci feathering/Ei orm of Slope ebris:	ndom J niption: ] rosion: ( n Failure/	ints? Follow Solution Solution Hard Degrada	52072: 3' CAN 30 57 2' M 52072: MALD 3205 M TIMES TO & 0774 BELINKS 0774 BELINKS MINOR MINOR 2. 70 3' 8.	LACK MITH FILL ME VUGGY LO CLYSTALLAIL 1 - 3' THAC CLYSTALLAIL 1 - 3' THAC CLYSTALLAIL CLYSTALL CL	and By 13' 1 What / STOPPAN GLOC, SLAND ILONEL / JACO MARE STUP SC 2 5245 ANIO 32495 Xm) ON B	AF SOFTIL WIL AT ANY MARY OC TO Y WARY OC TO Y WARY OC TO THE SOLUTION SOLUTION SOLUTION TO THE THE SOLUTION THE SOLUTION TO THE SOLUTION THE SOLU	ATTALLAD LS WICHLO CHANSE FILL - 12-21 WOID, ATTANK ALLINE BEDG AND ADDS WICHAY FIL THIS ANCH IS B POINT THAT IS FOLLOWED ATTAL MESS RANGES 6 <sup>10</sup> -4 FILTURE INF ON SATTAN
ocasional Ra edding Desc feathering/Ei orm of Siope ebris:	ndom Ja niption: ] rosion: ( h Failure/ <u>i (PP4C)</u>	ints? Falls Falls Scilling New? Degrada	51072: 3' CAN 30 57 2' M 51072: MALD 3205 M TIMES TO L 0774 BELINKS MINOR MINOR 2. 70 3' B. ULANS BLOCKS	LACK MITH FILL ME VUGGY LO CLYSTALLAIL I - 3' THAC ALT PALL PALL UPP BLOCK PALL LOCK PALL G" - 7" - 59	and By 13' 1 What / SIDERAN GLOC, SLAND ILONEL / SIDERAN MALE SILL ANIO SUPPORT ANIO SUPORT ANIO SUPORT ANIO SUPORT ANIO SUPORT ANIO SUPPORT ANIO	AF SAFTUL WIL AT ANY MARY OC TO Y WARRY OC TO HANG CAYON SALL THET'S STATE TO THE THE CAY THE	ATTALLAD LS WICHLO CHANSE FILL C 12-2 / WOID, ATTAINE ALLINE BEDG AND ARDS WICHAY FIL THIS AREA IS & POINT THAT IS POINT THAT IS THIS CANCERS 6"-4 FILTURES INF ON SATTAM
ocasional Ra edding Desc leathering/Ei orm of Slope ebris:	ndom Ja niption: ] 	ints? Falls Falls Salution Salution Neva Degrada	51092: 3' CAN 30 57 2' M 51092: MALD 3205 M TIMES TO L 0774 BLANKS MINOR 2. 70 3' B. LANS BLANKS 17762 5 MAL	LOCK MITH FILL ME VUGGY LO OLYSTALLAIL I - 3' THAC ALTIFULD STANDLI MA L PALL MA BLOCK FALL G"- 7' - 59 L TALUS, OCC	and By 13' 1 Whe / SIDEAN GLOC, SLAND ILONEL JUNC MARE SILL ANIO SUPS NEM SLACK (-	AF SEFTIL WIL AT ANY MARY OC TO Y WARY OC TO Y WARY OC TO THE SELUCTION OF SELUCTION OF THE SELUCTION THE SECOND THE S	ATTALLAD LS WICHLO CHANSE FILL C 12-2 / WOID, ATTAINE ALLINE BEDG AND ARDS WICHAY FIL THIS ANCH IS & POINT THAT IS POINT THAT IS THIS CANCERS 6"-4 FILTURES INF ON SATTAM
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#### Page 3 of 4 Code 211-2

### **TxDOT Rock Mass Field Description**

	Sca	nline Descriptions	
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If with one layer, la Length of scanline Strike of scanline (	(ft): if different from face):	-	
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#### Debris Description

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of 4 Code 211-2

#### Scanline Descriptions



obs #	obs# Sta.	Set	Strik	e wit b	o expo	sur	Dip	wir to	ежров	ure	Persist.	Condin
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Date: 6/10/95 Page: 1466-2-4-5 Code: 211-3

 SLOPE 5:
 22 ft. High; 15'-17' bench

 Top to Bottom: 4' hard bed, 5' hard bed, 6-1' crystalline beds, 7' hard bed. (all slightly vuggy)

 Debris: None

 Joints: 1 set NSSE, 65SE, dip away from cut, 115' true specing, tight/vrtu/dry/persistent.

 1 set N60E, 60NIV, dip into cut, 115' true specing, same condition

 SLOPE 4:
 20' high, 15' bench

 Top to Bottom: One massive bed all, from crys. to vuggy to nodular

 Debris: Scattered 4' - 1' blocks

 Failunc minor block fail along joint/face intersection at top of slope, minor raveling

 Joints: two criss-crossing sets: N45E, 60NW, 23' true specing, same condition

20' high, 15'-18' bench SLOPE 3: Top to Bottom: One massive crystalline (porcelainic bed) Debris: v.little Failure: minor block at jt./face contact Joints: two sets: N10E, 55SE, dips into cut, 40' true spacing N70E, 65NW, dips into cut, 25' true specing Both sets generally tight but up to 25 mm separation along portions of some joints, very rough, stained, most extend entire height of slope 3, 50% filled with fine grained soil. 20' high, 20'-25' wide bench SLOPE 2: Top to Boltom: 5, 4, 4, hard crys. beds (sl. vuggy), followed by 7 of 1-2 highly fractured hard beds Debris: v. little. sporadic 2 block Failure: None observed, however, loose blocks observed at top of slope (2-5 block size). SEE SCANLINE FOR JOINTING INFORMATION

SLOPE 1: 17 high Top to Bottom: 7 of 1'-3' hard highly fractured beds followed by 10' of 3'-2' softer dolomitic and marty beds. Solution collapses observed in both parlions of slope. Seepage along bedding planes in lower 10 of slope. Debris: soil to 1.5' boulder at toe and in ditch. Failurs: Raveling, spalling

Page 3 of 5

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#### Page 5 of 5 Code 2/-3

#### **TxDOT Rock Mass Field Description**



#### **Scanline Descriptions**

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Elevation (it) looking W

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eature	Strike	Dip	Condition	Persistence		Rema	rits.
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ledding D Veatherin	)escription: g/Erosion:	PAN Ne D/54	13 FROM Milly Bry Blottener	2/ 9-7. 10 * 09\$5344 # FHCZ,	ASSINE 20 Nowe o	U/AVE 6	
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Page 4 of 4 Code 1291-/



#### Scanline Descriptions

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Page 2 of \_\_\_\_\_\_

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ledding D Veatherin form of Si vebris:	lescription: g/Erosion: liope Pailure/ <u>6 p.h2.5</u> <u>07-</u>	HAD) Sell Ribs Ribs Degradal 2 4 Securi	CANSTAU VIIM COLL (3"-6")9 20007 8 1032 15 M 11 20000 11 20000 11 20000 11 - 1' 0 11 - 1' 0 11 - 1' 0	NS. <1' ARE DANS ADDAATING ADD	TO B' I ME SMOUT OF THICKLE MORE SPAL MORE SPAL MORE SPAL MORE SPAL MORE SPAL MORE SPAL	W/MG 5 NON SKE MES. SOLLTON MELDER HUG DEC TOLUS P.	-6' THICK TEH. OCC THIN COLLAPSE. AT OF SLIFE PHITES) SAMALL BLOCK.
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Bedding D Weatherin Form of Si Debris: Waintenan Available (	Vescription: g/Erosion: iope Pailure/ <u>4 P.H.2.5</u> ere nce Record: Geotechnica	HAC) Sec. Rispi Rispi EEA Mais Degradal Sec. 1 Detta:	CANSTALL CTIM COLL (3"-6")9 EXCOUT B MAL IS M 11 RADRED IN RADRED IN COLLAR MAL IS M 11 RADRED MAL IS M 11 RADRED	NS. <1 AREL PARS ARDENTING AREA AND AREA A	TO B'	W/Mg 5 Not Sta MES. Solution MEC (222 LING DEC TRUS P.	-6' THICK TEH. O'C THIN COLLARSS. MT OF SLIPE PHITOS) SMALL BLOCK NE NT BASE

# Page 3 of 4 Code 1283-2

1+00

#### **TxDOT Rock Mass Field Description**

#### Scanline Descriptions

Horizontal Scanline Number: Horizontal Location (locate on sketch): BATTIES CUT (1997 PACE) Height above base of cut (ft):  $\underline{\delta}' - \underline{\delta}'$  if with one layer, layer thickness: Length of scanline (fl): <u>Retries.cut</u> Strike of scanline (if different from face):

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0+50 Scanline Sketch (Include seepage locations)

#### **Debris Description**

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11

Page 4 of 4 Code 1253-2

#### **TxDOT Rock Mass Field Description**



#### Scanline Descriptions



Elevation (It) looking 157

Page 2 of 4 Code 175-1

Other Structural Features       Features       Features       Features       Features       Coccasional Random Joints?       YES + BUT RED Condition       Persistence       Remarks       Occasional Random Joints?       YES + BUT RED Condition       Remarks       Remarks       Occasional Random Joints?       YES + BUT RED Condition       Remarks       Mediation       Secting Description:       3' To metssynt.       Mediation       Secting Description:       3' To metssynt.       Mediation       Secting Description:       3' To metssynt.       Mediation:       Mediation:       Mediation:       Mediation:       Mediation:       Coccel:       To Mediation:			ess Separation/ Filling	Persistence	Weathering	Remarks
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Defer Structural Features         Feature         Feature         Strike       Dip         Condition       Persistence         Remarks         Sociational Random Joints?       YES_BUT RED ConFideD         Nocational Random Joints?       YES_BUT RED ConFideD         NewLY       Fallemarks         Market Palamatic States       States (ALL BUT VULSY LAMAL) Add.         Market Palamatic States       Market Palamatic States         NewLY       Fallemarks       Market Palamatic States         NewLY       States       Control States         NewLY       States       Control States         International States       North Control States       North Control States         International States       North Control States       States         International Dates:       North Control States       North Control States     <	-					
Deter Structural Features         Teature Strike Dip Condition Persistence Remarks         Strike Dip Condition Persistence Remarks         Vocasional Random Joints?       YES_BUT RED ConFidED.         Nocasional Random Joints?       YES_BUT RED ConFidED.         New Y Fanctines Bythink/TINK Blacky Amenatical Confidence on Free       Remarks on Free         New Y Fanctines Bythink/TINK Blacky Amenatical Confidence on Free       Reprint Resonance in Free         New Y Fanctines Bythink/TINK Blacky Amenatical Confidence on Free       Reprint Resonance in Free         New Y Fanctines Device Lander Hits ELODED Back Subjects and Election where the Reprint Confidence on Free       New Y Confidence on Free         Image: Image Pailure/Degraduation:       Lock/SED Son, Black's, Bane CLING (Y. HINNE)         Image: Y. LITTLE GRAVEL To CoSBIZ 6126       Image: Structure on Structure						
Other Structural Features         Feature         Strike       Dip         Condition       Persistence         Remarks         Cocasional Random Joints? <u>YES, BUT RED ConFinED</u> .         Secting Description: <u>3'</u> To messprit o HACD 55DS (ALL BUT VULLY LAYER) Ast.         Member Factorsto British Time Block Amendance on Factorsto British Time Block Amendance on Factorsto British Time Block Amendance on Factorsto British Time Block States Amendance (of the Market on Block Amendance (of the Market on Block Amendance Of the Block States on Block States	-					
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Deter Structural Features         Teature       Dip       Condition       Persistence       Remarks         Strike       Dip       Condition       Persistence       Remarks         Structural Features       V25, BUT RED ConFineD.       Remarks         Scassional Random Joints?       Y25, BUT RED ConFineD.         Scassional Random Joints?       Scassional Random Joints?         Scassional Random Joints?       Y25, BUT RED ConFineD.         Scassional Random Joints?       Scarse Scanse ConFineD.         Scassional Random Joints?       Y25, Scassion Random Joints?         Scassional Random Joints?       Y25, Scassion Random Joints?         Scanse Configure       Mack Scanse Configure         Scanse Configure       Scanse Configure         Scanse Con	-	1				
Strike       Dip       Condition       Persistence       Remarks         Nocasional Random Joints?       YES_BUT RED_ConFineD.		Atures				
Decessional Random Joints?         YES, BUT RED CM/FIRED.           Secking Description:         3' To messive o HARD SBDS (ALL BUT VULLY LAYRE) AAL           MARKY FARTINGS BARGETINE BLOCK AMERIANUS on FACE           Pathonals MA WRY FIRST IN GARGAR (ormal minute on FACE           Section Record:           Westhering/Erosion:           Ballock Site Coece           Ballock Site Coece           Westris:           Y. LITTILE	Dip	Dip Condition	Persistence		Remark	G
Decessional Random Joints? <u>YES, BUT RED ContEntED</u> Bedding Description: <u>3' To messive o HARD BEDS (ALL BUT VULLY LAYLE) Ast</u> <u>Manney Factores Butter Vully Americanel (or Manney Content Factores Butter)</u> Butters MA VERY THEFT IN SATURAL (or Manney E on BLOCKS A Gentrus multime Vestimening/Erosion: <u>VICCY SILVITION LAYER HAS SILODED BACK SULMITEY Cash</u> <u>1'-2' Locklicte Contrilleviels</u> . NJ SESPECE 	1					
Docessional Random Joints? <u>YES_BUT RED CWIFINED</u> Sedding Description: <u>3' To messive o HARD ESDS (ALL BUT VULLY LAYOR) ALL</u> <u>MARKEY FARTIALS BEAMS DESCENTIONE BLOCKY AMALABANEL (OPAN MARKE CO ON FACE</u> DERCHARTS MA VARY THEY IN GANSAR (OPAN MARKE CO BLOCKS A GENTLE POLISION Vestimening/Erosion: <u>VICCY SILVITATO LAYOR</u> HAS SLODED BACK SLUMPTLY CALA <u>1'-2' Local INFO</u> CANTILEVELS. NI SESPACE form of Slope Failure/Degradation: <u>Local /280 Son, Blocks, Bave LLINE (Y. MINON)</u> <u>MODE SIRE COMES TO YARY FRom SEVERAL MORES TO</u> Vestimenance Record: valiable Geolechnical Data:						and the second s
orm of Skope Failure/Degradation: <u>Local/280 Son, Blocks, Bave (Link, (Y. Hinon)</u> <u>Block Sitt Caecs To YARY Ellow Striked indets 70</u> ebris: <u>Y. LITTLE GRAVEL TO COSBIZ BIZE</u> aintenance Record:	W667	1-2' LOCALA	TO LAYER HA	S SLOPEL	BACK SU	CATEY CALATI
Torm of Stope Failure/Degradation: <u>LCCAURED</u> State <u>BLOCKS</u> , <u>Bave LLING</u> (Y. HUNDE) <u>BLOCK SIEL CONCS</u> TO YARY FRom SEVERAL INDEES TO Debris: <u>Y. LITTLE GRAVEL TO COSBIE 6126</u> Initianance Record:	_					
Vallable Geolechnical Date:	Degrada	Degradation: 200	4/230 Sm.	Leeks, a	WELLING (Y	-
Valiable Geolechnical Data:	1000 B 10000		3// L	71.1004	ingen Statu	- MATS 71 3
Asintenance Record:		TTLE GRAVEL	TO COSBIE	5126		
Valiable Geolechnical Data:	1722					
Maintenance Record:	1722					
Available Geotechnical Data:	722					
weilable Geolechnical Data:	122					
vailable Geolechnical Data:	1722					
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# **TxDOT Rock Mass Field Description**

Horizontal Scanline Number: Horizontal Location (locate on sketch): Height above base of out (ft): If win one layer, layer thickness: Length of scanline (ft): Strike of scanline (if different from face	Scanline Descriptions	TRET, DISC'S AFREDUNT BUT B CONFINED. MUT NEW VERTER.	<b>S</b> 7
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#### Debris Description

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Page <u>4</u> of <u>4</u> Code \_\_\_\_\_73-1



#### Scanline Descriptions

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# TxDOT Rock Mass Field Description Glen Rose Formation

Set#	Strike	Dip	Roughness	Separation/	Persistence	Weathering	Remarks
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canare	Sanke	Dip	Condition	Persistence	Rem	larks	
edding De	ecription:	AT N Los	AY #2/6/07 	t where is	1 1: 4"-1"	BLALLAND)	The / Record Country (Country)
ledding De	escription:	AT N Los	AY HEADAT	* 4427724) * 199984 /0 19442 104452	1 1: 4"-1" WE ASD (	ALDS, DANT BLALLAND)	The / Record ( currently)
ledding De Veathering	vErosion:	AT N Les	6744 4 AY HERAT TA 15' 15 L-70 58	soft of	1 15 4"-1" WE ALD (	BIDS, DAIT BLACKARD)	ni/lice <u>er/conso</u> )
ledding De Veathering	vErosion:	AT N Les Arm	2744 4 AY HEART The 15' 15 L-70 5P	soft of	( 1: 4"-1" W ALD (	ALDS, DAIT BLANGALD)	TU / Ucc <u>er (cuit a)</u>
Sedding De Veathering	vErosion:	AT N Les AJPN	2744 4 Ay 46687 Au 15' 15 L-70 58	SALL AND RAIL	( ): +(*-1) WE ALD ( ULWE - E-	ALDS DAIT BLARAND)	E 2 Laura of
Sedding De Veathering	veription: Verosion: ope Failure/	Art ~~ Lec Artriv	6744 4 Ay HEADAT TA 15' 15 2.70 5P	SAL OF	( ); + - ; " (VC 755) (	ALDS, DAIT BLARAND)	E 2 LAURTING OF
Sedding De Veathering	vErosion: vErosion: ope Failure/	AT ~ Lev Lev Ay Priv	6744 0 Ay HERET A 15' 15 E 70 5P	ANT ALL TED) THE MAR IS SHE OF SHE OF WINTERALL WINTERALL	( ): 4"-1" NE 250 ( LLMG : IN ZNO (555	8125, 9417 BLALAND) (104144 Q P-19) 423	re 2 lacerons of the indications of
Sedding De Neathering Form of Sic	veription: Verosion: ope Failuro/	Ar and an and an and an	0744 0 Ay HEARPT An 15' 15 E-70 5PH 1001 USAN hLOCK FO W BLOCK FO	SALE ALL DWE MASS	( ): 4"-1" WE ALD ( LLANG · E) ENIO (515 1"-3"(F	8105, 9417 8105, 9417 8106,00-20) 1106,0021 0 P-19) 122 1106,0021 0 P-19) 122	E 2 LOCATIONS OF THE PROPERTY OF THE SALE
Sedding De Veathering form of Sid	veription: VErosion: ope Failure/ V2/2.9	07 20 Lev A/201 Degradat	0744 0 Ay HEARPT An 15' 15 2.70 5PH 1001: U2AY 1 ALOCK FO W/ BLOCK FO 22 ( COALL	SALE TED) SHE MASS SHE OF SHE OF SHE OF SHE OF SHE SHE SHE SHE SHE SHE SHE SHE	( 1: 4"-1" WE ALD ( LLANG - IN LLANG -	8125, 944 8125, 944 8125, 944 8125, 944 1104, 104 1104, 104	te 2 lacerons of the fill of the second seco
Sedding De Neathering Sorm of Sic	veription: Verosion: ope Failuro/ vz/c.y	   Degradat	6744 0 Ay HEART The 15' 15 E-70 584 E-70 584 NOR USAN MOLECK MOLECK 22 / CARL	E WAR IS DWE MARSE SAL MARSE SAL OF SAL OF SAL OF SAL SAL SAL SAL SAL SAL SAL SAL	( ); 4"-1" WE ABD ( BBD ( BDD / 515 1"-3"(P-	ALDS, DAIT ALGARAND) (1004x24 0 P=19) L21 (1), Fort 2	E 2 LOCATION OF The State of the second of
Sedding De Veathering Form of Sic	vErosion: vpe Failure/	AF N Les AFN Degradat	6744 4 Ay HEADT A 15' 15 2.70 5P 1001: 1244 MARK FA	SALL ALL ALL ALL ALL ALL ALL ALL ALL ALL	( ): 4"-1" (VE ALD ( LLANG - IV ENIO / 514 1"-3" (P-	ALDS, DAIT BLARENED) (104x24 0 P=19) 224 (1), Imit 2	E 2 LALATING OF
Sedding De Veathering Form of Sic	vErosion: vErosion: ope Failure/ v2/2.y	Ar ~ Lev Lev Avres Degradal	0744 0 Ay HEADT A. 15' 15 E. 70 5P E. 70 5P Kon: U344 1 block For W BLOCK 50 W BLOCK 50 KL CHAL	E WAR 10 DALE MARS DALE MARS SALE OF WARDE RAVE E NUME LA FIRES MARS E SILLE)	( ); +1"-1" (VE 755) (UMA : EV ENO / 555 1"-3"(+-	8105, 0017 BLARENED) (104104 0 P-19) L20 (1), 1971 2	EL / BLOCEY (CURLE) E 2 LOCATIONS OF IT GUID IN MILLION FR OND IN MILLION RUNCE
Sedding De Veathering Form of Sic	vErosion: vErosion: ope Failure/ v2/2.y/ as Record:	Ar N Lev Arriv Degradal	6744 4 Ay HEART A 15' 15 E 70 5P E 70 5P Kon: VIAY 1 ALOUGE F M BLOCK 22 / CARL	E WAR (15) I WAR	( ): 4"-1" NE ALD ( LLANG : IN ZNO / 555 . " - 3" (P-	8125, 9417 <u>8125, 9417</u> <u>8125, 9417</u> <u>8155, 9455</u> <u>8155, 9555</u> <u>8155, 9555</u> <u>81555, 95555</u> <u>81555, 955555</u> <u>81555555555555555555555555555555555555</u>	FL/BLOCEY(LUBLD) FL /BLOCEY(LUBLD) FL /BLOCEFIETS #FL FL JAND 19 FLOWE FR MARK & BLOCKEF
Sedding De Neathering Form of Sic Debris:	vErosion: vErosion: ver Failure/ ver/ver/ e Record:	07 20 Lev A/ Fri Degradat	0744 0 Ay HEARPT An 15' 15 2-70 5PH 1001 U2AY 1 51000 FF W 81000 FF W 81000 FF 22 (CHAL	E WINGE RAVE SHE OF SHE OF SHE OF SHE OF SHE OF SHE SHE SHE SHE SHE SHE SHE SHE	( ): 4"-1" W 340 ( 100 340 ( 100 / 514 1"-3"(F-	8105, 9417 8105, 9417 8105, 9417 1105,	The / Block ( LUBAD) E 2 LOCATIONS OF IT AND IT FILMS FR HOLE & BLOCKS
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Sedding De Veathering Sorm of Sic Sebris:	vErosion: vErosion: verefailure/ verefailure/ e Record:	07	0744 0 Ay HEADT A 15' 15 2.70 5P 1001: U344 1 block 54 W BLOCK 54 22 (C244)	SALL ALL (15) PHIL MARK (15) PHIL MARKS SAR OF SAR	( ); 4"-1" (VE ASD ( 2010 / 513 ) - 3' (P	8125, QUIT BLARENED) (104421 C P-19) L24 (1), Imit L	EL / BLOCEY (CURLE) E 2 LOCATIONS OF IT AND IT PLANT FR OOR, PROJESS BLOCK
Sedding De Veathering Form of Sic Debris:	vErosion: vErosion: vz/2.v/ vz/2.v/ æ Record:	AT N Lev Avrni Degradal	0744 0 Ay HEART A 15' 15 E 70 5P 1001 U344 1 61000 50 W BLOOK 50 W BLOOK 50 122 / CORRE	E WINDL RAVE SAL OF SAL OF WANTL RAVE SC NUME L. FIDES WAYSE L SIZE)	( ); 41"-1" (VE ALD ( LLMA : EV ENO / SLA . 1"-3"(+-	8105, 0007 BLARAND) (104001 0 P-19) 220 (1), 1971 2	The / Block (CUBAD) E 2 LOCATIONS OF IT SAID IT FILMS FR AND IT FILMS FR AND IT FILMS FR AND IT FILMS FR
Sedding De Veathering Sorm of Sic Vebris:	vErosion: vErosion: verosion:	07 200 200 200 Degradat 2/77	0744 0 Ay HEARPT A. 15' 15 E. 70 5P 1001: U3AY 1 ALOCK FO W/ BLOCK T 22 / CAASL	L WAR (15) JUNE MARK JUNE MARK SAR OF WANTE RAVE SC NOR L. TOPES MAYSE E SIEE)	( ): 4'-1' NC 355 ( LLMG : I ZNO /555 . J'-3'(F	8125, 9417 <u>8125, 9417</u> <u>8125, 9417</u> <u>8155, 9455</u> <u>8155, 9555</u> <u>8155, 9555</u> <u>8155, 95555</u> <u>81555, 955555</u> <u>81555555555555555555555555555555555555</u>	The / Blocky (200342) E 2 Locarisms and IT and it mission for ands, Proceeding Alexands
ledding De Veathering form of Sic Jebris:	vErosion: vErosion: verosion:	  Degradat  	0744 0 Ay HEARPT A. 15' 15 E. 70 5P 1001: UZAN 1001: UZAN 1002: Em 1002: Em 10	SALE ALL	( ): 4'-1' WE ALD ( LLANG - EX LLANG - EX SNO /515 1'-3'(F	(104x24 0 P-19) L22 (1), Imp 2	E 2 LOLATING OF

**Glen Rose Formation** 

# Page 3 of 4\_\_\_\_\_

1+00

#### Scanline Descriptions

Horizontal Scanline Number:

Horizontal Location (locate on sketch):

Height above base of cut (ft): \_\_\_\_

If win one layer, layer thickness: \_\_\_\_\_\_ Length of scanline (ft):

Strike of scanline (if different from face):

0+00

0+50

Scanline Sketch (include seepage locations)

#### Debris Description

obs #	Sta.	Set	Strike wit to exposure			Dipv	to e	orposu	re	Persist	Condition	
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## TxDOT Rock Mass Field Description Glen Rose Formation

Page 4 of 4 Code I 10 Th



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#### **General Exposure Description**





Code 5-1 Page 2 of 4

Summary Geologic Description

#### Bedding Description: Strike/dip:

[	Layer	Thickness	Geologic Formation	Physical Properties	Remarks	Sample	
Top	5	1'	EDWARDS	MASSELE	CAPROCK	No	
	4	1/2'		DARK CLAY/CALES		1	
[	Э	10'	_ /	MASSEVE			
1	2	1/2'					
Banert	1	8'	1	MASSEUR		1	

### Joint Description Summary

Joint Set	Strike	Dip	Condition	Persistence

### Major Structural Features

Feature	Strike	Dip	Condition	Persistence	Remarks

## Differential Weathering: Collapse / ENFELL AREAS Smort Accelerated EROSTON OTHERWESE Little Wenthering is ENTORINT (confined to this body) Active Erosion: MESTLY CONSINCE TO AREAS OF Solution CollApse FINESE

Geotechnical Data (core available, site investigation report?):

Form of Slope Degradation:

TxDOT Contact: \_\_\_\_\_ TxDOT Record of Maintenance: \_\_\_\_

HONE

GELBERT GAVEA

Code <u>5-1</u> Page <u>3 of 4</u>

#### Scanline Descriptions

Horizontal Scanline Number: \_\_\_\_

Horizontal Location (key into profile sketch and elevation sketch):

Height above base of cut (ft): \_\_\_\_

If within one layer, layer thickness (ft): \_\_\_\_

Length of scanline (ft): \_\_\_\_\_

Strike of scanline:



Small blacks and tel

Debris Description

#### Scanline Information:

Obse	bss Station Set Strike (w/r to exposure)				ure)	Dip (	w/r to e	xposure	)	Persist	Cond'n	Remarks	
			±20°	20-45	45-90"	R/L	±20"	20-45	45-90*	RAL			
1					1			1					
2													
3					0								
4								0.000					
5	8 1							19-11					
6		1	-										

#### Description Keys:

Strike or D	hip: R = into L = into	slope to the right the slope to the left	Persisten	ce exposed length (ft) continuous through outgrop
Condition:	Closed	rough undulating planar slickensided		bed-confined termination index: T S
	Filled	sandy clayey gouge filling thickness	Debris:	R Estimated block size (ft) Joint or blast formation Differential Weathering

Code <u>5 -1</u> Page <u>4 of 4</u>

### Scanline Descriptions

Scanline Sketch

Scanline Information:

Obsa	Station	Set	Strike	Strike (w/r to exposure)			Dip (w/r to exposure)			Persist	Condin	Remarks	
		-	±20°	20-45	45-90	R/L	+20	20-45	45-90"	R/L	1	-	
1			1		1	1		1	1	1			
2		-								1		1	
3			1			-	-	1	1	1		1	
4						1				-			
5								1					
6		-				-		1					

Fracture Frequency (disc/ft):

Estimated RQD: 75-90 Ken



Code <u>5-2</u> Fage <u>2 of </u>4

#### Summary Geologic Description

#### Bedding Description: Strike/dip: \_\_\_\_\_

Layer	Thickness	Geologic Formation	Physical Properties	Remarks	Samples Taken
2	5'			NEATRA	
1	13'			NIIGSY	

#### Joint Description Summary

Joint Set	Strike	Dip	Condition	Persistence
A				
31				. 7

#### Major Structural Features

Feature	Strike	Dip	Condition	Persistence	Remarks

Differential Weathering: WEATHEDET

Active Erosion: NONE 757

Geotechnical Data (core available, site investigation report?):

Form of Slope Degradation:

TxDOT Contact: \_\_\_\_\_ TxDOT Record of Maintenance: \_\_\_\_

NONE

Elber Gazie

Code 5-2 Page 3 of 4

### Scanline Descriptions

#### Horizontal Scanline Number: \_\_\_\_

Horizontal Location (key into profile sketch and elevation sketch): \_\_\_\_\_

Height above base of cut (ft): \_\_\_\_

If within one layer, layer thickness (ft): \_\_\_\_

Length of scanline (ft): 140

Strike of scanline:



#### Debris Description

#### Scanline Information:

Obsa	Obse Station Set			Strike (w/r to exposure)				Dip (w/r to exposure)				Condin	Remarks
			±20*	20-45	45-90	R/L	+20	20-45	45-90	R/L			
1		1		1	1	L	1		12	L		Read	elized
2		Z	1	1	11	R			.1	R		14	11
3			1	1		1		1					
4									1				
5										1			
6													

#### Description Keys:

Strike or I	hp: $R = into$ L = into	slope to the right the slope to the left	Persisten	ce exposed length (ft) continuous through outcrop
Condition:	Closed	rough undulating planar slickensided		bed-confined termination index: . T S
	Filled	sandy clayey gouge filling thickness	Debris:	R Estimated block size (ft) Joint or blast formation Differential Weathering

Code Page .

### Scanline Descriptions

Scanline Sketch

Scanline Information:

Obs¤	Station	Set	Strike (w/r to exposure) Dip (w/r to exposure)							)	Persist	Cond'a	Remark:
			±20"	20-45	45-90"	R/L	±20*	20-45	45-90"	R/L		1	
1													
2													
3			1		-	1							
4					-		-						
5													
6													

Fracture Frequency (disc/ft): \_

Estimated RQD: 45-60 North Internet 60-75

# APPENDIX B Maintenance Data

Coc	le Geologic Formation	Type of Failure	Age of Cut (years)	f Maintenance requirements and type and size of	Does debri reach road (Y/N, Freq	s Additional comments	M
300-	I Kgr	R,W,DE	10	**Clean cobble to 1m size rocks, from ditch 1-	Y, "occasionally"	Failure after rain	2
360-;	2 Ked, Kwa, Kgr	R	18,7	**Before benching in 1988, cleaned debris (cobble to 1.2m) from road and ditch 5-10x/yr. After benching, clean ditch only 2 to 3x/yr.	Y (before 1988), 5-6x/yr	Benching resulted in 50% reduction in maintenance effort in the entire Travis South maintenance section. Failures occur after rain. Most degradation is due to a the	0-1
360-3	Kgr	R	18	Nous		Walnut Formation which is only	
20-1	Kgr	R, possible DF	10	None	N	exposed in the upper bench.	100
20-2	Kgr	R	7	N/A	N/A		3
244-	Kgr	R	12	None	N		-
244				Clear 0.3-0.6m rock from	N	Failure after role	3
244-	Kgr	R,DE	7	Clear 0.3-0.6m rock from	N	to the state of the state.	3
WP-	Kgr	R,DE	8	ditch, 1x every 2-3yr		Pailure after heavy rain.	3
00		Lawrence and the second		14086	N	Failure after min annu	
KR-	Kgr	R,DE	6-7	0.45-0.6m rocks cleared	Y 4.6xhu	seepage onto road.	3
4-1	Kar			from road every 2-3 months	1,4-0.034	Failure after rain, constant scepage	0
2		K,DE	20-25	Clean debris up to 2.5m size from road and ditch,	Y	Slope was scaled 3 to 4 years	0
~	Kgr	R,DE	5-6	No maintenance, cut is in	NZA	rain.	
-3	Ked	P	0	trainage channel	1974	Would require maintenance if	0-1
-4	Ked	R DE	22 N	lo information	N	located along roadway.	
lates	**	K,DE	40-45 C	Accasional small rocks < 0.5m) cleaned from aved ditch evens 2.2	N	Has performed better over time	<u>N/A</u> 3

Table B.1. Maintenance Information for Austin District Sites

'MR = Maintenance Rating (Table 5.5)

Site Code	Geologic Formation	Type of Failure	Age of Cut (years)	Maintenance requirements and type and size of debris	Does debris reach road? (Y/N, Freq.)	MR'
D-1	Austin Chalk, Eagle Ford Shale	R,DE	15	Prior to 1986 cleared rock and soil debris from road 2x/yr. Guard rail installed in 1986. Rail removed, rock debris cleared, and rail reinstalled in 1995.	Y (prior to installation of guard rail). 2x/yr	2
D-2	Austin Chalk	R	35	No reported maintenance prior to installation of rock-nailed wall under bridge abutment	N	3
D-3	Austin Chalk Eagle Ford Shale	C,R,DE	35	Sloughed material from Eagle Ford pushed back and re-seeded 2x/yr during rainy season	N	2
D-4	Austin Chalk	R	1	No information	No information	-
D-5	Austin Chalk	R,DE	15	No Maintenance	N	3
FW-1	Comanche Peak	B,R	17	Cobble to 1m size debris cleared from ditch 1- 2x/yr.	N	2
FW-2	Winchell/Wolf Mt.		18, 1	Prior to 1994 cleared up to 0.6m debris from road 2-3x/mo. One 6x6m block on road. Re- excavated in 1994	Y, prior to re-excavation 2- 3x/mo.	0

Table B.2. Maintenance Information for Dallas and Ft. Worth District Sites.

Notes: 'MR = Maintenance Rating (Table 5.5)

Site Code	Geologic Formatio n	Type of Failure	Age (yrs )	Maintenance requirements and type and size of debris	Does debris reach road? (Y/N, Freq.)	Additional comments	MR <sup>1</sup>
281-1	Kgr	R,DE	32	Clear cobble to small boulder size debris 2x/yr	N	Dependent on rainfall	2
281-2	Kgr	R,W	32	Clear 1m to cobble size debris 1x every 5 yr.	N		3
281-3	Kgr	R,DE	32	Clear soil to 0.9m debris from ditch 3-4x/yr. One 1.2x2.5m block.	N	Most problematic slope in Boerne maintenance section. Rainfall dependent	0-1
281-4	Kgr	P,R	32	Clear cobble to 0.9m size debris 2-3x/yr.	N		1
281-5	Kgr	P,R	32	Clear cobble to 0.6m size debris 2-3x/yr.	N		1
1376-1	Kgr	R	40	Clear 0.3-0.6m debris from road 3-4x/yr.	Y, 3-4x/yr		0-1
1376-2	Kgr	R,T	40	Clear soil to 0.6m debris from road 5-6x/yr. In last 25 yrs, a 1.8x3.6m block has fallen onto roadway.	Y, 5-6x/yr	Rainfall dependent	0
I-10-5	Kgr	R,DE	25	Occasional 0.9m rock cleared from easement for mower access, 1x/2-3yr	N	Rainfall dependent	3
2722-1	Kgr	R	25,1 5	**0.9 to 1.2m blocks cleared from road (1-2x/yr) prior to benching 15 years ago. No maintenance after bench was constructed.	Y, prior to beaching		2
2673-1	Kgr	R,DE	25	0.3-0.9m rocks cleared from ditch and road 1x/yr.	Y, 1x/yr.	Failures occur after hard rain	2
3159-1	Ked	R	15- 20	Occasional 0.3-0.9m rock cleared for mower access.	N		2-3
I-10-1	Ked/Kgr	R, DE(Kgr)	25	Clear small rocks from easement 1x/yr for mower access. One 3x3.6m rock on shoulder after rain.	Y, one time after rain		2
1-10-2	Ked	R	25	Clear small rocks from easement 1x/yr for mower access	N		2
I-10-3	Ked/Kgr	R, (C,DE- Kgr)	25	**No maintenance	N	Debris is contained on benches	3
I-10-4	Ked/Kgr	R	25	Clear occasional small rock from easement 1x/yr for mower access	N		2
I-10-6	Ked	R	25	Clear occasional small rock from ditch 1x/yr for mower access	N		2
I-10-7	Ked	none	25	Very little maintenance	N		3

Table B.3. Maintenance Information for San Antonio District Sites.

Site Code	Geologic Formatio n	Type of Failure	Age (yrs )	Maintenance requirements and type and size of debris	Does debris reach road? (Y/N, Freq.)	Additional comments	MR <sup>1</sup>
I-10-9	Ked	R	25	No maintenance	N		3
41-1	Ked	R	25- 30	Clear 0.3-0.5m debris from easement 1x/yr for mower access	N		2
187-1	Ked	R	30+	Clear soil to 0.3m debris 1x/3yr	Y, 1x/3yr	Rainfall dependent	3
337-1	Ked/Kgr	R, T(Ked) DE(Kgr)	20	Clear <0.3m size debris 4-5x/yr. Scale blasting done in 1987 to remove large blocks in Ked.	Y, 4-5x/yr	Rainfall dependent, performed better over time	0
337-2	Ked	R	20	Clear up to 0.6m size debris 2-3x/yr.	Y, one time	Rainfall dependent	1
470-1	Ked/Kgr	R,DE(Kgr)	30+	Prior to installation of chain link fence, cleared soil to 1.2m debris from road 1x/yr. After fence, clear behind fence 1x/3yr.	Y, 1x/yr prior to fence	Rainfall dependent	2
211-1	Ked	R	3	**Cleared 0.3-0.9 m rocks from ditch one time.	N		3
211-2	Ked	R	3	**Cleared small number of 0.6-0.9m rocks from bench one time	N		3
211-3	Ked	R	3	**Cleared large amount of small (<0.3m) debris 2x/3yr.	N		2
1283-1	Kgr	R	18- 20	Very little maintenance, small debris pushed back into ditch 1x/3yr	N		3
1283-2	Ked	R	18- 20	Silt to cobble size debris from fault collapse zone cleared 1x/1.5yr	N	Fault collapse zone is source of ravelling debris, rainfall dependent	2
173-1	Ked	R	30+	No maintenance	N		3
S-1	Ked	R	5-10	Clear occasional small rock (<0.3m) from easement for mower access, 1x/yr	N		2
S-2	Ked	R	1	No maintenance	N		3

Table B.3. (con'd) Maintenance Information for San Antonio District Sites.

Notes: \*\* performance and maintenance affected by benching 'MR = Maintenance Rating (Table 5.5)

## APPENDIX C

## Boring Logs

#### EXPLANATION OF D TERM: USED ON LOGS OF DURINGS



Severely

Weathered .... Complete discoloration and decomposition, approaching soil texture and appearance

slightly decomposed rock

Calcareous	Containing calcium carbonate
Slickensided	The presence of planes of weakness having a slick and glossy appearance
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Laminated	Alternating thin layers or lenses of varying material or color
Interbedded	Alternating layers of varying material

\* RQD is defined as the sum of the lengths of all core pieces 4 inches or longer, divided by the length of the core run. Core less than 4 inches in length broken by handling or the drilling process should be fitted together and counted in the RQD determination. If it is uncertain as to the nature of the break, the particular piece should not be counted.

# LOG Ol

## Project: 620 @ MANSFIELD DAM

			•	
Location: ABON 5-	NAILED WALL	Date:	6-6-95 Type: NX-CORE	В

Boring No: /

المتألفة والمتحد ومحمد والمحالي والترك

	· · ·		C NINCE					
DEPTH FEET	SYMBOL	SAMPLE	TEST RESULTS	DIAMOND 1317 MATERIAL DESCRIPTION	FORMATION	ROCK CORE REC./RQD %	ELEV.	DEPTH
			S 917 % S 97% VCS +1381 pri WCS 703 ps; VCS 1608 ps; - UCS 126 ps; UCS 1306 ps; UCS 1306 ps; UCS 1071 ps; VCS 1306 ps; UCS 1306 ps; UCS 1306 ps; UCS 1306 ps;	SANDY LEAN CLAY; WITH WEATHERED LIMESTONE FRAGMENTS WEATHERED LIMESTONE; THAN, FRACTURED BURDOWED LIMESTONE; GRAY, BURDOWED, FOSSILIFERDUS, WITHY MARLY LAYERS AS SHOWN DISCONTINUTY: 75°, Hight, rough, Undulating, no filling gin. marky layer gin. marky layer BOTTOM OF WALL	GLZN ROSZ	$\frac{10070}{27/0} \frac{96}{40} \frac{100}{194} \frac{100}{94} \frac{100}{94} \frac{100}{94} \frac{100}{100} \frac{100}$	816.2	
				T.D. = 40,0' BORING WAS ADVANCED TO I.Y FEET PRIOR TO USING DRILLING FLUID TO ADVANCE THE HOLE AND GROUNDWATER WAS NOT OBSERVED ABOVE THAT DEPTH.				

## LOG O

Project: 620 @ MANSFIELD DAM

Location: ABOVE FRESH WT Date: 6/6/95 Type: NX ROTALY CORE Boring No: 2

OEPTH	Ē	SYMBOL	SAMPLE	TEST Results	DIAMOND BIT	FORMATION	ROCK CORE REC./ROD %	й 246.61
	2		/		ASOHALT + BASE MATERIAL			
E		4			- SANDY CLAY; brown	11		
F	1974	ゴタ		ucs 1791 ps	Sin. thick marty layer		68 26	
5	P.	Ŧ			WEATHERED LIMESTONE; THI, ARACTURED			
-	4	숙		•	BURROWED, WITH MARLY SEAMS FOR LAYERS		-1	
	E C			UCS 1992 pst UCS 1751 pst			10	
E-10	っ日	玉					00	
F	Ë	3						
	E	I.			LIMESTONE: GRAY, FINE GRAINED, BURROWED,		00	
F	L	+1	F		FOSSILIFELOUS, WITH MARLY LAYERS AS SHOWN		65	
F 19		ᅿ			+	5		
-	I	5	半	551 %	f 1 pt marky layer	8	100	
	E	-			· ·		10	
-2	o苷	5				道		
	Æ			0.0546	· · ·	N	Les	l.
-	E	5		UCS IBIZ PE		0	83	
-2	Æ	<u>-</u>	ŀ	5 88 %				
- "	Ħ							
E	F	Ŧ					100	
F	E	I			· · ·		93	
-30	った	H						
	H	ᅻ			BOTTOM OF CUT		100	814.0
F	E	T					83	1
3		나						
_	E	1			Some mark land r		1.00	
Ξ	Í	1			Concentrate of the second		\$7	L- 1
- 00	۶Æ	Ę.	E					50/2.6-
E-40			ĺ		T.D. = 40.0'			
-				1	BORING WAS ADVANCED TO A DSPTH OF			
					2.7 FEET BEFORE USING OUTLING FORE			
			*		THAT DEPTA,			harris

## **LOG 0**]

Project: IH 30 @ HAMPTON ROAD

Boring No: / Date: 6-14-95 Type: NX-CORE\_ Location: 160'N, SI'S OF CUT ROCK CORE REC./ROD % FORMATION ELEV HLABO SYMBOL SAMPLE TEST RESULTS DEPTH MATERIAL DESCRIPTION WEATHERED LIMESTONE (CHALK); 79 tan ; gray 0 \_ -5 - Di D', smooth, fight, staised 85 -30% : 0°, placer, sweeth, stiple, stained - D: D", planar, smooth, tight, stringed 5994 "D: 80", undulating, 4 rough, a sam apprive, stained 10 UCS 133399: UCS 413 41 ٠ 86 10 15 96 8 - Di 60°, undukting, Knowsh, tight, staired CHANGED FROM CARBIOL TO DURMING BIT uts 165# psi - 70 1105 1798 post 100 1 94 - Sciels", Undukting, rough, right Stained EST. BOTTOM OF CUT -25 100 97 30 - UCS 1021 PS 100 100 35 LIMESTONE (CHALK); gray 100 100 SHALE; 21mg . 40 T.D. = 39.7' Epich BORING WAS ADVINCED TO a 2' PRIPH TO VSING DRILLING FLUID TO ADVANCE THE HOLE AND GROUND WATER WAS NOT OBSERVED ABOVE THAT DEPTH.

## LOG 0]

Project: IH 30 @ HAMPTON ROAD



# LOG O

Project: LOOP 1604 @ BITTERS ROAD

ocatic	)n: 5	0'	W AND 20	N OF CUT Date: 6-8-95 Type: NX CORE	B	oring	No: /	
DEPTH	SYMBOL	SAMPLE	TEST RESULTS	DI AMINID BIT	FORMATION	ROCK CORE REC./ROD %	ELEV.	DEPTH
-	和研		VC5 2076 pt	WEATHERED LIMESTONE; tan 100 % WATER LOSS		90 26	_	111
				SLIEWTLY WORY () <u>5'-B':</u> PIGNLY FLACTIMED (W-3" PIECES) COARSE 7ENTURED, FOSSILIFERDU: () <u>8'-10'</u> : ()		86 10 80/0 31		111111
					EDWARDS	0 38 0 23 0		
-25			ucz 2545 psi	-DISCONTINUTY: 60°-70°, Rough, Underlooding, tite, no filling -DISCONTINUTY: 60°-70°, Rough, Underlood, tite, no filling -D: 75°, Rough, underholing, Stained, tite, no filling -CUERI		31 0 2014		1111111111
-30	文字を中立			EST. SETTEMOLE COST		3/0 2/0 2/0 2		1111111
- 40.	(H)			24'-40': D 7.2. = 40.0'		0		11111

## LOG O

Project: LOOP 1604 @ BITTERS ROAD

Boring No: 2 Location: 26'S AND 30'W FOUT Date: 6-8-95 Type: NX-CORE DIAMOND BIT ROCK CORE REC./ROD % FORMATION TEST SYMBOL ELEV. SAMPLE FEET MATERIAL DESCRIPTION SAMOY CLAY; BROWN WEATHERED LIMESTONE; tan & light gry ues the pei 100 33 -D: 10"-7:", phnar, slickensided, tite, stained, this costing of clay 5 CLAY SEAN OL POCKET 69 0 0.5 -12" HIGNLY FARCTURED 11"-4" HITCES), STAINED, FREELAINIL, OCC. STALL WORS 10 P UCS 2528 15 -D: 45"-50", undukting, slicklensider, the, unweathered - UCS 6379 Mi 100 42 15 12-15-5 1 HATED WITH SK. BROWN CHERT 100 /57 16.5"-17.5" & GOARSE TEXTIRED, IM. VUGS, SHELL PRAGS 100 EDWARDS very vussy 20 95/25 · UCS 3499 psi - SON/O WATER LOSS 100/0 151/8 25 50/0 50/0 100/0 -D: 90°, Vadulating , slickleasided , tite , 87/0 EST. BOTTOM OF CUT 36 no filling 80/0 10010 17.5 - 40.0 = HARD, THN & ERAY, PORCELAINIC, MENLY PRACTURED, 50/0 UCS 8137 Pri SOLUTIONED 5010 35 1230 102/2 100/0 40 T.D. = 40.0'

## APPENDIX D

Laboratory Test Results

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#### Table D.3. Laboratory Test Results for San Antonio District Sites.

Sim Code	Sample Identification <sup>3</sup>	Formation	Description	Depth (m)	Field- observed Eradibility 2	Water content (%)	Carbonatz sources (%)	Second cycle slate durability (%)	Unionial compressive strenght 64Pa)	E from P-wave testing (MPa)	E_secant (MPa)*	E_ungent at 50% of offimate strength (MPa)	Splitting tensile through (MPa)	Hardness on Moh's scale
281-3	281-3_14	Gles Rose	Light grey, hard Limestone	NAP	NE	0.9	100	97	NYAV	NVAV	NAV	NAV	NAV	2003
281-3	281- 3Mari_II	Ciles Rose	Grey Marl	NAP	E	2.5	68	63	MIAV	NAV	NIAV	NAV	NAV	1 10 2
261-4	281-4 _Marl_E	Clen Rose	Tan, marly Lineatone	N/AP	E	8.6	78	47	MIAV	NWAV	NAV	N/AV	NVAV	1 10 2
1-10-1	1-10-1_5-1	Fort Terret / Gign Rose	Grey / light grey Limestone	N/AP	E	2,1	80	95	MAV	NVAV	NAV	N/AV	NAV	2 10 3
1-10-3	1-10-3_5-1	Fort Terrel/ Glen Rose	Tan / yellow, clayey Dolomite	N/AP	6	3.4	94	32	HAV	NAV	NAV	WAV	NAV	1 10 2
1-10-4	1-10-4_5-1	Fort Tenev Gizn Rose	Soft, light tan Dolomise	NAP	8	6.0	99	78	BAV .	NAY	NAV	NAV	NAV	1 10 2
1-10-5	1-10-5_5-1	Glen Rose	Tan, madium hardness Limestone	NVAP	E	2.0	#2	63	WAY	NAY	NAV	NAV	NYAY	1107
470-1	470-1 W_MABL_1	Fort Terret/ Glen Rost	Light tan, highly weathered crumbly Marl	N/AP		3.0	82	40	NAV	NAV	NAV	NIAV	NAV	1 to 2
470-1	470. L.F.MARL,	Fort Terres/ Gien Rose	Dark tan, clayey Mari	NVAP	E	8.7	84	58	WAY	NAV	NAV	N/AV	NAV	1 10 2
470-1 3	470-1_MR	Fort Terret/ Glan Rose	Light tan to white, hard Limestone	N/AP	NE	0.5	100	97	MAN	NAV	NAV	N/AV	NAV	21+3
S-1	B-I CI	Edwards Limestone	Tas, hard Limestone	1.07 -1.34	NAP	6.7	87	NAV	H3I	N/AV	2813	3610	2.17	2103
5-1	B-1 C6	Edwards Limestone	Grey, hard Limestone	7.92 -8.1	N/AF	3.4	89	NAV	17.55	NAV	2564	3024	NAV	2103
5-1	B-2C5	Edwards Linestone	Tas, half Limestone	0.76 - 0.88	NAP	59	90	NAV	12.44	NAV	4325	4992	NAV	2103
\$1	B-2 C6	Edwards	Grey, hard Limestone	3.5 - 3.66	NIAP	27	94	NAV	17.43	NAV	2869	4309	1.15	310.4
S-1	B-2 C7	Elivarda	Grey, hard Limestone	3,93 - 4.08	NAP	ы	84	NWAV	0.91	NAV	10390	12536	NAV	3414
5-1	B-2 C13	Edwards	Grey, hard Limestone	6.76-6.92	NAP	6.6	89	N/AV	24.13	NAV	6635	10055	WAV	-
S-1	B-2 C15	Edwards Limestone	Grey, hard Limeatone	80.48 - 10.61	NIAP	49	90	WAV	96.10	NAV	WAV	WAV	NAV	

<sup>&</sup>lt;sup>1</sup> E1 = sample obtained from here hole 1: E2 = sample obtained from here hole 2.
<sup>2</sup>Key: E = Esodible; NE = Nos-crodible; R = Hard; MR = More resistant to erosion; LR = Less resistant to erosion; W = Weathered; (7) = missing data; N/AP = Not applicable; N/AV = Information not available

# Table D.2. Laboratory Test Results for Dallas and Fort Worth District Sites.

Sile	Samuela	English					200000000000000000000000000000000000000	of sounds thig	Port Worth District	Siles					
5ite Code D-2 D-2 D-2 D-2 D-2 D-2 D-2 D-2 D-2 D-2	Sumple identification <sup>1</sup> BI C4 BI C5 BI C7 BI C8 BI C7 BI C8 BI C7 BI C4 BI C7 BI C4 BI C5 BI C4 BI C5 BI C5 BI C4 BI C5 BI C	Fermation Autoin Chalk Assis Chalk Autoin Chalk Autoin Chalk Autoin Chalk Autoin Chalk Autoin Chalk Autoin Chalk	Description Tas Cholk Tas Cholk III tas, 1/2 grey Chalk Grey Chalk Grey Chalk Tas Chalk	Color code <sup>2</sup>	Depth (m) 2.74-3.05 3.05-3.2 6.03-6.25 6.25-6.55 9.05-9.48	Field observed Erodthätty' NE NE NE NE NE	Water coatest (%) 15.0 16.7 15.3 13.5 11.7	Carborete clance (%) E3 72 92 89 89	Becoul cycle slake durability (%) 94 N/AV N/AV N/AV	Siles, Uniasial temprensise (MPa) 9,19 4,23 11,43 12,01	E Stan P-wave Issing (MPa) N/AV N/AV	E_secani (MPa) <sup>+</sup> 756 330 1612	E_tangent at 50% of ultimars strength (MPa) 1446 427 2738	Splining intersile (MPa) 1.35 1.14 9.30	Hardness on Moh's scale 1 to 2 1 to 2
D-2 D-2 D-2	B2 C6 B2 C12 B2 C20	Austin Chaik Austin Chaik Austin Chaik Austin Chaik	Tas Chulk Ten Chalk Grey Chalk Grey Chalk Grey Chalk	1 1 3 5	1.16 - 1.40 1.77 - 1.92 2.22 - 2.41 5.06 - 5.30 7.16 - 7.37	NE NE NE NE	11.7 13.6 14.5 14.4 10.5 12.5	79 90 80 82 87 87 87	96 NAV NAV NAV NAV NAV	12.01 7,04 11.31 10,85 6,00 17.78 1.71	NAV NAV NAV NAV NAV NAV	1304 695 1228 1240 N/AV 1755 N/AV	2738 1465 N/AV 1902 2721 N/AV 2428 N/AV	0.30 1.39 1.46 1.13 0.54 N/AV 1.79 N/AV	1 to 2 2 to 3 2 to 3 2 to 3 1 to 2 1 to 2 2 to 3 1 to 2 2 to 3 1 to 2 2 to 3 1 to 2 1 to 2 1 to 2 1 to 2 1 to 2 1 to 2 1 to 3 1 to 3 1 to 3 1 to 2 1 to 2

Bt = sample from hore hole 1; B2 = sample from hore hole 2.

Sile

- Color codes for Austin Chaik are assigned as follows: : while 2: Kight dork; 3: mixed grey and dark; 4: dark; 5: very dark. Oteon at al. 1991)

#### Table D.I. Laboratory Test Results for Austin Disariet Sites.

Site Code	Sample Identification	Formation	Description	Dapih (m)	Field-abserved Eradibility	Water content (%)	Carbonate content (%)	Second cycle slake darability (%)	Uniacial compositive strenght (MPa)	E from P-wave toding (MPa)	E_secunt (MPa)*	E_tangent at 50% of ultimate atrength (MPa)	Splitting tensile trength (MPa)	Hardsass on Mel/s state
360-1	360 CASE STUDY SITE_INE	Gikn Rose	White / SgSt grey, hard Linesione	NVAP	ME	7.8	100	97	NAV	N/AV	NAV	NAV	N/AV	2 to 3
360-1	360 CASE STUDY SITE_IE	Glen Rose	Grey, soft Mart	N/AP	E	7.0	¥2	K5	NAV	NAV	NAV	NAV	NAV	102
360-2	360-2_1_E	Clen Rroz/Edwards/ Walnut formation	Grey Mail	N/AP	E	19	84	75	NIAV	NAV	NVAV	NAV	NAV	2 to 3
620-1	FM 620 N I MR	Glen Rass	Geey, hard Linvestone	NAP	- NE	22	92	93	NAV	N/AV	NAV	NAV	NAV	2.m3
620-12	FM 620_N_2_LR	Clen Rose	Dark grey, fossiliferrous marly Limissione	NAP	E		62	72	NAV	N/AV	NAV	NAV	NAV	2 10 3
620-1	B-1 C5	Glen Rose	Tae, hard Limestone	2.13 - 2.25	NE	12.4	19	97	NAV	NAV	NAV	NAV	NAV	2:03
620-1	BICS	Gien Rose	Tas. bard, Limestone	2.44 - 2.65	NE	66	100	97	30.20	17123	4850	4886	N/AV	2 to 3
620-1	B-1 C7	Gien Rose	Tax Limestore	2.65 -2.83	NE	6.5	92	NAV	NAV	8028	NVAV	SYAY	NVAV	2 10 3
620-1	B-1 C8	Glen Rose	Tan Limestone	2.83 - 2.95	NE	6.8	87	NAV	4.85	7061	354	338	NAV	2103
620-1	BICI3	Glen Rose	Hard, grey Limestoria	4.14-4.45	NE	7,2	94	NAV	11.08	15658	1238	2996	NAV	2 10 3
623-1	81 C20	Glen Rass	Marly, dark grey, Limestone	6.22-6.43	B		63	50	0.87	705	21.10	35.85	NAV	1 to 2
620-1	B-1 C22A	Gien Rose	Goty Linestone	7/01 - 7.25	NE	6.1	87	NAV	9.00	6854	123	2241	NAV	2 to 3
620-1	B-1 C22B	Gien Rose	Grey Limestore	7.01 - 7.25	NE	6.4	84	NAV	7,39	17175	732	3991	N/AV	2103
620-1	B-1 C29A	Glen Rose	Grey Linestone	12.15 -10.21	NE	6.7	77	NAV	7.85	N/AV	738		NAV	2:03
620-1	B-1 C29B	Clen Rose	Gery Linestone	12.15-10.21	NE	6.3	89	NAV	15.81	NAV	2001	2281	NUAV	2 to 3
620-1	B2C4	Glen Ruse	Tan, hard, Limestone	1.04 -1.16	E	4,6	100	NAV	12.35	28112	5043	6153	NVAV	2 to 3
620-1	B-2CSA	Glen Rnie	Tan Limestone	2.25 - 2.53	NE.	6,5	82	NAV	13.74	16972	1809	2934	NAV	2103
620-1	B-2 C58	Glen Rose	Tas Limestons	2.25 - 2.53	NE	6,6	97	N/AV	12.07	19215	1589	2859	NAV	2103
620-1	8-2 Cb	Gien Rose	Tan Limesione	2.65-2.80	NE	8,8	80	NAV	NAV	10650	N/AV	NAV	NVAV	2103
020-1	8-2015	Girn Rose	Grey, maily, limettose	4,72-5.39	E	2.9	75	11	N/AV	NAV	NAV	NAV	NAV	2103
620-1	B 2 C 29	Glen Roie	Hard, dark grey Limestone	6.7-6.92	NE	6.9	97	95	13.04	NAV	2862	3117	N/AV	2103
620-1	B-2 C20	Clen Rose	Grey Linestone	6.7-6.92	NE	NAV	NAV	NAV	NAV	17556	N/AV	NAV	NAV	NAV
620-1	B-2 C20	Clen Itale	Grey Lunasione	0.7-0.92	PHE.	NAY	NAV	NAV	NAV	7811	NAV	NAV	NAV	-
6,0-1	0-2023	Citer Rose	Gory, hard, Limestone	7.25-7.53	THE.	1.2	80		NAV	NAV	NYAY	NAV	NAV	-
2244.7	2204-1-0-1	Cites Rose	Tail, medium bardhess Linestone	PWAP	E	1.0	92	89	NAV	NVAY	NAV	DIAV	NAV	-
2244-2	2294-2.3-1	Cles Rose	Greyish ian Limesione	PWAP -	Cit:	2,9	89	4	NAV	NAV	NIAV	NIAV	NAV	-
2019-2	2244-2_0-3	CHES FLORE	Limentone	PHAP			1.5	87	INAV	Pinv	DUAY	NAV	NAV	
SWP-1	SWPI_51	Glan Ross	Grey, medium hard Limerions with fossil shells	NAP	4	4.8	NAV	91	WAV	NAV	NAV	NAV	NAV	
SWP-t	SWP1_52	Glan Rosa	Yan, medium hard Limestone	NVAP	E.	2,0	N/AV	88	NAV	NWAY	NVAV	NAV	NAV	
SWP-1	SWP1_53	Glen Ross	Tan, medium hardwess Limestone	NAP	1	1.3	92	.90	NAV	WAV	NAV	NVÁV.	NAV	
Au-2	2222 @ 350_E	Ginn Rose	Dark grey, very soft Mari	NVAP	E	10.9	68	41	NAV	NAV	NAV	NAV	NAV	
Au-2	2222 @ 360_H	Glen Rose	Light tan Limesions	NAP	NE	0.5	92	98	NAV	N/AV	NAV	N/AV	N/AV	

<sup>&</sup>lt;sup>1</sup>B1 = sample obtained from hore hole 1; B2 = sample obtained from hore hole 2.
<sup>1</sup>Key: E = Endible; NE = Non-endible; H = Hard; MR = More resistant to ensities; LR = Less resistant to ensities; W = Weathered; (3) = minsing data; N/AP = Not applicable; WAV= Information not available.

## APPENDIX E

Performance Data Analysis

### Appendix E

This appendix contains detailed engineering geologic data utilized for this project. Plots were made of the potential factors affecting performance vs. the performance measures (e.g. Maintenance Rating, Visual Stability Rating, and Degree of Differential Erosion). Several of the variables were normalized by age because it was initially thought that some of these factors would be influenced by the slope age (e.g. degree of differential erosion). Due to the geologic variability among sites, however, age did not appear to influence the relationships. Also included in this Appendix are summary tables of the RMR and SMR determinations. Histograms of certain variables are included to show the distribution of certain factors such as: age, height RQD, SMR, and RMR.

	27	(m)	1	m	SLA	KE	SEEPAGE	SLOPE	ION	DD	EAV	G. V	SR	MR	Av	g.   A
360-	1	22.1	58	10	-	12	VEC			í	1	-			RM	RSI
360-3	3	6	.6	18	-	-	MO		180		2	70	1			-
620-1	1	10.	5	1	-	22	VER		235		0	90	3.6		09	1.5
620-2	2	9	9	7		4	TES		270		0 8	14	4	3	-	36 7
2244	1	6.	6	7	-	-	NU		155	-	0 7	0	-	3	1	5 6
2244-	2	5.	4	7	-	井	NO		240	(	67	5	-	3	7	1
SWP.	1	7.	1	-		2	res		250	1	82	5	2	3	6	2
SRR-		6	-	25	3	910	NO I	1	180	0.5	77	-	4	3	7	1 77
AU-1	-	>15	1 2	0.0	_	ľ	ES	2	65	2	67.	-	-	3	7	1 1
AU-2	+	75	-	2.0	_	N	0		+	1	- WE.4	1 .	.5	0	58,5	54
281-1	+	1.4	-	0.0	50	sγ	ES		50	2	877	-	2	0		
281-2	+	75	-	32		Y	ES	16	65	2	62.5	-	1	0		
281.3	+	7.5	_	32	_	N	0		0	-	042.0	-	1	2	58	5
281_4	+	10.5		32	29	YE	ES	10	20	2	63	-	2	3	68	6
281.5	-	4.5		32	48	NK	0	16	10	4	/0	-	2 1	0.5	60	66
1378.4	+	9		32		NC		20	0	-	65		2	1	65	40
1376 0	1	3,5	-	10		YE	S			4	95		3	1	67	57
10.5	-	9	4	0		NO		26		9	50	0.5	0	.5	46	44
10-5		7.5	2	5	32	NO		300	-	0	70	0.5		0	67	50
122-1	10,	5°	1	5		NO		100	1	2	62.5	1		3	67	68
0/3-1	1	7.5	2	5	1	VO		108	-	9	62.5	4		2	62	12
283-1		15	15		N	10		80		1	62.5	0.5		2	56	58
fean	9	.2	19,5		+	-		199	_	0	65	3		3	72	79
td. dev.	4	.6	12.5	-	+	-			0,	7	69.5	2.1	1.	1	4.0	
ovar.	48	.5	62.9		-	-			0.	9	10.1	1.1	1.	1	7.0	61.7
otes:" in	dicate	es he	eht .	of sin	00.00				120.4	5	14.5	53.8	68.5	1	0.0	16.0
SR = Vi	innel S	Stabil	iev D	ALC: NO	he of I	0.4	Cit seach for	benched out	TABLE	_				1 "	0.4	26,9

Table E.1 Pertinent Data for Glen Rose Sites

SITE I

SITE	H (m)*	AGE (Y)	SEEPAGE	SLOPE	DDE	AVG. RQD	VSR	MR	Avg. RMR	Avg. SMR
AU-3	14	22	NO		0	57.5			61	53
AU-4	12	42.5	NO	145	0	70		3	68	68
3159-1	6	17.5	NO	225	0	90	4	2.5	76	66
1-10-2	7.5	25	NO	100	0	80	3	2	66	69
1-10-6	21	25	NO	270	0	85	4	3	76	77
1-10-7	5.5	25	NO	120	0	80	4	3	76	84
1-10-9	7.5	25	NO	285	0	20	3	3	55	65
41-1	10.5	27.5	NO	255	0	70	2	2	65	63
167-1	15	30	NO	40	0	92.5	3.5	3	88	98
337-2	7.5	20	NO	90	0	77.5	3	1	76	75
211-1	6*	3	NO	25	0	30	2	3	62	70
211-2	68	3	NO	235	0	40.5	2.5	3	65	74
211-3	5.1 °	3	YES	140	0	60	2.5	2	73	74
1283-2	10.5	19	NO	0	0	75	3	2	72	75
173-1	15	30	NO	350	0	75	3.5	3	74	74
8-1	8	10	NO	222	a	25	3.5	2	68	65
S-2	5.5	1	NO		Ò	60	4	3	62	62
mean	9.6	19.3			-	64.0	3.2	2.5	69.4	71.1
std. dev	4.5	11.7				22.8	0.7	0.6	7.9	9.5
covar.	47.0	60.6				35.3	22.1	24.4	11.3	13.7

Table E.2 Pertinent Data for Edwards Sites

Notes: \* indicates height of slope or lowest bench for benched cuts, DDE = Degree of Differential Erosion, VSR = Visual Stability Rating, MR = Maintenance Rating, covar. = coefficient of variation

Table E.3 Pertinent Data for Sites Where Edwards is Exposed over Glen Rose

(m) <sup>b</sup>	AGE (Y)	SLAKE	SEEPAGE	SLOPE	DDE	AVG. RQD	VSR	MR	Avg. RMR	Avg. SMR
6.6*	25	5	yes	180	2	82.5	4	2	77	85
5.4	25	63	yes	90	2	37.5	1	2	66	65
16.5	25	22	no	270	1	82.5	3	2	80	89
24	25	8	yes	280	2	95	3	1	82	67
18	20		yes	90	1	80	1.5	0	68	70
16.5	30	42	yes	240	2	46.5	0.5	2	56	56
14.5	25.0				1.7	70.7	2.2	1.5	71.3	71.6
7.2	3.2				0.5	23.0	1.4	0.8	10.0	12.6
49.3	12.6		1		31.0	32.5	63.1	55.8	14.0	17.6
	H (m) <sup>b</sup> 5.4 <sup>s</sup> 16.5 16.5 18 16.5 14.5 7.2 49.3	H AGE (m) <sup>b</sup> (Y) 6.6 <sup>b</sup> 25 5.4 <sup>s</sup> 25 16.5 25 16.5 25 18 20 16.5 30 16.5 30 14.5 25.0 7.2 3.2 49.3 12.6	H (m) <sup>b</sup> AGE (Y)         ⊥ SLAKE           6.6 <sup>4</sup> 25         5           5.4 <sup>5</sup> 25         63           16.5         25         22           24         25         18           16.5         30         42           14.5         25.0         7.2           3.2         49.3         12.6	H (m)         AGE (Y)         L SLAKE         SEEPAGE           6.6*         25         5         yes           5.4*         25         63         yes           16.5         25         22         no           24         25         92         yes           18         20         yes           16.5         30         42         yes           14.5         25.0         1         1           7.2         3.2         1         1         1	H (m)         AGE (Y)         AGE SLAKE         SEEPAGE         SLOPE ORIENTATION           6.6*         25         5         yes         180           5.4*         25         63         yes         90           16.5         25         22         no         270           24         25         22         no         280           18         20         yes         900           16.5         30         42         yes         240           14.5         25.0           240           14.5         25.0              7.2         3.2	H (m) <sup>b</sup> AGE (Y)         ∆ SLAKE         SEEPAGE ORIENTATION         SLOPE ORIENTATION         DDE ORIENTATION           6.6 <sup>b</sup> 25         5         yes         180         2           5.4 <sup>s</sup> 25         63         yes         90         2           16.5         25         22         no         270         1           24         25         22         no         270         1           18         20         yes         280         2           18.5         30         42         yes         240         2           14.5         30         42         yes         240         2           14.5         25.0           0.5         49.3         12.6	H (m)         AGE (Y)         L SLAKE         SEEPAGE SEPAGE ORIENTATION         SLOPE ORIENTATION         DDE RQD         AVG. RQD           6.6*         25         5         yes         180         2         82.5           5.4*         25         63         yes         90         2         37.5           16.5         25         22         no         270         1         82.5           24         25         yes         280         2         95           18         20         yes         980         1         80           16.5         30         42         yes         240         2         46.5           14.5         25.0           1.7         70.7           7.2         3.2           31.0         32.5	H (m)         AGE (Y)         AKE         SEEPAGE         SLOPE ORIENTATION         DDE R         AVG. RQD         VSR. RQD           6.6*         25         5         yes         160         2         82.5         4           5.4*         25         63         yes         90         2         37.5         1           16.5         25         22         no         270         1         82.5         3           24         25         22         no         270         1         82.5         3           18         20         yes         280         2         95         3           18         20         yes         240         2         46.5         0.5           16.5         30         42         yes         240         2         46.5         0.5           14.5         25.0           0.5         23.0         1.4           49.3         12.6           31.0         32.5         63.1	H (m)         AGE (Y)         ALAKE         SEEPAGE SLAKE         SLOPE ORIENTATION         DDE RQD         AVG. RQD         VSR         MR           6.6 <sup>4</sup> 25         5         yes         180         2         82.5         4         2           5.4 <sup>4</sup> 25         63         yes         90         2         37.5         1         2           16.5         25         22         no         270         1         82.5         3         2           24         25         22         no         270         1         82.5         3         2           18         20         yes         280         2         95         3         1           18         20         yes         240         2         46.5         0.5         2           14.5         30         42         yes         240         2         46.5         0.5         2           14.5         25.0           1.7         70.7         2.2         1.5           7.2         3.2            31.0         32.5         63.1         65.8 <td>H (m)         AGE (Y)         L SLAKE         SEEPAGE SUPPE ORIENTATION         DDE RQD         AVG. RQD         VSR RQD         MR 20         Avg. RMR           6.6<sup>+</sup>         25         5         yes         180         2         82.5         4         2         77           5.4<sup>+</sup>         25         63         yes         90         2         37.5         1         2         65           16.5         25         22         no         270         1         82.5         3         2         80           24         25         22         no         270         1         82.5         3         2         80           24         25         yes         280         2         95         3         1         82           18         20         yes         280         2         95         3         1         82           18         20         yes         240         2         46.5         0.5         2         56           14.5         25.0          1.7         70.7         2.2         1.5         71.3           7.2         3.2           31.0</td>	H (m)         AGE (Y)         L SLAKE         SEEPAGE SUPPE ORIENTATION         DDE RQD         AVG. RQD         VSR RQD         MR 20         Avg. RMR           6.6 <sup>+</sup> 25         5         yes         180         2         82.5         4         2         77           5.4 <sup>+</sup> 25         63         yes         90         2         37.5         1         2         65           16.5         25         22         no         270         1         82.5         3         2         80           24         25         22         no         270         1         82.5         3         2         80           24         25         yes         280         2         95         3         1         82           18         20         yes         280         2         95         3         1         82           18         20         yes         240         2         46.5         0.5         2         56           14.5         25.0          1.7         70.7         2.2         1.5         71.3           7.2         3.2           31.0

Notes: <sup>2</sup> indicates height of slope or lowest bench for benched cuts, DDE = Degree of Differential Erosion, VSR = Visual Stability Rating, MR = Maintenance Rating, covar. = coefficient of variation

Parameter			Range of Va	altyres	
UCS (MPa) Rating	> 250	100-250	50-100 7	25-50	5-25 1-5 <1 2 1 0
RQD Baring	90-100 20	17	50-75 13	25-50 - 8	<25 3
Spacing of Discontinuities Rating	>2m 20	0.6-2m 15	200-600 mana 10	60-200 mm &	< 60 mm. 5
Condition of Discontinuities Rating	V. rough surfaces, not continuos, No separation, unweathered wall rock 30	Slightly rough surfaces, separation <1 mm, slightly weathered walls 25	Slightly rough surfaces, separation <1 mm, highly weathered walls 20	Silckensided surfaces, or gouge <5 num thick, or suparation 1-5 man, continuous 10	Soft gouge >5 mm thick, or separation >5 mm thick, continuous 0
Groundwater in joints Raning	Completely Dry 15	Completely Damp Dry 15 10		Dripping 4	Flowing 0
Strike and dip orientations of discontinuities	Very Unfavorable	Favorable	Fair	Unfävorable	Very Unfavorable
Tuna Rating Foundation Sto	artis 0 Datas 0 pest 0	-1	-5 -7 -25	-10 -15 -50	-12 -25 -60

### Table E.4 Rock Mass Rating (Bieniawski, 1973)

Notes: UCS = uniatial compressive strength, RQD = Rock Quality Designation (Decre, 1963)

$$SMR = RMR + (F1*F2*F3) + F4$$
 (1)

Table	F S	Inint	Adjustment	Ratines	for	SMR	Classification	Romana	1003)
1 3010 1	L.J	JOHIL	AUTUALITET	Raunes	101	DISTAT	CIRCON COLLICIT	TACHT BELLENEL,	17331

Case	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable
P  a;-a,	> 30°	30-20°	20-10	10-5	< 5"
T 1 (a - a) - 180					
P/T FI	0.15	0.40	0,70	0.85	1.00
P  Bi	< 20	20-30	30-35	35-45	> 45
P F2	0.15	0,40	0.70	0.85	1.00
T F2	1	1	1	1	1
P A B.	> 101	10-0	0°	0 to =10"	< -10°
$T \beta_1 + \beta_2$	< 110°	110-120°	> 120"	-	
PAT FI	0	-6	-25	-50	-60

Notes: P = planar failure, T = toppling failure,  $a_j = joint dip direction$ ,  $a_n = slope dip direction$ ,  $\beta_j = joint dip$ ,  $\beta_n = slope dip$ 

Table E.6 Adjustment Rating for Method of Excavation (Romana, 1993)

Method	Natural Slope	Pre-splitting	Smooth Blasting	Blasting or Mechanical	Deficient Blasting
F4	+15	+10	+8	0	-8

Site	UCS	RQD	Js	Je	Jw	RMR	Fl	F2	F3	F4	SMR
360-1	2	15	20	23	9.5	70	0.18	1	-25	10	75
360-3	2	17	15	17	15	66	0.25	1	-6	10	75
620-1	2	18.5	20	23	11.5	75	0.13	1	-60	0	67
620-2	2	15	15	24	15	71	0.15	0.15	0	0	71
2244-1	2	17	15	21	7	62	0.15	0.15	0	10	72
2244-2	12	13	20	21	15	71	0.58	1	-6	10	78
SWP-1	2	15	15	24	15	71	0.15	0.15	0	10	81
SRR-1	2	13	15	19	9.5	59	0.28	1	-50	10	55
281-1	2	13	15	22	5.5	58	0.15	0.15	0	0	58
281-2	2	12.5	20	18	15	68	0.25	0.85	60	10	65
281-3	2	13	20	21	4	60	0.25	1	-6	10	69
281-4	2	13	20	15	15	65	0.43	1	-60	10	49
281-5	2	20	20	10	15	67	0.35	2	-60	10	\$7
1376-1	2	10.5	12.5	14	7	46	0.28	1	-6	0	44
1376-2	2	15	15	20	15	67	0.68	1	-25	0	50
-10-5	2	13	15	22	15	67	0.18	1	-60	10	66
2722-1	2	13	15	17	15	62	1	1	-60	10	12
2673-1	2	13	17	17	7	56	0.15	1	0	0	56
1283-1	2	13	20	22	15	72	0.15	1	-60	10	73
Mean	2	14.3	17.1	19.5	11.9	64.8	0.3	0.8	-28.6	6.8	61.7
Std. Dev.	0	2.4	2.7	3.7	4.0	7.0	8.2	0.4	27.4	4.8	15.9

Table E.7 Summary of RMR and SMR Factors for Glen Rose Sites

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Notes: Is = joint spacing, Ic = joint condition, Iw = joint water, F1-F3 relate to discontinuity orientations (see Tables E.4-E.6), F4 relates to method of construction.

- Child	1 063	RQD	Je	In	1 1		- north	La TOT L	suward	5 Sites	
Au-3	6	13	11 5	16	Jw	RMR	F1	F2	F4	1 104	
Au-4	2.5	15	16	13	15	61	0.15	0.15	10	14	SMR
3159-1	4	18 5	130	20	15	68	0.15	0.15	0	-8	53
1-10-2	4	110	20	18	15	76	0.33	1	100	0	68
1-10-6	4	117	15	22	15	66	0.15	1	-00	10	66
-10-7	14	11/	20	20	15	76	0.15	1	-50	10	69
-10-9		117	20	20	15	76	0.15	1	-60	10	77
11-1	4	3	8	25	15	55	0.4	1	-6	10	84
87.1	-	10.5	15	20	15	65	0.15	0.15	1	10	65
27.7	14	18.5	20	30	115	00	0.15	0.15	-60	0	63
11.1	14	17	18	22	15	76	0.15	0.15	0	10	00
11-1	4	5.5	12.5	25	15	10	0.43	1	-25	10	75
11-2	4	10	13	23	15	04	0.4	1	-6	10	20
11-3	4	14	20	20	16	05	0.15	1	-6	10	70
283-2	4	15	20	18	12	73	0.15	1	-60	10	14
/3-1	4	15	10	20	15	72 0	0.15	1	-50	10	74
1	4	14	15	30	15	74 0	0.115	0.15	0	10	75
2	5	12	10	20	15	68 0	.15	0.15	0	0	74
can	4.1	12 2	10.0	20	15	62 0	.15	0.15	0	0	68
L Dev.	0.7	11	5.5	21.6	15.0	59.4 0	2	0.6	0	0	62
s: Ja=io	inf snacing	4	12	4.0 0	2.0 1	.9 0	1	0.0	-22.5	6.0	71.3
	THE REPORT OF TH	the second second second		the second se							

Table E.8 Summary of RMR and SMR Factors for Edwards Sit

Notes: Js=joint spacing, Jc=joint condition, Jw=joint water, F1-F3 relate to discontinuity orientations (see Tables E.4-E.6), F4 relates to method of construction.

Table E.9 Summary of RMR and SMR Factors for Edward

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Sile

Site	1 UCS	POD		the second s		a detora	IOF EC	Wards.	OVer Cl	lan D.	
1-10-1	14	- AQD	J5	Je	Jw	RMR	1 121	1	over G	ien Ros	e Sites
1.10.2		17	20	21	115	27	11	12	F3	F4	SMP
1 10 5	13	8	15	25	16	11	0.4	1	-6	10	OF
1-10-4	3	17	20	25	14	00	0.15	0.15	-60	10	0.5
1-10-8	3.5	20	20	122	15	80	0.15	0.15	-50	110	65
337-1	3	15	20	123	115	82	1	1	26	110	89
470-1	2.5	10	20	15	15	68	0.33	1 ·	-43	10	67
Mean	2.2	10	17	19	7	56	0.15	-	-25	10	70
Cut Day	3.6	14.5	18.7	21.3	13.7	71 2	0.13	1	0	0	56
na. Dev.	0.5	4.6	2.2	3.9	2.2	11.3	0.4	0.7	-29.3	6.7	71 6
0485: Js=	Oint soucin	n Inches	and the second designed to the second designe		2.3	10.0	03	0.1			11.0

Notes: J<sub>8</sub>=joint spacing, J<sub>2</sub>=joint condition, J<sub>W</sub>=joint water, F1-F3 relate to discontinuity orientations (see Tables E.4-E.6), F4 relates to method of construction.



Fig. E.1 Height distribution of Glen Rose sites.



Fig. E.3 Age distribution of Glen Rose sites.



Fig. E.2 Height distribution of Edwards sites







Fig. E.5 VSR vs. age for Glen Rose sites. Increasing VSR values indicate increased performance.



Fig. E.6 VSR vs. age for Edwards sites.



Fig. E.7 MR vs. age for Glen Rose sites. Note, increasing MR indicates decreasing maintenance frequency.



Fig. E.8 MR vs. age for Edwards sites. Note, increasing MR indicates decreasing maintenance frequency.


Fig E. 9 VSR normalized by age vs. height for Glen Rose sites. Increasing VSR values indicate increased performance.



Fig. E.10 VSR normalized by age vs. height for Edwards sites. Note that stability increases with increasing VSR.



Fig. E.11 MR vs. height for Glen Rose sites. Note, increasing MR indicates decreasing maintenance frequency.



Fig. E.12 MR vs. difference in slake durability. Includes Glen Rose and Edwards over glen Rose sites.



Fig. E.13 DDE vs. difference in slake durability. Includes Gien Rose and Edwards over Gien Rose sites.



Fig. E.14 MR vs. DDE normalized by age of slope. Includes Glen Rose and Edwards over Glen Rose sites.



Fig. E.15 VSR vs. DDE normalized by age. Includes Glen Rose and Edwards over Glen Rose sites.



Fig. E.16 MR vs. VSR for Glen Rose sites. Notice there is no relationship between these two performance measures.



Fig. E.17 MR vs. VSR for Edwards sites. There is no correlation between the two, however, both variables are higher than those for the Glen Rose (see Fig. E.16).



Fig. E.18 MR vs. average RMR for Glen Rose sites.



Fig. E.19 MR vs. average RMR for Edwards sites.



Fig. E.20 MR vs. average SMR for Glen Rose sites. Value at (12, 1.9) is site 2722-1 which has a joint set daylighting into the slope face, thus dramatically lowering the SMR.



Fig. E.21 MR vs. average SMR for Edwards sites.



Fig. E.22 VSR vs. average RMR for Glen Rose sites.



Fig. E.23 VSR vs. average RMR for Edwards sites.



Fig. E.24 VSR vs. average SMR for Glen Rose sites.



Fig. E.25 VSR vs. average SMR for Edwards sites.



Fig. E.26 MR vs. average RQD for Glen Rose sites.



Fig. E.27 MR vs. average RQD for Edwards sites.



Fig. E.28 VSR vs. average RQD for Glen Rose sites. Notice slight relationship.



Fig. E.29 VSR normalized by slope age vs. average RQD for Glen Rose sites.



Fig. E.30 VSR vs. average RQD for Edwards sites.



Fig. E.31 VSR normalized by slope age vs. average RQD for Edwards sites.



Fig. E.32 Effect of seepage on the average SMR ratings for Glen Rose and Edwards over Glen Rose sites.



Fig. E.33 Distribution of average SMR values for Glen Rose sites.



Fig. E.34 Distribution of average RMR values for Glen Rose sites.



Fig. E.35 Distribution of SMR ratings for Edwards sites.



Fig. E.36 Distribution of RMR ratings for Edwards sites.



Fig. E.37 RQD vs. depth for Glen Rose Formation from CTR core borings and local geotechnical reports. Only 1.5 m or longer core runs were used for RQD determination. Notice the extreme variability at depths less than 10 m. This is most likely attributed to the weathered zone of the formation. Below 10 m, RQD shows a fair correlation with depth. The majority of road cuts observed for this project, in the Glen Rose, are 15 m or less in height.



Fig. E.38 Distribution of RQD values for the Glen Rose in the Austin, TX area from local geotechnical reports (TETCO, 1985-1995).



Fig. E.39 Distribution of estimated and calculated RQD values in Glen Rose from CTR 1407.







Fig. E.41 Distribution of RQD's from TETCO (1985-1995) for Edwards Formation in the Austin, TX area.



Fig. E.42 Calculated and estimated RQD's for Edwards sites for CTR 1407.



Fig. E.43 Distribution of uniaxial compressive strength values for Glen Rose Formation in the Austin, TX area from TETCO (1985-1995).



Fig. E.44 Distribution of UCS values for the Edwards Formation in the Austin, TX area from TETCO (1985-1995). Note that the UCS values for the Edwards are about 2 times greater than that of the Glen Rose (Fig. E.43).



Fig. E.45 Average and range of estimated and/or calculated RQD's from sites in the Glen Rose and Edwards Formations.



Fig. E.46 Average and range of RMR ratings for sites in the Edwards and Glen Rose Formations.



Fig. E.47 Average and range of SMR ratings for Edwards and Glen Rose Formations.



Fig. E.48 Average and range of VSR values. Notice the higher avg. VSR values for the Edwards Formation sites.



Fig. E.49 Average and range of MR values. Notice the higher average MR for the Edwards Formation.

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Page 4 of 4 Code \_\_\_\_\_\_

## **TxDOT Rock Mase Field Description**



#### Scanline Descriptions

Scanline Information:

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# **TxDOT Rock Mass Field Description**

Set#	Setika	Dip	Roughness	Filling	Persistence	Weathoring	Remand
-	N35"W	85 5	VR	Ther	P	ヨーヨ	FALL IN FILLING WAR
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eature	SUIKE	Dip	Condition	Perssence		Public	
	-						
		-			-		
ledding [	Xescription:	2'-4	1 MARDIN	BIDS UP	AS MEST	MAR MAR	LY (2'-4') 3355
ledding C Veatherir	Description: ng/Enceion:	2'-L Logui - Di li - Di li	1' MARDON 30 10'. HO WES. JUNT OF. Polosi 3930 IN	BROS UP T AS SUFT SETEL TH IN OF hot (and not)	ALLY FONE	BUT NU	LY (2'-4') 3385 mate +335 4 070 + 1'-2' RETACT
Sedding C Weatheriz	Description: ng/Encsion: Slope Failum	Z'-4 Gen Dri Ovgrada	1 MARDON M 10'. HI TES. JUST STEP IN STEP IN	BEDS UP I DT MS SUFT SETEL TH IM OF MAR LANCE MAR LANCE BE	OUR IS'	BLOCK F	LY (21.41) 2385 MATE #335000 of other H 11-21 RETAINS
Sedding C Veatherir Form of S Debris:	Description: ng/Encsion: Slops Failunt <i>LoT</i>	Z'-4 Generation Definition Degradation	1 MARDON 30 101. HIS WES. JUST SF. PALOSI 3934 IN 1934 IN 1934 IN 1935 IN 19 19 19 19 19 19 19 19 19 19 19 19 19	BEDS UP I DT MS SUFT SETEL TH IM OF MAR LOWAL MOL IL MAR BL Y FROM GO IL MAR BL Y FROM GO	OCK FALL, MAL MELL CLY FONE CLY F	BLOCE E	LY (21.41) 23355 MATE 13336400 A ATT Y 11-21 RETARKAT ALL, RAVELLING
Sedding C Veatherir Form of S Debris:	Description: ng/Encsion: Slope Failure	2'-4 Generation Drif Overstan S of 3	1' MARDON 30 10' NG AFES JUST STEP IN STEP IN HOUSE CAN'TI HOUSE SE	BEDS UP I SETEL TH SETEL TH W OF MAR LONG MAR LONG AL Y FREE LO DIL TO	OR 15' AS MOST AN UNICL ELY FONE ELY FONE ELY FONE ELY FONE ELY FONE ELY FONE ELY FONE ELY FONE ELY FONE ELY FONE OCK FALL North Law S' BLOCK	BLOCK F	LY (2'-4') 3385 MATE ASSENDED A ATT Y 1'-2' RETARA Y 1'-2' RETARA
Sedding C Weatherin Form of S Debris: Waintena	Description: ng/Erosion: iope Failure 	2'-4 60 90 90 90 90 90 90 90 90 90 90 90 90 90	1' MARDON 30 10' HI AFES. JUST SAJA IN SAJA IN MORE CAN'T MORE CAN'T MORE CAN'T MORE CAN'T	BIDS OFF	OR 15' AS MOST AND UNICE ELY FONE ELY FONE	BLOCK F	LY (2'-4') BIES MATE ASSEND A ATT Y 1'-2' RETAINS
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# Summary of Engineering Geologic Data

TxDOT Rock N	lass Field Description	Page 2 of 4 Code 2473-7
	Scaniine Descriptions	-A-
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#### Debris Description

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### **TxDOT Rock Mass Field Description**



#### Scanline Descriptions

#### Scaline Information:

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