APPENDIX G Pressuremeter Testing Report

Report of In Situ Pressuremeter Testing
Last Chance Grade Project
South of Crescent City, CA

Submitted to:
Kleinfelder
2882 Prospect Park Drive, Suite 200
Rancho Cordova, CA 95670

Kleinfelder Project Number: 1154000099
In Situ Engineering Project Number: 1874
Field Work: September 23, 2020 – December 18, 2020
Report Date: May 28, 2021
Revised Report Date: April 5, 2022

Testing conducted and report prepared by:

In Situ Engineering

6232 195th Avenue SE

Snohomish, WA 98290 360-568-2807

TABLE OF CONTENTS

CONTENTS

1.0 INTRODUCTION 4
2.0 PURPOSE 4
3.0 PRESSUREMETER TESTING 4
  3.1 Instrumentation 5
  3.2 Pre- Bored Hole Formation 6
  3.3 Test Procedure 6
4.0 Analysis of the Shear Modulus 8
5.0 Material Strength Analysis 10
  5.1 Determination of the Limit Pressure and Shear Strength by Log Method 10
  5.2 Material Properties by Model Analyses 13
  5.3 Cohesive Strength Properties Derived from Gibson Model Analysis 15
  5.4 Arnold's Method of Shear Strength Analysis 17
  5.5 Frictional Strength Properties Derived from PMT Analysis 18
6.0 Pile Displacement Curves (P-Y) 19
7.0 CONCLUSIONS 23
8.0 REFERENCES 24

FIGURES

Figure 1 Schematic Details of the Pre-Bored Pressuremeter Instrument 5
Figure 2 Example PMT Curve 8
Figure 3 Modulus Analysis of Test RC-20-019 9
Figure 4 Limit Pressure by Visual Inspection 11
Figure 5 Limit Pressure by Log Method 12
Figure 6 Cohesive Stress Path 15
Figure 7 Cohesive Mohr's Circle 16
Figure 8 Shear Strength Analysis by Gibson Model 17
Figure 9 Arnold's Method 18
Figure 10 Example Frictional Model 19
Figure 11 Spring action acting on a length of pile 20
Figure 12 Ideal pressuremeter test 20
Figure 13 P-Y data developed from a pressuremeter test 21
Figure 14 Example Load Displacement Data 22
Appendix I – Data Tables 25
Appendix II – Pressuremeter Data 30

TABLES

Table 1 – Numeric test qualification and data analysis explanation notes: 25
Table 2 – Pressuremeter Test Depths and Material Descriptions 26
Table 3 – Shear Modulus and Test Pocket Quantitative Values 27
Table 4 – Shear Strength and Limit Pressure Values 28
Table 5 – Friction Angle and Lateral Stresses Values 29

1.0 INTRODUCTION

This report contains the test results and analysis for electronic pressuremeter testing (PMT) performed by In Situ Engineering under contract to Kleinfelder, Rancho Cordova, California, for the Last Chance Grade Project, located along US Hwy 101 between PM 12.0 and PM 15.5. This stretch of roadway has experienced decades of failure due to landslides.

Drilling on the project was performed by two drilling contractors; Crux Subsurface, Inc, Spokane, Washington, and Gregg Drilling, LLC, Signal Hill, California. Crux used two different Burly Terracon drill rigs for this project. Gregg Drilling used a track mounted GeoProbe 32 rig for the first day of testing. The remaining six days of PMT testing with Gregg drilling was performed with a truck-mounted CME 850. Testing in the boreholes was performed between 13.5 and 110 feet below the ground surface. Test depths are recorded using the bottom of the pressuremeter as a reference. In general, the material tested was mélange (argillite) and greywacke (sandstone). Testing in RC-020-019 and RC-020-020 were performed in “earthflow”. The borehole name, test depths and preliminary material descriptions are presented in Appendix I, Table 2.

2.0 PURPOSE

The purpose of this project was to explore the feasibility of six options for rerouting US Hwy 101 to avoid unstable portions of the highway. A total of 24 PMT tests were performed in eight borings. The in-situ material properties derived from testing are as follows:

Shear Modulus
Limit Pressure
Shear or Frictional Strength
Lateral Stress Estimation

3.0 PRESSUREMETER TESTING

A total of 24 pressuremeter tests were attempted in eight boreholes, 21 of which produced useable data. A variety of drillers and drill rigs were used to advance the PMT test for a specific interval of formations. Each driller and associated drill rig are listed in Table 2 in the appendix. All tests were performed using the pre-bored pressuremeter instrument (PBPM) in argillite, greywacke, and earthflow. Tests LCG-007, 008 and 009 were attempted in oversized pockets, and thus produced no useable data. Pressuremeter testing was conducted over four separate mobilizations spanning from September 21st – December 18th of 2020. The details of the pressuremeter testing and interpretations of these tests are included in the following sections of this report.

3.1 Instrumentation

Both instruments used for this study were pre-bored (PBPM) mono cell high pressure instrument. All pressuremeters are equipped with a pressure sensor and three electronic displacement sensors spaced 120 degrees apart and located at the center of the instrument. A flexible membrane is placed over the sensors and clamped at each end. The membrane is covered by a protective sheet of stainless steel strips referred to as a shield. The unit is pressurized using compressed air, which expands the membrane to deform the adjacent material. The electronic signals from the displacement sensors and pressure sensor are transmitted via cable to the surface. During the test, the average expansion versus pressure is displayed on a computer screen. The membrane is expanded and drained by regulating the flow of compressed air to the instrument with a control panel operated by the field engineer. A schematic of the instruments is shown below in Figure 1.

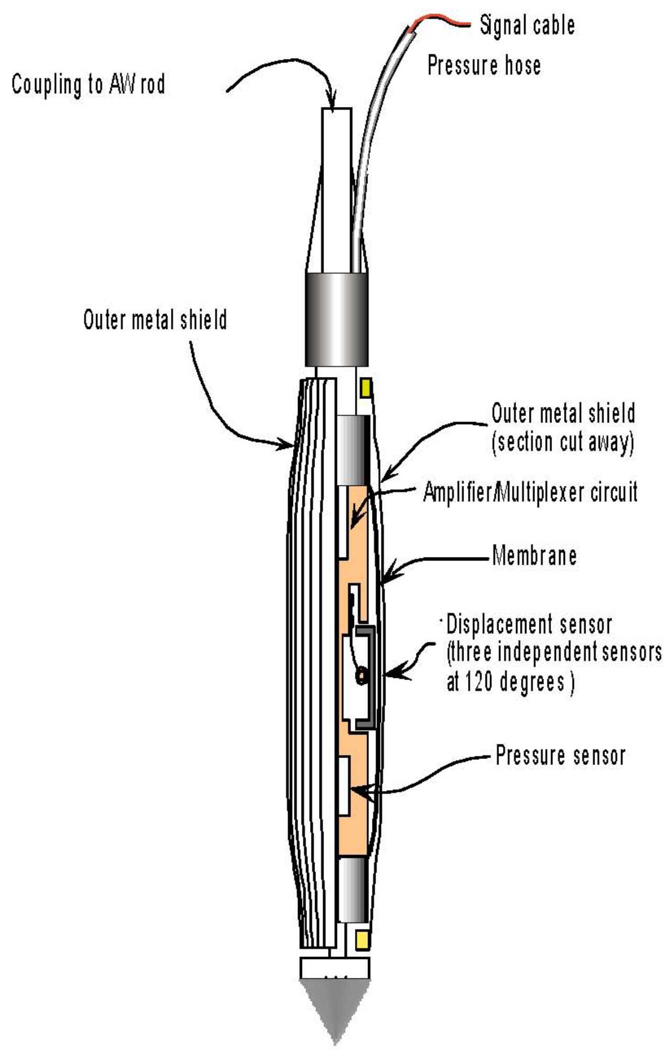


Figure 1 Schematic Details of the Pre-Bored Pressuremeter Instrument

The data recorded at the time of testing are uncorrected data. The flexible membrane has a given strength and stiffness. To correct for these effects, membrane correction tests are performed (air correction and tube correction) each time a membrane is replaced on the instrument. The strength of the membrane is removed by applying an air correction.

To correct for the strength of the membrane, an air correction is applied to the raw data. The instrument is inflated, at the surface, several times (normally 0% to 14% strain). A stress-strain response is a recorded which quantifies the amount of resistance to expansion caused by the membrane, or membrane strength. This response is approximately linear within the range of membrane expansion for the test. A membrane correction was performed prior to beginning field work.

To correct for membrane compressibility and the effect of pressure on the electronics on the PBPM, a tube test is performed. The instrument is placed vertically inside a thick-walled steel tube and inflated to high pressures up to 2000 psi. The resulting stress strain curve is a record of the membrane's stiffness and pressure effects on the electronics. All data presented in this report are corrected for membrane effects.

Test depths are recorded using the bottom of the pressuremeter as a reference. The expansion of the pressuremeter occurs approximately between 6.5 inches and 24 inches above the reference depth. For example, if the test depth is 6.0 feet, the actual test zones would be between 5.45 and 4.5 feet.

3.2 Pre- Bored Hole Formation

The borehole and test pockets were formed using both mud rotary and rock coring techniques. Generally, all tests performed by Gregg Drilling employed mud rotary techniques, while all PMT performed with Crux employed rock coring techniques. With mud rotary, the test pockets were drilled with a 2-$^{15}/_{16}$" diameter tri-cone bit. Once the test interval was opened, the instrument was then lowered down to the bottom of the pocket with AWJ rod above the instrument and a test was performed. The instrument was then raised 18 inches and a second test was performed. After testing each pocket, the instrument was removed, and the pocket was over-drilled with a larger diameter tri-cone bit such as 4.5 inch. Very little quick gel (sodium bentonite substitute) was used. When using rock coring techniques, the borings were drilled with HQ core. When the top of a test interval was reached, drillers switched to NQ core to open the test interval. Once testing was complete, drillers then switched back to HQ core and advance to next test zone.

3.3 Test Procedure

After advancing the instrument to the bottom of a newly created test pocket, the membrane is inflated by controlling the flow of compressed air into the pressuremeter, increasing the pressure until the membrane starts to expand against the borehole wall. After the instrument has begun to deform the material, the first of a series of unload-reload cycles (loop) is performed. The point of initiation of the unload-reload loop is a judgment call of the field engineer, but usually there is a series of loops which are spaced more or less evenly through the pressure-expansion curve. The loops are formed by reducing the applied pressure by no more than 40% of the initiation point of the loop, then increasing again.

The resulting unload-reload loop can be used to evaluate the elastic behavior of the material. In materials which behave in a plastic manner, the loops will exhibit a hysteretic behavior. That is, the unloading path will follow the "mirror" image of the reloading path. Materials such as sand the loops will be very tight, exhibiting little hysteretic behavior. In materials such as clay, the loops will exhibit large hysteretic behavior. Occasionally, an unload/reload loop will exhibit unusual characteristics, such as an open "V" shape. In these circumstances, a three-minute creep hold is sometimes performed to recompress an overly relaxed formation which was disturbed by the drilling process.

The pressure is then advanced until a sufficient increase in stress or strain has occurred before completing a second unload-reload loop. This process is then repeated a third or fourth time as the test is conducted. If the disturbance from drilling is small and the material behavior is consistent with increased strain, the slope of the loops will tend to be parallel.

After the strain reaches the maximum range (16% to 18%) or the stress reaches the maximum range (~2000 psi), the pressure is reduced to zero. The exact maximum stress or strain at which the pressure is reduced to zero is a decision made by the operator based on the behavior of the three arms, instrument response and other limiting conditions. Tests may be terminated before the failure of the material if one of the following occurs: the limit of any one strain arm is reached, the maximum pressure of the pressure bottle is reached, electronic failure occurs, the membrane ruptures, or the instrument response is such that membrane rupture may be imminent.

An example of the PMT curve is shown below in Figure 2. Examining the figure, we can see four unload-reload loops were performed. The unload-reload loops were initiated at approximately 2.0%, 5.5%, 9% and 13% strain.

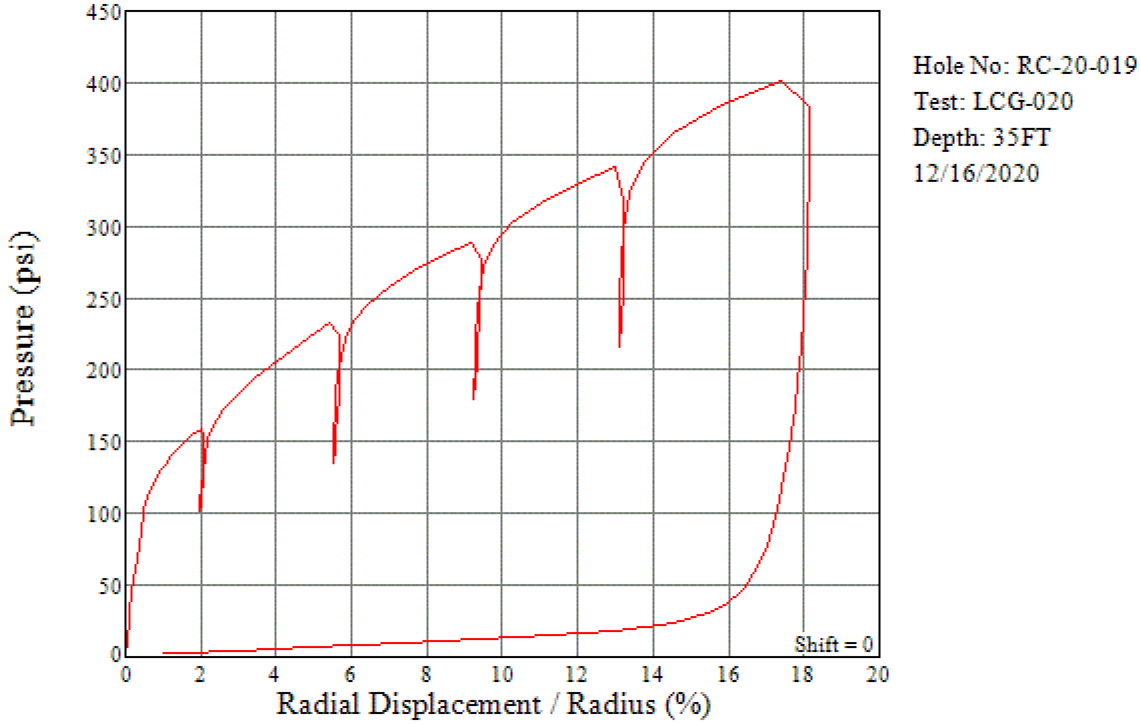


Figure 2 Example PMT Curve

4.0 Analysis of the Shear Modulus

If the material surrounding the pressuremeter is assumed to extend to infinity, and assumed to behave as an idealized linear elastic, homogeneous material, which does not fail under shear or tension, then the displacement on the boundary of the pressuremeter, u_a, for a given pressure, P, is given by:

$$\mu_a = P(a)\,(1 + \upsilon) / E \qquad 1)$$

where:

"E" is Young's Modulus
"a" is radius of the pressuremeter cavity
"υ" is Poisson's ratio.

As the shear modulus, "G", and the Young's modulus, "E", are related by the following relationship:

$$E = 2\,(G)\,(1 + \upsilon) \qquad 2)$$

Equation 1 reduces to:

$$\mu_a = 0.5\,P(a) / G \qquad 3)$$

Hence, the shear modulus G is given by:

$$G = 0.5\ (\Delta \text{ Pressure} / \Delta \text{ (radial displacement / radius)}) \quad 4)$$

The American Society for Testing and Materials (ASTM) D4719, Section 9.5 defines a pressuremeter modulus (E_p). This is derived from using the shear modulus for the average slope of the initial loading curve of the pressuremeter curve. This "initial shear modulus" is converted to a Young's modulus or E_p (Poisson's ratio of 0.33 is used if no other information known) using equation 2 above. However, in most tests a straight section in this part of the curve is not sufficiently well defined to enable the modulus to be determined and the initial curve is often prone to drilling disturbance resulting in lower modulus values or if the instrument pushed (shoved in) resulting very high modulus values. In the example of Figure 3, we can see that the slope of the tangent line and hence the value the initial shear modulus is highly dependent and very subjective of which portion of the curve is applied. We do not recommend the use of this initial shear modulus for the soils on this project.

The modulus determined from an unload-reload loop is more accurately defined and is more representative of the modulus for the *in-situ* material. Figure 3, shown below, is an example of the shear moduli determined from unload-reload loops.

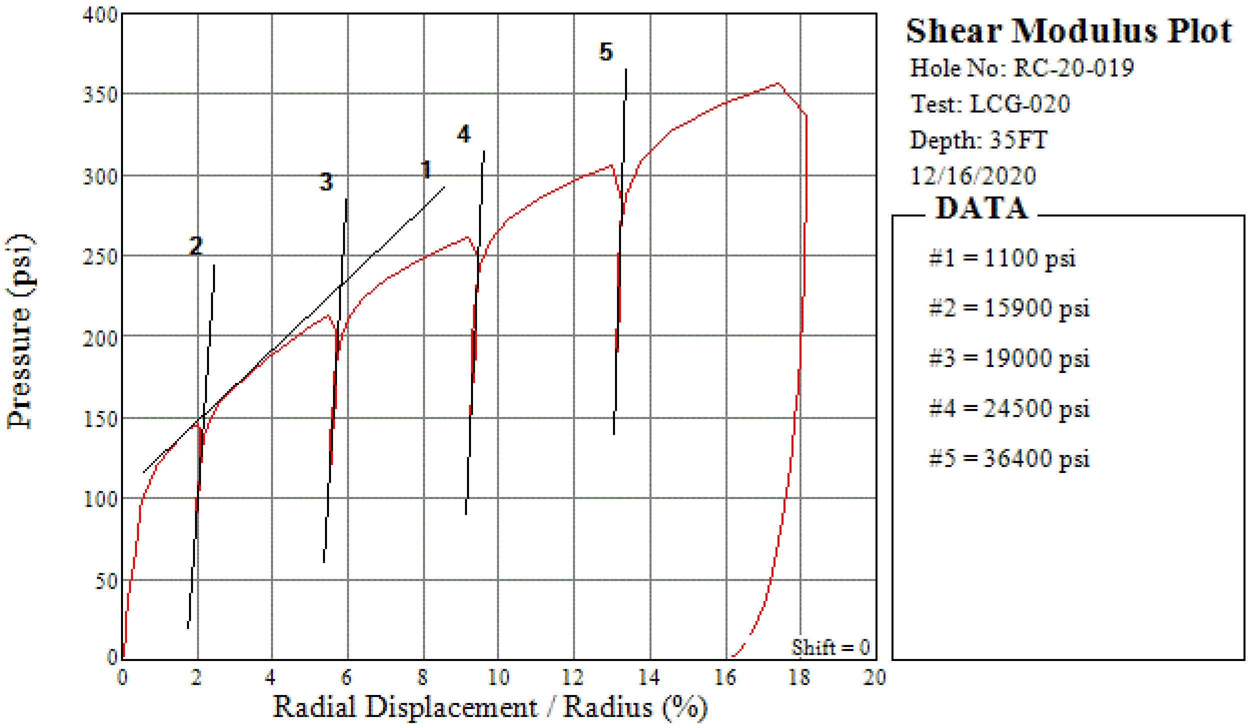


Figure 3 Modulus Analysis of Test RC-20-019

Typically, by performing multiple unload-reload loops during a test, two or more of the loops tend to be parallel, confirming a particular shear modulus value and indicating that the material is not disturbed. However, if the test pocket is highly disturbed, then parallel loops can be difficult to obtain. Also, these unload-reload loops may exhibit anti-parallel behavior (decreasing or increasing shear modulus) due to the nature of the material. In other words, the material behavior may change with strain. In general, *frictional material will exhibit strain hardening and cohesive materials strain softening*. In the example shown above, it appears that the moduli, defined by the loops, are increasing, representing more frictional behavior and that a strain hardening phenomena is occurring.

The initial shear modulus, #1 in the example above, can be converted to the pressuremeter modulus or E_p using equation 2.

The shear modulus values are summarized in Appendix I, Table 3.

5.0 Material Strength Analysis

Strength determination from pressuremeter testing is determined by several mathematical methods. It is strongly emphasized that all the methods used in this study have assumptions and therefore limitations in their applicability. This is especially true because most of the material tested was on a fault zone, not either cohesive soil or frictional soil. As a broken rock formation, it fails using slightly different mechanisms than soils. The highly interbedded nature further complicates analysis as it cannot be considered homogeneous. That being stated, the soil models which are applied in this report should provide a reasonable approximation of strengths. The report user should keep the following in mind:

1. The shear strength and limit pressure as determined by the log method will probably overstate the strength as the Greywacke may fail in brittle behavior before the limits are reached.
2. The instrument used is a high pressure instrument but the rocks are considerably stronger in most cases and the instrument can not provide sufficient lateral force to fail them.
3. The frictional strengths are generally very high but should only be applicable to the small strains before the instrument capacity was reached.
4. The shear strength using the Gibson method in most cases provides a minimum strength. The actual strength is probably much higher. The true shear strength probably lies between that determined by the log method (high) and the Gibson method (low).
5. Some of the weathered (Earthflow) behaved as a cohesive material and the strength values derived for these materials should be considered good values.

5.1 Determination of the Limit Pressure and Shear Strength by Log Method

From a visual inspection of a typical PMT curve, Figure 4 shown below, it is observable that the rate of strain increase is continual (6% - 10%) but increase in pressure is decreased. And pressure will eventually reach a maximum no matter how large the strain. A visual observation of test BWER-021 would indicate that the maximum or limiting pressure reached would be above 1500-1600 psi.

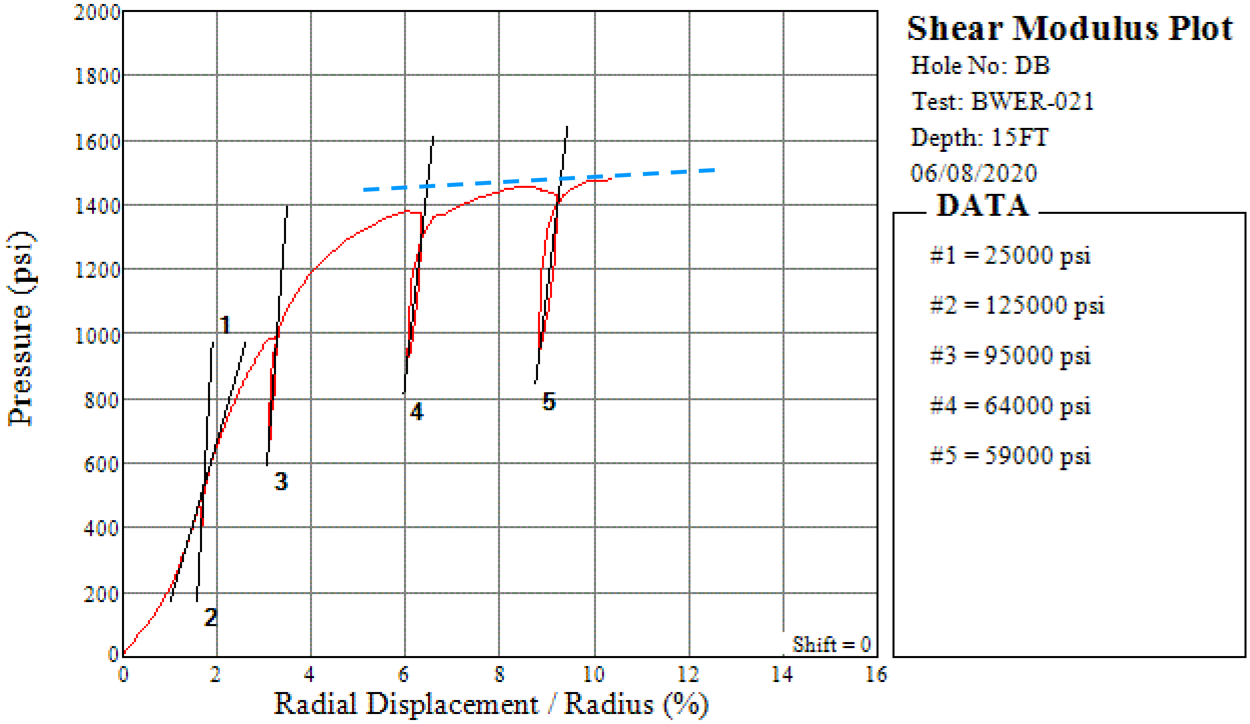


Figure 4 Limit Pressure by Visual Inspection

Different materials reach their limit pressure at different strains. For consistency, the limit pressure has been defined by ASTM D-47619 as that pressure which occurs when the volume of the pressuremeter has doubled. This arbitrary limit pressure was initially defined because virtually all-natural materials have totally failed when they have strained that far. Few pressuremeters can expand this far before reaching the limit of the strain sensing system. It is actually preferable that they do not expand this much, at this large expansion the deformation does not resemble a right circular cylinder, but more closely resembles a football. The mathematical equations are not relevant at high strains, and the membrane is over deformed. The pressuremeters used in this investigation will only expand to about 18% before the displacement limit is reached. Therefore, the double volume must be mathematically extrapolated. This is performed by plotting the data on a semi-log scale and extrapolating to 41% strain, which is mathematically equivalent to doubling the cavity volume. Figure 5 below shows how the limit pressure is obtained using the log method.

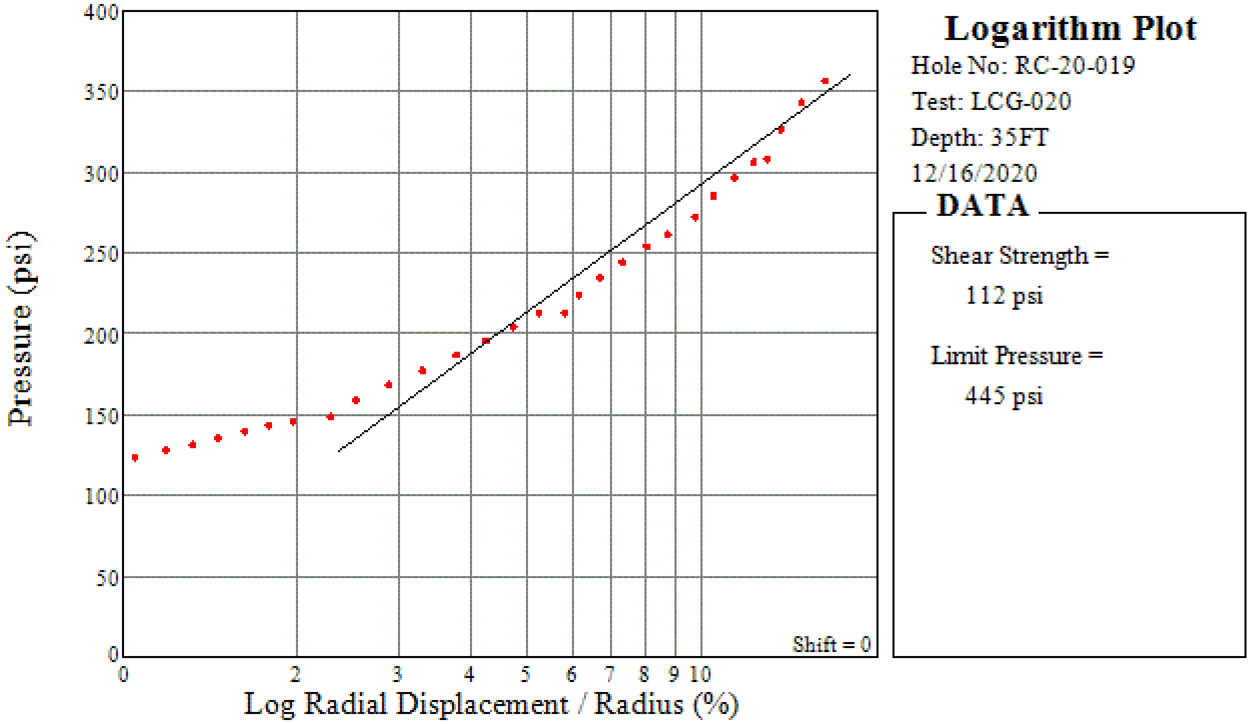


Figure 5 Limit Pressure by Log Method

If the material being tested is assumed to behave as an elastic cohesive material, then the equation governing the pressure-displacement curve is given by:

$$P = P_L + (c)\log_e (u_a/a) \qquad 5)$$

$$P_L = P_o + c + (c)\log_e [G/c] \qquad 6)$$

Where:

P_L" is the theoretical limit pressure at infinite expansion

"c" is the undrained cohesive strength,

"P_O" is the total *in-situ* lateral stress, and "G" is the shear modulus.

From Equation 5, a plot of pressure P against the log of u_a/a will be a straight line, provided the shear strength remains constant with strain. The slope of this line will provide a measure of the undrained shear strength, c. If any disturbance is present, the above method of determining the cohesive strength usually provides an overly optimistic value. The above method applies only to cohesive materials with no frictional component. The limit pressure and shear strength results are tabulated in Appendix I, Table 4. The computer program plots both limit pressure and shear strength tests (shown in Appendix II) even though the shear strength is not technically valid for the decomposed rocks tested which are not purely cohesive. The engineer should be cautioned of the limited applicability of cohesive shear strength in Earthflow and frictional soils which are denoted with Ø or Ø-C on the tables in Appendix I.

5.2 Material Properties by Model Analyses

The strength of a material being tested can be determined if a failure mechanism or model is assumed. The modeling approach incorporates assumptions about the material properties and mechanism of failure. Each type of model has input variables. The simpler the model, the fewer the number of variables, whereas more complex models have more variables. In most modeling, the variables are input, and the resultant curve examined against the field curve. The variables are then adjusted until a best fit curve is obtained.

The analysis of the data is performed in the office and utilizes a proprietary computer program developed by the In-Situ Engineering. This computer program analyzes shear strength, shear modulus, limit pressure, lateral earth pressure and frictional strength using various methods and models. These methods and models are described in more detail in the References cited in Section 8.0.

In Situ Engineering uses three primary models in analysis. These are the *Gibson and Anderson cohesive model*, the *Hughes friction model* and the *Arnold cohesive model*. According to B.G. Clarke in *Pressuremeters in Geotechnical Design*: "There are two approaches to the theoretical interpretation of a pressuremeter test. The first is to assume a constitutive model for the ground and derive an equation that will give an approximate fit to the test curve. The second is to fit a mathematical function to that curve and then derive parameters from that function using a constitutive model". The Hughes and Gibson methods are the former and the Arnold is the later. In that sense, the better the field curve fits to either the Hughes or Gibson model, then the more closely the material is to the ideal of the model. In the Palmer/Anderson model, the points on the field curve are chosen by the engineer and the model is almost always a near perfect fit. Judgement must be utilized in the application of any of the results, particularly where the field material does not fit the model assumptions. In general, we like to analyze the material in as many ways as possible as this gives us insight into the material behavior and helps us to either reinforce or eliminate solutions.

Modeling analysis involves fitting a theoretical curve to the field curve data. For instance, if the field material is a sand, then a theoretical friction model curve can be overlain, and the input parameters adjusted until the theoretical curve fits the field curve. The input parameters are a solution set. As can be imagined, there are multiple solutions sets because the input parameters are all variables unless they can be determined as constants. For example, the friction model developed by Hughes has input parameters that are water pressure, critical friction angle, effective lateral stress, friction angle and shear modulus. Water pressure is usually a known value from piezometers; the shear modulus is known from performing an unload-reload loop during the test; and the critical friction angle is normally about 32 degrees for dilatant granular materials; thus 3 of the 5 input parameters are essentially constants. In this example, the friction angle and the effective lateral stress become variables. If one of these can be constrained or determined by some other method, then the last remaining input parameter can be determined. If frictional data is available from other sources, such as laboratory shear testing, then that variable could be constrained and thus provide the lateral stress.

One of the limitations we have in modeling analysis is that the model has certain assumptions. Following are lists of assumptions and boundary conditions of each model:

Cohesive Model by Gibson.

Variables:
1. Shear strength
2. Total lateral stress
3. Shear modulus

Assumptions:
1. Material deforms as a right circular cylinder
2. Material behaves as a purely cohesive material with no friction
3. Shear strength remains constant during failure
4. No volume change

Cohesive Model by Palmer with Arnold's Analysis

Variables:
1. Model the curve with three points

Assumptions:
1. Material deforms as a right circular cylinder
2. Material behaves as a purely cohesive material with no friction
3. Shear strength remains constant during failure
4. No volume change

Friction Model by Hughes Sand Model

Variables:
1. Friction angle
2. Lateral effective stress
3. Critical friction angle is constant
4. Water pressure
5. Shear modulus

Assumptions:
1. Material deforms as a right circular cylinder
2. Material behaves as a purely frictional material with no cohesion
3. Frictional strength remains constant

Experience has taught us how to observe the curve form and quickly determine if the material is behaving predominately as either a frictional or a cohesive material. Most of the materials tested on this project conform to the idealized behavior of either cohesive or frictional material. This is denoted on all data Tables as either Ø for frictional materials, C for cohesive materials or Ø-C for materials which are exhibiting hybrid properties.

The sections following describe each of the models and analyses in more detail.

5.3 Cohesive Strength Properties Derived from Gibson Model Analysis

As mentioned previously, the PMT curve can be used directly to determine the *in-situ* material strength properties such as the cohesive strength through modeling analysis. To accomplish this, a material model and failure mechanism must be assumed. During a pressuremeter test, a simple assumption is the material surrounding the instrument deforms as a right cylinder. Initially, the material is assumed to behave as an elastic material. As the pressure builds inside the instrument, the material on the cavity boundary will start to fail under shear. As the pressure continues to build, the zone of failed material expands while the cavity radius increases. The stress path of an element along the boundary will follow the form shown in Figure 6.

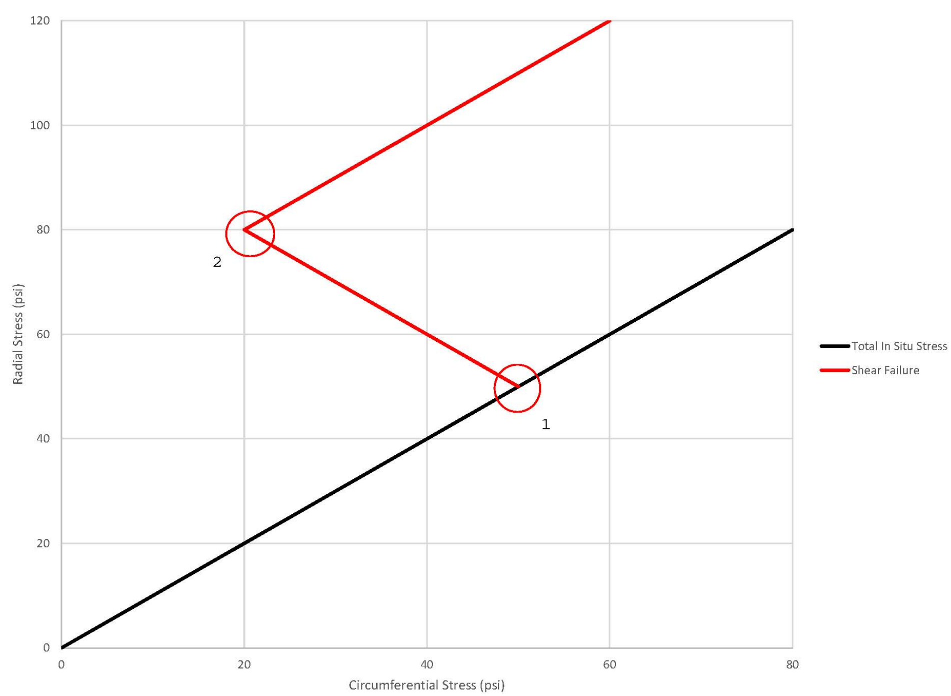


Figure 6 Cohesive Stress Path

The *in situ* stress state is set at 50psi, point 1. The shear strength is 30psi, point 2. As the pressure is increased from the *in situ* stress state, the stress path will move from point 1 to point 2. After the initiation of failure, point 2, the plastic zone forms and increases in size as the pressuremeter is expanded. The shear stress and volume strain will remain constant while in this plastic zone. Figure 7, shown below, is the same example but using Mohr's circle for the illustration.

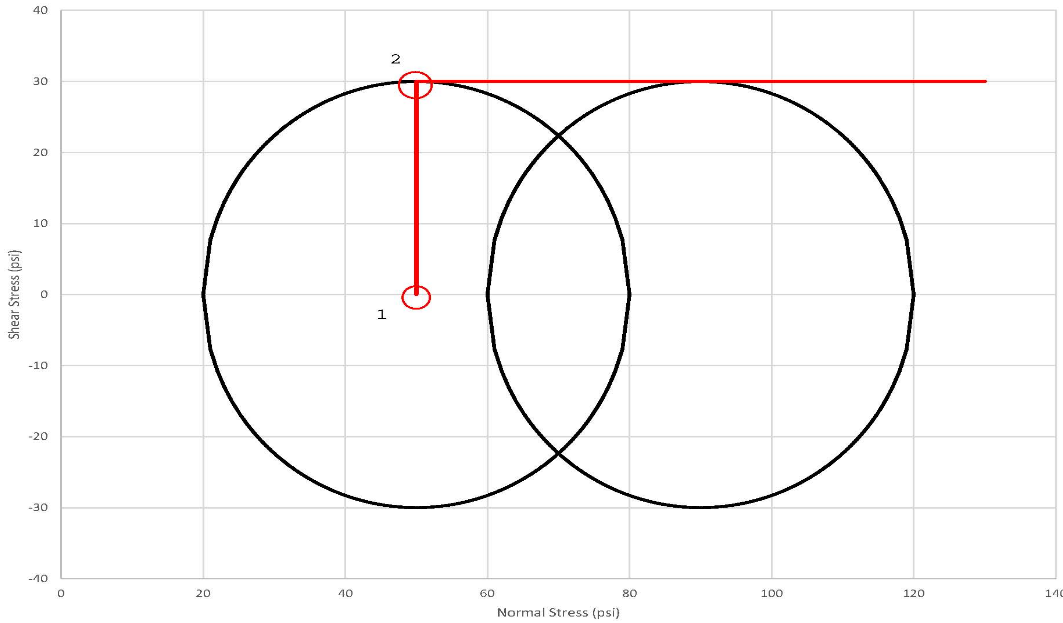


Figure 7 Cohesive Mohr's Circle

There are two phases of the PMT curve. The first is the elastic phase and the following is the equation governing the displacement:

$$U = R * (P - P_o) / 0.5G \qquad 7)$$

Where:

"G" is Shear Modulus
"P" is Pressure
"P_o" is *in situ* lateral stress
"R" is radius of the hole

Once the pressure has been increased so that shear failure has accord, point 2 in Figure 8, the basic equation that describes this behavior developed by Gibson is:

$$P - P_o = c_u * (1 + \log_e (G / c_u)) + c_u * (\log_e (2 * U/R)) \qquad 8)$$

Figure 8, shown below, is an example of the above method on borehole RC-20-020. The example shows separately analyzed loading and unloading curves. This example illustrates how the loading/unloading field curve fits the theoretical cohesive curve near perfectly.

Where appropriate, cohesive shear strength values determined by Gibson modeling are recorded in Appendix I, Table 4.

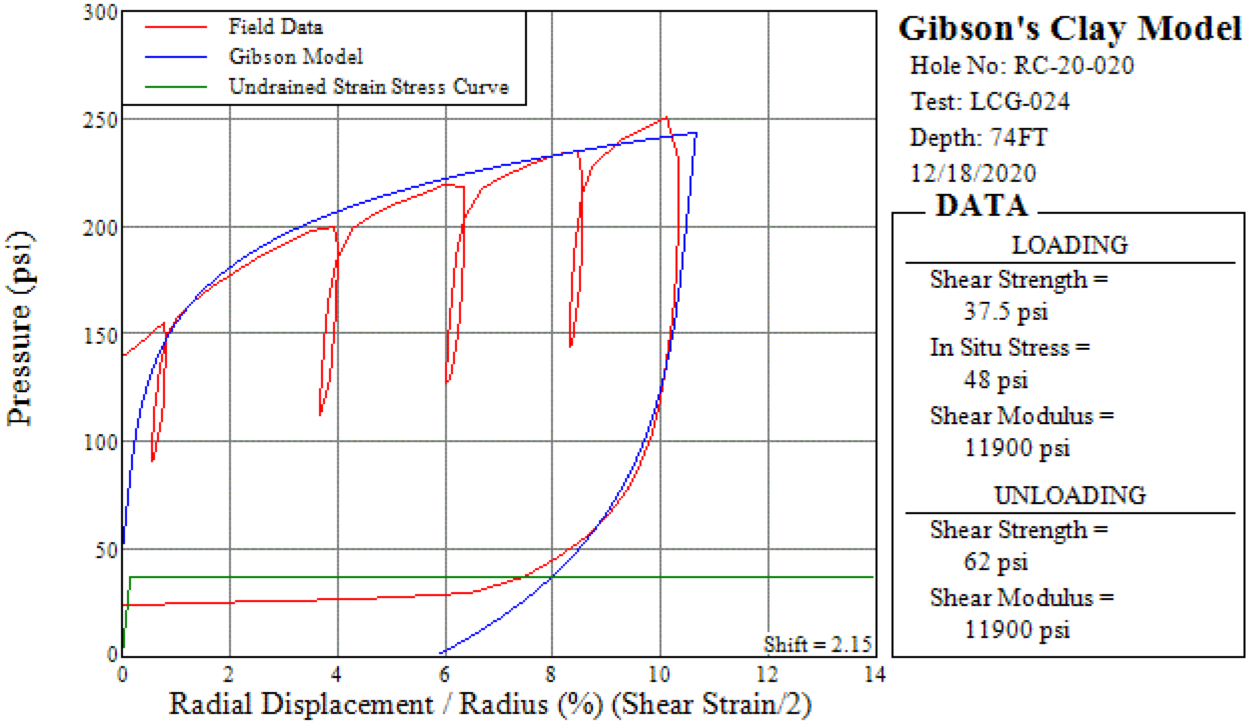


Figure 8 Shear Strength Analysis by Gibson Model

5.4 Arnold's Method of Shear Strength Analysis

An alternative method put forward by Arnold can be used to determine whether the strength reduces with strain. Arnold proposed that the pressure displacement curve can be approximated by a hyperbolic function,

$$P(a) = (u_a/a) / (a+b(u_a/a)) + c \qquad 9)$$

where a, b, and c are constants. The constants are selected by visually estimating the pressure at three points on the pressuremeter curve. Our software has predetermined three strain points of 1%, 2.5%, and 7.5%. The computer then calculates the three constants and draws the ideal curve. If the ideal curve does not fit the pressures at the selected strain points, then the pressures are adjusted until the ideal curve best fits the field curve.

The method of Palmer (1972) is used to determine the ideal undrained stress-strain curve. This method requires the differentiation of the ideal pressuremeter curve to give the shear stress versus shear strain. The shear strain is equal to twice the radial strain (u_a/a).

$$T = a^*(u_a/a) / (a+b(u_a/a))^2 \qquad 8)$$

Figure 9, shown below, is an example of the Arnold's method. The material's strength reduces with strain as shown by the green line. The peak shear strength is close to 149 psi at 19.8% shear strain while decreasing to 129 psi at 10% shear strain. Values derived from Arnold's method are shown in Table 4.

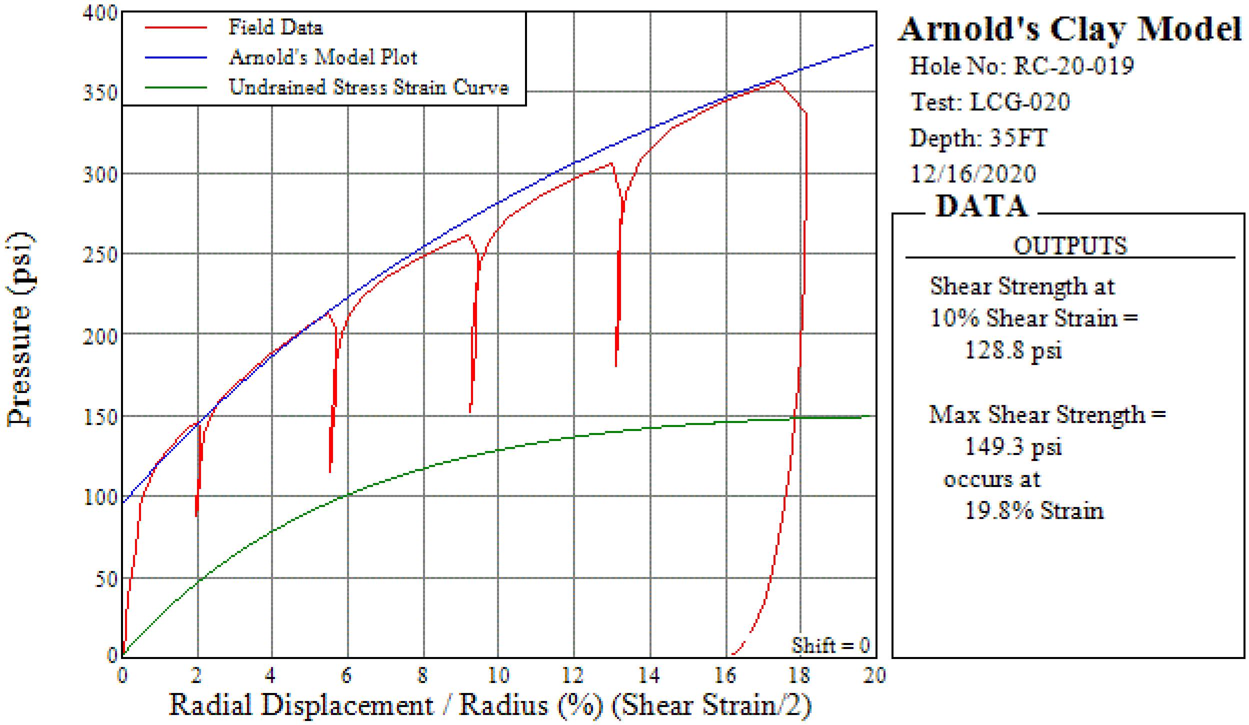


Figure 9 Arnold's Method

5.5 Frictional Strength Properties Derived from PMT Analysis

The PMT data can be used directly to determine the *in-situ* material properties such as friction angle on cohesionless material. For frictional materials it is assumed that the material surrounding the pressuremeter deforms as a uniform right cylinder; that is, it deforms in plane strain. Another assumption is that the material has a constant friction angle and little to no cohesion. The method used for interpretation is based on analysis presented by Hughes *et* al (1977), this can also be found in Mair and Wood, *Pressuremeter Testing*.

The friction angle and lateral stress are adjusted, using engineering judgment, until a best fit is obtained. Figure 10, shown below, is an example of the model analysis.

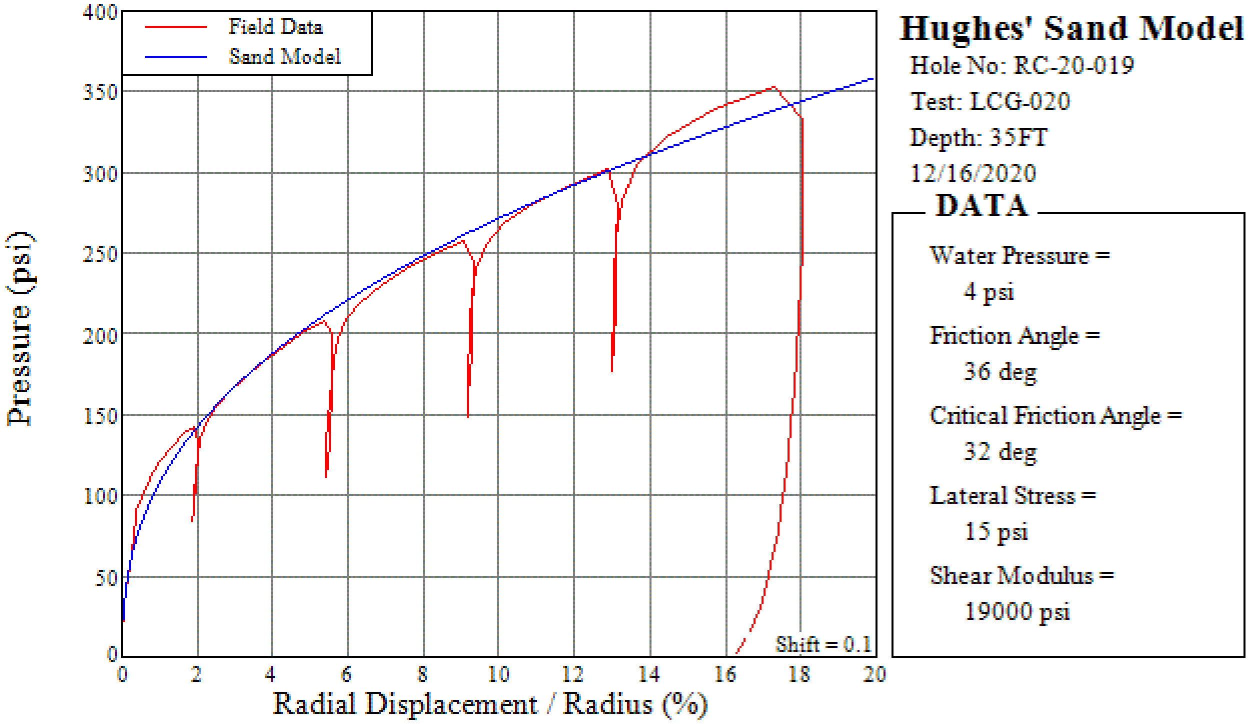


Figure 10 Example Frictional Model

The results of this model analysis have been presented in Appendix I, Table 5.

6.0 Pile Displacement Curves (P-Y)

The design of laterally loaded piles can be considered in two ways. Firstly, the ground can be considered as a continuum with some ideal material properties. That is each element in the surrounding soil is influenced by neighboring elements in three dimensions. A simple model would include a stiffness strength and lateral stress. Finite element or FLAC models are useful for that approach. Alternatively, the soil can be divided up into discrete horizontal layers with each layer acting as a spring against the pile. An example of this is shown in Figure 11. However, in this case the layers do not interact with each other. This is a much simpler approach from an analytical point of view. The pile is considered as a continuous elastic member with known properties and the lateral resistance of the soil is considered as a series of independent springs.

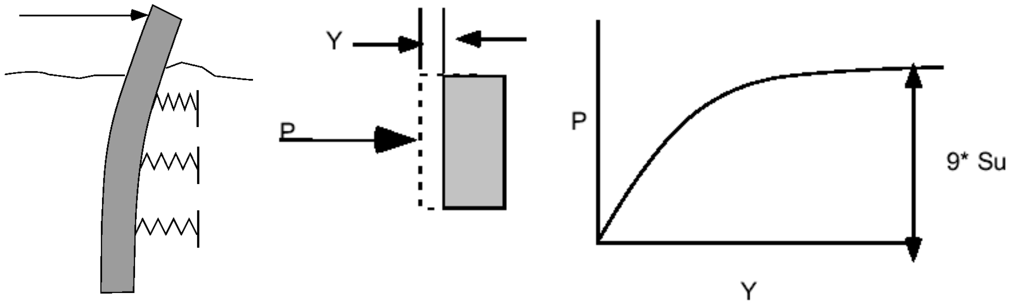


Figure 11 Spring action acting on a length of pile.

From back calculation of lateral loading tests (Briaud 1986) it has been found that in medium clays the spring stiffness of the soil is geometrically similar to the loading stage of a pressuremeter tests. However, some adjustment to the pressuremeter curve is necessary. If a section of pile, some distance below the ground surface (at least 4 diameters) is pushed laterally the ultimate resistance will be approximately 9 * the cohesive strength (Figure 11 – right side). In contrast the Limit Pressure from the pressuremeter test is approximately 5 * the cohesive strength + the static lateral pressure, shown below in Figure 12.

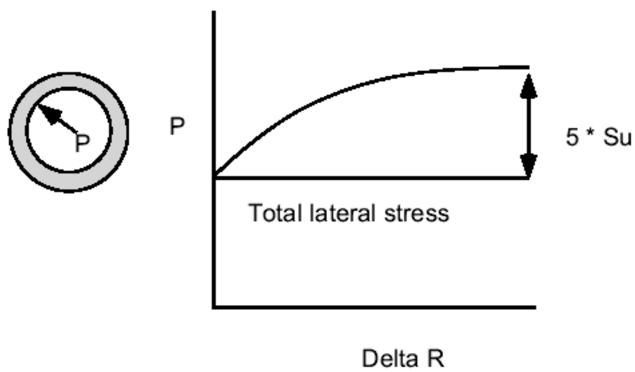


Figure 12 Ideal pressuremeter test

Hence the P/Y curve can be developed from the ideal pressuremeter curve by increasing the pressure (less the lateral pressure) by a factor. For clays this factor is 2 and for sands it is 1.5. An example representative P/Y curve is shown in Figure 13.

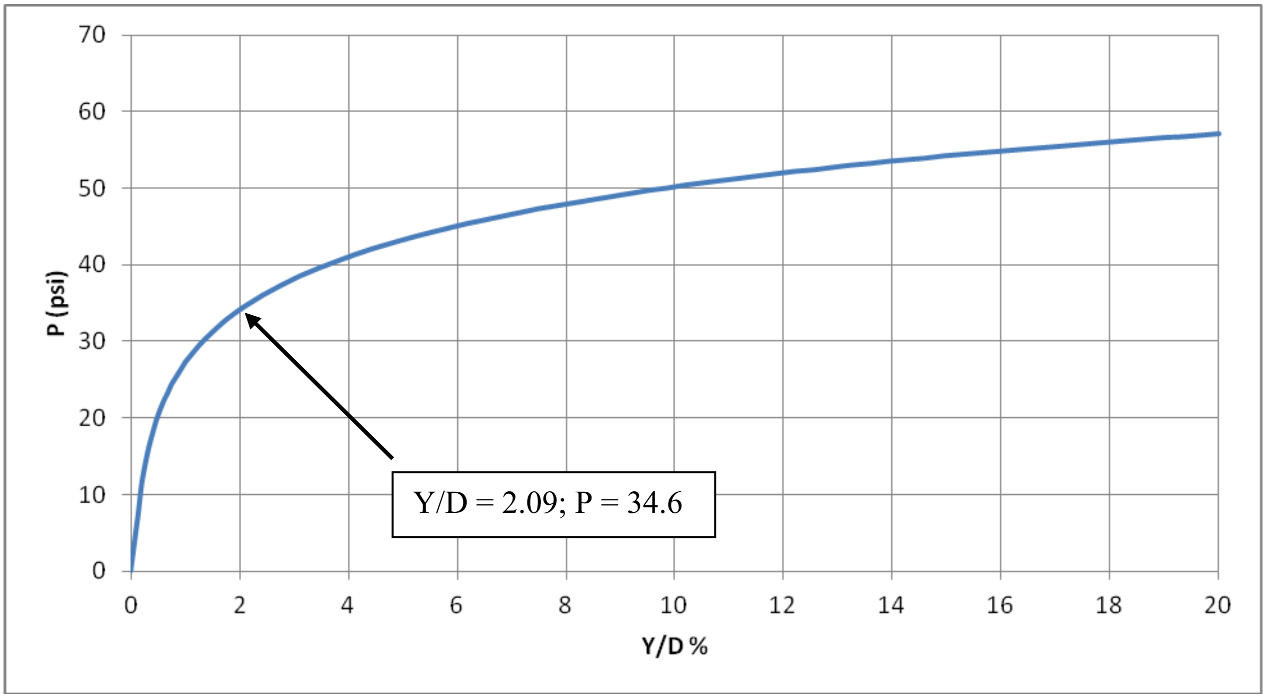


Figure 13 P-Y data developed from a pressuremeter test

The chart shown above displays the P-Y data as a pressure on the vertical axis and displacement divided by pile diameter on the horizontal axis.

For example, using a drilled shaft foundation 36 inches in diameter with the springs at 72-inch centre then the load displacement curve is shown in Figure 14.

An example calculation using the point shown in Figure 13:
The projected area of a 36 inch diameter shaft for a 72 inch increment with the applied 34.6 psi load is: 36*72 *34.6= 89,683 lbs.
The corresponding displacement is: Y/D = 2.09%; therefore Y = (36*2.09)/100= .752 inches

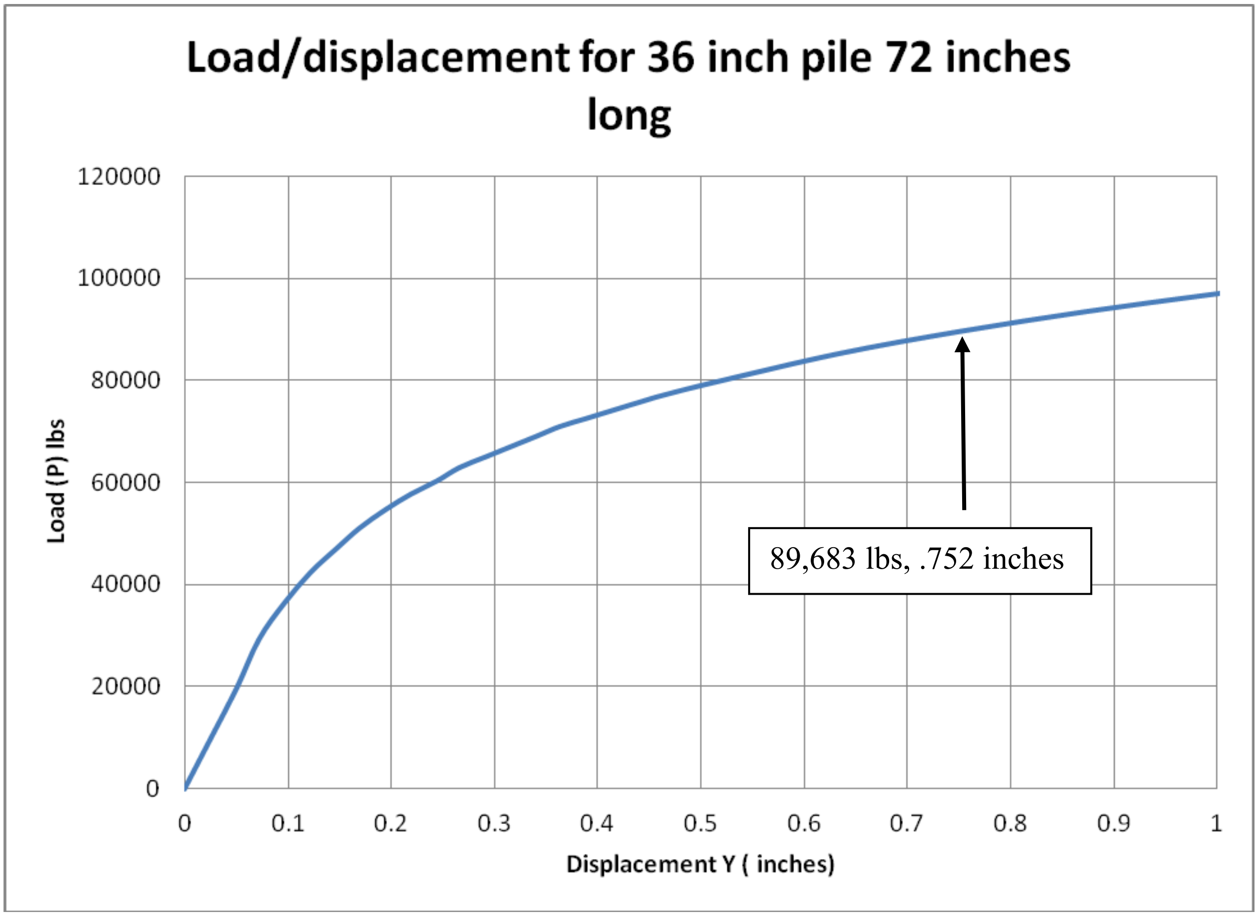


Figure 14 Example Load Displacement Data

P-Y curves for field curve responses are provided in the Appendices.

7.0 CONCLUSIONS

The test program was successful in that all tests provided high quality and useful data except oversized test pockets of LCG-007, LCG-008 and LCG-009, which are all on borehole RC-20-006. An initial disturbance is present in some tests which is normal for pre-drilled pressuremeter testing. The quality of drilling services should be considered excellent and contributed greatly to the success of the program. Only one protective shield was damaged throughout the testing.

Ten tests exhibited primarily frictional behavior and four tests exhibited primarily cohesive behavior while seven tests exhibited both frictional and cohesive behavior.

The limit pressure extrapolations should be considered of high quality. Shear strength derived from the log method should be used with good engineering judgment, as the method is not strictly applicable to materials with any frictional component. Both the shear strength and limit pressure are based upon extrapolated trends. However, it can be used in the onsite materials to give an indication of the strength and limit pressure that can be applied to the ground. The Engineer should use caution using these values at stresses above those reached in the field.

The shear moduli derived from the unload-reload loops should be considered of high quality. Care should be taken to not use values that are in the disturbed portion of the curves. Shear moduli can be converted to Elastic (Young's) modulus using equation 2 in section 4.

Strength of materials was determined using the Hughes Sand frictional model for frictional materials, whereas the Gibson cohesive model and Arnold's method for cohesive soils. The materials tested on RC-20-003 and RC-20-007 are generally purely frictional that they exhibited a higher lateral stress and higher friction angle. The calculated in-situ lateral stress ratio is about 0.8. Boreholes RC-20-004 and RC-20-011 are also frictional materials with relatively higher frictional angle, but the models fit better with lower calculated in-situ lateral stress ratio between 0.4 & 0.6.

Each test pocket is quantitatively assessed between 0 to 4. The quality notes are shown in the appendix I on each table. Unfortunately, some tests in this region tend to be in disturbed material, such that the pressuremeter curves are not well defined. Hence, they denoted 0 to 3 cannot be analyzed with any certainty. For most of the tests in this scope of work, the limiting factor was the maximum strain of the instrument.

P-Y curves were developed from both Hughes friction model and Gibson cohesive model. Plots of the curves are supplied in the appendix and text files of the P-Y response are supplied separately.

The test methods used for determination of strength are of good quality and should be considered useful when properly applied with a factor of safety. As always, the Engineer should use his professional judgement in the application of these values and using a prudent factor of safety.

8.0 REFERENCES

Mair, R.J. and Wood, D.M. 1987. Pressuremeter testing: methods and interpretation. CIRIA Ground Engineering Report. Butterworths, London.

ASTM D-4719. 2007. Standard tests method for pressuremeter testing in soils.

Clarke, B.G.,1995, Pressuremeters in Geotechnical Design, Blackie Academia and Professional, Glasgow

Appendix I – Data Tables

Table 1 – Numeric test qualification and data analysis explanation notes:

C	Cohesive material behavior
ϕ	Frictional material behavior
C - ϕ	Test material behaved both as frictional and cohesive
	Blank values indicate that no data could be derived from the test OR no analysis performed
0	Poor test, oversized hole, no usable data
1	Fair hole with some degree of oversize, insufficient data to determine strength of material
2	Good hole size, but instrument failed /membrane rupture during test. Partial data may be used
3	Good hole with some percentage of oversizing but good usable data quality
4	Very good tight hole, excellent usable data quality
5	The shear strength by log method shown may not be strictly applicable for materials with frictional component as the theory is based upon purely cohesive, non-dilative material. However, it can be used in the onsite materials to give an indication of the strength and limit pressure that can be applied to the ground.
6	Primarily frictional material but consists cohesive properties.
7	Primarily cohesive material but consists frictional properties.

Table 2 – Pressuremeter Test Depths and Material Descriptions

Test	Original Bore ID	Official CalTrans Boring ID	Date	Test Depth (ft)	Drilling Com.	Driller	Drill Rig	Material	Material Behavior
LCG-001	B-40	D-20-002	9/24/2020	45.0	Gregg	D.C.	GeoProbe 32	Mélange (Argillite)	Ø – C
LCG-002	B-40	D-20-002	9/24/2020	43.5	Gregg	D.C.	GeoProbe 32	Mélange (Argillite)	Ø – C
LCG-003	B-13	RC-20-003	9/25/2020	110.0	Gregg	Francisco	CME 850	Sandstone/Greywacke (Broken Formation)	Ø
LCG-004	B-13	RC-20-003	9/25/2020	108.5	Gregg	Francisco	CME 850	Sandstone/Greywacke (Broken Formation)	Ø
LCG-005	B-11	RC-20-004	10/1/2020	60.7	Crux	Tommy	Burly 5500	Mélange (Argillite)	Ø
LCG-006	B-11	RC-20-004	10/1/2020	59.2	Crux	Tommy	Burly 5500	Mélange (Argillite)	Ø
LCG-007	B-22	RC-20-006	10/2/2020	53.5	Crux	TJ	Burly 4500	Sandstone	
LCG-008	B-22	RC-20-006	10/3/2020	60.0	Crux	TJ	Burly 4500	Mélange (Argillite)	
LCG-009	B-22	RC-20-006	10/3/2020	58.5	Crux	TJ	Burly 4500	Mélange (Argillite)	
LCG-010	B-22	RC-20-006	10/3/2020	66.5	Crux	TJ	Burly 4500	Mélange (Argillite)	C
LCG-011	B-22	RC-20-006	10/3/2020	65.0	Crux	TJ	Burly 4500	Mélange (Argillite)	Ø – C
LCG-012	B-16	RC-20-007	10/6/2020	35.0	Gregg	Francisco	CME 850	Sandstone/Greywacke (Broken Formation)	Ø
LCG-013	B-16	RC-20-007	10/6/2020	33.5	Gregg	Francisco	CME 850	Sandstone/Greywacke (Broken Formation)	Ø
LCG-014	B-32	RC-20-011	10/23/2020	93.6	Gregg	Francisco	CME 850	Mélange (Argillite)	Ø
LCG-015	B-32	RC-20-011	10/23/2020	92.1	Gregg	Francisco	CME 850	Sandstone/Greywacke (Broken Formation)	Ø
LCG-016	B-50	RC-20-019	12/15/2020	15.0	Crux	Jerrod	Burly 5500	Earthflow (Decomposed Sandstone)	Ø – C
LCG-017	B-50	RC-20-019	12/15/2020	13.5	Crux	Jerrod	Burly 5500	Earthflow (Decomposed Sandstone)	Ø – C
LCG-018	B-50	RC-20-019	12/16/2020	20.0	Crux	Jerrod	Burly 5500	Earthflow (Decomposed Sandstone)	Ø – C
LCG-019	B-50	RC-20-019	12/16/2020	18.5	Crux	Jerrod	Burly 5500	Earthflow (Decomposed Sandstone)	Ø – C
LCG-020	B-50	RC-20-019	12/16/2020	35.0	Crux	Jerrod	Burly 5500	Earthflow (Argillite)	Ø
LCG-021	B-50	RC-20-019	12/16/2020	33.5	Crux	Jerrod	Burly 5500	Earthflow (Decomposed Sandstone)	Ø
LCG-022	B-46	RC-20-020	12/17/2020	43.5	Crux	TJ	Burly 4500	Earthflow (Argillite)	C
LCG-023	B-46	RC-20-020	12/17/2020	53.7	Crux	TJ	Burly 4500	Sandstone (Landslide Failure Zone)	C
LCG-024	B-46	RC-20-020	12/18/2020	74.0	Crux	TJ	Burly 4500	Mélange (Argillite)	C

Table 3 – Shear Modulus and Test Pocket Quantitative Values

Test	Original Borehole ID	CalTrans Boring ID	Test Depth (ft)	Initial Shear Modulus (psi)	Unload-Reload Shear Modulus (psi)				Material Property	Test Pocket Quality
LCG-001	B-40	D-20-002	45.0	730	1760	2330	2370		Ø – C	3
LCG-002	B-40	D-20-002	43.5	310	1500	1520	1970	2440	Ø – C	3
LCG-003	B-13	RC-20-003	110.0	167000	477000	640000	801000		Ø	4
LCG-004	B-13	RC-20-003	108.5	107500	233300	594900	813400		Ø	4
LCG-005	B-11	RC-20-004	60.7	2100	4500	6800	13000		Ø	3
LCG-006	B-11	RC-20-004	59.2	2160	5500	13700	33700		Ø	3
LCG-007	B-22	RC-20-006	53.5							0
LCG-008	B-22	RC-20-006	60.0							0
LCG-009	B-22	RC-20-006	58.5							0
LCG-010	B-22	RC-20-006	66.5	150	390	740	910		C	1
LCG-011	B-22	RC-20-006	65.0	750	3450	6150	9420	12010	Ø – C	4
LCG-012	B-16	RC-20-007	35.0	77000	211000	401000	542000		Ø	3
LCG-013	B-16	RC-20-007	33.5	116000	289000	475000	566000		Ø	3
LCG-014	B-32	RC-20-011	93.6	5100	27800	60600	95900	108500	Ø	3
LCG-015	B-32	RC-20-011	92.1	4300	20000	36000	51000	76000	Ø [6]	3
LCG-016	B-50	RC-20-019	15.0	950	6720	11780	12550		Ø – C	3
LCG-017	B-50	RC-20-019	13.5	940	4200	6300	8300		Ø – C	3
LCG-018	B-50	RC-20-019	20.0	2400	8200	16300	19400		Ø – C	3
LCG-019	B-50	RC-20-019	18.5	1600	8600	14000	18900		Ø – C	3
LCG-020	B-50	RC-20-019	35.0	1100	15900	19000	24500	36400	Ø [6]	4
LCG-021	B-50	RC-20-019	33.5	2500	21700	28800	35100	33400	Ø [6]	4
LCG-022	B-46	RC-20-020	43.5	1900	11100	21600	32500	47200	C [7]	4
LCG-023	B-46	RC-20-020	53.7	3700	34100	60000	43600		C [7]	4
LCG-024	B-46	RC-20-020	74.0	1000	10500	11900	12600	16200	C [7]	4

Table 4 – Shear Strength and Limit Pressure Values

Test	Test Depth (ft)	Log [5] (psi)	Gibson Load (psi)	Gibson Unload (psi)	Arnold Max (psi)	Arnold 10% Strain (psi)	Limit [5] Pressure (psi)	Material Behavior	Test Pocket Quality
LCG-001	45.0	20	16	20/2= 10	19	14	117	Ø – C	3
LCG-002	43.5	24	13	18/2= 9	25	24	101	Ø – C	3
LCG-003	110.0	7115					25469	Ø	4
LCG-004	108.5	5243					19853	Ø	4
LCG-005	60.7	117					491	Ø	3
LCG-006	59.2	155					665	Ø	3
LCG-007	53.5								0
LCG-008	60.0								0
LCG-009	58.5								0
LCG-010	66.5	12	12		12	10	87	C	1
LCG-011	65.0	83	46	86/2= 43	93	82	346	Ø – C	4
LCG-012	35.0	1918					8432	Ø	3
LCG-013	33.5	2094					8839	Ø	3
LCG-014	93.6	532					2089	Ø	3
LCG-015	92.1	271	151 [6]	240/2= 120	348 [6]	347	1213	Ø [6]	3
LCG-016	15.0	31	24	39/2= 20	30	27	189	Ø – C	3
LCG-017	13.5	27	19	30/2= 15	28	20	153	Ø – C	3
LCG-018	20.0	56	43	58/2= 29	59	47	331	Ø – C	3
LCG-019	18.5	37	25	38/2= 19	37	30	222	Ø – C	3
LCG-020	35.0	112	63 [6]	142/2= 71	120 [6]	95	483	Ø [6]	4
LCG-021	33.5	65	59 [6]	112/2= 56	109 [6]	97	440	Ø [6]	4
LCG-022	43.5	52	39	70/2= 35	57	55	326	C [7]	4
LCG-023	53.7	91	58	86/2= 43	95	82	526	C [7]	4
LCG-024	74.0	39	38	62/2= 31	44	42	296	C [7]	4

Table 5 – Friction Angle and Lateral Stresses Values

Test	Test Depth (ft)	K_0 Sand Model	Pore Pressure (psi)	Shear Modulus (psi)	Effective Lateral σ'_h (psi)	Friction Angle (degrees)	Test Pocket Quality	Material Behavior
LCG-001	45.0	0.35	0	2330	15	29	3	Ø – C
LCG-002	43.5	0.35	0	1500	15	25	3	Ø – C
LCG-003	110.0	0.80	0	801000	89	45	4	Ø
LCG-004	108.5	0.80	0	813400	87	44	4	Ø
LCG-005	60.7	0.43	0	6800	25	41	3	Ø
LCG-006	59.2	0.45	0	13700	26	41	3	Ø
LCG-007	53.5						0	
LCG-008	60.0						0	
LCG-009	58.5						0	
LCG-010	66.5	0.40	17	390	19	27 [7]	1	C [7]
LCG-011	65.0	0.46	17	6150	21	36	4	Ø – C
LCG-012	35.0	0.80	0	542000	28	49	3	Ø
LCG-013	33.5	0.80	0	566000	27	50	3	Ø
LCG-014	93.6	0.55	0	95600	52	38	3	Ø
LCG-015	92.1	0.46	0	51000	43	38	3	Ø [6]
LCG-016	15.0	0.70	0	11780	10	34	3	Ø – C
LCG-017	13.5	0.70	0	8000	9	34	3	Ø – C
LCG-018	20.0	0.90	0	16300	17	36	3	Ø – C
LCG-019	18.5	0.85	0	17000	15	32	3	Ø – C
LCG-020	35.0	0.50	4	19000	15	36	4	Ø [6]
LCG-021	33.5	0.53	4	33400	15	35	4	Ø [6]
LCG-022	43.5	0.83	14	21600	23	29 [7]	4	C [7]
LCG-023	53.7	0.70	18	43600	25	33 [7]	4	C [7]
LCG-024	74.0	0.45	27	11900	21	32 [7]	4	C [7]

Appendix II – Pressuremeter Data

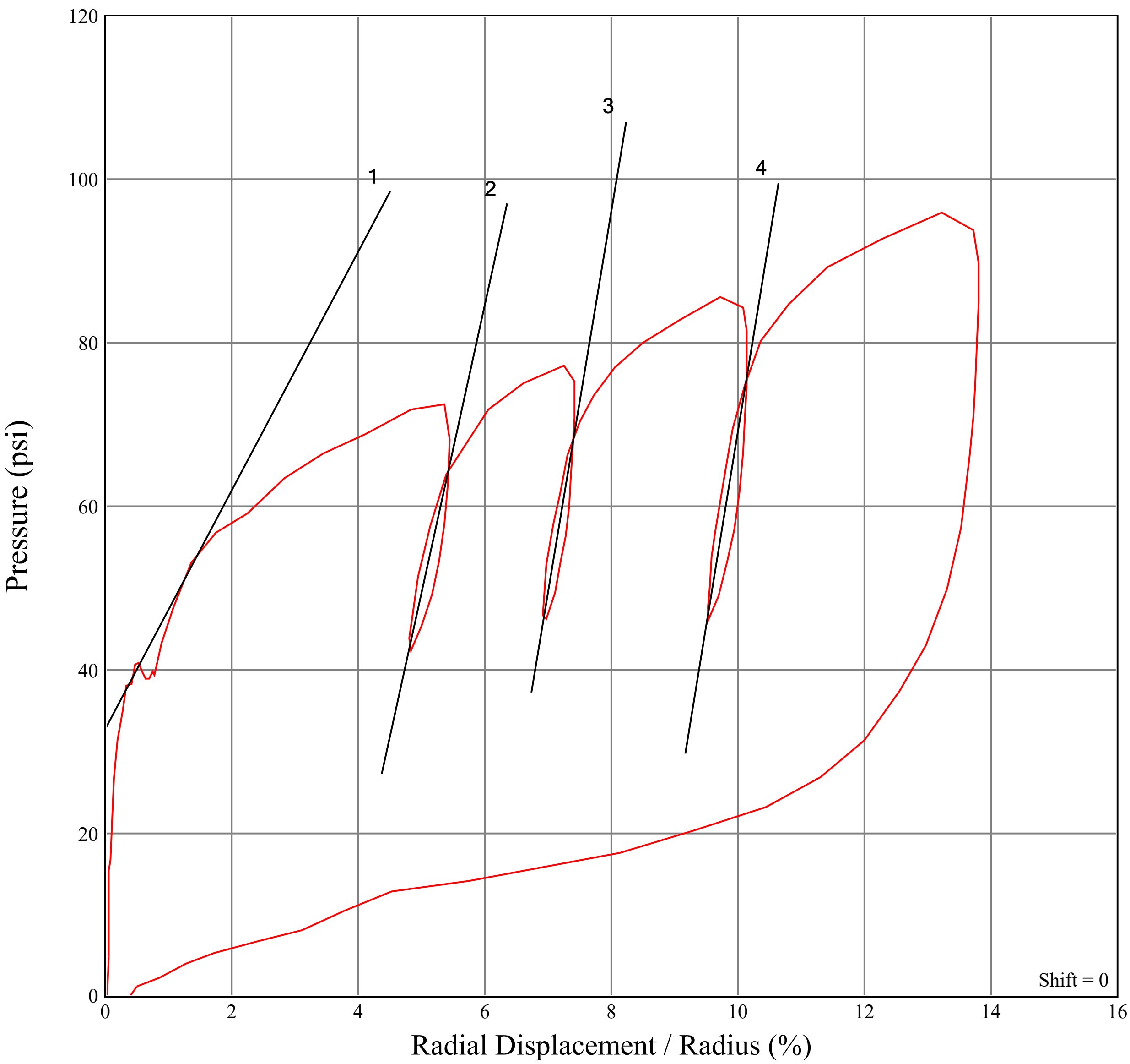
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: D-20-002 Test: LCG-001 Depth: 45FT Date: 09/24/2020

Oper: Mayfield Job # 01154000099 Time of Test: 03:25 PM Inst: 06



DATA

#1 Shear Modulus = 730 psi

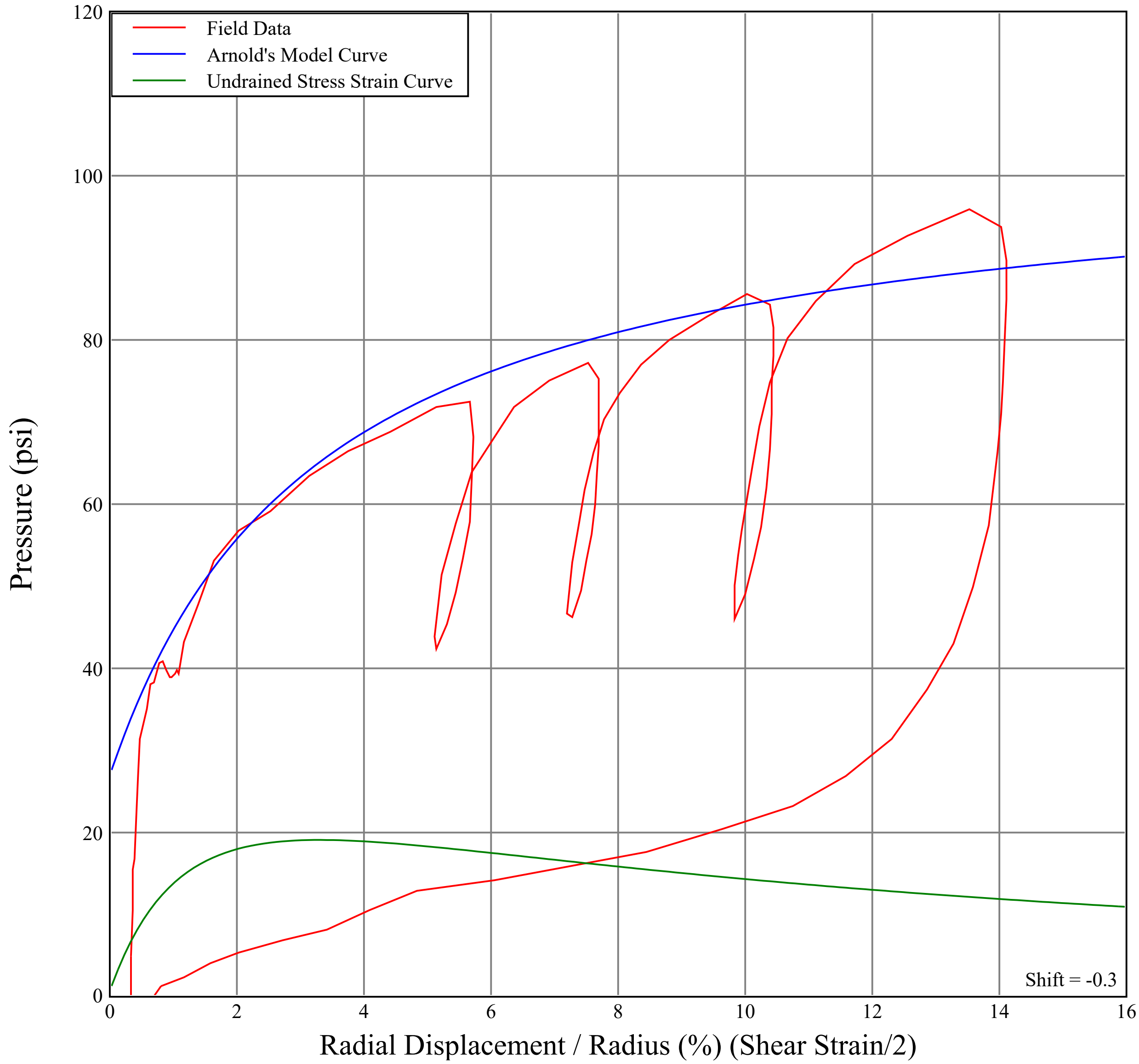
#2 Shear Modulus = 1760 psi

#3 Shear Modulus = 2330 psi

#4 Shear Modulus = 2370 psi

In Situ Engineering - Arnold's Clay Model

Kleinfelder
Last Chance Grade
Boring: D-20-002 Test: LCG-001 Depth: 45FT Date: 09/24/2020
Oper: Mayfield Job # 01154000099 Time of Test: 03:25 PM Inst: 06



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 45 psi	Shear Strength at 10% Strain = 14.2 psi
Pressure at 2.5% Strain = 60 psi	Max Shear Strength = 19.0 psi
Pressure at 7.5% Strain = 80 psi	occurs at 3.3% Strain

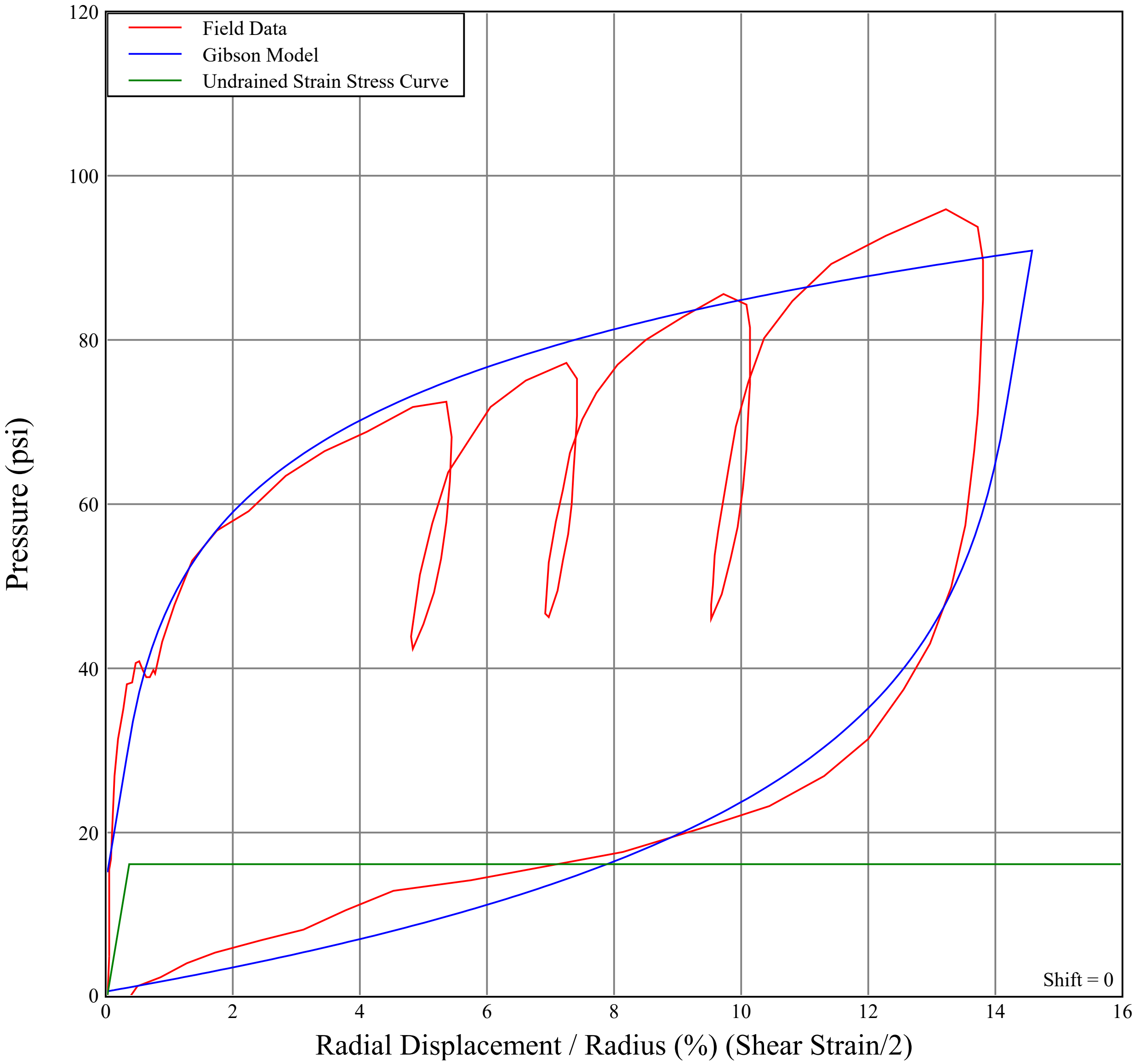
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: D-20-002 Test: LCG-001 Depth: 45FT Date: 09/24/2020

Oper: Mayfield Job # 01154000099 Time of Test: 03:25 PM Inst: 06



DATA

LOADING	UNLOADING
Shear Strength = 16 psi	Shear Strength = 20 psi
In Situ Stress = 15 psi	Shear Modulus = 2330 psi
Shear Modulus = 2330 psi	

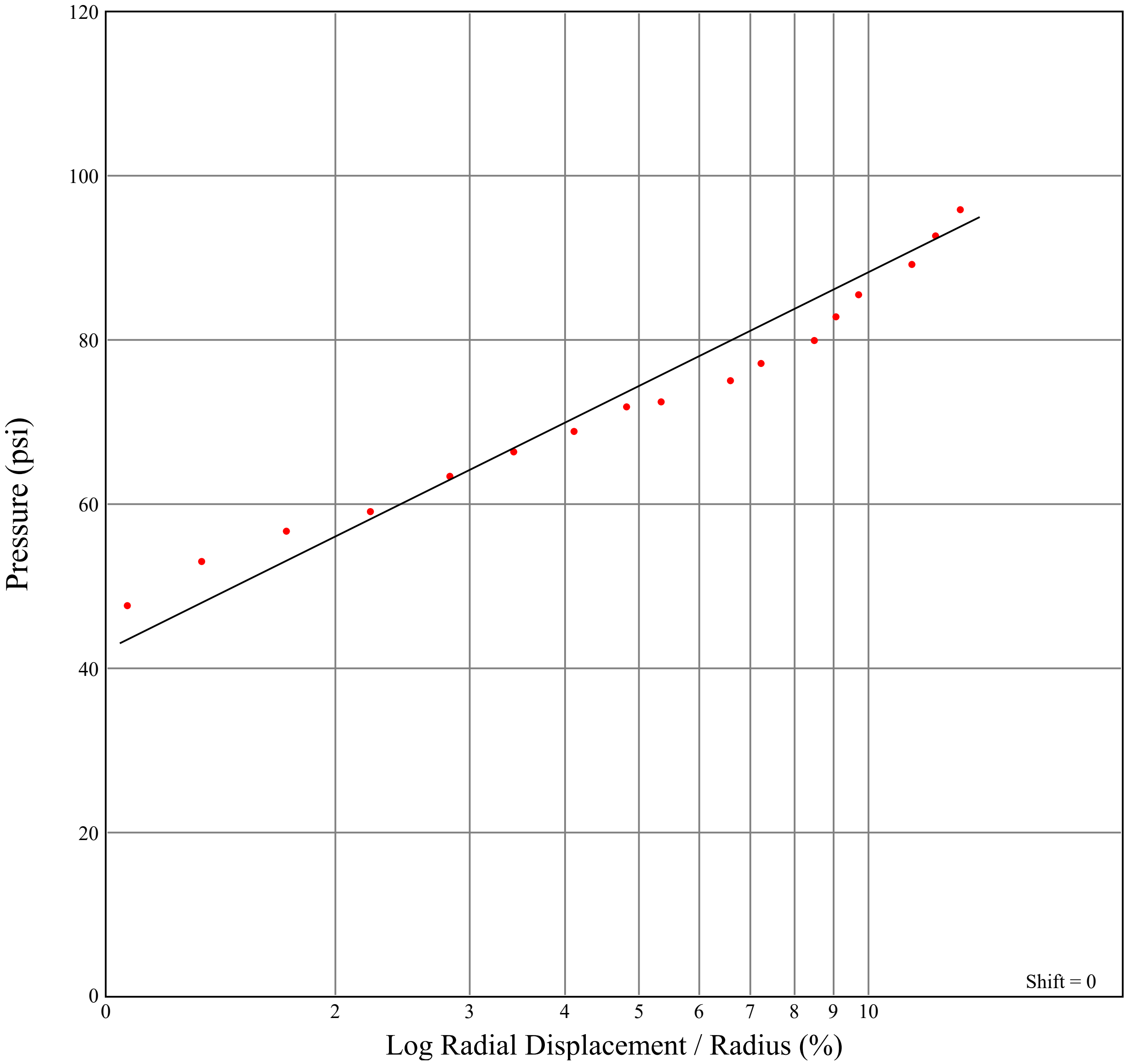
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: D-20-002 Test: LCG-001 Depth: 45FT Date: 09/24/2020

Oper: Mayfield Job # 01154000099 Time of Test: 03:25 PM Inst: 06



DATA

Shear Strength = 20 psi

Limit Pressure = 117 psi

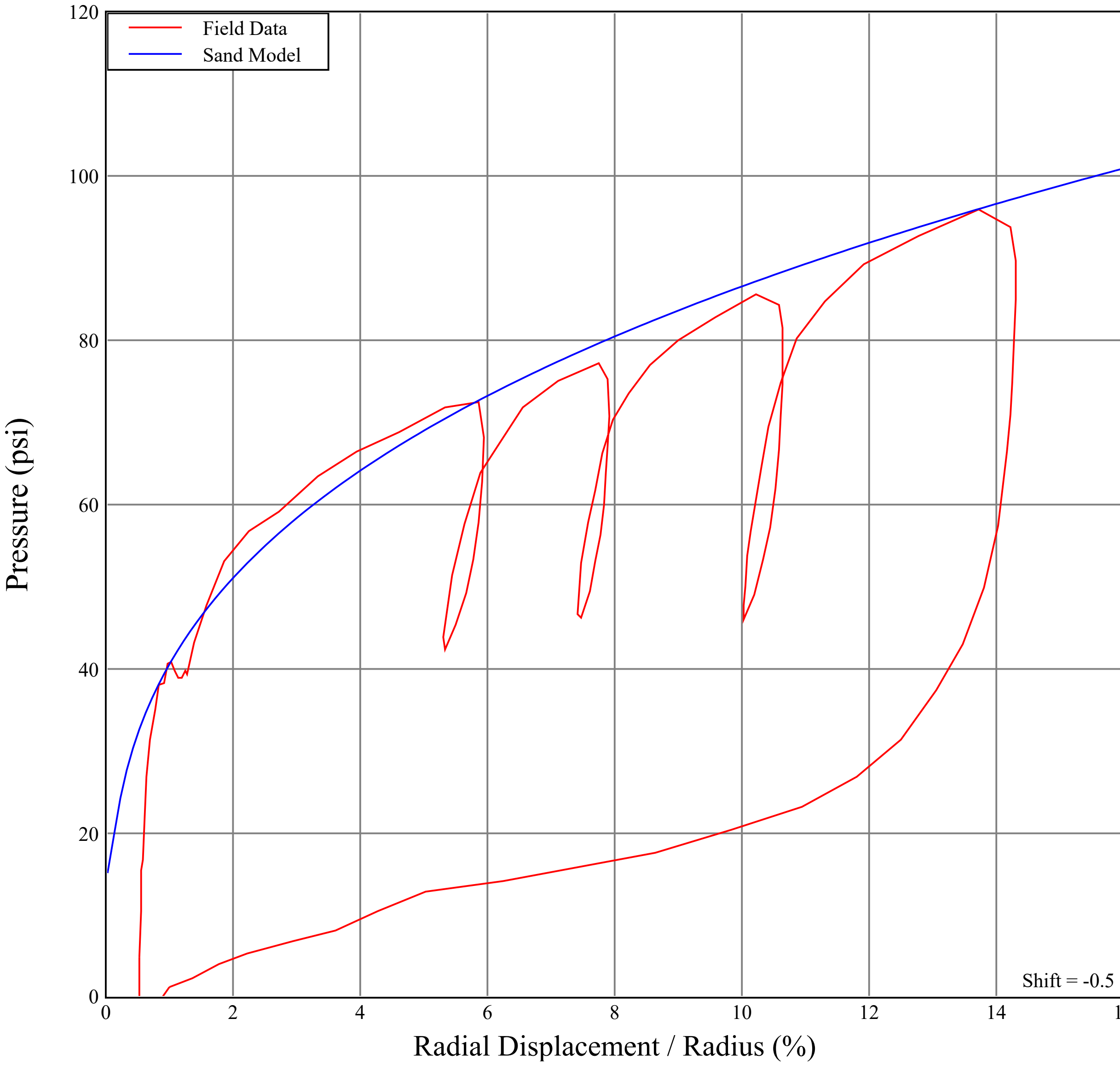
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: D-20-002 Test: LCG-001 Depth: 45FT Date: 09/24/2020

Oper: Mayfield Job # 01154000099 Time of Test: 03:25 PM Inst: 06



DATA

Water Pressure = 0 psi

Lateral Stress = 15 psi

Friction Angle = 29 deg

Shear Modulus = 2330 psi

Critical Friction Angle = 29 deg

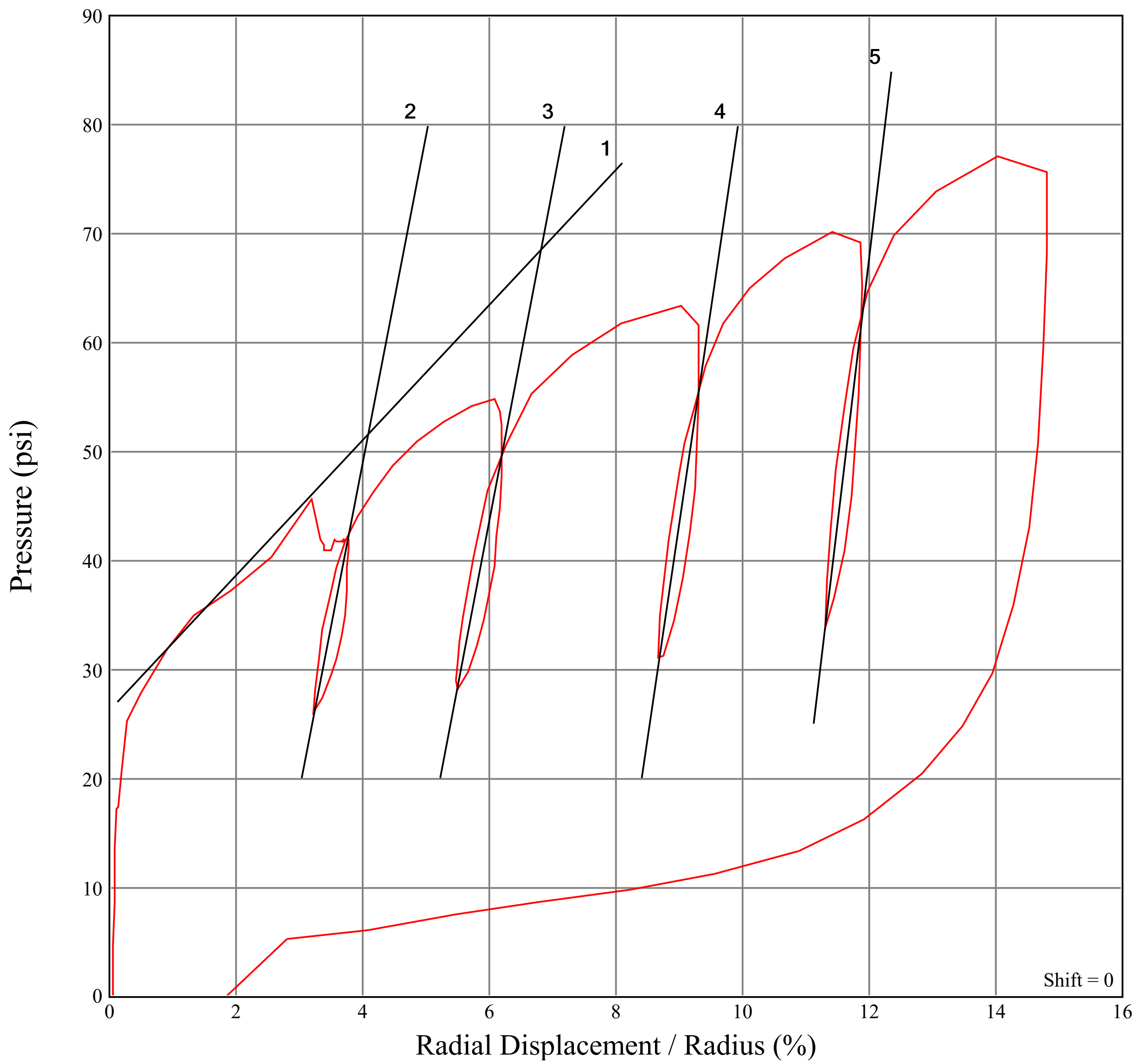
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: D-20-002   Test: LCG-002   Depth: 43.5FT   Date: 09/24/2020

Oper: Mayfield   Job # 01154000099   Time of Test: 04:05 PM   Inst: 06



DATA

#1 Shear Modulus = 310 psi

#2 Shear Modulus = 1500 psi

#3 Shear Modulus = 1520 psi

#4 Shear Modulus = 1970 psi

#5 Shear Modulus = 2440 psi

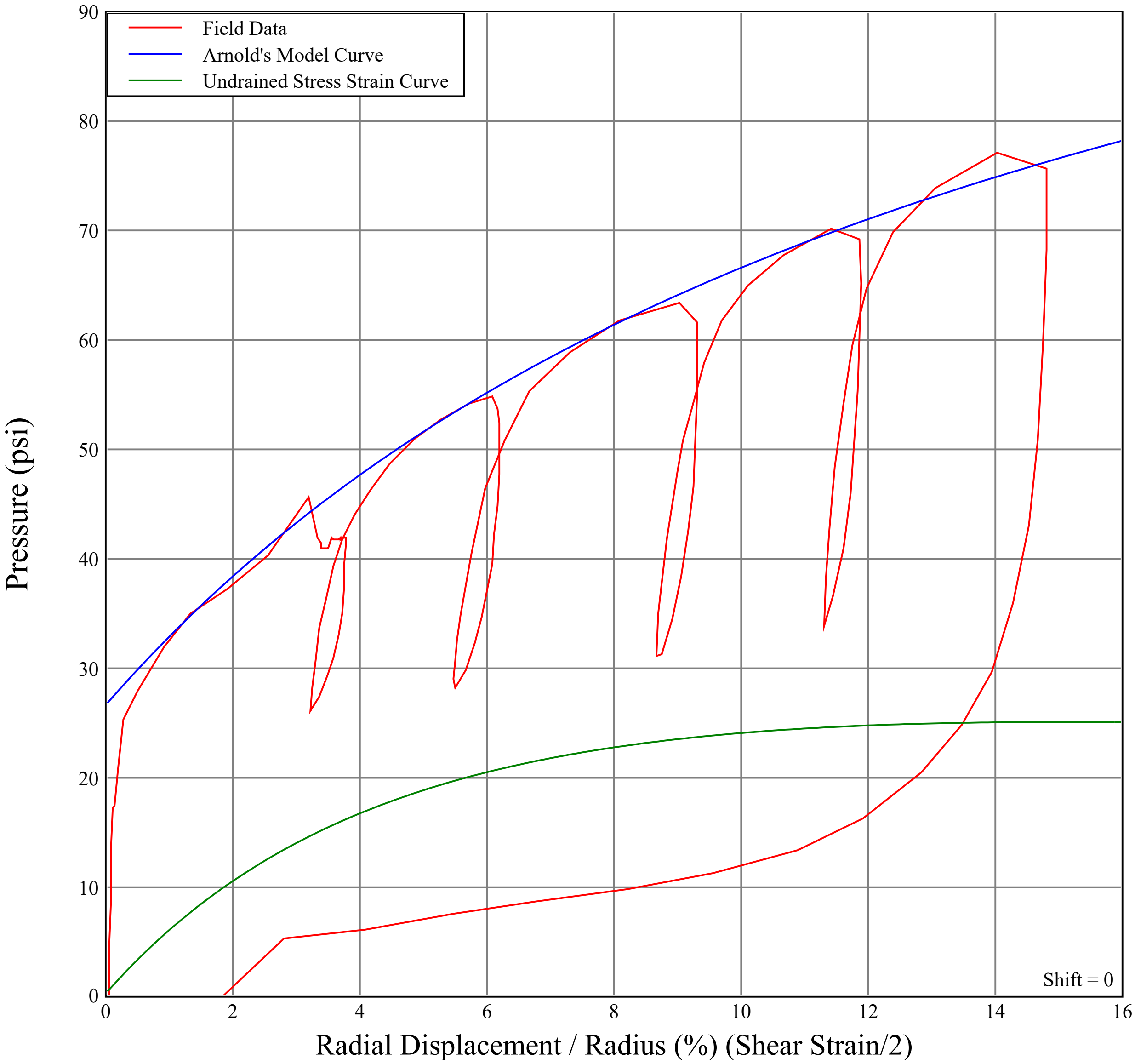
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: D-20-002 Test: LCG-002 Depth: 43.5FT Date: 09/24/2020

Oper: Mayfield Job # 01154000099 Time of Test: 04:05 PM Inst: 06



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 33 psi	Shear Strength at 10% Strain = 24.0 psi
Pressure at 2.5% Strain = 41 psi	Max Shear Strength = 25.0 psi
Pressure at 7.5% Strain = 60 psi	occurs at 15.1% Strain

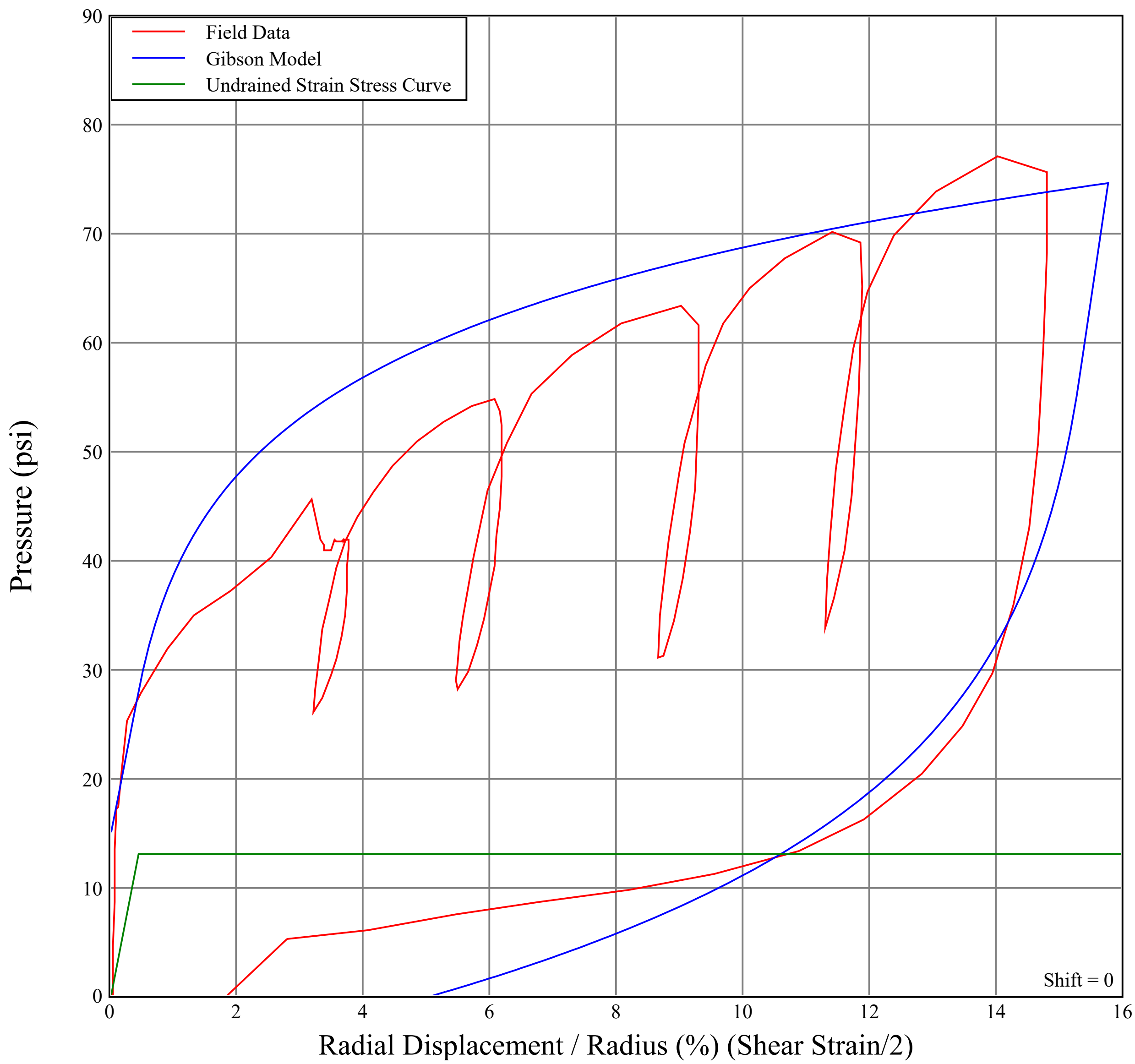
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: D-20-002 Test: LCG-002 Depth: 43.5FT Date: 09/24/2020

Oper: Mayfield Job # 01154000099 Time of Test: 04:05 PM Inst: 06



DATA

LOADING	UNLOADING
Shear Strength = 13 psi	Shear Strength = 18 psi
In Situ Stress = 15 psi	Shear Modulus = 1970 psi
Shear Modulus = 1500 psi	

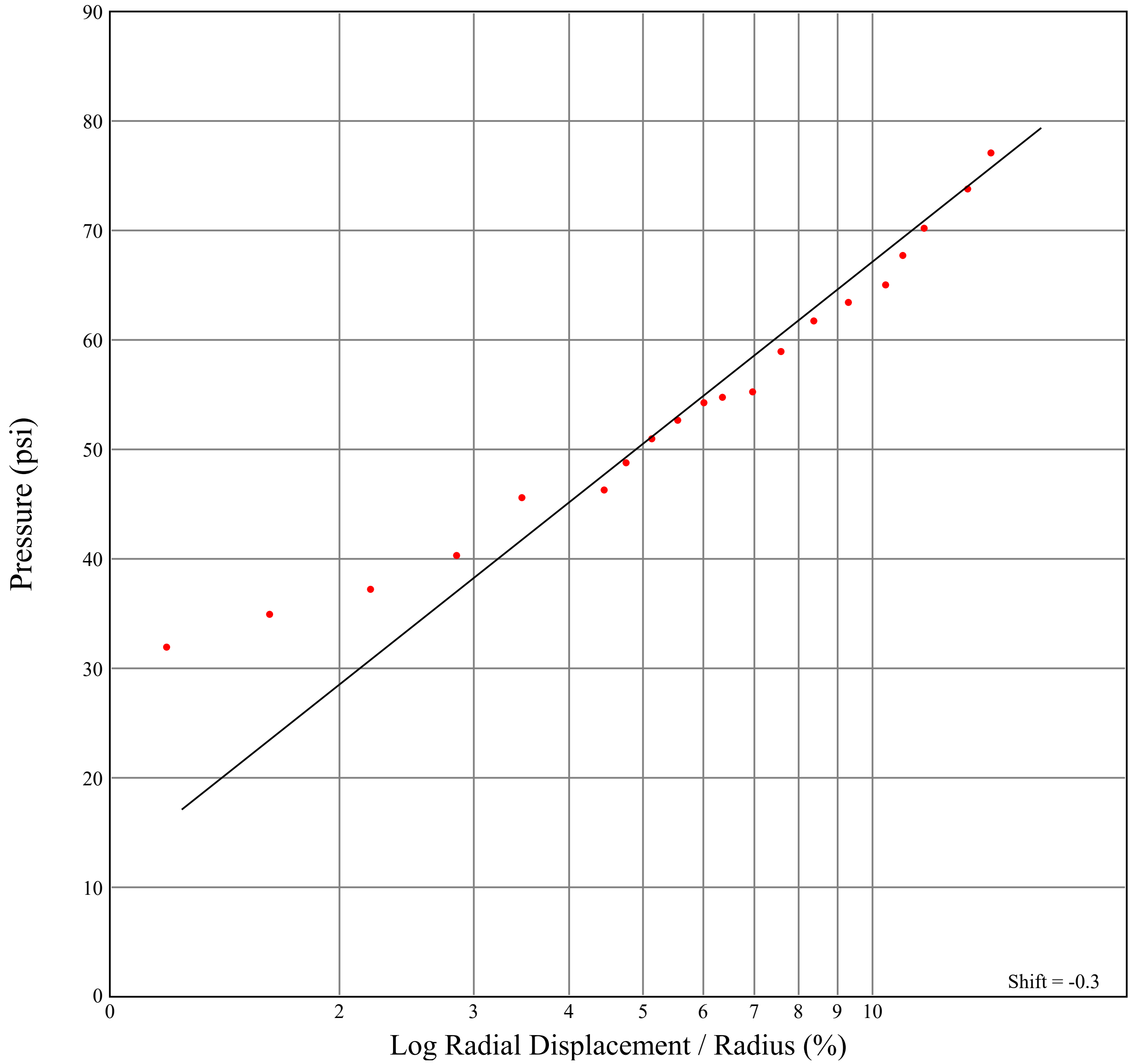
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: D-20-002 Test: LCG-002 Depth: 43.5FT Date: 09/24/2020

Oper: Mayfield Job # 01154000099 Time of Test: 04:05 PM Inst: 06



DATA

Shear Strength = 24 psi

Limit Pressure = 101 psi

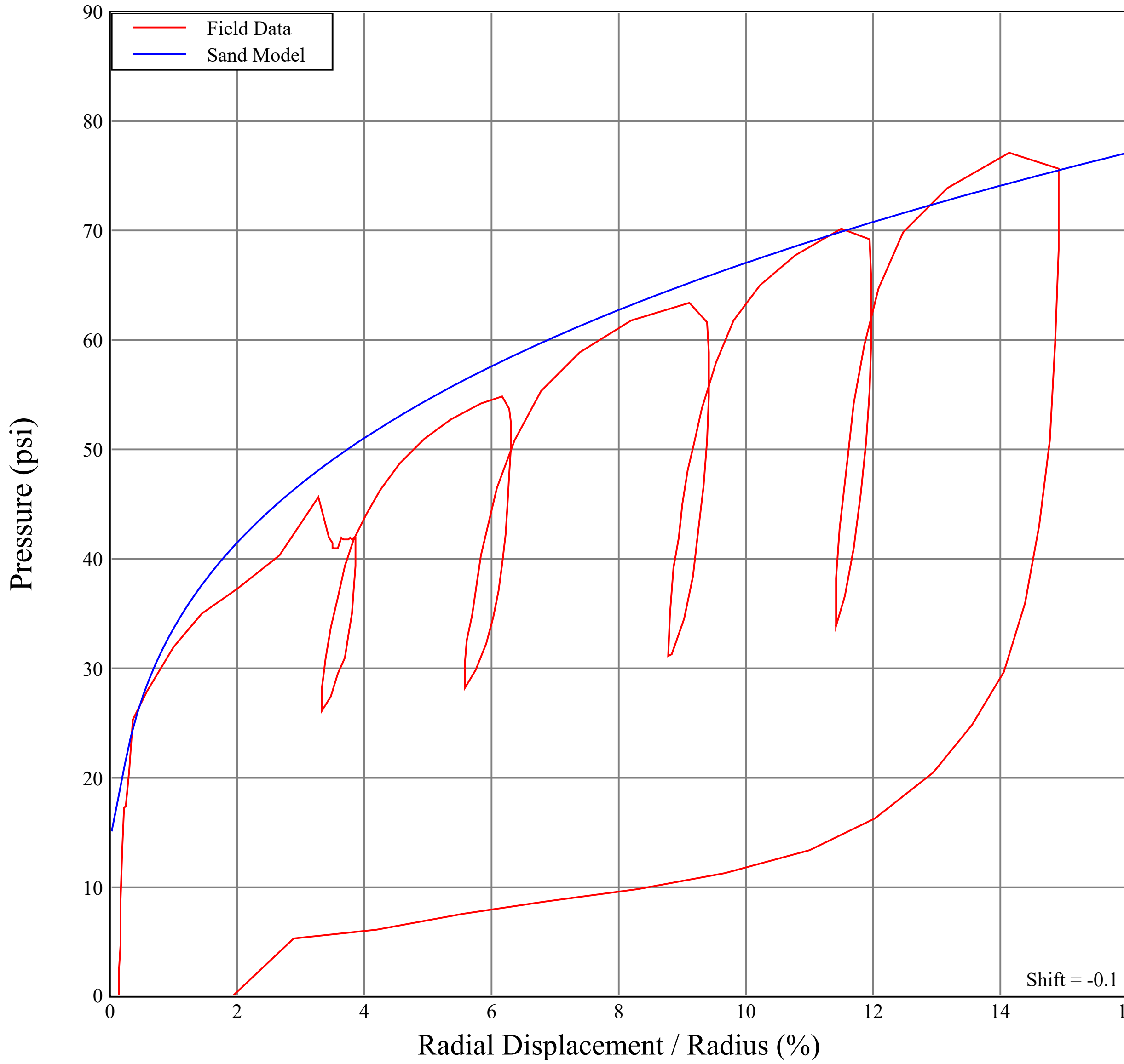
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: D-20-002   Test: LCG-002   Depth: 43.5FT   Date: 09/24/2020

Oper: Mayfield   Job # 01154000099   Time of Test: 04:05 PM   Inst: 06



DATA

Water Pressure = 0 psi

Lateral Stress = 15 psi

Friction Angle = 25 deg

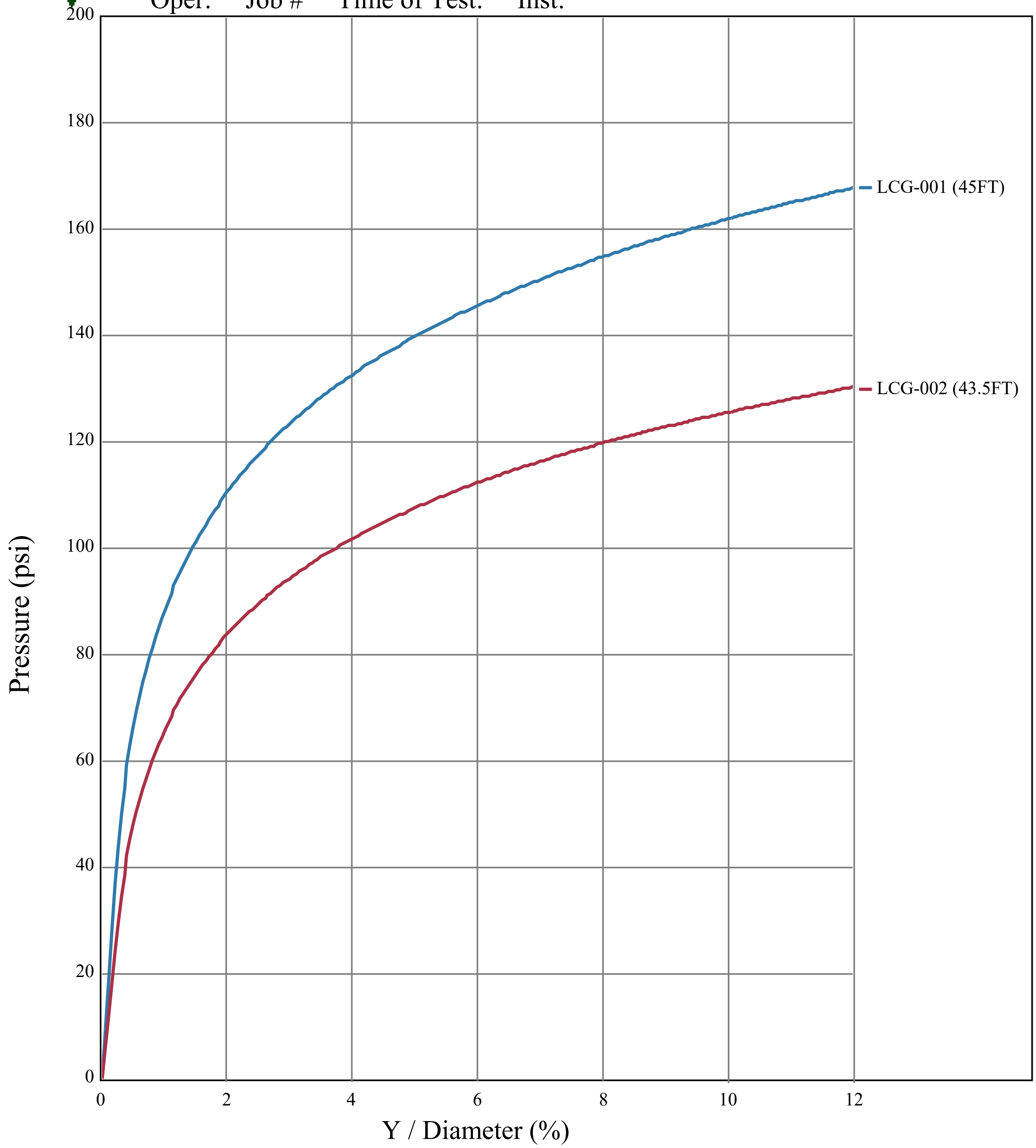
Shear Modulus = 1500 psi

Critical Friction Angle = 25 deg

In Situ Engineering - PY Data - Cohesive

Kleinfelder

Last	Chance	Grade
Boring:		D-20-002
Oper:	Job #	Time of Test: Inst:



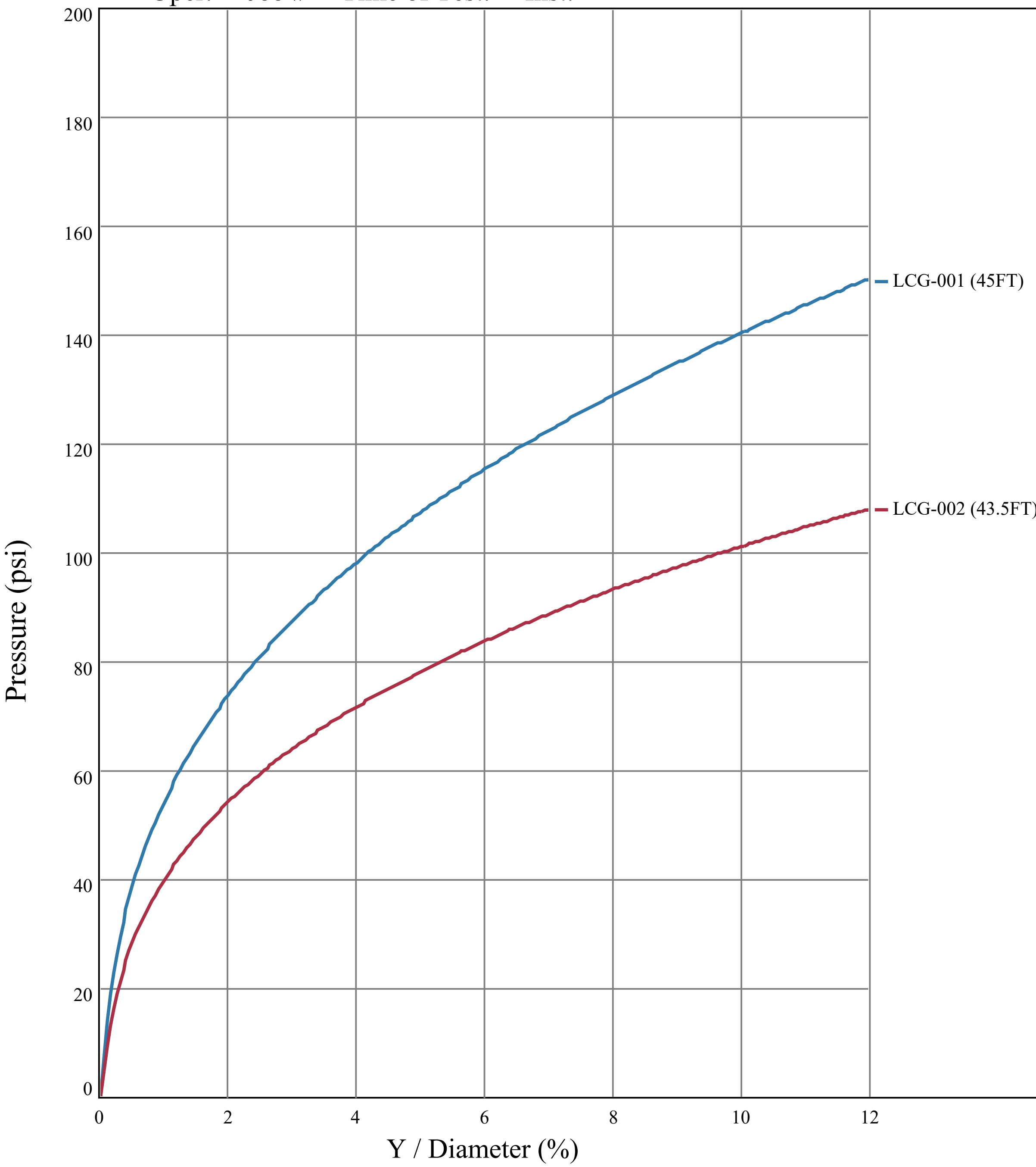
In Situ Engineering - PY Data - Frictional

Kleinfelder

Last Chance Grade

Boring: D-20-002

Oper: Job # Time of Test: Inst:



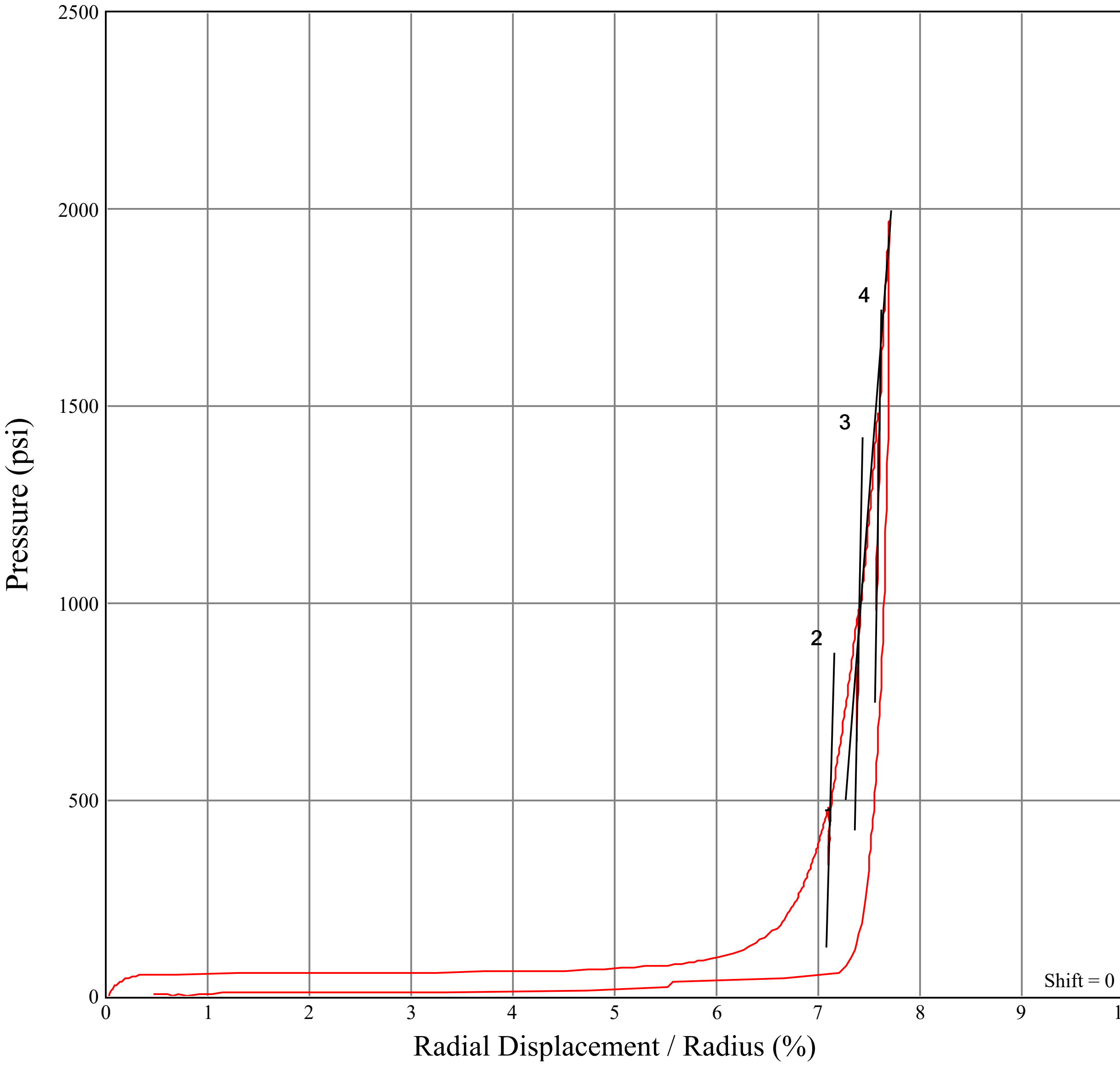
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-003 Test: LCG-003 Depth: 110FT Date: 09/25/2020

Oper: Mayfield Job # 01154000099 Time of Test: 02:02 PM Inst: 06



DATA

#1 Shear Modulus = 167000 psi

#2 Shear Modulus = 477000 psi

#3 Shear Modulus = 640000 psi

#4 Shear Modulus = 801000 psi

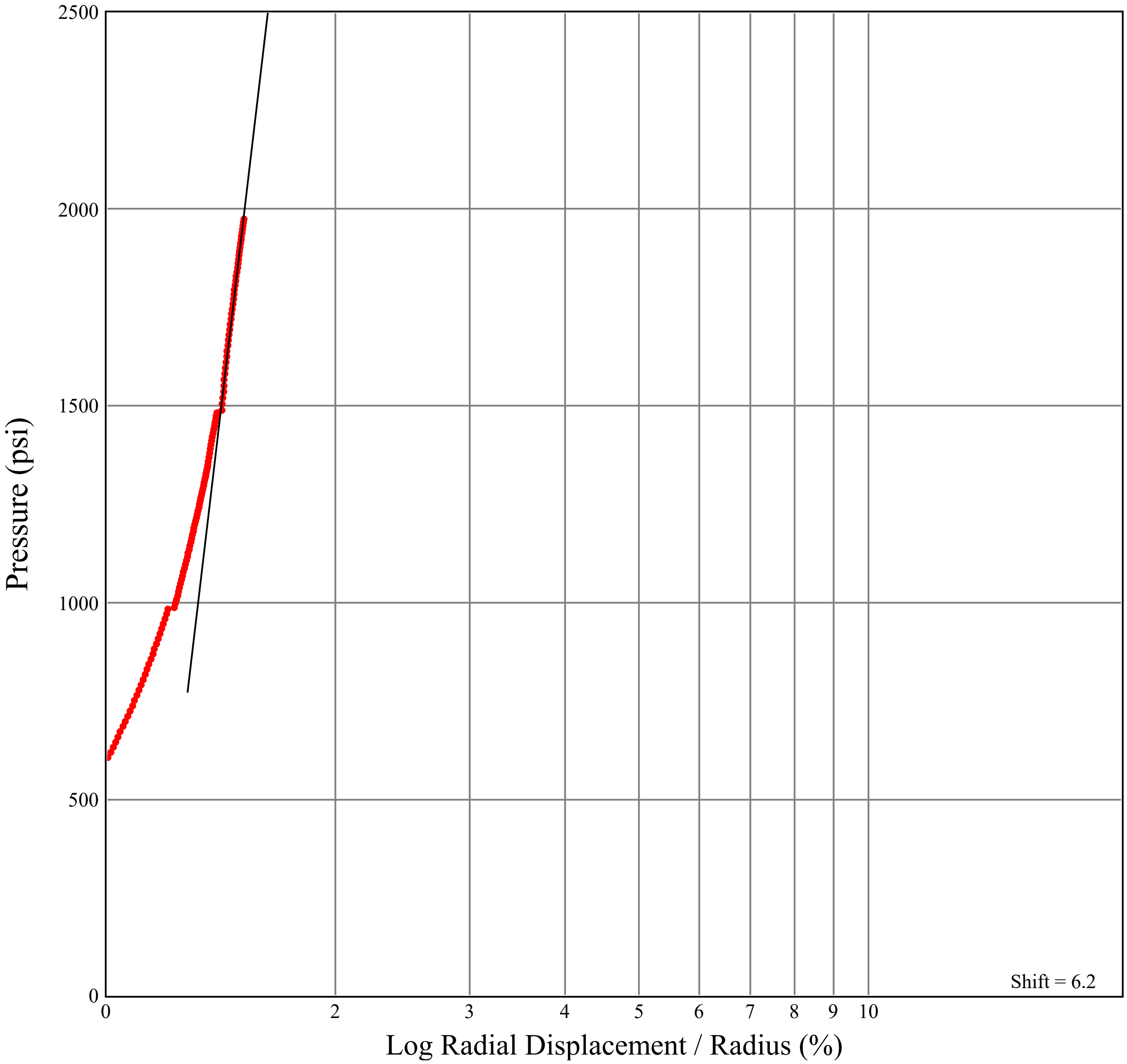
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-003 Test: LCG-003 Depth: 110FT Date: 09/25/2020

Oper: Mayfield Job # 01154000099 Time of Test: 02:02 PM Inst: 06



DATA

Shear Strength = 7115 psi

Limit Pressure = 25469 psi

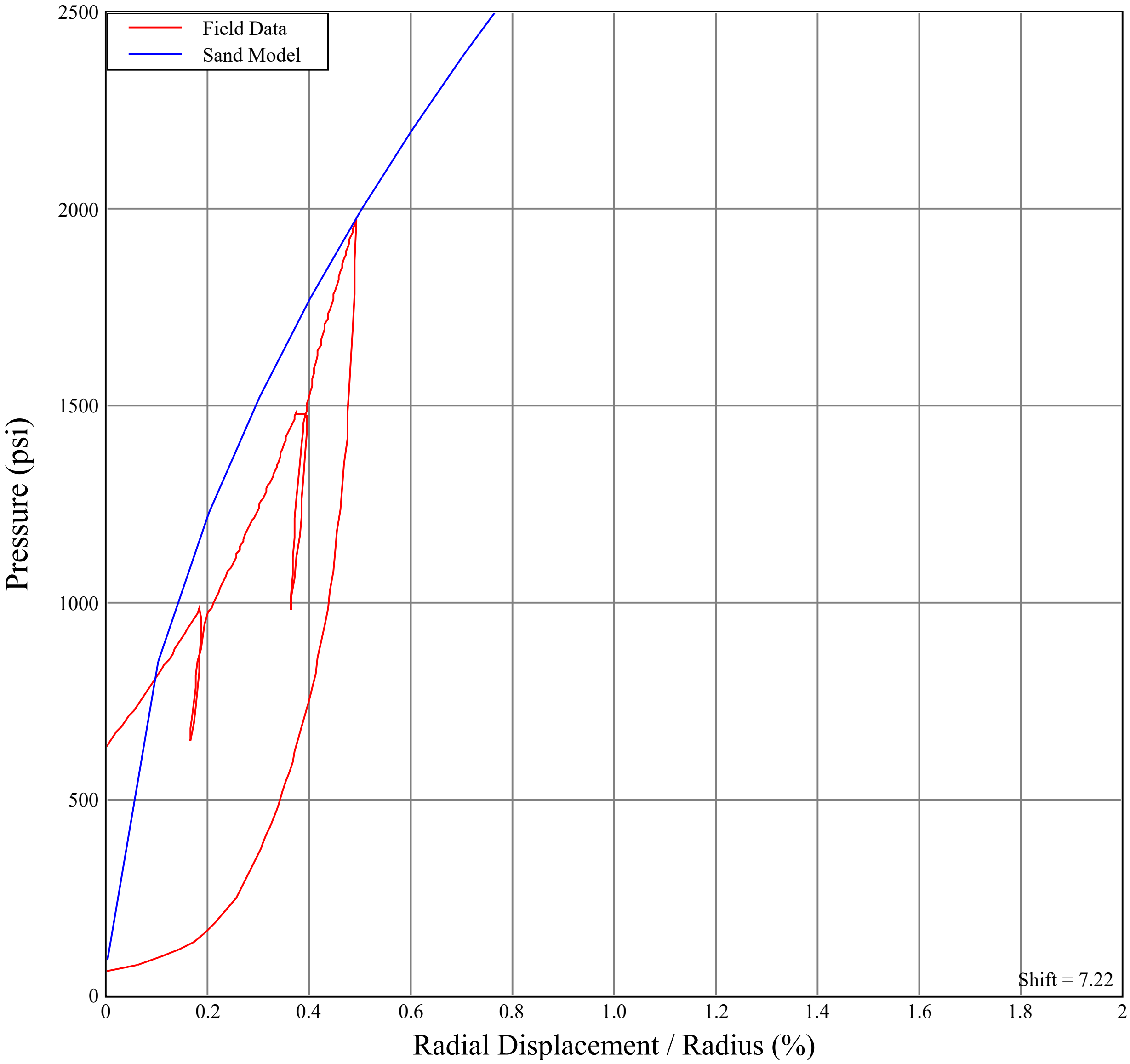
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-003 Test: LCG-003 Depth: 110FT Date: 09/25/2020

Oper: Mayfield Job # 01154000099 Time of Test: 02:02 PM Inst: 06



DATA

Water Pressure = 0 psi

Friction Angle = 45 deg

Critical Friction Angle = 32 deg

Lateral Stress = 89 psi

Shear Modulus = 801000 psi

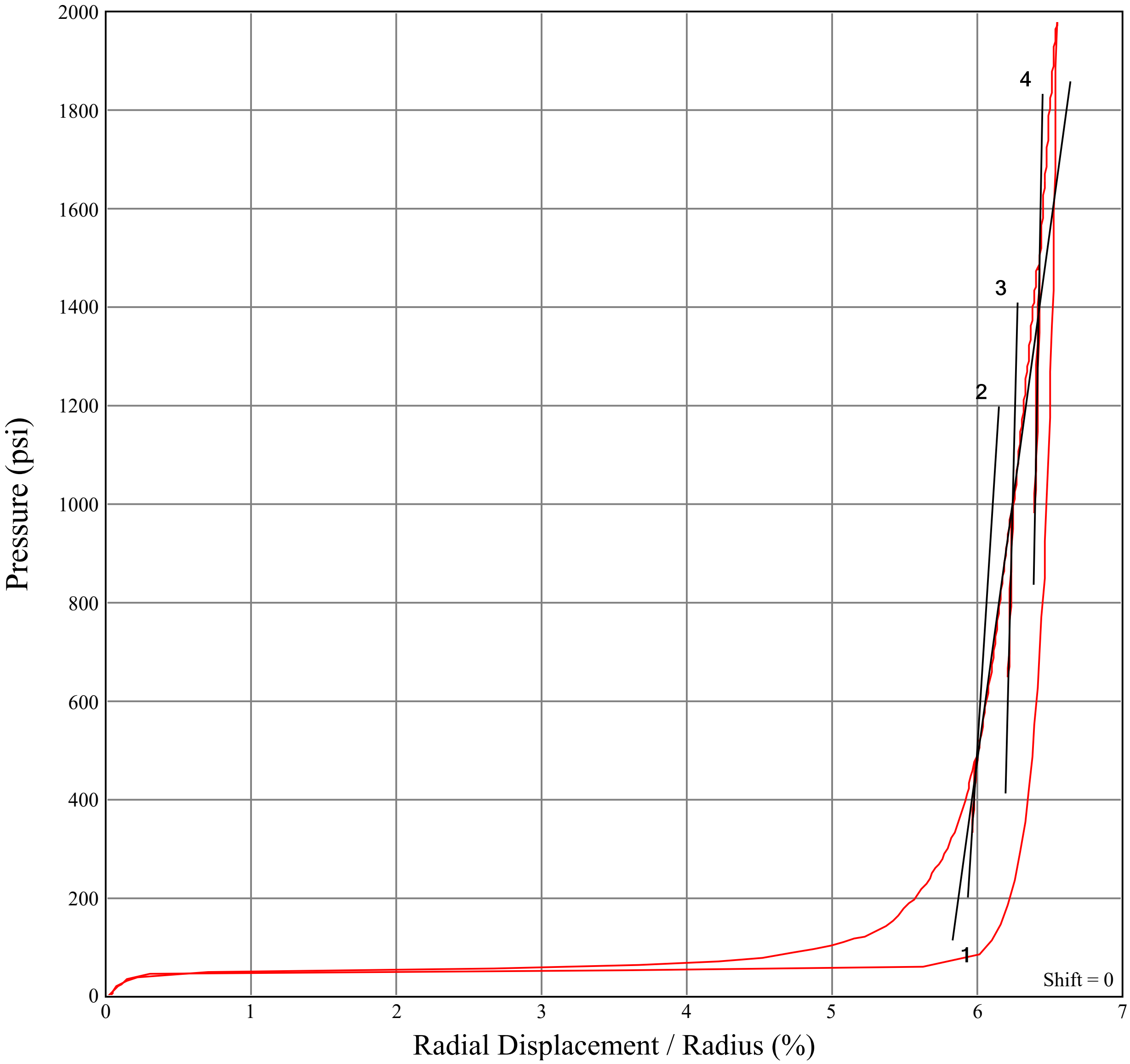
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-003 Test: LCG-004 Depth: 108.5FT Date: 09/25/2020

Oper: Mayfield Job # 01154000099 Time of Test: 02:37 PM Inst: 06



DATA

#1 Shear Modulus = 107500 psi

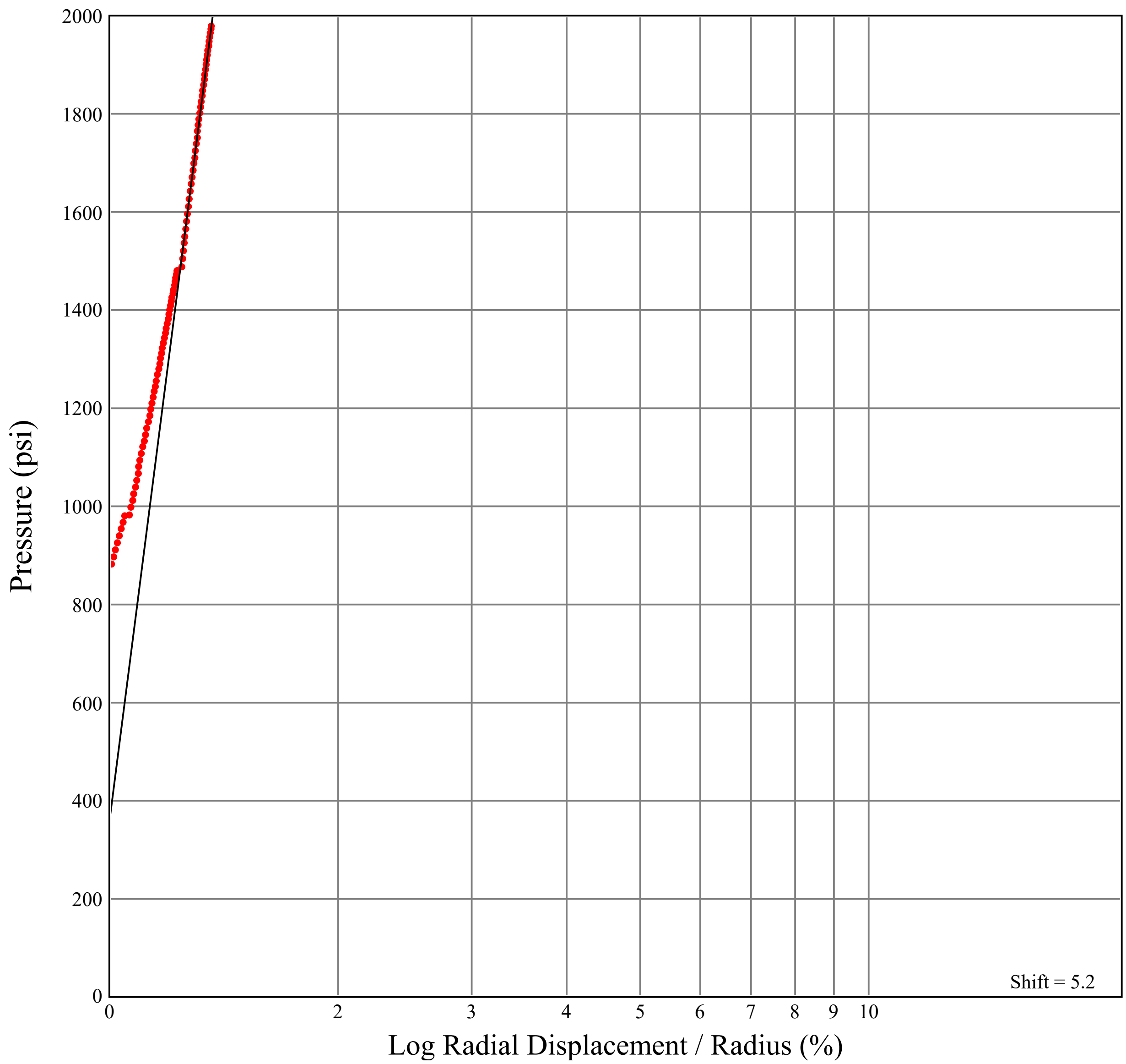
#2 Shear Modulus = 233300 psi

#3 Shear Modulus = 594900 psi

#4 Shear Modulus = 813400 psi

In Situ Engineering - Logarithm Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-003   Test: LCG-004   Depth: 108.5FT   Date: 09/25/2020
Oper: Mayfield   Job # 01154000099   Time of Test: 02:37 PM   Inst: 06



DATA

Shear Strength = 5243 psi

Limit Pressure = 19853 psi

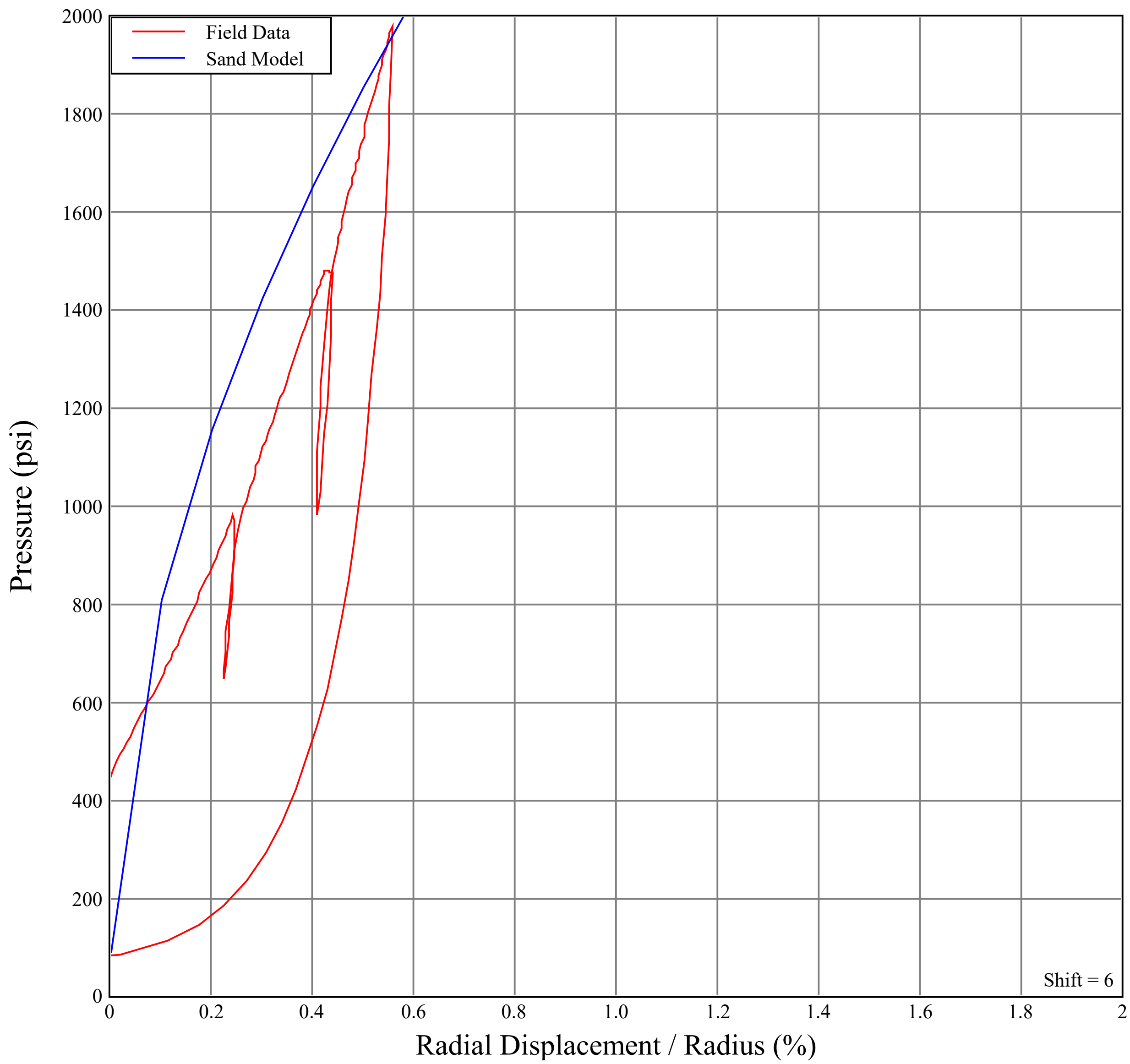
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-003 Test: LCG-004 Depth: 108.5FT Date: 09/25/2020

Oper: Mayfield Job # 01154000099 Time of Test: 02:37 PM Inst: 06



DATA

Water Pressure = 0 psi

Lateral Stress = 87 psi

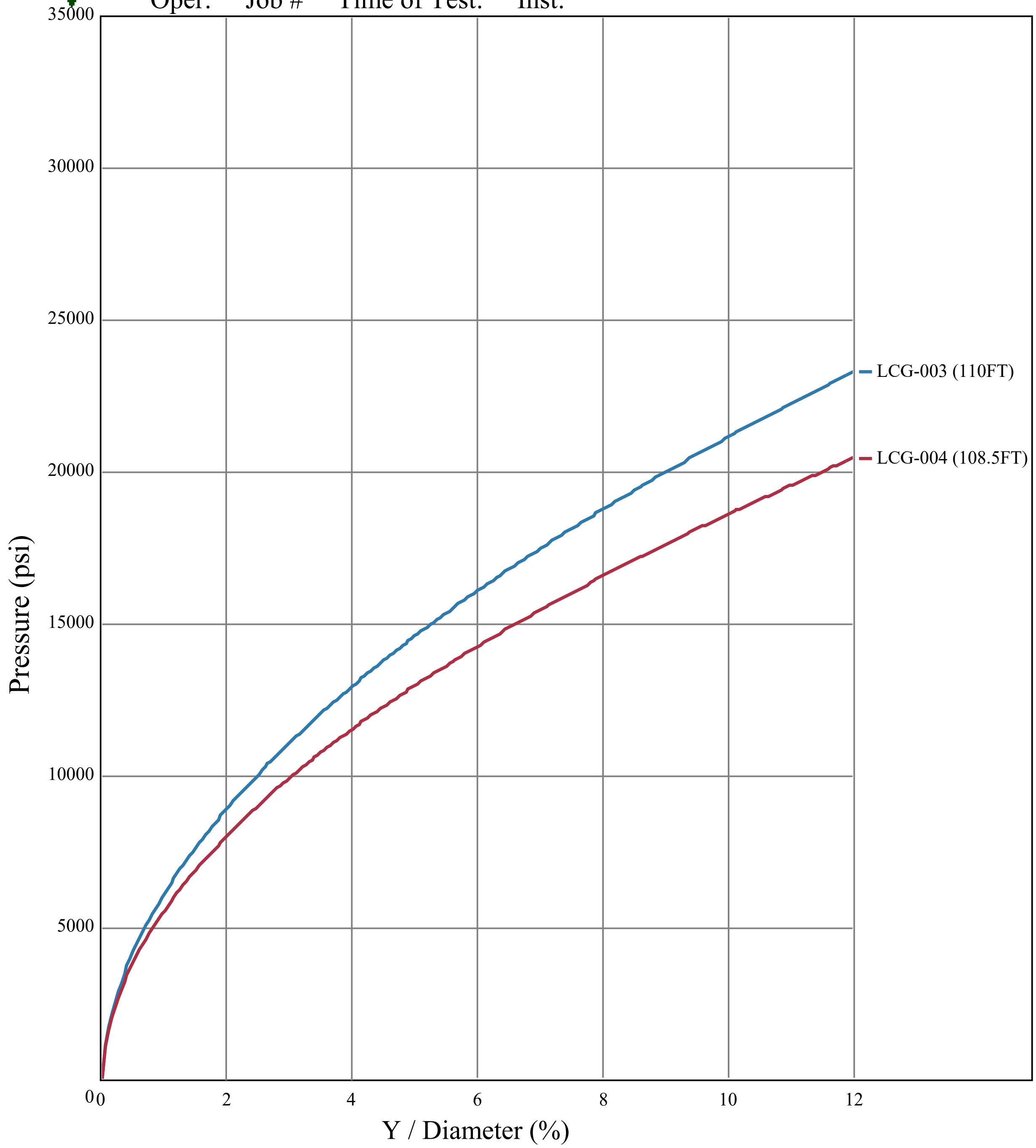
Friction Angle = 44 deg

Shear Modulus = 813400 psi

Critical Friction Angle = 32 deg

In Situ Engineering - PY Data - Frictional

Kleinfelder
Last Chance Grade
Boring: RC-20-003
Oper: Job # Time of Test: Inst:



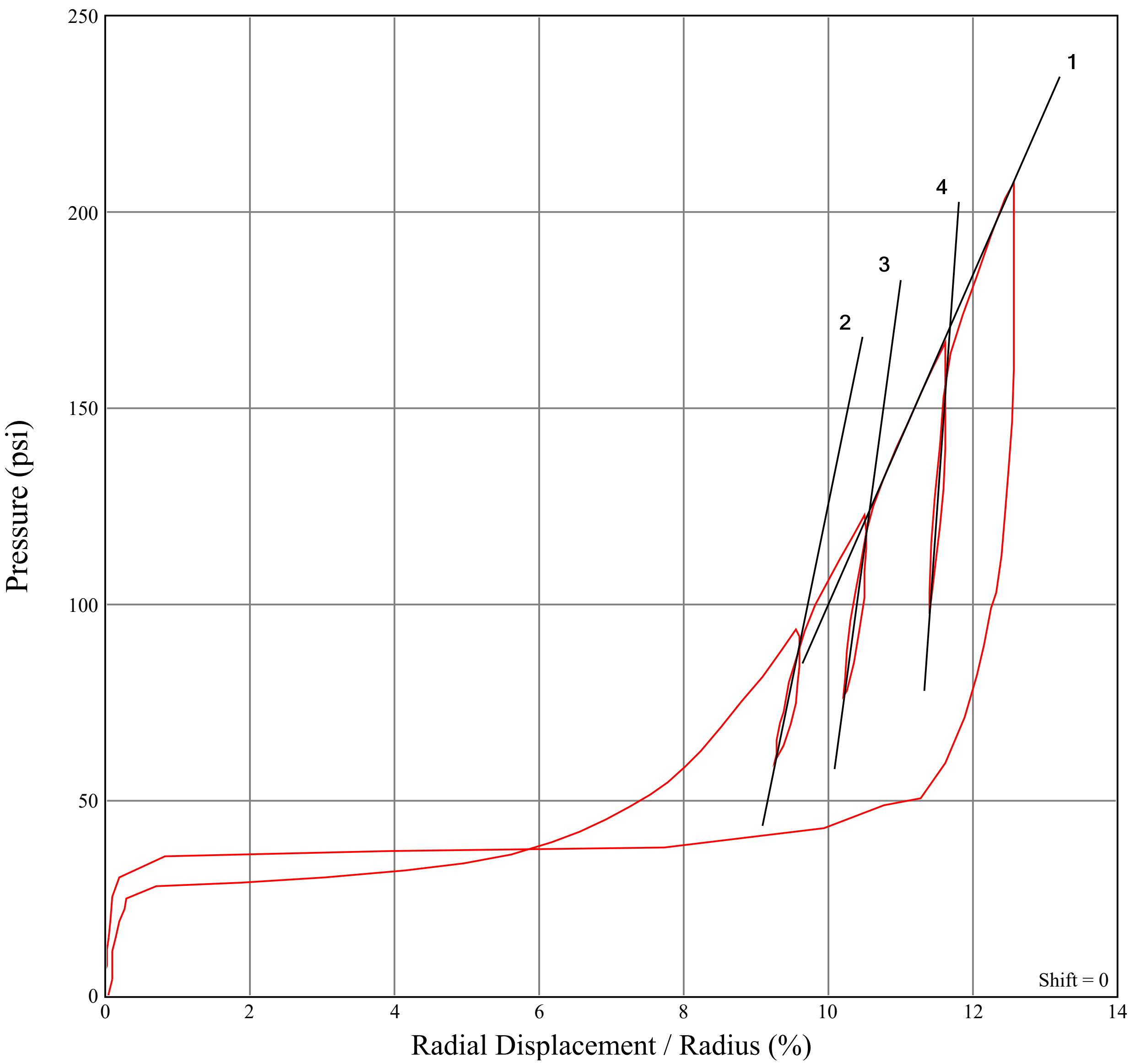
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-004 Test: LCG-005 Depth: 60.7FT Date: 10/01/2020

Oper: Mayfield Job # 0115000099 Time of Test: 02:38 PM Inst: 06



DATA

#1 Shear Modulus = 2100 psi

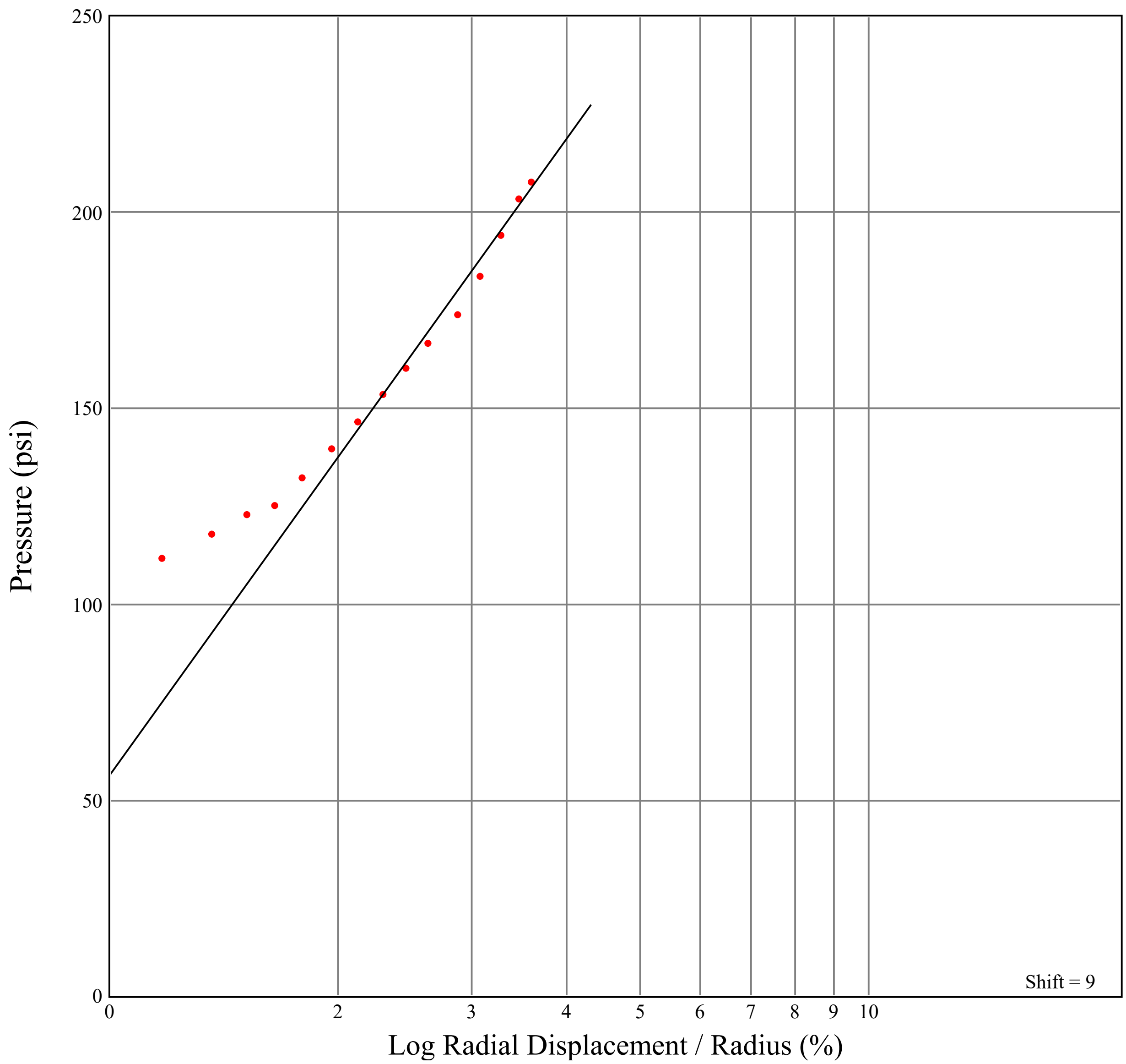
#2 Shear Modulus = 4500 psi

#3 Shear Modulus = 6800 psi

#4 Shear Modulus = 13000 psi

In Situ Engineering - Logarithm Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-004 Test: LCG-005 Depth: 60.7FT Date: 10/01/2020
Oper: Mayfield Job # 0115000099 Time of Test: 02:38 PM Inst: 06



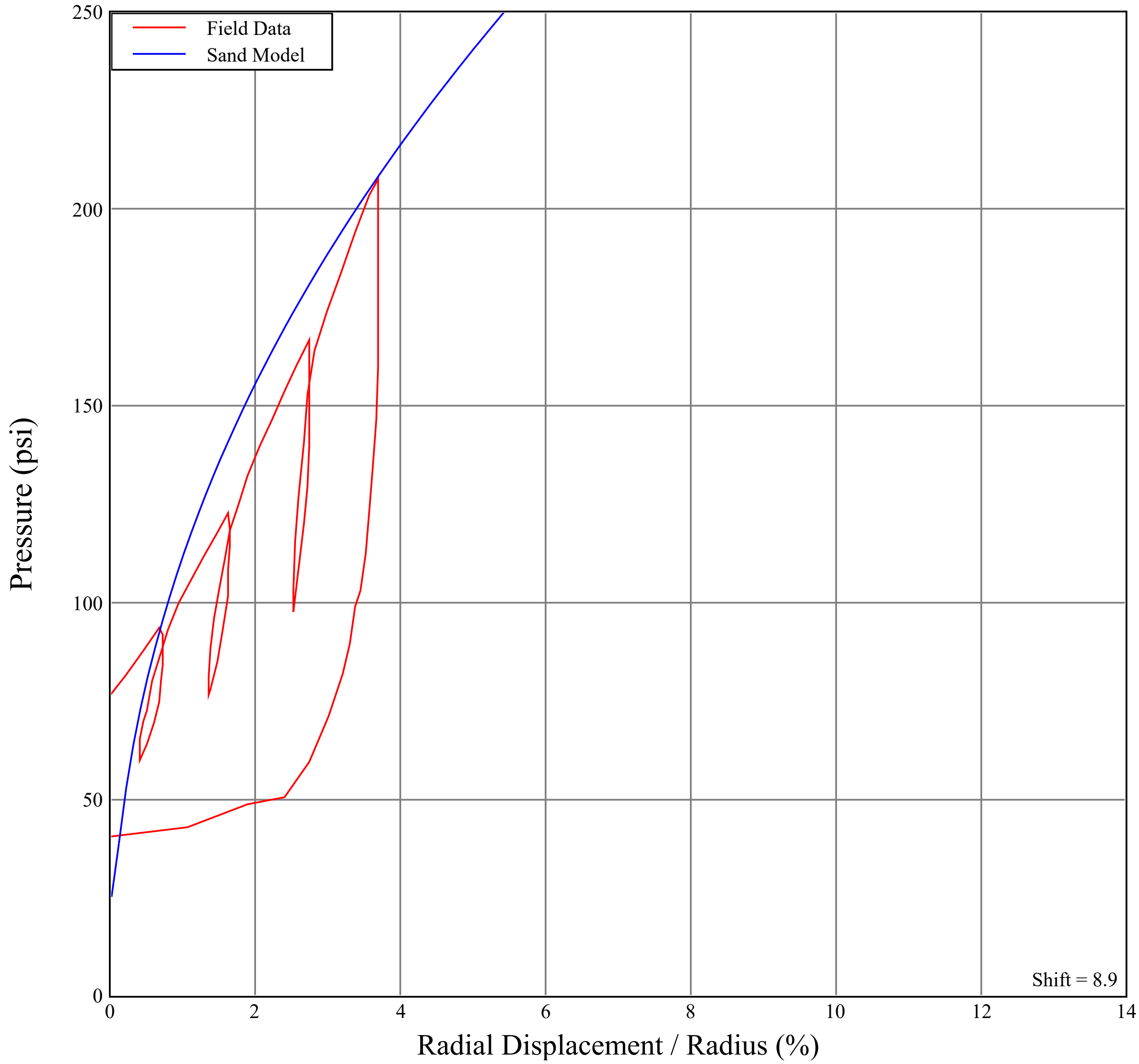
DATA

Shear Strength = 117 psi

Limit Pressure = 491 psi

In Situ Engineering - Hughes' Sand Model

Kleinfelder
Last Chance Grade
Boring: RC-20-004 Test: LCG-005 Depth: 60.7FT Date: 10/01/2020
Oper: Mayfield Job # 0115000099 Time of Test: 02:38 PM Inst: 06



DATA

Water Pressure = 0 psi

Friction Angle = 41 deg

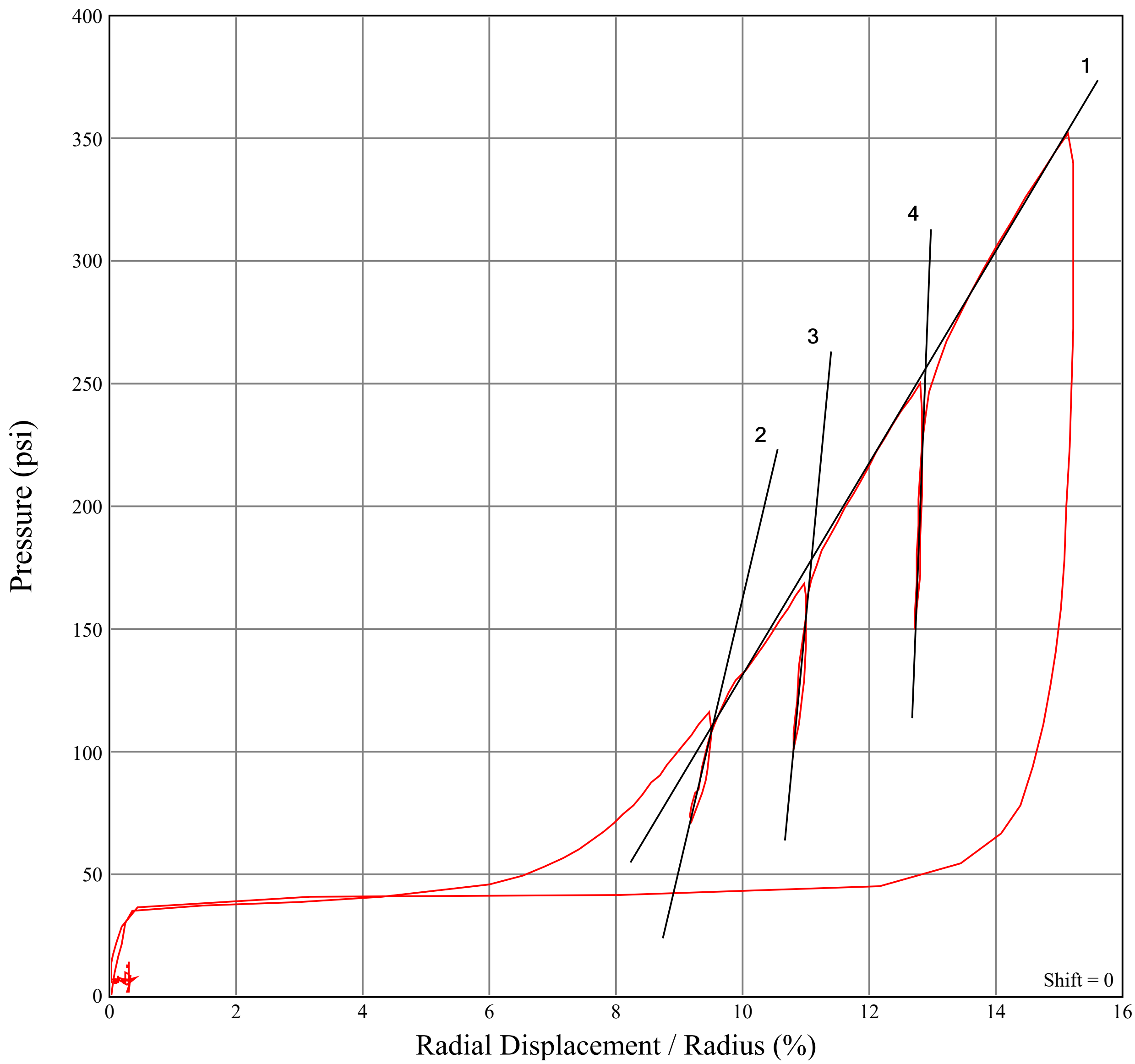
Critical Friction Angle = 32 deg

Lateral Stress = 25 psi

Shear Modulus = 6800 psi

In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-004 Test: LCG-006 Depth: 59.2FT Date: 10/01/2020
Oper: Mayfield Job # 0115000099 Time of Test: 02:54 PM Inst: 06



DATA

#1 Shear Modulus = 2160 psi

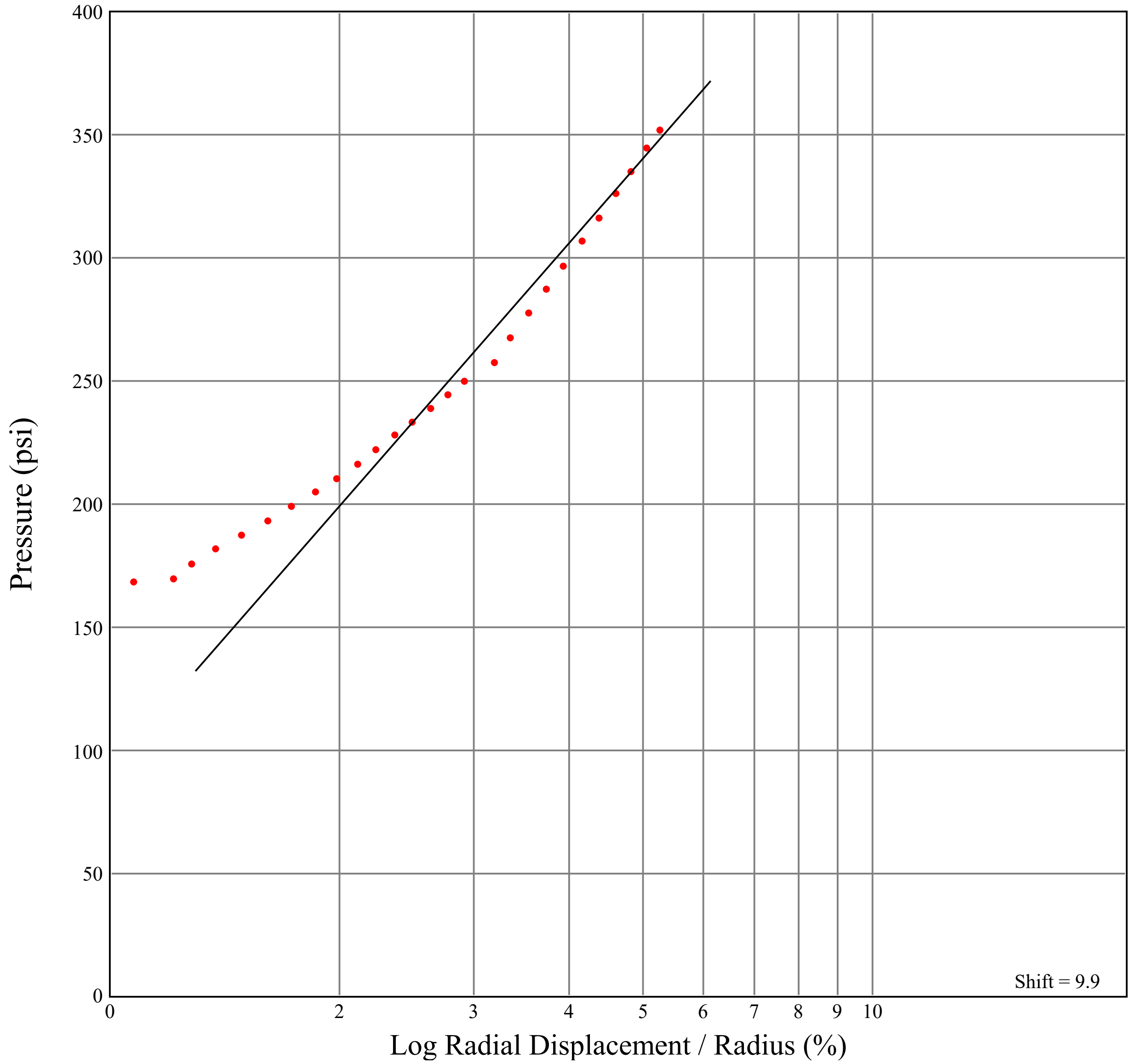
#2 Shear Modulus = 5500 psi

#3 Shear Modulus = 13700 psi

#4 Shear Modulus = 33700 psi

In Situ Engineering - Logarithm Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-004 Test: LCG-006 Depth: 59.2FT Date: 10/01/2020
Oper: Mayfield Job # 0115000099 Time of Test: 02:54 PM Inst: 06



DATA

Shear Strength = 154 psi

Limit Pressure = 665 psi

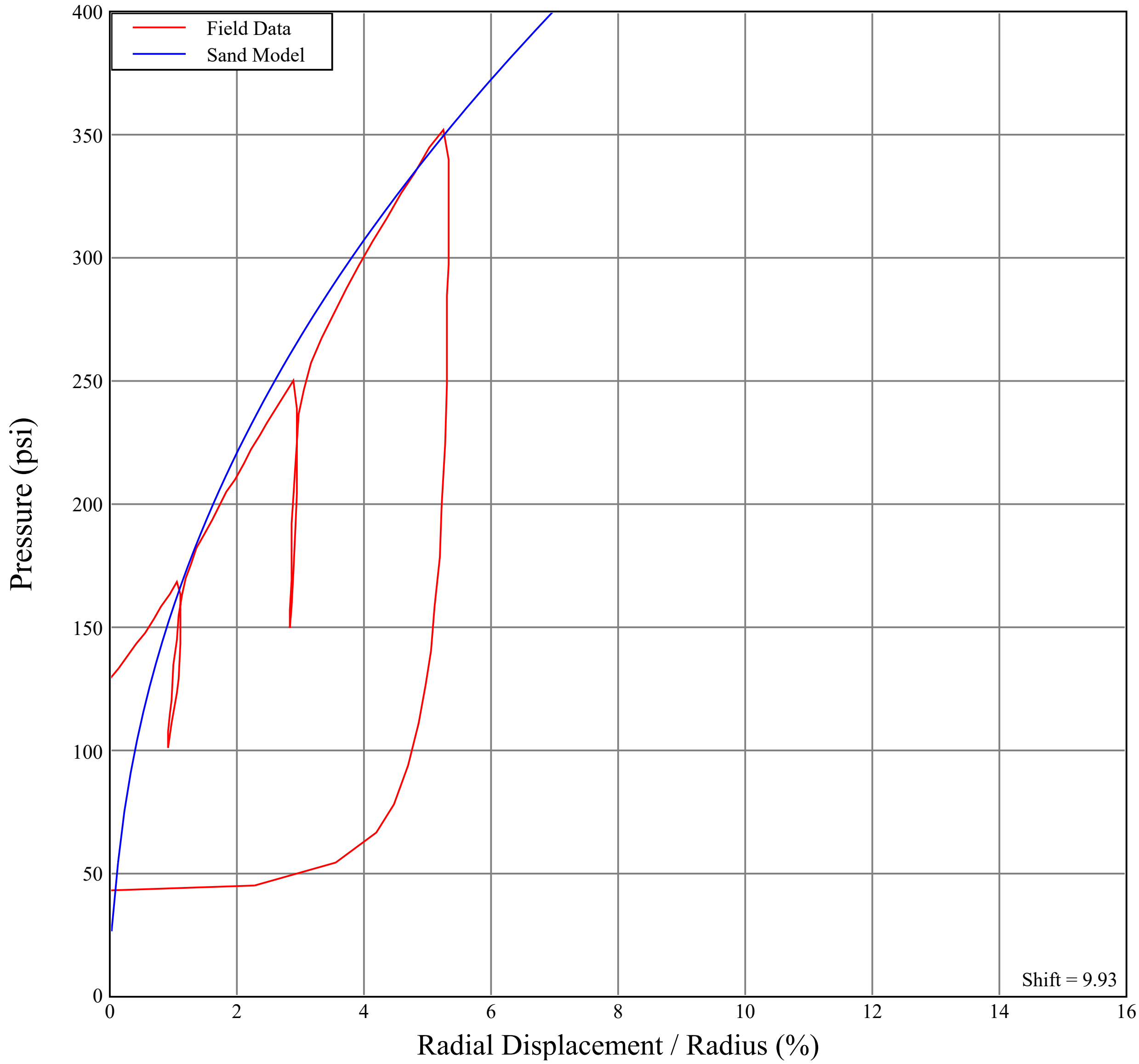
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-004 Test: LCG-006 Depth: 59.2FT Date: 10/01/2020

Oper: Mayfield Job # 0115000099 Time of Test: 02:54 PM Inst: 06



DATA

Water Pressure = 0 psi

Friction Angle = 41 deg

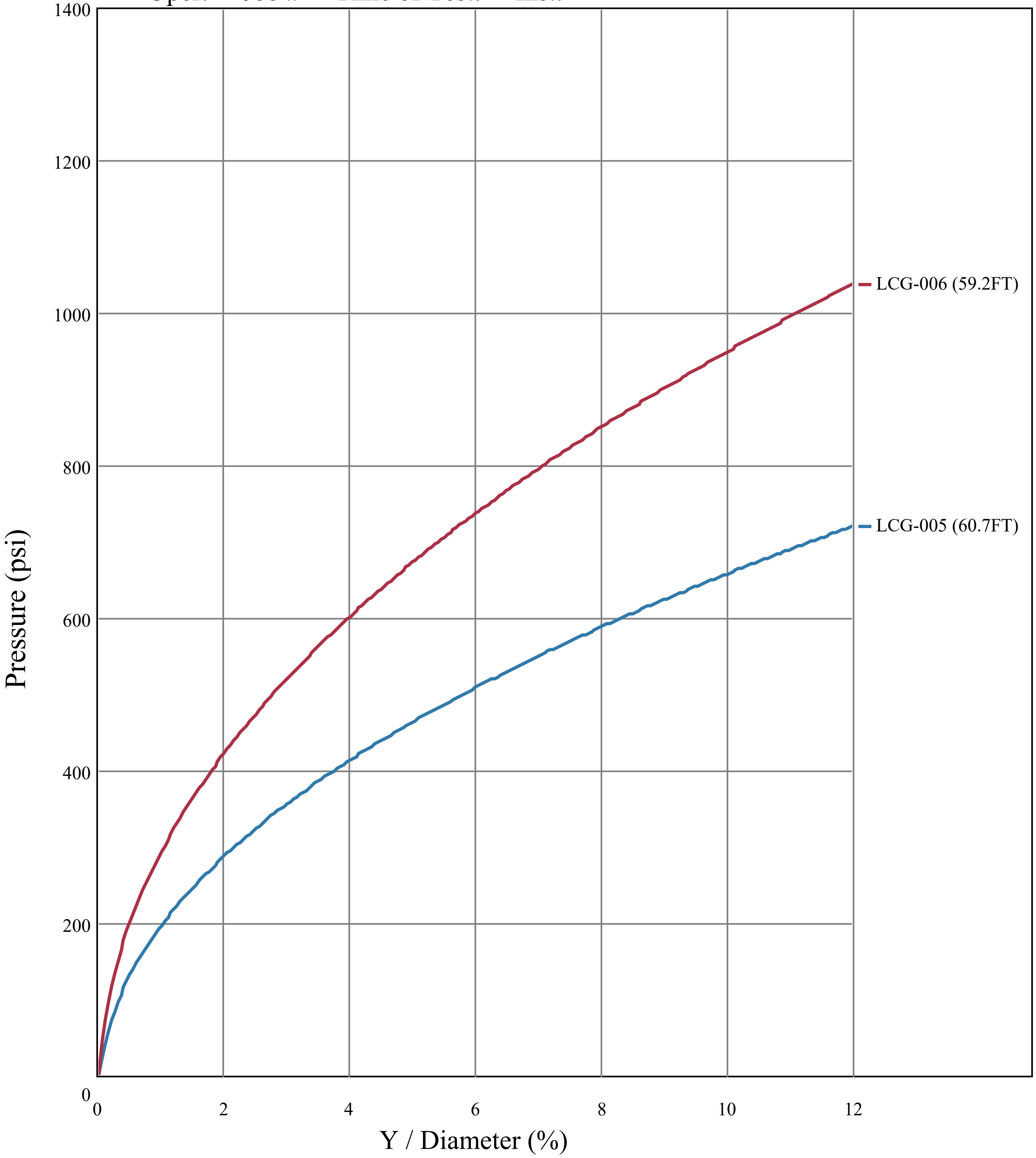
Critical Friction Angle = 32 deg

Lateral Stress = 26 psi

Shear Modulus = 13700 psi

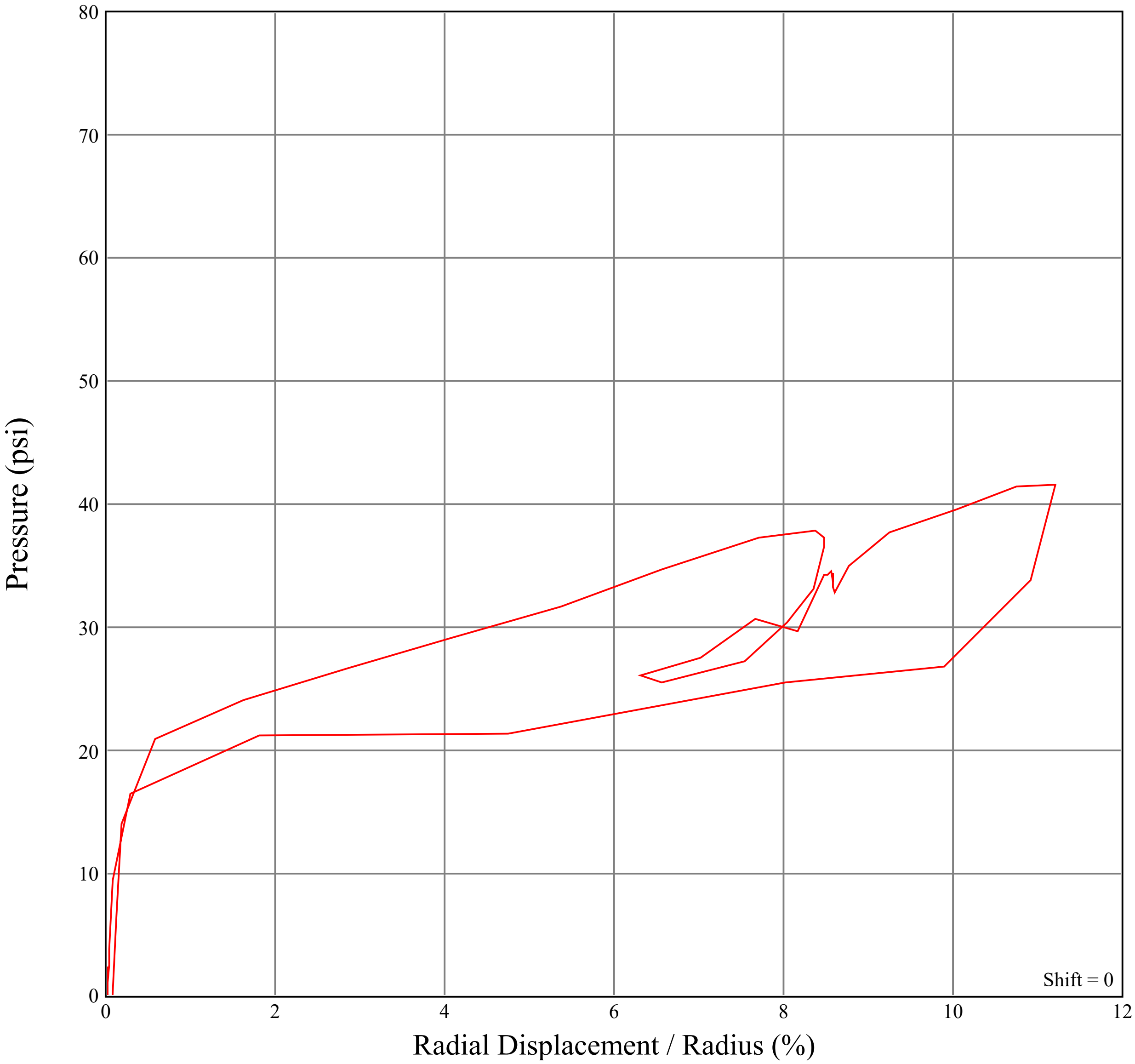
In Situ Engineering - PY Data - Frictional

Kleinfelder
Last Chance Grade
Boring: RC-20-004
Oper: Job # Time of Test: Inst:



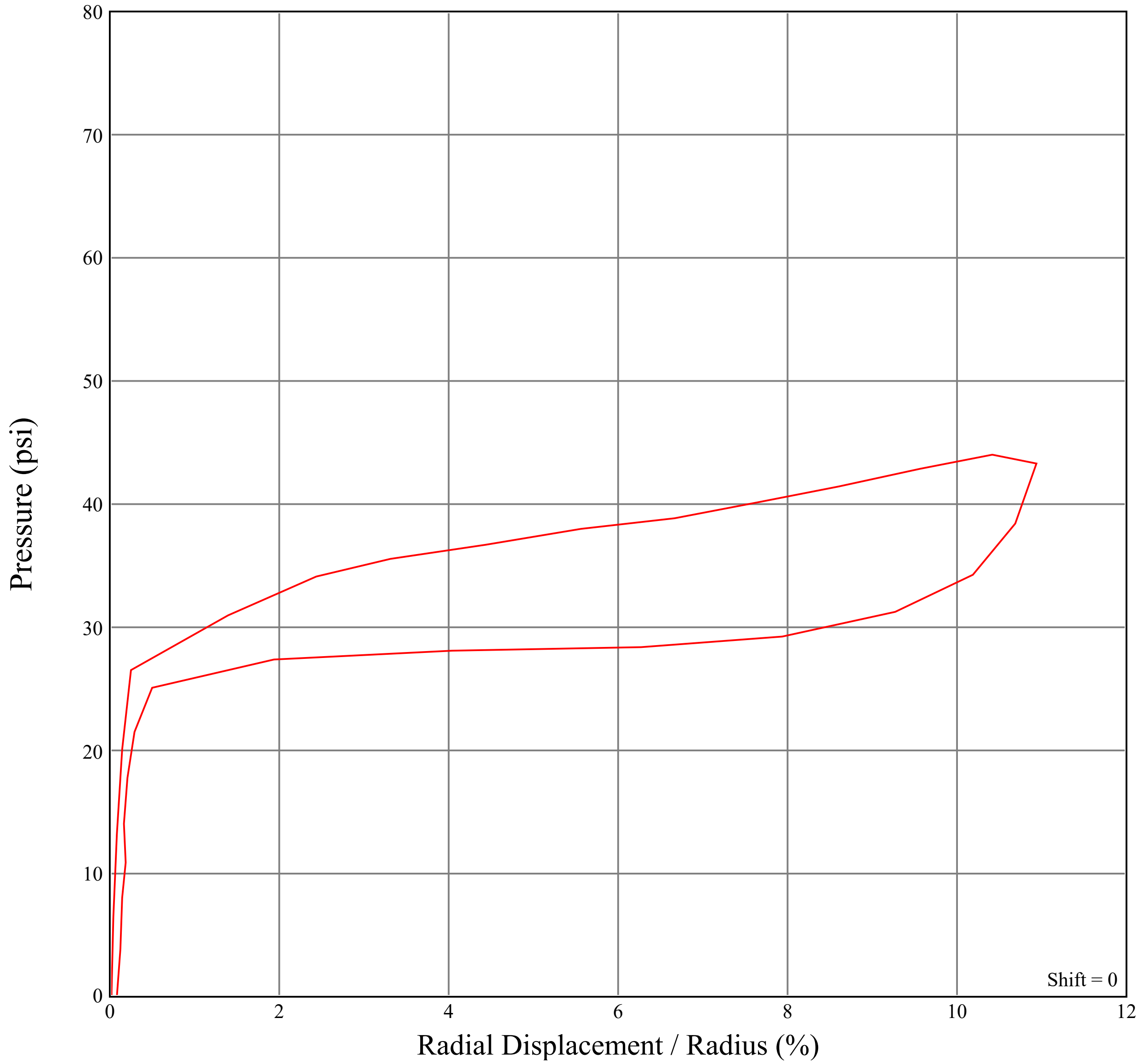
In Situ Engineering

Kleinfelder
Last Chance Grade
Boring: RC-20-006 Test: LCG-007 Depth: 53.5FT Date: 10/02/2020
Oper: Mayfield Job # 0115000099 Time of Test: 03:07 PM Inst: 06
Response indicative of highly disturbed sidewall sloughing and oversize test pocket.



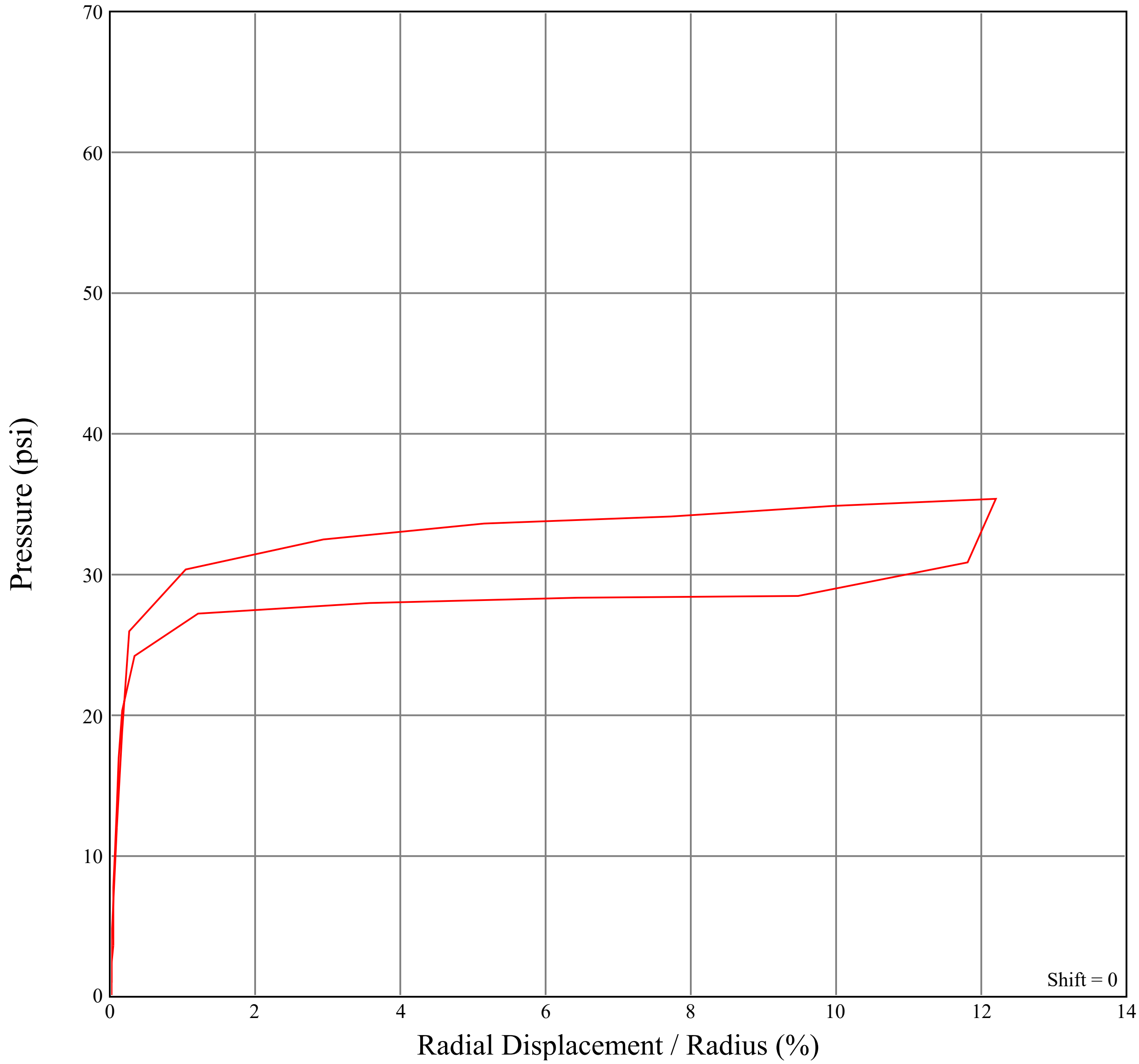
In Situ Engineering

Kleinfelder
Last Chance Grade
Boring: RC-20-006 Test: LCG-008 Depth: 60FT Date: 10/03/2020
Oper: Mayfield Job # 0115000099 Time of Test: 09:47 AM Inst: 06
Response indicative of oversize test pocket.



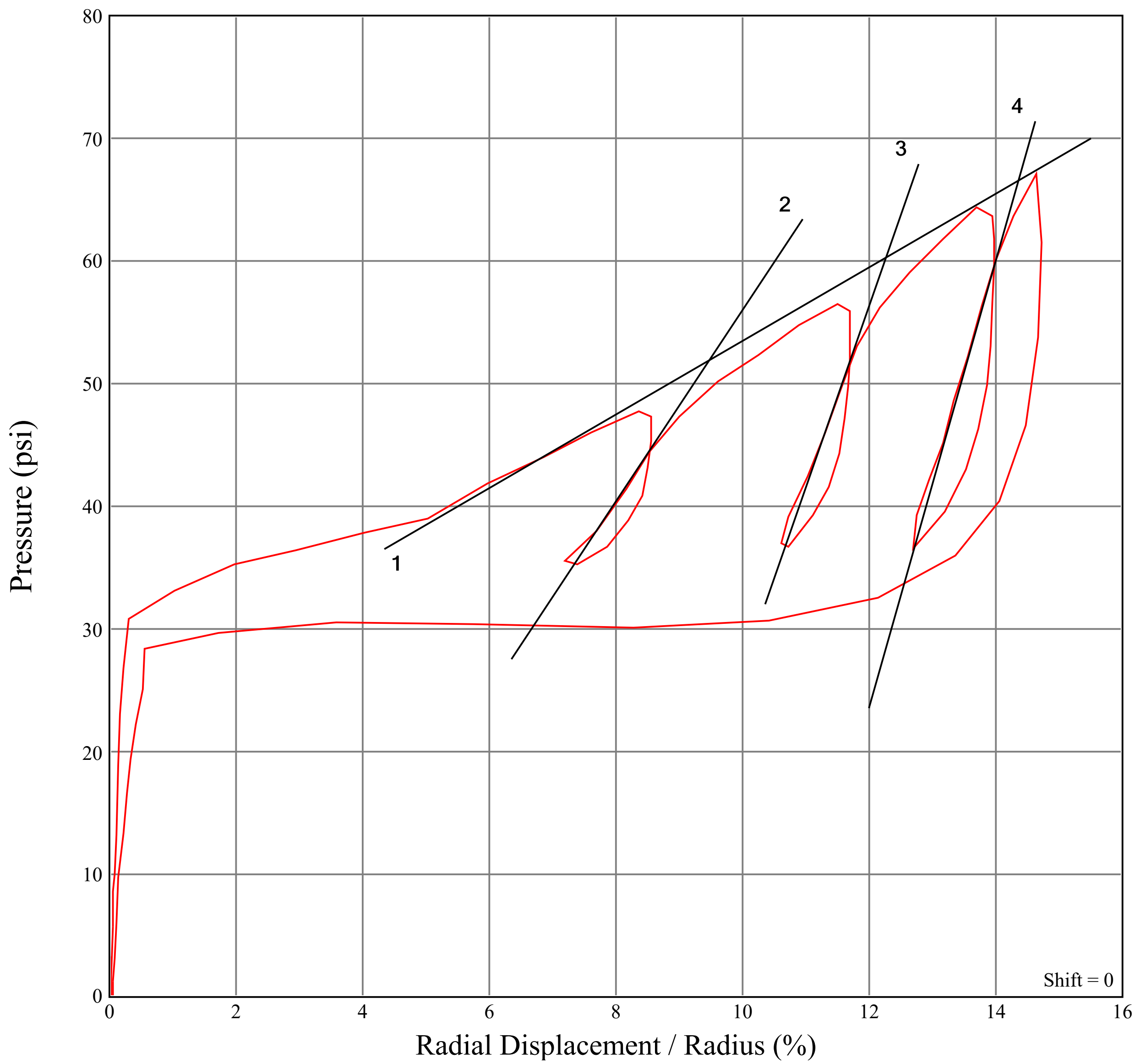
In Situ Engineering

Kleinfelder
Last Chance Grade
Boring: RC-20-006 Test: LCG-009 Depth: 58.5FT Date: 10/03/2020
Oper: Mayfield Job # 0115000099 Time of Test: 09:59 AM Inst: 06
Response indicative of oversize test pocket.



In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-006 Test: LCG-010 Depth: 66.5FT Date: 10/03/2020
Oper: Mayfield Job # 0115000099 Time of Test: 01:39 PM Inst: 06
This test may be either disturbed material or very weak intact material



DATA

#1 Shear Modulus = 150 psi

#2 Shear Modulus = 390 psi

#3 Shear Modulus = 740 psi

#4 Shear Modulus = 910 psi

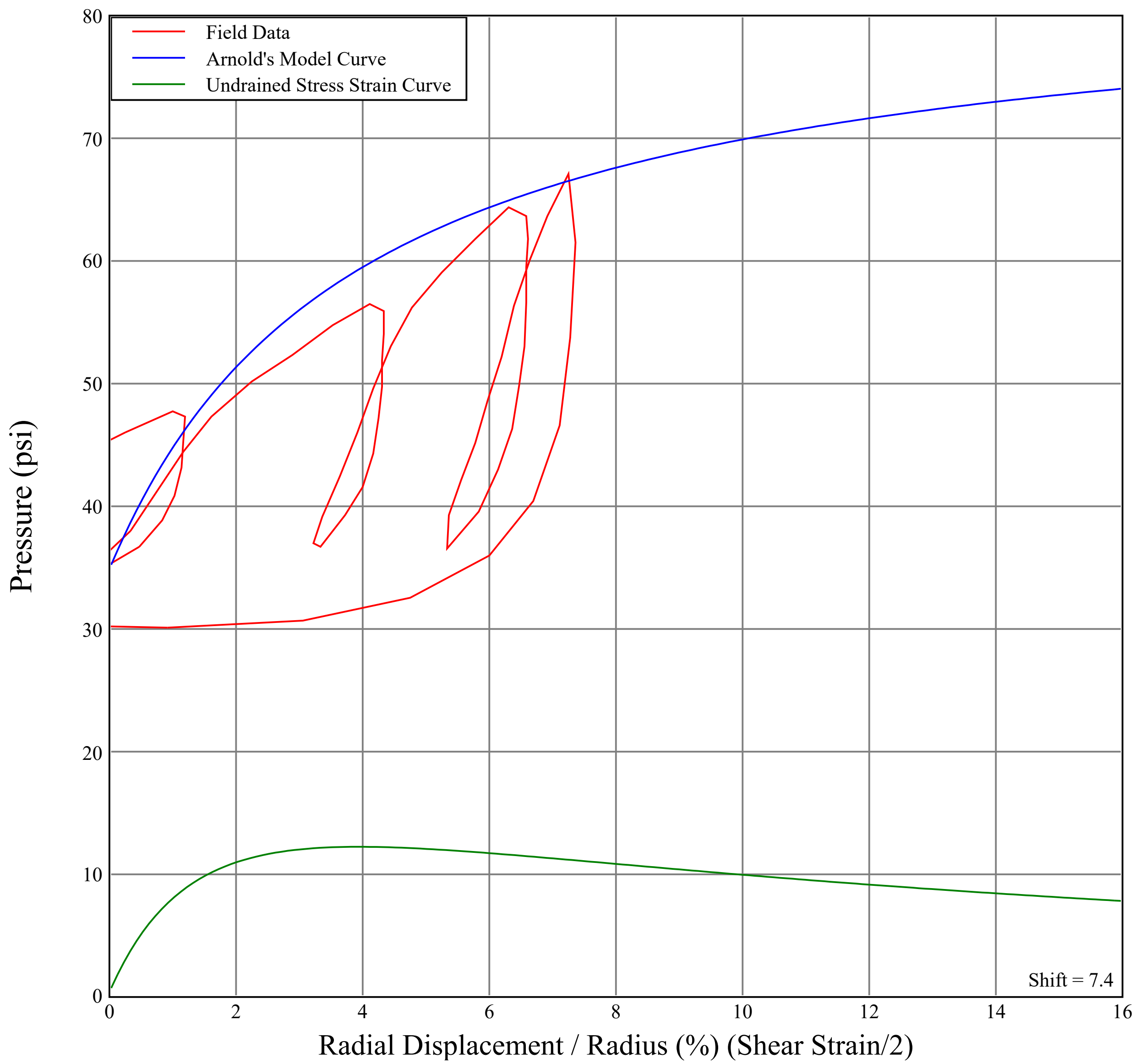
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-006   Test: LCG-010   Depth: 66.5FT   Date: 10/03/2020

Oper: Mayfield   Job # 0115000099   Time of Test: 01:39 PM   Inst: 06



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 45 psi	Shear Strength at 10% Strain = 9.9 psi
Pressure at 2.5% Strain = 54 psi	Max Shear Strength = 12.2 psi
Pressure at 7.5% Strain = 67 psi	occurs at 3.9% Strain

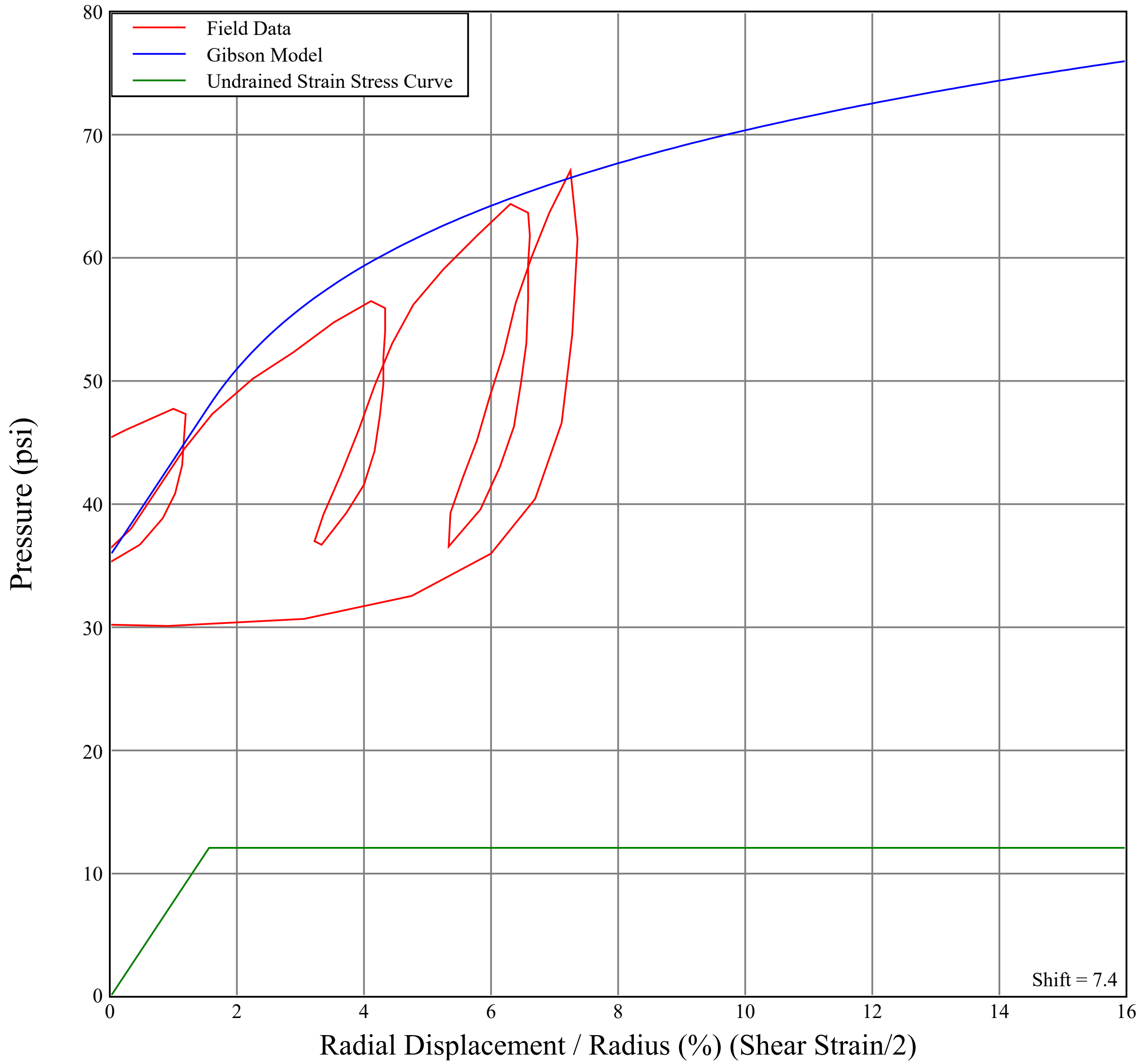
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-006 Test: LCG-010 Depth: 66.5FT Date: 10/03/2020

Oper: Mayfield Job # 0115000099 Time of Test: 01:39 PM Inst: 06



DATA

LOADING

Shear Strength = 12 psi

In Situ Stress = 36 psi

Shear Modulus = 390 psi

In Situ Engineering - Logarithm Plot

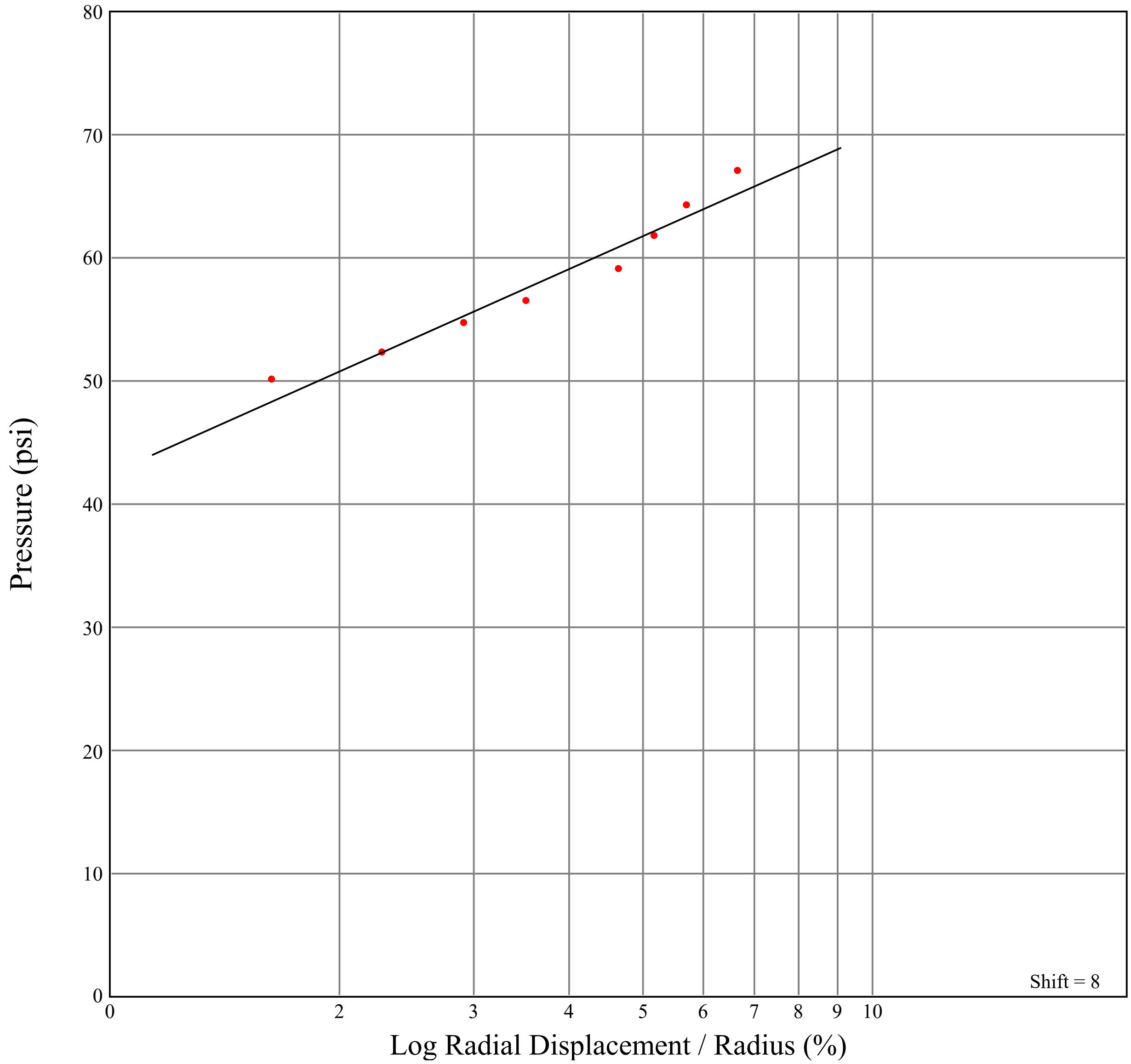
Kleinfelder

Last Chance Grade

Boring: RC-20-006   Test: LCG-010   Depth: 66.5FT   Date: 10/03/2020

Oper: Mayfield   Job # 0115000099   Time of Test: 01:39 PM   Inst: 06

This test may be either disturbed material or very weak intact material



DATA

Shear Strength = 12 psi

Limit Pressure = 87 psi

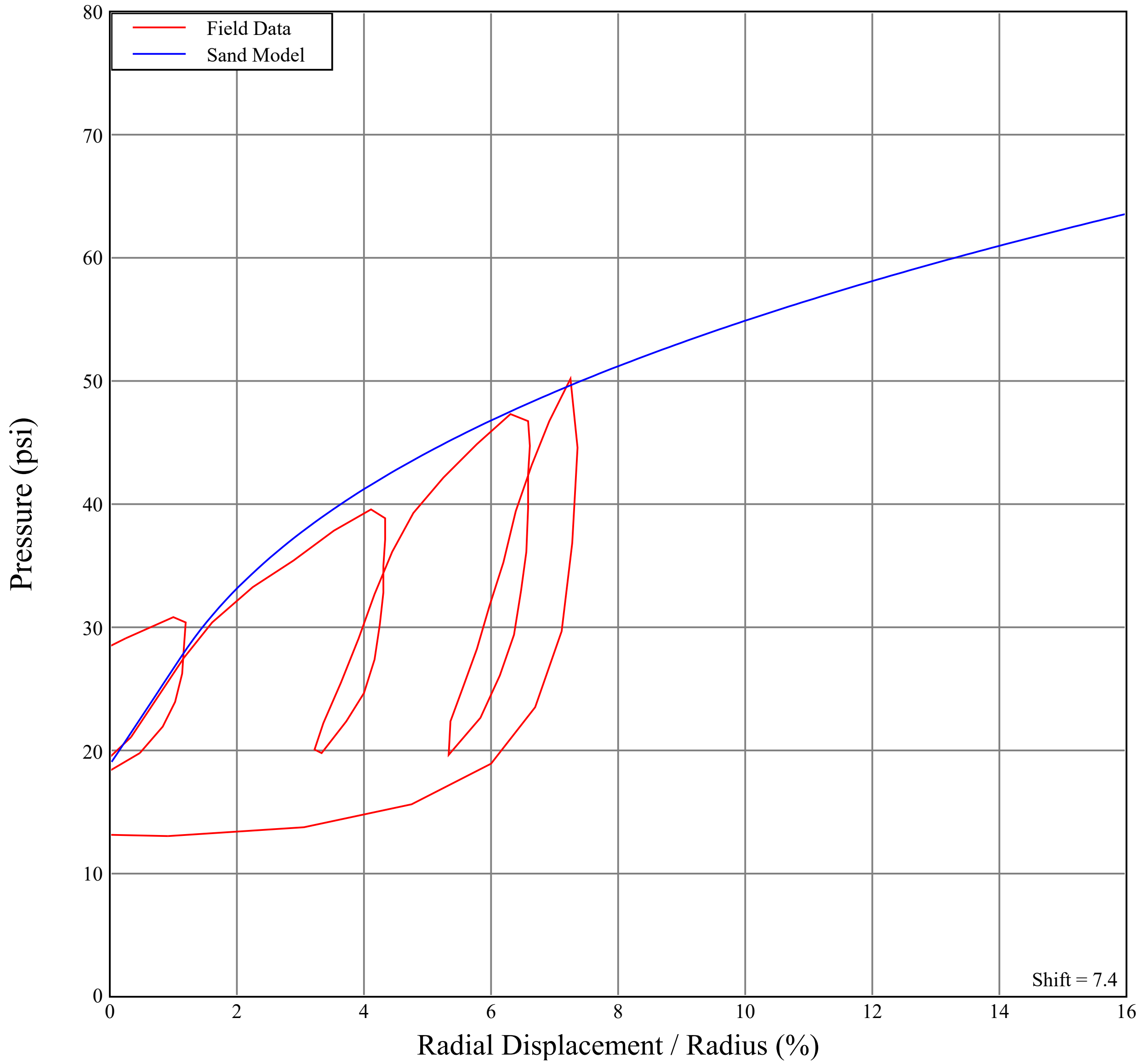
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-006 Test: LCG-010 Depth: 66.5FT Date: 10/03/2020

Oper: Mayfield Job # 0115000099 Time of Test: 01:39 PM Inst: 06



DATA

Water Pressure = 17 psi

Lateral Stress = 19 psi

Friction Angle = 27 deg

Shear Modulus = 390 psi

Critical Friction Angle = 27 deg

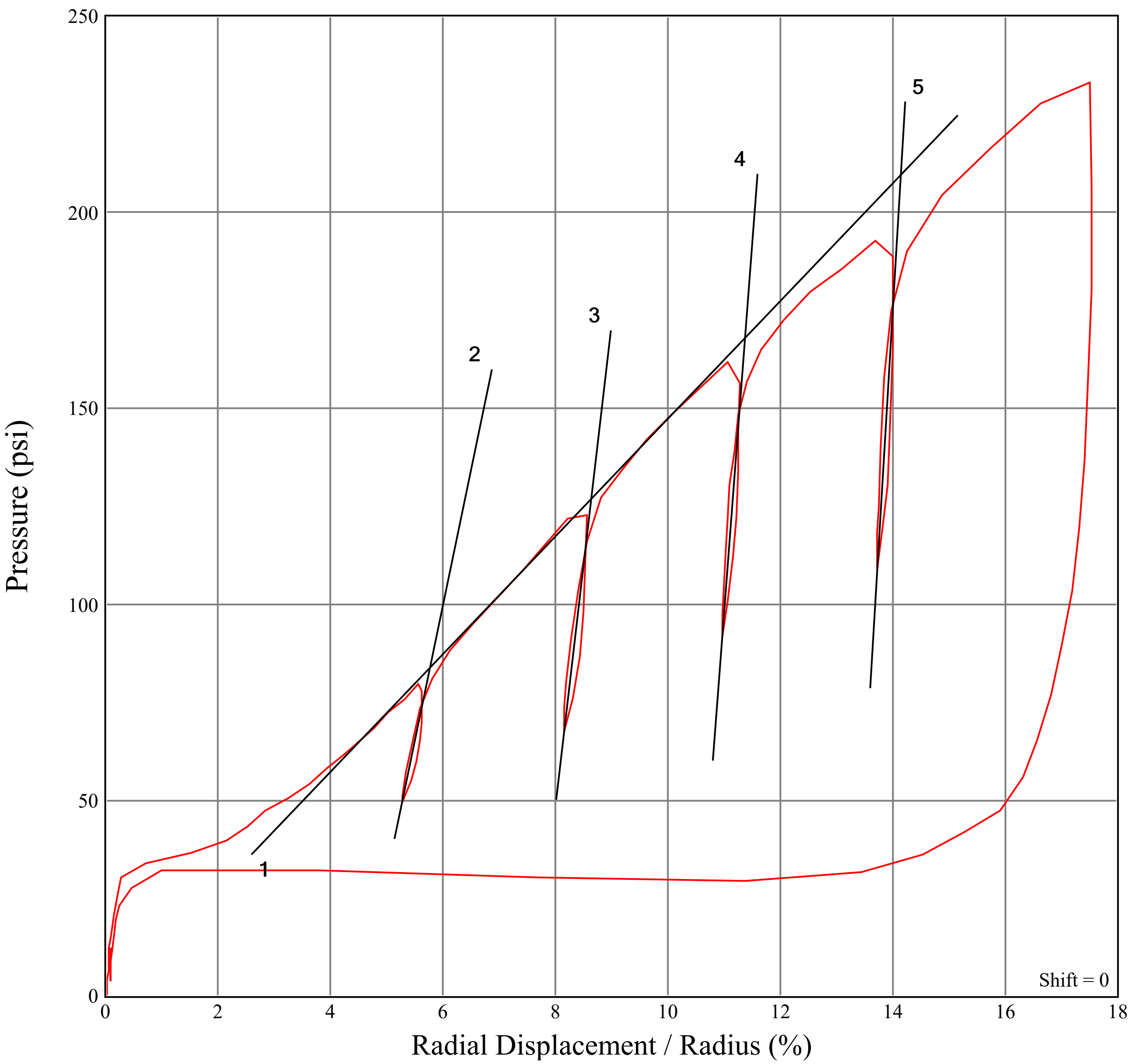
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-006 Test: LCG-011 Depth: 65FT Date: 10/03/2020

Oper: Mayfield Job # 0115000099 Time of Test: 01:51 PM Inst: 06



DATA

#1 Shear Modulus = 750 psi

#2 Shear Modulus = 3450 psi

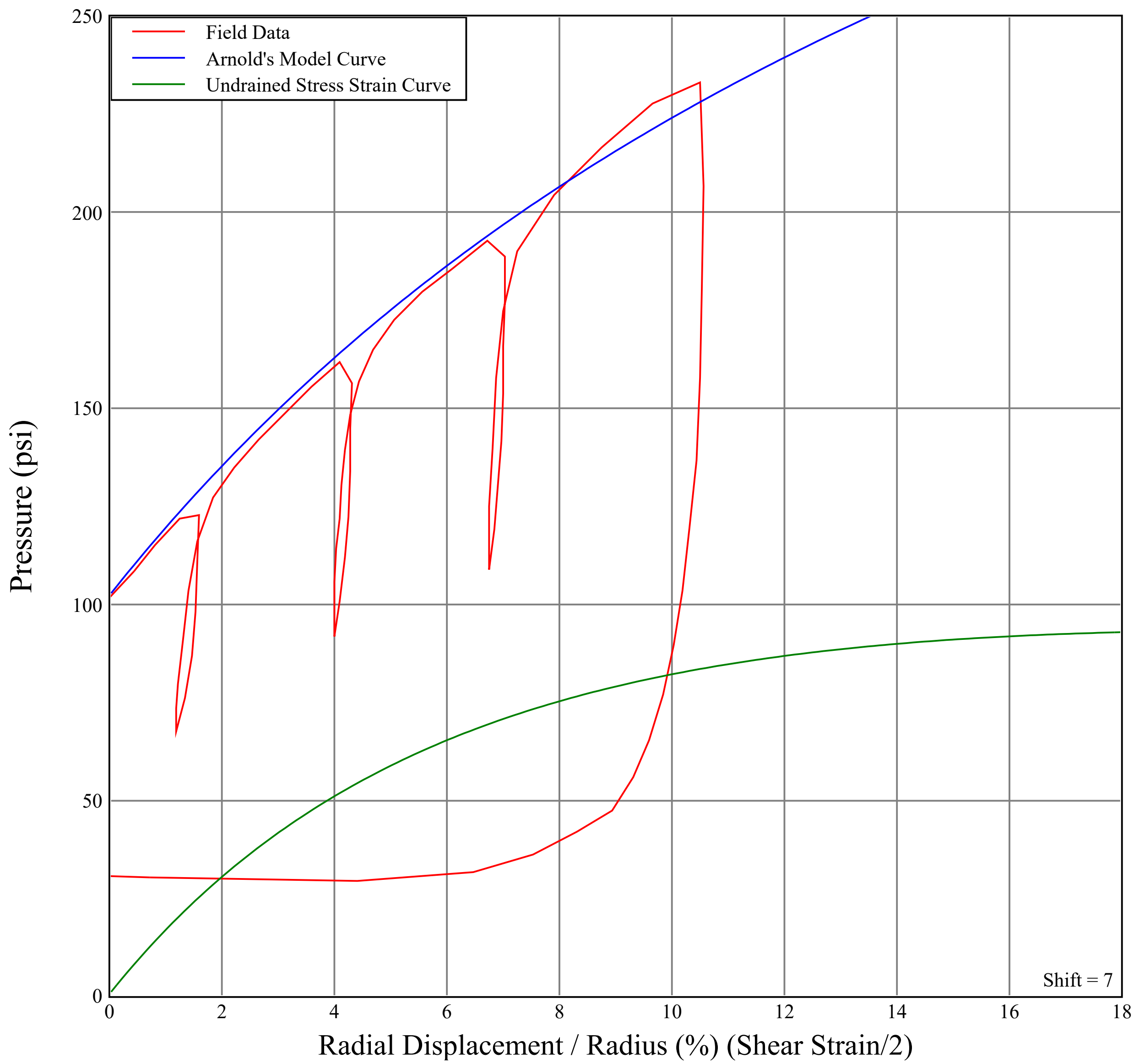
#3 Shear Modulus = 6150 psi

#4 Shear Modulus = 9420 psi

#5 Shear Modulus = 12010 psi

In Situ Engineering - Arnold's Clay Model

Kleinfelder
Last Chance Grade
Boring: RC-20-006 Test: LCG-011 Depth: 65FT Date: 10/03/2020
Oper: Mayfield Job # 0115000099 Time of Test: 01:51 PM Inst: 06



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 120 psi	Shear Strength at 10% Strain = 82.1 psi
Pressure at 2.5% Strain = 143 psi	Max Shear Strength = 93.2 psi
Pressure at 7.5% Strain = 202 psi	occurs at 19.8% Strain

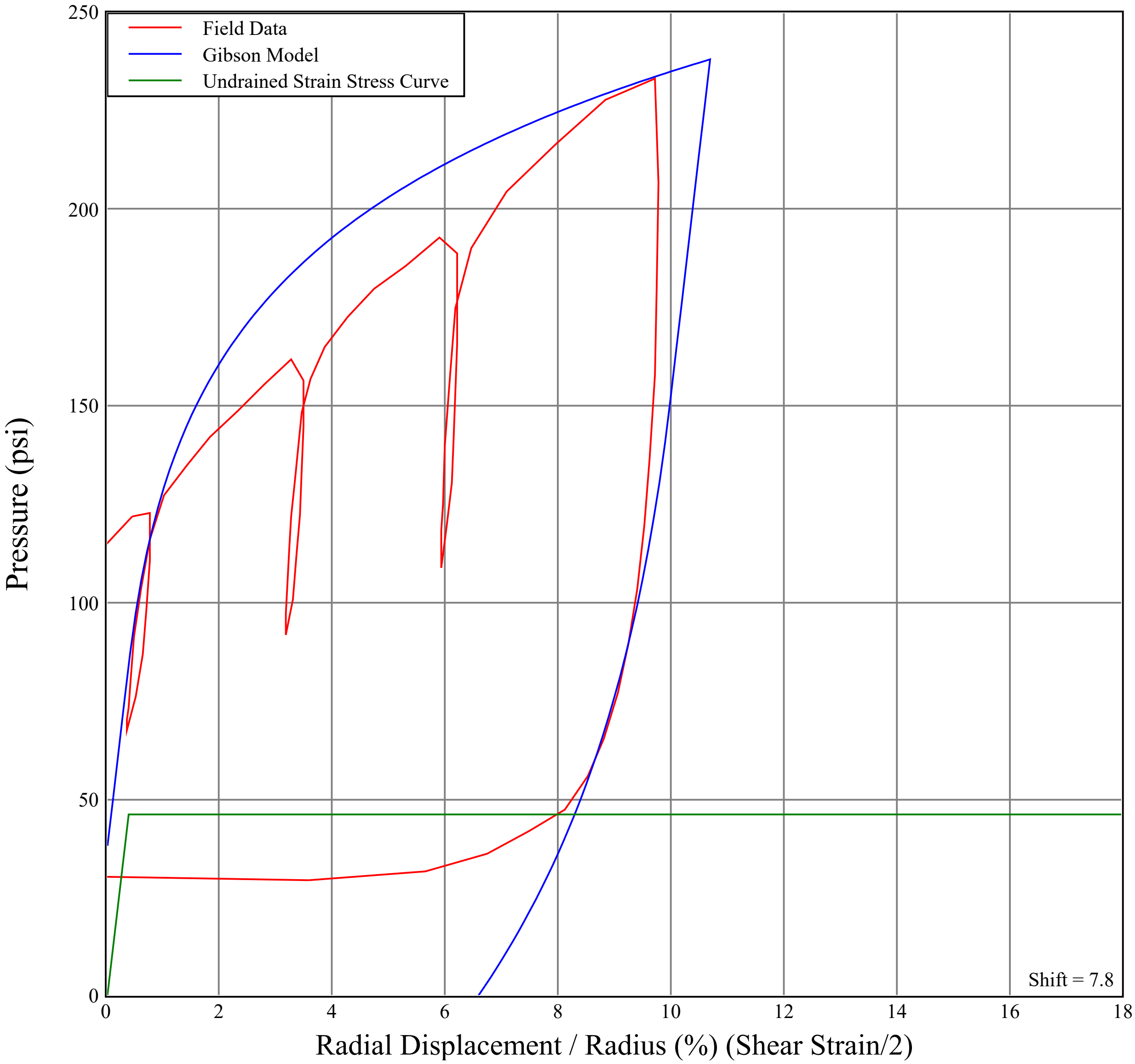
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-006 Test: LCG-011 Depth: 65FT Date: 10/03/2020

Oper: Mayfield Job # 0115000099 Time of Test: 01:51 PM Inst: 06

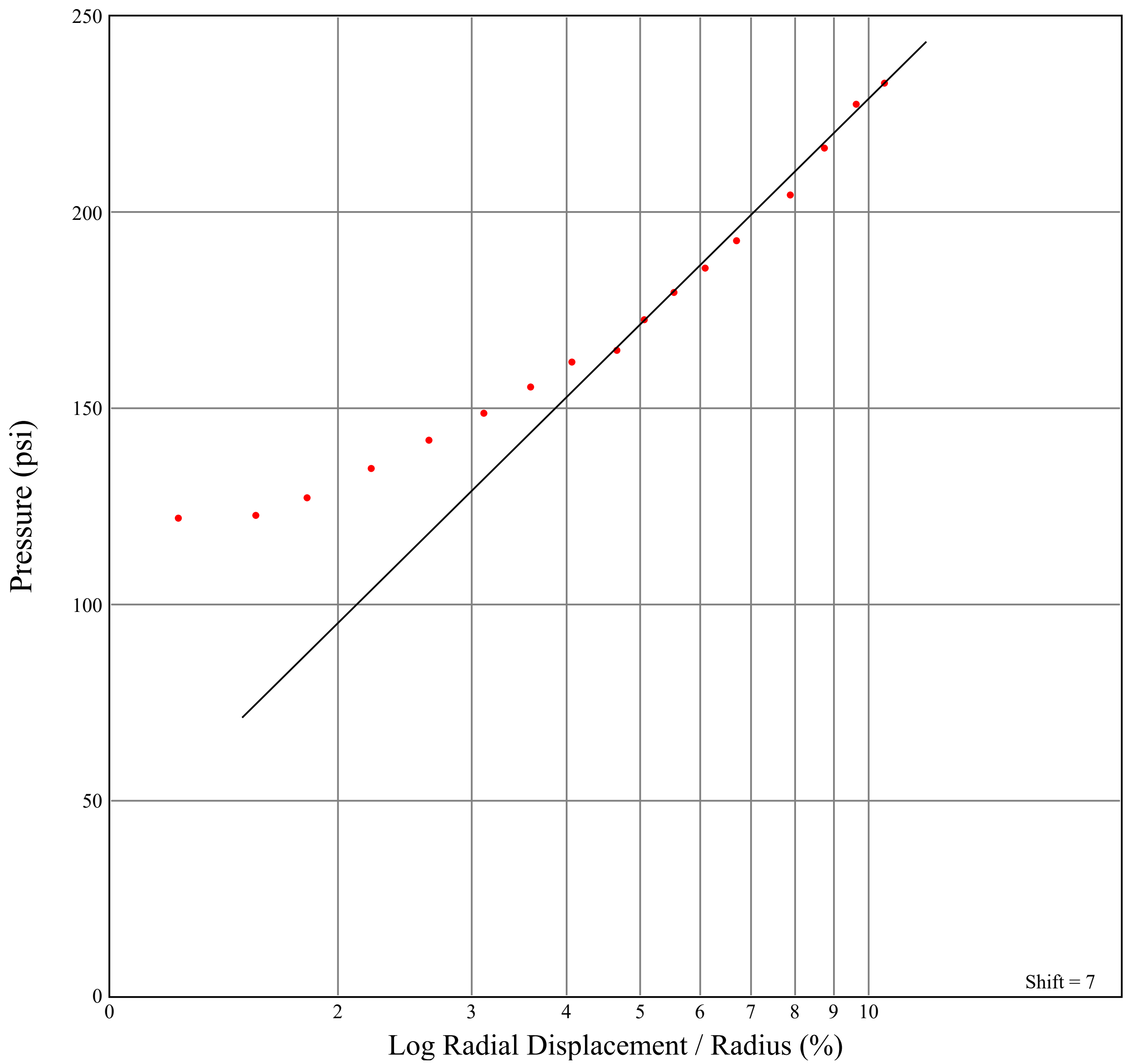


DATA

LOADING	UNLOADING
Shear Strength = 46 psi	Shear Strength = 86 psi
In Situ Stress = 38 psi	Shear Modulus = 6150 psi
Shear Modulus = 6150 psi	

In Situ Engineering - Logarithm Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-006 Test: LCG-011 Depth: 65FT Date: 10/03/2020
Oper: Mayfield Job # 0115000099 Time of Test: 01:51 PM Inst: 06



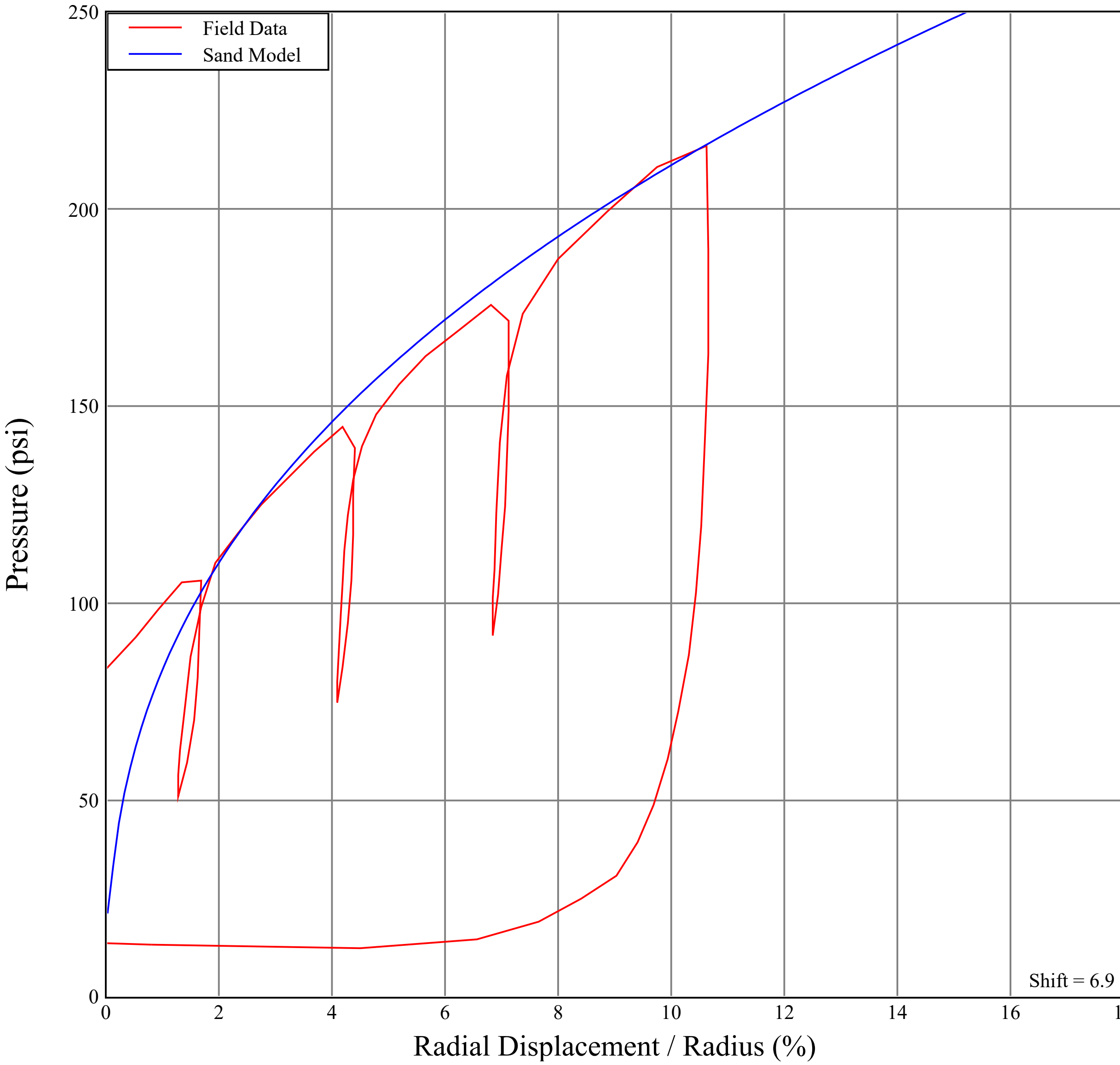
DATA

Shear Strength = 83 psi

Limit Pressure = 346 psi

In Situ Engineering - Hughes' Sand Model

Kleinfelder
Last Chance Grade
Boring: RC-20-006   Test: LCG-011   Depth: 65FT   Date: 10/03/2020
Oper: Mayfield   Job # 0115000099   Time of Test: 01:51 PM   Inst: 06



DATA

Water Pressure = 17 psi
Lateral Stress = 21 psi
Friction Angle = 36 deg
Shear Modulus = 6150 psi
Critical Friction Angle = 32 deg

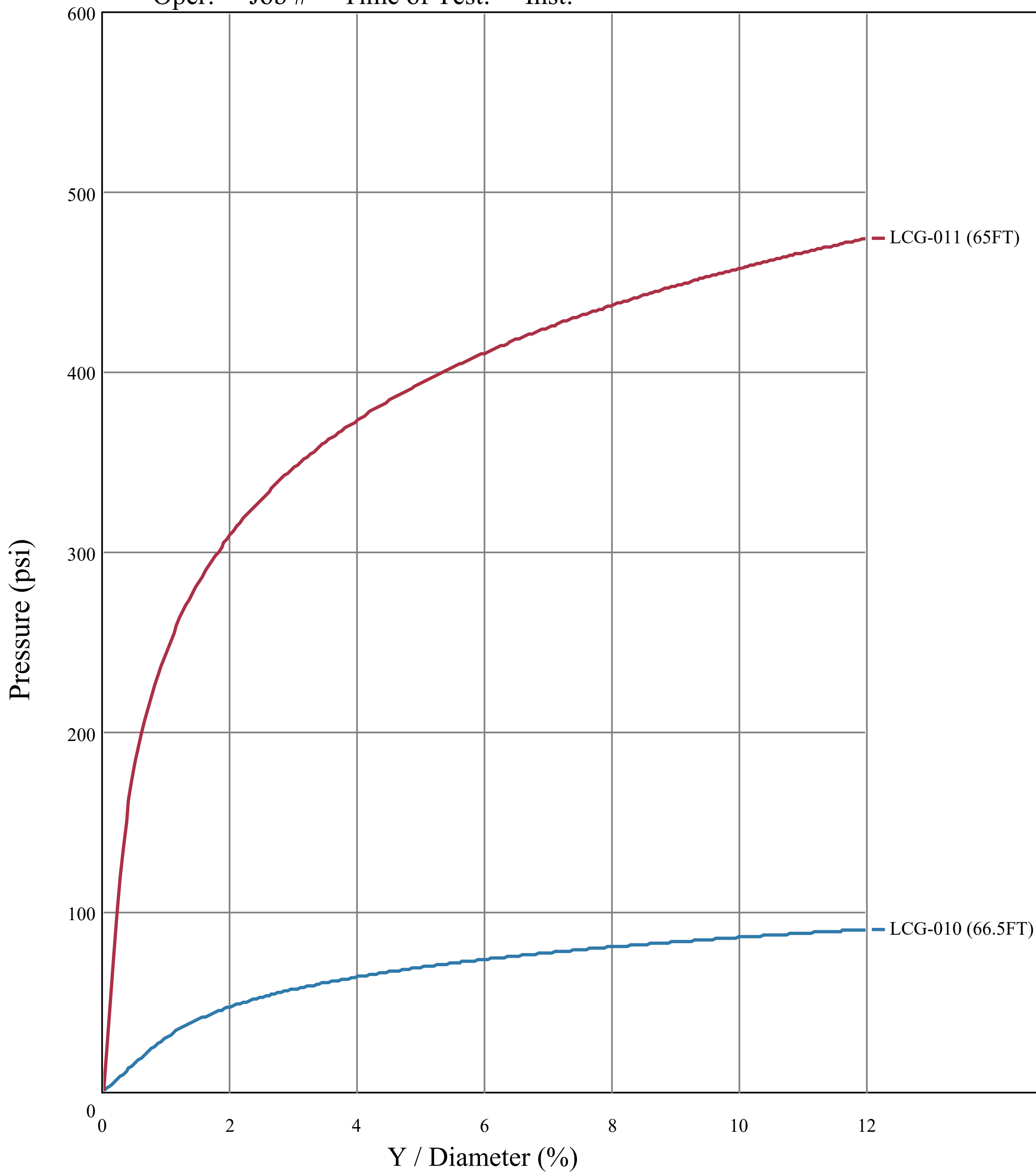
In Situ Engineering - PY Data - Cohesive

Kleinfelder

Last Chance Grade

Boring:RC-20-006

Oper: Job # Time of Test: Inst:



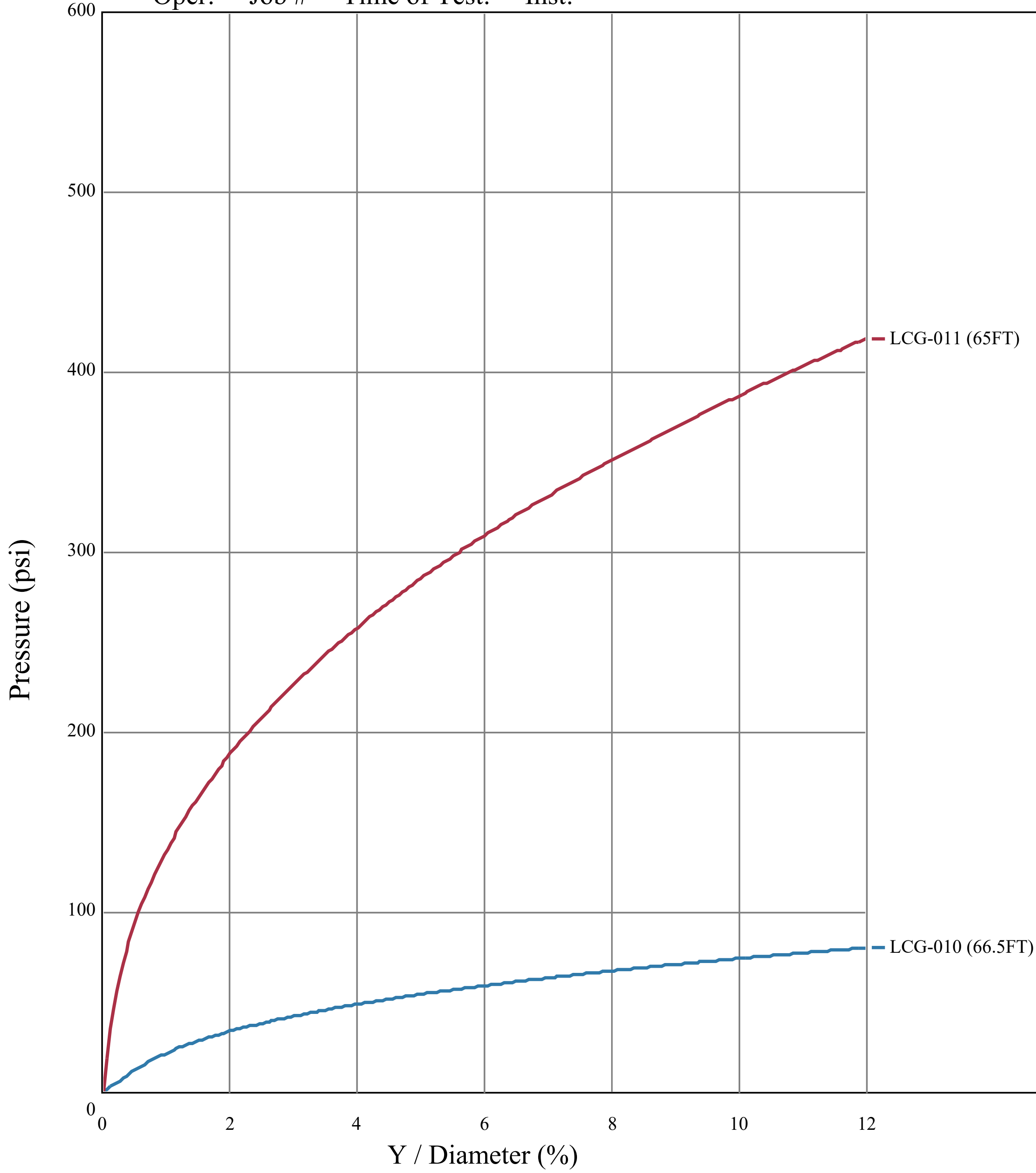
In Situ Engineering - PY Data - Frictional

Kleinfelder

Last Chance Grade

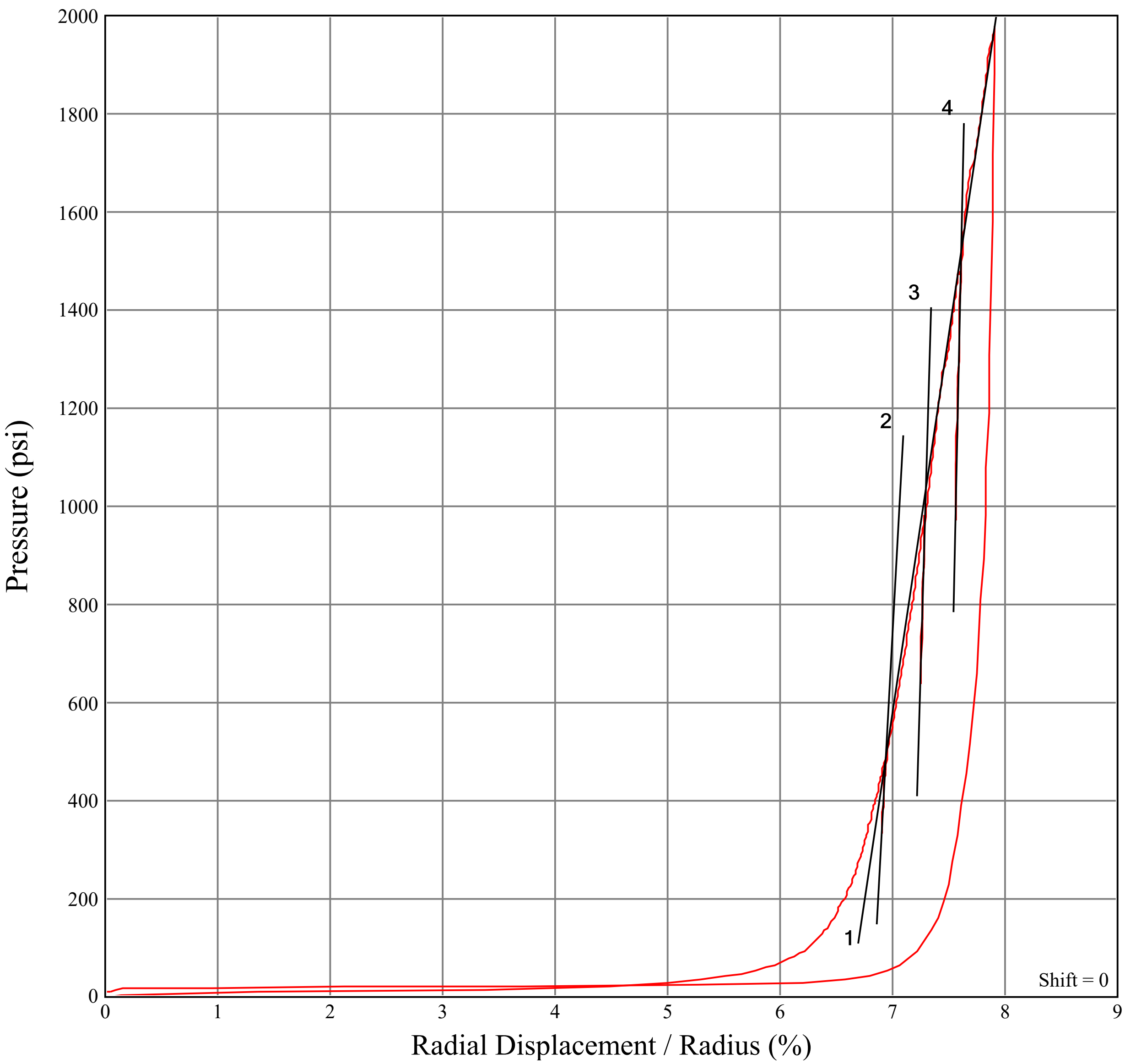
Boring:RC-20-006

Oper: Job # Time of Test: Inst:



In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-007 Test: LCG-012 Depth: 35FT Date: 10/06/2020
Oper: Mayfield Job # 0115000099 Time of Test: 10:40 AM Inst: 06



DATA

#1 Shear Modulus = 77000 psi

#2 Shear Modulus = 211000 psi

#3 Shear Modulus = 401000 psi

#4 Shear Modulus = 542000 psi

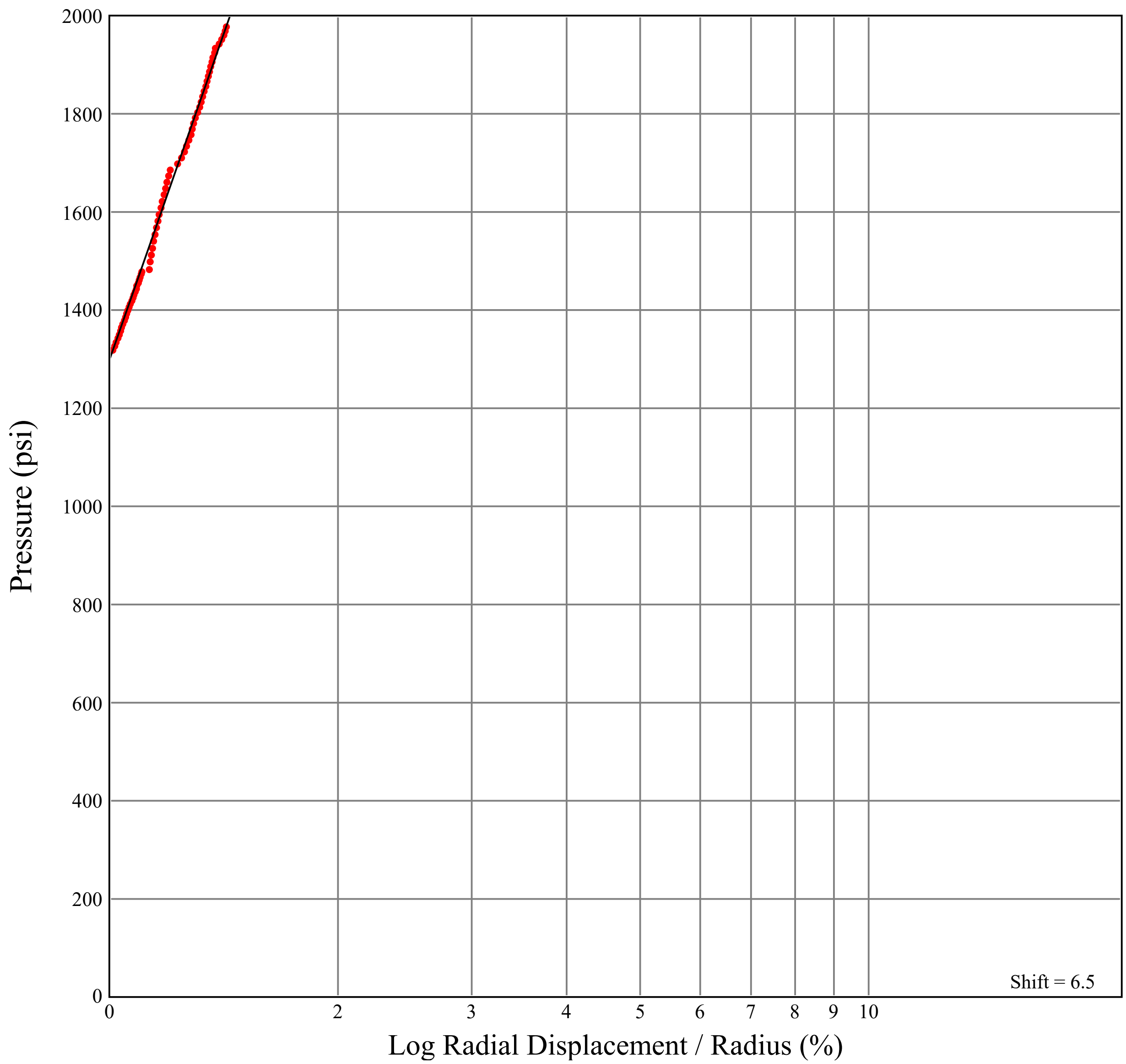
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-007 Test: LCG-012 Depth: 35FT Date: 10/06/2020

Oper: Mayfield Job # 0115000099 Time of Test: 10:40 AM Inst: 06



DATA

Shear Strength = 1918 psi

Limit Pressure = 8432 psi

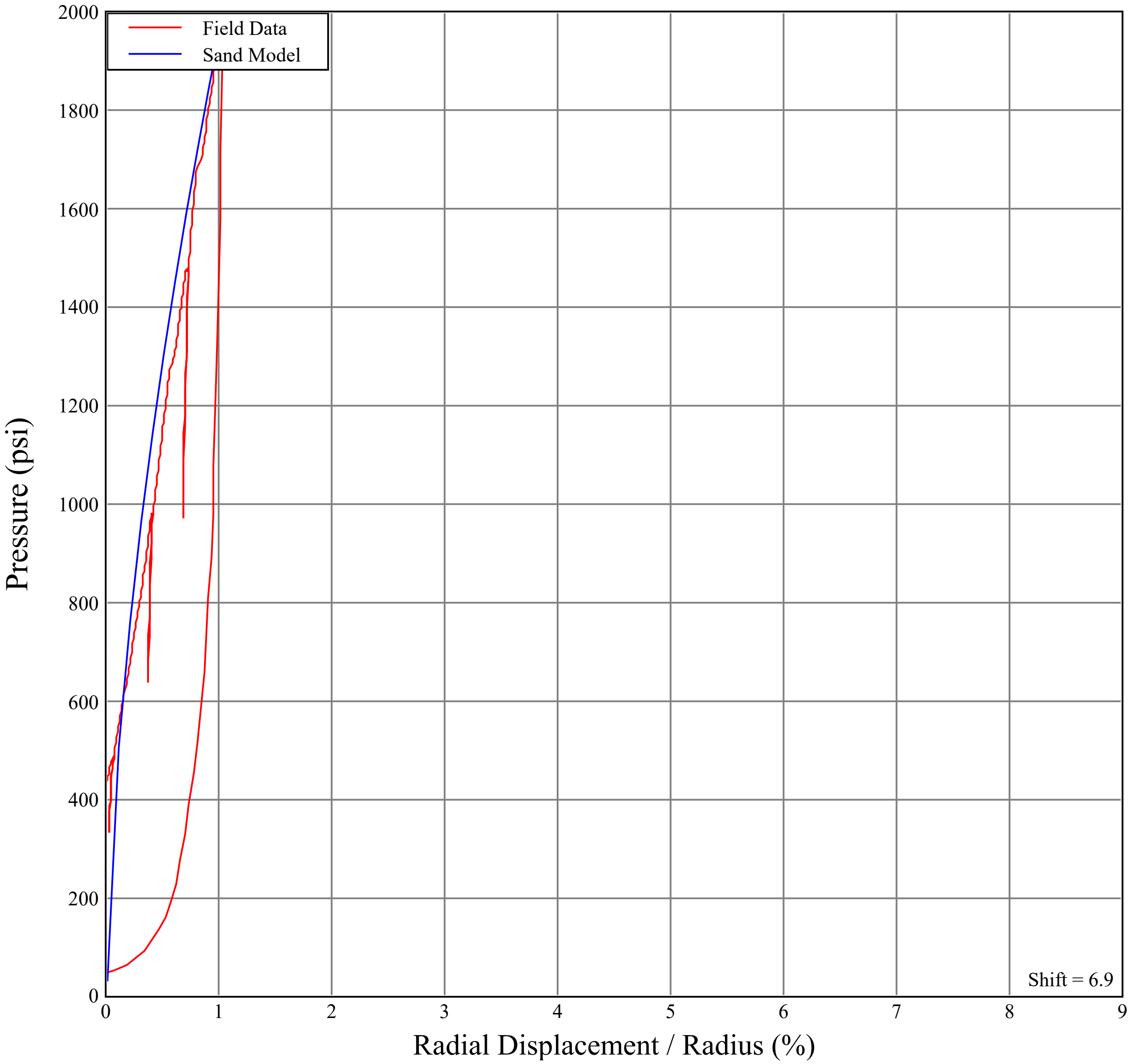
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-007 Test: LCG-012 Depth: 35FT Date: 10/06/2020

Oper: Mayfield Job # 0115000099 Time of Test: 10:40 AM Inst: 06



DATA

Water Pressure = 0 psi

Lateral Stress = 28 psi

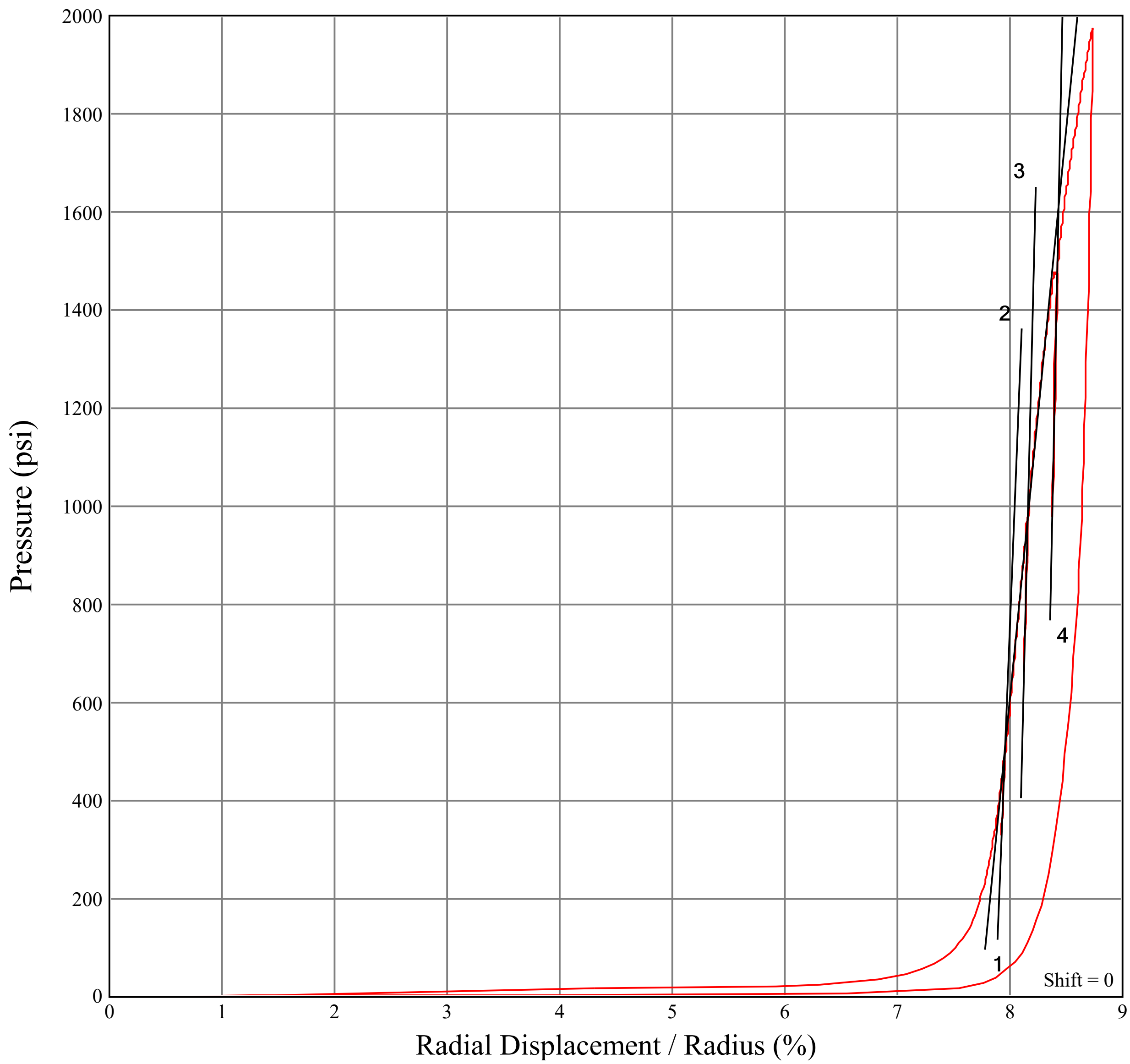
Friction Angle = 49 deg

Shear Modulus = 542000 psi

Critical Friction Angle = 32 deg

In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-007 Test: LCG-013 Depth: 33.5FT Date: 10/06/2020
Oper: Mayfield Job # 0115000099 Time of Test: 11:12 AM Inst: 06



DATA

#1 Shear Modulus = 116000 psi

#2 Shear Modulus = 289000 psi

#3 Shear Modulus = 475000 psi

#4 Shear Modulus = 566000 psi

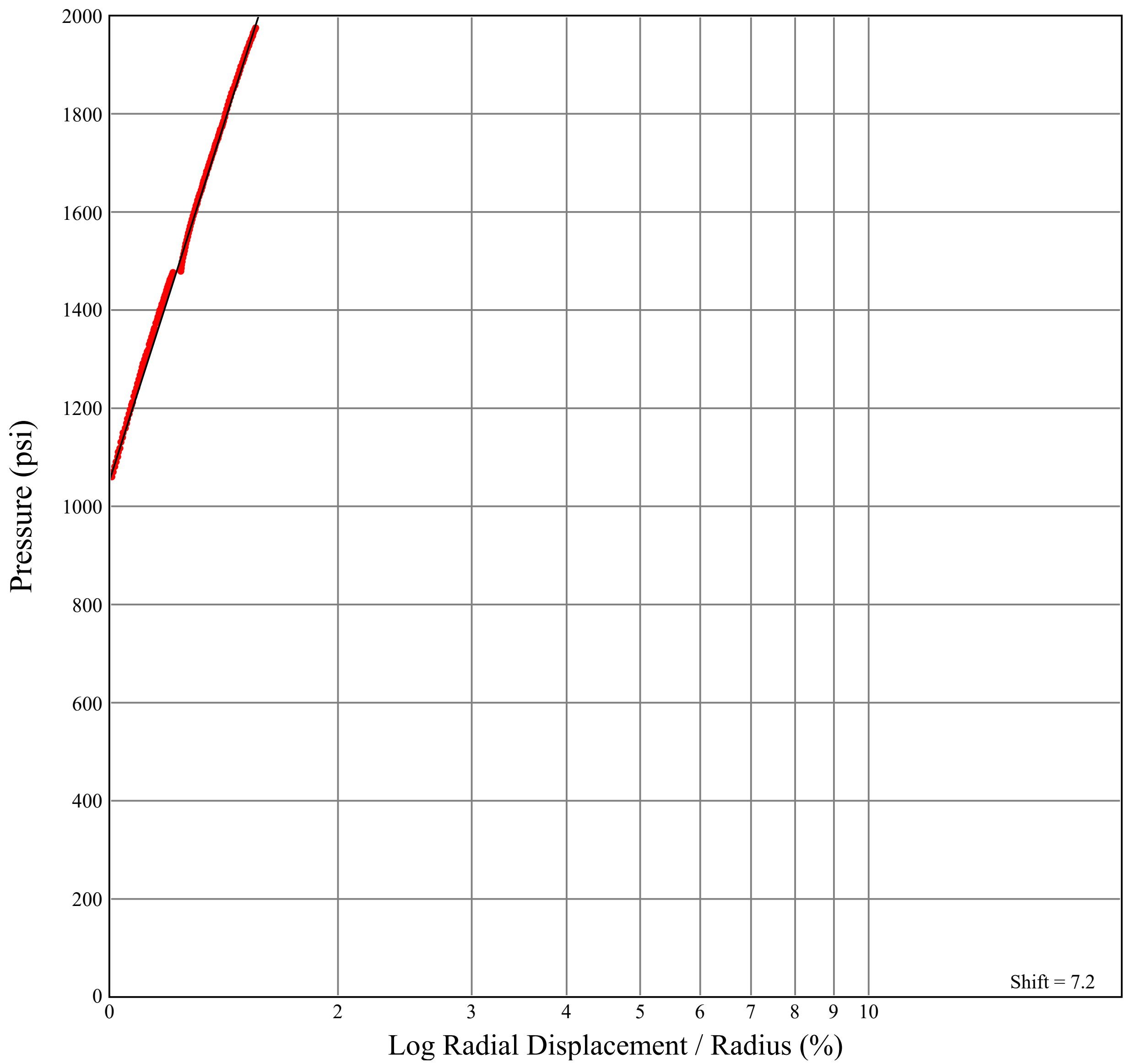
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-007 Test: LCG-013 Depth: 33.5FT Date: 10/06/2020

Oper: Mayfield Job # 0115000099 Time of Test: 11:12 AM Inst: 06



DATA

Shear Strength = 2094 psi

Limit Pressure = 8839 psi

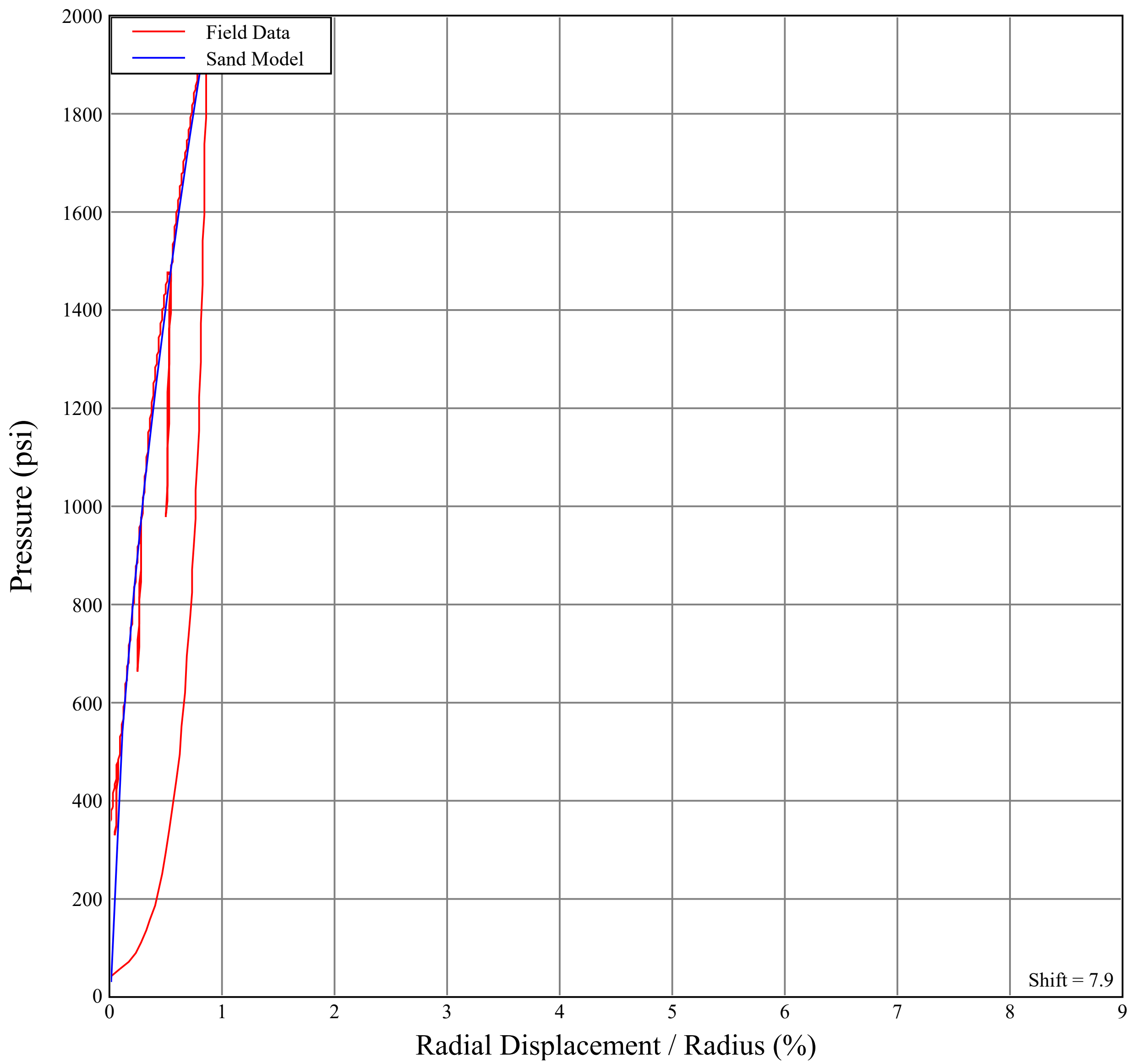
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-007 Test: LCG-013 Depth: 33.5FT Date: 10/06/2020

Oper: Mayfield Job # 0115000099 Time of Test: 11:12 AM Inst: 06



DATA

Water Pressure = 0 psi

Lateral Stress = 27 psi

Friction Angle = 50 deg

Shear Modulus = 566000 psi

Critical Friction Angle = 32 deg

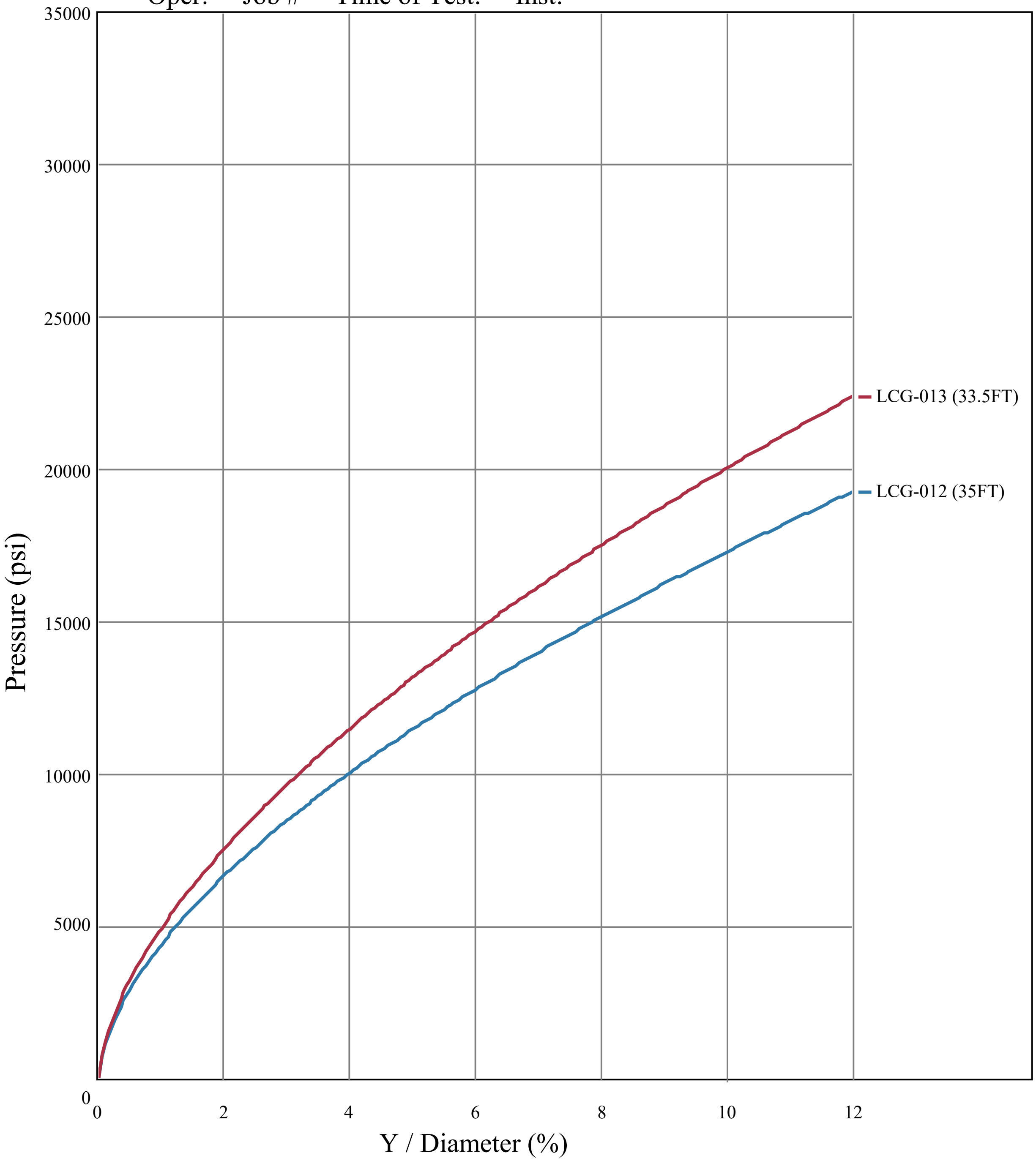
In Situ Engineering - PY Data - Frictional

Kleinfelder

Last Chance Grade

Boring: RC-20-007

Oper: Job # Time of Test: Inst:



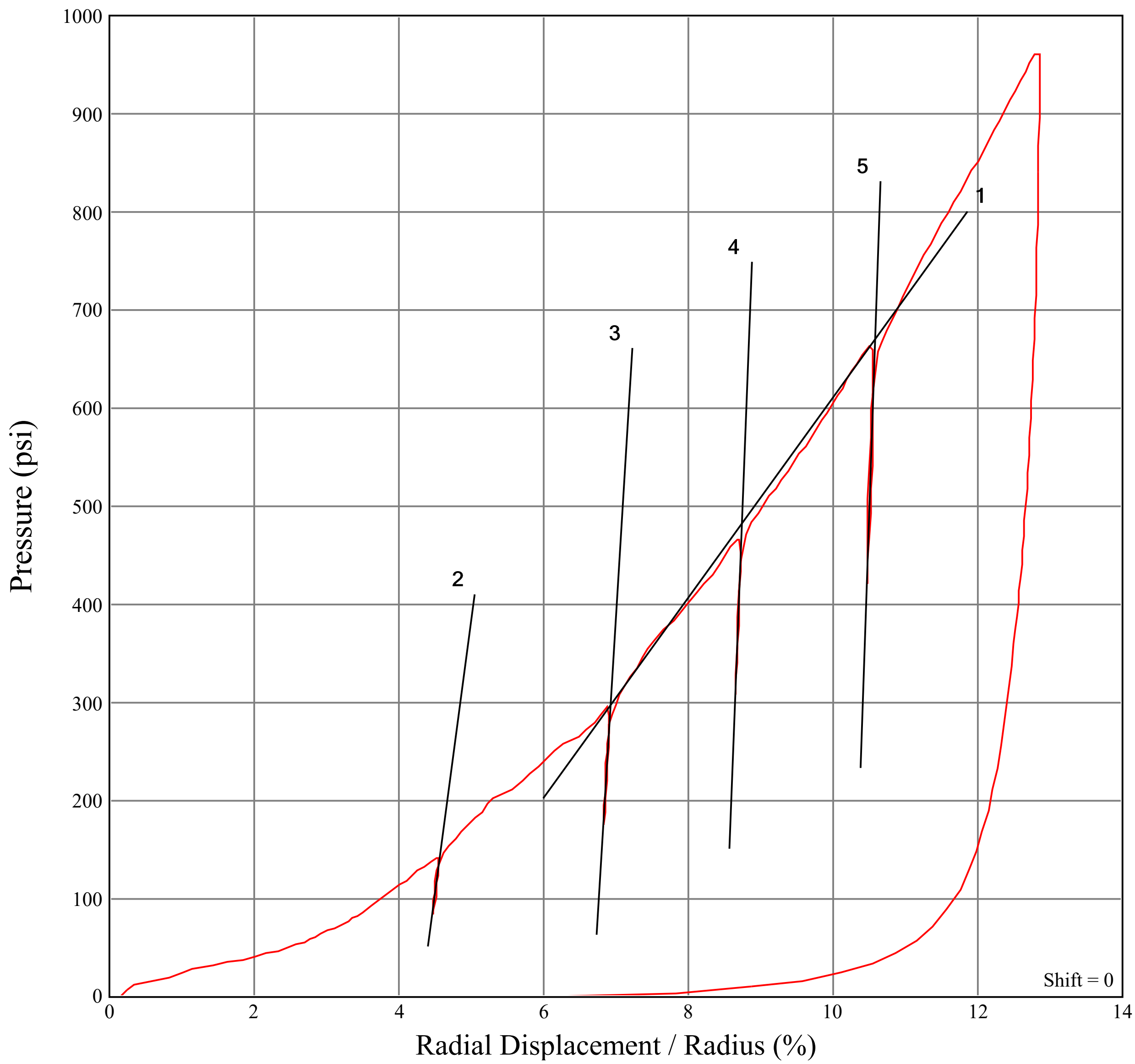
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-011 Test: LCG-014 Depth: 93.6FT Date: 10/23/2020

Oper: Mayfield Job # 0115000099 Time of Test: 03:50 PM Inst: 04



DATA

#1 Shear Modulus = 5100 psi

#2 Shear Modulus = 27800 psi

#3 Shear Modulus = 60600 psi

#4 Shear Modulus = 95900 psi

#5 Shear Modulus = 108500 psi

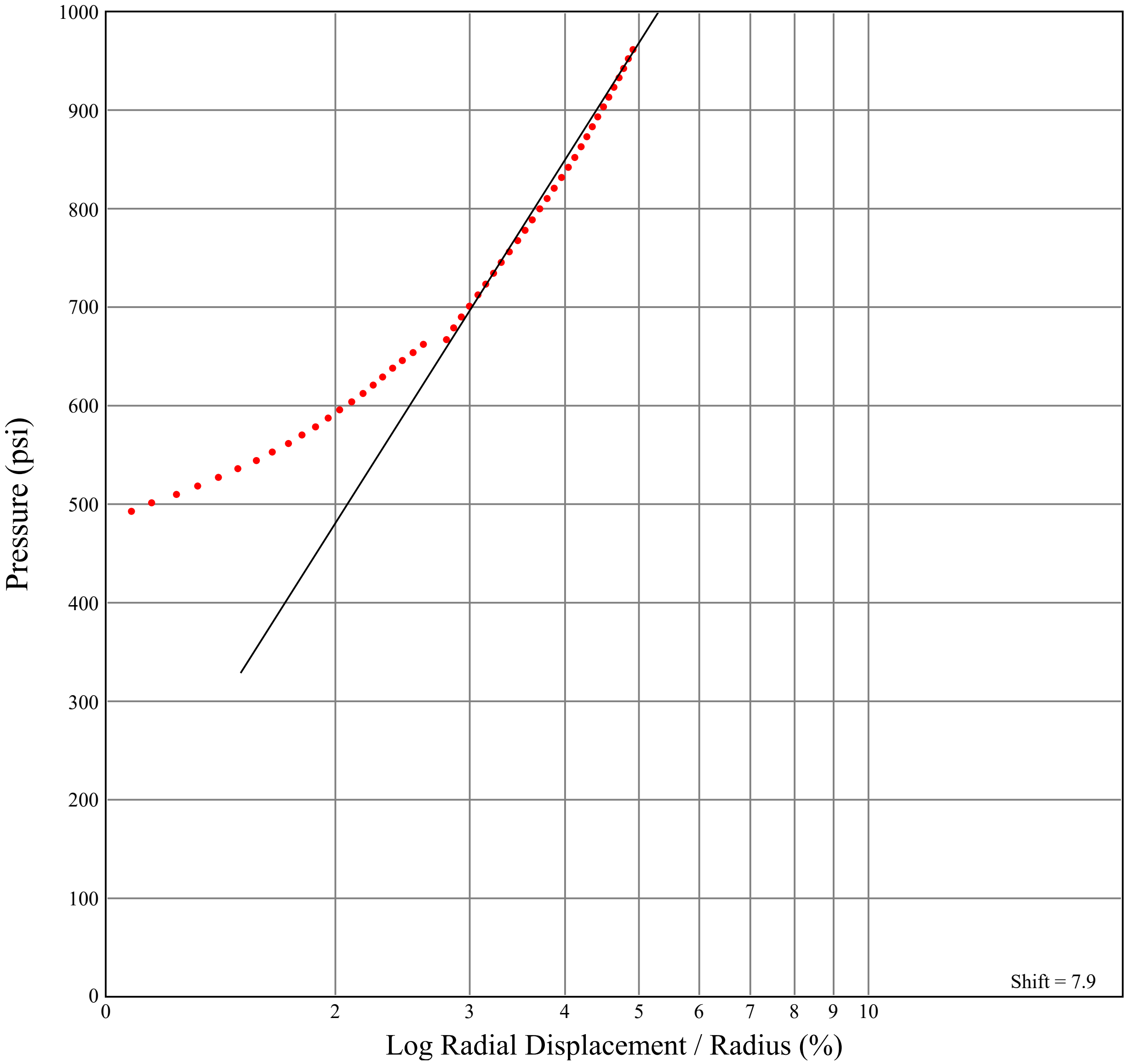
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-011 Test: LCG-014 Depth: 93.6FT Date: 10/23/2020

Oper: Mayfield Job # 0115000099 Time of Test: 03:50 PM Inst: 04



DATA

Shear Strength = 532 psi

Limit Pressure = 2089 psi

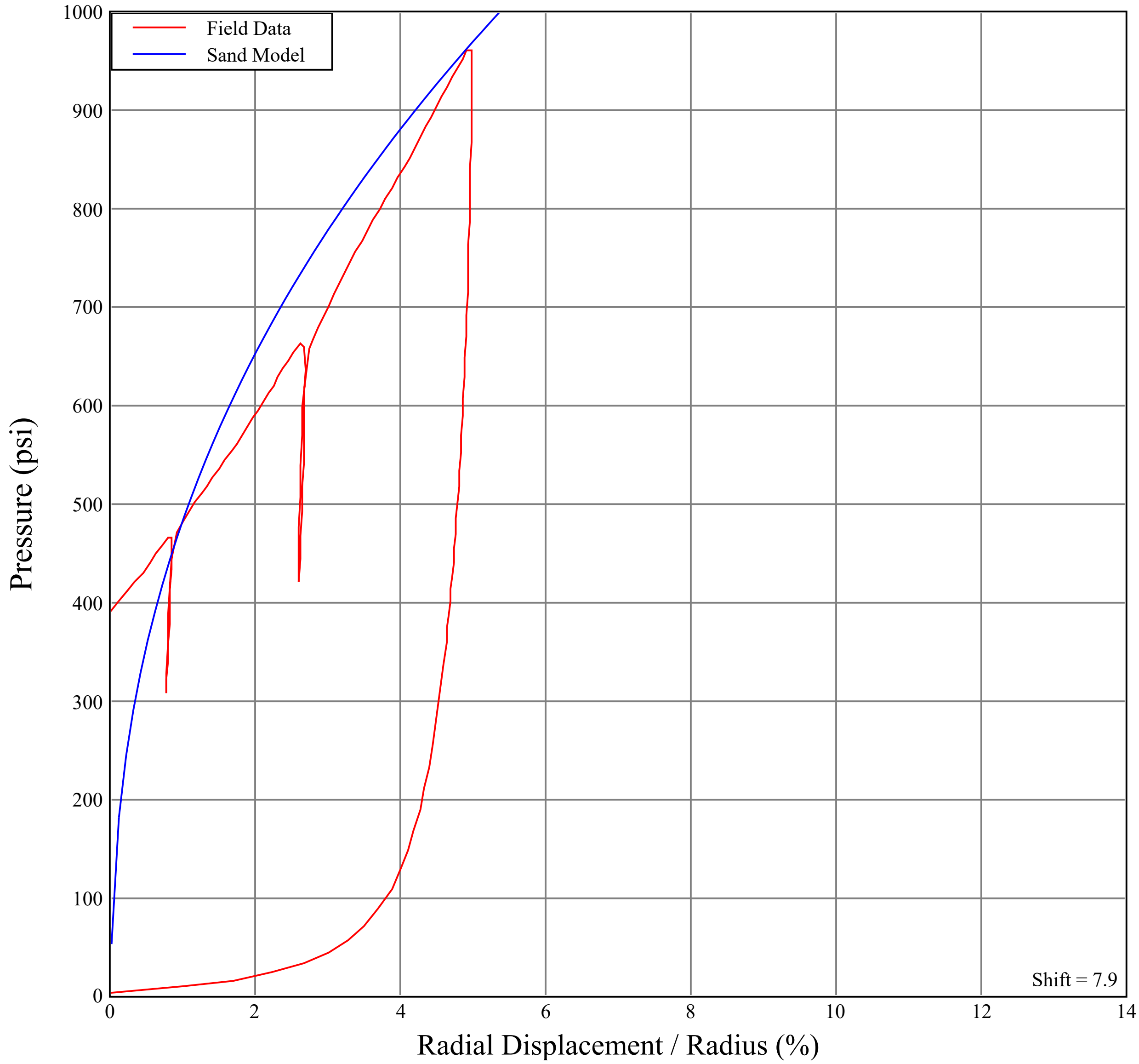
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-011 Test: LCG-014 Depth: 93.6FT Date: 10/23/2020

Oper: Mayfield Job # 0115000099 Time of Test: 03:50 PM Inst: 04



DATA

Water Pressure = 0 psi

Friction Angle = 38 deg

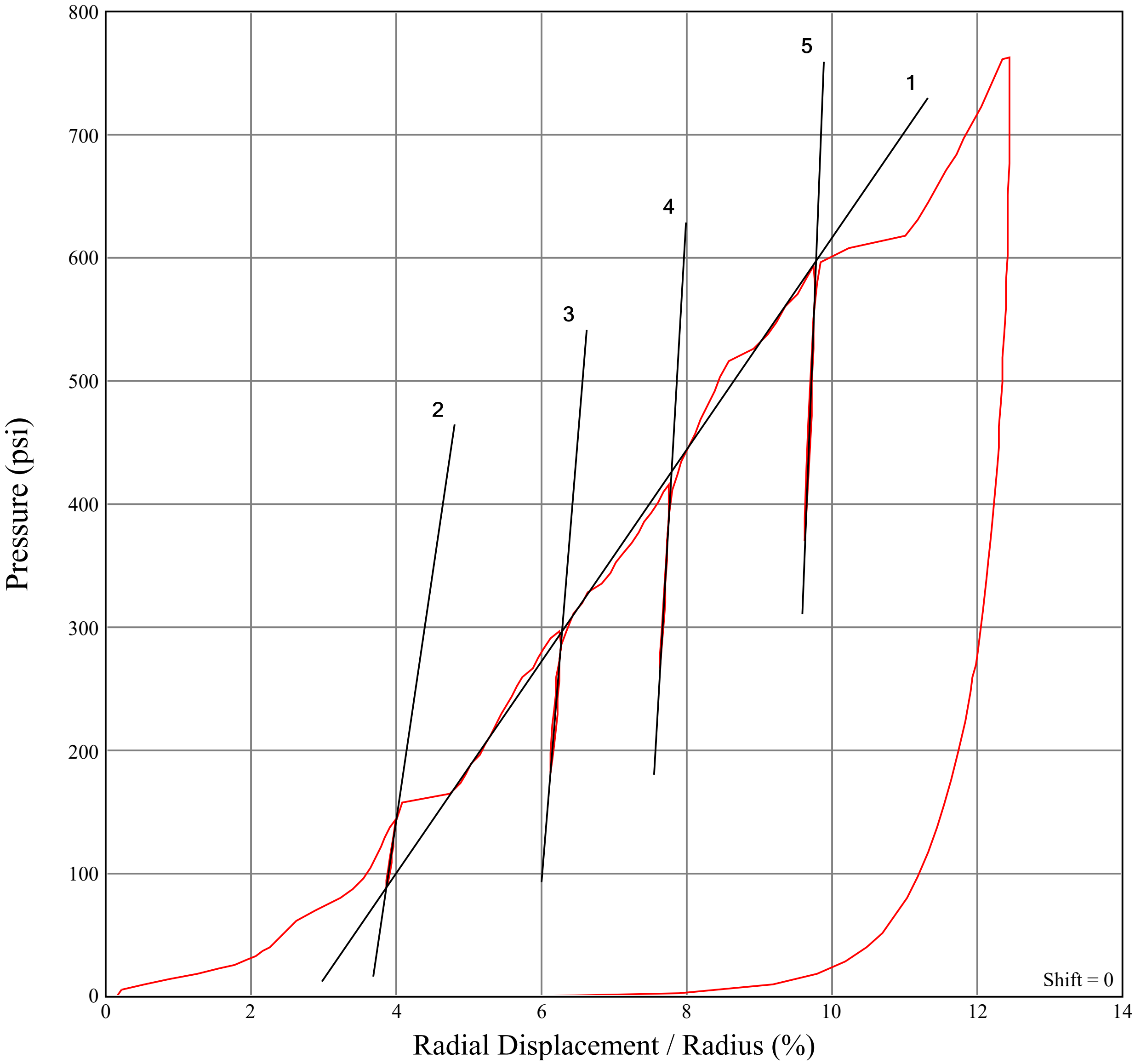
Critical Friction Angle = 32 deg

Lateral Stress = 52 psi

Shear Modulus = 95600 psi

In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-011 Test: LCG-015 Depth: 92.1FT Date: 10/23/2020
Oper: Mayfield Job # 0115000099 Time of Test: 04:17 PM Inst: 04



DATA

#1 Shear Modulus = 4300 psi

#2 Shear Modulus = 20000 psi

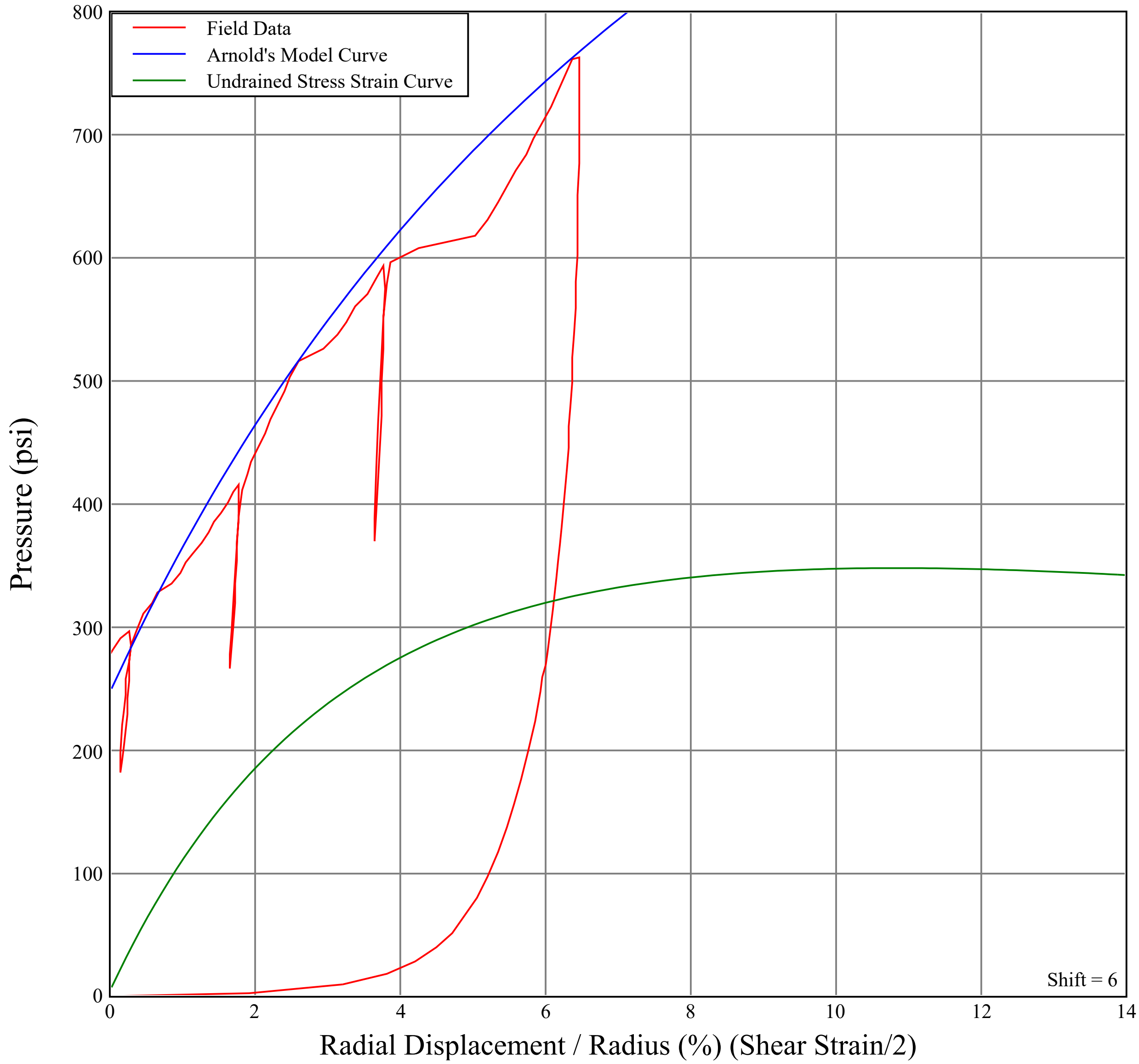
#3 Shear Modulus = 36000 psi

#4 Shear Modulus = 51000 psi

#5 Shear Modulus = 76000 psi

In Situ Engineering - Arnold's Clay Model

Kleinfelder
Last Chance Grade
Boring: RC-20-011 Test: LCG-015 Depth: 92.1FT Date: 10/23/2020
Oper: Mayfield Job # 0115000099 Time of Test: 04:17 PM Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 367 psi	Shear Strength at 10% Strain = 347.4 psi
Pressure at 2.5% Strain = 510 psi	Max Shear Strength = 348.0 psi
Pressure at 7.5% Strain = 818 psi	occurs at 10.8% Strain

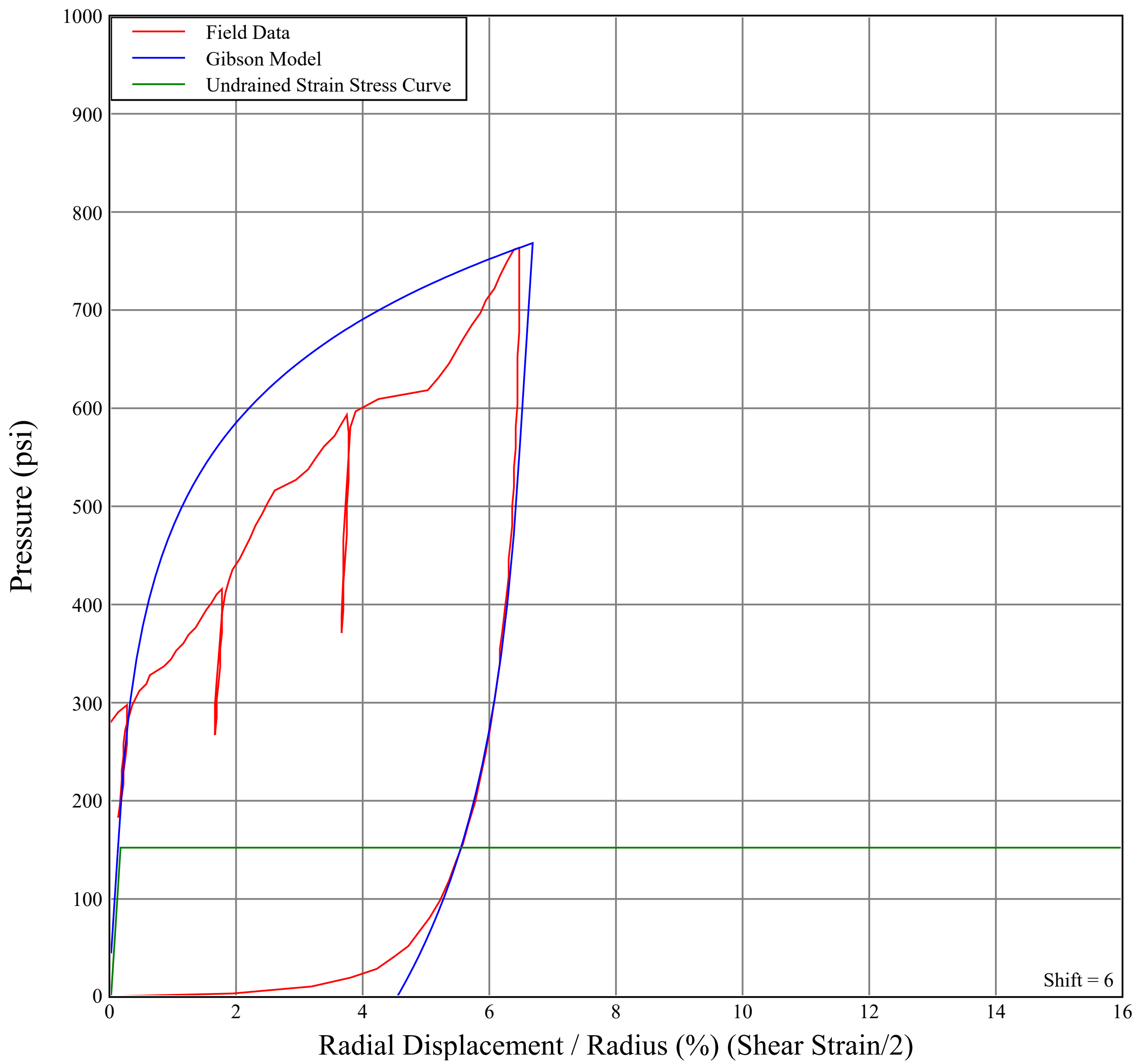
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-011 Test: LCG-015 Depth: 92.1FT Date: 10/23/2020

Oper: Mayfield Job # 0115000099 Time of Test: 04:17 PM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 151 psi	Shear Strength = 240 psi
In Situ Stress = 43 psi	Shear Modulus = 51000 psi
Shear Modulus = 51000 psi	

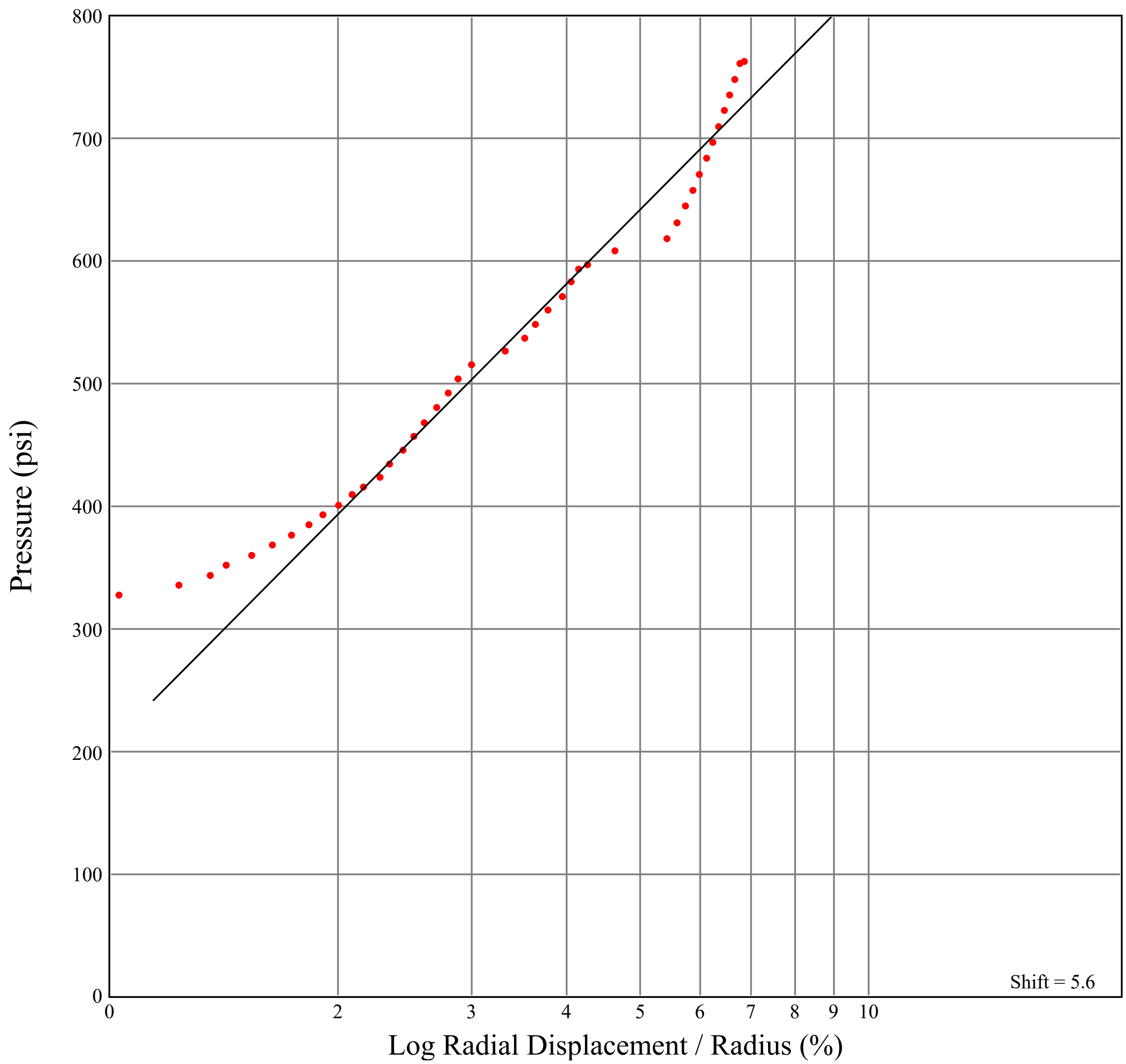
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-011 Test: LCG-015 Depth: 92.1FT Date: 10/23/2020

Oper: Mayfield Job # 0115000099 Time of Test: 04:17 PM Inst: 04



DATA

Shear Strength = 271 psi

Limit Pressure = 1213 psi

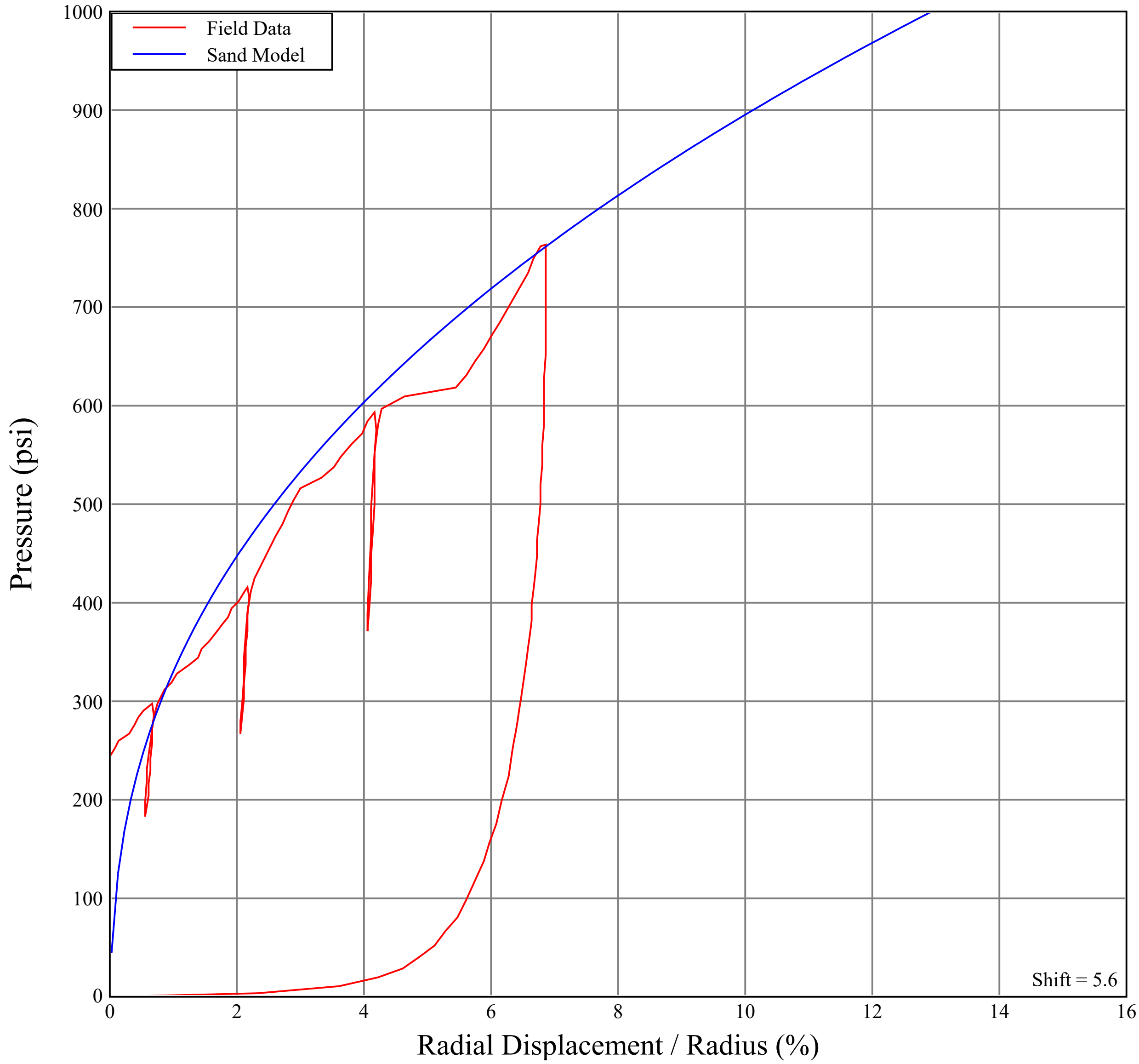
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-011 Test: LCG-015 Depth: 92.1FT Date: 10/23/2020

Oper: Mayfield Job # 0115000099 Time of Test: 04:17 PM Inst: 04



DATA

Water Pressure = 0 psi

Lateral Stress = 43 psi

Friction Angle = 38 deg

Shear Modulus = 51000 psi

Critical Friction Angle = 32 deg

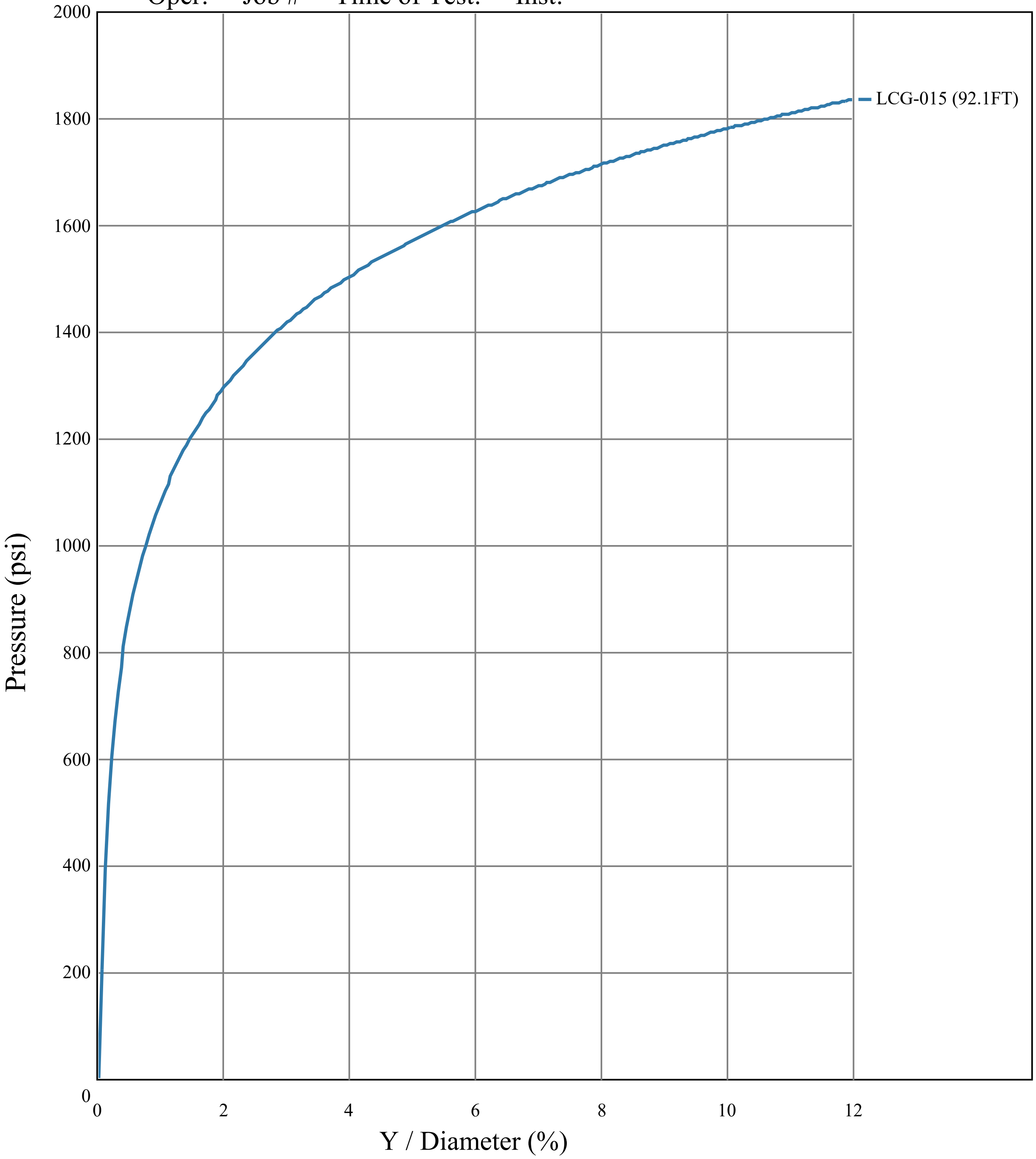
In Situ Engineering - PY Data - Cohesive

Kleinfelder

Last Chance Grade

Boring: RC-20-011

Oper: Job # Time of Test: Inst:



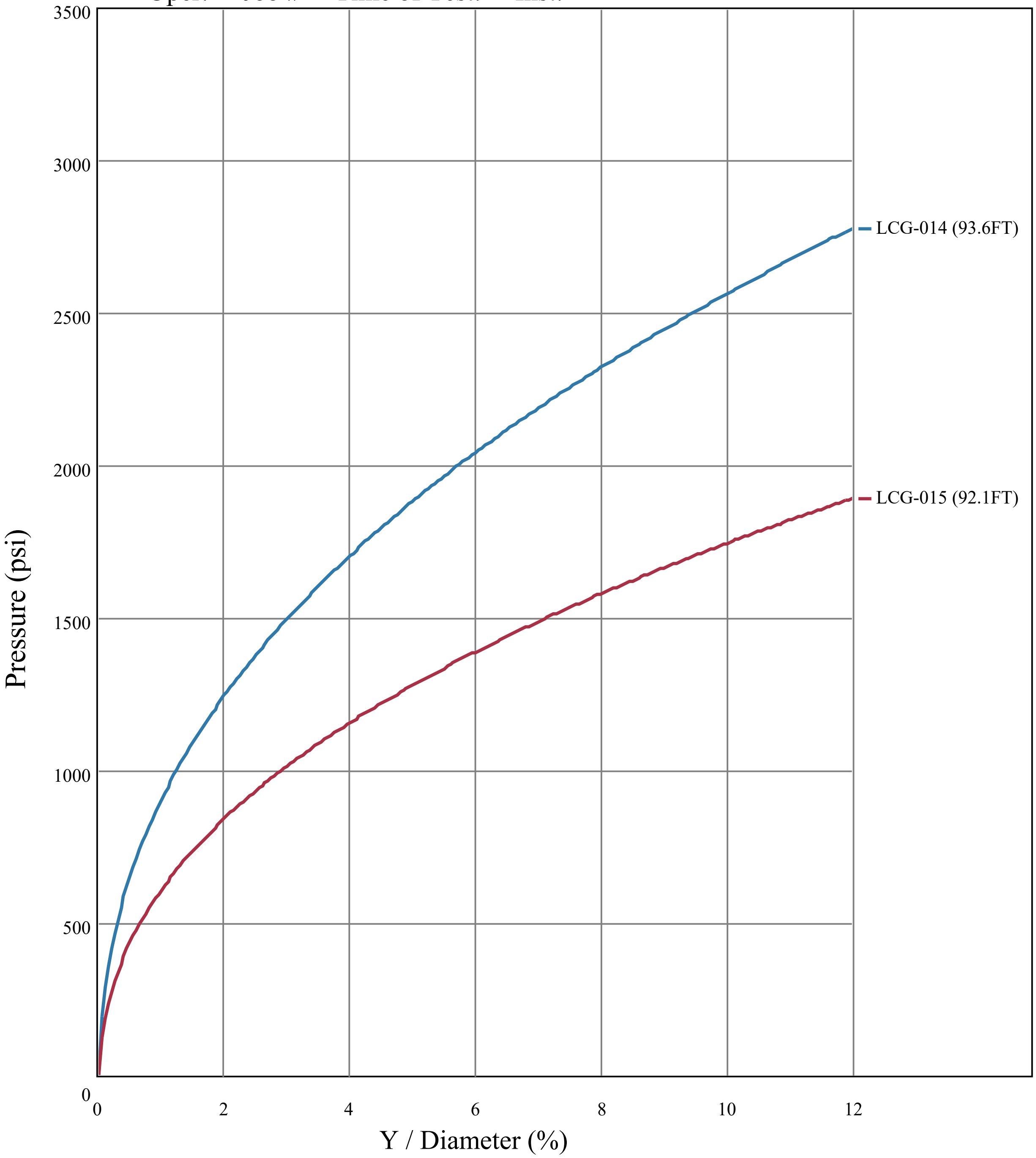
In Situ Engineering - PY Data - Frictional

Kleinfelder

Last Chance Grade

Boring: RC-20-011

Oper: Job # Time of Test: Inst:



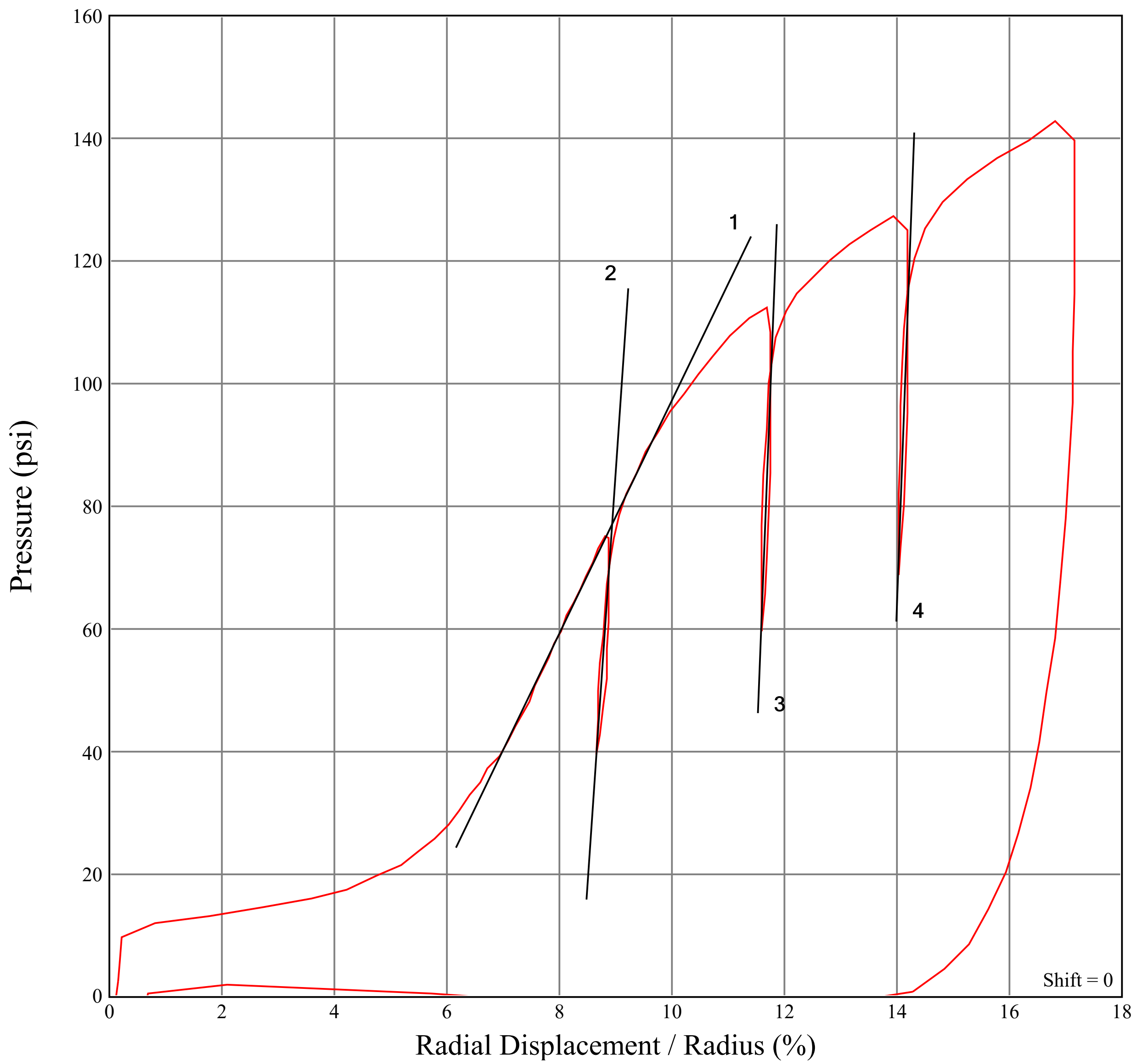
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-016 Depth: 15FT Date: 12/15/2020

Oper: Mayfield Job # 0115000099 Time of Test: 03:44 PM Inst: 04



DATA

#1 Shear Modulus = 950 psi

#2 Shear Modulus = 6720 psi

#3 Shear Modulus = 11780 psi

#4 Shear Modulus = 12550 psi

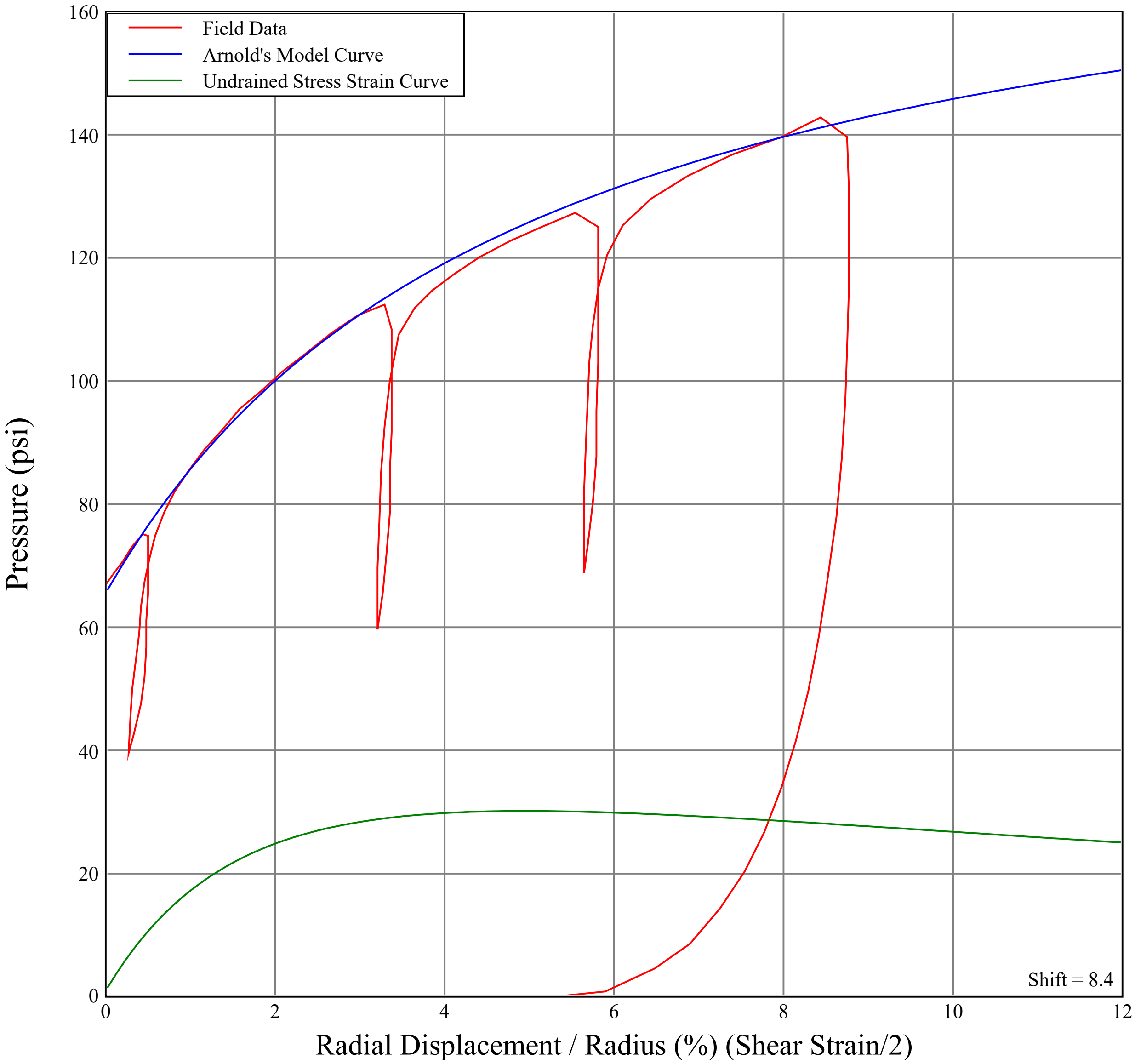
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-016 Depth: 15FT Date: 12/15/2020

Oper: Mayfield Job # 0115000099 Time of Test: 03:44 PM Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 86 psi	Shear Strength at 10% Strain = 26.6 psi
Pressure at 2.5% Strain = 106 psi	Max Shear Strength = 30.0 psi
Pressure at 7.5% Strain = 138 psi	occurs at 5% Strain

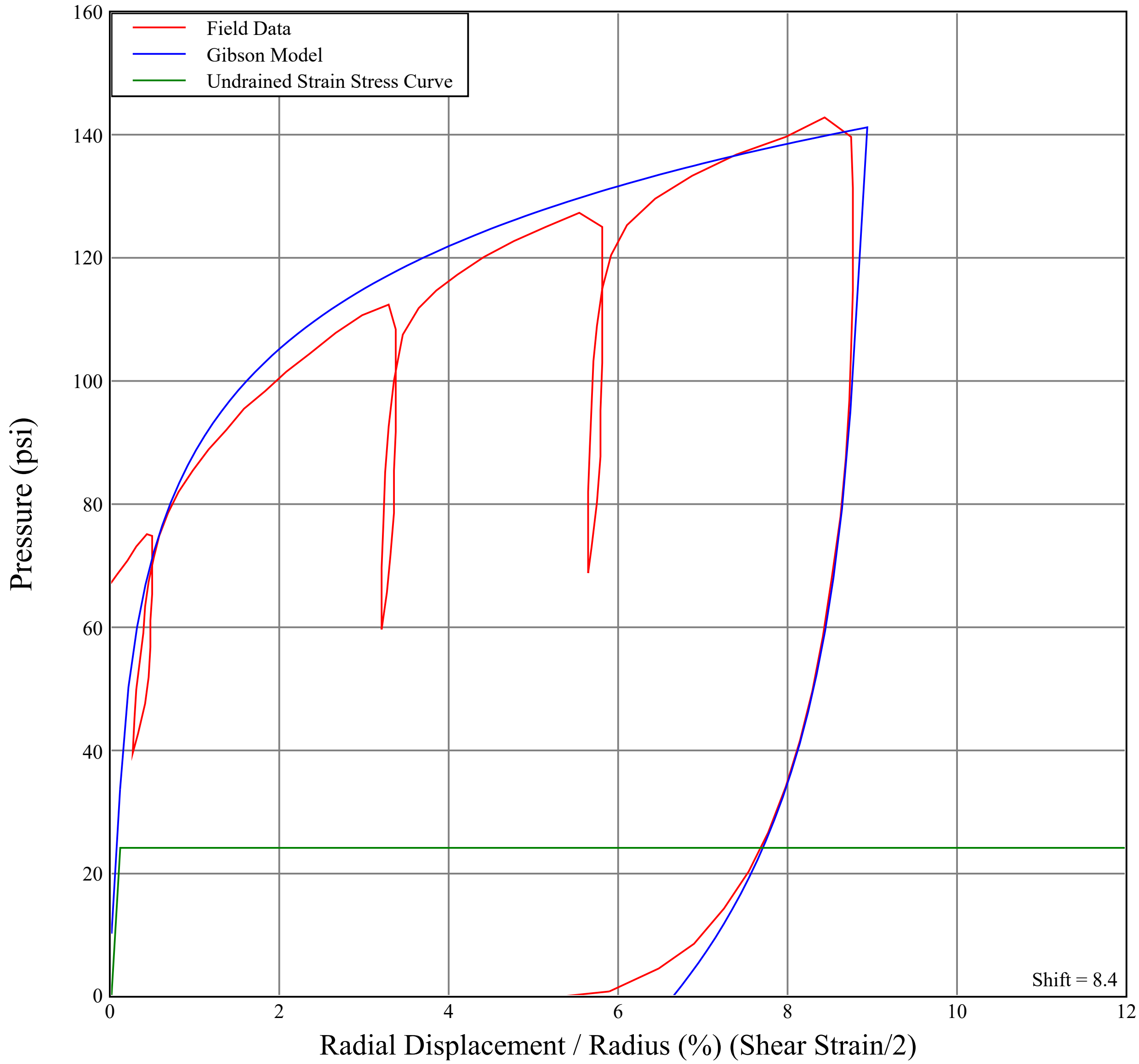
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-016 Depth: 15FT Date: 12/15/2020

Oper: Mayfield Job # 0115000099 Time of Test: 03:44 PM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 24 psi	Shear Strength = 39 psi
In Situ Stress = 10 psi	Shear Modulus = 11780 psi
Shear Modulus = 11780 psi	

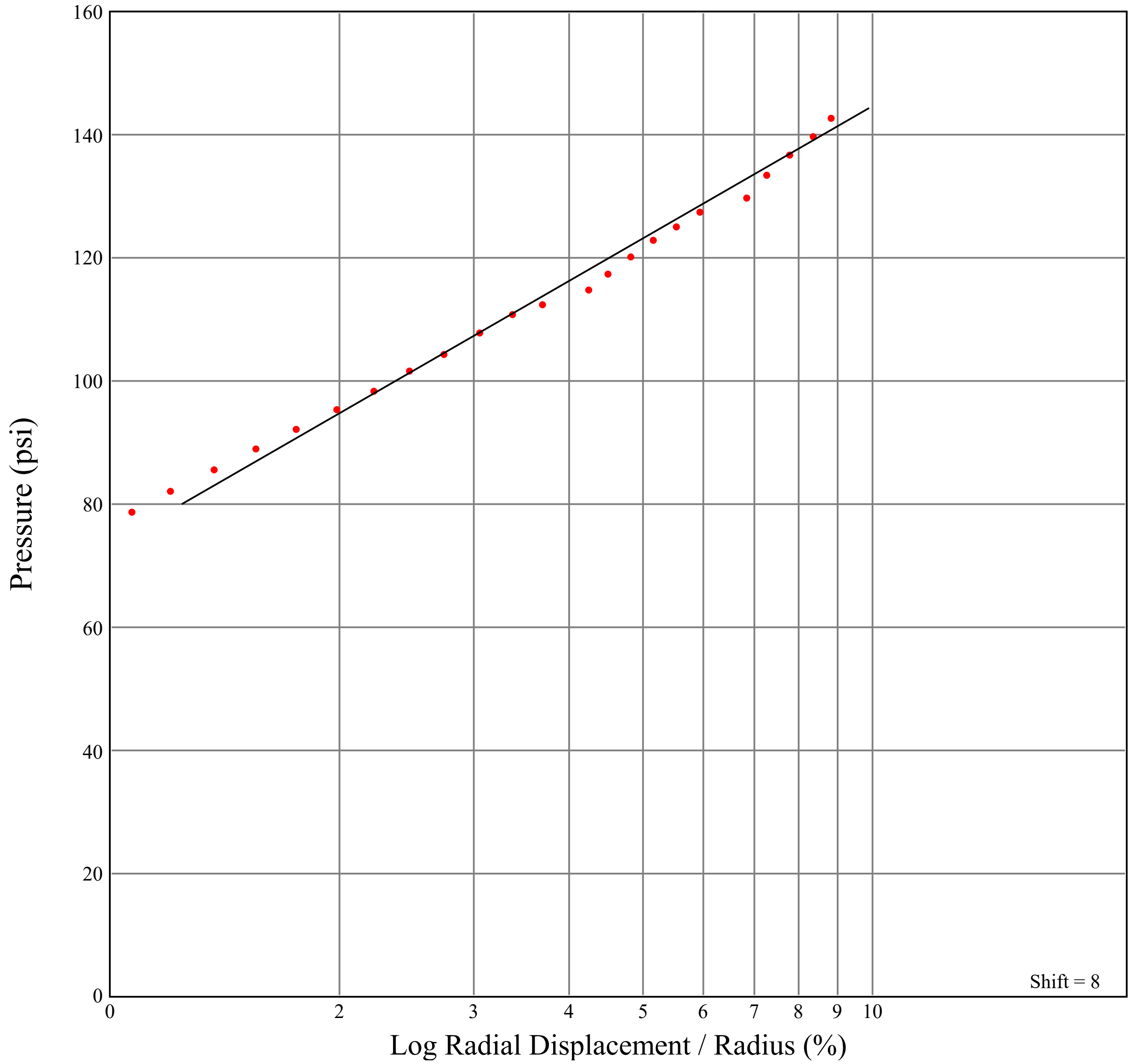
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-016 Depth: 15FT Date: 12/15/2020

Oper: Mayfield Job # 0115000099 Time of Test: 03:44 PM Inst: 04



DATA

Shear Strength = 31 psi

Limit Pressure = 189 psi

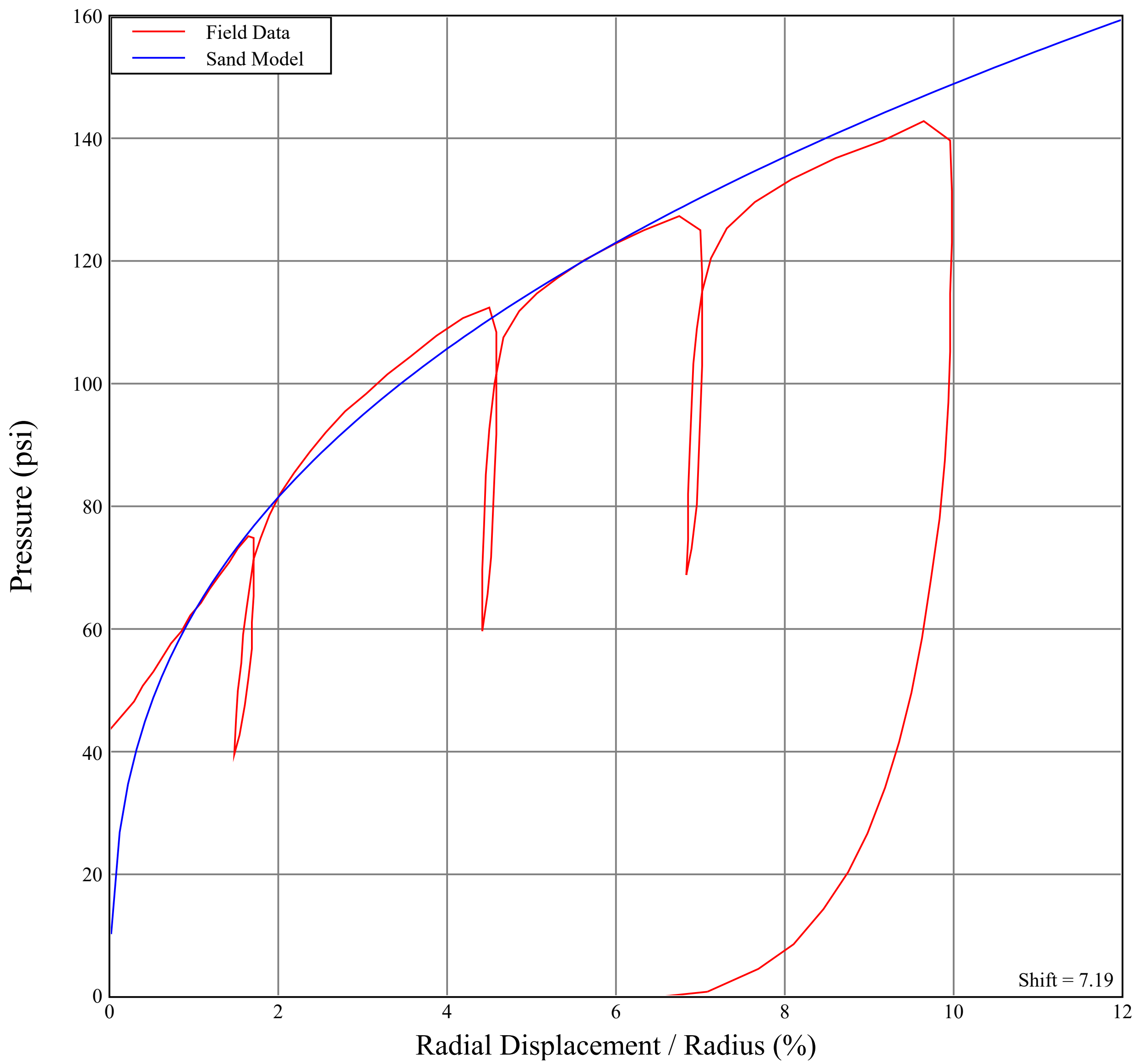
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-016 Depth: 15FT Date: 12/15/2020

Oper: Mayfield Job # 0115000099 Time of Test: 03:44 PM Inst: 04



DATA

Water Pressure = 0 psi

Lateral Stress = 10 psi

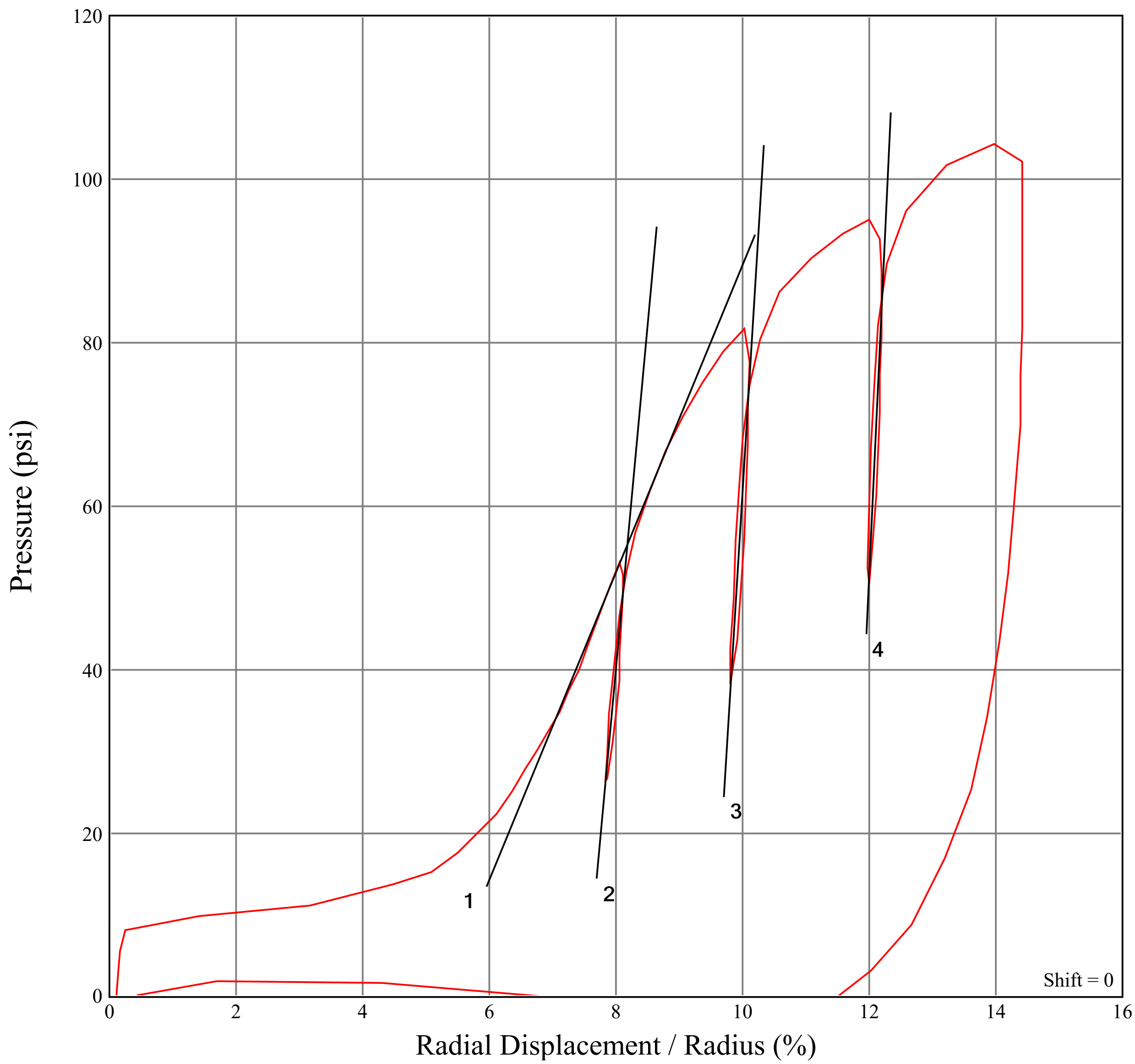
Friction Angle = 34 deg

Shear Modulus = 11780 psi

Critical Friction Angle = 32 deg

In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-019   Test: LCG-017   Depth: 13.5FT   Date: 12/15/2020
Oper: Mayfield   Job # 0115000099   Time of Test: 04:01 PM   Inst: 04



DATA

#1 Shear Modulus = 940 psi

#2 Shear Modulus = 4200 psi

#3 Shear Modulus = 6300 psi

#4 Shear Modulus = 8300 psi

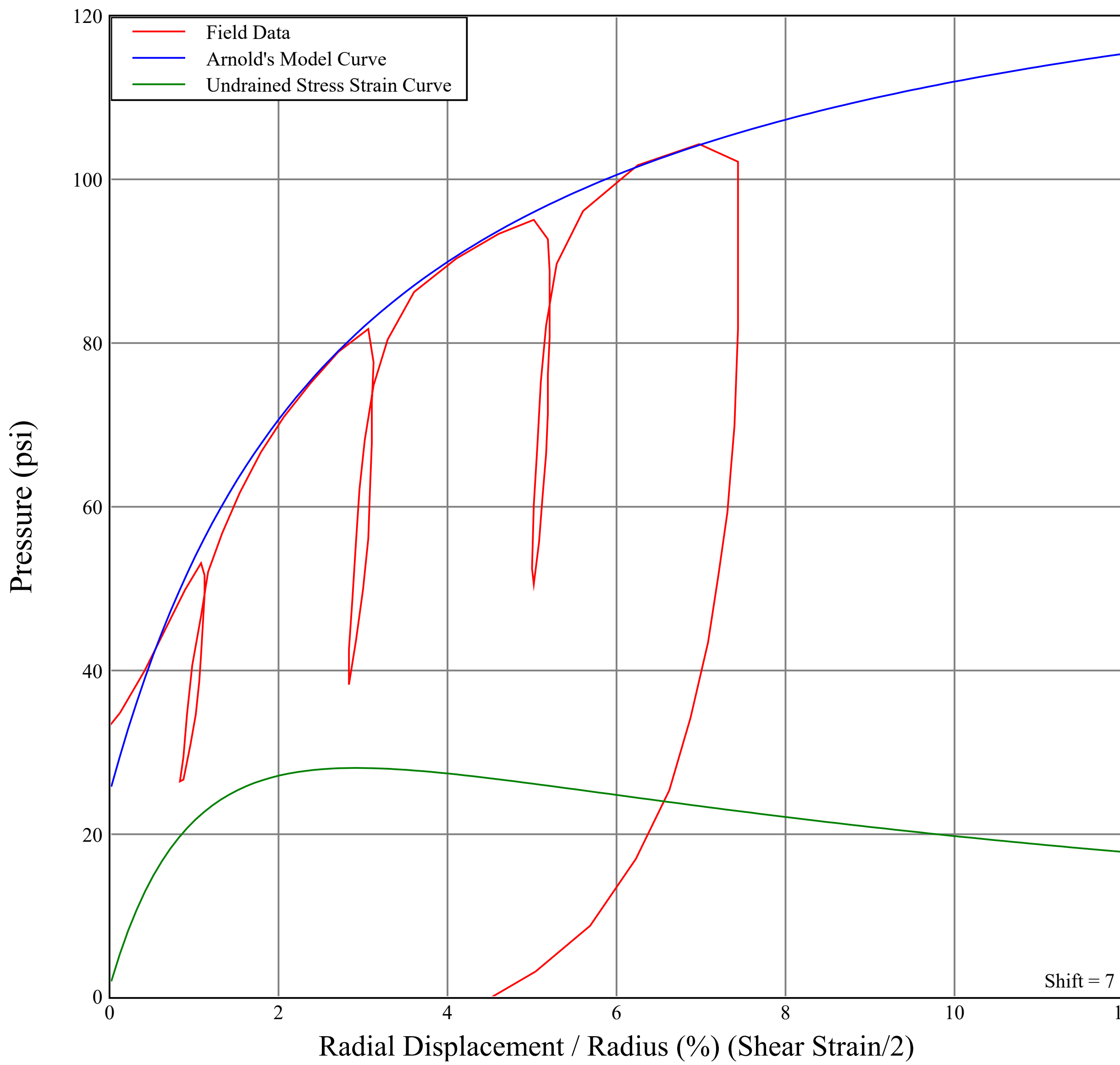
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019   Test: LCG-017   Depth: 13.5FT   Date: 12/15/2020

Oper: Mayfield   Job # 0115000099   Time of Test: 04:01 PM   Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 54 psi	Shear Strength at 10% Strain = 19.7 psi
Pressure at 2.5% Strain = 77 psi	Max Shear Strength = 28.0 psi
Pressure at 7.5% Strain = 106 psi	occurs at 2.9% Strain

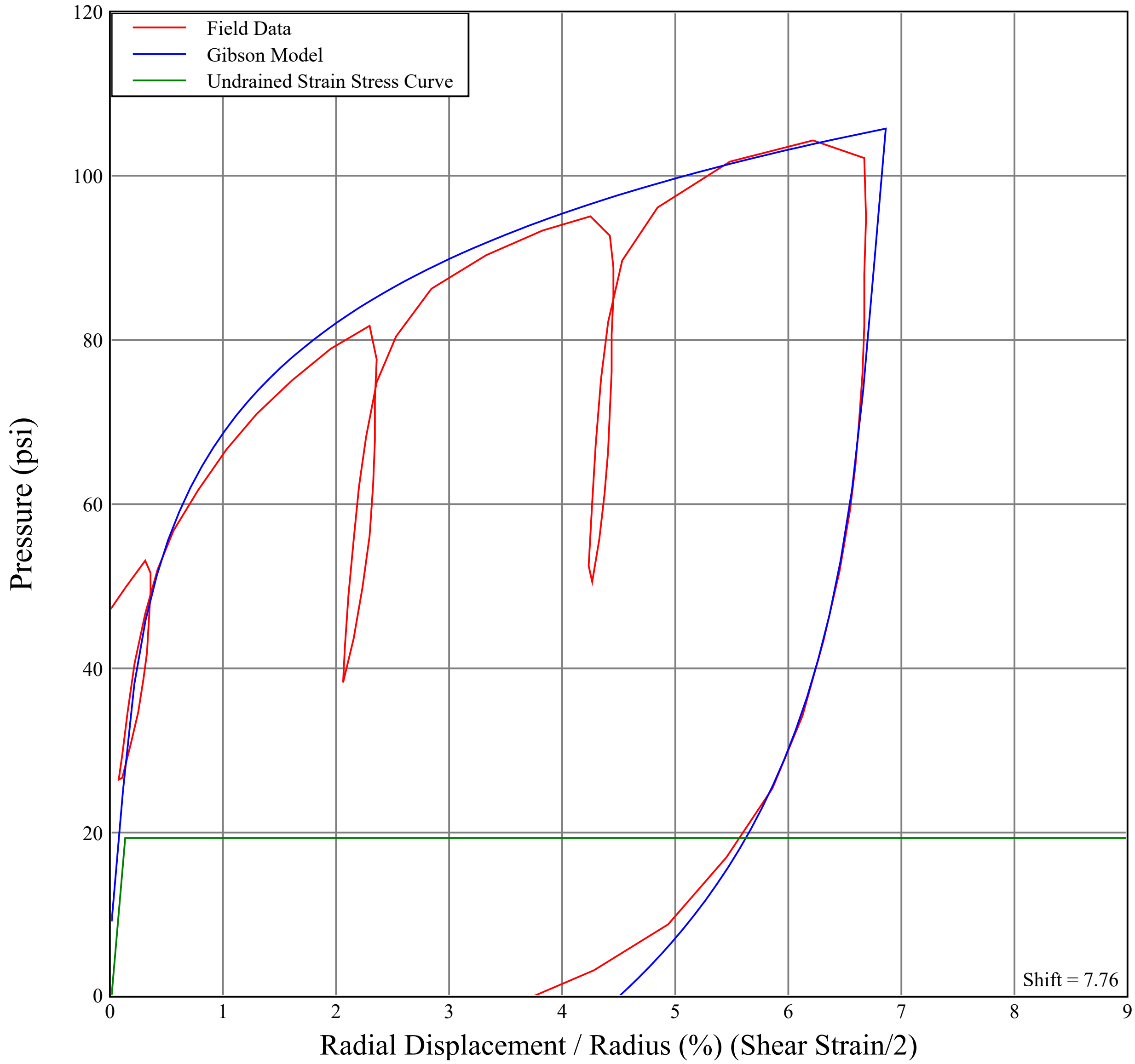
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-017 Depth: 13.5FT Date: 12/15/2020

Oper: Mayfield Job # 0115000099 Time of Test: 04:01 PM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 19.2 psi	Shear Strength = 30 psi
In Situ Stress = 9 psi	Shear Modulus = 8000 psi
Shear Modulus = 8000 psi	

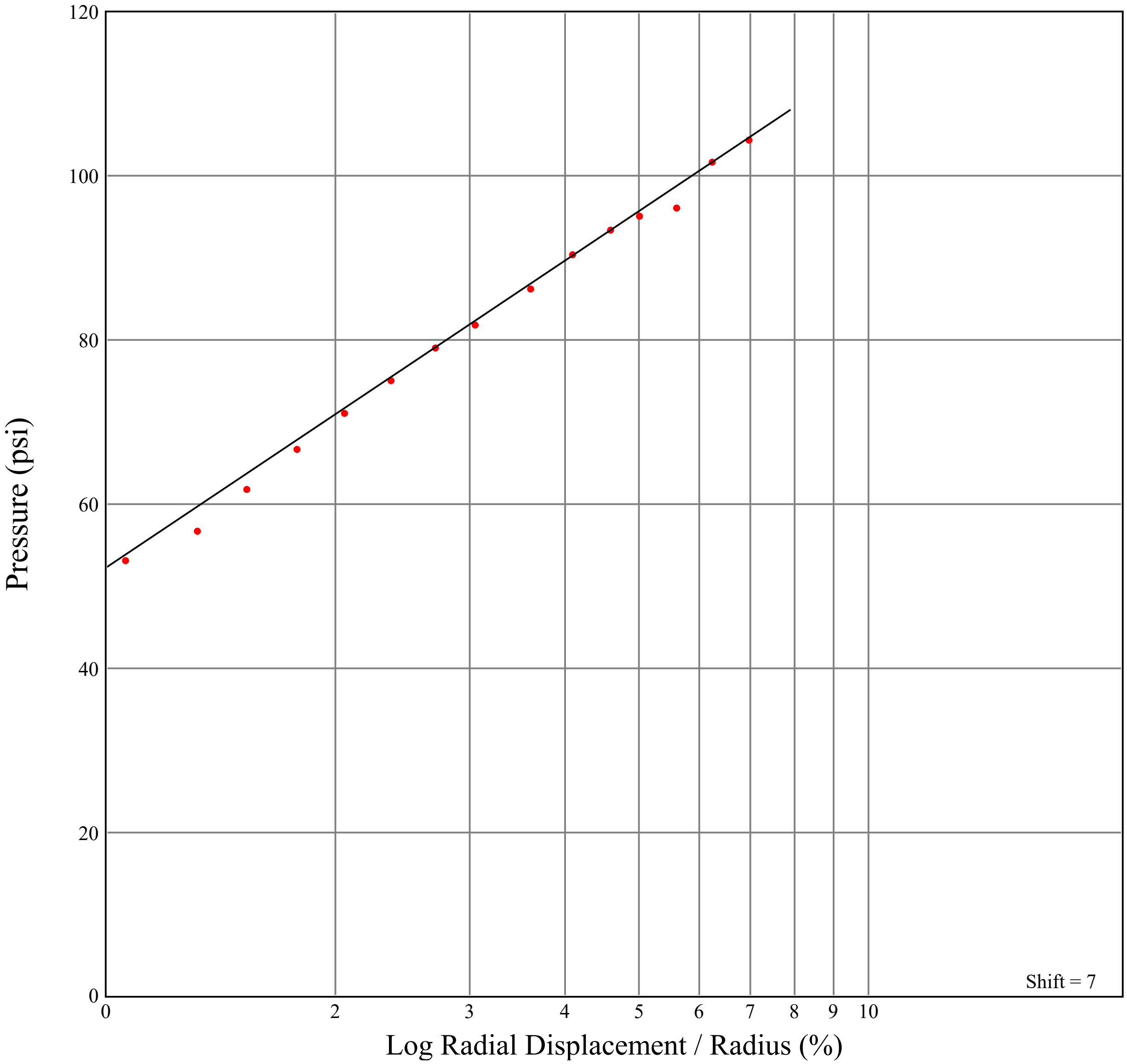
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-017 Depth: 13.5FT Date: 12/15/2020

Oper: Mayfield Job # 0115000099 Time of Test: 04:01 PM Inst: 04



DATA

Shear Strength = 27 psi

Limit Pressure = 153 psi

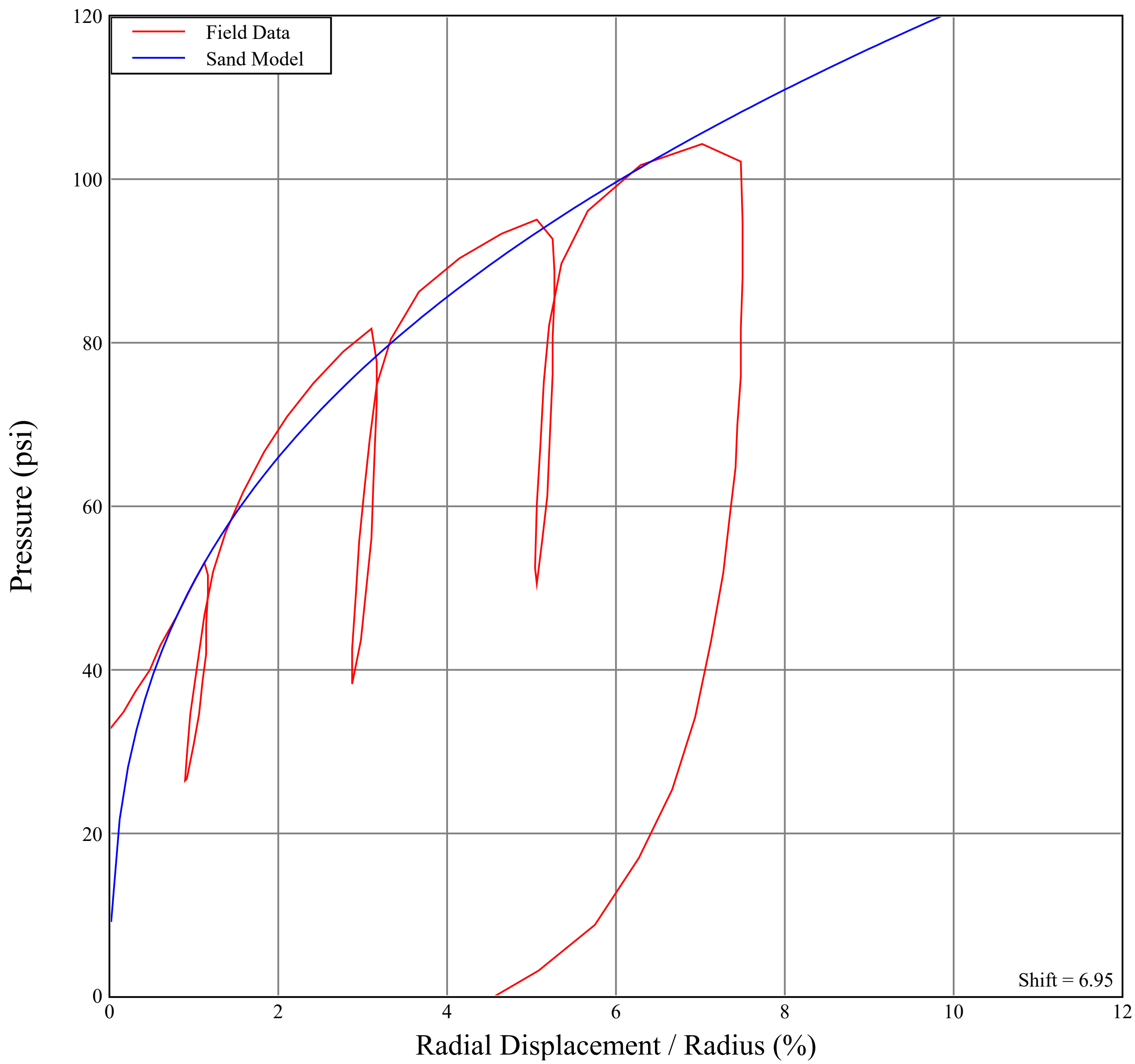
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019   Test: LCG-017   Depth: 13.5FT   Date: 12/15/2020

Oper: Mayfield   Job # 0115000099   Time of Test: 04:01 PM   Inst: 04



DATA

Water Pressure = 0 psi	Lateral Stress = 9 psi
Friction Angle = 34 deg	Shear Modulus = 8000 psi
Critical Friction Angle = 32 deg	

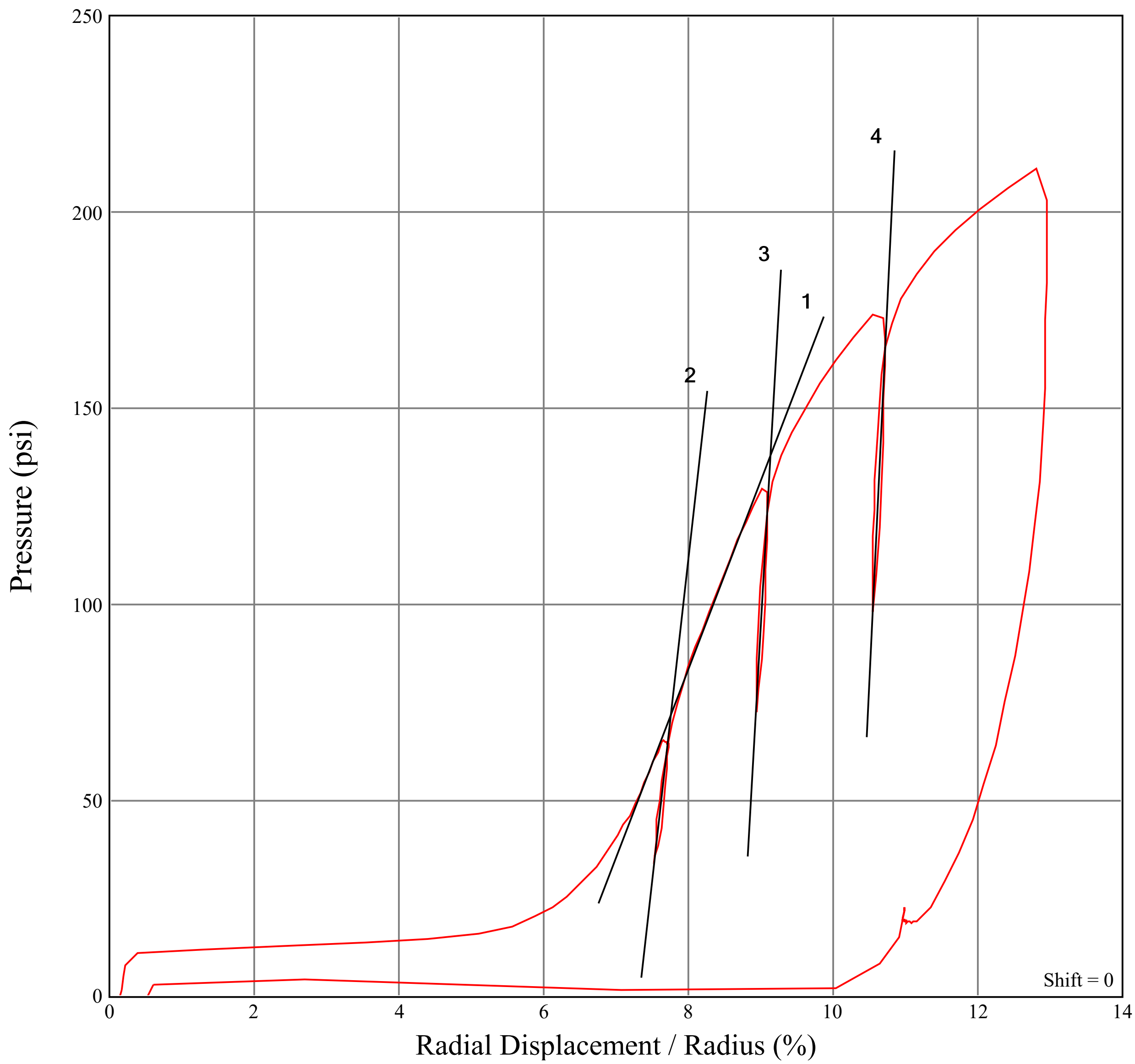
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-018 Depth: 20FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 09:16 AM Inst: 04



DATA

#1 Shear Modulus = 2400 psi

#2 Shear Modulus = 8200 psi

#3 Shear Modulus = 16300 psi

#4 Shear Modulus = 19400 psi

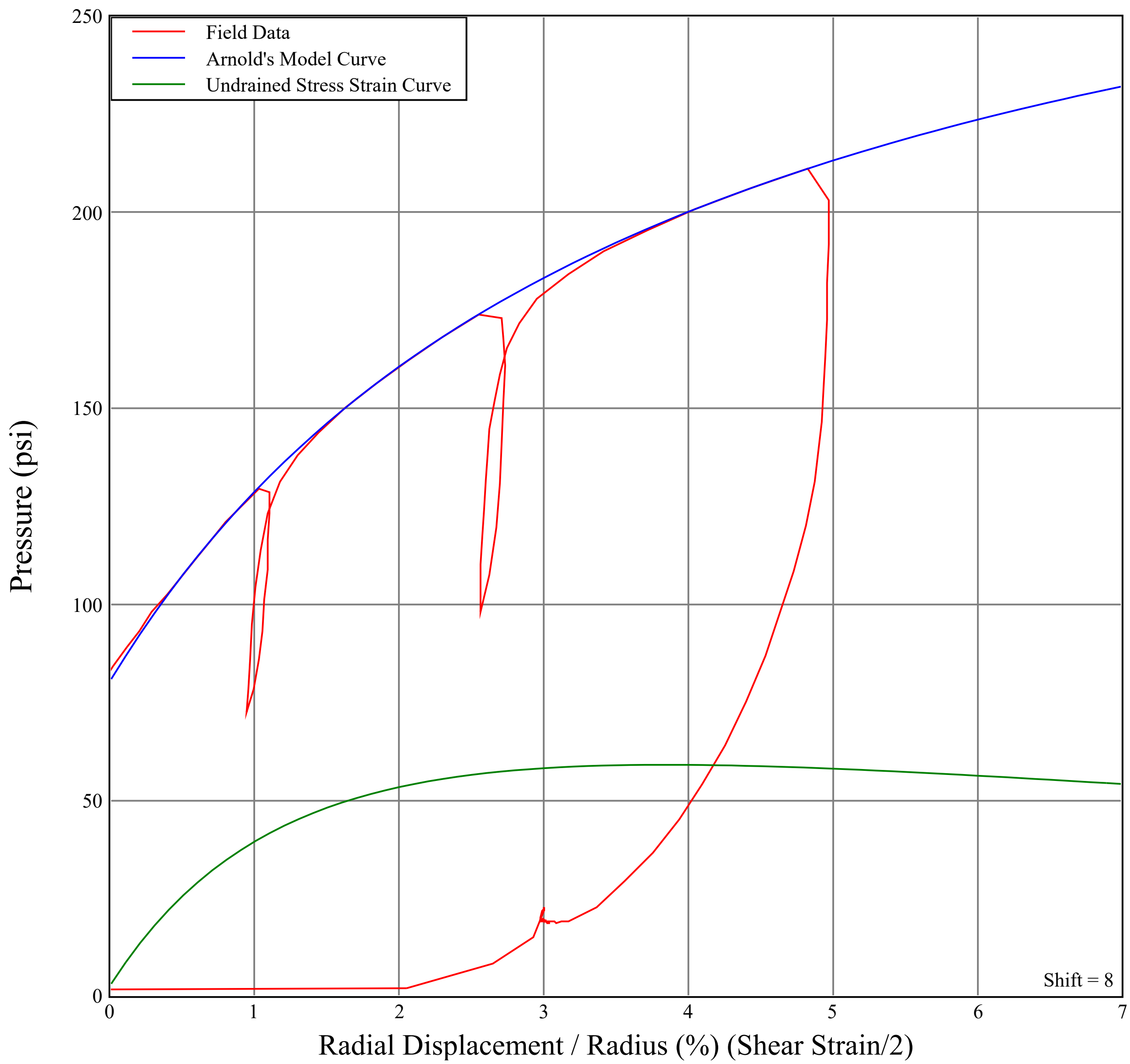
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-018 Depth: 20FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 09:16 AM Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 129 psi	Shear Strength at 10% Strain = 47.4 psi
Pressure at 2.5% Strain = 173 psi	Max Shear Strength = 58.9 psi
Pressure at 7.5% Strain = 236 psi	occurs at 3.8% Strain

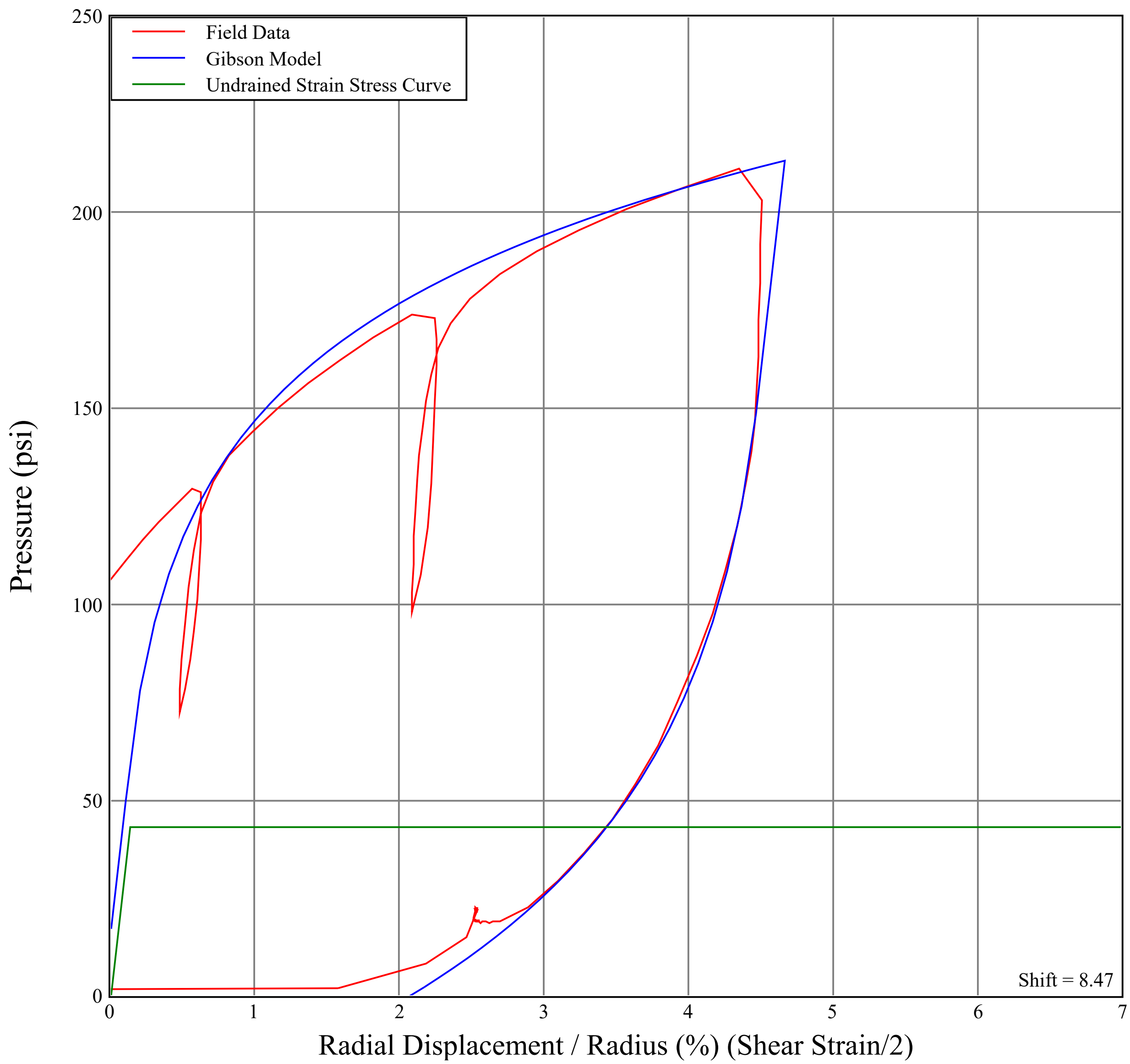
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-018 Depth: 20FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 09:16 AM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 43 psi	Shear Strength = 58 psi
In Situ Stress = 17 psi	Shear Modulus = 16300 psi
Shear Modulus = 16300 psi	

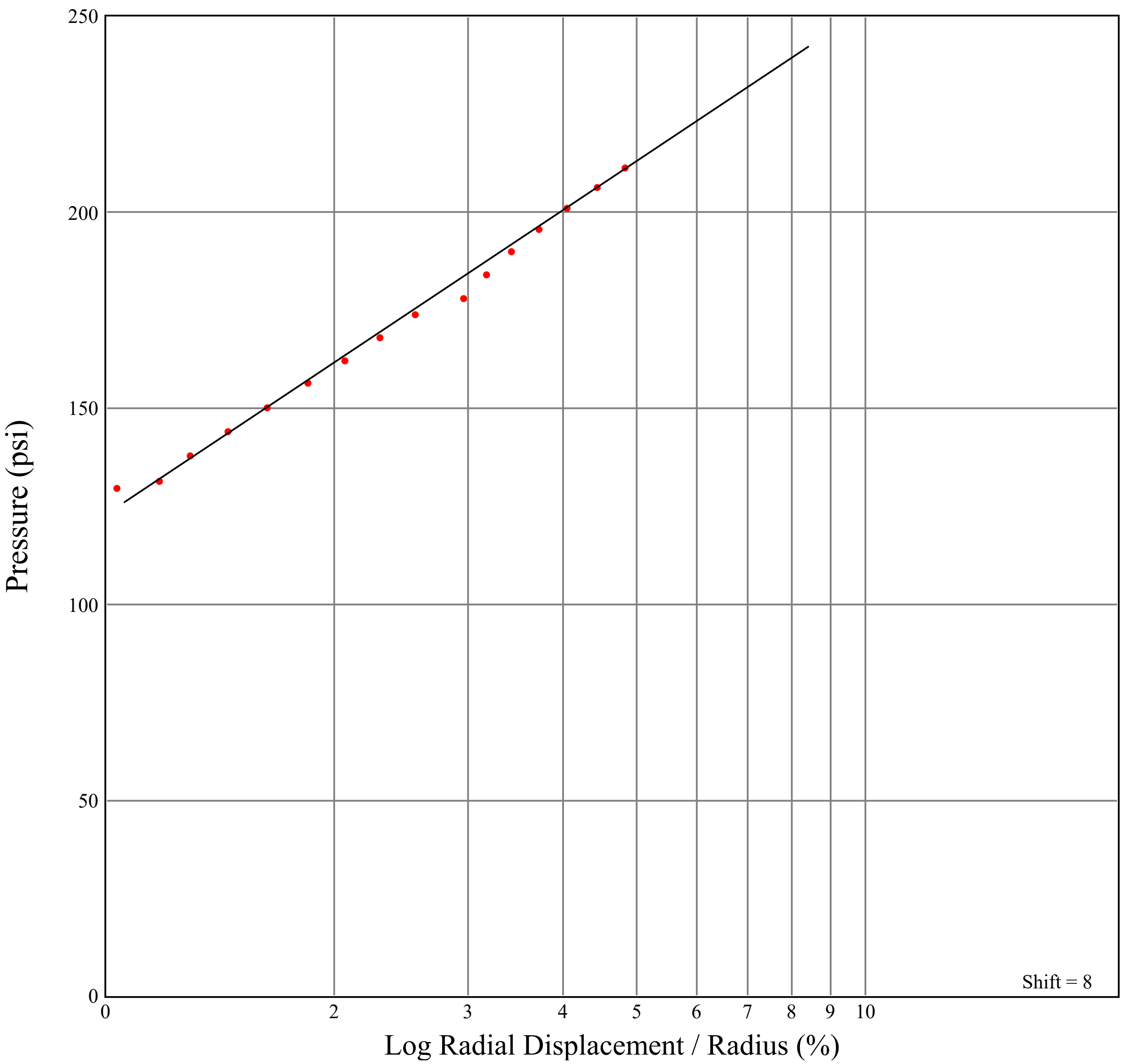
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-018 Depth: 20FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 09:16 AM Inst: 04



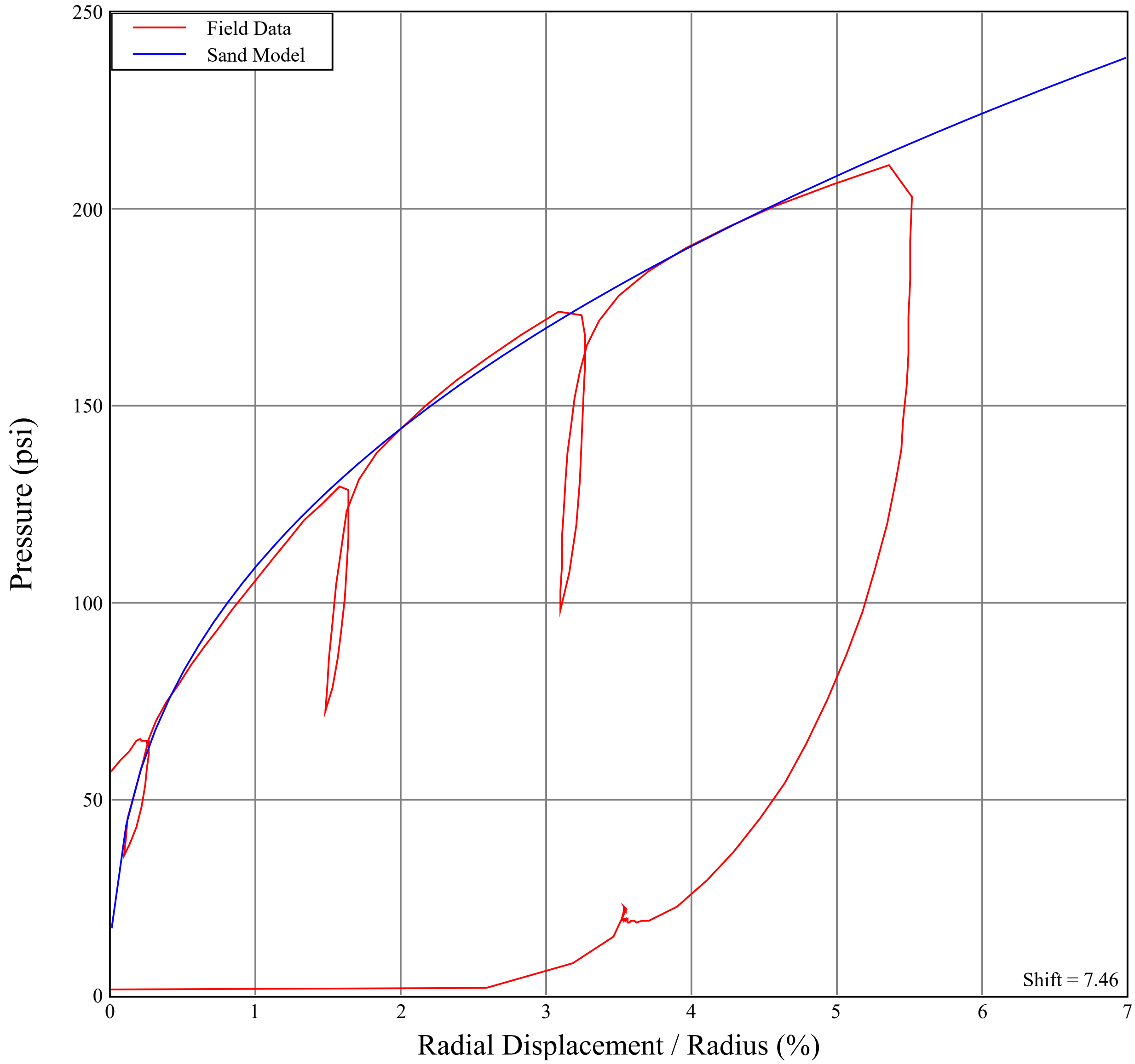
DATA

Shear Strength = 56 psi

Limit Pressure = 331 psi

In Situ Engineering - Hughes' Sand Model

Kleinfelder
Last Chance Grade
Boring: RC-20-019 Test: LCG-018 Depth: 20FT Date: 12/16/2020
Oper: Mayfield Job # 0115000099 Time of Test: 09:16 AM Inst: 04

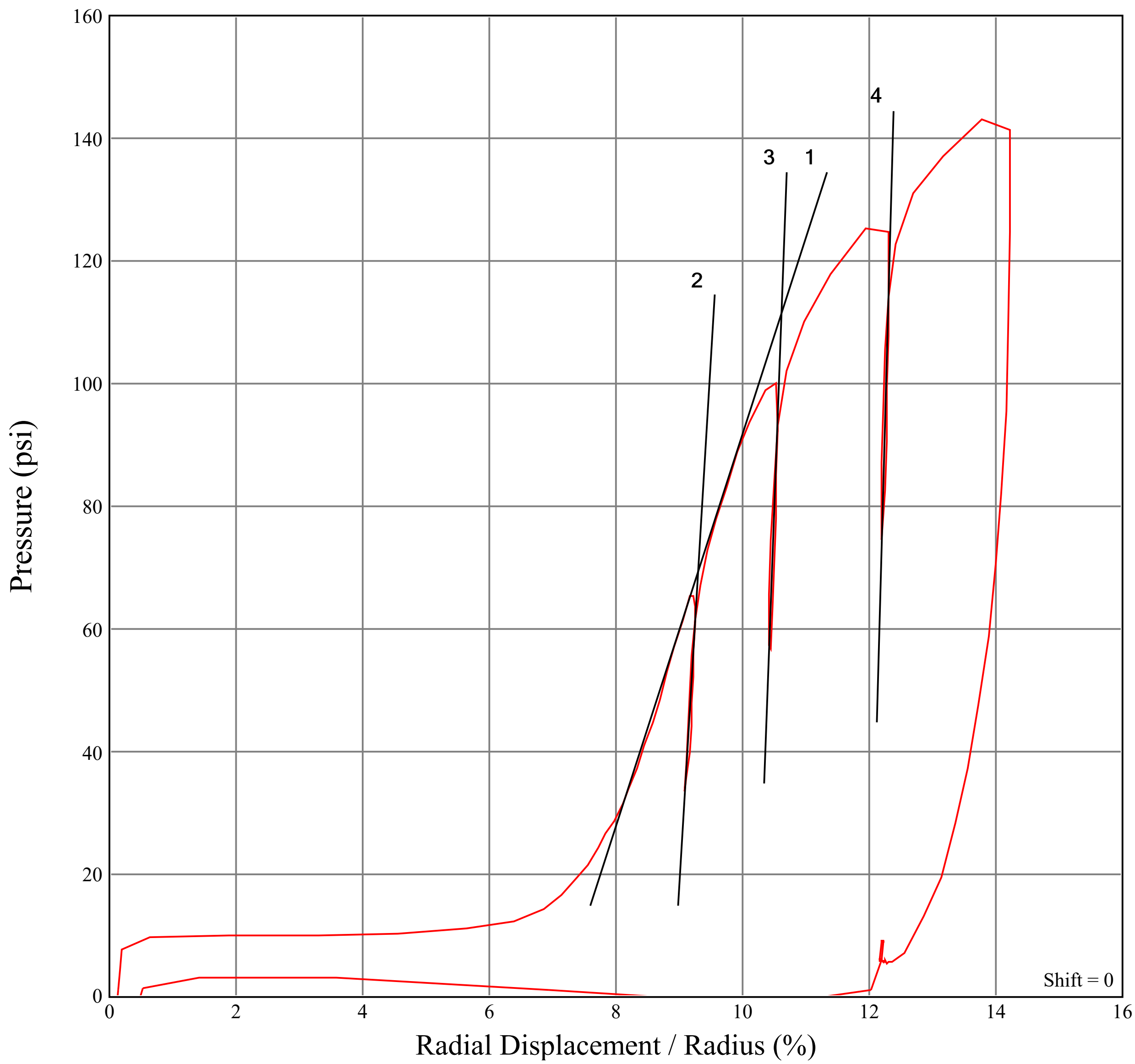


DATA

Water Pressure = 0 psi
Friction Angle = 36 deg
Critical Friction Angle = 32 deg
Lateral Stress = 17 psi
Shear Modulus = 16300 psi

In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-019 Test: LCG-019 Depth: 18.5FT Date: 12/16/2020
Oper: Mayfield Job # 0115000099 Time of Test: 09:37 AM Inst: 04



DATA

#1 Shear Modulus = 1600 psi

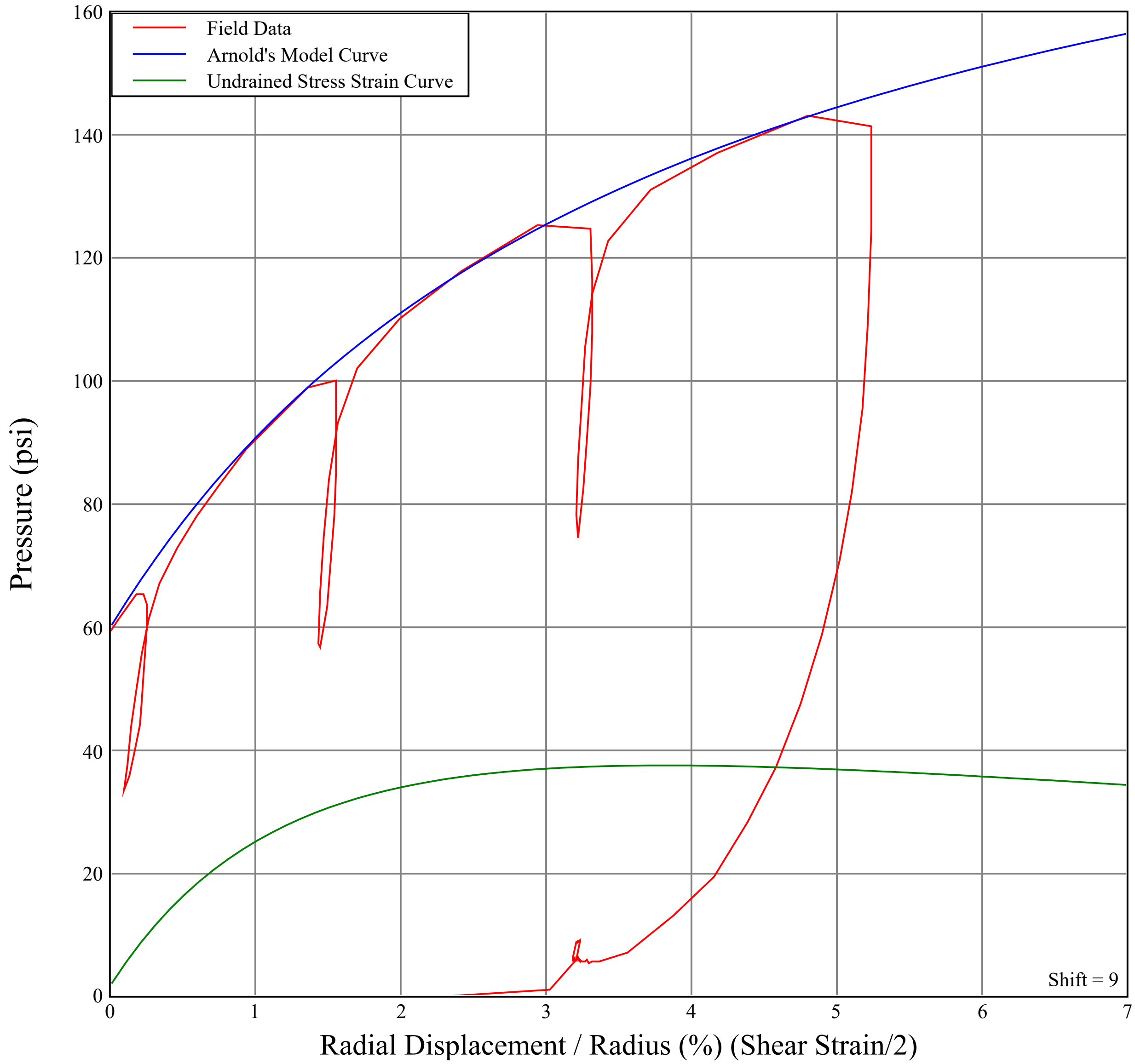
#2 Shear Modulus = 8600 psi

#3 Shear Modulus = 14000 psi

#4 Shear Modulus = 18900 psi

In Situ Engineering - Arnold's Clay Model

Kleinfelder
Last Chance Grade
Boring: RC-20-019 Test: LCG-019 Depth: 18.5FT Date: 12/16/2020
Oper: Mayfield Job # 0115000099 Time of Test: 09:37 AM Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 91 psi	Shear Strength at 10% Strain = 30.1 psi
Pressure at 2.5% Strain = 119 psi	Max Shear Strength = 37.4 psi
Pressure at 7.5% Strain = 159 psi	occurs at 3.8% Strain

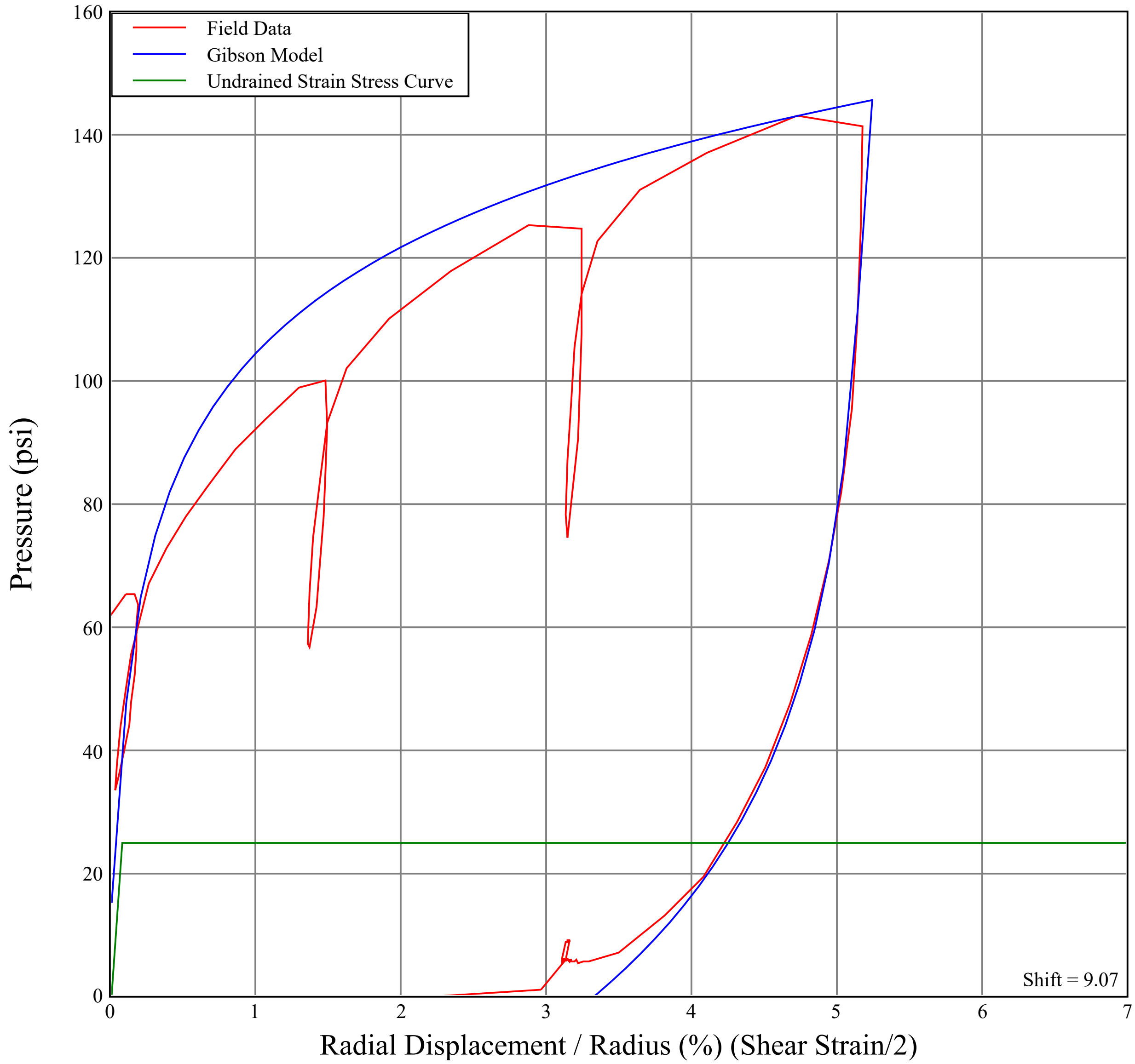
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-019 Depth: 18.5FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 09:37 AM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 24.8 psi	Shear Strength = 38 psi
In Situ Stress = 15 psi	Shear Modulus = 17000 psi
Shear Modulus = 17000 psi	

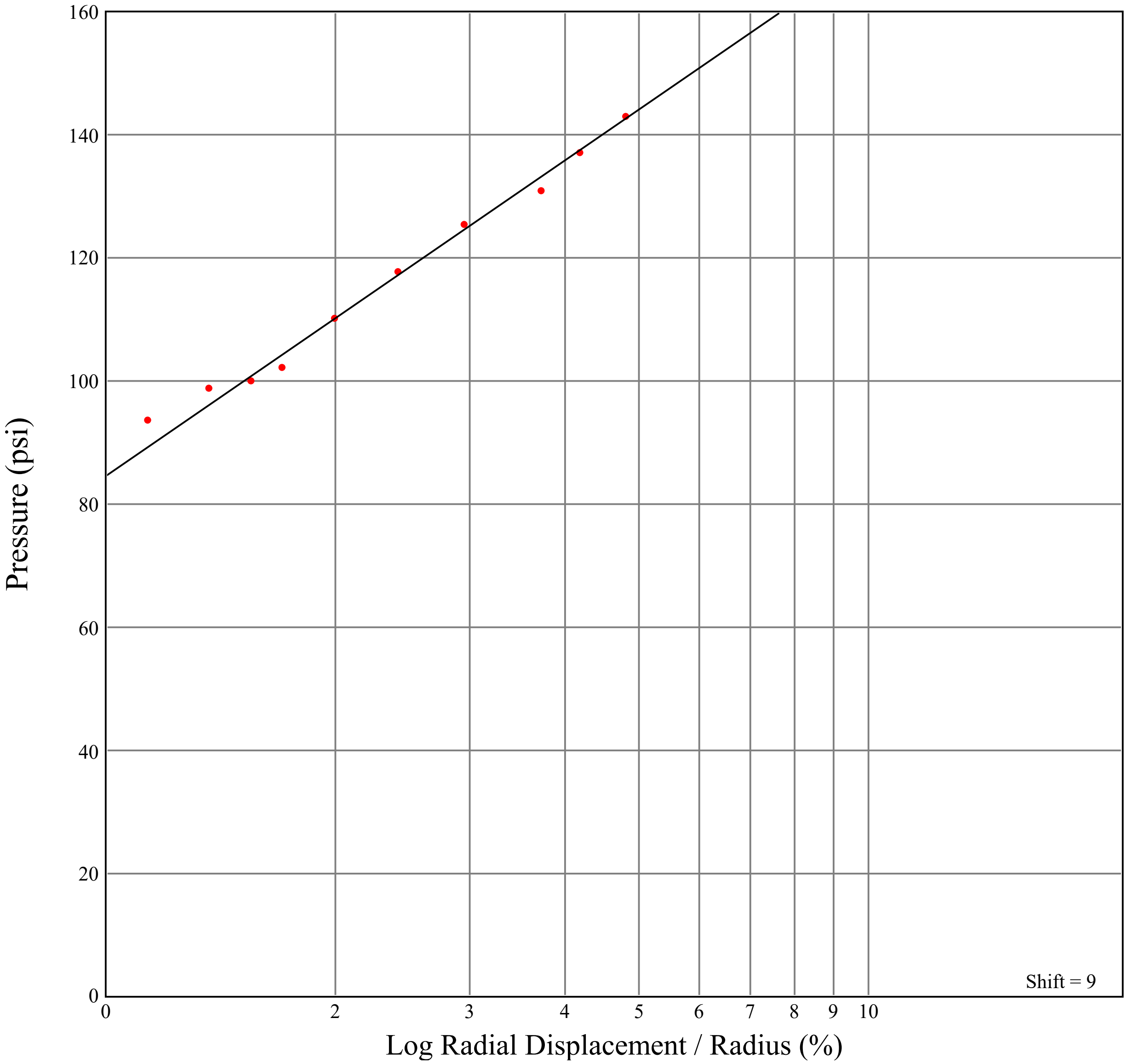
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-019 Depth: 18.5FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 09:37 AM Inst: 04



DATA

Shear Strength = 37 psi

Limit Pressure = 222 psi

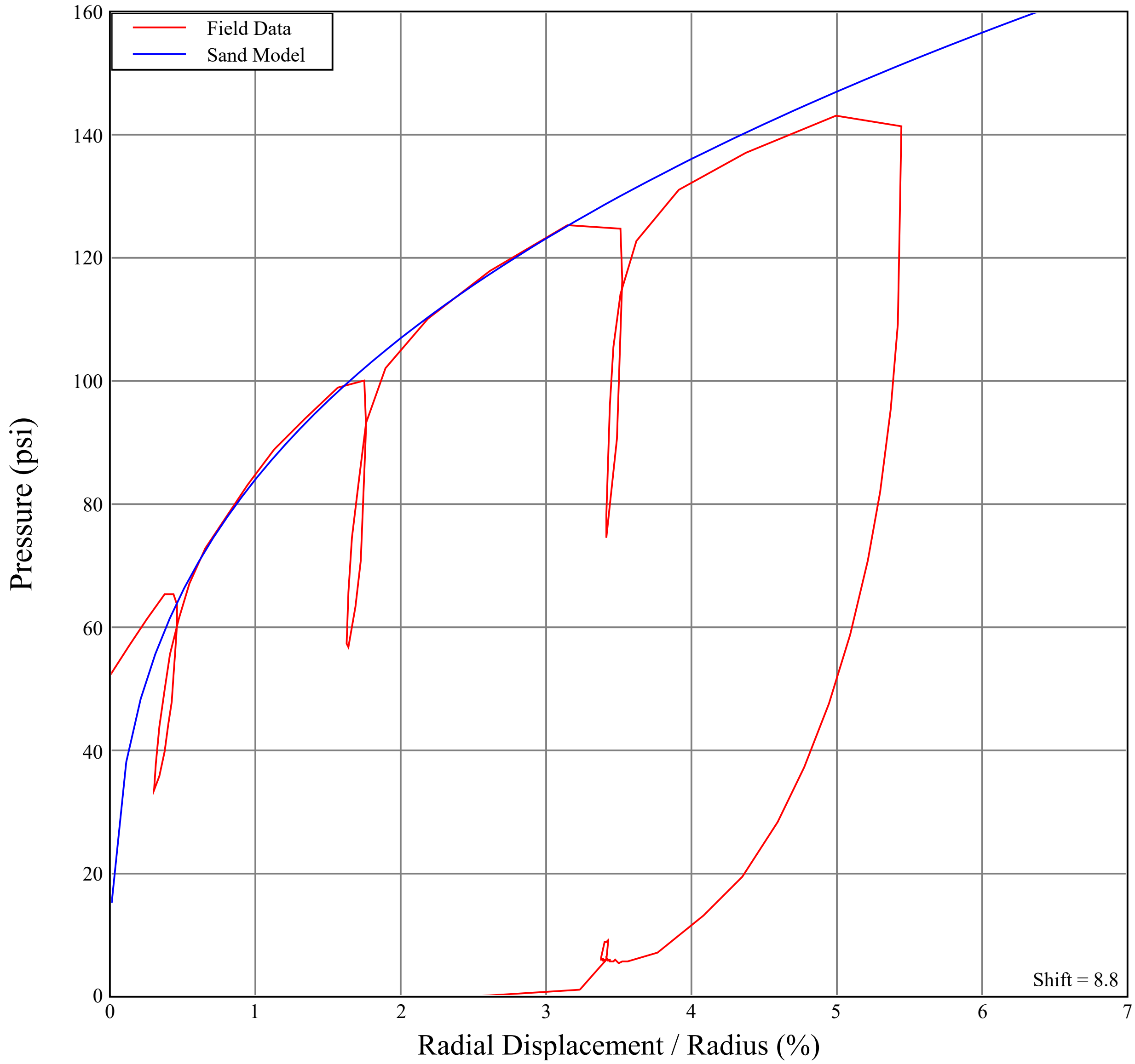
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019   Test: LCG-019   Depth: 18.5FT   Date: 12/16/2020

Oper: Mayfield   Job # 0115000099   Time of Test: 09:37 AM   Inst: 04



DATA

Water Pressure = 0 psi

Lateral Stress = 15 psi

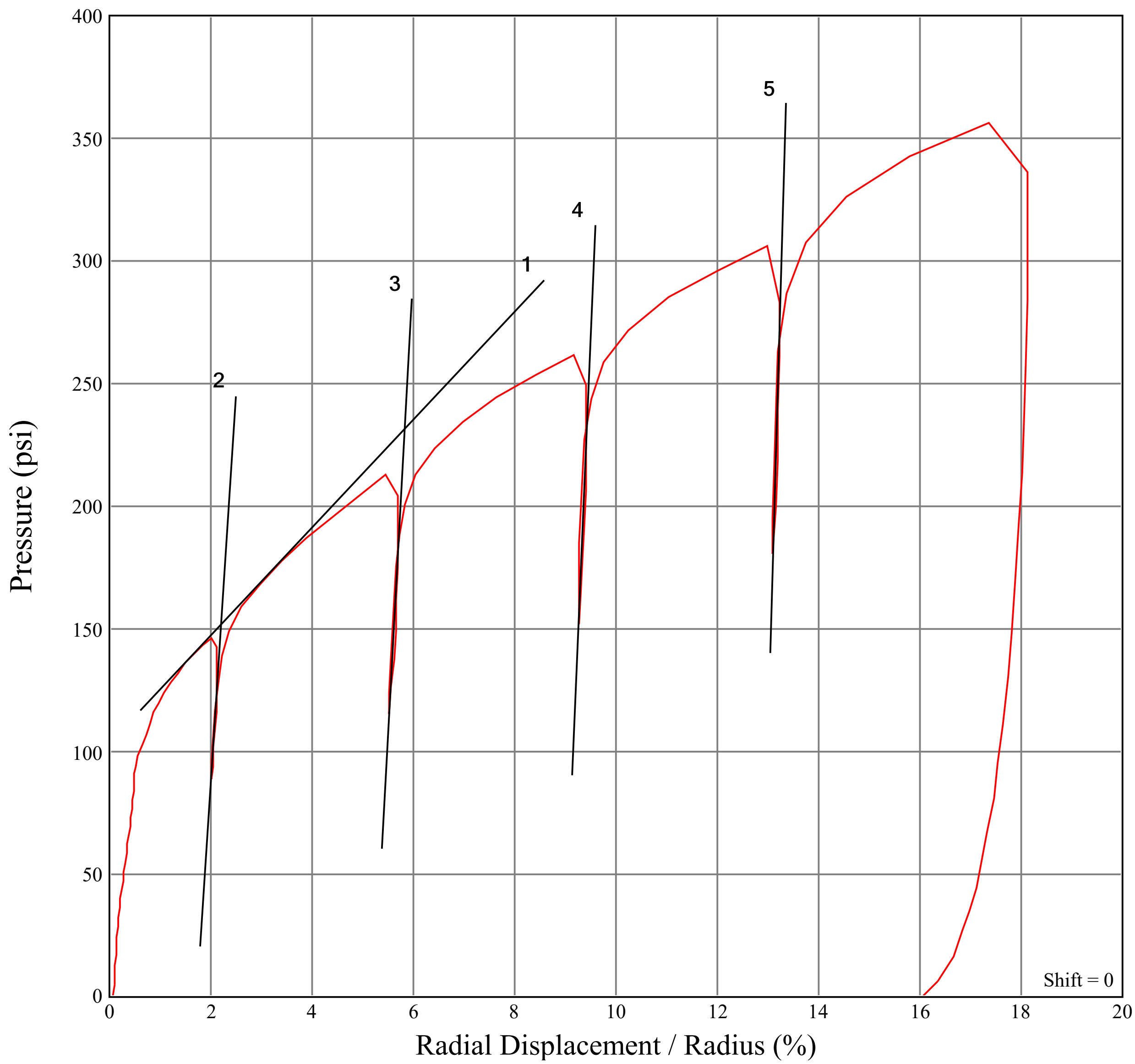
Friction Angle = 32 deg

Shear Modulus = 17000 psi

Critical Friction Angle = 32 deg

In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-019 Test: LCG-020 Depth: 35FT Date: 12/16/2020
Oper: Mayfield Job # 0115000099 Time of Test: 01:55 PM Inst: 04



DATA

#1 Shear Modulus = 1100 psi

#2 Shear Modulus = 15900 psi

#3 Shear Modulus = 19000 psi

#4 Shear Modulus = 24500 psi

#5 Shear Modulus = 36400 psi

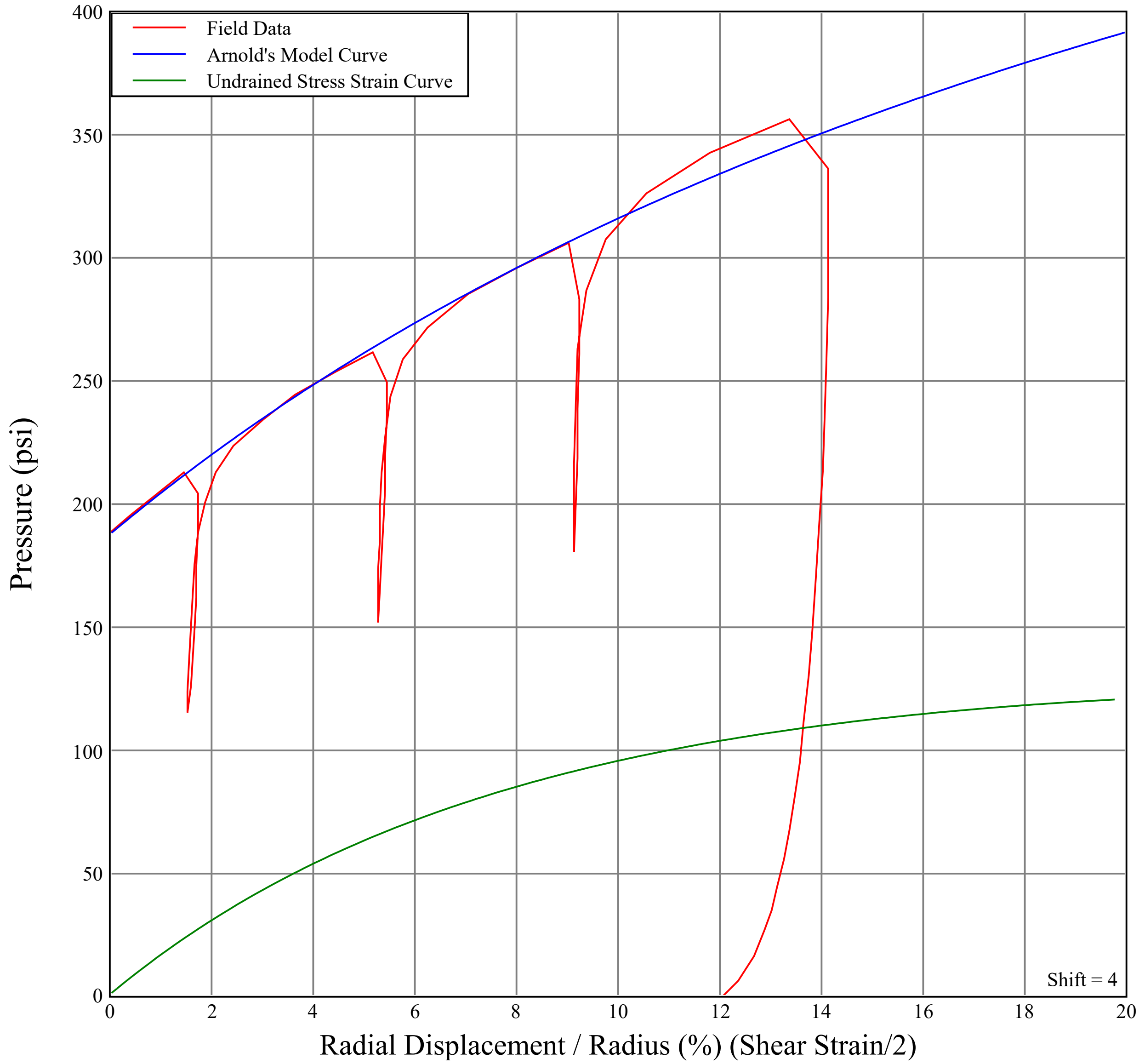
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-020 Depth: 35FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 01:55 PM Inst: 04

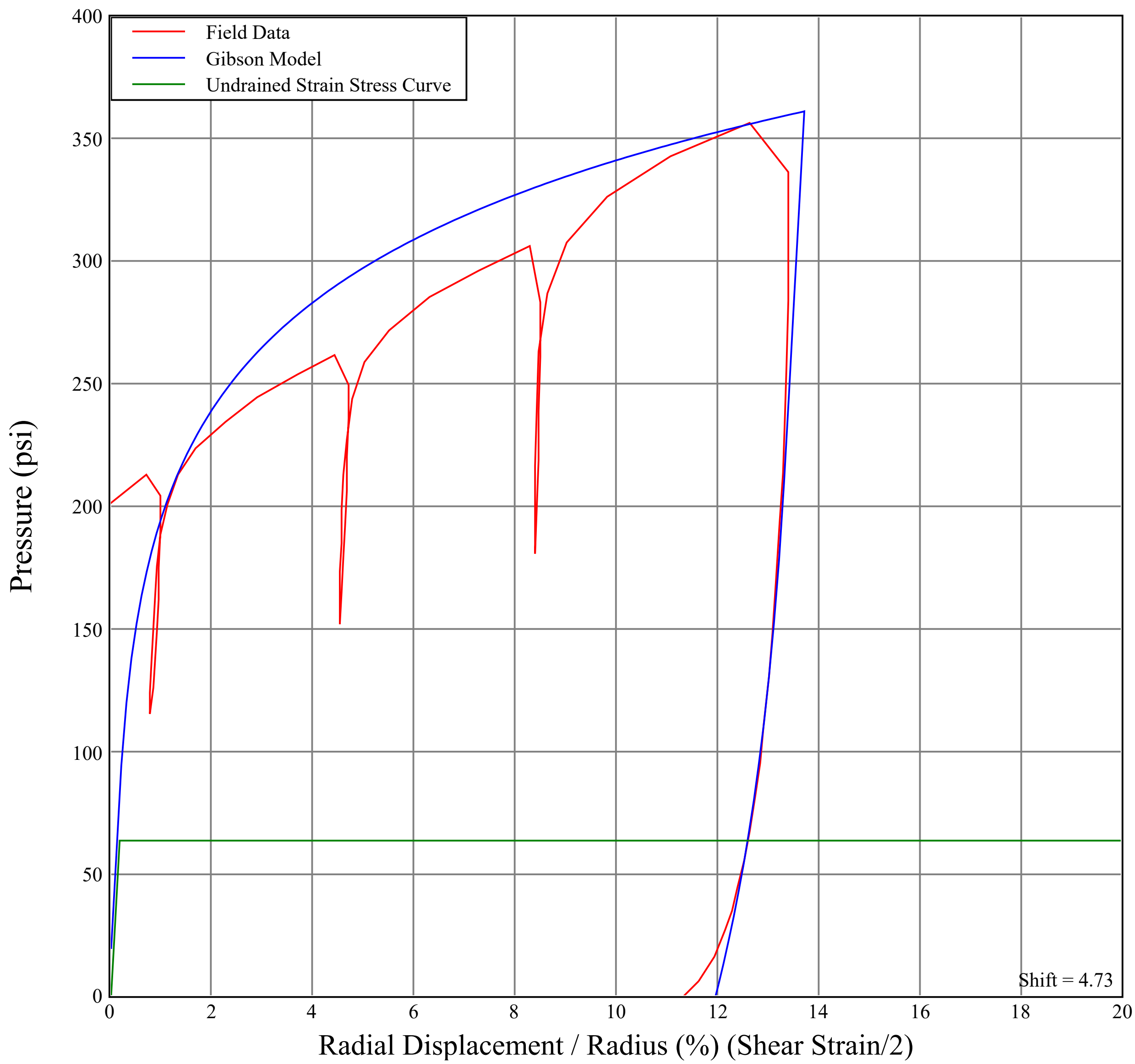


DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 205 psi	Shear Strength at 10% Strain = 95.4 psi
Pressure at 2.5% Strain = 228 psi	Max Shear Strength = 120.4 psi
Pressure at 7.5% Strain = 291 psi	occurs at 19.8% Strain

In Situ Engineering - Gibson's Clay Model

Kleinfelder
Last Chance Grade
Boring: RC-20-019 Test: LCG-020 Depth: 35FT Date: 12/16/2020
Oper: Mayfield Job # 0115000099 Time of Test: 01:55 PM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 63.3 psi	Shear Strength = 142 psi
In Situ Stress = 19 psi	Shear Modulus = 19000 psi
Shear Modulus = 19000 psi	

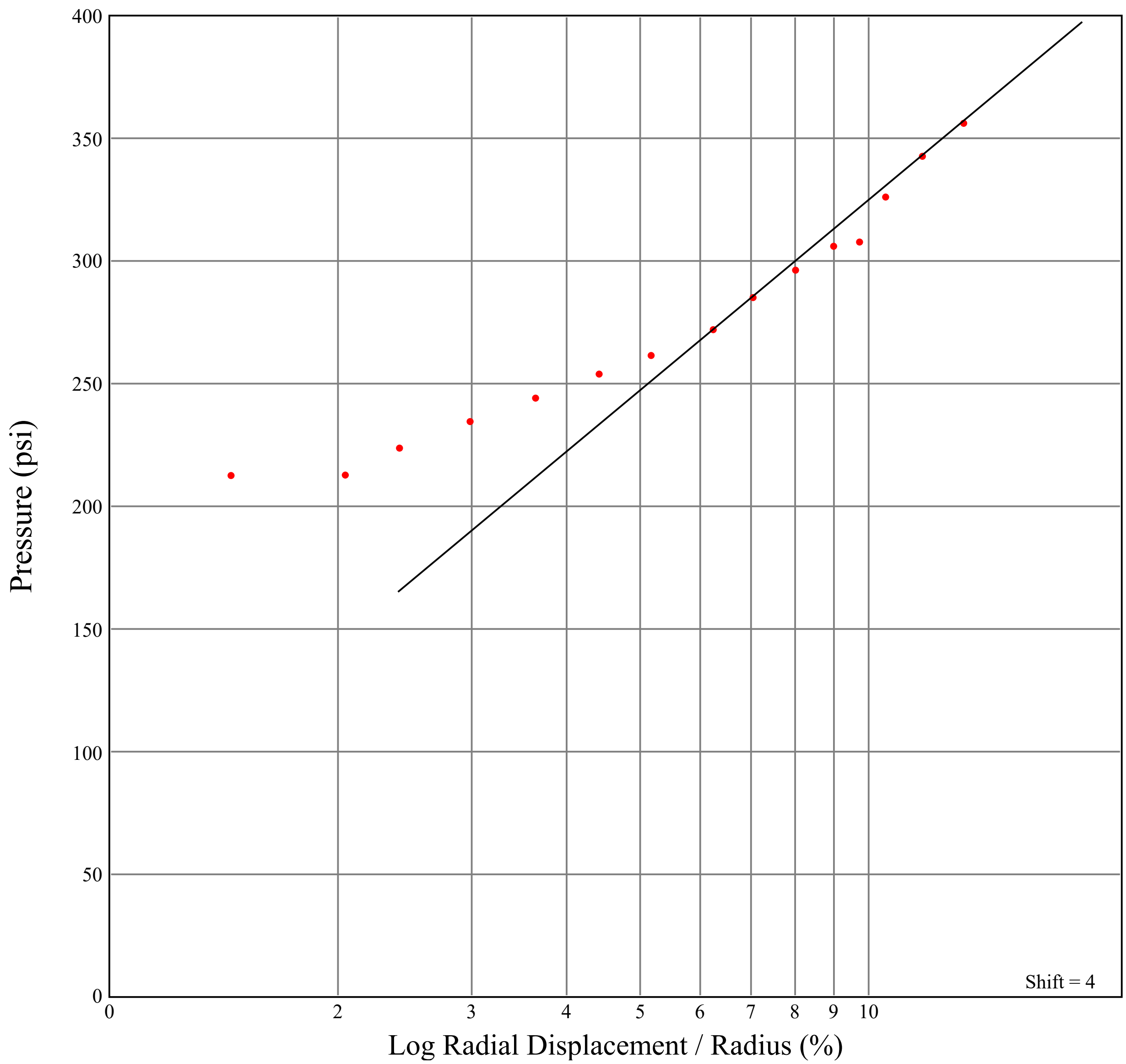
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-020 Depth: 35FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 01:55 PM Inst: 04



DATA

Shear Strength = 112 psi

Limit Pressure = 483 psi

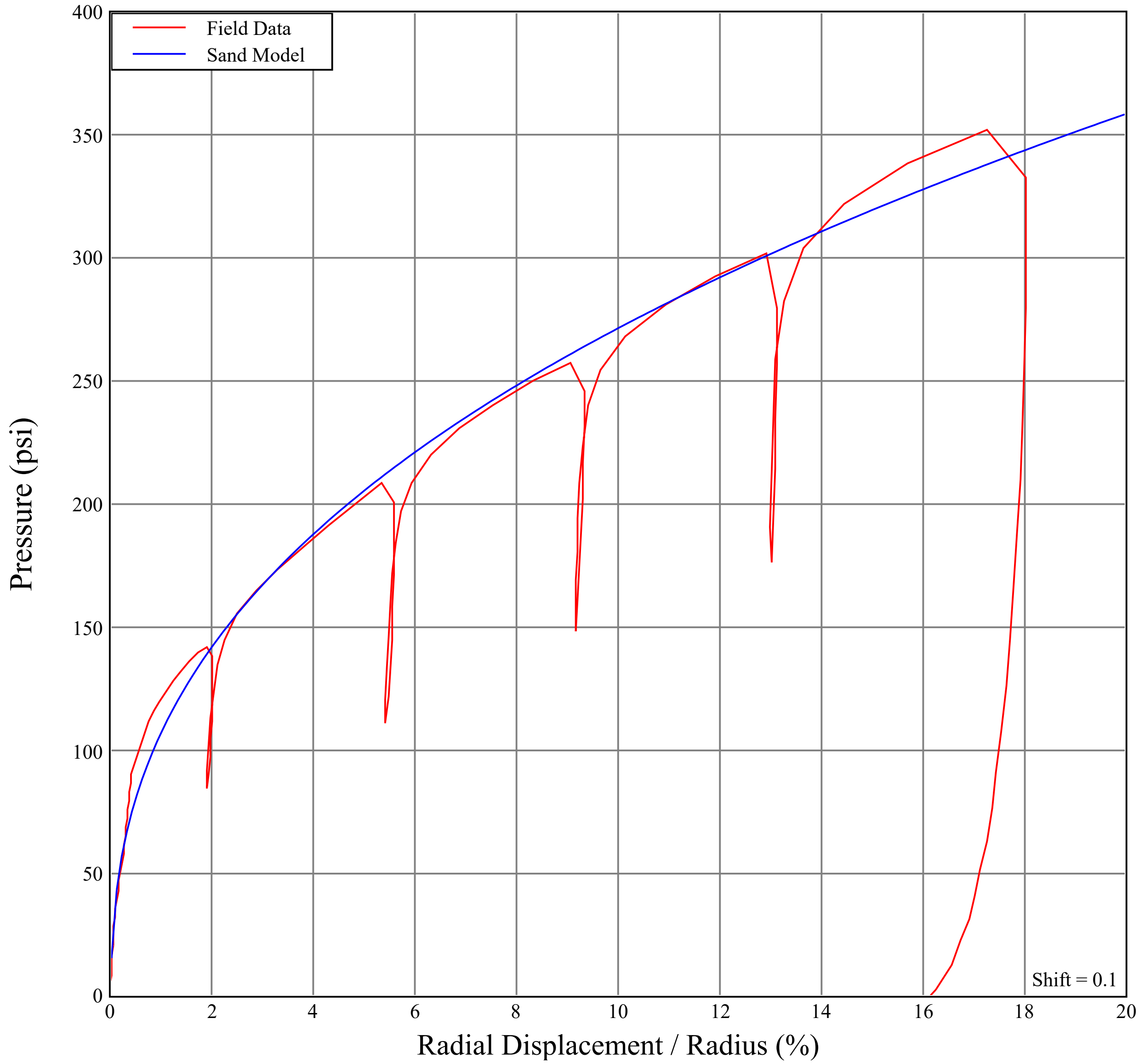
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019   Test: LCG-020   Depth: 35FT   Date: 12/16/2020

Oper: Mayfield   Job # 0115000099   Time of Test: 01:55 PM   Inst: 04



DATA

Water Pressure = 4 psi

Friction Angle = 36 deg

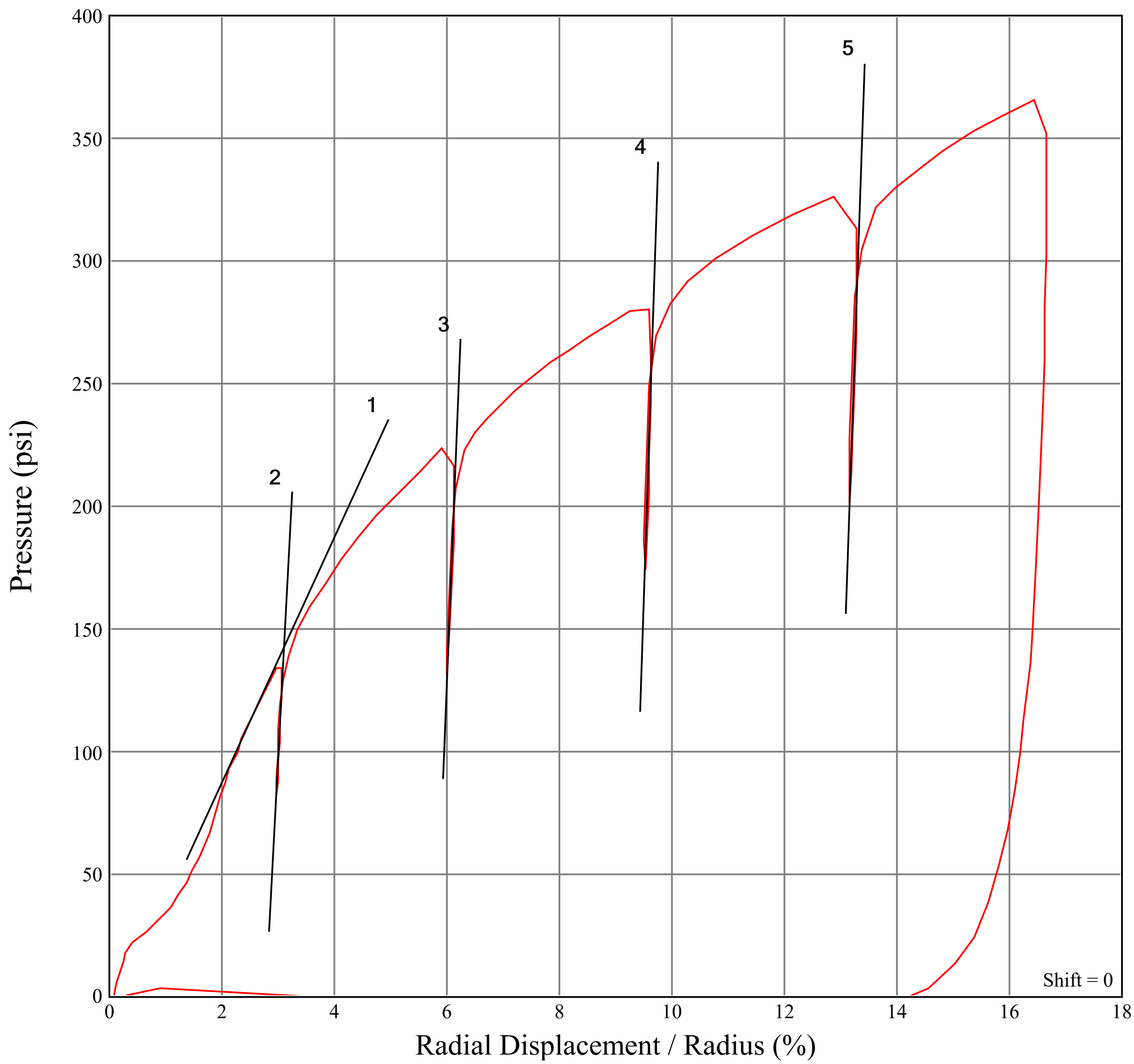
Critical Friction Angle = 32 deg

Lateral Stress = 15 psi

Shear Modulus = 19000 psi

In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-019   Test: LCG-021   Depth: 33.5FT   Date: 12/16/2020
Oper: Mayfield   Job # 0115000099   Time of Test: 02:11 PM   Inst: 04



DATA

#1 Shear Modulus = 2500 psi

#2 Shear Modulus = 21700 psi

#3 Shear Modulus = 28800 psi

#4 Shear Modulus = 35100 psi

#5 Shear Modulus = 33400 psi

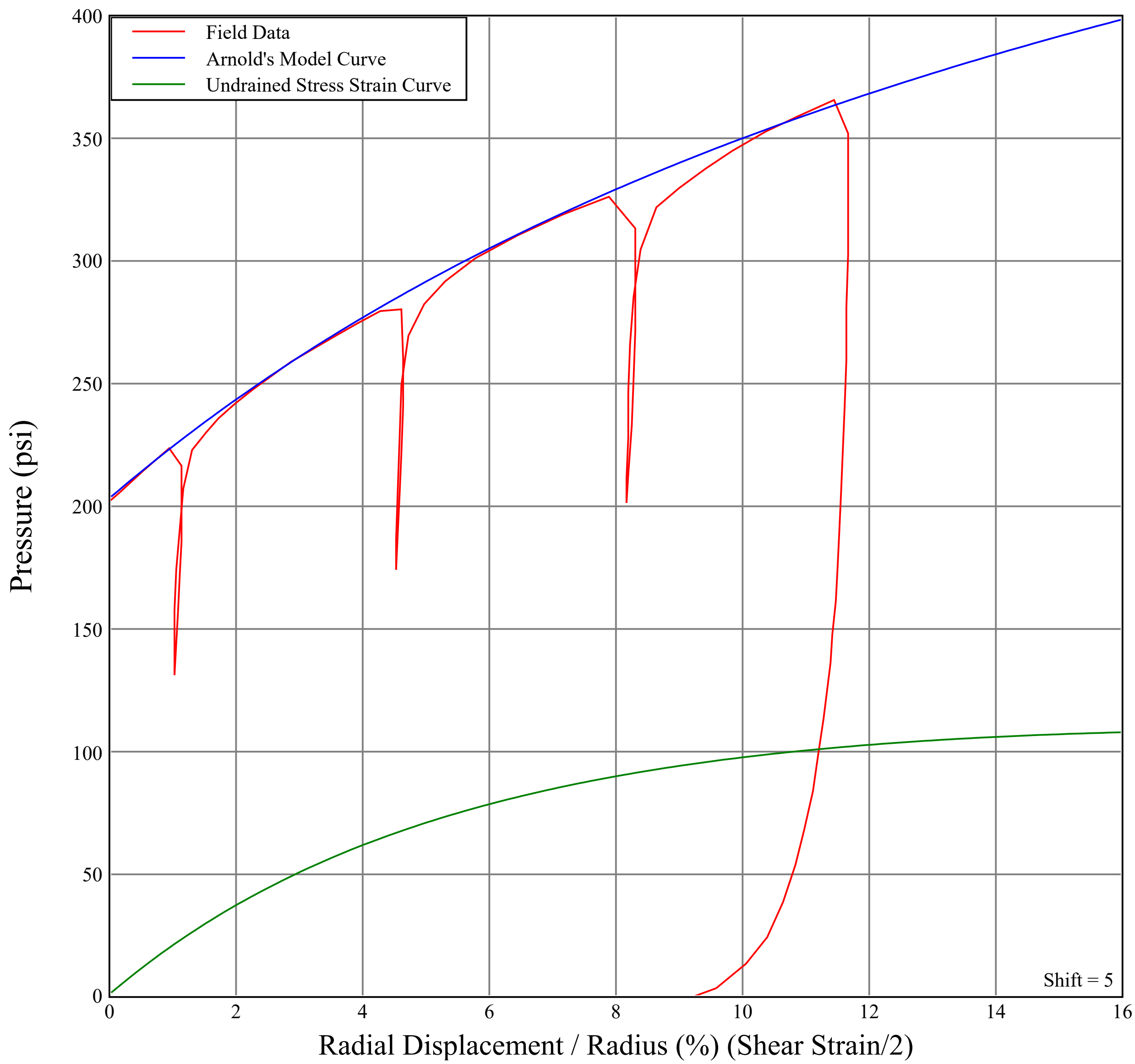
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-021 Depth: 33.5FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 02:11 PM Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 225 psi	Shear Strength at 10% Strain = 97.3 psi
Pressure at 2.5% Strain = 253 psi	Max Shear Strength = 108.7 psi
Pressure at 7.5% Strain = 324 psi	occurs at 19.6% Strain

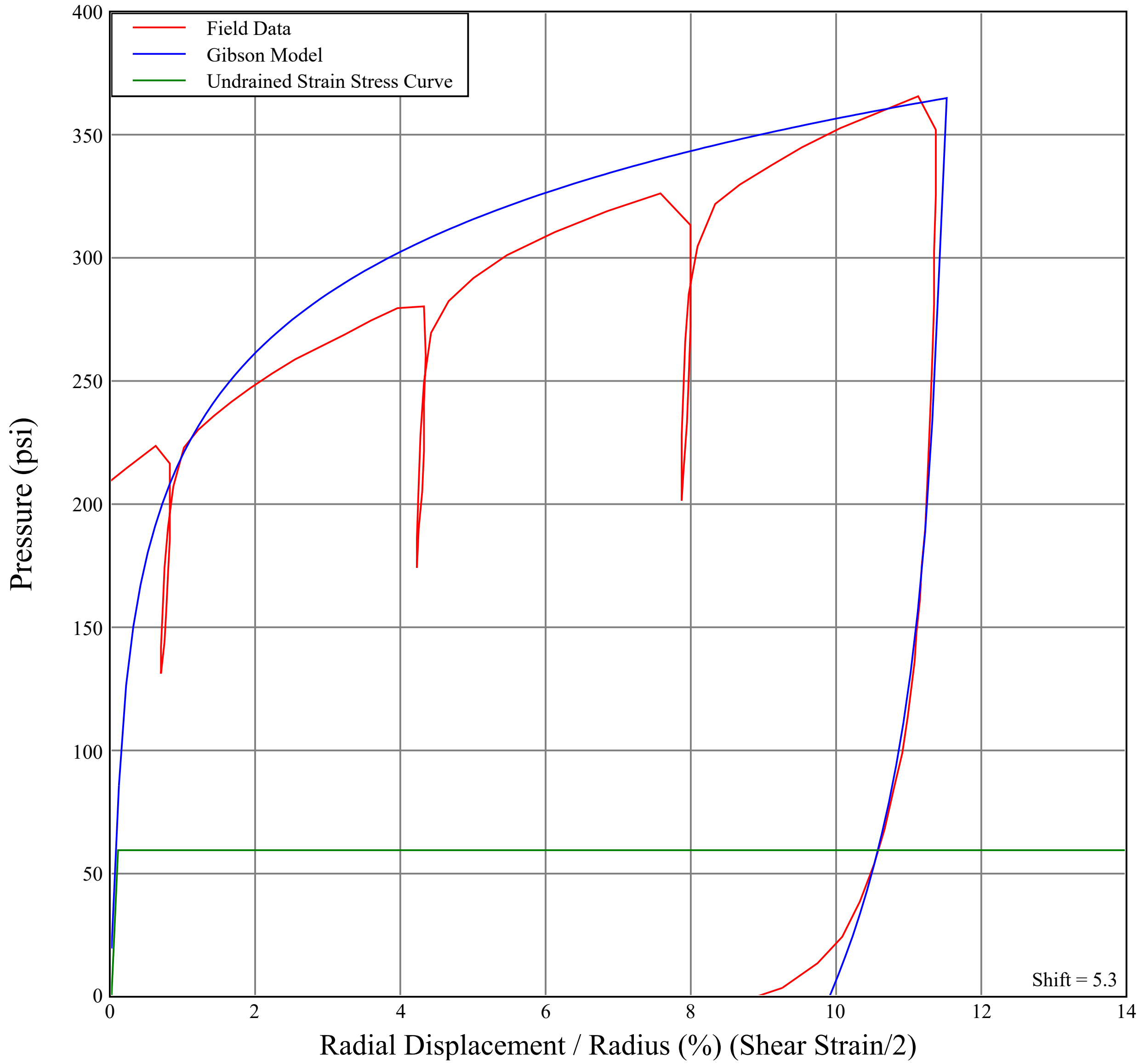
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-021 Depth: 33.5FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 02:11 PM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 59 psi	Shear Strength = 112 psi
In Situ Stress = 19 psi	Shear Modulus = 33400 psi
Shear Modulus = 33400 psi	

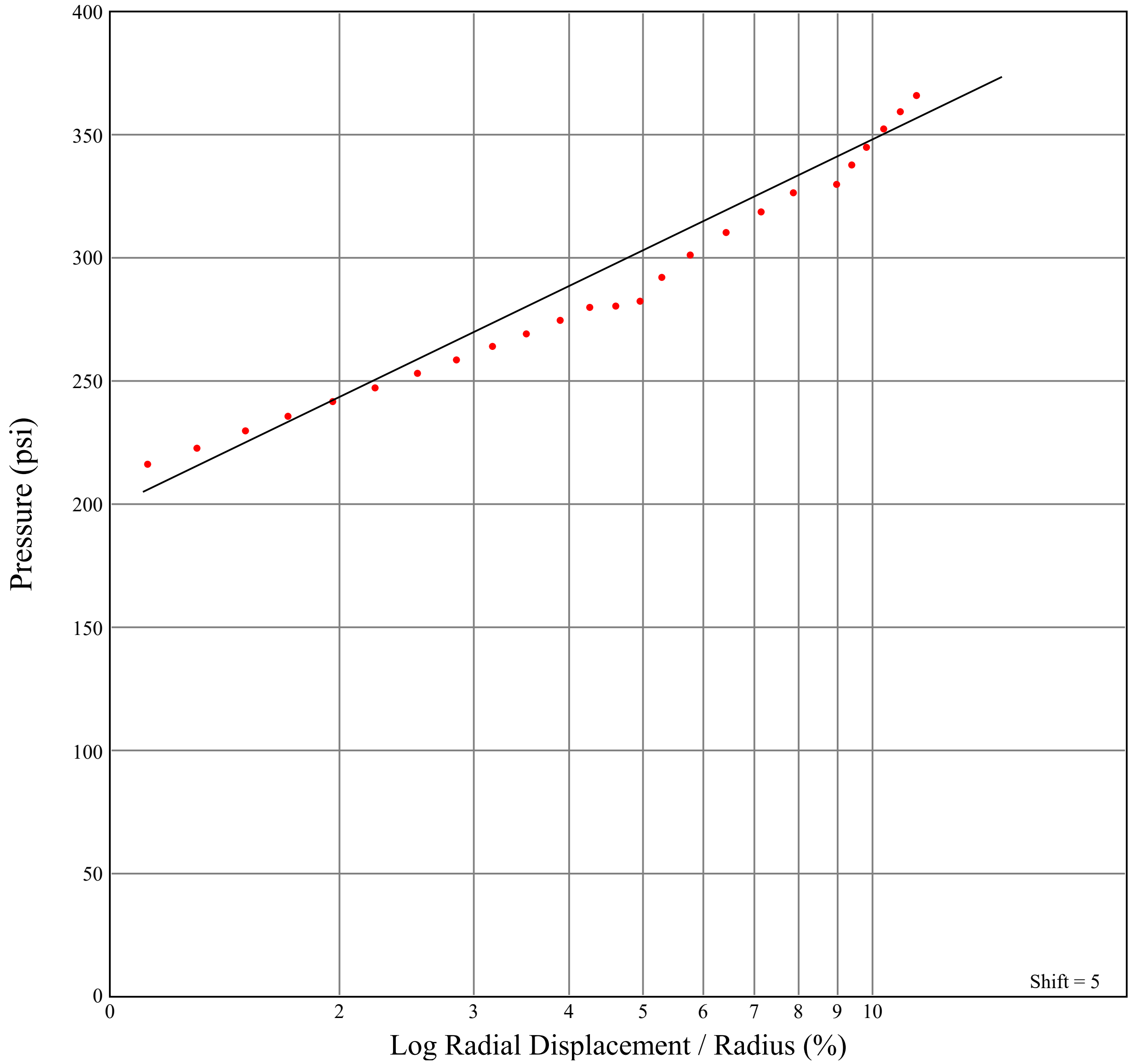
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-019 Test: LCG-021 Depth: 33.5FT Date: 12/16/2020

Oper: Mayfield Job # 0115000099 Time of Test: 02:11 PM Inst: 04



DATA

Shear Strength = 65 psi

Limit Pressure = 440 psi

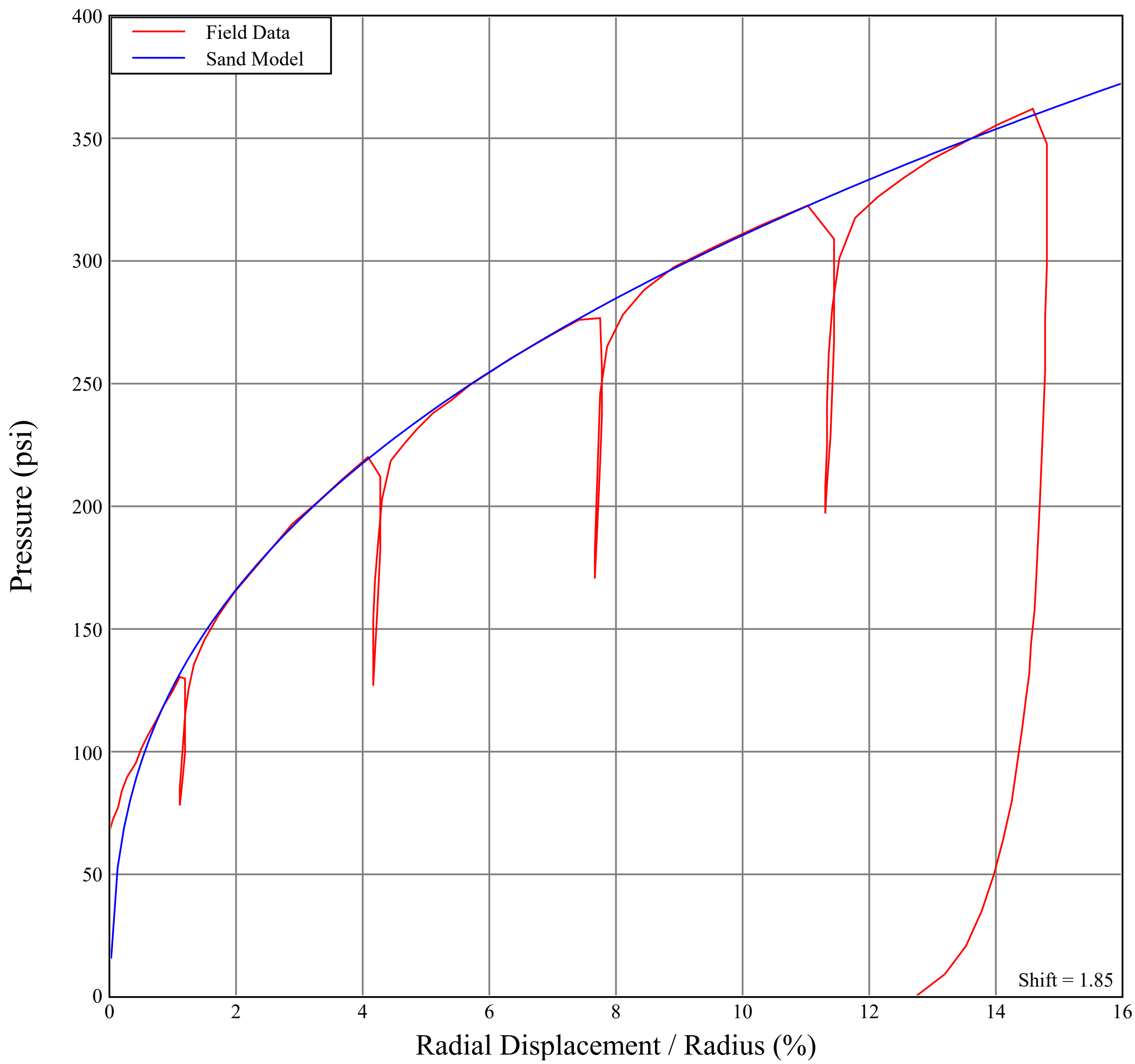
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-019   Test: LCG-021   Depth: 33.5FT   Date: 12/16/2020

Oper: Mayfield   Job # 0115000099   Time of Test: 02:11 PM   Inst: 04



DATA

Water Pressure = 4 psi

Lateral Stress = 15 psi

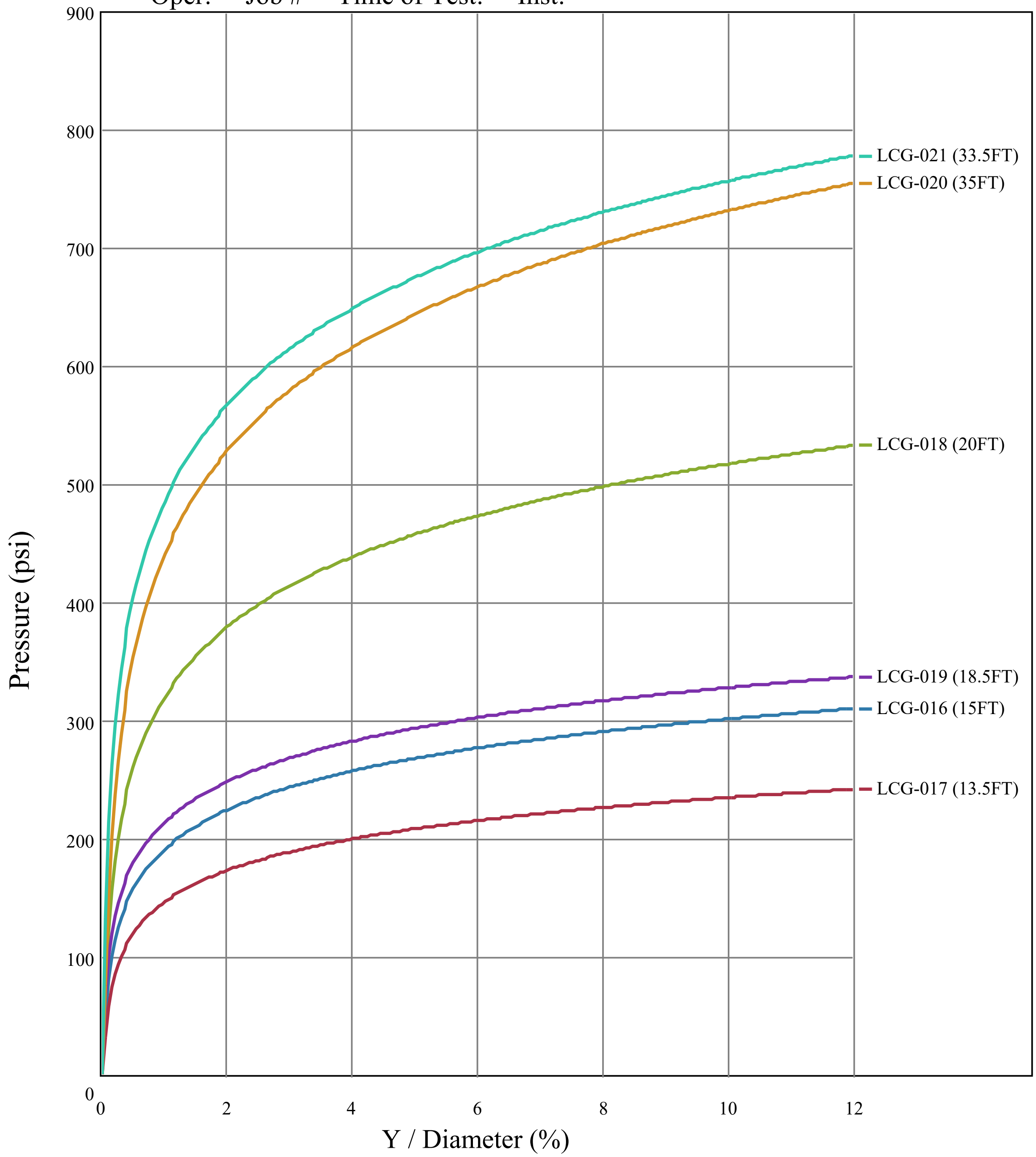
Friction Angle = 35 deg

Shear Modulus = 33400 psi

Critical Friction Angle = 32 deg

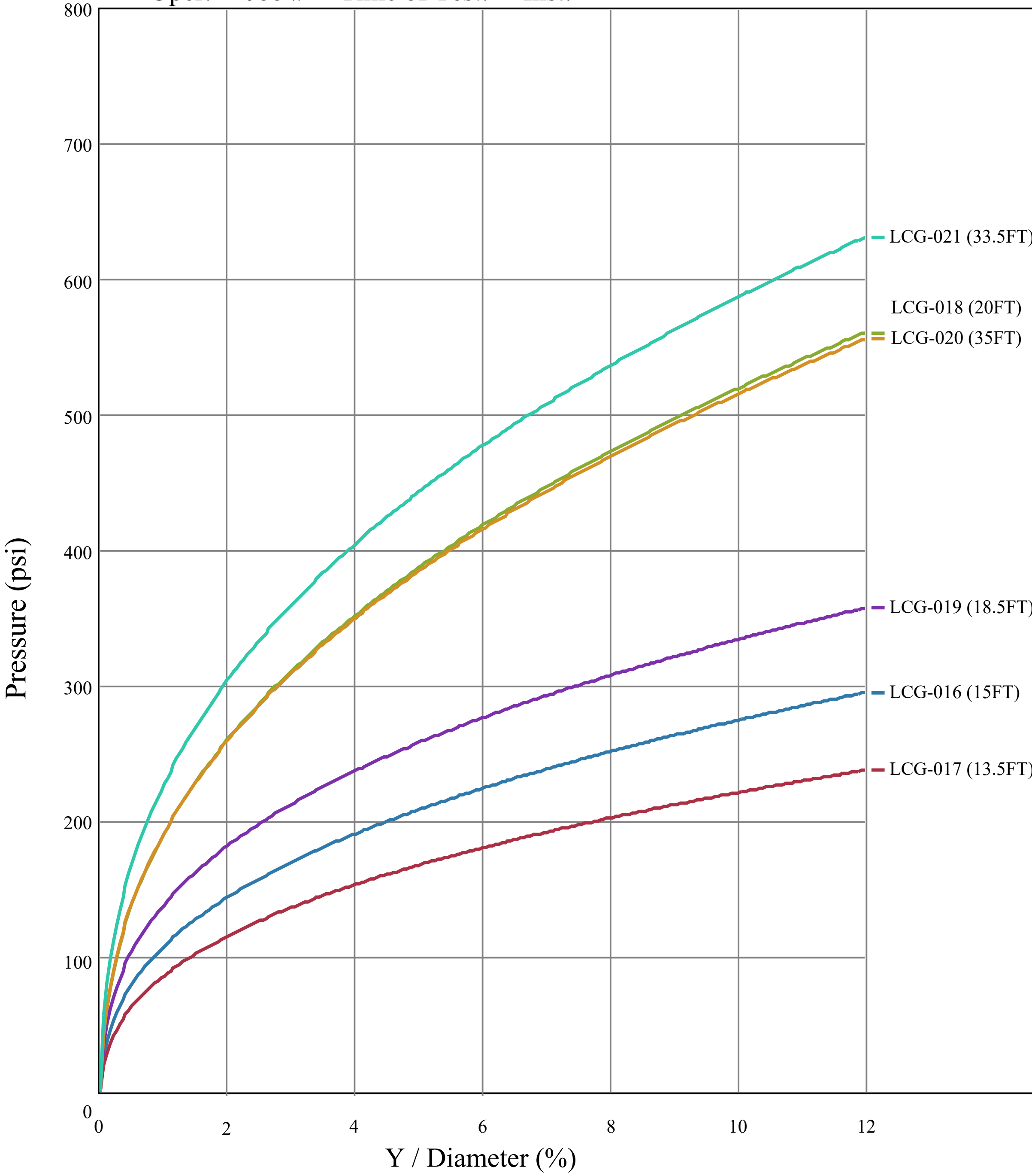
In Situ Engineering - PY Data - Cohesive

Kleinfelder
Last Chance Grade
Boring: RC-20-019
Oper: Job # Time of Test: Inst:



In Situ Engineering - PY Data - Frictional

Kleinfelder
Last Chance Grade
Boring: RC-20-019
Oper: Job # Time of Test: Inst:



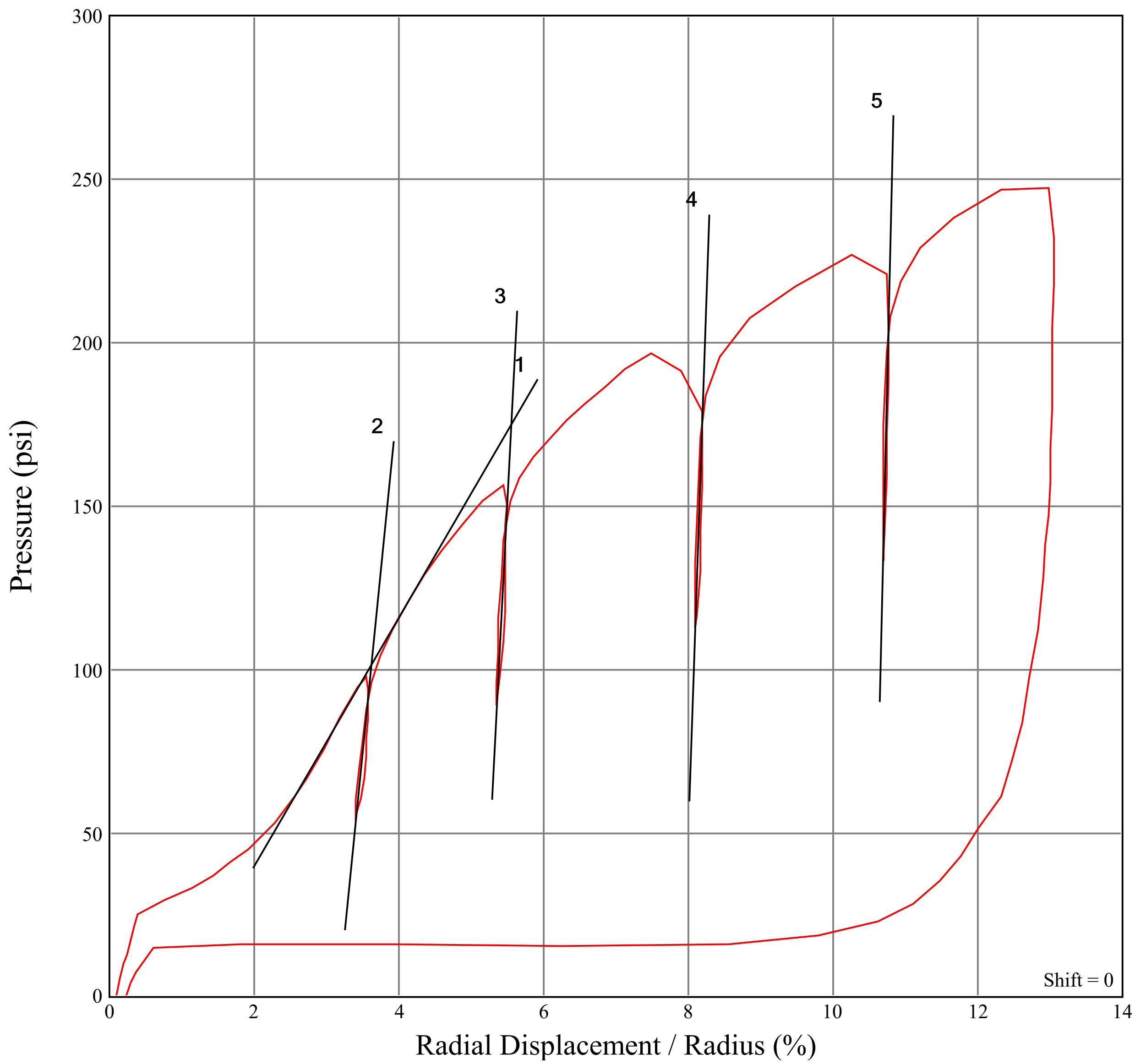
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-022 Depth: 43.5FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 08:18 AM Inst: 04



DATA

#1 Shear Modulus = 1900 psi

#2 Shear Modulus = 11100 psi

#3 Shear Modulus = 21600 psi

#4 Shear Modulus = 32500 psi

#5 Shear Modulus = 47200 psi

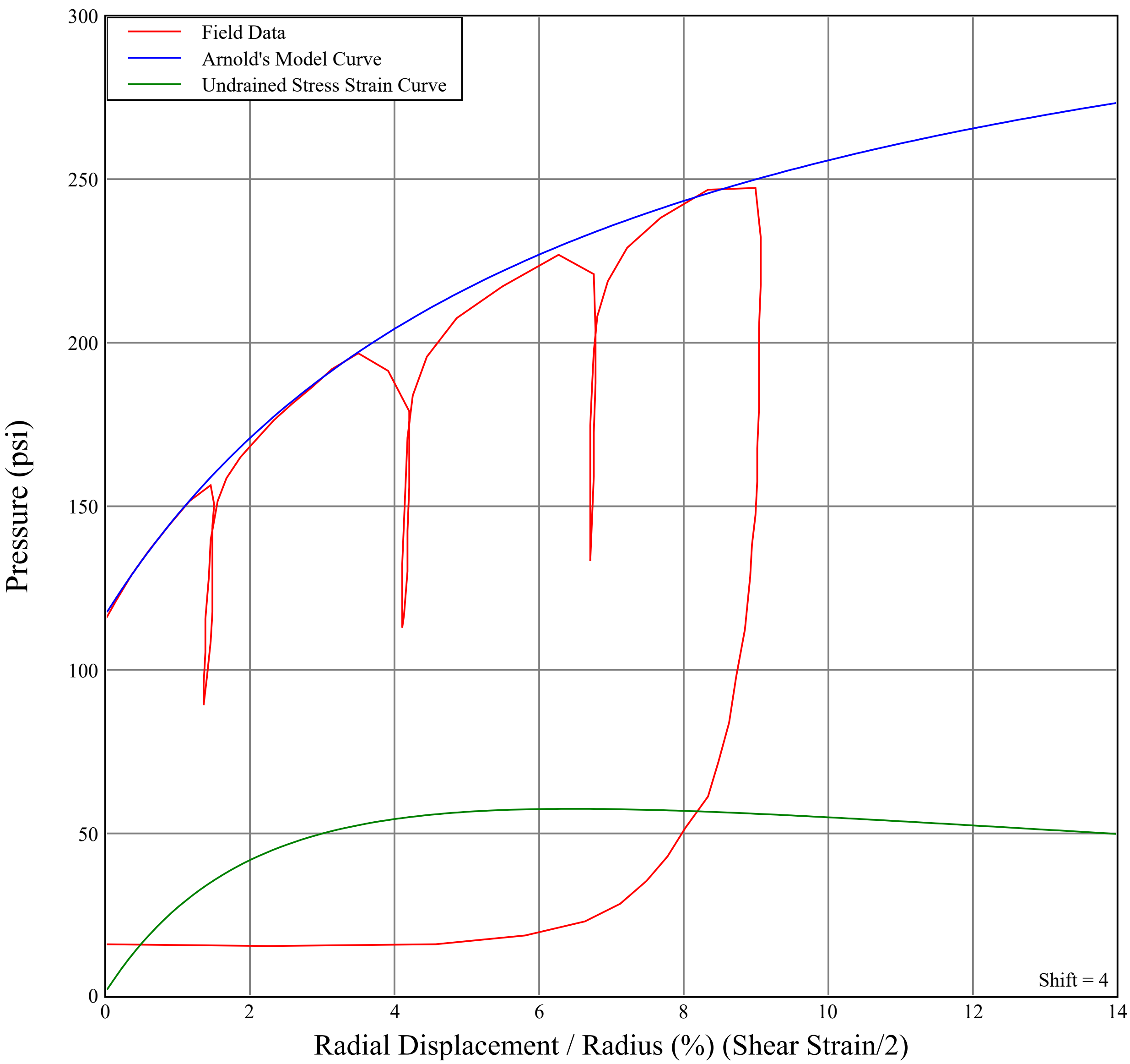
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-022 Depth: 43.5FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 08:18 AM Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 148 psi	Shear Strength at 10% Strain = 54.6 psi
Pressure at 2.5% Strain = 181 psi	Max Shear Strength = 57.2 psi
Pressure at 7.5% Strain = 240 psi	occurs at 6.5% Strain

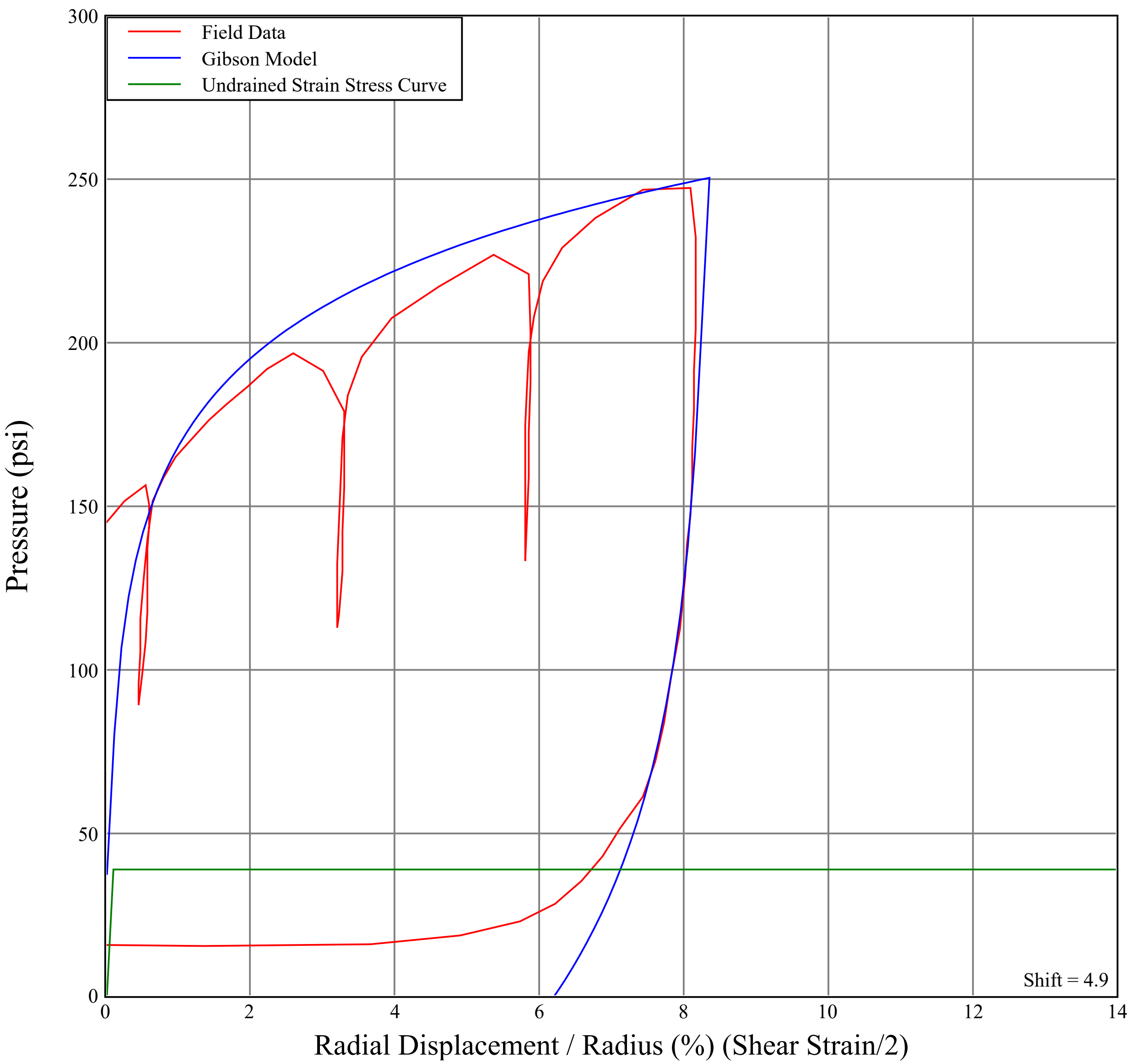
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-022 Depth: 43.5FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 08:18 AM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 38.6 psi	Shear Strength = 70 psi
In Situ Stress = 37 psi	Shear Modulus = 21600 psi
Shear Modulus = 21600 psi	

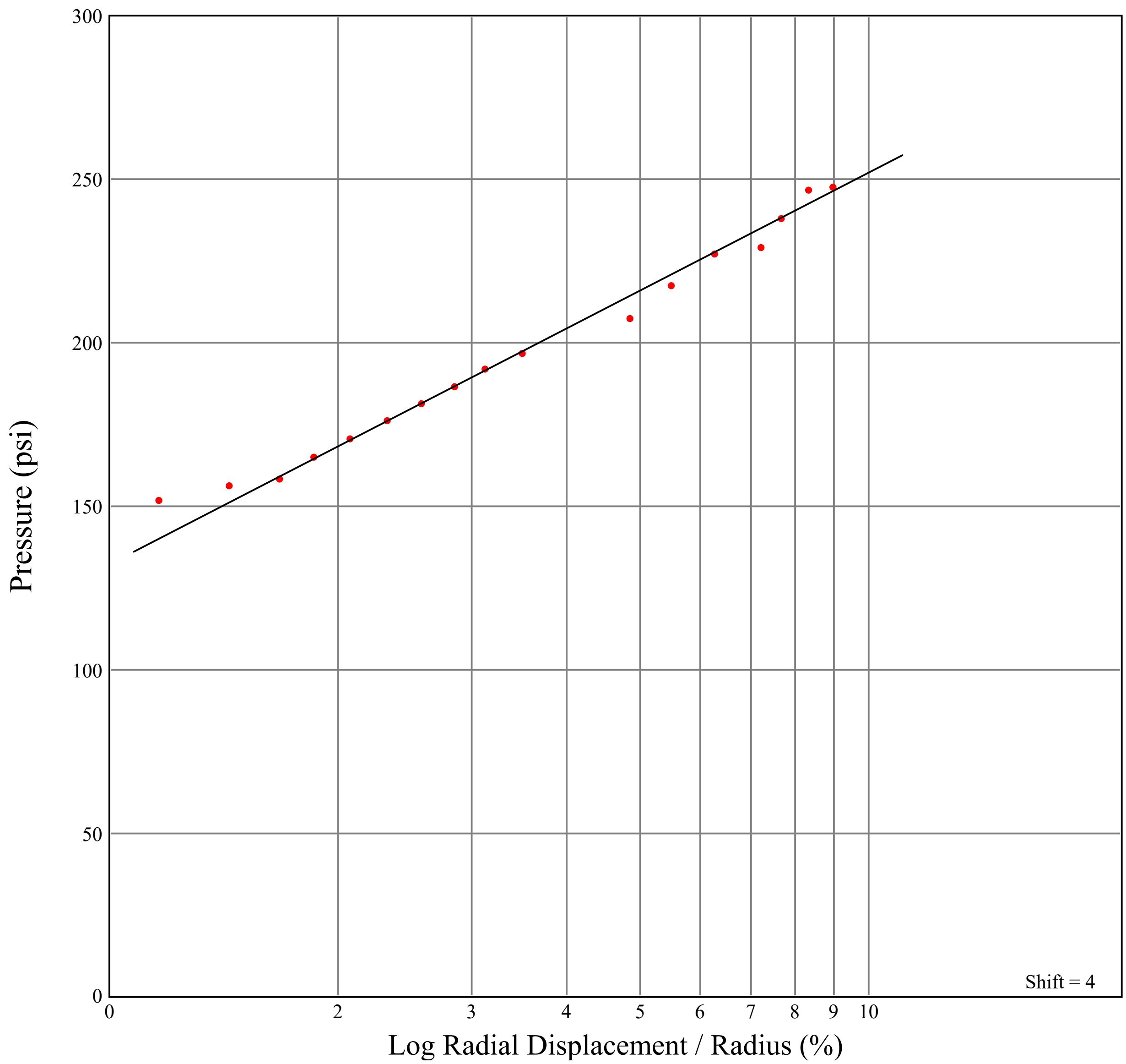
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-022 Depth: 43.5FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 08:18 AM Inst: 04



DATA

Shear Strength = 52 psi

Limit Pressure = 326 psi

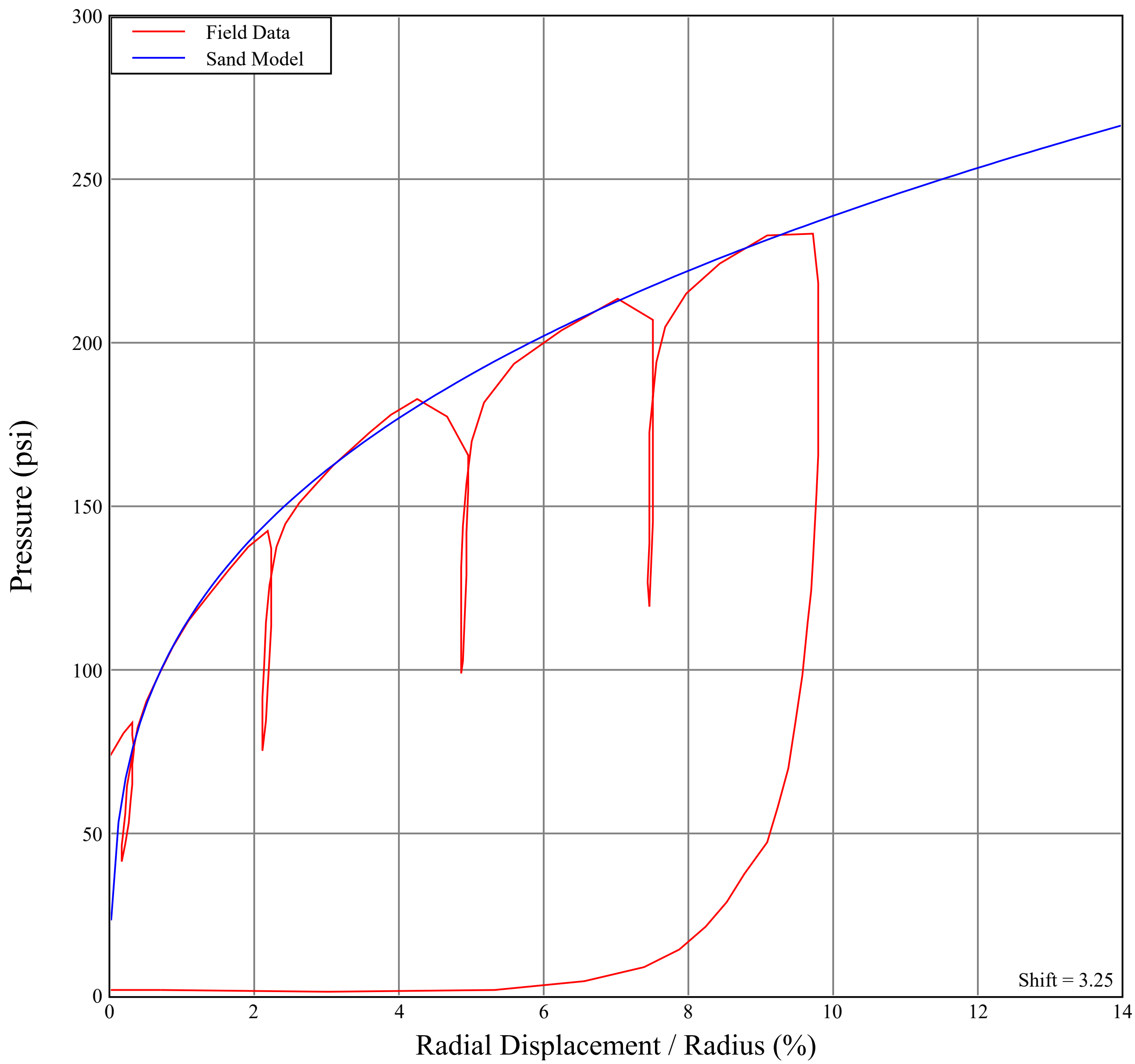
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-022 Depth: 43.5FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 08:18 AM Inst: 04



DATA

Water Pressure = 14 psi

Lateral Stress = 23 psi

Friction Angle = 29 deg

Shear Modulus = 21600 psi

Critical Friction Angle = 29 deg

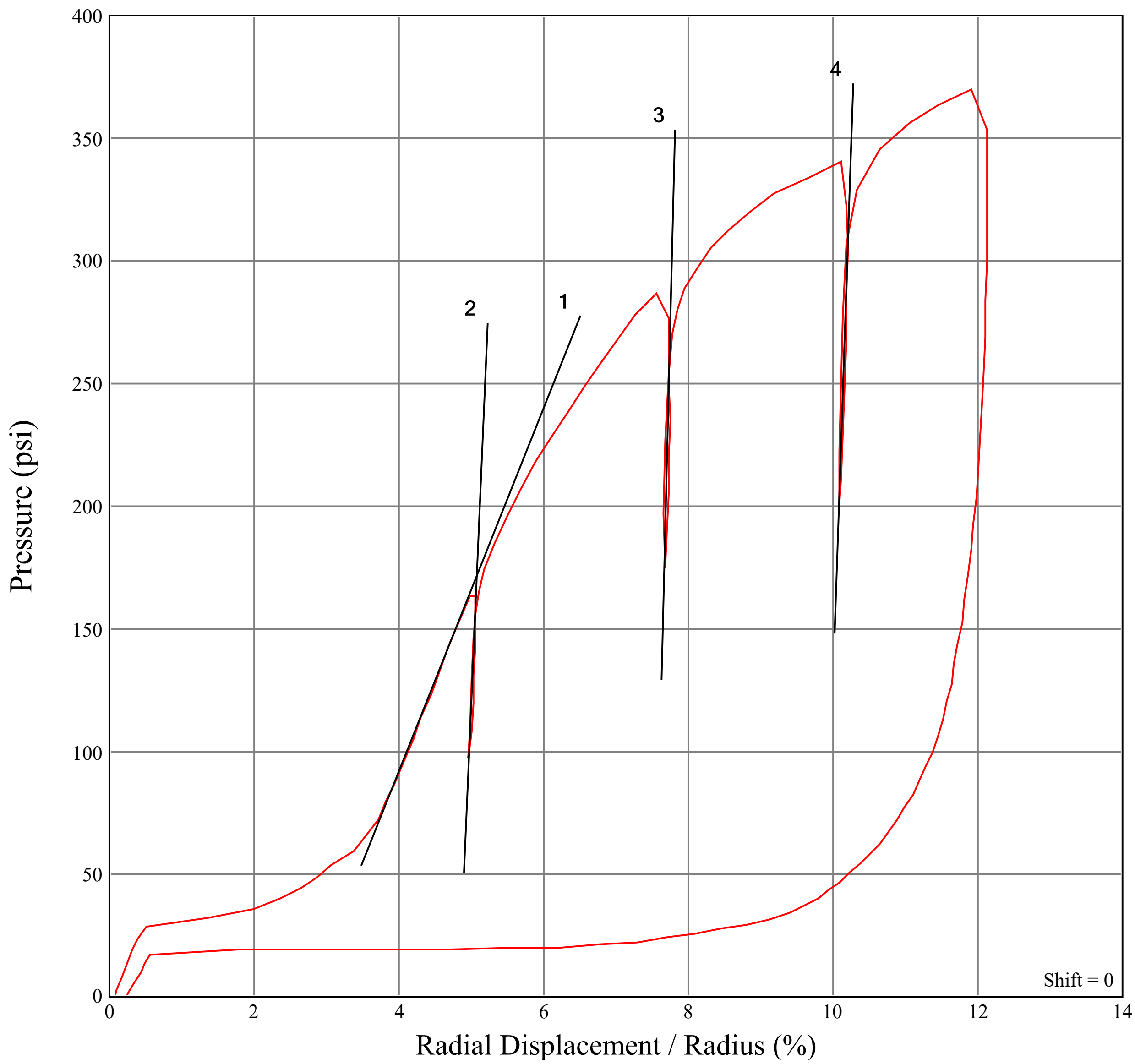
In Situ Engineering - Shear Modulus Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-023 Depth: 53.7FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 10:52 AM Inst: 04



DATA

#1 Shear Modulus = 3700 psi

#2 Shear Modulus = 34100 psi

#3 Shear Modulus = 60000 psi

#4 Shear Modulus = 43600 psi

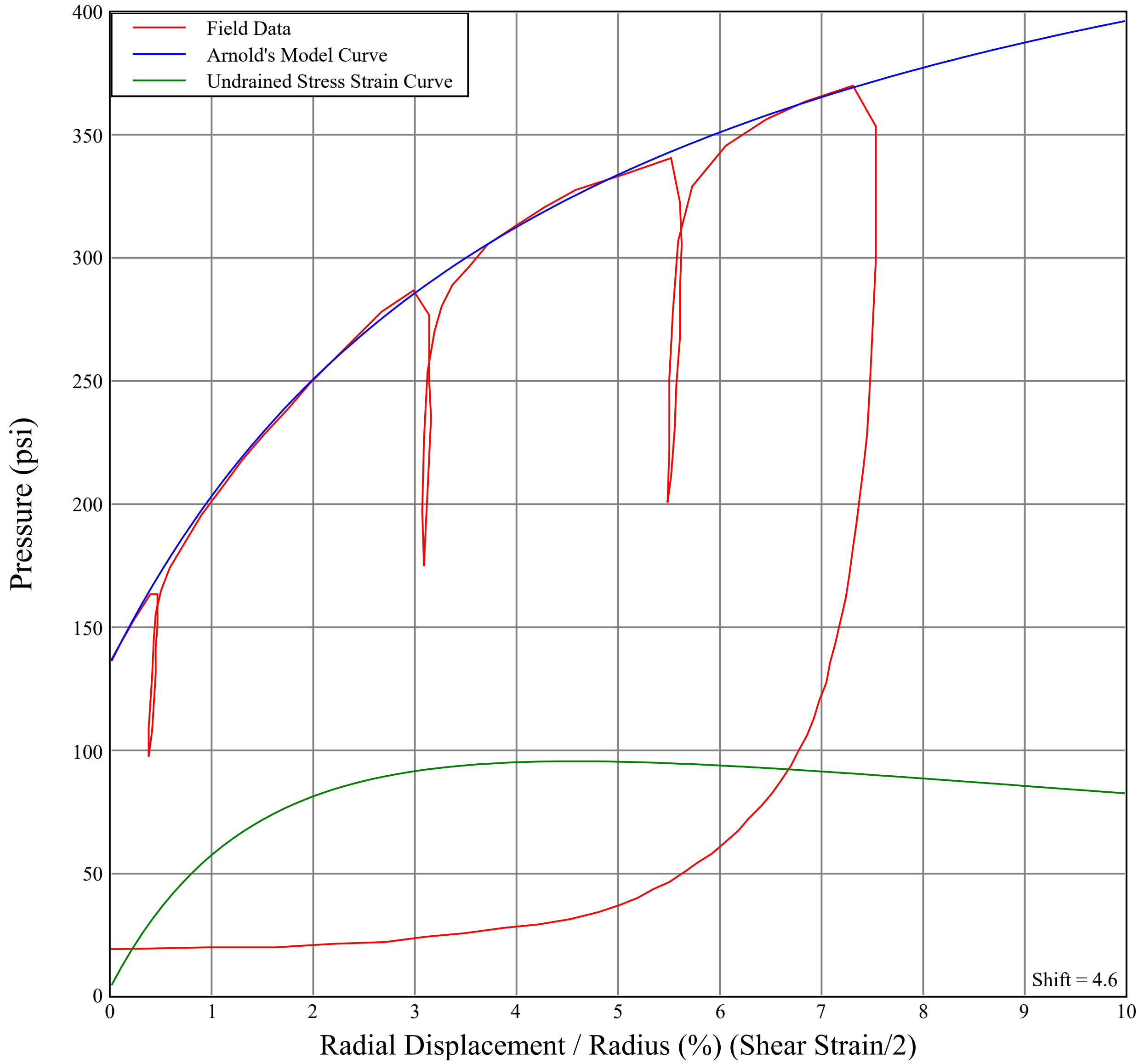
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-023 Depth: 53.7FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 10:52 AM Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 204 psi	Shear Strength at 10% Strain = 82.2 psi
Pressure at 2.5% Strain = 270 psi	Max Shear Strength = 95.3 psi
Pressure at 7.5% Strain = 372 psi	occurs at 4.6% Strain

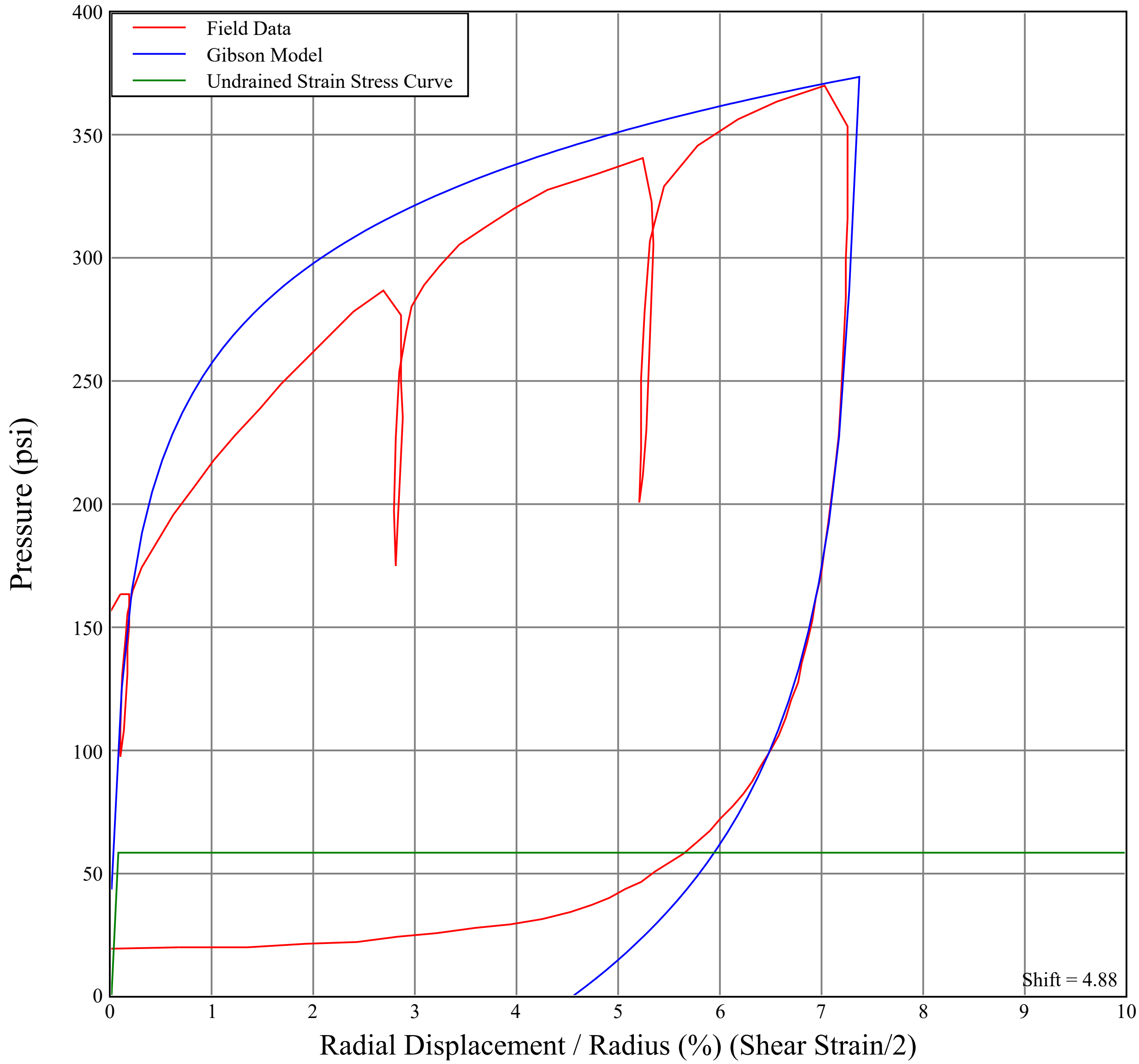
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-023 Depth: 53.7FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 10:52 AM Inst: 04



DATA

LOADING	UNLOADING
Shear Strength = 58 psi	Shear Strength = 86 psi
In Situ Stress = 43 psi	Shear Modulus = 43600 psi
Shear Modulus = 43600 psi	

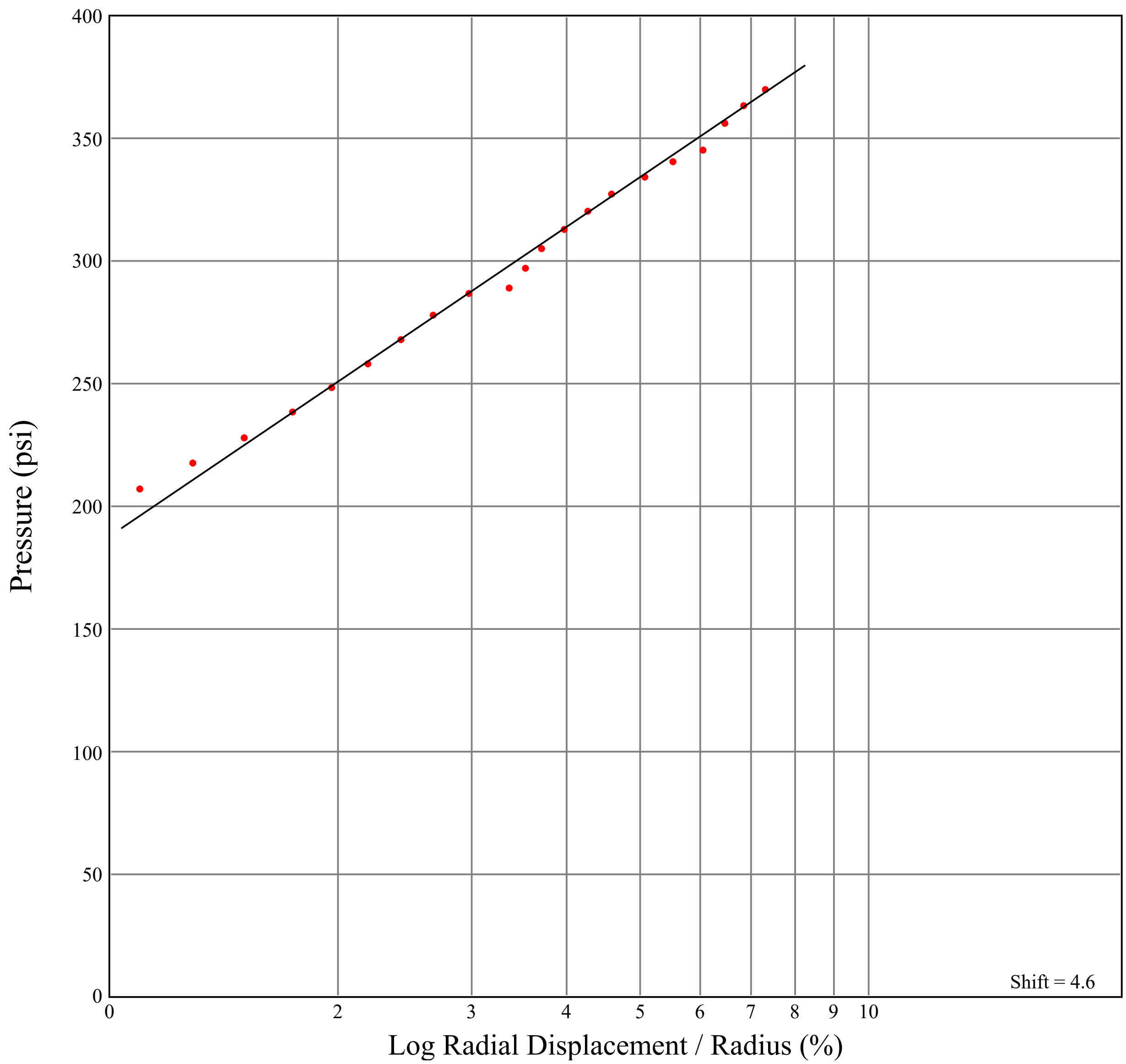
In Situ Engineering - Logarithm Plot

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-023 Depth: 53.7FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 10:52 AM Inst: 04



DATA

Shear Strength = 91 psi

Limit Pressure = 526 psi

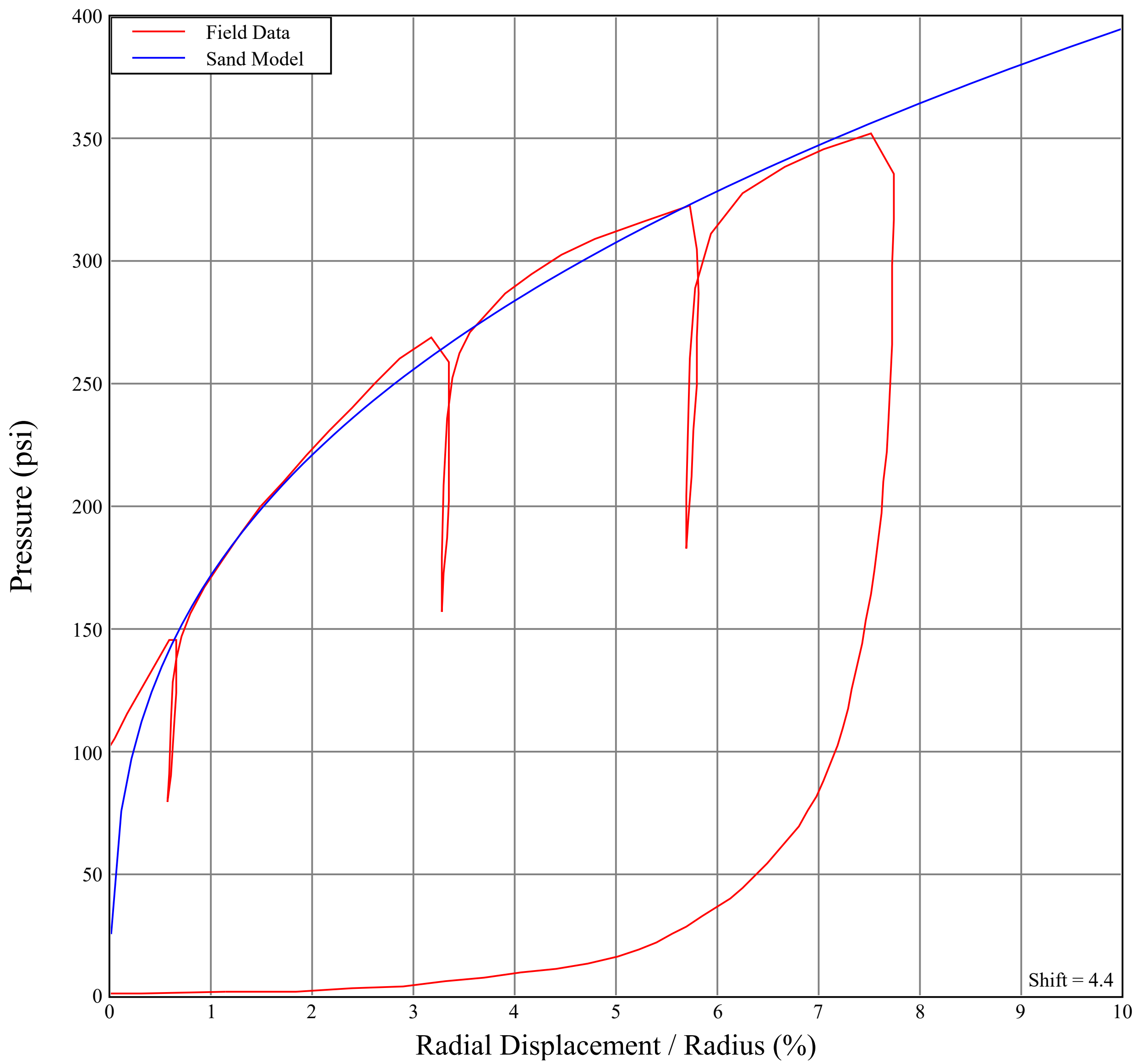
In Situ Engineering - Hughes' Sand Model

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-023 Depth: 53.7FT Date: 12/17/2020

Oper: Mayfield Job # 0115000099 Time of Test: 10:52 AM Inst: 04



DATA

Water Pressure = 18 psi

Lateral Stress = 25 psi

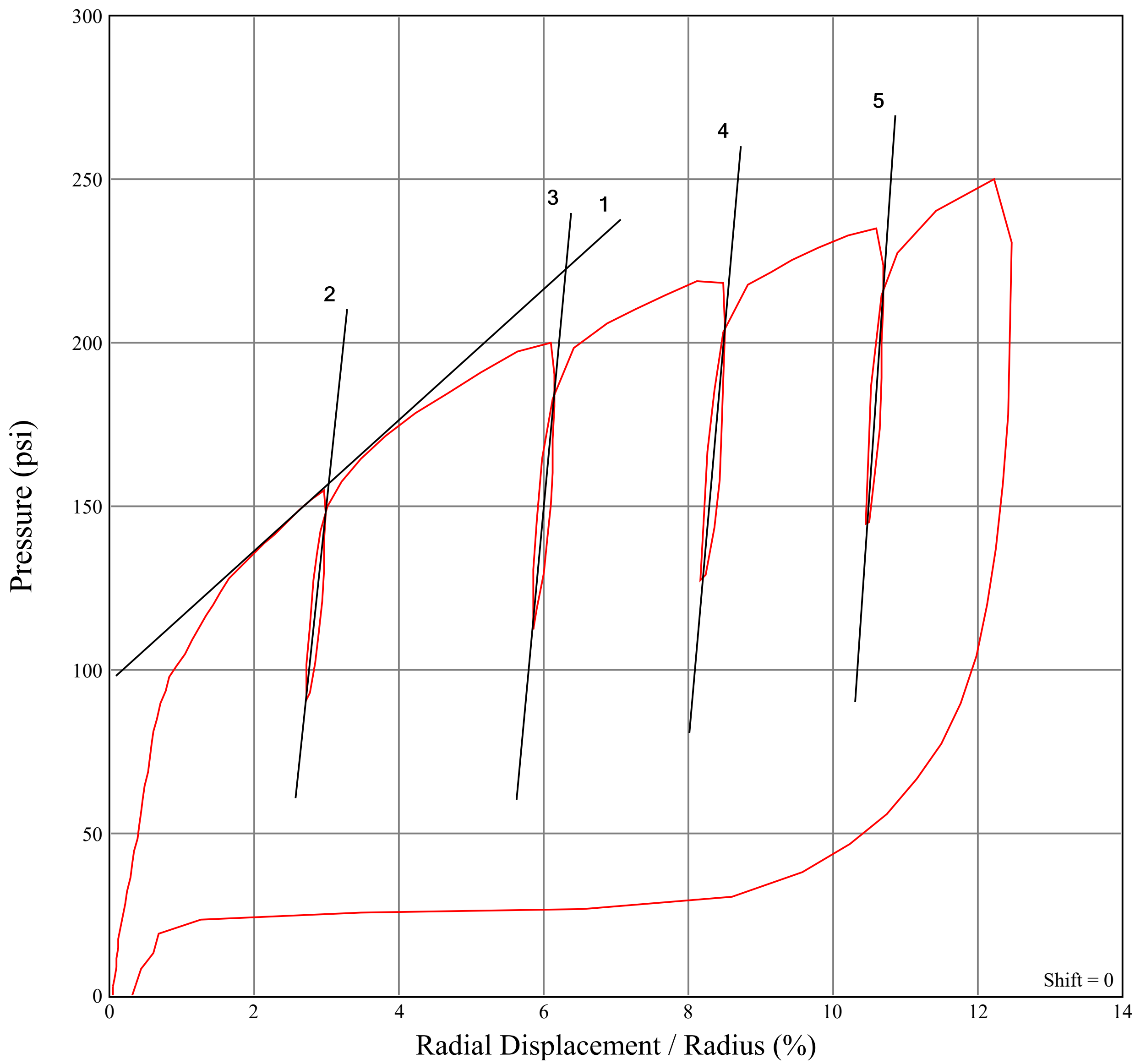
Friction Angle = 33 deg

Shear Modulus = 43600 psi

Critical Friction Angle = 32 deg

In Situ Engineering - Shear Modulus Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-020 Test: LCG-024 Depth: 74FT Date: 12/18/2020
Oper: Mayfield Job # 0115000099 Time of Test: 02:43 PM Inst: 04



DATA

#1 Shear Modulus = 1000 psi
#2 Shear Modulus = 10500 psi
#3 Shear Modulus = 11900 psi
#4 Shear Modulus = 12600 psi
#5 Shear Modulus = 16200 psi

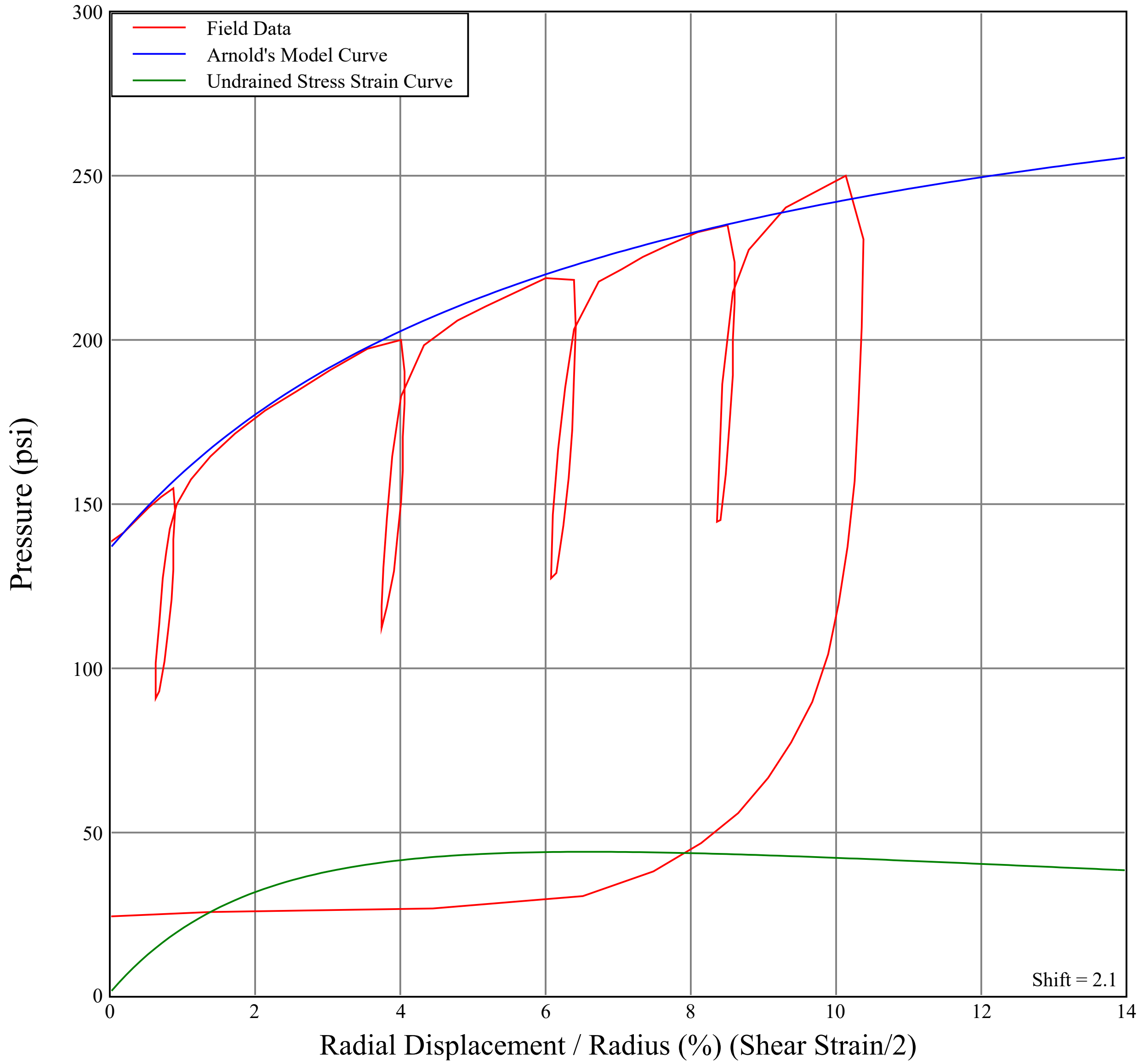
In Situ Engineering - Arnold's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-024 Depth: 74FT Date: 12/18/2020

Oper: Mayfield Job # 0115000099 Time of Test: 02:43 PM Inst: 04



DATA

INPUTS	OUTPUT
Pressure at 1% Strain = 160 psi	Shear Strength at 10% Strain = 41.9 psi
Pressure at 2.5% Strain = 185 psi	Max Shear Strength = 43.8 psi
Pressure at 7.5% Strain = 230 psi	occurs at 6.6% Strain

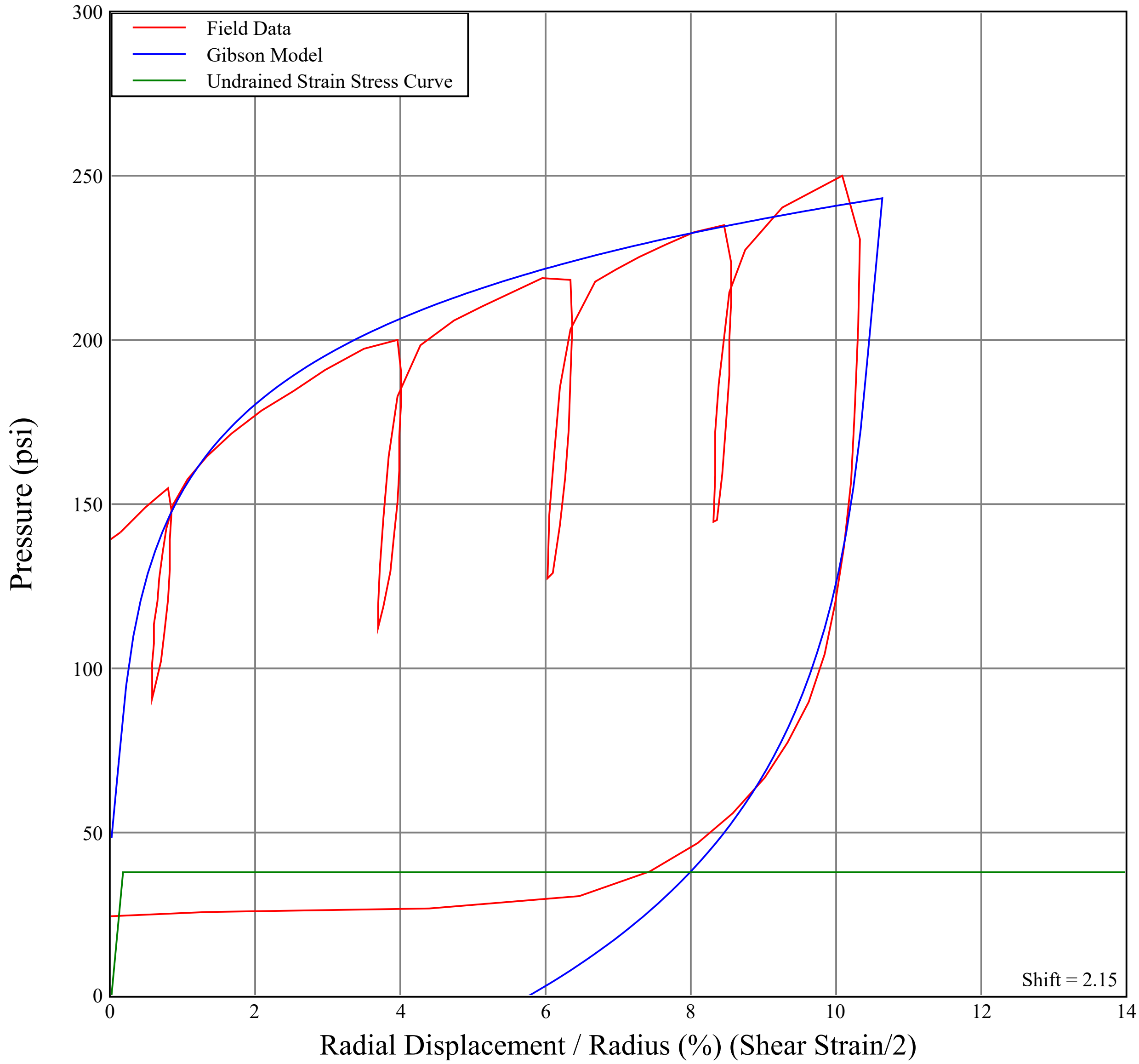
In Situ Engineering - Gibson's Clay Model

Kleinfelder

Last Chance Grade

Boring: RC-20-020 Test: LCG-024 Depth: 74FT Date: 12/18/2020

Oper: Mayfield Job # 0115000099 Time of Test: 02:43 PM Inst: 04

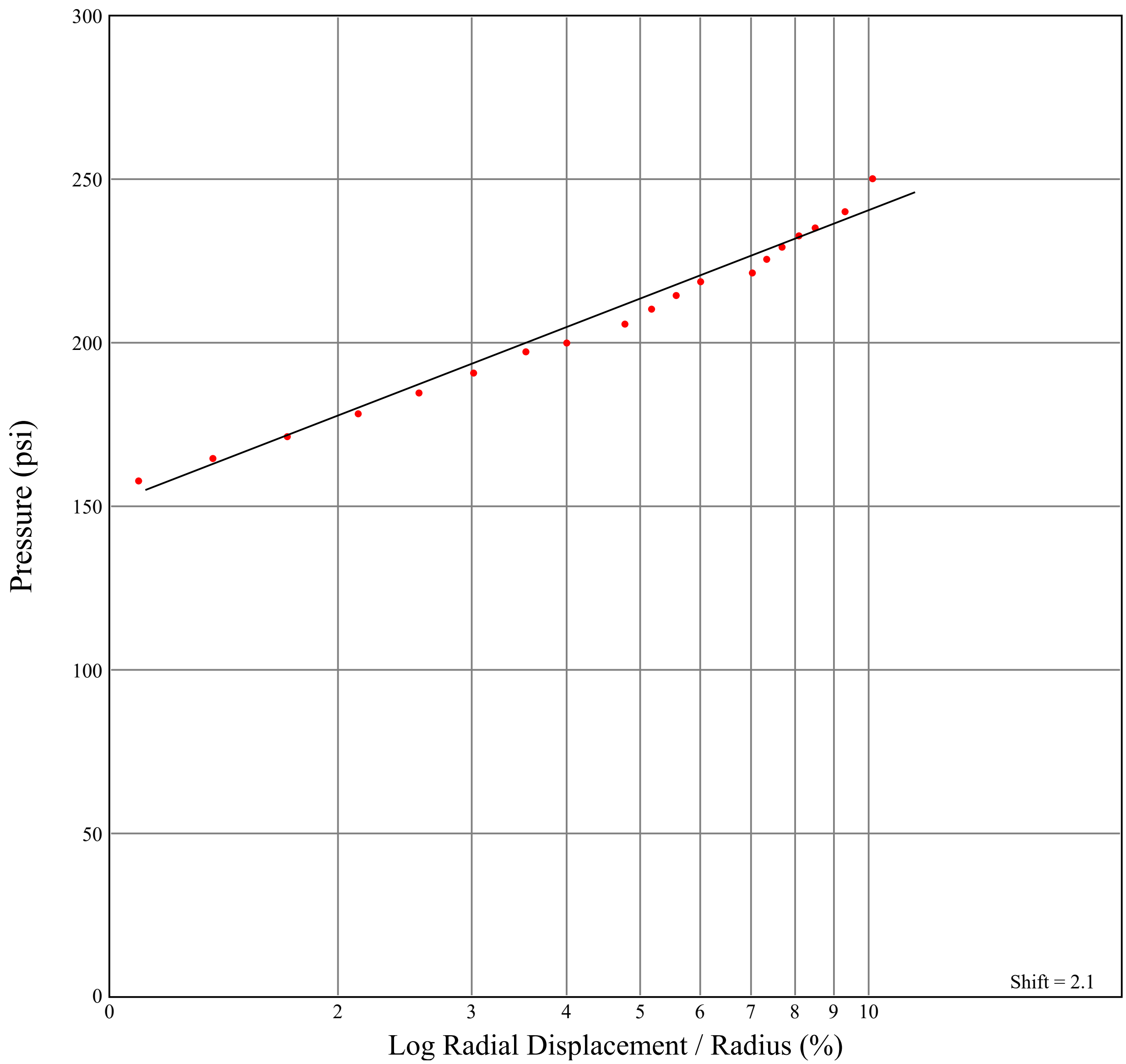


DATA

LOADING	UNLOADING
Shear Strength = 37.5 psi	Shear Strength = 62 psi
In Situ Stress = 48 psi	Shear Modulus = 11900 psi
Shear Modulus = 11900 psi	

In Situ Engineering - Logarithm Plot

Kleinfelder
Last Chance Grade
Boring: RC-20-020 Test: LCG-024 Depth: 74FT Date: 12/18/2020
Oper: Mayfield Job # 0115000099 Time of Test: 02:43 PM Inst: 04



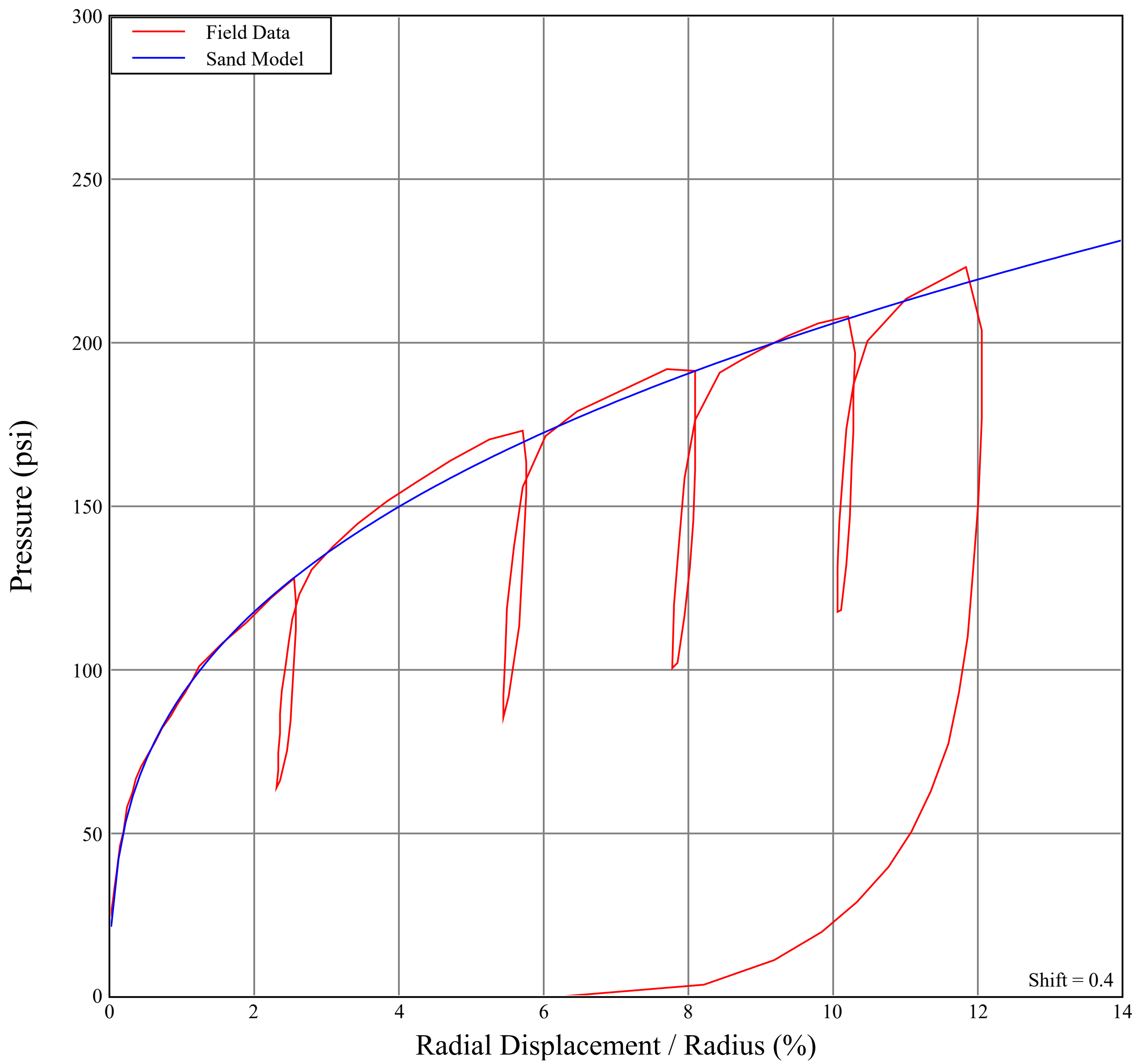
DATA

Shear Strength = 39 psi

Limit Pressure = 296 psi

In Situ Engineering - Hughes' Sand Model

Kleinfelder
Last Chance Grade
Boring: RC-20-020   Test: LCG-024   Depth: 74FT   Date: 12/18/2020
Oper: Mayfield   Job # 0115000099   Time of Test: 02:43 PM   Inst: 04



DATA

Water Pressure = 27 psi
Lateral Stress = 21 psi
Friction Angle = 32 deg
Shear Modulus = 11900 psi
Critical Friction Angle = 32 deg

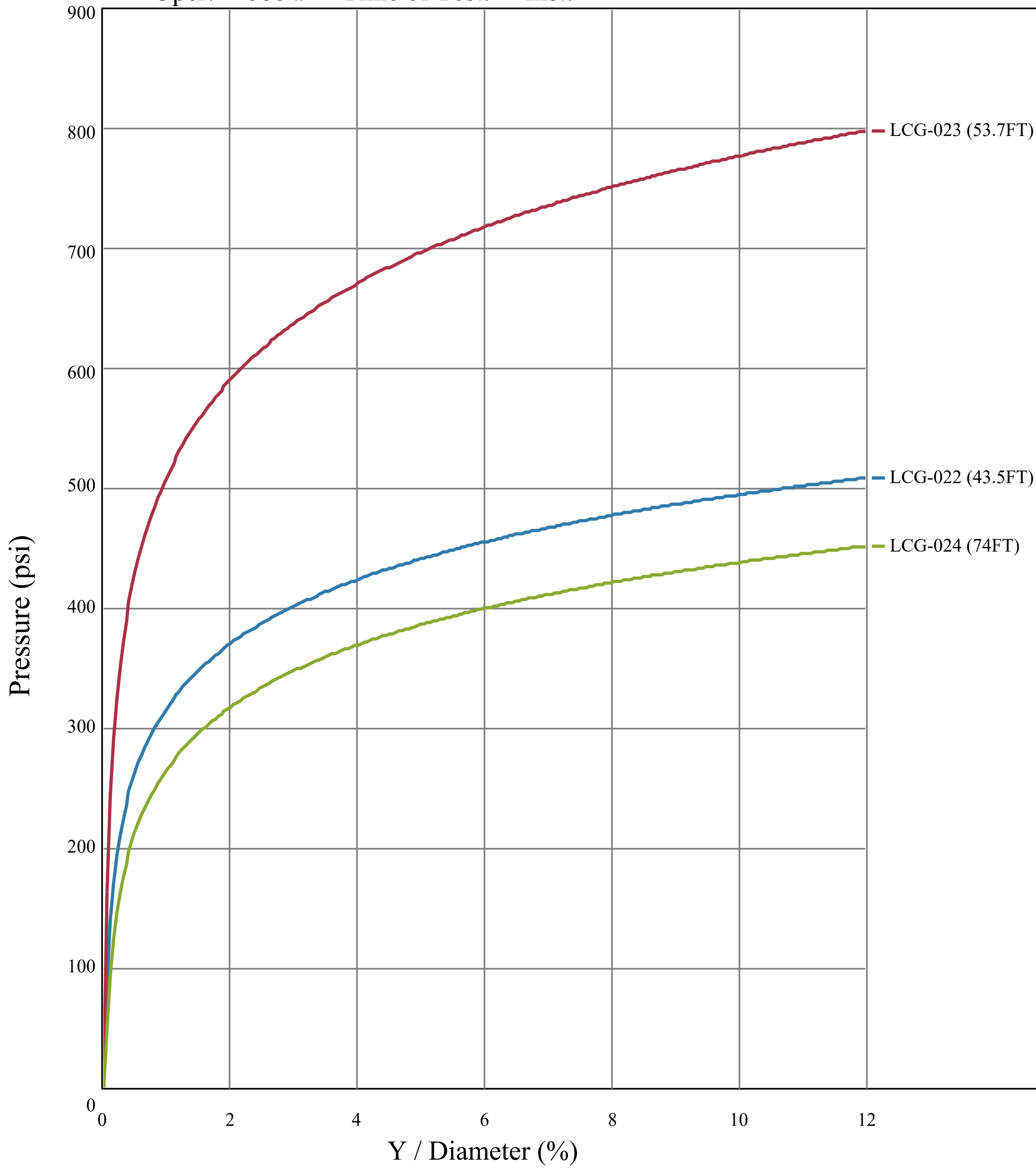
In Situ Engineering - PY Data - Cohesive

Kleinfelder

Last Chance Grade

Boring: RC-20-020

Oper: Job # Time of Test: Inst:



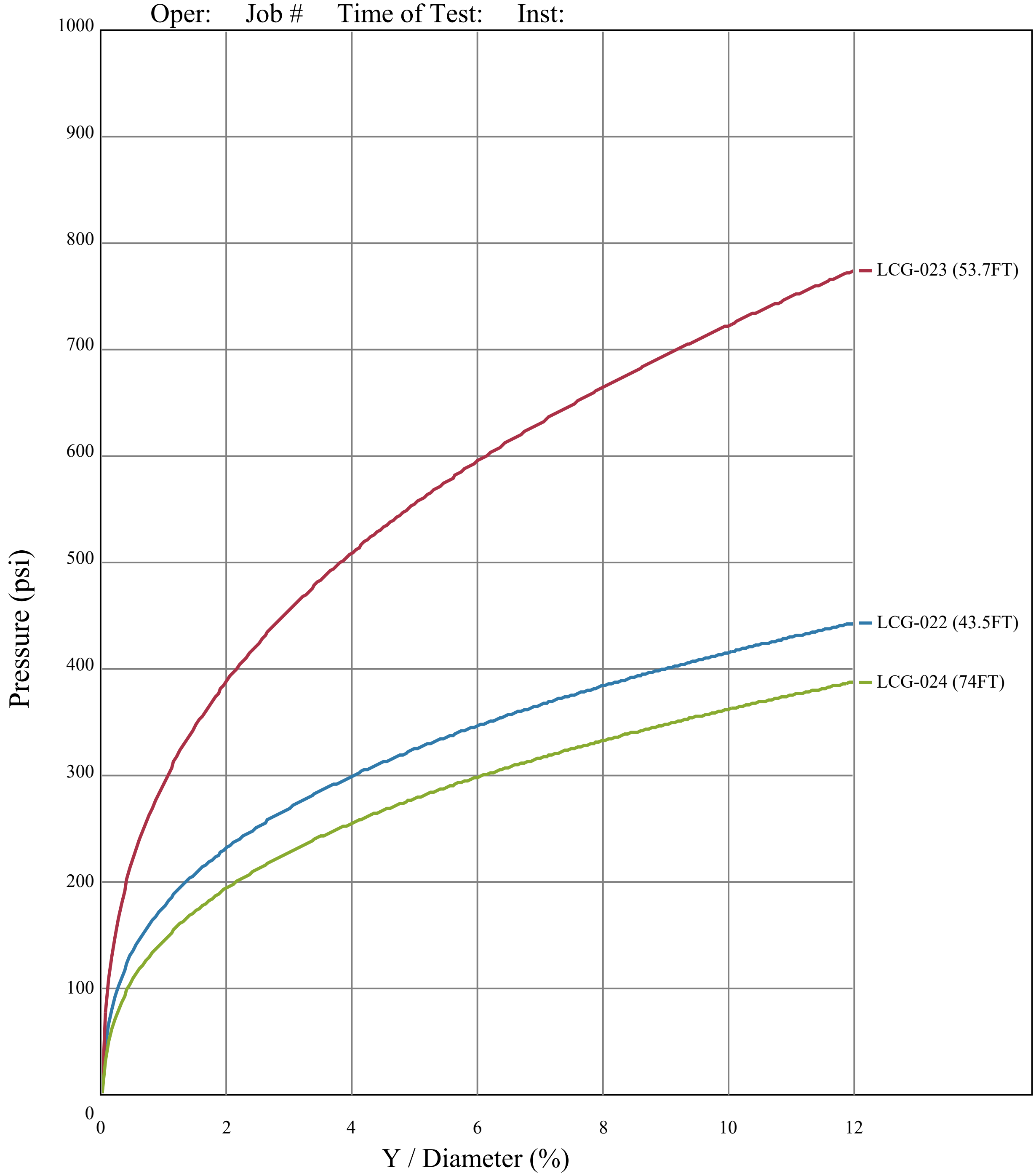
In Situ Engineering - PY Data - Frictional

Kleinfelder

Last Chance Grade

Boring: RC-20-020

Oper: Job # Time of Test: Inst:

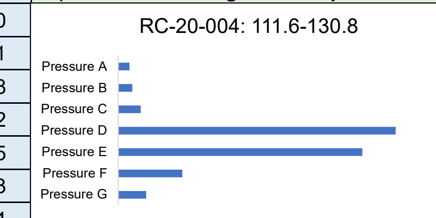
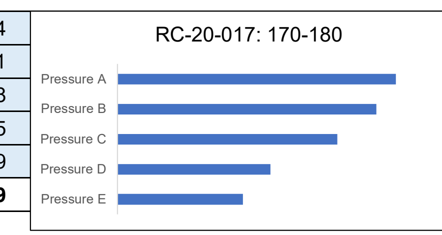


APPENDIX H Packer Permeability Test Data

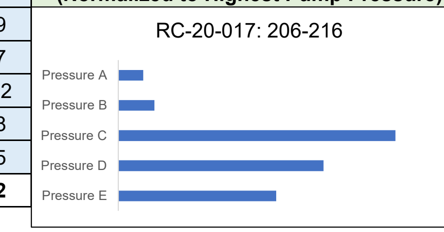
Packer Permeability Test Data

Recorded Test Data							Field Data						Hydraulic Conductivity Calculation						Lugeon Calculation			
Boring Identification Number (ID)	Initial ID	Top Depth D_t ft	Bottom Depth D_b ft	Depth to Groundwater DTW ft	Well Radius R ft	Pumping Pressure p_{pump} psi	Step	Volumetric Injection Rate (Q) 1 gpm	2 gpm	3 gpm	4 gpm	5 gpm	Average Volumetric Injection Rate Q gpm	Q ft^3/sec	Net Injection Head H ft	Hydraulic Conductivity K ft/sec	K cm/sec	K ft/day	Volumetric Injection Rate Q liter/min	Test Section Length L meters	Net Injection Pressure P MPa	Lugeon Lu
RC-20-004	B-11	111.6	130.8	130.8	0.16	50	1	0.14	0.12	0.13	0.10	0.11	0.12	2.67E-04	249.3	4.25E-08	1.30E-06	0.004	0.45	5.85	0.745	0.10
RC-20-004	B-11	111.6	130.8	130.8	0.16	60	2	0.17	0.17	0.11	0.14	0.13	0.14	3.12E-04	272.4	4.55E-08	1.39E-06	0.004	0.53	5.85	0.814	0.11
RC-20-004	B-11	111.6	130.8	130.8	0.16	70	3	0.21	0.21	0.25	0.25	0.27	0.24	5.35E-04	295.5	7.18E-08	2.19E-06	0.006	0.91	5.85	0.883	0.18
RC-20-004	B-11	111.6	130.8	130.8	0.16	80	4	2.31	2.97	3.53	3.90	4.34	3.41	7.60E-03	318.6	9.47E-07	2.89E-05	0.082	12.91	5.85	0.952	2.32
RC-20-004	B-11	111.6	130.8	130.8	0.16	70	5	2.88	2.80	2.83	2.78	2.66	2.79	6.22E-03	295.5	8.35E-07	2.55E-05	0.072	10.57	5.85	0.883	2.05
RC-20-004	B-11	111.6	130.8	130.8	0.16	60	6	0.65	0.66	0.66	0.67	0.66	0.66	1.47E-03	272.4	2.14E-07	6.52E-06	0.018	2.50	5.85	0.814	0.53
RC-20-004	B-11	111.6	130.8	130.8	0.16	50	7	0.55	0.20	0.16	0.25	0.23	0.28	6.24E-04	249.3	9.93E-08	3.03E-06	0.009	1.06	5.85	0.745	0.24
															K_{ave}=	**3.88E-07**	**1.19E-05**	**0.034**	**5.07**	**5.850**	**0.855**	**0.95**
RC-20-007	B-16	42.5	48	48.0	0.16	120	1	0.05	0.05	0.03	0.05	0.04	0.04	8.91E-05	328.2	2.78E-08	8.47E-07	0.002	0.15	1.68	0.980	0.09
RC-20-007	B-16	42.5	48	48.0	0.16	130	2	0.11	0.09	0.10	0.10	0.10	0.10	2.23E-04	351.3	6.50E-08	1.98E-06	0.006	0.38	1.68	1.049	0.22
RC-20-007	B-16	42.5	48	48.0	0.16	140	3	0.14	0.20	0.25	0.30	0.28	0.23	5.12E-04	374.4	1.40E-07	4.27E-06	0.012	0.87	1.68	1.118	0.46
															K_{ave}=						**$L_{u,ave}$=**	
RC-20-017	B-18	170.0	180	180.0	0.16	20	1	0.93	0.89	0.97	1.03	0.99	0.96	2.14E-03	229.2	6.14E-07	1.87E-05	0.053	3.64	3.05	0.685	1.74
RC-20-017	B-18	170.0	180	180.0	0.16	40	2	1.05	1.06	1.08	1.09	1.09	1.07	2.38E-03	275.4	5.69E-07	1.73E-05	0.049	4.04	3.05	0.823	1.61
RC-20-017	B-18	170.0	180	180.0	0.16	80	3	1.56	-0.41	3.18	0.91	0.88	1.22	2.72E-03	367.8	4.87E-07	1.48E-05	0.042	4.62	3.05	1.099	1.38
RC-20-017	B-18	170.0	180	180.0	0.16	40	4	0.60	0.63	0.61	0.64	0.65	0.63	1.40E-03	275.4	3.35E-07	1.02E-05	0.029	2.38	3.05	0.823	0.95
RC-20-017	B-18	170.0	180	180.0	0.16	20	5	0.43	0.44	0.45	0.43	0.44	0.44	9.80E-04	229.2	2.81E-07	8.56E-06	0.024	1.66	3.05	0.685	0.79
															K_{ave}=	**4.57E-07**	**1.39E-05**	**0.039**	**3.27**	**3.050**	**$L_{u,ave}$=**	**1.29**

Lugeon Pattern

Boring ID	Houlsby (1976) Lugeon Patterns (Normalized to Highest Pump Pressure)	Interpretation
RC-20-004		**Pattern:** **Dilation** **Average Lugeon Value:** 0.79
RC-20-007	**Failed Test**	**Pattern:** **Average Lugeon Value:**
RC-20-017		**Pattern:** **Void Filling** **Average Lugeon Value:** 1.29

Packer Permeability Test Data

Recorded Test Data							Field Data						Hydraulic Conductivity Calculation						Lugeon Calculation				Lugeon Pattern	
Boring Identification Number (ID)	Initial ID	Top Depth D_t	Bottom Depth D_b	Depth to Groundwater DTW	Well Radius R	Pumping Pressure p_{pump}	Step	Volumetric Injection Rate (Q) 1	2	3	4	5	Average Volumetric Injection Rate Q		Net Injection Head H	Hydraulic Conductivity K			Volumetric Injection Rate Q	Test Section Length L	Net Injection Pressure P	Lugeon Lu	Houlsby (1976) Lugeon Patterns (Normalized to Highest Pump Pressure)	Interpretation
		ft	ft	ft	ft	psi		gpm					gpm	ft^3/sec	ft	ft/sec	cm/sec	ft/day	liter/min	meters	MPa	Lu		
RC-20-017	B-18	206.0	216	193.0	0.16	20	1	0.47	0.52	0.62	0.65	0.66	0.58	1.29E-03	242.2	3.51E-07	1.07E-05	0.030	2.19	3.05	0.724	0.99		Pattern: Wash-out
RC-20-017	B-18	206.0	216	193.0	0.16	50	2	1.15	-0.12	1.94	0.88	1.29	1.03	2.29E-03	311.5	4.84E-07	1.48E-05	0.042	3.89	3.05	0.931	1.37		Average
RC-20-017	B-18	206.0	216	193.0	0.16	100	3	9.57	8.01	11.48	13.91	11.09	10.81	2.41E-02	426.9	3.72E-06	1.13E-04	0.321	40.94	3.05	1.276	10.52		Lugeon Value: 5.32
RC-20-017	B-18	206.0	216	193.0	0.16	50	4	6.89	5.24	13.14	-4.11	8.09	5.85	1.30E-02	311.5	2.75E-06	8.38E-05	0.238	22.08	3.05	0.931	7.78		
RC-20-017	B-18	206.0	216	193.0	0.16	20	5	3.51	3.05	3.11	4.27	3.40	3.47	7.73E-03	242.2	2.10E-06	6.40E-05	0.181	13.13	3.05	0.724	5.95		
															K_{ave}=	**1.88E-06**	**5.73E-05**	**0.162**	**16.45**	**3.050**	$L_{u,ave}$=	**5.32**		
RC-20-017	B-18	275.0	285	193.0	0.16	30	1	3.18	2.90	2.61	2.93		2.91	6.48E-03	265.3	1.61E-06	4.91E-05	0.139	11.01	3.05	0.793	4.55	**Failed Test**	Pattern:
RC-20-017	B-18	275.0	285	193.0	0.16	70	2	10.86	10.90	12.38	13.35	13.61	12.22	2.72E-02	357.7	5.00E-06	1.52E-04	0.432	46.21	3.05	1.069	14.17		Average
RC-20-017	B-18	275.0	285	193.0	0.16	30	4	8.40	8.96	9.33	8.77	9.16	8.92	1.99E-02	265.3	4.94E-06	1.51E-04	0.427	33.81	3.05	0.793	13.98		Lugeon Value:
															K_{ave}=						$L_{u,ave}$=			
RC-20-011	B-32	272.0	292	91.0	0.16	30	1	8.61	7.93	8.22	7.65	8.43	8.17	1.82E-02	164.8	4.24E-06	1.29E-04	0.366	30.92	6.10	0.492	10.30	**Failed Test**	Pattern:
RC-20-011	B-32	272.0	292	91.0	0.16	40	2	9.86	10.03	10.02	10.05	9.95	9.98	2.22E-02	187.9	4.54E-06	1.38E-04	0.392	37.71	6.10	0.561	11.02		Average
RC-20-011	B-32	272.0	292	91.0	0.16	50	3	11.06	8.96	11.12	11.95	10.96	10.81	2.41E-02	211.0	4.39E-06	1.34E-04	0.379	40.94	6.10	0.630	10.65		Lugeon Value:
															K_{ave}=						$L_{u,ave}$=			

Packer Permeability Test Data

Recorded Test Data							Field Data						Hydraulic Conductivity Calculation						Lugeon Calculation				Lugeon Pattern	
Boring Identification Number (ID)	Initial ID	Top Depth D_t (ft)	Bottom Depth D_b (ft)	Depth to Groundwater DTW (ft)	Well Radius R (ft)	Pumping Pressure p_{pump} (psi)	Step	Volumetric Injection Rate (Q) 1 (gpm)	2 (gpm)	3 (gpm)	4 (gpm)	5 (gpm)	Average Volumetric Injection Rate Q (gpm)	Q (ft^3/sec)	Net Injection Head H (ft)	Hydraulic Conductivity K (ft/sec)	K (cm/sec)	K (ft/day)	Volumetric Injection Rate Q (liter/min)	Test Section Length L (meters)	Net Injection Pressure P (MPa)	Lugeon Lu	Houlsby (1976) Lugeon Patterns (Normalized to Highest Pump Pressure)	Interpretation
RC-20-014	B-29	163.0	173	173.0	0.16	10	1	10.61	10.38	10.32	9.97	10.40	10.34	2.30E-02	199.1	7.60E-06	2.32E-04	0.657	39.07	3.05	0.595	21.53	**Failed Test**	**Pattern:**
RC-20-014	B-29	163.0	173	173.0	0.16	20	2	20.80	12.61	12.87	12.78	12.62	14.34	3.19E-02	222.2	9.45E-06	2.88E-04	0.816	54.19	3.05	0.664	26.76		**Average**
															K_{ave}=						**$L_{u,ave}$=**			**Lugeon Value:**
RC-20-014	B-29	220.0	230	230.0	0.16	20	1	1.02	0.92	0.83	0.80	0.76	0.87	1.94E-03	279.2	4.57E-07	1.39E-05	0.039	3.30	3.05	0.834	1.30		**Pattern:** **Laminar**
RC-20-014	B-29	220.0	230	230.0	0.16	50	2	1.95	1.07	1.00	1.01	0.96	1.20	2.67E-03	348.5	5.04E-07	1.54E-05	0.044	4.54	3.05	1.041	1.43		**Average**
RC-20-014	B-29	220.0	230	230.0	0.16	100	3	1.97	2.51	1.57	1.62	1.53	1.84	4.10E-03	463.9	5.82E-07	1.77E-05	0.050	6.96	3.05	1.386	1.65		**Lugeon Value:** 1.39
RC-20-014	B-29	220.0	230	230.0	0.16	50	4	1.78	1.05	1.02	1.01	1.01	1.17	2.61E-03	348.5	4.93E-07	1.50E-05	0.043	4.43	3.05	1.041	1.40		
RC-20-014	B-29	220.0	230	230.0	0.16	20	5	1.07	0.74	0.73	0.70	0.74	0.80	1.78E-03	279.2	4.20E-07	1.28E-05	0.036	3.02	3.05	0.834	1.19		
															K_{ave}=	**4.91E-07**	**1.50E-05**	**0.042**	**4.45**	**3.050**	**$L_{u,ave}$=**	**1.39**		
RC-20-014	B-29	290.0	300	300.0	0.16	30	1	0.28	0.18	0.17	0.15	0.10	0.18	4.01E-04	372.3	7.09E-08	2.16E-06	0.006	0.68	3.05	1.112	0.20		**Pattern:** **Void Filling**
RC-20-014	B-29	290.0	300	300.0	0.16	70	2	0.44	0.26	0.18	0.16	0.15	0.24	5.35E-04	464.7	7.58E-08	2.31E-06	0.007	0.91	3.05	1.389	0.21		**Average**
RC-20-014	B-29	290.0	300	300.0	0.16	140	3	0.19	0.41	0.39	0.37	0.36	0.34	7.58E-04	626.3	7.97E-08	2.43E-06	0.007	1.29	3.05	1.871	0.23		**Lugeon Value:** 0.18
RC-20-014	B-29	290.0	300	300.0	0.16	70	4	0.27	0.16	0.16	0.17	0.14	0.18	4.01E-04	464.7	5.68E-08	1.73E-06	0.005	0.68	3.05	1.389	0.16		
RC-20-014	B-29	290.0	300	300.0	0.16	30	5	0.12	0.06	0.05	0.06	0.04	0.07	1.56E-04	372.3	2.76E-08	8.41E-07	0.002	0.27	3.05	1.112	0.08		
															K_{ave}=	**6.22E-08**	**1.89E-06**	**0.005**	**0.77**	**3.050**	**$L_{u,ave}$=**	**0.18**