Analysis of Time-Deflection Consolidation Data

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ANALYSIS OF
TIME-DEFLECTION CONSOLIDATION DATA

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A computerized statistical curve-fitting algorithm has been developed for determining the time-dependent properties of conventional (load-incremental) consolidation test data. Analytical models of the graphical methods developed by Taylor and Casagrande and of the Naylor-Doran method of successive approximations determine values for the coefficients of consolidation, permeability, and the values of deflection corresponding to the beginning and ending of primary consolidation. The coefficients of volume change and secondary compression are also calculated. A modified statistical definition is used to select the linear portions of the data curves and is applicable to other data-fitting problems. After the Naylor-Doran method has been used, the coefficient of consolidation \( c_v \) is calculated according to a definition independent of errors in the deflection at the beginning of primary consolidation \( d_0 \). Input instructions, coding sheets, example problems, a flow chart, and source listing are provided. The computer program is in Fortran IV for the IBM 370/165 computer and Calcomp 663 drum plotter and has proven to be extremely effective in the analysis of over 30 sets of time-deflection consolidation test data.
INTRODUCTION

Predicting the rate of consolidation of saturated clays is one of the most difficult problems in geotechnical engineering. Terzaghi's theory of consolidation (1), the basis for predicting rates of consolidation settlement, uses many simplifying assumptions to obtain the following differential equation describing the dissipation of excess hydrostatic pressures, \( u \), in one-dimensional flow:

\[
[k(1 + e)/a_v \gamma_w] \frac{\partial^2 u}{\partial z^2} = \frac{\partial u}{\partial t} \tag{1}
\]

in which 
- \( z \) = coordinate in vertical direction,
- \( u \) = excess pore pressure,
- \( t \) = time,
- \( k \) = permeability in the vertical direction,
- \( e \) = void ratio,
- \( a_v \) = coefficient of compressibility,
- \( \gamma_w \) = unit of weight of water.

Terzaghi's non-dimensional solution to this differential equation is

\[
U = \frac{1}{1} \cdot \frac{(8/\pi^2)}{((2N + 1)^2)} \exp \left[-((2N + 1)^2 \pi^2 T_v/4)\right] \tag{2}
\]

in which 
- \( U \) = degree of consolidation
- \( u \) = initial excess pore pressure,
- \( u_0 \) = initial excess pore pressure,
- \( T_v \) = dimensionless time factor
- \( c_v \) = coefficient of consolidation
- \( N \) = number of data points.

METHODS OF ANALYSIS

Various procedures have been developed to determine the coefficient of consolidation, \( c_v \), from conventional (incremental-load) laboratory consolidation tests. Taylor (2) and Casagrande (3) developed empirical graphical procedures for obtaining \( c_v \); Naylor and Doran (4) developed an analytical method based on iterative, successive approximations. Figure 1 shows the essential elements of the well-known Taylor square-root-of-time method. If a clear linear trend is present in the initial portion of the deflection-versus-square-root-of-time data, Taylor's method can usually provide a reasonable and consistent estimation of \( d_0 \), the deflection reading corresponding to zero-percent primary consolidation. However, if substantial secondary compression has occurred when \( U \) equals 90-percent consolidation, \( t_{90} \) will be inaccurate. This will result in an inaccurate estimate of the coefficient of consolidation, \( c_v \).

In contrast, the Casagrande logarithm-of-time method (shown in Figure 2) usually provides a more consistent estimate of \( d_{100} \). Even though the Casagrande method of finding \( d_{100} \) has no theoretical basis, it is very useful in establishing an upper bound for \( d_{100} \). For instance, if the \( d_{100} \) determined from the square-root-of-time method is larger than the one obtained from the logarithm-of-time curve (assuming deflection increases with time), this usually means that the \( c_v \) obtained from the square-root-of-time method is in error due to the inclusion of secondary compression data. Next, the deflection corresponding to zero-percent consolidation, \( d_0 \), can be estimated from the initial portion of the logarithm-of-time curve assuming the curve conforms approximately to a parabola. Even though it is often very difficult to determine where the parabolic portion ends, values of \( d_0 \) determined on this assumption will compare closely to values obtained

![Taylor Square-Root-of-Time Method](image)
from the square-root-of-time method (5). Hence, the ambiguity in the location of the initial parabolic portion of the logarithm-of-time data will not generally affect the determination of $d_0$.

The Naylor-Doran analytical method is an iterative procedure to obtain the straight line between 60- and 80-percent consolidation ($0.2 < 1 - U < 0.4$) when the natural logarithm of $(1 - U)$ is plotted versus the dimensionless time factor $T_v$. A straight line results because the higher-order terms appearing in Equation 2 are negligible before 80-percent consolidation. Figure 3 illustrates the theoretical relationship between the time factor $T_v$ and the natural logarithm of $(1 - U)$ for the Naylor-Doran method. Values of $d_0$ and $d_{100}$ are assumed and then corrected by an iterative process of successive approximations that narrows the differences between the assumed and calculated values until they are sufficiently small. Although the Naylor-Doran method may yield the most reliable values (6), the method has remained largely a research tool because the iterative procedures required are too involved for manual application.

Murray (7) attempted to computerize the Taylor and Casagrande methods along with an iterative procedure different from the one proposed by Naylor and Doran (4).

Reduction of the effort required in analyzing conventional (incremental-load) time-deflection consolidation data has been accomplished by developing a computer algorithm that can apply each of the three methods discussed above. This computer program is unique in several ways. First, a modified statistical definition is used to evaluate the representativeness of a given linear least-squares fit for a particular type of line. Second, this computer program is the first known application of the Naylor-Doran method as it was first published in 1948. In addition, the precision gained in using this method has been extended, and a new equation is used for calculating the coefficient of consolidation, $c_v$. The advantages in using this equation in conjunction with the Naylor-Doran method are also presented. Third, the program can analyze an entire series of time-deflection data from several consolidation tests, including rebound or unloading data. In addition, the program determines several parameters using one or all of the methods under discussion. These parameters include the coefficients of consolidation, $c_v$, of compressibility, $m_v$, of secondary compression, $c_{v_2}$, and of permeability, $k$; the ratios of initial, primary, and secondary amounts of compression to total compression; and the deflection readings corresponding to zero- and 100-percent consolidation, $d_0$ and $d_{100}$, respectively. Analyses of data from each load increment are plotted with a summary of results. The computer program is in Fortran IV and was developed on the IBM 370/168 computer and the Calcomp 663 drum plotter.

**METHOD OF SOLUTION**

Three methods are applied using a linear least-squares analysis to fit a straight line through groups of data sampled from the data curves associated with each particular method. In addition, a modified statistical

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**Figure 2.** Casagrande Logarithm-of-Time Method.

**Figure 3.** Theoretical Relationship between Time Factor, $T_v$, and Natural Logarithm of $(1 - U)$. 

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procedure is used to analytically determine how well various groups of data represent the types of lines found in the square-root and logarithm-of-time methods. The linear least-squares analysis yields values for the slope, \( m \), and intercept, \( b \), of the straight-line equation

\[ Y = mX + b. \]  

(4)

The familiar least-squares definition of the slope (regression coefficient) is

\[
m = \frac{\left[\left(\sum X_i Y_i \right) - \left(\sum X_i \right) \left(\sum Y_i \right)\right]}{\left[\left(\sum X_i^2 \right) - \left(\sum X_i \right)^2\right]}.
\]  

(5)

The familiar least squares definition of the intercept is

\[
b = \frac{\left(\sum X_i^2 \right) \left(\sum X_i Y_i \right)}{\left(\sum X_i^2 \right) - \left(\sum X_i \right)^2} - \frac{\left(\sum X_i \right) \left(\sum Y_i \right)}{\left[\sum X_i^2 \right] - \left(\sum X_i \right)^2}. \]  

(6)

in which \( X_i \) and \( Y_i \) are individual abscissae and ordinate values, respectively, for the data points and \( N \) is the number of data points.

Statistical procedures used to evaluate the representativeness of the least-square fits on sample groups of data are based on the unbiased standard error of the estimate, \( S_e \) (the standard deviation of the residuals). The residuals are the deviations of the actual ordinate values, \( Y_i \), from the predicted ordinate values, \( Y_p \); i.e., \( Y_i - Y_p \). The following equation is used to calculate the unbiased standard error of estimate:

\[
S_e = \left\{ \left(\sum Y_i^2 - b \sum Y_i - m \sum X_i Y_i\right) \right\}^{1/2} / (N - 2).
\]  

(7)

The unbiased standard error of estimate measures the scatter in the dependent variable, \( Y \), in Equation 4. The value of \( S_e \) is expressed in the units associated with \( Y \). In deflection-versus-time conventional consolidation test data, deflection is the dependent variable; time is the independent variable.

At first it may seem appropriate to use the group of data points having the smallest value of \( S_e \) to select the best straight-line portion of a given data set. For example, this procedure may seem to be a logical way of finding the early straight-line portion of the square-root-of-time curve because there is only one unique straight-line portion. However, the use of the smallest value of \( S_e \) to select the best straight-line portion of the data breaks down in the case of the logarithm-of-time curve because two unique linear portions of the data need to be selected. In this case, the smallest value for \( S_e \) would randomly select only one of the desired lines. In other words, there is nothing to guarantee which line would be selected.

A less obvious problem with using the minimum value of \( S_e \) to select the most representative linear portion of any data curve is shown in Figure 4. There an extreme but useful example of a small group of data points that happen to have the smallest value of \( S_e \) but fails to provide a suitable representation of the straight-line portion of primary compression is shown. This group of data points has a slope incompatible with this part of the curve. Also, this group of data points spans a curve length too small to be considered significant. These results show that the value of \( S_e \) does not depend on the slope or curve length spanned by the points. The value of \( S_e \) depends solely on the scatter in the ordinate values of the data points. These facts along with other properties of \( S_e \) are discussed in APPENDIX A.

Because the value of \( S_e \) is not influenced by the slope and length characteristics of the fitted data, a statistical definition is needed that would not only measure the vertical scatter of a group of data points about a fitted straight line but also would evaluate the representativeness of a group of data points based on

![Figure 4. Inappropriate Representation of the Linear Portions of Consolidation Data Using Only the Unbiased Standard Error of Estimate, \( S_e \).](image-url)
their length and slope properties. If a given transformation of data has more than one straight-line portion, the new statistical definition should be able to define the length and slope components in unique ways for each straight-line portion. To achieve these goals, a statistical weighting was invented to develop this modified statistical definition. These weighting factors adjust the absolute amount of scatter, \(S_e\), so that length and slope properties of the data can be used to evaluate the representativeness of the straight-line fit. For example, if two different groups of data points had the same values of slope and \(S_e\), but were different only in the curve lengths spanned by the data, it would be reasonable to consider the set of data covering a larger portion of the curve as being more representative. Length significance will be measured by a dimensionless parameter called the length weighting factor, \(WFL\).

On the other hand, if the only difference between the linear fits of two different sets of data points is the slopes, then the more representative fit should be selected on the basis of which set of data has the more desirable value of slope. To do this, a criteria of what constitutes a more desirable value of slope must be established. For example, if the straight-line portion of primary compression on the logarithm-of-time curve was being sought, then the group of data points with the larger slope would be more representative. In other words, the least-squares slope of a line going through a particular group of data points can be used to establish what will be termed the position weighting factor, \(WFp\).

The statistical weighting factors introduced above are used to modify the absolute amount of scatter, \(S_e\), to yield the following new statistical definition:

\[
S_e \text{ (adjusted)} = WFp \cdot WFL \cdot S_e. \tag{8}
\]

The group of data points having the smallest adjusted value of \(S_e\) is selected as the best representation of a particular type of line. This means that the length and position weighting factors, \(WFL\) and \(WFp\), take on smaller values as the length and slope properties become more representative of the desired linear portion of a given curve. Equation 8 is a general definition applicable to finding the most representative linear portions of any curves that have length and slope characteristics defined by a set of weighting factors, \(WFL\) and \(WFp\). The weighting factors are linearly proportional to the length and slope of the line they describe. The value of \(S_e\) varies linearly with the differences between ordinate values – i.e., the amount of vertical scatter. Therefore, the three variables, \(WFp\), \(WFL\), and \(S_e\), in Equation 8 are similar in that they vary linearly with the values of length, slope, and vertical scatter, respectively. However, because \(S_e\) can become so small that it will grossly overshadow the important length and position characteristics of a group of data points, limits have been placed on how small values of \(S_e\) can become. Limiting values for \(S_e\) are needed only in special cases because most values of \(S_e\) will be greater than the established limiting values. For example, a small cluster of data points can drastically lower the value of \(S_e\). Also, if any data points fit perfectly on a straight-line as previously shown in Figure 4, \(S_e\) will be equal to zero. Limiting values were determined from trial and error. When these situations were encountered in the square-root and logarithm-of-time curves, the limiting values of \(S_e\) were increased until the resultant value of \(S_e\) (adjusted) corresponded to a group of data points that produced a reasonable representation of the desired straight-line portion of the curve. The limiting values of \(S_e\) are only working estimates and may be revised.

**SQUARE-ROOT-OF-TIME**

Because only one straight line is fitted through the deflection-versus-square-root-of-time data, there is only one definition for \(WFL\) and only one definition for \(WFp\). To give greater length significance to fitted data points spanning a larger ordinate distance, \(WFL\) is defined as

\[
WFL = \left| \frac{VHAT}{YBOT} \right|, \tag{9}
\]

in which \(VHAT\) = total vertical distance spanned by deflection data and \(YBOT\) = vertical distance spanned by fitted portion of data. Both \(VHAT\) and \(YBOT\) are shown in Figure 5.

The value of \(YBOT\) becomes very small when the fitted data points are in the flat portion of the square-root-of-time curve. Consequently, the length weighting factor, \(WFL\), becomes very large as \(YBOT\) goes to zero. Hence, when \(S_e\) is multiplied by a large value of \(WFL\), the large product indicates that the group of data points spanning the ordinate distance, \(YBOT\), does not possess significant length characteristics.

Groups of data points having larger values of slope are given more position significance by formulating the position weighting as

\[
WFp = \frac{SHAT}{SBOT}, \tag{10}
\]

in which \(SHAT\) = maximum slope on square-
Figure 5. Components of the Length and Position Weighting Factors Used in Square-Root-of-Time Analysis.

$\text{SQUARE \, ftOOF \, ELAPSED \, TiME}$

$\text{SQUARE \, ftOOF \, ELAPSED \, TiME}$

Both SHAT and SBOT are shown in Figure 5. The value of WFp becomes smaller as the slope of the fitted data becomes larger. The smaller WFp becomes, the greater the position significance of the fitted data.

The weighting factors contain a constant and a variable term. The slope and length characteristics to be defined determine which term is placed in the numerator and which is placed in the denominator.

The remaining weighting factors to be presented have these same characteristics.

The adjusted standard error of estimate, as defined by Equation 8, is evaluated for each group of data points sampled from the data curve and fitted with a least-squares straight line. The least-squares line through the data points having the smallest value for $S_e$ (adjusted) is used to represent the straight-line portion of the square-root-of-time curve. As mentioned earlier, the value of $S_e$ on the right-hand side of Equation 8 is restricted as to how small it may become to avoid overshadowing the length and position characteristics of the fitted data. In the square-root-of-time portion of the algorithm, $S_e$ will be greater than $5.6 \times 10^{-5}$ inches.

LOGARITHM-OF-TIME METHOD

The statistical weighting factors WF_l and WF_p for the logarithm-of-time method depend on whether the line representation of the primary or secondary compression data is being sought. These weighting factors are used again with Equation 8 to find the group of data points that has the smallest value of $S_e$ (adjusted).

To select the linear primary compression portion of the logarithm-of-time data curve, only small changes are made in the definitions of the square-root-of-time weighting factors. As before, the length weighting factor, WF_l, is formulated to give more length significance to the values of $S_e$ associated with groups of data spanning a large ordinate distance, as given in Equation 9. The parameters VHA and YBOT are illustrated in Figure 6 in the context of the logarithm-of-time curve. The parameter SBOT is still the least-squares slope of the fitted data under consideration. The total adjustment of the value of $S_e$ to reflect
these characteristics of length and slope is accomplished by substituting the new definitions of $WFL$ and $WFp$ into Equation 8. There are two advantages in using the weighting factors described above. First, any group of data points having the same or nearly the same ordinate values will be given less significance by the length weighting factor. These points will either lie in a flat portion of the compression curve or be spurious data points caused by reading errors in the deflection values and (or) frictional effects in the equipment. Second, giving position significance to fitted data having larger slopes will make it more likely that a group of points near the steeper portion of the curve will be selected. Again, the group of data points having the smallest value of $Se$ (adjusted) will be considered to have the best combination of length, slope, and scatter characteristics. This group of data points will be used to represent the linear portion of primary compression. Because $Se$, on the right-hand side of Equation 8, can take on very small values, a lower bound of $5.0 \times 10^{-5}$ inches has been established when the linear portion of primary compression is being sought.

Different definitions for the weighting factors are used to select the linear representation of the secondary compression data. First, the length weighting factor, $WFL$, is based on abscissa (horizontal) rather than ordinate (vertical) distance. The expression for the length weighting that gives significance to larger horizontal distances is

$$WFL = \frac{XHAT}{XBOT}, \quad (11)$$

in which $XHAT$ = total horizontal distance spanned by fitted logarithm-of-time data and $XBOT$ = horizontal distance spanned by fitted data.

Both $XHAT$ and $XBOT$ are defined in Figure 7. As the horizontal distance between the first and last data points of the group becomes larger, the value of $WFL$ calculated by Equation 11 becomes smaller because $XHAT$ remains constant. As before, smaller values of $WFL$ indicate more significant length properties. Defining $WFL$ according to the abscissa distances spanned by each group of data points avoids giving length significance to groups of fitted data that may encompass portions of the primary compression curve.

To give position significance to groups of data points lying in the flatter portion of the logarithm-of-time curve, that is, groups of data points having small values of slope, the position weighting factor $WFp$ is defined as

$$WFp = \frac{STOP}{SHAT}, \quad (12)$$

in which $STOP = \text{slope of fitted data and}$

$$SHAT = \text{slope of line between first and last data points on logarithm-of-time curve.}$$

Both $STOP$ and $SHAT$ are defined in Figure 7. Hence, the smaller the slope of the linear fit, the greater the position significance of that group of data points. Since the value of $WFp$ becomes smaller as the value of slope, $STOP$, gets smaller, a slope equal to zero would produce a value of $WFp$ equal to zero. Consequently, the value of $Se$ (adjusted) would become zero according to Equation 8 and fail to reflect the length and scatter properties of the data points. For this reason, the value of $WFp$ is prevented from going to zero by setting a lower bound value of 0.5. In addition, the relatively large value of 0.5 is used as a lower bound because, as the conventional incremental-load consolidation test enters the phase of secondary compression,
the effects of side friction increase. If side friction begins to increase as the rate of movement decreases, the effect will tend to flatten the secondary compression curve more than if friction were not present. The magnitude of this lower bound value of \( \text{WFp} \) may be revised should additional insights be gained regarding this supposition.

Finally, the group of data points having the smallest value of \( S_e \) (adjusted) using the new definitions for \( \text{WFf} \) and \( \text{WFp} \) in Equation 8 is used to represent the linear portion of the secondary compression curve. A lower bound of \( 1.0 \times 10^{-5} \) inches is used for the value of \( S_e \) on the right-hand side of Equation 8. Again, this lower bound is only a working estimate that prevents small values of \( S_e \) from grossly overshadowing the length and position characteristics of a group of fitted data points. However, this lower bound is smaller than those previously presented for \( S_e \) because the large horizontal distances often encountered between data in the secondary compression region produce very small values of \( \text{WFf} \).

**NAYLOR-DORAN METHOD**

The basic equations used in the algorithmic modeling of the Naylor-Doran method are described below. These equations are used in the iterative procedures to obtain precise values of \( d_0 \) and \( d_{100} \). The derivation of the following equations is presented in APPENDIX B.

The first step in the algorithmic application of the Naylor-Doran method is to assume values for the deflection readings corresponding to zero- and 100-percent consolidation. The value of deflection corresponding to zero-percent consolidation as determined by the square-root-of-time method is usually used as the initial assumed value of \( d_0 \) in the Naylor-Doran method. Similarly, the value of deflection determined by the logarithm-of-time method to correspond to 100-percent average degree of consolidation is usually selected as the initial assumed value for \( d_{100} \). The deflection readings are then used to calculate

\[
(1 - U') = \frac{(d - d_{100}')}{(d_0' - d_{100}')},
\]

in which

- \( U' \) = average degree of consolidation,
- \( d \) = deflection reading,
- \( d_0' \) = assumed deflection corresponding to zero-percent consolidation, and
- \( d_{100}' \) = assumed deflection corresponding to 100-percent consolidation.

The quantity \( (1 - U') \) is calculated for each deflection reading, \( d \), between the assumed values of \( d_0 \) and \( d_{100} \). From the \( \log((1 - U')) \)-versus-time relationship, the errors in the assumed values of \( d_{100} \) and \( d_0 \) are evaluated.

The error in \( d_{100} \), \( \text{err}_{100} \), can be calculated using the ratio of the slopes of the tangents to the \( \log((1 - U')) \)-versus-time curve at 60- and 80-percent consolidation. The value of \( \text{err}_{100} \) is calculated from

\[
\text{err}_{100} = 0.4 \left( \frac{\text{DY}_1}{\text{DY}_2} - 1 \right) \div (1 - 2\frac{\text{DY}_1}{\text{DY}_2}),
\]

in which

- \( \text{DY}_1 \) = least-squares slope of the \( \log((1 - U')) \)-versus-time relationship at 60-percent average degree of consolidation and
- \( \text{DY}_2 \) = least-squares slope of the \( \log((1 - U')) \)-versus-time relationship at 80-percent average degree of consolidation.

The slope parameters, \( \text{DY}_1 \) and \( \text{DY}_2 \), are illustrated in Figure 8. When these slopes are equal, the value of \( \text{err}_{100} \) becomes zero in accordance with Equation 14. In the manual application of this method, Naylor and Doran used an alternate procedure where

![Graphical Interpretation of the Slope Parameters DY1 and DY2](image_url)

Figure 8. Graphical Interpretation of the Slope Parameters DY1 and DY2 (Experimental Relationship between Elapsed Time and Natural Logarithm of \( (1 - U') \)).
the value of \( \text{err}_{100} \) was read directly from a nomograph. In deriving Equation 14, Naylor and Doran left unstated the important simplifying assumption that the error in \( d_{100} \), \( \text{err}_0 \), be considered equal to \( \text{err}_{100} \). This assumption prevented the unknown \( \text{err}_0 \) from appearing in Equation 14. Even though this simplifying assumption is not strictly valid, actual experience with experimental data has shown that the error in \( d_{100} \) has a much greater effect on the slope of the \( \log_e(1 - U') \)-versus-time relationship than the error in \( d_{100} \).

The error in \( d_{100} \) is used to correct the assumed value \( d_{100} \) to obtain a new assumed value as

\[
d_{100}'(\text{new}) = (d_{100}' \cdot \text{err}_{100}d_{100}') / (1 - \text{err}_{100}).
\] (15)

The values of \( 1 - U' \) are recalculated using \( d_{100}' \) in Equation 13. The transformation of the data to \( \log_e(1 - U') \)-versus-time is repeated and the error in this new assumed value of \( d_{100}' \) is evaluated. This process can be repeated a number of times until the value of \( \text{err}_{100} \) becomes less than five percent. This error is further reduced to less than 0.1 percent using procedures that follow.

Once a reasonably accurate estimate of \( d_{100}' \) has been obtained, the error in \( d_{100}' \), \( \text{err}_0 \), is evaluated using

\[
\text{err}_0 = \log_e (8/\pi^2) \cdot AC
\]

\[
= - (0.21 + AC),
\] (16)

in which \( \log_e (8/\pi^2) = \) theoretical intercept and \( AC = \) experimental intercept of the linear portion of \( \log_e(1 - U') \)-versus-time relationship.

The value of \( \text{err}_0 \) is used to correct the value of \( d_{100}' \) according to

\[
d_{100}'(\text{new}) = (d_{100}' + \text{err}_0d_{100}') / (1 + \text{err}_0).
\] (17a)

Naylor and Doran eliminated the term associated with \( \text{err}_{100} \) by setting \( \text{err}_{100} \) equal to zero to obtain

\[
d_{100}'(\text{new}) = (d_{100}' + \text{err}_0d_{100}') / (1 + \text{err}_0).
\] (17b)

However, \( \text{err}_{100} \) will generally not be equal to zero and may be quite large. The term eliminated by Naylor and Doran actually contained the unknown true values, \( d_0 \) and \( d_{100} \) (see APPENDIX B). Instead of ignoring this term entirely, it is better to assume that these unknown true values of \( d_0 \) and \( d_{100} \) can be approximated by \( d_0' \) and \( d_{100}' \), respectively. This has been done in Equation 17a. Experience with actual data has shown that \( \text{err}_0 \) has a greater effect than \( \text{err}_{100} \) on the value of the intercept for the linear portion of \( \log_e(1 - U') \)-versus-time curve. The differences incurred in using Equation 17a opposed to Equation 17b are usually negligible. However, since \( \text{err}_{100} \) is often not equal to zero, Equation 17a is used in the computer algorithm.

The values of \( 1 - U' \) are recalculated by Equation 13 using the new value of \( d_0' \) determined by Equation 17a. The data are again transformed to the \( \log_e(1 - U') \)-versus-time relationship, and the error in this new assumed value of \( d_0' \) is reevaluated. The value of \( d_0' \) can be estimated to within plus or minus five percent by repeating the use of Equations 13, 16, and 17a a number of times. As mentioned earlier, the error in the assumed value of \( d_0' \) is further reduced using error enhancement procedures that will be presented later.

The Naylor-Doran procedure is repeated three times to refine estimates of \( d_0 \) and \( d_{100} \). The purpose of the iterative procedures is to correct the errors in the deflection values of \( d_{100}' \) and \( d_0' \) so that the experimental data can be transformed to match the theoretical relationship given in Figure 3. Once this has been accomplished, the coefficient of consolidation can be calculated in the usual manner or by a new procedure, both of which will be shown below.

**Calculation of the Coefficient of Consolidation, \( c_v \)**

After the Naylor-Doran method has been used, the coefficient of consolidation can be calculated in two different ways. Both ways make use of the fact that Equation 2 is sufficiently accurate when the first term solution (\( N = 0 \)) is used and rearranged as follows:

\[
(1 - U') = (8/\pi^2) \exp (-\pi^2 T_v/4).
\] (18)

Substituting Equation 3 for \( T_v \) yields

\[
(1 - U') = (8/\pi^2) \exp (-\pi^2 c_v t/4H^2).
\] (19)

Taking the natural logarithm of both sides of Equation
19 yields the linear relationship

\[ \log_e(1 - U') = \log_e \left( \frac{8}{\pi^2} \right) - \pi^2 c_v t / 4 H^2. \]  (20)

This equation provides the basis for two possible ways of calculating the coefficient of consolidation, \( c_v \). First, the traditional way involves solving Equation 20 directly for \( c_v \) to get the expression

\[ c_v = \left[ 4 H^2 (\log_e(8/\pi^2) - \log_e(1 - U')) \right] / \pi^2 t. \]  (21)

When the value of elapsed time, \( t \), corresponds to that for 80-percent consolidation, Equation 21 reduces to

\[ c_v = \frac{0.5672 H^2}{t_{80}}. \]  (22)

Equation 22 can be used to determine the value for \( c_v \) once \( t_{80} \) is known. Naylor and Doran (4) manually obtained \( t_{80} \) using the graph of the \( \log_e (1 - U') \)-versus-time relationship shown in Figure 9. At 80-percent consolidation, the ordinate value equals 0.2. The point on the straight-line portion of the \( \log_e (1 - U') \)-versus-time curve having this ordinate value has an elapsed time corresponding to \( t_{80} \). However, there is one disadvantage in this method of determining \( c_v \). It will be shown in APPENDIX B that any errors in the assumed value of deflection corresponding to zero-percent primary consolidation, \( d_0 \), will shift the Naylor-Doran curve up or down from the correct vertical location and consequently affect \( t_{80} \).

A way of determining \( c_v \) that is not affected by errors in \( d_0 \) is to eliminate the use of the elapsed time, \( t \), in Equation 20. This can be done by taking the first derivative of Equation 20 with respect to the elapsed time to obtain

\[ \frac{d(\log_e(1 - U'))}{dt} = \frac{\pi^2 c_v}{4 H^2}, \]  (23)

in which \( \text{UTSLOP} = \text{slope of linear portion of } \log_e(1 - U') \text{-versus-time curve.} \)

Equation 23 shows that the slope of the straight-line portion of the \( \log_e(1 - U') \)-versus-time curve is directly proportional to the coefficient of consolidation, \( c_v \). Solving for \( c_v \) yields

\[ c_v = \frac{(-4 H^2/\pi^2)(\text{UTSLOP})}{}. \]  (24)

Figure 10 gives a graphical interpretation of the slope, UTSLOP.

Values of \( c_v \) obtained from Equations 22 and 24 are the same only if the intercept of the straight-line portion of the \( \log_e (1 - U') \)-versus-time curve is equal to \( \log_e(8/\pi^2) \), or more simply, -0.21. When the intercept is not equal to -0.21, the values of \( c_v \) obtained from Equation 22 will differ slightly from the values determined by Equation 24. Equation 24 is a better procedure for two reasons. First, Equation 24 is independent of \( d_0 \); and consequently, the equation is independent of the intercept of the linear portion of the \( \log_e (1 - U') \)-versus-time curve. This results from the removal of the intercept and elapsed time terms from Equation 20 upon differentiation. Second, \( c_v \) is dependent only on the slope of the linear portion of the \( \log_e(1 - U') \)-versus-time relationship. This conforms to the inherent meaning of the coefficient of consolidation because \( c_v \) describes only the rate of the consolidation process and does not yield any information on the path of this process as contained in the time and intercept components of Equation 20.

For these reasons, the slope equation given by Equation 24 is used by the algorithm to calculate the value for \( c_v \) after the Naylor-Doran method is applied. Equation 24 was encountered incidentally by Murray (7) during an attempt to avoid using discrete points from the \( \log_e(1 - U') \)-versus-time relationship to
Figure 10. New Method of Calculating the Coefficient of Consolidation, \( c_v \), after the Naylor-Doran Method Has Been Used.

\[
\begin{align*}
\text{INTERCEPT OF LINEAR PORTION OF THEORETICAL RELATION HAS VALUE OF } & \frac{1}{2} \\
C_v = \left( -\frac{4}{H^2 / \pi^2} \right) & \text{ UTILSOP}
\end{align*}
\]

calculate \( c_v \) because these points are subject to experimental error. Obviously, using Equation 24 has many other advantages.

**PROCEDURES UNIQUE TO THE COMPUTER SOLUTION**

There are three procedures unique to the computer solution. First, there are those procedures used to sample portions of the square-root- and logarithm-of-time curves in the search for their linear portions. Next, the square-root and logarithm-of-time methods use a variety of procedures that deal with such considerations as interpolation, rejection of spurious least-squares fits, and the calculation of \( d_0 \) for the logarithm-of-time method by an approximation procedure. Finally, the computer procedures used in the application of the Naylor-Doran analytical method are discussed.

**SQUARE-ROOT-OF-TIME SAMPLING PROCEDURES**

A series of sampling intervals are generated from a single set of ordinate values by subdividing the vertical distance spanned by the entire data curve. These sampling intervals are varied in size and position in the vertical direction. When three or more data points have ordinate values within the vertical region spanned by a given sampling interval, the slope, intercept, and value of \( S_o \) for the least-squares linear fit are calculated. The essence of the sampling procedure is shown in Figure 11. Two sets of sampling intervals having different lengths are labeled as intervals 1 and 2 with initial offset locations A, B, and C. The Size-1 interval samples data between every other generated ordinate value as it is moved down the square-root-of-time curve in the vertical direction from initial offsets A and B. Similarly, the sampling interval can be increased to Size 2 using a sequence of ordinate values spaced further apart. Starting from initial offset locations, A, B, and C, the sampling interval of Size 2 is moved down the curve in the vertical direction. Additional passes are made through the data as the size of the sampling intervals are increased. Each pass starts from various initial offset locations to obtain groups of data points covering a wide range of length and position combinations. A complete graphical summary of the sampling intervals generated by the computer program for the square-root-of-time method is presented in APPENDIX C. This graphical summary makes the procedure easier to understand and to modify.

The sampling procedure is started from a point where the compression of air and seating effects
appear to have little significance. The vertical distance between the first two points must not be greater than twice the size of the smallest sampling interval. If the distance is too large, the second data point is used to start the generation of the sampling intervals. This procedure avoids the possibility of assigning inappropriately small values for the length and position weighting factors, \(WF_L\) and \(WF_p\), respectively. A large vertical distance and a steep slope between the first two points may be due to the compression of air in the specimen and/or initial slippage in the seating of the top cap or porous stone. In accordance with this procedure, the first point in Figure 11 was not used to start the generation of the sampling intervals.

**LOGARITHM-OF-TIME SAMPLING PROCEDURES**

Data points are selected from the secondary and primary portions of the logarithm-of-time curve using sampling intervals that move in the horizontal direction. The procedures for generating these sampling intervals are described below along with a procedure that insures that the same group of points will never be selected for the linear representations of both lines.

**SECONDARY COMPRESSION**

In the selection of a linear representation of the secondary compression data, sampling intervals of varying widths, \(B_i\), are generated near the end of the curve as shown in Figure 12. The data points located in intervals \(B_i\) are analyzed using statistical procedures outlined previously to evaluate the representativeness of the linear least-squares fits. New starting points are progressively chosen at earlier data points labeled as LLL in Figure 12. These starting points are used to generate groups of data points that do not include portions of the data at the end of the curve. This is done to remove the effect of any possibly unrepresentative data points that could distort the linear representation selected for the secondary compression data. For example, at LLL = 1 in Figure 12, the last data point serves as the starting point for backward generation of the increasingly large sampling intervals, \(B_i\). When LLL equals 2, the last data point will be ignored, and the next to last data point is used as the new starting point for the backward generation of another set of sampling intervals. In other words, after one pass has been made through the data with sampling intervals generated from LLL = 1, another pass is made with intervals generated from LLL = 2. Similar reasoning is followed for values of LLL = 3, 4, and up to 30 percent of the total number of data points. If the total number of data points is equal to 34, then the maximum value of LLL would be 10. The value of LLL is never allowed to become greater than 30. This procedure is explained graphically in APPENDIX C. Limits have arbitrarily been placed on how much of the logarithm-of-time curve is considered in the search for a linear representation of the secondary compression data to reduce the number of unnecessary calculations performed by the computer. Similarly, each sampling interval is checked so that it does not contain the same data points found in the preceding interval.

The least-square slope and intercept, along with the value of \(S_e\) (adjusted) defined previously, are determined for the data points lying within each sampling interval. The group of data points found to have the smallest value of \(S_e\) (adjusted) is used to provide the linear representation of the secondary compression data. To avoid selecting these points as the linear representation of the primary compression data, the slope, intercept, and standard error of the estimate, \(S_e\), of the chosen least-squares fit are first multiplied by \(10^6\) and stored in integer form. These integer values are subsequently compared to the integer forms of the slope, intercept, and \(S_e\) characteristics of the groups of data sampled in the search for

![Figure 12. Sampling Procedures Used in Search for Linear Portion of Secondary Compression on Logarithm-of-Time Curve.](image-url)
the linear portion of primary compression. This comparison of integers will be discussed further in the following section.

**PRIMARY COMPRESSION**

The linear portion of the primary compression data is found by generating sampling intervals of widths $B$ as shown in Figure 13. There are two stages to this sampling procedure. In the first, $B$ is set to a large value by dividing the horizontal distance spanned by the data set into eight equal parts. Three passes are made through the data with this $B$. After the first pass, the horizontal location of the sampling intervals is changed in the remaining passes by offsetting these intervals slightly to the right. This results in a more efficient sampling procedure because the sampling interval covers many more different portions of the data curve. During each pass through the data with a given $B$, the interval having the group of points with the largest slope is found. The groups of data sampled in the vicinity of this large slope are checked to find which group has the smallest $S_e$ (adjusted). The values of the slope, intercept, and scatter $S_e$ for the least-squares fit of those points having this small value of $S_e$ (adjusted) are stored. If a smaller $S_e$ (adjusted) is not found during sampling, the characteristics of the least-squares line with this value will be used for the linear representation of primary compression. A graphical summary of the sampling procedure described above can be found in APPENDIX C.

The second stage of this sampling procedure generates smaller sampling intervals over the region surrounding the steeper portion of the logarithm-of-time curve. In other words, fewer data points will be sampled by each sampling interval. There is one basic difference between the first and the second stages of the sampling procedure. Instead of dividing the entire horizontal length of the curve into sampling intervals in the first stage, the horizontal distance spanned by those intervals in the vicinity of the largest slope is used in the second stage. This distance is divided into ten equally spaced sampling intervals. These new sampling intervals now cover a smaller region centered near the steepest portion of the logarithm-of-time data curve. As before, these sampling intervals are slightly offset to the right in subsequent passes through the data of interest. Similarly, the group of data points in the vicinity of the largest slope having the smallest value of $S_e$ (adjusted) are checked to see if this value of $S_e$ (adjusted) is a new minimum. This second stage of the sampling procedure is repeated several times until each sampling interval becomes so small that it either contains only three points or has passed a maximum of five iterations. APPENDIX C provides a graphical synopsis of the sampling procedures described above.

To prevent the selection of the group of data points used for the linear representation of the secondary compression data, the forward progress of the sampling interval $B$ as shown in Figure 13 is halted whenever these data points are sampled. In other words, only the data points lying before those selected as the linear representation of the secondary compression data can be sampled when the linear portion of the primary compression is being sought. By multiplying the slope, intercept, and value of $S_e$ obtained for each least-square fit by $10^6$ and storing these values in integer form, a second sampling of the same group of data points can be detected. When the integer characteristics of both lines are equal, then the data used for linear representation of secondary compres-

![Figure 13. Sampling Procedures Used in Search for Linear Portion of Primary Compression on Logarithm-of-Time Curve.](image-url)
sion have been selected. Consequently, the forward progress of the sampling intervals is stopped for the current value B.

MISCELLANEOUS PROCEDURES FOR SQUARE-ROOT- AND LOGARITHM-OF-TIME METHODS

Interpolation for t90 and t50 by Least-Squares Parabola – The interpolation parabola fits those data points in the vicinity of d90 and d50. The quadratic formula is used to solve for the two possible roots associated with both t90 and t50. The extraneous roots are discarded in each case. A three-, five-, and nine-point least-squares parabola is used, depending on the number of data points in a given set of time-deflection data. When the number of data points exceeds 40, a nine-point parabola is used. A five-point parabola is used when the number of data points is greater than 15 but not more than 40. The three-point parabola is used when there are fewer than 15 data points. When interpolation by a given type of parabola cannot be performed in the square-root-of-time method, linear interpolation is used. However, linear interpolation is not used as a default procedure in the case of the logarithm-of-time method because it is too approximate.

Rejection of Spurious Least-Square Fits – Sometimes the value of the slope for a group of points is incompatible with the trend of the rest of the curve. For instance, when there is a considerable amount of scatter in the data, there may be a group of points having a positive slope when the rest of the curve shows a negative slope. This group of points should be considered spurious and have its least-squares fit rejected from further consideration. This is accomplished by assigning the value of 999.0 inches to the value of scatter, S_e, associated with the spurious least-square fit. Increasing values of deflection with time have arbitrarily been chosen to indicate compressive loading. Hence, values of slope that are not positive for groups of data from a compressive loading curve are spurious. Similarly, decreasing values of deflection with time have been chosen to indicate an unloading or rebound time-deflection curve. In this case, the computer program must encounter negative values of slope when the groups of data points are sampled. Otherwise, the values of S_e associated with groups of points having positive slopes are set to 999.0 inches.

Calculation of d0 for Logarithm-of-Time Method – The early portion of the logarithm-of-time curve is known to approximate a parabola. The first data point having a value of elapsed time greater than or equal to 0.1 minute is selected as t1. The first data point having a value of elapsed time greater than or equal to 4t1 is used as t2. The difference in deflection between the two points with times in the ratio of 4 to 1 is calculated; then a distance equal to this difference is located above the upper point.

NAYLOR-DORAN COMPUTER PROCEDURES

Two special procedures are used in the computer application of the Naylor-Doran method. First, the least-squares slopes, DY1 and DY2, are calculated at three points in the vicinity of (1 - U') equal to 0.2 and 0.4, respectively. These slopes are used in Equation 14. Second, a special procedure is used to obtain more accurate values of d100' and d0'. The value of d100' and d0' obtained from Equations 15 and 17 generally converge to minimum values that oscillate between plus and minus values of one to five percent. True convergence below five percent is often not obtained because of this oscillation. To break this pattern of oscillation, the computer program uses an interpolative procedure to reduce the errors in d100' and d0' much further. The plus and minus error associated with consecutive values of d100' and d0' are used with linear interpolation to obtain new assumed values of d100' and d0' with errors much closer to zero. Figure 14 illustrates a typical relationship between err100 and d100'. The linear interpolation procedure is used when the value of err100 does not converge to less than 0.1 percent after four iterations (IK = 4) with Equations 13 through 15. If convergence has not been obtained by IK = 10, then the most recent value of d100' less than 10 percent is used (at IK = 9 in Figure 14). Linear interpolation for d0' is used after two iterations.

CAPABILITIES OF THE COMPUTER PROGRAM

Range of Assigned Values – The amount of data that can be analyzed by the computer program is limited internally and externally. Internally, the array storage space available within the computer program allows time-deflection data from a maximum of 20 load increments for a single consolidation test. Each load increment can have a maximum of 400 pieces of time-deflection data. Externally, the amount of central processing unit (CPU) time allowed by the computer system determines how many sets of consolidation data can be analyzed. The time allowed depends on two principal factors: job control information and execution time required by the computer program to process the data. These are discussed in the section entitled "Data Inputs."

Limitations on the Formulation of a Test Problem – If the computer program is to be used, the data to be analyzed must resemble the data curves typically encountered when the square-root-of-time, logarithm-of-time, and Naylor-Doran methods are used. If the
Figure 14. Typical Relationship for \( e_\text{100} \) as a Function of \( d_\text{100} \).

The data are input from punched cards using the format described by the coding sheet forms and instructions contained in APPENDIX D. All deflection information must be converted to inches by selecting an appropriate value for the Deflection Calibration Factor (DCF). Finally, a negative value of DCF must be used when decreasing values of deflection indicate specimen shortening. This is necessary to conform to the arbitrary relationship established between deflection and time for compression and unloading.

A description of the job control information needed to use the computer program on the IBM 370 system is given in APPENDIX D along with a description of the computer system. The job control information describes how the computer program can be used at the University of Kentucky computing center. Approximate execution times are also given in APPENDIX D.

COMPUTER PROGRAM OPTIONS

Options within the computer program are described in detail in APPENDIX D. These can be placed into three categories: analysis, graphical output, and debugging options.

Analysis Options – There are four main analysis options found within the computer program. First and primarily, the user can select either one or all of the three possible methods available within the computer program to calculate the coefficient of consolidation. If nothing is specified, the computer program will use all three methods. Second, the user may specify that single or double drainage be considered in the calculation of \( c_v \). If this is not specified by the user, the computer program will assume double drainage. Next, there is an option for specifying the manner in which the initial deflection reading is selected. Either the first deflection of the current load increment or the last deflection reading of the preceding load increment can be used as the initial deflection. If nothing is specified, the computer program uses the first deflection of each set of time-deflection data as the initial deflection. Lastly, the logarithm-of-time method has an option which allows the value of \( d_0 \) determined by the square-root-of-time analysis to be used instead of the value determined by the 4-times-\( t_1 \) approach.

Graphical Output Options – There are six options for specifying the type of graphical output. The output can be produced by the line printer along with the tabulated results or produced by the Calcomp plotter from information stored on an 800 bpi magnetic tape. First, the size of the plots produced on the plotter can be reduced or increased using an option that allows the user to specify a reduction or magnification factor. For reproduction...
purposes, large plots are desirable. For routine work, smaller plots will reduce the cost of plotting. In any case, the width of the plotting paper and the legibility of the plotting characters will limit the selection. A second option allows the use of printer-plotter routines if they are available on the particular computer system. These routines must be compatible with those called by the computer program. With this option, the curves can be produced on the line printer. However, these plots do not show graphical constructions. A third option allows the user to prepare summary plots of the coefficients of consolidation and secondary compression $c_v$ and $c_{sh}$, respectively, without having to plot the individual curves produced during the analysis of each incremental loading. These two coefficients are plotted as functions of the logarithm of effective stress on the Calcomp plotter. In case a check on the fits of the interpolation parabolas on the data points in the vicinity of $d_{90}$ and $d_{50}$ is desired, there is an option to show the parabolas and data points that were fitted. Another option allows the user to check the underlying assumptions used in the Naylor-Doran method by print-plotting the error-versus-$d_{100}$ or $d'_0$ relationships. Finally, there are additional types of output options available within the computer program, and these are discussed in the input instructions found in APPENDIX D.

Debugging Options - Options are available for debugging any of the three methods of analysis used by the computer program and for debugging the plotting subroutines. The use of these options is described by the input instructions found in APPENDIX D.

NUMERICAL EXAMPLES

To establish the credibility of this computer program, several numerical examples are presented below. First, a fully documented example problem is presented complete with the plotted and printed output. Next, results for data published and manually analyzed by Naylor and Doran (4) are compared to results obtained by the computer program. Naylor and Doran used their method, along with the square-root- and logarithm-of-time methods, to analyze the data. Results obtained for $d_{90}$ and $d_{100}$ are compared with those values obtained from the computer program in Table 3. Table 4 compares the values of time ($t_{90}$, $t_{50}$, $t_{80}$) obtained manually against those obtained from the computer program for 90-, 50-, and 80-percent consolidation, respectively. Both Tables 3 and 4 show good agreement between values obtained by the computer program and by Naylor and Doran. The computerized version of all three methods gave nearly the same results for the coefficient of consolidation, $c_v$. However, since Naylor and Doran did not report any values for $c_v$, no comparison with the computer results could be made.

PROGRAM VERSATILITY

Some options available within the computer program are demonstrated herein along with the fact that the program will analyze consolidation data

<table>
<thead>
<tr>
<th>LOAD INCREMENT (kPa)</th>
<th>TAYLOR $c_v$ (ft$^2$/DAY)</th>
<th>CASAGRANDE $c_v$ (ft$^2$/DAY)</th>
<th>NAYLOR-DORAN $c_v$ (ft$^2$/DAY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 (24.0)</td>
<td>3.609 (0.3352)</td>
<td>2.047 (0.1902)</td>
<td>5.224 (0.4850)</td>
</tr>
<tr>
<td>0.50 (47.9)</td>
<td>0.787 (0.0731)</td>
<td>0.862 (0.0800)</td>
<td>0.735 (0.0683)</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.344 (0.0312)</td>
<td>0.302 (0.0281)</td>
<td>0.404 (0.0375)</td>
</tr>
<tr>
<td>2.00 (191.6)</td>
<td>0.251 (0.0233)</td>
<td>0.195 (0.0181)</td>
<td>0.243 (0.0226)</td>
</tr>
<tr>
<td>4.00 (383.2)</td>
<td>0.265 (0.0246)</td>
<td>0.280 (0.0260)</td>
<td>0.300 (0.0279)</td>
</tr>
<tr>
<td>8.00 (766.4)</td>
<td>0.400 (0.0372)</td>
<td>0.379 (0.0352)</td>
<td>0.416 (0.0386)</td>
</tr>
<tr>
<td>16.00 (1532.8)</td>
<td>0.494 (0.0459)</td>
<td>0.511 (0.0475)</td>
<td>0.566 (0.0526)</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>1.401 (0.1302)</td>
<td>0.450 (.0418)</td>
<td>0.820 (0.0762)</td>
</tr>
</tbody>
</table>

Results for the values of $c_v$, $d_0$, and $d_{100}$ are summarized in Tables 1 and 2.
TABLE 2. COMPUTER RESULTS FOR INITIAL AND FINAL VALUES OF PRIMARY CONSOLIDATION BY THREE METHODS (REMOLED KAOLINITE K-517.201)

<table>
<thead>
<tr>
<th>LOAD INCREMENT tef (kPa)</th>
<th>INITIAL VALUES, d₀</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TAYLOR CASAGRANDE</td>
<td>NAYLOR-DORAN</td>
<td>TAYLOR CASAGRANDE</td>
<td>NAYLOR-DORAN</td>
</tr>
<tr>
<td>0.25 (24.0)</td>
<td>0.1796</td>
<td>0.1794</td>
<td>0.1795</td>
<td>0.1815</td>
</tr>
<tr>
<td>0.50 (47.9)</td>
<td>0.1838</td>
<td>0.1835</td>
<td>0.1839</td>
<td>0.1872</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.1902</td>
<td>0.1901</td>
<td>0.1899</td>
<td>0.1996</td>
</tr>
<tr>
<td>2.00 (191.6)</td>
<td>0.2043</td>
<td>0.2043</td>
<td>0.2039</td>
<td>0.2252</td>
</tr>
<tr>
<td>4.00 (383.2)</td>
<td>0.2300</td>
<td>0.2300</td>
<td>0.2288</td>
<td>0.2581</td>
</tr>
<tr>
<td>8.00 (766.4)</td>
<td>0.2647</td>
<td>0.2640</td>
<td>0.2642</td>
<td>0.2917</td>
</tr>
<tr>
<td>16.00 (1532.8)</td>
<td>0.2988</td>
<td>0.2982</td>
<td>0.2975</td>
<td>0.3330</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.3376</td>
<td>0.3376</td>
<td>0.3357</td>
<td>0.3166</td>
</tr>
</tbody>
</table>

TABLE 3. INITIAL AND FINAL VALUES OF PRIMARY CONSOLIDATION OBTAINED BY MANUAL VERSUS COMPUTER APPLICATION OF THREE METHODS (TEST DATA FROM NAYLOR AND DORAN (4))

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>INITIAL VALUES, d₀</th>
<th>FINAL VALUES, d₁₀₀</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TAYLOR CASAGRANDE</td>
<td>NAYLOR-DORAN</td>
</tr>
<tr>
<td>Naylor-Doran</td>
<td>1940 (1940)</td>
<td>1952</td>
</tr>
<tr>
<td>Computer</td>
<td>1928 (1928)</td>
<td>1957</td>
</tr>
</tbody>
</table>

TABLE 4. VALUES OF t₉₀, t₅₀, AND t₈₀ FOR 90-, 50-, AND 80-PERCENT CONSOLIDATION, RESPECTIVELY, BY MANUAL VERSUS COMPUTER APPLICATION OF THREE METHODS

<table>
<thead>
<tr>
<th>TIME (IN MINUTES)</th>
<th>NAYLOR-DORAN (MANUALLY)</th>
<th>COMPUTER PROGRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>t₉₀</td>
<td>140.4</td>
<td>147.5</td>
</tr>
<tr>
<td>t₅₀</td>
<td>30.3</td>
<td>31.4</td>
</tr>
<tr>
<td>t₈₀</td>
<td>88.5</td>
<td>83.6</td>
</tr>
</tbody>
</table>

from soils of different geologic origins. In addition, one example is given to show that the computer program can be used to analyze data curves from laboratory tests that are similar to those obtained from the conventional consolidation test.

DEMONSTRATION OF OPTIONS

A few of the options available within the computer program are demonstrated with the data published by Naylor and Doran (4) in APPENDIX F. Three options were used. The option that plots deflection output in millimeters is shown along with the option that allows the use of the square-root-of-time d₀ in the logarithm-of-time method. Finally, the option that allows the plotting of the interpolation
parabolas for the square-root-of-time and logarithm-of-time methods is shown.

**DATA FROM SOILS OF DIFFERENT GEOLOGIC ORIGENS**

Specimens from field samples of two different geologic origins were tested, and the data analyzed by the computer program. Index properties of both soils are given in Table 5.

The first test was run on material sampled from a site near the Western Kentucky Parkway in Elizabethtown, Kentucky, in the Mississippian Plateaus. The region is characterized by deep residual soils, many of which contain large amounts of nontronite, an iron-rich montmorillonite clay. The results for the coefficient of consolidation $c_v$ and the deflections corresponding to initial and final primary consolidation, $d_0$ and $d_{100}$, respectively, are summarized in Tables 6 and 7.

The second test used a soil from near US 27 in Fayette County in the Bluegrass. The residual soils in this area are from the Lexington and Cynthiana limestones and are a brown, phosphate-rich material. The fragmentary structure of the soil along with the jointed and cracked nature of the limestone produces a well-drained soil profile. The principal results of the analysis are summarized in Tables 8 and 9. Plots of the data are provided in APPENDIX F.

**SPECIAL APPLICATION OF THE COMPUTER PROGRAM**

Curves analogous to those obtained from the conventional consolidation test may be analyzed by the computer program. For example, the plotted results of a swell-deflection test on an undisturbed shale sample are presented in APPENDIX F. The test was performed in a conventional consolidation apparatus by inundating an unsaturated shale specimen and recording the time-deflection data produced during the swelling process. The time-deflection curves associated with this test closely resemble those associated with the conventional consolidation test. Hence, the computer program can be used to estimate a coefficient of

**CONCLUSIONS**

The newly-developed statistical definition based on the use of standard error of estimate is very effective in selecting the best representations of the linear portions of the data curves. This permits the evaluation of the representativeness of various linear least-squares fits on a given curve.

The computer program can analyze any set of conventional (incremental-load) consolidation data in the form of

**TABLE 5. INDEX PROPERTIES OF TWO SOILS HAVING DIFFERENT GEOLOGIC ORIGINS**

<table>
<thead>
<tr>
<th>DEPTH (FEET)</th>
<th>DEPTH (METERS)</th>
<th>SAMPLE NUMBER</th>
<th>LIQUID LIMIT</th>
<th>PLASTICITY INDEX</th>
<th>NATURAL MOISTURE CONTENT (%)</th>
<th>CLASSIFICATION</th>
<th>GRADATION (%)</th>
<th>UNIFIED</th>
<th>AASHTO</th>
<th>SAND</th>
<th>SILT</th>
<th>CLAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELIZABETHTOWN H-3.5-7C</td>
<td>35 - 37.5 10.7 - 11.4</td>
<td>7</td>
<td>84</td>
<td>36</td>
<td>48</td>
<td>MH</td>
<td>A-7.5</td>
<td>0</td>
<td>18</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PARIS PIKE H-2.5-2B</td>
<td>3-5.5 0.1 - 1.7</td>
<td>2</td>
<td>41</td>
<td>11</td>
<td>25</td>
<td>ML</td>
<td>A-7.5</td>
<td>20</td>
<td>32</td>
<td>48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 6. COMPUTER RESULTS FOR $c_v$ BY THREE METHODS (ELIZABETHTOWN H-3.5-7C CONSOLIDATION TEST)**

<table>
<thead>
<tr>
<th>LOAD INCREMENT (kPa)</th>
<th>TAYLOR $c_v$ (ft²/DAY)</th>
<th>CASAGRANDE $c_v$ (ft²/DAY)</th>
<th>NAYLOR-DORAN $c_v$ (ft²/DAY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 (24.0)</td>
<td>2.423 (0.225)</td>
<td>0.441 (0.041)</td>
<td>0.474 (0.040)</td>
</tr>
<tr>
<td>0.50 (47.9)</td>
<td>0.978 (0.090)</td>
<td>0.440 (0.040)</td>
<td>0.474 (0.040)</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.516 (0.047)</td>
<td>0.379 (0.035)</td>
<td>0.474 (0.040)</td>
</tr>
<tr>
<td>2.00 (191.6)</td>
<td>0.259 (0.024)</td>
<td>0.255 (0.023)</td>
<td>0.289 (0.020)</td>
</tr>
<tr>
<td>4.00 (383.2)</td>
<td>0.118 (0.010)</td>
<td>0.069 (0.006)</td>
<td>0.074 (0.006)</td>
</tr>
<tr>
<td>8.00 (766.4)</td>
<td>0.051 (0.004)</td>
<td>0.043 (0.003)</td>
<td>0.043 (0.003)</td>
</tr>
<tr>
<td>16.00 (1532.8)</td>
<td>0.046 (0.002)</td>
<td>0.037 (0.002)</td>
<td>0.040 (0.003)</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.067 (0.003)</td>
<td>0.033 (0.003)</td>
<td>0.039 (0.003)</td>
</tr>
</tbody>
</table>
TABLE 7. COMPUTER RESULTS FOR INITIAL AND FINAL VALUES OF PRIMARY CONSOLIDATION BY THREE METHODS (ELIZABETHTOWN H-3 S-7C)

<table>
<thead>
<tr>
<th>LOAD INCREMENT (kPa)</th>
<th>INITIAL VALUES, ( d_0 )</th>
<th>FINAL VALUES, ( d_{100} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TAYLOR</td>
<td>CASAGRANDE</td>
</tr>
<tr>
<td>0.25 (24.0)</td>
<td>0.0771</td>
<td>0.0771</td>
</tr>
<tr>
<td>0.50 (47.9)</td>
<td>0.0782</td>
<td>0.0781</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.0811</td>
<td>0.0811</td>
</tr>
<tr>
<td>2.00 (191.6)</td>
<td>0.0917</td>
<td>0.0908</td>
</tr>
<tr>
<td>4.00 (383.2)</td>
<td>0.1111</td>
<td>0.1111</td>
</tr>
<tr>
<td>8.00 (766.4)</td>
<td>0.1836</td>
<td>0.1836</td>
</tr>
<tr>
<td>16.00 (1532.8)</td>
<td>0.2809</td>
<td>0.2811</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.3630</td>
<td>0.3631</td>
</tr>
</tbody>
</table>

TABLE 8. COMPUTER RESULTS FOR INITIAL VALUES, \( d_0 \), OF PRIMARY CONSOLIDATION BY THREE METHODS (PARIS PIKE H-2 S-2B CONSOLIDATION TEST)

<table>
<thead>
<tr>
<th>LOAD INCREMENT (kPa)</th>
<th>TAYLOR, ( C_u ) (m²/day)</th>
<th>CASAGRANDE, ( C_u ) (m²/day)</th>
<th>NAYLOR-DORAN, ( C_u ) (m²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 (24.0)</td>
<td>2.004 (0.01862)</td>
<td>0.523 (0.00494)</td>
<td>1.908 (0.1773)</td>
</tr>
<tr>
<td>0.50 (47.9)</td>
<td>1.823 (0.1694)</td>
<td>0.586 (0.0344)</td>
<td>2.001 (0.1859)</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>1.754 (0.1630)</td>
<td>0.503 (0.0467)</td>
<td>1.264 (0.1174)</td>
</tr>
<tr>
<td>2.00 (191.6)</td>
<td>1.883 (0.1749)</td>
<td>0.463 (0.0430)</td>
<td>0.649 (0.0603)</td>
</tr>
<tr>
<td>4.00 (383.2)</td>
<td>0.417 (0.0387)</td>
<td>0.293 (0.0272)</td>
<td>0.452 (0.0420)</td>
</tr>
<tr>
<td>8.00 (766.4)</td>
<td>0.505 (0.0469)</td>
<td>0.209 (0.0194)</td>
<td>0.180 (0.0167)</td>
</tr>
<tr>
<td>16.00 (1532.8)</td>
<td>0.118 (0.0110)</td>
<td>0.126 (0.0117)</td>
<td>0.147 (0.0137)</td>
</tr>
<tr>
<td>32.00 (3056.6)</td>
<td>0.306 (0.0264)</td>
<td>0.131 (0.0122)</td>
<td>0.095 (0.0088)</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.380 (0.0353)</td>
<td>0.068 (0.0063)</td>
<td>0.052 (0.0048)</td>
</tr>
</tbody>
</table>

using either the square-root-of-time, the logarithm-of-time, or the Naylor-Doran methods as long as the representation of the transformed time-deflection data remotely conform to the traditional curve shapes associated with each particular method. The traditional curve shapes associated with each method are shown in Figures 1, 2, and 3. In other words, if the data can be analyzed by hand, then the data can usually be analyzed by the computer program. All three methods to determine \( C_u \) give essentially the same values of \( d_0 \).

Values of \( d_{100} \) determined by the square-root-of-time and Naylor-Doran methods generally tend to be reasonably close and, consequently, give values for the coefficient of consolidation that are reasonably close. In contrast, the logarithm-of-time method tends to give values of \( d_{100} \) that produce slightly lower values of \( C_u \).

Even though Naylor and Doran made two simplifying assumptions in the development of their method that are not strictly valid, the underlying idea that the errors in \( d_{100} \) and \( d_0 \) are independent of each other is still valid in a practical sense.

Since the slope of the log(1 - \( U' \))-versus-time curve is not influenced significantly by the errors in \( d_0 \), the best way to calculate the coefficient of consolidation for the Naylor-Doran method is to use Equation 24.

The precision that can be obtained in the computerized version of the Naylor-Doran method should not be considered to indicate the accuracy obtained in estimating the true values of \( d_0 \) and \( d_{100} \). The
<table>
<thead>
<tr>
<th>LOAD INCREMENT</th>
<th>INITIAL VALUES, d₀</th>
<th>FISCAL VALUES, d₁₀₀</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TAYLOR</td>
<td>CASAGRANDE</td>
</tr>
<tr>
<td>0.25 (24.0)</td>
<td>0.0043</td>
<td>0.0042</td>
</tr>
<tr>
<td>0.50 (47.9)</td>
<td>0.0114</td>
<td>0.0114</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.0195</td>
<td>0.0194</td>
</tr>
<tr>
<td>2.00 (191.6)</td>
<td>0.0337</td>
<td>0.0336</td>
</tr>
<tr>
<td>4.00 (383.2)</td>
<td>0.0517</td>
<td>0.0503</td>
</tr>
<tr>
<td>8.00 (766.4)</td>
<td>0.0732</td>
<td>0.0723</td>
</tr>
<tr>
<td>16.00 (1532.8)</td>
<td>0.0991</td>
<td>0.0962</td>
</tr>
<tr>
<td>32.0 (3065.6)</td>
<td>0.1293</td>
<td>0.1286</td>
</tr>
<tr>
<td>1.00 (95.8)</td>
<td>0.1463</td>
<td>0.1469</td>
</tr>
</tbody>
</table>

true values of $d_0$ and $d_{100}$ would have to be determined through some alternate means, probably by direct measurements of pore pressures.

REFERENCES


2. Taylor, D. W.; Research on Consolidation of Clays, Serial 82, Massachusetts Institute of Technology, Department of Civil and Sanitary Engineering, August 1942.


**NOTATION**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, A&lt;sub&gt;i&lt;/sub&gt;</td>
<td>Abscissa value at left end of sampling interval used in search for linear portion of secondary compression in logarithm-of-time data</td>
</tr>
<tr>
<td>a&lt;sub&gt;ν&lt;/sub&gt;</td>
<td>Coefficient of compressibility</td>
</tr>
<tr>
<td>b</td>
<td>Intercept</td>
</tr>
<tr>
<td>B, B&lt;sub&gt;i&lt;/sub&gt;</td>
<td>Width of sampling interval used in search for linear portion of primary compression in logarithm-of-time data</td>
</tr>
<tr>
<td>CALPHA, C-SUB-ALPHA</td>
<td>Coefficient of secondary compression</td>
</tr>
<tr>
<td>c&lt;sub&gt;ν&lt;/sub&gt;</td>
<td>Coefficient of consolidation of square-root-of-time, logarithm-of-time, and Naylor-Doran methods, respectively</td>
</tr>
<tr>
<td>CVROOT</td>
<td>Coefficients of consolidation, ft&lt;sup&gt;2&lt;/sup&gt;/day</td>
</tr>
<tr>
<td>CVLOG, CVND</td>
<td>Deflection readings corresponding to 0%, 50%, 90%, and 100 percent consolidation</td>
</tr>
<tr>
<td>DEFI, d&lt;sub&gt;i&lt;/sub&gt;</td>
<td>Initial deflection reading for current load increment</td>
</tr>
<tr>
<td>DEFLEC(NO), df</td>
<td>Final deflection reading for current load increment</td>
</tr>
<tr>
<td>d&lt;sub&gt;0&lt;/sub&gt;, D&lt;sub&gt;0&lt;/sub&gt;</td>
<td>Values of deflection assumed for initial and primary consolidation, respectively, in Naylor-Doran method</td>
</tr>
<tr>
<td>d&lt;sub&gt;50&lt;/sub&gt;, d&lt;sub&gt;90&lt;/sub&gt;</td>
<td>Least-squares slopes of experimental log&lt;sub&gt;e&lt;/sub&gt;(1 - U&lt;sup&gt;1&lt;/sup&gt;)-versus-time relationship at 60- and 80-percent consolidation, respectively</td>
</tr>
<tr>
<td>d&lt;sub&gt;100&lt;/sub&gt;, d&lt;sub&gt;100'&lt;/sub&gt;</td>
<td>Least-squares slopes of experimental log&lt;sub&gt;e&lt;/sub&gt;(1 - U&lt;sup&gt;1&lt;/sup&gt;)-versus-time relationship before application of new load increment</td>
</tr>
<tr>
<td>dy/dt</td>
<td>Slope of theoretical log&lt;sub&gt;e&lt;/sub&gt;(1 - U&lt;sup&gt;1&lt;/sup&gt;)-versus-time relationship</td>
</tr>
<tr>
<td>DY1, dY1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Least-squares slopes of experimental log&lt;sub&gt;e&lt;/sub&gt;(1 - U&lt;sup&gt;1&lt;/sup&gt;)-versus-time relationship at 60- and 80-percent consolidation, respectively</td>
</tr>
<tr>
<td>DY2, dY2&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Least-squares slopes of experimental log&lt;sub&gt;e&lt;/sub&gt;(1 - U&lt;sup&gt;1&lt;/sup&gt;)-versus-time relationship at 60- and 80-percent consolidation, respectively</td>
</tr>
<tr>
<td>e</td>
<td>Void ratio</td>
</tr>
<tr>
<td>err&lt;sub&gt;0&lt;/sub&gt;</td>
<td>Error in assumed value of d&lt;sub&gt;0&lt;/sub&gt;</td>
</tr>
<tr>
<td>err 100</td>
<td>Error in assumed value of d&lt;sub&gt;100&lt;/sub&gt;</td>
</tr>
<tr>
<td>H</td>
<td>Length of drainage path in z direction or thickness of soil specimen</td>
</tr>
<tr>
<td>INCREI</td>
<td>Do-loop increment for square-root-of-time sampling procedure</td>
</tr>
<tr>
<td>IK</td>
<td>Iteration number</td>
</tr>
<tr>
<td>INTERCEPT</td>
<td>Intercept of straight-line portion of experimental log&lt;sub&gt;e&lt;/sub&gt;(1 - U&lt;sup&gt;1&lt;/sup&gt;)-versus-time curve</td>
</tr>
<tr>
<td>k</td>
<td>Permeability in vertical direction</td>
</tr>
<tr>
<td>KOUNT</td>
<td>Numerical designation for a given size of sampling interval</td>
</tr>
<tr>
<td>LOGTIM(1)</td>
<td>Abscissa values of first and last data points on logarithm-of-time curve</td>
</tr>
<tr>
<td>LOGTIM(ISTART)</td>
<td>Abscissa value of beginning and ending data points for new sampling region in search for linear portion of primary compression data</td>
</tr>
<tr>
<td>LOGTIM(IEND)</td>
<td>Starting point for backward generation of secondary compression sampling intervals</td>
</tr>
<tr>
<td>LLL</td>
<td>Array location of last ordinate position used to generate a series of sampling intervals</td>
</tr>
<tr>
<td>LSTOP</td>
<td>Starting point for backward generation of primary compression sampling intervals</td>
</tr>
<tr>
<td>m</td>
<td>Least-squares definition of slope</td>
</tr>
<tr>
<td>m&lt;sub&gt;ν&lt;/sub&gt;, MV</td>
<td>Coefficient of volume change</td>
</tr>
<tr>
<td>N</td>
<td>Number of data points or observations</td>
</tr>
<tr>
<td>PINCR(II)</td>
<td>Applied load increment in tsf</td>
</tr>
<tr>
<td>r&lt;sub&gt;1&lt;/sub&gt;, r&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Coefficient of correlation, determination</td>
</tr>
<tr>
<td>R&lt;sub&gt;i&lt;/sub&gt;, R&lt;sub&gt;p&lt;/sub&gt;, R&lt;sub&gt;s&lt;/sub&gt;</td>
<td>Ratios of amounts of initial, primary, and secondary compression to total compression</td>
</tr>
<tr>
<td>SBOT</td>
<td>Least-squares slope of group of sampled data points</td>
</tr>
<tr>
<td>S&lt;sub&gt;0&lt;/sub&gt;</td>
<td>Unbiased standard error of estimate</td>
</tr>
<tr>
<td>SHAT</td>
<td>Either a large value of slope in square-root-of-time data set or slope of line between first and last points of logarithm-of-time data set</td>
</tr>
<tr>
<td>SLOPA</td>
<td>Arithmetic slope of linear representation of secondary compression data</td>
</tr>
<tr>
<td>t</td>
<td>Elapsed time</td>
</tr>
<tr>
<td>THIKI</td>
<td>Initial thickness of soil specimen</td>
</tr>
<tr>
<td>THIKNS(II)</td>
<td>Thickness of soil specimen before application of new load increment</td>
</tr>
<tr>
<td>T&lt;sub&gt;ν&lt;/sub&gt;</td>
<td>Dimensionless time factor</td>
</tr>
<tr>
<td>t&lt;sub&gt;50&lt;/sub&gt;, T&lt;sub&gt;50&lt;/sub&gt;</td>
<td>Elapsed times to 50-, 80-, and 90-percent consolidation</td>
</tr>
<tr>
<td>t&lt;sub&gt;100&lt;/sub&gt;, T&lt;sub&gt;100&lt;/sub&gt;, t&lt;sub&gt;90&lt;/sub&gt;, T&lt;sub&gt;90&lt;/sub&gt;</td>
<td>Elapsed times to 50-, 80-, and 90-percent consolidation</td>
</tr>
<tr>
<td>u</td>
<td>Excess pore pressure</td>
</tr>
<tr>
<td>u&lt;sub&gt;0&lt;/sub&gt;</td>
<td>Initial excess pore pressure</td>
</tr>
<tr>
<td>U</td>
<td>Degree of consolidation</td>
</tr>
<tr>
<td>U&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Experimental degree of consolidation</td>
</tr>
<tr>
<td>UTSLOP</td>
<td>Least-squares slope of data between 60- and 80-percent consolidation of log&lt;sub&gt;e&lt;/sub&gt;(1 - U&lt;sup&gt;1&lt;/sup&gt;)-versus-time relationship</td>
</tr>
<tr>
<td>U'TSLOP</td>
<td>Vertical distance spanned by data in square-root-of-time data sets</td>
</tr>
<tr>
<td>V&lt;sub&gt;H&lt;/sub&gt;</td>
<td>Vertical distance spanned by data in square-root-of-time data sets</td>
</tr>
<tr>
<td>WF&lt;sub&gt;L&lt;/sub&gt;</td>
<td>Length weighting factor</td>
</tr>
<tr>
<td>WF&lt;sub&gt;P&lt;/sub&gt;</td>
<td>Position weighting factor</td>
</tr>
<tr>
<td>X</td>
<td>Horizontal coordinate axis</td>
</tr>
<tr>
<td>XBOT</td>
<td>Abscissa distance spanned by sampled group of data points</td>
</tr>
</tbody>
</table>
$X_i$ - Abscissa value of a data point
$Y$ - Vertical coordinate axis
$y$ - $\log_e(1 - U)$
$y'$ - $\log_e(1 - U')$
YBOT - Ordinate distance spanned by sampled group of points
$Y_i$ - Ordinate value of a point
$z$ - Coordinate in vertical direction

\[
\begin{align*}
(1 - U)_1 & \quad \text{Ordinate value on experimental log,(!} - U)\text{-versus-time relationship corresponding to 60-and 80-percent consolidation, respectively} \\
(1 - U')_2 & \\
\gamma_w & \quad \text{Unit weight of water} \\
\delta/\eta & \quad \text{Theoretical value of intercept for straight-line portion of log,(! - U)-versus-time relationship} \\
\Delta \varepsilon_v & \quad \text{Change in ordinary vertical strain} \\
\Delta H & \quad \text{Change in thickness of soil specimen} \\
\Delta \sigma_v & \quad \text{Change in vertical effective stress}
\end{align*}
\]
APPENDIX A

CONSIDERATIONS IN THE USE OF 
THE STANDARD ERROR OF ESTIMATE
CONSIDERATIONS IN THE USE OF THE STANDARD ERROR OF ESTIMATE

The properties of $S_e$ demonstrated in Figures 15 through 20 are emphasized by contrasting them with the variables that affect the Pearson correlation coefficient, $r$, and its companion form, $r^2$. The standard error of estimate measures the scatter in the dependent variable undergoing a linear least-squares fit. The value of $S_e$ will not change if the horizontal distance spanned by the data is increased while the vertical scatter is held constant. This can be seen by comparing Figures 15a and b. The value of $S_e$ is independent of the length of curve covered by the data. This is in sharp contrast to $r^2$ which increases as the data are spread farther apart. This increase in $r^2$ occurs even though the fit does not have less vertical scatter.

Because $S_e$ measures only the scatter in the ordinate values of the data, $S_e$ is not influenced by the slope of the fitted line. Figures 16a, b, c, and d show that changing the slope does not change the value of $S_e$ so long as the vertical scatter of the data points about the fitted line remains the same. In contrast, $r^2$ is affected by the slope even though the vertical scatter is held constant. These figures show that $r^2$ increases as the slope increases. The coefficient, $r$, is a special form of the t-test (9), a statistical test used to determine the significance of a given value of the slope.

Therefore, the greater the slope, the more significant $t$ is and the larger the value of $r^2$ for the linear fit. The portion of $r^2$ that depends on the slope does not measure the so-called "goodness of fit" as far as the scatter of the data points is concerned. Many who routinely use the correlation coefficient are not aware of this.

Next, changes in $S_e$ are directly and linearly proportional to the changes in the vertical scatter in data undergoing a linear least-squares fit. A summary of the results obtained from Figures 17a, b, and c is shown in Figure 17d. If the difference between the ordinate values in Figure 17a is increased by a factor of $10^4$, the $S_e$ is increased by the same amount in Figure 17b. In contrast, $r$ and $r^2$ cannot vary in a linear manner because the magnitude of their values can only range from zero to one. In other words, if the amount of scatter is multiplied by $10^4$, the value of $r$ or $r^2$ cannot change by the same factor.

Finally, the effect of the number of data points on the value of $S_e$ should be considered. As the number of data points is increased, Figures 18a, b, and c show that the value of $S_e$ decreases. For this reason, there is no need to test for the significance of $S_e$ in terms of the degrees of freedom, that is, the number of data points minus two. Smaller values of $S_e$ are always more significant. Similarly, the correlation coefficient, $r$, and its companion form, $r^2$, take on smaller values as the number of data points is increased as shown in Figures 18a, b, and c. These results raise questions as to how to select the most significant value of $r$ and $r^2$ if it has been assumed that a larger $r$ or $r^2$ is automatically more significant. Suppose there are two values of $r$, say 0.94 and 0.53, from two sets of data having 4 and 14 data points, respectively. The corresponding values of $r^2$ are 0.884 and 0.281, respectively. Which group of data points has the most significant value of $r$ or $r^2$? To automatically choose the group of data points associated with the largest value of $r$ and $r^2$ is incorrect and indicates a cursory investigation of the data has been performed. The most significant values of $r$ and $r^2$ in this case are actually 0.53 and 0.281, respectively. This conclusion is reached using the following definition for the t-statistic (9) to test the significance of each value of $r$:

\[ t = r \sqrt{\frac{(N - 2)}{(1 - r^2)}}^{1/2}. \] (25)

For a given number of degrees of freedom, $(N - 2)$, where $N$ is the number of data points, there is a critical value for $t$ called $t_c$. The critical value must be smaller
Figure 16. Standard Error of Estimate, \( S_e \), Not Influenced by the Value of Slope in Contrast to the Coefficient of Determination, \( r^2 \): (a) Slope = 0.25; (b) Slope = 0.5; (c) Slope = 2.0; (d) Slope = 4.0.
Figure 17. Standard Error of Estimate, $S_e$, Directly and Linearly Proportional to Vertical Scatter in Data: (a) Scatter = $2.0 \times 10^{-5}$; (b) Scatter = $2.0 \times 10^{-4}$; (c) Scatter = 0.2; (d) Summary.
Figure 18. Effects of the Number of Data Points on the Values of $S_e$ and $r^2$: (a) $N = 4$; (b) $N = 8$; (c) $N = 14$. 

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than the value of $t$ associated with a given value of the correlation coefficient, $r$, before it can be considered statistically meaningful or significant. The value of $r$ equal to 0.94 has a value of $t$ equal to 3.9. At the five percent level of significance for two degrees of freedom, the critical value $t_c$ is equal to 4.3. Consequently, because $t$ is less than $t_c$, it is not meaningful. In contrast, the $r$ corresponding to 0.53 has a $t$ equal to 2.165. At the five percent level of significance for 12 degrees of freedom, the critical value of $t_c$ is equal to 2.145. Because this critical value is less than the $t$ value, the $r$ value of 0.53 is statistically significant. Therefore, to determine the significance of values of $r$ and $r^2$, one must consider the degrees of freedom associated with each value of $r$. Consequently, values of $S_e$ are easier to compare because the significance of a greater number of data points is automatically reflected in smaller values.

The quantities $S_e$ and $r$ were calculated using the formulas found in the SPSS manual (9). These formulas are repeated below:

$$S_e = \frac{\left\{(\sum Y_i^2 - b \sum Y_i \cdot m \sum X_i Y_i)\right\}^{1/2}}{(N \cdot 2)} \quad (26)$$

$$r = \frac{\sum X_i Y_i - (\sum X_i)(\sum Y_i)/N}{\left\{(\sum X_i^2 - (\sum X_i)^2/N)\right\}^{1/2}} \quad (27)$$

in which $X_i$ = $i$th observation of variable $X$, $Y_i$ = $i$th observation of variable $Y$, and $N$ = number of observations.

When these definitions are expressed in Fortran IV on the IBM 370 computer, their arguments must be stored as double precision variables to prevent truncation errors.

Because the previous discussion may have raised some questions about the correlation coefficient, a few additional comments are in order. First, a high value for the correlation coefficient that is significant for a given number of degrees of freedom does not necessarily mean that the relationship between two variables is linear. Figures 19a and b illustrate how values of $r$ close to unity can actually be misleading if the data are not distributed in a way that shows the true relationship between the two variables. The simplest way to avoid being misled by the value of $r$ is to plot the data. Another way is to design the data collection procedure to collect data over a wide range of values at regularly spaced intervals.
On the other hand, if the value of $r$ is almost or actually equal to zero, it should not be automatically assumed there is no relationship. For example, a value of $r$ equal to zero is obtained when there is definite relationship (Figure 20a). Similarly, a value of $r$ equal to zero does not necessarily mean the data points do not lie on a straight line (Figure 20b). For these reasons, extreme caution should always be exercised when one is making decisions based on the correlation coefficient.

Next, values of $r$ or $r^2$ cannot be compared to determine the "better" of two linear relationships if the two regression equations being considered have the same independent and dependent variables. This is true even when the correlation coefficients have satisfied a given level of statistical significance. If two linear equations are different for the same independent and dependent variables, then some unknown variable has not been accounted for. In this situation, one can consider a multiple regression approach if it is felt that the difficulty lies within the regression model and not with the quality of the data.

An excellent review of multiple regression analysis can be found in Chapter 13 of Statistical Methods, Sixth Edition, by Snedecor and Cochran (10). In a multiple regression analysis, the same rules concerning the use of the correlation coefficient in the case of one independent and one dependent variable apply. The most important rule is that the significance of each value of the correlation coefficient obtained from a multiple regression analysis must be tested. However, if the primary objective in a multiple regression analysis is to construct a linear prediction equation in a set of independent variables, $X$, that gives the best prediction of values of $Y$, the use of the correlation coefficient should be abandoned entirely in favor of the procedure outlined in Section 13.3 of Reference 10. Prediction equations can be considered of value if the F-test of the regression coefficients satisfy the 1-percent level of significance and if the 95-percent confidence limits for the coefficients are small and do not cross zero. Similar procedures are discussed in great detail in References 9 and 10.
APPENDIX B

DERIVATION OF THE NAYLOR-DORAN ANALYTICAL METHOD
DERIVATION OF THE NAYLOR-DORAN ANALYTICAL METHOD

The Naylor-Doran analytical method is based on the fact that, if Equation 28 is plotted as the natural logarithm of one minus the degree of consolidation, \((1 - U)\), versus the dimensionless time factor, \(T_v\), a straight line is obtained for the portion of the curve lying between 60- and 80-percent consolidation (0.2 \(\lesssim (1 - U) < 0.4\)). One minus the degree of consolidation, \((1 - U)\), can be defined as

\[
1 - U = \left(\frac{8}{\pi^2}\right) \sum (2N + 1)^2 \exp \left(-\left(\frac{(2N + 1)^2 \pi^2 T_v}{4}\right)\right),
\]

in which

\[
T_v = \frac{c_v t}{H^2},
\]

\(H\) = length of drainage path in z direction,
\(t\) = elapsed time from beginning of loading,
\(c_v\) = coefficient of consolidation, and
\(N\) = number of data points.

A straight line is obtained because higher order terms in Equation 28a contribute very little for values of \((1 - U)\) less than 0.4. Also, a straight line exists for \((1 - U)\) less than 0.2 (80-percent consolidation) because Naylor and Doran suggested that the effects of secondary compression can be avoided up to this point.

Taking only the first term of Equation 28a (i.e. \(N = 0\)) yields

\[
(1 - U) = \left(\frac{8}{\pi^2}\right) \exp \left(-\frac{\pi^2 T_v}{4}\right).
\]

Taking the natural logarithm of both sides produces the linear relationship

\[
\log_e(1 - U) = \log_e \left(\frac{8}{\pi^2}\right) - \frac{\pi^2 T_v}{4}.
\]

Since the degree of consolidation, \(U\), can be expressed as

\[
U = \frac{(d_0 - d)}{(d_0 - d_{100})},
\]

the term \((1 - U)\) can be defined as

\[
(1 - U) = \frac{(d - d_{100})}{(d_0 - d_{100})}.
\]

in which \(d_0\) and \(d_{100}\) are the deflection readings corresponding to zero- and 100-percent primary consolidation, respectively, and \(d\) is a particular deflection reading.

For a given load increment in the conventional consolidation test, Equation 28b shows that the elapsed time, \(t\), is directly proportional to the dimensionless time factor, \(T_v\). Consequently, a straight line should be obtained when the natural logarithm of \((1 - U)\) is plotted against the elapsed time for all values of \((1 - U)\) less than 0.4. However, errors in the values used for \(d_0\) and \(d_{100}\) will change the way in which the natural logarithm of \((1 - U)\)-versus-elapsed time relationship is plotted. The effect of these errors in \(d_0\) and \(d_{100}\) can be substantially eliminated using the iterative procedure of successive approximations proposed by Naylor and Doran. Four major aspects of the development of their procedure are described below. First, the errors in the value of deflection assumed for the correct but unknown values of \(d_0\) and \(d_{100}\) are defined. Second, the definitions for the experimental degree of consolidation \(U'\) and the related quantity \((1 - U')\) are expressed in terms of these errors. Third, the simplifying assumptions and mathematical manipulations used to calculate the errors in the deflection values assumed for \(d_0\) and \(d_{100}\) are described. Fourth, when the error relationship for each of these deflections is derived, the procedure for correcting the assumed deflections is shown.

DEFINITIONS OF ERROR IN \(d_0'\) AND \(d_{100}'\)

The assumed deflections corresponding to zero- and 100-percent primary consolidation, \(d_0'\) and \(d_{100}'\), respectively, have the corresponding errors \(err_0\) and \(err_{100}\). These errors are defined as follows:

\[
err_0 = \frac{(d_0' - d_0)}{(d_0 - d_{100})},
\]

and

\[
err_{100} = \frac{(d_{100}' - d_{100})}{(d_0 - d_{100})}.
\]

DEFINITIONS FOR \(U'\) AND \((1 - U')\)

The experimental values for the degree of consolidation, \(U'\), can be expressed in terms of the assumed values of \(d_0'\) and \(d_{100}'\) using Equation 31 to obtain

\[
U' = \frac{(d_0' - d)}{(d_0 - d_{100})}.
\]

Similarly, the quantity \((1 - U')\) can be defined by Equation 32 as

\[
(1 - U') = \frac{(d - d_{100})}{(d_0 - d_{100})}.
\]

Solving Equation 36 for the deflection reading, \(d\), yields
\[ d = (1 - U')(d_0' - d_{100'}) + d_{100}. \]  

(37)

Solving Equation 32 in a similar fashion gives

\[ d = (1 - U)(d_0 - d_{100}) + d_{100}. \]  

(38)

Setting Equations 37 and 38 equal to each other eliminates the deflection reading, \( d \), and produces the relationship

\[ (1 - U)(d_0 - d_{100}) + d_{100} = (1 - U')(d_0' - d_{100'}) + d_{100}. \]  

(39)

Because Equations 33 and 34 can be rearranged so that

\[ d_0' = \text{err}_0 (d_0 - d_{100}) + d_0 \]  

(40a)

and

\[ d_{100}' = \text{err}_{100}(d_0 - d_{100}) + d_{100}. \]  

(40b)

Substitution of Equations 40a and 40b into Equation 39 yields

\[ (1 - U)(d_0 - d_{100}) + d_{100} = (1 - U')(d_0' - d_{100'}) + d_{100}. \]  

(41)

Subtracting \( d_{100} \) from both sides of Equation 41 and simplifying the right-hand side gives

\[ (1 - U)(d_0 - d_{100}) = (1 - U')(\text{err}_0 - \text{err}_{100} + 1) \]  

(42)

\[ (d_0 - d_{100}) + \text{err}_{100}(d_0 - d_{100}). \]

Finally, dividing through by the quantity \( (d_0 - d_{100}) \) yields

\[ (1 - U) = (1 - U')(\text{err}_0 - \text{err}_{100} + 1) + \text{err}_{100}. \]  

(43)

**CALCULATION AND CORRECTION OF ERRORS IN \( d_0' \) AND \( d_{100}' \)**

In its present form, Equation 43 contains too many unknowns to allow the determination of either \( \text{err}_{100} \) or \( \text{err}_0 \). A series of mathematical operations is presented below to eliminate several of the unknowns.

To eliminate the term \( (1 - U) \), a change in variables

\[ y = \log_e(1 - U) \]  

(44a)

and

\[ y' = \log_e(1 - U') \]  

(44b)

in which

\[ e^y = (1 - U) \]  

(45a)

and

\[ e^{y'} = (1 - U'). \]  

(45b)

Substituting Equations 45a and b into Equation 43 yields

\[ e^y = e^{y'}(\text{err}_0 - \text{err}_{100} + 1) + \text{err}_{100}. \]  

(46)

Taking the first derivative of both sides of this equation with respect to the elapsed time, \( t \), gives

\[ e^y \frac{dy}{dt} = (\text{err}_0 - \text{err}_{100} + 1)e^{y'} \frac{dy'}{dt}. \]  

(47)

Solving for \( \frac{dy'}{dt} \) yields

\[ \frac{dy'}{dt} = \frac{(dy/dt)(e^{y'/e^y})[1/((1 + \text{err}_0 - \text{err}_{100})]}{1/(1 + \text{err}_0 - \text{err}_{100})}. \]  

(48)

Next, the definition for \( e^y \) in Equation 46 is substituted into the above equation to give

\[ dy'/dt = (dy/dt)[(e^{y'}\text{err}_0 - \text{err}_{100} + 1) + \text{err}_{100}]/e^{y'}[1/(1 + \text{err}_0 - \text{err}_{100})]. \]  

(49)

Rearranging Equation 49 gives

\[ dy'/dt = (dy/dt)[1/(1 + \text{err}_0 - \text{err}_{100})] \]  

\[ [\text{err}_0 - \text{err}_{100} + 1] + \text{err}_{100}/e^{y'}. \]  

(50)

This equation reduces to
\[ \frac{dy'}{dt} = (dy/dt)[1 + err_{100}] \]
\[ \frac{dy'}{dt} (err_0 - err_{100} + 1)] \]  
(51)

Substituting the relationship for \( e^{y'} \) from Equation 45b into Equation 51 yields
\[ \frac{dy'}{dt} = (dy/dt)[1 + err_{100}] \]
\[ (\cdot \cdot \cdot (1 - U')(err_0 - err_{100} + 1)] \]  
(52)

At this point, the unknown quantity \((1 - U)\) still remains in terms of \( dy/dt \). Equation 52 defines the slope of the \( \log_e (1 - U') \)-versus-time relationship as a function of the correct slope \( dy/dt \) in linear combination with the terms \( err_0, err_{100}, \) and \((1 - U)\). Of the four terms on the right-hand side of Equation 52, only \((1 - U)\) is known. The slope at various portions of the experimental or \( \log_e (1 - U') \)-versus-time data curve \( dy'/dt \) can be estimated directly by calculating the least-squares slope of a line going through the three data points closest to a specified value of \((1 - U)\).

Hence, \( dy'/dt \) can be taken as a known quantity. However, it is still impossible to solve Equation 52 for any of the remaining unknowns. To solve for one of these unknowns, \( err_{100} \), Naylor and Doran found it necessary to use a simplifying assumption and a mathematical trick.

First, Naylor and Doran left unstated an important assumption to this point in the derivation of their method. They apparently removed the unknown error in \( d_0' \), \( err_0 \), from Equation 52 by assuming that
\[ \text{err}_0 = \text{err}_{100}. \]  
(53)

Using this assumption, Equation 52 reduces to
\[ \frac{dy'}{dt} = (dy/dt) [1 + err_{100} \]
\[ \cdot (1 - U')] \]  
(54)

Hence, the slope of the experimental or \( \log_e (1 - U') \)-versus-time curve is now considered independent of the error in \( d_0' \), \( err_0 \). Strictly, the slope of the experimental curve \( dy'/dt \) is not entirely independent of \( err_0 \). However, experience indicates the assumption stated in Equation 53 does not have a significant effect on the results. This assumption is very powerful because it enables the solution of an otherwise very difficult equation.

Since Equation 54 still contains the unknown, \( dy/dt, err_{100} \) cannot be evaluated directly unless the following mathematical trick is performed. If two points \( y_1' \) and \( y_2' \) on the \( \log_e (1 - U') \)-versus-time curve are selected, \( dy/dt \) can be eliminated by estimating the slope \( dy'/dt \) at both points and dividing Equation 54 by itself as shown below:
\[ \frac{(dy_1'/dt)/(dy_2'/dt)}{\cdot (dy/dt) (1 + err_{100}/(1 - U')_1 \]
\[ \cdot (1 + err_{100}/(1 - U')_2). \]  
(55)

This equation then becomes
\[ \frac{(dy_1'/dt)/(dy_2'/dt)}{\cdot (1 + err_{100}/(1 - U')_1 \]
\[ \cdot (1 + err_{100}/(1 - U')_2). \]  
(56)

Selecting \((1 - U)\) at 60- and 80-percent consolidation,
\[ (1 - U)'_1 = (1 - 0.6) = 0.4 \]  
(57)

and
\[ (1 - U)'_2 = (1 - 0.8) = 0.2. \]  
(58)

Substitution of Equations 57 and 58 into Equation 56 yields
\[ \frac{(dy_1'/dt)/(dy_2'/dt)}{\cdot (1 + err_{100}/0.4 \]
\[ \cdot (1 + err_{100}/0.2). \]  
(59)

Rearranging terms on the right side of Equation 59 gives
\[ (dy_1'/dt)/(dy_2'/dt) = (0.4 + err_{100}) \]
\[ \cdot (0.4 + 2 err_{100}). \]  
(60)

Solving for \( err_{100} \) will give the final expression:
\[ err_{100} = [0.4(dy_1'/dt)/(dy_2'/dt) - 1] \]
\[ \cdot [1 - 2(dy_1'/dt)/(dy_2'/dt)]. \]  
(61)

Equation 61 shows that when the slopes at 60- and 80-percent consolidation, \( dy_1'/dt \) and \( dy_2'/dt \), respectively, are equal, the error in \( d_{100} \) will be zero. Hence, Equation 61 shows that errors in \( d_{100} \) change the slope of the \( \log_e (1 - U') \)-versus-time curve. The effect of these errors is shown in Figure 21. An error in \( d_{100} \) will bend the curve up or down from the linear relationship as shown by the top and bottom.
curves in Figure 21. Only when \( \text{err}_{100} \) is very small will the linear relationship shown by the middle curve in Figure 21 be obtained.

Having solved for \( \text{err}_{100} \), the assumed value of deflection \( d_{100} \) can be corrected. Equation 40b is solved for the correct value of deflection corresponding to 100-percent primary consolidation, \( d_{100} \), to yield

\[
d_{100} = \frac{(d_{100}' \cdot \text{err}_{100} \cdot d_0)}{(1 \cdot \text{err}_{100})}.
\]

However, an additional assumption must be made since the correct value of deflection corresponding to zero-percent consolidation, \( d_0 \), can never be known. Naylor and Doran made the unstated assumption that \( d_0 \) can be reasonably approximated by \( d_0' \). Substituting \( d_0' \) for \( d_0 \) is not a particularly bad approximation when \( d_0' \) has been initially taken as the value determined by either the square-root-of-time or logarithm-of-time methods. Therefore, Equation 62 becomes

\[
d_{100} = \frac{(d_{100}' \cdot \text{err}_{100} \cdot d_0')}{(1 \cdot \text{err}_{100})}.
\]

Because the correct value of deflection corresponding to 100-percent primary consolidation can never actually be known, \( d_{100} \) in Equation 63 should be called the newly assumed value for \( d_{100} \):

\[
d_{100}('\text{new}) = \frac{(d_{100}' \cdot \text{err}_{100} \cdot d_0')}{(1 \cdot \text{err}_{100})}.
\]

The error in \( d_{100}('\text{new}) \) can be evaluated using Equation 61 after \( (1 \cdot U') \) has been recalculated using Equation 36. Equations 36 and 61 can be used in the iterative procedure described by the flow chart given in Figure 22. When the error in \( d_{100}('\text{new}) \) becomes sufficiently small, a good estimate of the correct value of \( d_{100} \) has been obtained. Also, if the simplifying assumptions made up to this point are valid, the \( (1 \cdot U') \) data should contain only an error in the assumed value \( d_0' \).

To determine the error in the assumed deflection value corresponding to zero-percent primary consolidation, \( d_0' \), a procedure similar to one outlined above is derived below. First, the linear representation of the experimental or log\(_e\)(1 - \( U' \))-versus-time data can be expressed as

\[
y' = t \frac{dy'}{dt} + \text{INTERCEPT},
\]

in which \( y' = \log_e (1 - U') \),

\( \frac{dy'}{dt} = \text{slope}, \) and

\( \text{INTERCEPT} = \text{intercept of the linear representation of the log}_e(1 - U')-\text{versus-time data lying between values for } (1 \cdot U') \text{ of } 0.4 \text{ and } 0.2. \)

Rearranging Equation 65, the relationship becomes

\[
\text{INTERCEPT} = y' - t \frac{dy'}{dt}.
\]

Figure 22. Flow Chart of Iterative Procedure Used to Correct Errors in Assumed Value of \( d_{100}' \).
The simplifying assumption made in obtaining Equation 52 removes the effect of the errors in $d_0'$ on the slope $dy'/dt$. Also, because the error in $d_{100}$ is supposedly small at this stage of the Naylor-Doran analytical method, the slope can be considered the correct value, $dy'/dt$. Consequently, Equation 66 can be rewritten as

$$\text{INTERCEPT} = y' - t \frac{dy'}{dt}. \quad (67)$$

Now that the intercept is independent of $err_{100}$, Naylor and Doran define $y'$ only in terms of the correct value $y$ and the error in $d_0'$, $err_0$, as

$$y' = y - err_0. \quad (68)$$

Substituting into Equation 67, an expression can be written in terms of the correct values $y$, $dy/dt$, and $err_0$, as follows:

$$\text{INTERCEPT} = y - t \frac{dy}{dt} - err_0. \quad (69)$$

To derive an analytical expression for the term $y$, Equations 30 and 44 are set equal to each other and Equation 28b substituted for the dimensionless time factor, $T_v$, to yield

$$y - \log_e(1 - U) = \log_e \left( \frac{8}{\pi^2} \right) - \frac{\pi^2 \alpha_{wL}}{4H^2}. \quad (70)$$

At the value of elapsed time $t$ equal to zero, Equation 70 reduces to

$$y = \log_e \left( \frac{8}{\pi^2} \right). \quad (71)$$

Substituting this value of $y$ into Equation 67 with elapsed time $t$ equal to zero yields

$$\text{INTERCEPT} = \log_e \left( \frac{8}{\pi^2} \right) - err_0. \quad (72)$$

Finally, solving for $err_0$ yields

$$err_0 = \log_e \left( \frac{8}{\pi^2} \right) - \text{INTERCEPT}. \quad (73)$$

Therefore, the error in the assumed value $d_0'$ can be determined by comparing the intercept of the straight-line portion of the experimental $\log_e(1 - U)$-versus-time data against the theoretical intercept, having the value of $\log_e(8/\pi^2)$ or -0.21. Also, Equation 73 shows that errors in the assumed value $d_0'$ only change the vertical position of the experimental or $\log_e(1 - U)$-versus-time curve. In other words, the slope of the $\log_e(1 - U)$-versus-time curve is unaffected by errors in the assumed value $d_0'$. The effect of $err_0$ on the $\log_e(1 - U)$-versus-time curve is shown in Figure 23. When $err_0$ has a value of zero, the intercept of the straight-line portion of the $\log_e(1 - U)$-versus-time curve corresponds exactly with the theoretical value. In contrast, an error in the assumed value $d_0'$ will shift the $\log_e(1 - U)$-versus-time curve up or down in the vertical direction as shown in Figure 23.

To correct the experimental $\log_e(1 - U)$-versus-time data for the error in $d_0'$ determined by Equation 73, Equation 33 must first be solved for the correct but unknown value $d_0$ to obtain

$$d_0 = \frac{(d_0' + err_0 d_{100})}{(1 + err_0)}. \quad (74)$$

However, since $d_{100}$ is never known, Equation 34 is solved for $d_{100}$ yielding

$$d_{100} = d_{100}' - err_{100} \left( d_0 - d_{100} \right). \quad (75)$$

Substitution into Equation 74 gives

$$d_0 = \frac{(d_0' + err_0 \left[ d_{100}' - err_{100} \left( d_0 - d_{100} \right) \right])}{(1 + err_0)}. \quad (76)$$

Figure 23. Error in the Assumed Value of $d_0'$ - Shifts the Linear Portion of the Relationship Vertically.

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Because the true values $d_0$ and $d_{100}$ can never be known, an additional simplifying assumption is necessary. Naylor and Doran assumed that $err_{100}$ could be set equal to zero since it would supposedly be small at this stage of the procedure. Consequently, the unknown term $(d_0 - d_{100})$ is conveniently eliminated to yield

$$d_0 = \frac{(d_0' + erro_0 d_{100}')(1 + erro)}{1 + erro_0}.$$  \hspace{1cm} (77a)

The value of $err_{100}$ will generally not be equal to zero. In certain cases, $err_{100}$ may be quite large. For this reason, it is better to approximate the true but unknown values of $d_0$ and $d_{100}$ found in Equation 49 by $d_0'$ and $d_{100}'$, respectively, to yield

$$d_0 = \frac{[d_0' + erro_0 (d_{100}' - erro_0)]}{1 + erro_0}.$$  \hspace{1cm} (77b)

Since the correct value of deflection corresponding to zero-percent primary consolidation is never known, $d_0$ in Equation 50b should be called the newly assumed value for $d_0$

$$d_0^\prime (\text{new}) = \frac{(d_0' + erro_0 d_{100}')(1 + erro)}{1 + erro_0}. \hspace{1cm} (78)$$

The error in $d_0^\prime$ (new) can be evaluated using Equation 46 after the $(1 - U)$ data has been recalculated using Equation 36. Equations 36 and 73 can be used in the iterative procedure described by the flow chart (Figure 24). When the error in $d_0^\prime$ (new) becomes sufficiently small, a good estimate of the correct value $d_0$ has been obtained. Finally, the iterative procedures outlined in Figures 22 and 24 can be used more than one time to enhance the precision in the estimated values of $d_0'$ and $d_{100}'$.

![Flow Chart of Iterative Procedure Used to Correct Errors in Assumed Value of $d_0'$](image)

Figure 24. Flow Chart of Iterative Procedure Used to Correct Errors in Assumed Value of $d_0'$.  

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APPENDIX C

GRAPHICAL DESCRIPTION OF SAMPLING PROCEDURES

The figures in this appendix aid in deciphering the Fortran statements that generate the sampling intervals.
COMPLETE GRAPHICAL DESCRIPTION OF SAMPLING PROCEDURE USED FOR SQUARE-ROOT-OF-TIME ANALYSIS
DEFINITION OF PARAMETERS USED
IN GENERATING SAMPLING INTERVALS
SQUARE ROOT OF TIME

KOUNT = NUMERICAL DESIGNATION
FOR A GIVEN SIZE OF
SAMPLING
INCREI = DO-LOOP INCREMENT
LSTOP = ARRAY LOCATION OF
LAST ORDINATE POSITION
USED TO GENERATE A
SERIES OF SAMPLING INTERVALS

Figure 25. Graphical Summary of the Sampling Intervals Generated by the Computer
Program for the Square-Root-of-Time Method: (a) Parameter Definitions;
(b) through (i) Graphical Summaries.
Figure 25. Graphical Summary of the Sampling Intervals Generated by the Computer Program for the Square-Root-of-Time Method: (a) Parameter Definitions; (b) through (i) Graphical Summaries.
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Figure 25. Graphical Summary of the Sampling Intervals Generated by the Computer Program for the Square-Root-of-Time Method: (a) Parameter Definitions; (b) through (i) Graphical Summaries.
Figure 25. Graphical Summary of the Sampling Intervals Generated by the Computer Program for the Square-Root-of-Time Method: (a) Parameter Definitions; (b) through (i) Graphical Summaries.
GRAPHICAL SUMMARIES
OF SAMPLING PROCEDURES USED WITH
LOGARITHM-OF-TIME ANALYSIS
Figure 26. Graphical Synopsis of Procedures Used in Generation of Sampling Intervals in Search for Linear Portion of Secondary Compression Data.
APPENDIX D

INPUT INSTRUCTIONS, CODING SHEETS,
JOB CONTROL INFORMATION, EXECUTION TIMES,
AND COMPUTER SYSTEM DESCRIPTION
Graphical Synopsis of Sampling Procedures Used in Search for Linear Portion of Primary Compression Data

**FIRST STAGE**

Data points in this interval are found to have the smallest value of $s_e$ (adjusted). The interval having largest slope is used to look for minimum value of $s_e$ (adjusted) in nearby sampling intervals and to setup region over which smaller sampling intervals will be generated in stage two.

- Sampling intervals around largest value of slope used to find smallest value of $s_e$ (adjusted)
- Sampling intervals having largest value of slope

**SECOND STAGE**

Sampling intervals around largest slope create new sampling area.

Process repeated with smaller sampling intervals. The group of data points having smallest value of $s_e$ (adjusted) used as linear portion of primary compression.

- Sampling intervals around largest value of slope
- Sampling intervals having largest value of slope
- Sampling intervals around largest slope

Figure 27. Graphical Synopsis of Sampling Procedures Used in Search for Linear Portion of Primary Compression Data: (a) First Stage; (b) Second Stage.
INPUT INSTRUCTIONS
FOR
ANALYSIS OF TIME-DEFLECTION INCREMENTAL-LOAD CONSOLIDATION DATA

<table>
<thead>
<tr>
<th>COLUMNS</th>
<th>NAME</th>
<th>FORMAT</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>INITIAL DEFLECTION CHARACTERISTICS CARD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-10</td>
<td>THIK1</td>
<td>F10.0</td>
<td>THIK1 is the initial thickness of the soil specimen in inches after placement in the consolidometer or a previously measured height. A decimal must be included. If Columns 1-10 are left blank, a default value of 1 inch is assumed.</td>
</tr>
<tr>
<td>11-20</td>
<td>DEFZ</td>
<td>F10.0</td>
<td>DEFZ is the zero deflection reading corresponding to the initial thickness or height of the soil specimen. A decimal must be included. If Columns 11-20 are left blank, a default value of zero is assumed.</td>
</tr>
<tr>
<td>21-30</td>
<td>DEFI</td>
<td>F10.0</td>
<td>DEFI is the initial deflection reading corresponding to the value of elapsed time equal to zero.</td>
</tr>
<tr>
<td>31-40</td>
<td>DCF</td>
<td>F10.0</td>
<td>DCF is the deflection calibration factor and must be expressed with a decimal in terms of inches per unit of deflection. A positive value for DCF must be used if increasing deflection readings indicate specimen shortening. A negative value for DCF must be used if decreasing deflection readings indicate specimen shortening. If Columns 31-40 are left blank, a default value of 1.000 inches per unit of deflection is used.</td>
</tr>
<tr>
<td>41-50</td>
<td>PFACTR</td>
<td>F10.0</td>
<td>This variable assists the user in scaling plotted output from the Calcomp plotter. It changes the x and y plotting factors by the same amount with one call of subroutine FACTOR. A call factor (0.5) causes all plotting to be half the size of a normal plot (PFACTR = 0.5). The computer program defaults to a value of PFACTR = 0.8 when Columns 41-50 are left blank.</td>
</tr>
</tbody>
</table>
2. NUMBER OF LOAD INCREMENTS AND OPTIONS CARDS

1-2  NLOADS   I2  The number of consecutive load increments associated with the initial deflection characteristics given in Card 1 is entered as a right justified integer value in Columns 1-2. Maximum number that can be specified is 20.

3-4  NDRAIN  I2  The number of drainage boundaries, NDRAIN, is used to determine the length of the drainage path. A '1' entered in Column 4 stipulates single drainage. If left blank, the computer programs assumes a default value of '2', that is, double drainage.

5-6  IDEFI  I2  This option parameter allows the use of the final deflection reading of the preceding load increment as the initial deflection reading, DEFI. To do this, a non-zero integer value, say '99', must be placed in Columns 5-6. If these two columns are left blank, the computer program will take the deflection reading at elapsed time equal to zero as the initial deflection reading.

11-12  IAXIS  I2  If these columns are left blank, the computer program scales the deflection axis in units of inches. If IAXIS is given a non-zero integer value, the deflection axis is scaled in millimeters.

13-14  IRTDO  I2  If a '1' is entered into Column 14, the value of $d_0$ used in the logarithm-of-time method is set equal to the value of $d_0$ determined by the square-root-of-time method.

21-22  IGRAPH  I2  If Columns 21-22 are left blank, none of the following graphical output options are used.

A '1' entered into Column 22 plots the interpolation parabola used to estimate a value of elapsed time corresponding to 90-percent consolidation.

A '2' entered into Column 22 plots the interpolation parabola used to estimate a value of elapsed time corresponding to 50-percent consolidation.

A '3' entered into Column 22 plots the interpolation parabolas used in the square-root-of-time and logarithm-of-time analyses.
A '4' entered into Column 22 produces only summary plots of the coefficients of consolidation, \(c_v\), and of secondary compression, \(c_d\), for an analyzed series of incremental loads. All other Calcomp output is suppressed.

A '5' entered into Column 22 uses the print-plot capabilities of the line printer to plot the curves associated with the square-root-of-time, logarithm-of-time, and Naylor-Doran methods of analysis.

Special error information can be obtained during the use of the Naylor-Doran procedure by entering the following values for the variable IGRAPH.

A '55' entered into Columns 21-22 permits a graphical study of the effects of errors in \(d_{100}'\) on the \(\log_{10}(1-U')\)-versus-time curve. Considerable plot output is produced on the line printer.

A '56' entered into Columns 21-22 will allow graphical study of the effects of errors in \(d_{0}'\) on the \(\log_{10}(1 - U)\)-versus-time curve. Considerable output is produced by the line printer.

A '6' entered into Column 22 will plot on the line printer the errors in values of \(d_{100}'\) against the corresponding values of \(d_{100}'\).

If a '1' is entered into Column 24, the horizontal axis of the square-root-of-time plot is adjusted so that the maximum value plotted by the Calcomp plotter is less than two times the value of elapsed time corresponding to 90-percent primary consolidation, \(t_{90}\), and at least equal to 1 minute.

If a non-zero integer value is entered into Columns 31-32, the intermediate steps in the execution of the square-root-of-time analysis are printed. When a '2' is entered into Column 32, the steps involved with the sampling of portions of the data curve are omitted from the printed output.
A non-zero integer value entered into Columns 41-42 causes the intermediate steps in the logarithm-of-time analysis to be printed. When a '2' is entered into Column 42, printed output associated with the sampling of data from the secondary compression portion of the logarithm-of-time curve is omitted.

The intermediate steps in the Naylor-Doran method are printed when a non-zero integer value is entered in Columns 51-52.

Values of the interpolation parabolas and scales factors are printed at various stages of execution in subroutine TPLOTS when a non-zero integer value is entered into Columns 61-62.

If a non-zero integer value is entered into Columns 71-72, the intermediate steps in the entire computer program are printed out. There is a large amount of printed output produced by this option.

3. LOAD INCREMENT AND ANALYSIS OPTIONS CARDS
(One card for each load increment up to a maximum of 20 cards)

1-10 PRESS( ) F10.0 Pressure in tons per square foot (tsf) before application of the next load increment is entered in Columns 1-10 and expressed as a decimal.

11-20 PINCR ( ) F10.0 Applied pressure increment in tons per square foot is entered in Columns 11-20 and expressed as a decimal.

21-22 ISQRT1( ) I2 If these columns are left blank, the square-root-of-time analysis will be performed on data for the loading specified in Columns 1-20 of this same card. However, a non-zero integer value in these two columns will cause the computer program to skip the square-root-of-time analysis for the loading specified on this card.

31-32 ILOG1( ) I2 If these columns are left blank, the logarithm-of-time analysis will be performed. However, if a non-zero integer value is entered into Columns 31-32, the logarithm-of-time analysis is bypassed. When the logarithm-of-time analysis is not performed, the values assumed for $d_0$ and $d_{100}$ in the beginning of the Naylor-Doran
analytical method are taken to be those found in the square-root-of-time method. If neither the square-root-of-time or logarithm-of-time are used, the Naylor-Doran method assumes that the values for \( d_0 \) and \( d_{100} \) correspond to the initial and final deflection readings, respectively.

If these columns are left blank, the Naylor-Doran method is performed. If a non-zero integer value is entered, the Naylor-Doran analytical method is not performed on time-deflection data associated with the loading given in Columns 1-20.

Note: Card 3 is repeated for each load increment in order of their application. These cards must total to the value of NLOADS given in Columns 1-2 of Card 2.

4. LOADING DESIGNATION AND TEST DESCRIPTION CARD
1-80 BCD 20A4 The entire card allows the input of alphanumeric information that will serve as the plot title and description of test. This test description should include load increment applied and series number of test, borehole location and number, sample number and description, and any other information pertinent to the data and testing procedures.

5. TIME-DEFLECTION DATA CARDS
1-7 TIM( ) F7.0 Elapsed time reading after application of load increment is entered with a decimal in Columns 1-7.

8-14 DEFLEC( ) F7.0 Deflection reading corresponding to elapsed time reading given in Columns 1-7 is entered with a decimal in Columns 8-14.

15-16 LEND I2 A '1' entered into Column 16 signals this is the last data card associated with the given load increment. Otherwise, these columns are left blank.

Note: Repeat Cards 4 and 5 for each load increment specified on Card 3.
Figure 28. Program Coding Sheets for Analysis of Time-Deflection Consolidation Data.

CVCON-O

TIME-DEFLECTION CONSOLIDATION
TEST DATA ANALYSIS

PROGRAM CODING SHEET

1. INITIAL DEFLECTION CHARACTERISTICS CARD
   THIKI -- Initial Thickness of specimen in inches
   DEFZ -- Zero Deflection reading
   DEFI -- Initial Deflection reading
   DCF -- Deflection Calibration Factor (inches/unit)
   PFACTR -- Plotting Factor; default value is 0.8

2. NUMBER OF LOAD INCREMENTS AND OPTIONS CARD
   NLOADS -- Number of Load Increments up to maximum of twenty
   NDRAIN -- Drainage Option:
             Leave blank for double drainage
             Enter '1' for single drainage
   IDEFI -- Initial Deflection Reading Option:
             Leave blank to use deflection reading at time equal zero
             Enter '1' to use final deflection reading of preceeding
             set of load-increment data
   IAXIS -- Units of Deflection Axis Option:
             Leave blank to have inches
             Enter '1' to have millimeters
   IRTDO -- Logarithm-of-Time $d_0$ Option:
             Leave blank to have $d_0$ determined in log-time method by
             $4 \times t$ approach
             Enter '1' to use $d_0$ determined by square-root-time method
   IGRAPH -- Graphical Output Option (See Input Instructions)
   IEXPAN -- Square-root-time Horizontal Axis Option (See Input Instructions)
   IBUG1 -- Square-root-time Debug Option (See Input Instructions)
   IBUG2 -- Logarithm-time Debug Option (See Input Instructions)
   IBUG3 -- Naylor-Doran Debug Option (See Input Instructions)
   IBUG4 -- Plotting Subroutine Debug Option (See Input Instructions)
   IDEBUG -- Total Program Debug Option (See Input Instructions)
3. LOAD INCREMENT AND ANALYSIS OPTION CARDS

One card is necessary for each load increment up to a maximum of twenty cards.

PRESS( ) — Pressure (Tsf) before application of load increment
PINCR( ) — Applied pressure increment (Tsf)

During routine use of computer program, the remaining columns are left blank

ISQRT1( ) — Skip Option for square-root-of-time analysis; enter '1' if desired
ILOG1( ) — Skip Option for logarithm-of-time analysis; enter '1' if desired
IND1( ) — Skip Option for Naylor-Doran analysis; enter '1' if desired

<table>
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<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</tbody>
</table>
4. LOADING DESIGNATION AND TEST DESCRIPTION CARD

LOADING DESIGNATION AND TEST DESCRIPTION (BCD)

5. TIME-DEFLECTION DATA CARDS (LABORATORY READINGS)

LEND — Enter '1' for last data card; Otherwise, leave blank

NOTE: Repeat Cards 4 through 5 for each load increment specified on Card 3
JOB CONTROL CARDS

The following groups of job control cards apply when the University of Kentucky's IBM 370 at McVey Hall is used. These cards describe the JCL necessary for a source deck run, object deck run, source deck run with production of an object deck, and a source or object deck run in which the plot output is suppressed.

A standard JOB card which includes the waste paper option is the following:

```
//P74EGM JOB(9999-99999,1,,,,W), MCNULTY, MSGLEVEL=1, REGION=268K
```

FOR RUN WITH SOURCE DECK

```
FORTRAN Source Deck

/*
//GO.SYSIN DD *
  *
  *
DATA
  *
*/
```

To produce an object deck from a source deck run, change the EXEC JCL card to the following:

```
//P74EGM EXEC FORTGCLP, PARM.FORT=DECK
```

FOR RUN WITH OBJECT DECK

```
FORTRAN Object Deck

/*
//GO.SYSIN DD *
  *
  *
DATA
  *
*/
```

To run either source or object deck versions of programs without production of plotted output, add the following card before the //GOSYSIN DD* Card:

```
//GO.PLOTTAPE DD DUMMY
```

NOTE: See Figure 29
COMPUTER SYSTEM DESCRIPTION

Computer

- Manufacturer: IBM
- Model number: System/370 Model 165 II
- Word length: Single Precision - 4 bytes, 32 bits
  Double Precision - 8 bytes, 64 bits
- Core access speed: 700 nano seconds
- Virtual storage: 16 mega bytes (maximum)

Peripheral Equipment

- Line printers: IBM/3211 Chain Printers
- Card readers: IBM/2821-5 I/O Control Unit
- Card punch: IBM/3505 Card Reader
- Magnetic tape drivers: IBM/029 Card Key Punch
- IBM Tape Unit 2401 processes tape at 75 inches/second
- Uses 800 bytes per inch density magnetic tape
- Processes 60,000 bytes/second
- Uses either 9 or 7 track tapes
- Calcomp 663 Digital Incremental Drum Plotter

Plotters

Storage Requirements of Source Program

Total storage requirements of computer program is approximately 248K

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<td>1174</td>
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<tr>
<td>TPlots</td>
<td>20900</td>
</tr>
</tbody>
</table>

Plot buffer requires up to 160K

Figure 29. Approximate Central Processing Unit (CPU) Time versus Number of Load Increments for Object Version of CVCON-0.
Figure 30. Example Use of Coding Sheets for Test on Remolded Kaolinite.

CVCON-0

TIME-DEFLECTION CONSOLIDATION
TEST DATA ANALYSIS

PROGRAM CODING SHEET

1. INITIAL DEFLECTION CHARACTERISTICS CARD
   - THIKI — Initial Thickness of specimen in inches
   - DEFZ — Zero Deflection reading
   - DEFI — Initial Deflection reading
   - DCF — Deflection Calibration Factor (inches/unit)
   - PFACTR — Plotting Factor; default value is 0.8

<table>
<thead>
<tr>
<th>THIKI</th>
<th>DEFZ</th>
<th>DEFI</th>
<th>DCF</th>
<th>PFACTR</th>
</tr>
</thead>
</table>

   2. NUMBER OF LOAD INCREMENTS AND OPTIONS CARD
   - NLOADS — Number of Load Increments up to maximum of twenty
   - NDRAIN — Drainage Option:
     Leave blank for double drainage
     Enter '1' for single drainage
   - IDEFI — Initial Deflection Reading Option:
     Leave blank to use deflection reading at time equal zero
     Enter '1' to use final deflection reading of preceding
     set of load-increment data
   - IAXIS — Units of Deflection Axis Option:
     Leave blank to have inches
     Enter '1' to have millimeters
   - IRTDO — Logarithm-of-Time d₀ Option:
     Leave blank to have d₀ determined in log-time method by
     4 times t approach
     Enter '1' to use d₀ determined by square-root-time method
   - IGRAPH — Graphical Output Option (See Input Instructions)
   - IEXPAN — Square-root-time Horizontal Axis Option (See Input Instructions)
   - IBDUG1 — Square-root-time Debug Option (See Input Instructions)
   - IBDUG2 — Logarithm-time Debug Option (See Input Instructions)
   - IBDUG3 — Naylor-Doran Debug Option (See Input Instructions)
   - IBUG4 — Plotting Subroutine Debug Option (See Input Instructions)
   - IDEBUG — Total Program Debug Option (See Input Instructions)
3. LOAD INCREMENT AND ANALYSIS OPTION CARDS

One card is necessary for each load increment up to a maximum of twenty cards.

PRESS( ) — Pressure (Tsf) before application of load increment
PINCR( ) — Applied pressure increment (Tsf)

DURING ROUTINE USE OF COMPUTER PROGRAM, THE REMAINING COLUMNS ARE LEFT BLANK

ISQRT1( ) — Skip Option for square-root-of-time analysis; enter '1' if desired
ILOG1( ) — Skip Option for logarithm-of-time analysis; enter '1' if desired
IND1( ) — Skip Option for Naylor-Doran analysis; enter '1' if desired
4. LOADING DESIGNATION AND TEST DESCRIPTION CARD

LOADING DESIGNATION AND TEST DESCRIPTION (BCD)

5. TIME-DEFLECTION DATA CARDS (LABORATORY READINGS)

LEND — Enter '1' for last data card: Otherwise, leave blank

NOTE: Repeat Cards 4 through 5 for each load increment specified on Card 3
4. **LOADING DESIGNATION AND TEST DESCRIPTION CARD**

**LOADING DESIGNATION AND TEST DESCRIPTION (BCD)**

5. **TIME-DEFLECTION DATA CARDS (LABORATORY READINGS)**

LEND — Enter '1' for last data card: Otherwise, leave blank

NOTE: Repeat Cards 4 through 5 for each load increment specified on Card 3
4. LOADING DESIGNATION AND TEST DESCRIPTION CARD

LOADING DESIGNATION AND TEST DESCRIPTION (BCD)

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LOADING DESIGNATION AND TEST DESCRIPTION (BCD)

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NOTE: Repeat Cards 4 through 5 for each load increment specified on Card 3
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LOADING DESIGNATION AND TEST DESCRIPTION (BCD)

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LEND — Enter '1' for last data card: Otherwise, leave blank

NOTE: Repeat Cards 4 through 5 for each load increment specified on Card 3
4. **LOADING DESIGNATION AND TEST DESCRIPTION CARD**

**LOADING DESIGNATION AND TEST DESCRIPTION (BCD)**

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<th>Column</th>
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</table>

5. **TIME-DEFLECTION DATA CARDS (LABORATORY READINGS)**

LENDEF = Enter '1' for last data card: Otherwise, leave blank

NOTE: Repeat Cards 4 through 5 for each load increment specified on Card 3
APPENDIX F

NUMERICAL EXAMPLES DEMONSTRATING
THE VERSATILITY OF THE COMPUTER PROGRAM
Figure 31. Printed Output from Computer Program for Consolidation Test on Remolded Kaolinite.

<table>
<thead>
<tr>
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<th>ISQR</th>
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<th>IND</th>
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LOAD-INCREMENT NO. 1 0.25 TSF REMOLED KAOLINITE K-517-201
SINGLE DRAINAGE

THICKNESS                          PRESSURE INCREMENT
INITIAL  25.9562MM.  (1.02190IN.)  0.0 KPA/SQ.M.  (0.0 T/SQ.FT.)
FINAL   25.8318MM.  (1.01700IN.)  23.95KPA/SQ.M.  (0.2500T/SQ.FT.)

TAYLOR'S  CASAGRANDE'S  NAYLOR - DORAN
SQUARE ROOT TIME  LOGARITHM TIME  ANALYTICAL METHOD
T90 = 2.44 MIN.  T50 = 1.00 MIN.  T80 = 1.10 MIN.
O90 = 0.1813 IN.  D50 = 0.1808 IN.  D80 = 0.1809 IN.

CONSOLIDATION COEFFICIENT
122.39SQ.M/Y (3.609SQ.FT./D)  69.435SQ.M/Y (2.047SQ.FT./D)  177.195SQ.M/Y (5.225SQ.FT./D)

DIAL RDG. AT ZERO % PRIMARY
4.5610MM.  (0.1796IN.)  4.5568MM.  (0.1794IN.)  4.5591MM.  (0.1795IN.)
DIAL RDG. AT 100 % PRIMARY
4.6099MM.  (0.1815IN.)  4.6278MM.  (0.1822IN.)  4.6039MM.  (0.1813IN.)
EST. PRIMARY CONSOLIDATION
0.0490MM.  (0.0019IN.)  0.0711MM.  (0.0028IN.)  0.0448MM.  (0.0018IN.)

COMPRESSIBILITY, M-SUB-V
0.2046 SQ.M./MPA (0.0196 SQ.FT./TON)
CALPHA = 0.00040  UTSLDP = -1.124 /MIN.

PRIMARY COMP. RATIO  0.3933
SECONDARY COMP. RATIO  0.3077
INITIAL COMP. RATIO  0.2990

PERMEABILITY COEFFICIENT
0.78E-06 CM./SEC.  0.44E-06 CM./SEC.  0.11E-05CM./SEC.

<table>
<thead>
<tr>
<th>ELAPSED TIME</th>
<th>DEFLECTION</th>
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</thead>
<tbody>
<tr>
<td>0.0998 MIN.</td>
<td>0.17810 IN. (4.5237 MM.)</td>
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<tr>
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<tr>
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<tr>
<td>0.4000 MIN.</td>
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<tr>
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<tr>
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ELAPSED TIME                          DEFLECTION
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<tr>
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<td>LOGARITHM TIME</td>
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<tr>
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<tr>
<td>0.0977MM. ( 0.0034IN. )</td>
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<tr>
<td><strong>NAYLOR-ODRAN</strong></td>
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<tr>
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<tr>
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<td>CASAGRANDE'S LOGARITHM TIME</td>
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<td>NAYLOR - DORAN ANALYTICAL METHOD</td>
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<tr>
<td>4.0000 MIN.</td>
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LOAD-INCREMENT NO. 4 2.0 TSF REMOLDED KAOLINITE K-517-201

SINGLE DRAINAGE

THICKNESS
INITIAL 25.3124MM. (0.99655IN.)
FINAL 24.6608MM. (0.97090IN.)

PRESSURE INCREMENT
95.80KPA/SQ.M. (1.0000T/SQ.FT.)
191.60KPA/SQ.M. (2.0000T/SQ.FT.)

TAYLOR'S
SQUARE ROOT TIME
I90 = 32.63 MIN.
D90 = 0.2231 IN.

CONSOLIDATION COEFFICIENT
8.53SQ.M/Y (0.251SQ.FT./D)
DIAL RDG. AT ZERO % PRIMARY 5.1880MM. (0.2043IN.)
DIAL RDG. AT 100 % PRIMARY 5.7199MM. (0.2252IN.)
EST. PRIMARY CONSOLIDATION 0.5319MM. (0.0209IN.)

CALPHA • 0.00061
UTSLOP = -0.620E-01/MIN.

PROPERTY

PRIM. COMP. RATIO 0.8164
SECON. COMP. RATIO 0.1523
INITIAL COMP. RATIO 0.0313

PERMEABILITY COEFFICIENT 0.71E-07 CM./SEC.
0.55E-07 CM./SEC.
0.69E-07CM./SEC.

ELAPSED TIME 0.0998 MIN. 0.20345 IN. 5.1676 MM.
0.1000 MIN. 0.20550 IN. 5.2197 MM.
0.2000 MIN. 0.20600 IN. 5.2324 MM.
0.3000 MIN. 0.20640 IN. 5.2426 MM.
0.4000 MIN. 0.20670 IN. 5.2502 MM.
0.5000 MIN. 0.20700 IN. 5.2578 MM.
0.6000 MIN. 0.20720 IN. 5.2629 MM.
0.7000 MIN. 0.20740 IN. 5.2680 MM.
0.8000 MIN. 0.20760 IN. 5.2730 MM.
0.9000 MIN. 0.20780 IN. 5.2781 MM.
1.0000 MIN. 0.20800 IN. 5.2832 MM.
1.5000 MIN. 0.20880 IN. 5.3035 MM.
2.0000 MIN. 0.20950 IN. 5.3213 MM.
3.0000 MIN. 0.21075 IN. 5.3530 MM.
4.0000 MIN. 0.21185 IN. 5.3810 MM.

DEFORMATION 6.00 MIN. 0.21365 IN. 5.4267 MM.
9.00 MIN. 0.21580 IN. 5.4813 MM.
16.00 MIN. 0.21935 IN. 5.5715 MM.
25.00 MIN. 0.22220 IN. 5.6439 MM.
36.00 MIN. 0.22400 IN. 5.6896 MM.
49.00 MIN. 0.22530 IN. 5.7226 MM.
64.00 MIN. 0.22610 IN. 5.7429 MM.
81.00 MIN. 0.22680 IN. 5.7607 MM.
100.00 MIN. 0.22710 IN. 5.7836 MM.
150.00 MIN. 0.22770 IN. 5.7836 MM.
200.00 MIN. 0.22810 IN. 5.7937 MM.
230.00 MIN. 0.22825 IN. 5.7975 MM.
380.00 MIN. 0.22875 IN. 5.8102 MM.
460.00 MIN. 0.22910 IN. 5.8191 MM.

LOAD-INCREMENT NO. 4 2.0 TSF REMOLDED KAOLINITE K-517-201

SINGLE DRAINAGE

THICKNESS
INITIAL 25.3124MM. (0.99655IN.)
FINAL 24.6608MM. (0.97090IN.)

PRESSURE INCREMENT
95.80KPA/SQ.M. (1.0000T/SQ.FT.)
191.60KPA/SQ.M. (2.0000T/SQ.FT.)

TAYLOR'S
SQUARE ROOT TIME
I90 = 32.63 MIN.
D90 = 0.2231 IN.

CONSOLIDATION COEFFICIENT
8.53SQ.M/Y (0.251SQ.FT./D)
DIAL RDG. AT ZERO % PRIMARY 5.1880MM. (0.2043IN.)
DIAL RDG. AT 100 % PRIMARY 5.7199MM. (0.2252IN.)
EST. PRIMARY CONSOLIDATION 0.5319MM. (0.0209IN.)

CALPHA • 0.00061
UTSLOP = -0.620E-01/MIN.

PROPERTY

PRIM. COMP. RATIO 0.8164
SECON. COMP. RATIO 0.1523
INITIAL COMP. RATIO 0.0313

PERMEABILITY COEFFICIENT 0.71E-07 CM./SEC.
0.55E-07 CM./SEC.
0.69E-07CM./SEC.

ELAPSED TIME 0.0998 MIN. 0.20345 IN. 5.1676 MM.
0.1000 MIN. 0.20550 IN. 5.2197 MM.
0.2000 MIN. 0.20600 IN. 5.2324 MM.
0.3000 MIN. 0.20640 IN. 5.2426 MM.
0.4000 MIN. 0.20670 IN. 5.2502 MM.
0.5000 MIN. 0.20700 IN. 5.2578 MM.
0.6000 MIN. 0.20720 IN. 5.2629 MM.
0.7000 MIN. 0.20740 IN. 5.2680 MM.
0.8000 MIN. 0.20760 IN. 5.2730 MM.
0.9000 MIN. 0.20780 IN. 5.2781 MM.
1.0000 MIN. 0.20800 IN. 5.2832 MM.
1.5000 MIN. 0.20880 IN. 5.3035 MM.
2.0000 MIN. 0.20950 IN. 5.3213 MM.
3.0000 MIN. 0.21075 IN. 5.3530 MM.
4.0000 MIN. 0.21185 IN. 5.3810 MM.

DEFORMATION 6.00 MIN. 0.21365 IN. 5.4267 MM.
9.00 MIN. 0.21580 IN. 5.4813 MM.
16.00 MIN. 0.21935 IN. 5.5715 MM.
25.00 MIN. 0.22220 IN. 5.6439 MM.
36.00 MIN. 0.22400 IN. 5.6896 MM.
49.00 MIN. 0.22530 IN. 5.7226 MM.
64.00 MIN. 0.22610 IN. 5.7429 MM.
81.00 MIN. 0.22680 IN. 5.7607 MM.
100.00 MIN. 0.22710 IN. 5.7836 MM.
150.00 MIN. 0.22770 IN. 5.7836 MM.
200.00 MIN. 0.22810 IN. 5.7937 MM.
230.00 MIN. 0.22825 IN. 5.7975 MM.
380.00 MIN. 0.22875 IN. 5.8102 MM.
460.00 MIN. 0.22910 IN. 5.8191 MM.
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<th>4.0 TSF</th>
<th>REMOLDED KAOLINITE K-517-201</th>
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<tr>
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<td>383.20KPA/SQ.M.</td>
<td>4.0000T/SQ.FT.</td>
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</table>

| **TAYLOR'S**          |        | **CASAGRANDE'S**          | **NAYLOR - DORAN**  |
| SQUARE ROOT TIME      |        | LOGARITHM TIME            | ANALYTICAL METHOD   |
| T90                   | 29.05 MIN. | T50 = 6.40 MIN. | T80 = 17.21 MIN. |
| D90                   | 0.2553 IN. | D50 = 0.2437 IN. | D80 = 0.2516 IN. |

| CONSOLIDATION COEFFICIENT | 9.00SQ.M/Y | 9.50SQ.M/Y | 10.17SQ.M/Y |
|                          | 0.265SQ.FT./O | 0.280SQ.FT./O | 0.300SQ.FT./O |

| DIAL RDG. AT ZERO % PRIMARY | 5.8412MM. | 0.2300IN. | 5.8128MM. | 0.2288IN. |
| DIAL RDG. AT 100 % PRIMARY  | 6.5566MM. | 0.2581IN. | 6.5382MM. | 0.2574IN. |
| EST. PRIMARY CONSOLIDATION  | 0.7143MM. | 0.0281IN. | 0.7230MM. | 0.0285IN. |

| **COMPRESSIBILITY, M-SUB-V** | 0.1795 SQ.M./MPA (0.0172 SQ.FT./TON) | CALPHA = 0.00434 |
| **UTSLOP**                  |                                      |                  |
| PRIMARY COMP. RATIO          | 0.8175                               | 0.7968           |
| SECONDARY COMP. RATIO        | 0.1572                               | 0.1770           |
| INITIAL COMP. RATIO          | 0.0253                               | -0.0073          |
| PERMEABILITY COEFFICIENT     | 0.50E-07 CM./SEC.                    | 0.53E-07 CM./SEC.|
|                             |                                      | 0.57E-07CM./SEC.|

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<th><strong>ELAPSED TIME</strong></th>
<th><strong>DEFLECTION</strong></th>
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<td>0.23170 IN.</td>
<td>5.8852 MM.</td>
<td>6.00 MIN.</td>
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LOAD-INCREMENT NO. 6 8.0 TSF REMOLED KAOLINITE K-517-201

SINGLE DRAINAGE

<table>
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<tr>
<td>INITIAL</td>
<td>FINAL</td>
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<tr>
<td>23.787MM (0.93650IN)</td>
<td>22.9260MM (0.90260IN)</td>
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TAYLOR'S

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CONSOLIDATION COEFFICIENT

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COMPRESSIBILITY, M-SUB-V 0.0885 SQ.M./MPA (0.0085 SQ.FT./TDN)

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| 0.37E-07 CM./SEC. | 0.35E-07 CM./SEC. | 0.39E-07CM./SEC. |

ELAPSED TIME

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**COMPRESSIBILITY, M-SUB-V**

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<th>CONSOLIDATION COEFFICIENT</th>
<th>47.52 SQ.M/Y (1.401 SQ.FT./DI)</th>
<th>15.27 SQ.M/Y (0.450 SQ.FT./DI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIAL RDG. AT ZERO % PRIMARY</td>
<td>8.5741 MM. (0.33761 IN.)</td>
<td>8.5763 MM. (0.33761 IN.)</td>
</tr>
<tr>
<td>DIAL RDG. AT 100 % PRIMARY</td>
<td>8.0422 MM. (0.31661 IN.)</td>
<td>7.7214 MM. (0.30601 IN.)</td>
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<tr>
<td>EST. PRIMARY CONSOLIDATION</td>
<td>-0.5319 MM. (-0.02091 IN.)</td>
<td>-0.8549 MM. (-0.03371 IN.)</td>
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</table>

<table>
<thead>
<tr>
<th>COMPRESSION M-SUB-V</th>
<th>0.0258 SQ.M/MPA (0.0025 SQ.FT./TON)</th>
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<tbody>
<tr>
<td>PRIMARY COMP. RATIO</td>
<td>0.5652</td>
</tr>
<tr>
<td>SECONDARY COMP. RATIO</td>
<td>0.3880</td>
</tr>
<tr>
<td>INITIAL COMP. RATIO</td>
<td>0.0469</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PERMEABILITY COEFFICIENT</th>
<th>0.38E-07 CM./SEC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELAPSED TIME</td>
<td>DEFLECTION</td>
</tr>
<tr>
<td>0.0998 MIN.</td>
<td>0.33930 IN. (8.618 MM.)</td>
</tr>
<tr>
<td>0.1000 MIN.</td>
<td>0.33450 IN. (8.496 MM.)</td>
</tr>
<tr>
<td>0.2000 MIN.</td>
<td>0.33310 IN. (8.4607 MM.)</td>
</tr>
<tr>
<td>0.3000 MIN.</td>
<td>0.33210 IN. (8.4353 MM.)</td>
</tr>
<tr>
<td>0.4000 MIN.</td>
<td>0.33120 IN. (8.4125 MM.)</td>
</tr>
<tr>
<td>0.5000 MIN.</td>
<td>0.33050 IN. (8.3947 MM.)</td>
</tr>
<tr>
<td>0.6000 MIN.</td>
<td>0.32980 IN. (8.3769 MM.)</td>
</tr>
<tr>
<td>0.7000 MIN.</td>
<td>0.32910 IN. (8.3591 MM.)</td>
</tr>
<tr>
<td>0.8000 MIN.</td>
<td>0.32855 IN. (8.3452 MM.)</td>
</tr>
<tr>
<td>0.9000 MIN.</td>
<td>0.32810 IN. (8.3337 MM.)</td>
</tr>
<tr>
<td>1.0000 MIN.</td>
<td>0.32760 IN. (8.3210 MM.)</td>
</tr>
<tr>
<td>1.5000 MIN.</td>
<td>0.32560 IN. (8.2702 MM.)</td>
</tr>
<tr>
<td>2.0000 MIN.</td>
<td>0.32400 IN. (8.2296 MM.)</td>
</tr>
<tr>
<td>3.0000 MIN.</td>
<td>0.32160 IN. (8.1686 MM.)</td>
</tr>
<tr>
<td>4.0000 MIN.</td>
<td>0.31970 IN. (8.1204 MM.)</td>
</tr>
<tr>
<td>6.0000 MIN.</td>
<td>0.31970 IN. (8.1204 MM.)</td>
</tr>
</tbody>
</table>

| ELAPSED TIME | DEFLECTION |
| 9.00 MIN. | 0.31440 IN. (7.9628 MM.) |
| 16.00 MIN. | 0.31095 IN. (7.8981 MM.) |
| 25.00 MIN. | 0.30830 IN. (7.8308 MM.) |
| 36.00 MIN. | 0.30645 IN. (7.7658 MM.) |
| 49.00 MIN. | 0.30515 IN. (7.7460 MM.) |
| 64.00 MIN. | 0.30460 IN. (7.7368 MM.) |
| 81.00 MIN. | 0.30445 IN. (7.7330 MM.) |
| 100.00 MIN. | 0.30420 IN. (7.7303 MM.) |
| 144.00 MIN. | 0.30360 IN. (7.7125 MM.) |
| 175.00 MIN. | 0.30325 IN. (7.7115 MM.) |
| 200.00 MIN. | 0.30300 IN. (7.7103 MM.) |
| 300.00 MIN. | 0.30275 IN. (7.6988 MM.) |
| 360.00 MIN. | 0.30250 IN. (7.6962 MM.) |
| 440.00 MIN. | 0.30225 IN. (7.6948 MM.) |
| 600.00 MIN. | 0.30200 IN. (7.6932 MM.) |
| 900.00 MIN. | 0.30150 IN. (7.6913 MM.) |
| 1200.00 MIN. | 0.30125 IN. (7.6898 MM.) |
| 1800.00 MIN. | 0.30075 IN. (7.6882 MM.) |
| 2400.00 MIN. | 0.30030 IN. (7.6867 MM.) |
| 3600.00 MIN. | 0.30000 IN. (7.6850 MM.) |
| 4800.00 MIN. | 0.29960 IN. (7.6834 MM.) |
| 6000.00 MIN. | 0.29925 IN. (7.6820 MM.) |

<table>
<thead>
<tr>
<th>CASAGRADE'S LOGARITHM TIME</th>
<th>T50 = 3.30 MIN.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMARY TIME</td>
<td>5.35 MIN.</td>
</tr>
<tr>
<td>SECONDARY TIME</td>
<td>0.3178 IN.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CALPH = -0.00133</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5652</td>
</tr>
<tr>
<td>0.3880</td>
</tr>
<tr>
<td>0.0469</td>
</tr>
<tr>
<td>0.38E-07 CM./SEC.</td>
</tr>
<tr>
<td>0.12E-07 CM./SEC.</td>
</tr>
<tr>
<td>0.22E-07 CM./SEC.</td>
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<table>
<thead>
<tr>
<th>PRESSURE INCREMENT</th>
<th>1532.80 KPA/SQ.M. (15.0000 T/SQ.FT.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INITIAL</td>
<td>21.8618 MM. (0.86070 IN.)</td>
</tr>
<tr>
<td>FINAL</td>
<td>22.8028 MM. (0.89775 IN.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PRESSURE INCREMENT</th>
<th>95.80 KPA/SQ.M. (1.0000 T/SQ.FT.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INITIAL</td>
<td>21.8618 MM. (0.86070 IN.)</td>
</tr>
<tr>
<td>FINAL</td>
<td>22.8028 MM. (0.89775 IN.)</td>
</tr>
</tbody>
</table>
### SQUARE ROOT OF TIME

<table>
<thead>
<tr>
<th>LOAD INCREMENT (TSF)</th>
<th>0.01 LOAD DEFLECTION READING (INCHES)</th>
<th>FINAL DEFLECTION READING (INCHES)</th>
<th>COEFFICIENT OF CONSOLIDATION (FT²/DAY)</th>
<th>COEFFICIENT OF PERMEABILITY (CM/SEC)</th>
<th>T90 MINUTES</th>
<th>INITIAL</th>
<th>PRIMARY</th>
<th>SECONDARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2500</td>
<td>0.18149</td>
<td>0.18300</td>
<td>3.60915</td>
<td>0.78E-06</td>
<td>2.4</td>
<td>0.2900</td>
<td>0.29332</td>
<td>0.30768</td>
</tr>
<tr>
<td>0.5000</td>
<td>0.18718</td>
<td>0.18925</td>
<td>0.78697</td>
<td>0.22E-06</td>
<td>11.</td>
<td>0.12848</td>
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<td>25.</td>
<td>0.06517</td>
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<td>0.22910</td>
<td>0.25150</td>
<td>0.71E-07</td>
<td>33.</td>
<td>0.03134</td>
<td>0.81637</td>
<td>0.15229</td>
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<td>4.0000</td>
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<td>0.26350</td>
<td>0.26549</td>
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<td>0.02525</td>
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<td>0.40049</td>
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### LOGARITHM OF TIME

<table>
<thead>
<tr>
<th>LOAD INCREMENT (TSF)</th>
<th>0.01 LOAD DEFLECTION READING (INCHES)</th>
<th>FINAL DEFLECTION READING (INCHES)</th>
<th>COEFFICIENT OF SECONDARY COMPRESSION (CALPHA)</th>
<th>COEFFICIENT OF PERMEABILITY (CM/SEC)</th>
<th>T90 MINUTES</th>
<th>INITIAL</th>
<th>PRIMARY</th>
<th>SECONDARY</th>
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<tbody>
<tr>
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<td>0.00213</td>
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### NAYLOR - DORAN ANALYTICAL METHOD

<table>
<thead>
<tr>
<th>LOAD INCREMENT (TSF)</th>
<th>0.01 LOAD DEFLECTION READING (INCHES)</th>
<th>FINAL DEFLECTION READING (INCHES)</th>
<th>COEFFICIENT OF CONSOLIDATION (FT²/DAY)</th>
<th>COEFFICIENT OF PERMEABILITY (CM/SEC)</th>
<th>UTSLOP 1/MINUTES</th>
<th>INITIAL</th>
<th>PRIMARY</th>
<th>SECONDARY</th>
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<tbody>
<tr>
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<td>-0.26</td>
<td>0.09673</td>
<td>0.60431</td>
<td>0.29895</td>
</tr>
</tbody>
</table>
Figure 32. Plotted Output from Computer Program for Consolidation Test on Remolded Kaolinite.
0.50 TSF REMOLDED KAOLINITE K-517-201

\( C_y = 24.93 \text{ %B.H.} / \text{ft} / \text{M} \)  
\( T_{pp} = 7.796 \text{ MINS} \)

PERMEABILITY, \( k = 2.0232 \times 10^{-3} \text{ CM} / \text{SEC.} \)
\( \theta_0 = 4.5700 \text{ MM.} / (0.1872 \text{ IN.}) \)
\( \psi = -0.1785 \text{ MINUES} \)

ELAPSED TIME (MIN.)

-3.00 -2.00 -1.00 0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00
1.0 TSF REMOLDED KAOLINITE K-517-201

$C_v = 11.06$ BW/h/ft$^2$ (0.944 BW/ft$^2$/sec)  \[ t_{eq} = 24.933 \text{ min} \]

PERMEABILITY, $K = 1.2753 \times 10^{-5}$ cm$^2$/sec.

$Q_0 = 5.9324$ mm. (0.1502 in.)

$V = 0.05$ BW/h/ft$^2$. $F_D = 0.026$ ft$^2$/ft$^2$.

ELAPSED TIME (MIN.)

---

1.0 TSF REMOLDED KAOLINITE K-517-201

$C_v = 12.25$ BW/h/ft$^2$ (0.944 BW/ft$^2$/sec)  \[ t_{eq} = 24.933 \text{ min} \]

PERMEABILITY, $K = 0.9045 \times 10^{-5}$ cm$^2$/sec.

$Q_0 = 4.9266$ mm. (0.1501 in.)

$C_{SUS-RP} = 0.00213$

$V = 0.1013$ BW. (0.0028 in.)

LOG. OF ELAPSED TIME (MIN.)

---

1.0 TSF REMOLDED KAOLINITE K-517-201

$C_v = 13.71$ BW/h/ft$^2$ (0.944 BW/ft$^2$/sec)  \[ t_{eq} = 14.195 \text{ min} \]

PERMEABILITY, $K = 1.2633 \times 10^{-5}$ cm$^2$/sec.

$Q_0 = 5.9744$ mm. (0.1503 in.)

$V = -0.0090$ /MINUTES

$V_{eq} = 5.0666$ mm. (0.1006 in.)

ELAPSED TIME (MIN.)

---

82
2.0 TSF REMOLDED KAOLINITE K-517-201

$C_v = 0.25 \text{ gals./ft}^2$ (6.9 gals./ft$^2$)

$T_{100} = 32.976 \text{ min}$

Permeability, $K = 0.0065 \times 10^{-9} \text{ cm/sec}$.

$D_0 = 5.1785 \text{ mm, } 0.0205 \text{ in.}$

UTSLOP = $-0.0020 \text{ /minutes}$

$D_{100} = 5.1785 \text{ mm, } 0.0205 \text{ in.}$

SQUARE ROOT OF ELAPSED TIME (SQ.RT. MIN.)

ELAPSED TIME (MIN.)

LOGIC OF ELAPSED TIME (MIN.)
Figure 33. Plotted Output for Computer Run on Data Published by Naylor and Doran (4): (a) Square-Root-of-Time-Method; (b) Logarithm-of-Time-Method; (c) Naylor-Doran Method.
Figure 34. Plotted Output from Computer Run on Data from the Consolidation Test on the Elizabethtown Specimen.

0.25 TSF ELIZABETHTOWN H-3 S-7C

0.25 TSF ELIZABETHTOWN H-3 S-7C

\[ C_0 = 0.25 \text{ sec./ft.} \]

\[ \rho_0 = 0.83 \text{ min} \]

\[ K = 0.2 \times 10^{-7} \text{ ft./sec.} \]

\[ H = 0.05 \text{ sec./sec.} \]

\[ f = 0.005 \text{ ft/sec} \]

\[ \mu = 0.2 \text{ sec/ml.} \]

\[ \gamma = 0.00 \text{ sec./min.} \]

\[ \beta = 0.01 \text{ sec./min.} \]

\[ \alpha = 0.00 \text{ sec./min.} \]

\[ \gamma = 0.01 \text{ sec./min.} \]

\[ \beta = 0.00 \text{ sec./min.} \]

\[ \alpha = 0.00 \text{ sec./min.} \]

\[ \gamma = 0.01 \text{ sec./min.} \]

\[ \beta = 0.00 \text{ sec./min.} \]

\[ \alpha = 0.00 \text{ sec./min.} \]

\[ \gamma = 0.01 \text{ sec./min.} \]

\[ \beta = 0.00 \text{ sec./min.} \]

\[ \alpha = 0.00 \text{ sec./min.} \]

\[ \gamma = 0.01 \text{ sec./min.} \]

\[ \beta = 0.00 \text{ sec./min.} \]

\[ \alpha = 0.00 \text{ sec./min.} \]

\[ \gamma = 0.01 \text{ sec./min.} \]

\[ \beta = 0.00 \text{ sec./min.} \]

\[ \alpha = 0.00 \text{ sec./min.} \]

\[ \gamma = 0.01 \text{ sec./min.} \]

\[ \beta = 0.00 \text{ sec./min.} \]

\[ \alpha = 0.00 \text{ sec./min.} \]

\[ \gamma = 0.01 \text{ sec./min.} \]

\[ \beta = 0.00 \text{ sec./min.} \]

\[ \alpha = 0.00 \text{ sec./min.} \]

\[ \gamma = 0.01 \text{ sec./min.} \]

\[ \beta = 0.00 \text{ sec./min.} 

\[ \alpha = 0.00 \text{ sec./min.} \]
1.0 TSF ELIZABETHTOWN H-3 S-7C

$C_f = 17.91 \text{ gals./ft}^2$  $G = 0.016 \text{ sq. ft./ft}$

$E_{30} = 3.019 \text{ min}$

PERMEABILITY, $k = 1.0774 \times 10^{-10} \text{ cm}^2/\text{sec}$

$D_0 = 2.0608 \text{ mm} \times 0.00001 \text{ in.}$

$D_0 = 2.107 \text{ mm} \times 0.00001 \text{ in.}$

SQUARE ROOT OF ELAPSED TIME (SQR. MIN.)

LOG. OF ELAPSED TIME (MIN.)

1.0 TSF ELIZABETHTOWN H-3 S-7C

$C_f = 15.26 \text{ gals./ft}^2$  $G = 0.176 \text{ sq. ft./ft}$

$E_{30} = 1.187 \text{ min}$

PERMEABILITY, $k = 0.7883 \times 10^{-10} \text{ cm}^2/\text{sec}$

$D_0 = 2.0556 \text{ mm} \times 0.00001 \text{ in.}$

$D_0 = 2.072 \text{ mm} \times 0.00001 \text{ in.}$

1.0 TSF ELIZABETHTOWN H-3 S-7C

$C_f = 16.36 \text{ gals./ft}^2$  $G = 0.474 \text{ sq. ft./ft}$

$E_{30} = 2.636 \text{ min}$

PERMEABILITY, $k = 0.3259 \times 10^{-10} \text{ cm}^2/\text{sec}$

$D_0 = 3.0675 \text{ mm} \times 0.00001 \text{ in.}$

$D_0 = 2.107 \text{ mm} \times 0.00001 \text{ in.}$

ELAPSED TIME (MIN.)
2.0 TSF ELIZABETHTOWN H-3 S-7C

\( C_v = 0.10 \text{ sq. ft./s} \times 0.255 \text{ sq. ft.} \times 0.1 \)

\( t_0 = 0.977 \text{ min} \)

PERMEABILITY, \( k = 0.595 \times 10^{-5} \text{ cm./sec.} \)

\( q_0 = 2.326 \text{ in.} \times 0.0917 \text{ in.} \)

\( r_0 = 2.717 \text{ in.} \times 0.1070 \text{ in.} \)

SQUARE ROOT OF ELAPSED TIME (SQR T. MIN.)

![Graph 1](image1)

LOGIO. OF ELAPSED TIME (MIN.)

![Graph 2](image2)

2.0 TSF ELIZABETHTOWN H-3 S-7C

\( C_v = 0.95 \text{ sq. ft./s} \times 0.255 \text{ sq. ft.} \times 0.1 \)

\( t_0 = 1.077 \text{ min} \)

PERMEABILITY, \( k = 0.595 \times 10^{-5} \text{ cm./sec.} \)

\( q_0 = 2.302 \text{ in.} \times 0.0917 \text{ in.} \)

\( r_0 = 2.792 \text{ in.} \times 0.1080 \text{ in.} \)

2.0 TSF ELIZABETHTOWN H-3 S-7C

\( C_v = 0.76 \text{ sq. ft./s} \times 0.255 \text{ sq. ft.} \times 0.1 \)

\( t_0 = 4.168 \text{ min} \)

PERMEABILITY, \( k = 0.595 \times 10^{-5} \text{ cm./sec.} \)

\( q_0 = 2.500 \text{ in.} \times 0.0928 \text{ in.} \)

\( r_0 = 2.707 \text{ in.} \times 0.1080 \text{ in.} \)

ELAPSED TIME (MIN.)

![Graph 3](image3)

93
Figure 35. Plotted Output from Computer Run on Data from the Consolidation Test on the Paris Pike Specimen.

0.25 TSF PARIS PIKE H-2 S-28

$C_v = 0.72$ GPa/1, $P_{def} = 1.968$ MIN
PERMEABILITY, $k = 0.092 \times 10^{-14}$ CM./SEC.
$\eta_p = 0.090$ MM. (0.003 IN.)
$\eta_0 = 0.088$ MM. (0.003 IN.)

SQUARE ROOT OF ELAPSED TIME (SQR. MIN.)

ELAPSED TIME (MIN.)

0.25 TSF PARIS PIKE H-2 S-28

$C_v = 0.72$ GPa/1, $P_{def} = 1.968$ MIN
PERMEABILITY, $k = 0.092 \times 10^{-14}$ CM./SEC.
$\eta_p = 0.090$ MM. (0.003 IN.)
$\eta_0 = 0.088$ MM. (0.003 IN.)

LOGO. OF ELAPSED TIME (MIN.)

0.25 TSF PARIS PIKE H-2 S-28

$C_v = 0.72$ GPa/1, $P_{def} = 1.968$ MIN
PERMEABILITY, $k = 0.092 \times 10^{-14}$ CM./SEC.
$\eta_p = 0.090$ MM. (0.003 IN.)
$\eta_0 = 0.088$ MM. (0.003 IN.)

ELAPSED TIME (MIN.)
B.00 TSF PARIS PIKE H-2 S-2B

Cv = 17.12 50.9 Ft. / 1 (0.563 50.9 Ft. / 2)

PERMEABILITY, X = 0.3252 x 10^-9 CH./SEC.

Tgo = 2.555 MINS

Bgo = 0.05 50.9 Ft. / 2 (0.006 50.9 Ft. / 2)

Pgo = 0.1033 50.9 Ft. (0.0027 50.9 Ft.)

SQUARE ROOT OF ELAPSED TIME (SQ.RT. MINS.)

-0.00 6.00 12.00 18.00 24.00 30.00 36.00

DEFORMATION

0.00

0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

ELAPSED TIME (MIN.)

-0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

-0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

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-0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

6.00 TSF PARIS PIKE H-2 S-2B

Cv = 7.30 50.9 Ft. / 1 (0.208 50.9 Ft. / 2)

PERMEABILITY, X = 0.1365 x 10^-9 CH./SEC.

Tgo = 1.000 MINS

Bgo = 0.1994 50.9 Ft. (0.0073 50.9 Ft.)

C-50% LPHA = 0.00482

LOGIO. OF ELAPSED TIME (MIN.)

2.00 -1.00 -0.00 0.00 1.00 2.00 3.00 4.00

-0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

-0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

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-0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00

B.00 TSF PARIS PIKE H-2 S-2B

Cv = 6.12 50.9 Ft. / 1 (0.100 50.9 Ft. / 2)

PERMEABILITY, X = 0.1182 x 10^-9 CH./SEC.

Tgo = 0.305 MINS

Bgo = 1.0075 50.9 Ft. (0.0748 50.9 Ft.)

UTSLPM = -2.2161 /MINUTES

0.100 = 2.1081 50.9 Ft. (0.0083 50.9 Ft.)
16.0 TSF PARIS PIKE H-2 S-2B

$C_v = 0.90$ $50.8$ $(0.015$ $50.8$ $/G)

$T_{gg} = 16.741$ HN

$PENETRATION$: $K = 0.0555+10^{-3}$ CH./SEC.

$B = 2.5163$ MM. $(0.0088$ IN.)

$B_{100} = 2.3014$ MM. $(0.00088$ IN.)

$C_{SUB-M.P.M} = 0.0210$

$B_{100} = 5.04(17$ MM. $(0.1178$ IN.)

**SQUARE ROOT OF ELAPSED TIME (MIN.)**

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16.0 TSF PARIS PIKE H-2 S-2B

$C_v = 4.07$ $50.8$ $(0.147$ $50.8$ $/G)

$T_{gg} = 7.720$ HN

$PENETRATION$: $K = 0.0625+10^{-3}$ CH./SEC.

$B = 2.5052$ MM. $(0.00988$ IN.)

$B_{100} = 2.4053$ MM. $(0.000988$ IN.)

**ELAPSED TIME (MIN.)**

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</table>
32.0 TSF PARIS PIKE H-2 S-2B

\[ \phi_0 = 10.37 \text{ SG.R./ft}^2 / (0.105 \text{ SG.FT.}/\text{ft}) \]

ELAPSED TIME (MIN.)

-2.00  0.00  2.00  4.00  6.00  8.00  10.00  12.00  14.00  16.00

32.0 TSF PARIS PIKE H-2 S-2B

\[ \phi_0 = 4.27 \text{ SG.R./ft}^2 / (0.105 \text{ SG.FT.}/\text{ft}) \]

SQUARE ROOT OF ELAPSED TIME (SQ.RT. MIN.)

-2.00  0.00  2.00  4.00  6.00  8.00  10.00  12.00  14.00  16.00

LOG. OF ELAPSED TIME (MIN.)

-4.00  -2.00  0.00  2.00  4.00  6.00  8.00  10.00  12.00  14.00  16.00

PENETRABILITY, K = 0.078 \times 10^{-6} \text{ CH./SEC.}
1.0 TSF REBOUND PARIS PIKE H-2 S-2B

\[ C_y = 12.80 \text{ Gal./ft} \times 0.005 \text{ gal./ft} = 0.064 \text{ gal./ft} \]

\[ T = 4.120 \text{ min} \]

PENETRATION, \( k = 0.0036 \times 10^{-1} \text{ in./sec} \)

\[ q_0 = 3.715 \text{ in.} \times 0.10 \text{ in.} \]

\[ q_{100} = 3.487 \text{ in.} \times 0.10 \text{ in.} \]

1.0 TSF REBOUND PARIS PIKE H-2 S-2B

\[ C_y = 2.32 \text{ Gal./ft} \times 0.005 \text{ gal./ft} = 0.012 \text{ gal./ft} \]

\[ T = 6.827 \text{ min} \]

PENETRATION, \( k = 0.0005 \times 10^{-1} \text{ in./sec} \)

\[ q_0 = 3.735 \text{ in.} \times 0.10 \text{ in.} \]

\[ q_{100} = 3.470 \text{ in.} \times 0.10 \text{ in.} \]

1.0 TSF REBOUND PARIS PIKE H-2 S-2B

\[ C_y = 1.76 \text{ Gal./ft} \times 0.005 \text{ gal./ft} = 0.088 \text{ gal./ft} \]

\[ T = 20.872 \text{ min} \]

PENETRATION, \( k = 0.0004 \times 10^{-1} \text{ in./sec} \)

\[ q_0 = 3.846 \text{ in.} \times 0.10 \text{ in.} \]

\[ q_{100} = 3.588 \text{ in.} \times 0.10 \text{ in.} \]
Figure 36. Plotted Output for Computer Run on Data from a Shale Swell-Deflection Test.

HENLEY SHALE SWELL DEFLECTION TEST #2

\[ Cv = 1.10 \text{ scm.} / \text{ft} \] (0.035 scm. ft\(^{-2}\))

\[ T_0 = 36.579 \text{ min} \]

PERMEABILITY \( K = 0.853 \times 10^{-4} \text{ cm.} / \text{sec.} \)

\[ C_{SUND} = 3.725 \text{ cm.} \text{ (1.046 in.)} \]

\[ C_{SUND} = 0.1838 \text{ cm.} \text{ (0.0074 in.)} \]

SQUARE ROOT OF ELAPSED TIME (MIN. M.)

LOG10. OF ELAPSED TIME (MIN.)

HENLEY SHALE SWELL DEFLECTION TEST #2

\[ Cv = 0.49 \text{ scm.} / \text{ft} \] (0.016 scm. ft\(^{-2}\))

\[ T_0 = 22.005 \text{ min} \]

PERMEABILITY \( K = 0.2954 \times 10^{-5} \text{ cm.} / \text{sec.} \)

\[ C_{SUND} = 2.786 \text{ cm.} \text{ (0.1094 in.)} \]

\[ C_{SUND} = 0.0013 \text{ cm.} \text{ (0.0005 in.)} \]

ELAPSED TIME (MIN.)

EDGE (1.0 in.)
APPENDIX G

EQUATIONS USED BY THE COMPUTER PROGRAM TO CALCULATE SOIL PARAMETERS
COEFFICIENT OF CONSOLIDATION, $c_v$
(Single Drainage)

Square-root-of-time Analysis:
$$CV_{ROOT} = 8.48 \frac{H^2}{T90} \text{ (ft}^2\text{/day)}$$

Logarithm-of-time Analysis:
$$CV_{LOG} = 1.97 \frac{H^2}{T50} \text{ (ft}^2\text{/day)}$$

Naylor-Doran Analytical Method:
$$CV_{ND} = (-40 \frac{H^2}{Pr^2}) \text{ UTSLOP} \text{ (ft}^2\text{/day)}$$

in which $PI = 3.14159...$ and
$$\text{UTSLOP} = \text{slope of loge}(1 - U')-\text{versus-time relationship (1/minute)}$$

For double drainage: $CV = CV$ (single drainage)/4.0

$$H = \text{average thickness of specimen}$$
$$= THIKNS(II) \cdot \frac{[DEFLC(NO) - DEFI]}{2.0}$$

in which $THIKNS(II) = \text{thickness (inches) of soil specimen before application of new load increment,}$
$DEFLC(NO) = \text{final deflection reading (inches) of current load increment, and}$
$DEFI = \text{initial deflection reading (inches) of current load increment}$

COEFFICIENT OF VOLUME CHANGE, $m_v$

$$m_v = \frac{\Delta \epsilon_v}{\Delta \sigma_v'}$$

in which $\Delta \epsilon_v = \text{change in ordinary vertical strain and}$
$\Delta \sigma_v' = \text{change in vertical effective stress}.$

Computer Expression:
$$MV = \frac{(DEFLC(NO) - DEFI)\cdot(THIKNS(PINCR(II))}{THIKNS(PINCR(II)) \cdot (DEFLC(PINCR(II)))} \text{ (ft}^2\text{/ton)}$$

in which $\text{THIKNS} = \text{initial thickness of soil specimen (inches) before application of first load increment and}$
$\text{PINCR} = \text{applied load increment (tsf)}$

COEFFICIENT OF SECONDARY COMPRESSION, $c_a$
(Single Drainage)

$$c_a = \frac{(\Delta H/H)\log(t_2/t_1)}{\text{change in thickness of soil specimen between values of elapsed time } t_1 \text{ and } t_2}$$

Computer Expression:
$$\text{CALPHA} = \frac{\text{SLOPA}/(THIKNS(II) - (DEFLC(NO) - DEFI)/2)}{2}$$
in which SLOPA = arithmetic slope of linear representation of secondary compression data

For double drainage: CALPHA = 2*CALPHA (single drainage)

**TIME-DEPENDENT COMPRESSION RATIOS FOR EACH CONSOLIDATION PHASE (11)**

Compression Ratio for Primary Consolidation:
\[ R_p = \frac{(d_{100} - d_i)}{(d_f - d_i)} \]

Compression Ratio for Initial Compression:
\[ R_i = \frac{(d_0 - d_i)}{(d_f - d_i)} \]

Compression Ratio for Secondary Compression:
\[ R_s = 1 - R_p \cdot R_i \]

in which
- \( d_{100} \) = deflection reading corresponding to 100-percent primary consolidation,
- \( d_0 \) = deflection reading corresponding to zero-percent primary consolidation,
- \( d_i \) = initial deflection reading for current load increment, and
- \( d_f \) = final deflection reading for current load increment

**COEFFICIENT OF PERMEABILITY, k**

\[ k = c_v m_v \gamma_w \]

in which
- \( c_v \) = coefficient of consolidation (ft²/day),
- \( m_v \) = coefficient of volume change (ft²/ton), and
- \( \gamma_w \) = unit weight of water, 62.4 (pcf)

To calculate \( k \) in SI units, the following expression is used:
\[ k = c_v m_v \times 1.10067 \times 10^{-5} \text{ (cm/sec)} \]
APPENDIX H

FLOW CHART OF
COMPUTER PROGRAM CVCON-0
Figure 37. Flow Chart of Computer Program, CVCON-0.

START

CALL CALCOMP PLOT BUFFER

READ INITIAL THICKNESS OF SPECIMEN, ZERO AND INITIAL DEFLECTION READINGS, DEFLECTION CALIBRATION FACTOR (INCHES/PER UNIT OF DEFLECTION), AND PLOT SIZE FACTOR

READ NUMBER OF LOAD INCREMENTS AND VALUES FOR OPTIONS

READ INITIAL AND INCREMENTAL VALUES OF PRESSURE AND ANALYSIS OPTION VALUES

READING LOADING DESIGNATION AND TEST DESCRIPTION

READ INPUT VALUES OF ELAPSED TIME, DEFLECTION, AND TRIP ARGUMENT

OBTAIN SQUARE-ROOTS AND LOGARITHMS OF ELAPSED TIME READINGS

SQUARE-ROOT-OF-TIME ANALYSIS

DETERMINE NUMBER OF POINTS TO BE FITTED BY INTERPOLATION PARABOLAS (3, 5, OR 9)

GENERATE SAMPLING INTERVALS FOR SQUARE-ROOT-OF-TIME PROCEDURE

DIVIDE ORDINATE DISTANCE BETWEEN FIRST AND LAST DATA POINT INTO 35 EQUAL INTERVALS

A

ANALYZE DATA FROM NEXT CONSOLIDATION TEST

READ NEXT SET OF TIME-DEFLECTION DATA IF FROM SAME CONSOLIDATION TEST

BB

CC
CALCULATE ORDINATE VALUES DEFINING VERTICAL POSITION OF EACH INTERVAL

TOP 32 INTERVALS GENERATE SAMPLING INTERVALS USED IN SEARCH FOR LINEAR PORTION OF SQUARE-ROOT-OF TIME CURVE

SAMPLING INTERVALS OF NINE DIFFERENT SIZES ARE USED IN VARIETY OF POSITION COMBINATIONS

OFFSET VERTICAL POSITION OF A GIVEN SIZE OF SAMPLING INTERVAL TO GET A WIDE VARIETY OF POSITION COMBINATIONS

LOCATE DATA POINTS BETWEEN ORDINATE VALUES DEFINING CURRENT INTERVAL (A MINIMUM OF THREE REQUIRED)

FIT THESE DATA POINTS BY LINEAR LEAST-SQUARES AND DETERMINE SCATTER IN DEPENDENT VARIABLE, DEFLECTION, BY COMPUTING THE STANDARD ERROR OR THE ESTIMATE, $\sigma$, IN UNITS OF INCHES USING DOUBLE PRECISION

DIVIDE DISTANCE BETWEEN SECOND AND LAST DATA POINT INTO 35 EQUAL INTERVALS TO AVOID ENCOUNTERING PROBABLE SEATING AND AIR COMPRESSION EFFECTS BETWEEN FIRST TWO DATA POINTS

HAVE NUMBER OF ASSIGNED PASSES BEEN COMPLETED FOR THIS SIZE OF SAMPLING INTERVAL?
CALCULATE LENGTH WEIGHTING FACTOR, $WFL$, TO MEASURE LENGTH SIGNIFICANCE OF FITTED DATA POINTS:

$$WFL = |YHAT/YBOT|$$

POSITION WEIGHTING FACTOR, $WFp$, IS CALCULATED TO MEASURE POSITION SIGNIFICANCE OF FITTED DATA POINTS:

$$WFp = |SHAT/SBOT|$$

SMALL VALUES OF $WFL$ AND $WFp$ ARE SIGNIFICANT

ADJUSTED STANDARD ERROR OF THE ESTIMATE, $S_e$ (ADJUSTED), MEASURES COMBINED SCATTER, LENGTH, AND POSITION CHARACTERISTICS OF THE FITTED DATA POINTS:

$$S_e \text{ (ADJUSTED)} = WFL \times WFp \times S_e$$

SET $S_e$ EQUAL TO $5.6 \times 10^{-5}$ INCHES TO PREVENT OVERSHADOWING LENGTH AND POSITION CHARACTERISTICS OF DATA WHEN $S_e$ (ADJUSTED) IS CALCULATED

SET $S_e$ EQUAL TO 999.0 INCHES TO PREVENT SELECTION OF THESE POINTS

IS THIS THE SMALLEST VALUE OF $S_e$ (ADJUSTED) YET ENCOUNTERED?

IF A SMALLER VALUE OF $S_e$ (ADJUSTED) IS NOT FOUND, DATA POINTS ASSOCIATED WITH THIS VALUE WILL BE USED FOR LINEAR PORTION OF SQUARE-ROOT-OF-TIME CURVE

SET $S_e$ EQUAL TO 999.0 INCHES TO PREVENT SELECTION OF THESE POINTS

$C$
Has square-root-of-time sampling procedure been completed?

Yes

Reduce slope through data having smallest value of $S_e$ (adjusted)
by factor of 1.15

Find data points between which this line intersects square-root-of-time curve

Are these data points too close to beginning of data to use interpolation parabola?

Yes

No

Fit data points in vicinity of $d_{90}$ with least-squares parabola

Linearly combine equations of line having reduced slope and
interpolation parabola

Calculate discriminate of quadratic formula for above linear combination

Discriminate greater than or equal to zero?

No

Yes

D

E
COMPUTE POSSIBLE VALUES OF \( t_{90} \) BY QUADRATIC FORMULA

ARE ANY OF ROOTS BETWEEN DATA POINTS SURROUNDING \( d_{90} \)?

Yes

DISCARD EXTRANEOUS ROOT, CALCULATE \( d_{90} \), AND SQUARE SELECTED ROOT TO ESTIMATE \( t_{90} \)

CALCULATE COEFFICIENT OF CONSOLIDATION, \( C_v = 0.197h^2/t_{90} \)

CALCULATE COEFFICIENT OF VOLUME
CHANGE, \( M_v \), BASED ON CHANGES IN ORDINARY STRAIN

CALCULATE OTHER RELEVANT INFORMATION

STORE THESE RESULTS FOR OUTPUT

SUMMARY OF ALL SQUARE-ROOT-OF-TIME ANALYSES PERFORMED ON DATA FROM CURRENT CONSOLIDATION TEST

LOGARITHM-OF-TIME ANALYSIS

ESTIMATE \( d_0 \) BY 4 TIMES \( t_1 \); UNLESS \( d_0 \) FROM SQUARE-ROOT-OF-TIME METHOD IS USED

FIND LINEAR REPRESENTATION OF SECONDARY COMPRESSION DATA

No

ATTEMPT LINEAR INTERPOLATION FOR ESTIMATE OF \( t_{90} \) AND \( d_{90} \)

LINEAR INTERPOLATION SUCCESSFULLY COMPLETED

ABANDON SQUARE-ROOT-OF-TIME METHOD AND SET ALL PARAMETERS EQUAL TO ZERO
ARBITRARILY USE 30 PERCENT OF NUMBER OF DATA POINTS AS STARTING POSITIONS FOR BACKWARD GENERATION OF HORIZONTAL SAMPLING INTERVALS (MAXIMUM OF 30)

DIFFERENT STARTING POINTS USED TO TEST AROUND ANY BAD DATA THAT MAY BE FOUND AT END OF SECONDARY COMPRESSION CURVE

STARTING POINTS FOR BACKWARD GENERATION OF SAMPLING INTERVALS

CALCULATE ABSCISSA 'A' AT LEFT OF SAMPLING INTERVAL THAT WILL BE EXTENDED BACKWARDS FROM SELECTED STARTING POINT

FIND DATA POINTS IN THIS SAMPLING INTERVAL (i.e., DATA BETWEEN STARTING POINT AND 'A')

WERE DATA POINTS IN THIS SAMPLING INTERVAL IN PRECEDING INTERVAL?

Yes -> CALCULATE A NEW 'A'

No

AT LEAST THREE POINTS IN INTERVAL?

Yes

STORE ARRAY LOCATIONS OF FIRST AND LAST DATA POINTS IN SAMPLING INTERVAL TO MAKE SURE THEY ARE NOT SAMPLED IN NEXT PASS

No

SELECT ANOTHER STARTING POINT EARLIER ON THE CURVE
CALL STERR
PERFORM LINEAR LEAST-SQUARES FIT AND COMPUTE \( S_e \) IN INCHES USING DOUBLE PRECISION

\( S_e < 1.0 \times 10^{-5} \) INCHES

Yes

SET \( S_e \) EQUAL TO \( 1.0 \times 10^{-5} \) INCHES TO PREVENT OVER-SHADOWING LENGTH AND POSITION CHARACTERISTICS OF DATA WHEN \( S_e \) (ADJUSTED) IS CALCULATED

No

DOES SLOPES OF FITTED DATA CONFORM TO SIGN CONVENTION ESTABLISHED FOR LOADING (+) AND UNLOADING (-)?

Yes

SET \( S_e \) EQUAL TO 999.0 INCHES TO PREVENT SELECTION OF THESE POINTS

No

CALCULATE LENGTH WEIGHTING FACTOR, \( W_{FL} = \frac{X_{HAT}}{S_{BOT}} \)

CALCULATE POSITION WEIGHTING FACTOR, \( W_{FP} = \frac{Y_{TOP}}{S_{HAT}} \)

\( W_{FP} < 0.5 \)

Yes

SET \( W_{FP} \) EQUAL TO 0.5 TO PREVENT GIVING UNDUE SIGNIFICANCE TO SLOPES APPROACHING ZERO WHEN \( S_e \) (ADJUSTED) IS CALCULATED

No

CALCULATE \( S_e \) (ADJUSTED) = \( W_{FL} \times W_{FP} \times S_e \)

H
IF A SMALLER VALUE OF $s_e$ (ADJUSTED) IS NOT FOUND, LEAST-SQUARES FIT HAVING THIS VALUE IS USED FOR LINEAR REPRESENTATION OF SECONDARY COMPRESSION DATA.

STORE SLOPE, INTERCEPT, AND $s_e$ FOR CHOSEN LEAST-SQUARES FIT AS INTEGERS FOR COMPARISON PURPOSES DURING SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION DATA.

FIND LINEAR REPRESENTATION OF PRIMARY COMPRESSION DATA.

DETERMINE HOW MANY DIFFERENTLY SIZED SAMPLING INTERVALS WILL BE USED.

NUMBER OF SAMPLING INTERVALS SET TO 8 DURING FIRST PASS THROUGH ENTIRE LOGARITHM-OF-TIME CURVE.

FIND FIRST AND LAST DATA POINTS OF PORTION OF LOGARITHM-OF-TIME CURVE TO BE EXAMINED.

TERMINATE SAMPLING PROCESS AND SELECT LEAST-SQUARES FIT HAVING SMALLEST $s_e$ (ADJUSTED) AS LINEAR REPRESENTATION OF SECONDARY COMPRESSION DATA.

NUMBER OF SAMPLING INTERVALS SET TO 10.
COMPUTE WIDTH OF SAMPLING INTERVAL, 'B', BY DIVIDING HORIZONTAL DISTANCE BETWEEN FIRST AND LAST DATA POINT NOTED ABOVE

USE ABSCISSA OF FIRST DATA POINT OF REGION TO BE EXAMINED AS 'A', ABSCISSA OF LEFT HAND SIDE OF SAMPLING INTERVAL HAVING WIDTH 'B'

FIND FIRST DATA POINT AFTER ABSCISSA, 'A'

FIND DATA POINTS IN SAMPLING INTERVAL 'B'

WERE POINTS IN THIS INTERVAL FOUND IN PRECEDEING INTERVAL?

CALL STDERR
PERFORM LINEAR LEAST-SQUARE FIT AND COMPUTE $\delta_e$ IN INCHES

DOES SLOPE OF FITTED DATA CONFORM TO SIGN CONVENTION ESTABLISHED FOR LOADING (+) AND UNLOADING (-)?

SET $\delta_e$ EQUAL TO 999.0 INCHES TO PREVENT SELECTION OF THESE POINTS
No TEMPORARILY STORE THIS VALUE OF $s_0$ TO CHECK THAT THESE POINTS HAVE NOT ALREADY BEEN SELECTED FOR LINEAR REPRESENTATION OF SECONDARY COMPRESSION DATA.

$S_0 \leq 5.0 \times 10^{-5}$ INCHES

Yes

SET $S_0$ EQUAL TO $1.0 \times 10^{-5}$ INCHES FOR COMPARISON PURPOSES

No

CALCULATE LENGTH WEIGHTING FACTOR,
$WF_L = \left[ \frac{WAT}{YBOT} \right]$

CALCULATE POSITION WEIGHTING FACTOR,
$WF_P = \left[ \frac{SBAT}{SBOT} \right]$

SMALL VALUES OF $WF_L$ AND $WF_P$ ARE SIGNIFICANT

CALCULATE
$S_0$ (ADJUSTED) = $WF_L \times WF_P \times S_0$

STORE SLOPE, INTERCEPT, $S_0$ (TEMP) AND $S_0$ (ADJUSTED) AS INTEGERS TO CHECK WHETHER LINEAR REPRESENTATION OF SECONDARY COMPRESSION DATA HAS BEEN REACHED

Yes

SET $S_0$ EQUAL TO $5.0 \times 10^{-5}$ INCHES TO PREVENT OVERSHADOWING LENGTH AND POSITION CHARACTERISTICS OF DATA WHEN $S_0$ (ADJUSTED) IS CALCULATED
FIND INTERVAL CONTAINING DATA POINTS WITH LARGEST SLOPE FOR CURRENT SAMPLING WIDTH, 'B'

CONSIDER ONLY DATA BEFORE THIS POINT

SELECT AT LEAST FIVE INTERVALS IN VICINITY OF LARGE SLOPE

DO ANY OF THESE INTERVALS CONTAIN DATA HAVING A NEW MINIMUM FOR \( S_e \) (ADJUSTED)?

IF SMALLER \( S_e \) (ADJUSTED) IS NOT FOUND, LEAST-SQUARES FIT WITH THIS VALUE OF \( S_e \) (ADJUSTED) WILL BE USED FOR LINEAR REPRESENTATION OF PRIMARY COMPRESSION

STORE ARRAY LOCATION OF THIS SLOPE

IS THIS SLOPE A NEW MAXIMUM FOR CURRENT 'B'?
Yes

DETERMINE INTERSECTIONS OF LINEAR REPRESENTATIONS OF PRIMARY AND SECONDARY COMPRESSION DATA TO ESTIMATE $d_{100}$

Calculate

$$d_{50} = \frac{(d_2 + d_{100})}{2}$$

Are there sufficient data in vicinity of $d_{50}$ for parabolic interpolation of $t_{50}$?

No

ABANDON LOGARITHM-OF-TIME ANALYSIS AND SET ALL PARAMETERS EQUAL TO ZERO

Yes

FIT DATA IN VICINITY OF $d_{50}$ WITH LEAST-SQUARES PARABOLA

Compute $t_{50}$ by substituting scaled value of $d_{50}$ into equation of least-squares parabola

Calculate coefficient of consolidation,

$$C_v = 0.848t_{50}^2/d_{50}$$

Calculate coefficient of secondary compression, $C_m$, and other relevant information

No

DEFAULT TO TAKE $d_{100}$ AS EQUAL TO LAST DEFORMATION READING

CHANGE VALUE OF $d_{100}$ TO PLOT INTERPOLATION PARABOLA
STORE THESE RESULTS FOR OUTPUT
SUMMARY OF ALL LOGARITHM-OF-TIME
ANALYSES PERFORMED ON DATA
FROM CURRENT CONSOLIDATION TEST

NAYLOR-DORAN ANALYTICAL METHOD

ITERATION NUMBER, IK, SET TO ZERO

ASSUME \( d_{100} \), \( d_{0} \)
USUALLY \( d_{100} \) SET EQUAL TO \( d_{100} \)
FROM LOGARITHM-OF-TIME ANALYSIS,
\( d_{0} \) SET EQUAL TO \( d_{0} \) FROM
SQUARE-ROOT-OF-TIME ANALYSIS

CALCULATE \((1 - U')\) FOR
DEFLECTIONS LYING BETWEEN
\( d_{0} \) AND \( d_{100} \)

IK = IK + 1

FIND VALUE OF \( d_{100} \) HAVING
SMALLEST ERROR, \( ERR_{100} \)

FIND VALUES OF ELAPSED TIME
CORRESPONDING TO 60- AND 80-PERCENT
CONSOLIDATION, \((1 - U')\) EQUAL
TO 0.4 AND 0.2, RESPECTIVELY

DETERMINE SLOPES, \( DY_{1} \) AND \( DY_{2} \), OF
EXPERIMENTAL \( \log_{e}(1 - U') \)-
VERSUS-TIME RELATIONSHIP AT 60-
AND 80-PERCENT CONSOLIDATION,
RESPECTIVELY

DETERMINE ERROR IN \( d_{100} \).
\( ERR_{100} = 0.4 \left( \frac{DY_{1}/DY_{2} - 1}{(1 - 2DY_{1}/DY_{2})} \right) \)
COMPUTE NEW $d_{100}'$ BY $d_{100}'$ (NEW) =
($d_{100}' - ERR_{100}d_{100}'$) / ($1 - ERR_{100}$)

TAKE PRECEEDING TWO VALUES OF $d_{100}'$ AND $ERR_{100}$ AND INTERPOLATE LINEARLY FOR $d_{100}'$ (NEW) CORRESPONDING TO $ERR_{100} = 0$.

IF A SMALLER VALUE OF $ERR_{100}$ IS NOT FOUND, THIS VALUE OF $d_{100}'$ WILL BE USED IN FINAL CALCULATION OF $(1 - u')$ DATA

SET ALL PARAMETERS EQUAL TO ZERO AND NAYLOR-DORAN METHOD IS ABANDONED
FIND VALUE OF \( d_0' \) HAVING SMALLEST ERROR, ERR_0

FIND DATA IN VICINITY OF 60-PERCENT CONSOLIDATION

PERFORM LINEAR LEAST-SQUARES FIT ON THESE DATA POINTS AND DETERMINE INTERCEPT AT ELAPSED TIME EQUAL TO ZERO

ERROR IN \( d_0' \), ERR_0, IS DIFFERENCE BETWEEN THEORETICAL \( (8/\pi^2) \) AND EXPERIMENTAL INTERCEPTS:

\[
ERR_0 = \log_e(8/\pi^2) - \text{-INTERCEPT}
\]

COMPUTE NEW \( d_0' \) BY

\[
d_0' \text{(NEW)} = (d_0' + ERR_0(d_{100}' + ERR_{100}(d_0' - d_{100}')))/(1 + ERR_0)
\]

IS IK GREATER THAN 2 AND HAVE PRECEEDING TWO VALUES OF ERR_0 CHANGED SIGN?

Yes

INTERPOLATE LINEARLY FOR \( d_0' \) (NEW) CORRESPONDING TO ERR_0 = 0 BY USING PRECEEDING TWO VALUES OF ERR_0 AND \( d_0' \)

RECALCULATE \( (1 - U') \) DATA WITH NEW VALUE OF \( d_0' \)

\( d_0' \) (NEW) BECOMES \( d_0' \)
If a smaller value of ERR is not found, this value of do will be used in final calculation of (1 - U') data.

Have three complete passes been made through entire Matlov-Doray procedure?

Recalculate (1 - U') data for final time with values of d100' and do' having smallest values of error.

Calculate slope, UTSLOP, of linear least-square fit through data between 60- and 80-percent consolidation on the Loge (1 - U')-versus-time curve.

For comparison purposes, estimate t80 from linear portion of Loge (1 - U')-versus-time relationship.

Calculate coefficient of consolidation by

\[ C_v = \left( \frac{-4H^2}{\pi} \right) (UTSLOP) \]  

in which H is length of drainage path.
STORE DATA TO BE USED IN PLOTTING \( \log_e (1 - U') \)-VERSUS-TIME RELATIONSHIP

OUTPUT RESULTS FROM ALL THREE METHODS OF ANALYSIS FOR CURRENT SET OF TIME-DEFLECTION DATA AND TABULATE TIME-DEFLECTION INPUT DATA

CALL TPLOTS
TO PLOT GRAPHICAL RESULTS OF SQUARE-ROOT, LOGARITHM-OF-TIME, AND NAYLOR-DORAN ANALYSES AND PERTINENT INFORMATION AND RESULTS

ANY MORE TIME-DEFLECTION DATA ASSOCIATED WITH THIS CONSOLIDATION TEST?
Yes

SUMMARIZE RESULTS OF EACH METHOD OF ANALYSIS FOR INCREMENTAL-LOAD DATA WITH THIS CONSOLIDATION TEST

PLOT SEPARATELY THE COEFFICIENTS OF CONSOLIDATION, \( C_v \), AND SECONDARY COMPRESSION, \( C_s \), VERSUS \( \log_{10} \) OF EFFECTIVE STRESS

ANALYZE ANOTHER SET OF CONSOLIDATION TEST DATA?
Yes

TERMINATE EXECUTION OF COMPUTER PROGRAM UPON ENCOUNTERING A CONTROL CARD

STOP
APPENDIX I

SOURCE LISTING FOR CVCON-0
**Computerized Analysis of Time Dependent Conventional Consolidation Data (Load-Incremental)**

**Using**

**Taylor, Casagrande, and Naylor-Doran Methods**

**To Determine**

**The Coefficient of Consolidation, CV**

**By**

**Edmund Gregory McNulty**

**This computer program employs a statistical algorithm for analyzing the time-dependent properties of conventional consolidation test data. The Taylor, square root-of-time and Casagrande log-arithmetic-of-time methods are analytically represented along with a modified version of the Naylor-Doran analytical method. The coefficient of consolidation and values of deflection corresponding to the beginning and end of primary consolidation are determined by each of the three methods.**
THIS COMPUTER PROGRAM IS WRITTEN IN FORTRAN IV AND PRODUCES 'LOTTED OUTPUT USING THE IBM 370/165 II COMPUTER AND CALCOMP 663 PLOTTER. THE COMPUTER PROGRAM WAS DEVELOPED UNDER THE SUSPICES OF THE

KENTUCKY DEPARTMENT OF TRANSPORTATION

BUREAU OF HIGHWAYS

DIVISION OF RESEARCH
SOILS SECTION
533 S. LIMESTONE ST.
LEXINGTON, KENTUCKY
40508
PH. 606 254-4475 EXT 29

GENERALLY, ONLY OBJECT DECK VERSIONS OF COMPUTER PROGRAM WILL BE MADE AVAILABLE. AVAILABILITY OF A SOURCE LISTING AND/OR DECK WILL BE CONSIDERED ON THE MERITS OF EACH INDIVIDUAL INQUIRY. THE USER IS SOLEY RESPONSIBLE FOR THE INTERPRETATION AND USE OF RESULTS DERIVED IN THE UTILIZATION OF THE COMPUTER PROGRAM.

THIS COMPUTER PROGRAM WAS DEVELOPED IN COOPERATION WITH THE U.S. DEPARTMENT OF TRANSPORTATION; FEDERAL HIGHWAY ADMINISTRATION, UNDER THE STUDY TITLE: CONTROLLED RATE OF STRAIN AND CONTROLLED GRADIENT CONSOLIDATION TESTING, KYHPR-76-74. THIS IS A PUBLIC DOMAIN COMPUTER PROGRAM AND SUBJECT TO A FEW RESTRICTIONS. THE AUTHOR, EDMUND GREGORY MCNULTY, ASKS THAT ANY COPIES OF THIS COMPUTER PROGRAM CONTAIN THE DOCUMENTATION CARDS FOUND AT THE BEGINNING OF THE PROGRAM. ALSO, LABEL ANY FUTURE MODIFICATIONS OF THE COMPUTER PROGRAM BY COMMENT CARDS WHICH STATE PURPOSE, DATE, AND PERSON MAKING THE MODIFICATION. THIS WILL ENABLE SUBSEQUENT USERS OF COMPUTER PROGRAM TO UNDERSTAND AND TO WHOM TO DIRECT ANY QUESTIONS ABOUT THE CHANGES.

FINALLY, THE AUTHOR OF THIS PROGRAM WOULD LIKE TO KNOW OF ANY PROBLEMS DEALING WITH THE ALGORITHM. JUST SEND A PUNCHED COPY OF THE DATA AND OUTPUT FROM COMPUTER RUN AND THE AUTHOR WILL TRY TO CORRECT THE PROBLEM.
THE COMPUTER PROGRAM REQUIRES THE FOLLOWING SUBROUTINES AND ON-LINE COMPUTER BUFFERS:

1. MAIN PROGRAM

2. SUBROUTINE FINDT - DETERMINES VALUES OF ELASPED TIME CORRESPONDING TO 60 OR 80 -PERCENT CONSOLIDATION.

3. SUBROUTINE PLOTS - SETS UP ON-LINE CALCOMP PLOT LIBRARY BUFFER ON IBM 370/165 II COMPUTER.

4. SUBROUTINE POLFIT - PARABOLIC INTERPOLATION SUBROUTINE.

5. SUBROUTINE SLOPEU - DETERMINES SLOPES ON LOGE(1-U)-VERSUS-TIME CURVE.

6. SUBROUTINE STDERR - CALCULATES THE UNBIASED STANDARD ERROR OF THE ESTIMATE.

7. SUBROUTINE TPLOTS - PLOTS RESULTS OF TAYLOR, CASAGRANDE, AND NAYLORDORAN ANALYSES.

8. CALCOMP PLOT LIBRARY SUBROUTINES:
   - AXIS
   - OASHLN
   - FACTOR
   - LINE
   - LOGAXS
   - NUMBER
   - PLOT
   - PLOTS
   - SCALE
   - SYMBOL

9. LINE-PRINTER PLOTTING SUBROUTINES:
   - BOX
   - DPLORM
   - GRAPH
   - PLOTEM
   - SCALER
   - SQUARE

10. LIBRARY FUNCTIONS:
    - ABS
    - ALOG
    - ALOG10
    - DABS
    - DSQRT
    - END
    - EXP
    - SQRT

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EGM01220
EGM01230
EGM01240
EGM01250
EGM01260
EGM01270
EGM01280
EGM01290
EGM01300
EGM01310
EGM01320
EGM01330
EGM01340
EGM01350
EGM01360
EGM01370
EGM01380
EGM01390
EGM01400
EGM01410
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EGM01620
EGM01630
EGM01640
EGM01650
EGM01660
EGM01670
EGM01680
EGM01690
EGM01700
EGM01710
EGM01720
FGM01730
EGM01740
EGM01750
EGM01760
EGM01770
EGM01780
EGM01790
EGM01800
EGM01810
EGM01820
MAIN PROGRAM

VARIABLE DEFINITIONS

A
ABCissa value at left of sampling interval in search for linear representation of secondary compression data.

ABS
Absolute value function.

AC
Intercept of linear least-squares fit of group of data points from $\log(e(1-U'))$-versus-time relationship at $(1-U')=0.4$.

 ALOG
Natural logarithm function.

 ALOG10
Logarithm base10 function.

ATTENI
Variable which will print out asterisks when both values of slopes, dy1 and dy2, are equal to zero.

AZ
Ordinate equal to 0.4 on $\log(e(1-U'))$-versus-time relationship.

B
Width of horizontal sampling intervals used in logarithm-of-time search procedures.

BC
Intercept of linear least-squares fit of group of data points from $\log(e(1-U'))$-versus-time relationship at $(1-U')=0.2$.

BCD
Loading designation and test description to be used as plot title.

BOX
Line-printer plotting function which produces box around print-plot.

BZ
Ordinate equal to 0.2 on $\log(e(1-U'))$-versus-time relationship.

C
Abscissa value at right of sampling interval in search for linear representation of primary compression data.

CALPHA
Coefficient of secondary compression.

CEPMIN
Intercept of linear least-squares fit associated with group of data points having smallest value of the adjusted standard error of the estimate.
CEPTA
INTERCEPT OF LEAST-SQUARES FIT OF GROUP OF DATA POINTS CHOSEN FOR LINEAR REPRESENTATION OF SECONDARY COMPRESSION.

CEPTB
INTERCEPT OF LEAST-SQUARES FIT OF GROUP OF DATA POINTS CHOSEN FOR LINEAR REPRESENTATION OF PRIMARY COMPRESSION.

CLOG0
QUADRATIC COEFFICIENT FOR CONSTANT TERM OF LOGARITHM-OF-TIME PARABOLA.

CLOG1
QUADRATIC COEFFICIENT FOR FIRST ORDER TERM OF LOGARITHM-OF-TIME PARABOLA.

CLOG2
QUADRATIC COEFFICIENT FOR SECOND ORDER TERM OF LOGARITHM-OF-TIME PARABOLA.

COR
COEFFICIENT OF CORRELATION, R (CALCULATED IN DOUBLE PRECISION).

COR2
COEFFICIENT OF DETERMINATION, R^2.

CSQRT0
QUADRATIC COEFFICIENT FOR CONSTANT TERM OF SQUARE-ROOT-OF-TIME PARABOLA.

CSQRT1
QUADRATIC COEFFICIENT FOR FIRST ORDER TERM OF SQUARE-ROOT-OF-TIME PARABOLA.

CSQRT2
QUADRATIC COEFFICIENT FOR SECOND ORDER TERM OF SQUARE-ROOT-OF-TIME PARABOLA.

CV
COEFFICIENT OF CONSOLIDATION, FT2/DAY, USING T80 FROM N-D METHOD.

CVANAL
STORAGE ARRAY FOR SUMMARIZING RESULTS OF THE NAYLOR-DORAN METHOD FOR CONSECUTIVE LOAD INCREMENTS.

CVLOGS1, CVLOG
COEFFICIENTS OF CONSOLIDATION FROM LOG-T METHOD IN UNITS OF SQUARE METERS/YEAR AND FT2/DAY, RESPECTIVELY.

CVLOGT
STORAGE ARRAY FOR SUMMARIZING RESULTS OF THE LOG-T METHOD FOR CONSECUTIVE LOAD INCREMENTS.

CVND, CVNDSI
COEFFICIENTS OF CONSOLIDATION FROM NAYLOR-DORAN METHOD, FT2/DAY AND SQUARE METERS/YEAR, RESPECTIVELY.

CVROOT, CVRTSI
COEFFICIENTS OF CONSOLIDATION FROM SQUARE-ROOT-OF-TIME METHOD, IN UNITS OF FT2/DAY AND SQUARE METERS/YEAR, RESPECTIVELY.

CVSQRT( )
STORAGE ARRAY FOR SUMMARIZING RESULTS OF SQUARE-ROOT-OF-TIME METHOD FOR CONSECUTIVE LOAD INCREMENTS.

DABS
ABSOLUTE VALUE FUNCTION FOR DOUBLE PRECISION.

DCENT
FIRST ORDINATE VALUE USED IN GENERATION OF SAMPLING INTERVALS DURING SQUARE-ROOT-OF-TIME METHOD.

DCF
DEFLECTION CALIBRATION FACTOR (INCHES/UNIT OF DEFLECTION).

DEFI
INITIAL DEFLECTION READING WHICH IS LATER CONVERTED TO INCHES.

DEFIR
RAW (INPUT) VALUE OF INITIAL DEFLECTION READING.

DEFLEC( )
ARRAY USED TO STORE VALUES OF DEFLECTION IN INCHES.

DEFZ
ZERO DEFLECTION READING (RAW (INPUT) VALUE).

DEGN( )
ARRAY USED TO STORE CALCULATED VALUES OF (1-U*), THAT IS ONE MINUS EXPERIMENTAL DEGREE OF CONSOLIDATION.

DELTA
INCREMENTAL DIFFERENCE BETWEEN TWO VALUES.

DELTAF
ASSUMED VALUE OF D100 DURING NAYLOR-DORAN ITERATIVE PROCEDURE.

DELTAI
ASSUMED VALUE OF D0 DURING NAYLOR-DORAN ITERATIVE PROCEDURE.

OFMIN
ASSUMED VALUE OF D100 HAVING SMALLEST ERROR, E100.

DIALRO( )
ARRAY FOR STORAGE OF ASSUMED VALUES OF DO (DELTAI), WHICH WILL LATER BE USED IN PLOTTING ERROR-VERSUS-DELTAI.

DIFF
DIFFERENCE BETWEEN TWO VALUES (E.G. DIFF = DELTAF - DELTAI).

DIMIN
ASSUMED VALUE OF DO HAVING SMALLEST ERROR, ERO.

DMAX
LARGEST DEFLECTION VALUE WHICH WILL BE SCALLED BY LINE-PRINTER SUBROUTINE SCALER( ) BEFORE CREATION OF ERROR-DEFL. PLOT.

OMIN
SMALLEST DEFLECTION VALUE WHICH WILL BE SCALLED BY LINE-PRINTER
SUBROUTINE SCALER.

DPLOTM
LINE-PRINTER LIBRARY SUBROUTINE THAT PLOTS SYMBOLS FOR DOUBLE PRECISION ARGUMENTS.

DRAIN
EQUAl TO '1' FOR SINGLE DRAINAGE, TO '2' FOR DOUBLE DRAINAGE.

DSAVE
TEMPORARY STORAGE FOR DEFLEC(I).

DSAVEF
TEMPORARY STORAGE FOR DELTAF DURING ERROR INTERPOLATION PROCEDURE IN NAYLOR-DORAN METHOD.

DSAVEI
TEMPORARY STORAGE FOR DELTAI DURING ERROR INTERPOLATION PROCEDURE IN NAYLOR-DORAN METHOD.

DSAVE1
TEMPORARY STORAGE FOR DEFLECTION CORRESPONDING TO FIRST POINT HAVING ELAPSED-TIME GREATER THAN OR EQUAL TO 0.010 MINUTES.

DSAVE4
TEMPORARY STORAGE FOR DEFLECTION OF FIRST DATA POINT WITH ELAPSED-TIME GREATER THAN OR EQUAL TO FOUR TIMES THE VALUE FOR POINT HAVING DEFLECTION 'DSAVE1'.

DSAVEF2
TEMPORARY STORAGE FOR DELTAF HAVING VALUE OF E100 OPPOSITE IN SIGN TO E100 FOR DSAVEF DURING ERROR INTERPOLATION PROCEDURE IN NAYLOR-DORAN METHOD.

DSAVEI2
TEMPORARY STORAGE FOR DELTAI HAVING VALUE OF ERROR OPPOSITE IN SIGN TO ERROR FOR DSAVEI DURING ERROR INTERPOLATION PROCEDURE IN NAYLOR-DORAN METHOD.

DSQRT
SQUARE-ROOT FUNCTION FOR DOUBLE PRECISION ARGUMENTS.

DS50
VALUE OF DEFLECTION CORRESPONDING TO 50-PERCENT CONSOLIDATION FROM LOG-T METHOD AFTER IT HAS BEEN SCALeD BY A FACTOR OF 100. THIS FACTOR REDUCES TRUNCATION ERROR IN DETERMINATION OF COEFFICIENTS A, B, AND C.

DTEST
CHECK ON DIFFERENCES IN DEFLECTION OF FIRST TWO DATA POINTS ON SQUARE-ROOT-OF-TIME CURVE BEFORE SAMPLING PROCEDURE IS BEGUN.

DUM
DUMMY ARGUMENT.

DY1
SLOPE OF LOGE(1-U')-VERSUS-TIME RELATIONSHIP AT 60-PERCENT CONSOLIDATION.

DY2
SLOPE OF LOGE(1-U')-VERSUS-TIME RELATIONSHIP AT 80-PERCENT CONSOLIDATION.
CONSOLIDATION.

`DLOG, DLOGS`
DEFLECTIONS CORRESPONDING TO ZERO-PERCENT PRIMARY CONSOLIDATION
FOR LOG-T ANALYSIS, IN INCHES AND MILLIMETERS, RESPECTIVELY.

`DOND, DOND1`
DEFLECTIONS CORRESPONDING TO ZERO-PERCENT PRIMARY CONSOLIDATION
FOR NAYLOR-DORAN ANALYSIS, INCHES AND MILLIMETERS, RESPECTIVELY.

`100, 90, AND 80`
DEFLECTIONS CORRESPONDING TO 100-, 90-, AND 80-PERCENT
CONSOLIDATION (INCHES), RESPECTIVELY.

`E2, D4`
ESTIMATED VALUES OF DEFLECTION IN INCHES CORRESPONDING TO 80-
AND 60-PERCENT CONSOLIDATION, RESPECTIVELY.

`EMIN`
SMALLEST ERROR VALUE WHICH WILL BE SCALLED BY LINE-PRINTER
SUBROUTINE SCALER BEFORE CREATION OF E100-VERSUS-DELTAF PLOT.

`EMIN`
SMALLEST VALUE OF ERROR WHICH WILL BE USED IN SCALING LINE-PRINTER
PLOT OF ERROR-VERSUS-DELTAF.

`EMAX`
LARGEST VALUE OF ERROR WHICH WILL BE USED TO SCALE LINE-PRINTER
PLOTS.

`EMIN`
SMALLEST VALUE OF ERROR WHICH WILL BE USED TO SCALE LINE-PRINTER
PLOTS.

`ERROR()`
ARRAY STORAGE LOCATION FOR VALUES OF ERROR.

`ERROR`
ERROR IN ASSUMED VALUE OF DEFLECTION, DELTAF.

`ESAVE`
TEMPORARY STORAGE FOR ERROR DURING ERROR INTERPOLATION
PROCEDURE.

`E100`
ERROR IN ASSUMED VALUE OF DEFLECTION, DELTAF.

`FACTOR()`
CALCOMP PLOTTING SUBROUTINE WHICH IS USED TO REDUCE OR ENLARGE
SIZE OF PLOTS.

`FACTOR`
ADJUSTS THE VALUE OF 'A' DURING LOG-T SAMPLING PROCEDURES.

`GRAPH()`
LINE-PRINTER LIBRARY SUBROUTINE FOR LABELING OF PRINT PLOTS.

`HBAR`
LENGTH OF DRAINAGE PATH IN CONSOLIDATION SPECIMEN.

`HF, HFSI`
HEIGHT OF SPECIMEN AT END OF LOADING, UNITS OF INCHES AND MILLIMETERS RESPECTIVELY.

HI, HSI
HEIGHT OF SPECIMEN BEFORE NEW LOADING, INCHES AND MILLIMETERS, RESPECTIVELY.

I
DO-LOOP PARAMETER.

IA
ARRAY LOCATION OF DATA POINT IN VICINITY OF 60-PERCENT CONSOLIDATION IN NAYLOR-DORAN METHOD.

IABS
ABSOLUTE VALUE FUNCTION FOR INTEGER VALUES.

IAPLOT
NUMBER OF NAYLOR-DORAN ANALYSIS WHICH WILL BE SUMMARIZED.

IAXIS
OPTION PARAMETER FOR UNITS OF DEFLECTION.

IB
ARRAY LOCATION OF DATA POINT IN VICINITY OF 80-PERCENT CONSOLIDATION IN NAYLOR-DORAN METHOD.

IBA
DIFFERENCE IN ARRAY LOCATIONS OF DATA POINTS FOR 60 AND 80-PERCENT CONSOLIDATION IN NAYLOR-DORAN METHOD.

IBEGIN
ARRAY LOCATION OF FIRST DATA POINT PAST DEFORMATION ASSUMED TO CORRESPOND TO ZERO-PERCENT PRIMARY IN NAYLOR-DORAN METHOD.

IBUF
ARRAY USED TO SET UP PLOT BUFFER.

ICONT
DO-LOOP PARAMETER USED TO DETERMINE HOW MANY ITERATIONS ARE PERFORMED IN SEARCH FOR STRAIGHT-LINE PORTION OF PRIMARY COMPRESSION ON LOG-T CURVE.

IDBUG1, IDBUG2, IDBUG3, IDBUG4, IDEBUG
OPTION PARAMETERS FOR DEBUGGING COMPUTER PROGRAM BY PRINTING OUT INTERMEDIATE STEPS IN DIFFERENT PARTS OF THE PROGRAM (SEE INPUT INSTRUCTIONS).

IDEFI
OPTION PARAMETER FOR SPECIFICATION OF INITIAL DEFLECTION (DEFI).

IEND
ARRAY POSITION OF THE LAST POINT IN ANY GROUP OF DATA.

IEXPAN
OPTION PARAMETER FOR ADJUSTING HORIZONTAL PLOT AXIS OF SQUARE-ROOT OF-TIME DATA SO THAT ONLY POINTS HAVING ABSISSA VALUES LESS THAN 2*T90 ARE SHOWN.

IFIRST
DO-LOOP PARAMETER USED TO CHANGE INITIAL STARTING POSITION IN SQUARE-ROOT-OF-TIME SAMPLING PROCEDURES.

GRAPH
OPTION PARAMETER FOR GRAPHICAL OUTPUT (SEE INPUT INSTRUCTIONS).

II, IIII
DO-LOOP PARAMETERS.

IJ, IJJ
ARRAY POSITIONS OF GROUPS OF DATA POINTS WHICH SPAN LARGEST SLOPE ENCOUNTERED DURING PRECEEDING PASS THROUGH LOGARITHM-OF-TIME DATA.

IK
ITERATION NUMBER DURING NAYLOR-DORAN PROCEDURE.

IK1
DO-LOOP PARAMETER EQUAL TO TOTAL NUMBER OF ITERATIONS PLUS ONE.

ILAST
ARRAY POSITION OF LAST DATA POINT FITTED BY INTERPOLATION PARABOLA IN SQUARE-ROOT-OF-TIME PROCEDURE.

ILINEA
ARRAY POSITION OF DATA POINT JUST BEFORE VALUE OF D90 (NECESSARY FOR LINEAR INTERPOLATION.)

ILOG
OPTION PARAMETER FOR SKIPPING LOGARITHM-OF-TIME ANALYSIS WHEN UNEQUAL TO ZERO.

ILOGII
ARRAY FOR STORAGE OF VALUES OF ILOG (OPTION PARAMETER FOR LOG-T SKIP OPTION) FOR EACH LOAD-INCREMENT.

ILOOP
DO-LOOP PARAMETER TO COUNT NUMBER OF COMPLETE PASSES THROUGH NAYLOR-DORAN METHOD DURING EACH LOAD-INCREMENT.

ILPLOT
NUMBER OF ANALYSIS ATTEMPTED WITH LOG-T METHOD WHICH WILL BE SUMMARIZED.

IN
PORTION OF ARBITRARILY ESTABLISHED SAMPLING INTERVALS WHICH ARE ACTUALLY USED IN SQUARE-ROOT-OF-TIME PROCEDURE.

INCREI
INCREMENT FOR DO-LOOP GENERATING SAMPLING INTERVALS USED IN SQUARE-ROOT-OF-TIME PROCEDURE.

INCREL
DO-LOOP PARAMETER IN SQUARE-ROOT-OF-TIME SAMPLING PROCEDURE, USUALLY EQUAL TO ONE.

INCREM
DO-LOOP PARAMETER IN LOG-T INTERPOLATION PROCEDURE.

IND
OPTION PARAMETER FOR SKIPPING NAYLOR-DORAN ANALYSIS WHEN UNEQUAL
TO ZERO.

IND1( )
ARRAY FOR STORAGE OF VALUES OF 'IND' ASSOCIATED WITH EACH LOAD INCREMENT.

INEG
TRIP PARAMETER WHICH INDICATES THAT TEST VARIABLE 'TEMP' HAS CHANGED SIGN DURING SEARCH FOR APPROXIMATE LOCATION OF D90.

INDO
DO-LOOP PARAMETER USED IN SEARCH FOR DATA POINTS AROUND VALUE OF D90. THIS PARAMETER CAUSES SEARCH TO START FROM END OF DATA CURVE AND TO WORK BACK.

INPUT
COMPUTER INPUT UTILITY DEVICE NUMBER FOR READ STATEMENTS.

INTERV
NUMBER OF SUBDIVISIONS MADE IN HORIZONTAL REGION WHERE SAMPLING INTERVALS ARE GENERATED IN SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION.

IOUT
COMPUTER OUTPUT UTILITY DEVICE NUMBER FOR WRITE STATEMENTS.

IPOINT
ARRAY POSITION OF ONE OF TWO DATA POINTS SURROUNDING VALUE OF D90.

IQUIT
NUMBER OF PASSES WHICH WILL BE MADE THROUGH LOG-T DATA IN SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION.

IRTDO
OPTION PARAMETER TO SPECIFY USE OF SQUARE-ROOT-OF-TIME DO IN CALCULATION OF CV IN THE LOGARITHM-OF-TIME METHOD.

ISAVE1, ISAVE2
BEGINNING AND ENDING DATA POINT OF GROUP SAMPLED AND ANALYZED IN SEARCH FOR STRAIGHT-LINE PORTION OF PRIMARY COMPRESSION.

ISERRA
STORAGE LOCATION FOR THE INTEGER FORM OF THE STANDARD ERROR OF THE ESTIMATE, S-SUB-E, ASSOCIATED WITH THE LINEAR REPRESENTATION OF SECONDARY COMPRESSION. THIS PARAMETER IS ONE OF THREE USED TO MAKE SURE THAT THE SAME GROUP OF DATA POINTS IS NOT SELECTED FOR THE LINEAR REPRESENTATION OF PRIMARY COMPRESSION.

ISERRB( )
ARRAY FOR STORING THE VALUES OF THE STANDARD ERROR OF THE ESTIMATE AS INTEGER VALUES FOR THOSE DATA POINTS SAMPLED IN THE SEARCH FOR THE LINEAR PORTION OF PRIMARY COMPRESSION. THESE VALUES ALONG WITH TWO OTHERS, ARE COMPARED WITH THE VALUES MENTIONED IN THE DESCRIPTION OF 'ISERRA'.

ISIGN
PARAMETER USED FOR TESTING WHETHER A GIVEN TREND IS POSITIVE OR NEGATIVE.
ISIGN1, ISIGN2.
PARAMETERS USED IN NAYLOR-DORAN METHOD TO DETERMINE WHETHER TWO CONSECUTIVE VALUES OF ERROR HAVE CHANGED SIGN.

ISLMIN
INTEGER FORM OF SLOPE ASSOCIATED WITH LEAST-SQUARES LINEAR FIT OF PRIMARY COMPRESSION DATA WHICH HAS SMALLEST ADJUSTED VALUE OF THE STANDARD ERROR OF THE ESTIMATE.

ISLOPA
INTEGER VALUE OF SLOPE OF LINE REPRESENTATION OF SECONDARY COMPRESSION. THIS VALUE IS COMPARED TO INTEGER VALUES OF SLOPE STORED DURING SEARCH FOR LINEAR REPRESENTATION OF PRIMARY COMPRESSION.

ISLOPE()
ARRAY FOR STORING INTEGER FORMS OF SLOPES OBTAINED IN SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION.

ISPACE
NUMBER OF SAMPLING INTERVALS USED TO BRACKET THE INTERVAL HAVING THE LARGEST VALUE OF SLOPE ENCOUNTERED DURING A GIVEN SAMPLING PASS IN THE SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION. THIS PARAMETER CHANGES FROM 2 TO 4 WHEN ICONT EQUALS IQUIT (I.E. LAST PASS WITH A GIVEN SIZE INTERVAL). THE REGION SET UP BY THIS VARIABLE IS USED TO FIND MINIMUM SE AND MAKE SMALLER SAMPLING INTERVALS.

ISPLIT
NUMBER OF ANALYSIS ATTEMPTED WITH SQRT-TIME METHOD WHICH WILL BE SUMMARIZED.

ISQRT
OPTION PARAMETER FOR SKIPPING SQUARE-ROOT-OF-TIME ANALYSIS WHEN VALUE IS NONZERO.

ISQRTI()
ARRAY FOR STORAGE OF VALUES OF 'ISQRT' ASSOCIATED WITH EACH SET OF LOAD-INCREMENT DATA.

ISTART
ARRAY POSITION OF DATA POINT BEGINNING REGION OVER WHICH SAMPLING INTERVALS FOR SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION.

ISTNER()
ARRAY FOR INTEGER STORAGE OF THE ADJUSTED VALUES OF THE STANDARD ERROR OF THE ESTIMATE WHICH WILL BE USED IN FINDING MINIMUM VALUE.

ITCEPT()
ARRAY FOR INTEGER STORAGE OF INTERCEPTS FOR LINEAR LEAST SQUARES FITS OF SAMPLED DATA DURING SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION.

ITCMIN
INTEGER FORM OF INTERCEPT ASSOCIATED WITH LEAST-SQUARES LINEAR FIT OF PRIMARY COMPRESSION DATA WHICH HAS SMALLEST ADJUSTED VALUE OF THE STANDARD ERROR OF THE ESTIMATE.

ITEST
DO-LOOP PARAMETER FOR CHECKING NUMBER OF ITERATIONS AND SIZE OF
ARRAY POSITION VALUE.

ITOT
COUNTER WHICH MAKES SURE AT LEAST THREE DATA POINTS ARE SAMPLED EACH TIME DURING SQUARE-ROOT-OF TIME PROCEDURE.

ITOTAL
TOTAL NUMBER OF INTERVALS AROUND ONE HAVING LARGEST SLOPE ON LOG-T CURVE.

ITYPE
ARGUMENT ALLOWS COMPUTER PROGRAM TO COMPARE ORDINATE VALUES OF GENERATED INTERPOLATION PARABOLA WITH FIRST AND LAST DEFLECTION VALUES TO MAKE SURE PARABOLA IS NOT PLOTTED OUT OF RANGE OF DATA.

ITYPE1
TEMPORARY STORAGE LOCATION FOR VALUE OF ITYPE.

J
DO-LOOP PARAMETER.

JEND
TRIP ARGUMENT USED TO AVOID UNNECESSARY CONSIDERATION OF THE SAME GROUP OF DATA POINTS WHEN THE END OF THE DATA CURVE HAS BEEN REACHED IN THE SEARCH FOR THE LINEAR PORTION OF PRIMARY COMPRESSION.

K
ARRAY SUBSCRIPT.

KCOUNT
DO-LOOP PARAMETER WHICH TERMINATES ITERATION PROCESS FOR A GIVEN VALUE OF 'B' WHEN KCOUNT BECOMES GREATER THAN 20 DURING LOG-T, PRIMARY COMPRESSION PROCEDURE.

KKK
ARRAY SUBSCRIPT.

KLOOP
ARRAY SUBSCRIPT.

KLOOP
DO-LOOP PARAMETER USED TO FIND LARGEST SLOPE ENCOUNTERED DURING PASS THROUGH PRIMARY COMPRESSION (LOG-T) DATA.

KM
ARRAY SUBSCRIPT FOR VALUES OF DEFLECTION DURING SQUARE-ROOT-OF-TIME SAMPLING PROCEDURES.

KMIN
ARRAY POSITION OF GROUP OF DATA POINTS SAMPLED DURING SQUARE-ROOT-OF-TIME ANALYSIS THAT HAS BEEN SELECTED TO REPRESENT LINEAR PORTION OF DATA CURVE.

KMM
DO-LOOP PARAMETER DURING SQUARE-ROOT-OF-TIME SAMPLING PROCEDURE.

KTEST
USED IN CHECKING WHETHER END OF DATA HAS BEEN REACHED IN SQUARE-T METHOD.
KNO
- NUMBER OF DATA POINTS FROM LOGE(1-U) RELATIONSHIP WHICH WILL BE PRINT-PLOTTED.

KOUNT
- NUMERICAL DESIGNATION FOR A GIVEN SIZE OF SAMPLING INTERVAL (SQUARE-ROOT-OF-TIME METHOD).

KSERRB
- VARIABLE FOR TEMPORARY STORAGE OF STANDARD ERROR OF THE ESTIMATE AS AN INTEGER VALUE DURING SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION (LOG-T).

KSLOPE
- TEMPORARY STORAGE OF SLOPE AS AN INTEGER.

KSTNER
- TEMPORARY STORAGE OF ADJUSTED STANDARD ERROR OF THE ESTIMATE AS AN INTEGER.

KTCEPT
- TEMPORARY STORAGE OF INTERCEPT AS AN INTEGER.

KTOLOG
- COEFFICIENT OF PERMEABILITY AS DETERMINED FROM USE OF MV AND CV FROM LOG-T ANALYSIS (FOR TOTAL COMPRESSION DURING GIVEN LOAD INCREMENT).

KTND
- COEFFICIENT OF PERMEABILITY AS DETERMINED FROM USE OF MV AND CV FROM NAYLOR-DORAN ANALYSIS (FOR TOTAL COMPRESSION).

KTROOT
- COEFFICIENT OF PERMEABILITY CALCULATED FROM SQUARE-ROOT-OF-TIME RESULTS.

L
- ARRAY SUBSCRIPT.

LASTPT
- LAST DATA POINT OF GROUP OF DATA UNDER CONSIDERATION.

LDISI, LD100
- D100 FROM LOG-T METHOD IN MILLIMETERS AND INCHES, RESPECTIVELY.

LEND
- TRIP ARGUMENT WHICH MUST APPEAR IN COLUMNS 15-16 OF LAST TIME-DEFLECTION DATA CARD TO SEPARATE DIFFERENT LOAD INCREMENTS AND DIFFERENT SETS OF TESTS DATA.

LERROR
- TRIP ARGUMENT USED IN PRINTING ERROR-VERSUS-D100 GRAPH.

LI
- ARRAY SUBSCRIPT USED IN FINDING DATA POINTS WITHIN A GIVEN SAMPLING INTERVAL DURING USE OF SQUARE-ROOT-OF-TIME METHOD.

LINK
- TRIP ARGUMENT USED IN SUBROUTINE TPLOTS FOR PLOTTING PURPOSES.
LITEST
PARAMETER USED IN CHECKING DO-LOOP PARAMETERS 'LI' AND 'INCRE'.

LL
DO-LOOP PARAMETER.

LLL
DO-LOOP PARAMETER USED TO START BACKWARD GENERATION OF
SAMPLING INTERVALS FOR SECONDARY COMPRESSION PROCEDURE FROM
POSITIONS OTHER THAN LAST DATA POINT.

LLNO
DO-LOOP PARAMETER USED IN SAMPLING DATA SAMPLING SECONDARY
COMPRESSION DATA.

LLOOP
DO-LOOP PARAMETER.

LN
ARRAY SUBSCRIPT USED IN SQUARE-T PARABOLIC INTERPOLATION.

LNO
DO-LOOP PARAMETER

LN3
TEMPORARY STORAGE INTEGER.

LOCATA( , ), LOCATB( , )
ARRAYS USED TO CHECK BEGINNING AND END POINTS OF GROUPS OF DATA
SAMPLED FOR SECONDARY AND PRIMARY PORTIONS OF LOGT CURVE,
RESPECTIVELY, TO AVOID SAMPLING SAME GROUP.

LOCAT1( ), LOCAT2( )
ARRAYS USED TO STORE ARRAY POSITIONS OF BEGINNING AND END
POINTS OF A SAMPLED GROUP OF DATA POINTS.

LOGTIM( )
ARRAY FOR STORAGE OF LOGARITHM, BASE10, OF VALUES OF ELAPSED TIME.

LSTOP
ARRAY LOCATION OF LAST ORDI NATE POSITION USED TO GENERATE A SERIES
OF SAMPLING INTERVALS DURING SQUARE-ROOT-OF-TIME PROCEDURE. EACH
VALUE OF 'KOUNT' HAS A UNIQUE VALUE ASSIGNED FOR LSTOP.

LSTORE
TEMPORARY STORAGE VARIABLE FOR VALUE OF 'LLL' DURING SAMPLING OF
SECONDARY COMPRESSION DATA.

LITEST
PARAMETER FOR CHECKING VALUE OF ARRAY SUBSCRIPT IN SAMPLING
OF SECONDARY COMPRESSION DATA.

M
ARRAY SUBSCRIPT.

MARK
CHECKS FOR A SUFFICIENT NUMBER OF DATA POINTS IN VICINITY OF
D50 FOR FITTING BY INTERPOLATION PARABOLA.

MK
ARRAY SUBSCRIPT FOR ARRAYS USED FOR SAMPLED DATA POINTS IN
SQUARE-ROOT-OF-TIME METHOD.

MVLSI, MVLOG
COEFFICIENTS OF VOLUME CHANGE VARIABLES FOR LOG-T ANALYSIS WHICH HAVE UNITS OF SQUARE METERS PER MEGAPASCALS AND SQUARE FEET PER SHORT TON (2000 LBS.), RESPECTIVELY.

MVND, MVNDSI
COEFFICIENTS OF VOLUME CHANGE VARIABLES FOR NAYLOR-DORAN METHOD WHICH HAVE UNITS OF FEET SQUARED PER TON AND METERS SQUARED PER MEGAPASCALS, RESPECTIVELY.

MVROOT, MVS1
COEFFICIENTS OF VOLUME CHANGE VARIABLES FOR SQUARE-ROOT-OF-TIME ANALYSIS WHICH HAVE UNITS OF FEET SQUARED PER TON AND METERS SQUARED PER SHORT TON, RESPECTIVELY.

N
ARRAY SUBSCRIPT.

NDAFF
DO-LOOP PARAMETER FOR OFF SETTING HORIZONTAL POSITION OF A GIVEN SIZE OF SAMPLING INTERVAL DURING SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION ON LOG-T CURVE.

NDISI, ND100
DEFLECTIONS CORRESPONDING TO D100 FOR NAYLOR-DORAN ANALYSIS WHICH HAVE UNITS OF MILLIMETERS AND INCHES, RESPECTIVELY.

NDRAIN
NUMBER OF DRAINAGE BOUNDARIES.

ND
DO-LOOP PARAMETER WHICH COUNTS NUMBER OF DATA POINTS WHICH WILL BE FITTED BY INTERPOLATION PARABOLA IN SQUARE-ROOT-OF-TIME METHOD DURING INTERPOLATION FOR T90.

NLOADS
NUMBER OF LOAD-INCREMENTS ASSOCIATED WITH SET OF CONSOLIDATION DATA.

NLOG
NUMBER OF DATA POINTS FITTED BY INTERPOLATION PARABOLA IN LOGARITHM-OF-TIME METHOD.

NMARK
NUMBER OF DATA POINTS AFTER D50 WHICH ARE FITTED BY LOG-T INTERPOLATION PARABOLA.

NO
NUMBER OF READINGS TAKEN DURING ONE INCREMENTAL LOADING.

NOMARK
EQUAL TO 'NO.'

NOPTS
NUMBER OF READINGS TAKEN DURING ONE LOAD INCREMENT PLUS HALF THE NUMBER OF DATA POINTS BEING FITTED BY INTERPOLATION PARABOLA PLUS TWO.

NO1
DO-LOOP PARAMETER, NUMBER OF READINGS PLUS ONE.

NPOINT
NUMBER OF POINTS FITTED BY INTERPOLATION PARABOLA.

NPTS
NUMBER OF DATA POINTS BEFORE DEFLECTION VALUE FROM WHICH AN
ABSCISSA VALUE WILL BE INTERPOLATED BY THE PARABOLA. EQUAL TO
'NPOINT' PLUS ONE, DIVIDED BY TWO.

NQUIT
TRIP PARAMETER FOR TERMINATING ITERATION PROCESS DURING NAYLOR-
DORAN PROCEDURE.

NSQRT
NUMBER OF DATA POINTS FITTED BY INTERPOLATION PARABOLA DURING
SQUARE-ROOT-OF-TIME METHOD.

NSTORE
VARIABLE FOR STORING SUBSCRIPT OF ARRAY CURRENTLY BEING USED IN
SEARCH FOR LINEAR REPRESENTATION OF SECONDARY COMPRESSION.

PERCEN
VERTICAL OR HORIZONTAL DISTANCE USED IN DETERMINING SIZE OF
SAMPLING INTERVALS.

PERCE2
PARAMETER USED TO CHECK THAT VERTICAL DISTANCE BETWEEN FIRST TWO
POINTS ON SQUARE-ROOT-OF-TIME CURVE DOES NOT EXCEED TWO TIMES
THE DISTANCE BETWEEN ANY TWO SEARCH ORDINATE VALUES.

PF
FINAL PRESSURE AFTER ADDITION OF A NEW LOAD INCREMENT IN TSF.

PFACTR
INPUT FACTOR BY WHICH THE SIZE OF THE CALCOMP PLOT OUTPUT IS
INCREASED OR DECREASED.

PFSI
FINAL PRESSURE AFTER ADDITION OF A NEW LOAD INCREMENT IN KPA PER
METERS SquARED.

PI
PRESSURE BEFORE ADDITION OF A NEW LOAD-INCREMENT IN TSF.

PINCR()
APPLIED PRESSURE INCREMENT IN TONS PER SQUARE FOOT.

PISI
PRESSURE IN KPA PER SQUARE METERS BEFORE ADDITION OF A NEW LOAD
INCREMENT.

PLOT()
CALCOMP PLOTTING ROUTINE WHICH SPECIFIES NEW PEN POSITION.

PLOTEM()
LINE-PRINTER LIBRARY SUBROUTINE.

PLOTS()
CALCOMP LIBRARY SUBROUTINE FOR SETTING UP PLOT BUFFER.
PRECED

SAME AS THE INITIAL DEFLECTION READING, DEF1. AS ITS NAME IMPLIES, PRECED CAN BE TAKEN AS THE LAST DEFLECTION READING OF THE PRECEDING LOAD INCREMENT.

FINAL DEFLECTION READING IN PRECEDING SET OF LOAD-INCREMENT DATA IS STORED IN 'PRECED' IF OPTION PARAMETER 'IDEF1' OF INPUT CARD #2 IS SET EQUAL TO A NONZERO INTEGER VALUE. THIS DEFLECTION IS THEN USED AS THE INITIAL DEFLECTION READING FOR THE NEXT SET OF TIME-DEFLECTION DATA. THIS MEANS THAT THE AVERAGE LENGTH OF THE DRAINAGE PATH WILL BE CALCULATED WITH 'PRECED.' IF OPTION PARAMETER 'IDEF1' IS LEFT EQUAL TO ZERO, THEN 'PRECED' WILL SIMPLY BE THE DEFLECTION READING AT ELAPSED TIME EQUAL TO ZERO.

PRESS()

PRESSURE BEFORE ADDITION OF NEXT LOAD INCREMENT IN TSF.

PRESSO

DIFFERENCE BETWEEN INITIAL AND FINAL PRESSURES, PISI AND PFSI, IN UNITS OF KPA PER SQUARE METERS.

PRILOG, PRLGSI; PRIMND, PRNDSI; PRIMRT, PROTSI.

AMOUNT OF PRIMARY COMPRESSION IN INCHES AND MILLIMETERS FOR LOGARITHM-OF-TIME, NAYLOR-DORAN, AND SQUARE-ROOT-OF-TIME METHODS, RESPECTIVELY.

R

RATIO OF SLOPES AT 60 AND 80-PERCENT CONSOLIDATION FROM LOGE(1-U')-VERSUS-TIME RELATIONSHIP.

RILOG, RIND, RIROOT

RATIOS OF INITIAL COMPRESSION TO TOTAL COMPRESSION FOR LOGARITHM-OF-TIME, NAYLOR-DORAN, AND SQUARE-ROOT-OF-TIME METHODS, RESPECTIVELY.

RNU

SAME AS ERROR, THAT IS, ERROR IN ASSUMED VALUE OF DO.

ROOTTIM()

ARRAY FOR ABSISSA VALUES OF DATA POINTS ON SQUARE-ROOT-OF-TIME CURVE.

RPLOG, RPND, RPROOT

RATIOS OF PRIMARY COMPRESSION TO TOTAL COMPRESSION FOR LOGARITHM-OF-TIME, NAYLOR-DORAN, AND SQUARE-ROOT-OF-TIME METHODS, RESPECTIVELY.

RSLOG, RSND, RSROOT

RATIOS OF SECONDARY COMPRESSION TO TOTAL COMPRESSION FOR LOGARITHM-OF-TIME, NAYLOR-DORAN AND SQUARE-ROOT-OF-TIME METHODS, RESPECTIVELY.

RTDO, RTDOSI

DEFLECTION CORRESPONDING TO ZERO PERCENT PRIMARY CONSOLIDATION IN INCHES AND MILLIMETERS, AS DETERMINED BY SQUARE-ROOT-OF-TIME PROCEDURE.

RTDISI, RTD100

DEFLECTION CORRESPONDING TO 100-PERCENT PRIMARY CONSOLIDATION IN MILLIMETERS AND INCHES, AS DETERMINED BY SQUARE-ROOT-OF-TIME PROCEDURE.
SCALER( )
  LIBRARY SUBROUTINE THAT SCALES DATA TO BE PLOTTED BY LINE-PRINTER.

SCSLOP
  SLOPE HAVING VALUE WHICH IS 15-PERCENT LESS THAN LINEAR PORTION
  OF SQUARE-ROOT-OF-TIME CURVE AND WHICH HAS BEEN MULTIPLIED BY
  100.0 BEFORE USE IN QUADRATIC FORMULA.

SET
  TRIP ARGUMENT WHICH CHANGES VALUES IN NAYLOR-DORAN PROCEDURE
  AFTER VALUE OF E100 BECOMES LESS THAN 0.001.

'SHAT
  CONSTANT VALUE OF SLOPE FOUND IN EQUATION FOR POSITION WEIGHTING
  FACTOR, WFP. IT IS EITHER SLOPE BETWEEN FIRST TWO DATA POINTS
  OF SQUARE-ROOT-OF-TIME CURVE OR SLOPE BETWEEN FIRST AND LAST DATA
  POINTS OF LOGARITHM-OF-TIME DATA CURVE.

SLOMAX
  LARGEST SLOPE ENCOUNTERED DURING EACH PASS THROUGH PRIMARY
  COMPRESSION DATA ON LOG-T CURVE.

SLOMIN
  SLOPE OF LINE SELECTED AS LINEAR REPRESENTATION OF LOG-T SECONDARY
  COMPRESSION DATA.

SLOPA
  SLOPE OF LINEAR REPRESENTATION OF SECONDARY COMPRESSION DATA

SLOPB
  SLOPE OF LINE SELECTED TO REPRESENT LINEAR PORTION OF PRIMARY
  COMPRESSION DATA ON LOG-T DATA CURVE.

SLOPE
  SLOPE OF LINEAR PORTION OF SQUARE-ROOT-OF-TIME DATA CURVE.

SQRT( )
  SQUARE ROOT LIBRARY FUNCTION FOR SINGLE PRECISION.

SQRT90
  SQUARE root OF ELAPSED TIME, T90.

SQUARE
  LIBRARY FUNCTION THAT IS CALLED IN CONJUNCTION WITH PRINT-PLOTTING
  SUBROUTINES.

STNDER( )
  ARRAY USED FOR BOTH STANDARD OF THE ESTIMATE AND ADJUSTED
  STANDARD ERROR OF THE ESTIMATE.

STNMIN
  MINIMUM ADJUSTED STANDARD ERROR OF ESTIMATE.

STOP
  LEAST-SQUARES SLOPE OF DATA POINTS SAMPLED IN SEARCH FOR LINEAR
  PORTION OF PRIMARY COMPRESSION.

SYMBOL( )
  CALCOMP LIBRARY ROUTINE FOR PLOTTING SYMBOLS AND LABELS.

TCEPT( )
ARRAY FOR STORAGE OF VALUES OF LEAST-SQUARES INTERCEPTS.

TEMP
TEMPORARY STORAGE VARIABLE.

TEMPA
DISCRIMINATE OF QUADRATIC FORMULA AND TEMPORARY STORAGE VARIABLE FOR OUTPUT CONSIDERATIONS.

TEMPB
TEMPORARY STORAGE FOR OUTPUTTING DEFLECTIONS IN MILLIMETERS.

TEMPC
TEMPORARY OUTPUT VARIABLE.

TEMPD
TEMPORARY OUTPUT VARIABLE.

TEST
TRIP ARGUMENT AND TEST VALUE USED THROUGHOUT COMPUTER PROGRAM.

THIKI
INITIAL THICKNESS OF CONSOLIDATION SPECIMEN IN INCHES.

THIKNS( )
THICKNESS OF CONSOLIDATION SPECIMEN BEFORE EACH NEW LOADING.

TIM( )
ARRAY USED FOR STORAGE OF ELAPSED TIME READINGS.

TIMX( )
ELAPSED TIME VALUES WHICH WILL BE USED DURING NAYLOR-DORAN METHOD.

TMAX, TMIN
MAXIMUM AND MINIMUM VALUES OF ELAPSED TIME USED IN SCALING DATA FOR PRINT PLOTTING.

TSAVE4
ELAPSED TIME CORRESPONDING TO 4 TIMES VALUE CHOSEN AS T1 IN CALCULATION OF DO FOR LOGARITHM-OF-TIME DATA.

TSLOP( )
LEAST-SQUARES VALUE OF SLOPE.

T50, T80, T90
ELAPSED TIMES IN MINUTES CORRESPONDING TO 50-, 80-, AND 90-PERCENT PRIMARY CONSOLIDATION.

UTSLOP
SLOPE OF LINEAR PORTION OF LOGE(1-U*)-VERSUS-TIME CURVE WHICH IS USED TO CALCULATE CV AFTER NAYLOR-DORAN PROCEDURE HAS BEEN COMPLETED.

VHAT
DIFFERENCE IN DEFLECTION BETWEEN FIRST AND LAST DATA POINT OF A GIVEN SET OF LOAD-INCREMENT DATA.

WFL, WFP
LENGTH AND POSITION WEIGHTING FACTORS, RESPECTIVELY.

XB
SLOPE OF LOGE(1-U')-VERSUS-TIME RELATIONSHIP.

XBIG

VARIABLE USED TO CHECK LENGTH OF SAMPLING INTERVAL USED IN SEARCH FOR LINEAR PORTION OF SECONDARY COMPRESSION DATA.

XBOT

DIFFERENCE IN ABSCISSA VALUES OF FIRST AND LAST DATA POINT OF A GROUP OF SAMPLED DATA IN LOG-T PROCEDURE.

XHAT

DIFFERENCE BETWEEN ABSCISSAS OF FIRST AND LAST POINTS OF LOGARITHMEGM12310-OF-TIME DATA CURVE.

XK

INTERCEPT OF LEAST-SQUARES LINEAR REPRESENTATION OF STRAIGHT PORTION OF LOGE(1-U')-VERSUS-TIME RELATIONSHIP.

XN

MULTIPLYING FACTOR USED TO CHANGE SIZE OF SAMPLING INTERVALS PRODUCED DURING SEARCH FOR LINEAR PORTION OF PRIMARY COMPRESSION DATA. ALSO, REAL STORAGE LOCATION FOR VALUE OF N.

XSQRT( )

STORAGE ARRAY OF ABSCISSA VALUES FITTED BY INTERPOLATION PARABOLA FOR SQUARE-ROOT-OF-TIME PROCEDURE.

XWORH( )

SINGLE PRECISION STORAGE ARRAY FOR ABSCISSA VALUES.

XWORK( )

DOUBLE PRECISION STORAGE ARRAY FOR ABSCISSA VALUES.

X1

SMALLER OF TWO ROOTS PRODUCED BY QUADRATIC EQUATION USED TO ESTIMATE T90.

X2

LARGER OF TWO ROOTS PRODUCED BY QUADRATIC EQUATION USED TO ESTIMATE T90.

Y

ORDINATE CALCULATED IN ORDER TO FIND ARRAY SUBSCRIPTS BETWEEN WHICH 090 IS LOCATED.

YBOT

DIFFERENCE IN DEFLECTION BETWEEN FIRST AND LAST POINTS OF DATA GROUP BEING FITTED.

YCEPT

INTERCEPT OF LINEAR PORTION OF SQUARE-ROOT-OF-TIME DATA OR ESTIMATED VALUE OF DO FOR LOGARITHM-OF-TIME METHOD.

YLOG( )

ARRAY STORING FIRST AND LAST DATA POINTS FITTED BY LOGARITHM-OF-TIME INTERPOLATION PARABOLA.

YSCALE

INTERCEPT OF LINEAR PORTION OF SQUARE-ROOT-OF-TIME CURVE IS MULTIPLIED BY 100.0 SO THAT IT CAN BE USED WITH PARABOLIC COEFFICIENTS A, B, AND C IN QUADRATIC FORMULA TO DETERMINE T90.
YS EARC( )

ORDINATE VALUES WHICH ARE USED TO DEFINE SAMPLING INTERVALS USED
IN SEARCH FOR LINEAR PORTION OF SQUARE-ROOT-OF-TIME CURVE.

YWORK( )

SINGLE PRECISION ARRAY USED FOR TEMPORARY STORAGE OF ORDINATE
VALUES.

YWORK( )

DOUBLE PRECISION ARRAY USED FOR TEMPORARY STORAGE OF ORDINATE
VALUES.

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** MAIN PROGRAM **

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REAL D8 DSQRT,DA8S
REAL MVROOT,MVSI,MVLOG,MVLOGS,MVND,MVNDSI
REAL KTROOT,KTLOG,KTN
REAL LOGTIM,L01SI,L01100,N01LSI,N01100
COMMON /BLOKI/ ROOTIM(400),DEFLEC(400),PINC(20),YSARC(50),
1XWORK(150),YWORK(150),DEGN(400),TIMX(400),I8UF(1024),PRESS(20),
28CD(20)
COMMON /BLOK2/ LOGTIM(400),NO,YCEPT,SLOPE,II,PISI,PFIS,
1LINK,SLOPA,CEPTA,SLOPE8,CEPT8,KND,ITYPE,D100,IGRAPH,1DBUG4
COMMON /CURVE/ CSQRTO,CQR1,CSQR2,CLOGO,CLOG1,CLOG2,
1XSQRT(100),YLOG(100),NLOG,NSQRT,D50,IAXIS,UTSLOP,KX,IXEPI,ISSQT,
2LOG,IND,DCF,LASTPT,PFAC
COMMON /BL0K3/ T90,RTD0,RTD1,RTD1100,CVRTSI,CRVOT,
1T50,DOLOGS,DOLOG,DL1SI,DL1100,CVLGSI,CVLLOG,DONDSI,DOND,N0D100,
2N0D1SI,CVNDSI,CNVD,T80
COMMON /BL0K4/ KTROOT,KTLOG,KTN,Press,MVROOT,MVSI
COMMON /SUMM/ CVSQR(20,9),CVLOGT(20,10),CVNAN(20,9),1SPLT,
1LPLT,1APLOT,1LOAD
COMMON /FINDT/ IBEGIN,IE00,1DBUG3
COMMON /COR/ COR

DIMENSION DIALRD(100),ERROR(100)
DIMENSION THIKN(20),TIM(400)
DIMENSION TSLOP(300),TCEPT(300),STNDER(300)
DIMENSION LOCAT(60),LOCAT2(60),LOCAT8(18,2),LOCAT2(50,2)
DIMENSION XW0RH(102),YW0RH(102)
DIMENSION ISLOPE(18),ITCEPT(18),ISTNER(18),ISERR8(18)
DIMENSION ISQRT(20),1LOGI(20),IND1(20)
DOUBLE PRECISION XWORK,YWORK,1OR

CALL PLOTS(I8UF,4096)
CALL PLOT(0.0,12.0,-3)
CALL SYMBOL(0.0,2.0,0.35,'E.G.M. START ',90.0,13)

INPUT UTILITY NUMBERS FOR READ AND WRITE STATEMENTS.

INPUT=5
IDOUT=6

IGRAF 0
;10 CONTINUE
ITYPE=0
CSTO=0.0
IDEBUG=0
IDBUG1=0
IDBUG2=0
IDBUG3=0
IDBUG4=0
ISPLT=0
ILPLOT=0
IOPLT=0
CSQRT1=0.0
CSQRT2=0.0
CLOG1=0.0
CLOG2=0.0
CVLOG=0.0
III=0
II=1

***********************

INPUT CARD NUMBER 1

***********************

READ IN INITIAL THICKNESS OF SPECIMEN, ZERO DEFLECTION READING, INITIAL DEFLECTION READING, DEFLECTION CALIBRATION FACTOR (INCHES/UNIT OF DEFLECTION), AND PLOT SIZE FACTOR.

THIKI - INITIAL THICKNESS OF SAMPLE AT TIME OF PLACEMENT INTO CONSOLIDOMETER. IF LEFT BLANK, A DEFAULT VALUE OF ONE INCH IS ASSUMED.

DEFZ - ZERO DEFLECTION READING. DEFLECTION READING TAKEN WHEN SAMPLE IS AT INITIAL THICKNESS, THIKI.

DEFI - USUALLY 'DEFI' IS SIMPLY THE VALUE OF DEFLECTION AT ELAPSED TIME, T, EQUAL TO ZERO. HOWEVER, IF OPTION PARAMETER 'IDEFI' IS SET EQUAL TO A NONZERO INTEGER VALUE, 'DEFI' WILL BE SET EQUAL TO THE VALUE OF FINAL DEFLECTION FROM PRECEEDING LOAD-INCREMENTS, 'PRECED.'

DCF - DEFLECTION CALIBRATION FACTOR (INCHES/UNITS). A POSITIVE VALUE FOR DCF IS USED IF INCREASING DEFLECTION READINGS INDICATE SPECIMEN SHORTENING. A NEGATIVE VALUE FOR DCF IS USED IF DECREASING DEFLECTION READINGS INDICATE SPECIMEN SHORTENING.

PFACTR - THIS VARIABLE ASSISTS THE USER IN SCALING PLOTTED OUTPUT FROM THE CALCOMP DRUM PLOTTER. IT PROVIDES THE FACILITY TO CHANGE BOTH THE X AND Y PLOTTING FACTORS BY THE SAME AMOUNT WITH ONE CALL OF SUBROUTINE FACTOR. A CALL FACTOR (0.5) CAUSES
ALL PLOTTING TO BE HALF THE SIZE OF A NORMAL PLOT WHEN PFACTR=0.5. THE COMPUTER PROGRAM DEFAULTS TO A VALUE OF PFACTR=0.8 WHEN COLUMNS 41-50 ARE LEFT BLANK.

READ IN INITIAL THICKNESS OF SAMPLE (INCHES) AT TIME OF PLACEMENT INTO CONSOLIDOMETER, ZERO DEFLECTION READING CORRESPONDING TO THIS THICKNESS, INITIAL DEFLECTION READING, AND DEFLECTION CALIBRATION FACTOR.

READ(INPUT,1010,END=2420) THIKI,DEFZ,DEFI,DCF,PFACTR
WRITE(IOUT,1000) THIKI,DEFZ,DEFI,DCF,PFACTR

000 FORMAT(*1*,"THIKI =",F10.5,* INCHES",5X,*DEFZ =",F10.5,5X,*DEFI =",F10.5,5X,*DCF =",F10.5,"PFACTR =",F10.5)
IF (PFACTR.LT.1.0E-03) PFACTR=0.8
IF (ABS(THIKI).LT.0.0001) THIKI=1.0
IF (ABS(DCF).LT.0.0001) DCF=1.0
DEFI=DEFI
IF (III.EQ.0) PRECED=DEFI*DCF
DEFI=DEFI*DCF

010 FORMAT(8F10.0)

******************************

INPUT CARD NUMBER 2

******************************

READ IN NUMBER OF CONSECUTIVE LOADS ASSOCIATED WITH THE GIVEN DATA SET HAVING THE ZERO DIAL GAUGE READING AND INITIAL THICKNESS ENTERED FORM ABOVE.

NLOADS - NUMBER OF CONSECUTIVE LOADS ASSOCIATED WITH THE PRECEEDING INITIAL DEFLECTION INFORMATION (COLS. 1-2).

NDRAIN - OPTION STIPULATES NUMBER OF DRAINAGE BOUNDARIES.
NDRAIN=0 STIPULATES DOUBLE DRAINAGE (COLS. 3-4).
NDRAIN=1 STIPULATES SINGLE DRAINAGE (COLS. 3-4).

IDEFI - OPTION PARAMETER FOR STIPULATING USE OF FINAL DEFLECTION READING OF PRECEEDING LOAD INCREMENT AS INITIAL DEFLECTION READING, "DEFI." TO DO THIS, A NONZERO INTEGER VALUE MUST BE PLACED IN COLUMNS 5-6. OTHERWISE, THE COMPUTER PROGRAM WILL DEFAULT TO TAKE THE DEFLECTION READING AT ELAPSED TIME EQUAL TO ZERO AS THE INITIAL DEFLECTION READING.

IAXIS - IF EQUAL TO ZERO, DEFLECTION EXPRESSED IN INCHES.
IF NOT EQUAL TO ZERO, DEFLECTION AXIS EXPRESSED IN MILLIMETERS (COLS. 11-12).

IRTDO - IF EQUAL TO '1', THE DO FOR THE LOGARITHM-OF-TIME WILL BE MADE EQUAL TO THE DO CALCULATED IN THE SQUARE-ROOT-OF-TIME ANALYSIS (COLS. 13 - 14).
IGRAPH - IF EQUAL TO ONE, INTERPOLATION PARABOLA IS PLOTTED ON THE SQUARE ROOT OF TIME DATA. PLACE A RIGHT JUSTIFIED INTEGER IN COLUMNS 21-22. IF IGRAPH EQUALS '2', THE INTERPOLATION PARABOLA IS PLOTTED ON THE LOG TIME DATA. IF IGRAPH EQUALS '3', THE INTERPOLATION PARABOLA WILL BE PLOTTED FOR BOTH SQUARE ROOT OF TIME AND LOG TIME DATA. IF IGRAPH EQUALS '4', ONLY THE SUMMARY PLOTS FOR C-SUB-V AND C-SUB-ALPHA WILL BE PLOTTED FOR AN ANALYZED SERIES OF LOAD INCREMENTS. IF IGRAPH EQUALS '5', PRINT PLOT OPTION WILL BE USED TO PLOT SQUARE ROOT TIME AND LOG-TIME DATA ON COMPUTER PRINTOUT.

SPECIAL ERROR INFORMATION FROM NAYLOR-DORAN PROCEDURES:

IGRAPH=55: EFFECT OF D100 ERROR ON LOGE (1-U)-TIME PLOT CAN BE STUDIED (LARGE AMOUNT OF OUTPUT).

IGRAPH=56: EFFECT OF D0 ERROR ON LOGE (1-U)-TIME PLOT CAN BE STUDIED (LARGE AMOUNT OF OUTPUT).

IGRAPH=6 : PLOT OF ERROR IN D100 AGAINST VALUE OF D100 WILL BE OBTAINED.

IEXPAN=0

IEXPAN - IF EQUAL TO ONE, SQ. RT. TIME PLOT AXIS IS ADJUSTED SO THAT MAXIMUM TIME SHOWN IS LESS THAN 2.0*T90 AND AT LEAST EQUAL TO 1.0 MINUTES (COLS.23-24).

DEBUG OPTIONS

IDBUG1 - PRINTS OUT INTERMEDIATE CALCULATIONS FOR SQ.RT. TIME ANALYSIS WHEN IDBUG1 IS MADE NONZERO (COLS.31-32). IF IDBUG1 SET EQUAL TO '2', LENGHTY SEARCH CALCULATIONS WIT NOT BE SHOWN.

IDBUG2 - PRINTS OUT INTERMEDIATE CALCULATIONS FOR LOG.TIME ANALYSIS WHEN IDBUG2 IS MADE NONZERO (COLS. 41-42). IF IDBUG2 SET EQUAL TO '2', SEARCH CALCULATIONS FOR LINEAR REPRESENTATION OF SECONDARY COMPRESSION CURVE WILL BE OMITTED FROM OUTPUT.

IDBUG3 - PRINTS OUT INTERMEDIATE CALCULATIONS FOR ANALYTICAL NAYLOR-DORAN PROCEDURE (COLS. 51-52).

IDBUG4 - PRINTS OUT SCALE FACTORS AT VARIOUS STAGES OF EXECUTION OF PLOT SUBROUTINE, TPLOTS, ALONG WITH GENERATED VALUES OF THE INTERPOLATION PARABOLA (COLS. 61-62).

IDDEBUG - PRINTS OUT ALL INTERMEDIATE CALCULATIONS FOR ALL THREE METHODS WHEN IT IS NONZERO (COLS. 71-72).

DRAIN=2.0

IDEFI=0

READ (INPUT,1020) NLOADS, NDRAIN, IDEFI, IAXIS, IRTDO, IGRAPH, IEXPAN,
1 IDBUG1, IDBUG2, IDBUG3, IDBUG4, IDDEBUG
020 FORMAT (I2, I2, I2, 4X, I2, I2, 6X, I2, I2, 6X, 5(I2, BX))
WRITE (IOUT, 1030) NLOADS, NDRAIN, IDEFI, IAXIS, IRTDO, IGRAPH, IEXPAN,
1 IDBUG1, IDBUG2, IDBUG3, IDBUG4, IDDEBUG
030 FORMAT ('0.0', 'NLOADS =', I3, 2X, 'NDRAIN =', I3, 2X, 'IDEFI =', I3, 5X,
1 'IAXIS =', I3, 2X, 'IRTDO =', I3, 5X, 'IGRAPH =', I3, 2X, 'IEXPAN =', I3, 2X/
2/I1, IDBUG1, 2, 3, AND 4 =*, I4(I3, 2X), 3X, 'IDDEBUG =', I3)
IF (NDRAIN.EQ.0) DRAIN = 2.0
IF (NDRAIN.EQ.1) DRAIN = 1.0

IF (IDBUG .NE. 0) IDBUG1 = 91
IF (IDBUG .NE. 0) IDBUG2 = 91
IF (IDBUG .NE. 0) IDBUG3 = 91
IF (IDBUG .NE. 0) IDBUG4 = 91

WRITE (IOUT, 1040)
040 FORMAT ('0.0', 'PRESS', 7X, 'PINCR', BX, 'ISQRT', 5X, 'ILOG', 6X, 'IND')
050 FORMAT (2F10.0, 3I12, 8X)
DO 20 I = 1, NLOADS

******************************************************************************

INPUT CARD NUMBER 3 TYPE
******************************************************************************

ENTER ON SEPARATE CARDS IN CHRONOLOGICAL ORDER THE PRESSURE BEFORE EACH PRESSURE INCREMENT IS APPLIED AND THE APPLIED PRESSURE INCREMENT IN TSF. THE NUMBER OF THESE TYPE OF CARDS SHOULD BE EQUAL TO NLOADS. THE DATA GROUPS DESCRIBING LOADING PHASES OF THE TESTS SHOULD BE ENTERED IN FIRST TO BE FOLLOWED BY THE REBOUNDING DATA GROUPS IN CHRONOLOGICAL ORDER AGAIN.

PRESS(I) - PRESSURE (TSF) BEFORE ADDITION OF NEXT LOAD INCREMENT

PINCR(I) - APPLIED PRESSURE INCREMENT (TSF).

ISQRT - SET ISQRT TO NONZERO INTEGER TO SKIP SQRT(T) ANALYSIS.
ILOG - SET ILOG TO NONZERO INTEGER TO SKIP LOG(T) ANALYSIS.
IND - SET IND TO NONZERO INTEGER TO SKIP NAYLOR-DORAN ANALYSIS.

READ (INPUT, 1050) PRESS(1), PINCR(1), ISQRT(1), ILOG1(1), IND1(1)
050 FORMAT (2F10.0, 3I12, 8X)
WRITE (IOUT, 1060) I, PRESS(I), PINCR(I), ISQRT(I), ILOG1(I), IND1(I)
060 FORMAT ('0.0', I2, F9.4, 3X, F10.5, 7X, I2, 8X, I2, 7X, I2)
20 CONTINUE

30 CONTINUE

IIII=1+III
ISQRT = ISQRT1(III)
ILOG = ILOG1(III)
IND = IND1(III)
IF (IDEF1.EQ.0) GOTO 40
IF (III.GT.1) PRECED = DEFLEC(NO)
IF (III.GT.1.AND.IAXIS.NE.0) PRECED = DEFLEC(NO)/25.4
IF (III.GT.1) DEFI = PRECED
IF (III.GT.1) DEFI = DEFLEC(NO)/DCF

157
IF(I334.GT.1.AND.IAXIS.NE.0) DEFIR=DEFLEC(N0)/25.4/DCF
THIKNS(I334)=THIKI+(DEFZ-DEFIR)*DCF
40 CONTINUE

***************
INPUT CARD NUMBER 4 TYPE
***************

TEST DESCRIPTION AND LOADING DESIGNATION
READ(INPUT,1070) BCD
1070 FORMAT (20A4)

WRITE (IOUT,1080) BCD
1080 FORMAT ('1',//,21X,20A4//)

***************
INPUT CARD NUMBER 5 TYPE
***************

INPUT ELAPSED TIME READINGS (MINUTES), RAW VALUES OF DEFLECTION, AND TRIP ARGUMENT.
TRIP ARGUMENT = LEND

LEND = +1 : END OF CURRENT INCREMENTAL LOADING DATA SET. THIS VALUE OF LEND TELLS THE PROGRAM TO LOOK FOR A NEW SET OF INCREMENTAL LOADING DATA UNDER THE SAME TEST DESCRIPTION.

LEND = -1 : END OF CURRENT INCREMENTAL LOADING DATA SET AND END OF CURRENT TEST PROBLEM. IF NLOADS IS EQUAL TO ONE, AS FOR THE CASE WITH A SINGLE SET OF INCREMENTAL DATA, LEND MAY BE LEFT AS A +1 AND STILL HAVE THE EFFECT OF ENDING THE CURRENT TEST PROBLEM.

WRITE (IOUT,1090)
1090 FORMAT ('1',TB,'CARD NO.',T22,'TIME',T34,'RAW',T49,'DEFLECTION'/)
DO 50 I=1,400
READ (INPUT,1100) TIM(I),DEFLEC(I),LEND
1100 FORMAT (F7.0,F7.0,2(I2,4X))
IF (TIM(I).LT.0.00010) TIM(I) = 0.00010
TEMP=DEFLEC(I)*DCF
WRITE (IOUT,1110) I,TIM(I),DEFLEC(I),TEMP
1110 FORMAT (10X,I3,5X,3(F10.5,5X))
NO = I
IF (I.EQ.1) GO TO 50
IF (LEND.NE.0) GO TO 60
50 CONTINUE
60 CONTINUE
IF (I indef1.EQ.0) PRECED=DEFLEC(1)
IF(IDEF1.EQ.0) DEFI=DEFLEC(1)
IF(IDEF1.EQ.0) DEFIR=DEFLEC(1)/DCF
IF(IDEF1.EQ.0) THIKNS(III)=THIKI*(DEFZ-DEFIR)*DCF

********************************************************************************

TAYLOR'S SQUARE ROOT OF TIME ANALYSIS

********************************************************************************

DD 70 I = 1, NO
DEGND(I)=-DEFLEC(I)
ROOTIM(I)=SQRT(TIM(I))

MUST ADJUST INITIAL TIME VALUE SO THAT IT MAY BE PLOTTED ON
3-CYCLED LOG10 SCALE WITH INITIAL EXPONENT OF -1.
IF(TIM(I) .LT. 0.001 .AND. TIM(2) .GT. 0.05)
1 TIM(I)=0.0998
70 LOGTIM(I)=ALOG10(TIM(I))
IF (IGRAPH .NE. 5) GOTO 80
TMAX=40.0
TMIN=0.0
IF(PINCRI(III).GT.0) DMAX=-DEFLEC(1)
IF(PINCRI(III).LT.0) DMAX=-DEFLEC(0)
IF(PINCRI(III).GT.0)DMIN=-DEFLEC(0)
IF(PINCRI(III).LT.0)DMIN=-DEFLEC(1)
CALL SCALER(TMUX,TMIN,DMAX,DMIN)
CALL SQUARE
CALL BOX
CALL PLOTEM('*',ROOTIM,DEGND,NO)
CALL GRAPH('SQUARE ROOT TIME, MINUTES',27,'DEFLECTION, INCHES',18)
TMAX=LOGTIM(NO)
TMIN=LOGTIM(1)
IF(TMIN.LT.-1.2 .AND. TIM(2) .GT. -1.2) TMIN=-1.2
CALL SCALER(TMUX,TMIN,DMAX,DMIN)
CALL SQUARE
CALL BOX
CALL PLOTEM('*',LOGTIM,DEGND,NO)
CALL GRAPH('LOGARITHM OF TIME, MINUTES',26,'DEFLECTION, INCHES',18)
1 80 CONTINUE

IF(IDBUG1 .NE. 0) WRITE(IOUT,1120)
120 FORMAT('1'//10X,'SEARCHING FOR LINEAR PORTION OF SQUARE ROOT',
1 ' TIME DATA'//10X)

********************************************************************************

DECIDING WHETHER TO USE FIVE OR NINE POINT INTERPOLATION
PARABOLA BASED UPON THE TOTAL NUMBER OF DATA POINTS.

********************************************************************************

IF(NO .LE. 40) NPOINT=5
IF(NO .GT. 40) NPOINT=9
IF(NO .LT. 15) NPOINT=3
NPTS=(NPOINT+1)/2

MAKING SURE THAT SEARCH ORDINATES SAMPLE MAIN BODY OF DATA AND
NOT A LARGE ORDINATE VOID BETWEEN FIRST AND SECOND DEFLECTION VALUES.

DCENT = DEFLEC(1) - 0.00001*DCF*DEFLEC(1)

PERCEN = (DEFLEC(NO) - DCENT) / 35

PERCE2 = 2.0*PERCEN

DELTA = ABS(DEFLEC(2) - DEFLEC(1))

IF DEFLECTION DIFFERENCE (DELTA) BETWEEN FIRST TWO DATA POINTS IS GREATER THAN TWO TIMES THE ORDINATE-SEARCH INCREMENT (PERCEN), THE SECOND DATA POINT WILL BE USED TO INITIATE THE SEARCH PROCEDURE. THIS AVOIDS ANY LARGE GAPS BETWEEN THE FIRST AND SECOND DEFLECTION VALUES.

IF (DELTA.GT.PERCE2.AND.NO.GE.4) DCENT = DEFLEC(2) - 0.00001*DCF*DEFLEC(1)

IC(2) = 1

PERCEN = (DEFLEC(NO) - DCENT) / 35.0

TESTING TO MAKE SURE INITIAL SLOPE BETWEEN POINTS 1 & 2 NOT ZERO.

DTEST = (DEFLEC(2) - DEFLEC(1))

IF (ABS(DTEST).GT.1.0E-07) SHAT = (DEFLEC(2) - DEFLEC(1)) / (ROOTIM(2) - ROOTIM(1))

ISIGN = 0

IF (NO.GT.4) ISIGN = ABS(DEFLEC(NO) - DEFLEC(1)) / (DEFLEC(NO) - DEFLEC(4))

IF (NO.EQ.4) ISIGN = ABS(DEFLEC(4) - DEFLEC(1)) / (DEFLEC(NO) - DEFLEC(3))

IF (ISIGN.EQ.0) SHAT = 0.01

IF (ISIGN.GE.1.AND.ABS(DTEST).LT.1.0E-07) SHAT = 0.01

IF (ISIGN.LT.0.AND.ABS(DTEST).LT.1.0E-07) SHAT = -0.01

VHAT = ABS(DEFLEC(NO) - DCENT)

IF (ABS(SHAT).LT.0.010) SHAT = 0.010

IF (IDBUG1.NE.0) WRITE (IOUT,1130) VHAT, SHAT

1130 FORMAT ('Q',10X,'VHAT=',E14.7,' SHAT=',E14.7)

YSEARC(1) = DEFLEC(1) - 0.000001*DCF*DEFLEC(1)

IF (DELTA.GT.PERCE2.AND.NO.GE.4) YSEARC(1) = DEFLEC(2) - 0.000001*DCF*DEFLEC(1)

1DEFLEC(2)

****************************

SETTING UP SEARCH OR SAMPLING ORDINATES FOR UP TO 90% OF TOTAL DEFLECTION.

SEARCH ORDINATES ARE USED TO GENERATE THE SAMPLE-DATA GROUPS WHICH ARE EVALUATED FOR THE ADJUSTED STANDARD ERROR OF THE ESTIMATE AND USED TO DETERMINE THE MOST REPRESENTATIVE LINEAR PORTION OF THE SQUARE-ROOT-OF-TIME DATA.

****************************

DO 90 I = 2,35

YSEARC(I) = YSEARC(I-1) * PERCEN

90 CONTINUE

TESTING TO SKIP SQRT(T) ANALYSIS.

IF(ISQRT.NE.0) GOTO 210

****************************

SEARCHING FOR PORTION OF DATA THAT HAS BEST LINEAR REPRESENTATION
(That is, smallest value of adjusted standard error of the estimate).

K=1
LSTOP=7
KOUNT=0
100 CONTINUE

90-percent of total number of search or sampling intervals, 35, equals 32.

IN=32
KOUNT=1+KOUNT
IF(KOUNT.EQ.1) INCREL=1
IF(KOUNT.EQ.1) LSTOP=2
IF(KOUNT.EQ.1) INCREI=2
IF(KOUNT.EQ.2) INCREL=1
IF(KOUNT.EQ.2) LSTOP=3
IF(KOUNT.EQ.2) INCREI=3
IF(KOUNT.EQ.3) INCREL=1
IF(KOUNT.EQ.3) LSTOP=4
IF(KOUNT.EQ.3) INCREI=4
IF(KOUNT.EQ.4) INCREL=1
IF(KOUNT.EQ.4) LSTOP=5
IF(KOUNT.EQ.4) INCREI=5
IF(KOUNT.EQ.5) INCREL=1
IF(KOUNT.EQ.5) LSTOP=6
IF(KOUNT.EQ.5) INCREI=6
IF(KOUNT.EQ.6) LSTOP=7
IF(KOUNT.EQ.6) INCREL=1
IF(KOUNT.EQ.6) INCREI=7
IF(KOUNT.EQ.7) INCREL=1
IF(KOUNT.EQ.7) LSTOP=8
IF(KOUNT.EQ.7) INCREI=8
IF(KOUNT.EQ.8) INCREL=1
IF(KOUNT.EQ.8) LSTOP=16
IF(KOUNT.EQ.8) INCREI=12
IF(KOUNT.EQ.9) INCREL=1
IF(KOUNT.EQ.9) LSTOP=16
IF(KOUNT.EQ.9) INCREI=16
DO 18O L=1,LSTOP,INCREL

The next six 'IF' statements avoid unnecessary repetitions of beginning data samplings. These initial data point samplings are taken care of in KOUNT=7.

IFIRST=1
IF (KOUNT.EQ.1) IFIRST=3
IF (KOUNT.EQ.2) IFIRST=4
IF (KOUNT.EQ.3) IFIRST=5
IF (KOUNT.EQ.4) IFIRST=6
IF (KOUNT.EQ.5) IFIRST=7
IF (KOUNT.EQ.6) IFIRST=8
IF (KOUNT.EQ.8) IFIRST=13
IF (KOUNT.EQ.9) IFIRST=17

DO 170 I=IFIRST,NIN,INCREI
LI=L+1-I
IF(LI.GT.IN) GOTO 180

KM=1

110 CONTINUE
IF (KOUNT.EQ.7.AND.I.EQ.IFIRST) KMM=1
IF (ABS(PINCR(III)).LT.1.0E-07) WRITE(IOUT,1140) PINCR(III)
140 FORMAT(3I14,1X,'**** ERROR IN INPUT VALUE OF PINCR ****, PINCR ','
'CAN NOT BE EQUAL TO ',F10.5,' TSF///')

IF (ABS(PINCR(III)).LT.1.0E-07) GOTO 2430
IF (KOUNT.EQ.7.AND.I.EQ.IFIRST) GOTO 120

KMM=KMM
IF(KM.EQ.(NO-2)) GOTO 120
IF (PINCR(III).GT.0.AND.DEFLEC(KM).GT.YSEARC(LI-INCREI)) GOTO 120

KM=KM+1
GOTO 120

SAMPLING DATA POINTS IN INTERVAL PAST PREVIOUS SEARCH ORDINATES.

120 MK=0
IROT=1
KMTEST=NO-2
IF(KM.GT.KMTEST) KMM=NO-2
DO 140 M=KMM,NO

MK=MK+1
XWORK(MK)=ROOTIM(M)
YWORK(MK)=DEFLEC(M)

IF THERE IS A LARGE ORDI NATE GAP BETWEEN FIRST AND SECOND DATA
POINTS, THE WORKING ORDINATE OF FIRST DATA POINT WILL BE MADE
EQUAL TO DCENT. THIS WILL REDUCE THE WEIGHTED SIGNIFICANCE OF
THE FIRST TWO DATA POINTS.

IF (PINCR(III).GT.0.AND.YWORK(1).LT.DCENT.AND.MK.EQ.1.AND.
1 YWORK(MK).LT.YSEARC(1)) YWORK(1)=DCENT
IF (PINCR(III).LT.0.AND.YWORK(1).GT.DCENT.AND.MK.EQ.1.AND.
1 YWORK(MK).GT.YSEARC(1)) YWORK(1)=DCENT
IF (IDBUG1.EQ.2) GOTO 130

LITEST=LI-INCREI
IF (LITEST.LE.0) LITEST=1
IF (IDBUG1.NE.0) WRITE(IOUT,1150) XWORK(MK),YWORK(MK),LI,
1 YSEARC(LI),LITEST,YSEARC(LITEST)

1150 FORMAT(10X,'ROOTIM = ',G12.4,3X,'DEFLEC = ',G12.4,
1 XSEARC(*,I3,*),=',G13.5,* YSEARC(*,I3,*),=',G13.5)

130 CONTINUE
IF (PINCR(III).GT.0.AND.YWORK(MK).GT.YSEARC(LI).AND.ITOT.GT.2)
1 GOTO 150
IF (PINCR(III).LT.0.AND.YWORK(MK).LT.YSEARC(LI).AND.ITOT.GT.2)
1 GOTO 150
IROT=IROT+1

140 CONTINUE
150 CALL STDERR(XWORK,YWORK,MK,STNDER(K),TSLOP(K),TCEPT(K))
VALUES LESS THAN 5.6E-05 FOR STD ERR-EST ARE ASSUMED TO BE
EXCEPTIONAL AND OVERSHADOW LENGTH AND POSITION PROPERTIES OF DATA.

IF (STNDER(K).LT.5.6E-05) STNDER(K)=5.6E-05

******************************************************************************

TEMP=STNDER(K)

******************************************************************************

THE STANDARD ERROR TO THE ESTIMATE IS ADJUSTED BY THE USE
OF STATISTICAL WEIGHTING FACTORS. THE STATISTICAL WEIGHTING
FACTORS ARE FORMULATED TO ACCOUNT FOR THE LENGTH AND POSITION
SIGNIFICANCE OF THE ABSOLUTE SCATTER FOR THE SAMPLE-DATA GROUP
BEING ANALYZED. LENGTH SIGNIFICANCE IS GIVEN TO SAMPLE DATA
GROUPS SPANNING LARGE VERTICAL DISTANCES. POSITION SIGNIFICANCE
IS GIVEN TO SAMPLE-DATA GROUPS HAVING LARGE VALUES OF SLOPE.

REMOVING BAD TEST SAMPLES OF DATA FROM STATISTICAL SELECTION

IF (PINCRIII).GT.0.AND.TSLOP(K).LT.0) STNDER(K)=999.0
IF (PINCRIII).LT.0.AND.TSLOP(K).GT.0) STNDER(K)=999.0

YBOT=DABS(YWORK(MK)-YWORK(1))
IF (ABS(TSLOP(K)).LT.1.0E-07) TSLOP(K)=1.0E-07
IF (ABS(YBOT).LT.1.0E-07) YBOT=1.0E-07
WFL=ABSA(VHAT/YBOT)
WFP=ABSA(SHAT/TSLOP(K))
STNDER(K)=WFL*WFP*STNDER(K)

******************************************************************************

IF (KOUNT.EQ.1.AND.K.EQ.1) STNMN=STNDER(K)
IF (KOUNT.EQ.1.AND.K.EQ.1) SLOMIN=TSLOP(K)
IF (KOUNT.EQ.1.AND.K.EQ.1) CEPMIN=TCEPT(K)
IF (KOUNT.EQ.1.AND.K.EQ.1) KMIN=K
IF (STNDER(K).LT.STNMN) SLOMIN=TSLOP(K)
IF (STNDER(K).LT.STNMN) CEPMIN=TCEPT(K)
IF (STNDER(K).LT.STNMN) KMIN=K
IF (STNDER(K).LT.STNMN) STNDER(K)=STNMN

1160 FORMAT(*0*)
160 CONTINUE
170 K=K+1
180 CONTINUE

IF (KOUNT.LT.9) GO TO 100
STNDER(1)=STNMN
TSLOP(1)=SLOMIN
CEPT(1)=CEPMIN
YCEPT=CEPT(1)
SLOPE=TSLOP(1)
IF (IDBUG1.NE.0) WRITE(IOUT,1170) KMIN,SLOPE,YCEPT

163
1170 FORMAT('0'/10X,'DATA GROUP NO.'//I3,' SELECTED FOR REPRESENTING EGM19520 1,' LINEAR PORTION OF SQUARE-ROOT OF TIME DATA.'//10X,' SLOPE OF ', EGM19530 2 'LINE IS EQUAL TO ',F9.6,' DIAL RDG. AT 0% PRIMARY AND LINE', EGM19540 3 ' INTERCEPT IS':','F9.6,'.'//)

EGM19550
EGM19560
EGM19570
EGM19580
EGM19590
EGM19600
EGM19610
EGM19620
EGM19630
EGM19640
EGM19650
EGM19660
EGM19670
EGM19680
EGM19690
EGM19700
EGM19710
EGM19720
EGM19730
EGM19740
EGM19750
EGM19760
EGM19770

************* FINDING APPROXIMATE LOCATION OF D90. *************

************* IF(IDBUG1.NE.0) WRITE(IOUT,1190)

180 FORMAT('0'//2X,'SEARCHING FOR POINTS IN VICINITY OF T90 FOR DETERMINATION OF ITS CURVE LOCATION BY INTERPOLATION PARABOLA'/'//2X,' OR LINEAR INTERPOLATION'//)

N=0
INEG=0
ILINEA=0
K=1
DO 190 I=1,N
INO=NO-I+1
Y=(SLOPE*ROOTIM(INO))/L.15+YCEPT
TEMP=Y-DEFLEC(INO)
M=INO
IF(IDBUG1.NE.0) WRITE(IOUT,1190) N, INO, Y, DEFLEC(INO), TEMP

190 FORMAT('0',10X,'N=',I3,'XO=',I3,'6X','Y=',F8.4,'4X','DEFLEC=',F8.4,'4X','TEMP='F8.4)

IF8.4)' TEMP='F8.4)
IF (PINCRI.IIII.LT.0.AND.TEMP.GT.0) INEG=INEG+1
IF (PINCRI.IIII.LT.0.AND.TEMP.GT.0.AND.INEG.EQ.1) ILINEA=INO
IF (PINCRI.IIII.GT.0.AND.TEMP.LT.0.AND.INO.LE.(NO-1)) GOTO 190
IF (PINCRI.IIII.LT.0.AND.TEMP.GT.0.AND.INO.LE.(NO-2)) GOTO 190
IF (PINCRI.IIII.LT.0.AND.TEMP.LT.0) GOTO 190
IF (PINCRI.IIII.GT.0.AND.TEMP.LT.0) GOTO 190
N=N+1
IF(N.EQ.NPTS) GOTO 220
190 CONTINUE
IF(N.EQ.1) GOTO 230

IF N EQUALS ZERO. THE S.15 ABSCISSA LINE DOES NOT INTERSECT ANY DATA POINTS. INTERPOLATION PARABOLA WILL BE EXTENDED PASSE LAST THREE DATA POINTS SO THAT AN APPROXIMATE VALUE OF T90 MAY BE DETERMINED.

IF(N.EQ.0) NPTS=0
IF(N.EQ.0) GOTO 240

INTERSECTION OF LINE HAVING REDUCED SLOPE IS TOO CLOSE TO BEGINNING OF SQRT-TIME DATA FOR PARABOLIC INTERPOLATION OF T90. LINEAR INTERPOLATION WILL NOT BE ATTEMPTED. SQRT-TIME ANALYSIS IS TERMINATED. IMPROVEMENTS CAN BE MADE HERE TO ACCOUNT FOR ADDITIONAL CASES.

200 WRITE(IOUT,1200)
200 FORMAT('0',I1200) CVROOT=0
210 HF=THIKNS(II)-(DEFLEC(NO)-(DEFI-DEFZ))
HI=THIKNS(II)
HIS=HI*25.4

164
MVROOT = (DEFLEC(NO) - DEFI) / (THIKI*PINCRII)
MVSI = MVROOT * 1000 / 95.8
GOTO 360

*****************************************************************************
CHECK ON NUMBER OF DATA POINTS AVAILABLE FOR FITTING BY PARABOLA
*****************************************************************************

220 CONTINUE
IF((M-NPTS).LE.0) WRITE(IOUT,1210) NPTS, M, NPOINT
IF((M-NPTS).LE.0) GOTO 230
N=M+NPTS
IF(N.GT.NO) N=NO
GOTO 240

230 CONTINUE

*****************************************************************************
LINEAR INTERPOLATION FOR D90,T90.
*****************************************************************************

IF LINEAR INTERPOLATION PROCEDURE IS USED, THERE WILL BE NO
PLOTTING OF INTERPOLATION PARABOLAS (LOGIT) INCLUDED.
IF(IGRAPH.EQ.1) IGRAPH=0
IF(IGRAPH.EQ.3) IGRAPH=2

IPOINT=ILINEA+1
IF(IPOINT.GT.NO.AND.PINCRII.GT.0.AND.DEFLEC(1).GT.DEFLEC(NO))
1 WRITE(IOUT,1220)
IF(IPOINT.GT.NO.AND.PINCRII.LT.0.AND.DEFLEC(1).LT.DEFLEC(NO))
1 WRITE(IOUT,1230)

1220 FORMAT(*", "DIRECTION OF INCREASING DEFLECTION READINGS ARE ", *
1 'INCOMPATIBLE WITH POSITIVE PRESSURE INCREMENT.")
1230 FORMAT(*", "DIRECTION OF INCREASING DEFLECTION READINGS ARE ", *
1 'INCOMPATIBLE WITH NEGATIVE PRESSURE INCREMENT.")
IF(IPOINT.GT.NO) ILINEA=NC-1
IF(IPOINT.GT.NO) IPOINT=NO
WRITE(IOUT,1240) ILINEA, IPOINT

1240 FORMAT(*", "LINEAR INTERPOLATION USED IN SQUARE ROOT OF TIME", *
1 'FOR GETTING D90."", D90 CHOSEN BETWEEN DATA POINTS", I3, *
1 ' AND", I3//)

*****************************************************************************
ESTIMATE T90 AND D90 BY LINEAR INTERPOLATION.
T90=(DEFLEC(ILINEA)-(DEFLEC(ILINEA)-DEFLEC(IPOINT))*ROOTIM(ILINEA))EGM20720
1/(ROOTIM(ILINEA)-ROOTIM(IPOINT)) - YCEPT/(SLOPE/1.15 -

EGM20730
2 (DEFLEC(IPOINT) - DEFLEC(ILINEA) ) / (ROOTIM(IPOINT) -
3 ROOTIM(ILINEA) )

IF SLOPE BETWEEN LAST TWO DATA POINTS IS GREATER THAN LINE
WITH REDUCED SLOPE, APPROXIMATE T90 AS FOLLOWS:

IF (T90.LT.ROOTIM(ILINEA)) T90=1.15*(DEFLEC(IPOINT) - YCEPT)/SLOPE
D90=(SLOPE/1.15)*T90 + YCEPT

*****************************

T90=T90**2
WRITE(IOUT,1250) D90,T90
.
.250 FORMAT(*0*,*DEFLECTION RDG. AT 90% CONSOLIDATION ESTIMATED AS*,
1F9.5,*,2X,*INCHES AND T90 DETERMINED AS*,F9.4,*,MINUTES.*)
GOTO 350

240 TEST = -1.0
IF (N.EQ.0) IGRAPH=1
IF (N.EQ.0) N=NO-2

NI=0
DO 250 L=1,NO
LN=L*N
NPTST=NO+NPTST+2
IF (LN.GE.NOPTS) WRITE(IOUT,1260) LN,NOPTS,L,N,M
.
.260 FORMAT(*0*,*,LN =,,I3,* IS GT. OR EQ. TO *,,I3,5X,*L =,,I3,3X,*
1*N =,,I3,3X,*M =,,I3)
IF (TEST.GT.0.AND.NI.GE.NPOINT) GOTO 260
IF (LN.GE.NOPTS.AND.NI.GE.3) GOTO 260
IF (LN.GE.NOPTS) GOTO 230
NI=NI+1
NSORT=NI
XWORK(L)=DEFLEC(LN-NPTS-1)*100.0
XWORK(L)=ROOTIM(LN-NPTS-1)
IF (IDBUG1.NE.0) WRITE(IOUT,1270) XWORK(L),XWORK(L),L,NI
.
.1270 FORMAT(10X,*POLY FIT PTS. ROOTIM =,,G12.4,3X,*DEFLEC =,,G12.4,
13X,*L =,,I3,* NI =,,I3)
TEST=10.0
IF (L.EQ.1) GOTO 250

WANT TO AVOID INCLUDING POINTS HAVING THE SAME DIAL READING.
THIS PROBABLY INDICATES THAT THE DIAL GAUGE GOT STUCK.

TEST = DABS(YWORK(L)-YWORK(L-1))
IF (TEMP.LT.1.0E-6) NI=NI-1
IF (TEMP.LT.1.0E-6) XWORK(L)=XWORK(L-1)
IF (TEMP.LT.1.0E-6) GOTO 250
.
.250 CONTINUE
WRITE(IOUT,1280) TEST
`
260 CONTINUE
CALL POLFIT(YWORK,XWORK,NI,A,B,C)
IF(ABS(A).LT.1.0E-07) A=1.0E-07
IF(ABS(B).LT.1.0E-07) B=1.0E-07
IF(ABS(C).LT.1.0E-07) C=1.0E-07
DO 270 L = 1,NI
IF(IDBUG1.NE.0) WRITE(IOUT,1270) XWORK(L),YWORK(L),L,NI
XSQRT(L)=XWORK(L)
270 CONTINUE
IF(IDBUG1.NE.0) WRITE(IOUT,1290) NI,XSQRT(1),XSQRT(NI),L
290 FORMAT(10*E13.5X,XSQRT(1)="*,G14.7,5X,XSQRT(NI)="
1,G14.7,5X,L='13)
CSQRT0=A
CSQRT1=B
CSQRT2=C
IF(PINCR(III).GT.0.AND.DCF.LT.0) ITYPE=999
IF(PINCR(III).LT.0.AND.DCF.LT.0) ITYPE=0
VALUES FROM SQRT-T INTERPOLATION PARABOLA ARE CALCULATED IF
SUBROUTINE TPLOTS IS DEBUGGED.
IF(IDBUG4.EQ.0) GOTO 310
YWORK(I)=YWORK(1)
IF(IDBUG4.NE.0) WRITE(IOUT,1300) XSQRT(1),YWORK(1),XSQRT(NSQT)
300 FORMAT(10*E13.5X,XSQRT(1),YWORK(1),XSQRT(NSQT)="*,4(F12.5,3X))
DELTA=(XSQRT(NSQT)-XSQRT(1))/98.
XWORK(I)=XSQRT(1)
I TEST=0
ITEST=1+I TEST
IF (I TEST.EQ.99) GO TO 310
YWORK(1)=+(CSQRT0+CSQRT1*XWORK(1)+CSQRT2*XWORK(1)*XWORK(1))/100.*2EGM21670
15.4
IF (IAxis.EQ.0) YWORK(1)=YWORK(1)/25.4
I=1
IF(IDBUG4.NE.0) WRITE(IOUT,1310) I,XWORK(I),I,YWORK(I)
DO 300 I = 2,98
XWORK(I)=XWORK(I-1)+DELTA
GOTO 290
280 CONTINUE
I TEST=1+I TEST
IF(I TEST.EQ.100) GOTO 310
XWORK(I)=XWORK(I)+DELTA
IF(IDBUG4.NE.0) WRITE(IOUT,1310) I,XWORK(I),I,YWORK(I)
IF(IDBUG4.NE.0) WRITE(IOUT,1310) ITEST
290 CONTINUE
YWORK(I)=+(CSQRT0+CSQRT1*XWORK(I)+CSQRT2*XWORK(I)*XWORK(I))/100.
EGM21680
YWORK(1)=+(CSQRT0+CSQRT1*XWORK(1)+CSQRT2*XWORK(1)*XWORK(1))/100.
1WORH(I)/100.0
IF(I TYPE.EQ.0.AND.ABS(YWORK(1)).GT.ABS(DEFLEC(NO))) GOTO 280
IF (I TYPE.EQ.0.AND.ABS(YWORK(I)).LT.ABS(DEFLEC(1))) XWORK(I)=XWORHEGM21860
1(I-1)
EGM21870
IF (I TYPE.EQ.0.AND.ABS(YWORK(I)).LT.ABS(DEFLEC(1))) YWORK(I)=YWORHEGM21880
1(I+DELTA)
EGM21890
IF(I TYPE.EQ.0.AND.ABS(YWORK(1)).GT.ABS(DEFLEC(1))) GOTO 280
IF(I TYPE.EQ.0.AND.ABS(YWORK(I)).LT.ABS(DEFLEC(NO))) XWORK(I)=XWORHEGM21910
1(I-1)
EGM21920
IF(I TYPE.EQ.0.AND.ABS(YWORK(I)).LT.ABS(DEFLEC(NO))) YWORK(I)=YWORHEGM21930
1(I-1)
EGM21940
IF(IDBUG4.NE.0) WRITE(IOUT,1310) I,XWORK(I),I,YWORK(I)
EGM21950
1310 FORMAT(10X,'XWORK(',I3,') = ',G12.5,5X,'YWORK(',I3,') = ',G12.4)
300 CONTINUE
310 CONTINUE

********************************************************************************

SCSLOP=SLOPE*100.0/1.15
YSCALE=YCEPT*100.0

LINEAR COMBINATION OF EQUATIONS FOR LINE WITH SLOPE REDUCED BY 1.15 AND INTERPOLATION PARABOLA.

CALCULATION OF DISCRIMINATE, SQRT(B**2-4*A*C).
TEMPA=(B-SCSLOP)**2-4.0*C*(A-YSCALE)

1320 FORMAT(*0*,DISCRIMINATE LESS THAN ZERO =',G12.4,5X,'A, AND C =',G12.4)
1',3(F9.5,3X)//1X,'SCSLOP AND YSCALE =',2(F9.5,3X))

IF(TEMPA.LT.0) GOTO 230
TEMP=SQRT(TEMPA)

TWO POSSIBLE ROOTS BY QUADRATIC FORMULA, X1 AND X2.
X1=(SCSLOP-B+TEMP)/(2.0*C)
X2=(SCSLOP-B-TEMP)/(2.0*C)

IF(IDBUG1.NE.0) WRITE(IOUT,1320) TEMP,A,B,C,SCSLOP,YSCALE

1330 FORMAT(*0*,POSSIBLE ROOTS: X1 =',F9.5,** AND** X2 =',F9.5,**/1X,**
1'SELECTED ROOT SHOULD BE BETWEEN ROOTIM(ILINEA) =',F9.5,** AND**,
2' ROOTIM(IPROJ) =',F9.5)
TEMP=1000000.0

ARBITRARY TEST TO MAKE SURE PARABOLA NOT BEING FITTED TOO CLOSE TO END POINTS OF DATA SET.
IPOINT=ILINEA+1

IF ILINEA EQUALS NO. OF DATA POINTS, 1.15 ABCISSA LIES OUTSIDE DATA SET.
IF(ILINEA.EQ.NO) IPOINT=NO-1

320 T90=X1**2
GOTO 340
330 T90=X2**2
GOTO 340

340 D90=SLOPE*SQRT(T90)/1.15+YCEPT
SQRT90=SQRT(T90)

IF(IDBUG1.NE.0) WRITE(IOUT,1340) SQRT90

1340 FORMAT(*0*, SQUARE ROOT OF T90 =',F9.5)

********************************************************************************

C-SUB-V IN FT2/YEAR

350 CVROOT=3095.20*(((THIKNS(II)-(DEFLEC(NO)-PRECED)/2.000)**2/T90

EGM22500
EGM22510
EGM22520
EGM22530
EGM22540
EGM22550
EGM22560
CVROOT = CVROOT/(DRAIN**2)

********************************************************************************

ILAST = LN-NPTS-2
IF(IDBUG1 .NE.0) WRITE(IDOUT,1350) NI,ILAST,CSQRT0,CSQRT1,CSQRT2
.350 FORMAT('0', 'NO. OF PTS. FITTED =',I2,4X,'LAST PT. =',I3,4X,
1'SQRT. COEF =',3(F9.5,2X))
IF(CVROOT.LE.0) GOTO 200
PRIMRT = (D90-YCEPT)*1.1111
RTD100 = YCEPT + PRIMRT
RTD151 = 25.4*RTD100

SHORT TONS ARE USED IN CALCULATION OF MSUBV (1 SHORT TON=2000 LBS)

MVROOT = (DEFLEC(NO)-DEFI)/(THIKS*PINCR(I))
RIROOT = (YCEPT-DEFI)/(DEFLEC(NO)-DEFI)
RPROOT = PRIMRT/(DEFLEC(NO)-DEFI)
RSROOT = 1.0 - RIROOT - RPROOT
HF = THIKNS(I) - (DEFLEC(NO)-DEFI)
HI = THIKNS(I)
HBAR = (THIKNS(I) - (DEFLEC(NO)-PRECE)) / 2.00
IF(IDBUG1 .NE.0) WRITE(IDOUT,1360) THIKNS(I), DEFLEC(NO), DEFI, II,
1 PRECE, HBAR
.360 FORMAT('0', 'THIKNS, DEFLEC(NO), DEFI, II =',F8.5,2X,I3,3X,
1 'PRECE =',F8.5,3X, 'HBAR =',F8.5)

HI = HI*25.4
MVSI = MVROOT*1000/95.8
PFSI = 0.10753*PINCR(I)
PROTSI = PRIMRT*25.4

********************************************************************************

C-SUB-V IN SQUARE METERS PER YEAR

CVRTSI = CVROOT/10.76329

********************************************************************************

C-SUB-V IN FT2/DAY

CVROOT = 8.480*((THIKNS(I) - (DEFLEC(NO)-PRECE))/2.000)**2)/T90
CVROOT = CVROOT/(DRAIN**2)

KTRoot = CVROOT*MVROOT*1.100667E-05

********************************************************************************

RTDO = YCEPT
RTDO1 = 25.4*RTDO
ISPLTS = ISPLT+1
CVSQT = ISPLT,1
CVSQT = ISPLT,2 = RIROOT
CVSQT = ISPLT,3 = DEFLEC(NO)
CVSQT = ISPLT,4 = PINCR(J)/PRESS(I)
360 PRIMRT=0
T90=0.0
D90=0
PROTS1=0
CVROOT=0
CVRTSI=0

ANY OPTION TO USE RTDO IN LOGARITHM OF TIME ANALYSIS IS BEING TERMINATED HERE.

IRTDO=0
RTDO=YCEPT

RTDOSI=0.0
RTD100=0.0
RTD1SI=0.0
RPROOT=0
RSROOT=0
KROOT=0
RROOT=0

IF (ISQRT.NE.0) WRITE(IOUT,1370)

370 FORMAT(*0*,'SKIP OPTION SPECIFIED FOR SQUARE ROOT OF TIME ANALYSIS.'

1'/')

IF(ISQRT.NE.0) GOTO 370
ISPLT=ISPLT+1
CVSQRT(ISPLT,1)=0.0
CVSQRT(ISPLT,2)=0.0
CVSQRT(ISPLT,3)=DEFLEC(NO)
CVSQRT(ISPLT,4)=PINCRIII)+PRESIII)
CVSQRT(ISPLT,5)=0.0
CVSQRT(ISPLT,6)=0.0
CVSQRT(ISPLT,7)=0.0
CVSQRT(ISPLT,8)=0.0
CVSQRT(ISPLT,9)=0.0

SQUARE ROOT OF TIME ANALYSIS HAS BEEN COMPLETED.

370 PERCEN=(LOGTIM(NO)-LOGTIM(1))/50.0

******************************************************************************
CASAGRANDE'S LOGARITHM OF TIME ANALYSIS
******************************************************************************

ASSUMING PARABOLIC NATURE IN EARLIER PORTIONS OF LOG (T) CONSOLIDATION CURVE TO DETERMINE INITIAL DIAL READING.

IF(IDBUG2.NE.0) WRITE(IOUT,1380)
1380 FORMAT('I1///10X,'START OF CASAGRANDE LOGARITHM OF TIME ANALYSIS,EGM23790,
1///10X,'ESTIMATED VALUE OF ZERO ',EGM23800,
2,'DIAL READING BY 4*T1 APPROACH ///')

ISERRA=999
LASTPT=NO
I=1
DSAVE1=0.0
OSAVE4=0.0
TSAVE4=0.0
IF (IRTD0.EQ.1) YCEPT=RTDO
IF (IRTD0.EQ.1) GOTO 410
DO 390 I = 1,NO
IF (IDBUG2.NE.0) WRITE(IOUT,1110) I,TIM(I),DEFLEC(I)
IF(DCF.LT.0) GOTO 380
IF (PINCR(III).LT.0) GO TO 380
IF (TIM(I).GE.0.0999.AND.DSAVE1.LT.0.00001.AND.DEFL(E(I).GE.DCEN(T)) EGM23950
ITSAVE4=4*TIM(I)-0.0001
IF (TIM(I).GE.0.0999.AND.DSAVE1.LT.0.00001.AND.DEFL(E(I).GE.DCEN(T)) EGM23970
IDSAVE1=DEFLEC(I)
IF (TIM(I).GE.TSAVE4.AND.DSAVE4.LT.0.00001.AND.TSAVE4.GT.0.001) EGM23990
IDSAVE4=DEFLEC(I)
IF (DSAVE4.GT.0.00001) GO TO 400
IF (PINCR(III).GT.0) GO TO 390
380 CONTINUE
IF(ITI M(I).GE.0.0999.AND.ABS(DSAVE1).LT.0.00001.AND.ABS(DEFLEC(I)) EGM24040
1.LE.ABS(DCF)) TSAVE4=4*TIM(I)-0.0001
1.LE.ABS(DCF)) DSAVE1=DEFLEC(I)
IF(ITI M(I).GE.0.0999.AND.ABS(DSAVE1).LT.0.00001.AND.ABS(DEFLEC(I)) EGM24060
1.DSAVE4=DEFLEC(I)
IF (ABS(DSAVE4).GT.0.00001) GO TO 400
390 CONTINUE
400 CONTINUE
YCEPT=DSAVE1-(DSAVE4-DSAVE1)
410 CONTINUE
IF(IDBUG2.NE.0) WRITE(IOUT,1110) I,DCF
IF(IDBUG2.NE.0) WRITE(IOUT,1110) I,TSAVE4,DSAVE4
IF(IDBUG2.NE.0) WRITE(IOUT,1110) I,YCEPT,DSAVE1
DSAVE=DEFLEC(1)
DIFF=TIM(I)-TIM(2)
IF (ABS(DIFF).LT.0.00005) DEFLEC(1)=DEFLEC(2)
TESTING TO SKIP LOG(T) ANALYSIS.
IF(ILOG.NE.0) GOTO 820

*********************************************************************************************
SEARCHING FOR LINE REPRESENTATION OF SECONDARY COMPRESSION DATA.
*********************************************************************************************

IF(IDBUG2.NE.0) WRITE(IOUT,1390)
1390 FORMAT('0///10X,'SEARCHING FOR LINEAR REPRESENTATION OF SECONDARY COMPRESSION DATA, LINE-A///')

TESTING AROUND POSSIBLY BAD DATA POINTS AT END OF DATA SET.

VARIOUS STARTING POINTS ARE SELECTED NEAR END OF TEST TO GENERATE DATA GROUPS BY PROGRESSIVELY ADDING DATA POINTS FROM EARLIER

EGM24310
EGM24320
EGM24330
EGM24340
EGM24350
EGM24370
EGM24380
EGM24390

EGM24210
EGM24220
EGM24230
EGM24240
EGM24250
EGM24260
EGM24270
EGM24280
EGM24290
EGM24300
EGM24310
EGM24320
EGM24330
EGM24340
EGM24350
EGM24360
EGM24370
EGM24380
EGM24390
STAGES OF THE TEST. THE USE OF DIFFERENT STARTING POINTS AVOIDS THE EFFECTS OF POSSIBLY NONREPRESENTATIVE DATA POINTS IN FINAL FOUR OR FIVE DATA POINTS.

ARBITRARILY USING 30% OF TOTAL NUMBER OF DATA POINTS TO PROVIDE THE DIFFERENT STARTING POINTS FOR INITIATING THE SEARCH FOR THE REPRESENTATIVE LINEAR PORTION OF SECONDARY COMPRESSION DATA.

AT LLL=1, SEARCH PROCEDURES COMMENCED FROM LAST DATA POINT TOWARD BEGINNING OF DATA SET.

AT LLL=5, SEARCH PROCEDURES COMMENCED FROM 5TH POINT FROM END OF DATA SET.

LNO=0.30*NO
IF(LNO.LT.1) LNO=1
LL=-1
DO 480 LLL=1,LNO
IF(LLL.GT.30) GO TO 490
LL=LL+1

XN=1
DO 470 N=4,49
KOUNT=0
XN=XN+1
A=LOGTIM(NO-LL)-XN*PERCEN
B=XN*PERCEN
LLNO=NO-LL
CONTINUE

L=0
FOR EACH NEW VALUE OF 'A' A GROUP OF DATA POINTS IS SAMPLED BELOW

DO 440 K=1,LLNO
IK=NO-K+1-LL
IF (K.EQ.1) ISAVE1=IK

THE GROUP OF DATA POINTS ASSOCIATED WITH EACH NEW VALUE OF 'A' IS CHECKED TO MAKE SURE THEY ARE NOT THE SAME DATA POINTS WHICH WERE JUST PREVIOUSLY SAMPLED.

IF (A.GT.LOGTIM(IK).AND.L.GE.3) ISAVE2=IK+1
IF (A.GT.LOGTIM(IK).AND.L.GE.3) LOCATA(N-3,1)=ISAVE1
IF (A.GT.LOGTIM(IK).AND.L.GE.3) LOCATA(N-3,2)=ISAVE2
IF (KOUNT.GT.20) GOTO 430
IF (N.EQ.4) GO TO 430
IF (K.EQ.30) GOTO 430
KOUNT=KOUNT+1
IF (ISAVE2.EQ.LOCATA(N-4,2).AND.ISAVE2.EQ.1) 1
XN=XN-1
IF (ISAVE2.EQ.LOCATA(N-4,2).AND.ISAVE2.EQ.1) 1
A=LOGTIM(NO-LL)-XN*PERCEN
IF (ISAVE2.EQ.LOCATA(N-4,2).AND.ISAVE2.EQ.1) 1
GO TO 430

IF(A.LT.LOGTIM(IK)) GO TO 430
IF(LOCATA(N-3,1).EQ.LOCATA(N-4,1).AND.LOCATA(N-3,2).EQ.LOCATA(N-4,1)) 1
XN=XN+1
IF(LOCATA(N-3,1).EQ.LOCATA(N-4,1).AND.LOCATA(N-3,2).EQ.LOCATA(N-4,1)) 1
A=LOGTIM(NO-LL)-XN*PERCEN
IF(LOCATA(N-3,1).EQ.LOCATA(N-4,1).AND.LOCATA(N-3,2).EQ.LOCATA(N-4,1)) 1
GO TO 430

430 CONTINUE
IF (A.GT.LOGTIM(IK).AND.L.GE.3) LOCATA(N-3,1)=ISAVE1
IF (A.GT.LOGTIM(IK).AND.L.GE.3) LOCATA(N-3,2)=ISAVE2
IF (A.GT.LOGTIM(IK).AND.L.GE.3) GOTO 450
XWORK(K)=LOGTIM(IK)
YWORK(K)=DEFLEC(IK)

440 L=L+1
450 CALL STDERR(XWORK,YWORK,L,STNDER(N-3),TSLOP(N-3),TCEPT(N-3))

*******************************************************************************

ADJUSTMENT OF STANDARD ERROR OF ESTIMATE IN SECONDARY COMPRESSION.

WFL - LENGTH SIGNIFICANCE BASED ON ABSCISSA(HORIZONTAL) DISTANCE.
GREATER THE DISTANCE, GREATER THE SIGNIFICANCE.

WFP - POSITION SIGNIFICANCE GIVEN TO SMALL VALUES OF SLOPE.
WFP IS PREVENTED FROM GOING TO ZERO BECAUSE THE ADJUSTED
VALUE OF STD-ERR-EST WOULD BECOME ZERO AND FAIL TO REFLECT
LENGTH AND SCATTER PROPERTIES OF LINEAR REPRESENTATION OF
SAMPLE-DATA GROUP.

THE FOLLOWING STATEMENTS ARE AN APPROXIMATE WAY OF GIVING
GREATER WEIGHT TO THOSE DATA POINT GROUPS SPANNING A GREATER
RELATIVE LENGTH OF THE CURVE.

IN SELECTING THE LINEAR REPRESENTATION OF THE SECONDARY COM-
PRESSION CURVE, THE STANDARD ERROR OF THE ESTIMATE IS BIASED SO
THAT THE DATA GROUP SPANNING THE GREATEST ABSCISSA DISTANCE IS
GIVEN GREATER SIGNIFICANCE.

*******************************************************************************

REMOVING BAD TEST SAMPLES OF DATA FROM STATISTICAL SELECTION
PROCESS.

IF(PINCRI(III).GT.0.AND.TSLOP(N-3).LT.0) STNDER(N-3)=999.0
IF(PINCRI(III).LT.0.AND.TSLOP(N-3).GT.0) STNDER(N-3)=999.0

*******************************************************************************

XBOT=XWORK(L)-XWORK(1)

SLOPES HAVING VALUES NEAR TO ZERO IN SECONDARY COMPRESSION CURVE
GENERALLY GIVE VALUES FOR D100 THAT GIVE LOWER VALUES FOR CV AS
COMPARED TO VALUES DETERMINED BY SQUARE-ROOT-OF-TIME OR BY THE
NAYLOR-DORAN ANALYTICAL METHOD.

IF(ABS(TSLOP(N-3)).LT.1.0E-05.AND.STNDER(N-3).LT.1.0E-05)
 1 STNDER(N-3)=1.0E-04

*******************************************************************************
VALUES LESS THAN 1.0E-05 FOR STD ERR-EST ARE EXCEPTIONAL
AND DESTROY LENGTH AND POSITION CHARACTERISTICS OF DATA.
IF(STNDER(N-3).LT.1.0E-05) STNDER(N-3)=1.0E-05

************************************************************
WHAT=LOGTIM(NO)-LOGTIM(1)
ABSCISSA DISTANCE BETWEEN FIRST AND LAST POINTS OF LOG-T CURVE.
XHAT=LOGTIM(NO)-LOGTIM(1)
TEMP=STNDER(N-3).
WFL=ABS(XHAT/XBOT)
STNDER(N-3)=WFL*STNDER(N-3)

************************************************************
SMALLER ABSOLUTE VALUES OF SLOPE BEING MADE MORE SIGNIFICANT.
STOP=TSLOP(N-3)
SHAT=(DEFLEC(NO)-DEFLEC(1))/(LOGTIM(NO)-LOGTIM(1))
WFP = ABS(STOP/SHAT)

THE MINIMUM VALUE OF 'WFP' IS LIMITED TO 0.50 TO PREVENT GIVING
UNDUE SIGNIFICANCE TO VALUES OF SLOPE APPROACHING ZERO.

ALSO, TRYING TO AVOID GIVING SIGNIFICANCE TO DATA WHERE RING
IS HAVING UNDUE EFFECT IN DECREASING SLOPE OF LINE REPRESENTATION
OF SECONDARY COMPRESSION DATA.

IF(WFP.LT.0.50) WFP=0.50
STNDER(N-3)=ABS(WFP)*STNDER(N-3)
IF (N.EQ.4.AND.LLL.EQ.1) STNMIN=STNDER(N-3)

************************************************************
TESTING TO SEE IF EXTENT OF SEARCH DISTANCE IS GREATER THAN 80%
OF TOTAL ABSCISSA (HORIZONTAL) DISTANCE BETWEEN FIRST AND LAST
DATA POINTS ON LOGARITHM-OF-TIME CURVE.

DIFF=LOGTIM(NO)-A
XBIG=DIFF/XHAT
IF(.ABS(XBIG).GT.0.80) GOTO 480

************************************************************
LN3=N-3
WFL - WEIGHTING FACTOR FOR LENGTH
WFP - WEIGHTING FACTOR FOR POSITION
XHAT=WHAT
WFL = ABS(XHAT/XBOT)
IF(IDBUG2.EQ.2) GOTO 460
IF(IDBUG2.NE.0) WRITE(IOUT,1400) LLL,LN3,STNDER(N-3),WFL,WFP,
1 TEMP,L,ISAVE1,ISAVE2
400 FORMAT(1X,'LLL = ',I2,3X,'ADJ STD ERR EST(',I2,') = ',F10.6,
1': WFL = ',F6.3,'; WFP = ',F6.3,'; STD ERR EST = ',
2F10.6,';','I3,' PTS BETWEEN POINTS ','I3,' AND ','I3/')
460 CONTINUE
   IF (STNDER(N-3).LE.STNMIN) SLOMIN=TSLOP(N-3)
   IF (STNDER(N-3).LE.STNMIN) CEPMIN=TCEPT(N-3)
   IF (STNDER(N-3).LE.STNMIN) LSTORE=LLL
   IF (STNDER(N-3).LE.STNMIN) NSTORE=N-3
   IF (STNDER(N-3).LE.STNMIN) LASTPT=ISAVE1
   IF (STNDER(N-3).LE.STNMIN) ISERRA=TEMP*100000
   IF (STNDER(N-3).LE.STNMIN) STNMIN=STNDER(N-3)
470 CONTINUE
480 CONTINUE
490 CONTINUE

******************************************************************************
   IF( IDBUG2 .NE.0) WRITE( IOUT, 1410) LSTORE, NSTORE, STNMIN, SLOMIN
   410 FORMAT( '0', 10X, 'AT LLL = ', I3, 5X, 'N = ', I3, 7X, 'MIN STD ERROR EST = ' )
   1, G14.6, 10X, 'SLOPE OF LINE-A = ', G14.6//
   SLOPA=SLOMIN
   CEPTA=CEPMIN
   ISLOPA=SLOPA*100000
   IF( IDBUG2 .NE.0) WRITE( IOUT, 1420) ISERRA, ISLOPA
   420 FORMAT( '0', 10X, 'INTEGER VALUES OF STD-ERR AND SLOPE-A = ', 2(I6,4X) )

   ISTART=1
   IEND=NO
   ICONT=1
   C=1.0
   IF (NO.LT.40) IQUIT=3
   ISPACE=2
   IF (NO.GT.40) IQUIT=4
   IF (NO.GT.50) IQUIT=5

******************************************************************************
   SEARCHING FOR LINEAR PORTION OF PRIMARY CONSOLIDATION ON
   LOGARITHM-OF-TIME VERSUS DEFLECTION CURVE (LINE-8).
******************************************************************************

   STNMIN=99900000
   ISLMIN=0
   LTEST=1
   DO 500 N=1,1B
   LOCATB(N,1)=0
   LOCATB(N,2)=0
500 CONTINUE
   IF( ICONT.EQ.1) INTERV=8.0

510 PERCEN=(LOGTIM(IEND)-LOGTIM(ISTART))/INTERV
          B=PERCEN
   IF( IDBUG2 .NE.0) WRITE( IOUT, 1430)
   .430 FORMAT( '1'///10X, 'SEARCHING FOR STRAIGHT LINE PORTION OF PRIMARY',
   1' COMPRESSION DATA, LINE-8'///)
   FACTOR=1.0
   A=LOGTIM(ISTART)
   DO 720 NAOFF=1,3
   A=LOGTIM(ISTART)+PERCEN*(NAOFF-1)/3.0
   IF( IDBUG2 .NE.0) WRITE( IOUT, 1440) C, A, PERCEN
KLOOP=0
JEND=0
DO 650 N=1,INTERV
KCOUNT=0
M=1

520 CONTINUE
L=1
TEST=LOGTIM(NO)-0.000001
IF(M.LT.4.AND.K.GT.NO.AND.C.GT.TEST.AND.KLOOP.NE.0) A=A-FACTOR*PERCENT

1CN
IF(LTEST.GE.NO.AND.KLOOP.NE.0) A=A-FACTOR*PERCENT
IF(LTEST.GE.NO.AND.C.LT.LOGTIM(NO)) C=C+B
DO 530 I=1,NO
IF M.LT.4.AND.C.GT.I, CONTINUE
L=L+1

530 CONTINUE
IF(C.GE.TEST) GOTO 550
IF(M.LT.4.AND.ISAVE2.EQ.NO) GOTO 550
IF(LTEST.GE.NO) GOTO 550
C=A+B

540 CONTINUE
IF(debug2.NE.0) WRITE(IOUT,1440) C,A,B
NO1=NO+1
KCOUNT=KCOUNT+1
IF(KCOUNT.GT.20) GOTO 660
IF(L.GT.(NO-2)) L=NO-2
LTEST=L

440 FORMAT(10X,C,A,B = '3(F8.3,2X))
DO 610 K=L,NO1
IF(K.EQ.L) ISAVE1=K
IF(C.GE.TEST) GOTO 520

550 CONTINUE
IF(M.LT.4.AND.C.GT.TEST) GOTO 550
IF(M.LT.4.AND.C.LT.LOGTIM(L)) C=C+B
IF(M.LT.4.AND.C.LT.LOGTIM(L)) GOTO 560

560 CONTINUE
IF(M.LT.4.AND.K.GT.NO) GOTO 520
IF(M.LT.4.AND.K.GT.NO.AND.C.GT.TEST.AND.KLOOP.NE.0) ISAVE2=NO
IF(M.LT.4.AND.K.GT.NO.AND.C.GT.LOGTIM(NO)) GOTO 520
IF(M.LT.4) GOTO 600
IF(K.GT.NO) GOTO 570
IF(C.LE.TEST(K)) ISAVE2=K-1

570 CONTINUE
IF(C.GT.TEST(NO).AND.M.GT.3.AND.K.EQ.NO) ISAVE2=NO
IF(L.EQ.(NC-2)) LOCATB(N,1)=ISAVE1
IF(L.NE.(NO-2)) LOCATB(N,2)=ISAVE2
IF(N.EQ.1) GOTO 580

IF(debug2.NE.0) WRITE(IOUT,1450) ISAVE1,ISAVE2,LOCATB(N-1,1),
1 LOCATB(N-1,2),NO

580 FORMAT(1X,ISAVE1,2 = '2(I3,2X),5X,LOCATB(N-1,1 & 2) = '2(I3,2X),
1 NO = '2(I3,2X)
IF(ISAVE2.EQ.LOCA TB(N-1,2).AND.ISAVE2.EQ.NO)

******

IF THERE ARE NO DATA POINTS BETWEEN SEARCH BOUNDARIES C AND A,
INCREASE C.

560 CONTINUE
IF(M.LT.4.AND.C.LT.LOGTIM(L)) GOTO 560

******

IF(M.LT.4.AND.K.GT.NO) GOTO 520
IF(M.LT.4.AND.K.GT.NO.AND.C.GT.TEST.AND.KLOOP.NE.0) ISAVE2=NO
IF(M.LT.4.AND.K.GT.NO.AND.C.GT.LOGTIM(NO)) GOTO 520
IF(M.LT.4) GOTO 600
IF(K.GT.NO) GOTO 570
IF(C.LE.TEST(K)) ISAVE2=K-1

570 CONTINUE
IF(C.GT.TEST(NO).AND.M.GT.3.AND.K.EQ.NO) ISAVE2=NO
IF(L.EQ.(NC-2)) LOCATB(N,1)=ISAVE1
IF(L.NE.(NO-2)) LOCATB(N,2)=ISAVE2
IF(N.EQ.1) GOTO 580

IF(debug2.NE.0) WRITE(IOUT,1450) ISAVE1,ISAVE2,LOCATB(N-1,1),
1 LOCATB(N-1,2),NO

580 FORMAT(1X,ISAVE1,2 = '2(I3,2X),5X,LOCATB(N-1,1 & 2) = '2(I3,2X),
1 NO = '2(I3,2X)
IF(ISAVE2.EQ.LOCA TB(N-1,2).AND.ISAVE2.EQ.NO)
LA=FACTOR*PERCEN
IF (ISAVE2.EQ.LOCATB(N-1,2).AND.ISAVE2.EQ.NO1)
C=A+B+B
IF (ISAVE2.EQ.LOCATB(N-1,2).AND.ISAVE2.EQ.NO)
1 GO TO 580

*****************************************************************************

THE FOLLOWING STATEMENTS PREVENT THE REPEATITION OF THE SAME DATA
POINTS EVEN WHEN DIFFERENT SAMPLING INTERVALS ARE USED. THE
THE SAMPLING INTERVAL IS DEFINED BY PARAMETERS 'A' AND 'C'.

IF (ISAVE1.EQ.LOCATB(N-1,1).AND.ISAVE2.EQ.LOCATB(N-1,2))
1 A=A+FACTOR*PERCEN
IF (ISAVE1.EQ.LOCATB(N-1,1).AND.ISAVE2.EQ.LOCATB(N-1,2))
1 C=A+B
IF (ISAVE1.EQ.LOCATB(N-1,1).AND.ISAVE2.EQ.LOCATB(N-1,2))
1 GOTO 520

*****************************************************************************

580 CONTINUE
IF (K.GT.NO) GOTO 590
IF (C.LE.LOGTIM(K)) LOCATB(N,1)=ISAVE1
IF (C.LE.LOGTIM(K)) LOCATB(N,2)=ISAVE2

590 CONTINUE
IF (C.GE.LOGTIM(NO).AND.M.GT.3) LOCATB(N,1)=ISAVE1
IF (C.GE.LOGTIM(NO).AND.M.GT.3) LOCATB(N,2)=ISAVE2
IF (K.GT.NO) GOTO 620
IF (C.LE.LOGTIM(K).AND.M.GT.3) GOTO 620

600 XWORK(M)=LOGTIM(K)
YWORK(M)=DEFLEC(K)

610 M=M+1
620 M=M-1
CALL STDERR(XWORK,YWORK,M,STNDER(N),TSLOP(N),TCEPT(N))
LOCATB(N,1)=L
LOCATB(N,2)=L+M-1
LOCAT1(N)=L
LOCAT2(N)=L+M-1
ISAVE2=L+M-1
IF (LOCAT2(N).EQ.IEND.AND.JEND.EQ.0) JEND=999
IF (JEND.GE.999) JEND=JEND+1
IF (JEND.GE.1001) GOTO 630
GOTO 640

630 CONTINUE
LOCAT1(N)=LOCAT1(N-1)
LOCAT2(N)=LOCAT2(N-1)
TSLOP(N)=TSLOP(N-1)
STNDER(N)=STNDER(N-1)
M=LOCAT2(N)-LOCAT1(N)
ISAVE1=LOCAT1(N)
ISAVE2=LOCAT2(N)
COR=99

640 CONTINUE

*****************************************************************************

THE FOLLOWING STATEMENTS ARE AN APPROXIMATE WAY OF GIVING
GREATER WEIGHT TO THOSE DATA POINT GROUPS SPANNING A GREATER
RELATIVE LENGTH OF THE CURVE.

IN SELECTING LINEAR PORTION OF PRIMARY-LOG(T) CONSOLIDATION CURVE,
THE STANDARD ERROR OF THE ESTIMATE IS BIASED SO THAT THE DATA
GROUP SPANNING THE GREATEST ORDINATE DISTANCE IS GIVEN GREATER
SIGNIFICANCE.

XBOT=XWORK(M)-XWORK(1)
YBOT=YWORK(M)-YWORK(1)
VHAT=DEFLEC(NO)-DCENT

IF(ABS(YBOT).LT.0.00001) WRITE(IOUT,1460) YWORK(M),YWORK(1)
1460 FORMAT('0.4',YWORK(M)=',G11.4,' YWORK(1)=',G11.4)
IF(ABS(YBOT).LT.0.00001) YBOT=0.00001

**********************************************************

REMOVING BAD TEST SAMPLES OF DATA FROM STATISTICAL SELECTION
PROCESS.

IF(ABS(TSLOP(N)).LT.1.0E-06) STNDER(N)=999.0
IF(PINCR(III).LT.0.AND.TSLOP(N).LT.0) STNDER(N)=999.0
IF(PINCR(III).LT.0.AND.TSLOP(N).GT.0) STNDER(N)=999.0

**********************************************************

VALUES LESS THAN 1.0E-05 FOR STD ERR-EST ARE EXCEPTIONAL
AND DESTROY LENGTH AND POSITION CHARACTERISTICS OF DATA.
IF(STNDER(N).LT.1.0E-05) STNDER(N)=1.0E-05

THIS LOWER LIMIT VALUE OF STNMIN IS COMPATIBLE WITH ONE USED IN
SELECTING LINE REPRESENTATION OF SECONDARY COMPRESSION DATA. THIS
LOWER LIMIT VALUE IS STORED IN TEMP AND IS USED ONLY TO MAKE SURE
THAT THE SAME DATA POINTS ARE NOT SELECTED FOR THE LINEAR PORTION
OF PRIMARY COMPRESSION.

TEMP=STNDER(N)

A DIFFERENT LOWER LIMIT OF 5.0E-05 (INCHES) IS USED FOR STNMIN
TO PREVENT THE SCATTER PROPERTIES FROM OVERSHADOWING THE
LENGTH AND POSITION PROPERTIES OF THE DATA. THIS VALUE HAS BEEN
ARRIVED AT BY EXPERIENCE THROUGH TRIAL AND ERROR. IT MAY BE
RAISED OR LOWERED IN THE FUTURE IF NECESSARY.

IF(STNDER(N).LT.5.0E-05) STNDER(N)=5.0E-05

WFL=ABS(VHAT/YBOT)
STNDER(N)=WFL*STNDER(N)
IF(ABS(TSLOP(N)).LT.1.0E-07) TSLOP(N)=1.0E-07
WFP=ABS(SHAT/TSLOP(N))
STNDER(N)=WFP*STNDER(N)

**********************************************************

COR2=COR*COR
IF(DBGUG2.NE.0) WRITE(IOUT,1470) N,M,ISAVE1,ISAVE2,TSLOP(N),
1STNDER(N),WFP,WFL,TEMP,COR2
470 FORMAT(1X,'SAMPLE-DATA GROUP NO. *=I3,5X,I3,=' POINTS BETWEEN*
1, 'DATA POINTS', 'I3', 'AND', 'I3/1X', 'SLOPE =', 'F8.5', '3X', 'ADJ STD ERR =', 'EGM28670
2, 'EST =', 'E15.8', '5X', 'WFP =', 'F6.3', '*', 'WFL =', 'F6.3', '*', 'STD ERR-EST =', 'EGM28680
3E15.8', 'CORR2 =', 'F8.5)

IF (N.EQ.1) KLOOP=1
IF (N.EQ.1) ISLOPE(KLOOP)=TSLOP(N)*1000000
IF (N.EQ.1) ICEPT(KLOOP)=TCEPT(N)*1000000
IF (N.EQ.1) ISTNER(KLOOP)=STNDER(N)*1000000
IF (N.EQ.1) ISERRB(KLOOP)=TEMP*1000000
KSLOPE=TSLOP(N)*1000000
KCEPT=TCEPT(N)*1000000
KSTNER=STNDER(N)*1000000
KSERRB=TEMP*1000000
IF (JEND.GE.1000) GOTO 660
IF (KSLLOPE.EQ.ISLOPE(KLOOP)) GO TO 650
IF (KSLLOPE.NE.ISLOPE(KLOOP)) KLOOP=KLOOP+1
IF (KSLLOPE.NE.ISLOPE(KLOOP-1)) ISTNER(KLOOP)=KSTNER
IF (KSLLOPE.NE.ISLOPE(KLOOP-1)) ICEPT(KLOOP)=KCEPT
IF (KSLLOPE.NE.ISLOPE(KLOOP-1)) ISLOPE(KLOOP)=KSLOPE
IF (KSLLOPE.NE.ISLOPE(KLOOP-1)) ISERRB(KLOOP)=KSERRB

650 A=A+FACTOR*PERCEN
660 CONTINUE
ITOTAL=2*ISPACE+1
IF (ITOTAL.EQ.KLOOP) ISPACE=ISPACE-1

***********************************************************************

FININD DATA GROUPS AROUND ONE HAVING LARGEST SLOPE.

***********************************************************************

J=0
IF (NAOFF.EQ.1.AND.ICONT.EQ.1) SLOMAX=0.0
IF (ICONT.GT.1) SLOMAX=0.0
LLOOP = KLOOP
ISPACE=2

***********************************************************************

DO 670 L=1,KLOOP

IF THERE ARE FEW DATA POINTS IN THE PRIMARY COMPRESSION
CURVE, DATA POINTS FROM SECONDARY MAY HAVE SCATTER PROPERTIES
THAT ARE OF ORDERS OF SIGNIFICANCE MUCH GREATER THAN THAT WHICH
CAN BE ADJUSTED FOR BY LENGTH AND POSITION PROPERTIES OF
SIGNIFICANCE THAT FAVOR POINTS IN PRIMARY COMPRESSION. THE
STATEMENTS ARE AN ATTEMPT TO AVOID THIS DIFFICULTY.

IF (IDBUGZ.NE.0.AND.L.EQ.1) WRITE(IOUT,1480)
480 FORMAT('0'///)
IF (IAABS(ISLOPE(L)).LE.IABS(ISLOPA).AND.ISERRB(L).LE.ISERRA.AND.
  L.NE.1.AND.ABS(SLOMAX).GT.1.0E-07.AND.ISMIN.NE.0) LLOOP=L-1
IF (IDBUGZ.NE.0) WRITE(IOUT,1490) L,ISLOPE(L),ISERRB(L),LLOOP,SLOMAX
IF (LLOOP.EQ.0) LLOOP=1
IF (IAABS(ISLOPE(L)).LT.ABS(SLOMAX)) GOTO 670
490 FORMAT(10X,'L=',13,4X,'TSLOP =','16,5X,'ISERRB =','110,5X,'LLOOP =','179
1,I3,7X,'SLOMAX =','1F13.5)
IF MAXIMUM SLOPE FOUND AT L=1, IGNORE IT BECAUSE IT IS PROBABLY A POOR SELECTION FOR THE LINE REPRESENTATION OF PRIMARY LOG(T) COMPRESSION WHEN DOING SEARCH FIRST TIME AROUND.

IF (L.EQ.1.AND.ICONT.NE.IQUIT) GOTO 670

J=L
SLOMAX=ISLOPE(L)

670 CONTINUE

*******************************************************************************

IF(ICONT.EQ.IQUIT) ISPACE=4
IF(J.EQ.0) IJ=1
IF(J.EQ.0) IJJ=LLOOP
IF(J.EQ.0) GOTO 700
IJ=J-ISPACE
IJJ=J+ISPACE
IF(ICONT.EQ.1) IJJ=J+ISPACE-1

680 IF(IJ.GE.1) GOTO 690
IJ=IJ+1
IJJ=IJ+1
GOTO 680

690 IF (IJJ.LE.LLOOP) GOTO 700
IF(IJ.GE.2) IJ=IJ-1
IF(IJJ.LT.2) GOTO 700
IJJ=IJJ-1
GOTO 690

*******************************************************************************

OF DATA GROUPS AROUND ONE HAVING MAXIMUM SLOPE, THE DATA GROUP HAVING SMALLEST VALUE FOR ADJUSTED STANDARD ERROR OF THE ESTIMATE IS SELECTED AS REPRESENTING LINEAR PORTION OF PRIMARY LOG(T) CONSOLIDATION.

*******************************************************************************

700 DO 710 I=IJ, IJJ
IF(IDBUG2.NE.0) WRITE(IOUT,1500) I,ISTNER(I),STNMN,ISLOPE(I)

500 FORMAT('0',10X,' AT DATA GROUP 'I2,' STD ERROR EST =',100,1I0,' MIN STD ERR EST =',G10.2,' INTEGER SLOPE =',1000)
IF(STNMN.LE.ISTNER(I)) GOTO 710
IF(IABS(ISLOPE(I)).LE.IABS(ISLOPA)) GOTO 710
IF(IABS(ISTNER(I)).LT.ABS(STNMN)) ISLMI=ISLOPE(I)
IF(IABS(ISTNER(I)).LT.ABS(STNMN)) ITCMN=ITCEPT(I)
IF(IABS(ISTNER(I)).LT.ABS(STNMN)) STNMN=IABS(ISTNER(I))
ISLOPE(I)

710 CONTINUE

*******************************************************************************

720 CONTINUE

IF(ISLMI.EQ.0.AND.ICONT.EQ.IQUIT) ITCMN=CEPTA*1000000
IF(ISLMI.EQ.0.AND.ICONT.EQ.IQUIT) ISLMI=ISLOPA
SLOPB=ISLMI/1000000.
CEPTB=ITCMN/1000000.
CALPHA=SLOPA/(THIKNS(11)-DEFLEC(NODE)-PRECED(ND))/DRAIN
IF(IDBUG2.NE.0) WRITE(IOUT,1510) SLOPA,SLOPB
510 FORMAT('O',10X,'SLOPA = ',F8.4,' SLOPB = ',F8.4//)
 IF (ICONT.EQ.IQUIT) GO TO 730
 ICONT=ICONT+1
 INTERV=10
 ISTART=LOCAT1(IJ)
 IEND=LOCAT2(IJJ)
 GO TO 510
730 CONTINUE
 IF (ABS(SLOPA).GE.ABS(SLOPB)) WRITE(IOUT,1520)
 IF (ABS(SLOPA).GE.ABS(SLOPB).AND.IGRAPH.EQ.1) IGRAPH=3
 IF (ABS(SLOPA).GE.ABS(SLOPB).AND.IGRAPH.NE.3.AND.IGRAPH.NE.2) IGRAPH=2
1=2
 IF (ABS(SLOPA).GE.ABS(SLOPB)) D100=DEFLEC(NO)
 IF (ABS(SLOPA).GE.ABS(SLOPB)) GOTO 740
520 FORMAT('O',*INCOMPATIBLE SLOPES, D100 TAKEN TO BE LAST DEFLECTION)

********************************************************************
DETERMINATION OF D50 AND ITS LOCATION IN THE DATA SET SO THAT
A VALUE OF T50 CAN BE ESTIMATED BY PARABOLIC INTERPOLATION.
********************************************************************

D100=(SLOPB*CEPTA-SLOPA*CEPTB)/(SLOPB-SLOPA)
740 CONTINUE
 D50=(D100+YCEPT)/2.0
 I=1
 MARK=0
 NMARK=NPTS-1
 NOMARK=NO
 CONTINUE
 IF (IDBUG2.NE.0) WRITE(IOUT,1530) MARK,NMARK,D50,I,DEFLEC(I)
530 FORMAT('O',10X,'MARK = ',I3,'X MARK = ',I3,'X D50 = ',F9.5,'X,
 'DEFLEC(',I3,'X) = ',F9.5)
 IF (PINCR(IIII).GT.0.AND.DEFLEC(I).LT.D50) GO TO 760
 IF (PINCR(IIII).LT.0.AND.DEFLEC(I).GT.D50) GO TO 760
 IF (MARK.EQ.NMARK) GOTO 770
 MARK=MARK+1
 I=1+1
 IF (I.GE.NMARK) WRITE(IOUT,1530) MARK,NMARK,D50,I
 IF (I.GE.NOMARK) GOTO 810
 GOTO 750
770 I=I-1
 IF (IDBUG2.NE.0) WRITE(IOUT,1790) I
 IF (I.LT.0) I=0
 M=0
 TEST=-1.0
 INCREM=NO-I
 IF (I.EQ.0) I=1
 DO 790 K=1,INCREM
 IK=I+K-1
 IF (IK.GE.NO.AND.M.GE.3) GOTO 780
 IF (IK.GE.NO) GOTO 810
 IF (TEST.GT.0.AND.M.GE.NPCIINT) GOTO 780
 XWORK(IK)=LOGTIM(IK)
 YWORK(IK)=DEFLEC(IK)*100.0
 IF (IDBUG2.NE.0) WRITE(IOUT,1540) XWORK(IK),YWORK(IK)
540 FORMAT('O',10X,'PTS. FOR INTERPOLATION PARABOLA LOGTIM.=',
 '1 F8.4, ' DEFLEC = ',F8.4)
780 CONTINUE
   IF (K.EQ.1) GO TO 790
   IF (TEST.GT.0.AND.M.GE.NPOINT) GO TO 800
   IF (PINCR(I).GT.0.AND.YWORK(K).GT.YWORK(K-1)) TEST = 10.0
   IF (PINCR(I).LT.0.AND.YWORK(K).LT.YWORK(K-1)) TEST = 10.0
790   M=M+1
800 CONTINUE
550 FORMAT(*0.,10X,* TEST =*,F8.4)
   IF(IDBUG2.NE.0) WRITE(IOUT,1550) TEST
   IF(TEST.LT.0) WRITE(IOUT,1550) TEST
   IF(TEST.LT.0) GOTO 810
   DS50=100.0*D50.

*******************************************************************************
PARABOLIC INTERPOLATION FOR T50.
*******************************************************************************

CALL POLFIT(XWORK,YWORK,M,A,B,C)
NLOG=M
YLOG(1)=YWORK(1)
YLOG(NLOG)=YWORK(M)
CLOG0=A
CLOG1=B
CLOG2=C
T50=A+B*DS50+C*DS50**2
T50=10.**T50
LD100=D100
LD1SI=25.4*D100

*******************************************************************************
C-SUB-V IN FT2/YEAR
CVLOG=719.05*((THIKNS(II)-(DEFLEC(NO)-PRECED)/2.000)**2)/T50
CVLOG=CVLOG/(DRAIN**2)
*******************************************************************************

*******************************************************************************
C-SUB-V IN SQUARE METERS PER YEAR
CVLGSI=CVLOG/10.76329
*******************************************************************************

*******************************************************************************
PRILOG=DI00-YCEPT
MVLOG=(DEFLEC(NO)-DEFI)/(THIKI*PINCR(I))
MVLSI=MVLOG*1000/95.8
PRILOG=MVLOG*25.4
RPLOG=PRILOG/(DEFLEC(NO)-DEFI)
RILOG=(YCEPT-DEFI)/(DEFLEC(NO)-DEFI)
RSLG=1.0-RILOG-RPLOG
*******************************************************************************

C-SUB-V IN FT2/DAY
CVLOG=1.97*((THIKNS(II)-(DEFLEC(NO)-PRECED)/2.000)**2)/T50
CVLOG=CVLOG/(DRAIN**2)
KTLOG=CVLOG*MVLOG*1.00667E-05

**************
IFI ISLOP.EQ.ISLMIN) CALPHA=0.0
DOLOG=YCEPT
DOLOGS=25.4*DOLOG
ILPLOT=ILPLOT+1
CVLOGT(ILPLOT,1)=CVLOG
CVLOGT(ILPLOT,2)=RLOG
CVLOGT(ILPLOT,3)=DEFLEC(NO)
CVLOGT(ILPLOT,4)=PINCR(III)+PRESS(III)
CVLOGT(ILPLOT,5)=CALPHA
CVLOGT(ILPLOT,6)=D100
CVLOGT(ILPLOT,7)=KTL0G
CVLOGT(ILPLOT,8)=T00
CVLOGT(ILPLOT,9)=RPLOG
CVLOGT(ILPLOT,10)=RSLOG
GOTO 830

810 WRITE(IOUT,1560)

560 FORMAT(* * , DATA UNSUITED FOR LOGARITHM-OF-TIME ANALYSIS* ) )
IFI (PINCR(III).GT.O.AND.(SLOPA.GE.SLOPB)) WRITE(IOUT,1570)
IFI (PINCR(III).LT.O.AND.(SLOPA.LE.SLOPB)) WRITE(IOUT,1570)
IFI (PINCR(III).GT.O.AND.(SLOPA.GE.SLOPB)) WRITE(IOUT,1510) SLOPA,
1 SLOP8
IFI (PINCR(III).LT.O.AND.(SLOPA.LE.SLOPB)) WRITE(IOUT,1510) SLOPA
1 SLOPB

570 FORMAT(* *, SLOPES OF LINES A & B ARE INCOMPATIBLE* )
IFI(MARK.LT.NMARK) WRITE(IOUT,1580) D50

580 FORMAT(* * , VALUE OF D50 **F10.4, * * THIS VALUE IS NOT NEAR * ,
1'A SUFFICIENT NUMBER OF DATA POINTS TO ALLOW FOR PARABOLIC* )
IFI (LOG.NE.0) CALPHA=0.0
D50=0
LD100=0.0
LD1SI=0.0
PRLGSI=0
CVLGSI=0
RPLOG=0
RSLOG=0
KTL0G=0

IFI (LOG.NE.0) WRITE(IOUT,1590)

590 FORMAT(* * ,51HSKIP OPTION SPECIFIED FOR CASAGRANDE'S LOGARITHM OF,
1 ' TIME ANALYSIS.** )
IFI (LOG.NE.0) GOTO 830
ILPLOT=ILPLOT+1
CVLOGT(ILPLOT,1)=0.0
CVLOGT(ILPLOT,2)=0.0
CVLOGT(ILPLOT,3)=DEFLEC(NO)
CVLOGT(ILPLOT,4)=PINCR(III)+PRESS(III)
CVLOGT(ILPLOT,5)=0.0
CVLOGT(ILPLOT,6)=0.0
CVLOGT(ILPLOT,7)=0.0
CVLOGT(ILPLOT,8)=0.0
CVLOGT(ILPLOT,9)=0.0
CVLOGT(1PLOT,10)=0.0
CASAGRANDE'S LOGARITHM OF TIME ANALYSIS HAS BEEN COMPLETED.

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ANALYTICAL DETERMINATION OF PRIMARY CONSOLIDATION

BY
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PROGRAMED

BY
E.G. MCNULTY

1978

******************************************************************************

130 IK=0
  NQUIT=0
  DFMIN=0.0
  EFMIN=999
  DIMIN=0.0
  E1MIN=999
  M=0
  ESAVE=0
  E100=0.0
  DSAVEF=0
  PI=355./113.

******************************************************************************

STEP 1
TAKE TIME READINGS AND CORRESPONDING DEFLECTION READINGS.

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STEP 2
ASSUME VALUES OF DEFLECTION FOR D0 AND D100.

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DEFLEC(1)=DSAVE
DELTAI=DEFLEC(1)
DELTAF=DEFLEC(0)
IF(ISQRT.EQ.0.AND.CVROOT.GT.0) DELTAI=RTDO
IF(ISQRT.NE.0.AND.CVLOG.GT.0) DELTAF=DOLOG
IF(CVLOG.GT.0.OR.CVROOT.LE.0) GOTO 840
IF(ISQRT.EQ.0) DELTAF=RTDO+PRIMRT
GOTO 860
840 CONTINUE
IF(CVLOG.GT.0) DELTAF=D100
IF DELTAI NOT COMPATIBLE WITH DELTAI, ASSUME SQUARE ROOT OF TIME
VALUE FOR D100.
IF(ISQRT.NE.0) GOTO 850
IF(PINCR(I).GT.0.AND.DELTAI.GT.DELTA) DELTAF=RTDO+PRIMRT
IF(PINCR(I).LT.0.AND.DELTAI.LT.DELTA) DELTAF=RTDO+PRIMRT
GOTO 860
850 CONTINUE
IF(PINCR(I).GT.0.AND.DELTAI.GT.DELTA) DELTAF=DEFLEC(NO)
IF(PINCR(I).GT.0.AND.DELTAI.GT.DELTA) DELTAF=DEFLEC(1)
IF(PINCR(I).LT.0.AND.DELTAI.LT.DELTA) DELTAF=DEFLEC(NO)
IF(PINCR(I).LT.0.AND.DELTAI.LT.DELTA) DELTAF=DEFLEC(1)
GOTO 860
860 AZ=0.4
BZ=0.2
TESTING TO SKIP MODIFIED N-D ANALYSIS.
IF(IDBUG3.NE.0) WRITE(IOUT,1640) DELTAF,DELTAI
IF (IND.NE.0) GOTO 940
ILOOP=0
B70 CONTINUE
I=1
ILOOP=ILOOP+1
IF(IDBUG3.NE.0) WRITE(IOUT,1600)
600 FORMAT('I1,'//1X,'SOME INTERMEDIATE STEPS OF MODIFIED NAYLOR--'
,1,'DORAN PROCEDURE'///)
SET=-10.0
IK=0
880 CONTINUE
THE FOLLOWING TWO CARDS DISTINGUISH BETWEEN COMPRESSION AND
REBOUND DATA.
IF ((PINCR(I).GT.0).AND.DEFLEC(I).GE.DELTAI) GO TO 890
IF ((PINCR(I).LT.0).AND.DEFLEC(I).LE.DELTAI) GO TO 890
I=I+1
IF (I.GT.NO) GO TO 890
GOTO 880
890 K=1
SERVER=0
IF(IDBUG3.NE.0) WRITE(IOUT,1670) DELTAF
DIFF=DELTAF-DELTAI

******************************************************************************************

STEP 3
CALCULATE (1-%CONSOLIDATION)

******************************************************************************************

DO 900 L=1,NO
IF (K.EQ.1) IBEGIN=1
DEGN(K)=(DELTAF-DEFLEC(L))/DIFF
TIMX(K)=TIM(L)
IF(IDBUG3.NE.0) WRITE(IOUT,1610) K,DEGN(K),TIMX(K)
IF (IDBUG3.NE.0.AND.DEGND(K).LE.0) WRITE(IOUT,1610) K,DEGN(K)
610 FORMAT(1X,'K=',I3,3X,'DEGN =',F10.5,'TIMX =',F8.3)
IEND=K-1
KOUTN=K
IF(DEGND(K),LE,0) GOTO 910
XWORH(K)=TIMX(K)
YWORH(K)=ALOG(DEGND(K))
00 K=K+1
10 IF(SET.GT.0) GOTO 970
CALL FINDT(DEGND,AZ,IA)
CALL FINDT(DEGND,BZ,IB)
IF(IDBUG3.NE.0) WRITE(OUT,1620) AZ,IA,BZ,IB
20 FORMAT(5X,'AZ =',F6.3,3X,'IA =',I3,5X,'BZ =',F6.3,I8,'IB =',I3)
IF(IA.LE.0) GOTO 940
IF(IA.EQ.IB) GOTO 940

IF(GRAPH.NE.55) GOTO 920
DMAX=0.0
DMIN=-1.0
TMAX=100.0
TMIN=0.0
CALL SCALER(TMAX,TMIN,DMAX,DMIN)
CALL SQUARE
CALL BOX
CALL PLOTEM(**,XWORH,YWCRH,IEND)
CALL GRAPH('TIME, MINUTES',13,'LOGE(1-U) D100',14)
120 CONTINUE

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STEP 4
ANALYTICALLY REPRESENT DATA AS LOGE (1-%CONSOLIDATION)-VERSUS-TIME

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***********************************************************************************************

STEP 5
DETERMINE SLOPES OF LOGE(1-U)-VERSUS-TIME CURVE AT 60% AND 80% CONSOLIDATION.

***********************************************************************************************

N=3
CALL SLOPEU(TIMX,DEGND,N,IA,DY1,AC)
IF (IA.GE.NO) IB=NO
IF(IA.EQ.IB) GOTO 940
CALL SLOPEU(TIMX,DEGND,N,IB,DY2,BC)
J=0
IF(IDBUG3.NE.0) WRITE(OUT,1630) DY1,DY2
530 FORMAT(6X,'DY1 =',F10.4,3X,'DY2 =',F10.4)
IF(ABS(DY1).LE.1.0E-7 OR ABS(DY2).LE.1.0E-7) WRITE(OUT,1640) DELTA
IF(ABS(DY1).LE.1.0E-7 OR ABS(DY2).LE.1.0E-7) GOTO 950
R=DY1/DY2

D4 - DIAL READING AT 60% CONSOLIDATION.
D2 - DIAL READING AT 80% CONSOLIDATION.
D4 = 0.4 * DELTA1 + 0.6 * DELTAF
D2 = 0.2 * DELTA1 + 0.8 * DELTAF
IF (IDBUG3 . NE. 0) WRITE (IOUT, 1640) DELTAF, DELTA1
340 FORMAT (*0*, *DELTAF = ', F8.5, '10X, *DELTA1 = ', F8.5)

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STEP 6
SOLVE FOR ERROR IN DEFORMATION READING ASSUMED FOR D100.
******************************************************************************

E100 = 0.4 * (DY1 / DY2 - 1.0) / (1.0 - 2.0 * DY1 / DY2)
XWORK (IK+1) = DELTAF
YWORK (IK+1) = E100
IF (ABS(E100).LT.ABS(EFMIN)) DFMIN=DELTAF
IF (ABS(E100).LT.ABS(EFMIN)) EFMIN=E100

******************************************************************************

STEP 7
RECALCULATE A NEW DEFORMATION READING FOR D100.
******************************************************************************

DELTAF = (DELTAF-E100*DELTA1) / (1-E100)
IF (IDBUG3 . NE. 0) WRITE (IOUT, 1650) K, R, D4, D2, E100
16X, ' ERROR DIFFERENCE = ', G12.4/

IF (IDBUG3 . NE. 0) WRITE (IOUT, 1640) DELTAF
IF (IDBUG3 . NE. 0) WRITE (IOUT, 1680) IK
IF (IDBUG3 . NE. 0) WRITE (IOUT, 1720) E100
IF (IK.LE.3) GOTO 930
ISIGN1 = 999
ISIGN2 = 999
ESAVE = YWORK (IK)
DSAVEF = XWORK (IK)
DSAVF2 = XWORK (IK+1)
IF (ESAVE.LE.0) ISIGN1 = 0
IF (ESAVE.GT.0) ISIGN1 = 1
IF (E100.LE.0) ISIGN2 = 0
IF (E100.GT.0) ISIGN2 = 1
IF (ISIGN1.EQ.ISIGN2) GOTO 930
IF (IK.GT.3.AND.ABS(E100).LT.0.20) DELTAF = (E100-DSAVF2*(E100-ESAVE)) / (1-(DSAVF2-DSAVEF) / ((E100-ESAVE) / (DSAVF2-DSAVEF) * (-1)))
1/1(DSAVF2-DSAVEF))/((E100-ESAVE)/(DSAVF2-DSAVEF)*(-1))
IF (IDBUG3 . NE. 0.AND.IK.GT.3.AND.ABS(E100).LT.0.20) WRITE (IOUT, 1660)
1 DELTAF, DSAVEF, ESAVE, DSAVF2, E100
1 G11.4)
670 FORMAT ('0', 'DELTAF = ', F8.5)
930 CONTINUE

IS CORRECTED D100 CLOSE ENOUGH TO ASSUMED D100?
IF (ABS(E100).LT.0.10.AND.IK.EQ.10) WRITE (IOUT, 1720) E100

EGM3350
EGM3355
EGM3360
EGM3365
EGM3370
EGM3375
EGM3380
EGM3385
EGM3390
EGM3395
EGM3400
EGM3405
EGM3410
EGM3415
EGM3420
EGM3425
EGM3430
EGM3435
EGM3440
EGM3445
EGM3450
EGM3455
EGM3460
EGM3465
EGM3470
EGM3475
EGM3480
EGM3485
EGM3490
EGM3495
EGM3500
EGM3505
EGM3510
EGM3515
EGM3520
EGM3525
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EGM3540
EGM3545
EGM3550
EGM3555
EGM3560
EGM3565
EGM3570
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EGM3580
EGM3585
EGM3590
EGM3595
EGM3600
EGM3605
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EGM3975
EGM3980
EGM3985
EGM3990
EGM3995
EGM4000
EGM4005
EGM4010
EGM4015
EGM4020
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EGM4080
EGM4085
EGM4090
EGM4095
EGM4100
EGM4105
EGM4110
EGM4115
EGM4120
EGM4125
EGM4130
EGM4135
EGM4140
EGM4145
EGM4150
EGM4155
**STEPS 8 & 9**

IF THE ERROR IN THE VALUE OF DEFLECTION ASSUMED FOR D100 IS NOT
SMALL ENOUGH, REPEAT STEPS 3 THROUGH 6 USING THE NEW ASSUMED
VALUE FOR D100 UNTIL THE ERROR CRITERIA IS SATISFIED.

**STEPS B & 9**

IF IA BSI ElO O.I LT .0.0I AND,J K.E Q. lOI GOTO 960
IF(IK.EQ.10.AND.ABS(E100).GT.0.0I.AND.ABS(EFMIN).LT.0.0I)
1 DE LTA F=DFMIN
IF(IK.EQ.10.AND.ABS(E100).GT.0.0I.AND.ABS(EFMIN).LT.0.0I)
1 ESA VE=EFMIN
IF(IK.EQ.10.AND.ABS(E100).GT.0.0I.AND.ABS(EFMIN).LT.0.0I GOTO
1 960

*** *** *** ** ***** *** ***** ***** **** ** *********************** ****** ****

IF (ABS(E100).LT.0.001) GOTO 960
IK=IK+1
IF(IDEBUG3.NE.0) WRITE(IOUT,1680) IK
;80 FORMAT(*'***',* * * * * ITERATION NUMBER, IK = ',I3)
IF(IK.LE.10) GOTO 890
740 CVND=0
DOND=0.0
DONDSI=0.0
DBO=0.0
TBO=0.0
NDD100=0.0
NDD1SI=0.0
PRIMND=0
RIND=0
RPND=0
RSND=0
CVNDSI=0
PRNDSI=0
MVND=0
MVNDSI=0
KTND=0
UTSLOP=0.0
IF (IND.NE.0) E100=0
IF (ABS(E100).GT.0.05) WRITE(IOUT,1690) E100
;90 FORMAT(*'ANALYTICAL METHOD NOT CONVERGING',5X,'E100= ',G14.4)
IF (IND.NE.0) I=4
IF(IND.EQ.0) I=IB-IA
IFI.LT.3) WRITE(IOUT,1700) I
700 FORMAT(*'ANALYTICAL METHOD FAILS BECAUSE THERE ARE ONLY ',I3,
1 ' DATA POINTS FOUND BETWEEN 60 AND 80 PERCENT CONSOLIDATION. ')
IF (IND.NE.0) WRITE(IOUT,1710)
710 FORMAT(*'METHOD OF ANALYSIS',/*'/')
IF(IND.NE.0) GOTO 2040
IAPLOT=IAPLOT+1
CVANAL(IAPLOT,1)=0.0
CVANAL(IAPLOT,2)=0.0
CVANAL(IAPLOT,3)=DEFLEC(NO)
CVANAL(IAPLOT,4)=PINCR(III)+PRESS(III)
CVANAL(IAPLOT,5)=0.0
CVANAL(IAPLOT,6)=0.0
NEXT SIX STATEMENTS ATTEMPT TO DEAL WITH THE CASE WHERE ONE OR
BOTH SLOPES EQUAL ZERO.

IF (DCF.LT.0.0) DELTAF=DELTAF*0.95
IF (DCF.GT.0.0) DELTAF=DELTAF*1.05
IF(ABS(DY1).LE.1.0E-7.AND.ABS(DY2).LE.1.0E-7) GOTO 940
WRITE(IOUT,1640) DELTAF,ATTEN
GOTO 890

360 SET=10.0
IF(IK.EQ.10.AND.ABS(E100).GT.0.10.AND.ABS(ESAVE).LT.0.10)
1 E100=ESAVE
IF(IDBUG3.NE.0) WRITE(IOUT,1720) E100
20 FORMAT('0',*ERROR IN DELTAF, E100 =',G11.4)
IF(IDBUG3.NE.0.OR.IK.EQ.10) WRITE(IOUT,1680) IK
GOTO 890

770 YWORK(IK)=ALOG(DEGND(IK))
XWORK(IK)=TIMX(IK)
IF(IDBUG3.NE.0) WRITE(IOUT,1780) I,J,YWORK(IK),J,XWORK(IK)

350 CONTINUE

920 FORMAT('0',*MAX,DMIN,EMAX,EMIN = ',4(F8.4,2X))
CALL SCALER(DMAX,DMIN,EMAX,EMIN)
CALL SQUARE
CALL BOX
IK1=IK+1
WRITE(IOUT,1740) XWORK(KK),YWORK(KK)
340 FORMAT('0',*DIALRD =*,F8.5,*ERROR =*,F8.4)
980 CONTINUE
CALL DPRINT('**',XWORK,YWORK,IK1)
CALL PRINT('DIAL READING, DELTAF',20,'ERROR IN DELTAF',15)
990 CONTINUE

200 CONTINUE
LERROR=999
IF (SET.GT.0) IK=0
IF (SET.GT.0) SET=0.0
CALL FINDT(DEGND,AZ,IA)
CALL FINDT(DEGND,BZ,IB)
IBA=IB-IA
IF(I1A.LT.3) IBA=3
760 IF(DEGND(J).LE.AZ.AND.DEGND(J).GT.0) GOTO 1770
J=J+1
IF(J.GT.NO.OR.J.GT.KOUNT) WRITE(IOUT,1620) AZ,IA,BZ,IB
IF(J.GT.NO.OR.J.GT.KOUNT) GOTO 940
GOTO 1760

770 YWORK(IK)=ALOG(DEGND(J))
XWORK(IK)=TIMX(IK)
IF(IDBUG3.NE.0) WRITE(IOUT,1780) I,J,YWORK(IK),J,XWORK(IK)
**80** FORMAT('IX,I3',' LOG(1-U)'(',I3,') ='F8.5,'TIMX(',I3,') ='F9.4') EGM35380
 IF (IOBUG3.NE.0) WRITE(IOUT,1790) I
 IF (DEGND(J).LE.BZ.AND.IOBUG3.NE.0) WRITE(IOUT,1790) I

**90** FORMAT('O',*5X,'I ='',I3/)
 IF(DEGND(J).LE.BZ) GOTO 1800
 IF(I.EQ.(IBA+2)) GOTO 1810
 IF(DEGND(J).LE.0) GOTO 1800
 I=I+1.
 J=J+1
 GOTO 1770

100 CONTINUE

**IF** NUMBER OF DATA POINTS BETWEEN 60% AND 80% CONSOLIDATION EQUALS TWO, INCLUDE THE DATA POINT BEFORE 60% CONSOLIDATION SO THAT AN ESTIMATE OF C-SUB-V CAN STILL BE MADE BY THE ANALYTICAL METHOD.
 TEST=J-3
 IF( (TEST.LE.0) GOTO 940
 IF( (I.LT.2) GOTO 940
 IF( (I.LT.3) XWORK(3)=TIMX(J-3)
 IF( (I.LT.3) YWORK(3)=ALOG(DEGND(J-3))
 IF( (I.EQ.2) I=3
 IF( (I.LT.3) GO TO 940

10 CALL STDERR(XWORK,YWORK,DUM,UTSLOP,XK)
 IF(NQUIT.EQ.999) GOTO 1980
 IF(IK.GT.6) GOTO 1920
 RNU=ALOG(8.0/(3.14159**2.011)-XK
 IF (IOBUG3.NE.0) WRITE(IOUT,1860) XK,DELTAI,RNU
 IK=IK+1

**********************************************************************************************************

**STEP 10**
 FIND DATA POINTS IN VICINITY OF 60-PERCENT CONSOLIDATION AND EXTEND STRAIGHT LINE REPRESENTATION BACK TO ELAPSED TIME EQUAL TO ZERO TO FIND INTERCEPT 'AC'.

**********************************************************************************************************

CALL FINDT(DEGND,AZ,IA)
 IF(DEGND(1).LT.0.40) WRITE(IOUT,1850) ERR,DELTAI
 IF(DEGND(1).LT.0.40) WRITE(IOUT,1610) IA,DEGND(1),TIM(1)
 IF(DEGND(1).LT.0.40) GOTO 940
 CALL SLOPEU(TIMX,DEGND,N,IA,DY1,AC)

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**STEP 11**
 CALCULATE DIFFERENCE BETWEEN THEORETICAL INTERCEPT AND ACTUAL INTERCEPT FOR LOGE(1-U) VERSUS TIME CURVE.

**********************************************************************************************************

ERR=ALOG(8/PI**2.01)-AC
ERR=RNU
 IF(Abs(ERR).LT.Abs(EIMIN)) DIM=DELTAI
 IF(Abs(ERR).LT.Abs(EIMIN) EIM=ERR
 DIALR(IK+1)=DELTAI
 ERROR(IK+1)=ERR
STEP 12
CALCULATE A NEW DEFLECTION READING FOR DO.

DELTAI = ((DELTAI + ERROR * (DELTAF - E100 * (DELTAI - DELTAF)))/(1 + ERROR)
IF(IDBUG3 .NE. 0) WRITE(IOUT, 1680) IK
ISIGN1 = 999
ISIGN2 = 999
ESAVE = ERROR(IK)
DSAVEI = DIALRD(IK)
DSAVE2 = DIALRD(IK + 1)
IF(ESAVE .LT. 0) ISIGN1 = 0
IF(ESAVE .GT. 0) ISIGN1 = 1
IF(ERROR .LT. 0) ISIGN2 = 0
IF(ERROR .GT. 0) ISIGN2 = 1
IF(ISIGN1 .EQ. ISIGN2) GOTO 1830
IF(IDBUG3 .NE. 0) WRITE(IOUT, 1820) DSAVEI, ESAVE, DSAVE2, ERROR
I20 FORMAT(*', 'D SAVEI = ', F8.5, ', ESAVE = ', F8.5, ', DSAVE2 = ', F8.4, '
1 ', ERROR = ', F8.5)
IF(IK .GT. 2) DELTAI = (ERROR - DSAVE2 * (ERROR - ESAVE))/
1 (DSAVE2 - DSAVEI) / ((ERROR - ESAVE) / (DSAVE2 - DSAVEI) * (-1))
IF(IK .GT. 2) WRITE(IOUT, 1840) DELTAI
130 CONTINUE
140 FORMAT(*', 'NOW USING INTERPOLATED VALUE OF DELTAI = ', F8.5)
IF(IDBUG3 .NE. 0) WRITE(IOUT, 1850) ERROR, DELTAI
150 FORMAT(*', 'ERROR IN DELTAI = ', F9.4, ', DELTAI = ', F9.4)
160 FORMAT(*', 'XK = ', F8.5, ', DELTAI = ', F8.5, ', RNU = ', F8.5)
D2 = 0.2 * DELTAI + 0.8 * DELTAF
D80 = D2

STEP 13
RECALCULATE LOGE(1-U) VERSUS TIME DATA USING NEW ASSUMED VALUE
FOR DELTAI.

I=1
370 CONTINUE
IF (PINCRI I I I).GT.0 .AND. DEFLEC(I).GE. DELTAI) GO TO 1880
IF (PINCRI I I I).LT.0 .AND. DEFLEC(I).LE. DELTAI) GO TO 1880
I = I + 1
GOTO 1870
880 DIFF = DELTAF - DELTAI
K = 1
DD 1890 L = I, NO
DEGND(K) = (DELTAF - DEFLEC(L))/DIFF
IF(DEGND(K).GT.1.0) WRITE(IOUT, 1850) ERROR, DELTAI
IF(DEGND(K).GT.1.0) WRITE(IOUT, 1610) K, DEGND(K), TIMX(K)
IF(DEGND(K).GT.1.0) GOTO 940
IF(DEGND(L).GT.0) YWORH(K) = ALOG(DEGND(L))
IF(DEGND(L).GT.0) XWORH(K) = TIM(L)
IF(DEGND(LT).GT.0) IEND = K
TIMX(K)=TIM(L)
IF (IDBUG3.NE.0.) WRITE(IOUT,1610) K,DEGNDL,TIMX(K)

*********************************************************************************************************************

STEP 14
IF VALUE OF ERROR IN DELTAI IS NOT SUFFICIENTLY SMALL,
RETURN AND RECALCULATE LN(1-U) VERSUS TIME CURVE USING CORRECTED
VALUES OF D100 AND DO AND DETERMINE SLOPE OF LINEAR PORTION OF
CURVE.

*********************************************************************************************************************

IF(DEGND(K).LE.0.AND.ABS(ERRO).GT.0.005.AND.IK.LT.5) GOTO 970
IF(DEGND(K).LE.0.AND.ABS(ERRO).LT.0.005) GOTO 1920
IF(DEGND(K).LE.0) GOTO 1900

190 K=K+1
100 I=1
J=1

IF(IGRAPH.NE.56) GOTO 1910
DMAX=0.0
DMIN=-1.0
TMAX=100.0
TMN=0.0
CALL SCALER(TMAX,TMN,DMAX,DMIN)
CALL SQUARE
CALL BOX
CALL PLTETM(*,XWORH,YWORH,IEND)
CALL GRAPH('TIME, MINUTES',13,'LOGE(1-U) DO',13)
10 CONTINUE
AZ=0.4
BZ=0.2
CALL FNDTDEGND(AZ,IA)
CALL FNDTDEGND(BZ,IB)
IBA=IB-IA
IF(IBA.LT.3) IBA=3
GOTO 1760
120 CONTINUE
IF(ILOOP.LT.3) GOTO 870
IF(IDBUG3.NE.0) WRITE(IOUT,170) EFMIN,DFMIN,EIMIN,DIMIN
I=1
130 CONTINUE
IF(PINCR(III).GT.0.AND.DEFLEC(I).GE.DIMIN) GO TO 1400
IF(PINCR(III).LT.0.AND.DEFLEC(I).LE.DIMIN) GO TO 1400
I=I+1
GOTO 1930
140 DIFF=DFMIN-DIMIN
DELTAF=DFMIN
DELTAF=DIMIN
K=1
DO 1950 L=1,NO
DEGNDL=(DFMIN-DEFLEC(L))/DIFF
TIMX(K)=TIM(L)
IEND=K
IF(DEGND(K).LE.0) GOTO 1960
50 K=K+1
60 CONTINUE
CALL FNDTDEGND(BZ,IB)
IF(IA.LE.0) GOTO 940
STEP 15

CALCULATING THE COEFFICIENT OF CONSOLIDATION.

\[ C - \text{SUB-V} = \left( -\frac{4}{3.14159^2} \right) \times \left( \frac{HBAR}{2} \right) \times \text{SLOPE} \]

**NAYLOR-DORAN METHOD OF CALCULATING C-SUB-V:**

FIND VALUE OF ELAPSED TIME CORRESPONDING TO \( U = 0.8 \), \( T_0 \), AND CALCULATE C-SUB-V BY USING CORRESPONDING VALUE FOR THE TIME FACTOR. THIS IS DONE ONLY AS A CHECK IN CASE IT IS NEEDED.

CALL FINDT(DEGND,BZ,IB)
CALL SLOPEU(TIMX,DEGND,N,IB,XB,AC)

C-SUB-V IN FT2/YEAR
CVND = (UTSLOP*1479.29*(HBAR**2))
CVND = CVND/(DRAIN**2)

**NAYLOR-DORAN METHOD OF CALCULATING C-SUB-V:**

FIND VALUE OF ELAPSED TIME CORRESPONDING TO \( U = 0.8 \), \( T_0 \), AND CALCULATE C-SUB-V BY USING CORRESPONDING VALUE FOR THE TIME FACTOR. THIS IS DONE ONLY AS A CHECK IN CASE IT IS NEEDED.

CALL FINDT(DEGND,BZ,IB)
CALL SLOPEU(TIMX,DEGND,N,IB,XB,AC)

C-SUB-V IN FT2/DAY
T80 = (ALOG(0.2) - AC)/XB
CV = (0.565*HBAR**2/T80)*10.0/(DRAIN**2)
IF (IDBUG3.NE.0) WRITE(IOUT,1990) CVND
I90 FORMAT ('0',10X,'CV (NAYLOR-DORAN) =',F8.4,2X,'CEPT =',F8.4,
1' T80 =',F8.4,5X,'SLOPE =',F8.5,5X,' UTSLOP =',F8.5)
IF (IDBUG3.NE.0) WRITE(IOUT,1990) CV,AC,T80,XB,UTSLOP
CV = (ALOG(0.2) - ALOG(8/PI**2))*(-4/PI**2)*HBAR**2/T80*10.0/DRAIN**2
IF (IDBUG3.NE.0) WRITE(IOUT,2000) CV
J00 FORMAT ('0',10X,'AT U = 80%, TIME FACTOR = 0.5672, CV =',F8.4)
KND = 0
IF (K.GT.NO) K = NO
DO 2010 I = 1, K
IF (DEGND(I).LE.0) GOTO 2020
TEST = ALOG(DEGND(I))

EGM37210
EGM37220
EGM37230
EGM37240
EGM37250
EGM37260
EGM37270
EGM37280
EGM37290
EGM37300
EGM37310
EGM37320
EGM37330
EGM37340
EGM37350
EGM37360
EGM37370
EGM37380
EGM37390
EGM37400
EGM37410
EGM37420
EGM37430
EGM37440
EGM37450
EGM37460
EGM37470
EGM37480
EGM37490
EGM37500
EGM37510
EGM37520
EGM37530
EGM37540
EGM37550
EGM37560
EGM37570
EGM37580
EGM37590
EGM37600
EGM37610
EGM37620
EGM37630
EGM37640
EGM37650
EGM37660
EGM37670
EGM37680
EGM37690
EGM37700
EGM37710
EGM37720
EGM37730
EGM37740
EGM37750
EGM37760
EGM37770
EGM37780
EGM37790
EGM37800
EGM37810
IF (TEST.LT.-3.0) GOTO 20
KND=KNO+1
10 DEGND(I)=ALOG(DEGND(I))
20 PRIMND=DELTAF-DELTAI
   D4=0.4*DELTAI+0.6*DELTAF
   D2=0.2*DELTAI+0.8*DELTAF
   ONDI=DELTAI
   DONDSI=25.4*DOND
   NDD100=DELTAF
   NDD1SI=25.4*DELTAF
   RIND=(DELTAI-DEFI)/(DEFLEC(NO)-DEFI)
   RPND=PRIMND/(DEFLEC(NO)-DEFI)
   RSNDD=1.0-RIND-RPND

***************
C-SUB-V IN SQUARE METERS PER YEAR
CVNDSI=CVND/10.76329

***************

PRNDSI=PRIMND*25.4
MVND=(DEFLEC(NO)-DEFI)/(THIKI*PINCR IIII)
MVNDSI=MVND*1000/95.8

***************
C-SUB-V IN FT2/DAY
CVND=-(UTSLOP*(40/(PI**2)))*(HBAR)**2
CVND=CVND/(DRAIN**2)
KTND=CVND*MVND*1.100667E-05

***************

IAPLOT=IAPLOT+1
CVANAL (IAPLOT,1)=CVND
CVANAL (IAPLOT,2)=RIND
CVANAL (IAPLOT,3)=DEFLEC(NO)
CVANAL (IAPLOT,4)=PINCR IIII+PRESS IIII
CVANAL (IAPLOT,5)=DELTAF
CVANAL (IAPLOT,6)=KTND
CVANAL (IAPLOT,7)=UTSLOP
CVANAL (IAPLOT,8)=RPND
CVANAL (IAPLOT,9)=RSND
IF (IGRAPH .NE.5) GOTO 2030
DMAX=DEGND(I)
DMIN=DEGND(KNO)
TMAX=TIMX(KNO)
TMIN=0.0
CALL SCALER(TMXX,TMIN,DMAX,DMIN)
CALL SQUARE
CALL 80X
CALL PLOTEM('**',TIMX,DEGND,KNO)
CALL GRAPH('TIME, MINUTES',13,'LOGE(1 - U)',11)
30 CONTINUE

NAYLOR-DORAN PROCEDURE HAS BEEN COMPLETED.
OUTPut OF RESULTs

40 WRITE(IOUT,2050) II,BCD
50 FORMAT('1*','25X','LOAD-INCREMENT NO.:',I3,5X,20A4)
   IF(NDRAIN.NE.1) WRITE(IOUT,2060)
   IF(NDRAIN.EQ.1) WRITE(IOUT,2070)
60 FORMAT('0*','25X','DOUBLE DRAINAGE')
70 FORMAT('0*','25X','SINGLE DRAINAGE')
   PI=PRESS(I)
   PF=PINCRI(I)+PI
   PINCRI(I)=2.0*PINCRI(I)
   HFSI=HF*25.4
   PISI=95.8*PI
   PFSI=95.8*PF
   WRITE(IOUT,2080)
80 FORMAT('0*','40X','THICKNESS*','40X','PRESSURE INCREMENT')
   WRITE(IOUT,2090)HISI,HI,PISI,PI
90 FORMAT('0*','20X','INITIAL*','8X,F9.4*','MM. (','F9.5*','IN.),'16X,F9.2*','KPA/EGM38460
   1/SQ.M. (','F9.4*','T/SQ.FT.))
   WRITE(IOUT,2100)HFSI,HI,PFSI,PF
00 FORMAT('0*','22X','FINAL*','8X,F9.4*','MM. (','F9.5*','IN.),'16X,F9.2*','KPA/EGM38460
   1/SQ.M. (','F9.4*','T/SQ.FT.))
   WRITE(IOUT,2110)
   WRITE(IOUT,2120)
10 FORMAT('0*','34X','8HTAYLOR*S,25X,12HCASAGRANDE*S,22X,NAYLOR - DORAN*EGM38710
   1')
20 FORMAT('0*','30X','SQUARE ROOT TIME*','20X','LOGARITHM TIME*','20X','ANALYTEG38730
   GICAL METHOD')
   WRITE(IOUT,2130)T90,T50,T80
   WRITE(IOUT,2140)D90,D50,D80
   WRITE(IOUT,2150)CVRTSI,CVRROOT,CVLSGI,CVLOG,CVNDI,CVND
30 FORMAT('0*','30X','T90 =','F6.2*','MIN. ','19X','T50 =','F6.2*','MIN. ','1
   20X','T80 =','F6.2*','MIN. ')
40 FORMAT('0*','30X','D90 =','F8.4*','IN. ','18X','D50 =','F8.4*','IN. ','20X
   1*80 =','F8.4*','IN. ')
50 FORMAT('0*','1X','CONSOLIDATION COEFFICIENT*','1X,F8.2*','SQ.M/ Y (','F6.3,EGM38820
   1/SQ.FT./D'),1X,F8.2*','SQ.M/Y (','F6.3*','SQ.FT./D),6X,F8.2*','SQ.M/Y (','F6.3*','SQ.FT./D)
   WRITE(IOUT,2160)RTDOSI,RTDO,DOLOGS,DOLOG,DODNSI,DOND
60 FORMAT('0*','1DIAL RDG. AT ZERO % PRIMARY*','2X,F8.4*','MM. (','F7.4*','IN.EM38860
   1*IN.),'13X,F7.4*','MM. (','F7.4*','IN.EM38870
   1))
   WRITE(IOUT,2170)RTD1SI,RTD100,LD1SI,LD100,ND1SI,ND100
70 FORMAT('0*','DIAL RDG. AT 100 % PRIMARY*','4X,F7.4*','MM. (','F7.4*','ING38900
   1IN.),'13X,F7.4*','MM. (','F7.4*','IN.EM38910
   1)
   WRITE(IOUT,2180)PROTSI,PRIMRT,PRLOG,PRILOG,PRNDI,PRIMND
80 FORMAT('0*','EST. PRIMARY CONSOLIDATION*','4X,F7.4*','MM. (','F7.4*','ING38940
   1IN.),'13X,F7.4*','MM. (','F7.4*','IN.EM38950
   1))
   WRITE(IOUT,2190)MYSI,MVRoot,CALPHA,UTSLOP
90 FORMAT('0*','COMPRESSION M-Sub-V*','1X,F7.4*','SQ.M/MPA (','F6.4,EGM38970
   1*SQ.FT./TON),3X,CALPHA =','F8.5,18X,'UTSLOP =','G10.3,'/MIN.EM38980
   WRITE(IOUT,2200)RSROOT,RSLOG,RSND
00 FORMAT('0*','7X','PRIMARY COMP. RATIO*','8X,F7.4*','28X,F7.4*','27X,F7.4
   WRITE(IOUT,2210)RSROOT,RSLOG,RSND
10 FORMAT('0*','5X','SECONDARY COMP. RATIO*','7X,F8.4,27X,F8.4,26X,F8.4
   WRITE(IOUT,2220)RIROOT,RILOG,RIND
220 FORMAT('O',7X,'INITIAL COMP. RATIO',7X,F8.4,27X,F8.4,26X,F8.4) EGM39040
WRITE(IOUT,2230)KROOT,KTLOG,KTND EGM39050
230 FORMAT('O',2X,'PERMEABILITY COEFFICIENT',3X,G10.2,' CM./SEC.',11X,G10.2,' CM./SEC.',14X,G10.2,'CM./SEC.') EGM39060
WRITE(IOUT,2240) EGM39070
240 FORMAT('1',6X,'ELAPSED TIME',18X,'DEFLECTION',19X,'ELAPSED TIME',119X,'DEFLECTION *)
J=NO.
K=NO/2
L=0
DO 2250 M=1,K
MK=M*K+L
TEMPA=DEFLEC(M)
TEMPB=TEMPA*25.4
TEMPC=DEFLEC(MK)
TEMPD=TEMPC*25.4
WRITE(IOUT,2250)TIM(M),TEMPA,TEMPB,TIM(MK),TEMPC,TEMPD EGM39080
250 FORMAT('1',3X,F10.4,' MIN.',F17.5,' IN. (' ,F8.4,' MM.)',F17.2,' IN.',F9.5,' MIN. (' ,F9.5,' FT/2/DAY')
100 FORMA T('1', '8X,'SQUARE ROOT OF TIME', '19', '100', '34', 'FINAL') EGM39090
1T4G,'COEFFICIENT',T61,'COEFFICIENT',T75/
2T5,'LOAD',T16,'DEFLECTION',T31,'DEFLECTION',T50,'OF',T65,'OF',
3T102,'COMPRESSION RATIOS'/
4T3,'INCREMENT',T18,'READING',T33,'READING',T45,'CONSOLIDATION'
5,'T60', 'PERMEABILITY', T79,'T90'/
6T4,'TSF',T18,'( INCHES)',T32,'( INCHES)',T47,'(FT2/DAY)',
7T62,'(CM/SEC)',T77,'MINUTES',T93,'INITIAL',T108,'PRIMARY',
8T122,'SECONDARY'//)
DO 2320 I =1,ISPLT
WRITE(IOUT,2310)CVSQRT(I,4),CVSQRT(I,5),CVSQRT(I,3),CVSQRT(I,1) EGM39100
1CVSQRT(I,6),CVSQRT(I,7),CVSQRT(I,2),CVSQRT(I,8),CVSQRT(I,9) EGM39110
196
230 CONTINUE
130 CONTINUE
IF (IILPLOT.EQ.0) GOTO 2370
IF (NLOADS.GT.1.AND.III.EQ.NLOADS) WRITE(IOUT,2340)
40 FORMAT(1/'T58,'LOGARITHM OF TIME'/T62,'COEFFICIENT'/
1T19,'D100',T34,'FINAL',T46,'COEFFICIENT',T66,'OF',T76,
2'C1EFFICIENT',T90,8'T5','LOAD',T16,'DEFLECTION',
3'T31,'DEFLECTION',T50,'OF',T62,'SECONDARY',T80,'OF',
4'T91,'TI10,'COMPRESSION RATIOS'/
5'T3,'INCREMENT',T18,'READING',T33,'REFERENCE',T45,'CONSOLIDATION',
6'T61,'COMPRESSION',T75,'PERMEABILITY',T90,'OF',T50,8'
7'T4,'(TSF)',T18,'(INCHES)',T32,'(INCHES)',T47,'(FT2/DAY)',
8'T64,'C1ALPHA',T77,'(CM/SEC)',T92,'MINUTES',T105,'INITIAL',T115,
9'PRIMARY',T125,'SECONDARY///)
DO 2360 I = 1,IPLO
WRITE(IOUT,2350) CVLOGT(I,4),CVLOGT(I,6),CVLOGT(I,3),CVLOGT(I,1),
1CVLOGT(I,5),CVLOGT(I,7),CVLOGT(I,8),CVLOGT(I,2),CVLOGT(I,9),
2CVLOGT(I,10)
50 FORMAT(1X,F8.4,6X,2(F9.5,6X),F9.5,6X,F9.5,2(5X,G10.2),
14X,F8.5,3X,F7.5,3X,F7.5)
60 CONTINUE
70 CONTINUE
IF (IAPLOT.EQ.0) GOTO 2400
IF (NLOADS.GT.1.AND.III.EQ.NLOADS) WRITE(IOUT,2380)
80 FORMAT(1/'T58,'NAYLOR - DORAN ANALYTICAL METHOD'/T19,'D100',
1T34,'FINAL',T46,'COEFFICIENT',T66,'OF',T76,
2'T5,'LOAD',T16,'DEFLECTION',T31,'DEFLECTION',T50,'OF',T65,'OF',
3'T66,'TI10,'COMPRESSION RATIOS'/
5,T60,'PERMEABILITY',T75,'UTSLOP'/
6'T4,'(TSF)',T18,'(INCHES)',T32,'(INCHES)',T47,'(FT2/DAY)',
7'T62,'(CM/SEC)',T77,'1/MINUTES',T93,'INITIAL',T108,'PRIMARY',
8'T122,'SECONDARY///)
DO 2390 I = 1,IPLO
WRITE(IOUT,2310) CVANAL(I,4),CVANAL(I,5),CVANAL(I,3),CVANAL(I,1),
1CVANAL(I,6),CVANAL(I,7),CVANAL(I,2),CVANAL(I,8),CVANAL(I,9)
90 CONTINUE
00 CONTINUE
WRITE(IOUT,1080)
10 CONTINUE
GOTO 2430
20 CONTINUE

JOB CONTROL CARD HAS BEEN ENCOUNTERED, SIGNIFYING END OF DATA.
LEND=91
30 CONTINUE
IF (LEND.EQ.-1) GO TO 10
IF (III.EQ.NLOADS.AND.LEND.EQ.1) GO TO 10
IF (LEND.EQ.9) GO TO 10
CALL SYMBOL(0.0,3.0,0.35, 'E.G.MCNULTY END', 90.0,15)
CALL PLOT(5.0,-2.0,999)
STOP
END

SUBROUTINE POLFIT(X,Y,N,A,B,C)

***********************************************************************

POLFIT
PARABOLIC INTERPOLATION SUBROUTINE

197
ORDINATE VALUES ARE MULTIPLIED BY 100.0 TO REDUCE TRUNCATION ERROR BEFORE THIS SUBROUTINE IS USED.

A
QUADRATIC COEFFICIENT FOR SECOND ORDER TERM.

B
QUADRATIC COEFFICIENT FOR FIRST ORDER TERM.

C
COEFFICIENT FOR CONSTANT TERM.

DEN
DENOMINATOR OF EXPRESSIONS FOR COEFFICIENTS 'A', 'B', AND 'C'.

DENA
NUMERATOR OF EXPRESSION FOR COEFFICIENT 'A'.

DENB
NUMERATOR OF EXPRESSION FOR COEFFICIENT 'B'.

DENC
NUMERATOR OF EXPRESSION FOR COEFFICIENT 'C'.

SUM
SUM OF ORDINATE VALUES BEING FITTED.

SUMCU
SUM OF CUBES OF INDIVIDUAL ORDINATE VALUES.

SUMPRO
SUM OF PRODUCTS BETWEEN ABSCISSA AND ORDINATE VALUES FOR EACH DATA POINT UNDER CONSIDERATION.

SUMSQ
SUM OF SQUARES OF ORDINATE VALUES.

SUMT
SUM OF ABSCISSA VALUES BEING FITTED.

SUMFO
INDIVIDUAL ORDINATE VALUES RAISED TO FOURTH POWER, THEN SUMMED.

SUSQPR
PRODUCT OF ABSCISSA VALUES AND ORDINATE VALUES SQUARED, THEN SUM.

TEMP
TEMPORARY STORAGE VARIABLE (REAL).

X
ABSCISSA VARIABLE.
**DOUBLE PRECISION** X,Y
**DIMENSION** X(N),Y(N)

**DOUBLE PRECISION** SUMSQ,SUMCU,SUMFO,SUM,SUMT,SUMPRO,SUSQPR

I=N/2+1
TEMP=Y(I)
DO 10 M=1,N
Y(M)=Y(M)-TEMP
10 CONTINUE
SUMSQ=0
SUMCU=0
SUMFO=0
SUM=0
SUMT=0
SUMPRO=0
SUSQPR=0
DO 20 M=1,N
SUM=SUM+X(M)
SUMCU=SUMCU+X(M)**2
SUMFO=SUMFO+X(M)**3
SUMT=SUMT+X(M)
SUMPRO=SUMPRO+X(M)*Y(M)
20 SUSQPR=SUSQPR+Y(M)**2*X(M)

**DO 30 M = LoN**
YIMI=VIMI+TEMP
30 CONTINUE

**IF**ABS(DEN).LT.1.0E-07**DEN = 1.0E-7**
A=DENA/DEN
B=DENB/DEN
C=DENC/DEN
A=A-B*TEMP+C*TEMP**2
B=B-2.0*C*TEMP
RETURN
END

**SUBROUTINE** SLOPEU(T,DEG,N,M,SLOPE,CEPT)

********************************************************************

**SUBROUTINE** SLOPEU
DETERMINES SLOPES ON LOGE(1-U)-VERSUS-TIME CURVE

*****************************************************************************************************************************************

CEPT

INTERCEPT OF LINE FITTED TO THREE DATA POINTS ON LOGE(1-U*)-VERSUS-TIME RELATIONSHIP.

DEG

ONE MINUS THE DEGREE OF CONSOLIDATION.

IBEGIN

ARRAY LOCATION OF FIRST DATA POINT IN PRIMARY CONSOLIDATION.

IEND

ARRAY LOCATION OF LAST DATA POINT IN ANY GROUP OF DATA POINTS.

MKJ

ARRAY LOCATION OF VALUES OF ONE MINUS THE DEGREE OF CONSOLIDATION.

NN

SAME AS 'N'.

SLOPE

LEAST-SQUARES VALUE OF SLOPE THROUGH ANY GROUP OF DATA POINTS.

SUMPRO

SUM OF PRODUCTS BETWEEN VALUES OF ELAPSED TIME AND NATURAL LOG OF (1-U*).

SUMT

SUM OF VALUES OF ELAPSED-TIME FOR DATA POINTS BEING FITTED.

SUMTSQ

SUM OF SQUARES OF VALUES OF ELAPSED-TIME.

SUMU

SUM OF NATURAL LOGS OF VALUES OF (1-U*).

T( )

ARRAY LOCATION FOR VALUES OF ELAPSED TIME FROM LOGE(1-U*)-VERSUS-TIME RELATIONSHIP.

COMMON /FINDT1/, IBEGIN, IEND, IDBUG3

DIMENSION T(400), DEG(400)

IDUT=6

K=N/2+1

IF(IDBUG3.NE.0) WRITE(IDUT,1000) N,K,M

NN=N

SUMT=0

SUMU=0

SUMPRO=0

SUMTSQ=0

DO 10 J=1,NN

MKJ=M-K+J

10 CONTINUE

SLO41460
SLO41470
SLO41480
SLO41490
SLO41500
SLO41510
SLO41520
SLO41530
SLO41540
SLO41550
SLO41560
SLO41570
SLO41580
SLO41590
SLO41600
SLO41610
SLO41620
SLO41630
SLO41640
SLO41650
SLO41660
SLO41670
SLO41680
SLO41690
SLO41700
SLO41710
SLO41720
SLO41730
SLO41740
SLO41750
SLO41760
SLO41770
SLO41780
SLO41790
SLO41800
SLO41810
SLO41820
SLO41830
SLO41840
SLO41850
SLO41860
SLO41870
SLO41880
SLO41890
SLO41900
SLO41910
SLO41920
SLO41930
SLO41940
SLO41950
SLO41960
SLO41970
SLO41980
SLO41990
SLO42000
SLO42010
SLO42020
SLO42030
SLO42040
SLO42050
SLO42060
IF(MKJ.LE.0) MKJ=1
IF(IDBUG3.NE.0) WRITE(IOUT,1010) MKJ,DEG(MKJ),MKJ,T(MKJ)
IF(MKJ.LE.0) MKJ=1
IF(DEG(MKJ).LT.0) N=J-1
IF(DEG(MKJ).LT.0) GOTO 10
SUMT=SUMT+T(MKJ)
SUMU=SUMU+ALOG(DEG(MKJ))
SUMPRO=SUMPRO+T(MKJ)*ALOG(DEG(MKJ))
SUMTSQ=SUMTSQ+T(MKJ)*T(MKJ)
10 CONTINUE
SLOPE=(SUMPRO-SUMT*SUMU/N)/(SUMTSQ-SUMT**2/N)
CEPT=(SUMT*SUMPRO-SUMU*SUMTSQ)/(SUMT**2-N*SUMTSQ)
IF(IDBUG3.NE.0) WRITE(IOUT,1020) SLOPE,CEPT
100 FORMAT('O',SLOPEU:'N=I3,5X,'K=I3,'M=I3
110 FORMAT('I3,5X,'Y(I3,I3,I3)'=F8.4,'Y(I3,I3,I3)'=F8.4)
120 FORMAT('O',SLOPEU:='F9.4,5X,'INTERCEPT='F9.4)
RETURN
END

SUBROUTINE FINDT(X,DY1,I)

******************************************************************************

SUBROUTINE FINDT

DETERMINES VALUE OF ELAPSED TIME

CORRESPONDING TO EITHER 60 OR 80-PERCENT CONSOLIDATION

******************************************************************************

COMMON /FINDTL/ IBEGIN,IEND,IDBUG3
COMMON /BLOK2/ LOGTIM(400),NO,YCEPT,SLOPE,II,PSI,PSI,
1LINK,SLOPA,CEPTA,SLOPB,CEPTB,KNO,ITYPE,D100,GRAPH,IDBUG4
DIMENSION X(400)
I=1
J=0
IF(IDBUG3.NE.0) WRITE(6,1000) IEND
10 IF(X(I).GT.DY1) GOTO 20
J=J+1
IF(J.EQ.3) GOTO 30
20 CONTINUE
I=I+1
100 FORMAT('O','LAST X AT IEND=',I3)
110 FORMAT('I',NO) GOTO 30
120 FORMAT(I,ITYPE,(IEND+1)) GOTO 30
GOTO 10
30 RETURN
END

SUBROUTINE STDERR(X,Y,N,EVAL,SLOPE,XCEPT)

******************************************************************************

SUBROUTINE STDERR
DETERMINES STANDARD ERROR OF ESTIMATE

CORRELATION COEFFICIENT (DOUBLE PRECISION VALUE).

CORTESE
VARIABLE FOR CHECKING THAT DENOMINATOR OF COEFFICIENT OF CORRELATION IS GREATER THAN 1.0E-15.

DSLOPE
DOUBLE PRECISION VALUE OF LINEAR LEAST-SQUARES SLOPE.

DXCEPT
DOUBLE PRECISION VALUE OF LINEAR LEAST-SQUARES INTERCEPT.

EVAL
UNBIASED STANDARD ERROR OF THE ESTIMATE (DOUBLE-PRECISION VALUE).

ITEST
TEST VARIABLE FOR CHECKING THAT NUMBER OF DATA POINTS BEING FITTED IS NOT LESS THAN 3.

SUMD
SUM OF FITTED ORDIKATE VALUES.

SUMDSQ
SUM OF SQUARE OF ORDIKATE VALUES BEING FITTED

SUMTSQ
SUM OF SQUARE OF VALUES OF ELAPSED TIME BEING FITTED.

TEST
TEST VARIABLE TO AVOID DIVISION BY ZERO.

XCEPT
SAME AS 'CEPT'.

COMMON /CORR1/ COR
REAL*8 D SQRT, DABS
DOUBLE PRECISION X,Y, SUMPRO, SUMTSQ, SUMDSQ, SUMT, SUMD, COR, CORTESE, ITEST, DSLOPE, DXCEPT
DIMENSION X(N), Y(N)
SUMT=0
SUMD=0
SUMPRO=0
SUMTSQ=0
SUMDSQ=0
DO 10 M=1,N
SUMPRO=SUMPRO+X(M)*Y(M)
SUMTSQ=SUMTSQ+X(M)**2
SUMDSQ=SUMDSQ+Y(M)**2
SUMT=SUMT+X(M)
10 SUMD=SUMD+Y(M)
XN=N
IF(N.LE.1) XN=1.001
CORTESE=(SUMTSQ-SUMT*SUMT/XN)*(SUMDSQ-SUMD*SUMP/XN)
IF (DABS(COR) .LT. 1.0E-15) COR = 1.0E-15
COR = (SUMPRO - SUMT * SUMD / XN) / DSQRT(COR)
TEST = (SUMT*SUMD/SUMD/XN)
IF (DABS(TEST) .LT. 1.0E-15) TEST = 1.0E-15
DSLOPE = (SUMPRO - (SUMT * SUMD / XN) / TEST)
DXCEPT = (SUMT*SUMPRO-SUMD*SUMTSQ)/(SUMT*SUMD/XN/SUMTSQ)
SLOPE = DSLOPE
XCEPT = DXCEPT
ITEST = N - 2
EVAL = 0.75
IF (ITEST .LE. 0) GOTO 20
EVAL = D SQRT(DABS(SUMDSQ - DXCEPT * SUMD - DSLOPE * SUMPRO) / (N - 2))
20 CONTINUE
RETURN
END

SUBROUTINE TPLOTS

******************************************************************************

SUBROUTINE TPLOTS

PLOTS RESULTS OF TAYLOR, CASAGRANDE, AND NAYLOR-DORAN ANALYSES

******************************************************************************

CVA(1), CVB(1), CVC(1)
STORAGE ARRAYS FOR LOG-BASE10 OF EFFECTIVE STRESSES IMPOSED ON CONSOLIDATION SPECIMEN FOR SQUARE-ROOT, LOGARITHM-OF-TIME, AND NAYLOR-DORAN ANALYSIS. THE ABCISSA VALUES STORED IN THESE ARRAYS ARE NEEDED IN PLOTTING CV AND CALPHA VERSUS LOG10 OF EFFECTIVE STRESS.

V1(1), CV2(1), CV3(1)
ARRAYS CONTAINING VALUES FOR COEFFICIENTS OF CONSOLIDATION FROM SQUARE-ROOT, LOGARITHM-OF-TIME, AND NAYLOR-DORAN METHODS, RESPECTIVELY.

FACTOR
PROPORTION BY WHICH SIZE OF CALCOMP PLOTS WILL BE REDUCED OR INCREASED AS COMPARED TO THE ORIGINAL PROGRAMMED SIZE.

FPN
DUMMY VARIABLE USED IN PLOTTING SINGLE PRECISION, REAL NUMBERS. (FLOATING POINT NUMBER).

HOLD
TEMPORARY STORAGE VARIABLE FOR STARTING VALUE NEEDED IN PLOTTING ALL DEFLECTION DATA ASSOCIATED WITH ONE LOADING.

HOLD0
TEMPORARY STORAGE VARIABLE FOR SCALE FACTOR NEEDED IN PLOTTING ALL DEFLECTION DATA ASSOCIATED WITH ONE LOADING.

HOLD1
TEMPORARY STORAGE VARIABLE FOR STARTING ABCISSA NEEDED IN PLOTTING ENTIRE SET OF SQUARE-ROOT-OF-TIME DATA.
HOLD2
TEMPORARY STORAGE VARIABLE FOR SCALE FACTOR NEEDED IN PLOTTING
ABSCISSA VALUES OF ENTIRE SET OF SQUARE-ROOT-OF-TIME DATA.

HOLD3
TEMPORARY STORAGE VARIABLE FOR STARTING DEFLECTION VALUE NEEDED
IN PLOTTING ENTIRE SET OF SQUARE-ROOT-OF-TIME DATA.

HOLD4
TEMPORARY STORAGE VARIABLE FOR SCALE FACTOR NEEDED IN PLOTTING
DEFLECTIONS FOR ENTIRE SET OF SQUARE-ROOT-OF-TIME DATA.

NOHOLD
STORAGE VARIABLE FOR TOTAL NUMBER OF DATA POINTS, NO.

PLOT90
LARGEST ABSCISSA VALUE WHICH WILL BE PLOTTED WHEN 'IEXPAN' OPTION
TO SPREAD OUT HORIZONTAL AXIS OF SQUARE-ROOT-OF-TIME PLOT IS USED.

RSEC(
ARRAY FOR STORAGE OF RATIOS OF SECONDARY COMPRESSION TO TOTAL
COMPRESSION TO BE USED IN SUMMARY PLOTS.

SALPHA(
ARRAY FOR STORAGE OF COEFFICIENTS OF SECONDARY COMPRESSION,
CALPHA TO BE USED IN SUMMARY PLOTS.

SCALEF
VARIABLE USED IN FINDING LARGEST SCALE.

START
STARTING VALUE OF VERTICAL AXIS OF CV SUMMARY PLOT.

ST90
SQUARE-ROOT-OF-ELAPSED TIME, T90.

TESTNO
TEMPORARY STORAGE LOCATION OF -100 TIMES FINAL VALUE OF
DEFLECTION. USED IN PREVENTING INTERPOLATION PARABOLA FROM
BEING PLOTTED OUTSIDE OF THE BOUNDARIES OF THE PLOT AXIS.

TEST1
SIMILAR TO 'TESTNO' WITH THE EXCEPTION THAT IT IS -100 TIMES
FIRST VALUE OF DEFLECTION.

XXX
TEMPORARY STORAGE VARIABLE FOR PLOTTING OF REAL NUMBERS.

COMMON /BLOK1/ ROOTIM(400),DEFLEC(400),PINCR(20),YSEARC(50),
1DXWORK(150),DYWORK(150),DEGND(400),TIMX(400),IBUF(1024),PRESS(20),TPL44380
2BCD(20)
COMMON /BLOK2/ LOGTIM(400),NO,YCEPT,SLOPE,II,PISI,PFSI,
1LINK,SLOPA,CEPTA,SLOPB,CEPTB,KNO,ITYPE,D100,IGRAPH,IBUG4
COMMON /CURVE/ CSQRT0,CSQRT1,CSQRT2,CSQRT3,CSQRT4,CSQRT5,
1XSQRT100,YLOG100,NLOG,NSQRT,D50,IAxis,UTSLOP,XK,ITPAN,ISQRT,
2LOG,IND,DCF,LASTPT,PFCTR
COMMON /BLOK3/ T90,RDTD1,RTDO,RTD1I,RTD1O,CVRTSI,CVRROOT,
1T50,DOLOGS,DOLOG,LD1I,LDI00,CVLSI,CVLOG,DONDSI,DOND,NDD100,
2NDDISI,CVNDISI,CVND,T80
COMMON /BLOK4/ KROOT,KTLOG,KTND,PRESSO,MVROOT,MVSI
COMMON /SUMMAR/ CVSQR(20,9),CVLOGT(20,10),CVANAL(20,9),ISPLOT,
I1PLT,IAIPLT,NLOADS
DIMENSION CV1(22),CV2(22),CV3(22),CVA(22),CVB(22),CVC(22)
DIMENSION XWORK(100),YWORK(100),SALPHA(22),RSEC(22)
DOUBLE PRECISION DXWORK,DYWORK
REAL LDIS1,LD100,NODIS1,NDD100
REAL MVROOT,MVSI,MVLOG,MVLGSI,MVND,MVNSI
REAL KROOT,KTLOG,KTND
REAL LOGTIM,UTSLOP

IOUT=6
IF(IGRAPH.EQ.4) GOTO 240
IF(IGRAPH.EQ.6.AND.I.I.LT.B) GOTO 240
PRESSO=PFSI-PISI
IF (PRESSO.LT.0) ITYPE = 999
IF (PRESSO.GT.0) ITYPE = 0
CALL PLOT(3.0,1.5,-3)
CALL FACTOR(0.75)
IPLACE=1
IF(IDBUG4.NE.0) WRITE(IOUT,1000) IPLACE
00 FORMAT('I0','IPLACE = ',I13)
IF(IDBUG4.NE.0) WRITE(IOUT,1010) BCD
10 FORMAT('F0','F20.4)
CALL SYMBOL(-3.0,0.50,0.15,BCD,90.0,80)
CALL SYMBOL(-2.0,0.50,0.15,'PRESSURE INCREMENT *90.0,19)
CALL NUMBER(999,999,0.15,PRESSO,90.0,3)
CALL SYMBOL(999,999,0.15,'(KPA/SQ.M.)',90.0,12)
IDATA = NO

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PLOT TAYLOR SQUARE-ROOT-OF-TIME PLOT

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CALL FACTOR(PFACTR)
CALL PLOT(-0.5,2.0,-3)
IF (ISQRT.NE.0) LINK=1
IF (ISQRT.NE.0) GOTO 20
CALL SYMBOL(0.0,8.7,0.20,BCD,0.0,B0)
CALL SYMBOL(0.0,B.2,0.10,'C = ',0.0,4)
CALL SYMBOL(0.1,B.15,0.10,'V',0.0,1)
CALL NUMBER (0.5,B.2,0.10,CVRTSI,0.0,2)
CALL SYMBOL(999,0,999,0,10,' SQ.M./Y ','0.0,11)
CALL NUMBER(999,0,999,0.0,1,CVROOT,0.0,3)
CALL SYMBOL(999,0,999,0.0,10,' SQ.FT./D','0.0,10)
CALL SYMBOL (0.0,7.7,0.10,'PERMEABILITY, K = ','0.0,18)
FPN=KROOT*10.**7
CALL NUMBER (1.9,7.7,0.10,FPN,0.0,4)

CALL SYMBOL STATEMENT HAS DOUBLE PUNCH CHARACTER IN COLUMN 42
RAISES '10' TO THE '*-7' POWER.

IPLACE=IPLACE+1
IF(IDBUG4.NE.0) WRITE(IOUT,1000) IPLACE
CALL SYMBOL (999,0,999,0,10,***10-7 CM./SEC.*,0.0,16)
FPN=MVSI
CALL SYMBOL (0.0,7.2,0.10,'MV = ','0.0,5)
CALL NUMBER(999.0,999.0,10,FPN,0.0,2)
CALL SYMBOL(999.0,999.0,0.10,' SQ.M./MPA( ',0.0,12) TPL45090
FPN=MVROOT TPL45100
CALL NUMBER(999.0,999.0,0.10,FPN,0.0,3) TPL45110
CALL SYMBOL(999.0,999.0,0.10,' FT2/TI' ,0.0,7) TPL45120
CALL SYMBOL (4.4,7.7,0.10,' D = MM. ( IN. )',0.0,29) TPL45130
CALL SYMBOL (4.4,7.2,0.10,'D = MM. ( IN. )',0.0,0) TPL45140
131)
CALL SYMBOL (4.5,7.15,0.10,'100',0.0,3) TPL45150
CALL SYMBOL (4.5,8.2,0.10,' T = ',0.0,5) TPL45160
CALL SYMBOL (4.5,8.15,0.10,'90',0.0,2) TPL45170
CALL NUMBER (5.1,8.2,0.10,T90,0.0,3) TPL45180
CALL SYMBOL (999.0,999.0,0.10,' MIN',0.0,4) TPL45190
CALL SYMBOL (4.5,7.65,0.10,'0',0.0,1) TPL45200
XXX=4.9 TPL45210
IF(DCF.LT.0) XXX=4.8 TPL45220
CALL NUMBER(XXX,7.7,0.10,RTDOSI,0.0,4) TPL45230
XXX=6.2 TPL45240
IF(DCF.LT.0) XXX=6.1 TPL45250
CALL NUMBER (XXX,7.7,0.10,RTD0,0.0,4) TPL45260
XXX=5.1 TPL45270
IF(DCF.LT.0) XXX=5.0 TPL45280
CALL NUMBER (XXX,7.2,0.10,RTD1SI,0.0,4) TPL45290
XXX=6.4 TPL45300
IF(DCF.LT.0) XXX=6.3 TPL45310
CALL NUMBER (XXX,7.2,0.10,RTD100,0.0,4) TPL45320
CALL PLOT(0.5,0.0,-3) TPL45330
PLOT90=(ROOTIM(IDATA)**2) TPL45340
IF (IEXPAN.EQ.1) PLOT90=2.0*T90 TPL45350
IF (IEXPAN.EQ.1.AND.PLOT90.LT.1.0) PLOT90=1.0 TPL45360
IF OPTION TO EXPAND SQUARE ROOT OF TIME AXIS HAS BEEN SPECIFIED,
THE NEXT FEW STATEMENTS ARE USED. TPL45370
   DO 10 I = 1,NO TPL45380
      IF (ROOTIM(I).GT.PLOT90) GO TO 20 TPL45390
      IDATA=I TPL45400
10 CONTINUE TPL45410
   20 CONTINUE TPL45420
      NOHOLD = NO TPL45430
      HOLD1=ROOTIM(IDATA+1) TPL45440
      HOLD2=ROOTIM(IDATA+2) TPL45450
      HOLD3=DEFLEC(IDATA+1) TPL45460
      HOLD4=DEFLEC(IDATA+2) TPL45470
      IPLACE=IPLACE+1 TPL45480
      IF(IBUG4.NE.0) WRITE(IOUT,1000) IPLACE TPL45490
      CALL SCALE(DEFLEC,6.00,NO,1) TPL45500
      HOLD=DEFLEC(NO+1) TPL45510
VALUES OF DEFLECTION ARE BEING MADE NEGATIVE TO FACILITATE THE
PLOTTING OF INCREASING DEFLECTION IN A DOWNWARD DIRECTION. TPL45520
   DO 30 I = 1,NO TPL45530
      DEFLEC(I)=-DEFLEC(I) TPL45540
30 CONTINUE TPL45550
      IPLACE=IPLACE+1 TPL45560
      IF(IBUG4.NE.0) WRITE(IOUT,1000) IPLACE TPL45570
      CALL SCALE(DEFLEC,6.00,NO,1) TPL45580
      IF(IBUG4.NE.0) WRITE(IOUT,1020) DEFLEC(NO+2),DEFLEC(NO+1) TPL45590
      HOLD0=DEFLEC(NO+2) TPL45600
      IF(IBUG4.NE.0) WRITE(IOUT,1020) DEFLEC(NO+2),DEFLEC(NO+1) TPL45610
      20 FORMAT(10X,* YSCALE FACTOR =*,F9.5,* Y START VALUE =*,F9.5) TPL45620
      DEFLEC(IDATA+1)=DEFLEC(NO+1) TPL45630
DEFLEC(IDATA+2)=DEFLEC(NO+2)  TPL45700
NO = IDATA  TPL45710
IPLACE=IPLACE+1  TPL45720
IF(ISQRT.NE.0) GO TO 35  TPL45730
CALL SCALE(ROOTIM,5.0,NO,1)  TPL45740
CALL PLOT(0.0,6.00,-3)  TPL45750
CALL AXIS(0.0,0.0,'SQUARE ROOT OF ELAPSED TIME (SQ.RT. MIN.)', 41) TPL45760
15.0,0.0,ROOTIM(NO+1),ROOTIM(NO+2))  TPL45770
YECP=-RTDO  TPL45780
SLOPE=-SLOPE  TPL45790
35 SLOPB=-SLOPB  TPL45800
SLOPA=-SLOPA  TPL45810
CEPTA=-CEPTA  TPL45820
CEPTB=-CEPTB  TPL45830
D100=-D100  TPL45840
D50=-D50  TPL45850
IF(IAXIS.EQ.0.AND.ISQRT.EQ.0)CALL AXIS(0.0,0.0,'DEFLECTION (IN.)') TPL45860
1,17,6.00,270.0,HOLD,DEFLEC(NO+2))  TPL45870
IF(IAXIS.NE.0.AND.ISQRT.EQ.0)CALL AXIS(0.0,0.0,'DEFLECTION (MM.)') TPL45880
1,17,6.00,270.0,HOLD,DEFLEC(NO+2))  TPL45890
DEFLEC(NOHOLD+1)=HOLD  TPL45900
DEFLEC(NO+1)=HOLD  TPL45910
DEFLEC(NOHOLD+2)=HOLD0  TPL45920
DEFLEC(NO+2)=HOLD0  TPL45930
IF(ISQRT.NE.0) GO TO 100  TPL45940
35 PLOTTING OF SQUARE ROOT OF TIME VERSUS DEFLECTION.  TPL45950
CALL LINE(ROOTIM,DEFLEC,IDATA,1,-1,1)  TPL45960
IF(ABS(SLOPE).LT.1.0E-07) GOTO 80  TPL45970
IF(IAXIS.NE.0) YCEPT=25.4*YCEPT  TPL45980
IF(IAXIS.NE.0) SLOPE=25.4*SLOPE  TPL45990
IF(IDBUG4.NE.0) WRITE(6,1050) SLOPE,YCEPT  TPL46000
XWORK(1)=ROOTIM(1)  TPL46010
XWORK(3)=ROOTIM(NO+1)  TPL46020
XWORK(4)=ROOTIM(NO+2)  TPL46030
YWORK(3)=DEFLEC(NO+1)  TPL46040
YWORK(4)=DEFLEC(NO+2)  TPL46050
YWORK(1)=SLOPE*ROOTIM(1)+YCEPT  TPL46060
XWORK(2)=(DEFLEC(NO)-YCEPT)/SLOPE  TPL46070
YWORK(2)=DEFLEC(NO)  TPL46080
CALL LINE(XWORK,YWORK,2,1,0,0)  TPL46090
30 FORMAT(*'0.15X','X,Y WORK 1 AND 2 = 4(F10.4,2X))  TPL46100
XWORK(1)=XWORK(1)*1.15  TPL46110
XWORK(2)=XWORK(2)*1.15  TPL46120
IF(IDBUG4.NE.0)WRITE(IOUT,1030)XWORK(1),YWORK(1),XWORK(2),YWORK(2) TPL46130
CALL LINE(XWORK,YWORK,2,1,0,0)  TPL46140
XWORK(99)=XWORK(3)  TPL46150
XWORK(100)=XWORK(4)  TPL46160
YWORK(99)=YWORK(3)  TPL46170
YWORK(100)=YWORK(4)  TPL46180
IF(IDBUG4.NE.0) WRITE(IOUT,1040) IGRAPH,YCEPT,ITYPE  TPL46190
PLOT INTERPOLATION PARABOLA?  TPL46200
IF(IGRAPH.EQ.0) GO TO 70  TPL46210
IF(IGRAPH.EQ.2) GOTO 70  TPL46220
IF(IGRAPH.EQ.4) GOTO 70  TPL46230
IF(IGRAPH.EQ.5) GOTO 70  TPL46240
IF(IGRAPH.EQ.6) GOTO 70  TPL46250
ITYPE1=ITYPE  TPL46260
IF(PRESSO.LT.0.AND.DCF.LT.0) ITYPE=0  TPL46270
IF(PRESSO.GT.0.AND.DCF.LT.0) ITYPE=999  TPL46280
IPLACE=IPLACE+1  TPL46290
IF(IDBUG4.NE.0) WRITE(IOUT,1000) IPLACE  TPL46300
ST90=SQRT(ST90)
IF(XSQRT(NSQRT).LT.ST90) XSQRT(NSQRT)=ST90
IF(IDBUG4.NE.0) WRITE(IOUT,1030) XSQRT(1),YWORK(1),XSQRT(NSQRT)
DELTA=(XSQRT(NSQRT)-XSQRT(1))/98.

XWORK(1)=XSQRT(NSQRT)
XWORK(1)=XSQRT(1)
XWORK(1)=XSQRT(1)
ITEST=0

IF (ITEST.EQ.99) GO TO 70

15.4
IF (IAXIS.EQ.0) YWORK(1)=YWORK(1)/25.4

DO 60 I = 2,98
XWORK(I)=XWORK(I-1)+DELTA
GOTO 50

40 CONTINUE

ITEST=1+ITEST
IF (ITEST.EQ.100) GOTO 70
XWORK(I)=XWORK(I)+DELTA
IF(IDBUG4.NE.0) WRITE(IOUT,1040) I,XWORK(I),I,YWORK(I)

50 CONTINUE

YWORK(I)=-(CSQRT0+CSQRT1*XWORK(I)+CSQRT2*XWORK(I)*XWORK(I))/100.

IF(IAXIS.NE.0) YWORK(I)=-(CSQRT0+CSQRT1*XWORK(I)+CSQRT2*XWORK(I)*XWORK(I))/100.*25.4

FPN=ABS(DEFLEC(NO))+0.0010
IF(ITYPE.EQ.0.AND.ABS(YWORK(I)).GT.ABS(FPN)) GOTO 40

IF (ITYPE.EQ.0.AND.ABS(YWORK(I)).LT.ABS(DEFLEC(1))) YWORK(I)=XWORK(I)

IF (ITYPE.EQ.0.AND.ABS(YWORK(I)).LT.ABS(DEFLEC(1))) YWORK(I)=YWORK(I)

40 FORMAT(10X,'XWORK(',I3,')','=','F8.5,5X,'YWORK(',I3,')','=','F10.4)

60 CONTINUE

CALL LINE (XWORK,YWORK,98,1,0,0)
ITYPE=ITYPE1

70 CONTINUE

IF (IDBUG4.NE.0) WRITE(IOUT,1020) DEFLEC(NO+2),DEFLEC(NO+1)
ROOTIM(IDATA+1)=HOLD1
ROOTIM(IDATA+2)=HOLD2
DEFLEC(IDATA+1)=HOLD3
DEFLEC(IDATA+2)=HOLD4

80 CONTINUE

CALL PLOT (0.0,-6.00,-3)
NO=NOHOLD
DEFLEC(NO+1)=HOLD
DEFLEC(NO+2)=HOLD0

90 CONTINUE

CALL PLOT(12.0,0.0,-3)
00 GOTO (110,200,220),LINK
10 CALL SCALE (LOGTIM, 8.0, NO, 1)
IF (ABS (SLOPA - SLOPB). LE. 1.0E-05) CEPTA = D100
IF (ABS (SLOPA - SLOPB). LE. 1.0E-05) SLOPA = 0.0
IF (ILOG. NE. 0) LINK = 2
IF (ILOG. NE. 0) GOTO 100
IF (DBUG4. NE. 0) WRITE (IOUT, 1020) DEFLEC (NO+2), DEFLEC (NO+1)
CALL FACTOR (PFACTR)
CALL PLOT (-0.5, 0.0, -3)
CALL SYMBOL (0.0, 8.7, 0.20, BCD, 0.0, 80)
CALL SYMBOL (0.0, 8.2, 0.10, 'C', 0.0, 4)
CALL NUMBER (0.5, 8.2, 0.10, CVLOGT, 0.0, 2)
CALL SYMBOL (999.0, 999.0, 0.10, 'SQ.M/Y', 0.0, 11)
CALL NUMBER (999.0, 999.0, 0.1, CVLOG, 0.0, 3)
CALL SYMBOL (999.0, 999.0, 0.10, 'SQ.FT./D', 0.0, 10)
CALL SYMBOL (0.0, 7.7, 0.10, 'PERMEABILITY, K = ', 0.0, 18)
FPN = KLOG*10**7
CALL NUMBER (1.9, 7.7, 0.10, FPN, 0.0, 4)
CALL SYMBOL (999.0, 999.0, 0.10, '*10-7 CM./SEC.', 0.0, 16)
CALL SYMBOL (0.0, 7.2, 0.10, 'C-SUB-ALPHA = ', 0.0, 14)
FPN = CVLOG (11, 5)
CALL NUMBER (999.0, 999.0, 0.10, FPN, 0.0, 5)
CALL SYMBOL (4.4, 8.2, 0.10, 'T' = ', 0.0, 5)
CALL SYMBOL (4.5, 8.15, 0.10, '50', 0.0, 2)
CALL NUMBER (5.1, 8.2, 0.10, T50, 0.0, 31)
CALL SYMBOL (999.0, 999.0, 0.10, 'MIN', 0.0, 4)
CALL SYMBOL (4.4, 7.7, 0.10, 'D' = 'MM. (IN.')*0.0, 0.29)
CALL SYMBOL (4.5, 7.65, 0.10, '*4', 0.0, 1)
XXX = 4.9
IF (DCF. LT. 0) XXX = 4.8
CALL NUMBER (XXX, 7.7, 0.10, DOLOGS, 0.0, 4)
XXX = 6.2
IF (DCF. LT. 0) XXX = 6.1
CALL NUMBER (XXX, 7.7, 0.10, DOLOGS, 0.0, 4)
CALL SYMBOL (4.4, 7.2, 0.10, 'D' = 'MM. (IN.')*0.0, 0.0)
1311
CALL SYMBOL (4.5, 7.15, 0.10, '*100', 0.0, 3)
XXX = 5.1
IF (DCF. LT. 0) XXX = 5.0
CALL NUMBER (XXX, 7.2, 0.10, LD1SI, 0.0, 4)
XXX = 6.4
IF (DCF. LT. 0) XXX = 6.3
CALL NUMBER (XXX, 7.2, 0.10, LD100, 0.0, 4)
CALL PLOT (0.5, 0.0, -3)
CALL PLOT (0.0, 6.0, 0.0, -3)
CALL AXIS (0.0, 0.0, 'LOG10. OF ELASPED TIME (MIN.)', 31, 8.0,
10.0, LOGTIM (NO+1), LOGTIM (NO+2))
IF (IAXIS. EQ. 0) CALL AXIS (0.0, 0.0, 'DEFLECTION (IN.)', -17, 6.00,
1270.0, HOLD, DEFLEC (NO+2))
IF (IAXIS. NE. 0) CALL AXIS (0.0, 0.0, 'DEFLECTION (MM.)', -17, 6.00,
1270.0, HOLD, DEFLEC (NO+2))
IF (DBUG4. NE. 0) WRITE (IOUT, 1020) DEFLEC (NO+2), DEFLEC (NO+1)
CALL LINE (LOGTIM, DEFLEC, NO, 1, 0, 1)
IF (DBUG4. NE. 0) WRITE (IOUT, 1050) SLOPA, CEPTA, SLOPB, CEPTB, D100
IF (IAXIS. NE. 0) SLOPA = 25.4 * SLOPA
IF (IAXIS. NE. 0) CEPTA = 25.4 * CEPTA
IF (IAXIS.NE.0) SLOPB = 25.4*SLOPB
IF (IAXIS.NE.0) CEPTB = 25.4*CEPTB
IF (IDBUG4.NE.0) WRITE (IOUT, 1050) SLOPA, CEPTA, SLOPB, CEPTB, D100
      FORMAT (*0, 10X, *SLOPA, CEPTA, SLOPB, CEPTB, D100 = 'F10.4, 5X')
      IF (IAXIS.NE.0) YWORK(1) = D100*25.4
      IF (IAXIS.NE.0) D100 = 25.4*D100
      IF (IAXIS.EQ.0) YWORK(1) = D100
      XWORK(1) = (CEPTA - CEPTB)/(SLOPB - SLOPA)
      IF (IDBUG4.NE.0) WRITE (IOUT, 1060) YWORK(1), D100
      FORMAT (10X, *CEPTB, D100 = 'F8.3, 2X')
      XWORK(2) = LOGTIM(LASTPT)
      YWORK(2) = LOGTIM(LASTPT)*SLOPA + CEPTA
      IF (IDBUG4.NE.0) WRITE (IOUT, 1030) XWORK(1), YWORK(1), XWORK(2), YWORK(2)
      XWORK(3) = LOGTIM(N0+1)
      XWORK(4) = LOGTIM(N0+2)
      YWORK(3) = DEFLEC(N0+1)
      YWORK(4) = DEFLEC(N0+2)
      CALL LINE (XWORK, YWORK, 2, 1, 0, 0)
      XWORK(2) = (CEPTA - CEPTB)/(SLOPB - SLOPA)
      YWORK(1) = 0.1*(DEFLEC(N0) - DEFLEC(1)) + DEFLEC(1)
      XWORK(1) = (YWORK(11) - CEPTB)/SLOPB
      IF (XWORK(1).LT. XWORK(3)) YWORK(1) = XWORK(3)*SLOPB + CEPTB
      IF (XWORK(1).LT. XWORK(3)) XWORK(1) = XWORK(3)
      CALL LINE (XWORK, YWORK, 2, 1, 0, 0)
      XWORK(99) = XWORK(3)
      XWORK(100) = XWORK(4)
      YWORK(99) = YWORK(3)
      YWORK(100) = YWORK(4)

      PLOT INTERPOLATION PARABOLA?
      IF (IGRAPH.EQ.0) GOTO 170
      IF (IGRAPH.EQ.4) GOTO 170
      IF (IGRAPH.EQ.1) GOTO 170
      IF (IGRAPH.EQ.5) GOTO 170
      IF (IGRAPH.EQ.6) GOTO 170
      IYPE1 = IYPE
      YWORK(11) = YLOG(1)
      WRITE (IOUT, 1040) NLOG, YLCG(NLOG), NLOG, YLOG(1)
      DELTA = (YLOG(NLOG) - YLOG(1))/98.
      I = 1
      ITEST = 0
      CONTINUE
      ITEST = ITEST + 1
      IF (IEST.GT.99) GOTO 160
      XWORK(1) = (CLOGO+CLOG1+YWORK(1)+CLOG2*YWORK(1))*YWORK(1)
      IF (IDBUG4.NE.0) WRITE (IOUT, 1030) XWORK(11), YWORK(11)
      IF (XWORK(1).LT. -1.0) YWORK(1) = YWORK(1) + DELTA
      IF (XWORK(1).LT. -1.0) GOTO 120
      IF (XWORK(1).GT. 3.0) YWORK(1) = YWORK(1) + DELTA
      IF (XWORK(1).GT. 3.0) GOTO 120
      WRITE (IOUT, 1040) NLOG, YLCG(NLOG), NLOG, YWORK(1)
      DELTA = (YLOG(NLOG) - YWORK(1))/98.
      DO 150 I = 2, 98
          YWORK(I) = YWORK(I-1) + DELTA
          IF (IAXIS.EQ.0) YWORK(I-1) = -YWORK(I-1)*1.00/100.
          IF (IAXIS.NE.0) YWORK(I-1) = -YWORK(I-1)*25.4/100.
          XWORK(I) = (CLOGO+CLOG1+YWORK(I)+CLOG2*YWORK(I))*YWORK(I)
          IF (XWORK(I).GT. 3.0) YWORK(I) = ABS(YWORK(I-1)*100.0)
          IF (XWORK(I).GT. 3.0) XWORK(I) = XWORK(I-1)
          IF (XWORK(I).LT. -1.0) YWORK(I) = ABS(YWORK(I-1)*100.0)
          IF (XWORK(I).LT. -1.0) XWORK(I) = XWORK(I-1)
      END
IF (XWORK(I).LT.-1.) XWORK(I)=XWORK(I-1)
IF (IDBUG4.NE.0) WRITE(IOUT,1040) I,XWORK(I),I,YWORK(I)
TEST1=-DEFLEC(I)*100.0
TESTND=-100.0*DEFLC(ND)
IF (IAxis.NE.0) YWORK(I)=25.4*YWORK(I)
IF (IDCFL.T.0) GOTO 130
IF (TYPE.EQ.0.AND.ABS(YWORK(I)).GT.ABS(TSTNO)) YWORK(I)=TSTNO
IF (TYPE.EQ.0.AND.ABS(YWOR(I)).LT.ABS(TST1)) YWORK(I)=TST1
IF (TYPE.EQ.999.AND.ABS(YWORK(I)).LT.ABS(TSTNO)) YWORK(I)=TSTNO
IF (TYPE.EQ.999.AND.ABS(YWORK(I)).GT.ABS(TST1)) YWORK(I)=TST1
GOTO 140
30 CONTINUE
IF (TYPE.EQ.0.AND.ABS(YWORK(I)).LT.ABS(TSTNO)) YWORK(I)=TSTNO
IF (TYPE.EQ.0.AND.ABS(YWORK(I)).GT.ABS(TST1)) YWORK(I)=TST1
IF (TYPE.EQ.999.AND.ABS(YWORK(I)).GT.ABS(TSTNO)) YWORK(I)=TSTNO
IF (TYPE.EQ.999.AND.ABS(YWORK(I)).LT.ABS(TST1)) YWORK(I)=TST1
GOTO 140
40 CONTINUE
IF (IAxis.NE.0) YWORK(I)=YWORK(I)/25.4
IF (XWORK(I).LT.-1.0.AND.IAXIS.NE.0) YWORK(I)=YWORK(I)/25.4
IF (XWORK(I).GT.3.0.AND.IAXIS.NE.0) YWORK(I)=YWORK(I)/25.4
IF (IDBUG4.NE.0) WRITE(IOUT,1040) I,XWORK(I),I,YWORK(I)
50 CONTINUE
IF (IAxis.NE.0) YWORK(98)=-YWORK(98)*25.4/100.
IF (IAxis.EQ.0) YWORK(98)=-YWORK(98)*1.00/100.
IF (IGRAPH.NE.0) CALL LINE (XWORK,YWORK,98,1,0,0)
60 CONTINUE
ITYPE=ITYPE1
70 CONTINUE
XWORK(I1)=XWORK(99)
YWORK(11)=YWOR(99)
XWORK(12)=XWORK(100)
YWORK(12)=YWOR(100)
IF (T50.LE.0) GOTO 190
XWORK(I)=ALOGI(T50)
IF (IAxis.NE.0) YWORK(1)=D50*25.4
IF (IAxis.EQ.0) YWORK(1)=D50*1.000
DELTA = 3.0*YWORK(12)/10.0
DO 180 I=2,100
XWORK(I)=ALOGI(T50)
YWORK(I)=YWORK(I-1)+DELTA
IF (IDBUG4.NE.0) WRITE(IOUT,1040) I,XWORK(I),I,YWORK(I)
80 CONTINUE
CALL DASHLM(XWORK,YWORK,10,1)
90 LINK=2
CALL PLOT(0.0,-6.00,-3)
GOTO 90

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PLOT NAYLOR-DORAN LOGE(1-U)-TIME PLOT

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:00 CONTINUE
IF (CVNO.LE.0) LINK=3
IF (CVNO.LE.0) GOTO 100
IF (IND.NE.0) LINK=3
IF (IND,NE,0) GOTO 100
CALL SCALE(TIMX,8.0,KNO,1)
CALL SCALE(DEGND,6.00,KNO,1)
CALL FACTOR(PFACTR)
CALL PLOT(0.5,0.0,-3)
CALL SYMBOL(0.0,8.7,0.20,BCD,0.0,80)
CALL SYMBOL(0.0,8.2,0.10,°C =",0,0,4)
CALL SYMBOL(0.1,8.15,0.10,"V",0,0,1)
CALL NUMBER(0.5,8.2,0.10,CVNDST,0,0,2)
CALL SYMBOL(999.0,999.0,0.10,* SQ,M./Y (°,0.0,11)
CALL NUMBER(999.0,999.0,0.1,ECVNDST,0,0,3)
CALL SYMBOL(999.0,999.0,10,* SQ,FT./D,"0,0,10)
CALL SYMBOL(0.0,7.7,0.10,"PERMEABILITY, K =",0,0,18)
FPN=KTND*10.**7
CALL NUMBER(1.9,7.7,0.10,FPN,0,0,4)
CALL SYMBOL(999.0,999.0,0.10,* 10 -7 CM./SEC.,0.0,16)
CALL SYMBOL(0.0,7.2,0.10,"UTSLOP =",0,0,9)
FPN=UTSLOP
CALL NUMBER(999.0,999.0,0.10,FPN,0,0,4)
CALL SYMBOL(999.0,999.0,0.10,*/MINUTES.,0.9)
CALL SYMBOL(4.4,8.2,0.10,"T =",0,0,5)
CALL SYMBOL(4.5,8.15,0.10,"BO =",0,0,2)
CALL NUMBER(5.1,8.2,0.10,TBO,0,0,3)
CALL SYMBOL(999.0,999.0,0.10,* MIN,0,0.4)
CALL SYMBOL(4.4,7.7,0.10,"D = MM. ( IN.)*,0.0,29)
CALL SYMBOL(4.5,7.65,0.10,°,0.0,1)
XXX=4.9
IF(DCF.LT.0) XXX=4.8
CALL NUMBER(XXX,7.7,0.10,DONDSI,0,0,4)
XXX=6.2
IF(DCF.LT.0) XXX=6.1
CALL NUMBER(XXX,7.7,0.10,DOND,0,0,4)
CALL SYMBOL(4.4,7.2,0.10,"D = MM. ( IN.)*,0.0,1)
131)
CALL SYMBOL(4.5,7.15,0.10,"100°,0.0,3)
XXX=5.1
IF(DCF.LT.0) XXX=5.0
CALL NUMBER(XXX,7.2,0.10,NDDISI,0,0,4)
XXX=6.4
IF(DCF.LT.0) XXX=6.3
CALL NUMBER(XXX,7.2,0.10,NDD100,0,0,4)
CALL PLOT(0.5,0.0,-3)
CALL PLOT(0.0,6.0,-3)
CALL AXIS(0.0,0.0,*ELAPSED TIME (MIN.)*,19,B,0,0,0,TIMX(KNO+1),
ITIMX(KNO+2))
CALL PLOT(0.0,-6.0,-3)
CALL AXIS(0.0,0.0,* LOGE (1-U)*,10,6.00,90.0,DEGND(KNO+1),DEGND
(1(KNO+2))
CALL LINE(TIMX,DEGND,KNO,1,-1,3)
IF(CVNO.LE.0) GOTO 210
XWORK(1)=TIMX(1)
XWORK(2)=TIMX(KNO)
XWORK(3)=TIMX(KNO+1)
XWORK(4)=TIMX(KNO+2)
YWORK(1)=UTSLOP*XWORK(1)+XK
YWORK(2)=UTSLOP*XWORK(2)+XK
YWORK(3)=DEGND(KNO+1)
YWORK(4)=DEGND(KNO+2)
IF(IDBUG4,NE,0) WRITE(1,OUT,1020) DEGND(KNO+2),DEGND(KNO+1)
IF(IDBUG4,NE,0) WRITE(1,OUT,1030)XWORK(1),YWORK(1),XWORK(2),YWORK(2)
CHECK=YWORK(3)+YWORK(4)*6.00
TPL48750
TPL48760
TPL48770
TPL48780
TPL48790
TPL48800
TPL48810
TPL48820
TPL48830
TPL48840
TPL48850
TPL48860
TPL48870
TPL48880
TPL48890
TPL48900
TPL48910
TPL48920
TPL48930
TPL48940
TPL48950
TPL48960
TPL48970
TPL48980
TPL48990
TPL49000
TPL49010
TPL49020
TPL49030
TPL49040
TPL49050
TPL49060
TPL49070
TPL49080
TPL49090
TPL49100
TPL49110
TPL49120
TPL49130
TPL49140
TPL49150
TPL49160
TPL49170
TPL49180
TPL49190
TPL49200
TPL49210
TPL49220
TPL49230
TPL49240
TPL49250
TPL49260
TPL49270
TPL49280
TPL49290
TPL49300
TPL49310
TPL49320
TPL49330
TPL49340
TPL49350
IF (IDBUG4, NE, 0) WRITE(IOUT, 1030) UTSLOP, UTSLOP, XK, XK
CHECK = YWORK(3)
IF (IDBUG4, NE, 0) WRITE(IOUT, 1030) CHECK, CHECK, YWORK(1), YWORK(2)
IF (YWORK(2), LT, CHECK) XWORK(2) = (CHECK - XK) / UTSLOP
IF (YWORK(2), LT, CHECK) YWORK(2) = UTSLOP * XWORK(2) * XK
IF (IDBUG4, NE, 0) WRITE(IOUT, 1030) XWORK(1), YWORK(1), XWORK(2), YWORK(2)
CALL LINE(XWORK, YWORK, 2, 1, 0, 0)
10 CONTINUE
LINK = 3
CALL PLOT(0.0, -6.0, -3)
GOTO 90
20 CONTINUE
IYTYPE = 0
VALUES OF DEFORMATION ARE RETURNED TO THEIR ORIGINAL SIGN.
DO 230 I = 1, NO
DEFLEC(I) = -DEFLEC(I)
30 CONTINUE
CALL PLOT(0.0, -1.5, -3)
40 CONTINUE
IF (NLOADS, EQ, 1) GOTO 340
IF (I1, NE, NLOADS) GOTO 340
IF (ISQRT, NE, 0) GOTO 260
IF (ISPLTO, EQ, 0) GOTO 260

**************
SUMMARY PLOTS
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CALL PLOT(2.0, 0.0, -3)
DO 250 I = 1, ISPLTO
CV1(I) = CVSQRT(I, 1)
IF (CVSQRT(I, 4), LT, 0.1) CVSQRT(I, 4) = 0.1
CVA(I) = ALOG(10) (CVSQRT(I, 4))
IF (I1, EQ, 1) GOTO 250
IF (CVSQRT(I, 1), LE, 0.0 AND CVSQRT(I-1, 1), GT, 0) CV1(I) = CV1(I-1)
IF (CVSQRT(I, 1), LE, 0.0 AND CVSQRT(I-1, 1), GT, 0) CVSQRT(I, 1) = CVSQRT(I-1, 1)
50 CONTINUE
60 CONTINUE
IF (ILOG, NE, 0) GOTO 280
IF (ILPLOT, EQ, 0) GOTO 280
DO 270 I = 1, ILPLOT
CV2(I) = CVLOG(I, 1)
SALPHA(I) = CVLOG(I, 5)
RSEC(I) = CVLOG(I, 10)
IF (CVLOG(I, 4), LT, 0.1) CVLOG(I, 4) = 0.1
CVB(I) = ALOG(10) (CVLOG(I, 4))
IF (I1, EQ, 1) GOTO 270
IF (CVLOG(I, 1), LE, 0.0 AND CVLOG(I-1, 1), GT, 0) CV2(I) = CV2(I-1)
IF (CVLOG(I, 1), LE, 0.0 AND CVLOG(I-1, 1), GT, 0) SALPHA(I) = SALPHA(I-1)
IF (CVLOG(I, 1), LE, 0.0 AND CVLOG(I-1, 1), GT, 0) RSEC(I) = RSEC(I-1)
IF (CVLOG(I, 1), LE, 0.0 AND CVLOG(I-1, 1), GT, 0) CVLOG(I, 1) = CVLOG(I-1, 1)
70 CONTINUE
80 CONTINUE
IF (IND, NE, 0) GOTO 300
IF(ILPLOT.EQ.0) GOTO 300
DO 290 I=1,IAPLOT
   CV3(I)=CVANAL(I,1)
   IF(CVANAL(I,4).LT.0.1) CVANAL(I,4)=0.1
   CVC(I)=ALOG10(CVANAL(I,4))
   IF(I.EQ.1) GOTO 290
   IF(CVANAL(I,1).LE.0.AND.CVANAL(I-1,1).GT.0) CV3(I)=CV3(I-1)
   IF(CVANAL(I,1).LE.0.AND.CVANAL(I-1,1).GT.0) CVANAL(I,1)=CVANAL(I-1)
90 CONTINUE
00 CONTINUE
   SCALEF=0.0
   START=999B
   CV1(ISPLOT+1)=9999
   CV2(ILPLOT+1)=9999
   CV3(IAPLOT+1)=9999
   CV1(ISPLOT+2)=0
   CV2(ILPLOT+2)=0
   CV3(IAPLOT+2)=0
   IF(ISQRT.EQ.0.AND.ISPLOT.NE.0) CALL SCALE( CV1,8.0,ISPLOT,1)
   IF (ILOG.EQ.0.AND.ILPLOT.NE.0) CALL SCALE( CV2,8.0,ILPLOT,1)
   IF (IND.EQ.0.AND.IAPLOT.NE.0) CALL SCALE(CV3,8.0,IAPLOT,1)
   IF(CV1(ISPLOT+1).LT.START) START=CV1(ISPLOT+1)
   IF(CV2(ILPLOT+1).LT.START) START=CV2(ILPLOT+1)
   IF(CV3(IAPLOT+1).LT.START) START=CV3(IAPLOT+1)
   IF(CV1(ISPLOT+2).GT.SCALEF) SCALEF=CV1(ISPLOT+2)
   IF(CV2(ILPLOT+2).GT.SCALEF) SCALEF=CV2(ILPLOT+2)
   IF(CV3(IAPLOT+2).GT.SCALEF) SCALEF=CV3(IAPLOT+2)
   IF(DBG4.NE.0) WRITE(6,1070) START,SCALEF
70 FORMAT('0.0',4(F8.4,2X))
   CALL PLOT(0.0,1.5,-3)
   CALL LOGAXS(0.0,0.0,'LOG(VERTICAL EFF. STRESS, TSF)',-30,10.,0.0,1.0,0.300)
   CALL AXIS(0.0,0.0,'COEFFICIENT OF CONSOLIDATION, CV (FT2/DAY)',
   1-1.0,0.300)
   CALL SYMBOL(8.0,5.0,'START',SCALEF)
   CALL SYMBOL(8.0,8.0,'BCD',0.0,80)
   IF(ISQRT.NE.0) GOTO 310
   IF(ISPLOT.EQ.0) GOTO 310
   CALL SYMBOL(8.0,7.0,'TIME',0.0,-1)
   CALL SYMBOL (999.0,999.0,0.10,' - SQUARE ROOT TIME',0.0,19)
   CV1(ISPLOT+1)=START
   CV1(ISPLOT+2)=SCALEF
   CV2(ISPLOT+1)=-1.000
   CV2(ISPLOT+2)=0.3000
   CALL LINE(CVA,CV1,ISPLOT,1,1,1)
10 CONTINUE
   IF(ILOG.NE.0) GOTO 320
   IF(ILPLOT.EQ.0) GOTO 320
   CALL SYMBOL (8.0,6.0,'TIME',0.0,-1)
   CALL SYMBOL (999.0,999.0,0.10,' - LOGARITHM OF TIME',0.0,20)
   CV2(ILPLOT+1)=START
   CV2(ILPLOT+2)=SCALEF
   CVB(ILPLOT+1)=-1.000
   CVB(ILPLOT+2)=0.3000
   CALL LINE(CVB,CV2,ILPLOT,1,1,5)
20 CONTINUE
   IF (IND.NE.0) GOTO 330
   IF (IAPLOT.EQ.0) GOTO 330
   CALL SYMBOL(8.0,5.0,'TIME',0.0,-1)
   CALL SYMBOL (999.0,999.0,0.10,' - ANALYTICAL',0.0,13)
   CV3(IAPLOT+1)=START
CV3(IAPLOT+2) = SCALEF
CVC(IAPLOT+1) = -1.000
CVC(IAPLOT+2) = 0.3000
CALL LINE(CVC,CV3,IAPLOT,1,1,3)
0 CONTINUE
CALL PLOT(16.0,0.0,-3)
CALL SCALE(RSEC,B.0,ILPLOT,1)
CALL SCALE(SALPHA,B.0,ILPLOT,1)
CALL AXIS(-1.0,0.0,'SECONDARY COMPRESSION RATIO',27,8.0,90.0,
1RSEC(ILPLOT+1),RSEC(ILPLOT+2))
CALL AXIS(0.0,0.0,'COEFFICIENT OF SECONDARY COMPRESSION, C-SUB-ALPHA',TPL50680
1HA',49,8.0,90.0,SALPHA(ILPLOT+1),SALPHA(ILPLOT+2))
CALL LOGAXS(0.0,0.0,'LOG(VERTICAL EFF. STRESS, TSF)',-30,10.0,0.0,
1-1.0,0.300)
CALL LINE(CVB,SALPHA,ILPLOT,1,1,1)
CALL LINE(CVB,RSEC,ILPLOT,1,-1,3)
CALL DASHLN(CVB,RSEC,ILPLOT,1)
CALL SYMBOL(B.0,8.0,0.10,BCD,0.0,80)
CALL SYMBOL(B.0,7.0,0.10,'LOGARITHM OF TIME',0.0,17)
CALL SYMBOL(B.0,6.0,0.10,1.0,0.0,-1)
CALL SYMBOL(999.0,999.0,0.0,10,' - C-SUB-ALPHA',0.0,14)
CALL SYMBOL(999.0,5.0,0.10,3.0,0.0,-1)
CALL SYMBOL(999.0,999.0,0.10,' - SECONDARY COMPRESSION RATIO',
10.0,30)
CALL PLOT(0.0,-1.5,-3)
CALL PLOT(14.0,0.0,-3)
0 CONTINUE
RETURN
END